

Ultra-low-power 32-bit MCU ARM-based Cortex-M0+, up to 64KB Flash, 8KB SRAM, 2KB EEPROM, LCD, USB, ADC, DAC

Datasheet - preliminary data

Features

- Ultra-low-power platform
 - 1.65 V to 3.6 V power supply
 - -40 to 105/125 °C temperature range
 - 0.27 µA Standby mode (2 wakeup pins)
 - 0.4 µA Stop mode (16 wakeup lines)
 - 0.8 µA Stop mode + RTC + 8 KB RAM retention
 - 139 µA/MHz Run mode at 32 MHz
 - 3.5 µs wakeup time (from RAM)
 - 5 µs wakeup time (from Flash)
 - Core: ARM® 32-bit Cortex™-M0+ with MPU
 - From 32 kHz up to 32 MHz max.
 - 26 DMIPS peak (Dhrystone 2.1)
 - Reset and supply management
 - Ultra-safe, low-power BOR (brownout reset) with 5 selectable thresholds
 - Ultralow power POR/PDR
 - Programmable voltage detector (PVD)
 - Clock sources
 - 1 to 24 MHz crystal oscillator
 - 32 kHz oscillator for RTC with calibration
 - High speed internal 16 MHz factory-trimmed RC (+/- 1%)
 - Internal low-power 37 kHz RC
 - Internal multispeed low-power 65 kHz to 4.2 MHz RC
 - Internal self calibration of 48 MHz RC for USB
 - PLL for CPU clock
 - Pre-programmed bootloader
 - USART, SPI supported
 - Development support
 - Serial wire debug supported
 - Up to 51 fast I/Os (45 I/Os 5V tolerant)
 - Memories
 - Up to 64 KB Flash with ECC
 - 8 KB RAM
- 

LQFP64 10x10 mm
LQFP48 7x7 mm

TFPGA64 5x5 mm
- 2 KB of data EEPROM with ECC
 - 20-byte backup register
 - Sector protection against R/W operation
 - LCD Driver for up to 8×28 segments
 - Support contrast adjustment
 - Support blinking mode
 - Step-up converted on board
 - Rich Analog peripherals (down to 1.8 V)
 - 12-bit ADC 1.14 Msps up to 16 channels
 - 12-bit 1 channel DAC with output buffers
 - 2x ultra-low-power comparators (window mode and wake up capability)
 - Up to 24 capacitive sensing channels supporting touchkey, linear and rotary touch sensors
 - 7-channel DMA controller, supporting ADC, SPI, I2C, USART, DAC, Timers
 - 8x peripherals communication interface
 - 1x USB 2.0 crystal-less, battery charging detection and LPM
 - 2x USART (ISO 7816, IrDA), 1x UART (low power)
 - 2x SPI 16 Mbits/s
 - 2x I2C (SMBus/PMBus)
 - 9x timers: 1x 16-bit with up to 4 channels, 2x 16-bit with up to 2 channels, 1x 16-bit ultra-low-power timer, 1x SysTick, 1x RTC, 1x 16-bit basic for DAC, and 2x watchdogs (independent/window)
 - CRC calculation unit, 96-bit unique ID
 - True RNG and firewall protection
 - All packages are ECOPACK®2

Contents

1	Introduction	8
2	Description	9
2.1	Device overview	10
2.2	Ultra-low-power device continuum	12
3	Functional overview	13
3.1	Low-power modes	13
3.2	ARM® Cortex™-M0+ core with MPU	17
3.3	Reset and supply management	18
3.3.1	Power supply schemes	18
3.3.2	Power supply supervisor	18
3.3.3	Voltage regulator	19
3.3.4	Boot modes	19
3.4	Clock management	20
3.5	Low-power real-time clock and backup registers	23
3.6	General-purpose inputs/outputs (GPIOs)	23
3.7	Memories	24
3.8	Direct memory access (DMA)	24
3.9	Liquid crystal display (LCD)	25
3.10	Analog-to-digital converter (ADC)	25
3.11	Temperature sensor	25
3.11.1	Internal voltage reference (V_{REFINT})	26
3.11.2	V_{LCD} voltage monitoring	26
3.12	Digital-to-analog converter (DAC)	27
3.13	Ultra-low-power comparators and reference voltage	27
3.14	System configuration controller	27
3.15	Touch sensing controller (TSC)	28
3.16	Timers and watchdogs	29
3.16.1	General-purpose timers (TIM2, TIM21 and TIM22)	29
3.16.2	Low-power Timer (LPTIM)	29
3.16.3	Basic timer (TIM6)	30

3.16.4	SysTick timer	30
3.16.5	Independent watchdog (IWDG)	30
3.16.6	Window watchdog (WWDG)	30
3.17	Communication interfaces	30
3.17.1	I2C bus	30
3.17.2	Universal synchronous/asynchronous receiver transmitter (USART)	31
3.17.3	Low-power universal asynchronous receiver transmitter (LPUART)	32
3.17.4	Serial peripheral interface (SPI)/Inter-integrated sound (I2S)	32
3.17.5	Universal serial bus (USB)	33
3.18	Clock recovery system (CRS)	33
3.19	Cyclic redundancy check (CRC) calculation unit	33
3.20	Serial wire debug port (SW-DP)	34
4	Memory mapping	35
5	Pin descriptions	36
6	Electrical characteristics	49
6.1	Parameter conditions	49
6.1.1	Minimum and maximum values	49
6.1.2	Typical values	49
6.1.3	Typical curves	49
6.1.4	Loading capacitor	49
6.1.5	Pin input voltage	49
6.1.6	Power supply scheme	50
6.1.7	Optional LCD power supply scheme	51
6.1.8	Current consumption measurement	51
6.2	Absolute maximum ratings	52
6.3	Operating conditions	53
6.3.1	General operating conditions	53
6.3.2	Embedded reset and power control block characteristics	54
6.3.3	Embedded internal reference voltage	56
6.3.4	Supply current characteristics	57
6.3.5	Wakeup time from low-power mode	69
6.3.6	External clock source characteristics	70
6.3.7	Internal clock source characteristics	76
6.3.8	PLL characteristics	79

6.3.9	Memory characteristics	79
6.3.10	EMC characteristics	81
6.3.11	Electrical sensitivity characteristics	82
6.3.12	I/O current injection characteristics	83
6.3.13	I/O port characteristics	84
6.3.14	NRST pin characteristics	87
6.3.15	12-bit ADC characteristics	88
6.3.16	DAC electrical specifications	93
6.3.17	Temperature sensor characteristics	95
6.3.18	Comparators	96
6.3.19	Timer characteristics	97
6.3.20	Communications interfaces	98
6.3.21	LCD controller	105
7	Package characteristics	107
7.1	Package mechanical data	107
7.1.1	LQFP64 10 x 10 mm low profile quad flat package	107
7.1.2	LQFP48 7 x 7 mm low profile quad flat package	110
7.1.3	TFBGA64 5 x 5 mm thin profile fine pitch ball grid array package	113
7.2	Thermal characteristics	115
7.2.1	Reference document	115
8	Ordering information	116
9	Revision history	117

List of tables

Table 1.	Ultra-low-power STM32L053x6/8 device features and peripheral counts	10
Table 2.	Functionalities depending on the operating power supply range	15
Table 3.	CPU frequency range depending on dynamic voltage scaling	15
Table 4.	Functionalities depending on the working mode (from Run/active down to standby)	16
Table 5.	Temperature sensor calibration values	26
Table 6.	Internal voltage reference measured values	26
Table 7.	Capacitive sensing GPIOs available on STM32L053x6/8 devices	28
Table 8.	Timer feature comparison	29
Table 9.	Comparison of I2C analog and digital filters	31
Table 10.	STM32L053x6/8 I ² C implementation	31
Table 11.	USART implementation	32
Table 12.	SPI/I2S implementation	33
Table 13.	Legend/abbreviations used in the pinout table	39
Table 14.	STM32L053x6/8 pin definitions	39
Table 15.	Alternate function port A	45
Table 16.	Alternate function port B	46
Table 17.	Alternate function port C	47
Table 18.	Alternate function port D	47
Table 19.	Alternate function port H	48
Table 20.	Voltage characteristics	52
Table 21.	Current characteristics	52
Table 22.	Thermal characteristics	53
Table 23.	General operating conditions	53
Table 24.	Embedded reset and power control block characteristics	54
Table 25.	Embedded internal reference voltage calibration values	56
Table 26.	Embedded internal reference voltage	56
Table 27.	Current consumption in Run mode, code with data processing running from Flash	58
Table 28.	Current consumption in Run mode, code with data processing running from RAM	59
Table 29.	Current consumption in Sleep mode	60
Table 30.	Current consumption in Low-power run mode	61
Table 31.	Current consumption in Low-power Sleep mode	62
Table 32.	Typical and maximum current consumptions in Stop mode	62
Table 33.	Typical and maximum current consumptions in Standby mode	66
Table 34.	Peripheral current consumption	67
Table 35.	Low-power mode wakeup timings	70
Table 36.	High-speed external user clock characteristics	71
Table 37.	Low-speed external user clock characteristics	72
Table 38.	HSE oscillator characteristics	73
Table 39.	LSE oscillator characteristics ($f_{LSE} = 32.768$ kHz)	74
Table 40.	16 MHz HSI16 oscillator characteristics	76
Table 41.	HSI48 oscillator characteristics	76
Table 42.	LSI oscillator characteristics	77
Table 43.	MSI oscillator characteristics	77
Table 44.	PLL characteristics	79
Table 45.	RAM and hardware registers	79
Table 46.	Flash memory and data EEPROM characteristics	80
Table 47.	Flash memory and data EEPROM endurance and retention	80
Table 48.	EMS characteristics	81

Table 49.	EMI characteristics	82
Table 50.	ESD absolute maximum ratings	82
Table 51.	Electrical sensitivities	83
Table 52.	I/O current injection susceptibility	83
Table 53.	I/O static characteristics	84
Table 54.	Output voltage characteristics	85
Table 55.	I/O AC characteristics	86
Table 56.	NRST pin characteristics	87
Table 57.	ADC characteristics	88
Table 58.	R_{AIN} max for $f_{ADC} = 14$ MHz	90
Table 59.	ADC accuracy	90
Table 60.	DAC characteristics	93
Table 61.	Temperature sensor calibration values	95
Table 62.	Temperature sensor characteristics	95
Table 63.	Comparator 1 characteristics	96
Table 64.	Comparator 2 characteristics	96
Table 65.	TIMx characteristics	97
Table 66.	I2C analog filter characteristics	98
Table 67.	SPI characteristics	99
Table 68.	I2S characteristics	102
Table 69.	USB startup time	104
Table 70.	USB DC electrical characteristics	104
Table 71.	USB: full speed electrical characteristics	105
Table 72.	LCD controller characteristics	105
Table 73.	LQFP64, 10 x 10 mm 64-pin low-profile quad flat package mechanical data	108
Table 74.	LQFP48, 7 x 7 mm, 48-pin low-profile quad flat package mechanical data	111
Table 75.	TFBGA64, 5 x 5 mm, 64-bump thin profile fine pitch ball grid array package mechanical data	113
Table 76.	Thermal characteristics	115
Table 77.	STM32L053x6/8 ordering information scheme	116
Table 78.	Document revision history	117

