S32SDK User Manual

S32K1xx RTM 4.0.2

Generated by Doxygen 1.8.10

Fri Jun 11 2021 08:14:09

Contents

1 S32 SDK

Introduction

This topic provides an introduction to the S32 software development kit (S32 SDK), including intended audience, purpose and scope, and detailed sections on technical considerations.

Intended Audience

S32 SDK documentation is written for software developers and system engineers who have a technical background, and a working knowledge of embedded programming. The audience for the S32 SDK are users of S32 Processors.

Purpose and Scope

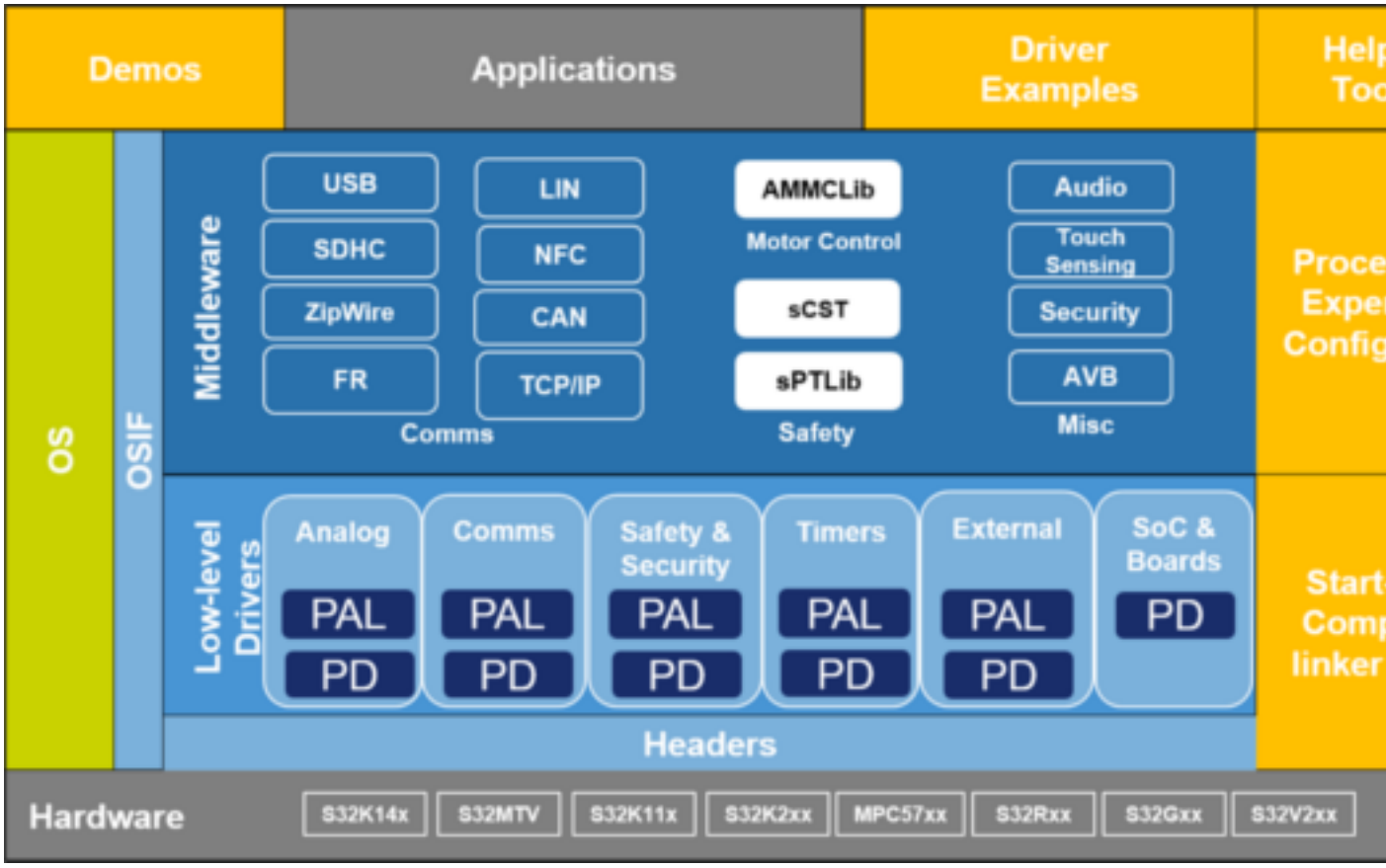
The S32 SDK is a embedded oriented development kit. It allows users to

1. Evaluate and explore the features of the S32 processors; experience how they are supported by working "out of the box" on NXP development boards.

2. Develop embedded solutions; the NXP SDK is thoroughly tested from development to production.

S32 SDK Architecture Overview

The S32 SDK is an extensive suite of robust hardware interface and hardware abstraction layers, peripheral drivers, RTOS, stacks, and middleware designed to simplify and accelerate application development on NXP S32 SOCs. The addition of Processor Expert technology for software and board configuration provides unmatched ease of use and flexibility. Included in the S32 SDK is full source code under a permissive open-source license for all hardware abstraction and peripheral driver software. See the Release Notes for details. The S32 SDK consists of the following runtime software components written in C:



2 Components

Header file

The S32 SDK contains a device-specific header files which provide direct access to the peripheral registers. Each supported device in S32 SDK has an overall System-on-Chip (SoC) memory-mapped header file. This header file contains the memory map and register base address for each peripheral and the IRQ vector table with associated vector numbers.

Feature Header File

The PAL is designed to be reusable regardless of the peripheral configuration differences from one SOC device to another. An overall Peripheral Feature Header File is provided for device to define the feature or configuration differences for each SOC sub-family device.

Peripheral Abstraction Layer

The PAL provides unified interfaces for families of peripherals, allowing for cross-platform compatibility of application code. The main goal is to provide an application programming interface that is independent of the underlying peripheral implementation.

The PAL supports all instances of each peripheral from a certain family instantiated on the SOC by using a simple integer parameter for the peripheral instance number.

The PAL instances should be configured bearing in mind possible limitations of the underlying peripherals - some features may not be supported on some hardware modules. It is the user's responsibility to correctly handle hardware resources, especially when porting the application to a different platform.

The PAL drivers can be found in the platform/pal directory.

Peripheral Drivers

The Peripheral Drivers are high-level drivers that implement high-level logic transactions based on an internal register access abstraction layer, other Peripheral Drivers, and/or System Services. For example, the UART register access abstraction layer mainly focuses on byte-level basic functional primitives, while the UART Peripheral Driver operates on an interrupt-driven level using data buffers to transfer a stream of bytes. In general, if a driver, that is mainly based on one peripheral, interfaces with functions beyond the register access abstraction layer and/or requires interrupt servicing, the driver is considered a high-level Peripheral Driver.

The Peripheral Drivers support all instances of each peripheral instantiated on the SOC by using a simple integer parameter for the peripheral instance number.The user of the Peripheral Driver does not need to know the peripheral memory-mapped base address.

The Peripheral Drivers operate on a high-level logic that requires data storage for internal operation context handling. However, the Peripheral Drivers do not allocate this memory space. Rather, the user passes in the memory for the driver internal operation through the driver initialization function.

The Peripheral Drivers are designed to handle the entire functionality for a targeted use-case. An application should be able to use only the Peripheral Driver to accomplish its purpose.

The Peripheral Drivers can be found in the platform/drivers directory.

System Services

The System Services contain a set of software entities that can be used by the Peripheral Drivers. They may be used with PAL Drivers to build the Peripheral Drivers or they can be used by an application directly. The following sections describe each of the System Services software entities. These System Services are in the platform/drivers directory.

Interrupt Manager

The Interrupt Manager provides functions to enable and disable individual interrupts within the Nested Vector Interrupt Controller (NVIC). It also provides functions to enable and disable the ARM core global interrupt (via the CPSIE and CPSID instructions) for bare-metal critical section implementation. In addition to providing functions for interrupt enabling and disabling, the Interrupt Manager provides Interrupt Service Routine (ISR) registration that allows the application software to register or replace the interrupt handler for a specified IRQ vector. The drivers do not set interrupt priorities. The interrupt priority scheme is entirely determined by the specific application logic and its setting is handled by the user application. The user application manages the interrupt priorities.

Clock Manager

The Clock Manager provides centralized clock-related functions for the entire system. It can dynamically set the system clock and perform clock gating/un-gating for specific peripherals. The Clock Manager also maintains knowledge of the clock sources required for each peripheral and provides functions to obtain the clock frequency for each supported clock used by the peripheral. The Clock Manager provides a notification framework which the software components, such as drivers, uses to register callback functions and execute the predefined code flow during the clock mode transition.

Power Manager

The Power Manager provides centralized power-related functions for the entire system. It dynamically sets the system power mode. The Power Manager provides a notification framework which the software components, such as drivers, uses to register callback functions and execute the predefined code flow during the power mode transition.

Examples

The examples provided show how to build user applications using the S32 SDK. The examples can be found in the top-level example directory. For details please see Examples_and_Demos .

3 PAL vs PD usage

PAL - Peripheral Abstraction layer

- Interface abstraction for a family of peripherals (E.g. LPUART + LINFlexD_UART + eSCI + FlexIO_UART + etc.)
- Single layer per SDK
- Same generic API on multiple platforms

PD - Peripheral Drivers

- IP dedicated low-level drivers
- Designed for efficiency and IP features set coverage

When to use the Peripheral Abstraction Layer (PAL)?

- Whenever an application needs a simplified, generic interface that abstracts as much as possible the underlying silicon features.
- Whenever developing portable higher level generic code that is meant to run on different NXP platforms. This may include anything from low level console utility libraries to communication stacks like TCP/IP.

When to use Peripheral Drivers?

- Whenever developing for high efficiency (code size, execution speed, etc.) or planning to use specific peripheral features.

4 Supported Platforms

Supported board and SoC versions can be found in the Release Notes. (SDK\ReleaseNotes.pdf)

5 Installation

Prerequisites

SDK can be used in two ways: bundled in S32 Design Studio and standalone.

S32 SDK is delivered bundled in the S32 Design Studio. In this case it's already configured and ready to use.

S32 SDK is also delivered through a standalone installer. Using the standalone installer is recommended when using a compiler which is not supported in S32 Design Studio or when the graphical interface is not required. In this case the installer can configure an existing S32 Design Studio to use the configuration files delivered in the installer.

If the integration with the S32 Design Studio is not needed the path to S32 Design Studio can be left empty – and in this case only the S32 SDK will be installed and configured.

Steps

1. Start the installer S32_SDK_<ReleaseSpecifc>.exe
2. Set the destination folder for the SDK, give optional location of S32DS and install. Example of S32DS path: C:\NXP\S32ARMv1.3
3. Start using the SDK by creating a new project or importing a project

Background

The installer does the following things in background:

- Puts the SDK in the selected destination directory.
- Appends to S32SDK_PATH the path of the SDK.
  - Note: Please make sure you uninstall previous SDK so that this variable will be empty.
- Copies necessary files into S32 Design Studio installation location.
- Overwrites existing SDK from S32 Design Studio with the version from destination directory

Uninstaller

When the SDK is installed using the standalone the installer, the user can use "uninst.exe" from the root of the destination to uninstall the SDK.

Note: If you want to reinstall the SDK please use a clean copy of S32DS. When you uninstall this does not delete the copied files (ex: Config_01.pez), so a clean copy is needed.

6 Build Tools

Introduction

S32 SDK supports and is tested with multiple compiler toolchains.

Note

The toolchain list, versions and their options specific for the platform and release can be found in the Release Notes. (SDK\ReleaseNotes.pdf)
Toolchain versions and options can be found in the Release Notes. (SDK\ReleaseNotes.pdf)

Compiler warnings disabled for S32 SDK

For *Wind River DIAB Compiler* the following warnings are not checked at S32 SDK build time:

- #1824: *explicit cast discards volatile qualifier*
  Motivation: this warning has been deactivated because of false positive occurrences reported for Wind River DIAB Compiler 5.9.4.8 under tickets TCDIAB-13994, TCDIAB-14098.
- #5387: *explicit conversion of a 64-bit integral type to a smaller integral type (potential portability problem)*
  Motivation: this warning has been disabled because it is reported for conversions required by the internal SDK algorithms. Intermediary results requiring high precision are stored as uint64_t variables and converted into uint32_t variables. Checks have been put in place to ensure that the cast is only done if the value to be converted fits on 32 bits.
- #5388: *conversion from pointer to same-sized integral type (potential portability problem)*
  Motivation: for S32 SDK conversions between uint32_t and memory addresses are made assuming that pointers are stored on 32bits.

Makefiles

Multiple makefile projects are provided in the 'examples' folder, for all supported compilers. These projects can be modified by adding application code, or the makefiles can be reused in different projects, after reconfiguring the paths/variables. Please note that these projects require the designated compiler to be already installed on the host; also, the makefile path to compiler executable must be updated before running make utility.

S32 Design Studio

S32 Design Studio is delivered with platform specific gcc cross compiler included ("{S32_Design_Studio_install_↩ path}\Cross_Tools). Eclipse plugins for gcc are already installed in S32 Design Studio IDE, so new projects for this toolchain can be created and built directly from the IDE. To add S32 SDK source files to a clean S32 Design Studio project, eclipse "linked resources" feature can be used: project properties->New->Folder->Advanced->'Link to alternate location' (e.g. "{S32_SDK_PATH}"). For S32 Design Studio project with Processor Expert support, please import a project from "{S32_SDK_PATH} Name".

7 IDE Support

S32 Design Studio

- S32 Design Studio is delivered with Processor Expert support included. Please see Configuration chapter.
- To configure the S32 SDK path of the project, eclipse "S32 SDK Specific" feature can be used: patch project properties->Processor Expert->S32 SDK Specific->SDK path
- Processor Expert repositories and paths can be configured as it follows: Window -> Preferences -> Processor Expert -> Repositories and Paths.
- S32 Design Studio projects can be imported from S32 SDK package. Please see Examples_and_Demos chapter.

IAR Embedded Workbench

- NOT applicable to platforms which do not support IAR compiler. Please see Release Notes.
- There is no configuration support for S32 SDK in IAR.
- IAR Embedded Workbench projects can be imported from S32 SDK package. Please see Examples_and↩ _Demos chapter.

8 Configuration

Processor Expert software allows generation of configuration structures for peripheral drivers from S32 SDK. With the help of Eclipse based graphical interface where you can configure your driver and generate corresponding configuration structure. This tool doesn't generate source code for S32 family, it only generates configurations data structures.

Processor Expert generates configuration header files that are included by application source code. The configuration data structures from these files are defined in S32 SDK. All these header files are generated by this tool in ${ProjName}/Generated_Code directory.

Peripheral drivers are not stored directly in the project directory, these drivers are stored in S32 SDK repository. Shared peripheral drivers repository is advantageous when more projects should share the same version of peripheral drivers. In this case, peripheral drivers are not physically placed in the project directory but each project is virtually linked with shared, common repository from S32 SDK. This way the management of the projects' drivers can be done in one place and any changes made in the shared repository is automatically distributed across all of the linked projects, for example in case of bug fixing or library update and also backup or archiving of the peripheral drivers versions is very simple.

9 Acronyms and Abbreviations

Acronym	Description
CPSIE, CPSID	Change Processor State Interrupt Enable / Disable
EAR	Early Access Release
EVB	Evaluation board
PAL	Peripheral Abstraction Layer
IRQ	Interrupt Request
ISR	Interrupt Service Routine
LLWU	Low Leakage Wakeup Unit
NVIC	Nested Vector Interrupt Controller
RTOS	Real Time Operating System
S32DS	S32 Design Studio
SDK	Software Development Kit
SOC	System-on-Chip
UART	Universal Asynchronous Receiver / Transmitter

10 MISRA Compliance

This section describes how the S32 SDK project addresses MISRA Compliance.

The S32 SDK SW components which are implemented to be compliant with MISRA C 2012 are:

- all drivers & PALs
- generated driver code (including Cpu.c & .h)
- main.c (generated via graphical configurator)

Violations of MISRA C 2012 guidelines which remain not fixed, shall be documented as deviations at file level.

Other SW components included in the S32 SDK package which are not subject to MISRA C 2012 compliance:

- demo_apps & driver examples
- FreeRTOS

11 Development guidelines

Set of guidelines to improve the usability of the S32 SDK.

Some usual guidelines on SDK programming model:

1. Driver state structures should be declared as global or static variables as they are used in the whole time when the driver is used.
2. Driver state structures content should not be used or modified by the application code.
3. Peripheral drivers, PALs and Middleware code are not handling clock and pins initialization. Configuration of the clock and pins driver has to be done by the application.To make sure these are properly initialized before other modules are used, please call the corresponding initialization:

```
/* Initialize and configure clocks */
CLOCK_SYS_Init(g_clockManConfigsArr, CLOCK_MANAGER_CONFIG_CNT,
                   g_clockManCallbacksArr, CLOCK_MANAGER_CALLBACK_CNT);
CLOCK_SYS_UpdateConfiguration(0U,
      CLOCK_MANAGER_POLICY_AGREEMENT);

/* Initialize pins */
PINS_DRV_Init(NUM_OF_CONFIGURED_PINS, g_pin_mux_InitConfigArr);
```

Note

The configuration structure names used in this example are the default names generated by Processor Expert components for clock and pins. Applications not using Processor Expert might have different names for these structures.

4. The recommended approach at development time is to add DEV_ERROR_DETECT symbol to the compiler defines. This will enable DEV_ASSERT mechanism which can catch application code errors in the early development stage.
5. High care should be taken to have a backup option when debug pins are routed to other functionalities.

12 Error detection and reporting

S32 SDK drivers can use a mechanism to validate data coming from upper software layers (application code) by performing a number of checks on input parameters' range or other invariants that can be statically checked (not dependent on runtime conditions). A failed validation is indicative of a software bug in application code, therefore it is important to use this mechanism during development.

The validation is performed by using DEV_ASSERT macro. A default implementation of this macro is provided in this file. However, application developers can provide their own implementation in a custom file. This requires defining the CUSTOM_DEVASSERT symbol with the specific file name in the project configuration (for example: -DCUSTOM_DEVASSERT="custom_devassert.h")

The default implementation accommodates two behaviors, based on DEV_ERROR_DETECT symbol:

- When DEV_ERROR_DETECT symbol is defined in the project configuration (for example: -DDEV_ER↩ ROR_DETECT), the validation performed by the DEV_ASSERT macro is enabled, and a failed validation triggers a software breakpoint and further execution is prevented (application spins in an infinite loop) This configuration is recommended for development environments, as it prevents further execution and allows investigating potential problems from the point of error detection.
- When DEV_ERROR_DETECT symbol is not defined, the DEV_ASSERT macro is implemented as no-op, therefore disabling all validations. This configuration can be used to eliminate the overhead of development-time checks.

It is the application developer's responsibility to decide the error detection strategy for production code: one can opt to disable development-time checking altogether (by not defining DEV_ERROR_DETECT symbol), or one can opt to keep the checks in place and implement a recovery mechanism in case of a failed validation, by defining CUSTOM_DEVASSERT to point to the file containing the custom implementation.

13 Examples and Demos

Applications that show the user how to initialize the peripherals for the basic use cases

13.1 Introduction

S32 SDK examples structure:

- Demo Applications (SDK/examples/<CPU>/demo_apps), are demo applications for various IDEs and compilers. Also this examples are using more advanced use-cases - FreeRTOS integration, LIN Stack, FlexCAN usage and Clock Setup.
- Driver Examples (SDK/examples/<CPU>/driver_examples), are simple applications which exemplify a basic use-case for a specific driver.

13.2 Usage

13.2.1 How to build

For makefile project

There are makefile projects in all compilers supported. In order to used them:

- **Make** utility (eg. GNU Make)
- **Toolchain** (eg. GCC Toolchain)
- **Make sure the make and compiler are in Path (for Microsoft Windows : System -> Environmental Variables)**
- From command line execute the makefile: **make all**

The makefiles generate binary files for both RAM and FLASH configurations.

For IAR Embedded Workbench

From IAR Workbench for ARM use File > Open > Workspace and browse to the desired project. After the project was opened you can see the files in "Workspace Files". Finally, the project can be executed from Project > Download and Debug. Make sure that the debug probe you are using is selected and configured in Project options > Debugger > Driver.

For S32 Design Studio

From S32 Design Studio (See Release notes for the S32 Design Studio version), go to File -> New -> New Project from Example and select the example you wish to import. This will copy the example project into workspace. Next steps:

- Examples will run without an active configuration, however if any changes are required, a configuration needs to be generated. Use Open S32 Configuration button, make the desired changes (if any) then click on the "Update Code" button.
- Use Project > Build to build the project
- Use Project > Debug and launch your preferred debug configuration

13.2.2 How to debug

This section explains how to upload and debug the binary files generated after build. This assumes that you have a debug probe(see release notes for supported debug probes) and a debug software installed on the machine.

Generic steps:

1. Launch the debug software
2. Load the binary file into the MCU
3. Execute the application

Loading with PEmicro OpenSDA/MultiLink:

- Download and install the latest drivers and GDB server, named *P&E GDB Server for Kinetis with Windows GUI*, from their site
- Download your favorite GDB client (eg. arm-none-eabi-gdb)
- Browse to PEmicro GDB Server installation folder and launch **P&E GDB Server for Kinetis**
- Select the appropriate part from the device list and click on **Connect**
- Open the GDB client and connect to the configured port - by default localhost:7224
- Upload the file and execute (see GDB client user manual for details regarding the commands used)

The following table is a small list of commands used in GNU ARM GDB with PEmicro GDB server to connect and run the application:

Command	Description
target remote:PortNumber	Connect to the remote target at a specified port. Please replace PortNumber with the port configured in the GDB server.
monitor reset	Reset the target MCU
file ApplicationName.elf	Load the file and symbols. Please change ApplicationName with your application name
load	Download the executable to the target MCU
continue	Begin executing the application

13.2.3 Using terminal emulator

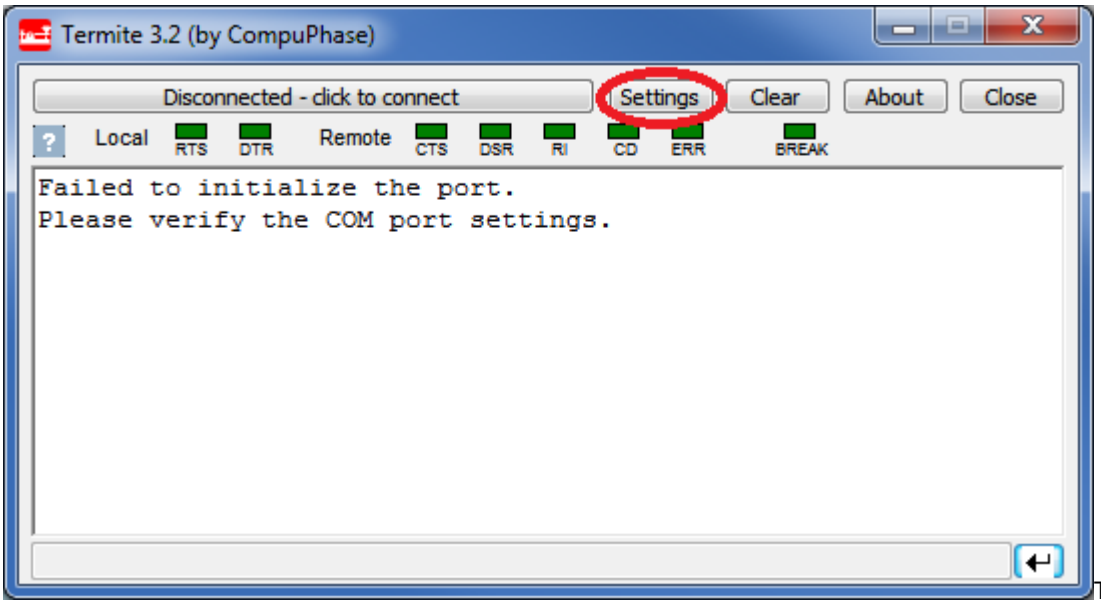
To run the examples that use LPUART to help you visualize data you must download a terminal emulator (eg. Putty, Termite, TeraTerm) and configure it.

Unless otherwise noted the standard communication parameters are:

- 115200 baud
- One stop bit
- No parity
- No flow control

Example configuration for Termite using OpenSDA

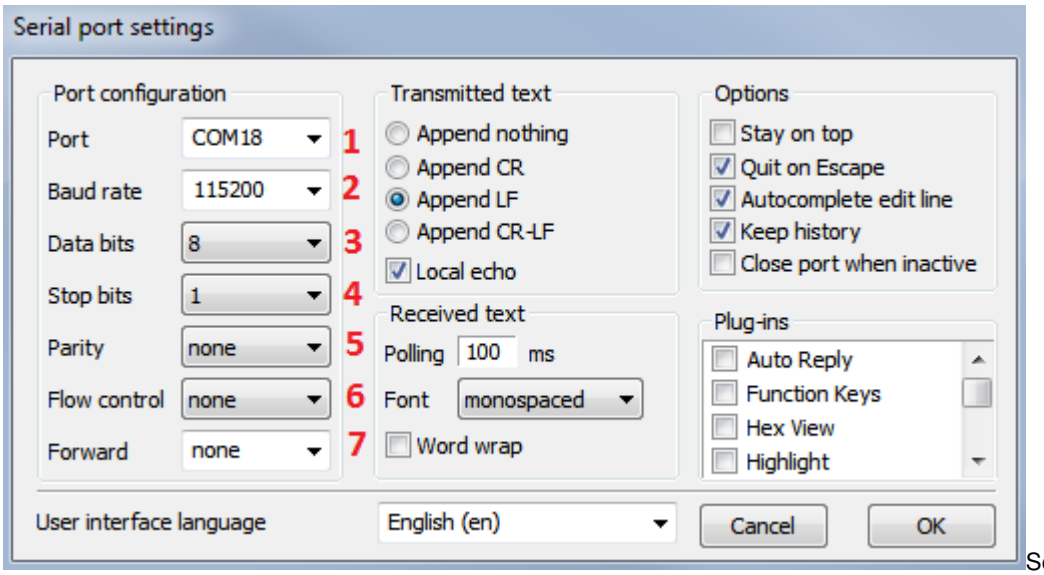
1) Download Termite from their site
2) Run the installer. Wait for the installation to be completed
3) Go to **Start** -> **All Programs** -> **Termite** and launch the program. The window from Fig.1 will appear ...



Termite window

4) Click on **Settings**
5) As seen in Fig.2, configure the following communication parameters:

- **Port(1)** : COMx - where x must be replaced with the COM port number
- **Baud Rate(2)** : 115200
- **Data Bits(3)** : 8
- **Stop Bits(4)** : 1
- **Parity(5)** : None
- **Flow Control(6)** : None
- **Forward(7)** : None



Settings window

6) Click **OK**. Now the terminal should be configured

Note

For further help consult the terminal's documentation

13.3 Demo Applications

Applications that show more advanced use cases

Available demo applications:
Click on one of the project to see the corresponding documentation

- ADC Low Power
- CSEC BOOT PROTECTION
- Hello World - Makefile
- FreeMASTER
- FreeRTOS
- Hello World
- AMMCLib
- Structural Core Self Test Example
- Hello World
- LIN MASTER
- LIN SLAVE

13.3.1 ADC Low Power

Demonstrates ADC trigger scheme using TRGMUX and LPIT, switches the power mode to stop and sends data using LPUART and DMA

Application description

The purpose of this demo application is to show you the usage of a subset of the peripherals found on the S32↩ K142W SoC.

- The application uses LPIT to trigger ADC conversions every 100ms via TRGMUX with the CPU in sleep mode. The ADC is using Hardware Compare feature to validate an conversion only if the value is greater than half of the reference voltage, in this case **VDD/2**. This way the CPU is woken up from sleep mode only if the condition is met.

- When the conversion is complete the data is transformed into a bar graph and it is sent via LPUART using DMA memory to peripheral transfer to the host PC. This way, the CPU can be put into a low power mode to reduce the energy used.

How the example works:

- Connect to the serial port using settings found in Notes section
- The user should receive a welcome message on the terminal emulator, with application details (user can refer the message in the main.c file)
- The value of Vref will display
- The user must press "A" or "a" for the example to run
- The potentiometer(R44 - connected to ADC1 channel 10) must be rotated in order to generate valid ADC conversions
- Once a valid conversion is done then a bargraph will be printed on the terminal emulator, like: "Starting example ... Move potentiometer to get a bargraph and some information displayed. ADC1-CH10 [################################] Vin=4034mV Raw=4095"

Prerequisites

To run the example you will need to have the following items:

- 1 S32K142W board
- 1 Power Adapter 12V
- 1 Personal Computer
- 1 PEMicro Multilink Debugger
- 1 USB Type-B cable for UART connect to J16 on mother board

Boards supported

The following boards are supported by this application:

- Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- Mother Board S32K-MB PCB RevA SCH RevB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K14xCVD-Q064 PCB	XS32K14WEVB-Q064
ADC POT	ADC1 Channel 10 (**PTE2**) - wired on the board	ADC0 Channel 9 (**PTC1**) - wired on the board

Make sure the following jumpers are set:

Jumper Name	S32K-MB

JP20	Set jumper on position 1-2
JP20	Set jumper on position 4-5
JP21	Set jumper on position 1-2

Jumper Name	XS32K14WEVB-Q064
J10	Set jumper on position 2-3

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New** -> **S32DS Project From** and select **adc_low_power_↩ s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace. Wait for the S32 Configuration was initialized and ready.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Right click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configuration (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. No RAM configuration is available because the elf file does not fit in RAM.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be one debug configuration for this project:

Configuration Name	Description
adc_low_power_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

Notes

For this example it is necessary to open a terminal emulator and configure it with:

- 115200 baud
- One stop bit
- No parity
- No flow control

13.3.2 CSEC BOOT PROTECTION

Basic application that presents the boot protection functionality of the CSEc module

Note

This example works only for CSEc enabled parts. SIM_SDID indicates whether CSEc is available on your device.
The first time when running the example on the board, or after a key erase, this example should be ran from RAM.
After the user key was loaded using this example, any further full erase of the Flash requires a Challenge-Authentication process. This can be done by setting the FLASH_MODIFY macro to 1.
After partitioning Flash for CSEc operation, using the JLink Flash configuration of any other project will not work anymore. Workaround:

- Run csec_boot_protection example with FLASH_MODIFY 1, using PEmicro Flash debug configuration

Application description

The purpose of this demo application is to show the user how to use the boot protection feature of the Cryptographic Services Engine module from the S32K142W MCU with the S32 SDK API.

The implementation demonstrates the following:

- the enablement of the CSEc module, by showing how the Flash should be partitioned (using the Flash driver);
- configuring the MASTER_ECU key;
- configuring the first user key, using the MASTER_ECU key as an authorization with boot protection enabled;
- configuring and enabling secure boot;
- availability of the user key after a secure boot when the flash was modified or not.
  Erasing all the configured keys (including the MASTER_ECU key) and disabling the secure boot can be done by changing the value of the FLASH_MODIFY macro to 1. This will place the part back into factory status (the partition command will need to be run again).
  Here is a table describing the outcome based on the value of FLASH_MODIFY and if the FLASH_TARGET is defined:

FLASH_MODIFY	FLASH_TARGET	Result
0	UNDEFINED	Write initial code to flash
1	UNDEFINED	Write modified code to flash
0	DEFINED	Write keys and enable secure boot
1	DEFINED	Erase keys and partition flash

Application usage

1. The first step is to run the application from RAM having the FLASH_MODIFY macro set to 1 in order to partition the flash. After this step, comment the #define INIT_PHASE line
2. Load the test program to it by setting the FLASH_MODIFY to 0 and running the application from FLASH.
3. Run the application from RAM with the FLASH_MODIFY macro set to 0 in order to load the keys necessary for secure boot and the test key with boot protection enabled.

4. Run the application from FLASH with the FLASH_MODIFY macro set to 0 in order to test secure boot. The secure boot process and the encryption using the test key should be successful.

5. Run the application from FLASH with the FLASH_MODIFY macro set to 1 this time in order to modify the flash. This will result in the secure boot to fail and the test key will be unavailable so the encryption operation will be unsuccessful.

6. Run the application from FLASH with the FLASH_MODIFY macro set to 0 in order to successfully secure boot. The test key is available again and the encryption operation is successful.

7. Set the FLASH_MODIFY macro to 1 and run the application from RAM in order to erase the keys and flash.

Note

If the FLASH_MODIFY is set to 1 at step 2 then the secure boots after the step 3 will be successful only if the FLASH_MODIFY macro is set to 1 and unsuccessful if it is set to 0.
If an assert fails at step 3, start over at step 1, decommenting the #define INIT_PHASE line and setting FLASH_MODIFY to 1.

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro

Boards supported

The following boards are supported by this application:

- S32K14xCVD-Q064 with S32K-MB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064	S32K14xCVD-Q064 with S32K-MB
LED_RED (**PTC0**)		LED0 - wired on the board
LED_GREEN (**PTC1**)		LED1 - wired on the board
LED_RED (**PTE0**)	RGB_RED - wired on the board	
LED_GREEN (**PTE7**)	RGB_GREEN - wired on the board	

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From** and select **csec_boot_protection_↩ s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace. Wait for the S32 Configuration was initialized and ready.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **RAM** (Debug_RAM) or **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
csec_boot_protection_s32k142w_debug_ram_↩ pemicro	Debug the RAM configuration using PEMicro debuggers
csec_boot_protection_s32k142w_debug_flash_↩ pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.3.3 Hello World - Makefile

Basic application that presents the project scenarios for S32 SDK using makefiles for various compilers

Application description

The purpose of this demo is to provide the user with an out-of-the box example application for S32K142W platform, using S32 SDK. The demo uses Pins and Clock driver to initialize the MCU and to toggle two LEDs alternatively.

There are five projects delivered with this package:

- Makefile project (GCC compiler)
- Makefile project (GHS compiler)
- Makefile project (IAR compiler)
- Makefile project (DCC compiler)
- Makefile project (ARM compiler)

Note

For information about how to run the makefile please refer to Usage

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro

Boards supported

The following boards are supported by this application:

- XS32K14WEVB-Q064
- S32K14xCVD-Q064 with S32K-MB

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064	S32K14xCVD-Q064 with S32K-MB
LED1 (**PTE0**/**PTC0**)	RGB_RED - wired on the board	LED_0 - JP49 (wired on the board)
LED2 (**PTE7**/**PTC1**)	RGB_GREEN - wired on the board	LED_1 - JP50 (wired on the board)

13.3.4 FreeMASTER

Example application showing FreeMASTER Serial Communication usage

Application description

The purpose of this demo application is to show you how to use the FreeMASTER serial communication using S32K142W on OpenSDA with this SDK.

This demo uses the FreeMASTER Run-Time Debugging Tool to visualise ADC conversions and allows the user to monitor the ADC sampling rate for different ADC configurations (ADC sampling time and resolution can be controlled through FreeMASTER Application Commands).

The ADC is configured to perform continous conversions and generate an interrupt after each conversion. The LPTMR is configured to generate a periodic interrupt at 10 ms which reads the number of ADC conversions.

Note

This example will work only in FLASH target.

Prerequisites

To run the example you will need to have the following items:

- 1 S32K142W board
- 1 Power Adapter 12V
- 1 Dupont male to male cable

- 1 Personal Computer
- Debug probe (JLink, PEmicro, OpenSDA)
- FreeMASTER host application

Boards supported

The following boards are supported by this application:

- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064
LPUART1 TX (**PTC9**)	UART_TX - wired on the board
LPUART1 RX (**PTC8**)	UART_RX - wired on the board
ADC0 Input 9 (**PTC1**)	POT - wired on the board

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New** -> **S32DS Project From** and select **freemaster_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace. Wait for the S32 Configuration was initialized and ready.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be one debug configuration for this project:

Configuration Name	Description
freemaster_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Open the FreeMASTER project (**freemaster_s32k142w.pmp**) and set the communication parameters:

- Go to **Project** -> **Options** -> **Comm**, choose **Direct RS232** and set the COM port and speed 9600.

- Go to **Project** -> **Options** -> **MAP** Files and make sure the ∗.elf file of your project's current Debug Configuration is selected and set file format to ELF/DWARF.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

Notes

FreeMASTER host application can be downloaded from NXP's website. FreeMASTER Serial Communication is included into the project (V2.0).

13.3.5 FreeRTOS

Demo application showing the integration of FreeRTOS and S32 SDK

Application description

The purpose of this demo application is to show you how to use the FreeRTOS with the S32 SDK for the S32K142W MCU.

This project defines a very simple demo that creates two tasks, one queue, and one timer. It also demonstrates how Cortex-M4 interrupts can interact with FreeRTOS tasks/timers.

The idle hook function: The idle hook function demonstrates how to query the amount of FreeRTOS heap space that is remaining (see vApplicationIdleHook() defined in this file).

The main() Function: main() creates one software timer, one queue, and two tasks. It then starts the scheduler.

The Queue Send Task: The queue send task is implemented by the prvQueueSendTask() function in this file. prv↩QueueSendTask() sits in a loop that causes it to repeatedly block for 200 milliseconds, before sending the value 100 to the queue that was created within main(). Once the value is sent, the task loops back around to block for another 200 milliseconds.

The Queue Receive Task: The queue receive task is implemented by the prvQueueReceiveTask() function in this file. prvQueueReceiveTask() sits in a loop that causes it to repeatedly attempt to read data from the queue that was created within main(). When data is received, the task checks the value of the data, and if the value equals the expected 100, toggles LED0. The 'block time' parameter passed to the queue receive function specifies that the task should be held in the Blocked state indefinitely to wait for data to be available on the queue. The queue receive task will only leave the Blocked state when the queue send task writes to the queue. As the queue send task writes to the queue every 200 milliseconds, the queue receive task leaves the Blocked state every 200 milliseconds, and therefore toggles LED0 every 200 milliseconds.

The LED Software Timer and the Button Interrupt: The user button BTN0 is configured to generate an interrupt each time it is pressed. The interrupt service routine switches LED1, and resets the LED software timer. The LED timer has a 5000 millisecond (5 second) period, and uses a callback function that is defined to just turn the LED off again. Therefore, pressing the user button will turn the LED on, and the LED will remain on until a full five seconds pass without the button being pressed.

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 2 Dupont male to male cable
- 1 Personal Computer

- 1 PEMicro Multilink Debugger

Boards supported

The following boards are supported by this application:

- XS32K14WEVB-Q064
- S32K14xCVD-Q064 with S32K-MB

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064	S32K14xCVD-Q064	S32K-MB
LED0 (**PTD15**)	RGB_RED - wired on board	LED0 - wired on the board	JP49.1 - JP49.2
LED1 (**PTD16**)	RGB_GREEN - wired on board	LED1 - wired on the board	JP50.1 - JP50.2
BTN0 (**PTC13**)	SW2 - wired on board	BTN0 - wired on the board	JP39.1 - JP39.2 and J70.1 - J70.2 and J69.2 - J69.3

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New** -> **S32DS Project From** and select **freertos_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace. Wait for the S32 Configuration to be initialized and ready.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code"

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
freertos_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers

freertos_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.3.6 Hello World

Basic application that presents the project scenarios for S32 SDK

Application description

The purpose of this demo is to provide the user with an out-of-the box example application for S32K142W platform, using S32 SDK. The demo uses Clock and Pins drivers in order to toggle two LEDs alternatively.

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro

Boards supported

The following boards are supported by this application:

- XS32K14WEVB-Q064
- S32K14xCVD-Q064 with S32K-MB

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064	S32K14xCVD-Q064 with S32K-MB
LED1 (**PTE0**/**PTC0**)	RGB_RED - wired on the board	LED_0 - JP49 (wired on the board)
LED2 (**PTE7**/**PTC1**)	RGB_GREEN - wired on the board	LED_1 - JP50 (wired on the board)

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New** -> **S32DS Project From** and select **hello_world_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace. Wait for the S32 Configuration was initialized and ready.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **RAM** (Debug_RAM) or **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
hello_world_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
hello_world_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.3.7 AMMCLib

Provides an example of integration of AMMCLib and S32 SDK

Application description

The purpose of this demo application is to show you how to integrate the S32 SDK with AMMCLib.

The application starts by sending a welcome message to the terminal with instructions regarding how to select between the two parts:

1. The first part:
   - The board sends a welcome message to the console with the supported operations and how to return to the menu.
   - It uses LPUART to communicate with the user and get the simple mathematical expressions.
   - The received expression is then interpreted and the result is calculated using mathematical functions from AMMCLib and then sent back to the terminal as a floating point with a precision of 4.
2. The second part:
   - The board sends a welcome message to the console with further instructions and how to return to the menu.
   - It uses LPTMR to generate samples of a sinusoidal signal, once every 1 ms, using trigonometric functions from the AMMCLib.
     The sinusoidal signal can be seen using the FreeMASTER host application.

Calculated signal samples are then scaled to be in the range of the FTM PWM duty cycle and are used to change the intensity of the RGB leds.
The frequency of each sine can be controlled with the command set_RGB_frequency() from FreeMA↩ STER project. The frequency sent is in mHz and the default value is 0,25Hz.

- Also, it implements an exponential moving average filter using the Potentiometer on ADC channel 12 as input.
  The output of the filter can be seen using the FreeMASTER host application.
  The filter's smoothing factor (lambda) can be controlled using the command set_FilterMA_lambda() from FreeMASTER project.

Note

For more detailed information on the AMMCLib's functions please consult the available documentation.

Prerequisites

To run the example you will need to have the following items:

- 1 S32K142W board
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro
- FreeMASTER host application
- UART to USB converter if it is not included on the target board. (Please consult your boards documentation to check if UART-USB converter is present).

Boards supported

The following boards are supported by this application:

- S32K14xCVD-Q064 with S32K-MB

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K14xCVD-Q064 with S32K-MB	XS32K14WEVB-Q064
FTM1 Channel 0	D10 - wired on the board	RGB_RED J2.6 - J3.8
FTM1 Channel 1	D19 - wired on the board	RGB_GREEN J2.5 - J3.6
FTM1 Channel 2	D20 - wired on the board	RGB_BLUE J5.9 - J3.14
ADC1 Input 11 (**PTE6**)	R45(POT) - wired on the board	R13(POT) - wired on the board

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New** -> **S32DS Project From** and select **ammclib_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace. Wait for the S32 Configuration was initialized and ready.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code". Wait for the code generation to be completed before continuing to the next step.

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be one debug configuration for this project:

Configuration Name	Description
ammclib_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

A terminal emulator configured with the following communication parameters is needed by this application:

- 9600 Baud rate
- 8 Data bits
- 1 Stop bit
- No parity
- No flow control

For the first part of the application follow the instructions in the terminal.
For the second part of the application you need to:

1. exit the mathematical section by typing **exit** in the terminal
2. select second section by typing **2** in the terminal
3. disconnect the terminal and start FreeMASTER.

Open the FreeMASTER project (**ammclib.pmp**) and set the communication parameters:

- Go to **Project** -> **Options** -> **Comm**, choose **Direct RS232** and set the COM port and speed 9600.
- Go to **Project** -> **Options** -> **MAP** Files and make sure the $*$.elf file of your project's current Debug Configuration is selected and set file format to ELF/DWARF.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

Notes

FreeMASTER host application can be downloaded from NXP's website.
FreeMASTER Serial Communication is included into the project (V2.0).

13.3.8 Structural Core Self Test Example

Basic application that presents the project scenarios for S32 SDK

Application description

The purpose of this demo application is to show you how to integrate the S32 SDK with sCST.

- The application will run the core self tests from the Structural Core Self Test library and will report the result using the user leds.
- Please consult the sCST manual for more information about the library.

  Note

  This application uses a modified version of the linker file which defines the section used by the library. As a consequence, the application will only run in flash.

  Verification:

- If the tests do not find any error, LED2 will be turned on. Otherwise LED1 will be turned on.

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- Debug probe (PEmicro)

Boards supported

The following boards are supported by this application:

- XS32K14WEVB-Q064
- S32K14xCVD-Q064 with S32K-MB

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064	S32K14xCVD-Q064 with S32K-MB
LED1 (**PTE0**)	RGB_RED - wired on board	D17 - wired on the board
LED2 (**PTE7**)	RGB_GREEN - wired on board	D18 - wired on the board

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **scst_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace. Wait for the S32 Configuration was initialized and ready.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
scst_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.3.9 Hello World

Basic application that presents the project scenarios for S32 SDK

Application description

The purpose of this demo application is to show you the usage of the FlexCAN module configured to use Flexible Data Rate and the CSEc module from the S32K142W CPU using the S32 SDK API.

- In the first part, the application will setup the board clocks, pins and other system functions such as SBC if the board uses this module as a CAN transceiver.
- Then it will configure the FlexCAN module features such as FD, Bitrate and Message buffers
- The application will wait for frames to be received on the configured message buffer or for an event raised by pressing one of the two buttons which will trigger a frame send to the recipient.
- Pressing SW3 2 button of board 1 shall trigger a CAN transfer that results in toggling the BLUE led on board 2.
- Pressing SW2 1 button of board 1 shall trigger a CAN transfer that results in toggling the GREEN led on board 2.
- Pressing both SW3 2 and SW2 1 buttons shall enable the encrypted communication. This event is signaled by the RED led toggling.
- The frames are sent in plain text by default.
- This demo application requires two boards, one configured as master and the other one configured as slave (see MASTER/SLAVE defines in application code).
- NOTE: Red led will turn on when init ,so when Pressing SW3 2 or SW2 1 buttons the light on can be a mix of red and green, blue lights.

Prerequisites

To run the example you will need to have the following items:

- 1 S32K144EVB-Q100(or another S32K EVB board which supports FLEXCAN)
- 1 XS32K14WEVB-Q064
- 1 Power Adapters 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEMicro Debugger (optional, users can use Open SDA)

Boards supported

The following boards are supported by this application:

- S32K14xCVD-Q064 with S32K-MB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064	S32K144EVB-Q100
CAN HIGH (∗)	CAN HIGH - J109.8	CAN HIGH - J13.1
CAN LOW (∗)	CAN LOW - J109.7	CAN LOW - J13.2
GND (**GND**)	GND - J109.6	GND - J13.4
BUTTON 1 (**PTD2**)	SW2 - wired on the board	SW2 - wired on the board
BUTTON 2 (**PTD3**)	SW3 - wired on the board	SW3 - wired on the board
RED_LED (**PTE0**)	RGB_RED - wired on the board	RGB_RED - wired on the board
GREEN_LED (**PTE3**)	RGB_GREEN - wired on the board	RGB_GREEN - wired on the board
BLUE_LED (**PTE7**)	RGB_BLUE - wired on the board	RGB_BLUE - wired on the board

(∗) Those lines must be modulated using a transceiver, if it is not specified the boards already include the CAN transceiver. The CAN transceiver should be in Forced Normal Mode operation (default mode). To reset the CAN transceiver to default mode connect the SBC transceiver in next configuration with the board XS32K14WEVB-Q064 power off : • pin RSTN from SBC is held LOW • CANH(J109.8) is pulled up to VBA↩ T(J109.5) • CANL(J109.7) is pulled down to GND(J109.6) Power on the board with external supply 12V (J16) This project only applies to S32K14W board. For S32K144EVB board or other S32K EVB boards, please refer corresponding example to get the right way to setup hardware correctly.

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New** -> **S32DS Project From** and select **hello_world_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace. Wait for the S32 Configuration was initialized and ready.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Right click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those

will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **RAM** (Debug_RAM) or **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
flexcan_encrypted_s32k142w_debug_flash_↩ pemicro	Debug the FLASH configuration using PEMicro debuggers
flexcan_encrypted_s32k142w_debug_ram_↩ pemicro	Debug the RAM configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.3.10 LIN MASTER

Example that shows the usage of the LIN driver in master mode

Application description

This example demonstrates the LIN communication between S32K142W Master and Slave using unconditional frames.

- The Master SeatECU is in NormalTable schedule table and it uses the LIN frame Motor1State_Cycl to receive temperature signal Motor1Temp from Slave Motor1 and send selection signal Motor1Selection to Slave Motor1 by frame Motor1Control. The first turn on GREEN_LED, then 5s GREEN_LED and BLUE_LED will toggle alternately.

- If value of temperature signal is higher than MOTOR1_OVER_TEMP value, Master SeatECU will send STOP command through Motor1Selection signal to stop motor and turn on RED_LED.

- If value of temperature signal is in range from MOTOR1_MAX_TEMP value to MOTOR1_OVER_TEMP value, master SeatECU will send DECREASE MOTOR SPEED command through Motor1Selection signal to reduce motor speed and turn on BLUE_LED.

- If value of temperature signal is lower than MOTOR1_MAX_TEMP value, master will send INCREASE MO↩ TOR SPEED command through Motor1Selection signal to increase motor speed and turn on GREEN_LED.

- When users press button BUTTON 0 on the Master board, the Master SeatECU switches its schedule table to go-to-sleep table. So the Slave and Master enter sleep mode, RGB LEDS are off.

- When LIN cluster is in sleep mode, users press button BUTTON 1 on the Master board, the Master board sends a wakeup signal to wakeup slave nodes, then switches its table to NormalTable.

Prerequisites

To run the example you will need to have the following items:

- 2 XS32K14WEVB-Q064 boards
- 1 Power Adapter 12V
- 2 Dupont female to female cable
- 1 Personal Computer
- 1 Jlink Lite Debugger (optional, users can use Open SDA)

Boards supported

The following boards are supported by this application:

- S32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K14WEVB-Q064-Master	S32K14WEVB-Q064-Slave
BUTTON 0 (**PTD2**)	SW2 - wired on the board	SW2 - wired on the board
BUTTON 1 (**PTD3**)	SW3 - wired on the board	SW3 - wired on the board
RED_LED (**PTE7**)	RGB_RED - wired on the board	RGB_RED - wired on the board
GREEN_LED (**PTE0**)	RGB_GREEN - wired on the board	RGB_GREEN - wired on the board
BLUE_LED (**PTE3**)	RGB_BLUE - wired on the board	RGB_BLUE - wired on the board
LIN (∗)	J11-1 - LIN	J11-1 - LIN
GND (**GND**)	J11-4 - GND	J11-4 - GND

(∗) Those lines must be modulated using a transceiver, if it is not specified the boards already include the LIN transceiver

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **lin_master_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. First go to **Project Explorer** View in S32 DS and select the current project(**lin_master_s32k142w**). Select the "ConfigTools" menu then click on the desired configuration (Pins, Clocks, Peripherals etc...). Clicking on any one of those will generate all the components. Make the desired changes(if any) then click on the "ConfigTools->Update Code" button.

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be four debug configurations for this project:

Configuration Name	Description
lin_master_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.3.11 LIN SLAVE

Example that shows the usage of the LIN driver in slave mode

Application description

This example demonstrates the LIN communication between S32K142W Master and Slave using unconditional frames.

- The Master SeatECU is in NormalTable schedule table and it uses the LIN frame Motor1State_Cycl to receive temperature signal Motor1Temp from Slave Motor1 and send selection signal Motor1Selection to Slave Motor1 by frame Motor1Control. The first turn on GREEN_LED, then 5s GREEN_LED and BLUE_LED will toggle alternately.
- When user press button BUTTON 0 on the Slave board, value of temperature signal (Motor1_temp) will be increased 60 unit.
- When user press button BUTTON 1 on the Slave board, value of temperature signal will be set to value which is lower MOTOR1_MAX_TEMP value and turn on GREEN_LED.
- If value of temperature signal is higher than MOTOR1_OVER_TEMP value, Master SeatECU will send STOP command through Motor1Selection signal to stop motor and turn on RED_LED.
- If value of temperature signal is in range from MOTOR1_MAX_TEMP value to MOTOR1_OVER_TEMP value, master SeatECU will send DECREASE MOTOR SPEED command through Motor1Selection signal to reduce motor speed and turn on BLUE_LED.
- If value of temperature signal is lower than MOTOR1_MAX_TEMP value, master will send INCREASE MOTOR SPEED command through Motor1Selection signal to increase motor speed and turn on GREEN_LED.
- When users press button BUTTON 0 on the Master board, the Master SeatECU switches its schedule table to go-to-sleep table. So the Slave and Master enter sleep mode, all LEDs are off.
- When LIN cluster is in sleep mode, users press button BUTTON 1 on the Master board, the Master board sends a wakeup signal to wakeup slave nodes, then switches its table to NormalTable.

Prerequisites

To run the example you will need to have the following items:

- 2 XS32K14WEVB-Q064 boards
- 1 Power Adapter 12V
- 2 Dupont female to female cable
- 1 Personal Computer
- 1 Jlink Lite Debugger (optional, users can use Open SDA)

Boards supported

The following boards are supported by this application:

- S32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K14WEVB-Q064-Master	S32K14WEVB-Q064-Slave
BUTTON 0 (**PTD2**)	SW2 - wired on the board	SW2 - wired on the board
BUTTON 1 (**PTD3**)	SW3 - wired on the board	SW3 - wired on the board
RED_LED (**PTE7**)	RGB_RED - wired on the board	RGB_RED - wired on the board
GREEN_LED (**PTE0**)	RGB_GREEN - wired on the board	RGB_GREEN - wired on the board
BLUE_LED (**PTE3**)	RGB_BLUE - wired on the board	RGB_BLUE - wired on the board
LIN (∗)	J11-1 - LIN	J11-1 - LIN
GND (**GND**)	J11-4 - GND	J11-4 - GND

(∗) Those lines must be modulated using a transceiver, if it is not specified the boards already include the LIN transceiver

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **lin_slave_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. First go to **Project Explorer** View in S32 DS and select the current project(**lin_slave_s32k142w**). Select the "ConfigTools" menu then click on the desired configuration (Pins, Clocks, Peripherals etc...). Clicking on any one of those will generate all the components. Make the desired changes(if any) then click on the "ConfigTools->Update Code" button.

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be four debug configurations for this project:

Configuration Name	Description
lin_slave_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4 Driver Examples

Applications that show the user how to initialize the peripherals for the basic use cases

There are currently examples for the following categories:
Click on one of the categories to see the available projects

- Analog Driver Examples
- Communication Driver Examples
- System Driver Examples
- Timer Driver Examples

13.4.1 Analog Driver Examples

Applications that show the user how to initialize the analog peripherals

There are currently driver examples with the following modules:
Click on one of the module to see the available projects

- ADC Hardware Trigger
- ADC PAL example
- ADC Software Trigger
- CMP DAC

13.4.2 ADC Hardware Trigger

How to trigger the ADC by hardware

Application description

The purpose of this demo application is to show you the usage of the ADC module triggered in hardware by the Programmable Delay Block from the S32K142W CPU using the S32 SDK API.

- The application uses PDB to trigger ADC conversions every 1s.
- When the conversion is complete the data is sent to the host PC using LPUART.

How the example works:

- Connect to the serial port using settings found in Notes section
- The user should receive a welcome message on the terminal emulator, with application details (user can refer the message in the main.c file)
- The potentiometer(R44 - connected to ADC1 channel 10) must be rotated in order to generate valid ADC conversions
- Once a valid conversion is done then converted value will be printed on the terminal emulator, like: "ADC result: 1.8371 V ADC result: 1.8372 V ADC result: 1.8420 V"

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro debugger
- 1 USB Type-B cable for UART

Boards supported

The following boards are supported by this application:

- Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- Mother Board S32K-MB PCB RevA SCH RevB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K14xCVD-Q064 PCB	XS32K14WEVB-Q064
ADC POT	ADC1 Channel 10 (**PTE2**) - wired on the board	ADC0 Channel 9 (**PTC1**) - wired on the board

Make sure the following jumpers are set:

Jumper Name	S32K-MB
JP20	Set jumper on position 1-2
JP20	Set jumper on position 4-5
JP21	Set jumper on position 1-2

Jumper Name	XS32K14WEVB-Q064
J10	Set jumper on position 2-3

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New** -> **S32DS Project From** and select **adc_hwtrigger_↩ s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace. Wait for the S32 Configuration to be initialized and ready.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **RAM** (Debug_RAM) or **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
adc_hwtrigger_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
adc_hwtrigger_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

Notes

For this example it is necessary to open a terminal emulator and configure it with:

- 115200 baud
- One stop bit
- No parity
- No flow control

13.4.3 ADC PAL example

Example for ADC PAL usage

Application description

The purpose of this demo application is to present the basic functionality of the Analog to Digital Converter Peripheral Abstraction Layer (ADC PAL) on S32K14x MCU.

The application uses ADC PAL to trigger multiple executions of two groups of ADC conversions: first group configured for SW triggering and second group for HW triggering. For each execution of a group of conversions, an average conversion value is computed in SW, and the average value is printed on UART.
example is divided in 2 parts:

- Part 1: SW triggered group of conversions
  After each complete execution of the group, results are read, the average value is calculated and printed to console. A delay is inserted and then the SW group is triggered again. The process is repeated for a fixed number of iterations.
- Part 2: HW triggered group of conversions
  LPTMR is configured to provide a trigger event with a fixed periodicity. The selected HW group is enabled. After each complete execution of the group, results are read, the average value is calculated and printed to console. After a fixed number of iterations, the HW trigger group of conversions is disabled, and the LPTMR is stopped.

How the example works:

- Connect to the serial port using settings found in Notes section
- The user should receive a welcome message on the terminal emulator, with application details
- A message announcing part 1 will be displayed followed by the values gathered from the software triggered conversions
- A message announcing part 2 will be displayed followed by the values gathered from the hardware triggered conversions
- The potentiometer(R44 - connected to ADC1 channel 10) can be rotated to change the value being read by the ADC module
- After the fixed number of iterations of the part 2 of the example, a message will be displayed announcing that the execution finished
- The user can refer to these messages in the main.c file

Note: both HW and SW triggered groups are configured to run all conversions on a single ADC InputChannel(A↩ DC1 channel 10) because it is connected to a potentiometer(R44 on S32K-MB). However, the ADC PAL supports different InputChannels to be used in the same group. For more details please refer to the ADC PAL documentation.

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEMicro Multilink Debugger
- 1 USB Type-B cable for UART

Boards supported

The following boards are supported by this application:

- Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- Mother Board S32K-MB PCB RevA SCH RevB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K14xCVD-Q064 PCB	XS32K14WEVB-Q064
ADC POT	ADC1 Channel 10 (**PTE2**) - wired on the board	ADC0 Channel 9 (**PTC1**) - wired on the board

Make sure the following jumpers are set:

Jumper Name	S32K-MB
JP20	Set jumper on position 1-2
JP20	Set jumper on position 4-5
JP21	Set jumper on position 1-2

Jumper Name	XS32K14WEVB-Q064
J10	Set jumper on position 2-3

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New** -> **S32DS Project From** and select **adc_pal_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace. Wait for the S32 Configuration to be initialized and ready.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code"

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be one debug configuration for this project:

Configuration Name	Description
adc_pal_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

Notes

For this example it is necessary to open a terminal emulator and configure it with:

- 115200 baud
- One stop bit
- No parity
- No flow control

13.4.4 ADC Software Trigger

How to trigger ADC by software

Application description

The purpose of this demo application is to show you the usage of the ADC module triggered by software from the S32K142 CPU using the S32 SDK API.

- The application measures the value generated by the potentiometer(R44 on S32K-MB) connected to ADC1 Channel 10.
- The application uses software to trigger ADC conversions every 1s.
- When the conversion is complete the data is sent to the host PC using LPUART.

How the example works:

- Connect to the serial port using settings found in Notes section
- The user should receive a welcome message on the terminal emulator, with application details (user can refer the message in the main.c file)
- The value read from the ADC value, converted in volts will be displayed
- The potentiometer(R44 - connected to ADC1 channel 10) can be rotated to change the value being read by the ADC module

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEMicro Multilink Debugger
- 1 USB Type-B cable for UART

Boards supported

The following boards are supported by this application:

- S32K14xCVD-Q064 with S32K-MB

Boards supported

The following boards are supported by this application:

- Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- Mother Board S32K-MB PCB RevA SCH RevB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K14xCVD-Q064 PCB	XS32K14WEVB-Q064
ADC POT	ADC1 Channel 10 (**PTE2**) - wired on the board	ADC0 Channel 9 (**PTC1**) - wired on the board

Make sure the following jumpers are set:

Jumper Name	S32K-MB
JP20	Set jumper on position 1-2
JP20	Set jumper on position 4-5
JP21	Set jumper on position 1-2

Jumper Name	XS32K14WEVB-Q064
J10	Set jumper on position 2-3

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New** -> **S32DS Project From** and select **adc_swtrigger_↩ s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace. Wait for the S32 Configuration to be initialized and ready.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **RAM** (Debug_RAM) or **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
adc_swtrigger_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
adc_swtrigger_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

Notes

For this example it is necessary to open a terminal emulator and configure it with:

- 115200 baud

- One stop bit
- No parity
- No flow control

13.4.5 CMP DAC

Driver examples showing the basic usage scenario of the CMP

Application description

The purpose of this demo application is to show you how to use the Analog Comparator of the S32K142W MCU using the S32 SDK API.
The Comparator is configured to compare analog input 0(AIN0) with half the reference voltage generated with the internal DAC. Based on the input from the potentiometer the LEDs light by the following rules:

- 1) Vin $<$ DAC voltage : RED on, GREEN off
- 2) Vin $>$ DAC voltage : RED off, GREEN on
- 3) Unknown state : RED on, GREEN on

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board or S32K-MB
- 1 Power Adapter 12V
- 1 Personal Computer
- 1 PEmicro Debugger

Boards supported

The following boards are supported by this application:

- S32K-MB

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064	S32K142W-MB
LED0 (**PTC2** MB)	RGB_RED - wired on the board	JP51.1 - JP51.2
LED1 (**PTC3** MB)	RGB_GREEN - wired on the board	JP52.1 - JP52.2
CMP Input 0 (**PTA0**)	J5.4 - J5.7	J21.1 - J9.31

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **cmp_dac_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 Configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated.
The initial configuration will have the same settings as the default example settings. Right click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar).
In S32 Configuration menu, click on the desired configuration (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components.
Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user.
Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
cmp_dac_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
cmp_dac_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.6 Communication Driver Examples

Applications that show the user how to initialize the communication peripherals

There are currently driver examples with the following modules:
Click on one of the module to see the available projects

- LIN MASTER BAREMETAL
- LIN SLAVE BAREMETAL
- LPSPI Transfer
- LPSPI DMA
- SPI PAL
- UART PAL
- LPUART

- I2C PAL
- I2S PAL MASTER
- I2S PAL SLAVE
- FLEXIO I2C
- FLEXIO I2S MASTER
- FLEXIO I2S SLAVE
- FLEXIO SPI
- FLEXIO UART
- LPI2C MASTER
- LPI2C SLAVE
- CAN PAL

13.4.7 LIN MASTER BAREMETAL

Example that shows the usage of the LIN driver in master mode

Application description

This example demonstrates the LIN communication between S32K142W Master and Slave using LIN driver without LIN Stack

- A frame contains header and data. The Master node can send header and data, but Slave node only can send data. Base on header, Master node or Slave node will take corresponding action. On Master node:
- Press BUTTON 0:
  - For the first time, Master node sends FRAME_MASTER_RECEIVE_DATA header and require slave node responds by sending data (txBuff2).
  - For the second time, Master sends FRAME_SLAVE_RECEIVE_DATA header, then continue sending data (txBuff1) and slave node will receive the data.
  - If node successful receives data, this node will turn on LED2/GREEN_LED, otherwise turn on LED1/↩ RED_LED.
- Press BUTTON 1:
  - Master node will check current node state. If the state is LIN_NODE_STATE_SLEEP_MODE, Master node will send wakeup signal and LED0/BLUE_LED will be turned on both nodes, otherwise Master node will send header to set Master node and Slave node to sleep mode and all LED will be turned off both nodes.

Prerequisites

To run the example you will need to have the following items:

- 1 Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- 1 Mother Board S32K-MB PCB RevA SCH RevB
- 1 XS32K14WEVB-Q064 Board
- 1 Power Adapter 12V
- 4 Dupont female to female cable
- 1 Personal Computer
- 1 PEmicro Debugger

Boards supported

The following boards are supported by this application:

- 1 Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- 1 Mother Board S32K-MB PCB RevA SCH RevB

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K-MB	XS32K14WEVB-Q064
BUTTON 0 (**PTB12**/**PTD2**)	BUTTON 0 - wired on the board(set J39, J70 1-2, J69 2-3)	SW2
BUTTON 1 (**PTB13**/**PTD3**)	BUTTON 1 - wired on the board(set J38, J68 1-2, J67 2-3)	SW3
LED0 (**PTC0**/**PTCD3**)	LED0 - wired on the board(set JP49)	BLUE_LED
LED1 (**PTC1**/**PTCD7**)	LED1 - wired on the board(set JP50)	RED_LED
LED2 (**PTC2**/**PTCD0**)	LED2 - wired on the board(set JP51)	GREEN_LED
GND (**GND**)	J6 - Slave GND	J11.4 - Slave GND
LIN (∗)	J48.4 - Slave LIN(set J51(2-3,5-6), J26(1-2), JP31(2-3), JP53(1-2))	J11.1 - Slave LIN

(∗) Those lines must be modulated using a transceiver, if it is not specified the boards already include the LIN transceiver

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **lin_master_baremetal**↩**_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. First go to **Project Explorer** View in S32 DS and select the current project(**lin_master_baremetal_s32k142w**). Select the "ConfigTools" menu then click on the desired configuration (Pins, Clocks, Peripherals etc...). Clicking on any one of those will generate all the components. Make the desired changes(if any) then click on the "ConfigTools->Update Code" button.

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be four debug configurations for this project:

Configuration Name	Description
lin_master_baremetal_s32k142w_debug_ram_↩ pemicro	Debug the RAM configuration using PEMicro debuggers
lin_master_baremetal_s32k142w_debug_flash_↩ pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.8 LIN SLAVE BAREMETAL

Example that shows the usage of the LIN driver in slave mode

Application description

This example demonstrates the LIN communication between S32K142W Master and Slave using LIN driver without LIN Stack

- A frame contains header and data. The Master node can send header and data, but Slave node only can send data. Base on header, Master node or Slave node will take corresponding action.
- If Slave node receives FRAME_MASTER_RECEIVE_DATA header, Slave node will respond by sending data (txBuff2).
- If Slave node receives FRAME_SLAVE_RECEIVE_DATA header, Slave node will receive and check data. If data is success, Slave node will turn on LED2/GREEN_LED, otherwise turn on LED1/RED_LED
- If Slave node receives FRAME_GO_TO_SLEEP header, Slave node will go to sleep mode and turn off all led.
- If Slave node receives a wakeup signal, it will check current node state, if the node state is sleep mode, Slave node will wakeup and turn on LED0/BLUE_LED, otherwise wakeup signal is aborted and keep the previous state.

Prerequisites

To run the example you will need to have the following items:

- 1 Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- 1 Mother Board S32K-MB PCB RevA SCH RevB
- 1 XS32K14WEVB-Q064 Board
- 1 Power Adapter 12V
- 4 Dupont female to female cable
- 1 Personal Computer
- 1 PEmicro Debugger

Boards supported

The following boards are supported by this application:

- 1 Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- 1 Mother Board S32K-MB PCB RevA SCH RevB

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K-MB	XS32K14WEVB-Q064
BUTTON 0 (**PTB12**/**PTD2**)	BUTTON 0 - wired on the board(set J39, J70 1-2, J69 2-3)	SW2
BUTTON 1 (**PTB13**/**PTD3**)	BUTTON 1 - wired on the board(set J38, J68 1-2, J67 2-3)	SW3
LED0 (**PTC0**/**PTCD3**)	LED0 - wired on the board(set JP49)	BLUE_LED
LED1 (**PTC1**/**PTCD7**)	LED1 - wired on the board(set JP50)	RED_LED
LED2 (**PTC2**/**PTCD0**)	LED2 - wired on the board(set JP51)	GREEN_LED
GND (**GND**)	J6 - Master GND	J11.4 - Master GND
LIN (∗)	J48.4 - Master LIN(set J51(2-3,5-6), J26(1-2), JP31(2-3), JP53(1-2))	J11.1 - Master LIN

(∗) Those lines must be modulated using a transceiver, if it is not specified the boards already include the LIN transceiver

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **lin_slave_baremetal_↩ s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. First go to **Project Explorer** View in S32 DS and select the current project(**lin_slave_baremetal_s32k142w**). Select the "ConfigTools" menu then click on the desired configuration (Pins, Clocks, Peripherals etc...). Clicking on any one of those will generate all the components. Make the desired changes(if any) then click on the "ConfigTools->Update Code" button.

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be four debug configurations for this project:

Configuration Name	Description
lin_slave_baremetal_s32k142w_debug_ram_↩ pemicro	Debug the RAM configuration using PEMicro debuggers
lin_slave_baremetal_s32k142w_debug_flash_↩ pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.9 LPSPI Transfer

Driver example that will show the LPSPI Master and Slave functionalities

Application description

The purpose of this application is to show the user how to use the Low Power Serial Peripheral Interface on the S32K142W using the S32 SDK API.

- The application uses two on board instances of LPSPI, one in master configuration and the other one is slave to communicate data via the SPI bus. Data will be gathered periodically from the ADC input and will be sent to the master device which transforms it into a PWM signal. In this way the potentiometer controls the LED intensity.

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V
- 6 Dupont male to male cables
- 1 Personal Computer
- 1 PEmicro Debugger

Boards supported

The following boards are supported by this application:

- S32K-MB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064	S32K-MB
LPSPI0 CS (**PTB5**)	J2.3 - J5.8	J10.28 - J13.32
LPSPI0 SCK (**PTD15**)	J1.3 - J2.2	J12.18 - J12.31
LPSPI0 MOSI (**PTB4**)	J2.4 - J2.1	J10.27 - J12.32
LPSPI0 MISO (**PTD16**)	J1.4 - J3.6	J12.15 - J13.31
LPSPI1 CS (**PTE1**)	J2.3 - J5.8	J13.32 - J10.28
LPSPI1 SCK (**PTD0**)	J1.3 - J2.2	J12.31 - J12.18
LPSPI1 MOSI (**PTD1**)	J2.4 - J2.1	J12.32 - J10.27
LPSPI1 MISO (**PTE0**)	J1.4 - J3.6	J13.31 - J12.15
ADC0 Input 9 (**PTC1**)	wired on the board	J21.1 - J11.32
FTM0 Chn 7 (**PTE7**)	wired on the board	J13.26 - J5.1

Note that on the EVB, the Green LED is connected to PTE0 so you will see it lights up. In which case, on a successful transfer, the Red LED will lights up after, resulting a yellow-ish light

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **lpspi_transfer_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 Configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated.
The initial configuration will have the same settings as the default example settings. Right click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar).
In S32 Configuration menu, click on the desired configuration (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components.
Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user.
Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be one debug configurations for this project:

Configuration Name	Description
lpspi_transfer_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.10 LPSPI DMA

Driver example that will show the LPSPI Master and Slave functionalities

Application description

The purpose of this application is to show you how to use the Low Power Serial Peripheral Interface on the S32↩ K142W using the S32 SDK API.

The application uses two on board instances of LPSPI, one in master configuration and the other one is slave to communicate data via the SPI bus using DMA.

To check if the transmission is successful the user has to verify that the data sent is the same as the received data. If transfer is successful, RED led will be on, otherwise it will be off.

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V
- 4 Dupont male to male cables
- 1 Personal Computer
- 1 PEMicro Debugger

Boards supported

The following boards are supported by this application:

- S32K-MB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064	S32K-MB
LPSPI0 CS (**PTB5**)	J2.3 - J5.8	J10.28 - J13.32

LPSPI0 SCK (**PTD15**)	J1.3 - J2.2	J12.18 - J12.31
LPSPI0 MOSI (**PTB4**)	J2.4 - J2.1	J10.27 - J12.32
LPSPI0 MISO (**PTD16**)	J1.4 - J3.6	J12.15 - J13.31
LPSPI1 CS (**PTE1**)	J2.3 - J5.8	J13.32 - J10.28
LPSPI1 SCK (**PTD0**)	J1.3 - J2.2	J12.31 - J12.18
LPSPI1 MOSI (**PTD1**)	J2.4 - J2.1	J12.32 - J10.27
LPSPI1 MISO (**PTE0**)	J1.4 - J3.6	J13.31 - J12.15
LED (**PTE7**)	LED - wired on the board	J13.26 - J5.1

Note that on the EVB, the Green LED is connected to PTE0 so you will see it lights up. In which case, on a successful transfer, the Red LED will lights up after, resulting a yellow-ish light

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **lpspi_dma_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 Configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated.
The initial configuration will have the same settings as the default example settings. Right click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar).
In S32 Configuration menu, click on the desired configuration (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components.
Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user.
Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
lpspi_dma_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
lpspi_dma_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.11 SPI PAL

Driver example using SPI

Application description

The purpose of this application is to show you how to use the LPSPI Interfaces over SPI PAL on the S32K142W using the S32 SDK API.

The application uses one board instance of LPSPI in slave configuration and other board instance of LPSPI in master configuration to communicate data via the SPI bus using interrupts. It also verifies that the data sent is the same as the received data. If transfer is successful, RED led will be on, otherwise it will be off.

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V
- 1 Personal Computer
- 4 Dupont male to male cable
- 1 PEmicro Debugger

Boards supported

The following boards are supported by this application:

- S32K-MB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064	S32K-MB
LPSPI0 CS (**PTB5**)	J2.3 - J5.8	J10.28 - J13.32
LPSPI0 SCK (**PTD15**)	J1.3 - J2.2	J12.18 - J12.31
LPSPI0 MOSI (**PTB4**)	J2.4 - J2.1	J10.27 - J12.32
LPSPI0 MISO (**PTD16**)	J1.4 - J3.6	J12.15 - J13.31
LPSPI1 CS (**PTE1**)	J2.3 - J5.8	J13.32 - J10.28
LPSPI1 SCK (**PTD0**)	J1.3 - J2.2	J12.31 - J12.18
LPSPI1 MOSI (**PTD1**)	J2.4 - J2.1	J12.32 - J10.27
LPSPI1 MISO (**PTE0**)	J1.4 - J3.6	J13.31 - J12.15
LED (**PTE7**)	LED - wired on the board	J13.26 - J5.1

Note that on the EVB, the Green LED is connected to PTE0 so you will see it lights up. In which case, on a successful transfer, the Red LED will lights up after, resulting a yellow-ish light

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **spi_pal**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 Configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated.
The initial configuration will have the same settings as the default example settings. Right click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar).
In S32 Configuration menu, click on the desired configuration (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components.
Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user.
Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
spi_pal_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
spi_pal_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.12 UART PAL

Basic application that presents the project scenarios for S32 SDK

Application description

The purpose of this demo is to show the user how UART PAL works over FLEXIO_UART or LPUART peripherals. The user can choose whether to use FLEXIO_UART or LPUART (see USE_FLEXIO_UART define from The board sends a welcome message to the console with further instructions.)

- The welcome message is sent via UART: "This example is an simple echo using UART_PAL it will send back any character you send to it. The board will greet you if you send 'Hello!' Now you can begin typing:" - User shall send "Hello!" string. If the board receives the user's string, then the "Hello World!" string shall be sent again. User need to add EOL character to string which will be sent to board. Blue led(devkit) or led 1(Motherboard) shall be turned on if the communication is done over FLEXIO_UART; similarly the led shall be turned off if the communication is done over LPUART.

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board

- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 2 Dupont male to male cable
- 1 Personal Computer
- 1 PEmicro

Boards supported

The following boards are supported by this application:

- S32K14xCVD-Q064 with S32K-MB

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064	S32K14xCVD-Q64 PCB	S32K-MB
RGB_BLUE (**PTE3**)	wired on the board		
LED1 (**PTC1**)		wired on the board	JP50 - jump 50 on motherboard
LPUART1 TX (**PTC9**)	UART_TX - wired on the board	UART_TX - wired on the board	J20.3 - J20.2
LPUART1 RX (**PTC8**)	UART_RX - wired on the board	UART_RX - wired on the board	J20.6 - J20.5
FLEXIO_UART TX (**PTD1**)	J2.1 - J6.6	wired on the board	J12.32 - J20.5
FLEXIO_UART RX (**PTD0**)	J2.2 - J6.5	wired on the board	J12.31 - J20.2

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New** -> **S32DS Project From** and select **hello_world_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace. Wait for the S32 Configuration was initialized and ready.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **RAM** (Debug_RAM) or **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
uart_pal_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
uart_pal_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

Notes

For this example it is necessary to open a terminal emulator and configure it with:

- 9600 baud
- One stop bit
- No parity
- No flow control
- '\n' line ending

13.4.13 LPUART

Example application using the LPUART driver

Application description

The purpose of this demo application is to show you how to use the Low Power UART from the S32K142W CPU using the S32 SDK API.

- The welcome message is sent via UART: "This example is an simple echo using LPUART it will send back any character you send to it. The board will greet you if you send 'Hello Board' Now you can begin typing:" - User shall send "Hello Board" string. If the board receives the user's string, then the "Hello World" string shall be sent again. User need to add EOL character to string which will be sent to board.

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro debugger
- 1 USB type B connect with J16 on Mother Board S32K-MB (if using S32K14xCVD-Q064 with S32K-MB)
- UART to USB converter if it is not included on the target board. (Please consult your boards documentation to check if UART-USB converter is present).

Boards supported

The following boards are supported by this application:

- XS32K14WEVB-Q064
- S32K14xCVD-Q064 with S32K-MB

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064	S32K14xCVD-Q64 PCB	S32K-MB
UART_TX	LPUART1 TX (PTC9) - wired on the board	LPUART1 TX (PTC9) - wired on the board	J20.3 - J20.2
UART_RX	LPUART1 RX (PTC8) - wired on the board	LPUART1 RX (PTC8) - wired on the board	J20.6 - J20.5

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **lpuart_S32K142W**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Right click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configuration (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
lpuart_S32K142W_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
lpuart_S32K142W_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

Notes

For this example it is necessary to open a terminal emulator and configure it with:

- 9600 baud
- One stop bit
- No parity
- No flow control
- '\n' line ending

13.4.14 I2C PAL

Driver example using I2C

Application description

The purpose of this application is to show you how to use the LPI2C and FLEXIO Interfaces on the S32K142w using the S32 SDK API.

The application uses one board instance of LPI2C in slave configuration and one board instance of FLEXIO in master configuration to communicate data via the I2C bus using interrupts.

The RED or GREEN led will be turn on or turn off depending on the check result. Red led will turn on if data does not match. Green led will turn on if then data is transfered correctly.

Prerequisites

To run the example you will need to have the following items:

- 1 S32K14xCVD-Q064 with S32K-MB
- 1 XS32K14WEVB-Q064
- 1 Power Adapter 12V (if the board can't be powered from the USB)
- 1 Personal Computer
- 4 Dupont male to male cable
- 1 PEmicro

Boards supported

The following boards are supported by this application:

- S32K14xCVD-Q064 with S32K-MB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K14xCVD-Q064 with S32K-MB	XS32K14WEVB-Q064
FLEXIO SDA (**PTD0**)	J9.29 - J12.31	J3.10 - J1.1
FLEXIO SCL (**PTA11**)	J9.30 - J9.22	J3.16 - J1.2
LPI2C SDA (**PTA2**)	J9.29 - J12.31	J1.1 - J3.10
LPI2C SCL (**PTA3**)	J9.30 - J9.22	J1.2 - J3.16

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New** -> **S32DS Project From** and select **i2c_pal_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace. Wait for the S32 Configuration was initialized and ready.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There is a debug configurations for this project:

Configuration Name	Description
i2c_pal_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.15 I2S PAL MASTER

Driver example using I2S

Application description

The purpose of this application is to show you how to use the i2s_pal driver on the S32K142W.

The application uses one instance of FLEXIO in slave board and one instance of FLEXIO in master board to communicate data via the I2S bus using both of interrupts and DMA The application will work in conjunction with the i2s_pal_slave demo on S32K1xx.

The application displays on the host PC terminal a menu in which the user can select to: For Slave board: "Press: 1) [Slave] Send data 2) [Slave] Received data Enter your input:"

For Master board: "Press: 1) [Master] Send data 2) [Master] Received data Enter your input:"

Select Send/Receive on Slave first. After that select Receive/Send on Master.

The slave buffers and master buffers will be checked after each transfer by the application:

- On EVB: RED or GREEN led will be lit depend on the check result.
- Red led will turn if data does not match.
- Green led will turn if then data is transfered correctly.
- On mother board: LED0 or LED1 will be lit depend on the check result.
- LED0 led will turn if data does not match.
- LED1 led will turn if then data is transfered correctly.

Prerequisites

To run the example you will need to have the following items:

- 2 S32K MOTHER BOARD (SCH-28767)
- 2 S32K14xCVD-Q064 (SCH-29454)
- 1 Personal Computer
- 4 male to male jump wires
- 2 J-link Lite Debugger (optional, users can use Open SDA)
- 2 Power Adapter 12V (if the board can't be powered from the USB)

Boards supported

The following boards are supported by this application:

- S32K MOTHER BOARD (SCH-28767) + S32K14xCVD-Q064 (SCH-29454)
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064 MASTER	XS32K14WEVB-Q064 SLAVE
FLEXIO SCK	J2.2 (**PTD0**)	J1.1 (**PTA2**)
FLEXIO WS	J2.1 (**PTD1**)	J1.2 (**PTA3**)
FLEXIO MASTER TX - SLAVE RX	J5.4 (**PTA0**)	J6.1 (**PTD3**)
FLEXIO MASTER RX - SLAVE TX	J5.3 (**PTA1**)	J6.2 (**PTD2**)
RED_LED (**PTE7**)	RGB_RED - wired on board	RGB_RED - wired on board
GREEN_LED (**PTE0**)	RGB_GREEN - wired on board	RGB_GREEN - wired on board
UART	Wired on board	Wired on board

PIN FUNCTION	S32K-Mother MASTER	S32K-Mother SLAVE
FLEXIO SCK	J12.31 (**PTD0**)	J9.29(**PTA2**)
FLEXIO WS	J12.32 (**PTD1**)	J9.30 (**PTA3**)

FLEXIO MASTER TX - SLAVE RX	J9.31 (**PTA0**)	J12.30 (**PTD3**)
FLEXIO MASTER RX - SLAVE TX	J9.32 (**PTA1**)	J12.29 (**PTD2**)
LED0	J13.26 (**PTE7**) - JP49.1	J13.26 (**PTE7**) - JP49.1
LED1	J13.31 (**PTE0**) - JP50.1	J13.31 (**PTE0**) - JP50.1
UART	Wired on board	Wired on board

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **i2s_pal_master_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. First go to **Project Explorer** View in S32 DS and select the current project(**i2s_pal_master_s32k142w**). Select the "Config Tools" menu then click on the desired configuration (Pins, Cocks, Peripherals etc...). Clicking on any one of those will generate all the components. Make the desired changes(if any) then click on the "ConfigTools->Update Code" button.

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be one debug configuration for this project:

Configuration Name	Description
i2s_pal_master_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

Notes

For this example it is necessary to open a terminal emulator and configure it with:

- 9600 baud
- One stop bit
- No parity
- No flow control
- '\n' line ending

13.4.16 I2S PAL SLAVE

Driver example using I2S

Application description

The purpose of this application is to show you how to use the i2s_pal driver on the S32K142W.

The application uses one instance of FLEXIO in slave board and one instance of FLEXIO in master board to communicate data via the I2S bus using both of interrupts and DMA The application will work in conjunction with the i2s_pal_master demo on S32K1xx.

The application displays on the host PC terminal a menu in which the user can select to: For Slave board: "Press: 1) [Slave] Send data 2) [Slave] Received data Enter your input:"

For Master board: "Press: 1) [Master] Send data 2) [Master] Received data Enter your input:"

Select Send/Receive on Slave first. After that select Receive/Send on Master.

The slave buffers and master buffers will be checked after each transfer by the application:

- On EVB: RED or GREEN led will be lit depend on the check result.
- Red led will turn if data does not match.
- Green led will turn if then data is transfered correctly.
- On mother board: LED0 or LED1 will be lit depend on the check result.
- LED0 led will turn if data does not match.
- LED1 led will turn if then data is transfered correctly.

Prerequisites

To run the example you will need to have the following items:

- 2 S32K MOTHER BOARD (SCH-28767)
- 2 S32K14xCVD-Q064 (SCH-29454)
- 1 Personal Computer
- 4 male to male jump wires
- 2 J-link Lite Debugger (optional, users can use Open SDA)
- 2 Power Adapter 12V (if the board can't be powered from the USB)

Boards supported

The following boards are supported by this application:

- S32K MOTHER BOARD (SCH-28767) + S32K14xCVD-Q064 (SCH-29454)
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064 MASTER	XS32K14WEVB-Q064 SLAVE
FLEXIO SCK	J2.2 (**PTD0**)	J1.1 (**PTA2**)

FLEXIO WS	J2.1 (**PTD1**)	J1.2 (**PTA3**)
FLEXIO MASTER TX - SLAVE RX	J5.4 (**PTA0**)	J6.1 (**PTD3**)
FLEXIO MASTER RX - SLAVE TX	J5.3 (**PTA1**)	J6.2 (**PTD2**)
RED_LED (**PTE7**)	RGB_RED - wired on board	RGB_RED - wired on board
GREEN_LED (**PTE0**)	RGB_GREEN - wired on board	RGB_GREEN - wired on board
UART	Wired on board	Wired on board

PIN FUNCTION	**S32K-Mother MASTER**	**S32K-Mother SLAVE**
FLEXIO SCK	J12.31 (**PTD0**)	J9.29(**PTA2**)
FLEXIO WS	J12.32 (**PTD1**)	J9.30 (**PTA3**)
FLEXIO MASTER TX - SLAVE RX	J9.31 (**PTA0**)	J12.30 (**PTD3**)
FLEXIO MASTER RX - SLAVE TX	J9.32 (**PTA1**)	J12.29 (**PTD2**)
LED0	J13.26 (**PTE7**) - JP49.1	J13.26 (**PTE7**) - JP49.1
LED1	J13.31 (**PTE0**) - JP50.1	J13.31 (**PTE0**) - JP50.1
UART	Wired on board	Wired on board

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **i2s_pal_slave_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. First go to **Project Explorer** View in S32 DS and select the current project(**i2s_pal_slave_s32k142w**). Select the "Config↩ Tools" menu then click on the desired configuration (Pins, Cocks, Peripherals etc...). Clicking on any one of those will generate all the components. Make the desired changes(if any) then click on the "ConfigTools->Update Code" button.

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be one debug configuration for this project:

Configuration Name	**Description**
i2s_pal_slave_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

Notes

For this example it is necessary to open a terminal emulator and configure it with:

- 9600 baud

- One stop bit
- No parity
- No flow control
- '\n' line ending

13.4.17 FLEXIO I2C

Example application showing FlexIO I2C driver usage

Application description

The purpose of this demo application is to show you the usage of the FlexIO I2C driver found on the S32K142W SoC using S32 SDK API.

The application uses FlexIO I2C driver as master to make a send and a receive data request. The slave device for this example is the LPI2C instance, which is configured to act as a bus slave. The setup can't be changed to use FlexIO I2C as slave because this mode is not supported by FlexIO module. The slave and master buffers will be checked after each transfer by the application, user shall check **isTransferOk** variable to see if the transmissions are successful. If transfers is **Ok** led on board will turn **Green** otherwise **notOk** led will turn **Red**.

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V (if the board can't be powered from the USB)
- 1 Personal Computer
- 1 PEMicro Multilink Debugger

Boards supported

The following boards are supported by this application:

- S32K14xCVD-Q064 with S32K-MB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064	S32K144W-MB
FLEXIO SDA (**PTD0**)	J2.2 - J1.1	J9.22 - J9.29
FLEXIO SCL (**PTD1**)	J2.1 - J1.2	J9.31 - J9.30
LPI2C SDA (**PTA2**)	J1.1 - J2.2	J9.29 - J9.22
LPI2C SCL (**PTA3**)	J1.2 - J2.1	J9.30 - J9.31
RED_LED (**PTE7**)	RGB_RED - wired on board	

GREEN_LED (**PTE0**)	RGB_GREEN - wired on board	

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New** -> **S32DS Project From** and select **flexio_i2c_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Debugging the project

Go to **Run** and select **Debug Configurations**. There will be four debug configurations for this project:

Configuration Name	Description
flexio_i2c_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.18 FLEXIO I2S MASTER

Example application showing FlexIO I2S driver usage

Application description

The purpose of this demo application is to show you the usage of the FlexIO I2S driver found on the S32K142W SoC using S32 SDK API.

The application uses FlexIO I2S driver to make a data transfer of a defined size. The application will work in conjunction with the flexio_i2s_slave demo on S32K14xw.

The application displays on the host PC terminal a menu in which the user can select to: For Slave board: "Press: 1) [Slave] Send data 2) [Slave] Received data Enter your input:"

For Master board: "Press: 1) [Master] Send data 2) [Master] Received data Enter your input:"

Select Send/Receive on Slave first. After that select Receive/Send on Master.

The slave buffers and master buffers will be checked after each transfer by the application:

- On EVB: RED or GREEN led will be lit depend on the check result.
- Red led will turn if data does not match.
- Green led will turn if then data is transfered correctly.
- On mother board: LED0 or LED1 will be lit depend on the check result.
- LED0 led will turn if data does not match.
- LED1 led will turn if then data is transfered correctly.

The MASTER I2S driver is configured to use DMA for transfers.

Data size is configured by TRANSFER_SIZE define, by default is configured to be 64 Bytes.

Prerequisites

To run the example you will need to have the following items:

- 2 XS32K14WEVB-Q064 board
- 2 Power Adapter 12V (if the board can't be powered from the USB)
- 4 Dupont male to male cable
- 1 Personal Computer
- 2 PEMicro Multilink Debugger (optional, users can use J-link)

Boards supported

The following boards are supported by this application:

- XS32K14WEVB-Q064 or S32K MB

Hardware Wiring

The following connections must be done to for this example application to work: Connect each FlexIO pin board master to pin board slave.

PIN FUNCTION	XS32K14WEVB-Q064 MASTER	XS32K14WEVB-Q064 SLAVE
FLEXIO SCK	J2.2 (**PTD0**)	J1.1 (**PTA2**)
FLEXIO WS	J2.1 (**PTD1**)	J1.2 (**PTA3**)
FLEXIO MASTER TX - SLAVE RX	J5.4 (**PTA0**)	J6.1 (**PTD3**)
FLEXIO MASTER RX - SLAVE TX	J5.3 (**PTA1**)	J6.2 (**PTD2**)
RED_LED (**PTE7**)	RGB_RED - wired on board	RGB_RED - wired on board
GREEN_LED (**PTE0**)	RGB_GREEN - wired on board	RGB_GREEN - wired on board
UART	Wired on board	Wired on board

PIN FUNCTION	S32K-Mother MASTER	S32K-Mother SLAVE
FLEXIO SCK	J12.31 (**PTD0**)	J9.29(**PTA2**)
FLEXIO WS	J12.32 (**PTD1**)	J9.30 (**PTA3**)
FLEXIO MASTER TX - SLAVE RX	J9.31 (**PTA0**)	J12.30 (**PTD3**)
FLEXIO MASTER RX - SLAVE TX	J9.32 (**PTA1**)	J12.29 (**PTD2**)
LED0	J13.26 (**PTE7**) - JP49.1	J13.26 (**PTE7**) - JP49.1

LED1	J13.31 (**PTE0**) - JP50.1	J13.31 (**PTE0**) - JP50.1
UART	Wired on board	Wired on board

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New** -> **S32DS Project From** and select **flexio_i2s_master_↩ s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Debugging the project

Go to **Run** and select **Debug Configurations**. There will be four debug configurations for this project:

Configuration Name	Description
flexio_i2s_master_s32k142w_debug_flash_↩ pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

Notes

For this example it is necessary to open a terminal emulator and configure it with:

- 9600 baud
- One stop bit
- No parity
- No flow control
- '\n' line ending

13.4.19 FLEXIO I2S SLAVE

Example application showing FlexIO I2S driver usage

Application description

The purpose of this demo application is to show you the usage of the FlexIO I2S driver found on the S32K142W SoC using S32 SDK API.

The application uses FlexIO I2S driver to make a data transfer of a defined size. The application will work in conjunction with the flexio_i2s_master demo on S32K14xw.

The application displays on the host PC terminal a menu in which the user can select to: For Slave board: "Press: 1) [Slave] Send data 2) [Slave] Received data Enter your input:"

For Master board: "Press: 1) [Master] Send data 2) [Master] Received data Enter your input:"

Select Send/Receive on Slave first. After that select Receive/Send on Master.

The slave buffers and master buffers will be checked after each transfer by the application:

- On EVB: RED or GREEN led will be lit depend on the check result.
- Red led will turn if data does not match.
- Green led will turn if then data is transfered correctly.
- On mother board: LED0 or LED1 will be lit depend on the check result.
- LED0 led will turn if data does not match.
- LED1 led will turn if then data is transfered correctly.

The SLAVE I2S driver is configured to use interrupt for transfers.

Data size is configured by TRANSFER_SIZE define, by default is configured to be 64 Bytes.

Prerequisites

To run the example you will need to have the following items:

- 2 XS32K14WEVB-Q064 board or S32K MB
- 2 Power Adapter 12V (if the board can't be powered from the USB)
- 4 Dupont male to male cable
- 1 Personal Computer
- 2 PEMicro Multilink Debugger (optional, users can use J-link)

Boards supported

The following boards are supported by this application:

- XS32K14WEVB-Q064 or S32K MB

Hardware Wiring

The following connections must be done to for this example application to work: Connect each FlexIO pin board master to pin board slave.

PIN FUNCTION	XS32K14WEVB-Q064 MASTER	XS32K14WEVB-Q064 SLAVE

FLEXIO SCK	J2.2 (**PTD0**)	J1.1 (**PTA2**)
FLEXIO WS	J2.1 (**PTD1**)	J1.2 (**PTA3**)
FLEXIO MASTER TX - SLAVE RX	J5.4 (**PTA0**)	J6.1 (**PTD3**)
FLEXIO MASTER RX - SLAVE TX	J5.3 (**PTA1**)	J6.2 (**PTD2**)
RED_LED (**PTE7**)	RGB_RED - wired on board	RGB_RED - wired on board
GREEN_LED (**PTE0**)	RGB_GREEN - wired on board	RGB_GREEN - wired on board
UART	Wired on board	Wired on board

PIN FUNCTION	**S32K-Mother MASTER**	**S32K-Mother SLAVE**
FLEXIO SCK	J12.31 (**PTD0**)	J9.29(**PTA2**)
FLEXIO WS	J12.32 (**PTD1**)	J9.30 (**PTA3**)
FLEXIO MASTER TX - SLAVE RX	J9.31 (**PTA0**)	J12.30 (**PTD3**)
FLEXIO MASTER RX - SLAVE TX	J9.32 (**PTA1**)	J12.29 (**PTD2**)
LED0	J13.26 (**PTE7**) - JP49.1	J13.26 (**PTE7**) - JP49.1
LED1	J13.31 (**PTE0**) - JP50.1	J13.31 (**PTE0**) - JP50.1
UART	Wired on board	Wired on board

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New** -> **S32DS Project From** and select **flexio_i2s_slave_↩ s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Debugging the project

Go to **Run** and select **Debug Configurations**. There will be four debug configurations for this project:

Configuration Name	**Description**
flexio_i2s_slave_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

Notes

For this example it is necessary to open a terminal emulator and configure it with:

- 9600 baud

- One stop bit
- No parity
- No flow control
- '\n' line ending

13.4.20 FLEXIO SPI

Example application showing FlexIO SPI driver usage

Application description

The purpose of this demo application is to show you the usage of the FlexIO SPI driver found on the S32K142W SoC using S32 SDK API.

The application uses FlexIO SPI driver to make a data transfer of a defined size. The slave device for this example is a second FlexIO SPI driver using the same FlexIO instance, which is configured to act as a bus slave. The slave and master buffers will be checked after each transfer by the application, user shall check **isTransferOk** variable to see if the transmissions are successful(Green led will turn on), otherise red led will turn on.

Prerequisites

To run the example you will need to have the following items:

- 1 S32K14xCVD-Q064 with S32K-MB
- 1 XS32K14WEVB-Q064
- 1 Power Adapter 12V (if the board can't be powered from the USB)
- 1 Personal Computer
- 1 PEMicro Multilink Debugger

Boards supported

The following boards are supported by this application:

- S32K14xCVD-Q064 with S32K-MB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K142W-MB	XS32K14WEVB-Q064
FLEXIO_MASTER SS (**PTD0**)	J12.31 - J9.29	J2.2 - J1.1
FLEXIO_MASTER SCK (**PTD1**)	J12.32 - J9.30	J2.1 - J1.2
FLEXIO_MASTER MOSI (**PTA0**)	J9.31 - J13.27	J5.4 - J6.10
FLEXIO_MASTER MISO (**PTA1**)	J9.32 - J13.28	J5.3 - J6.9
FLEXIO_SLAVE SS (**PTA2**)	J9.29 - J12.31	J1.1 - J2.2

FLEXIO_SLAVE SCK (**PTA3**)	J9.30 - J12.32	J1.2 - J2.1
FLEXIO_SLAVE MOSI (**PTE4**)	J13.27 - J9.31	J6.10 - J5.4
FLEXIO_SLAVE MISO (**PTE5**)	J13.28 - J9.32	J6.9 - J5.3
RED_LED (**PTE7**)	RGB_RED - wired on board	J13.12 - JP49.2
GREEN_LED (**PTE0**)	RGB_GREEN - wired on board	J13.12 - JP50.2

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New** -> **S32DS Project From** and select **flexio_spi_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Debugging the project

Go to **Run** and select **Debug Configurations**. There will be four debug configurations for this project:

Configuration Name	Description
flexio_spi_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
flexio_spi_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.21 FLEXIO UART

Example application showing FlexIO UART driver usage

Application description

The purpose of this demo application is to show you the usage of the FlexIO UART driver found on the S32K142W SoC using S32 SDK API.

Two instances of the FlexIO UART driver are used to display a welcome message ("Hello World") and then echo the data received from host.

User shall send a string. If the board receives the user's string, then the same string shall be sent again.

Prerequisites

To run the example you will need to have the following items:

- 1 S32K14xCVD-Q064 with S32K-MB
- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V (if the board can't be powered from the USB)
- 1 Personal Computer
- 2 Dupont female to female cable
- 1 PEmicro Debugger (optional, users can use Open SDA)

Boards supported

The following boards are supported by this application:

- S32K14xCVD-Q064 with S32K-MB
- S32K142WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K142W-MB
FLEXIO_UART RX (**PTD1**)	J12.32 - J20.5
FLEXIO_UART TX (**PTD0**)	J12.31 - J20.2

PIN FUNCTION	XS32K14WEVB-Q064
FLEXIO_UART TX (**PTD1**)	J2.1 - J6.6
FLEXIO_UART RX (**PTD0**)	J2.2 - J6.5

Note

The application uses on board USB - UART chips to transfer data from board to host PC. Use an USB type B cable to connect to the J16 connector on the mainboard.

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New** -> **S32DS Project From** and select **flexio_uart_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Debugging the project

Go to **Run** and select **Debug Configurations**. There will be four debug configurations for this project:

Configuration Name	Description
flexio_uart_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
flexio_uart_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

Notes

For this example it is necessary to open a terminal emulator and configure it with:

- 115200 baud
- One stop bit
- No parity
- No flow control

13.4.22 LPI2C MASTER

Driver example that will show the LPI2C Master functionality

Application description

The purpose of this demo application is to show you the usage of the LPI2C module available on the S32K142W MCU as a **master** using S32 SDK.

- The application uses S32 SDK API to initialize the LPI2C module as a master node and in Fast operation speed after configuring the clocks and pins needed to use the I2C. The example sends to requests to a slave, found at the configured address, the first being a TX request, while the other being a RX request. Run Slave first, after that Run Master. The master buffers will be checked after each transfer by the application, RED or GREEN led will be turn on or turn off depending on the check result. Red led will turn on if data does not match. Green led will turn on if then data is transfered correctly.

Prerequisites

To run the example you will need to have the following items:

- 1 S32K14xCVD-Q064 with S32K-MB

- 1 XS32K14WEVB-Q064
- 3 Dupont cables (male to male or female to female depending on the boards)
- 1 Personal Computer
- 1 PEmicro

Boards supported

The following boards are supported by this application:

- S32K14xCVD-Q064 with S32K-MB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K14xCVD-Q064 with S32K-MB	XS32K14WEVB-Q064
LPI2C SCL (**PTA3**)	J9-30 - Slave SCL	J1.2 - Slave SCL
LPI2C SDA (**PTA2**)	J9-29 - Slave SDA	J1.1 - Slave SDA
GND (**GND**)	J6 - Slave GND	J2.7 - Slave GND

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New** -> **S32DS Project From** and select **lpi2c_master_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace. Wait for the S32 Configuration was initialized and ready.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **RAM** (Debug_RAM) or **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be four debug configurations for this project:

Configuration Name	Description
lpi2c_master_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers

lpi2c_master_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.23 LPI2C SLAVE

Driver example that will show the LPI2C Slave functionality

Application description

The purpose of this demo application is to show you the usage of the LPI2C module available on the S32K142W MCU as a **slave** using S32 SDK.

- The application uses S32 SDK API to initialize the LPI2C module as a slave node and in Fast operation speed after configuring the clocks and pins needed to use the I2C. example uses the LPI2C callback to respond to requests such as:
  - data receive
  - data transmit
  - buffer full or empty. Run Slave first, after that Run Master. The slave buffers will be checked after each transfer by the application, RED or GREEN led will be turn on or turn off depending on the check result. Red led will turn on if data does not match. Green led will turn on if then data is transfered correctly.

Prerequisites

To run the example you will need to have the following items:

- 1 S32K14xCVD-Q064 with S32K-MB
- 1 XS32K14WEVB-Q064
- 3 Dupont cables (male to male or female to female depending on the boards)
- 1 Personal Computer
- 1 PEmicro

Boards supported

The following boards are supported by this application:

- S32K14xCVD-Q064 with S32K-MB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K14xCVD-Q064 with S32K-MB	XS32K14WEVB-Q064
LPI2C SCL (**PTA3**)	J9-30 - Master SCL	J1.2 - Master SCL
LPI2C SDA (**PTA2**)	J9-29 - Master SDA	J1.1 - Master SDA
GND (**GND**)	J6 - Master GND	J2.7 - Master GND

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New** -> **S32DS Project From** and select **lpi2c_slave_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace. Wait for the S32 Configuration was initialized and ready.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **RAM** (Debug_RAM) or **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be four debug configurations for this project:

Configuration Name	Description
lpi2c_slave_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
lpi2c_slave_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.24 CAN PAL

Demo application showing the CAN PAL functionalities

Application description

The purpose of this demo application is to show you the usage of the CAN PAL module configured to use Flexible Data Rate from the S32K142W CPU using the S32 SDK API.

- In the first part, the application will setup the board clocks, pins and other system functions such as SBC if the board uses this module as a CAN transceiver.

- Then it will configure the CAN PAL module features such as FD, Bitrate and buffers
- The application will wait for frames to be received on the configured buffer or for an event raised by pressing one of the two buttons which will trigger a frame send to the recipient.
- Pressing SW3 button of board 1 shall trigger a CAN transfer that results in toggling the GREEN led on board 2.
- Pressing SW2 button of board 1 shall trigger a CAN transfer that results in toggling the RED led on board 2.
- This demo application requires two boards, one configured as master and the other one configured as slave (see MASTER/SLAVE defines in application code).

Prerequisites

To run the example you will need to have the following items:

- 1 S32K144EVB-Q100(or another S32K EVB board which supports CAN)
- 1 XS32K14WEVB-Q064
- 2 Power Adapters 12V
- 3 Dupont female to female cable
- 1 Personal Computer
- 1 PEMicro Debugger (optional, users can use Open SDA for S32K144EVB-Q100)

Boards supported

The following boards are supported by this application:

- XS32K14WEVB-Q064
- S32K14xCVD-Q064 with S32K-MB

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K144EVB-Q100	XS32K14WEVB-Q064
CAN HIGH (∗)	CAN HIGH - J13.1	CAN HIGH - J109.8
CAN LOW (∗)	CAN LOW - J13.2	CAN LOW - J109.7
GND (**GND**)	GND - J13.4	GND - J109.6
BUTTON 1 (**PTB13**)	SW3 - wired on the board	SW3 - wired on the board
BUTTON 0 (**PTB12**)	SW2 - wired on the board	SW2 - wired on the board
LED0 (**PTC0**)	RGB_RED - wired on the board	RGB_RED - wired on the board
LED1 (**PTC1**)	RGB_GREEN - wired on the board	RGB_GREEN - wired on the board

(∗) Those lines must be modulated using a transceiver, if it is not specified the boards already include the CAN transceiver.
The CAN transceiver should be in Forced Normal Mode operation (default mode).
To reset the CAN transceiver to default mode connect the SBC transceiver in next configuration with the board XS32K14WEVB-Q064 power off:

- **pin RSTN from SBC is held LOW**
- **CANH(J109.8) is pulled up to VBAT(J109.5)**

- **CANL(J109.7) is pulled down to GND(J109.6)**

Power on the board with external supply 12V (J16) This project only applies to S32K14W board. For S32K144↩ EVB board or other S32K EVB boards, please refer corresponding example to get the right way to setup hardware correctly.

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New** -> **S32DS Project From** and select **can_pal_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace. Wait for the S32 Configuration was initialized and ready.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Right click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **RAM** (Debug_RAM) or **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be four debug configurations for this project:

Configuration Name	Description
can_pal_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
can_pal_s32k142W_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.25 System Driver Examples

Applications that show the user how to initialize the communication peripherals

There are currently driver examples with the following modules:
Click on one of the module to see the available projects

- CRC Checksum

- MPU PAL Memory Protection
- MPU Memory Protect Unit
- FLASH Partitioning
- EIM INJECTION
- ERM REPORT
- EWM Interrupt
- WDOG Interrupt
- Trigger MUX Control
- EDMA transfer
- Power Mode Switch
- CSEc key configuration
- SECURITY PAL
- WDG PAL Interrupt

13.4.26 CRC Checksum

Example application showing the usage of the CRC module

Application description

The purpose of this demo application is to show you how to use the Cyclic Redundancy Check of the S32K142W with this SDK.

In this example, The CRC is configured to generate a configuration for CCITT standard following:

- CCITT 16 bits standard:

```
{
    .crcWidth = CRC_BITS_16,
    .seed = 0xFFFFU,
    .polynomial = 0x1021U,
    .writeTranspose = CRC_TRANSPOSE_NONE,
    .readTranspose = CRC_TRANSPOSE_NONE,
    .complementChecksum = false
}
```

The application:

1. After reset starts with both LED0 and LED1 turned off.

2. Initializes CRC module with the above CCITT 16 bits standard configuration.
3. Pressing the SW button CRC calculation is initialized with CRC_data array from input_data.c file.
4. If the result is correct LED0 is turned on. Otherwise LED1 will be turned on.
5. The program stops.

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro

Boards supported

The following boards are supported by this application:

- XS32K14WEVB-Q064
- S32K14xCVD-Q064 with S32K-MB

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064	S32K14xCVD-Q064 with S32K-MB
LED0 (**PTE0**/**PTC0**)	RGB_GREEN - wired on the board	LED_0 - JP49 (wired on the board)
LED1 (**PTE7**/**PTC1**)	RGB_RED - wired on the board	LED_1 - JP50 (wired on the board)
SW (**PTD3**/**PTB12**)	SW3	BUTTON 0 - wired on the board

Make sure the following jumpers are set:

Jumper Name	S32K-MB
JP49	Set jumper on position 1-2
JP50	Set jumper on position 1-2
JP39	Set jumper on position 1-2
J69	Set jumper on position 1-2
J70	Set jumper on position 2-3

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From** and select **crc_checksum_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace. Wait for the S32 Configuration was initialized and ready.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
crc_checksum_s32k142_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
crc_checksum_s32k142_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Notes

The CRC module in S32K platform supports both big endian and little endian in source data.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.27 MPU PAL Memory Protection

Example application that shows how to use the MPU PAL

Application description

The purpose of this demo application is to show you how to use the Memory Protection Unit PAL of the S32K142W MCU with this SDK.

In this example, MPU PAL regions are configured to have access rights as following:

Region	Core	Debugger	DMA	Address
0	—	rwx	rwx	0x00000000 - 0xFFFFFFFF
1	rwx	rwx	rwx	0x00000000 - 0x0003FEFF
2	-wx	rwx	rwx	0x0003FF00 - 0x0003FF1F

3	r–	rwx	rwx	0x0003FF00 - 0x0003FF1F
4	rwx	rwx	rwx	0x0003FF20 - 0xFFFFFFFF

Run the example

1. After reset, MPU PAL will be initialized according to configuration above.
2. Read flash memory at address 0x0003FF04 is permitted.
3. Press button (SW) on the board to ignore read permission by disabling region 3.
4. Read flash memory at address 0x0003FF04 is violated.
5. MPU PAL report the detail of error access on slave port 0 (Crossbar slave port 0 -> Flash Controller).

Verification

1. LED0 on indicate that MPU PAL initialization successful.
2. LED1 on (LED0 off) indicate that there is violated read access reported by MPU PAL.

Prerequisites

To run the example you will need to have the following items:

- 1 Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- 1 Mother Board S32K-MB PCB RevA SCH RevB
- 1 Board XS32K14WEVB-Q064
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro Debugger

Boards supported

The following boards are supported by this application:

- Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- Mother Board S32K-MB PCB RevA SCH RevB
- Board XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K-MB	XS32K14WEVB-Q064
LED0 (**PTC0**/**PTE0**)	LED0 - JP49	LED GREEN - D11
LED1 (**PTC1**/**PTE7**)	LED1 - JP50	LED RED - D11
SW (**PTB12**/**PTD2**)	BUTTON0 - J69(2-3), J70(1-2), JP39	SW2

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **mpu_pal_memory_↩ protection_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Right click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configuration (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code"."

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
mpu_pal_memory_protection_s32k142w_debug↩ _ram_pemicro	Debug the RAM configuration using PEMicro debuggers
mpu_pal_memory_protection_s32k142w_debug↩ _flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.28 MPU Memory Protect Unit

Basic application that presents the project scenarios for S32 SDK

Application description

The purpose of this demo application is to show you how to use the Memory Protection Unit of the S32K142W MCU with this SDK.

In this example, MPU regions are configured to have access rights as following:

Region	Core	Debugger	DMA	Address
0	—	rwx	rwx	0x00000000 - 0xFFFFFFFF
1	rwx	rwx	rwx	0x00000000 - 0x0007FEFF

2	-wx	rwx	rwx	0x0007FF00 - 0x0007FF1F
3	r–	rwx	rwx	0x0007FF00 - 0x0007FF1F
4	rwx	rwx	rwx	0x0007FF20 - 0xFFFFFFFF

Boards supported

The following boards are supported by this application:

- Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- Mother Board S32K-MB PCB RevA SCH RevB
- Board XS32K14WEVB-Q064

Run the example

1. After reset, MPU will be initialized according to configuration above.
2. Read flash memory at address 0x0007FF04 is permitted.
3. Press button (SW) on the board to ignore read permission by disabling region 3.
4. Read flash memory at address 0x0007FF04 is violated.
5. MPU report the detail of error access on slave port 0 (Crossbar slave port 0 -> Flash Controller).

Verification

1. LED1 on indicate that MPU initialization successful.
2. LED0 on (LED1 off) indicate that there is violated read access reported by MPU.

Prerequisites

To run the example you will need to have the following items:

- 1 Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- 1 Mother Board S32K-MB PCB RevA SCH RevB
- 1 Board XS32K14WEVB-Q064
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro Debugger

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K-MB	XS32K14WEVB-Q064
LED0 (**PTC0**/**PTE0**)	LED0 - JP49	LED GREEN - D11

LED1 (**PTC1**/**PTE7**)	LED1 - JP50	LED RED - D11
SW (**PTB12**/**PTD2**)	BUTTON0 - J69(2-3), J70(1-2), JP39	SW2

```
## How to run ##
```

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **mpu_memory_↩ protection_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32CT configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Right click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configuration (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code"."

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
mpu_memory_protection_s32k142w_debug_↩ ram_pemicro	Debug the RAM configuration using PEMicro debuggers
mpu_memory_protection_s32k142w_debug_↩ flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.29 FLASH Partitioning

Example application which shows the basic operations of the FLASH driver

Application description

The purpose of this demo application is to show you the usage of the FLASH driver with the S32 SDK API.

The examples does the following operations:

- Partitions the flash
- Configures FlexNVM region as EEPROM
- Erases flash

- Programs flash
- Write data to EEPROM. Check the status of API which confirms activities of flash module. In addition, user can view value at memory from address 0x3F000 when erases or programs flash. Checks the value at memory from address 0x14000000 when writes data to EEPROM.

Note

The FlexNVM memory is partitioned to EEPROM use and is blocked for some erase commands (Erase Sector and Erase Block). As a consequence, loading the program to flash memory may fail on some debuggers. Please perform a mass erase operation on Flash to remove this partitioning after running the example to be able to update your application on target.

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro Debugger

Boards supported

The following boards are supported by this application:

- XS32K14WEVB-Q064
- S32K142-MB

Hardware Wiring

No connections are required for this example.

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **flash_partitioning_↩ s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Right click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configuration (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
flash_partitioning_s32k142w_debug_ram_↩ pemicro	Debug the RAM configuration using PEMicro debuggers
flash_partitioning_s32k142w_debug_flash_↩ pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.30 EIM INJECTION

Driver example that shows the user how to use the Error Injection Module

Application description

The EIM module enables the user to inject 1 bit error or 2 bit errors into bus data, when read from a designated RAM area. The ECC module must correct all 1 bit errors. The ERM module reports any detected memory error. The example runs only on FLASH.

Run the code

1. After reset, LED_RED is turned off, LED_GREEN is turned on and the value of the test address is initialized.
2. Press button BUTTON0 to initialize the ERM and EIM modules.
3. Read the initialized address; if the value read from the test address is the same as the initialized value, then LED_GREEN will be turned off and LED_RED will be turned on.

If application runs success, LED_GREEN will be turned off and LED_RED will be turned on after press button 0.

Prerequisites

To run the example you will need to have the following items:

- 1 Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- 1 Mother Board S32K-MB PCB RevA SCH RevB
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro Debugger (optional OpenSDA)
- 1 XS32K14WEVB-Q064 EVB board

Boards supported

The following boards are supported by this application:

- Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with s32k142W
- Mother Board S32K-MB PCB RevA SCH RevB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064
RED_LED (**PTE7**)	LED_0 - Wired on the board
GREEN_LED (**PTE0**)	LED_1 - Wired on the board
SW (**PTD2**)	SW2-BTN0

PIN FUNCTION	S32K-MB
RED_LED (**PTC0**)	LED_0 - JP49 (wired on the board)
GREEN_LED (**PTC1**)	LED_1 - JP50 (wired on the board)
SW (**PTB12**)	BUTTON0 - J69(2-3), J70(1-2), JP39

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **eim_injection_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be one debug configuration for this project:

Configuration Name	Description
eim_injection_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.31 ERM REPORT

Driver example that shows the user how to use the Error reporting module.

Application description

The EIM module enables the user to inject 1 bit error or 2 bit errors into bus data, when read from a designated RAM area. The ECC module must correct all 1 bit errors. The ERM module reports any detected memory error. The example runs only on FLASH

Run the code

1. After reset, LED_RED is turned off, LED_GREEN is turned on and the value for address used to test is initialized.
2. Press button SW2(BUTTON0) to initialize ERM and EIM modules.
3. Read the address which was initialized, ERM will trigger an interrupt notification which also turns off LED_↩ GREEN, and turns on the LED_RED to report a single-bit correction event.
4. Error event details are reported by ERM.

Prerequisites

- 1 Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- 1 Mother Board S32K-MB PCB RevA SCH RevB
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro Debugger (optional, users can use Open SDA)
- 1 XS32K14WEVB-Q064 EVB board

Boards supported

The following boards are supported by this application:

- Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with s32k142W
- Mother Board S32K-MB PCB RevA SCH RevB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064
RED_LED (**PTE7**)	LED_0 - Wired on the board
GREEN_LED (**PTE0**)	LED_1 - Wired on the board
SW (**PTD2**)	SW2-BTN0

PIN FUNCTION	S32K-MB
LED0 (**PTC0**)	LED_0 - JP49 (wired on the board)
LED1 (**PTC1**)	LED_1 - JP50 (wired on the board)
SW (**PTB12**)	BUTTON0 - J69(2-3), J70(1-2), JP39

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **erm_report_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be one debug configuration for this project:

Configuration Name	Description
erm_report_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.
This Example only run on Flash

13.4.32 EWM Interrupt

Driver example that shows the user how to use the External Watchdog Monitor

Application description

The purpose of this driver application is to show the user how to use the EWM from the S32K142w using the S32 SDK API.

Run the code

1. Turn off LED0 and LED1.
2. The examples uses the SysTick timer from the ARM core to refresh the EWM counter for 30 times. After each refresh, LED0 is also toggled. Within this interval the user can press the button associated with the EWM input pin to assert the interrupt and output pin.
3. After the EWM counter is refreshed 30 times or the user presses the button before refreshing ends, the EWM interrupt is triggered and both LED0 and LED1 are turned ON, then SysTick timer is disabled.

Expected output:

- If the button 0 is not pressed, the LED0 is toggled 30 times, after that LED0 and LED0 are turned ON.
- If the button 0 is pressed, LED0 and LED1 are turned ON immediately.

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V
- 2 Dupont male to male cable
- 1 Personal Computer
- 1 PEMicro Debugger (optional, users can use Open SDA)

Boards supported

The following boards are supported by this application:

- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064
LED0 (**PTE7**)	RGB_RED - wired on the board
LED1 (**PTE0**)	RGB_GREEN - wired on the board
EWM_IN (**PTA3**)	J1.2(EWM INPUT) - J6.2(SW2_BTN0)

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **ewm_interrupt_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
ewm_interrupt_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
ewm_interrupt_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.33 WDOG Interrupt

Example application that will show the usage of the Watchdog

Application description

The purpose of this driver application is to show the user how to use the WDOG from the S32K142w using the S32 SDK API.

The examples uses the SysTick timer from the ARM core to refresh the WDOG counter for 8 times. After this the Watchdog counter will expire and the CPU will be reset. If the FLASH configuration will be used, then the code will use the Reset Control Module to detect if the reset was caused by the Watchdog and will stop the execution of the program.

Run the example on Devkit:

1. After reset, LED 1 and LED 0 is off.
2. Initialize WDOG Interrupt above then LED 0 is toggle 8 times(on 4 times and off 4 times).
3. Watchdog timeout happen then MCU reset and LED 0 and LED 1 is on and The program will stopped.

Prerequisites

To run the example you will need to have the following items:

- 1 S32K142W board
- 1 Power Adapter 12V
- 2 Dupont male to male cable
- 1 Personal Computer
- 1 PEmicro Debugger

Boards supported

The following boards are supported by this application:

- Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- Mother Board S32K-MB PCB RevA SCH RevB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064	S32K14xCVD-Q064	S32K-MB
LED0	RGB_RED - wired on the board	LED0 - wired on the board	JP49.1 - JP49.2
LED1	RGB_GREEN - wired on the board	LED1 - wired on the board	JP50.1 - JP50.2

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **wdog_interrupt_↩ s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32CT configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Right click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configuration (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code"."

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be one debug configurations for this project:

Configuration Name	Description
wdog_interrupt_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.34 Trigger MUX Control

Example application showing the usage of the TRGMUX module

Application description

The purpose of this demo application is to show you how to use the Trigger MUX Control of the S32K14xW MCU with this SDK.

The examples use TRGMUX to connect Pin Trigger Mux In3 and LPIT channel 0 on motherboard or connect Pin Trigger Mux In5 and LPIT channel 1 in EVB board

- Initialize TRGMUX with source trigger from TRGMUX_IN3 and target module is LPIT_CH0 for motherboard or Initialize TRGMUX with source trigger from TRGMUX_IN5 and target module is LPIT_CH1 for EVB board

- Initialize the LPIT Channel 0 for motherboard or Initialize the LPIT Channel 1 for EVB board.
- LED ORANGE on Motherboard or RGB_RED led on EVB board is used to blink led
- Each time when user presses button SW4 on Motherboard or SW2 in EVB board will generate a trigger signal that actives LPIT via TRGMUX. After 1s, LPIT will create an event interrupt and toggle LED

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board (S32K14xCVD-Q064)
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro Debugger (optional, users can use Open SDA)

Boards supported

The following boards are supported by this application:

- S32K142W-MB
- XS32K14WEVB-Q064

Hardware Wiring

PIN FUNCTION	S32K142W-MB	XS32K14WEVB-Q064
LED0 (**PTC0**)	JP49.1 - JP49.2	REG_RED (PTE7)- wired on the board
BUTTON3 ()	JP36.1-JP42.1, J63.2-3, J64.1-2	SW2 (PTD2) -wired on the board

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **trgmux_lpit_s32k142W**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Right click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configuration (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
trgmux_lpit_s32k142W_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
trgmux_lpit_s32k142W_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

Notes

The TRGMUX module in S32K platform supports both big endian and little endian in source data.

13.4.35 EDMA transfer

Example application showing the usage of the EDMA module

Application description

The purpose of this driver example is to show you how to use the eDMA in the following transfer scenarios for the S32K142W MCU using the S32 SDK API.

- Loop memory-to-memory transfer

If the application works correctly, the data shall be transfered correctly to destination memory and a transmission complete interrupt shall be triggered. And the application will not jump to any DEV_ASSERT.

Prerequisites

To run the example you will need to have the following items:

- 1 Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- 1 Mother Board S32K-MB PCB RevA SCH RevB
- 1 Power Adapter 12V (if the board can't be powered from the USB)
- 1 Personal Computer
- 1 PEmicro Debugger

Boards supported

The following boards are supported by this application:

- Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- Mother Board S32K-MB PCB RevA SCH RevB
- XS32K14WEVB-Q064

Hardware Wiring

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **edma_transfer_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. First go to **Project Explorer** View in S32 DS and select the current project(**edma_transfer_s32k142w**). Select the "Config↩ Tools" menu then click on the desired configuration (Pins, Cocks, Peripherals etc...). Clicking on any one of those will generate all the components. Make the desired changes(if any) then click on the "ConfigTools->Update Code" button.

3. Building the project

Select the configuration to be built **RAM** (Debug_RAM) or **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be one debug configurations for this project:

Configuration Name	Description
edma_transfer_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
edma_transfer_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.36 Power Mode Switch

Example application demonstrating S32K142W power modes

Application description

The purpose of the application is to show the user how to enter various power modes of the S32K142W SoC using the S32 SDK API.

The application displays on the host PC terminal a menu in which the user can select to enter:

- Normal Run (RUN)
- Very Low Power Run (VLPR)
- STOP mode 1 (STOP1)

- STOP mode 2 (STOP2)
- Very Low Power Stop (VLPS)

When user selects a mode, PC terminal will show the following text:

Press:
1) for RUN
2) for VLPR
3) for STOP1
4) for STOP2
5) for VLPS
–>Press SW3 to wake up the CPU from STOP1,STOP2 or VLPS mode
Enter your input:

Expected Output:

- If STOP1, STOP2 or VLPS is selected by entering the character: '3', '4' or '5' into PC terminal, LED_RED will turn on, LED_GREEN will turn off and the PC terminal will show:

Mode	The content informs
STOP1	******** CPU is going in STOP1 mode...
STOP2	******** CPU is going in STOP2 mode...
VLPS	******** CPU is going in VLPS mode...

- The CPU can be woken up from sleep modes by pressing button SW3 in EVB board, then LED_RED turn off, LED_GREEN turn on and PC terminal will show:

Mode	The content informs
STOP1	CPU was entered STOP1 mode successfully and then woke up to exit STOP1 mode.
STOP2	CPU was entered STOP2 mode successfully and then woke up to exit STOP2 mode.
VLPS	CPU was entered VLPS mode successfully and then woke up to exit VLPS mode.

- If user selects RUN or VLPR, the PC terminal will show:

Mode	The content informs
RUN	********** CPU is in RUN mode ********** Core frequency: 48000000[Hz]
VLPR	********** CPU is in VLPR mode ********** Core frequency: 1000000[Hz]

Prerequisites

To run the example you will need to have the following items:

- 1 S32K142W board
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro Debugger
- 1 Micro Usb Cable

Boards supported

The following boards are supported by this application:

- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064
GREEN_LED (**PTE0**)	RGB_RED - wired on board
RED_LED (**PTE7**)	RGB_GREEN - wired on board
BUTTON (**PTD3**)	SW3 - wired on the board

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From** and select **power_mode_switch_↩ s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace. Wait for the S32 Configuration was initialized and ready.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated.
The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar).
In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components.
Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be four debug configurations for this project:

Configuration Name	Description
power_mode_switch_S32K142w_debug_flash_↩ pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

Notes

For this example it is necessary to open a terminal emulator and configure it with:

- 9600 baud
- One stop bit
- No parity
- No flow control
- '\n' line ending

Clock source is remained in SIRC (8 MHz) before MCU switches from RUN to VLP mode.
In order to set to default clock for RUN mode. User presses option for RUN or re-initializes clock configuration.

13.4.37 CSEc key configuration

Basic application that presents basic usecases for the CSEc driver

Note

This example works only for CSEc enabled parts. SIM_SDID indicates whether CSEc is available on your device.
The first time when running the example on the board, or after a key erase, this example should be ran from RAM.
The user keys are non-volatile. Once the key was loaded, in order to update it, the counter should be increased.
After the user key was loaded using this example, any further full erase of the Flash requires a Challenge-Authentication process. This can be done by setting the ERASE_ALL_KEYS macro to 1.
After partitioning Flash for CSEc operation, using the JLink Flash configuration of any other project will not work anymore. Workaround:

- Run csec_keyconfig example with ERASE_ALL_KEYS 1, using PEmicro Flash debug configuration

Application description

The purpose of this demo application is to show the user how to use the Cryptographic Services Engine module from the S32K142W MCU with the S32 SDK API.

The implementation demonstrates the following:

- the enablement of the CSEc module, by showing how the Flash should be partitioned (using the Flash driver);
- configuring the MASTER_ECU key;
- configuring the first user key, using the MASTER_ECU key as an authorization;
- using the user key for an encryption. In order to update the user key after they were configured using the example, the user should increase the counter used for loading the key. Please note that user should increase counter in order to keep the encryption take its place successfully for 2 cases:
- The user key was already loaded by previous run.
- The example already ran from RAM for CSEc partition. Erasing all the configured keys (including the MA↩ STER_ECU key) can be done by changing the value of the ERASE_ALL_KEYS macro to 1. This will place the part back into factory status (the partition command will need to be run again). Please note that when the Flash is partitioned (the first time running the example on the board, or after a key erase), the example should not be run from Flash (please use the RAM configuration).

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro

Boards supported

The following boards are supported by this application:

- S32K14xCVD-Q064 with S32K-MB

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064	S32K14xCVD-Q064 with S32K-MB
LED_ERROR (**PTC0**)	N/A	LED0 - wired on the board
LED_OK (**PTC1**)	N/A	LED1 - wired on the board
LED_ERROR (**PTE0**)	RGB_RED - wired on the board	N/A
LED_OK (**PTE7**)	RGB_GREEN - wired on the board	N/A

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From** and select **csec_keyconfig_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace. Wait for the S32 Configuration was initialized and ready.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **RAM** (Debug_RAM) or **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
csec_keyconfig_s32k142W_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
csec_keyconfig_s32k142W_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.38 SECURITY PAL

Basic application that presents basic usecases for the Security PAL.

Note

This example works only for CSEc enabled parts. SIM_SDID indicates whether CSEc is available on your device.
The first time when running the example on the board, or after a key erase, this example should be ran from RAM.
This example generates a random number.
This example demonstrates CBC Encryption/Decryption.

Application description

The purpose of this demo application is to show the user how to use the Security PAL in conjuction with Cryptographic Services Engine module from the S32K14x MCU with the S32 SDK API.

The implementation demonstrates the following:

- the enablement of the Security PAL, used over CSEc module, by showing how the Flash should be partitioned (using the Flash driver);
- initializing the Random Number Generator and generating a vector of 128 random bits;
- configuring the RAM key, with a 128-bit plaintext;
- using the user key for a CBC encryption and a CBC decryption;

If no errors occur during the cryptographic operations, the LED0 will be turned on upon completion; if the red LED1 is lit, the program failed during one of the steps.

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro debugger

Boards supported

The following boards are supported by this application:

- XS32K14WEVB-Q064
- S32K14xCVD-Q064 with S32K-MB

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **security_pal**. Select "Copy projects into workspace" and then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Right click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configuration (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code"."

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug** Configurations. There will be two debug configurations for this project:

Configuration Name	Description
security_pal_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers
security_pal_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.39 WDG PAL Interrupt

Example application that will show the usage of the Watchdog

Application description

The purpose of this driver application is to show the user how to use the WDG PAL from the S32k142W using the S32 SDK API.

The example uses the SysTick timer from the ARM core to refresh the WDG PAL counter for 30 times. LED0 will toggle when WDG PAL counter is refreshed. After this the WDG PAL counter will expire, WDG PAL interrupt will happen and turn off LED0, LED1. Then the CPU will be reset. If the FLASH configuration will be used, then the program will use the Reset Control Module to detect if the reset was caused by the Watchdog and will stop the execution of the program and turn on LED0, LED1.

Prerequisites

To run the example you will need to have the following items:

- 1 Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- 1 Mother Board S32K-MB PCB RevA SCH RevB
- 1 Power Adapter 12V
- 2 Dupont male to male cable
- 1 Personal Computer
- 1 PEmicro Debugger

Boards supported

The following boards are supported by this application:

- Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- Mother Board S32K-MB PCB RevA SCH RevB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064	S32K14xCVD-Q064	S32K-MB
LED0	RGB_RED - wired on the board	LED0 - wired on the board	JP49.1 - JP49.2
LED1	RGB_GREEN - wired on the board	LED1 - wired on the board	JP50.1 - JP50.2

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **wdg_pal_interrupt_↩ s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Right click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configuration (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code"." Wait for the code generation to be completed before continuing to the next step.

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be one debug configurations for this project:

Configuration Name	Description
wdg_pal_interrupt_s32k142w_debug_flash_↩ pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.40 Timer Driver Examples

Applications that show the user how to initialize the timer peripherals

There are currently driver examples with the following modules:
Click on one of the module to see the available projects

- FTM Combined PWM
- FTM Periodic Interrupt
- FTM PWM
- FTM Signal Measurement
- IC PAL
- LPTMR Periodic Interrupt
- LPTMR Periodic Interrupt
- PDB Periodic Interrupt
- RTC Alarm
- TIMING PAL
- PWM PAL
- OC PAL

- LPIT Periodic Interrupt

13.4.41 FTM Combined PWM

Example application showing the FTM's combined PWM functionality

Application description

The purpose of this demo application is to show you the usage of the Combined PWM mode of the FlexTimer module on S32K142W using S32 SDK API.

The examples does the following operations:

- Increment or decrement duty cycle
- Update channel duty cycle
- Wait for a number of cycles to make the change visible

Run the example

1. After reset, two LEDs wired on the board will increment or decrement light intensity
2. Use oscilloscope to verify the output signal

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 or 1 S32K144-MB
- 1 S32K144-MB
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro Debugger
- 1 microUSB cable

Boards supported

The following boards are supported by this application:

- XS32K14WEVB-Q064
- S32K144-MB

Hardware Wiring

PIN FUNCTION	S32K144-MB	XS32K14WEVB-Q064
FTM0 Channel 0	LED0 - wired on the board - JP49 (1-2)	RGB_GREEN - J3.6 - J4.2

FTM0 Channel 1	LED1 - wired on the board - JP50 (1-2)	RGB_RED - J5.7 - J3.8

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **ftm_combined_pwm_↩ s32k142w**. Then click on **Finish**.
The project should now be copied into your current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. First go to **Project Explorer** View in S32 DS and select the current project(**ftm_combined_pwm_s32k142w**). Right click on the current project ->" S32 Configuration Tool" menu then click on the desired configuration (Pins, Cocks, Peripherals etc...). Clicking on any one of those will generate all the components. Make the desired changes(if any) then click on the "ConfigTools->Update Code" button.

3. Building the project

Select the configuration **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) to be built by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There are two debug configurations for this project:

Configuration Name	Description
ftm_combined_pwm_s32k142w_debug_ram_↩ pemicro	Debug the RAM configuration using PEMicro debugger
ftm_combined_pwm_s32k142w_debug_flash_↩ pemicro	Debug the FLASH configuration using PEMicro debugger

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.42 FTM Periodic Interrupt

Example application showing the FTM's Timer functionality

Application description

The purpose of this demo application is to show you the usage of the FlexTimer's Timer functionality on S32K142W CPU using the S32 SDK API

- The application configures FTM to generate an interrupt every 1 second
- The interrupt will toggle the configured LED0 wired on the board

Prerequisites

To run the example you will need to have the following items:

- 1S32K144-MB or 1 XS32K14WEVB-Q064
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 microUSB cable
- 1 PEmicro Debugger

Boards supported

The following boards are supported by this application:

- S32K144-MB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K144-MB	XS32K14WEVB-Q064
LED0 (wired on the board)	LED0 (PTC0) - JP49 (1-2)	RGB_GREEN (PTE0)

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **ftm_periodic_interrupt_s32k142w**. Then click on **Finish**.
The project should now be copied into your current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. First go to **Project Explorer** View in S32 DS and select the current project(**ftm_periodic_interrupt_s32k142w**). Right click on the current project ->" S32 Configuration Tool" menu then click on the desired configuration (Pins, Cocks, Peripherals etc...). Clicking on any one of those will generate all the components. Make the desired changes(if any) then click on the "ConfigTools->Update Code" button.

3. Building the project

Select the configuration **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) to be built by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There are two debug configurations for this project:

Configuration Name	Description
ftm_periodic_interrupt_s32k142w_debug_ram_↩ pemicro	Debug the RAM configuration using PEMicro debuggers
ftm_periodic_interrupt_s32k142w_debug_flash_↩ pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.43 FTM PWM

Example application showing the FTM's PWM functionality

Application description

The purpose of this demo application is to show you the usage of the PWM mode of the FlexTimer module found on the S32K142W using S32 SDK API. The examples does the following operations:

- Increment or decrement duty cycle
- Update channel duty cycle
- Wait for a number of cycles to make the change visible

Run the example

1. After run debug, the LED wired on board will increment or decrement light intensity
2. Use oscilloscope to verify the output signal

Prerequisites

To run the example you will need to have the following items:

- 1S32K144-MB or 1 XS32K14WEVB-Q064
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 microUSB cable
- 1 PEmicro Debugger

Boards supported

The following boards are supported by this application:

- S32K144-MB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K144-MB	XS32K14WEVB-Q064
FTM0 Channel 0 (**PTC0**)	LED0 wired on the board - JP49 (1-2)	
FTM0 Channel 7 (**PTE7**)		RGB_RED - LED0 wired on the board

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **ftm_pwm_s32k142w**. Then click on **Finish**.
The project should now be copied into your current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. First go to **Project Explorer** View in S32 DS and select the current project(**ftm_pwm_s32k142w**). Right click on the current project ->" S32 Configuration Tool" menu then click on the desired configuration (Pins, Cocks, Peripherals etc...). Clicking on any one of those will generate all the components. Make the desired changes(if any) then click on the "ConfigTools->Update Code" button.

3. Building the project

Select the configuration **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) to be built by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There are two debug configurations for this project:

Configuration Name	Description
ftm_pwm_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debugger
ftm_pwm_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debugger

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.44 FTM Signal Measurement

Example application showing the FTM's Signal Measurement functionality

Application description

The purpose of this demo application is to show you the usage of the FlexTimer's Signal Measurement functionality from the S32K144W CPU using the S32 SDK API.

- The application is configured to generate a PWM signal with a variable frequency which will be measured by another FTM instance. The frequency will range from 1000 Hz to 3000 Hz. Each step changes 100 Hz. The

measurement result will be sent to the host PC via LPUART. User is able to compare pwm frequency and measurement frequency.

The pwm frequency must be in measurable frequency range of FTM_IC. For example, here are the measurable ranges corresponding to the clock source = System clock (48 MHz)

Clock source prescaler	Maximum frequency (Hz)	Minimum frequency (Hz)
1	48,000,000	732.42
2	24,000,000	366.21
4	12,000,000	183.10
8	6,000,000	91.55
16	3,000,000	45.77
32	1,500,000	22.88
64	750,000	11.44
128	375,000	5.72

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 or 1 S32K144-MB
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro Debugger
- 1 microUSB cable

Boards supported

The following boards are supported by this application:

- XS32K14WEVB-Q064
- S32K144-MB

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K144-MB	XS32K14WEVB-Q064
FTM0 Output Channel 0 (**PTC0**)	J11.31 - J10.29	J4.06 - J2.06
FTM1 Input Channel 0 (**PTB2**)	J10.29 - J11.31	J2.06 - J4.06
UART_TX	J20.01 - J20.02	Wired on the board
UART_RX	J20.04 - J20.05	Wired on the board
USB_MICRO_AB	J41 - microUSB cable	J7 - microUSB cable

Notes

For this example it is necessary to open a terminal emulator and configure it with:

- 9600 baud
- One stop bit
- No parity
- No flow control
- '\n' line ending

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **ftm_signal_measurement_s32k142w**. Then click on **Finish**.
The project should now be copied into your current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. First go to **Project Explorer** View in S32 DS and select the current project(**ftm_signal_measurement_s32k142w**). Right click on the current project ->" S32 Configuration Tool" menu then click on the desired configuration (Pins, Cocks, Peripherals etc...). Clicking on any one of those will generate all the components. Make the desired changes(if any) then click on the "ConfigTools->Update Code" button.

3. Building the project

Select the configuration **FLASH** (Debug_FLASH) to be built by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There is a debug configuration for this project:

Configuration Name	Description
ftm_signal_measurement_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debugger

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

5. Output display on Terminal

Welcome message:

```
This example will show you how to use FTM's signal measurement feature.
To achieve that we will generate a modifiable frequency PWM and read
it with Input Capture
Press any key to initiate a new conversion...
```

Expected output:

```
PWM frequency:  1000      Measured frequency:   1000    [Hz]
PWM frequency:  1100      Measured frequency:   1100    [Hz]
PWM frequency:  1200      Measured frequency:   1200    [Hz]
PWM frequency:  1300      Measured frequency:   1300    [Hz]
PWM frequency:  1400      Measured frequency:   1400    [Hz]
PWM frequency:  1500      Measured frequency:   1500    [Hz]
PWM frequency:  1600      Measured frequency:   1600    [Hz]
PWM frequency:  1700      Measured frequency:   1700    [Hz]
PWM frequency:  1800      Measured frequency:   1800    [Hz]
PWM frequency:  1900      Measured frequency:   1900    [Hz]
PWM frequency:  2000      Measured frequency:   2000    [Hz]
PWM frequency:  2100      Measured frequency:   2100    [Hz]
PWM frequency:  2200      Measured frequency:   2200    [Hz]
PWM frequency:  2300      Measured frequency:   2300    [Hz]
PWM frequency:  2400      Measured frequency:   2400    [Hz]
PWM frequency:  2500      Measured frequency:   2500    [Hz]
PWM frequency:  2600      Measured frequency:   2600    [Hz]
PWM frequency:  2700      Measured frequency:   2700    [Hz]
PWM frequency:  2800      Measured frequency:   2800    [Hz]
PWM frequency:  2900      Measured frequency:   2900    [Hz]
PWM frequency:  3000      Measured frequency:   3000    [Hz]
```

```
Press any key to initiate a new conversion...
```

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.45 IC PAL

Example application showing the IC's Signal Measurement functionality

Application description

The purpose of this demo application is to show you the usage of the IC's Signal Measurement functionality from the S32K142W CPU using the S32 SDK API.

- The application is configured to generate a PWM signal with a variable frequency which will be measured by IC_PAL. The frequency will range from 1000 Hz to 3000 Hz. Each step changes 100 Hz. The measurement result will be sent to the host PC via LPUART. User is able to compare pwm frequency and measurement frequency.

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 or 1 S32K144-MB
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro Debugger
- 1 microUSB cable

Boards supported

The following boards are supported by this application:

- XS32K14WEVB-Q064
- S32K144-MB

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K144-MB	XS32K14WEVB-Q064
FTM0 Output Channel 0 (**PTC0**)	J11.31 - J10.29	J4.06 - J2.06
FTM1 Input Channel 0 (**PTB2**)	J10.29 - J11.31	J2.06 - J4.06
UART_TX	J20.01 - J20.02	Wired on the board
UART_RX	J20.04 - J20.05	Wired on the board
USB_MICRO_AB	J41 - microUSB cable	J7 - microUSB cable

Notes

For this example it is necessary to open a terminal emulator and configure it with:

- 9600 baud
- One stop bit
- No parity
- No flow control
- '\n' line ending

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **ic_pal_s32k142w**. Then click on **Finish**.
The project should now be copied into your current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. First go to **Project Explorer** View in S32 DS and select the current project(**ic_pal_s32k142w**). Right click on the current project ->" S32 Configuration Tool" menu then click on the desired configuration (Pins, Cocks, Peripherals etc...). Clicking on any one of those will generate all the components. Make the desired changes(if any) then click on the "ConfigTools->Update Code" button.

3. Building the project

Select the configuration **FLASH** (Debug_FLASH) to be built by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There is a debug configuration for this project:

Configuration Name	Description
ic_pal_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debugger

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

5. Output display on Terminal

Welcome message:

```
This example will show you how to use IC's signal measurement feature.
To achieve that we will generate a modifiable frequency PWM and read
it with Input Capture
Press any key to initiate a new conversion...
```

Expected output:

```
PWM frequency:  1000      Measured frequency:   1000    [Hz]
PWM frequency:  1100      Measured frequency:   1100    [Hz]
PWM frequency:  1200      Measured frequency:   1200    [Hz]
```

```
PWM frequency:  1300      Measured frequency:   1300    [Hz]
PWM frequency:  1400      Measured frequency:   1400    [Hz]
PWM frequency:  1500      Measured frequency:   1500    [Hz]
PWM frequency:  1600      Measured frequency:   1600    [Hz]
PWM frequency:  1700      Measured frequency:   1700    [Hz]
PWM frequency:  1800      Measured frequency:   1800    [Hz]
PWM frequency:  1900      Measured frequency:   1900    [Hz]
PWM frequency:  2000      Measured frequency:   2000    [Hz]
PWM frequency:  2100      Measured frequency:   2100    [Hz]
PWM frequency:  2200      Measured frequency:   2200    [Hz]
PWM frequency:  2300      Measured frequency:   2300    [Hz]
PWM frequency:  2400      Measured frequency:   2400    [Hz]
PWM frequency:  2500      Measured frequency:   2500    [Hz]
PWM frequency:  2600      Measured frequency:   2600    [Hz]
PWM frequency:  2700      Measured frequency:   2700    [Hz]
PWM frequency:  2800      Measured frequency:   2800    [Hz]
PWM frequency:  2900      Measured frequency:   2900    [Hz]
PWM frequency:  3000      Measured frequency:   3000    [Hz]
Press any key to initiate a new conversion...
```

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.46 LPTMR Periodic Interrupt

Example application that shows the LPTMR's Timer feature

Application description

The purpose of this demo application is to show you how to use the LPTMR's Timer functionality from the S32↩ K142W using the S32 SDK API.

- The LPTMR is configured to generate a periodic interrupt at 1 seconds which toggles a LED.

Prerequisites

To run the example you will need to have the following items:

- 1 Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- 1 Mother Board S32K-MB PCB RevA SCH RevB
- 1 Power Adapter 12V (if the board can't be powered from the USB)
- 1 Personal Computer
- 1 PEmicro Debugger

Boards supported

The following boards are supported by this application:

- Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- Mother Board S32K-MB PCB RevA SCH RevB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K-MB	XS32K14WEVB-Q064
LED0	(PTC0) JP49.1 - JP49.2	(PTE7) wired on the board

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **lptmr_periodic_interrupt_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. First go to **Project Explorer** View in S32 DS and select the current project(**lptmr_periodic_interrupt_s32k142w**). Select the "ConfigTools" menu then click on the desired configurator (Pins, Cocks, Peripherals etc...). Clicking on any one of those will generate all the components. Make the desired changes(if any) then click on the "ConfigTools->Update Code" button.

3. Building the project

Select the configuration to be built **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
lptmr_periodic_interrupt_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
lptmr_periodic_interrupt_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.47 LPTMR Periodic Interrupt

Example application that shows the LPTMR's Pulse Counting feature

Application description

The purpose of this demo application is to show you how to use the Low Power Timer's Pulse Counter functionality from the S32K142W using the S32 SDK API.

- The example is configured to trigger an interrupt and toggle an LED after three pulses, sourced from one of the board's buttons.

Prerequisites

To run the example you will need to have the following items:

- 1 Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- 1 Mother Board S32K-MB PCB RevA SCH RevB
- 1 Power Adapter 12V (if the board can't be powered from the USB)
- 1 Personal Computer
- 1 PEmicro Debugger

Boards supported

The following boards are supported by this application:

- Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- Mother Board S32K-MB PCB RevA SCH RevB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K-MB	XS32K14WEVB-Q064
LED0	(PTC0) JP49.1 - JP49.2	(PTE7) wired on the board
BUTTON3 (**PTE11**)	J36.1-2, J63.2-3, J64.1-2	SW2(J6.2) - J4.3

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **lptmr_pulse_counter_↩ s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. First go to **Project Explorer** View in S32 DS and select the current project(**lptmr_pulse_counter_s32k142w**). Select the "ConfigTools" menu then click on the desired configurator (Pins, Cocks, Peripherals etc...). Clicking on any one of those will generate all the components. Make the desired changes(if any) then click on the "ConfigTools->Update Code" button.

3. Building the project

Select the configuration to be built **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
lptmr_pulse_counter_s32k142w_debug_ram_↩ pemicro	Debug the RAM configuration using PEMicro debuggers

lptmr_pulse_counter_s32k142w_debug_flash_↩ pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.48 PDB Periodic Interrupt

Driver example using PDB for demonstrating PDB timer functionality

Application description

The purpose of this demo application is to show the use of PDB driver for configuring PDB as timer. The PDB is configured to generate a periodic interrupt which toggles an LED.

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro debugger (optional, users can use Open SDA)

Boards supported

The following boards are supported by this application:

- S32K14xCVD-Q064 with S32K-MB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K14xCVD-Q064 with S32K-MB	XS32K14WEVB-Q064
LED0	(PTC0) JP49 must be connected	(PTE7) wired on the board

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New** -> **S32DS Project From** and select **pdb_periodic_interrupt↩ _s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace. Wait for the S32 Configuration was initialized and ready.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **RAM** (Debug_RAM) or **FLASH** (Debug_FLASH) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
pdb_periodic_interrupt_s32k142w_debug_ram_↩ pemicro	Debug the RAM configuration using PEMicro debuggers
pdb_periodic_interrupt_s32k142w_debug_flash↩ _pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.49 RTC Alarm

Example application showing basic use cases for the RTC module

Application description

The purpose of this demo application is to show you how to use the Real Time Clock module from the S32K142W MCU with the S32 SDK API.

The RTC is configured to generate an interrupt every 1 second toggling LED0. If the alarm button is pressed an alarm interrupt toggles the alarm LED1 after 5 seconds.

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 2 Dupont male to male cable
- 1 Personal Computer
- 1 PEmicro

Boards supported

The following boards are supported by this application:

- XS32K14WEVB-Q064
- S32K14xCVD-Q064 with S32K-MB

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064	S32K14xCVD-Q064
LED0	RGB_GREEN - wired on the board	LED0 - wired on the board
LED1	RGB_RED - wired on the board	LED1 - wired on the board
BUTTON	SW3 - wired on the board	BUTTON 0 - wired on the board

Make sure the following jumpers are set:

Jumper Name	S32K-MB
JP49	Set jumper on position 1-2
JP50	Set jumper on position 1-2
JP39	Set jumper on position 1-2
J69	Set jumper on position 1-2
J70	Set jumper on position 2-3

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From** and select **rtc_alarm_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace. Wait for the S32 Configuration was initialized and ready.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Left click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configurator (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code".

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
rtc_alarm_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers

rtc_alarm_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Notes

If the example doesn't work, please Flash the Debug_FLASH configuration and enforce a power on reset of the board.
This is caused by the fact that the register which configures the RTC clock source can only be written once.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.50 TIMING PAL

Driver example using TIMING PAL

Application description

The purpose of this application is to show you how to use the TIMING PAL over LPIT, LPTMR and FTM timers on the S32K142W using the S32 SDK API.

The application uses one board instance of LPIT, LPTMR and FTM to periodically toggle 3 leds.

Prerequisites

To run the example you will need to have the following items:

- 1 Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- 1 Mother Board S32K-MB PCB RevA SCH RevB
- 1 Power Adapter 12V (if the board can't be powered from the USB)
- 1 Personal Computer
- 1 PEmicro Debugger

Boards supported

The following boards are supported by this application:

- Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- Mother Board S32K-MB PCB RevA SCH RevB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064	S32K142W-MB
LED0 (**PTC0**)	RGB_GREEN - wired on the board	JP49.1 - JP49.2
LED1 (**PTC1**)	RGB_RED - wired on the board	JP50.1 - JP50.2
LED2 (**PTC2**)	RGB_BLUE - wired on the board	JP51.1 - JP51.2

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **timing_pal_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. First go to **Project Explorer** View in S32 DS and select the current project(**timing_pal_s32k142w**). Select the "ConfigTools" menu then click on the desired configurator (Pins, Cocks, Peripherals etc...). Clicking on any one of those will generate all the components. Make the desired changes(if any) then click on the "ConfigTools->Update Code" button.

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description
timing_pal_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
timing_pal_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.51 PWM PAL

Example application using the PWM PAL

Application description

The purpose of this demo application is to show you how to use the PWM PAL from the S32K142W CPU using the S32 SDK API. The example will dim the ORANGE LED on mother board or RGB_GREEN led on EVB board by varying the duty cycle of the PWM signal.

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro Debugger (optional, users can use Open SDA)

Boards supported

The following boards are supported by this application:

- S32K142W-MB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K142W-MB	XS32K14WEVB-Q064
FTM0 Channel 0 (**PTC0**)	LED_ORANGE - Connected J49.1 to J49.2	LED_GREEN - Connected J4.6 to J3.6

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **pwm_pal_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. Right click on the current project, then click "Open S32 Configuration" (it has blue chip symbol on the top of the toolbar). In S32 Configuration menu, click on the desired configuration (Pins, Clock, Peripherals, etc.). Clicking on any one of those will generate all the components. Pay attention to any error and warning message. If any configured value is invalid, they will be shown for user. Make the desired changes (if any) then click "Update Code"."

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configurations for this project:

Configuration Name	Description

pwm_pal_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
pwm_pal_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.52 OC PAL

Driver example using OC PAL

Application description

The purpose of this demo application is to show you how to use the OC PAL of the S32K142W MCU with this SDK. The demo is configured to toggle a LED in an interrupt callback.

The examples use OC PAL over FTM0.

- Initialize the OC PAL module with interrupt function callback.
- This application will toggle green led with period 2 second after each OC PAL interrupt.

Prerequisites

To run the example you will need to have the following items:

- 1 XS32K14WEVB-Q064 board
- 1 Power Adapter 12V (if the board can't be powered from the USB)
- 1 Personal Computer
- 1 PEmicro Debugger (optional, users can use Open SDA)

Boards supported

The following boards are supported by this application:

- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	XS32K14WEVB-Q064
FTM0 Channel 0 (**PTE0**)	RGB_GREEN - wired on the board

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **oc_pal_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. First go to **Project Explorer** View in S32 DS and select the current project(**oc_pal_s32k142w**). Select the "ConfigTools" menu then click on the desired configurator (Pins, Cocks, Peripherals etc...). Clicking on any one of those will generate all the components. Make the desired changes(if any) then click on the "ConfigTools->Update Code" button.

3. Building the project

Select the configuration to be built **FLASH** (Debug_FLASH) or **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be one debug configuration for this project:

Configuration Name	Description
oc_pal_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
oc_pal_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

13.4.53 LPIT Periodic Interrupt

Driver example that will show the LPIT functionality

Application description

The purpose of this demo application is to show you how to use the Low Power Interrupt Timer from the S32K142W using the S32 SDK API.

- The example is configured to trigger an interrupt every second, which toggles a LED.

See also

For other LPIT usage scenario check: ADC_LOW_POWER_group

Prerequisites

To run the example you will need to have the following items:

- 1 Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- 1 Mother Board S32K-MB PCB RevA SCH RevB
- 1 Power Adapter 12V (if the board cannot be powered from the USB port)
- 1 Personal Computer
- 1 PEmicro Debugger
- XS32K14WEVB-Q064

Boards supported

The following boards are supported by this application:

- Daughter Card S32K14xCVD-Q64 PCB RevX2 SCH RevA1 with S32K142W
- Mother Board S32K-MB PCB RevA SCH RevB
- XS32K14WEVB-Q064

Hardware Wiring

The following connections must be done to for this example application to work:

PIN FUNCTION	S32K-MB	XS32K14WEVB-Q064
LED0	(PTC0) JP49.1 - JP49.2	(PTE0) wired on the board

How to run

1. Importing the project into the workspace

After opening S32 Design Studio, go to **File** -> **New S32DS Project From**... and select **lpit_periodic_interrupt_s32k142w**. Then click on **Finish**.
The project should now be copied into you current workspace.

2. Generating the S32 configuration

The example will run without an active configuration, however if any changes are required, a configuration needs to be generated. The initial configuration will have the same settings as the default example settings. First go to **Project Explorer** View in S32 DS and select the current project(**lpit_periodic_interrupt_s32k142w**). Select the "ConfigTools" menu then click on the desired configurator (Pins, Cocks, Peripherals etc...). Clicking on any one of those will generate all the components. Make the desired changes(if any) then click on the "ConfigTools->Update Code" button.

3. Building the project

Select the configuration to be built **RAM** (Debug_RAM) by left clicking on the downward arrow corresponding to the **build** button(. Wait for the build action to be completed before continuing to the next step.

4. Running the project

Go to **Run** and select **Debug Configurations**. There will be two debug configuration for this project:

Configuration Name	Description
lpit_periodic_interrupt_s32k142w_debug_ram_pemicro	Debug the RAM configuration using PEMicro debuggers
lpit_periodic_interrupt_s32k142w_debug_flash_pemicro	Debug the FLASH configuration using PEMicro debuggers

Select the desired debug configuration and click on **Launch**. Now the perspective will change to the **Debug Perspective**.
Use the controls to control the program flow.

Note

For more detailed information related to S32 Design Studio usage please consult the available documentation.

14 Module Index

14.1 Modules

Here is a list of all modules:

15 Data Structure Index

15.1 Data Structures

Here are the data structures with brief descriptions:

16 Module Documentation

16.1 ADC Driver

16.1.1 Detailed Description

Analog to Digital Converter Peripheral Driver.

The ADC is a configurable 12-bit (selectable to between 8-bit, 10-bit and 12-bit resolution) single-ended SA↩ R converter.

Features of the ADC include:

- up to 32 control channels (depending on the device variant), with configurable triggers

- up to 32 selectable external input sources (depending on the device variant) and multiple internal input sources
- hardware compare and average functions
- auto-calibration feature

Hardware background

The ADC included in the S32K14x series is a selectable resolution (8, 10, 12-bit), single-ended, SAR converter. Depending on the device variant, each ADC instance has up to 40 selectable input channels (up to 32 external and up to 8 internal) and up to 32 control channels (each with a result register, an input channel selection register and interrupt enable).

Sample time is configurable through selection of A/D clock and a configurable sample time (in A/D clocks).

Also provided are the Hardware Average and Hardware Compare Features.

Hardware Average will sample a selectable number of measurements and average them before signaling a Conversion Complete.

Hardware Compare can be used to signal if an input channel goes outside (or inside) of a predefined range.

The **Calibration** features can be used to automatically calibrate or fine-tune the ADC before use.

Driver consideration

The ADC Driver provides access to all features, but not all need to be configured to use the ADC. The user application can use the default for most settings, changing only what is necessary. For example, if Compare or Average features are not used, the user does not need to configure them.

The Driver uses structures for configuration. Each structure contains members that are specific to its respective functionality. There is a **converter** structure, a hardware **compare** structure, a hardware **average** structure and a **calibration** structure. Each struct has a corresponding `InitStruct()` method that can be used to initialize the members to reset values, so the user can change only the values that are specific to the application.

The Driver also includes support for configuring the Trigger Latching and Arbitration Unit controlled from a separate hardware module - System Integration Module (SIM).

Interrupt handling

The ADC Driver in S32 SDK does not use interrupts internally. These can be defined by the user application. There are two ways to add an ADC interrupt:

1. Using the weak symbols defined by start-up code. If the methods `ADC`**`x`**`_Handler(void)` (x denotes instance number) are not defined, the linker uses a default ISR. An error will be generated if methods with the same name are defined multiple times. This method works regardless of the placement of the interrupt vector table (Flash or RAM).
2. Using the Interrupt Manager's `INT_SYS_InstallHandler()` method. This can be used to dynamically change the ISR at run-time. This method works only if the interrupt vector table is located in RAM (S32 SDK behavior). To get the ADC instance's interrupt number, use `ADC_DRV_GetInterruptNumber()`.

Clocking and pin configuration

The ADC Driver does not handle clock setup (from PCC) or any kind of pin configuration (done by PORT module). This is handled by the Clock Manager and PORT module, respectively. The driver assumes that correct clock configurations have been made, so it is the user's responsibility to set up clocking and pin configurations correctly.

Triggering a conversion

There are two separate ways for triggering an ADC conversion from a control channel:

1. Software triggering Only conversion from first control channel may be triggered from software - must enabled

at converter configuration Initiated by writing a valid input channel ID to the first control channel - use ADC_DRV_ConfigChan().

2. Hardware triggering Conversion from any control channel may be hardware triggered - however for first control channel it must be enabled at converter configuration.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
* ${S32SDK_PATH}\platform\drivers\src\adc_driver.c
*
```

Include path

The following paths need to be added to the include path of the toolchain:

```
* ${S32SDK_PATH}\platform\drivers\inc\
*
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager

Data Structures

- struct adc_converter_config_t

  Defines the converter configuration. More...
- struct adc_compare_config_t

  Defines the hardware compare configuration. More...
- struct adc_average_config_t

  Defines the hardware average configuration. More...
- struct adc_chan_config_t

  Defines the control channel configuration. More...
- struct adc_calibration_t

  Defines the user calibration configuration. More...

Enumerations

- enum adc_clk_divide_t { ADC_CLK_DIVIDE_1 = 0x00U, ADC_CLK_DIVIDE_2 = 0x01U, ADC_CLK_DIVIDE_4 = 0x02U, ADC_CLK_DIVIDE_8 = 0x03U }

  Clock Divider selection.
- enum adc_resolution_t { ADC_RESOLUTION_8BIT = 0x00U, ADC_RESOLUTION_12BIT = 0x01U, ADC_RESOLUTION_10BIT = 0x02U }

  Conversion resolution selection.
- enum adc_input_clock_t { ADC_CLK_ALT_1 = 0x00U, ADC_CLK_ALT_2 = 0x01U, ADC_CLK_ALT_3 = 0x02U, ADC_CLK_ALT_4 = 0x03U }

  Input clock source selection.
- enum adc_trigger_t { ADC_TRIGGER_SOFTWARE = 0x00U, ADC_TRIGGER_HARDWARE = 0x01U }

  Trigger type selection.

- enum adc_pretrigger_sel_t { ADC_PRETRIGGER_SEL_PDB = 0x00U, ADC_PRETRIGGER_SEL_TRGMUX = 0x01U, ADC_PRETRIGGER_SEL_SW = 0x02U }

  Pretrigger types selectable from Trigger Latching and Arbitration Unit.
- enum adc_trigger_sel_t { ADC_TRIGGER_SEL_PDB = 0x00U, ADC_TRIGGER_SEL_TRGMUX = 0x01U }

  Trigger source selectable from Trigger Latching and Arbitration Unit.
- enum adc_sw_pretrigger_t { ADC_SW_PRETRIGGER_DISABLED = 0x00U, ADC_SW_PRETRIGGER_0 = 0x04U, ADC_SW_PRETRIGGER_1 = 0x05U, ADC_SW_PRETRIGGER_2 = 0x06U, ADC_SW_PRETRIGGER_3 = 0x07U }

  Software pretriggers which may be set from Trigger Latching and Arbitration Unit.
- enum adc_voltage_reference_t { ADC_VOLTAGEREF_VREF = 0x00U, ADC_VOLTAGEREF_VALT = 0x01U }

  Voltage reference selection.
- enum adc_average_t { ADC_AVERAGE_4 = 0x00U, ADC_AVERAGE_8 = 0x01U, ADC_AVERAGE_16 = 0x02U, ADC_AVERAGE_32 = 0x03U }

  Hardware average selection.
- enum adc_inputchannel_t { ADC_INPUTCHAN_EXT0 = 0x00U, ADC_INPUTCHAN_EXT1 = 0x01U, ADC_INPUTCHAN_EXT3 = 0x03U, ADC_INPUTCHAN_EXT4 = 0x04U, ADC_INPUTCHAN_EXT5 = 0x05U, ADC_INPUTCHAN_EXT6 = 0x06U, ADC_INPUTCHAN_EXT7 = 0x07U, ADC_INPUTCHAN_EXT9 = 0x09U, ADC_INPUTCHAN_EXT10 = 0x0AU, ADC_INPUTCHAN_EXT11 = 0x0BU, ADC_INPUTCHAN_EXT12 = 0x0CU, ADC_INPUTCHAN_EXT13 = 0x0DU, ADC_INPUTCHAN_EXT14 = 0x0EU, ADC_INPUTCHAN_DISABLED = ADC_SC1_ADCH_MASK, ADC_INPUTCHAN_INT0 = 0x15, ADC_INPUTCHAN_INT1 = 0x16, ADC_INPUTCHAN_INT2 = 0x17, ADC_INPUTCHAN_INT3 = 0x1C, ADC_INPUTCHAN_TEMP = 0x1A, ADC_INPUTCHAN_BANDGAP = 0x1B, ADC_INPUTCHAN_VREFSH = 0x1D, ADC_INPUTCHAN_VREFSL = 0x1E, ADC_INPUTCHAN_SUPPLY_VDD = 0xF00U, ADC_INPUTCHAN_SUPPLY_VDDA = 0xF01U, ADC_INPUTCHAN_SUPPLY_VREFH = 0xF02U, ADC_INPUTCHAN_SUPPLY_VDD_3V = 0xF03U, ADC_INPUTCHAN_SUPPLY_VDD_FLASH_3V = 0xF04U, ADC_INPUTCHAN_SUPPLY_VDD_LV = 0xF05U }

  Enumeration of input channels assignable to a control channel.
  ***Note 0**: entries in this enum are affected by ::FEATURE_ADC_NUM_EXT_CHANS, which is device dependent and controlled from "device_name"_features.h file.*
- enum adc_latch_clear_t { ADC_LATCH_CLEAR_WAIT, ADC_LATCH_CLEAR_FORCE }

  Defines the trigger latch clear method Implements : adc_latch_clear_t_Class.

Converter

Converter specific methods. These are used to configure and use the A/D Converter specific functionality, including:

- clock input and divider
- sample time in A/D clocks
- resolution
- trigger source
- voltage reference
- enable DMA
- enable continuous conversion on one channel

To start a conversion, a control channel (see Channel Configuration) and a trigger source must be configured. Once a conversion is started, the user application can wait for it to be finished by calling the ADC_DRV_WaitConvDone() function.

Only the first control channel can be triggered by software. To start a conversion in this case, an input channel must be written in the channel selection register using the ADC_DRV_ConfigChan() method. Writing a value to the control channel while a conversion is being performed on that channel will start a new conversion.

- void ADC_DRV_InitConverterStruct (adc_converter_config_t *const config)

  Initializes the converter configuration structure.
- void ADC_DRV_ConfigConverter (const uint32_t instance, const adc_converter_config_t *const config)

  Configures the converter with the given configuration structure.
- void ADC_DRV_GetConverterConfig (const uint32_t instance, adc_converter_config_t *const config)

  Gets the current converter configuration.
- void ADC_DRV_Reset (const uint32_t instance)

  Resets the converter (sets all configurations to reset values)
- void ADC_DRV_WaitConvDone (const uint32_t instance)

  Waits for a conversion/calibration to finish.
- bool ADC_DRV_GetConvCompleteFlag (const uint32_t instance, const uint8_t chanIndex)

  Gets the control channel Conversion Complete Flag state.

Hardware Compare

The Hardware Compare feature of the S32K144 ADC is a versatile mechanism that can be used to monitor that a value is within certain values. Measurements can be monitored to be within certain ranges:

- less than/ greater than a fixed value
- inside or outside of a certain range

Two compare values can be configured (the second value is used only for range function mode). The compare values must be written in 12-bit resolution mode regardless of the actual used resolution mode.

Once the hardware compare feature is enabled, a conversion is considered complete only when the measured value is within the allowable range set by the configuration.

- void ADC_DRV_InitHwCompareStruct (adc_compare_config_t *const config)

  Initializes the Hardware Compare configuration structure.
- void ADC_DRV_ConfigHwCompare (const uint32_t instance, const adc_compare_config_t *const config)

  Configures the Hardware Compare feature with the given configuration structure.
- void ADC_DRV_GetHwCompareConfig (const uint32_t instance, adc_compare_config_t *const config)

  Gets the current Hardware Compare configuration.

Hardware Average

The Hardware Average feature of the S32K144 allows for a set of measurements to be averaged together as a single conversion. The number of samples to be averaged is selectable (4, 8, 16 or 32 samples).

- void ADC_DRV_InitHwAverageStruct (adc_average_config_t *const config)

  Initializes the Hardware Average configuration structure.
- void ADC_DRV_ConfigHwAverage (const uint32_t instance, const adc_average_config_t *const config)

  Configures the Hardware Average feature with the given configuration structure.
- void ADC_DRV_GetHwAverageConfig (const uint32_t instance, adc_average_config_t *const config)

  Gets the current Hardware Average configuration.

Channel configuration

Control register specific functions. These functions control configurations for each control channel (input channel selection and interrupt enable).

When software triggering is enabled, calling the ADC_DRV_ConfigChan() method for control channel 0 starts a new conversion.

After a conversion is finished, the result can be retrieved using the ADC_DRV_GetChanResult() method.

- void ADC_DRV_InitChanStruct (adc_chan_config_t *const config)

  Initializes the control channel configuration structure.
- void ADC_DRV_ConfigChan (const uint32_t instance, const uint8_t chanIndex, const adc_chan_config_t *const config)

  Configures the selected control channel with the given configuration structure.
- void ADC_DRV_GetChanConfig (const uint32_t instance, const uint8_t chanIndex, adc_chan_config_t *const config)

  Gets the current control channel configuration for the selected channel index.
- void ADC_DRV_SetSwPretrigger (const uint32_t instance, const adc_sw_pretrigger_t swPretrigger)

  This function sets the software pretrigger - affects only first 4 control channels.
- void ADC_DRV_GetChanResult (const uint32_t instance, const uint8_t chanIndex, uint16_t *const result)

  Gets the last result for the selected control channel.

Automatic Calibration

These methods control the Calibration feature of the ADC.

The ADC_DRV_AutoCalibration() method can be called to execute a calibration sequence, or a calibration can be retrieved with the ADC_DRV_GetUserCalibration() and saved to non-volatile storage, to avoid calibration on every power-on. The calibration structure can be written with the ADC_DRV_ConfigUserCalibration() method.

- void ADC_DRV_AutoCalibration (const uint32_t instance)

  Executes an Auto-Calibration.
- void ADC_DRV_InitUserCalibrationStruct (adc_calibration_t *const config)

  Initializes the User Calibration configuration structure.
- void ADC_DRV_ConfigUserCalibration (const uint32_t instance, const adc_calibration_t *const config)

  Configures the User Calibration feature with the given configuration structure.
- void ADC_DRV_GetUserCalibration (const uint32_t instance, adc_calibration_t *const config)

  Gets the current User Calibration configuration.

Interrupts

This method returns the interrupt number for an ADC instance, which can be used to configure the interrupt, like in Interrupt Manager.

- IRQn_Type ADC_DRV_GetInterruptNumber (const uint32_t instance)

  Returns the interrupt number for the ADC instance.

Latched triggers processing

These functions provide basic operations for using the trigger latch mechanism.

- void ADC_DRV_ClearLatchedTriggers (const uint32_t instance, const adc_latch_clear_t clearMode)

  Clear latched triggers under processing.

- void ADC_DRV_ClearTriggerErrors (const uint32_t instance)

  Clear all latch trigger error.
- uint32_t ADC_DRV_GetTriggerErrorFlags (const uint32_t instance)

  Get the trigger error flags bits of the ADC instance.

16.1.2 Data Structure Documentation

16.1.2.1 struct adc_converter_config_t

Defines the converter configuration.

This structure is used to configure the ADC converter

Implements : adc_converter_config_t_Class

Definition at line 249 of file adc_driver.h.

Data Fields

- adc_clk_divide_t clockDivide
- uint8_t sampleTime
- adc_resolution_t resolution
- adc_input_clock_t inputClock
- adc_trigger_t trigger
- adc_pretrigger_sel_t pretriggerSel
- adc_trigger_sel_t triggerSel
- bool dmaEnable
- adc_voltage_reference_t voltageRef
- bool continuousConvEnable
- bool supplyMonitoringEnable

Field Documentation

16.1.2.1.1 adc_clk_divide_t clockDivide

Divider of the input clock for the ADC

Definition at line 251 of file adc_driver.h.

16.1.2.1.2 bool continuousConvEnable

Enable Continuous conversions

Definition at line 260 of file adc_driver.h.

16.1.2.1.3 bool dmaEnable

Enable DMA for the ADC

Definition at line 258 of file adc_driver.h.

16.1.2.1.4 adc_input_clock_t inputClock

Input clock source

Definition at line 254 of file adc_driver.h.

16.1.2.1.5 adc_pretrigger_sel_t pretriggerSel

Pretrigger source selected from Trigger Latching and Arbitration Unit - affects only the first 4 control channels

Definition at line 256 of file adc_driver.h.

16.1.2.1.6 adc_resolution_t resolution

ADC resolution (8,10,12 bit)

Definition at line 253 of file adc_driver.h.

16.1.2.1.7 uint8_t sampleTime

Sample time in AD Clocks

Definition at line 252 of file adc_driver.h.

16.1.2.1.8 bool supplyMonitoringEnable

Only available for ADC 0. Enable internal supply monitoring - enables measurement of ADC_INPUTCHAN_SUP↩ PLY_ sources.

Definition at line 261 of file adc_driver.h.

16.1.2.1.9 adc_trigger_t trigger

ADC trigger type (software, hardware) - affects only the first control channel

Definition at line 255 of file adc_driver.h.

16.1.2.1.10 adc_trigger_sel_t triggerSel

Trigger source selected from Trigger Latching and Arbitration Unit

Definition at line 257 of file adc_driver.h.

16.1.2.1.11 adc_voltage_reference_t voltageRef

Voltage reference used

Definition at line 259 of file adc_driver.h.

16.1.2.2 struct adc_compare_config_t

Defines the hardware compare configuration.

This structure is used to configure the hardware compare feature for the ADC

Implements : adc_compare_config_t_Class

Definition at line 272 of file adc_driver.h.

Data Fields

- bool compareEnable
- bool compareGreaterThanEnable
- bool compareRangeFuncEnable
- uint16_t compVal1
- uint16_t compVal2

Field Documentation

16.1.2.2.1 bool compareEnable

Enable the compare feature

Definition at line 274 of file adc_driver.h.

16.1.2.2.2 bool compareGreaterThanEnable

Enable Greater-Than functionality

Definition at line 275 of file adc_driver.h.

16.1.2.2.3 bool compareRangeFuncEnable

Enable Range functionality

Definition at line 276 of file adc_driver.h.

16.1.2.2.4 uint16_t compVal1

First Compare Value

Definition at line 277 of file adc_driver.h.

16.1.2.2.5 uint16_t compVal2

Second Compare Value

Definition at line 278 of file adc_driver.h.

16.1.2.3 struct adc_average_config_t

Defines the hardware average configuration.

This structure is used to configure the hardware average feature for the ADC

Implements : adc_average_config_t_Class

Definition at line 289 of file adc_driver.h.

Data Fields

- bool hwAvgEnable
- adc_average_t hwAverage

Field Documentation

16.1.2.3.1 adc_average_t hwAverage

Selection for number of samples used for averaging

Definition at line 292 of file adc_driver.h.

16.1.2.3.2 bool hwAvgEnable

Enable averaging functionality

Definition at line 291 of file adc_driver.h.

16.1.2.4 struct adc_chan_config_t

Defines the control channel configuration.

This structure is used to configure a control channel of the ADC

Implements : adc_chan_config_t_Class

Definition at line 303 of file adc_driver.h.

Data Fields

- bool interruptEnable
- adc_inputchannel_t channel

Field Documentation

16.1.2.4.1 adc_inputchannel_t channel

Selection of input channel for measurement

Definition at line 306 of file adc_driver.h.

16.1.2.4.2 bool interruptEnable

Enable interrupts for this channel

Definition at line 305 of file adc_driver.h.

16.1.2.5 struct adc_calibration_t

Defines the user calibration configuration.

This structure is used to configure the user calibration parameters of the ADC.

Implements : adc_calibration_t_Class

Definition at line 317 of file adc_driver.h.

Data Fields

- uint16_t userGain
- uint16_t userOffset

Field Documentation

16.1.2.5.1 uint16_t userGain

User-configurable gain

Definition at line 319 of file adc_driver.h.

16.1.2.5.2 uint16_t userOffset

User-configurable Offset (2's complement, subtracted from result)

Definition at line 320 of file adc_driver.h.

16.1.3 Enumeration Type Documentation

16.1.3.1 enum adc_average_t

Hardware average selection.

Implements : adc_average_t_Class

Enumerator

ADC_AVERAGE_4 Hardware average of 4 samples.

ADC_AVERAGE_8 Hardware average of 8 samples.

ADC_AVERAGE_16 Hardware average of 16 samples.

ADC_AVERAGE_32 Hardware average of 32 samples.

Definition at line 154 of file adc_driver.h.

16.1.3.2 enum adc_clk_divide_t

Clock Divider selection.

Implements : adc_clk_divide_t_Class

Enumerator

ADC_CLK_DIVIDE_1 Input clock divided by 1.

ADC_CLK_DIVIDE_2 Input clock divided by 2.

ADC_CLK_DIVIDE_4 Input clock divided by 4.

ADC_CLK_DIVIDE_8 Input clock divided by 8.

Definition at line 57 of file adc_driver.h.

16.1.3.3 enum adc_input_clock_t

Input clock source selection.

Implements : adc_input_clock_t_Class

Enumerator

ADC_CLK_ALT_1 Input clock alternative 1.

ADC_CLK_ALT_2 Input clock alternative 2.

ADC_CLK_ALT_3 Input clock alternative 3.

ADC_CLK_ALT_4 Input clock alternative 4.

Definition at line 82 of file adc_driver.h.

16.1.3.4 enum adc_inputchannel_t

Enumeration of input channels assignable to a control channel.
Note 0: entries in this enum are affected by ::FEATURE_ADC_NUM_EXT_CHANS, which is device dependent and controlled from *"device_name"_features.h* file.

Note 1: the actual number of external channels may differ between device packages and ADC instances. Reading a channel that is not connected externally, will return a random value within the range. Please refer to the Reference Manual for the maximum number of external channels for each device variant and ADC instance.

Note 2: ADC_INPUTCHAN_SUPPLY_ select which internal supply channel to be measured. They are only available for ADC0 and measured internally via internal input channel 0. Please note that supply monitoring needs to be enabled separately via dedicated flag in adc_converter_config_t.

Implements : adc_inputchannel_t_Class

Enumerator

ADC_INPUTCHAN_EXT0 External input channel 0

ADC_INPUTCHAN_EXT1 External input channel 1

ADC_INPUTCHAN_EXT3 External input channel 3

ADC_INPUTCHAN_EXT4 External input channel 4

ADC_INPUTCHAN_EXT5 External input channel 5

ADC_INPUTCHAN_EXT6 External input channel 6

ADC_INPUTCHAN_EXT7 External input channel 7

ADC_INPUTCHAN_EXT9 External input channel 9

ADC_INPUTCHAN_EXT10 External input channel 10

ADC_INPUTCHAN_EXT11 External input channel 11

ADC_INPUTCHAN_EXT12 External input channel 12

ADC_INPUTCHAN_EXT13 External input channel 13

ADC_INPUTCHAN_EXT14 External input channel 14

ADC_INPUTCHAN_DISABLED Channel disabled
ADC_INPUTCHAN_INT0 Internal input channel 0
ADC_INPUTCHAN_INT1 Internal input channel 1
ADC_INPUTCHAN_INT2 Internal input channel 2
ADC_INPUTCHAN_INT3 Internal input channel 3
ADC_INPUTCHAN_TEMP Temperature Sensor
ADC_INPUTCHAN_BANDGAP Band Gap
ADC_INPUTCHAN_VREFSH Voltage Reference Select High
ADC_INPUTCHAN_VREFSL Voltage Reference Select Low
ADC_INPUTCHAN_SUPPLY_VDD Monitor internal supply 5 V input VDD supply.
ADC_INPUTCHAN_SUPPLY_VDDA Monitor internal supply 5 V input analog supply.
ADC_INPUTCHAN_SUPPLY_VREFH Monitor internal supply ADC reference supply.
ADC_INPUTCHAN_SUPPLY_VDD_3V Monitor internal supply 3.3 V oscillator regulator output.
ADC_INPUTCHAN_SUPPLY_VDD_FLASH_3V Monitor internal supply 3.3 V flash regulator output.
ADC_INPUTCHAN_SUPPLY_VDD_LV Monitor internal supply 1.2 V core regulator output.

Definition at line 177 of file adc_driver.h.

16.1.3.5 enum adc_latch_clear_t

Defines the trigger latch clear method Implements : adc_latch_clear_t_Class.

Enumerator

ADC_LATCH_CLEAR_WAIT Clear by waiting all latched triggers to be processed
ADC_LATCH_CLEAR_FORCE Process current trigger and clear all latched

Definition at line 327 of file adc_driver.h.

16.1.3.6 enum adc_pretrigger_sel_t

Pretrigger types selectable from Trigger Latching and Arbitration Unit.

Implements : adc_pretrigger_sel_t_Class

Enumerator

ADC_PRETRIGGER_SEL_PDB PDB pretrigger selected.
ADC_PRETRIGGER_SEL_TRGMUX TRGMUX pretrigger selected.
ADC_PRETRIGGER_SEL_SW Software pretrigger selected.

Definition at line 106 of file adc_driver.h.

16.1.3.7 enum adc_resolution_t

Conversion resolution selection.

Implements : adc_resolution_t_Class

Enumerator

ADC_RESOLUTION_8BIT 8-bit resolution mode
ADC_RESOLUTION_12BIT 12-bit resolution mode
ADC_RESOLUTION_10BIT 10-bit resolution mode

Definition at line 70 of file adc_driver.h.

16.1.3.8 enum adc_sw_pretrigger_t

Software pretriggers which may be set from Trigger Latching and Arbitration Unit.

Implements : adc_sw_pretrigger_t_Class

Enumerator

ADC_SW_PRETRIGGER_DISABLED SW pretrigger disabled.
ADC_SW_PRETRIGGER_0 SW pretrigger 0.
ADC_SW_PRETRIGGER_1 SW pretrigger 1.
ADC_SW_PRETRIGGER_2 SW pretrigger 2.
ADC_SW_PRETRIGGER_3 SW pretrigger 3.

Definition at line 129 of file adc_driver.h.

16.1.3.9 enum adc_trigger_sel_t

Trigger source selectable from Trigger Latching and Arbitration Unit.

Implements : adc_trigger_sel_t_Class

Enumerator

ADC_TRIGGER_SEL_PDB PDB trigger selected.
ADC_TRIGGER_SEL_TRGMUX TRGMUX trigger selected.

Definition at line 118 of file adc_driver.h.

16.1.3.10 enum adc_trigger_t

Trigger type selection.

Implements : adc_trigger_t_Class

Enumerator

ADC_TRIGGER_SOFTWARE Software trigger.
ADC_TRIGGER_HARDWARE Hardware trigger.

Definition at line 95 of file adc_driver.h.

16.1.3.11 enum adc_voltage_reference_t

Voltage reference selection.

Implements : adc_voltage_reference_t_Class

Enumerator

ADC_VOLTAGEREF_VREF VrefH and VrefL as Voltage reference.
ADC_VOLTAGEREF_VALT ValtH and ValtL as Voltage reference.

Definition at line 143 of file adc_driver.h.

16.1.4 Function Documentation

16.1.4.1 void ADC_DRV_AutoCalibration (const uint32_t *instance*)

Executes an Auto-Calibration.

This functions executes an Auto-Calibration sequence. It is recommended to run this sequence before using the ADC converter.

Parameters

in	*instance*	instance number

Definition at line 555 of file adc_driver.c.

16.1.4.2 void ADC_DRV_ClearLatchedTriggers (const uint32_t *instance*, const adc_latch_clear_t *clearMode*)

Clear latched triggers under processing.

This function clears all trigger latched flags of the ADC instance. This function must be called after the hardware trigger source for the ADC has been deactivated.

Parameters

in	*instance*	instance number of the ADC
in	*clearMode*	The clearing method for the latched triggers • ADC_LATCH_CLEAR_WAIT : Wait for all latched triggers to be processed. • ADC_LATCH_CLEAR_FORCE : Clear latched triggers and wait for trigger being process to finish.

Definition at line 712 of file adc_driver.c.

16.1.4.3 void ADC_DRV_ClearTriggerErrors (const uint32_t *instance*)

Clear all latch trigger error.

This function clears all trigger error flags of the ADC instance.

Parameters

in	*instance*	instance number of the ADC

Definition at line 737 of file adc_driver.c.

16.1.4.4 void ADC_DRV_ConfigChan (const uint32_t *instance*, const uint8_t *chanIndex*, const adc_chan_config_t *const *config*)

Configures the selected control channel with the given configuration structure.

When Software Trigger mode is enabled, configuring control channel index 0, implicitly triggers a new conversion on the selected ADC input channel. Therefore, ADC_DRV_ConfigChan can be used for sw-triggering conversions.

Configuring any control channel while it is actively controlling a conversion (sw or hw triggered) will implicitly abort the on-going conversion.

Parameters

in	*instance*	instance number
in	*chanIndex*	the control channel index
in	*config*	the configuration structure

Definition at line 381 of file adc_driver.c.

16.1.4.5 void ADC_DRV_ConfigConverter (const uint32_t *instance*, const adc_converter_config_t *const *config*)

Configures the converter with the given configuration structure.

This function configures the ADC converter with the options provided in the provided structure.

Parameters

in	*instance*	instance number
in	*config*	the configuration structure

Definition at line 94 of file adc_driver.c.

16.1.4.6 void ADC_DRV_ConfigHwAverage (const uint32_t *instance*, const adc_average_config_t *const *config*)

Configures the Hardware Average feature with the given configuration structure.

This function sets the configuration for the Hardware Average feature.

Parameters

in	*instance*	instance number
in	*config*	the configuration structure

Definition at line 318 of file adc_driver.c.

16.1.4.7 void ADC_DRV_ConfigHwCompare (const uint32_t *instance*, const adc_compare_config_t *const *config*)

Configures the Hardware Compare feature with the given configuration structure.

This functions sets the configuration for the Hardware Compare feature using the configuration structure.

Parameters

in	*instance*	instance number
in	*config*	the configuration structure

Definition at line 255 of file adc_driver.c.

16.1.4.8 void ADC_DRV_ConfigUserCalibration (const uint32_t *instance*, const adc_calibration_t *const *config*)

Configures the User Calibration feature with the given configuration structure.

This function sets the configuration for the user calibration registers.

Parameters

in	*instance*	instance number
in	*config*	the configuration structure

Definition at line 658 of file adc_driver.c.

16.1.4.9 void ADC_DRV_GetChanConfig (const uint32_t *instance*, const uint8_t *chanIndex*, adc_chan_config_t *const *config*)

Gets the current control channel configuration for the selected channel index.

This function returns the configuration for a control channel

Parameters

in	*instance*	instance number
in	*chanIndex*	the control channel index
out	*config*	the configuration structure

Definition at line 406 of file adc_driver.c.

16.1.4.10 void ADC_DRV_GetChanResult (const uint32_t *instance*, const uint8_t *chanIndex*, uint16_t *const *result*)

Gets the last result for the selected control channel.

This function returns the conversion result from a control channel.

Parameters

in	*instance*	instance number
in	*chanIndex*	the converter control channel index
out	*result*	the result raw value

Definition at line 517 of file adc_driver.c.

16.1.4.11 bool ADC_DRV_GetConvCompleteFlag (const uint32_t *instance*, const uint8_t *chanIndex*)

Gets the control channel Conversion Complete Flag state.

This function returns the state of the Conversion Complete flag for a control channel. This flag is set when a conversion is complete or the condition generated by the Hardware Compare feature is evaluated to true.

Parameters

in	*instance*	instance number
in	*chanIndex*	the adc control channel index

Returns

the Conversion Complete Flag state

Definition at line 490 of file adc_driver.c.

16.1.4.12 void ADC_DRV_GetConverterConfig (const uint32_t *instance*, adc_converter_config_t *const *config*)

Gets the current converter configuration.

This functions returns the configuration for converter in the form of a configuration structure.

Parameters

in	*instance*	instance number
out	*config*	the configuration structure

Definition at line 140 of file adc_driver.c.

16.1.4.13 void ADC_DRV_GetHwAverageConfig (const uint32_t *instance*, adc_average_config_t *const *config*)

Gets the current Hardware Average configuration.

This function returns the configuration for the Hardware Average feature.

Parameters

in	*instance*	instance number
out	*config*	the configuration structure

Definition at line 337 of file adc_driver.c.

16.1.4.14 void ADC_DRV_GetHwCompareConfig (const uint32_t *instance*, adc_compare_config_t *const *config*)

Gets the current Hardware Compare configuration.

This function returns the configuration for the Hardware Compare feature.

Parameters

in	*instance*	instance number
out	*config*	the configuration structure

Definition at line 277 of file adc_driver.c.

16.1.4.15 IRQn_Type ADC_DRV_GetInterruptNumber (const uint32_t *instance*)

Returns the interrupt number for the ADC instance.

This function returns the interrupt number for the specified ADC instance.

Parameters

in	*instance*	instance number of the ADC

Returns

irq_number: the interrupt number (index) of the ADC instance, used to configure the interrupt

Definition at line 695 of file adc_driver.c.

16.1.4.16 uint32_t ADC_DRV_GetTriggerErrorFlags (const uint32_t *instance*)

Get the trigger error flags bits of the ADC instance.

This function returns the trigger error flags bits of the ADC instance.

Parameters

in	*instance*	instance number of the ADC

Returns

trigErrorFlags The Trigger Error Flags bit-mask

Definition at line 753 of file adc_driver.c.

16.1.4.17 void ADC_DRV_GetUserCalibration (const uint32_t *instance*, adc_calibration_t *const *config*)

Gets the current User Calibration configuration.

This function returns the current user calibration register values.

Parameters

in	*instance*	instance number
out	*config*	the configuration structure

Definition at line 677 of file adc_driver.c.

16.1.4.18 void ADC_DRV_InitChanStruct (adc_chan_config_t *const *config*)

Initializes the control channel configuration structure.

This function initializes the control channel configuration structure to default values (Reference Manual resets). This function should be called on a structure before using it to configure a channel (ADC_DRV_ConfigChan), otherwise all members must be written by the caller. This function insures that all members are written with safe values, so the user can modify only the desired members.

Parameters

out	*config*	the configuration structure

Definition at line 359 of file adc_driver.c.

16.1.4.19 void ADC_DRV_InitConverterStruct (adc_converter_config_t *const *config*)

Initializes the converter configuration structure.

This function initializes the members of the adc_converter_config_t structure to default values (Reference Manual resets). This function should be called on a structure before using it to configure the converter with ADC_DRV↩

_ConfigConverter(), otherwise all members must be written (initialized) by the user. This function insures that all members are written with safe values, so the user can modify only the desired members.

Parameters

out	*config*	the configuration structure

Definition at line 69 of file adc_driver.c.

16.1.4.20 void ADC_DRV_InitHwAverageStruct (adc_average_config_t *const *config*)

Initializes the Hardware Average configuration structure.

This function initializes the Hardware Average configuration structure to default values (Reference Manual resets). This function should be called before configuring the Hardware Average feature (ADC_DRV_ConfigHwAverage), otherwise all members must be written by the caller. This function insures that all members are written with safe values, so the user can modify the desired members.

Parameters

out	*config*	the configuration structure

Definition at line 302 of file adc_driver.c.

16.1.4.21 void ADC_DRV_InitHwCompareStruct (adc_compare_config_t *const *config*)

Initializes the Hardware Compare configuration structure.

This function initializes the Hardware Compare configuration structure to default values (Reference Manual resets). This function should be called before configuring the Hardware Compare feature (ADC_DRV_ConfigHwCompare), otherwise all members must be written by the caller. This function insures that all members are written with safe values, so the user can modify the desired members.

Parameters

out	*config*	the configuration structure

Definition at line 236 of file adc_driver.c.

16.1.4.22 void ADC_DRV_InitUserCalibrationStruct (adc_calibration_t *const *config*)

Initializes the User Calibration configuration structure.

This function initializes the User Calibration configuration structure to default values (Reference Manual resets). This function should be called on a structure before using it to configure the User Calibration feature (ADC_DRV_↩ ConfigUserCalibration), otherwise all members must be written by the caller. This function insures that all members are written with safe values, so the user can modify only the desired members. this function will check and reset clock divide based the adc frequency. an error will be displayed if frequency is greater than required clock for calibration.

Parameters

out	*config*	the configuration structure

Definition at line 642 of file adc_driver.c.

16.1.4.23 void ADC_DRV_Reset (const uint32_t *instance*)

Resets the converter (sets all configurations to reset values)

This function resets all the internal ADC registers to reset values.

Parameters

in	*instance*	instance number

Definition at line 178 of file adc_driver.c.

16.1.4.24 void ADC_DRV_SetSwPretrigger (const uint32_t *instance,* const adc_sw_pretrigger_t *swPretrigger*)

This function sets the software pretrigger - affects only first 4 control channels.

Parameters

in	*instance*	instance number
in	*swPretrigger*	the swPretrigger to be enabled

Definition at line 426 of file adc_driver.c.

16.1.4.25 void ADC_DRV_WaitConvDone (const uint32_t *instance*)

Waits for a conversion/calibration to finish.

This functions waits for a conversion to complete by continuously polling the Conversion Active Flag.

Parameters

in	*instance*	instance number

Definition at line 470 of file adc_driver.c.

16.2 Analog to Digital Converter - Peripheral Abstraction Layer (ADC PAL)

16.2.1 Detailed Description

Analog to Digital Converter - Peripheral Abstraction Layer (ADC PAL).

ADC PAL general consideration

The ADC PAL is an interface abstraction layer for multiple Analog to Digital Converter peripherals.
The ADC PAL allows configuration of groups of successive conversions started by a single trigger event.
Each conversion in a group is mapped to an ADC input channel - the **conversion group** is actually defined by an array of input channels, which is a member of the adc_group_config_t structure. The order of the input channels will also give the order of execution of the conversions within the group.
Note: all conversion groups need to be configured at PAL initialization time.

The trigger event for a group can be SW or HW, and needs to be selected at configuration time.

1. Execution of **SW triggered groups** may be started/stopped by calling a dedicated function ADC_StartGroupConversion(), ADC_StopGroupConversion().
2. **HW triggered groups** need to be enabled for execution by calling a dedicated function - the actual execution will be started by the occurrence of the selected hardware trigger event ADC_EnableHardwareTrigger(), ADC_DisableHardwareTrigger().
   Note: for HW triggered groups the ADC PAL does not configure the peripherals which provide the triggering events (timers, counters, etc.) - they will need to be configured separately by the ADC PAL user.

Each group needs to have associated a **result buffer** which needs to be allocated by the PAL user. The length of the result buffer is defined by two configuration parameters:
∗ *numChannels* - defines also the size of the inputChannelArray
∗ *numSetsResultBuffer* - defines the number of sets of results which can be stored in the result buffer.
The *length of the result buffer = numChannels ∗ numSetsResultBuffer*. Each time a group of conversions finishes execution, a set of results for all conversions in the group will be copied by the PAL into the corresponding result buffer. The PAL considers the result buffer as circular, with the length configured via previously described.

On some platforms, HW triggered groups may support **delay(s)** between the occurrence of the HW trigger event and the actual start of conversions. This feature can be controlled for each HW triggered group via *delayType* and *delayArray* parameters in adc_group_config_t. For SW triggered groups, these parameters are ignored. For details please refer to ADC PAL platform specific information.

Each group can also have associated a **notification callback** which will be executed when all conversions finish execution. The callback shall receive as parameter a pointer to adc_callback_info_t containing the *group index* for which the notification is called, and *result buffer tail* - offset of the most recent conversion result in the result buffer. Notifications can be enabled and disabled using ADC_EnableNotification() and ADC_DisableNotification(). By default the notification is set to active when enabling a HW triggered group or starting a SW triggered group.
Note: The notification callback may be set to NULL and thus it will not be called.

For SW triggered groups, **continuous mode** can be enabled at configuration time.
E.g.: a group with 3 conversions *InputCh0, InputCh1, InputCh2* -> with continuous mode enabled will continuously repeat the series of conversions until it is stopped: *InputCh0, InputCh1, InputCh2, InputCh0, InputCh1, InputCh2,...*
The user needs to dimension accordingly the result buffer, such that it has sufficient time to read the results before they are overwritten.
For HW triggered groups, continuous mode parameter is not available.

The ADC PAL implicitly configures and uses other peripherals besides ADC - these resources should not be used simultaneously from other parts of the application. For details please refer to the platform specific details.

The ADC PAL module needs to include a configuration file named adc_pal_cfg.h, which defines which IPs are used.

The ADC PAL allows configuration of platform specific parameters via a pointer to a platform specific structure, following the naming convention: extension_adc_<platform>_t. E.g.: extension_adc_s32k1xx_t

Important note

The ADC PAL configuration structure passed via reference to ADC_Init(), including all arrays referenced by structure members, must be persistent throughout the usage of the ADC PAL. Storing them to memory sections which get freed or altered during ADC PAL usage, will lead to unpredictable behavior.

Platform specific details

S32K1xx device family

On these platforms, each instance of ADC PAL uses:

- one instance of PDB linked to the selected ADC (ADCn - PDBn) - used for both SW and HW triggered groups
- the TRGMUX_TARGET_MODULE_PDBn_TRG_IN targets from TRGMUX - used only for HW triggered groups

These platforms are supported by the ADC PAL of type **ADC_PAL_S32K1xx**.

Important details:

1. The PAL supports configuring any number of conversion groups at PAL initialization time, but every time a HW/SW triggered group is enabled/started, the underlying hardware peripherals are reconfigured.
2. The same input channel may appear multiple times in a group.

Group delay support:

- no delay between HW trigger event and conversions start:
  delayType = ADC_DELAY_TYPE_NO_DELAY and *delayArray* = NULL
- group delay between HW trigger event and the start of the first conversion in the group - the rest of conversions start right after the previous one
  delayType = ADC_DELAY_TYPE_GROUP_DELAY and *delayArray* set to point to a single uint16_t variable storing the delay value, expressed in PDB ticks (affected by PDB prescaler configurable via config extension)
- individual delays between HW trigger event and the start of each conversion in the group *delayType* = ADC↩_DELAY_TYPE_INDIVIDUAL_DELAY and *delayArray* set to point to an uin16_t array with length equal with the number of conversions in the group
  Delays are expressed in PDB ticks (affected by PDB prescaler configurable via config extension). Delay values are measured relative to the trigger event. When a delay expires, a PDB pretrigger is issued.
  Note: the pretriggers must not occur while another conversion in the group is running, otherwise the ADC freezes. It is the user's responsibility to make sure they do not overlap, i.e. delayN_plus_1 $>$ (delayN + conversion_duration).

MPC5746C and MPC5748G device families

On these platforms, each instance of ADC PAL uses:

- one instance of BCTU - used only for HW triggered groups
- all ADC instances connected to the selected BCTU instance. Please note that the ADC instances may have different resolutions

These platforms are supported by the ADC PAL of type **ADC_PAL_MPC574xC_G_R**.

Group delay support:

- groups do not support delays, so in adc_group_config_t structures *delayType* must be set to ADC_DELAY↩ _TYPE_NO_DELAY and *delayArray* to NULL, in adc_group_config_t.

Important details:

1. The PAL supports any number of **SW triggered** conversion groups at PAL initialization time. SW triggered groups will be configured directly in ADC, each time ADC_StartGroupConversion() is called.
2. The maximum supported number of **HW triggered** conversion groups is expressed in two steps:
   - for groups which include a minimum of 2 conversions: the total number of conversions within all these groups shall be less than or equal with the number of BCTU LIST HW registers. (E.g. 1 group of 8 conversions & 1 group of 24 conversions: 8 + 24 <= 32)
   - for groups which include a single conversion: the total number of such groups shall be less than or equal with the total number of BCTU Triggers minus the number of configured groups with at least 2 conversions
3. An input channel may only appear once in the group, otherwise the last conversion result will appear for each occurrence of the channel index in the group. This is a platform limitation: BCTU has only a single result register per ADC instance, and the ADC has a single result register per channel.
4. A conversion group (SW and HW triggered) can target only conversions on a single ADC instance.
5. The same trigger source cannot be assigned to multiple HW triggered groups.
6. Multiple HW triggered groups may be enabled simultaneously.
   However, the user must make sure that the actual HW trigger events do not occur simultaneously and that conversions from multiple groups do not overlap in time. Otherwise hardware errors may occur and results may be overwritten.

MPC574xP and S32Rx7x device families

On these platforms, each instance of ADC PAL uses:

- one instance of CTU - used only for HW triggered groups and statically configured to CTU triggered mode
- all ADC instances connected to the selected CTU instance

These platforms are supported by the ADC PAL of type **ADC_PAL_SAR_CTU**.

Group delay support:

- no delay between HW trigger event and conversions start:
  delayType = ADC_DELAY_TYPE_NO_DELAY and *delayArray* = NULL
- group delay between HW trigger event and the start of the first conversion in the group - the rest of conversions start right after the previous one
  delayType = ADC_DELAY_TYPE_GROUP_DELAY and *delayArray* set to point to a single uint16_t variable storing the delay value, expressed in CTU ticks (affected by CTU prescaler)

Important details:

1. The PAL supports any number of **SW triggered** conversion groups at PAL initialization time. SW triggered groups will be configured directly in ADC, each time ADC_StartGroupConversion() is called.
2. The maximum supported number of **HW triggered** conversion groups is equal with the number of CTU result FIFOs - defined in platform header file as CTU_FR_COUNT. The total number of conversions in all HW triggered groups must be <= the length of the CTU ADC command list - defined in platform header file as CTU_CHANNEL_COUNT.

3. A conversion group (SW and HW triggered) can target only conversions on a single ADC instance.
4. An input channel may only appear once in a SW triggered group, otherwise the last conversion result will appear for each occurrence of the channel index in the group. This is a platform limitation: the ADC has a single result register per channel. For HW triggered groups this restriction doesn't apply.
5. All HW triggered groups can be enabled simultaneously.
   However, the user must make sure that the actual HW trigger events do not occur simultaneously and that conversions from multiple groups do not overlap in time. Otherwise hardware errors may occur and results may be overwritten.
6. Each HW triggered group has assigned a CTU result FIFO. The number of channels in each group must be less than the CTU result FIFO length - note that not all FIFOs have the same length. FIFOs are assigned in the same order in which the HW triggered groups are configured in the PAL init state: FIFO#0 assigned to first group, FIFO#1 to second, etc.
7. The trigger sources enabled for a group can implicitly start also the rest of the enabled HW triggered groups. E.g. SourceX configured for group0, sourceY configured for group1. If both groups are enabled, when event from sourceX occurs, both group0 and group1 will execute; the same when event from sourceY occurs.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\pal\src\adc\adc_pal.c
${S32SDK_PATH}\platform\pal\src\adc\adc_irq.c
```

Additionally, it is required to compile also the .c files from the dependencies listed for each ADC PAL type (please see Dependencies subsection below).

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\pal\inc\
${S32SDK_PATH}\platform\drivers\inc\
```

An additional file, named *adc_pal_cfg.h*, must be created by the user and added to one of the include paths. The user has to add to the file the definitions of preprocessor symbols according to the ADC PAL type used. These symbols are specified in the next subsection.
When using the S32 SDK configuration tool, the file is generated by the configurator.

The pal type ADC_PAL_S32K1xx also requires:

```
${S32SDK_PATH}\platform\drivers\src\adc\
```

Compile symbols

1. Define for selecting one of the ADC PAL type to be used:

   ```
   ADC_PAL_S32K1xx
   ADC_PAL_MPC574xC_G_R
   ADC_PAL_SAR_CTU
   ```

2. Define the maximum number of HW triggered groups which may be enabled simultaneously. For ADC_PA↩ L_S32K1xx the maximum value of the define is 1.

   ```
   ADC_PAL_MAX_NUM_HW_GROUPS_EN
   ```

3. For ADC_PAL_MPC574xC_G_R and ADC_PAL_SAR_CTU types, define the total number of configured groups.

   ```
   ADC_PAL_TOTAL_NUM_GROUPS
   ```

Dependencies

Interrupt Manager (Interrupt)
OS Interface (OSIF)

- The pal type ADC_PAL_S32K1xx also depends on:
  ADC Driver
  PDB Driver
  TRGMUX Driver

- The pal type ADC_PAL_MPC574xC_G_R also depends on:
  adc_c55_driver
  bctu_driver

- The pal type ADC_PAL_SAR_CTU also depends on:
  adc_c55_driver
  ctu_driver

Data Structures

- struct adc_group_config_t

  Defines the configuration structure for an ADC PAL conversion group. More...
- struct adc_config_t

  Defines the configuration structure for ADC PAL. More...
- struct extension_adc_s32k1xx_t

  Defines the extension structure for ADC S32K1xx. More...

Typedefs

- typedef adc_inputchannel_t adc_input_chan_t

  Defines the enumeration with ADC PAL input channels.
- typedef trgmux_trigger_source_t adc_trigger_source_t

  Defines the enumeration with ADC PAL hardware trigger sources.

Enumerations

- enum adc_delay_type_t { ADC_DELAY_TYPE_NO_DELAY = 0u, ADC_DELAY_TYPE_GROUP_DELAY = 1u, ADC_DELAY_TYPE_INDIVIDUAL_DELAY = 2u }

  Defines an enumeration which contains the types of delay configurations for ADC conversions within a group.

Functions

- status_t ADC_Init (const adc_instance_t *const instance, const adc_config_t *const config)

  Initializes the ADC PAL instance.
- status_t ADC_Deinit (const adc_instance_t *const instance)

  Deinitializes the ADC PAL instance.
- status_t ADC_EnableHardwareTrigger (const adc_instance_t *const instance, const uint32_t groupIdx)

Enables the selected HW trigger for a conversion group, if the conversion group has support for HW trigger.

- status_t ADC_DisableHardwareTrigger (const adc_instance_t *const instance, const uint32_t groupIdx, const uint32_t timeout)

  Disables the selected HW trigger for a conversion group, if the conversion group is HW triggered.
- status_t ADC_StartGroupConversion (const adc_instance_t *const instance, const uint32_t groupIdx)

  Starts the execution of a selected SW triggered ADC conversion group.
- status_t ADC_StopGroupConversion (const adc_instance_t *const instance, const uint32_t groupIdx, const uint32_t timeout)

  Stops the selected SW triggered ADC conversion group execution.
- status_t ADC_EnableNotification (const adc_instance_t *const instance, const uint32_t groupIdx)

  Enables the notification callback for a configured group.
- status_t ADC_DisableNotification (const adc_instance_t *const instance, const uint32_t groupIdx)

  Disables the notification callback for a configured group.

16.2.2 Data Structure Documentation

16.2.2.1 struct adc_group_config_t

Defines the configuration structure for an ADC PAL conversion group.

Implements : adc_group_config_t_Class

Definition at line 129 of file adc_pal.h.

Data Fields

- const adc_input_chan_t * inputChannelArray
- uint16_t * resultBuffer
- uint8_t numChannels
- uint8_t numSetsResultBuffer
- bool hwTriggerSupport
- adc_trigger_source_t triggerSource
- adc_delay_type_t delayType
- uint16_t * delayArray
- bool continuousConvEn
- adc_callback_t callback
- void * callbackUserData

Field Documentation

16.2.2.1.1 adc_callback_t callback

Callback function associated with group conversion complete

Definition at line 145 of file adc_pal.h.

16.2.2.1.2 void* callbackUserData

Pointer to additional user data to be passed by the callback

Definition at line 146 of file adc_pal.h.

16.2.2.1.3 bool continuousConvEn

Flag for enabling continuous conversions of a group - used only for SW triggered groups i.e. hwTrigger↩ Support==false.

Definition at line 143 of file adc_pal.h.

16.2.2.1.4 uint16_t* delayArray

Pointer to array of delay values introduced from the occurrence of a HW trigger event until each ADC conversion in the group can start execution. Expressed in clock ticks. Note: the delay might be bigger if there is an overlap with another conversion already executing.

Definition at line 141 of file adc_pal.h.

16.2.2.1.5 adc_delay_type_t delayType

Type of delay configuration. Supported values are platform dependent.

Definition at line 140 of file adc_pal.h.

16.2.2.1.6 bool hwTriggerSupport

Conversion group is HW triggered (true) or SW triggered (false).

Definition at line 137 of file adc_pal.h.

16.2.2.1.7 const adc_input_chan_t* inputChannelArray

Pointer to the array of ADC input channels. Each entry in this array corresponds to an individual conversion in the group. Only on some of the platforms the same input channel may appear multiple times - see device family specific details in the ADC PAL documentation.

Definition at line 131 of file adc_pal.h.

16.2.2.1.8 uint8_t numChannels

Number of input channels in the array

Definition at line 134 of file adc_pal.h.

16.2.2.1.9 uint8_t numSetsResultBuffer

Number of sets of results which can be stored in result buffer: length of the result buffer = numChannels x num↩SetsResultBuffer

Definition at line 135 of file adc_pal.h.

16.2.2.1.10 uint16_t* resultBuffer

Pointer to the array for conversion results

Definition at line 133 of file adc_pal.h.

16.2.2.1.11 adc_trigger_source_t triggerSource

HW trigger source associated with the conversion group. Will be ignored if (hwTriggerSupport == false). Note for ADC_SAR_CTU: this enables the HW trigger source for all other groups; the actual order of execution of groups depends on the order of occurrence of triggers.

Definition at line 138 of file adc_pal.h.

16.2.2.2 struct adc_config_t

Defines the configuration structure for ADC PAL.

Implements : adc_config_t_Class

Definition at line 155 of file adc_pal.h.

Data Fields

- const adc_group_config_t * groupConfigArray

- uint16_t numGroups
- uint8_t sampleTicks
- void * extension

Field Documentation

16.2.2.2.1 void* extension

This field is used to add extra IP specific settings to the basic configuration.

Definition at line 161 of file adc_pal.h.

16.2.2.2.2 const adc_group_config_t* groupConfigArray

Array of group configurations

Definition at line 157 of file adc_pal.h.

16.2.2.2.3 uint16_t numGroups

Number of elements in groupConfigArray

Definition at line 158 of file adc_pal.h.

16.2.2.2.4 uint8_t sampleTicks

Duration of sample time expressed in ADC clock ticks

Definition at line 160 of file adc_pal.h.

16.2.2.3 struct extension_adc_s32k1xx_t

Defines the extension structure for ADC S32K1xx.

Implements : extension_adc_s32k1xx_t_Class

Definition at line 171 of file adc_pal.h.

Data Fields

- adc_clk_divide_t clockDivide
- adc_resolution_t resolution
- adc_input_clock_t inputClock
- adc_voltage_reference_t voltageRef
- bool supplyMonitoringEnable
- pdb_clk_prescaler_div_t pdbPrescaler

Field Documentation

16.2.2.3.1 adc_clk_divide_t clockDivide

Divider of the input clock for the ADC

Definition at line 173 of file adc_pal.h.

16.2.2.3.2 adc_input_clock_t inputClock

Input clock source

Definition at line 175 of file adc_pal.h.

16.2.2.3.3 pdb_clk_prescaler_div_t pdbPrescaler

PDB clock prescaler. Delays are measured based on PDB clock divided by prescaler. Only relevant if delays are used.

Definition at line 178 of file adc_pal.h.

16.2.2.3.4 adc_resolution_t resolution

ADC resolution (8,10,12 bit)

Definition at line 174 of file adc_pal.h.

16.2.2.3.5 bool supplyMonitoringEnable

Enable internal supply monitoring

Definition at line 177 of file adc_pal.h.

16.2.2.3.6 adc_voltage_reference_t voltageRef

Voltage reference used

Definition at line 176 of file adc_pal.h.

16.2.3 Typedef Documentation

16.2.3.1 typedef adc_inputchannel_t adc_input_chan_t

Defines the enumeration with ADC PAL input channels.

Implements : adc_input_chan_t_Class

Definition at line 54 of file adc_pal.h.

16.2.3.2 typedef trgmux_trigger_source_t adc_trigger_source_t

Defines the enumeration with ADC PAL hardware trigger sources.

Implements : adc_trigger_source_t_Class

Definition at line 61 of file adc_pal.h.

16.2.4 Enumeration Type Documentation

16.2.4.1 enum adc_delay_type_t

Defines an enumeration which contains the types of delay configurations for ADC conversions within a group.

Implements : adc_delay_type_t_Class

Enumerator

ADC_DELAY_TYPE_NO_DELAY First conversion can start right after the trigger occurrence, and the rest of conversions execute one after another

ADC_DELAY_TYPE_GROUP_DELAY Delay only first conversion, and the rest execute one after another

ADC_DELAY_TYPE_INDIVIDUAL_DELAY Individual delay for each conversion in the group (each measured from the occurrence of the trigger)

Definition at line 117 of file adc_pal.h.

16.2.5 Function Documentation

16.2.5.1 status_t ADC_Deinit (const adc_instance_t *const *instance*)

Deinitializes the ADC PAL instance.

This function resets the ADC PAL instance, including the other platform specific HW units used together with ADC, if there are no active conversions.

Parameters

in	*instance*	Pointer to ADC PAL instance number structure

Returns

status:
- STATUS_BUSY: there is already a HW triggered group enabled or executing, or a SW triggered group executing
- STATUS_BUSY: on MPC574x platforms, if the BCTU module could not be reset
- STATUS_SUCCESS: ADC PAL initialized successfully

Definition at line 338 of file adc_pal.c.

16.2.5.2 status_t ADC_DisableHardwareTrigger (const adc_instance_t *const *instance*, const uint32_t *groupIdx*, const uint32_t *timeout*)

Disables the selected HW trigger for a conversion group, if the conversion group is HW triggered.

This function disables the HW trigger for a configured conversion group and also may stop its execution (depending on platform), if called when a conversion group is executing. If stopping is supported, the execution shall be stopped according to device specific procedures. The function shall wait for the procedures to complete within the given timeout interval and return error code if they do not succeed. : the function prevents new conversions from the group from starting, then waits until the current active conversion finishes execution (if the function call occurred while an ADC conversion from the group is executing) or timeout occurs. : the execution of a HW triggered group of conversions cannot be stopped, so the function shall wait until it is complete or timeout occurs. : the function always returns STATUS_SUCCESS (even if a conversion is still executing) and doesn't use 'timeout' parameter. If it is called during a control cycle, between MRS and actual group conversion start, there will be an additional execution of the group, without callback.

Parameters

in	*instance*	Pointer to ADC PAL instance number structure
in	*groupIdx*	Index of the selected group configured via groupConfigArray in adc_config_t
in	*timeout*	Timeout interval in milliseconds

Returns

status:
- STATUS_TIMEOUT: the operation did not complete successfully within the provided timeout interval
- STATUS_SUCCESS: the operation completed successfully within the provided timeout interval

Definition at line 529 of file adc_pal.c.

16.2.5.3 status_t ADC_DisableNotification (const adc_instance_t *const *instance*, const uint32_t *groupIdx*)

Disables the notification callback for a configured group.

This function disables the notification callback for a selected group of ADC conversions.

Parameters

in	*instance*	Pointer to ADC PAL instance number structure
in	*groupIdx*	Index of the selected group configured via groupConfigArray in adc_config_t

Returns

status:
- STATUS_ERROR: the selected group is not active (SW triggered running or HW triggered running or enabled)
- STATUS_SUCCESS: the notification has been disabled successfully

Definition at line 870 of file adc_pal.c.

16.2.5.4 status_t ADC_EnableHardwareTrigger (const adc_instance_t *const *instance*, const uint32_t *groupIdx*)

Enables the selected HW trigger for a conversion group, if the conversion group has support for HW trigger.

Enables the selected HW trigger for a conversion group, if the conversion group has support for HW trigger. The function will return an error code if there is a conversion group already active. If the function succeeds, the conversion group will be triggered for execution when the selected HW trigger occurs.

Parameters

in	*instance*	Pointer to ADC PAL instance number structure
in	*groupIdx*	Index of the selected group configured via groupConfigArray in adc_config_t

Returns

status:
- STATUS_BUSY: there is already a HW triggered group enabled or executing, or a SW triggered group executing
- STATUS_SUCCESS: HW trigger enabled successfully for the selected conversion group

Definition at line 437 of file adc_pal.c.

16.2.5.5 status_t ADC_EnableNotification (const adc_instance_t *const *instance*, const uint32_t *groupIdx*)

Enables the notification callback for a configured group.

This function enables the notification callback for a selected group of ADC conversions.

Parameters

in	*instance*	Pointer to ADC PAL instance number structure
in	*groupIdx*	Index of the selected group configured via groupConfigArray in adc_config_t

Returns

status:
- STATUS_ERROR: the selected group is not active (SW triggered running or HW triggered running or enabled)
- STATUS_SUCCESS: the notification has been enabled successfully

Definition at line 820 of file adc_pal.c.

16.2.5.6 status_t ADC_Init (const adc_instance_t *const *instance*, const adc_config_t *const *config*)

Initializes the ADC PAL instance.

This function initializes the ADC PAL instance, including the other platform specific HW units used together with ADC. Notifications are default enabled after init.

Parameters

in	*instance*	Pointer to ADC PAL instance number structure
in	*config*	The ADC PAL configuration structure

Returns

status:
- STATUS_ERROR: platform specific error encountered while initializing one of the HW modules used by ADC PAL. On MPC574x returned if ADC calibration did not succeed for all the selected ADCs. On S32K1xx returned if it cannot reconfigure successfully the TRGMUX trigger source of the used PDB instance.
- STATUS_BUSY: on MPC574x platforms, if the BCTU module could not be reset
- STATUS_SUCCESS: ADC PAL initialized successfully

Definition at line 255 of file adc_pal.c.

16.2.5.7 status_t ADC_StartGroupConversion (const adc_instance_t *const *instance*, const uint32_t *groupIdx*)

Starts the execution of a selected SW triggered ADC conversion group.

This function starts execution of a selected ADC conversion group, if there is no other conversion group active. Conversion groups started by ADC_StartGroupConversion shall not be preempted by HW triggered conversion groups.

Parameters

in	*instance*	Pointer to ADC PAL instance number structure
in	*groupIdx*	Index of the selected group configured via groupConfigArray in adc_config_t

Returns

status:
- STATUS_BUSY: there is already a HW triggered group enabled or executing, or a SW triggered group executing
- STATUS_SUCCESS: group conversion successfully triggered

Definition at line 640 of file adc_pal.c.

16.2.5.8 status_t ADC_StopGroupConversion (const adc_instance_t *const *instance*, const uint32_t *groupIdx*, const uint32_t *timeout*)

Stops the selected SW triggered ADC conversion group execution.

This function stops the execution of a SW triggered conversion group. The execution shall be stopped according to device specific procedures. The function shall wait for the procedures to complete within the given timeout interval and return error code if they do not succeed. For ADC_SAR_CTU type and MPC574xC_G_R a conversion already started for execution cannot be stopped, so the function shall wait until it finishes or timeout occurs.

Parameters

in	*instance*	Pointer to ADC PAL instance number structure
in	*groupIdx*	Index of the selected group configured via groupConfigArray in adc_config_t
in	*timeout*	Timeout interval in milliseconds

Returns

status:
- STATUS_TIMEOUT: the operation did not complete successfully within the provided timeout interval
- STATUS_SUCCESS: the operation completed successfully within the provided timeout interval

Definition at line 720 of file adc_pal.c.

16.3 Automotive Math and Motor Control Library

Automotive Math and Motor Control Library integration with S32 SDK
.

General Information

The Automotive Math and Motor Control Library Set is a precompiled off-the-shelf software library containing the building blocks for a wide range of motor control and general mathematical applications. The Automotive Math and Motor Control Library Set is delivered as a precompiled or source code library, and a provides production-ready, highly speed-optimized, intensively tested and easy to use solution for the rapid development of user motor control and general mathematical applications. An integral part of the Automotive Math and Motor Control Library Set are the Matlab/Simulink® models of all supported functions to allow modelling of the user application using the Matlab/Simulink® environment, and extensive user documentation. The Automotive Math and Motor Control Library Set support three major arithmetic: 32-bit fixed-point, 16-bit fixed-point and single precision floating-point. For more information, application notes and demos please visit AMMCLib page from NXP website. AMMCLIB package contains the following:

- **bam** : contains Bit Accurate Models of all the functions for Matlab/Simulink
- **doc** : contains the User Manual
- **include** : contains all the header files, including the master header files of each library to be included in the user application
- **lib** : contains the compiled library file to be included in the user application

Note

For an overview of what is included in the Automotive Math and Motor Control Library and it's capabilities you can check the document found in <SDK_Location>/doc/AMMCLIB_OnePager_S32SDK.pdf
This is just a brief description of the Automotive Math and Motor Control Library, for more information please check the full library documentation found in <SDK_Location>/lib/<CPU_Family>/AMMCLIB/doc/S32K14XMCLUG.pdf
The library is provided in binary format, compiled using GCC, GHS, IAR and for evaluation purposes only. Please consult license.txt file for more information found in <SDK_Location>/lib/<CPU_Family>/AMMCLIB/license.txt

How to use

To add AMMCLib in your application you need to follow four steps:

- 1) Add AMMCLib S32CT component into your project. The component will automatically add the required include paths.
- 2) Add ":S32K14x_AMMCLIB.a" in Libraries (-l) and add "${workspace_loc:/${ProjName}/SDK/lib/AMMCLIB/lib/<compiler>}" in Library search path (-L)
- 3) Select the implementations from the AMMCLib component(Fixed 16, Fixed 32 or Float). If you are using the float implementation you need to enable FPU in the toolchain settings.
- 4) Use the library API to execute the required tests.

You can use the AMMCLib examples as a practical implementation of the steps described above.

Note

IAR compiler:

- The compiler is not able to distinguish the sequence of read and write operations inside an inline assembly block in GFLIB_VMin.h and it make the Warning[Pe549] messages. In that case, C option "--diag_suppress Pe549" should be added to suppress those warnings or "--warnings_are_errors" should be removed to not treat those warnings as errors.

16.4 Backward Compatibility Symbols for S32K142W

This module covers backward compatibility symbols.

16.5 CRC Driver

16.5.1 Detailed Description

Cyclic Redundancy Check Peripheral Driver.

This section describes the programming interface of the CRC driver.

Data Structures

- struct crc_user_config_t

  CRC configuration structure. Implements : crc_user_config_t_Class. More...

Enumerations

- enum crc_transpose_t { CRC_TRANSPOSE_NONE = 0x00U, CRC_TRANSPOSE_BITS = 0x01U, CRC_↩ TRANSPOSE_BITS_AND_BYTES = 0x02U, CRC_TRANSPOSE_BYTES = 0x03U }

  CRC type of transpose of read write data Implements : crc_transpose_t_Class.

CRC DRIVER API

- status_t CRC_DRV_Init (uint32_t instance, const crc_user_config_t ∗userConfigPtr)

  Initializes the CRC module.
- status_t CRC_DRV_Deinit (uint32_t instance)

  Sets the default configuration.
- uint32_t CRC_DRV_GetCrc32 (uint32_t instance, uint32_t data, bool newSeed, uint32_t seed)

  Appends 32-bit data to the current CRC calculation and returns new result.
- uint32_t CRC_DRV_GetCrc16 (uint32_t instance, uint16_t data, bool newSeed, uint32_t seed)

  Appends 16-bit data to the current CRC calculation and returns new result.
- uint32_t CRC_DRV_GetCrc8 (uint32_t instance, uint8_t data, bool newSeed, uint32_t seed)

  Appends 8-bit data to the current CRC calculation and returns new result.
- void CRC_DRV_WriteData (uint32_t instance, const uint8_t ∗data, uint32_t dataSize)

  Appends a block of bytes to the current CRC calculation.
- uint32_t CRC_DRV_GetCrcResult (uint32_t instance)

  Returns the current result of the CRC calculation.
- status_t CRC_DRV_Configure (uint32_t instance, const crc_user_config_t ∗userConfigPtr)

  Configures the CRC module from a user configuration structure.
- status_t CRC_DRV_GetConfig (uint32_t instance, crc_user_config_t ∗const userConfigPtr)

  Get configures of the CRC module currently.
- status_t CRC_DRV_GetDefaultConfig (crc_user_config_t ∗const userConfigPtr)

  Get default configures the CRC module for configuration structure.

16.5.2 Data Structure Documentation

16.5.2.1 struct crc_user_config_t

CRC configuration structure. Implements : crc_user_config_t_Class.

Definition at line 83 of file crc_driver.h.

Data Fields

- crc_transpose_t writeTranspose
- bool complementChecksum
- uint32_t seed

Field Documentation

16.5.2.1.1 bool complementChecksum

True if the result shall be complement of the actual checksum.

Definition at line 95 of file crc_driver.h.

16.5.2.1.2 uint32_t seed

Starting checksum value.

Definition at line 96 of file crc_driver.h.

16.5.2.1.3 crc_transpose_t writeTranspose

Type of transpose when writing CRC input data.

Definition at line 94 of file crc_driver.h.

16.5.3 Enumeration Type Documentation

16.5.3.1 enum crc_transpose_t

CRC type of transpose of read write data Implements : crc_transpose_t_Class.

Enumerator

CRC_TRANSPOSE_NONE No transpose

CRC_TRANSPOSE_BITS Transpose bits in bytes

CRC_TRANSPOSE_BITS_AND_BYTES Transpose bytes and bits in bytes

CRC_TRANSPOSE_BYTES Transpose bytes

Definition at line 44 of file crc_driver.h.

16.5.4 Function Documentation

16.5.4.1 status_t CRC_DRV_Configure (uint32_t *instance*, const crc_user_config_t * *userConfigPtr*)

Configures the CRC module from a user configuration structure.

This function configures the CRC module from a user configuration structure

Parameters

in	*instance*	The CRC instance number
in	*userConfigPtr*	Pointer to structure of initialization

Returns

Execution status (success)

Definition at line 236 of file crc_driver.c.

16.5.4.2 status_t CRC_DRV_Deinit (uint32_t *instance*)

Sets the default configuration.

This function sets the default configuration

Parameters

in	*instance*	The CRC instance number

Returns

Execution status (success)

Definition at line 88 of file crc_driver.c.

16.5.4.3 status_t CRC_DRV_GetConfig (uint32_t *instance,* crc_user_config_t *const *userConfigPtr)

Get configures of the CRC module currently.

This function Get configures of the CRC module currently

Parameters

in	*instance*	The CRC instance number
out	*userConfigPtr*	Pointer to structure of initialization

Returns

Execution status (success)

Definition at line 268 of file crc_driver.c.

16.5.4.4 uint32_t CRC_DRV_GetCrc16 (uint32_t *instance,* uint16_t *data,* bool *newSeed,* uint32_t *seed*)

Appends 16-bit data to the current CRC calculation and returns new result.

This function appends 16-bit data to the current CRC calculation and returns new result. If the newSeed is true, seed set and result are calculated from the seed new value (new CRC calculation)

Parameters

in	*instance*	The CRC instance number
in	*data*	Input data for CRC calculation
in	*newSeed*	Sets new CRC calculation • true: New seed set and used for new calculation. • false: Seed argument ignored, continues old calculation.
in	*seed*	New seed if newSeed is true, else ignored

Returns

New CRC result

Definition at line 139 of file crc_driver.c.

16.5.4.5 uint32_t CRC_DRV_GetCrc32 (uint32_t *instance,* uint32_t *data,* bool *newSeed,* uint32_t *seed*)

Appends 32-bit data to the current CRC calculation and returns new result.

This function appends 32-bit data to the current CRC calculation and returns new result. If the newSeed is true, seed set and result are calculated from the seed new value (new CRC calculation)

Parameters

in	*instance*	The CRC instance number
in	*data*	Input data for CRC calculation
in	*newSeed*	Sets new CRC calculation • true: New seed set and used for new calculation. • false: Seed argument ignored, continues old calculation.
in	*seed*	New seed if newSeed is true, else ignored

Returns

New CRC result

Definition at line 108 of file crc_driver.c.

16.5.4.6 uint32_t CRC_DRV_GetCrc8 (uint32_t *instance,* uint8_t *data,* bool *newSeed,* uint32_t *seed*)

Appends 8-bit data to the current CRC calculation and returns new result.

This function appends 8-bit data to the current CRC calculation and returns new result. If the newSeed is true, seed set and result are calculated from the seed new value (new CRC calculation)

Parameters

in	*instance*	The CRC instance number
in	*data*	Input data for CRC calculation
in	*newSeed*	Sets new CRC calculation • true: New seed set and used for new calculation. • false: Seed argument ignored, continues old calculation.
in	*seed*	New seed if newSeed is true, else ignored

Returns

New CRC result

Definition at line 169 of file crc_driver.c.

16.5.4.7 uint32_t CRC_DRV_GetCrcResult (uint32_t *instance*)

Returns the current result of the CRC calculation.

This function returns the current result of the CRC calculation

Parameters

in	*instance*	The CRC instance number

Returns

Result of CRC calculation

Definition at line 220 of file crc_driver.c.

16.5.4.8 status_t CRC_DRV_GetDefaultConfig (crc_user_config_t *const *userConfigPtr*)

Get default configures the CRC module for configuration structure.

This function Get default configures the CRC module for user configuration structure

Parameters

out	*userConfigPtr*	Pointer to structure of initialization

Returns

Execution status (success)

Definition at line 300 of file crc_driver.c.

16.5.4.9 status_t CRC_DRV_Init (uint32_t *instance*, const crc_user_config_t * *userConfigPtr*)

Initializes the CRC module.

This function initializes CRC driver based on user configuration input. The user must make sure that the clock is enabled

Parameters

in	*instance*	The CRC instance number
in	*userConfigPtr*	Pointer to structure of initialization

Returns

Execution status (success)

Definition at line 65 of file crc_driver.c.

16.5.4.10 void CRC_DRV_WriteData (uint32_t *instance*, const uint8_t * *data*, uint32_t *dataSize*)

Appends a block of bytes to the current CRC calculation.

This function appends a block of bytes to the current CRC calculation

Parameters

in	*instance*	The CRC instance number
in	*data*	Data for current CRC calculation
in	*dataSize*	Length of data to be calculated

Definition at line 197 of file crc_driver.c.

16.6 CSEc Driver

16.6.1 Detailed Description

Cryptographic Services Engine Peripheral Driver.

How to use the CSEc driver in your application

To access the command feature set, the part must be configured for EEE operation, using the PGMPART command. This can be implemented by using the Flash driver. By enabling security features and configuring a number of user keys, the total size of the 4 KByte EEERAM will be reduced by the space required to store the user keys. The user key space will then effectively be unaddressable space in the EEERAM.

At the bottom of this page is an example of making this configuration using the Flash driver. For more details related to the FLASH_DRV_DEFlashPartition function, please refer to the Flash driver documentation. Please note that this configuration is required only once and should not be lanched from Flash memory.

In order to use the CSEc driver in your application, the **CSEC_DRV_Init** function should be called prior to using the rest of the API. The parameter of this function is used for holding the internal state of the driver throughout the lifetime of the application.

Key/seed/random number generation

This is the high level flow in which to initialize and generate random numbers.

1. Run **CSEC_DRV_InitRNG** to initialize a random seed from the internal TRNG
   - **CSEC_DRV_InitRNG** must be run after every POR, and before the first execution of CSEC_DRV_↩ GenerateRND
   - Note that if the next step (run **CSEC_DRV_GenerateRND**) is run without initializing the seed, **CSEC**↩ **_RNG_SEED** will be returned.
2. Run **CSEC_DRV_GenerateRND** to generate a random numer The PRNG uses the PRNG_STATE/KEY and Seed per SHE spec and the AIS20 standard.
3. For additional random numbers the user may continue executing **CSEC_DRV_GenerateRND** unless a POR event occurred.

Memory update protocol

In order to update a key, the user must have knowledge of a valid authentication secret, i.e. another key (AuthID). If the key AuthID is empty, the key update will only work if AuthID = ID (the key that will be updated will represent the AuthID from now on), otherwise **CSEC_KEY_EMPTY** is returned.

The M1-M3 values need to be computed according to the SHE Specification in order to update a key slot. The **CSEC_DRV_LoadKey** function will require those values. After successfully updating the key slot, two verification values will be returned: M4 and M5. The user can compute the two values and compare them with the ones returned by the **CSEC_DRV_LoadKey** function in order to ensure the slot was updated as desired. Please refer to the CSEc driver example for a reference implementation of the memory update protocol.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\csec\csec_driver.c
${S32SDK_PATH}\platform\drivers\src\csec\csec_hw_access.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
```

Preprocessor symbols

No special symbols are required for this component

Important Note

While executing CSEC_DRV_GenerateMACAddrMode and CSEC_DRV_VerifyMACAddrMode functions, it is not possible to execute code from the FLASH block targeted by the current operation. This includes interrupt handlers for any interrupt that might occur during this time. It is the responsibility of the application to ensure that any such code is placed in a different FLASH block or in RAM. Functions can be placed in RAM section by using the START/END_FUNCTION_DEFINITION/DECLARATION_RAMSECTION macros.

Dependencies

Interrupt Manager (Interrupt) OS Interface (OSIF)

Examples:

Using the Flash driver to partition Flash for CSEc operation, the below code section applies for S32K14x:

```
flash_ssd_config_t flashSSDConfig;

FLASH_DRV_Init(&flash1_InitConfig0, &flashSSDConfig);

/* Configure the part for EEE operation, with 20 keys for CSEc */
FLASH_DRV_DEFlashPartition(&flashSSDConfig, 0x2, 0x4, 0x3, false, true);
```

The example partition code for S32K11x:

```
flash_ssd_config_t flashSSDConfig;

FLASH_DRV_Init(&flash1_InitConfig0, &flashSSDConfig);

/* Configure the part for EEE operation, with 20 keys for CSEc */
FLASH_DRV_DEFlashPartition(&flashSSDConfig, 0x3, 0x3, 0x3, false, true);
```

Encryption using AES EBC mode

```
uint8_t plainText[16] = {0x00, 0x11, 0x22, 0x33, 0x44, 0x55, 0x66, 0x77, 0x88,
    0x99, 0xAA, 0xBB, 0xCC, 0xDD, 0xEE, 0xFF};
uint8_t plainKey[16] = {0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07, 0x08,
    0x09, 0x0a, 0x0b, 0x0c, 0x0d, 0x0e, 0x0f};

csec_error_code_t stat;
uint8_t cipherText[16];

csec_state_t csecState;

CSEC_DRV_Init(&csecState);

stat = CSEC_DRV_LoadPlainKey(plainKey);
if (stat != CSEC_NO_ERROR)
{
    /* Loading the key failed, encryption will not have the expected result */
    return false;
}

stat = CSEC_DRV_EncryptECB(CSEC_RAM_KEY, plainText, 16U, cipherText, 1U);
if (stat != CSEC_NO_ERROR)
{
    /* Encryption was successful */
    return true;
}
```

Generating and verifying CMAC for a message

```
uint8_t plainKey[16] = {0x2b, 0x7e, 0x15, 0x16, 0x28, 0xae, 0xd2, 0xa6, 0xab,
    0xf7, 0x15, 0x88, 0x09, 0xcf, 0x4f, 0x3c};
uint8_t msg[16] = {0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07, 0x08,
    0x09, 0x0a, 0x0b, 0x0c, 0x0d, 0x0e, 0x0f};
uint8_t cmac[16];
bool verifStatus;
csec_error_code_t stat;
```

```
csec_state_t csecState;

CSEC_DRV_Init(&csecState);

stat = CSEC_DRV_LoadPlainKey(plainKey);
if (stat != CSEC_NO_ERROR)
    return false;

stat = CSEC_DRV_GenerateMAC(CSEC_RAM_KEY, msg, 128U, cmac, 1U);
if (stat != CSEC_NO_ERROR)
    return false;

stat = CSEC_DRV_VerifyMAC(CSEC_RAM_KEY, msg, 128U, cmac, 128U, &verifStatus,
      1U);
if (stat != CSEC_NO_ERROR)
    return false;

if (!verifStatus)
{
    /* The given CMAC did not matched with the one computed internally */
    return false;
}
```

Generating random bits

```
csec_error_code_t stat;
csec_status_t status;
uint8_t rnd[16];

csec_state_t csecState;

CSEC_DRV_Init(&csecState);

stat = CSEC_DRV_InitRNG();
if (stat != CSEC_NO_ERROR)
    return false;

/* Check RNG is initialized */
status = CSEC_DRV_GetStatus();
if (!(status & CSEC_STATUS_RND_INIT))
    return false;

stat = CSEC_DRV_GenerateRND(rnd);
if (stat != CSEC_NO_ERROR)
    return false;
```

Data Structures

- struct csec_state_t

  Internal driver state information. More...

Macros

- #define CSEC_STATUS_BUSY (0x1U)

  The bit is set whenever SHE is processing a command.
- #define CSEC_STATUS_SECURE_BOOT (0x2U)

  The bit is set if the secure booting is activated.
- #define CSEC_STATUS_BOOT_INIT (0x4U)

  The bit is set if the secure booting has been personalized during the boot sequence.
- #define CSEC_STATUS_BOOT_FINISHED (0x8U)

  The bit is set when the secure booting has been finished by calling either CMD_BOOT_FAILURE or CMD_BOOT↩ _OK or if CMD_SECURE_BOOT failed in verifying BOOT_MAC.
- #define CSEC_STATUS_BOOT_OK (0x10U)

  The bit is set if the secure booting (CMD_SECURE_BOOT) succeeded. If CMD_BOOT_FAILURE is called the bit is erased.
- #define CSEC_STATUS_RND_INIT (0x20U)

  The bit is set if the random number generator has been initialized.
- #define CSEC_STATUS_EXT_DEBUGGER (0x40U)

The bit is set if an external debugger is connected to the chip.

- #define CSEC_STATUS_INT_DEBUGGER (0x80U)

  The bit is set if the internal debugging mechanisms of SHE are activated.

Typedefs

- typedef uint8_t csec_status_t

  Represents the status of the CSEc module. Provides one bit for each status code as per SHE specification. CSEC_STATUS_∗ masks can be used for verifying the status.

Enumerations

- enum csec_key_id_t {
  CSEC_SECRET_KEY = 0x0U, CSEC_MASTER_ECU, CSEC_BOOT_MAC_KEY, CSEC_BOOT_MAC,
  CSEC_KEY_1, CSEC_KEY_2, CSEC_KEY_3, CSEC_KEY_4,
  CSEC_KEY_5, CSEC_KEY_6, CSEC_KEY_7, CSEC_KEY_8,
  CSEC_KEY_9, CSEC_KEY_10, CSEC_RAM_KEY = 0xFU, CSEC_KEY_11 = 0x14U,
  CSEC_KEY_12, CSEC_KEY_13, CSEC_KEY_14, CSEC_KEY_15,
  CSEC_KEY_16, CSEC_KEY_17 }

  Specify the KeyID to be used to implement the requested cryptographic operation.
- enum csec_cmd_t {
  CSEC_CMD_ENC_ECB = 0x1U, CSEC_CMD_ENC_CBC, CSEC_CMD_DEC_ECB, CSEC_CMD_DEC_CBC,
  CSEC_CMD_GENERATE_MAC, CSEC_CMD_VERIFY_MAC, CSEC_CMD_LOAD_KEY, CSEC_CMD_LOAD_PLAIN_KEY,
  CSEC_CMD_EXPORT_RAM_KEY, CSEC_CMD_INIT_RNG, CSEC_CMD_EXTEND_SEED, CSEC_CMD_RND,
  CSEC_CMD_RESERVED_1, CSEC_CMD_BOOT_FAILURE, CSEC_CMD_BOOT_OK, CSEC_CMD_GET_ID,
  CSEC_CMD_BOOT_DEFINE, CSEC_CMD_DBG_CHAL, CSEC_CMD_DBG_AUTH, CSEC_CMD_RESERVED_2,
  CSEC_CMD_RESERVED_3, CSEC_CMD_MP_COMPRESS }

  CSEc commands which follow the same values as the SHE command definition.
- enum csec_call_sequence_t { CSEC_CALL_SEQ_FIRST, CSEC_CALL_SEQ_SUBSEQUENT }

  Specifies if the information is the first or a following function call.
- enum csec_boot_flavor_t { CSEC_BOOT_STRICT, CSEC_BOOT_SERIAL, CSEC_BOOT_PARALLEL, CSEC_BOOT_NOT_DEFINED }

  Specifies the boot type for the BOOT_DEFINE command.

Functions

- void CSEC_DRV_Init (csec_state_t ∗state)

  Initializes the internal state of the driver and enables the FTFC interrupt.
- void CSEC_DRV_Deinit (void)

  Clears the internal state of the driver and disables the FTFC interrupt.
- status_t CSEC_DRV_EncryptECB (csec_key_id_t keyId, const uint8_t ∗plainText, uint32_t length, uint8_t ∗cipherText, uint32_t timeout)

  Performs the AES-128 encryption in ECB mode.
- status_t CSEC_DRV_DecryptECB (csec_key_id_t keyId, const uint8_t ∗cipherText, uint32_t length, uint8_t ∗plainText, uint32_t timeout)

  Performs the AES-128 decryption in ECB mode.
- status_t CSEC_DRV_EncryptCBC (csec_key_id_t keyId, const uint8_t ∗plainText, uint32_t length, const uint8_t ∗iv, uint8_t ∗cipherText, uint32_t timeout)

Performs the AES-128 encryption in CBC mode.

- status_t CSEC_DRV_DecryptCBC (csec_key_id_t keyId, const uint8_t *cipherText, uint32_t length, const uint8_t *iv, uint8_t *plainText, uint32_t timeout)

  Performs the AES-128 decryption in CBC mode.

- status_t CSEC_DRV_GenerateMAC (csec_key_id_t keyId, const uint8_t *msg, uint32_t msgLen, uint8_t *cmac, uint32_t timeout)

  Calculates the MAC of a given message using CMAC with AES-128.

- status_t CSEC_DRV_GenerateMACAddrMode (csec_key_id_t keyId, const uint8_t *msg, uint32_t msgLen, uint8_t *cmac)

  Calculates the MAC of a given message (located in Flash) using CMAC with AES-128.

- status_t CSEC_DRV_VerifyMAC (csec_key_id_t keyId, const uint8_t *msg, uint32_t msgLen, const uint8_t *mac, uint16_t macLen, bool *verifStatus, uint32_t timeout)

  Verifies the MAC of a given message using CMAC with AES-128.

- status_t CSEC_DRV_VerifyMACAddrMode (csec_key_id_t keyId, const uint8_t *msg, uint32_t msgLen, const uint8_t *mac, uint16_t macLen, bool *verifStatus)

  Verifies the MAC of a given message (located in Flash) using CMAC with AES-128.

- status_t CSEC_DRV_LoadKey (csec_key_id_t keyId, const uint8_t *m1, const uint8_t *m2, const uint8_t *m3, uint8_t *m4, uint8_t *m5)

  Updates an internal key per the SHE specification.

- status_t CSEC_DRV_LoadPlainKey (const uint8_t *plainKey)

  Updates the RAM key memory slot with a 128-bit plaintext.

- status_t CSEC_DRV_ExportRAMKey (uint8_t *m1, uint8_t *m2, uint8_t *m3, uint8_t *m4, uint8_t *m5)

  Exports the RAM_KEY into a format protected by SECRET_KEY.

- status_t CSEC_DRV_InitRNG (void)

  Initializes the seed and derives a key for the PRNG.

- status_t CSEC_DRV_ExtendSeed (const uint8_t *entropy)

  Extends the seed of the PRNG.

- status_t CSEC_DRV_GenerateRND (uint8_t *rnd)

  Generates a vector of 128 random bits.

- status_t CSEC_DRV_BootFailure (void)

  Signals a failure detected during later stages of the boot process.

- status_t CSEC_DRV_BootOK (void)

  Marks a successful boot verification during later stages of the boot process.

- status_t CSEC_DRV_BootDefine (uint32_t bootSize, csec_boot_flavor_t bootFlavor)

  Implements an extension of the SHE standard to define both the user boot size and boot method.

- static csec_status_t CSEC_DRV_GetStatus (void)

  Returns the content of the status register.

- status_t CSEC_DRV_GetID (const uint8_t *challenge, uint8_t *uid, uint8_t *sreg, uint8_t *mac)

  Returns the identity (UID) and the value of the status register protected by a MAC over a challenge and the data.

- status_t CSEC_DRV_DbgChal (uint8_t *challenge)

  Obtains a random number which the user shall use along with the MASTER_ECU_KEY and UID to return an authorization request.

- status_t CSEC_DRV_DbgAuth (const uint8_t *authorization)

  Erases all keys (actual and outdated) stored in NVM Memory if the authorization is confirmed by CSEc.

- status_t CSEC_DRV_MPCompress (const uint8_t *msg, uint16_t msgLen, uint8_t *mpCompress, uint32_t timeout)

  Compresses the given messages by accessing the Miyaguchi-Prenell compression feature with in the CSEc feature set.

- status_t CSEC_DRV_EncryptECBAsync (csec_key_id_t keyId, const uint8_t *plainText, uint32_t length, uint8_t *cipherText)

  Asynchronously performs the AES-128 encryption in ECB mode.

- status_t CSEC_DRV_DecryptECBAsync (csec_key_id_t keyId, const uint8_t *cipherText, uint32_t length, uint8_t *plainText)

  Asynchronously performs the AES-128 decryption in ECB mode.
- status_t CSEC_DRV_EncryptCBCAsync (csec_key_id_t keyId, const uint8_t *plainText, uint32_t length, const uint8_t *iv, uint8_t *cipherText)

  Asynchronously performs the AES-128 encryption in CBC mode.
- status_t CSEC_DRV_DecryptCBCAsync (csec_key_id_t keyId, const uint8_t *cipherText, uint32_t length, const uint8_t *iv, uint8_t *plainText)

  Asynchronously performs the AES-128 decryption in CBC mode.
- status_t CSEC_DRV_GenerateMACAsync (csec_key_id_t keyId, const uint8_t *msg, uint32_t msgLen, uint8_t *cmac)

  Asynchronously calculates the MAC of a given message using CMAC with AES-128.
- status_t CSEC_DRV_VerifyMACAsync (csec_key_id_t keyId, const uint8_t *msg, uint32_t msgLen, const uint8_t *mac, uint16_t macLen, bool *verifStatus)

  Asynchronously verifies the MAC of a given message using CMAC with AES-128.
- status_t CSEC_DRV_GetAsyncCmdStatus (void)

  Checks the status of the execution of an asynchronous command.
- void CSEC_DRV_InstallCallback (security_callback_t callbackFunc, void *callbackParam)

  Installs a callback function which will be invoked when an asynchronous command finishes its execution.
- void CSEC_DRV_CancelCommand (void)

  Cancels a previously launched asynchronous command.

16.6.2 Data Structure Documentation

16.6.2.1 struct csec_state_t

Internal driver state information.

Note

The contents of this structure are internal to the driver and should not be modified by users. Also, contents of the structure are subject to change in future releases.

Implements : csec_state_t_Class

Definition at line 183 of file csec_driver.h.

Data Fields

- bool cmdInProgress
- csec_cmd_t cmd
- const uint8_t * inputBuff
- uint8_t * outputBuff
- uint32_t index
- uint32_t fullSize
- uint32_t partSize
- csec_key_id_t keyId
- status_t errCode
- const uint8_t * iv
- csec_call_sequence_t seq
- uint32_t msgLen
- bool * verifStatus
- bool macWritten
- const uint8_t * mac
- uint32_t macLen
- security_callback_t callback
- void * callbackParam

Field Documentation

16.6.2.1.1 security_callback_t callback

The callback invoked when an asynchronous command is completed

Definition at line 200 of file csec_driver.h.

16.6.2.1.2 void* callbackParam

User parameter for the command completion callback

Definition at line 201 of file csec_driver.h.

16.6.2.1.3 csec_cmd_t cmd

Specifies the type of the command in execution

Definition at line 185 of file csec_driver.h.

16.6.2.1.4 bool cmdInProgress

Specifies if a command is in progress

Definition at line 184 of file csec_driver.h.

16.6.2.1.5 status_t errCode

Specifies the error code of the last executed command

Definition at line 192 of file csec_driver.h.

16.6.2.1.6 uint32_t fullSize

Specifies the size of the input of the command in execution

Definition at line 189 of file csec_driver.h.

16.6.2.1.7 uint32_t index

Specifies the index in the input buffer of the command in execution

Definition at line 188 of file csec_driver.h.

16.6.2.1.8 const uint8_t* inputBuff

Specifies the input of the command in execution

Definition at line 186 of file csec_driver.h.

16.6.2.1.9 const uint8_t* iv

Specifies the IV of the command in execution (for encryption/decryption using CBC mode)

Definition at line 193 of file csec_driver.h.

16.6.2.1.10 csec_key_id_t keyId

Specifies the key used for the command in execution

Definition at line 191 of file csec_driver.h.

16.6.2.1.11 const uint8_t* mac

Specifies the MAC to be verified for a MAC verification command

Definition at line 198 of file csec_driver.h.

16.6.2.1.12 uint32_t macLen

Specifies the number of bits of the MAC to be verified for a MAC verification command

Definition at line 199 of file csec_driver.h.

16.6.2.1.13 bool macWritten

Specifies if the MAC to be verified was written in CSE_PRAM for a MAC verification command

Definition at line 197 of file csec_driver.h.

16.6.2.1.14 uint32_t msgLen

Specifies the message size (in bits) for the command in execution (for MAC generation/verification)

Definition at line 195 of file csec_driver.h.

16.6.2.1.15 uint8_t* outputBuff

Specifies the output of the command in execution

Definition at line 187 of file csec_driver.h.

16.6.2.1.16 uint32_t partSize

Specifies the size of the chunck of the input currently processed

Definition at line 190 of file csec_driver.h.

16.6.2.1.17 csec_call_sequence_t seq

Specifies if the information is the first or a following function call.

Definition at line 194 of file csec_driver.h.

16.6.2.1.18 bool* verifStatus

Specifies the result of the last executed MAC verification command

Definition at line 196 of file csec_driver.h.

16.6.3 Macro Definition Documentation

16.6.3.1 #define CSEC_STATUS_BOOT_FINISHED (0x8U)

The bit is set when the secure booting has been finished by calling either CMD_BOOT_FAILURE or CMD_BOO↩ T_OK or if CMD_SECURE_BOOT failed in verifying BOOT_MAC.

Definition at line 70 of file csec_driver.h.

16.6.3.2 #define CSEC_STATUS_BOOT_INIT (0x4U)

The bit is set if the secure booting has been personalized during the boot sequence.

Definition at line 66 of file csec_driver.h.

16.6.3.3 #define CSEC_STATUS_BOOT_OK (0x10U)

The bit is set if the secure booting (CMD_SECURE_BOOT) succeeded. If CMD_BOOT_FAILURE is called the bit is erased.

Definition at line 73 of file csec_driver.h.

16.6.3.4 #define CSEC_STATUS_BUSY (0x1U)

The bit is set whenever SHE is processing a command.

Definition at line 61 of file csec_driver.h.

16.6.3.5 #define CSEC_STATUS_EXT_DEBUGGER (0x40U)

The bit is set if an external debugger is connected to the chip.

Definition at line 77 of file csec_driver.h.

16.6.3.6 #define CSEC_STATUS_INT_DEBUGGER (0x80U)

The bit is set if the internal debugging mechanisms of SHE are activated.

Definition at line 80 of file csec_driver.h.

16.6.3.7 #define CSEC_STATUS_RND_INIT (0x20U)

The bit is set if the random number generator has been initialized.

Definition at line 75 of file csec_driver.h.

16.6.3.8 #define CSEC_STATUS_SECURE_BOOT (0x2U)

The bit is set if the secure booting is activated.

Definition at line 63 of file csec_driver.h.

16.6.4 Typedef Documentation

16.6.4.1 typedef uint8_t csec_status_t

Represents the status of the CSEc module. Provides one bit for each status code as per SHE specification. CSE↩ C_STATUS_∗ masks can be used for verifying the status.

Implements : csec_status_t_Class

Definition at line 89 of file csec_driver.h.

16.6.5 Enumeration Type Documentation

16.6.5.1 enum csec_boot_flavor_t

Specifies the boot type for the BOOT_DEFINE command.

Implements : csec_boot_flavor_t_Class

Enumerator

CSEC_BOOT_STRICT

CSEC_BOOT_SERIAL

CSEC_BOOT_PARALLEL

CSEC_BOOT_NOT_DEFINED

Definition at line 167 of file csec_driver.h.

16.6.5.2 enum csec_call_sequence_t

Specifies if the information is the first or a following function call.

Implements : csec_call_sequence_t_Class

Enumerator

CSEC_CALL_SEQ_FIRST

CSEC_CALL_SEQ_SUBSEQUENT

Definition at line 157 of file csec_driver.h.

16.6.5.3 enum csec_cmd_t

CSEc commands which follow the same values as the SHE command definition.

Implements : csec_cmd_t_Class

Enumerator

CSEC_CMD_ENC_ECB

CSEC_CMD_ENC_CBC

CSEC_CMD_DEC_ECB

CSEC_CMD_DEC_CBC

CSEC_CMD_GENERATE_MAC

CSEC_CMD_VERIFY_MAC

CSEC_CMD_LOAD_KEY

CSEC_CMD_LOAD_PLAIN_KEY

CSEC_CMD_EXPORT_RAM_KEY

CSEC_CMD_INIT_RNG

CSEC_CMD_EXTEND_SEED

CSEC_CMD_RND

CSEC_CMD_RESERVED_1

CSEC_CMD_BOOT_FAILURE

CSEC_CMD_BOOT_OK

CSEC_CMD_GET_ID

CSEC_CMD_BOOT_DEFINE

CSEC_CMD_DBG_CHAL

CSEC_CMD_DBG_AUTH

CSEC_CMD_RESERVED_2

CSEC_CMD_RESERVED_3

CSEC_CMD_MP_COMPRESS

Definition at line 127 of file csec_driver.h.

16.6.5.4 enum csec_key_id_t

Specify the KeyID to be used to implement the requested cryptographic operation.

Implements : csec_key_id_t_Class

Enumerator

CSEC_SECRET_KEY

CSEC_MASTER_ECU

CSEC_BOOT_MAC_KEY

CSEC_BOOT_MAC

CSEC_KEY_1

CSEC_KEY_2

CSEC_KEY_3

CSEC_KEY_4

CSEC_KEY_5

CSEC_KEY_6

CSEC_KEY_7

CSEC_KEY_8

CSEC_KEY_9

CSEC_KEY_10

CSEC_RAM_KEY

CSEC_KEY_11

CSEC_KEY_12

CSEC_KEY_13

CSEC_KEY_14

CSEC_KEY_15

CSEC_KEY_16

CSEC_KEY_17

Definition at line 97 of file csec_driver.h.

16.6.6 Function Documentation

16.6.6.1 status_t CSEC_DRV_BootDefine (uint32_t *bootSize,* csec_boot_flavor_t *bootFlavor*)

Implements an extension of the SHE standard to define both the user boot size and boot method.

The function implements an extension of the SHE standard to define both the user boot size and boot method.

Parameters

in	*bootSize*	Number of blocks of 128-bit data to check on boot. Maximum size is 512k↩ Bytes.
in	*bootFlavor*	The boot method.

Returns

Error Code after command execution.

Definition at line 928 of file csec_driver.c.

16.6.6.2 status_t CSEC_DRV_BootFailure (void)

Signals a failure detected during later stages of the boot process.

The function is called during later stages of the boot process to detect a failure.

Returns

Error Code after command execution.

Definition at line 860 of file csec_driver.c.

16.6.6.3 status_t CSEC_DRV_BootOK (void)

Marks a successful boot verification during later stages of the boot process.

The function is called during later stages of the boot process to mark successful boot verification.

Returns

Error Code after command execution.

Definition at line 894 of file csec_driver.c.

16.6.6.4 void CSEC_DRV_CancelCommand (void)

Cancels a previously launched asynchronous command.

Definition at line 1784 of file csec_driver.c.

16.6.6.5 status_t CSEC_DRV_DbgAuth (const uint8_t * *authorization*)

Erases all keys (actual and outdated) stored in NVM Memory if the authorization is confirmed by CSEc.

This function erases all keys (actual and outdated) stored in NVM Memory if the authorization is confirmed by CSEc.

Parameters

in	*authorization*	Pointer to the 128-bit buffer containing the authorization value.

Returns

Error Code after command execution.

Definition at line 1059 of file csec_driver.c.

16.6.6.6 status_t CSEC_DRV_DbgChal (uint8_t * *challenge*)

Obtains a random number which the user shall use along with the MASTER_ECU_KEY and UID to return an authorization request.

This function obtains a random number which the user shall use along with the MASTER_ECU_KEY and UID to return an authorization request.

Parameters

out	*challenge*	Pointer to the 128-bit buffer where the challenge data will be stored.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 1019 of file csec_driver.c.

16.6.6.7 status_t CSEC_DRV_DecryptCBC (csec_key_id_t *keyId,* const uint8_t * *cipherText,* uint32_t *length,* const uint8_t * *iv,* uint8_t * *plainText,* uint32_t *timeout*)

Performs the AES-128 decryption in CBC mode.

This function performs the AES-128 decryption in CBC mode of the input cipher text buffer.

Parameters

in	*keyId*	KeyID used to perform the cryptographic operation.
in	*cipherText*	Pointer to the cipher text buffer.
in	*length*	Number of bytes of cipher text message to be decrypted. It should be multiple of 16 bytes.
in	*iv*	Pointer to the initialization vector buffer.
out	*plainText*	Pointer to the plain text buffer. The buffer shall have the same size as the cipher text buffer.
in	*timeout*	Timeout in milliseconds.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 327 of file csec_driver.c.

16.6.6.8 status_t CSEC_DRV_DecryptCBCAsync (csec_key_id_t *keyId*, const uint8_t * *cipherText*, uint32_t *length*, const uint8_t * *iv*, uint8_t * *plainText*)

Asynchronously performs the AES-128 decryption in CBC mode.

This function performs the AES-128 decryption in CBC mode of the input cipher text buffer, in an asynchronous manner.

Parameters

in	*keyId*	KeyID used to perform the cryptographic operation.
in	*cipherText*	Pointer to the cipher text buffer.
in	*length*	Number of bytes of cipher text message to be decrypted. It should be multiple of 16 bytes.
in	*iv*	Pointer to the initialization vector buffer.
out	*plainText*	Pointer to the plain text buffer. The buffer shall have the same size as the cipher text buffer.

Returns

STATUS_SUCCESS if the command was successfully launched, STATUS_BUSY if another command was already launched. CSEC_DRV_GetAsyncCmdStatus can be used in order to check the execution status.

Definition at line 1282 of file csec_driver.c.

16.6.6.9 status_t CSEC_DRV_DecryptECB (csec_key_id_t *keyId*, const uint8_t * *cipherText*, uint32_t *length*, uint8_t * *plainText*, uint32_t *timeout*)

Performs the AES-128 decryption in ECB mode.

This function performs the AES-128 decryption in ECB mode of the input cipher text buffer.

Parameters

in	*keyId*	KeyID used to perform the cryptographic operation
in	*cipherText*	Pointer to the cipher text buffer.
in	*length*	Number of bytes of cipher text message to be decrypted. It should be multiple of 16 bytes.
out	*plainText*	Pointer to the plain text buffer. The buffer shall have the same size as the cipher text buffer.

in	*timeout*	Timeout in milliseconds.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 219 of file csec_driver.c.

16.6.6.10 status_t CSEC_DRV_DecryptECBAsync (csec_key_id_t *keyId*, const uint8_t * *cipherText*, uint32_t *length*, uint8_t * *plainText*)

Asynchronously performs the AES-128 decryption in ECB mode.

This function performs the AES-128 decryption in ECB mode of the input cipher text buffer, in an asynchronous manner.

Parameters

in	*keyId*	KeyID used to perform the cryptographic operation
in	*cipherText*	Pointer to the cipher text buffer.
in	*length*	Number of bytes of cipher text message to be decrypted. It should be multiple of 16 bytes.
out	*plainText*	Pointer to the plain text buffer. The buffer shall have the same size as the cipher text buffer.

Returns

STATUS_SUCCESS if the command was successfully launched, STATUS_BUSY if another command was already launched. CSEC_DRV_GetAsyncCmdStatus can be used in order to check the execution status.

Definition at line 1215 of file csec_driver.c.

16.6.6.11 void CSEC_DRV_Deinit (void)

Clears the internal state of the driver and disables the FTFC interrupt.

Definition at line 151 of file csec_driver.c.

16.6.6.12 status_t CSEC_DRV_EncryptCBC (csec_key_id_t *keyId*, const uint8_t * *plainText*, uint32_t *length*, const uint8_t * *iv*, uint8_t * *cipherText*, uint32_t *timeout*)

Performs the AES-128 encryption in CBC mode.

This function performs the AES-128 encryption in CBC mode of the input plaintext buffer.

Parameters

in	*keyId*	KeyID used to perform the cryptographic operation.
in	*plainText*	Pointer to the plain text buffer.
in	*length*	Number of bytes of plain text message to be encrypted. It should be multiple of 16 bytes.
in	*iv*	Pointer to the initialization vector buffer.
in	*timeout*	Timeout in milliseconds.
out	*cipherText*	Pointer to the cipher text buffer. The buffer shall have the same size as the plain text buffer.
in	*timeout*	Timeout in milliseconds.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 271 of file csec_driver.c.

16.6.6.13 status_t CSEC_DRV_EncryptCBCAsync (csec_key_id_t *keyId,* const uint8_t * *plainText,* uint32_t *length,* const uint8_t * *iv,* uint8_t * *cipherText*)

Asynchronously performs the AES-128 encryption in CBC mode.

This function performs the AES-128 encryption in CBC mode of the input plaintext buffer, in an asynchronous manner.

Parameters

in	*keyId*	KeyID used to perform the cryptographic operation.
in	*plainText*	Pointer to the plain text buffer.
in	*length*	Number of bytes of plain text message to be encrypted. It should be multiple of 16 bytes.
in	*iv*	Pointer to the initialization vector buffer.
out	*cipherText*	Pointer to the cipher text buffer. The buffer shall have the same size as the plain text buffer.

Returns

STATUS_SUCCESS if the command was successfully launched, STATUS_BUSY if another command was already launched. CSEC_DRV_GetAsyncCmdStatus can be used in order to check the execution status.

Definition at line 1247 of file csec_driver.c.

16.6.6.14 status_t CSEC_DRV_EncryptECB (csec_key_id_t *keyId,* const uint8_t * *plainText,* uint32_t *length,* uint8_t * *cipherText,* uint32_t *timeout*)

Performs the AES-128 encryption in ECB mode.

This function performs the AES-128 encryption in ECB mode of the input plain text buffer

Parameters

in	*keyId*	KeyID used to perform the cryptographic operation.
in	*plainText*	Pointer to the plain text buffer.
in	*length*	Number of bytes of plain text message to be encrypted. It should be multiple of 16 bytes.
out	*cipherText*	Pointer to the cipher text buffer. The buffer shall have the same size as the plain text buffer.
in	*timeout*	Timeout in milliseconds.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 166 of file csec_driver.c.

16.6.6.15 status_t CSEC_DRV_EncryptECBAsync (csec_key_id_t *keyId,* const uint8_t * *plainText,* uint32_t *length,* uint8_t * *cipherText*)

Asynchronously performs the AES-128 encryption in ECB mode.

This function performs the AES-128 encryption in ECB mode of the input plain text buffer, in an asynchronous manner.

Parameters

in	*keyId*	KeyID used to perform the cryptographic operation.
in	*plainText*	Pointer to the plain text buffer.
in	*length*	Number of bytes of plain text message to be encrypted. It should be multiple of 16 bytes.
out	*cipherText*	Pointer to the cipher text buffer. The buffer shall have the same size as the plain text buffer.

Returns

STATUS_SUCCESS if the command was successfully launched, STATUS_BUSY if another command was already launched. CSEC_DRV_GetAsyncCmdStatus can be used in order to check the execution status.

Definition at line 1183 of file csec_driver.c.

16.6.6.16 status_t CSEC_DRV_ExportRAMKey (uint8_t * *m1,* uint8_t * *m2,* uint8_t * *m3,* uint8_t * *m4,* uint8_t * *m5*)

Exports the RAM_KEY into a format protected by SECRET_KEY.

This function exports the RAM_KEY into a format protected by SECRET_KEY.

Parameters

out	*m1*	Pointer to a buffer where the M1 parameter will be exported.
out	*m2*	Pointer to a buffer where the M2 parameter will be exported.
out	*m3*	Pointer to a buffer where the M3 parameter will be exported.
out	*m4*	Pointer to a buffer where the M4 parameter will be exported.
out	*m5*	Pointer to a buffer where the M5 parameter will be exported.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 693 of file csec_driver.c.

16.6.6.17 status_t CSEC_DRV_ExtendSeed (const uint8_t * *entropy*)

Extends the seed of the PRNG.

Extends the seed of the PRNG by compressing the former seed value and the supplied entropy into a new seed. This new seed is then to be used to generate a random number by invoking the CMD_RND command. The random number generator must be initialized by CMD_INIT_RNG before the seed may be extended.

Parameters

in	*entropy*	Pointer to a 128-bit buffer containing the entropy.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 782 of file csec_driver.c.

16.6.6.18 status_t CSEC_DRV_GenerateMAC (csec_key_id_t *keyId,* const uint8_t * *msg,* uint32_t *msgLen,* uint8_t * *cmac,* uint32_t *timeout*)

Calculates the MAC of a given message using CMAC with AES-128.

This function calculates the MAC of a given message using CMAC with AES-128.

Parameters

in	*keyId*	KeyID used to perform the cryptographic operation.
in	*msg*	Pointer to the message buffer.
in	*msgLen*	Number of bits of message on which CMAC will be computed.
out	*cmac*	Pointer to the buffer containing the result of the CMAC computation.
in	*timeout*	Timeout in milliseconds.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 383 of file csec_driver.c.

16.6.6.19 status_t CSEC_DRV_GenerateMACAddrMode (csec_key_id_t *keyId*, const uint8_t * *msg*, uint32_t *msgLen*, uint8_t * *cmac*)

Calculates the MAC of a given message (located in Flash) using CMAC with AES-128.

This function calculates the MAC of a given message using CMAC with AES-128. It is different from the CSEC_↩ DRV_GenerateMAC function in the sense that it does not involve an extra copy of the data on which the CMAC is computed and the message pointer should be a pointer to Flash memory.

Parameters

in	*keyId*	KeyID used to perform the cryptographic operation.
in	*msg*	Pointer to the message buffer (pointing to Flash memory).
in	*msgLen*	Number of bits of message on which CMAC will be computed.
out	*cmac*	Pointer to the buffer containing the result of the CMAC computation.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 439 of file csec_driver.c.

16.6.6.20 status_t CSEC_DRV_GenerateMACAsync (csec_key_id_t *keyId*, const uint8_t * *msg*, uint32_t *msgLen*, uint8_t * *cmac*)

Asynchronously calculates the MAC of a given message using CMAC with AES-128.

This function calculates the MAC of a given message using CMAC with AES-128, in an asynchronous manner.

Parameters

in	*keyId*	KeyID used to perform the cryptographic operation.
in	*msg*	Pointer to the message buffer.
in	*msgLen*	Number of bits of message on which CMAC will be computed.
out	*cmac*	Pointer to the buffer containing the result of the CMAC computation.

Returns

STATUS_SUCCESS if the command was successfully launched, STATUS_BUSY if another command was already launched. CSEC_DRV_GetAsyncCmdStatus can be used in order to check the execution status.

Definition at line 1317 of file csec_driver.c.

16.6.6.21 status_t CSEC_DRV_GenerateRND (uint8_t * *rnd*)

Generates a vector of 128 random bits.

The function returns a vector of 128 random bits. The random number generator has to be initialized by calling CSEC_DRV_InitRNG before random numbers can be supplied.

Parameters

out	*rnd*	Pointer to a 128-bit buffer where the generated random number has to be stored.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 820 of file csec_driver.c.

16.6.6.22 status_t CSEC_DRV_GetAsyncCmdStatus (void)

Checks the status of the execution of an asynchronous command.

This function checks the status of the execution of an asynchronous command. If the command is still in progress, returns STATUS_BUSY.

Returns

Error Code after command execution.

Definition at line 1390 of file csec_driver.c.

16.6.6.23 status_t CSEC_DRV_GetID (const uint8_t * *challenge*, uint8_t * *uid*, uint8_t * *sreg*, uint8_t * *mac*)

Returns the identity (UID) and the value of the status register protected by a MAC over a challenge and the data.

This function returns the identity (UID) and the value of the status register protected by a MAC over a challenge and the data.

Parameters

in	*challenge*	Pointer to the 128-bit buffer containing Challenge data.
out	*uid*	Pointer to 120 bit buffer where the UID will be stored.
out	*sreg*	Value of the status register.
out	*mac*	Pointer to the 128 bit buffer where the MAC generated over challenge and UID and status will be stored.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 967 of file csec_driver.c.

16.6.6.24 static csec_status_t CSEC_DRV_GetStatus (void) [inline], [static]

Returns the content of the status register.

The function shall return the content of the status register.

Returns

Value of the status register.

Implements : CSEC_DRV_GetStatus_Activity

Definition at line 526 of file csec_driver.h.

16.6.6.25 void CSEC_DRV_Init (csec_state_t * *state*)

Initializes the internal state of the driver and enables the FTFC interrupt.

Parameters

in	*state*	Pointer to the state structure which will be used for holding the internal state of the driver.

Definition at line 131 of file csec_driver.c.

16.6.6.26 status_t CSEC_DRV_InitRNG (void)

Initializes the seed and derives a key for the PRNG.

The function initializes the seed and derives a key for the PRNG. The function must be called before CMD_RND after every power cycle/reset.

Returns

Error Code after command execution.

Definition at line 745 of file csec_driver.c.

16.6.6.27 void CSEC_DRV_InstallCallback (security_callback_t *callbackFunc,* void * *callbackParam*)

Installs a callback function which will be invoked when an asynchronous command finishes its execution.

Parameters

in	*callbackFunc*	The function to be invoked.
in	*callbackParam*	The parameter to be passed to the callback function.

Definition at line 1769 of file csec_driver.c.

16.6.6.28 status_t CSEC_DRV_LoadKey (csec_key_id_t *keyId,* const uint8_t * *m1,* const uint8_t * *m2,* const uint8_t * *m3,* uint8_t * *m4,* uint8_t * *m5*)

Updates an internal key per the SHE specification.

This function updates an internal key per the SHE specification.

Parameters

in	*keyId*	KeyID of the key to be updated.
in	*m1*	Pointer to the 128-bit M1 message containing the UID, Key ID and Authentication Key ID.
in	*m2*	Pointer to the 256-bit M2 message contains the new security flags, counter and the key value all encrypted using a derived key generated from the Authentication Key.
in	*m3*	Pointer to the 128-bit M3 message is a MAC generated over messages M1 and M2.
out	*m4*	Pointer to a 256 bits buffer where the computed M4 parameter is stored.
out	*m5*	Pointer to a 128 bits buffer where the computed M5 parameters is stored.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 602 of file csec_driver.c.

16.6.6.29 status_t CSEC_DRV_LoadPlainKey (const uint8_t * *plainKey*)

Updates the RAM key memory slot with a 128-bit plaintext.

The function updates the RAM key memory slot with a 128-bit plaintext. The key is loaded without encryption and verification of the key, i.e. the key is handed over in plaintext. A plain key can only be loaded into the RAM_KEY slot.

Parameters

in	*plainKey*	Pointer to the 128-bit buffer containing the key that needs to be copied in RAM_KEY slot.

Returns

Error Code after command execution.

Definition at line 656 of file csec_driver.c.

16.6.6.30 status_t CSEC_DRV_MPCompress (const uint8_t * *msg*, uint16_t *msgLen*, uint8_t * *mpCompress*, uint32_t *timeout*)

Compresses the given messages by accessing the Miyaguchi-Prenell compression feature with in the CSEc feature set.

This function accesses a Miyaguchi-Prenell compression feature within the CSEc feature set to compress the given messages.

Parameters

in	*msg*	Pointer to the messages to be compressed. Messages must be pre-processed per SHE specification if they do not already meet the full 128-bit block size requirement.
in	*msgLen*	The number of 128 bit messages to be compressed.
out	*mpCompress*	Pointer to the 128 bit buffer storing the compressed data.
in	*timeout*	Timeout in milliseconds.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 1096 of file csec_driver.c.

16.6.6.31 status_t CSEC_DRV_VerifyMAC (csec_key_id_t *keyId*, const uint8_t * *msg*, uint32_t *msgLen*, const uint8_t * *mac*, uint16_t *macLen*, bool * *verifStatus*, uint32_t *timeout*)

Verifies the MAC of a given message using CMAC with AES-128.

This function verifies the MAC of a given message using CMAC with AES-128.

Parameters

in	*keyId*	KeyID used to perform the cryptographic operation.
in	*msg*	Pointer to the message buffer.
in	*msgLen*	Number of bits of message on which CMAC will be computed.
in	*mac*	Pointer to the buffer containing the CMAC to be verified.
in	*macLen*	Number of bits of the CMAC to be compared. A macLength value of zero indicates that all 128-bits are compared.
out	*verifStatus*	Status of MAC verification command (true: verification operation passed, false: verification operation failed).
in	*timeout*	Timeout in milliseconds.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 484 of file csec_driver.c.

16.6.6.32 status_t CSEC_DRV_VerifyMACAddrMode (csec_key_id_t *keyId*, const uint8_t * *msg*, uint32_t *msgLen*, const uint8_t * *mac*, uint16_t *macLen*, bool * *verifStatus*)

Verifies the MAC of a given message (located in Flash) using CMAC with AES-128.

This function verifies the MAC of a given message using CMAC with AES-128. It is different from the CSEC_DRV↩ _VerifyMAC function in the sense that it does not involve an extra copy of the data on which the CMAC is computed and the message pointer should be a pointer to Flash memory.

Parameters

in	*keyId*	KeyID used to perform the cryptographic operation.
in	*msg*	Pointer to the message buffer (pointing to Flash memory).
in	*msgLen*	Number of bits of message on which CMAC will be computed.
in	*mac*	Pointer to the buffer containing the CMAC to be verified.
in	*macLen*	Number of bits of the CMAC to be compared. A macLength value of zero indicates that all 128-bits are compared.
out	*verifStatus*	Status of MAC verification command (true: verification operation passed, false: verification operation failed).

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 547 of file csec_driver.c.

16.6.6.33 status_t CSEC_DRV_VerifyMACAsync (csec_key_id_t *keyId*, const uint8_t * *msg*, uint32_t *msgLen*, const uint8_t * *mac*, uint16_t *macLen*, bool * *verifStatus*)

Asynchronously verifies the MAC of a given message using CMAC with AES-128.

This function verifies the MAC of a given message using CMAC with AES-128, in an asynchronous manner.

Parameters

in	*keyId*	KeyID used to perform the cryptographic operation.
in	*msg*	Pointer to the message buffer.
in	*msgLen*	Number of bits of message on which CMAC will be computed.
in	*mac*	Pointer to the buffer containing the CMAC to be verified.
in	*macLen*	Number of bits of the CMAC to be compared. A macLength value of zero indicates that all 128-bits are compared.
out	*verifStatus*	Status of MAC verification command (true: verification operation passed, false: verification operation failed).

Returns

STATUS_SUCCESS if the command was successfully launched, STATUS_BUSY if another command was already launched. CSEC_DRV_GetAsyncCmdStatus can be used in order to check the execution status.

Definition at line 1350 of file csec_driver.c.

16.7 Clock

16.7.1 Detailed Description

Dynamic clock setting

- status_t CLOCK_DRV_GetFreq (clock_names_t clockName, uint32_t *frequency)

  Gets the clock frequency for a specific clock name.
- status_t CLOCK_DRV_Init (clock_user_config_t const *config)

  Set clock configuration according to pre-defined structure.

16.7.2 Function Documentation

16.7.2.1 status_t CLOCK_DRV_GetFreq (clock_names_t *clockName*, uint32_t * *frequency*)

Gets the clock frequency for a specific clock name.

This function checks the current clock configurations and then calculates the clock frequency for a specific clock name defined in clock_names_t. Clock modules must be properly configured before using this function. See features.h for supported clock names for different chip families. The returned value is in Hertz. If it cannot find the clock name or the name is not supported for a specific chip family, it returns an STATUS_UNSUPPORTED. If frequency is required for a peripheral and the module is not clocked, then STATUS_MCU_GATED_OFF status is returned. Frequency is returned if a valid address is provided. If frequency is required for a peripheral that doesn't support protocol clock, the zero value is provided.

Parameters

in	*clockName*	Clock names defined in clock_names_t
out	*frequency*	Returned clock frequency value in Hertz

Returns

status Error code defined in status_t

Definition at line 1902 of file clock_S32K1xx.c.

16.7.2.2 status_t CLOCK_DRV_Init (clock_user_config_t const * *config*)

Set clock configuration according to pre-defined structure.

This function sets system to target clock configuration; It sets the clock modules registers for clock mode change.

Parameters

in	*config*	Pointer to configuration structure.

Returns

Error code.

Note

If external clock is used in the target mode, please make sure it is enabled, for example, if the external oscillator is used, please setup correctly.
If the configuration structure is NULL, the function will set a default configuration for clock.

Definition at line 603 of file clock_S32K1xx.c.

16.8 Clock Manager

16.8.1 Detailed Description

This module covers the clock management API and clock related functionality.

This section describes the programming interface of the clock_manager driver. Clock_manager achieves its functionality by configuring the hardware modules involved in clock distribution and management.

Driver consideration

The Clock Manager driver is developed on top of an appropriate hardware access layer. The Clock Manager provides API to handle the clock configuration. The Driver uses structures for configuration. The actual format of the structure is defined by the underlying device specific header file. These structures may be generated using S32DS configuration. The user application can use the default for most settings, changing only what is necessary.

This driver provides functions for initializing system clock and peripheral clock.

All methods that access the hardware layer will return an error code to signal if the operation succeeded or failed. The values are defined by the status_t enumeration, and the possible values include: success, error.

Modules

- Clock Manager Driver

  This module covers the device-specific clock_manager functionality implemented for S32K1xx SOC.

16.9 Clock Manager Driver

16.9.1 Detailed Description

This module covers the device-specific clock_manager functionality implemented for S32K1xx SOC.

The support for S32K1xx consist in the following items:

1. Clock names enumeration clock_names_t is an enumeration which contains all clock names which are relevant for S32K1xx.
2. Submodule configuration structures
   - scg_config_t
   - pcc_config_t
   - sim_clock_config_t
   - pmc_config_t
3. Submodule configuration functions The following functions were implemented for S32K1xx:
   - CLOCK_SYS_SetScgConfiguration
   - CLOCK_SYS_SetPccConfiguration
   - CLOCK_SYS_SetSimConfiguration
   - CLOCK_SYS_SetPmcConfiguration

Hardware background

Features of clock_manager module include the following clock sources:

- 4 - 40 MHz fast external oscillator (SOSC)
- 48 MHz Fast Internal RC oscillator (FIRC)
- 8 MHz Slow Internal RC oscillator (SIRC)
- 128 kHz Low Power Oscillator (LPO)
- Up to 112 MHz (HSRUN) System Phased Lock Loop (SPLL)

How to use the CLOCK_MANAGER driver in your application

In order to be able to use the clock_manager in your application, **CLOCK_DRV_Init** function has to be called. The same function is called when another configuration is loaded and clock configuration is updated.

Code Example

This is an example for switching between two configurations:

```
CLOCK_SYS_Init(g_clockManConfigsArr,
               CLOCK_MANAGER_CONFIG_CNT,
               g_clockManCallbacksArr,
               CLOCK_MANAGER_CALLBACK_CNT);

CLOCK_SYS_UpdateConfiguration(0,
      CLOCK_MANAGER_POLICY_FORCIBLE);
CLOCK_SYS_UpdateConfiguration(1,
      CLOCK_MANAGER_POLICY_FORCIBLE);
```

Notes

Current implementation assumes that the clock configurations are valid and are applied in a valid sequence. Mainly this means that the configuration doesn't reinitialize the clock used as the system clock.

According to Errata e10777, when the power mode is being switched, the core clock frequency is incorrectly read. As a result, when switching from VLPR mode to HSRUN, the frequency has to be read twice or after some time has passed.

The S32DS do not support generate Callbacks configuration. It's alway empty.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\clock\S32K1xx\clock_S32K1xx.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
${S32SDK_PATH}\platform\drivers\src\clock\
${S32SDK_PATH}\platform\drivers\src\clock\S32K1xx\
```

Compile symbols

No special symbols are required for this component

Dependencies

Interrupt Manager (Interrupt)

Data Structures

- struct sim_clock_out_config_t

  SIM ClockOut configuration. Implements sim_clock_out_config_t_Class. More...
- struct sim_lpo_clock_config_t

  SIM LPO Clocks configuration. Implements sim_lpo_clock_config_t_Class. More...
- struct sim_tclk_config_t

  SIM Platform Gate Clock configuration. Implements sim_tclk_config_t_Class. More...
- struct sim_plat_gate_config_t

  SIM Platform Gate Clock configuration. Implements sim_plat_gate_config_t_Class. More...
- struct sim_qspi_ref_clk_gating_t

  SIM QSPI reference clock gating. Implements sim_qspi_ref_clk_gating_t_Class. More...
- struct sim_trace_clock_config_t

  SIM Debug Trace clock configuration. Implements sim_trace_clock_config_t_Class. More...
- struct sim_clock_config_t

  SIM configure structure. Implements sim_clock_config_t_Class. More...
- struct scg_system_clock_config_t

  SCG system clock configuration. Implements scg_system_clock_config_t_Class. More...
- struct scg_sosc_config_t

  SCG system OSC configuration. Implements scg_sosc_config_t_Class. More...
- struct scg_sirc_config_t

  SCG slow IRC clock configuration. Implements scg_sirc_config_t_Class. More...
- struct scg_firc_config_t

SCG fast IRC clock configuration. Implements scg_firc_config_t_Class. More...

- struct scg_spll_config_t

  SCG system PLL configuration. Implements scg_spll_config_t_Class. More...
- struct scg_rtc_config_t

  SCG RTC configuration. Implements scg_rtc_config_t_Class. More...
- struct scg_clock_mode_config_t

  SCG Clock Mode Configuration structure. Implements scg_clock_mode_config_t_Class. More...
- struct scg_clockout_config_t

  SCG ClockOut Configuration structure. Implements scg_clockout_config_t_Class. More...
- struct scg_config_t

  SCG configure structure. Implements scg_config_t_Class. More...
- struct peripheral_clock_config_t

  PCC peripheral instance clock configuration. Implements peripheral_clock_config_t_Class. More...
- struct pcc_config_t

  PCC configuration. Implements pcc_config_t_Class. More...
- struct pmc_lpo_clock_config_t

  PMC LPO configuration. Implements pmc_lpo_clock_config_t_Class. More...
- struct pmc_config_t

  PMC configure structure. Implements pmc_config_t_Class. More...
- struct clock_manager_user_config_t

  Clock configuration structure. Implements clock_manager_user_config_t_Class. More...
- struct module_clk_config_t

  module clock configuration. Implements module_clk_config_t_Class More...
- struct sys_clk_config_t

  System clock configuration. Implements sys_clk_config_t_Class. More...
- struct clock_source_config_t

  Clock source configuration. Implements clock_source_config_t_Class. More...
- struct clock_notify_struct_t

  Clock notification structure passed to clock callback function. Implements clock_notify_struct_t_Class. More...
- struct clock_manager_callback_user_config_t

  Structure for callback function and its parameter. Implements clock_manager_callback_user_config_t_Class. More...
- struct clock_manager_state_t

  Clock manager state structure. Implements clock_manager_state_t_Class. More...

Macros

- #define NUMBER_OF_TCLK_INPUTS 3U

  TClk clock frequency.
- #define SYS_CLK_MAX_NO 3U

  The maximum number of system clock dividers and system clock divider indexes.
- #define CORE_CLK_INDEX 0U
- #define BUS_CLK_INDEX 1U
- #define SLOW_CLK_INDEX 2U
- #define CLK_SRC_OFF 0x00U
- #define CLK_SRC_SOSC 0x01U
- #define CLK_SRC_SIRC 0x02U
- #define CLK_SRC_FIRC 0x03U
- #define CLK_SRC_SPLL 0x06U
- #define CLK_SRC_SOSC_DIV1 0x01U
- #define CLK_SRC_SIRC_DIV1 0x02U
- #define CLK_SRC_FIRC_DIV1 0x03U

- #define CLK_SRC_SPLL_DIV1 0x06U
- #define CLK_SRC_SOSC_DIV2 0x01U
- #define CLK_SRC_SIRC_DIV2 0x02U
- #define CLK_SRC_FIRC_DIV2 0x03U
- #define CLK_SRC_SPLL_DIV2 0x06U

Typedefs

- typedef uint8_t peripheral_clock_source_t

  PCC clock source select Implements peripheral_clock_source_t_Class.
- typedef clock_manager_user_config_t clock_user_config_t
- typedef status_t(∗ clock_manager_callback_t) (clock_notify_struct_t ∗notify, void ∗callbackData)

  Type of clock callback functions.

Enumerations

- enum sim_rtc_clk_sel_src_t { SIM_RTCCLK_SEL_SOSCDIV1_CLK = 0x0U, SIM_RTCCLK_SEL_LPO_32K = 0x1U, SIM_RTCCLK_SEL_RTC_CLKIN = 0x2U, SIM_RTCCLK_SEL_FIRCDIV1_CLK = 0x3U }

  SIM CLK32KSEL clock source select Implements sim_rtc_clk_sel_src_t_Class.
- enum sim_lpoclk_sel_src_t { SIM_LPO_CLK_SEL_LPO_128K = 0x0, SIM_LPO_CLK_SEL_NO_CLOCK = 0x1, SIM_LPO_CLK_SEL_LPO_32K = 0x2, SIM_LPO_CLK_SEL_LPO_1K = 0x3 }

  SIM LPOCLKSEL clock source select Implements sim_lpoclk_sel_src_t_Class.
- enum sim_clkout_src_t {
  SIM_CLKOUT_SEL_SYSTEM_SCG_CLKOUT = 0U, SIM_CLKOUT_SEL_SYSTEM_SOSC_DIV2_CLK = 2U, SIM_CLKOUT_SEL_SYSTEM_SIRC_DIV2_CLK = 4U, SIM_CLKOUT_SEL_SYSTEM_FIRC_DIV2_CLK = 6U,
  SIM_CLKOUT_SEL_SYSTEM_HCLK = 7U, SIM_CLKOUT_SEL_SYSTEM_SPLL_DIV2_CLK = 8U, SIM_CLKOUT_SEL_SYSTEM_BUS_CLK = 9U, SIM_CLKOUT_SEL_SYSTEM_LPO_128K_CLK = 10U,
  SIM_CLKOUT_SEL_SYSTEM_LPO_CLK = 12U, SIM_CLKOUT_SEL_SYSTEM_RTC_CLK = 14U }

  SIM CLKOUT select Implements sim_clkout_src_t_Class.
- enum sim_clkout_div_t {
  SIM_CLKOUT_DIV_BY_1 = 0x0U, SIM_CLKOUT_DIV_BY_2 = 0x1U, SIM_CLKOUT_DIV_BY_3 = 0x2U, SIM_CLKOUT_DIV_BY_4 = 0x3U,
  SIM_CLKOUT_DIV_BY_5 = 0x4U, SIM_CLKOUT_DIV_BY_6 = 0x5U, SIM_CLKOUT_DIV_BY_7 = 0x6U, SIM_CLKOUT_DIV_BY_8 = 0x7U }

  SIM CLKOUT divider Implements sim_clkout_div_t_Class.
- enum clock_trace_src_t { CLOCK_TRACE_SRC_CORE_CLK = 0x0 }

  Debug trace clock source select Implements clock_trace_src_t_Class.
- enum scg_system_clock_src_t { SCG_SYSTEM_CLOCK_SRC_SYS_OSC = 1U, SCG_SYSTEM_CLOCK_SRC_SIRC = 2U, SCG_SYSTEM_CLOCK_SRC_FIRC = 3U, SCG_SYSTEM_CLOCK_SRC_NONE = 255U }

  SCG system clock source. Implements scg_system_clock_src_t_Class.
- enum scg_system_clock_div_t {
  SCG_SYSTEM_CLOCK_DIV_BY_1 = 0U, SCG_SYSTEM_CLOCK_DIV_BY_2 = 1U, SCG_SYSTEM_CLOCK_DIV_BY_3 = 2U, SCG_SYSTEM_CLOCK_DIV_BY_4 = 3U,
  SCG_SYSTEM_CLOCK_DIV_BY_5 = 4U, SCG_SYSTEM_CLOCK_DIV_BY_6 = 5U, SCG_SYSTEM_CLOCK_DIV_BY_7 = 6U, SCG_SYSTEM_CLOCK_DIV_BY_8 = 7U,
  SCG_SYSTEM_CLOCK_DIV_BY_9 = 8U, SCG_SYSTEM_CLOCK_DIV_BY_10 = 9U, SCG_SYSTEM_CLOCK_DIV_BY_11 = 10U, SCG_SYSTEM_CLOCK_DIV_BY_12 = 11U,
  SCG_SYSTEM_CLOCK_DIV_BY_13 = 12U, SCG_SYSTEM_CLOCK_DIV_BY_14 = 13U, SCG_SYSTEM_CLOCK_DIV_BY_15 = 14U, SCG_SYSTEM_CLOCK_DIV_BY_16 = 15U }

  SCG system clock divider value. Implements scg_system_clock_div_t_Class.

- enum scg_async_clock_div_t {
  SCG_ASYNC_CLOCK_DISABLE = 0U, SCG_ASYNC_CLOCK_DIV_BY_1 = 1U, SCG_ASYNC_CLOCK_↩
  DIV_BY_2 = 2U, SCG_ASYNC_CLOCK_DIV_BY_4 = 3U,
  SCG_ASYNC_CLOCK_DIV_BY_8 = 4U, SCG_ASYNC_CLOCK_DIV_BY_16 = 5U, SCG_ASYNC_CLOC↩
  K_DIV_BY_32 = 6U, SCG_ASYNC_CLOCK_DIV_BY_64 = 7U }

  SCG asynchronous clock divider value. Implements scg_async_clock_div_t_Class.
- enum scg_sosc_monitor_mode_t { SCG_SOSC_MONITOR_DISABLE = 0U, SCG_SOSC_MONITOR_INT = 1U, SCG_SOSC_MONITOR_RESET = 2U }

  SCG system OSC monitor mode. Implements scg_sosc_monitor_mode_t_Class.
- enum scg_sosc_range_t { SCG_SOSC_RANGE_MID = 2U, SCG_SOSC_RANGE_HIGH = 3U }

  SCG OSC frequency range select Implements scg_sosc_range_t_Class.
- enum scg_sosc_gain_t { SCG_SOSC_GAIN_LOW = 0x0, SCG_SOSC_GAIN_HIGH = 0x1 }

  SCG OSC high gain oscillator select. Implements scg_sosc_gain_t_Class.
- enum scg_sosc_ext_ref_t { SCG_SOSC_REF_EXT = 0x0, SCG_SOSC_REF_OSC = 0x1 }

  SCG OSC external reference clock select. Implements scg_sosc_ext_ref_t_Class.
- enum scg_sirc_range_t { SCG_SIRC_RANGE_HIGH = 1U }

  SCG slow IRC clock frequency range. Implements scg_sirc_range_t_Class.
- enum scg_firc_range_t { SCG_FIRC_RANGE_48M }

  SCG fast IRC clock frequency range. Implements scg_firc_range_t_Class.
- enum scg_spll_monitor_mode_t { SCG_SPLL_MONITOR_DISABLE = 0U, SCG_SPLL_MONITOR_INT = 1U, SCG_SPLL_MONITOR_RESET = 2U }

  SCG system PLL monitor mode. Implements scg_spll_monitor_mode_t_Class.
- enum scg_spll_clock_prediv_t {
  SCG_SPLL_CLOCK_PREDIV_BY_1 = 0U, SCG_SPLL_CLOCK_PREDIV_BY_2 = 1U, SCG_SPLL_CLO↩
  CK_PREDIV_BY_3 = 2U, SCG_SPLL_CLOCK_PREDIV_BY_4 = 3U,
  SCG_SPLL_CLOCK_PREDIV_BY_5 = 4U, SCG_SPLL_CLOCK_PREDIV_BY_6 = 5U, SCG_SPLL_CLO↩
  CK_PREDIV_BY_7 = 6U, SCG_SPLL_CLOCK_PREDIV_BY_8 = 7U }

  SCG system PLL predivider.
- enum scg_spll_clock_multiply_t {
  SCG_SPLL_CLOCK_MULTIPLY_BY_16 = 0U, SCG_SPLL_CLOCK_MULTIPLY_BY_17 = 1U, SCG_SPL↩
  L_CLOCK_MULTIPLY_BY_18 = 2U, SCG_SPLL_CLOCK_MULTIPLY_BY_19 = 3U,
  SCG_SPLL_CLOCK_MULTIPLY_BY_20 = 4U, SCG_SPLL_CLOCK_MULTIPLY_BY_21 = 5U, SCG_SPL↩
  L_CLOCK_MULTIPLY_BY_22 = 6U, SCG_SPLL_CLOCK_MULTIPLY_BY_23 = 7U,
  SCG_SPLL_CLOCK_MULTIPLY_BY_24 = 8U, SCG_SPLL_CLOCK_MULTIPLY_BY_25 = 9U, SCG_SPL↩
  L_CLOCK_MULTIPLY_BY_26 = 10U, SCG_SPLL_CLOCK_MULTIPLY_BY_27 = 11U,
  SCG_SPLL_CLOCK_MULTIPLY_BY_28 = 12U, SCG_SPLL_CLOCK_MULTIPLY_BY_29 = 13U, SCG_S↩
  PLL_CLOCK_MULTIPLY_BY_30 = 14U, SCG_SPLL_CLOCK_MULTIPLY_BY_31 = 15U,
  SCG_SPLL_CLOCK_MULTIPLY_BY_32 = 16U, SCG_SPLL_CLOCK_MULTIPLY_BY_33 = 17U, SCG_S↩
  PLL_CLOCK_MULTIPLY_BY_34 = 18U, SCG_SPLL_CLOCK_MULTIPLY_BY_35 = 19U,
  SCG_SPLL_CLOCK_MULTIPLY_BY_36 = 20U, SCG_SPLL_CLOCK_MULTIPLY_BY_37 = 21U, SCG_S↩
  PLL_CLOCK_MULTIPLY_BY_38 = 22U, SCG_SPLL_CLOCK_MULTIPLY_BY_39 = 23U,
  SCG_SPLL_CLOCK_MULTIPLY_BY_40 = 24U, SCG_SPLL_CLOCK_MULTIPLY_BY_41 = 25U, SCG_S↩
  PLL_CLOCK_MULTIPLY_BY_42 = 26U, SCG_SPLL_CLOCK_MULTIPLY_BY_43 = 27U,
  SCG_SPLL_CLOCK_MULTIPLY_BY_44 = 28U, SCG_SPLL_CLOCK_MULTIPLY_BY_45 = 29U, SCG_S↩
  PLL_CLOCK_MULTIPLY_BY_46 = 30U, SCG_SPLL_CLOCK_MULTIPLY_BY_47 = 31U }

  SCG system PLL multiplier.
- enum peripheral_clock_frac_t { MULTIPLY_BY_ONE = 0x00U, MULTIPLY_BY_TWO = 0x01U }

  PCC fractional value select Implements peripheral_clock_frac_t_Class.
- enum peripheral_clock_divider_t {
  DIVIDE_BY_ONE = 0x00U, DIVIDE_BY_TWO = 0x01U, DIVIDE_BY_THREE = 0x02U, DIVIDE_BY_FOUR = 0x03U,
  DIVIDE_BY_FIVE = 0x04U, DIVIDE_BY_SIX = 0x05U, DIVIDE_BY_SEVEN = 0x06U, DIVIDE_BY_EIGTH = 0x07U }

  PCC divider value select Implements peripheral_clock_divider_t_Class.

- enum pwr_modes_t {
  NO_MODE = 0U, RUN_MODE = (1U<<0U), VLPR_MODE = (1U<<1U), HSRUN_MODE = (1U<<2U),
  STOP_MODE = (1U<<3U), VLPS_MODE = (1U<<4U), ALL_MODES = 0x7FFFFFFF }

  Power mode. Implements pwr_modes_t_Class.
- enum xosc_ref_t { XOSC_EXT_REF = 0U, XOSC_INT_OSC = 1U }

  XOSC reference clock select (internal oscillator is bypassed or not) Implements xosc_ref_t_Class.
- enum clock_manager_notify_t { CLOCK_MANAGER_NOTIFY_RECOVER = 0x00U, CLOCK_MANAGER_NOTIFY_BEFORE = 0x01U, CLOCK_MANAGER_NOTIFY_AFTER = 0x02U }

  The clock notification type. Implements clock_manager_notify_t_Class.
- enum clock_manager_callback_type_t { CLOCK_MANAGER_CALLBACK_BEFORE = 0x01U, CLOCK_MANAGER_CALLBACK_AFTER = 0x02U, CLOCK_MANAGER_CALLBACK_BEFORE_AFTER = 0x03U }

  The callback type, indicates what kinds of notification this callback handles. Implements clock_manager_callback_type_t_Class.
- enum clock_manager_policy_t { CLOCK_MANAGER_POLICY_AGREEMENT, CLOCK_MANAGER_POLICY_FORCIBLE }

  Clock transition policy. Implements clock_manager_policy_t_Class.

Functions

- void CLOCK_DRV_SetModuleClock (clock_names_t peripheralClock, const module_clk_config_t *moduleClkConfig)

  Configures module clock.
- status_t CLOCK_DRV_SetSystemClock (const pwr_modes_t *mode, const sys_clk_config_t *sysClkConfig)

  Configures the system clocks.
- void CLOCK_DRV_GetSystemClockSource (sys_clk_config_t *sysClkConfig)

  Gets the system clock source.
- status_t CLOCK_DRV_SetClockSource (clock_names_t clockSource, const clock_source_config_t *clkSrcConfig)

  This function configures a clock source.
- status_t CLOCK_SYS_Init (clock_manager_user_config_t const **clockConfigsPtr, uint8_t configsNumber, clock_manager_callback_user_config_t **callbacksPtr, uint8_t callbacksNumber)

  Install pre-defined clock configurations.
- status_t CLOCK_SYS_UpdateConfiguration (uint8_t targetConfigIndex, clock_manager_policy_t policy)

  Set system clock configuration according to pre-defined structure.
- status_t CLOCK_SYS_SetConfiguration (clock_manager_user_config_t const *config)

  Set system clock configuration.
- uint8_t CLOCK_SYS_GetCurrentConfiguration (void)

  Get current system clock configuration.
- clock_manager_callback_user_config_t * CLOCK_SYS_GetErrorCallback (void)

  Get the callback which returns error in last clock switch.
- status_t CLOCK_SYS_GetFreq (clock_names_t clockName, uint32_t *frequency)

  Wrapper over CLOCK_DRV_GetFreq function. It's part of the old API.

Variables

- const uint8_t peripheralFeaturesList [CLOCK_NAME_COUNT]

  Peripheral features list Constant array storing the mappings between clock names of the peripherals and feature lists.
- uint32_t g_TClkFreq [NUMBER_OF_TCLK_INPUTS]
- uint32_t g_xtal0ClkFreq

  EXTAL0 clock frequency.
- uint32_t g_RtcClkInFreq

  RTC_CLKIN clock frequency.

SCG Clockout.

- enum scg_clockout_src_t {
  SCG_CLOCKOUT_SRC_SCG_SLOW = 0U, SCG_CLOCKOUT_SRC_SOSC = 1U, SCG_CLOCKOUT_S↩
  RC_SIRC = 2U, SCG_CLOCKOUT_SRC_FIRC = 3U,
  SCG_CLOCKOUT_SRC_SPLL = 6U }

  SCG ClockOut type. Implements scg_clockout_src_t_Class.

16.9.2 Data Structure Documentation

16.9.2.1 struct sim_clock_out_config_t

SIM ClockOut configuration. Implements sim_clock_out_config_t_Class.

Definition at line 142 of file clock_S32K1xx.h.

Data Fields

- bool initialize
- bool enable
- sim_clkout_src_t source
- sim_clkout_div_t divider

Field Documentation

16.9.2.1.1 sim_clkout_div_t divider

SIM ClockOut divide ratio.

Definition at line 147 of file clock_S32K1xx.h.

16.9.2.1.2 bool enable

SIM ClockOut enable.

Definition at line 145 of file clock_S32K1xx.h.

16.9.2.1.3 bool initialize

Initialize or not the ClockOut clock.

Definition at line 144 of file clock_S32K1xx.h.

16.9.2.1.4 sim_clkout_src_t source

SIM ClockOut source select.

Definition at line 146 of file clock_S32K1xx.h.

16.9.2.2 struct sim_lpo_clock_config_t

SIM LPO Clocks configuration. Implements sim_lpo_clock_config_t_Class.

Definition at line 155 of file clock_S32K1xx.h.

Data Fields

- bool initialize
- sim_rtc_clk_sel_src_t sourceRtcClk
- sim_lpoclk_sel_src_t sourceLpoClk
- bool enableLpo32k
- bool enableLpo1k

Field Documentation

16.9.2.2.1 bool enableLpo1k

MSCM Clock Gating Control enable.

Definition at line 161 of file clock_S32K1xx.h.

16.9.2.2.2 bool enableLpo32k

MSCM Clock Gating Control enable.

Definition at line 160 of file clock_S32K1xx.h.

16.9.2.2.3 bool initialize

Initialize or not the LPO clock.

Definition at line 157 of file clock_S32K1xx.h.

16.9.2.2.4 sim_lpoclk_sel_src_t sourceLpoClk

LPO clock source select.

Definition at line 159 of file clock_S32K1xx.h.

16.9.2.2.5 sim_rtc_clk_sel_src_t sourceRtcClk

RTC_CLK source select.

Definition at line 158 of file clock_S32K1xx.h.

16.9.2.3 struct sim_tclk_config_t

SIM Platform Gate Clock configuration. Implements sim_tclk_config_t_Class.

Definition at line 168 of file clock_S32K1xx.h.

Data Fields

- bool initialize
- uint32_t tclkFreq [NUMBER_OF_TCLK_INPUTS]
- uint32_t extPinSrc [FTM_INSTANCE_COUNT]

Field Documentation

16.9.2.3.1 uint32_t extPinSrc[FTM_INSTANCE_COUNT]

FTMx frequency.

Definition at line 172 of file clock_S32K1xx.h.

16.9.2.3.2 bool initialize

Initialize or not the TCLK clock.

Definition at line 170 of file clock_S32K1xx.h.

16.9.2.3.3 uint32_t tclkFreq[NUMBER_OF_TCLK_INPUTS]

TCLKx frequency.

Definition at line 171 of file clock_S32K1xx.h.

16.9.2.4 struct sim_plat_gate_config_t

SIM Platform Gate Clock configuration. Implements sim_plat_gate_config_t_Class.

Definition at line 179 of file clock_S32K1xx.h.

Data Fields

- bool initialize
- bool enableMscm
- bool enableMpu
- bool enableDma
- bool enableErm
- bool enableEim

Field Documentation

16.9.2.4.1 bool enableDma

DMA Clock Gating Control enable.

Definition at line 184 of file clock_S32K1xx.h.

16.9.2.4.2 bool enableEim

EIM Clock Gating Control enable.

Definition at line 186 of file clock_S32K1xx.h.

16.9.2.4.3 bool enableErm

ERM Clock Gating Control enable.

Definition at line 185 of file clock_S32K1xx.h.

16.9.2.4.4 bool enableMpu

MPU Clock Gating Control enable.

Definition at line 183 of file clock_S32K1xx.h.

16.9.2.4.5 bool enableMscm

MSCM Clock Gating Control enable.

Definition at line 182 of file clock_S32K1xx.h.

16.9.2.4.6 bool initialize

Initialize or not the Trace clock.

Definition at line 181 of file clock_S32K1xx.h.

16.9.2.5 struct sim_qspi_ref_clk_gating_t

SIM QSPI reference clock gating. Implements sim_qspi_ref_clk_gating_t_Class.

Definition at line 193 of file clock_S32K1xx.h.

Data Fields

- bool enableQspiRefClk

Field Documentation

16.9.2.5.1 bool enableQspiRefClk

qspi internal reference clock gating control enable.

Definition at line 195 of file clock_S32K1xx.h.

16.9.2.6 struct sim_trace_clock_config_t

SIM Debug Trace clock configuration. Implements sim_trace_clock_config_t_Class.

Definition at line 213 of file clock_S32K1xx.h.

Data Fields

- bool initialize
- bool divEnable
- clock_trace_src_t source
- uint8_t divider
- bool divFraction

Field Documentation

16.9.2.6.1 bool divEnable

Trace clock divider enable.

Definition at line 216 of file clock_S32K1xx.h.

16.9.2.6.2 bool divFraction

Trace clock divider fraction.

Definition at line 219 of file clock_S32K1xx.h.

16.9.2.6.3 uint8_t divider

Trace clock divider divisor.

Definition at line 218 of file clock_S32K1xx.h.

16.9.2.6.4 bool initialize

Initialize or not the Trace clock.

Definition at line 215 of file clock_S32K1xx.h.

16.9.2.6.5 clock_trace_src_t source

Trace clock select.

Definition at line 217 of file clock_S32K1xx.h.

16.9.2.7 struct sim_clock_config_t

SIM configure structure. Implements sim_clock_config_t_Class.

Definition at line 226 of file clock_S32K1xx.h.

Data Fields

- sim_clock_out_config_t clockOutConfig
- sim_lpo_clock_config_t lpoClockConfig
- sim_tclk_config_t tclkConfig
- sim_plat_gate_config_t platGateConfig
- sim_trace_clock_config_t traceClockConfig
- sim_qspi_ref_clk_gating_t qspiRefClkGating

Field Documentation

16.9.2.7.1 sim_clock_out_config_t clockOutConfig

Clock Out configuration.

Definition at line 228 of file clock_S32K1xx.h.

16.9.2.7.2 sim_lpo_clock_config_t lpoClockConfig

Low Power Clock configuration.

Definition at line 229 of file clock_S32K1xx.h.

16.9.2.7.3 sim_plat_gate_config_t platGateConfig

Platform Gate Clock configuration.

Definition at line 231 of file clock_S32K1xx.h.

16.9.2.7.4 sim_qspi_ref_clk_gating_t qspiRefClkGating

Qspi Reference Clock Gating.

Definition at line 233 of file clock_S32K1xx.h.

16.9.2.7.5 sim_tclk_config_t tclkConfig

TCLK, FTM option Clock configuration.

Definition at line 230 of file clock_S32K1xx.h.

16.9.2.7.6 sim_trace_clock_config_t traceClockConfig

Trace clock configuration.

Definition at line 232 of file clock_S32K1xx.h.

16.9.2.8 struct scg_system_clock_config_t

SCG system clock configuration. Implements scg_system_clock_config_t_Class.

Definition at line 280 of file clock_S32K1xx.h.

Data Fields

- scg_system_clock_div_t divSlow
- scg_system_clock_div_t divBus
- scg_system_clock_div_t divCore
- scg_system_clock_src_t src

Field Documentation

16.9.2.8.1 scg_system_clock_div_t divBus

BUS clock divider.

Definition at line 283 of file clock_S32K1xx.h.

16.9.2.8.2 scg_system_clock_div_t divCore

Core clock divider.

Definition at line 284 of file clock_S32K1xx.h.

16.9.2.8.3 scg_system_clock_div_t divSlow

Slow clock divider.

Definition at line 282 of file clock_S32K1xx.h.

16.9.2.8.4 scg_system_clock_src_t src

System clock source.

Definition at line 285 of file clock_S32K1xx.h.

16.9.2.9 struct scg_sosc_config_t

SCG system OSC configuration. Implements scg_sosc_config_t_Class.

Definition at line 370 of file clock_S32K1xx.h.

Data Fields

- uint32_t freq
- scg_sosc_monitor_mode_t monitorMode
- scg_sosc_ext_ref_t extRef
- scg_sosc_gain_t gain
- scg_sosc_range_t range
- scg_async_clock_div_t div1
- scg_async_clock_div_t div2
- bool enableInStop
- bool enableInLowPower
- bool locked
- bool initialize

Field Documentation

16.9.2.9.1 scg_async_clock_div_t div1

Asynchronous peripheral source.

Definition at line 381 of file clock_S32K1xx.h.

16.9.2.9.2 scg_async_clock_div_t div2

Asynchronous peripheral source.

Definition at line 382 of file clock_S32K1xx.h.

16.9.2.9.3 bool enableInLowPower

System OSC is enable or not in low power mode.

Definition at line 385 of file clock_S32K1xx.h.

16.9.2.9.4 bool enableInStop

System OSC is enable or not in stop mode.

Definition at line 384 of file clock_S32K1xx.h.

16.9.2.9.5 scg_sosc_ext_ref_t extRef

System OSC External Reference Select.

Definition at line 376 of file clock_S32K1xx.h.

16.9.2.9.6 uint32_t freq

System OSC frequency.

Definition at line 372 of file clock_S32K1xx.h.

16.9.2.9.7 scg_sosc_gain_t gain

System OSC high-gain operation.

Definition at line 377 of file clock_S32K1xx.h.

16.9.2.9.8 bool initialize

Initialize or not the System OSC module.

Definition at line 389 of file clock_S32K1xx.h.

16.9.2.9.9 bool locked

System OSC Control Register can be written.

Definition at line 387 of file clock_S32K1xx.h.

16.9.2.9.10 scg_sosc_monitor_mode_t monitorMode

System OSC Clock monitor mode.

Definition at line 374 of file clock_S32K1xx.h.

16.9.2.9.11 scg_sosc_range_t range

System OSC frequency range.

Definition at line 379 of file clock_S32K1xx.h.

16.9.2.10 struct scg_sirc_config_t

SCG slow IRC clock configuration. Implements scg_sirc_config_t_Class.

Definition at line 405 of file clock_S32K1xx.h.

Data Fields

- scg_sirc_range_t range
- scg_async_clock_div_t div1
- scg_async_clock_div_t div2
- bool initialize
- bool enableInStop
- bool enableInLowPower
- bool locked

Field Documentation

16.9.2.10.1 scg_async_clock_div_t div1

Asynchronous peripheral source.

Definition at line 409 of file clock_S32K1xx.h.

16.9.2.10.2 scg_async_clock_div_t div2

Asynchronous peripheral source.

Definition at line 410 of file clock_S32K1xx.h.

16.9.2.10.3 bool enableInLowPower

SIRC is enable or not in low power mode.

Definition at line 414 of file clock_S32K1xx.h.

16.9.2.10.4 bool enableInStop

SIRC is enable or not in stop mode.

Definition at line 413 of file clock_S32K1xx.h.

16.9.2.10.5 bool initialize

Initialize or not the SIRC module.

Definition at line 412 of file clock_S32K1xx.h.

16.9.2.10.6 bool locked

SIRC Control Register can be written.

Definition at line 416 of file clock_S32K1xx.h.

16.9.2.10.7 scg_sirc_range_t range

Slow IRC frequency range.

Definition at line 407 of file clock_S32K1xx.h.

16.9.2.11 struct scg_firc_config_t

SCG fast IRC clock configuration. Implements scg_firc_config_t_Class.

Definition at line 432 of file clock_S32K1xx.h.

Data Fields

- scg_firc_range_t range
- scg_async_clock_div_t div1
- scg_async_clock_div_t div2
- bool enableInStop
- bool enableInLowPower
- bool regulator
- bool locked
- bool initialize

Field Documentation

16.9.2.11.1 scg_async_clock_div_t div1

Asynchronous peripheral source.

Definition at line 436 of file clock_S32K1xx.h.

16.9.2.11.2 scg_async_clock_div_t div2

Asynchronous peripheral source.

Definition at line 437 of file clock_S32K1xx.h.

16.9.2.11.3 bool enableInLowPower

FIRC is enable or not in lowpower mode.

Definition at line 440 of file clock_S32K1xx.h.

16.9.2.11.4 bool enableInStop

FIRC is enable or not in stop mode.

Definition at line 439 of file clock_S32K1xx.h.

16.9.2.11.5 bool initialize

Initialize or not the FIRC module.

Definition at line 444 of file clock_S32K1xx.h.

16.9.2.11.6 bool locked

FIRC Control Register can be written.

Definition at line 442 of file clock_S32K1xx.h.

16.9.2.11.7 scg_firc_range_t range

Fast IRC frequency range.

Definition at line 434 of file clock_S32K1xx.h.

16.9.2.11.8 bool regulator

FIRC regulator is enable or not.

Definition at line 441 of file clock_S32K1xx.h.

16.9.2.12 struct scg_spll_config_t

SCG system PLL configuration. Implements scg_spll_config_t_Class.

Definition at line 518 of file clock_S32K1xx.h.

Data Fields

- scg_spll_monitor_mode_t monitorMode
- uint8_t prediv
- uint8_t mult
- uint8_t src
- scg_async_clock_div_t div1
- scg_async_clock_div_t div2
- bool enableInStop
- bool locked
- bool initialize

Field Documentation

16.9.2.12.1 scg_async_clock_div_t div1

Asynchronous peripheral source.

Definition at line 526 of file clock_S32K1xx.h.

16.9.2.12.2 scg_async_clock_div_t div2

Asynchronous peripheral source.

Definition at line 527 of file clock_S32K1xx.h.

16.9.2.12.3 bool enableInStop

System PLL clock is enable or not in stop mode.

Definition at line 529 of file clock_S32K1xx.h.

16.9.2.12.4 bool initialize

Initialize or not the System PLL module.

Definition at line 532 of file clock_S32K1xx.h.

16.9.2.12.5 bool locked

System PLL Control Register can be written.

Definition at line 531 of file clock_S32K1xx.h.

16.9.2.12.6 scg_spll_monitor_mode_t monitorMode

Clock monitor mode selected.

Definition at line 520 of file clock_S32K1xx.h.

16.9.2.12.7 uint8_t mult

System PLL multiplier.

Definition at line 523 of file clock_S32K1xx.h.

16.9.2.12.8 uint8_t prediv

PLL reference clock divider.

Definition at line 522 of file clock_S32K1xx.h.

16.9.2.12.9 uint8_t src

System PLL source.

Definition at line 524 of file clock_S32K1xx.h.

16.9.2.13 struct scg_rtc_config_t

SCG RTC configuration. Implements scg_rtc_config_t_Class.

Definition at line 539 of file clock_S32K1xx.h.

Data Fields

- uint32_t rtcClkInFreq
- bool initialize

Field Documentation

16.9.2.13.1 bool initialize

Initialize or not the RTC.

Definition at line 542 of file clock_S32K1xx.h.

16.9.2.13.2 uint32_t rtcClkInFreq

RTC_CLKIN frequency.

Definition at line 541 of file clock_S32K1xx.h.

16.9.2.14 struct scg_clock_mode_config_t

SCG Clock Mode Configuration structure. Implements scg_clock_mode_config_t_Class.

Definition at line 549 of file clock_S32K1xx.h.

Data Fields

- scg_system_clock_config_t rccrConfig
- scg_system_clock_config_t vccrConfig
- scg_system_clock_config_t hccrConfig
- scg_system_clock_src_t alternateClock
- bool initialize

Field Documentation

16.9.2.14.1 scg_system_clock_src_t alternateClock

Alternate clock used during initialization

Definition at line 554 of file clock_S32K1xx.h.

16.9.2.14.2 scg_system_clock_config_t hccrConfig

HSRUN Clock Control configuration.

Definition at line 553 of file clock_S32K1xx.h.

16.9.2.14.3 bool initialize

Initialize or not the Clock Mode Configuration.

Definition at line 555 of file clock_S32K1xx.h.

16.9.2.14.4 scg_system_clock_config_t rccrConfig

Run Clock Control configuration.

Definition at line 551 of file clock_S32K1xx.h.

16.9.2.14.5 scg_system_clock_config_t vccrConfig

VLPR Clock Control configuration.

Definition at line 552 of file clock_S32K1xx.h.

16.9.2.15 struct scg_clockout_config_t

SCG ClockOut Configuration structure. Implements scg_clockout_config_t_Class.

Definition at line 562 of file clock_S32K1xx.h.

Data Fields

- scg_clockout_src_t source
- bool initialize

Field Documentation

16.9.2.15.1 bool initialize

Initialize or not the ClockOut.

Definition at line 565 of file clock_S32K1xx.h.

16.9.2.15.2 scg_clockout_src_t source

ClockOut source select.

Definition at line 564 of file clock_S32K1xx.h.

16.9.2.16 struct scg_config_t

SCG configure structure. Implements scg_config_t_Class.

Definition at line 572 of file clock_S32K1xx.h.

Data Fields

- scg_sirc_config_t sircConfig
- scg_firc_config_t fircConfig
- scg_sosc_config_t soscConfig
- scg_spll_config_t spllConfig
- scg_rtc_config_t rtcConfig
- scg_clockout_config_t clockOutConfig
- scg_clock_mode_config_t clockModeConfig

Field Documentation

16.9.2.16.1 scg_clock_mode_config_t clockModeConfig

SCG Clock Mode Configuration.

Definition at line 580 of file clock_S32K1xx.h.

16.9.2.16.2 scg_clockout_config_t clockOutConfig

SCG ClockOut Configuration.

Definition at line 579 of file clock_S32K1xx.h.

16.9.2.16.3 scg_firc_config_t fircConfig

Fast internal reference clock configuration.

Definition at line 575 of file clock_S32K1xx.h.

16.9.2.16.4 scg_rtc_config_t rtcConfig

Real Time Clock configuration.

Definition at line 578 of file clock_S32K1xx.h.

16.9.2.16.5 scg_sirc_config_t sircConfig

Slow internal reference clock configuration.

Definition at line 574 of file clock_S32K1xx.h.

16.9.2.16.6 scg_sosc_config_t soscConfig

System oscillator configuration.

Definition at line 576 of file clock_S32K1xx.h.

16.9.2.16.7 scg_spll_config_t spllConfig

System Phase locked loop configuration.

Definition at line 577 of file clock_S32K1xx.h.

16.9.2.17 struct peripheral_clock_config_t

PCC peripheral instance clock configuration. Implements peripheral_clock_config_t_Class.

Definition at line 632 of file clock_S32K1xx.h.

Data Fields

- clock_names_t clockName
- bool clkGate
- peripheral_clock_source_t clkSrc
- peripheral_clock_frac_t frac
- peripheral_clock_divider_t divider

Field Documentation

16.9.2.17.1 bool clkGate

Peripheral clock gate.

Definition at line 642 of file clock_S32K1xx.h.

16.9.2.17.2 peripheral_clock_source_t clkSrc

Peripheral clock source.

Definition at line 643 of file clock_S32K1xx.h.

16.9.2.17.3 clock_names_t clockName

Definition at line 641 of file clock_S32K1xx.h.

16.9.2.17.4 peripheral_clock_divider_t divider

Peripheral clock divider value.

Definition at line 645 of file clock_S32K1xx.h.

16.9.2.17.5 peripheral_clock_frac_t frac

Peripheral clock fractional value.

Definition at line 644 of file clock_S32K1xx.h.

16.9.2.18 struct pcc_config_t

PCC configuration. Implements pcc_config_t_Class.

Definition at line 651 of file clock_S32K1xx.h.

Data Fields

- uint32_t count
- peripheral_clock_config_t * peripheralClocks

Field Documentation

16.9.2.18.1 uint32_t count

Number of peripherals to be configured.

Definition at line 653 of file clock_S32K1xx.h.

16.9.2.18.2 peripheral_clock_config_t* peripheralClocks

Pointer to the peripheral clock configurations array.

Definition at line 654 of file clock_S32K1xx.h.

16.9.2.19 struct pmc_lpo_clock_config_t

PMC LPO configuration. Implements pmc_lpo_clock_config_t_Class.

Definition at line 660 of file clock_S32K1xx.h.

Data Fields

- bool initialize
- bool enable
- int8_t trimValue

Field Documentation

16.9.2.19.1 bool enable

Enable/disable LPO

Definition at line 663 of file clock_S32K1xx.h.

16.9.2.19.2 bool initialize

Initialize or not the PMC LPO settings.

Definition at line 662 of file clock_S32K1xx.h.

16.9.2.19.3 int8_t trimValue

LPO trimming value

Definition at line 664 of file clock_S32K1xx.h.

16.9.2.20 struct pmc_config_t

PMC configure structure. Implements pmc_config_t_Class.

Definition at line 671 of file clock_S32K1xx.h.

Data Fields

- pmc_lpo_clock_config_t lpoClockConfig

Field Documentation

16.9.2.20.1 pmc_lpo_clock_config_t lpoClockConfig

Low Power Clock configuration.

Definition at line 673 of file clock_S32K1xx.h.

16.9.2.21 struct clock_manager_user_config_t

Clock configuration structure. Implements clock_manager_user_config_t_Class.

Definition at line 680 of file clock_S32K1xx.h.

Data Fields

- scg_config_t scgConfig
- sim_clock_config_t simConfig
- pcc_config_t pccConfig
- pmc_config_t pmcConfig

Field Documentation

16.9.2.21.1 pcc_config_t pccConfig

PCC Clock configuration.

Definition at line 684 of file clock_S32K1xx.h.

16.9.2.21.2 pmc_config_t pmcConfig

PMC Clock configuration.

Definition at line 685 of file clock_S32K1xx.h.

16.9.2.21.3 scg_config_t scgConfig

SCG Clock configuration.

Definition at line 682 of file clock_S32K1xx.h.

16.9.2.21.4 sim_clock_config_t simConfig

SIM Clock configuration.

Definition at line 683 of file clock_S32K1xx.h.

16.9.2.22 struct module_clk_config_t

module clock configuration. Implements module_clk_config_t_Class

Definition at line 720 of file clock_S32K1xx.h.

Data Fields

- bool gating
- clock_names_t source
- uint16_t mul
- uint16_t div

Field Documentation

16.9.2.22.1 uint16_t div

Divider (some modules don't have divider)

Definition at line 725 of file clock_S32K1xx.h.

16.9.2.22.2 bool gating

Clock gating.

Definition at line 722 of file clock_S32K1xx.h.

16.9.2.22.3 uint16_t mul

Multiplier (some modules don't have fractional)

Definition at line 724 of file clock_S32K1xx.h.

16.9.2.22.4 clock_names_t source

Clock source input (some modules don't have protocol clock)

Definition at line 723 of file clock_S32K1xx.h.

16.9.2.23 struct sys_clk_config_t

System clock configuration. Implements sys_clk_config_t_Class.

Definition at line 733 of file clock_S32K1xx.h.

Data Fields

- clock_names_t src
- uint16_t dividers [SYS_CLK_MAX_NO]

Field Documentation

16.9.2.23.1 uint16_t dividers[SYS_CLK_MAX_NO]

System clock dividers. Value by which system clock is divided. 0 means that system clock is not divided.

Definition at line 736 of file clock_S32K1xx.h.

16.9.2.23.2 clock_names_t src

System clock source.

Definition at line 735 of file clock_S32K1xx.h.

16.9.2.24 struct clock_source_config_t

Clock source configuration. Implements clock_source_config_t_Class.

Definition at line 743 of file clock_S32K1xx.h.

Data Fields

- bool enable
- xosc_ref_t refClk
- uint32_t refFreq
- uint16_t mul
- uint16_t div
- uint16_t outputDiv1
- uint16_t outputDiv2

Field Documentation

16.9.2.24.1 uint16_t div

Divider. It applies to PLL clock sources. Valid range is 1-8.

Definition at line 749 of file clock_S32K1xx.h.

16.9.2.24.2 bool enable

Enable/disable clock source.

Definition at line 745 of file clock_S32K1xx.h.

16.9.2.24.3 uint16_t mul

Multiplier. It applies to PLL clock sources. Valid range is 16 - 47.

Definition at line 748 of file clock_S32K1xx.h.

16.9.2.24.4 uint16_t outputDiv1

First output divider. It's used as protocol clock by modules. Zero means that divider is disabled. / Possible values 0(disabled), 1, 2, 4, 8, 16, 32, 64; all the other values are not valid. /

Definition at line 751 of file clock_S32K1xx.h.

16.9.2.24.5 uint16_t outputDiv2

Second output divider. It's used as protocol clock by modules. Zero means that divider is disabled. / Possible values 0(disabled), 1, 2, 4, 8, 16, 32, 64; all the other values are not valid. /

Definition at line 754 of file clock_S32K1xx.h.

16.9.2.24.6 xosc_ref_t refClk

Bypass option. It applies to external oscillator clock sources

Definition at line 746 of file clock_S32K1xx.h.

16.9.2.24.7 uint32_t refFreq

Frequency of the input reference clock. It applies to external oscillator clock sources

Definition at line 747 of file clock_S32K1xx.h.

16.9.2.25 struct clock_notify_struct_t

Clock notification structure passed to clock callback function. Implements clock_notify_struct_t_Class.

Definition at line 797 of file clock_S32K1xx.h.

Data Fields

- uint8_t targetClockConfigIndex
- clock_manager_policy_t policy
- clock_manager_notify_t notifyType

Field Documentation

16.9.2.25.1 clock_manager_notify_t notifyType

Clock notification type.

Definition at line 801 of file clock_S32K1xx.h.

16.9.2.25.2 clock_manager_policy_t policy

Clock transition policy.

Definition at line 800 of file clock_S32K1xx.h.

16.9.2.25.3 uint8_t targetClockConfigIndex

Target clock configuration index.

Definition at line 799 of file clock_S32K1xx.h.

16.9.2.26 struct clock_manager_callback_user_config_t

Structure for callback function and its parameter. Implements clock_manager_callback_user_config_t_Class.

Definition at line 814 of file clock_S32K1xx.h.

Data Fields

- clock_manager_callback_t callback
- clock_manager_callback_type_t callbackType
- void * callbackData

Field Documentation

16.9.2.26.1 clock_manager_callback_t callback

Entry of callback function.

Definition at line 816 of file clock_S32K1xx.h.

16.9.2.26.2 void* callbackData

Parameter of callback function.

Definition at line 818 of file clock_S32K1xx.h.

16.9.2.26.3 clock_manager_callback_type_t callbackType

Callback type.

Definition at line 817 of file clock_S32K1xx.h.

16.9.2.27 struct clock_manager_state_t

Clock manager state structure. Implements clock_manager_state_t_Class.

Definition at line 825 of file clock_S32K1xx.h.

Data Fields

- clock_manager_user_config_t const ** configTable
- uint8_t clockConfigNum
- uint8_t curConfigIndex
- clock_manager_callback_user_config_t ** callbackConfig
- uint8_t callbackNum
- uint8_t errorCallbackIndex

Field Documentation

16.9.2.27.1 clock_manager_callback_user_config_t** callbackConfig

Pointer to callback table.

Definition at line 830 of file clock_S32K1xx.h.

16.9.2.27.2 uint8_t callbackNum

Number of clock callbacks.

Definition at line 831 of file clock_S32K1xx.h.

16.9.2.27.3 uint8_t clockConfigNum

Number of clock configurations.

Definition at line 828 of file clock_S32K1xx.h.

16.9.2.27.4 clock_manager_user_config_t const** configTable

Pointer to clock configure table.

Definition at line 827 of file clock_S32K1xx.h.

16.9.2.27.5 uint8_t curConfigIndex

Index of current configuration.

Definition at line 829 of file clock_S32K1xx.h.

16.9.2.27.6 uint8_t errorCallbackIndex

Index of callback returns error.

Definition at line 832 of file clock_S32K1xx.h.

16.9.3 Macro Definition Documentation

16.9.3.1 #define BUS_CLK_INDEX 1U

Definition at line 69 of file clock_S32K1xx.h.

16.9.3.2 #define CLK_SRC_FIRC 0x03U

SCGFIRCLK - Fast IRC Clock

Definition at line 591 of file clock_S32K1xx.h.

16.9.3.3 #define CLK_SRC_FIRC_DIV1 0x03U

SCGFIRCLK - Fast IRC Clock

Definition at line 595 of file clock_S32K1xx.h.

16.9.3.4 #define CLK_SRC_FIRC_DIV2 0x03U

SCGFIRCLK - Fast IRC Clock

Definition at line 599 of file clock_S32K1xx.h.

16.9.3.5 #define CLK_SRC_OFF 0x00U

Clock is off

Definition at line 588 of file clock_S32K1xx.h.

16.9.3.6 #define CLK_SRC_SIRC 0x02U

SCGIRCLK - Slow IRC Clock

Definition at line 590 of file clock_S32K1xx.h.

16.9.3.7 #define CLK_SRC_SIRC_DIV1 0x02U

SCGIRCLK - Slow IRC Clock

Definition at line 594 of file clock_S32K1xx.h.

16.9.3.8 #define CLK_SRC_SIRC_DIV2 0x02U

SCGIRCLK - Slow IRC Clock

Definition at line 598 of file clock_S32K1xx.h.

16.9.3.9 #define CLK_SRC_SOSC 0x01U

OSCCLK - System Oscillator Bus Clock

Definition at line 589 of file clock_S32K1xx.h.

16.9.3.10 #define CLK_SRC_SOSC_DIV1 0x01U

OSCCLK - System Oscillator Bus Clock

Definition at line 593 of file clock_S32K1xx.h.

16.9.3.11 #define CLK_SRC_SOSC_DIV2 0x01U

OSCCLK - System Oscillator Bus Clock

Definition at line 597 of file clock_S32K1xx.h.

16.9.3.12 #define CLK_SRC_SPLL 0x06U

SCGPCLK System PLL clock

Definition at line 592 of file clock_S32K1xx.h.

16.9.3.13 #define CLK_SRC_SPLL_DIV1 0x06U

SCGPCLK System PLL clock

Definition at line 596 of file clock_S32K1xx.h.

16.9.3.14 #define CLK_SRC_SPLL_DIV2 0x06U

SCGPCLK System PLL clock

Definition at line 600 of file clock_S32K1xx.h.

16.9.3.15 #define CORE_CLK_INDEX 0U

Definition at line 68 of file clock_S32K1xx.h.

16.9.3.16 #define NUMBER_OF_TCLK_INPUTS 3U

TClk clock frequency.

Definition at line 57 of file clock_S32K1xx.h.

16.9.3.17 #define SLOW_CLK_INDEX 2U

Definition at line 70 of file clock_S32K1xx.h.

16.9.3.18 #define SYS_CLK_MAX_NO 3U

The maximum number of system clock dividers and system clock divider indexes.

Definition at line 67 of file clock_S32K1xx.h.

16.9.4 Typedef Documentation

16.9.4.1 typedef status_t(∗ clock_manager_callback_t) (clock_notify_struct_t ∗notify, void ∗callbackData)

Type of clock callback functions.

Definition at line 807 of file clock_S32K1xx.h.

16.9.4.2 typedef clock_manager_user_config_t clock_user_config_t

Definition at line 688 of file clock_S32K1xx.h.

16.9.4.3 typedef uint8_t peripheral_clock_source_t

PCC clock source select Implements peripheral_clock_source_t_Class.

Definition at line 586 of file clock_S32K1xx.h.

16.9.5 Enumeration Type Documentation

16.9.5.1 enum clock_manager_callback_type_t

The callback type, indicates what kinds of notification this callback handles. Implements clock_manager_callback↩ _type_t_Class.

Enumerator

CLOCK_MANAGER_CALLBACK_BEFORE Callback handles BEFORE notification.
CLOCK_MANAGER_CALLBACK_AFTER Callback handles AFTER notification.
CLOCK_MANAGER_CALLBACK_BEFORE_AFTER Callback handles BEFORE and AFTER notification

Definition at line 776 of file clock_S32K1xx.h.

16.9.5.2 enum clock_manager_notify_t

The clock notification type. Implements clock_manager_notify_t_Class.

Enumerator

CLOCK_MANAGER_NOTIFY_RECOVER Notify IP to recover to previous work state.
CLOCK_MANAGER_NOTIFY_BEFORE Notify IP that system will change clock setting.
CLOCK_MANAGER_NOTIFY_AFTER Notify IP that have changed to new clock setting.

Definition at line 765 of file clock_S32K1xx.h.

16.9.5.3 enum clock_manager_policy_t

Clock transition policy. Implements clock_manager_policy_t_Class.

Enumerator

CLOCK_MANAGER_POLICY_AGREEMENT Clock transfers gracefully.
CLOCK_MANAGER_POLICY_FORCIBLE Clock transfers forcefully.

Definition at line 787 of file clock_S32K1xx.h.

16.9.5.4 enum clock_trace_src_t

Debug trace clock source select Implements clock_trace_src_t_Class.

Enumerator

CLOCK_TRACE_SRC_CORE_CLK core clock

Definition at line 203 of file clock_S32K1xx.h.

16.9.5.5 enum peripheral_clock_divider_t

PCC divider value select Implements peripheral_clock_divider_t_Class.

Enumerator

DIVIDE_BY_ONE Divide by 1 (pass-through, no clock divide)
DIVIDE_BY_TWO Divide by 2
DIVIDE_BY_THREE Divide by 3
DIVIDE_BY_FOUR Divide by 4
DIVIDE_BY_FIVE Divide by 5
DIVIDE_BY_SIX Divide by 6
DIVIDE_BY_SEVEN Divide by 7
DIVIDE_BY_EIGTH Divide by 8

Definition at line 617 of file clock_S32K1xx.h.

16.9.5.6 enum peripheral_clock_frac_t

PCC fractional value select Implements peripheral_clock_frac_t_Class.

Enumerator

MULTIPLY_BY_ONE Fractional value is zero
MULTIPLY_BY_TWO Fractional value is one

Definition at line 608 of file clock_S32K1xx.h.

16.9.5.7 enum pwr_modes_t

Power mode. Implements pwr_modes_t_Class.

Enumerator

NO_MODE
RUN_MODE
VLPR_MODE
HSRUN_MODE
STOP_MODE
VLPS_MODE
ALL_MODES

Definition at line 694 of file clock_S32K1xx.h.

16.9.5.8 enum scg_async_clock_div_t

SCG asynchronous clock divider value. Implements scg_async_clock_div_t_Class.

Enumerator

SCG_ASYNC_CLOCK_DISABLE Clock output is disabled.
SCG_ASYNC_CLOCK_DIV_BY_1 Divided by 1.
SCG_ASYNC_CLOCK_DIV_BY_2 Divided by 2.
SCG_ASYNC_CLOCK_DIV_BY_4 Divided by 4.
SCG_ASYNC_CLOCK_DIV_BY_8 Divided by 8.
SCG_ASYNC_CLOCK_DIV_BY_16 Divided by 16.
SCG_ASYNC_CLOCK_DIV_BY_32 Divided by 32.
SCG_ASYNC_CLOCK_DIV_BY_64 Divided by 64.

Definition at line 312 of file clock_S32K1xx.h.

16.9.5.9 enum scg_clockout_src_t

SCG ClockOut type. Implements scg_clockout_src_t_Class.

Enumerator

SCG_CLOCKOUT_SRC_SCG_SLOW SCG SLOW.
SCG_CLOCKOUT_SRC_SOSC System OSC.
SCG_CLOCKOUT_SRC_SIRC Slow IRC.
SCG_CLOCKOUT_SRC_FIRC Fast IRC.
SCG_CLOCKOUT_SRC_SPLL System PLL.

Definition at line 297 of file clock_S32K1xx.h.

16.9.5.10 enum scg_firc_range_t

SCG fast IRC clock frequency range. Implements scg_firc_range_t_Class.

Enumerator

SCG_FIRC_RANGE_48M Fast IRC is trimmed to 48MHz.

Definition at line 423 of file clock_S32K1xx.h.

16.9.5.11 enum scg_sirc_range_t

SCG slow IRC clock frequency range. Implements scg_sirc_range_t_Class.

Enumerator

SCG_SIRC_RANGE_HIGH Slow IRC high range clock (8 MHz).

Definition at line 396 of file clock_S32K1xx.h.

16.9.5.12 enum scg_sosc_ext_ref_t

SCG OSC external reference clock select. Implements scg_sosc_ext_ref_t_Class.

Enumerator

SCG_SOSC_REF_EXT External reference clock requested
SCG_SOSC_REF_OSC Internal oscillator of OSC requested.

Definition at line 360 of file clock_S32K1xx.h.

16.9.5.13 enum scg_sosc_gain_t

SCG OSC high gain oscillator select. Implements scg_sosc_gain_t_Class.

Enumerator

SCG_SOSC_GAIN_LOW Configure crystal oscillator for low-power operation
SCG_SOSC_GAIN_HIGH Configure crystal oscillator for high-gain operation

Definition at line 350 of file clock_S32K1xx.h.

16.9.5.14 enum scg_sosc_monitor_mode_t

SCG system OSC monitor mode. Implements scg_sosc_monitor_mode_t_Class.

Enumerator

SCG_SOSC_MONITOR_DISABLE Monitor disable.
SCG_SOSC_MONITOR_INT Interrupt when system OSC error detected.
SCG_SOSC_MONITOR_RESET Reset when system OSC error detected.

Definition at line 329 of file clock_S32K1xx.h.

16.9.5.15 enum scg_sosc_range_t

SCG OSC frequency range select Implements scg_sosc_range_t_Class.

Enumerator

SCG_SOSC_RANGE_MID Medium frequency range selected for the crystal OSC (4 Mhz to 8 Mhz).
SCG_SOSC_RANGE_HIGH High frequency range selected for the crystal OSC (8 Mhz to 40 Mhz).

Definition at line 340 of file clock_S32K1xx.h.

16.9.5.16 enum scg_spll_clock_multiply_t

SCG system PLL multiplier.

Enumerator

SCG_SPLL_CLOCK_MULTIPLY_BY_16
SCG_SPLL_CLOCK_MULTIPLY_BY_17
SCG_SPLL_CLOCK_MULTIPLY_BY_18
SCG_SPLL_CLOCK_MULTIPLY_BY_19
SCG_SPLL_CLOCK_MULTIPLY_BY_20
SCG_SPLL_CLOCK_MULTIPLY_BY_21
SCG_SPLL_CLOCK_MULTIPLY_BY_22
SCG_SPLL_CLOCK_MULTIPLY_BY_23
SCG_SPLL_CLOCK_MULTIPLY_BY_24
SCG_SPLL_CLOCK_MULTIPLY_BY_25
SCG_SPLL_CLOCK_MULTIPLY_BY_26
SCG_SPLL_CLOCK_MULTIPLY_BY_27
SCG_SPLL_CLOCK_MULTIPLY_BY_28
SCG_SPLL_CLOCK_MULTIPLY_BY_29
SCG_SPLL_CLOCK_MULTIPLY_BY_30
SCG_SPLL_CLOCK_MULTIPLY_BY_31
SCG_SPLL_CLOCK_MULTIPLY_BY_32
SCG_SPLL_CLOCK_MULTIPLY_BY_33
SCG_SPLL_CLOCK_MULTIPLY_BY_34
SCG_SPLL_CLOCK_MULTIPLY_BY_35
SCG_SPLL_CLOCK_MULTIPLY_BY_36
SCG_SPLL_CLOCK_MULTIPLY_BY_37
SCG_SPLL_CLOCK_MULTIPLY_BY_38
SCG_SPLL_CLOCK_MULTIPLY_BY_39
SCG_SPLL_CLOCK_MULTIPLY_BY_40
SCG_SPLL_CLOCK_MULTIPLY_BY_41
SCG_SPLL_CLOCK_MULTIPLY_BY_42
SCG_SPLL_CLOCK_MULTIPLY_BY_43
SCG_SPLL_CLOCK_MULTIPLY_BY_44
SCG_SPLL_CLOCK_MULTIPLY_BY_45
SCG_SPLL_CLOCK_MULTIPLY_BY_46
SCG_SPLL_CLOCK_MULTIPLY_BY_47

Definition at line 478 of file clock_S32K1xx.h.

16.9.5.17 enum scg_spll_clock_prediv_t

SCG system PLL predivider.

Enumerator

SCG_SPLL_CLOCK_PREDIV_BY_1
SCG_SPLL_CLOCK_PREDIV_BY_2

SCG_SPLL_CLOCK_PREDIV_BY_3
SCG_SPLL_CLOCK_PREDIV_BY_4
SCG_SPLL_CLOCK_PREDIV_BY_5
SCG_SPLL_CLOCK_PREDIV_BY_6
SCG_SPLL_CLOCK_PREDIV_BY_7
SCG_SPLL_CLOCK_PREDIV_BY_8

Definition at line 462 of file clock_S32K1xx.h.

16.9.5.18 enum scg_spll_monitor_mode_t

SCG system PLL monitor mode. Implements scg_spll_monitor_mode_t_Class.

Enumerator

SCG_SPLL_MONITOR_DISABLE Monitor disable.
SCG_SPLL_MONITOR_INT Interrupt when system PLL error detected.
SCG_SPLL_MONITOR_RESET Reset when system PLL error detected.

Definition at line 451 of file clock_S32K1xx.h.

16.9.5.19 enum scg_system_clock_div_t

SCG system clock divider value. Implements scg_system_clock_div_t_Class.

Enumerator

SCG_SYSTEM_CLOCK_DIV_BY_1 Divided by 1.
SCG_SYSTEM_CLOCK_DIV_BY_2 Divided by 2.
SCG_SYSTEM_CLOCK_DIV_BY_3 Divided by 3.
SCG_SYSTEM_CLOCK_DIV_BY_4 Divided by 4.
SCG_SYSTEM_CLOCK_DIV_BY_5 Divided by 5.
SCG_SYSTEM_CLOCK_DIV_BY_6 Divided by 6.
SCG_SYSTEM_CLOCK_DIV_BY_7 Divided by 7.
SCG_SYSTEM_CLOCK_DIV_BY_8 Divided by 8.
SCG_SYSTEM_CLOCK_DIV_BY_9 Divided by 9.
SCG_SYSTEM_CLOCK_DIV_BY_10 Divided by 10.
SCG_SYSTEM_CLOCK_DIV_BY_11 Divided by 11.
SCG_SYSTEM_CLOCK_DIV_BY_12 Divided by 12.
SCG_SYSTEM_CLOCK_DIV_BY_13 Divided by 13.
SCG_SYSTEM_CLOCK_DIV_BY_14 Divided by 14.
SCG_SYSTEM_CLOCK_DIV_BY_15 Divided by 15.
SCG_SYSTEM_CLOCK_DIV_BY_16 Divided by 16.

Definition at line 256 of file clock_S32K1xx.h.

16.9.5.20 enum scg_system_clock_src_t

SCG system clock source. Implements scg_system_clock_src_t_Class.

Enumerator

SCG_SYSTEM_CLOCK_SRC_SYS_OSC System OSC.
SCG_SYSTEM_CLOCK_SRC_SIRC Slow IRC.
SCG_SYSTEM_CLOCK_SRC_FIRC Fast IRC.
SCG_SYSTEM_CLOCK_SRC_NONE MAX value.

Definition at line 241 of file clock_S32K1xx.h.

16.9.5.21 enum sim_clkout_div_t

SIM CLKOUT divider Implements sim_clkout_div_t_Class.

Enumerator

SIM_CLKOUT_DIV_BY_1 Divided by 1

SIM_CLKOUT_DIV_BY_2 Divided by 2

SIM_CLKOUT_DIV_BY_3 Divided by 3

SIM_CLKOUT_DIV_BY_4 Divided by 4

SIM_CLKOUT_DIV_BY_5 Divided by 5

SIM_CLKOUT_DIV_BY_6 Divided by 6

SIM_CLKOUT_DIV_BY_7 Divided by 7

SIM_CLKOUT_DIV_BY_8 Divided by 8

Definition at line 125 of file clock_S32K1xx.h.

16.9.5.22 enum sim_clkout_src_t

SIM CLKOUT select Implements sim_clkout_src_t_Class.

Enumerator

SIM_CLKOUT_SEL_SYSTEM_SCG_CLKOUT SCG CLKOUT

SIM_CLKOUT_SEL_SYSTEM_SOSC_DIV2_CLK SOSC DIV2 CLK

SIM_CLKOUT_SEL_SYSTEM_SIRC_DIV2_CLK SIRC DIV2 CLK

SIM_CLKOUT_SEL_SYSTEM_FIRC_DIV2_CLK FIRC DIV2 CLK

SIM_CLKOUT_SEL_SYSTEM_HCLK HCLK

SIM_CLKOUT_SEL_SYSTEM_SPLL_DIV2_CLK SPLL DIV2 CLK

SIM_CLKOUT_SEL_SYSTEM_BUS_CLK BUS_CLK

SIM_CLKOUT_SEL_SYSTEM_LPO_128K_CLK LPO_CLK 128 Khz

SIM_CLKOUT_SEL_SYSTEM_LPO_CLK LPO_CLK as selected by SIM LPO CLK Select

SIM_CLKOUT_SEL_SYSTEM_RTC_CLK RTC CLK as selected by SIM CLK 32 KHz Select

Definition at line 100 of file clock_S32K1xx.h.

16.9.5.23 enum sim_lpoclk_sel_src_t

SIM LPOCLKSEL clock source select Implements sim_lpoclk_sel_src_t_Class.

Enumerator

SIM_LPO_CLK_SEL_LPO_128K 128 kHz LPO clock

SIM_LPO_CLK_SEL_NO_CLOCK No clock

SIM_LPO_CLK_SEL_LPO_32K 32 kHz LPO clock which is divided by the 128 kHz LPO clock

SIM_LPO_CLK_SEL_LPO_1K 1 kHz LPO clock which is divided by the 128 kHz LPO clock

Definition at line 88 of file clock_S32K1xx.h.

16.9.5.24 enum sim_rtc_clk_sel_src_t

SIM CLK32KSEL clock source select Implements sim_rtc_clk_sel_src_t_Class.

Enumerator

SIM_RTCCLK_SEL_SOSCDIV1_CLK SOSCDIV1 clock

SIM_RTCCLK_SEL_LPO_32K 32 kHz LPO clock

SIM_RTCCLK_SEL_RTC_CLKIN RTC_CLKIN clock

SIM_RTCCLK_SEL_FIRCDIV1_CLK FIRCDIV1 clock

Definition at line 76 of file clock_S32K1xx.h.

16.9.5.25 enum xosc_ref_t

XOSC reference clock select (internal oscillator is bypassed or not) Implements xosc_ref_t_Class.

Enumerator

XOSC_EXT_REF Internal oscillator is bypassed, external reference clock requested.

XOSC_INT_OSC Internal oscillator of XOSC requested.

Definition at line 711 of file clock_S32K1xx.h.

16.9.6 Function Documentation

16.9.6.1 void CLOCK_DRV_GetSystemClockSource (sys_clk_config_t * *sysClkConfig*)

Gets the system clock source.

This function gets the current system clock source.

Returns

Value of the current system clock source.

Definition at line 3713 of file clock_S32K1xx.c.

16.9.6.2 status_t CLOCK_DRV_SetClockSource (clock_names_t *clockSource,* const clock_source_config_t * *clkSrcConfig*)

This function configures a clock source.

The clock source is configured based on the provided configuration. All values from the previous configuration of clock source are overwritten. If no configuration is provided, then a default one is used.

Parameters

in	*clockSource*	Clock name of the configured clock source
in	*clkSrcConfig*	Pointer to the configuration structure

Returns

Status of clock source initialization

Definition at line 4065 of file clock_S32K1xx.c.

16.9.6.3 void CLOCK_DRV_SetModuleClock (clock_names_t *peripheralClock,* const **module_clk_config_t** ∗ *moduleClkConfig*)

Configures module clock.

This function configures a module clock according to the configuration. If no configuration is provided (moduleClk↩ Config is null), then a default one is used moduleClkConfig must be passed as null when module doesn't support protocol clock.

Parameters

in	*peripheralClock*	Clock name of the configured module clock
in	*moduleClk↩ Config*	Pointer to the configuration structure.

Definition at line 3490 of file clock_S32K1xx.c.

16.9.6.4 status_t CLOCK_DRV_SetSystemClock (const pwr_modes_t * *mode,* const sys_clk_config_t * *sysClkConfig*)

Configures the system clocks.

This function configures the system clocks (core, bus and flash clocks) in the specified power mode. If no power mode is specified (null parameter) then it is the current power mode.

Parameters

in	*mode*	Pointer to power mode for which the configured system clocks apply
in	*sysClkConfig*	Pointer to the system clocks configuration structure.

Definition at line 3644 of file clock_S32K1xx.c.

16.9.6.5 uint8_t CLOCK_SYS_GetCurrentConfiguration (void)

Get current system clock configuration.

Returns

Current clock configuration index.

Definition at line 4292 of file clock_S32K1xx.c.

16.9.6.6 clock_manager_callback_user_config_t* CLOCK_SYS_GetErrorCallback (void)

Get the callback which returns error in last clock switch.

When graceful policy is used, if some IP is not ready to change clock setting, the callback will return error and system stay in current configuration. Applications can use this function to check which IP callback returns error.

Returns

Pointer to the callback which returns error.

Definition at line 4304 of file clock_S32K1xx.c.

16.9.6.7 status_t CLOCK_SYS_GetFreq (clock_names_t *clockName,* uint32_t * *frequency*)

Wrapper over CLOCK_DRV_GetFreq function. It's part of the old API.

Parameters

in	*clockName*	Clock names defined in clock_names_t
out	*frequency*	Returned clock frequency value in Hertz

Returns

status Error code defined in status_t

Definition at line 4327 of file clock_S32K1xx.c.

16.9.6.8 status_t CLOCK_SYS_Init (clock_manager_user_config_t const ** *clockConfigsPtr,* uint8_t *configsNumber,* clock_manager_callback_user_config_t ** *callbacksPtr,* uint8_t *callbacksNumber*)

Install pre-defined clock configurations.

This function installs the pre-defined clock configuration table to clock manager.

Parameters

in	*clockConfigsPtr*	Pointer to the clock configuration table.
in	*configsNumber*	Number of clock configurations in table.
in	*callbacksPtr*	Pointer to the callback configuration table.
in	*callbacks↩ Number*	Number of callback configurations in table.

Returns

Error code.

Definition at line 4140 of file clock_S32K1xx.c.

16.9.6.9 status_t CLOCK_SYS_SetConfiguration (clock_manager_user_config_t const * *config*)

Set system clock configuration.

This function sets the system to target configuration, it only sets the clock modules registers for clock mode change, but not send notifications to drivers. This function is different by different SoCs.

Parameters

in	*config*	Target configuration.

Returns

Error code.

Note

If external clock is used in the target mode, please make sure it is enabled, for example, if the external oscillator is used, please setup EREFS/HGO correctly and make sure OSCINIT is set. This function should be called only on run mode.

Definition at line 4339 of file clock_S32K1xx.c.

16.9.6.10 status_t CLOCK_SYS_UpdateConfiguration (uint8_t *targetConfigIndex,* clock_manager_policy_t *policy*)

Set system clock configuration according to pre-defined structure.

This function sets system to target clock configuration; before transition, clock manager will send notifications to all drivers registered to the callback table. When graceful policy is used, if some drivers are not ready to change, clock transition will not occur, all drivers still work in previous configuration and error is returned. When forceful policy is used, all drivers should stop work and system changes to new clock configuration. The function should be called only on run mode.

Parameters

in	*targetConfig↩ Index*	Index of the clock configuration.
in	*policy*	Transaction policy, graceful or forceful.

Returns

Error code.

Note

If external clock is used in the target mode, please make sure it is enabled, for example, if the external oscillator is used, please setup EREFS/HGO correctly and make sure OSCINIT is set.

Definition at line 4173 of file clock_S32K1xx.c.

16.9.7 Variable Documentation

16.9.7.1 uint32_t g_RtcClkInFreq

RTC_CLKIN clock frequency.

Definition at line 81 of file clock_S32K1xx.c.

16.9.7.2 uint32_t g_TClkFreq[NUMBER_OF_TCLK_INPUTS]

TCLKx clocks

Definition at line 78 of file clock_S32K1xx.c.

16.9.7.3 uint32_t g_xtal0ClkFreq

EXTAL0 clock frequency.

Definition at line 84 of file clock_S32K1xx.c.

16.9.7.4 const uint8_t peripheralFeaturesList[CLOCK_NAME_COUNT]

Peripheral features list Constant array storing the mappings between clock names of the peripherals and feature lists.

Definition at line 432 of file clock_S32K1xx.c.

16.10 Common Core API.

16.10.1 Detailed Description

This group contains general core APIs that used for both protocol LIN 2.1 and J2602.

Modules

- Driver and cluster management

  API perform the initialization of the LIN core.
- Interface management

  This group contains APIs that help users manage interface(s) in LIN node.
- Notification

  This group contains APIs that let users know when a signal's value changed.
- Schedule management

  This group contains APIs that help users manage schedule tables in master node only.
- Signal interaction

  This group contains APIs that help users interract with signals of LIN node.
- User provided call-outs

  This group contains APIs which may be called from within the LIN module in order to enable/disable LIN communication interrupts.

Macros

- #define SAVE_CONFIG_SET 0x0040U
- #define EVENT_TRIGGER_COLLISION_SET 0x0020U
- #define BUS_ACTIVITY_SET 0x0010U
- #define GO_TO_SLEEP_SET 0x0008U
- #define OVERRUN 0x0004U
- #define SUCCESSFULL_TRANSFER 0x0002U
- #define ERROR_IN_RESPONSE 0x0001U

16.10.2 Macro Definition Documentation

16.10.2.1 #define BUS_ACTIVITY_SET 0x0010U

Bus activity

Definition at line 32 of file lin_common_api.h.

16.10.2.2 #define ERROR_IN_RESPONSE 0x0001U

Error in response

Definition at line 36 of file lin_common_api.h.

16.10.2.3 #define EVENT_TRIGGER_COLLISION_SET 0x0020U

Event triggered frame collision

Definition at line 31 of file lin_common_api.h.

16.10.2.4 #define GO_TO_SLEEP_SET 0x0008U

Go to sleep

Definition at line 33 of file lin_common_api.h.

16.10.2.5 #define OVERRUN 0x0004U

Overrun

Definition at line 34 of file lin_common_api.h.

16.10.2.6 #define SAVE_CONFIG_SET 0x0040U

Save configuration

Definition at line 30 of file lin_common_api.h.

16.10.2.7 #define SUCCESSFULL_TRANSFER 0x0002U

Successful transfer

Definition at line 35 of file lin_common_api.h.

16.11 Common Transport Layer API

16.11.1 Detailed Description

Contains Transport Layer APIs that used for both protocols LIN 2.1 and J2602.

Modules

- Cooked API

  Cooked processing of diagnostic messages manages one complete message at a time.
- Initialization

  Initialize transport layer (queues, status, ...).
- Raw API

  The raw API is operating on PDU level and it is typically used to gateway PDUs between CAN and LIN.

Macros

- #define LD_READ_OK 0x33U
- #define LD_LENGTH_TOO_SHORT 0x34U
- #define LD_DATA_ERROR 0x43U
- #define LD_LENGTH_NOT_CORRECT 0x44U
- #define LD_SET_OK 0x45U
- #define SERVICE_TARGET_RESET 0xB5U
- #define RES_POSITIVE 0x40U
- #define LIN_PRODUCT_ID 0x00U
- #define LIN_SERIAL_NUMBER 0x01U
- #define LD_BROADCAST 0x7FU
- #define LD_FUNCTIONAL_NAD 0x7EU
- #define LD_ANY_SUPPLIER 0x7FFFU
- #define LD_ANY_FUNCTION 0xFFFFU
- #define LD_ANY_MESSAGE 0xFFFFU
- #define RES_NEGATIVE 0x7FU
- #define GENERAL_REJECT 0x10U
- #define SERVICE_NOT_SUPPORTED 0x11U
- #define SUBFUNCTION_NOT_SUPPORTED 0x12U
- #define NEGATIVE 0U
- #define POSITIVE 1U
- #define TRANSMITTING 0U
- #define RECEIVING 1U
- #define DIAG_SERVICE_CALLBACK_HANDLER(iii, sid) lin_diag_service_callback((iii), (sid))

Functions

- void lin_diag_service_callback (l_ifc_handle iii, l_u8 sid)

16.11.2 Macro Definition Documentation

16.11.2.1 #define DIAG_SERVICE_CALLBACK_HANDLER(*iii, sid*) lin_diag_service_callback((iii), (sid))

Definition at line 86 of file lin_commontl_api.h.

16.11.2.2 #define GENERAL_REJECT 0x10U

Error code raised when request for service not supported comes

Definition at line 71 of file lin_commontl_api.h.

16.11.2.3 #define LD_ANY_FUNCTION 0xFFFFU

Function

Definition at line 66 of file lin_commontl_api.h.

16.11.2.4 #define LD_ANY_MESSAGE 0xFFFFU

Message

Definition at line 67 of file lin_commontl_api.h.

16.11.2.5 #define LD_ANY_SUPPLIER 0x7FFFU

Supplier

Definition at line 65 of file lin_commontl_api.h.

16.11.2.6 #define LD_BROADCAST 0x7FU

Broadcast NAD

Definition at line 63 of file lin_commontl_api.h.

16.11.2.7 #define LD_DATA_ERROR 0x43U

Data error

Definition at line 50 of file lin_commontl_api.h.

16.11.2.8 #define LD_FUNCTIONAL_NAD 0x7EU

Functional NAD

Definition at line 64 of file lin_commontl_api.h.

16.11.2.9 #define LD_LENGTH_NOT_CORRECT 0x44U

Length not correct

Definition at line 51 of file lin_commontl_api.h.

16.11.2.10 #define LD_LENGTH_TOO_SHORT 0x34U

Length too short

Definition at line 48 of file lin_commontl_api.h.

16.11.2.11 #define LD_READ_OK 0x33U

Read OK

Definition at line 47 of file lin_commontl_api.h.

16.11.2.12 #define LD_SET_OK 0x45U

Set OK

Definition at line 52 of file lin_commontl_api.h.

16.11.2.13 #define LIN_PRODUCT_ID 0x00U

Node product identifier

Definition at line 59 of file lin_commontl_api.h.

16.11.2.14 #define LIN_SERIAL_NUMBER 0x01U

Serial number

Definition at line 60 of file lin_commontl_api.h.

16.11.2.15 #define NEGATIVE 0U

Negative response

Definition at line 76 of file lin_commontl_api.h.

16.11.2.16 #define POSITIVE 1U

Positive response

Definition at line 77 of file lin_commontl_api.h.

16.11.2.17 #define RECEIVING 1U

Receiving

Definition at line 80 of file lin_commontl_api.h.

16.11.2.18 #define RES_NEGATIVE 0x7FU

Negative response

Definition at line 70 of file lin_commontl_api.h.

16.11.2.19 #define RES_POSITIVE 0x40U

Positive response

Definition at line 56 of file lin_commontl_api.h.

16.11.2.20 #define SERVICE_NOT_SUPPORTED 0x11U

Error code in negative response for not supported service

Definition at line 72 of file lin_commontl_api.h.

16.11.2.21 #define SERVICE_TARGET_RESET 0xB5U

Target reset service

Definition at line 55 of file lin_commontl_api.h.

16.11.2.22 #define SUBFUNCTION_NOT_SUPPORTED 0x12U

Error code in negative response for not supported sub function

Definition at line 73 of file lin_commontl_api.h.

16.11.2.23 #define TRANSMITTING 0U

Transmitting

Definition at line 79 of file lin_commontl_api.h.

16.11.3 Function Documentation

16.11.3.1 void lin_diag_service_callback (l_ifc_handle *iii,* l_u8 *sid*)

Definition at line 1041 of file lin_diagnostic_service.c.

16.12 Comparator (CMP)

16.12.1 Detailed Description

Hardware background

The comparator (CMP) module is an analog comparator integrated in MCU.

Features of the CMP module include:

- 8 bit DAC with 2 voltage reference source
- 8 analog inputs from external pins
- Round robin check. In summary, this allow the CMP to operate independently in STOP and VLPS mode, whilst being triggered periodically to sample up to 8 inputs. Only if an input changes state is a full wakeup generated.
- Operational over the entire supply range
- Inputs may range from rail to rail
- Programmable hysteresis control
- Selectable interrupt on rising-edge, falling-edge, or both rising or falling edges of the comparator output
- Selectable inversion on comparator output
- Capability to produce a wide range of outputs such as: sampled, windowed, which is ideal for certain PWM zero-crossing-detection applications and digitally filtered
- A comparison event can be selected to trigger a DMA transfer
- The window and filter functions are not available in STOP modes.

How to use the CMP driver in your application

The user can configure the CMP in many ways: -CMP_DRV_Init - configures all CMP features -CMP_DRV_↩ ConfigDAC - configures only DAC features -CMP_DRV_ConfigTriggerMode - configures only trigger mode features -CMP_DRV_ConfigComparator - configures only analog comparator features -CMP_DRV_ConfigMUX - configures only MUX features

Also the current configuration can be read using: -CMP_DRV_GetConfigAll - gets all CMP configuration -CM↩ P_DRV_GetDACConfig - gets only DAC configuration -CMP_DRV_GetMUXConfig - gets only MUX configuration -CMP_DRV_GetInitTriggerMode - gets only trigger mode configuration -CMP_DRV_GetComparatorConfig - gets only analog comparator features

A default configuration can be read using: -CMP_DRV_GetDefaultConfig - gets a default configuration for the comparator

When the MCU exits from STOP mode CMP_DRV_GetInputFlags can be used to get the channel which triggered the wakeup. Please use this function only in this use case. CMP_DRV_ClearInputFlags will be used to clear this input change flags.

CMP_DRV_GetOutputFlags can be used to get output flag state and CMP_DRV_ClearOutputFlags to clear them.

The main structure used to configure your application is **cmp_module_t**. This structure includes configuration structures for trigger mode, MUX, DAC and comparator: **cmp_comparator_t**, **cmp_anmux_t**, **cmp_dac_t** and **cmp_trigger_mode_t**

```
If application use CMP as wakeup source from Standby mode on MPC574x devices is mandatory to enable channel 3

## Integration guideline ##
```

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\cmp\cmp_driver.c
${S32SDK_PATH}\platform\drivers\src\cmp\cmp_hw_access.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
${S32SDK_PATH}\platform\drivers\src\cmp\
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager Interrupt Manager (Interrupt) PinSettings

Example for S32K14x:

The next example will compare 2 external signals (CMP input 0 an CMP input 1). The output can be measured on port E, pin 4.

```
const cmp_module_t cmp_general_config =
 {
     {
         .dmaTriggerState        = false,
         .outputInterruptTrigger = CMP_NO_EVENT,
         .mode                   = CMP_CONTINUOUS,
         .filterSamplePeriod     = 0,
         .filterSampleCount      = 0,
         .powerMode              = CMP_LOW_SPEED,
         .inverterState          = CMP_NORMAL,
         .outputSelect           = CMP_COUT,
         .pinState               = CMP_AVAILABLE,
         .offsetLevel            = CMP_LEVEL_OFFSET_0,
         .hysteresisLevel        = CMP_LEVEL_HYS_0
     },

     {
         .positivePortMux        = CMP_MUX,
         .negativePortMux        = CMP_MUX,
         .positiveInputMux       = 0,
         .negativeInputMux       = 1
     },

     {
         .voltageReferenceSource = CMP_VIN1,
         .voltage                = 120,
         .state                  = false
     },

     {
         .roundRobinState            = false,
         .roundRobinInterruptState   = false,
         .fixedPort                  = CMP_PLUS_FIXED,
         .fixedChannel               = 0,
         .samples                    = 0,
         .initializationDelay        = 0,
         /* Channel 0 is enabled for round robin check */
         /* Channel 1 is enabled for round robin check */
         /* Channel 2 is enabled for round robin check */
         /* Channel 3 is enabled for round robin check */
         /* Channel 4 is enabled for round robin check */
         /* Channel 5 is enabled for round robin check */
         /* Channel 6 is enabled for round robin check */
         /* Channel 7 is enabled for round robin check */
         .roundRobinChannelsState    = 255,
         /* Initial comparison result for channel 0 is 1 */
         /* Initial comparison result for channel 1 is 1 */
         /* Initial comparison result for channel 2 is 1 */
         /* Initial comparison result for channel 3 is 1 */
         /* Initial comparison result for channel 4 is 1 */
```

```
        /* Initial comparison result for channel 5 is 1 */
        /* Initial comparison result for channel 6 is 1 */
        /* Initial comparison result for channel 7 is 1 */
        .programedState             = 255
    }
};

#define COMPARATOR_PORT         PORTA
#define COMPARATOR_INPUT1_PIN   0UL
#define COMPARATOR_INPUT2_PIN   1UL
#define COMPARATOR_OUTPUT       4UL
#define COMPARATOR_INSTANCE     0UL

int main(void)
{
    /* Initialize and configure clocks
     *  -   Setup system clocks
     *  -   Enable clock feed for Ports and Comparator
     *  -   See Clock Manager component for more info
     */
    CLOCK_SYS_Init(g_clockManConfigsArr, CLOCK_MANAGER_CONFIG_CNT,
                   g_clockManCallbacksArr, CLOCK_MANAGER_CALLBACK_CNT);
    CLOCK_SYS_UpdateConfiguration(0U,
     CLOCK_MANAGER_POLICY_AGREEMENT);

    /* Set pins used by CMP */
    /* The negative port is connected to PTA0 and positive port is connected to PTA1. The
     comparator output can be visualized on PTA4 */
    /* Initialize pins
     *  -   Setup input pins for Comparator
     *  -   Setup output pins for LEDs
     *  -   See PinSettings component for more info
     */
    PINS_DRV_Init(NUM_OF_CONFIGURED_PINS, g_pin_mux_InitConfigArr);

    /* Init CMP module */
    CMP_DRV_Init(COMPARATOR_INSTANCE, &cmp_general_config);
    for (;;)
        {}
    return(0);
}
```

Example for MPC574XG:

The next example will compare 2 external signals (CMP input 0 an CMP input 1). The output can be measured on port E, pin 4.

```
const cmp_module_t cmp_general_config =
 {
     {
         .dmaTriggerState        = false,
         .outputInterruptTrigger = CMP_NO_EVENT,
         .mode                   = CMP_CONTINUOUS,
         .filterSamplePeriod     = 0,
         .filterSampleCount      = 0,
         .powerMode              = CMP_LOW_SPEED,
         .inverterState          = CMP_NORMAL,
         .outputSelect           = CMP_COUT,
         .pinState               = CMP_AVAILABLE,
         .hysteresisLevel        = CMP_LEVEL_HYS_0
     },

     {
         .positivePortMux        = CMP_MUX,
         .negativePortMux        = CMP_MUX,
         .positiveInputMux       = 0,
         .negativeInputMux       = 1
     },

     {
         .voltageReferenceSource = CMP_VIN1,
         .voltage                = 120,
         .state                  = false,
         .fixRefInputMux         = false
     },

     {
         .roundRobinState            = false,
         .roundRobinInterruptState   = false,
         .fixedPort                  = CMP_PLUS_FIXED,
         .fixedChannel               = 0,
         .samples                    = 0,
         /* Channel 0 is enabled for round robin check */
         /* Channel 1 is enabled for round robin check */
```

```
        /* Channel 2 is enabled for round robin check */
        /* Channel 3 is enabled for round robin check */
        /* Channel 4 is enabled for round robin check */
        /* Channel 5 is enabled for round robin check */
        /* Channel 6 is enabled for round robin check */
        /* Channel 7 is enabled for round robin check */
        .roundRobinChannelsState    = 255,
        /* Initial comparison result for channel 0 is 1 */
        /* Initial comparison result for channel 1 is 1 */
        /* Initial comparison result for channel 2 is 1 */
        /* Initial comparison result for channel 3 is 1 */
        /* Initial comparison result for channel 4 is 1 */
        /* Initial comparison result for channel 5 is 1 */
        /* Initial comparison result for channel 6 is 1 */
        /* Initial comparison result for channel 7 is 1 */
        .programedState             = 255
    }
};

#define COMPARATOR_PORT         PORTA
#define COMPARATOR_INPUT1_PIN   0UL
#define COMPARATOR_INPUT2_PIN   1UL
#define COMPARATOR_OUTPUT       4UL
#define COMPARATOR_INSTANCE     0UL

int main(void)
{
    /* Write your local variable definition here */
    /* Initialize and configure clocks
     *  -   Setup system clocks
     *  -   Enable clock feed for Ports and Comparator
     *  -   See Clock Manager component for more info
     */
    CLOCK_SYS_Init(g_clockManConfigsArr, CLOCK_MANAGER_CONFIG_CNT,
                   g_clockManCallbacksArr, CLOCK_MANAGER_CALLBACK_CNT);
    CLOCK_SYS_UpdateConfiguration(0U,
     CLOCK_MANAGER_POLICY_AGREEMENT);

    /* Set pins used by CMP */
    /* The negative port is connected to PTA0 and positive port is connected to PTA1. The
     comparator output can be visualized on PTA4 */
    /* Initialize pins
     *  -   Setup input pins for Comparator
     *  -   Setup output pins for LEDs
     *  -   See PinSettings component for more info
     */
    PINS_DRV_Init(NUM_OF_CONFIGURED_PINS, g_pin_mux_InitConfigArr);

    /* Init CMP module */
    CMP_DRV_Init(COMPARATOR_INSTANCE, &cmp_general_config);
    for (;;)
        {}
    return(0);
}
```

Modules

- Comparator Driver

  Comparator Peripheral Driver.

16.13 Comparator Driver

16.13.1 Detailed Description

Comparator Peripheral Driver.

Definitions

Data Structures

- struct cmp_comparator_t

  Defines the block configuration. More...
- struct cmp_anmux_t

  Defines the analog mux. More...
- struct cmp_dac_t

  Defines the DAC block. More...
- struct cmp_trigger_mode_t

  Defines the trigger mode. More...
- struct cmp_module_t

  Defines the comparator module configuration. More...

Macros

- #define CMP_INPUT_FLAGS_MASK 0xFF0000
- #define CMP_INPUT_FLAGS_SHIFT 16U
- #define CMP_ROUND_ROBIN_CHANNELS_MASK 0xFF0000
- #define CMP_ROUND_ROBIN_CHANNELS_SHIFT 16U

Typedefs

- typedef uint8_t cmp_ch_list_t

  Comparator channels list (1bit/channel) |--------|--------|----|--------|--------| |CH7_state|CH6_state|.....|CH1_↩ state|CH0_state| |--------|--------|----|--------|--------| Implements : cmp_ch_list_t_Class.
- typedef uint8_t cmp_ch_number_t

  Number of channel Implements : cmp_ch_number_t_Class.

Enumerations

- enum cmp_power_mode_t { CMP_LOW_SPEED = 0U, CMP_HIGH_SPEED = 1U }

  Power Modes selection Implements : cmp_power_mode_t_Class.
- enum cmp_voltage_reference_t { CMP_VIN1 = 0U, CMP_VIN2 = 1U }

  Voltage Reference selection Implements : cmp_voltage_reference_t_Class.
- enum cmp_port_mux_t { CMP_DAC = CMP_DAC_SOURCE, CMP_MUX = CMP_MUX_SOURCE }

  Port Mux Source selection Implements : cmp_port_mux_t_Class.
- enum cmp_inverter_t { CMP_NORMAL = 0U, CMP_INVERT = 1U }

  Comparator output invert selection Implements : cmp_inverter_t_Class.
- enum cmp_output_select_t { CMP_COUT = 0U, CMP_COUTA = 1U }

  Comparator output select selection Implements : cmp_output_select_t_Class.
- enum cmp_output_enable_t { CMP_UNAVAILABLE = 0U, CMP_AVAILABLE = 1U }

  Comparator output pin enable selection Implements : cmp_output_enable_t_Class.
- enum cmp_hysteresis_t { CMP_LEVEL_HYS_0 = 0U, CMP_LEVEL_HYS_1 = 1U, CMP_LEVEL_HYS_2 = 2U, CMP_LEVEL_HYS_3 = 3U }

Comparator hysteresis control Implements : cmp_hysteresis_t_Class.

- enum cmp_fixed_port_t { CMP_PLUS_FIXED = 0U, CMP_MINUS_FIXED = 1U }

  Comparator Round-Robin fixed port Implements : cmp_fixed_port_t_Class.
- enum cmp_output_trigger_t { CMP_NO_EVENT = 0U, CMP_FALLING_EDGE = 1U, CMP_RISING_EDGE = 2U, CMP_BOTH_EDGES = 3U }

  Comparator output interrupt configuration Implements : cmp_output_trigger_t_Class.
- enum cmp_mode_t {
  CMP_DISABLED = 0U, CMP_CONTINUOUS = 1U, CMP_SAMPLED_NONFILTRED_INT_CLK = 2U, CMP_SAMPLED_NONFILTRED_EXT_CLK = 3U,
  CMP_SAMPLED_FILTRED_INT_CLK = 4U, CMP_SAMPLED_FILTRED_EXT_CLK = 5U, CMP_WINDOWED = 6U, CMP_WINDOWED_RESAMPLED = 7U,
  CMP_WINDOWED_FILTRED = 8U }

  Comparator functional modes Implements : cmp_mode_t_Class.

cMP DRV.

- status_t CMP_DRV_Reset (const uint32_t instance)

  Reset all registers.
- status_t CMP_DRV_GetInitConfigAll (cmp_module_t *config)

  Get reset configuration for all registers.
- status_t CMP_DRV_GetDefaultConfig (cmp_module_t *const config)

  Gets a default comparator configuration.
- status_t CMP_DRV_Init (const uint32_t instance, const cmp_module_t *const config)

  Configure all comparator features with the given configuration structure.
- status_t CMP_DRV_GetConfigAll (const uint32_t instance, cmp_module_t *const config)

  Gets the current comparator configuration.
- status_t CMP_DRV_GetInitConfigDAC (cmp_dac_t *config)

  Get reset configuration for registers related with DAC.
- status_t CMP_DRV_ConfigDAC (const uint32_t instance, const cmp_dac_t *config)

  Configure only the DAC component.
- status_t CMP_DRV_GetDACConfig (const uint32_t instance, cmp_dac_t *const config)

  Return current configuration for DAC.
- status_t CMP_DRV_GetInitConfigMUX (cmp_anmux_t *config)

  Get reset configuration for registers related with MUX.
- status_t CMP_DRV_ConfigMUX (const uint32_t instance, const cmp_anmux_t *config)

  Configure only the MUX component.
- status_t CMP_DRV_GetMUXConfig (const uint32_t instance, cmp_anmux_t *const config)

  Return configuration only for the MUX component.
- status_t CMP_DRV_GetInitTriggerMode (cmp_trigger_mode_t *config)

  Get reset configuration for registers related with Trigger Mode.
- status_t CMP_DRV_ConfigTriggerMode (const uint32_t instance, const cmp_trigger_mode_t *config)

  Configure trigger mode.
- status_t CMP_DRV_GetTriggerModeConfig (const uint32_t instance, cmp_trigger_mode_t *const config)

  Get current trigger mode configuration.
- status_t CMP_DRV_GetOutputFlags (const uint32_t instance, cmp_output_trigger_t *flags)

  Get comparator output flags.
- status_t CMP_DRV_ClearOutputFlags (const uint32_t instance)

  Clear comparator output flags.
- status_t CMP_DRV_GetInputFlags (const uint32_t instance, cmp_ch_list_t *flags)

  Gets input channels change flags.
- status_t CMP_DRV_ClearInputFlags (const uint32_t instance)

Clear comparator input channels flags.

- status_t CMP_DRV_GetInitConfigComparator (cmp_comparator_t *config)

  Get reset configuration for registers related with comparator features.

- status_t CMP_DRV_ConfigComparator (const uint32_t instance, const cmp_comparator_t *config)

  Configure only comparator features.

- status_t CMP_DRV_GetComparatorConfig (const uint32_t instance, cmp_comparator_t *config)

  Return configuration for comparator from CMP module.

16.13.2 Data Structure Documentation

16.13.2.1 struct cmp_comparator_t

Defines the block configuration.

This structure is used to configure only comparator block module(filtering, sampling, power_mode etc.) Implements : cmp_comparator_t_Class

Definition at line 178 of file cmp_driver.h.

Data Fields

- bool dmaTriggerState
- cmp_output_trigger_t outputInterruptTrigger
- cmp_mode_t mode
- uint8_t filterSamplePeriod
- uint8_t filterSampleCount
- cmp_power_mode_t powerMode
- cmp_inverter_t inverterState
- cmp_output_enable_t pinState
- cmp_output_select_t outputSelect
- cmp_hysteresis_t hysteresisLevel

Field Documentation

16.13.2.1.1 bool dmaTriggerState

True if DMA transfer trigger from comparator is enable.

Definition at line 180 of file cmp_driver.h.

16.13.2.1.2 uint8_t filterSampleCount

Number of sample count for filtering.

Definition at line 187 of file cmp_driver.h.

16.13.2.1.3 uint8_t filterSamplePeriod

Filter sample period.

Definition at line 186 of file cmp_driver.h.

16.13.2.1.4 cmp_hysteresis_t hysteresisLevel

CMP_LEVEL_HYS_0 if hard block output has level 0 hysteresis. CMP_LEVEL_HYS_1 if hard block output has level 1 hysteresis. CMP_LEVEL_HYS_2 if hard block output has level 2 hysteresis. CMP_LEVEL_HYS_3 if hard block output has level 3 hysteresis.

Definition at line 200 of file cmp_driver.h.

16.13.2.1.5 cmp_inverter_t inverterState

CMP_NORMAL if does not invert the comparator output. CMP_INVERT if inverts the comparator output.

Definition at line 190 of file cmp_driver.h.

16.13.2.1.6 cmp_mode_t mode

Configuration structure which define: the comparator functional mode, sample period and sample count.

Definition at line 185 of file cmp_driver.h.

16.13.2.1.7 cmp_output_trigger_t outputInterruptTrigger

CMP_NO_INTERRUPT comparator output would not trigger any interrupt. CMP_FALLING_EDGE comparator output would trigger an interrupt on falling edge. CMP_RISING_EDGE comparator output would trigger an interrupt on rising edge. CMP_BOTH_EDGES comparator output would trigger an interrupt on rising and falling edges.

Definition at line 181 of file cmp_driver.h.

16.13.2.1.8 cmp_output_select_t outputSelect

CMP_COUT if output signal is equal to COUT(filtered). CMP_COUTA if output signal is equal to COUTA(unfiltered).

Definition at line 194 of file cmp_driver.h.

16.13.2.1.9 cmp_output_enable_t pinState

CMP_UNAVAILABLE if comparator output is not available to package pin. CMP_AVAILABLE if comparator output is available to package pin.

Definition at line 192 of file cmp_driver.h.

16.13.2.1.10 cmp_power_mode_t powerMode

CMP_LOW_SPEED if low speed mode is selected. CMP_HIGH_SPEED if high speed mode is selected

Definition at line 188 of file cmp_driver.h.

16.13.2.2 struct cmp_anmux_t

Defines the analog mux.

This structure is used to configure the analog multiplexor to select compared signals Implements : cmp_anmux_t_Class

Definition at line 212 of file cmp_driver.h.

Data Fields

- cmp_port_mux_t positivePortMux
- cmp_port_mux_t negativePortMux
- cmp_ch_number_t positiveInputMux
- cmp_ch_number_t negativeInputMux

Field Documentation

16.13.2.2.1 cmp_ch_number_t negativeInputMux

Select which channel is selected for the minus mux.

Definition at line 222 of file cmp_driver.h.

16.13.2.2.2 cmp_port_mux_t negativePortMux

Select negative port signal. CMP_DAC if source is digital to analog converter. CMP_MUX if source is 8 ch MUX

Definition at line 217 of file cmp_driver.h.

16.13.2.2.3 cmp_ch_number_t positiveInputMux

Select which channel is selected for the plus mux.

Definition at line 221 of file cmp_driver.h.

16.13.2.2.4 cmp_port_mux_t positivePortMux

Select positive port signal. CMP_DAC if source is digital to analog converter. CMP_MUX if source is 8 ch MUX

Definition at line 214 of file cmp_driver.h.

16.13.2.3 struct cmp_dac_t

Defines the DAC block.

This structure is used to configure the DAC block integrated in comparator module Implements : cmp_dac_t_Class

Definition at line 231 of file cmp_driver.h.

Data Fields

- cmp_voltage_reference_t voltageReferenceSource
- uint8_t voltage
- bool state

Field Documentation

16.13.2.3.1 bool state

True if DAC is enabled.

Definition at line 236 of file cmp_driver.h.

16.13.2.3.2 uint8_t voltage

The digital value which is converted to analog signal.

Definition at line 235 of file cmp_driver.h.

16.13.2.3.3 cmp_voltage_reference_t voltageReferenceSource

CMP_VIN1 if selected voltage reference is VIN1. CMP_VIN2 if selected voltage reference is VIN2.

Definition at line 233 of file cmp_driver.h.

16.13.2.4 struct cmp_trigger_mode_t

Defines the trigger mode.

This structure is used to configure the trigger mode operation when MCU enters STOP modes Implements : cmp↩_trigger_mode_t_Class

Definition at line 251 of file cmp_driver.h.

Data Fields

- bool roundRobinState
- bool roundRobinInterruptState
- cmp_fixed_port_t fixedPort
- cmp_ch_number_t fixedChannel
- uint8_t samples
- cmp_ch_list_t roundRobinChannelsState
- cmp_ch_list_t programedState

Field Documentation

16.13.2.4.1 cmp_ch_number_t fixedChannel

Select which channel would be assigned to the fixed port.

Definition at line 257 of file cmp_driver.h.

16.13.2.4.2 cmp_fixed_port_t fixedPort

CMP_PLUS_FIXED if plus port is fixed. CMP_MINUS_FIXED if minus port is fixed.

Definition at line 255 of file cmp_driver.h.

16.13.2.4.3 cmp_ch_list_t programedState

Pre-programmed state for comparison result.

Definition at line 266 of file cmp_driver.h.

16.13.2.4.4 cmp_ch_list_t roundRobinChannelsState

One bite for each channel state. |———|———|—|———|———| |CH7_state|CH6_state|.....|CH1_state|CH0↩ _state| |--------—|--------—|-—|--------—|--------—|

Definition at line 262 of file cmp_driver.h.

16.13.2.4.5 bool roundRobinInterruptState

True if Round-Robin interrupt is enabled.

Definition at line 254 of file cmp_driver.h.

16.13.2.4.6 bool roundRobinState

True if Round-Robin is enabled.

Definition at line 253 of file cmp_driver.h.

16.13.2.4.7 uint8_t samples

Select number of round-robin clock cycles for a given channel.

Definition at line 258 of file cmp_driver.h.

16.13.2.5 struct cmp_module_t

Defines the comparator module configuration.

This structure is used to configure all components of comparator module Implements : cmp_module_t_Class

Definition at line 275 of file cmp_driver.h.

Data Fields

- cmp_comparator_t comparator
- cmp_anmux_t mux
- cmp_dac_t dac
- cmp_trigger_mode_t triggerMode

Field Documentation

16.13.2.5.1 cmp_comparator_t comparator

Definition at line 277 of file cmp_driver.h.

16.13.2.5.2 cmp_dac_t dac

Definition at line 279 of file cmp_driver.h.

16.13.2.5.3 cmp_anmux_t mux

Definition at line 278 of file cmp_driver.h.

16.13.2.5.4 cmp_trigger_mode_t triggerMode

Definition at line 280 of file cmp_driver.h.

16.13.3 Macro Definition Documentation

16.13.3.1 #define CMP_INPUT_FLAGS_MASK 0xFF0000

Definition at line 39 of file cmp_driver.h.

16.13.3.2 #define CMP_INPUT_FLAGS_SHIFT 16U

Definition at line 40 of file cmp_driver.h.

16.13.3.3 #define CMP_ROUND_ROBIN_CHANNELS_MASK 0xFF0000

Definition at line 41 of file cmp_driver.h.

16.13.3.4 #define CMP_ROUND_ROBIN_CHANNELS_SHIFT 16U

Definition at line 42 of file cmp_driver.h.

16.13.4 Typedef Documentation

16.13.4.1 typedef uint8_t cmp_ch_list_t

Comparator channels list (1bit/channel) |--------—|--------—|-—-|--------—|--------—| |CH7_state|CH6_state|.....|CH1_↩ state|CH0_state| |--------—|--------—|-—-|--------—|--------—| Implements : cmp_ch_list_t_Class.

Definition at line 165 of file cmp_driver.h.

16.13.4.2 typedef uint8_t cmp_ch_number_t

Number of channel Implements : cmp_ch_number_t_Class.

Definition at line 170 of file cmp_driver.h.

16.13.5 Enumeration Type Documentation

16.13.5.1 enum cmp_fixed_port_t

Comparator Round-Robin fixed port Implements : cmp_fixed_port_t_Class.

Enumerator

CMP_PLUS_FIXED The Plus port is fixed. Only the inputs to the Minus port are swept in each round.

CMP_MINUS_FIXED The Minus port is fixed. Only the inputs to the Plus port are swept in each round.

Definition at line 126 of file cmp_driver.h.

16.13.5.2 enum cmp_hysteresis_t

Comparator hysteresis control Implements : cmp_hysteresis_t_Class.

Enumerator

CMP_LEVEL_HYS_0

CMP_LEVEL_HYS_1

CMP_LEVEL_HYS_2

CMP_LEVEL_HYS_3

Definition at line 115 of file cmp_driver.h.

16.13.5.3 enum cmp_inverter_t

Comparator output invert selection Implements : cmp_inverter_t_Class.

Enumerator

CMP_NORMAL Output signal isn't inverted.

CMP_INVERT Output signal is inverted.

Definition at line 77 of file cmp_driver.h.

16.13.5.4 enum cmp_mode_t

Comparator functional modes Implements : cmp_mode_t_Class.

Enumerator

CMP_DISABLED

CMP_CONTINUOUS

CMP_SAMPLED_NONFILTRED_INT_CLK

CMP_SAMPLED_NONFILTRED_EXT_CLK

CMP_SAMPLED_FILTRED_INT_CLK

CMP_SAMPLED_FILTRED_EXT_CLK

CMP_WINDOWED

CMP_WINDOWED_RESAMPLED

CMP_WINDOWED_FILTRED

Definition at line 146 of file cmp_driver.h.

16.13.5.5 enum cmp_output_enable_t

Comparator output pin enable selection Implements : cmp_output_enable_t_Class.

Enumerator

CMP_UNAVAILABLE Comparator output isn't available to a specific pin

CMP_AVAILABLE Comparator output is available to a specific pin

Definition at line 95 of file cmp_driver.h.

16.13.5.6 enum cmp_output_select_t

Comparator output select selection Implements : cmp_output_select_t_Class.

Enumerator

CMP_COUT Select COUT as comparator output signal.

CMP_COUTA Select COUTA as comparator output signal.

Definition at line 86 of file cmp_driver.h.

16.13.5.7 enum cmp_output_trigger_t

Comparator output interrupt configuration Implements : cmp_output_trigger_t_Class.

Enumerator

CMP_NO_EVENT Comparator output interrupts are disabled OR no event occurred.

CMP_FALLING_EDGE Comparator output interrupts will be generated only on falling edge OR only falling edge event occurred.

CMP_RISING_EDGE Comparator output interrupts will be generated only on rising edge OR only rising edge event occurred.

CMP_BOTH_EDGES Comparator output interrupts will be generated on both edges OR both edges event occurred.

Definition at line 135 of file cmp_driver.h.

16.13.5.8 enum cmp_port_mux_t

Port Mux Source selection Implements : cmp_port_mux_t_Class.

Enumerator

CMP_DAC Select DAC as source for the comparator port.

CMP_MUX Select MUX8 as source for the comparator port.

Definition at line 68 of file cmp_driver.h.

16.13.5.9 enum cmp_power_mode_t

Power Modes selection Implements : cmp_power_mode_t_Class.

Enumerator

CMP_LOW_SPEED Module in low speed mode.

CMP_HIGH_SPEED Module in high speed mode.

Definition at line 50 of file cmp_driver.h.

16.13.5.10 enum cmp_voltage_reference_t

Voltage Reference selection Implements : cmp_voltage_reference_t_Class.

Enumerator

CMP_VIN1 Use Vin1 as supply reference source for DAC.

CMP_VIN2 Use Vin2 as supply reference source for DAC.

Definition at line 59 of file cmp_driver.h.

16.13.6 Function Documentation

16.13.6.1 status_t CMP_DRV_ClearInputFlags (const uint32_t *instance*)

Clear comparator input channels flags.

This function clear comparator input channels flags.

Parameters

instance	- instance number

Returns

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 562 of file cmp_driver.c.

16.13.6.2 status_t CMP_DRV_ClearOutputFlags (const uint32_t *instance*)

Clear comparator output flags.

This function clear comparator output flags(rising and falling edge).

Parameters

instance	- instance number

Returns

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 517 of file cmp_driver.c.

16.13.6.3 status_t CMP_DRV_ConfigComparator (const uint32_t *instance,* const **cmp_comparator_t** * *config*)

Configure only comparator features.

This function configure only features related with comparator: DMA request, power mode, output select, interrupts enable, invert, offset, hysteresis.

Parameters

instance	- instance number
config	- the configuration structure

Returns

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 611 of file cmp_driver.c.

16.13.6.4 status_t CMP_DRV_ConfigDAC (const uint32_t *instance,* const **cmp_dac_t** * *config*)

Configure only the DAC component.

This function configures the DAC with the options provided in the config structure.

Parameters

instance	- instance number
config	- the configuration structure

Returns

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 316 of file cmp_driver.c.

16.13.6.5 status_t CMP_DRV_ConfigMUX (const uint32_t *instance,* const cmp_anmux_t * *config*)

Configure only the MUX component.

This function configures the MUX with the options provided in the config structure.

Parameters

instance	- instance number
config	- the configuration structure

Returns

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 381 of file cmp_driver.c.

16.13.6.6 status_t CMP_DRV_ConfigTriggerMode (const uint32_t *instance,* const cmp_trigger_mode_t * *config*)

Configure trigger mode.

This function configures the trigger mode with the options provided in the config structure.

Parameters

instance	- instance number
config	- the configuration structure

Returns

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 445 of file cmp_driver.c.

16.13.6.7 status_t CMP_DRV_GetComparatorConfig (const uint32_t *instance,* cmp_comparator_t * *config*)

Return configuration for comparator from CMP module.

This function return configuration for features related with comparator: DMA request, power mode, output select, interrupts enable, invert, offset, hysteresis.

Parameters

instance	- instance number

config	- the configuration structure returned

Returns

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 641 of file cmp_driver.c.

16.13.6.8 status_t CMP_DRV_GetConfigAll (const uint32_t *instance*, cmp_module_t *const *config*)

Gets the current comparator configuration.

This function returns the current configuration for comparator as a configuration structure.

Parameters

instance	- instance number
config	- the configuration structure

Returns

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 242 of file cmp_driver.c.

16.13.6.9 status_t CMP_DRV_GetDACConfig (const uint32_t *instance*, cmp_dac_t *const *config*)

Return current configuration for DAC.

This function returns current configuration only for DAC.

Parameters

instance	- instance number
config	- the configuration structure

Returns

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 340 of file cmp_driver.c.

16.13.6.10 status_t CMP_DRV_GetDefaultConfig (cmp_module_t *const *config*)

Gets a default comparator configuration.

This function returns a default configuration for the comparator as a configuration structure.

Parameters

instance	- instance number
config	- the configuration structure

Returns

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 137 of file cmp_driver.c.

16.13.6.11 status_t CMP_DRV_GetInitConfigAll (cmp_module_t * config)

Get reset configuration for all registers.

This function returns a configuration structure with reset values for all registers from comparator module.

Parameters

config	- the configuration structure

Returns

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 85 of file cmp_driver.c.

16.13.6.12 status_t CMP_DRV_GetInitConfigComparator (cmp_comparator_t * config)

Get reset configuration for registers related with comparator features.

This function return a configuration structure with reset values for features associated with comparator (DMA request, power mode, output select, interrupts enable, invert, offset, hysteresis).

Parameters

config	- the configuration structure

Returns

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 584 of file cmp_driver.c.

16.13.6.13 status_t CMP_DRV_GetInitConfigDAC (cmp_dac_t * config)

Get reset configuration for registers related with DAC.

This function returns a configuration structure with reset values for features associated with DAC.

Parameters

config	- the configuration structure

Returns

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 295 of file cmp_driver.c.

16.13.6.14 status_t CMP_DRV_GetInitConfigMUX (cmp_anmux_t * config)

Get reset configuration for registers related with MUX.

This function returns a configuration structure with reset values for features associated with MUX.

Parameters

config	- the configuration structure

Returns

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 362 of file cmp_driver.c.

16.13.6.15 status_t CMP_DRV_GetInitTriggerMode (cmp_trigger_mode_t * *config*)

Get reset configuration for registers related with Trigger Mode.

This function returns a configuration structure with reset values for features associated with Trigger Mode.

Parameters

config	- the configuration structure

Returns

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 422 of file cmp_driver.c.

16.13.6.16 status_t CMP_DRV_GetInputFlags (const uint32_t *instance,* cmp_ch_list_t * *flags*)

Gets input channels change flags.

This function return in <flags> all input channels flags as uint8_t(1 bite for each channel flag).

Parameters

instance	- instance number
flags	- pointer to input flags

Returns

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 544 of file cmp_driver.c.

16.13.6.17 status_t CMP_DRV_GetMUXConfig (const uint32_t *instance,* cmp_anmux_t *const *config*)

Return configuration only for the MUX component.

This function returns current configuration to determine which signals go to comparator ports.

Parameters

instance	- instance number
config	- the configuration structure

Returns

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 402 of file cmp_driver.c.

16.13.6.18 status_t CMP_DRV_GetOutputFlags (const uint32_t *instance,* cmp_output_trigger_t * *flags*)

Get comparator output flags.

This function returns in <flags> comparator output flags(rising and falling edge).

Parameters

instance	- instance number
-	flags - pointer to output flags NO_EVENT RISING_EDGE FALLING_EDGE BOTH_EDGE

Returns

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 499 of file cmp_driver.c.

16.13.6.19 status_t CMP_DRV_GetTriggerModeConfig (const uint32_t *instance,* cmp_trigger_mode_t *const *config*)

Get current trigger mode configuration.

This function returns the current trigger mode configuration for trigger mode.

Parameters

instance	- instance number
config	- the configuration structure

Returns

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 472 of file cmp_driver.c.

16.13.6.20 status_t CMP_DRV_Init (const uint32_t *instance,* const cmp_module_t *const *config*)

Configure all comparator features with the given configuration structure.

This function configures the comparator module with the options provided in the config structure.

Parameters

instance	- instance number
config	- the configuration structure

Returns

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 188 of file cmp_driver.c.

16.13.6.21 status_t CMP_DRV_Reset (const uint32_t *instance*)

Reset all registers.

This function set all CMP registers to reset values.

Parameters

instance	- instance number

Returns

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 66 of file cmp_driver.c.

16.14 Controller Area Network - Peripheral Abstraction Layer (CAN PAL)

16.14.1 Detailed Description

The S32 SDK provides a Peripheral Abstraction Layer for Controller Area Network (CAN) modules of S32 SDK devices.

The CAN PAL driver allows communication over a CAN bus. It was designed to be portable across all platforms and IPs which support CAN communication.

How to integrate CAN PAL in your application

Unlike the other drivers, CAN PAL modules need to include a configuration file named can_pal_cfg.h, which allows the user to specify which IPSs are used and how many resources are allocated for each of them (state structures). The following code example shows how to configure one instance for each available CAN IP.

```
#ifndef can_pal_cfg_H
#define can_pal_cfg_H

/* Define which IP instance will be used in current project */
#define CAN_OVER_FLEXCAN

/* Define the resources necessary for current project */
#define NO_OF_FLEXCAN_INSTS_FOR_CAN    1U

#endif /* can_pal_cfg_H */
```

The following table contains the matching between platforms and available IPs

IP/↩ M↩ CU	S32↩ K116	S32↩ K118	S32↩ K142	S32↩ K144	S32↩ K146	S32↩ K148	S32↩ V234	MP↩ C5748↩ G	MP↩ C5746↩ C	MP↩ C5744↩ P	S32↩ R274	S32↩ R372
Flex↩ CAN	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Features

- Standard data frames
- Extended data frames
- Flexible data rate (FD)
- Bitrate switch inside FD format frames (BRS)
- Zero to sixty four bytes data length
- Programmable bit rate
- Flexible buffers configurable to store 0 to 8, 16, 32 or 64 bytes data length depending of platform support
- Each buffer configurable as receive or transmit, all supporting standard and extended messages
- Individual Rx Masking per buffer
- Loop-Back mode
- Remote request frames

  The following table contains the matching between platforms and available features

FEATURE/MCU	S32K116	S32K118	S32K142	S32K144	S32K146	S32K148	S32V234	MPC5748G	MPC5746C	MPC5744P	S32R274	S32R372
FD/BRS	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO	YES	YES
data length > 8B	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO	YES	YES

Functionality

Initialization

In order to use the CAN PAL driver it must be first initialized, using **CAN_Init()** function. Once initialized, it cannot be initialized again for the same CAN module instance until it is de-initialized, using **CAN_Deinit()**. Different CAN modules instances can function independently of each other.

The **can_user_config_t** structure allows you to configure the following:

- the number of buffers needed;
- the operation mode, which can be one of the following:
  - normal mode;
  - loopback mode;
  - disable mode;
- the Protocol Engine clock source:
  - oscillator clock;
  - peripheral clock;
- the payload size of the buffers:
  - 8 bytes;
  - 16 bytes (only available with the FD feature enabled);
  - 32 bytes (only available with the FD feature enabled);
  - 64 bytes (only available with the FD feature enabled);
- enable/disable the Flexible Data-rate feature;
- the bitrate used for standard frames or for the arbitration phase of FD frames;
- the bitrate used for the data phase of FD frames;

The bitrate is represented by a **can_time_segment_t** structure, with the following fields:

- propagation segment;
- phase segment 1;
- phase segment 2;
- clock prescaler division factor;

- resync jump width.

In order to use a buffer for transmission/reception, it has to be initialized using either **CAN_ConfigRxBuff** or **CAN_ConfigTxBuff**.

After having the buffer configured, you can start sending/receiving data by calling one of the following functions:

- CAN_Send;
- CAN_SendBlocking;
- CAN_Receive;
- CAN_ReceiveBlocking.

FlexCAN Rx FIFO extension

When used over FlexCAN, the PAL allows extending the basic configuration with an Rx FIFO feature. The Rx FIFO is receive-only and 6-message deep. The application can read the received messages sequentially, in the order they were received, by repeatedly reading the data from buffer 0 (zero). A powerful filtering scheme is provided to accept only frames intended for the target application. The FIFO and filtering criteria are configured by passing a structure of **extension_flexcan_rx_fifo_t** type, through the extension field of the user configuration structure.

```
/* ID Filter table */
flexcan_id_table_t filterTable[] = {
  {
   .isExtendedFrame = false,
   .isRemoteFrame = false,
   .id = 1U
  },
  ...
};

/* Rx FIFO extension */
extension_flexcan_rx_fifo_t  can_pal1_rx_fifo_ext0 = {
  .numIdFilters = FLEXCAN_RX_FIFO_ID_FILTERS_8,
  .idFormat = FLEXCAN_RX_FIFO_ID_FORMAT_A,
  /* User must pass reference to the ID filter table. */
  .idFilterTable = NULL
};

can_pal1_rx_fifo_ext0.idFilterTable = filterTable;
```

The number of elements in the ID filter table is defined by the following formula:

- for format A: the number of Rx FIFO ID filters
- for format B: twice the number of Rx FIFO ID filters
- for format C: four times the number of Rx FIFO ID filters The user must provide the exact number of elements in order to avoid any misconfiguration.

Each element in the ID filter table specifies an ID to be used as acceptance criteria for the FIFO as follows:

- for format A: In the standard frame format, bits 10 to 0 of the ID are used for frame identification. In the extended frame format, bits 28 to 0 are used.
- for format B: In the standard frame format, bits 10 to 0 of the ID are used for frame identification. In the extended frame format, only the 14 most significant bits (28 to 15) of the ID are compared to the 14 most significant bits (28 to 15) of the received ID.
- for format C: In both standard and extended frame formats, only the 8 most significant bits (7 to 0 for standard, 28 to 21 for extended) of the ID are compared to the 8 most significant bits (7 to 0 for standard, 28 to 21 for extended) of the received ID.

When Rx FIFO feature is enabled, buffer 0 (zero) cannot be used for transmission or reconfigured for reception using **CAN_ConfigRxBuff()** and **CAN_SetRxFilter()** functions.

Important Notes

- Before using the CAN PAL driver the module clock must be configured. Refer to **Clock Manager** component for clock configuration.
- The driver enables the interrupts for the corresponding CAN module, but any interrupt priority must be done by the application.
- The board specific configurations must be done prior to driver calls; the driver has no influence on the functionality of the RX/TX pins - they must be configured by application. Refer to **PinSettings** component for pin configuration.
- Some features are not available for all platforms (see the table above for the matching between platforms and available features).
- When used **CAN_ReceiveBlocking()** and **CAN_SendBlocking()** with timeout parameter 0 and the message is already in mailbox configured will report timeout and successful transmit or receive the message.

Example code

```
#define TX_BUFF_IDX    0U
#define RX_BUFF_IDX    1U

uint32_t msgID = 0xAB;

/* CAN PAL instance information */
const can_instance_t can_pal1_instance = {CAN_INST_TYPE_FLEXCAN, 0U};

/* User configuration structure */
can_user_config_t config = {
  .maxBuffNum = 2U,
  .mode = CAN_LOOPBACK_MODE,
  .peClkSrc = CAN_CLK_SOURCE_OSC,
  .enableFD = false,
  .payloadSize = CAN_PAYLOAD_SIZE_8,
  .nominalBitrate = {
      .propSeg = 7,
      .phaseSeg1 = 4,
      .phaseSeg2 = 1,
      .preDivider = 0,
      .rJumpwidth = 1
  },
  .dataBitrate = {
      .propSeg = 7,
      .phaseSeg1 = 4,
      .phaseSeg2 = 1,
      .preDivider = 0,
      .rJumpwidth = 1
  },
  .extension = NULL
};

/* Initialize CAN */
CAN_Init(&can_pal1_instance, &config);

/* Buffer configuration */
can_buff_config_t buffConfig = {
  .enableFD = false,
  .enableBRS = false,
  .fdPadding = 0xCC,
  .idType = CAN_MSG_ID_STD,
  .isRemote = false
};

CAN_ConfigTxBuff(&can_pal1_instance, TX_BUFF_IDX, &buffConfig);
CAN_ConfigRxBuff(&can_pal1_instance, RX_BUFF_IDX, &buffConfig, msgID);

can_message_t recvMsg, sendMsg = {
  .id = msgID,
  .length = 5U,
  .data = {"Hello"}
};

/* Send data using buffer configured for transmission */
CAN_Send(&can_pal1_instance, TX_BUFF_IDX, &sendMsg);
while(CAN_GetTransferStatus(&can_pal1_instance, TX_BUFF_IDX) == STATUS_BUSY);

/* Receive data using buffer configured for reception */
CAN_Receive(&can_pal1_instance, RX_BUFF_IDX, &recvMsg);
while(CAN_GetTransferStatus(&can_pal1_instance, RX_BUFF_IDX) == STATUS_BUSY);
```

```
/* De-initialize CAN */
CAN_Deinit(&can_pal1_instance);
```

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\pal\src\can\can_pal.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\pal\inc\
```

Preprocessor symbols

No special symbols are required for this component

Dependencies

Controller Area Network with Flexible Data Rate (FlexCAN) Clock Manager Interrupt Manager (Interrupt) Enhanced Direct Memory Access (eDMA)

Data Structures

- struct can_time_segment_t

  CAN bit timing variables Implements : can_time_segment_t_Class. More...
- struct can_buff_config_t

  CAN buffer configuration Implements : can_buff_config_t_Class. More...
- struct can_message_t

  CAN message format Implements : can_message_t_Class. More...
- struct can_user_config_t

  CAN controller configuration Implements : can_user_config_t_Class. More...
- struct extension_flexcan_rx_fifo_t

  FlexCAN Rx FIFO configuration Implements : extension_flexcan_rx_fifo_t_Class. More...

Enumerations

- enum can_operation_modes_t { CAN_NORMAL_MODE = 0U, CAN_LOOPBACK_MODE = 2U, CAN_DISABLE_MODE = 4U }

  CAN controller operation modes Implements : can_operation_modes_t_Class.
- enum can_fd_payload_size_t { CAN_PAYLOAD_SIZE_8 = 0, CAN_PAYLOAD_SIZE_16, CAN_PAYLOAD_SIZE_32, CAN_PAYLOAD_SIZE_64 }

  CAN buffer payload sizes Implements : can_fd_payload_size_t_Class.
- enum can_bitrate_phase_t { CAN_NOMINAL_BITRATE, CAN_FD_DATA_BITRATE }

  CAN bitrate phase (nominal/data) Implements : can_bitrate_phase_t_Class.
- enum can_msg_id_type_t { CAN_MSG_ID_STD, CAN_MSG_ID_EXT }

  CAN Message Buffer ID type Implements : can_msg_id_type_t_Class.
- enum can_clk_source_t { CAN_CLK_SOURCE_OSC = 0U, CAN_CLK_SOURCE_PERIPH = 1U }

  CAN PE clock sources Implements : can_clk_source_t_Class.

Functions

- status_t CAN_Init (const can_instance_t *const instance, const can_user_config_t *config)

  Initializes the CAN module.
- status_t CAN_Deinit (const can_instance_t *const instance)

  De-initializes the CAN module.
- status_t CAN_SetBitrate (const can_instance_t *const instance, can_bitrate_phase_t phase, const can_time_segment_t *bitTiming)

  Configures the CAN bitrate.
- status_t CAN_GetBitrate (const can_instance_t *const instance, can_bitrate_phase_t phase, can_time_segment_t *bitTiming)

  Returns the CAN bitrate.
- status_t CAN_ConfigTxBuff (const can_instance_t *const instance, uint32_t buffIdx, const can_buff_config_t *config)

  Configures a buffer for transmission.
- status_t CAN_ConfigRemoteResponseBuff (const can_instance_t *const instance, uint32_t buffIdx, const can_buff_config_t *config, const can_message_t *message)

  Configures a transmit buffer for remote frame response.
- status_t CAN_ConfigRxBuff (const can_instance_t *const instance, uint32_t buffIdx, const can_buff_config_t *config, uint32_t acceptedId)

  Configures a buffer for reception.
- status_t CAN_Send (const can_instance_t *const instance, uint32_t buffIdx, const can_message_t *message)

  Sends a CAN frame using the specified buffer.
- status_t CAN_SendBlocking (const can_instance_t *const instance, uint32_t buffIdx, const can_message_t *message, uint32_t timeoutMs)

  Sends a CAN frame using the specified buffer, in a blocking manner.
- status_t CAN_Receive (const can_instance_t *const instance, uint32_t buffIdx, can_message_t *message)

  Receives a CAN frame using the specified message buffer.
- status_t CAN_ReceiveBlocking (const can_instance_t *const instance, uint32_t buffIdx, can_message_t *message, uint32_t timeoutMs)

  Receives a CAN frame using the specified buffer, in a blocking manner.
- status_t CAN_AbortTransfer (const can_instance_t *const instance, uint32_t buffIdx)

  Ends a non-blocking CAN transfer early.
- status_t CAN_SetRxFilter (const can_instance_t *const instance, can_msg_id_type_t idType, uint32_t buffIdx, uint32_t mask)

  Configures an ID filter for a specific reception buffer.
- status_t CAN_GetTransferStatus (const can_instance_t *const instance, uint32_t buffIdx)

  Returns the state of the previous CAN transfer.
- status_t CAN_InstallEventCallback (const can_instance_t *const instance, can_callback_t callback, void *callbackParam)

  Installs a callback function for the IRQ handler.
- void CAN_GetDefaultConfig (can_instance_t *instance, can_user_config_t *config)

  Returns the Default configuration for CAN_PAL instance 0 over FlexCan with a 500K Baud in normal mode, without flexible datarate with oscillator clock source for PE and 8 Bytes payload size.

16.14.2 Data Structure Documentation

16.14.2.1 struct can_time_segment_t

CAN bit timing variables Implements : can_time_segment_t_Class.

Definition at line 59 of file can_pal.h.

Data Fields

- uint32_t propSeg
- uint32_t phaseSeg1
- uint32_t phaseSeg2
- uint32_t preDivider
- uint32_t rJumpwidth

Field Documentation

16.14.2.1.1 uint32_t phaseSeg1

Phase segment 1

Definition at line 61 of file can_pal.h.

16.14.2.1.2 uint32_t phaseSeg2

Phase segment 2

Definition at line 62 of file can_pal.h.

16.14.2.1.3 uint32_t preDivider

Clock prescaler division factor

Definition at line 63 of file can_pal.h.

16.14.2.1.4 uint32_t propSeg

Propagation segment

Definition at line 60 of file can_pal.h.

16.14.2.1.5 uint32_t rJumpwidth

Resync jump width

Definition at line 64 of file can_pal.h.

16.14.2.2 struct can_buff_config_t

CAN buffer configuration Implements : can_buff_config_t_Class.

Definition at line 94 of file can_pal.h.

Data Fields

- bool enableFD
- bool enableBRS
- uint8_t fdPadding
- can_msg_id_type_t idType
- bool isRemote

Field Documentation

16.14.2.2.1 bool enableBRS

Enable bit rate switch inside a CAN FD frame

Definition at line 96 of file can_pal.h.

16.14.2.2.2 bool enableFD

Enable flexible data rate

Definition at line 95 of file can_pal.h.

16.14.2.2.3 uint8_t fdPadding

Value used for padding when the data length code (DLC) specifies a bigger payload size than the actual data length

Definition at line 97 of file can_pal.h.

16.14.2.2.4 can_msg_id_type_t idType

Specifies whether the frame format is standard or extended

Definition at line 99 of file can_pal.h.

16.14.2.2.5 bool isRemote

Specifies if the frame is standard or remote

Definition at line 100 of file can_pal.h.

16.14.2.3 struct can_message_t

CAN message format Implements : can_message_t_Class.

Definition at line 106 of file can_pal.h.

Data Fields

- uint32_t cs
- uint32_t id
- uint8_t data [64]
- uint8_t length

Field Documentation

16.14.2.3.1 uint32_t cs

Code and Status

Definition at line 107 of file can_pal.h.

16.14.2.3.2 uint8_t data[64]

Data bytes of the CAN message

Definition at line 109 of file can_pal.h.

16.14.2.3.3 uint32_t id

ID of the message

Definition at line 108 of file can_pal.h.

16.14.2.3.4 uint8_t length

Length of payload in bytes

Definition at line 110 of file can_pal.h.

16.14.2.4 struct can_user_config_t

CAN controller configuration Implements : can_user_config_t_Class.

Definition at line 116 of file can_pal.h.

Data Fields

- uint32_t maxBuffNum
- can_operation_modes_t mode
- can_clk_source_t peClkSrc
- bool enableFD
- can_fd_payload_size_t payloadSize
- can_time_segment_t nominalBitrate
- can_time_segment_t dataBitrate
- void * extension

Field Documentation

16.14.2.4.1 can_time_segment_t dataBitrate

Bit timing segments for data bitrate

Definition at line 124 of file can_pal.h.

16.14.2.4.2 bool enableFD

Enable flexible data rate

Definition at line 121 of file can_pal.h.

16.14.2.4.3 void* extension

This field will be used to add extra settings to the basic configuration like FlexCAN Rx FIFO settings

Definition at line 125 of file can_pal.h.

16.14.2.4.4 uint32_t maxBuffNum

Set maximum number of buffers

Definition at line 118 of file can_pal.h.

16.14.2.4.5 can_operation_modes_t mode

Set operation mode

Definition at line 119 of file can_pal.h.

16.14.2.4.6 can_time_segment_t nominalBitrate

Bit timing segments for nominal bitrate

Definition at line 123 of file can_pal.h.

16.14.2.4.7 can_fd_payload_size_t payloadSize

Set size of buffer payload

Definition at line 122 of file can_pal.h.

16.14.2.4.8 can_clk_source_t peClkSrc

The clock source of the CAN Protocol Engine (PE).

Definition at line 120 of file can_pal.h.

16.14.2.5 struct extension_flexcan_rx_fifo_t

FlexCAN Rx FIFO configuration Implements : extension_flexcan_rx_fifo_t_Class.

Definition at line 133 of file can_pal.h.

Data Fields

- flexcan_rx_fifo_id_filter_num_t numIdFilters
- flexcan_rx_fifo_id_element_format_t idFormat
- flexcan_id_table_t * idFilterTable

Field Documentation

16.14.2.5.1 flexcan_id_table_t* idFilterTable

Rx FIFO ID table

Definition at line 137 of file can_pal.h.

16.14.2.5.2 flexcan_rx_fifo_id_element_format_t idFormat

RX FIFO ID format

Definition at line 136 of file can_pal.h.

16.14.2.5.3 flexcan_rx_fifo_id_filter_num_t numIdFilters

The number of Rx FIFO ID filters needed

Definition at line 135 of file can_pal.h.

16.14.3 Enumeration Type Documentation

16.14.3.1 enum can_bitrate_phase_t

CAN bitrate phase (nominal/data) Implements : can_bitrate_phase_t_Class.

Enumerator

CAN_NOMINAL_BITRATE Nominal (FD arbitration) bitrate

CAN_FD_DATA_BITRATE FD data bitrate

Definition at line 70 of file can_pal.h.

16.14.3.2 enum can_clk_source_t

CAN PE clock sources Implements : can_clk_source_t_Class.

Enumerator

CAN_CLK_SOURCE_OSC The CAN engine clock source is the oscillator clock.

CAN_CLK_SOURCE_PERIPH The CAN engine clock source is the peripheral clock.

Definition at line 86 of file can_pal.h.

16.14.3.3 enum can_fd_payload_size_t

CAN buffer payload sizes Implements : can_fd_payload_size_t_Class.

Enumerator

CAN_PAYLOAD_SIZE_8 CAN message buffer payload size in bytes

CAN_PAYLOAD_SIZE_16 CAN message buffer payload size in bytes

CAN_PAYLOAD_SIZE_32 CAN message buffer payload size in bytes

CAN_PAYLOAD_SIZE_64 CAN message buffer payload size in bytes

Definition at line 49 of file can_pal.h.

16.14.3.4 enum can_msg_id_type_t

CAN Message Buffer ID type Implements : can_msg_id_type_t_Class.

Enumerator

CAN_MSG_ID_STD Standard ID

CAN_MSG_ID_EXT Extended ID

Definition at line 78 of file can_pal.h.

16.14.3.5 enum can_operation_modes_t

CAN controller operation modes Implements : can_operation_modes_t_Class.

Enumerator

CAN_NORMAL_MODE Normal mode or user mode

CAN_LOOPBACK_MODE Loop-back mode

CAN_DISABLE_MODE Module disable mode

Definition at line 40 of file can_pal.h.

16.14.4 Function Documentation

16.14.4.1 status_t CAN_AbortTransfer (const can_instance_t *const *instance*, uint32_t *buffIdx*)

Ends a non-blocking CAN transfer early.

Note

When the Rx FIFO extension is used, buffer 0 (zero) is used to read the contents of the FIFO and is configured at the initialization of the driver.

Parameters

in	*instance*	Instance information structure.
in	*buffIdx*	buffer index.

Returns

STATUS_SUCCESS if successful; STATUS_CAN_NO_TRANSFER_IN_PROGRESS if no transfer was running

Definition at line 903 of file can_pal.c.

16.14.4.2 status_t CAN_ConfigRemoteResponseBuff (const can_instance_t *const *instance*, uint32_t *buffIdx*, const can_buff_config_t * *config*, const can_message_t * *message*)

Configures a transmit buffer for remote frame response.

Parameters

in	*instance*	Instance information structure.
in	*buffIdx*	buffer index.
in	*config*	buffer configuration.
in	*message*	frame to be sent as remote response.

Returns

STATUS_SUCCESS if successful; STATUS_CAN_BUFF_OUT_OF_RANGE if the buffer index is out of range; STATUS_ERROR if invalid instance number is used;

Definition at line 553 of file can_pal.c.

16.14.4.3 status_t CAN_ConfigRxBuff (const can_instance_t *const *instance*, uint32_t *buffIdx*, const can_buff_config_t * *config*, uint32_t *acceptedId*)

Configures a buffer for reception.

This function configures a buffer for reception.

Note

When the Rx FIFO extension is used, buffer 0 (zero) is used to read the contents of the FIFO and is configured at the initialization of the driver. The user should not reconfigure this buffer for classical buffer reception.

Parameters

in	*instance*	Instance information structure.
in	*buffIdx*	buffer index.
in	*config*	buffer configuration.
in	*acceptedId*	ID used for accepting frames.

Returns

STATUS_SUCCESS if successful; STATUS_CAN_BUFF_OUT_OF_RANGE if the buffer index is out of range; STATUS_ERROR if invalid instance number is used;

Definition at line 616 of file can_pal.c.

16.14.4.4 status_t CAN_ConfigTxBuff (const can_instance_t *const *instance*, uint32_t *buffIdx*, const can_buff_config_t * *config*)

Configures a buffer for transmission.

This function configures a buffer for transmission.

Note

When the Rx FIFO extension is used, buffer 0 (zero) is used to read the contents of the FIFO and is configured at the initialization of the driver. The user should not reconfigure this buffer for transmission.

Parameters

in	*instance*	Instance information structure.
in	*buffIdx*	buffer index.

in	*config*	buffer configuration.

Returns

STATUS_SUCCESS if successful; STATUS_CAN_BUFF_OUT_OF_RANGE if the buffer index is out of range; STATUS_ERROR if invalid instance number is used;

Definition at line 489 of file can_pal.c.

16.14.4.5 status_t CAN_Deinit (const can_instance_t *const *instance*)

De-initializes the CAN module.

This function de-initializes the CAN module.

Parameters

in	*instance*	Instance information structure

Returns

STATUS_SUCCESS if successful; STATUS_ERROR if unsuccessful or invalid instance number;

Definition at line 369 of file can_pal.c.

16.14.4.6 status_t CAN_GetBitrate (const can_instance_t *const *instance,* can_bitrate_phase_t *phase,* can_time_segment_t * *bitTiming*)

Returns the CAN bitrate.

This function returns the CAN configured bitrate.

Parameters

in	*instance*	Instance information structure.
in	*phase*	selects between nominal/data phase bitrate.
out	*bitTiming*	configured bit timing variables.

Returns

STATUS_SUCCESS if successful; STATUS_ERROR if invalid instance number is used;

Definition at line 449 of file can_pal.c.

16.14.4.7 void CAN_GetDefaultConfig (can_instance_t * *instance,* can_user_config_t * *config*)

Returns the Default configuration for CAN_PAL instance 0 over FlexCan with a 500K Baud in normal mode, without flexible datarate with oscillator clock source for PE and 8 Bytes payload size.

Parameters

out	*instance*	Pointer for can_instance structure.
out	*config*	Pointer for can_user_config structure.

Definition at line 1072 of file can_pal.c.

16.14.4.8 status_t CAN_GetTransferStatus (const can_instance_t *const *instance,* uint32_t *buffIdx*)

Returns the state of the previous CAN transfer.

When performing an async transfer, call this function to ascertain the state of the current transfer: in progress or complete.

Note

When the Rx FIFO extension is used, buffer 0 (zero) is used to read the contents of the FIFO and is configured at the initialization of the driver.

Parameters

in	*instance*	Instance information structure.
in	*buffIdx*	buffer index.

Returns

STATUS_SUCCESS if successful; STATUS_BUSY if a resource is busy; STATUS_ERROR if invalid instance number is used;

Definition at line 985 of file can_pal.c.

16.14.4.9 status_t CAN_Init (const can_instance_t *const *instance,* const can_user_config_t * *config*)

Initializes the CAN module.

This function initializes and enables the requested CAN module.

Note

When the Rx FIFO extension is used, buffer 0 (zero) is used to read the contents of the FIFO and is configured at the initialization of the driver.

Parameters

in	*instance*	Instance information structure
in	*config*	The configuration structure

Returns

STATUS_SUCCESS if successful; STATUS_ERROR if unsuccessful or invalid instance number;

Definition at line 263 of file can_pal.c.

16.14.4.10 status_t CAN_InstallEventCallback (const can_instance_t *const *instance,* can_callback_t *callback,* void * *callbackParam*)

Installs a callback function for the IRQ handler.

Parameters

in	*instance*	Instance information structure.
in	*callback*	The callback function.
in	*callbackParam*	User parameter passed to the callback function through the state parameter.

Returns

STATUS_SUCCESS if successful; STATUS_ERROR if invalid instance number is used;

Definition at line 1024 of file can_pal.c.

16.14.4.11 status_t CAN_Receive (const can_instance_t *const *instance,* uint32_t *buffIdx,* can_message_t * *message*)

Receives a CAN frame using the specified message buffer.

This function receives a CAN frame using a configured buffer. The function returns immediately. If a callback is installed, it will be invoked after the frame was received and read into the specified buffer.

Note

When the Rx FIFO extension is used, buffer 0 (zero) is used to read the contents of the FIFO and is configured at the initialization of the driver. The user should use this buffer to receive frames in the FIFO.

Parameters

in	*instance*	Instance information structure.
in	*buffIdx*	buffer index.
out	*message*	received message.

Returns

STATUS_SUCCESS if successful; STATUS_BUSY if the current buffer is involved in another transfer; STATUS_CAN_BUFF_OUT_OF_RANGE if the buffer index is out of range; STATUS_ERROR if invalid instance number is used;

Definition at line 797 of file can_pal.c.

16.14.4.12 status_t CAN_ReceiveBlocking (const can_instance_t *const *instance*, uint32_t *buffIdx*, can_message_t * *message*, uint32_t *timeoutMs*)

Receives a CAN frame using the specified buffer, in a blocking manner.

This function receives a CAN frame using a configured buffer. The function blocks until either a frame was received, or the specified timeout expired.

Note

When the Rx FIFO extension is used, buffer 0 (zero) is used to read the contents of the FIFO and is configured at the initialization of the driver. The user should use this buffer to receive frames in the FIFO.

Parameters

in	*instance*	Instance information structure.
in	*buffIdx*	buffer index.
out	*message*	received message.
in	*timeoutMs*	A timeout for the transfer in milliseconds.

Returns

STATUS_SUCCESS if successful; STATUS_BUSY if the current buffer is involved in another transfer; STATUS_TIMEOUT if the timeout is reached; STATUS_CAN_BUFF_OUT_OF_RANGE if the buffer index is out of range; STATUS_ERROR if invalid instance number is used;

Definition at line 849 of file can_pal.c.

16.14.4.13 status_t CAN_Send (const can_instance_t *const *instance*, uint32_t *buffIdx*, const can_message_t * *message*)

Sends a CAN frame using the specified buffer.

This function sends a CAN frame using a configured buffer. The function returns immediately. If a callback is installed, it will be invoked after the frame was sent.

Note

When the Rx FIFO extension is used, buffer 0 (zero) is used to read the contents of the FIFO and is configured at the initialization of the driver. The user should not use this buffer for transmission.

Parameters

in	*instance*	Instance information structure.
in	*buffIdx*	buffer index.
in	*message*	message to be sent.

Returns

STATUS_SUCCESS if successful; STATUS_BUSY if the current buffer is involved in another transfer; ST↩ ATUS_CAN_BUFF_OUT_OF_RANGE if the buffer index is out of range; STATUS_ERROR if invalid instance number is used;

Definition at line 678 of file can_pal.c.

16.14.4.14 status_t CAN_SendBlocking (const can_instance_t *const *instance,* uint32_t *buffIdx,* const can_message_t * *message,* uint32_t *timeoutMs*)

Sends a CAN frame using the specified buffer, in a blocking manner.

This function sends a CAN frame using a configured buffer. The function blocks until either the frame was sent, or the specified timeoutMs expired.

Note

When the Rx FIFO extension is used, buffer 0 (zero) is used to read the contents of the FIFO and is configured at the initialization of the driver. The user should not use this buffer for transmission.

Parameters

in	*instance*	Instance information structure.
in	*buffIdx*	buffer index.
in	*message*	message to be sent.
in	*timeoutMs*	A timeout for the transfer in milliseconds.

Returns

STATUS_SUCCESS if successful; STATUS_BUSY if the current buffer is involved in another transfer; ST↩ ATUS_TIMEOUT if the timeout is reached; STATUS_CAN_BUFF_OUT_OF_RANGE if the buffer index is out of range; STATUS_ERROR if invalid instance number is used;

Definition at line 737 of file can_pal.c.

16.14.4.15 status_t CAN_SetBitrate (const can_instance_t *const *instance,* can_bitrate_phase_t *phase,* const can_time_segment_t * *bitTiming*)

Configures the CAN bitrate.

This function configures the CAN bit timing variables.

Parameters

in	*instance*	Instance information structure.
in	*phase*	selects between nominal/data phase bitrate.
in	*bitTiming*	bit timing variables.

Returns

STATUS_SUCCESS if successful; STATUS_ERROR if invalid instance number is used;

Definition at line 402 of file can_pal.c.

16.14.4.16 status_t CAN_SetRxFilter (const can_instance_t *const *instance*, can_msg_id_type_t *idType*, uint32_t *buffIdx*, uint32_t *mask*)

Configures an ID filter for a specific reception buffer.

This function configures an ID filter for each reception buffer.

Note

When the Rx FIFO extension is used, buffer 0 (zero) is used to read the contents of the FIFO and is configured at the initialization of the driver. The user should not reconfigure the Rx filter for this buffer.

Parameters

in	*instance*	Instance information structure.
in	*idType*	selects between standard and extended ID.
in	*buffIdx*	buffer index.
in	*mask*	mask value for ID filtering.

Returns

STATUS_SUCCESS if successful; STATUS_CAN_BUFF_OUT_OF_RANGE if the buffer index is out of range; STATUS_ERROR if invalid instance number is used;

Definition at line 942 of file can_pal.c.

16.15 Controller Area Network with Flexible Data Rate (FlexCAN)

16.15.1 Detailed Description

The S32 SDK provides a Peripheral Driver for the FlexCAN module of S32 SDK devices.

Hardware background

The FlexCAN module is a communication controller implementing the CAN protocol according to the ISO 11898-1 standard and CAN 2.0 B protocol specifications. The FlexCAN module is a full implementation of the CAN protocol specification, the CAN with Flexible Data rate (CAN FD) protocol and the CAN 2.0 version B protocol, which supports both standard and extended message frames and long payloads up to 64 bytes transferred at faster rates up to 8 Mbps. The message buffers are stored in an embedded RAM dedicated to the FlexCAN module.

The FlexCAN module includes these distinctive features:

- Full implementation of the CAN with Flexible Data Rate (CAN FD) protocol specification and CAN protocol specification, Version 2.0 B (see the FEATURE_CAN_HAS_FD define for the availability of this feature on each platform)
  - Standard data frames
  - Extended data frames
  - Zero to sixty four bytes data length
  - Programmable bit rate (see the chip-specific FlexCAN information for the specific maximum bit rate configuration)
  - Content-related addressing
- Compliant with the ISO 11898-1 standard
- Flexible mailboxes configurable to store 0 to 8, 16, 32 or 64 bytes data length (payloads longer than 8 bytes are available only for some platforms, see the FEATURE_CAN_HAS_FD define)
- Each mailbox configurable as receive or transmit, all supporting standard and extended messages
- Individual Rx Mask registers per mailbox
- Full-featured Rx FIFO with storage capacity for up to six frames and automatic internal pointer handling with DMA support (DMA support is available only for some platforms, see the FEATURE_CAN_HAS_DMA_EN↩ ABLE define)
- Transmission abort capability
- Flexible message buffers (MBs) configurable as Rx or Tx (see the FEATURE_CAN_MAX_MB_NUM define for the specific maximum number of message buffers configurable on each platform)
- Programmable clock source to the CAN Protocol Interface, either peripheral clock or oscillator clock (this feature might differ depending on the platform, see FEATURE_CAN_HAS_PE_CLKSRC_SELECT define for the availability of this feature on each platform)
- RAM not used by reception or transmission structures can be used as general purpose RAM space
- Listen-Only mode capability
- Programmable Loop-Back mode supporting self-test operation
- Maskable interrupts
- Short latency time due to an arbitration scheme for high-priority messages
- Low power modes or matching with received frames - Pretended Networking (see FEATURE_CAN_HAS_↩ PRETENDED_NETWORKING define for the availability of this feature on each platform)
- Transceiver Delay Compensation feature when transmitting CAN FD messages at faster data rates (see the FEATURE_CAN_HAS_FD define for the availability of this feature on each platform)

- Remote request frames may be handled automatically or by software
- CAN bit time settings and configuration bits can only be written in Freeze mode
- SYNCH bit available in Error in Status 1 register to inform that the module is synchronous with CAN bus
- CRC status for transmitted message
- Rx FIFO Global Mask register
- Selectable priority between mailboxes and Rx FIFO during matching process
- Powerful Rx FIFO ID filtering, capable of matching incoming IDs against either 128 extended, 256 standard, or 512 partial (8 bit) IDs, with up to 32 individual masking capability
- 100% backward compatibility with previous FlexCAN version
- Supports Pretended Networking functionality in low power: Stop mode (see FEATURE_CAN_HAS_PRET↩ ENDED_NETWORKING define for the availability of this feature on each platform)
- Supports detection and correction of errors in memory read accesses. Errors in one bit can be corrected and errors in 2 bits can be detected but not corrected (this feature might not be available on some platforms, see chip-specific FlexCAN information for details)
- Supports Self Wake Up feature when FlexCAN is in a low power mode: Stop mode (see FEATURE_CAN_↩ HAS_SELF_WAKE_UP define for the availability of this feature on each platform)
- Disable Detection and Correction of Memory Errors Feature for devices that supports it. This feature can cause Freeze Mode of CAN interface. (see FEATURE_CAN_HAS_MEM_ERR_DET define availability of the feature in module)

Modules

- FlexCAN Driver

16.16 Cooked API

16.16.1 Detailed Description

Cooked processing of diagnostic messages manages one complete message at a time.

Functions

- void ld_send_message (l_ifc_handle iii, l_u16 length, l_u8 NAD, const l_u8 *const data)

  Pack the information specified by data and length into one or multiple diagnostic frames.
- void ld_receive_message (l_ifc_handle iii, l_u16 *const length, l_u8 *const NAD, l_u8 *const data)

  Prepare the LIN diagnostic module to receive one message and store it in the buffer pointed to by data.
- l_u8 ld_tx_status (l_ifc_handle iii)

  Get the status of the last made call to ld_send_message.
- l_u8 ld_rx_status (l_ifc_handle iii)

  Get the status of the last made call to ld_send_message.

16.16.2 Function Documentation

16.16.2.1 void ld_receive_message (l_ifc_handle *iii*, l_u16 *const *length*, l_u8 *const *NAD*, l_u8 *const *data*)

Prepare the LIN diagnostic module to receive one message and store it in the buffer pointed to by data.

Parameters

in	*iii*	Lin interface handle
in	*length*	Length of data to receive
in	*NAD*	Node address of slave node
in	*data*	Data to be sent

Returns

void

Prepare the LIN diagnostic module to receive one message and store it in the buffer pointed to by data. At the call, length shall specify the maximum length allowed. When the reception has completed, length is changed to the actual length and NAD to the NAD in the message.

Definition at line 261 of file lin_commontl_api.c.

16.16.2.2 l_u8 ld_rx_status (l_ifc_handle *iii*)

Get the status of the last made call to ld_send_message.

Parameters

in	*iii*	Lin interface handle

Returns

l_u8

The call returns the status of the last made call to ld_receive_message. < br / > The following values can be returned: < br / > LD_IN_PROGRESS: The reception is not yet completed. < br / > LD_COMPLETED: The reception has completed successfully and all < br / > information (length, NAD, data) is available. (You can < br / > also issue a new ld_receive_message call). This < br / > value is also returned after initialization of the < br / > transport layer. < br / > LD_FAILED: The reception ended in an error. The data was only < br / > partially received and should not be trusted. Initialize < br / > before processing further transport layer messages. < br /

> For LIN2.0 and J2602 Users can make a new call to ld_receive_message. For LIN2.1 and above, the transport layer shall be reinitialized before processing further messages. To find out why a transmission has failed, check the status management function l_ifc_read_status. ∗ LD_N_CR_TIMEOUT The reception failed because of a N_Cr timeout (For LIN2.1 and above only)< br / > LD_WRONG_SN The reception failed because of an unexpected sequence number. (For LIN2.1 and above only)

Definition at line 307 of file lin_commontl_api.c.

16.16.2.3 void ld_send_message (l_ifc_handle *iii*, l_u16 *length*, l_u8 *NAD*, const l_u8 ∗const *data*)

Pack the information specified by data and length into one or multiple diagnostic frames.

Parameters

in	*iii*	Lin interface handle
in	*length*	Length of data to send
in	*NAD*	Node address of slave node
in	*data*	Data to be sent

Returns

void

Pack the information specified by data and length into one or multiple diagnostic frames. If the call is made in a master node application the frames are transmitted to the slave node with the address NAD. If the call is made in a slave node application the frames are transmitted to the master node with the address NAD. The parameter NAD is not used in slave nodes.

Definition at line 207 of file lin_commontl_api.c.

16.16.2.4 l_u8 ld_tx_status (l_ifc_handle *iii*)

Get the status of the last made call to ld_send_message.

Parameters

in	*iii*	Lin interface handle

Returns

l_u8

Get the status of the last made call to ld_send_message. The following values can be returned: LD_IN_PRO↩ GRESS: The transmission is not yet completed. LD_COMPLETED: The transmission has completed successfully (and you can issue a new ld_send_message call). This value is also returned after initialization of the transport layer. LD_FAILED: The transmission ended in an error. The data was only partially sent. The transport layer shall be reinitialized before processing further messages. To find out why a transmission has failed, check the status management function l_read_status. For LIN2.0 and J2602 Users can make a new call to ld_send_message. For LIN2.1 and above, the transport layer shall be reinitialized before processing further messages. LD_N_AS_TIME↩ OUT: The transmission failed because of a N_As timeout. This applies for LIN2.1 and above only.

Definition at line 291 of file lin_commontl_api.c.

16.17 Cryptographic Services Engine (CSEc)

16.17.1 Detailed Description

The S32 SDK provides a Peripheral Driver for the Cryptographic Services Engine (CSEc) module of S32 SDK devices.

The FTFC module has added features to comply with the SHE specification. By using an embedded processor, firmware and hardware assisted AES-128 sub-block, the FTFC macro enables encryption, decryption and message generation and authentication algorithms for secure messaging applications. Additionally a TRNG and Miyaguchi-Prenell compression sub-blocks enables true random number generation (entropy generator for PRNG in AES sub-block).

Hardware background

Features of the CSEc module include:

- Secure cryptographic key storage (ranging from 3 to 21 user keys)
- AES-128 encryption and decryption
- AES-128 CMAC (Cipher-based Message Authentication Code) calculation and authentication
- ECB (Electronic Cypher Book) Mode - encryption and decryption
- CBC (Cipher Block Chaining) Mode - encryption and decryption
- True and Pseudo random number generation
- Miyaguchi-Prenell compression function
- Secure Boot Mode (user configurable)
  - Sequential Boot Mode
  - Parallel Boot Mode
  - Strict Sequential Boot Mode (unchangeable once set)

Modules

- CSEc Driver

  Cryptographic Services Engine Peripheral Driver.

16.18 Cyclic Redundancy Check (CRC)

16.18.1 Detailed Description

The S32 SDK provides Peripheral Drivers for the Cyclic Redundancy Check (CRC) module.

1. CRC with S32K1xx and **S32K1xxW:**
   - Generate 16/32-bit CRC code for error detection.
   - Provides a programmable polynomial, seed, and other parameters required to implement 16/32-bit CRC standard.
   - Calculate 16/32-bit code for 32 bits of data at a time.
2. CRC with MPC574x and S32Rx7x:
   - Generate 8/16/32-bit CRC code for error detection.
   - Provides a programmable polynomial, seed, and other parameters required to implement 8/16/32-bit CRC standard.
   - Calculate 8/16/32-bit code for 32 bits of data at a time.

Important note when use CRC module with MPC574x and S32Rx7x devices:

- When generating CRC-32 for the ITU-T V.42 standard the user needs to set SWAP_BYTEWISE together with INV and SWAP.
- When generating CRC-16-CCITT(0x1021) standard the user needs to set SWAP_BITWISE bit.

Basic Operations of CRC

1. To initialize the CRC module, call CRC_DRV_Init() function and pass the user configuration data structure to it. This is example code to configure the CRC driver using CRC_DRV_GetDefaultConfig() function:

```
#define INST_CRC1 (0U)

/* Configuration structure crc1_InitConfig0 */
crc_user_config_t crc1_InitConfig0;

/* Get default configuration for CRC module: CRC-16-CCITT (0x1021) standard */
CRC_DRV_GetDefaultConfig(&crc1_InitConfig0);

/* Initializes the CRC */
CRC_DRV_Init(INST_CRC1, &crc1_InitConfig0);
```

2. To configure and operate the CRC module: Function CRC_DRV_Configure() shall be used to write user configuration to CRC hardware module before starting operation by calling CRC_DRV_WriteData(). Finally, using CRC_DRV_GetCrcResult() function to get the result of CRC calculation. This is example code to configure and get CRC block for S32K1xx:

```
#define INST_CRC1 (0U)

uint8_t buffer[] = { 0x31, 0x32, 0x33, 0x34, 0x35, 0x36, 0x37, 0x38, 0x39, 0x30 };
uint32_t result;

/* Set the CRC configuration: CRC-16-CCITT (0x1021) standard */
CRC_DRV_Configure(INST_CRC1, &crc1_InitConfig0);
/* Write data to the current CRC calculation */
CRC_DRV_WriteData(INST_CRC1, buffer, 10U);
/* Get result of CRC calculation (0x3218U) */
result = CRC_DRV_GetCrcResult(INST_CRC1);

/* De-init */
CRC_DRV_Deinit(INST_CRC1);
```

3. To get result of 32-bit data call CRC_DRV_GetCrc32() function.

```
#define INST_CRC1 (0U)

uint32_t seed = 0xFFFFU;
uint32_t data = 0x12345678U;
uint32_t result;

/* Get result of 32-bit data (0x30EC) at CRC-16-CCITT (0x1021) standard configuration mode */
result = CRC_DRV_GetCrc32(INST_CRC1, data, true, seed);
```

4. To get result of 16-bit data call CRC_DRV_GetCrc16() function.

```
#define INST_CRC1 (0U)

uint32_t seed = 0xFFFFU;
uint16_t data = 0x1234U;
uint32_t result;

/* Get result of 16-bit data (0x0EC9) at CRC-16-CCITT (0x1021) standard configuration mode */
result = CRC_DRV_GetCrc16(INST_CRC1, data, true, seed);
```

5. To get current configuration of the CRC module, just call CRC_DRV_GetConfig() function.

```
#define INST_CRC1 (0U)
crc_user_config_t crc1_InitConfig0;

/* Get current configuration of the CRC module */
CRC_DRV_GetConfig(INST_CRC1, &crc1_InitConfig0);
```

6. To Get default configuration of the CRC module, just call CRC_DRV_GetDefaultConfig() function.

```
#define INST_CRC1 (0U)
crc_user_config_t crc1_InitConfig0;

/* Get default configuration of the CRC module */
CRC_DRV_GetDefaultConfig(&crc1_InitConfig0);
```

Integration guideline

Compilation units

The following files need to be compiled in the project: For **S32K1xx** and **S32K1xxW:**

```
${S32SDK_PATH}\platform\drivers\src\crc\crc_driver.c
${S32SDK_PATH}\platform\drivers\src\crc\crc_hw_access.c
```

For **MPC574x** and **S32Rx7x:**

```
${S32SDK_PATH}\platform\drivers\src\crc\crc_driver.c
${S32SDK_PATH}\platform\drivers\src\crc\crc_c55_hw_access.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager

Modules

- CRC Driver

  Cyclic Redundancy Check Peripheral Driver.

16.19 Diagnostic services

16.19.1 Detailed Description

Diagnostic services defines methods to implement diagnostic data transfer between a master node connected with a diagnostic tester and the slave nodes.

Three different classes of diagnostic nodes are supported.

The master node and the diagnostic tester are connected via a back-bone bus (e.g. CAN). The master node shall receive all diagnostic requests addressed to the slave nodes from the back-bone bus, and gateway them to the correct LIN cluster(s). Responses from the slave nodes shall be gatewayed back to the back-bone bus through the master node.