List of figures

Figure 1.	Ultra-low-power STM32L053x6/8 block diagram	11
Figure 2.	Clock tree	22
Figure 3.	Memory map	35
Figure 4.	STM32L053x6/8 LQFP64 pinout - 10 x 10 mm	36
Figure 5.	STM32L053x6/8 TFBGA64 pinout - 5x 5 mm.	37
Figure 6.	STM32L053x6/8 LQFP48 pinout - 7 x 7 mm	38
Figure 7.	Pin loading conditions	49
Figure 8.	Pin input voltage	49
Figure 9.	Power supply scheme	50
Figure 10.	Optional LCD power supply scheme	51
Figure 11.	Current consumption measurement scheme	51
Figure 12.	High-speed external clock source AC timing diagram	71
Figure 13.	Low-speed external clock source AC timing diagram	72
Figure 14.	HSE oscillator circuit diagram	74
Figure 15.	Typical application with a 32.768 kHz crystal	75
Figure 16.	I/O AC characteristics definition	87
Figure 17.	Recommended NRST pin protection	88
Figure 18.	ADC accuracy characteristics	91
Figure 19.	Typical connection diagram using the ADC	91
Figure 20.	Power supply and reference decoupling (V_{REF+} not connected to V_{DDA})	92
Figure 21.	Power supply and reference decoupling (V_{REF+} connected to V_{DDA})	92
Figure 22.	12-bit buffered/non-buffered DAC	95
Figure 23.	SPI timing diagram - slave mode and CPHA = 0	100
Figure 24.	SPI timing diagram - slave mode and CPHA = 1 ⁽¹⁾	100
Figure 25.	SPI timing diagram - master mode ⁽¹⁾	101
Figure 26.	I ² S slave timing diagram (Philips protocol) ⁽¹⁾	103
Figure 27.	I ² S master timing diagram (Philips protocol) ⁽¹⁾	103
Figure 28.	USB timings: definition of data signal rise and fall time	105
Figure 29.	LQFP64, 10 x 10 mm, 64-pin low-profile quad flat package outline	107
Figure 30.	LQFP64 recommended footprint	108
Figure 31.	LQFP64 package top view	109
Figure 32.	LQFP48, 7 x 7 mm, 48-pin low-profile quad flat package outline	110
Figure 33.	LQFP48 recommended footprint	112
Figure 34.	LQFP48 package top view	112
Figure 35.	TFBGA64, 5 x 5 mm, 64-bump thin profile fine pitch ball grid array package outline	113
Figure 36.	TFBGA64 package top view	114

1 Introduction

The ultra-low-power STM32L053x6/8 family includes devices in 2 different package types: from 48 pins to 64 pins. Depending on the device chosen, different sets of peripherals are included, the description below gives an overview of the complete range of peripherals proposed in this family.

These features make the ultra-low-power STM32L053x6/8 microcontrollers suitable for a wide range of applications:

- Medical and hand-held equipment
- Application control and user interface
- PC peripherals, gaming, GPS and sport equipment
- Alarm systems, wired and wireless sensors, Video intercom
- Utility metering

This STM32L053x6/8 datasheet should be read in conjunction with the STM32L0x3x8 reference manual (RM0367).

For information on the ARM® Cortex™-M0+ core please refer to the Cortex™-M0+ Technical Reference Manual, available from the www.arm.com website at the following address: <http://infocenter.arm.com/help/index.jsp?topic=/com.arm.doc.ddi0484c/index.html>.

Figure 1 shows the general block diagram of the device family.

2 Description

The ultra-low-power STM32L053x6/8 incorporates the connectivity power of the universal serial bus (USB 2.0 crystal-less) with the high-performance ARM Cortex™-M0+ 32-bit RISC core operating at a 32 MHz frequency, a memory protection unit (MPU), high-speed embedded memories (up to 64 Kbytes of Flash program memory, 2 Kbytes of data EEPROM and 8 Kbytes of RAM) plus an extensive range of enhanced I/Os and peripherals.

The STM32L053x6/8 devices provides high power efficiency for a wide range of performance. It is achieved with a large choice of internal and external clock sources, an internal voltage adaptation and several low-power modes.

The STM32L053x6/8 devices offer several analog features, one 12-bit ADC, one DAC, two ultra-low-power comparators, several timers, one low-power timer (LPTIM), three general-purpose 16-bit timers and one basic timer, one RTC and one SysTick which can be used as timebases. They also feature two watchdogs, one watchdog with independent clock and window capability and one window watchdog based on bus clock.

Moreover, the STM32L053x6/8 devices embed standard and advanced communication interfaces: up to two I2Cs, two SPIs, two I2S, three USARTs and a crystal-less USB. The devices offer up to 24 capacitive sensing channels to simply add touch sensing functionality to any application.

They also include a real-time clock and a set of backup registers that remain powered in Standby mode.

Finally, their integrated LCD controller has a built-in LCD voltage generator that allows to drive up to 8 multiplexed LCDs with contrast independent of the supply voltage.

The ultra-low-power STM32L053x6/8 devices operate from a 1.8 to 3.6 V power supply (down to 1.65 V at power down) with BOR and from a 1.65 to 3.6 V power supply without BOR option. They are available in the -40 to +105 °C temperature range, extended to 125 °C in low-power dissipation state. A comprehensive set of power-saving modes allows the design of low-power applications.



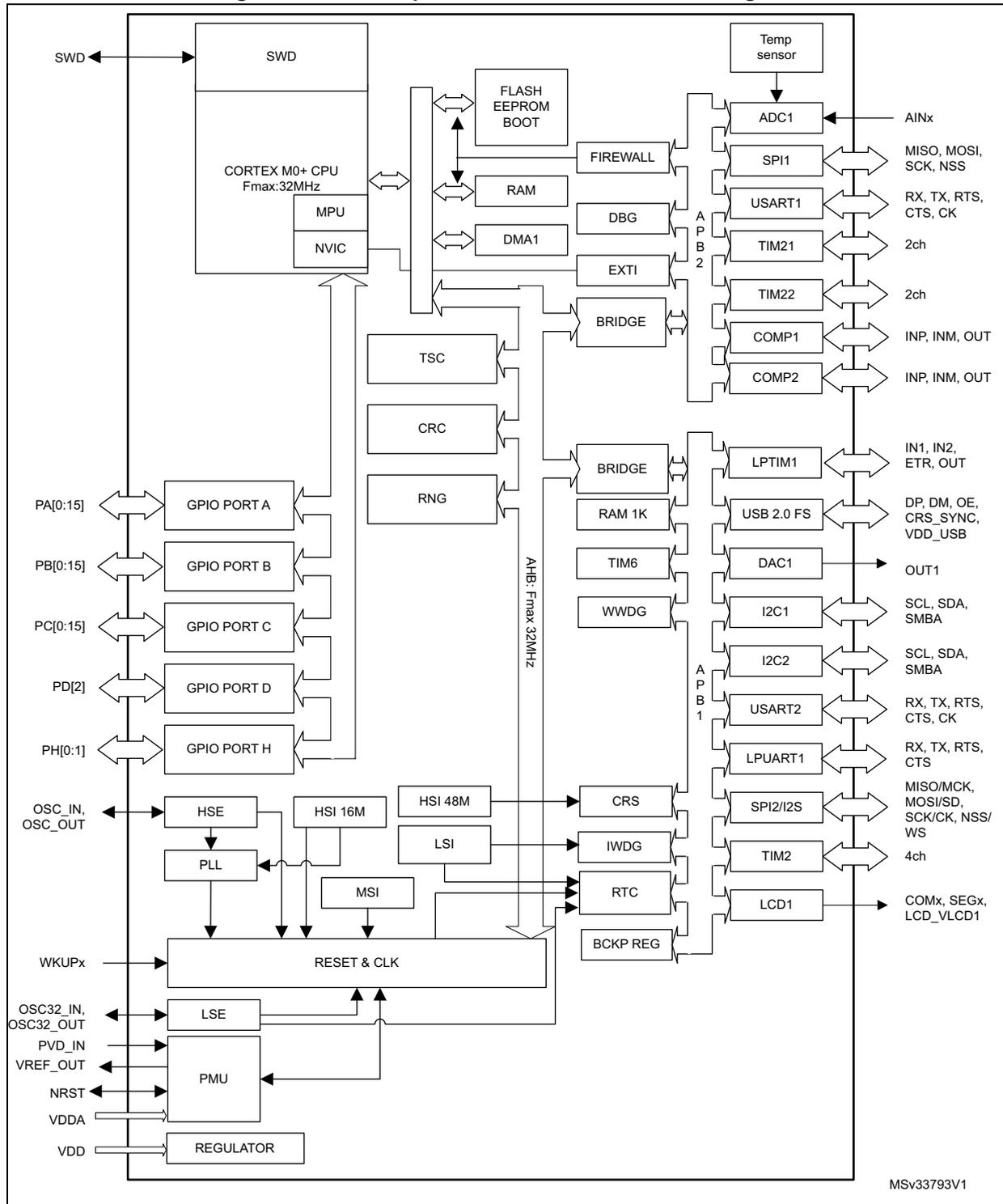
2.1 Device overview

Table 1. Ultra-low-power STM32L053x6/8 device features and peripheral counts

Peripheral		STM32L053C6	STM32L053R6	STM32L053C8	STM32L053R8
Flash (Kbytes)		32		64	
Data EEPROM (Kbytes)		2		2	
RAM (Kbytes)		8		8	
Timers	General-purpose	3		3	
	Basic	1		1	
	LPTIMER	1		1	
RTC/SYSTICK/IWDG/WWDG		1/1/1/1		1/1/1/1	
Communication interfaces	SPI/I2S	2/(1)		2/(1)	
	I ² C	2		2	
	USART	2		2	
	LPUART	1		1	
	USB/(USB_VDD)	1/(1)		1/(1)	
GPIOs		37	51 ⁽¹⁾	37	51 ⁽¹⁾
Clocks: HSE/LSE/HSI/MSI/LSI		1/1/1/1/1		1/1/1/1/1	
12-bit synchronized ADC Number of channels		1 10	1 16	1 10	1 16
12-bit DAC Number of channels		1 1 ⁽¹⁾		1 1 ⁽¹⁾	
LCD COM x SEG		1 4x18	1 4x32 or 8x28 ⁽¹⁾	1 4x18	1 4x32 or 8x28 ⁽¹⁾
Comparators		2		2	
Capacitive sensing channels		17	24 ⁽¹⁾	17	24 ⁽¹⁾
Max. CPU frequency		32 MHz			
Operating voltage		1.8 V to 3.6 V (down to 1.65 V at power-down) with BOR option 1.65 V to 3.6 V without BOR option			
Operating temperatures		Ambient temperature: –40 to +105 °C Junction temperature: –40 to +125 °C			
Packages		LQFP48	LQFP64, TFBGA64	LQFP48	LQFP64, TFBGA64

1. TFBGA64 has one GPIO, one LCD COM x SEG, one ADC input and one capacitive sensing channel less than LQFP64.

Figure 1. Ultra-low-power STM32L053x6/8 block diagram



2.2 Ultra-low-power device continuum

The ultra-low-power family offers a large choice of core and features, from proprietary 8-bit core to up ARM Cortex™-M3, including ARM Cortex™-M0+. The STM32Lx series are the best choice to answer your needs in terms of ultra-low-power features. The STM32 Ultra-low-power series are the best solution for applications such as gaz/water meter, keyboard/mouse or fitness and healthcare application. Several built-in features like LCD drivers, dual-bank memory, low-power Run mode, operational amplifiers, AES 128-bit, DAC, crystal-less USB and many other definitely help you building a highly cost optimized application by reducing BOM cost. STMicroelectronics, as a reliable and long-term manufacturer, ensures as much as possible pin-to-pin compatibility between all STM8Lx and STM32Lx on one hand, and between all STM32Lx and STM32Fx on the other hand. Thanks to this unprecedented scalability, your legacy application can be upgraded to respond to the latest market feature and efficiency requirements.

3 Functional overview

3.1 Low-power modes

The ultra-low-power STM32L053x6/8 devices support dynamic voltage scaling to optimize its power consumption in Run mode. The voltage from the internal low-drop regulator that supplies the logic can be adjusted according to the system's maximum operating frequency and the external voltage supply.

There are three power consumption ranges:

- Range 1 (V_{DD} range limited to 1.71-3.6 V), with the CPU running at up to 32 MHz
- Range 2 (full V_{DD} range), with a maximum CPU frequency of 16 MHz
- Range 3 (full V_{DD} range), with a maximum CPU frequency limited to 4.2 MHz

Seven low-power modes are provided to achieve the best compromise between low-power consumption, short startup time and available wakeup sources:

- **Sleep mode**

In Sleep mode, only the CPU is stopped. All peripherals continue to operate and can wake up the CPU when an interrupt/event occurs. Sleep mode power consumption at 16 MHz is about 1 mA with all peripherals off.
- **Low-power run mode**

This mode is achieved with the multispeed internal (MSI) RC oscillator set to the low-speed clock (max 131 kHz), execution from SRAM or Flash memory, and internal regulator in low-power mode to minimize the regulator's operating current. In Low-power run mode, the clock frequency and the number of enabled peripherals are both limited.
- **Low-power sleep mode**

This mode is achieved by entering Sleep mode with the internal voltage regulator in low-power mode to minimize the regulator's operating current. In Low-power sleep mode, both the clock frequency and the number of enabled peripherals are limited; a typical example would be to have a timer running at 32 kHz.

When wakeup is triggered by an event or an interrupt, the system reverts to the Run mode with the regulator on.
- **Stop mode with RTC**

The Stop mode achieves the lowest power consumption while retaining the RAM and register contents and real time clock. All clocks in the V_{CORE} domain are stopped, the PLL, MSI RC, HSI RC and HSE crystal oscillators are disabled. The LSE or LSI is still running. The voltage regulator is in the low-power mode.

Some peripherals featuring wakeup capability can enable the HSI RC during Stop mode to detect their wakeup condition.

The device can be woken up from Stop mode by any of the EXTI line, in 3.5 μ s, the processor can serve the interrupt or resume the code. The EXTI line source can be any GPIO. It can be the PVD output, the comparator 1 event or comparator 2 event (if

internal reference voltage is on), it can be the RTC alarm/tamper/timestamp/wakeup events, the USB/USART/I2C/LPUART/LPTIMER wakeup events.

- **Stop mode without RTC**

The Stop mode achieves the lowest power consumption while retaining the RAM and register contents. All clocks are stopped, the PLL, MSI RC, HSI and LSI RC, LSE and HSE crystal oscillators are disabled.

Some peripherals featuring wakeup capability can enable the HSI RC during Stop mode to detect their wakeup condition.

The voltage regulator is in the low-power mode. The device can be woken up from Stop mode by any of the EXTI line, in 3.5 μ s, the processor can serve the interrupt or resume the code. The EXTI line source can be any GPIO. It can be the PVD output, the comparator 1 event or comparator 2 event (if internal reference voltage is on). It can also be wakened by the USB/USART/I2C/LPUART/LPTIMER wakeup events.

- **Standby mode with RTC**

The Standby mode is used to achieve the lowest power consumption and real time clock. The internal voltage regulator is switched off so that the entire V_{CORE} domain is powered off. The PLL, MSI RC, HSI RC and HSE crystal oscillators are also switched off. The LSE or LSI is still running. After entering Standby mode, the RAM and register contents are lost except for registers in the Standby circuitry (wakeup logic, IWDG, RTC, LSI, LSE Crystal 32 KHz oscillator, RCC_CSR register).

The device exits Standby mode in 60 μ s when an external reset (NRST pin), an IWDG reset, a rising edge on one of the three WKUP pins, RTC alarm (Alarm A or Alarm B), RTC tamper event, RTC timestamp event or RTC Wakeup event occurs.

- **Standby mode without RTC**

The Standby mode is used to achieve the lowest power consumption. The internal voltage regulator is switched off so that the entire V_{CORE} domain is powered off. The PLL, MSI RC, HSI and LSI RC, HSE and LSE crystal oscillators are also switched off. After entering Standby mode, the RAM and register contents are lost except for registers in the Standby circuitry (wakeup logic, IWDG, RTC, LSI, LSE Crystal 32 KHz oscillator, RCC_CSR register).

The device exits Standby mode in 60 μ s when an external reset (NRST pin) or a rising edge on one of the three WKUP pin occurs.

Note: The RTC, the IWDG, and the corresponding clock sources are not stopped automatically by entering Stop or Standby mode. The LCD is not stopped automatically by entering Stop mode.

Table 2. Functionalities depending on the operating power supply range

Operating power supply range	Functionalities depending on the operating power supply range			
	DAC and ADC operation	USB	Dynamic voltage scaling range	I/O operation
$V_{DD} = 1.65$ to 1.71 V	Not functional	Not functional	Range 2 or range 3	Degraded speed performance
$V_{DD} = 1.71$ to 1.8 V ⁽¹⁾	Not functional	Functional ⁽²⁾	Range 1, range 2 or range 3	Degraded speed performance
$V_{DD} = 1.8$ to 2.0 V ⁽¹⁾	Conversion time up to 1.14 Msps	Functional ⁽²⁾	Range 1, range 2 or range 3	Degraded speed performance
$V_{DD} = 2.0$ to 2.4 V	Conversion time up to 1.14 Msps	Functional ⁽²⁾	Range 1, range 2 or range 3	Full speed operation
$V_{DD} = 2.4$ to 3.6 V	Conversion time up to 1.14 Msps	Functional ⁽²⁾	Range 1, range 2 or range 3	Full speed operation

1. CPU frequency changes from initial to final must respect "fcpu initial <4*fcpu final". It must also respect 5 μ s delay between two changes. For example to switch from 4.2 MHz to 32 MHz, you can switch from 4.2 MHz to 16 MHz, wait 5 μ s, then switch from 16 MHz to 32 MHz.
2. To be USB compliant from the I/O voltage standpoint, the minimum V_{DD_USB} is 3.0 V.

Table 3. CPU frequency range depending on dynamic voltage scaling

CPU frequency range	Dynamic voltage scaling range
16 MHz to 32 MHz (1ws) 32 kHz to 16 MHz (0ws)	Range 1
8 MHz to 16 MHz (1ws) 32 kHz to 8 MHz (0ws)	Range 2
32 kHz to 4.2 MHz (0ws)	Range 3

Table 4. Functionalities depending on the working mode (from Run/active down to standby)

IPs	Run/Active	Sleep	Low-power run	Low-power sleep	Stop		Standby	
					Wakeup capability	Wakeup capability		
CPU	Y	--	Y	--	--		--	
Flash memory	Y	Y	Y	N	--		--	
RAM	Y	Y	Y	Y	Y		--	
Backup registers	Y	Y	Y	Y	Y		Y	
EEPROM	Y	--	Y	Y	Y		--	
Brown-out rest (BOR)	Y	Y	Y	Y	Y	Y	Y	
DMA	Y	Y	Y	Y	--		--	
Programmable Voltage Detector (PVD)	Y	Y	Y	Y	Y	Y	Y	
Power On Reset (POR)	Y	Y	Y	Y	Y	Y	Y	
Power Down Rest (PDR)	Y	Y	Y	Y	Y		Y	
High Speed Internal (HSI)	Y	Y	--	--	--		--	
High Speed External (HSE)	Y	Y	--	--	--		--	
Low Speed Internal (LSI)	Y	Y	Y	Y	Y		--	
Low Speed External (LSE)	Y	Y	Y	Y	Y		--	
Multi-Speed Internal (MSI)	Y	Y	Y	Y	--		--	
Inter-Connect Controller	Y	Y	Y	Y	--		--	
RTC	Y	Y	Y	Y	Y	Y	Y	
RTC Tamper	Y	Y	Y	Y	Y	Y	Y	Y
Auto WakeUp (AWU)	Y	Y	Y	Y	Y	Y	Y	Y
LCD	Y	Y	Y	Y	Y		--	
USB	Y	Y	--	--	--	Y	--	
USART	Y	Y	Y	Y	Y	Y	--	
LPUART	Y	Y	Y	Y	Y	Y	-	
SPI	Y	Y	Y	Y			--	
I2C	Y	Y	Y	Y		Y	--	

Table 4. Functionalities depending on the working mode (from Run/active down to standby)

IPs	Run/Active	Sleep	Low-power run	Low-power sleep	Stop		Standby	
					Wakeup capability	Wakeup capability		
ADC	Y	Y	--	--	--		--	
DAC	Y	Y	Y	Y	Y		--	
Temperature sensor	Y	Y	Y	Y	Y		--	
Comparators	Y	Y	Y	Y	Y	Y	--	
16-bit and 32-bit Timers	Y	Y	Y	Y	--		--	
LPTIMER	Y	Y	Y	Y	Y	Y		
IWDG	Y	Y	Y	Y	Y	Y	Y	Y
WWDG	Y	Y	Y	Y	--		--	
Touch sensing controller (TSC)	Y	Y	--	--	--		--	
SysTick Timer	Y	Y	Y	Y			--	
GPIOs	Y	Y	Y	Y	Y	Y		2 pins
Wakeup time to Run mode	0 μ s	0.36 μ s	3 μ s	32 μ s	3.5 μ s		50 μ s	
Consumption V_{DD} =1.8 to 3.6 V (Typ)	Down to 140 μ A/MHz (from Flash)	Down to 37 μ A/MHz (from Flash)	Down to 8 μ A	Down to 4.5 μ A	0.4 μ A (No RTC) V_{DD} =1.8 V		0.28 μ A (No RTC) V_{DD} =1.8 V	
					0.8 μ A (with RTC) V_{DD} =1.8 V		0.65 μ A (with RTC) V_{DD} =1.8 V	
					0.4 μ A (No RTC) V_{DD} =3.0 V		0.29 μ A (No RTC) V_{DD} =3.0 V	
					1 μ A (with RTC) V_{DD} =3.0 V		0.85 μ A (with RTC) V_{DD} =3.0 V	

3.2 ARM® Cortex™-M0+ core with MPU

The Cortex-M0+ processor is an entry-level 32-bit ARM Cortex processor designed for a broad range of embedded applications. It offers significant benefits to developers, including:

- a simple architecture that is easy to learn and program
- ultra-low power, energy-efficient operation
- excellent code density
- deterministic, high-performance interrupt handling
- upward compatibility with Cortex-M processor family
- platform security robustness, with integrated Memory Protection Unit (MPU).