All diagnostic requests and responses (services) addressed to the slave nodes can be routed in the network layer (i.e. no application layer routing). In this case, the master node must implement the LIN transport protocol, see Transport Layer Specification, as well as the transport protocols used on the back- bone busses (e.g. ISO15765-2 on CAN).

Currently, LinStack support some service. With other service which LinStack doesn't support or user want to add action when any service is received, user can choose or create service in supported services of PEX GUI and use API of transport layer to implement it. in application.

Example in slave node:

```
for(;;)
{
     /* length shall specify the maximum length allowed */
     length = 106;
     ld_receive_message(LI0,&length, &nad, req_data);
     /* if receive READ_DATA_BY_IDENTIFIER master request successfully */
     if(diag_get_flag(LI0, LI0_DIAGSRV_READ_DATA_BY_IDENTIFIER_ORDER))
     {
          diag_clear_flag(LI0, LI0_DIAGSRV_READ_DATA_BY_IDENTIFIER_ORDER);
          /* implement what you want to do when receive this message
             length will return real length of this message
             req_data will contain SID and data of this message */
          /* send back response data */
          ld_send_message(LI0,17,nad, res_data);
     }
}
```

Modules

- Node configuration

  This group contains APIs that used for node configuration purpose.
- Node identification

  This group contains API that used for node identification purpose.

Functions

- void diag_read_data_by_identifier (l_ifc_handle iii, const l_u8 NAD, const l_u8 number_of_id, const l_u16 *const list_of_id)

  This function reads data by identifier, Diagnostic Class II service (0x22).
- void diag_write_data_by_identifier (l_ifc_handle iii, const l_u8 NAD, l_u16 data_length, const l_u8 *const data)

  Write Data by Identifier for a specified node - Diagnostic Class II service (0x2E)
- void diag_session_control (l_ifc_handle iii, const l_u8 NAD, const l_u8 session_type)

  This function is used for master node only. It will pack data and send request to slave node with service ID = 0x10: Session control.
- void diag_fault_memory_read (l_ifc_handle iii, const l_u8 NAD, l_u16 data_length, const l_u8 *const data)

This function is used for master node only. It will pack data and send request to slave node with service ID = 0x19: Fault memory read.

- void diag_fault_memory_clear (l_ifc_handle iii, const l_u8 NAD, const l_u8 *const groupOfDTC)

  This function is used for master node only. It will pack data and send request to slave node with service ID = 0x14: Fault memory clear.
- void diag_IO_control (l_ifc_handle iii, const l_u8 NAD, l_u16 data_length, const l_u8 *const data)

  This function is used for master node only. It will pack data and send request to slave node with service ID = 0x2F: Input/Output control service.
- l_u8 diag_get_flag (l_ifc_handle iii, l_u8 flag_order)

  This function will return flag of diagnostic service, if LIN slave node receive master request of the diagnostic service.
- void diag_clear_flag (l_ifc_handle iii, l_u8 flag_order)

  This function will clear flag of diagnostic service,.

16.19.2 Function Documentation

16.19.2.1 void diag_clear_flag (l_ifc_handle *iii,* l_u8 *flag_order*)

This function will clear flag of diagnostic service,.

Parameters

in	*iii*	LIN interface handle
in	*flag_order*	Order of service flag

Returns

void

Definition at line 1013 of file lin_diagnostic_service.c.

16.19.2.2 void diag_fault_memory_clear (l_ifc_handle *iii,* const l_u8 *NAD,* const l_u8 *const *groupOfDTC*)

This function is used for master node only. It will pack data and send request to slave node with service ID = 0x14: Fault memory clear.

Parameters

in	*iii*	LIN interface handle
in	*NAD*	Node address value of the destination node for the transmission
in	*groupOfDTC*	contain 3 byte will be transmit follow (byte 0: HighByte, byte 1: Middle Byte, byte 2: Low Byte) to be transmitted

Returns

void

Definition at line 759 of file lin_diagnostic_service.c.

16.19.2.3 void diag_fault_memory_read (l_ifc_handle *iii,* const l_u8 *NAD,* l_u16 *data_length,* const l_u8 *const *data*)

This function is used for master node only. It will pack data and send request to slave node with service ID = 0x19: Fault memory read.

Parameters

in	*iii*	LIN interface handle
in	*NAD*	Node address value of the destination node for the transmission
in	*data_length*	Data length of frame
in	*data*	Buffer for the data to be transmitted

Returns

void

Definition at line 713 of file lin_diagnostic_service.c.

16.19.2.4 l_u8 diag_get_flag (l_ifc_handle *iii,* l_u8 *flag_order*)

This function will return flag of diagnostic service, if LIN slave node receive master request of the diagnostic service.

Parameters

in	*iii*	LIN interface handle
in	*flag_order*	Order of service flag

Returns

1 if LIN Slave node receives master request of the diagnostic service, and the flag has not been cleared by diag_clear_flag
0 default value
0xFF if service is not supported

Definition at line 982 of file lin_diagnostic_service.c.

16.19.2.5 void diag_IO_control (l_ifc_handle *iii,* const l_u8 *NAD,* l_u16 *data_length,* const l_u8 ∗const *data*)

This function is used for master node only. It will pack data and send request to slave node with service ID = 0x2F: Input/Output control service.

Parameters

in	*iii*	LIN interface handle
in	*NAD*	Node address value of the destination node for the transmission
in	*data_length*	Data length of frame
in	*data*	Buffer for the data to be transmitted

Returns

void

Definition at line 796 of file lin_diagnostic_service.c.

16.19.2.6 void diag_read_data_by_identifier (l_ifc_handle *iii,* const l_u8 *NAD,* const l_u8 *number_of_id,* const l_u16 ∗const *list_of_id*)

This function reads data by identifier, Diagnostic Class II service (0x22).

Parameters

in	*iii*	LIN interface handle
in	*NAD*	Node address value of the destination node for the transmission

in	*number_of_id*	number id that send in this request
in	*list_of_id*	list of id that send in this request

Returns

void

This function is for Master node only.

Definition at line 580 of file lin_diagnostic_service.c.

16.19.2.7 void diag_session_control (l_ifc_handle *iii*, const l_u8 *NAD*, const l_u8 *session_type*)

This function is used for master node only. It will pack data and send request to slave node with service ID = 0x10: Session control.

Parameters

in	*iii*	LIN interface handle
in	*NAD*	Node address value of the destination node for the transmission
in	*session_type*	is sub function of diagnostic session master request

Returns

void

Definition at line 679 of file lin_diagnostic_service.c.

16.19.2.8 void diag_write_data_by_identifier (l_ifc_handle *iii*, const l_u8 *NAD*, l_u16 *data_length*, const l_u8 *const *data*)

Write Data by Identifier for a specified node - Diagnostic Class II service (0x2E)

Parameters

in	*iii*	Lin interface handle
in	*NAD*	Node address value of the destination node for the transmission
in	*data_length*	Data length of frame
in	*data*	Buffer for the data to be transmitted

Returns

void

This function is for Master node only.

Definition at line 629 of file lin_diagnostic_service.c.

16.20 Driver and cluster management

16.20.1 Detailed Description

API perform the initialization of the LIN core.

Functions

- l_bool l_sys_init (void)

  This function performs the initialization of the LIN core; is the first call a user must use in the LIN core before using any other API functions. The implementation of this function can be replaced by user if needed.

16.20.2 Function Documentation

16.20.2.1 l_bool l_sys_init (void)

This function performs the initialization of the LIN core; is the first call a user must use in the LIN core before using any other API functions. The implementation of this function can be replaced by user if needed.

Returns

Operation status = Zero, which is equivalent to 'Initialization was successful'.

Definition at line 57 of file lin_common_api.c.

16.21 EDMA Driver

16.21.1 Detailed Description

This module covers the functionality of the Enhanced Direct Memory Access (eDMA) peripheral driver.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32KSDK_PATH}\platform\drivers\src\edma\edma_driver.c
${S32KSDK_PATH}\platform\drivers\src\edma\edma_hw_access.c
${S32KSDK_PATH}\platform\drivers\src\edma\edma_irq.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32KSDK_PATH}\platform\drivers\inc\
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager Interrupt Manager (Interrupt)

The eDMA driver implements direct memory access functionality with multiple features: (single block/multi block/loop/scatter-gather transfers); the main usage of this module is to offload the bus read/write accesses from the core to the eDMA engine.

Features

- Memory-to-memory, peripheral-to-memory, memory-to-peripheral transfers
- Simple single-block transfers with minimum configuration
- Multi-block transfers with minimum configuration (based on subsequent requests)
- Loop transfers for complex use-cases (e.g. double buffering)
- Scatter/gather
- Dynamic channel allocation

Functionality

Initialization

In order to use the eDMA driver, the module must be first initialized, using EDMA_DRV_Init() function. Once initialized, it cannot be initialized again until it is de-initialized, using EDMA_DRV_Deinit(). The initialization function does the following operations:

- resets eDMA and DMAMUX modules
- clears the eDMA driver state structure
- sets the arbitration mode and halt settings
- enables error and channel interrupts

Upon module initialization, the application must initialize the channel(s) to be used, using EDMA_DRV_Channel↩Init() function. This operation means enabling an eDMA channel number (or dynamically allocating one), selecting a source trigger (eDMA request multiplexed via DMAMUX) and setting the channel priority. Additionally, a user callback can be installed for each channel, which will be called when the corresponding interrupt is triggered.

Transfer Configuration

After initialization, the transfer control descriptor for the selected channel must be configured before use. Depending on the application use-case, on of the three transfer configuration methods should be called.

Single-block transfer

For the simplest use-case where a contiguous chunk of data must be transferred, the most suitable function is EDMA_DRV_ConfigSingleBlockTransfer(). This takes the source/destination addresses as parameters, as well as transfer type/size and data buffer size, and configures the channel TCD to read/write the data in a single request. The looping and scatter/gather features are not used in this scenario. The driver computes the appropriate offsets for source/destination addresses and set the other TCD fields.

Multi-block transfer

This type of transfer can be seen as a sequence of single-block transfers, as described above, which are triggered by subsequent requests. This configuration is suitable for contiguous chunks of data which need to be transferred in multiple steps (e.g. writing one/several bytes from a memory buffer to a peripheral data register each time the module is free - eDMA-based communication). In order to configure this kind of transfer, EDMA_DRV_Config↩MultiBlockTransfer function should be used; aside from the EDMA_DRV_ConfigSingleBlockTransfer parameters, this function also takes two additional parameters: the number of transfer loops (expected number of requests to finish the data) and a boolean variable configuring whether requests should be disabled for the current channel upon transfer completion.

Loop transfer

The eDMA IP supports complex addressing modes. One of the methods to configure complex transfers in multiple requests is using the minor/major loop support. The EDMA_DRV_ConfigLoopTransfer() function sets up the transfer control descriptor for subsequent requests to trigger multiple transfers. The addresses are adjusted after each minor/major loop, according to user setup. This method takes a transfer configuration structure as parameter, with settings for all the fields that control addressing mode (source/destination offsets, minor loop offset, channel linking, minor/major loop count, address last adjustments). It is the responsibility of the application to correctly initialize the configuration structure passed to this function, according to the addressed use-case.

Scatter/gather

The eDMA driver also supports scatter/gather feature, which allows various transfer scenarios. When scatter/gather is enabled, a new TCD structure is automatically loaded in the current channel's TCD registers when a transfer is complete, allowing the application to define multiple different subsequent transfers. The EDMA_DRV_Config↩ScatterGatherTransfer() function sets up a list of TCD structures based on the parameters received and configures the eDMA channel for the first transfer; upon completion, the second TCD from the list will be loaded and the channel will be ready to start the new transfer when a new request is received.
The application must allocate memory for the TCD list passed to this function (with an extra 32-bytes buffer, as the TCD structures need to be 32 bytes aligned); nevertheless, the driver will take care of initializing the array of descriptors, based on the other parameters passed. The function also received two lists of scatter/gather configuration structures (for source and destination, respectively), which define the address, length and type for each transfer. Besides these, the other parameters received are the transfer size, the number of bytes to be transferred on each request and the number of TCD structures to be used. This method will initialize all the descriptors according to user input and link them together; the linkage is done by writing the address of the next descriptor in the appropriate field of each one, similar to a linked-list data structure. The first descriptor is also copied to the TCD registers of the selected channel; if no errors are returned, after calling this function the channel is configured for the transfer defined by the first descriptor.

Virtual Channel Definition

The virtual channel is used to map multiple hardware channels across multiple eDMA instances. If only one eDMA instance is available, then the virtual channels will map one-on-one with the hardware channels. If more than one eDMA instance is available, then the virtual channels will map continuously and linearly over all of the harware channels. Example: If the SOC has 4 eDMA modules, each with 32 channels, then the user will be able to address a total of 128 virtual channels, that seamlessly map onto the hardware channels.

Virtual Channel Control

The eDMA driver provides functions that allow the user to start, stop, allocate and release an eDMA virtual channel.
The EDMA_DRV_StartChannel() enables the eDMA requests for a virtual channel; this function should be called when the virtual channel is already initialized, as the first request received after the function call will trigger the transfer based on the current values of the virtual channel's TCD registers.
The EDMA_DRV_StopChannel() function disables requests for the selected virtual channel; this function should be called whenever the application needs to ignore eDMA requests for a virtual channel. It is automatically called when the virtual channel is released.
The EDMA_DRV_SetChannelRequestAndTrigger() function configures the selected virtual channel request and also configures the periodic trigger functionality of the eDMA channel.
Periodic triggering is used by an internal timer to control an eDMA channel.

The EDMA_DRV_ReleaseChannel() function frees the hardware and software resources allocated for that virtual channel; it clears the virtual channel state structure, updates the driver state and disables requests for that virtual channel.

Important Notes

- Before using the eDMA driver the clock for eDMA and DMAMUX modules must be configured
- The driver enables the interrupts for the eDMA module, but any interrupt priority must be done by the application
- When using the modulo feature, application is responsible with ensuring that the source/destination address is properly aligned on a modulo-size boudary.
- The source/destination address must be aligned with transfer size. Ex: With transfer size is 8 bytes, the source/destination address is multiple of 8.
- When using Single-block transfer or Multi-block transfer, NBYTES (Number of bytes to be transferred in each service request of the channel) shall be always configurable on 30 bits instead of 32 bits. This is a limitation only on EDMA Hardware version 2 (S32K1xx platform).
- Limitation of IAR compiler: function alignment is not supported using ALIGNED() macro.

Data Structures

- struct edma_user_config_t

  The user configuration structure for the eDMA driver. More...
- struct edma_chn_state_t

  Data structure for the eDMA channel state. Implements : edma_chn_state_t_Class. More...
- struct edma_channel_config_t

  The user configuration structure for the an eDMA driver channel. More...
- struct edma_scatter_gather_list_t

  Data structure for configuring a discrete memory transfer. Implements : edma_scatter_gather_list_t_Class. More...
- struct edma_state_t

  Runtime state structure for the eDMA driver. More...
- struct edma_loop_transfer_config_t

  eDMA loop transfer configuration. More...
- struct edma_transfer_config_t

eDMA transfer size configuration. More...

- struct edma_software_tcd_t

  eDMA TCD Implements : edma_software_tcd_t_Class More...

Macros

- #define STCD_SIZE(number) (((number) * 32U) - 1U)

  Macro for the memory size needed for the software TCD.
- #define STCD_ADDR(address) (((uint32_t)address + 31UL) & ~0x1FUL)
- #define EDMA_ERR_LSB_MASK 1U

  Macro for accessing the least significant bit of the ERR register.

Typedefs

- typedef void(* edma_callback_t) (void *parameter, edma_chn_status_t status)

  Definition for the eDMA channel callback function.

Enumerations

- enum edma_channel_interrupt_t { EDMA_CHN_ERR_INT = 0U, EDMA_CHN_HALF_MAJOR_LOOP_INT, EDMA_CHN_MAJOR_LOOP_INT }

  eDMA channel interrupts. Implements : edma_channel_interrupt_t_Class
- enum edma_arbitration_algorithm_t { EDMA_ARBITRATION_FIXED_PRIORITY = 0U, EDMA_ARBITRATION_ROUND_ROBIN }

  eDMA channel arbitration algorithm used for selection among channels. Implements : edma_arbitration_algorithm_t_Class
- enum edma_channel_priority_t {
  EDMA_CHN_PRIORITY_0 = 0U, EDMA_CHN_PRIORITY_1 = 1U, EDMA_CHN_PRIORITY_2 = 2U, EDMA_CHN_PRIORITY_3 = 3U,
  EDMA_CHN_PRIORITY_4 = 4U, EDMA_CHN_PRIORITY_5 = 5U, EDMA_CHN_PRIORITY_6 = 6U, EDMA_CHN_PRIORITY_7 = 7U,
  EDMA_CHN_PRIORITY_8 = 8U, EDMA_CHN_PRIORITY_9 = 9U, EDMA_CHN_PRIORITY_10 = 10U, EDMA_CHN_PRIORITY_11 = 11U,
  EDMA_CHN_PRIORITY_12 = 12U, EDMA_CHN_PRIORITY_13 = 13U, EDMA_CHN_PRIORITY_14 = 14U, EDMA_CHN_PRIORITY_15 = 15U,
  EDMA_CHN_DEFAULT_PRIORITY = 255U }

  eDMA channel priority setting Implements : edma_channel_priority_t_Class
- enum edma_modulo_t {
  EDMA_MODULO_OFF = 0U, EDMA_MODULO_2B, EDMA_MODULO_4B, EDMA_MODULO_8B,
  EDMA_MODULO_16B, EDMA_MODULO_32B, EDMA_MODULO_64B, EDMA_MODULO_128B,
  EDMA_MODULO_256B, EDMA_MODULO_512B, EDMA_MODULO_1KB, EDMA_MODULO_2KB,
  EDMA_MODULO_4KB, EDMA_MODULO_8KB, EDMA_MODULO_16KB, EDMA_MODULO_32KB,
  EDMA_MODULO_64KB, EDMA_MODULO_128KB, EDMA_MODULO_256KB, EDMA_MODULO_512KB,
  EDMA_MODULO_1MB, EDMA_MODULO_2MB, EDMA_MODULO_4MB, EDMA_MODULO_8MB,
  EDMA_MODULO_16MB, EDMA_MODULO_32MB, EDMA_MODULO_64MB, EDMA_MODULO_128MB,
  EDMA_MODULO_256MB, EDMA_MODULO_512MB, EDMA_MODULO_1GB, EDMA_MODULO_2GB }

  eDMA modulo configuration Implements : edma_modulo_t_Class
- enum edma_transfer_size_t { EDMA_TRANSFER_SIZE_1B = 0x0U, EDMA_TRANSFER_SIZE_2B = 0x1U, EDMA_TRANSFER_SIZE_4B = 0x2U }

  eDMA transfer configuration Implements : edma_transfer_size_t_Class
- enum edma_chn_status_t { EDMA_CHN_NORMAL = 0U, EDMA_CHN_ERROR }

  Channel status for eDMA channel.
- enum edma_transfer_type_t { EDMA_TRANSFER_PERIPH2MEM = 0U, EDMA_TRANSFER_MEM2PERIPH, EDMA_TRANSFER_MEM2MEM, EDMA_TRANSFER_PERIPH2PERIPH }

  A type for the DMA transfer. Implements : edma_transfer_type_t_Class.

eDMA peripheral driver module level functions

- status_t EDMA_DRV_Init (edma_state_t *edmaState, const edma_user_config_t *userConfig, edma_chn_state_t *const chnStateArray[ ], const edma_channel_config_t *const chnConfigArray[ ], uint32_t chnCount)

  Initializes the eDMA module.
- status_t EDMA_DRV_Deinit (void)

  De-initializes the eDMA module.

eDMA peripheral driver channel management functions

- status_t EDMA_DRV_ChannelInit (edma_chn_state_t *edmaChannelState, const edma_channel_config_t *edmaChannelConfig)

  Initializes an eDMA channel.
- status_t EDMA_DRV_ReleaseChannel (uint8_t virtualChannel)

  Releases an eDMA channel.

eDMA peripheral driver transfer setup functions

- void EDMA_DRV_PushConfigToReg (uint8_t virtualChannel, const edma_transfer_config_t *tcd)

  Copies the channel configuration to the TCD registers.
- void EDMA_DRV_PushConfigToSTCD (const edma_transfer_config_t *config, edma_software_tcd_t *stcd)

  Copies the channel configuration to the software TCD structure.
- status_t EDMA_DRV_ConfigSingleBlockTransfer (uint8_t virtualChannel, edma_transfer_type_t type, uint32_t srcAddr, uint32_t destAddr, edma_transfer_size_t transferSize, uint32_t dataBufferSize)

  Configures a simple single block data transfer with DMA.
- status_t EDMA_DRV_ConfigMultiBlockTransfer (uint8_t virtualChannel, edma_transfer_type_t type, uint32_t srcAddr, uint32_t destAddr, edma_transfer_size_t transferSize, uint32_t blockSize, uint32_t blockCount, bool disableReqOnCompletion)

  Configures a multiple block data transfer with DMA.
- status_t EDMA_DRV_ConfigLoopTransfer (uint8_t virtualChannel, const edma_transfer_config_t *transferConfig)

  Configures the DMA transfer in loop mode.
- status_t EDMA_DRV_ConfigScatterGatherTransfer (uint8_t virtualChannel, edma_software_tcd_t *stcd, edma_transfer_size_t transferSize, uint32_t bytesOnEachRequest, const edma_scatter_gather_list_t *srcList, const edma_scatter_gather_list_t *destList, uint8_t tcdCount)

  Configures the DMA transfer in a scatter-gather mode.
- void EDMA_DRV_CancelTransfer (bool error)

  Cancel the running transfer.

eDMA Peripheral driver channel operation functions

- status_t EDMA_DRV_StartChannel (uint8_t virtualChannel)

  Starts an eDMA channel.
- status_t EDMA_DRV_StopChannel (uint8_t virtualChannel)

  Stops the eDMA channel.
- status_t EDMA_DRV_SetChannelRequestAndTrigger (uint8_t virtualChannel, uint8_t request, bool enableTrigger)

  Configures the DMA request for the eDMA channel.
- void EDMA_DRV_ClearTCD (uint8_t virtualChannel)

  Clears all registers to 0 for the channel's TCD.
- void EDMA_DRV_SetSrcAddr (uint8_t virtualChannel, uint32_t address)

  Configures the source address for the eDMA channel.

- void EDMA_DRV_SetSrcOffset (uint8_t virtualChannel, int16_t offset)

  Configures the source address signed offset for the eDMA channel.
- void EDMA_DRV_SetSrcReadChunkSize (uint8_t virtualChannel, edma_transfer_size_t size)

  Configures the source data chunk size (transferred in a read sequence).
- void EDMA_DRV_SetSrcLastAddrAdjustment (uint8_t virtualChannel, int32_t adjust)

  Configures the source address last adjustment.
- void EDMA_DRV_SetDestAddr (uint8_t virtualChannel, uint32_t address)

  Configures the destination address for the eDMA channel.
- void EDMA_DRV_SetDestOffset (uint8_t virtualChannel, int16_t offset)

  Configures the destination address signed offset for the eDMA channel.
- void EDMA_DRV_SetDestWriteChunkSize (uint8_t virtualChannel, edma_transfer_size_t size)

  Configures the destination data chunk size (transferred in a write sequence).
- void EDMA_DRV_SetDestLastAddrAdjustment (uint8_t virtualChannel, int32_t adjust)

  Configures the destination address last adjustment.
- void EDMA_DRV_SetMinorLoopBlockSize (uint8_t virtualChannel, uint32_t nbytes)

  Configures the number of bytes to be transferred in each service request of the channel.
- void EDMA_DRV_SetMajorLoopIterationCount (uint8_t virtualChannel, uint32_t majorLoopCount)

  Configures the number of major loop iterations.
- uint32_t EDMA_DRV_GetRemainingMajorIterationsCount (uint8_t virtualChannel)

  Returns the remaining major loop iteration count.
- void EDMA_DRV_SetScatterGatherLink (uint8_t virtualChannel, uint32_t nextTCDAddr)

  Configures the memory address of the next TCD, in scatter/gather mode.
- void EDMA_DRV_DisableRequestsOnTransferComplete (uint8_t virtualChannel, bool disable)

  Disables/Enables the DMA request after the major loop completes for the TCD.
- void EDMA_DRV_ConfigureInterrupt (uint8_t virtualChannel, edma_channel_interrupt_t intSrc, bool enable)

  Disables/Enables the channel interrupt requests.
- void EDMA_DRV_TriggerSwRequest (uint8_t virtualChannel)

  Triggers a sw request for the current channel.

eDMA Peripheral callback and interrupt functions

- status_t EDMA_DRV_InstallCallback (uint8_t virtualChannel, edma_callback_t callback, void ∗parameter)

  Registers the callback function and the parameter for eDMA channel.

eDMA Peripheral driver miscellaneous functions

- edma_chn_status_t EDMA_DRV_GetChannelStatus (uint8_t virtualChannel)

  Gets the eDMA channel status.

16.21.2 Data Structure Documentation

16.21.2.1 struct edma_user_config_t

The user configuration structure for the eDMA driver.

Use an instance of this structure with the EDMA_DRV_Init() function. This allows the user to configure settings of the EDMA peripheral with a single function call. Implements : edma_user_config_t_Class

Definition at line 232 of file edma_driver.h.

Data Fields

- edma_arbitration_algorithm_t chnArbitration
- bool haltOnError

Field Documentation

16.21.2.1.1 edma_arbitration_algorithm_t chnArbitration

eDMA channel arbitration.

Definition at line 233 of file edma_driver.h.

16.21.2.1.2 bool haltOnError

Any error causes the HALT bit to set. Subsequently, all service requests are ignored until the HALT bit is cleared.

Definition at line 241 of file edma_driver.h.

16.21.2.2 struct edma_chn_state_t

Data structure for the eDMA channel state. Implements : edma_chn_state_t_Class.

Definition at line 268 of file edma_driver.h.

Data Fields

- uint8_t virtChn
- edma_callback_t callback
- void * parameter
- volatile edma_chn_status_t status

Field Documentation

16.21.2.2.1 edma_callback_t callback

Callback function pointer for the eDMA channel. It will be called at the eDMA channel complete and eDMA channel error.

Definition at line 270 of file edma_driver.h.

16.21.2.2.2 void* parameter

Parameter for the callback function pointer.

Definition at line 273 of file edma_driver.h.

16.21.2.2.3 volatile edma_chn_status_t status

eDMA channel status.

Definition at line 274 of file edma_driver.h.

16.21.2.2.4 uint8_t virtChn

Virtual channel number.

Definition at line 269 of file edma_driver.h.

16.21.2.3 struct edma_channel_config_t

The user configuration structure for the an eDMA driver channel.

Use an instance of this structure with the EDMA_DRV_ChannelInit() function. This allows the user to configure settings of the EDMA channel with a single function call. Implements : edma_channel_config_t_Class

Definition at line 284 of file edma_driver.h.

Data Fields

- edma_channel_priority_t channelPriority

- uint8_t virtChnConfig
- edma_callback_t callback
- void * callbackParam
- bool enableTrigger

Field Documentation

16.21.2.3.1 edma_callback_t callback

Callback that will be registered for this channel

Definition at line 297 of file edma_driver.h.

16.21.2.3.2 void* callbackParam

Parameter passed to the channel callback

Definition at line 298 of file edma_driver.h.

16.21.2.3.3 edma_channel_priority_t channelPriority

eDMA channel priority - only used when channel arbitration mode is 'Fixed priority'.

Definition at line 291 of file edma_driver.h.

16.21.2.3.4 bool enableTrigger

Enables the periodic trigger capability for the DMA channel.

Definition at line 299 of file edma_driver.h.

16.21.2.3.5 uint8_t virtChnConfig

eDMA virtual channel number

Definition at line 293 of file edma_driver.h.

16.21.2.4 struct edma_scatter_gather_list_t

Data structure for configuring a discrete memory transfer. Implements : edma_scatter_gather_list_t_Class.

Definition at line 315 of file edma_driver.h.

Data Fields

- uint32_t address
- uint32_t length
- edma_transfer_type_t type

Field Documentation

16.21.2.4.1 uint32_t address

Address of buffer.

Definition at line 316 of file edma_driver.h.

16.21.2.4.2 uint32_t length

Length of buffer.

Definition at line 317 of file edma_driver.h.

16.21.2.4.3 edma_transfer_type_t type

Type of the DMA transfer

Definition at line 318 of file edma_driver.h.

16.21.2.5 struct edma_state_t

Runtime state structure for the eDMA driver.

This structure holds data that is used by the eDMA peripheral driver to manage multi eDMA channels. The user passes the memory for this run-time state structure and the eDMA driver populates the members. Implements : edma_state_t_Class

Definition at line 330 of file edma_driver.h.

Data Fields

- edma_chn_state_t ∗volatile virtChnState [(uint32_t) FEATURE_DMA_VIRTUAL_CHANNELS]

Field Documentation

16.21.2.5.1 edma_chn_state_t∗ volatile virtChnState[(uint32_t) FEATURE_DMA_VIRTUAL_CHANNELS]

Pointer array storing channel state.

Definition at line 331 of file edma_driver.h.

16.21.2.6 struct edma_loop_transfer_config_t

eDMA loop transfer configuration.

This structure configures the basic minor/major loop attributes. Implements : edma_loop_transfer_config_t_Class

Definition at line 340 of file edma_driver.h.

Data Fields

- uint32_t majorLoopIterationCount
- bool srcOffsetEnable
- bool dstOffsetEnable
- int32_t minorLoopOffset
- bool minorLoopChnLinkEnable
- uint8_t minorLoopChnLinkNumber
- bool majorLoopChnLinkEnable
- uint8_t majorLoopChnLinkNumber

Field Documentation

16.21.2.6.1 bool dstOffsetEnable

Selects whether the minor loop offset is applied to the destination address upon minor loop completion.

Definition at line 344 of file edma_driver.h.

16.21.2.6.2 bool majorLoopChnLinkEnable

Enables channel-to-channel linking on major loop complete.

Definition at line 351 of file edma_driver.h.

16.21.2.6.3 uint8_t majorLoopChnLinkNumber

The number of the next channel to be started by DMA engine when major loop completes.

Definition at line 352 of file edma_driver.h.

16.21.2.6.4 uint32_t majorLoopIterationCount

Number of major loop iterations.

Definition at line 341 of file edma_driver.h.

16.21.2.6.5 bool minorLoopChnLinkEnable

Enables channel-to-channel linking on minor loop complete.

Definition at line 348 of file edma_driver.h.

16.21.2.6.6 uint8_t minorLoopChnLinkNumber

The number of the next channel to be started by DMA engine when minor loop completes.

Definition at line 349 of file edma_driver.h.

16.21.2.6.7 int32_t minorLoopOffset

Sign-extended offset applied to the source or destination address to form the next-state value after the minor loop completes.

Definition at line 346 of file edma_driver.h.

16.21.2.6.8 bool srcOffsetEnable

Selects whether the minor loop offset is applied to the source address upon minor loop completion.

Definition at line 342 of file edma_driver.h.

16.21.2.7 struct edma_transfer_config_t

eDMA transfer size configuration.

This structure configures the basic source/destination transfer attribute. Implements : edma_transfer_config_t_↩ Class

Definition at line 362 of file edma_driver.h.

Data Fields

- uint32_t srcAddr
- uint32_t destAddr
- edma_transfer_size_t srcTransferSize
- edma_transfer_size_t destTransferSize
- int16_t srcOffset
- int16_t destOffset
- int32_t srcLastAddrAdjust
- int32_t destLastAddrAdjust
- edma_modulo_t srcModulo
- edma_modulo_t destModulo
- uint32_t minorByteTransferCount
- bool scatterGatherEnable
- uint32_t scatterGatherNextDescAddr
- bool interruptEnable
- edma_loop_transfer_config_t * loopTransferConfig

Field Documentation

16.21.2.7.1 uint32_t destAddr

Memory address pointing to the destination data.

Definition at line 364 of file edma_driver.h.

16.21.2.7.2 int32_t destLastAddrAdjust

Last destination address adjustment. Note here it is only valid when scatter/gather feature is not enabled.

Definition at line 374 of file edma_driver.h.

16.21.2.7.3 edma_modulo_t destModulo

Destination address modulo.

Definition at line 377 of file edma_driver.h.

16.21.2.7.4 int16_t destOffset

Sign-extended offset applied to the current destination address to form the next-state value as each source read/write is completed.

Definition at line 370 of file edma_driver.h.

16.21.2.7.5 edma_transfer_size_t destTransferSize

Destination data transfer size.

Definition at line 366 of file edma_driver.h.

16.21.2.7.6 bool interruptEnable

Enable the interrupt request when the major loop count completes

Definition at line 385 of file edma_driver.h.

16.21.2.7.7 edma_loop_transfer_config_t* loopTransferConfig

Pointer to loop transfer configuration structure (defines minor/major loop attributes) Note: this field is only used when minor loop mapping is enabled from DMA configuration.

Definition at line 387 of file edma_driver.h.

16.21.2.7.8 uint32_t minorByteTransferCount

Number of bytes to be transferred in each service request of the channel.

Definition at line 378 of file edma_driver.h.

16.21.2.7.9 bool scatterGatherEnable

Enable scatter gather feature.

Definition at line 380 of file edma_driver.h.

16.21.2.7.10 uint32_t scatterGatherNextDescAddr

The address of the next descriptor to be used, when scatter/gather feature is enabled. Note: this value is not used when scatter/gather feature is disabled.

Definition at line 381 of file edma_driver.h.

16.21.2.7.11 uint32_t srcAddr

Memory address pointing to the source data.

Definition at line 363 of file edma_driver.h.

16.21.2.7.12 int32_t srcLastAddrAdjust

Last source address adjustment.

Definition at line 373 of file edma_driver.h.

16.21.2.7.13 edma_modulo_t srcModulo

Source address modulo.

Definition at line 376 of file edma_driver.h.

16.21.2.7.14 int16_t srcOffset

Sign-extended offset applied to the current source address to form the next-state value as each source read/write is completed.

Definition at line 367 of file edma_driver.h.

16.21.2.7.15 edma_transfer_size_t srcTransferSize

Source data transfer size.

Definition at line 365 of file edma_driver.h.

16.21.2.8 struct edma_software_tcd_t

eDMA TCD Implements : edma_software_tcd_t_Class

Definition at line 397 of file edma_driver.h.

Data Fields

- uint32_t SADDR
- int16_t SOFF
- uint16_t ATTR
- uint32_t NBYTES
- int32_t SLAST
- uint32_t DADDR
- int16_t DOFF
- uint16_t CITER
- int32_t DLAST_SGA
- uint16_t CSR
- uint16_t BITER

Field Documentation

16.21.2.8.1 uint16_t ATTR

Definition at line 400 of file edma_driver.h.

16.21.2.8.2 uint16_t BITER

Definition at line 408 of file edma_driver.h.

16.21.2.8.3 uint16_t CITER

Definition at line 405 of file edma_driver.h.

16.21.2.8.4 uint16_t CSR

Definition at line 407 of file edma_driver.h.

16.21.2.8.5 uint32_t DADDR

Definition at line 403 of file edma_driver.h.

16.21.2.8.6 int32_t DLAST_SGA

Definition at line 406 of file edma_driver.h.

16.21.2.8.7 int16_t DOFF

Definition at line 404 of file edma_driver.h.

16.21.2.8.8 uint32_t NBYTES

Definition at line 401 of file edma_driver.h.

16.21.2.8.9 uint32_t SADDR

Definition at line 398 of file edma_driver.h.

16.21.2.8.10 int32_t SLAST

Definition at line 402 of file edma_driver.h.

16.21.2.8.11 int16_t SOFF

Definition at line 399 of file edma_driver.h.

16.21.3 Macro Definition Documentation

16.21.3.1 #define EDMA_ERR_LSB_MASK 1U

Macro for accessing the least significant bit of the ERR register.

The erroneous channels are retrieved from ERR register by subsequently right shifting all the ERR bits + "AND"-ing the result with this mask.

Definition at line 65 of file edma_driver.h.

16.21.3.2 #define STCD_ADDR(*address*) (((uint32_t)address + 31UL) & ∼0x1FUL)

Definition at line 57 of file edma_driver.h.

16.21.3.3 #define STCD_SIZE(*number*) (((number) ∗ 32U) - 1U)

Macro for the memory size needed for the software TCD.

Software TCD is aligned to 32 bytes. We don't need a software TCD structure for the first descriptor, since the configuration is pushed directly to registers. To make sure the software TCD can meet the eDMA module requirement regarding alignment, allocate memory for the remaining descriptors with extra 31 bytes.

Definition at line 56 of file edma_driver.h.

16.21.4 Typedef Documentation

16.21.4.1 typedef void(∗ edma_callback_t) (void ∗parameter, edma_chn_status_t status)

Definition for the eDMA channel callback function.

Prototype for the callback function registered in the eDMA driver. Implements : edma_callback_t_Class

Definition at line 263 of file edma_driver.h.

16.21.5 Enumeration Type Documentation

16.21.5.1 enum edma_arbitration_algorithm_t

eDMA channel arbitration algorithm used for selection among channels. Implements : edma_arbitration_algorithm_t_Class

Enumerator

EDMA_ARBITRATION_FIXED_PRIORITY Fixed Priority

EDMA_ARBITRATION_ROUND_ROBIN Round-Robin arbitration

Definition at line 79 of file edma_driver.h.

16.21.5.2 enum edma_channel_interrupt_t

eDMA channel interrupts. Implements : edma_channel_interrupt_t_Class

Enumerator

EDMA_CHN_ERR_INT Error interrupt

EDMA_CHN_HALF_MAJOR_LOOP_INT Half major loop interrupt.

EDMA_CHN_MAJOR_LOOP_INT Complete major loop interrupt.

Definition at line 70 of file edma_driver.h.

16.21.5.3 enum edma_channel_priority_t

eDMA channel priority setting Implements : edma_channel_priority_t_Class

Enumerator

EDMA_CHN_PRIORITY_0

EDMA_CHN_PRIORITY_1

EDMA_CHN_PRIORITY_2

EDMA_CHN_PRIORITY_3

EDMA_CHN_PRIORITY_4

EDMA_CHN_PRIORITY_5

EDMA_CHN_PRIORITY_6

EDMA_CHN_PRIORITY_7

EDMA_CHN_PRIORITY_8

EDMA_CHN_PRIORITY_9

EDMA_CHN_PRIORITY_10

EDMA_CHN_PRIORITY_11

EDMA_CHN_PRIORITY_12

EDMA_CHN_PRIORITY_13

EDMA_CHN_PRIORITY_14

EDMA_CHN_PRIORITY_15

EDMA_CHN_DEFAULT_PRIORITY

Definition at line 87 of file edma_driver.h.

16.21.5.4 enum edma_chn_status_t

Channel status for eDMA channel.

A structure describing the eDMA channel status. The user can get the status by callback parameter or by calling EDMA_DRV_getStatus() function. Implements : edma_chn_status_t_Class

Enumerator

EDMA_CHN_NORMAL eDMA channel normal state.

EDMA_CHN_ERROR An error occurred in the eDMA channel.

Definition at line 252 of file edma_driver.h.

16.21.5.5 enum edma_modulo_t

eDMA modulo configuration Implements : edma_modulo_t_Class

Enumerator

EDMA_MODULO_OFF
EDMA_MODULO_2B
EDMA_MODULO_4B
EDMA_MODULO_8B
EDMA_MODULO_16B
EDMA_MODULO_32B
EDMA_MODULO_64B
EDMA_MODULO_128B
EDMA_MODULO_256B
EDMA_MODULO_512B
EDMA_MODULO_1KB
EDMA_MODULO_2KB
EDMA_MODULO_4KB
EDMA_MODULO_8KB
EDMA_MODULO_16KB
EDMA_MODULO_32KB
EDMA_MODULO_64KB
EDMA_MODULO_128KB
EDMA_MODULO_256KB
EDMA_MODULO_512KB
EDMA_MODULO_1MB
EDMA_MODULO_2MB
EDMA_MODULO_4MB
EDMA_MODULO_8MB
EDMA_MODULO_16MB
EDMA_MODULO_32MB
EDMA_MODULO_64MB
EDMA_MODULO_128MB
EDMA_MODULO_256MB
EDMA_MODULO_512MB
EDMA_MODULO_1GB
EDMA_MODULO_2GB

Definition at line 159 of file edma_driver.h.

16.21.5.6 enum edma_transfer_size_t

eDMA transfer configuration Implements : edma_transfer_size_t_Class

Enumerator

EDMA_TRANSFER_SIZE_1B

EDMA_TRANSFER_SIZE_2B

EDMA_TRANSFER_SIZE_4B

Definition at line 197 of file edma_driver.h.

16.21.5.7 enum edma_transfer_type_t

A type for the DMA transfer. Implements : edma_transfer_type_t_Class.

Enumerator

EDMA_TRANSFER_PERIPH2MEM Transfer from peripheral to memory

EDMA_TRANSFER_MEM2PERIPH Transfer from memory to peripheral

EDMA_TRANSFER_MEM2MEM Transfer from memory to memory

EDMA_TRANSFER_PERIPH2PERIPH Transfer from peripheral to peripheral

Definition at line 305 of file edma_driver.h.

16.21.6 Function Documentation

16.21.6.1 void EDMA_DRV_CancelTransfer (bool *error*)

Cancel the running transfer.

This function cancels the current transfer, optionally signalling an error.

Parameters

bool	error If true, an error will be logged for the current transfer.

Definition at line 1487 of file edma_driver.c.

16.21.6.2 status_t EDMA_DRV_ChannelInit (edma_chn_state_t * *edmaChannelState,* const edma_channel_config_t * *edmaChannelConfig*)

Initializes an eDMA channel.

This function initializes the run-time state structure for a eDMA channel, based on user configuration. It will request the channel, set up the channel priority and install the callback.

Parameters

edmaChannel↩ State	Pointer to the eDMA channel state structure. The user passes the memory for this run-time state structure and the eDMA peripheral driver populates the members. This run-time state structure keeps track of the eDMA channel status. The memory must be kept valid before calling the EDMA_DRV_ReleaseChannel.

edmaChannel↩ Config	User configuration structure for eDMA channel. The user populates the members of this structure and passes the pointer of this structure into the function.

Returns

STATUS_ERROR or STATUS_SUCCESS.

Definition at line 287 of file edma_driver.c.

16.21.6.3 void EDMA_DRV_ClearTCD (uint8_t *virtualChannel*)

Clears all registers to 0 for the channel's TCD.

Parameters

virtualChannel	eDMA virtual channel number.

Definition at line 1019 of file edma_driver.c.

16.21.6.4 status_t EDMA_DRV_ConfigLoopTransfer (uint8_t *virtualChannel,* const edma_transfer_config_t * *transferConfig*)

Configures the DMA transfer in loop mode.

This function configures the DMA transfer in a loop chain. The user passes a block of memory into this function that configures the loop transfer properties (minor/major loop count, address offsets, channel linking). The DMA driver copies the configuration to TCD registers, only when the loop properties are set up correctly and minor loop mapping is enabled for the eDMA module.

Parameters

virtualChannel	eDMA virtual channel number.
transferConfig	Pointer to the transfer configuration strucutre; this structure defines fields for setting up the basic transfer and also a pointer to a memory strucure that defines the loop chain properties (minor/major).

Returns

STATUS_ERROR or STATUS_SUCCESS

Definition at line 689 of file edma_driver.c.

16.21.6.5 status_t EDMA_DRV_ConfigMultiBlockTransfer (uint8_t *virtualChannel,* edma_transfer_type_t *type,* uint32_t *srcAddr,* uint32_t *destAddr,* edma_transfer_size_t *transferSize,* uint32_t *blockSize,* uint32_t *blockCount,* bool *disableReqOnCompletion*)

Configures a multiple block data transfer with DMA.

This function configures the descriptor for a multi-block transfer. The function considers contiguous memory blocks, thus it configures the TCD source/destination offset fields to cover the data buffer without gaps, according to "transferSize" parameter (the offset is equal to the number of bytes transferred in a source read/destination write). The buffer is divided in multiple block, each block being transferred upon a single DMA request.

NOTE: For transfers to/from peripherals, make sure the transfer size is equal to the data buffer size of the peripheral used, otherwise only truncated chunks of data may be transferred (e.g. for a communication IP with an 8-bit data register the transfer size should be 1B, whereas for a 32-bit data register, the transfer size should be 4B). The rationale of this constraint is that, on the peripheral side, the address offset is set to zero, allowing to read/write data from/to the peripheral in a single source read/destination write operation.

Parameters

virtualChannel	eDMA virtual channel number.
type	Transfer type (M->M, P->M, M->P, P->P).
srcAddr	A source register address or a source memory address.
destAddr	A destination register address or a destination memory address.
transferSize	The number of bytes to be transferred on every DMA write/read. Source/Dest share the same write/read size.
blockSize	The total number of bytes inside a block.
blockCount	The total number of data blocks (one block is transferred upon a DMA request).
disableReqOnCompletion	This parameter specifies whether the DMA channel should be disabled when the transfer is complete (further requests will remain untreated).

Returns

STATUS_ERROR or STATUS_SUCCESS

Definition at line 629 of file edma_driver.c.

16.21.6.6 status_t EDMA_DRV_ConfigScatterGatherTransfer (uint8_t *virtualChannel*, edma_software_tcd_t * *stcd*, edma_transfer_size_t *transferSize*, uint32_t *bytesOnEachRequest*, const edma_scatter_gather_list_t * *srcList*, const edma_scatter_gather_list_t * *destList*, uint8_t *tcdCount*)

Configures the DMA transfer in a scatter-gather mode.

This function configures the descriptors into a single-ended chain. The user passes blocks of memory into this function. The interrupt is triggered only when the last memory block is completed. The memory block information is passed with the edma_scatter_gather_list_t data structure, which can tell the memory address and length. The DMA driver configures the descriptor for each memory block, transfers the descriptor from the first one to the last one, and stops.

Parameters

virtualChannel	eDMA virtual channel number.
stcd	Array of empty software TCD structures. The user must prepare this memory block. We don't need a software TCD structure for the first descriptor, since the configuration is pushed directly to registers.The "stcd" buffer must align with 32 bytes; if not, an error occurs in the eDMA driver. Thus, the required memory size for "stcd" is equal to tcdCount * size_of(edma_software_tcd_t) - 1; the driver will take care of the memory alignment if the provided memory buffer is big enough. For proper allocation of the "stcd" buffer it is recommended to use STCD_SIZE macro.
transferSize	The number of bytes to be transferred on every DMA write/read.
bytesOnEachRequest	Bytes to be transferred in each DMA request.
srcList	Data structure storing the address, length and type of transfer (M->M, M->P, P->M, P->P) for the bytes to be transferred for source memory blocks. If the source memory is peripheral, the length is not used.
destList	Data structure storing the address, length and type of transfer (M->M, M->P, P->M, P->P) for the bytes to be transferred for destination memory blocks. In the memory-to-memory transfer mode, the user must ensure that the length of the destination scatter gather list is equal to the source scatter gather list. If the destination memory is a peripheral register, the length is not used.

tcdCount	The number of TCD memory blocks contained in the scatter gather list.

Returns

STATUS_ERROR or STATUS_SUCCESS

Definition at line 759 of file edma_driver.c.

16.21.6.7 status_t EDMA_DRV_ConfigSingleBlockTransfer (uint8_t *virtualChannel,* edma_transfer_type_t *type,* uint32_t *srcAddr,* uint32_t *destAddr,* edma_transfer_size_t *transferSize,* uint32_t *dataBufferSize*)

Configures a simple single block data transfer with DMA.

This function configures the descriptor for a single block transfer. The function considers contiguous memory blocks, thus it configures the TCD source/destination offset fields to cover the data buffer without gaps, according to "transferSize" parameter (the offset is equal to the number of bytes transferred in a source read/destination write).

NOTE: For memory-to-peripheral or peripheral-to-memory transfers, make sure the transfer size is equal to the data buffer size of the peripheral used, otherwise only truncated chunks of data may be transferred (e.g. for a communication IP with an 8-bit data register the transfer size should be 1B, whereas for a 32-bit data register, the transfer size should be 4B). The rationale of this constraint is that, on the peripheral side, the address offset is set to zero, allowing to read/write data from/to the peripheral in a single source read/destination write operation.

Parameters

virtualChannel	eDMA virtual channel number.
type	Transfer type (M->M, P->M, M->P, P->P).
srcAddr	A source register address or a source memory address.
destAddr	A destination register address or a destination memory address.
transferSize	The number of bytes to be transferred on every DMA write/read. Source/Dest share the same write/read size.
dataBufferSize	The total number of bytes to be transferred.

Returns

STATUS_ERROR or STATUS_SUCCESS

Definition at line 509 of file edma_driver.c.

16.21.6.8 void EDMA_DRV_ConfigureInterrupt (uint8_t *virtualChannel,* edma_channel_interrupt_t *intSrc,* bool *enable*)

Disables/Enables the channel interrupt requests.

This function enables/disables error, half major loop and complete major loop interrupts for the current channel.

Parameters

virtualChannel	eDMA virtual channel number.
interrupt	Interrupt event (error/half major loop/complete major loop).
enable	Enable (true)/Disable (false) interrupts for the current channel.

Definition at line 1439 of file edma_driver.c.

16.21.6.9 status_t EDMA_DRV_Deinit (void)

De-initializes the eDMA module.

This function resets the eDMA module to reset state and disables the interrupt to the core.

Returns

STATUS_ERROR or STATUS_SUCCESS.

Definition at line 239 of file edma_driver.c.

16.21.6.10 void EDMA_DRV_DisableRequestsOnTransferComplete (uint8_t *virtualChannel,* bool *disable*)

Disables/Enables the DMA request after the major loop completes for the TCD.

If disabled, the eDMA hardware automatically clears the corresponding DMA request when the current major iteration count reaches zero.

Parameters

virtualChannel	eDMA virtual channel number.
disable	Disable (true)/Enable (false) DMA request after TCD complete.

Definition at line 1409 of file edma_driver.c.

16.21.6.11 edma_chn_status_t EDMA_DRV_GetChannelStatus (uint8_t *virtualChannel*)

Gets the eDMA channel status.

Parameters

virtualChannel	eDMA virtual channel number.

Returns

Channel status.

Definition at line 1711 of file edma_driver.c.

16.21.6.12 uint32_t EDMA_DRV_GetRemainingMajorIterationsCount (uint8_t *virtualChannel*)

Returns the remaining major loop iteration count.

Gets the number minor loops yet to be triggered (major loop iterations).

Parameters

virtualChannel	eDMA virtual channel number.

Returns

number of major loop iterations yet to be triggered

Definition at line 1348 of file edma_driver.c.

16.21.6.13 status_t EDMA_DRV_Init (edma_state_t * *edmaState,* const edma_user_config_t * *userConfig,* edma_chn_state_t *const *chnStateArray[ ],* const edma_channel_config_t *const *chnConfigArray[ ],* uint32_t *chnCount*)

Initializes the eDMA module.

This function initializes the run-time state structure to provide the eDMA channel allocation release, protect, and track the state for channels. This function also resets the eDMA modules, initializes the module to user-defined settings and default settings.

Parameters

edmaState	The pointer to the eDMA peripheral driver state structure. The user passes the memory for this run-time state structure and the eDMA peripheral driver populates the members. This run-time state structure keeps track of the eDMA channels status. The memory must be kept valid before calling the EDMA_DRV_DeInit.

userConfig	User configuration structure for eDMA peripheral drivers. The user populates the members of this structure and passes the pointer of this structure into the function.
chnStateArray	Array of pointers to run-time state structures for eDMA channels; will populate the state structures inside the eDMA driver state structure.
chnConfigArray	Array of pointers to channel initialization structures.
chnCount	The number of eDMA channels to be initialized.

Returns

STATUS_ERROR or STATUS_SUCCESS.

Definition at line 123 of file edma_driver.c.

16.21.6.14 status_t EDMA_DRV_InstallCallback (uint8_t *virtualChannel,* edma_callback_t *callback,* void * *parameter*)

Registers the callback function and the parameter for eDMA channel.

This function registers the callback function and the parameter into the eDMA channel state structure. The callback function is called when the channel is complete or a channel error occurs. The eDMA driver passes the channel status to this callback function to indicate whether it is caused by the channel complete event or the channel error event.

To un-register the callback function, set the callback function to "NULL" and call this function.

Parameters

virtualChannel	eDMA virtual channel number.
callback	The pointer to the callback function.
parameter	The pointer to the callback function's parameter.

Returns

STATUS_ERROR or STATUS_SUCCESS.

Definition at line 365 of file edma_driver.c.

16.21.6.15 void EDMA_DRV_PushConfigToReg (uint8_t *virtualChannel,* const edma_transfer_config_t * *tcd*)

Copies the channel configuration to the TCD registers.

Parameters

virtualChannel	eDMA virtual channel number.
tcd	Pointer to the channel configuration structure.

Definition at line 1589 of file edma_driver.c.

16.21.6.16 void EDMA_DRV_PushConfigToSTCD (const edma_transfer_config_t * *config,* edma_software_tcd_t * *stcd*)

Copies the channel configuration to the software TCD structure.

This function copies the properties from the channel configuration to the software TCD structure; the address of the software TCD can be used to enable scatter/gather operation (pointer to the next TCD).

Parameters

config	Pointer to the channel configuration structure.

stcd	Pointer to the software TCD structure.

Definition at line 1545 of file edma_driver.c.

16.21.6.17 status_t EDMA_DRV_ReleaseChannel (uint8_t *virtualChannel*)

Releases an eDMA channel.

This function stops the eDMA channel and disables the interrupt of this channel. The channel state structure can be released after this function is called.

Parameters

virtualChannel	eDMA virtual channel number.

Returns

STATUS_ERROR or STATUS_SUCCESS.

Definition at line 391 of file edma_driver.c.

16.21.6.18 status_t EDMA_DRV_SetChannelRequestAndTrigger (uint8_t *virtualChannel,* uint8_t *request,* bool *enableTrigger*)

Configures the DMA request for the eDMA channel.

Selects which DMA source is routed to a DMA channel. The DMA sources are defined in the file <MCU>_↩ Features.h Configures the periodic trigger capability for the triggered DMA channel.

Parameters

virtualChannel	eDMA virtual channel number.
request	DMA request source.
enableTrigger	DMA channel periodic trigger.

Returns

STATUS_SUCCESS or STATUS_UNSUPPORTED.

Definition at line 970 of file edma_driver.c.

16.21.6.19 void EDMA_DRV_SetDestAddr (uint8_t *virtualChannel,* uint32_t *address*)

Configures the destination address for the eDMA channel.

Parameters

virtualChannel	eDMA virtual channel number.
address	The pointer to the destination memory address.

Definition at line 1198 of file edma_driver.c.

16.21.6.20 void EDMA_DRV_SetDestLastAddrAdjustment (uint8_t *virtualChannel,* int32_t *adjust*)

Configures the destination address last adjustment.

Adjustment value added to the destination address at the completion of the major iteration count. This value can be applied to restore the destination address to the initial value, or adjust the address to reference the next data structure.

Parameters

virtualChannel	eDMA virtual channel number.
adjust	Adjustment value.

Definition at line 1168 of file edma_driver.c.

16.21.6.21 void EDMA_DRV_SetDestOffset (uint8_t *virtualChannel,* int16_t *offset*)

Configures the destination address signed offset for the eDMA channel.

Sign-extended offset applied to the current destination address to form the next-state value as each destination write is complete.

Parameters

virtualChannel	eDMA virtual channel number.
offset	signed-offset

Definition at line 1228 of file edma_driver.c.

16.21.6.22 void EDMA_DRV_SetDestWriteChunkSize (uint8_t *virtualChannel,* edma_transfer_size_t *size*)

Configures the destination data chunk size (transferred in a write sequence).

Destination data write transfer size (1/2/4/16/32 bytes).

Parameters

virtualChannel	eDMA virtual channel number.
size	Destination transfer size.

Definition at line 1258 of file edma_driver.c.

16.21.6.23 void EDMA_DRV_SetMajorLoopIterationCount (uint8_t *virtualChannel,* uint32_t *majorLoopCount*)

Configures the number of major loop iterations.

Sets the number of major loop iterations; each major loop iteration will be served upon a request for the current channel, transferring the data block configured for the minor loop (NBYTES).

Parameters

virtualChannel	eDMA virtual channel number.
majorLoopCount	Number of major loop iterations.

Definition at line 1318 of file edma_driver.c.

16.21.6.24 void EDMA_DRV_SetMinorLoopBlockSize (uint8_t *virtualChannel,* uint32_t *nbytes*)

Configures the number of bytes to be transferred in each service request of the channel.

Sets the number of bytes to be transferred each time a request is received (one major loop iteration). This number needs to be a multiple of the source/destination transfer size, as the data block will be transferred within multiple read/write sequences (minor loops).

Parameters

virtualChannel	eDMA virtual channel number.
nbytes	Number of bytes to be transferred in each service request of the channel

Definition at line 1288 of file edma_driver.c.

16.21.6.25 void EDMA_DRV_SetScatterGatherLink (uint8_t *virtualChannel,* uint32_t *nextTCDAddr*)

Configures the memory address of the next TCD, in scatter/gather mode.

This function configures the address of the next TCD to be loaded form memory, when scatter/gather feature is enabled. This address points to the beginning of a 0-modulo-32 byte region containing the next transfer TCD to be

loaded into this channel. The channel reload is performed as the major iteration count completes. The scatter/gather address must be 0-modulo-32-byte. Otherwise, a configuration error is reported.

Parameters

virtualChannel	eDMA virtual channel number.
nextTCDAddr	The address of the next TCD to be linked to this TCD.

Definition at line 1379 of file edma_driver.c.

16.21.6.26 void EDMA_DRV_SetSrcAddr (uint8_t *virtualChannel,* uint32_t *address*)

Configures the source address for the eDMA channel.

Parameters

virtualChannel	eDMA virtual channel number.
address	The pointer to the source memory address.

Definition at line 1048 of file edma_driver.c.

16.21.6.27 void EDMA_DRV_SetSrcLastAddrAdjustment (uint8_t *virtualChannel,* int32_t *adjust*)

Configures the source address last adjustment.

Adjustment value added to the source address at the completion of the major iteration count. This value can be applied to restore the source address to the initial value, or adjust the address to reference the next data structure.

Parameters

virtualChannel	eDMA virtual channel number.
adjust	Adjustment value.

Definition at line 1138 of file edma_driver.c.

16.21.6.28 void EDMA_DRV_SetSrcOffset (uint8_t *virtualChannel,* int16_t *offset*)

Configures the source address signed offset for the eDMA channel.

Sign-extended offset applied to the current source address to form the next-state value as each source read is complete.

Parameters

virtualChannel	eDMA virtual channel number.
offset	Signed-offset for source address.

Definition at line 1078 of file edma_driver.c.

16.21.6.29 void EDMA_DRV_SetSrcReadChunkSize (uint8_t *virtualChannel,* edma_transfer_size_t *size*)

Configures the source data chunk size (transferred in a read sequence).

Source data read transfer size (1/2/4/16/32 bytes).

Parameters

virtualChannel	eDMA virtual channel number.
size	Source transfer size.

Definition at line 1108 of file edma_driver.c.

16.21.6.30 status_t EDMA_DRV_StartChannel (uint8_t *virtualChannel*)

Starts an eDMA channel.

This function enables the eDMA channel DMA request.

Parameters

virtualChannel	eDMA virtual channel number.

Returns

STATUS_ERROR or STATUS_SUCCESS.

Definition at line 907 of file edma_driver.c.

16.21.6.31 status_t EDMA_DRV_StopChannel (uint8_t *virtualChannel*)

Stops the eDMA channel.

This function disables the eDMA channel DMA request.

Parameters

virtualChannel	eDMA virtual channel number.

Returns

STATUS_ERROR or STATUS_SUCCESS.

Definition at line 938 of file edma_driver.c.

16.21.6.32 void EDMA_DRV_TriggerSwRequest (uint8_t *virtualChannel*)

Triggers a sw request for the current channel.

This function starts a transfer using the current channel (sw request).

Parameters

virtualChannel	eDMA virtual channel number.

Definition at line 1516 of file edma_driver.c.

16.22 EIM Driver

16.22.1 Detailed Description

Error Injection Module Peripheral Driver.
EIM PD provides a set of high-level APIs/services to configure the Error Injection Module (EIM) module.

Important Note:

1. Make sure that STACK memory is located in RAM different than where EIM will inject a non-correctable error.

2. For single bit error generation, flip only one bit out of DATA_MASK or CHKBIT_MASK bit-fields in EIM control registers.

3. For Double bit error generation, flip only two bits out of DATA_MASK or CHKBIT_MASK bit-fields in EIM control registers.

4. If more than 2 bits are flipped that there is no guarantee in design that what type of error get generated.

5. When generating double bit error or more than 2 bits error:

   - S32K11x: After injecting the error, the program jumps to HardFault_Handler(). User needs to cancel the HardFault_Handler() by disabling the EIM module inside the HardFault_Handler() function. Example shown below: HardFault_Handler() { EIM_DRV_Deinit(INST_EIM1); }
   - S32Rx7x An uncorrectable ECC error occurs on an access generated by the DMA only. If a CPU access to the TCD causes an uncorrectable ECC error, that access will receive a bus error response.

6. When using double bit error generation on S32K11x, user needs to define one region called ram_low then move the stack and m_interrupts to that region, otherwise the module can't be enabled because the RAM ECC mechanism can only correct one single error.

Basic Operations of EIM

1. To initialize EIM, call EIM_DRV_Init() with an user channel configuration array. In the following code, EIM is initialized with default settings (after reset) for check-bit mask and data mask and both channels is enabled.

```
1.1 With instance S32K14x
    #define INST_EIM1 (0U)

    #define EIM_CHANNEL_COUNT0 (2U)
    /* Configuration structure array */
    eim_user_channel_config_t userChannelConfigArr[] =
    {
        /* Configuration channel 0 */
        {
            .channel = 0x0U,
            .checkBitMask = 0x00U,
            .dataMask = 0x00U,
            .enable = true
        },
        /* Configuration channel 1 */
        {
            .channel = 0x1U,
            .checkBitMask = 0x00U,
            .dataMask = 0x00U,
            .enable = true
        }
    };
1.2 With instance S32K11x
```

```
    #define INST_EIM1 (0U)

    #define EIM_CHANNEL_COUNT0 (1U)
    /* Configuration structure array */
    eim_user_channel_config_t userChannelConfigArr[] =
    {
        /* Configuration channel 0 */
        {
            .channel = 0x0U,
            .checkBitMask = 0x01U,
            .dataMask = 0x00U,
            .enable = true
        },
    };
1.3 With instance S32Rx7x
    #define INST_EIM1 (0U)

    #define EIM_CHANNEL_COUNT0 (1U)
    /* Configuration structure array */
    eim_user_channel_config_t userChannelConfigArr[] =
    {
        /* Configuration channel 0 */
        {
            .channel = 0x0U,
            .checkBitMask = 0x01U,
            .dataMask = 0x00U,
            .dataMask1= 0x00U,
            .enable = true
        },
    };
    /* Initialize the EIM instance 0 with configured channel number of 2 and userChannelConfigArr */
    EIM_DRV_Init(INST_EIM1, EIM_CHANNEL_COUNT0 , userChannelConfigArr);
```

2. To get the default configuration (data mask, check-bit mask and enable status) of a channel in EIM, just call EIM_DRV_GetDefaultConfig(). Make sure that the operation is not execute in target RAM where EIM inject the error

```
eim_user_channel_config_t channelConfig;

/* Get default configuration of EIM channel 1*/
EIM_DRV_GetDefaultConfig(1U, &channelConfig);
```

3. To de-initialize EIM, just call the EIM_DRV_Deinit() function. This function sets all registers to reset values and disables EIM.

```
/* De-initializes the EIM module */
EIM_DRV_Deinit(INST_EIM1);
```

Data Structures

- struct eim_user_channel_config_t

  EIM channel configuration structure. More...

Macros

- #define EIM_CHECKBITMASK_DEFAULT (0x01U)

  The value default of EIM check-bit mask.
- #define EIM_DATAMASK_DEFAULT (0x00U)

  The value default of EIM data mask.

EIM Driver API

- void EIM_DRV_Init (uint32_t instance, uint8_t channelCnt, const eim_user_channel_config_t *channel↩ ConfigArr)

  Initializes the EIM module.

- void EIM_DRV_Deinit (uint32_t instance)
  De-initializes the EIM module.
- void EIM_DRV_ConfigChannel (uint32_t instance, const eim_user_channel_config_t *userChannelConfig)
  Configures the EIM channel.
- void EIM_DRV_GetChannelConfig (uint32_t instance, uint8_t channel, eim_user_channel_config_t *channelConfig)
  Gets the EIM channel configuration.
- void EIM_DRV_GetDefaultConfig (uint8_t channel, eim_user_channel_config_t *channelConfig)
  Gets the EIM channel configuration default.

16.22.2 Data Structure Documentation

16.22.2.1 struct eim_user_channel_config_t

EIM channel configuration structure.

This structure holds the configuration settings for the EIM channel Implements : eim_user_channel_config_t_Class

Definition at line 55 of file eim_driver.h.

Data Fields

- uint8_t channel
- uint8_t checkBitMask
- uint32_t dataMask
- bool enable

Field Documentation

16.22.2.1.1 uint8_t channel

EIM channel number

Definition at line 57 of file eim_driver.h.

16.22.2.1.2 uint8_t checkBitMask

Specifies whether the corresponding bit of the check-bit bus from the target RAM should be inverted or remain unmodified

Definition at line 58 of file eim_driver.h.

16.22.2.1.3 uint32_t dataMask

Specifies whether the corresponding bit of the read data bus from the target RAM should be inverted or remain unmodified

Definition at line 60 of file eim_driver.h.

16.22.2.1.4 bool enable

true : EIM channel operation is enabled false : EIM channel operation is disabled

Definition at line 66 of file eim_driver.h.

16.22.3 Macro Definition Documentation

16.22.3.1 #define EIM_CHECKBITMASK_DEFAULT (0x01U)

The value default of EIM check-bit mask.

Definition at line 45 of file eim_driver.h.

16.22.3.2 #define EIM_DATAMASK_DEFAULT (0x00U)

The value default of EIM data mask.

Definition at line 47 of file eim_driver.h.

16.22.4 Function Documentation

16.22.4.1 void EIM_DRV_ConfigChannel (uint32_t *instance,* const eim_user_channel_config_t * *userChannelConfig*)

Configures the EIM channel.

This function configures check-bit mask, data mask and operation status(enable/disable) for EIM channel. The EIM channel configuration structure shall be passed as arguments.

This is an example demonstrating how to define a EIM channel configuration structure:

```
1 eim_user_channel_config_t eimTestInit = {
2      .channel = 0x1U,
3      .checkBitMask = 0x25U,
4      .dataMask = 0x11101100U,
5      .enable = true
6 };
```

Parameters

in	*instance*	EIM module instance number
in	*userChannel↩ Config*	Pointer to EIM channel configuration structure

Definition at line 115 of file eim_driver.c.

16.22.4.2 void EIM_DRV_Deinit (uint32_t *instance*)

De-initializes the EIM module.

This function sets all registers to reset value and disables EIM module. In order to use the EIM module again, EIM_DRV_Init must be called.

Parameters

in	*instance*	EIM module instance number

Definition at line 92 of file eim_driver.c.

16.22.4.3 void EIM_DRV_GetChannelConfig (uint32_t *instance,* uint8_t *channel,* eim_user_channel_config_t * *channelConfig*)

Gets the EIM channel configuration.

This function gets check bit mask, data mask and operation status of EIM channel.

Parameters

in	*instance*	EIM module instance number
in	*channel*	EIM channel number
out	*channelConfig*	Pointer to EIM channel configuration structure

Definition at line 145 of file eim_driver.c.

16.22.4.4 void EIM_DRV_GetDefaultConfig (uint8_t *channel,* eim_user_channel_config_t * *channelConfig*)

Gets the EIM channel configuration default.

This function gets check bit mask, data mask and operation status default of EIM channel.

Parameters

in	*channel*	EIM channel number
out	*channelConfig*	Pointer to EIM channel configuration structure default

Definition at line 176 of file eim_driver.c.

16.22.4.5 void EIM_DRV_Init (uint32_t *instance*, uint8_t *channelCnt*, const eim_user_channel_config_t * *channelConfigArr*)

Initializes the EIM module.

This function configures for EIM channels. The EIM channel configuration structure array and number of configured channels shall be passed as arguments. This function should be called before calling any other EIM driver function.

This is an example demonstrating how to define a EIM channel configuration structure array:

```
1 eim_user_channel_config_t channelConfigArr[] =
2 {
3 {
4 .channel = 0x0U,
5 .checkBitMask = 0x12U,
6 .dataMask = 0x01234567U,
7 .enable = true
8 },
9 {
10 .channel = 0x1U,
11 .checkBitMask = 0x22U,
12 .dataMask = 0x01234444U,
13 .enable = false
14 }
15 };
```

Parameters

in	*instance*	EIM module instance number.
in	*channelCnt*	Number of configured channels
in	*channelConfig↩ Arr*	EIM channel configuration structure array

Definition at line 62 of file eim_driver.c.

16.23 ERM Driver

16.23.1 Detailed Description

Error Reporting Module Peripheral Driver.

This section describes the programming interface of the ERM driver.

16.23.2 ERM Driver Initialization

In order to be able to use the error reporting in your application, the first thing to do is initializing it with user configuration input. This is done by calling the **ERM_DRV_Init** function. Note that: channelCnt takes values between 1 and the maximum channel count supported by the hardware.

16.23.3 ERM Driver Operation

After ERM initialization, the ERM_DRV_SetInterruptConfig() shall be used to set interrupt notification based on interrupt notification configuration.
The ERM_DRV_GetInterruptConfig() shall be used to get the current interrupt configuration of the available events (which interrupts are enabled/disabled).

The ERM_DRV_GetErrorDetail() shall be used to get the address of the last ECC event in Memory n and ECC event.

The ERM_DRV_ClearEvent() shall be used to clear both the record of an event and the corresponding interrupt notification.

This is example code to configure the ERM driver:

```
/* Device instance number */
#define INST_ERM1 (0U)

/* 1.1 With instance for S32K14x: */
    /* The number of configured channel(s) */
    #define ERM_NUM_OF_CFG_CHANNEL (2U)

    /* Interrupt configuration 0 */
    const erm_interrupt_config_t erm1_Interrupt0 =
    {
        .enableSingleCorrection = false,
        .enableNonCorrectable   = true
    };

    /* Interrupt configuration 1 */
    const erm_interrupt_config_t erm1_Interrupt1 =
    {
        .enableSingleCorrection = true,
        .enableNonCorrectable   = true
    };


    /* User configuration */
    const erm_user_config_t erm1_InitConfig[] =
    {
        /* Channel 0U */
        {
            .channel      = 0U,
            .interruptCfg = &erm1_Interrupt0
        },

        /* Channel 1U */
        {
            .channel      = 1U,
            .interruptCfg = &erm1_Interrupt1
        }
    };

    /*  1.2 With instance for S32K11x: */
    /* The number of configured channel(s) */
    #define ERM_NUM_OF_CFG_CHANNEL (1U)
```

```
    /* Interrupt configuration 0 */
    const erm_interrupt_config_t erm1_Interrupt0 =
    {
        .enableSingleCorrection = false,
        .enableNonCorrectable   = true
    };


    /* User configuration */
    const erm_user_config_t erm1_InitConfig[] =
    {
        /* Channel 0U */
        {
            .channel      = 0U,
            .interruptCfg = &erm1_Interrupt0
        }
    };

int main()
{
    /* Initializes the ERM module */
    ERM_DRV_Init(INST_ERM1, ERM_NUM_OF_CFG_CHANNEL, erm1_InitConfig);
    ...
    /* De-Initializes the ERM module */
    ERM_DRV_Deinit(INST_ERM1);
    ...
    return 0;
}

/* Interrupt handler */
/* Interrupt handler for single bit */
void ERM_single_fault_IRQHandler()
{
    /* Clears the event for channel 1 */
    ERM_DRV_ClearEvent(INST_ERM1, 1U, ERM_EVENT_SINGLE_BIT);
    ...
}

/* Interrupt handler for non correctable */
void ERM_double_fault_IRQHandler()
{
    /* Clears the event for channel 0 */
    ERM_DRV_ClearEvent(INST_ERM1, 0U,
      ERM_EVENT_NON_CORRECTABLE);
    /* Clears the event for channel 1 */
    ERM_DRV_ClearEvent(INST_ERM1, 1U,
      ERM_EVENT_NON_CORRECTABLE);
    ...
}
```

Data Structures

- struct erm_interrupt_config_t

  ERM interrupt notification configuration structure Implements : erm_interrupt_config_t_Class. More...
- struct erm_user_config_t

  ERM user configuration structure Implements : erm_user_config_t_Class. More...

Enumerations

- enum erm_ecc_event_t { ERM_EVENT_NONE = 0U, ERM_EVENT_SINGLE_BIT = 1U, ERM_EVENT_N↩ ON_CORRECTABLE = 2U }

  ERM types of ECC events Implements : erm_ecc_event_t_Class.

ERM DRIVER API

- void ERM_DRV_Init (uint32_t instance, uint8_t channelCnt, const erm_user_config_t *userConfigArr)

  Initializes the ERM module.
- void ERM_DRV_Deinit (uint32_t instance)

  Sets the default configuration.
- void ERM_DRV_SetInterruptConfig (uint32_t instance, uint8_t channel, erm_interrupt_config_t interruptCfg)

Sets interrupt notification.

- void ERM_DRV_GetInterruptConfig (uint32_t instance, uint8_t channel, erm_interrupt_config_t ∗const interruptPtr)

  Gets interrupt notification.

- void ERM_DRV_ClearEvent (uint32_t instance, uint8_t channel, erm_ecc_event_t eccEvent)

  Clears error event and the corresponding interrupt notification.

- erm_ecc_event_t ERM_DRV_GetErrorDetail (uint32_t instance, uint8_t channel, uint32_t ∗addressPtr)

  Gets the address of the last ECC event in Memory n and ECC event.

16.23.4 Data Structure Documentation

16.23.4.1 struct erm_interrupt_config_t

ERM interrupt notification configuration structure Implements : erm_interrupt_config_t_Class.

Definition at line 53 of file erm_driver.h.

Data Fields

- bool enableSingleCorrection
- bool enableNonCorrectable

Field Documentation

16.23.4.1.1 bool enableNonCorrectable

Enable Non-Correctable Interrupt Notification

Definition at line 56 of file erm_driver.h.

16.23.4.1.2 bool enableSingleCorrection

Enable Single Correction Interrupt Notification

Definition at line 55 of file erm_driver.h.

16.23.4.2 struct erm_user_config_t

ERM user configuration structure Implements : erm_user_config_t_Class.

Definition at line 63 of file erm_driver.h.

Data Fields

- uint8_t channel
- const erm_interrupt_config_t ∗ interruptCfg

Field Documentation

16.23.4.2.1 uint8_t channel

The channel assignments

Definition at line 65 of file erm_driver.h.

16.23.4.2.2 const erm_interrupt_config_t∗ interruptCfg

Interrupt configuration

Definition at line 66 of file erm_driver.h.

16.23.5 Enumeration Type Documentation

16.23.5.1 enum erm_ecc_event_t

ERM types of ECC events Implements : erm_ecc_event_t_Class.

Enumerator

ERM_EVENT_NONE None events

ERM_EVENT_SINGLE_BIT Single-bit correction ECC events

ERM_EVENT_NON_CORRECTABLE Non-correctable ECC events

Definition at line 42 of file erm_driver.h.

16.23.6 Function Documentation

16.23.6.1 void ERM_DRV_ClearEvent (uint32_t *instance,* uint8_t *channel,* erm_ecc_event_t *eccEvent*)

Clears error event and the corresponding interrupt notification.

This function clears the record of an event. If the corresponding interrupt is enabled, the interrupt notification will be cleared

Parameters

in	*instance*	The ERM instance number
in	*channel*	The configured memory channel
in	*eccEvent*	The types of ECC events

Definition at line 142 of file erm_driver.c.

16.23.6.2 void ERM_DRV_Deinit (uint32_t *instance*)

Sets the default configuration.

This function sets the default configuration

Parameters

in	*instance*	The ERM instance number

Definition at line 82 of file erm_driver.c.

16.23.6.3 erm_ecc_event_t ERM_DRV_GetErrorDetail (uint32_t *instance,* uint8_t *channel,* uint32_t * *addressPtr*)

Gets the address of the last ECC event in Memory n and ECC event.

This function gets the address of the last ECC event in Memory n and the types of the event

Parameters

in	*instance*	The ERM instance number
in	*channel*	The examined memory channel
out	*addressPtr*	The pointer to address of the last ECC event in Memory n with ECC event

Returns

The last occurred ECC event

Definition at line 174 of file erm_driver.c.

16.23.6.4 void ERM_DRV_GetInterruptConfig (uint32_t *instance,* uint8_t *channel,* erm_interrupt_config_t ∗const *interruptPtr*)

Gets interrupt notification.

This function gets the current interrupt configuration of the available events (which interrupts are enabled/disabled)

Parameters

in	*instance*	The ERM instance number
in	*channel*	The examined memory channel
out	*interruptPtr*	The pointer to the ERM interrupt configuration structure

Definition at line 120 of file erm_driver.c.

16.23.6.5 void ERM_DRV_Init (uint32_t *instance,* uint8_t *channelCnt,* const erm_user_config_t ∗ *userConfigArr*)

Initializes the ERM module.

This function initializes ERM driver based on user configuration input, channelCnt takes values between 1 and the maximum channel count supported by the hardware

Parameters

in	*instance*	The ERM instance number
in	*channelCnt*	The number of channels
in	*userConfigArr*	The pointer to the array of ERM user configure structure

Definition at line 54 of file erm_driver.c.

16.23.6.6 void ERM_DRV_SetInterruptConfig (uint32_t *instance,* uint8_t *channel,* erm_interrupt_config_t *interruptCfg*)

Sets interrupt notification.

This function sets interrupt notification based on interrupt notification configuration input

Parameters

in	*instance*	The ERM instance number
in	*channel*	The configured memory channel
in	*interruptCfg*	The ERM interrupt configuration structure

Definition at line 99 of file erm_driver.c.

16.24 EWM Driver

16.24.1 Detailed Description

External Watchdog Monitor Peripheral Driver.

Hardware background

Features:

- Independent LPO clock source
- Programmable time-out period specified in terms of number of EWM LPO clock cycles.
- Windowed refresh option
  - Provides robust check that program flow is faster than expected.
  - Programmable window.
  - Refresh outside window leads to assertion of EWM_out.
- Robust refresh mechanism
  - Write values of **0xB4** and **0x2C** to EWM Refresh Register within 15 (**EWM_service_time**) peripheral bus clock cycles.
- One output port, **EWM_out**, when asserted is used to reset or place the external circuit into safe mode
- One Input port, **EWM_in**, allows an external circuit to control the **EWM_out** signal.

The EWM can be initialized only once as all the configuration registers are write once per reset

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
* ${S32SDK_PATH}\platform\drivers\src\ewm\ewm_driver.c
*
```

Include path

The following paths need to be added to the include path of the toolchain:

```
* ${S32SDK_PATH}\platform\drivers\inc\
*
```

Compile symbols

No special symbols are required for this component

Dependencies

No special dependencies are required for this component

Clocking and pin configuration

The EWM Driver does not handle clock setup (from PCC) or any kind of pin configuration (done by PORT module). This is handled by the Clock Manager and PORT module, respectively. The driver assumes that correct clock configurations have been made, so it is the user's responsibility to set up clocking and pin configurations correctly.

Interrupts

The EWM module can generate interrupts, if enabled on EWM_DRV_Init() but they are not handled by the driver. The EWM shares the interrupt vector with the Watchdog Timer. The following code snippet is an example of how enable the interrupt and assign a handler:

```
/* EWM and watchdog interrupt service routine */
void EWM_Watchdog_ISR()
{
     /* Do something(e.g perform a clean reset) */
     ...
}
int main()
 {
     /* Init clocks, pins, other modules */
     ...
     /* Install interrupt handler for EWM and Watchdog */
     INT_SYS_InstallHandler(WDOG_EWM_IRQn, &EWM_Watchdog_ISR, (
      isr_t *)0);
     /* Enable the interrupt */
     INT_SYS_EnableIRQ(WDOG_EWM_IRQn);

     /* Init EWM */
     ...
     /* Infinite loop*/
     while(1)
     {
         /* Do something until the counter needs to be refreshed */
         ...
         /* Refresh the counter */
         EWM_DRV_Refresh(EWM_INSTANCE);
     }
 }
```

Using the EWM driver in your application

```
/* Declare the EWM instance you want to use */
#define EWM_INSTANCE    0UL

int main()
{
    /* Declare the EWM configuration structure */
    ewm_init_config_t ewmConfig;
    /* Variable where to store the init status */
    status_t ewmStatus;
    /* Init clocks, pins, other modules */
    ...

    /* Get the default configuration values */
    EWM_DRV_GetDefaultConfig(&ewmConfig);
    /* Init the module instance */
    ewmStatus = EWM_DRV_Init(EWM_INSTANCE, &ewmConfig);

    /* Infinite loop*/
    while(1)
    {
        /* Do something until the counter needs to be refreshed */
        ...
        /* Refresh the counter */
        EWM_DRV_Refresh(EWM_INSTANCE);
    }
}
```

Data Structures

- struct ewm_init_config_t

  EWM configuration structure This structure is used to configure the EWM prescaler, window, interrupt and input pin. More...

Enumerations

- enum ewm_in_assert_logic_t { EWM_IN_ASSERT_DISABLED = 0x00U, EWM_IN_ASSERT_ON_LOGIC↩ _ZERO = 0x01U, EWM_IN_ASSERT_ON_LOGIC_ONE = 0x02U }

  EWM input pin configuration Configures if the input pin is enabled and when is asserted Implements : ewm_in_↩ assert_logic_t_Class.

EWM Driver API

- status_t EWM_DRV_Init (uint32_t instance, const ewm_init_config_t *config)

  Init EWM. This method initializes EWM instance to the configuration from the passed structure. The user must make sure that the clock is enabled. This is the only method needed to be called to start the module.
- void EWM_DRV_GetDefaultConfig (ewm_init_config_t *config)

  Init configuration structure to default values.
- void EWM_DRV_Refresh (uint32_t instance)

  Refresh EWM. This method needs to be called within the window period specified by the Compare Low and Compare High registers.
- ewm_in_assert_logic_t EWM_DRV_GetInputPinAssertLogic (uint32_t instance)

  Get the Input pin assert logic.

16.24.2 Data Structure Documentation

16.24.2.1 struct ewm_init_config_t

EWM configuration structure This structure is used to configure the EWM prescaler, window, interrupt and input pin.

Implements : ewm_init_config_t_Class

Definition at line 54 of file ewm_driver.h.

Data Fields

- ewm_in_assert_logic_t assertLogic
- bool interruptEnable
- uint8_t prescaler
- uint8_t compareLow
- uint8_t compareHigh

Field Documentation

16.24.2.1.1 ewm_in_assert_logic_t assertLogic

Assert logic for EWM input pin

Definition at line 56 of file ewm_driver.h.

16.24.2.1.2 uint8_t compareHigh

Compare high value

Definition at line 60 of file ewm_driver.h.

16.24.2.1.3 uint8_t compareLow

Compare low value

Definition at line 59 of file ewm_driver.h.

16.24.2.1.4 bool interruptEnable

Enable EWM interrupt

Definition at line 57 of file ewm_driver.h.

16.24.2.1.5 uint8_t prescaler

EWM clock prescaler

Definition at line 58 of file ewm_driver.h.

16.24.3 Enumeration Type Documentation

16.24.3.1 enum ewm_in_assert_logic_t

EWM input pin configuration Configures if the input pin is enabled and when is asserted Implements : ewm_in_↩ assert_logic_t_Class.

Enumerator

EWM_IN_ASSERT_DISABLED Input pin disabled

EWM_IN_ASSERT_ON_LOGIC_ZERO Input pin asserts EWM when on logic 0

EWM_IN_ASSERT_ON_LOGIC_ONE Input pin asserts EWM when on logic 1

Definition at line 40 of file ewm_driver.h.

16.24.4 Function Documentation

16.24.4.1 void EWM_DRV_GetDefaultConfig (ewm_init_config_t * *config*)

Init configuration structure to default values.

Parameters

out	*config*	Pointer to the configuration structure to initialize

Returns

None

Definition at line 128 of file ewm_driver.c.

16.24.4.2 ewm_in_assert_logic_t EWM_DRV_GetInputPinAssertLogic (uint32_t *instance*)

Get the Input pin assert logic.

Parameters

in	*instance*	EWM instance number

Returns

The input pin assert logic:

- EWM_IN_ASSERT_DISABLED - EWM in disabled
- EWM_IN_ASSERT_ON_LOGIC_ZERO - EWM is asserted when EWM_in is logic 0
- EWM_IN_ASSERT_ON_LOGIC_ONE - EWM is asserted when EWM_in is logic 1

Definition at line 172 of file ewm_driver.c.

16.24.4.3 status_t EWM_DRV_Init (uint32_t *instance*, const ewm_init_config_t * *config*)

Init EWM. This method initializes EWM instance to the configuration from the passed structure. The user must make sure that the clock is enabled. This is the only method needed to be called to start the module.

Example configuration structure:

```
1 ewm_init_config_t ewmUserCfg = {
2     .assertLogic        = EWM_IN_ASSERT_ON_LOGIC_ZERO,
3     .interruptEnable    = true,
4     .prescaler          = 128,
5     .compareLow         = 0,
6     .compareHigh        = 254
7 };
```

This configuration will enable the peripheral, with input pin configured to assert on logic low, interrupt enabled, prescaler 128 and maximum refresh window.

The EWM can be initialized only once per CPU reset as the registers are write once.

Parameters

in	*instance*	EWM instance number
in	*config*	Pointer to the module configuration structure.

Returns

status_t Will return the status of the operation:

- STATUS_SUCCESS if the operation is successful
- STATUS_ERROR if the windows values are not correct or if the instance is already enabled

Definition at line 60 of file ewm_driver.c.

16.24.4.4 void EWM_DRV_Refresh (uint32_t *instance*)

Refresh EWM. This method needs to be called within the window period specified by the Compare Low and Compare High registers.

Parameters

in	*instance*	EWM instance number

Returns

None

Definition at line 150 of file ewm_driver.c.

16.25 Enhanced Direct Memory Access (eDMA)

16.25.1 Detailed Description

The S32 SDK provides Peripheral Driver for the Enhanced Direct Memory Access (eDMA) module.
The direct memory access engine features are used for performing complex data transfers with minimal intervention from the host processor. These sections describe the S32 SDK software modules API that can be used for initializing, configuring and triggering eDMA transfers.

Modules

- EDMA Driver

  This module covers the functionality of the Enhanced Direct Memory Access (eDMA) peripheral driver.

16.26 Error Injection Module (EIM)

16.26.1 Detailed Description

The S32 SDK provides Peripheral Drivers for the Error Injection Module (EIM) of S32 MCU.

The Error Injection Module (EIM) is mainly used for diagnostic purposes. It provides a method for diagnostic coverage of the peripheral memories and offers support for inducing single-bit and multi-bit inversions on read data when accessing peripheral RAMs.

Injecting faults on memory accesses can be used to exercise the SEC-DED ECC function of the related system. Each EIM channel n corresponds to a source of potential memory error events.

The following table shows the channel assignments of the module:

EIM channel n	S32K14x	S32K14xW	S32K11x	S32Rx7x	MPC5746R	MPC5777C	S32V23x
0	SRAM_L	SRAM_L	SRAM_U	DMA TCD RAM	DMA TCD RAM	PRAMC_0	Cortex-M4 TCM upper (bits31-0)
1	SRAM_U	SRAM_U	Reserved	Reserved	Reserved	PRAMC_1	Cortex-M4 TCM upper (bits63-32)
2	Reserved	Reserved	Reserved	Reserved	Reserved	FEC MIB	Cortex-M4 TCM lower (bits31-0)
3	Reserved	Reserved	Reserved	Reserved	Reserved	FEC RIF	Cortex-M4 TCM lower (bits63-32)
4	Reserved	Reserved	Reserved	Reserved	Reserved	eDMA_0 TCD RAM	Cortex-M4 Code Cache Tag Way0
5	Reserved	Reserved	Reserved	Reserved	Reserved	eDMA_1 TCD RAM	Cortex-M4 Code Cache Tag Way1
6	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Cortex-M4 Code Cache Data Way0
7	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Cortex-M4 Code Cache Data Way1
8	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Cortex-M4 System Cache Tag Way0
9	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Cortex-M4 System Cache Tag Way1

10	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Cortex-M4 System Cache Data Way0
11	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Cortex-M4 System Cache Data Way1
12	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	DMA TCD RAM

/*!

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\eim\eim_driver.c
${S32SDK_PATH}\platform\drivers\src\eim\eim_hw_access.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
```

Compile symbols

No special symbols are required for this component

Dependencies

No special dependencies are required for this component

Modules

- EIM Driver

  Error Injection Module Peripheral Driver.
  EIM PD provides a set of high-level APIs/services to configure the Error Injection Module (EIM) module.

16.27 Error Reporting Module (ERM)

16.27.1 Detailed Description

The S32 SDK provides Peripheral Drivers for the Error Reporting Module (ERM) module of S32 SDK devices.

The Error Reporting Module (ERM) provides information and optional interrupt notification on memory errors events associated with ECC (Error Correction Code).

The ERM includes the following features:

- Capture of address information on single-bit correction and non-correctable ECC events.
- Optional interrupt notification on captured ECC events.
- Support for ECC event capturing for memory sources, with individual reporting fields and interrupt configuration per memory channel.

Each ERM channel n corresponds to a source of potential memory error events. The following table shows the channel assignments:

ERM channel n	S32K14x	S32K14xW	S32K11x	MPC5777C	S32V23x
0	SRAM_L	SRAM_L	SRAM_U	PRAMC_0	Cortex-M4 TCM upper
1	SRAM_U	SRAM_U	Reserved	PRAMC_1	Cortex-M4 TCM lower
2	Reserved	Reserved	Reserved	eDMA_0 TCD RAM	Cortex-M4 Code Cache Tag
3	Reserved	Reserved	Reserved	eDMA_1 TCD RAM	Cortex-M4 Code Cache Data
4	Reserved	Reserved	Reserved	FEC MIB	Cortex-M4 System Cache Tag
5	Reserved	Reserved	Reserved	FEC RIF	Cortex-M4 System Cache Data
6	Reserved	Reserved	Reserved	PFLASH port 0	DMA TCD RAM
7	Reserved	Reserved	Reserved	PFLASH port 1	Reserved
8	Reserved	Reserved	Reserved	AIPS_0	Reserved
9	Reserved	Reserved	Reserved	AIPS_1	Reserved
10	Reserved	Reserved	Reserved	FEC e2eECC	Reserved
11	Reserved	Reserved	Reserved	CSE	Reserved
12	Reserved	Reserved	Reserved	SIPI	Reserved
13	Reserved	Reserved	Reserved	Core0 instruction	Reserved
14	Reserved	Reserved	Reserved	Core0 data	Reserved
15	Reserved	Reserved	Reserved	Core1 instruction	Reserved
16	Reserved	Reserved	Reserved	Core1 data	Reserved
17	Reserved	Reserved	Reserved	eDMA_0 e2eECC	Reserved

18	Reserved	Reserved	Reserved	eDMA_1 e2eECC	Reserved
19	Reserved	Reserved	Reserved	EBI e2eECC	Reserved

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\erm\erm_driver.c
${S32SDK_PATH}\platform\drivers\src\erm\erm_hw_access.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
```

Compile symbols

No special symbols are required for this component

Dependencies

No special dependencies are required for this component

Modules

- ERM Driver

  Error Reporting Module Peripheral Driver.

16.28 External Watchdog Monitor (EWM)

16.28.1 Detailed Description

The S32 SDK provides the Peripheral Drivers for the External Watchdog Monitor (EWM) module of S32K devices.

For safety, a redundant watchdog system, External Watchdog Monitor (EWM), is designed to monitor external circuits, as well as the MCU software flow. This provides a back-up mechanism to the internal watchdog that resets the MCU's CPU and peripherals.

The EWM differs from the internal watchdog in that it does not reset the MCU's CPU and peripherals. The EWM if allowed to time-out, provides an independent EWM_out pin that when asserted resets or places an external circuit into a safe mode. The CPU resets the EWM counter that is logically ANDed with an external digital input pin. This pin allows an external circuit to influence the reset_out signal.

Modules

- EWM Driver

  External Watchdog Monitor Peripheral Driver.

16.29 Flash Memory (Flash)

16.29.1 Detailed Description

This section describes the programming interface of the Flash Peripheral Driver.

Data Structures

- struct flash_user_config_t

  Flash User Configuration Structure. More...
- struct flash_ssd_config_t

  Flash SSD Configuration Structure. More...
- struct flash_eeprom_status_t

  EEPROM status structure. More...

Macros

- #define CLEAR_FTFx_FSTAT_ERROR_BITS FTFx_FSTAT = (uint8_t)(FTFx_FSTAT_FPVIOL_MASK | F↩ TFx_FSTAT_ACCERR_MASK | FTFx_FSTAT_RDCOLERR_MASK)
- #define FTFx_WORD_SIZE 0x0002U
- #define FTFx_LONGWORD_SIZE 0x0004U
- #define FTFx_PHRASE_SIZE 0x0008U
- #define FTFx_DPHRASE_SIZE 0x0010U
- #define FTFx_RSRC_CODE_REG FTFx_FCCOB8
- #define FTFx_VERIFY_BLOCK 0x00U
- #define FTFx_VERIFY_SECTION 0x01U
- #define FTFx_PROGRAM_CHECK 0x02U
- #define FTFx_READ_RESOURCE 0x03U
- #define FTFx_PROGRAM_LONGWORD 0x06U
- #define FTFx_PROGRAM_PHRASE 0x07U
- #define FTFx_ERASE_BLOCK 0x08U
- #define FTFx_ERASE_SECTOR 0x09U
- #define FTFx_PROGRAM_SECTION 0x0BU
- #define FTFx_VERIFY_ALL_BLOCK 0x40U
- #define FTFx_READ_ONCE 0x41U
- #define FTFx_PROGRAM_ONCE 0x43U
- #define FTFx_ERASE_ALL_BLOCK 0x44U
- #define FTFx_SECURITY_BY_PASS 0x45U
- #define FTFx_PFLASH_SWAP 0x46U
- #define FTFx_ERASE_ALL_BLOCK_UNSECURE 0x49U
- #define FTFx_PROGRAM_PARTITION 0x80U
- #define FTFx_SET_EERAM 0x81U
- #define RESUME_WAIT_CNT 0x20U

  Resume wait count used in FLASH_DRV_EraseResume function.
- #define SUSPEND_WAIT_CNT 0x40U

  Suspend wait count used in FLASH_DRV_EraseSuspend function.
- #define DFLASH_IFR_READRESOURCE_ADDRESS 0x8000FCU
- #define GET_BIT_0_7(value) ((uint8_t)(((uint32_t)(value)) & 0xFFU))
- #define GET_BIT_8_15(value) ((uint8_t)((((uint32_t)(value)) >> 8) & 0xFFU))
- #define GET_BIT_16_23(value) ((uint8_t)((((uint32_t)(value)) >> 16) & 0xFFU))
- #define GET_BIT_24_31(value) ((uint8_t)(((uint32_t)(value)) >> 24))
- #define FLASH_SECURITY_STATE_KEYEN 0x80U
- #define FLASH_SECURITY_STATE_UNSECURED 0x02U

- #define CSE_KEY_SIZE_CODE_MAX 0x03U
- #define FTFx_FSTAT_ERROR_BITS (FTFx_FSTAT & (FTFx_FSTAT_MGSTAT0_MASK | FTFx_FSTAT↩ _FPVIOL_MASK | FTFx_FSTAT_ACCERR_MASK | FTFx_FSTAT_RDCOLERR_MASK))
- #define FLASH_CALLBACK_CS 0x0AU

  Callback period count for FlashCheckSum.

Typedefs

- typedef void(∗ flash_callback_t) (void)

  Call back function pointer data type.

Enumerations

- enum flash_flexRam_function_control_code_t {
  EEE_ENABLE = 0x00U, EEE_QUICK_WRITE = 0x55U, EEE_STATUS_QUERY = 0x77U, EEE_COMPL↩ ETE_INTERRUPT_QUICK_WRITE = 0xAAU,
  EEE_DISABLE = 0xFFU }

  FlexRAM Function control Code.

Variables

- uint32_t PFlashBase
- uint32_t PFlashSize
- uint32_t DFlashBase
- uint32_t EERAMBase
- flash_callback_t CallBack
- uint32_t PFlashBase
- uint32_t PFlashSize
- uint32_t DFlashBase
- uint32_t DFlashSize
- uint32_t EERAMBase
- uint32_t EEESize
- flash_callback_t CallBack
- uint8_t brownOutCode
- uint16_t numOfRecordReqMaintain
- uint16_t sectorEraseCount

PFlash swap control codes

- #define FTFx_SWAP_SET_INDICATOR_ADDR 0x01U

  Initialize Swap System control code.
- #define FTFx_SWAP_SET_IN_PREPARE 0x02U

  Set Swap in Update State.
- #define FTFx_SWAP_SET_IN_COMPLETE 0x04U

  Set Swap in Complete State.
- #define FTFx_SWAP_REPORT_STATUS 0x08U

  Report Swap Status.

PFlash swap states

- #define FTFx_SWAP_UNINIT 0x00U

  Uninitialized swap mode.
- #define FTFx_SWAP_READY 0x01U

  Ready swap mode.
- #define FTFx_SWAP_UPDATE 0x02U

  Update swap mode.
- #define FTFx_SWAP_UPDATE_ERASED 0x03U

  Update-Erased swap mode.
- #define FTFx_SWAP_COMPLETE 0x04U

  Complete swap mode.

Flash security status

- #define FLASH_NOT_SECURE 0x01U

  Flash currently not in secure state.
- #define FLASH_SECURE_BACKDOOR_ENABLED 0x02U

  Flash is secured and backdoor key access enabled.
- #define FLASH_SECURE_BACKDOOR_DISABLED 0x04U

  Flash is secured and backdoor key access disabled.

Null Callback function definition

- #define NULL_CALLBACK ((flash_callback_t)0xFFFFFFFFU)

  Null callback.

Flash driver APIs

- status_t FLASH_DRV_Init (const flash_user_config_t *const pUserConf, flash_ssd_config_t *const pSSD↩ Config)

  Initializes Flash.
- void FLASH_DRV_GetPFlashProtection (uint32_t *protectStatus)

  P-Flash get protection.
- status_t FLASH_DRV_SetPFlashProtection (uint32_t protectStatus)

  P-Flash set protection.
- void FLASH_DRV_GetSecurityState (uint8_t *securityState)

  Flash get security state.
- status_t FLASH_DRV_SecurityBypass (const flash_ssd_config_t *pSSDConfig, const uint8_t *keyBuffer)

  Flash security bypass.
- status_t FLASH_DRV_EraseAllBlock (const flash_ssd_config_t *pSSDConfig)

  Flash erase all blocks.
- status_t FLASH_DRV_VerifyAllBlock (const flash_ssd_config_t *pSSDConfig, uint8_t marginLevel)

  Flash verify all blocks.
- status_t FLASH_DRV_EraseSector (const flash_ssd_config_t *pSSDConfig, uint32_t dest, uint32_t size)

  Flash erase sector.
- status_t FLASH_DRV_VerifySection (const flash_ssd_config_t *pSSDConfig, uint32_t dest, uint16_t number, uint8_t marginLevel)

  Flash verify section.
- void FLASH_DRV_EraseSuspend (void)

  Flash erase suspend.

- void FLASH_DRV_EraseResume (void)

  Flash erase resume.
- status_t FLASH_DRV_ReadOnce (const flash_ssd_config_t *pSSDConfig, uint8_t recordIndex, uint8_t *p↩ DataArray)

  Flash read once.
- status_t FLASH_DRV_ProgramOnce (const flash_ssd_config_t *pSSDConfig, uint8_t recordIndex, const uint8_t *pDataArray)

  Flash program once.
- status_t FLASH_DRV_Program (const flash_ssd_config_t *pSSDConfig, uint32_t dest, uint32_t size, const uint8_t *pData)

  Flash program.
- status_t FLASH_DRV_ProgramCheck (const flash_ssd_config_t *pSSDConfig, uint32_t dest, uint32_t size, const uint8_t *pExpectedData, uint32_t *pFailAddr, uint8_t marginLevel)

  Flash program check.
- status_t FLASH_DRV_CheckSum (const flash_ssd_config_t *pSSDConfig, uint32_t dest, uint32_t size, uint32_t *pSum)

  Calculates check sum.
- status_t FLASH_DRV_EnableCmdCompleteInterupt (void)

  Enable the command complete interrupt.
- void FLASH_DRV_DisableCmdCompleteInterupt (void)

  Disable the command complete interrupt.
- static bool FLASH_DRV_GetCmdCompleteFlag (void)

  Check the command complete flag has completed or not.
- status_t FLASH_DRV_EnableReadColisionInterupt (void)

  Enable the read collision error interrupt.
- void FLASH_DRV_DisableReadColisionInterupt (void)

  Disable the read collision error interrupt.
- static bool FLASH_DRV_GetReadColisionFlag (void)

  Check the read collision error flag is detected or not.
- static void FLASH_DRV_ClearReadColisionFlag (void)

  Clear the read collision error flag.
- void FLASH_DRV_GetDefaultConfig (flash_user_config_t *const config)

  Get default flash configuration.

16.29.2 Data Structure Documentation

16.29.2.1 struct flash_user_config_t

Flash User Configuration Structure.

Implements : flash_user_config_t_Class

Definition at line 786 of file flash_driver.h.

Data Fields

- uint32_t PFlashBase
- uint32_t PFlashSize
- uint32_t DFlashBase
- uint32_t EERAMBase
- flash_callback_t CallBack

16.29.2.2 struct flash_ssd_config_t

Flash SSD Configuration Structure.

The structure includes the static parameters for C90TFS/FTFx which are device-dependent. The fields including PFlashBlockBase, PFlashBlockSize, DFlashBlockBase, EERAMBlockBase, and CallBack are passed via flash_↩ user_config_t. The rest of parameters such as DFlashBlockSize, and EEEBlockSize will be initialized in FLASH_↩ DRV_Init() automatically.

Implements : flash_ssd_config_t_Class

Definition at line 810 of file flash_driver.h.

Data Fields

- uint32_t PFlashBase
- uint32_t PFlashSize
- uint32_t DFlashBase
- uint32_t DFlashSize
- uint32_t EERAMBase
- uint32_t EEESize
- flash_callback_t CallBack

16.29.2.3 struct flash_eeprom_status_t

EEPROM status structure.

Implements : flash_eeprom_status_t_Class

Definition at line 832 of file flash_driver.h.

Data Fields

- uint8_t brownOutCode
- uint16_t numOfRecordReqMaintain
- uint16_t sectorEraseCount

16.29.3 Macro Definition Documentation

16.29.3.1 #define CLEAR_FTFx_FSTAT_ERROR_BITS FTFx_FSTAT = (uint8_t)(FTFx_FSTAT_FPVIOL_MASK | FTFx_FSTAT_ACCERR_MASK | FTFx_FSTAT_RDCOLERR_MASK)

Definition at line 602 of file flash_driver.h.

16.29.3.2 #define CSE_KEY_SIZE_CODE_MAX 0x03U

Definition at line 699 of file flash_driver.h.

16.29.3.3 #define DFLASH_IFR_READRESOURCE_ADDRESS 0x8000FCU

Definition at line 681 of file flash_driver.h.

16.29.3.4 #define FLASH_CALLBACK_CS 0x0AU

Callback period count for FlashCheckSum.

This value is only relevant for FlashCheckSum operation, where a high rate of calling back can impair performance. The rest of the flash operations invoke the callback as often as possible while waiting for the flash controller to finish the requested operation.

Definition at line 744 of file flash_driver.h.

16.29.3.5 #define FLASH_NOT_SECURE 0x01U

Flash currently not in secure state.

Definition at line 727 of file flash_driver.h.

16.29.3.6 #define FLASH_SECURE_BACKDOOR_DISABLED 0x04U

Flash is secured and backdoor key access disabled.

Definition at line 731 of file flash_driver.h.

16.29.3.7 #define FLASH_SECURE_BACKDOOR_ENABLED 0x02U

Flash is secured and backdoor key access enabled.

Definition at line 729 of file flash_driver.h.

16.29.3.8 #define FLASH_SECURITY_STATE_KEYEN 0x80U

Definition at line 690 of file flash_driver.h.

16.29.3.9 #define FLASH_SECURITY_STATE_UNSECURED 0x02U

Definition at line 691 of file flash_driver.h.

16.29.3.10 #define FTFx_DPHRASE_SIZE 0x0010U

Definition at line 611 of file flash_driver.h.

16.29.3.11 #define FTFx_ERASE_ALL_BLOCK 0x44U

Definition at line 635 of file flash_driver.h.

16.29.3.12 #define FTFx_ERASE_ALL_BLOCK_UNSECURE 0x49U

Definition at line 638 of file flash_driver.h.

16.29.3.13 #define FTFx_ERASE_BLOCK 0x08U

Definition at line 629 of file flash_driver.h.

16.29.3.14 #define FTFx_ERASE_SECTOR 0x09U

Definition at line 630 of file flash_driver.h.

16.29.3.15 #define FTFx_FSTAT_ERROR_BITS (FTFx_FSTAT & (FTFx_FSTAT_MGSTAT0_MASK | FTFx_FSTAT_FPVIOL_MASK | FTFx_FSTAT_ACCERR_MASK | FTFx_FSTAT_RDCOLERR_MASK))

Definition at line 700 of file flash_driver.h.

16.29.3.16 #define FTFx_LONGWORD_SIZE 0x0004U

Definition at line 607 of file flash_driver.h.

16.29.3.17 #define FTFx_PFLASH_SWAP 0x46U

Definition at line 637 of file flash_driver.h.

16.29.3.18 #define FTFx_PHRASE_SIZE 0x0008U

Definition at line 609 of file flash_driver.h.

16.29.3.19 #define FTFx_PROGRAM_CHECK 0x02U

Definition at line 625 of file flash_driver.h.

16.29.3.20 #define FTFx_PROGRAM_LONGWORD 0x06U

Definition at line 627 of file flash_driver.h.

16.29.3.21 #define FTFx_PROGRAM_ONCE 0x43U

Definition at line 634 of file flash_driver.h.

16.29.3.22 #define FTFx_PROGRAM_PARTITION 0x80U

Definition at line 639 of file flash_driver.h.

16.29.3.23 #define FTFx_PROGRAM_PHRASE 0x07U

Definition at line 628 of file flash_driver.h.

16.29.3.24 #define FTFx_PROGRAM_SECTION 0x0BU

Definition at line 631 of file flash_driver.h.

16.29.3.25 #define FTFx_READ_ONCE 0x41U

Definition at line 633 of file flash_driver.h.

16.29.3.26 #define FTFx_READ_RESOURCE 0x03U

Definition at line 626 of file flash_driver.h.

16.29.3.27 #define FTFx_RSRC_CODE_REG FTFx_FCCOB8

Definition at line 617 of file flash_driver.h.

16.29.3.28 #define FTFx_SECURITY_BY_PASS 0x45U

Definition at line 636 of file flash_driver.h.

16.29.3.29 #define FTFx_SET_EERAM 0x81U

Definition at line 640 of file flash_driver.h.

16.29.3.30 #define FTFx_SWAP_COMPLETE 0x04U

Complete swap mode.

Definition at line 670 of file flash_driver.h.

16.29.3.31 #define FTFx_SWAP_READY 0x01U

Ready swap mode.

Definition at line 664 of file flash_driver.h.

16.29.3.32 #define FTFx_SWAP_REPORT_STATUS 0x08U

Report Swap Status.

Definition at line 654 of file flash_driver.h.

16.29.3.33 #define FTFx_SWAP_SET_IN_COMPLETE 0x04U

Set Swap in Complete State.

Definition at line 652 of file flash_driver.h.

16.29.3.34 #define FTFx_SWAP_SET_IN_PREPARE 0x02U

Set Swap in Update State.

Definition at line 650 of file flash_driver.h.

16.29.3.35 #define FTFx_SWAP_SET_INDICATOR_ADDR 0x01U

Initialize Swap System control code.

Definition at line 648 of file flash_driver.h.

16.29.3.36 #define FTFx_SWAP_UNINIT 0x00U

Uninitialized swap mode.

Definition at line 662 of file flash_driver.h.

16.29.3.37 #define FTFx_SWAP_UPDATE 0x02U

Update swap mode.

Definition at line 666 of file flash_driver.h.

16.29.3.38 #define FTFx_SWAP_UPDATE_ERASED 0x03U

Update-Erased swap mode.

Definition at line 668 of file flash_driver.h.

16.29.3.39 #define FTFx_VERIFY_ALL_BLOCK 0x40U

Definition at line 632 of file flash_driver.h.

16.29.3.40 #define FTFx_VERIFY_BLOCK 0x00U

Definition at line 623 of file flash_driver.h.

16.29.3.41 #define FTFx_VERIFY_SECTION 0x01U

Definition at line 624 of file flash_driver.h.

16.29.3.42 #define FTFx_WORD_SIZE 0x0002U

Definition at line 605 of file flash_driver.h.

16.29.3.43 #define GET_BIT_0_7(*value*) ((uint8_t)(((uint32_t)(value)) & 0xFFU))

Definition at line 684 of file flash_driver.h.

16.29.3.44 #define GET_BIT_16_23(*value*) ((uint8_t)((((uint32_t)(value)) >> 16) & 0xFFU))

Definition at line 686 of file flash_driver.h.

16.29.3.45 #define GET_BIT_24_31(*value*) ((uint8_t)(((uint32_t)(value)) >> 24))

Definition at line 687 of file flash_driver.h.

16.29.3.46 #define GET_BIT_8_15(*value*) ((uint8_t)((((uint32_t)(value)) >> 8) & 0xFFU))

Definition at line 685 of file flash_driver.h.

16.29.3.47 #define NULL_CALLBACK ((flash_callback_t)0xFFFFFFFFU)

Null callback.

Definition at line 755 of file flash_driver.h.

16.29.3.48 #define RESUME_WAIT_CNT 0x20U

Resume wait count used in FLASH_DRV_EraseResume function.

Definition at line 674 of file flash_driver.h.

16.29.3.49 #define SUSPEND_WAIT_CNT 0x40U

Suspend wait count used in FLASH_DRV_EraseSuspend function.

Definition at line 676 of file flash_driver.h.

16.29.4 Typedef Documentation

16.29.4.1 typedef void(* flash_callback_t) (void)

Call back function pointer data type.

If using callback in the application, any code reachable from this function must not be placed in a Flash block targeted for a program/erase operation. Functions can be placed in RAM section by using the START/END_FUN↩ CTION_DEFINITION/DECLARATION_RAMSECTION macros.

Definition at line 772 of file flash_driver.h.

16.29.5 Enumeration Type Documentation

16.29.5.1 enum flash_flexRam_function_control_code_t

FlexRAM Function control Code.

Implements : flash_flexRAM_function_control_code_t_Class

Enumerator

EEE_ENABLE Make FlexRAM available for emulated EEPROM

EEE_QUICK_WRITE Make FlexRAM available for EEPROM quick writes

EEE_STATUS_QUERY EEPROM quick write status query

EEE_COMPLETE_INTERRUPT_QUICK_WRITE Complete interrupted EEPROM quick write process

EEE_DISABLE Make FlexRAM available as RAM

Definition at line 713 of file flash_driver.h.

16.29.6 Function Documentation

16.29.6.1 status_t FLASH_DRV_CheckSum (const flash_ssd_config_t * *pSSDConfig,* uint32_t *dest,* uint32_t *size,* uint32_t * *pSum*)

Calculates check sum.

This API performs 32 bit sum of each byte data over a specified Flash memory range without carry which provides rapid method for checking data integrity. The callback time period of this API is determined via FLASH_CALLBA↩ CK_CS macro in flash_driver.h which is used as a counter value for the CallBack() function calling in this API. This value can be changed as per the user requirement. User can change this value to obtain the maximum permissible callback time period. This API always returns STATUS_SUCCESS if size provided by user is zero regardless of the input validation.

Parameters

in	*pSSDConfig*	The SSD configuration structure pointer.
in	*dest*	Start address of the Flash range to be summed.
in	*size*	Size in byte of the Flash range to be summed.
in	*pSum*	To return the sum value.

Returns

operation status

- STATUS_SUCCESS: Operation was successful.
- STATUS_ERROR: Operation failure was occurred.

Definition at line 1041 of file flash_driver.c.

16.29.6.2 static void FLASH_DRV_ClearReadColisionFlag (void) [inline], [static]

Clear the read collision error flag.

Implements : FLASH_DRV_ClearReadColisionFlag_Activity

Definition at line 1690 of file flash_driver.h.

16.29.6.3 void FLASH_DRV_DisableCmdCompleteInterupt (void)

Disable the command complete interrupt.

Definition at line 2004 of file flash_driver.c.

16.29.6.4 void FLASH_DRV_DisableReadColisionInterupt (void)

Disable the read collision error interrupt.

Definition at line 2039 of file flash_driver.c.

16.29.6.5 status_t FLASH_DRV_EnableCmdCompleteInterupt (void)

Enable the command complete interrupt.

This function will enable the command complete interrupt is generated when an FTFC command completes.

Returns

operation status

- STATUS_SUCCESS: Operation was successful.

Definition at line 1986 of file flash_driver.c.

16.29.6.6 status_t FLASH_DRV_EnableReadColisionInterupt (void)

Enable the read collision error interrupt.

This function will enable the read collision error interrupt generation when an FTFC read collision error occurs.

Returns

operation status

- STATUS_SUCCESS: Operation was successful.

Definition at line 2021 of file flash_driver.c.

16.29.6.7 status_t FLASH_DRV_EraseAllBlock (const flash_ssd_config_t * *pSSDConfig*)

Flash erase all blocks.

This API erases all Flash memory, initializes the FlexRAM, verifies all memory contents, and then releases the MCU security.

Parameters

in	*pSSDConfig*	The SSD configuration structure pointer.

Returns

operation status

- STATUS_SUCCESS: Operation was successful.
- STATUS_ERROR: Operation failure was occurred.
- STATUS_BUSY: Operation was busy.

Definition at line 461 of file flash_driver.c.

16.29.6.8 void FLASH_DRV_EraseResume (void)

Flash erase resume.

This API is used to resume a previous suspended operation of Flash erase sector command This function must be located in RAM memory or different Flash blocks which are targeted for writing to avoid RWW error.

Definition at line 707 of file flash_driver.c.

16.29.6.9 status_t FLASH_DRV_EraseSector (const flash_ssd_config_t * *pSSDConfig,* uint32_t *dest,* uint32_t *size*)

Flash erase sector.

This API erases one or more sectors in P-Flash or D-Flash memory. This API always returns FTFx_OK if size provided by the user is zero regardless of the input validation.

Parameters

in	*pSSDConfig*	The SSD configuration structure pointer.
in	*dest*	Address in the first sector to be erased. User need to make sure the dest address in of P-FLASH or D-FLASH block. This address should be aligned to bytes following a below table

FLASH TYPE/MCU	S32K116	S32K118	S32K142	S32K144	S32K146	S32K148	S32K142W	S32K144W
P-FLASH	8	8	8	16	16	16	8	16
D-FLASH	8	8	8	8	8	16	8	8

in	*size*	Size to be erased in bytes. It is used to determine number of sectors to be erased. This size should be aligned to bytes following a below table

FLASH TYPE/MCU	S32K116	S32K118	S32K142	S32K144	S32K146	S32K148	S32K142W	S32K144W
P-FLASH	8	8	8	16	16	16	8	16
D-FLASH	8	8	8	8	8	16	8	8

Returns

operation status

- STATUS_SUCCESS: Operation was successful.
- STATUS_ERROR: Operation failure was occurred.
- STATUS_BUSY: Operation was busy.

Definition at line 531 of file flash_driver.c.

16.29.6.10 void FLASH_DRV_EraseSuspend (void)

Flash erase suspend.

This API is used to suspend a current operation of Flash erase sector command. This function must be located in RAM memory or different Flash blocks which are targeted for writing to avoid the RWW error.

Definition at line 682 of file flash_driver.c.

16.29.6.11 static bool FLASH_DRV_GetCmdCompleteFlag (void) [inline], [static]

Check the command complete flag has completed or not.

Returns

the command complete flag

- true: The FTFC command has completed.
- false: The FTFC command is in progress.

Implements : FLASH_DRV_GetCmdCompleteFlag_Activity

Definition at line 1649 of file flash_driver.h.

16.29.6.12 void FLASH_DRV_GetDefaultConfig (flash_user_config_t *const *config*)

Get default flash configuration.

This API will get default flash user configuration.

Parameters

out	*config*	Pointer flash user configuration structure.

Definition at line 2191 of file flash_driver.c.

16.29.6.13 void FLASH_DRV_GetPFlashProtection (uint32_t * *protectStatus*)

P-Flash get protection.

This API retrieves the current P-Flash protection status. Considering the time consumption for getting protection is very low and even can be ignored. It is not necessary to utilize the Callback function to support the time-critical events.

Parameters

out	*protectStatus*	To return the current value of the P-Flash Protection. Each bit is corresponding to protection of 1/32 of the total P-Flash. The least significant bit is corresponding to the lowest address area of P-Flash. The most significant bit is corresponding to the highest address area of P-Flash and so on. There are two possible cases as below: • 0: this area is protected. • 1: this area is unprotected.

Definition at line 314 of file flash_driver.c.

16.29.6.14 static bool FLASH_DRV_GetReadColisionFlag (void) [inline], [static]

Check the read collision error flag is detected or not.

Returns

the read collision error flag

- true: Collision error detected.
- false: No collision error detected.

Implements : FLASH_DRV_GetReadColisionFlag_Activity

Definition at line 1680 of file flash_driver.h.

16.29.6.15 void FLASH_DRV_GetSecurityState (uint8_t * *securityState*)

Flash get security state.

This API retrieves the current Flash security status, including the security enabling state and the back door key enabling state.

Parameters

out	*securityState*	To return the current security status code. • FLASH_NOT_SECURE (0x01U): Flash currently not in secure state • FLASH_SECURE_BACKDOOR_ENABLED (0x02U): Flash is secured and back door key access enabled • FLASH_SECURE_BACKDOOR_DISABLED (0x04U): Flash is secured and back door key access disabled.

Definition at line 378 of file flash_driver.c.

16.29.6.16 status_t FLASH_DRV_Init (const flash_user_config_t *const *pUserConf,* flash_ssd_config_t *const *pSSDConfig*)

Initializes Flash.

This API initializes Flash module by reporting the memory configuration via SSD configuration structure.

Parameters

in	*pUserConf*	The user configuration structure pointer.
in	*pSSDConfig*	The SSD configuration structure pointer.

Returns

operation status

- STATUS_SUCCESS: Operation was successful.

Definition at line 225 of file flash_driver.c.

16.29.6.17 status_t FLASH_DRV_Program (const flash_ssd_config_t * *pSSDConfig,* uint32_t *dest,* uint32_t *size,* const uint8_t * *pData*)

Flash program.

This API is used to program 4 consecutive bytes (for program long word command) and 8 consecutive bytes (for program phrase command) on P-Flash or D-Flash block. This API always returns FTFx_OK if size provided by user is zero regardless of the input validation

Parameters

in	*pSSDConfig*	The SSD configuration structure pointer.
in	*dest*	Start address for the intended program operation. This address should be aligned to 8 bytes.
in	*size*	Size in byte to be programmed. This size should be aligned to 8 bytes.
in	*pData*	Pointer of source address from which data has to be taken for program operation.

Returns

operation status

- STATUS_SUCCESS: Operation was successful.
- STATUS_ERROR: Operation failure was occurred.
- STATUS_BUSY: Operation was busy.

Definition at line 908 of file flash_driver.c.

16.29.6.18 status_t FLASH_DRV_ProgramCheck (const flash_ssd_config_t * *pSSDConfig,* uint32_t *dest,* uint32_t *size,* const uint8_t * *pExpectedData,* uint32_t * *pFailAddr,* uint8_t *marginLevel*)

Flash program check.

This API tests a previously programmed P-Flash or D-Flash long word to see if it reads correctly at the specified margin level. This API always returns FTFx_OK if size provided by user is zero regardless of the input validation

Parameters

in	*pSSDConfig*	The SSD configuration structure pointer.
in	*dest*	Start address for the intended program check operation. This address should be aligned to 4 bytes.
in	*size*	Size in byte to check accuracy of program operation. This size should be aligned to 4 bytes.
in	*pExpectedData*	The pointer to the expected data.
in	*pFailAddr*	Returned the first aligned failing address.
in	*marginLevel*	Read margin choice as follows: • marginLevel = 0x1U: read at User margin 1/0 level. • marginLevel = 0x2U: read at Factory margin 1/0 level.

Returns

operation status

- STATUS_SUCCESS: Operation was successful.
- STATUS_ERROR: Operation failure was occurred.
- STATUS_BUSY: Operation was busy.

Definition at line 1000 of file flash_driver.c.

16.29.6.19 status_t FLASH_DRV_ProgramOnce (const flash_ssd_config_t * *pSSDConfig,* uint8_t *recordIndex,* const uint8_t * *pDataArray*)

Flash program once.

This API is used to program to a reserved 64 byte field located in the P-Flash IFR via given number of record. See the corresponding reference manual to get correct value of this number.

Parameters

in	*pSSDConfig*	The SSD configuration structure pointer.
in	*recordIndex*	The record index will be read. It can be from 0x0U to 0x7U or from 0x0U to 0xF according to specific derivative.
in	*pDataArray*	Pointer to the array from which data will be taken for program once command.

Returns

operation status

- STATUS_SUCCESS: Operation was successful.
- STATUS_ERROR: Operation failure was occurred.
- STATUS_BUSY: Operation was busy.

Definition at line 783 of file flash_driver.c.

16.29.6.20 status_t FLASH_DRV_ReadOnce (const flash_ssd_config_t * *pSSDConfig,* uint8_t *recordIndex,* uint8_t * *pDataArray*)

Flash read once.

This API is used to read out a reserved 64 byte field located in the P-Flash IFR via given number of record. See the corresponding reference manual to get the correct value of this number.

Parameters

in	*pSSDConfig*	The SSD configuration structure pointer.
in	*recordIndex*	The record index will be read. It can be from 0x0U to 0x7U or from 0x0U to 0xF according to specific derivative.
in	*pDataArray*	Pointer to the array to return the data read by the read once command.

Returns

operation status

- STATUS_SUCCESS: Operation was successful.
- STATUS_ERROR: Operation failure was occurred.
- STATUS_BUSY: Operation was busy.

Definition at line 732 of file flash_driver.c.

16.29.6.21 status_t FLASH_DRV_SecurityBypass (const flash_ssd_config_t * *pSSDConfig*, const uint8_t * *keyBuffer*)

Flash security bypass.

This API un-secures the device by comparing the user's provided back door key with the ones in the Flash Configuration Field. If they are matched, the security is released. Otherwise, an error code is returned.

Parameters

in	*pSSDConfig*	The SSD configuration structure pointer.
in	*keyBuffer*	Point to the user buffer containing the back door key.

Returns

operation status

- STATUS_SUCCESS: Operation was successful.
- STATUS_ERROR: Operation failure was occurred.
- STATUS_BUSY: Operation was busy.

Definition at line 420 of file flash_driver.c.

16.29.6.22 status_t FLASH_DRV_SetPFlashProtection (uint32_t *protectStatus*)

P-Flash set protection.

This API sets the P-Flash protection to the intended protection status. Setting P-Flash protection status is subject to a protection, transition restriction. If there is a setting violation, it returns an error code and the current protection status will not be changed.

Parameters

in	*protectStatus*	The expected protect status user wants to set to P-Flash protection register. Each bit is corresponding to protection of 1/32 of the total P-Flash. The least significant bit is corresponding to the lowest address area of P-Flash. The most significant bit is corresponding to the highest address area of P- Flash, and so on. There are two possible cases as shown below: • 0: this area is protected. • 1: this area is unprotected.

Returns

operation status

- STATUS_SUCCESS: Operation was successful.
- STATUS_ERROR: Operation failure was occurred.

Definition at line 337 of file flash_driver.c.

16.29.6.23 status_t FLASH_DRV_VerifyAllBlock (const flash_ssd_config_t * *pSSDConfig,* uint8_t *marginLevel*)

Flash verify all blocks.

This function checks to see if the P-Flash and/or D-Flash, EEPROM backup area, and D-Flash IFR have been erased to the specified read margin level, if applicable, and releases security if the readout passes.

Parameters

in	*pSSDConfig*	The SSD configuration structure pointer.
in	*marginLevel*	Read Margin Choice as follows: • marginLevel = 0x0U: use the Normal read level • marginLevel = 0x1U: use the User read • marginLevel = 0x2U: use the Factory read

Returns

operation status

- STATUS_SUCCESS: Operation was successful.
- STATUS_ERROR: Operation failure was occurred.
- STATUS_BUSY: Operation was busy.

Definition at line 495 of file flash_driver.c.

16.29.6.24 status_t FLASH_DRV_VerifySection (const flash_ssd_config_t * *pSSDConfig,* uint32_t *dest,* uint16_t *number,* uint8_t *marginLevel*)

Flash verify section.

This API checks if a section of the P-Flash or the D-Flash memory is erased to the specified read margin level.

Parameters

<table>
<tr><td>in</td><td>pSSDConfig</td><td>The SSD configuration structure pointer.</td></tr>
<tr><td>in</td><td>dest</td><td>Start address for the intended verify operation. User need to make sure the dest address in of P-FLASH or D-FLASH block. This address should be aligned to bytes following a below table
<table>
<tr><th>FLASH TYPE/MCU</th><th>S32K116</th><th>S32K118</th><th>S32K142</th><th>S32K144</th><th>S32K146</th><th>S32K148</th><th>S32K142W</th><th>S32K144W</th></tr>
<tr><td>P-FLASH</td><td>8</td><td>8</td><td>8</td><td>16</td><td>16</td><td>16</td><td>8</td><td>16</td></tr>
<tr><td>D-FLASH</td><td>8</td><td>8</td><td>8</td><td>8</td><td>8</td><td>16</td><td>8</td><td>8</td></tr>
</table></td></tr>
<tr><td>in</td><td>number</td><td>Number of alignment unit to be verified. Refer to corresponding reference manual to get correct information of alignment constrain.</td></tr>
<tr><td>in</td><td>marginLevel</td><td>Read Margin Choice as follows:
marginLevel = 0x0U: use Normal read level
marginLevel = 0x1U: use the User read
marginLevel = 0x2U: use the Factory read</td></tr>
</table>

Returns

operation status

- STATUS_SUCCESS: Operation was successful.
- STATUS_ERROR: Operation failure was occurred.
- STATUS_BUSY: Operation was busy.

Definition at line 612 of file flash_driver.c.

16.29.7 Variable Documentation

16.29.7.1 uint8_t brownOutCode

Brown-out detection code

Definition at line 834 of file flash_driver.h.

16.29.7.2 flash_callback_t CallBack

Call back function to service the time critical events. Any code reachable from this function must not be placed in a Flash block targeted for a program/erase operation

Definition at line 794 of file flash_driver.h.

16.29.7.3 flash_callback_t CallBack

Call back function to service the time critical events. Any code reachable from this function must not be placed in a Flash block targeted for a program/erase operation

Definition at line 823 of file flash_driver.h.

16.29.7.4 uint32_t DFlashBase

For FlexNVM device, this is the base address of D-Flash memory (FlexNVM memory); For non-FlexNVM device, this field is unused

Definition at line 790 of file flash_driver.h.

16.29.7.5 uint32_t DFlashBase

For FlexNVM device, this is the base address of D-Flash memory (FlexNVM memory); For non-FlexNVM device, this field is unused

Definition at line 814 of file flash_driver.h.

16.29.7.6 uint32_t DFlashSize

For FlexNVM device, this is the size in byte of area which is used as D-Flash from FlexNVM memory; For non-↩ FlexNVM device, this field is unused

Definition at line 816 of file flash_driver.h.

16.29.7.7 uint32_t EEESize

For FlexNVM device, this is the size in byte of EEPROM area which was partitioned from FlexRAM; For non-Flex↩ NVM device, this field is unused

Definition at line 821 of file flash_driver.h.

16.29.7.8 uint32_t EERAMBase

The base address of FlexRAM (for FlexNVM device) or acceleration RAM memory (for non-FlexNVM device)

Definition at line 792 of file flash_driver.h.

16.29.7.9 uint32_t EERAMBase

The base address of FlexRAM (for FlexNVM device) or acceleration RAM memory (for non-FlexNVM device)

Definition at line 819 of file flash_driver.h.

16.29.7.10 uint16_t numOfRecordReqMaintain

Number of EEPROM quick write records requiring maintenance

Definition at line 835 of file flash_driver.h.

16.29.7.11 uint32_t PFlashBase

The base address of P-Flash memory

Definition at line 788 of file flash_driver.h.

16.29.7.12 uint32_t PFlashBase

The base address of P-Flash memory

Definition at line 812 of file flash_driver.h.

16.29.7.13 uint32_t PFlashSize

The size in byte of P-Flash memory

Definition at line 789 of file flash_driver.h.

16.29.7.14 uint32_t PFlashSize

The size in byte of P-Flash memory

Definition at line 813 of file flash_driver.h.

16.29.7.15 uint16_t sectorEraseCount

EEPROM sector erase count

Definition at line 836 of file flash_driver.h.

16.30 Flash Memory (Flash)

16.30.1 Detailed Description

Flash Memory Module provides the general flash APIs.

Flash memory is ideal for single-supply applications, permitting in-the-field erase and reprogramming operations without the need for any external high voltage power sources. The flash module includes a memory controller that executes commands to modify flash memory contents. An erased bit reads '1' and a programmed bit reads '0'. The programming operation is unidirectional; it can only move bits from the '1' state (erased) to the '0' state (programmed). Only the erase operation restores bits from '0' to '1'; bits cannot be programmed from a '0' to a '1'.

C90TFS Flash Driver

The C90TFS flash module includes the following accessible memory regions.

1. Program flash memory for vector space and code store.
2. FlexNVM for data store, additional code store and also non-volatile storage for the EEPROM filing system representing data written to the FlexRAM requiring highest endurance.
3. FlexRAM for high-endurance EEPROM data store or traditional RAM.

Some platforms may be designed to have only program flash memory or all of them.

The S32 SDK provides the C90TFS Flash driver of S32K platforms. The driver includes general APIs to handle specific operations on C90TFS Flash module. The user can use those APIs directly in the application.

EEPROM feature

For platforms with FlexNVM, the flash module provides a built-in hardware emulation scheme to emulate the characteristics of an EEPROM by effectively providing a high-endurance, byte write-able NVM. The EEPROM system is shown in the following figure.

Figure 1. EEPROM Architecture

To handle with various customer's requirements, the FlexRAM and FlexNVM blocks can be split into partitions:

1. EEPROM partition(EEESIZE) — The amount of FlexRAM used for EEPROM can be set from 0 Bytes (no EEPROM) to the maximum FlexRAM size. The remainder of the FlexRAM not used for EEPROM is not accessible while the FlexRAM is configured for EEPROM.The EEPROM partition grows upward from the bottom of the FlexRAM address space.
2. Data flash partition(DEPART) — The amount of FlexNVM memory used for data flash can be programmed from 0 bytes (all of the FlexNVM block is available for EEPROM backup) to the maximum size of the FlexNVM block.
3. FlexNVM EEPROM partition — The amount of FlexNVM memory used for EEPROM backup, which is equal to the FlexNVM block size minus the data flash memory partition size. The EEPROM backup size must be at least 16 times the EEPROM partition size in FlexRAM.

The partition information (EEESIZE, DEPART) is programmed using the **#FLASH_DRV_DEFlashPartition** API.

The function of FlexRAM can be changed from EEPROM usage to traditional RAM for accelerate programming in **#FLASH_DRV_ProgramSection** API and vice versa by **#FLASH_DRV_SetFlexRamFunction** API.

This is example code of EEE usage sequence:

```
/* Provide information about the flash blocks. */
const flash_user_config_t Flash_InitConfig0 = {
.PFlashBase  = 0x00000000U,                    /* Base address of Program Flash block */
.PFlashSize  = 0x00100000U,                    /* Size of Program Flash block */
.DFlashBase  = 0x10000000U,                    /* Base address of Data Flash block */
```

```
    .EERAMBase   = 0x14000000U,                    /* Base address of FlexRAM block */
    /* If using callback, any code reachable from this function must not be placed in a Flash block
       targeted for a program/erase operation.*/
    .CallBack    = NULL_CALLBACK
    };

    /* Declare a FLASH configuration structure which is initialized by FlashInit, and will be used by all
       flash APIs */
    flash_ssd_config_t flashSSDConfig;
    status_t ret;        /* Store the driver APIs return code */

    /* Data source for program operation */
    #define BUFFER_SIZE         0x100u          /* Size of data source */
    #define SIZE_WRITE_EEE      0x7u          /* Size of data write in EEPROM */
    uint8_t sourceBuffer[BUFFER_SIZE];

    /* Init source data */
    for (i = 0u; i < BUFFER_SIZE; i++)
    {
        sourceBuffer[i] = i;
    }

    /* Always initialize the driver before calling other functions */
    ret = FLASH_DRV_Init(&Flash_InitConfig0, &flashSSDConfig);
    if (ret != STATUS_SUCCESS)
    {
        return ret;
    }

#if ((FEATURE_FLS_HAS_FLEX_NVM == 1u) & (FEATURE_FLS_HAS_FLEX_RAM == 1u))
    /* Configure FlexRAM as EEPROM if it is currently used as traditional RAM */
    if (flashSSDConfig.EEESize == 0u)
    {
        /* Configure FlexRAM as EEPROM and FlexNVM as EEPROM backup region,
           DEFlashPartition will be failed if the IFR region isn't blank.
           Refer to the device document for valid EEPROM Data Size Code
           and FlexNVM Partition Code. For example on S32K144:
           - EEEDataSizeCode = 0x02u: EEPROM size = 4 Kbytes
           - DEPartitionCode = 0x08u: EEPROM backup size = 64 Kbytes */
        ret = FLASH_DRV_DEFlashPartition(&flashSSDConfig, 0x02u, 0x08u, 0x0, false, true);
        DEV_ASSERT(STATUS_SUCCESS == ret);
        else
        {
            /* Re-initialize the driver to update the new EEPROM configuration */
            ret = FLASH_DRV_Init(&Flash_InitConfig0, &flashSSDConfig);
            if (ret != STATUS_SUCCESS)
            {
                return ret;
            }

            /* Make FlexRAM available for EEPROM */
            ret = FLASH_DRV_SetFlexRamFunction(&flashSSDConfig, EEE_ENABLE, 0x0u, NULL);
            DEV_ASSERT(STATUS_SUCCESS == ret);
        }
    }
    else    /* FLexRAM is already configured as EEPROM */
    {
        /* Make FlexRAM available for EEPROM, make sure that FlexNVM and FlexRAM
           are already partitioned successfully before */
        ret = FLASH_DRV_SetFlexRamFunction(&flashSSDConfig, EEE_ENABLE, 0x0u, NULL);
        DEV_ASSERT(STATUS_SUCCESS == ret);
    }
#endif

    /* Erase the sixth PFlash sector */
    /* Configure address, size to erase sector function. For example on S32K144 */
    address = 6u * FEATURE_FLS_PF_BLOCK_SECTOR_SIZE; /* A sector size is 4KB */
    size = FEATURE_FLS_PF_BLOCK_SECTOR_SIZE;
    ret = FLASH_DRV_EraseSector(&flashSSDConfig, address, size);
    DEV_ASSERT(STATUS_SUCCESS == ret);

    /* Verify the erase operation at margin level value of 1, user read */
    ret = FLASH_DRV_VerifySection(&flashSSDConfig, address, size, 1u);
    DEV_ASSERT(STATUS_SUCCESS == ret);

    /* Write some data to the erased PFlash sector */
    size = BUFFER_SIZE;
    ret = FLASH_DRV_Program(&flashSSDConfig, address, size, sourceBuffer);
    DEV_ASSERT(STATUS_SUCCESS == ret);

    /* Verify the program operation at margin level value of 1, user margin */
    ret = FLASH_DRV_ProgramCheck(&flashSSDConfig, address, size, sourceBuffer, &
      failAddr, 1u);
    DEV_ASSERT(STATUS_SUCCESS == ret);

    /* Try to write data to EEPROM if FlexRAM is configured as EEPROM */
    if (flashSSDConfig.EEESize != 0u)
```

```
{
    address = flashSSDConfig.EERAMBase;
    size =  SIZE_WRITE_EEE;
    ret = FLASH_DRV_EEEWrite(&flashSSDConfig, address, size, sourceBuffer);
    DEV_ASSERT(STATUS_SUCCESS == ret);
}
```

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\flash\flash_driver.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager

Important Note

1. If using callback in the application, any code reachable from this function must not be placed in a Flash block targeted for a program/erase operation to avoid the RWW error. Functions can be placed in RAM section by using the START/END_FUNCTION_DEFINITION/DECLARATION_RAMSECTION macros.
2. To suspend the sector erase operation for a simple method, invoke the **FLASH_DRV_EraseSuspend** function within callback of **FLASH_DRV_EraseSector**. In this case, the **FLASH_DRV_EraseSuspend** must not be placed in the same block in which the Flash erase sector command is going on.
3. **#FLASH_DRV_CommandSequence**, **FLASH_DRV_EraseSuspend** and **FLASH_DRV_EraseResume** should be executed from RAM or different Flash blocks which are targeted for writing to avoid the RWW error. **FLASH_DRV_EraseSuspend** and **FLASH_DRV_EraseResume** functions should be called in pairs.
4. To guarantee the correct execution of this driver, the Flash cache in the Flash memory controller module should be disabled before invoking any API.
5. Partitioning FlexNVM and FlexRAM for EEPROM usage shall be executed only once in the lifetime of the device.
6. After successfully partitioning FlexNVM and FlexRAM for EEPROM usage, user needs to call **FLASH_DRV_Init** to update memory information in global structure.
7. Can not erase or program flash when MCU is high speed run mode or very low power mode.
8. S32K14xW needs to enable FlexRAM as traditional RAM for the first time using silicon.

Modules

- Flash Memory (Flash)

16.31 FlexCAN Driver

16.31.1 Detailed Description

How to use the FlexCAN driver in your application

In order to be able to use the FlexCAN in your application, the first thing to do is initializing it with the desired configuration. This is done by calling the **FLEXCAN_DRV_Init** function. One of the arguments passed to this function is the configuration which will be used for the FlexCAN module, specified by the **flexcan_user_config_t** structure.

The **flexcan_user_config_t** structure allows you to configure the following:

- the number of message buffers needed;
- the number of Rx FIFO ID filters needed;
- enable/disable the Rx FIFO feature;
- the operation mode, which can be one of the following:
  - normal mode;
  - listen-only mode;
  - loopback mode;
  - freeze mode;
  - disable mode;
- the payload size of the message buffers:
  - 8 bytes;
  - 16 bytes (only available with the FD feature enabled);
  - 32 bytes (only available with the FD feature enabled);
  - 64 bytes (only available with the FD feature enabled);
- enable/disable the Flexible Data-rate feature;
- the clock source of the CAN Protocol Engine (PE);
- the bitrate used for standard frames or for the arbitration phase of FD frames;
- the bitrate used for the data phase of FD frames;
- the Rx FIFO transfer type, which can be one of the following:
  - using interrupts;
  - using DMA, only on supported platforms;
- the DMA channel number to be used for DMA transfers, only on supported platforms;

The bitrate is represented by a **flexcan_time_segment_t** structure, with the following fields:

- propagation segment;
- phase segment 1;
- phase segment 2;
- clock prescaler division factor;
- resync jump width.

Details about these fields can be found in the reference manual.

In order to use a mailbox for transmission/reception, it should be initialized using either **FLEXCAN_DRV_Config↩ RxMb**, **FLEXCAN_DRV_ConfigRxFifo** or **FLEXCAN_DRV_ConfigTxMb**.

After having the mailbox configured, you can start sending/receiving data using the specified mailbox, by calling one of the following functions:

- FLEXCAN_DRV_Send;
- FLEXCAN_DRV_SendBlocking;
- FLEXCAN_DRV_Receive;
- FLEXCAN_DRV_ReceiveBlocking;
- FLEXCAN_DRV_RxFifo;
- FLEXCAN_DRV_RxFifoBlocking.

A default FlexCAN configuration can be accesed by calling the **FLEXCAN_DRV_GetDefaultConfig** function. This function takes as argument a **flexcan_user_config_t** structure and fills it according to the following settings:

- 16 message buffers
- flexible data rate disabled
- Rx FIFO disabled
- normal operation mode
- 8 byte payload size
- Protocol Engine clock = Oscillator clock
- bitrate of 500 Kbit/s (computed for PE clock = 8 MHz with sample point = 87.5)

FlexCAN Rx FIFO configuration

The Rx FIFO is receive-only and 6-message deep. The user can read the received messages sequentially, in the order they were received, by repeatedly reading Message Buffer 0 (zero). The Rx FIFO ID filter table (configurable from 8 to 128 table elements) specifies filtering criteria for accepting frames into the FIFO. This table is represented through a structure of **flexcan_id_table_t** type, which specifies if specifies if Remote Frames are accepted into the FIFO if they match the target ID, whether extended or standard frames are accepted into the FIFO if they match the target ID and the target ID.

```
/* ID Filter table */
const flexcan_id_table_t filterTable[] = {
  {
   .isExtendedFrame = false,
   .isRemoteFrame = false,
   .id = 1U
  },
  ...
};

FLEXCAN_DRV_ConfigRxFifo(INST_CANCOM1,
      FLEXCAN_RX_FIFO_ID_FORMAT_A, filterTable);
```

The number of elements in the ID filter table is defined by the following formula:

- for format A: the number of Rx FIFO ID filters
- for format B: twice the number of Rx FIFO ID filters
- for format C: four times the number of Rx FIFO ID filters The user must provide the exact number of elements in order to avoid any misconfiguration.

Each element in the ID filter table specifies an ID to be used as acceptance criteria for the FIFO, as follows:

- for format A: In the standard frame format, bits 10 to 0 of the ID are used for frame identification. In the extended frame format, bits 28 to 0 are used.
- for format B: In the standard frame format, bits 10 to 0 of the ID are used for frame identification. In the extended frame format, only the 14 most significant bits (28 to 15) of the ID are compared to the 14 most significant bits (28 to 15) of the received ID.
- for format C: In both standard and extended frame formats, only the 8 most significant bits (7 to 0 for standard, 28 to 21 for extended) of the ID are compared to the 8 most significant bits (7 to 0 for standard, 28 to 21 for extended) of the received ID.

When Rx FIFO feature is enabled, buffer 0 (zero) cannot be used for transmission. The transfer status in case of FIFO enable feature can be monitored by calling **FLEXCAN_DRV_GetTransferStatus** for buffer index 0.

In order to use Rx FIFO filter mask options, enabled by **FLEXCAN_DRV_SetRxIndividualMask()** and **FLEXCAN_DRV_SetRxFifoGlobalMask()** user needs to call **FLEXCAN_DRV_ConfigRxFifo()** before using these functions in Rx FIFO mode. In case of RxFIFO ID filter format B or C the **FLEXCAN_DRV_SetRxFifoGlobalMask()** will apply the same mask for all filters IDs.

The FLEXCAN_DRV_SetRxIndividualMask() can self determine if CAN is in normal mode and will only set acceptance ID Mask. If CAN is in Rx FIFO mode, will determine the ID format type and will set the acceptance ID Mask as corresponding Id Filter Format corresponding to individual mask number the user must ensure that the ID Element is not affected by RxFIFO Global Mask in this case the ID Filter will be set as normal configuration to allow functionality of receiving as normal MB of the remaining MBs outside of RxFIFO use.

Important Notes

- The FlexCAN driver does not handle clock setup or any kind of pin configuration. This is handled by the **Clock Manager** and **PinSettings** modules, respectively. The driver assumes that the correct clock configurations have been made, so it is the user's responsibility to set up clocking and pin configurations correctly.
- For some platforms, the clock source of the CAN Protocol Engine (PE) is not configurable from the FlexCAN module. If this feature is not supported, the *pe_clock* field from the FlexCAN configuration structure is not present.
- DMA module has to be initialized prior to FlexCAN Rx FIFO usage in DMA mode; also, the DMA channel needs to be allocated by the application (the driver only takes care of configuring the DMA channel received in the configuration structure).
- When used **FLEXCAN_DRV_ReceiveBlocking()** and **FLEXCAN_DRV_SendBlocking()** with timeout parameter 0 and the message is already in mailbox configured will report timeout and successful transmit or receive the message.
- For Cortex-M0 architecture S32K116 and S32K118 CPUs need to pass as transmission/reception buffers memory aligned, the only allowed exceptions are for **FLEXCAN_DRV_Send()**, **FLEXCAN_DRV_SendBlocking()**, **FLEXCAN_DRV_ConfigRemoteResponseMb** with a payload length less then 3 bytes
- When used the Pretended Network Mode, in Stop Mode the Interface Clock(CHI) (from Clock_Manager) need to be disabled and Protocol Engine (PE) clock source enabled as selected from Can Module. Be aware that on wakeup Run Mode to have enabled the Interface Clock(CHI).
- In case inside the callback function is called another blocking reception (**FLEXCAN_DRV_ReceiveBlocking**/**FLEXCAN_DRV_RxFifoBlocking**) or abort **FLEXCAN_DRV_AbortTransfer** without polling previous operation status this can lead to undetermined behavior.

Example:

```
#define INST_CANCOM1 (0U)
#define RX_MAILBOX   (1U)
#define MSG_ID       (2U)

flexcan_state_t canCom1_State;
```

```
const flexcan_user_config_t canCom1_InitConfig0 = {
    .fd_enable = true,
    .pe_clock = FLEXCAN_CLK_SOURCE_OSC,
    .max_num_mb = 16,
    .num_id_filters = FLEXCAN_RX_FIFO_ID_FILTERS_8,
    .is_rx_fifo_needed = false,
    .flexcanMode = FLEXCAN_NORMAL_MODE,
    .payload = FLEXCAN_PAYLOAD_SIZE_8,
    .bitrate = {
        .propSeg = 7,
        .phaseSeg1 = 4,
        .phaseSeg2 = 1,
        .preDivider = 0,
        .rJumpwidth = 1
    },
    .bitrate_cbt = {
        .propSeg = 11,
        .phaseSeg1 = 1,
        .phaseSeg2 = 1,
        .preDivider = 0,
        .rJumpwidth = 1
    },
    .transfer_type = FLEXCAN_RXFIFO_USING_INTERRUPTS,
    .rxFifoDMAChannel = 0U
};

/* Initialize FlexCAN driver */
FLEXCAN_DRV_Init(INST_CANCOM1, &canCom1_State, &canCom1_InitConfig0);

/* Set information about the data to be received */
flexcan_data_info_t dataInfo =
{
    .data_length = 1U,
    .msg_id_type = FLEXCAN_MSG_ID_STD,
    .enable_brs  = true,
    .fd_enable   = true,
    .fd_padding  = 0U
};

/* Configure Rx message buffer with index 1 to receive frames with ID 2 */
FLEXCAN_DRV_ConfigRxMb(INST_CANCOM1, RX_MAILBOX, &dataInfo, MSG_ID);

/* Receive a frame in the recvBuff variable */
flexcan_msgbuff_t recvBuff;

FLEXCAN_DRV_Receive(INST_CANCOM1, RX_MAILBOX, &recvBuff);
/* Wait for the message to be received */
while (FLEXCAN_DRV_GetTransferStatus(INST_CANCOM1, RX_MAILBOX) == STATUS_BUSY)
      ;