The Cortex-M0+ processor is built on a highly area and power optimized 32-bit processor core, with a 2-stage pipeline von Neumann architecture. The processor delivers exceptional

energy efficiency through a small but powerful instruction set and extensively optimized design, providing high-end processing hardware including a single-cycle multiplier.

The Cortex-M0+ processor provides the exceptional performance expected of a modern 32-bit architecture, with a higher code density than other 8-bit and 16-bit microcontrollers.

Owing to its embedded ARM core, the STM32L053x6/8 are compatible with all ARM tools and software.

Nested vectored interrupt controller (NVIC)

The ultra-low-power STM32L053x6/8 embed a nested vectored interrupt controller able to handle up to 32 maskable interrupt channels and 4 priority levels.

The Cortex-M0+ processor closely integrates a configurable Nested Vectored Interrupt Controller (NVIC), to deliver industry-leading interrupt performance. The NVIC:

- includes a Non-Maskable Interrupt (NMI)
- provides zero jitter interrupt option
- provides four interrupt priority levels

The tight integration of the processor core and NVIC provides fast execution of Interrupt Service Routines (ISRs), dramatically reducing the interrupt latency. This is achieved through the hardware stacking of registers, and the ability to abandon and restart load-multiple and store-multiple operations. Interrupt handlers do not require any assembler wrapper code, removing any code overhead from the ISRs. Tail-chaining optimization also significantly reduces the overhead when switching from one ISR to another.

To optimize low-power designs, the NVIC integrates with the sleep modes, that include a deep sleep function that enables the entire device to enter rapidly stop or standby mode.

This hardware block provides flexible interrupt management features with minimal interrupt latency.

3.3 Reset and supply management

3.3.1 Power supply schemes

- $V_{DD} = 1.65$ to 3.6 V: external power supply for I/Os and the internal regulator. Provided externally through V_{DD} pins.
- V_{SSA} , $V_{DDA} = 1.65$ to 3.6 V: external analog power supplies for ADC, reset blocks, RCs and PLL (minimum voltage to be applied to V_{DDA} is 1.8 V when the ADC is used). V_{DDA} and V_{SSA} must be connected to V_{DD} and V_{SS} , respectively.
- $V_{DD_USB} = 1.65$ to 3.6 V: external power supply for USB transceiver, USB_DM (PA11) and USB_DP (PA12). To guarantee a correct voltage level for USB communication V_{DD_USB} must be above 3.0 V. If USB is not used this pin must be tied to V_{DD} .

3.3.2 Power supply supervisor

The device has an integrated ZEROPOWER power-on reset (POR)/power-down reset (PDR) that can be coupled with a brownout reset (BOR) circuitry.

The device exists in two versions:

- The version with BOR activated at power-on operates between 1.8 V and 3.6 V.
- The other version without BOR operates between 1.65 V and 3.6 V.

After the V_{DD} threshold is reached (1.65 V or 1.8 V depending on the BOR which is active or not at power-on), the option byte loading process starts, either to confirm or modify default thresholds, or to disable the BOR permanently: in this case, the VDD min value becomes 1.65 V (whatever the version, BOR active or not, at power-on).

When BOR is active at power-on, it ensures proper operation starting from 1.8 V whatever the power ramp-up phase before it reaches 1.8 V. When BOR is not active at power-up, the power ramp-up should guarantee that 1.65 V is reached on V_{DD} at least 1 ms after it exits the POR area.

Five BOR thresholds are available through option bytes, starting from 1.8 V to 3 V. To reduce the power consumption in Stop mode, it is possible to automatically switch off the internal reference voltage (V_{REFINT}) in Stop mode. The device remains in reset mode when V_{DD} is below a specified threshold, $V_{POR/PDR}$ or V_{BOR} , without the need for any external reset circuit.

Note: The start-up time at power-on is typically 3.3 ms when BOR is active at power-up, the start-up time at power-on can be decreased down to 1 ms typically for devices with BOR inactive at power-up.

The device features an embedded programmable voltage detector (PVD) that monitors the V_{DD}/V_{DDA} power supply and compares it to the V_{PVD} threshold. This PVD offers 7 different levels between 1.85 V and 3.05 V, chosen by software, with a step around 200 mV. An interrupt can be generated when V_{DD}/V_{DDA} drops below the V_{PVD} threshold and/or when V_{DD}/V_{DDA} is higher than the V_{PVD} threshold. The interrupt service routine can then generate a warning message and/or put the MCU into a safe state. The PVD is enabled by software.

3.3.3 Voltage regulator

The regulator has three operation modes: main (MR), low power (LPR) and power down.

- MR is used in Run mode (nominal regulation)
- LPR is used in the Low-power run, Low-power sleep and Stop modes
- Power down is used in Standby mode. The regulator output is high impedance, the kernel circuitry is powered down, inducing zero consumption but the contents of the registers and RAM are lost except for the standby circuitry (wake-up logic, IWDG, RTC, LSI, LSE crystal 32 KHz oscillator, RCC_CSR).

3.3.4 Boot modes

At startup, BOOT0 pin and BOOT1 option bit are used to select one of three boot options:

- Boot from Flash memory
- Boot from System memory
- Boot from embedded RAM

The boot loader is located in System memory. It is used to reprogram the Flash memory by using USART1(PA9, PA10), USART2(PA2, PA3), SPI1(PA4, PA5, PA6, PA7) or SPI2(PB12, PB13, PB14, PB15). See STM32™ microcontroller system memory boot mode AN2606 for details.

3.4 Clock management

The clock controller distributes the clocks coming from different oscillators to the core and the peripherals. It also manages clock gating for low-power modes and ensures clock robustness. It features:

- **Clock prescaler**

To get the best trade-off between speed and current consumption, the clock frequency to the CPU and peripherals can be adjusted by a programmable prescaler.
- **Safe clock switching**

Clock sources can be changed safely on the fly in Run mode through a configuration register.
- **Clock management**

To reduce power consumption, the clock controller can stop the clock to the core, individual peripherals or memory.
- **System clock source**

Three different clock sources can be used to drive the master clock SYSCLK:

 - 1-24 MHz high-speed external crystal (HSE), that can supply a PLL
 - 16 MHz high-speed internal RC oscillator (HSI), trimmable by software, that can supply a PLL
 - Multispeed internal RC oscillator (MSI), trimmable by software, able to generate 7 frequencies (65 kHz, 131 kHz, 262 kHz, 524 kHz, 1.05 MHz, 2.1 MHz, 4.2 MHz). When a 32.768 kHz clock source is available in the system (LSE), the MSI frequency can be trimmed by software down to a $\pm 0.5\%$ accuracy.
- **Auxiliary clock source**

Two ultra-low-power clock sources that can be used to drive the LCD controller and the real-time clock:

 - 32.768 kHz low-speed external crystal (LSE)
 - 37 kHz low-speed internal RC (LSI), also used to drive the independent watchdog. The LSI clock can be measured using the high-speed internal RC oscillator for greater precision.
- **RTC and LCD clock sources**

The LSI, LSE or HSE sources can be chosen to clock the RTC and the LCD, whatever the system clock.
- **USB clock source**

A 48 MHz clock trimmed through the USB SOF supplies the USB interface.
- **Startup clock**

After reset, the microcontroller restarts by default with an internal 2 MHz clock (MSI). The prescaler ratio and clock source can be changed by the application program as soon as the code execution starts.
- **Clock security system (CSS)**

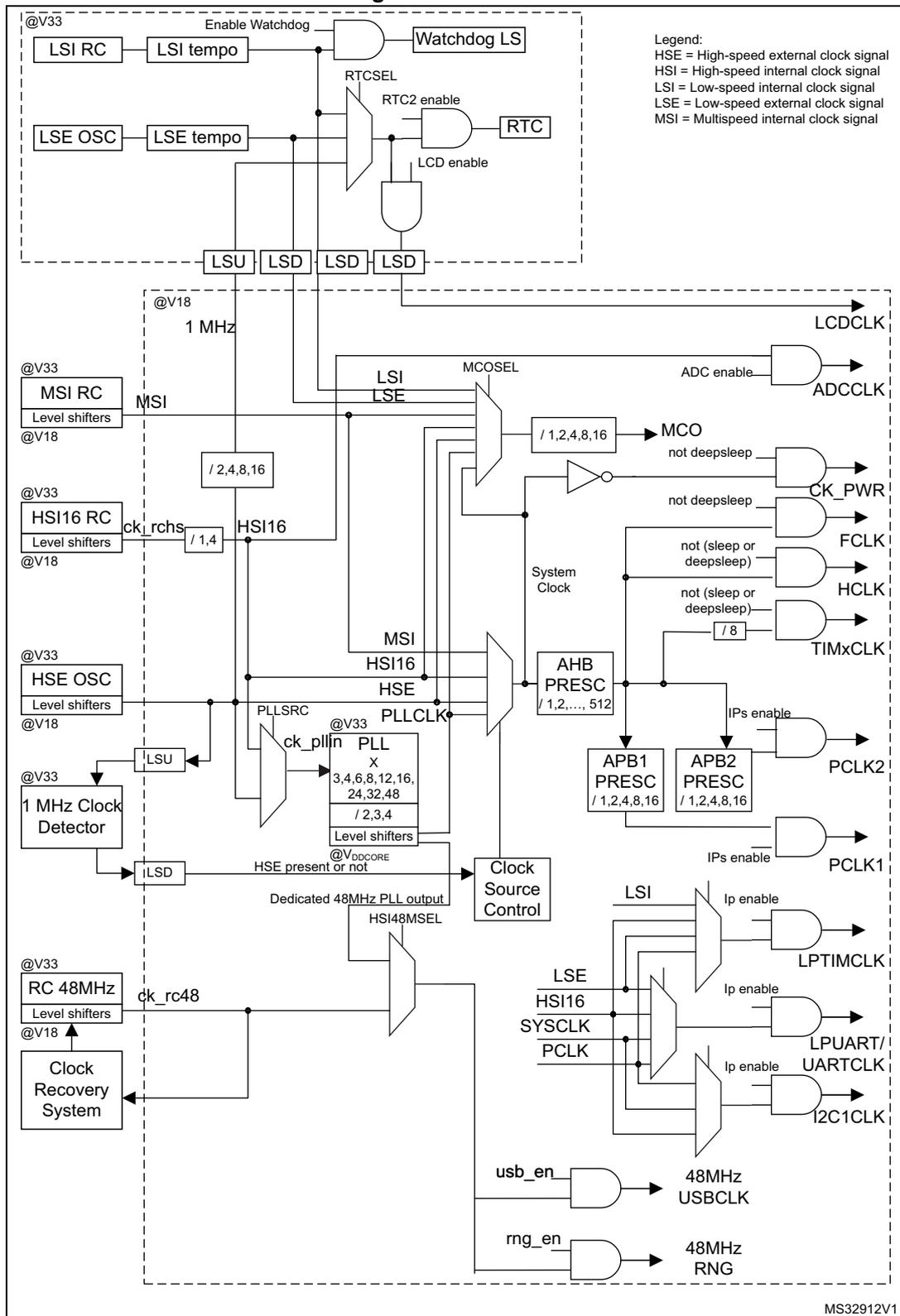
This feature can be enabled by software. If an HSE clock failure occurs, the master clock is automatically switched to HSI and a software interrupt is generated if enabled. Another clock security system can be enabled, in case of failure of the LSE it provides an interrupt or wakeup event which is generated if enabled.