/* De-initialize driver */
FLEXCAN_DRV_Deinit(INST_CANCOM1);
```

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\flexcan\flexcan_driver.c
${S32SDK_PATH}\platform\drivers\src\flexcan\flexcan_hw_access.c
${S32SDK_PATH}\platform\drivers\src\flexcan\flexcan_irq.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager Interrupt Manager (Interrupt) Enhanced Direct Memory Access (eDMA)

Data Structures

- struct flexcan_msgbuff_t

  FlexCAN message buffer structure Implements : flexcan_msgbuff_t_Class. More...
- struct flexcan_mb_handle_t

  Information needed for internal handling of a given MB. Implements : flexcan_mb_handle_t_Class. More...
- struct FlexCANState

  Internal driver state information. More...
- struct flexcan_data_info_t

  FlexCAN data info from user Implements : flexcan_data_info_t_Class. More...
- struct flexcan_id_table_t

  FlexCAN Rx FIFO ID filter table structure Implements : flexcan_id_table_t_Class. More...
- struct flexcan_time_segment_t

  FlexCAN bitrate related structures Implements : flexcan_time_segment_t_Class. More...
- struct flexcan_user_config_t

  FlexCAN configuration. More...

Typedefs

- typedef struct FlexCANState flexcan_state_t

  Internal driver state information.
- typedef void(∗ flexcan_callback_t) (uint8_t instance, flexcan_event_type_t eventType, uint32_t buffIdx, flexcan_state_t ∗flexcanState)

  FlexCAN Driver callback function type Implements : flexcan_callback_t_Class.
- typedef void(∗ flexcan_error_callback_t) (uint8_t instance, flexcan_event_type_t eventType, flexcan_state_t ∗flexcanState)

  FlexCAN Driver error callback function type Implements : flexcan_error_callback_t_Class.

Enumerations

- enum flexcan_rxfifo_transfer_type_t { FLEXCAN_RXFIFO_USING_INTERRUPTS }

  The type of the RxFIFO transfer (interrupts/DMA). Implements : flexcan_rxfifo_transfer_type_t_Class.
- enum flexcan_event_type_t { FLEXCAN_EVENT_RX_COMPLETE, FLEXCAN_EVENT_RXFIFO_COMPLETE, FLEXCAN_EVENT_RX↩ FIFO_WARNING, FLEXCAN_EVENT_RXFIFO_OVERFLOW, FLEXCAN_EVENT_TX_COMPLETE, FLEXCAN_EVENT_ERROR }

  The type of the event which occurred when the callback was invoked. Implements : flexcan_event_type_t_Class.
- enum flexcan_mb_state_t { FLEXCAN_MB_IDLE, FLEXCAN_MB_RX_BUSY, FLEXCAN_MB_TX_BUSY }

  The state of a given MB (idle/Rx busy/Tx busy). Implements : flexcan_mb_state_t_Class.
- enum flexcan_msgbuff_id_type_t { FLEXCAN_MSG_ID_STD, FLEXCAN_MSG_ID_EXT }

  FlexCAN Message Buffer ID type Implements : flexcan_msgbuff_id_type_t_Class.
- enum flexcan_rx_fifo_id_filter_num_t { FLEXCAN_RX_FIFO_ID_FILTERS_8 = 0x0, FLEXCAN_RX_FIFO_ID_FILTERS_16 = 0x1, FLEXCAN_R↩ X_FIFO_ID_FILTERS_24 = 0x2, FLEXCAN_RX_FIFO_ID_FILTERS_32 = 0x3, FLEXCAN_RX_FIFO_ID_FILTERS_40 = 0x4, FLEXCAN_RX_FIFO_ID_FILTERS_48 = 0x5, FLEXCAN_↩ RX_FIFO_ID_FILTERS_56 = 0x6, FLEXCAN_RX_FIFO_ID_FILTERS_64 = 0x7, FLEXCAN_RX_FIFO_ID_FILTERS_72 = 0x8, FLEXCAN_RX_FIFO_ID_FILTERS_80 = 0x9, FLEXCAN_↩ RX_FIFO_ID_FILTERS_88 = 0xA, FLEXCAN_RX_FIFO_ID_FILTERS_96 = 0xB, FLEXCAN_RX_FIFO_ID_FILTERS_104 = 0xC, FLEXCAN_RX_FIFO_ID_FILTERS_112 = 0xD, FLEXCA↩ N_RX_FIFO_ID_FILTERS_120 = 0xE, FLEXCAN_RX_FIFO_ID_FILTERS_128 = 0xF }

  FlexCAN Rx FIFO filters number Implements : flexcan_rx_fifo_id_filter_num_t_Class.
- enum flexcan_rx_mask_type_t { FLEXCAN_RX_MASK_GLOBAL, FLEXCAN_RX_MASK_INDIVIDUAL }

FlexCAN Rx mask type. Implements : flexcan_rx_mask_type_t_Class.

- enum flexcan_rx_fifo_id_element_format_t { FLEXCAN_RX_FIFO_ID_FORMAT_A, FLEXCAN_RX_FIFO↩ _ID_FORMAT_B, FLEXCAN_RX_FIFO_ID_FORMAT_C, FLEXCAN_RX_FIFO_ID_FORMAT_D }

  ID formats for Rx FIFO Implements : flexcan_rx_fifo_id_element_format_t_Class.
- enum flexcan_operation_modes_t { FLEXCAN_NORMAL_MODE, FLEXCAN_LISTEN_ONLY_MODE, FLEXCAN_LOOPBACK_MODE, FLEX↩ CAN_FREEZE_MODE, FLEXCAN_DISABLE_MODE }

  FlexCAN operation modes Implements : flexcan_operation_modes_t_Class.

Bit rate

- void FLEXCAN_DRV_SetBitrate (uint8_t instance, const flexcan_time_segment_t *bitrate)

  Sets the FlexCAN bit rate for standard frames or the arbitration phase of FD frames.
- void FLEXCAN_DRV_GetBitrate (uint8_t instance, flexcan_time_segment_t *bitrate)

  Gets the FlexCAN bit rate for standard frames or the arbitration phase of FD frames.

Rx MB and Rx FIFO masks

- void FLEXCAN_DRV_SetRxMaskType (uint8_t instance, flexcan_rx_mask_type_t type)

  Sets the Rx masking type.
- void FLEXCAN_DRV_SetRxFifoGlobalMask (uint8_t instance, flexcan_msgbuff_id_type_t id_type, uint32_t mask)

  Sets the FlexCAN Rx FIFO global mask (standard or extended). This mask is applied to all filters ID regardless the ID Filter format.
- void FLEXCAN_DRV_SetRxMbGlobalMask (uint8_t instance, flexcan_msgbuff_id_type_t id_type, uint32_t mask)

  Sets the FlexCAN Rx MB global mask (standard or extended).
- void FLEXCAN_DRV_SetRxMb14Mask (uint8_t instance, flexcan_msgbuff_id_type_t id_type, uint32_t mask)

  Sets the FlexCAN Rx MB 14 mask (standard or extended).
- void FLEXCAN_DRV_SetRxMb15Mask (uint8_t instance, flexcan_msgbuff_id_type_t id_type, uint32_t mask)

  Sets the FlexCAN Rx MB 15 mask (standard or extended).
- status_t FLEXCAN_DRV_SetRxIndividualMask (uint8_t instance, flexcan_msgbuff_id_type_t id_type, uint8↩ _t mb_idx, uint32_t mask)

  Sets the FlexCAN Rx individual mask (standard or extended).

Initialization and Shutdown

- uint32_t FLEXCAN_DRV_GetDefaultConfig (flexcan_user_config_t *config)

  Gets the default configuration structure.
- status_t FLEXCAN_DRV_Init (uint8_t instance, flexcan_state_t *state, const flexcan_user_config_t *data)

  Initializes the FlexCAN peripheral.
- status_t FLEXCAN_DRV_Deinit (uint8_t instance)

  Shuts down a FlexCAN instance.

Send configuration

- status_t FLEXCAN_DRV_ConfigTxMb (uint8_t instance, uint8_t mb_idx, const flexcan_data_info_t *tx_info, uint32_t msg_id)

  FlexCAN transmit message buffer field configuration.
- status_t FLEXCAN_DRV_ConfigRemoteResponseMb (uint8_t instance, uint8_t mb_idx, const flexcan_↩ data_info_t *tx_info, uint32_t msg_id, const uint8_t *mb_data)

Configures a transmit message buffer for remote frame response.

- status_t FLEXCAN_DRV_SendBlocking (uint8_t instance, uint8_t mb_idx, const flexcan_data_info_t *tx_info, uint32_t msg_id, const uint8_t *mb_data, uint32_t timeout_ms)

  Sends a CAN frame using the specified message buffer, in a blocking manner.
- status_t FLEXCAN_DRV_Send (uint8_t instance, uint8_t mb_idx, const flexcan_data_info_t *tx_info, uint32_t msg_id, const uint8_t *mb_data)

  Sends a CAN frame using the specified message buffer.

Receive configuration

- status_t FLEXCAN_DRV_ConfigRxMb (uint8_t instance, uint8_t mb_idx, const flexcan_data_info_t *rx_info, uint32_t msg_id)

  FlexCAN receive message buffer field configuration.
- void FLEXCAN_DRV_ConfigRxFifo (uint8_t instance, flexcan_rx_fifo_id_element_format_t id_format, const flexcan_id_table_t *id_filter_table)

  FlexCAN Rx FIFO field configuration.
- status_t FLEXCAN_DRV_ReceiveBlocking (uint8_t instance, uint8_t mb_idx, flexcan_msgbuff_t *data, uint32_t timeout_ms)

  Receives a CAN frame using the specified message buffer, in a blocking manner.
- status_t FLEXCAN_DRV_Receive (uint8_t instance, uint8_t mb_idx, flexcan_msgbuff_t *data)

  Receives a CAN frame using the specified message buffer.
- status_t FLEXCAN_DRV_RxFifoBlocking (uint8_t instance, flexcan_msgbuff_t *data, uint32_t timeout_ms)

  Receives a CAN frame using the message FIFO, in a blocking manner.
- status_t FLEXCAN_DRV_RxFifo (uint8_t instance, flexcan_msgbuff_t *data)

  Receives a CAN frame using the message FIFO.

Transfer status

- status_t FLEXCAN_DRV_AbortTransfer (uint8_t instance, uint8_t mb_idx)

  Ends a non-blocking FlexCAN transfer early.
- status_t FLEXCAN_DRV_GetTransferStatus (uint8_t instance, uint8_t mb_idx)

  Returns whether the previous FlexCAN transfer has finished.
- uint32_t FLEXCAN_DRV_GetErrorStatus (uint8_t instance)

  Returns reported error conditions.

IRQ handler callback

- void FLEXCAN_DRV_InstallEventCallback (uint8_t instance, flexcan_callback_t callback, void *callback↩ Param)

  Installs a callback function for the IRQ handler.
- void FLEXCAN_DRV_InstallErrorCallback (uint8_t instance, flexcan_error_callback_t callback, void *callbackParam)

  Installs an error callback function for the IRQ handler and enables error interrupts.

16.31.2 Data Structure Documentation

16.31.2.1 struct flexcan_msgbuff_t

FlexCAN message buffer structure Implements : flexcan_msgbuff_t_Class.

Definition at line 100 of file flexcan_driver.h.

Data Fields

- uint32_t cs
- uint32_t msgId
- uint8_t data [64]
- uint8_t dataLen

Field Documentation

16.31.2.1.1 uint32_t cs

Code and Status

Definition at line 101 of file flexcan_driver.h.

16.31.2.1.2 uint8_t data[64]

Data bytes of the FlexCAN message

Definition at line 103 of file flexcan_driver.h.

16.31.2.1.3 uint8_t dataLen

Length of data in bytes

Definition at line 104 of file flexcan_driver.h.

16.31.2.1.4 uint32_t msgId

Message Buffer ID

Definition at line 102 of file flexcan_driver.h.

16.31.2.2 struct flexcan_mb_handle_t

Information needed for internal handling of a given MB. Implements : flexcan_mb_handle_t_Class.

Definition at line 110 of file flexcan_driver.h.

Data Fields

- flexcan_msgbuff_t * mb_message
- semaphore_t mbSema
- volatile flexcan_mb_state_t state
- bool isBlocking
- bool isRemote

Field Documentation

16.31.2.2.1 bool isBlocking

True if the transfer is blocking

Definition at line 114 of file flexcan_driver.h.

16.31.2.2.2 bool isRemote

True if the frame is a remote frame

Definition at line 115 of file flexcan_driver.h.

16.31.2.2.3 flexcan_msgbuff_t* mb_message

The FlexCAN MB structure

Definition at line 111 of file flexcan_driver.h.

16.31.2.2.4 semaphore_t mbSema

Semaphore used for signaling completion of a blocking transfer

Definition at line 112 of file flexcan_driver.h.

16.31.2.2.5 volatile flexcan_mb_state_t state

The state of the current MB (idle/Rx busy/Tx busy)

Definition at line 113 of file flexcan_driver.h.

16.31.2.3 struct FlexCANState

Internal driver state information.

Note

The contents of this structure are internal to the driver and should not be modified by users. Also, contents of the structure are subject to change in future releases. Implements : flexcan_state_t_Class

Definition at line 126 of file flexcan_driver.h.

Data Fields

- flexcan_mb_handle_t mbs [FEATURE_CAN_MAX_MB_NUM]
- void(∗ callback)(uint8_t instance, flexcan_event_type_t eventType, uint32_t buffIdx, struct FlexCANState ∗driverState)
- void ∗ callbackParam
- void(∗ error_callback)(uint8_t instance, flexcan_event_type_t eventType, struct FlexCANState ∗driverState)
- void ∗ errorCallbackParam
- flexcan_rxfifo_transfer_type_t transferType

Field Documentation

16.31.2.3.1 void(∗ callback) (uint8_t instance, flexcan_event_type_t eventType, uint32_t buffIdx, struct FlexCANState ∗driverState)

IRQ handler callback function.

Definition at line 129 of file flexcan_driver.h.

16.31.2.3.2 void∗ callbackParam

Parameter used to pass user data when invoking the callback function.

Definition at line 133 of file flexcan_driver.h.

16.31.2.3.3 void(∗ error_callback) (uint8_t instance, flexcan_event_type_t eventType, struct FlexCANState ∗driverState)

Error IRQ handler callback function.

Definition at line 136 of file flexcan_driver.h.

16.31.2.3.4 void∗ errorCallbackParam

Parameter used to pass user data when invoking the error callback function.

Definition at line 140 of file flexcan_driver.h.

16.31.2.3.5 flexcan_mb_handle_t mbs[FEATURE_CAN_MAX_MB_NUM]

Array containing information related to each MB

Definition at line 127 of file flexcan_driver.h.

16.31.2.3.6 flexcan_rxfifo_transfer_type_t transferType

Type of RxFIFO transfer.

Definition at line 147 of file flexcan_driver.h.

16.31.2.4 struct flexcan_data_info_t

FlexCAN data info from user Implements : flexcan_data_info_t_Class.

Definition at line 153 of file flexcan_driver.h.

Data Fields

- flexcan_msgbuff_id_type_t msg_id_type
- uint32_t data_length
- bool is_remote

Field Documentation

16.31.2.4.1 uint32_t data_length

Length of Data in Bytes

Definition at line 155 of file flexcan_driver.h.

16.31.2.4.2 bool is_remote

Specifies if the frame is standard or remote

Definition at line 162 of file flexcan_driver.h.

16.31.2.4.3 flexcan_msgbuff_id_type_t msg_id_type

Type of message ID (standard or extended)

Definition at line 154 of file flexcan_driver.h.

16.31.2.5 struct flexcan_id_table_t

FlexCAN Rx FIFO ID filter table structure Implements : flexcan_id_table_t_Class.

Definition at line 209 of file flexcan_driver.h.

Data Fields

- bool isRemoteFrame
- bool isExtendedFrame
- uint32_t id

Field Documentation

16.31.2.5.1 uint32_t id

Rx FIFO ID filter element

Definition at line 212 of file flexcan_driver.h.

16.31.2.5.2 bool isExtendedFrame

Extended frame

Definition at line 211 of file flexcan_driver.h.

16.31.2.5.3 bool isRemoteFrame

Remote frame

Definition at line 210 of file flexcan_driver.h.

16.31.2.6 struct flexcan_time_segment_t

FlexCAN bitrate related structures Implements : flexcan_time_segment_t_Class.

Definition at line 241 of file flexcan_driver.h.

Data Fields

- uint32_t propSeg
- uint32_t phaseSeg1
- uint32_t phaseSeg2
- uint32_t preDivider
- uint32_t rJumpwidth

Field Documentation

16.31.2.6.1 uint32_t phaseSeg1

Phase segment 1

Definition at line 243 of file flexcan_driver.h.

16.31.2.6.2 uint32_t phaseSeg2

Phase segment 2

Definition at line 244 of file flexcan_driver.h.

16.31.2.6.3 uint32_t preDivider

Clock prescaler division factor

Definition at line 245 of file flexcan_driver.h.

16.31.2.6.4 uint32_t propSeg

Propagation segment

Definition at line 242 of file flexcan_driver.h.

16.31.2.6.5 uint32_t rJumpwidth

Resync jump width

Definition at line 246 of file flexcan_driver.h.

16.31.2.7 struct flexcan_user_config_t

FlexCAN configuration.

Definition at line 253 of file flexcan_driver.h.

Data Fields

- uint32_t max_num_mb
- flexcan_rx_fifo_id_filter_num_t num_id_filters
- bool is_rx_fifo_needed
- flexcan_operation_modes_t flexcanMode
- flexcan_time_segment_t bitrate
- flexcan_rxfifo_transfer_type_t transfer_type

Field Documentation

16.31.2.7.1 flexcan_time_segment_t bitrate

The bitrate used for standard frames or for the arbitration phase of FD frames.

Definition at line 269 of file flexcan_driver.h.

16.31.2.7.2 flexcan_operation_modes_t flexcanMode

User configurable FlexCAN operation modes.

Definition at line 260 of file flexcan_driver.h.

16.31.2.7.3 bool is_rx_fifo_needed

1 if needed; 0 if not. This controls whether the Rx FIFO feature is enabled or not.

Definition at line 258 of file flexcan_driver.h.

16.31.2.7.4 uint32_t max_num_mb

The maximum number of Message Buffers

Definition at line 254 of file flexcan_driver.h.

16.31.2.7.5 flexcan_rx_fifo_id_filter_num_t num_id_filters

The number of RX FIFO ID filters needed

Definition at line 256 of file flexcan_driver.h.

16.31.2.7.6 flexcan_rxfifo_transfer_type_t transfer_type

Specifies if the Rx FIFO uses interrupts or DMA.

Definition at line 273 of file flexcan_driver.h.

16.31.3 Typedef Documentation

16.31.3.1 typedef void(∗ flexcan_callback_t) (uint8_t instance, flexcan_event_type_t eventType, uint32_t buffIdx, flexcan_state_t ∗flexcanState)

FlexCAN Driver callback function type Implements : flexcan_callback_t_Class.

Definition at line 335 of file flexcan_driver.h.

16.31.3.2 typedef void(∗ flexcan_error_callback_t) (uint8_t instance, flexcan_event_type_t eventType, flexcan_state_t ∗flexcanState)

FlexCAN Driver error callback function type Implements : flexcan_error_callback_t_Class.

Definition at line 341 of file flexcan_driver.h.

16.31.3.3 typedef struct FlexCANState flexcan_state_t

Internal driver state information.

Note

The contents of this structure are internal to the driver and should not be modified by users. Also, contents of the structure are subject to change in future releases. Implements : flexcan_state_t_Class

16.31.4 Enumeration Type Documentation

16.31.4.1 enum flexcan_event_type_t

The type of the event which occurred when the callback was invoked. Implements : flexcan_event_type_t_Class.

Enumerator

FLEXCAN_EVENT_RX_COMPLETE A frame was received in the configured Rx MB.

FLEXCAN_EVENT_RXFIFO_COMPLETE A frame was received in the Rx FIFO.

FLEXCAN_EVENT_RXFIFO_WARNING Rx FIFO is almost full (5 frames).

FLEXCAN_EVENT_RXFIFO_OVERFLOW Rx FIFO is full (incoming message was lost).

FLEXCAN_EVENT_TX_COMPLETE A frame was sent from the configured Tx MB.

FLEXCAN_EVENT_ERROR

Definition at line 49 of file flexcan_driver.h.

16.31.4.2 enum flexcan_mb_state_t

The state of a given MB (idle/Rx busy/Tx busy). Implements : flexcan_mb_state_t_Class.

Enumerator

FLEXCAN_MB_IDLE The MB is not used by any transfer.

FLEXCAN_MB_RX_BUSY The MB is used for a reception.

FLEXCAN_MB_TX_BUSY The MB is used for a transmission.

Definition at line 70 of file flexcan_driver.h.

16.31.4.3 enum flexcan_msgbuff_id_type_t

FlexCAN Message Buffer ID type Implements : flexcan_msgbuff_id_type_t_Class.

Enumerator

FLEXCAN_MSG_ID_STD Standard ID

FLEXCAN_MSG_ID_EXT Extended ID

Definition at line 82 of file flexcan_driver.h.

16.31.4.4 enum flexcan_operation_modes_t

FlexCAN operation modes Implements : flexcan_operation_modes_t_Class.

Enumerator

FLEXCAN_NORMAL_MODE Normal mode or user mode

FLEXCAN_LISTEN_ONLY_MODE Listen-only mode

FLEXCAN_LOOPBACK_MODE Loop-back mode

FLEXCAN_FREEZE_MODE Freeze mode

FLEXCAN_DISABLE_MODE Module disable mode

Definition at line 218 of file flexcan_driver.h.

16.31.4.5 enum flexcan_rx_fifo_id_element_format_t

ID formats for Rx FIFO Implements : flexcan_rx_fifo_id_element_format_t_Class.

Enumerator

FLEXCAN_RX_FIFO_ID_FORMAT_A One full ID (standard and extended) per ID Filter Table element.

FLEXCAN_RX_FIFO_ID_FORMAT_B Two full standard IDs or two partial 14-bit (standard and extended) IDs per ID Filter Table element.

FLEXCAN_RX_FIFO_ID_FORMAT_C Four partial 8-bit Standard IDs per ID Filter Table element.

FLEXCAN_RX_FIFO_ID_FORMAT_D All frames rejected.

Definition at line 198 of file flexcan_driver.h.

16.31.4.6 enum flexcan_rx_fifo_id_filter_num_t

FlexCAN Rx FIFO filters number Implements : flexcan_rx_fifo_id_filter_num_t_Class.

Enumerator

FLEXCAN_RX_FIFO_ID_FILTERS_8 8 Rx FIFO Filters.

FLEXCAN_RX_FIFO_ID_FILTERS_16 16 Rx FIFO Filters.

FLEXCAN_RX_FIFO_ID_FILTERS_24 24 Rx FIFO Filters.

FLEXCAN_RX_FIFO_ID_FILTERS_32 32 Rx FIFO Filters.

FLEXCAN_RX_FIFO_ID_FILTERS_40 40 Rx FIFO Filters.

FLEXCAN_RX_FIFO_ID_FILTERS_48 48 Rx FIFO Filters.

FLEXCAN_RX_FIFO_ID_FILTERS_56 56 Rx FIFO Filters.

FLEXCAN_RX_FIFO_ID_FILTERS_64 64 Rx FIFO Filters.

FLEXCAN_RX_FIFO_ID_FILTERS_72 72 Rx FIFO Filters.

FLEXCAN_RX_FIFO_ID_FILTERS_80 80 Rx FIFO Filters.

FLEXCAN_RX_FIFO_ID_FILTERS_88 88 Rx FIFO Filters.

FLEXCAN_RX_FIFO_ID_FILTERS_96 96 Rx FIFO Filters.

FLEXCAN_RX_FIFO_ID_FILTERS_104 104 Rx FIFO Filters.

FLEXCAN_RX_FIFO_ID_FILTERS_112 112 Rx FIFO Filters.

FLEXCAN_RX_FIFO_ID_FILTERS_120 120 Rx FIFO Filters.

FLEXCAN_RX_FIFO_ID_FILTERS_128 128 Rx FIFO Filters.

Definition at line 168 of file flexcan_driver.h.

16.31.4.7 enum flexcan_rx_mask_type_t

FlexCAN Rx mask type. Implements : flexcan_rx_mask_type_t_Class.

Enumerator

FLEXCAN_RX_MASK_GLOBAL Rx global mask

FLEXCAN_RX_MASK_INDIVIDUAL Rx individual mask

Definition at line 190 of file flexcan_driver.h.

16.31.4.8 enum flexcan_rxfifo_transfer_type_t

The type of the RxFIFO transfer (interrupts/DMA). Implements : flexcan_rxfifo_transfer_type_t_Class.

Enumerator

FLEXCAN_RXFIFO_USING_INTERRUPTS Use interrupts for RxFIFO.

Definition at line 39 of file flexcan_driver.h.

16.31.5 Function Documentation

16.31.5.1 status_t FLEXCAN_DRV_AbortTransfer (uint8_t *instance,* uint8_t *mb_idx*)

Ends a non-blocking FlexCAN transfer early.

Parameters

instance	A FlexCAN instance number
mb_idx	The index of the message buffer

Returns

STATUS_SUCCESS if successful; STATUS_CAN_NO_TRANSFER_IN_PROGRESS if no transfer was running

Definition at line 1950 of file flexcan_driver.c.

16.31.5.2 status_t FLEXCAN_DRV_ConfigRemoteResponseMb (uint8_t *instance,* uint8_t *mb_idx,* const **flexcan_data_info_t** * *tx_info,* uint32_t *msg_id,* const uint8_t * *mb_data*)

Configures a transmit message buffer for remote frame response.

Parameters

instance	A FlexCAN instance number
mb_idx	Index of the message buffer
tx_info	Data info
msg_id	ID of the message to transmit
mb_data	Bytes of the FlexCAN message

Returns

STATUS_SUCCESS if successful; STATUS_CAN_BUFF_OUT_OF_RANGE if the index of the message buffer is invalid

Definition at line 931 of file flexcan_driver.c.

16.31.5.3 void FLEXCAN_DRV_ConfigRxFifo (uint8_t *instance,* **flexcan_rx_fifo_id_element_format_t** *id_format,* const **flexcan_id_table_t** * *id_filter_table*)

FlexCAN Rx FIFO field configuration.

Note

The number of elements in the ID filter table is defined by the following formula:

- for format A: the number of Rx FIFO ID filters
- for format B: twice the number of Rx FIFO ID filters
- for format C: four times the number of Rx FIFO ID filters The user must provide the exact number of elements in order to avoid any misconfiguration.

Each element in the ID filter table specifies an ID to be used as acceptance criteria for the FIFO as follows:

- for format A: In the standard frame format, bits 10 to 0 of the ID are used for frame identification. In the extended frame format, bits 28 to 0 are used.
- for format B: In the standard frame format, bits 10 to 0 of the ID are used for frame identification. In the extended frame format, only the 14 most significant bits (28 to 15) of the ID are compared to the 14 most significant bits (28 to 15) of the received ID.
- for format C: In both standard and extended frame formats, only the 8 most significant bits (7 to 0 for standard, 28 to 21 for extended) of the ID are compared to the 8 most significant bits (7 to 0 for standard, 28 to 21 for extended) of the received ID.

Parameters

instance	A FlexCAN instance number
id_format	The format of the Rx FIFO ID Filter Table Elements
id_filter_table	The ID filter table elements which contain RTR bit, IDE bit, and Rx message ID

Definition at line 1175 of file flexcan_driver.c.

16.31.5.4 status_t FLEXCAN_DRV_ConfigRxMb (uint8_t *instance,* uint8_t *mb_idx,* const flexcan_data_info_t * *rx_info,* uint32_t *msg_id*)

FlexCAN receive message buffer field configuration.

Parameters

instance	A FlexCAN instance number
mb_idx	Index of the message buffer
rx_info	Data info
msg_id	ID of the message to transmit

Returns

STATUS_SUCCESS if successful; STATUS_CAN_BUFF_OUT_OF_RANGE if the index of a message buffer is invalid;

Definition at line 1113 of file flexcan_driver.c.

16.31.5.5 status_t FLEXCAN_DRV_ConfigTxMb (uint8_t *instance,* uint8_t *mb_idx,* const flexcan_data_info_t * *tx_info,* uint32_t *msg_id*)

FlexCAN transmit message buffer field configuration.

Parameters

instance	A FlexCAN instance number
mb_idx	Index of the message buffer
tx_info	Data info
msg_id	ID of the message to transmit

Returns

STATUS_SUCCESS if successful; STATUS_CAN_BUFF_OUT_OF_RANGE if the index of the message buffer is invalid

Definition at line 887 of file flexcan_driver.c.

16.31.5.6 status_t FLEXCAN_DRV_Deinit (uint8_t *instance*)

Shuts down a FlexCAN instance.

Parameters

instance	A FlexCAN instance number

Returns

STATUS_SUCCESS if successful; STATUS_ERROR if failed

Definition at line 1379 of file flexcan_driver.c.

16.31.5.7 void FLEXCAN_DRV_GetBitrate (uint8_t *instance,* flexcan_time_segment_t * *bitrate*)

Gets the FlexCAN bit rate for standard frames or the arbitration phase of FD frames.

Parameters

instance	A FlexCAN instance number
bitrate	A pointer to a variable for returning the FlexCAN bit rate settings

Definition at line 236 of file flexcan_driver.c.

16.31.5.8 uint32_t FLEXCAN_DRV_GetDefaultConfig (flexcan_user_config_t * *config*)

Gets the default configuration structure.

This function gets the default configuration structure, with the following settings:

- 16 message buffers
- flexible data rate disabled
- Rx FIFO disabled
- normal operation mode
- 8 byte payload size
- Protocol Engine clock = Oscillator clock
- bitrate of 500 Kbit/s (computed for sample point = 87.5)

Parameters

out	*config*	The configuration structure

Returns

The bitrate for generated configuration structure.

Definition at line 2759 of file flexcan_driver.c.

16.31.5.9 uint32_t FLEXCAN_DRV_GetErrorStatus (uint8_t *instance*)

Returns reported error conditions.

Reports various error conditions detected in the reception and transmission of a CAN frame and some general status of the device.

Parameters

instance	The FlexCAN instance number.

Returns

value of the Error and Status 1 register;

Definition at line 1931 of file flexcan_driver.c.

16.31.5.10 status_t FLEXCAN_DRV_GetTransferStatus (uint8_t *instance,* uint8_t *mb_idx*)

Returns whether the previous FlexCAN transfer has finished.

When performing an async transfer, call this function to ascertain the state of the current transfer: in progress (or busy) or complete (success).

Parameters

instance	The FlexCAN instance number.
mb_idx	The index of the message buffer.

Returns

STATUS_SUCCESS if successful; STATUS_BUSY if a resource is busy; STATUS_ERROR in case of a DMA error transfer;

Definition at line 1898 of file flexcan_driver.c.

16.31.5.11 status_t FLEXCAN_DRV_Init (uint8_t *instance,* flexcan_state_t * *state,* const flexcan_user_config_t * *data*)

Initializes the FlexCAN peripheral.

This function initializes

Parameters

instance	A FlexCAN instance number
state	Pointer to the FlexCAN driver state structure.
data	The FlexCAN platform data

Returns

STATUS_SUCCESS if successful; STATUS_CAN_BUFF_OUT_OF_RANGE if the index of a message buffer is invalid; STATUS_ERROR if other error occurred

Definition at line 687 of file flexcan_driver.c.

16.31.5.12 void FLEXCAN_DRV_InstallErrorCallback (uint8_t *instance,* flexcan_error_callback_t *callback,* void * *callbackParam*)

Installs an error callback function for the IRQ handler and enables error interrupts.

Parameters

instance	The FlexCAN instance number.
callback	The error callback function.
callbackParam	User parameter passed to the error callback function through the state parameter.

Definition at line 2469 of file flexcan_driver.c.

16.31.5.13 void FLEXCAN_DRV_InstallEventCallback (uint8_t *instance,* flexcan_callback_t *callback,* void * *callbackParam*)

Installs a callback function for the IRQ handler.

Parameters

instance	The FlexCAN instance number.
callback	The callback function.
callbackParam	User parameter passed to the callback function through the state parameter.

Definition at line 2449 of file flexcan_driver.c.

16.31.5.14 status_t FLEXCAN_DRV_Receive (uint8_t *instance,* uint8_t *mb_idx,* flexcan_msgbuff_t * *data*)

Receives a CAN frame using the specified message buffer.

This function receives a CAN frame using a configured message buffer. The function returns immediately. If a callback is installed, it will be invoked after the frame was received and read into the specified buffer.

Parameters

instance	A FlexCAN instance number
mb_idx	Index of the message buffer
data	The FlexCAN receive message buffer data.

Returns

STATUS_SUCCESS if successful; STATUS_CAN_BUFF_OUT_OF_RANGE if the index of a message buffer is invalid; STATUS_BUSY if a resource is busy

Definition at line 1268 of file flexcan_driver.c.

16.31.5.15 status_t FLEXCAN_DRV_ReceiveBlocking (uint8_t *instance,* uint8_t *mb_idx,* flexcan_msgbuff_t * *data,* uint32_t *timeout_ms*)

Receives a CAN frame using the specified message buffer, in a blocking manner.

This function receives a CAN frame using a configured message buffer. The function blocks until either a frame was received, or the specified timeout expired.

Parameters

instance	A FlexCAN instance number
mb_idx	Index of the message buffer
data	The FlexCAN receive message buffer data.
timeout_ms	A timeout for the transfer in milliseconds.

Returns

STATUS_SUCCESS if successful; STATUS_CAN_BUFF_OUT_OF_RANGE if the index of a message buffer is invalid; STATUS_BUSY if a resource is busy; STATUS_TIMEOUT if the timeout is reached

Definition at line 1209 of file flexcan_driver.c.

16.31.5.16 status_t FLEXCAN_DRV_RxFifo (uint8_t *instance,* flexcan_msgbuff_t * *data*)

Receives a CAN frame using the message FIFO.

This function receives a CAN frame using the Rx FIFO. The function returns immediately. If a callback is installed, it will be invoked after the frame was received and read into the specified buffer.

Parameters

instance	A FlexCAN instance number
data	The FlexCAN receive message buffer data.

Returns

STATUS_SUCCESS if successful; STATUS_BUSY if a resource is busy; STATUS_ERROR if other error occurred

Definition at line 1358 of file flexcan_driver.c.

16.31.5.17 status_t FLEXCAN_DRV_RxFifoBlocking (uint8_t *instance,* flexcan_msgbuff_t * *data,* uint32_t *timeout_ms*)

Receives a CAN frame using the message FIFO, in a blocking manner.

This function receives a CAN frame using the Rx FIFO. The function blocks until either a frame was received, or the specified timeout expired.

Parameters

instance	A FlexCAN instance number
data	The FlexCAN receive message buffer data.
timeout_ms	A timeout for the transfer in milliseconds.

Returns

STATUS_SUCCESS if successful; STATUS_BUSY if a resource is busy; STATUS_TIMEOUT if the timeout is reached; STATUS_ERROR if other error occurred

Definition at line 1298 of file flexcan_driver.c.

16.31.5.18 status_t FLEXCAN_DRV_Send (uint8_t *instance,* uint8_t *mb_idx,* const flexcan_data_info_t * *tx_info,* uint32_t *msg_id,* const uint8_t * *mb_data*)

Sends a CAN frame using the specified message buffer.

This function sends a CAN frame using a configured message buffer. The function returns immediately. If a callback is installed, it will be invoked after the frame was sent.

Parameters

instance	A FlexCAN instance number
mb_idx	Index of the message buffer
tx_info	Data info
msg_id	ID of the message to transmit
mb_data	Bytes of the FlexCAN message.

Returns

STATUS_SUCCESS if successful; STATUS_CAN_BUFF_OUT_OF_RANGE if the index of a message buffer is invalid; STATUS_BUSY if a resource is busy

Definition at line 1070 of file flexcan_driver.c.

16.31.5.19 status_t FLEXCAN_DRV_SendBlocking (uint8_t *instance,* uint8_t *mb_idx,* const flexcan_data_info_t * *tx_info,* uint32_t *msg_id,* const uint8_t * *mb_data,* uint32_t *timeout_ms*)

Sends a CAN frame using the specified message buffer, in a blocking manner.

This function sends a CAN frame using a configured message buffer. The function blocks until either the frame was sent, or the specified timeout expired.

Parameters

instance	A FlexCAN instance number
mb_idx	Index of the message buffer
tx_info	Data info
msg_id	ID of the message to transmit
mb_data	Bytes of the FlexCAN message
timeout_ms	A timeout for the transfer in milliseconds.

Returns

STATUS_SUCCESS if successful; STATUS_CAN_BUFF_OUT_OF_RANGE if the index of a message buffer is invalid; STATUS_BUSY if a resource is busy; STATUS_TIMEOUT if the timeout is reached

Definition at line 968 of file flexcan_driver.c.

16.31.5.20 void FLEXCAN_DRV_SetBitrate (uint8_t *instance,* const flexcan_time_segment_t * *bitrate*)

Sets the FlexCAN bit rate for standard frames or the arbitration phase of FD frames.

Parameters

instance	A FlexCAN instance number
bitrate	A pointer to the FlexCAN bit rate settings.

Definition at line 159 of file flexcan_driver.c.

16.31.5.21 void FLEXCAN_DRV_SetRxFifoGlobalMask (uint8_t *instance,* flexcan_msgbuff_id_type_t *id_type,* uint32_t *mask*)

Sets the FlexCAN Rx FIFO global mask (standard or extended). This mask is applied to all filters ID regardless the ID Filter format.

Parameters

instance	A FlexCAN instance number
id_type	Standard ID or extended ID mask type
mask	Mask Value. In FIFO mode, when using ID Format A or B, bit 31 encodes RTR check and bit 30 encodes IDE check respectively. For ID Format C, bits 31 and 30 are ignored.

Definition at line 317 of file flexcan_driver.c.

16.31.5.22 status_t FLEXCAN_DRV_SetRxIndividualMask (uint8_t *instance,* flexcan_msgbuff_id_type_t *id_type,* uint8_t *mb_idx,* uint32_t *mask*)

Sets the FlexCAN Rx individual mask (standard or extended).

Parameters

instance	A FlexCAN instance number
id_type	A standard ID or an extended ID
mb_idx	Index of the message buffer
mask	Mask Value. In FIFO mode, when using ID Format A or B, bit 31 encodes RTR check and bit 30 encodes IDE check respectively. For ID Format C, bits 31 and 30 are ignored.

Returns

STATUS_SUCCESS if successful; STATUS_CAN_BUFF_OUT_OF_RANGE if the index of the message buffer is invalid.

Definition at line 504 of file flexcan_driver.c.

16.31.5.23 void FLEXCAN_DRV_SetRxMaskType (uint8_t *instance,* flexcan_rx_mask_type_t *type*)

Sets the Rx masking type.

Parameters

instance	A FlexCAN instance number
type	The FlexCAN RX mask type

Definition at line 288 of file flexcan_driver.c.

16.31.5.24 void FLEXCAN_DRV_SetRxMb14Mask (uint8_t *instance,* flexcan_msgbuff_id_type_t *id_type,* uint32_t *mask*)

Sets the FlexCAN Rx MB 14 mask (standard or extended).

Parameters

instance	A FlexCAN instance number

id_type	Standard ID or extended ID
mask	Mask value

Definition at line 416 of file flexcan_driver.c.

16.31.5.25 void FLEXCAN_DRV_SetRxMb15Mask (uint8_t *instance,* flexcan_msgbuff_id_type_t *id_type,* uint32_t *mask*)

Sets the FlexCAN Rx MB 15 mask (standard or extended).

Parameters

instance	A FlexCAN instance number
id_type	Standard ID or extended ID
mask	Mask value

Definition at line 460 of file flexcan_driver.c.

16.31.5.26 void FLEXCAN_DRV_SetRxMbGlobalMask (uint8_t *instance,* flexcan_msgbuff_id_type_t *id_type,* uint32_t *mask*)

Sets the FlexCAN Rx MB global mask (standard or extended).

Parameters

instance	A FlexCAN instance number
id_type	Standard ID or extended ID
mask	Mask value

Definition at line 372 of file flexcan_driver.c.

16.32 FlexIO Common Driver

16.32.1 Detailed Description

Common services for FlexIO drivers.

The Flexio Common driver layer contains services used by all Flexio drivers. The need for this layer derives from the requirement to allow multiple Flexio drivers to run in parallel on the same device, to the extent that enough hardware resources (shifters and timers) are available.

Functionality

The Flexio Common driver layer provides functions for device initialization and reset. Before using any Flexio driver the device must first be initialized using function FLEXIO_DRV_InitDevice(). Then any number of Flexio drivers can be initialized on the same device, to the extent that enough hardware resources (shifters and timers) are available. Driver initialization functions will return STATUS_ERROR if not enough resources are available for a new driver.

Important Notes

Calling any Flexio common function will destroy any driver that is active on that device. Normally these functions should be called only when there are no active driver instances on the device.

Enumerations

- enum flexio_driver_type_t { FLEXIO_DRIVER_TYPE_INTERRUPTS = 0U, FLEXIO_DRIVER_TYPE_POL↩ LING = 1U, FLEXIO_DRIVER_TYPE_DMA = 2U }

  Driver type: interrupts/polling/DMA Implements : flexio_driver_type_t_Class.

FLEXIO_I2C Driver

- status_t FLEXIO_DRV_InitDevice (uint32_t instance, flexio_device_state_t ∗deviceState)

  Initializes the FlexIO device.
- status_t FLEXIO_DRV_DeinitDevice (uint32_t instance)

  De-initializes the FlexIO device.
- status_t FLEXIO_DRV_Reset (uint32_t instance)

  Resets the FlexIO device.

16.32.2 Enumeration Type Documentation

16.32.2.1 enum flexio_driver_type_t

Driver type: interrupts/polling/DMA Implements : flexio_driver_type_t_Class.

Enumerator

FLEXIO_DRIVER_TYPE_INTERRUPTS Driver uses interrupts for data transfers

FLEXIO_DRIVER_TYPE_POLLING Driver is based on polling

FLEXIO_DRIVER_TYPE_DMA Driver uses DMA for data transfers

Definition at line 46 of file flexio.h.

16.32.3 Function Documentation

16.32.3.1 status_t FLEXIO_DRV_DeinitDevice (uint32_t *instance*)

De-initializes the FlexIO device.

This function de-initializes the FlexIO device.

Parameters

instance	FLEXIO peripheral instance number

Returns

Error or success status returned by API

Definition at line 125 of file flexio_common.c.

16.32.3.2 status_t FLEXIO_DRV_InitDevice (uint32_t *instance*, flexio_device_state_t * *deviceState*)

Initializes the FlexIO device.

This function resets the FlexIO device, enables interrupts in interrupt manager and enables the device.

Parameters

instance	FLEXIO peripheral instance number
deviceState	Pointer to the FLEXIO device context structure. The driver uses this memory area for its internal logic. The application must make no assumptions about the content of this structure, and must not free this memory until the device is de-initialized using FLEXIO_DRV_Deinit↩ Device().

Returns

Error or success status returned by API

Definition at line 86 of file flexio_common.c.

16.32.3.3 status_t FLEXIO_DRV_Reset (uint32_t *instance*)

Resets the FlexIO device.

This function resets the FlexIO device.

Parameters

instance	FLEXIO peripheral instance number

Returns

Error or success status returned by API

Definition at line 150 of file flexio_common.c.

16.33 FlexIO I2C Driver

16.33.1 Detailed Description

I2C communication over FlexIO module (FLEXIO_I2C)

The FLEXIO_I2C Driver allows communication on an I2C bus using the FlexIO module in the S32K1xx processors.

Features

- Master operation only
- Interrupt, DMA or polling mode
- Provides blocking and non-blocking transmit and receive functions
- 7-bit addressing
- Clock stretching
- Configurable baud rate

Functionality

Before using any Flexio driver the device must first be initialized using function FLEXIO_DRV_InitDevice. Then the FLEXIO_I2C Driver must be initialized using functions FLEXIO_I2C_DRV_MasterInit(). It is possible to use more driver instances on the same FlexIO device, as long as sufficient resources are available. Different driver instances on the same FlexIO device can function independently of each other. When it is no longer needed, the driver can be de-initialized, using FLEXIO_I2C_DRV_MasterDeinit(). This will release the hardware resources, allowing other driver instances to be initialized.

Master Mode

Master Mode provides functions for transmitting or receiving data to/from any I2C slave. Slave address and baud rate are provided at initialization time through the master configuration structure, but they can be changed at runtime by using FLEXIO_I2C_DRV_MasterSetBaudRate() or FLEXIO_I2C_DRV_MasterSetSlaveAddr(). Note that due to module limitation not any baud rate can be achieved. The driver will set a baud rate as close as possible to the requested baud rate, but there may still be substantial differences, for example if requesting a high baud rate while using a low-frequency FlexIO clock. The application should call FLEXIO_I2C_DRV_MasterGetBaudRate() after FLEXIO_I2C_DRV_MasterSetBaudRate() to check what baud rate was actually set.

To send or receive data to/from the currently configured slave address, use functions FLEXIO_I2C_DRV_MasterSendData() or FLEXIO_I2C_DRV_MasterReceiveData() (or their blocking counterparts). Parameter `sendStop` can be used to chain multiple transfers with repeated START condition between them, for example when sending a command and then immediately receiving a response. The application should ensure that any send or receive transfer with `sendStop` set to `false` is followed by another transfer. The last transfer from a chain should always have `sendStop` set to `true`. This driver does not support continuous send/receive using a user callback function. The callback function is only used to signal the end of a transfer.

Blocking operations will return only when the transfer is completed, either successfully or with error. Non-blocking operations will initiate the transfer and return STATUS_SUCCESS, but the module is still busy with the transfer and another transfer can't be initiated until the current transfer is complete. The application will be notified through the user callback when the transfer completes, or it can check the status of the current transfer by calling FLEXIO_I2C_DRV_MasterGetStatus(). If the transfer is still ongoing this function will return STATUS_BUSY. If the transfer is completed, the function will return either STATUS_SUCCESS or an error code, depending on the outcome of the last transfer.

The driver supports interrupt, DMA and polling mode. In polling mode the function FLEXIO_I2C_DRV_MasterGetStatus() ensures the progress of the transfer by checking and handling transmit and receive events reported by the FlexIO module. The application should ensure that this function is called often enough (at least once per transferred byte) to avoid Tx underflows or Rx overflows. In DMA mode the DMA channels that will be used by the driver are received through the configuration structure. The channels must be initialized by the application before the flexio_i2c driver is initialized. The flexio_i2c driver will only set the DMA request source.

Important Notes

- There is one limitation of flexio_i2c which no Stop condition is generated when aborting a transfer due to NACK reception.
- Before using the FLEXIO_I2C Driver the FlexIO clock must be configured. Refer to Clock Manager for clock configuration.
- Before using the FLEXIO_I2C Driver the pins must be routed to the FlexIO module. Refer to PINS Driver for pin routing configuration. Note that any of the available FlexIO pins can be used for SDA and SCL (configurable at initialization time).
- The driver enables the interrupts for the corresponding FlexIO module, but any interrupt priority setting must be done by the application.
- Aborting a transfer with the function FLEXIO_I2C_DRV_MasterTransferAbort() can't generally be done safely due to device limitation; there is no way to know the exact stage of the transfer, and if we disable the module during the ACK bit (transmit) or during a 0 data bit (receive) the slave will hold the SDA line low forever and block the I2C bus. Therefore this function should only be used in extreme circumstances, and the application must have a way to reset the I2C slave. NACK reception is the only exception, as there is no slave to hold the line low, so in this case the driver will automatically abort the transfer.
- The module can handle clock stretching done by the slave, but will not do clock stretching when the application does not provide data fast enough, so Tx underflows and Rx overflows are possible. This can be an issue especially in polling mode if the function FLEXIO_I2C_DRV_MasterGetStatus() is not called often enough.
- Due to device limitations it is not always possible to tell the difference between NACK reception and receiver overflow. When in doubt, the driver will treat these events as overflow and continue the transfer, in order to avoid the risk of blocking the i2c bus.
- The driver does not support multi-master mode. It does not detect arbitration loss condition.
- Timeout feature for blocking transfers does not work in polling mode.
- This driver needs two shifters and two timers for its operation. Initialization will fail if there are not enough shifters and timers available on the FlexIO device.
- This driver needs two DMA channels for its operation when it is initialized in DMA mode. The DMA channels must be initialized by the application before initializing the driver. Refer to EDMA driver for DMA channels initialization.
- If the application uses an RTOS, this driver uses a semaphore for blocking transfers. Initialization will fail if the semaphore cannot be created. If the driver uses polling mode no semaphore is used.
- If the application uses an RTOS, the FlexIO drivers use a mutex for channel allocation. Only one mutex per device is needed, not per driver instance. Device initialization will fail if the mutex cannot be created.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\flexio\flexio_common.c
${S32SDK_PATH}\platform\drivers\src\flexio\flexio_i2c_driver.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc
${S32SDK_PATH}\platform\drivers\src\flexio
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager OS Interface (OSIF) Interrupt Manager (Interrupt) Enhanced Direct Memory Access (eDMA)

Data Structures

- struct flexio_i2c_master_user_config_t

  Master configuration structure. More...
- struct flexio_i2c_master_state_t

  Master internal context structure. More...

FLEXIO_I2C Driver

- status_t FLEXIO_I2C_DRV_MasterInit (uint32_t instance, const flexio_i2c_master_user_config_t ∗user↩ ConfigPtr, flexio_i2c_master_state_t ∗master)

  Initialize the FLEXIO_I2C master mode driver.
- status_t FLEXIO_I2C_DRV_MasterDeinit (flexio_i2c_master_state_t ∗master)

  De-initialize the FLEXIO_I2C master mode driver.
- status_t FLEXIO_I2C_DRV_MasterSetBaudRate (flexio_i2c_master_state_t ∗master, uint32_t baudRate)

  Set the baud rate for any subsequent I2C communication.
- status_t FLEXIO_I2C_DRV_MasterGetBaudRate (flexio_i2c_master_state_t ∗master, uint32_t ∗baudRate)

  Get the currently configured baud rate.
- status_t FLEXIO_I2C_DRV_MasterSetSlaveAddr (flexio_i2c_master_state_t ∗master, const uint16_t address)

  Set the slave address for any subsequent I2C communication.
- status_t FLEXIO_I2C_DRV_MasterSendData (flexio_i2c_master_state_t ∗master, const uint8_t ∗txBuff, uint32_t txSize, bool sendStop)

  Perform a non-blocking send transaction on the I2C bus.
- status_t FLEXIO_I2C_DRV_MasterSendDataBlocking (flexio_i2c_master_state_t ∗master, const uint8_↩ t ∗txBuff, uint32_t txSize, bool sendStop, uint32_t timeout)

  Perform a blocking send transaction on the I2C bus.
- status_t FLEXIO_I2C_DRV_MasterReceiveData (flexio_i2c_master_state_t ∗master, uint8_t ∗rxBuff, uint32_t rxSize, bool sendStop)

  Perform a non-blocking receive transaction on the I2C bus.
- status_t FLEXIO_I2C_DRV_MasterReceiveDataBlocking (flexio_i2c_master_state_t ∗master, uint8_t ∗rx↩ Buff, uint32_t rxSize, bool sendStop, uint32_t timeout)

  Perform a blocking receive transaction on the I2C bus.
- status_t FLEXIO_I2C_DRV_MasterTransferAbort (flexio_i2c_master_state_t ∗master)

  Aborts a non-blocking I2C master transaction.
- status_t FLEXIO_I2C_DRV_MasterGetStatus (flexio_i2c_master_state_t ∗master, uint32_t ∗bytes↩ Remaining)

  Get the status of the current non-blocking I2C master transaction.
- void FLEXIO_I2C_DRV_GetDefaultConfig (flexio_i2c_master_user_config_t ∗userConfigPtr)

  Returns default configuration structure for FLEXIO_I2C.
- status_t FLEXIO_I2C_DRV_GenerateNineClock (flexio_i2c_master_state_t ∗master)

  Generate nine clock on SCL line to free SDA line.
- status_t FLEXIO_I2C_DRV_StatusGenerateNineClock (flexio_i2c_master_state_t ∗master)

  Indicate the generation nine clock is done or not.
- bool FLEXIO_I2C_DRV_GetBusStatus (const flexio_i2c_master_state_t ∗master, bool sdaLine)

  Check status whether SDA or SCL line be low or high.

16.33.2 Data Structure Documentation

16.33.2.1 struct flexio_i2c_master_user_config_t

Master configuration structure.

This structure is used to provide configuration parameters for the flexio_i2c master at initialization time. Implements : flexio_i2c_master_user_config_t_Class

Definition at line 84 of file flexio_i2c_driver.h.

Data Fields

- uint16_t slaveAddress
- flexio_driver_type_t driverType
- uint32_t baudRate
- uint8_t sdaPin
- uint8_t sclPin
- i2c_master_callback_t callback
- void * callbackParam
- uint8_t rxDMAChannel
- uint8_t txDMAChannel

Field Documentation

16.33.2.1.1 uint32_t baudRate

Baud rate in hertz

Definition at line 88 of file flexio_i2c_driver.h.

16.33.2.1.2 i2c_master_callback_t callback

User callback function. Note that this function will be called from the interrupt service routine, so its execution time should be as small as possible. It can be NULL if it is not needed

Definition at line 91 of file flexio_i2c_driver.h.

16.33.2.1.3 void* callbackParam

Parameter for the callback function

Definition at line 95 of file flexio_i2c_driver.h.

16.33.2.1.4 flexio_driver_type_t driverType

Driver type: interrupts/polling/DMA

Definition at line 87 of file flexio_i2c_driver.h.

16.33.2.1.5 uint8_t rxDMAChannel

Rx DMA channel number. Only used in DMA mode

Definition at line 96 of file flexio_i2c_driver.h.

16.33.2.1.6 uint8_t sclPin

Flexio pin to use as I2C SCL pin

Definition at line 90 of file flexio_i2c_driver.h.

16.33.2.1.7 uint8_t sdaPin

Flexio pin to use as I2C SDA pin

Definition at line 89 of file flexio_i2c_driver.h.

16.33.2.1.8 uint16_t slaveAddress

Slave address, 7-bit

Definition at line 86 of file flexio_i2c_driver.h.

16.33.2.1.9 uint8_t txDMAChannel

Tx DMA channel number. Only used in DMA mode

Definition at line 97 of file flexio_i2c_driver.h.

16.33.2.2 struct flexio_i2c_master_state_t

Master internal context structure.

This structure is used by the driver for its internal logic. It must be provided by the application through the FLEXIO_I2C_DRV_MasterInit() function, then it cannot be freed until the driver is de-initialized using FLEXIO_I2C_DRV_MasterDeinit(). The application should make no assumptions about the content of this structure.

Definition at line 109 of file flexio_i2c_driver.h.

16.33.3 Function Documentation

16.33.3.1 status_t FLEXIO_I2C_DRV_GenerateNineClock (flexio_i2c_master_state_t * master)

Generate nine clock on SCL line to free SDA line.

This function should be called when SDA line be stuck in low.

Parameters

master	Pointer to the FLEXIO_I2C master driver context structure.

Returns

STATUS_BUSY: Driver is transfering data, STATUS_SUCCESS: Function started generating clock

Definition at line 1681 of file flexio_i2c_driver.c.

16.33.3.2 bool FLEXIO_I2C_DRV_GetBusStatus (const flexio_i2c_master_state_t * master, bool sdaLine)

Check status whether SDA or SCL line be low or high.

Parameters

master	Pointer to the FLEXIO_I2C master driver context structure.
sdaLine	true - function return status of SDA line. false - function return status of SCL line.

Returns

true: Pin selected is high, false: Pin selected is low

Definition at line 1766 of file flexio_i2c_driver.c.

16.33.3.3 void FLEXIO_I2C_DRV_GetDefaultConfig (flexio_i2c_master_user_config_t * userConfigPtr)

Returns default configuration structure for FLEXIO_I2C.

Parameters

userConfigPtr	Pointer to the FLEXIO_I2C user configuration structure.

Definition at line 1658 of file flexio_i2c_driver.c.

16.33.3.4 status_t FLEXIO_I2C_DRV_MasterDeinit (flexio_i2c_master_state_t * *master*)

De-initialize the FLEXIO_I2C master mode driver.

This function de-initializes the FLEXIO_I2C driver in master mode. The driver can't be used again until reinitialized. The context structure is no longer needed by the driver and can be freed after calling this function.

Parameters

master	Pointer to the FLEXIO_I2C master driver context structure.

Returns

Error or success status returned by API

Definition at line 1286 of file flexio_i2c_driver.c.

16.33.3.5 status_t FLEXIO_I2C_DRV_MasterGetBaudRate (flexio_i2c_master_state_t * *master,* uint32_t * *baudRate*)

Get the currently configured baud rate.

This function returns the currently configured I2C baud rate.

Parameters

master	Pointer to the FLEXIO_I2C master driver context structure.
baudRate	the current baud rate in hertz

Returns

Error or success status returned by API

Definition at line 1356 of file flexio_i2c_driver.c.

16.33.3.6 status_t FLEXIO_I2C_DRV_MasterGetStatus (flexio_i2c_master_state_t * *master,* uint32_t * *bytesRemaining*)

Get the status of the current non-blocking I2C master transaction.

This function returns the current status of a non-blocking I2C master transaction. A return code of STATUS_BUSY means the transfer is still in progress. Otherwise the function returns a status reflecting the outcome of the last transfer. When the driver is initialized in polling mode this function also advances the transfer by checking and handling the transmit and receive events, so it must be called frequently to avoid overflows or underflows.

Parameters

master	Pointer to the FLEXIO_I2C master driver context structure.
bytesRemaining	The remaining number of bytes to be transferred

Returns

Error or success status returned by API

Definition at line 1603 of file flexio_i2c_driver.c.

16.33.3.7 status_t FLEXIO_I2C_DRV_MasterInit (uint32_t *instance,* const flexio_i2c_master_user_config_t * *userConfigPtr,* flexio_i2c_master_state_t * *master*)

Initialize the FLEXIO_I2C master mode driver.

This function initializes the FLEXIO_I2C driver in master mode.

Parameters

instance	FLEXIO peripheral instance number
userConfigPtr	Pointer to the FLEXIO_I2C master user configuration structure. The function reads configuration data from this structure and initializes the driver accordingly. The application may free this structure after the function returns.
master	Pointer to the FLEXIO_I2C master driver context structure. The driver uses this memory area for its internal logic. The application must make no assumptions about the content of this structure, and must not free this memory until the driver is de-initialized using FLEXIO_I2C_DRV_MasterDeinit().

Returns

Error or success status returned by API

Definition at line 1195 of file flexio_i2c_driver.c.

16.33.3.8 status_t FLEXIO_I2C_DRV_MasterReceiveData (flexio_i2c_master_state_t * *master*, uint8_t * *rxBuff*, uint32_t *rxSize*, bool *sendStop*)

Perform a non-blocking receive transaction on the I2C bus.

This function starts the reception of a block of data from the currently configured slave address and returns immediately. The rest of the transmission is handled by the interrupt service routine (if the driver is initialized in interrupt mode) or by the FLEXIO_I2C_DRV_MasterGetStatus function (if the driver is initialized in polling mode). Use FLEXIO_I2C_DRV_MasterGetStatus() to check the progress of the reception.

Parameters

master	Pointer to the FLEXIO_I2C master driver context structure.
rxBuff	pointer to the buffer where to store received data
rxSize	length in bytes of the data to be transferred
sendStop	specifies whether or not to generate stop condition after the reception

Returns

Error or success status returned by API

Definition at line 1494 of file flexio_i2c_driver.c.

16.33.3.9 status_t FLEXIO_I2C_DRV_MasterReceiveDataBlocking (flexio_i2c_master_state_t * *master*, uint8_t * *rxBuff*, uint32_t *rxSize*, bool *sendStop*, uint32_t *timeout*)

Perform a blocking receive transaction on the I2C bus.

This function receives a block of data from the currently configured slave address, and only returns when the transmission is complete.

Parameters

master	Pointer to the FLEXIO_I2C master driver context structure.
rxBuff	pointer to the buffer where to store received data
rxSize	length in bytes of the data to be transferred
sendStop	specifies whether or not to generate stop condition after the reception
timeout	timeout for the transfer in milliseconds

Returns

Error or success status returned by API

Definition at line 1523 of file flexio_i2c_driver.c.

16.33.3.10 status_t FLEXIO_I2C_DRV_MasterSendData (flexio_i2c_master_state_t * *master*, const uint8_t * *txBuff*, uint32_t *txSize*, bool *sendStop*)

Perform a non-blocking send transaction on the I2C bus.

This function starts the transmission of a block of data to the currently configured slave address and returns immediately. The rest of the transmission is handled by the interrupt service routine (if the driver is initialized in interrupt mode) or by the FLEXIO_I2C_DRV_MasterGetStatus function (if the driver is initialized in polling mode). Use FLEXIO_I2C_DRV_MasterGetStatus() to check the progress of the transmission.

Parameters

master	Pointer to the FLEXIO_I2C master driver context structure.
txBuff	pointer to the data to be transferred
txSize	length in bytes of the data to be transferred
sendStop	specifies whether or not to generate stop condition after the transmission

Returns

Error or success status returned by API

Definition at line 1417 of file flexio_i2c_driver.c.

16.33.3.11 status_t FLEXIO_I2C_DRV_MasterSendDataBlocking (flexio_i2c_master_state_t * *master*, const uint8_t * *txBuff*, uint32_t *txSize*, bool *sendStop*, uint32_t *timeout*)

Perform a blocking send transaction on the I2C bus.

This function sends a block of data to the currently configured slave address, and only returns when the transmission is complete.

Parameters

master	Pointer to the FLEXIO_I2C master driver context structure.
txBuff	pointer to the data to be transferred
txSize	length in bytes of the data to be transferred
sendStop	specifies whether or not to generate stop condition after the transmission
timeout	timeout for the transfer in milliseconds

Returns

Error or success status returned by API

Definition at line 1446 of file flexio_i2c_driver.c.

16.33.3.12 status_t FLEXIO_I2C_DRV_MasterSetBaudRate (flexio_i2c_master_state_t * *master*, uint32_t *baudRate*)

Set the baud rate for any subsequent I2C communication.

This function sets the baud rate (SCL frequency) for the I2C master. Note that due to module limitation not any baud rate can be achieved. The driver will set a baud rate as close as possible to the requested baud rate, but there may still be substantial differences, for example if requesting a high baud rate while using a low-frequency FlexIO clock. The application should call FLEXIO_I2C_DRV_MasterGetBaudRate() after FLEXIO_I2C_DRV_MasterSetBaudRate() to check what baud rate was actually set.

Parameters

master	Pointer to the FLEXIO_I2C master driver context structure.

baudRate	the desired baud rate in hertz

Returns

Error or success status returned by API

Definition at line 1312 of file flexio_i2c_driver.c.

16.33.3.13 status_t FLEXIO_I2C_DRV_MasterSetSlaveAddr (flexio_i2c_master_state_t * *master,* const uint16_t *address*)

Set the slave address for any subsequent I2C communication.

This function sets the slave address which will be used for any future transfer.

Parameters

master	Pointer to the FLEXIO_I2C master driver context structure.
address	slave address, 7-bit

Returns

Error or success status returned by API

Definition at line 1395 of file flexio_i2c_driver.c.

16.33.3.14 status_t FLEXIO_I2C_DRV_MasterTransferAbort (flexio_i2c_master_state_t * *master*)

Aborts a non-blocking I2C master transaction.

This function aborts a non-blocking I2C transfer.

Parameters

master	Pointer to the FLEXIO_I2C master driver context structure.

Returns

Error or success status returned by API

Definition at line 1571 of file flexio_i2c_driver.c.

16.33.3.15 status_t FLEXIO_I2C_DRV_StatusGenerateNineClock (flexio_i2c_master_state_t * *master*)

Indicate the generation nine clock is done or not.

Parameters

master	Pointer to the FLEXIO_I2C master driver context structure.

Returns

STATUS_BUSY: Clock generation not done yet, STATUS_SUCCESS: Device finished generating nine clock

Definition at line 1730 of file flexio_i2c_driver.c.

16.34 FlexIO I2S Driver

16.34.1 Detailed Description

I2S communication over FlexIO module (FLEXIO_I2S)

The FLEXIO_I2S Driver allows communication on an I2S bus using the FlexIO module in the S32K1xx processors.

Features

- Master or slave operation
- Interrupt, DMA or polling mode
- Provides blocking and non-blocking transmit and receive functions
- Configurable baud rate and bit count

Functionality

Before using any Flexio driver the device must first be initialized using function FLEXIO_DRV_InitDevice. Then the FLEXIO_I2S Driver must be initialized, using functions FLEXIO_I2S_DRV_MasterInit() or FLEXIO_I2S_DRV_SlaveInit(). It is possible to use more driver instances on the same FlexIO device, as long as sufficient resources are available. Different driver instances on the same FlexIO device can function independently of each other. When it is no longer needed, the driver can be de-initialized, using FLEXIO_I2S_DRV_MasterDeinit() or FLEXIO_I2S_DRV_SlaveDeinit(). This will release the hardware resources, allowing other driver instances to be initialized.

Master Mode

Master Mode provides functions for transmitting or receiving data to/from any I2S slave. The number of bits per word and the baud rate are provided at initialization time through the master configuration structure, but they can be changed at runtime by using FLEXIO_I2S_DRV_MasterSetConfig(). Note that due to module limitation not any baud rate can be achieved. The driver will set a baud rate as close as possible to the requested baud rate, but there may still be substantial differences, for example if requesting a high baud rate while using a low-frequency FlexIO clock. The application should call FLEXIO_I2S_DRV_MasterGetBaudRate() to check what baud rate was actually set.

To send or receive data to/from the currently configured slave address, use functions FLEXIO_I2S_DRV_MasterSendData() or FLEXIO_I2S_DRV_MasterReceiveData() (or their blocking counterparts). The driver is not full-duplex, only one direction (send or receive) can be used at one time. It is possible to configure both Rx and Tx pin to use the same Flexio pin.

Continuous send/receive can be realized by registering a user callback function. When the driver completes the transmission or reception of the current buffer, it will invoke the user callback with an appropriate event. The callback function can the use FLEXIO_I2S_DRV_MasterSetTxBuffer() or FLEXIO_I2S_DRV_MasterSetRxBuffer() to provide a new buffer.

Blocking operations will return only when the transfer is completed, either successfully or with error. Non-blocking operations will initiate the transfer and return STATUS_SUCCESS, but the module is still busy with the transfer and another transfer can't be initiated until the current transfer is complete. The application will be notified through the user callback when the transfer completes, or it can check the status of the current transfer by calling FLEXIO_I2S_DRV_MasterGetStatus(). If the transfer is still ongoing this function will return STATUS_BUSY. If the transfer is completed, the function will return either STATUS_SUCCESS or an error code, depending on the outcome of the last transfer.

The driver supports interrupt, DMA and polling mode. In polling mode the function FLEXIO_I2S_DRV_MasterGetStatus() ensures the progress of the transfer by checking and handling transmit and receive events reported by the FlexIO module. The application should ensure that this function is called often enough (at least once per transferred byte) to avoid Tx underflows or Rx overflows. In DMA mode the DMA channels that will be used by the driver are received through the configuration structure. The channels must be initialized by the application before the flexio_i2s driver is initialized. The flexio_i2s driver will only set the DMA request source.

Slave Mode

Slave Mode is very similar to master mode, the main difference being that the FLEXIO_I2S_DRV_SlaveInit() function initializes the FlexIO module to use the clock signal received from the master instead of generating it. Consequently, there is no baud rate setting in slave mode. Other than that, the slave mode offers a similar interface to the master mode. FLEXIO_I2S_DRV_MasterSendData() or FLEXIO_I2S_DRV_MasterReceiveData() (or their blocking counterparts) can be used to initiate transfers, and FLEXIO_I2S_DRV_SlaveGetStatus() is used to check the status of the transfer and advance the transfer in polling mode. All other specifications from the Master Mode description apply for Slave Mode too.

Important Notes

- Before using the FLEXIO_I2S Driver the FlexIO clock must be configured. Refer to Clock Manager for clock configuration.
- Before using the FLEXIO_I2S Driver the pins must be routed to the FlexIO module. Refer to PINS Driver for pin routing configuration. Note that any of the available FlexIO pins can be used for any of the TX, RX, SCK and WS signals (configurable at initialization time). If more than one driver instance is used on the same Flexio module, it is the responsibility of the application to ensure there are no conflicts between pins.
- The driver enables the interrupts for the corresponding FlexIO module, but any interrupt priority setting must be done by the application.
- Timeout feature for blocking transfers does not work in polling mode.
- This driver needs two shifters and two timers for its operation. Initialization will fail if there are not enough shifters and timers available on the FlexIO device.
- This driver needs two DMA channels for its operation when it is initialized in DMA mode. The DMA channels must be initialized by the application before initializing the driver. Refer to EDMA driver for DMA channels initialization.
- If the application uses an RTOS, this driver uses a semaphore for blocking transfers. Initialization will fail if the semaphore cannot be created. If the driver uses polling mode no semaphore is used.
- If the application uses an RTOS, the FlexIO drivers use a mutex for channel allocation. Only one mutex per device is needed, not per driver instance. Device initialization will fail if the mutex cannot be created.
- For transfers where the data size is more than 1 byte (bitsWidth is greater than 8) the driver assumes that the data buffers are defined with the proper type (uint16_t or uint32_t) and are properly aligned.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\flexio\flexio_common.c
${S32SDK_PATH}\platform\drivers\src\flexio\flexio_i2s_driver.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc
${S32SDK_PATH}\platform\drivers\src\flexio
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager OS Interface (OSIF) Interrupt Manager (Interrupt) Enhanced Direct Memory Access (eDMA)

Data Structures

- struct flexio_i2s_master_user_config_t

  Master configuration structure. More...
- struct flexio_i2s_slave_user_config_t

  Slave configuration structure. More...
- struct flexio_i2s_master_state_t

  Master internal context structure. More...

Typedefs

- typedef flexio_i2s_master_state_t flexio_i2s_slave_state_t

  Slave internal context structure.

FLEXIO_I2S Driver

- status_t FLEXIO_I2S_DRV_MasterInit (uint32_t instance, const flexio_i2s_master_user_config_t *user↩ ConfigPtr, flexio_i2s_master_state_t *master)

  Initialize the FLEXIO_I2S master mode driver.
- status_t FLEXIO_I2S_DRV_MasterDeinit (flexio_i2s_master_state_t *master)

  De-initialize the FLEXIO_I2S master mode driver.
- status_t FLEXIO_I2S_DRV_MasterSetConfig (flexio_i2s_master_state_t *master, uint32_t baudRate, uint8_t bitsWidth)

  Set the baud rate and bit width for any subsequent I2S communication.
- status_t FLEXIO_I2S_DRV_MasterGetBaudRate (flexio_i2s_master_state_t *master, uint32_t *baudRate)

  Get the currently configured baud rate.
- status_t FLEXIO_I2S_DRV_MasterSendData (flexio_i2s_master_state_t *master, const uint8_t *txBuff, uint32_t txSize)

  Perform a non-blocking send transaction on the I2S bus.
- status_t FLEXIO_I2S_DRV_MasterSendDataBlocking (flexio_i2s_master_state_t *master, const uint8_↩ t *txBuff, uint32_t txSize, uint32_t timeout)

  Perform a blocking send transaction on the I2S bus.
- status_t FLEXIO_I2S_DRV_MasterReceiveData (flexio_i2s_master_state_t *master, uint8_t *rxBuff, uint32_t rxSize)

  Perform a non-blocking receive transaction on the I2S bus.
- status_t FLEXIO_I2S_DRV_MasterReceiveDataBlocking (flexio_i2s_master_state_t *master, uint8_t *rx↩ Buff, uint32_t rxSize, uint32_t timeout)

  Perform a blocking receive transaction on the I2S bus.
- status_t FLEXIO_I2S_DRV_MasterTransferAbort (flexio_i2s_master_state_t *master)

  Aborts a non-blocking I2S master transaction.
- status_t FLEXIO_I2S_DRV_MasterGetStatus (flexio_i2s_master_state_t *master, uint32_t *bytes↩ Remaining)

  Get the status of the current non-blocking I2S master transaction.
- status_t FLEXIO_I2S_DRV_MasterSetRxBuffer (flexio_i2s_master_state_t *master, uint8_t *rxBuff, uint32↩ _t rxSize)

  Provide a buffer for receiving data.
- status_t FLEXIO_I2S_DRV_MasterSetTxBuffer (flexio_i2s_master_state_t *master, const uint8_t *txBuff, uint32_t txSize)

  Provide a buffer for transmitting data.
- status_t FLEXIO_I2S_DRV_SlaveInit (uint32_t instance, const flexio_i2s_slave_user_config_t *userConfig↩ Ptr, flexio_i2s_slave_state_t *slave)

  Initialize the FLEXIO_I2S slave mode driver.

- status_t FLEXIO_I2S_DRV_SlaveDeinit (flexio_i2s_slave_state_t *slave)

  De-initialize the FLEXIO_I2S slave mode driver.
- status_t FLEXIO_I2S_DRV_SlaveSetConfig (flexio_i2s_slave_state_t *slave, uint8_t bitsWidth)

  Set the bit width for any subsequent I2S communication.
- status_t FLEXIO_I2S_DRV_SlaveSendData (flexio_i2s_slave_state_t *slave, const uint8_t *txBuff, uint32_t txSize)

  Perform a non-blocking send transaction on the I2S bus.
- status_t FLEXIO_I2S_DRV_SlaveSendDataBlocking (flexio_i2s_slave_state_t *slave, const uint8_t *txBuff, uint32_t txSize, uint32_t timeout)

  Perform a blocking send transaction on the I2S bus.
- status_t FLEXIO_I2S_DRV_SlaveReceiveData (flexio_i2s_slave_state_t *slave, uint8_t *rxBuff, uint32_t rxSize)

  Perform a non-blocking receive transaction on the I2S bus.
- status_t FLEXIO_I2S_DRV_SlaveReceiveDataBlocking (flexio_i2s_slave_state_t *slave, uint8_t *rxBuff, uint32_t rxSize, uint32_t timeout)

  Perform a blocking receive transaction on the I2S bus.
- status_t FLEXIO_I2S_DRV_SlaveTransferAbort (flexio_i2s_slave_state_t *slave)

  Aborts a non-blocking I2S slave transaction.
- status_t FLEXIO_I2S_DRV_SlaveGetStatus (flexio_i2s_slave_state_t *slave, uint32_t *bytesRemaining)

  Get the status of the current non-blocking I2S slave transaction.
- status_t FLEXIO_I2S_DRV_SlaveSetRxBuffer (flexio_i2s_slave_state_t *slave, uint8_t *rxBuff, uint32_t rxSize)

  Provide a buffer for receiving data.
- status_t FLEXIO_I2S_DRV_SlaveSetTxBuffer (flexio_i2s_slave_state_t *slave, const uint8_t *txBuff, uint32_t txSize)

  Provide a buffer for transmitting data.
- void FLEXIO_I2S_DRV_MasterGetDefaultConfig (flexio_i2s_master_user_config_t *userConfigPtr)

  Returns default configuration structure for FLEXIO_I2S master.
- void FLEXIO_I2S_DRV_SlaveGetDefaultConfig (flexio_i2s_slave_user_config_t *userConfigPtr)

  Returns default configuration structure for FLEXIO_I2S slave.

16.34.2 Data Structure Documentation

16.34.2.1 struct flexio_i2s_master_user_config_t

Master configuration structure.

This structure is used to provide configuration parameters for the flexio_i2s master at initialization time. Implements : flexio_i2s_master_user_config_t_Class

Definition at line 67 of file flexio_i2s_driver.h.

Data Fields

- flexio_driver_type_t driverType
- uint32_t baudRate
- uint8_t bitsWidth
- uint8_t txPin
- uint8_t rxPin
- uint8_t sckPin
- uint8_t wsPin
- i2s_callback_t callback
- void * callbackParam
- uint8_t rxDMAChannel
- uint8_t txDMAChannel

Field Documentation

16.34.2.1.1 uint32_t baudRate

Baud rate in hertz

Definition at line 70 of file flexio_i2s_driver.h.

16.34.2.1.2 uint8_t bitsWidth

Number of bits in a word - multiple of 8

Definition at line 71 of file flexio_i2s_driver.h.

16.34.2.1.3 i2s_callback_t callback

User callback function. Note that this function will be called from the interrupt service routine, so its execution time should be as small as possible. It can be NULL if it is not needed

Definition at line 76 of file flexio_i2s_driver.h.

16.34.2.1.4 void* callbackParam

Parameter for the callback function

Definition at line 80 of file flexio_i2s_driver.h.

16.34.2.1.5 flexio_driver_type_t driverType

Driver type: interrupts/polling/DMA

Definition at line 69 of file flexio_i2s_driver.h.

16.34.2.1.6 uint8_t rxDMAChannel

Rx DMA channel number. Only used in DMA mode

Definition at line 81 of file flexio_i2s_driver.h.

16.34.2.1.7 uint8_t rxPin

Flexio pin to use for receive

Definition at line 73 of file flexio_i2s_driver.h.

16.34.2.1.8 uint8_t sckPin

Flexio pin to use for serial clock

Definition at line 74 of file flexio_i2s_driver.h.

16.34.2.1.9 uint8_t txDMAChannel

Tx DMA channel number. Only used in DMA mode

Definition at line 82 of file flexio_i2s_driver.h.

16.34.2.1.10 uint8_t txPin

Flexio pin to use for transmit

Definition at line 72 of file flexio_i2s_driver.h.

16.34.2.1.11 uint8_t wsPin

Flexio pin to use for word select

Definition at line 75 of file flexio_i2s_driver.h.

16.34.2.2 struct flexio_i2s_slave_user_config_t

Slave configuration structure.

This structure is used to provide configuration parameters for the flexio_i2s slave at initialization time. Implements : flexio_i2s_slave_user_config_t_Class

Definition at line 92 of file flexio_i2s_driver.h.

Data Fields

- flexio_driver_type_t driverType
- uint8_t bitsWidth
- uint8_t txPin
- uint8_t rxPin
- uint8_t sckPin
- uint8_t wsPin
- i2s_callback_t callback
- void * callbackParam
- uint8_t rxDMAChannel
- uint8_t txDMAChannel

Field Documentation

16.34.2.2.1 uint8_t bitsWidth

Number of bits in a word - multiple of 8

Definition at line 95 of file flexio_i2s_driver.h.

16.34.2.2.2 i2s_callback_t callback

User callback function. Note that this function will be called from the interrupt service routine, so its execution time should be as small as possible. It can be NULL if it is not needed

Definition at line 100 of file flexio_i2s_driver.h.

16.34.2.2.3 void* callbackParam

Parameter for the callback function

Definition at line 104 of file flexio_i2s_driver.h.

16.34.2.2.4 flexio_driver_type_t driverType

Driver type: interrupts/polling/DMA

Definition at line 94 of file flexio_i2s_driver.h.

16.34.2.2.5 uint8_t rxDMAChannel

Rx DMA channel number. Only used in DMA mode

Definition at line 105 of file flexio_i2s_driver.h.

16.34.2.2.6 uint8_t rxPin

Flexio pin to use for receive

Definition at line 97 of file flexio_i2s_driver.h.

16.34.2.2.7 uint8_t sckPin

Flexio pin to use for serial clock

Definition at line 98 of file flexio_i2s_driver.h.

16.34.2.2.8 uint8_t txDMAChannel

Tx DMA channel number. Only used in DMA mode

Definition at line 106 of file flexio_i2s_driver.h.

16.34.2.2.9 uint8_t txPin

Flexio pin to use for transmit

Definition at line 96 of file flexio_i2s_driver.h.

16.34.2.2.10 uint8_t wsPin

Flexio pin to use for word select

Definition at line 99 of file flexio_i2s_driver.h.

16.34.2.3 struct flexio_i2s_master_state_t

Master internal context structure.

This structure is used by the driver for its internal logic. It must be provided by the application through the FLEXIO_I2S_DRV_MasterInit() function, then it cannot be freed until the driver is de-initialized using FLEXIO_I2S_DRV_MasterDeinit(). The application should make no assumptions about the content of this structure.

Definition at line 118 of file flexio_i2s_driver.h.

16.34.3 Typedef Documentation

16.34.3.1 typedef flexio_i2s_master_state_t flexio_i2s_slave_state_t

Slave internal context structure.

This structure is used by the driver for its internal logic. It must be provided by the application through the FLEXIO_I2S_DRV_SlaveInit() function, then it cannot be freed until the driver is de-initialized using FLEXIO_I2S_DRV_SlaveDeinit(). The application should make no assumptions about the content of this structure.

Definition at line 150 of file flexio_i2s_driver.h.

16.34.4 Function Documentation

16.34.4.1 status_t FLEXIO_I2S_DRV_MasterDeinit (flexio_i2s_master_state_t * *master*)

De-initialize the FLEXIO_I2S master mode driver.

This function de-initializes the FLEXIO_I2S driver in master mode. The driver can't be used again until reinitialized. The context structure is no longer needed by the driver and can be freed after calling this function.

Parameters

master	Pointer to the FLEXIO_I2S master driver context structure.

Returns

Error or success status returned by API

Definition at line 1082 of file flexio_i2s_driver.c.

16.34.4.2 status_t FLEXIO_I2S_DRV_MasterGetBaudRate (flexio_i2s_master_state_t * *master,* uint32_t * *baudRate*)

Get the currently configured baud rate.

This function returns the currently configured I2S baud rate.

Parameters

master	Pointer to the FLEXIO_I2S master driver context structure.
baudRate	the current baud rate in hertz

Returns

Error or success status returned by API

Definition at line 1161 of file flexio_i2s_driver.c.

16.34.4.3 void FLEXIO_I2S_DRV_MasterGetDefaultConfig (flexio_i2s_master_user_config_t * *userConfigPtr*)

Returns default configuration structure for FLEXIO_I2S master.

Parameters

userConfigPtr	Pointer to the FLEXIO_I2S user configuration structure.

Definition at line 1655 of file flexio_i2s_driver.c.

16.34.4.4 status_t FLEXIO_I2S_DRV_MasterGetStatus (flexio_i2s_master_state_t * *master,* uint32_t * *bytesRemaining*)

Get the status of the current non-blocking I2S master transaction.

This function returns the current status of a non-blocking I2S master transaction. A return code of STATUS_BUSY means the transfer is still in progress. Otherwise the function returns a status reflecting the outcome of the last transfer. When the driver is initialized in polling mode this function also advances the transfer by checking and handling the transmit and receive events, so it must be called frequently to avoid overflows or underflows.

Parameters

master	Pointer to the FLEXIO_I2S master driver context structure.
bytesRemaining	the remaining number of bytes to be transferred

Returns

Error or success status returned by API

Definition at line 1429 of file flexio_i2s_driver.c.

16.34.4.5 status_t FLEXIO_I2S_DRV_MasterInit (uint32_t *instance,* const flexio_i2s_master_user_config_t * *userConfigPtr,* flexio_i2s_master_state_t * *master*)

Initialize the FLEXIO_I2S master mode driver.

This function initializes the FLEXIO_I2S driver in master mode.

Parameters

instance	FLEXIO peripheral instance number
userConfigPtr	Pointer to the FLEXIO_I2S master user configuration structure. The function reads configuration data from this structure and initializes the driver accordingly. The application may free this structure after the function returns.

master	Pointer to the FLEXIO_I2S master driver context structure. The driver uses this memory area for its internal logic. The application must make no assumptions about the content of this structure, and must not free this memory until the driver is de-initialized using FLEXIO_I2S↩ _DRV_MasterDeinit().

Returns

Error or success status returned by API

Definition at line 991 of file flexio_i2s_driver.c.

16.34.4.6 status_t FLEXIO_I2S_DRV_MasterReceiveData (flexio_i2s_master_state_t * *master*, uint8_t * *rxBuff*, uint32_t *rxSize*)

Perform a non-blocking receive transaction on the I2S bus.

This function starts the reception of a block of data and returns immediately. The rest of the reception is handled by the interrupt service routine (if the driver is initialized in interrupt mode) or by the FLEXIO_I2S_DRV_MasterGet↩ Status function (if the driver is initialized in polling mode). Use FLEXIO_I2S_DRV_MasterGetStatus() to check the progress of the reception.

Parameters

master	Pointer to the FLEXIO_I2S master driver context structure.
rxBuff	pointer to the buffer where to store received data
rxSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API

Definition at line 1302 of file flexio_i2s_driver.c.

16.34.4.7 status_t FLEXIO_I2S_DRV_MasterReceiveDataBlocking (flexio_i2s_master_state_t * *master*, uint8_t * *rxBuff*, uint32_t *rxSize*, uint32_t *timeout*)

Perform a blocking receive transaction on the I2S bus.

This function receives a block of data and only returns when the reception is complete.

Parameters

master	Pointer to the FLEXIO_I2S master driver context structure.
rxBuff	pointer to the buffer where to store received data
rxSize	length in bytes of the data to be transferred
timeout	timeout for the transfer in milliseconds

Returns

Error or success status returned by API

Definition at line 1372 of file flexio_i2s_driver.c.

16.34.4.8 status_t FLEXIO_I2S_DRV_MasterSendData (flexio_i2s_master_state_t * *master*, const uint8_t * *txBuff*, uint32_t *txSize*)

Perform a non-blocking send transaction on the I2S bus.

This function starts the transmission of a block of data and returns immediately. The rest of the transmission is handled by the interrupt service routine (if the driver is initialized in interrupt mode) or by the FLEXIO_I2S_DRV_↩ MasterGetStatus function (if the driver is initialized in polling mode). Use FLEXIO_I2S_DRV_MasterGetStatus() to check the progress of the transmission.

Parameters

master	Pointer to the FLEXIO_I2S master driver context structure.
txBuff	pointer to the data to be transferred
txSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API

Definition at line 1201 of file flexio_i2s_driver.c.

16.34.4.9 status_t FLEXIO_I2S_DRV_MasterSendDataBlocking (flexio_i2s_master_state_t * *master*, const uint8_t * *txBuff*, uint32_t *txSize*, uint32_t *timeout*)

Perform a blocking send transaction on the I2S bus.

This function sends a block of data, and only returns when the transmission is complete.

Parameters

master	Pointer to the FLEXIO_I2S master driver context structure.
txBuff	pointer to the data to be transferred
txSize	length in bytes of the data to be transferred
timeout	timeout for the transfer in milliseconds

Returns

Error or success status returned by API

Definition at line 1269 of file flexio_i2s_driver.c.

16.34.4.10 status_t FLEXIO_I2S_DRV_MasterSetConfig (flexio_i2s_master_state_t * *master*, uint32_t *baudRate*, uint8_t *bitsWidth*)

Set the baud rate and bit width for any subsequent I2S communication.

This function sets the baud rate (SCK frequency) and bit width for the I2S master. Note that due to module limitation not any baud rate can be achieved. The driver will set a baud rate as close as possible to the requested baud rate, but there may still be substantial differences, for example if requesting a high baud rate while using a low-frequency FlexIO clock. The application should call FLEXIO_I2S_DRV_MasterGetBaudRate() after FLEXIO_I2S_DRV_↩ MasterSetConfig() to check what baud rate was actually set.

Parameters

master	Pointer to the FLEXIO_I2S master driver context structure.
baudRate	the desired baud rate in hertz
bitsWidth	number of bits per word

Returns

Error or success status returned by API

Definition at line 1108 of file flexio_i2s_driver.c.

16.34.4.11 status_t FLEXIO_I2S_DRV_MasterSetRxBuffer (flexio_i2s_master_state_t * *master*, uint8_t * *rxBuff*, uint32_t *rxSize*)

Provide a buffer for receiving data.

This function can be used to provide a new buffer for receiving data to the driver. It can be called from the user callback when event STATUS_I2S_RX_OVERRUN is reported. This way the reception will continue without interruption.

Parameters

master	Pointer to the FLEXIO_I2S master driver context structure.
rxBuff	pointer to the buffer where to store received data
rxSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API

Definition at line 1484 of file flexio_i2s_driver.c.

16.34.4.12 status_t FLEXIO_I2S_DRV_MasterSetTxBuffer (flexio_i2s_master_state_t * *master*, const uint8_t * *txBuff*, uint32_t *txSize*)

Provide a buffer for transmitting data.

This function can be used to provide a new buffer for transmitting data to the driver. It can be called from the user callback when event STATUS_I2S_TX_UNDERRUN is reported. This way the transmission will continue without interruption.

Parameters

master	Pointer to the FLEXIO_I2S master driver context structure.
txBuff	pointer to the buffer containing transmit data
txSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API

Definition at line 1506 of file flexio_i2s_driver.c.

16.34.4.13 status_t FLEXIO_I2S_DRV_MasterTransferAbort (flexio_i2s_master_state_t * *master*)

Aborts a non-blocking I2S master transaction.

This function aborts a non-blocking I2S transfer.

Parameters

master	Pointer to the FLEXIO_I2S master driver context structure.

Returns

Error or success status returned by API

Definition at line 1405 of file flexio_i2s_driver.c.

16.34.4.14 status_t FLEXIO_I2S_DRV_SlaveDeinit (flexio_i2s_slave_state_t * *slave*)

De-initialize the FLEXIO_I2S slave mode driver.

This function de-initializes the FLEXIO_I2S driver in slave mode. The driver can't be used again until reinitialized. The context structure is no longer needed by the driver and can be freed after calling this function.

Parameters

slave	Pointer to the FLEXIO_I2S slave driver context structure.

Returns

Error or success status returned by API

This function de-initializes the FLEXIO_I2S driver in slave mode. The driver can't be used again until reinitialized. The context structure is no longer needed by the driver and can be freed after calling this function.

Parameters

slave	Pointer to the FLEXIO_I2S slave driver context structure.

Returns

Error or success status returned by API Implements : FLEXIO_I2S_DRV_SlaveDeinit_Activity

Definition at line 1708 of file flexio_i2s_driver.c.

16.34.4.15 void FLEXIO_I2S_DRV_SlaveGetDefaultConfig (flexio_i2s_slave_user_config_t * *userConfigPtr*)

Returns default configuration structure for FLEXIO_I2S slave.

Parameters

userConfigPtr	Pointer to the FLEXIO_I2S user configuration structure.

Definition at line 1680 of file flexio_i2s_driver.c.

16.34.4.16 status_t FLEXIO_I2S_DRV_SlaveGetStatus (flexio_i2s_slave_state_t * *slave,* uint32_t * *bytesRemaining*)

Get the status of the current non-blocking I2S slave transaction.

This function returns the current status of a non-blocking I2S slave transaction. A return code of STATUS_BUSY means the transfer is still in progress. Otherwise the function returns a status reflecting the outcome of the last transfer. When the driver is initialized in polling mode this function also advances the transfer by checking and handling the transmit and receive events, so it must be called frequently to avoid overflows or underflows.

Parameters

slave	Pointer to the FLEXIO_I2S slave driver context structure.
bytesRemaining	the remaining number of bytes to be transferred

Returns

Error or success status returned by API

This function returns the current status of a non-blocking I2S slave transaction. A return code of STATUS_BUSY means the transfer is still in progress. Otherwise the function returns a status reflecting the outcome of the last transfer. When the driver is initialized in polling mode this function also advances the transfer by checking and handling the transmit and receive events, so it must be called frequently to avoid overflows or underflows.

Parameters

slave	Pointer to the FLEXIO_I2S slave driver context structure.
bytesRemaining	the remaining number of bytes to be transferred

Returns

Error or success status returned by API Implements : FLEXIO_I2S_DRV_SlaveGetStatus_Activity

Definition at line 1834 of file flexio_i2s_driver.c.

16.34.4.17 status_t FLEXIO_I2S_DRV_SlaveInit (uint32_t *instance,* const flexio_i2s_slave_user_config_t * *userConfigPtr,* flexio_i2s_slave_state_t * *slave*)

Initialize the FLEXIO_I2S slave mode driver.

This function initializes the FLEXIO_I2S driver in slave mode.

Parameters

instance	FLEXIO peripheral instance number
userConfigPtr	Pointer to the FLEXIO_I2S slave user configuration structure. The function reads configuration data from this structure and initializes the driver accordingly. The application may free this structure after the function returns.
slave	Pointer to the FLEXIO_I2S slave driver context structure. The driver uses this memory area for its internal logic. The application must make no assumptions about the content of this structure, and must not free this memory until the driver is de-initialized using FLEXIO_I2S↩ _DRV_SlaveDeinit().

Returns

Error or success status returned by API

Definition at line 1530 of file flexio_i2s_driver.c.

16.34.4.18 status_t FLEXIO_I2S_DRV_SlaveReceiveData (flexio_i2s_slave_state_t * *slave*, uint8_t * *rxBuff*, uint32_t *rxSize*)

Perform a non-blocking receive transaction on the I2S bus.

This function starts the reception of a block of data and returns immediately. The rest of the reception is handled by the interrupt service routine (if the driver is initialized in interrupt mode) or by the FLEXIO_I2S_DRV_SlaveGet↩ Status function (if the driver is initialized in polling mode). Use FLEXIO_I2S_DRV_SlaveGetStatus() to check the progress of the reception.

Parameters

slave	Pointer to the FLEXIO_I2S slave driver context structure.
rxBuff	pointer to the buffer where to store received data
rxSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API

This function starts the reception of a block of data and returns immediately. The rest of the reception is handled by the interrupt service routine (if the driver is initialized in interrupt mode) or by the FLEXIO_I2S_DRV_SlaveGet↩ Status function (if the driver is initialized in polling mode). Use FLEXIO_I2S_DRV_SlaveGetStatus() to check the progress of the reception.

Parameters

slave	Pointer to the FLEXIO_I2S slave driver context structure.
rxBuff	pointer to the buffer where to store received data
rxSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API Implements : FLEXIO_I2S_DRV_SlaveReceiveData_Activity

Definition at line 1775 of file flexio_i2s_driver.c.

16.34.4.19 status_t FLEXIO_I2S_DRV_SlaveReceiveDataBlocking (flexio_i2s_slave_state_t * *slave*, uint8_t * *rxBuff*, uint32_t *rxSize*, uint32_t *timeout*)

Perform a blocking receive transaction on the I2S bus.

This function receives a block of data and only returns when the reception is complete.

Parameters

slave	Pointer to the FLEXIO_I2S slave driver context structure.
rxBuff	pointer to the buffer where to store received data
rxSize	length in bytes of the data to be transferred
timeout	timeout for the transfer in milliseconds

Returns

Error or success status returned by API

This function receives a block of data and only returns when the reception is complete.

Parameters

slave	Pointer to the FLEXIO_I2S slave driver context structure.
rxBuff	pointer to the buffer where to store received data
rxSize	length in bytes of the data to be transferred
timeout	timeout for the transfer in milliseconds

Returns

Error or success status returned by API Implements : FLEXIO_I2S_DRV_SlaveReceiveDataBlocking_Activity

Definition at line 1795 of file flexio_i2s_driver.c.

16.34.4.20 status_t FLEXIO_I2S_DRV_SlaveSendData (flexio_i2s_slave_state_t * *slave*, const uint8_t * *txBuff*, uint32_t *txSize*)

Perform a non-blocking send transaction on the I2S bus.

This function starts the transmission of a block of data and returns immediately. The rest of the transmission is handled by the interrupt service routine (if the driver is initialized in interrupt mode) or by the FLEXIO_I2S_DRV↩ _SlaveGetStatus function (if the driver is initialized in polling mode). Use FLEXIO_I2S_DRV_SlaveGetStatus() to check the progress of the transmission.

Parameters

slave	Pointer to the FLEXIO_I2S slave driver context structure.
txBuff	pointer to the data to be transferred
txSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API

This function starts the transmission of a block of data and returns immediately. The rest of the transmission is handled by the interrupt service routine (if the driver is initialized in interrupt mode) or by the FLEXIO_I2S_DRV↩ _SlaveGetStatus function (if the driver is initialized in polling mode). Use FLEXIO_I2S_DRV_SlaveGetStatus() to check the progress of the transmission.

Parameters

slave	Pointer to the FLEXIO_I2S slave driver context structure.
txBuff	pointer to the data to be transferred
txSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API Implements : FLEXIO_I2S_DRV_SlaveSendData_Activity

Definition at line 1729 of file flexio_i2s_driver.c.

16.34.4.21 status_t FLEXIO_I2S_DRV_SlaveSendDataBlocking (flexio_i2s_slave_state_t * *slave*, const uint8_t * *txBuff*, uint32_t *txSize*, uint32_t *timeout*)

Perform a blocking send transaction on the I2S bus.

This function sends a block of data, and only returns when the transmission is complete.

Parameters

slave	Pointer to the FLEXIO_I2S slave driver context structure.
txBuff	pointer to the data to be transferred
txSize	length in bytes of the data to be transferred
timeout	timeout for the transfer in milliseconds

Returns

Error or success status returned by API

This function sends a block of data, and only returns when the transmission is complete.

Parameters

slave	Pointer to the FLEXIO_I2S slave driver context structure.
txBuff	pointer to the data to be transferred
txSize	length in bytes of the data to be transferred
timeout	timeout for the transfer in milliseconds

Returns

Error or success status returned by API Implements : FLEXIO_I2S_DRV_SlaveSendDataBlocking_Activity

Definition at line 1751 of file flexio_i2s_driver.c.

16.34.4.22 status_t FLEXIO_I2S_DRV_SlaveSetConfig (flexio_i2s_slave_state_t * *slave*, uint8_t *bitsWidth*)

Set the bit width for any subsequent I2S communication.

This function sets the bit width for the I2S slave.

Parameters

slave	Pointer to the FLEXIO_I2S slave driver context structure.
bitsWidth	number of bits per word

Returns

Error or success status returned by API

Definition at line 1612 of file flexio_i2s_driver.c.

16.34.4.23 status_t FLEXIO_I2S_DRV_SlaveSetRxBuffer (flexio_i2s_slave_state_t * *slave*, uint8_t * *rxBuff*, uint32_t *rxSize*)

Provide a buffer for receiving data.

This function can be used to provide a driver with a new buffer for receiving data. It can be called from the user callback when event STATUS_I2S_RX_OVERRUN is reported. This way the reception will continue without interruption.

Parameters

slave	Pointer to the FLEXIO_I2S slave driver context structure.
rxBuff	pointer to the buffer where to store received data
rxSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API

This function can be used to provide a driver with a new buffer for receiving data. It can be called from the user callback when event STATUS_I2S_RX_OVERRUN is reported. This way the reception will continue without interruption.

Parameters

slave	Pointer to the FLEXIO_I2S slave driver context structure.
rxBuff	pointer to the buffer where to store received data
rxSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API Implements : FLEXIO_I2S_DRV_SlaveSetRxBuffer_Activity

Definition at line 1853 of file flexio_i2s_driver.c.

16.34.4.24 status_t FLEXIO_I2S_DRV_SlaveSetTxBuffer (flexio_i2s_slave_state_t * *slave*, const uint8_t * *txBuff*, uint32_t *txSize*)

Provide a buffer for transmitting data.

This function can be used to provide a driver with a new buffer for transmitting data. It can be called from the user callback when event STATUS_I2S_TX_UNDERRUN is reported. This way the transmission will continue without interruption.

Parameters

slave	Pointer to the FLEXIO_I2S slave driver context structure.
txBuff	pointer to the buffer containing transmit data
txSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API

This function can be used to provide a driver with a new buffer for transmitting data. It can be called from the user callback when event STATUS_I2S_TX_UNDERRUN is reported. This way the transmission will continue without interruption.

Parameters

slave	Pointer to the FLEXIO_I2S slave driver context structure.
txBuff	pointer to the buffer containing transmit data
txSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API Implements : FLEXIO_I2S_DRV_SlaveSetTxBuffer_Activity

Definition at line 1874 of file flexio_i2s_driver.c.

16.34.4.25 status_t FLEXIO_I2S_DRV_SlaveTransferAbort (flexio_i2s_slave_state_t * *slave*)

Aborts a non-blocking I2S slave transaction.

This function aborts a non-blocking I2S transfer.

Parameters

slave	Pointer to the FLEXIO_I2S slave driver context structure.

Returns

Error or success status returned by API

This function aborts a non-blocking I2S transfer.

Parameters

slave	Pointer to the FLEXIO_I2S slave driver context structure.

Returns

Error or success status returned by API Implements : FLEXIO_I2S_DRV_SlaveTransferAbort_Activity

Definition at line 1813 of file flexio_i2s_driver.c.

16.35 FlexIO SPI Driver

16.35.1 Detailed Description

SPI communication over FlexIO module (FLEXIO_SPI)

The FLEXIO_SPI Driver allows communication on an SPI bus using the FlexIO module in the S32K1xx processors.

Features

- Master or slave operation
- Interrupt, DMA or polling mode
- Provides blocking and non-blocking transfer functions
- Configurable baud rate
- Configurable clock polarity and phase
- Configurable bit order and data size

Functionality

Before using any Flexio driver the device must first be initialized using function FLEXIO_DRV_InitDevice. Then the FLEXIO_SPI Driver must be initialized, using functions FLEXIO_SPI_DRV_MasterInit() or FLEXIO_SPI_DRV_SlaveInit(). It is possible to use more driver instances on the same FlexIO device, as long as sufficient resources are available. Different driver instances on the same FlexIO device can function independently of each other. When it is no longer needed, the driver can be de-initialized, using FLEXIO_SPI_DRV_MasterDeinit() or FLEXIO_SPI_DRV_SlaveDeinit(). This will release the hardware resources, allowing other driver instances to be initialized other.

Master Mode

Master Mode provides functions for transmitting or receiving data to/from an SPI slave. Baud rate is provided at initialization time through the master configuration structure, but can be changed at runtime by using FLEXIO_SPI_DRV_MasterSetBaudRate() function. Note that due to module limitation not any baud rate can be achieved. The driver will set a baud rate as close as possible to the requested baud rate, but there may still be substantial differences, for example if requesting a high baud rate while using a low-frequency FlexIO clock. The application should call FLEXIO_SPI_DRV_MasterGetBaudRate() after FLEXIO_SPI_DRV_MasterSetBaudRate() to check what baud rate was actually set.

To send or receive data, use function FLEXIO_SPI_DRV_MasterTransfer(). The transmit and receive buffers, together with parameters for the transfer are provided through the flexio_spi_transfer_t structure. If only transmit or receive is desired, any one of the Rx/Tx buffers can be set to NULL. This driver does not support continuous send/receive using a user callback function. The callback function is only used to signal the end of a transfer.

Blocking operations will return only when the transfer is completed, either successfully or with error. Non-blocking operations will initiate the transfer and return STATUS_SUCCESS, but the module is still busy with the transfer and another transfer can't be initiated until the current transfer is complete. The application will be notified through the user callback when the transfer completes, or it can check the status of the current transfer by calling FLEXIO_SPI_DRV_MasterGetStatus(). If the transfer is still ongoing this function will return STATUS_BUSY. If the transfer is completed, the function will return either STATUS_SUCCESS or an error code, depending on the outcome of the last transfer.

The driver supports interrupt, DMA and polling mode. In polling mode the function FLEXIO_SPI_DRV_MasterGetStatus() ensures the progress of the transfer by checking and handling transmit and receive events reported by the FlexIO module. The application should ensure that this function is called often enough (at least once per transferred byte)to avoid Tx underflows or Rx overflows. In DMA mode the DMA channels that will be used by the driver are received through the configuration structure. The channels must be initialized by the application before the flexio_spi driver is initialized. The flexio_spi driver will only set the DMA request source.

Slave Mode

Slave Mode is very similar to master mode, the main difference being that the FLEXIO_SPI_DRV_SlaveInit() function initializes the FlexIO module to use the clock signal received from the master instead of generating it. Consequently, there is no `SetBaudRate` function in slave mode. Other than that, the slave mode offers a similar interface to the master mode. FLEXIO_SPI_DRV_MasterTransfer() can be used to initiate transfers, and FLEXIO_SPI_DRV_SlaveGetStatus() is used to check the status of the transfer and advance the transfer in polling mode. All other specifications from the Master Mode description apply for Slave Mode too

Important Notes

- Before using the FLEXIO_SPI Driver the protocol clock of the module must be configured. Refer to Clock Manager for clock configuration.
- Before using the FLEXIO_SPI Driver the pins must be routed to the FlexIO module. Refer to PINS Driver for pin routing configuration. Note that any of the available FlexIO pins can be used for MOSI, MISO, SCK and SS (configurable at initialization time).
- The driver enables the interrupts for the corresponding FlexIO module, but any interrupt priority setting must be done by the application.
- The driver does not support back-to-back transmission mode for CPHA = 1
- The driver does not support configurable polarity for SS signal (only active-low is supported)
- Timeout feature for blocking transfers does not work in polling mode.
- This driver needs two shifters and two timers for its operation. Initialization will fail if there are not enough shifters and timers available on the FlexIO device.
- This driver needs two DMA channels for its operation when it is initialized in DMA mode. The DMA channels must be initialized by the application before initializing the driver. Refer to EDMA driver for DMA channels initialization.
- If the application uses an RTOS, this driver uses a semaphore for blocking transfers. Initialization will fail if the semaphore cannot be created. If the driver uses polling mode no semaphore is used.
- If the application uses an RTOS, the FlexIO drivers use a mutex for channel allocation. Only one mutex per device is needed, not per driver instance. Device initialization will fail if the mutex cannot be created.
- For transfers where the data size is more than 1 byte (transferSize is 2 or 4) the driver assumes that the data buffers are defined with the proper type (uint16_t or uint32_t) and are properly aligned.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\flexio\flexio_common.c
${S32SDK_PATH}\platform\drivers\src\flexio\flexio_spi_driver.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc
${S32SDK_PATH}\platform\drivers\src\flexio
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager OS Interface (OSIF) Interrupt Manager (Interrupt) Enhanced Direct Memory Access (eDMA)

Data Structures

- struct flexio_spi_master_user_config_t

  Master configuration structure. More...
- struct flexio_spi_slave_user_config_t

  Slave configuration structure. More...
- struct flexio_spi_master_state_t

  Master internal context structure. More...

Typedefs

- typedef flexio_spi_master_state_t flexio_spi_slave_state_t

  Slave internal context structure.

Enumerations

- enum flexio_spi_transfer_bit_order_t { FLEXIO_SPI_TRANSFER_MSB_FIRST = 0U, FLEXIO_SPI_TRAN↩SFER_LSB_FIRST = 1U }

  Order in which the data bits are transferred Implements : flexio_spi_transfer_bit_order_t_Class.
- enum flexio_spi_transfer_size_t { FLEXIO_SPI_TRANSFER_1BYTE = 1U, FLEXIO_SPI_TRANSFER_2B↩YTE = 2U, FLEXIO_SPI_TRANSFER_4BYTE = 4U }

  Size of transferred data in bytes Implements : flexio_spi_transfer_size_t_Class.

FLEXIO_SPI Driver

- status_t FLEXIO_SPI_DRV_MasterInit (uint32_t instance, const flexio_spi_master_user_config_t ∗user↩ConfigPtr, flexio_spi_master_state_t ∗master)

  Initialize the FLEXIO_SPI master mode driver.
- status_t FLEXIO_SPI_DRV_MasterDeinit (flexio_spi_master_state_t ∗master)

  De-initialize the FLEXIO_SPI master mode driver.
- status_t FLEXIO_SPI_DRV_MasterSetBaudRate (flexio_spi_master_state_t ∗master, uint32_t baudRate)

  Set the baud rate for any subsequent SPI communication.
- status_t FLEXIO_SPI_DRV_MasterGetBaudRate (flexio_spi_master_state_t ∗master, uint32_t ∗baudRate)

  Get the currently configured baud rate.
- status_t FLEXIO_SPI_DRV_MasterTransfer (flexio_spi_master_state_t ∗master, const uint8_t ∗txData, uint8_t ∗rxData, uint32_t dataSize)

  Perform a non-blocking SPI master transaction.
- status_t FLEXIO_SPI_DRV_MasterTransferBlocking (flexio_spi_master_state_t ∗master, const uint8_t ∗tx↩Data, uint8_t ∗rxData, uint32_t dataSize, uint32_t timeout)

  Perform a blocking SPI master transaction.
- status_t FLEXIO_SPI_DRV_MasterTransferAbort (flexio_spi_master_state_t ∗master)

  Aborts a non-blocking SPI master transaction.
- status_t FLEXIO_SPI_DRV_MasterGetStatus (flexio_spi_master_state_t ∗master, uint32_t ∗bytes↩Remaining)

  Get the status of the current non-blocking SPI master transaction.
- status_t FLEXIO_SPI_DRV_SlaveInit (uint32_t instance, const flexio_spi_slave_user_config_t ∗userConfig↩Ptr, flexio_spi_slave_state_t ∗slave)

Initialize the FLEXIO_SPI slave mode driver.

- status_t FLEXIO_SPI_DRV_SlaveDeinit (flexio_spi_slave_state_t *slave)

  De-initialize the FLEXIO_SPI slave mode driver.
- status_t FLEXIO_SPI_DRV_SlaveTransfer (flexio_spi_slave_state_t *slave, const uint8_t *txData, uint8_t *rxData, uint32_t dataSize)

  Perform a non-blocking SPI slave transaction.
- status_t FLEXIO_SPI_DRV_SlaveTransferBlocking (flexio_spi_slave_state_t *slave, const uint8_t *txData, uint8_t *rxData, uint32_t dataSize, uint32_t timeout)

  Perform a blocking SPI slave transaction.
- status_t FLEXIO_SPI_DRV_SlaveTransferAbort (flexio_spi_slave_state_t *slave)

  Aborts a non-blocking SPI slave transaction.
- status_t FLEXIO_SPI_DRV_SlaveGetStatus (flexio_spi_slave_state_t *slave, uint32_t *bytesRemaining)

  Get the status of the current non-blocking SPI slave transaction.
- void FLEXIO_SPI_DRV_MasterGetDefaultConfig (flexio_spi_master_user_config_t *userConfigPtr)

  Returns default configuration structure for FLEXIO_SPI master.
- void FLEXIO_SPI_DRV_SlaveGetDefaultConfig (flexio_spi_slave_user_config_t *userConfigPtr)

  Returns default configuration structure for FLEXIO_SPI slave.

16.35.2 Data Structure Documentation

16.35.2.1 struct flexio_spi_master_user_config_t

Master configuration structure.

This structure is used to provide configuration parameters for the flexio_spi master at initialization time. Implements : flexio_spi_master_user_config_t_Class

Definition at line 67 of file flexio_spi_driver.h.

Data Fields

- uint32_t baudRate
- flexio_driver_type_t driverType
- flexio_spi_transfer_bit_order_t bitOrder
- flexio_spi_transfer_size_t transferSize
- uint8_t clockPolarity
- uint8_t clockPhase
- uint8_t mosiPin
- uint8_t misoPin
- uint8_t sckPin
- uint8_t ssPin
- spi_callback_t callback
- void * callbackParam
- uint8_t rxDMAChannel
- uint8_t txDMAChannel

Field Documentation

16.35.2.1.1 uint32_t baudRate

Baud rate in hertz

Definition at line 69 of file flexio_spi_driver.h.

16.35.2.1.2 flexio_spi_transfer_bit_order_t bitOrder

Bit order: LSB-first / MSB-first

Definition at line 71 of file flexio_spi_driver.h.

16.35.2.1.3 spi_callback_t callback

User callback function. Note that this function will be called from the interrupt service routine, so its execution time should be as small as possible. It can be NULL if it is not needed

Definition at line 79 of file flexio_spi_driver.h.

16.35.2.1.4 void* callbackParam

Parameter for the callback function

Definition at line 83 of file flexio_spi_driver.h.

16.35.2.1.5 uint8_t clockPhase

Clock Phase (CPHA) 0 = sample on leading clock edge; 1 = sample on trailing clock edge

Definition at line 74 of file flexio_spi_driver.h.

16.35.2.1.6 uint8_t clockPolarity

Clock Polarity (CPOL) 0 = active-high clock; 1 = active-low clock

Definition at line 73 of file flexio_spi_driver.h.

16.35.2.1.7 flexio_driver_type_t driverType

Driver type: interrupts/polling/DMA

Definition at line 70 of file flexio_spi_driver.h.

16.35.2.1.8 uint8_t misoPin

Flexio pin to use as MISO pin

Definition at line 76 of file flexio_spi_driver.h.

16.35.2.1.9 uint8_t mosiPin

Flexio pin to use as MOSI pin

Definition at line 75 of file flexio_spi_driver.h.

16.35.2.1.10 uint8_t rxDMAChannel

Rx DMA channel number. Only used in DMA mode

Definition at line 84 of file flexio_spi_driver.h.

16.35.2.1.11 uint8_t sckPin

Flexio pin to use as SCK pin

Definition at line 77 of file flexio_spi_driver.h.

16.35.2.1.12 uint8_t ssPin

Flexio pin to use as SS pin

Definition at line 78 of file flexio_spi_driver.h.

16.35.2.1.13 flexio_spi_transfer_size_t transferSize

Transfer size in bytes: 1/2/4

Definition at line 72 of file flexio_spi_driver.h.

16.35.2.1.14 uint8_t txDMAChannel

Tx DMA channel number. Only used in DMA mode

Definition at line 85 of file flexio_spi_driver.h.

16.35.2.2 struct flexio_spi_slave_user_config_t

Slave configuration structure.

This structure is used to provide configuration parameters for the flexio_spi slave at initialization time. Implements : flexio_spi_slave_user_config_t_Class

Definition at line 94 of file flexio_spi_driver.h.

Data Fields

- flexio_driver_type_t driverType
- flexio_spi_transfer_bit_order_t bitOrder
- flexio_spi_transfer_size_t transferSize
- uint8_t clockPolarity
- uint8_t clockPhase
- uint8_t mosiPin
- uint8_t misoPin
- uint8_t sckPin
- uint8_t ssPin
- spi_callback_t callback
- void * callbackParam
- uint8_t rxDMAChannel
- uint8_t txDMAChannel

Field Documentation

16.35.2.2.1 flexio_spi_transfer_bit_order_t bitOrder

Bit order: LSB-first / MSB-first

Definition at line 97 of file flexio_spi_driver.h.

16.35.2.2.2 spi_callback_t callback

User callback function. Note that this function will be called from the interrupt service routine, so its execution time should be as small as possible. It can be NULL if it is not needed

Definition at line 105 of file flexio_spi_driver.h.

16.35.2.2.3 void* callbackParam

Parameter for the callback function

Definition at line 109 of file flexio_spi_driver.h.

16.35.2.2.4 uint8_t clockPhase

Clock Phase (CPHA) 0 = sample on leading clock edge; 1 = sample on trailing clock edge

Definition at line 100 of file flexio_spi_driver.h.

16.35.2.2.5 uint8_t clockPolarity

Clock Polarity (CPOL) 0 = active-low clock; 1 = active-high clock

Definition at line 99 of file flexio_spi_driver.h.

16.35.2.2.6 flexio_driver_type_t driverType

Driver type: interrupts/polling/DMA

Definition at line 96 of file flexio_spi_driver.h.

16.35.2.2.7 uint8_t misoPin

Flexio pin to use as MISO pin

Definition at line 102 of file flexio_spi_driver.h.

16.35.2.2.8 uint8_t mosiPin

Flexio pin to use as MOSI pin

Definition at line 101 of file flexio_spi_driver.h.

16.35.2.2.9 uint8_t rxDMAChannel

Rx DMA channel number. Only used in DMA mode

Definition at line 110 of file flexio_spi_driver.h.

16.35.2.2.10 uint8_t sckPin

Flexio pin to use as SCK pin

Definition at line 103 of file flexio_spi_driver.h.

16.35.2.2.11 uint8_t ssPin

Flexio pin to use as SS pin

Definition at line 104 of file flexio_spi_driver.h.

16.35.2.2.12 flexio_spi_transfer_size_t transferSize

Transfer size in bytes: 1/2/4

Definition at line 98 of file flexio_spi_driver.h.

16.35.2.2.13 uint8_t txDMAChannel

Tx DMA channel number. Only used in DMA mode

Definition at line 111 of file flexio_spi_driver.h.

16.35.2.3 struct flexio_spi_master_state_t

Master internal context structure.

This structure is used by the master-mode driver for its internal logic. It must be provided by the application through the FLEXIO_SPI_DRV_MasterInit() function, then it cannot be freed until the driver is de-initialized using FLEXIO_SPI_DRV_MasterDeinit(). The application should make no assumptions about the content of this structure.

Definition at line 123 of file flexio_spi_driver.h.

16.35.3 Typedef Documentation

16.35.3.1 typedef flexio_spi_master_state_t flexio_spi_slave_state_t

Slave internal context structure.

This structure is used by the slave-mode driver for its internal logic. It must be provided by the application through the FLEXIO_SPI_DRV_SlaveInit() function, then it cannot be freed until the driver is de-initialized using FLEXIO

_SPI_DRV_SlaveDeinit(). The application should make no assumptions about the content of this structure.

Definition at line 155 of file flexio_spi_driver.h.

16.35.4 Enumeration Type Documentation

16.35.4.1 enum flexio_spi_transfer_bit_order_t

Order in which the data bits are transferred Implements : flexio_spi_transfer_bit_order_t_Class.

Enumerator

FLEXIO_SPI_TRANSFER_MSB_FIRST Transmit data starting with most significant bit

FLEXIO_SPI_TRANSFER_LSB_FIRST Transmit data starting with least significant bit

Definition at line 39 of file flexio_spi_driver.h.

16.35.4.2 enum flexio_spi_transfer_size_t

Size of transferred data in bytes Implements : flexio_spi_transfer_size_t_Class.

Enumerator

FLEXIO_SPI_TRANSFER_1BYTE Data size is 1-byte

FLEXIO_SPI_TRANSFER_2BYTE Data size is 2-bytes

FLEXIO_SPI_TRANSFER_4BYTE Data size is 4-bytes

Definition at line 48 of file flexio_spi_driver.h.

16.35.5 Function Documentation

16.35.5.1 status_t FLEXIO_SPI_DRV_MasterDeinit (flexio_spi_master_state_t * *master*)

De-initialize the FLEXIO_SPI master mode driver.

This function de-initializes the FLEXIO_SPI driver in master mode. The driver can't be used again until reinitialized. The context structure is no longer needed by the driver and can be freed after calling this function.

Parameters

master	Pointer to the FLEXIO_SPI master driver context structure.

Returns

Error or success status returned by API

Definition at line 982 of file flexio_spi_driver.c.

16.35.5.2 status_t FLEXIO_SPI_DRV_MasterGetBaudRate (flexio_spi_master_state_t * *master,* uint32_t * *baudRate*)

Get the currently configured baud rate.

This function returns the currently configured SPI baud rate.

Parameters

master	Pointer to the FLEXIO_SPI master driver context structure.
baudRate	the current baud rate in hertz

Returns

Error or success status returned by API

Definition at line 1054 of file flexio_spi_driver.c.

16.35.5.3 void FLEXIO_SPI_DRV_MasterGetDefaultConfig (flexio_spi_master_user_config_t * *userConfigPtr*)

Returns default configuration structure for FLEXIO_SPI master.

Parameters

userConfigPtr	Pointer to the FLEXIO_SPI user configuration structure.

Definition at line 1352 of file flexio_spi_driver.c.

16.35.5.4 status_t FLEXIO_SPI_DRV_MasterGetStatus (flexio_spi_master_state_t * *master,* uint32_t * *bytesRemaining*)

Get the status of the current non-blocking SPI master transaction.

This function returns the current status of a non-blocking SPI master transaction. A return code of STATUS_BUSY means the transfer is still in progress. Otherwise the function returns a status reflecting the outcome of the last transfer. When the driver is initialized in polling mode this function also advances the transfer by checking and handling the transmit and receive events, so it must be called frequently to avoid overflows or underflows.

Parameters

master	Pointer to the FLEXIO_SPI master driver context structure.
bytesRemaining	the remaining number of bytes to be transferred

Returns

Error or success status returned by API

Definition at line 1225 of file flexio_spi_driver.c.

16.35.5.5 status_t FLEXIO_SPI_DRV_MasterInit (uint32_t *instance,* const flexio_spi_master_user_config_t * *userConfigPtr,* flexio_spi_master_state_t * *master*)

Initialize the FLEXIO_SPI master mode driver.

This function initializes the FLEXIO_SPI driver in master mode.

Parameters

instance	FLEXIO peripheral instance number
userConfigPtr	Pointer to the FLEXIO_SPI master user configuration structure. The function reads configuration data from this structure and initializes the driver accordingly. The application may free this structure after the function returns.
master	Pointer to the FLEXIO_SPI master driver context structure. The driver uses this memory area for its internal logic. The application must make no assumptions about the content of this structure, and must not free this memory until the driver is de-initialized using FLEXIO_SPI_DRV_MasterDeinit().

Returns

Error or success status returned by API

Definition at line 893 of file flexio_spi_driver.c.

16.35.5.6 status_t FLEXIO_SPI_DRV_MasterSetBaudRate (flexio_spi_master_state_t * *master*, uint32_t *baudRate*)

Set the baud rate for any subsequent SPI communication.

This function sets the baud rate for the SPI master. Note that due to module limitation not any baud rate can be achieved. The driver will set a baud rate as close as possible to the requested baud rate, but there may still be substantial differences, for example if requesting a high baud rate while using a low-frequency FlexIO clock. The application should call FLEXIO_SPI_DRV_MasterGetBaudRate() after FLEXIO_SPI_DRV_MasterSetBaudRate() to check what baud rate was actually set.

Parameters

master	Pointer to the FLEXIO_SPI master driver context structure.
baudRate	the desired baud rate in hertz

Returns

Error or success status returned by API

Definition at line 1009 of file flexio_spi_driver.c.

16.35.5.7 status_t FLEXIO_SPI_DRV_MasterTransfer (flexio_spi_master_state_t * *master*, const uint8_t * *txData*, uint8_t * *rxData*, uint32_t *dataSize*)

Perform a non-blocking SPI master transaction.

This function performs an SPI full-duplex transaction, transmit and receive in parallel. If only transmit or receive are required, it is possible to provide NULL pointers for txData or rxData. The transfer is non-blocking, the function only initiates the transfer and then returns, leaving the transfer to complete asynchronously). FLEXIO_SPI_DRV↩_MasterGetStatus() can be called to check the status of the transfer.

Parameters

master	Pointer to the FLEXIO_SPI master driver context structure.
txData	pointer to the data to be transmitted
rxData	pointer to the buffer where to store received data
dataSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API

Definition at line 1095 of file flexio_spi_driver.c.

16.35.5.8 status_t FLEXIO_SPI_DRV_MasterTransferAbort (flexio_spi_master_state_t * *master*)

Aborts a non-blocking SPI master transaction.

This function aborts a non-blocking SPI transfer.

Parameters

master	Pointer to the FLEXIO_SPI master driver context structure.

Returns

Error or success status returned by API

Definition at line 1201 of file flexio_spi_driver.c.

16.35.5.9 status_t FLEXIO_SPI_DRV_MasterTransferBlocking (flexio_spi_master_state_t * *master*, const uint8_t * *txData*, uint8_t * *rxData*, uint32_t *dataSize*, uint32_t *timeout*)

Perform a blocking SPI master transaction.

This function performs an SPI full-duplex transaction, transmit and receive in parallel. If only transmit or receive are required, it is possible to provide NULL pointers for txData or rxData. The transfer is blocking, the function only returns when the transfer is complete.

Parameters

master	Pointer to the FLEXIO_SPI master driver context structure.
txData	pointer to the data to be transmitted
rxData	pointer to the buffer where to store received data
dataSize	length in bytes of the data to be transferred
timeout	timeout for the transfer in milliseconds

Returns

Error or success status returned by API

Definition at line 1160 of file flexio_spi_driver.c.

16.35.5.10 status_t FLEXIO_SPI_DRV_SlaveDeinit (flexio_spi_slave_state_t * *slave*)

De-initialize the FLEXIO_SPI slave mode driver.

This function de-initializes the FLEXIO_SPI driver in slave mode. The driver can't be used again until reinitialized. The context structure is no longer needed by the driver and can be freed after calling this function.

Parameters

slave	Pointer to the FLEXIO_SPI slave driver context structure.

Returns

Error or success status returned by API

This function de-initializes the FLEXIO_SPI driver in slave mode. The driver can't be used again until reinitialized. The context structure is no longer needed by the driver and can be freed after calling this function.

Parameters

slave	Pointer to the FLEXIO_SPI slave driver context structure.

Returns

Error or success status returned by API Implements : FLEXIO_SPI_DRV_SlaveDeinit_Activity

Definition at line 1411 of file flexio_spi_driver.c.

16.35.5.11 void FLEXIO_SPI_DRV_SlaveGetDefaultConfig (flexio_spi_slave_user_config_t * *userConfigPtr*)

Returns default configuration structure for FLEXIO_SPI slave.

Parameters

userConfigPtr	Pointer to the FLEXIO_SPI user configuration structure.

Definition at line 1380 of file flexio_spi_driver.c.

16.35.5.12 status_t FLEXIO_SPI_DRV_SlaveGetStatus (flexio_spi_slave_state_t * *slave*, uint32_t * *bytesRemaining*)

Get the status of the current non-blocking SPI slave transaction.

This function returns the current status of a non-blocking SPI slave transaction. A return code of STATUS_BUSY means the transfer is still in progress. Otherwise the function returns a status reflecting the outcome of the last transfer. When the driver is initialized in polling mode this function also advances the transfer by checking and handling the transmit and receive events, so it must be called frequently to avoid overflows or underflows.

Parameters

slave	Pointer to the FLEXIO_SPI slave driver context structure.
bytesRemaining	the remaining number of bytes to be transferred

Returns

Error or success status returned by API

This function returns the current status of a non-blocking SPI slave transaction. A return code of STATUS_BUSY means the transfer is still in progress. Otherwise the function returns a status reflecting the outcome of the last transfer. When the driver is initialized in polling mode this function also advances the transfer by checking and handling the transmit and receive events, so it must be called frequently to avoid overflows or underflows.

Parameters

slave	Pointer to the FLEXIO_SPI slave driver context structure.
bytesRemaining	the remaining number of bytes to be transferred

Returns

Error or success status returned by API Implements : FLEXIO_SPI_DRV_SlaveGetStatus_Activity

Definition at line 1498 of file flexio_spi_driver.c.

16.35.5.13 status_t FLEXIO_SPI_DRV_SlaveInit (uint32_t *instance,* const flexio_spi_slave_user_config_t * *userConfigPtr,* flexio_spi_slave_state_t * *slave*)

Initialize the FLEXIO_SPI slave mode driver.

This function initializes the FLEXIO_SPI driver in slave mode.

Parameters

instance	FLEXIO peripheral instance number
userConfigPtr	Pointer to the FLEXIO_SPI slave user configuration structure. The function reads configuration data from this structure and initializes the driver accordingly. The application may free this structure after the function returns.
slave	Pointer to the FLEXIO_SPI slave driver context structure. The driver uses this memory area for its internal logic. The application must make no assumptions about the content of this structure, and must not free this memory until the driver is de-initialized using FLEXIO_SPI_DRV_SlaveDeinit().

Returns

Error or success status returned by API

Definition at line 1273 of file flexio_spi_driver.c.

16.35.5.14 status_t FLEXIO_SPI_DRV_SlaveTransfer (flexio_spi_slave_state_t * *slave,* const uint8_t * *txData,* uint8_t * *rxData,* uint32_t *dataSize*)

Perform a non-blocking SPI slave transaction.

This function performs an SPI full-duplex transaction, transmit and receive in parallel. If only transmit or receive are required, it is possible to provide NULL pointers for txData or rxData. The transfer is non-blocking, the function only initiates the transfer and then returns, leaving the transfer to complete asynchronously). FLEXIO_SPI_DRV_SlaveGetStatus() can be called to check the status of the transfer.

Parameters

slave	Pointer to the FLEXIO_SPI slave driver context structure.
txData	pointer to the data to be transmitted
rxData	pointer to the buffer where to store received data
dataSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API

This function performs an SPI full-duplex transaction, transmit and receive in parallel. If only transmit or receive are required, it is possible to provide NULL pointers for txData or rxData. The transfer is non-blocking, the function only initiates the transfer and then returns, leaving the transfer to complete asynchronously). FLEXIO_SPI_DRV↩ _SlaveGetStatus() can be called to check the status of the transfer.

Parameters

slave	Pointer to the FLEXIO_SPI slave driver context structure.
txData	pointer to the data to be transmitted
rxData	pointer to the buffer where to store received data
dataSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API Implements : FLEXIO_SPI_DRV_SlaveTransfer_Activity

Definition at line 1433 of file flexio_spi_driver.c.

16.35.5.15 status_t FLEXIO_SPI_DRV_SlaveTransferAbort (flexio_spi_slave_state_t * *slave*)

Aborts a non-blocking SPI slave transaction.

This function aborts a non-blocking SPI transfer.

Parameters

slave	Pointer to the FLEXIO_SPI slave driver context structure.

Returns

Error or success status returned by API

This function aborts a non-blocking SPI transfer.

Parameters

slave	Pointer to the FLEXIO_SPI slave driver context structure.

Returns

Error or success status returned by API Implements : FLEXIO_SPI_DRV_SlaveTransferAbort_Activity

Definition at line 1477 of file flexio_spi_driver.c.

16.35.5.16 status_t FLEXIO_SPI_DRV_SlaveTransferBlocking (flexio_spi_slave_state_t * *slave*, const uint8_t * *txData*, uint8_t * *rxData*, uint32_t *dataSize*, uint32_t *timeout*)

Perform a blocking SPI slave transaction.

This function performs an SPI full-duplex transaction, transmit and receive in parallel. If only transmit or receive are required, it is possible to provide NULL pointers for txData or rxData. The transfer is blocking, the function only returns when the transfer is complete.

Parameters

slave	Pointer to the FLEXIO_SPI slave driver context structure.
txData	pointer to the data to be transmitted
rxData	pointer to the buffer where to store received data
dataSize	length in bytes of the data to be transferred
timeout	timeout for the transfer in milliseconds

Returns

Error or success status returned by API

This function performs an SPI full-duplex transaction, transmit and receive in parallel. If only transmit or receive are required, it is possible to provide NULL pointers for txData or rxData. The transfer is blocking, the function only returns when the transfer is complete.

Parameters

slave	Pointer to the FLEXIO_SPI slave driver context structure.
txData	pointer to the data to be transmitted
rxData	pointer to the buffer where to store received data
dataSize	length in bytes of the data to be transferred
timeout	timeout for the transfer in milliseconds

Returns

Error or success status returned by API Implements : FLEXIO_SPI_DRV_SlaveTransferBlocking_Activity

Definition at line 1458 of file flexio_spi_driver.c.

16.36 FlexIO UART Driver

16.36.1 Detailed Description

UART communication over FlexIO module (FLEXIO_UART)

The FLEXIO_UART Driver allows UART communication using the FlexIO module in the S32K1xx processors.

Features

- Interrupt, DMA or polling mode
- Provides blocking and non-blocking transmit and receive functions
- Configurable baud rate and number of bits
- Single stop bit only
- Parity bit not supported

Functionality

Initialization

Before using any Flexio driver the device must first be initialized using function FLEXIO_DRV_InitDevice. Then the FLEXIO_UART Driver must be initialized, using function FLEXIO_UART_DRV_Init(). It is possible to use more driver instances on the same FlexIO device, as long as sufficient resources are available. Different driver instances on the same FlexIO device can function independently of each other. When it is no longer needed, the driver can be de-initialized, using FLEXIO_UART_DRV_Deinit(). This will release the hardware resources, allowing other driver instances to be initialized.

Choosing transmit/receive mode

To initialize the UART driver in transmit / receive mode the `direction` field of the configuration structure must be set to `FLEXIO_UART_DIRECTION_TX` / `FLEXIO_UART_DIRECTION_RX` when calling FLEXIO_UAR↩T_DRV_Init(). Once configured for one direction the driver must be used only for the chosen direction until it is de-initialized. One driver instance can only work in one direction at a time, but more driver instances can be created on the same device, up to the number of shifters present on the device (for example on S32K144 up to 4 driver instances can run in parallel on one device).

Setting the baud rate and bit count

The baud rate and bit count are provided at initialization time through the master configuration structure, but they can be changed at runtime by using function FLEXIO_UART_DRV_SetConfig(). Note that due to module limitation not any baud rate can be achieved. The driver will set a baud rate as close as possible to the requested baud rate, but there may still be substantial differences, for example if requesting a high baud rate while using a low-frequency FlexIO clock. The application should call FLEXIO_UART_DRV_GetBaudRate() to check what baud rate was actually set.

Transmitting / Receiving

To send or receive data to/from the currently configured slave address, use functions FLEXIO_UART_DRV_Send↩Data() or FLEXIO_UART_DRV_ReceiveData() (or their blocking counterparts). Continuous send/receive can be realized by registering a user callback function. When the driver completes the transmission or reception of the current buffer, it will invoke the user callback with an appropriate event. The callback function can the use FLEXI↩O_UART_DRV_SetTxBuffer() orFLEXIO_UART_DRV_SetRxBuffer() to provide a new buffer.

Blocking operations will return only when the transfer is completed, either successfully or with error. Non-blocking operations will initiate the transfer and return STATUS_SUCCESS, but the module is still busy with the transfer and another transfer can't be initiated until the current transfer is complete. The application will be notified through the user callback when the transfer completes, or it can check the status of the current transfer by calling FLEXIO↩_UART_DRV_GetStatus(). If the transfer is still ongoing this function will return STATUS_BUSY. If the transfer is

completed, the function will return either STATUS_SUCCESS or an error code, depending on the outcome of the last transfer.

The driver supports interrupt, DMA and polling mode. In polling mode the function FLEXIO_UART_DRV_Get↩ Status() ensures the progress of the transfer by checking and handling transmit and receive events reported by the FlexIO module. The application should ensure that this function is called often enough (at least once per transferred byte) to avoid Tx underflows or Rx overflows. In DMA mode the DMA channel that will be used by the driver is received through the configuration structure. The channel must be initialized by the application before the flexio_↩ uart driver is initialized. The flexio_uart driver will only set the DMA request source.

Important Notes

- Before using the FLEXIO_UART Driver the FlexIO clock must be configured. Refer to Clock Manager for clock configuration.
- Before using the FLEXIO_UART Driver the pins must be routed to the FlexIO module. Refer to PINS Driver for pin routing configuration. Note that any of the available FlexIO pins can be used for the UART TX / RX line (configurable at initialization time). If more than one driver instance is used on the same Flexio module, it is the responsibility of the application to ensure there are no conflicts between pins.
- The driver enables the interrupts for the corresponding FlexIO module, but any interrupt priority setting must be done by the application.
- Timeout feature for blocking transfers does not work in polling mode.
- This driver needs one shifter and one timer for its operation. Initialization will fail if there are not enough shifters and timers available on the FlexIO device.
- This driver needs one DMA channel for its operation when it is initialized in DMA mode. The DMA channels must be initialized by the application before initializing the driver. Refer to EDMA driver for DMA channels initialization.
- If the application uses an RTOS, this driver uses a semaphore for blocking transfers. Initialization will fail if the semaphore cannot be created. If the driver uses polling mode no semaphore is used.
- If the application uses an RTOS, the FlexIO drivers use a mutex for channel allocation. Only one mutex per device is needed, not per driver instance. Device initialization will fail if the mutex cannot be created.
- For transfers where the data size is 2 bytes (bitCount is greater than 8) the driver assumes that the data buffers are defined with the proper type (uint16_t) and are properly aligned.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\flexio\flexio_common.c
${S32SDK_PATH}\platform\drivers\src\flexio\flexio_uart_driver.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc
${S32SDK_PATH}\platform\drivers\src\flexio
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager OS Interface (OSIF) Interrupt Manager (Interrupt) Enhanced Direct Memory Access (eDMA)

Data Structures

- struct flexio_uart_user_config_t
  Driver configuration structure. More...
- struct flexio_uart_state_t
  Driver internal context structure. More...

Enumerations

- enum flexio_uart_driver_direction_t { FLEXIO_UART_DIRECTION_TX = 0x01U, FLEXIO_UART_DIRECT↩ ION_RX = 0x00U }
  flexio_uart driver direction (tx or rx)

FLEXIO_UART Driver

- status_t FLEXIO_UART_DRV_Init (uint32_t instance, const flexio_uart_user_config_t ∗userConfigPtr, flexio_uart_state_t ∗state)
  Initialize the FLEXIO_UART driver.
- status_t FLEXIO_UART_DRV_Deinit (flexio_uart_state_t ∗state)
  De-initialize the FLEXIO_UART driver.
- status_t FLEXIO_UART_DRV_SetConfig (flexio_uart_state_t ∗state, uint32_t baudRate, uint8_t bitCount)
  Set the baud rate and bit width for any subsequent UART communication.
- status_t FLEXIO_UART_DRV_GetBaudRate (flexio_uart_state_t ∗state, uint32_t ∗baudRate)
  Get the currently configured baud rate.
- status_t FLEXIO_UART_DRV_SendDataBlocking (flexio_uart_state_t ∗state, const uint8_t ∗txBuff, uint32↩ _t txSize, uint32_t timeout)
  Perform a blocking UART transmission.
- status_t FLEXIO_UART_DRV_SendData (flexio_uart_state_t ∗state, const uint8_t ∗txBuff, uint32_t txSize)
  Perform a non-blocking UART transmission.
- status_t FLEXIO_UART_DRV_ReceiveDataBlocking (flexio_uart_state_t ∗state, uint8_t ∗rxBuff, uint32_↩ t rxSize, uint32_t timeout)
  Perform a blocking UART reception.
- status_t FLEXIO_UART_DRV_ReceiveData (flexio_uart_state_t ∗state, uint8_t ∗rxBuff, uint32_t rxSize)
  Perform a non-blocking UART reception.
- status_t FLEXIO_UART_DRV_GetStatus (flexio_uart_state_t ∗state, uint32_t ∗bytesRemaining)
  Get the status of the current non-blocking UART transfer.
- status_t FLEXIO_UART_DRV_TransferAbort (flexio_uart_state_t ∗state)
  Aborts a non-blocking UART transfer.
- status_t FLEXIO_UART_DRV_SetRxBuffer (flexio_uart_state_t ∗state, uint8_t ∗rxBuff, uint32_t rxSize)
  Provide a buffer for receiving data.
- status_t FLEXIO_UART_DRV_SetTxBuffer (flexio_uart_state_t ∗state, const uint8_t ∗txBuff, uint32_t txSize)
  Provide a buffer for transmitting data.
- void FLEXIO_UART_DRV_GetDefaultConfig (flexio_uart_user_config_t ∗userConfigPtr)
  Returns default configuration structure for FLEXIO_UART.

16.36.2 Data Structure Documentation

16.36.2.1 struct flexio_uart_user_config_t

Driver configuration structure.

This structure is used to provide configuration parameters for the flexio_uart driver at initialization time. Implements : flexio_uart_user_config_t_Class

Definition at line 60 of file flexio_uart_driver.h.

Data Fields

- flexio_driver_type_t driverType
- uint32_t baudRate
- uint8_t bitCount
- flexio_uart_driver_direction_t direction
- uint8_t dataPin
- uart_callback_t callback
- void * callbackParam
- uint8_t dmaChannel

Field Documentation

16.36.2.1.1 uint32_t baudRate

Baud rate in hertz

Definition at line 63 of file flexio_uart_driver.h.

16.36.2.1.2 uint8_t bitCount

Number of bits per word

Definition at line 64 of file flexio_uart_driver.h.

16.36.2.1.3 uart_callback_t callback

User callback function. Note that this function will be called from the interrupt service routine, so its execution time should be as small as possible. It can be NULL if it is not needed

Definition at line 67 of file flexio_uart_driver.h.

16.36.2.1.4 void* callbackParam

Parameter for the callback function

Definition at line 71 of file flexio_uart_driver.h.

16.36.2.1.5 uint8_t dataPin

Flexio pin to use as Tx or Rx pin

Definition at line 66 of file flexio_uart_driver.h.

16.36.2.1.6 flexio_uart_driver_direction_t direction

Driver direction: Tx or Rx

Definition at line 65 of file flexio_uart_driver.h.

16.36.2.1.7 uint8_t dmaChannel

DMA channel number. Only used in DMA mode

Definition at line 72 of file flexio_uart_driver.h.

16.36.2.1.8 flexio_driver_type_t driverType

Driver type: interrupts/polling/DMA

Definition at line 62 of file flexio_uart_driver.h.

16.36.2.2 struct flexio_uart_state_t

Driver internal context structure.

This structure is used by the flexio_uart driver for its internal logic. It must be provided by the application through the FLEXIO_UART_DRV_Init() function, then it cannot be freed until the driver is de-initialized using FLEXIO_U↩ ART_DRV_DeInit(). The application should make no assumptions about the content of this structure.

Definition at line 84 of file flexio_uart_driver.h.

16.36.3 Enumeration Type Documentation

16.36.3.1 enum flexio_uart_driver_direction_t

flexio_uart driver direction (tx or rx)

This structure describes the direction configuration options for the flexio_uart driver. Implements : flexio_uart_↩ driver_direction_t_Class

Enumerator

FLEXIO_UART_DIRECTION_TX Tx UART driver

FLEXIO_UART_DIRECTION_RX Rx UART driver

Definition at line 42 of file flexio_uart_driver.h.

16.36.4 Function Documentation

16.36.4.1 status_t FLEXIO_UART_DRV_Deinit (flexio_uart_state_t * *state*)

De-initialize the FLEXIO_UART driver.

This function de-initializes the FLEXIO_UART driver. The driver can't be used again until reinitialized. The context structure is no longer needed by the driver and can be freed after calling this function.

Parameters

state	Pointer to the FLEXIO_UART driver context structure.

Returns

Error or success status returned by API

Definition at line 1065 of file flexio_uart_driver.c.

16.36.4.2 status_t FLEXIO_UART_DRV_GetBaudRate (flexio_uart_state_t * *state*, uint32_t * *baudRate*)

Get the currently configured baud rate.

This function returns the currently configured UART baud rate.

Parameters

state	Pointer to the FLEXIO_UART driver context structure.
baudRate	the current baud rate in hertz

Returns

Error or success status returned by API

Definition at line 1142 of file flexio_uart_driver.c.

16.36.4.3 void FLEXIO_UART_DRV_GetDefaultConfig (flexio_uart_user_config_t * *userConfigPtr*)

Returns default configuration structure for FLEXIO_UART.

Parameters

userConfigPtr	Pointer to the FLEXIO_UART user configuration structure.

Definition at line 1495 of file flexio_uart_driver.c.

16.36.4.4 status_t FLEXIO_UART_DRV_GetStatus (flexio_uart_state_t * *state*, uint32_t * *bytesRemaining*)

Get the status of the current non-blocking UART transfer.

This function returns the current status of a non-blocking UART transfer. A return code of STATUS_BUSY means the transfer is still in progress. Otherwise the function returns a status reflecting the outcome of the last transfer. When the driver is initialized in polling mode this function also advances the transfer by checking and handling the transmit and receive events, so it must be called frequently to avoid overflows or underflows.

Parameters

state	Pointer to the FLEXIO_UART driver context structure.
bytesRemaining	the remaining number of bytes to be transferred

Note

In DMA mode, this parameter may not be accurate, in case the transfer completes right after calling this function; in this edge-case, the parameter will reflect the initial transfer size, due to automatic reloading of the major loop count in the DMA transfer descriptor.

Returns

Error or success status returned by API

Definition at line 1396 of file flexio_uart_driver.c.

16.36.4.5 status_t FLEXIO_UART_DRV_Init (uint32_t *instance*, const flexio_uart_user_config_t * *userConfigPtr*, flexio_uart_state_t * *state*)

Initialize the FLEXIO_UART driver.

This function initializes the FLEXIO_UART driver.

Parameters

instance	FLEXIO peripheral instance number
userConfigPtr	Pointer to the FLEXIO_UART user configuration structure. The function reads configuration data from this structure and initializes the driver accordingly. The application may free this structure after the function returns.
state	Pointer to the FLEXIO_UART driver context structure. The driver uses this memory area for its internal logic. The application must make no assumptions about the content of this structure, and must not free this memory until the driver is de-initialized using FLEXIO_UART_DRV_Deinit().

Returns

Error or success status returned by API

Definition at line 959 of file flexio_uart_driver.c.

16.36.4.6 status_t FLEXIO_UART_DRV_ReceiveData (flexio_uart_state_t * *state*, uint8_t * *rxBuff*, uint32_t *rxSize*)

Perform a non-blocking UART reception.

This function receives a block of data and returns immediately. The rest of the transmission is handled by the interrupt service routine (if the driver is initialized in interrupt mode) or by the FLEXIO_UART_DRV_GetReceiveStatus() function (if the driver is initialized in polling mode).

Parameters

state	Pointer to the FLEXIO_UART driver context structure.
rxBuff	pointer to the receive buffer
rxSize	length in bytes of the data to be received

Returns

Error or success status returned by API

Definition at line 1278 of file flexio_uart_driver.c.

16.36.4.7 status_t FLEXIO_UART_DRV_ReceiveDataBlocking (flexio_uart_state_t * *state*, uint8_t * *rxBuff*, uint32_t *rxSize*, uint32_t *timeout*)

Perform a blocking UART reception.

This function receives a block of data and only returns when the transmission is complete.

Parameters

state	Pointer to the FLEXIO_UART driver context structure.
rxBuff	pointer to the receive buffer
rxSize	length in bytes of the data to be received
timeout	timeout for the transfer in milliseconds

Returns

Error or success status returned by API

Definition at line 1339 of file flexio_uart_driver.c.

16.36.4.8 status_t FLEXIO_UART_DRV_SendData (flexio_uart_state_t * *state*, const uint8_t * *txBuff*, uint32_t *txSize*)

Perform a non-blocking UART transmission.

This function sends a block of data and returns immediately. The rest of the transmission is handled by the interrupt service routine (if the driver is initialized in interrupt mode) or by the FLEXIO_UART_DRV_GetTransmitStatus() function (if the driver is initialized in polling mode).

Parameters

state	Pointer to the FLEXIO_UART driver context structure.
txBuff	pointer to the data to be transferred
txSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API

Definition at line 1182 of file flexio_uart_driver.c.

16.36.4.9 status_t FLEXIO_UART_DRV_SendDataBlocking (flexio_uart_state_t * *state*, const uint8_t * *txBuff*, uint32_t *txSize*, uint32_t *timeout*)

Perform a blocking UART transmission.

This function sends a block of data and only returns when the transmission is complete.

Parameters

state	Pointer to the FLEXIO_UART driver context structure.
txBuff	pointer to the data to be transferred
txSize	length in bytes of the data to be transferred
timeout	timeout for the transfer in milliseconds

Returns

Error or success status returned by API

Definition at line 1245 of file flexio_uart_driver.c.

16.36.4.10 status_t FLEXIO_UART_DRV_SetConfig (flexio_uart_state_t * *state*, uint32_t *baudRate*, uint8_t *bitCount*)

Set the baud rate and bit width for any subsequent UART communication.

This function sets the baud rate and bit width for the UART driver. Note that due to module limitation not any baud rate can be achieved. The driver will set a baud rate as close as possible to the requested baud rate, but there may still be substantial differences, for example if requesting a high baud rate while using a low-frequency FlexIO clock. The application should call FLEXIO_UART_DRV_GetBaudRate() after FLEXIO_UART_DRV_SetConfig() to check what baud rate was actually set.

Parameters

state	Pointer to the FLEXIO_UART driver context structure.
baudRate	the desired baud rate in hertz
bitCount	number of bits per word

Returns

Error or success status returned by API

Definition at line 1092 of file flexio_uart_driver.c.

16.36.4.11 status_t FLEXIO_UART_DRV_SetRxBuffer (flexio_uart_state_t * *state*, uint8_t * *rxBuff*, uint32_t *rxSize*)

Provide a buffer for receiving data.

This function can be used to provide a new buffer for receiving data to the driver. It can be called from the user callback when event STATUS_UART_RX_OVERRUN is reported. This way the reception will continue without interruption.

Parameters

state	Pointer to the FLEXIO_UART driver context structure.
rxBuff	pointer to the buffer where to store received data
rxSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API

Definition at line 1449 of file flexio_uart_driver.c.

16.36.4.12 status_t FLEXIO_UART_DRV_SetTxBuffer (flexio_uart_state_t * *state*, const uint8_t * *txBuff*, uint32_t *txSize*)

Provide a buffer for transmitting data.

This function can be used to provide a new buffer for transmitting data to the driver. It can be called from the user callback when event STATUS_UART_TX_UNDERRUN is reported. This way the transmission will continue without interruption.

Parameters

state	Pointer to the FLEXIO_UART driver context structure.
txBuff	pointer to the buffer containing transmit data
txSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API

Definition at line 1471 of file flexio_uart_driver.c.

16.36.4.13 status_t FLEXIO_UART_DRV_TransferAbort (flexio_uart_state_t * *state*)

Aborts a non-blocking UART transfer.

This function aborts a non-blocking UART transfer.

Parameters

state	Pointer to the FLEXIO_UART driver context structure.

Returns

Error or success status returned by API

Definition at line 1372 of file flexio_uart_driver.c.

16.37 FlexTimer (FTM)

16.37.1 Detailed Description

FlexTimer Peripheral Driver.

Hardware background

The FTM of the S32K1xx is based on a 16 bits counter and supports: input capture, output compare, PWM and some instances include quadrature decoder. The main features are:

•FTM source clock is selectable (Source clock can be the system clock, the fixed frequency clock, or an external clock)

•Prescaler: 1, 2, 4, 8, 16, 32, 64, 128

•16 bit counter (up and up-down counting)

•Each channel can be configured for input capture, output compare, or PWM mode.

•Input Capture mode (single edge, dual edge or measure period/duty cycle)

•Output Compare mode (set, cleared or toggle on match)

•All channels can be configured for center-aligned PWM mode.

•Each pair of channels can be combined to generate a PWM signal with independent control of both edges of PWM signal and with dead-time insertion.

•Up to 4 fault inputs for global fault control

•Dual edge capture for pulse and period width measurement

•Quadrature decoder with input filters, relative position counting, and interrupt on position count or capture of position count on external event.

Modules

- FlexTimer Input Capture Driver (FTM_IC)

  FlexTimer Input Capture Peripheral Driver.
- FlexTimer Module Counter Driver (FTM_MC)

  FlexTimer Module Counter Peripheral Driver.
- FlexTimer Output Compare Driver (FTM_OC)

  FlexTimer Output Compare Peripheral Driver.
- FlexTimer Pulse Width Modulation Driver (FTM_PWM)

  FlexTimer Pulse Width Modulation Peripheral Driver.
- FlexTimer Quadrature Decoder Driver (FTM_QD)

  FlexTimer Quadrature Decoder Peripheral Driver.

Data Structures

- struct ftm_state_t

  FlexTimer state structure of the driver. More...
- struct ftm_pwm_sync_t

  FlexTimer Registers sync parameters Please don't use software and hardware trigger simultaneously Implements : ftm_pwm_sync_t_Class. More...
- struct ftm_user_config_t

  Configuration structure that the user needs to set. More...

Macros

- #define FTM_RMW_SC(base, mask, value) (((base)->SC) = ((((base)->SC) & ∼(mask)) | (value)))

  FTM_SC - Read and modify and write to Status And Control (RW)
- #define FTM_RMW_CNT(base, mask, value) (((base)->CNT) = ((((base)->CNT) & ∼(mask)) | (value)))

  FTM_CNT - Read and modify and write to Counter (RW)
- #define FTM_RMW_MOD(base, mask, value) (((base)->MOD) = ((((base)->MOD) & ∼(mask)) | (value)))

  FTM_MOD - Read and modify and write Modulo (RW)
- #define FTM_RMW_CNTIN(base, mask, value) (((base)->CNTIN) = ((((base)->CNTIN) & ∼(mask)) | (value)))

  FTM_CNTIN - Read and modify and write Counter Initial Value (RW)
- #define FTM_RMW_STATUS(base, mask, value) (((base)->STATUS) = ((((base)->STATUS) & ∼(mask)) | (value)))

  FTM_STATUS - Read and modify and write Capture And Compare Status (RW)
- #define FTM_RMW_MODE(base, mask, value) (((base)->MODE) = ((((base)->MODE) & ∼(mask)) | (value)))

  FTM_MODE - Read and modify and write Counter Features Mode Selection (RW)
- #define FTM_RMW_CnSCV_REG(base, channel, mask, value) (((base)->CONTROLS[channel].CnSC) = ((((base)->CONTROLS[channel].CnSC) & ∼(mask)) | (value)))

  FTM_CnSCV - Read and modify and write Channel (n) Status And Control (RW)
- #define FTM_RMW_DEADTIME(base, mask, value) (((base)->DEADTIME) = ((((base)->DEADTIME) & ∼(mask)) | (value)))

  FTM_DEADTIME - Read and modify and write Dead-time Insertion Control (RW)
- #define FTM_RMW_EXTTRIG_REG(base, mask, value) (((base)->EXTTRIG) = ((((base)->EXTTRIG) & ∼(mask)) | (value)))

  FTM_EXTTRIG - Read and modify and write External Trigger Control (RW)
- #define FTM_RMW_FLTCTRL(base, mask, value) (((base)->FLTCTRL) = ((((base)->FLTCTRL) & ∼(mask)) | (value)))

  FTM_FLTCTRL - Read and modify and write Fault Control (RW)
- #define FTM_RMW_FMS(base, mask, value) (((base)->FMS) = ((((base)->FMS) & ∼(mask)) | (value)))

  FTM_FMS - Read and modify and write Fault Mode Status (RW)
- #define FTM_RMW_CONF(base, mask, value) (((base)->CONF) = ((((base)->CONF) & ∼(mask)) | (value)))

  FTM_CONF - Read and modify and write Configuration (RW)
- #define FTM_RMW_POL(base, mask, value) (((base)->POL) = ((((base)->POL) & ∼(mask)) | (value)))

  POL - Read and modify and write Polarity (RW)
- #define FTM_RMW_FILTER(base, mask, value) (((base)->FILTER) = ((((base)->FILTER) & ∼(mask)) | (value)))

  FILTER - Read and modify and write Filter (RW)
- #define FTM_RMW_SYNC(base, mask, value) (((base)->SYNC) = ((((base)->SYNC) & ∼(mask)) | (value)))

  SYNC - Read and modify and write Synchronization (RW)
- #define FTM_RMW_QDCTRL(base, mask, value) (((base)->QDCTRL) = ((((base)->QDCTRL) & ∼(mask)) | (value)))

  QDCTRL - Read and modify and write Quadrature Decoder Control And Status (RW)
- #define FTM_RMW_PAIR0DEADTIME(base, mask, value) (((base)->PAIR0DEADTIME) = ((((base)->PA↩IR0DEADTIME) & ∼(mask)) | (value)))

  FTM_PAIR0DEADTIME - Read and modify and write Dead-time Insertion Control for the pair 0 (RW)
- #define FTM_RMW_PAIR1DEADTIME(base, mask, value) (((base)->PAIR1DEADTIME) = ((((base)->PA↩IR1DEADTIME) & ∼(mask)) | (value)))

  FTM_PAIR1DEADTIME - Read and modify and write Dead-time Insertion Control for the pair 1 (RW)
- #define FTM_RMW_PAIR2DEADTIME(base, mask, value) (((base)->PAIR2DEADTIME) = ((((base)->PA↩IR2DEADTIME) & ∼(mask)) | (value)))

  FTM_PAIR2DEADTIME - Read and modify and write Dead-time Insertion Control for the pair 2 (RW)

- #define FTM_RMW_PAIR3DEADTIME(base, mask, value) (((base)->PAIR3DEADTIME) = ((((base)->PA↩ IR3DEADTIME) & ∼(mask)) | (value)))

  FTM_PAIR3DEADTIME - Read and modify and write Dead-time Insertion Control for the pair 3 (RW)
- #define CHAN0_IDX (0U)

  Channel number for CHAN1.
- #define CHAN1_IDX (1U)

  Channel number for CHAN2.
- #define CHAN2_IDX (2U)

  Channel number for CHAN3.
- #define CHAN3_IDX (3U)

  Channel number for CHAN4.
- #define CHAN4_IDX (4U)

  Channel number for CHAN5.
- #define CHAN5_IDX (5U)

  Channel number for CHAN6.
- #define CHAN6_IDX (6U)

  Channel number for CHAN7.
- #define CHAN7_IDX (7U)

Enumerations

- enum ftm_config_mode_t { FTM_MODE_NOT_INITIALIZED = 0x00U, FTM_MODE_INPUT_CAPTURE = 0x01U, FTM_MODE_OUT↩ PUT_COMPARE = 0x02U, FTM_MODE_EDGE_ALIGNED_PWM = 0x03U, FTM_MODE_CEN_ALIGNED_PWM = 0x04U, FTM_MODE_QUADRATURE_DECODER = 0x05U, FTM_↩ MODE_UP_TIMER = 0x06U, FTM_MODE_UP_DOWN_TIMER = 0x07U, FTM_MODE_EDGE_ALIGNED_PWM_AND_INPUT_CAPTURE = 0x08U }

  FlexTimer operation mode.
- enum ftm_clock_source_t { FTM_CLOCK_SOURCE_NONE = 0x00U, FTM_CLOCK_SOURCE_SYSTEM↩ CLK = 0x01U, FTM_CLOCK_SOURCE_FIXEDCLK = 0x02U, FTM_CLOCK_SOURCE_EXTERNALCLK = 0x03U }

  FlexTimer clock source selection.
- enum ftm_clock_ps_t { FTM_CLOCK_DIVID_BY_1 = 0x00U, FTM_CLOCK_DIVID_BY_2 = 0x01U, FTM_CLOCK_DIVID_BY_4 = 0x02U, FTM_CLOCK_DIVID_BY_8 = 0x03U, FTM_CLOCK_DIVID_BY_16 = 0x04U, FTM_CLOCK_DIVID_BY_32 = 0x05U, FTM_CLOCK_DIVID_BY_64 = 0x06U, FTM_CLOCK_DIVID_BY_128 = 0x07U }

  FlexTimer pre-scaler factor selection for the clock source. In quadrature decoder mode set FTM_CLOCK_DIVID_↩ BY_1.
- enum ftm_interrupt_option_t { FTM_CHANNEL0_INT_ENABLE = 0x00000001U, FTM_CHANNEL1_INT_ENABLE = 0x00000002U, FT↩ M_CHANNEL2_INT_ENABLE = 0x00000004U, FTM_CHANNEL3_INT_ENABLE = 0x00000008U, FTM_CHANNEL4_INT_ENABLE = 0x00000010U, FTM_CHANNEL5_INT_ENABLE = 0x00000020U, FT↩ M_CHANNEL6_INT_ENABLE = 0x00000040U, FTM_CHANNEL7_INT_ENABLE = 0x00000080U, FTM_FAULT_INT_ENABLE = 0x00000100U, FTM_TIME_OVER_FLOW_INT_ENABLE = 0x00000200↩ U, FTM_RELOAD_INT_ENABLE = 0x00000400U }

  List of FTM interrupts.
- enum ftm_status_flag_t { FTM_CHANNEL0_FLAG = 0x00000001U, FTM_CHANNEL1_FLAG = 0x00000002U, FTM_CHANNEL2_↩ FLAG = 0x00000004U, FTM_CHANNEL3_FLAG = 0x00000008U, FTM_CHANNEL4_FLAG = 0x00000010U, FTM_CHANNEL5_FLAG = 0x00000020U, FTM_CHANNEL6_↩ FLAG = 0x00000040U, FTM_CHANNEL7_FLAG = 0x00000080U, FTM_FAULT_FLAG = 0x00000100U, FTM_TIME_OVER_FLOW_FLAG = 0x00000200U, FTM_RELOAD↩ _FLAG = 0x00000400U, FTM_CHANNEL_TRIGGER_FLAG = 0x00000800U }

List of FTM flags.

- enum ftm_reg_update_t { FTM_SYSTEM_CLOCK = 0U, FTM_PWM_SYNC = 1U }

  FTM sync source.
- enum ftm_pwm_sync_mode_t { FTM_WAIT_LOADING_POINTS = 0U, FTM_UPDATE_NOW = 1U }

  FTM update register.
- enum ftm_deadtime_ps_t { FTM_DEADTIME_DIVID_BY_1 = 0x01U, FTM_DEADTIME_DIVID_BY_4 = 0x02U, FTM_DEADTIME_DIVID_BY_16 = 0x03U }

  FlexTimer pre-scaler factor for the dead-time insertion.
- enum ftm_bdm_mode_t { FTM_BDM_MODE_00 = 0x00U, FTM_BDM_MODE_01 = 0x01U, FTM_BDM_MODE_10 = 0x02U, FTM_BDM_MODE_11 = 0x03U }

  Options for the FlexTimer behavior in BDM Mode.

Functions

- static void FTM_DRV_SetClockFilterPs (FTM_Type *const ftmBase, uint8_t filterPrescale)

  Sets the filter Pre-scaler divider.
- static uint8_t FTM_DRV_GetClockFilterPs (const FTM_Type *ftmBase)

  Reads the FTM filter clock divider.
- static uint16_t FTM_DRV_GetCounter (const FTM_Type *ftmBase)

  Returns the FTM peripheral current counter value.
- static uint16_t FTM_DRV_GetMod (const FTM_Type *ftmBase)

  Returns the FTM peripheral counter modulo value.
- static uint16_t FTM_DRV_GetCounterInitVal (const FTM_Type *ftmBase)

  Returns the FTM peripheral counter initial value.
- static void FTM_DRV_ClearChSC (FTM_Type *const ftmBase, uint8_t channel)

  Clears the content of Channel (n) Status And Control.
- static uint8_t FTM_DRV_GetChnEdgeLevel (const FTM_Type *ftmBase, uint8_t channel)

  Gets the FTM peripheral timer channel edge level.
- static void FTM_DRV_SetChnIcrstCmd (FTM_Type *const ftmBase, uint8_t channel, bool enable)

  Configure the feature of FTM counter reset by the selected input capture event.
- static bool FTM_DRV_IsChnIcrst (const FTM_Type *ftmBase, uint8_t channel)

  Returns whether the FTM FTM counter is reset.
- static void FTM_DRV_SetChnDmaCmd (FTM_Type *const ftmBase, uint8_t channel, bool enable)

  Enables or disables the FTM peripheral timer channel DMA.
- static bool FTM_DRV_IsChnDma (const FTM_Type *ftmBase, uint8_t channel)

  Returns whether the FTM peripheral timer channel DMA is enabled.
- static void FTM_DRV_SetTrigModeControlCmd (FTM_Type *const ftmBase, uint8_t channel, bool enable)

  Enables or disables the trigger generation on FTM channel outputs.
- static bool FTM_DRV_GetTriggerControled (const FTM_Type *ftmBase, uint8_t channel)

  Returns whether the trigger mode is enabled.
- static bool FTM_DRV_GetChInputState (const FTM_Type *ftmBase, uint8_t channel)

  Get the state of channel input.
- static bool FTM_DRV_GetChOutputValue (const FTM_Type *ftmBase, uint8_t channel)

  Get the value of channel output.
- static uint16_t FTM_DRV_GetChnCountVal (const FTM_Type *ftmBase, uint8_t channel)

  Gets the FTM peripheral timer channel counter value.
- static bool FTM_DRV_GetChnEventStatus (const FTM_Type *ftmBase, uint8_t channel)

  Gets the FTM peripheral timer channel event status.
- static uint32_t FTM_DRV_GetEventStatus (const FTM_Type *ftmBase)

  Gets the FTM peripheral timer status info for all channels.
- static void FTM_DRV_ClearChnEventStatus (FTM_Type *const ftmBase, uint8_t channel)

Clears the FTM peripheral timer all channel event status.

- static void FTM_DRV_SetChnOutputMask (FTM_Type *const ftmBase, uint8_t channel, bool mask)

  Sets the FTM peripheral timer channel output mask.
- static void FTM_DRV_SetChnOutputInitStateCmd (FTM_Type *const ftmBase, uint8_t channel, bool state)

  Sets the FTM peripheral timer channel output initial state 0 or 1.
- static void FTM_DRV_DisableFaultInt (FTM_Type *const ftmBase)

  Disables the FTM peripheral timer fault interrupt.
- static void FTM_DRV_SetCaptureTestCmd (FTM_Type *const ftmBase, bool enable)

  Enables or disables the FTM peripheral timer capture test mode.
- static bool FTM_DRV_IsFtmEnable (const FTM_Type *ftmBase)

  Get status of the FTMEN bit in the FTM_MODE register.
- static void FTM_DRV_SetCountReinitSyncCmd (FTM_Type *const ftmBase, bool enable)

  Determines if the FTM counter is re-initialized when the selected trigger for synchronization is detected.
- static bool FTM_DRV_IsWriteProtectionEnabled (const FTM_Type *ftmBase)

  Checks whether the write protection is enabled.
- static bool FTM_DRV_IsFaultInputEnabled (const FTM_Type *ftmBase)

  Checks whether the logic OR of the fault inputs is enabled.
- static bool FTM_DRV_IsFaultFlagDetected (const FTM_Type *ftmBase, uint8_t channel)

  Checks whether a fault condition is detected at the fault input.
- static void FTM_DRV_ClearFaultFlagDetected (FTM_Type *const ftmBase, uint8_t channel)

  Clear a fault condition is detected at the fault input.
- static void FTM_DRV_SetDualChnInvertCmd (FTM_Type *const ftmBase, uint8_t chnlPairNum, bool enable)

  Enables or disables the channel invert for a channel pair.
- static void FTM_DRV_SetChnSoftwareCtrlCmd (FTM_Type *const ftmBase, uint8_t channel, bool enable)

  Enables or disables the channel software output control.
- static void FTM_DRV_SetChnSoftwareCtrlVal (FTM_Type *const ftmBase, uint8_t channel, bool enable)

  Sets the channel software output control value. Despite the odd channels are configured as HIGH/LOW, they will be inverted in the following configuration: COMP bit = 1 and CH(n)OCV and CH(n+1)OCV are HIGH. Please check Software output control behavior chapter from RM.
- static void FTM_DRV_SetGlobalLoadCmd (FTM_Type *const ftmBase)

  Set the global load mechanism.
- static void FTM_DRV_SetLoadCmd (FTM_Type *const ftmBase, bool enable)

  Enable the global load.
- static void FTM_DRV_SetHalfCycleCmd (FTM_Type *const ftmBase, bool enable)

  Enable the half cycle reload.
- static void FTM_DRV_SetPwmLoadCmd (FTM_Type *const ftmBase, bool enable)

  Enables or disables the loading of MOD, CNTIN and CV with values of their write buffer.
- static void FTM_DRV_SetPwmLoadChnSelCmd (FTM_Type *const ftmBase, uint8_t channel, bool enable)

  Includes or excludes the channel in the matching process.
- static void FTM_DRV_SetInitTrigOnReloadCmd (FTM_Type *const ftmBase, bool enable)

  Enables or disables the FTM initialization trigger on Reload Point.
- static void FTM_DRV_SetGlobalTimeBaseOutputCmd (FTM_Type *const ftmBase, bool enable)

  Enables or disables the FTM global time base signal generation to other FTM's.
- static void FTM_DRV_SetGlobalTimeBaseCmd (FTM_Type *const ftmBase, bool enable)

  Enables or disables the FTM timer global time base.
- static void FTM_DRV_SetLoadFreq (FTM_Type *const ftmBase, uint8_t val)

  Sets the frequency of reload points.
- static void FTM_DRV_SetExtPairDeadtimeValue (FTM_Type *const ftmBase, uint8_t channelPair, uint8_↩ t value)

  Sets the FTM extended dead-time value for the channel pair.

- static void FTM_DRV_SetPairDeadtimePrescale (FTM_Type *const ftmBase, uint8_t channelPair, ftm_↩ deadtime_ps_t divider)

  Sets the FTM dead time divider for the channel pair.
- static void FTM_DRV_SetPairDeadtimeCount (FTM_Type *const ftmBase, uint8_t channelPair, uint8_t count)

  Sets the FTM dead-time value for the channel pair.
- status_t FTM_DRV_Init (uint32_t instance, const ftm_user_config_t *info, ftm_state_t *state)

  Initializes the FTM driver.
- status_t FTM_DRV_Deinit (uint32_t instance)

  Shuts down the FTM driver.
- void FTM_DRV_GetDefaultConfig (ftm_user_config_t *const config)

  This function will get the default configuration values in the structure which is used as a common use-case.
- status_t FTM_DRV_MaskOutputChannels (uint32_t instance, uint32_t channelsMask, bool softwareTrigger)

  This function will mask the output of the channels and at match events will be ignored by the masked channels.
- status_t FTM_DRV_SetInitialCounterValue (uint32_t instance, uint16_t counterValue, bool softwareTrigger)

  This function configure the initial counter value. The counter will get this value after an overflow event.
- status_t FTM_DRV_SetHalfCycleReloadPoint (uint32_t instance, uint16_t reloadPoint, bool softwareTrigger)

  This function configure the value of the counter which will generates an reload point.
- status_t FTM_DRV_SetSoftOutChnValue (uint32_t instance, uint8_t channelsValues, bool softwareTrigger)

  This function will force the output value of a channel to a specific value. Before using this function it's mandatory to mask the match events using FTM_DRV_MaskOutputChannels and to enable software output control using FT↩ M_DRV_SetSoftwareOutputChannelControl. : When the PWM signal is configured with LOW/HIGH polarity on the channel (n). It should be set the safe state as LOW level state. However, We will have an issue with COMP bit is zero and CH(n)OCV is HIGH and CH(n+1)OCV is LOW.in the independent channel configuration. Code configuration↩ : { .polarity = FTM_POLARITY_HIGH, .safeState = FTM_POLARITY_LOW, .enableSecondChannelOutput = true, .secondChannelPolarity = FTM_MAIN_DUPLICATED, }.
- status_t FTM_DRV_SetSoftwareOutputChannelControl (uint32_t instance, uint8_t channelsMask, bool softwareTrigger)

  This function will configure which output channel can be software controlled. Software output control forces the following values on channels (n) and (n+1) when the COMP bit is zero and POL bit is zero. CH(n)OC|CH(n+1)OC|↩ CH(n)OCV|CH(n+1)OCV|Channel (n) Output | Channel (n+1) Output 0 | 0 | X | X | is not modified by SWOC| is not modified by SWOC 1 | 1 | 0 | 0 | is forced to zero | is forced to zero 1 | 1 | 0 | 1 | is forced to zero | is forced to one 1 | 1 | 1 | 0 | is forced to one | is forced to zero 1 | 1 | 1 | 1 | is forced to one | is forced to one.
- status_t FTM_DRV_SetAllChnSoftwareOutputControl (uint32_t instance, uint8_t channelMask, uint8_↩ t channelValueMask, bool softwareTrigger)

  This function will control list of channels by software to force the output to specified value. Despite the odd channels are configured as HIGH/LOW, they will be inverted in the following configuration: COMP bit = 1 and CH(n)OCV and CH(n+1)OCV are HIGH. Please check software output control behavior chapter from reference manual. : When the PWM signal is configured with LOW/HIGH polarity on the channel (n). It should be set the safe state as LOW level state. However, We will have an issue with COMP bit is zero and CH(n)OCV is HIGH and CH(n+1)OCV is LOW.in the independent channel configuration. Code configuration: { .polarity = FTM_POLARITY_HIGH, .safeState = F↩ TM_POLARITY_LOW, .enableSecondChannelOutput = true, .secondChannelPolarity = FTM_MAIN_DUPLICATED, }.
- status_t FTM_DRV_SetInvertingControl (uint32_t instance, uint8_t channelsPairMask, bool softwareTrigger)

  This function will configure if the second channel of a pair will be inverted or not.
- status_t FTM_DRV_SetModuloCounterValue (uint32_t instance, uint16_t counterValue, bool softwareTrigger)

  This function configure the maximum counter value.
- status_t FTM_DRV_SetOutputlevel (uint32_t instance, uint8_t channel, uint8_t level)

  This function will set the channel edge or level on the selection of the channel mode.
- status_t FTM_DRV_SetSync (uint32_t instance, const ftm_pwm_sync_t *param)

  This function configures sync mechanism for some FTM registers (MOD, CNINT, HCR, CnV, OUTMASK, INVCTRL, SWOCTRL).
- status_t FTM_DRV_GenerateHardwareTrigger (uint32_t instance)

  This function is used to configure a trigger source for FTM instance. This allow a hardware trigger input which can be used in PWM synchronization. Note that the hardware trigger is implemented only on trigger 1 for each instance.
- status_t FTM_DRV_EnableInterrupts (uint32_t instance, uint32_t interruptMask)

This function will enable the generation a list of interrupts. It includes the FTM overflow interrupts, the reload point interrupt, the fault interrupt and the channel (n) interrupt.

- void FTM_DRV_DisableInterrupts (uint32_t instance, uint32_t interruptMask)

  This function is used to disable some interrupts.
- uint32_t FTM_DRV_GetEnabledInterrupts (uint32_t instance)

  This function will get the enabled FTM interrupts.
- uint32_t FTM_DRV_GetStatusFlags (uint32_t instance)

  This function will get the FTM status flags. : Regarding the duty cycle is 100% at the channel output, the match interrupt has no event due to the C(n)V and C(n+1)V value are not between CNTIN value and MOD value.
- void FTM_DRV_ClearStatusFlags (uint32_t instance, uint32_t flagMask)

  This function is used to clear the FTM status flags.
- uint32_t FTM_DRV_GetFrequency (uint32_t instance)

  Retrieves the frequency of the clock source feeding the FTM counter.
- uint16_t FTM_DRV_ConvertFreqToPeriodTicks (uint32_t instance, uint32_t freqencyHz)

  This function is used to covert the given frequency to period in ticks.
- status_t FTM_DRV_CounterReset (uint32_t instance, bool softwareTrigger)

  This function will allow the FTM to restart the counter to its initial counting value in the register. Note that the configuration is set in the FTM_DRV_SetSync() function to make sure that the FTM registers are updated by software trigger or hardware trigger.

Variables

- FTM_Type ∗const g_ftmBase [FTM_INSTANCE_COUNT]

  Table of base addresses for FTM instances.
- const IRQn_Type g_ftmIrqId [FTM_INSTANCE_COUNT][FEATURE_FTM_CHANNEL_COUNT]

  Interrupt vectors for the FTM peripheral.
- const IRQn_Type g_ftmFaultIrqId [FTM_INSTANCE_COUNT]
- const IRQn_Type g_ftmOverflowIrqId [FTM_INSTANCE_COUNT]
- const IRQn_Type g_ftmReloadIrqId [FTM_INSTANCE_COUNT]
- ftm_state_t ∗ ftmStatePtr [FTM_INSTANCE_COUNT]

  Pointer to runtime state structure.

16.37.2 Data Structure Documentation

16.37.2.1 struct ftm_state_t

FlexTimer state structure of the driver.

Implements : ftm_state_t_Class

Definition at line 376 of file ftm_common.h.

Data Fields

- ftm_clock_source_t ftmClockSource
- ftm_config_mode_t ftmMode
- uint16_t ftmModValue
- uint16_t ftmPeriod
- uint32_t ftmSourceClockFrequency
- uint16_t measurementResults [FEATURE_FTM_CHANNEL_COUNT]
- void ∗ channelsCallbacksParams [FEATURE_FTM_CHANNEL_COUNT]
- ic_callback_t channelsCallbacks [FEATURE_FTM_CHANNEL_COUNT]
- bool enableNotification [FEATURE_FTM_CHANNEL_COUNT]

Field Documentation

16.37.2.1.1 ic_callback_t channelsCallbacks[FEATURE_FTM_CHANNEL_COUNT]

The callback function for channels events

Definition at line 385 of file ftm_common.h.

16.37.2.1.2 void* channelsCallbacksParams[FEATURE_FTM_CHANNEL_COUNT]

The parameters of callback function for channels events

Definition at line 384 of file ftm_common.h.

16.37.2.1.3 bool enableNotification[FEATURE_FTM_CHANNEL_COUNT]

To save channels enable the notification on the callback application

Definition at line 386 of file ftm_common.h.

16.37.2.1.4 ftm_clock_source_t ftmClockSource

Clock source used by FTM counter

Definition at line 378 of file ftm_common.h.

16.37.2.1.5 ftm_config_mode_t ftmMode

Mode of operation for FTM

Definition at line 379 of file ftm_common.h.

16.37.2.1.6 uint16_t ftmModValue

This field is used only in input capture mode to store MOD value

Definition at line 380 of file ftm_common.h.

16.37.2.1.7 uint16_t ftmPeriod

This field is used only in PWM mode to store signal period

Definition at line 381 of file ftm_common.h.

16.37.2.1.8 uint32_t ftmSourceClockFrequency

The clock frequency is used for counting

Definition at line 382 of file ftm_common.h.

16.37.2.1.9 uint16_t measurementResults[FEATURE_FTM_CHANNEL_COUNT]

This field is used only in input capture mode to store edges time stamps

Definition at line 383 of file ftm_common.h.

16.37.2.2 struct ftm_pwm_sync_t

FlexTimer Registers sync parameters Please don't use software and hardware trigger simultaneously Implements : ftm_pwm_sync_t_Class.

Definition at line 394 of file ftm_common.h.

Data Fields

- bool softwareSync
- bool hardwareSync0

- bool hardwareSync1
- bool hardwareSync2
- bool maxLoadingPoint
- bool minLoadingPoint
- ftm_reg_update_t inverterSync
- ftm_reg_update_t outRegSync
- ftm_reg_update_t maskRegSync
- ftm_reg_update_t initCounterSync
- bool autoClearTrigger
- ftm_pwm_sync_mode_t syncPoint

Field Documentation

16.37.2.2.1 bool autoClearTrigger

Available only for hardware trigger

Definition at line 412 of file ftm_common.h.

16.37.2.2.2 bool hardwareSync0

True - enable hardware 0 sync, False - disable hardware 0 sync

Definition at line 398 of file ftm_common.h.

16.37.2.2.3 bool hardwareSync1

True - enable hardware 1 sync, False - disable hardware 1 sync

Definition at line 400 of file ftm_common.h.

16.37.2.2.4 bool hardwareSync2

True - enable hardware 2 sync, False - disable hardware 2 sync

Definition at line 402 of file ftm_common.h.

16.37.2.2.5 ftm_reg_update_t initCounterSync

Configures CNTIN sync

Definition at line 411 of file ftm_common.h.

16.37.2.2.6 ftm_reg_update_t inverterSync

Configures INVCTRL sync

Definition at line 408 of file ftm_common.h.

16.37.2.2.7 ftm_reg_update_t maskRegSync

Configures OUTMASK sync

Definition at line 410 of file ftm_common.h.

16.37.2.2.8 bool maxLoadingPoint

True - enable maximum loading point, False - disable maximum loading point

Definition at line 404 of file ftm_common.h.

16.37.2.2.9 bool minLoadingPoint

True - enable minimum loading point, False - disable minimum loading point

Definition at line 406 of file ftm_common.h.

16.37.2.2.10 ftm_reg_update_t outRegSync

Configures SWOCTRL sync

Definition at line 409 of file ftm_common.h.

16.37.2.2.11 bool softwareSync

True - enable software sync, False - disable software sync

Definition at line 396 of file ftm_common.h.

16.37.2.2.12 ftm_pwm_sync_mode_t syncPoint

Configure synchronization method (waiting next loading point or immediate)

Definition at line 413 of file ftm_common.h.

16.37.2.3 struct ftm_user_config_t

Configuration structure that the user needs to set.

Implements : ftm_user_config_t_Class

Definition at line 422 of file ftm_common.h.

Data Fields

- ftm_pwm_sync_t syncMethod
- ftm_config_mode_t ftmMode
- ftm_clock_ps_t ftmPrescaler
- ftm_clock_source_t ftmClockSource
- ftm_bdm_mode_t BDMMode
- bool isTofIsrEnabled
- bool enableInitializationTrigger

Field Documentation

16.37.2.3.1 ftm_bdm_mode_t BDMMode

Select FTM behavior in BDM mode

Definition at line 430 of file ftm_common.h.

16.37.2.3.2 bool enableInitializationTrigger

true: enable the generation of initialization trigger false: disable the generation of initialization trigger

Definition at line 433 of file ftm_common.h.

16.37.2.3.3 ftm_clock_source_t ftmClockSource

Select clock source for FTM

Definition at line 429 of file ftm_common.h.

16.37.2.3.4 ftm_config_mode_t ftmMode

Mode of operation for FTM

Definition at line 426 of file ftm_common.h.

16.37.2.3.5 ftm_clock_ps_t ftmPrescaler

Register pre-scaler options available in the ftm_clock_ps_t enumeration

Definition at line 427 of file ftm_common.h.

16.37.2.3.6 bool isTofIsrEnabled

true: enable interrupt, false: write interrupt is disabled

Definition at line 431 of file ftm_common.h.

16.37.2.3.7 ftm_pwm_sync_t syncMethod

Register sync options available in the ftm_sync_method_t enumeration

Definition at line 424 of file ftm_common.h.

16.37.3 Macro Definition Documentation

16.37.3.1 #define CHAN0_IDX (0U)

Channel number for CHAN1.

Definition at line 205 of file ftm_common.h.

16.37.3.2 #define CHAN1_IDX (1U)

Channel number for CHAN2.

Definition at line 207 of file ftm_common.h.

16.37.3.3 #define CHAN2_IDX (2U)

Channel number for CHAN3.

Definition at line 209 of file ftm_common.h.

16.37.3.4 #define CHAN3_IDX (3U)

Channel number for CHAN4.

Definition at line 211 of file ftm_common.h.

16.37.3.5 #define CHAN4_IDX (4U)

Channel number for CHAN5.

Definition at line 213 of file ftm_common.h.

16.37.3.6 #define CHAN5_IDX (5U)

Channel number for CHAN6.

Definition at line 215 of file ftm_common.h.

16.37.3.7 #define CHAN6_IDX (6U)

Channel number for CHAN7.

Definition at line 217 of file ftm_common.h.

16.37.3.8 #define CHAN7_IDX (7U)

Definition at line 219 of file ftm_common.h.

16.37.3.9 #define FTM_RMW_CnSCV_REG(base, channel, mask, value) (((base)->CONTROLS[channel].CnSC) = ((((base)->CONTROLS[channel].CnSC) & ∼(mask)) | (value)))

FTM_CnSCV - Read and modify and write Channel (n) Status And Control (RW)

Definition at line 112 of file ftm_common.h.

16.37.3.10 #define FTM_RMW_CNT(base, mask, value) (((base)->CNT) = ((((base)->CNT) & ∼(mask)) | (value)))

FTM_CNT - Read and modify and write to Counter (RW)

Definition at line 87 of file ftm_common.h.

16.37.3.11 #define FTM_RMW_CNTIN(base, mask, value) (((base)->CNTIN) = ((((base)->CNTIN) & ∼(mask)) | (value)))

FTM_CNTIN - Read and modify and write Counter Initial Value (RW)

Definition at line 97 of file ftm_common.h.

16.37.3.12 #define FTM_RMW_CONF(base, mask, value) (((base)->CONF) = ((((base)->CONF) & ∼(mask)) | (value)))

FTM_CONF - Read and modify and write Configuration (RW)

Definition at line 136 of file ftm_common.h.

16.37.3.13 #define FTM_RMW_DEADTIME(base, mask, value) (((base)->DEADTIME) = ((((base)->DEADTIME) & ∼(mask)) | (value)))

FTM_DEADTIME - Read and modify and write Dead-time Insertion Control (RW)

Definition at line 117 of file ftm_common.h.

16.37.3.14 #define FTM_RMW_EXTTRIG_REG(base, mask, value) (((base)->EXTTRIG) = ((((base)->EXTTRIG) & ∼(mask)) | (value)))

FTM_EXTTRIG - Read and modify and write External Trigger Control (RW)

Definition at line 121 of file ftm_common.h.

16.37.3.15 #define FTM_RMW_FILTER(base, mask, value) (((base)->FILTER) = ((((base)->FILTER) & ∼(mask)) | (value)))

FILTER - Read and modify and write Filter (RW)

Definition at line 146 of file ftm_common.h.

16.37.3.16 #define FTM_RMW_FLTCTRL(base, mask, value) (((base)->FLTCTRL) = ((((base)->FLTCTRL) & ∼(mask)) | (value)))

FTM_FLTCTRL - Read and modify and write Fault Control (RW)

Definition at line 126 of file ftm_common.h.

16.37.3.17 #define FTM_RMW_FMS(base, mask, value) (((base)->FMS) = ((((base)->FMS) & ∼(mask)) | (value)))

FTM_FMS - Read and modify and write Fault Mode Status (RW)

Definition at line 131 of file ftm_common.h.

16.37.3.18 #define FTM_RMW_MOD(base, mask, value) (((base)->MOD) = ((((base)->MOD) & ∼(mask)) | (value)))

FTM_MOD - Read and modify and write Modulo (RW)

Definition at line 92 of file ftm_common.h.

16.37.3.19 #define FTM_RMW_MODE(base, mask, value) (((base)->MODE) = ((((base)->MODE) & ∼(mask)) | (value)))

FTM_MODE - Read and modify and write Counter Features Mode Selection (RW)

Definition at line 107 of file ftm_common.h.

16.37.3.20 #define FTM_RMW_PAIR0DEADTIME(base, mask, value) (((base)->PAIR0DEADTIME) = ((((base)->PAIR0DEADTIME) & ∼(mask)) | (value)))

FTM_PAIR0DEADTIME - Read and modify and write Dead-time Insertion Control for the pair 0 (RW)

Definition at line 161 of file ftm_common.h.

16.37.3.21 #define FTM_RMW_PAIR1DEADTIME(base, mask, value) (((base)->PAIR1DEADTIME) = ((((base)->PAIR1DEADTIME) & ∼(mask)) | (value)))

FTM_PAIR1DEADTIME - Read and modify and write Dead-time Insertion Control for the pair 1 (RW)

Definition at line 166 of file ftm_common.h.

16.37.3.22 #define FTM_RMW_PAIR2DEADTIME(base, mask, value) (((base)->PAIR2DEADTIME) = ((((base)->PAIR2DEADTIME) & ∼(mask)) | (value)))

FTM_PAIR2DEADTIME - Read and modify and write Dead-time Insertion Control for the pair 2 (RW)

Definition at line 171 of file ftm_common.h.

16.37.3.23 #define FTM_RMW_PAIR3DEADTIME(base, mask, value) (((base)->PAIR3DEADTIME) = ((((base)->PAIR3DEADTIME) & ∼(mask)) | (value)))

FTM_PAIR3DEADTIME - Read and modify and write Dead-time Insertion Control for the pair 3 (RW)

Channel number for CHAN0.

Definition at line 176 of file ftm_common.h.

16.37.3.24 #define FTM_RMW_POL(base, mask, value) (((base)->POL) = ((((base)->POL) & ∼(mask)) | (value)))

POL - Read and modify and write Polarity (RW)

Definition at line 141 of file ftm_common.h.

16.37.3.25 #define FTM_RMW_QDCTRL(base, mask, value) (((base)->QDCTRL) = ((((base)->QDCTRL) & ∼(mask)) | (value)))

QDCTRL - Read and modify and write Quadrature Decoder Control And Status (RW)

Definition at line 156 of file ftm_common.h.

16.37.3.26 #define FTM_RMW_SC(base, mask, value) (((base)->SC) = ((((base)->SC) & ∼(mask)) | (value)))

FTM_SC - Read and modify and write to Status And Control (RW)

Definition at line 82 of file ftm_common.h.

16.37.3.27 #define FTM_RMW_STATUS(base, mask, value) (((base)->STATUS) = ((((base)->STATUS) & ∼(mask)) | (value)))

FTM_STATUS - Read and modify and write Capture And Compare Status (RW)

Definition at line 102 of file ftm_common.h.

16.37.3.28 #define FTM_RMW_SYNC(base, mask, value) (((base)->SYNC) = ((((base)->SYNC) & ∼(mask)) | (value)))

SYNC - Read and modify and write Synchronization (RW)

Definition at line 151 of file ftm_common.h.

16.37.4 Enumeration Type Documentation

16.37.4.1 enum ftm_bdm_mode_t

Options for the FlexTimer behavior in BDM Mode.

Implements : ftm_bdm_mode_t_Class

Enumerator

FTM_BDM_MODE_00 FTM counter stopped, CH(n)F bit can be set, FTM channels in functional mode, writes to MOD,CNTIN and C(n)V registers bypass the register buffers

FTM_BDM_MODE_01 FTM counter stopped, CH(n)F bit is not set, FTM channels outputs are forced to their safe value , writes to MOD,CNTIN and C(n)V registers bypass the register buffers

FTM_BDM_MODE_10 FTM counter stopped, CH(n)F bit is not set, FTM channels outputs are frozen when chip enters in BDM mode, writes to MOD, CNTIN and C(n)V registers bypass the register buffers

FTM_BDM_MODE_11 FTM counter in functional mode, CH(n)F bit can be set, FTM channels in functional mode, writes to MOD,CNTIN and C(n)V registers is in fully functional mode

Definition at line 355 of file ftm_common.h.

16.37.4.2 enum ftm_clock_ps_t

FlexTimer pre-scaler factor selection for the clock source. In quadrature decoder mode set FTM_CLOCK_DIVID↩ _BY_1.

Implements : ftm_clock_ps_t_Class

Enumerator

FTM_CLOCK_DIVID_BY_1 Divide by 1

FTM_CLOCK_DIVID_BY_2 Divide by 2

FTM_CLOCK_DIVID_BY_4 Divide by 4

FTM_CLOCK_DIVID_BY_8 Divide by 8

FTM_CLOCK_DIVID_BY_16 Divide by 16

FTM_CLOCK_DIVID_BY_32 Divide by 32

FTM_CLOCK_DIVID_BY_64 Divide by 64

FTM_CLOCK_DIVID_BY_128 Divide by 128

Definition at line 261 of file ftm_common.h.

16.37.4.3 enum ftm_clock_source_t

FlexTimer clock source selection.

Implements : ftm_clock_source_t_Class

Enumerator

FTM_CLOCK_SOURCE_NONE None use clock for FTM

FTM_CLOCK_SOURCE_SYSTEMCLK System clock

FTM_CLOCK_SOURCE_FIXEDCLK Fixed clock

FTM_CLOCK_SOURCE_EXTERNALCLK External clock

Definition at line 247 of file ftm_common.h.

16.37.4.4 enum ftm_config_mode_t

FlexTimer operation mode.

Implements : ftm_config_mode_t_Class

Enumerator

FTM_MODE_NOT_INITIALIZED The driver is not initialized

FTM_MODE_INPUT_CAPTURE Input capture

FTM_MODE_OUTPUT_COMPARE Output compare

FTM_MODE_EDGE_ALIGNED_PWM Edge aligned PWM

FTM_MODE_CEN_ALIGNED_PWM Center aligned PWM

FTM_MODE_QUADRATURE_DECODER Quadrature decoder

FTM_MODE_UP_TIMER Timer with up counter

FTM_MODE_UP_DOWN_TIMER timer with up-down counter

FTM_MODE_EDGE_ALIGNED_PWM_AND_INPUT_CAPTURE Edge aligned PWM and input capture

Definition at line 229 of file ftm_common.h.

16.37.4.5 enum ftm_deadtime_ps_t

FlexTimer pre-scaler factor for the dead-time insertion.

Implements : ftm_deadtime_ps_t_Class

Enumerator

FTM_DEADTIME_DIVID_BY_1 Divide by 1

FTM_DEADTIME_DIVID_BY_4 Divide by 4

FTM_DEADTIME_DIVID_BY_16 Divide by 16

Definition at line 343 of file ftm_common.h.

16.37.4.6 enum ftm_interrupt_option_t

List of FTM interrupts.

Implements : ftm_interrupt_option_t_Class

Enumerator

FTM_CHANNEL0_INT_ENABLE Channel 0 interrupt

FTM_CHANNEL1_INT_ENABLE Channel 1 interrupt

FTM_CHANNEL2_INT_ENABLE Channel 2 interrupt

FTM_CHANNEL3_INT_ENABLE Channel 3 interrupt

FTM_CHANNEL4_INT_ENABLE Channel 4 interrupt

FTM_CHANNEL5_INT_ENABLE Channel 5 interrupt

FTM_CHANNEL6_INT_ENABLE Channel 6 interrupt

FTM_CHANNEL7_INT_ENABLE Channel 7 interrupt

FTM_FAULT_INT_ENABLE Fault interrupt

FTM_TIME_OVER_FLOW_INT_ENABLE Time overflow interrupt

FTM_RELOAD_INT_ENABLE Reload interrupt; Available only on certain SoC's

Definition at line 278 of file ftm_common.h.

16.37.4.7 enum ftm_pwm_sync_mode_t

FTM update register.

Implements : ftm_pwm_sync_mode_t_Class

Enumerator

FTM_WAIT_LOADING_POINTS FTM register is updated at first loading point

FTM_UPDATE_NOW FTM register is updated immediately

Definition at line 332 of file ftm_common.h.

16.37.4.8 enum ftm_reg_update_t

FTM sync source.

Implements : ftm_reg_update_t_Class

Enumerator

FTM_SYSTEM_CLOCK Register is updated with its buffer value at all rising edges of system clock

FTM_PWM_SYNC Register is updated with its buffer value at the FTM synchronization

Definition at line 319 of file ftm_common.h.

16.37.4.9 enum ftm_status_flag_t

List of FTM flags.

Implements : ftm_status_flag_t_Class

Enumerator

FTM_CHANNEL0_FLAG Channel 0 Flag

FTM_CHANNEL1_FLAG Channel 1 Flag

FTM_CHANNEL2_FLAG Channel 2 Flag

FTM_CHANNEL3_FLAG Channel 3 Flag

FTM_CHANNEL4_FLAG Channel 4 Flag

FTM_CHANNEL5_FLAG Channel 5 Flag

FTM_CHANNEL6_FLAG Channel 6 Flag

FTM_CHANNEL7_FLAG Channel 7 Flag

FTM_FAULT_FLAG Fault Flag

FTM_TIME_OVER_FLOW_FLAG Time overflow Flag

FTM_RELOAD_FLAG Reload Flag; Available only on certain SoC's

FTM_CHANNEL_TRIGGER_FLAG Channel trigger Flag

Definition at line 298 of file ftm_common.h.

16.37.5 Function Documentation

16.37.5.1 static void FTM_DRV_ClearChnEventStatus (FTM_Type *const *ftmBase,* uint8_t *channel*) [inline], [static]

Clears the FTM peripheral timer all channel event status.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channel*	The FTM peripheral channel number

Implements : FTM_DRV_ClearChnEventStatus_Activity

Definition at line 782 of file ftm_common.h.

16.37.5.2 static void FTM_DRV_ClearChSC (FTM_Type *const *ftmBase*, uint8_t *channel*) [inline], [static]

Clears the content of Channel (n) Status And Control.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channel*	The FTM peripheral channel number

Implements : FTM_DRV_ClearChSC_Activity

Definition at line 529 of file ftm_common.h.

16.37.5.3 static void FTM_DRV_ClearFaultFlagDetected (FTM_Type *const *ftmBase*, uint8_t *channel*) [inline], [static]

Clear a fault condition is detected at the fault input.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channel*	The FTM peripheral channel

Implements : FTM_DRV_ClearFaultFlagDetected_Activity

Definition at line 968 of file ftm_common.h.

16.37.5.4 void FTM_DRV_ClearStatusFlags (uint32_t *instance*, uint32_t *flagMask*)

This function is used to clear the FTM status flags.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*flagMask*	The status flags to clear. This is a logical OR of members of the enumeration ftm_status_flag_t

Definition at line 739 of file ftm_common.c.

16.37.5.5 uint16_t FTM_DRV_ConvertFreqToPeriodTicks (uint32_t *instance*, uint32_t *freqencyHz*)

This function is used to covert the given frequency to period in ticks.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*freqencyHz*	Frequency value in Hz.

Returns

The value in ticks of the frequency

Definition at line 835 of file ftm_common.c.

16.37.5.6 status_t FTM_DRV_CounterReset (uint32_t *instance*, bool *softwareTrigger*)

This function will allow the FTM to restart the counter to its initial counting value in the register. Note that the configuration is set in the FTM_DRV_SetSync() function to make sure that the FTM registers are updated by software trigger or hardware trigger.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*softwareTrigger*	Selects the software trigger or hardware trigger to update COUNT register. • true: A software trigger is generate to update register • false: A software trigger is not implemented and need to update later or select a hardware trigger and waiting an external trigger for updating register.

Definition at line 857 of file ftm_common.c.

16.37.5.7 status_t FTM_DRV_Deinit (uint32_t *instance*)

Shuts down the FTM driver.

Parameters

in	*instance*	The FTM peripheral instance number.

Returns

operation status
- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 196 of file ftm_common.c.

16.37.5.8 static void FTM_DRV_DisableFaultInt (FTM_Type *const *ftmBase*) [inline], [static]

Disables the FTM peripheral timer fault interrupt.

Parameters

in	*ftmBase*	The FTM base address pointer

Implements : FTM_DRV_DisableFaultInt_Activity

Definition at line 855 of file ftm_common.h.

16.37.5.9 void FTM_DRV_DisableInterrupts (uint32_t *instance*, uint32_t *interruptMask*)

This function is used to disable some interrupts.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*interruptMask*	The mask of interrupt. This is a logical OR of members of the enumeration ftm_interrupt_option_t

Definition at line 594 of file ftm_common.c.

16.37.5.10 status_t FTM_DRV_EnableInterrupts (uint32_t *instance*, uint32_t *interruptMask*)

This function will enable the generation a list of interrupts. It includes the FTM overflow interrupts, the reload point interrupt, the fault interrupt and the channel (n) interrupt.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*interruptMask*	The mask of interrupt. This is a logical OR of members of the enumeration ftm_interrupt_option_t

Returns

operation status

- STATUS_SUCCESS : Completed successfully.

Definition at line 543 of file ftm_common.c.

16.37.5.11 status_t FTM_DRV_GenerateHardwareTrigger (uint32_t *instance*)

This function is used to configure a trigger source for FTM instance. This allow a hardware trigger input which can be used in PWM synchronization. Note that the hardware trigger is implemented only on trigger 1 for each instance.

Parameters

in	*instance*	The FTM peripheral instance number.

Returns

operation status

- STATUS_SUCCESS : Completed successfully.

Definition at line 524 of file ftm_common.c.

16.37.5.12 static bool FTM_DRV_GetChInputState (const FTM_Type * *ftmBase,* uint8_t *channel*) [inline], [static]

Get the state of channel input.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channel*	The FTM peripheral channel number

Returns

State of the channel inputs

- true : The channel input is one
- false: The channel input is zero

Implements : FTM_DRV_GetChInputState_Activity

Definition at line 695 of file ftm_common.h.

16.37.5.13 static uint16_t FTM_DRV_GetChnCountVal (const FTM_Type * *ftmBase,* uint8_t *channel*) [inline], [static]

Gets the FTM peripheral timer channel counter value.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channel*	The FTM peripheral channel number

Returns

Channel counter value

Implements : FTM_DRV_GetChnCountVal_Activity

Definition at line 732 of file ftm_common.h.

16.37.5.14 static uint8_t FTM_DRV_GetChnEdgeLevel (const FTM_Type * *ftmBase,* uint8_t *channel*) [inline], [static]

Gets the FTM peripheral timer channel edge level.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channel*	The FTM peripheral channel number

Returns

The ELSnB:ELSnA mode value, will be 00, 01, 10, 11

Implements : FTM_DRV_GetChnEdgeLevel_Activity

Definition at line 551 of file ftm_common.h.

16.37.5.15 static bool FTM_DRV_GetChnEventStatus (const FTM_Type * *ftmBase,* uint8_t *channel*) [inline], [static]

Gets the FTM peripheral timer channel event status.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channel*	The FTM peripheral channel number

Returns

Channel event status

- true : A channel event has occurred
- false : No channel event has occurred

Implements : FTM_DRV_GetChnEventStatus_Activity

Definition at line 752 of file ftm_common.h.

16.37.5.16 static bool FTM_DRV_GetChOutputValue (const FTM_Type * *ftmBase,* uint8_t *channel*) [inline], [static]

Get the value of channel output.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channel*	The FTM peripheral channel number

Returns

Value of the channel outputs

- true : The channel output is one
- false: The channel output is zero

Implements : FTM_DRV_GetChOutputValue_Activity

Definition at line 714 of file ftm_common.h.

16.37.5.17 static uint8_t FTM_DRV_GetClockFilterPs (const FTM_Type * *ftmBase*) [inline], [static]

Reads the FTM filter clock divider.

Parameters

in	*ftmBase*	The FTM base address pointer

Returns

The FTM filter clock pre-scale divider

Implements : FTM_DRV_GetClockFilterPs_Activity

Definition at line 474 of file ftm_common.h.

16.37.5.18 static uint16_t FTM_DRV_GetCounter (const FTM_Type * *ftmBase*) [inline], [static]

Returns the FTM peripheral current counter value.

Parameters

in	*ftmBase*	The FTM base address pointer

Returns

The current FTM timer counter value

Implements : FTM_DRV_GetCounter_Activity

Definition at line 488 of file ftm_common.h.

16.37.5.19 static uint16_t FTM_DRV_GetCounterInitVal (const FTM_Type * *ftmBase*) [inline], [static]

Returns the FTM peripheral counter initial value.

Parameters

in	*ftmBase*	The FTM base address pointer

Returns

FTM timer counter initial value

Implements : FTM_DRV_GetCounterInitVal_Activity

Definition at line 516 of file ftm_common.h.

16.37.5.20 void FTM_DRV_GetDefaultConfig (ftm_user_config_t *const *config*)

This function will get the default configuration values in the structure which is used as a common use-case.

Parameters

out	*config*	Pointer to the structure in which the configuration will be saved.

Returns

None

Definition at line 216 of file ftm_common.c.

16.37.5.21 uint32_t FTM_DRV_GetEnabledInterrupts (uint32_t *instance*)

This function will get the enabled FTM interrupts.

Parameters

in	*instance*	The FTM peripheral instance number.

Returns

The enabled interrupts. This is the logical OR of members of the enumeration ftm_interrupt_option_t

Definition at line 643 of file ftm_common.c.

16.37.5.22 static uint32_t FTM_DRV_GetEventStatus (const FTM_Type * *ftmBase*) [inline],[static]

Gets the FTM peripheral timer status info for all channels.

Parameters

in	*ftmBase*	The FTM base address pointer

Returns

Channel event status value

Implements : FTM_DRV_GetEventStatus_Activity

Definition at line 769 of file ftm_common.h.

16.37.5.23 uint32_t FTM_DRV_GetFrequency (uint32_t *instance*)

Retrieves the frequency of the clock source feeding the FTM counter.

Function will return a 0 if no clock source is selected and the FTM counter is disabled

Parameters

in	*instance*	The FTM peripheral instance number.

Returns

The frequency of the clock source running the FTM counter (0 if counter is disabled)

Definition at line 791 of file ftm_common.c.

16.37.5.24 static uint16_t FTM_DRV_GetMod (const FTM_Type * *ftmBase*) [inline],[static]

Returns the FTM peripheral counter modulo value.

Parameters

in	*ftmBase*	The FTM base address pointer

Returns

FTM timer modulo value

Implements : FTM_DRV_GetMod_Activity

Definition at line 502 of file ftm_common.h.

16.37.5.25 uint32_t FTM_DRV_GetStatusFlags (uint32_t *instance*)

This function will get the FTM status flags. : Regarding the duty cycle is 100% at the channel output, the match interrupt has no event due to the C(n)V and C(n+1)V value are not between CNTIN value and MOD value.

Parameters

in	*instance*	The FTM peripheral instance number.

Returns

The status flags. This is the logical OR of members of the enumeration ftm_status_flag_t

Definition at line 689 of file ftm_common.c.

16.37.5.26 static bool FTM_DRV_GetTriggerControled (const FTM_Type * *ftmBase,* uint8_t *channel*) [inline], [static]

Returns whether the trigger mode is enabled.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channel*	The FTM peripheral channel number

Returns

State of the channel outputs

- true : Enabled a trigger generation on channel output
- false: PWM outputs without generating a pulse

Implements : FTM_DRV_GetTriggerControled_Activity

Definition at line 676 of file ftm_common.h.

16.37.5.27 status_t FTM_DRV_Init (uint32_t *instance,* const ftm_user_config_t * *info,* ftm_state_t * *state*)

Initializes the FTM driver.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*info*	The FTM user configuration structure, see ftm_user_config_t.
out	*state*	The FTM state structure of the driver.

Returns

operation status

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 114 of file ftm_common.c.

16.37.5.28 static bool FTM_DRV_IsChnDma (const FTM_Type * *ftmBase,* uint8_t *channel*) [inline], [static]

Returns whether the FTM peripheral timer channel DMA is enabled.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channel*	The FTM peripheral channel number

Returns

State of the FTM peripheral timer channel DMA

- true : Enabled DMA transfers
- false: Disabled DMA transfers

Implements : FTM_DRV_IsChnDma_Activity

Definition at line 636 of file ftm_common.h.

16.37.5.29 static bool FTM_DRV_IsChnIcrst (const FTM_Type * *ftmBase,* uint8_t *channel*) [inline],[static]

Returns whether the FTM FTM counter is reset.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channel*	The FTM peripheral channel number

Returns

State of the FTM peripheral timer channel ICRST

- true : Enabled the FTM counter reset
- false: Disabled the FTM counter reset

Implements : FTM_DRV_IsChnIcrst_Activity

Definition at line 596 of file ftm_common.h.

16.37.5.30 static bool FTM_DRV_IsFaultFlagDetected (const FTM_Type * *ftmBase,* uint8_t *channel*) [inline], [static]

Checks whether a fault condition is detected at the fault input.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channel*	The FTM peripheral channel

Returns

the fault condition status

- true : A fault condition was detected at the fault input
- false: No fault condition was detected at the fault input

Implements : FTM_DRV_IsFaultFlagDetected_Activity

Definition at line 952 of file ftm_common.h.

16.37.5.31 static bool FTM_DRV_IsFaultInputEnabled (const FTM_Type * *ftmBase*) [inline],[static]

Checks whether the logic OR of the fault inputs is enabled.

Parameters

in	*ftmBase*	The FTM base address pointer

Returns

the enabled fault inputs status

- true : The logic OR of the enabled fault inputs is 1

- false: The logic OR of the enabled fault inputs is 0

Implements : FTM_DRV_IsFaultInputEnabled_Activity

Definition at line 935 of file ftm_common.h.

16.37.5.32 static bool FTM_DRV_IsFtmEnable (const FTM_Type * *ftmBase*) [inline],[static]

Get status of the FTMEN bit in the FTM_MODE register.

Parameters

in	*ftmBase*	The FTM base address pointer

Returns

the FTM Enable status

- true : TPM compatibility. Free running counter and synchronization compatible with TPM
- false: Free running counter and synchronization are different from TPM behavior

Implements : FTM_DRV_IsFtmEnable_Activity

Definition at line 886 of file ftm_common.h.

16.37.5.33 static bool FTM_DRV_IsWriteProtectionEnabled (const FTM_Type * *ftmBase*) [inline],[static]

Checks whether the write protection is enabled.

Parameters

in	*ftmBase*	The FTM base address pointer

Returns

Write-protection status

- true : If enabled
- false: If not

Implements : FTM_DRV_IsWriteProtectionEnabled_Activity

Definition at line 919 of file ftm_common.h.

16.37.5.34 status_t FTM_DRV_MaskOutputChannels (uint32_t *instance,* uint32_t *channelsMask,* bool *softwareTrigger*)

This function will mask the output of the channels and at match events will be ignored by the masked channels.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*channelsMask*	The mask which will select which channels will ignore match events.
in	*softwareTrigger*	If true a software trigger is generate to update PWM parameters.

Returns

success

- STATUS_SUCCESS : Completed successfully.

Definition at line 249 of file ftm_common.c.

16.37.5.35 status_t FTM_DRV_SetAllChnSoftwareOutputControl (uint32_t *instance,* uint8_t *channelMask,* uint8_t *channelValueMask,* bool *softwareTrigger*)

This function will control list of channels by software to force the output to specified value. Despite the odd channels are configured as HIGH/LOW, they will be inverted in the following configuration: COMP bit = 1 and CH(n)OCV and CH(n+1)OCV are HIGH. Please check software output control behavior chapter from reference manual. : When the PWM signal is configured with LOW/HIGH polarity on the channel (n). It should be set the safe state as LOW level state. However, We will have an issue with COMP bit is zero and CH(n)OCV is HIGH and CH(n+1)OCV is LOW.in the independent channel configuration. Code configuration: { .polarity = FTM_POLARITY_HIGH, .safeState = FT↩ M_POLARITY_LOW, .enableSecondChannelOutput = true, .secondChannelPolarity = FTM_MAIN_DUPLICATED, }.

Workaround: Configure the safe state as HIGH level state. The expected output will be correctly controlling Should change configuration as following: { .polarity = FTM_POLARITY_HIGH, .safeState = FTM_HIGH_STATE, .enable↩ SecondChannelOutput = true, .secondChannelPolarity = FTM_MAIN_DUPLICATED, }

Parameters

in	*instance*	The FTM peripheral instance number.
in	*channelMask*	The mask which will configure the channels which can be software controlled.
in	*channelValue↩ Mask*	The values which will be software configured for channels.
in	*softwareTrigger*	If true a software trigger is generate to update registers.

Returns

success

- STATUS_SUCCESS : Completed successfully.

Definition at line 357 of file ftm_common.c.

16.37.5.36 static void FTM_DRV_SetCaptureTestCmd (FTM_Type ∗const *ftmBase,* bool *enable*) [inline], [static]

Enables or disables the FTM peripheral timer capture test mode.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*enable*	Capture Test Mode Enable • true : Capture test mode is enabled • false: Capture test mode is disabled

Implements : FTM_DRV_SetCaptureTestCmd_Activity

Definition at line 870 of file ftm_common.h.

16.37.5.37 static void FTM_DRV_SetChnDmaCmd (FTM_Type ∗const *ftmBase,* uint8_t *channel,* bool *enable*) [inline], [static]

Enables or disables the FTM peripheral timer channel DMA.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channel*	The FTM peripheral channel number
in	*enable*	Enable DMA transfers for the channel • true : Enabled DMA transfers • false: Disabled DMA transfers

Implements : FTM_DRV_SetChnDmaCmd_Activity

Definition at line 615 of file ftm_common.h.

16.37.5.38 static void FTM_DRV_SetChnIcrstCmd (FTM_Type ∗const *ftmBase,* uint8_t *channel,* bool *enable*) [inline], [static]

Configure the feature of FTM counter reset by the selected input capture event.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channel*	The FTM peripheral channel number
in	*enable*	Enable the FTM counter reset • true : FTM counter is reset • false: FTM counter is not reset

Implements : FTM_DRV_SetChnIcrstCmd_Activity

Definition at line 575 of file ftm_common.h.

16.37.5.39 static void FTM_DRV_SetChnOutputInitStateCmd (FTM_Type ∗const *ftmBase,* uint8_t *channel,* bool *state*) [inline], [static]

Sets the FTM peripheral timer channel output initial state 0 or 1.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channel*	The FTM peripheral channel number
in	*state*	Initial state for channels output • true : The initialization value is 1 • false: The initialization value is 0

Implements : FTM_DRV_SetChnOutputInitStateCmd_Activity

Definition at line 832 of file ftm_common.h.

16.37.5.40 static void FTM_DRV_SetChnOutputMask (FTM_Type ∗const *ftmBase,* uint8_t *channel,* bool *mask*) [inline], [static]

Sets the FTM peripheral timer channel output mask.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channel*	The FTM peripheral channel number
in	*mask*	Value to set Output Mask • true : Channel output is masked • false: Channel output is not masked

Implements : FTM_DRV_SetChnOutputMask_Activity

Definition at line 805 of file ftm_common.h.

16.37.5.41 static void FTM_DRV_SetChnSoftwareCtrlCmd (FTM_Type ∗const *ftmBase,* uint8_t *channel,* bool *enable*) [inline], [static]

Enables or disables the channel software output control.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channel*	Channel to be enabled or disabled
in	*enable*	State of channel software output control • true : To enable the channel output will be affected by software output control • false: To disable the channel output is unaffected

Implements : FTM_DRV_SetChnSoftwareCtrlCmd_Activity

Definition at line 1018 of file ftm_common.h.

16.37.5.42 static void FTM_DRV_SetChnSoftwareCtrlVal (FTM_Type ∗const *ftmBase,* uint8_t *channel,* bool *enable*) [inline],[static]

Sets the channel software output control value. Despite the odd channels are configured as HIGH/LOW, they will be inverted in the following configuration: COMP bit = 1 and CH(n)OCV and CH(n+1)OCV are HIGH. Please check Software output control behavior chapter from RM.

Parameters

in	*ftmBase*	The FTM base address pointer.
in	*channel*	Channel to be configured
in	*enable*	State of software output control value • true : to force 1 to the channel output • false: to force 0 to the channel output

Implements : FTM_DRV_SetChnSoftwareCtrlVal_Activity

Definition at line 1048 of file ftm_common.h.

16.37.5.43 static void FTM_DRV_SetClockFilterPs (FTM_Type ∗const *ftmBase,* uint8_t *filterPrescale*) [inline], [static]

Sets the filter Pre-scaler divider.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*filterPrescale*	The FTM peripheral clock pre-scale divider

Implements : FTM_DRV_SetClockFilterPs_Activity

Definition at line 459 of file ftm_common.h.

16.37.5.44 static void FTM_DRV_SetCountReinitSyncCmd (FTM_Type ∗const *ftmBase,* bool *enable*) [inline], [static]

Determines if the FTM counter is re-initialized when the selected trigger for synchronization is detected.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*enable*	FTM counter re-initialization selection • true : To update FTM counter when triggered • false: To count normally

Implements : FTM_DRV_SetCountReinitSyncCmd_Activity

Definition at line 902 of file ftm_common.h.

16.37.5.45 static void FTM_DRV_SetDualChnInvertCmd (FTM_Type ∗const *ftmBase,* uint8_t *chnlPairNum,* bool *enable*) [inline], [static]

Enables or disables the channel invert for a channel pair.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*chnlPairNum*	The FTM peripheral channel pair number
in	*enable*	State of channel invert for a channel pair • true : To enable channel inverting • false: To disable channel inversion

Implements : FTM_DRV_SetDualChnInvertCmd_Activity

Definition at line 991 of file ftm_common.h.

16.37.5.46 static void FTM_DRV_SetExtPairDeadtimeValue (FTM_Type ∗const *ftmBase,* uint8_t *channelPair,* uint8_t *value*) [inline], [static]

Sets the FTM extended dead-time value for the channel pair.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channelPair*	The FTM peripheral channel pair (n)
in	*value*	The FTM peripheral extend pre-scale divider using the concatenation with the dead-time value

Implements : FTM_DRV_SetExtPairDeadtimeValue_Activity

Definition at line 1245 of file ftm_common.h.

16.37.5.47 static void FTM_DRV_SetGlobalLoadCmd (FTM_Type ∗const *ftmBase*) [inline], [static]

Set the global load mechanism.

Parameters

in	*ftmBase*	The FTM base address pointer

Implements : FTM_DRV_SetGlobalLoadCmd_Activity

Definition at line 1072 of file ftm_common.h.

16.37.5.48 static void FTM_DRV_SetGlobalTimeBaseCmd (FTM_Type ∗const *ftmBase,* bool *enable*) [inline], [static]

Enables or disables the FTM timer global time base.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*enable*	State of global time base • true : To enable an external global time base signal • false: To disable an external global time base signal

Implements : FTM_DRV_SetGlobalTimeBaseCmd_Activity

Definition at line 1216 of file ftm_common.h.

16.37.5.49 static void FTM_DRV_SetGlobalTimeBaseOutputCmd (FTM_Type *const *ftmBase,* bool *enable*) [inline], [static]

Enables or disables the FTM global time base signal generation to other FTM's.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*enable*	State of global time base signal • true : To enable the golobal time base generation to other FTM instances • false: To disable the golobal time base generation to other FTM instances

Implements : FTM_DRV_SetGlobalTimeBaseOutputCmd_Activity

Definition at line 1200 of file ftm_common.h.

16.37.5.50 static void FTM_DRV_SetHalfCycleCmd (FTM_Type ∗const *ftmBase,* bool *enable*) [inline],[static]

Enable the half cycle reload.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*enable*	State of the half cycle match as a reload opportunity • true : Half cycle reload is enabled • false: Half cycle reload is disabled

Implements : FTM_DRV_SetHalfCycleCmd_Activity

Definition at line 1110 of file ftm_common.h.

16.37.5.51 status_t FTM_DRV_SetHalfCycleReloadPoint (uint32_t *instance,* uint16_t *reloadPoint,* bool *softwareTrigger*)

This function configure the value of the counter which will generates an reload point.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*reloadPoint*	Counter value which generates the reload point.
in	*softwareTrigger*	If true a software trigger is generate to update parameters.

Returns

success

- STATUS_SUCCESS : Completed successfully.

Definition at line 291 of file ftm_common.c.

16.37.5.52 status_t FTM_DRV_SetInitialCounterValue (uint32_t *instance,* uint16_t *counterValue,* bool *softwareTrigger*)

This function configure the initial counter value. The counter will get this value after an overflow event.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*counterValue*	Initial counter value.
in	*softwareTrigger*	If true a software trigger is generate to update parameters.

Returns

success

- STATUS_SUCCESS : Completed successfully.

Definition at line 270 of file ftm_common.c.

16.37.5.53 static void FTM_DRV_SetInitTrigOnReloadCmd (FTM_Type *const *ftmBase,* bool *enable*) [inline], [static]

Enables or disables the FTM initialization trigger on Reload Point.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*enable*	bit controls whether an initialization trigger is generated • true : Trigger is generated when a reload point is reached • false: Trigger is generated on counter wrap events

Implements : FTM_DRV_SetInitTrigOnReloadCmd_Activity

Definition at line 1184 of file ftm_common.h.

16.37.5.54 status_t FTM_DRV_SetInvertingControl (uint32_t *instance,* uint8_t *channelsPairMask,* bool *softwareTrigger*)

This function will configure if the second channel of a pair will be inverted or not.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*channelsPair↩ Mask*	The mask which will configure which channel pair will invert the second channel.
in	*softwareTrigger*	If true a software trigger is generate to update registers.

Returns

success
- STATUS_SUCCESS : Completed successfully.

Definition at line 383 of file ftm_common.c.

16.37.5.55 static void FTM_DRV_SetLoadCmd (FTM_Type ∗const *ftmBase,* bool *enable*) [inline], [static]

Enable the global load.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*enable*	State of the global load mechanism • true : Global Load OK enabled • false: Global Load OK disabled

Implements : FTM_DRV_SetLoadCmd_Activity

Definition at line 1087 of file ftm_common.h.

16.37.5.56 static void FTM_DRV_SetLoadFreq (FTM_Type ∗const *ftmBase,* uint8_t *val*) [inline], [static]

Sets the frequency of reload points.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*val*	Value of the TOF bit set frequency

Implements : FTM_DRV_SetLoadFreq_Activity

Definition at line 1230 of file ftm_common.h.

16.37.5.57 status_t FTM_DRV_SetModuloCounterValue (uint32_t *instance,* uint16_t *counterValue,* bool *softwareTrigger*)

This function configure the maximum counter value.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*counterValue*	Maximum counter value
in	*softwareTrigger*	If true a software trigger is generate to update parameters.

Returns

success

- STATUS_SUCCESS : Completed successfully.

Definition at line 403 of file ftm_common.c.

16.37.5.58 status_t FTM_DRV_SetOutputlevel (uint32_t *instance,* uint8_t *channel,* uint8_t *level*)

This function will set the channel edge or level on the selection of the channel mode.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*channel*	The channel number.
in	*level*	The level or edge selection for channel mode.

Returns

success

- STATUS_SUCCESS : Completed successfully.

Definition at line 424 of file ftm_common.c.

16.37.5.59 static void FTM_DRV_SetPairDeadtimeCount (FTM_Type ∗const *ftmBase,* uint8_t *channelPair,* uint8_t *count*) [inline], [static]

Sets the FTM dead-time value for the channel pair.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channelPair*	The FTM peripheral channel pair (n)
in	*count*	The FTM peripheral selects the dead-time value • 0U : no counts inserted • 1U : 1 count is inserted • 2U : 2 count is inserted • ... up to a possible 63 counts

Implements : FTM_DRV_SetPairDeadtimeCount_Activity

Definition at line 1323 of file ftm_common.h.

16.37.5.60 static void FTM_DRV_SetPairDeadtimePrescale (FTM_Type ∗const *ftmBase,* uint8_t *channelPair,* ftm_deadtime_ps_t *divider*) [inline], [static]

Sets the FTM dead time divider for the channel pair.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channelPair*	The FTM peripheral channel pair (n)
in	*divider*	The FTM peripheral pre-scaler divider • FTM_DEADTIME_DIVID_BY_1 : Divide by 1 • FTM_DEADTIME_DIVID_BY_4 : Divide by 4 • FTM_DEADTIME_DIVID_BY_16: Divide by 16

Implements : FTM_DRV_SetPairDeadtimePrescale_Activity

Definition at line 1284 of file ftm_common.h.

16.37.5.61 static void FTM_DRV_SetPwmLoadChnSelCmd (FTM_Type ∗const *ftmBase,* uint8_t *channel,* bool *enable*) [inline],[static]

Includes or excludes the channel in the matching process.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channel*	Channel to be configured
in	*enable*	State of channel • true : means include the channel in the matching process • false: means do not include channel in the matching process

Implements : FTM_DRV_SetPwmLoadChnSelCmd_Activity

Definition at line 1157 of file ftm_common.h.

16.37.5.62 static void FTM_DRV_SetPwmLoadCmd (FTM_Type ∗const *ftmBase,* bool *enable*) [inline],[static]

Enables or disables the loading of MOD, CNTIN and CV with values of their write buffer.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*enable*	State of loading updated values • true : To enable the loading of value of their buffer • false: To disable the loading of value of their buffer

Implements : FTM_DRV_SetPwmLoadCmd_Activity

Definition at line 1133 of file ftm_common.h.

16.37.5.63 status_t FTM_DRV_SetSoftOutChnValue (uint32_t *instance,* uint8_t *channelsValues,* bool *softwareTrigger*)

This function will force the output value of a channel to a specific value. Before using this function it's mandatory to mask the match events using FTM_DRV_MaskOutputChannels and to enable software output control using FT↩ M_DRV_SetSoftwareOutputChannelControl. : When the PWM signal is configured with LOW/HIGH polarity on the channel (n). It should be set the safe state as LOW level state. However, We will have an issue with COMP bit is zero and CH(n)OCV is HIGH and CH(n+1)OCV is LOW.in the independent channel configuration. Code configuration↩ : { .polarity = FTM_POLARITY_HIGH, .safeState = FTM_POLARITY_LOW, .enableSecondChannelOutput = true, .secondChannelPolarity = FTM_MAIN_DUPLICATED, }.

Workaround: Configure the safe state as HIGH level state. The expected output will be correctly controlling Should change configuration as following: { .polarity = FTM_POLARITY_HIGH, .safeState = FTM_HIGH_STATE, .enable↩ SecondChannelOutput = true, .secondChannelPolarity = FTM_MAIN_DUPLICATED, }

Parameters

in	*instance*	The FTM peripheral instance number.
in	*channelsValues*	The values which will be software configured for channels.
in	*softwareTrigger*	If true a software trigger is generate to update registers.

Returns

success

- STATUS_SUCCESS : Completed successfully.

Definition at line 314 of file ftm_common.c.

16.37.5.64 status_t FTM_DRV_SetSoftwareOutputChannelControl (uint32_t *instance,* uint8_t *channelsMask,* bool *softwareTrigger*)

This function will configure which output channel can be software controlled. Software output control forces the following values on channels (n) and (n+1) when the COMP bit is zero and POL bit is zero. CH(n)OC|CH(n+1)O↩C|CH(n)OCV|CH(n+1)OCV|Channel (n) Output | Channel (n+1) Output 0 | 0 | X | X | is not modified by SWOC| is not modified by SWOC 1 | 1 | 0 | 0 | is forced to zero | is forced to zero 1 | 1 | 0 | 1 | is forced to zero | is forced to one 1 | 1 | 1 | 0 | is forced to one | is forced to zero 1 | 1 | 1 | 1 | is forced to one | is forced to one.

Software output control forces the following values on channels (n) and (n+1) when the COMP bit is one and POL bit is zero. CH(n)OC|CH(n+1)OC|CH(n)OCV|CH(n+1)OCV|Channel (n) Output | Channel (n+1) Output 0 | 0 | X | X | is not modified by SWOC| is not modified by SWOC 1 | 1 | 0 | 0 | is forced to zero | is forced to zero 1 | 1 | 0 | 1 | is forced to zero | is forced to one 1 | 1 | 1 | 0 | is forced to one | is forced to zero 1 | 1 | 1 | 1 | is forced to one | is forced to zero

Parameters

in	*instance*	The FTM peripheral instance number.
in	*channelsMask*	The mask which will configure the channels which can be software controlled.
in	*softwareTrigger*	If true a software trigger is generate to update registers.

Returns

success

- STATUS_SUCCESS : Completed successfully.

Definition at line 334 of file ftm_common.c.

16.37.5.65 status_t FTM_DRV_SetSync (uint32_t *instance,* const ftm_pwm_sync_t * *param*)

This function configures sync mechanism for some FTM registers (MOD, CNINT, HCR, CnV, OUTMASK, INVCTRL, SWOCTRL).

Parameters

in	*instance*	The FTM peripheral instance number.
in	*param*	The sync configuration structure.

Returns

operation status

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 448 of file ftm_common.c.

16.37.5.66 static void FTM_DRV_SetTrigModeControlCmd (FTM_Type ∗const *ftmBase,* uint8_t *channel,* bool *enable*) [inline], [static]

Enables or disables the trigger generation on FTM channel outputs.

Parameters

in	*ftmBase*	The FTM base address pointer
in	*channel*	The FTM peripheral channel number
in	*enable*	Trigger mode control • false : Enable PWM output without generating a pulse • true : Disable a trigger generation on channel output

Implements : FTM_DRV_SetTrigModeControlCmd_Activity

Definition at line 655 of file ftm_common.h.

16.37.6 Variable Documentation

16.37.6.1 ftm_state_t* ftmStatePtr[FTM_INSTANCE_COUNT]

Pointer to runtime state structure.

Definition at line 81 of file ftm_common.c.

16.37.6.2 FTM_Type* const g_ftmBase[FTM_INSTANCE_COUNT]

Table of base addresses for FTM instances.

Definition at line 68 of file ftm_common.c.

16.37.6.3 const IRQn_Type g_ftmFaultIrqId[FTM_INSTANCE_COUNT]

Definition at line 72 of file ftm_common.c.

16.37.6.4 const IRQn_Type g_ftmIrqId[FTM_INSTANCE_COUNT][FEATURE_FTM_CHANNEL_COUNT]

Interrupt vectors for the FTM peripheral.

Definition at line 71 of file ftm_common.c.

16.37.6.5 const IRQn_Type g_ftmOverflowIrqId[FTM_INSTANCE_COUNT]

Definition at line 73 of file ftm_common.c.

16.37.6.6 const IRQn_Type g_ftmReloadIrqId[FTM_INSTANCE_COUNT]

Definition at line 74 of file ftm_common.c.

16.38 FlexTimer Input Capture Driver (FTM_IC)

16.38.1 Detailed Description

FlexTimer Input Capture Peripheral Driver.

Hardware background

The FTM of the S32K1xx is based on a 16 bits counter and supports: input capture, output compare, PWM and some instances include quadrature decoder.

How to use FTM driver in your application

For all operation modes (without Quadrature Decoder mode) the user need to configure ftm_user_config_t. This structure will be used for initialization (FTM_DRV_Init). The next functions used are specific for each operation mode.

Single edge input capture mode

For this mode the user needs to configure parameters such: maximum counter value, number of channels, input capture operation mode (for single edge input are used edge detect mode) and edge alignment. All this information is included in the ftm_input_param_t structure.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\ftm\ftm_ic_driver.c
${S32SDK_PATH}\platform\drivers\src\ftm\ftm_common.c
${S32SDK_PATH}\platform\drivers\src\ftm\ftm_hw_access.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
${S32SDK_PATH}\platform\drivers\src\ftm\
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager Interrupt Manager (Interrupt)

Example:

```
/* The state structure of instance in the input capture mode */
ftm_state_t stateInputCapture;
#define FTM_IC_INSTANCE        0UL
/* Channels configuration structure for inputCapture input capture */
ftm_input_ch_param_t inputCapture_InputCaptureChannelConfig[1] =
{
    {
    0U,                             /* Channel Id */
    FTM_EDGE_DETECT,                /* Input capture operation Mode */
    FTM_RISING_EDGE,                /* Edge alignment Mode */
    FTM_NO_MEASUREMENT,             /* Signal measurement operation type */
    0U,                             /* Filter value */
    false,                          /* Filter disabled */
    true                            /* Continuous mode measurement */
    NULL,                           /* Vector of callbacks  parameters for channels events */
    NULL                            /* Vector of callbacks for channels events */
    }
```

```
};
/* Input capture configuration for inputCapture */
ftm_input_param_t inputCapture_InputCaptureConfig =
{
    1U,                                     /* Number of channels */
    65535U,                                 /* Maximum count value */
    inputCapture_InputCaptureChannelConfig  /* Channels configuration */
};
/* Timer mode configuration for inputCapture */
/* Global configuration of inputCapture */
ftm_user_config_t  inputCapture_InitConfig =
{
    {
        false,                      /* Software trigger state */
        false,                      /* Hardware trigger 1 state */
        false,                      /* Hardware trigger 2 state */
        false,                      /* Hardware trigger 3 state */
        false,                      /* Maximum loading point state */
        false,                      /* Min loading point state */
        FTM_SYSTEM_CLOCK,           /* Update mode for INVCTRL register */
        FTM_SYSTEM_CLOCK,           /* Update mode for SWOCTRL register */
        FTM_SYSTEM_CLOCK,           /* Update mode for OUTMASK register */
        FTM_SYSTEM_CLOCK,           /* Update mode for CNTIN register */
        false,                      /* Auto clear trigger state for hardware trigger */
        FTM_UPDATE_NOW,             /* Select synchronization method */
    },
    FTM_MODE_INPUT_CAPTURE,         /* Mode of operation for FTM */
    FTM_CLOCK_DIVID_BY_4,           /* FTM clock pre-scaler */
    FTM_CLOCK_SOURCE_SYSTEMCLK,     /* FTM clock source */
    FTM_BDM_MODE_00,                /* FTM debug mode */
    false,                          /* Interrupt state */
    false                           /* Initialization trigger */
};
FTM_DRV_Init(FTM_IC_INSTANCE, &inputCapture_InitConfig, &stateInputCapture);
FTM_DRV_InitInputCapture(FTM_IC_INSTANCE, &inputCapture_InputCaptureConfig);
counter = FTM_DRV_GetInputCaptureMeasurement(FTM_IC_INSTANCE, 0UL);
```

FTM_DRV_GetInputCaptureMeasurement is now used in interrupt mode and this function is used to save time stamps in internal buffers.

Edge-Aligned PWM and Input Capture mode

- Support both Edge-Aligned PWM and Input Capture mode can work over the same FTM instance.
- The guideline can be found here FlexTimer Pulse Width Modulation Driver (FTM_PWM)

Data Structures

- struct ftm_input_ch_param_t

  FlexTimer driver Input capture parameters for each channel. More...
- struct ftm_input_param_t

  FlexTimer driver input capture parameters. More...

Enumerations

- enum ftm_input_op_mode_t { FTM_EDGE_DETECT = 0U, FTM_SIGNAL_MEASUREMENT = 1U, FTM_↩ NO_OPERATION = 2U }

  Selects mode operation in the input capture.
- enum ftm_signal_measurement_mode_t { FTM_NO_MEASUREMENT = 0x00U, FTM_RISING_EDGE_PERIOD_MEASUREMENT = 0x01U, FTM_F↩ ALLING_EDGE_PERIOD_MEASUREMENT = 0x02U, FTM_PERIOD_ON_MEASUREMENT = 0x03U, FTM_PERIOD_OFF_MEASUREMENT = 0x04U }

  FlexTimer input capture measurement type for dual edge input capture.
- enum ftm_edge_alignment_mode_t { FTM_NO_PIN_CONTROL = 0x00U, FTM_RISING_EDGE = 0x01U, FTM_FALLING_EDGE = 0x02U, FTM_BOTH_EDGES = 0x03U }

  FlexTimer input capture edge mode as rising edge or falling edge.

- enum ftm_ic_op_mode_t {
  FTM_DISABLE_OPERATION = 0x00U, FTM_TIMESTAMP_RISING_EDGE = 0x01U, FTM_TIMESTAMP↩
  _FALLING_EDGE = 0x02U, FTM_TIMESTAMP_BOTH_EDGES = 0x03U,
  FTM_MEASURE_RISING_EDGE_PERIOD = 0x04U, FTM_MEASURE_FALLING_EDGE_PERIOD = 0x05U, FTM_MEASURE_PULSE_HIGH = 0x06U, FTM_MEASURE_PULSE_LOW = 0x07U }

  The measurement type for input capture mode Implements : ftm_ic_op_mode_t_Class.

Functions

- status_t FTM_DRV_InitInputCapture (uint32_t instance, const ftm_input_param_t *param)

  This function configures the channel in the Input Capture mode for either getting time-stamps on edge detection or on signal measurement. When the edge specified in the captureMode argument occurs on the channel and then the FTM counter is captured into the CnV register. The user have to read the CnV register separately to get this value. The filter function is disabled if the filterVal argument passed as 0. The filter feature. is available only on channels 0,1,2,3.
- status_t FTM_DRV_DeinitInputCapture (uint32_t instance, const ftm_input_param_t *param)

  Disables input capture mode and clears FTM timer configuration.
- uint16_t FTM_DRV_GetInputCaptureMeasurement (uint32_t instance, uint8_t channel)

  This function is used to calculate the measurement and/or time stamps values which are read from the C(n, n+1)V registers and stored to the static buffers.
- status_t FTM_DRV_StartNewSignalMeasurement (uint32_t instance, uint8_t channel)

  Starts new single-shot signal measurement of the given channel.
- status_t FTM_IC_DRV_SetChannelMode (uint32_t instance, uint8_t channel, ftm_ic_op_mode_t inputMode, bool enableContinuousCapture)

  Set mode operation for channel in the input capture mode.

16.38.2 Data Structure Documentation

16.38.2.1 struct ftm_input_ch_param_t

FlexTimer driver Input capture parameters for each channel.

Implements : ftm_input_ch_param_t_Class

Definition at line 96 of file ftm_ic_driver.h.

Data Fields

- uint8_t hwChannelId
- ftm_input_op_mode_t inputMode
- ftm_edge_alignment_mode_t edgeAlignement
- ftm_signal_measurement_mode_t measurementType
- uint16_t filterValue
- bool filterEn
- bool continuousModeEn
- void * channelsCallbacksParams
- ic_callback_t channelsCallbacks

Field Documentation

16.38.2.1.1 ic_callback_t channelsCallbacks

The callback function for channels events

Definition at line 106 of file ftm_ic_driver.h.

16.38.2.1.2 void* channelsCallbacksParams

The parameters of callback functions for channels events

Definition at line 105 of file ftm_ic_driver.h.

16.38.2.1.3 bool continuousModeEn

Continuous measurement state

Definition at line 104 of file ftm_ic_driver.h.

16.38.2.1.4 ftm_edge_alignment_mode_t edgeAlignement

Edge alignment Mode for signal measurement

Definition at line 100 of file ftm_ic_driver.h.

16.38.2.1.5 bool filterEn

Input capture filter state

Definition at line 103 of file ftm_ic_driver.h.

16.38.2.1.6 uint16_t filterValue

Filter Value

Definition at line 102 of file ftm_ic_driver.h.

16.38.2.1.7 uint8_t hwChannelId

Physical hardware channel ID

Definition at line 98 of file ftm_ic_driver.h.

16.38.2.1.8 ftm_input_op_mode_t inputMode

FlexTimer module mode of operation

Definition at line 99 of file ftm_ic_driver.h.

16.38.2.1.9 ftm_signal_measurement_mode_t measurementType

Measurement Mode for signal measurement

Definition at line 101 of file ftm_ic_driver.h.

16.38.2.2 struct ftm_input_param_t

FlexTimer driver input capture parameters.

Implements : ftm_input_param_t_Class

Definition at line 114 of file ftm_ic_driver.h.

Data Fields

- uint8_t nNumChannels
- uint16_t nMaxCountValue
- ftm_input_ch_param_t * inputChConfig

Field Documentation

16.38.2.2.1 ftm_input_ch_param_t* inputChConfig

Input capture channels configuration

Definition at line 118 of file ftm_ic_driver.h.

16.38.2.2.2 uint16_t nMaxCountValue

Maximum counter value. Minimum value is 0 for this mode

Definition at line 117 of file ftm_ic_driver.h.

16.38.2.2.3 uint8_t nNumChannels

Number of input capture channel used

Definition at line 116 of file ftm_ic_driver.h.

16.38.3 Enumeration Type Documentation

16.38.3.1 enum ftm_edge_alignment_mode_t

FlexTimer input capture edge mode as rising edge or falling edge.

Implements : ftm_edge_alignment_mode_t_Class

Enumerator

FTM_NO_PIN_CONTROL No trigger
FTM_RISING_EDGE Rising edge trigger
FTM_FALLING_EDGE Falling edge trigger
FTM_BOTH_EDGES Rising and falling edge trigger

Definition at line 67 of file ftm_ic_driver.h.

16.38.3.2 enum ftm_ic_op_mode_t

The measurement type for input capture mode Implements : ftm_ic_op_mode_t_Class.

Enumerator

FTM_DISABLE_OPERATION Have no operation
FTM_TIMESTAMP_RISING_EDGE Rising edge trigger
FTM_TIMESTAMP_FALLING_EDGE Falling edge trigger
FTM_TIMESTAMP_BOTH_EDGES Rising and falling edge trigger
FTM_MEASURE_RISING_EDGE_PERIOD Period measurement between two consecutive rising edges
FTM_MEASURE_FALLING_EDGE_PERIOD Period measurement between two consecutive falling edges
FTM_MEASURE_PULSE_HIGH The time measurement taken for the pulse to remain ON or HIGH state
FTM_MEASURE_PULSE_LOW The time measurement taken for the pulse to remain OFF or LOW state

Definition at line 79 of file ftm_ic_driver.h.

16.38.3.3 enum ftm_input_op_mode_t

Selects mode operation in the input capture.

Implements : ftm_input_op_mode_t_Class

Enumerator

FTM_EDGE_DETECT FTM edge detect
FTM_SIGNAL_MEASUREMENT FTM signal measurement
FTM_NO_OPERATION FTM no operation

Definition at line 41 of file ftm_ic_driver.h.

16.38.3.4 enum ftm_signal_measurement_mode_t

FlexTimer input capture measurement type for dual edge input capture.

Implements : ftm_signal_measurement_mode_t_Class

Enumerator

FTM_NO_MEASUREMENT No measurement

FTM_RISING_EDGE_PERIOD_MEASUREMENT Period measurement between two consecutive rising edges

FTM_FALLING_EDGE_PERIOD_MEASUREMENT Period measurement between two consecutive falling edges

FTM_PERIOD_ON_MEASUREMENT The time measurement taken for the pulse to remain ON or HIGH state

FTM_PERIOD_OFF_MEASUREMENT The time measurement taken for the pulse to remain OFF or LOW state

Definition at line 53 of file ftm_ic_driver.h.

16.38.4 Function Documentation

16.38.4.1 status_t FTM_DRV_DeinitInputCapture (uint32_t *instance,* const ftm_input_param_t * *param*)

Disables input capture mode and clears FTM timer configuration.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*param*	Configuration of the output compare channel.

Returns

success

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 333 of file ftm_ic_driver.c.

16.38.4.2 uint16_t FTM_DRV_GetInputCaptureMeasurement (uint32_t *instance,* uint8_t *channel*)

This function is used to calculate the measurement and/or time stamps values which are read from the C(n, n+1)V registers and stored to the static buffers.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*channel*	For getting the time stamp of the last edge (in normal input capture) this parameter represents the channel number. For getting the last measured value (in dual edge input capture) this parameter is the lowest channel number of the pair (EX: 0, 2, 4, 6).

Returns

value The measured value

Definition at line 403 of file ftm_ic_driver.c.

16.38.4.3 status_t FTM_DRV_InitInputCapture (uint32_t *instance,* const ftm_input_param_t * *param*)

This function configures the channel in the Input Capture mode for either getting time-stamps on edge detection or on signal measurement. When the edge specified in the captureMode argument occurs on the channel and then the FTM counter is captured into the CnV register. The user have to read the CnV register separately to get this value. The filter function is disabled if the filterVal argument passed as 0. The filter feature. is available only on channels 0,1,2,3.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*param*	Configuration of the input capture channel.

Returns

success

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 215 of file ftm_ic_driver.c.

16.38.4.4 status_t FTM_DRV_StartNewSignalMeasurement (uint32_t *instance,* uint8_t *channel*)

Starts new single-shot signal measurement of the given channel.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*channel*	Configuration of the output compare channel.

Returns

success

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 427 of file ftm_ic_driver.c.

16.38.4.5 status_t FTM_IC_DRV_SetChannelMode (uint32_t *instance,* uint8_t *channel,* ftm_ic_op_mode_t *inputMode,* bool *enableContinuousCapture*)

Set mode operation for channel in the input capture mode.

This function will change the channel mode at run time or when stopping channel. The channel mode is selected in the ftm_ic_op_mode_t enumeration type.

Parameters

in	*instance*	The input capture instance number.
in	*channel*	The channel number.
in	*inputMode*	The channel operation mode.
in	*enable↩ Continuous↩ Capture*	Enable/disable the continuous capture mode.

Returns

success

- STATUS_SUCCESS : Completed successfully.

Definition at line 466 of file ftm_ic_driver.c.

16.39 FlexTimer Module Counter Driver (FTM_MC)

16.39.1 Detailed Description

FlexTimer Module Counter Peripheral Driver.

Hardware background

The FTM of the S32K1xx is based on a 16 bits counter and supports: input capture, output compare, PWM and some instances include quadrature decoder.

How to use FTM driver in your application

For all operation modes (without Quadrature Decoder mode) the user need to configure ftm_user_config_t. This structure will be used for initialization (FTM_DRV_Init). The next functions used are specific for each operation mode.

Counter mode

For this mode the user needs to configure parameters like: counter mode (up-counting or up-down counting), maximum counter value, initial counter value. All this information is included in the ftm_timer_param_t structure.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\ftm\ftm_mc_driver.c
${S32SDK_PATH}\platform\drivers\src\ftm\ftm_common.c
${S32SDK_PATH}\platform\drivers\src\ftm\ftm_hw_access.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
${S32SDK_PATH}\platform\drivers\src\ftm\
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager Interrupt Manager (Interrupt)

Example:

```
/* The state structure of instance in the input capture mode */
ftm_state_t stateTimer;
#define FTM_TIMER_INSTANCE        1UL
/* Timer mode configuration for Timer */
ftm_timer_param_t Timer_TimerConfig =
{
    FTM_MODE_UP_TIMER,              /* Counter mode */
    0U,                             /* Initial counter value */
    0x8000U                         /* Final counter value */
};

/* Global configuration of Timer*/
ftm_user_config_t  Timer_InitConfig =
{
    {
        false,                      /* Software trigger state */
        false,                      /* Hardware trigger 1 state */
        false,                      /* Hardware trigger 2 state */
        false,                      /* Hardware trigger 3 state */
```

```
        false,                      /* Maximum loading point state */
        false,                      /* Min loading point state */
        FTM_SYSTEM_CLOCK,           /* Update mode for INVCTRL register */
        FTM_SYSTEM_CLOCK,           /* Update mode for SWOCTRL register */
        FTM_SYSTEM_CLOCK,           /* Update mode for OUTMASK register */
        FTM_SYSTEM_CLOCK,           /* Update mode for CNTIN register */
        false,                      /* Auto clear trigger state for hardware trigger */
        FTM_UPDATE_NOW,             /* Select synchronization method */
    },
    FTM_MODE_UP_TIMER,              /* Mode of operation for FTM */
    FTM_CLOCK_DIVID_BY_2,           /* FTM clock pre-scaler */
    FTM_CLOCK_SOURCE_SYSTEMCLK,     /* FTM clock source */
    FTM_BDM_MODE_11,                /* FTM debug mode */
    false,                          /* Interrupt state */
    false                           /* Initialization trigger */
};
FTM_DRV_Init(FTM_TIMER_INSTANCE,&Timer_InitConfig, &stateTimer);
FTM_DRV_InitCounter(FTM_TIMER_INSTANCE, &Timer_TimerConfig);
FTM_DRV_CounterStart(FTM_TIMER_INSTANCE);
```

Data Structures

- struct ftm_timer_param_t

  The configuration structure in timer mode. More...

Functions

- status_t FTM_DRV_InitCounter (uint32_t instance, const ftm_timer_param_t *timer)

  Initialize the FTM counter.
- status_t FTM_DRV_CounterStart (uint32_t instance)

  Starts the FTM counter.
- status_t FTM_DRV_CounterStop (uint32_t instance)

  Stops the FTM counter.
- uint32_t FTM_DRV_CounterRead (uint32_t instance)

  Reads back the current value of the FTM counter.
- void FTM_MC_DRV_GetDefaultConfig (ftm_timer_param_t *const config)

  This function will get the default configuration values in the structure which is used as a common use-case.

16.39.2 Data Structure Documentation

16.39.2.1 struct ftm_timer_param_t

The configuration structure in timer mode.

Implements : ftm_timer_param_t_Class

Definition at line 41 of file ftm_mc_driver.h.

Data Fields

- ftm_config_mode_t mode
- uint16_t initialValue
- uint16_t finalValue

Field Documentation

16.39.2.1.1 uint16_t finalValue

Final counter value

Definition at line 45 of file ftm_mc_driver.h.

16.39.2.1.2 uint16_t initialValue

Initial counter value

Definition at line 44 of file ftm_mc_driver.h.

16.39.2.1.3 ftm_config_mode_t mode

FTM mode

Definition at line 43 of file ftm_mc_driver.h.

16.39.3 Function Documentation

16.39.3.1 uint32_t FTM_DRV_CounterRead (uint32_t *instance*)

Reads back the current value of the FTM counter.

Parameters

in	*instance*	The FTM peripheral instance number.

Returns

The current counter value

Definition at line 150 of file ftm_mc_driver.c.

16.39.3.2 status_t FTM_DRV_CounterStart (uint32_t *instance*)

Starts the FTM counter.

Parameters

in	*instance*	The FTM peripheral instance number.

Returns

operation status

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 111 of file ftm_mc_driver.c.

16.39.3.3 status_t FTM_DRV_CounterStop (uint32_t *instance*)

Stops the FTM counter.

Parameters

in	*instance*	The FTM peripheral instance number.

Returns

operation status

- STATUS_SUCCESS : Completed successfully.

Definition at line 132 of file ftm_mc_driver.c.

16.39.3.4 status_t FTM_DRV_InitCounter (uint32_t *instance,* const ftm_timer_param_t * *timer*)

Initialize the FTM counter.

Starts the FTM counter. This function provides access to the FTM counter settings. The counter can be run in Up counting and Up-down counting modes. To run the counter in Free running mode, choose Up counting option and provide 0x0 value for the initialValue and 0xFFFF for finalValue. Please call this function only when FTM is used as timer/counter. User must call the FTM_DRV_Deinit and the FTM_DRV_Init to Re-Initialize the FTM before calling FTM_DRV_InitCounter for the second time and afterwards.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*timer*	Timer configuration structure.

Returns

operation status

- STATUS_SUCCESS : Initialized successfully.

Definition at line 52 of file ftm_mc_driver.c.

16.39.3.5 void FTM_MC_DRV_GetDefaultConfig (ftm_timer_param_t *const *config*)

This function will get the default configuration values in the structure which is used as a common use-case.

Parameters

out	*config*	Pointer to the structure in which the configuration will be saved.

Returns

None

Definition at line 166 of file ftm_mc_driver.c.

16.40 FlexTimer Output Compare Driver (FTM_OC)

16.40.1 Detailed Description

FlexTimer Output Compare Peripheral Driver.

Hardware background

The FTM of the S32K1xx is based on a 16 bits counter and supports: input capture, output compare, PWM and some instances include quadrature decoder.

How to use FTM driver in your application

For all operation modes (without Quadrature Decoder mode) the user need to configure ftm_user_config_t. This structure will be used for initialization (FTM_DRV_Init). The next functions used are specific for each operation mode.

Output compare mode

For this mode the user needs to configure maximum counter value, number of channels used and output mode for each channel (toggle/clear/set on match). This information is stored in ftm_output_cmp_param_t structure type and are used in FTM_DRV_InitOutputCompare function. Next step is to set a value for comparison with the FTM_DR↩V_UpdateOutputCompareChannel function.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\ftm\ftm_oc_driver.c
${S32SDK_PATH}\platform\drivers\src\ftm\ftm_common.c
${S32SDK_PATH}\platform\drivers\src\ftm\ftm_hw_access.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
${S32SDK_PATH}\platform\drivers\src\ftm\
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager Interrupt Manager (Interrupt)

Example:

```
/* The state structure of instance in the output compare mode */
ftm_state_t stateOutputCompare;
#define FTM_OUTPUT_COMPARE_INSTANCE        1UL
/* Channels configuration structure for PWM output compare */
ftm_output_cmp_ch_param_t PWM_OutputCompareChannelConfig[2] =
{
    {
        0U,                         /* Channel id */
        FTM_TOGGLE_ON_MATCH,        /* Output mode */
        10000U,                     /* Compared value */
        false,                      /* External Trigger */
    },
    {
        1U,                         /* Channel id */
        FTM_TOGGLE_ON_MATCH,        /* Output mode */
        20000U,                     /* Compared value */
```

```
        false,                      /* External Trigger */
    }
};

/* Output compare configuration for PWM */
ftm_output_cmp_param_t PWM_OutputCompareConfig =
{
    2U,                             /* Number of channels */
    FTM_MODE_OUTPUT_COMPARE,        /* FTM mode */
    40000U,                         /* Maximum count value */
    PWM_OutputCompareChannelConfig  /* Channels configuration */
};
/* Timer mode configuration for PWM */
/* Global configuration of PWM */
ftm_user_config_t  PWM_InitConfig =
{
    {
        true,                       /* Software trigger state */
        false,                      /* Hardware trigger 1 state */
        false,                      /* Hardware trigger 2 state */
        false,                      /* Hardware trigger 3 state */
        true,                       /* Maximum loading point state */
        true,                       /* Min loading point state */
        FTM_SYSTEM_CLOCK,           /* Update mode for INVCTRL register */
        FTM_SYSTEM_CLOCK,           /* Update mode for SWOCTRL register */
        FTM_SYSTEM_CLOCK,           /* Update mode for OUTMASK register */
        FTM_SYSTEM_CLOCK,           /* Update mode for CNTIN register */
        false,                      /* Auto clear trigger state for hardware trigger */
        FTM_UPDATE_NOW,             /* select synchronization method */
    },
    FTM_MODE_OUTPUT_COMPARE,        /* Mode of operation for FTM */
    FTM_CLOCK_DIVID_BY_4,           /* FTM clock pre-scaler */
    FTM_CLOCK_SOURCE_SYSTEMCLK,     /* FTM clock source */
    FTM_BDM_MODE_11,                /* FTM debug mode */
    false,                          /* Interrupt state */
    false                           /* Initialization trigger */
};
FTM_DRV_Init(FTM_OUTPUT_COMPARE_INSTANCE, &PWM_InitConfig, &stateOutputCompare);
FTM_DRV_InitOutputCompare(FTM_OUTPUT_COMPARE_INSTANCE, &PWM_OutputCompareConfig);
/* If you want to change compared value */
FTM_DRV_UpdateOutputCompareChannel(FTM_OUTPUT_COMPARE_INSTANCE, 0UL, 1500
      0U );
```

Data Structures

- struct ftm_output_cmp_ch_param_t

  FlexTimer driver PWM parameters each channel in the output compare mode. More...
- struct ftm_output_cmp_param_t

  FlexTimer driver PWM parameters which is configured for the list of channels. More...

Enumerations

- enum ftm_output_compare_mode_t { FTM_DISABLE_OUTPUT = 0x00U, FTM_TOGGLE_ON_MATCH = 0x01U, FTM_CLEAR_ON_MATCH = 0x02U, FTM_SET_ON_MATCH = 0x03U }

  FlexTimer Mode configuration for output compare mode.
- enum ftm_output_compare_update_t { FTM_RELATIVE_VALUE = 0x00U, FTM_ABSOLUTE_VALUE = 0x01U }

  FlexTimer input capture type of the next output compare value.

Functions

- status_t FTM_DRV_InitOutputCompare (uint32_t instance, const ftm_output_cmp_param_t *param)

  Configures the FTM to generate timed pulses (Output compare mode).
- status_t FTM_DRV_DeinitOutputCompare (uint32_t instance, const ftm_output_cmp_param_t *param)

  Disables compare match output control and clears FTM timer configuration.
- status_t FTM_DRV_UpdateOutputCompareChannel (uint32_t instance, uint8_t channel, uint16_t next↩ ComparematchValue, ftm_output_compare_update_t update, bool softwareTrigger)

  Sets the next compare match value based on the current counter value.

16.40.2 Data Structure Documentation

16.40.2.1 struct ftm_output_cmp_ch_param_t

FlexTimer driver PWM parameters each channel in the output compare mode.

Implements : ftm_output_cmp_ch_param_t_Class

Definition at line 65 of file ftm_oc_driver.h.

Data Fields

- uint8_t hwChannelId
- ftm_output_compare_mode_t chMode
- uint16_t comparedValue
- bool enableExternalTrigger

Field Documentation

16.40.2.1.1 ftm_output_compare_mode_t chMode

Channel output mode

Definition at line 68 of file ftm_oc_driver.h.

16.40.2.1.2 uint16_t comparedValue

The compared value

Definition at line 69 of file ftm_oc_driver.h.

16.40.2.1.3 bool enableExternalTrigger

true: enable the generation of a trigger is used for on-chip modules false: disable the generation of a trigger

Definition at line 70 of file ftm_oc_driver.h.

16.40.2.1.4 uint8_t hwChannelId

Physical hardware channel ID

Definition at line 67 of file ftm_oc_driver.h.

16.40.2.2 struct ftm_output_cmp_param_t

FlexTimer driver PWM parameters which is configured for the list of channels.

Implements : ftm_output_cmp_param_t_Class

Definition at line 79 of file ftm_oc_driver.h.

Data Fields

- uint8_t nNumOutputChannels
- ftm_config_mode_t mode
- uint16_t maxCountValue
- ftm_output_cmp_ch_param_t * outputChannelConfig

Field Documentation

16.40.2.2.1 uint16_t maxCountValue

Maximum count value in ticks

Definition at line 83 of file ftm_oc_driver.h.

16.40.2.2.2 ftm_config_mode_t mode

FlexTimer PWM operation mode

Definition at line 82 of file ftm_oc_driver.h.

16.40.2.2.3 uint8_t nNumOutputChannels

Number of output compare channels

Definition at line 81 of file ftm_oc_driver.h.

16.40.2.2.4 ftm_output_cmp_ch_param_t* outputChannelConfig

Output compare channels configuration

Definition at line 84 of file ftm_oc_driver.h.

16.40.3 Enumeration Type Documentation

16.40.3.1 enum ftm_output_compare_mode_t

FlexTimer Mode configuration for output compare mode.

Implements : ftm_output_compare_mode_t_Class

Enumerator

FTM_DISABLE_OUTPUT No action on output pin

FTM_TOGGLE_ON_MATCH Toggle on match

FTM_CLEAR_ON_MATCH Clear on match

FTM_SET_ON_MATCH Set on match

Definition at line 41 of file ftm_oc_driver.h.

16.40.3.2 enum ftm_output_compare_update_t

FlexTimer input capture type of the next output compare value.

Implements : ftm_output_compare_update_t_Class

Enumerator

FTM_RELATIVE_VALUE Next compared value is relative to current value

FTM_ABSOLUTE_VALUE Next compared value is absolute

Definition at line 54 of file ftm_oc_driver.h.

16.40.4 Function Documentation

16.40.4.1 status_t FTM_DRV_DeinitOutputCompare (uint32_t *instance,* const ftm_output_cmp_param_t * *param*)

Disables compare match output control and clears FTM timer configuration.

Parameters

in	*instance*	The FTM peripheral instance number.

in	*param*	Configuration of the output compare channel

Returns

success

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 107 of file ftm_oc_driver.c.

16.40.4.2 status_t FTM_DRV_InitOutputCompare (uint32_t *instance,* const ftm_output_cmp_param_t * *param*)

Configures the FTM to generate timed pulses (Output compare mode).

When the FTM counter matches the value of CnV, the channel output is changed based on what is specified in the mode argument. The signal period can be modified using param->maxCountValue. After this function when the max counter value and CnV are equal. FTM_DRV_UpdateOutputCompareChannel function can be used to change CnV value.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*param*	configuration of the output compare channels

Returns

success

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 42 of file ftm_oc_driver.c.

16.40.4.3 status_t FTM_DRV_UpdateOutputCompareChannel (uint32_t *instance,* uint8_t *channel,* uint16_t *nextComparematchValue,* ftm_output_compare_update_t *update,* bool *softwareTrigger*)

Sets the next compare match value based on the current counter value.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*channel*	Configuration of the output compare channel
in	*next↩ Comparematch↩ Value*	Timer value in ticks until the next compare match event should appear
in	*update*	• FTM_RELATIVE_VALUE : nextComparemantchValue will be added to current counter value • FTM_ABSOLUTE_VALUE : nextComparemantchValue will be written in counter register as it is

in	*softwareTrigger*	This parameter will be true if software trigger sync is enabled and the user want to generate a software trigger (the value from buffer will be moved to register immediate or at next loading point depending on the sync configuration). Otherwise this parameter must be false and the next compared value will be stored in buffer until a trigger signal will be received.

Returns

success

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 150 of file ftm_oc_driver.c.

16.41 FlexTimer Pulse Width Modulation Driver (FTM_PWM)

16.41.1 Detailed Description

FlexTimer Pulse Width Modulation Peripheral Driver.

Hardware background

The FlexTimer module is based on a 16 bits counter and supports: input capture, output compare, PWM and some instances include quadrature decoder.

How to use FTM driver in your application

For all operation modes (without Quadrature Decoder mode) the user need to configure ftm_user_config_t. This structure will be used for initialization (FTM_DRV_Init). The next functions used are specific for each operation mode.

PWM mode

For this mode, the user needs to configure parameters such: number of PWM channels, frequency, dead time, fault channels and duty cycle, alignment (edge or center). All this information is included in the ftm_pwm_param_t structure.

FTM_DRV_UpdatePwmChannel can be used to update duty cycles at run time. If the type of update in the duty cycle when the duty cycle can have value between 0x0 (0%) and 0x8000 (100%). If the type of update in ticks when the firstEdge and secondEdge variables can have value between 0 and ftmPeriod which is stored in the state structure.

Safe state and polarity of the PWM channels

These 2 parameters are dependent from FTM hardware perspective, but the FTM_PWM driver can handle them independently, so polarity field configures the final polarity measured at MCU pins and safeState field is the value of the PWM channel when fault is detected and fault is configured to use safe state, not tri-state mode. The same behavior is available for combined mode, polarity and safe state can be configured independently.

API code changes

In BETA 2.9.0 the following changes were made in FTM_PWM API:

- from ftm_independent_ch_param_t the following fields were removed: levelSelect
- in ftm_independent_ch_param_t safeState field was added
- from ftm_combined_ch_param_t the following fields were removed: levelSelect, levelSelectOnNextChn.
- in ftm_combined_ch_param_t mainChannelSafeState and secondChannelSafeState fields were added.
- ftm_safe_state_polarity_t enum was changed

From application perspective the impact is the following:

- second channel can't be used in independent channels, just in combined channels
- polarity and safe state should be checked with the new API.

The advantages of the FTM_PWM API from BETA 2.9,0 are:

- safe state and polarity can be configured without strong understatement of the Reference Manual
- dead time will be always inserted Note that:

- In the ftm_independent_ch_param_t structure has the "ftm_safe_state_polarity_t safeState" variable which user can configure the polarity of PWM signal on the channel n+1. and the "ftm_second_channel_polarity_t secondChannelPolarity" is only used to configure the channel n+1 in the complementary mode for the inverted or duplicated channel n.
- In the combined channel, the configuration structure has same feature as in the independent mode. It is only difference which the "ftm_safe_state_polarity_t secondChannelSafeState" variable should be set the channel (n+1) polarity if needed.
- When the fault input is disabled in the configuration the user should be set the ftm_safe_state_polarity_t as FTM_LOW_STATE for both cases in the independent and combined channel because it is not necessary.
- On S32K1xx, the clock source for Deadtime is always the System Clock, regardless of the current Clock Source used for FTM (Fixed, External).

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\ftm\ftm_pwm_driver.c
${S32SDK_PATH}\platform\drivers\src\ftm\ftm_common.c
${S32SDK_PATH}\platform\drivers\src\ftm\ftm_hw_access.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
${S32SDK_PATH}\platform\drivers\src\ftm\
```

Preprocessor symbols

No special symbols are required for this component

Dependencies

Clock Manager Interrupt Manager (Interrupt)

Example:

```
/* The state structure of instance in the PWM mode */
ftm_state_t statePwm;
#define FTM_PWM_INSTANCE        1UL
/* Fault configuration structure */
ftm_pwm_fault_param_t PWM_FaultConfig =
{
    false,
    true,
    5U,                             /* Fault filter value */
    FTM_FAULT_CONTROL_MAN_EVEN,
    {
        {
            true,                   /* Fault channel state (Enabled/Disabled) */
            false,                  /* Fault channel filter state (Enabled/Disabled) */
            FTM_POLARITY_HIGH,      /* Channel output state on fault */
        },
        {
            false,                  /* Fault Channel state (Enabled/Disabled) */
            false,                  /* Fault channel filter state (Enabled/Disabled) */
            FTM_POLARITY_LOW        /* Channel output state on fault */
        },
        {
            false,                  /* Fault Channel state (Enabled/Disabled) */
            false,                  /* Fault channel filter state (Enabled/Disabled) */
            FTM_POLARITY_LOW        /* Channel output state on fault */
        },
        {
            false,                  /* Fault Channel state (Enabled/Disabled) */
            false,                  /* Fault channel filter state (Enabled/Disabled) */
```

```
            FTM_POLARITY_LOW        /* Channel output state on fault */
        }
    }
};

/* Independent channels configuration structure for PWM */
ftm_independent_ch_param_t PWM_IndependentChannelsConfig[1] =
{
    {
    0U,                     /* hwChannelId */
    FTM_POLARITY_LOW,         /* Polarity of the PWM signal */
    4096U,                    /* Duty cycle percent 0-0x8000 */
    false,                    /* External Trigger */
    FTM_LOW_STATE,            /* Safe state of the PWM channel when faults are detected */
    }
};

/* PWM configuration for PWM */
ftm_pwm_param_t PWM_PwmConfig =
{
    1U,                             /* Number of independent PWM channels */
    0U,                             /* Number of combined PWM channels */
    FTM_MODE_EDGE_ALIGNED_PWM,      /* PWM mode */
    0U,                             /* DeadTime Value */
    FTM_DEADTIME_DIVID_BY_4,        /* DeadTime clock divider */
    7481U,                          /* PWM frequency */
    PWM_IndependentChannelsConfig,  /* Independent PWM channels configuration structure */
    NULL,                           /* Combined PWM channels configuration structure */
    &PWM_FaultConfig                /* PWM fault configuration structure */
};

/* Timer mode configuration for PWM */
/* Global configuration of PWM */
ftm_user_config_t  PWM_InitConfig =
{
    {
        true,                       /* Software trigger state */
        false,                      /* Hardware trigger 1 state */
        false,                      /* Hardware trigger 2 state */
        false,                      /* Hardware trigger 3 state */
        true,                       /* Maximum loading point state */
        true,                       /* Min loading point state */
        FTM_SYSTEM_CLOCK,           /* Update mode for INVCTRL register */
        FTM_SYSTEM_CLOCK,           /* Update mode for SWOCTRL register */
        FTM_SYSTEM_CLOCK,           /* Update mode for OUTMASK register */
        FTM_SYSTEM_CLOCK,           /* Update mode for CNTIN register */
        false,                      /* Auto clear trigger state for hardware trigger */
        FTM_UPDATE_NOW,             /* Select synchronization method */
    },
    FTM_MODE_EDGE_ALIGNED_PWM,      /* PWM mode */
    FTM_CLOCK_DIVID_BY_4,           /* FTM clock pre-scaler */
    FTM_CLOCK_SOURCE_SYSTEMCLK,     /* FTM clock source */
    FTM_BDM_MODE_11,                /* FTM debug mode */
    false,                          /* Interrupt state */
    false                           /* Initialization trigger */
};
FTM_DRV_Init(FTM_PWM_INSTANCE, &PWM_InitConfig, &statePwm);
FTM_DRV_InitPwm(FTM_PWM_INSTANCE, &PWM_PwmConfig);
/* It's recommended to use softwareTrigger = true */
/* The SECOND_EDGE value is used only when PWM is used in combined mode */
FTM_DRV_UpdatePwmChannel(FTM_PWM_INSTANCE, 0UL,
      FTM_PWM_UPDATE_IN_DUTY_CYCLE, 0x800U, 0x2000U, true);
```

PWM in Modified Combine mode

For this mode the user needs to configure parameters such: number of PWM channels, frequency, dead time, fault channels and duty cycle, alignment (edge or center). All this information is included in ftm_pwm_param_t data type. The Modified Combine PWM mode is intended to support the generation of PWM signals where the period is not modified while the signal is being generated, but the duty cycle will be varied. FTM_DRV_UpdatePwmChannel can be used to update duty cycles at run time. If the type of update in the duty cycle when the duty cycle can have value between 0x0 (0%) and 0x8000 (100%). If the type of update in ticks when the firstEdge and secondEdge variables can have value between 0 and ftmPeriod which is stored in the state structure.In this mode, an even channel (n) and adjacent odd channel (n+1) are combined to generate a PWM signal in the channel (n) output. Thus, the channel (n) match edge is fixed and the channel (n+1) match edge can be varied.

Example:

```
/* The state structure of instance in the PWM mode */
ftm_state_t statePwm;
#define FTM_PWM_INSTANCE        0UL
```

```
/* Fault configuration structure */
ftm_pwm_fault_param_t PWM_FaultConfig =
{
    false,
    true,
    5U,                             /* Fault filter value */
    FTM_FAULT_CONTROL_MAN_EVEN,
    {
        {
            true,                   /* Fault channel state (Enabled/Disabled )*/
            false,                  /* Fault channel filter state (Enabled/Disabled) */
            FTM_POLARITY_HIGH,      /* Channel output state on fault */
        },
        {
            false,                  /* Fault Channel state (Enabled/Disabled) */
            false,                  /* Fault channel filter state (Enabled/Disabled) */
            FTM_POLARITY_LOW        /* Channel output state on fault */
        },
        {
            false,                  /* Fault Channel state (Enabled/Disabled) */
            false,                  /* Fault channel filter state (Enabled/Disabled) */
            FTM_POLARITY_LOW        /* Channel output state on fault */
        },
        {
            false,                  /* Fault Channel state (Enabled/Disabled) */
            false,                  /* Fault channel filter state (Enabled/Disabled) */
            FTM_POLARITY_LOW        /* Channel output state on fault */
        }
    }
};
/* Combine channels configuration structure for PWM */
ftm_combined_ch_param_t flexTimer1_CombinedChannelsConfig[1] =
{
    {
        2U,                   /* Hardware channel for channel (n) */
        0U,                   /* First edge time */
        0U,                   /* Second edge time */
        true,                 /* Dead time enabled/disabled */
        true,                 /* The modified combine mode enabled/disabled */
        FTM_POLARITY_HIGH,     /* Select channel (n) polarity */
        true,                 /* Enabled/disabled the channel (n+1) output */
        FTM_MAIN_INVERTED,     /* Select channel (n+1) output relative to channel (n) */
        false,                 /* External Trigger on the channel (n) */
        false,                 /* External Trigger on the channel (n+1) */
        FTM_LOW_STATE,         /* Safe state of the PWM channel n when faults are detected */
        FTM_LOW_STATE,         /* Safe state of the PWM channel n+1 when faults are detected
      */
    }
};
/* PWM configuration for PWM */
ftm_pwm_param_t PWM_PwmConfig =
{
    0U,                                 /* Number of independent PWM channels */
    1U,                                 /* Number of combined PWM channels */
    FTM_MODE_EDGE_ALIGNED_PWM,          /* PWM mode */
    0U,                                 /* DeadTime Value */
    FTM_DEADTIME_DIVID_BY_4,            /* DeadTime clock divider */
    7481U,                              /* PWM frequency */
    NULL,                               /* Independent PWM channels configuration structure */
    flexTimer1_CombinedChannelsConfig, /* Combined PWM channels configuration structure */
    &PWM_FaultConfig                    /* PWM fault configuration structure */
};
/* Timer mode configuration for PWM */
/* Global configuration of PWM */
ftm_user_config_t  PWM_InitConfig =
{
    {
        true,                       /* Software trigger state */
        false,                      /* Hardware trigger 1 state */
        false,                      /* Hardware trigger 2 state */
        false,                      /* Hardware trigger 3 state */
        true,                       /* Maximum loading point state */
        true,                       /* Min loading point state */
        FTM_SYSTEM_CLOCK,           /* Update mode for INVCTRL register */
        FTM_SYSTEM_CLOCK,           /* Update mode for SWOCTRL register */
        FTM_SYSTEM_CLOCK,           /* Update mode for OUTMASK register */
        FTM_SYSTEM_CLOCK,           /* Update mode for CNTIN register */
        false,                      /* Auto clear trigger state for hardware trigger */
        FTM_UPDATE_NOW,             /* Select synchronization method */
    },
    FTM_MODE_EDGE_ALIGNED_PWM,      /* PWM mode */
    FTM_CLOCK_DIVID_BY_4,           /* FTM clock pre-scaler */
    FTM_CLOCK_SOURCE_SYSTEMCLK,     /* FTM clock source */
    FTM_BDM_MODE_11,                /* FTM debug mode */
    false,                          /* Interrupt state */
    false                           /* Initialization trigger */
};
```

```
FTM_DRV_Init(FTM_PWM_INSTANCE, &PWM_InitConfig, &statePwm);
FTM_DRV_InitPwm(FTM_PWM_INSTANCE, &PWM_PwmConfig);
/* It's recommended to use softwareTrigger = true */
/* Only second edge can be updated when FTM is running. */
FTM_DRV_UpdatePwmChannel(FTM_PWM_INSTANCE, 0UL,
      FTM_PWM_UPDATE_IN_DUTY_CYCLE, 0x0U, 0x2000U, true);
```

Edge-Aligned PWM and Input Capture mode

Support an additional Input Capture mode on other channels in the same FTM instance:

- The measurement range of Input Capture will depend on PWM configuration. The frequency of measured signal must greater than frequency of PWM signal.
- For this mode, the recommended synchronization point is the next loading point (not immediately) to avoid breaking the current measurement signal from Input Capture.
- The S32CT configuration is not possible to add both drivers on the same instance, even if the driver support this. The initialization sequences below:

```
/* The state structure of instance in the PWM and Input Capture mode */
ftm_state_t statePwmIc;
#define FTM_PWM_IC_INSTANCE        0UL
/* Fault configuration structure */
ftm_pwm_fault_param_t PWM_FaultConfig =
{
    false,
    true,
    5U,                             /* Fault filter value */
    FTM_FAULT_CONTROL_MAN_EVEN,
    {
        {
            true,                   /* Fault channel state (Enabled/Disabled )*/
            false,                  /* Fault channel filter state (Enabled/Disabled) */
            FTM_POLARITY_HIGH,      /* Channel output state on fault */
        },
        {
            false,                  /* Fault Channel state (Enabled/Disabled) */
            false,                  /* Fault channel filter state (Enabled/Disabled) */
            FTM_POLARITY_LOW        /* Channel output state on fault */
        },
        {
            false,                  /* Fault Channel state (Enabled/Disabled) */
            false,                  /* Fault channel filter state (Enabled/Disabled) */
            FTM_POLARITY_LOW        /* Channel output state on fault */
        },
        {
            false,                  /* Fault Channel state (Enabled/Disabled) */
            false,                  /* Fault channel filter state (Enabled/Disabled) */
            FTM_POLARITY_LOW        /* Channel output state on fault */
        }
    }
};
/* Combine channels configuration structure for PWM */
ftm_combined_ch_param_t flexTimer1_CombinedChannelsConfig[1] =
{
    {
        0U,                   /* Hardware channel for channel 0 and channel 1 */
        0U,                   /* First edge time */
        0x2000U,              /* Second edge time */
        true,                 /* Dead time enabled/disabled */
        true,                 /* The modified combine mode enabled/disabled */
        FTM_POLARITY_HIGH,     /* Select channel (n) polarity */
        true,                 /* Enabled/disabled the channel (n+1) output */
        FTM_MAIN_INVERTED,     /* Select channel (n+1) output relative to channel (n) */
        false,                 /* External Trigger on the channel (n) */
        false,                 /* External Trigger on the channel (n+1) */
        FTM_LOW_STATE,         /* Safe state of the PWM channel n when faults are detected */
        FTM_LOW_STATE,         /* Safe state of the PWM channel n+1 when faults are detected
      */
    }
};
/* PWM configuration for PWM */
ftm_pwm_param_t PWM_PwmConfig =
{
    0U,                                 /* Number of independent PWM channels */
    1U,                                 /* Number of combined PWM channels */
    FTM_MODE_EDGE_ALIGNED_PWM,          /* PWM mode */
    0U,                                 /* DeadTime Value */
    FTM_DEADTIME_DIVID_BY_4,            /* DeadTime clock divider */
    7481U,                              /* PWM frequency */
```

```
    NULL,                               /* Independent PWM channels configuration structure */
    flexTimer1_CombinedChannelsConfig, /* Combined PWM channels configuration structure */
    &PWM_FaultConfig                    /* PWM fault configuration structure */
};
/* Channels configuration structure for inputCapture input capture */
ftm_input_ch_param_t inputCapture_InputCaptureChannelConfig[1] =
{
    {
    3U,                             /* Channel 3 (Make sure that the channel ID must different than PWM
       channels) */
    FTM_EDGE_DETECT,                /* Input capture operation Mode */
    FTM_RISING_EDGE,                /* Edge alignment Mode */
    FTM_NO_MEASUREMENT,             /* Signal measurement operation type */
    0U,                             /* Filter value */
    false,                          /* Filter disabled */
    true                            /* Continuous mode measurement */
    NULL,                           /* Vector of callbacks  parameters for channels events */
    NULL                            /* Vector of callbacks for channels events */
    }
};
/* Input capture configuration for inputCapture */
ftm_input_param_t inputCapture_InputCaptureConfig =
{
    1U,                                     /* Number of channels */
    65535U,                                 /* Maximum count value (This value is ignored and replaced by
       period value calculated from PWM configuration) */
    inputCapture_InputCaptureChannelConfig  /* Channels configuration */
};
/* Timer mode configuration for PWM and Input Capture */
ftm_user_config_t  PWM_IC_InitConfig =
{
    {
        true,                       /* Software trigger state */
        false,                      /* Hardware trigger 1 state */
        false,                      /* Hardware trigger 2 state */
        false,                      /* Hardware trigger 3 state */
        true,                       /* Maximum loading point state */
        true,                       /* Min loading point state */
        FTM_SYSTEM_CLOCK,           /* Update mode for INVCTRL register */
        FTM_SYSTEM_CLOCK,           /* Update mode for SWOCTRL register */
        FTM_SYSTEM_CLOCK,           /* Update mode for OUTMASK register */
        FTM_SYSTEM_CLOCK,           /* Update mode for CNTIN register */
        false,                      /* Auto clear trigger state for hardware trigger */
        FTM_WAIT_LOADING_POINTS,    /* Select synchronization method (Next Loading
       Point is recommended) */
    },
    FTM_MODE_EDGE_ALIGNED_PWM,      /* Edge-Align PWM mode that can be used with
       Input Capture mode */
    FTM_CLOCK_DIVID_BY_4,           /* FTM clock pre-scaler */
    FTM_CLOCK_SOURCE_SYSTEMCLK,     /* FTM clock source */
    FTM_BDM_MODE_11,                /* FTM debug mode */
    false,                          /* Interrupt state */
    false                           /* Initialization trigger */
};

/* Initialize FTM module */
FTM_DRV_Init(FTM_PWM_IC_INSTANCE, &PWM_IC_InitConfig, &statePwmIc);
/* Initialize PWM cofiguration (Clock configuration for both PWM and Input Capture mode)
 * Initialize the additional Input Capture mode for other channels
 * FTM_DRV_InitPwm() must be called first before user calls FTM_DRV_InitInputCapture()
 */
FTM_DRV_InitPwm(FTM_PWM_IC_INSTANCE, &PWM_PwmConfig);
FTM_DRV_InitInputCapture(FTM_PWM_IC_INSTANCE, &inputCapture_InputCaptureConfig);

...

/* De-initialize Input Capture first
 * PWM signal still work normally
 */
FTM_DRV_DeinitInputCapture(FTM_PWM_IC_INSTANCE, &inputCapture_InputCaptureConfig);
/* De-initialize PWM (FTM counter will be disabled) */
FTM_DRV_DeinitPwm(FTM_PWM_IC_INSTANCE);
```

Data Structures

- struct ftm_pwm_ch_fault_param_t

  FlexTimer driver PWM Fault channel parameters. More...
- struct ftm_pwm_fault_param_t

  FlexTimer driver PWM Fault parameter. More...
- struct ftm_independent_ch_param_t

  FlexTimer driver independent PWM parameter. More...

- struct ftm_combined_ch_param_t

  FlexTimer driver combined PWM parameter. More...
- struct ftm_pwm_param_t

  FlexTimer driver PWM parameters. More...

Macros

- #define FTM_MAX_DUTY_CYCLE (0x8000U)

  Maximum value for PWM duty cycle.
- #define FTM_DUTY_TO_TICKS_SHIFT (15U)

  Shift value which converts duty to ticks.

Enumerations

- enum ftm_pwm_update_option_t { FTM_PWM_UPDATE_IN_DUTY_CYCLE = 0x00U, FTM_PWM_UPDATE_IN_TICKS = 0x01U }

  FlexTimer Configure type of PWM update in the duty cycle or in ticks.
- enum ftm_polarity_t { FTM_POLARITY_LOW = 0x00U, FTM_POLARITY_HIGH = 0x01U }

  The polarity of the channel output is configured in PWM signal.
- enum ftm_second_channel_polarity_t { FTM_MAIN_INVERTED = 0x01U, FTM_MAIN_DUPLICATED = 0x00U }

  FlexTimer PWM channel (n+1) polarity for combine mode.
- enum ftm_fault_mode_t { FTM_FAULT_CONTROL_DISABLED = 0x00U, FTM_FAULT_CONTROL_MAN_EVEN = 0x01U, FTM_FAULT_CONTROL_MAN_ALL = 0x02U, FTM_FAULT_CONTROL_AUTO_ALL = 0x03U }

  FlexTimer fault control.
- enum ftm_safe_state_polarity_t { FTM_LOW_STATE = 0x00U, FTM_HIGH_STATE = 0x01U }

  Select level of the channel (n) output at the beginning.

Functions

- status_t FTM_DRV_DeinitPwm (uint32_t instance)

  Stops all PWM channels .
- status_t FTM_DRV_InitPwm (uint32_t instance, const ftm_pwm_param_t *param)

  Configures the duty cycle and frequency and starts the output of the PWM on all channels configured in the param structure. The independent channel configuration need to clarify the polarity and safe state as following:
- status_t FTM_DRV_UpdatePwmChannel (uint32_t instance, uint8_t channel, ftm_pwm_update_option_t typeOfUpdate, uint16_t firstEdge, uint16_t secondEdge, bool softwareTrigger)

  This function updates the waveform output in PWM mode (duty cycle and phase).
- status_t FTM_DRV_FastUpdatePwmChannels (uint32_t instance, uint8_t numberOfChannels, const uint8_t *channels, const uint16_t *duty, bool softwareTrigger)

  This function will update the duty cycle of PWM output for multiple channels.
- status_t FTM_DRV_UpdatePwmPeriod (uint32_t instance, ftm_pwm_update_option_t typeOfUpdate, uint32_t newValue, bool softwareTrigger)

  This function will update the new period in the frequency or in the counter value into mode register which modify the period of PWM signal on the channel output.
- status_t FTM_DRV_ControlChannelOutput (uint32_t instance, uint8_t channel, bool enableChannelOutput)

  This function is used to control the final logic of the channel output.

16.41.2 Data Structure Documentation

16.41.2.1 struct ftm_pwm_ch_fault_param_t

FlexTimer driver PWM Fault channel parameters.

Implements : ftm_pwm_ch_fault_param_t_Class

Definition at line 112 of file ftm_pwm_driver.h.

Data Fields

- bool faultChannelEnabled
- bool faultFilterEnabled
- ftm_polarity_t ftmFaultPinPolarity

Field Documentation

16.41.2.1.1 bool faultChannelEnabled

Fault channel state

Definition at line 114 of file ftm_pwm_driver.h.

16.41.2.1.2 bool faultFilterEnabled

Fault channel filter state

Definition at line 115 of file ftm_pwm_driver.h.

16.41.2.1.3 ftm_polarity_t ftmFaultPinPolarity

Channel output state on fault

Definition at line 116 of file ftm_pwm_driver.h.

16.41.2.2 struct ftm_pwm_fault_param_t

FlexTimer driver PWM Fault parameter.

Implements : ftm_pwm_fault_param_t_Class

Definition at line 124 of file ftm_pwm_driver.h.

Data Fields

- bool pwmOutputStateOnFault
- bool pwmFaultInterrupt
- uint8_t faultFilterValue
- ftm_fault_mode_t faultMode
- ftm_pwm_ch_fault_param_t ftmFaultChannelParam [FTM_FEATURE_FAULT_CHANNELS]

Field Documentation

16.41.2.2.1 uint8_t faultFilterValue

Fault filter value

Definition at line 128 of file ftm_pwm_driver.h.

16.41.2.2.2 ftm_fault_mode_t faultMode

Fault mode

Definition at line 129 of file ftm_pwm_driver.h.

16.41.2.2.3 ftm_pwm_ch_fault_param_t ftmFaultChannelParam[FTM_FEATURE_FAULT_CHANNELS]

Fault channels configuration

Definition at line 130 of file ftm_pwm_driver.h.

16.41.2.2.4 bool pwmFaultInterrupt

PWM fault interrupt state

Definition at line 127 of file ftm_pwm_driver.h.

16.41.2.2.5 bool pwmOutputStateOnFault

Output pin state on fault (safe state or tri-state)

Definition at line 126 of file ftm_pwm_driver.h.

16.41.2.3 struct ftm_independent_ch_param_t

FlexTimer driver independent PWM parameter.

Implements : ftm_independent_ch_param_t_Class

Definition at line 138 of file ftm_pwm_driver.h.

Data Fields

- uint8_t hwChannelId
- ftm_polarity_t polarity
- uint16_t uDutyCyclePercent
- bool enableExternalTrigger
- ftm_safe_state_polarity_t safeState
- bool enableSecondChannelOutput
- ftm_second_channel_polarity_t secondChannelPolarity
- bool deadTime

Field Documentation

16.41.2.3.1 bool deadTime

Enable/disable dead time for channel

Definition at line 150 of file ftm_pwm_driver.h.

16.41.2.3.2 bool enableExternalTrigger

true: enable the generation of a trigger is used for on-chip modules false: disable the generation of a trigger

Definition at line 144 of file ftm_pwm_driver.h.

16.41.2.3.3 bool enableSecondChannelOutput

Enable complementary mode on next channel

Definition at line 148 of file ftm_pwm_driver.h.

16.41.2.3.4 uint8_t hwChannelId

Physical hardware channel ID

Definition at line 140 of file ftm_pwm_driver.h.

16.41.2.3.5 ftm_polarity_t polarity

Polarity of the PWM signal generated on MCU pin.

Definition at line 141 of file ftm_pwm_driver.h.

16.41.2.3.6 ftm_safe_state_polarity_t safeState

Logical state of the PWM channel n when an fault is detected and to set up the polarity of PWM signal on the channel (n+1)

Definition at line 146 of file ftm_pwm_driver.h.

16.41.2.3.7 ftm_second_channel_polarity_t secondChannelPolarity

Polarity of the channel n+1 relative to channel n in the complementary mode

Definition at line 149 of file ftm_pwm_driver.h.

16.41.2.3.8 uint16_t uDutyCyclePercent

PWM pulse width, value should be between 0 (0%) to FTM_MAX_DUTY_CYCLE (100%)

Definition at line 142 of file ftm_pwm_driver.h.

16.41.2.4 struct ftm_combined_ch_param_t

FlexTimer driver combined PWM parameter.

Implements : ftm_combined_ch_param_t_Class

Definition at line 159 of file ftm_pwm_driver.h.

Data Fields

- uint8_t hwChannelId
- uint16_t firstEdge
- uint16_t secondEdge
- bool deadTime
- bool enableModifiedCombine
- ftm_polarity_t mainChannelPolarity
- bool enableSecondChannelOutput
- ftm_second_channel_polarity_t secondChannelPolarity
- bool enableExternalTrigger
- bool enableExternalTriggerOnNextChn
- ftm_safe_state_polarity_t mainChannelSafeState
- ftm_safe_state_polarity_t secondChannelSafeState

Field Documentation

16.41.2.4.1 bool deadTime

Enable/disable dead time for channel

Definition at line 166 of file ftm_pwm_driver.h.

16.41.2.4.2 bool enableExternalTrigger

The generation of the channel (n) trigger true: enable the generation of a trigger on the channel (n) false: disable the generation of a trigger on the channel (n)

Definition at line 171 of file ftm_pwm_driver.h.

16.41.2.4.3 bool enableExternalTriggerOnNextChn

The generation of the channel (n+1) trigger true: enable the generation of a trigger on the channel (n+1) false: disable the generation of a trigger on the channel (n+1)

Definition at line 174 of file ftm_pwm_driver.h.

16.41.2.4.4 bool enableModifiedCombine

Enable/disable the modified combine mode for channels (n) and (n+1)

Definition at line 167 of file ftm_pwm_driver.h.

16.41.2.4.5 bool enableSecondChannelOutput

Select if channel (n+1) output is enabled/disabled for the complementary mode

Definition at line 169 of file ftm_pwm_driver.h.

16.41.2.4.6 uint16_t firstEdge

First edge time. This time is relative to signal period. The value for this parameter is between 0 and FTM_MAX_↩ DUTY_CYCLE(0 = 0% from period and FTM_MAX_DUTY_CYCLE = 100% from period)

Definition at line 162 of file ftm_pwm_driver.h.

16.41.2.4.7 uint8_t hwChannelId

Physical hardware channel ID for channel (n)

Definition at line 161 of file ftm_pwm_driver.h.

16.41.2.4.8 ftm_polarity_t mainChannelPolarity

Polarity of the PWM signal generated on MCU pin for channel n.

Definition at line 168 of file ftm_pwm_driver.h.

16.41.2.4.9 ftm_safe_state_polarity_t mainChannelSafeState

The selection of the channel (n) state when fault is detected

Definition at line 177 of file ftm_pwm_driver.h.

16.41.2.4.10 ftm_second_channel_polarity_t secondChannelPolarity

Select channel (n+1) polarity relative to channel (n) in the complementary mode

Definition at line 170 of file ftm_pwm_driver.h.

16.41.2.4.11 ftm_safe_state_polarity_t secondChannelSafeState

The selection of the channel (n+1) state when fault is detected and set up the polarity of PWM signal on the channel (n+1)

Definition at line 178 of file ftm_pwm_driver.h.

16.41.2.4.12 uint16_t secondEdge

Second edge time. This time is relative to signal period. The value for this parameter is between 0 and FTM_MA↩ X_DUTY_CYCLE(0 = 0% from period and FTM_MAX_DUTY_CYCLE = 100% from period)

Definition at line 164 of file ftm_pwm_driver.h.

16.41.2.5 struct ftm_pwm_param_t

FlexTimer driver PWM parameters.

Implements : ftm_pwm_param_t_Class

Definition at line 187 of file ftm_pwm_driver.h.

Data Fields

- uint8_t nNumIndependentPwmChannels
- uint8_t nNumCombinedPwmChannels
- ftm_config_mode_t mode
- uint8_t deadTimeValue
- ftm_deadtime_ps_t deadTimePrescaler
- uint32_t uFrequencyHZ
- ftm_independent_ch_param_t * pwmIndependentChannelConfig
- ftm_combined_ch_param_t * pwmCombinedChannelConfig
- ftm_pwm_fault_param_t * faultConfig

Field Documentation

16.41.2.5.1 ftm_deadtime_ps_t deadTimePrescaler

Dead time pre-scaler value[ticks]

Definition at line 193 of file ftm_pwm_driver.h.

16.41.2.5.2 uint8_t deadTimeValue

Dead time value in [ticks]

Definition at line 192 of file ftm_pwm_driver.h.

16.41.2.5.3 ftm_pwm_fault_param_t* faultConfig

Configuration for PWM fault

Definition at line 197 of file ftm_pwm_driver.h.

16.41.2.5.4 ftm_config_mode_t mode

FTM mode

Definition at line 191 of file ftm_pwm_driver.h.

16.41.2.5.5 uint8_t nNumCombinedPwmChannels

Number of combined PWM channels

Definition at line 190 of file ftm_pwm_driver.h.

16.41.2.5.6 uint8_t nNumIndependentPwmChannels

Number of independent PWM channels

Definition at line 189 of file ftm_pwm_driver.h.

16.41.2.5.7 ftm_combined_ch_param_t* pwmCombinedChannelConfig

Configuration for combined PWM channels

Definition at line 196 of file ftm_pwm_driver.h.