- **Clock-out capability (MCO: microcontroller clock output)**

It outputs one of the internal clocks for external use by the application.

Several prescalers allow the configuration of the AHB frequency, each APB (APB1 and APB2) domains. The maximum frequency of the AHB and the APB domains is 32 MHz. See [Figure 2](#) for details on the clock tree.

Figure 2. Clock tree



1. For the USB function to be available, both HSE and PLL must be enabled, with the CPU running at either 24 MHz or 32 MHz.

3.5 Low-power real-time clock and backup registers

The real time clock (RTC) and the 5 backup registers are supplied in all modes including standby mode. The backup registers are five 32-bit registers used to store 20 bytes of user application data. They are not reset by a system reset, or when the device wakes up from Standby mode.

The RTC is an independent BCD timer/counter. Its main features are the following:

- Calendar with subsecond, seconds, minutes, hours (12 or 24 format), week day, date, month, year, in BCD (binary-coded decimal) format
- Automatically correction for 28, 29 (leap year), 30, and 31 day of the month
- Two programmable alarms with wake up from Stop and Standby mode capability
- Periodic wakeup from Stop and Standby with programmable resolution and period
- On-the-fly correction from 1 to 32767 RTC clock pulses. This can be used to synchronize it with a master clock.
- Reference clock detection: a more precise second source clock (50 or 60 Hz) can be used to enhance the calendar precision.
- Digital calibration circuit with 1 ppm resolution, to compensate for quartz crystal inaccuracy
- 2 anti-tamper detection pins with programmable filter. The MCU can be woken up from Stop and Standby modes on tamper event detection.
- Timestamp feature which can be used to save the calendar content. This function can be triggered by an event on the timestamp pin, or by a tamper event. The MCU can be woken up from Stop and Standby modes on timestamp event detection.

The RTC clock sources can be:

- A 32.768 kHz external crystal
- A resonator or oscillator
- The internal low-power RC oscillator (typical frequency of 37 kHz)
- The high-speed external clock

3.6 General-purpose inputs/outputs (GPIOs)

Each of the GPIO pins can be configured by software as output (push-pull or open-drain), as input (with or without pull-up or pull-down) or as peripheral alternate function. Most of the GPIO pins are shared with digital or analog alternate functions, and can be individually remapped using dedicated alternate function registers. All GPIOs are high current capable. Each GPIO output, speed can be slowed (40 MHz, 10 MHz, 2 MHz, 400 kHz). The alternate function configuration of I/Os can be locked if needed following a specific sequence in order to avoid spurious writing to the I/O registers. The I/O controller is connected to a dedicated IO bus with a toggling speed of up to 32 MHz.

Extended interrupt/event controller (EXTI)

The extended interrupt/event controller consists of 28 edge detector lines used to generate interrupt/event requests. Each line can be individually configured to select the trigger event (rising edge, falling edge, both) and can be masked independently. A pending register maintains the status of the interrupt requests. The EXTI can detect an external line with a pulse width shorter than the Internal APB2 clock period. Up to 51 GPIOs can be connected to the 16 configurable interrupt/event lines. The 12 other lines are connected to PVD, RTC, USB, USARTs, LPUART, LPTIMER or comparator events.

3.7 Memories

The STM32L053x6/8 devices have the following features:

- 8 Kbytes of embedded SRAM accessed (read/write) at CPU clock speed with 0 wait states. With the enhanced bus matrix, operating the RAM does not lead to any performance penalty during accesses to the system bus (AHB and APB buses).
- The non-volatile memory is divided into three arrays:
 - 32 or 64 Kbytes of embedded Flash program memory
 - 2 Kbytes of data EEPROM
 - Information block containing 32 user and factory options bytes plus 4 Kbytes of system memory

The user options bytes are used to write-protect or read-out protect the memory (with 4 Kbyte granularity) and/or readout-protect the whole memory with the following options:

- **Level 0:** no protection
- **Level 1:** memory readout protected.
The Flash memory cannot be read from or written to if either debug features are connected or boot in RAM is selected
- **Level 2:** chip readout protected, debug features (Cortex-M0+ serial wire) and boot in RAM selection disabled (debugline fuse)

The firewall protects parts of code/data from access by the rest of the code that is executed outside of the protected area. The granularity of the protected code segment or the non-volatile data segment is 256 bytes (Flash or EEPROM) against 64 bytes for the volatile data segment (RAM).

The whole non-volatile memory embeds the error correction code (ECC) feature.

3.8 Direct memory access (DMA)

The flexible 7-channel, general-purpose DMA is able to manage memory-to-memory, peripheral-to-memory and memory-to-peripheral transfers. The DMA controller supports circular buffer management, avoiding the generation of interrupts when the controller reaches the end of the buffer.

Each channel is connected to dedicated hardware DMA requests, with software trigger support for each channel. Configuration is done by software and transfer sizes between source and destination are independent.

The DMA can be used with the main peripherals: SPI, I²C, USART, LPUART, general-purpose timers, DAC and ADC.

3.9 Liquid crystal display (LCD)

The LCD drives up to 8 common terminals and 32 segment terminals to drive up to 224 pixels.

- Internal step-up converter to guarantee functionality and contrast control irrespective of V_{DD} . This converter can be deactivated, in which case the V_{LCD} pin is used to provide the voltage to the LCD
- Supports static, 1/2, 1/3, 1/4 and 1/8 duty
- Supports static, 1/2, 1/3 and 1/4 bias
- Phase inversion to reduce power consumption and EMI
- Up to 8 pixels can be programmed to blink
- Unneeded segments and common pins can be used as general I/O pins
- LCD RAM can be updated at any time owing to a double-buffer
- The LCD controller can operate in Stop mode
- V_{LCD} rails decoupling capability

3.10 Analog-to-digital converter (ADC)

A native 12-bit, extended to 16-bit through hardware oversampling, analog-to-digital converter is embedded into STM32L053x6/8 devices. It has up to 16 external channels and 3 internal channels (temperature sensor, voltage reference, $1/4V_{LCD}$ voltage measurement). It performs conversions in single-shot or scan mode. In scan mode, automatic conversion is performed on a selected group of analog inputs.

The ADC frequency is independent from the CPU frequency, allowing maximum sampling rate of 1.14 MSPS even with a low CPU speed. The ADC consumption is low at all frequencies (~25 μ A at 10 kSPS, ~200 μ A at 1MSPS). An auto-shutdown function guarantees that the ADC is powered off except during the active conversion phase.

The ADC can be served by the DMA controller.

The ADC features a hardware oversampler up to 256 samples, this improves the resolution to 16 bits (see AN2668).

An analog watchdog feature allows very precise monitoring of the converted voltage of one, some or all scanned channels. An interrupt is generated when the converted voltage is outside the programmed thresholds.

The events generated by the general-purpose timers (TIMx) can be internally connected to the ADC start triggers, to allow the application to synchronize A/D conversions and timers.

3.11 Temperature sensor

The temperature sensor (T_{SENSE}) generates a voltage V_{SENSE} that varies linearly with temperature.

The temperature sensor is internally connected to the ADC_IN18 input channel which is used to convert the sensor output voltage into a digital value.

The sensor provides good linearity but it has to be calibrated to obtain good overall accuracy of the temperature measurement. As the offset of the temperature sensor varies

from chip to chip due to process variation, the uncalibrated internal temperature sensor is suitable for applications that detect temperature changes only.

To improve the accuracy of the temperature sensor measurement, each device is individually factory-calibrated by ST. The temperature sensor factory calibration data are stored by ST in the system memory area, accessible in read-only mode.

Table 5. Temperature sensor calibration values

Calibration value name	Description	Memory address
TSENSE_CAL1	TS ADC raw data acquired at temperature of 30 °C, $V_{DDA} = 3\text{ V}$	0x1FF8 007A - 0x1FF8 007B
TSENSE_CAL2	TS ADC raw data acquired at temperature of 130 °C $V_{DDA} = 3\text{ V}$	0x1FF8 007E - 0x1FF8 007F

3.11.1 Internal voltage reference (V_{REFINT})

The internal voltage reference (V_{REFINT}) provides a stable (bandgap) voltage output for the ADC and Comparators. V_{REFINT} is internally connected to the ADC_IN17 input channel. It enables accurate monitoring of the V_{DD} value (when no external voltage, V_{REF+} , is available for ADC). The precise voltage of V_{REFINT} is individually measured for each part by ST during production test and stored in the system memory area. It is accessible in read-only mode.

Table 6. Internal voltage reference measured values

Calibration value name	Description	Memory address
VREFINT_CAL	Raw data acquired at temperature of 30 °C $V_{DDA} = 3\text{ V}$	0x1FF8 0078 - 0x1FF8 0079

3.11.2 V_{LCD} voltage monitoring

This embedded hardware feature allows the application to measure the V_{LCD} supply voltage using the internal ADC channel ADC_IN16. As the V_{LCD} voltage may be higher than V_{DDA} , and thus outside the ADC input range, the ADC input is connected to LCD_VLCD1 (which provides $1/3V_{LCD}$ when the LCD is configured 1/3Bias and $1/4V_{LCD}$ when the LCD is configured 1/4Bias or 1/2Bias).