16.41.2.5.8 ftm_independent_ch_param_t* pwmIndependentChannelConfig

Configuration for independent PWM channels

Definition at line 195 of file ftm_pwm_driver.h.

16.41.2.5.9 uint32_t uFrequencyHZ

PWM period in Hz

Definition at line 194 of file ftm_pwm_driver.h.

16.41.3 Macro Definition Documentation

16.41.3.1 #define FTM_DUTY_TO_TICKS_SHIFT (15U)

Shift value which converts duty to ticks.

Definition at line 42 of file ftm_pwm_driver.h.

16.41.3.2 #define FTM_MAX_DUTY_CYCLE (0x8000U)

Maximum value for PWM duty cycle.

Definition at line 40 of file ftm_pwm_driver.h.

16.41.4 Enumeration Type Documentation

16.41.4.1 enum ftm_fault_mode_t

FlexTimer fault control.

Implements : ftm_fault_mode_t_Class

Enumerator

FTM_FAULT_CONTROL_DISABLED Fault control is disabled for all channels

FTM_FAULT_CONTROL_MAN_EVEN Fault control is enabled for even channels only (channels 0, 2, 4, and 6), and the selected mode is the manual fault clearing

FTM_FAULT_CONTROL_MAN_ALL Fault control is enabled for all channels, and the selected mode is the manual fault clearing

FTM_FAULT_CONTROL_AUTO_ALL Fault control is enabled for all channels, and the selected mode is the automatic fault clearing

Definition at line 84 of file ftm_pwm_driver.h.

16.41.4.2 enum ftm_polarity_t

The polarity of the channel output is configured in PWM signal.

Implements : ftm_polarity_t_Class

Enumerator

FTM_POLARITY_LOW The channel polarity is active LOW which is defined again

FTM_POLARITY_HIGH The channel polarity is active HIGH which is defined again

Definition at line 60 of file ftm_pwm_driver.h.

16.41.4.3 enum ftm_pwm_update_option_t

FlexTimer Configure type of PWM update in the duty cycle or in ticks.

Implements : ftm_pwm_update_option_t_Class

Enumerator

FTM_PWM_UPDATE_IN_DUTY_CYCLE The type of PWM update in the duty cycle/pulse or also use in frequency update

FTM_PWM_UPDATE_IN_TICKS The type of PWM update in ticks

Definition at line 49 of file ftm_pwm_driver.h.

16.41.4.4 enum ftm_safe_state_polarity_t

Select level of the channel (n) output at the beginning.

Implements : ftm_safe_state_polarity_t_Class

Enumerator

FTM_LOW_STATE When fault is detected PWM channel is low.

FTM_HIGH_STATE When fault is detected PWM channel is high.

Definition at line 101 of file ftm_pwm_driver.h.

16.41.4.5 enum ftm_second_channel_polarity_t

FlexTimer PWM channel (n+1) polarity for combine mode.

Implements : ftm_second_channel_polarity_t_Class

Enumerator

FTM_MAIN_INVERTED The channel (n+1) output is the inverse of the channel (n) output

FTM_MAIN_DUPLICATED The channel (n+1) output is the same as the channel (n) output

Definition at line 71 of file ftm_pwm_driver.h.

16.41.5 Function Documentation

16.41.5.1 status_t FTM_DRV_ControlChannelOutput (uint32_t *instance,* uint8_t *channel,* bool *enableChannelOutput*)

This function is used to control the final logic of the channel output.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*channel*	The channel which is used in PWM mode.
in	*enable↩ ChannelOutput*	Enable/disable the channel output.

Returns

success

- STATUS_SUCCESS : Completed successfully.

Definition at line 675 of file ftm_pwm_driver.c.

16.41.5.2 status_t FTM_DRV_DeinitPwm (uint32_t *instance*)

Stops all PWM channels .

Parameters

in	*instance*	The FTM peripheral instance number.

Returns

counter the current counter value

Definition at line 382 of file ftm_pwm_driver.c.

16.41.5.3 status_t FTM_DRV_FastUpdatePwmChannels (uint32_t *instance,* uint8_t *numberOfChannels,* const uint8_t * *channels,* const uint16_t * *duty,* bool *softwareTrigger*)

This function will update the duty cycle of PWM output for multiple channels.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*numberOf↩ Channels*	The number of channels which should be updated.
in	*channels*	The list of channels which should be updated.
in	*duty*	The list of duty cycles for selected channels.
in	*softwareTrigger*	If true a software trigger is generate to update PWM parameters.

Returns

success

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 643 of file ftm_pwm_driver.c.

16.41.5.4 status_t FTM_DRV_InitPwm (uint32_t *instance,* const ftm_pwm_param_t * *param*)

Configures the duty cycle and frequency and starts the output of the PWM on all channels configured in the param structure. The independent channel configuration need to clarify the polarity and safe state as following:

- In the first channel, the POL bit is the value of safeState variable. In the second channel, the POL bit is the same value of safeSate with the inverted channel and the POL bit is inverted safeState with the duplicated channel.
- If the polarity and sate state are the value, it will be Low-true pulses. It means the ELSB:ELSA = 0:1. Otherwise, it will be High-true pulses. It means the ELSB:ELSA = 1:0. Regarding the combined channel configuration:
- In both channels, the POL bit is the same value with the safeState variable
- If the polarity and sate state are the value, it will be Low-true pulses. It means the ELSB:ELSA = 0:1. Otherwise, it will be High-true pulses. It means the ELSB:ELSA = 1:0.
- COMP bit will be true when the polarity and safeState are the same value, the second channel is inverted .the first channel or when the polarity and safeState are difference value, the second channel is duplicated the first channel.
- COMP bit will be false when the polarity and safeState are the same value, the second channel is duplicated .the first channel or when the polarity and safeState are difference value, the second channel is inverted the first channel.

: These configuration will impact to the FTM_DRV_SetSoftwareOutputChannelControl and FTM_DRV_SetAllChn↩ SoftwareOutputControl function. Because the software output control behavior depends on the polarity and COMP bit.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*param*	FTM driver PWM parameter to configure PWM options.

Returns

success

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 258 of file ftm_pwm_driver.c.

16.41.5.5 status_t FTM_DRV_UpdatePwmChannel (uint32_t *instance,* uint8_t *channel,* ftm_pwm_update_option_t *typeOfUpdate,* uint16_t *firstEdge,* uint16_t *secondEdge,* bool *softwareTrigger*)

This function updates the waveform output in PWM mode (duty cycle and phase).

: Regarding the type of updating PWM in the duty cycle, if the expected duty is 100% then the value that is to be written to hardware will be exceed value of period. It means that the FTM counter will not match the value of the CnV register in this case.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*channel*	The channel number. In combined mode, the code finds the channel.
in	*typeOfUpdate*	The type of PWM update in the duty cycle/pulse or in ticks.
in	*firstEdge*	Duty cycle or first edge time for PWM mode. Can take value between 0 - FTM_MAX_DUTY_CYCLE(0 = 0% from period and FTM_MAX_DUTY_CYCLE = 100% from period) Or value in ticks for the first of the PWM mode in which can have value between 0 and ftmPeriod is stored in the state structure.
in	*secondEdge*	Second edge time - only for combined mode. Can take value between 0 - FTM_MAX_DUTY_CYCLE(0 = 0% from period and FTM_MAX_DUTY_CYCLE = 100% from period). Or value in ticks for the second of the PWM mode in which can have value between 0 and ftmPeriod is stored in the state structure.
in	*softwareTrigger*	If true a software trigger is generate to update PWM parameters.

Returns

success

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 447 of file ftm_pwm_driver.c.

16.41.5.6 status_t FTM_DRV_UpdatePwmPeriod (uint32_t *instance,* ftm_pwm_update_option_t *typeOfUpdate,* uint32_t *newValue,* bool *softwareTrigger*)

This function will update the new period in the frequency or in the counter value into mode register which modify the period of PWM signal on the channel output.

Parameters

in	*instance*	The FTM peripheral instance number.
in	*typeOfUpdate*	The type of PWM update is a period in Hz or in ticks. • For FTM_PWM_UPDATE_IN_DUTY_CYCLE which reuse in FTM_DRV_UpdatePwmChannel function will update in Hz. • For FTM_PWM_UPDATE_IN_TICKS will update in ticks.
in	*newValue*	The frequency or the counter value which will select with modified value for PWM signal. If the type of update in the duty cycle, the newValue parameter must be value between 1U and maximum is the frequency of the FTM counter. If the type of update in ticks, the newValue parameter must be value between 1U and 0xFFFFU.

in	*softwareTrigger*	If true a software trigger is generate to update PWM parameters.

Returns

operation status

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 576 of file ftm_pwm_driver.c.

16.42 FlexTimer Quadrature Decoder Driver (FTM_QD)

16.42.1 Detailed Description

FlexTimer Quadrature Decoder Peripheral Driver.

Hardware background

The FTM of the S32K1xx is based on a 16 bits counter and supports: input capture, output compare, PWM and some instances include quadrature decoder.

How to use FTM driver in your application

For all operation modes (without Quadrature Decoder mode) the user need to configure ftm_user_config_t. This structure will be used for initialization (FTM_DRV_Init). The next functions used are specific for each operation mode.

Quadrature decoder mode

For this mode the user needs to configure parameters like: maximum counter value, initial counter value, mode (Count and Direction Encoding mode), and for both input phases polarity and filtering. All this information is included in ftm_quad_decode_config_t. In this mode, the counter is clocked by the phase A and phase B. The current state of the decoder can be obtained using FTM_DRV_QuadGetState.

Hardware limitation:

In count and direction mode if initial value of the PHASE_A is HIGH the counter will be incremented.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\ftm\ftm_qd_driver.c
${S32SDK_PATH}\platform\drivers\src\ftm\ftm_common.c
${S32SDK_PATH}\platform\drivers\src\ftm\ftm_hw_access.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
${S32SDK_PATH}\platform\drivers\src\ftm\
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager Interrupt Manager (Interrupt)

Example:

```
/* The state structure of instance in the quadrature mode */
ftm_state_t stateQuad;
#define FTM_QUADRATURE_INSTANCE    1UL
ftm_quad_decoder_state_t quadra_state;
ftm_quad_decode_config_t quadrature_decoder_configuration =
{
    FTM_QUAD_COUNT_AND_DIR,         /* Quadrature decoder mode */
    0U,                             /* Initial counter value */
    32500U,                         /* Maximum counter value */
    {
```

```
        false,                      /* Filter state */
        0U,                         /* Filter value */
        FTM_QUAD_PHASE_NORMAL       /* Phase polarity */
    },
    {
        false,                      /* Filter state */
        0U,                         /* Filter value */
        FTM_QUAD_PHASE_NORMAL       /* Phase polarity */
    }
};
/* Timer mode configuration for Quadrature */
/* Global configuration of Quadrature */
ftm_user_config_t  Quadrature_InitConfig =
{
    {
        false,                      /* Software trigger state */
        false,                      /* Hardware trigger 1 state */
        false,                      /* Hardware trigger 2 state */
        false,                      /* Hardware trigger 3 state */
        false,                      /* Maximum loading point state */
        false,                      /* Min loading point state */
        FTM_SYSTEM_CLOCK,           /* Update mode for INVCTRL register */
        FTM_SYSTEM_CLOCK,           /* Update mode for SWOCTRL register */
        FTM_SYSTEM_CLOCK,           /* Update mode for OUTMASK register */
        FTM_SYSTEM_CLOCK,           /* Update mode for CNTIN register */
        false,                      /* Auto clear trigger state for hardware trigger */
        FTM_UPDATE_NOW,             /* Select synchronization method */
    },
    FTM_MODE_QUADRATURE_DECODER,    /* Mode of operation for FTM */
    FTM_CLOCK_DIVID_BY_2,           /* FTM clock pre-scaler */
    FTM_CLOCK_SOURCE_SYSTEMCLK,     /* FTM clock source */
    FTM_BDM_MODE_11,                /* FTM debug mode */
    false,                          /* Interrupt state */
    false                           /* Initialization trigger */
};
FTM_DRV_Init(FTM_QUADRATURE_INSTANCE, &Quadrature_InitConfig, &stateQuad);
FTM_DRV_QuadDecodeStart(FTM_QUADRATURE_INSTANCE, &quadrature_decoder_configuration);
quadra_state = FTM_DRV_QuadGetState(FTM_QUADRATURE_INSTANCE);
```

Data Structures

- struct ftm_phase_params_t

  FlexTimer quadrature decoder channel parameters. *More...*
- struct ftm_quad_decode_config_t

  FTM quadrature configure structure. *More...*
- struct ftm_quad_decoder_state_t

  FTM quadrature state(counter value and flags) *More...*

Enumerations

- enum ftm_quad_decode_mode_t { FTM_QUAD_PHASE_ENCODE = 0x00U, FTM_QUAD_COUNT_AND↩ _DIR = 0x01U }

  FlexTimer quadrature decode modes, phase encode or count and direction mode.
- enum ftm_quad_phase_polarity_t { FTM_QUAD_PHASE_NORMAL = 0x00U, FTM_QUAD_PHASE_INVE↩ RT = 0x01U }

  FlexTimer quadrature phase polarities, normal or inverted polarity.

Functions

- status_t FTM_DRV_QuadDecodeStart (uint32_t instance, const ftm_quad_decode_config_t *config)

  Configures the quadrature mode and starts measurement.
- status_t FTM_DRV_QuadDecodeStop (uint32_t instance)

  De-activates the quadrature decode mode.
- ftm_quad_decoder_state_t FTM_DRV_QuadGetState (uint32_t instance)

  Return the current quadrature decoder state (counter value, overflow flag and overflow direction)
- void FTM_QD_DRV_GetDefaultConfig (ftm_quad_decode_config_t *const config)

  This function will get the default configuration values in the structure which is used as a common use-case.

16.42.2 Data Structure Documentation

16.42.2.1 struct ftm_phase_params_t

FlexTimer quadrature decoder channel parameters.

Implements : ftm_phase_params_t_Class

Definition at line 64 of file ftm_qd_driver.h.

Data Fields

- bool phaseInputFilter
- uint8_t phaseFilterVal
- ftm_quad_phase_polarity_t phasePolarity

Field Documentation

16.42.2.1.1 uint8_t phaseFilterVal

Filter value (if input filter is enabled)

Definition at line 68 of file ftm_qd_driver.h.

16.42.2.1.2 bool phaseInputFilter

false: disable phase filter, true: enable phase filter

Definition at line 66 of file ftm_qd_driver.h.

16.42.2.1.3 ftm_quad_phase_polarity_t phasePolarity

Phase polarity

Definition at line 69 of file ftm_qd_driver.h.

16.42.2.2 struct ftm_quad_decode_config_t

FTM quadrature configure structure.

Implements : ftm_quad_decode_config_t_Class

Definition at line 77 of file ftm_qd_driver.h.

Data Fields

- ftm_quad_decode_mode_t mode
- uint16_t initialVal
- uint16_t maxVal
- ftm_phase_params_t phaseAConfig
- ftm_phase_params_t phaseBConfig

Field Documentation

16.42.2.2.1 uint16_t initialVal

Initial counter value

Definition at line 80 of file ftm_qd_driver.h.

16.42.2.2.2 uint16_t maxVal

Maximum counter value

Definition at line 81 of file ftm_qd_driver.h.

16.42.2.2.3 ftm_quad_decode_mode_t mode

FTM_QUAD_PHASE_ENCODE or FTM_QUAD_COUNT_AND_DIR

Definition at line 79 of file ftm_qd_driver.h.

16.42.2.2.4 ftm_phase_params_t phaseAConfig

Configuration for the input phase a

Definition at line 82 of file ftm_qd_driver.h.

16.42.2.2.5 ftm_phase_params_t phaseBConfig

Configuration for the input phase b

Definition at line 83 of file ftm_qd_driver.h.

16.42.2.3 struct ftm_quad_decoder_state_t

FTM quadrature state(counter value and flags)

Implements : ftm_quad_decoder_state_t_Class

Definition at line 91 of file ftm_qd_driver.h.

Data Fields

- uint16_t counter
- bool overflowFlag
- bool overflowDirection
- bool counterDirection

Field Documentation

16.42.2.3.1 uint16_t counter

Counter value

Definition at line 93 of file ftm_qd_driver.h.

16.42.2.3.2 bool counterDirection

False FTM counter is decreasing, True FTM counter is increasing

Definition at line 98 of file ftm_qd_driver.h.

16.42.2.3.3 bool overflowDirection

False if overflow occurred at minimum value, True if overflow occurred at maximum value

Definition at line 96 of file ftm_qd_driver.h.

16.42.2.3.4 bool overflowFlag

True if overflow occurred, False if overflow doesn't occurred

Definition at line 94 of file ftm_qd_driver.h.

16.42.3 Enumeration Type Documentation

16.42.3.1 enum ftm_quad_decode_mode_t

FlexTimer quadrature decode modes, phase encode or count and direction mode.

Implements : ftm_quad_decode_mode_t_Class

Enumerator

FTM_QUAD_PHASE_ENCODE Phase encoding mode

FTM_QUAD_COUNT_AND_DIR Counter and direction encoding mode

Definition at line 40 of file ftm_qd_driver.h.

16.42.3.2 enum ftm_quad_phase_polarity_t

FlexTimer quadrature phase polarities, normal or inverted polarity.

Implements : ftm_quad_phase_polarity_t_Class

Enumerator

FTM_QUAD_PHASE_NORMAL Phase input signal is not inverted before identifying the rising and falling edges of this signal

FTM_QUAD_PHASE_INVERT Phase input signal is inverted before identifying the rising and falling edges of this signal

Definition at line 51 of file ftm_qd_driver.h.

16.42.4 Function Documentation

16.42.4.1 status_t FTM_DRV_QuadDecodeStart (uint32_t *instance,* const ftm_quad_decode_config_t * *config*)

Configures the quadrature mode and starts measurement.

Parameters

in	*instance*	Instance number of the FTM module.
in	*config*	Configuration structure(quadrature decode mode, polarity for both phases, initial and maximum value for the counter, filter configuration).

Returns

success

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 47 of file ftm_qd_driver.c.

16.42.4.2 status_t FTM_DRV_QuadDecodeStop (uint32_t *instance*)

De-activates the quadrature decode mode.

Parameters

in	*instance*	Instance number of the FTM module.

Returns

success

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 106 of file ftm_qd_driver.c.

16.42.4.3 ftm_quad_decoder_state_t FTM_DRV_QuadGetState (uint32_t *instance*)

Return the current quadrature decoder state (counter value, overflow flag and overflow direction)

Parameters

in	*instance*	Instance number of the FTM module.

Returns

The current state of quadrature decoder

Definition at line 128 of file ftm_qd_driver.c.

16.42.4.4 void FTM_QD_DRV_GetDefaultConfig (ftm_quad_decode_config_t *const *config*)

This function will get the default configuration values in the structure which is used as a common use-case.

Parameters

out	*config*	Pointer to the structure in which the configuration will be saved.

Returns

None

Definition at line 150 of file ftm_qd_driver.c.

16.43 Flexible I/O (FlexIO)

16.43.1 Detailed Description

The FlexIO is a highly configurable module providing a wide range of functionality including:

- Emulation of a variety of serial communication protocols, such as SPI, I2C, I2S or UART, while requiring low CPU overhead and being more efficient that having multiple dedicated peripherals for each protocol.
- Flexible 16-bit timers with support for a variety of trigger, reset, enable and disable conditions
- PWM/Waveform generation

Several drivers are provided for this device, implementing a variety of communication protocols. There is also a common layer on which all the drivers are based, allowing more driver instances, either of the same type or different types, to function in parallel on the same FlexIO device. Each driver instance needs a certain number of FlexIO resources (shifters and timers) and as long as there are enough free resources new driver instances can be initialized. The table below shows the driver types and the number of resources needed by each one:

Drivers	Timers	Shifters	Pins
SPI	2	2	4
I2C	2	2	2
I2S	2	2	4
UART	1	1	1

The number of timers and shifters available on a specific device can be found in the reference manual.

Modules

- FlexIO Common Driver

  Common services for FlexIO drivers.
- FlexIO I2C Driver

  I2C communication over FlexIO module (FLEXIO_I2C)
- FlexIO I2S Driver

  I2S communication over FlexIO module (FLEXIO_I2S)
- FlexIO SPI Driver

  SPI communication over FlexIO module (FLEXIO_SPI)
- FlexIO UART Driver

  UART communication over FlexIO module (FLEXIO_UART)

16.44 FreeRTOS

FreeRTOS is a Real Time Operating System (RTOS) design to run on microcontrollers which have size constraints and dedicated end applications.

FreeRTOS provides:

- core real time scheduling functionality
- inter-task communication
- timing and synchronisation primitives

Additonal functionality can be included with add-on components.

More information about FreeRTOS can be found on the FreeRTOS website: www.freertos.org

Compiler Settings

Please refer to the "Compiler options" section in Release Notes document when creating a new project. The provided compiler options must match with the project to avoid compilation issue or undefined behavior.

16.45 I2S - Peripheral Abstraction Layer (I2S PAL)

16.45.1 Detailed Description

The S32 SDK provides a Peripheral Abstraction Layer for I2S modules of S32 SDK devices.

The I2S PAL is designed to be portable across all platforms and IPs which support I2S communication.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\pal\src\i2s\i2s_pal.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\pal\inc
i2s_pal_cfg.h path (this file is provided by user or generated by pex)
```

Compile symbols

No special symbols are required for this component

Dependencies

sai flexio_i2s Enhanced Direct Memory Access (eDMA) OS Interface (OSIF) Clock manager Interrupt Manager (Interrupt)

How to integrate I2S PAL in your application

Unlike the other drivers, I2S PAL modules need to include a configuration file named i2s_pal_cfg.h, which allows the user to specify which IPSs are used and how many resources are allocated for each of them (state structures). The following code example shows how to configure one instance for each available I2S IPs.

```
#ifndef i2s_pal_cfg_H
#define i2s_pal_cfg_H

/* Define which IP instance will be used in current project */
#define I2S_OVER_FLEXIO
#define I2S_OVER_SAI

/* Define the resources necessary for current project */
#define NO_OF_FLEXIO_MASTER_INSTS_FOR_I2S 1U
#define NO_OF_FLEXIO_SLAVE_INSTS_FOR_I2S 1U
#define NO_OF_SAI_INSTS_FOR_I2S  1U

#endif /* i2s_pal_cfg_H */
```

The following table contains the matching between platforms and available IPs

IP/MCU	S32K116	S32K118	S32K142	S32K144	S32K146	S32K148	MP↩ C5748G	MP↩ C5746C
SAI	NO	NO	NO	NO	NO	YES	YES	YES
FLEXI↩ O_I2S	YES	YES	YES	YES	YES	YES	NO	NO

In order to use the I2S driver it must be first initialized using function I2S_Init. Once initialized, it cannot be initialized again for the same instance until it is de-initialized, using I2S_Deinit. Different instances can work independently of each other.

Important Notes

- I2S PAL only works in half duplex mode, meaning it cannot send and receive simultaneously over one instance.

- The driver enables the interrupts for the corresponding module, but any interrupt priority setting must be done by the application.
- When using SAI module for I2S, a success status of sending operation means that all data has been pushed to hardware fifo (not output pin), up to 8 tx words will be discarded if users call deinit or switch to receiving operation right after that.

Example code

```
  /* Buffers */

 uint8_t tx[6] = {1,2,3,4,5,6};

 /* Callback to continue sending data */
void i2s_Callback0(i2s_event_t event, void *userData)
{
    /* Get from userData the I2S instance of the I2S module */
    i2s_instance_t* instance;
    instance = (i2s_instance_t*)(userData);

    /* Check the event type:
     *  - set TX buffers on I2S_EVENT_TX_EMPTY
     */
    if (event == I2S_EVENT_TX_EMPTY)
    {
        I2S_SetTxBuffer(instance, tx, 6UL);
    }
}
 /* Define I2S instance */
i2s_instance_t flexioInst = {I2S_INST_TYPE_FLEXIO,0UL};
 /* Configure I2S */
i2s_user_config_t i2sUserConfig0 =
{
    .baudRate      = 100000U,
    .mode          = I2S_MASTER,
    .wordWidth     = 8U,
    .transferType  = I2S_USING_INTERRUPT,
    .rxDMAChannel  = 0U,
    .txDMAChannel  = 0U,
    .callback      = i2s_Callback0,
    .callbackParam = &flexioInst,
    .extension     = NULL
};

 /* Configure FLEXIO pins routing */
 extension_flexio_for_i2s_t extension;
 extension.txPin = 0U;
 extension.rxPin = 1U;
 extension.sckPin = 2U;
 extension.wsPin = 3U;
 i2sUserConfig0.extension = &extension;

 /* Initializes i2s master for flexio 0 and send 6 words */
 I2S_Init(&flexioInst, &i2sUserConfig0);
 I2S_SendData(&flexioInst, tx, 6UL);
 /* Wait for sending complete */
 while (I2S_GetStatus(&flexioInst, NULL) == STATUS_BUSY);
 I2S_Deinit(&flexioInst);
```

Data Structures

- struct i2s_user_config_t

  I2S user configuration structure. More...
- struct extension_flexio_for_i2s_t

  Defines the extension structure for the I2S over FLEXIO. More...

Enumerations

- enum i2s_transfer_type_t { I2S_USING_INTERRUPT = 0U, I2S_USING_DMA = 1U }

  Defines the transfer type.
- enum i2s_mode_t { I2S_MASTER = 0U, I2S_SLAVE = 1U }

  Master or slave.

Functions

- status_t I2S_Init (const i2s_instance_t *instance, const i2s_user_config_t *config)
  Initializes the I2S module.
- status_t I2S_Deinit (const i2s_instance_t *instance)
  De-initializes the I2S module.
- status_t I2S_GetBaudRate (const i2s_instance_t *instance, uint32_t *configuredBaudRate)
  Returns the i2s baud rate.
- status_t I2S_SetTxBuffer (const i2s_instance_t *instance, const uint8_t *txBuff, uint32_t txSize)
  Keep sending.
- status_t I2S_SetRxBuffer (const i2s_instance_t *instance, uint8_t *rxBuff, uint32_t rxSize)
  Keep receiving.
- status_t I2S_SendDataBlocking (const i2s_instance_t *instance, const uint8_t *txBuff, uint32_t txSize, uint32_t timeout)
  Perform a blocking I2S transmission.
- status_t I2S_SendData (const i2s_instance_t *instance, const uint8_t *txBuff, uint32_t txSize)
  Perform a non-blocking I2S transmission.
- status_t I2S_GetStatus (const i2s_instance_t *instance, uint32_t *countRemaining)
  Get the status of the current I2S transfer.
- status_t I2S_ReceiveDataBlocking (const i2s_instance_t *instance, uint8_t *rxBuff, uint32_t rxSize, uint32_t timeout)
  Perform a blocking I2S reception.
- status_t I2S_ReceiveData (const i2s_instance_t *instance, uint8_t *rxBuff, uint32_t rxSize)
  Perform a non-blocking I2S reception.
- status_t I2S_Abort (const i2s_instance_t *instance)
  Terminates a non-blocking transfer early.
- void I2S_GetDefaultConfig (i2s_user_config_t *const config)
  Return default configuration.

16.45.2 Data Structure Documentation

16.45.2.1 struct i2s_user_config_t

I2S user configuration structure.

Implements : i2s_user_config_t_Class

Definition at line 59 of file i2s_pal.h.

Data Fields

- i2s_transfer_type_t transferType
- i2s_mode_t mode
- uint32_t baudRate
- uint8_t wordWidth
- i2s_callback_t callback
- void * callbackParam
- uint8_t rxDMAChannel
- uint8_t txDMAChannel
- void * extension

Field Documentation

16.45.2.1.1 uint32_t baudRate

Baud rate in hertz

Definition at line 63 of file i2s_pal.h.

16.45.2.1.2 i2s_callback_t callback

User callback function. Can be null if not needed.

Definition at line 67 of file i2s_pal.h.

16.45.2.1.3 void* callbackParam

Parameter for the callback function

Definition at line 68 of file i2s_pal.h.

16.45.2.1.4 void* extension

This field will be used to add extra settings to the basic configuration like FlexIO data pins

Definition at line 71 of file i2s_pal.h.

16.45.2.1.5 i2s_mode_t mode

Master or slave

Definition at line 62 of file i2s_pal.h.

16.45.2.1.6 uint8_t rxDMAChannel

Rx DMA channel number. Only used in DMA mode

Definition at line 69 of file i2s_pal.h.

16.45.2.1.7 i2s_transfer_type_t transferType

Driver type: interrupts/DMA

Definition at line 61 of file i2s_pal.h.

16.45.2.1.8 uint8_t txDMAChannel

Tx DMA channel number. Only used in DMA mode

Definition at line 70 of file i2s_pal.h.

16.45.2.1.9 uint8_t wordWidth

Number of bits in a word - multiple of 8. The word size in transfer functions depends on this parameter Word size for each buffer read/write is 1 byte, 2 bytes or 4 byte, whichever larger and close to wordWidth the most

Definition at line 64 of file i2s_pal.h.

16.45.2.2 struct extension_flexio_for_i2s_t

Defines the extension structure for the I2S over FLEXIO.

Definition at line 78 of file i2s_pal.h.

Data Fields

- uint8_t txPin
- uint8_t rxPin
- uint8_t sckPin
- uint8_t wsPin

Field Documentation

16.45.2.2.1 uint8_t rxPin

Flexio pin to use for receive

Definition at line 81 of file i2s_pal.h.

16.45.2.2.2 uint8_t sckPin

Flexio pin to use for serial clock

Definition at line 82 of file i2s_pal.h.

16.45.2.2.3 uint8_t txPin

Flexio pin to use for transmit

Definition at line 80 of file i2s_pal.h.

16.45.2.2.4 uint8_t wsPin

Flexio pin to use for word select

Definition at line 83 of file i2s_pal.h.

16.45.3 Enumeration Type Documentation

16.45.3.1 enum i2s_mode_t

Master or slave.

Implements : i2s_mode_t_Class

Enumerator

I2S_MASTER Generate bit clock and word select signal

I2S_SLAVE Receive bit clock and word select signal

Definition at line 48 of file i2s_pal.h.

16.45.3.2 enum i2s_transfer_type_t

Defines the transfer type.

Implements : i2s_transfer_type_t_Class

Enumerator

I2S_USING_INTERRUPT Driver uses interrupts for data transfers

I2S_USING_DMA Driver uses DMA for data transfers

Definition at line 37 of file i2s_pal.h.

16.45.4 Function Documentation

16.45.4.1 status_t I2S_Abort (const i2s_instance_t * *instance*)

Terminates a non-blocking transfer early.

Parameters

instance	Instance number

Definition at line 694 of file i2s_pal.c.

16.45.4.2 status_t I2S_Deinit (const i2s_instance_t * *instance*)

De-initializes the I2S module.

This function de-initializes the I2S module.

Parameters

in	*instance*	Instance number

Definition at line 453 of file i2s_pal.c.

16.45.4.3 status_t I2S_GetBaudRate (const i2s_instance_t * *instance,* uint32_t * *configuredBaudRate*)

Returns the i2s baud rate.

This function returns the i2s configured baud rate, only call this when instance is configured as master.

Parameters

	instance	Instance number.
out	*configured*↩ *BaudRate*	configured baud rate.

Returns

STATUS_SUCCESS

Definition at line 494 of file i2s_pal.c.

16.45.4.4 void I2S_GetDefaultConfig (i2s_user_config_t *const *config*)

Return default configuration.

Return default config for 8 kHz sample rate, 16 bit sample width and 2 channels.

Parameters

out	*Pointer*	to configuration structure

Definition at line 907 of file i2s_pal.c.

16.45.4.5 status_t I2S_GetStatus (const i2s_instance_t * *instance,* uint32_t * *countRemaining*)

Get the status of the current I2S transfer.

Parameters

instance	Instance number
countRemaining	Pointer to value that is populated with the number of words that have been sent in the active transfer

Returns

The transmit status.

Return values

STATUS_SUCCESS	The transmit has completed successfully.
STATUS_BUSY	The transmit is still in progress. will be filled with the number of words that have been transferred so far.
STATUS_I2S_ABORTED	The transmit was aborted.
STATUS_TIMEOUT	A timeout was reached.
STATUS_ERROR	An error occurred.

Definition at line 749 of file i2s_pal.c.

16.45.4.6 status_t I2S_Init (const i2s_instance_t * *instance,* const i2s_user_config_t * *config*)

Initializes the I2S module.

This function initializes and enables the requested I2S module. Note that when use I2S over SAI, tx and rx line are separated with SAI0, with other SAI instance tx and rx share one line.

Parameters

in	*instance*	Instance number
in	*config*	The configuration structure

Definition at line 294 of file i2s_pal.c.

16.45.4.7 status_t I2S_ReceiveData (const i2s_instance_t * *instance,* uint8_t * *rxBuff,* uint32_t *rxSize*)

Perform a non-blocking I2S reception.

This function receives a block of data and returns immediately. The rest of the transmission is handled by the interrupt service routine (if the driver is initialized in interrupt mode).

Parameters

in	*instance*	Instance number
in	*rxBuff*	pointer to the data to be transferred
in	*rxSize*	length in words of the data to be transferred

Definition at line 858 of file i2s_pal.c.

16.45.4.8 status_t I2S_ReceiveDataBlocking (const i2s_instance_t * *instance,* uint8_t * *rxBuff,* uint32_t *rxSize,* uint32_t *timeout*)

Perform a blocking I2S reception.

This function receives a block of data and only returns when the transmission is complete.

Parameters

in	*instance*	Instance number
	rxBuff	pointer to the receive buffer
	rxSize	length in words of the data to be received
	timeout	timeout for the transfer in milliseconds

Returns

Error, success or timed out status

Definition at line 808 of file i2s_pal.c.

16.45.4.9 status_t I2S_SendData (const i2s_instance_t * *instance,* const uint8_t * *txBuff,* uint32_t *txSize*)

Perform a non-blocking I2S transmission.

This function sends a block of data and returns immediately. The rest of the transmission is handled by the interrupt service routine (if the driver is initialized in interrupt mode).

Parameters

in	*instance*	Instance number
in	*txBuff*	pointer to the data to be transferred
in	*txSize*	length in words of the data to be transferred

Definition at line 649 of file i2s_pal.c.

16.45.4.10 status_t I2S_SendDataBlocking (const i2s_instance_t * *instance*, const uint8_t * *txBuff*, uint32_t *txSize*, uint32_t *timeout*)

Perform a blocking I2S transmission.

This function sends a block of data and only returns when the transmission is complete.

Parameters

in	*instance*	Instance number
in	*txBuff*	pointer to the data to be transferred
in	*txSize*	length in words of the data to be transferred
in	*timeout*	timeout value in milliseconds

Returns

Error, success or timed out status

Definition at line 526 of file i2s_pal.c.

16.45.4.11 status_t I2S_SetRxBuffer (const i2s_instance_t * *instance*, uint8_t * *rxBuff*, uint32_t *rxSize*)

Keep receiving.

This function must be called in callback function when RX_FULl event is reported to ensure rx operation working continuously.

Parameters

in	*instance*	Instance number
in	*rxBuff*	pointer to the data to be transferred
in	*rxSize*	length in words of the data to be transferred

Definition at line 572 of file i2s_pal.c.

16.45.4.12 status_t I2S_SetTxBuffer (const i2s_instance_t * *instance*, const uint8_t * *txBuff*, uint32_t *txSize*)

Keep sending.

This function must be called in callback function when TX_EMPTY event is reported to ensure tx operation working continuously.

Parameters

in	*instance*	Instance number
in	*txBuff*	pointer to the data to be transferred
in	*txSize*	length in words of the data to be transferred

Definition at line 611 of file i2s_pal.c.

16.46 Initialization

16.46.1 Detailed Description

Initialize transport layer (queues, status, ...).

Functions

- void ld_init (l_ifc_handle iii)

  Initialize or reinitialize the raw and cooked layers.

16.46.2 Function Documentation

16.46.2.1 void ld_init (l_ifc_handle *iii*)

Initialize or reinitialize the raw and cooked layers.

Parameters

in	*iii*	Interface name

Returns

void

Initialize or reinitialize the raw and cooked layers on the interface iii. All the transport layer buffers will be initialized.

Definition at line 49 of file lin_commontl_api.c.

16.47 Input Capture - Peripheral Abstraction Layer (IC PAL)

16.47.1 Detailed Description

The S32 SDK provides a Peripheral Abstraction Layer for the input capture mode of S32 SDK devices.

The IC PAL driver allows to detect the input signal and measure pulse width or period of the channel input signal. It was designed to be portable across all platforms and IPs which support FTM , eMIOS, FLEXPWM and ETIMER.

How to integrate IC PAL in your application

Unlike the other drivers, IC PAL modules need to include a configuration file named ic_pal_cfg.h, which allows the user to specify which IPs are used. The following code example shows how to configure one instance for each available IC IPs.

```
#ifndef IC_PAL_CFG_H
#define IC_PAL_CFG_H

/* Define which IP instance will be used in current project */
#define IC_PAL_OVER_FTM

#endif /* IC_PAL_CFG_H */
```

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\pal\src\ic\ic_pal.c
${S32SDK_PATH}\platform\pal\src\ic\ic_irq.c
${S32SDK_PATH}\platform\pal\src\ic\ic_irq.h
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\pal\inc\
```

Compile symbols

No special symbols are required for this component

Dependencies

ftm_ic emios_ic etimer flexpwm

The following table contains the matching between platforms and available IPs

IP/MCU	S32K116	S32K118	S32K142	S32K144	S32K146	S32K148	MPC5748G	MPC5746C	MPC5744P	S32R274	S32R372	S32K142W	S32K144W
FTM_IC	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO	NO	YES	YES
eMIOS_IC	NO	NO	NO	NO	NO	NO	YES	YES	NO	NO	NO	NO	NO

E↩ TI↩ M↩ ER	NO	NO	NO	NO	NO	NO	NO	NO	Y↩ ES	Y↩ ES	Y↩ ES	NO	NO
FL↩ E↩ X↩ P↩ WM	NO	NO	NO	NO	NO	NO	NO	NO	Y↩ ES	Y↩ ES	Y↩ ES	NO	NO

Features

- Start timer channel counting with period in ticks function
- Start/stop the channel in the input capture mode
- Get the measured value in ticks for the detection or measurement

Functionality

Initialization

In order to use the IC PAL driver it must be first initialized, using IC_Init() function. Once initialized, it should be de-initialized before initialized again for the same IC module instance, using IC_Deinit(). The initialization function does the following operations:

- sets the clock source, clock prescaler
- sets the number of channel input capture are used
- configures in the input capture mode for detection or measurement signal

Example:

```
/*PAL instance information */
ic_instance_t ic_pal1_instance = { IC_INST_TYPE_FTM, 0U };

ic_input_ch_param_t icPalChnConfig[1] =
{
  {
    .hwChannelId           = 0U,
    .inputCaptureMode      = IC_DETECT_RISING_EDGE,
    .filterEn              = false,
    .filterValue           = 0U,
    .channelExtension      = &ftmChnExtension0,
    .channelCallbackParams = NULL,
    .channelCallbacks      = ic_pal1_channel_callBack0
  }
};

channel_extension_ftm_for_ic_t ftmChnExtension0 =
{
    .continuousModeEn = true
};

extension_ftm_for_ic_t ftmExtensionConfig =
{
    .ftmClockSource = FTM_CLOCK_SOURCE_SYSTEMCLK,
    .ftmPrescaler   = FTM_CLOCK_DIVID_BY_1
};

ic_config_t icPal1_InitConfig =
{
    .nNumChannels  = 1U,
    .inputChConfig = icPalChnConfig,
    .extension     = &ftmExtensionConfig
};

/* Initialize input capture mode */
IC_Init(&ic_pal1_instance, &icPal1_InitConfig);
```

De-initialize a input capture instance

This function will disable the input capture mode. The driver can't be used again until reinitialized. All register are reset to default value and counter is stopped.

Example:

```
/* De-initialize input capture mode */
IC_Deinit(&ic_pal1_instance);
```

Start the channel in the input capture mode

This function will set the channel is in the input capture mode.

Example:

```
uint8_t hwChannel = icPal1_InitConfig.inputChConfig[0].hwChannelId;

/* Start channel in the input capture mode */
IC_StartChannel(&ic_pal1_instance, hwChannel);
```

Stop the channel in the input capture mode

This function will set the channel is used in GPIO mode or other peripheral.

Example:

```
uint8_t hwChannel = icPal1_InitConfig.inputChConfig[0].hwChannelId;

/* Stop channel in the input capture mode */
IC_StopChannel(&ic_pal1_instance, hwChannel);
```

Get the measured value

The pulse width measurement and the period measurement can be made after the channel input is in the input capture mode. The value is last captured by count. Note that to get true value of measurement at the first of pulse, please use the IC_GetValueMeasurement function in interrupt.

Example:

```
uint16_t retResult = 0U;
uint8_t hwChannel = icPal1_InitConfig.inputChConfig[0].hwChannelId;

/* Get the last captured value */
retResult = IC_GetMeasurement(&ic_pal1_instance, hwChannel);
```

Enable notifications on the channel

The notification is executed in the callback application with the IC_EVENT_MEASUREMENT_COMPLETE event which indicates that the measurement of input signal is completed.

Example:

```
uint8_t hwChannel = icPal1_InitConfig.inputChConfig[0].hwChannelId;

/* Enable the notification */
IC_EnableNotification(&ic_pal1_instance, hwChannel);
```

Disable notifications on the channel

The callback application will be not executed when the notification is disabled.

Example:

```
uint8_t hwChannel = icPal1_InitConfig.inputChConfig[0].hwChannelId;

/* Disable the notification */
IC_DisableNotification(&ic_pal1_instance, hwChannel);
```

Important Notes

- Before using the IC PAL driver the module clock must be configured. Refer to Clock Manager for clock configuration.
- The board specific configurations must be done prior to driver after that can call APIs.
- Some features are not available for all IC IPs and incorrect parameters will be handled by DEV_ASSERT.

Data Structures

- struct ic_input_ch_param_t

  The configuration structure of input capture parameters for each channel. More...
- struct ic_config_t

  Defines the configuration structures are used in the input capture mode. More...
- struct channel_extension_ftm_for_ic_t

  Defines the extension structure for the channel configuration over FTM. More...
- struct extension_ftm_for_ic_t

  Defines the extension structure for the input capture mode over FTM. More...
- struct ic_pal_state_t

  The internal context structure. More...

Enumerations

- enum ic_option_mode_t {
  IC_DISABLE_OPERATION = 0x00U, IC_TIMESTAMP_RISING_EDGE = 0x01U, IC_TIMESTAMP_FALLI↩
  NG_EDGE = 0x02U, IC_TIMESTAMP_BOTH_EDGES = 0x03U,
  IC_MEASURE_RISING_EDGE_PERIOD = 0x04U, IC_MEASURE_FALLING_EDGE_PERIOD = 0x05U, I↩
  C_MEASURE_PULSE_HIGH = 0x06U, IC_MEASURE_PULSE_LOW = 0x07U }

  The measurement type for input capture mode Implements : ic_option_mode_t_Class.

Functions

- status_t IC_Init (const ic_instance_t *const instance, const ic_config_t *configPtr)

  Initializes the input capture mode.
- status_t IC_Deinit (const ic_instance_t *const instance)

  De-initialize a input capture instance.
- void IC_StartChannel (const ic_instance_t *const instance, uint8_t channel)

  Start the counter.
- void IC_StopChannel (const ic_instance_t *const instance, uint8_t channel)

  Stop the counter.
- status_t IC_SetChannelMode (const ic_instance_t *const instance, uint8_t channel, ic_option_mode_↩
  t channelMode)

  Get the measured value.
- uint16_t IC_GetMeasurement (const ic_instance_t *const instance, uint8_t channel)

  Get the measured value.
- void IC_EnableNotification (const ic_instance_t *const instance, uint8_t channel)

  Enable channel notifications.
- void IC_DisableNotification (const ic_instance_t *const instance, uint8_t channel)

  Disable channel notifications.

16.47.2 Data Structure Documentation

16.47.2.1 struct ic_input_ch_param_t

The configuration structure of input capture parameters for each channel.

Implements : ic_input_ch_param_t_Class

Definition at line 132 of file ic_pal.h.

Data Fields

- uint8_t hwChannelId
- ic_option_mode_t inputCaptureMode
- bool filterEn
- uint16_t filterValue
- void * channelExtension
- void * channelCallbackParams
- ic_callback_t channelCallbacks

Field Documentation

16.47.2.1.1 void* channelCallbackParams

The parameter of callback application for channels event

Definition at line 139 of file ic_pal.h.

16.47.2.1.2 ic_callback_t channelCallbacks

The callback function for channels event

Definition at line 140 of file ic_pal.h.

16.47.2.1.3 void* channelExtension

The IP specific configuration structure for channel

Definition at line 138 of file ic_pal.h.

16.47.2.1.4 bool filterEn

Input capture filter state

Definition at line 136 of file ic_pal.h.

16.47.2.1.5 uint16_t filterValue

Filter Value

Definition at line 137 of file ic_pal.h.

16.47.2.1.6 uint8_t hwChannelId

Physical hardware channel ID

Definition at line 134 of file ic_pal.h.

16.47.2.1.7 ic_option_mode_t inputCaptureMode

Input capture mode of operation

Definition at line 135 of file ic_pal.h.

16.47.2.2 struct ic_config_t

Defines the configuration structures are used in the input capture mode.

Implements : ic_config_t_Class

Definition at line 148 of file ic_pal.h.

Data Fields

- uint8_t nNumChannels
- const ic_input_ch_param_t * inputChConfig
- void * extension

Field Documentation

16.47.2.2.1 void* extension

IP specific configuration structure

Definition at line 152 of file ic_pal.h.

16.47.2.2.2 const ic_input_ch_param_t* inputChConfig

Input capture channels configuration

Definition at line 151 of file ic_pal.h.

16.47.2.2.3 uint8_t nNumChannels

Number of input capture channel used

Definition at line 150 of file ic_pal.h.

16.47.2.3 struct channel_extension_ftm_for_ic_t

Defines the extension structure for the channel configuration over FTM.

Part of FTM channel configuration structure Implements : channel_extension_ftm_for_ic_t_Class

Definition at line 162 of file ic_pal.h.

Data Fields

- bool continuousModeEn

Field Documentation

16.47.2.3.1 bool continuousModeEn

Continuous measurement state

Definition at line 164 of file ic_pal.h.

16.47.2.4 struct extension_ftm_for_ic_t

Defines the extension structure for the input capture mode over FTM.

Part of FTM configuration structure Implements : extension_ftm_for_ic_t_Class

Definition at line 173 of file ic_pal.h.

Data Fields

- ftm_clock_source_t ftmClockSource
- ftm_clock_ps_t ftmPrescaler

Field Documentation

16.47.2.4.1 ftm_clock_source_t ftmClockSource

Select clock source for FTM

Definition at line 175 of file ic_pal.h.

16.47.2.4.2 ftm_clock_ps_t ftmPrescaler

Register pre-scaler options available in the ftm_clock_ps_t enumeration

Definition at line 176 of file ic_pal.h.

16.47.2.5 struct ic_pal_state_t

The internal context structure.

This structure is used by the driver for its internal logic. It must be provided by the application through the IC_Init() function, then it cannot be freed until the driver is de-initialized using IC_Deinit(). The application should make no assumptions about the content of this structure.

Definition at line 248 of file ic_pal.h.

16.47.3 Enumeration Type Documentation

16.47.3.1 enum ic_option_mode_t

The measurement type for input capture mode Implements : ic_option_mode_t_Class.

Enumerator

IC_DISABLE_OPERATION Have no operation

IC_TIMESTAMP_RISING_EDGE Rising edge trigger

IC_TIMESTAMP_FALLING_EDGE Falling edge trigger

IC_TIMESTAMP_BOTH_EDGES Rising and falling edge trigger

IC_MEASURE_RISING_EDGE_PERIOD Period measurement between two consecutive rising edges

IC_MEASURE_FALLING_EDGE_PERIOD Period measurement between two consecutive falling edges

IC_MEASURE_PULSE_HIGH The time measurement taken for the pulse to remain ON or HIGH state

IC_MEASURE_PULSE_LOW The time measurement taken for the pulse to remain OFF or LOW state

Definition at line 115 of file ic_pal.h.

16.47.4 Function Documentation

16.47.4.1 status_t IC_Deinit (const ic_instance_t *const *instance*)

De-initialize a input capture instance.

This function will disable the input capture mode. The driver can't be used again until reinitialized. The context structure is no longer needed by the driver and can be freed after calling this function.

Parameters

in	*instance*	The pointer to instance number structure.

Returns

Operation status

- STATUS_SUCCESS: Operation was successful

Definition at line 1043 of file ic_pal.c.

16.47.4.2 void IC_DisableNotification (const ic_instance_t *const *instance*, uint8_t *channel*)

Disable channel notifications.

This function disables channel notification.

Parameters

in	*instance*	The pointer to instance number structure.
in	*channel*	The channel number.

Definition at line 1551 of file ic_pal.c.

16.47.4.3 void IC_EnableNotification (const ic_instance_t *const *instance*, uint8_t *channel*)

Enable channel notifications.

This function enables channel notification.

Parameters

in	*instance*	The pointer to instance number structure.
in	*channel*	The channel number.

Definition at line 1500 of file ic_pal.c.

16.47.4.4 uint16_t IC_GetMeasurement (const ic_instance_t *const *instance*, uint8_t *channel*)

Get the measured value.

This function will get the value of measured signal in ticks.

Parameters

in	*instance*	The pointer to instance number structure.
in	*channel*	The channel number.

Returns

The last value of measured signal in ticks.

Definition at line 1423 of file ic_pal.c.

16.47.4.5 status_t IC_Init (const ic_instance_t *const *instance*, const ic_config_t * *configPtr*)

Initializes the input capture mode.

This function will initialize the IC PAL instance, including the other platform specific HW units used together in the input capture mode. This function configures a group of channels in instance to detect or measure the input signal. : If the filter input is enabled on the channel 0,1,2 or 3 over FTM. The filter pre-scaler will be configured to divide by 4. The maximum frequency for the channel input to be detected correctly is FTM input clock divided by 16.

Parameters

in	*instance*	The pointer to instance number structure.

in	*configPtr*	The pointer to configuration structure.

Returns

Operation status

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 971 of file ic_pal.c.

16.47.4.6 status_t IC_SetChannelMode (const ic_instance_t *const *instance*, uint8_t *channel*, ic_option_mode_t *channelMode*)

Get the measured value.

This function will get the value of measured signal in ticks.

Parameters

in	*instance*	The pointer to instance number structure.
in	*channel*	The channel number.

Returns

The last value of measured signal in ticks.

Definition at line 1297 of file ic_pal.c.

16.47.4.7 void IC_StartChannel (const ic_instance_t *const *instance*, uint8_t *channel*)

Start the counter.

This function start channel counting.

Parameters

in	*instance*	The pointer to instance number structure.
in	*channel*	The channel number.

Definition at line 1160 of file ic_pal.c.

16.47.4.8 void IC_StopChannel (const ic_instance_t *const *instance*, uint8_t *channel*)

Stop the counter.

This function stop channel counting.

Parameters

in	*instance*	The pointer to instance number structure.
in	*channel*	The channel number.

Definition at line 1232 of file ic_pal.c.

16.48 Inter Integrated Circuit - Peripheral Abstraction Layer(I2C PAL)

16.48.1 Detailed Description

Inter Integrated Circuit- Peripheral Abstraction Layer.

The I2C PAL driver allows communication on an I2C bus. It was designed to be portable across all platforms and IPs which support I2C communication.

How to integrate I2C in your application

I2C PAL modules need to include a configuration file named i2c_pal_cfg.h, which allows the user to specify which IPSs are used and how many resources are allocated for each of them (state structures). The following code example shows how to configure one instance for each available I2C IPs.

```
#ifndef I2C_PAL_cfg_H
#define I2C_PAL_cfg_H

/* Define which IP instance will be used in current project */
#define I2C_OVER_LPI2C
#define I2C_OVER_FLEXIO
#define I2C_OVER_I2C
#define I2C_OVER_SWI2C

/* Define the resources necessary for current project */
#define NO_OF_LPI2C_INSTS_FOR_I2C 2
#define NO_OF_FLEXIO_INSTS_FOR_I2C 1
#define NO_OF_I2C_INSTS_FOR_I2C 0
#define NO_OF_SWI2C_INSTS_FOR_I2C 1
#endif /* I2C_PAL_cfg_H */
```

The following table contains the matching between platforms and available IPs

IP/↩ M↩ CU	S32↩ K116	S32↩ K118	S32↩ K142	S32↩ K144	S32↩ K146	S32↩ K148	M↩ P↩ C5748 G	M↩ P↩ C5746 C	M↩ P↩ C5744 P	S32↩ R274	S32↩ R372	S32↩ K144↩ W	S32↩ K142↩ W
LP↩ I2C	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	NO	NO	NO	NO	NO	Y↩ ES	Y↩ ES
Flex↩ IO	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	NO	NO	NO	NO	NO	Y↩ ES	Y↩ ES
I2C	NO	NO	NO	NO	NO	NO	Y↩ ES	Y↩ ES	NO	Y↩ ES	Y↩ ES	NO	NO
S↩ W↩ I2C	NO	NO	NO	NO	NO	NO	Y↩ ES	Y↩ ES	Y↩ ES	NO	NO	NO	NO

In order to use the I2C driver it must be first initialized in either master or slave mode, using functions I2C_Master↩ Init() or I2C_SlaveInit(). Once initialized, it cannot be initialized again for the same I2C module instance until it is de-initialized, using I2C_SlaveDeinit() or I2C_MasterDeinit. Different I2C module instances can work independently of each other.

In each mode (master/slave) are available two types of transfers: blocking and non-blocking. The functions which initiate blocking transfers will configure the time out for transmission. If time expires the blocking functions will return STATUS_TIMEOUT and transmission will be aborted. The blocking functions are: I2C_MasterSendDataBlocking, I2C_MasterReceiveDataBlocking, I2C_SlaveSendDataBlocking and I2C_SlaveReceiveDataBlocking.

Slave Mode provides functions for transmitting or receiving data to/from any I2C master. There are two slave operating modes, selected by the field `slaveListening` in the slave configuration structure:

- Slave always listening: the slave interrupt is enabled at initialization time and the slave always listens to the line for a master addressing it. Any events are reported to the application through the callback function provided at initialization time.
- On-demand operation: the slave is commanded to transmit or receive data through the call of I2C_Slave↩ SendData() and I2C_SlaveReceiveData() (or their blocking counterparts). The actual moment of the transfer

depends on the I2C master.

The configuration structure includes a special field named extension. It will be used only for I2C transfers over FLEXIO and should contain a pointer to extension_flexio_for_i2c_t structure. The purpose of this structure is to configure which FLEXIO pins are used by the applications and their functionality (SDA and SCL).

Important Notes

- The I2C transfers could be done using interrupts and DMA mode.
- FlexIO driver only supports master mode.
- The driver enables the interrupts for the corresponding module, but any interrupt priority setting must be done by the application.
- SWI2C driver supports only master mode.
- For send/receive blocking functions the timeout parameter is unused for SWI2C driver. The driver has a timeout independent of this parameter.
- The baud rate for SWI2C can reach a maximum value of 90Kbps.
- SWI2C baud rate depends on many parameters such as CPU frequency, compiler, optimizations and pull-up resistors. The I2C_MasterSetBaudrate is considering the maximum baud rate for swi2c device to be 90Kbps and it was tested using gcc compiler with -O1 optimizations, system clock of 200MHz and external pull-up resistors of 2KOhm each.
- Aborting a transfer with the function I2C_MasterAbortTransferData() can't be done safely due to device limitation; the user must ensure that the address is sent before aborting the transfer.

Example code

```
 /* Configure I2C master */
i2c_master_t i2c1_MasterConfig0 =
{
    .slaveAddress        = 10,
    .is10bitAddr         = false,
    .baudRate            = 100000,
    .transferType        = I2C_PAL_USING_INTERRUPTS,
    .operatingMode       = I2C_PAL_STANDARD_MODE,
    .dmaChannel1         = 255,
    .dmaChannel2         = 255,
    .callback            = NULL,
    .callbackParam       = NULL,
    .extension           = NULL
};

 /* Configure I2C slave */
i2c_slave_t i2c2_SlaveConfig0 =
{
    .slaveAddress       = 10,
    .is10bitAddr        = false,
    .slaveListening     = true,
    .transferType       = I2C_PAL_USING_INTERRUPTS,
    .dmaChannel         = 255,
    .callback           = i2c2_SlaveCallback0,
    .callbackParam      = NULL
};

i2c_instance_t i2c1_instance = {I2C_INST_TYPE_FLEXIO, 0U};
i2c_instance_t i2c2_instance = {I2C_INST_TYPE_LPI2C, 0U};
i2c_instance_t i2c3_instance = {I2C_INST_TYPE_LPI2C, 1U};

 /* Callback for I2C slave */
void i2c2_SlaveCallback0(i2c_slave_event_t slaveEvent, void *userData)
{
    /* Get instance number from userData */
    i2c_instance_t * instance;
    instance = (i2c_instance_t *) userData;

    /* Check the event type:
     *  - set RX or TX buffers depending on the master request type
     */
    if (slaveEvent == I2C_SLAVE_EVENT_RX_REQ)
        I2C_SlaveSetRxBuffer(instance, slaveRxBuffer, TRANSFER_SIZE);
```

```
    if (slaveEvent == I2C_SLAVE_EVENT_TX_REQ)
        I2C_SlaveSetTxBuffer(instance, slaveTxBuffer, TRANSFER_SIZE);
}

 /* Configure FLEXIO pins routing */
extension_flexio_for_i2c_t extension;
extension.sclPin = 1;
extension.sdaPin = 0;
i2c1_MasterConfig0.extension = &extension;

 /* Buffers */
 uint8_t slaveTxBuffer[16]  = {0x0, 0x1, 0x2, 0x3, 0x4, 0x5, 0x6, 0x7, 0x8, 0x9, 0xA, 0xB, 0xC, 0xD, 0xE,
      0xF};
 uint8_t slaveRxBuffer[16]  = {0x0, 0x0, 0x0, 0x0, 0x0, 0x0, 0x0, 0x0, 0x0, 0x0, 0x0, 0x0, 0x0, 0x0, 0x0,
      0x0};
 uint8_t masterTxBuffer[16] = {0x0, 0x1, 0x2, 0x3, 0x4, 0x5, 0x6, 0x7, 0x8, 0x9, 0xA, 0xB, 0xC, 0xD, 0xE,
      0xF};
 uint8_t masterRxBuffer[16] = {0x0, 0x0, 0x0, 0x0, 0x0, 0x0, 0x0, 0x0, 0x0, 0x0, 0x0, 0x0, 0x0, 0x0, 0x0,
      0x0};

 /* Initializes I2C master for FlexIO */
 I2C_MasterInit(&i2c1_instance, &i2c1_MasterConfig0);

 /* Initialize I2C slave instance for LPI2C driver*/
 I2C_SlaveInit(&i2c2_instance, &i2c2_SlaveConfig0);

 /* FlexIO master sends masterTxBuffer to LPI2C0 configured as slave */
 I2C_MasterSendDataBlocking(&i2c1_instance, masterTxBuffer, BUFFER_SIZE, true, 0
      xFF);

 /* Initialize I2C master for LPI2C1 instance */
 I2C_MasterInit(&i2c3_instance, &i2c1_MasterConfig0);

 /* LPI2C1 master sends data to LPI2C0 configured as slave */
 I2C_MasterSendDataBlocking(&i2c3_instance,  masterTxBuffer, BUFFER_SIZE, true, 0
      xFF);

 /* De-initialize I2C modules */
 I2C_MasterDeinit(&i2c1_instance);
 I2C_MasterDeinit(&i2c3_instance);
 I2C_SlaveDeinit(&i2c2_instance);
```

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\pal\src\i2c\i2c_pal.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\pal\inc
i2c_pal_cfg.h path
```

Compile symbols

No special symbols are required for this component

Dependencies

i2c swi2c Low Power Inter-Integrated Circuit (LPI2C) flexio_i2c Enhanced Direct Memory Access (eDMA) OS Interface (OSIF) Clock manager Interrupt Manager (Interrupt)

Data Structures

- struct extension_flexio_for_i2c_t

  Defines the extension structure for the I2C over FLEXIO Implements : extension_flexio_for_i2c_t_Class. More...
- struct i2c_master_t

  Defines the configuration structure for I2C master Implements : i2c_master_t_Class. More...

- struct i2c_slave_t

  Defines the configuration structure for I2C slave Implements : i2c_slave_t_Class. More...

Enumerations

- enum i2c_pal_transfer_type_t { I2C_PAL_USING_DMA = 0U, I2C_PAL_USING_INTERRUPTS = 1U }

  Defines the mechanism to update the rx or tx buffers Implements : i2c_pal_transfer_type_t_Class.
- enum i2c_operating_mode_t {
  I2C_PAL_STANDARD_MODE = 0x0U, I2C_PAL_FAST_MODE = 0x1U, I2C_PAL_FASTPLUS_MODE = 0x2U, I2C_PAL_HIGHSPEED_MODE = 0x3U,
  I2C_PAL_ULTRAFAST_MODE = 0x4U }

  Defines the operation mode of the i2c pal Implements : i2c_operating_mode_t_Class.

Functions

- status_t I2C_MasterInit (const i2c_instance_t *const instance, const i2c_master_t *config)

  Initializes the I2C module in master mode.
- status_t I2C_MasterSendData (const i2c_instance_t *const instance, const uint8_t *txBuff, uint32_t txSize, bool sendStop)

  Perform a non-blocking send transaction on the I2C bus.
- status_t I2C_MasterSendDataBlocking (const i2c_instance_t *const instance, const uint8_t *txBuff, uint32_t txSize, bool sendStop, uint32_t timeout)

  Perform a blocking send transaction on the I2C bus.
- status_t I2C_MasterReceiveData (const i2c_instance_t *const instance, uint8_t *rxBuff, uint32_t rxSize, bool sendStop)

  Perform a non-blocking receive transaction on the I2C bus.
- status_t I2C_MasterReceiveDataBlocking (const i2c_instance_t *const instance, uint8_t *rxBuff, uint32_t rxSize, bool sendStop, uint32_t timeout)

  Perform a blocking receive transaction on the I2C bus.
- status_t I2C_MasterSetSlaveAddress (const i2c_instance_t *const instance, const uint16_t address, const bool is10bitAddr)

  Set the slave address for the I2C communication.
- status_t I2C_MasterDeinit (const i2c_instance_t *const instance)

  De-initializes the I2C master module.
- status_t I2C_GetDefaultMasterConfig (i2c_master_t *config)

  Gets the default configuration structure for master.
- status_t I2C_GetDefaultSlaveConfig (i2c_slave_t *config)

  Gets the default configuration structure for slave.
- status_t I2C_SlaveInit (const i2c_instance_t *const instance, const i2c_slave_t *config)

  Initializes the I2C module in slave mode.
- status_t I2C_SlaveSendData (const i2c_instance_t *const instance, const uint8_t *txBuff, uint32_t txSize)

  Perform a non-blocking send transaction on the I2C bus.
- status_t I2C_SlaveSendDataBlocking (const i2c_instance_t *const instance, const uint8_t *txBuff, uint32_t txSize, uint32_t timeout)

  Perform a blocking send transaction on the I2C bus.
- status_t I2C_SlaveReceiveData (const i2c_instance_t *const instance, uint8_t *rxBuff, uint32_t rxSize)

  Perform a non-blocking receive transaction on the I2C bus.
- status_t I2C_SlaveReceiveDataBlocking (const i2c_instance_t *const instance, uint8_t *rxBuff, uint32_t rxSize, uint32_t timeout)

  Perform a blocking receive transaction on the I2C bus.
- status_t I2C_SlaveSetRxBuffer (const i2c_instance_t *const instance, uint8_t *rxBuff, uint32_t rxSize)

  Provide a buffer for receiving data.

- status_t I2C_SlaveSetTxBuffer (const i2c_instance_t *const instance, const uint8_t *txBuff, uint32_t txSize)

  Provide a buffer for transmitting data.
- status_t I2C_SlaveDeinit (const i2c_instance_t *const instance)

  De-initializes the i2c slave module.
- status_t I2C_MasterGetTransferStatus (const i2c_instance_t *const instance, uint32_t *bytesRemaining)

  Return the current status of the I2C master transfer.
- status_t I2C_SlaveGetTransferStatus (const i2c_instance_t *const instance, uint32_t *bytesRemaining)

  Return the current status of the I2C slave transfer.
- status_t I2C_MasterSetBaudRate (const i2c_instance_t *const instance, const i2c_master_t *config, uint32_t baudRate)

  Set the master baud rate for the I2C communication.
- status_t I2C_MasterGetBaudRate (const i2c_instance_t *const instance, uint32_t *baudRate)

  Get the master baud rate for the I2C communication.
- status_t I2C_MasterAbortTransfer (const i2c_instance_t *const instance)

  Abort a non-blocking I2C Master transmission or reception.
- status_t I2C_SlaveAbortTransfer (const i2c_instance_t *const instance)

  Abort a non-blocking I2C slave transmission or reception.

16.48.2 Data Structure Documentation

16.48.2.1 struct extension_flexio_for_i2c_t

Defines the extension structure for the I2C over FLEXIO Implements : extension_flexio_for_i2c_t_Class.

Definition at line 62 of file i2c_pal.h.

Data Fields

- uint8_t sclPin
- uint8_t sdaPin

Field Documentation

16.48.2.1.1 uint8_t sclPin

FlexIO pin for SCL

Definition at line 64 of file i2c_pal.h.

16.48.2.1.2 uint8_t sdaPin

FlexIO pin for SDA

Definition at line 65 of file i2c_pal.h.

16.48.2.2 struct i2c_master_t

Defines the configuration structure for I2C master Implements : i2c_master_t_Class.

Definition at line 101 of file i2c_pal.h.

Data Fields

- uint16_t slaveAddress
- bool is10bitAddr
- uint32_t baudRate
- uint8_t dmaChannel1
- uint8_t dmaChannel2

- i2c_pal_transfer_type_t transferType
- i2c_operating_mode_t operatingMode
- i2c_master_callback_t callback
- void * callbackParam
- void * extension

Field Documentation

16.48.2.2.1 uint32_t baudRate

Baud rate in hertz

Definition at line 105 of file i2c_pal.h.

16.48.2.2.2 i2c_master_callback_t callback

User callback function. Note that this function will be called from the interrupt service routine, so its execution time should be as small as possible. It can be NULL if it is not needed

Definition at line 111 of file i2c_pal.h.

16.48.2.2.3 void* callbackParam

Parameter for the callback function

Definition at line 115 of file i2c_pal.h.

16.48.2.2.4 uint8_t dmaChannel1

DMA channel number. Only used in DMA mode

Definition at line 106 of file i2c_pal.h.

16.48.2.2.5 uint8_t dmaChannel2

DMA channel used only by Flexio I2C which needs two DMA channels, one for receiving and one for transmitting.

Definition at line 107 of file i2c_pal.h.

16.48.2.2.6 void* extension

This field will be used to add extra settings to the basic configuration like FlexIO pins

Definition at line 116 of file i2c_pal.h.

16.48.2.2.7 bool is10bitAddr

Selects 7-bit or 10-bit slave address

Definition at line 104 of file i2c_pal.h.

16.48.2.2.8 i2c_operating_mode_t operatingMode

I2C Operating mode

Definition at line 110 of file i2c_pal.h.

16.48.2.2.9 uint16_t slaveAddress

Slave address, 7-bit or 10-bit

Definition at line 103 of file i2c_pal.h.

16.48.2.2.10 i2c_pal_transfer_type_t transferType

Type of I2C transfer (interrupts or DMA)

Definition at line 109 of file i2c_pal.h.

16.48.2.3 struct i2c_slave_t

Defines the configuration structure for I2C slave Implements : i2c_slave_t_Class.

Definition at line 124 of file i2c_pal.h.

Data Fields

- uint16_t slaveAddress
- bool is10bitAddr
- bool slaveListening
- i2c_operating_mode_t operatingMode
- i2c_pal_transfer_type_t transferType
- uint8_t dmaChannel
- i2c_slave_callback_t callback
- void * callbackParam

Field Documentation

16.48.2.3.1 i2c_slave_callback_t callback

Callback function.

Definition at line 133 of file i2c_pal.h.

16.48.2.3.2 void* callbackParam

Parameter for the slave callback function

Definition at line 134 of file i2c_pal.h.

16.48.2.3.3 uint8_t dmaChannel

Channel number for DMA channel. If DMA mode is not supported or is not used this field will be ignored.

Definition at line 131 of file i2c_pal.h.

16.48.2.3.4 bool is10bitAddr

Selects 7-bit or 10-bit slave address

Definition at line 127 of file i2c_pal.h.

16.48.2.3.5 i2c_operating_mode_t operatingMode

I2C Operating mode

Definition at line 129 of file i2c_pal.h.

16.48.2.3.6 uint16_t slaveAddress

Slave address, 7-bit or 10-bit

Definition at line 126 of file i2c_pal.h.

16.48.2.3.7 bool slaveListening

Slave mode (always listening or on demand only)

Definition at line 128 of file i2c_pal.h.

16.48.2.3.8 i2c_pal_transfer_type_t transferType

Type of the I2C transfer

Definition at line 130 of file i2c_pal.h.

16.48.3 Enumeration Type Documentation

16.48.3.1 enum i2c_operating_mode_t

Defines the operation mode of the i2c pal Implements : i2c_operating_mode_t_Class.

Enumerator

I2C_PAL_STANDARD_MODE Standard-mode (Sm), bidirectional data transfers up to 100 kbit/s

I2C_PAL_FAST_MODE Fast-mode (Fm), bidirectional data transfers up to 400 kbit/s

I2C_PAL_FASTPLUS_MODE Fast-mode Plus (Fm+), bidirectional data transfers up to 1 Mbit/s

I2C_PAL_HIGHSPEED_MODE High-speed Mode (Hs-mode), bidirectional data transfers up to 3.4 Mbit/s

I2C_PAL_ULTRAFAST_MODE Ultra Fast Mode (UFm), unidirectional data transfers up to 5 Mbit/s

Definition at line 87 of file i2c_pal.h.

16.48.3.2 enum i2c_pal_transfer_type_t

Defines the mechanism to update the rx or tx buffers Implements : i2c_pal_transfer_type_t_Class.

Enumerator

I2C_PAL_USING_DMA The driver will use DMA to perform I2C transfer

I2C_PAL_USING_INTERRUPTS The driver will use interrupts to perform I2C transfer

Definition at line 52 of file i2c_pal.h.

16.48.4 Function Documentation

16.48.4.1 status_t I2C_GetDefaultMasterConfig (i2c_master_t * *config*)

Gets the default configuration structure for master.

The default configuration structure is:

Parameters

out	*config*	Pointer to configuration structure

Returns

Error or success status returned by API

Definition at line 876 of file i2c_pal.c.

16.48.4.2 status_t I2C_GetDefaultSlaveConfig (i2c_slave_t * *config*)

Gets the default configuration structure for slave.

The default configuration structure is:

Parameters

out	*config*	Pointer to configuration structure

Returns

Error or success status returned by API

16.48.4.3 status_t I2C_MasterAbortTransfer (const i2c_instance_t *const *instance*)

Abort a non-blocking I2C Master transmission or reception.

Parameters

instance	I2C peripheral instance number

Returns

Error or success status returned by API

Definition at line 1372 of file i2c_pal.c.

16.48.4.4 status_t I2C_MasterDeinit (const i2c_instance_t *const *instance*)

De-initializes the I2C master module.

This function de-initialized the I2C master module.

Parameters

in	*instance*	The name of the instance

Returns

Error or success status returned by API

Definition at line 635 of file i2c_pal.c.

16.48.4.5 status_t I2C_MasterGetBaudRate (const i2c_instance_t *const *instance*, uint32_t * *baudRate*)

Get the master baud rate for the I2C communication.

This function returns the master baud rate of the I2C master module.

Parameters

instance	I2C peripheral instance number

Returns

the baud rate in Hz

Definition at line 821 of file i2c_pal.c.

16.48.4.6 status_t I2C_MasterGetTransferStatus (const i2c_instance_t *const *instance*, uint32_t * *bytesRemaining*)

Return the current status of the I2C master transfer.

This function can be called during a non-blocking transmission to check the status of the transfer.

Parameters

instance	I2C peripheral instance number
bytesRemaining	the number of remaining bytes in the active I2C transfer

Returns

Error or success status returned by API

Definition at line 1267 of file i2c_pal.c.

16.48.4.7 status_t I2C_MasterInit (const i2c_instance_t *const *instance*, const i2c_master_t * *config*)

Initializes the I2C module in master mode.

This function initializes and enables the requested I2C module in master mode, configuring the bus parameters.

Parameters

in	*instance*	The name of the instance
in	*config*	The configuration structure

Returns

Error or success status returned by API

Definition at line 210 of file i2c_pal.c.

16.48.4.8 status_t I2C_MasterReceiveData (const i2c_instance_t *const *instance*, uint8_t * *rxBuff*, uint32_t *rxSize*, bool *sendStop*)

Perform a non-blocking receive transaction on the I2C bus.

This function starts the reception of a block of data from the currently configured slave address and returns immediately. The rest of the reception is handled by the interrupt service routine.

Parameters

instance	The name of the instance
rxBuff	pointer to the buffer where to store received data
rxSize	length in bytes of the data to be transferred
sendStop	specifies whether or not to generate stop condition after the reception

Returns

Error or success status returned by API

Definition at line 533 of file i2c_pal.c.

16.48.4.9 status_t I2C_MasterReceiveDataBlocking (const i2c_instance_t *const *instance*, uint8_t * *rxBuff*, uint32_t *rxSize*, bool *sendStop*, uint32_t *timeout*)

Perform a blocking receive transaction on the I2C bus.

This function receives a block of data from the currently configured slave address, and only returns when the transmission is complete.

Parameters

instance	The name of the instance
rxBuff	pointer to the buffer where to store received data
rxSize	length in bytes of the data to be transferred
sendStop	specifies whether or not to generate stop condition after the reception
timeout	timeout for the transfer in milliseconds

Returns

Error or success status returned by API

Definition at line 585 of file i2c_pal.c.

16.48.4.10 status_t I2C_MasterSendData (const i2c_instance_t *const *instance*, const uint8_t * *txBuff*, uint32_t *txSize*, bool *sendStop*)

Perform a non-blocking send transaction on the I2C bus.

This function starts the transmission of a block of data to the currently configured slave address and returns immediately. The rest of the transmission is handled by the interrupt service routine.

Parameters

instance	The name of the instance
txBuff	pointer to the data to be transferred
txSize	length in bytes of the data to be transferred
sendStop	specifies whether or not to generate stop condition after the transmission

Returns

Error or success status returned by API

Definition at line 422 of file i2c_pal.c.

16.48.4.11 status_t I2C_MasterSendDataBlocking (const i2c_instance_t *const *instance*, const uint8_t * *txBuff*, uint32_t *txSize*, bool *sendStop*, uint32_t *timeout*)

Perform a blocking send transaction on the I2C bus.

This function sends a block of data to the currently configured slave address, and only returns when the transmission is complete.

Parameters

instance	The name of the instance
txBuff	pointer to the data to be transferred
txSize	length in bytes of the data to be transferred
sendStop	specifies whether or not to generate stop condition after the transmission
timeout	timeout for the transfer in milliseconds

Returns

Error or success status returned by API

Definition at line 479 of file i2c_pal.c.

16.48.4.12 status_t I2C_MasterSetBaudRate (const i2c_instance_t *const *instance*, const i2c_master_t * *config*, uint32_t *baudRate*)

Set the master baud rate for the I2C communication.

This function sets the master baud rate of the I2C master module.

Parameters

instance	I2C peripheral instance number
baudRate	the desired baud rate in Hz

Definition at line 742 of file i2c_pal.c.

16.48.4.13 status_t I2C_MasterSetSlaveAddress (const i2c_instance_t *const *instance*, const uint16_t *address*, const bool *is10bitAddr*)

Set the slave address for the I2C communication.

This function sets the slave address which will be used for any future transfer initiated by the I2C master.

Parameters

instance	I2C peripheral instance number
address	slave 7-bit or 10-bit address

Definition at line 689 of file i2c_pal.c.

16.48.4.14 status_t I2C_SlaveAbortTransfer (const i2c_instance_t *const *instance*)

Abort a non-blocking I2C slave transmission or reception.

Parameters

instance	I2C peripheral instance number

Returns

Error or success status returned by API

Definition at line 1425 of file i2c_pal.c.

16.48.4.15 status_t I2C_SlaveDeinit (const i2c_instance_t *const *instance*)

De-initializes the i2c slave module.

This function de-initialized the i2c slave module.

Parameters

in	*instance*	The name of the instance

Returns

Error or success status returned by API

Definition at line 1224 of file i2c_pal.c.

16.48.4.16 status_t I2C_SlaveGetTransferStatus (const i2c_instance_t *const *instance*, uint32_t * *bytesRemaining*)

Return the current status of the I2C slave transfer.

This function can be called during a non-blocking transmission to check the status of the transfer.

Parameters

instance	I2C peripheral instance number
bytesRemaining	the number of remaining bytes in the active I2C transfer

Returns

Error or success status returned by API

Definition at line 1324 of file i2c_pal.c.

16.48.4.17 status_t I2C_SlaveInit (const i2c_instance_t *const *instance*, const i2c_slave_t * *config*)

Initializes the I2C module in slave mode.

This function initializes and enables the requested I2C module in slave mode, configuring the bus parameters.

Parameters

in	*instance*	The name of the instance
in	*config*	The configuration structure

Returns

Error or success status returned by API

Definition at line 350 of file i2c_pal.c.

16.48.4.18 status_t I2C_SlaveReceiveData (const i2c_instance_t *const *instance*, uint8_t * *rxBuff*, uint32_t *rxSize*)

Perform a non-blocking receive transaction on the I2C bus.

Performs a non-blocking receive transaction on the I2C bus when the slave is not in listening mode (initialized with slaveListening = false). It starts the reception and returns immediately. The rest of the reception is handled by the interrupt service routine.

Parameters

instance	The name of the instance
rxBuff	pointer to the buffer where to store received data
rxSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API

Definition at line 1024 of file i2c_pal.c.

16.48.4.19 status_t I2C_SlaveReceiveDataBlocking (const i2c_instance_t *const *instance*, uint8_t * *rxBuff*, uint32_t *rxSize*, uint32_t *timeout*)

Perform a blocking receive transaction on the I2C bus.

Performs a blocking receive transaction on the I2C bus when the slave is not in listening mode (initialized with slaveListening = false). It sets up the reception and then waits for the transfer to complete before returning.

Parameters

instance	The name of the instance
rxBuff	pointer to the buffer where to store received data
rxSize	length in bytes of the data to be transferred
timeout	timeout for the transfer in milliseconds

Returns

Error or success status returned by API

Definition at line 1074 of file i2c_pal.c.

16.48.4.20 status_t I2C_SlaveSendData (const i2c_instance_t *const *instance*, const uint8_t * *txBuff*, uint32_t *txSize*)

Perform a non-blocking send transaction on the I2C bus.

Performs a non-blocking send transaction on the I2C bus when the slave is not in listening mode (initialized with slaveListening = false). It starts the transmission and returns immediately. The rest of the transmission is handled by the interrupt service routine.

Parameters

instance	The name of the instance
txBuff	pointer to the data to be transferred
txSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API

Definition at line 924 of file i2c_pal.c.

16.48.4.21 status_t I2C_SlaveSendDataBlocking (const i2c_instance_t *const *instance*, const uint8_t * *txBuff*, uint32_t *txSize*, uint32_t *timeout*)

Perform a blocking send transaction on the I2C bus.

Performs a blocking send transaction on the I2C bus when the slave is not in listening mode (initialized with slaveListening = false). It sets up the transmission and then waits for the transfer to complete before returning.

Parameters

instance	The name of the instance
txBuff	pointer to the data to be transferred
txSize	length in bytes of the data to be transferred
timeout	timeout for the transfer in milliseconds

Returns

Error or success status returned by API

Definition at line 973 of file i2c_pal.c.

16.48.4.22 status_t I2C_SlaveSetRxBuffer (const i2c_instance_t *const *instance*, uint8_t * *rxBuff*, uint32_t *rxSize*)

Provide a buffer for receiving data.

This function provides a buffer in which the I2C slave-mode driver can store received data. It can be called for example from the user callback provided at initialization time, when the driver reports events I2C_SLAVE_EVENT_RX_REQ or I2C_SLAVE_EVENT_RX_FULL.

Parameters

instance	I2C peripheral instance number
rxBuff	pointer to the data to be transferred
rxSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API

Definition at line 1126 of file i2c_pal.c.

16.48.4.23 status_t I2C_SlaveSetTxBuffer (const i2c_instance_t *const *instance*, const uint8_t * *txBuff*, uint32_t *txSize*)

Provide a buffer for transmitting data.

This function provides a buffer from which the I2C slave-mode driver can transmit data. It can be called for example from the user callback provided at initialization time, when the driver reports events I2C_SLAVE_EVENT_TX_REQ or I2C_SLAVE_EVENT_TX_EMPTY.

Parameters

instance	I2C peripheral instance number
txBuff	pointer to the data to be transferred
txSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API

Definition at line 1174 of file i2c_pal.c.

16.49 Interface management

16.49.1 Detailed Description

This group contains APIs that help users manage interface(s) in LIN node.

Functions

- l_bool l_ifc_init (l_ifc_handle iii)

  Initialize the controller specified by name, i.e. sets up internal functions such as the baud rate. The default schedule set by the l_ifc_init call will be the L_NULL_SCHEDULE where no frames will be sent and received. This is the first call a user must perform, before using any other interface related LIN API functions. The function returns zero if the initialization was successful and non-zero if failed.
- void l_ifc_goto_sleep (l_ifc_handle iii)

  Request slave nodes on the cluster connected to the interface to enter bus sleep mode by issuing one go to sleep command. This API is available only for Master nodes.
- void l_ifc_wake_up (l_ifc_handle iii)

  Transmit the wake up signal.
- l_u16 l_ifc_read_status (l_ifc_handle iii)

  This function will return the status of the previous communication.

16.49.2 Function Documentation

16.49.2.1 void l_ifc_goto_sleep (l_ifc_handle *iii*)

Request slave nodes on the cluster connected to the interface to enter bus sleep mode by issuing one go to sleep command. This API is available only for Master nodes.

Note

After sending go to sleep command successfully, the master node sets go to sleep flag to 1 and goes to sleep mode. At the end of Go to sleep schedule table, at the end of frame slot of go to sleep command, in l_sch_tick() the master node actually switches its active schedule table to Null to stop all communication. To start LIN communication, the master node shall call l_ifc_wake_up() to wake up LIN cluster and l_sch_set() to activate normal schedule table.

Parameters

in	*iii*	Interface name

Returns

void

Definition at line 376 of file lin_common_api.c.

16.49.2.2 l_bool l_ifc_init (l_ifc_handle *iii*)

Initialize the controller specified by name, i.e. sets up internal functions such as the baud rate. The default schedule set by the l_ifc_init call will be the L_NULL_SCHEDULE where no frames will be sent and received. This is the first call a user must perform, before using any other interface related LIN API functions. The function returns zero if the initialization was successful and non-zero if failed.

Parameters

in	*iii*	Interface name

Returns

Operation status

- Zero: Initialization was successful.
- Non-zero: Initialization failed.

Definition at line 405 of file lin_common_api.c.

16.49.2.3 l_u16 l_ifc_read_status (l_ifc_handle *iii*)

This function will return the status of the previous communication.

Parameters

in	*iii*	Interface name

Returns

l_u16

Definition at line 469 of file lin_common_api.c.

16.49.2.4 void l_ifc_wake_up (l_ifc_handle *iii*)

Transmit the wake up signal.

Parameters

in	*iii*	Interface name

Returns

void

Definition at line 455 of file lin_common_api.c.

16.50 Interrupt Manager (Interrupt)

16.50.1 Detailed Description

The S32 SDK Interrupt Manager provides a set of API/services to configure the Interrupt Controller (NVIC).

The Nested-Vectored Interrupt Controller (NVIC) module implements a relocatable vector table supporting many external interrupts, a single non-maskable interrupt (NMI), and priority levels. The NVIC contains the address of the function to execute for a particular handler. The address is fetched via the instruction port allowing parallel register stacking and look-up. The first sixteen entries are allocated to internal sources with the others mapping to MCU-defined interrupts.

Overview

The Interrupt Manager provides a set of APIs so that the application can enable or disable an interrupt for a specific device and also set priority, and other features. Additionally, it provides a way to update the vector table for a specific device interrupt handler.

Interrupt Names

Each chip has its own set of supported interrupt names defined in the chip-specific header file (see IRQn_Type).

This is an example to enable/disable an interrupt for the ADC0_IRQn:

```
#include "interrupt_manager.h"

INT_SYS_EnableIRQ(ADC0_IRQn);

INT_SYS_DisableIRQ(ADC0_IRQn);
```

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\interrupt\interrupt_manager.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
```

Compile symbols

No special symbols are required for this component

Dependencies

This component does not have any dependencies.

Note

1. When the vector table is not in ram (**flash_vector_table** = 1):
    - INT_SYS_InstallHandler shall check if the function pointer provided as parameter for the new handler is already present in the vector table for the given IRQ number.
    - The user will be required to manually add the correct handlers in the startup files

Typedefs

- typedef void(∗ isr_t) (void)

  Interrupt handler type.

Functions

- void DefaultISR (void)

  Default ISR.

Interrupt manager APIs

- void INT_SYS_InstallHandler (IRQn_Type irqNumber, const isr_t newHandler, isr_t ∗const oldHandler)

  Installs an interrupt handler routine for a given IRQ number.
- void INT_SYS_EnableIRQ (IRQn_Type irqNumber)

  Enables an interrupt for a given IRQ number.
- void INT_SYS_DisableIRQ (IRQn_Type irqNumber)

  Disables an interrupt for a given IRQ number.
- void INT_SYS_EnableIRQGlobal (void)

  Enables system interrupt.
- void INT_SYS_DisableIRQGlobal (void)

  Disable system interrupt.
- void INT_SYS_SetPriority (IRQn_Type irqNumber, uint8_t priority)

  Set Interrupt Priority.
- uint8_t INT_SYS_GetPriority (IRQn_Type irqNumber)

  Get Interrupt Priority.

16.50.2 Typedef Documentation

16.50.2.1 typedef void(∗ isr_t) (void)

Interrupt handler type.

Definition at line 76 of file interrupt_manager.h.

16.50.3 Function Documentation

16.50.3.1 void DefaultISR (void)

Default ISR.

16.50.3.2 void INT_SYS_DisableIRQ (IRQn_Type *irqNumber*)

Disables an interrupt for a given IRQ number.

This function disables the individual interrupt for a specified IRQ number.

Parameters

irqNumber	IRQ number

Definition at line 219 of file interrupt_manager.c.

16.50.3.3 void INT_SYS_DisableIRQGlobal (void)

Disable system interrupt.

This function disables the global interrupt by calling the core API.

Definition at line 271 of file interrupt_manager.c.

16.50.3.4 void INT_SYS_EnableIRQ (IRQn_Type *irqNumber*)

Enables an interrupt for a given IRQ number.

This function enables the individual interrupt for a specified IRQ number.

Parameters

irqNumber	IRQ number

Definition at line 190 of file interrupt_manager.c.

16.50.3.5 void INT_SYS_EnableIRQGlobal (void)

Enables system interrupt.

This function enables the global interrupt by calling the core API.

Definition at line 248 of file interrupt_manager.c.

16.50.3.6 uint8_t INT_SYS_GetPriority (IRQn_Type *irqNumber*)

Get Interrupt Priority.

The function gets the priority of an interrupt.

Parameters

irqNumber	Interrupt number.

Returns

priority Priority of the interrupt.

Definition at line 354 of file interrupt_manager.c.

16.50.3.7 void INT_SYS_InstallHandler (IRQn_Type *irqNumber,* const isr_t *newHandler,* isr_t ∗const *oldHandler*)

Installs an interrupt handler routine for a given IRQ number.

This function lets the application register/replace the interrupt handler for a specified IRQ number. See a chip-specific reference manual for details and the startup_<SoC>.s file for each chip family to find out the default interrupt handler for each device.

Note

This method is applicable only if interrupt vector is copied in RAM.

Parameters

irqNumber	IRQ number
newHandler	New interrupt handler routine address pointer
oldHandler	Pointer to a location to store current interrupt handler

Definition at line 114 of file interrupt_manager.c.

16.50.3.8 void INT_SYS_SetPriority (IRQn_Type *irqNumber,* uint8_t *priority*)

Set Interrupt Priority.

The function sets the priority of an interrupt.

Parameters

irqNumber	Interrupt number.
priority	Priority to set.

Definition at line 289 of file interrupt_manager.c.

16.51 Interrupt vector numbers for S32K142W

This module covers interrupt number allocation.

16.52 J2602 Specific API

J2602 protocol is LIN 2.0 based. It contains LIN 2.0's modules to support Signal management, network management, scheduler and J2602 status management. The goal of J2602 is to improve the interoperability and interchangeability of LIN devices within a network by resolving those LIN2.0 requirements that are ambiguous, conflicting, or optional. Moreover, J2602 provides additional requirements that are not present in LIN2.0. For example: fault tolerant, operation, network topology, etc. Different to LIN2.1 protocol, J2602 does not support sporadic and event trigger frames in communication.

16.53 J2602 Transport Layer specific API

16.53.1 Detailed Description

Contains Transport Layer APIs that only used for J2602 protocol.

Modules

- Node configuration

  This group contains APIs that used for node configuration purpose.

16.54 LIN 2.1 Specific API

16.54.1 Detailed Description

LIN 2.1 is extended from in LIN 2.0 specification through diagnostic services and few functions were removed as obsolete.

1. LIN 2.1 is compatible with LIN 2.0:
   - A LIN 2.1 master node may handle a LIN 2.0 slave node if the master node also contains all functionality of a LIN 2.0 master node, e.g. obsolete functions like Assign frame Id.
   - A LIN 2.1 slave node can be used in a cluster with a LIN 2.0 master node if the LIN 2.1 slave node is pre-configured, i.e. the LIN 2.1 slave node has a valid configuration after reset.
2. Changes between LIN 2.0 and LIN 2.1:
   - LIN2.1 enhance the capacity of LIN2.0 on event-triggered frame collision handling and diagnostic services supported. Besides, several features are added to fulfill powerful capacity of LIN network such as configuration service, assign frame ID range configuration, etc.

Functions

- void lin_collision_resolve (l_ifc_handle iii, l_u8 pid)

  Switch to collision resolve table.
- void lin_update_word_status_lin21 (l_ifc_handle iii, lin_lld_event_id_t event_id)

  Update node status flags.
- void lin_update_err_signal (l_ifc_handle iii, l_u8 frm_id)

  Update error signal.
- void lin_make_res_evnt_frame (l_ifc_handle iii, l_u8 pid)

  This function packs signals associated with event trigger frame into buffer.
- void lin_update_rx_evnt_frame (l_ifc_handle iii, l_u8 pid)

  The function updates the receive flags associated with signals/frames in case receive an event trigger frame.

16.54.2 Function Documentation

16.54.2.1 void lin_collision_resolve (l_ifc_handle *iii,* l_u8 *pid*)

Switch to collision resolve table.

Parameters

in	*iii*	Interface name
in	*pid*	PID to process

Returns

void

Definition at line 32 of file lin_lin21_proto.c.

16.54.2.2 void lin_make_res_evnt_frame (l_ifc_handle *iii,* l_u8 *pid*)

This function packs signals associated with event trigger frame into buffer.

Parameters

in	*iii*	Interface name
in	*pid*	PID to process

Returns

void

Definition at line 221 of file lin_lin21_proto.c.

16.54.2.3 void lin_update_err_signal (l_ifc_handle *iii,* l_u8 *frm_id*)

Update error signal.

Parameters

in	*iii*	Interface name
in	*frm_id*	Frame index

Returns

void

Definition at line 147 of file lin_lin21_proto.c.

16.54.2.4 void lin_update_rx_evnt_frame (l_ifc_handle *iii,* l_u8 *pid*)

The function updates the receive flags associated with signals/frames in case receive an event trigger frame.

Parameters

in	*iii*	Interface name
in	*pid*	PID to process

Returns

void

Definition at line 184 of file lin_lin21_proto.c.

16.54.2.5 void lin_update_word_status_lin21 (l_ifc_handle *iii,* lin_lld_event_id_t *event_id*)

Update node status flags.

Parameters

in	*iii*	Interface name
in	*event_id*	Event id

Returns

void

Definition at line 67 of file lin_lin21_proto.c.

16.55 LIN Core API

16.55.1 Detailed Description

The LIN core API handles initialization, processing and a signal based interaction between the application and the LIN core. Refer to chapter 7, LIN 2.2A specification.

- Core API layer consists of API functions as defined by the LIN2.1/J2602 specifications.
- Enabling the user to utilize the LIN2.1/J2602 communication within the user application.
- Both the static and dynamic modes for calling the API functions are supported.
- The core API layer interacts with the low level layer and can be called by such upper layers as LIN2.1 TL API, LIN TL J2602 or application for diagnostic implementation.

Modules

- Common Core API.
- J2602 Specific API
- LIN 2.1 Specific API

16.56 LIN Driver

16.56.1 Detailed Description

This section describes the programming interface of the Peripheral driver for LIN.

16.56.2 LIN Driver Overview

The LIN (Local Interconnect Network) Driver is an use-case driven High Level Peripheral Driver. The driver provides users important key features. NXP provides LIN Stack as a middleware software package that is developed on LIN driver. Users also can create their own LIN applications and LIN stack that are compatible with LIN Specification.
In this release package, LIN Driver is built on LPUART interface.

16.56.3 LIN Driver Device structures

The driver uses instantiations of the lin_state_t to maintain the current state of a particular LIN Hardware instance module driver.
The user is required to provide memory for the driver state structures during the initialization. The driver itself does not statically allocate memory.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\lin\lin_common.c
${S32SDK_PATH}\platform\drivers\src\lin\lin_driver.c
${S32SDK_PATH}\platform\drivers\src\lin\lin_irq.c
${S32SDK_PATH}\platform\drivers\src\lpuart\lin_lpuart_driver.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
${S32SDK_PATH}\platform\drivers\src\lpuart\
```

Compile symbols

No special symbols are required for this component

Dependencies

- Clock Manager
- Interrupt Manager (Interrupt)
- OS Interface (OSIF)
- Low Power Universal Asynchronous Receiver-Transmitter (LPUART)

16.56.4 LIN Driver Initialization

1. To initialize the LIN driver, call the LIN_DRV_Init() function and pass the instance number of the relevant LIN hardware interface instance which is LPUART instance in this release.
   For example: to use LPUART0 pass value 0 to the initialization function.

2. Pass a user configuration structure lin_user_config_t as shown here:

```
/* LIN Driver configuration structure */
typedef struct {
    uint32_t baudRate;
    bool nodeFunction;
    bool autobaudEnable;
    lin_timer_get_time_interval_t timerGetTimeIntervalCallback;
} lin_user_config_t;
```

3. For LIN, typically the user configures the lin_user_config_t instantiation with a baudrate from 1000bps to 20000bps.
   -E.g. 19200 bps linUserConfig.baudRate = 19200U.

4. Node function can be MASTER or SLAVE.
   -E.g. linUserConfig.nodeFunction = MASTER

5. If users do not want to use Autobaud feature, then just configure linUserConfig.autobaudEnable = FALSE.

6. Users shall assign measurement callback function pointer that is *timerGetTimeIntervalCallback*. This function must return time period between two consecutive calls in nano seconds with accuracy at least 0.1 microsecond and if this function is called for the first time, it will start the timer to measure time. When an event (such as detecting a falling edge of a dominant signal while node is in sleep mode) occurs, LIN driver will call *timerGetTimeIntervalCallback* to start time measurement. Then on rising edge of that signal, LIN driver will call *timerGetTimeIntervalCallback* function to get time interval of that dominant signal in nano seconds. If Autobaud feature is enabled, LIN driver uses *timerGetTimeIntervalCallback* to measure two bit time length between two consecutive falling edges of the sync byte in order to evaluate Master's baudrate. Users can implement this function in their applications. -E.g. linUserConfig.timerGetTimeIntervalCallback = timerGet↩ TimeIntervalCallback0; This is a code example to set up a FTM0 for LIN Driver:

```
/* Global variables */
uint16_t timerCounterValue[2] = {0u};
uint16_t timerOverflowInterruptCount = 0u;

/* Callback function to get time interval in nano seconds */
uint32_t timerGetTimeIntervalCallback0(uint32_t *ns)
{
    timerCounterValue[1] = (uint16_t)(ftmBase->CNT);
    *ns = ((uint32_t)(timerCounterValue[1] + timerOverflowInterruptCount*65536u - timerCounterValue[0]))*10
      00 / TIMER_1US;
    timerOverflowInterruptCount = 0U;
    timerCounterValue[0] = timerCounterValue[1];
    return 0U;
}
```

7. This is a code example to set up a user LIN Driver configuration instantiation:

```
/* Device instance number as LPUART instance*/
#define LI0 (0U)

lin_state_t linState;
lin_user_config_t linUserConfig;
/* Set baudrate 19200 bps */
linUserConfig.baudRate = 19200U;
/* Node is MASTER */
linUserConfig.nodeFunction = MASTER;
/* Disable autobaud feature */
linUserConfig.autobaudEnable = FALSE;
/* Callback function to get time interval in nano seconds */
linUserConfig.timerGetTimeIntervalCallback = (lin_timer_get_time_t)
      timerGetTimeIntervalCallback0;

/* Initialize LIN Hardware interface */
LIN_DRV_Init(LI0, (lin_user_config_t *) &linUserConfig, (
      lin_state_t *) &linState);
```

8. The users are required to initialize a timer for LIN.
   E.g. a Flex Timer (FTM). FTM instance should be initialized in Output Compare mode with an interrupt(E.g. FTM0_Ch0_Ch1_IRQHandler) period of about 500 us. Users can choose a different interrupt period that is appropriate to their applications. In timer interrupt handler, users shall call LIN_DRV_TimeoutService to handle linCurrentState->timeoutCounter while sending or receiving data.

16.56.5 LIN Data Transfers

The driver implements transmit and receive functions to transfer buffers of data by blocking and non-blocking modes.

The blocking transmit and receive functions include LIN_DRV_SendFrameDataBlocking() and the LIN_DRV_ReceiveFrameDataBlocking() functions.

The non-blocking (async) transmit and receive functions include the LIN_DRV_SendFrameData() and the LIN_DRV_ReceiveFrameData() functions.

The LIN_DRV_ReceiveFrameData() function is recommended to be called in an interrupt event of receiving PID as implemented in LIN Stack middleware.

The LIN_DRV_ReceiveFrameData() function should be called before data is transferring on the LIN bus. The LIN_DRV_ReceiveFrameDataBlocking() function should be called before frame is transferring on the LIN bus. Otherwise, some data may be lost.

Master nodes can transmit frame headers in non-blocking mode using LIN_DRV_MasterSendHeader().

In all these cases, the functions are interrupt-driven.

16.56.6 Autobaud feature

AUTOBAUD is an extensive feature in LIN Driver which allows a slave node to automatically detect baudrate of LIN bus and adapt its original baudrate to bus value. Auto Baud is applied when the baudrate of the incoming data is unknown. Currently autobaud feature is supported to detect LIN bus baudrates 2400, 4800, 9600, 14400, 19200 bps.

1. If autobaud feature is enabled, at LIN driver initialization slave's baudrate is set to 19200bps. The application should use a timer interrupt in input capture mode of both rising and falling edges(E.g FTM), call LIN_DRV_AutoBaudCapture(uint32_t instance) function to calculate and set Slave's baudrate like Master's baudrate. When receiving a frame header, the slave detect LIN bus's baudrate based on the synchronization byte and adapts its baudrate accordingly. On changing baudrate, the slave set current event ID to LIN_BAUDRATE_ADJUSTED and call the callback function. In that callback function users might change the frame data count timeout. Users can look at CallbackHandler() in lin.c of lin middleware for a reference.

   Note: Lin driver should be initiated before initiating a timer interrupt(E.g FTM).

2. Baudrate evaluation process is executed until autobaud successfully. During run-time if LIN bus's baudrate is changed suddenly to a value other than the slave's current baudrate, users shall reset MCU to execute baudrate evaluation process.

Note

1. When the vector table is not in ram (**flash_vector_table** = 1):
   - INT_SYS_InstallHandler shall check if the function pointer provided as parameter for the new handler is already present in the vector table for the given IRQ number.
   - The user will be required to manually add the correct handlers in the startup files

Data Structures

- struct lin_user_config_t

LIN hardware configuration structure Implements : lin_user_config_t_Class. More...

- struct lin_state_t

  Runtime state of the LIN driver. More...

Macros

- #define SLAVE 0U
- #define MASTER 1U
- #define MAKE_PARITY 0U
- #define CHECK_PARITY 1U

Typedefs

- typedef uint32_t(* lin_timer_get_time_interval_t) (uint32_t *nanoSeconds)

  Callback function to get time interval in nanoseconds Implements : lin_timer_get_time_interval_t_Class.
- typedef void(* lin_callback_t) (uint32_t instance, void *linState)

  LIN Driver callback function type Implements : lin_callback_t_Class.

Enumerations

- enum lin_event_id_t {
  LIN_NO_EVENT = 0x00U, LIN_WAKEUP_SIGNAL = 0x01U, LIN_BAUDRATE_ADJUSTED = 0x02U, LIN↩
  _RECV_BREAK_FIELD_OK = 0x03U,
  LIN_SYNC_OK = 0x04U, LIN_SYNC_ERROR = 0x05U, LIN_PID_OK = 0x06U, LIN_PID_ERROR = 0x07U,
  LIN_FRAME_ERROR = 0x08U, LIN_READBACK_ERROR = 0x09U, LIN_CHECKSUM_ERROR = 0x0AU,
  LIN_TX_COMPLETED = 0x0BU,
  LIN_RX_COMPLETED = 0x0CU, LIN_RX_OVERRUN = 0x0DU }

  Defines types for an enumerating event related to an Identifier. Implements : lin_event_id_t_Class.
- enum lin_node_state_t {
  LIN_NODE_STATE_UNINIT = 0x00U, LIN_NODE_STATE_SLEEP_MODE = 0x01U, LIN_NODE_STATE↩
  _IDLE = 0x02U, LIN_NODE_STATE_SEND_BREAK_FIELD = 0x03U,
  LIN_NODE_STATE_RECV_SYNC = 0x04U, LIN_NODE_STATE_SEND_PID = 0x05U, LIN_NODE_STA↩
  TE_RECV_PID = 0x06U, LIN_NODE_STATE_RECV_DATA = 0x07U,
  LIN_NODE_STATE_RECV_DATA_COMPLETED = 0x08U, LIN_NODE_STATE_SEND_DATA = 0x09U, L↩
  IN_NODE_STATE_SEND_DATA_COMPLETED = 0x0AU }

  Define type for an enumerating LIN Node state. Implements : lin_node_state_t_Class.

Variables

- isr_t g_linLpuartIsrs [LPUART_INSTANCE_COUNT]

LIN DRIVER

- status_t LIN_DRV_Init (uint32_t instance, lin_user_config_t *linUserConfig, lin_state_t *linCurrentState)

  Initializes an instance LIN Hardware Interface for LIN Network.
- void LIN_DRV_Deinit (uint32_t instance)

  Shuts down the LIN Hardware Interface by disabling interrupts and transmitter/receiver.
- void LIN_DRV_GetDefaultConfig (bool isMaster, lin_user_config_t *linUserConfig)

  Initializes the LIN user configuration structure with default values.
- lin_callback_t LIN_DRV_InstallCallback (uint32_t instance, lin_callback_t function)

  Installs callback function that is used for LIN_DRV_IRQHandler.

- status_t LIN_DRV_SendFrameDataBlocking (uint32_t instance, const uint8_t *txBuff, uint8_t txSize, uint32_t timeoutMSec)

  Sends Frame data out through the LIN Hardware Interface using blocking method. This function will calculate the checksum byte and send it with the frame data. Blocking means that the function does not return until the transmission is complete. This function checks if txSize is in range from 1 to 8. If not, it will return STATUS_ERROR. This function also returns STATUS_ERROR if node's current state is in SLEEP mode. This function checks if the isBusBusy is false, if not it will return LIN_BUS_BUSY. The function does not return until the transmission is complete. If the transmission is successful, it will return STATUS_SUCCESS. If not, it will return STATUS_TIMEOUT.

- status_t LIN_DRV_SendFrameData (uint32_t instance, const uint8_t *txBuff, uint8_t txSize)

  Sends frame data out through the LIN Hardware Interface using non-blocking method. This enables an a-sync method for transmitting data. Non-blocking means that the function returns immediately. The application has to get the transmit status to know when the transmit is complete. This function will calculate the checksum byte and send it with the frame data. The function will return immediately after calling this function. If txSize is equal to 0 or greater than 8 or node's current state is in SLEEP mode then the function will return STATUS_ERROR. If isBusBusy is currently true then the function will return LIN_BUS_BUSY.

- status_t LIN_DRV_GetTransmitStatus (uint32_t instance, uint8_t *bytesRemaining)

  Get status of an on-going non-blocking transmission While sending frame data using non-blocking method, users can use this function to get status of that transmission. The bytesRemaining shows number of bytes that still needed to transmit.

- status_t LIN_DRV_ReceiveFrameDataBlocking (uint32_t instance, uint8_t *rxBuff, uint8_t rxSize, uint32_t timeoutMSec)

  Receives frame data through the LIN Hardware Interface using blocking method. This function receives data from LPUART module using blocking method, the function does not return until the receive is complete. The interrupt handler LIN_LPUART_DRV_IRQHandler will check the checksum byte. If the checksum is correct, it will receive the frame data. If the checksum is incorrect, this function will return STATUS_TIMEOUT and data in rxBuff might be wrong. This function also check if rxSize is in range from 1 to 8. If not, it will return STATUS_ERROR. This function also returns STATUS_ERROR if node's current state is in SLEEP mode. This function checks if the isBusBusy is false, if not it will return LIN_BUS_BUSY.

- status_t LIN_DRV_ReceiveFrameData (uint32_t instance, uint8_t *rxBuff, uint8_t rxSize)

  Receives frame data through the LIN Hardware Interface using non-blocking method. This function will check the checksum byte. If the checksum is correct, it will receive it with the frame data. Non-blocking means that the function returns immediately. The application has to get the receive status to know when the reception is complete. The interrupt handler LIN_LPUART_DRV_IRQHandler will check the checksum byte. If the checksum is correct, it will receive the frame data. If the checksum is incorrect, this function will return STATUS_TIMEOUT and data in rxBuff might be wrong. This function also check if rxSize is in range from 1 to 8. If not, it will return STATUS_ERROR. This function also returns STATUS_ERROR if node's current state is in SLEEP mode. This function checks if the isBusBusy is false, if not it will return LIN_BUS_BUSY.

- status_t LIN_DRV_AbortTransferData (uint32_t instance)

  Aborts an on-going non-blocking transmission/reception. While performing a non-blocking transferring data, users can call this function to terminate immediately the transferring.

- status_t LIN_DRV_GetReceiveStatus (uint32_t instance, uint8_t *bytesRemaining)

  Get status of an on-going non-blocking reception. This function returns whether the data reception is complete. When performing non-blocking transmit, the user can call this function to ascertain the state of the current receive progress: in progress (STATUS_BUSY) or timeout (STATUS_TIMEOUT) or complete (STATUS_SUCCESS). In addition, if the reception is still in progress, the user can obtain the number of bytes that still needed to receive.

- status_t LIN_DRV_GoToSleepMode (uint32_t instance)

  Puts current LIN node to sleep mode This function changes current node state to LIN_NODE_STATE_SLEEP_MODE.

- status_t LIN_DRV_GotoIdleState (uint32_t instance)

  Puts current LIN node to Idle state This function changes current node state to LIN_NODE_STATE_IDLE.

- status_t LIN_DRV_SendWakeupSignal (uint32_t instance)

  Sends a wakeup signal through the LIN Hardware Interface.

- lin_node_state_t LIN_DRV_GetCurrentNodeState (uint32_t instance)

  Get the current LIN node state.

- void LIN_DRV_TimeoutService (uint32_t instance)

Callback function for Timer Interrupt Handler Users may use (optional, not required) LIN_DRV_TimeoutService to check if timeout has occurred during non-blocking frame data transmission and reception. User may initialize a timer (for example FTM) in Output Compare Mode with period of 500 micro seconds (recommended). In timer IRQ handler, call this function.

- void LIN_DRV_SetTimeoutCounter (uint32_t instance, uint32_t timeoutValue)

  Set Value for Timeout Counter that is used in LIN_DRV_TimeoutService.
- status_t LIN_DRV_MasterSendHeader (uint32_t instance, uint8_t id)

  Sends frame header out through the LIN Hardware Interface using a non-blocking method. This function sends LIN Break field, sync field then the ID with correct parity. This function checks if the interface is Master, if not, it will return STATUS_ERROR.This function checks if id is in range from 0 to 0x3F, if not it will return STATUS_ERROR.
- status_t LIN_DRV_EnableIRQ (uint32_t instance)

  Enables LIN hardware interrupts.
- status_t LIN_DRV_DisableIRQ (uint32_t instance)

  Disables LIN hardware interrupts.
- void LIN_DRV_IRQHandler (uint32_t instance)

  Interrupt handler for LIN Hardware Interface.
- uint8_t LIN_DRV_ProcessParity (uint8_t PID, uint8_t typeAction)

  Makes or checks parity bits. If action is checking parity, the function returns ID value if parity bits are correct or 0xFF if parity bits are incorrect. If action is making parity bits, then from input value of ID, the function returns PID. This is not a public API as it is called by other API functions.
- uint8_t LIN_DRV_MakeChecksumByte (const uint8_t *buffer, uint8_t sizeBuffer, uint8_t PID)

  Makes the checksum byte for a frame. For PID of identifiers, if PID is 0x3C (ID 0x3C) or 0x7D (ID 0x3D) or 0xFE (ID 0x3E) or 0xBF (ID 0x3F) apply classic checksum and apply enhanced checksum for other PID. In case user want to calculate classic checksum please set PID to zero.
- status_t LIN_DRV_AutoBaudCapture (uint32_t instance)

  Captures time interval to capture baudrate automatically when enable autobaud feature. This function should only be used in Slave. The timer should be in input capture mode of both rising and falling edges. The timer input capture pin should be externally connected to RXD pin.

16.56.7 Data Structure Documentation

16.56.7.1 struct lin_user_config_t

LIN hardware configuration structure Implements : lin_user_config_t_Class.

Definition at line 70 of file lin_driver.h.

Data Fields

- uint32_t baudRate
- bool nodeFunction
- bool autobaudEnable
- lin_timer_get_time_interval_t timerGetTimeIntervalCallback
- uint8_t * classicPID
- uint8_t numOfClassicPID

Field Documentation

16.56.7.1.1 bool autobaudEnable

Enable Autobaud feature

Definition at line 73 of file lin_driver.h.

16.56.7.1.2 uint32_t baudRate

baudrate of LIN Hardware Interface to configure

Definition at line 71 of file lin_driver.h.

16.56.7.1.3 uint8_t* classicPID

List of PIDs use classic checksum

Definition at line 75 of file lin_driver.h.

16.56.7.1.4 bool nodeFunction

Node function as Master or Slave

Definition at line 72 of file lin_driver.h.

16.56.7.1.5 uint8_t numOfClassicPID

Number of PIDs use classic checksum

Definition at line 76 of file lin_driver.h.

16.56.7.1.6 lin_timer_get_time_interval_t timerGetTimeIntervalCallback

Callback function to get time interval in nanoseconds

Definition at line 74 of file lin_driver.h.

16.56.7.2 struct lin_state_t

Runtime state of the LIN driver.

Note that the caller provides memory for the driver state structures during initialization because the driver does not statically allocate memory. Implements : lin_state_t_Class

Definition at line 131 of file lin_driver.h.

Data Fields

- const uint8_t * txBuff
- uint8_t * rxBuff
- uint8_t cntByte
- volatile uint8_t txSize
- volatile uint8_t rxSize
- uint8_t checkSum
- volatile bool isTxBusy
- volatile bool isRxBusy
- volatile bool isBusBusy
- volatile bool isTxBlocking
- volatile bool isRxBlocking
- lin_callback_t Callback
- uint8_t currentId
- uint8_t currentPid
- volatile lin_event_id_t currentEventId
- volatile lin_node_state_t currentNodeState
- volatile uint32_t timeoutCounter
- volatile bool timeoutCounterFlag
- volatile bool baudrateEvalEnable
- volatile uint8_t fallingEdgeInterruptCount
- uint32_t linSourceClockFreq
- semaphore_t txCompleted
- semaphore_t rxCompleted

Field Documentation

16.56.7.2.1 volatile bool baudrateEvalEnable

Baudrate Evaluation Process Enable

Definition at line 150 of file lin_driver.h.

16.56.7.2.2 lin_callback_t Callback

Callback function to invoke after receiving a byte or transmitting a byte.

Definition at line 143 of file lin_driver.h.

16.56.7.2.3 uint8_t checkSum

Checksum byte.

Definition at line 137 of file lin_driver.h.

16.56.7.2.4 uint8_t cntByte

To count number of bytes already transmitted or received.

Definition at line 134 of file lin_driver.h.

16.56.7.2.5 volatile lin_event_id_t currentEventId

Current ID Event

Definition at line 146 of file lin_driver.h.

16.56.7.2.6 uint8_t currentId

Current ID

Definition at line 144 of file lin_driver.h.

16.56.7.2.7 volatile lin_node_state_t currentNodeState

Current Node state

Definition at line 147 of file lin_driver.h.

16.56.7.2.8 uint8_t currentPid

Current PID

Definition at line 145 of file lin_driver.h.

16.56.7.2.9 volatile uint8_t fallingEdgeInterruptCount

Falling Edge count of a sync byte

Definition at line 151 of file lin_driver.h.

16.56.7.2.10 volatile bool isBusBusy

True if there are data, frame headers being transferred on bus

Definition at line 140 of file lin_driver.h.

16.56.7.2.11 volatile bool isRxBlocking

True if receive is blocking transaction.

Definition at line 142 of file lin_driver.h.

16.56.7.2.12 volatile bool isRxBusy

True if the LIN interface is receiving frame data.

Definition at line 139 of file lin_driver.h.

16.56.7.2.13 volatile bool isTxBlocking

True if transmit is blocking transaction.

Definition at line 141 of file lin_driver.h.

16.56.7.2.14 volatile bool isTxBusy

True if the LIN interface is transmitting frame data.

Definition at line 138 of file lin_driver.h.

16.56.7.2.15 uint32_t linSourceClockFreq

Frequency of the source clock for LIN

Definition at line 152 of file lin_driver.h.

16.56.7.2.16 uint8_t* rxBuff

The buffer of received data.

Definition at line 133 of file lin_driver.h.

16.56.7.2.17 semaphore_t rxCompleted

Used to wait for LIN interface ISR to complete reception

Definition at line 154 of file lin_driver.h.

16.56.7.2.18 volatile uint8_t rxSize

The remaining number of bytes to be received.

Definition at line 136 of file lin_driver.h.

16.56.7.2.19 volatile uint32_t timeoutCounter

Value of the timeout counter

Definition at line 148 of file lin_driver.h.

16.56.7.2.20 volatile bool timeoutCounterFlag

Timeout counter flag

Definition at line 149 of file lin_driver.h.

16.56.7.2.21 const uint8_t* txBuff

The buffer of data being sent.

Definition at line 132 of file lin_driver.h.

16.56.7.2.22 semaphore_t txCompleted

Used to wait for LIN interface ISR to complete transmission.

Definition at line 153 of file lin_driver.h.

16.56.7.2.23 volatile uint8_t txSize

The remaining number of bytes to be transmitted.

Definition at line 135 of file lin_driver.h.

16.56.8 Macro Definition Documentation

16.56.8.1 #define CHECK_PARITY 1U

Definition at line 50 of file lin_driver.h.

16.56.8.2 #define MAKE_PARITY 0U

Definition at line 49 of file lin_driver.h.

16.56.8.3 #define MASTER 1U

Definition at line 48 of file lin_driver.h.

16.56.8.4 #define SLAVE 0U

Definition at line 47 of file lin_driver.h.

16.56.9 Typedef Documentation

16.56.9.1 typedef void(* lin_callback_t) (uint32_t instance, void *linState)

LIN Driver callback function type Implements : lin_callback_t_Class.

Definition at line 122 of file lin_driver.h.

16.56.9.2 typedef uint32_t(* lin_timer_get_time_interval_t) (uint32_t *nanoSeconds)

Callback function to get time interval in nanoseconds Implements : lin_timer_get_time_interval_t_Class.

Definition at line 64 of file lin_driver.h.

16.56.10 Enumeration Type Documentation

16.56.10.1 enum lin_event_id_t

Defines types for an enumerating event related to an Identifier. Implements : lin_event_id_t_Class.

Enumerator

LIN_NO_EVENT No event yet

LIN_WAKEUP_SIGNAL Received a wakeup signal

LIN_BAUDRATE_ADJUSTED Indicate that baudrate was adjusted to Master's baudrate

LIN_RECV_BREAK_FIELD_OK Indicate that correct Break Field was received

LIN_SYNC_OK Sync byte is correct

LIN_SYNC_ERROR Sync byte is incorrect

LIN_PID_OK PID correct

LIN_PID_ERROR PID incorrect

LIN_FRAME_ERROR Framing Error

LIN_READBACK_ERROR Readback data is incorrect

LIN_CHECKSUM_ERROR Checksum byte is incorrect

LIN_TX_COMPLETED Sending data completed

LIN_RX_COMPLETED Receiving data completed

LIN_RX_OVERRUN RX overrun flag

Definition at line 83 of file lin_driver.h.

16.56.10.2 enum lin_node_state_t

Define type for an enumerating LIN Node state. Implements : lin_node_state_t_Class.

Enumerator

LIN_NODE_STATE_UNINIT Uninitialized state

LIN_NODE_STATE_SLEEP_MODE Sleep mode state

LIN_NODE_STATE_IDLE Idle state

LIN_NODE_STATE_SEND_BREAK_FIELD Send break field state

LIN_NODE_STATE_RECV_SYNC Receive the synchronization byte state

LIN_NODE_STATE_SEND_PID Send PID state

LIN_NODE_STATE_RECV_PID Receive PID state

LIN_NODE_STATE_RECV_DATA Receive data state

LIN_NODE_STATE_RECV_DATA_COMPLETED Receive data completed state

LIN_NODE_STATE_SEND_DATA Send data state

LIN_NODE_STATE_SEND_DATA_COMPLETED Send data completed state

Definition at line 104 of file lin_driver.h.

16.56.11 Function Documentation

16.56.11.1 status_t LIN_DRV_AbortTransferData (uint32_t *instance*)

Aborts an on-going non-blocking transmission/reception. While performing a non-blocking transferring data, users can call this function to terminate immediately the transferring.

Parameters

instance	LIN Hardware Interface instance number

Returns

function always return STATUS_SUCCESS

Definition at line 266 of file lin_driver.c.

16.56.11.2 status_t LIN_DRV_AutoBaudCapture (uint32_t *instance*)

Captures time interval to capture baudrate automatically when enable autobaud feature. This function should only be used in Slave. The timer should be in input capture mode of both rising and falling edges. The timer input capture pin should be externally connected to RXD pin.

Parameters

instance	LIN Hardware Interface instance number

Returns

operation status

- STATUS_SUCCESS: Operation was successful.
- STATUS_BUSY: Operation is running.
- STATUS_ERROR: Operation failed due to break char incorrect, wakeup signal incorrect or calculate baudrate failed.

Definition at line 493 of file lin_driver.c.

16.56.11.3 void LIN_DRV_Deinit (uint32_t *instance*)

Shuts down the LIN Hardware Interface by disabling interrupts and transmitter/receiver.

Parameters

instance	LIN Hardware Interface instance number

Returns

void

Definition at line 80 of file lin_driver.c.

16.56.11.4 status_t LIN_DRV_DisableIRQ (uint32_t *instance*)

Disables LIN hardware interrupts.

Parameters

instance	LIN Hardware Interface instance number

Returns

function always return STATUS_SUCCESS.

Definition at line 455 of file lin_driver.c.

16.56.11.5 status_t LIN_DRV_EnableIRQ (uint32_t *instance*)

Enables LIN hardware interrupts.

Parameters

instance	LIN Hardware Interface instance number.

Returns

function always return STATUS_SUCCESS.

Definition at line 437 of file lin_driver.c.

16.56.11.6 lin_node_state_t LIN_DRV_GetCurrentNodeState (uint32_t *instance*)

Get the current LIN node state.

Parameters

instance	LIN Hardware Interface instance number

Returns

current LIN node state

Definition at line 363 of file lin_driver.c.

16.56.11.7 void LIN_DRV_GetDefaultConfig (bool *isMaster,* lin_user_config_t * *linUserConfig*)

Initializes the LIN user configuration structure with default values.

This function initializes a configuration structure received from the application with default values. Note: Users shall assign measurement callback function pointer that is timerGetTimeIntervalCallback for linUserConfig. Users can see detail in doxygen.

Parameters

in	*isMaster*	Node function: • true if node is MASTER • false if node is SLAVE
out	*linUserConfig*	the default configuration

Returns

void

Definition at line 95 of file lin_driver.c.

16.56.11.8 status_t LIN_DRV_GetReceiveStatus (uint32_t *instance,* uint8_t * *bytesRemaining*)

Get status of an on-going non-blocking reception. This function returns whether the data reception is complete. When performing non-blocking transmit, the user can call this function to ascertain the state of the current receive progress: in progress (STATUS_BUSY) or timeout (STATUS_TIMEOUT) or complete (STATUS_SUCCESS). In addition, if the reception is still in progress, the user can obtain the number of bytes that still needed to receive.

Parameters

instance	LIN Hardware Interface instance number
bytesRemaining	Number of bytes still needed to receive

Returns

operation status:

- STATUS_SUCCESS : The reception is complete.
- STATUS_TIMEOUT : The reception isn't complete.
- STATUS_BUSY : The reception is on going

Definition at line 289 of file lin_driver.c.

16.56.11.9 status_t LIN_DRV_GetTransmitStatus (uint32_t *instance,* uint8_t * *bytesRemaining*)

Get status of an on-going non-blocking transmission While sending frame data using non-blocking method, users can use this function to get status of that transmission. The bytesRemaining shows number of bytes that still needed to transmit.

Parameters

instance	LIN Hardware Interface instance number
bytesRemaining	Number of bytes still needed to transmit

Returns

operation status:

- STATUS_SUCCESS : The transmission is successful.
- STATUS_BUSY : The transmission is sending
- STATUS_TIMEOUT : Operation failed due to timeout has occurred.

Definition at line 187 of file lin_driver.c.

16.56.11.10 status_t LIN_DRV_GotoIdleState (uint32_t *instance*)

Puts current LIN node to Idle state This function changes current node state to LIN_NODE_STATE_IDLE.

Parameters

instance	LIN Hardware Interface instance number

Returns

function always return STATUS_SUCCESS

Definition at line 327 of file lin_driver.c.

16.56.11.11 status_t LIN_DRV_GoToSleepMode (uint32_t *instance*)

Puts current LIN node to sleep mode This function changes current node state to LIN_NODE_STATE_SLEEP_↩ MODE.

Parameters

instance	LIN Hardware Interface instance number

Returns

function always return STATUS_SUCCESS

Definition at line 309 of file lin_driver.c.

16.56.11.12 status_t LIN_DRV_Init (uint32_t *instance*, lin_user_config_t * *linUserConfig*, lin_state_t * *linCurrentState*)

Initializes an instance LIN Hardware Interface for LIN Network.

The caller provides memory for the driver state structures during initialization. The user must select the LIN Hardware Interface clock source in the application to initialize the LIN Hardware Interface.

Parameters

instance	LIN Hardware Interface instance number
linUserConfig	user configuration structure of type lin_user_config_t
linCurrentState	pointer to the LIN Hardware Interface driver state structure

Returns

operation status:

- STATUS_SUCCESS : Operation was successful.
- STATUS_ERROR : Operation failed due to semaphores initialize error.

Definition at line 59 of file lin_driver.c.

16.56.11.13 lin_callback_t LIN_DRV_InstallCallback (uint32_t *instance,* lin_callback_t *function*)

Installs callback function that is used for LIN_DRV_IRQHandler.

Note

After a callback is installed, it bypasses part of the LIN Hardware Interface IRQHandler logic. Therefore, the callback needs to handle the indexes of txBuff and txSize.

Parameters

instance	LIN Hardware Interface instance number.
function	the LIN receive callback function.

Returns

Former LIN callback function pointer.

Definition at line 111 of file lin_driver.c.

16.56.11.14 void LIN_DRV_IRQHandler (uint32_t *instance*)

Interrupt handler for LIN Hardware Interface.

Parameters

instance	LIN Hardware Interface instance number

Returns

void

Definition at line 475 of file lin_driver.c.

16.56.11.15 uint8_t LIN_DRV_MakeChecksumByte (const uint8_t * *buffer,* uint8_t *sizeBuffer,* uint8_t *PID*)

Makes the checksum byte for a frame. For PID of identifiers, if PID is 0x3C (ID 0x3C) or 0x7D (ID 0x3D) or 0xFE (ID 0x3E) or 0xBF (ID 0x3F) apply classic checksum and apply enhanced checksum for other PID. In case user want to calculate classic checksum please set PID to zero.

Parameters

buffer	Pointer to Tx buffer
sizeBuffer	Number of bytes that are contained in the buffer.
PID	Protected Identifier byte.

Returns

the checksum byte.

Definition at line 100 of file lin_common.c.

16.56.11.16 status_t LIN_DRV_MasterSendHeader (uint32_t *instance,* uint8_t *id*)

Sends frame header out through the LIN Hardware Interface using a non-blocking method. This function sends LIN Break field, sync field then the ID with correct parity. This function checks if the interface is Master, if not, it will return STATUS_ERROR.This function checks if id is in range from 0 to 0x3F, if not it will return STATUS_ERROR.

Parameters

instance	LIN Hardware Interface instance number
id	Frame Identifier

Returns

operation status:

- STATUS_SUCCESS : The transmission is successful.
- STATUS_BUSY : Bus busy flag is true.
- STATUS_ERROR : The interface isn't Master or id isn't in range from 0 to 0x3F or node's current state is in SLEEP mode.

Definition at line 418 of file lin_driver.c.

16.56.11.17 uint8_t LIN_DRV_ProcessParity (uint8_t *PID,* uint8_t *typeAction*)

Makes or checks parity bits. If action is checking parity, the function returns ID value if parity bits are correct or 0xFF if parity bits are incorrect. If action is making parity bits, then from input value of ID, the function returns PID. This is not a public API as it is called by other API functions.

Parameters

PID	PID byte in case of checking parity bits or ID byte in case of making parity bits.
typeAction	1 for Checking parity bits, 0 for making parity bits

Returns

Value has 8 bit:

- 0xFF : Parity bits are incorrect,
- ID : Checking parity bits are correct.
- PID : typeAction is making parity bits.

Definition at line 55 of file lin_common.c.

16.56.11.18 status_t LIN_DRV_ReceiveFrameData (uint32_t *instance,* uint8_t * *rxBuff,* uint8_t *rxSize*)

Receives frame data through the LIN Hardware Interface using non-blocking method. This function will check the checksum byte. If the checksum is correct, it will receive it with the frame data. Non-blocking means that the function returns immediately. The application has to get the receive status to know when the reception is complete. The interrupt handler LIN_LPUART_DRV_IRQHandler will check the checksum byte. If the checksum is correct, it will receive the frame data. If the checksum is incorrect, this function will return STATUS_TIMEOUT and data in rxBuff might be wrong. This function also check if rxSize is in range from 1 to 8. If not, it will return STATUS_ERROR. This function also returns STATUS_ERROR if node's current state is in SLEEP mode. This function checks if the isBusBusy is false, if not it will return LIN_BUS_BUSY.

Note

If users use LIN_DRV_TimeoutService in a timer interrupt handler, then before using this function, users have to set timeout counter to an appropriate value by using LIN_DRV_SetTimeoutCounter(instance, timeout↩ Value). The timeout value should be big enough to complete the reception. Timeout in real time is (timeout↩ Value) * (time period that LIN_DRV_TimeoutService is called). For example, if LIN_DRV_TimeoutService is called in an timer interrupt with period of 500 micro seconds, then timeout in real time is timeoutValue * 500 micro seconds.

Parameters

instance	LIN Hardware Interface instance number
rxBuff	buffer containing 8-bit received data
rxSize	the number of bytes to receive

Returns

operation status:

- STATUS_SUCCESS : The receives frame data is successful.
- STATUS_TIMEOUT : The checksum is incorrect.
- STATUS_BUSY : Bus busy flag is true.
- STATUS_ERROR : Operation failed due is equal to 0 or greater than 8 or node's current state is in SLEEP mode

Definition at line 244 of file lin_driver.c.

16.56.11.19 status_t LIN_DRV_ReceiveFrameDataBlocking (uint32_t *instance,* uint8_t * *rxBuff,* uint8_t *rxSize,* uint32_t *timeoutMSec*)

Receives frame data through the LIN Hardware Interface using blocking method. This function receives data from LPUART module using blocking method, the function does not return until the receive is complete. The interrupt handler LIN_LPUART_DRV_IRQHandler will check the checksum byte. If the checksum is correct, it will receive the frame data. If the checksum is incorrect, this function will return STATUS_TIMEOUT and data in rxBuff might be wrong. This function also check if rxSize is in range from 1 to 8. If not, it will return STATUS_ERROR. This function also returns STATUS_ERROR if node's current state is in SLEEP mode. This function checks if the isBusBusy is false, if not it will return LIN_BUS_BUSY.

Parameters

instance	LIN Hardware Interface instance number
rxBuff	buffer containing 8-bit received data
rxSize	the number of bytes to receive
timeoutMSec	timeout value in milliseconds

Returns

operation status:

- STATUS_SUCCESS : The receives frame data is successful.
- STATUS_TIMEOUT : The checksum is incorrect.
- STATUS_BUSY : Bus busy flag is true.
- STATUS_ERROR : Operation failed due is equal to 0 or greater than 8 or node's current state is in SLEEP mode

Definition at line 214 of file lin_driver.c.

16.56.11.20 status_t LIN_DRV_SendFrameData (uint32_t *instance,* const uint8_t * *txBuff,* uint8_t *txSize*)

Sends frame data out through the LIN Hardware Interface using non-blocking method. This enables an a-sync method for transmitting data. Non-blocking means that the function returns immediately. The application has to get the transmit status to know when the transmit is complete. This function will calculate the checksum byte and send it with the frame data. The function will return immediately after calling this function. If txSize is equal to 0 or greater than 8 or node's current state is in SLEEP mode then the function will return STATUS_ERROR. If isBusBusy is currently true then the function will return LIN_BUS_BUSY.

Note

If users use LIN_DRV_TimeoutService in a timer interrupt handler, then before using this function, users have to set timeout counter to an appropriate value by using LIN_DRV_SetTimeoutCounter(instance, timeout↩ Value). The timeout value should be big enough to complete the transmission. Timeout in real time is (timeoutValue) ∗ (time period that LIN_DRV_TimeoutService is called). For example, if LIN_DRV_Timeout↩ Service is called in an timer interrupt with period of 500 micro seconds, then timeout in real time is timeout↩ Value ∗ 500 micro seconds.

Parameters

instance	LIN Hardware Interface instance number
txBuff	source buffer containing 8-bit data chars to send
txSize	the number of bytes to send

Returns

operation status:

- STATUS_SUCCESS : The transmission is successful.
- STATUS_BUSY : Operation failed due to isBusBusy is currently true.
- STATUS_ERROR : Operation failed due to txSize is equal to 0 or greater than 8 or node's current state is in SLEEP mode

Definition at line 162 of file lin_driver.c.

16.56.11.21 status_t LIN_DRV_SendFrameDataBlocking (uint32_t *instance,* const uint8_t ∗ *txBuff,* uint8_t *txSize,* uint32_t *timeoutMSec*)

Sends Frame data out through the LIN Hardware Interface using blocking method. This function will calculate the checksum byte and send it with the frame data. Blocking means that the function does not return until the transmission is complete. This function checks if txSize is in range from 1 to 8. If not, it will return STATUS_ER↩ ROR. This function also returns STATUS_ERROR if node's current state is in SLEEP mode. This function checks if the isBusBusy is false, if not it will return LIN_BUS_BUSY. The function does not return until the transmission is complete. If the transmission is successful, it will return STATUS_SUCCESS. If not, it will return STATUS_TIME↩ OUT.

Parameters

instance	LIN Hardware Interface instance number
txBuff	source buffer containing 8-bit data chars to send
txSize	the number of bytes to send
timeoutMSec	timeout value in milliseconds

Returns

operation status:

- STATUS_SUCCESS : The transmission is successful.
- STATUS_TIMEOUT : The transmission isn't successful.

Definition at line 137 of file lin_driver.c.

16.56.11.22 status_t LIN_DRV_SendWakeupSignal (uint32_t *instance*)

Sends a wakeup signal through the LIN Hardware Interface.

Parameters

instance	LIN Hardware Interface instance number

Returns

operation status:

- STATUS_SUCCESS : Bus busy flag is false.
- STATUS_BUSY : Bus busy flag is true.

Definition at line 345 of file lin_driver.c.

16.56.11.23 void LIN_DRV_SetTimeoutCounter (uint32_t *instance,* uint32_t *timeoutValue*)

Set Value for Timeout Counter that is used in LIN_DRV_TimeoutService.

Parameters

instance	LIN Hardware Interface instance number
timeoutValue	Timeout Value to be set

Returns

void

Definition at line 398 of file lin_driver.c.

16.56.11.24 void LIN_DRV_TimeoutService (uint32_t *instance*)

Callback function for Timer Interrupt Handler Users may use (optional, not required) LIN_DRV_TimeoutService to check if timeout has occurred during non-blocking frame data transmission and reception. User may initialize a timer (for example FTM) in Output Compare Mode with period of 500 micro seconds (recommended). In timer IRQ handler, call this function.

Parameters

instance	LIN Hardware Interface instance number

Returns

void

Definition at line 383 of file lin_driver.c.

16.56.12 Variable Documentation

16.56.12.1 isr_t g_linLpuartIsrs[LPUART_INSTANCE_COUNT]

Definition at line 88 of file lin_irq.c.

16.57 LIN Stack

16.57.1 Detailed Description

This section covers the functionality of the LIN Stack middleware layer in S32 SDK.

Introduction

LIN Stack Package Components

LIN Stack is a Middleware package that supports the LIN 1.3, 2.0, 2.1 and above, LIN2.1 and J2602 specifications. In LIN Stack, LIN 2.1 covers all LIN 2.1, LIN 2.2 and LIN 2.2A specifications, as the changes following LIN 2.1 are only spelling corrections and clarifications.

- 1. **LIN Stack:**

The layered architecture of the LIN Stack is shown on Figure 1. Such architecture aims maximum reusability of common code base for LIN2.1 and J2602 specifications for S32 Freescale automotive MCU portfolio.

The core API layer of LIN2.1/ J2602 handles initialization, processing and signal based interaction between applications and LIN Core.

The LIN2.1 TL (Transport Layer) provides methods for diagnostic services.

The low level layer offers methods for handling signal transmission between user applications and hardware such as interface initialization and deinitialization, frame header sending, response receiving, etc. The low level layer is builded on top of LIN Driver which is builded on top of LPUART HAL layer in the current release.

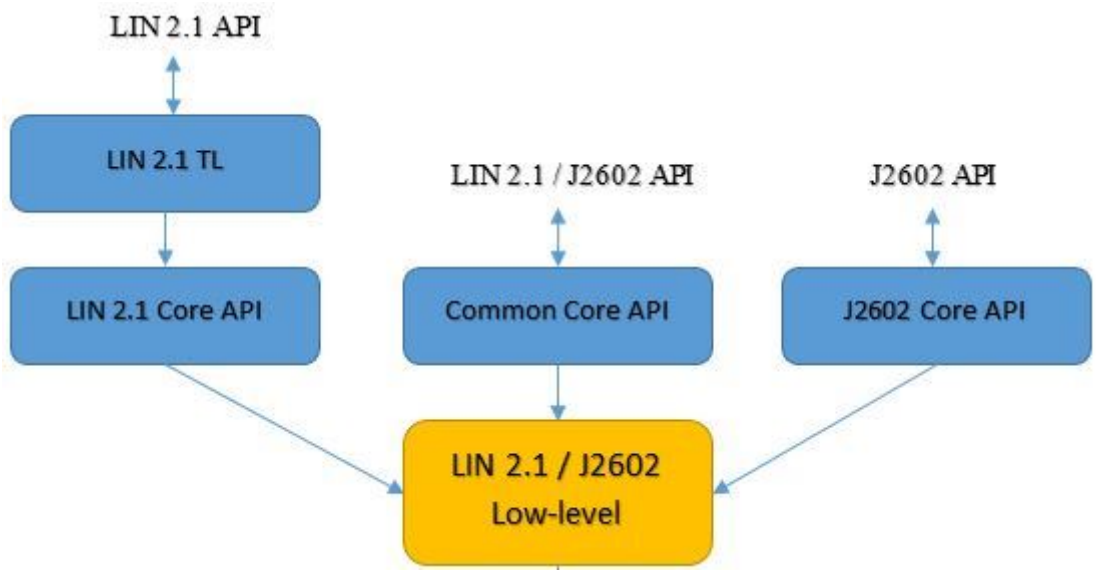


Figure 1. LIN Stack Architecture diagram

2. **Node Configuration Tool:**

To generate configuration files, users can use the Node Configuration Tool that is LIN Stack PEX component which allows to parse existed LDF files and reflect their contents to LIN Stack component GUI, to create new LDF files, to configure LIN cluster definitions and Node definitions. Using LIN Stack PEX component, users can easily generate the node configuration files (lin_cfg.h and lin_cfg.c) that are needed for LIN Stack to work properly.

Figure 2. Shows the diagram of configuration data flow.

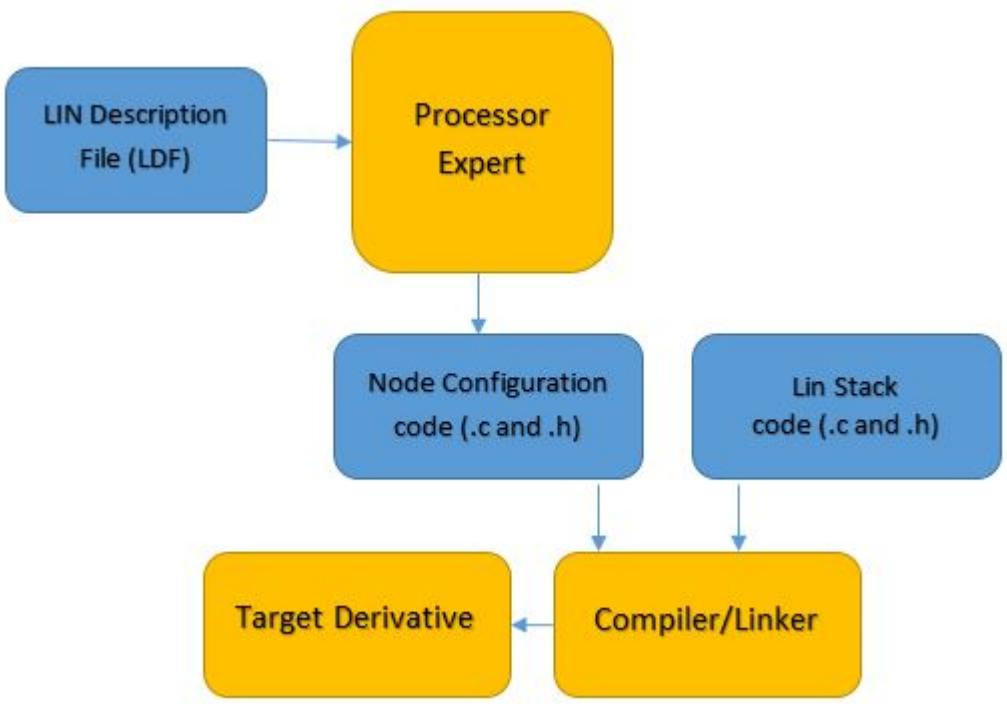


Figure 2. Configuration data

The LDF files describe complete LIN cluster definition including Master/slave mode definition, signals, frames, schedules, timing, etc.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
* ${S32SDK_PATH}\middleware\lin\coreapi\lin_common_api.c
* ${S32SDK_PATH}\middleware\lin\coreapi\lin_common_proto.c
* ${S32SDK_PATH}\middleware\lin\coreapi\lin_j2602_proto.c
* ${S32SDK_PATH}\middleware\lin\coreapi\lin_lin21_proto.c
* ${S32SDK_PATH}\middleware\lin\diagnostic\lin_diagnostic_service.c
* ${S32SDK_PATH}\middleware\lin\lowlevel\lin.c
* ${S32SDK_PATH}\middleware\lin\transport\lin_commontl_api.c
* ${S32SDK_PATH}\middleware\lin\transport\lin_commontl_proto.c
*
```

Include path

The following paths need to be added to the include path of the toolchain:

```
* ${S32SDK_PATH}\rtos\osif
* ${S32SDK_PATH}\platform\drivers\inc
* ${S32SDK_PATH}\platform\drivers\src\lin
* ${S32SDK_PATH}\platform\drivers\src\lpuart
* ${S32SDK_PATH}\middleware\lin\include
* ${S32SDK_PATH}\middleware\lin\lowlevel
* ${S32SDK_PATH}\middleware\lin\coreapi
* ${S32SDK_PATH}\middleware\lin\transport
*
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager Pins Driver (PINS) LIN Driver Low Power Universal Asynchronous Receiver-Transmitter (L↩ PUART)

Modules

- Diagnostic services

  Diagnostic services defines methods to implement diagnostic data transfer between a master node connected with a diagnostic tester and the slave nodes.
- LIN Core API

  The LIN core API handles initialization, processing and a signal based interaction between the application and the LIN core. Refer to chapter 7, LIN 2.2A specification.
- Low level API

  Low level layer consists of functions that call LIN driver API.
- Transport layer API

  Transport layer stands between the application layer and the core API layer.

16.58 LPI2C Driver

16.58.1 Detailed Description

Low Power Inter-Integrated Circuit (LPI2C) Peripheral Driver.

Low Power Inter-Integrated Circuit Driver.

The LPI2C driver allows communication on an I2C bus using the LPI2C module in the S32144K processor.

Features

- Interrupt based
- Master or slave operation
- Provides blocking and non-blocking transmit and receive functions
- 7-bit or 10-bit addressing
- Configurable baud rate
- Provides support for all operating modes supported by the hardware
  - Standard-mode (Sm): bidirectional data transfers up to 100 kbit/s
  - Fast-mode (Fm): bidirectional data transfers up to 400 kbit/s

Functionality

In order to use the LPI2C driver it must be first initialized in either master of slave mode, using functions LPI2C_DRV_MasterInit() or LPI2C_DRV_SlaveInit(). Once initialized, it cannot be initialized again for the same LPI2C module instance until it is de-initialized, using LPI2C_DRV_MasterDeinit() or LPI2C_DRV_SlaveDeinit(). Different LPI2C module instances can function independently of each other.

Master Mode

Master Mode provides functions for transmitting or receiving data to/from any I2C slave. Slave address and baud rate are provided at initialization time through the master configuration structure, but they can be changed at run-time by using LPI2C_DRV_MasterSetBaudRate() or LPI2C_DRV_MasterSetSlaveAddr(). Note that due to module limitation not any baud rate can be achieved. The driver will set a baud rate as close as possible to the requested baud rate, but there may still be substantial differences, for example if requesting a high baud rate while using a low-frequency protocol clock for the LPI2C module. The application should call LPI2C_DRV_MasterGetBaudRate() after LPI2C_DRV_MasterSetBaudRate() to check what baud rate was actually set.

To send or receive data to/from the currently configured slave address, use functions LPI2C_DRV_MasterSendData() or LPI2C_DRV_MasterReceiveData() (or their blocking counterparts). Parameter `sendStop` can be used to chain multiple transfers with repeated START condition between them, for example when sending a command and then immediately receiving a response. The application should ensure that any send or receive transfer with `sendStop` set to `false` is followed by another transfer, otherwise the LPI2C master will hold the SCL line low indefinitely and block the I2C bus. The last transfer from a chain should always have `sendStop` set to `true`.

Blocking operations will return only when the transfer is completed, either successfully or with error. Non-blocking operations will initiate the transfer and return STATUS_SUCCESS, but the module is still busy with the transfer and another transfer can't be initiated until the current transfer is complete. The application can check the status of the current transfer by calling LPI2C_DRV_MasterGetTransferStatus(). If the transfer is completed, the functions will return either STATUS_SUCCESS or an error code, depending on the outcome of the last transfer.

The driver supports any operating mode supported by the module. The operating mode is set together with the baud rate, by LPI2C_DRV_MasterSetBaudRate(). For High-Speed mode a second baud rate is required, for high-speed communication. Note that due to module limitation (common prescaler setting for normal and fast baud rate) there is a limit on the maximum difference between the two baud rates. LPI2C_DRV_MasterGetBaudRate() can be used to check the baud rate setting for both modes.

Slave Mode

Slave Mode provides functions for transmitting or receiving data to/from any I2C master. There are two slave operating modes, selected by the field `slaveListening` in the slave configuration structure:

- Slave always listening: the slave interrupt is enabled at initialization time and the slave always listens to the line for a master addressing it. Any events are reported to the application through the callback function provided at initialization time. The callback can use LPI2C_DRV_SlaveSetRxBuffer() or LPI2C_DRV_SlaveSetTxBuffer() to provide the appropriate buffers for transmit or receive, as needed.
- On-demand operation: the slave is commanded to transmit or receive data through the call of LPI2C_DRV_SlaveSendData() and LPI2C_DRV_SlaveReceiveData() (or their blocking counterparts). The actual moment of the transfer depends on the I2C master. The use of callbacks optional in this case, for example to treat events like LPI2C_SLAVE_EVENT_TX_EMPTY or LPI2C_SLAVE_EVENT_RX_FULL. Outside the commanded receive / transmit operations the LPI2C interrupts are disabled and the module will not react to master transfer requests.

Important Notes

- Before using the LPI2C driver in master mode the protocol clock of the module must be configured. Refer to SCG HAL and PCC HAL for clock configuration.
- Before using the LPI2C driver the pins must be routed to the LPI2C module. Refer to PORT HAL for pin routing configuration.
- The driver enables the interrupts for the corresponding LPI2C module, but any interrupt priority setting must be done by the application.
- Fast+, high-speed and ultra-fast mode aren't supported.
- Aborting a master reception is not currently supported due to hardware behavior (the module will continue a started reception even if the FIFO is reset).
- In listening mode, the init function must be called before the master starts the transfer. In non-listening mode, the init function and the appropriate send/receive function must be called before the master starts the transfer.
- Aborting a transfer with the function LPI2C_DRV_MasterAbortTransferData() can't be done safely due to device limitation; the user must ensure that the address is sent before aborting the transfer.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\lpi2c\lpi2c_irq.c
${S32SDK_PATH}\platform\drivers\src\lpi2c\lpi2c_hw_access.c
${S32SDK_PATH}\platform\drivers\src\lpi2c\lpi2c_driver.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc
${S32SDK_PATH}\platform\drivers\src\lpi2c
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager OS Interface (OSIF) Interrupt Manager (Interrupt) Enhanced Direct Memory Access (eDMA)

Data Structures

- struct lpi2c_master_user_config_t

  Defines the example structure. More...
- struct lpi2c_slave_user_config_t

  Slave configuration structure. More...
- struct lpi2c_baud_rate_params_t

  Baud rate structure. More...
- struct lpi2c_master_state_t

  Master internal context structure. More...
- struct lpi2c_slave_state_t

  Slave internal context structure. More...

Enumerations

- enum lpi2c_mode_t { LPI2C_STANDARD_MODE = 0x0U, LPI2C_FAST_MODE = 0x1U }

  I2C operating modes Implements : lpi2c_mode_t_Class.
- enum lpi2c_transfer_type_t { LPI2C_USING_DMA = 0, LPI2C_USING_INTERRUPTS = 1 }

  Type of LPI2C transfer (based on interrupts or DMA). Implements : lpi2c_transfer_type_t_Class.

LPI2C Driver

- status_t LPI2C_DRV_MasterInit (uint32_t instance, const lpi2c_master_user_config_t *userConfigPtr, lpi2c_master_state_t *master)

  Initialize the LPI2C master mode driver.
- status_t LPI2C_DRV_MasterDeinit (uint32_t instance)

  De-initialize the LPI2C master mode driver.
- void LPI2C_DRV_MasterGetBaudRate (uint32_t instance, lpi2c_baud_rate_params_t *baudRate)

  Get the currently configured baud rate.
- status_t LPI2C_DRV_MasterSetBaudRate (uint32_t instance, const lpi2c_mode_t operatingMode, const lpi2c_baud_rate_params_t baudRate)

  Set the baud rate for any subsequent I2C communication.
- void LPI2C_DRV_MasterSetSlaveAddr (uint32_t instance, const uint16_t address, const bool is10bitAddr)

  Set the slave address for any subsequent I2C communication.
- status_t LPI2C_DRV_MasterSendData (uint32_t instance, const uint8_t *txBuff, uint32_t txSize, bool sendStop)

  Perform a non-blocking send transaction on the I2C bus.
- status_t LPI2C_DRV_MasterSendDataBlocking (uint32_t instance, const uint8_t *txBuff, uint32_t txSize, bool sendStop, uint32_t timeout)

  Perform a blocking send transaction on the I2C bus.
- status_t LPI2C_DRV_MasterAbortTransferData (uint32_t instance)

  Abort a non-blocking I2C Master transmission or reception.
- status_t LPI2C_DRV_MasterReceiveData (uint32_t instance, uint8_t *rxBuff, uint32_t rxSize, bool sendStop)

  Perform a non-blocking receive transaction on the I2C bus.
- status_t LPI2C_DRV_MasterReceiveDataBlocking (uint32_t instance, uint8_t *rxBuff, uint32_t rxSize, bool sendStop, uint32_t timeout)

  Perform a blocking receive transaction on the I2C bus.
- status_t LPI2C_DRV_MasterGetTransferStatus (uint32_t instance, uint32_t *bytesRemaining)

  Return the current status of the I2C master transfer.
- void LPI2C_DRV_MasterIRQHandler (uint32_t instance)

  Handle master operation when I2C interrupt occurs.

- status_t LPI2C_DRV_SlaveInit (uint32_t instance, const lpi2c_slave_user_config_t *userConfigPtr, lpi2c_slave_state_t *slave)

  Initialize the I2C slave mode driver.
- status_t LPI2C_DRV_SlaveDeinit (uint32_t instance)

  De-initialize the I2C slave mode driver.
- status_t LPI2C_DRV_SlaveSetTxBuffer (uint32_t instance, const uint8_t *txBuff, uint32_t txSize)

  Provide a buffer for transmitting data.
- status_t LPI2C_DRV_SlaveSetRxBuffer (uint32_t instance, uint8_t *rxBuff, uint32_t rxSize)

  Provide a buffer for receiving data.
- status_t LPI2C_DRV_SlaveSendData (uint32_t instance, const uint8_t *txBuff, uint32_t txSize)

  Perform a non-blocking send transaction on the I2C bus.
- status_t LPI2C_DRV_SlaveSendDataBlocking (uint32_t instance, const uint8_t *txBuff, uint32_t txSize, uint32_t timeout)

  Perform a blocking send transaction on the I2C bus.
- status_t LPI2C_DRV_SlaveReceiveData (uint32_t instance, uint8_t *rxBuff, uint32_t rxSize)

  Perform a non-blocking receive transaction on the I2C bus.
- status_t LPI2C_DRV_SlaveReceiveDataBlocking (uint32_t instance, uint8_t *rxBuff, uint32_t rxSize, uint32_t timeout)

  Perform a blocking receive transaction on the I2C bus.
- status_t LPI2C_DRV_SlaveGetTransferStatus (uint32_t instance, uint32_t *bytesRemaining)

  Return the current status of the I2C slave transfer.
- status_t LPI2C_DRV_SlaveAbortTransferData (uint32_t instance)

  Abort a non-blocking I2C Master transmission or reception.
- void LPI2C_DRV_SlaveIRQHandler (uint32_t instance)

  Handle slave operation when I2C interrupt occurs.
- void LPI2C_DRV_MasterGetDefaultConfig (lpi2c_master_user_config_t *config)

  Gets the default configuration structure for master.
- void LPI2C_DRV_SlaveGetDefaultConfig (lpi2c_slave_user_config_t *config)

  Gets the default configuration structure for slave.
- void LPI2C_DRV_SetMasterBusIdleTimeout (uint32_t instance, uint16_t timeout)

  Set bus idle timeout for LPI2C.

16.58.2 Data Structure Documentation

16.58.2.1 struct lpi2c_master_user_config_t

Defines the example structure.

This structure is used as an example.

Master configuration structure

This structure is used to provide configuration parameters for the LPI2C master at initialization time. Implements : lpi2c_master_user_config_t_Class

Definition at line 111 of file lpi2c_driver.h.

Data Fields

- uint16_t slaveAddress
- bool is10bitAddr
- lpi2c_mode_t operatingMode
- uint32_t baudRate
- lpi2c_transfer_type_t transferType
- uint8_t dmaChannel
- i2c_master_callback_t masterCallback
- void * callbackParam

Field Documentation

16.58.2.1.1 uint32_t baudRate

The baud rate in hertz to use with current slave device

Definition at line 116 of file lpi2c_driver.h.

16.58.2.1.2 void* callbackParam

Parameter for the master callback function

Definition at line 127 of file lpi2c_driver.h.

16.58.2.1.3 uint8_t dmaChannel

Channel number for DMA channel. If DMA mode isn't used this field will be ignored.

Definition at line 122 of file lpi2c_driver.h.

16.58.2.1.4 bool is10bitAddr

Selects 7-bit or 10-bit slave address

Definition at line 114 of file lpi2c_driver.h.

16.58.2.1.5 i2c_master_callback_t masterCallback

Master callback function. Note that this function will be called from the interrupt service routine at the end of a transfer, so its execution time should be as small as possible. It can be NULL if you want to check manually the status of the transfer.

Definition at line 123 of file lpi2c_driver.h.

16.58.2.1.6 lpi2c_mode_t operatingMode

I2C Operating mode

Definition at line 115 of file lpi2c_driver.h.

16.58.2.1.7 uint16_t slaveAddress

Slave address, 7-bit or 10-bit

Definition at line 113 of file lpi2c_driver.h.

16.58.2.1.8 lpi2c_transfer_type_t transferType

Type of LPI2C transfer

Definition at line 121 of file lpi2c_driver.h.

16.58.2.2 struct lpi2c_slave_user_config_t

Slave configuration structure.

This structure is used to provide configuration parameters for the LPI2C slave at initialization time. Implements : lpi2c_slave_user_config_t_Class

Definition at line 136 of file lpi2c_driver.h.

Data Fields

- uint16_t slaveAddress
- bool is10bitAddr
- lpi2c_mode_t operatingMode

- bool slaveListening
- lpi2c_transfer_type_t transferType
- uint8_t dmaChannel
- i2c_slave_callback_t slaveCallback
- void * callbackParam

Field Documentation

16.58.2.2.1 void* callbackParam

Parameter for the slave callback function

Definition at line 149 of file lpi2c_driver.h.

16.58.2.2.2 uint8_t dmaChannel

Channel number for DMA rx channel. If DMA mode isn't used this field will be ignored.

Definition at line 143 of file lpi2c_driver.h.

16.58.2.2.3 bool is10bitAddr

Selects 7-bit or 10-bit slave address

Definition at line 139 of file lpi2c_driver.h.

16.58.2.2.4 lpi2c_mode_t operatingMode

I2C Operating mode

Definition at line 140 of file lpi2c_driver.h.

16.58.2.2.5 uint16_t slaveAddress

Slave address, 7-bit or 10-bit

Definition at line 138 of file lpi2c_driver.h.

16.58.2.2.6 i2c_slave_callback_t slaveCallback

Slave callback function. Note that this function will be called from the interrupt service routine, so its execution time should be as small as possible. It can be NULL if the slave is not in listening mode (slaveListening = false)

Definition at line 144 of file lpi2c_driver.h.

16.58.2.2.7 bool slaveListening

Slave mode (always listening or on demand only)

Definition at line 141 of file lpi2c_driver.h.

16.58.2.2.8 lpi2c_transfer_type_t transferType

Type of LPI2C transfer

Definition at line 142 of file lpi2c_driver.h.

16.58.2.3 struct lpi2c_baud_rate_params_t

Baud rate structure.

This structure is used for setting or getting the baud rate. Implements : lpi2c_baud_rate_params_t_Class

Definition at line 158 of file lpi2c_driver.h.

Data Fields

- uint32_t baudRate

Field Documentation

16.58.2.3.1 uint32_t baudRate

Definition at line 160 of file lpi2c_driver.h.

16.58.2.4 struct lpi2c_master_state_t

Master internal context structure.

This structure is used by the master-mode driver for its internal logic. It must be provided by the application through the LPI2C_DRV_MasterInit() function, then it cannot be freed until the driver is de-initialized using LPI2C_DRV_↩ MasterDeinit(). The application should make no assumptions about the content of this structure.

Definition at line 200 of file lpi2c_driver.h.

16.58.2.5 struct lpi2c_slave_state_t

Slave internal context structure.

This structure is used by the slave-mode driver for its internal logic. It must be provided by the application through the LPI2C_DRV_SlaveInit() function, then it cannot be freed until the driver is de-initialized using LPI2C_DRV_↩ SlaveDeinit(). The application should make no assumptions about the content of this structure.

Definition at line 238 of file lpi2c_driver.h.

16.58.3 Enumeration Type Documentation

16.58.3.1 enum lpi2c_mode_t

I2C operating modes Implements : lpi2c_mode_t_Class.

Enumerator

LPI2C_STANDARD_MODE Standard-mode (Sm), bidirectional data transfers up to 100 kbit/s

LPI2C_FAST_MODE Fast-mode (Fm), bidirectional data transfers up to 400 kbit/s

Definition at line 71 of file lpi2c_driver.h.

16.58.3.2 enum lpi2c_transfer_type_t

Type of LPI2C transfer (based on interrupts or DMA). Implements : lpi2c_transfer_type_t_Class.

Enumerator

LPI2C_USING_DMA The driver will use DMA to perform I2C transfer

LPI2C_USING_INTERRUPTS The driver will use interrupts to perform I2C transfer

Definition at line 89 of file lpi2c_driver.h.

16.58.4 Function Documentation

16.58.4.1 status_t LPI2C_DRV_MasterAbortTransferData (uint32_t *instance*)

Abort a non-blocking I2C Master transmission or reception.

Parameters

instance	LPI2C peripheral instance number

Returns

Error or success status returned by API

Definition at line 1653 of file lpi2c_driver.c.

16.58.4.2 status_t LPI2C_DRV_MasterDeinit (uint32_t *instance*)

De-initialize the LPI2C master mode driver.

This function de-initializes the LPI2C driver in master mode. The driver can't be used again until reinitialized. The context structure is no longer needed by the driver and can be freed after calling this function.

Parameters

instance	LPI2C peripheral instance number

Returns

Error or success status returned by API

Definition at line 1221 of file lpi2c_driver.c.

16.58.4.3 void LPI2C_DRV_MasterGetBaudRate (uint32_t *instance,* lpi2c_baud_rate_params_t * *baudRate*)

Get the currently configured baud rate.

This function returns the currently configured baud rate.

Parameters

instance	LPI2C peripheral instance number
baudRate	structure that contains the current baud rate in hertz and the baud rate in hertz for High-speed mode (unused in other modes, can be NULL)

Definition at line 1285 of file lpi2c_driver.c.

16.58.4.4 void LPI2C_DRV_MasterGetDefaultConfig (lpi2c_master_user_config_t * *config*)

Gets the default configuration structure for master.

The default configuration structure is:

Parameters

config	Pointer to configuration structure

Definition at line 1879 of file lpi2c_driver.c.

16.58.4.5 status_t LPI2C_DRV_MasterGetTransferStatus (uint32_t *instance,* uint32_t * *bytesRemaining*)

Return the current status of the I2C master transfer.

This function can be called during a non-blocking transmission to check the status of the transfer.

Parameters

instance	LPI2C peripheral instance number
bytesRemaining	the number of remaining bytes in the active I2C transfer

Returns

Error or success status returned by API

Definition at line 1837 of file lpi2c_driver.c.

16.58.4.6 status_t LPI2C_DRV_MasterInit (uint32_t *instance*, const lpi2c_master_user_config_t * *userConfigPtr*, lpi2c_master_state_t * *master*)

Initialize the LPI2C master mode driver.

This function initializes the LPI2C driver in master mode.

Parameters

instance	LPI2C peripheral instance number
userConfigPtr	Pointer to the LPI2C master user configuration structure. The function reads configuration data from this structure and initializes the driver accordingly. The application may free this structure after the function returns.
master	Pointer to the LPI2C master driver context structure. The driver uses this memory area for its internal logic. The application must make no assumptions about the content of this structure, and must not free this memory until the driver is de-initialized using LPI2C_DRV_Master↩ Deinit().

Returns

Error or success status returned by API

Definition at line 1136 of file lpi2c_driver.c.

16.58.4.7 void LPI2C_DRV_MasterIRQHandler (uint32_t *instance*)

Handle master operation when I2C interrupt occurs.

This is the interrupt service routine for the LPI2C master mode driver. It handles the rest of the transfer started by one of the send/receive functions.

Parameters

instance	LPI2C peripheral instance number

Definition at line 1897 of file lpi2c_driver.c.

16.58.4.8 status_t LPI2C_DRV_MasterReceiveData (uint32_t *instance*, uint8_t * *rxBuff*, uint32_t *rxSize*, bool *sendStop*)

Perform a non-blocking receive transaction on the I2C bus.

This function starts the reception of a block of data from the currently configured slave address and returns immediately. The rest of the reception is handled by the interrupt service routine. Use LPI2C_DRV_MasterGetReceive↩ Status() to check the progress of the reception.

Parameters

instance	LPI2C peripheral instance number
rxBuff	pointer to the buffer where to store received data
rxSize	length in bytes of the data to be transferred

sendStop	specifies whether or not to generate stop condition after the reception

Returns

Error or success status returned by API

Definition at line 1686 of file lpi2c_driver.c.

16.58.4.9 status_t LPI2C_DRV_MasterReceiveDataBlocking (uint32_t *instance,* uint8_t * *rxBuff,* uint32_t *rxSize,* bool *sendStop,* uint32_t *timeout*)

Perform a blocking receive transaction on the I2C bus.

This function receives a block of data from the currently configured slave address, and only returns when the transmission is complete.

Parameters

instance	LPI2C peripheral instance number
rxBuff	pointer to the buffer where to store received data
rxSize	length in bytes of the data to be transferred
sendStop	specifies whether or not to generate stop condition after the reception
timeout	timeout for the transfer in milliseconds

Returns

Error or success status returned by API

Definition at line 1782 of file lpi2c_driver.c.

16.58.4.10 status_t LPI2C_DRV_MasterSendData (uint32_t *instance,* const uint8_t * *txBuff,* uint32_t *txSize,* bool *sendStop*)

Perform a non-blocking send transaction on the I2C bus.

This function starts the transmission of a block of data to the currently configured slave address and returns immediately. The rest of the transmission is handled by the interrupt service routine. Use LPI2C_DRV_MasterGetSend↩ Status() to check the progress of the transmission.

Parameters

instance	LPI2C peripheral instance number
txBuff	pointer to the data to be transferred
txSize	length in bytes of the data to be transferred
sendStop	specifies whether or not to generate stop condition after the transmission

Returns

Error or success status returned by API

Definition at line 1532 of file lpi2c_driver.c.

16.58.4.11 status_t LPI2C_DRV_MasterSendDataBlocking (uint32_t *instance,* const uint8_t * *txBuff,* uint32_t *txSize,* bool *sendStop,* uint32_t *timeout*)

Perform a blocking send transaction on the I2C bus.

This function sends a block of data to the currently configured slave address, and only returns when the transmission is complete.

Parameters

instance	LPI2C peripheral instance number
txBuff	pointer to the data to be transferred
txSize	length in bytes of the data to be transferred
sendStop	specifies whether or not to generate stop condition after the transmission
timeout	timeout for the transfer in milliseconds

Returns

Error or success status returned by API

Definition at line 1613 of file lpi2c_driver.c.

16.58.4.12 status_t LPI2C_DRV_MasterSetBaudRate (uint32_t *instance*, const lpi2c_mode_t *operatingMode*, const lpi2c_baud_rate_params_t *baudRate*)

Set the baud rate for any subsequent I2C communication.

This function sets the baud rate (SCL frequency) for the I2C master. It can also change the operating mode. If the operating mode is High-Speed, a second baud rate must be provided for high-speed communication. Note that due to module limitation not any baud rate can be achieved. The driver will set a baud rate as close as possible to the requested baud rate, but there may still be substantial differences, for example if requesting a high baud rate while using a low-frequency protocol clock for the LPI2C module. The application should call LPI2C_DRV_MasterGetBaudRate() after LPI2C_DRV_MasterSetBaudRate() to check what baud rate was actually set.

Parameters

instance	LPI2C peripheral instance number
operatingMode	I2C operating mode
baudRate	structure that contains the baud rate in hertz to use by current slave device and also the baud rate in hertz for High-speed mode (unused in other modes)

Returns

Error or success status returned by API

Definition at line 1337 of file lpi2c_driver.c.

16.58.4.13 void LPI2C_DRV_MasterSetSlaveAddr (uint32_t *instance*, const uint16_t *address*, const bool *is10bitAddr*)

Set the slave address for any subsequent I2C communication.

This function sets the slave address which will be used for any future transfer initiated by the LPI2C master.

Parameters

instance	LPI2C peripheral instance number
address	slave address, 7-bit or 10-bit
is10bitAddr	specifies if provided address is 10-bit

Definition at line 1511 of file lpi2c_driver.c.

16.58.4.14 void LPI2C_DRV_SetMasterBusIdleTimeout (uint32_t *instance*, uint16_t *timeout*)

Set bus idle timeout for LPI2C.

This function sets time out for bus idle for Master.If both SCL and SDA are high for longer than Timeout cycles, then the I2C bus is assumed to be idle and the master can generate a START condition

Parameters

baseAddr	base address of the LPI2C module
timeout	bus idle timeout period in clock cycle. Zero means no bus idle timeout

Definition at line 1253 of file lpi2c_driver.c.

16.58.4.15 status_t LPI2C_DRV_SlaveAbortTransferData (uint32_t *instance*)

Abort a non-blocking I2C Master transmission or reception.

Parameters

instance	LPI2C peripheral instance number

Returns

Error or success status returned by API

Definition at line 2524 of file lpi2c_driver.c.

16.58.4.16 status_t LPI2C_DRV_SlaveDeinit (uint32_t *instance*)

De-initialize the I2C slave mode driver.

This function de-initializes the LPI2C driver in slave mode. The driver can't be used again until reinitialized. The context structure is no longer needed by the driver and can be freed after calling this function.

Parameters

instance	LPI2C peripheral instance number

Returns

Error or success status returned by API

Definition at line 2153 of file lpi2c_driver.c.

16.58.4.17 void LPI2C_DRV_SlaveGetDefaultConfig (lpi2c_slave_user_config_t * *config*)

Gets the default configuration structure for slave.

The default configuration structure is:

Parameters

config	Pointer to configuration structure

Definition at line 2551 of file lpi2c_driver.c.

16.58.4.18 status_t LPI2C_DRV_SlaveGetTransferStatus (uint32_t *instance,* uint32_t * *bytesRemaining*)

Return the current status of the I2C slave transfer.

This function can be called during a non-blocking transmission to check the status of the transfer.

Parameters

instance	LPI2C peripheral instance number
bytesRemaining	the number of remaining bytes in the active I2C transfer

Returns

Error or success status returned by API

Definition at line 2485 of file lpi2c_driver.c.

16.58.4.19 status_t LPI2C_DRV_SlaveInit (uint32_t *instance,* const lpi2c_slave_user_config_t * *userConfigPtr,* lpi2c_slave_state_t * *slave*)

Initialize the I2C slave mode driver.

Parameters

instance	LPI2C peripheral instance number
userConfigPtr	Pointer to the LPI2C slave user configuration structure. The function reads configuration data from this structure and initializes the driver accordingly. The application may free this structure after the function returns.
slave	Pointer to the LPI2C slave driver context structure. The driver uses this memory area for its internal logic. The application must make no assumptions about the content of this structure, and must not free this memory until the driver is de-initialized using LPI2C_DRV_Slave↩ Deinit().

Returns

Error or success status returned by API

Definition at line 2032 of file lpi2c_driver.c.

16.58.4.20 void LPI2C_DRV_SlaveIRQHandler (uint32_t *instance*)

Handle slave operation when I2C interrupt occurs.

This is the interrupt service routine for the LPI2C slave mode driver. It handles any transfer initiated by an I2C master and notifies the application via the provided callback when relevant events occur.

Parameters

instance	LPI2C peripheral instance number

Definition at line 2606 of file lpi2c_driver.c.

16.58.4.21 status_t LPI2C_DRV_SlaveReceiveData (uint32_t *instance*, uint8_t * *rxBuff*, uint32_t *rxSize*)

Perform a non-blocking receive transaction on the I2C bus.

Performs a non-blocking receive transaction on the I2C bus when the slave is not in listening mode (initialized with slaveListening = false). It starts the reception and returns immediately. The rest of the reception is handled by the interrupt service routine. Use LPI2C_DRV_SlaveGetReceiveStatus() to check the progress of the reception.

Parameters

instance	LPI2C peripheral instance number
rxBuff	pointer to the buffer where to store received data
rxSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API

Definition at line 2370 of file lpi2c_driver.c.

16.58.4.22 status_t LPI2C_DRV_SlaveReceiveDataBlocking (uint32_t *instance*, uint8_t * *rxBuff*, uint32_t *rxSize*, uint32_t *timeout*)

Perform a blocking receive transaction on the I2C bus.

Performs a blocking receive transaction on the I2C bus when the slave is not in listening mode (initialized with slaveListening = false). It sets up the reception and then waits for the transfer to complete before returning.

Parameters

instance	LPI2C peripheral instance number
rxBuff	pointer to the buffer where to store received data
rxSize	length in bytes of the data to be transferred
timeout	timeout for the transfer in milliseconds

Returns

Error or success status returned by API

Definition at line 2443 of file lpi2c_driver.c.

16.58.4.23 status_t LPI2C_DRV_SlaveSendData (uint32_t *instance*, const uint8_t * *txBuff*, uint32_t *txSize*)

Perform a non-blocking send transaction on the I2C bus.

Performs a non-blocking send transaction on the I2C bus when the slave is not in listening mode (initialized with slaveListening = false). It starts the transmission and returns immediately. The rest of the transmission is handled by the interrupt service routine. Use LPI2C_DRV_SlaveGetTransmitStatus() to check the progress of the transmission.

Parameters

instance	LPI2C peripheral instance number
txBuff	pointer to the data to be transferred
txSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API

Definition at line 2246 of file lpi2c_driver.c.

16.58.4.24 status_t LPI2C_DRV_SlaveSendDataBlocking (uint32_t *instance*, const uint8_t * *txBuff*, uint32_t *txSize*, uint32_t *timeout*)

Perform a blocking send transaction on the I2C bus.

Performs a blocking send transaction on the I2C bus when the slave is not in listening mode (initialized with slave↩ Listening = false). It sets up the transmission and then waits for the transfer to complete before returning.

Parameters

instance	LPI2C peripheral instance number
txBuff	pointer to the data to be transferred
txSize	length in bytes of the data to be transferred
timeout	timeout for the transfer in milliseconds

Returns

Error or success status returned by API

Definition at line 2332 of file lpi2c_driver.c.

16.58.4.25 status_t LPI2C_DRV_SlaveSetRxBuffer (uint32_t *instance*, uint8_t * *rxBuff*, uint32_t *rxSize*)

Provide a buffer for receiving data.

This function provides a buffer in which the LPI2C slave-mode driver can store received data. It can be called for example from the user callback provided at initialization time, when the driver reports events LPI2C_SLAVE_EV↩ ENT_RX_REQ or LPI2C_SLAVE_EVENT_RX_FULL.

Parameters

instance	LPI2C peripheral instance number
rxBuff	pointer to the data to be transferred
rxSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API

Definition at line 2219 of file lpi2c_driver.c.

16.58.4.26 status_t LPI2C_DRV_SlaveSetTxBuffer (uint32_t *instance*, const uint8_t * *txBuff*, uint32_t *txSize*)

Provide a buffer for transmitting data.

This function provides a buffer from which the LPI2C slave-mode driver can transmit data. It can be called for example from the user callback provided at initialization time, when the driver reports events LPI2C_SLAVE_EV↩ ENT_TX_REQ or LPI2C_SLAVE_EVENT_TX_EMPTY.

Parameters

instance	LPI2C peripheral instance number
txBuff	pointer to the data to be transferred
txSize	length in bytes of the data to be transferred

Returns

Error or success status returned by API

Definition at line 2192 of file lpi2c_driver.c.

16.59 LPIT Driver

16.59.1 Detailed Description

Low Power Interrupt Timer Peripheral Driver.

Hardware background

Each LPIT timer channel can be configured to run in one of 4 modes:
32-bit Periodic Counter: In this mode the counter will load and then decrement down to zero. It will then set the timer interrupt flag and assert the output pre-trigger.
Dual 16-bit Periodic Counter: In this mode, the counter will load and then the lower 16-bits will decrement down to zero, which will assert the output pre-trigger. The upper 16-bits will then decrement down to zero, which will negate the output pre-trigger and set the timer interrupt flag.
32-bit Trigger Accumulator: In this mode, the counter will load on the first trigger rising edge and then decrement down to zero on each trigger rising edge. It will then set the timer interrupt flag and assert the output pre-trigger.
32-bit Trigger Input Capture: In this mode, the counter will load with 0xFFFF_FFFF and then decrement down to zero. If a trigger rising edge is detected, it will store the inverse of the current counter value in the load value register, set the timer interrupt flag and assert the output pre-trigger.
In these modes, the timer channel operation is further controlled by Trigger Control bits (TSOT, TSOI, TROT) which control the load, reload, start and restart of the timer channels.

Driver consideration

The Driver uses structures for configuration. Each structure contains members that are specific to its respective functionality. There are **lpit_user_config_t** and **lpit_user_channel_config_t**.

Interrupt handling

Each LPIT timer channel has a corresponding interrupt handler. The LPIT Driver does not define interrupt handler internally. These interrupt handler methods can be defined by the user application. There are two ways to add an LPIT interrupt handler:

1. Using the weak symbols defined by start-up code. if the methods `LPIT`**x**`_Handler(void)` (x denotes instance number) are not defined, the linker use a default ISR. An error will be generated if methods with the same name are defined multiple times. This method works regardless of the placement of the interrupt vector table (Flash or RAM).
2. Using the Interrupt Manager's `INT_SYS_InstallHandler()` method. This can be used to dynamically change the ISR at run-time. This method works only if the interrupt vector table is located in RAM.

Clocking configuration

The LPIT Driver does not handle clock setup (from PCC) configuration. This is handled by the Clock Manager. The driver assumes that clock configurations have been made, so it is the user's responsibility to set up clocking and pin configurations correctly.

Basic operations

1. Pre-Initialization information of LPIT module
   - Before using the LPIT driver, the protocol clock of the module must be configured by the application using PCC module.
   - Configures Trigger MUX Control (TRGMUX) if want to use external trigger for LPIT module.
   - Configures different peripherals if want to use them in LPIT interrupt routine.
   - Provides configuration data structure to LPIT initialization API.
2. To initialize the LPIT module, just call the LPIT_DRV_Init() function with the user configuration data structure. This function configures LPIT module operation when MCU enters DEBUG and DOZE (Low power mode) modes and enables LPIT module. This function must be called firstly.

In the following code, LPIT module is initialized to continue to run when MCU enters both Debug and DOZE modes.

```
#define BOARD_LPIT_INSTANCE 0U
/* LPIT module configuration stucture */
lpit_user_config_t lpitconfig =
{
    .enableRunInDebug = true,
    .enableRunInDoze  = true
};
/* Initializes the LPIT module. */
LPIT_DRV_Init(BOARD_LPIT_INSTANCE, &lpitconfig);
```

3. After calling the LPIT_DRV_Init() function, call LPIT_DRV_InitChannel() function with user channel configuration structure to initialize timer channel.
   This function configures timer channel chaining, timer channel mode, timer channel period, interrupt generation, trigger source, trigger select, reload on trigger, stop on interrupt and start on trigger. In the following code, timer channel is initialized with the channel chaining is disabled, interrupt generation is enabled, operation mode is 32 bit periodic counter mode, trigger source is external, reload on trigger is disabled, stop on interrupt is disabled, start on trigger is disabled and timer period is 1 second. Note that:

   - Trigger select is not effective if trigger source is external.
   - Timer channel period must be suitable for operation mode.
   - The timer channel 0 can not be chained.

   ```
   /* Channel 0 configuration structure */
   lpit_user_channel_config_t chnlconfig =
   {
       .timerMode = LPIT_PERIODIC_COUNTER,
       .periodUnits = LPIT_PERIOD_UNITS_MICROSECONDS,
       .period = 1000000U,
       .triggerSource = LPIT_TRIGGER_SOURCE_INTERNAL,
       .triggerSelect = 1U,
       .enableReloadOnTrigger = false,
       .enableStopOnInterrupt = false,
       .enableStartOnTrigger = false,
       .chainChannel = false,
       .isInterruptEnabled = true
   };
   /* Initializes the channel 0 */
   LPIT_DRV_InitChannel(BOARD_LPIT_INSTANCE, 0, &chnlconfig);
   ```

4. To reconfigure timer channel period , just call LPIT_DRV_SetTimerPeriodByUs() or LPIT_DRV_SetTimer↩PeriodByCount() with corresponding new period. In the following code, the timer channel period is reconfigured with new period in count unit.

   ```
   /* Reconfigures timer channel period with new period of 10000 count*/
   LPIT_DRV_SetTimerPeriodByCount(BOARD_LPIT_INSTANCE, 0, 10000);
   ```

5. To start timer channel counting, just call LPIT_DRV_StartTimerChannels() with timer channels starting mask. In the following code, the timer channel 0 is started with the mask of 0x1U.

   ```
   /* Starts channel 0 counting*/
   LPIT_DRV_StartTimerChannels(BOARD_LPIT_INSTANCE, 0x1U);
   ```

6. To stop timer channel counting, just call LPIT_DRV_StopTimerChannels() with timer channels stopping mask. In the following code, the timer channel 0 is stopped with the mask of 0x1U.

   ```
   /* Stops channel 0 counting*/
   LPIT_DRV_StopTimerChannels(BOARD_LPIT_INSTANCE, 0x1U);
   ```

7. To disable LPIT module, just call LPIT_DRV_Deinit().

   ```
   /* Disables LPIT module*/
   LPIT_DRV_Deinit(BOARD_LPIT_INSTANCE);
   ```

API

Some of the features exposed by the API are targeted specifically for timer channel mode. For example, set/get timer period in dual 16 mode function makes sense if timer channel mode is dual 16 mode, so therefor it is restricted for use in other modes.

For any invalid configuration the functions will either return an error code or trigger DEV_ASSERT (if enabled). For more details, please refer to each function description.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\lpit_driver.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager Interrupt Manager (Interrupt)

Data Structures

- struct lpit_user_config_t

  LPIT configuration structure. More...
- struct lpit_user_channel_config_t

  Structure to configure the channel timer. More...

Macros

- #define MAX_PERIOD_COUNT (0xFFFFFFFFU)

  Max period in count of all operation mode except for dual 16 bit periodic counter mode.
- #define MAX_PERIOD_COUNT_IN_DUAL_16BIT_MODE (0x1FFFEU)

  Max period in count of dual 16 bit periodic counter mode.
- #define MAX_PERIOD_COUNT_16_BIT (0xFFFFU)

  Max count of 16 bit.

Enumerations

- enum lpit_timer_modes_t { LPIT_PERIODIC_COUNTER = 0x00U, LPIT_DUAL_PERIODIC_COUNTER = 0x01U, LPIT_TRIGGER_ACCUMULATOR = 0x02U, LPIT_INPUT_CAPTURE = 0x03U }

  Mode options available for the LPIT timer Implements : lpit_timer_modes_t_Class.
- enum lpit_trigger_source_t { LPIT_TRIGGER_SOURCE_EXTERNAL = 0x00U, LPIT_TRIGGER_SOURCE_INTERNAL = 0x01U }

  Trigger source options.
- enum lpit_period_units_t { LPIT_PERIOD_UNITS_COUNTS = 0x00U, LPIT_PERIOD_UNITS_MICROSECONDS = 0x01U }

  Unit options for LPIT period.

Initialization and De-initialization

- void LPIT_DRV_GetDefaultConfig (lpit_user_config_t *const config)

  Gets the default LPIT configuration.
- void LPIT_DRV_GetDefaultChanConfig (lpit_user_channel_config_t *const config)

  Gets the default timer channel configuration.
- void LPIT_DRV_Init (uint32_t instance, const lpit_user_config_t *userConfig)

  Initializes the LPIT module.
- void LPIT_DRV_Deinit (uint32_t instance)

  De-Initializes the LPIT module.
- status_t LPIT_DRV_InitChannel (uint32_t instance, uint32_t channel, const lpit_user_channel_config_t *userChannelConfig)

  Initializes the LPIT channel.

Timer Start and Stop

- void LPIT_DRV_StartTimerChannels (uint32_t instance, uint32_t mask)

  Starts the timer channel counting.
- void LPIT_DRV_StopTimerChannels (uint32_t instance, uint32_t mask)

  Stops the timer channel counting.

Timer Period

- status_t LPIT_DRV_SetTimerPeriodByUs (uint32_t instance, uint32_t channel, uint32_t periodUs)

  Sets the timer channel period in microseconds.
- status_t LPIT_DRV_SetTimerPeriodInDual16ModeByUs (uint32_t instance, uint32_t channel, uint16_t periodHigh, uint16_t periodLow)

  Sets the timer channel period in microseconds.
- uint64_t LPIT_DRV_GetTimerPeriodByUs (uint32_t instance, uint32_t channel)

  Gets the timer channel period in microseconds.
- uint64_t LPIT_DRV_GetCurrentTimerUs (uint32_t instance, uint32_t channel)

  Gets the current timer channel counting value in microseconds.
- void LPIT_DRV_SetTimerPeriodByCount (uint32_t instance, uint32_t channel, uint32_t count)

  Sets the timer channel period in count unit.
- void LPIT_DRV_SetTimerPeriodInDual16ModeByCount (uint32_t instance, uint32_t channel, uint16_t periodHigh, uint16_t periodLow)

  Sets the timer channel period in count unit.
- uint32_t LPIT_DRV_GetTimerPeriodByCount (uint32_t instance, uint32_t channel)

  Gets the current timer channel period in count unit.
- uint32_t LPIT_DRV_GetCurrentTimerCount (uint32_t instance, uint32_t channel)

  Gets the current timer channel counting value in count.

Interrupt

- void LPIT_DRV_EnableTimerChannelInterrupt (uint32_t instance, uint32_t mask)

  Enables the interrupt generation of timer channel.
- void LPIT_DRV_DisableTimerChannelInterrupt (uint32_t instance, uint32_t mask)

  Disables the interrupt generation of timer channel.
- uint32_t LPIT_DRV_GetInterruptFlagTimerChannels (uint32_t instance, uint32_t mask)

  Gets the current interrupt flag of timer channels.
- void LPIT_DRV_ClearInterruptFlagTimerChannels (uint32_t instance, uint32_t mask)

  Clears the interrupt flag of timer channels.

16.59.2 Data Structure Documentation

16.59.2.1 struct lpit_user_config_t

LPIT configuration structure.

This structure holds the configuration settings for the LPIT peripheral to enable or disable LPIT module in DEBUG and DOZE mode Implements : lpit_user_config_t_Class

Definition at line 108 of file lpit_driver.h.

Data Fields

- bool enableRunInDebug
- bool enableRunInDoze

Field Documentation

16.59.2.1.1 bool enableRunInDebug

True: Timer channels continue to run in debug mode False: Timer channels stop in debug mode

Definition at line 110 of file lpit_driver.h.

16.59.2.1.2 bool enableRunInDoze

True: Timer channels continue to run in doze mode False: Timer channels stop in doze mode

Definition at line 112 of file lpit_driver.h.

16.59.2.2 struct lpit_user_channel_config_t

Structure to configure the channel timer.

This structure holds the configuration settings for the LPIT timer channel Implements : lpit_user_channel_config↩_t_Class

Definition at line 121 of file lpit_driver.h.

Data Fields

- lpit_timer_modes_t timerMode
- lpit_period_units_t periodUnits
- uint32_t period
- lpit_trigger_source_t triggerSource
- uint32_t triggerSelect
- bool enableReloadOnTrigger
- bool enableStopOnInterrupt
- bool enableStartOnTrigger
- bool chainChannel
- bool isInterruptEnabled

Field Documentation

16.59.2.2.1 bool chainChannel

Channel chaining enable

Definition at line 137 of file lpit_driver.h.

16.59.2.2.2 bool enableReloadOnTrigger

True: Timer channel will reload on selected trigger False: Timer channel will not reload on selected trigger

Definition at line 129 of file lpit_driver.h.

16.59.2.2.3 bool enableStartOnTrigger

True: Timer channel starts to decrement when rising edge on selected trigger is detected. False: Timer starts to decrement immediately based on restart condition

Definition at line 133 of file lpit_driver.h.

16.59.2.2.4 bool enableStopOnInterrupt

True: Timer will stop after timeout False: Timer channel does not stop after timeout

Definition at line 131 of file lpit_driver.h.

16.59.2.2.5 bool isInterruptEnabled

Timer channel interrupt generation enable

Definition at line 138 of file lpit_driver.h.

16.59.2.2.6 uint32_t period

Period of timer channel

Definition at line 125 of file lpit_driver.h.

16.59.2.2.7 lpit_period_units_t periodUnits

Timer period value units

Definition at line 124 of file lpit_driver.h.

16.59.2.2.8 lpit_timer_modes_t timerMode

Operation mode of timer channel

Definition at line 123 of file lpit_driver.h.

16.59.2.2.9 uint32_t triggerSelect

Selects one trigger from the internal trigger sources this field makes sense if trigger source is internal

Definition at line 127 of file lpit_driver.h.

16.59.2.2.10 lpit_trigger_source_t triggerSource

Selects between internal and external trigger sources

Definition at line 126 of file lpit_driver.h.

16.59.3 Macro Definition Documentation

16.59.3.1 #define MAX_PERIOD_COUNT (0xFFFFFFFFU)

Max period in count of all operation mode except for dual 16 bit periodic counter mode.

Definition at line 58 of file lpit_driver.h.

16.59.3.2 #define MAX_PERIOD_COUNT_16_BIT (0xFFFFU)

Max count of 16 bit.

Definition at line 62 of file lpit_driver.h.

16.59.3.3 #define MAX_PERIOD_COUNT_IN_DUAL_16BIT_MODE (0x1FFFEU)

Max period in count of dual 16 bit periodic counter mode.

Definition at line 60 of file lpit_driver.h.

16.59.4 Enumeration Type Documentation

16.59.4.1 enum lpit_period_units_t

Unit options for LPIT period.

This is used to determine unit of timer period Implements : lpit_period_units_t_Class

Enumerator

LPIT_PERIOD_UNITS_COUNTS Period value unit is count

LPIT_PERIOD_UNITS_MICROSECONDS Period value unit is microsecond

Definition at line 95 of file lpit_driver.h.

16.59.4.2 enum lpit_timer_modes_t

Mode options available for the LPIT timer Implements : lpit_timer_modes_t_Class.

Enumerator

LPIT_PERIODIC_COUNTER 32-bit Periodic Counter

LPIT_DUAL_PERIODIC_COUNTER Dual 16-bit Periodic Counter

LPIT_TRIGGER_ACCUMULATOR 32-bit Trigger Accumulator

LPIT_INPUT_CAPTURE 32-bit Trigger Input Capture

Definition at line 68 of file lpit_driver.h.

16.59.4.3 enum lpit_trigger_source_t

Trigger source options.

This is used for both internal and external trigger sources. The actual trigger options available is SoC specific, user should refer to the reference manual. Implements : lpit_trigger_source_t_Class

Enumerator

LPIT_TRIGGER_SOURCE_EXTERNAL Use external trigger

LPIT_TRIGGER_SOURCE_INTERNAL Use internal trigger

Definition at line 83 of file lpit_driver.h.

16.59.5 Function Documentation

16.59.5.1 void LPIT_DRV_ClearInterruptFlagTimerChannels (uint32_t *instance,* uint32_t *mask*)

Clears the interrupt flag of timer channels.

This function clears the interrupt flag of timer channels after their interrupt event occurred.

Parameters

in	*instance*	LPIT module instance number
in	*mask*	The interrupt flag clearing mask that decides which channels will be cleared interrupt flag • For example: – with mask = 0x01u then the interrupt flag of channel 0 only will be cleared – with mask = 0x02u then the interrupt flag of channel 1 only will be cleared – with mask = 0x03u then the interrupt flags of channel 0 and channel 1 will be cleared

Definition at line 744 of file lpit_driver.c.

16.59.5.2 void LPIT_DRV_Deinit (uint32_t *instance*)

De-Initializes the LPIT module.

This function disables LPIT module. In order to use the LPIT module again, LPIT_DRV_Init must be called.

Parameters

in	*instance*	LPIT module instance number

Definition at line 177 of file lpit_driver.c.

16.59.5.3 void LPIT_DRV_DisableTimerChannelInterrupt (uint32_t *instance,* uint32_t *mask*)

Disables the interrupt generation of timer channel.

This function allows disabling interrupt generation of timer channel when timeout occurs or input trigger occurs.

Parameters

in	*instance*	LPIT module instance number
in	*mask*	The mask that decides which channels will be disable interrupt. • For example: – with mask = 0x01u then the interrupt of channel 0 will be disable – with mask = 0x02u then the interrupt of channel 1 will be disable – with mask = 0x03u then the interrupt of channel 0 and channel 1 will be disable

Definition at line 701 of file lpit_driver.c.

16.59.5.4 void LPIT_DRV_EnableTimerChannelInterrupt (uint32_t *instance,* uint32_t *mask*)

Enables the interrupt generation of timer channel.

This function allows enabling interrupt generation of timer channel when timeout occurs or input trigger occurs.

Parameters

in	*instance*	LPIT module instance number.

in	*mask*	The mask that decides which channels will be enabled interrupt. • For example: – with mask = 0x01u then the interrupt of channel 0 will be enabled – with mask = 0x02u then the interrupt of channel 1 will be enabled – with mask = 0x03u then the interrupt of channel 0 and channel 1 will be enabled

Definition at line 680 of file lpit_driver.c.

16.59.5.5 uint32_t LPIT_DRV_GetCurrentTimerCount (uint32_t *instance,* uint32_t *channel*)

Gets the current timer channel counting value in count.

This function returns the real-time timer channel counting value, the value in a range from 0 to timer channel period. Need to make sure the running time does not exceed the timer channel period.

Parameters

in	*instance*	LPIT module instance number
in	*channel*	Timer channel number

Returns

Current timer channel counting value in count

Definition at line 648 of file lpit_driver.c.

16.59.5.6 uint64_t LPIT_DRV_GetCurrentTimerUs (uint32_t *instance,* uint32_t *channel*)

Gets the current timer channel counting value in microseconds.

This function returns an absolute time stamp in microseconds. One common use of this function is to measure the running time of a part of code. Call this function at both the beginning and end of code. The time difference between these two time stamps is the running time. The return counting value here makes sense if the operation mode of timer channel is 32 bit periodic counter or dual 16 bit periodic counter or 32-bit trigger input capture. Need to make sure the running time will not exceed the timer channel period.

Parameters

in	*instance*	LPIT module instance number
in	*channel*	Timer channel number

Returns

Current timer channel counting value in microseconds

Definition at line 512 of file lpit_driver.c.

16.59.5.7 void LPIT_DRV_GetDefaultChanConfig (lpit_user_channel_config_t ∗const *config*)

Gets the default timer channel configuration.

This function gets the default timer channel configuration structure, with the following settings:

- Timer mode: 32-bit Periodic Counter
- Period unit: Period value unit is microsecond
- Period: 1000000 microseconds(1 second)
- Trigger sources: External trigger

- Trigger select: Trigger from channel 0
- Reload on trigger: Disable
- Stop on interrupt : Disable
- Start on trigger: Disable
- Channel chaining: Disable
- Interrupt generating: Enable

Parameters

out	*config*	The channel configuration structure

Definition at line 102 of file lpit_driver.c.

16.59.5.8 void LPIT_DRV_GetDefaultConfig (lpit_user_config_t *const *config*)

Gets the default LPIT configuration.

This function gets default LPIT module configuration structure, with the following settings:

- PIT runs in debug mode: Disable
- PIT runs in doze mode: Disable

Parameters

out	*config*	The configuration structure

Definition at line 87 of file lpit_driver.c.

16.59.5.9 uint32_t LPIT_DRV_GetInterruptFlagTimerChannels (uint32_t *instance,* uint32_t *mask*)

Gets the current interrupt flag of timer channels.

This function gets the current interrupt flag of timer channels. In compare modes, the flag sets to 1 at the end of the timer period. In capture modes, the flag sets to 1 when the trigger asserts.

Parameters

in	*instance*	LPIT module instance number.
in	*mask*	The interrupt flag getting mask that decides which channels will be got interrupt flag. • For example: – with mask = 0x01u then the interrupt flag of channel 0 only will be got – with mask = 0x02u then the interrupt flag of channel 1 only will be got – with mask = 0x03u then the interrupt flags of channel 0 and channel 1 will be got

Returns

Current the interrupt flag of timer channels

Definition at line 723 of file lpit_driver.c.

16.59.5.10 uint32_t LPIT_DRV_GetTimerPeriodByCount (uint32_t *instance,* uint32_t *channel*)

Gets the current timer channel period in count unit.

This function returns current period of timer channel given as argument.

Parameters

in	*instance*	LPIT module instance number
in	*channel*	Timer channel number

Returns

Timer channel period in count unit

Definition at line 614 of file lpit_driver.c.

16.59.5.11 uint64_t LPIT_DRV_GetTimerPeriodByUs (uint32_t *instance,* uint32_t *channel*)

Gets the timer channel period in microseconds.

This function gets the timer channel period in microseconds. The returned period here makes sense if the operation mode of timer channel is 32 bit periodic counter or dual 16 bit periodic counter.

Parameters

in	*instance*	LPIT module instance number
in	*channel*	Timer channel number

Returns

Timer channel period in microseconds

Definition at line 453 of file lpit_driver.c.

16.59.5.12 void LPIT_DRV_Init (uint32_t *instance,* const lpit_user_config_t * *userConfig*)

Initializes the LPIT module.

This function resets LPIT module, enables the LPIT module, configures LPIT module operation in Debug and DOZE mode. The LPIT configuration structure shall be passed as arguments. This configuration structure affects all timer channels. This function should be called before calling any other LPIT driver function.

This is an example demonstrating how to define a LPIT configuration structure:

```
1 lpit_user_config_t lpitInit =
2 {
3      .enableRunInDebug = false,
4      .enableRunInDoze = true
5 };
```

Parameters

in	*instance*	LPIT module instance number.
in	*userConfig*	Pointer to LPIT configuration structure.

Definition at line 130 of file lpit_driver.c.

16.59.5.13 status_t LPIT_DRV_InitChannel (uint32_t *instance,* uint32_t *channel,* const lpit_user_channel_config_t * *userChannelConfig*)

Initializes the LPIT channel.

This function initializes the LPIT timers by using a channel, this function configures timer channel chaining, timer channel mode, timer channel period, interrupt generation, trigger source, trigger select, reload on trigger, stop on interrupt and start on trigger. The timer channel number and its configuration structure shall be passed as arguments. Timer channels do not start counting by default after calling this function. The function LPIT_DRV_↩ StartTimerChannels must be called to start the timer channel counting. In order to re-configures the period, call the LPIT_DRV_SetTimerPeriodByUs or LPIT_DRV_SetTimerPeriodByCount.

This is an example demonstrating how to define a LPIT channel configuration structure:

```
1 lpit_user_channel_config_t lpitTestInit =
2 {
3  .timerMode = LPIT_PERIODIC_COUNTER,
4  .periodUnits = LPTT_PERIOD_UNITS_MICROSECONDS,
5  .period = 1000000U,
6  .triggerSource = LPIT_TRIGGER_SOURCE_INTERNAL,
7  .triggerSelect = 1U,
8  .enableReloadOnTrigger = false,
9  .enableStopOnInterrupt = false,
10  .enableStartOnTrigger = false,
11  .chainChannel = false,
12  .isInterruptEnabled = true
13 };
```

Parameters

in	*instance*	LPIT module instance number
in	*channel*	Timer channel number
in	*userChannel↩ Config*	Pointer to LPIT channel configuration structure

Returns

Operation status

- STATUS_SUCCESS: Operation was successful.
- STATUS_ERROR: The channel 0 is chained.
- STATUS_ERROR: The input period is invalid.

Definition at line 204 of file lpit_driver.c.

16.59.5.14 void LPIT_DRV_SetTimerPeriodByCount (uint32_t *instance,* uint32_t *channel,* uint32_t *count*)

Sets the timer channel period in count unit.

This function sets the timer channel period in count unit. The counter period of a running timer channel can be modified by first setting a new load value, the value will be loaded after the timer channel expires. To abort the current cycle and start a timer channel period with the new value, the timer channel must be disabled and enabled again.

Parameters

in	*instance*	LPIT module instance number
in	*channel*	Timer channel number
in	*count*	Timer channel period in count unit

Definition at line 560 of file lpit_driver.c.

16.59.5.15 status_t LPIT_DRV_SetTimerPeriodByUs (uint32_t *instance,* uint32_t *channel,* uint32_t *periodUs*)

Sets the timer channel period in microseconds.

This function sets the timer channel period in microseconds when timer channel mode is 32 bit periodic or dual 16 bit counter mode. The period range depends on the frequency of the LPIT functional clock and operation mode of timer channel. If the required period is out of range, use the suitable mode if applicable. This function is only valid for one single channel.

Parameters

in	*instance*	LPIT module instance number
in	*channel*	Timer channel number

in	*periodUs*	Timer channel period in microseconds

Returns

Operation status

- STATUS_SUCCESS: Input period of timer channel is valid.
- STATUS_ERROR: Input period of timer channel is invalid.

Definition at line 329 of file lpit_driver.c.

16.59.5.16 void LPIT_DRV_SetTimerPeriodInDual16ModeByCount (uint32_t *instance,* uint32_t *channel,* uint16_t *periodHigh,* uint16_t *periodLow*)

Sets the timer channel period in count unit.

This function sets the timer channel period in count unit when timer channel mode is dual 16 periodic counter mode. The counter period of a running timer channel can be modified by first setting a new load value, the value will be loaded after the timer channel expires. To abort the current cycle and start a timer channel period with the new value, the timer channel must be disabled and enabled again.

Parameters

in	*instance*	LPIT module instance number
in	*channel*	Timer channel number
in	*periodHigh*	Period of higher 16 bit in count unit
in	*periodLow*	Period of lower 16 bit in count unit

Definition at line 588 of file lpit_driver.c.

16.59.5.17 status_t LPIT_DRV_SetTimerPeriodInDual16ModeByUs (uint32_t *instance,* uint32_t *channel,* uint16_t *periodHigh,* uint16_t *periodLow*)

Sets the timer channel period in microseconds.

This function sets the timer channel period in microseconds when timer channel mode is dual 16 bit periodic counter mode. The period range depends on the frequency of the LPIT functional clock and operation mode of timer channel. If the required period is out of range, use the suitable mode if applicable. This function is only valid for one single channel.

Parameters

in	*instance*	LPIT module instance number
in	*channel*	Timer channel number
in	*periodHigh*	Period of higher 16 bit in microseconds
in	*periodLow*	Period of lower 16 bit in microseconds

Returns

Operation status

- STATUS_SUCCESS: Input period of timer channel is valid.
- STATUS_ERROR: Input period of timer channel is invalid.

Definition at line 400 of file lpit_driver.c.

16.59.5.18 void LPIT_DRV_StartTimerChannels (uint32_t *instance,* uint32_t *mask*)

Starts the timer channel counting.

This function allows starting timer channels simultaneously . After calling this function, timer channels are going operate depend on mode and control bits which controls timer channel start, reload and restart.

Parameters

in	*instance*	LPIT module instance number
in	*mask*	Timer channels starting mask that decides which channels will be started • For example: – with mask = 0x01U then channel 0 will be started – with mask = 0x02U then channel 1 will be started – with mask = 0x03U then channel 0 and channel 1 will be started

Definition at line 279 of file lpit_driver.c.

16.59.5.19 void LPIT_DRV_StopTimerChannels (uint32_t *instance,* uint32_t *mask*)

Stops the timer channel counting.

This function allows stop timer channels simultaneously from counting. Timer channels reload their periods respectively after the next time they call the LPIT_DRV_StartTimerChannels. Note that: In 32-bit Trigger Accumulator mode, the counter will load on the first trigger rising edge.

Parameters

in	*instance*	LPIT module instance number
in	*mask*	Timer channels stopping mask that decides which channels will be stopped • For example: – with mask = 0x01U then channel 0 will be stopped – with mask = 0x02U then channel 1 will be stopped – with mask = 0x03U then channel 0 and channel 1 will be stopped

Definition at line 303 of file lpit_driver.c.

16.60 LPSPI Driver

16.60.1 Detailed Description

Low Power Serial Peripheral Interface Peripheral Driver.

Data Structures

- struct lpspi_master_config_t

  Data structure containing information about a device on the SPI bus. More...
- struct lpspi_state_t

  Runtime state structure for the LPSPI master driver. More...
- struct lpspi_slave_config_t

  User configuration structure for the SPI slave driver. Implements : lpspi_slave_config_t_Class. More...

Enumerations

- enum lpspi_which_pcs_t { LPSPI_PCS0 = 0U, LPSPI_PCS1 = 1U, LPSPI_PCS2 = 2U, LPSPI_PCS3 = 3U }

  LPSPI Peripheral Chip Select (PCS) configuration (which PCS to configure). Implements : lpspi_which_pcs_t_Class.
- enum lpspi_signal_polarity_t { LPSPI_ACTIVE_HIGH = 1U, LPSPI_ACTIVE_LOW = 0U }

  LPSPI Signal (PCS and Host Request) Polarity configuration. Implements : lpspi_signal_polarity_t_Class.
- enum lpspi_clock_phase_t { LPSPI_CLOCK_PHASE_1ST_EDGE = 0U, LPSPI_CLOCK_PHASE_2ND_E↩ DGE = 1U }

  LPSPI clock phase configuration. Implements : lpspi_clock_phase_t_Class.
- enum lpspi_sck_polarity_t { LPSPI_SCK_ACTIVE_HIGH = 0U, LPSPI_SCK_ACTIVE_LOW = 1U }

  LPSPI Clock Signal (SCK) Polarity configuration. Implements : lpspi_sck_polarity_t_Class.
- enum lpspi_transfer_type { LPSPI_USING_DMA = 0, LPSPI_USING_INTERRUPTS }

  Type of LPSPI transfer (based on interrupts or DMA). Implements : lpspi_transfer_type_Class.
- enum transfer_status_t { LPSPI_TRANSFER_OK = 0U, LPSPI_TRANSMIT_FAIL, LPSPI_RECEIVE_FAIL }

  Type of error reported by LPSPI.

Functions

- void LPSPI_DRV_SlaveIRQHandler (uint32_t instance)

  Interrupt handler for LPSPI slave mode. This handler uses the buffers stored in the lpspi_master_state_t structs to transfer data.
- void LPSPI_DRV_IRQHandler (uint32_t instance)

  The function LPSPI_DRV_IRQHandler passes IRQ control to either the master or slave driver.
- void LPSPI_DRV_FillupTxBuffer (uint32_t instance)

  The function LPSPI_DRV_FillupTxBuffer writes data in TX hardware buffer depending on driver state and number of bytes remained to send.
- void LPSPI_DRV_ReadRXBuffer (uint32_t instance)

  The function LPSPI_DRV_ReadRXBuffer reads data from RX hardware buffer and writes this data in RX software buffer.
- void LPSPI_DRV_DisableTEIEInterrupts (uint32_t instance)

  Disable the TEIE interrupts at the end of a transfer. Disable the interrupts and clear the status for transmit/receive errors.
- void LPSPI_DRV_SlaveGetDefaultConfig (lpspi_slave_config_t *spiConfig)

  Return default configuration for SPI master.
- status_t LPSPI_DRV_SlaveInit (uint32_t instance, lpspi_state_t *lpspiState, const lpspi_slave_config_↩ t *slaveConfig)

  Initializes a LPSPI instance for a slave mode operation, using interrupt mechanism.

- status_t LPSPI_DRV_SlaveDeinit (uint32_t instance)

  Shuts down an LPSPI instance interrupt mechanism.
- status_t LPSPI_DRV_SlaveTransferBlocking (uint32_t instance, const uint8_t ∗sendBuffer, uint8_t ∗receive↩ Buffer, uint16_t transferByteCount, uint32_t timeout)

  Transfers data on LPSPI bus using a blocking call.
- status_t LPSPI_DRV_SlaveTransfer (uint32_t instance, const uint8_t ∗sendBuffer, uint8_t ∗receiveBuffer, uint16_t transferByteCount)

  Starts the transfer data on LPSPI bus using a non-blocking call.
- status_t LPSPI_DRV_SlaveAbortTransfer (uint32_t instance)

  Aborts the transfer that started by a non-blocking call transfer function.
- status_t LPSPI_DRV_SlaveGetTransferStatus (uint32_t instance, uint32_t ∗bytesRemained)

  Returns whether the previous transfer is finished.
- void LPSPI0_IRQHandler (void)

  This function is the implementation of LPSPI0 handler named in startup code.
- void LPSPI1_IRQHandler (void)

  This function is the implementation of LPSPI1 handler named in startup code.
- void LPSPI2_IRQHandler (void)

  This function is the implementation of LPSPI2 handler named in startup code.

Variables

- LPSPI_Type ∗ g_lpspiBase [LPSPI_INSTANCE_COUNT]

  Table of base pointers for SPI instances.
- IRQn_Type g_lpspiIrqId [LPSPI_INSTANCE_COUNT]

  Table to save LPSPI IRQ enumeration numbers defined in the CMSIS header file.
- lpspi_state_t ∗ g_lpspiStatePtr [LPSPI_INSTANCE_COUNT]

Initialization and shutdown

- void LPSPI_DRV_MasterGetDefaultConfig (lpspi_master_config_t ∗spiConfig)

  Return default configuration for SPI master.
- status_t LPSPI_DRV_MasterInit (uint32_t instance, lpspi_state_t ∗lpspiState, const lpspi_master_config_t ∗spiConfig)

  Initializes a LPSPI instance for interrupt driven master mode operation.
- status_t LPSPI_DRV_MasterDeinit (uint32_t instance)

  Shuts down a LPSPI instance.
- status_t LPSPI_DRV_MasterSetDelay (uint32_t instance, uint32_t delayBetwenTransfers, uint32_t delayS↩ CKtoPCS, uint32_t delayPCStoSCK)

  Configures the LPSPI master mode bus timing delay options.

Bus configuration

- status_t LPSPI_DRV_MasterConfigureBus (uint32_t instance, const lpspi_master_config_t ∗spiConfig, uint32_t ∗calculatedBaudRate)

  Configures the LPSPI port physical parameters to access a device on the bus when the LSPI instance is configured for interrupt operation.
- status_t LPSPI_DRV_SetPcs (uint32_t instance, lpspi_which_pcs_t whichPcs, lpspi_signal_polarity_t polarity)

  Select the chip to communicate with.

Blocking transfers

- status_t LPSPI_DRV_MasterTransferBlocking (uint32_t instance, const uint8_t *sendBuffer, uint8_t *receiveBuffer, uint16_t transferByteCount, uint32_t timeout)

  Performs an interrupt driven blocking SPI master mode transfer.

Non-blocking transfers

- status_t LPSPI_DRV_MasterTransfer (uint32_t instance, const uint8_t *sendBuffer, uint8_t *receiveBuffer, uint16_t transferByteCount)

  Performs an interrupt driven non-blocking SPI master mode transfer.
- status_t LPSPI_DRV_MasterGetTransferStatus (uint32_t instance, uint32_t *bytesRemained)

  Returns whether the previous interrupt driven transfer is completed.
- status_t LPSPI_DRV_MasterAbortTransfer (uint32_t instance)

  Terminates an interrupt driven asynchronous transfer early.
- void LPSPI_DRV_MasterIRQHandler (uint32_t instance)

  Interrupt handler for LPSPI master mode. This handler uses the buffers stored in the lpspi_master_state_t structs to transfer data.

16.60.2 Data Structure Documentation

16.60.2.1 struct lpspi_master_config_t

Data structure containing information about a device on the SPI bus.

The user must populate these members to set up the LPSPI master and properly communicate with the SPI device. Implements : lpspi_master_config_t_Class

Definition at line 49 of file lpspi_master_driver.h.

Data Fields

- uint32_t bitsPerSec
- lpspi_which_pcs_t whichPcs
- lpspi_signal_polarity_t pcsPolarity
- bool isPcsContinuous
- uint16_t bitcount
- uint32_t lpspiSrcClk
- lpspi_clock_phase_t clkPhase
- lpspi_sck_polarity_t clkPolarity
- bool lsbFirst
- lpspi_transfer_type transferType
- uint8_t rxDMAChannel
- uint8_t txDMAChannel
- spi_callback_t callback
- void * callbackParam

Field Documentation

16.60.2.1.1 uint16_t bitcount

Number of bits/frame, minimum is 8-bits

Definition at line 55 of file lpspi_master_driver.h.

16.60.2.1.2 uint32_t bitsPerSec

Baud rate in bits per second

Definition at line 51 of file lpspi_master_driver.h.

16.60.2.1.3 spi_callback_t callback

Select the callback to transfer complete

Definition at line 63 of file lpspi_master_driver.h.

16.60.2.1.4 void* callbackParam

Select additional callback parameters if it's necessary

Definition at line 64 of file lpspi_master_driver.h.

16.60.2.1.5 lpspi_clock_phase_t clkPhase

Selects which phase of clock to capture data

Definition at line 57 of file lpspi_master_driver.h.

16.60.2.1.6 lpspi_sck_polarity_t clkPolarity

Selects clock polarity

Definition at line 58 of file lpspi_master_driver.h.

16.60.2.1.7 bool isPcsContinuous

Keeps PCS asserted until transfer complete

Definition at line 54 of file lpspi_master_driver.h.

16.60.2.1.8 uint32_t lpspiSrcClk

Module source clock

Definition at line 56 of file lpspi_master_driver.h.

16.60.2.1.9 bool lsbFirst

Option to transmit LSB first

Definition at line 59 of file lpspi_master_driver.h.

16.60.2.1.10 lpspi_signal_polarity_t pcsPolarity

PCS polarity

Definition at line 53 of file lpspi_master_driver.h.

16.60.2.1.11 uint8_t rxDMAChannel

Channel number for DMA rx channel. If DMA mode isn't used this field will be ignored.

Definition at line 61 of file lpspi_master_driver.h.

16.60.2.1.12 lpspi_transfer_type transferType

Type of LPSPI transfer

Definition at line 60 of file lpspi_master_driver.h.

16.60.2.1.13 uint8_t txDMAChannel

Channel number for DMA tx channel. If DMA mode isn't used this field will be ignored.

Definition at line 62 of file lpspi_master_driver.h.

16.60.2.1.14 lpspi_which_pcs_t whichPcs

Selects which PCS to use

Definition at line 52 of file lpspi_master_driver.h.

16.60.2.2 struct lpspi_state_t

Runtime state structure for the LPSPI master driver.

This structure holds data that is used by the LPSPI peripheral driver to communicate between the transfer function and the interrupt handler. The interrupt handler also uses this information to keep track of its progress. The user must pass the memory for this run-time state structure. The LPSPI master driver populates the members. Implements : lpspi_state_t_Class

Definition at line 124 of file lpspi_shared_function.h.

Data Fields

- uint16_t bitsPerFrame
- uint16_t bytesPerFrame
- bool isPcsContinuous
- bool isBlocking
- uint32_t lpspiSrcClk
- volatile bool isTransferInProgress
- const uint8_t * txBuff
- uint8_t * rxBuff
- volatile uint16_t txCount
- volatile uint16_t rxCount
- volatile uint16_t txFrameCnt
- volatile uint16_t rxFrameCnt
- volatile bool lsb
- uint8_t fifoSize
- uint8_t rxDMAChannel
- uint8_t txDMAChannel
- lpspi_transfer_type transferType
- semaphore_t lpspiSemaphore
- transfer_status_t status
- spi_callback_t callback
- void * callbackParam
- uint32_t dummy

Field Documentation

16.60.2.2.1 uint16_t bitsPerFrame

Number of bits per frame: 8- to 4096-bits; needed for TCR programming

Definition at line 126 of file lpspi_shared_function.h.

16.60.2.2.2 uint16_t bytesPerFrame

Number of bytes per frame: 1- to 512-bytes

Definition at line 128 of file lpspi_shared_function.h.

16.60.2.2.3 spi_callback_t callback

Select the callback to transfer complete

Definition at line 147 of file lpspi_shared_function.h.

16.60.2.2.4 void* callbackParam

Select additional callback parameters if it's necessary

Definition at line 148 of file lpspi_shared_function.h.

16.60.2.2.5 uint32_t dummy

This field is used for the cases when TX is NULL and LPSPI is in DMA mode

Definition at line 149 of file lpspi_shared_function.h.

16.60.2.2.6 uint8_t fifoSize

RX/TX fifo size

Definition at line 141 of file lpspi_shared_function.h.

16.60.2.2.7 bool isBlocking

Save the transfer type

Definition at line 131 of file lpspi_shared_function.h.

16.60.2.2.8 bool isPcsContinuous

Option to keep chip select asserted until transfer complete; needed for TCR programming

Definition at line 129 of file lpspi_shared_function.h.

16.60.2.2.9 volatile bool isTransferInProgress

True if there is an active transfer

Definition at line 133 of file lpspi_shared_function.h.

16.60.2.2.10 semaphore_t lpspiSemaphore

The semaphore used for blocking transfers

Definition at line 145 of file lpspi_shared_function.h.

16.60.2.2.11 uint32_t lpspiSrcClk

Module source clock

Definition at line 132 of file lpspi_shared_function.h.

16.60.2.2.12 volatile bool lsb

True if first bit is LSB and false if first bit is MSB

Definition at line 140 of file lpspi_shared_function.h.

16.60.2.2.13 uint8_t* rxBuff

The buffer into which received bytes are placed

Definition at line 135 of file lpspi_shared_function.h.

16.60.2.2.14 volatile uint16_t rxCount

Number of bytes remaining to receive

Definition at line 137 of file lpspi_shared_function.h.

16.60.2.2.15 uint8_t rxDMAChannel

Channel number for DMA rx channel

Definition at line 142 of file lpspi_shared_function.h.

16.60.2.2.16 volatile uint16_t rxFrameCnt

Number of bytes from current frame which were already received

Definition at line 139 of file lpspi_shared_function.h.

16.60.2.2.17 transfer_status_t status

The status of the current

Definition at line 146 of file lpspi_shared_function.h.

16.60.2.2.18 lpspi_transfer_type transferType

Type of LPSPI transfer

Definition at line 144 of file lpspi_shared_function.h.

16.60.2.2.19 const uint8_t* txBuff

The buffer from which transmitted bytes are taken

Definition at line 134 of file lpspi_shared_function.h.

16.60.2.2.20 volatile uint16_t txCount

Number of bytes remaining to send

Definition at line 136 of file lpspi_shared_function.h.

16.60.2.2.21 uint8_t txDMAChannel

Channel number for DMA tx channel

Definition at line 143 of file lpspi_shared_function.h.

16.60.2.2.22 volatile uint16_t txFrameCnt

Number of bytes from current frame which were already sent

Definition at line 138 of file lpspi_shared_function.h.

16.60.2.3 struct lpspi_slave_config_t

User configuration structure for the SPI slave driver. Implements : lpspi_slave_config_t_Class.

Definition at line 47 of file lpspi_slave_driver.h.

Data Fields

- lpspi_signal_polarity_t pcsPolarity
- uint16_t bitcount
- lpspi_clock_phase_t clkPhase
- lpspi_which_pcs_t whichPcs
- lpspi_sck_polarity_t clkPolarity

- bool lsbFirst
- lpspi_transfer_type transferType
- uint8_t rxDMAChannel
- uint8_t txDMAChannel
- spi_callback_t callback
- void * callbackParam

Field Documentation

16.60.2.3.1 uint16_t bitcount

Number of bits/frame, minimum is 8-bits

Definition at line 50 of file lpspi_slave_driver.h.

16.60.2.3.2 spi_callback_t callback

Select the callback to transfer complete

Definition at line 58 of file lpspi_slave_driver.h.

16.60.2.3.3 void* callbackParam

Select additional callback parameters if it's necessary

Definition at line 59 of file lpspi_slave_driver.h.

16.60.2.3.4 lpspi_clock_phase_t clkPhase

Selects which phase of clock to capture data

Definition at line 51 of file lpspi_slave_driver.h.

16.60.2.3.5 lpspi_sck_polarity_t clkPolarity

Selects clock polarity

Definition at line 53 of file lpspi_slave_driver.h.

16.60.2.3.6 bool lsbFirst

Option to transmit LSB first

Definition at line 54 of file lpspi_slave_driver.h.

16.60.2.3.7 lpspi_signal_polarity_t pcsPolarity

PCS polarity

Definition at line 49 of file lpspi_slave_driver.h.

16.60.2.3.8 uint8_t rxDMAChannel

Channel number for DMA rx channel. If DMA mode isn't used this field will be ignored.

Definition at line 56 of file lpspi_slave_driver.h.

16.60.2.3.9 lpspi_transfer_type transferType

Type of LPSPI transfer

Definition at line 55 of file lpspi_slave_driver.h.

16.60.2.3.10 uint8_t txDMAChannel

Channel number for DMA tx channel. If DMA mode isn't used this field will be ignored.

Definition at line 57 of file lpspi_slave_driver.h.

16.60.2.3.11 lpspi_which_pcs_t whichPcs

Definition at line 52 of file lpspi_slave_driver.h.

16.60.3 Enumeration Type Documentation

16.60.3.1 enum lpspi_clock_phase_t

LPSPI clock phase configuration. Implements : lpspi_clock_phase_t_Class.

Enumerator

LPSPI_CLOCK_PHASE_1ST_EDGE Data captured on SCK 1st edge, changed on 2nd.

LPSPI_CLOCK_PHASE_2ND_EDGE Data changed on SCK 1st edge, captured on 2nd.

Definition at line 80 of file lpspi_shared_function.h.

16.60.3.2 enum lpspi_sck_polarity_t

LPSPI Clock Signal (SCK) Polarity configuration. Implements : lpspi_sck_polarity_t_Class.

Enumerator

LPSPI_SCK_ACTIVE_HIGH Signal is Active High (idles low).

LPSPI_SCK_ACTIVE_LOW Signal is Active Low (idles high).

Definition at line 89 of file lpspi_shared_function.h.

16.60.3.3 enum lpspi_signal_polarity_t

LPSPI Signal (PCS and Host Request) Polarity configuration. Implements : lpspi_signal_polarity_t_Class.

Enumerator

LPSPI_ACTIVE_HIGH Signal is Active High (idles low).

LPSPI_ACTIVE_LOW Signal is Active Low (idles high).

Definition at line 71 of file lpspi_shared_function.h.

16.60.3.4 enum lpspi_transfer_type

Type of LPSPI transfer (based on interrupts or DMA). Implements : lpspi_transfer_type_Class.

Enumerator

LPSPI_USING_DMA The driver will use DMA to perform SPI transfer

LPSPI_USING_INTERRUPTS The driver will use interrupts to perform SPI transfer

Definition at line 99 of file lpspi_shared_function.h.

16.60.3.5 enum lpspi_which_pcs_t

LPSPI Peripheral Chip Select (PCS) configuration (which PCS to configure). Implements : lpspi_which_pcs_t_↩ Class.

Enumerator

LPSPI_PCS0 PCS[0]

LPSPI_PCS1 PCS[1]

LPSPI_PCS2 PCS[2]

LPSPI_PCS3 PCS[3]

Definition at line 60 of file lpspi_shared_function.h.

16.60.3.6 enum transfer_status_t

Type of error reported by LPSPI.

Enumerator

LPSPI_TRANSFER_OK Transfer OK

LPSPI_TRANSMIT_FAIL Error during transmission

LPSPI_RECEIVE_FAIL Error during reception

Definition at line 107 of file lpspi_shared_function.h.

16.60.4 Function Documentation

16.60.4.1 void LPSPI0_IRQHandler (void)

This function is the implementation of LPSPI0 handler named in startup code.

It passes the instance to the shared LPSPI IRQ handler.

Definition at line 115 of file lpspi_irq.c.

16.60.4.2 void LPSPI1_IRQHandler (void)

This function is the implementation of LPSPI1 handler named in startup code.

It passes the instance to the shared LPSPI IRQ handler.

Definition at line 127 of file lpspi_irq.c.

16.60.4.3 void LPSPI2_IRQHandler (void)

This function is the implementation of LPSPI2 handler named in startup code.

It passes the instance to the shared LPSPI IRQ handler.

Definition at line 139 of file lpspi_irq.c.

16.60.4.4 void LPSPI_DRV_DisableTEIEInterrupts (uint32_t *instance*)

Disable the TEIE interrupts at the end of a transfer. Disable the interrupts and clear the status for transmit/receive errors.

Definition at line 235 of file lpspi_shared_function.c.

16.60.4.5 void LPSPI_DRV_FillupTxBuffer (uint32_t *instance*)

The function LPSPI_DRV_FillupTxBuffer writes data in TX hardware buffer depending on driver state and number of bytes remained to send.

The function LPSPI_DRV_FillupTxBuffer writes data in TX hardware buffer depending on driver state and number of bytes remained to send.

Definition at line 123 of file lpspi_shared_function.c.

16.60.4.6 void LPSPI_DRV_IRQHandler (uint32_t *instance*)

The function LPSPI_DRV_IRQHandler passes IRQ control to either the master or slave driver.

The address of the IRQ handlers are checked to make sure they are non-zero before they are called. If the IRQ handler's address is zero, it means that driver was not present in the link (because the IRQ handlers are marked as weak). This would actually be a program error, because it means the master/slave config for the IRQ was set incorrectly.

Definition at line 100 of file lpspi_shared_function.c.

16.60.4.7 status_t LPSPI_DRV_MasterAbortTransfer (uint32_t *instance*)

Terminates an interrupt driven asynchronous transfer early.

During an a-sync (non-blocking) transfer, the user has the option to terminate the transfer early if the transfer is still in progress.

Parameters

instance	The instance number of the LPSPI peripheral.

Returns

STATUS_SUCCESS The transfer was successful, or LPSPI_STATUS_NO_TRANSFER_IN_PROGRESS No transfer is currently in progress.

Definition at line 578 of file lpspi_master_driver.c.

16.60.4.8 status_t LPSPI_DRV_MasterConfigureBus (uint32_t *instance,* const lpspi_master_config_t * *spiConfig,* uint32_t * *calculatedBaudRate*)

Configures the LPSPI port physical parameters to access a device on the bus when the LSPI instance is configured for interrupt operation.

In this function, the term "spiConfig" is used to indicate the SPI device for which the LPSPI master is communicating. This is an optional function as the spiConfig parameters are normally configured in the initialization function or the transfer functions, where these various functions would call the configure bus function. This is an example to set up the lpspi_master_config_t structure to call the LPSPI_DRV_MasterConfigureBus function by passing in these parameters:

```
1 lpspi_master_config_t spiConfig1;   You can also declare spiConfig2, spiConfig3, etc
2 spiConfig1.bitsPerSec = 500000;
3 spiConfig1.whichPcs = LPSPI_PCS0;
4 spiConfig1.pcsPolarity = LPSPI_ACTIVE_LOW;
5 spiConfig1.isPcsContinuous = false;
6 spiConfig1.bitCount = 16;
7 spiConfig1.clkPhase = LPSPI_CLOCK_PHASE_1ST_EDGE;
8 spiConfig1.clkPolarity = LPSPI_ACTIVE_HIGH;
9 spiConfig1.lsbFirst= false;
10 spiConfig.transferType = LPSPI_USING_INTERRUPTS;
```

Parameters

instance	The instance number of the LPSPI peripheral.
spiConfig	Pointer to the spiConfig structure. This structure contains the settings for the SPI bus configuration. The SPI device parameters are the desired baud rate (in bits-per-sec), bits-per-frame, chip select attributes, clock attributes, and data shift direction.

calculated↩ BaudRate	The calculated baud rate passed back to the user to determine if the calculated baud rate is close enough to meet the needs. The baud rate never exceeds the desired baud rate.

Returns

STATUS_SUCCESS The transfer has completed successfully, or STATUS_ERROR if driver is error and needs to clean error.

Definition at line 309 of file lpspi_master_driver.c.

16.60.4.9 status_t LPSPI_DRV_MasterDeinit (uint32_t *instance*)

Shuts down a LPSPI instance.

This function resets the LPSPI peripheral, gates its clock, and disables the interrupt to the core. It first checks to see if a transfer is in progress and if so returns an error status.

Parameters

instance	The instance number of the LPSPI peripheral.

Returns

STATUS_SUCCESS The transfer has completed successfully, or STATUS_BUSY The transfer is still in progress. STATUS_ERROR if driver is error and needs to clean error.

Definition at line 219 of file lpspi_master_driver.c.

16.60.4.10 void LPSPI_DRV_MasterGetDefaultConfig (lpspi_master_config_t * *spiConfig*)

Return default configuration for SPI master.

Initializes a structured provided by user with the configuration of an interrupt based LPSPI transfer. Source clock for LPSPI is configured to 8MHz. If the applications uses other frequency is necessary to update lpspiSrcClk field.

Parameters

spiConfig	Pointer to configuration structure which is filled with default configuration

Definition at line 131 of file lpspi_master_driver.c.

16.60.4.11 status_t LPSPI_DRV_MasterGetTransferStatus (uint32_t *instance,* uint32_t * *bytesRemained*)

Returns whether the previous interrupt driven transfer is completed.

When performing an a-sync (non-blocking) transfer, the user can call this function to ascertain the state of the current transfer: in progress (or busy) or complete (success). In addition, if the transfer is still in progress, the user can get the number of words that have been transferred up to now.

Parameters

instance	The instance number of the LPSPI peripheral.
bytesRemained	Pointer to a value that is filled in with the number of bytes that must be received.

Returns

STATUS_SUCCESS The transfer has completed successfully, or STATUS_BUSY The transfer is still in progress. framesTransferred is filled with the number of words that have been transferred so far.

Definition at line 549 of file lpspi_master_driver.c.

16.60.4.12 status_t LPSPI_DRV_MasterInit (uint32_t *instance,* lpspi_state_t * *lpspiState,* const lpspi_master_config_t * *spiConfig*)

Initializes a LPSPI instance for interrupt driven master mode operation.

This function uses an interrupt-driven method for transferring data. In this function, the term "spiConfig" is used to indicate the SPI device for which the LPSPI master is communicating. This function initializes the run-time state structure to track the ongoing transfers, un-gates the clock to the LPSPI module, resets the LPSPI module, configures the IRQ state structure, enables the module-level interrupt to the core, and enables the LPSPI module. This is an example to set up the lpspi_master_state_t and call the LPSPI_DRV_MasterInit function by passing in these parameters:

```
1 lpspi_master_state_t lpspiMasterState;  <- the user  allocates memory for this structure
2 lpspi_master_config_t spiConfig;  Can declare more configs for use in transfer functions
3 spiConfig.bitsPerSec = 500000;
4 spiConfig.whichPcs = LPSPI_PCS0;
5 spiConfig.pcsPolarity = LPSPI_ACTIVE_LOW;
6 spiConfig.isPcsContinuous = false;
7 spiConfig.bitCount = 16;
8 spiConfig.clkPhase = LPSPI_CLOCK_PHASE_1ST_EDGE;
9 spiConfig.clkPolarity = LPSPI_ACTIVE_HIGH;
10 spiConfig.lsbFirst= false;
11 spiConfig.transferType = LPSPI_USING_INTERRUPTS;
12 LPSPI_DRV_MasterInit(masterInstance, &lpspiMasterState, &spiConfig);
```

Parameters

instance	The instance number of the LPSPI peripheral.
lpspiState	The pointer to the LPSPI master driver state structure. The user passes the memory for this run-time state structure. The LPSPI master driver populates the members. This run-time state structure keeps track of the transfer in progress.
spiConfig	The data structure containing information about a device on the SPI bus

Returns

An error code or STATUS_SUCCESS.

Definition at line 166 of file lpspi_master_driver.c.

16.60.4.13 void LPSPI_DRV_MasterIRQHandler (uint32_t *instance*)

Interrupt handler for LPSPI master mode. This handler uses the buffers stored in the lpspi_master_state_t structs to transfer data.

Parameters

instance	The instance number of the LPSPI peripheral.

Interrupt handler for LPSPI master mode. This handler uses the buffers stored in the lpspi_master_state_t structs to transfer data.

Definition at line 867 of file lpspi_master_driver.c.

16.60.4.14 status_t LPSPI_DRV_MasterSetDelay (uint32_t *instance,* uint32_t *delayBetwenTransfers,* uint32_t *delaySCKtoPCS,* uint32_t *delayPCStoSCK*)

Configures the LPSPI master mode bus timing delay options.

This function involves the LPSPI module's delay options to "fine tune" some of the signal timings and match the timing needs of a slower peripheral device. This is an optional function that can be called after the LPSPI module has been initialized for master mode. The timings are adjusted in terms of cycles of the baud rate clock. The bus timing delays that can be adjusted are listed below:

SCK to PCS Delay: Adjustable delay option between the last edge of SCK to the de-assertion of the PCS signal.

PCS to SCK Delay: Adjustable delay option between the assertion of the PCS signal to the first SCK edge.

Delay between Transfers: Adjustable delay option between the de-assertion of the PCS signal for a frame to the assertion of the PCS signal for the next frame.

Parameters

instance	The instance number of the LPSPI peripheral.
delayBetwen↩ Transfers	Minimum delay between 2 transfers in clock cycles
delaySCKtoP↩ CS	Minimum delay between SCK and PCS in clock cycles
delayPCStoS↩ CK	Minimum delay between PCS and SCK in clock cycles

Returns

STATUS_SUCCESS The transfer has completed successfully, or STATUS_ERROR if driver is error and needs to clean error.

Definition at line 266 of file lpspi_master_driver.c.

16.60.4.15 status_t LPSPI_DRV_MasterTransfer (uint32_t *instance,* const uint8_t * *sendBuffer,* uint8_t * *receiveBuffer,* uint16_t *transferByteCount*)

Performs an interrupt driven non-blocking SPI master mode transfer.

This function simultaneously sends and receives data on the SPI bus, as SPI is naturally a full-duplex bus. The function returns immediately after initiating the transfer. The user needs to check whether the transfer is complete using the LPSPI_DRV_MasterGetTransferStatus function. This function allows the user to optionally pass in a SPI configuration structure which allows the user to change the SPI bus attributes in conjunction with initiating a SPI transfer. The difference between passing in the SPI configuration structure here as opposed to the configure bus function is that the configure bus function returns the calculated baud rate where this function does not. The user can also call the configure bus function prior to the transfer in which case the user would simply pass in a NULL to the transfer function's device structure parameter. Depending on frame size sendBuffer and receiveBuffer must be aligned like this: -1 byte if frame size <= 8 bits -2 bytes if 8 bits < frame size <= 16 bits -4 bytes if 16 bits < frame size

Parameters

instance	The instance number of the LPSPI peripheral.
spiConfig	Pointer to the SPI configuration structure. This structure contains the settings for the SPI bus configuration in this transfer. You may pass NULL for this parameter, in which case the current bus configuration is used unmodified. The device can be configured separately by calling the LPSPI_DRV_MasterConfigureBus function.
sendBuffer	The pointer to the data buffer of the data to send. You may pass NULL for this parameter and bytes with a value of 0 (zero) is sent.
receiveBuffer	Pointer to the buffer where the received bytes are stored. If you pass NULL for this parameter, the received bytes are ignored.
transferByte↩ Count	The number of bytes to send and receive which is equal to size of send or receive buffers

Returns

STATUS_SUCCESS The transfer was successful, or STATUS_BUSY Cannot perform transfer because a transfer is already in progress

Definition at line 511 of file lpspi_master_driver.c.

16.60.4.16 status_t LPSPI_DRV_MasterTransferBlocking (uint32_t *instance,* const uint8_t * *sendBuffer,* uint8_t * *receiveBuffer,* uint16_t *transferByteCount,* uint32_t *timeout*)

Performs an interrupt driven blocking SPI master mode transfer.

This function simultaneously sends and receives data on the SPI bus, as SPI is naturally a full-duplex bus. The function does not return until the transfer is complete. This function allows the user to optionally pass in a SPI

configuration structure which allows the user to change the SPI bus attributes in conjunction with initiating a SPI transfer. The difference between passing in the SPI configuration structure here as opposed to the configure bus function is that the configure bus function returns the calculated baud rate where this function does not. The user can also call the configure bus function prior to the transfer in which case the user would simply pass in a NULL to the transfer function's device structure parameter. Depending on frame size sendBuffer and receiveBuffer must be aligned like this: -1 byte if frame size <= 8 bits -2 bytes if 8 bits < frame size <= 16 bits -4 bytes if 16 bits < frame size

Parameters

instance	The instance number of the LPSPI peripheral.
sendBuffer	The pointer to the data buffer of the data to send. You may pass NULL for this parameter and bytes with a value of 0 (zero) is sent.
receiveBuffer	Pointer to the buffer where the received bytes are stored. If you pass NULL for this parameter, the received bytes are ignored.
transferByteCount	The number of bytes to send and receive which is equal to size of send or receive buffers
timeout	A timeout for the transfer in milliseconds. If the transfer takes longer than this amount of time, the transfer is aborted and a STATUS_TIMEOUT error returned.

Returns

STATUS_SUCCESS The transfer was successful, or STATUS_BUSY Cannot perform transfer because a transfer is already in progress, or STATUS_TIMEOUT The transfer timed out and was aborted.

Definition at line 424 of file lpspi_master_driver.c.

16.60.4.17 void LPSPI_DRV_ReadRXBuffer (uint32_t *instance*)

The function LPSPI_DRV_ReadRXBuffer reads data from RX hardware buffer and writes this data in RX software buffer.

The function LPSPI_DRV_ReadRXBuffer reads data from RX hardware buffer and writes this data in RX software buffer.

Definition at line 192 of file lpspi_shared_function.c.

16.60.4.18 status_t LPSPI_DRV_SetPcs (uint32_t *instance,* lpspi_which_pcs_t *whichPcs,* lpspi_signal_polarity_t *polarity*)

Select the chip to communicate with.

The main purpose of this function is to set the PCS and the appropriate polarity.

Parameters

instance	LPSPI instance
whichPcs	selected chip
polarity	chip select line polarity

Returns

STATUS_SUCCESS The transfer has completed successfully, or STATUS_ERROR if driver is error and needs to clean error.

Definition at line 600 of file lpspi_master_driver.c.

16.60.4.19 status_t LPSPI_DRV_SlaveAbortTransfer (uint32_t *instance*)

Aborts the transfer that started by a non-blocking call transfer function.

This function stops the transfer which was started by the calling the SPI_DRV_SlaveTransfer() function.

Parameters

instance	The instance number of SPI peripheral

Returns

STATUS_SUCCESS if everything is OK.

Definition at line 512 of file lpspi_slave_driver.c.

16.60.4.20 status_t LPSPI_DRV_SlaveDeinit (uint32_t *instance*)

Shuts down an LPSPI instance interrupt mechanism.

Disables the LPSPI module, gates its clock, and changes the LPSPI slave driver state to NonInit for the LPSPI slave module which is initialized with interrupt mechanism. After de-initialization, the user can re-initialize the LPSPI slave module with other mechanisms.

Parameters

instance	The instance number of the LPSPI peripheral.

Returns

STATUS_SUCCESS if driver starts to send/receive data successfully. STATUS_ERROR if driver is error and needs to clean error. STATUS_BUSY if a transfer is in progress

Definition at line 201 of file lpspi_slave_driver.c.

16.60.4.21 void LPSPI_DRV_SlaveGetDefaultConfig (lpspi_slave_config_t * *spiConfig*)

Return default configuration for SPI master.

Initializes a structured provided by user with the configuration of an interrupt based LPSPI transfer.

Definition at line 105 of file lpspi_slave_driver.c.

16.60.4.22 status_t LPSPI_DRV_SlaveGetTransferStatus (uint32_t *instance,* uint32_t * *bytesRemained*)

Returns whether the previous transfer is finished.

When performing an a-sync transfer, the user can call this function to ascertain the state of the current transfer: in progress (or busy) or complete (success). In addition, if the transfer is still in progress, the user can get the number of bytes that have been transferred up to now.

Parameters

instance	The instance number of the LPSPI peripheral.
bytesRemained	Pointer to value that is filled in with the number of frames that have been sent in the active transfer. A frame is defined as the number of bits per frame.

Returns

STATUS_SUCCESS The transfer has completed successfully, or STATUS_BUSY The transfer is still in progress. STATUS_ERROR if driver is error and needs to clean error.

Definition at line 550 of file lpspi_slave_driver.c.

16.60.4.23 status_t LPSPI_DRV_SlaveInit (uint32_t *instance,* lpspi_state_t * *lpspiState,* const lpspi_slave_config_t * *slaveConfig*)

Initializes a LPSPI instance for a slave mode operation, using interrupt mechanism.

This function un-gates the clock to the LPSPI module, initializes the LPSPI for slave mode. After it is initialized, the LPSPI module is configured in slave mode and the user can start transmitting and receiving data by calling send, receive, and transfer functions. This function indicates LPSPI slave uses an interrupt mechanism.

Parameters

instance	The instance number of the LPSPI peripheral.
lpspiState	The pointer to the LPSPI slave driver state structure.
slaveConfig	The configuration structure lpspi_slave_user_config_t which configures the data bus format.

Returns

An error code or STATUS_SUCCESS.

Definition at line 125 of file lpspi_slave_driver.c.

16.60.4.24 void LPSPI_DRV_SlaveIRQHandler (uint32_t *instance*)

Interrupt handler for LPSPI slave mode. This handler uses the buffers stored in the lpspi_master_state_t structs to transfer data.

Parameters

instance	The instance number of the LPSPI peripheral.

Definition at line 437 of file lpspi_slave_driver.c.

16.60.4.25 status_t LPSPI_DRV_SlaveTransfer (uint32_t *instance,* const uint8_t * *sendBuffer,* uint8_t * *receiveBuffer,* uint16_t *transferByteCount*)

Starts the transfer data on LPSPI bus using a non-blocking call.

This function checks the driver status and mechanism and transmits/receives data through the LPSPI bus. If the sendBuffer is NULL, the transmit process is ignored. If the receiveBuffer is NULL, the receive process is ignored. If both the receiveBuffer and the sendBuffer are available, the transmit and the receive progress is processed. If only the receiveBuffer is available, the receive is processed. Otherwise, the transmit is processed. This function only returns when the processes are completed. This function uses an interrupt mechanism. Depending on frame size sendBuffer and receiveBuffer must be aligned like this: -1 byte if frame size <= 8 bits -2 bytes if 8 bits < frame size <= 16 bits -4 bytes if 16 bits < frame size

Parameters

instance	The instance number of LPSPI peripheral
sendBuffer	The pointer to data that user wants to transmit.
receiveBuffer	The pointer to data that user wants to store received data.
transferByte↩ Count	The number of bytes to send and receive which is equal to size of send or receive buffers

Returns

STATUS_SUCCESS if driver starts to send/receive data successfully. STATUS_ERROR if driver is error and needs to clean error. STATUS_BUSY if a transfer is in progress

Definition at line 280 of file lpspi_slave_driver.c.

16.60.4.26 status_t LPSPI_DRV_SlaveTransferBlocking (uint32_t *instance,* const uint8_t * *sendBuffer,* uint8_t * *receiveBuffer,* uint16_t *transferByteCount,* uint32_t *timeout*)

Transfers data on LPSPI bus using a blocking call.

This function checks the driver status and mechanism and transmits/receives data through the LPSPI bus. If the sendBuffer is NULL, the transmit process is ignored. If the receiveBuffer is NULL, the receive process is ignored. If both the receiveBuffer and the sendBuffer are available, the transmit and the receive progress is processed. If only the receiveBuffer is available, the receive is processed. Otherwise, the transmit is processed. This function only returns when the processes are completed. This function uses an interrupt mechanism. Depending on frame size sendBuffer and receiveBuffer must be aligned like this: -1 byte if frame size <= 8 bits -2 bytes if 8 bits < frame size <= 16 bits -4 bytes if 16 bits < frame size

Parameters

instance	The instance number of LPSPI peripheral
sendBuffer	The pointer to data that user wants to transmit.
receiveBuffer	The pointer to data that user wants to store received data.
transferByte↩ Count	The number of bytes to send and receive which is equal to size of send or receive buffers
timeout	The maximum number of milliseconds that function waits before timed out reached.

Returns

STATUS_SUCCESS if driver starts to send/receive data successfully. STATUS_ERROR if driver is error and needs to clean error. STATUS_BUSY if a transfer is in progress STATUS_TIMEOUT if time out reached while transferring is in progress.

Definition at line 230 of file lpspi_slave_driver.c.

16.60.5 Variable Documentation

16.60.5.1 LPSPI_Type* g_lpspiBase[LPSPI_INSTANCE_COUNT]

Table of base pointers for SPI instances.

Definition at line 78 of file lpspi_shared_function.c.

16.60.5.2 IRQn_Type g_lpspiIrqId[LPSPI_INSTANCE_COUNT]

Table to save LPSPI IRQ enumeration numbers defined in the CMSIS header file.

Definition at line 81 of file lpspi_shared_function.c.

16.60.5.3 lpspi_state_t* g_lpspiStatePtr[LPSPI_INSTANCE_COUNT]

Definition at line 84 of file lpspi_shared_function.c.

16.61 LPTMR Driver

16.61.1 Detailed Description

Low Power Timer Peripheral Driver.

The LPTMR is a configurable general-purpose 16-bit counter that has two operational modes: Timer and Pulse-↩ Counter.

Depending on the configured operational mode, the counter in the LPTMR can be incremented using a clock input (Timer mode) or an event counter (external events like button presses or internal events from different trigger sources).

Timer Mode

In Timer mode, the LPTMR increments the internal counter from a selectable clock source. An optional 16-bit prescaler can be configured.

Pulse-Counter Mode

In Pulse-Counter Mode, the LPTMR counter increments from a selectable trigger source, input pin, which can be an external event (like a button press) or internal events (like triggers from TRGMUX).

An optional 16-bit glitch-filter can be configured to reject events that have a duration below a set period.

Initialization prerequisites

Before configuring the LPTMR, the peripheral clock must be enabled from the PCC module.

The peripheral clock must not be confused with the counter clock, which is selectable within the LPTMR.

Driver configuration

The LPTMR driver allows configuring the LPTMR for Pulse-Counter Mode or Timer Mode via the general configuration structure.

Configurable options:

- work mode (timer or pulse-counter)
- enable interrupts and DMA requests
- free running mode (overflow mode of the counter)
- compare value (interrupt generation on counter value)
- compare value measurement units (counter ticks or microseconds)
- input clock selection
- prescaler/glitch filter configuration
- enable bypass prescaler
- pin select (for pulse-counter mode)
- input pin and polarity (for pulse-counter mode)

```
/* LPTMR initialization of config structure */
lptmr_config_t config = {
  .workMode = LPTMR_WORKMODE_TIMER,
  .dmaRequest = false,
  .interruptEnable = false,
  .freeRun = false,
  .compareValue = 1000U,
  .counterUnits = LPTMR_COUNTER_UNITS_TICKS,
  .clockSelect = LPTMR_CLOCKSOURCE_SIRCDIV2,
  .prescaler = LPTMR_PRESCALE_2,
  .bypassPrescaler = false,
```

```
  .pinSelect = LPTMR_PINSELECT_TRGMUX,
  .pinPolarity = LPTMR_PINPOLARITY_RISING,
};

/* Initialize the LPTMR and start the counter in a separate operation */
status = LPTMR_DRV_Init(0, &config, false);
/* Start timer counting */
LPTMR_DRV_StartCounter(0);
```

API

Some of the features exposed by the API are targeted specifically for Timer Mode or Pulse-Counter Mode. For example, configuring the Compare Value in microseconds makes sense only for Timer Mode, so therefor it is restricted for use in Pulse-Counter mode.

For any invalid configuration the functions will either return an error code or trigger DEV_ASSERT (if enabled). For more details, please refer to each function description.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\lptmr_driver.c
${S32SDK_PATH}\platform\drivers\src\lptmr_hw_access.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager

Data Structures

- struct lptmr_config_t

  Defines the configuration structure for LPTMR. More...

Enumerations

- enum lptmr_pinselect_t { LPTMR_PINSELECT_TRGMUX = 0x00u, LPTMR_PINSELECT_ALT2 = 0x02u, LPTMR_PINSELECT_ALT3 = 0x03u }

  Pulse Counter Input selection Implements : lptmr_pinselect_t_Class.
- enum lptmr_pinpolarity_t { LPTMR_PINPOLARITY_RISING = 0u, LPTMR_PINPOLARITY_FALLING = 1u }

  Pulse Counter input polarity Implements : lptmr_pinpolarity_t_Class.
- enum lptmr_workmode_t { LPTMR_WORKMODE_TIMER = 0u, LPTMR_WORKMODE_PULSECOUNTER = 1u }

  Work Mode Implements : lptmr_workmode_t_Class.
- enum lptmr_prescaler_t { LPTMR_PRESCALE_2 = 0x00u, LPTMR_PRESCALE_4_GLITCHFILTER_2 = 0x01u, LPTMR_PRESCALE_8_GLITCHFILTER_4 = 0x02u, LPTMR_PRESCALE_16_GLITCHFILTER_8 = 0x03u, LPTMR_PRESCALE_32_GLITCHFILTER_16 = 0x04u, LPTMR_PRESCALE_64_GLITCHFILTER_32 =

0x05u, LPTMR_PRESCALE_128_GLITCHFILTER_64 = 0x06u, LPTMR_PRESCALE_256_GLITCHFILT↩ ER_128 = 0x07u,
LPTMR_PRESCALE_512_GLITCHFILTER_256 = 0x08u, LPTMR_PRESCALE_1024_GLITCHFILTER_512 = 0x09u, LPTMR_PRESCALE_2048_GLITCHFILTER_1024 = 0x0Au, LPTMR_PRESCALE_4096_GLITC↩ HFILTER_2048 = 0x0Bu,
LPTMR_PRESCALE_8192_GLITCHFILTER_4096 = 0x0Cu, LPTMR_PRESCALE_16384_GLITCHFILTE↩ R_8192 = 0x0Du, LPTMR_PRESCALE_32768_GLITCHFILTER_16384 = 0x0Eu, LPTMR_PRESCALE_↩ 65536_GLITCHFILTER_32768 = 0x0Fu }

Prescaler Selection Implements : lptmr_prescaler_t_Class.

- enum lptmr_clocksource_t { LPTMR_CLOCKSOURCE_SIRCDIV2 = 0x00u, LPTMR_CLOCKSOURCE_1↩ KHZ_LPO = 0x01u, LPTMR_CLOCKSOURCE_RTC = 0x02u, LPTMR_CLOCKSOURCE_PCC = 0x03u }

  Clock Source selection Implements : lptmr_clocksource_t_Class.
- enum lptmr_counter_units_t { LPTMR_COUNTER_UNITS_TICKS = 0x00U, LPTMR_COUNTER_UNITS_↩ MICROSECONDS = 0x01U }

  Defines the LPTMR counter units available for configuring or reading the timer compare value.

LPTMR Driver Functions

- void LPTMR_DRV_InitConfigStruct (lptmr_config_t ∗const config)

  Initialize a configuration structure with default values.
- void LPTMR_DRV_Init (const uint32_t instance, const lptmr_config_t ∗const config, const bool startCounter)

  Initialize a LPTMR instance with values from an input configuration structure.
- void LPTMR_DRV_SetConfig (const uint32_t instance, const lptmr_config_t ∗const config)

  Configure a LPTMR instance.
- void LPTMR_DRV_GetConfig (const uint32_t instance, lptmr_config_t ∗const config)

  Get the current configuration of a LPTMR instance.
- void LPTMR_DRV_Deinit (const uint32_t instance)

  De-initialize a LPTMR instance.
- status_t LPTMR_DRV_SetCompareValueByCount (const uint32_t instance, const uint16_t compareValue↩ ByCount)

  Set the compare value in counter tick units, for a LPTMR instance.
- void LPTMR_DRV_GetCompareValueByCount (const uint32_t instance, uint16_t ∗const compareValueBy↩ Count)

  Get the compare value in counter tick units, of a LPTMR instance.
- status_t LPTMR_DRV_SetCompareValueByUs (const uint32_t instance, const uint32_t compareValueUs)

  Set the compare value for Timer Mode in microseconds, for a LPTMR instance.
- void LPTMR_DRV_GetCompareValueByUs (const uint32_t instance, uint32_t ∗const compareValueUs)

  Get the compare value in microseconds, of a LPTMR instance.
- bool LPTMR_DRV_GetCompareFlag (const uint32_t instance)

  Get the current state of the Compare Flag of a LPTMR instance.
- void LPTMR_DRV_ClearCompareFlag (const uint32_t instance)

  Clear the Compare Flag of a LPTMR instance.
- bool LPTMR_DRV_IsRunning (const uint32_t instance)

  Get the run state of a LPTMR instance.
- void LPTMR_DRV_SetInterrupt (const uint32_t instance, const bool enableInterrupt)

  Enable/disable the LPTMR interrupt.
- uint16_t LPTMR_DRV_GetCounterValueByCount (const uint32_t instance)

  Get the current counter value in counter tick units.
- void LPTMR_DRV_StartCounter (const uint32_t instance)

  Enable the LPTMR / Start the counter.
- void LPTMR_DRV_StopCounter (const uint32_t instance)

  Disable the LPTMR / Stop the counter.

- void LPTMR_DRV_SetPinConfiguration (const uint32_t instance, const lptmr_pinselect_t pinSelect, const lptmr_pinpolarity_t pinPolarity)

  Set the Input Pin configuration for Pulse Counter mode.

16.61.2 Data Structure Documentation

16.61.2.1 struct lptmr_config_t

Defines the configuration structure for LPTMR.

Implements : lptmr_config_t_Class

Definition at line 110 of file lptmr_driver.h.

Data Fields

- bool dmaRequest
- bool interruptEnable
- bool freeRun
- lptmr_workmode_t workMode
- lptmr_clocksource_t clockSelect
- lptmr_prescaler_t prescaler
- bool bypassPrescaler
- uint32_t compareValue
- lptmr_counter_units_t counterUnits
- lptmr_pinselect_t pinSelect
- lptmr_pinpolarity_t pinPolarity

Field Documentation

16.61.2.1.1 bool bypassPrescaler

Enable/Disable prescaler bypass

Definition at line 120 of file lptmr_driver.h.

16.61.2.1.2 lptmr_clocksource_t clockSelect

Clock selection for Timer/Glitch filter

Definition at line 118 of file lptmr_driver.h.

16.61.2.1.3 uint32_t compareValue

Compare value

Definition at line 121 of file lptmr_driver.h.

16.61.2.1.4 lptmr_counter_units_t counterUnits

Compare value units

Definition at line 122 of file lptmr_driver.h.

16.61.2.1.5 bool dmaRequest

Enable/Disable DMA requests

Definition at line 113 of file lptmr_driver.h.

16.61.2.1.6 bool freeRun

Enable/Disable Free Running Mode

Definition at line 115 of file lptmr_driver.h.

16.61.2.1.7 bool interruptEnable

Enable/Disable Interrupt

Definition at line 114 of file lptmr_driver.h.

16.61.2.1.8 lptmr_pinpolarity_t pinPolarity

Pin Polarity for Pulse-Counter

Definition at line 125 of file lptmr_driver.h.

16.61.2.1.9 lptmr_pinselect_t pinSelect

Pin selection for Pulse-Counter

Definition at line 124 of file lptmr_driver.h.

16.61.2.1.10 lptmr_prescaler_t prescaler

Prescaler Selection

Definition at line 119 of file lptmr_driver.h.

16.61.2.1.11 lptmr_workmode_t workMode

Time/Pulse Counter Mode

Definition at line 116 of file lptmr_driver.h.

16.61.3 Enumeration Type Documentation

16.61.3.1 enum lptmr_clocksource_t

Clock Source selection Implements : lptmr_clocksource_t_Class.

Enumerator

LPTMR_CLOCKSOURCE_SIRCDIV2 SIRC clock

LPTMR_CLOCKSOURCE_1KHZ_LPO 1kHz LPO clock

LPTMR_CLOCKSOURCE_RTC RTC clock

LPTMR_CLOCKSOURCE_PCC PCC configured clock

Definition at line 87 of file lptmr_driver.h.

16.61.3.2 enum lptmr_counter_units_t

Defines the LPTMR counter units available for configuring or reading the timer compare value.

Implements : lptmr_counter_units_t_Class

Enumerator

LPTMR_COUNTER_UNITS_TICKS

LPTMR_COUNTER_UNITS_MICROSECONDS

Definition at line 99 of file lptmr_driver.h.

16.61.3.3 enum lptmr_pinpolarity_t

Pulse Counter input polarity Implements : lptmr_pinpolarity_t_Class.

Enumerator

LPTMR_PINPOLARITY_RISING Count pulse on rising edge

LPTMR_PINPOLARITY_FALLING Count pulse on falling edge

Definition at line 49 of file lptmr_driver.h.

16.61.3.4 enum lptmr_pinselect_t

Pulse Counter Input selection Implements : lptmr_pinselect_t_Class.

Enumerator

LPTMR_PINSELECT_TRGMUX Count pulses from TRGMUX trigger

LPTMR_PINSELECT_ALT2 Count pulses from pin alternative 2

LPTMR_PINSELECT_ALT3 Count pulses from pin alternative 3

Definition at line 37 of file lptmr_driver.h.

16.61.3.5 enum lptmr_prescaler_t

Prescaler Selection Implements : lptmr_prescaler_t_Class.

Enumerator

LPTMR_PRESCALE_2 Timer mode: prescaler 2, Glitch filter mode: invalid

LPTMR_PRESCALE_4_GLITCHFILTER_2 Timer mode: prescaler 4, Glitch filter mode: 2 clocks

LPTMR_PRESCALE_8_GLITCHFILTER_4 Timer mode: prescaler 8, Glitch filter mode: 4 clocks

LPTMR_PRESCALE_16_GLITCHFILTER_8 Timer mode: prescaler 16, Glitch filter mode: 8 clocks

LPTMR_PRESCALE_32_GLITCHFILTER_16 Timer mode: prescaler 32, Glitch filter mode: 16 clocks

LPTMR_PRESCALE_64_GLITCHFILTER_32 Timer mode: prescaler 64, Glitch filter mode: 32 clocks

LPTMR_PRESCALE_128_GLITCHFILTER_64 Timer mode: prescaler 128, Glitch filter mode: 64 clocks

LPTMR_PRESCALE_256_GLITCHFILTER_128 Timer mode: prescaler 256, Glitch filter mode: 128 clocks

LPTMR_PRESCALE_512_GLITCHFILTER_256 Timer mode: prescaler 512, Glitch filter mode: 256 clocks

LPTMR_PRESCALE_1024_GLITCHFILTER_512 Timer mode: prescaler 1024, Glitch filter mode: 512 clocks

LPTMR_PRESCALE_2048_GLITCHFILTER_1024 Timer mode: prescaler 2048, Glitch filter mode: 1024 clocks

LPTMR_PRESCALE_4096_GLITCHFILTER_2048 Timer mode: prescaler 4096, Glitch filter mode: 2048 clocks

LPTMR_PRESCALE_8192_GLITCHFILTER_4096 Timer mode: prescaler 8192, Glitch filter mode: 4096 clocks

LPTMR_PRESCALE_16384_GLITCHFILTER_8192 Timer mode: prescaler 16384, Glitch filter mode: 8192 clocks

LPTMR_PRESCALE_32768_GLITCHFILTER_16384 Timer mode: prescaler 32768, Glitch filter mode↩ : 16384 clocks

LPTMR_PRESCALE_65536_GLITCHFILTER_32768 Timer mode: prescaler 65536, Glitch filter mode↩ : 32768 clocks

Definition at line 65 of file lptmr_driver.h.

16.61.3.6 enum lptmr_workmode_t

Work Mode Implements : lptmr_workmode_t_Class.

Enumerator

LPTMR_WORKMODE_TIMER Timer

LPTMR_WORKMODE_PULSECOUNTER Pulse counter

Definition at line 57 of file lptmr_driver.h.

16.61.4 Function Documentation

16.61.4.1 void LPTMR_DRV_ClearCompareFlag (const uint32_t *instance*)

Clear the Compare Flag of a LPTMR instance.

Parameters

in	*instance*	- LPTMR instance number

16.61.4.2 void LPTMR_DRV_Deinit (const uint32_t *instance*)

De-initialize a LPTMR instance.

Parameters

in	*instance*	- LPTMR instance number

16.61.4.3 bool LPTMR_DRV_GetCompareFlag (const uint32_t *instance*)

Get the current state of the Compare Flag of a LPTMR instance.

Parameters

in	*instance*	- LPTMR instance number

Returns

The state of the Compare Flag

16.61.4.4 void LPTMR_DRV_GetCompareValueByCount (const uint32_t *instance,* uint16_t *const *compareValueByCount*)

Get the compare value in counter tick units, of a LPTMR instance.

Parameters

in	*instance*	- LPTMR instance number
out	*compareValue↩ ByCount*	- Pointer to current compare value, in counter ticks

16.61.4.5 void LPTMR_DRV_GetCompareValueByUs (const uint32_t *instance,* uint32_t *const *compareValueUs*)

Get the compare value in microseconds, of a LPTMR instance.

Parameters

in	*instance*	- LPTMR instance number
out	*compareValue↩ Us*	- Pointer to current compare value, in microseconds

16.61.4.6 void LPTMR_DRV_GetConfig (const uint32_t *instance,* lptmr_config_t ∗const *config*)

Get the current configuration of a LPTMR instance.

Parameters

in	*instance*	- LPTMR instance number
out	*config*	- Pointer to the output configuration structure

16.61.4.7 uint16_t LPTMR_DRV_GetCounterValueByCount (const uint32_t *instance*)

Get the current counter value in counter tick units.

Parameters

in	*instance*	- LPTMR instance number

Returns

The current counter value

16.61.4.8 void LPTMR_DRV_Init (const uint32_t *instance,* const lptmr_config_t ∗const *config,* const bool *startCounter*)

Initialize a LPTMR instance with values from an input configuration structure.

When (counterUnits == LPTMR_COUNTER_UNITS_MICROSECONDS) the function will automatically configure the timer for the input compareValue in microseconds. The input parameters for 'prescaler' and 'bypassPrescaler' will be ignored - their values will be adapted by the function, to best fit the input compareValue (in microseconds) for the operating clock frequency.

LPTMR_COUNTER_UNITS_MICROSECONDS may only be used for LPTMR_WORKMODE_TIMER mode. Otherwise the function shall not convert 'compareValue' in ticks and this is likely to cause erroneous behavior.

When (counterUnits == LPTMR_COUNTER_UNITS_TICKS) the function will use the 'prescaler' and 'bypass↩ Prescaler' provided in the input configuration structure.

Parameters

in	*instance*	- LPTMR instance number
in	*config*	- Pointer to the input configuration structure
in	*startCounter*	- Flag for starting the counter immediately after configuration

16.61.4.9 void LPTMR_DRV_InitConfigStruct (lptmr_config_t ∗const *config*)

Initialize a configuration structure with default values.

Parameters

out	*config*	- Pointer to the configuration structure to be initialized

16.61.4.10 bool LPTMR_DRV_IsRunning (const uint32_t *instance*)

Get the run state of a LPTMR instance.

Parameters

in	*instance*	- LPTMR instance number

Returns

The run state of the LPTMR instance:

- true: Timer/Counter started
- false: Timer/Counter stopped

16.61.4.11 status_t LPTMR_DRV_SetCompareValueByCount (const uint32_t *instance,* const uint16_t *compareValueByCount*)

Set the compare value in counter tick units, for a LPTMR instance.

Parameters

in	*instance*	- LPTMR instance number
in	*compareValue↩ ByCount*	- The compare value in counter ticks, to be written

Returns

Operation status:

- STATUS_SUCCESS: completed successfully
- STATUS_ERROR: cannot reconfigure compare value (TCF not set)
- STATUS_TIMEOUT: compare value greater then current counter value

16.61.4.12 status_t LPTMR_DRV_SetCompareValueByUs (const uint32_t *instance,* const uint32_t *compareValueUs*)

Set the compare value for Timer Mode in microseconds, for a LPTMR instance.

Parameters

in	*instance*	- LPTMR peripheral instance number
in	*compareValue↩ Us*	- Compare value in microseconds

Returns

Operation status:

- STATUS_SUCCESS: completed successfully
- STATUS_ERROR: cannot reconfigure compare value
- STATUS_TIMEOUT: compare value greater then current counter value

16.61.4.13 void LPTMR_DRV_SetConfig (const uint32_t *instance,* const lptmr_config_t *const *config*)

Configure a LPTMR instance.

When (counterUnits == LPTMR_COUNTER_UNITS_MICROSECONDS) the function will automatically configure the timer for the input compareValue in microseconds. The input parameters for 'prescaler' and 'bypassPrescaler' will be ignored - their values will be adapted by the function, to best fit the input compareValue (in microseconds) for the operating clock frequency.

LPTMR_COUNTER_UNITS_MICROSECONDS may only be used for LPTMR_WORKMODE_TIMER mode. Otherwise the function shall not convert 'compareValue' in ticks and this is likely to cause erroneous behavior.

When (counterUnits == LPTMR_COUNTER_UNITS_TICKS) the function will use the 'prescaler' and 'bypass↩ Prescaler' provided in the input configuration structure.

Parameters

in	*instance*	- LPTMR instance number
in	*config*	- Pointer to the input configuration structure

16.61.4.14 void LPTMR_DRV_SetInterrupt (const uint32_t *instance,* const bool *enableInterrupt*)

Enable/disable the LPTMR interrupt.

Parameters

in	*instance*	- LPTMR instance number
in	*enableInterrupt*	- The new state of the LPTMR interrupt enable flag.

16.61.4.15 void LPTMR_DRV_SetPinConfiguration (const uint32_t *instance,* const **lptmr_pinselect_t** *pinSelect,* const **lptmr_pinpolarity_t** *pinPolarity*)

Set the Input Pin configuration for Pulse Counter mode.

Parameters

in	*instance*	- LPTMR instance number
in	*pinSelect*	- LPTMR pin selection
in	*pinPolarity*	- Polarity on which to increment counter (rising/falling edge)

16.61.4.16 void LPTMR_DRV_StartCounter (const uint32_t *instance*)

Enable the LPTMR / Start the counter.

Parameters

in	*instance*	- LPTMR instance number

16.61.4.17 void LPTMR_DRV_StopCounter (const uint32_t *instance*)

Disable the LPTMR / Stop the counter.

Parameters

in	*instance*	- LPTMR instance number

16.62 LPUART Driver

16.62.1 Detailed Description

This module covers the functionality of the Low Power Universal Asynchronous Receiver-Transmitter (LPUART) peripheral driver.

The LPUART driver implements serial communication using the LPUART module in the S32K1xx platforms.

Features

- Interrupt based, DMA based and polling communication
- Provides blocking and non-blocking transmit and receive functions
- Configurable baud rate
- 8/9/10 bits per char

Functionality

In order to use the LPUART driver it must be first initialized, using LPUART_DRV_Init() function. Once initialized, it cannot be initialized again for the same LPUART module instance until it is de-initialized, using LPUART_DRV_↩ Deinit(). The initialization function does the following operations:

- sets the baud rate
- sets parity/bit count/stop bits count
- initializes the state structure for the current instance Different LPUART module instances can function independently of each other.

Interrupt-based communication

After initialization, a serial communication can be triggered by calling LPUART_DRV_SendData() function; this will save the reference of the data buffer received as parameter in the internal tx buffer pointer, then copy the first byte to the data register. The transmitter then automatically shifts the data and triggers a 'Transmit buffer empty' interrupt when all bits are shifted. The drivers interrupt handler takes care of transmitting the next byte in the buffer, by increasing the data pointer and decreasing the data size. The same sequence of operations is executed until all bytes in the tx buffer have been transmitted.

Similarly, data reception is triggered by calling LPUART_DRV_ReceiveData() function, passing the rx buffer as parameter. When the receiver copies the received bits in the data register, the 'Receive buffer full' interrupt is triggered; the driver irq handler clears the flag by reading the received byte, saves it in the rx buffer, then increments the data pointer and decrements the data size. This is repeated until all bytes are received.

The workflow applies to send/receive operations using blocking method (triggered by LPUART_DRV_SendData↩ Blocking() and LPUART_DRV_ReceiveDataBlocking()), with the single difference that the send/receive function will not return until the send/receive operation is complete (all bytes are successfully transferred or a timeout occurred). The timeout for the blocking method is passed as parameter by the user.

DMA-based communication

In DMA operation, both blocking and non-blocking transmission methods configure a DMA channel to copy data from the buffer to the data register (for tx), or viceversa (for rx). The driver assumes the DMA channel is already allocated and the proper requests are routed to it via DMAMUX. After configuring the DMA channel, the driver enables DMA requests for rx/tx, then the DMA engine takes care of moving data to/from the data buffer.

Polling mode

The driver also provides polling methods for send and receive (LPUART_DRV_SendDataPolling() and LPUART↩ _DRV_ReceiveDataPolling()). These functions are blocking (return only when the transfer is complete) and do not use interrupt or DMA services. The tx buffer empty and rx buffer full flags are polled by software in order to copy data to/from the data register.

Error handling

The driver treats the following errors on reception:

- rx overrun
- parity error
- framing error
- noise error
  In case any of these error events occur on the rx line during an ongoing reception, the transfer is aborted and rx status is updated accordingly. LPUART_DRV_GetReceiveStatus() function can be called to retrieve the status of the last reception. If a receive callback is installed, it is called right after aborting the current transfer (with UART_EVENT_ERROR parameter).

Callbacks

The driver provides callback notifications for asynchronous transfers. LPUART_DRV_InstallTxCallback() function can be used for installing a callback routine to be called when the transmission is finished. The tx callback is called twice: first when the tx buffer becomes empty (no more data to be transmitted) - at this point the application can call LPUART_DRV_SetTxBuffer() inside the callback in order to provide more data, resulting in a continuous transmission; if there is no more data to be transmitted, the callback is called again when the transmission is complete (all the bytes have been shifted out on the line). The event parameter in the callback signature differentiates these two calls - the values are UART_EVENT_TX_EMPTY and UART_EVENT_END_TRANSFER, respectively.
Similarly, LPUART_DRV_InstallRxCallback() installs a callback routine for reception. This callback is called twice (UART_EVENT_RX_FULL and UART_EVENT_END_TRANSFER); if a new buffer is provided within the first callback call (LPUART_DRV_SetRxBuffer()), the reception will continue without interruption. In case of an error detected during an ongoing reception, the transfer is aborted and the callback is called with UART_EVENT_ERROR parameter. The driver treats rx overrun, parity, framing and noise errors.

Important Notes

- Before using the LPUART driver the module clock must be configured
- The driver enables the interrupts for the corresponding LPUART module, but any interrupt priority must be done by the application
- The board specific configurations must be done prior to driver calls; the driver has no influence on the functionality of the rx/tx pins - they must be configured by application
- DMA module has to be initialized prior to LPUART usage in DMA mode; also, DMA channels need to be allocated for LPUART usage by the application (the driver only takes care of configuring the DMA channels received in the configuration structure)
- For 9/10 bits characters, the application must provide the appropriate buffers; the size of the tx/rx buffers in this scenario needs to be an even number, as the transferred characters will be split in two bytes (bit 8 for 9-bits chars and bits 8 & 9 for 10-bits chars will be stored in the subsequent byte). 9/10 bits chars are only supported in interrupt-based and polling communications
- For 10-bits word length, parity cannot be enabled.
- When the vector table is not in ram (**flash_vector_table** = 1):
  - INT_SYS_InstallHandler shall check if the function pointer provided as parameter for the new handler is already present in the vector table for the given IRQ number.
  - The user will be required to manually add the correct handlers in the startup files

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\lpuart\lpuart_driver.c
${S32SDK_PATH}\platform\drivers\src\lpuart\lpuart_hw_access.c
${S32SDK_PATH}\platform\drivers\src\lpuart\lpuart_irq.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager Interrupt Manager (Interrupt) Enhanced Direct Memory Access (eDMA)

Data Structures

- struct lpuart_state_t

  Runtime state of the LPUART driver. More...
- struct lpuart_user_config_t

  LPUART configuration structure. More...

Enumerations

- enum lpuart_transfer_type_t { LPUART_USING_DMA = 0, LPUART_USING_INTERRUPTS }

  Type of LPUART transfer (based on interrupts or DMA).
- enum lpuart_bit_count_per_char_t { LPUART_8_BITS_PER_CHAR = 0x0U, LPUART_9_BITS_PER_CHAR = 0x1U, LPUART_10_BITS_PER_CHAR = 0x2U }

  LPUART number of bits in a character.
- enum lpuart_parity_mode_t { LPUART_PARITY_DISABLED = 0x0U, LPUART_PARITY_EVEN = 0x2U, LPUART_PARITY_ODD = 0x3U }

  LPUART parity mode.
- enum lpuart_stop_bit_count_t { LPUART_ONE_STOP_BIT = 0x0U, LPUART_TWO_STOP_BIT = 0x1U }

  LPUART number of stop bits.

LPUART Driver

- void LPUART_DRV_GetDefaultConfig (lpuart_user_config_t *lpuartUserConfig)

  Initializes the LPUART configuration structure with default values.
- status_t LPUART_DRV_Init (uint32_t instance, lpuart_state_t *lpuartStatePtr, const lpuart_user_config_t *lpuartUserConfig)

  Initializes an LPUART operation instance.
- status_t LPUART_DRV_Deinit (uint32_t instance)

  Shuts down the LPUART by disabling interrupts and transmitter/receiver.
- uart_callback_t LPUART_DRV_InstallRxCallback (uint32_t instance, uart_callback_t function, void *callbackParam)

Installs callback function for the LPUART receive.

- uart_callback_t LPUART_DRV_InstallTxCallback (uint32_t instance, uart_callback_t function, void *callbackParam)

  Installs callback function for the LPUART transmit.

- status_t LPUART_DRV_SendDataBlocking (uint32_t instance, const uint8_t *txBuff, uint32_t txSize, uint32_t timeout)

  Sends data out through the LPUART module using a blocking method.

- status_t LPUART_DRV_SendDataPolling (uint32_t instance, const uint8_t *txBuff, uint32_t txSize)

  Send out multiple bytes of data using polling method.

- status_t LPUART_DRV_SendData (uint32_t instance, const uint8_t *txBuff, uint32_t txSize)

  Sends data out through the LPUART module using a non-blocking method. This enables an a-sync method for transmitting data. When used with a non-blocking receive, the LPUART can perform a full duplex operation. Non-blocking means that the function returns immediately. The application has to get the transmit status to know when the transmit is complete.

- status_t LPUART_DRV_GetTransmitStatus (uint32_t instance, uint32_t *bytesRemaining)

  Returns whether the previous transmit is complete.

- status_t LPUART_DRV_AbortSendingData (uint32_t instance)

  Terminates a non-blocking transmission early.

- status_t LPUART_DRV_ReceiveDataBlocking (uint32_t instance, uint8_t *rxBuff, uint32_t rxSize, uint32_t timeout)

  Gets data from the LPUART module by using a blocking method. Blocking means that the function does not return until the receive is complete.

- status_t LPUART_DRV_ReceiveDataPolling (uint32_t instance, uint8_t *rxBuff, uint32_t rxSize)

  Receive multiple bytes of data using polling method.

- status_t LPUART_DRV_ReceiveData (uint32_t instance, uint8_t *rxBuff, uint32_t rxSize)

  Gets data from the LPUART module by using a non-blocking method. This enables an a-sync method for receiving data. When used with a non-blocking transmission, the LPUART can perform a full duplex operation. Non-blocking means that the function returns immediately. The application has to get the receive status to know when the receive is complete.

- status_t LPUART_DRV_GetReceiveStatus (uint32_t instance, uint32_t *bytesRemaining)

  Returns whether the previous receive is complete.

- status_t LPUART_DRV_AbortReceivingData (uint32_t instance)

  Terminates a non-blocking receive early.

- status_t LPUART_DRV_SetBaudRate (uint32_t instance, uint32_t desiredBaudRate)

  Configures the LPUART baud rate.

- void LPUART_DRV_GetBaudRate (uint32_t instance, uint32_t *configuredBaudRate)

  Returns the LPUART baud rate.

- status_t LPUART_DRV_SetTxBuffer (uint32_t instance, const uint8_t *txBuff, uint32_t txSize)

  Sets the internal driver reference to the tx buffer.

- status_t LPUART_DRV_SetRxBuffer (uint32_t instance, uint8_t *rxBuff, uint32_t rxSize)

  Sets the internal driver reference to the rx buffer.

16.62.2 Data Structure Documentation

16.62.2.1 struct lpuart_state_t

Runtime state of the LPUART driver.

Note that the caller provides memory for the driver state structures during initialization because the driver does not statically allocate memory.

Implements : lpuart_state_t_Class

Definition at line 89 of file lpuart_driver.h.

Data Fields

- const uint8_t * txBuff
- uint8_t * rxBuff
- volatile uint32_t txSize
- volatile uint32_t rxSize
- volatile bool isTxBusy
- volatile bool isRxBusy
- volatile bool isTxBlocking
- volatile bool isRxBlocking
- lpuart_bit_count_per_char_t bitCountPerChar
- uart_callback_t rxCallback
- void * rxCallbackParam
- uart_callback_t txCallback
- void * txCallbackParam
- lpuart_transfer_type_t transferType
- semaphore_t rxComplete
- semaphore_t txComplete
- volatile status_t transmitStatus
- volatile status_t receiveStatus

Field Documentation

16.62.2.1.1 lpuart_bit_count_per_char_t bitCountPerChar

number of bits in a char (8/9/10)

Definition at line 99 of file lpuart_driver.h.

16.62.2.1.2 volatile bool isRxBlocking

True if receive is blocking transaction.

Definition at line 98 of file lpuart_driver.h.

16.62.2.1.3 volatile bool isRxBusy

True if there is an active receive.

Definition at line 96 of file lpuart_driver.h.

16.62.2.1.4 volatile bool isTxBlocking

True if transmit is blocking transaction.

Definition at line 97 of file lpuart_driver.h.

16.62.2.1.5 volatile bool isTxBusy

True if there is an active transmit.

Definition at line 95 of file lpuart_driver.h.

16.62.2.1.6 volatile status_t receiveStatus

Status of last driver receive operation

Definition at line 120 of file lpuart_driver.h.

16.62.2.1.7 uint8_t* rxBuff

The buffer of received data.

Definition at line 92 of file lpuart_driver.h.

16.62.2.1.8 uart_callback_t rxCallback

Callback to invoke for data receive Note: when the transmission is interrupt based, the callback is being called upon receiving a byte; when DMA transmission is used, the bytes are copied to the rx buffer by the DMA engine and the callback is called when all the bytes have been transferred.

Definition at line 100 of file lpuart_driver.h.

16.62.2.1.9 void* rxCallbackParam

Receive callback parameter pointer.

Definition at line 105 of file lpuart_driver.h.

16.62.2.1.10 semaphore_t rxComplete

Synchronization object for blocking Rx timeout condition

Definition at line 117 of file lpuart_driver.h.

16.62.2.1.11 volatile uint32_t rxSize

The remaining number of bytes to be received.

Definition at line 94 of file lpuart_driver.h.

16.62.2.1.12 lpuart_transfer_type_t transferType

Type of LPUART transfer (interrupt/dma based)

Definition at line 112 of file lpuart_driver.h.

16.62.2.1.13 volatile status_t transmitStatus

Status of last driver transmit operation

Definition at line 119 of file lpuart_driver.h.

16.62.2.1.14 const uint8_t* txBuff

The buffer of data being sent.

Definition at line 91 of file lpuart_driver.h.

16.62.2.1.15 uart_callback_t txCallback

Callback to invoke for data send Note: when the transmission is interrupt based, the callback is being called upon sending a byte; when DMA transmission is used, the bytes are copied to the tx buffer by the DMA engine and the callback is called when all the bytes have been transferred.

Definition at line 106 of file lpuart_driver.h.

16.62.2.1.16 void* txCallbackParam

Transmit callback parameter pointer.

Definition at line 111 of file lpuart_driver.h.

16.62.2.1.17 semaphore_t txComplete

Synchronization object for blocking Tx timeout condition

Definition at line 118 of file lpuart_driver.h.

16.62.2.1.18 volatile uint32_t txSize

The remaining number of bytes to be transmitted.

Definition at line 93 of file lpuart_driver.h.

16.62.2.2 struct lpuart_user_config_t

LPUART configuration structure.

Implements : lpuart_user_config_t_Class

Definition at line 127 of file lpuart_driver.h.

Data Fields

- uint32_t baudRate
- lpuart_parity_mode_t parityMode
- lpuart_stop_bit_count_t stopBitCount
- lpuart_bit_count_per_char_t bitCountPerChar
- lpuart_transfer_type_t transferType
- uint8_t rxDMAChannel
- uint8_t txDMAChannel

Field Documentation

16.62.2.2.1 uint32_t baudRate

LPUART baud rate

Definition at line 129 of file lpuart_driver.h.

16.62.2.2.2 lpuart_bit_count_per_char_t bitCountPerChar

number of bits in a character (8-default, 9 or 10); for 9/10 bits chars, users must provide appropriate buffers to the send/receive functions (bits 8/9 in subsequent bytes); for DMA transmission only 8-bit char is supported.

Definition at line 132 of file lpuart_driver.h.

16.62.2.2.3 lpuart_parity_mode_t parityMode

parity mode, disabled (default), even, odd

Definition at line 130 of file lpuart_driver.h.

16.62.2.2.4 uint8_t rxDMAChannel

Channel number for DMA rx channel. If DMA mode isn't used this field will be ignored.

Definition at line 137 of file lpuart_driver.h.

16.62.2.2.5 lpuart_stop_bit_count_t stopBitCount

number of stop bits, 1 stop bit (default) or 2 stop bits

Definition at line 131 of file lpuart_driver.h.

16.62.2.2.6 lpuart_transfer_type_t transferType

Type of LPUART transfer (interrupt/dma based)

Definition at line 136 of file lpuart_driver.h.

16.62.2.2.7 uint8_t txDMAChannel

Channel number for DMA tx channel. If DMA mode isn't used this field will be ignored.

Definition at line 139 of file lpuart_driver.h.

16.62.3 Enumeration Type Documentation

16.62.3.1 enum lpuart_bit_count_per_char_t

LPUART number of bits in a character.

Implements : lpuart_bit_count_per_char_t_Class

Enumerator

LPUART_8_BITS_PER_CHAR 8-bit data characters
LPUART_9_BITS_PER_CHAR 9-bit data characters
LPUART_10_BITS_PER_CHAR 10-bit data characters

Definition at line 53 of file lpuart_driver.h.

16.62.3.2 enum lpuart_parity_mode_t

LPUART parity mode.

Implements : lpuart_parity_mode_t_Class

Enumerator

LPUART_PARITY_DISABLED parity disabled
LPUART_PARITY_EVEN parity enabled, type even, bit setting: PE|PT = 10
LPUART_PARITY_ODD parity enabled, type odd, bit setting: PE|PT = 11

Definition at line 64 of file lpuart_driver.h.

16.62.3.3 enum lpuart_stop_bit_count_t

LPUART number of stop bits.

Implements : lpuart_stop_bit_count_t_Class

Enumerator

LPUART_ONE_STOP_BIT one stop bit
LPUART_TWO_STOP_BIT two stop bits

Definition at line 75 of file lpuart_driver.h.

16.62.3.4 enum lpuart_transfer_type_t

Type of LPUART transfer (based on interrupts or DMA).

Implements : lpuart_transfer_type_t_Class

Enumerator

LPUART_USING_DMA The driver will use DMA to perform UART transfer
LPUART_USING_INTERRUPTS The driver will use interrupts to perform UART transfer

Definition at line 43 of file lpuart_driver.h.

16.62.4 Function Documentation

16.62.4.1 status_t LPUART_DRV_AbortReceivingData (uint32_t *instance*)

Terminates a non-blocking receive early.

Parameters

instance	LPUART instance number

Returns

Whether the receiving was successful or not.

Definition at line 891 of file lpuart_driver.c.

16.62.4.2 status_t LPUART_DRV_AbortSendingData (uint32_t *instance*)

Terminates a non-blocking transmission early.

Parameters

instance	LPUART instance number

Returns

Whether the aborting is successful or not.

Definition at line 580 of file lpuart_driver.c.

16.62.4.3 status_t LPUART_DRV_Deinit (uint32_t *instance*)

Shuts down the LPUART by disabling interrupts and transmitter/receiver.

Parameters

instance	LPUART instance number

Returns

STATUS_SUCCESS if successful; STATUS_ERROR if an error occurred

Definition at line 278 of file lpuart_driver.c.

16.62.4.4 void LPUART_DRV_GetBaudRate (uint32_t *instance,* uint32_t * *configuredBaudRate*)

Returns the LPUART baud rate.

This function returns the LPUART configured baud rate.

Parameters

	instance	LPUART instance number.
out	*configured↩ BaudRate*	LPUART configured baud rate.

Definition at line 1036 of file lpuart_driver.c.

16.62.4.5 void LPUART_DRV_GetDefaultConfig (lpuart_user_config_t * *lpuartUserConfig*)

Initializes the LPUART configuration structure with default values.

This function initializes a configuration structure received from the application with default values.

Parameters

lpuartUserConfig	user configuration structure of type lpuart_user_config_t

Definition at line 145 of file lpuart_driver.c.

16.62.4.6 status_t LPUART_DRV_GetReceiveStatus (uint32_t *instance,* uint32_t * *bytesRemaining*)

Returns whether the previous receive is complete.

Parameters

instance	LPUART instance number
bytesRemaining	pointer to value that is filled with the number of bytes that still need to be received in the active transfer.

Note

In DMA mode, this parameter may not be accurate, in case the transfer completes right after calling this function; in this edge-case, the parameter will reflect the initial transfer size, due to automatic reloading of the major loop count in the DMA transfer descriptor.

Returns

The receive status.

Return values

STATUS_SUCCESS	the receive has completed successfully.
STATUS_BUSY	the receive is still in progress. *bytesReceived* will be filled with the number of bytes that have been received so far.
STATUS_UART_ABORTED	The receive was aborted.
STATUS_TIMEOUT	A timeout was reached.
STATUS_UART_RX_OVERRUN,STATUS_UART_FRAMING_ERROR,STATUS_UART_PARITY_ERROR,or	STATUS_UART_NOISE_ERROR, STATUS_ERROR An error occurred during reception.

Definition at line 846 of file lpuart_driver.c.

16.62.4.7 status_t LPUART_DRV_GetTransmitStatus (uint32_t *instance,* uint32_t * *bytesRemaining*)

Returns whether the previous transmit is complete.

Parameters

instance	LPUART instance number
bytesRemaining	Pointer to value that is populated with the number of bytes that have been sent in the active transfer

Note

In DMA mode, this parameter may not be accurate, in case the transfer completes right after calling this function; in this edge-case, the parameter will reflect the initial transfer size, due to automatic reloading of the major loop count in the DMA transfer descriptor.

Returns

The transmit status.

Return values

STATUS_SUCCESS	The transmit has completed successfully.
STATUS_BUSY	The transmit is still in progress. *bytesRemaining* will be filled with the number of bytes that are yet to be transmitted.
STATUS_UART_ABORTED	The transmit was aborted.
STATUS_TIMEOUT	A timeout was reached.
STATUS_ERROR	An error occurred.

Definition at line 534 of file lpuart_driver.c.

16.62.4.8 status_t LPUART_DRV_Init (uint32_t *instance*, lpuart_state_t * *lpuartStatePtr*, const lpuart_user_config_t * *lpuartUserConfig*)

Initializes an LPUART operation instance.

The caller provides memory for the driver state structures during initialization. The user must select the LPUART clock source in the application to initialize the LPUART.

Parameters

instance	LPUART instance number
lpuartUserConfig	user configuration structure of type lpuart_user_config_t
lpuartStatePtr	pointer to the LPUART driver state structure

Returns

STATUS_SUCCESS if successful; STATUS_ERROR if an error occurred

Definition at line 181 of file lpuart_driver.c.

16.62.4.9 uart_callback_t LPUART_DRV_InstallRxCallback (uint32_t *instance*, uart_callback_t *function*, void * *callbackParam*)

Installs callback function for the LPUART receive.

Note

After a callback is installed, it bypasses part of the LPUART IRQHandler logic. Therefore, the callback needs to handle the indexes of txBuff and txSize.

Parameters

instance	The LPUART instance number.
function	The LPUART receive callback function.
rxBuff	The receive buffer used inside IRQHandler. This buffer must be kept as long as the callback is alive.
callbackParam	The LPUART receive callback parameter pointer.

Returns

Former LPUART receive callback function pointer.

Definition at line 319 of file lpuart_driver.c.

16.62.4.10 uart_callback_t LPUART_DRV_InstallTxCallback (uint32_t *instance*, uart_callback_t *function*, void * *callbackParam*)

Installs callback function for the LPUART transmit.

Note

After a callback is installed, it bypasses part of the LPUART IRQHandler logic. Therefore, the callback needs to handle the indexes of txBuff and txSize.

Parameters

instance	The LPUART instance number.
function	The LPUART transmit callback function.
txBuff	The transmit buffer used inside IRQHandler. This buffer must be kept as long as the callback is alive.
callbackParam	The LPUART transmit callback parameter pointer.

Returns

Former LPUART transmit callback function pointer.

Definition at line 342 of file lpuart_driver.c.

16.62.4.11 status_t LPUART_DRV_ReceiveData (uint32_t *instance*, uint8_t * *rxBuff*, uint32_t *rxSize*)

Gets data from the LPUART module by using a non-blocking method. This enables an a-sync method for receiving data. When used with a non-blocking transmission, the LPUART can perform a full duplex operation. Non-blocking means that the function returns immediately. The application has to get the receive status to know when the receive is complete.

Parameters

instance	LPUART instance number
rxBuff	buffer containing 8-bit read data chars received
rxSize	the number of bytes to receive

Returns

STATUS_SUCCESS if successful; STATUS_BUSY if the resource is busy

Definition at line 803 of file lpuart_driver.c.

16.62.4.12 status_t LPUART_DRV_ReceiveDataBlocking (uint32_t *instance*, uint8_t * *rxBuff*, uint32_t *rxSize*, uint32_t *timeout*)

Gets data from the LPUART module by using a blocking method. Blocking means that the function does not return until the receive is complete.

Parameters

instance	LPUART instance number
rxBuff	buffer containing 8-bit read data chars received
rxSize	the number of bytes to receive
timeout	timeout value in milliseconds

Returns

STATUS_SUCCESS if successful; STATUS_TIMEOUT if the timeout was reached; STATUS_BUSY if the resource is busy; STATUS_UART_FRAMING_ERROR if a framing error occurred; STATUS_UART_NOISE_ERROR if a noise error occurred; STATUS_UART_PARITY_ERROR if a parity error occurred; STATUS_UART_RX_OVERRUN if an overrun error occurred; STATUS_ERROR if a DMA error occurred;

Definition at line 618 of file lpuart_driver.c.

16.62.4.13 status_t LPUART_DRV_ReceiveDataPolling (uint32_t *instance*, uint8_t * *rxBuff*, uint32_t *rxSize*)

Receive multiple bytes of data using polling method.

Parameters

instance	LPUART instance number.
rxBuff	The buffer pointer which saves the data to be received.
rxSize	Size of data need to be received in unit of byte.

Returns

STATUS_SUCCESS if the transaction is successful; STATUS_BUSY if the resource is busy; STATUS_UA↩ RT_RX_OVERRUN if an overrun error occurred.

Definition at line 683 of file lpuart_driver.c.

16.62.4.14 status_t LPUART_DRV_SendData (uint32_t *instance*, const uint8_t * *txBuff*, uint32_t *txSize*)

Sends data out through the LPUART module using a non-blocking method. This enables an a-sync method for transmitting data. When used with a non-blocking receive, the LPUART can perform a full duplex operation. Non-blocking means that the function returns immediately. The application has to get the transmit status to know when the transmit is complete.

Parameters

instance	LPUART instance number
txBuff	source buffer containing 8-bit data chars to send
txSize	the number of bytes to send

Returns

STATUS_SUCCESS if successful; STATUS_BUSY if the resource is busy;

Definition at line 490 of file lpuart_driver.c.

16.62.4.15 status_t LPUART_DRV_SendDataBlocking (uint32_t *instance*, const uint8_t * *txBuff*, uint32_t *txSize*, uint32_t *timeout*)

Sends data out through the LPUART module using a blocking method.

Blocking means that the function does not return until the transmission is complete.

Parameters

instance	LPUART instance number
txBuff	source buffer containing 8-bit data chars to send
txSize	the number of bytes to send
timeout	timeout value in milliseconds

Returns

STATUS_SUCCESS if successful; STATUS_TIMEOUT if the timeout was reached; STATUS_BUSY if the resource is busy; STATUS_ERROR if an error occurred

Definition at line 365 of file lpuart_driver.c.

16.62.4.16 status_t LPUART_DRV_SendDataPolling (uint32_t *instance*, const uint8_t * *txBuff*, uint32_t *txSize*)

Send out multiple bytes of data using polling method.

Parameters

instance	LPUART instance number.
txBuff	The buffer pointer which saves the data to be sent.
txSize	Size of data to be sent in unit of byte.

Returns

STATUS_SUCCESS if successful; STATUS_BUSY if the resource is busy;

Definition at line 430 of file lpuart_driver.c.

16.62.4.17 status_t LPUART_DRV_SetBaudRate (uint32_t *instance,* uint32_t *desiredBaudRate*)

Configures the LPUART baud rate.

This function configures the LPUART baud rate. In some LPUART instances the user must disable the transmitter/receiver before calling this function. Generally, this may be applied to all LPUARTs to ensure safe operation.

Parameters

instance	LPUART instance number.
desiredBaud↩ Rate	LPUART desired baud rate.

Returns

STATUS_BUSY if called during an on-going transfer, STATUS_SUCCESS otherwise

Definition at line 931 of file lpuart_driver.c.

16.62.4.18 status_t LPUART_DRV_SetRxBuffer (uint32_t *instance,* uint8_t * *rxBuff,* uint32_t *rxSize*)

Sets the internal driver reference to the rx buffer.

This function can be called from the rx callback to provide the driver with a new buffer, for continuous reception.

Parameters

instance	LPUART instance number
rxBuff	destination buffer containing 8-bit data chars to receive
rxSize	the number of bytes to receive

Returns

STATUS_SUCCESS

Definition at line 1089 of file lpuart_driver.c.

16.62.4.19 status_t LPUART_DRV_SetTxBuffer (uint32_t *instance,* const uint8_t * *txBuff,* uint32_t *txSize*)

Sets the internal driver reference to the tx buffer.

This function can be called from the tx callback to provide the driver with a new buffer, for continuous transmission.

Parameters

instance	LPUART instance number

txBuff	source buffer containing 8-bit data chars to send
txSize	the number of bytes to send

Returns

STATUS_SUCCESS

Definition at line 1065 of file lpuart_driver.c.

16.63 Local Interconnect Network (LIN)

16.63.1 Detailed Description

The S32 SDK provides both driver and middleware layers for the Local Interconnect Network (LIN) protocol, emulated on top of LPUART serial communication IP.

Modules

- LIN Driver

  This section describes the programming interface of the Peripheral driver for LIN.
- LIN Stack

  This section covers the functionality of the LIN Stack middleware layer in S32 SDK.

16.64 Low Power Inter-Integrated Circuit (LPI2C)

16.64.1 Detailed Description

The LPI2C is a low power Inter-Integrated Circuit (I2C) module that supports an efficient interface to an I2C bus as a master and/or a slave.

Modules

- LPI2C Driver

  Low Power Inter-Integrated Circuit (LPI2C) Peripheral Driver.

16.65 Low Power Interrupt Timer (LPIT)

16.65.1 Detailed Description

The Low Power Periodic Interrupt Timer (LPIT) is a multi-channel timer module generating independent pre-trigger and trigger outputs. These timer channels can operate individually or can be chained together. The LPIT can operate in low power modes if configured to do so. The pre-trigger and trigger outputs can be used to trigger other modules on the device.

The S32 SDK provides Peripheral Drivers for the Low Power Interrupt Timer (LPIT) module of S32 devices.

Modules

- LPIT Driver

  Low Power Interrupt Timer Peripheral Driver.

16.66 Low Power Serial Peripheral Interface (LPSPI)

16.66.1 Detailed Description

Low Power Serial Peripheral Interface (LPSPI) Peripheral Driver.

The LPSPI driver allows communication on an SPI bus using the LPSPI module in the S32K1xx processors.

Features

- Interrupt based
- Master or slave operation
- Provides blocking and non-blocking transmit and receive functions
- RX and TX hardware buffers (4 words)
- 4 configurable chip select
- Configurable baud rate

How to integrate LPSPI in your application

In order to use the LPSPI driver it must be first initialized in either master or slave mode, using functions LPSPI_DRV_MasterInit() or LPSPI_DRV_SlaveInit(). Once initialized, it cannot be initialized again for the same LPSPI module instance until it is de-initialized, using LPSPI_DRV_MasterDeinit() or LPSPI_DRV_SlaveDeinit(). Different LPSPI module instances can function independently of each other.

In each mode (master/slave) are available two types of transfers: blocking and non-blocking. The functions which initiate blocking transfers will configure the time out for transmission. If time expires LPSPI_MasterTransferBlocking/LPSPI_SlaveTransferBlocking will return error and the transmission will be aborted.

Depending on frame size receive and transmit buffers must be aligned as is presented in the next table:

Bits/frame	less or equal with 8	between 9 and 16	more than 16
Alignment	1 byte	2 bytes	4 bytes

This alignment requirements should be taken into consideration when "transferByteCount" is configured. For a better understanding these are some examples of how to calculate the right value to "transferByteCount":

Bits/frame	number of frames	bytes per frame	transferByteCount
8	10	1	10
10	10	2	20
24	10	4	40
32	10	4	40
40	10	8	80
64	10	8	80

If frame size is bigger than 32 bits MSB/LSB option is applicable for each uint32_t, not for the entire frame. The application should enssure the uint32_t order in buffers, depending on MSB/LSB configuration.

```
## Important Notes ##
```

- The driver enables the interrupts for the corresponding LPSPI module,
  but any interrupt priority setting must be done by the application.
- The watermarks will be set by the application.
- The driver will configure SCK to PCS delay, PCS to SCK delay, delay between transfers with default values. If your application needs other values for this parameters LPSPI_DRV_MasterSetDelay function can be used.
- The driver cannot be used in the case SPI transfer in slave mode over DMA with invalid address of tx buffer, the driver will never finish the transfer.

- The driver cannot be used with a configuration with bit/frame greater than 32 bits and MSB endianness in either slave or master mode.
- LPSPI2 instance is only available on 64-pin variant of S32K14xW and not available on 48-pin variant. If you need a frame larger than 32 bits with MSB the application must handle the data positioning.

Example code

```
const lpspi_master_config_t Send_MasterConfig0 = {
    .bitsPerSec = 50000U,
    .whichPcs = LPSPI_PCS0,
    .pcsPolarity = LPSPI_ACTIVE_HIGH,
    .isPcsContinuous = false,
    .bitcount = 8U,
    .lpspiSrcClk = 8000000U,
    .clkPhase = LPSPI_CLOCK_PHASE_1ST_EDGE,
    .clkPolarity = LPSPI_SCK_ACTIVE_HIGH,
    .lsbFirst = false,
    .transferType = LPSPI_USING_INTERRUPTS,
};
const lpspi_slave_config_t Receive_SlaveConfig0 = {
    .pcsPolarity = LPSPI_ACTIVE_HIGH,
    .bitcount = 8U,
    .clkPhase = LPSPI_CLOCK_PHASE_1ST_EDGE,
    .whichPcs = LPSPI_PCS0,
    .clkPolarity = LPSPI_SCK_ACTIVE_HIGH,
    .lsbFirst = false,
    .transferType = LPSPI_USING_INTERRUPTS,
};
/* Initialize clock and pins */
LPSPI_DRV_MasterInit(0U, &masterState, &Send_MasterConfig0);
/* Set delay between transfer, PCStoSCK and SCKtoPCS to 10 microseconds. */
LPSPI_DRV_MasterSetDelay(0U, 10U, 10U, 10u);
/* Initialize LPSPI1 (Slave)*/
LPSPI_DRV_SlaveInit(1U, &slaveState, &Receive_SlaveConfig0);
/* Allocate memory */
masterDataSend = (uint8_t*)calloc(100, sizeof(uint8_t));
masterDataReceive = (uint8_t*)calloc(100, sizeof(uint8_t));
slaveDataSend = (uint8_t*)calloc(100, sizeof(uint8_t));
slaveDataReceive = (uint8_t*)calloc(100, sizeof(uint8_t));
bufferSize = 100U;
testStatus[0] = true;
LPSPI_DRV_SlaveTransfer(0U, slaveDataSend,
              slaveDataReceive, bufferSize);
LPSPI_DRV_MasterTransferBlocking(1U, &Send_MasterConfig0, masterDataSend,
              masterDataReceive, bufferSize, TIMEOUT);
```

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\lpspi\lpspi_irq.c
${S32SDK_PATH}\platform\drivers\src\lpspi\lpspi_master_driver.c
${S32SDK_PATH}\platform\drivers\src\lpspi\lpspi_shared_function.c
${S32SDK_PATH}\platform\drivers\src\lpspi\lpspi_slave_driver.c
${S32SDK_PATH}\platform\drivers\src\lpspi\lpspi_hw_access.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc
${S32SDK_PATH}\platform\drivers\src\lpspi
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager OS Interface (OSIF) Interrupt Manager (Interrupt) Enhanced Direct Memory Access (eDMA)

Modules

- LPSPI Driver

  Low Power Serial Peripheral Interface Peripheral Driver.

16.67 Low Power Timer (LPTMR)

16.67.1 Detailed Description

The S32 SDK provides Peripheral Drivers for the Low Power Timer (LPTMR) module of S32 SDK devices.

The LPTMR is a configurable 16-bit counter that can operate in two functional modes:

- Timer mode with selectable prescaler and clock source (periodic or free-running).
- Pulse-Counter mode, with configurable glitch filter, that can count events (internal or external)

Modules

- LPTMR Driver

  Low Power Timer Peripheral Driver.

16.68 Low Power Universal Asynchronous Receiver-Transmitter (LPUART)

16.68.1 Detailed Description

The S32 SDK provides a Peripheral Driver for the Low Power Universal Asynchronous Receiver-Transmitter (LP↩UART) module of S32 SDK devices.
The LPUART module is used for serial communication, supporting LIN master and slave operation. These sections describe the S32 SDK software modules API that can be used for initializing and configuring the module, as well as initiating serial communications using the interrupt-based method.

Modules

- LPUART Driver

  This module covers the functionality of the Low Power Universal Asynchronous Receiver-Transmitter (LPUART) peripheral driver.

16.69 Low level API

16.69.1 Detailed Description

Low level layer consists of functions that call LIN driver API.

This layer contains the implementation of LIN hardware initialization and deinitialization, getting LIN node's current state, sending wakeup signals, enabling and disabling interrupts, sending frame data from a buffer, receiving frame data into a buffer, handling timeout and callbacks from LIN driver.

Data Structures

- struct lin_word_status_str_t

  status of LIN bus Implements : lin_word_status_str_t_Class More...
- struct lin_serial_number_t

  Serial number Implements : lin_serial_number_t_Class. More...
- struct lin_node_attribute_t

  Attributes of LIN node Implements : lin_node_attribute_t_Class. More...
- struct lin_associate_frame_t

  Informations of associated frame Implements : lin_associate_frame_t_Class. More...
- struct lin_frame_t

  Frame description structure Implements : lin_frame_t_Class. More...
- struct lin_schedule_data_t

  LIN schedule structure Implements : lin_schedule_data_t_Class. More...
- struct lin_schedule_t

  Schedule table description Implements : lin_schedule_t_Class. More...
- struct lin_transport_layer_queue_t

  Transport layer queue Implements : lin_transport_layer_queue_t_Class. More...
- struct lin_tl_descriptor_t

  Transport layer description Implements : lin_tl_descriptor_t_Class. More...
- struct lin_protocol_user_config_t

  Configuration structure Implements : lin_protocol_user_config_t_Class. More...
- struct lin_master_data_t

  LIN master configuration structure Implements : lin_master_data_t_Class. More...
- struct lin_protocol_state_t

  LIN protocol status structure Implements : lin_protocol_state_t_Class. More...

Macros

- #define SERVICE_ASSIGN_NAD 0xB0U
- #define SERVICE_ASSIGN_FRAME_ID 0xB1U
- #define SERVICE_READ_BY_IDENTIFY 0xB2U
- #define SERVICE_CONDITIONAL_CHANGE_NAD 0xB3U
- #define SERVICE_SAVE_CONFIGURATION 0xB6U
- #define SERVICE_ASSIGN_FRAME_ID_RANGE 0xB7U
- #define SERVICE_READ_DATA_BY_IDENTIFY 0x22U
- #define SERVICE_WRITE_DATA_BY_IDENTIFY 0x2EU
- #define SERVICE_SESSION_CONTROL 0x10U
- #define SERVICE_IO_CONTROL_BY_IDENTIFY 0x2FU
- #define SERVICE_FAULT_MEMORY_READ 0x19U
- #define SERIVCE_FAULT_MEMORY_CLEAR 0x14U
- #define PCI_SAVE_CONFIGURATION 0x01U
- #define PCI_RES_READ_BY_IDENTIFY 0x06U

- #define PCI_RES_SAVE_CONFIGURATION 0x01U
- #define PCI_RES_ASSIGN_FRAME_ID_RANGE 0x01U
- #define LIN_READ_USR_DEF_MIN 32U
- #define LIN_READ_USR_DEF_MAX 63U
- #define LD_NEGATIVE_RESPONSE 0x53U
- #define LD_POSITIVE_RESPONSE 0x54U
- #define LIN_LLD_OK 0x00U
- #define LIN_LLD_ERROR 0xFFU
- #define LIN_SLAVE 0

  Mode of LIN node (master or slave)
- #define LIN_MASTER 1
- #define LIN_TL_CALLBACK_HANDLER(iii, tl_event_id, id) lin_tl_callback_handler((iii), (tl_event_id), (id))
- #define CALLBACK_HANDLER(iii, event_id, id) lin_pid_resp_callback_handler((iii), (event_id), (id))

  CALLBACK_HANDLER.

Typedefs

- typedef l_u8 lin_tl_pdu_data_t[8]

  PDU data. Implements : lin_tl_pdu_data_t_Class.
- typedef l_u8 lin_tl_queue_t[8]

  LIN transport layer queue Implements : lin_tl_queue_t_Class.

Enumerations

- enum lin_lld_event_id_t {
  LIN_LLD_PID_OK = 0x00U, LIN_LLD_TX_COMPLETED = 0x01U, LIN_LLD_RX_COMPLETED = 0x02U, LIN_LLD_PID_ERR = 0x03U,
  LIN_LLD_FRAME_ERR = 0x04U, LIN_LLD_CHECKSUM_ERR = 0x05U, LIN_LLD_READBACK_ERR = 0x06U, LIN_LLD_NODATA_TIMEOUT = 0x07U,
  LIN_LLD_BUS_ACTIVITY_TIMEOUT = 0x08U }

  Event id Implements : lin_lld_event_id_t_Class.
- enum lin_protocol_handle_t { LIN_PROTOCOL_21 = 0x00U, LIN_PROTOCOL_J2602 = 0x01U, LIN_PROTOCOL_13 = 0x02U, LIN_PROTOCOL_20 = 0x03U }

  List of protocols Implements : lin_protocol_handle_t_Class.
- enum lin_diagnostic_class_t { LIN_DIAGNOSTIC_CLASS_I = 0x01U, LIN_DIAGNOSTIC_CLASS_II = 0x02U, LIN_DIAGNOSTIC_CLASS_III = 0x03U }

  List of diagnostic classes Implements : lin_diagnostic_class_t_Class.
- enum lin_frame_type_t { LIN_FRM_UNCD = 0x00U, LIN_FRM_EVNT = 0x01U, LIN_FRM_SPRDC = 0x10U, LIN_FRM_DIAG = 0x11U }

  Types of frame Implements : lin_frame_type_t_Class.
- enum lin_frame_response_t { LIN_RES_PUB = 0x00U, LIN_RES_SUB = 0x01U }

  LIN frame response Implements : lin_frame_response_t_Class.
- enum lin_sch_tbl_type_t {
  LIN_SCH_TBL_NULL = 0x00U, LIN_SCH_TBL_NORM = 0x01U, LIN_SCH_TBL_DIAG = 0x02U, LIN_SCH_TBL_GO_TO_SLEEP = 0x03U,
  LIN_SCH_TBL_COLL_RESOLV = 0x04U }

  Types of schedule tables Implements : lin_sch_tbl_type_t_Class.
- enum l_diagnostic_mode_t { DIAG_NONE = 0x00U, DIAG_INTERLEAVE_MODE = 0x01U, DIAG_ONLY_MODE = 0x02U }

  Diagnostic mode Implements : l_diagnostic_mode_t_Class.
- enum lin_service_status_t { LD_SERVICE_BUSY = 0x00U, LD_REQUEST_FINISHED = 0x01U, LD_SERVICE_IDLE = 0x02U, LD_SERVICE_ERROR = 0x03U }

  Status of the last configuration call for LIN 2.1 Implements : lin_service_status_t_Class.

- enum lin_last_cfg_result_t { LD_SUCCESS = 0x00U, LD_NEGATIVE = 0x01U, LD_NO_RESPONSE = 0x02U, LD_OVERWRITTEN = 0x03U }

  Status of the last configuration call completed Implements : lin_last_cfg_result_t_Class.
- enum lin_tl_event_id_t { TL_MAKE_RES_DATA = 0x00U, TL_SLAVE_GET_ACTION = 0x01U, TL_TX_COMPLETED = 0x02U, TL_RX_COMPLETED = 0x03U, TL_ERROR = 0x04U, TL_TIMEOUT_SERVICE = 0x05U, TL_HANDLER_INTERLEAVE_MODE = 0x06U, TL_RECEIVE_MESSAGE = 0x07U }

  Transport layer event IDs Implements : lin_tl_event_id_t_Class.
- enum lin_tl_callback_return_t { TL_ACTION_NONE = 0x00U, TL_ACTION_ID_IGNORE = 0x01U }

  Transport layer event IDs Implements : lin_tl_callback_return_t_Class.
- enum ld_queue_status_t { LD_NO_DATA = 0x00U, LD_DATA_AVAILABLE = 0x01U, LD_RECEIVE_ERROR = 0x02U, LD_QUEUE_FULL = 0x03U, LD_QUEUE_AVAILABLE = 0x04U, LD_QUEUE_EMPTY = 0x05U, LD_TRANSMIT_ERROR = 0x06U, LD_TRANSFER_ERROR = 0x07U }

  Status of queue Implements : ld_queue_status_t_Class.
- enum lin_message_status_t { LD_NO_MSG = 0x00U, LD_IN_PROGRESS = 0x01U, LD_COMPLETED = 0x02U, LD_FAILED = 0x03U, LD_N_AS_TIMEOUT = 0x04U, LD_N_CR_TIMEOUT = 0x05U, LD_WRONG_SN = 0x06U }

  Status of LIN message Implements : lin_message_status_t_Class.
- enum lin_diagnostic_state_t { LD_DIAG_IDLE = 0x01U, LD_DIAG_TX_PHY = 0x02U, LD_DIAG_TX_FUNCTIONAL = 0x03U, LD_DIAG_TX_INTERLEAVED = 0x04U, LD_DIAG_RX_PHY = 0x05U, LD_DIAG_RX_FUNCTIONAL = 0x06U, LD_DIAG_RX_INTERLEAVED = 0x07U }

  LIN diagnostic state Implements : lin_diagnostic_state_t_Class.
- enum lin_message_timeout_type_t { LD_NO_CHECK_TIMEOUT = 0x00U, LD_CHECK_N_AS_TIMEOUT = 0x01U, LD_CHECK_N_CR_TIMEOUT = 0x02U }

  Types of message timeout Implements : lin_message_timeout_type_t_Class.
- enum diag_interleaved_state_t { DIAG_NOT_START = 0x00U, DIAG_NO_RESPONSE = 0x01U, DIAG_RESPONSE = 0x02U }

  State of diagnostic interleaved mode Implements : diag_interleaved_state_t_Class.

Functions

- lin_tl_callback_return_t lin_tl_callback_handler (l_ifc_handle iii, lin_tl_event_id_t tl_event_id, l_u8 id)
- l_u8 ld_read_by_id_callout (l_ifc_handle iii, l_u8 id, l_u8 *data)
- static l_u16 lin_calc_max_header_timeout_cnt (l_u32 baudRate)

  Computes maximum header timeout.
- static l_u16 lin_calc_max_res_timeout_cnt (l_u32 baudRate, l_u8 size)

  Computes the maximum response timeout.
- l_u8 lin_process_parity (l_u8 pid, l_u8 typeAction)

  Makes or checks parity bits. If action is checking parity, the function returns ID value if parity bits are correct or 0xFF if parity bits are incorrect. If action is making parity bits, then from input value of ID, the function returns PID.
- void lin_pid_resp_callback_handler (l_ifc_handle iii, const lin_lld_event_id_t event_id, l_u8 id)

  Callback handler for low level events.
- l_bool lin_lld_init (l_ifc_handle iii)

  This function initializes a LIN hardware instance for operation. This function will initialize the run-time state structure to keep track of the on-going transfers, initialize the module to user defined settings and default settings, configure the IRQ state structure and enable the module-level interrupt to the core, and enable the LIN hardware module transmitter and receiver.
- void lin_lld_deinit (l_ifc_handle iii)

  This function disconnect the node from the cluster and free all hardware used.

- l_u8 lin_lld_int_enable (l_ifc_handle iii)

  Enable the interrupt related to the interface.
- l_u8 lin_lld_int_disable (l_ifc_handle iii)

  Disable the interrupt related to the interface.
- lin_node_state_t lin_lld_get_state (l_ifc_handle iii)

  This function gets current state of an interface.
- l_u8 lin_lld_tx_header (l_ifc_handle iii, l_u8 id)

  This function sends frame header for the input PID.
- l_u8 lin_lld_tx_wake_up (l_ifc_handle iii)

  This function send a wakeup signal.
- l_u8 lin_lld_ignore_response (l_ifc_handle iii)

  This function terminates an on-going data transmission/reception.
- l_u8 lin_lld_set_low_power_mode (l_ifc_handle iii)

  Let the low level driver go to low power mode.
- l_u8 lin_lld_set_response (l_ifc_handle iii, l_u8 response_length)

  This function sends frame data that is contained in LIN_lld_response_buffer[iii].
- l_u8 lin_lld_rx_response (l_ifc_handle iii, l_u8 response_length)

  This function receives frame data into the LIN_lld_response_buffer[iii] buffer.
- void lin_lld_timeout_service (l_ifc_handle iii)

  Callback function for Timer Interrupt Handler In timer IRQ handler, call this function. Used to check if frame timeout has occurred during frame data transmission and reception, to check for N_As and N_Cr timeout for LIN 2.1 and above. This function also check if there is no LIN bus communication (no headers and no frame data transferring) for Idle timeout (s), then put LIN node to Sleep mode. Users may initialize a timer (for example FTM)with period of Timeout unit (default: 500 micro seconds) to call lin_lld_timeout_service(). For an interface iii, Idle timeout (s) = max_idle_timeout_cnt ∗ Timeout unit (us) frame timeout (us) = frame_timeout_cnt ∗ Timeout unit (us) N_As timeout (us) = N_As_timeout ∗ Timeout unit (us) N_Cr timeout (us) = N_Cr_timeout ∗ Timeout unit (us)

Variables

- const lin_node_attribute_t g_lin_node_attribute_array [LIN_NUM_OF_SLAVE_IFCS]
- lin_master_data_t g_lin_master_data_array [LIN_NUM_OF_MASTER_IFCS]
- lin_tl_descriptor_t g_lin_tl_descriptor_array [LIN_NUM_OF_IFCS]
- const lin_protocol_user_config_t g_lin_protocol_user_cfg_array [LIN_NUM_OF_IFCS]
- lin_protocol_state_t g_lin_protocol_state_array [LIN_NUM_OF_IFCS]
- volatile l_u8 g_lin_frame_data_buffer [LIN_FRAME_BUF_SIZE]
- volatile l_u8 g_lin_flag_handle_tbl [LIN_FLAG_BUF_SIZE]
- volatile l_bool g_lin_frame_flag_handle_tbl [LIN_NUM_OF_FRMS]
- const l_u32 g_lin_virtual_ifc [LIN_NUM_OF_IFCS]
- const l_ifc_handle g_lin_hardware_ifc [HARDWARE_INSTANCE_COUNT]
- const lin_timer_get_time_interval_t timerGetTimeIntervalCallbackArr [LIN_NUM_OF_IFCS]
- volatile l_u8 g_buffer_backup_data [8]
- volatile l_u8 g_lin_frame_updating_flag_tbl [LIN_NUM_OF_FRMS]

16.69.2 Data Structure Documentation

16.69.2.1 struct lin_word_status_str_t

status of LIN bus Implements : lin_word_status_str_t_Class

Definition at line 148 of file lin.h.

Data Fields

- unsigned int error_in_res: 1
- unsigned int successful_transfer: 1
- unsigned int overrun: 1
- unsigned int go_to_sleep_flg: 1
- unsigned int bus_activity: 1
- unsigned int event_trigger_collision_flg: 1
- unsigned int save_config_flg: 1
- unsigned int reserved: 1
- unsigned int last_pid: 8

Field Documentation

16.69.2.1.1 unsigned int bus_activity

Bus activity

Definition at line 154 of file lin.h.

16.69.2.1.2 unsigned int error_in_res

Error in response

Definition at line 150 of file lin.h.

16.69.2.1.3 unsigned int event_trigger_collision_flg

Event trigger collision

Definition at line 155 of file lin.h.

16.69.2.1.4 unsigned int go_to_sleep_flg

Goto sleep

Definition at line 153 of file lin.h.

16.69.2.1.5 unsigned int last_pid

Last PID

Definition at line 158 of file lin.h.

16.69.2.1.6 unsigned int overrun

Overrun

Definition at line 152 of file lin.h.

16.69.2.1.7 unsigned int reserved

Dummy

Definition at line 157 of file lin.h.

16.69.2.1.8 unsigned int save_config_flg

Save configuration

Definition at line 156 of file lin.h.

16.69.2.1.9 unsigned int successful_transfer

Successful transfer

Definition at line 151 of file lin.h.

16.69.2.2 struct lin_serial_number_t

Serial number Implements : lin_serial_number_t_Class.

Definition at line 175 of file lin.h.

Data Fields

- l_u8 serial_0
- l_u8 serial_1
- l_u8 serial_2
- l_u8 serial_3

Field Documentation

16.69.2.2.1 l_u8 serial_0

Serial 0

Definition at line 177 of file lin.h.

16.69.2.2.2 l_u8 serial_1

Serial 1

Definition at line 178 of file lin.h.

16.69.2.2.3 l_u8 serial_2

Serial 2

Definition at line 179 of file lin.h.

16.69.2.2.4 l_u8 serial_3

Serial 3

Definition at line 180 of file lin.h.

16.69.2.3 struct lin_node_attribute_t

Attributes of LIN node Implements : lin_node_attribute_t_Class.

Definition at line 187 of file lin.h.

Data Fields

- l_u8 * configured_NAD_ptr
- l_u8 initial_NAD
- lin_product_id_t product_id
- lin_serial_number_t serial_number
- l_u8 * resp_err_frm_id_ptr
- l_u8 num_frame_have_esignal
- l_signal_handle response_error
- l_u16 * response_error_byte_offset_ptr
- l_u8 * response_error_bit_offset_ptr
- l_u8 num_of_fault_state_signal
- const l_signal_handle * fault_state_signal_ptr
- l_u16 P2_min
- l_u16 ST_min
- l_u16 N_As_timeout

- l_u16 N_Cr_timeout
- l_u8 number_support_sid
- const l_u8 * service_supported_ptr
- l_u8 * service_flags_ptr

Field Documentation

16.69.2.3.1 l_u8* configured_NAD_ptr

NAD value used in configuration command

Definition at line 189 of file lin.h.

16.69.2.3.2 const l_signal_handle* fault_state_signal_ptr

List of fault state signal

Definition at line 199 of file lin.h.

16.69.2.3.3 l_u8 initial_NAD

Initial NAD

Definition at line 190 of file lin.h.

16.69.2.3.4 l_u16 N_As_timeout

N_As_timeout

Definition at line 202 of file lin.h.

16.69.2.3.5 l_u16 N_Cr_timeout

N_Cr_timeout

Definition at line 203 of file lin.h.

16.69.2.3.6 l_u8 num_frame_have_esignal

Number of frame contain error signal

Definition at line 194 of file lin.h.

16.69.2.3.7 l_u8 num_of_fault_state_signal

Number of Fault state signal

Definition at line 198 of file lin.h.

16.69.2.3.8 l_u8 number_support_sid

Number of supported diagnostic services

Definition at line 204 of file lin.h.

16.69.2.3.9 l_u16 P2_min

P2 min

Definition at line 200 of file lin.h.

16.69.2.3.10 lin_product_id_t product_id

Product ID

Definition at line 191 of file lin.h.

16.69.2.3.11 l_u8* resp_err_frm_id_ptr

List index of frame contain response error signal

Definition at line 193 of file lin.h.

16.69.2.3.12 l_signal_handle response_error

Signal used to update response error

Definition at line 195 of file lin.h.

16.69.2.3.13 l_u8* response_error_bit_offset_ptr

Bit offset of response error signal

Definition at line 197 of file lin.h.

16.69.2.3.14 l_u16* response_error_byte_offset_ptr

Byte offset of response error signal

Definition at line 196 of file lin.h.

16.69.2.3.15 lin_serial_number_t serial_number

Serial number

Definition at line 192 of file lin.h.

16.69.2.3.16 l_u8* service_flags_ptr

List of associated flags with supported diagnostic services

Definition at line 206 of file lin.h.

16.69.2.3.17 const l_u8* service_supported_ptr

List of supported diagnostic service

Definition at line 205 of file lin.h.

16.69.2.3.18 l_u16 ST_min

ST min

Definition at line 201 of file lin.h.

16.69.2.4 struct lin_associate_frame_t

Informations of associated frame Implements : lin_associate_frame_t_Class.

Definition at line 238 of file lin.h.

Data Fields

- l_u8 num_of_associated_uncond_frames
- const l_frame_handle * associated_uncond_frame_ptr
- l_u8 coll_resolv_schd

Field Documentation

16.69.2.4.1 const l_frame_handle* associated_uncond_frame_ptr

Associated unconditional frame ID

Definition at line 241 of file lin.h.

16.69.2.4.2 l_u8 coll_resolv_schd

Collision resolver index in the schedule table, used in event trigger frame case MASTER

Definition at line 242 of file lin.h.

16.69.2.4.3 l_u8 num_of_associated_uncond_frames

Number of associated unconditional frame ID

Definition at line 240 of file lin.h.

16.69.2.5 struct lin_frame_t

Frame description structure Implements : lin_frame_t_Class.

Definition at line 249 of file lin.h.

Data Fields

- lin_frame_type_t frm_type
- l_u8 frm_len
- lin_frame_response_t frm_response
- l_u16 frm_offset
- l_u16 flag_offset
- l_u8 flag_size
- const lin_associate_frame_t * frame_data_ptr

Field Documentation

16.69.2.5.1 l_u16 flag_offset

Flag byte offset in flag buffer

Definition at line 255 of file lin.h.

16.69.2.5.2 l_u8 flag_size

Flag size in flag buffer

Definition at line 256 of file lin.h.

16.69.2.5.3 const lin_associate_frame_t* frame_data_ptr

List of Signal to which the frame is associated and its offset

Definition at line 257 of file lin.h.

16.69.2.5.4 l_u8 frm_len

Length of the frame

Definition at line 252 of file lin.h.

16.69.2.5.5 l_u16 frm_offset

Frame byte offset in frame buffer

Definition at line 254 of file lin.h.

16.69.2.5.6 lin_frame_response_t frm_response

Action response when received PID

Definition at line 253 of file lin.h.

16.69.2.5.7 lin_frame_type_t frm_type

Frame information (unconditional or event triggered..)

Definition at line 251 of file lin.h.

16.69.2.6 struct lin_schedule_data_t

LIN schedule structure Implements : lin_schedule_data_t_Class.

Definition at line 286 of file lin.h.

Data Fields

- l_frame_handle frm_id
- l_u8 delay_integer
- lin_tl_queue_t tl_queue_data

Field Documentation

16.69.2.6.1 l_u8 delay_integer

Actual slot time in INTEGER for one frame

Definition at line 289 of file lin.h.

16.69.2.6.2 l_frame_handle frm_id

Frame ID, in case of unconditional or event triggered frame. For sporadic frame the value will be 0 (zero)

Definition at line 288 of file lin.h.

16.69.2.6.3 lin_tl_queue_t tl_queue_data

Data used in case of diagnostic or configuration frame

Definition at line 290 of file lin.h.

16.69.2.7 struct lin_schedule_t

Schedule table description Implements : lin_schedule_t_Class.

Definition at line 297 of file lin.h.

Data Fields

- l_u8 num_slots
- lin_sch_tbl_type_t sch_tbl_type
- const lin_schedule_data_t * ptr_sch_data_ptr

Field Documentation

16.69.2.7.1 l_u8 num_slots

Number of frame slots in the schedule table

Definition at line 299 of file lin.h.

16.69.2.7.2 const lin_schedule_data_t* ptr_sch_data_ptr

Address of the schedule table

Definition at line 301 of file lin.h.

16.69.2.7.3 lin_sch_tbl_type_t sch_tbl_type

Schedule table type

Definition at line 300 of file lin.h.

16.69.2.8 struct lin_transport_layer_queue_t

Transport layer queue Implements : lin_transport_layer_queue_t_Class.

Definition at line 435 of file lin.h.

Data Fields

- l_u16 queue_header
- l_u16 queue_tail
- ld_queue_status_t queue_status
- l_u16 queue_current_size
- l_u16 queue_max_size
- lin_tl_pdu_data_t * tl_pdu_ptr

Field Documentation

16.69.2.8.1 l_u16 queue_current_size

Current size

Definition at line 440 of file lin.h.

16.69.2.8.2 l_u16 queue_header

The first element of queue

Definition at line 437 of file lin.h.

16.69.2.8.3 l_u16 queue_max_size

Maximum size

Definition at line 441 of file lin.h.

16.69.2.8.4 ld_queue_status_t queue_status

Status of queue

Definition at line 439 of file lin.h.

16.69.2.8.5 l_u16 queue_tail

The last element of queue

Definition at line 438 of file lin.h.

16.69.2.8.6 lin_tl_pdu_data_t* tl_pdu_ptr

PDU data

Definition at line 442 of file lin.h.

16.69.2.9 struct lin_tl_descriptor_t

Transport layer description Implements : lin_tl_descriptor_t_Class.

Definition at line 461 of file lin.h.

Data Fields

- lin_transport_layer_queue_t tl_tx_queue
- lin_transport_layer_queue_t tl_rx_queue
- lin_message_status_t rx_msg_status
- l_u16 rx_msg_size
- lin_message_status_t tx_msg_status
- l_u16 tx_msg_size
- lin_last_cfg_result_t last_cfg_result
- l_u8 last_RSID
- l_u8 ld_error_code
- lin_message_timeout_type_t check_timeout_type
- l_u16 check_timeout
- lin_product_id_t * product_id_ptr
- l_u8 num_of_pdu
- l_u8 frame_counter
- lin_diagnostic_state_t diag_state
- diag_interleaved_state_t diag_interleave_state
- l_u16 interleave_timeout_counter
- l_u8 slave_resp_cnt
- lin_service_status_t service_status
- bool ld_return_data
- bool FF_pdu_received
- l_u8 * receive_message_ptr
- l_u8 * receive_NAD_ptr
- l_u16 * receive_message_length_ptr

Field Documentation

16.69.2.9.1 l_u16 check_timeout

Timeout counter for N_As and N_Cr timeout

Definition at line 481 of file lin.h.

16.69.2.9.2 lin_message_timeout_type_t check_timeout_type

Timeout type

Definition at line 480 of file lin.h.

16.69.2.9.3 diag_interleaved_state_t diag_interleave_state

state of diagnostic interleaved mode

Definition at line 486 of file lin.h.

16.69.2.9.4 lin_diagnostic_state_t diag_state

Diagnostic state

Definition at line 485 of file lin.h.

16.69.2.9.5 bool FF_pdu_received

Status of FF pdu

Definition at line 492 of file lin.h.

16.69.2.9.6 l_u8 frame_counter

Frame counter in received message

Definition at line 484 of file lin.h.

16.69.2.9.7 l_u16 interleave_timeout_counter

Interleaved timeout counter

Definition at line 487 of file lin.h.

16.69.2.9.8 lin_last_cfg_result_t last_cfg_result

Status of the last configuration service

Definition at line 476 of file lin.h.

16.69.2.9.9 l_u8 last_RSID

RSID of the last node configuration service

Definition at line 477 of file lin.h.

16.69.2.9.10 l_u8 ld_error_code

Error code in case of positive response

Definition at line 478 of file lin.h.

16.69.2.9.11 bool ld_return_data

Decide return data of diagnostic frame to pointer of ld_receive_message function

Definition at line 491 of file lin.h.

16.69.2.9.12 l_u8 num_of_pdu

Number of received pdu

Definition at line 483 of file lin.h.

16.69.2.9.13 lin_product_id_t* product_id_ptr

To store address of RAM area contain response

Definition at line 482 of file lin.h.

16.69.2.9.14 l_u16* receive_message_length_ptr

Pointer to receive_message_length of user

Definition at line 497 of file lin.h.

16.69.2.9.15 l_u8* receive_message_ptr

Pointer to receive_message array of user

Definition at line 495 of file lin.h.

16.69.2.9.16 l_u8* receive_NAD_ptr

Pointer to receive_NAD of user

Definition at line 496 of file lin.h.

16.69.2.9.17 l_u16 rx_msg_size

Size of message in queue

Definition at line 470 of file lin.h.

16.69.2.9.18 lin_message_status_t rx_msg_status

Cooked rx status

Definition at line 469 of file lin.h.

16.69.2.9.19 lin_service_status_t service_status

Status of the last configuration service

Definition at line 489 of file lin.h.

16.69.2.9.20 l_u8 slave_resp_cnt

Slave Response data counter

Definition at line 488 of file lin.h.

16.69.2.9.21 lin_transport_layer_queue_t tl_rx_queue

Pointer to receive queue on TL

Definition at line 465 of file lin.h.

16.69.2.9.22 lin_transport_layer_queue_t tl_tx_queue

Pointer to transmit queue on TL

Definition at line 464 of file lin.h.

16.69.2.9.23 l_u16 tx_msg_size

Size of message in queue

Definition at line 474 of file lin.h.

16.69.2.9.24 lin_message_status_t tx_msg_status

Cooked tx status

Definition at line 473 of file lin.h.

16.69.2.10 struct lin_protocol_user_config_t

Configuration structure Implements : lin_protocol_user_config_t_Class.

Definition at line 507 of file lin.h.

Data Fields

- lin_protocol_handle_t protocol_version
- lin_protocol_handle_t language_version
- lin_diagnostic_class_t diagnostic_class
- bool function
- l_u8 number_of_configurable_frames
- l_u8 frame_start
- const lin_frame_t * frame_tbl_ptr
- const l_u16 * list_identifiers_ROM_ptr
- l_u8 * list_identifiers_RAM_ptr

- l_u16 max_idle_timeout_cnt
- l_u8 num_of_schedules
- l_u8 schedule_start
- const lin_schedule_t * schedule_tbl
- l_ifc_slave_handle slave_ifc_handle
- l_ifc_master_handle master_ifc_handle
- lin_user_config_t * lin_user_config_ptr
- lin_tl_pdu_data_t * tl_tx_queue_data_ptr
- lin_tl_pdu_data_t * tl_rx_queue_data_ptr
- l_u16 max_message_length

Field Documentation

16.69.2.10.1 lin_diagnostic_class_t diagnostic_class

Diagnostic class

Definition at line 511 of file lin.h.

16.69.2.10.2 l_u8 frame_start

Start index of frame list

Definition at line 515 of file lin.h.

16.69.2.10.3 const lin_frame_t* frame_tbl_ptr

Frame list except diagnostic frames

Definition at line 516 of file lin.h.

16.69.2.10.4 bool function

Function LIN_MASTER or LIN_SLAVE_)

Definition at line 512 of file lin.h.

16.69.2.10.5 lin_protocol_handle_t language_version

Language version

Definition at line 510 of file lin.h.

16.69.2.10.6 lin_user_config_t* lin_user_config_ptr

Pointer to LIN driver user configuration structure

Definition at line 526 of file lin.h.

16.69.2.10.7 l_u8* list_identifiers_RAM_ptr

Configuration in RAM

Definition at line 519 of file lin.h.

16.69.2.10.8 const l_u16* list_identifiers_ROM_ptr

Configuration in ROM

Definition at line 518 of file lin.h.

16.69.2.10.9 l_ifc_master_handle master_ifc_handle

Interface handler of master node

Definition at line 525 of file lin.h.

16.69.2.10.10 l_u16 max_idle_timeout_cnt

Max Idle timeout counter

Definition at line 520 of file lin.h.

16.69.2.10.11 l_u16 max_message_length

Max message length

Definition at line 530 of file lin.h.

16.69.2.10.12 l_u8 num_of_schedules

Number of schedule table

Definition at line 521 of file lin.h.

16.69.2.10.13 l_u8 number_of_configurable_frames

Number of frame except diagnostic frames

Definition at line 514 of file lin.h.

16.69.2.10.14 lin_protocol_handle_t protocol_version

Protocol version

Definition at line 509 of file lin.h.

16.69.2.10.15 l_u8 schedule_start

Start index of schedule table list

Definition at line 522 of file lin.h.

16.69.2.10.16 const lin_schedule_t* schedule_tbl

Schedule table list

Definition at line 523 of file lin.h.

16.69.2.10.17 l_ifc_slave_handle slave_ifc_handle

Interface handler of slave node

Definition at line 524 of file lin.h.

16.69.2.10.18 lin_tl_pdu_data_t* tl_rx_queue_data_ptr

Rx queue data

Definition at line 529 of file lin.h.

16.69.2.10.19 lin_tl_pdu_data_t* tl_tx_queue_data_ptr

Tx queue data

Definition at line 528 of file lin.h.

16.69.2.11 struct lin_master_data_t

LIN master configuration structure Implements : lin_master_data_t_Class.

Definition at line 538 of file lin.h.

Data Fields

- l_u8 active_schedule_id
- l_u8 previous_schedule_id
- l_u8 * schedule_start_entry_ptr
- l_bool event_trigger_collision_flg
- l_u8 master_data_buffer [8]
- l_u16 frm_offset
- l_u8 frm_size
- l_u16 flag_offset
- l_u8 flag_size
- l_bool send_slave_res_flg
- l_bool send_functional_request_flg

Field Documentation

16.69.2.11.1 l_u8 active_schedule_id

Active schedule table id

Definition at line 540 of file lin.h.

16.69.2.11.2 l_bool event_trigger_collision_flg

Flag trigger collision event

Definition at line 543 of file lin.h.

16.69.2.11.3 l_u16 flag_offset

Flag offset

Definition at line 547 of file lin.h.

16.69.2.11.4 l_u8 flag_size

Flag size

Definition at line 548 of file lin.h.

16.69.2.11.5 l_u16 frm_offset

Frame offset

Definition at line 545 of file lin.h.

16.69.2.11.6 l_u8 frm_size

Size of frame

Definition at line 546 of file lin.h.

16.69.2.11.7 l_u8 master_data_buffer[8]

Master data buffer

Definition at line 544 of file lin.h.

16.69.2.11.8 l_u8 previous_schedule_id

Previous schedule table id

Definition at line 541 of file lin.h.

16.69.2.11.9 l_u8* schedule_start_entry_ptr

Start entry of each schedule table

Definition at line 542 of file lin.h.

16.69.2.11.10 l_bool send_functional_request_flg

Flag send Functional Request

Definition at line 550 of file lin.h.

16.69.2.11.11 l_bool send_slave_res_flg

Flag to send Slave Response Schedule

Definition at line 549 of file lin.h.

16.69.2.12 struct lin_protocol_state_t

LIN protocol status structure Implements : lin_protocol_state_t_Class.

Definition at line 557 of file lin.h.

Data Fields

- l_u16 baud_rate
- l_u8 * response_buffer_ptr
- l_u8 response_length
- l_u8 successful_transfer
- l_u8 error_in_response
- l_bool go_to_sleep_flg
- l_u8 current_id
- l_u8 last_pid
- l_u8 num_of_processed_frame
- l_u8 overrun_flg
- lin_word_status_str_t word_status
- l_u8 next_transmit_tick
- l_bool save_config_flg
- l_diagnostic_mode_t diagnostic_mode
- l_u16 frame_timeout_cnt
- l_u16 idle_timeout_cnt
- l_bool transmit_error_resp_sig_flg

Field Documentation

16.69.2.12.1 l_u16 baud_rate

Adjusted baud rate

Definition at line 560 of file lin.h.

16.69.2.12.2 l_u8 current_id

Current PID

Definition at line 566 of file lin.h.

16.69.2.12.3 l_diagnostic_mode_t diagnostic_mode

Diagnostic mode

Definition at line 573 of file lin.h.

16.69.2.12.4 l_u8 error_in_response

Error response

Definition at line 564 of file lin.h.

16.69.2.12.5 l_u16 frame_timeout_cnt

Frame timeout counter for monitoring if timeout occurs during data transferring

Definition at line 574 of file lin.h.

16.69.2.12.6 l_bool go_to_sleep_flg

Go to sleep flag

Definition at line 565 of file lin.h.

16.69.2.12.7 l_u16 idle_timeout_cnt

Idle timeout counter

Definition at line 575 of file lin.h.

16.69.2.12.8 l_u8 last_pid

Last PID

Definition at line 567 of file lin.h.

16.69.2.12.9 l_u8 next_transmit_tick

Used to count the next transmit tick

Definition at line 571 of file lin.h.

16.69.2.12.10 l_u8 num_of_processed_frame

Number of processed frames

Definition at line 568 of file lin.h.

16.69.2.12.11 l_u8 overrun_flg

overrun flag

Definition at line 569 of file lin.h.

16.69.2.12.12 l_u8* response_buffer_ptr

Response buffer

Definition at line 561 of file lin.h.

16.69.2.12.13 l_u8 response_length

Response length

Definition at line 562 of file lin.h.

16.69.2.12.14 l_bool save_config_flg

Set when save configuration request has been received

Definition at line 572 of file lin.h.

16.69.2.12.15 l_u8 successful_transfer

Transfer flag

Definition at line 563 of file lin.h.

16.69.2.12.16 l_bool transmit_error_resp_sig_flg

Flag indicates that the error response signal is going to be sent

Definition at line 576 of file lin.h.

16.69.2.12.17 lin_word_status_str_t word_status

Word status

Definition at line 570 of file lin.h.

16.69.3 Macro Definition Documentation

16.69.3.1 #define CALLBACK_HANDLER(*iii, event_id, id*) lin_pid_resp_callback_handler((iii), (event_id), (id))

CALLBACK_HANDLER.

Note

call lin_pid_resp_callback_handler() function in MASTER mode

Definition at line 684 of file lin.h.

16.69.3.2 #define LD_NEGATIVE_RESPONSE 0x53U

Negative response

Definition at line 84 of file lin.h.

16.69.3.3 #define LD_POSITIVE_RESPONSE 0x54U

Positive response

Definition at line 85 of file lin.h.

16.69.3.4 #define LIN_LLD_ERROR 0xFFU

Return value is ERROR

Definition at line 89 of file lin.h.

16.69.3.5 #define LIN_LLD_OK 0x00U

Return value is OK

Definition at line 88 of file lin.h.

16.69.3.6 #define LIN_MASTER 1

Master node

Definition at line 166 of file lin.h.

16.69.3.7 #define LIN_READ_USR_DEF_MAX 63U

Max user defined

Definition at line 81 of file lin.h.

16.69.3.8 #define LIN_READ_USR_DEF_MIN 32U

Min user defined

Definition at line 80 of file lin.h.

16.69.3.9 #define LIN_SLAVE 0

Mode of LIN node (master or slave)

Slave node

Definition at line 165 of file lin.h.

16.69.3.10 #define LIN_TL_CALLBACK_HANDLER(*iii, tl_event_id, id*) lin_tl_callback_handler((iii), (tl_event_id), (id))

Definition at line 372 of file lin.h.

16.69.3.11 #define PCI_RES_ASSIGN_FRAME_ID_RANGE 0x01U

PCI response value assign frame id range

Definition at line 77 of file lin.h.

16.69.3.12 #define PCI_RES_READ_BY_IDENTIFY 0x06U

PCI response value read by identify

Definition at line 75 of file lin.h.

16.69.3.13 #define PCI_RES_SAVE_CONFIGURATION 0x01U

PCI response value save configuration

Definition at line 76 of file lin.h.

16.69.3.14 #define PCI_SAVE_CONFIGURATION 0x01U

PCI value save configuration

Definition at line 72 of file lin.h.

16.69.3.15 #define SERIVCE_FAULT_MEMORY_CLEAR 0x14U

Service fault memory clear

Definition at line 69 of file lin.h.

16.69.3.16 #define SERVICE_ASSIGN_FRAME_ID 0xB1U

Assign frame id service

Definition at line 58 of file lin.h.

16.69.3.17 #define SERVICE_ASSIGN_FRAME_ID_RANGE 0xB7U

Assign frame id range service

Definition at line 62 of file lin.h.

16.69.3.18 #define SERVICE_ASSIGN_NAD 0xB0U

Assign NAD service

Definition at line 57 of file lin.h.

16.69.3.19 #define SERVICE_CONDITIONAL_CHANGE_NAD 0xB3U

Conditional change NAD service

Definition at line 60 of file lin.h.

16.69.3.20 #define SERVICE_FAULT_MEMORY_READ 0x19U

Service fault memory read

Definition at line 68 of file lin.h.

16.69.3.21 #define SERVICE_IO_CONTROL_BY_IDENTIFY 0x2FU

Service I/O control

Definition at line 67 of file lin.h.

16.69.3.22 #define SERVICE_READ_BY_IDENTIFY 0xB2U

Read by identify service

Definition at line 59 of file lin.h.

16.69.3.23 #define SERVICE_READ_DATA_BY_IDENTIFY 0x22U

Service read data by identifier

Definition at line 64 of file lin.h.

16.69.3.24 #define SERVICE_SAVE_CONFIGURATION 0xB6U

Save configuration service

Definition at line 61 of file lin.h.

16.69.3.25 #define SERVICE_SESSION_CONTROL 0x10U

Service session control

Definition at line 66 of file lin.h.

16.69.3.26 #define SERVICE_WRITE_DATA_BY_IDENTIFY 0x2EU

Service write data by identifier

Definition at line 65 of file lin.h.

16.69.4 Typedef Documentation

16.69.4.1 typedef l_u8 lin_tl_pdu_data_t[8]

PDU data. Implements : lin_tl_pdu_data_t_Class.

Definition at line 95 of file lin.h.

16.69.4.2 typedef l_u8 lin_tl_queue_t[8]

LIN transport layer queue Implements : lin_tl_queue_t_Class.

Definition at line 267 of file lin.h.

16.69.5 Enumeration Type Documentation

16.69.5.1 enum diag_interleaved_state_t

State of diagnostic interleaved mode Implements : diag_interleaved_state_t_Class.

Enumerator

DIAG_NOT_START Not into slave response schedule with interleaved mode

DIAG_NO_RESPONSE Master send 0x3D but slave does not response

DIAG_RESPONSE Response receive

Definition at line 450 of file lin.h.

16.69.5.2 enum l_diagnostic_mode_t

Diagnostic mode Implements : l_diagnostic_mode_t_Class.

Enumerator

DIAG_NONE None

DIAG_INTERLEAVE_MODE Interleave mode

DIAG_ONLY_MODE Diagnostic only mode

Definition at line 311 of file lin.h.

16.69.5.3 enum ld_queue_status_t

Status of queue Implements : ld_queue_status_t_Class.

Enumerator

LD_NO_DATA Rx Queue is empty, has no data

LD_DATA_AVAILABLE Data in queue is available

LD_RECEIVE_ERROR Receive data is error for LIN21 and above

LD_QUEUE_FULL The queue is full

LD_QUEUE_AVAILABLE Queue is available for insert data for LIN21 and above

LD_QUEUE_EMPTY Tx Queue is empty

LD_TRANSMIT_ERROR Error while transmitting for LIN21 and above

LD_TRANSFER_ERROR Error while transmitting/receiving for LIN20 and J2602

Definition at line 378 of file lin.h.

16.69.5.4 enum lin_diagnostic_class_t

List of diagnostic classes Implements : lin_diagnostic_class_t_Class.

Enumerator

LIN_DIAGNOSTIC_CLASS_I LIN Diagnostic Class 1

LIN_DIAGNOSTIC_CLASS_II LIN Diagnostic Class 2

LIN_DIAGNOSTIC_CLASS_III LIN Diagnostic Class 3

Definition at line 137 of file lin.h.

16.69.5.5 enum lin_diagnostic_state_t

LIN diagnostic state Implements : lin_diagnostic_state_t_Class.

Enumerator

LD_DIAG_IDLE IDLE

LD_DIAG_TX_PHY Diagnostic transmit physical

LD_DIAG_TX_FUNCTIONAL Diagnostic transmit active

LD_DIAG_TX_INTERLEAVED Diagnostic transmit in interleave mode

LD_DIAG_RX_PHY Diagnostic receive in physical

LD_DIAG_RX_FUNCTIONAL Diagnostic receive functional request

LD_DIAG_RX_INTERLEAVED Diagnostic receive in interleave mode

Definition at line 409 of file lin.h.

16.69.5.6 enum lin_frame_response_t

LIN frame response Implements : lin_frame_response_t_Class.

Enumerator

LIN_RES_PUB Publisher response

LIN_RES_SUB Subscriber response

Definition at line 228 of file lin.h.

16.69.5.7 enum lin_frame_type_t

Types of frame Implements : lin_frame_type_t_Class.

Enumerator

LIN_FRM_UNCD Unconditional frame

LIN_FRM_EVNT Event triggered frame

LIN_FRM_SPRDC Sporadic frame

LIN_FRM_DIAG Diagnostic frame

Definition at line 216 of file lin.h.

16.69.5.8 enum lin_last_cfg_result_t

Status of the last configuration call completed Implements : lin_last_cfg_result_t_Class.

Enumerator

LD_SUCCESS The service was successfully carried out

LD_NEGATIVE The service failed, more information can be found by parsing error_code

LD_NO_RESPONSE No response was received on the request

LD_OVERWRITTEN The slave response frame has been overwritten by another operation

Definition at line 334 of file lin.h.

16.69.5.9 enum lin_lld_event_id_t

Event id Implements : lin_lld_event_id_t_Class.

Enumerator

LIN_LLD_PID_OK LIN_LLD_PID_OK
LIN_LLD_TX_COMPLETED LIN_LLD_TX_COMPLETED
LIN_LLD_RX_COMPLETED LIN_LLD_RX_COMPLETED
LIN_LLD_PID_ERR LIN_LLD_PID_ERR
LIN_LLD_FRAME_ERR LIN_LLD_FRAME_ERR
LIN_LLD_CHECKSUM_ERR LIN_LLD_CHECKSUM_ERR
LIN_LLD_READBACK_ERR LIN_LLD_READBACK_ERR
LIN_LLD_NODATA_TIMEOUT No data timeout or received part of data but not completed
LIN_LLD_BUS_ACTIVITY_TIMEOUT LIN_LLD_BUS_ACTIVITY_TIMEOUT

Definition at line 105 of file lin.h.

16.69.5.10 enum lin_message_status_t

Status of LIN message Implements : lin_message_status_t_Class.

Enumerator

LD_NO_MSG No message
LD_IN_PROGRESS In progress
LD_COMPLETED Completed
LD_FAILED Failed
LD_N_AS_TIMEOUT N_As timeout
LD_N_CR_TIMEOUT N_Cr timeout
LD_WRONG_SN Wrong sequence number

Definition at line 394 of file lin.h.

16.69.5.11 enum lin_message_timeout_type_t

Types of message timeout Implements : lin_message_timeout_type_t_Class.

Enumerator

LD_NO_CHECK_TIMEOUT No check timeout
LD_CHECK_N_AS_TIMEOUT check N_As timeout
LD_CHECK_N_CR_TIMEOUT check N_Cr timeout

Definition at line 424 of file lin.h.

16.69.5.12 enum lin_protocol_handle_t

List of protocols Implements : lin_protocol_handle_t_Class.

Enumerator

LIN_PROTOCOL_21 LIN protocol version 2.1, 2.2
LIN_PROTOCOL_J2602 J2602 protocol
LIN_PROTOCOL_13 LIN protocol version 1.3
LIN_PROTOCOL_20 LIN protocol version 2.0

Definition at line 125 of file lin.h.

16.69.5.13 enum lin_sch_tbl_type_t

Types of schedule tables Implements : lin_sch_tbl_type_t_Class.

Enumerator

LIN_SCH_TBL_NULL Run nothing

LIN_SCH_TBL_NORM Normal schedule table

LIN_SCH_TBL_DIAG Diagnostic schedule table

LIN_SCH_TBL_GO_TO_SLEEP Goto sleep schedule table

LIN_SCH_TBL_COLL_RESOLV Collision resolving schedule table

Definition at line 273 of file lin.h.

16.69.5.14 enum lin_service_status_t

Status of the last configuration call for LIN 2.1 Implements : lin_service_status_t_Class.

Enumerator

LD_SERVICE_BUSY Service is ongoing

LD_REQUEST_FINISHED The configuration request has been completed

LD_SERVICE_IDLE The configuration request/response combination has been completed

LD_SERVICE_ERROR The configuration request or response experienced an error

Definition at line 322 of file lin.h.

16.69.5.15 enum lin_tl_callback_return_t

Transport layer event IDs Implements : lin_tl_callback_return_t_Class.

Enumerator

TL_ACTION_NONE Default return value of call back function

TL_ACTION_ID_IGNORE Ignore this ID

Definition at line 362 of file lin.h.

16.69.5.16 enum lin_tl_event_id_t

Transport layer event IDs Implements : lin_tl_event_id_t_Class.

Enumerator

TL_MAKE_RES_DATA Make master request data

TL_SLAVE_GET_ACTION Get slave action

TL_TX_COMPLETED Transmit completed

TL_RX_COMPLETED Receive completed

TL_ERROR Transport error

TL_TIMEOUT_SERVICE Transmit timeout

TL_HANDLER_INTERLEAVE_MODE Interleave mode

TL_RECEIVE_MESSAGE Return data for ld_receive_message function

Definition at line 346 of file lin.h.

16.69.6 Function Documentation

16.69.6.1 l_u8 ld_read_by_id_callout (l_ifc_handle *iii,* l_u8 *id,* l_u8 * *data*)

16.69.6.2 static l_u16 lin_calc_max_header_timeout_cnt (l_u32 *baudRate*) [inline],[static]

Computes maximum header timeout.

Theader_Maximum = 1.4 * THeader_Nominal, THeader_Nominal = 34 * TBit, (13 nominal bits of break; 1 nominal bit of break delimiter; 10 bits for SYNC and 10 bits of PID) TIME_OUT_UNIT_US is in micro second

Parameters

in	*baudRate*	LIN network baud rate

Returns

maximum timeout for the selected baud rate

Implements : lin_calc_max_header_timeout_cnt_Activity

Definition at line 626 of file lin.h.

16.69.6.3 static l_u16 lin_calc_max_res_timeout_cnt (l_u32 *baudRate,* l_u8 *size*) [inline],[static]

Computes the maximum response timeout.

TResponse_Maximum = 1.4 * TResponse_Nominal, TResponse_Nominal = 10 * (NData+ 1) * TBit

Parameters

in	*baudRate*	LIN network baud rate
in	*size*	frame size in bytes

Returns

maximum response timeout for the given baud rate and frame size

Implements : lin_calc_max_res_timeout_cnt_Activity

Definition at line 642 of file lin.h.

16.69.6.4 void lin_lld_deinit (l_ifc_handle *iii*)

This function disconnect the node from the cluster and free all hardware used.

Parameters

in	*iii*	LIN interface that is being handled

Returns

Zero for success
void

Definition at line 153 of file lin.c.

16.69.6.5 lin_node_state_t lin_lld_get_state (l_ifc_handle *iii*)

This function gets current state of an interface.

Parameters

in	*iii*	LIN interface that is being handled

Returns

current LIN node state

Definition at line 174 of file lin.c.

16.69.6.6 l_u8 lin_lld_ignore_response (l_ifc_handle *iii*)

This function terminates an on-going data transmission/reception.

Parameters

in	*iii*	LIN interface that is being handled

Returns

Zero for success
Non-zero for error

Definition at line 294 of file lin.c.

16.69.6.7 l_bool lin_lld_init (l_ifc_handle *iii*)

This function initializes a LIN hardware instance for operation. This function will initialize the run-time state structure to keep track of the on-going transfers, initialize the module to user defined settings and default settings, configure the IRQ state structure and enable the module-level interrupt to the core, and enable the LIN hardware module transmitter and receiver.

Parameters

in	*iii*	LIN interface that is being handled

Returns

zero if the initialization was successful and non-zero if failed

Definition at line 88 of file lin.c.

16.69.6.8 l_u8 lin_lld_int_disable (l_ifc_handle *iii*)

Disable the interrupt related to the interface.

Parameters

in	*iii*	LIN interface that is being handled

Returns

Zero for success
Non-zero for error

Definition at line 271 of file lin.c.

16.69.6.9 l_u8 lin_lld_int_enable (l_ifc_handle *iii*)

Enable the interrupt related to the interface.

Parameters

in	*iii*	LIN interface that is being handled

Returns

Zero for success
Non-zero for error

Definition at line 248 of file lin.c.

16.69.6.10 l_u8 lin_lld_rx_response (l_ifc_handle *iii,* l_u8 *response_length*)

This function receives frame data into the LIN_lld_response_buffer[iii] buffer.

This function will prepare LIN interface to receive data and then return. Data bytes will be received to the buffer in the interrupt handler of LIN interface. This function returns zero if preparation of receiving data was successful.

Parameters

in	*iii*	LIN interface that is being handled
in	*response_length*	Length of response

Returns

Zero for success
Non-zero for error

Definition at line 376 of file lin.c.

16.69.6.11 l_u8 lin_lld_set_low_power_mode (l_ifc_handle *iii*)

Let the low level driver go to low power mode.

Parameters

in	*iii*	LIN interface that is being handled

Returns

Zero for success
Non-zero for error

Definition at line 317 of file lin.c.

16.69.6.12 l_u8 lin_lld_set_response (l_ifc_handle *iii,* l_u8 *response_length*)

This function sends frame data that is contained in LIN_lld_response_buffer[iii].

This function will send the first data byte in the buffer and then return. Next data bytes will be sent in the interrupt handler of LIN interface. This function returns zero if sending of first data byte was successful.

Parameters

in	*iii*	LIN interface that is being handled
in	*response_length*	Length of response

Returns

Zero for success
Non-zero for error

Definition at line 340 of file lin.c.

16.69.6.13 void lin_lld_timeout_service (l_ifc_handle *iii*)

Callback function for Timer Interrupt Handler In timer IRQ handler, call this function. Used to check if frame timeout has occurred during frame data transmission and reception, to check for N_As and N_Cr timeout for LIN 2.1 and above. This function also check if there is no LIN bus communication (no headers and no frame data transferring) for Idle timeout (s), then put LIN node to Sleep mode. Users may initialize a timer (for example FTM)with period of Timeout unit (default: 500 micro seconds) to call lin_lld_timeout_service(). For an interface iii, Idle timeout (s) = max_idle_timeout_cnt ∗ Timeout unit (us) frame timeout (us) = frame_timeout_cnt ∗ Timeout unit (us) N_As timeout (us) = N_As_timeout ∗ Timeout unit (us) N_Cr timeout (us) = N_Cr_timeout ∗ Timeout unit (us)

Parameters

in	*iii*	LIN interface that is being handled

Returns

void

Definition at line 407 of file lin.c.

16.69.6.14 l_u8 lin_lld_tx_header (l_ifc_handle *iii*, l_u8 *id*)

This function sends frame header for the input PID.

This function only initializes the sending of break field and then return. Then the sync byte and PID will be sent in the interrupt handler of LIN interface.

Parameters

in	*iii*	LIN interface that is being handled
in	*id*	ID of the header to be sent

Returns

Zero for success
Non-zero for error

Definition at line 197 of file lin.c.

16.69.6.15 l_u8 lin_lld_tx_wake_up (l_ifc_handle *iii*)

This function send a wakeup signal.

Parameters

in	*iii*	LIN interface that is being handled

Returns

Zero for success
Non-zero for error

Definition at line 225 of file lin.c.

16.69.6.16 void lin_pid_resp_callback_handler (l_ifc_handle *iii*, const lin_lld_event_id_t *event_id*, l_u8 *id*)

Callback handler for low level events.

This callback handler is being called from the LIN driver callback

Parameters

in	*iii*	LIN interface that is being handled
in	*event_id*	Low level event id lin_lld_event_id_t
in	*id*	Current protected identifier under processing by driver

Definition at line 74 of file lin_common_proto.c.

16.69.6.17 l_u8 lin_process_parity (l_u8 *pid,* l_u8 *typeAction*)

Makes or checks parity bits. If action is checking parity, the function returns ID value if parity bits are correct or 0xFF if parity bits are incorrect. If action is making parity bits, then from input value of ID, the function returns PID.

Parameters

pid	PID byte in case of checking parity bits or ID byte in case of making parity bits.
typeAction	TRUE for Checking parity bits, FALSE for making parity bits

Returns

0xFF if parity bits are incorrect, ID in case of checking parity bits and they are correct. Function returns PID in case of making parity bits.

Definition at line 71 of file lin.c.

16.69.6.18 lin_tl_callback_return_t lin_tl_callback_handler (l_ifc_handle *iii,* lin_tl_event_id_t *tl_event_id,* l_u8 *id*)

Definition at line 81 of file lin_commontl_proto.c.

16.69.7 Variable Documentation

16.69.7.1 volatile l_u8 g_buffer_backup_data[8]

16.69.7.2 volatile l_u8 g_lin_flag_handle_tbl[LIN_FLAG_BUF_SIZE]

16.69.7.3 volatile l_u8 g_lin_frame_data_buffer[LIN_FRAME_BUF_SIZE]

16.69.7.4 volatile l_bool g_lin_frame_flag_handle_tbl[LIN_NUM_OF_FRMS]

16.69.7.5 volatile l_u8 g_lin_frame_updating_flag_tbl[LIN_NUM_OF_FRMS]

16.69.7.6 const l_ifc_handle g_lin_hardware_ifc[HARDWARE_INSTANCE_COUNT]

16.69.7.7 lin_master_data_t g_lin_master_data_array[LIN_NUM_OF_MASTER_IFCS]

Global array for storing the master interfaces configurations

Definition at line 49 of file lin.c.

16.69.7.8 const lin_node_attribute_t g_lin_node_attribute_array[LIN_NUM_OF_SLAVE_IFCS]

16.69.7.9 lin_protocol_state_t g_lin_protocol_state_array[LIN_NUM_OF_IFCS]

Global array for storing the protocol state for each interface

Definition at line 47 of file lin.c.

16.69.7.10 const lin_protocol_user_config_t g_lin_protocol_user_cfg_array[LIN_NUM_OF_IFCS]

16.69.7.11 lin_tl_descriptor_t g_lin_tl_descriptor_array[LIN_NUM_OF_IFCS]

Global array for storing transport configuration for each interface

Definition at line 46 of file lin.c.

16.69.7.12 const l_u32 g_lin_virtual_ifc[LIN_NUM_OF_IFCS]

16.69.7.13 const lin_timer_get_time_interval_t timerGetTimeIntervalCallbackArr[LIN_NUM_OF_IFCS]

16.70 MPU Driver

16.70.1 Detailed Description

Memory Protection Unit Peripheral Driver.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\mpu\mpu_driver.c
${S32SDK_PATH}\platform\drivers\src\mpu\mpu_hw_access.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
```

Compile symbols

No special symbols are required for this component

Dependencies

No special dependencies are required for this component

Pre-Initialization information of MPU module

1. Before using the MPU driver the protocol clock of the module must be configured by the application using clock module.
2. Bus fault or Hard fault exception must be configured to handle MPU access violation.

To initialize the MPU module, call the MPU_DRV_Init() function and provide the user configuration data structure. This function sets the configuration of the MPU module automatically and enables the MPU module.
The default settings for the Region Descriptor 0 (RGD0):

- The access right for **CORE, DMA,..** can be **changed** except **DEBUGGER** master.
- The **start address**, **end address**, **process identifier** and **process identifier mask** are **ignored**.

This is example code to configure the MPU driver:

1. Define MPU instance

```
/* MPU 0 */
#define INST_MPU 0U

/* Status variable */
status_t status;
```

2. Configuration
   User configuration

```
/* Region count */
#define REGION_CNT (1U)

/* Master access configuration
   FEATURE_MPU_MASTER_COUNT macro has been already defined (number of masters supported by hardware)
 */
```

```
mpu_master_access_right_t masterAccRight[FEATURE_MPU_MASTER_COUNT] =
{
   /* CORE */
    {
        .masterNum   = FEATURE_MPU_MASTER_CORE,        /* Master number */
        .accessRight = MPU_SUPERVISOR_RWX_USER_RWX,    /* Access right */
        .processIdentifierEnable = false,              /* Process identifier enable */
    },
    /* The rest masters should be defined here */
    ...
}
/* User configuration */
mpu_user_config_t userConfig[REGION_CNT] =
{
    /* Region 0 */
    {
        .startAddr          = 0x00000000U,       /* Memory region start address */
        .endAddr            = 0xFFFFFFFFU,       /* Memory region end address */
        .masterAccRight     = masterAccRight,    /* Master access right */
        .processIdEnable    = false,             /* Process identifier enable */
        .processIdentifier  = 0x00U,             /* Process identifier */
        .processIdMask      = 0x00U              /* Process identifier mask */
    }
}
```

or get default configuration

```
/* Defines master access right structure */
mpu_master_access_right_t masterAccRight[FEATURE_MPU_MASTER_COUNT];

/* Gets default region configuration
   Cover entire memory
   Access right of all masters are allowed
 */
mpu_user_config_t regionConfig0 =
      MPU_DRV_GetDefaultRegionConfig(masterAccRight);
mpu_user_config_t userConfig[REGION_CNT] =
{
    regionConfig0
};
```

3. Initializes

```
/* Initializes the MPU instance */
status = MPU_DRV_Init(INST_MPU, REGION_CNT, userConfig);
```

4. De-initializes

```
/* De-initializes the MPU instance */
MPU_DRV_Deinit(INST_MPU);
```

After MPU initialization:

- The MPU_DRV_SetRegionConfig() can be used to add/update the new/existing region descriptor.

```
/* Add the new region descriptor.
   Region 1 to be the same with region 0.
 */
status = MPU_DRV_SetRegionConfig(INST_MPU, 1U, &userConfig[0U]);

/* Updates the existing region descriptor.
   Updates PID mask value on region 1.
 */
userConfig[0U].processIdMask = 0xFFU;
status = MPU_DRV_SetRegionConfig(INST_MPU, 1U, &userConfig[0U]);
```

- The MPU_DRV_SetRegionAddr() can be used to update the start and end address on an existing region descriptor.

```
/* Updates region 1 location (0x20000000 - 0x2FFFFFFF) */
MPU_DRV_SetRegionAddr(INST_MPU, 1U, 0x20000000U, 0x2FFFFFFFU);
```

- The MPU_DRV_SetMasterAccessRights() can be used to update access permission of master in the region.

```
/* DMA can only operate on region 1 */
mpu_master_access_right_t DMA_AccRight;
DMA_AccRight.masterNum = FEATURE_MPU_MASTER_DMA;
/* Removes all access rights of DMA on region 0 */
DMA_AccRight.accessRight = MPU_SUPERVISOR_USER_NONE;
status = MPU_DRV_SetMasterAccessRights(INST_MPU, 0U, &DMA_AccRight);
/* Allows all access to region 1 from DMA */
DMA_AccRight.accessRight = MPU_SUPERVISOR_USER_RWX;
status = MPU_DRV_SetMasterAccessRights(INST_MPU, 1U, &DMA_AccRight);
```

- The MPU_DRV_GetDetailErrorAccessInfo() API can be used to get the status of a slave port and the detail when an error occurred.

```
/* DMA access to SRAML
   - Access type: read
   - Address: 0x1FFEFF00 (region 0)
 */
...
/* Checks and gets error status on slave port 1 (SRAML backdoor) */
bool errStatus = false;
mpu_access_err_info_t errReport;
errStatus =  MPU_DRV_GetDetailErrorAccessInfo(INST_MPU,
      FEATURE_MPU_SLAVE_SRAM_BACKDOOR, &errReport);
/* Checks status:
  - errStatus: true
  - errReport:
    - errReport.master: FEATURE_MPU_MASTER_DMA (DMA logical ID)
    - errReport.attributes: MPU_DATA_ACCESS_IN_SUPERVISOR_MODE (Data access in supervisor mode)
    - errReport.accessType: MPU_ERR_TYPE_READ (Read access)
    - errReport.accessCtr: 0x8000 (Access violation occurs on region 0 - MSB is region 0 and so on)
    - errReport.addr: 0x1FFEFF00 (Data access in supervisor mode)
    - errReport.processorIdentification: 0U (Do not support for non-core processor)
 */
...
```

- The MPU_DRV_EnableRegion() can be used to enable or disable region descriptor.

```
/* Disables DMA - disable region 1 descriptor */
MPU_DRV_EnableRegion(INST_MPU, 1U, false);
/* Enables again */
MPU_DRV_EnableRegion(INST_MPU, 1U, true);
```

Power management:

- To minimizes power dissipation, disables MPU module or regions by using MPU_DRV_Deinit()/MPU_DRV↩ _EnableRegion() when they are unused anymore.

Data Structures

- struct mpu_access_err_info_t

  MPU detail error access info Implements : mpu_access_err_info_t_Class. More...
- struct mpu_master_access_right_t

  MPU master access rights. Implements : mpu_master_access_right_t_Class. More...
- struct mpu_user_config_t

  MPU user region configuration structure. This structure is used when calling the MPU_DRV_Init function. Implements : mpu_user_config_t_Class. More...

Enumerations

- enum mpu_err_access_type_t { MPU_ERR_TYPE_READ = 0U, MPU_ERR_TYPE_WRITE = 1U }

  MPU access error Implements : mpu_err_access_type_t_Class.
- enum mpu_err_attributes_t { MPU_INSTRUCTION_ACCESS_IN_USER_MODE = 0U, MPU_DATA_ACC↩ ESS_IN_USER_MODE = 1U, MPU_INSTRUCTION_ACCESS_IN_SUPERVISOR_MODE = 2U, MPU_DA↩ TA_ACCESS_IN_SUPERVISOR_MODE = 3U }

  MPU access error attributes Implements : mpu_err_attributes_t_Class.

- enum mpu_access_rights_t {
  MPU_SUPERVISOR_RWX_USER_NONE = 0x00U, MPU_SUPERVISOR_RWX_USER_X = 0x01U, MPU_SUPERVISOR_RWX_USER_W = 0x02U, MPU_SUPERVISOR_RWX_USER_WX = 0x03U,
  MPU_SUPERVISOR_RWX_USER_R = 0x04U, MPU_SUPERVISOR_RWX_USER_RX = 0x05U, MPU_SUPERVISOR_RWX_USER_RW = 0x06U, MPU_SUPERVISOR_RWX_USER_RWX = 0x07U,
  MPU_SUPERVISOR_RX_USER_NONE = 0x08U, MPU_SUPERVISOR_RX_USER_X = 0x09U, MPU_SUPERVISOR_RX_USER_W = 0x0AU, MPU_SUPERVISOR_RX_USER_WX = 0x0BU,
  MPU_SUPERVISOR_RX_USER_R = 0x0CU, MPU_SUPERVISOR_RX_USER_RX = 0x0DU, MPU_SUPERVISOR_RX_USER_RW = 0x0EU, MPU_SUPERVISOR_RX_USER_RWX = 0x0FU,
  MPU_SUPERVISOR_RW_USER_NONE = 0x10U, MPU_SUPERVISOR_RW_USER_X = 0x11U, MPU_SUPERVISOR_RW_USER_W = 0x12U, MPU_SUPERVISOR_RW_USER_WX = 0x13U,
  MPU_SUPERVISOR_RW_USER_R = 0x14U, MPU_SUPERVISOR_RW_USER_RX = 0x15U, MPU_SUPERVISOR_RW_USER_RW = 0x16U, MPU_SUPERVISOR_RW_USER_RWX = 0x17U,
  MPU_SUPERVISOR_USER_NONE = 0x18U, MPU_SUPERVISOR_USER_X = 0x19U, MPU_SUPERVISOR_USER_W = 0x1AU, MPU_SUPERVISOR_USER_WX = 0x1BU,
  MPU_SUPERVISOR_USER_R = 0x1CU, MPU_SUPERVISOR_USER_RX = 0x1DU, MPU_SUPERVISOR_USER_RW = 0x1EU, MPU_SUPERVISOR_USER_RWX = 0x1FU,
  MPU_NONE = 0x80U, MPU_W = 0xA0U, MPU_R = 0xC0U, MPU_RW = 0xE0U }

  MPU access rights.

Code	Supervisor	User	Description
MPU_SUPERVISOR_RWX_USER_NONE	*r w x*	*- - -*	*Allow Read, write, execute in supervisor mode; no access in user mode*
MPU_SUPERVISOR_RWX_USER_X	*r w x*	*- - x*	*Allow Read, write, execute in supervisor mode; execute in user mode*
MPU_SUPERVISOR_RWX_USER_W	*r w x*	*- w -*	*Allow Read, write, execute in supervisor mode; write in user mode*
MPU_SUPERVISOR_RWX_USER_WX	*r w x*	*- w x*	*Allow Read, write, execute in supervisor mode; write and execute in user mode*
MPU_SUPERVISOR_RWX_USER_R	*r w x*	*r - -*	*Allow Read, write, execute in supervisor mode; read in user mode*
MPU_SUPERVISOR_RWX_USER_RX	*r w x*	*r - x*	*Allow Read, write, execute in supervisor mode; read and execute in user mode*
MPU_SUPERVISOR_RWX_USER_RW	*r w x*	*r w -*	*Allow Read, write, execute in supervisor mode; read and write in user mode*
MPU_SUPERVISOR_RWX_USER_RWX	*r w x*	*r w x*	*Allow Read, write, execute in supervisor mode; read, write and execute in user mode*
MPU_SUPERVISOR_RX_USER_NONE	*r - x*	*- - -*	*Allow Read, execute in supervisor mode; no access in user mode*
MPU_SUPERVISOR_RX_USER_X	*r - x*	*- - x*	*Allow Read, execute in supervisor mode; execute in user mode*

MPU_SUPERVISOR_↩ RX_USER_W	*r - x*	*- w -*	*Allow Read, execute in supervisor mode; write in user mode*
MPU_SUPERVISOR_↩ RX_USER_WX	*r - x*	*- w x*	*Allow Read, execute in supervisor mode; write and execute in user mode*
MPU_SUPERVISOR_↩ RX_USER_R	*r - x*	*r - -*	*Allow Read, execute in supervisor mode; read in user mode*
MPU_SUPERVISOR_↩ RX_USER_RX	*r - x*	*r - x*	*Allow Read, execute in supervisor mode; read and execute in user mode*
MPU_SUPERVISOR_↩ RX_USER_RW	*r - x*	*r w -*	*Allow Read, execute in supervisor mode; read and write in user mode*
MPU_SUPERVISOR_↩ RX_USER_RWX	*r - x*	*r w x*	*Allow Read, execute in supervisor mode; read, write and execute in user mode*
MPU_SUPERVISOR_↩ RW_USER_NONE	*r w -*	*- - -*	*Allow Read, write in supervisor mode; no access in user mode*
MPU_SUPERVISOR_↩ RW_USER_X	*r w -*	*- - x*	*Allow Read, write in supervisor mode; execute in user mode*
MPU_SUPERVISOR_↩ RW_USER_W	*r w -*	*- w -*	*Allow Read, write in supervisor mode; write in user mode*
MPU_SUPERVISOR_↩ RW_USER_WX	*r w -*	*- w x*	*Allow Read, write in supervisor mode; write and execute in user mode*
MPU_SUPERVISOR_↩ RW_USER_R	*r w -*	*r - -*	*Allow Read, write in supervisor mode; read in user mode*
MPU_SUPERVISOR_↩ RW_USER_RX	*r w -*	*r - x*	*Allow Read, write in supervisor mode; read and execute in user mode*
MPU_SUPERVISOR_↩ RW_USER_RW	*r w -*	*r w -*	*Allow Read, write in supervisor mode; read and write in user mode*
MPU_SUPERVISOR_↩ RW_USER_RWX	*r w -*	*r w x*	*Allow Read, write in supervisor mode; read, write and execute in user mode*
MPU_SUPERVISOR_↩ USER_NONE	*- - -*	*- - -*	*No access allowed in user and supervisor modes*
MPU_SUPERVISOR_↩ USER_X	*- - x*	*- - x*	*Execute operation is allowed in user and supervisor modes*
MPU_SUPERVISOR_↩ USER_W	*- w -*	*- w -*	*Write operation is allowed in user and supervisor modes*

MPU_SUPERVISOR_↩ USER_WX	*- w x*	*- w x*	*Write and execute operations are allowed in user and supervisor modes*
MPU_SUPERVISOR_↩ USER_R	*r - -*	*r - -*	*Read operation is allowed in user and supervisor modes*
MPU_SUPERVISOR_↩ USER_RX	*r - x*	*r - x*	*Read and execute operations are allowed in user and supervisor modes*
MPU_SUPERVISOR_↩ USER_RW	*r w -*	*r w -*	*Read and write operations are allowed in user and supervisor modes*
MPU_SUPERVISOR_↩ USER_RWX	*r w x*	*r w x*	*Read write and execute operations are allowed in user and supervisor modes*

MPU Driver API

- status_t MPU_DRV_Init (uint32_t instance, uint8_t regionCnt, const mpu_user_config_t *userConfigArr)

  The function initializes the memory protection unit by setting the access configurations of all available masters, process identifier and the memory location for the given regions; and activate module finally. Please note that access rights for region 0 will always be configured and regionCnt takes values between 1 and the maximum region count supported by the hardware. e.g. In S32K144 the number of supported regions is 8. The user must make sure that the clock is enabled.

- void MPU_DRV_Deinit (uint32_t instance)

  De-initializes the memory protection unit by reseting all regions to default and disable module.

- void MPU_DRV_SetRegionAddr (uint32_t instance, uint8_t regionNum, uint32_t startAddr, uint32_t endAddr)

  Sets the region start and end address.

- status_t MPU_DRV_SetRegionConfig (uint32_t instance, uint8_t regionNum, const mpu_user_config_↩ t *userConfigPtr)

  Sets the region configuration. Updates the access configuration of all available masters, process identifier and memory location in a given region.

- status_t MPU_DRV_SetMasterAccessRights (uint32_t instance, uint8_t regionNum, const mpu_master_↩ access_right_t *accessRightsPtr)

  Configures access permission for bus master in region.

- bool MPU_DRV_GetDetailErrorAccessInfo (uint32_t instance, uint8_t slavePortNum, mpu_access_err_info↩ _t *errInfoPtr)

  Checks and gets the MPU access error detail information for a slave port. Clears bus error flag if an error occurs.

- mpu_user_config_t MPU_DRV_GetDefaultRegionConfig (mpu_master_access_right_t *masterAccRight)

  Gets default region configuration. Grants all access rights for masters and disables PID on entire memory.

- void MPU_DRV_EnableRegion (uint32_t instance, uint8_t regionNum, bool enable)

  Enables/Disables region descriptor. Please note that region 0 should not be disabled.

16.70.2 Data Structure Documentation

16.70.2.1 struct mpu_access_err_info_t

MPU detail error access info Implements : mpu_access_err_info_t_Class.

Definition at line 63 of file mpu_driver.h.

Data Fields

- uint8_t master
- mpu_err_attributes_t attributes
- mpu_err_access_type_t accessType
- uint16_t accessCtr
- uint32_t addr

Field Documentation

16.70.2.1.1 uint16_t accessCtr

Access error control

Definition at line 68 of file mpu_driver.h.

16.70.2.1.2 mpu_err_access_type_t accessType

Access error type

Definition at line 67 of file mpu_driver.h.

16.70.2.1.3 uint32_t addr

Access error address

Definition at line 69 of file mpu_driver.h.

16.70.2.1.4 mpu_err_attributes_t attributes

Access error attributes

Definition at line 66 of file mpu_driver.h.

16.70.2.1.5 uint8_t master

Access error master

Definition at line 65 of file mpu_driver.h.

16.70.2.2 struct mpu_master_access_right_t

MPU master access rights. Implements : mpu_master_access_right_t_Class.

Definition at line 173 of file mpu_driver.h.

Data Fields

- uint8_t masterNum
- mpu_access_rights_t accessRight

Field Documentation

16.70.2.2.1 mpu_access_rights_t accessRight

Access right

Definition at line 176 of file mpu_driver.h.

16.70.2.2.2 uint8_t masterNum

Master number

Definition at line 175 of file mpu_driver.h.

16.70.2.3 struct mpu_user_config_t

MPU user region configuration structure. This structure is used when calling the MPU_DRV_Init function. Implements : mpu_user_config_t_Class.

Definition at line 187 of file mpu_driver.h.

Data Fields

- uint32_t startAddr
- uint32_t endAddr
- const mpu_master_access_right_t * masterAccRight

Field Documentation

16.70.2.3.1 uint32_t endAddr

Memory region end address

Definition at line 190 of file mpu_driver.h.

16.70.2.3.2 const mpu_master_access_right_t* masterAccRight

Access permission for masters

Definition at line 191 of file mpu_driver.h.

16.70.2.3.3 uint32_t startAddr

Memory region start address

Definition at line 189 of file mpu_driver.h.

16.70.3 Enumeration Type Documentation

16.70.3.1 enum mpu_access_rights_t

MPU access rights.

Code	Supervisor	User	Description
MPU_SUPERVISOR_↩ RWX_USER_NONE	r w x	- - -	Allow Read, write, execute in supervisor mode; no access in user mode
MPU_SUPERVISOR_↩ RWX_USER_X	r w x	- - x	Allow Read, write, execute in supervisor mode; execute in user mode
MPU_SUPERVISOR_↩ RWX_USER_W	r w x	- w -	Allow Read, write, execute in supervisor mode; write in user mode
MPU_SUPERVISOR_↩ RWX_USER_WX	r w x	- w x	Allow Read, write, execute in supervisor mode; write and execute in user mode

MPU_SUPERVISOR_↩ RWX_USER_R	r w x	r - -	Allow Read, write, execute in supervisor mode; read in user mode
MPU_SUPERVISOR_↩ RWX_USER_RX	r w x	r - x	Allow Read, write, execute in supervisor mode; read and execute in user mode
MPU_SUPERVISOR_↩ RWX_USER_RW	r w x	r w -	Allow Read, write, execute in supervisor mode; read and write in user mode
MPU_SUPERVISOR_↩ RWX_USER_RWX	r w x	r w x	Allow Read, write, execute in supervisor mode; read, write and execute in user mode
MPU_SUPERVISOR_↩ RX_USER_NONE	r - x	- - -	Allow Read, execute in supervisor mode; no access in user mode
MPU_SUPERVISOR_↩ RX_USER_X	r - x	- - x	Allow Read, execute in supervisor mode; execute in user mode
MPU_SUPERVISOR_↩ RX_USER_W	r - x	- w -	Allow Read, execute in supervisor mode; write in user mode
MPU_SUPERVISOR_↩ RX_USER_WX	r - x	- w x	Allow Read, execute in supervisor mode; write and execute in user mode
MPU_SUPERVISOR_↩ RX_USER_R	r - x	r - -	Allow Read, execute in supervisor mode; read in user mode
MPU_SUPERVISOR_↩ RX_USER_RX	r - x	r - x	Allow Read, execute in supervisor mode; read and execute in user mode
MPU_SUPERVISOR_↩ RX_USER_RW	r - x	r w -	Allow Read, execute in supervisor mode; read and write in user mode
MPU_SUPERVISOR_↩ RX_USER_RWX	r - x	r w x	Allow Read, execute in supervisor mode; read, write and execute in user mode
MPU_SUPERVISOR_↩ RW_USER_NONE	r w -	- - -	Allow Read, write in supervisor mode; no access in user mode
MPU_SUPERVISOR_↩ RW_USER_X	r w -	- - x	Allow Read, write in supervisor mode; execute in user mode
MPU_SUPERVISOR_↩ RW_USER_W	r w -	- w -	Allow Read, write in supervisor mode; write in user mode

MPU_SUPERVISOR_↩ RW_USER_WX	r w -	- w x	Allow Read, write in supervisor mode; write and execute in user mode
MPU_SUPERVISOR_↩ RW_USER_R	r w -	r - -	Allow Read, write in supervisor mode; read in user mode
MPU_SUPERVISOR_↩ RW_USER_RX	r w -	r - x	Allow Read, write in supervisor mode; read and execute in user mode
MPU_SUPERVISOR_↩ RW_USER_RW	r w -	r w -	Allow Read, write in supervisor mode; read and write in user mode
MPU_SUPERVISOR_↩ RW_USER_RWX	r w -	r w x	Allow Read, write in supervisor mode; read, write and execute in user mode
MPU_SUPERVISOR_↩ USER_NONE	- - -	- - -	No access allowed in user and supervisor modes
MPU_SUPERVISOR_↩ USER_X	- - x	- - x	Execute operation is allowed in user and supervisor modes
MPU_SUPERVISOR_↩ USER_W	- w -	- w -	Write operation is allowed in user and supervisor modes
MPU_SUPERVISOR_↩ USER_WX	- w x	- w x	Write and execute operations are allowed in user and supervisor modes
MPU_SUPERVISOR_↩ USER_R	r - -	r - -	Read operation is allowed in user and supervisor modes
MPU_SUPERVISOR_↩ USER_RX	r - x	r - x	Read and execute operations are allowed in user and supervisor modes
MPU_SUPERVISOR_↩ USER_RW	r w -	r w -	Read and write operations are allowed in user and supervisor modes
MPU_SUPERVISOR_↩ USER_RWX	r w x	r w x	Read write and execute operations are allowed in user and supervisor modes

Code	Read/Write permission	Description
MPU_NONE	- -	No Read/Write access permission
MPU_W	- w	Write access permission
MPU_R	r -	Read access permission
MPU_RW	r w	Read/Write access permission

Implements : mpu_access_rights_t_Class

Enumerator

MPU_SUPERVISOR_RWX_USER_NONE 0b00000000U : rwx|—

MPU_SUPERVISOR_RWX_USER_X 0b00000001U : rwx|–x

MPU_SUPERVISOR_RWX_USER_W 0b00000010U : rwx|-w-

MPU_SUPERVISOR_RWX_USER_WX 0b00000011U : rwx|-wx

MPU_SUPERVISOR_RWX_USER_R 0b00000100U : rwx|r–

MPU_SUPERVISOR_RWX_USER_RX 0b00000101U : rwx|r-x

MPU_SUPERVISOR_RWX_USER_RW 0b00000110U : rwx|rw-

MPU_SUPERVISOR_RWX_USER_RWX 0b00000111U : rwx|rwx

MPU_SUPERVISOR_RX_USER_NONE 0b00001000U : r-x|—

MPU_SUPERVISOR_RX_USER_X 0b00001001U : r-x|–x

MPU_SUPERVISOR_RX_USER_W 0b00001010U : r-x|-w-

MPU_SUPERVISOR_RX_USER_WX 0b00001011U : r-x|-wx

MPU_SUPERVISOR_RX_USER_R 0b00001100U : r-x|r–

MPU_SUPERVISOR_RX_USER_RX 0b00001101U : r-x|r-x

MPU_SUPERVISOR_RX_USER_RW 0b00001110U : r-x|rw-

MPU_SUPERVISOR_RX_USER_RWX 0b00001111U : r-x|rwx

MPU_SUPERVISOR_RW_USER_NONE 0b00010000U : rw-|—

MPU_SUPERVISOR_RW_USER_X 0b00010001U : rw-|–x

MPU_SUPERVISOR_RW_USER_W 0b00010010U : rw-|-w-

MPU_SUPERVISOR_RW_USER_WX 0b00010011U : rw-|-wx

MPU_SUPERVISOR_RW_USER_R 0b00010100U : rw-|r–

MPU_SUPERVISOR_RW_USER_RX 0b00010101U : rw-|r-x

MPU_SUPERVISOR_RW_USER_RW 0b00010110U : rw-|rw-

MPU_SUPERVISOR_RW_USER_RWX 0b00010111U : rw-|rwx

MPU_SUPERVISOR_USER_NONE 0b00011000U : —|—

MPU_SUPERVISOR_USER_X 0b00011001U : –x|–x

MPU_SUPERVISOR_USER_W 0b00011010U : -w-|-w-

MPU_SUPERVISOR_USER_WX 0b00011011U : -wx|-wx

MPU_SUPERVISOR_USER_R 0b00011100U : r–|r–

MPU_SUPERVISOR_USER_RX 0b00011101U : r-x|r-x

MPU_SUPERVISOR_USER_RW 0b00011110U : rw-|rw-

MPU_SUPERVISOR_USER_RWX 0b00011111U : rwx|rwx

MPU_NONE 0b10000000U : –

MPU_W 0b10100000U : w-

MPU_R 0b11000000U : -r

MPU_RW 0b11100000U : wr

Definition at line 121 of file mpu_driver.h.

16.70.3.2 enum mpu_err_access_type_t

MPU access error Implements : mpu_err_access_type_t_Class.

Enumerator

MPU_ERR_TYPE_READ MPU error type: read

MPU_ERR_TYPE_WRITE MPU error type: write

Definition at line 41 of file mpu_driver.h.

16.70.3.3 enum mpu_err_attributes_t

MPU access error attributes Implements : mpu_err_attributes_t_Class.

Enumerator

MPU_INSTRUCTION_ACCESS_IN_USER_MODE Access instruction error in user mode

MPU_DATA_ACCESS_IN_USER_MODE Access data error in user mode

MPU_INSTRUCTION_ACCESS_IN_SUPERVISOR_MODE Access instruction error in supervisor mode

MPU_DATA_ACCESS_IN_SUPERVISOR_MODE Access data error in supervisor mode

Definition at line 51 of file mpu_driver.h.

16.70.4 Function Documentation

16.70.4.1 void MPU_DRV_Deinit (uint32_t *instance*)

De-initializes the memory protection unit by reseting all regions to default and disable module.

Parameters

in	*instance*	The MPU peripheral instance number.

Definition at line 105 of file mpu_driver.c.

16.70.4.2 void MPU_DRV_EnableRegion (uint32_t *instance,* uint8_t *regionNum,* bool *enable*)

Enables/Disables region descriptor. Please note that region 0 should not be disabled.

Parameters

in	*instance*	The MPU peripheral instance number.
in	*regionNum*	The region number.
in	*enable*	Valid state • true : Enable region. • false : Disable region.

Definition at line 344 of file mpu_driver.c.

16.70.4.3 mpu_user_config_t MPU_DRV_GetDefaultRegionConfig (mpu_master_access_right_t * *masterAccRight*)

Gets default region configuration. Grants all access rights for masters and disables PID on entire memory.

Parameters

out	*masterAccRight*	The pointer to master configuration structure, see mpu_master_access_right_t. The length of array should be defined by number of masters supported by hardware.

Returns

The default region configuration, see mpu_user_config_t.

Definition at line 308 of file mpu_driver.c.

16.70.4.4 bool MPU_DRV_GetDetailErrorAccessInfo (uint32_t *instance,* uint8_t *slavePortNum,* mpu_access_err_info_t * *errInfoPtr*)

Checks and gets the MPU access error detail information for a slave port. Clears bus error flag if an error occurs.

Parameters

in	*instance*	The MPU peripheral instance number.
in	*slavePortNum*	The slave port number to get Error Detail.
out	*errInfoPtr*	The pointer to access error info structure, #see mpu_access_err_info_t.

Returns

operation status

- true : An error has occurred.
- false : No error has occurred.

Definition at line 256 of file mpu_driver.c.

16.70.4.5 status_t MPU_DRV_Init (uint32_t *instance*, uint8_t *regionCnt*, const mpu_user_config_t * *userConfigArr*)

The function initializes the memory protection unit by setting the access configurations of all available masters, process identifier and the memory location for the given regions; and activate module finally. Please note that access rights for region 0 will always be configured and regionCnt takes values between 1 and the maximum region count supported by the hardware. e.g. In S32K144 the number of supported regions is 8. The user must make sure that the clock is enabled.

Parameters

in	*instance*	The MPU peripheral instance number.
in	*regionCnt*	The number of configured regions.
in	*userConfigArr*	The pointer to the array of MPU user configure structure, see mpu_user_config_t.

Returns

operation status

- STATUS_SUCCESS: Operation was successful.
- STATUS_ERROR: Operation failed due to master number is out of range supported by hardware.

Definition at line 62 of file mpu_driver.c.

16.70.4.6 status_t MPU_DRV_SetMasterAccessRights (uint32_t *instance*, uint8_t *regionNum*, const mpu_master_access_right_t * *accessRightsPtr*)

Configures access permission for bus master in region.

Parameters

in	*instance*	The MPU peripheral instance number.
in	*regionNum*	The MPU region number.
in	*accessRightsPtr*	The pointer to access permission structure, #see mpu_master_access_right_t.

Returns

operation status

- STATUS_SUCCESS: Operation was successful.
- STATUS_ERROR: Operation failed due to master number is out of range supported by hardware.

Definition at line 224 of file mpu_driver.c.

16.70.4.7 void MPU_DRV_SetRegionAddr (uint32_t *instance*, uint8_t *regionNum*, uint32_t *startAddr*, uint32_t *endAddr*)

Sets the region start and end address.

Parameters

in	*instance*	The MPU peripheral instance number.
in	*regionNum*	The region number.
in	*startAddr*	The region start address.
in	*endAddr*	The region end address.

Definition at line 137 of file mpu_driver.c.

16.70.4.8 status_t MPU_DRV_SetRegionConfig (uint32_t *instance,* uint8_t *regionNum,* const mpu_user_config_t * *userConfigPtr*)

Sets the region configuration. Updates the access configuration of all available masters, process identifier and memory location in a given region.

Parameters

in	*instance*	The MPU peripheral instance number.
in	*regionNum*	The region number.
in	*userConfigPtr*	The region configuration structure pointer.

Returns

operation status

- STATUS_SUCCESS: Operation was successful.
- STATUS_ERROR: Operation failed due to master number is out of range supported by hardware.

Definition at line 164 of file mpu_driver.c.

16.71 MPU PAL

16.71.1 Detailed Description

Memory Protection Unit Peripheral Abstraction Layer.

Data Structures

- struct mpu_error_info_t

  MPU detail error access info Implements : mpu_error_info_t_Class. More...
- struct mpu_master_access_permission_t

  MPU master access permission. Implements : mpu_master_access_permission_t_Class. More...
- struct mpu_region_config_t

  MPU region configuration structure. Implements : mpu_region_config_t_Class. More...

Typedefs

- typedef mpu_access_rights_t mpu_access_permission_t

  MPU detail access permission For specific master:

Code	Supervisor	User	Description
MPU_SUPERVISOR_↩ RWX_USER_NONE	*r w x*	*- - -*	*Allow Read, write, execute in supervisor mode; no access in user mode*
MPU_SUPERVISOR_↩ RWX_USER_X	*r w x*	*- - x*	*Allow Read, write, execute in supervisor mode; execute in user mode*
MPU_SUPERVISOR_↩ RWX_USER_W	*r w x*	*- w -*	*Allow Read, write, execute in supervisor mode; write in user mode*
MPU_SUPERVISOR_↩ RWX_USER_WX	*r w x*	*- w x*	*Allow Read, write, execute in supervisor mode; write and execute in user mode*
MPU_SUPERVISOR_↩ RWX_USER_R	*r w x*	*r - -*	*Allow Read, write, execute in supervisor mode; read in user mode*
MPU_SUPERVISOR_↩ RWX_USER_RX	*r w x*	*r - x*	*Allow Read, write, execute in supervisor mode; read and execute in user mode*
MPU_SUPERVISOR_↩ RWX_USER_RW	*r w x*	*r w -*	*Allow Read, write, execute in supervisor mode; read and write in user mode*
MPU_SUPERVISOR_↩ RWX_USER_RWX	*r w x*	*r w x*	*Allow Read, write, execute in supervisor mode; read, write and execute in user mode*

MPU_SUPERVISOR_↩ RX_USER_NONE	*r - x*	*- - -*	*Allow Read, execute in supervisor mode; no access in user mode*
MPU_SUPERVISOR_↩ RX_USER_X	*r - x*	*- - x*	*Allow Read, execute in supervisor mode; execute in user mode*
MPU_SUPERVISOR_↩ RX_USER_W	*r - x*	*- w -*	*Allow Read, execute in supervisor mode; write in user mode*
MPU_SUPERVISOR_↩ RX_USER_WX	*r - x*	*- w x*	*Allow Read, execute in supervisor mode; write and execute in user mode*
MPU_SUPERVISOR_↩ RX_USER_R	*r - x*	*r - -*	*Allow Read, execute in supervisor mode; read in user mode*
MPU_SUPERVISOR_↩ RX_USER_RX	*r - x*	*r - x*	*Allow Read, execute in supervisor mode; read and execute in user mode*
MPU_SUPERVISOR_↩ RX_USER_RW	*r - x*	*r w -*	*Allow Read, execute in supervisor mode; read and write in user mode*
MPU_SUPERVISOR_↩ RX_USER_RWX	*r - x*	*r w x*	*Allow Read, execute in supervisor mode; read, write and execute in user mode*
MPU_SUPERVISOR_↩ RW_USER_NONE	*r w -*	*- - -*	*Allow Read, write in supervisor mode; no access in user mode*
MPU_SUPERVISOR_↩ RW_USER_X	*r w -*	*- - x*	*Allow Read, write in supervisor mode; execute in user mode*
MPU_SUPERVISOR_↩ RW_USER_W	*r w -*	*- w -*	*Allow Read, write in supervisor mode; write in user mode*
MPU_SUPERVISOR_↩ RW_USER_WX	*r w -*	*- w x*	*Allow Read, write in supervisor mode; write and execute in user mode*
MPU_SUPERVISOR_↩ RW_USER_R	*r w -*	*r - -*	*Allow Read, write in supervisor mode; read in user mode*
MPU_SUPERVISOR_↩ RW_USER_RX	*r w -*	*r - x*	*Allow Read, write in supervisor mode; read and execute in user mode*
MPU_SUPERVISOR_↩ RW_USER_RW	*r w -*	*r w -*	*Allow Read, write in supervisor mode; read and write in user mode*
MPU_SUPERVISOR_↩ RW_USER_RWX	*r w -*	*r w x*	*Allow Read, write in supervisor mode; read, write and execute in user mode*

MPU_SUPERVISOR_↩ USER_NONE	*- - -*	*- - -*	*No access allowed in user and supervisor modes*
MPU_SUPERVISOR_↩ USER_X	*- - x*	*- - x*	*Execute operation is allowed in user and supervisor modes*
MPU_SUPERVISOR_↩ USER_W	*- w -*	*- w -*	*Write operation is allowed in user and supervisor modes*
MPU_SUPERVISOR_↩ USER_WX	*- w x*	*- w x*	*Write and execute operations are allowed in user and supervisor modes*
MPU_SUPERVISOR_↩ USER_R	*r - -*	*r - -*	*Read operation is allowed in user and supervisor modes*
MPU_SUPERVISOR_↩ USER_RX	*r - x*	*r - x*	*Read and execute operations are allowed in user and supervisor modes*
MPU_SUPERVISOR_↩ USER_RW	*r w -*	*r w -*	*Read and write operations are allowed in user and supervisor modes*
MPU_SUPERVISOR_↩ USER_RWX	*r w x*	*r w x*	*Read write and execute operations are allowed in user and supervisor modes*

Enumerations

- enum mpu_error_access_type_t { MPU_ERROR_TYPE_READ = 0U, MPU_ERROR_TYPE_WRITE = 1U }

  MPU access error Implements : mpu_error_access_type_t_Class.
- enum mpu_error_attributes_t { MPU_ERROR_USER_MODE_INSTRUCTION_ACCESS = 0U, MPU_ERR↩ OR_USER_MODE_DATA_ACCESS = 1U, MPU_ERROR_SUPERVISOR_MODE_INSTRUCTION_ACCE↩ SS = 2U, MPU_ERROR_SUPERVISOR_MODE_DATA_ACCESS = 3U }

  MPU access error attributes Implements : mpu_error_attributes_t_Class.

MPU PAL API

- status_t MPU_Init (const mpu_instance_t *const instance, uint8_t regionCnt, const mpu_region_config_↩ t *configPtr)

  Initializes memory protection unit by allocating regions and granting access rights for masters.
- status_t MPU_Deinit (const mpu_instance_t *const instance)

  De-initializes memory protection unit by reseting all regions and masters to default and disable module.
- status_t MPU_GetDefautRegionConfig (const mpu_instance_t *const instance, mpu_master_access_↩ permission_t *masterAccRight, mpu_region_config_t *regionConfig)

  Gets default region configuration. Grants all access rights for masters; disable PID and cache; unlock region descriptor.
- status_t MPU_UpdateRegion (const mpu_instance_t *const instance, uint8_t regionNum, const mpu_↩ region_config_t *configPtr)

  Updates region configuration.
- status_t MPU_EnableRegion (const mpu_instance_t *const instance, uint8_t regionNum, bool enable)

  Enables or disables an exist region configuration.
- bool MPU_GetError (const mpu_instance_t *const instance, uint8_t channel, mpu_error_info_t *errPtr)

  Checks and gets the access error detail information then clear error flag if the error caused by a master.

- enum mpu_inst_type_t

  Enumeration with the types of peripherals supported by MPU PAL.

16.71.2 Data Structure Documentation

16.71.2.1 struct mpu_error_info_t

MPU detail error access info Implements : mpu_error_info_t_Class.

Definition at line 67 of file mpu_pal.h.

Data Fields

- uint8_t master
- bool overrun
- mpu_error_attributes_t attributes
- mpu_error_access_type_t accessType
- uint32_t accessCtr
- uint32_t addr
- uint8_t processId

Field Documentation

16.71.2.1.1 uint32_t accessCtr

Access error control

Definition at line 73 of file mpu_pal.h.

16.71.2.1.2 mpu_error_access_type_t accessType

Access error type

Definition at line 72 of file mpu_pal.h.

16.71.2.1.3 uint32_t addr

Access error address

Definition at line 74 of file mpu_pal.h.

16.71.2.1.4 mpu_error_attributes_t attributes

Access error attributes

Definition at line 71 of file mpu_pal.h.

16.71.2.1.5 uint8_t master

Access error master

Definition at line 69 of file mpu_pal.h.

16.71.2.1.6 bool overrun

Access error master overrun

Definition at line 70 of file mpu_pal.h.

16.71.2.1.7 uint8_t processId

Access error process identification

Definition at line 75 of file mpu_pal.h.

16.71.2.2 struct mpu_master_access_permission_t

MPU master access permission. Implements : mpu_master_access_permission_t_Class.

Definition at line 141 of file mpu_pal.h.

Data Fields

- uint8_t masterNum
- mpu_access_permission_t accessRight

Field Documentation

16.71.2.2.1 mpu_access_permission_t accessRight

Privilege right

Definition at line 144 of file mpu_pal.h.

16.71.2.2.2 uint8_t masterNum

Master number

Definition at line 143 of file mpu_pal.h.

16.71.2.3 struct mpu_region_config_t

MPU region configuration structure. Implements : mpu_region_config_t_Class.

Definition at line 151 of file mpu_pal.h.

Data Fields

- uint32_t startAddr
- uint32_t endAddr
- const mpu_master_access_permission_t * masterAccRight
- uint8_t processIdEnable
- uint8_t processIdentifier
- uint8_t processIdMask
- void * extension

Field Documentation

16.71.2.3.1 uint32_t endAddr

Memory region end address

Definition at line 154 of file mpu_pal.h.

16.71.2.3.2 void* extension

This field will be used to add extra settings to the basic region configuration

Definition at line 162 of file mpu_pal.h.

16.71.2.3.3 const mpu_master_access_permission_t* masterAccRight

Access permission for masters

Definition at line 155 of file mpu_pal.h.

16.71.2.3.4 uint8_t processIdEnable

Process identifier enable For MPU: the bit index corresponding with masters For SMPU: disable if equal zero, otherwise enable

Definition at line 156 of file mpu_pal.h.

16.71.2.3.5 uint8_t processIdentifier

Process identifier

Definition at line 159 of file mpu_pal.h.

16.71.2.3.6 uint8_t processIdMask

Process identifier mask. The setting bit will ignore the same bit in process identifier

Definition at line 160 of file mpu_pal.h.

16.71.2.3.7 uint32_t startAddr

Memory region start address

Definition at line 153 of file mpu_pal.h.

16.71.3 Typedef Documentation

16.71.3.1 typedef mpu_access_rights_t mpu_access_permission_t

MPU detail access permission For specific master:

Code	Supervisor	User	Description
MPU_SUPERVISOR_↩ RWX_USER_NONE	r w x	- - -	Allow Read, write, execute in supervisor mode; no access in user mode
MPU_SUPERVISOR_↩ RWX_USER_X	r w x	- - x	Allow Read, write, execute in supervisor mode; execute in user mode
MPU_SUPERVISOR_↩ RWX_USER_W	r w x	- w -	Allow Read, write, execute in supervisor mode; write in user mode
MPU_SUPERVISOR_↩ RWX_USER_WX	r w x	- w x	Allow Read, write, execute in supervisor mode; write and execute in user mode
MPU_SUPERVISOR_↩ RWX_USER_R	r w x	r - -	Allow Read, write, execute in supervisor mode; read in user mode
MPU_SUPERVISOR_↩ RWX_USER_RX	r w x	r - x	Allow Read, write, execute in supervisor mode; read and execute in user mode
MPU_SUPERVISOR_↩ RWX_USER_RW	r w x	r w -	Allow Read, write, execute in supervisor mode; read and write in user mode

MPU_SUPERVISOR_↩ RWX_USER_RWX	r w x	r w x	Allow Read, write, execute in supervisor mode; read, write and execute in user mode
MPU_SUPERVISOR_↩ RX_USER_NONE	r - x	- - -	Allow Read, execute in supervisor mode; no access in user mode
MPU_SUPERVISOR_↩ RX_USER_X	r - x	- - x	Allow Read, execute in supervisor mode; execute in user mode
MPU_SUPERVISOR_↩ RX_USER_W	r - x	- w -	Allow Read, execute in supervisor mode; write in user mode
MPU_SUPERVISOR_↩ RX_USER_WX	r - x	- w x	Allow Read, execute in supervisor mode; write and execute in user mode
MPU_SUPERVISOR_↩ RX_USER_R	r - x	r - -	Allow Read, execute in supervisor mode; read in user mode
MPU_SUPERVISOR_↩ RX_USER_RX	r - x	r - x	Allow Read, execute in supervisor mode; read and execute in user mode
MPU_SUPERVISOR_↩ RX_USER_RW	r - x	r w -	Allow Read, execute in supervisor mode; read and write in user mode
MPU_SUPERVISOR_↩ RX_USER_RWX	r - x	r w x	Allow Read, execute in supervisor mode; read, write and execute in user mode
MPU_SUPERVISOR_↩ RW_USER_NONE	r w -	- - -	Allow Read, write in supervisor mode; no access in user mode
MPU_SUPERVISOR_↩ RW_USER_X	r w -	- - x	Allow Read, write in supervisor mode; execute in user mode
MPU_SUPERVISOR_↩ RW_USER_W	r w -	- w -	Allow Read, write in supervisor mode; write in user mode
MPU_SUPERVISOR_↩ RW_USER_WX	r w -	- w x	Allow Read, write in supervisor mode; write and execute in user mode
MPU_SUPERVISOR_↩ RW_USER_R	r w -	r - -	Allow Read, write in supervisor mode; read in user mode
MPU_SUPERVISOR_↩ RW_USER_RX	r w -	r - x	Allow Read, write in supervisor mode; read and execute in user mode

MPU_SUPERVISOR_↩ RW_USER_RW	r w -	r w -	Allow Read, write in supervisor mode; read and write in user mode
MPU_SUPERVISOR_↩ RW_USER_RWX	r w -	r w x	Allow Read, write in supervisor mode; read, write and execute in user mode
MPU_SUPERVISOR_↩ USER_NONE	- - -	- - -	No access allowed in user and supervisor modes
MPU_SUPERVISOR_↩ USER_X	- - x	- - x	Execute operation is allowed in user and supervisor modes
MPU_SUPERVISOR_↩ USER_W	- w -	- w -	Write operation is allowed in user and supervisor modes
MPU_SUPERVISOR_↩ USER_WX	- w x	- w x	Write and execute operations are allowed in user and supervisor modes
MPU_SUPERVISOR_↩ USER_R	r - -	r - -	Read operation is allowed in user and supervisor modes
MPU_SUPERVISOR_↩ USER_RX	r - x	r - x	Read and execute operations are allowed in user and supervisor modes
MPU_SUPERVISOR_↩ USER_RW	r w -	r w -	Read and write operations are allowed in user and supervisor modes
MPU_SUPERVISOR_↩ USER_RWX	r w x	r w x	Read write and execute operations are allowed in user and supervisor modes

For normal master:

Code	Read/Write permission	Description
MPU_NONE	- -	No Read/Write access permission
MPU_W	- w	Write access permission
MPU_R	r -	Read access permission
MPU_RW	r w	Read/Write access permission

Implements : mpu_access_permission_t_Class

Definition at line 126 of file mpu_pal.h.

16.71.4 Enumeration Type Documentation

16.71.4.1 enum mpu_error_access_type_t

MPU access error Implements : mpu_error_access_type_t_Class.

Enumerator

MPU_ERROR_TYPE_READ Error type: read

MPU_ERROR_TYPE_WRITE Error type: write

Definition at line 45 of file mpu_pal.h.

16.71.4.2 enum mpu_error_attributes_t

MPU access error attributes Implements : mpu_error_attributes_t_Class.

Enumerator

MPU_ERROR_USER_MODE_INSTRUCTION_ACCESS Instruction access error in user mode

MPU_ERROR_USER_MODE_DATA_ACCESS Data access error in user mode

MPU_ERROR_SUPERVISOR_MODE_INSTRUCTION_ACCESS Instruction access error in supervisor mode

MPU_ERROR_SUPERVISOR_MODE_DATA_ACCESS Data access error in supervisor mode

Definition at line 55 of file mpu_pal.h.

16.71.4.3 enum mpu_inst_type_t

Enumeration with the types of peripherals supported by MPU PAL.

This enumeration contains the types of peripherals supported by MPU PAL. Implements : mpu_inst_type_t_Class

Definition at line 51 of file mpu_pal_mapping.h.

16.71.5 Function Documentation

16.71.5.1 status_t MPU_Deinit (const mpu_instance_t *const *instance*)

De-initializes memory protection unit by reseting all regions and masters to default and disable module.

Parameters

in	*instance*	The pointer to MPU instance number.

Returns

operation status

- STATUS_SUCCESS : Operation was successful.
- STATUS_ERROR : Operation failed due to the region was locked by another master or all masters are locked.
- STATUS_UNSUPPORTED : Operation was unsupported.

Definition at line 276 of file mpu_pal.c.

16.71.5.2 status_t MPU_EnableRegion (const mpu_instance_t *const *instance,* uint8_t *regionNum,* bool *enable*)

Enables or disables an exist region configuration.

Parameters

in	*instance*	The pointer to MPU instance number.
in	*regionNum*	The region number.
in	*enable*	Valid state • true : Enable region. • false : Disable region.

Returns

operation status

- STATUS_SUCCESS : Operation was successful.
- STATUS_ERROR : Operation failed due to the region was locked by another master or all masters are locked.
- STATUS_UNSUPPORTED : Operation was unsupported.

Definition at line 425 of file mpu_pal.c.

16.71.5.3 status_t MPU_GetDefautRegionConfig (const mpu_instance_t *const *instance*, mpu_master_access_permission_t * *masterAccRight*, mpu_region_config_t * *regionConfig*)

Gets default region configuration. Grants all access rights for masters; disable PID and cache; unlock region descriptor.

Parameters

in	*instance*	The pointer to MPU instance number.
out	*masterAccRight*	The pointer to master configuration structure, see mpu_master_access_permission_t. The length of array should be defined by number of masters supported by hardware.
out	*regionConfig*	The pointer to default region configuration structure, see mpu_region_config_t.

Returns

operation status

- STATUS_SUCCESS : Operation was successful.
- STATUS_UNSUPPORTED : Operation was unsupported.

Definition at line 311 of file mpu_pal.c.

16.71.5.4 bool MPU_GetError (const mpu_instance_t *const *instance*, uint8_t *channel*, mpu_error_info_t * *errPtr*)

Checks and gets the access error detail information then clear error flag if the error caused by a master.

Parameters

in	*instance*	The pointer to MPU instance number.
in	*channel*	The error capture channel For MPU: corresponding with the slave port number For SMPU: corresponding with the the master number
out	*errPtr*	The pointer to access error info structure, see mpu_error_info_t.

Returns

operation status

- true : An error has occurred.
- false : No error has occurred or the operation was unsupported.

Definition at line 462 of file mpu_pal.c.

16.71.5.5 status_t MPU_Init (const mpu_instance_t *const *instance*, uint8_t *regionCnt*, const mpu_region_config_t * *configPtr*)

Initializes memory protection unit by allocating regions and granting access rights for masters.

Parameters

in	*instance*	The pointer to MPU instance number.
in	*regionCnt*	The number of regions configured.
in	*configPtr*	The pointer to regions configuration structure, see mpu_region_config_t.

Returns

operation status

- STATUS_SUCCESS : Operation was successful.
- STATUS_ERROR : Operation failed due to invalid master number or the region was locked by another master or all masters are locked.
- STATUS_UNSUPPORTED : Operation was unsupported.

Definition at line 213 of file mpu_pal.c.

16.71.5.6 status_t MPU_UpdateRegion (const mpu_instance_t *const *instance*, uint8_t *regionNum*, const mpu_region_config_t * *configPtr*)

Updates region configuration.

Parameters

in	*instance*	The pointer to MPU instance number.
in	*regionNum*	The region number.
in	*configPtr*	The pointer to region configuration structure, see mpu_region_config_t.

Returns

operation status

- STATUS_SUCCESS : Operation was successful.
- STATUS_ERROR : Operation failed due to invalid master number or the region was locked by another master or all masters are locked.
- STATUS_UNSUPPORTED : Operation was unsupported.

Definition at line 380 of file mpu_pal.c.

16.72 Memory Protection Unit (MPU)

16.72.1 Detailed Description

The S32 SDK provides Peripheral Driver for the Memory Protection Unit (MPU) module of S32 SDK devices.

The memory protection unit (MPU) provides hardware access control for all memory references generated in the device.

Hardware background

The MPU concurrently monitors all system bus transactions and evaluates their appropriateness using pre-programmed region descriptors that define memory spaces and their access rights. Memory references that have sufficient access control rights are allowed to complete, while references that are not mapped to any region descriptor or have insufficient rights are terminated with a protection error response.

The MPU implements a two-dimensional hardware array of memory region descriptors and the crossbar slave ports to continuously monitor the legality of every memory reference generated by each bus master in the system.

The feature set includes:

- 8(16 for S32K148) program-visible 128-bit region descriptors, accessible by four 32-bit words each
  - Each region descriptor defines a modulo-32 byte space, aligned anywhere in memory
    - Region sizes can vary from 32 bytes to 4 Gbytes
  - Two access control permissions defined in a single descriptor word
    - Masters 0–3: read, write, and execute attributes for supervisor and user accesses
    - Masters 4–7: read and write attributes
  - Hardware-assisted maintenance of the descriptor valid bit minimizes coherency issues
  - Alternate programming model view of the access control permissions word
  - Priority given to granting permission over denying access for overlapping region descriptors
- Detects access protection errors if a memory reference does not hit in any memory region, or if the reference is illegal in all hit memory regions. If an access error occurs, the reference is terminated with an error response, and the MPU inhibits the bus cycle being sent to the targeted slave device.
- Error registers, per slave port, capture the last faulting address, attributes, and other information
- Global MPU enable/disable control bit

Logical Bus Master Assignments and Possible Access Types

ID	Master	User	Super-visor	Data	Instruc-tion	Read	Write	Exe-cute	PID
0	Core	x	x	x	x	x	x	x	x
1	Debug-ger	x	x	x	x	x	x	x	x
2	DMA		x	x		x	x		
3	ENET	x		x		x	x		

ID	S32K1xx	S32MTV	S32K1xxW
0	x	x	x
1	x	x	x
2	x	x	x
3	x(1)		x(1)

1: S32K148 only.

Logical Slave Port Assignments

Port	Source	Destination
0	Crossbar slave port 0	Flash Controller
1	Crossbar slave port 1	SRAM backdoor
2	Code Bus	SRAM_L frontdoor
3	System Bus	SRAM_U frontdoor
4	Crossbar slave port 3	QuadSPI

Port	S32K11x	S32K14x	S32MTV	S32K1xxW
0	x	x	x	x
1	x(1)	x	x	x
2		x	x	x
3		x	x	x
4		x(2)		x(2)

1: Destination: SRAM controller/MTB/DWT/MCM. 2: S32K148 only.

AHB-AP

AHB-AP provides the debugger access to all memory and registers in the system.
The MPU includes default settings and protections for the Region Descriptor 0 (RGD0) such that the Debugger always has access to the entire address space and those rights cannot be changed by the core or any other bus master.

ERRATA

- S32K148:
  - E11109: The MPU requires a special programming sequence to protect the QSPI space as it is unable to see the two MSB bits of the QSPI address on slave port 4.
    This programming sequence requires 2 Region Descriptors [RGDx]:
    * One will cover the region 0x280x_xxxx and the other one will cover region 0x680x_xxxx.
    * When any master without permissions tries to access region 0x680x_xxxx, an error will be captured in both, EDR3 and EDR4 registers. Moreover, the address of the failed access is captured on EAR3 and EAR4 registers. However, EAR3 will capture the address 0x680x_xxxx, which is the one that belongs to the QSPI space. While EAR4 will capture the 0x280x_xxxx address.

Note

- S32K14x, S32K14xW:
  - In order to protect cache data, AHB LMEM will distribute all transactions to MPU slave port 2 for any access to the whole cacheable code bus memory domain.
    * If there is a Pflash access protection error by CM4, both slave port 0 & slave port 2 will report the same error.

Modules

- MPU Driver

  Memory Protection Unit Peripheral Driver.

16.73 Memory Protection Unit Peripheral Abstraction Layer (MPU PAL)

16.73.1 Detailed Description

The S32 SDK provides a Peripheral Abstraction Layer for Memory Protection Unit (MPU) modules of S32 SDK devices.

The MPU PAL driver provides memory protection functionality via allocate regions and restrict access rights of all masters on the region. It was designed to be portable across all platforms and IPs which support Memory Protection Unit.

Integration guideline

Unlike the other drivers, MPU PAL modules need to include a configuration file named mpu_pal_cfg.h, which allows the user to specify which IPs are used and how many resources are allocated for each of them (state structures). The following code example shows how to configure one instance for each available MPU IPs.

```
#ifndef MPU_PAL_CFG_H
#define MPU_PAL_CFG_H

/* Define which IP instance which supported on this device */
#define MPU_OVER_MPU
#define MPU_OVER_SMPU

#endif /* MPU_PAL_CFG_H */
```

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\pal\src\mpu\mpu_pal.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\pal\inc\
```

Compile symbols

No special symbols are required for this component

Dependencies

Memory Protection Unit (MPU) smpu

IPs specification

The following tables contains IPs specification on platforms:

- Available

IP/MCU	S32K1xx	MPC574x	S32Rx7x
MPU	x		
SMPU		x	x

- Number of supported instances

IP/MCU	S32K1xx	MPC574x	S32Rx7x
MPU	1	–	–
SMPU	–	1(1)	2

1: 2 instances with MPC5747C, MPC5748C, MPC5746G, MPC5747G and MPC5748G.

SMPU instance	MPC574x	S32Rx7x
0	Flash and peripherals	Data XBAR (XBAR_0)
1	RAM	instruction XBAR (XBAR_1)

MPC574x: The cores on the device treats the following memory region as guarded by default:

- *Guarded Region0: Address 0xFC00_0000 to 0xFFFF_FFFF*
- *Guarded Region1: Address 0xF800_0000 to 0xFBFF_FFFF*

- *Number of supported regions*

IP/MCU	S32K1xx	MPC574x	S32Rx7x
MPU	*8(1)*	*–*	*–*
SMPU	*–*	*16*	*16*

1: 16 regions with S32K148.

Note

- *S32K14x, S32K14xW:*
  - *In order to protect cache data, AHB LMEM will distribute all transactions to MPU slave port 2 for any access to the whole cacheable code bus memory domain.*
    - *If there is a Pflash access protection error by CM4, both slave port 0 & slave port 2 will report the same error.*

Initialization & De-initialization

- *In order to use the MPU PAL driver it must be first initialized, using MPU_Init() function to initialize or re-initialize module.*
- *Example:*

1. *Definitions for MPU IP (MPU_OVER_MPU)*

```
/* Define MPU PAL instance */
mpu_instance_t mpu_pal_Instance =
{
  .instType = MPU_INST_TYPE_MPU, /* MPU PAL over MPU */
  .instIdx  = 0U                 /* MPU instance 0 */
}

/* Define number of masters supported by platform */
#define MPU_PAL_MASTER_COUNT  (16U)

/* Define number of used regions (should be in range supported by platform) */
#define MPU_PAL_REGION_COUNT  (1U)

/* Status variable */
status_t status;
```

2. *Region configuration*

```
/* Master configuration */
mpu_master_access_permission_t mpu_pal_masterAccRight[MPU_PAL_MASTER_COUNT] =
{
  /* Master */
  {
    .masterNum = FEATURE_MPU_MASTER_CORE,              /* Core */
    .accessRight = MPU_ACCESS_SUPERVISOR_RWX_USER_RWX  /* Access right: read, write and execute
                                                       for both supervisor and user mode */
  },
  /* Define the rest masters here */
  ...
};

/* Region configuration */
mpu_region_config_t mpu_pal_regionConfigs[MPU_PAL_REGION_COUNT] =
{
  /* Region 0 */
  {
    .startAddr = 0U,                        /* Start address */
    .endAddr = 0xFFFFFFFFU,                 /* End address */
```

```
    .masterAccRight = mpu_pal_masterAccRight, /* Pointer to access right of all masters */
  /* If support PID */
    .processIdEnable = 0x01U,                 /* 8'b00000001 Enable PID for logical master 0 (Core) */
    .processIdentifier = 0x00U,               /* Process identifier */
    .processIdMask = 0xFFU,                   /* Process identifier mask */
  /* End if */
  /* Extension */
    .extension = NULL                         /* This field will be used to add extra settings
                                              to the basic region configuration */
  /* End extension */
  }
};
```

Or using MPU_GetDefaultConfig()

```
/* Master configuration */
mpu_master_access_permission_t mpu_pal_masterAccRight[MPU_PAL_MASTER_COUNT];
/* Region configuration */
mpu_region_config_t regionConfig0;

/* Get default region configuration */
status = MPU_GetDefaultConfig(&mpu_pal_Instance, mpu_pal_masterAccRight, &regionConfig0);
mpu_region_config_t mpu_pal_regionConfigs[MPU_PAL_REGION_COUNT] =
{
  regionConfig0
};
```

3. *Initialization*

```
/* Initializes MPU PAL */
status = MPU_Init(&mpu_pal_Instance, MPU_PAL_REGION_COUNT, mpu_pal_regionConfigs);
```

4. *De-initialization*

```
/* De-initializes MPU PAL */
status = MPU_Deinit(&mpu_pal_Instance);
```

Updates region configuration

- *The MPU PAL driver provides a function named MPU_UpdateRegion() to update a region configuration (address, access rights of all masters, process identifier,...).*
- *In order to remove unused region or add again, MPU_EnableRegion() can be used.*
- *Please note the region will be unlocked if the update succeed.*
- *Example:*

1. *Modify (or add new) region after initialization*

```
/* Disables process identifier functionality on region 0 */
regionConfig0.processIdEnable = 0x00U;

/* Updates region 0 */
status = MPU_UpdateRegion(&mpu_pal_Instance, 0U, &regionConfig0);
```

2. *Enables/Disables an exist region configuration*

```
/* Enables region 1 */
status = MPU_EnableRegion(&mpu_pal_Instance, 1U, true);

/* Disables region 2 */
status = MPU_EnableRegion(&mpu_pal_Instance, 2U, false);
```

Detects access protection errors

- *The MPU PAL driver provides a function named MPU_GetError() to detect an access protection error on error capture channel. The channel can be different among IPs.*
- *Example:*

```
/* Define error variable */
mpu_error_info_t mpu_pal_errVal;

/* Gets information on channel 0 */
bool errStatus = MPU_GetError(&mpu_pal_Instance, 0U, &mpu_pal_errVal)
```

Other IP specific details

- ***MPU*** *(MPU_OVER_MPU)*
  - *Support PID for specific masters corresponding with the processIdEnable bit index.*
  - *Detects an access error on slave ports:*

Source	Slave port	Destination	S32K11x	S32K14x	S32MTV
Crossbar slave port 0	*0*	*Flash Controller*	*x*	*x*	*x*
Crossbar slave port 1	*1*	*SRAM backdoor*	*x(1)*	*x*	*x*
Code Bus	*2*	*SRAM_L frontdoor*		*x*	*x*
System Bus	*3*	*SRAM_U frontdoor*		*x*	*x*
Crossbar slave port 2	*4*	*QuadSPI*		*x(2)*	

1: Destination: SRAM controller/MTB/DWT/MCM.
2: S32K148 only.

- ***SMPU*** *(MPU_OVER_SMPU)*
  - *Support PID for for all specific masters (processIdEnable same as bool)*
  - *Detects an access error on bus masters.*
  - *Supports lock and cache inhibit features in region extension.*
    - *An address range specified in an MPU region descriptor for a cacheable space (that is, CI = 0) must be defined with a starting address aligned on a 0-modulo-32 byte address and with a multiple of the 32 byte cache line size factoring into the end address.*
  - *MPU_UpdateRegionLock() can be used to update lock configuration on a region.*
  - *MPU_GetRegionLockInfo() can be used to get lock status on a region.*
  - *Example:*

1. *Extension*

```
/* E.g. MPC5748G */
/* SMPU region extension with normal access rights */
mpu_over_smpu_extension mpu_pal_extension =
{
  /* If specific access supported */
  .specAccessEnable   = false,     /* Use normal access rights */
  .specAccessSet      = NULL,      /* Specific access configuration
                                  Only use when specific access enabled */
  /* End if */
  .cacheInhibitEnable = true,      /* The region cannot be cached */
  .lockConfig         = MPU_UNLOCK /* The region is unlocked */
}

/* Use specific access rights */
#define MPU_PAL_REGION_ACCESS_SET_COUNT 3U /* Support 3 configurations on each region */
mpu_specific_access_permission_t mpu_pal_SpecificAccessConfig[MPU_PAL_REGION_ACCESS_SET_COUNT] =
{
  /* Set 1 */
  MPU_SUPERVISOR_RWX_USER_RWX, /* Allow read, write and execute for both
       supervisor and user mode */
  /* Set 2 */
  MPU_SUPERVISOR_RWX_USER_RWX, /* Allow read, write and execute for both
       supervisor and user mode */
  /* Set 3 */
  MPU_SUPERVISOR_RWX_USER_RWX  /* Allow read, write and execute for both supervisor and user mode */
}

mpu_pal_extension.specAccessEnable = true;
mpu_pal_extension.specAccessSet = true;

/* SMPU Master configuration /
#define MPU_PAL_MASTER_COUNT 15U
mpu_master_access_permission_t mpu_pal_masterAccRight[MPU_PAL_MASTER_COUNT] =
{
  /* Master */
  {
```

```
    .masterNum   = FEATURE_SMPU_MASTER_CORE_Z4A, /* Core Z4A */
    .accessRight = MPU_RW_OR_SET_3               /* Normal access rights: read, write and execute for both
       supervisor and user mode
                                                    Specific access: use set 3 in region configuration */
  },
  /* Define the rest masters here */
  ...
};

/* SMPU region configuration */
#define MPU_PAL_REGION_COUNT 1U
mpu_region_config_t mpu_pal_regionConfigs[MPU_PAL_REGION_COUNT] =
{
  /* Region 0 */
  {
    .startAddr = 0U,                          /* Start address */
    .endAddr = 0xFFFFFFFFU,                   /* End address */
    .masterAccRight = mpu_pal_masterAccRight, /* Pointer to access right of all masters */
  /* If support PID */
    .processIdEnable = true,                  /* Enable process identifier for all masters */
    .processIdentifier = 0x00U,               /* Process identifier */
    .processIdMask = 0xFFU,                   /* Process identifier mask */
  /* End if */
  /* Extension */
    .extension = &mpu_pal_extension           /* This field will be used to add extra settings
                                                 to the basic region configuration */
  /* End extension */
  }
}

/* Initialization */
...
```

2. *Update lock configuration and get lock status on region*

```
/* All masters cannot write to region descriptor 0 (cannot modify region 0 configuration) */
status = MPU_UpdateRegionLock(&mpu_pal_Instance, 0U, MPU_ALL_LOCK);

/* Gets lock status on region 0 */
mpu_region_lock_t lockStatus;
status = MPU_GetRegionLockInfo(&mpu_pal_Instance, 0U, &lockStatus);
```

Modules

- MPU PAL

  Memory Protection Unit Peripheral Abstraction Layer.

16.74 Node configuration

16.74.1 Detailed Description

This group contains APIs that used for node configuration purpose.

Functions

- l_bool ld_is_ready_j2602 (l_ifc_handle iii)

  Verifies a state of node setting (using for J2602 and LIN 2.0).
- l_u8 ld_check_response_j2602 (l_ifc_handle iii, l_u8 *const RSID, l_u8 *const error_code)

  Verifies the state of response (using for J2602 and LIN 2.0) Master node only.
- l_bool ld_reconfig_msg_ID (l_ifc_handle iii, l_u8 dnn)

  This function reconfigures frame identifiers of a J2602 slave node based on input dnn.
- l_bool ld_assign_NAD_j2602 (l_ifc_handle iii, l_u8 dnn)

  This function assigns NAD of a J2602 slave device based on input DNN that is Device Node Number. NAD is (0x60+ DNN).

16.74.2 Function Documentation

16.74.2.1 l_bool ld_assign_NAD_j2602 (l_ifc_handle *iii*, l_u8 *dnn*)

This function assigns NAD of a J2602 slave device based on input DNN that is Device Node Number. NAD is (0x60+ DNN).

Parameters

in	*iii*	LIN interface handle
in	*dnn*	DNN of the device

Returns

l_bool: 0: successful: New Configured NAD is 0x60 + DNN
l_bool: 1: Unsuccesfull: for either one of the following reasons:

- The protocol of this interface is not J2602
- This device is a Master node in this interface
- The input DNN is greater than 0xD that is invalid

Definition at line 1740 of file lin_diagnostic_service.c.

16.74.2.2 l_u8 ld_check_response_j2602 (l_ifc_handle *iii*, l_u8 *const *RSID*, l_u8 *const *error_code*)

Verifies the state of response (using for J2602 and LIN 2.0) Master node only.

Parameters

in	*iii*	LIN interface handle
out	*RSID*	buffer for saving the response ID
out	*error_code*	buffer for saving the error code

Returns

l_u8 status of the last service

Definition at line 1528 of file lin_diagnostic_service.c.

16.74.2.3 l_bool ld_is_ready_j2602 (l_ifc_handle *iii*)

Verifies a state of node setting (using for J2602 and LIN 2.0).

Parameters

in	*iii*	LIN interface handle

Returns

l_bool

Definition at line 1502 of file lin_diagnostic_service.c.

16.74.2.4 l_bool ld_reconfig_msg_ID (l_ifc_handle *iii*, l_u8 *dnn*)

This function reconfigures frame identifiers of a J2602 slave node based on input dnn.

Parameters

in	*iii*	LIN interface handle
in	*dnn*	DNN of the device

Returns

l_bool: 0: successful: Frame Identifiers were reconfigured based on input DNN according to NAD Message ID mapping table.
l_bool: 1: Unsuccesfull: for either one of the following reasons:

- The protocol of this interface is not J2602
- This device is a Master node in this interface
- The input DNN is greater than 0xD that is invalid
- The slave has more than 16 configurable frames
- The slave has 9-16 configurable frames, and dnn is 0xC or 0xD
- The slave has 5-8 configurable frames, and dnn is not 0x00, 0x2, 0x4, 0x6, 0x8, 0xA, 0xC.

Definition at line 1622 of file lin_diagnostic_service.c.

16.75 Node configuration

16.75.1 Detailed Description

This group contains APIs that used for node configuration purpose.

With protocol lin2.1 in slave node, some service like (Data dump, Conditional change nad with id from 2 to 255) are not supported by LinStack but user can implement it in application by use function ld_receive_message and ld_send_message in transport layer.

With protocol J2602 in slave node, some service like (Data dump, Assign NAD, Conditional change NAD) are not supported by LinStack but user can implement it in application by choosing these services in supported_sid in PEX GUI and use function ld_receive_message and ld_send_message in transport layer. When received target reset master request slave node just update status_byte and send response positive message.

Functions

- l_u8 ld_is_ready (l_ifc_handle iii)

  This call returns the status of the last requested configuration service.
- void ld_check_response (l_ifc_handle iii, l_u8 ∗const RSID, l_u8 ∗const error_code)

  This call returns the result of the last node configuration service, in the parameters RSID and error_code. A value in RSID is always returned but not always in the error_code. Default values for RSID and error_code is 0 (zero).
- void ld_assign_frame_id_range (l_ifc_handle iii, l_u8 NAD, l_u8 start_index, const l_u8 ∗const PIDs)

  This function assigns the protected identifier of up to four frames.
- void ld_save_configuration (l_ifc_handle iii, l_u8 NAD)

  This function to issue a save configuration request to a slave node.
- l_u8 ld_read_configuration (l_ifc_handle iii, l_u8 ∗const data, l_u8 ∗const length)

  This function copies current configuration in a reserved area.
- l_u8 ld_set_configuration (l_ifc_handle iii, const l_u8 ∗const data, l_u16 length)

  This function configures slave node according to data.
- void ld_assign_NAD (l_ifc_handle iii, l_u8 initial_NAD, l_u16 supplier_id, l_u16 function_id, l_u8 new_NAD)

  This call assigns the NAD (node diagnostic address) of all slave nodes that matches the initial_NAD, the supplier ID and the function ID. Master node only.
- void ld_conditional_change_NAD (l_ifc_handle iii, l_u8 NAD, l_u8 id, l_u8 byte_data, l_u8 mask, l_u8 invert, l_u8 new_NAD)

  This call changes the NAD if the node properties fulfill the test specified by id, byte, mask and invert. Master node only.

16.75.2 Function Documentation

16.75.2.1 void ld_assign_frame_id_range (l_ifc_handle *iii,* l_u8 *NAD,* l_u8 *start_index,* const l_u8 ∗const *PIDs*)

This function assigns the protected identifier of up to four frames.

Parameters

in	*iii*	lin interface handle
in	*NAD*	Node address value of the target node
in	*start_index*	specifies which is the first frame to assign a PID
in	*PIDs*	list of protected identifier

Returns

void

This API is available for master interfaces only

Definition at line 149 of file lin_diagnostic_service.c.

16.75.2.2 void ld_assign_NAD (l_ifc_handle *iii,* l_u8 *initial_NAD,* l_u16 *supplier_id,* l_u16 *function_id,* l_u8 *new_NAD*)

This call assigns the NAD (node diagnostic address) of all slave nodes that matches the initial_NAD, the supplier ID and the function ID. Master node only.

Parameters

in	*iii*	LIN interface handle
in	*initial_NAD*	Initial node address of the target node
in	*supplier_id*	Supplier ID of the target node
in	*function_id*	Function identifier of the target node
in	*new_NAD*	New node address

Returns

void

This call assigns the NAD (node diagnostic address) of all slave nodes that matches the initial_NAD, the supplier ID and the function ID. The new NAD of the slave node will be new_NAD. This function is used for master node only.

Definition at line 845 of file lin_diagnostic_service.c.

16.75.2.3 void ld_check_response (l_ifc_handle *iii,* l_u8 ∗const *RSID,* l_u8 ∗const *error_code*)

This call returns the result of the last node configuration service, in the parameters RSID and error_code. A value in RSID is always returned but not always in the error_code. Default values for RSID and error_code is 0 (zero).

For slave interfaces ld_check_response shall do nothing

Parameters

in	*iii*	lin interface handle
out	*RSID*	buffer for saving the response ID
out	*error_code*	buffer for saving the error code

This API is available for master interfaces only

Definition at line 118 of file lin_diagnostic_service.c.

16.75.2.4 void ld_conditional_change_NAD (l_ifc_handle *iii,* l_u8 *NAD,* l_u8 *id,* l_u8 *byte_data,* l_u8 *mask,* l_u8 *invert,* l_u8 *new_NAD*)

This call changes the NAD if the node properties fulfill the test specified by id, byte, mask and invert. Master node only.

Parameters

in	*iii*	:LIN interface handle
in	*NAD*	Current NAD value of the target node
in	*id*	Property ID of the target node
in	*byte*	Byte location of property value to be read from the target node
in	*mask*	Value for masking the read property byte
in	*invert*	Value for excluding the read property byte
in	*new_NAD*	New NAD value to be assigned when the condition is met

Returns

void

This call changes the NAD if the node properties fulfill the test specified by id, byte, mask and invert.

Definition at line 886 of file lin_diagnostic_service.c.

16.75.2.5 l_u8 ld_is_ready (l_ifc_handle *iii*)

This call returns the status of the last requested configuration service.

Parameters

in	*iii*	lin interface handle

Returns

LD_SERVICE_BUSY Service is ongoing.
LD_REQUEST_FINISHED The configuration request has been completed. This is a intermediate status between the configuration request and configuration response.
LD_SERVICE_IDLE The configuration request/response combination has been completed, i.e. the response is valid and may be analyzed. Also, this value is returned if no request has yet been called.
LD_SERVICE_ERROR The configuration request or response experienced an error. Error here means error on the bus, and not a negative configuration response from the slave node.

Definition at line 92 of file lin_diagnostic_service.c.

16.75.2.6 l_u8 ld_read_configuration (l_ifc_handle *iii,* l_u8 ∗const *data,* l_u8 ∗const *length*)

This function copies current configuration in a reserved area.

Parameters

in	*iii*	Lin interface handle
out	*data*	Data area to save configuration,
out	*length*	Length of data area (1 + n, NAD + PIDs)

Returns

LD_READ_OK If the service was successful.
LD_LENGTH_TOO_SHORT If the configuration size is greater than the length. It means that the data area does not contain a valid configuration.

This function is implemented Slave Only. Set the expected length value to EXP = NN + NF, where : NN = the number of NAD. NF = the number of configurable frames; Moreover: Not taken PID's diagnostics frame: 3C, 3D

Definition at line 446 of file lin_diagnostic_service.c.

16.75.2.7 void ld_save_configuration (l_ifc_handle *iii,* l_u8 *NAD*)

This function to issue a save configuration request to a slave node.

Parameters

in	*iii*	Interface name
in	*NAD*	Node address of target

Returns

void

This function is available for master nodes only. This function is available for all diagnostic classes and only for LIN2.1 and above. This function is called to send a save configuration request to a specific slave node with the given NAD, or to all slave nodes if NAD is set to broadcast This function is implemented for Master Only.

Definition at line 191 of file lin_diagnostic_service.c.

16.75.2.8 l_u8 ld_set_configuration (l_ifc_handle *iii,* const l_u8 ∗const *data,* l_u16 *length*)

This function configures slave node according to data.

Parameters

in	*iii*	Lin interface handle
in	*data*	Structure containing the NAD and all the n PIDs for the frames of the specified NAD,
in	*length*	Length of data area (1 + n, NAD + PIDs)

Returns

LD_SET_OK If the service was successful
LD_LENGTH_NOT_CORRECT If the required size of the configuration is not equal to the given length.
LD_DATA_ERROR The set of configuration could not be made.

This function is implemented Slave Only. Set the expected length value to EXP = NN + NF, where : NN = the number of NAD. NF = the number of configurable frames; Moreover: Not taken PID's diagnostics frame: 3C, 3D

Definition at line 511 of file lin_diagnostic_service.c.

16.76 Node identification

16.76.1 Detailed Description

This group contains API that used for node identification purpose.

Read by identifier service just support id 0 and 1. User can implement for other id by modify function ld_read_by↩ _id_callout in generated file lin_cfg.c.

Functions

- void ld_read_by_id (l_ifc_handle iii, l_u8 NAD, l_u16 supplier_id, l_u16 function_id, l_u8 id, lin_product_id_t ∗const data)

  The call requests the slave node selected with the NAD to return the property associated with the id parameter. Master node only.

16.76.2 Function Documentation

16.76.2.1 void ld_read_by_id (l_ifc_handle *iii,* l_u8 *NAD,* l_u16 *supplier_id,* l_u16 *function_id,* l_u8 *id,* lin_product_id_t ∗const *data*)

The call requests the slave node selected with the NAD to return the property associated with the id parameter. Master node only.

Parameters

in	*iii*	LIN interface handle
in	*NAD*	Value of the target node
in	*supplier_id*	Supplier ID of the target node
in	*function_id*	Function ID of the target node
in	*id*	ID of the target node
out	*data*	Buffer for saving the data read from the node

Returns

void

The call requests the slave node selected with the NAD to return the property associated with the id parameter.

Definition at line 933 of file lin_diagnostic_service.c.

16.77 Notification

This group contains APIs that let users know when a signal's value changed.

16.78 OS Interface (OSIF)

16.78.1 Detailed Description

OS Interface Layer (OSIF)

The OSIF layer is a minimal wrapper layer for common RTOS services, intended to be used by SDK drivers and middlewares. It can be used by the user application, but it is not recommended. The operations supported by OSIF:

- mutex lock/unlock
- semaphore post/wait
- time delay and get time elapsed

OSIF currently comes in two variants: bare-metal and FreeRTOS. Steps to use each one are described below.

FreeRTOS

To integrate the FreeRTOS OSIF variant, two steps are necessary:

- compile and link the osif_freertos.c file
- define a project-wide compile symbol:

  `USING_OS_FREERTOS`

FreeRTOSConfig.h dependencies

FreeRTOS configuration file needs to have these options activated (set to 1 in FreeRTOSConfig.h):

- `INCLUDE_xQueueGetMutexHolder`
- `INCLUDE_xTaskGetCurrentTaskHandle`

Hardware resources

FreeRTOS OSIF uses the FreeRTOS API and services, does not use any additional hardware or software resources.

FreeRTOS supported platforms

The SDK platforms supported by FreeRTOS can be found in the following table. If a platform is supported by FreeRTOS, both osif variants, bare-metal and freertos, are supported. If the platform is not supported by FreeRTOS, only osif bare-metal variant is applicable:

Platform	FreeRTOS support
S32K11x	Yes
S32K14x	Yes
S32K14xW	Yes
MPC5746C	Yes
MPC5748G	Yes
MPC5744P	Yes
S32R274	Yes
S32R372	Yes

FreeRTOS static vs dynamic memory allocation

OSIF objects will use static memory allocation schemes (FreeRTOS 9.0.0 and above) if the feature is enabled.

This should be transparent for the upper layer which uses OSIF.

The FreeRTOS configuration option is

`configSUPPORT_STATIC_ALLOCATION`

If it's set to 1, the OSIF will use static memory allocation.

Bare-metal

To integrate the bare-metal OSIF variant:

- compile and link the osif_baremetal.c file

Mutex operations are dummy operations (always return success) and semaphore is implemented as a simple counter.

Hardware resources

Bare-metal OSIF uses a hardware timer to accurately measure time. The timer and channel used are platform-dependent, are chosen to be the same as the FreeRTOS implementation if possible.

The table below shows which timers and channels are used on each platform:

Platform	Timer	Channel
S32K11x	Systick	N/A
S32K14x	Systick	N/A
S32K14xW	Systick	N/A
MPC5746C	PIT	15
MPC5748G	PIT	15
MPC5744P	PIT	3
S32R274	PIT0	3
S32R372	PIT0	3

Bare-metal timing limitations

For bare-metal OSIF, the timer is initialized at the first call in OSIF that needs timing. That is either OSIF_Time↩Delay, OSIF_MutexLock or OSIF_SemaWait (functions with timeout). The timer configuration, but not the counter, is updated at each subsequent call to these functions.

Do not assume OSIF_GetMilliseconds will return a global value since system initialization. It will return the global value since the very first timer initialization, mentioned above.

Integration guideline

Compilation units

The following files need to be compiled in the project:

- for baremetal variant:

```
${S32SDK_PATH}\rtos\osif\osif_baremetal.c
```

- for FreeRTOS variant:

```
${S32SDK_PATH}\rtos\osif\osif_freertos.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\rtos\osif\
```

Compile symbols

- for baremetal variant: No special symbols are required for this component
- for FreeRTOS variant: The following symbol must be added to the compile symbols of the toolchain:

```
USING_OS_FREERTOS
```

Dependencies

- for baremetal variant:

Clock Manager

Interrupt Manager (Interrupt)

- for FreeRTOS variant:

FreeRTOS

Macros

- #define OSIF_WAIT_FOREVER 0xFFFFFFFFu

Functions

- void OSIF_TimeDelay (const uint32_t delay)
  Delays execution for a number of milliseconds.
- uint32_t OSIF_GetMilliseconds (void)
  Returns the number of miliseconds elapsed since starting the internal timer or starting the scheduler.
- status_t OSIF_MutexLock (const mutex_t *const pMutex, const uint32_t timeout)
  Waits for a mutex and locks it.
- status_t OSIF_MutexUnlock (const mutex_t *const pMutex)
  Unlocks a previously locked mutex.
- status_t OSIF_MutexCreate (mutex_t *const pMutex)
  Create an unlocked mutex.
- status_t OSIF_MutexDestroy (const mutex_t *const pMutex)
  Destroys a previously created mutex.
- status_t OSIF_SemaWait (semaphore_t *const pSem, const uint32_t timeout)
  Decrement a semaphore with timeout.
- status_t OSIF_SemaPost (semaphore_t *const pSem)
  Increment a semaphore.
- status_t OSIF_SemaCreate (semaphore_t *const pSem, const uint8_t initValue)
  Creates a semaphore with a given value.
- status_t OSIF_SemaDestroy (const semaphore_t *const pSem)
  Destroys a previously created semaphore.

16.78.2 Macro Definition Documentation

16.78.2.1 #define OSIF_WAIT_FOREVER 0xFFFFFFFFu

Definition at line 71 of file osif.h.

16.78.3 Function Documentation

16.78.3.1 uint32_t OSIF_GetMilliseconds (void)

Returns the number of miliseconds elapsed since starting the internal timer or starting the scheduler.

Returns

the number of miliseconds elapsed

Definition at line 233 of file osif_baremetal.c.

16.78.3.2 status_t OSIF_MutexCreate (mutex_t *const *pMutex*)

Create an unlocked mutex.

Parameters

in	*pMutex*	reference to the mutex object

Returns

One of the possible status codes:

- STATUS_SUCCESS: mutex created
- STATUS_ERROR: mutex could not be created

Definition at line 281 of file osif_baremetal.c.

16.78.3.3 status_t OSIF_MutexDestroy (const mutex_t *const *pMutex*)

Destroys a previously created mutex.

Parameters

in	*pMutex*	reference to the mutex object

Returns

One of the possible status codes:

- STATUS_SUCCESS: mutex destroyed

Definition at line 295 of file osif_baremetal.c.

16.78.3.4 status_t OSIF_MutexLock (const mutex_t *const *pMutex,* const uint32_t *timeout*)

Waits for a mutex and locks it.

Parameters

in	*pMutex*	reference to the mutex object
in	*timeout*	time-out value in milliseconds

Returns

One of the possible status codes:

- STATUS_SUCCESS: mutex lock operation success
- STATUS_ERROR: mutex already owned by current thread
- STATUS_TIMEOUT: mutex lock operation timed out

Definition at line 251 of file osif_baremetal.c.

16.78.3.5 status_t OSIF_MutexUnlock (const mutex_t *const *pMutex*)

Unlocks a previously locked mutex.

Parameters

in	*pMutex*	reference to the mutex object

Returns

One of the possible status codes:

- STATUS_SUCCESS: mutex unlock operation success
- STATUS_ERROR: mutex unlock failed

Definition at line 267 of file osif_baremetal.c.

16.78.3.6 status_t OSIF_SemaCreate (semaphore_t *const *pSem,* const uint8_t *initValue*)

Creates a semaphore with a given value.

Parameters

in	*pSem*	reference to the semaphore object
in	*initValue*	initial value of the semaphore

Returns

One of the possible status codes:

- STATUS_SUCCESS: semaphore created
- STATUS_ERROR: semaphore could not be created

Definition at line 402 of file osif_baremetal.c.

16.78.3.7 status_t OSIF_SemaDestroy (const semaphore_t *const *pSem*)

Destroys a previously created semaphore.

Parameters

in	*pSem*	reference to the semaphore object

Returns

One of the possible status codes:

- STATUS_SUCCESS: semaphore destroyed

Definition at line 420 of file osif_baremetal.c.

16.78.3.8 status_t OSIF_SemaPost (semaphore_t *const *pSem*)

Increment a semaphore.

Parameters

in	*pSem*	reference to the semaphore object

Returns

One of the possible status codes:

- STATUS_SUCCESS: semaphore post operation success
- STATUS_ERROR: semaphore could not be incremented

Definition at line 375 of file osif_baremetal.c.

16.78.3.9 status_t OSIF_SemaWait (semaphore_t *const *pSem,* const uint32_t *timeout*)

Decrement a semaphore with timeout.

Parameters

in	*pSem*	reference to the semaphore object
in	*timeout*	time-out value in milliseconds

Returns

One of the possible status codes:

- STATUS_SUCCESS: semaphore wait operation success
- STATUS_TIMEOUT: semaphore wait timed out

Definition at line 311 of file osif_baremetal.c.

16.78.3.10 void OSIF_TimeDelay (const uint32_t *delay*)

Delays execution for a number of milliseconds.

Parameters

in	*delay*	Time delay in milliseconds.

Definition at line 208 of file osif_baremetal.c.

16.79 Output Compare - Peripheral Abstraction Layer (OC PAL)

16.79.1 Detailed Description

The S32 SDK provides a Peripheral Abstraction Layer for the output compare mode of S32 SDK devices.

The OC PAL driver allows to set pin, clear pin or toggle pin. It was designed to be portable across all platforms and IPs which support FTM, eMIOS, FlexPWM and eTIMER.

How to integrate OC PAL in your application

Unlike the other drivers, OC PAL modules need to include a configuration file named oc_pal_cfg.h. This one allows the user to specify which IPs are used. The following code example shows how to configure one instance for each available OC IPs.