3.12 Digital-to-analog converter (DAC)

One 12-bit buffered DAC can be used to convert digital signal into analog voltage signal output. An optional amplifier can be used to reduce the output signal impedance.

This digital Interface supports the following features:

- One data holding register
- Left or right data alignment in 12-bit mode
- Synchronized update capability
- Noise-wave generation
- Triangular-wave generation
- DMA capability (including the underrun interrupt)
- External triggers for conversion
- Input reference voltage V_{REF+}

Four DAC trigger inputs are used in the STM32L053x6/8. The DAC channel is triggered through the timer update outputs that are also connected to different DMA channels.

3.13 Ultra-low-power comparators and reference voltage

The STM32L053x6/8 embed two comparators sharing the same current bias and reference voltage. The reference voltage can be internal or external (coming from an I/O).

- One comparator with ultra low consumption
- One comparator with rail-to-rail inputs, fast or slow mode.
- The threshold can be one of the following:
 - DAC output
 - External I/O pins
 - Internal reference voltage (V_{REFINT})
 - submultiple of Internal reference voltage(1/4, 1/2, 3/4) for the rail to rail comparator.

Both comparators can wake up the devices from Stop mode, and be combined into a window comparator.

The internal reference voltage is available externally via a low-power / low-current output buffer (driving current capability of 1 μ A typical).

3.14 System configuration controller

The system configuration controller provides the capability to remap some alternate functions on different I/O ports.

The highly flexible routing interface allows the application firmware to control the routing of different I/Os to the TIM2, TIM21, TIM22 and LPTIM timer input captures. It also controls the routing of internal analog signals to the USB internal oscillator, ADC, COMP1 and COMP2 and the internal reference voltage V_{REFINT} .

3.15 Touch sensing controller (TSC)

The STM32L053x6/8 devices provide a simple solution for adding capacitive sensing functionality to any application. These devices offer up to 24 capacitive sensing channels distributed over 8 analog I/O groups.

Capacitive sensing technology is able to detect the presence of a finger near a sensor which is protected from direct touch by a dielectric (such as glass, plastic). The capacitive variation introduced by the finger (or any conductive object) is measured using a proven implementation based on a surface charge transfer acquisition principle. It consists of charging the sensor capacitance and then transferring a part of the accumulated charges into a sampling capacitor until the voltage across this capacitor has reached a specific threshold. To limit the CPU bandwidth usage, this acquisition is directly managed by the hardware touch sensing controller and only requires few external components to operate.

The touch sensing controller is fully supported by the STMTouch touch sensing firmware library, which is free to use and allows touch sensing functionality to be implemented reliably in the end application.

Table 7. Capacitive sensing GPIOs available on STM32L053x6/8 devices

Group	Capacitive sensing signal name	Pin name	Group	Capacitive sensing signal name	Pin name
1	TSC_G1_IO1	PA0	5	TSC_G5_IO1	PB3
	TSC_G1_IO2	PA1		TSC_G5_IO2	PB4
	TSC_G1_IO3	PA2		TSC_G5_IO3	PB6
	TSC_G1_IO4	PA3		TSC_G5_IO4	PB7
2	TSC_G2_IO1	PA4	6	TSC_G6_IO1	PB11
	TSC_G2_IO2	PA5		TSC_G6_IO2	PB12
	TSC_G2_IO3	PA6		TSC_G6_IO3	PB13
	TSC_G2_IO4	PA7		TSC_G6_IO4	PB14
3	TSC_G3_IO1	PC5	7	TSC_G7_IO1	PC0
	TSC_G3_IO2	PB0		TSC_G7_IO2	PC1
	TSC_G3_IO3	PB1		TSC_G7_IO3	PC2
	TSC_G3_IO4	PB2		TSC_G7_IO4	PC3
4	TSC_G4_IO1	PA9	8	TSC_G8_IO1	PC6
	TSC_G4_IO2	PA10		TSC_G8_IO2	PC7
	TSC_G4_IO3	PA11		TSC_G8_IO3	PC8
	TSC_G4_IO4	PA12		TSC_G8_IO4	PC9

3.16 Timers and watchdogs

The ultra-low-power STM32L053x6/8 devices include three general-purpose timers, one low-power timer (LPTM), one basic timer, two watchdog timers and the SysTick timer.

[Table 8](#) compares the features of the general-purpose and basic timers.

Table 8. Timer feature comparison

Timer	Counter resolution	Counter type	Prescaler factor	DMA request generation	Capture/compare channels	Complementary outputs
TIM2	16-bit	Up, down, up/down	Any integer between 1 and 65536	Yes	4	No
TIM21, TIM22	16-bit	Up, down, up/down	Any integer between 1 and 65536	No	2	No
TIM6	16-bit	Up	Any integer between 1 and 65536	Yes	0	No

3.16.1 General-purpose timers (TIM2, TIM21 and TIM22)

There are three synchronizable general-purpose timers embedded in the STM32L053x6/8 devices (see [Table 8](#) for differences).

TIM2

TIM2 is based on 16-bit auto-reload up/down counter. It includes a 16-bit prescaler. It features four independent channels each for input capture/output compare, PWM or one-pulse mode output.

The TIM2 general-purpose timers can work together or with the TIM21 and TIM22 general-purpose timers via the Timer Link feature for synchronization or event chaining. Their counter can be frozen in debug mode. Any of the general-purpose timers can be used to generate PWM outputs.

TIM2 have independent DMA request generation.

This timer is capable of handling quadrature (incremental) encoder signals and the digital outputs from 1 to 3 hall-effect sensors.

TIM21 and TIM22

TIM21 and TIM22 are based on a 16-bit auto-reload up/down counter. They include a 16-bit prescaler. They have two independent channels for input capture/output compare, PWM or one-pulse mode output. They can work together and be synchronized with the TIM2, full-featured general-purpose timers.

They can also be used as simple time bases and be clocked by the LSE clock source (32.768 kHz) to provide time bases independent from the main CPU clock.

3.16.2 Low-power Timer (LPTIM)

The low-power timer has an independent clock and is running also in Stop mode if it is clocked by LSE, LSI or an external clock. It is able to wakeup the devices from Stop mode.

This low-power timer supports the following features:

- 16-bit up counter with 16-bit autoreload register
- 16-bit compare register
- Configurable output: pulse, PWM
- Continuous / one shot mode
- Selectable software / hardware input trigger
- Selectable clock source
 - Internal clock source: LSE, LSI, HSI or APB clock
 - External clock source over LPTIM input (working even with no internal clock source running, used by the Pulse Counter Application)
- Programmable digital glitch filter
- Encoder mode

3.16.3 Basic timer (TIM6)

This timer is mainly used for DAC trigger generation. It can also be used as a generic 16-bit timebase.

3.16.4 SysTick timer

This timer is dedicated to the OS, but could also be used as a standard downcounter. It is based on a 24-bit downcounter with autoreload capability and a programmable clock source. It features a maskable system interrupt generation when the counter reaches '0'.

3.16.5 Independent watchdog (IWDG)

The independent watchdog is based on a 12-bit downcounter and 8-bit prescaler. It is clocked from an independent 37 kHz internal RC and, as it operates independently of the main clock, it can operate in Stop and Standby modes. It can be used either as a watchdog to reset the device when a problem occurs, or as a free-running timer for application timeout management. It is hardware- or software-configurable through the option bytes. The counter can be frozen in debug mode.

3.16.6 Window watchdog (WWDG)

The window watchdog is based on a 7-bit downcounter that can be set as free-running. It can be used as a watchdog to reset the device when a problem occurs. It is clocked from the main clock. It has an early warning interrupt capability and the counter can be frozen in debug mode.

3.17 Communication interfaces

3.17.1 I²C bus

Up to two I²C interfaces (I2C1 and I2C2) can operate in multimaster or slave modes. Both can support Standard mode (Sm, up to 100 kbit/s), Fast mode (Fm, up to 400 kbit/s) and Fast Mode Plus (Fm+, up to 1 Mbit/s) with 20 mA output drive on some I/Os.

Both support 7-bit and 10-bit addressing modes, multiple 7-bit slave addresses (2 addresses, 1 with configurable mask). They also include programmable analog and digital noise filters.

Table 9. Comparison of I2C analog and digital filters

	Analog filter	Digital filter
Pulse width of suppressed spikes	≥ 50 ns	Programmable length from 1 to 15 I2C peripheral clocks
Benefits	Available in Stop mode	1. Extra filtering capability vs. standard requirements. 2. Stable length
Drawbacks	Variations depending on temperature, voltage, process	Wakeup from Stop on address match is not available when digital filter is enabled.

In addition, I2C1 provides hardware support for SMBus 2.0 and PMBus 1.1: ARP capability, Host notify protocol, hardware CRC (PEC) generation/verification, timeouts verifications and ALERT protocol management. I2C1 also has a clock domain independent from the CPU clock, allowing the I2C1 to wake up the MCU from Stop mode on address match.

The I2C interfaces can be served by the DMA controller.

Refer to [Table 10](#) for the differences between I2C1 and I2C2.

Table 10. STM32L053x6/8 I²C implementation

I2C features ⁽¹⁾	I2C1	I2C2
7-bit addressing mode	X	X
10-bit addressing mode	X	X
Standard mode (up to 100 kbit/s)	X	X
Fast mode (up to 400 kbit/s)	X	X
Fast Mode Plus with 20 mA output drive I/Os (up to 1 Mbit/s)	X	X ⁽²⁾
Independent clock	X	-
SMBus	X	-
Wakeup from STOP	X	-

1. X = supported.

2. See [Table 14: STM32L053x6/8 pin definitions on page 39](#) for the list of I/Os that feature Fast Mode Plus capability

3.17.2 Universal synchronous/asynchronous receiver transmitter (USART)

The two USART interfaces (USART1 and USART2) are able to communicate at speeds of up to 4 Mbit/s.

They provide hardware management of the CTS, RTS and RS485 driver enable (DE) signals, multiprocessor communication mode, master synchronous communication and single-wire half-duplex communication mode. The support also SmartCard communication (ISO 7816), IrDA SIR ENDEC, LIN Master/Slave capability, auto baud rate feature and has

a clock domain independent from the CPU clock, allowing to wake up the MCU from Stop mode.

All USART interfaces can be served by the DMA controller.

Refer to [Table 11](#) for the supported modes and features of USART1 and USART2.

Table 11. USART implementation

USART modes/features ⁽¹⁾	USART1 and USART2
Hardware flow control for modem	X
Continuous communication using DMA	X
Multiprocessor communication	X
Synchronous mode	X
Smartcard mode	X
Single-wire half-duplex communication	X
IrDA SIR ENDEC block	X
LIN mode	X
Dual clock domain and wakeup from Stop mode	X
Receiver timeout interrupt	X
Modbus communication	X
Auto baud rate detection (4 modes)	X
Driver Enable	X

1. X = supported.

3.17.3 Low-power universal asynchronous receiver transmitter (LPUART)

The devices embed one Low-power UART. The LPUART supports asynchronous serial communication with minimum power consumption. It supports half duplex single wire communication and modem operations (CTS/RTS). It allows multiprocessor communication.

The LPUART has a clock domain independent from the CPU clock, and can wake up the system from Stop mode. The Wakeup events from Stop mode are programmable and can be:

- Start bit detection
- Or any received data frame
- Or a specific programmed data frame

Only a 32.768 kHz clock (LSE) is needed to allow LPUART communication up to 9600 baud. Therefore, even in Stop mode, the LPUART can wait for an incoming frame while having an extremely low energy consumption. Higher speed clock can be used to reach higher baudrates.

LPUART interface can be served by the DMA controller.

3.17.4 Serial peripheral interface (SPI)/Inter-integrated sound (I2S)

Up to two SPIs are able to communicate at up to 16 Mbits/s in slave and master modes in full-duplex and half-duplex communication modes. The 3-bit prescaler gives 8 master mode

frequencies and the frame is configurable to 8 bits or 16 bits. The hardware CRC generation/verification supports basic SD Card/MMC modes.

One standard I2S interfaces (multiplexed with SPI2) is available. It can operate in master or slave mode, and can be configured to operate with a 16-/32-bit resolution as input or output channels. Audio sampling frequencies from 8 kHz up to 192 kHz are supported. When the I2S interfaces is configured in master mode, the master clock can be output to the external DAC/CODEC at 256 times the sampling frequency.

The SPIs can be served by the DMA controller.

Refer to [Table 12](#) for the differences between SPI1 and SPI2.

Table 12. SPI/I2S implementation

SPI features ⁽¹⁾	SPI1	SPI2
Hardware CRC calculation	X	X
Rx/Tx FIFO	X	X
NSS pulse mode	X	X
I2S mode	-	X
TI mode	X	X

1. X = supported.

3.17.5 Universal serial bus (USB)

The STM32L053x6/8 embeds a full-speed USB device peripheral compliant with the USB specification version 2.0. The internal USB PHY supports USB FS signaling, embedded DP pull-up and also battery charging detection according to Battery Charging Specification Revision 1.2. The USB interface implements a full-speed (12 Mbit/s) function interface with added support for USB 2.0 Link Power Management. It has software-configurable endpoint setting with packet memory up to 1 KB and suspend/resume support. It requires a precise 48 MHz clock which can be generated from the internal main PLL (the clock source must use a HSE crystal oscillator) or by the internal 48 MHz oscillator in automatic trimming mode. The synchronization for this oscillator can be taken from the USB data stream itself (SOF signalization) which allows crystal-less operation.

3.18 Clock recovery system (CRS)

The STM32L053x6/8 embeds a special block which allows automatic trimming of the internal 48 MHz oscillator to guarantee its optimal accuracy over the whole device operational range. This automatic trimming is based on the external synchronization signal, which could be either derived from USB SOF signalization, from LSE oscillator, from an external signal on CRS_SYNC pin or generated by user software. For faster lock-in during startup it is also possible to combine automatic trimming with manual trimming action.

3.19 Cyclic redundancy check (CRC) calculation unit

The CRC (cyclic redundancy check) calculation unit is used to get a CRC code using a configurable generator polynomial value and size.

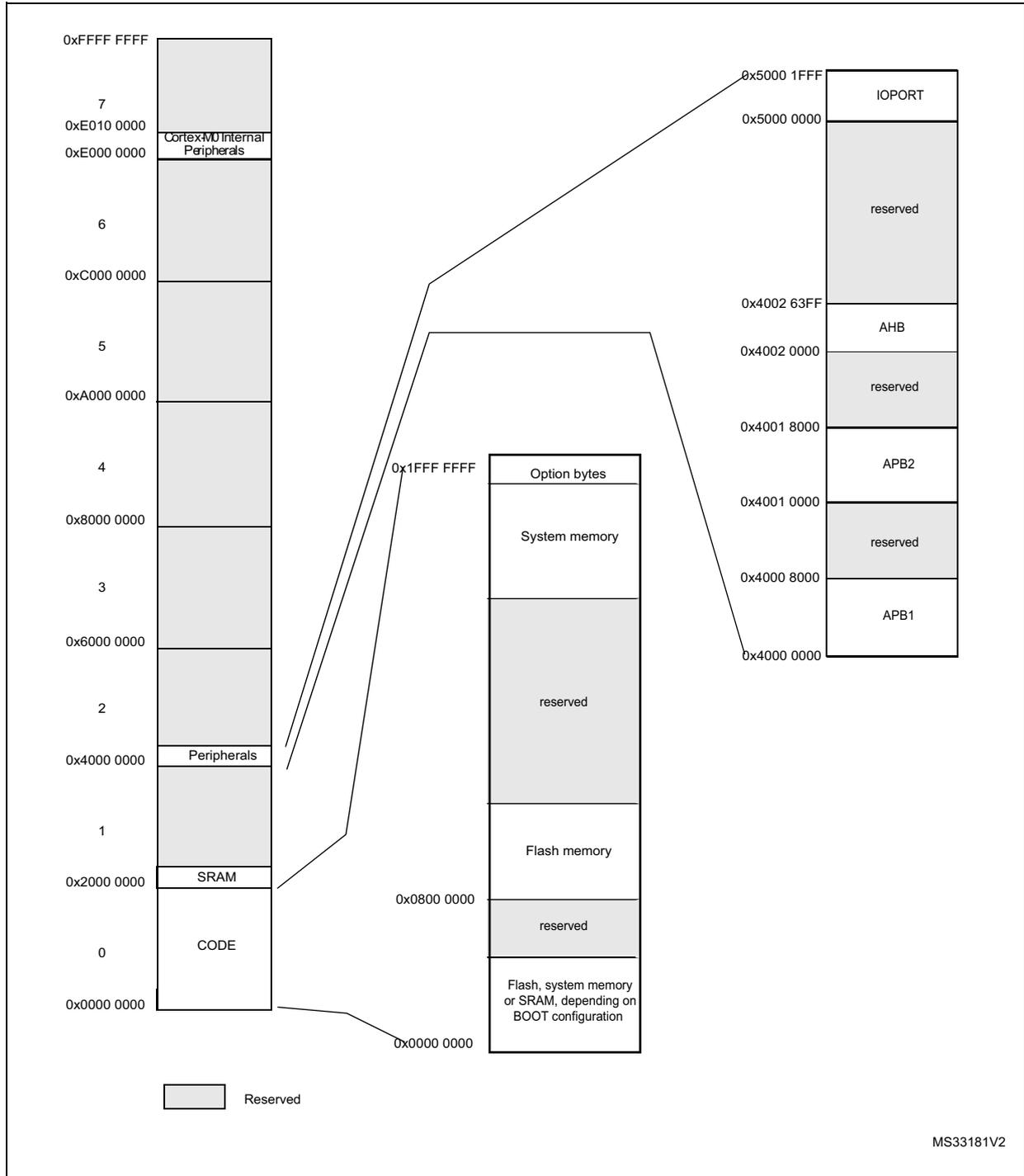
Among other applications, CRC-based techniques are used to verify data transmission or storage integrity. In the scope of the EN/IEC 60335-1 standard, they offer a means of verifying the Flash memory integrity. The CRC calculation unit helps compute a signature of the software during runtime, to be compared with a reference signature generated at linktime and stored at a given memory location.

3.20 Serial wire debug port (SW-DP)

An ARM SW-DP interface is provided to allow a serial wire debugging tool to be connected to the MCU.