```
#ifndef OC_PAL_CFG_H
#define OC_PAL_CFG_H

/* Define which IP instance will be used in current project */
#define OC_PAL_OVER_EMIOS

#endif /* OC_PAL_CFG_H */
```

The following table contains the matching between platforms and available IPs

IP/↩ M↩ CU	S32↩ K116	S32↩ K118	S32↩ K142	S32↩ K142↩ W	S32↩ K144	S32↩ K144↩ W	S32↩ K146	S32↩ K148	M↩ P↩ C5748 G	M↩ P↩ C5746 C	M↩ P↩ C5744 P	S32↩ R274	S32↩ R372
FT↩ M↩ _↩ OC	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	NO	NO	NO	NO	NO
e↩ MI↩ O↩ S_↩ OC	NO	NO	NO	NO	NO	NO	NO	NO	Y↩ ES	Y↩ ES	NO	NO	NO
eT↩ IM↩ ER	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	Y↩ ES	Y↩ ES	Y↩ ES
Flex↩ P↩ WM	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	Y↩ ES	Y↩ ES	Y↩ ES

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\pal\src\oc\oc_pal.c
${S32SDK_PATH}\platform\pal\src\oc\oc_irq.c
${S32SDK_PATH}\platform\pal\src\oc\oc_irq.h
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\pal\inc\
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager Interrupt Manager (Interrupt) ftm_oc emios_oc etimer flexpwm

Features

- Set the output signal can be set, cleared, or toggled pin
- Start/stop the channel in the output compare mode
- Force the channel output to high or low level

Functionality

Initialization

In order to use the OC PAL driver it must be first initialized, using OC_Init() function. Once initialized, it should be de-initialized before initialized again for the same OC module instance, using OC_Deinit(). The initialization function does the following operations:

- sets the clock source, clock prescaler
- sets the number of channel output compare are used
- configures the channel output to set or clear or toggle pin

Example:

```
const oc_instance_t oc_pal1_instance = { OC_INST_TYPE_ETIMER, 0U };


channel_extension_etimer_for_oc_t oc_pal1_etimerChnExtension0 =
{
    .primaryInput =
    {
         .source = ETIMER_IN_SRC_CLK_DIV_128,
         .polarity = ETIMER_POLARITY_POSITIVE,
    },
    .outputPin =
    {
         .enable = true,
         .polarity = ETIMER_POLARITY_POSITIVE,
    },
};

oc_output_ch_param_t oc_pal1_ChnConfig[1] =
{
    /* Channel configuration 0 */
    {
         .hwChannelId           = 4U,
         .chMode                = OC_TOGGLE_ON_MATCH,
         .comparedValue         = 62500,
         .channelExtension      = &oc_pal1_etimerChnExtension0,
         .channelCallbackParams = NULL,
         .channelCallbacks      = oc_pal1_channel_callBack0
    }
};

oc_config_t oc_pal1_InitConfig =
{
    .nNumChannels    = 1U,
    .outputChConfig  = oc_pal1_ChnConfig,
    .extension       = NULL
};

/* Initialize output compare mode */
OC_Init(&oc_pal1_instance, &oc_pal1_InitConfig);
```

De-initialize a output compare instance

This function will disable the output compare mode. The driver can't be used again until reinitialized. All register are reset to default value and counter is stopped.

Example:

```
/* De-initialize output compare mode */
OC_Deinit(&oc_pal1_instance);
```

Start the channel in the output compare mode

This function will set the channel is in the output compare mode.

Example:

```
uint8_t hwChannel = oc_pal1_InitConfig.outputChConfig->hwChannelId;

/* Start channel in the output compare  mode */
OC_StartChannel(&oc_pal1_instance, hwChannel);
```

Stop the channel in the output compare mode

This function will set the channel is used in GPIO mode or other peripheral.

Example:

```
uint8_t hwChannel = oc_pal1_InitConfig.outputChConfig->hwChannelId;

/* Stop channel in the output compare mode */
OC_StopChannel(&oc_pal1_instance, hwChannel);
```

Control the channel output by software

This function is used to forces the output pin to a specified value. It can be used to control the output pin value when the OC channel is disabled.

Example:

```
uint8_t hwChannel = oc_pal1_InitConfig.outputChConfig->hwChannelId;

/* Force the channel output by software */
OC_SetOutputState(&oc_pal1_instance, hwChannel, false);
```

Set the operation mode of channel output

This function will set the action executed on a compare match value to set output pin, clear output pin, toggle output pin.

Example:

```
uint8_t hwChannel = oc_pal1_InitConfig.outputChConfig->hwChannelId;

/* Change the channel output to toggle pin */
OC_SetOutputAction(&oc_pal1_instance, hwChannel,
      OC_TOGGLE_ON_MATCH);
```

Update the match value on the channel

This function will update the value of an output compare channel to the counter matches to this value.

Example:

```
uint8_t hwChannel = oc_pal1_InitConfig.outputChConfig->hwChannelId;

/* Set the match counter to new value */
OC_SetCompareValue(&oc_pal1_instance, hwChannel, 0x1000UL,
      OC_RELATIVE_VALUE);
```

Important Notes

- Before using the OC PAL driver the module clock must be configured. Refer to Clock Manager for clock configuration.

- The board specific configurations must be done prior to driver after that can call APIs.
- Some features are not available for all OC IPs and incorrect parameters will be handled by DEV_ASSERT.

Data Structures

- struct oc_output_ch_param_t

  The configuration structure of output compare parameters for each channel. More...
- struct oc_config_t

  Defines the configuration structures are used in the output compare mode. More...
- struct extension_ftm_for_oc_t

  Defines the extension structure for the output compare mode over FTM. More...

Enumerations

- enum oc_option_mode_t { OC_DISABLE_OUTPUT = 0x00U, OC_TOGGLE_ON_MATCH = 0x01U, OC_CLEAR_ON_MATCH = 0x02U, OC_SET_ON_MATCH = 0x03U }

  The type of comparison for output compare mode Implements : oc_option_mode_t_Class.
- enum oc_option_update_t { OC_RELATIVE_VALUE = 0x00U, OC_ABSOLUTE_VALUE = 0x01U }

  The type of update on the channel match Implements : oc_option_update_t_Class.

Functions

- status_t OC_Init (const oc_instance_t *const instance, const oc_config_t *const configPtr)

  Initializes the output compare mode.
- status_t OC_Deinit (const oc_instance_t *const instance)

  De-initialize the output compare instance.
- void OC_StartChannel (const oc_instance_t *const instance, const uint8_t channel)

  Start the counter.
- void OC_StopChannel (const oc_instance_t *const instance, const uint8_t channel)

  Stop the counter.
- status_t OC_SetOutputState (const oc_instance_t *const instance, const uint8_t channel, bool outputValue)

  Control the channel output by software.
- status_t OC_SetOutputAction (const oc_instance_t *const instance, const uint8_t channel, oc_option_mode_t channelMode)

  Set the operation mode of channel output.
- status_t OC_SetCompareValue (const oc_instance_t *const instance, const uint8_t channel, uint32_t nextCompareMatchValue, oc_option_update_t typeOfupdate)

  Update the match value on the channel.
- void OC_EnableNotification (const oc_instance_t *const instance, const uint8_t channel)

  Enable channel notifications.
- void OC_DisableNotification (const oc_instance_t *const instance, const uint8_t channel)

  Disable channel notifications.

16.79.2 Data Structure Documentation

16.79.2.1 struct oc_output_ch_param_t

The configuration structure of output compare parameters for each channel.

Implements : oc_output_ch_param_t_Class

Definition at line 83 of file oc_pal.h.

Data Fields

- uint8_t hwChannelId
- oc_option_mode_t chMode
- uint16_t comparedValue
- void * channelExtension
- void * channelCallbackParams
- oc_callback_t channelCallbacks

Field Documentation

16.79.2.1.1 void* channelCallbackParams

The parameter of callback application for channels event

Definition at line 89 of file oc_pal.h.

16.79.2.1.2 oc_callback_t channelCallbacks

The callback function for channels event

Definition at line 90 of file oc_pal.h.

16.79.2.1.3 void* channelExtension

The IP specific configuration structure for channel

Definition at line 88 of file oc_pal.h.

16.79.2.1.4 oc_option_mode_t chMode

Channel output mode

Definition at line 86 of file oc_pal.h.

16.79.2.1.5 uint16_t comparedValue

The compared value

Definition at line 87 of file oc_pal.h.

16.79.2.1.6 uint8_t hwChannelId

Physical hardware channel ID

Definition at line 85 of file oc_pal.h.

16.79.2.2 struct oc_config_t

Defines the configuration structures are used in the output compare mode.

Implements : oc_config_t_Class

Definition at line 98 of file oc_pal.h.

Data Fields

- uint8_t nNumChannels
- const oc_output_ch_param_t * outputChConfig
- void * extension

Field Documentation

16.79.2.2.1 void* extension

IP specific configuration structure

Definition at line 102 of file oc_pal.h.

16.79.2.2.2 uint8_t nNumChannels

Number of output compare channel used

Definition at line 100 of file oc_pal.h.

16.79.2.2.3 const oc_output_ch_param_t* outputChConfig

Output compare channels configuration

Definition at line 101 of file oc_pal.h.

16.79.2.3 struct extension_ftm_for_oc_t

Defines the extension structure for the output compare mode over FTM.

Part of FTM configuration structure Implements : extension_ftm_for_oc_t_Class

Definition at line 112 of file oc_pal.h.

Data Fields

- uint16_t maxCountValue
- ftm_clock_source_t ftmClockSource
- ftm_clock_ps_t ftmPrescaler

Field Documentation

16.79.2.3.1 ftm_clock_source_t ftmClockSource

Select clock source for FTM

Definition at line 115 of file oc_pal.h.

16.79.2.3.2 ftm_clock_ps_t ftmPrescaler

Register pre-scaler options available in the ftm_clock_ps_t enumeration

Definition at line 116 of file oc_pal.h.

16.79.2.3.3 uint16_t maxCountValue

Maximum count value in ticks

Definition at line 114 of file oc_pal.h.

16.79.3 Enumeration Type Documentation

16.79.3.1 enum oc_option_mode_t

The type of comparison for output compare mode Implements : oc_option_mode_t_Class.

Enumerator

OC_DISABLE_OUTPUT No action on output pin

OC_TOGGLE_ON_MATCH Toggle on match

OC_CLEAR_ON_MATCH Clear on match

OC_SET_ON_MATCH Set on match

Definition at line 60 of file oc_pal.h.

16.79.3.2 enum oc_option_update_t

The type of update on the channel match Implements : oc_option_update_t_Class.

Enumerator

OC_RELATIVE_VALUE Next compared value is relative to current value

OC_ABSOLUTE_VALUE Next compared value is absolute

Definition at line 72 of file oc_pal.h.

16.79.4 Function Documentation

16.79.4.1 status_t OC_Deinit (const oc_instance_t *const *instance*)

De-initialize the output compare instance.

This function will disable the output compare mode. The driver can't be used again until reinitialized. The context structure is no longer needed by the driver and can be freed after calling this function.

Parameters

in	*instance*	The output compare instance number.

Returns

Operation status

- STATUS_SUCCESS: Operation was successful

Definition at line 1126 of file oc_pal.c.

16.79.4.2 void OC_DisableNotification (const oc_instance_t *const *instance,* const uint8_t *channel*)

Disable channel notifications.

This function disables channel notification.

Parameters

in	*instance*	The output compare instance number
in	*channel*	The channel number

Definition at line 1706 of file oc_pal.c.

16.79.4.3 void OC_EnableNotification (const oc_instance_t *const *instance,* const uint8_t *channel*)

Enable channel notifications.

This function enables channel notification.

Parameters

in	*instance*	The output compare instance number
in	*channel*	The channel number

Definition at line 1672 of file oc_pal.c.

16.79.4.4 status_t OC_Init (const oc_instance_t *const *instance,* const oc_config_t *const *configPtr*)

Initializes the output compare mode.

This function will initialize the OC PAL instance, including the other platform specific HW units used together in the output compare mode. This function configures a group of channels in instance to set, clear toggle the output signal.

Parameters

in	*instance*	The output compare instance number.
in	*configPtr*	The pointer to configuration structure.

Returns

Operation status

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 1062 of file oc_pal.c.

16.79.4.5 status_t OC_SetCompareValue (const oc_instance_t *const *instance*, const uint8_t *channel*, uint32_t *nextCompareMatchValue*, oc_option_update_t *typeOfupdate*)

Update the match value on the channel.

This function will update the value of an output compare channel to the counter matches to this value.

Parameters

in	*instance*	The output compare instance number.
in	*channel*	The channel number.
in	*nextCompare↩ MatchValue*	The timer value in ticks until the next compare match event should be appeared.
in	*typeOfupdate*	The type of update: • OC_RELATIVE_VALUE : nextCompareMatchValue will be added to current counter value into the channel value register • OC_ABSOLUTE_VALUE : nextCompareMatchValue will be written into the channel value register

Returns

Operation status

- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 1556 of file oc_pal.c.

16.79.4.6 status_t OC_SetOutputAction (const oc_instance_t *const *instance*, const uint8_t *channel*, oc_option_mode_t *channelMode*)

Set the operation mode of channel output.

This function will set the action executed on a compare match value to set output pin, clear output pin, toggle output pin.

Parameters

in	*instance*	The output compare instance number.
in	*channel*	The channel number.
in	*channelMode*	The channel mode in output compare: • OC_DISABLE_OUTPUT : No action on output pin • OC_TOGGLE_ON_MATCH : Toggle on match • OC_CLEAR_ON_MATCH : Clear on match • OC_SET_ON_MATCH : Set on match

Returns

Operation status
- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 1463 of file oc_pal.c.

16.79.4.7 status_t OC_SetOutputState (const oc_instance_t *const *instance*, const uint8_t *channel*, bool *outputValue*)

Control the channel output by software.

This function is used to forces the output pin to a specified value.

Parameters

in	*instance*	The output compare instance number.
in	*channel*	The channel number.
in	*outputValue*	The output value: • false : The software output control forces 0 to the channel output. • true : The software output control forces 1 to the channel output.

Returns

Operation status
- STATUS_SUCCESS : Completed successfully.
- STATUS_ERROR : Error occurred.

Definition at line 1389 of file oc_pal.c.

16.79.4.8 void OC_StartChannel (const oc_instance_t *const *instance*, const uint8_t *channel*)

Start the counter.

This function start channel counting.

Parameters

in	*instance*	The output compare instance number.
in	*channel*	The channel number.

Definition at line 1240 of file oc_pal.c.

16.79.4.9 void OC_StopChannel (const oc_instance_t *const *instance*, const uint8_t *channel*)

Stop the counter.

This function stop channel output.

Parameters

in	*instance*	The output compare instance number.
in	*channel*	The channel number.

Definition at line 1323 of file oc_pal.c.

16.80 PDB Driver

16.80.1 Detailed Description

Programmable Delay Block Peripheral Driver.

Overview

This section describes the programming interface of the PDB Peripheral driver. The PDB peripheral driver configures the PDB (Programmable Delay Block). It handles the triggers for ADC and pulse out to the CMP and the PDB counter.

The PDB contains a counter whose output is compared to several different digital values. If the PDB is enabled, then a trigger input event will reset the counter and make it start to count. A trigger input event is defined as a rising edge being detected on a selected trigger input source, or if software trigger is selected and a software trigger is issued. Each PDB channel is associated with 1 ADC block, and each PDB channel contains 8 pre-triggers. A pre-trigger has a delay associated and is mapped to an ADC channel; when the PDB counter is equal to the delay value configured for a pre-trigger, the pre-trigger is activated and selects the ADC channel that starts the conversion. Inside a PDB channel, the pre-triggers can be configured to work as chains, meaning that a pre-trigger is enabled automatically when the ADC conversion selected by the previous pre-trigger, completes it's execution. The pre-trigger delays and back-to-back operation must be configured, in such a way that at most one pre-trigger per PDB channel is activated at any given point - otherwise a PDB sequence error occurs. This feature is called back-to-back mode, and needs to be configured individually for each pre-trigger using PDB_DRV_ConfigAdcPreTrigger(). On some devices (depending on availability), chains can be configured between different PDB channels or PDB instances - this can be configured using interchannelBackToBackEnable or instanceBackToBackEnable.

PDB Initialization

For initializing the PDB counter, input triggers or general pre-trigger settings (instance or interchannel back-to-back modes) call **PDB_DRV_Init()** Note that all pre-triggers share the same counter. * The basic timing/counting step is set when initializing the main PDB counter: The basic timing/counting step = F_BusClkHz / pdb_timer_config_t.↩ clkPreDiv / pdb_timer_config_t.clkPreMultFactor

The F_BusClkHz is the frequency of bus clock in Hertz. The "clkPreDiv" and "clkPreMultFactor" are in the pdb_↩ timer_config_t structure. All pre-triggering delayes use this frequency.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
* ${S32SDK_PATH}\platform\drivers\src\pdb\pdb_driver.c
* ${S32SDK_PATH}\platform\drivers\src\pdb\pdb_hw_access.c
*
```

Include path

The following paths need to be added to the include path of the toolchain:

```
* ${S32SDK_PATH}\platform\drivers\inc\
* ${S32SDK_PATH}\platform\drivers\src\pdb\
*
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager Interrupt Manager (Interrupt)

PDB Call diagram

Three kinds of typical use cases are designed for the PDB module.

- Normal Timer/Counter - the basic use-case. The Timer/Counter starts after the PDB is initialized, when the input trigger (hardware or software) is asserted. When the counter reaches the compare value (set via modulus register), an interrupt or DMA transfer occur if enabled. In continuous mode, when the counter reaches the modulus compare value, it resets to zero and starts counting again.
- Triggering for ADC module. Depending on the number of ADC channels that need to be used, each pre-trigger must be configured using PDB_DRV_ConfigAdcPreTrigger(). The PDB counter starts counting whenn the input trigger (hardware or software) is asserted. If the pre-trigger is enabled in normal mode (back-to-back disabled), it will be activated (thus starting the corresponding ADC channel conversion) when the PDB counter is equal with the configured pre-trigger delay. If the pre-trigger is enabled in back-to-back mode, it will trigger the corresponding ADC channel conversion, when the ADC channel corresponding to the previous pre-trigger in the chain, completes the conversion (ADC COCO flag set).
- Generate pulse outputs of configurable width. The Pulse-Out is set to high/low when the PDB counter reaches the values set in POyDLY[DLY1/2], configured via PDB_DRV_SetCmpPulseOutDelayForHigh() or PDB_↩ DRV_SetCmpPulseOutDelayForLow. The Pulse-Out signal is connected to TRGMUX, which can route it to any other peripheral (e.g. can be used as a sample window for any CMP module).

These are the examples to initialize and configure the PDB driver for typical use cases.

Normal Timer/Counter:

```
#define PDB_INSTANCE    0UL

static volatile uint32_t gPdbIntCounter = 0U;
static volatile uint32_t gPdbInstance = 0U;
static void PDB_ISR_Counter(void);
void PDB_TEST_NormalTimer(uint32_t instance)
{
    pdb_timer_config_t PdbTimerConfig;
    PdbTimerConfig.loadValueMode            =
      PDB_LOAD_VAL_IMMEDIATELY;
    PdbTimerConfig.seqErrIntEnable          = false;
    PdbTimerConfig.clkPreDiv                = PDB_CLK_PREDIV_BY_8;
    PdbTimerConfig.clkPreMultFactor         =
      PDB_CLK_PREMULT_FACT_AS_40;
    PdbTimerConfig.triggerInput             = PDB_SOFTWARE_TRIGGER;
    PdbTimerConfig.continuousModeEnable     = true;
    PdbTimerConfig.dmaEnable                = false;
    PdbTimerConfig.intEnable                = true;
    PdbTimerConfig.instanceBackToBackEnable     = false;
    PdbTimerConfig.interchannelBackToBackEnable = false;
    PDB_DRV_Init(instance, &PdbTimerConfig);
    PDB_DRV_SetTimerModulusValue(instance, 0xFFFU);
    PDB_DRV_SetValueForTimerInterrupt(instance, 0xFFU);
    PDB_DRV_LoadValuesCmd(instance);
    gPdbIntCounter = 0U;
    gPdbInstance = instance;
    PDB_DRV_SoftTriggerCmd(instance);
    while (gPdbIntCounter < 20U) {}
    PRINTF("PDB Timer's delay interrupt generated.\r\n");
    PDB_DRV_Deinit(instance);
    PRINTF("OK.\r\n");
}

void PDB_IRQHandler()
{
    PDB_DRV_ClearTimerIntFlag(PDB_INSTANCE);
    if (gPdbIntCounter >= 0xFFFFU)
    {
        gPdbIntCounter = 0U;
    }
    else
    {
        gPdbIntCounter++;
    }
}

#if PDB_INSTANCE < 1
    void PDB0_IRQHandler(void)
    {
        PDB_IRQHandler();
```

```
    }
#elif PDB_INSTANCE < 2
    void PDB1_IRQHandler(void)
    {
        PDB_IRQHandler();
    }
#endif
```

Trigger for ADC module:

```
void PDB_TEST_AdcPreTrigger(uint32_t instance)
{
    pdb_timer_config_t PdbTimerConfig;
    pdb_adc_pretrigger_config_t PdbAdcPreTriggerConfig;
    PdbTimerConfig.loadValueMode            =
      PDB_LOAD_VAL_IMMEDIATELY;
    PdbTimerConfig.seqErrIntEnable          = false;
    PdbTimerConfig.clkPreDiv                = PDB_CLK_PREDIV_BY_8;
    PdbTimerConfig.clkPreMultFactor         =
      PDB_CLK_PREMULT_FACT_AS_40;
    PdbTimerConfig.triggerInput             = PDB_SOFTWARE_TRIGGER;
    PdbTimerConfig.continuousModeEnable     = false;
    PdbTimerConfig.dmaEnable                = false;
    PdbTimerConfig.intEnable                = false;
    PdbTimerConfig.instanceBackToBackEnable     = false;
    PdbTimerConfig.interchannelBackToBackEnable = false;
    PDB_DRV_Init(instance, &PdbTimerConfig);

    PdbAdcPreTriggerConfig.adcPreTriggerIdx             = 0U;
    PdbAdcPreTriggerConfig.preTriggerEnable             = true;
    PdbAdcPreTriggerConfig.preTriggerOutputEnable       = true;
    PdbAdcPreTriggerConfig.preTriggerBackToBackEnable   = false;
    PDB_DRV_ConfigAdcPreTrigger(instance, 0U, &PdbAdcPreTriggerConfig);

    PDB_DRV_SetTimerModulusValue(instance, 0xFFFU);
    PDB_DRV_SetAdcPreTriggerDelayValue(instance, 0U, 0U, 0xFFU);
    PDB_DRV_LoadValuesCmd(instance);
    PDB_DRV_SoftTriggerCmd(instance);
    while (1U != PDB_DRV_GetAdcPreTriggerFlags(instance, 0U, 1U)) {}
    PDB_DRV_ClearAdcPreTriggerFlags(instance, 0U, 1U);
    PRINTF("PDB ADC PreTrigger generated.\r\n");
    PDB_DRV_Deinit(instance);
    PRINTF("OK.\r\n");
}
```

Data Structures

- struct pdb_timer_config_t

  Defines the type of structure for basic timer in PDB. More...
- struct pdb_adc_pretrigger_config_t

  Defines the type of structure for configuring ADC's pre_trigger. More...

Enumerations

- enum pdb_load_value_mode_t { PDB_LOAD_VAL_IMMEDIATELY = 0U, PDB_LOAD_VAL_AT_MODUL↩ O_COUNTER = 1U, PDB_LOAD_VAL_AT_NEXT_TRIGGER = 2U, PDB_LOAD_VAL_AT_MODULO_CO↩ UNTER_OR_NEXT_TRIGGER = 3U }

  Defines the type of value load mode for the PDB module.
- enum pdb_clk_prescaler_div_t {
  PDB_CLK_PREDIV_BY_1 = 0U, PDB_CLK_PREDIV_BY_2 = 1U, PDB_CLK_PREDIV_BY_4 = 2U, PDB_↩ CLK_PREDIV_BY_8 = 3U,
  PDB_CLK_PREDIV_BY_16 = 4U, PDB_CLK_PREDIV_BY_32 = 5U, PDB_CLK_PREDIV_BY_64 = 6U, P↩ DB_CLK_PREDIV_BY_128 = 7U }

  Defines the type of prescaler divider for the PDB counter clock. Implements : pdb_clk_prescaler_div_t_Class.
- enum pdb_trigger_src_t { PDB_TRIGGER_IN0 = 0U, PDB_SOFTWARE_TRIGGER = 15U }

  Defines the type of trigger source mode for the PDB.
- enum pdb_clk_prescaler_mult_factor_t { PDB_CLK_PREMULT_FACT_AS_1 = 0U, PDB_CLK_PREMUL↩ T_FACT_AS_10 = 1U, PDB_CLK_PREMULT_FACT_AS_20 = 2U, PDB_CLK_PREMULT_FACT_AS_40 = 3U }

  Defines the type of the multiplication source mode for PDB.

Functions

- void PDB_DRV_Init (const uint32_t instance, const pdb_timer_config_t *userConfigPtr)

  Initializes the PDB counter and triggers input.
- void PDB_DRV_Deinit (const uint32_t instance)

  De-initializes the PDB module.
- void PDB_DRV_GetDefaultConfig (pdb_timer_config_t *const config)

  Gets the default configuration structure of PDB with default settings.
- void PDB_DRV_Enable (const uint32_t instance)

  Enables the PDB module.
- void PDB_DRV_Disable (const uint32_t instance)

  Disables the PDB module.
- void PDB_DRV_SoftTriggerCmd (const uint32_t instance)

  Triggers the PDB with a software trigger.
- uint32_t PDB_DRV_GetTimerValue (const uint32_t instance)

  Gets the current value of the PDB counter.
- bool PDB_DRV_GetTimerIntFlag (const uint32_t instance)

  Gets the PDB interrupt flag.
- void PDB_DRV_ClearTimerIntFlag (const uint32_t instance)

  Clears the interrupt flag.
- void PDB_DRV_LoadValuesCmd (const uint32_t instance)

  Executes the command of loading values.
- void PDB_DRV_SetTimerModulusValue (const uint32_t instance, const uint16_t value)

  Sets the value of timer modulus.
- void PDB_DRV_SetValueForTimerInterrupt (const uint32_t instance, const uint16_t value)

  Sets the value for the timer interrupt.
- void PDB_DRV_ConfigAdcPreTrigger (const uint32_t instance, const uint32_t chn, const pdb_adc_pretrigger_config_t *configPtr)

  Configures the ADC pre_trigger in the PDB module.
- uint32_t PDB_DRV_GetAdcPreTriggerFlags (const uint32_t instance, const uint32_t chn, const uint32_t preChnMask)

  Gets the ADC pre_trigger flag in the PDB module.
- void PDB_DRV_ClearAdcPreTriggerFlags (const uint32_t instance, const uint32_t chn, const uint32_t preChnMask)

  Clears the ADC pre_trigger flag in the PDB module.
- uint32_t PDB_DRV_GetAdcPreTriggerSeqErrFlags (const uint32_t instance, const uint32_t chn, const uint32_t preChnMask)

  Gets the ADC pre_trigger flag in the PDB module.
- void PDB_DRV_ClearAdcPreTriggerSeqErrFlags (const uint32_t instance, const uint32_t chn, const uint32_t preChnMask)

  Clears the ADC pre_trigger flag in the PDB module.
- void PDB_DRV_SetAdcPreTriggerDelayValue (const uint32_t instance, const uint32_t chn, const uint32_t preChn, const uint32_t value)

  Sets the ADC pre_trigger delay value in the PDB module.
- void PDB_DRV_SetCmpPulseOutEnable (const uint32_t instance, const uint32_t pulseChnMask, bool enable)

  Switches on/off the CMP pulse out in the PDB module.
- void PDB_DRV_SetCmpPulseOutDelayForHigh (const uint32_t instance, const uint32_t pulseChn, const uint32_t value)

  Sets the CMP pulse out delay value for high in the PDB module.
- void PDB_DRV_SetCmpPulseOutDelayForLow (const uint32_t instance, const uint32_t pulseChn, const uint32_t value)

  Sets the CMP pulse out delay value for low in the PDB module.

16.80.2 Data Structure Documentation

16.80.2.1 struct pdb_timer_config_t

Defines the type of structure for basic timer in PDB.

Definition at line 103 of file pdb_driver.h.

Data Fields

- pdb_load_value_mode_t loadValueMode
- bool seqErrIntEnable
- pdb_clk_prescaler_div_t clkPreDiv
- pdb_clk_prescaler_mult_factor_t clkPreMultFactor
- pdb_trigger_src_t triggerInput
- bool continuousModeEnable
- bool dmaEnable
- bool intEnable

Field Documentation

16.80.2.1.1 pdb_clk_prescaler_div_t clkPreDiv

Select the prescaler divider.

Definition at line 107 of file pdb_driver.h.

16.80.2.1.2 pdb_clk_prescaler_mult_factor_t clkPreMultFactor

Select multiplication factor for prescaler.

Definition at line 108 of file pdb_driver.h.

16.80.2.1.3 bool continuousModeEnable

Enable the continuous mode.

Definition at line 110 of file pdb_driver.h.

16.80.2.1.4 bool dmaEnable

Enable the dma for timer.

Definition at line 111 of file pdb_driver.h.

16.80.2.1.5 bool intEnable

Enable the interrupt for timer. : interrupt is generated only if DMA is disabled.

Definition at line 112 of file pdb_driver.h.

16.80.2.1.6 pdb_load_value_mode_t loadValueMode

Select the load mode.

Definition at line 105 of file pdb_driver.h.

16.80.2.1.7 bool seqErrIntEnable

Enable PDB Sequence Error Interrupt.

Definition at line 106 of file pdb_driver.h.

16.80.2.1.8 pdb_trigger_src_t triggerInput

Select the trigger input source.

Definition at line 109 of file pdb_driver.h.

16.80.2.2 struct pdb_adc_pretrigger_config_t

Defines the type of structure for configuring ADC's pre_trigger.

Definition at line 132 of file pdb_driver.h.

Data Fields

- uint32_t adcPreTriggerIdx
- bool preTriggerEnable
- bool preTriggerOutputEnable
- bool preTriggerBackToBackEnable

Field Documentation

16.80.2.2.1 uint32_t adcPreTriggerIdx

Setting pre_trigger's index.

Definition at line 134 of file pdb_driver.h.

16.80.2.2.2 bool preTriggerBackToBackEnable

Enable the back to back mode for ADC pre_trigger. If enabled, the pretrigger will be activated automatically when the ADC COCO flag corresponding to the previous pretrigger in the chain, is set. The previous pretrigger for pretriggers with index 0, depend on features instanceBackToBackEnable and interchannelBackToBackEnable.

Definition at line 137 of file pdb_driver.h.

16.80.2.2.3 bool preTriggerEnable

Enable the pre_trigger.

Definition at line 135 of file pdb_driver.h.

16.80.2.2.4 bool preTriggerOutputEnable

Enable the pre_trigger output.

Definition at line 136 of file pdb_driver.h.

16.80.3 Enumeration Type Documentation

16.80.3.1 enum pdb_clk_prescaler_div_t

Defines the type of prescaler divider for the PDB counter clock. Implements : pdb_clk_prescaler_div_t_Class.

Enumerator

PDB_CLK_PREDIV_BY_1 Counting divided by 1 x prescaler multiplication factor (selected by MULT).

PDB_CLK_PREDIV_BY_2 Counting divided by 2 x prescaler multiplication factor (selected by MULT).

PDB_CLK_PREDIV_BY_4 Counting divided by 4 x prescaler multiplication factor (selected by MULT).

PDB_CLK_PREDIV_BY_8 Counting divided by 8 x prescaler multiplication factor (selected by MULT).

PDB_CLK_PREDIV_BY_16 Counting divided by 16 x prescaler multiplication factor (selected by MULT).

PDB_CLK_PREDIV_BY_32 Counting divided by 32 x prescaler multiplication factor (selected by MULT).

PDB_CLK_PREDIV_BY_64 Counting divided by 64 x prescaler multiplication factor (selected by MULT).

PDB_CLK_PREDIV_BY_128 Counting divided by 128 x prescaler multiplication factor (selected by MULT).

Definition at line 58 of file pdb_driver.h.

16.80.3.2 enum pdb_clk_prescaler_mult_factor_t

Defines the type of the multiplication source mode for PDB.

Selects the multiplication factor of the prescaler divider for the PDB counter clock. Implements : pdb_clk_↩ prescaler_mult_factor_t_Class

Enumerator

PDB_CLK_PREMULT_FACT_AS_1 Multiplication factor is 1.

PDB_CLK_PREMULT_FACT_AS_10 Multiplication factor is 10.

PDB_CLK_PREMULT_FACT_AS_20 Multiplication factor is 20.

PDB_CLK_PREMULT_FACT_AS_40 Multiplication factor is 40.

Definition at line 89 of file pdb_driver.h.

16.80.3.3 enum pdb_load_value_mode_t

Defines the type of value load mode for the PDB module.

Some timing related registers, such as the MOD, IDLY, CHnDLYm, INTx and POyDLY, buffer the setting values. Only the load operation is triggered. The setting value is loaded from a buffer and takes effect. There are four loading modes to fit different applications. Implements : pdb_load_value_mode_t_Class

Enumerator

PDB_LOAD_VAL_IMMEDIATELY Loaded immediately after load operation.

PDB_LOAD_VAL_AT_MODULO_COUNTER Loaded when counter hits the modulo after load operation.

PDB_LOAD_VAL_AT_NEXT_TRIGGER Loaded when detecting an input trigger after load operation.

PDB_LOAD_VAL_AT_MODULO_COUNTER_OR_NEXT_TRIGGER Loaded when counter hits the modulo or detecting an input trigger after load operation.

Definition at line 42 of file pdb_driver.h.

16.80.3.4 enum pdb_trigger_src_t

Defines the type of trigger source mode for the PDB.

Selects the trigger input source for the PDB. The trigger input source can be internal or the software trigger. Implements : pdb_trigger_src_t_Class

Enumerator

PDB_TRIGGER_IN0 Source trigger comes from TRGMUX.

PDB_SOFTWARE_TRIGGER Select software trigger.

Definition at line 77 of file pdb_driver.h.

16.80.4 Function Documentation

16.80.4.1 void PDB_DRV_ClearAdcPreTriggerFlags (const uint32_t *instance,* const uint32_t *chn,* const uint32_t *preChnMask*)

Clears the ADC pre_trigger flag in the PDB module.

This function clears the ADC pre_trigger flags in the PDB module.

Parameters

in	*instance*	PDB instance ID.
in	*chn*	PDB channel.
in	*preChnMask*	ADC pre_trigger channels mask.

Definition at line 379 of file pdb_driver.c.

16.80.4.2 void PDB_DRV_ClearAdcPreTriggerSeqErrFlags (const uint32_t *instance*, const uint32_t *chn*, const uint32_t *preChnMask*)

Clears the ADC pre_trigger flag in the PDB module.

This function clears the ADC pre_trigger sequence error flags in the PDB module.

Parameters

in	*instance*	PDB instance ID.
in	*chn*	PDB channel.
in	*preChnMask*	ADC pre_trigger channels mask.

Definition at line 415 of file pdb_driver.c.

16.80.4.3 void PDB_DRV_ClearTimerIntFlag (const uint32_t *instance*)

Clears the interrupt flag.

This function clears the interrupt flag.

Parameters

in	*instance*	PDB instance ID.

Definition at line 278 of file pdb_driver.c.

16.80.4.4 void PDB_DRV_ConfigAdcPreTrigger (const uint32_t *instance*, const uint32_t *chn*, const pdb_adc_pretrigger_config_t * *configPtr*)

Configures the ADC pre_trigger in the PDB module.

This function configures the ADC pre_trigger in the PDB module. Important note: any pretrigger which is enabled and has the trigger output enabled (preTriggerOutputEnable and preTriggerEnable both true) must have the corresponding delay value set to a non-zero value by calling PDB_DRV_SetAdcPreTriggerDelayValue function.

Parameters

in	*instance*	PDB instance ID.
in	*chn*	PDB channel.
in	*configPtr*	Pointer to the user configuration structure. See pdb_adc_pretrigger_config_t.

Definition at line 340 of file pdb_driver.c.

16.80.4.5 void PDB_DRV_Deinit (const uint32_t *instance*)

De-initializes the PDB module.

This function de-initializes the PDB module. Calling this function shuts down the PDB module and reduces the power consumption.

Parameters

in	*instance*	PDB instance ID.

Definition at line 136 of file pdb_driver.c.

16.80.4.6 void PDB_DRV_Disable (const uint32_t *instance*)

Disables the PDB module.

This function disables the PDB module, counter is off also.

Parameters

in	*instance*	PDB instance ID.

Definition at line 215 of file pdb_driver.c.

16.80.4.7 void PDB_DRV_Enable (const uint32_t *instance*)

Enables the PDB module.

This function enables the PDB module, counter is on.

Parameters

in	*instance*	PDB instance ID.

Definition at line 200 of file pdb_driver.c.

16.80.4.8 uint32_t PDB_DRV_GetAdcPreTriggerFlags (const uint32_t *instance,* const uint32_t *chn,* const uint32_t *preChnMask*)

Gets the ADC pre_trigger flag in the PDB module.

This function gets the ADC pre_trigger flags in the PDB module.

Parameters

in	*instance*	PDB instance ID.
in	*chn*	PDB channel.
in	*preChnMask*	ADC pre_trigger channels mask.

Returns

Assertion of indicated flag.

Definition at line 361 of file pdb_driver.c.

16.80.4.9 uint32_t PDB_DRV_GetAdcPreTriggerSeqErrFlags (const uint32_t *instance,* const uint32_t *chn,* const uint32_t *preChnMask*)

Gets the ADC pre_trigger flag in the PDB module.

This function gets the ADC pre_trigger flags in the PDB module.

Parameters

in	*instance*	PDB instance ID.
in	*chn*	PDB channel.
in	*preChnMask*	ADC pre_trigger channels mask.

Returns

Assertion of indicated flag.

Definition at line 397 of file pdb_driver.c.

16.80.4.10 void PDB_DRV_GetDefaultConfig (pdb_timer_config_t *const *config*)

Gets the default configuration structure of PDB with default settings.

This function initializes the hardware configuration structure to default values (Reference Manual Resets). This function should be called before configuring the hardware feature by PDB_DRV_Init() function, otherwise all members be written by user. This function ensures that all members are written with safe values, but the user still can modify the desired members.

Parameters

out	*config*	Pointer to PDB configuration structure.

Definition at line 164 of file pdb_driver.c.

16.80.4.11 bool PDB_DRV_GetTimerIntFlag (const uint32_t *instance*)

Gets the PDB interrupt flag.

This function gets the PDB interrupt flag. It is asserted if the PDB interrupt occurs.

Parameters

in	*instance*	PDB instance ID.

Returns

Assertion of indicated event.

Definition at line 263 of file pdb_driver.c.

16.80.4.12 uint32_t PDB_DRV_GetTimerValue (const uint32_t *instance*)

Gets the current value of the PDB counter.

This function gets the current counter value.

Parameters

in	*instance*	PDB instance ID.

Returns

Current PDB counter value.

Definition at line 247 of file pdb_driver.c.

16.80.4.13 void PDB_DRV_Init (const uint32_t *instance*, const pdb_timer_config_t * *userConfigPtr*)

Initializes the PDB counter and triggers input.

This function initializes the PDB counter, input triggers and general pre-trigger settings. It resets PDB registers and enables the PDB clock. Therefore, it should be called before any other operation. After it is initialized, the PDB can act as a triggered timer, which enables other features in PDB module.

Parameters

in	*instance*	PDB instance ID.
in	*userConfigPtr*	Pointer to the user configuration structure. See the "pdb_user_config_t".

Definition at line 61 of file pdb_driver.c.

16.80.4.14 void PDB_DRV_LoadValuesCmd (const uint32_t *instance*)

Executes the command of loading values.

This function executes the command of loading values.

Parameters

in	*instance*	PDB instance ID.

Definition at line 293 of file pdb_driver.c.

16.80.4.15 void PDB_DRV_SetAdcPreTriggerDelayValue (const uint32_t *instance*, const uint32_t *chn*, const uint32_t *preChn*, const uint32_t *value*)

Sets the ADC pre_trigger delay value in the PDB module.

This function sets the ADC pre_trigger delay value in the PDB module.

Parameters

instance	PDB instance ID.
chn	ADC channel.
preChn	ADC pre_channel.
value	Setting value.

Definition at line 433 of file pdb_driver.c.

16.80.4.16 void PDB_DRV_SetCmpPulseOutDelayForHigh (const uint32_t *instance*, const uint32_t *pulseChn*, const uint32_t *value*)

Sets the CMP pulse out delay value for high in the PDB module.

This function sets the CMP pulse out delay value for high in the PDB module.

Parameters

in	*instance*	PDB instance ID.
in	*pulseChn*	Pulse channel.
in	*value*	Setting value.

Definition at line 471 of file pdb_driver.c.

16.80.4.17 void PDB_DRV_SetCmpPulseOutDelayForLow (const uint32_t *instance*, const uint32_t *pulseChn*, const uint32_t *value*)

Sets the CMP pulse out delay value for low in the PDB module.

This function sets the CMP pulse out delay value for low in the PDB module.

Parameters

in	*instance*	PDB instance ID.
in	*pulseChn*	Pulse channel.
in	*value*	Setting value.

Definition at line 489 of file pdb_driver.c.

16.80.4.18 void PDB_DRV_SetCmpPulseOutEnable (const uint32_t *instance*, const uint32_t *pulseChnMask*, bool *enable*)

Switches on/off the CMP pulse out in the PDB module.

This function switches the CMP pulse on/off in the PDB module.

Parameters

in	*instance*	PDB instance ID.
in	*pulseChnMask*	Pulse channel mask.

in	*enable*	Switcher to assert the feature.

Definition at line 454 of file pdb_driver.c.

16.80.4.19 void PDB_DRV_SetTimerModulusValue (const uint32_t *instance,* const uint16_t *value*)

Sets the value of timer modulus.

This function sets the value of timer modulus.

Parameters

in	*instance*	PDB instance ID.
in	*value*	Setting value.

Definition at line 308 of file pdb_driver.c.

16.80.4.20 void PDB_DRV_SetValueForTimerInterrupt (const uint32_t *instance,* const uint16_t *value*)

Sets the value for the timer interrupt.

This function sets the value for the timer interrupt.

Parameters

in	*instance*	PDB instance ID.
in	*value*	Setting value.

Definition at line 324 of file pdb_driver.c.

16.80.4.21 void PDB_DRV_SoftTriggerCmd (const uint32_t *instance*)

Triggers the PDB with a software trigger.

This function triggers the PDB with a software trigger. When the PDB is set to use the software trigger as input, calling this function triggers the PDB.

Parameters

in	*instance*	PDB instance ID.

Definition at line 232 of file pdb_driver.c.

16.81 PINS Driver

16.81.1 Detailed Description

This section describes the programming interface of the PINS driver.

Data Structures

- struct pin_settings_config_t

  Defines the converter configuration. More...

Typedefs

- typedef uint8_t pins_level_type_t

  Type of a port levels representation. Implements : pins_level_type_t_Class.

Enumerations

- enum port_data_direction_t { GPIO_INPUT_DIRECTION = 0x0U, GPIO_OUTPUT_DIRECTION = 0x1U, GPIO_UNSPECIFIED_DIRECTION = 0x2U }

  Configures the port data direction Implements : port_data_direction_t_Class.

PINS DRIVER API.

- status_t PINS_DRV_Init (uint32_t pinCount, const pin_settings_config_t config[])

  Initializes the pins with the given configuration structure.
- void PINS_DRV_WritePin (GPIO_Type *const base, pins_channel_type_t pin, pins_level_type_t value)

  Write a pin of a port with a given value.
- void PINS_DRV_WritePins (GPIO_Type *const base, pins_channel_type_t pins)

  Write all pins of a port.
- pins_channel_type_t PINS_DRV_GetPinsOutput (const GPIO_Type *const base)

  Get the current output from a port.
- void PINS_DRV_SetPins (GPIO_Type *const base, pins_channel_type_t pins)

  Write pins with 'Set' value.
- void PINS_DRV_ClearPins (GPIO_Type *const base, pins_channel_type_t pins)

  Write pins to 'Clear' value.
- void PINS_DRV_TogglePins (GPIO_Type *const base, pins_channel_type_t pins)

  Toggle pins value.
- pins_channel_type_t PINS_DRV_ReadPins (const GPIO_Type *const base)

  Read input pins.

16.81.2 Data Structure Documentation

16.81.2.1 struct pin_settings_config_t

Defines the converter configuration.

This structure is used to configure the pins Implements : pin_settings_config_t_Class

Definition at line 565 of file pins_driver.h.

Data Fields

- uint32_t pinPortIdx
- port_mux_t mux

  Pin (C55: Out) mux selection.
- GPIO_Type * gpioBase
- port_data_direction_t direction
- pins_level_type_t initValue

Field Documentation

16.81.2.1.1 port_data_direction_t direction

Configures the port data direction.

Definition at line 602 of file pins_driver.h.

16.81.2.1.2 GPIO_Type* gpioBase

GPIO base pointer.

Definition at line 601 of file pins_driver.h.

16.81.2.1.3 pins_level_type_t initValue

Initial value

Definition at line 638 of file pins_driver.h.

16.81.2.1.4 port_mux_t mux

Pin (C55: Out) mux selection.

Definition at line 588 of file pins_driver.h.

16.81.2.1.5 uint32_t pinPortIdx

Port pin number.

Definition at line 572 of file pins_driver.h.

16.81.3 Typedef Documentation

16.81.3.1 typedef uint8_t pins_level_type_t

Type of a port levels representation. Implements : pins_level_type_t_Class.

Definition at line 53 of file pins_driver.h.

16.81.4 Enumeration Type Documentation

16.81.4.1 enum port_data_direction_t

Configures the port data direction Implements : port_data_direction_t_Class.

Enumerator

GPIO_INPUT_DIRECTION General purpose input direction.

GPIO_OUTPUT_DIRECTION General purpose output direction.

GPIO_UNSPECIFIED_DIRECTION General purpose unspecified direction.

Definition at line 59 of file pins_driver.h.

16.81.5 Function Documentation

16.81.5.1 void PINS_DRV_ClearPins (GPIO_Type ∗const *base,* pins_channel_type_t *pins*)

Write pins to 'Clear' value.

This function configures output pins listed in parameter pins (bits that are '1') to have a 'cleared' value (LOW). Pins corresponding to '0' will be unaffected.

Parameters

in	*base*	GPIO base pointer (PTA, PTB, PTC, etc.)
in	*pins*	Pin mask of bits to be cleared. Each bit represents one pin (LSB is pin 0, MSB is pin 31). For each bit: • 0: corresponding pin is unaffected • 1: corresponding pin is cleared(set to LOW)

Definition at line 526 of file pins_driver.c.

16.81.5.2 pins_channel_type_t PINS_DRV_GetPinsOutput (const GPIO_Type ∗const *base*)

Get the current output from a port.

This function returns the current output that is written to a port. Only pins that are configured as output will have meaningful values.

Parameters

in	*base*	GPIO base pointer (PTA, PTB, PTC, etc.)

Returns

GPIO outputs. Each bit represents one pin (LSB is pin 0, MSB is pin 31). For each bit:

- 0: corresponding pin is set to LOW
- 1: corresponding pin is set to HIGH

Definition at line 497 of file pins_driver.c.

16.81.5.3 status_t PINS_DRV_Init (uint32_t *pinCount,* const pin_settings_config_t *config[ ]*)

Initializes the pins with the given configuration structure.

This function configures the pins with the options provided in the provided structure.

Parameters

in	*pinCount*	The number of configured pins in structure
in	*config*	The configuration structure

Returns

The status of the operation

Definition at line 50 of file pins_driver.c.

16.81.5.4 pins_channel_type_t PINS_DRV_ReadPins (const GPIO_Type ∗const *base*)

Read input pins.

This function returns the current input values from a port. Only pins configured as input will have meaningful values.

Parameters

in	*base*	GPIO base pointer (PTA, PTB, PTC, etc.)

Returns

GPIO inputs. Each bit represents one pin (LSB is pin 0, MSB is pin 31). For each bit:

- 0: corresponding pin is read as LOW
- 1: corresponding pin is read as HIGH

Definition at line 554 of file pins_driver.c.

16.81.5.5 void PINS_DRV_SetPins (GPIO_Type ∗const *base,* pins_channel_type_t *pins*)

Write pins with 'Set' value.

This function configures output pins listed in parameter pins (bits that are '1') to have a value of 'set' (HIGH). Pins corresponding to '0' will be unaffected.

Parameters

in	*base*	GPIO base pointer (PTA, PTB, PTC, etc.)
in	*pins*	Pin mask of bits to be set. Each bit represents one pin (LSB is pin 0, MSB is pin 31). For each bit: • 0: corresponding pin is unaffected • 1: corresponding pin is set to HIGH

Definition at line 511 of file pins_driver.c.

16.81.5.6 void PINS_DRV_TogglePins (GPIO_Type ∗const *base,* pins_channel_type_t *pins*)

Toggle pins value.

This function toggles output pins listed in parameter pins (bits that are '1'). Pins corresponding to '0' will be unaffected.

Parameters

in	*base*	GPIO base pointer (PTA, PTB, PTC, etc.)
in	*pins*	Pin mask of bits to be toggled. Each bit represents one pin (LSB is pin 0, MSB is pin 31). For each bit: • 0: corresponding pin is unaffected • 1: corresponding pin is toggled

Definition at line 540 of file pins_driver.c.

16.81.5.7 void PINS_DRV_WritePin (GPIO_Type ∗const *base,* pins_channel_type_t *pin,* pins_level_type_t *value*)

Write a pin of a port with a given value.

This function writes the given pin from a port, with the given value ('0' represents LOW, '1' represents HIGH).

Parameters

in	*base*	GPIO base pointer (PTA, PTB, PTC, etc.)

in	*pin*	Pin number to be written
in	*value*	Pin value to be written • 0: corresponding pin is set to LOW • 1: corresponding pin is set to HIGH

Definition at line 468 of file pins_driver.c.

16.81.5.8 void PINS_DRV_WritePins (GPIO_Type *const *base,* pins_channel_type_t *pins*)

Write all pins of a port.

This function writes all pins configured as output with the values given in the parameter pins. '0' represents LOW, '1' represents HIGH.

Parameters

in	*base*	GPIO base pointer (PTA, PTB, PTC, etc.)
in	*pins*	Pin mask to be written • 0: corresponding pin is set to LOW • 1: corresponding pin is set to HIGH

Definition at line 483 of file pins_driver.c.

16.82 Peripheral access layer for S32K142W

This module covers all memory mapped register available on SoC.

16.83 Pins Driver (PINS)

16.83.1 Detailed Description

The S32 SDK provides Peripheral Drivers for the PINS module of S32K1xx, S32MTV, S32V234, MPC574xx and S32Rx7x devices.

The module provides dedicated pad control to general-purpose pads that can be configured as either inputs or outputs. The PINS module provides registers that enable user software to read values from GPIO pads configured as inputs, and write values to GPIO pads configured as outputs:

- When configured as output, you can write to an internal register to control the state driven on the associated output pad.
- When configured as input, you can detect the state of the associated pad by reading the value from an internal register.
- When configured as input and output, the pad value can be read back, which can be used as a method of checking if the written value appeared on the pad.

The PINS supports these following features: For S32K1xx and S32MTV devices: Pins driver is based on PORT (Port Control and Interrupt) and GPIO (General-Purpose Input/Output) modules Pin interrupt

- Interrupt flag and enable registers for each pin
- Support for edge sensitive (rising, falling, both) or level sensitive (low, high) configured per pin
- Support for interrupt or DMA request configured per pin
- Asynchronous wake-up in low-power modes
- Pin interrupt is functional in all digital pin muxing modes
- Peripheral trigger output (active high, low) configured per pin Digital input filter
- Digital input filter for each pin, usable by any digital peripheral muxed onto the pin
- Individual enable or bypass control field per pin
- Selectable clock source for digital input filter with a five bit resolution on filter size
- Functional in all digital pin multiplexing modes Port control
- Individual pull control fields with pullup, pulldown, and pull-disable support
- Individual drive strength field supporting high and low drive strength
- Individual slew rate field supporting fast and slow slew rates
- Individual input passive filter field supporting enable and disable of the individual input passive filter
- Individual open drain field supporting enable and disable of the individual open drain output
- Individual over-current detect enable with over-current detect flag and associated interrupt
- Individual mux control field supporting analog or pin disabled, GPIO, and up to 6 chip-specific digital functions
- Pad configuration fields are functional in all digital pin muxing modes For S32V234, MPC574xx and S32Rx7x devices: Pins driver is based on SIUL2 (System Integration Unit Lite2) module The System Integration Unit Lite2 supports these distinctive features:
- 1 to 32 GPIO ports with data control
- Drive data to as many as 16 independent I/O channels
- Sample data from as many as 16 independent I/O channels Two 16-bit registers can be read/written with one access for a 32-bit port, if needed. External interrupt/DMA request support with:

- 1 to 4 system interrupt vectors for 1 to 4 interrupt sources with independent interrupt masks. For 32 external interrupt sources (REQ pins), four groups have eight interrupt sources each, and each of the four groups is assigned one system interrupt vector.
- 1 to 32 programmable digital glitch filters, one for each REQ pin
- 1 to 4 system DMA request channels up to 32 REQ pins, depending on device using
- Edge detection Additionally the SIUL2 contains the Multiplexed Signal Configuration Registers (MSCR) that configure the electrical parameters and settings for as many as 512 functional pads. The number of these registers that is actually implemented varies by device. These registers configure the following pad features:
- Drive strength
- Output impedance control
- Open drain/source output enable
- Slew rate control
- Hysteresis control
- Inversion control
- Internal pull control and pull selection
- Pin function assignment
- Control of analog path switches
- Safe mode behavior configuration

Modules

- PINS Driver

16.84 Power Manager

16.84.1 Detailed Description

The S32 SDK Power Manager provides a set of API/services that enables applications to configure and select among various operational and low power modes.

Driver consideration

The Power Manager driver is developed on top of an appropriate hardware access layer. The Power Manager provides API to handle the device power modes. It also supports run-time switching between multiple power modes. Each power mode is described by configuration structures with multiple power-related options. The Power Manager provides a notification mechanism for registered callbacks and API for static and dynamic callback registration.

The Driver uses structures for configuration. The actual format of the structure is defined by the underlying device specific header file. There is a power mode and a callback configuration structure. These structures may be generated using Processor Expert. The user application can use the default for most settings, changing only what is necessary.

This driver provides functions for initializing power manager and changing the power mode.

All methods that access the hardware layer will return an error code to signal if the operation succeeded or failed. The values are defined by the status_t enumeration, and the possible values include: success, switch error, callback notification errors, wrong clock setup error.

Modules

- Power Manager Driver

  This module covers the device-specific power_manager functionality implemented for S32K1xx, s32k14xW and S32MTV SOC.
- Power_s32k1xx

Data Structures

- struct power_manager_notify_struct_t

  Power mode user configuration structure. More...
- struct power_manager_callback_user_config_t

  callback configuration structure More...
- struct power_manager_state_t

  Power manager internal state structure. More...

Typedefs

- typedef void power_manager_callback_data_t

  Callback-specific data.
- typedef status_t(∗ power_manager_callback_t) (power_manager_notify_struct_t ∗notify, power_manager_↩ callback_data_t ∗dataPtr)

  Callback prototype.

Enumerations

- enum power_manager_policy_t { POWER_MANAGER_POLICY_AGREEMENT, POWER_MANAGER_P↩ OLICY_FORCIBLE }

  Power manager policies.
- enum power_manager_notify_t { POWER_MANAGER_NOTIFY_RECOVER = 0x00U, POWER_MANAGE↩ R_NOTIFY_BEFORE = 0x01U, POWER_MANAGER_NOTIFY_AFTER = 0x02U }

The PM notification type. Used to notify registered callbacks. Callback notifications can be invoked in following situations:

- enum power_manager_callback_type_t { POWER_MANAGER_CALLBACK_BEFORE = 0x01U, POWER_MANAGER_CALLBACK_AFTER = 0x02U, POWER_MANAGER_CALLBACK_BEFORE_AFTER = 0x03U }

  The callback type indicates when a callback will be invoked.

Functions

- status_t POWER_SYS_Init (power_manager_user_config_t *(*powerConfigsPtr)[ ], uint8_t configsNumber, power_manager_callback_user_config_t *(*callbacksPtr)[ ], uint8_t callbacksNumber)

  Power manager initialization for operation.
- status_t POWER_SYS_Deinit (void)

  This function deinitializes the Power manager.
- status_t POWER_SYS_SetMode (uint8_t powerModeIndex, power_manager_policy_t policy)

  This function configures the power mode.
- status_t POWER_SYS_GetLastMode (uint8_t *powerModeIndexPtr)

  This function returns the last successfully set power mode.
- status_t POWER_SYS_GetLastModeConfig (power_manager_user_config_t **powerModePtr)

  This function returns the user configuration structure of the last successfully set power mode.
- power_manager_modes_t POWER_SYS_GetCurrentMode (void)

  This function returns currently running power mode.
- uint8_t POWER_SYS_GetErrorCallbackIndex (void)

  This function returns the last failed notification callback.
- power_manager_callback_user_config_t * POWER_SYS_GetErrorCallback (void)

  This function returns the callback configuration structure for the last failed notification.
- void POWER_SYS_GetDefaultConfig (power_manager_user_config_t *const config)

  This function returns the default power_manager configuration structure.

Variables

- power_manager_state_t gPowerManagerState

  Power manager internal structure.

16.84.2 Data Structure Documentation

16.84.2.1 struct power_manager_notify_struct_t

Power mode user configuration structure.

This structure defines power mode with additional power options. This structure is implementation-defiend. Please refer to actual definition based on the underlying HAL (SMC, MC_ME etc). Applications may define multiple power modes and switch between them. A list of all defined power modes is passed to the Power manager during initialization as an array of references to structures of this type (see POWER_SYS_Init()). Power modes can be switched by calling POWER_SYS_SetMode(), which takes as argument the index of the reqested power mode in the list passed during manager initialization. The power mode currently in use can be retrieved by calling POWER_SYS_GetLastMode(), which provides the index of the current power mode, or by calling POWER_SYS_GetLastModeConfig(), which provides a pointer to the configuration structure of the current power mode. The members of the power mode configuration structure depend on power options available for a specific chip, and includes at least the power mode. The available power modes are chip-specific. See power_manager_modes_t defined in the underlying HAL for a list of all supported modes.

Power notification structure passed to registered callback function

Implements power_manager_notify_struct_t_Class

Definition at line 140 of file power_manager.h.

Data Fields

- power_manager_user_config_t * targetPowerConfigPtr
- uint8_t targetPowerConfigIndex
- power_manager_policy_t policy
- power_manager_notify_t notifyType

Field Documentation

16.84.2.1.1 power_manager_notify_t notifyType

Power mode notification type.

Definition at line 145 of file power_manager.h.

16.84.2.1.2 power_manager_policy_t policy

Power mode transition policy.

Definition at line 144 of file power_manager.h.

16.84.2.1.3 uint8_t targetPowerConfigIndex

Target power configuration index.

Definition at line 143 of file power_manager.h.

16.84.2.1.4 power_manager_user_config_t* targetPowerConfigPtr

Pointer to target power configuration

Definition at line 142 of file power_manager.h.

16.84.2.2 struct power_manager_callback_user_config_t

callback configuration structure

This structure holds configuration of callbacks passed to the Power manager during its initialization. Structures of this type are expected to be statically allocated. This structure contains following application-defined data: callback - pointer to the callback function callbackType - specifies when the callback is called callbackData - pointer to the data passed to the callback Implements power_manager_callback_user_config_t_Class

Definition at line 185 of file power_manager.h.

Data Fields

- power_manager_callback_t callbackFunction
- power_manager_callback_type_t callbackType
- power_manager_callback_data_t * callbackData

Field Documentation

16.84.2.2.1 power_manager_callback_data_t* callbackData

Definition at line 189 of file power_manager.h.

16.84.2.2.2 power_manager_callback_t callbackFunction

Definition at line 187 of file power_manager.h.

16.84.2.2.3 power_manager_callback_type_t callbackType

Definition at line 188 of file power_manager.h.

16.84.2.3 struct power_manager_state_t

Power manager internal state structure.

Power manager internal structure. Contains data necessary for Power manager proper functionality. Stores references to registered power mode configurations, callbacks, and other internal data. This structure is statically allocated and initialized by POWER_SYS_Init(). Implements power_manager_state_t_Class

Definition at line 201 of file power_manager.h.

Data Fields

- power_manager_user_config_t *(* configs)[ ]
- uint8_t configsNumber
- power_manager_callback_user_config_t *(* staticCallbacks)[ ]
- uint8_t staticCallbacksNumber
- uint8_t errorCallbackIndex
- uint8_t currentConfig

Field Documentation

16.84.2.3.1 power_manager_user_config_t*(* configs)[ ]

Pointer to power configure table.

Definition at line 203 of file power_manager.h.

16.84.2.3.2 uint8_t configsNumber

Number of power configurations

Definition at line 204 of file power_manager.h.

16.84.2.3.3 uint8_t currentConfig

Index of current configuration.

Definition at line 208 of file power_manager.h.

16.84.2.3.4 uint8_t errorCallbackIndex

Index of callback returns error.

Definition at line 207 of file power_manager.h.

16.84.2.3.5 power_manager_callback_user_config_t*(* staticCallbacks)[ ]

Pointer to callback table.

Definition at line 205 of file power_manager.h.

16.84.2.3.6 uint8_t staticCallbacksNumber

Max. number of callback configurations

Definition at line 206 of file power_manager.h.

16.84.3 Typedef Documentation

16.84.3.1 typedef void power_manager_callback_data_t

Callback-specific data.

Pointer to data of this type is passed during callback registration. The pointer is part of the power_manager_callback_user_config_t structure and is passed to the callback during power mode change notifications. Implements power_manager_callback_data_t_Class

Definition at line 115 of file power_manager.h.

16.84.3.2 typedef status_t(* power_manager_callback_t) (power_manager_notify_struct_t *notify, power_manager_callback_data_t *dataPtr)

Callback prototype.

Declaration of callback. It is common for all registered callbacks. Function pointer of this type is part of power_manager_callback_user_config_t callback configuration structure. Depending on the callback type, the callback function is invoked during power mode change (see POWER_SYS_SetMode()) before the mode change, after it, or in both cases to notify about the change progress (see power_manager_callback_type_t). When called, the type of the notification is passed as parameter along with a pointer to power mode configuration structure (see power_manager_notify_struct_t) and any data passed during the callback registration (see power_manager_callback_data_t). When notified before a mode change, depending on the power mode change policy (see power_manager_policy_t) the callback may deny the mode change by returning any error code other than STATUS_SUCCESS (see POWER_SYS_SetMode()).

Parameters

notify	Notification structure.
dataPtr	Callback data. Pointer to the data passed during callback registration. Intended to pass any driver or application data such as internal state information.

Returns

An error code or STATUS_SUCCESS. Implements power_manager_callback_t_Class

Definition at line 169 of file power_manager.h.

16.84.4 Enumeration Type Documentation

16.84.4.1 enum power_manager_callback_type_t

The callback type indicates when a callback will be invoked.

Used in the callback configuration structures (power_manager_callback_user_config_t) to specify when the registered callback will be called during power mode change initiated by POWER_SYS_SetMode().

Implements power_manager_callback_type_t_Class

Enumerator

POWER_MANAGER_CALLBACK_BEFORE Before callback.

POWER_MANAGER_CALLBACK_AFTER After callback.

POWER_MANAGER_CALLBACK_BEFORE_AFTER Before-After callback.

Definition at line 100 of file power_manager.h.

16.84.4.2 enum power_manager_notify_t

The PM notification type. Used to notify registered callbacks. Callback notifications can be invoked in following situations:

- before a power mode change (Callback return value can affect POWER_SYS_SetMode() execution. Refer to the POWER_SYS_SetMode() and power_manager_policy_t documentation).
- after a successful change of the power mode.

- after an unsuccessful attempt to switch power mode, in order to recover to a working state. Implements power_manager_notify_t_Class

Enumerator

POWER_MANAGER_NOTIFY_RECOVER Notify IP to recover to previous work state.

POWER_MANAGER_NOTIFY_BEFORE Notify IP that the system will change the power setting.

POWER_MANAGER_NOTIFY_AFTER Notify IP that the system has changed to a new power setting.

Definition at line 84 of file power_manager.h.

16.84.4.3 enum power_manager_policy_t

Power manager policies.

Defines whether the mode switch initiated by the POWER_SYS_SetMode() is agreed upon (depending on the result of notification callbacks), or forced. For POWER_MANAGER_POLICY_FORCIBLE the power mode is changed regardless of the callback results, while for POWER_MANAGER_POLICY_AGREEMENT policy any error code returned by one of the callbacks aborts the mode change. See also POWER_SYS_SetMode() description. Implements power_manager_policy_t_Class

Enumerator

POWER_MANAGER_POLICY_AGREEMENT Power mode is changed if all of the callbacks return success.

POWER_MANAGER_POLICY_FORCIBLE Power mode is changed regardless of the result of callbacks.

Definition at line 69 of file power_manager.h.

16.84.5 Function Documentation

16.84.5.1 status_t POWER_SYS_Deinit (void)

This function deinitializes the Power manager.

Returns

An error code or STATUS_SUCCESS.

Definition at line 110 of file power_manager.c.

16.84.5.2 power_manager_modes_t POWER_SYS_GetCurrentMode (void)

This function returns currently running power mode.

This function reads hardware settings and returns currently running power mode.

Returns

Currently used run power mode.

Definition at line 244 of file power_manager_S32K1xx.c.

16.84.5.3 void POWER_SYS_GetDefaultConfig (power_manager_user_config_t *const *config*)

This function returns the default power_manager configuration structure.

This function returns a pointer of the power_manager configuration structure. All structure members have default value when CPU is default power mode.

Definition at line 406 of file power_manager.c.

16.84.5.4 power_manager_callback_user_config_t* POWER_SYS_GetErrorCallback (void)

This function returns the callback configuration structure for the last failed notification.

This function returns a pointer to configuration structure of the last callback that failed during the power mode switch when POWER_SYS_SetMode() was called. If the last POWER_SYS_SetMode() call ended successfully, a NULL value is returned.

Returns

Pointer to the callback configuration which returns error.

Definition at line 208 of file power_manager.c.

16.84.5.5 uint8_t POWER_SYS_GetErrorCallbackIndex (void)

This function returns the last failed notification callback.

This function returns the index of the last callback that failed during the power mode switch when POWER_SY↩S_SetMode() was called. The returned value represents the index in the array of registered callbacks. If the last POWER_SYS_SetMode() call ended successfully, a value equal to the number of registered callbacks is returned.

Returns

Callback index of last failed callback or value equal to callbacks count.

Definition at line 196 of file power_manager.c.

16.84.5.6 status_t POWER_SYS_GetLastMode (uint8_t * *powerModeIndexPtr*)

This function returns the last successfully set power mode.

This function returns index of power mode which was last set using POWER_SYS_SetMode(). If the power mode was entered even though some of the registered callbacks denied the mode change, or if any of the callbacks invoked after the entering/restoring run mode failed, then the return code of this function has STATUS_ERROR value.

Parameters

out	*powerMode*↩*IndexPtr*	Power mode which has been set represented as an index into array of power mode configurations passed to the POWER_SYS_Init().

Returns

An error code or STATUS_SUCCESS.

Definition at line 133 of file power_manager.c.

16.84.5.7 status_t POWER_SYS_GetLastModeConfig (power_manager_user_config_t ** *powerModePtr*)

This function returns the user configuration structure of the last successfully set power mode.

This function returns a pointer to configuration structure which was last set using POWER_SYS_SetMode(). If the current power mode was entered even though some of the registered callbacks denied the mode change, or if any of the callbacks invoked after the entering/restoring run mode failed, then the return code of this function has STATUS_ERROR value.

Parameters

out	*powerModePtr*	Pointer to power mode configuration structure of the last set power mode.

Returns

An error code or STATUS_SUCCESS.

Definition at line 165 of file power_manager.c.

16.84.5.8 status_t POWER_SYS_Init (power_manager_user_config_t ∗(∗) *powerConfigsPtr[ ],* uint8_t *configsNumber,* power_manager_callback_user_config_t ∗(∗) *callbacksPtr[ ],* uint8_t *callbacksNumber*)

Power manager initialization for operation.

This function initializes the Power manager and its run-time state structure. Pointer to an array of Power mode configuration structures needs to be passed as a parameter along with a parameter specifying its size. At least one power mode configuration is required. Optionally, pointer to the array of predefined callbacks can be passed with its corresponding size parameter. For details about callbacks, refer to the power_manager_callback_user_config_t. As Power manager stores only pointers to arrays of these structures, they need to exist and be valid for the entire life cycle of Power manager.

Parameters

in	*powerConfigsPtr*	A pointer to an array of pointers to all power configurations which will be handled by Power manager.
in	*configsNumber*	Number of power configurations. Size of powerConfigsPtr array.
in	*callbacksPtr*	A pointer to an array of pointers to callback configurations. If there are no callbacks to register during Power manager initialization, use NULL value.
in	*callbacks↩ Number*	Number of registered callbacks. Size of callbacksPtr array.

Returns

An error code or STATUS_SUCCESS.

Definition at line 70 of file power_manager.c.

16.84.5.9 status_t POWER_SYS_SetMode (uint8_t *powerModeIndex,* power_manager_policy_t *policy*)

This function configures the power mode.

This function switches to one of the defined power modes. Requested mode number is passed as an input parameter. This function notifies all registered callback functions before the mode change (using POWER_MANAGE↩ R_CALLBACK_BEFORE set as callback type parameter), sets specific power options defined in the power mode configuration and enters the specified mode. In case of run modes (for example, Run, Very low power run, or High speed run), this function also invokes all registered callbacks after the mode change (using POWER_MANAGER↩ _CALLBACK_AFTER). In case of sleep or deep sleep modes, if the requested mode is not exited through a reset, these notifications are sent after the core wakes up. Callbacks are invoked in the following order: All registered callbacks are notified ordered by index in the callbacks array (see callbacksPtr parameter of POWER_SYS_Init()). The same order is used for before and after switch notifications. The notifications before the power mode switch can be used to obtain confirmation about the change from registered callbacks. If any registered callback denies the power mode change, further execution of this function depends on mode change policy: the mode change is either forced(POWER_MANAGER_POLICY_FORCIBLE) or aborted(POWER_MANAGER_POLICY_AGREE↩ MENT). When mode change is forced, the results of the before switch notifications are ignored. If agreement is requested, in case any callback returns an error code then further before switch notifications are cancelled and all already notified callbacks are re-invoked with POWER_MANAGER_CALLBACK_AFTER set as callback type parameter. The index of the callback which returned error code during pre-switch notifications is stored and can be obtained by using POWER_SYS_GetErrorCallback(). Any error codes during callbacks re-invocation (recover phase) are ignored. POWER_SYS_SetMode() returns an error code denoting the phase in which a callback failed. It is possible to enter any mode supported by the processor. Refer to the chip reference manual for the list of available power modes. If it is necessary to switch into an intermediate power mode prior to entering the requested

mode (for example, when switching from Run into Very low power wait through Very low power run mode), then the intermediate mode is entered without invoking the callback mechanism.

Parameters

in	*powerMode↩ Index*	Requested power mode represented as an index into array of user-defined power mode configurations passed to the POWER_SYS_Init().
in	*policy*	Transaction policy

Returns

An error code or STATUS_SUCCESS.

Definition at line 323 of file power_manager.c.

16.84.6 Variable Documentation

16.84.6.1 power_manager_state_t gPowerManagerState

Power manager internal structure.

Definition at line 52 of file power_manager_S32K1xx.c.

16.85 Power Manager Driver

This module covers the device-specific power_manager functionality implemented for S32K1xx, s32k14xW and S32MTV SOC.

Hardware background

System mode controller (SMC) is passing the system into and out of all low-power Stop and Run modes.
Controls the power, clocks and memories of the system to achieve the power consumption and functionality of that mode.

Driver consideration

Power mode entry and sleep-on-exit-value are provided at initialization time through the power manager user configuration structure.
With platform is S32K14x, the available power mode entries are the following ones: HSRUN, RUN, VLPR, STOP1, STOP2 and VLPS.
With platform is S32MTV,S32K11x and S32K14xW. The available power mode entries are the following ones: RUN, VLPR, STOP1, STOP2 and VLPS.

This is an example of configuration:

```
power_manager_user_config_t pwrMan1_InitConfig0 = {
    .powerMode = POWER_MANAGER_RUN,
    .sleepOnExitValue = false,
};

power_manager_user_config_t *powerConfigsArr[] = {
    &pwrMan1_InitConfig0
};

power_manager_callback_user_config_t * powerCallbacksConfigsArr[] = {(
      void *)0};

if (STATUS_SUCCESS != POWER_SYS_Init(&powerConfigsArr,1,&powerCallbacksConfigsArr,0)) {
    ...
}
else {
    ...
}

if (STATUS_SUCCESS != POWER_SYS_SetMode(0,
      POWER_MANAGER_POLICY_AGREEMENT)) {
    ...
}
else {
    ...
}
```

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\power_manager.c
${S32SDK_PATH}\platform\drivers\src\S32K1xx\power_manager_S32K1xx.c
${S32SDK_PATH}\platform\drivers\src\S32K1xx\power_smc_hw_access.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
${S32SDK_PATH}\platform\drivers\src\power\
${S32SDK_PATH}\platform\drivers\src\power\S32K1xx\
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager

Important Note

1. ERR01077: The SCG_RCCR[SCS] and SCG_HCCR[SCS] may have a corrupted status during the interval by the software to ensure when the system clock is switching.
   This errata did workaround by the SCS field was read twice the system clock switch has completed.
   The clock configuration is not immediately updated after MCU switched from very low power mode to run or high speed mode. It may be taking longer time than expected.

2. The power manager driver will disable SPLL, FIRC, SOSC source in RUN mode before MCU jumps from RUN,HSRUN to very low power mode.
   SIRC is clock source when MCU enters very low power mode. Driver will update initialize system clock configuration when MCU jumps to RUN or HSRUN mode again.
   It will enable all clock source again which is configured by clock configurations. This is executed when user calls the POWER_SYS_SetMode function for RUN or HSRUN.

3. When MCU switches from HSRUN to STOP or VLP mode, the driver code will auto switch RUN mode before MCU enters next mode.

4. Users need to take care peripherals clock frequency via SPLLDIVx_CLK, SIRCDIVx_CLK after MCU switched power mode.
   Clock configuration can be re-initialized when MCU returns to RUN mode. This way will make sure the clock for all peripherals.

16.86 Power_s32k1xx

16.86.1 Detailed Description

Data Structures

- struct power_manager_user_config_t

  Power mode user configuration structure. More...
- struct smc_power_mode_protection_config_t

  Power mode protection configuration. More...
- struct smc_power_mode_config_t

  Power mode control configuration used for calling the SMC_SYS_SetPowerMode API. More...

Enumerations

- enum power_manager_modes_t { POWER_MANAGER_RUN, POWER_MANAGER_VLPR, POWER_MANAGER_VLPS, POWER_MANAGER_MAX }

  Power modes enumeration.
- enum power_mode_stat_t {
  STAT_RUN = 0x01, STAT_STOP = 0x02, STAT_VLPR = 0x04, STAT_VLPW = 0x08,
  STAT_VLPS = 0x10, STAT_HSRUN = 0x80, STAT_INVALID = 0xFF }

  Power Modes in PMSTAT.
- enum smc_run_mode_t { SMC_RUN, SMC_RESERVED_RUN, SMC_VLPR, SMC_HSRUN }

  Run mode definition.
- enum smc_stop_mode_t { SMC_STOP = 0U, SMC_RESERVED_STOP1 = 1U, SMC_VLPS = 2U }

  Stop mode definition.
- enum smc_stop_option_t { SMC_STOP_RESERVED = 0x00, SMC_STOP1 = 0x01, SMC_STOP2 = 0x02 }

  STOP option.
- enum rcm_source_names_t {
  RCM_LOW_VOLT_DETECT = 1U, RCM_LOSS_OF_CLK = 2U, RCM_LOSS_OF_LOCK = 3U, RCM_WATCH_DOG = 5U,
  RCM_EXTERNAL_PIN = 6U, RCM_POWER_ON = 7U, RCM_SJTAG = 8U, RCM_CORE_LOCKUP = 9U,
  RCM_SOFTWARE = 10U, RCM_SMDM_AP = 11U, RCM_STOP_MODE_ACK_ERR = 13U, RCM_SRC_NAME_MAX }

  System Reset Source Name definitions Implements rcm_source_names_t_Class.

Functions

- status_t POWER_SYS_DoInit (void)

  This function implementation-specific configuration of power modes.
- status_t POWER_SYS_DoDeinit (void)

  This function implementation-specific de-initialization of power manager.
- status_t POWER_SYS_DoSetMode (const power_manager_user_config_t *const configPtr)

  This function configures the power mode.
- bool POWER_SYS_GetResetSrcStatusCmd (const RCM_Type *const baseAddr, const rcm_source_names_t srcName)

  Gets the reset source status.
- static void POWER_SYS_DoGetDefaultConfig (power_manager_user_config_t *const defaultConfig)

  Gets the default power_manager configuration structure.

16.86.2 Data Structure Documentation

16.86.2.1 struct power_manager_user_config_t

Power mode user configuration structure.

List of power mode configuration structure members depends on power options available for the specific chip. Complete list contains: mode - S32K power mode. List of available modes is chip-specific. See power_manager↩ _modes_t list of modes. sleepOnExitOption - Controls whether the sleep-on-exit option value is used(when set to true) or ignored(when set to false). See sleepOnExitValue. sleepOnExitValue - When set to true, ARM core returns to sleep (S32K wait modes) or deep sleep state (S32K stop modes) after interrupt service finishes. When set to false, core stays woken-up. Implements power_manager_user_config_t_Class

Definition at line 95 of file power_manager_S32K1xx.h.

Data Fields

- power_manager_modes_t powerMode
- bool sleepOnExitValue

Field Documentation

16.86.2.1.1 power_manager_modes_t powerMode

Definition at line 97 of file power_manager_S32K1xx.h.

16.86.2.1.2 bool sleepOnExitValue

Definition at line 98 of file power_manager_S32K1xx.h.

16.86.2.2 struct smc_power_mode_protection_config_t

Power mode protection configuration.

Definition at line 153 of file power_manager_S32K1xx.h.

Data Fields

- bool vlpProt

Field Documentation

16.86.2.2.1 bool vlpProt

VLP protect

Definition at line 155 of file power_manager_S32K1xx.h.

16.86.2.3 struct smc_power_mode_config_t

Power mode control configuration used for calling the SMC_SYS_SetPowerMode API.

Definition at line 165 of file power_manager_S32K1xx.h.

Data Fields

- power_manager_modes_t powerModeName

Field Documentation

16.86.2.3.1 power_manager_modes_t powerModeName

Power mode(enum), see power_manager_modes_t

Definition at line 167 of file power_manager_S32K1xx.h.

16.86.3 Enumeration Type Documentation

16.86.3.1 enum power_manager_modes_t

Power modes enumeration.

Defines power modes. Used in the power mode configuration structure (power_manager_user_config_t). From ARM core perspective, Power modes can be generally divided into run modes (High speed run, Run and Very low power run), sleep (Wait and Very low power wait) and deep sleep modes (all Stop modes). List of power modes supported by specific chip along with requirements for entering and exiting of these modes can be found in chip documentation. List of all supported power modes:

- POWER_MANAGER_HSRUN - High speed run mode.
- POWER_MANAGER_RUN - Run mode.
- POWER_MANAGER_VLPR - Very low power run mode.
- POWER_MANAGER_WAIT - Wait mode.
- POWER_MANAGER_VLPW - Very low power wait mode.
- POWER_MANAGER_PSTOP1 - Partial stop 1 mode.
- POWER_MANAGER_PSTOP2 - Partial stop 2 mode.
- POWER_MANAGER_PSTOP1 - Stop 1 mode.
- POWER_MANAGER_PSTOP2 - Stop 2 mode.
- POWER_MANAGER_VLPS - Very low power stop mode. Implements power_manager_modes_t_Class

Enumerator

POWER_MANAGER_RUN Run mode.

POWER_MANAGER_VLPR Very low power run mode.

POWER_MANAGER_VLPS Very low power stop mode.

POWER_MANAGER_MAX

Definition at line 58 of file power_manager_S32K1xx.h.

16.86.3.2 enum power_mode_stat_t

Power Modes in PMSTAT.

Enumerator

STAT_RUN 0000_0001 - Current power mode is RUN

STAT_STOP 0000_0010 - Current power mode is STOP

STAT_VLPR 0000_0100 - Current power mode is VLPR

STAT_VLPW 0000_1000 - Current power mode is VLPW

STAT_VLPS 0001_0000 - Current power mode is VLPS

STAT_HSRUN 1000_0000 - Current power mode is HSRUN

STAT_INVALID 1111_1111 - Non-existing power mode

Definition at line 105 of file power_manager_S32K1xx.h.

16.86.3.3 enum rcm_source_names_t

System Reset Source Name definitions Implements rcm_source_names_t_Class.

Enumerator

RCM_LOW_VOLT_DETECT Low voltage detect reset
RCM_LOSS_OF_CLK Loss of clock reset
RCM_LOSS_OF_LOCK Loss of lock reset
RCM_WATCH_DOG Watch dog reset
RCM_EXTERNAL_PIN External pin reset
RCM_POWER_ON Power on reset
RCM_SJTAG JTAG generated reset
RCM_CORE_LOCKUP core lockup reset
RCM_SOFTWARE Software reset
RCM_SMDM_AP MDM-AP system reset
RCM_STOP_MODE_ACK_ERR Stop mode ack error reset
RCM_SRC_NAME_MAX

Definition at line 181 of file power_manager_S32K1xx.h.

16.86.3.4 enum smc_run_mode_t

Run mode definition.

Enumerator

SMC_RUN normal RUN mode
SMC_RESERVED_RUN
SMC_VLPR Very-Low-Power RUN mode
SMC_HSRUN High Speed Run mode (HSRUN)

Definition at line 120 of file power_manager_S32K1xx.h.

16.86.3.5 enum smc_stop_mode_t

Stop mode definition.

Enumerator

SMC_STOP Normal STOP mode
SMC_RESERVED_STOP1 Reserved
SMC_VLPS Very-Low-Power STOP mode

Definition at line 131 of file power_manager_S32K1xx.h.

16.86.3.6 enum smc_stop_option_t

STOP option.

Enumerator

SMC_STOP_RESERVED Reserved stop mode
SMC_STOP1 Stop with both system and bus clocks disabled
SMC_STOP2 Stop with system clock disabled and bus clock enabled

Definition at line 142 of file power_manager_S32K1xx.h.

16.86.4 Function Documentation

16.86.4.1 status_t POWER_SYS_DoDeinit (void)

This function implementation-specific de-initialization of power manager.

This function performs the actual implementation-specific de-initialization.

Returns

Operation status

- STATUS_SUCCESS: Operation was successful.
- STATUS_ERROR: Operation failed.

Definition at line 200 of file power_manager_S32K1xx.c.

16.86.4.2 static void POWER_SYS_DoGetDefaultConfig (power_manager_user_config_t *const *defaultConfig*) [inline], [static]

Gets the default power_manager configuration structure.

This function gets the power_manager configuration structure of the default power mode.

Parameters

out	*defaultConfig*	: Pointer to power mode configuration structure of the default power mode.

< Power manager mode

< Sleep on exit value

Definition at line 261 of file power_manager_S32K1xx.h.

16.86.4.3 status_t POWER_SYS_DoInit (void)

This function implementation-specific configuration of power modes.

This function performs the actual implementation-specific initialization based on the provided power mode configurations. In addition, This function get all clock source were enabled. This one was used for update init clock when CPU jump from very low power mode to run or high speed run mode.

Returns

Operation status

- STATUS_SUCCESS: Operation was successful.
- STATUS_ERROR: Operation failed.

Definition at line 157 of file power_manager_S32K1xx.c.

16.86.4.4 status_t POWER_SYS_DoSetMode (const power_manager_user_config_t *const *configPtr*)

This function configures the power mode.

This function performs the actual implementation-specific logic to switch to one of the defined power modes.

Parameters

configPtr	Pointer to user configuration structure

Returns

Operation status

- STATUS_SUCCESS: Operation was successful.
- STATUS_MCU_TRANSITION_FAILED: Operation failed.

Definition at line 217 of file power_manager_S32K1xx.c.

16.86.4.5 bool POWER_SYS_GetResetSrcStatusCmd (const RCM_Type *const *baseAddr,* const rcm_source_names_t *srcName*)

Gets the reset source status.

This function gets the current reset source status for a specified source.

Parameters

in	*baseAddr*	Register base address of RCM
in	*srcName*	reset source name

Returns

status True or false for specified reset source

Definition at line 688 of file power_manager_S32K1xx.c.

16.87 Programmable Delay Block (PDB)

16.87.1 Detailed Description

The S32 SDK provides a peripheral driver for the Programmable Delay Block (PDB) module.

The PDB is a configurable counter that can generate events (triggers) that can be used by the ADC to start conversions or routed through TRGMUX to other modules in the device.

Modules

- PDB Driver

  Programmable Delay Block Peripheral Driver.

16.88 Pulse-width modulation - Peripheral Abstraction Layer (PWM PAL)

16.88.1 Detailed Description

The S32 SDK provides a Peripheral Abstraction Layer for the PWM mode.

The PWM PAL driver allows to generate PWM signals. It was designed to be portable across all platforms and IPs which support PWM features.

How to integrate PWM in your application

Unlike the other drivers, PWM PAL modules need to include a configuration file named pwm_pal_cfg.h, which allows the user to specify which IPSs are used and how many resources are allocated for each of them (state structures). The following code example shows how to configure one instance for each available PWM IP.

```
#ifndef PWM_PAL_cfg_H
#define PWM_PAL_cfg_H

/* Define which IP instance will be used in current project */
#define PWM_OVER_FTM
#define PWM_OVER_EMIOS
#define PWM_OVER_ETIMER

/* Define the resources necessary for current project */
#define NO_OF_FTM_INSTS_FOR_PWM       1U
#define NO_OF_EMIOS_INSTS_FOR_PWM     1U
#define NO_OF_ETIMER_INSTS_FOR_PWM    1U
#endif /* PWM_PAL_cfg_H */
```

The following table contains the matching between platforms and available IPs

IP/↩ M↩ CU	S32↩ K116	S32↩ K118	S32↩ K142	S32↩ K144	S32↩ K142↩ W	S32↩ K144↩ W	S32↩ K146	S32↩ K148	M↩ P↩ C5748 G	M↩ P↩ C5746 C	M↩ P↩ C5744 P	S32↩ R274	S32↩ R372
FTM	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	NO	NO	NO	NO	NO
e↩ MI↩ OS	NO	NO	NO	NO	NO	NO	NO	NO	Y↩ ES	Y↩ ES	NO	NO	NO
E↩ TI↩ M↩ ER	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	Y↩ ES	Y↩ ES	Y↩ ES

In order to use the PWM PAL driver it must be first initialized it using function PWM_Init(). Once initialized, it cannot be initialized again for the same PWM module instance until it is de-initialized, using PWM_Deinit(). Different PWM module instances can work independently of each other.

After initialization the duty cycle and pwm period can be updated with these functions: PWM_UpdateDuty() and PWM_UpdatePeriod(). The measurement unit for duty and period is clock ticks, so the application should be aware about the clock frequency of the timebase used by PWM channel.

Due to hardware limitation period changing for a specific channel can change the period for other channels if they share the same timebase. Also, for FTM all channels must have the same period and type.

Important Notes

- The driver enables the interrupts for the corresponding module, but any interrupt priority setting must be done by the application.
- Due to different hardware features is necessary to use different timebase configuration on each platform and some features are available only on some peripherals. To be sure that your applications doesn't try to use unsupported features check return status of called functions and activate DEV_ERROR_DETECT.

Basic code sequence

1. Initialize PWM_PAL instance

```
PWM_Init(&pwm_pal1Instance, &pwm_pal1Config);
```

2. Update duty cycle

```
PWM_UpdateDuty(&pwm_pal1Instance, 0, dutyCycle);
```

3. Update period

```
PWM_UpdatePeriod(&pwm_pal1Instance, 0, period);
```

4. De-initialize PWM_PAL instance

```
PWM_Deinit(&pwm_pal1Instance);
```

Hardware Limitations

eTimer

eTimer cannot generate 0% or 100% duty cycles. At least one clock tick will have inverted polarity.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\pal\src\pwm\pwm_pal.c
```

Additionally, it is required to compile also the .c files from the dependencies listed for each ADC PAL type (please see Dependencies subsection below).

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\pal\inc\
${S32SDK_PATH}\platform\drivers\inc\
```

An additional file, named *pwm_pal_cfg.h*, must be created by the user and added to one of the include paths. The user has to add to the file the definitions of preprocessor symbols according to the PWM PAL type used. These symbols are specified in the next subsection.
When using the S32 SDK configuration tool the file is generated by the configurator.

The pal type PWM_OVER_FTM also requires:

```
${S32SDK_PATH}\platform\drivers\src\ftm\
```

Compile symbols

Define for selecting one of the PWM PAL type to be used:

```
PWM_OVER_FTM
PWM_OVER_EMIOS
PWM_OVER_ETIMER
```

Dependencies

- The pal type PWM_OVER_FTM also depends on:
  FlexTimer Pulse Width Modulation Driver (FTM_PWM)
  FlexTimer (FTM)

- The pal type PWM_OVER_EMIOS also depends on:
  mc_emios_driver
  pwm_emios_driver

- The pal type PWM_OVER_ETIMER also depends on:
  etimer_drv

Data Structures

- struct pwm_ftm_timebase_t

  This structure is specific for platforms where FTM is available. Implements : pwm_ftm_timebase_t_Class. More...
- struct pwm_channel_t

  This structure includes the configuration for each channel Implements : pwm_channel_t_Class. More...
- struct pwm_global_config_t

  This structure is the configuration for initialization of PWM channels. Implements : pwm_global_config_t_Class. More...

Enumerations

- enum pwm_channel_type_t { PWM_EDGE_ALIGNED = 0, PWM_CENTER_ALIGNED = 1 }

  Defines the channel types Implements : pwm_channel_type_t_Class.
- enum pwm_polarity_t { PWM_ACTIVE_HIGH = 0, PWM_ACTIVE_LOW = 1 }

  Defines the polarity of pwm channels Implements : pwm_polarity_t_Class.
- enum pwm_complementarty_mode_t { PWM_DUPLICATED = 0, PWM_INVERTED = 1 }

  Defines the polarity of complementary pwm channels relative to main channel Implements : pwm_complementarty↩ _mode_t_Class.

Functions

- status_t PWM_Init (const pwm_instance_t *const instance, const pwm_global_config_t *config)

  Initialize PWM channels based on config parameter.
- status_t PWM_UpdateDuty (const pwm_instance_t *const instance, uint8_t channel, uint32_t duty)

  Update duty cycle. The measurement unit for duty is clock ticks.
- status_t PWM_UpdatePeriod (const pwm_instance_t *const instance, uint8_t channel, uint32_t period)

  Update period for specific a specific channel. This function changes period for all channels which shares the timebase with targeted channel.
- status_t PWM_OverwriteOutputChannels (const pwm_instance_t *const instance, uint32_t channelsMask, uint32_t channelsValues)

  This function change the output value for some channels. channelsMask select which channels will be overwrite, each bit filed representing one channel: 1 - channel is controlled by channelsValues, 0 - channel is controlled by pwm. channelsValues select output values to be write on corresponding channel. For PWM_PAL over FTM, when enable complementary channels, if this function is used to force output of complementary channels(n and n+1) with value is high, the output of channel n is going to be high and the output of channel n+1 is going to be low. Please refer to Software ouput control behavior table in the reference manual to get more detail.

- status_t PWM_Deinit (const pwm_instance_t *const instance)

  De-Initialize PWM instance.

16.88.2 Data Structure Documentation

16.88.2.1 struct pwm_ftm_timebase_t

This structure is specific for platforms where FTM is available. Implements : pwm_ftm_timebase_t_Class.

Definition at line 92 of file pwm_pal.h.

Data Fields

- ftm_clock_source_t sourceClock
- ftm_clock_ps_t prescaler
- ftm_deadtime_ps_t deadtimePrescaler

Field Documentation

16.88.2.1.1 ftm_deadtime_ps_t deadtimePrescaler

Prescaler for FTM dead-time insertion

Definition at line 96 of file pwm_pal.h.

16.88.2.1.2 ftm_clock_ps_t prescaler

Prescaler for FTM timebase

Definition at line 95 of file pwm_pal.h.

16.88.2.1.3 ftm_clock_source_t sourceClock

Clock source for FTM timebase

Definition at line 94 of file pwm_pal.h.

16.88.2.2 struct pwm_channel_t

This structure includes the configuration for each channel Implements : pwm_channel_t_Class.

Definition at line 147 of file pwm_pal.h.

Data Fields

- uint8_t channel
- pwm_channel_type_t channelType
- uint32_t period
- uint32_t duty
- pwm_polarity_t polarity
- bool insertDeadtime
- uint8_t deadtime
- bool enableComplementaryChannel
- pwm_complementarty_mode_t complementaryChannelPolarity
- void * timebase

Field Documentation

16.88.2.2.1 uint8_t channel

Channel number

Definition at line 149 of file pwm_pal.h.

16.88.2.2.2 pwm_channel_type_t channelType

Channel waveform type

Definition at line 150 of file pwm_pal.h.

16.88.2.2.3 pwm_complementarty_mode_t complementaryChannelPolarity

Configure the polarity of the complementary channel relative to the main channel

Definition at line 157 of file pwm_pal.h.

16.88.2.2.4 uint8_t deadtime

Dead-time value in ticks

Definition at line 155 of file pwm_pal.h.

16.88.2.2.5 uint32_t duty

Duty cycle in ticks

Definition at line 152 of file pwm_pal.h.

16.88.2.2.6 bool enableComplementaryChannel

Enable a complementary channel. This option can take control over other channel than the channel configured in this structure.

Definition at line 156 of file pwm_pal.h.

16.88.2.2.7 bool insertDeadtime

Enable/disable dead-time insertion. This feature is available only if complementary mode is enabled

Definition at line 154 of file pwm_pal.h.

16.88.2.2.8 uint32_t period

Period of the PWM signal in ticks

Definition at line 151 of file pwm_pal.h.

16.88.2.2.9 pwm_polarity_t polarity

Channel polarity

Definition at line 153 of file pwm_pal.h.

16.88.2.2.10 void* timebase

This field is platform specific and it's used to configure the clocking tree for different time-bases. If FTM is use this field must be filled by a pointer to pwm_ftm_timebase_t

Definition at line 158 of file pwm_pal.h.

16.88.2.3 struct pwm_global_config_t

This structure is the configuration for initialization of PWM channels. Implements : pwm_global_config_t_Class.

Definition at line 166 of file pwm_pal.h.

Data Fields

- pwm_channel_t * pwmChannels
- uint8_t numberOfPwmChannels

Field Documentation

16.88.2.3.1 uint8_t numberOfPwmChannels

Number of channels which are configured

Definition at line 169 of file pwm_pal.h.

16.88.2.3.2 pwm_channel_t* pwmChannels

Pointer to channels configurations

Definition at line 168 of file pwm_pal.h.

16.88.3 Enumeration Type Documentation

16.88.3.1 enum pwm_channel_type_t

Defines the channel types Implements : pwm_channel_type_t_Class.

Enumerator

PWM_EDGE_ALIGNED Counter used by this type of channel is in up counting mode and the edge is aligned to PWM period

PWM_CENTER_ALIGNED Counter used by this type of channel is in up-down counting mode and the duty is inserted in center of PWM period

Definition at line 60 of file pwm_pal.h.

16.88.3.2 enum pwm_complementarty_mode_t

Defines the polarity of complementary pwm channels relative to main channel Implements : pwm_↩ complementarty_mode_t_Class.

Enumerator

PWM_DUPLICATED Complementary channel is the same as main channel

PWM_INVERTED Complementary channel is inverted relative to main channel

Definition at line 80 of file pwm_pal.h.

16.88.3.3 enum pwm_polarity_t

Defines the polarity of pwm channels Implements : pwm_polarity_t_Class.

Enumerator

PWM_ACTIVE_HIGH Polarity is active high

PWM_ACTIVE_LOW Polarity is active low

Definition at line 70 of file pwm_pal.h.

16.88.4 Function Documentation

16.88.4.1 status_t PWM_Deinit (const pwm_instance_t *const *instance*)

De-Initialize PWM instance.

Parameters

in	*instance*	The name of the instance

Returns

Error or success status returned by API

Definition at line 819 of file pwm_pal.c.

16.88.4.2 status_t PWM_Init (const pwm_instance_t *const *instance*, const pwm_global_config_t * *config*)

Initialize PWM channels based on config parameter.

Parameters

in	*instance*	The name of the instance
in	*config*	The configuration structure used to initialize PWM modules

Returns

Error or success status returned by API

Definition at line 133 of file pwm_pal.c.

16.88.4.3 status_t PWM_OverwriteOutputChannels (const pwm_instance_t *const *instance*, uint32_t *channelsMask*, uint32_t *channelsValues*)

This function change the output value for some channels. channelsMask select which channels will be overwrite, each bit filed representing one channel: 1 - channel is controlled by channelsValues, 0 - channel is controlled by pwm. channelsValues select output values to be write on corresponding channel. For PWM_PAL over FTM, when enable complementary channels, if this function is used to force output of complementary channels(n and n+1) with value is high, the output of channel n is going to be high and the output of channel n+1 is going to be low. Please refer to Software ouput control behavior table in the reference manual to get more detail.

Parameters

in	*instance*	The name of the instance
in	*channelsMask*	The name mask used to select which channel is overwrite
in	*channelsValues*	The name overwrite values for all channels

Returns

Error or success status returned by API

Definition at line 775 of file pwm_pal.c.

16.88.4.4 status_t PWM_UpdateDuty (const pwm_instance_t *const *instance*, uint8_t *channel*, uint32_t *duty*)

Update duty cycle. The measurement unit for duty is clock ticks.

Parameters

in	*instance*	The name of the instance
in	*channel*	The channel which is update
in	*duty*	The duty cycle measured in ticks

Returns

Error or success status returned by API

Definition at line 574 of file pwm_pal.c.

16.88.4.5 status_t PWM_UpdatePeriod (const pwm_instance_t *const *instance,* uint8_t *channel,* uint32_t *period*)

Update period for specific a specific channel. This function changes period for all channels which shares the timebase with targeted channel.

Parameters

in	*instance*	The name of the instance
in	*channel*	The channel which is update
in	*period*	The period measured in ticks

Returns

Error or success status returned by API

Definition at line 669 of file pwm_pal.c.

16.89 RTC Driver

16.89.1 Detailed Description

Real Time Clock Peripheral Driver.

This section describes the programming interface of the RTC driver.

Data Structures

- struct rtc_timedate_t

  RTC Time Date structure Implements : rtc_timedate_t_Class. More...
- struct rtc_init_config_t

  RTC Initialization structure Implements : rtc_init_config_t_Class. More...
- struct rtc_alarm_config_t

  RTC alarm configuration Implements : rtc_alarm_config_t_Class. More...
- struct rtc_interrupt_config_t

  RTC interrupt configuration. It is used to configure interrupt other than Time Alarm and Time Seconds interrupt Implements : rtc_interrupt_config_t_Class. More...
- struct rtc_seconds_int_config_t

  RTC Seconds Interrupt Configuration Implements : rtc_seconds_int_config_t_Class. More...
- struct rtc_register_lock_config_t

  RTC Register Lock Configuration Implements : rtc_register_lock_config_t_Class. More...

Macros

- #define SECONDS_IN_A_DAY (86400UL)
- #define SECONDS_IN_A_HOUR (3600U)
- #define SECONDS_IN_A_MIN (60U)
- #define MINS_IN_A_HOUR (60U)
- #define HOURS_IN_A_DAY (24U)
- #define DAYS_IN_A_YEAR (365U)
- #define DAYS_IN_A_LEAP_YEAR (366U)
- #define YEAR_RANGE_START (1970U)
- #define YEAR_RANGE_END (2099U)

Enumerations

- enum rtc_second_int_cfg_t { RTC_INT_1HZ = 0x00U, RTC_INT_2HZ = 0x01U, RTC_INT_4HZ = 0x02U, RTC_INT_8HZ = 0x03U, RTC_INT_16HZ = 0x04U, RTC_INT_32HZ = 0x05U, RTC_INT_64HZ = 0x06U, RTC_INT_128HZ = 0x07U }

  RTC Seconds interrupt configuration Implements : rtc_second_int_cfg_t_Class.
- enum rtc_clk_out_config_t { RTC_CLKOUT_DISABLED = 0x00U, RTC_CLKOUT_SRC_TSIC = 0x01U, RTC_CLKOUT_SRC_32KHZ = 0x02U }

  RTC CLKOUT pin configuration Implements : rtc_clk_out_config_t_Class.
- enum rtc_clk_select_t { RTC_CLK_SRC_OSC_32KHZ = 0x00U, RTC_CLK_SRC_LPO_1KHZ = 0x01U }

  RTC clock select Implements : rtc_clk_select_t_Class.
- enum rtc_lock_register_select_t { RTC_LOCK_REG_LOCK = 0x00U, RTC_STATUS_REG_LOCK = 0x01U, RTC_CTRL_REG_LOCK = 0x02U, RTC_TCL_REG_LOCK = 0x03U }

  RTC register lock Implements : rtc_lock_register_select_t_Class.

Functions

- status_t RTC_DRV_Init (uint32_t instance, const rtc_init_config_t *const rtcUserCfg)

  This function initializes the RTC instance with the settings provided by the user via the rtcUserCfg parameter. The user must ensure that clock is enabled for the RTC instance used. If the Control register is locked then this method returns STATUS_ERROR. In order to clear the CR Lock the user must perform a power-on reset.
- status_t RTC_DRV_Deinit (uint32_t instance)

  This function deinitializes the RTC instance. If the Control register is locked then this method returns STATUS_ER↩ ROR.
- void RTC_DRV_GetDefaultConfig (rtc_init_config_t *const config)

  This function will set the default configuration values into the structure passed as a parameter.
- status_t RTC_DRV_StartCounter (uint32_t instance)

  Start RTC instance counter. Before calling this function the user should use RTC_DRV_SetTimeDate to configure the start time.
- status_t RTC_DRV_StopCounter (uint32_t instance)

  Disable RTC instance counter.
- status_t RTC_DRV_GetCurrentTimeDate (uint32_t instance, rtc_timedate_t *const currentTime)

  Get current time and date from RTC instance.
- status_t RTC_DRV_SetTimeDate (uint32_t instance, const rtc_timedate_t *const time)

  Set time and date for RTC instance. The user must stop the counter before using this function. Otherwise it will return an error.
- status_t RTC_DRV_ConfigureRegisterLock (uint32_t instance, const rtc_register_lock_config_t *const lockConfig)

  This method configures register lock for the corresponding RTC instance. Remember that all the registers are unlocked only by software reset or power on reset. (Except for CR that is unlocked only by POR).
- void RTC_DRV_GetRegisterLock (uint32_t instance, rtc_register_lock_config_t *const lockConfig)

  Get which registers are locked for RTC instance.
- status_t RTC_DRV_ConfigureTimeCompensation (uint32_t instance, uint8_t compInterval, int8_t compensation)

  This method configures time compensation. Data is passed by the compInterval and compensation parameters. For more details regarding coefficient calculation see the Reference Manual.
- void RTC_DRV_GetTimeCompensation (uint32_t instance, uint8_t *compInterval, int8_t *compensation)

  This retrieves the time compensation coefficients and saves them on the variables referenced by the parameters.
- void RTC_DRV_ConfigureFaultInt (uint32_t instance, rtc_interrupt_config_t *const intConfig)

  This method configures fault interrupts such as:
- void RTC_DRV_ConfigureSecondsInt (uint32_t instance, rtc_seconds_int_config_t *const intConfig)

  This method configures the Time Seconds Interrupt with the configuration from the intConfig parameter.
- status_t RTC_DRV_ConfigureAlarm (uint32_t instance, rtc_alarm_config_t *const alarmConfig)

  This method configures the alarm with the configuration from the alarmConfig parameter.
- void RTC_DRV_GetAlarmConfig (uint32_t instance, rtc_alarm_config_t *alarmConfig)

  Get alarm configuration for RTC instance.
- bool RTC_DRV_IsAlarmPending (uint32_t instance)

  Check if alarm is pending.
- void RTC_DRV_ConvertSecondsToTimeDate (const uint32_t *seconds, rtc_timedate_t *const timeDate)

  Convert seconds to rtc_timedate_t structure.
- void RTC_DRV_ConvertTimeDateToSeconds (const rtc_timedate_t *const timeDate, uint32_t *const seconds)

  Convert seconds to rtc_timedate_t structure.
- bool RTC_DRV_IsYearLeap (uint16_t year)

  Check if the current year is leap.
- bool RTC_DRV_IsTimeDateCorrectFormat (const rtc_timedate_t *const timeDate)

  Check if the date time struct is configured properly.
- status_t RTC_DRV_GetNextAlarmTime (uint32_t instance, rtc_timedate_t *const alarmTime)

Gets the next alarm time.

- void RTC_DRV_IRQHandler (uint32_t instance)

  This method is the API's Interrupt handler for generic and alarm IRQ. It will handle the alarm repetition and calls the user callbacks if they are not NULL.

- void RTC_DRV_SecondsIRQHandler (uint32_t instance)

  This method is the API's Interrupt handler for RTC Second interrupt. This ISR will call the user callback if defined.

16.89.2 Data Structure Documentation

16.89.2.1 struct rtc_timedate_t

RTC Time Date structure Implements : rtc_timedate_t_Class.

Definition at line 97 of file rtc_driver.h.

Data Fields

- uint16_t year
- uint16_t month
- uint16_t day
- uint16_t hour
- uint16_t minutes
- uint8_t seconds

Field Documentation

16.89.2.1.1 uint16_t day

Day

Definition at line 101 of file rtc_driver.h.

16.89.2.1.2 uint16_t hour

Hour

Definition at line 102 of file rtc_driver.h.

16.89.2.1.3 uint16_t minutes

Minutes

Definition at line 103 of file rtc_driver.h.

16.89.2.1.4 uint16_t month

Month

Definition at line 100 of file rtc_driver.h.

16.89.2.1.5 uint8_t seconds

Seconds

Definition at line 104 of file rtc_driver.h.

16.89.2.1.6 uint16_t year

Year

Definition at line 99 of file rtc_driver.h.

16.89.2.2 struct rtc_init_config_t

RTC Initialization structure Implements : rtc_init_config_t_Class.

Definition at line 111 of file rtc_driver.h.

Data Fields

- uint8_t compensationInterval
- int8_t compensation
- rtc_clk_select_t clockSelect
- rtc_clk_out_config_t clockOutConfig
- bool updateEnable
- bool nonSupervisorAccessEnable

Field Documentation

16.89.2.2.1 rtc_clk_out_config_t clockOutConfig

RTC Clock Out Source

Definition at line 116 of file rtc_driver.h.

16.89.2.2.2 rtc_clk_select_t clockSelect

RTC Clock Select

Definition at line 115 of file rtc_driver.h.

16.89.2.2.3 int8_t compensation

Compensation Value

Definition at line 114 of file rtc_driver.h.

16.89.2.2.4 uint8_t compensationInterval

Compensation Interval

Definition at line 113 of file rtc_driver.h.

16.89.2.2.5 bool nonSupervisorAccessEnable

Enable writes to the registers in non Supervisor Mode

Definition at line 118 of file rtc_driver.h.

16.89.2.2.6 bool updateEnable

Enable changing the Time Counter Enable bit even if the Status register is locked

Definition at line 117 of file rtc_driver.h.

16.89.2.3 struct rtc_alarm_config_t

RTC alarm configuration Implements : rtc_alarm_config_t_Class.

Definition at line 125 of file rtc_driver.h.

Data Fields

- rtc_timedate_t alarmTime
- uint32_t repetitionInterval
- uint32_t numberOfRepeats
- bool repeatForever

- bool alarmIntEnable
- void(∗ alarmCallback)(void ∗callbackParam)
- void ∗ callbackParams

Field Documentation

16.89.2.3.1 void(∗ alarmCallback) (void ∗callbackParam)

Pointer to the user callback method.

Definition at line 132 of file rtc_driver.h.

16.89.2.3.2 bool alarmIntEnable

Enable alarm interrupt

Definition at line 131 of file rtc_driver.h.

16.89.2.3.3 rtc_timedate_t alarmTime

Alarm time

Definition at line 127 of file rtc_driver.h.

16.89.2.3.4 void∗ callbackParams

Pointer to the callback parameters.

Definition at line 133 of file rtc_driver.h.

16.89.2.3.5 uint32_t numberOfRepeats

Number of alarm repeats

Definition at line 129 of file rtc_driver.h.

16.89.2.3.6 bool repeatForever

Repeat forever if set, discard number of repeats

Definition at line 130 of file rtc_driver.h.

16.89.2.3.7 uint32_t repetitionInterval

Interval of repetition in sec

Definition at line 128 of file rtc_driver.h.

16.89.2.4 struct rtc_interrupt_config_t

RTC interrupt configuration. It is used to configure interrupt other than Time Alarm and Time Seconds interrupt Implements : rtc_interrupt_config_t_Class.

Definition at line 141 of file rtc_driver.h.

Data Fields

- bool overflowIntEnable
- bool timeInvalidIntEnable
- void(∗ rtcCallback)(void ∗callbackParam)
- void ∗ callbackParams

Field Documentation

16.89.2.4.1 void* callbackParams

Pointer to the callback parameters.

Definition at line 146 of file rtc_driver.h.

16.89.2.4.2 bool overflowIntEnable

Enable Time Overflow Interrupt

Definition at line 143 of file rtc_driver.h.

16.89.2.4.3 void(* rtcCallback) (void *callbackParam)

Pointer to the user callback method.

Definition at line 145 of file rtc_driver.h.

16.89.2.4.4 bool timeInvalidIntEnable

Enable Time Invalid Interrupt

Definition at line 144 of file rtc_driver.h.

16.89.2.5 struct rtc_seconds_int_config_t

RTC Seconds Interrupt Configuration Implements : rtc_seconds_int_config_t_Class.

Definition at line 153 of file rtc_driver.h.

Data Fields

- rtc_second_int_cfg_t secondIntConfig
- bool secondIntEnable
- void(* rtcSecondsCallback)(void *callbackParam)
- void * secondsCallbackParams

Field Documentation

16.89.2.5.1 void(* rtcSecondsCallback) (void *callbackParam)

Pointer to the user callback method.

Definition at line 157 of file rtc_driver.h.

16.89.2.5.2 rtc_second_int_cfg_t secondIntConfig

Seconds Interrupt frequency

Definition at line 155 of file rtc_driver.h.

16.89.2.5.3 bool secondIntEnable

Seconds Interrupt enable

Definition at line 156 of file rtc_driver.h.

16.89.2.5.4 void* secondsCallbackParams

Pointer to the callback parameters.

Definition at line 158 of file rtc_driver.h.

16.89.2.6 struct rtc_register_lock_config_t

RTC Register Lock Configuration Implements : rtc_register_lock_config_t_Class.

Definition at line 165 of file rtc_driver.h.

Data Fields

- bool lockRegisterLock
- bool statusRegisterLock
- bool controlRegisterLock
- bool timeCompensationRegisterLock

Field Documentation

16.89.2.6.1 bool controlRegisterLock

Lock state of the Control Register

Definition at line 169 of file rtc_driver.h.

16.89.2.6.2 bool lockRegisterLock

Lock state of the Lock Register

Definition at line 167 of file rtc_driver.h.

16.89.2.6.3 bool statusRegisterLock

Lock state of the Status Register

Definition at line 168 of file rtc_driver.h.

16.89.2.6.4 bool timeCompensationRegisterLock

Lock state of the Time Compensation Register

Definition at line 170 of file rtc_driver.h.

16.89.3 Macro Definition Documentation

16.89.3.1 #define DAYS_IN_A_LEAP_YEAR (366U)

Definition at line 40 of file rtc_driver.h.

16.89.3.2 #define DAYS_IN_A_YEAR (365U)

Definition at line 39 of file rtc_driver.h.

16.89.3.3 #define HOURS_IN_A_DAY (24U)

Definition at line 38 of file rtc_driver.h.

16.89.3.4 #define MINS_IN_A_HOUR (60U)

Definition at line 37 of file rtc_driver.h.

16.89.3.5 #define SECONDS_IN_A_DAY (86400UL)

Definition at line 34 of file rtc_driver.h.

16.89.3.6 #define SECONDS_IN_A_HOUR (3600U)

Definition at line 35 of file rtc_driver.h.

16.89.3.7 #define SECONDS_IN_A_MIN (60U)

Definition at line 36 of file rtc_driver.h.

16.89.3.8 #define YEAR_RANGE_END (2099U)

Definition at line 42 of file rtc_driver.h.

16.89.3.9 #define YEAR_RANGE_START (1970U)

Definition at line 41 of file rtc_driver.h.

16.89.4 Enumeration Type Documentation

16.89.4.1 enum rtc_clk_out_config_t

RTC CLKOUT pin configuration Implements : rtc_clk_out_config_t_Class.

Enumerator

RTC_CLKOUT_DISABLED Clock out pin is disabled

RTC_CLKOUT_SRC_TSIC Output on RTC_CLKOUT as configured on Time seconds interrupt

RTC_CLKOUT_SRC_32KHZ Output on RTC_CLKOUT of the 32KHz clock

Definition at line 64 of file rtc_driver.h.

16.89.4.2 enum rtc_clk_select_t

RTC clock select Implements : rtc_clk_select_t_Class.

Enumerator

RTC_CLK_SRC_OSC_32KHZ RTC Prescaler increments using 32 KHz crystal

RTC_CLK_SRC_LPO_1KHZ RTC Prescaler increments using 1KHz LPO

Definition at line 75 of file rtc_driver.h.

16.89.4.3 enum rtc_lock_register_select_t

RTC register lock Implements : rtc_lock_register_select_t_Class.

Enumerator

RTC_LOCK_REG_LOCK RTC Lock Register lock

RTC_STATUS_REG_LOCK RTC Status Register lock

RTC_CTRL_REG_LOCK RTC Control Register lock

RTC_TCL_REG_LOCK RTC Time Compensation Reg lock

Definition at line 85 of file rtc_driver.h.

16.89.4.4 enum rtc_second_int_cfg_t

RTC Seconds interrupt configuration Implements : rtc_second_int_cfg_t_Class.

Enumerator

RTC_INT_1HZ RTC seconds interrupt occurs at 1 Hz

RTC_INT_2HZ RTC seconds interrupt occurs at 2 Hz

RTC_INT_4HZ RTC seconds interrupt occurs at 4 Hz

RTC_INT_8HZ RTC seconds interrupt occurs at 8 Hz

RTC_INT_16HZ RTC seconds interrupt occurs at 16 Hz

RTC_INT_32HZ RTC seconds interrupt occurs at 32 Hz

RTC_INT_64HZ RTC seconds interrupt occurs at 64 Hz

RTC_INT_128HZ RTC seconds interrupt occurs at 128 Hz

Definition at line 48 of file rtc_driver.h.

16.89.5 Function Documentation

16.89.5.1 status_t RTC_DRV_ConfigureAlarm (uint32_t *instance,* rtc_alarm_config_t ∗const *alarmConfig*)

This method configures the alarm with the configuration from the alarmConfig parameter.

Parameters

in	*instance*	The number of the RTC instance used
in	*alarmConfig*	Pointer to the structure which holds the alarm configuration

Returns

STATUS_SUCCESS if the configuration is successful or STATUS_ERROR if the alarm time is invalid.

Definition at line 933 of file rtc_driver.c.

16.89.5.2 void RTC_DRV_ConfigureFaultInt (uint32_t *instance,* rtc_interrupt_config_t ∗const *intConfig*)

This method configures fault interrupts such as:

- Time Overflow Interrupt
- Time Invalid Interrupt with the user provided configuration struct intConfig.

Parameters

in	*instance*	The number of the RTC instance used
in	*intConfig*	Pointer to the structure which holds the configuration

Returns

None

Definition at line 876 of file rtc_driver.c.

16.89.5.3 status_t RTC_DRV_ConfigureRegisterLock (uint32_t *instance,* const rtc_register_lock_config_t ∗const *lockConfig*)

This method configures register lock for the corresponding RTC instance. Remember that all the registers are unlocked only by software reset or power on reset. (Except for CR that is unlocked only by POR).

Parameters

in	*instance*	The number of the RTC instance used
in	*lockConfig*	Pointer to the lock configuration structure

Returns

STATUS_SUCCESS if the operation was successful, STATUS_ERROR if the Lock Register is locked.

Definition at line 426 of file rtc_driver.c.

16.89.5.4 void RTC_DRV_ConfigureSecondsInt (uint32_t *instance*, rtc_seconds_int_config_t *const *intConfig*)

This method configures the Time Seconds Interrupt with the configuration from the intConfig parameter.

Parameters

in	*instance*	The number of the RTC instance used
in	*intConfig*	Pointer to the structure which holds the configuration

Returns

None

Definition at line 903 of file rtc_driver.c.

16.89.5.5 status_t RTC_DRV_ConfigureTimeCompensation (uint32_t *instance*, uint8_t *compInterval*, int8_t *compensation*)

This method configures time compensation. Data is passed by the compInterval and compensation parameters. For more details regarding coefficient calculation see the Reference Manual.

Parameters

in	*instance*	The number of the RTC instance used
in	*compInterval*	Compensation interval
in	*compensation*	Compensation value

Returns

STATUS_SUCCESS if the operation was successful, STATUS_ERROR if the TC Register is locked.

Definition at line 501 of file rtc_driver.c.

16.89.5.6 void RTC_DRV_ConvertSecondsToTimeDate (const uint32_t * *seconds*, rtc_timedate_t *const *timeDate*)

Convert seconds to rtc_timedate_t structure.

Parameters

in	*seconds*	Pointer to the seconds
out	*timeDate*	Pointer to the structure in which to store the result

Returns

None

Definition at line 551 of file rtc_driver.c.

16.89.5.7 void RTC_DRV_ConvertTimeDateToSeconds (const rtc_timedate_t *const *timeDate*, uint32_t *const *seconds*)

Convert seconds to rtc_timedate_t structure.

Parameters

in	*timeDate*	Pointer to the source struct
out	*seconds*	Pointer to the variable in which to store the result

Returns

None

Definition at line 645 of file rtc_driver.c.

16.89.5.8 status_t RTC_DRV_Deinit (uint32_t *instance*)

This function deinitializes the RTC instance. If the Control register is locked then this method returns STATUS_E↩ RROR.

Parameters

in	*instance*	The number of the RTC instance used

Returns

STATUS_SUCCESS if the operation was successful or STATUS_ERROR if Control register is locked.

Definition at line 158 of file rtc_driver.c.

16.89.5.9 void RTC_DRV_GetAlarmConfig (uint32_t *instance,* rtc_alarm_config_t * *alarmConfig*)

Get alarm configuration for RTC instance.

Parameters

in	*instance*	The number of the RTC instance used
out	*alarmConfig*	Pointer to the structure in which to store the alarm configuration

Returns

None

Definition at line 987 of file rtc_driver.c.

16.89.5.10 status_t RTC_DRV_GetCurrentTimeDate (uint32_t *instance,* rtc_timedate_t *const *currentTime*)

Get current time and date from RTC instance.

Parameters

in	*instance*	The number of the RTC instance used
out	*currentTime*	Pointer to the variable in which to store the result

Returns

STATUS_SUCCESS if the operation was successful, STATUS_ERROR if there was a problem.

Definition at line 327 of file rtc_driver.c.

16.89.5.11 void RTC_DRV_GetDefaultConfig (rtc_init_config_t *const *config*)

This function will set the default configuration values into the structure passed as a parameter.

Parameters

out	*config*	Pointer to the structure in which the configuration will be saved.

Returns

None

Definition at line 194 of file rtc_driver.c.

16.89.5.12 status_t RTC_DRV_GetNextAlarmTime (uint32_t *instance*, rtc_timedate_t *const *alarmTime*)

Gets the next alarm time.

Parameters

in	*instance*	The number of the RTC instance used
out	*alarmTime*	Pointer to the variable in which to store the data

Returns

STATUS_SUCCESS if the next alarm time is valid, STATUS_ERROR if there is no new alarm or alarm configuration specified.

Definition at line 1019 of file rtc_driver.c.

16.89.5.13 void RTC_DRV_GetRegisterLock (uint32_t *instance*, rtc_register_lock_config_t *const *lockConfig*)

Get which registers are locked for RTC instance.

Parameters

in	*instance*	The number of the RTC instance used
out	*lockConfig*	Pointer to the lock configuration structure in which to save the data

Returns

None

Definition at line 473 of file rtc_driver.c.

16.89.5.14 void RTC_DRV_GetTimeCompensation (uint32_t *instance*, uint8_t * *compInterval*, int8_t * *compensation*)

This retrieves the time compensation coefficients and saves them on the variables referenced by the parameters.

Parameters

in	*instance*	The number of the RTC instance used
out	*compInterval*	Pointer to the variable in which to save the compensation interval
out	*compensation*	Pointer to the variable in which to save the compensation value

Returns

None

Definition at line 534 of file rtc_driver.c.

16.89.5.15 status_t RTC_DRV_Init (uint32_t *instance*, const rtc_init_config_t *const *rtcUserCfg*)

This function initializes the RTC instance with the settings provided by the user via the rtcUserCfg parameter. The user must ensure that clock is enabled for the RTC instance used. If the Control register is locked then this method returns STATUS_ERROR. In order to clear the CR Lock the user must perform a power-on reset.

Parameters

in	*instance*	The number of the RTC instance used
in	*rtcUserCfg*	Pointer to the user's configuration structure

Returns

STATUS_SUCCESS if the operation was successful, STATUS_ERROR if Control is locked.

Definition at line 97 of file rtc_driver.c.

16.89.5.16 void RTC_DRV_IRQHandler (uint32_t *instance*)

This method is the API's Interrupt handler for generic and alarm IRQ. It will handle the alarm repetition and calls the user callbacks if they are not NULL.

Parameters

in	*instance*	RTC instance used

Returns

None

Definition at line 773 of file rtc_driver.c.

16.89.5.17 bool RTC_DRV_IsAlarmPending (uint32_t *instance*)

Check if alarm is pending.

Parameters

in	*instance*	The number of the RTC instance used

Returns

True if the alarm has occurred, false if not

Definition at line 1002 of file rtc_driver.c.

16.89.5.18 bool RTC_DRV_IsTimeDateCorrectFormat (const rtc_timedate_t *const *timeDate*)

Check if the date time struct is configured properly.

Parameters

in	*timeDate*	Structure to check to check

Returns

True if the time date is in the correct format, false if not

Definition at line 695 of file rtc_driver.c.

16.89.5.19 bool RTC_DRV_IsYearLeap (uint16_t *year*)

Check if the current year is leap.

Parameters

in	*year*	Year to check

Returns

True if the year is leap, false if not

Definition at line 737 of file rtc_driver.c.

16.89.5.20 void RTC_DRV_SecondsIRQHandler (uint32_t *instance*)

This method is the API's Interrupt handler for RTC Second interrupt. This ISR will call the user callback if defined.

Parameters

in	*instance*	RTC instance used

Returns

None

Definition at line 850 of file rtc_driver.c.

16.89.5.21 status_t RTC_DRV_SetTimeDate (uint32_t *instance,* const rtc_timedate_t *const *time*)

Set time and date for RTC instance. The user must stop the counter before using this function. Otherwise it will return an error.

Parameters

in	*instance*	The number of the RTC instance used
in	*time*	Pointer to the variable in which the time is stored

Returns

STATUS_SUCCESS if the operation was successful, STATUS_ERROR if the time provided was invalid or if the counter was not stopped.

Definition at line 382 of file rtc_driver.c.

16.89.5.22 status_t RTC_DRV_StartCounter (uint32_t *instance*)

Start RTC instance counter. Before calling this function the user should use RTC_DRV_SetTimeDate to configure the start time.

Parameters

in	*instance*	The number of the RTC instance used

Returns

STATUS_SUCCESS if the operation was successful, STATUS_ERROR if the counter cannot be enabled or is already enabled.

Definition at line 265 of file rtc_driver.c.

16.89.5.23 status_t RTC_DRV_StopCounter (uint32_t *instance*)

Disable RTC instance counter.

Parameters

in	*instance*	The number of the RTC instance used

Returns

STATUS_SUCCESS if the operation was successful, STATUS_ERROR if the counter could not be stopped.

Definition at line 296 of file rtc_driver.c.

16.90 Raw API

16.90.1 Detailed Description

The raw API is operating on PDU level and it is typically used to gateway PDUs between CAN and LIN.

Usually, a FIFO is used to buffer PDUs in order to handle the different bus speeds.

Functions

- void ld_put_raw (l_ifc_handle iii, const l_u8 *const data)

  Queue the transmission of 8 bytes of data in one frame.
- void ld_get_raw (l_ifc_handle iii, l_u8 *const data)

  Copy the oldest received diagnostic frame data to the memory specified by data.
- l_u8 ld_raw_tx_status (l_ifc_handle iii)

  Get the status of the raw frame transmission function.
- l_u8 ld_raw_rx_status (l_ifc_handle iii)

  Get the status of the raw frame receive function.

16.90.2 Function Documentation

16.90.2.1 void ld_get_raw (l_ifc_handle *iii*, l_u8 *const *data*)

Copy the oldest received diagnostic frame data to the memory specified by data.

Parameters

in	*iii*	Interface name
in	*data*	Buffer for the data to be transmitted

Returns

void

Copy the oldest received diagnostic frame data to the memory specified by data. The data returned is received from master request frame for slave node and the slave response frame for master node.

Definition at line 161 of file lin_commontl_api.c.

16.90.2.2 void ld_put_raw (l_ifc_handle *iii*, const l_u8 *const *data*)

Queue the transmission of 8 bytes of data in one frame.

Parameters

in	*iii*	Interface name
in	*data*	Buffer for the data to be transmitted

Returns

void

Queue the transmission of 8 bytes of data in one frame The data is sent in the next suitable frame.

Definition at line 129 of file lin_commontl_api.c.

16.90.2.3 l_u8 ld_raw_rx_status (l_ifc_handle *iii*)

Get the status of the raw frame receive function.

Parameters

in	*iii*	Interface name

Returns

l_u8

Get the status of the raw frame receive function: LD_NO_DATA The receive queue is empty.(For LIN2.1 and above only) LD_DATA_AVAILABLE The receive queue contains data that can be read. LD_RECEIVE_ERROR LIN protocol errors occurred during the transfer; initialize and redo the transfer.(For LIN2.1 and above only). LD_TRA↩ NSFER_ERROR: (For LIN2.0 and J2602 only) LIN protocol errors occurred during the transfer; initialize and redo the transfer.

Definition at line 193 of file lin_commontl_api.c.

16.90.2.4 l_u8 ld_raw_tx_status (l_ifc_handle *iii*)

Get the status of the raw frame transmission function.

Parameters

in	*iii*	Interface name

Returns

l_u8

Get the status of the raw frame transmission function: This function is available for < br / > LD_QUEUE_EMPTY : The transmit queue is empty. In case previous calls to < br / > ld_put_raw, all frames in the queue have been < br / > transmitted. < br / > LD_QUEUE_AVAILABLE: The transmit queue contains entries, but is not full. < br / > (For LIN2.1 and above only). LD_QUEUE_FULL : The transmit queue is full and can not accept further < br / > frames. < br / > LD_TRANSMIT_ERROR : (For LIN2.1 and above only) LIN protocol errors occurred during the transfer; initialize and redo the transfer. LD_TRANSFER_ERROR: (For LIN2.0 and J2602 only) LIN protocol errors occurred during the transfer; initialize and redo the transfer.

Definition at line 178 of file lin_commontl_api.c.

16.91 Real Time Clock Driver (RTC)

16.91.1 Detailed Description

The S32 SDK provides the Peripheral Driver for the Real Time Clock (RTC) module of S32 SDK devices.

Hardware background

The Real Time Clock Module is a independent timer that keeps track of the exact date and time with no software overhead, with low power usage.

Features of the RTC module include:

- 32-bit seconds counter with roll-over protection and 32-bit alarm
- 16-bit prescaler with compensation that can correct errors between 0.12 ppm and 3906 ppm
- Option to increment prescaler using the LPO (prescaler increments by 32 every clock edge)
- Register write protection
- Lock register requires POR or software reset to enable write access
- Configurable 1, 2, 4, 8, 16, 32, 64 or 128 Hz square wave output with optional interrupt
- Alarm interrupt configured by the driver automatically refreshes alarm time configured by the user
- User interrupt handlers can be configured for all interrupts

How to use the RTC driver in your application

In order to be able to use the RTC in your application, the first thing to do is initializing it with the desired configuration. This is done by calling the **RTC_DRV_Init** function. One of the arguments passed to this function is the configuration which will be used for the RTC instance, specified by the **rtc_init_config_t** structure.

The **rtc_init_config_t** structure allows you to configure the following:

- RTC clock source (32 KHz clock or 1 KHz LPO clock)
- Clock Out pin configuration (Clock OUT pin source)
- Compensation (Interval and value)
- Update enable - this allows updates to Time Counter Enable bit if the Status Register under limited conditions
- Enable non supervisor writes to the registers

The **rtc_seconds_int_config_t** structure configures the **time seconds interrupt**. To setup an interrupt every seconds you have to configure the structure mentioned with the following parameters:

- Frequency of the interrupt
- Interrupt Handler
- If needed - interrupt handler parameters

An alarm is configured with **rtc_alarm_config_t** structure, which is described by the following parameters:

- Alarm time in date-time format
- Interval of alarm repeat in seconds
- Number of alarm repeats (use 0 if the alarm is not recursive)
- Repeat forever field (if set, the number of repeats field will be ignored)

- Alarm interrupt enable
- Alarm interrupt handler
- Alarm interrupt handler parameters

Note

If the alarm interrupt is not enabled, the user must make the updates of the alarm time manually.

After the **RTC_DRV_Init()** function call and, if needed, alarm and other configurations the RTC counter is started by calling **RTC_DRV_StartCounter()**.

To update desired time date use **RTC_DRV_SetTimeDate()** function, this method uses a Time and Date structure **rtc_timedate_t** in a calendar format mode.

To get the current time and date you can call **RTC_DRV_GetCurrentTimeDate()** function, this method will get the seconds from the Time Seconds Register and will convert into human readable format as **rtc_timedate_t**.

To check if a structure **rtc_timedate_t** is properly configured use **RTC_DRV_IsTimeDateCorrectFormat()** function that will return true if configuration is valid or false if configuration is invalid.

To set an alarm at a desired date and time use **RTC_DRV_ConfigureAlarm()** function, this method uses a structure **rtc_alarm_config_t** with Time, Date and Alarm Handler and will trigger at set time an interrupt set by user.

To get the configured alarm use **RTC_DRV_GetAlarmConfig()** function, this method will return the Time and Date for alarm in a structure **rtc_alarm_config_t**.

To check if an alarm is pending use **RTC_DRV_IsAlarmPending()** function, this method will return true if alarm is pending or false if no alarm pending.

To configure a seconds interrupt use **RTC_DRV_ConfigureSecondsInt()** function, this method use structure **rtc_seconds_int_config_t** to be configured with a callback function.

After driver configuration the user can use **RTC_DRV_StartCounter()** function to start the timer and **RTC_DRV_StopCounter()** function to stop it.

To lock access to RTC registers use **RTC_DRV_ConfigureRegisterLock()** function, this method uses a structure **rtc_register_lock_config_t** that describes what registers will be locked. Attention all the registers are unlocked only by software reset or power on reset.

To check if RTC registers are locked use **RTC_DRV_GetRegisterLock()** function, this will return a structure **rtc_register_lock_config_t** with locked registers.

To convert seconds to a human readable value use **RTC_DRV_ConvertSecondsToTimeDate()** function, this will return a structure **rtc_timedate_t** based on the seconds value.

To convert a time date to seconds use **RTC_DRV_ConvertTimeDateToSeconds()** function, this will return seconds value based on time date structure **rtc_timedate_t**.

To get the time date for next alarm use **RTC_DRV_GetNextAlarmTime()** function, this will return a structure **rtc_timedate_t**.

To configure a fault handler for cases as Overflow and Invalid Time use **RTC_DRV_ConfigureFaultInt()** function, this method will use a structure **rtc_interrupt_config_t** with a callback function.

Example

```
/* Time Seconds interrupt handler */
void secondsISR(void)
{
    /* Do Something */

}

void rtcAlarmCallback(void)
{
    rtc_timedate_t currentTime;
    RTC_DRV_GetCurrentTimeDate(0U, &currentTime);

    /* Do something with the time and date */
```

```
}

int main()
{
    rtc_seconds_int_config_t rtcTimer1_SecIntConfig0 =
    {
        .secondIntConfig               =    RTC_INT_1HZ,
        .secondIntEnable               =    true,
        .rtcSecondsCallback            =   secondsISR,
        .secondsCallbackParams         =   NULL
    };

    /* rtcTimer1 configuration structure */
    const rtc_init_config_t rtcTimer1_Config0 =
    {
        /* Time compensation interval */
        .compensationInterval       =   0U,
        /* Time compensation value */
        .compensation               =   0,
        /* RTC Clock Source is 32 KHz crystal */
        .clockSelect                =   RTC_CLK_SRC_OSC_32KHZ,
        /* RTC Clock Out is 32 KHz clock */
        .clockOutConfig             =   RTC_CLKOUT_SRC_32KHZ,
        /* Update of the TCE bit is not allowed */
        .updateEnable               =   false,
        /* Non-supervisor mode write accesses are not supported and generate
         * a bus error.
         */
        .nonSupervisorAccessEnable  =   false
    };

    /* RTC Initial Time and Date */
    rtc_timedate_t       rtcStartTime =
    {
        /* Year */
        .year       =   2016U,
        /* Month */
        .month      =   01U,
        /* Day */
        .day        =   01U,
        /* Hour */
        .hour       =   00U,
        /* Minutes */
        .minutes    =   00U,
        /* Seconds */
        .seconds    =   00U
    };

    /* rtcTimer1 Alarm configuration 0 */
    rtc_alarm_config_t   alarmConfig0 =
    {
        /* Alarm Date */
        .alarmTime           =
            {
                /* Year    */
                .year       =  2016U,
                /* Month   */
                .month      =  01U,
                /* Day     */
                .day        =  01U,
                /* Hour    */
                .hour       =  00U,
                /* Minutes */
                .minutes    =  00U,
                /* Seconds */
                .seconds    =  03U,
            },

        /* Alarm repeat interval */
        .repetitionInterval  =       3UL,

        /* Number of alarm repeats */
        .numberOfRepeats     =       0UL,

        /* Repeat alarm forever */
        .repeatForever       =       true,

        /* Alarm interrupt disabled */
        .alarmIntEnable      =       true,

        /* Alarm interrupt handler */
        .alarmCallback       =       (void *)rtcAlarmCallback,

        /* Alarm interrupt handler parameters */
        .callbackParams      =       (void *)NULL
    };
```

```
        /* Call the init function */
        RTC_DRV_Init(0UL, &rtcInitConfig);

        /* Set the time and date */
        RTC_DRV_SetTimeDate(0UL, &rtcStartTime);

        /* Configure RTC Time Seconds Interrupt */
        RTC_DRV_ConfigureSecondsInt(0UL, &rtcTimer1_SecIntConfig0);

        /* Start RTC counter */
        RTC_DRV_StartCounter(0UL);

        /* Configure an alarm every 3 seconds */
        RTC_DRV_ConfigureAlarm(0UL, &rtcAlarmConfig0);

        while(1);
}
```

Important Notes

- Before using the RTC driver the module clock must be configured

  Note

  When using the on chip LPO clock as source input for the RTC, the user needs to make sure that the LPO generates the desired frequency by adjusting the LPO trimming value.
  For more details about LPO trimming please consult the available documentation.

- The driver enables the interrupts for the corresponding RTC module, but any interrupt priority must be done by the application
- The board specific configurations must be done prior to driver calls; the driver has no influence on the functionality of the clockout pin - they must be configured by application
- If Non-supervisor mode write accesses are supported you need to set AIPS to allow usermode access to RTC Memory Space

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\rtc\rtc_driver.c
${S32SDK_PATH}\platform\drivers\src\rtc\rtc_hw_access.c
${S32SDK_PATH}\platform\drivers\src\rtc\rtc_irq.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
```

Compile symbols

No special symbols are required for this component

Dependencies

1. Clock Manager
2. Interrupt Manager (Interrupt)

Modules

- RTC Driver

  Real Time Clock Peripheral Driver.

16.92 S32K142W SoC Header file

16.92.1 Detailed Description

This module covers the S32K142W SoC Header file.

Modules

- Backward Compatibility Symbols for S32K142W

  This module covers backward compatibility symbols.
- Interrupt vector numbers for S32K142W

  This module covers interrupt number allocation.
- Peripheral access layer for S32K142W

  This module covers all memory mapped register available on SoC.

16.93 S32K142W System Files

This module covers the SoC support file for S32K142W.

SystemInit method is called automatically from start-up code to do the minimum setup of the SoC. It disables the watchdog, enables FPU and the power mode protection if the corresponding feature macro is enabled.

SystemCoreClockUpdate method can be used at any time to update SystemCoreClock. It evaluates the clock register settings and calculates the current core clock.

SystemSoftwareReset method initiates a system reset.

16.94 Schedule management

16.94.1 Detailed Description

This group contains APIs that help users manage schedule tables in master node only.

Functions

- l_u8 l_sch_tick (l_ifc_handle iii)

  This function follows a schedule. When a frame becomes due, its transmission is initiated. When the end of the current schedule is reached, this function starts again at the beginning of the schedule.
- void l_sch_set (l_ifc_handle iii, l_schedule_handle schedule_iii, l_u8 entry)

  Set up the next schedule to be followed by the l_sch_tick function for a certain interface. The new schedule will be activated as soon as the current schedule reaches its next schedule entry point.

16.94.2 Function Documentation

16.94.2.1 void l_sch_set (l_ifc_handle *iii*, l_schedule_handle *schedule_iii*, l_u8 *entry*)

Set up the next schedule to be followed by the l_sch_tick function for a certain interface. The new schedule will be activated as soon as the current schedule reaches its next schedule entry point.

Parameters

in	*iii*	Interface name
in	*schedule_iii*	Schedule table for interface
in	*entry*	Entry to be set

Returns

void

Definition at line 73 of file lin_common_api.c.

16.94.2.2 l_u8 l_sch_tick (l_ifc_handle *iii*)

This function follows a schedule. When a frame becomes due, its transmission is initiated. When the end of the current schedule is reached, this function starts again at the beginning of the schedule.

Parameters

in	*Interface*	name

Returns

Operation status

- Zero: if the next call of l_sch_tick will not start transmission of a frame.
- Non-Zero: if the next call of l_sch_tick will start transmission of a frame. The return value will in this case be the next schedule table entry's number (counted from the beginning of the schedule table) in the schedule table. The return value will be in range 1 to N if the schedule table has N entries.

Definition at line 240 of file lin_common_api.c.

16.95 Security PAL

16.95.1 Detailed Description

Security Peripheral Abstraction Layer.

Data Structures

- struct security_user_config_t

  Define user configuration Implements : security_user_config_t_Class. More...

Enumerations

- enum security_instance_t { SECURITY_INSTANCE0 = 0U }

  Define instances for SECURITY PAL Implements : security_instance_t_Class.
- enum security_key_id_t {
  SECURITY_SECRET_KEY = 0x0U, SECURITY_MASTER_ECU = 0x1U, SECURITY_BOOT_MAC_KEY = 0x2U, SECURITY_BOOT_MAC = 0x3U,
  SECURITY_KEY_1, SECURITY_KEY_2, SECURITY_KEY_3, SECURITY_KEY_4,
  SECURITY_KEY_5, SECURITY_KEY_6, SECURITY_KEY_7, SECURITY_KEY_8,
  SECURITY_KEY_9, SECURITY_KEY_10, SECURITY_RAM_KEY = 0xFU, SECURITY_KEY_11 = 0x14U,
  SECURITY_KEY_12, SECURITY_KEY_13, SECURITY_KEY_14, SECURITY_KEY_15,
  SECURITY_KEY_16, SECURITY_KEY_17 }

  Defines the security keys Implements : security_key_id_t_Class.
- enum security_boot_flavor_t { SECURITY_BOOT_STRICT = 0U, SECURITY_BOOT_SERIAL = 1U, SECURITY_BOOT_PARALLEL = 2U, SECURITY_BOOT_NOT_DEFINED = 3U }

  Defines the security boot flavor Implements : security_boot_flavor_t_Class.
- enum security_cmd_t {
  SECURITY_CMD_ENC_ECB = 1U, SECURITY_CMD_ENC_CBC, SECURITY_CMD_DEC_ECB, SECURITY_CMD_DEC_CBC,
  SECURITY_CMD_GENERATE_MAC, SECURITY_CMD_VERIFY_MAC, SECURITY_CMD_LOAD_KEY, SECURITY_CMD_LOAD_PLAIN_KEY,
  SECURITY_CMD_EXPORT_RAM_KEY, SECURITY_CMD_INIT_RNG, SECURITY_CMD_EXTEND_SEED, SECURITY_CMD_RND,
  SECURITY_CMD_RESERVED_1, SECURITY_CMD_BOOT_FAILURE, SECURITY_CMD_BOOT_OK, SECURITY_CMD_GET_ID,
  SECURITY_CMD_BOOT_DEFINE, SECURITY_CMD_DBG_CHAL, SECURITY_CMD_DBG_AUTH, SECURITY_CMD_RESERVED_2,
  SECURITY_CMD_RESERVED_3, SECURITY_CMD_MP_COMPRESS }

  Defines the security command Implements : security_cmd_t_Class.

Functions

- void SECURITY_GetDefaultConfig (security_user_config_t *config)

  Initializes the configuration structure.
- status_t SECURITY_Init (security_instance_t instance, const security_user_config_t *config)

  Initializes the SECURITY module.
- status_t SECURITY_Deinit (security_instance_t instance)

  De-initializes the SECURITY module.
- status_t SECURITY_EncryptEcbBlocking (security_instance_t instance, security_key_id_t keyId, const uint8_t *plainText, uint32_t msgLen, uint8_t *cipherText, uint32_t timeout)

  ECB Encryption.
- status_t SECURITY_DecryptEcbBlocking (security_instance_t instance, security_key_id_t keyId, const uint8_t *cipherText, uint32_t msgLen, uint8_t *plainText, uint32_t timeout)

ECB Decryption.

- status_t SECURITY_EncryptCbcBlocking (security_instance_t instance, security_key_id_t keyId, const uint8_t *plainText, uint32_t msgLen, const uint8_t *iv, uint8_t *cipherText, uint32_t timeout)

  CBC Decryption.
- status_t SECURITY_DecryptCbcBlocking (security_instance_t instance, security_key_id_t keyId, const uint8_t *cipherText, uint32_t msgLen, const uint8_t *iv, uint8_t *plainText, uint32_t timeout)

  CBC Decryption.
- status_t SECURITY_GenerateMacBlocking (security_instance_t instance, security_key_id_t keyId, const uint8_t *msg, uint64_t msgLen, uint8_t *cmac, uint32_t timeout)

  MAC Generation.
- status_t SECURITY_VerifyMacBlocking (security_instance_t instance, security_key_id_t keyId, const uint8_t *msg, uint64_t msgLen, const uint8_t *mac, uint16_t macLen, bool *verifStatus, uint32_t timeout)

  MAC Verification.
- status_t SECURITY_LoadKey (security_instance_t instance, security_key_id_t keyId, const uint8_t *m1, const uint8_t *m2, const uint8_t *m3, uint8_t *m4, uint8_t *m5, uint32_t timeout)

  Load Key.
- status_t SECURITY_LoadPlainKey (security_instance_t instance, const uint8_t *plainKey, uint32_t timeout)

  Load Plain Key.
- status_t SECURITY_ExportRamKey (security_instance_t instance, uint8_t *m1, uint8_t *m2, uint8_t *m3, uint8_t *m4, uint8_t *m5, uint32_t timeout)

  Export RAM key.
- status_t SECURITY_ExtendSeed (security_instance_t instance, const uint8_t *entropy, uint32_t timeout)

  Initialize Random Number Generator.
- status_t SECURITY_InitRng (security_instance_t instance, uint32_t timeout)

  Initialize Random Number Generator.
- status_t SECURITY_GenerateRnd (security_instance_t instance, uint8_t *rnd, uint32_t timeout)

  Generate RND.
- status_t SECURITY_GetId (security_instance_t instance, const uint8_t *challenge, uint8_t *uid, uint8_t *sreg, uint8_t *mac, uint32_t timeout)

  Get ID.
- status_t SECURITY_SecureBoot (security_instance_t instance, uint32_t bootImageSize, const uint8_t *bootImagePtr, uint32_t timeout)

  Secure boot.
- status_t SECURITY_BootFailure (security_instance_t instance, uint32_t timeout)

  Boot Failure.
- status_t SECURITY_BootOk (security_instance_t instance, uint32_t timeout)

  Boot Ok.
- status_t SECURITY_BootDefine (security_instance_t instance, uint32_t bootSize, security_boot_flavor_t bootFlavor, uint32_t timeout)

  Boot Define.
- status_t SECURITY_DbgChal (security_instance_t instance, uint8_t *challenge, uint32_t timeout)

  Debug Challenge.
- status_t SECURITY_DbgAuth (security_instance_t instance, const uint8_t *authorization, uint32_t timeout)

  Debug Authentification.
- status_t SECURITY_MPCompress (security_instance_t instance, const uint8_t *msg, uint32_t msgLen, uint8_t *mpCompress, uint32_t timeout)

  Miyaguchi-Prenell Compression.
- status_t SECURITY_GenerateTrnd (security_instance_t instance, uint8_t *trnd, uint32_t timeout)

  Generate True Random Number.
- status_t SECURITY_CancelCommand (security_instance_t instance)

  Cancel Command.
- status_t SECURITY_GetAsyncCmdStatus (security_instance_t instance)

Get asynchronous command status.

- status_t SECURITY_EncryptEcb (security_instance_t instance, security_key_id_t keyId, const uint8_t *plainText, uint32_t msgLen, uint8_t *cipherText)

  Encrypt ECB.

- status_t SECURITY_DecryptEcb (security_instance_t instance, security_key_id_t keyId, const uint8_t *cipherText, uint32_t msgLen, uint8_t *plainText)

  Decrypt ECB.

- status_t SECURITY_EncryptCbc (security_instance_t instance, security_key_id_t keyId, const uint8_t *plainText, uint32_t msgLen, const uint8_t *iv, uint8_t *cipherText)

  Encrypt CBC.

- status_t SECURITY_DecryptCbc (security_instance_t instance, security_key_id_t keyId, const uint8_t *cipherText, uint32_t msgLen, const uint8_t *iv, uint8_t *plainText)

  Decrypt CBC.

- status_t SECURITY_GenerateMac (security_instance_t instance, security_key_id_t keyId, const uint8_t *msg, uint64_t msgLen, uint8_t *cmac)

  Generate MAC.

- status_t SECURITY_VerifyMac (security_instance_t instance, security_key_id_t keyId, const uint8_t *msg, uint64_t msgLen, const uint8_t *mac, uint16_t macLen, bool *verifStatus)

  Verify MAC.

16.95.2 Data Structure Documentation

16.95.2.1 struct security_user_config_t

Define user configuration Implements : security_user_config_t_Class.

Definition at line 155 of file security_pal.h.

Data Fields

- security_callback_t callback
- void * callbackParam

Field Documentation

16.95.2.1.1 security_callback_t callback

The callback invoked when an asynchronous command is completed

Definition at line 157 of file security_pal.h.

16.95.2.1.2 void* callbackParam

User parameter for the command completion callback

Definition at line 158 of file security_pal.h.

16.95.3 Enumeration Type Documentation

16.95.3.1 enum security_boot_flavor_t

Defines the security boot flavor Implements : security_boot_flavor_t_Class.

Enumerator

SECURITY_BOOT_STRICT

SECURITY_BOOT_SERIAL

SECURITY_BOOT_PARALLEL
SECURITY_BOOT_NOT_DEFINED

Definition at line 97 of file security_pal.h.

16.95.3.2 enum security_cmd_t

Defines the security command Implements : security_cmd_t_Class.

Enumerator

SECURITY_CMD_ENC_ECB
SECURITY_CMD_ENC_CBC
SECURITY_CMD_DEC_ECB
SECURITY_CMD_DEC_CBC
SECURITY_CMD_GENERATE_MAC
SECURITY_CMD_VERIFY_MAC
SECURITY_CMD_LOAD_KEY
SECURITY_CMD_LOAD_PLAIN_KEY
SECURITY_CMD_EXPORT_RAM_KEY
SECURITY_CMD_INIT_RNG
SECURITY_CMD_EXTEND_SEED
SECURITY_CMD_RND
SECURITY_CMD_RESERVED_1
SECURITY_CMD_BOOT_FAILURE
SECURITY_CMD_BOOT_OK
SECURITY_CMD_GET_ID
SECURITY_CMD_BOOT_DEFINE
SECURITY_CMD_DBG_CHAL
SECURITY_CMD_DBG_AUTH
SECURITY_CMD_RESERVED_2
SECURITY_CMD_RESERVED_3
SECURITY_CMD_MP_COMPRESS

Definition at line 109 of file security_pal.h.

16.95.3.3 enum security_instance_t

Define instances for SECURITY PAL Implements : security_instance_t_Class.

Enumerator

SECURITY_INSTANCE0

Definition at line 49 of file security_pal.h.

16.95.3.4 enum security_key_id_t

Defines the security keys Implements : security_key_id_t_Class.

Enumerator

SECURITY_SECRET_KEY

SECURITY_MASTER_ECU
SECURITY_BOOT_MAC_KEY
SECURITY_BOOT_MAC
SECURITY_KEY_1
SECURITY_KEY_2
SECURITY_KEY_3
SECURITY_KEY_4
SECURITY_KEY_5
SECURITY_KEY_6
SECURITY_KEY_7
SECURITY_KEY_8
SECURITY_KEY_9
SECURITY_KEY_10
SECURITY_RAM_KEY
SECURITY_KEY_11
SECURITY_KEY_12
SECURITY_KEY_13
SECURITY_KEY_14
SECURITY_KEY_15
SECURITY_KEY_16
SECURITY_KEY_17

Definition at line 58 of file security_pal.h.

16.95.4 Function Documentation

16.95.4.1 status_t SECURITY_BootDefine (security_instance_t *instance,* uint32_t *bootSize,* security_boot_flavor_t *bootFlavor,* uint32_t *timeout*)

Boot Define.

Implements an extension of the SHE standard to define both the user boot size and boot method.

Parameters

in	*instance*	security module instance
in	*bootSize*	Number of blocks of 128-bit data to check on boot. Maximum size is 512k↩ Bytes.
in	*bootFlavor*	The boot method.
in	*timeout*	Specifies the maximum time allowed for command completion, else STATU↩ S_TIMEOUT is returned.

Returns

Error Code after command execution. Unsupported code if function is not available.

Definition at line 695 of file security_pal.c.

16.95.4.2 status_t SECURITY_BootFailure (security_instance_t *instance,* uint32_t *timeout*)

Boot Failure.

Signals a failure detected during later stages of the boot process.

Parameters

in	*instance*	security module instance
in	*timeout*	Specifies the maximum time allowed for command completion, else STATUS_TIMEOUT is returned.

Returns

Error Code after command execution.

Definition at line 641 of file security_pal.c.

16.95.4.3 status_t SECURITY_BootOk (security_instance_t *instance*, uint32_t *timeout*)

Boot Ok.

Marks a successful boot verification during later stages of the boot process.

Parameters

in	*instance*	security module instance
in	*timeout*	Specifies the maximum time allowed for command completion, else STATUS_TIMEOUT is returned.

Returns

Error Code after command execution.

Definition at line 668 of file security_pal.c.

16.95.4.4 status_t SECURITY_CancelCommand (security_instance_t *instance*)

Cancel Command.

Cancels a previously initiated command.

Parameters

in	*instance*	security module instance

Returns

STATUS_SUCCES

Definition at line 844 of file security_pal.c.

16.95.4.5 status_t SECURITY_DbgAuth (security_instance_t *instance*, const uint8_t * *authorization*, uint32_t *timeout*)

Debug Authentification.

Erases all keys (actual and outdated) stored in NVM Memory if the authorization is confirmed.

Parameters

in	*instance*	security module instance
in	*authorization*	Pointer to the 128-bit buffer containing the authorization value.
in	*timeout*	Specifies the maximum time allowed for command completion, else STATUS_TIMEOUT is returned.

Returns

Error Code after command execution.

Definition at line 756 of file security_pal.c.

16.95.4.6 status_t SECURITY_DbgChal (security_instance_t *instance,* uint8_t * *challenge,* uint32_t *timeout*)

Debug Challenge.

Obtains a random number which the user shall use along with the MASTER_ECU_KEY and UID to return an authorization request.

Parameters

in	*instance*	security module instance
out	*challenge*	Pointer to the 128-bit buffer where the challenge data will be stored.
in	*timeout*	Specifies the maximum time allowed for command completion, else STATUS_TIMEOUT is returned.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 728 of file security_pal.c.

16.95.4.7 status_t SECURITY_DecryptCbc (security_instance_t *instance,* security_key_id_t *keyId,* const uint8_t * *cipherText,* uint32_t *msgLen,* const uint8_t * *iv,* uint8_t * *plainText*)

Decrypt CBC.

Asynchronously performs the AES-128 decryption in CBC mode of the input cipher text buffer.

Parameters

in	*instance*	security module instance
in	*keyId*	KeyID used to perform the cryptographic operation.
in	*cipherText*	Pointer to the cipher text buffer.
in	*msgLen*	Number of bytes of cipher text message to be decrypted. It should be multiple of 16 bytes.
in	*iv*	Pointer to the initialization vector buffer.
out	*plainText*	Pointer to the plain text buffer. The buffer shall have the same size as the cipher text buffer.

Returns

STATUS_BUSY if another command is in execution, otherwise STATUS_SUCCESS.

Definition at line 982 of file security_pal.c.

16.95.4.8 status_t SECURITY_DecryptCbcBlocking (security_instance_t *instance,* security_key_id_t *keyId,* const uint8_t * *cipherText,* uint32_t *msgLen,* const uint8_t * *iv,* uint8_t * *plainText,* uint32_t *timeout*)

CBC Decryption.

Perform AES-128 decryption in CBC mode of the input cipher text buffer.

Parameters

in	*instance*	security module instance
in	*keyId*	KeyID used to perform the cryptographic operation
in	*cipherText*	Pointer to the cipher text buffer.
in	*msgLen*	Number of bytes of plain text message to be encrypted. It is multiple of 16 bytes.

in	*iv*	Pointer to the initialization vector buffer.
out	*plainText*	Pointer to the plain text buffer. The buffer shall have the same size as the cipher text buffer.
in	*timeout*	Specifies the maximum time allowed for command completion, else STATUS_TIMEOUT is returned.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 312 of file security_pal.c.

16.95.4.9 status_t SECURITY_DecryptEcb (security_instance_t *instance,* security_key_id_t *keyId,* const uint8_t * *cipherText,* uint32_t *msgLen,* uint8_t * *plainText*)

Decrypt ECB.

Asynchronously performs the AES-128 decryption in ECB mode of the input cipher text buffer.

Parameters

in	*instance*	security module instance
in	*keyId*	KeyID used to perform the cryptographic operation.
in	*cipherText*	Pointer to the cipher text buffer.
in	*msgLen*	Number of bytes of cipher text message to be decrypted. It should be multiple of 16 bytes.
out	*plainText*	Pointer to the plain text buffer. The buffer shall have the same size as the cipher text buffer.

Returns

STATUS_BUSY if another command is in execution, otherwise STATUS_SUCCESS.

Definition at line 923 of file security_pal.c.

16.95.4.10 status_t SECURITY_DecryptEcbBlocking (security_instance_t *instance,* security_key_id_t *keyId,* const uint8_t * *cipherText,* uint32_t *msgLen,* uint8_t * *plainText,* uint32_t *timeout*)

ECB Decryption.

Perform AES-128 decryption in ECB mode of the input cipher text buffer.

Parameters

in	*instance*	security module instance
in	*keyId*	KeyID used to perform the cryptographic operation
in	*cipherText*	Pointer to the cipher text buffer.
in	*msgLen*	Number of bytes of plain text message to be encrypted. It is multiple of 16 bytes.
out	*plainText*	Pointer to the plain text buffer. The buffer shall have the same size as the cipher text buffer.
in	*timeout*	Specifies the maximum time allowed for command completion, else STATUS_TIMEOUT is returned.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 251 of file security_pal.c.

16.95.4.11 status_t SECURITY_Deinit (security_instance_t *instance*)

De-initializes the SECURITY module.

This function de-initializes the requested SECURITY instance.

Parameters

in	*instance*	security module instance

Returns

Error or success status returned by API

Definition at line 188 of file security_pal.c.

16.95.4.12 status_t SECURITY_EncryptCbc (security_instance_t *instance*, security_key_id_t *keyId*, const uint8_t * *plainText*, uint32_t *msgLen*, const uint8_t * *iv*, uint8_t * *cipherText*)

Encrypt CBC.

Asynchronously performs the AES-128 encryption in CBC mode of the input plain text buffer.

Parameters

in	*instance*	security module instance
in	*keyId*	KeyID used to perform the cryptographic operation.
in	*plainText*	Pointer to the plain text buffer.
in	*msgLen*	Number of bytes of plain text message to be encrypted. It should be multiple of 16 bytes.
in	*iv*	Pointer to the initialization vector buffer.
out	*cipherText*	Pointer to the cipher text buffer. The buffer shall have the same size as the plain text buffer.

Returns

STATUS_BUSY if another command is in execution, otherwise STATUS_SUCCESS.

Definition at line 952 of file security_pal.c.

16.95.4.13 status_t SECURITY_EncryptCbcBlocking (security_instance_t *instance*, security_key_id_t *keyId*, const uint8_t * *plainText*, uint32_t *msgLen*, const uint8_t * *iv*, uint8_t * *cipherText*, uint32_t *timeout*)

CBC Decryption.

Perform AES-128 decryption in CBC mode of the input cipher text buffer.

Parameters

in	*instance*	security module instance
in	*keyId*	KeyID used to perform the cryptographic operation
in	*plainText*	Pointer to the plain text buffer. The buffer shall have the same size as the cipher text buffer.
in	*msgLen*	Number of bytes of plain text message to be encrypted. It is multiple of 16 bytes.
in	*iv*	Pointer to the initialization vector buffer.
out	*cipherText*	Pointer to the cipher text buffer.
in	*timeout*	Specifies the maximum time allowed for command completion, else STATU↩ S_TIMEOUT is returned.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 281 of file security_pal.c.

16.95.4.14 status_t SECURITY_EncryptEcb (security_instance_t *instance*, security_key_id_t *keyId*, const uint8_t * *plainText*, uint32_t *msgLen*, uint8_t * *cipherText*)

Encrypt ECB.

Asynchronously performs the AES-128 encryption in ECB mode of the input plain text buffer.

Parameters

in	*instance*	security module instance
in	*keyId*	KeyID used to perform the cryptographic operation.
in	*plainText*	Pointer to the plain text buffer.
in	*msgLen*	Number of bytes of plain text message to be encrypted. It should be multiple of 16 bytes.
out	*cipherText*	Pointer to the cipher text buffer. The buffer shall have the same size as the plain text buffer.

Returns

STATUS_BUSY if another command is in execution, otherwise STATUS_SUCCESS.

Definition at line 894 of file security_pal.c.

16.95.4.15 status_t SECURITY_EncryptEcbBlocking (security_instance_t *instance*, security_key_id_t *keyId*, const uint8_t * *plainText*, uint32_t *msgLen*, uint8_t * *cipherText*, uint32_t *timeout*)

ECB Encryption.

Perform AES-128 encryption in ECB mode of the input plain text buffer.

Parameters

in	*instance*	security module instance
in	*keyId*	KeyID used to perform the cryptographic operation
in	*plainText*	Pointer to the plain text buffer
in	*msgLen*	Number of bytes of plain text message to be encrypted. It is multiple of 16 bytes.
out	*cipherText*	Pointer to the cipher text buffer. The buffer shall have the same size as the plain text buffer.
in	*timeout*	Specifies the maximum time allowed for command completion, else STATUS_TIMEOUT is returned.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 221 of file security_pal.c.

16.95.4.16 status_t SECURITY_ExportRamKey (security_instance_t *instance*, uint8_t * *m1*, uint8_t * *m2*, uint8_t * *m3*, uint8_t * *m4*, uint8_t * *m5*, uint32_t *timeout*)

Export RAM key.

Exports the RAM_KEY into a format protected by SECRET_KEY.

Parameters

in	*instance*	security module instance

out	*m1*	Pointer to a buffer where the M1 parameter will be exported.
out	*m2*	Pointer to a buffer where the M2 parameter will be exported.
out	*m3*	Pointer to a buffer where the M3 parameter will be exported.
out	*m4*	Pointer to a buffer where the M4 parameter will be exported.
out	*m5*	Pointer to a buffer where the M5 parameter will be exported.
in	*timeout*	Specifies the maximum time allowed for command completion, else STATU↩ S_TIMEOUT is returned.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 467 of file security_pal.c.

16.95.4.17 status_t SECURITY_ExtendSeed (security_instance_t *instance,* const uint8_t * *entropy,* uint32_t *timeout*)

Initialize Random Number Generator.

Extends the seed of the PRNG by compressing the former seed value and the supplied entropy into a new seed. This new seed is then to be used to generate a random number by invoking the CMD_RND command. The random number generator must be initialized by CMD_INIT_RNG before the seed may be extended.

Parameters

in	*instance*	security module instance
in	*entropy*	pointer to a 128-bit buffer containing the entropy.
in	*timeout*	Specifies the maximum time allowed for command completion, else STATU↩ S_TIMEOUT is returned.

Returns

Error Code after command execution.

Definition at line 498 of file security_pal.c.

16.95.4.18 status_t SECURITY_GenerateMac (security_instance_t *instance,* security_key_id_t *keyId,* const uint8_t * *msg,* uint64_t *msgLen,* uint8_t * *cmac*)

Generate MAC.

Asynchronously calculates the MAC of a given message using CMAC with AES-128.

Parameters

in	*instance*	security module instance
in	*keyId*	KeyID used to perform the cryptographic operation.
in	*msg*	Pointer to the message buffer.
in	*msgLen*	Number of bits of message on which CMAC will be computed.
out	*cmac*	Pointer to the buffer containing the result of the CMAC computation.

Returns

STATUS_BUSY if another command is in execution, otherwise STATUS_SUCCESS.

Definition at line 1012 of file security_pal.c.

16.95.4.19 status_t SECURITY_GenerateMacBlocking (security_instance_t *instance,* security_key_id_t *keyId,* const uint8_t * *msg,* uint64_t *msgLen,* uint8_t * *cmac,* uint32_t *timeout*)

MAC Generation.

Calculates MAC of a given message using CMAC with AES-128.

Parameters

in	*instance*	security module instance
in	*keyId*	KeyID used to perform the cryptographic operation.
in	*msg*	Pointer to the message buffer.
in	*msgLen*	Number of bits of message on which CMAC will be computed.
out	*cmac*	Pointer to the buffer containing the result of the CMAC computation.
in	*timeout*	Specifies the maximum time allowed for command completion, else STATU↩ S_TIMEOUT is returned.
in	*timeout*	Specifies the maximum time allowed for command completion, else STATU↩ S_TIMEOUT is returned.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 342 of file security_pal.c.

16.95.4.20 status_t SECURITY_GenerateRnd (security_instance_t *instance*, uint8_t * *rnd*, uint32_t *timeout*)

Generate RND.

Generates a vector of 128 random bits.

Parameters

in	*instance*	security module instance
out	*rnd*	Pointer to a 128-bit buffer where the generated random number has to be stored.
in	*timeout*	Specifies the maximum time allowed for command completion, else STATU↩ S_TIMEOUT is returned.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 551 of file security_pal.c.

16.95.4.21 status_t SECURITY_GenerateTrnd (security_instance_t *instance*, uint8_t * *trnd*, uint32_t *timeout*)

Generate True Random Number.

Generates a vector of 128 random bits using TRNG.

Parameters

in	*instance*	security module instance
out	*trnd*	Pointer to a 128-bit buffer where the generated random number is stored.
in	*timeout*	Specifies the maximum time allowed for command completion, else STATU↩ S_TIMEOUT is returned.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS. Unsupported code if function is not available.

Definition at line 816 of file security_pal.c.

16.95.4.22 status_t SECURITY_GetAsyncCmdStatus (security_instance_t *instance*)

Get asynchronous command status.

Checks the status of the execution of an asynchronous command.

Parameters

in	*instance*	security module instance

Returns

Error Code after command execution; STATUS_BUSY if a command is still in progress.

Definition at line 869 of file security_pal.c.

16.95.4.23 void SECURITY_GetDefaultConfig (security_user_config_t * *config*)

Initializes the configuration structure.

This function initializes the configuration struct members to default values.

Parameters

out	*config*	configuration struct pointer

Definition at line 126 of file security_pal.c.

16.95.4.24 status_t SECURITY_GetId (security_instance_t *instance,* const uint8_t * *challenge,* uint8_t * *uid,* uint8_t * *sreg,* uint8_t * *mac,* uint32_t *timeout*)

Get ID.

Returns the identity (UID) and the value of the status register protected by a MAC over a challenge and the data.

Parameters

in	*instance*	security module instance
in	*challenge*	Pointer to the 128-bit buffer containing Challenge data.
out	*uid*	Pointer to 120 bit buffer where the UID will be stored.
out	*sreg*	Value of the status register.
out	*mac*	Pointer to the 128 bit buffer where the MAC generated over challenge and UID and status will be stored.
in	*timeout*	Specifies the maximum time allowed for command completion, else STATU↩ S_TIMEOUT is returned.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 579 of file security_pal.c.

16.95.4.25 status_t SECURITY_Init (security_instance_t *instance,* const security_user_config_t * *config*)

Initializes the SECURITY module.

This function initializes and enables the requested SECURITY instance.

Parameters

in	*instance*	security module instance
in	*config*	pointer to security module configuration structure

Returns

Error or success status returned by API

Definition at line 141 of file security_pal.c.

16.95.4.26 status_t SECURITY_InitRng (security_instance_t *instance,* uint32_t *timeout*)

Initialize Random Number Generator.

Initializes the seed and derive a key for the PRNG.

Parameters

in	*instance*	security module instance
in	*timeout*	Specifies the maximum time allowed for command completion, else STATUS_TIMEOUT is returned.

Returns

Error Code after command execution.

Definition at line 525 of file security_pal.c.

16.95.4.27 status_t SECURITY_LoadKey (security_instance_t *instance*, security_key_id_t *keyId*, const uint8_t * *m1*, const uint8_t * *m2*, const uint8_t * *m3*, uint8_t * *m4*, uint8_t * *m5*, uint32_t *timeout*)

Load Key.

Updates an internal key per the SHE specification.

Parameters

in	*instance*	security module instance
in	*keyId*	KeyID of the key to be updated.
in	*m1*	Pointer to the 128-bit M1 message containing the UID, Key ID and Authentication Key ID.
in	*m2*	Pointer to the 256-bit M2 message contains the new security flags, counter and the key value all encrypted using a derived key generated from the Authentication Key.
in	*m3*	Pointer to the 128-bit M3 message is a MAC generated over messages M1 and M2.
out	*m4*	Pointer to a 256 bits buffer where the computed M4 parameter is stored.
out	*m5*	Pointer to a 128 bits buffer where the computed M5 parameter is stored.
in	*timeout*	Specifies the maximum time allowed for command completion, else STATUS_TIMEOUT is returned.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 408 of file security_pal.c.

16.95.4.28 status_t SECURITY_LoadPlainKey (security_instance_t *instance*, const uint8_t * *plainKey*, uint32_t *timeout*)

Load Plain Key.

Updates the RAM key memory slot with a 128-bit plaintext.

Parameters

in	*instance*	security module instance
in	*plainKey*	Pointer to the 128-bit buffer containing the key that needs to be copied in RAM_KEY slot.
in	*timeout*	Specifies the maximum time allowed for command completion, else STATUS_TIMEOUT is returned.

Returns

Error Code after command execution.

Definition at line 440 of file security_pal.c.

16.95.4.29 status_t SECURITY_MPCompress (security_instance_t *instance*, const uint8_t * *msg*, uint32_t *msgLen*, uint8_t * *mpCompress*, uint32_t *timeout*)

Miyaguchi-Prenell Compression.

Compresses the given messages by accessing the Miyaguchi-Prenell compression feature with in the CSEc feature set.

Parameters

in	*instance*	security module instance
in	*msg*	Pointer to the messages to be compressed. Messages must be pre-processed per SHE specification if they do not already meet the full 128-bit block size requirement.
in	*msgLen*	The number of 128 bit messages to be compressed.
out	*mpCompress*	Pointer to the 128 bit buffer storing the compressed data.
in	*timeout*	Specifies the maximum time allowed for command completion, else STATUS_TIMEOUT is returned.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 785 of file security_pal.c.

16.95.4.30 status_t SECURITY_SecureBoot (security_instance_t *instance*, uint32_t *bootImageSize*, const uint8_t * *bootImagePtr*, uint32_t *timeout*)

Secure boot.

The function loads the command processor firmware and memory slot data and then executes the SHE secure boot protocol.

Parameters

in	*instance*	security module instance
in	*bootImageSize*	Boot image size (in bytes).
in	*bootImagePtr*	Boot image start address.

Note

Address passed in this parameter must be 32 bit aligned.

Parameters

in	*timeout*	Timeout in ms; the function returns STATUS_TIMEOUT if the command is not finished in the allocated period.

Returns

Error Code after command execution.

Definition at line 610 of file security_pal.c.

16.95.4.31 status_t SECURITY_VerifyMac (security_instance_t *instance*, security_key_id_t *keyId*, const uint8_t * *msg*, uint64_t *msgLen*, const uint8_t * *mac*, uint16_t *macLen*, bool * *verifStatus*)

Verify MAC.

Asynchronously verifies the MAC of a given message using CMAC with AES-128.

Parameters

in	*instance*	security module instance
in	*keyId*	KeyID used to perform the cryptographic operation.
in	*msg*	Pointer to the message buffer.
in	*msgLen*	Number of bits of message on which CMAC will be computed.
in	*mac*	Pointer to the buffer containing the CMAC to be verified.
in	*macLen*	Number of bits of the CMAC to be compared. A macLength value of zero indicates that all 128-bits are compared.
out	*verifStatus*	Status of MAC verification command (true: verification operation passed, false: verification operation failed).

Returns

STATUS_BUSY if another command is in execution, otherwise STATUS_SUCCESS.

Definition at line 1044 of file security_pal.c.

16.95.4.32 status_t SECURITY_VerifyMacBlocking (security_instance_t *instance,* security_key_id_t *keyId,* const uint8_t * *msg,* uint64_t *msgLen,* const uint8_t * *mac,* uint16_t *macLen,* bool * *verifStatus,* uint32_t *timeout*)

MAC Verification.

Verifies the MAC of a given message using CMAC with AES-128.

Parameters

in	*instance*	security module instance
in	*keyId*	KeyID used to perform the cryptographic operation.
in	*msg*	Pointer to the message buffer.
in	*msgLen*	Number of bits of message on which CMAC will be computed.
in	*mac*	Pointer to the buffer containing the CMAC to be verified.
in	*macLen*	Number of bits of the CMAC to be compared. A macLength value of zero indicates that all 128-bits are compared.
out	*verifStatus*	Status of MAC verification command (true: verification operation passed, false: verification operation failed).
in	*timeout*	Specifies the maximum time allowed for command completion, else STATUS_TIMEOUT is returned.

Returns

Error Code after command execution. Output parameters are valid if the error code is STATUS_SUCCESS.

Definition at line 374 of file security_pal.c.

16.96 Security Peripheral Abstraction Layer - SECURITY PAL

16.96.1 Detailed Description

The SECURITY PAL provides security features over specific modules like:
-> Cryptographic Services Engine (CSEc)
-> Hardware Security Module (HSM)

Features

- Secure cryptographic key storage
- AES-128 encryption and decryption
- AES-128 CMAC (Cipher-based Message Authentication Code) calculation and authentication
- ECB (Electronic Cypher Book) Mode - encryption and decryption
- CBC (Cipher Block Chaining) Mode - encryption and decryption
- True and Pseudo random number generation
- Miyaguchi-Prenell compression function
- Secure Boot Mode (user configurable)

How to use the SECURITY PAL in your application

The SECURITY PAL is designed to be used in conjunction with CSEc driver or HSM driver, based on hardware platform. The SECURITY PAL can't be used simultaneously over different driver types.

The following table contains the matching between platforms and available IPs:

IP/↩ MCU	S32↩ K116	S32↩ K118	S32↩ K142	S32↩ K144	S32↩ K142↩ W	S32↩ K144↩ W	S32↩ K146	S32↩ K148	S32↩ MTV	MP↩ C5746↩ C	MP↩ C5748↩ G
CS↩ EC	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO	NO
HSM	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES

The SECURITY PAL includes file security_pal_cfg.h, which allows the user to specify which IP is used and how many resources are allocated (state structure). The following code example shows how to configure one instance for one available security module.

```
#ifndef SECURITY_PAL_CFG_H
#define SECURITY_PAL_CFG_H

/* Define which IP instance will be used in current project */
#define SECURITY_OVER_CSEC
#define NO_OF_CSEC_INSTS_FOR_SECURITY 1

#endif /* SECURITY_PAL_CFG_H */
```

In order to use the SECURITY modules, the initialization procedure must be completed. Using the SECURITY_Init() function, the instance of the module is selected and configured using the user configuration structure.

The security features are available in two types: blocking and non-blocking. The blocking features have specified in their naming the 'blocking' attribute. All other functions are considered to be non-blocking. The blocking functions use the osif layer, providing timeout feature.

```
## Important Notes ##
```

- For advanced usage, user must verify the specific drivers documentation for CSEc or HSM.
- The SECURITY PAL enables the interrupts for the corresponding module. The application must configure the interrupts priorities.

- The SECURITY PAL API offers a "timeout" parameter for a number of functions. If "timeout" value is set to value '0', the returned status shall not be assumed as "STATUS_TIMEOUT". This behaviour is given by the response time of the OS system tick and the execution time of the called function. Example: If OS system tick is set to 1ms, then the response time for a timeout set to '0', is between 0ms and 0.99ms. If the execution time of the functon is 10us, then there is a high probability that the returned status shall be "STATUS_SUCCESS".

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\pal\src\security\security_pal.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc
${S32SDK_PATH}\platform\pal\inc
${S32_SDK_PATH}\rtos\osif
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager Interrupt Manager (Interrupt) OS Interface (OSIF)

```
## Example code ##

static security_user_config_t g_SecurityUserConfig;

void SecurityCallback(uint32_t completedCmd, void *callbackParam)
{
    security_cmd_t securityCmd = (security_cmd_t)completedCmd;
    switch (securityCmd)
    {
        case SECURITY_CMD_ENC_ECB:
            /* Do something... */
            break;
        default:
            /* Error... */
            break;
    }
}

void main()
{
    static status_t status = STATUS_SUCCESS;
    static uint8_t rndBuf[16];

    g_SecurityUserConfig.callback = SecurityCallback;

    status = SECURITY_Init(SECURITY_INSTANCE0, &g_SecurityUserConfig);
    if(status != STATUS_SUCCESS)
    {
        /* Error... */
    }
    status = SECURITY_InitRng(SECURITY_INSTANCE0, TIMEOUT);
    if(status != STATUS_SUCCESS)
    {
        /* Error... */
    }
    status = SECURITY_GenerateRnd(SECURITY_INSTANCE0, rndBuf, TIMEOUT
      );
    if(status != STATUS_SUCCESS)
    {
        /* Error... */
    }

    while(1);
}
```

Modules

- Security PAL

  Security Peripheral Abstraction Layer.

16.97 Serial Peripheral Interface - Peripheral Abstraction Layer(SPI PAL)

16.97.1 Detailed Description

Serial Peripheral Interface - Peripheral Abstraction Layer.

The SPI PAL driver allows communication on an SPI bus. It was designed to be portable across all platforms and IPs which support SPI communication.

How to integrate DSPI in your application

Unlike the other drivers, SPI PAL modules need to include a configuration file named spi_pal_cfg.h, which allows the user to specify which IPSs are used and how many resources are allocated for each of them (state structures). The following code example shows how to configure one instance for each available SPI IPs.

```
#ifndef SPI_PAL_cfg_H
#define SPI_PAL_cfg_H

/* Define which IP instance will be used in current project */
#define SPI_OVER_LPSPI
#define SPI_OVER_FLEXIO
#define SPI_OVER_DSPI

/* Define the resources necessary for current project */
#define NO_OF_LPSPI_INSTS_FOR_SPI       1U
#define NO_OF_FLEXIO_INSTS_FOR_SPI      1U
#define NO_OF_DSPI_INSTS_FOR_SPI        1U
#endif /* SPI_PAL_cfg_H */
```

The following table contains the matching between platforms and available IPs

IP/↩ M↩ CU	S32↩ K118	S32↩ K116	S32↩ K142	S32↩ K144	S32↩ K146	S32↩ K148	S32↩ K142↩ W	S32↩ K144↩ W	M↩ P↩ C5748 G	M↩ P↩ C5746 C	M↩ P↩ C5744 P	S32↩ R274	S32↩ R372
FL↩ E↩ XIO	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	NO	NO	NO	NO	NO
LP↩ S↩ PI	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	NO	NO	NO	NO	NO
D↩ S↩ PI/↩ S↩ PI	NO	NO	NO	NO	NO	NO	NO	NO	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES	Y↩ ES

In order to use the SPI driver it must be first initialized in either master or slave mode, using functions SPI_Master↩ Init() or SPI_SlaveInit(). Once initialized, it cannot be initialized again for the same SPI module instance until it is de-initialized, using SPI_SlaveDeinit() or SPI_MasterDeinit. Different SPI module instances can work independently of each other.

In each mode (master/slave) are available two types of transfers: blocking and non-blocking. The functions which initiate blocking transfers will configure the time out for transmission. If time expires SPI_MasterTransferBlocking() or SPI_SlaveTransferBlocking() will return error and the transmission will be aborted.

The configuration structure includes a special field named extension. It will be used only for SPI transfers over FLEXIO and should contain a pointer to extension_flexio_for_spi_t structure. The purpose of this structure is to configure which FLEXIO pins are used by the applications and their functionality (MISO, MOSI, SCK, SS). One FLEXIO hardware instance can implements spi, so if instType is SPI_INST_TYPE_FLEXIO instIdx can be 0 or 1.

If device name is from MPC574xP and S32Rx7x families it can't be used as master in DMA mode and PAL will automatically switch the functionality to interrupt mode. If DMA mode is mandatory please use DSPI driver.

Important Notes

- The driver enables the interrupts for the corresponding module, but any interrupt priority setting must be done by the application.

Example code

```
 /* Configure SPI master */
spi_master_t spi10_MasterConfig0 =
{
    .baudRate      = 100000,
    .ssPolarity    = SPI_ACTIVE_HIGH,
    .frameSize     = 8,
    .clockPhase    = READ_ON_ODD_EDGE,
    .clockPolarity = SPI_ACTIVE_HIGH,
    .bitOrder      = SPI_TRANSFER_MSB_FIRST,
    .transferType  = SPI_USING_INTERRUPTS,
    .rxDMAChannel  = 255,
    .txDMAChannel  = 255,
    .callback      = NULL,
    .callbackParam = NULL,
    .ssPin         = 0,
    .extension     = NULL
};

 /* Configure FLEXIO pins routing */
 extension_flexio_for_spi_t extension;
 extension.misoPin = 0;
 extension.mosiPin = 1;
 extension.sckPin = 2;
 extension.ssPin = 3;
 spi0_MasterConfig0.extension = &extension;

  /* Configure instances used in this example */
 spi_instance_t lpspiInstance, flexioInstance;
 lpspiInstance.instIdx = 0U;
 lpspiInstance.instType = SPI_INST_TYPE_LPSPI;
 flexioInstance.instIdx = 1U;
 lpspiInstance.instType = SPI_INST_TYPE_FLEXIO;

 /* Buffers */
 uint8_t tx[5] = {1,2,3,4,5};
 uint8_t rx[5];



 /* Initializes SPI master for LPSPI 0 and send 5 frames */
 SPI_MasterInit(&lpspiInstance, &spi0_MasterConfig0);
 SPI_MasterTransfer(&lpspiInstance, tx, rx, 5);
 /* Initializes SPI master for FLEXIO 0 and send 5 frames */
 SPI_MasterInit(&flexioInstance, &spi1_MasterConfig0);
 SPI_MasterTransfer(&flexioInstance, tx, rx, 5);
```

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\pal\src\spi\spi_pal.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\pal\inc
spi_pal_cfg.h path
```

Compile symbols

No special symbols are required for this component

Dependencies

Low Power Serial Peripheral Interface (LPSPI) flexio_spi Clock Manager OS Interface (OSIF) Interrupt Manager (Interrupt) Enhanced Direct Memory Access (eDMA)

Data Structures

- struct spi_master_t

  Defines the configuration structure for SPI master Implements : spi_master_t_Class. More...
- struct spi_slave_t

  Defines the configuration structure for SPI slave Implements : spi_slave_t_Class. More...
- struct extension_flexio_for_spi_t

  Defines the extension structure for the SPI over FLEXIO Implements : extension_flexio_for_spi_t_Class. More...

Enumerations

- enum spi_transfer_type_t { SPI_USING_DMA = 0U, SPI_USING_INTERRUPTS = 1U }

  Defines the mechanism to update the rx or tx buffers Implements : spi_transfer_type_t_Class.
- enum spi_polarity_t { SPI_ACTIVE_HIGH = 0U, SPI_ACTIVE_LOW = 1U }

  Defines the polarity of signals Implements : spi_polarity_t_Class.
- enum spi_clock_phase_t { READ_ON_ODD_EDGE = 0U, READ_ON_EVEN_EDGE = 1U }

  Defines the edges used for sampling and shifting Implements : spi_clock_phase_t_Class.
- enum spi_transfer_bit_order_t { SPI_TRANSFER_MSB_FIRST = 0U, SPI_TRANSFER_LSB_FIRST = 1U }

  Defines the bit order Implements : spi_transfer_bit_order_t_Class.

Functions

- status_t SPI_MasterInit (const spi_instance_t *const instance, const spi_master_t *config)

  Initializes the SPI module in master mode.
- status_t SPI_SlaveInit (const spi_instance_t *const instance, const spi_slave_t *config)

  Initializes the SPI module in slave mode.
- status_t SPI_SetSS (const spi_instance_t *const instance, uint8_t ss)

  Update the SS.
- status_t SPI_MasterTransfer (const spi_instance_t *const instance, const void *txBuffer, void *rxBuffer, uint16_t numberOfFrames)

  Initializes a non-blocking master transfer.
- status_t SPI_MasterTransferBlocking (const spi_instance_t *const instance, const void *txBuffer, void *rx↩ Buffer, uint16_t numberOfFrames, uint16_t timeout)

  Initializes a blocking master transfer.
- status_t SPI_SlaveTransfer (const spi_instance_t *const instance, const void *txBuffer, void *rxBuffer, uint16_t numberOfFrames)

  Initializes a non-blocking slave transfer.
- status_t SPI_SlaveTransferBlocking (const spi_instance_t *const instance, const void *txBuffer, void *rx↩ Buffer, uint16_t numberOfFrames, uint16_t timeout)

  Initializes a blocking slave transfer.
- status_t SPI_GetStatus (const spi_instance_t *const instance)

  Gets the status of the last transfer.
- status_t SPI_GetDefaultMasterConfig (spi_master_t *config)

  Gets the default configuration structure for master.
- status_t SPI_GetDefaultSlaveConfig (spi_slave_t *config)

  Gets the default configuration structure for slave.
- status_t SPI_MasterDeinit (const spi_instance_t *const instance)

  De-initializes the spi master module.
- status_t SPI_SlaveDeinit (const spi_instance_t *const instance)

  De-initializes the spi slave module.
- status_t SPI_MasterSetDelay (const spi_instance_t *const instance, uint32_t delayBetweenTransfers, uint32_t delaySCKtoPCS, uint32_t delayPCStoSCK)

  Configures the SPI_PAL master mode bus timing delay options.

16.97.2 Data Structure Documentation

16.97.2.1 struct spi_master_t

Defines the configuration structure for SPI master Implements : spi_master_t_Class.

Definition at line 82 of file spi_pal.h.

Data Fields

- uint32_t baudRate
- uint8_t frameSize
- spi_transfer_bit_order_t bitOrder
- spi_polarity_t clockPolarity
- spi_polarity_t ssPolarity
- spi_clock_phase_t clockPhase
- uint8_t ssPin
- spi_transfer_type_t transferType
- uint8_t rxDMAChannel
- uint8_t txDMAChannel
- spi_callback_t callback
- void * callbackParam
- void * extension

Field Documentation

16.97.2.1.1 uint32_t baudRate

Clock frequency

Definition at line 84 of file spi_pal.h.

16.97.2.1.2 spi_transfer_bit_order_t bitOrder

Select if first bit is MSB or LSB

Definition at line 86 of file spi_pal.h.

16.97.2.1.3 spi_callback_t callback

Select the callback to transfer complete

Definition at line 94 of file spi_pal.h.

16.97.2.1.4 void* callbackParam

Select additional callback parameters if it's necessary

Definition at line 95 of file spi_pal.h.

16.97.2.1.5 spi_clock_phase_t clockPhase

Select clock edges for sampling and shifting

Definition at line 89 of file spi_pal.h.

16.97.2.1.6 spi_polarity_t clockPolarity

Select polarity for Clock

Definition at line 87 of file spi_pal.h.

16.97.2.1.7 void* extension

This field will be used to add extra settings to the basic configuration like FlexIO pins

Definition at line 96 of file spi_pal.h.

16.97.2.1.8 uint8_t frameSize

Size of frame in bits

Definition at line 85 of file spi_pal.h.

16.97.2.1.9 uint8_t rxDMAChannel

Channel number for DMA rx channel

Definition at line 92 of file spi_pal.h.

16.97.2.1.10 uint8_t ssPin

Select which SS is used

Definition at line 90 of file spi_pal.h.

16.97.2.1.11 spi_polarity_t ssPolarity

Select polarity for SS

Definition at line 88 of file spi_pal.h.

16.97.2.1.12 spi_transfer_type_t transferType

Select if buffers are managed by internal interrupt handler or by DMA

Definition at line 91 of file spi_pal.h.

16.97.2.1.13 uint8_t txDMAChannel

Channel number for DMA tx channel

Definition at line 93 of file spi_pal.h.

16.97.2.2 struct spi_slave_t

Defines the configuration structure for SPI slave Implements : spi_slave_t_Class.

Definition at line 103 of file spi_pal.h.

Data Fields

- uint8_t frameSize
- spi_transfer_bit_order_t bitOrder
- spi_polarity_t clockPolarity
- spi_polarity_t ssPolarity
- spi_clock_phase_t clockPhase
- spi_transfer_type_t transferType
- uint8_t rxDMAChannel
- uint8_t txDMAChannel
- spi_callback_t callback
- void * callbackParam
- void * extension

Field Documentation

16.97.2.2.1 spi_transfer_bit_order_t bitOrder

Select if first bit is MSB or LSB

Definition at line 106 of file spi_pal.h.

16.97.2.2.2 spi_callback_t callback

Select the callback to transfer complete

Definition at line 113 of file spi_pal.h.

16.97.2.2.3 void* callbackParam

Select additional callback parameters if it's necessary

Definition at line 114 of file spi_pal.h.

16.97.2.2.4 spi_clock_phase_t clockPhase

Select clock edges for sampling and shifting

Definition at line 109 of file spi_pal.h.

16.97.2.2.5 spi_polarity_t clockPolarity

Select polarity for Clock

Definition at line 107 of file spi_pal.h.

16.97.2.2.6 void* extension

This field will be used to add extra settings to the basic configuration like FlexIO

Definition at line 115 of file spi_pal.h.

16.97.2.2.7 uint8_t frameSize

Size of frame in bits

Definition at line 105 of file spi_pal.h.

16.97.2.2.8 uint8_t rxDMAChannel

Channel number for DMA rx channel

Definition at line 111 of file spi_pal.h.

16.97.2.2.9 spi_polarity_t ssPolarity

Select polarity for SS

Definition at line 108 of file spi_pal.h.

16.97.2.2.10 spi_transfer_type_t transferType

Select if buffers are managed by internal interrupt handler or by DMA

Definition at line 110 of file spi_pal.h.

16.97.2.2.11 uint8_t txDMAChannel

Channel number for DMA tx channel

Definition at line 112 of file spi_pal.h.

16.97.2.3 struct extension_flexio_for_spi_t

Defines the extension structure for the SPI over FLEXIO Implements : extension_flexio_for_spi_t_Class.

Definition at line 123 of file spi_pal.h.

Data Fields

- uint8_t mosiPin
- uint8_t misoPin
- uint8_t sckPin
- uint8_t ssPin

Field Documentation

16.97.2.3.1 uint8_t misoPin

FlexIO pin for MISO

Definition at line 126 of file spi_pal.h.

16.97.2.3.2 uint8_t mosiPin

FlexIO pin for MOSI

Definition at line 125 of file spi_pal.h.

16.97.2.3.3 uint8_t sckPin

FlexIO pin for SCK

Definition at line 127 of file spi_pal.h.

16.97.2.3.4 uint8_t ssPin

FlexIO pin for SS

Definition at line 128 of file spi_pal.h.

16.97.3 Enumeration Type Documentation

16.97.3.1 enum spi_clock_phase_t

Defines the edges used for sampling and shifting Implements : spi_clock_phase_t_Class.

Enumerator

READ_ON_ODD_EDGE The SPI signal is read on odd edges of SCK and counting starts after SS activation

READ_ON_EVEN_EDGE The SPI signal is read on even edges of SCK and counting starts after SS activation

Definition at line 61 of file spi_pal.h.

16.97.3.2 enum spi_polarity_t

Defines the polarity of signals Implements : spi_polarity_t_Class.

Enumerator

SPI_ACTIVE_HIGH The signal is active high

SPI_ACTIVE_LOW The signal is active low

Definition at line 51 of file spi_pal.h.

16.97.3.3 enum spi_transfer_bit_order_t

Defines the bit order Implements : spi_transfer_bit_order_t_Class.

Enumerator

SPI_TRANSFER_MSB_FIRST Transmit data starting with most significant bit

SPI_TRANSFER_LSB_FIRST Transmit data starting with least significant bit

Definition at line 71 of file spi_pal.h.

16.97.3.4 enum spi_transfer_type_t

Defines the mechanism to update the rx or tx buffers Implements : spi_transfer_type_t_Class.

Enumerator

SPI_USING_DMA The driver will use DMA to perform SPI transfer

SPI_USING_INTERRUPTS The driver will use interrupts to perform SPI transfer

Definition at line 41 of file spi_pal.h.

16.97.4 Function Documentation

16.97.4.1 status_t SPI_GetDefaultMasterConfig (spi_master_t * *config*)

Gets the default configuration structure for master.

The default configuration structure is:

Parameters

out	*config*	Pointer to configuration structure

Returns

Error or success status returned by API

Definition at line 734 of file spi_pal.c.

16.97.4.2 status_t SPI_GetDefaultSlaveConfig (spi_slave_t * *config*)

Gets the default configuration structure for slave.

The default configuration structure is:

Parameters

out	*config*	Pointer to configuration structure

Returns

Error or success status returned by API

Definition at line 759 of file spi_pal.c.

16.97.4.3 status_t SPI_GetStatus (const spi_instance_t *const *instance*)

Gets the status of the last transfer.

This function return the status of the last transfer. Using this function the user can check if the transfer is still in progress or if time-out event occurred.

Parameters

in	*instance*	The name of the instance
in	*txBuffer*	Pointer to tx buffer.
in	*rxBuffer*	Pointer to rx buffer.
in	*numberOf↩ Frames*	Number of frames sent/received
in	*timeout*	Transfer time-out in ms

Returns

Error or success status returned by API

Definition at line 946 of file spi_pal.c.

16.97.4.4 status_t SPI_MasterDeinit (const spi_instance_t *const *instance*)

De-initializes the spi master module.

This function de-initialized the spi master module.

Parameters

in	*instance*	The name of the instance

Returns

Error or success status returned by API

Definition at line 782 of file spi_pal.c.

16.97.4.5 status_t SPI_MasterInit (const spi_instance_t *const *instance,* const spi_master_t * *config*)

Initializes the SPI module in master mode.

This function initializes and enables the requested SPI module in master mode, configuring the bus parameters.

Parameters

in	*instance*	The name of the instance
in	*config*	The configuration structure

Returns

Error or success status returned by API

Definition at line 248 of file spi_pal.c.

16.97.4.6 status_t SPI_MasterSetDelay (const spi_instance_t *const *instance,* uint32_t *delayBetweenTransfers,* uint32_t *delaySCKtoPCS,* uint32_t *delayPCStoSCK*)

Configures the SPI_PAL master mode bus timing delay options.

This function involves the DSPI module's delay options to "fine tune" some of the signal timings and match the timing needs of a slower peripheral device. This is an optional function that can be called after the SPI_PAL module has been initialized for master mode. The timings are adjusted in terms of microseconds. The bus timing delays that can be adjusted are listed below:

SCK to PCS Delay: Adjustable delay option between the last edge of SCK to the de-assertion of the PCS signal.

PCS to SCK Delay: Adjustable delay option between the assertion of the PCS signal to the first SCK edge.

Delay between Transfers: Adjustable delay option between the de-assertion of the PCS signal for a frame to the assertion of the PCS signal for the next frame.

Definition at line 1014 of file spi_pal.c.

16.97.4.7 status_t SPI_MasterTransfer (const spi_instance_t *const *instance*, const void * *txBuffer*, void * *rxBuffer*, uint16_t *numberOfFrames*)

Initializes a non-blocking master transfer.

This function initializes a non-blocking master transfer.

Parameters

in	*instance*	The name of the instance
in	*txBuffer*	Pointer to tx buffer.
in	*rxBuffer*	Pointer to rx buffer.
in	*numberOf↩ Frames*	Number of frames sent/received

Returns

Error or success status returned by API

Definition at line 373 of file spi_pal.c.

16.97.4.8 status_t SPI_MasterTransferBlocking (const spi_instance_t *const *instance*, const void * *txBuffer*, void * *rxBuffer*, uint16_t *numberOfFrames*, uint16_t *timeout*)

Initializes a blocking master transfer.

This function initializes a blocking master transfer.

Parameters

in	*instance*	The name of the instance
in	*txBuffer*	Pointer to tx buffer.
in	*rxBuffer*	Pointer to rx buffer.
in	*numberOf↩ Frames*	Number of frames sent/received
in	*timeout*	Transfer time-out in ms

Returns

Error or success status returned by API

Definition at line 436 of file spi_pal.c.

16.97.4.9 status_t SPI_SetSS (const spi_instance_t *const *instance*, uint8_t *ss*)

Update the SS.

This function changes the SS, if this feature is available.

Parameters

in	*instance*	The name of the instance
in	*ss*	The number of SS

Returns

Error or success status returned by API

Definition at line 900 of file spi_pal.c.

16.97.4.10 status_t SPI_SlaveDeinit (const spi_instance_t *const *instance*)

De-initializes the spi slave module.

This function de-initialized the spi slave module.

Parameters

in	*instance*	The name of the instance

Returns

Error or success status returned by API

Definition at line 844 of file spi_pal.c.

16.97.4.11 status_t SPI_SlaveInit (const spi_instance_t *const *instance*, const spi_slave_t * *config*)

Initializes the SPI module in slave mode.

This function initializes and enables the requested SPI module in slave mode, configuring the bus parameters.

Parameters

in	*instance*	The name of the instance
in	*config*	The configuration structure

Returns

Error or success status returned by API

Definition at line 499 of file spi_pal.c.

16.97.4.12 status_t SPI_SlaveTransfer (const spi_instance_t *const *instance*, const void * *txBuffer*, void * *rxBuffer*, uint16_t *numberOfFrames*)

Initializes a non-blocking slave transfer.

This function initializes a non-blocking slave transfer.

Parameters

in	*instance*	The name of the instance
in	*txBuffer*	Pointer to tx buffer.
in	*rxBuffer*	Pointer to rx buffer.
in	*numberOf↩ Frames*	Number of frames sent/received

Returns

Error or success status returned by API

Definition at line 608 of file spi_pal.c.

16.97.4.13 status_t SPI_SlaveTransferBlocking (const spi_instance_t *const *instance*, const void * *txBuffer*, void * *rxBuffer*, uint16_t *numberOfFrames*, uint16_t *timeout*)

Initializes a blocking slave transfer.

This function initializes a blocking slave transfer.

Parameters

in	*instance*	The name of the instance

in	*txBuffer*	Pointer to tx buffer.
in	*rxBuffer*	Pointer to rx buffer.
in	*numberOf↩ Frames*	Number of frames sent/received
in	*timeout*	Transfer time-out in ms

Returns

Error or success status returned by API

Definition at line 671 of file spi_pal.c.

16.98 Signal interaction

This group contains APIs that help users interract with signals of LIN node.

16.99 SoC Header file (SoC Header)

16.99.1 Detailed Description

This module covers SoC Header file.

This section describes the functionality supported by the header file. For usage please see soc_header_usage

Modules

- S32K142W SoC Header file

  This module covers the S32K142W SoC Header file.

16.100 SoC Support

16.100.1 Detailed Description

This module covers SoC support files.

This section describes the files that are used for supporting various SoCs.

The support files are:

1. Linker files
2. Start-up files
3. SVD file
4. Header files

Linker files

Linker files are used to control the linkage part of the project compilation and contain details regarding the following:

1. memory areas definition (type and ranges)
2. data and code segments definition and their mapping to the memory areas.

linker configuration files are provided for all supported linkers. Please see Build Tools for details.

Start-up files

Start-up files are used to control the SoC bring-up part and contain:

1. interrupt vector allocation
2. start-up code and routines

Start-up files are provided for all supported compilers. Please see Build Tools for details.

SVD file

SVD file contains details about registers and can be used with an IDE to allow mapping of memory location to the register definition and information.

Header file

For each SoC there are two header files provided in the SDK:

1. <SoC_name>.h
2. <SoC_name>_features.h

The <SoC_name>.h file contains information related to registers that is used by the SDK drivers and code. The <SoC_name>_features.h contains information related to the integration of modules in the SoC.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\devices\<SoC_name>\startup\system_<SoC_name>.c
${S32SDK_PATH}\platform\devices\startup.c
${S32SDK_PATH}\platform\devices\<SoC_name>\startup\<Toolchain>\startup_<SoC_name>.S
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\devices
${S32SDK_PATH}\platform\devices\<SoC_name>\
${S32SDK_PATH}\platform\devices\startup\
${S32SDK_PATH}\platform\devices\<SoC_name>\include\
${S32SDK_PATH}\platform\devices\common
```

Compile symbols

```
CPU_S32K144HFT0VLLT for S32K144
CPU_<SoC_name>
```

Dependencies

No special dependencies are required for this component

Limitations

IAR: Function alignment is not supported using ALIGNED() macro.

Modules

- S32K142W System Files

  This module covers the SoC support file for S32K142W.

16.101 Structural Core Self Test

Structural Core Self Test integration with S32 SDK
.

General Information

- The SCST library provides tests to achieve the claimed diagnostic coverage (analytically estimated).
- The SCST library can be executed periodically at run time. This way, it contributes to a Single-Point Fault metric. The library preserves execution context of application and device configuration.
- The included tests cover most of the core instructions, as well as the tests targeting specific IP blocks of the core:
  - Core control logic (branch control, exception control);
  - Core data path including:
    - Register file and register multiplexing;
    - ALU, multiplier, divider, load/store, and other execution units;
    - SIMDSAT;
    - Instruction decoder,16-Bit,32-Bit;
- Interrupts can be enabled during execution of the most of the tests. SCST library provides its own interrupt vector table and wrappers for interrupt service routines, which in case of unexpected for the library interrupt, forwards it to the corresponding interrupt handler of the OS / user application. SCST library supports nested interrupts without any limitations.
- SCST library can be compiled and linked with other SCST libraries (e.g. SCST library for Cortex A5 core) within the same application for which a single .elf file is generated.

Note

This is just a brief description of the Structural Core Self Test Library, for more information please check the full library documentation found in <SDK_Location>/lib/<CPU_Family>/SCST/User_Documentation/<CoreType>>_<CPU_Name>_SCST_User_Manual.pdf
The library is provided in binary format, compiled using GCC and for evaluation purposes only. Please consult license.txt file for more information found in <SDK_Location>/lib/<CPU_Family>/SCST/license.txt
The library was built with FPU(hard) enabled, so it must be enabled also in the application which will use it.

How to use

To add SCST in your application you need to follow four steps:

- 1) Add sCST S32CT component into your project. The component will automatically add the required include paths and library files to the compilation.
- 2) Check that **_m4_scst** is added to Libraries under Linker build settings. If it is not present add a new entry with text **:lib_m4_scst.a**
- 3) Check that **"${workspace_loc:/${ProjName}/SDK/lib/SCST/SCST/src/lib}"** is added to Library search paths under Linker build settings. If it is not present add a new entry with following text (include the quotes as well) **"${workspace_loc:/${ProjName}/SDK/lib/SCST/SCST/src/lib}"** or add the path to the folder where the library is located.
- 4) Add sCST code and data section to the linker file
  - Example(for GCC linker file):

```
.m4_scst :
{
  *(.m4_scst_test_code)
  *(.m4_scst_test_code_unprivileged)
  *(.m4_scst_test_code1_unprivileged)
  *(.m4_scst_test_shell_code)
  *(.m4_scst_rom_data)
  . = ALIGN(4);
  *(.m4_scst_exception_wrappers)
  *(.m4_scst_vector_table)
  . = ALIGN(4);
} > m_text

.m4_scst2 :
{
  __SCST_DATA_ROM = .;
  __scst_data_start__ = .;
  *(.m4_scst_test_shell_data)
  . = ALIGN(4);
  *(.m4_scst_ram_data)
  . = ALIGN(4);
  *(.m4_scst_ram_data_target0)
  . = ALIGN(4);
  *(.m4_scst_ram_data_target1)
  . = ALIGN(4);
  *(.m4_scst_ram_test_code)
  . = ALIGN(4);
  __scst_data_end__ = .;
} > m_data
```

- 5) Use the library API to execute the required tests.

You can use the sCST example as a practical implementation of the steps described above. SCST can not be used with RAM debug configuration due to RAM memory being to small.

16.102 System Basis Chip Driver (SBC) - UJA116xA Family

16.102.1 Detailed Description

System Basis Chip driver is a middleware driver for SBC settings and control.

Hardware background

The UJA116xA is a mini high-speed CAN System Basis Chip (SBC) containing an ISO 11898-2:201x compliant HS-CAN transceiver and an integrated 5 V or 3.3 V 250 mA scalable supply (V1) for a microcontroller and/or other loads. It also features a watchdog and a Serial Peripheral Interface (SPI). The UJA116xA can be operated in very low-current Standby and Sleep modes with bus and local wake-up capability. The UJA1169A comes in six variants. The UJA1169ATK, UJA1169ATK/F, UJA1169ATK/X and UJA1169ATK/X/F contain a 5 V regulator (V1). V1 is a 3.3 V regulator in the UJA1169ATK/3 and the UJA1169ATK/F/3. The UJA1169ATK, UJA1169ATK/F, UJA1169ATK/3 and UJA1169ATK/F/3 variants feature a second on-board 5 V regulator (V2) that supplies the internal CAN transceiver and can also be used to supply additional on-board hardware. The UJA1169ATK/X and UJA1169ATK/X/F are equipped with a 5 V supply (VEXT) for off-board components. VEXT is short-circuit proof to the battery, ground and negative voltages. The integrated CAN transceiver is supplied internally via V1, in parallel with the microcontroller. The UJA1168 comes in four variants. The UJA1168ATK, UJA1168ATK/FD, UJA1168ATK/VX and UJA1168ATK/VX/FD contain a 5 V regulator (V1). The UJA1168ATK and UJA1168ATK/FD versions contain a battery-related high-voltage output (INH) for controlling an external voltage regulator, while the UJA1168ATK/VX and UJA1168ATK/VX/FD are equipped with a 5 V sensor supply (VEXT). The UJA1169xx/F and UJA1168xx/FD variants support ISO 11898 compliant CAN partial networking with a selective wake-up function incorporating CAN FD-passive. CAN FD-passive is a feature that allows CAN FD bus traffic to be ignored in Sleep/Standby mode. CAN FD-passive partial networking is the perfect fit for networks that support both CAN FD and classic CAN communications. It allows normal CAN controllers that do not need to communicate CAN FD messages to remain in partial networking Sleep/Standby mode during CAN FD communication without generating bus errors. The UJA116xA implements the standard CAN physical layer as defined in the current ISO11898 standard (-2:2003, -5:2007, -6:2013). A dedicated LIMP output pin is provided to flag system failures on UJA1169 variants. A number of configuration settings are stored in non-volatile memory. This arrangement makes it possible to configure the power-on and limp-home behavior of the UJA116xA to meet the requirements of different applications.

How to use SBC driver in your application

In order to set up SBC device the user needs to configure sbc_int_config_t structure in which are included following structures: sbc_regulator_ctr_t, sbc_wtdog_ctr_t, sbc_mode_mc_t, sbc_fail_safe_lhc_t, sbc_sys_evnt_t, sbc_lock_t, sbc_can_conf_t, sbc_wake_t These nested structures correspond to individual registers. The sbc_int_config_t structure is passed as a parameter to Init function to initialize SBC device. The rest of the functions are related to individual registers.

Initialization

The SBC_InitDriver function takes a parameter which is an instance of SPI used for communication with UJA116xA. The SBC_InitDevice function is responsible for setting up the UJA116xA, according to user configuration data which is passed as parameter. The SBC_InitDevice function configures all SBC registers except factories configuration set up in non volatile memory, (Start up control and SBC configuration register.) The SBC_InitDevice function transitions the SBC to standby mode, where the configuration is performed, and then to a mode selected in the main configuration structure. Before the transition to standby mode all event capture registers are cleared. In order to read the pre-reset or wake-up events, use SBC_GetEventsStatus between SBC_InitDriver and SBC_InitDevice.

Mode transition

SBC_SetMode performs software transition from one mode to another. The transition is achieved by writing to mode control register. The event capture registers are cleared before device is moved to standby and sleep mode.

Writing to registers

In order to write to registers, there are several methods dedicated to some specific registers. These methods (names starting with SBC_Set) take a value or a pointer to structure containing values to be written to particular

registers as a parameter. Besides these methods there is also a method SBC_DataTransfer which is common to reading and writing to all registers. It takes three parameters. The first one is an address of a register to be written. Addresses of registers are defined in sbc_register_ t enum. The second argument is pointer to a value which should be sent to a register. The last argument is used for register reading only and its value is unused in this case. NULL pointer is used when parameter is unused.

Reading from registers

Content of a register is read by method SBC_DataTransfer, which provides both reading and writing to all registers. This method has three arguments. The first one is an address of a register to be read from, the third one is a pointer to a variable where the content of a register will be stored. Second argument is used for the register writing only and it should be NULL in this case. Addresses of registers are defined in enum sbc_register_t. Several methods to reading specific control and status register are available similarly to the register writing. Their names start with SBC_Get.

Reading status registers

Content of status register can be read by method SBC_DataTransfer or using appropriate function which starts with SBC_Get and finishes with Status. Event capture registers must be cleared using SBC_CleanEvents by setting to 1 appropriate status. For clear all events set all statuses to 1 or reading all event capture statuses using SBC_↩ GetEventsStatus before.

There are several functions which read status and store it to structure. The Table 3 sumarize which function reads appropriate status register.

Function name	Status register
SBC_GetMainStatus	Main status, Watchdog status
SBC_GetSupplyStatus	V2/VEXT status, V1 status
SBC_GetCanStatus	CAN transceiver status, CAN partial networking error, CAN partial networking status, CAN oscillator status, CAN-bus silence status, VCAN status, CAN failure status
SBC_GetWakeStatus	WAKE pin status
SBC_GetEventsStatus	Global event status, System event status, Supply event status, Transceiver event status, WAKE pin event status
SBC_GetAllStatus	Read all statuses from this table

Reading and writing non-volatile SBC configuration

The UJA116xA contains Multiple Time Programmable Non-Volatile (MTPNV) memory cells that allow some of the default device settings to be reconfigured. This non-volatile memory has limited write access. Programming of the NVM registers is performed in two steps. First, the required values are written. In the second step, reprogramming is confirmed by writing the correct CRC value to the MTPNV CRC control register. This memory is accessed by SBC_GetFactoriesSettings and SBC_ChangeFactoriesSettings methods. The only parameter is a pointer to sbc↩ _factories_conf_t data structure, which should be written to NTPNVM or where should be stored data read out from the NTPNVM. If the device has been programmed previously, the factory presets may need to be restored before reprogramming can begin. When the factory presets have been restored successfully, a system reset is generated automatically and UJA116xA switches back to Forced Normal mode. If SBC_ChangeFactoriesSettings method returns an error “SBC_UJA_NVN_ERROR” it means device was preconfigured from default settings and it is not possible to write to non-volatile memory. Restore factory preset values is needed. Factory preset values are restored if the following conditions apply continuously for at least td(MTPNV) during battery power-up: • pin RSTN is held LOW • CANH is pulled up to VBAT • CANL is pulled down to GND Now SBC_ChangeFactoriesSettings can be used for change factory preset values to custom configuration.

Error tracking

If an error during the R/W operations to UJA116xA registers occurs, the driver keeps track of it. If a method returns status different from STATUS_SUCCESS the status represents the type of error from sbc_status_t enum.

Example code snippets (for FRDM PK144-Q100 freedom board).

Initialization example

This example source code snippet shows how to initialize SPI and the SBC. The SPI instance used in this example is LPSPICOM1. The following structures are generated by the configuration tool or need to be created by the user: lpspiCom1_MasterConfig0, lpspiCom1State, sbc_uja116x_InitConfig0.

```
int main(void)
{
    ...

    sbc_status_t status = STATUS_SUCCESS;

    /* Initialization clocks. */
    ...

    /* Initialize pins. */
    ...

    /* Initialize LPSPI. */
    LPSPI_DRV_MasterInit(LPSPICOM1, &lpspiCom1State, &lpspiCom1_MasterConfig0);

    /* Initialize SBC. */
    status = SBC_InitDriver(LPSPICOM1);
    status |= SBC_InitDevice(&sbc_uja116x_InitConfig0);

    if(status != STATUS_SUCCESS)
    {
        /* Do something here. */
    }

    ...
}
```

```
### Write to Regulator control registers example ###
This example source code snippet shows how to configure Regulator control register.
Power distribution control (PDC), V2/VEXT configuration (V2C/ VETXT), V1 reset threshold can be
configured by writing to Regulator Control register.
Note: PDC can be set for UJA1169 variants (not UJA1168),
V2 can be set for models UJA1169ATK, UJA1169ATK/3, UJA1169ATK/F and UJA1169ATK/F/3,
VEXT can be set for models UJA1169ATK/X and UJA1169ATK/X/F. For more info read function description.
```

```
int main(void)
{
    ...

    sbc_status_t status = STATUS_SUCCESS;
    sbc_regulator_ctr_t regulator;
    regulator.regulator.pdc = SBC_UJA_REGULATOR_PDC_HV;
    regulator.regulator.v2c = SBC_UJA_REGULATOR_V2C_OFF;
    regulator.regulator.v1rtc = SBC_UJA_REGULATOR_V1RTC_80;

    regulator.supplyEvnt.v2oe = SBC_UJA_SUPPLY_EVNT_V2OE_EN;
    regulator.supplyEvnt.v2ue = SBC_UJA_SUPPLY_EVNT_V2UE_EN;
    regulator.supplyEvnt.v1ue = SBC_UJA_SUPPLY_EVNT_V1UE_DIS;

    status = SBC_SetVreg(&regulator);

    if(status != STATUS_SUCCESS)
    {
        /* Do something here. */
    }

    ...
}
```

Read from Regulator control registers example

This example source code snippet shows how to read from Regulator control registers. Reading Regulator control register gives information about Power distribution control (PDC), V2/VEXT configuration (V2C/ VETXT), V1 reset threshold current configuration. Using this method can be useful for check if the Regulator control register is configured correctly. For more info read function description.

```
int main(void)
{
```

```
    ...

    sbc_status_t status = STATUS_SUCCESS;
    sbc_regulator_ctr_t regulator;

    status = SBC_GetVreg(&regulator);

    if(status == STATUS_SUCCESS)
    {
        if(regulator.supplyEvnt.v2oe ==
      SBC_UJA_SUPPLY_EVNT_V2OE_EN)
        {
            /* Do something here. */
        }
    }

    ...
}
```

Reading all device status example

This example source code snippet shows how to read all SBC device statuses in one function. Variable allStatuses contains these registers: Main status register, Watchdog status register, Supply voltage status register, Transceiver status register, WAKE pin status register, Event capture registers. For more info read function description.

```
int main(void)
{
    ...

    sbc_status_t status = STATUS_SUCCESS;
    sbc_status_group_t allStatuses;

    while(1){

        status = SBC_GetAllStatus(&allStatuses);

        if(status == STATUS_SUCCESS)
        {

            if(allStatuses.trans.cbss == SBC_UJA_TRANS_STAT_CBSS_ACT)
            {
                /* Do something here. */
            }

            if(allStatuses.supply.v1s == SBC_UJA_SUPPLY_STAT_V1S_VAB)
            {
                /* Do something here. */
            }

            ...

            /* Periodically feed watchdog (anytime in watchdog period in case of timeout watchdog mode). */
            SBC_FeedWatchdog();
        }
    }
}
```

Reading Transceiver device status example

This example source code snippet shows how to read Transceiver device status from SBC. It contains CA↩ N transceiver status, CAN partial networking error, CAN partial networking status, CAN oscillator status, CAN-bus silence status, VCAN status, CAN failure status. For more info read function description. Note similar approach can be used for reading other status using different SBC_Get∗Status.

```
int main(void)
{
    ...

    sbc_status_t status = STATUS_SUCCESS;
    sbc_trans_stat_t transStatus;

    while(1){

        status = SBC_GetCanStatus(&transStatus);

        if(status == STATUS_SUCCESS)
        {

            if(transStatus.cbss == SBC_UJA_TRANS_STAT_CBSS_ACT)
```

```
            {
                /* Do something here. */
            }

            ...

            /* Periodically feed watchdog (anytime in watchdog period in case of timeout watchdog mode). */
            SBC_FeedWatchdog();
        }
    }
}
```

Change factories settings

This example source code snippet shows how to change factory preset value of non-volatile memmory. Device must be set to fatory preset. For more info read function description.

```
int main(void)
{
    ...

    sbc_status_t status = STATUS_SUCCESS;
    sbc_factories_conf_t factories;

    status = SBC_GetFactoriesSettings(&factories);

    factories.control.fnmc = SBC_UJA_SBC_SDMC_EN;
    factories.control.sdmc = SBC_UJA_SBC_SDMC_DIS;
    factories.startUp.rlc = SBC_UJA_START_UP_RLC_20_25p0;

    if(status == STATUS_SUCCESS)
    {
        status = SBC_ChangeFactoriesSettings(&factories);
    }

    if(status != STATUS_SUCCESS)
    {
        /* Do something here. */
    }
}
```

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\middleware\sbc\sbc_uja116x\source\sbc_uja116x_driver.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\middleware\sbc\sbc_uja116x\include
```

Compile symbols

No special symbols are required for this component

Dependencies

Low Power Serial Peripheral Interface (LPSPI) OS Interface (OSIF)

Modules

- UJA116xA SBC Driver

16.103 TRGMUX Driver

16.103.1 Detailed Description

Trigger MUX Control Peripheral Driver. The TRGMUX introduces an extremely flexible methodology for connecting various trigger sources to multiple pins/peripherals.

The S32 SDK provides Peripheral Drivers for the Trigger MUX Control (TRGMUX) module of S32 SDK devices.

Overview

This section describes the programing interface of the TRGMUX driver. The TRGMUX driver configures the TRGMUX (Trigger Mux Control). The Trigger MUX module allows software to configure the trigger inputs for various peripherals.

TRGMUX Driver model building

TRGMUX can be seen as a collection of muxes, each mux allowing to select one output from a list of input signals that are common to all muxes. The TRGMUX registers are identical as structure and all bitfields can be read/written using the TRGMUX driver API.

TRGMUX Initialization

The **TRGMUX_DRV_Init()** function is used to initialize the TRGMUX IP. The function receives as parameter a pointer to the trgmux_user_config_t structure. This structure contains a variable number of mappings between a trgmux trigger source and a trgmux target modules.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\trgmux\trgmux_driver.c
${S32SDK_PATH}\platform\drivers\src\trgmux\trgmux_hw_access.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
```

Compile symbols

No special symbols are required for this component

Dependencies

There are no dependencies with other components

TRGMUX API

After initialization, the driver allows the reconfiguration of the source trigger for a given target module using **TRGMUX_DRV_SetTrigSourceForTargetModule()**. Also, by using **TRGMUX_DRV_SetLockForTargetModule()**, a given target module can be locked, such that it cannot be updated until a reset.

Data Structures

- struct trgmux_inout_mapping_config_t

  Configuration structure for pairing source triggers with target modules. More...
- struct trgmux_user_config_t

User configuration structure for the TRGMUX driver. More...

Typedefs

- typedef enum trgmux_trigger_source_e trgmux_trigger_source_t
  Enumeration for trigger source module of TRGMUX.
- typedef enum trgmux_target_module_e trgmux_target_module_t
  Enumeration for target module of TRGMUX.

Functions

- status_t TRGMUX_DRV_Init (const uint32_t instance, const trgmux_user_config_t *const trgmuxUserConfig)
  Initialize a TRGMUX instance for operation.
- status_t TRGMUX_DRV_Deinit (const uint32_t instance)
  Reset to default values the source triggers corresponding to all target modules, if none of the target modules is locked.
- status_t TRGMUX_DRV_SetTrigSourceForTargetModule (const uint32_t instance, const trgmux_trigger_source_t triggerSource, const trgmux_target_module_t targetModule)
  Configure a source trigger for a selected target module.
- trgmux_trigger_source_t TRGMUX_DRV_GetTrigSourceForTargetModule (const uint32_t instance, const trgmux_target_module_t targetModule)
  Get the source trigger configured for a target module.
- void TRGMUX_DRV_SetLockForTargetModule (const uint32_t instance, const trgmux_target_module_t targetModule)
  Locks the TRGMUX register of a target module.
- bool TRGMUX_DRV_GetLockForTargetModule (const uint32_t instance, const trgmux_target_module_t targetModule)
  Get the Lock bit status of the TRGMUX register of a target module.
- void TRGMUX_DRV_GenSWTrigger (const uint32_t instance)
  Generate software triggers.

16.103.2 Data Structure Documentation

16.103.2.1 struct trgmux_inout_mapping_config_t

Configuration structure for pairing source triggers with target modules.

Use an instance of this structure to define a TRGMUX link between a trigger source and a target module. This structure is used by the user configuration structure.

Implements : trgmux_inout_mapping_config_t_Class

Definition at line 88 of file trgmux_driver.h.

Data Fields

- trgmux_trigger_source_t triggerSource
- trgmux_target_module_t targetModule
- bool lockTargetModuleReg

Field Documentation

16.103.2.1.1 bool lockTargetModuleReg

if true, the LOCK bit of the target module register will be set by TRGMUX_DRV_INIT(), after the current mapping is configured

Definition at line 92 of file trgmux_driver.h.

16.103.2.1.2 trgmux_target_module_t targetModule

selects one of the TRGMUX target modules

Definition at line 91 of file trgmux_driver.h.

16.103.2.1.3 trgmux_trigger_source_t triggerSource

selects one of the TRGMUX trigger sources

Definition at line 90 of file trgmux_driver.h.

16.103.2.2 struct trgmux_user_config_t

User configuration structure for the TRGMUX driver.

Use an instance of this structure with the TRGMUX_DRV_Init() function. This enables configuration of TRGMUX with the user defined mappings between inputs (source triggers) and outputs (target modules), via a single function call.

Implements : trgmux_user_config_t_Class

Definition at line 104 of file trgmux_driver.h.

Data Fields

- uint8_t numInOutMappingConfigs
- const trgmux_inout_mapping_config_t * inOutMappingConfig

Field Documentation

16.103.2.2.1 const trgmux_inout_mapping_config_t* inOutMappingConfig

pointer to array of in-out mapping structures

Definition at line 107 of file trgmux_driver.h.

16.103.2.2.2 uint8_t numInOutMappingConfigs

number of in-out mappings defined in TRGMUX configuration

Definition at line 106 of file trgmux_driver.h.

16.103.3 Typedef Documentation

16.103.3.1 typedef enum trgmux_target_module_e trgmux_target_module_t

Enumeration for target module of TRGMUX.

Describes all possible outputs (target modules) of the TRGMUX IP This enumeration depends on the supported instances in device

Implements : trgmux_target_module_t_Class

Definition at line 78 of file trgmux_driver.h.

16.103.3.2 typedef enum trgmux_trigger_source_e trgmux_trigger_source_t

Enumeration for trigger source module of TRGMUX.

Describes all possible inputs (trigger sources) of the TRGMUX IP This enumeration depends on the supported instances in device

Implements : trgmux_trigger_source_t_Class

Definition at line 68 of file trgmux_driver.h.

16.103.4 Function Documentation

16.103.4.1 status_t TRGMUX_DRV_Deinit (const uint32_t *instance*)

Reset to default values the source triggers corresponding to all target modules, if none of the target modules is locked.

Parameters

in	*instance*	The TRGMUX instance number.

Returns

Execution status:
STATUS_SUCCESS
STATUS_ERROR - if at least one of the target module register is locked.

Definition at line 114 of file trgmux_driver.c.

16.103.4.2 void TRGMUX_DRV_GenSWTrigger (const uint32_t *instance*)

Generate software triggers.

This function uses a SIM register in order to generate a software triggers to the target peripherals selected in TRGMUX

Parameters

param[in]	instance The TRGMUX instance number.

Definition at line 221 of file trgmux_driver.c.

16.103.4.3 bool TRGMUX_DRV_GetLockForTargetModule (const uint32_t *instance,* const **trgmux_target_module_t** *targetModule*)

Get the Lock bit status of the TRGMUX register of a target module.

This function gets the value of the LK bit from the TRGMUX register corresponding to the selected target module.

Parameters

in	*instance*	The TRGMUX instance number.
in	*targetModule*	One of the values in the trgmux_target_module_t enumeration

Returns

true - if the selected targetModule register is locked
false - if the selected targetModule register is not locked

Definition at line 203 of file trgmux_driver.c.

16.103.4.4 trgmux_trigger_source_t TRGMUX_DRV_GetTrigSourceForTargetModule (const uint32_t *instance,* const **trgmux_target_module_t** *targetModule*)

Get the source trigger configured for a target module.

This function returns the TRGMUX source trigger linked to a selected target module.

Parameters

in	*instance*	The TRGMUX instance number.
in	*targetModule*	One of the values in the trgmux_target_module_t enumeration.

Returns

Enum value corresponding to the trigger source configured for the selected target module.

Definition at line 168 of file trgmux_driver.c.

16.103.4.5 status_t TRGMUX_DRV_Init (const uint32_t *instance*, const trgmux_user_config_t *const *trgmuxUserConfig*)

Initialize a TRGMUX instance for operation.

This function first resets the source triggers of all TRGMUX target modules to their default values, then configures the TRGMUX with all the user defined in-out mappings. If at least one of the target modules is locked, the function will not change any of the TRGMUX target modules and return error code. This example shows how to set up the trgmux_user_config_t parameters and how to call the TRGMUX_DRV_Init() function with the required parameters:

```
1 trgmux_user_config_t             trgmuxConfig;
2 trgmux_inout_mapping_config_t    trgmuxInoutMappingConfig[] =
3 {
4     {TRGMUX_TRIG_SOURCE_TRGMUX_IN9,     TRGMUX_TARGET_MODULE_DMA_CH0,     false},
5     {TRGMUX_TRIG_SOURCE_FTM1_EXT_TRIG,  TRGMUX_TARGET_MODULE_TRGMUX_OUT4, true}
6 };
7
8 trgmuxConfig.numInOutMappingConfigs = 2;
9 trgmuxConfig.inOutMappingConfig     = trgmuxInoutMappingConfig;
10
11 TRGMUX_DRV_Init(instance, &trgmuxConfig);
```

Parameters

in	*instance*	The TRGMUX instance number.
in	*trgmuxUser↩ Config*	Pointer to the user configuration structure.

Returns

Execution status:
STATUS_SUCCESS
STATUS_ERROR - if at least one of the target module register is locked.

Definition at line 71 of file trgmux_driver.c.

16.103.4.6 void TRGMUX_DRV_SetLockForTargetModule (const uint32_t *instance*, const trgmux_target_module_t *targetModule*)

Locks the TRGMUX register of a target module.

This function sets the LK bit of the TRGMUX register corresponding to the selected target module. Please note that some TRGMUX registers can contain up to 4 SEL bitfields, meaning that these registers can be used to configure up to 4 target modules independently. Because the LK bit is only one per register, the configuration of all target modules referred from that register will be locked.

Parameters

in	*instance*	The TRGMUX instance number.
in	*targetModule*	One of the values in the trgmux_target_module_t enumeration

Definition at line 185 of file trgmux_driver.c.

16.103.4.7 status_t TRGMUX_DRV_SetTrigSourceForTargetModule (const uint32_t *instance*, const trgmux_trigger_source_t *triggerSource*, const trgmux_target_module_t *targetModule*)

Configure a source trigger for a selected target module.

This function configures a TRGMUX link between a source trigger and a target module, if the requested target module is not locked.

Parameters

in	*instance*	The TRGMUX instance number.
in	*triggerSource*	One of the values in the trgmux_trigger_source_t enumeration
in	*targetModule*	One of the values in the trgmux_target_module_t enumeration

Returns

Execution status:
STATUS_SUCCESS
STATUS_ERROR - if requested target module is locked

Definition at line 135 of file trgmux_driver.c.

16.104 Timing - Peripheral Abstraction Layer (TIMING PAL)

16.104.1 Detailed Description

The S32 SDK provides a Peripheral Abstraction Layer for timer modules of S32 SDK devices.

The TIMING PAL driver allows to generate period event. It was designed to be portable across all platforms and IPs which support LPIT, PIT, LPTMR, FTM, STM.

How to integrate TIMING PAL in your application

Unlike the other drivers, TIMING PAL modules need to include a configuration file named timing_pal_cfg.h, which allows the user to specify which IPs are used. The following code example shows how to configure one instance for each available TIMING IPs.

```
#ifndef TIMING_PAL_CFG_H
#define TIMING_PAL_CFG_H

/* Define which IP instance will be used in current project */
#define TIMING_OVER_LPIT
#define TIMING_OVER_FTM
#define TIMING_OVER_LPTMR

#endif /* TIMING_PAL_CFG_H */
```

The following table contains the matching between platforms and available IPs

IP/MCU	S32K116	S32K118	S32K142	S32K144	S32K146	S32K148	S32K142W	S32K144W	S32V234	S32R274	S32R372	MPC5748G	MPC5746C	MPC5744P
LPIT_TIMER	YES	YES	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO	NO	NO
LPTMR_TIMER	YES	YES	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO	NO	NO

FTM_TIMING	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO	NO
PIT_TIMING	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES	YES	YES	YES
STM_TIMING	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES	YES	YES	YES

Features

- Start timer channel counting with period in ticks function
- Generate one-shot or continuous notification(Event)
- Get elapsed time and remaining time functions
- Get tick resolution in engineering units (nanosecond, microsecond or millisecond)

Functionality

Initialization

In order to use the TIMING PAL driver it must be first initialized, using TIMING_Init() function. Once initialized, it should be de-initialized before initialized again for the same TIMING module instance, using TIMING_Deinit(). The initialization function does the following operations:

- sets the clock source, clock prescaler (except LPIT, PIT_TIMING)
- sets notification type and callback function of timer channel Different TIMING modules instances can function independently of each other.

Start/Stop a timer channel counting with new period

After initialization, a timer channel can be started by calling TIMING_StartChannel function. The input period unit is ticks, the max value of period depends on which timer is used for timing. The TIMING_StartChannel function can be called consecutively, it starts new period immediately but in case LPIT, PIT_TIMING when timer channel is running, to abort the current timer channel period and start a timer channel period with a new value, the timer channel must be stopped and started again. A timer channel can be stop by calling TIMING_StopChannel function.

Get elapsed and remaining time

When a timer channel is running, the elapsed and remaining timer can be got by calling TIMING_GetElapsed and TIMING_GetRemaining function. The elapsed and remaining time in nanosecond, microsecond or millisecond is the result of this function multiplies by the result of the TIMING_GetResolution.

Important Notes

- Before using the TIMING PAL driver the module clock must be configured. Refer to Clock Manager for clock configuration.
- The driver enables the interrupts for the corresponding TIMING module, but any interrupt priority must be done by the application
- When the vector table is not in ram (**flash_vector_table** = 1):
  - INT_SYS_InstallHandler shall check if the function pointer provided as parameter for the new handler is already present in the vector table for the given IRQ number.
  - The user will be required to manually add the correct handlers in the startup files
- The board specific configurations must be done prior to driver calls
- Some features are not available for all TIMING IPs and incorrect parameters will be handled by DEV_ASS↩ ERT
- Because of the driver code limit, when use FTM_TIMING or STM_TIMING the executing time of interrupt handler is about 4 microseconds, so the erroneous period is about 4 microsecond, should configure period enough to skip this erroneous period.
- In MPC574xG and MPC574xC devices, STM module has Errata e10200. If STM clock source is configured to use the FXOSC clock for the case application software reads the STM Count register(STM_CNT) while the counter is running, the value returned may be incorrect. Note the default clock source for the STM is the FS80 (divided system clock) and this configuration is working properly. Consequently the value returned by the function STM_DRV_GetCounterValue() may be incorrect when clock source is set to FXOSC option. Thus, this issue impacts to the functions that call STM_DRV_GetCounterValue() function:
  - TIMING_GetElapsed
  - TIMING_GetRemaining
  - TIMING_StartChannel only in case the timer is already started This issue should be taken care when using TMING over STM.

Example code

```
/* The timer channel number */
#define TIMER_CHANNEL 0U

/* The timer channel period by nanosecond */
#define TIMER_PERIOD_NANO 1000000000U

/* Counting variable */
uint32_t count = 0;

/* Callback function */
void My_Callback(void * data)
{
    (void)data;
    count = count + 1;
}

/* Configure timer channel */
timer_chan_config_t timing_pal1_channelArray[] =
{
  {
      TIMER_CHANNEL,
      TIMER_CHAN_TYPE_CONTINUOUS,
      My_Callback,
      NULL
  }
};

/* Configure FTM clock source */
extension_ftm_for_timer_t timing_pal1_ftmExtention =
{
  FTM_CLOCK_SOURCE_FIXEDCLK,
  FTM_CLOCK_DIVID_BY_1,
  0xFFFF
};

/* Configure TIMING instance */
```

```
  timer_config_t timing_pal1_InitConfig =
  {
      timing_pal1_channelArray,
      1,
      &timing_pal1_ftmExtention
  };

  /* TIMING instance number structure */
  timing_instance_t instance =
  {
      TIMING_INST_TYPE_LPIT,
      0U
  };

int main(void)
{
  uint64_t resolution;
  uint32_t elapsedTime;

  /* Initialize TIMING */
  TIMING_Init(&instance, &timing_pal1_InitConfig);

  /* Get tick resolution in nanosecond */
  TIMING_GetResolution(&instance,
      TIMER_RESOLUTION_TYPE_NANOSECOND, &resolution);

  /* Start channel counting with period is 1 second */
  TIMING_StartChannel(&instance, TIMER_CHANNEL, (TIMER_PERIOD_NANO / resolution));
   ....
  /* Get elapsed time in ticks */
  elapsedTime = TIMING_GetElapsed(&instance, TIMER_CHANNEL);

  /* Get elapsed time in nanosecond */
  elapsedTime = elapsedTime * resolution;

  /* De-initialize TIMING */
  TIMING_Deinit(&instance);
}
```

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\pal\src\timing\timing_pal.c
${S32SDK_PATH}\platform\pal\src\timing\timing_irq.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\pal\inc\
```

Compile symbols

No special symbols are required for this component

Dependencies

Common: Clock Manager Interrupt Manager (Interrupt)

S32K1xx: Low Power Interrupt Timer (LPIT) Low Power Timer (LPTMR) FlexTimer (FTM)

MPC574x and **S32Rx7x:** pit stm

Data Structures

- struct timer_chan_config_t

  Structure to configure the channel timer notification. More...
- struct timer_config_t

  Timer configuration structure. More...

- struct extension_lptmr_for_timer_t

  Defines the extension structure for the timer over LPTMR. More...
- struct extension_ftm_for_timer_t

  Defines the extension structure for the timer over FTM. More...

Enumerations

- enum timer_resolution_type_t { TIMER_RESOLUTION_TYPE_NANOSECOND, TIMER_RESOLUTION_↩ TYPE_MICROSECOND, TIMER_RESOLUTION_TYPE_MILISECOND }

  Type options available for tick resolution.
- enum timer_chan_type_t { TIMER_CHAN_TYPE_CONTINUOUS, TIMER_CHAN_TYPE_ONESHOT }

  Type options available for timer channel notification.

Functions

- status_t TIMING_Init (const timing_instance_t *const instance, const timer_config_t *const config)

  Initialize the timer instance and timer channels with value from input configuration structure.
- void TIMING_Deinit (const timing_instance_t *const instance)

  De-initialize a timer instance.
- void TIMING_StartChannel (const timing_instance_t *const instance, const uint8_t channel, const uint32_t periodTicks)

  Starts the timer channel counting.
- void TIMING_StopChannel (const timing_instance_t *const instance, const uint8_t channel)

  Stop the timer channel counting.
- uint32_t TIMING_GetElapsed (const timing_instance_t *const instance, const uint8_t channel)

  Get elapsed ticks.
- uint32_t TIMING_GetRemaining (const timing_instance_t *const instance, const uint8_t channel)

  Get remaining ticks.
- void TIMING_EnableNotification (const timing_instance_t *const instance, const uint8_t channel)

  Enable channel notifications.
- void TIMING_DisableNotification (const timing_instance_t *const instance, const uint8_t channel)

  Disable channel notifications.
- status_t TIMING_GetResolution (const timing_instance_t *const instance, const timer_resolution_type_↩ t type, uint64_t *const resolution)

  Get tick resolution.
- status_t TIMING_GetMaxPeriod (const timing_instance_t *const instance, const timer_resolution_type_↩ t type, uint64_t *const maxPeriod)

  Get max period in engineering units.
- void TIMING_InstallCallback (const timing_instance_t *const instance, const uint8_t channel, const timer_↩ callback_t callback, void *const callbackParam)

  Installs callback function for the timer channel.

16.104.2 Data Structure Documentation

16.104.2.1 struct timer_chan_config_t

Structure to configure the channel timer notification.

This structure holds the configuration settings for the timer channel notification Implements : timer_chan_config_↩ t_Class

Definition at line 77 of file timing_pal.h.

Data Fields

- uint8_t channel
- timer_chan_type_t chanType
- timer_callback_t callback
- void * callbackParam

Field Documentation

16.104.2.1.1 timer_callback_t callback

Callback function called on notification

Definition at line 81 of file timing_pal.h.

16.104.2.1.2 void* callbackParam

Callback parameter pointer

Definition at line 82 of file timing_pal.h.

16.104.2.1.3 uint8_t channel

Channel number

Definition at line 79 of file timing_pal.h.

16.104.2.1.4 timer_chan_type_t chanType

Continuous or One-shot

Definition at line 80 of file timing_pal.h.

16.104.2.2 struct timer_config_t

Timer configuration structure.

This structure holds the configuration settings for the timer Implements : timer_config_t_Class

Definition at line 91 of file timing_pal.h.

Data Fields

- const timer_chan_config_t * chanConfigArray
- uint8_t numChan
- void * extension

Field Documentation

16.104.2.2.1 const timer_chan_config_t* chanConfigArray

Channel configuration array

Definition at line 93 of file timing_pal.h.

16.104.2.2.2 void* extension

IP specific configuration structure

Definition at line 95 of file timing_pal.h.

16.104.2.2.3 uint8_t numChan

Number of elements in chanConfigArray

Definition at line 94 of file timing_pal.h.

16.104.2.3 struct extension_lptmr_for_timer_t

Defines the extension structure for the timer over LPTMR.

Part of LPTMR configuration structure Implements : extension_lptmr_for_timer_t_Class

Definition at line 114 of file timing_pal.h.

Data Fields

- lptmr_clocksource_t clockSelect
- lptmr_prescaler_t prescaler
- bool bypassPrescaler

Field Documentation

16.104.2.3.1 bool bypassPrescaler

Enable/Disable prescaler bypass

Definition at line 118 of file timing_pal.h.

16.104.2.3.2 lptmr_clocksource_t clockSelect

LPTMR clock source selection

Definition at line 116 of file timing_pal.h.

16.104.2.3.3 lptmr_prescaler_t prescaler

Prescaler Selection

Definition at line 117 of file timing_pal.h.

16.104.2.4 struct extension_ftm_for_timer_t

Defines the extension structure for the timer over FTM.

Part of FTM configuration structure Implements : extension_ftm_for_timer_t_Class

Definition at line 129 of file timing_pal.h.

Data Fields

- ftm_clock_source_t clockSelect
- ftm_clock_ps_t prescaler
- uint16_t finalValue

Field Documentation

16.104.2.4.1 ftm_clock_source_t clockSelect

FTM clock source selection

Definition at line 131 of file timing_pal.h.

16.104.2.4.2 uint16_t finalValue

The final value of FTM counter

Definition at line 133 of file timing_pal.h.

16.104.2.4.3 ftm_clock_ps_t prescaler

Prescaler Selection

Definition at line 132 of file timing_pal.h.

16.104.3 Enumeration Type Documentation

16.104.3.1 enum timer_chan_type_t

Type options available for timer channel notification.

Implements : timer_chan_type_t_Class

Enumerator

TIMER_CHAN_TYPE_CONTINUOUS Timer channel creates continuous notification

TIMER_CHAN_TYPE_ONESHOT Timer channel creates one-shot notification

Definition at line 65 of file timing_pal.h.

16.104.3.2 enum timer_resolution_type_t

Type options available for tick resolution.

Implements : timer_resolution_type_t_Class

Enumerator

TIMER_RESOLUTION_TYPE_NANOSECOND Tick resolution is nanosecond

TIMER_RESOLUTION_TYPE_MICROSECOND Tick resolution is microsecond

TIMER_RESOLUTION_TYPE_MILISECOND Tick resolution is millisecond

Definition at line 53 of file timing_pal.h.

16.104.4 Function Documentation

16.104.4.1 void TIMING_Deinit (const timing_instance_t *const *instance*)

De-initialize a timer instance.

This function de-initializes timer instance. In order to use the timer instance again, TIMING_Init must be called.

Parameters

in	*instance*	The pointer to timer instance number structure

Definition at line 604 of file timing_pal.c.

16.104.4.2 void TIMING_DisableNotification (const timing_instance_t *const *instance*, const uint8_t *channel*)

Disable channel notifications.

This function disables channel notification.

Parameters

in	*instance*	The pointer to timer instance number structure
in	*channel*	The channel number

Definition at line 1390 of file timing_pal.c.

16.104.4.3 void TIMING_EnableNotification (const timing_instance_t *const *instance*, const uint8_t *channel*)

Enable channel notifications.

This function enables channel notification.

Parameters

in	*instance*	The pointer to timer instance number structure
in	*channel*	The channel number

Definition at line 1292 of file timing_pal.c.

16.104.4.4 uint32_t TIMING_GetElapsed (const timing_instance_t *const *instance,* const uint8_t *channel*)

Get elapsed ticks.

This function gets elapsed time of the current period by ticks. The elapsed time by nanosecond, microsecond or millisecond is the result of this function multiplies by the result of the TIMING_GetResolution function. Note that: If the timer channel type is continuous, this function may not return value of the period at the moment period is timeout depending on timer frequency, optimizations, etc. The behavior occurs if the execution time of the function is significant relative to timer tick duration. If the timer channel type is one-shot, this function can be used to check whether the current period is timeout, in this case if the returned value is bigger or equal than the period, the current period is timeout or overflowed.

Parameters

in	*instance*	The pointer to timer instance number structure
in	*channel*	The channel number

Returns

Number of ticks elapsed of the current period

Definition at line 956 of file timing_pal.c.

16.104.4.5 status_t TIMING_GetMaxPeriod (const timing_instance_t *const *instance,* const timer_resolution_type_t *type,* uint64_t *const *maxPeriod*)

Get max period in engineering units.

This function gets max period in engineering units.

Parameters

in	*instance*	The pointer to timer instance number structure
in	*type*	Resolution type
out	*maxPeriod*	The pointer to max period in engineering units

Returns

Operation status

- STATUS_SUCCESS: Operation was successful
- STATUS_ERROR : The timer frequency is not fit to resolution type

Definition at line 1627 of file timing_pal.c.

16.104.4.6 uint32_t TIMING_GetRemaining (const timing_instance_t *const *instance,* const uint8_t *channel*)

Get remaining ticks.

This function gets remaining time of the current period by ticks. The remaining time by nanosecond, microsecond or millisecond is the result of this function multiplies by the result of the TIMING_GetResolution function. Note that: If the timer channel type is continuous, this function may not return 0 at the moment period is timeout depending on timer frequency, optimizations, etc. The behavior occurs if the execution time of the function is significant relative to timer tick duration. If the timer channel type is one-shot, this function can be used to check whether the current period is timeout, in this case if the returned value is 0, the current period is timeout or overflowed.

Parameters

in	*instance*	The pointer to timer instance number structure
in	*channel*	The channel number

Returns

Number of ticks remaining of the current period

Definition at line 1127 of file timing_pal.c.

16.104.4.7 status_t TIMING_GetResolution (const timing_instance_t *const *instance*, const timer_resolution_type_t *type*, uint64_t *const *resolution*)

Get tick resolution.

This function gets tick resolution in engineering units (nanosecond, microsecond or millisecond). The result of this function is used to calculate period, remaining time or elapsed time in engineering units.

Parameters

in	*instance*	The pointer to timer instance number structure
in	*type*	Resolution type
out	*resolution*	The pointer to resolution in engineering units

Returns

Operation status

- STATUS_SUCCESS: Operation was successful
- STATUS_ERROR : The timer frequency is not fit to resolution type

Definition at line 1481 of file timing_pal.c.

16.104.4.8 status_t TIMING_Init (const timing_instance_t *const *instance*, const timer_config_t *const *config*)

Initialize the timer instance and timer channels with value from input configuration structure.

This function initializes clock source, prescaler of the timer instance(except LPIT, PIT), the final value of counter (only FTM). This function also setups notification type and callback function of timer channel. The timer instance number and its configuration structure shall be passed as arguments. Timer channels do not start counting by default after calling this function. The function TIMING_StartChannel must be called to start the timer channel counting.

Parameters

in	*instance*	The pointer to timer instance number structure
in	*config*	The pointer to configuration structure

Returns

Operation status

- STATUS_SUCCESS: Operation was successful
- STATUS_ERROR : Operation was fail if the timer instance is out of range For example: Timing over LPIT but the instance is not LPIT instance(TIMING_OVER_LPIT0_INSTANCE)
- STATUS_ERROR : Operation was fail if the FTM instance has been initialized

Definition at line 526 of file timing_pal.c.

16.104.4.9 void TIMING_InstallCallback (const timing_instance_t *const *instance,* const uint8_t *channel,* const timer_callback_t *callback,* void *const *callbackParam*)

Installs callback function for the timer channel.

This function installs new callback function and callback parameter for the timer channel event. This function allows changing the callback function and parameter while the timer channel is running. If the provided callback function parameter is NULL, it is equivalent to removing the callback.

Parameters

in	*instance*	The pointer to timer instance number structure
in	*callback*	The new callback function for timer channel
in	*callbackParam*	The new callback parameter pointer

Definition at line 1785 of file timing_pal.c.

16.104.4.10 void TIMING_StartChannel (const timing_instance_t *const *instance,* const uint8_t *channel,* const uint32_t *periodTicks*)

Starts the timer channel counting.

This function starts channel counting with a new period in ticks. Note that:

- If the timer is PIT or LPIT, to abort the current timer channel period and start a timer channel period with a new value, the timer channel must be stopped and started again.
- If the timer is FTM, this function start channel by enable channel interrupt generation.
- LPTMR and FTM is 16 bit timer, so the input period must be smaller than 65535.
- LPTMR and FTM is 16 bit timer, so the input period must be smaller than 65535.

Parameters

in	*instance*	The pointer to timer instance number structure
in	*channel*	The channel number
in	*periodTicks*	The input period in ticks

Definition at line 678 of file timing_pal.c.

16.104.4.11 void TIMING_StopChannel (const timing_instance_t *const *instance,* const uint8_t *channel*)

Stop the timer channel counting.

This function stop channel counting. Note that if the timer is FTM, this function stop channel by disable channel interrupt generation.

Parameters

in	*instance*	The pointer to timer instance number structure
in	*channel*	The channel number

Definition at line 854 of file timing_pal.c.

16.105 Transport layer API

16.105.1 Detailed Description

Transport layer stands between the application layer and the core API layer.

This layer consists the implementation of data transportation which contains one or more LIN frames. It is situated between the application layer and the core API layer including LIN2.1 TL API and LIN TL J2602. This layer provides APIs for the transport protocol, node configuration and diagnostic services. For LIN 2.1, all components will be extended from LIN 2.0 specification. The node configuration for J2602 implements only some functions of LIN 2.0 specification.

Modules

- Common Transport Layer API

  Contains Transport Layer APIs that used for both protocols LIN 2.1 and J2602.
- J2602 Transport Layer specific API

  Contains Transport Layer APIs that only used for J2602 protocol.

16.106 UJA116xA SBC Driver

16.106.1 Detailed Description

Data Structures

- struct sbc_wtdog_ctr_t

  Watchdog control register structure. Watchdog configuration structure. More...
- struct sbc_sbc_t

  SBC configuration control register structure. Two operating modes have a major impact on the operation of the watchdog: Forced Normal mode and Software Development mode (Software Development mode is provided for test and development purposes only and is not a dedicated SBC operating mode; the UJA116xA can be in any functional operating mode with Software Development mode enabled). These modes are enabled and disabled via bits FNMC and SDMC respectively in the SBC configuration control register. Note that this register is located in the non-volatile memory area. The watchdog is disabled in Forced Normal mode (FNM). In Software Development mode (SDM), the watchdog can be disabled or activated for test and software debugging purposes. More...
- struct sbc_start_up_t

  Start-up control register structure. This structure contains settings of RSTN output reset pulse width and V2/VEXT start-up control. More...
- struct sbc_regulator_t

  Regulator control register structure. This structure set power distribution control, V2/VEXT configuration, set V1 reset threshold. More...
- struct sbc_supply_evnt_t

  Supply event capture enable register structure. This structure enables or disables detection of V2/VEXT overvoltage, undervoltage and V1 undervoltage enable. More...
- struct sbc_sys_evnt_t

  System event capture enable register structure. This structure enables or disables overtemperature warning, SPI failure enable. More...
- struct sbc_can_ctr_t

  CAN control register structure. This structure configure CAN peripheral behavior. More...
- struct sbc_trans_evnt_t

  Transceiver event capture enable register structure. Can bus silence, Can failure and Can wake-up settings. More...
- struct sbc_frame_t

  Frame control register structure. The wake-up frame format, standard (11-bit) or extended (29-bit) identifier, is selected via bit IDE in the Frame control register. More...
- struct sbc_can_conf_t

  CAN configuration group structure. This structure configure CAN peripheral behavior. More...
- struct sbc_wake_t

  WAKE pin event capture enable register structure. Local wake-up is enabled via bits WPRE and WPFE in the WAKE pin event capture enable register. A wake-up event is triggered by a LOW-to-HIGH (ifWPRE = 1) and/or a HIGH-to-LOW (if WPFE = 1) transition on the WAKE pin. This arrangement allows for maximum flexibility when designing a local wake-up circuit. In applications that do not use the local wake-up facility, local wake-up should be disabled and the WAKE pin connected to GND. More...
- struct sbc_regulator_ctr_t

  Regulator control register group. This structure is group of regulator settings. More...
- struct sbc_int_config_t

  Init configuration structure. This structure is used for initialization of sbc. More...
- struct sbc_factories_conf_t

  Factory configuration structure. It contains Start-up control register and SBC configuration control register. This is non-volatile memory with limited write access. The MTPNV cells can be reprogrammed a maximum of 200 times (Ncy(W)MTP; Bit NVMPS in the MTPNV status register indicates whether the non-volatile cells can be reprogrammed. This register also contains a write counter, WRCNTS, that is incremented each time the MTPNV cells are reprogrammed (up to a maximum value of 111111; there is no overflow; performing a factory reset also increments the counter). This counter is provided for information purposes only; reprogramming will not be rejected when it reaches its maximum value. Factory preset values are restored if the following conditions apply continuously for at least td(MTPNV) during battery power-up: pin RSTN is held LOW, CANH is pulled up to VBAT, CANL is pulled down to

GND After the factory preset values have been restored, the SBC performs a system reset and enters Forced normal Mode. Since the CAN-bus is clamped dominant, pin RXDC is forced LOW. Pin RXD is forced HIGH during the factory preset restore process (td(MTPNV)). A falling edge on RXD caused by bit PO being set after power-on indicates that the factory preset process has been completed. Note that the write counter, WRCNTS, in the MTPNV status register is incremented every time the factory presets are restored. More...

- struct sbc_main_status_t

  Main status register structure. The Main status register can be accessed to monitor the status of the overtemperature warning flag and to determine whether the UJA116xA has entered Normal mode after initial power-up. It also indicates the source of the most recent reset event. More...

- struct sbc_wtdog_status_t

  Watchdog status register structure. Information on the status of the watchdog is available from the Watchdog status register. This register also indicates whether Forced Normal and Software Development modes are active. More...

- struct sbc_supply_status_t

  Supply voltage status register structure. V2/VEXT and V1 undervoltage and overvoltage status. More...

- struct sbc_trans_stat_t

  Transceiver status register structure. There are stored CAN transceiver statuses. More...

- struct sbc_gl_evnt_stat_t

  Global event status register. The microcontroller can monitor events via the event status registers. An extra status register, the Global event status register, is provided to help speed up software polling routines. By polling the Global event status register, the microcontroller can quickly determine the type of event captured (system, supply, transceiver or WAKE pin) and then query the relevant event status register. More...

- struct sbc_sys_evnt_stat_t

  System event status register. Wake-up and interrupt event diagnosis in the UJA116xA is intended to provide the microcontroller with information on the status of a range of features and functions. This information is stored in the event status registers and is signaled on pin RXD, if enabled. More...

- struct sbc_sup_evnt_stat_t

  Supply event status register. More...

- struct sbc_trans_evnt_stat_t

  Transceiver event status register. More...

- struct sbc_wake_evnt_stat_t

  WAKE pin event status register. More...

- struct sbc_evn_capt_t

  Event capture registers structure. This structure contains Global event status, System event status, Supply event status, Transceiver event status, WAKE pin event status. More...

- struct sbc_mtpnv_stat_t

  MTPNV status register. The MTPNV cells can be reprogrammed a maximum of 200 times (Ncy(W)MTP). Bit N↩ VMPS in the MTPNV status register indicates whether the non-volatile cells can be reprogrammed. This register also contains a write counter, WRCNTS, that is incremented each time the MTPNV cells are reprogrammed (up to a maximum value of 111111; there is no overflow; performing a factory reset also increments the counter). This counter is provided for information purposes only; reprogramming will not be rejected when it reaches its maximum value. More...

- struct sbc_status_group_t

  Status group structure. All statuses of SBC are stored in this structure. More...

Macros

- #define SBC_UJA_TIMEOUT 1000U
- #define SBC_UJA_COUNT_ID_REG 4U
- #define SBC_UJA_COUNT_MASK 4U
- #define SBC_UJA_COUNT_DMASK 8U

Typedefs

- typedef uint8_t sbc_fail_safe_rcc_t

  Fail-safe control register, reset counter control (0x02). incremented every time the SBC enters Reset mode while FNMC = 0; RCC overflows from 11 to 00; default at power-on is 00.
- typedef uint8_t sbc_identifier_t

  ID registers, identifier format (0x27 to 0x2A). A valid WUF identifier is defined and stored in the ID registers. An ID mask can be defined to allow a group of identifiers to be recognized as valid by an individual node.
- typedef uint8_t sbc_identif_mask_t

  ID mask registers (0x2B to 0x2E). The identifier mask is defined in the ID mask registers, where a 1 means dont care.
- typedef uint8_t sbc_frame_ctr_dlc_t

  Frame control register, number of data bytes expected in a CAN frame (0x2F).
- typedef uint8_t sbc_data_mask_t

  Data mask registers. The data field indicates the nodes to be woken up. Within the data field, groups of nodes can be predefined and associated with bits in a data mask. By comparing the incoming data field with the data mask, multiple groups of nodes can be woken up simultaneously with a single wake-up message.
- typedef uint8_t sbc_mtpnv_stat_wrcnts_t

  MTPNV status register, write counter status (0x70). 6-bits - contains the number of times the MTPNV cells were reprogrammed.

Enumerations

- enum sbc_register_t {
  SBC_UJA_WTDOG_CTR = 0x00U, SBC_UJA_MODE = 0x01U, SBC_UJA_FAIL_SAFE = 0x02U, SBC_U↩
  JA_MAIN = 0x03U,
  SBC_UJA_SYSTEM_EVNT = 0x04U, SBC_UJA_WTDOG_STAT = 0x05U, SBC_UJA_MEMORY_0 = 0x06U, SBC_UJA_MEMORY_1 = 0x07U,
  SBC_UJA_MEMORY_2 = 0x08U, SBC_UJA_MEMORY_3 = 0x09U, SBC_UJA_LOCK = 0x0AU, SBC_UJ↩
  A_REGULATOR = 0x10U,
  SBC_UJA_SUPPLY_STAT = 0x1BU, SBC_UJA_SUPPLY_EVNT = 0x1CU, SBC_UJA_CAN = 0x20U, SB↩
  C_UJA_TRANS_STAT = 0x22U,
  SBC_UJA_TRANS_EVNT = 0x23U, SBC_UJA_DAT_RATE = 0x26U, SBC_UJA_IDENTIF_0 = 0x27U, S↩
  BC_UJA_IDENTIF_1 = 0x28U,
  SBC_UJA_IDENTIF_2 = 0x29U, SBC_UJA_IDENTIF_3 = 0x2AU, SBC_UJA_MASK_0 = 0x2BU, SBC_UJ↩
  A_MASK_1 = 0x2CU,
  SBC_UJA_MASK_2 = 0x2DU, SBC_UJA_MASK_3 = 0x2EU, SBC_UJA_FRAME_CTR = 0x2FU, SBC_U↩
  JA_DAT_MASK_0 = 0x68U,
  SBC_UJA_DAT_MASK_1 = 0x69U, SBC_UJA_DAT_MASK_2 = 0x6AU, SBC_UJA_DAT_MASK_3 = 0x6↩
  BU, SBC_UJA_DAT_MASK_4 = 0x6CU,
  SBC_UJA_DAT_MASK_5 = 0x6DU, SBC_UJA_DAT_MASK_6 = 0x6EU, SBC_UJA_DAT_MASK_7 = 0x6↩
  FU, SBC_UJA_WAKE_STAT = 0x4BU,
  SBC_UJA_WAKE_EN = 0x4CU, SBC_UJA_GL_EVNT_STAT = 0x60U, SBC_UJA_SYS_EVNT_STAT = 0x61U, SBC_UJA_SUP_EVNT_STAT = 0x62U,
  SBC_UJA_TRANS_EVNT_STAT = 0x63U, SBC_UJA_WAKE_EVNT_STAT = 0x64U, SBC_UJA_MTPNV↩
  _STAT = 0x70U, SBC_UJA_START_UP = 0x73U,
  SBC_UJA_SBC = 0x74U, SBC_UJA_MTPNV_CRC = 0x75U, SBC_UJA_IDENTIF = 0x7EU }

  Register map.
- enum sbc_wtdog_ctr_wmc_t { SBC_UJA_WTDOG_CTR_WMC_AUTO = SBC_UJA_WTDOG_CTR_WM↩
  C_F(1U), SBC_UJA_WTDOG_CTR_WMC_TIME = SBC_UJA_WTDOG_CTR_WMC_F(2U), SBC_UJA_↩
  WTDOG_CTR_WMC_WIND = SBC_UJA_WTDOG_CTR_WMC_F(4U) }

  Watchdog control register, watchdog mode control (0x00). The UJA116xA contains a watchdog that supports three operating modes: Window, Timeout and Autonomous. In Window mode (available only in SBC Normal mode), a watchdog trigger event within a defined watchdog window triggers and resets the watchdog timer. In Timeout mode, the watchdog runs continuously and can be triggered and reset at any time within the watchdog period by a watchdog trigger. Watchdog time-out mode can also be used for cyclic wake-up of the microcontroller. In Autonomous mode, the watchdog can be off or autonomously in Timeout mode, depending on the selected SBC mode. The watchdog mode

is selected via bits WMC in the Watchdog control register. The SBC must be in Standby mode when the watchdog mode is changed.

- enum sbc_wtdog_ctr_nwp_t { SBC_UJA_WTDOG_CTR_NWP_8 = 0x08U, SBC_UJA_WTDOG_CTR_NWP_16 = 0x01U, SBC_UJA_WTDOG_CTR_NWP_32 = 0x02U, SBC_UJA_WTDOG_CTR_NWP_64 = 0x0BU, SBC_UJA_WTDOG_CTR_NWP_128 = 0x04U, SBC_UJA_WTDOG_CTR_NWP_256 = 0x0DU, SBC_UJA_WTDOG_CTR_NWP_1024 = 0x0EU, SBC_UJA_WTDOG_CTR_NWP_4096 = 0x07U }

  Watchdog control register, nominal watchdog period (0x00). Eight watchdog periods are supported, from 8 ms to 4096 ms. The watchdog period is programmed via bits NWP. The selected period is valid for both Window and Timeout modes. The default watchdog period is 128 ms. A watchdog trigger event resets the watchdog timer. A watchdog trigger event is any valid write access to the Watchdog control register. If the watchdog mode or the watchdog period have changed as a result of the write access, the new values are immediately valid.

- enum sbc_mode_mc_t { SBC_UJA_MODE_MC_SLEEP = 0x01U, SBC_UJA_MODE_MC_STANDBY = 0x04U, SBC_UJA_MODE_MC_NORMAL = 0x07U }

  Mode control register, mode control (0x01)

- enum sbc_fail_safe_lhc_t { SBC_UJA_FAIL_SAFE_LHC_FLOAT = SBC_UJA_FAIL_SAFE_LHC_F(0U), SBC_UJA_FAIL_SAFE_LHC_LOW = SBC_UJA_FAIL_SAFE_LHC_F(1U) }

  Fail-safe control register, LIMP home control (0x02). The dedicated LIMP pin can be used to enable so called limp home hardware in the event of a serious ECU failure. Detectable failure conditions include SBC overtemperature events, loss of watchdog service, short-circuits on pins RSTN or V1 and user-initiated or external reset events. The LIMP pin is a battery-robust, active-LOW, open-drain output. The LIMP pin can also be forced LOW by setting bit LHC in the Fail-safe control register.

- enum sbc_main_otws_t { SBC_UJA_MAIN_OTWS_BELOW = SBC_UJA_MAIN_OTWS_F(0U), SBC_UJA_MAIN_OTWS_ABOVE = SBC_UJA_MAIN_OTWS_F(1U) }

  Main status register, Overtemperature warning status (0x03).

- enum sbc_main_nms_t { SBC_UJA_MAIN_NMS_NORMAL = SBC_UJA_MAIN_NMS_F(0U), SBC_UJA_MAIN_NMS_PWR_UP = SBC_UJA_MAIN_NMS_F(1U) }

  Main status register, normal mode status (0x03).

- enum sbc_main_rss_t { SBC_UJA_MAIN_RSS_OFF_MODE = 0x00U, SBC_UJA_MAIN_RSS_CAN_WAKEUP = 0x01U, SBC_UJA_MAIN_RSS_SLP_WAKEUP = 0x04U, SBC_UJA_MAIN_RSS_OVF_SLP = 0x0CU, SBC_UJA_MAIN_RSS_DIAG_WAKEUP = 0x0DU, SBC_UJA_MAIN_RSS_WATCH_TRIG = 0x0EU, SBC_UJA_MAIN_RSS_WATCH_OVF = 0x0FU, SBC_UJA_MAIN_RSS_ILLEG_WATCH = 0x10U, SBC_UJA_MAIN_RSS_RSTN_PULDW = 0x11U, SBC_UJA_MAIN_RSS_LFT_OVERTM = 0x12U, SBC_UJA_MAIN_RSS_V1_UNDERV = 0x13U, SBC_UJA_MAIN_RSS_ILLEG_SLP = 0x14U, SBC_UJA_MAIN_RSS_WAKE_SLP = 0x16U }

  Main status register, Reset source status (0x03).

- enum sbc_sys_evnt_otwe_t { SBC_UJA_SYS_EVNT_OTWE_DIS = SBC_UJA_SYS_EVNT_OTWE_F(0U), SBC_UJA_SYS_EVNT_OTWE_EN = SBC_UJA_SYS_EVNT_OTWE_F(1U) }

  System event capture enable, overtemperature warning enable (0x04).

- enum sbc_sys_evnt_spife_t { SBC_UJA_SYS_EVNT_SPIFE_DIS = SBC_UJA_SYS_EVNT_SPIFE_F(0U), SBC_UJA_SYS_EVNT_SPIFE_EN = SBC_UJA_SYS_EVNT_SPIFE_F(1U) }

  System event capture enable, SPI failure enable (0x04).

- enum sbc_wtdog_stat_fnms_t { SBC_UJA_WTDOG_STAT_FNMS_N_NORMAL = SBC_UJA_WTDOG_STAT_FNMS_F(0U), SBC_UJA_WTDOG_STAT_FNMS_NORMAL = SBC_UJA_WTDOG_STAT_FNMS_F(1U) }

  Watchdog status register, forced Normal mode status (0x05).

- enum sbc_wtdog_stat_sdms_t { SBC_UJA_WTDOG_STAT_SDMS_N_NORMAL = SBC_UJA_WTDOG_STAT_SDMS_F(0U), SBC_UJA_WTDOG_STAT_SDMS_NORMAL = SBC_UJA_WTDOG_STAT_SDMS_F(1U) }

  Watchdog status register, Software Development mode status (0x05).

- enum sbc_wtdog_stat_wds_t { SBC_UJA_WTDOG_STAT_WDS_OFF = SBC_UJA_WTDOG_STAT_WDS_F(0U), SBC_UJA_WTDOG_STAT_WDS_FIH = SBC_UJA_WTDOG_STAT_WDS_F(1U), SBC_UJA_WTDOG_STAT_WDS_SEH = SBC_UJA_WTDOG_STAT_WDS_F(2U) }

  Watchdog status register, watchdog status (0x05).

- enum sbc_lock_t { LK0C = SBC_UJA_LOCK_LK0C_MASK, LK1C = SBC_UJA_LOCK_LK1C_MASK, LK2C = SBC_UJA_LOCK_LK2C_MASK, LK3C = SBC_UJA_LOCK_LK3C_MASK, LK4C = SBC_UJA_LOCK_LK4C_MASK, LK5C = SBC_UJA_LOCK_LK5C_MASK, LK6C = SBC_UJA_LOCK_LK6C_MASK, LKAC = SBC_UJA_LOCK_LKNC_MASK }

  Lock control(0x0A). Sections of the register address area can be write-protected to protect against unintended modifications. This facility only protects locked bits from being modified via the SPI and will not prevent the UJA116xA updating status registers etc.

- enum sbc_regulator_pdc_t { SBC_UJA_REGULATOR_PDC_HV = SBC_UJA_REGULATOR_PDC_F(0U), SBC_UJA_REGULATOR_PDC_LV = SBC_UJA_REGULATOR_PDC_F(1U) }

  Regulator control register, power distribution control (0x10). PDC is not available on UJA1168 device variants, use any of these two values, the value written to the device will be ignored.

- enum sbc_regulator_v2c_t { SBC_UJA_REGULATOR_V2C_OFF = SBC_UJA_REGULATOR_V2C_F(0U), SBC_UJA_REGULATOR_V2C_N = SBC_UJA_REGULATOR_V2C_F(1U), SBC_UJA_REGULATOR_V2C_N_S_R = SBC_UJA_REGULATOR_V2C_F(2U), SBC_UJA_REGULATOR_V2C_N_S_S_R = SBC_UJA_REGULATOR_V2C_F(3U) }

  Regulator control register, V2/VEXT configuration (0x10).

- enum sbc_regulator_v1rtc_t { SBC_UJA_REGULATOR_V1RTC_90 = SBC_UJA_REGULATOR_V1RTC_F(0U), SBC_UJA_REGULATOR_V1RTC_80 = SBC_UJA_REGULATOR_V1RTC_F(1U), SBC_UJA_REGULATOR_V1RTC_70 = SBC_UJA_REGULATOR_V1RTC_F(2U), SBC_UJA_REGULATOR_V1RTC_60 = SBC_UJA_REGULATOR_V1RTC_F(3U) }

  Regulator control register, set V1 reset threshold (0x10).

- enum sbc_supply_stat_v2s_t { SBC_UJA_SUPPLY_STAT_V2S_VOK = SBC_UJA_SUPPLY_STAT_V2S_F(0U), SBC_UJA_SUPPLY_STAT_V2S_VBE = SBC_UJA_SUPPLY_STAT_V2S_F(1U), SBC_UJA_SUPPLY_STAT_V2S_VAB = SBC_UJA_SUPPLY_STAT_V2S_F(2U), SBC_UJA_SUPPLY_STAT_V2S_DIS = SBC_UJA_SUPPLY_STAT_V2S_F(3U) }

  Supply voltage status register, V2/VEXT status (0x1B).

- enum sbc_supply_stat_v1s_t { SBC_UJA_SUPPLY_STAT_V1S_VAB = SBC_UJA_SUPPLY_STAT_V1S_F(0U), SBC_UJA_SUPPLY_STAT_V1S_VBE = SBC_UJA_SUPPLY_STAT_V1S_F(1U) }

  Supply voltage status register, V1 status (0x1B).

- enum sbc_supply_evnt_v2oe_t { SBC_UJA_SUPPLY_EVNT_V2OE_DIS = SBC_UJA_SUPPLY_EVNT_V2OE_F(0U), SBC_UJA_SUPPLY_EVNT_V2OE_EN = SBC_UJA_SUPPLY_EVNT_V2OE_F(1U) }

  Supply event capture enable register, V2/VEXT overvoltage enable (0x1C).

- enum sbc_supply_evnt_v2ue_t { SBC_UJA_SUPPLY_EVNT_V2UE_DIS = SBC_UJA_SUPPLY_EVNT_V2UE_F(0U), SBC_UJA_SUPPLY_EVNT_V2UE_EN = SBC_UJA_SUPPLY_EVNT_V2UE_F(1U) }

  Supply event capture enable register, V2/VEXT undervoltage enable (0x1C).

- enum sbc_supply_evnt_v1ue_t { SBC_UJA_SUPPLY_EVNT_V1UE_DIS = SBC_UJA_SUPPLY_EVNT_V1UE_F(0U), SBC_UJA_SUPPLY_EVNT_V1UE_EN = SBC_UJA_SUPPLY_EVNT_V1UE_F(1U) }

  Supply event capture enable register, V1 undervoltage enable (0x1C).

- enum sbc_can_cfdc_t { SBC_UJA_CAN_CFDC_DIS = SBC_UJA_CAN_CFDC_F(0U), SBC_UJA_CAN_CFDC_EN = SBC_UJA_CAN_CFDC_F(1U) }

  CAN control register, CAN FD control (0x20).

- enum sbc_can_pncok_t { SBC_UJA_CAN_PNCOK_DIS = SBC_UJA_CAN_PNCOK_F(0U), SBC_UJA_CAN_PNCOK_EN = SBC_UJA_CAN_PNCOK_F(1U) }

  CAN control register, CAN partial networking configuration OK (0x20).

- enum sbc_can_cpnc_t { SBC_UJA_CAN_CPNC_DIS = SBC_UJA_CAN_CPNC_F(0U), SBC_UJA_CAN_CPNC_EN = SBC_UJA_CAN_CPNC_F(1U) }

  CAN control register, CAN partial networking control (0x20).

- enum sbc_can_cmc_t { SBC_UJA_CAN_CMC_OFMODE = SBC_UJA_CAN_CMC_F(0U), SBC_UJA_CAN_CMC_ACMODE_DA = SBC_UJA_CAN_CMC_F(1U), SBC_UJA_CAN_CMC_ACMODE_DD = SBC_UJA_CAN_CMC_F(2U), SBC_UJA_CAN_CMC_LISTEN = SBC_UJA_CAN_CMC_F(3U) }

  CAN control register, CAN mode control (0x20).

- enum sbc_trans_stat_cts_t { SBC_UJA_TRANS_STAT_CTS_INACT = SBC_UJA_TRANS_STAT_CTS_F(0U), SBC_UJA_TRANS_STAT_CTS_ACT = SBC_UJA_TRANS_STAT_CTS_F(1U) }

Transceiver status register, CAN transceiver status (0x22).

- enum sbc_trans_stat_cpnerr_t { SBC_UJA_TRANS_STAT_CPNERR_NO_DET = SBC_UJA_TRANS_STAT_CPNERR_F(0U), SBC_UJA_TRANS_STAT_CPNERR_DET = SBC_UJA_TRANS_STAT_CPNERR_F(1U) }

  Transceiver status register, CAN partial networking error (0x22).
- enum sbc_trans_stat_cpns_t { SBC_UJA_TRANS_STAT_CPNS_ERR = SBC_UJA_TRANS_STAT_CPNS_F(0U), SBC_UJA_TRANS_STAT_CPNS_OK = SBC_UJA_TRANS_STAT_CPNS_F(1U) }

  Transceiver status register, CAN partial networking status (0x22).
- enum sbc_trans_stat_coscs_t { SBC_UJA_TRANS_STAT_COSCS_NRUN = SBC_UJA_TRANS_STAT_COSCS_F(0U), SBC_UJA_TRANS_STAT_COSCS_RUN = SBC_UJA_TRANS_STAT_COSCS_F(1U) }

  Transceiver status register, CAN oscillator status (0x22).
- enum sbc_trans_stat_cbss_t { SBC_UJA_TRANS_STAT_CBSS_ACT = SBC_UJA_TRANS_STAT_CBSS_F(0U), SBC_UJA_TRANS_STAT_CBSS_INACT = SBC_UJA_TRANS_STAT_CBSS_F(1U) }

  Transceiver status register, CAN-bus silence status (0x22).
- enum sbc_trans_stat_vcs_t { SBC_UJA_TRANS_STAT_VCS_AB = SBC_UJA_TRANS_STAT_VCS_F(0U), SBC_UJA_TRANS_STAT_VCS_BE = SBC_UJA_TRANS_STAT_VCS_F(1U) }

  Transceiver status register, VCAN status (0x22).
- enum sbc_trans_stat_cfs_t { SBC_UJA_TRANS_STAT_CFS_NO_TXD = SBC_UJA_TRANS_STAT_CFS_F(0U), SBC_UJA_TRANS_STAT_CFS_TXD = SBC_UJA_TRANS_STAT_CFS_F(1U) }

  Transceiver status register, CAN failure status (0x22).
- enum sbc_trans_evnt_cbse_t { SBC_UJA_TRANS_EVNT_CBSE_DIS = SBC_UJA_TRANS_EVNT_CBSE_F(0U), SBC_UJA_TRANS_EVNT_CBSE_EN = SBC_UJA_TRANS_EVNT_CBSE_F(1U) }

  Transceiver event capture enable register, CAN-bus silence enable (0x23).
- enum sbc_trans_evnt_cfe_t { SBC_UJA_TRANS_EVNT_CFE_DIS = SBC_UJA_TRANS_EVNT_CFE_F(0U), SBC_UJA_TRANS_EVNT_CFE_EN = SBC_UJA_TRANS_EVNT_CFE_F(1U) }

  Transceiver event capture enable register, CAN failure enable (0x23).
- enum sbc_trans_evnt_cwe_t { SBC_UJA_TRANS_EVNT_CWE_DIS = SBC_UJA_TRANS_EVNT_CWE_F(0U), SBC_UJA_TRANS_EVNT_CWE_EN = SBC_UJA_TRANS_EVNT_CWE_F(1U) }

  Transceiver event capture enable register, CAN wake-up enable (0x23).
- enum sbc_dat_rate_t { SBC_UJA_DAT_RATE_CDR_50KB = SBC_UJA_DAT_RATE_CDR_F(0U), SBC_UJA_DAT_RATE_CDR_100KB = SBC_UJA_DAT_RATE_CDR_F(1U), SBC_UJA_DAT_RATE_CDR_125KB = SBC_UJA_DAT_RATE_CDR_F(2U), SBC_UJA_DAT_RATE_CDR_250KB = SBC_UJA_DAT_RATE_CDR_F(3U), SBC_UJA_DAT_RATE_CDR_500KB = SBC_UJA_DAT_RATE_CDR_F(5U), SBC_UJA_DAT_RATE_CDR_1000KB = SBC_UJA_DAT_RATE_CDR_F(7U) }

  Data rate register, CAN data rate selection (0x26). CAN partial networking configuration registers. Dedicated registers are provided for configuring CAN partial networking.
- enum sbc_frame_ctr_ide_t { SBC_UJA_FRAME_CTR_IDE_11B = SBC_UJA_FRAME_CTR_IDE_F(0U), SBC_UJA_FRAME_CTR_IDE_29B = SBC_UJA_FRAME_CTR_IDE_F(1U) }

  Frame control register, identifier format (0x2F). The wake-up frame format, standard (11-bit) or extended (29-bit) identifier, is selected via bit IDE in the Frame control register.
- enum sbc_frame_ctr_pndm_t { SBC_UJA_FRAME_CTR_PNDM_DCARE = SBC_UJA_FRAME_CTR_PNDM_F(0U), SBC_UJA_FRAME_CTR_PNDM_EVAL = SBC_UJA_FRAME_CTR_PNDM_F(1U) }

  Frame control register, partial networking data mask (0x2F).
- enum sbc_wake_stat_wpvs_t { SBC_UJA_WAKE_STAT_WPVS_BE = SBC_UJA_WAKE_STAT_WPVS_F(0U), SBC_UJA_WAKE_STAT_WPVS_AB = SBC_UJA_WAKE_STAT_WPVS_F(1U) }

  WAKE pin status register, WAKE pin status (0x4B).
- enum sbc_wake_en_wpre_t { SBC_UJA_WAKE_EN_WPRE_DIS = SBC_UJA_WAKE_EN_WPRE_F(0U), SBC_UJA_WAKE_EN_WPRE_EN = SBC_UJA_WAKE_EN_WPRE_F(1U) }

  WAKE pin event capture enable register, WAKE pin rising-edge enable (0x4C).
- enum sbc_wake_en_wpfe_t { SBC_UJA_WAKE_EN_WPFE_DIS = SBC_UJA_WAKE_EN_WPFE_F(0U), SBC_UJA_WAKE_EN_WPFE_EN = SBC_UJA_WAKE_EN_WPFE_F(1U) }

  WAKE pin event capture enable register, WAKE pin falling-edge enable (0x4C).

- enum sbc_gl_evnt_stat_wpe_t { SBC_UJA_GL_EVNT_STAT_WPE_NO = SBC_UJA_GL_EVNT_STAT_↩ WPE_F(0U), SBC_UJA_GL_EVNT_STAT_WPE = SBC_UJA_GL_EVNT_STAT_WPE_F(1U) }

  Global event status register, WAKE pin event (0x60).
- enum sbc_gl_evnt_stat_trxe_t { SBC_UJA_GL_EVNT_STAT_TRXE_NO = SBC_UJA_GL_EVNT_STAT_↩ TRXE_F(0U), SBC_UJA_GL_EVNT_STAT_TRXE = SBC_UJA_GL_EVNT_STAT_TRXE_F(1U) }

  Global event status register, transceiver event (0x60).
- enum sbc_gl_evnt_stat_supe_t { SBC_UJA_GL_EVNT_STAT_SUPE_NO = SBC_UJA_GL_EVNT_STAT↩ _SUPE_F(0U), SBC_UJA_GL_EVNT_STAT_SUPE = SBC_UJA_GL_EVNT_STAT_SUPE_F(1U) }

  Global event status register, supply event (0x60).
- enum sbc_gl_evnt_stat_syse_t { SBC_UJA_GL_EVNT_STAT_SYSE_NO = SBC_UJA_GL_EVNT_STAT↩ _SYSE_F(0U), SBC_UJA_GL_EVNT_STAT_SYSE = SBC_UJA_GL_EVNT_STAT_SYSE_F(1U) }

  Global event status register, system event (0x60).
- enum sbc_sys_evnt_stat_po_t { SBC_UJA_SYS_EVNT_STAT_PO_NO = SBC_UJA_SYS_EVNT_STAT_↩ PO_F(0U), SBC_UJA_SYS_EVNT_STAT_PO = SBC_UJA_SYS_EVNT_STAT_PO_F(1U) }

  System event status register, power-on (0x61).
- enum sbc_sys_evnt_stat_otw_t { SBC_UJA_SYS_EVNT_STAT_OTW_NO = SBC_UJA_SYS_EVNT_ST↩ AT_OTW_F(0U), SBC_UJA_SYS_EVNT_STAT_OTW = SBC_UJA_SYS_EVNT_STAT_OTW_F(1U) }

  System event status register, overtemperature warning (0x61).
- enum sbc_sys_evnt_stat_spif_t { SBC_UJA_SYS_EVNT_STAT_SPIF_NO = SBC_UJA_SYS_EVNT_STA↩ T_SPIF_F(0U), SBC_UJA_SYS_EVNT_STAT_SPIF = SBC_UJA_SYS_EVNT_STAT_SPIF_F(1U) }

  System event status register, SPI failure (0x61).
- enum sbc_sys_evnt_stat_wdf_t { SBC_UJA_SYS_EVNT_STAT_WDF_NO = SBC_UJA_SYS_EVNT_ST↩ AT_WDF_F(0U), SBC_UJA_SYS_EVNT_STAT_WDF = SBC_UJA_SYS_EVNT_STAT_WDF_F(1U) }

  System event status register, watchdog failure (0x61).
- enum sbc_sup_evnt_stat_v2o_t { SBC_UJA_SUP_EVNT_STAT_V2O_NO = SBC_UJA_SUP_EVNT_ST↩ AT_V2O_F(0U), SBC_UJA_SUP_EVNT_STAT_V2O = SBC_UJA_SUP_EVNT_STAT_V2O_F(1U) }

  Supply event status register, V2/VEXT overvoltage (0x62).
- enum sbc_sup_evnt_stat_v2u_t { SBC_UJA_SUP_EVNT_STAT_V2U_NO = SBC_UJA_SUP_EVNT_STA↩ T_V2U_F(0U), SBC_UJA_SUP_EVNT_STAT_V2U = SBC_UJA_SUP_EVNT_STAT_V2U_F(1U) }

  Supply event status register, V2/VEXT undervoltage (0x62).
- enum sbc_sup_evnt_stat_v1u_t { SBC_UJA_SUP_EVNT_STAT_V1U_NO = SBC_UJA_SUP_EVNT_STA↩ T_V1U_F(0U), SBC_UJA_SUP_EVNT_STAT_V1U = SBC_UJA_SUP_EVNT_STAT_V1U_F(1U) }

  Supply event status register, V1 undervoltage (0x62).
- enum sbc_trans_evnt_stat_pnfde_t { SBC_UJA_TRANS_EVNT_STAT_PNFDE_NO = SBC_UJA_TRANS↩ _EVNT_STAT_PNFDE_F(0U), SBC_UJA_TRANS_EVNT_STAT_PNFDE = SBC_UJA_TRANS_EVNT_S↩ TAT_PNFDE_F(1U) }

  Transceiver event status register,partial networking frame detection error (0x63).
- enum sbc_trans_evnt_stat_cbs_t { SBC_UJA_TRANS_EVNT_STAT_CBS_NO = SBC_UJA_TRANS_EV↩ NT_STAT_CBS_F(0U), SBC_UJA_TRANS_EVNT_STAT_CBS = SBC_UJA_TRANS_EVNT_STAT_CBS↩ _F(1U) }

  Transceiver event status register, CAN-bus status (0x63).
- enum sbc_trans_evnt_stat_cf_t { SBC_UJA_TRANS_EVNT_STAT_CF_NO = SBC_UJA_TRANS_EVNT_↩ STAT_CF_F(0U), SBC_UJA_TRANS_EVNT_STAT_CF = SBC_UJA_TRANS_EVNT_STAT_CF_F(1U) }

  Transceiver event status register, CAN failure (0x63).
- enum sbc_trans_evnt_stat_cw_t { SBC_UJA_TRANS_EVNT_STAT_CW_NO = SBC_UJA_TRANS_EVN↩ T_STAT_CW_F(0U), SBC_UJA_TRANS_EVNT_STAT_CW = SBC_UJA_TRANS_EVNT_STAT_CW_F(1U) }

  Transceiver event status register, CAN wake-up (0x63).
- enum sbc_wake_evnt_stat_wpr_t { SBC_UJA_WAKE_EVNT_STAT_WPR_NO = SBC_UJA_WAKE_EVN↩ T_STAT_WPR_F(0U), SBC_UJA_WAKE_EVNT_STAT_WPR = SBC_UJA_WAKE_EVNT_STAT_WPR_↩ F(1U) }

  WAKE pin event status register, WAKE pin rising edge (0x64).

- enum sbc_wake_evnt_stat_wpf_t { SBC_UJA_WAKE_EVNT_STAT_WPF_NO = SBC_UJA_WAKE_EVNT_STAT_WPF_F(0U), SBC_UJA_WAKE_EVNT_STAT_WPF = SBC_UJA_WAKE_EVNT_STAT_WPF_F(1U) }

  WAKE pin event status register, WAKE pin falling edge (0x64).
- enum sbc_mtpnv_stat_eccs_t { SBC_UJA_MTPNV_STAT_ECCS_NO = SBC_UJA_MTPNV_STAT_ECCS_F(0U), SBC_UJA_MTPNV_STAT_ECCS = SBC_UJA_MTPNV_STAT_ECCS_F(1U) }

  MTPNV status register, error correction code status (0x70).
- enum sbc_mtpnv_stat_nvmps_t { SBC_UJA_MTPNV_STAT_NVMPS_NO = SBC_UJA_MTPNV_STAT_NVMPS_F(0U), SBC_UJA_MTPNV_STAT_NVMPS = SBC_UJA_MTPNV_STAT_NVMPS_F(1U) }

  MTPNV status register, non-volatile memory programming status (0x70).
- enum sbc_start_up_rlc_t { SBC_UJA_START_UP_RLC_20_25p0 = SBC_UJA_START_UP_RLC_F(0U), SBC_UJA_START_UP_RLC_10_12p5 = SBC_UJA_START_UP_RLC_F(1U), SBC_UJA_START_UP_RLC_03p6_05 = SBC_UJA_START_UP_RLC_F(2U), SBC_UJA_START_UP_RLC_01_01p5 = SBC_UJA_START_UP_RLC_F(3U) }

  Start-up control register, RSTN output reset pulse width macros (0x73).
- enum sbc_start_up_v2suc_t { SBC_UJA_START_UP_V2SUC_00 = SBC_UJA_START_UP_V2SUC_F(0U), SBC_UJA_START_UP_V2SUC_11 = SBC_UJA_START_UP_V2SUC_F(1U) }

  Start-up control register, V2/VEXT start-up control (0x73).
- enum sbc_sbc_v1rtsuc_t { SBC_UJA_SBC_V1RTSUC_90 = SBC_UJA_SBC_V1RTSUC_F(0U), SBC_UJA_SBC_V1RTSUC_80 = SBC_UJA_SBC_V1RTSUC_F(1U), SBC_UJA_SBC_V1RTSUC_70 = SBC_UJA_SBC_V1RTSUC_F(2U), SBC_UJA_SBC_V1RTSUC_60 = SBC_UJA_SBC_V1RTSUC_F(3U) }

  SBC configuration control register, V1 undervoltage threshold (defined by bit V1RTC) at start-up (0x74).
- enum sbc_sbc_fnmc_t { SBC_UJA_SBC_FNMC_DIS = SBC_UJA_SBC_FNMC_F(0U), SBC_UJA_SBC_FNMC_EN = SBC_UJA_SBC_FNMC_F(1U) }

  SBC configuration control register, Forced Normal mode control (0x74).
- enum sbc_sbc_sdmc_t { SBC_UJA_SBC_SDMC_DIS = SBC_UJA_SBC_SDMC_F(0U), SBC_UJA_SBC_SDMC_EN = SBC_UJA_SBC_SDMC_F(1U) }

  SBC configuration control register, Software Development mode control (0x74).
- enum sbc_sbc_slpc_t { SBC_UJA_SBC_SLPC_AC = SBC_UJA_SBC_SLPC_F(0U), SBC_UJA_SBC_SLPC_IG = SBC_UJA_SBC_SLPC_F(1U) }

  SBC configuration control register, Sleep control (0x74).

16.106.2 Data Structure Documentation

16.106.2.1 struct sbc_wtdog_ctr_t

Watchdog control register structure. Watchdog configuration structure.

Implements : sbc_wtdog_ctr_t_Class

Definition at line 1086 of file sbc_uja116x_driver.h.

Data Fields

- sbc_wtdog_ctr_wmc_t modeControl
- sbc_wtdog_ctr_nwp_t nominalPeriod

Field Documentation

16.106.2.1.1 sbc_wtdog_ctr_wmc_t modeControl

Watchdog mode control.

Definition at line 1087 of file sbc_uja116x_driver.h.

16.106.2.1.2 sbc_wtdog_ctr_nwp_t nominalPeriod

Nominal watchdog period.

Definition at line 1088 of file sbc_uja116x_driver.h.

16.106.2.2 struct sbc_sbc_t

SBC configuration control register structure. Two operating modes have a major impact on the operation of the watchdog: Forced Normal mode and Software Development mode (Software Development mode is provided for test and development purposes only and is not a dedicated SBC operating mode; the UJA116xA can be in any functional operating mode with Software Development mode enabled). These modes are enabled and disabled via bits FNMC and SDMC respectively in the SBC configuration control register. Note that this register is located in the non-volatile memory area. The watchdog is disabled in Forced Normal mode (FNM). In Software Development mode (SDM), the watchdog can be disabled or activated for test and software debugging purposes.

Implements : sbc_sbc_t_Class

Definition at line 1107 of file sbc_uja116x_driver.h.

Data Fields

- sbc_sbc_v1rtsuc_t v1rtsuc
- sbc_sbc_fnmc_t fnmc
- sbc_sbc_sdmc_t sdmc
- sbc_sbc_slpc_t slpc

Field Documentation

16.106.2.2.1 sbc_sbc_fnmc_t fnmc

Forced Normal mode control.

Definition at line 1110 of file sbc_uja116x_driver.h.

16.106.2.2.2 sbc_sbc_sdmc_t sdmc

Software Development mode control.

Definition at line 1111 of file sbc_uja116x_driver.h.

16.106.2.2.3 sbc_sbc_slpc_t slpc

Sleep control.

Definition at line 1113 of file sbc_uja116x_driver.h.

16.106.2.2.4 sbc_sbc_v1rtsuc_t v1rtsuc

V1 undervoltage threshold (defined by bit V1RTC) at start-up (0x74).

Definition at line 1108 of file sbc_uja116x_driver.h.

16.106.2.3 struct sbc_start_up_t

Start-up control register structure. This structure contains settings of RSTN output reset pulse width and V2/VEXT start-up control.

Implements : sbc_start_up_t_Class

Definition at line 1123 of file sbc_uja116x_driver.h.

Data Fields

- sbc_start_up_rlc_t rlc
- sbc_start_up_v2suc_t v2suc

Field Documentation

16.106.2.3.1 sbc_start_up_rlc_t rlc

RSTN output reset pulse width macros.

Definition at line 1124 of file sbc_uja116x_driver.h.

16.106.2.3.2 sbc_start_up_v2suc_t v2suc

V2/VEXT start-up control.

Definition at line 1126 of file sbc_uja116x_driver.h.

16.106.2.4 struct sbc_regulator_t

Regulator control register structure. This structure set power distribution control, V2/VEXT configuration, set V1 reset threshold.

Implements : sbc_regulator_t_Class

Definition at line 1136 of file sbc_uja116x_driver.h.

Data Fields

- sbc_regulator_pdc_t pdc
- sbc_regulator_v2c_t v2c
- sbc_regulator_v1rtc_t v1rtc

Field Documentation

16.106.2.4.1 sbc_regulator_pdc_t pdc

Power distribution control.

Definition at line 1137 of file sbc_uja116x_driver.h.

16.106.2.4.2 sbc_regulator_v1rtc_t v1rtc

Set V1 reset threshold.

Definition at line 1139 of file sbc_uja116x_driver.h.

16.106.2.4.3 sbc_regulator_v2c_t v2c

V2/VEXT configuration.

Definition at line 1138 of file sbc_uja116x_driver.h.

16.106.2.5 struct sbc_supply_evnt_t

Supply event capture enable register structure. This structure enables or disables detection of V2/VEXT overvoltage, undervoltage and V1 undervoltage enable.

Implements : sbc_supply_evnt_t_Class

Definition at line 1149 of file sbc_uja116x_driver.h.

Data Fields

- sbc_supply_evnt_v2oe_t v2oe
- sbc_supply_evnt_v2ue_t v2ue
- sbc_supply_evnt_v1ue_t v1ue

Field Documentation

16.106.2.5.1 sbc_supply_evnt_v1ue_t v1ue

SV1 undervoltage enable.

Definition at line 1152 of file sbc_uja116x_driver.h.

16.106.2.5.2 sbc_supply_evnt_v2oe_t v2oe

V2/VEXT overvoltage enable.

Definition at line 1150 of file sbc_uja116x_driver.h.

16.106.2.5.3 sbc_supply_evnt_v2ue_t v2ue

V2/VEXT undervoltage enable.

Definition at line 1151 of file sbc_uja116x_driver.h.

16.106.2.6 struct sbc_sys_evnt_t

System event capture enable register structure. This structure enables or disables overtemperature warning, SPI failure enable.

Implements : sbc_sys_evnt_t_Class

Definition at line 1162 of file sbc_uja116x_driver.h.

Data Fields

- sbc_sys_evnt_otwe_t owte
- sbc_sys_evnt_spife_t spife

Field Documentation

16.106.2.6.1 sbc_sys_evnt_otwe_t owte

Overtemperature warning enable.

Definition at line 1163 of file sbc_uja116x_driver.h.

16.106.2.6.2 sbc_sys_evnt_spife_t spife

SPI failure enable.

Definition at line 1164 of file sbc_uja116x_driver.h.

16.106.2.7 struct sbc_can_ctr_t

CAN control register structure. This structure configure CAN peripheral behavior.

Implements : sbc_can_ctr_t_Class

Definition at line 1173 of file sbc_uja116x_driver.h.

Data Fields

- sbc_can_cfdc_t cfdc
- sbc_can_pncok_t pncok
- sbc_can_cpnc_t cpnc
- sbc_can_cmc_t cmc

Field Documentation

16.106.2.7.1 sbc_can_cfdc_t cfdc

CAN FD control.

Definition at line 1174 of file sbc_uja116x_driver.h.

16.106.2.7.2 sbc_can_cmc_t cmc

CAN mode control.

Definition at line 1179 of file sbc_uja116x_driver.h.

16.106.2.7.3 sbc_can_cpnc_t cpnc

CAN partial. networking control.

Definition at line 1177 of file sbc_uja116x_driver.h.

16.106.2.7.4 sbc_can_pncok_t pncok

CAN partial networking. configuration OK.

Definition at line 1175 of file sbc_uja116x_driver.h.

16.106.2.8 struct sbc_trans_evnt_t

Transceiver event capture enable register structure. Can bus silence, Can failure and Can wake-up settings.

Implements : sbc_trans_evnt_t_Class

Definition at line 1188 of file sbc_uja116x_driver.h.

Data Fields

- sbc_trans_evnt_cbse_t cbse
- sbc_trans_evnt_cfe_t cfe
- sbc_trans_evnt_cwe_t cwe

Field Documentation

16.106.2.8.1 sbc_trans_evnt_cbse_t cbse

CAN-bus silence enable.

Definition at line 1189 of file sbc_uja116x_driver.h.

16.106.2.8.2 sbc_trans_evnt_cfe_t cfe

CAN failure enable.

Definition at line 1190 of file sbc_uja116x_driver.h.

16.106.2.8.3 sbc_trans_evnt_cwe_t cwe

CAN wake-up enable.

Definition at line 1191 of file sbc_uja116x_driver.h.

16.106.2.9 struct sbc_frame_t

Frame control register structure. The wake-up frame format, standard (11-bit) or extended (29-bit) identifier, is selected via bit IDE in the Frame control register.

Implements : sbc_frame_t_Class

Definition at line 1201 of file sbc_uja116x_driver.h.

Data Fields

- sbc_frame_ctr_ide_t ide

- sbc_frame_ctr_pndm_t pndm
- sbc_frame_ctr_dlc_t dlc

Field Documentation

16.106.2.9.1 sbc_frame_ctr_dlc_t dlc

Number of data bytes expected.

Definition at line 1204 of file sbc_uja116x_driver.h.

16.106.2.9.2 sbc_frame_ctr_ide_t ide

Identifier format.

Definition at line 1202 of file sbc_uja116x_driver.h.

16.106.2.9.3 sbc_frame_ctr_pndm_t pndm

Partial networking data mask.

Definition at line 1203 of file sbc_uja116x_driver.h.

16.106.2.10 struct sbc_can_conf_t

CAN configuration group structure. This structure configure CAN peripheral behavior.

Implements : sbc_can_conf_t_Class

Definition at line 1213 of file sbc_uja116x_driver.h.

Data Fields

- sbc_can_ctr_t canConf
- sbc_trans_evnt_t canTransEvnt
- sbc_dat_rate_t datRate
- sbc_identifier_t identif [SBC_UJA_COUNT_ID_REG]
- sbc_identif_mask_t mask [SBC_UJA_COUNT_MASK]
- sbc_frame_t frame
- sbc_data_mask_t dataMask [SBC_UJA_COUNT_DMASK]

Field Documentation

16.106.2.10.1 sbc_can_ctr_t canConf

CAN control register.

Definition at line 1214 of file sbc_uja116x_driver.h.

16.106.2.10.2 sbc_trans_evnt_t canTransEvnt

Transceiver event capture enable register.

Definition at line 1215 of file sbc_uja116x_driver.h.

16.106.2.10.3 sbc_data_mask_t dataMask[SBC_UJA_COUNT_DMASK]

Data mask 0 - 7 configuration.

Definition at line 1221 of file sbc_uja116x_driver.h.

16.106.2.10.4 sbc_dat_rate_t datRate

CAN data rate selection.

Definition at line 1217 of file sbc_uja116x_driver.h.

16.106.2.10.5 sbc_frame_t frame

Frame control register.

Definition at line 1220 of file sbc_uja116x_driver.h.

16.106.2.10.6 sbc_identifier_t identif[SBC_UJA_COUNT_ID_REG]

ID registers.

Definition at line 1218 of file sbc_uja116x_driver.h.

16.106.2.10.7 sbc_identif_mask_t mask[SBC_UJA_COUNT_MASK]

ID mask registers.

Definition at line 1219 of file sbc_uja116x_driver.h.

16.106.2.11 struct sbc_wake_t

WAKE pin event capture enable register structure. Local wake-up is enabled via bits WPRE and WPFE in the WAKE pin event capture enable register. A wake-up event is triggered by a LOW-to-HIGH (ifWPRE = 1) and/or a HIGH-to-LOW (if WPFE = 1) transition on the WAKE pin. This arrangement allows for maximum flexibility when designing a local wake-up circuit. In applications that do not use the local wake-up facility, local wake-up should be disabled and the WAKE pin connected to GND.

Implements : sbc_wake_t_Class

Definition at line 1236 of file sbc_uja116x_driver.h.

Data Fields

- sbc_wake_en_wpre_t wpre
- sbc_wake_en_wpfe_t wpfe

Field Documentation

16.106.2.11.1 sbc_wake_en_wpfe_t wpfe

WAKE pin falling-edge enable.

Definition at line 1238 of file sbc_uja116x_driver.h.

16.106.2.11.2 sbc_wake_en_wpre_t wpre

WAKE pin rising-edge enable.

Definition at line 1237 of file sbc_uja116x_driver.h.

16.106.2.12 struct sbc_regulator_ctr_t

Regulator control register group. This structure is group of regulator settings.

Implements : sbc_regulator_ctr_t_Class

Definition at line 1247 of file sbc_uja116x_driver.h.

Data Fields

- sbc_regulator_t regulator
- sbc_supply_evnt_t supplyEvnt

Field Documentation

16.106.2.12.1 sbc_regulator_t regulator

Regulator control register.

Definition at line 1248 of file sbc_uja116x_driver.h.

16.106.2.12.2 sbc_supply_evnt_t supplyEvnt

Supply event capture enable register.

Definition at line 1249 of file sbc_uja116x_driver.h.

16.106.2.13 struct sbc_int_config_t

Init configuration structure. This structure is used for initialization of sbc.

Implements : sbc_int_config_t_Class

Definition at line 1259 of file sbc_uja116x_driver.h.

Data Fields

- sbc_regulator_ctr_t regulatorCtr
- sbc_wtdog_ctr_t watchdog
- sbc_mode_mc_t mode
- sbc_fail_safe_lhc_t lhc
- sbc_sys_evnt_t sysEvnt
- sbc_lock_t lockMask
- sbc_can_conf_t can
- sbc_wake_t wakePin

Field Documentation

16.106.2.13.1 sbc_can_conf_t can

CAN configuration group.

Definition at line 1267 of file sbc_uja116x_driver.h.

16.106.2.13.2 sbc_fail_safe_lhc_t lhc

LIMP home control.

Definition at line 1263 of file sbc_uja116x_driver.h.

16.106.2.13.3 sbc_lock_t lockMask

Lock control register.

Definition at line 1266 of file sbc_uja116x_driver.h.

16.106.2.13.4 sbc_mode_mc_t mode

Mode control register.

Definition at line 1262 of file sbc_uja116x_driver.h.

16.106.2.13.5 sbc_regulator_ctr_t regulatorCtr

Regulator control register group.

Definition at line 1260 of file sbc_uja116x_driver.h.

16.106.2.13.6 sbc_sys_evnt_t sysEvnt

System event capture enable registers.

Definition at line 1264 of file sbc_uja116x_driver.h.

16.106.2.13.7 sbc_wake_t wakePin

WAKE pin event capture enable register.

Definition at line 1268 of file sbc_uja116x_driver.h.

16.106.2.13.8 sbc_wtdog_ctr_t watchdog

Watchdog control register.

Definition at line 1261 of file sbc_uja116x_driver.h.

16.106.2.14 struct sbc_factories_conf_t

Factory configuration structure. It contains Start-up control register and SBC configuration control register. This is non-volatile memory with limited write access. The MTPNV cells can be reprogrammed a maximum of 200 times (Ncy(W)MTP; Bit NVMPS in the MTPNV status register indicates whether the non-volatile cells can be reprogrammed. This register also contains a write counter, WRCNTS, that is incremented each time the MTPNV cells are reprogrammed (up to a maximum value of 111111; there is no overflow; performing a factory reset also increments the counter). This counter is provided for information purposes only; reprogramming will not be rejected when it reaches its maximum value. Factory preset values are restored if the following conditions apply continuously for at least td(MTPNV) during battery power-up: pin RSTN is held LOW, CANH is pulled up to VBAT, CANL is pulled down to GND After the factory preset values have been restored, the SBC performs a system reset and enters Forced normal Mode. Since the CAN-bus is clamped dominant, pin RXDC is forced LOW. Pin RXD is forced HIGH during the factory preset restore process (td(MTPNV)). A falling edge on RXD caused by bit PO being set after power-on indicates that the factory preset process has been completed. Note that the write counter, WRCNTS, in the MTPNV status register is incremented every time the factory presets are restored.

Implements : sbc_factories_conf_t_Class

Definition at line 1298 of file sbc_uja116x_driver.h.

Data Fields

- sbc_start_up_t startUp
- sbc_sbc_t control

Field Documentation

16.106.2.14.1 sbc_sbc_t control

SBC configuration control register. Note that this register is located in the non-volatile memory area.

Definition at line 1300 of file sbc_uja116x_driver.h.

16.106.2.14.2 sbc_start_up_t startUp

Start-up control register.

Definition at line 1299 of file sbc_uja116x_driver.h.

16.106.2.15 struct sbc_main_status_t

Main status register structure. The Main status register can be accessed to monitor the status of the overtemperature warning flag and to determine whether the UJA116xA has entered Normal mode after initial power-up. It also indicates the source of the most recent reset event.

Implements : sbc_main_status_t_Class

Definition at line 1314 of file sbc_uja116x_driver.h.

Data Fields

- sbc_main_otws_t otws
- sbc_main_nms_t nms
- sbc_main_rss_t rss

Field Documentation

16.106.2.15.1 sbc_main_nms_t nms

Normal mode status.

Definition at line 1316 of file sbc_uja116x_driver.h.

16.106.2.15.2 sbc_main_otws_t otws

Overtemperature warning status.

Definition at line 1315 of file sbc_uja116x_driver.h.

16.106.2.15.3 sbc_main_rss_t rss

Reset source status.

Definition at line 1317 of file sbc_uja116x_driver.h.

16.106.2.16 struct sbc_wtdog_status_t

Watchdog status register structure. Information on the status of the watchdog is available from the Watchdog status register. This register also indicates whether Forced Normal and Software Development modes are active.

Implements : sbc_wtdog_status_t_Class

Definition at line 1328 of file sbc_uja116x_driver.h.

Data Fields

- sbc_wtdog_stat_fnms_t fnms
- sbc_wtdog_stat_sdms_t sdms
- sbc_wtdog_stat_wds_t wds

Field Documentation

16.106.2.16.1 sbc_wtdog_stat_fnms_t fnms

Forced Normal mode status.

Definition at line 1329 of file sbc_uja116x_driver.h.

16.106.2.16.2 sbc_wtdog_stat_sdms_t sdms

Software Development mode status.

Definition at line 1330 of file sbc_uja116x_driver.h.

16.106.2.16.3 sbc_wtdog_stat_wds_t wds

Watchdog status.

Definition at line 1331 of file sbc_uja116x_driver.h.

16.106.2.17 struct sbc_supply_status_t

Supply voltage status register structure. V2/VEXT and V1 undervoltage and overvoltage status.

Implements : sbc_supply_status_t_Class

Definition at line 1340 of file sbc_uja116x_driver.h.

Data Fields

- sbc_supply_stat_v2s_t v2s
- sbc_supply_stat_v1s_t v1s

Field Documentation

16.106.2.17.1 sbc_supply_stat_v1s_t v1s

V1 status.

Definition at line 1342 of file sbc_uja116x_driver.h.

16.106.2.17.2 sbc_supply_stat_v2s_t v2s

V2/VEXT status.

Definition at line 1341 of file sbc_uja116x_driver.h.

16.106.2.18 struct sbc_trans_stat_t

Transceiver status register structure. There are stored CAN transceiver statuses.

Implements : sbc_trans_stat_t_Class

Definition at line 1351 of file sbc_uja116x_driver.h.

Data Fields

- sbc_trans_stat_cts_t cts
- sbc_trans_stat_cpnerr_t cpnerr
- sbc_trans_stat_cpns_t cpns
- sbc_trans_stat_coscs_t coscs
- sbc_trans_stat_cbss_t cbss
- sbc_trans_stat_vcs_t vcs
- sbc_trans_stat_cfs_t cfs

Field Documentation

16.106.2.18.1 sbc_trans_stat_cbss_t cbss

CAN-bus silence status.

Definition at line 1356 of file sbc_uja116x_driver.h.

16.106.2.18.2 sbc_trans_stat_cfs_t cfs

CAN failure status.

Definition at line 1358 of file sbc_uja116x_driver.h.

16.106.2.18.3 sbc_trans_stat_coscs_t coscs

CAN oscillator status.

Definition at line 1355 of file sbc_uja116x_driver.h.

16.106.2.18.4 sbc_trans_stat_cpnerr_t cpnerr

CAN partial networking error.

Definition at line 1353 of file sbc_uja116x_driver.h.

16.106.2.18.5 sbc_trans_stat_cpns_t cpns

CAN partial networking status.

Definition at line 1354 of file sbc_uja116x_driver.h.

16.106.2.18.6 sbc_trans_stat_cts_t cts

CAN transceiver status.

Definition at line 1352 of file sbc_uja116x_driver.h.

16.106.2.18.7 sbc_trans_stat_vcs_t vcs

VCAN status.

Definition at line 1357 of file sbc_uja116x_driver.h.

16.106.2.19 struct sbc_gl_evnt_stat_t

Global event status register. The microcontroller can monitor events via the event status registers. An extra status register, the Global event status register, is provided to help speed up software polling routines. By polling the Global event status register, the microcontroller can quickly determine the type of event captured (system, supply, transceiver or WAKE pin) and then query the relevant event status register.

Implements : sbc_gl_evnt_stat_t_Class

Definition at line 1372 of file sbc_uja116x_driver.h.

Data Fields

- sbc_gl_evnt_stat_wpe_t wpe
- sbc_gl_evnt_stat_trxe_t trxe
- sbc_gl_evnt_stat_supe_t supe
- sbc_gl_evnt_stat_syse_t syse

Field Documentation

16.106.2.19.1 sbc_gl_evnt_stat_supe_t supe

Supply event.

Definition at line 1375 of file sbc_uja116x_driver.h.

16.106.2.19.2 sbc_gl_evnt_stat_syse_t syse

System event.

Definition at line 1376 of file sbc_uja116x_driver.h.

16.106.2.19.3 sbc_gl_evnt_stat_trxe_t trxe

Transceiver event.

Definition at line 1374 of file sbc_uja116x_driver.h.

16.106.2.19.4 sbc_gl_evnt_stat_wpe_t wpe

WAKE pin event.

Definition at line 1373 of file sbc_uja116x_driver.h.

16.106.2.20 struct sbc_sys_evnt_stat_t

System event status register. Wake-up and interrupt event diagnosis in the UJA116xA is intended to provide the microcontroller with information on the status of a range of features and functions. This information is stored in the

event status registers and is signaled on pin RXD, if enabled.

Implements : sbc_sys_evnt_stat_t_Class

Definition at line 1388 of file sbc_uja116x_driver.h.

Data Fields

- sbc_sys_evnt_stat_po_t po
- sbc_sys_evnt_stat_otw_t otw
- sbc_sys_evnt_stat_spif_t spif
- sbc_sys_evnt_stat_wdf_t wdf

Field Documentation

16.106.2.20.1 sbc_sys_evnt_stat_otw_t otw

Transceiver event, overtemperature warning

Definition at line 1390 of file sbc_uja116x_driver.h.

16.106.2.20.2 sbc_sys_evnt_stat_po_t po

Power-on.

Definition at line 1389 of file sbc_uja116x_driver.h.

16.106.2.20.3 sbc_sys_evnt_stat_spif_t spif

SPI failure.

Definition at line 1392 of file sbc_uja116x_driver.h.

16.106.2.20.4 sbc_sys_evnt_stat_wdf_t wdf

Watchdog failure.

Definition at line 1393 of file sbc_uja116x_driver.h.

16.106.2.21 struct sbc_sup_evnt_stat_t

Supply event status register.

Implements : sbc_sup_evnt_stat_t_Class

Definition at line 1401 of file sbc_uja116x_driver.h.

Data Fields

- sbc_sup_evnt_stat_v2o_t v2o
- sbc_sup_evnt_stat_v2u_t v2u
- sbc_sup_evnt_stat_v1u_t v1u

Field Documentation

16.106.2.21.1 sbc_sup_evnt_stat_v1u_t v1u

V1 undervoltage.

Definition at line 1404 of file sbc_uja116x_driver.h.

16.106.2.21.2 sbc_sup_evnt_stat_v2o_t v2o

V2/VEXT overvoltage.

Definition at line 1402 of file sbc_uja116x_driver.h.

16.106.2.21.3 sbc_sup_evnt_stat_v2u_t v2u

V2/VEXT undervoltage.

Definition at line 1403 of file sbc_uja116x_driver.h.

16.106.2.22 struct sbc_trans_evnt_stat_t

Transceiver event status register.

Implements : sbc_trans_evnt_stat_t_Class

Definition at line 1412 of file sbc_uja116x_driver.h.

Data Fields

- sbc_trans_evnt_stat_pnfde_t pnfde
- sbc_trans_evnt_stat_cbs_t cbs
- sbc_trans_evnt_stat_cf_t cf
- sbc_trans_evnt_stat_cw_t cw

Field Documentation

16.106.2.22.1 sbc_trans_evnt_stat_cbs_t cbs

CAN-bus status.

Definition at line 1415 of file sbc_uja116x_driver.h.

16.106.2.22.2 sbc_trans_evnt_stat_cf_t cf

CAN failure.

Definition at line 1416 of file sbc_uja116x_driver.h.

16.106.2.22.3 sbc_trans_evnt_stat_cw_t cw

CAN wake-up.

Definition at line 1417 of file sbc_uja116x_driver.h.

16.106.2.22.4 sbc_trans_evnt_stat_pnfde_t pnfde

Partial networking frame detection error.

Definition at line 1413 of file sbc_uja116x_driver.h.

16.106.2.23 struct sbc_wake_evnt_stat_t

WAKE pin event status register.

Implements : sbc_wake_evnt_stat_t_Class

Definition at line 1425 of file sbc_uja116x_driver.h.

Data Fields

- sbc_wake_evnt_stat_wpr_t wpr
- sbc_wake_evnt_stat_wpf_t wpf

Field Documentation

16.106.2.23.1 sbc_wake_evnt_stat_wpf_t wpf

WAKE pin falling edge.

Definition at line 1427 of file sbc_uja116x_driver.h.

16.106.2.23.2 sbc_wake_evnt_stat_wpr_t wpr

WAKE pin rising edge.

Definition at line 1426 of file sbc_uja116x_driver.h.

16.106.2.24 struct sbc_evn_capt_t

Event capture registers structure. This structure contains Global event status, System event status, Supply event status, Transceiver event status, WAKE pin event status.

Implements : sbc_evn_capt_t_Class

Definition at line 1437 of file sbc_uja116x_driver.h.

Data Fields

- sbc_gl_evnt_stat_t glEvnt
- sbc_sys_evnt_stat_t sysEvnt
- sbc_sup_evnt_stat_t supEvnt
- sbc_trans_evnt_stat_t transEvnt
- sbc_wake_evnt_stat_t wakePinEvnt

Field Documentation

16.106.2.24.1 sbc_gl_evnt_stat_t glEvnt

Global event status.

Definition at line 1438 of file sbc_uja116x_driver.h.

16.106.2.24.2 sbc_sup_evnt_stat_t supEvnt

Supply event status.

Definition at line 1440 of file sbc_uja116x_driver.h.

16.106.2.24.3 sbc_sys_evnt_stat_t sysEvnt

System event status.

Definition at line 1439 of file sbc_uja116x_driver.h.

16.106.2.24.4 sbc_trans_evnt_stat_t transEvnt

Transceiver event status.

Definition at line 1441 of file sbc_uja116x_driver.h.

16.106.2.24.5 sbc_wake_evnt_stat_t wakePinEvnt

WAKE pin event status.

Definition at line 1442 of file sbc_uja116x_driver.h.

16.106.2.25 struct sbc_mtpnv_stat_t

MTPNV status register. The MTPNV cells can be reprogrammed a maximum of 200 times (Ncy(W)MTP). Bit N↩ VMPS in the MTPNV status register indicates whether the non-volatile cells can be reprogrammed. This register also contains a write counter, WRCNTS, that is incremented each time the MTPNV cells are reprogrammed (up to a maximum value of 111111; there is no overflow; performing a factory reset also increments the counter). This counter is provided for information purposes only; reprogramming will not be rejected when it reaches its maximum value.

Implements : sbc_mtpnv_stat_t_Class

Definition at line 1458 of file sbc_uja116x_driver.h.

Data Fields

- sbc_mtpnv_stat_wrcnts_t wrcnts
- sbc_mtpnv_stat_eccs_t eccs
- sbc_mtpnv_stat_nvmps_t nvmps

Field Documentation

16.106.2.25.1 sbc_mtpnv_stat_eccs_t eccs

Error correction code status.

Definition at line 1460 of file sbc_uja116x_driver.h.

16.106.2.25.2 sbc_mtpnv_stat_nvmps_t nvmps

Non-volatile memory programming status.

Definition at line 1461 of file sbc_uja116x_driver.h.

16.106.2.25.3 sbc_mtpnv_stat_wrcnts_t wrcnts

Write counter status.

Definition at line 1459 of file sbc_uja116x_driver.h.

16.106.2.26 struct sbc_status_group_t

Status group structure. All statuses of SBC are stored in this structure.

Implements : sbc_status_group_t_Class

Definition at line 1472 of file sbc_uja116x_driver.h.

Data Fields

- sbc_main_status_t mainS
- sbc_wtdog_status_t wtdog
- sbc_supply_status_t supply
- sbc_trans_stat_t trans
- sbc_wake_stat_wpvs_t wakePin
- sbc_evn_capt_t events

Field Documentation

16.106.2.26.1 sbc_evn_capt_t events

Event capture registers.

Definition at line 1478 of file sbc_uja116x_driver.h.

16.106.2.26.2 sbc_main_status_t mainS

Main status.

Definition at line 1473 of file sbc_uja116x_driver.h.

16.106.2.26.3 sbc_supply_status_t supply

Supply voltage status.

Definition at line 1475 of file sbc_uja116x_driver.h.

16.106.2.26.4 sbc_trans_stat_t trans

Transceiver status.

Definition at line 1476 of file sbc_uja116x_driver.h.

16.106.2.26.5 sbc_wake_stat_wpvs_t wakePin

WAKE pin status.

Definition at line 1477 of file sbc_uja116x_driver.h.

16.106.2.26.6 sbc_wtdog_status_t wtdog

Watchdog status.

Definition at line 1474 of file sbc_uja116x_driver.h.

16.106.3 Macro Definition Documentation

16.106.3.1 #define SBC_UJA_COUNT_DMASK 8U

Definition at line 41 of file sbc_uja116x_driver.h.

16.106.3.2 #define SBC_UJA_COUNT_ID_REG 4U

Definition at line 39 of file sbc_uja116x_driver.h.

16.106.3.3 #define SBC_UJA_COUNT_MASK 4U

Definition at line 40 of file sbc_uja116x_driver.h.

16.106.3.4 #define SBC_UJA_TIMEOUT 1000U

Timeout for the transfer in milliseconds. If the transfer takes longer than this time, the transfer is aborted and LPSPI_STATUS_SBC_UJA_TIMEOUT error is reported.

Definition at line 33 of file sbc_uja116x_driver.h.

16.106.4 Typedef Documentation

16.106.4.1 typedef uint8_t sbc_data_mask_t

Data mask registers. The data field indicates the nodes to be woken up. Within the data field, groups of nodes can be predefined and associated with bits in a data mask. By comparing the incoming data field with the data mask, multiple groups of nodes can be woken up simultaneously with a single wake-up message.

Implements : sbc_data_mask_t_Class

Definition at line 706 of file sbc_uja116x_driver.h.

16.106.4.2 typedef uint8_t sbc_fail_safe_rcc_t

Fail-safe control register, reset counter control (0x02). incremented every time the SBC enters Reset mode while FNMC = 0; RCC overflows from 11 to 00; default at power-on is 00.

Implements : sbc_fail_safe_rcc_t_Class

Definition at line 195 of file sbc_uja116x_driver.h.

16.106.4.3 typedef uint8_t sbc_frame_ctr_dlc_t

Frame control register, number of data bytes expected in a CAN frame (0x2F).

Implements : sbc_frame_ctr_dlc_t_Class

Definition at line 695 of file sbc_uja116x_driver.h.

16.106.4.4 typedef uint8_t sbc_identif_mask_t

ID mask registers (0x2B to 0x2E). The identifier mask is defined in the ID mask registers, where a 1 means dont care.

Implements : sbc_identif_mask_t_Class

Definition at line 661 of file sbc_uja116x_driver.h.

16.106.4.5 typedef uint8_t sbc_identifier_t

ID registers, identifier format (0x27 to 0x2A). A valid WUF identifier is defined and stored in the ID registers. An ID mask can be defined to allow a group of identifiers to be recognized as valid by an individual node.

Implements : sbc_identifier_t_Class

Definition at line 652 of file sbc_uja116x_driver.h.

16.106.4.6 typedef uint8_t sbc_mtpnv_stat_wrcnts_t

MTPNV status register, write counter status (0x70). 6-bits - contains the number of times the MTPNV cells were reprogrammed.

Implements : sbc_mtpnv_stat_wrcnts_t_Class

Definition at line 967 of file sbc_uja116x_driver.h.

16.106.5 Enumeration Type Documentation

16.106.5.1 enum sbc_can_cfdc_t

CAN control register, CAN FD control (0x20).

Implements : sbc_can_cfdc_t_Class

Enumerator

SBC_UJA_CAN_CFDC_DIS CAN FD tolerance disabled.

SBC_UJA_CAN_CFDC_EN CAN FD tolerance enabled.

Definition at line 460 of file sbc_uja116x_driver.h.

16.106.5.2 enum sbc_can_cmc_t

CAN control register, CAN mode control (0x20).

Implements : sbc_can_cmc_t_Class

Enumerator

SBC_UJA_CAN_CMC_OFMODE Offline mode.

SBC_UJA_CAN_CMC_ACMODE_DA Active mode (when the SBC is in Normal mode); CAN supply undervoltage detection active.

SBC_UJA_CAN_CMC_ACMODE_DD Active mode (when the SBC is in Normal mode); CAN supply undervoltage detection disabled.

SBC_UJA_CAN_CMC_LISTEN Listen-only mode.

Definition at line 496 of file sbc_uja116x_driver.h.

16.106.5.3 enum sbc_can_cpnc_t

CAN control register, CAN partial networking control (0x20).

Implements : sbc_can_cpnc_t_Class

Enumerator

SBC_UJA_CAN_CPNC_DIS Disable CAN selective wake-up.

SBC_UJA_CAN_CPNC_EN Enable CAN selective wake-up.

Definition at line 484 of file sbc_uja116x_driver.h.

16.106.5.4 enum sbc_can_pncok_t

CAN control register, CAN partial networking configuration OK (0x20).

Implements : sbc_can_pncok_t_Class

Enumerator

SBC_UJA_CAN_PNCOK_DIS Partial networking register configuration invalid (wake-up via standard wake-up pattern only).

SBC_UJA_CAN_PNCOK_EN Partial networking registers configured successfully.

Definition at line 472 of file sbc_uja116x_driver.h.

16.106.5.5 enum sbc_dat_rate_t

Data rate register, CAN data rate selection (0x26). CAN partial networking configuration registers. Dedicated registers are provided for configuring CAN partial networking.

Implements : sbc_dat_rate_t_Class

Enumerator

SBC_UJA_DAT_RATE_CDR_50KB 50 kbit/s.

SBC_UJA_DAT_RATE_CDR_100KB 100 kbit/s.

SBC_UJA_DAT_RATE_CDR_125KB 125 kbit/s.

SBC_UJA_DAT_RATE_CDR_250KB 250 kbit/s.

SBC_UJA_DAT_RATE_CDR_500KB 500 kbit/s.

SBC_UJA_DAT_RATE_CDR_1000KB 1000 kbit/s.

Definition at line 635 of file sbc_uja116x_driver.h.

16.106.5.6 enum sbc_fail_safe_lhc_t

Fail-safe control register, LIMP home control (0x02). The dedicated LIMP pin can be used to enable so called limp home hardware in the event of a serious ECU failure. Detectable failure conditions include SBC overtemperature events, loss of watchdog service, short-circuits on pins RSTN or V1 and user-initiated or external reset events. The LIMP pin is a battery-robust, active-LOW, open-drain output. The LIMP pin can also be forced LOW by setting bit LHC in the Fail-safe control register.

Implements : sbc_fail_safe_lhc_t_Class

Enumerator

SBC_UJA_FAIL_SAFE_LHC_FLOAT LIMP pin is floating.

SBC_UJA_FAIL_SAFE_LHC_LOW LIMP pin is driven LOW.

Definition at line 183 of file sbc_uja116x_driver.h.

16.106.5.7 enum sbc_frame_ctr_ide_t

Frame control register, identifier format (0x2F). The wake-up frame format, standard (11-bit) or extended (29-bit) identifier, is selected via bit IDE in the Frame control register.

Implements : sbc_frame_ctr_ide_t_Class

Enumerator

SBC_UJA_FRAME_CTR_IDE_11B Standard frame format (11-bit).

SBC_UJA_FRAME_CTR_IDE_29B Extended frame format (29-bit).

Definition at line 670 of file sbc_uja116x_driver.h.

16.106.5.8 enum sbc_frame_ctr_pndm_t

Frame control register, partial networking data mask (0x2F).

Implements : sbc_frame_ctr_pndm_t_Class

Enumerator

SBC_UJA_FRAME_CTR_PNDM_DCARE Data length code and data field are do not care for wake-up.

SBC_UJA_FRAME_CTR_PNDM_EVAL Data length code and data field are evaluated at wake-up.

Definition at line 682 of file sbc_uja116x_driver.h.

16.106.5.9 enum sbc_gl_evnt_stat_supe_t

Global event status register, supply event (0x60).

Implements : sbc_gl_evnt_stat_supe_t_Class

Enumerator

SBC_UJA_GL_EVNT_STAT_SUPE_NO No pending supply event.

SBC_UJA_GL_EVNT_STAT_SUPE Supply event pending at address 0x62 .

Definition at line 773 of file sbc_uja116x_driver.h.

16.106.5.10 enum sbc_gl_evnt_stat_syse_t

Global event status register, system event (0x60).

Implements : sbc_gl_evnt_stat_syse_t_Class

Enumerator

SBC_UJA_GL_EVNT_STAT_SYSE_NO No pending system event.

SBC_UJA_GL_EVNT_STAT_SYSE System event pending at address 0x61.

Definition at line 785 of file sbc_uja116x_driver.h.

16.106.5.11 enum sbc_gl_evnt_stat_trxe_t

Global event status register, transceiver event (0x60).

Implements : sbc_gl_evnt_stat_trxe_t_Class

Enumerator

SBC_UJA_GL_EVNT_STAT_TRXE_NO No pending transceiver event.

SBC_UJA_GL_EVNT_STAT_TRXE Transceiver event pending at address 0x63.

Definition at line 761 of file sbc_uja116x_driver.h.

16.106.5.12 enum sbc_gl_evnt_stat_wpe_t

Global event status register, WAKE pin event (0x60).

Implements : sbc_gl_evnt_stat_wpe_t_Class

Enumerator

SBC_UJA_GL_EVNT_STAT_WPE_NO No pending WAKE pin event.

SBC_UJA_GL_EVNT_STAT_WPE WAKE pin event pending at address 0x64.

Definition at line 749 of file sbc_uja116x_driver.h.

16.106.5.13 enum sbc_lock_t

Lock control(0x0A). Sections of the register address area can be write-protected to protect against unintended modifications. This facility only protects locked bits from being modified via the SPI and will not prevent the UJ↩ A116xA updating status registers etc.

Implements : sbc_lock_t_Class

Enumerator

LK0C Lock control 0: address area 0x06 to 0x09 - general-purpose memory macros. Lock control 1: address area 0x10 to 0x1F - regulator control macros.

LK1C Lock control 2: address area 0x20 to 0x2F - transceiver control macros.

LK2C Lock control 3: address area 0x30 to 0x3F - unused register range macros.

LK3C Lock control 4: address area 0x40 to 0x4F - WAKE pin control macros.

LK4C Lock control 5: address area 0x50 to 0x5F.

LK5C Lock control 6: address area 0x68 to 0x6F macros.

LK6C Lock control All: address area 0x10 to 0x6F macros.

LKAC

Definition at line 317 of file sbc_uja116x_driver.h.

16.106.5.14 enum sbc_main_nms_t

Main status register, normal mode status (0x03).

Implements : sbc_main_nms_t_Class

Enumerator

SBC_UJA_MAIN_NMS_NORMAL UJA116xA has entered Normal mode (after power-up)

SBC_UJA_MAIN_NMS_PWR_UP UJA116xA has powered up but has not yet switched to Normal mode.

Definition at line 214 of file sbc_uja116x_driver.h.

16.106.5.15 enum sbc_main_otws_t

Main status register, Overtemperature warning status (0x03).

Implements : sbc_main_otws_t_Class

Enumerator

SBC_UJA_MAIN_OTWS_BELOW IC temperature below overtemperature warning threshold.

SBC_UJA_MAIN_OTWS_ABOVE IC temperature above overtemperature warning threshold.

Definition at line 202 of file sbc_uja116x_driver.h.

16.106.5.16 enum sbc_main_rss_t

Main status register, Reset source status (0x03).

Implements : sbc_main_rss_t_Class

Enumerator

SBC_UJA_MAIN_RSS_OFF_MODE Left Off mode (power-on).
SBC_UJA_MAIN_RSS_CAN_WAKEUP CAN wake-up in Sleep mode.
SBC_UJA_MAIN_RSS_SLP_WAKEUP Wake-up via WAKE pin in Sleep mode.
SBC_UJA_MAIN_RSS_OVF_SLP Watchdog overflow in Sleep mode (Timeout mode).
SBC_UJA_MAIN_RSS_DIAG_WAKEUP Diagnostic wake-up in Sleep mode
SBC_UJA_MAIN_RSS_WATCH_TRIG Watchdog triggered too early (Window mode).
SBC_UJA_MAIN_RSS_WATCH_OVF Watchdog overflow (Window mode or Timeout mode with WDF = 1)
SBC_UJA_MAIN_RSS_ILLEG_WATCH Illegal watchdog mode control access.
SBC_UJA_MAIN_RSS_RSTN_PULDW RSTN pulled down externally.
SBC_UJA_MAIN_RSS_LFT_OVERTM Left Overtemp mode.
SBC_UJA_MAIN_RSS_V1_UNDERV V1 undervoltage.
SBC_UJA_MAIN_RSS_ILLEG_SLP Illegal Sleep mode command received.
SBC_UJA_MAIN_RSS_WAKE_SLP Wake-up from Sleep mode due to a frame detect error

Definition at line 226 of file sbc_uja116x_driver.h.

16.106.5.17 enum sbc_mode_mc_t

Mode control register, mode control (0x01)

Implements : sbc_mode_mc_t_Class

Enumerator

SBC_UJA_MODE_MC_SLEEP Sleep mode.
SBC_UJA_MODE_MC_STANDBY Standby mode.
SBC_UJA_MODE_MC_NORMAL Normal mode.

Definition at line 165 of file sbc_uja116x_driver.h.

16.106.5.18 enum sbc_mtpnv_stat_eccs_t

MTPNV status register, error correction code status (0x70).

Implements : sbc_mtpnv_stat_eccs_t_Class

Enumerator

SBC_UJA_MTPNV_STAT_ECCS_NO No bit failure detected in non-volatile memory.
SBC_UJA_MTPNV_STAT_ECCS Bit failure detected and corrected in non-volatile memory.

Definition at line 974 of file sbc_uja116x_driver.h.

16.106.5.19 enum sbc_mtpnv_stat_nvmps_t

MTPNV status register, non-volatile memory programming status (0x70).

Implements : sbc_mtpnv_stat_nvmps_t_Class

Enumerator

SBC_UJA_MTPNV_STAT_NVMPS_NO MTPNV memory cannot be overwritten.
SBC_UJA_MTPNV_STAT_NVMPS MTPNV memory is ready to be reprogrammed.

Definition at line 986 of file sbc_uja116x_driver.h.

16.106.5.20 enum sbc_register_t

Register map.

Implements : sbc_register_t_Class

Enumerator

SBC_UJA_WTDOG_CTR
SBC_UJA_MODE
SBC_UJA_FAIL_SAFE
SBC_UJA_MAIN
SBC_UJA_SYSTEM_EVNT
SBC_UJA_WTDOG_STAT
SBC_UJA_MEMORY_0
SBC_UJA_MEMORY_1
SBC_UJA_MEMORY_2
SBC_UJA_MEMORY_3
SBC_UJA_LOCK
SBC_UJA_REGULATOR
SBC_UJA_SUPPLY_STAT
SBC_UJA_SUPPLY_EVNT
SBC_UJA_CAN
SBC_UJA_TRANS_STAT
SBC_UJA_TRANS_EVNT
SBC_UJA_DAT_RATE
SBC_UJA_IDENTIF_0
SBC_UJA_IDENTIF_1
SBC_UJA_IDENTIF_2
SBC_UJA_IDENTIF_3
SBC_UJA_MASK_0
SBC_UJA_MASK_1
SBC_UJA_MASK_2
SBC_UJA_MASK_3
SBC_UJA_FRAME_CTR
SBC_UJA_DAT_MASK_0
SBC_UJA_DAT_MASK_1
SBC_UJA_DAT_MASK_2
SBC_UJA_DAT_MASK_3
SBC_UJA_DAT_MASK_4
SBC_UJA_DAT_MASK_5
SBC_UJA_DAT_MASK_6
SBC_UJA_DAT_MASK_7
SBC_UJA_WAKE_STAT
SBC_UJA_WAKE_EN
SBC_UJA_GL_EVNT_STAT
SBC_UJA_SYS_EVNT_STAT
SBC_UJA_SUP_EVNT_STAT

SBC_UJA_TRANS_EVNT_STAT

SBC_UJA_WAKE_EVNT_STAT

SBC_UJA_MTPNV_STAT

SBC_UJA_START_UP

SBC_UJA_SBC

SBC_UJA_MTPNV_CRC

SBC_UJA_IDENTIF

Definition at line 51 of file sbc_uja116x_driver.h.

16.106.5.21 enum sbc_regulator_pdc_t

Regulator control register, power distribution control (0x10). PDC is not available on UJA1168 device variants, use any of these two values, the value written to the device will be ignored.

Implements : sbc_regulator_pdc_t_Class

Enumerator

SBC_UJA_REGULATOR_PDC_HV V1 threshold current for activating the external PNP transistor, load current rising; Ith(act)PNP (higher value) V1 threshold current for deactivating the external PNP transistor, load current falling; Ith(deact)PNP (higher value).

SBC_UJA_REGULATOR_PDC_LV V1 threshold current for activating the external PNP transistor; load current rising; Ith(act)PNP (lower value) V1 threshold current for deactivating the external PNP transistor; load current falling; Ith(deact)PNP (lower value).

Definition at line 344 of file sbc_uja116x_driver.h.

16.106.5.22 enum sbc_regulator_v1rtc_t

Regulator control register, set V1 reset threshold (0x10).

Implements : sbc_regulator_v1rtc_t_Class

Enumerator

SBC_UJA_REGULATOR_V1RTC_90 Reset threshold set to 90 % of V1 nominal output voltage.

SBC_UJA_REGULATOR_V1RTC_80 Reset threshold set to 80 % of V1 nominal output voltage.

SBC_UJA_REGULATOR_V1RTC_70 Reset threshold set to 70 % of V1 nominal output voltage.

SBC_UJA_REGULATOR_V1RTC_60 Reset threshold set to 60 % of V1 nominal output voltage.

Definition at line 378 of file sbc_uja116x_driver.h.

16.106.5.23 enum sbc_regulator_v2c_t

Regulator control register, V2/VEXT configuration (0x10).

Implements : sbc_regulator_v2c_t_Class

Enumerator

SBC_UJA_REGULATOR_V2C_OFF V2/VEXT off in all modes.

SBC_UJA_REGULATOR_V2C_N V2/VEXT on in Normal mode.

SBC_UJA_REGULATOR_V2C_N_S_R V2/VEXT on in Normal, Standby and Reset modes.

SBC_UJA_REGULATOR_V2C_N_S_S_R V2/VEXT on in Normal, Standby, Sleep and Reset modes.

Definition at line 362 of file sbc_uja116x_driver.h.

16.106.5.24 enum sbc_sbc_fnmc_t

SBC configuration control register, Forced Normal mode control (0x74).

Implements : sbc_sbc_fnmc_t_Class

Enumerator

SBC_UJA_SBC_FNMC_DIS Forced Normal mode disabled.

SBC_UJA_SBC_FNMC_EN Forced Normal mode enabled.

Definition at line 1043 of file sbc_uja116x_driver.h.

16.106.5.25 enum sbc_sbc_sdmc_t

SBC configuration control register, Software Development mode control (0x74).

Implements : sbc_sbc_sdmc_t_Class

Enumerator

SBC_UJA_SBC_SDMC_DIS Software Development mode disabled.

SBC_UJA_SBC_SDMC_EN Software Development mode enabled.

Definition at line 1056 of file sbc_uja116x_driver.h.

16.106.5.26 enum sbc_sbc_slpc_t

SBC configuration control register, Sleep control (0x74).

Implements : sbc_sbc_slpc_t_Class

Enumerator

SBC_UJA_SBC_SLPC_AC Sleep mode commands accepted. Factory preset value.

SBC_UJA_SBC_SLPC_IG Sleep mode commands ignored.

Definition at line 1069 of file sbc_uja116x_driver.h.

16.106.5.27 enum sbc_sbc_v1rtsuc_t

SBC configuration control register, V1 undervoltage threshold (defined by bit V1RTC) at start-up (0x74).

Implements : sbc_sbc_v1rtsuc_t_Class

Enumerator

SBC_UJA_SBC_V1RTSUC_90 V1 undervoltage detection at 90 % of nominal value at start-up (V1RTC = 00).

SBC_UJA_SBC_V1RTSUC_80 V1 undervoltage detection at 80 % of nominal value at start-up (V1RTC = 01).

SBC_UJA_SBC_V1RTSUC_70 V1 undervoltage detection at 70 % of nominal value at start-up V1RTC = 10).

SBC_UJA_SBC_V1RTSUC_60 V1 undervoltage detection at 60 % of nominal value at start-up (V1RTC = 11).

Definition at line 1027 of file sbc_uja116x_driver.h.

16.106.5.28 enum sbc_start_up_rlc_t

Start-up control register, RSTN output reset pulse width macros (0x73).

Implements : sbc_start_up_rlc_t_Class

Enumerator

SBC_UJA_START_UP_RLC_20_25p0 Tw(rst) = 20 ms to 25 ms.

SBC_UJA_START_UP_RLC_10_12p5 Tw(rst) = 10 ms to 12.5 ms.

SBC_UJA_START_UP_RLC_03p6_05 Tw(rst) = 3.6 ms to 5 ms.

SBC_UJA_START_UP_RLC_01_01p5 Tw(rst) = 1 ms to 1.5 ms.

Definition at line 998 of file sbc_uja116x_driver.h.

16.106.5.29 enum sbc_start_up_v2suc_t

Start-up control register, V2/VEXT start-up control (0x73).

Implements : sbc_start_up_v2suc_t_Class

Enumerator

SBC_UJA_START_UP_V2SUC_00 bits V2C/VEXTC set to 00 at power-up.

SBC_UJA_START_UP_V2SUC_11 bits V2C/VEXTC set to 11 at power-up.

Definition at line 1014 of file sbc_uja116x_driver.h.

16.106.5.30 enum sbc_sup_evnt_stat_v1u_t

Supply event status register, V1 undervoltage (0x62).

Implements : sbc_sup_evnt_stat_v1u_t_Class

Enumerator

SBC_UJA_SUP_EVNT_STAT_V1U_NO no V1 undervoltage event captured.

SBC_UJA_SUP_EVNT_STAT_V1U voltage on V1 has dropped below the 90 % undervoltage threshold while V1 is active (event is not captured in Sleep mode because V1 is off); V1U event capture is independent of the setting of bits V1RTC.

Definition at line 876 of file sbc_uja116x_driver.h.

16.106.5.31 enum sbc_sup_evnt_stat_v2o_t

Supply event status register, V2/VEXT overvoltage (0x62).

Implements : sbc_sup_evnt_stat_v2o_t_Class

Enumerator

SBC_UJA_SUP_EVNT_STAT_V2O_NO No V2/VEXT overvoltage event captured.

SBC_UJA_SUP_EVNT_STAT_V2O V2/VEXT overvoltage event captured.

Definition at line 852 of file sbc_uja116x_driver.h.

16.106.5.32 enum sbc_sup_evnt_stat_v2u_t

Supply event status register, V2/VEXT undervoltage (0x62).

Implements : sbc_sup_evnt_stat_v2u_t_Class

Enumerator

SBC_UJA_SUP_EVNT_STAT_V2U_NO No V2/VEXT undervoltage event captured.

SBC_UJA_SUP_EVNT_STAT_V2U V2/VEXT undervoltage event captured.

Definition at line 864 of file sbc_uja116x_driver.h.

16.106.5.33 enum sbc_supply_evnt_v1ue_t

Supply event capture enable register, V1 undervoltage enable (0x1C).

Implements : sbc_supply_evnt_v1ue_t_Class

Enumerator

SBC_UJA_SUPPLY_EVNT_V1UE_DIS V1 undervoltage detection disabled.
SBC_UJA_SUPPLY_EVNT_V1UE_EN V1 undervoltage detection enabled.

Definition at line 448 of file sbc_uja116x_driver.h.

16.106.5.34 enum sbc_supply_evnt_v2oe_t

Supply event capture enable register, V2/VEXT overvoltage enable (0x1C).

Implements : sbc_supply_evnt_v2oe_t_Class

Enumerator

SBC_UJA_SUPPLY_EVNT_V2OE_DIS V2/VEXT overvoltage detection disabled.
SBC_UJA_SUPPLY_EVNT_V2OE_EN V2/VEXT overvoltage detection enabled.

Definition at line 423 of file sbc_uja116x_driver.h.

16.106.5.35 enum sbc_supply_evnt_v2ue_t

Supply event capture enable register, V2/VEXT undervoltage enable (0x1C).

Implements : sbc_supply_evnt_v2ue_t_Class

Enumerator

SBC_UJA_SUPPLY_EVNT_V2UE_DIS V2/VEXT undervoltage detection disabled.
SBC_UJA_SUPPLY_EVNT_V2UE_EN V2/VEXT undervoltage detection enabled.

Definition at line 436 of file sbc_uja116x_driver.h.

16.106.5.36 enum sbc_supply_stat_v1s_t

Supply voltage status register, V1 status (0x1B).

Implements : sbc_supply_stat_v1s_t_Class

Enumerator

SBC_UJA_SUPPLY_STAT_V1S_VAB V1 output voltage above 90 % undervoltage threshold.
SBC_UJA_SUPPLY_STAT_V1S_VBE V1 output voltage below 90 % undervoltage threshold.

Definition at line 410 of file sbc_uja116x_driver.h.

16.106.5.37 enum sbc_supply_stat_v2s_t

Supply voltage status register, V2/VEXT status (0x1B).

Implements : sbc_supply_stat_v2s_t_Class

Enumerator

SBC_UJA_SUPPLY_STAT_V2S_VOK V2/VEXT voltage ok.
SBC_UJA_SUPPLY_STAT_V2S_VBE V2/VEXT output voltage below undervoltage threshold
SBC_UJA_SUPPLY_STAT_V2S_VAB V2/VEXT output voltage above overvoltage threshold
SBC_UJA_SUPPLY_STAT_V2S_DIS V2/VEXT disabled

Definition at line 394 of file sbc_uja116x_driver.h.

16.106.5.38 enum sbc_sys_evnt_otwe_t

System event capture enable, overtemperature warning enable (0x04).

Implements : sbc_sys_evnt_otwe_t_Class

Enumerator

SBC_UJA_SYS_EVNT_OTWE_DIS Overtemperature warning disabled.

SBC_UJA_SYS_EVNT_OTWE_EN Overtemperature warning enabled.

Definition at line 251 of file sbc_uja116x_driver.h.

16.106.5.39 enum sbc_sys_evnt_spife_t

System event capture enable, SPI failure enable (0x04).

Implements : sbc_sys_evnt_spife_t_Class

Enumerator

SBC_UJA_SYS_EVNT_SPIFE_DIS SPI failure detection disabled.

SBC_UJA_SYS_EVNT_SPIFE_EN SPI failure detection enabled.

Definition at line 263 of file sbc_uja116x_driver.h.

16.106.5.40 enum sbc_sys_evnt_stat_otw_t

System event status register, overtemperature warning (0x61).

Implements : sbc_sys_evnt_stat_otw_t_Class

Enumerator

SBC_UJA_SYS_EVNT_STAT_OTW_NO Overtemperature not detected.

SBC_UJA_SYS_EVNT_STAT_OTW The global chip temperature has exceeded the overtemperature warning threshold, Tth(warn)otp (not in Sleep mode).

Definition at line 809 of file sbc_uja116x_driver.h.

16.106.5.41 enum sbc_sys_evnt_stat_po_t

System event status register, power-on (0x61).

Implements : sbc_sys_evnt_stat_po_t_Class

Enumerator

SBC_UJA_SYS_EVNT_STAT_PO_NO No recent battery power-on.

SBC_UJA_SYS_EVNT_STAT_PO The UJA116xA has left Off mode after battery power-on.

Definition at line 797 of file sbc_uja116x_driver.h.

16.106.5.42 enum sbc_sys_evnt_stat_spif_t

System event status register, SPI failure (0x61).

Implements : sbc_sys_evnt_stat_spif_t_Class

Enumerator

SBC_UJA_SYS_EVNT_STAT_SPIF_NO No SPI failure detected

SBC_UJA_SYS_EVNT_STAT_SPIF SPI clock count error (only 16-, 24- and 32-bit commands are valid), illegal WMC, NWP or MC code or attempted write access to locked register (not in Sleep mode)

Definition at line 822 of file sbc_uja116x_driver.h.

16.106.5.43 enum sbc_sys_evnt_stat_wdf_t

System event status register, watchdog failure (0x61).

Implements : sbc_sys_evnt_stat_wdf_t_Class

Enumerator

SBC_UJA_SYS_EVNT_STAT_WDF_NO No watchdog failure event captured

SBC_UJA_SYS_EVNT_STAT_WDF Watchdog overflow in Window or Timeout mode or watchdog triggered too early in Window mode; a system reset is triggered immediately in response to a watchdog failure in Window mode; when the watchdog overflows in Timeout mode, a system reset is only performed if a WDF is already pending (WDF = 1).

Definition at line 836 of file sbc_uja116x_driver.h.

16.106.5.44 enum sbc_trans_evnt_cbse_t

Transceiver event capture enable register, CAN-bus silence enable (0x23).

Implements : sbc_trans_evnt_cbse_t_Class

Enumerator

SBC_UJA_TRANS_EVNT_CBSE_DIS CAN-bus silence detection disabled.

SBC_UJA_TRANS_EVNT_CBSE_EN CAN-bus silence detection enabled.

Definition at line 597 of file sbc_uja116x_driver.h.

16.106.5.45 enum sbc_trans_evnt_cfe_t

Transceiver event capture enable register, CAN failure enable (0x23).

Implements : sbc_trans_evnt_cfe_t_Class

Enumerator

SBC_UJA_TRANS_EVNT_CFE_DIS CAN failure detection disabled.

SBC_UJA_TRANS_EVNT_CFE_EN CAN failure detection enabled.

Definition at line 609 of file sbc_uja116x_driver.h.

16.106.5.46 enum sbc_trans_evnt_cwe_t

Transceiver event capture enable register, CAN wake-up enable (0x23).

Implements : sbc_trans_evnt_cwe_t_Class

Enumerator

SBC_UJA_TRANS_EVNT_CWE_DIS CAN wake-up detection disabled.

SBC_UJA_TRANS_EVNT_CWE_EN CAN wake-up detection enabled.

Definition at line 621 of file sbc_uja116x_driver.h.

16.106.5.47 enum sbc_trans_evnt_stat_cbs_t

Transceiver event status register, CAN-bus status (0x63).

Implements : sbc_trans_evnt_stat_cbs_t_Class

Enumerator

SBC_UJA_TRANS_EVNT_STAT_CBS_NO CAN-bus active.

SBC_UJA_TRANS_EVNT_STAT_CBS No activity on CAN-bus for tto(silence) (detected only when CBSE = 1 while bus active).

Definition at line 903 of file sbc_uja116x_driver.h.

16.106.5.48 enum sbc_trans_evnt_stat_cf_t

Transceiver event status register, CAN failure (0x63).

Implements : sbc_trans_evnt_stat_cf_t_Class

Enumerator

SBC_UJA_TRANS_EVNT_STAT_CF_NO No CAN failure detected.

SBC_UJA_TRANS_EVNT_STAT_CF CAN transceiver deactivated due to VCAN undervoltage OR dominant clamped TXD (not in Sleep mode)

Definition at line 916 of file sbc_uja116x_driver.h.

16.106.5.49 enum sbc_trans_evnt_stat_cw_t

Transceiver event status register, CAN wake-up (0x63).

Implements : sbc_trans_evnt_stat_cw_t_Class

Enumerator

SBC_UJA_TRANS_EVNT_STAT_CW_NO No CAN wake-up event detected.

SBC_UJA_TRANS_EVNT_STAT_CW CAN wake-up event detected while the transceiver is in CAN Offline Mode.

Definition at line 929 of file sbc_uja116x_driver.h.

16.106.5.50 enum sbc_trans_evnt_stat_pnfde_t

Transceiver event status register,partial networking frame detection error (0x63).

Implements : sbc_trans_evnt_stat_pnfde_t_Class

Enumerator

SBC_UJA_TRANS_EVNT_STAT_PNFDE_NO No partial networking frame detection error detected.

SBC_UJA_TRANS_EVNT_STAT_PNFDE Partial networking frame detection error detected.

Definition at line 891 of file sbc_uja116x_driver.h.

16.106.5.51 enum sbc_trans_stat_cbss_t

Transceiver status register, CAN-bus silence status (0x22).

Implements : sbc_trans_stat_cbss_t_Class

Enumerator

SBC_UJA_TRANS_STAT_CBSS_ACT CAN-bus active (communication detected on bus)

SBC_UJA_TRANS_STAT_CBSS_INACT CAN-bus inactive (for longer than t_to(silence)).

Definition at line 561 of file sbc_uja116x_driver.h.

16.106.5.52 enum sbc_trans_stat_cfs_t

Transceiver status register, CAN failure status (0x22).

Implements : sbc_trans_stat_cfs_t_Class

Enumerator

SBC_UJA_TRANS_STAT_CFS_NO_TXD No TXD dominant time-out event detected.

SBC_UJA_TRANS_STAT_CFS_TXD CAN transmitter disabled due to a TXD dominant time-out event.

Definition at line 585 of file sbc_uja116x_driver.h.

16.106.5.53 enum sbc_trans_stat_coscs_t

Transceiver status register, CAN oscillator status (0x22).

Implements : sbc_trans_stat_coscs_t_Class

Enumerator

SBC_UJA_TRANS_STAT_COSCS_NRUN CAN partial networking oscillator not running at target frequency.

SBC_UJA_TRANS_STAT_COSCS_RUN CAN partial networking oscillator running at target.

Definition at line 549 of file sbc_uja116x_driver.h.

16.106.5.54 enum sbc_trans_stat_cpnerr_t

Transceiver status register, CAN partial networking error (0x22).

Implements : sbc_trans_stat_cpnerr_t_Class

Enumerator

SBC_UJA_TRANS_STAT_CPNERR_NO_DET no CAN partial networking error detected (PNFDE = 0 AND PNCOK = 1).

SBC_UJA_TRANS_STAT_CPNERR_DET CAN partial networking error detected (PNFDE = 1OR PNCOK = 0; wake-up via standard wake-up pattern only).

Definition at line 524 of file sbc_uja116x_driver.h.

16.106.5.55 enum sbc_trans_stat_cpns_t

Transceiver status register, CAN partial networking status (0x22).

Implements : sbc_trans_stat_cpns_t_Class

Enumerator

SBC_UJA_TRANS_STAT_CPNS_ERR CAN partial networking configuration error detected(PNCOK = 0).

SBC_UJA_TRANS_STAT_CPNS_OK CAN partial networking configuration ok (PNCOK = 1).

Definition at line 537 of file sbc_uja116x_driver.h.

16.106.5.56 enum sbc_trans_stat_cts_t

Transceiver status register, CAN transceiver status (0x22).

Implements : sbc_trans_stat_cts_t_Class

Enumerator

SBC_UJA_TRANS_STAT_CTS_INACT CAN transceiver not in Active mode.

SBC_UJA_TRANS_STAT_CTS_ACT CAN transceiver in Active mode.

Definition at line 512 of file sbc_uja116x_driver.h.

16.106.5.57 enum sbc_trans_stat_vcs_t

Transceiver status register, VCAN status (0x22).

Implements : sbc_trans_stat_vcs_t_Class

Enumerator

SBC_UJA_TRANS_STAT_VCS_AB CAN supply voltage is above the 90 % threshold.

SBC_UJA_TRANS_STAT_VCS_BE CAN supply voltage is below the 90 % threshold

Definition at line 573 of file sbc_uja116x_driver.h.

16.106.5.58 enum sbc_wake_en_wpfe_t

WAKE pin event capture enable register, WAKE pin falling-edge enable (0x4C).

Implements : sbc_wake_en_wpfe_t_Class

Enumerator

SBC_UJA_WAKE_EN_WPFE_DIS Falling-edge detection on WAKE pin disabled.

SBC_UJA_WAKE_EN_WPFE_EN Falling-edge detection on WAKE pin enabled.

Definition at line 737 of file sbc_uja116x_driver.h.

16.106.5.59 enum sbc_wake_en_wpre_t

WAKE pin event capture enable register, WAKE pin rising-edge enable (0x4C).

Implements : sbc_wake_en_wpre_t_Class

Enumerator

SBC_UJA_WAKE_EN_WPRE_DIS Rising-edge detection on WAKE pin disabled.

SBC_UJA_WAKE_EN_WPRE_EN Rising-edge detection on WAKE pin enabled.

Definition at line 725 of file sbc_uja116x_driver.h.

16.106.5.60 enum sbc_wake_evnt_stat_wpf_t

WAKE pin event status register, WAKE pin falling edge (0x64).

Implements : sbc_wake_evnt_stat_wpf_t_Class

Enumerator

SBC_UJA_WAKE_EVNT_STAT_WPF_NO No falling edge detected on WAKE pin.

SBC_UJA_WAKE_EVNT_STAT_WPF Falling edge detected on WAKE pin.

Definition at line 953 of file sbc_uja116x_driver.h.

16.106.5.61 enum sbc_wake_evnt_stat_wpr_t

WAKE pin event status register, WAKE pin rising edge (0x64).

Implements : sbc_wake_evnt_stat_wpr_t_Class

Enumerator

SBC_UJA_WAKE_EVNT_STAT_WPR_NO No rising edge detected on WAKE pin.

SBC_UJA_WAKE_EVNT_STAT_WPR Rising edge detected on WAKE pin.

Definition at line 941 of file sbc_uja116x_driver.h.

16.106.5.62 enum sbc_wake_stat_wpvs_t

WAKE pin status register, WAKE pin status (0x4B).

Implements : sbc_wake_stat_wpvs_t_Class

Enumerator

SBC_UJA_WAKE_STAT_WPVS_BE Voltage on WAKE pin below switching threshold (Vth(sw)).

SBC_UJA_WAKE_STAT_WPVS_AB voltage on WAKE pin above switching threshold (Vth(sw)).

Definition at line 713 of file sbc_uja116x_driver.h.

16.106.5.63 enum sbc_wtdog_ctr_nwp_t

Watchdog control register, nominal watchdog period (0x00). Eight watchdog periods are supported, from 8 ms to 4096 ms. The watchdog period is programmed via bits NWP. The selected period is valid for both Window and Timeout modes. The default watchdog period is 128 ms. A watchdog trigger event resets the watchdog timer. A watchdog trigger event is any valid write access to the Watchdog control register. If the watchdog mode or the watchdog period have changed as a result of the write access, the new values are immediately valid.

Implements : sbc_wtdog_ctr_nwp_t_Class

Enumerator

SBC_UJA_WTDOG_CTR_NWP_8 8 ms.

SBC_UJA_WTDOG_CTR_NWP_16 16 ms.

SBC_UJA_WTDOG_CTR_NWP_32 32 ms.

SBC_UJA_WTDOG_CTR_NWP_64 64 ms.

SBC_UJA_WTDOG_CTR_NWP_128 128 ms.

SBC_UJA_WTDOG_CTR_NWP_256 256 ms.

SBC_UJA_WTDOG_CTR_NWP_1024 1024 ms.

SBC_UJA_WTDOG_CTR_NWP_4096 4096 ms.

Definition at line 149 of file sbc_uja116x_driver.h.

16.106.5.64 enum sbc_wtdog_ctr_wmc_t

Watchdog control register, watchdog mode control (0x00). The UJA116xA contains a watchdog that supports three operating modes: Window, Timeout and Autonomous. In Window mode (available only in SBC Normal mode), a watchdog trigger event within a defined watchdog window triggers and resets the watchdog timer. In Timeout mode, the watchdog runs continuously and can be triggered and reset at any time within the watchdog period by a watchdog trigger. Watchdog time-out mode can also be used for cyclic wake-up of the microcontroller. In Autonomous mode, the watchdog can be off or autonomously in Timeout mode, depending on the selected SBC mode. The watchdog mode is selected via bits WMC in the Watchdog control register. The SBC must be in Standby mode when the watchdog mode is changed.

Implements : sbc_wtdog_ctr_wmc_t_Class

Enumerator

SBC_UJA_WTDOG_CTR_WMC_AUTO Autonomous mode.

SBC_UJA_WTDOG_CTR_WMC_TIME Timeout mode.

SBC_UJA_WTDOG_CTR_WMC_WIND Window mode (available only in SBC Normal mode).

Definition at line 128 of file sbc_uja116x_driver.h.

16.106.5.65 enum sbc_wtdog_stat_fnms_t

Watchdog status register, forced Normal mode status (0x05).

Implements : sbc_wtdog_stat_fnms_t_Class

Enumerator

SBC_UJA_WTDOG_STAT_FNMS_N_NORMAL SBC is not in Forced Normal mode.

SBC_UJA_WTDOG_STAT_FNMS_NORMAL SBC is in Forced Normal mode.

Definition at line 275 of file sbc_uja116x_driver.h.

16.106.5.66 enum sbc_wtdog_stat_sdms_t

Watchdog status register, Software Development mode status (0x05).

Implements : sbc_wtdog_stat_sdms_t_Class

Enumerator

SBC_UJA_WTDOG_STAT_SDMS_N_NORMAL SBC is not in Software Development mode.

SBC_UJA_WTDOG_STAT_SDMS_NORMAL SBC is in Software Development mode.

Definition at line 287 of file sbc_uja116x_driver.h.

16.106.5.67 enum sbc_wtdog_stat_wds_t

Watchdog status register, watchdog status (0x05).

Implements : sbc_wtdog_stat_wds_t_Class

Enumerator

SBC_UJA_WTDOG_STAT_WDS_OFF Watchdog is off.

SBC_UJA_WTDOG_STAT_WDS_FIH Watchdog is in first half of the nominal period.

SBC_UJA_WTDOG_STAT_WDS_SEH Watchdog is in second half of the nominal period.

Definition at line 299 of file sbc_uja116x_driver.h.

16.107 Universal Asynchronous Receiver/Transmitter - Peripheral Abstraction Layer (UART PAL)

16.107.1 Detailed Description

The S32 SDK provides a Peripheral Abstraction Layer for Universal Asynchronous Receiver-Transmitter (UART) modules of S32 SDK devices.

The UART PAL driver allows communication over a serial port. It was designed to be portable across all platforms and IPs which support UART communication.

How to integrate UART PAL in your application

Unlike the other drivers, UART PAL modules need to include a configuration file named uart_pal_cfg.h, which allows the user to specify which IPSs are used and how many resources are allocated for each of them (state structures). The following code example shows how to configure one instance for each available UART IPs.

```
#ifndef uart_pal_cfg_H
#define uart_pal_cfg_H

/* Define which IP instance will be used in current project */
#define UART_OVER_LPUART
#define UART_OVER_FLEXIO
#define UART_OVER_LINFLEXD

/* Define the resources necessary for current project */
#define NO_OF_LPUART_INSTS_FOR_UART    1U
#define NO_OF_FLEXIO_INSTS_FOR_UART    1U
#define NO_OF_LINFLEXD_INSTS_FOR_UART  1U

#endif /* uart_pal_cfg_H */
```

The following table contains the matching between platforms and available IPs

IP/MCU	S32K11(	S32K11	S32K14	S32K14	S32K14	S32K14	S32V234	MPC574G	MPC574C	MPC574P	S32R274	S32R37	MPC574R	MPC574C	S32R294	S32G274A	S32R45	S32K144W
LPUART	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES
FLEXIO_UART	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES

LIN Flex_UART	NO	NO	NO	NO	NO	NO	YES	YES	YES	YES	YES	YES	YES	NO	YES	YES	YES	NO
eSCI_UART	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES	NO	NO	NO	NO

Features

- Interrupt or DMA mode
- Provides blocking and non-blocking transmit and receive functions
- Configurable baud rate and number of bits per char

The following table contains the matching between IPs and available features

IP/FEATURE	Bits per char	Parity	Stop Bits
LPUART	8, 9, 10	Disabled, Even, Odd	1, 2
FLEXIO_UART	7, 8, 9, 10, 15, 16	Disabled	1
LINFlexD_UART	7, 8, 15, 16	Disabled, Even, Odd	1, 2

Functionality

Initialization

In order to use the UART PAL driver it must be first initialized, using UART_Init() function. Once initialized, it cannot be initialized again for the same UART module instance until it is de-initialized, using UART_Deinit(). The initialization function does the following operations:

- sets the baud rate
- sets parity/bit count/stop bits count
- initializes the state structure for the current instance
- enables receiver/transmitter for the current instance Different UART modules instances can function independently of each other.

Interrupt-based communication

After initialization, a serial communication can be triggered by calling UART_SendData function. The driver interrupt handler takes care of transmitting all bytes in the TX buffer. Similarly, data reception is triggered by calling UART_ReceiveData function, passing the RX buffer as parameter. The driver interrupt handler reads the received byte

and saves them in the RX buffer. Non-blocking operations will initiate the transfer and return STATUS_SUCC↩ ESS, but the module is still busy with the transfer and another transfer can't be initiated until the current transfer is complete. The application can check the status of the current transfer by calling UART_GetTransmitStatus() / UART_GetReceiveStatus().

The workflow applies to send/receive operations using blocking method (triggered by UART_SendDataBlocking() and UART_ReceiveDataBlocking()), with the single difference that the send/receive function will not return until the send/receive operation is complete (all bytes are successfully transferred or a timeout occurred). The timeout for the blocking method is passed as parameter by the user.

When configured to use the LPUART or LINFlexD peripherals, if a user callback is installed for RX/TX, the callback has to take care of data handling and aborting the transfer when complete; the driver interrupt handler does not manipulate the buffers in this case. When using the UART PAL over FLEXIO, when the driver completes the transmission or reception of the current buffer, it will invoke the user callback (if installed) with an appropriate event.

DMA-based communication

In DMA operation, both blocking and non-blocking transmission methods configure a DMA channel to copy data to/from the buffer. The driver assumes the DMA channel is already allocated. In case of LPUART and LINFlexD, the application also assumes that the proper requests are routed to it via DMAMUX. The FLEXIO driver will set the DMA request source. After configuring the DMA channel, the driver enables DMA requests for RX/TX, then the DMA engine takes care of moving data to/from the data buffer. In this scenario, the callback is only called when the full transmission is done, that is when the DMA channel finishes the number of loops configured in the transfer descriptor.

Important Notes

- Before using the UART PAL driver the module clock must be configured. Refer to Clock Manager for clock configuration.
- The driver enables the interrupts for the corresponding UART module, but any interrupt priority must be done by the application
- The board specific configurations must be done prior to driver calls; the driver has no influence on the functionality of the TX/RX pins - they must be configured by application
- DMA module has to be initialized prior to UART usage in DMA mode; also, DMA channels need to be allocated for UART usage by the application (the driver only takes care of configuring the DMA channels received in the configuration structure)
- Some features are not available for all UART IPs and incorrect parameters will be handled by DEV_ASSERT
- The UART_SetBaudRate() function attempts to configure the requested baud rate for the selected UAR↩ T peripheral. Note that due to module limitation not any baud rate can be achieved. The driver will set a baud rate as close as possible to the requested baud rate, but there may still be substantial differences. The application should call UART_GetBaudRate() after UART_SetBaudRate() to check what baud rate was actually set.
- Due to different implementation of drivers, callback parameters in case of errors during reception may be different. LPUART and LINFLEXD_UART will pass UART_EVENT_ERROR as the event parameter for callbacks, whereas FLEXIO_UART will pass UART_EVENT_END_TRANSFER. In both cases, in order to retrieve the exact status of the latest reception, users can call the appropriate functions in the (UART_Get↩ ReceiveStatus).
- Due to DMA mechanism, bit character length should be recommended multiple by 8. So, LPUART only supports 8 bit chars while FLEXIO_UART supports 8 and 16 bit chars in DMA module. Specially, LIN↩ FLEXD_UART can process with all character lengths currently because it takes care of parity bit handling internally.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\pal\src\uart\uart_pal.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc
${S32SDK_PATH}\platform\pal\inc
${S32_SDK_PATH}\rtos\osif
```

Preprocessor symbols

No special symbols are required for this component

Dependencies

Clock Manager Interrupt Manager (Interrupt) Enhanced Direct Memory Access (eDMA) OS Interface (OSIF)

Example code

```
  uint32_t bytesRemaining;

/* Instance information structure */
uart_instance_t uart_pal1_instance = {
    .instType = UART_INST_TYPE_FLEXIO_UART,
    .instIdx = 0U
};

  /* Configure UART */
  uart_user_config_t uart_pal1_Config0 = {
    .baudRate          = 600U,
    .bitCount          = UART_7_BITS_PER_CHAR,
    .parityMode        = UART_PARITY_DISABLED,
    .stopBitCount      = UART_ONE_STOP_BIT,
    .transferType      = UART_USING_INTERRUPTS,
    .rxDMAChannel      = 0U,
    .txDMAChannel      = 0U,
    .rxCallback        = NULL,
    .rxCallbackParam   = NULL,
    .txCallback        = NULL,
    .txCallbackParam   = NULL,
    .extension         = NULL
  };

  /* Configure FLEXIO pins routing */
  extension_flexio_for_uart_t extension = {
    .dataPinTx = 0U,
    .dataPinRx = 1U,
  };
  uart_pal1_Config0.extension = &extension;

  /* Buffers */
  uint8_t tx[8] = {0, 1, 2, 3, 4, 5, 6, 7};
  uint8_t rx[8];

  /* Initialize UART */
  UART_Init(&uart_pal1_instance, &uart_pal1_Config0);

  /* Send 8 frames */
  UART_SendData(&uart_pal1_instance, tx, 8U);
  while(UART_GetTransmitStatus(&uart_pal1_instance, &bytesRemaining) !=
      STATUS_SUCCESS);

  /* Receive 8 frames */
  UART_ReceiveData(&uart_pal1_instance, rx, 8UL);
  /* Wait for transfer to be completed */
  while(UART_GetReceiveStatus(&uart_pal1_instance, &bytesRemaining) != STATUS_SUCCESS)
      ;

  /* De-initialize UART */
  UART_Deinit(&uart_pal1_instance);
```

Data Structures

- struct uart_user_config_t

  Defines the UART configuration structure. More...

- struct extension_flexio_for_uart_t

  Defines the extension structure for the UART over FLEXIO. More...

Enumerations

- enum uart_bit_count_per_char_t { UART_7_BITS_PER_CHAR = 0x0U, UART_8_BITS_PER_CHAR = 0x1U, UART_9_BITS_PER_CHAR = 0x2U, UART_10_BITS_PER_CHAR = 0x3U, UART_15_BITS_PER_CHAR = 0x4U, UART_16_BITS_PER_CHAR = 0x5U }

  Defines the number of bits in a character.
- enum uart_transfer_type_t { UART_USING_DMA = 0U, UART_USING_INTERRUPTS = 1U }

  Defines the transfer type.
- enum uart_parity_mode_t { UART_PARITY_DISABLED = 0x0U, UART_PARITY_EVEN = 0x2U, UART_PARITY_ODD = 0x3U }

  Defines the parity mode.
- enum uart_stop_bit_count_t { UART_ONE_STOP_BIT = 0x0U, UART_TWO_STOP_BIT = 0x1U }

  Defines the number of stop bits.

Functions

- void UART_GetDefaultConfig (uart_user_config_t *config)

  Gets the default configuration structure.
- status_t UART_Init (const uart_instance_t *const instance, const uart_user_config_t *config)

  Initializes the UART module.
- status_t UART_Deinit (const uart_instance_t *const instance)

  De-initializes the UART module.
- status_t UART_SetBaudRate (const uart_instance_t *const instance, uint32_t desiredBaudRate)

  Configures the UART baud rate.
- status_t UART_GetBaudRate (const uart_instance_t *const instance, uint32_t *configuredBaudRate)

  Returns the UART baud rate.
- status_t UART_SendDataBlocking (const uart_instance_t *const instance, const uint8_t *txBuff, uint32_t txSize, uint32_t timeout)

  Perform a blocking UART transmission.
- status_t UART_SendData (const uart_instance_t *const instance, const uint8_t *txBuff, uint32_t txSize)

  Perform a non-blocking UART transmission.
- status_t UART_AbortSendingData (const uart_instance_t *const instance)

  Terminates a non-blocking transmission early.
- status_t UART_GetTransmitStatus (const uart_instance_t *const instance, uint32_t *bytesRemaining)

  Get the status of the current non-blocking UART transmission.
- status_t UART_ReceiveDataBlocking (const uart_instance_t *const instance, uint8_t *rxBuff, uint32_t rxSize, uint32_t timeout)

  Perform a blocking UART reception.
- status_t UART_ReceiveData (const uart_instance_t *const instance, uint8_t *rxBuff, uint32_t rxSize)

  Perform a non-blocking UART reception.
- status_t UART_AbortReceivingData (const uart_instance_t *const instance)

  Terminates a non-blocking receive early.
- status_t UART_GetReceiveStatus (const uart_instance_t *const instance, uint32_t *bytesRemaining)

  Get the status of the current non-blocking UART reception.
- status_t UART_SetRxBuffer (const uart_instance_t *const instance, uint8_t *rxBuff, uint32_t rxSize)

  Provide a buffer for receiving data.
- status_t UART_SetTxBuffer (const uart_instance_t *const instance, const uint8_t *txBuff, uint32_t txSize)

  Provide a buffer for transmitting data.

16.107.2 Data Structure Documentation

16.107.2.1 struct uart_user_config_t

Defines the UART configuration structure.

Implements : uart_user_config_t_Class

Definition at line 88 of file uart_pal.h.

Data Fields

- uint32_t baudRate
- uart_bit_count_per_char_t bitCount
- uart_parity_mode_t parityMode
- uart_stop_bit_count_t stopBitCount
- uart_transfer_type_t transferType
- uint8_t rxDMAChannel
- uint8_t txDMAChannel
- uart_callback_t rxCallback
- void * rxCallbackParam
- uart_callback_t txCallback
- void * txCallbackParam
- void * extension

Field Documentation

16.107.2.1.1 uint32_t baudRate

Baud rate

Definition at line 90 of file uart_pal.h.

16.107.2.1.2 uart_bit_count_per_char_t bitCount

Number of bits in a character

Definition at line 91 of file uart_pal.h.

16.107.2.1.3 void* extension

This field will be used to add extra settings to the basic configuration like FlexIO data pins

Definition at line 101 of file uart_pal.h.

16.107.2.1.4 uart_parity_mode_t parityMode

Parity mode, disabled (default), even, odd

Definition at line 92 of file uart_pal.h.

16.107.2.1.5 uart_callback_t rxCallback

Callback to invoke for data receive

Definition at line 97 of file uart_pal.h.

16.107.2.1.6 void* rxCallbackParam

Receive callback parameter

Definition at line 98 of file uart_pal.h.

16.107.2.1.7 uint8_t rxDMAChannel

Channel number for DMA rx channel.

Definition at line 95 of file uart_pal.h.

16.107.2.1.8 uart_stop_bit_count_t stopBitCount

number of stop bits, 1 stop bit (default) or 2 stop bits

Definition at line 93 of file uart_pal.h.

16.107.2.1.9 uart_transfer_type_t transferType

Type of the transfer (interrupt/dma based)

Definition at line 94 of file uart_pal.h.

16.107.2.1.10 uart_callback_t txCallback

Callback to invoke for data send

Definition at line 99 of file uart_pal.h.

16.107.2.1.11 void* txCallbackParam

Transmit callback parameter

Definition at line 100 of file uart_pal.h.

16.107.2.1.12 uint8_t txDMAChannel

Channel number for DMA tx channel.

Definition at line 96 of file uart_pal.h.

16.107.2.2 struct extension_flexio_for_uart_t

Defines the extension structure for the UART over FLEXIO.

Implements : extension_flexio_for_uart_t_Class

Definition at line 110 of file uart_pal.h.

Data Fields

- uint8_t dataPinTx
- uint8_t dataPinRx

Field Documentation

16.107.2.2.1 uint8_t dataPinRx

Flexio pin to use as Rx pin

Definition at line 113 of file uart_pal.h.

16.107.2.2.2 uint8_t dataPinTx

Flexio pin to use as Tx pin

Definition at line 112 of file uart_pal.h.

16.107.3 Enumeration Type Documentation

16.107.3.1 enum uart_bit_count_per_char_t

Defines the number of bits in a character.

Implements : uart_bit_count_per_char_t_Class

Enumerator

UART_7_BITS_PER_CHAR 7-bit data characters
UART_8_BITS_PER_CHAR 8-bit data characters
UART_9_BITS_PER_CHAR 9-bit data characters
UART_10_BITS_PER_CHAR 10-bit data characters
UART_15_BITS_PER_CHAR 15-bit data characters
UART_16_BITS_PER_CHAR 16-bit data characters

Definition at line 39 of file uart_pal.h.

16.107.3.2 enum uart_parity_mode_t

Defines the parity mode.

Implements : uart_parity_mode_t_Class

Enumerator

UART_PARITY_DISABLED parity disabled
UART_PARITY_EVEN parity enabled, type even
UART_PARITY_ODD parity enabled, type odd

Definition at line 65 of file uart_pal.h.

16.107.3.3 enum uart_stop_bit_count_t

Defines the number of stop bits.

Implements : uart_stop_bit_count_t_Class

Enumerator

UART_ONE_STOP_BIT one stop bit
UART_TWO_STOP_BIT two stop bits

Definition at line 77 of file uart_pal.h.

16.107.3.4 enum uart_transfer_type_t

Defines the transfer type.

Implements : uart_transfer_type_t_Class

Enumerator

UART_USING_DMA Driver uses DMA for data transfers
UART_USING_INTERRUPTS Driver uses interrupts for data transfers

Definition at line 54 of file uart_pal.h.

16.107.4 Function Documentation

16.107.4.1 status_t UART_AbortReceivingData (const uart_instance_t *const *instance*)

Terminates a non-blocking receive early.

Parameters

in	*instance*	Pointer to the UART_PAL instance structure.

Returns

STATUS_SUCCESS: if successful; STATUS_ERROR : if invalid instance type;

Definition at line 1018 of file uart_pal.c.

16.107.4.2 status_t UART_AbortSendingData (const uart_instance_t *const *instance*)

Terminates a non-blocking transmission early.

Parameters

in	*instance*	Pointer to the UART_PAL instance structure.

Returns

STATUS_SUCCESS: if successful; STATUS_ERROR : if invalid instance type;

Definition at line 832 of file uart_pal.c.

16.107.4.3 status_t UART_Deinit (const uart_instance_t *const *instance*)

De-initializes the UART module.

This function de-initializes the UART module.

Parameters

in	*instance*	Pointer to the UART_PAL instance structure.

Returns

STATUS_SUCCESS: if successful; STATUS_BUSY: if TX/RX line is busy; STATUS_ERROR : if invalid instance type;

Definition at line 556 of file uart_pal.c.

16.107.4.4 status_t UART_GetBaudRate (const uart_instance_t *const *instance,* uint32_t * *configuredBaudRate*)

Returns the UART baud rate.

This function returns the UART configured baud rate.

Parameters

in	*instance*	Pointer to the UART_PAL instance structure.
out	*configured↩ BaudRate*	Pointer to configured baud rate.

Returns

STATUS_SUCCESS: if successful; STATUS_ERROR : if invalid instance type;

Definition at line 687 of file uart_pal.c.

16.107.4.5 void UART_GetDefaultConfig (uart_user_config_t * *config*)

Gets the default configuration structure.

This function gets the default configuration structure, with the following settings:

- Baud rate: 9600
- Number of bits in a character: 8
- Parity mode: disable
- Number of stop bits: 1 stop bit
- Type of the transfer: interrupt
- Callback to invoke for data receive: NULL
- Receive callback parameter: NULL
- Callback to invoke for data send: NULL
- Transmit callback parameter: NULL
- Setup pins for FLEXIO: NULL

Parameters

out	*config*	Pointer to the UART_PAL user configuration structure.

Returns

NONE

Definition at line 396 of file uart_pal.c.

16.107.4.6 status_t UART_GetReceiveStatus (const uart_instance_t *const *instance*, uint32_t * *bytesRemaining*)

Get the status of the current non-blocking UART reception.

Parameters

in	*instance*	Pointer to the UART_PAL instance structure.
out	*bytesRemaining*	Pointer to value that is filled with the number of bytes that still need to be received in the active transfer

Note

In DMA mode, this parameter may not be accurate, in case the transfer completes right after calling this function; in this edge-case, the parameter will reflect the initial transfer size, due to automatic reloading of the major loop count in the DMA transfer descriptor.

return STATUS_SUCCESS : The reception has completed successfully; STATUS_BUSY : The reception is still in progress. *bytesReceived* will be filled with the number of bytes that have been received so far; STATUS_UART_R↩X_OVERRUN : If an overrun error occurred during the reception; STATUS_UART_ABORTED : The reception was aborted; STATUS_TIMEOUT : A timeout was reached; STATUS_ERROR : An error occurred; return For LPUART used by UART_PAL: STATUS_UART_FRAMING_ERROR: If bit stop on frame is wrong; STATUS_UART_PARI↩TY_ERROR : If bit parity on frame is wrong; STATUS_UART_NOISE_ERROR : If noise happens on bus;

Definition at line 1062 of file uart_pal.c.

16.107.4.7 status_t UART_GetTransmitStatus (const uart_instance_t *const *instance*, uint32_t * *bytesRemaining*)

Get the status of the current non-blocking UART transmission.

Parameters

in	*instance*	Pointer to the UART_PAL instance structure.
out	*bytesRemaining*	Pointer to value that is populated with the number of bytes that have been sent in the active transfer.

Note

In DMA mode, this parameter may not be accurate, in case the transfer completes right after calling this function; in this edge-case, the parameter will reflect the initial transfer size, due to automatic reloading of the major loop count in the DMA transfer descriptor.

Returns

STATUS_SUCCESS : The transmit has completed successfully; STATUS_BUSY : The transmit is still in progress. *bytesTransmitted* will be filled with the number of bytes that have been transmitted so far; STATU↩ S_UART_ABORTED : The transmit was aborted; STATUS_TIMEOUT : A timeout was reached; STATUS_↩ ERROR : An error occurred;

Definition at line 876 of file uart_pal.c.

16.107.4.8 status_t UART_Init (const uart_instance_t ∗const *instance,* const uart_user_config_t ∗ *config*)

Initializes the UART module.

This function initializes and enables the requested UART module, configuring the bus parameters.

Parameters

in	*instance*	Pointer to the UART_PAL instance structure.
in	*config*	Pointer to the UART_PAL user configuration structure.

return STATUS_SUCCESS: if successful; STATUS_ERROR : if invalid instance type or init over supported hardware. return For LPUART, LINFLEXD_UART used by UART_PAL: STATUS_BUSY : if calling function while bus is busy;

Definition at line 419 of file uart_pal.c.

16.107.4.9 status_t UART_ReceiveData (const uart_instance_t ∗const *instance,* uint8_t ∗ *rxBuff,* uint32_t *rxSize*)

Perform a non-blocking UART reception.

This function receives a block of data and returns immediately. The rest of the transmission is handled by the interrupt service routine (if the driver is initialized in interrupt mode).

Parameters

in	*instance*	Pointer to the UART_PAL instance structure.
out	*rxBuff*	Pointer to the data to be transferred.
in	*rxSize*	Length in bytes of the data to be transferred.

Returns

STATUS_BUSY : if bus is busy; STATUS_SUCCESS: if successful; STATUS_ERROR : An error occurred;

Definition at line 972 of file uart_pal.c.

16.107.4.10 status_t UART_ReceiveDataBlocking (const uart_instance_t ∗const *instance,* uint8_t ∗ *rxBuff,* uint32_t *rxSize,* uint32_t *timeout*)

Perform a blocking UART reception.

This function receives a block of data and only returns when the transmission is complete.

Parameters

in	*instance*	Pointer to the UART_PAL instance structure.
out	*rxBuff*	Pointer to the receive buffer.
in	*rxSize*	Length in bytes of the data to be received.
in	*timeout*	Timeout for the transfer in milliseconds.

return STATUS_TIMEOUT : if waiting time for reception finished while receive data incompletely; STATUS_BUSY : if bus is busy; STATUS_SUCCESS : if successful; STATUS_UART_RX_OVERRUN : If an overrun error occurred during the reception; STATUS_ERROR : An error occurred; return For LPUART used by UART_PAL: STATUS_↩ UART_FRAMING_ERROR: If bit stop on frame is wrong; STATUS_UART_PARITY_ERROR : If bit parity on frame is wrong; STATUS_UART_NOISE_ERROR : If noise happens on bus;

Definition at line 921 of file uart_pal.c.

16.107.4.11 status_t UART_SendData (const uart_instance_t *const *instance*, const uint8_t * *txBuff*, uint32_t *txSize*)

Perform a non-blocking UART transmission.

This function sends a block of data and returns immediately. The rest of the transmission is handled by the interrupt service routine (if the driver is initialized in interrupt mode).

Parameters

in	*instance*	Pointer to the UART_PAL instance structure.
in	*txBuffer*	Pointer to the data to be transferred.
in	*txSize*	Length in bytes of the data to be transferred.

Returns

STATUS_BUSY : if bus is busy; STATUS_SUCCESS: if successful; STATUS_ERROR : An error occurred;

Definition at line 785 of file uart_pal.c.

16.107.4.12 status_t UART_SendDataBlocking (const uart_instance_t *const *instance*, const uint8_t * *txBuff*, uint32_t *txSize*, uint32_t *timeout*)

Perform a blocking UART transmission.

This function sends a block of data and only returns when the transmission is complete.

Parameters

in	*instance*	Pointer to the UART_PAL instance structure.
in	*txBuffer*	Pointer to the data to be transferred.
in	*txSize*	Length in bytes of the data to be transferred.
in	*timeout*	Timeout value in milliseconds.

Returns

STATUS_TIMEOUT: if waiting time for transfer finished but transmit data incompletely; STATUS_BUSY : if bus is busy; STATUS_SUCCESS: if successful; STATUS_ERROR : An error occurred;

Definition at line 732 of file uart_pal.c.

16.107.4.13 status_t UART_SetBaudRate (const uart_instance_t *const *instance*, uint32_t *desiredBaudRate*)

Configures the UART baud rate.

This function configures the UART baud rate. Note that due to module limitation not any baud rate can be achieved. The driver will set a baud rate as close as possible to the requested baud rate, but there may still be substantial differences. The application should call UART_GetBaudRate() after UART_SetBaudRate() to check what baud rate was actually set.

Parameters

in	*instance*	Pointer to the UART_PAL instance structure.
in	*desiredBaud↩ Rate*	Desired baud rate.

Returns

STATUS_SUCCESS: if successful; STATUS_BUSY : if calling function while bus is busy; STATUS_ERROR : if invalid instance type;

Definition at line 633 of file uart_pal.c.

16.107.4.14 status_t UART_SetRxBuffer (const uart_instance_t *const *instance*, uint8_t * *rxBuff*, uint32_t *rxSize*)

Provide a buffer for receiving data.

The function can be used to provide a new buffer for receiving data to the driver. Beside, It can be called from rx callback to provide a new buffer for continuous reception.

Parameters

in	*instance*	Pointer to the UART_PAL instance structure.
in	*rxBuff*	Pointer to buffer containing received data.
in	*rxSize*	The number of bytes to receive.

Returns

STATUS_SUCCESS: Provide completed; STATUS_ERROR : if invalid instance type;

Definition at line 1107 of file uart_pal.c.

16.107.4.15 status_t UART_SetTxBuffer (const uart_instance_t *const *instance*, const uint8_t * *txBuff*, uint32_t *txSize*)

Provide a buffer for transmitting data.

The function can be used to provide a new buffer for transmitting data to the driver. Beside, It can be called from tx callback to provide a new buffer for continuous transmission.

Parameters

in	*instance*	Pointer to the UART_PAL instance structure.
in	*txBuff*	Pointer to buffer containing transmitted data.
in	*txSize*	The number of bytes to transmit.

Returns

STATUS_SUCCESS: Provide completed; STATUS_ERROR : if invalid instance type;

Definition at line 1151 of file uart_pal.c.

16.108 User provided call-outs

16.108.1 Detailed Description

This group contains APIs which may be called from within the LIN module in order to enable/disable LIN communication interrupts.

Functions

- l_u16 l_sys_irq_disable (l_ifc_handle iii)

  Disable LIN related IRQ.
- void l_sys_irq_restore (l_ifc_handle iii)

  Enable LIN related IRQ.

16.108.2 Function Documentation

16.108.2.1 l_u16 l_sys_irq_disable (l_ifc_handle *iii*)

Disable LIN related IRQ.

Parameters

in	*iii*	Interface name

Returns

l_u16

Definition at line 543 of file lin_common_api.c.

16.108.2.2 void l_sys_irq_restore (l_ifc_handle *iii*)

Enable LIN related IRQ.

Parameters

in	*iii*	Interface name

Returns

void

Definition at line 557 of file lin_common_api.c.

16.109 WDG PAL

16.109.1 Detailed Description

Watchdog Peripheral Abstraction Layer.

Data Structures

- struct wdg_option_mode_t

  WDG PAL option mode configuration structure Implements : wdg_option_mode_t_Class. More...
- struct extension_ewm_for_wdg_t

  The extension structure for the EWM over WDOG peripheral Implements : extension_ewm_for_wdg_t_Class. More...
- struct wdg_config_t

  WDG PAL configuration structure Implements : wdg_config_t_Class. More...

Enumerations

- enum wdg_clock_source_t { WDG_PAL_BUS_CLOCK = 0x00U, WDG_PAL_LPO_CLOCK = 0x01U, WDG_PAL_SOSC_CLOCK = 0x02U, WDG_PAL_SIRC_CLOCK = 0x03U }

  Clock sources for the WDG PAL. Implements : wdg_clock_source_t_Class.
- enum wdg_in_assert_logic_t { WDG_IN_ASSERT_DISABLED = 0x00U, WDG_IN_ASSERT_ON_LOGIC_ZERO = 0x01U, WDG_IN_ASSERT_ON_LOGIC_ONE = 0x02U }

  WDG PAL input pin configuration Configures if the input pin is enabled and when is asserted Implements : wdg_in_assert_logic_t_Class.
- enum wdg_inst_type_t

  Enumeration with the types of peripherals supported by Watchdog PAL.

WDG PAL API

- status_t WDG_Init (const wdg_instance_t *const instance, const wdg_config_t *configPtr)

  Initializes the WDG PAL.
- void WDG_GetDefaultConfig (wdg_config_t *const config)

  Gets default configuration of the WDG PAL.
- void WDG_Refresh (const wdg_instance_t *const instance)

  Refreshes the WDG PAL counter.
- status_t WDG_Deinit (const wdg_instance_t *const instance)

  De-initializes the WDG PAL.
- status_t WDG_SetInt (const wdg_instance_t *const instance, bool enable)

  Set interrupt for WDG PAL.
- status_t WDG_SetTimeout (const wdg_instance_t *const instance, uint32_t value)

  Sets the value of the WDG PAL timeout.
- status_t WDG_SetWindow (const wdg_instance_t *const instance, bool enable, uint32_t value)

  Set window mode and window value of the WDG PAL.
- status_t WDG_GetCounter (const wdg_instance_t *const instance, uint32_t *value)

  Gets the value of the WDG PAL counter.
- void WDG_ClearIntFlag (const wdg_instance_t *const instance)

  Clears the Timeout Interrupt Flag.

16.109.2 Data Structure Documentation

16.109.2.1 struct wdg_option_mode_t

WDG PAL option mode configuration structure Implements : wdg_option_mode_t_Class.

Definition at line 64 of file wdg_pal.h.

Data Fields

- bool wait
- bool stop
- bool debug

Field Documentation

16.109.2.1.1 bool debug

Debug mode

Definition at line 68 of file wdg_pal.h.

16.109.2.1.2 bool stop

Stop mode

Definition at line 67 of file wdg_pal.h.

16.109.2.1.3 bool wait

Wait mode

Definition at line 66 of file wdg_pal.h.

16.109.2.2 struct extension_ewm_for_wdg_t

The extension structure for the EWM over WDOG peripheral Implements : extension_ewm_for_wdg_t_Class.

Definition at line 88 of file wdg_pal.h.

Data Fields

- wdg_in_assert_logic_t assertLogic
- uint8_t prescalerValue

Field Documentation

16.109.2.2.1 wdg_in_assert_logic_t assertLogic

Assert logic for EWM input pin

Definition at line 90 of file wdg_pal.h.

16.109.2.2.2 uint8_t prescalerValue

EWM clock prescaler

Definition at line 91 of file wdg_pal.h.

16.109.2.3 struct wdg_config_t

WDG PAL configuration structure Implements : wdg_config_t_Class.

Definition at line 99 of file wdg_pal.h.

Data Fields

- wdg_clock_source_t clkSource
- wdg_option_mode_t opMode
- uint32_t timeoutValue
- uint8_t percentWindow
- bool intEnable
- bool winEnable
- bool prescalerEnable
- void * extension

Field Documentation

16.109.2.3.1 wdg_clock_source_t clkSource

The clock source of the WDOG

Definition at line 101 of file wdg_pal.h.

16.109.2.3.2 void* extension

This field will be add extra settings to EWM's configuration

Definition at line 109 of file wdg_pal.h.

16.109.2.3.3 bool intEnable

If true, an interrupt request is generated before reset

Definition at line 105 of file wdg_pal.h.

16.109.2.3.4 wdg_option_mode_t opMode

The modes in which the WDOG is functional

Definition at line 102 of file wdg_pal.h.

16.109.2.3.5 uint8_t percentWindow

The window value compares to timeout value. Maximum value is 100

Definition at line 104 of file wdg_pal.h.

16.109.2.3.6 bool prescalerEnable

If true, prescaler is enabled(default prescaler = 256)

Definition at line 107 of file wdg_pal.h.

16.109.2.3.7 uint32_t timeoutValue

The timeout value

Definition at line 103 of file wdg_pal.h.

16.109.2.3.8 bool winEnable

If true, window mode is enabled

Definition at line 106 of file wdg_pal.h.

16.109.3 Enumeration Type Documentation

16.109.3.1 enum wdg_clock_source_t

Clock sources for the WDG PAL. Implements : wdg_clock_source_t_Class.

Enumerator

WDG_PAL_BUS_CLOCK Bus clock

WDG_PAL_LPO_CLOCK LPO clock

WDG_PAL_SOSC_CLOCK SOSC clock

WDG_PAL_SIRC_CLOCK SIRC clock

Definition at line 52 of file wdg_pal.h.

16.109.3.2 enum wdg_in_assert_logic_t

WDG PAL input pin configuration Configures if the input pin is enabled and when is asserted Implements : wdg_↩ in_assert_logic_t_Class.

Enumerator

WDG_IN_ASSERT_DISABLED Input pin disabled

WDG_IN_ASSERT_ON_LOGIC_ZERO Input pin asserts EWM when on logic 0

WDG_IN_ASSERT_ON_LOGIC_ONE Input pin asserts EWM when on logic 1

Definition at line 77 of file wdg_pal.h.

16.109.3.3 enum wdg_inst_type_t

Enumeration with the types of peripherals supported by Watchdog PAL.

This enumeration contains the types of peripherals supported by Watchdog PAL. Implements : wdg_inst_type_t↩ _Class

Definition at line 42 of file wdg_pal_mapping.h.

16.109.4 Function Documentation

16.109.4.1 void WDG_ClearIntFlag (const wdg_instance_t *const *instance*)

Clears the Timeout Interrupt Flag.

This function clears the Timeout Interrupt Flag.

Parameters

in	*instance*	The name of the instance.

Definition at line 488 of file wdg_pal.c.

16.109.4.2 status_t WDG_Deinit (const wdg_instance_t *const *instance*)

De-initializes the WDG PAL.

This function resets all configuration to default and disable the WDG PAL instance.

Parameters

in	*instance*	The name of the instance.

Returns

operation status

- STATUS_SUCCESS : Operation was successful.
- STATUS_ERROR : Operation failed due to WDG PAL was locked.
- STATUS_UNSUPPORTED : Operation was unsupported.

Definition at line 282 of file wdg_pal.c.

16.109.4.3 status_t WDG_GetCounter (const wdg_instance_t *const *instance*, uint32_t * *value*)

Gets the value of the WDG PAL counter.

This function gets counter of WDG PAL module. Note that: Counter will be reset to timeout value if WDG PAL uses SWT. The counter will continue to run if WDG PAL uses WDOG.

Parameters

in	*instance*	The name of the instance.
out	*value*	Pointer to the counter value

Returns

operation status

- STATUS_SUCCESS : Operation was successful.
- STATUS_ERROR : Operation failed due to SWT was lock by hard lock.
- STATUS_UNSUPPORTED : Operation was unsupported.

Definition at line 440 of file wdg_pal.c.

16.109.4.4 void WDG_GetDefaultConfig (wdg_config_t *const *config*)

Gets default configuration of the WDG PAL.

This function gets the default configuration of the WDG PAL.

Parameters

out	*configures*	the default configuration

Definition at line 206 of file wdg_pal.c.

16.109.4.5 status_t WDG_Init (const wdg_instance_t *const *instance*, const wdg_config_t * *configPtr*)

Initializes the WDG PAL.

This function initializes the WDG instance by user configuration

Parameters

in	*instance*	The name of the instance.
in	*configPtr*	Pointer to the WDG PAL user configuration structure

Returns

operation status

- STATUS_SUCCESS : Operation was successful.
- STATUS_ERROR : Operation failed. Possible causes: previous clock source or the one specified in the configuration structure is disabled; WDG PAL configuration updates are not allowed.

- STATUS_UNSUPPORTED : Operation was unsupported.

Definition at line 80 of file wdg_pal.c.

16.109.4.6 void WDG_Refresh (const wdg_instance_t *const *instance*)

Refreshes the WDG PAL counter.

This function resets the WDG PAL counter

Parameters

in	*instance*	The name of the instance.

Definition at line 243 of file wdg_pal.c.

16.109.4.7 status_t WDG_SetInt (const wdg_instance_t *const *instance,* bool *enable*)

Set interrupt for WDG PAL.

This function enables/disables the WDG PAL timeout interrupt and sets a function to be called when a timeout interrupt is received, before reset.

Parameters

in	*instance*	The name of the instance.
in	*enable*	• true : Enable interrupt • false : Disable interrupt

Returns

operation status

- STATUS_SUCCESS : Operation was successful.
- STATUS_ERROR : Operation failed. Possible causes: failed to WDG PAL configuration updates not allowed.
- STATUS_UNSUPPORTED: Operation was unsupported.

Definition at line 319 of file wdg_pal.c.

16.109.4.8 status_t WDG_SetTimeout (const wdg_instance_t *const *instance,* uint32_t *value*)

Sets the value of the WDG PAL timeout.

This function sets the value of the WDG PAL timeout.

Parameters

in	*instance*	The name of the instance.
in	*value*	The value of the WDG PAL timeout.

Returns

operation status

- STATUS_SUCCESS : Operation was successful.
- STATUS_ERROR : Operation failed due to WDG PAL was locked.
- STATUS_UNSUPPORTED : Operation was unsupported.

Definition at line 358 of file wdg_pal.c.

16.109.4.9 status_t WDG_SetWindow (const wdg_instance_t *const *instance,* bool *enable,* uint32_t *value*)

Set window mode and window value of the WDG PAL.

This function set window mode, window value is set when window mode enabled.

Parameters

in	*instance*	The name of the instance.
in	*enable*	• true : Enable window mode • false : Disable window mode
in	*value*	The value of the WDG PAL window.

Returns

operation status

- STATUS_SUCCESS : Operation was successful.
- STATUS_ERROR : Operation failed due to WDG PAL was locked.
- STATUS_UNSUPPORTED : Operation was unsupported.

Definition at line 397 of file wdg_pal.c.

16.110 WDOG Driver

16.110.1 Detailed Description

Watchdog Timer Peripheral Driver.

How to use the WDOG driver in your application

In order to be able to use the Watchdog in your application, the first thing to do is initializing it with the desired configuration. This is done by calling the **WDOG_DRV_Init** function. One of the arguments passed to this function is the configuration which will be used for the Watchdog, specified by the **wdog_user_config_t** structure.

The **wdog_user_config_t** structure allows you to configure the following:

- the clock source of the Watchdog;
- the prescaler (a fixed 256 pre-scaling of the Watchdog counter reference clock may be enabled);
- the operation modes in which the Watchdog is functional (by default, the Watchdog is not functional in Debug mode, Wait mode or Stop mode);
- the timeout value to which the Watchdog counter is compared;
- the window mode option for the refresh mechanism (by default, the window mode is disabled, but it may be enabled and a window value may be set);
- the Watchdog timeout interrupt (if enabled, after a reset-triggering event, the Watchdog first generates an interrupt request; next, the Watchdog delays 128 bus clocks before forcing a reset, to allow the interrupt service routine to perform tasks (like analyzing the stack to debug code));
- the update mechanism (by default, the Watchdog reconfiguration is enabled, but updates can be disabled)

Please note that if the updates are disabled the Watchdog cannot be later modified without forcing a reset (this implies that further calls of the **WDOG_DRV_Init**, **WDOG_DRV_Deinit** or **WDOG_DRV_SetInt** functions will lead to a reset).

As mentioned before, a timeout interrupt may be enabled by specifying it at the module initialization. The **WDOG_DRV_Init** only allows enabling/disabling the interrupt, and it does not set up the ISR to be used for the interrupt request. In order to set up a function to be called after a reset-triggering event (and also enable/disable the interrupt), the **WDOG_DRV_SetInt** function may be used. **Please note** that, due to the 128 bus clocks delay before the reset, a limited amount of job can be done in the ISR.

Integration guideline

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\drivers\src\wdog\wdog_driver.c
${S32SDK_PATH}\platform\drivers\src\wdog\wdog_hw_driver.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\drivers\inc\
```

Compile symbols

No special symbols are required for this component

Dependencies

Clock Manager Interrupt Manager (Interrupt)

Basic Operations of WDOG

1. To initialize WDOG, call WDOG_DRV_Init() with an user configuration structure. In the following code, WDOG is initialized with default settings.

```
#define INST_WDOG1 (0U)

wdog_user_config_t userConfigPtr = {
     .WDOG_LPO_CLOCK,           /* Use the LPO clock as source */
     .opMode = {                /* WDOG not functional in Wait/Debug/Stop mode */
         false,
         false,
         false
     },
     .true,                     /* Enable further updates of the WDOG configuration */
     .false,                    /* Timeout interrupt disabled */
     .false,                    /* Window mode disabled */
     .0U,                       /* Window value */
     .0x400,                    /* Timeout value */
     .false                     /* Prescaler disabled */
};

/* Initialize WDOG module */
WDOG_DRV_Init(INST_WDOG1, &userConfigPtr);
```

2. To get default configuration of WDOG module, just call the function WDOG_DRV_GetDefaultConfig(). Make sure that the operation before WDOG timeout executing.

```
wdog_user_config_t userConfigPtr;

/* Get default configuration of WDOG module */
WDOG_DRV_GetDefaultConfig(&userConfigPtr);
```

3. To refresh WDOG counter of WDOG module, just call the function WDOG_DRV_Trigger(). Make sure that the operation before WDOG timeout executing.

```
/* Refresh counter of WDOG counter */
WDOG_DRV_Trigger(INST_WDOG1);
```

4. To de-initialize WDOG module, just call the function WDOG_DRV_Deinit(). Make sure that the operation before WDOG timeout executing.

```
/* De-initialize WDOG module */
WDOG_DRV_Deinit(INST_WDOG1);
```

Example:

```
#define INST_WDOG1 (0U)

wdog_user_config_t userConfigPtr = {
     .WDOG_LPO_CLOCK,           /* Use the LPO clock as source */
     .opMode = {                /* WDOG not functional in Wait/Debug/Stop mode */
         false,
         false,
         false
     },
     .true,                     /* Enable further updates of the WDOG configuration */
     .false,                    /* Timeout interrupt disabled */
     .false,                    /* Window mode disabled */
     .0U,                       /* Window value */
     .0x400,                    /* Timeout value */
     .false                     /* Prescaler disabled */
};

/* Initialize WDOG module */
WDOG_DRV_Init(INST_WDOG1, &userConfigPtr);

/* Enable the timeout interrupt and set the ISR */
WDOG_DRV_SetInt(INST_WDOG1, true);

while (1) {

    /* Do something that takes between 0x100 and 0x400 clock cycles */

    /* Refresh the counter */
    WDOG_DRV_Trigger(INST_WDOG1);
}

/* De-initialize WDOG module */
WDOG_DRV_Deinit(INST_WDOG1);
```

Data Structures

- struct wdog_op_mode_t

  WDOG option mode configuration structure Implements : wdog_op_mode_t_Class. More...
- struct wdog_user_config_t

  WDOG user configuration structure Implements : wdog_user_config_t_Class. More...

Enumerations

- enum wdog_clk_source_t { WDOG_BUS_CLOCK = 0x00U, WDOG_LPO_CLOCK = 0x01U, WDOG_SOS↩C_CLOCK = 0x02U, WDOG_SIRC_CLOCK = 0x03U }

  Clock sources for the WDOG. Implements : wdog_clk_source_t_Class.
- enum wdog_test_mode_t { WDOG_TST_DISABLED = 0x00U, WDOG_TST_USER = 0x01U, WDOG_TS↩T_LOW = 0x02U, WDOG_TST_HIGH = 0x03U }

  Test modes for the WDOG. Implements : wdog_test_mode_t_Class.
- enum wdog_set_mode_t { WDOG_DEBUG_MODE = 0x00U, WDOG_WAIT_MODE = 0x01U, WDOG_ST↩OP_MODE = 0x02U }

  set modes for the WDOG. Implements : wdog_set_mode_t_Class

WDOG Driver API

- status_t WDOG_DRV_Init (uint32_t instance, const wdog_user_config_t ∗userConfigPtr)

  Initializes the WDOG driver.
- status_t WDOG_DRV_Deinit (uint32_t instance)

  De-initializes the WDOG driver.
- void WDOG_DRV_GetConfig (uint32_t instance, wdog_user_config_t ∗const config)

  Gets the current configuration of the WDOG.
- void WDOG_DRV_GetDefaultConfig (wdog_user_config_t ∗const config)

  Gets default configuration of the WDOG.
- status_t WDOG_DRV_SetInt (uint32_t instance, bool enable)

  Enables/Disables the WDOG timeout interrupt and sets a function to be called when a timeout interrupt is received, before reset.
- void WDOG_DRV_ClearIntFlag (uint32_t instance)

  Clear interrupt flag of the WDOG.
- void WDOG_DRV_Trigger (uint32_t instance)

  Refreshes the WDOG counter.
- uint16_t WDOG_DRV_GetCounter (uint32_t instance)

  Gets the value of the WDOG counter.
- status_t WDOG_DRV_SetWindow (uint32_t instance, bool enable, uint16_t windowvalue)

  Set window mode and window value of the WDOG.
- status_t WDOG_DRV_SetMode (uint32_t instance, bool enable, wdog_set_mode_t Setmode)

  Sets the mode operation of the WDOG.
- status_t WDOG_DRV_SetTimeout (uint32_t instance, uint16_t timeout)

  Sets the value of the WDOG timeout.
- status_t WDOG_DRV_SetTestMode (uint32_t instance, wdog_test_mode_t testMode)

  Changes the WDOG test mode.
- wdog_test_mode_t WDOG_DRV_GetTestMode (uint32_t instance)

  Gets the WDOG test mode.

16.110.2 Data Structure Documentation

16.110.2.1 struct wdog_op_mode_t

WDOG option mode configuration structure Implements : wdog_op_mode_t_Class.

Definition at line 84 of file wdog_driver.h.

Data Fields

- bool wait
- bool stop
- bool debug

Field Documentation

16.110.2.1.1 bool debug

Debug mode

Definition at line 88 of file wdog_driver.h.

16.110.2.1.2 bool stop

Stop mode

Definition at line 87 of file wdog_driver.h.

16.110.2.1.3 bool wait

Wait mode

Definition at line 86 of file wdog_driver.h.

16.110.2.2 struct wdog_user_config_t

WDOG user configuration structure Implements : wdog_user_config_t_Class.

Definition at line 95 of file wdog_driver.h.

Data Fields

- wdog_clk_source_t clkSource
- wdog_op_mode_t opMode
- bool updateEnable
- bool intEnable
- bool winEnable
- uint16_t windowValue
- uint16_t timeoutValue
- bool prescalerEnable

Field Documentation

16.110.2.2.1 wdog_clk_source_t clkSource

The clock source of the WDOG

Definition at line 97 of file wdog_driver.h.

16.110.2.2.2 bool intEnable

If true, an interrupt request is generated before reset

Definition at line 100 of file wdog_driver.h.

16.110.2.2.3 wdog_op_mode_t opMode

The modes in which the WDOG is functional

Definition at line 98 of file wdog_driver.h.

16.110.2.2.4 bool prescalerEnable

If true, a fixed 256 prescaling of the counter reference clock is enabled

Definition at line 104 of file wdog_driver.h.

16.110.2.2.5 uint16_t timeoutValue

The timeout value

Definition at line 103 of file wdog_driver.h.

16.110.2.2.6 bool updateEnable

If true, further updates of the WDOG are enabled

Definition at line 99 of file wdog_driver.h.

16.110.2.2.7 uint16_t windowValue

The window value

Definition at line 102 of file wdog_driver.h.

16.110.2.2.8 bool winEnable

If true, window mode is enabled

Definition at line 101 of file wdog_driver.h.

16.110.3 Enumeration Type Documentation

16.110.3.1 enum wdog_clk_source_t

Clock sources for the WDOG. Implements : wdog_clk_source_t_Class.

Enumerator

WDOG_BUS_CLOCK Bus clock
WDOG_LPO_CLOCK LPO clock
WDOG_SOSC_CLOCK SOSC clock
WDOG_SIRC_CLOCK SIRC clock

Definition at line 49 of file wdog_driver.h.

16.110.3.2 enum wdog_set_mode_t

set modes for the WDOG. Implements : wdog_set_mode_t_Class

Enumerator

WDOG_DEBUG_MODE Debug mode
WDOG_WAIT_MODE Wait mode
WDOG_STOP_MODE Stop mode

Definition at line 73 of file wdog_driver.h.

16.110.3.3 enum wdog_test_mode_t

Test modes for the WDOG. Implements : wdog_test_mode_t_Class.

Enumerator

WDOG_TST_DISABLED Test mode disabled

WDOG_TST_USER User mode enabled. (Test mode disabled.)

WDOG_TST_LOW Test mode enabled, only the low byte is used.

WDOG_TST_HIGH Test mode enabled, only the high byte is used.

Definition at line 61 of file wdog_driver.h.

16.110.4 Function Documentation

16.110.4.1 void WDOG_DRV_ClearIntFlag (uint32_t *instance*)

Clear interrupt flag of the WDOG.

Parameters

in	*instance*	WDOG peripheral instance number

Definition at line 270 of file wdog_driver.c.

16.110.4.2 status_t WDOG_DRV_Deinit (uint32_t *instance*)

De-initializes the WDOG driver.

Parameters

in	*instance*	WDOG peripheral instance number

Returns

operation status

- STATUS_SUCCESS: if allowed reconfigures WDOG module and de-initializes successful.
- STATUS_ERROR: Operation failed. Possible causes: failed to WDOG configuration updates not allowed.

Definition at line 160 of file wdog_driver.c.

16.110.4.3 void WDOG_DRV_GetConfig (uint32_t *instance,* wdog_user_config_t *const *config*)

Gets the current configuration of the WDOG.

Parameters

in	*instance*	WDOG peripheral instance number
out	*configures*	the current configuration

Definition at line 195 of file wdog_driver.c.

16.110.4.4 uint16_t WDOG_DRV_GetCounter (uint32_t *instance*)

Gets the value of the WDOG counter.

Parameters

in	*instance*	WDOG peripheral instance number.

Returns

the value of the WDOG counter.

Definition at line 301 of file wdog_driver.c.

16.110.4.5 void WDOG_DRV_GetDefaultConfig (wdog_user_config_t *const *config*)

Gets default configuration of the WDOG.

Parameters

out	*configures*	the default configuration

Definition at line 212 of file wdog_driver.c.

16.110.4.6 wdog_test_mode_t WDOG_DRV_GetTestMode (uint32_t *instance*)

Gets the WDOG test mode.

This function verifies the test mode of the WDOG.

Parameters

in	*instance*	WDOG peripheral instance number

Returns

Test modes for the WDOG

Definition at line 459 of file wdog_driver.c.

16.110.4.7 status_t WDOG_DRV_Init (uint32_t *instance,* const wdog_user_config_t * *userConfigPtr*)

Initializes the WDOG driver.

Parameters

in	*instance*	WDOG peripheral instance number
in	*userConfigPtr*	pointer to the WDOG user configuration structure

Returns

operation status

- STATUS_SUCCESS: Operation was successful.
- STATUS_ERROR: Operation failed. Possible causes: previous clock source or the one specified in the configuration structure is disabled; WDOG configuration updates are not allowed; WDOG instance has been initialized before; If window mode enabled and window value greater than or equal to the timeout value.

Definition at line 102 of file wdog_driver.c.

16.110.4.8 status_t WDOG_DRV_SetInt (uint32_t *instance,* bool *enable*)

Enables/Disables the WDOG timeout interrupt and sets a function to be called when a timeout interrupt is received, before reset.

Parameters

in	*instance*	WDOG peripheral instance number
in	*enable*	enable/disable interrupt

Returns

operation status

- STATUS_SUCCESS: if allowed reconfigures WDOG timeout interrupt.
- STATUS_ERROR: Operation failed. Possible causes: failed to WDOG configuration updates not allowed.

Definition at line 238 of file wdog_driver.c.

16.110.4.9 status_t WDOG_DRV_SetMode (uint32_t *instance,* bool *enable,* wdog_set_mode_t *Setmode*)

Sets the mode operation of the WDOG.

This function changes the mode operation of the WDOG.

Parameters

in	*instance*	WDOG peripheral instance number.
in	*enable*	enable/disable mode of the WDOG.
in	*Setmode*	select mode of the WDOG.

Returns

operation status

- STATUS_SUCCESS: if allowed reconfigures mode operation of the WDOG.
- STATUS_ERROR: Operation failed. Possible causes: failed to WDOG configuration updates not allowed.

Definition at line 352 of file wdog_driver.c.

16.110.4.10 status_t WDOG_DRV_SetTestMode (uint32_t *instance,* wdog_test_mode_t *testMode*)

Changes the WDOG test mode.

This function changes the test mode of the WDOG. If the WDOG is tested in mode, software should set this field to 0x01U in order to indicate that the WDOG is functioning normally.

Parameters

in	*instance*	WDOG peripheral instance number
in	*testMode*	Test modes for the WDOG.

Returns

operation status

- STATUS_SUCCESS: if allowed reconfigures WDOG test mode.
- STATUS_ERROR: Operation failed. Possible causes: failed to WDOG configuration updates not allowed.

Definition at line 426 of file wdog_driver.c.

16.110.4.11 status_t WDOG_DRV_SetTimeout (uint32_t *instance,* uint16_t *timeout*)

Sets the value of the WDOG timeout.

This function sets the value of the WDOG timeout.

Parameters

in	*instance*	WDOG peripheral instance number.
in	*timeout*	the value of the WDOG timeout.

Returns

operation status

- STATUS_SUCCESS: if allowed reconfigures WDOG timeout.
- STATUS_ERROR: Operation failed. Possible causes: failed to WDOG configuration updates not allowed.

Definition at line 397 of file wdog_driver.c.

16.110.4.12 status_t WDOG_DRV_SetWindow (uint32_t *instance,* bool *enable,* uint16_t *windowvalue*)

Set window mode and window value of the WDOG.

This function set window mode, window value is set when window mode enabled.

Parameters

in	*instance*	WDOG peripheral instance number.
in	*enable*	enable/disable window mode and window value.
in	*windowvalue*	the value of the WDOG window.

Returns

operation status

- STATUS_SUCCESS: if allowed reconfigures window value success.
- STATUS_ERROR: Operation failed. Possible causes: failed to WDOG configuration updates not allowed.

Definition at line 316 of file wdog_driver.c.

16.110.4.13 void WDOG_DRV_Trigger (uint32_t *instance*)

Refreshes the WDOG counter.

Parameters

in	*instance*	WDOG peripheral instance number

Definition at line 286 of file wdog_driver.c.

16.111 Watchdog Peripheral Abstraction Layer (WDG PAL)

16.111.1 Detailed Description

The S32 SDK provides a Peripheral Abstraction Layer for Watchdog (WDG PAL) modules of S32 SDK devices.

The Watchdog PAL driver allows to generate interrupt event to reset CPU or external circuit. It was designed to be portable across all platforms and IPs which support Watchdog Timer.

Integration guideline

Define IPs specification

Unlike the other drivers, WDG PAL modules need to include a configuration file named wdg_pal_cfg.h, which allows the user to specify which IPSs are used and how many resources are allocated for each of them (state structures). The following code example shows how to configure one instance for each available WDG IPs.

```
#ifndef WDG_PAL_CFG_H
#define WDG_PAL_CFG_H

/* Define which IP instance will be used in current project */
#define WDG_OVER_WDOG
#define WDG_OVER_EWM
#define WDG_OVER_SWT

/* Define the resources necessary for current project */
#define WDG_OVER_WDOG_INSTANCE_COUNT    1U
#define WDG_OVER_EWM_INSTANCE_COUNT     1U
#define WDG_OVER_SWT_INSTANCE_COUNT     0U

#endif /* WDG_PAL_CFG_H */
```

The following table contains the matching between platforms and available IPs

IP/MCU	S32K11x	S32K14x	MPC574x	S32Rx7x
WDOG	YES	YES	NO	NO
EWM	NO	YES	NO	NO
SWT	NO	NO	YES	YES

Compilation units

The following files need to be compiled in the project:

```
${S32SDK_PATH}\platform\pal\src\wdg\wdg_pal.c
```

Include path

The following paths need to be added to the include path of the toolchain:

```
${S32SDK_PATH}\platform\pal\inc
```

Compile symbols

No special symbols are required for this component

Dependencies

- Clock Manager
- Interrupt Manager (Interrupt)
- External Watchdog Monitor (EWM)

- Watchdog timer (WDOG)

- swt

Functionality

Initialization

In order to use the WDG PAL driver it must be first initialized, using WDG_Init() function. Once initialized, it cannot be initialized again for the same WDG module instance until it is de-initialized, using WDG_Deinit(). Different WDG modules instances can function independently of each other.

Interrupt event

After initialization, WDG PAL counter will count to timeout value. In window mode, when WDG PAL counter is refreshed, it will reset count to default value and count again. If WDG PAL counter count to timeout value, CPU or the external circuit will be reseted or placed into safe mode.

The configuration structure includes a special field named extension. It will be used only for WDG PAL over EWM peripheral and should contain a pointer to extension_ewm_for_wdg_t structure. The purpose of this structure is to configure which EWM_OUT pins and clock prescaler are used by the applications.

WDG PAL internal counter

WDG PAL internal counter is

- 8 bit if WDG PAL uses EWM
- 16 bit if WDG PAL uses WDOG
- 32 bit if WDG PAL uses SWT

WDG PAL's counter over EWM and WDOG will start to count from 0 to timeout value. WDG PAL's counter over SWT will start to count from timeout value to 0.

Important Notes

- Before using the WDG PAL driver the module clock must be configured. Refer to Clock Manager for clock configuration.
- The driver enables the interrupts for the corresponding WDG PAL module, but any interrupt priority must be done by the application
- For WDG PAL over SWT, if the counter clock is slow, the software needs a wait time (inversely proportional to counter clock frequency) to synchronization completed.

Example code

```
const wdg_instance_t wdg_pal1_Instance =
{
    .instType = WDG_INST_TYPE_WDOG,
    .instIdx  = 0U
};

const wdg_instance_t wdg_pal2_Instance =
{
    .instType = WDG_INST_TYPE_EWM,
    .instIdx  = 0U
};

const wdg_instance_t wdg_pal3_Instance =
{
    .instType = WDG_INST_TYPE_SWT,
    .instIdx  = 0U
};
```

```
/* Serial User Configurations */

const wdg_config_t wdg_pal1_Config0 =
{
    .clkSource       = WDG_PAL_LPO_CLOCK,
    .opMode          =
    {
        .wait        = false,
        .stop        = false,
        .debug       = false
    },
    .timeoutValue    = 1024,
    .percentWindow   = 50,
    .intEnable       = true,
    .winEnable       = true,
    .prescalerEnable = true
};

const wdg_config_t wdg_pal2_Config0 =
{
    .clkSource       = WDG_PAL_LPO_CLOCK,
    .opMode          =
    {
        .wait        = false,
        .stop        = false,
        .debug       = false
    },
    .timeoutValue    = 254,
    .percentWindow   = 100,
    .intEnable       = true,
    .winEnable       = true,
    .prescalerEnable = true,
    .extension       = &wdg_pal2_Extension0
};

extension_ewm_for_wdg_t wdg_pal2_Extension0 =
{
    .assertLogic     = WDG_IN_ASSERT_ON_LOGIC_ZERO,
    .prescalerValue  = 251
};

const wdg_config_t wdg_pal3_Config0 =
{
    .clkSource       = WDG_PAL_LPO_CLOCK,
    .opMode          =
    {
        .wait        = false,
        .stop        = false,
        .debug       = false
    },
    .timeoutValue    = 2560,
    .percentWindow   = 50,
    .intEnable       = true,
    .winEnable       = true,
    .prescalerEnable = false
};

int main()
{
    /* Init clocks, pins, led and other modules */
    ...

    /* Initialize WDG PAL */
    WDG_Init(&wdg_pal1_Instance, &wdg_pal1_Config0);

    /* Infinite loop*/
    while(1)
    {
        /* Do something until the counter needs to be refreshed */
        ...
        /* Reset WDG PAL counter */
        WDG_Refresh(&wdg_pal1_Instance);
    }
}
```

Modules

- WDG PAL

  Watchdog Peripheral Abstraction Layer.

16.112 Watchdog timer (WDOG)

16.112.1 Detailed Description

The S32 SDK provides Peripheral Driver for the Watchdog timer (WDOG) module of S32 SDK devices.
.

Hardware background

The Watchdog Timer (WDOG) module is an independent timer that is available for system use. It provides a safety feature to ensure that software is executing as planned and that the CPU is not stuck in an infinite loop or executing unintended code. If the WDOG module is not serviced (refreshed) within a certain period, it resets the MCU.

Features of the WDOG module include:

- Configurable clock source inputs independent from the bus clock
- Programmable timeout period
  - Programmable 16-bit timeout value
  - Optional fixed 256 clock prescaler when longer timeout periods are needed
- Window mode option for the refresh mechanism
  - Programmable 16-bit window value
  - Provides robust check that program flow is faster than expected
  - Early refresh attempts trigger a reset
- Optional timeout interrupt to allow post-processing diagnostics
  - Interrupt request to CPU with interrupt vector for an interrupt service routine (ISR)
  - Forced reset occurs 128 bus clocks after the interrupt vector fetch
- Configuration bits are write-once-after-reset to ensure watchdog configuration cannot be mistakenly altered
- Robust write sequence for unlocking write-once configuration bits

Modules

- WDOG Driver

  Watchdog Timer Peripheral Driver.

17 Data Structure Documentation

17.1 adc_callback_info_t Struct Reference

Defines a structure used to pass information to the ADC PAL callback.

`#include <platform/devices/callbacks.h>`

Data Fields

- uint32_t groupIndex
- uint16_t resultBufferTail

17.1.1 Detailed Description

Defines a structure used to pass information to the ADC PAL callback.

Implements : adc_callback_info_t_Class

Definition at line 108 of file callbacks.h.

17.1.2 Field Documentation

17.1.2.1 uint32_t groupIndex

Index of the group executing the callback.

Definition at line 110 of file callbacks.h.

17.1.2.2 uint16_t resultBufferTail

Offset of the most recent conversion result in the result buffer.

Definition at line 111 of file callbacks.h.

The documentation for this struct was generated from the following file:

- platform/devices/callbacks.h

17.2 adc_instance_t Struct Reference

Structure storing PAL instance information.

`#include <platform/pal/inc/adc_pal_mapping.h>`

Data Fields

- adc_inst_type_t instType
- uint32_t instIdx

17.2.1 Detailed Description

Structure storing PAL instance information.

This structure is used for storing PAL instance information. Implements : adc_instance_t_Class

Definition at line 74 of file adc_pal_mapping.h.

17.2.2 Field Documentation

17.2.2.1 uint32_t instIdx

Instance index of the peripheral (for ADC PAL the triggering peripheral) over which the PAL is used

Definition at line 77 of file adc_pal_mapping.h.

17.2.2.2 adc_inst_type_t instType

Peripheral over which the PAL is used

Definition at line 76 of file adc_pal_mapping.h.

The documentation for this struct was generated from the following file:

- platform/pal/inc/adc_pal_mapping.h

17.3 can_instance_t Struct Reference

Structure storing PAL instance information.

`#include <platform/pal/inc/can_pal_mapping.h>`

Data Fields

- can_inst_type_t instType
- uint32_t instIdx

17.3.1 Detailed Description

Structure storing PAL instance information.

This structure is used for storing PAL instance information. Implements : can_instance_t_Class

Definition at line 54 of file can_pal_mapping.h.

17.3.2 Field Documentation

17.3.2.1 uint32_t instIdx

Instance index of the peripheral over which the PAL is used

Definition at line 56 of file can_pal_mapping.h.

17.3.2.2 can_inst_type_t instType

Peripheral over which the PAL is used

Definition at line 55 of file can_pal_mapping.h.

The documentation for this struct was generated from the following file:

- platform/pal/inc/can_pal_mapping.h

17.4 drv_config_t Struct Reference

Data Fields

- sbc_wtdog_ctr_t watchdogCtr

- uint32_t lpspiIntace
- bool isInit

17.4.1 Detailed Description

Definition at line 58 of file sbc_uja116x_driver.c.

17.4.2 Field Documentation

17.4.2.1 bool isInit

Definition at line 61 of file sbc_uja116x_driver.c.

17.4.2.2 uint32_t lpspiIntace

Definition at line 60 of file sbc_uja116x_driver.c.

17.4.2.3 sbc_wtdog_ctr_t watchdogCtr

Definition at line 59 of file sbc_uja116x_driver.c.

The documentation for this struct was generated from the following file:

- middleware/sbc/sbc_uja116x/source/sbc_uja116x_driver.c

17.5 i2c_instance_t Struct Reference

Structure storing PAL instance information.

`#include <platform/pal/inc/i2c_pal_mapping.h>`

Data Fields

- i2c_inst_type_t instType
- uint32_t instIdx

17.5.1 Detailed Description

Structure storing PAL instance information.

This structure is used for storing PAL instance information. Implements : i2c_instance_t_Class

Definition at line 81 of file i2c_pal_mapping.h.

17.5.2 Field Documentation

17.5.2.1 uint32_t instIdx

Instance index of the peripheral over which the PAL is used

Definition at line 83 of file i2c_pal_mapping.h.

17.5.2.2 i2c_inst_type_t instType

Peripheral over which the PAL is used

Definition at line 82 of file i2c_pal_mapping.h.

The documentation for this struct was generated from the following file:

- platform/pal/inc/i2c_pal_mapping.h

17.6 i2s_instance_t Struct Reference

Structure storing PAL instance information.

`#include <platform/pal/inc/i2s_pal_mapping.h>`

Data Fields

- i2s_inst_type_t instType
- uint32_t instIdx

17.6.1 Detailed Description

Structure storing PAL instance information.

This structure is used for storing PAL instance information.

Definition at line 60 of file i2s_pal_mapping.h.

17.6.2 Field Documentation

17.6.2.1 uint32_t instIdx

Instance index of the peripheral over which the PAL is used

Definition at line 62 of file i2s_pal_mapping.h.

17.6.2.2 i2s_inst_type_t instType

Peripheral over which the PAL is used

Definition at line 61 of file i2s_pal_mapping.h.

The documentation for this struct was generated from the following file:

- platform/pal/inc/i2s_pal_mapping.h

17.7 ic_instance_t Struct Reference

Structure storing PAL instance information.

`#include <platform/pal/inc/ic_pal_mapping.h>`

Data Fields

- ic_inst_type_t instType
- uint32_t instIdx

17.7.1 Detailed Description

Structure storing PAL instance information.

This structure is used for storing PAL instance information. Implements : ic_instance_t_Class

Definition at line 132 of file ic_pal_mapping.h.

17.7.2 Field Documentation

17.7.2.1 uint32_t instIdx

Instance index of the peripheral over which the PAL is used

Definition at line 134 of file ic_pal_mapping.h.

17.7.2.2 ic_inst_type_t instType

Peripheral over which the PAL is used

Definition at line 133 of file ic_pal_mapping.h.

The documentation for this struct was generated from the following file:

- platform/pal/inc/ic_pal_mapping.h

17.8 lin_product_id_t Struct Reference

Product id structure Implements : lin_product_id_t_Class.

`#include <middleware/lin/include/lin_types.h>`

Data Fields

- l_u16 supplier_id
- l_u16 function_id
- l_u8 variant

17.8.1 Detailed Description

Product id structure Implements : lin_product_id_t_Class.

Definition at line 54 of file lin_types.h.

17.8.2 Field Documentation

17.8.2.1 l_u16 function_id

Function ID

Definition at line 57 of file lin_types.h.

17.8.2.2 l_u16 supplier_id

Supplier ID

Definition at line 56 of file lin_types.h.

17.8.2.3 l_u8 variant

Variant value

Definition at line 58 of file lin_types.h.

The documentation for this struct was generated from the following file:

- middleware/lin/include/lin_types.h

17.9 mpu_instance_t Struct Reference

Structure storing PAL instance information.

`#include <platform/pal/inc/mpu_pal_mapping.h>`

Data Fields

- mpu_inst_type_t instType
- uint32_t instIdx

17.9.1 Detailed Description

Structure storing PAL instance information.

This structure is used for storing PAL instance information. Implements : mpu_instance_t_Class

Definition at line 68 of file mpu_pal_mapping.h.

17.9.2 Field Documentation

17.9.2.1 uint32_t instIdx

Instance index of the peripheral over which the PAL is used

Definition at line 71 of file mpu_pal_mapping.h.

17.9.2.2 mpu_inst_type_t instType

Peripheral over which the PAL is used

Definition at line 70 of file mpu_pal_mapping.h.

The documentation for this struct was generated from the following file:

- platform/pal/inc/mpu_pal_mapping.h

17.10 oc_instance_t Struct Reference

Structure storing PAL instance information.

`#include <platform/pal/inc/oc_pal_mapping.h>`

Data Fields

- oc_inst_type_t instType
- uint32_t instIdx

17.10.1 Detailed Description

Structure storing PAL instance information.

This structure is used for storing PAL instance information. Implements : oc_instance_t_Class

Definition at line 110 of file oc_pal_mapping.h.

17.10.2 Field Documentation

17.10.2.1 uint32_t instIdx

Instance index of the peripheral over which the PAL is used

Definition at line 112 of file oc_pal_mapping.h.

17.10.2.2 oc_inst_type_t instType

Peripheral over which the PAL is used

Definition at line 111 of file oc_pal_mapping.h.

The documentation for this struct was generated from the following file:

- platform/pal/inc/oc_pal_mapping.h

17.11 oc_pal_state_t Struct Reference

The internal context structure.

17.11.1 Detailed Description

The internal context structure.

This structure is used by the driver for its internal logic. It must be provided by the application through the OC_Init() function, then it cannot be freed until the driver is de-initialized using OC_Deinit(). The application should make no assumptions about the content of this structure.

Definition at line 97 of file oc_pal.c.

The documentation for this struct was generated from the following file:

- platform/pal/src/oc/oc_pal.c

17.12 pwm_instance_t Struct Reference

Structure storing PAL instance information.

`#include <platform/pal/inc/pwm_pal_mapping.h>`

Data Fields

- pwm_inst_type_t instType
- uint32_t instIdx

17.12.1 Detailed Description

Structure storing PAL instance information.

This structure is used for storing PAL instance information. Implements : pwm_instance_t_Class

Definition at line 46 of file pwm_pal_mapping.h.

17.12.2 Field Documentation

17.12.2.1 uint32_t instIdx

Instance index of the peripheral over which the PAL is used

Definition at line 48 of file pwm_pal_mapping.h.

17.12.2.2 pwm_inst_type_t instType

Peripheral over which the PAL is used

Definition at line 47 of file pwm_pal_mapping.h.

The documentation for this struct was generated from the following file:

- platform/pal/inc/pwm_pal_mapping.h

17.13 spi_instance_t Struct Reference

Structure storing PAL instance information.

`#include <platform/pal/inc/spi_pal_mapping.h>`

Data Fields

- spi_inst_type_t instType
- uint32_t instIdx

17.13.1 Detailed Description

Structure storing PAL instance information.

This structure is used for storing PAL instance information. Implements : spi_instance_t_Class

Definition at line 50 of file spi_pal_mapping.h.

17.13.2 Field Documentation

17.13.2.1 uint32_t instIdx

Instance index of the peripheral over which the PAL is used

Definition at line 52 of file spi_pal_mapping.h.

17.13.2.2 spi_inst_type_t instType

Peripheral over which the PAL is used

Definition at line 51 of file spi_pal_mapping.h.

The documentation for this struct was generated from the following file:

- platform/pal/inc/spi_pal_mapping.h

17.14 timer_chan_state_t Struct Reference

Runtime state of the Timer channel.

17.14.1 Detailed Description

Runtime state of the Timer channel.

This structure is used by the driver for its internal logic The application should make no assumptions about the content of this structure

Definition at line 77 of file timing_pal.c.

The documentation for this struct was generated from the following file:

- platform/pal/src/timing/timing_pal.c

17.15 timing_instance_t Struct Reference

Structure storing PAL instance information.

`#include <platform/pal/inc/timing_pal_mapping.h>`

Data Fields

- timing_inst_type_t instType
- uint32_t instIdx

17.15.1 Detailed Description

Structure storing PAL instance information.

This structure is used for storing PAL instance information. Implements : timing_instance_t_Class

Definition at line 88 of file timing_pal_mapping.h.

17.15.2 Field Documentation

17.15.2.1 uint32_t instIdx

Instance index of the peripheral over which the PAL is used

Definition at line 90 of file timing_pal_mapping.h.

17.15.2.2 timing_inst_type_t instType

Peripheral over which the PAL is used

Definition at line 89 of file timing_pal_mapping.h.

The documentation for this struct was generated from the following file:

- platform/pal/inc/timing_pal_mapping.h

17.16 uart_instance_t Struct Reference

Structure storing PAL instance information.

`#include <platform/pal/inc/uart_pal_mapping.h>`

Data Fields

- uart_inst_type_t instType
- uint32_t instIdx

17.16.1 Detailed Description

Structure storing PAL instance information.

This structure is used for storing PAL instance information. Implements : uart_instance_t_Class

Definition at line 63 of file uart_pal_mapping.h.

17.16.2 Field Documentation

17.16.2.1 uint32_t instIdx

Instance index of the peripheral over which the PAL is used

Definition at line 66 of file uart_pal_mapping.h.

17.16.2.2 uart_inst_type_t instType

Peripheral over which the PAL is used

Definition at line 65 of file uart_pal_mapping.h.

The documentation for this struct was generated from the following file:

- platform/pal/inc/uart_pal_mapping.h

17.17 wdg_instance_t Struct Reference

Structure storing PAL instance information.

`#include <platform/pal/inc/wdg_pal_mapping.h>`

Data Fields

- wdg_inst_type_t instType
- uint32_t instIdx

17.17.1 Detailed Description

Structure storing PAL instance information.

This structure is used for storing PAL instance information. Implements : wdg_instance_t_Class

Definition at line 63 of file wdg_pal_mapping.h.

17.17.2 Field Documentation

17.17.2.1 uint32_t instIdx

Instance index of the peripheral over which the PAL is used

Definition at line 65 of file wdg_pal_mapping.h.

17.17.2.2 wdg_inst_type_t instType

Peripheral over which the PAL is used

Definition at line 64 of file wdg_pal_mapping.h.

The documentation for this struct was generated from the following file:

- platform/pal/inc/wdg_pal_mapping.h

Index