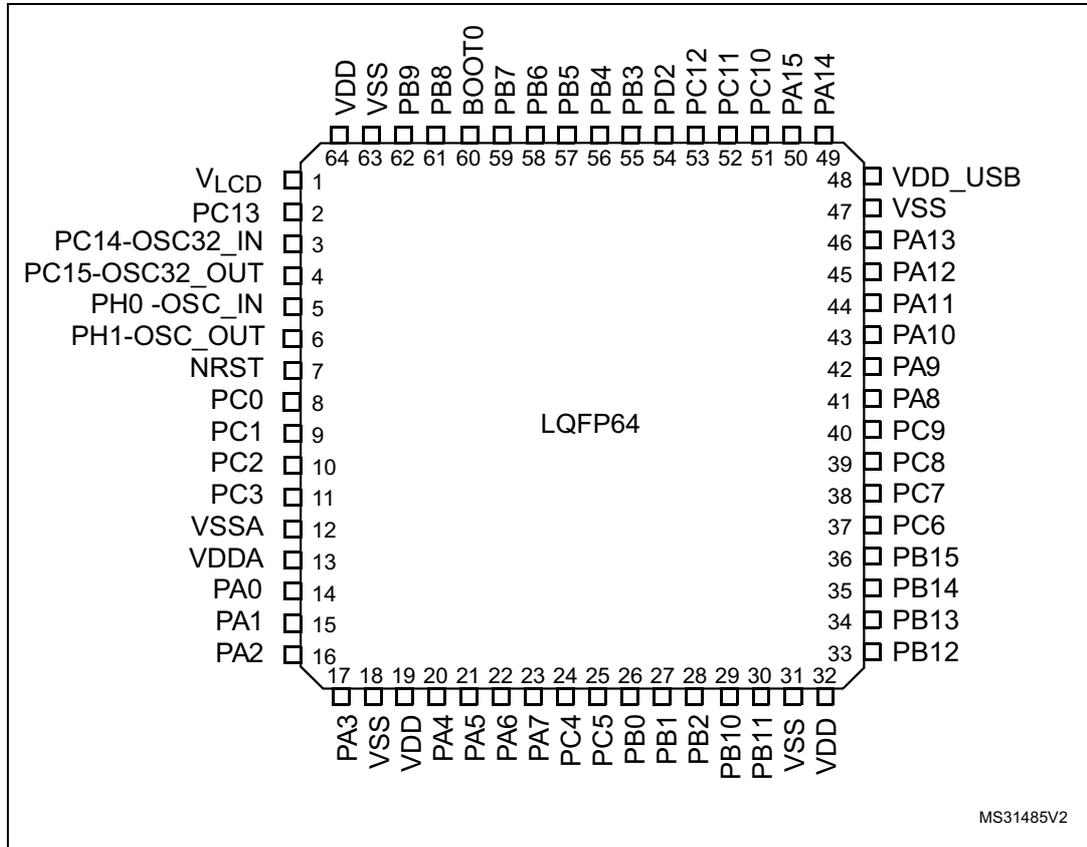
4 Memory mapping

Figure 3. Memory map



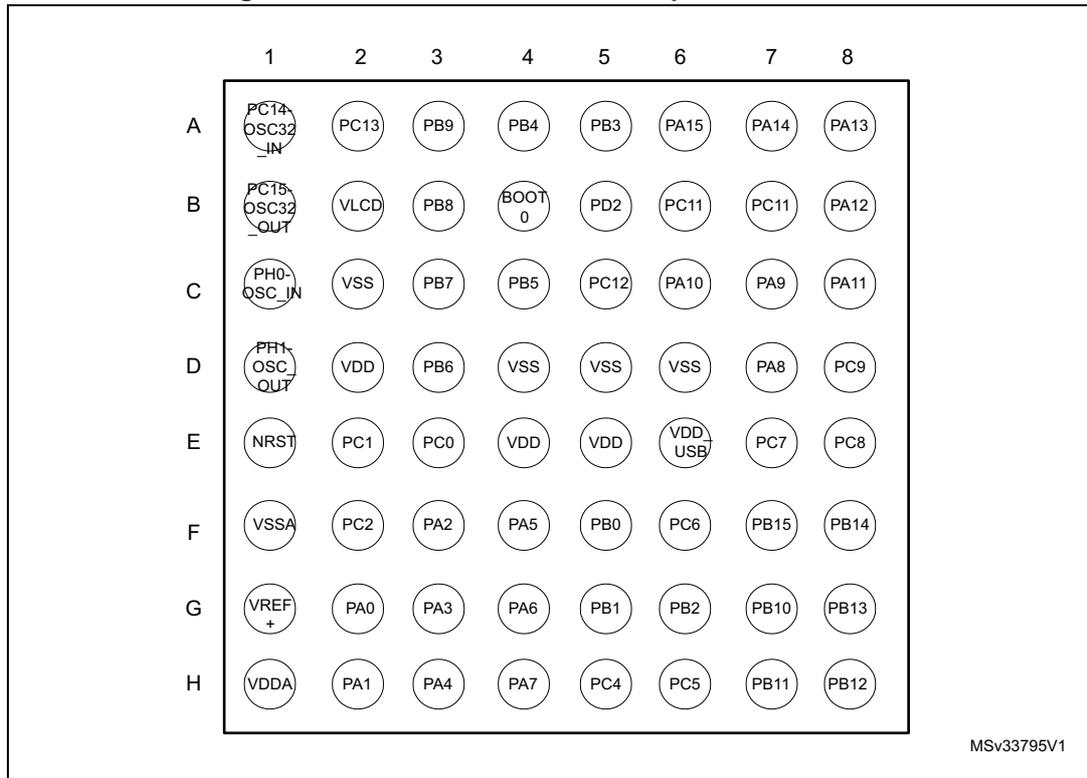
5 Pin descriptions

Figure 4. STM32L053x6/8 LQFP64 pinout - 10 x 10 mm



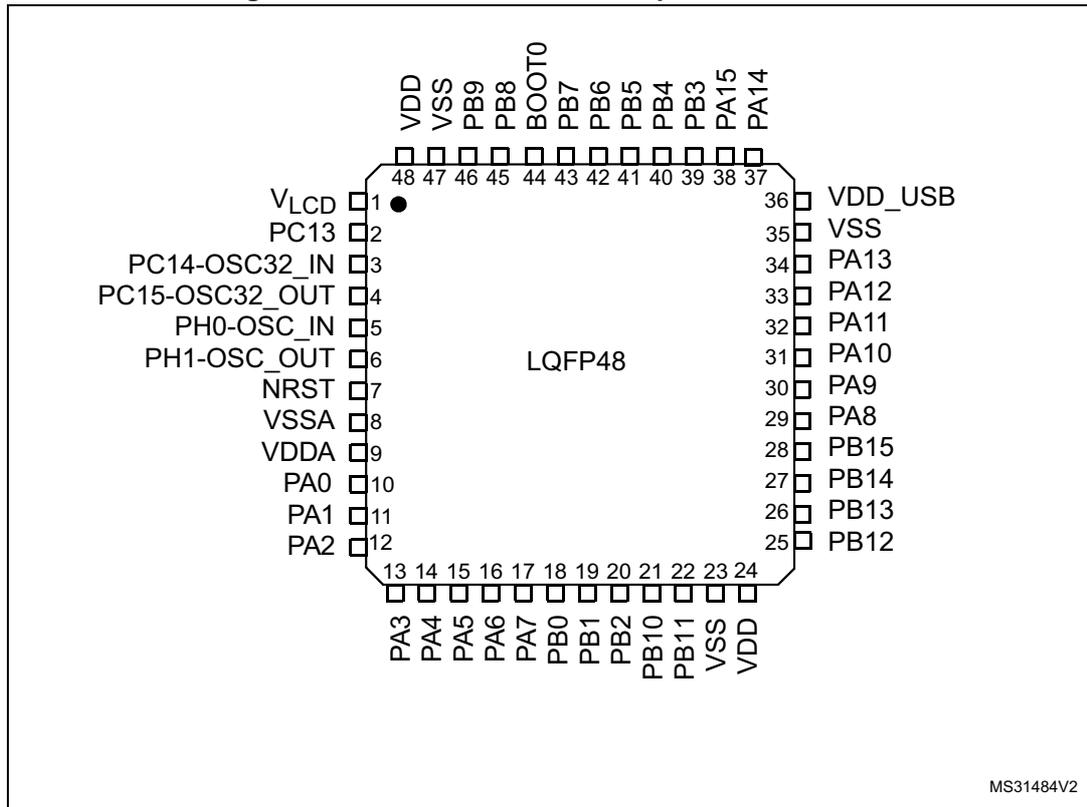
1. The above figure shows the package top view.

Figure 5. STM32L053x6/8 TFBGA64 pinout - 5x 5 mm



1. The above figure shows the package bump view.

Figure 6. STM32L053x6/8 LQFP48 pinout - 7 x 7 mm



1. The above figure shows the package top view.

Table 13. Legend/abbreviations used in the pinout table

Name		Abbreviation	Definition
Pin name		Unless otherwise specified in brackets below the pin name, the pin function during and after reset is the same as the actual pin name	
Pin type	S		Supply pin
	I		Input only pin
	I/O		Input / output pin
I/O structure	FT		5 V tolerant I/O
	TC		Standard 3.3V I/O
	FTf		5-V tolerant I/O, Fm+ capable
	B		Dedicated BOOT0 pin
	RST		Bidirectional reset pin with embedded weak pull-up resistor
Notes		Unless otherwise specified by a note, all I/Os are set as floating inputs during and after reset.	
Pin functions	Alternate functions	Functions selected through GPIOx_AFR registers	
	Additional functions	Functions directly selected/enabled through peripheral registers	

Table 14. STM32L053x6/8 pin definitions

Pin number			Pin name (function after reset)	Pin type	I/O structure	Notes	Alternate functions	Additional functions
LQFP48	LQFP64	TFBGA64						
1	1	B2	VLCD	S				
2	2	A2	PC13	I/O	FT			RTC_TAMP1/RTC_TS/RTC_OUT/WKUP2
3	3	A1	PC14-OSC32_IN (PC14)	I/O	TC			OSC32_IN
4	4	B1	PC15- OSC32_OUT (PC15)	I/O	TC			OSC32_OUT
5	5	C1	PH0-OSC_IN (PH0)	I/O	TC		USB_CR2_SYNC	OSC_IN
6	6	D1	PH1-OSC_OUT (PH1)	I/O	TC			OSC_OUT

Table 14. STM32L053x6/8 pin definitions (continued)

Pin number			Pin name (function after reset)	Pin type	I/O structure	Notes	Alternate functions	Additional functions
LQFP48	LQFP64	TFBGA64						
7	7	E1	NRST	I/O	RST			
-	8	E3	PC0	I/O	FT		LPTIM1_IN1, LCD_SEG18, EVENTOUT, TSC_G7_IO1	ADC_IN10
-	9	E2	PC1	I/O	FT		LPTIM1_OUT, LCD_SEG19, EVENTOUT, TSC_G7_IO2	ADC_IN11
-	10	F2	PC2	I/O	FT		LPTIM1_IN2, LCD_SEG20, SPI2_MISO/I2S2_MCK, TSC_G7_IO3	ADC_IN12
-	11	-	PC3	I/O	FT		LPTIM1_ETR, LCD_SEG21, SPI2_MOSI/I2S2_SD, TSC_G7_IO4	ADC_IN13
8	12	F1	VSSA	S				
-	-	G1	VREF+	S				
9	13	H1	VDDA	S				
10	14	G2	PA0	I/O	TC		TIM2_CH1, TSC_G1_IO1, USART2_CTS, TIM2_ETR, COMP1_OUT	COMP1_INM6, ADC_IN0, RTC_TAMP2/WKUP1
11	15	H2	PA1	I/O	FT		EVENTOUT, LCD_SEG0, TIM2_CH2, TSC_G1_IO2, USART2_RTS, TIM21_ETR	COMP1_INP, ADC_IN1
12	16	F3	PA2	I/O	FT		TIM21_CH1, LCD_SEG1, TIM2_CH3, TSC_G1_IO3, USART2_TX, COMP2_OUT	COMP2_INM6, ADC_IN2
13	17	G3	PA3	I/O	FT		TIM21_CH2, LCD_SEG2, TIM2_CH4, TSC_G1_IO4, USART2_RX	COMP2_INP, ADC_IN3
-	18	C2	VSS	S				
-	19	D2	VDD	S				

Table 14. STM32L053x6/8 pin definitions (continued)

Pin number			Pin name (function after reset)	Pin type	I/O structure	Notes	Alternate functions	Additional functions
LQFP48	LQFP64	TFBGA64						
14	20	H3	PA4	I/O	TC	(1)	SPI1_NSS, TSC_G2_IO1, USART2_CK, TIM22_ETR	COMP1_INM4, COMP2_INM4, ADC_IN4, DAC_OUT
15	21	F4	PA5	I/O	TC		SPI1_SCK, TIM2_ETR, TSC_G2_IO2, TIM2_CH1	COMP1_INM5, COMP2_INM5, ADC_IN5
16	22	G4	PA6	I/O	FT		SPI1_MISO, LCD_SEG3, TSC_G2_IO3, USART3_CTS, TIM22_CH1, EVENTOUT, COMP1_OUT	ADC_IN6
17	23	H4	PA7	I/O	FT		SPI1_MOSI, LCD_SEG4, TSC_G2_IO4, TIM22_CH2, EVENTOUT, COMP2_OUT	ADC_IN7
-	24	H5	PC4	I/O	FT		EVENTOUT, LCD_SEG22, USART3_TX	ADC_IN14
-	25	H6	PC5	I/O	FT		LCD_SEG23, USART3_RX, TSC_G3_IO1	ADC_IN15
18	26	F5	PB0	I/O	FT		EVENTOUT, LCD_SEG5, TSC_G3_IO2	LCD_VLCD3, ADC_IN8
19	27	G5	PB1	I/O	FT		LCD_SEG6, TSC_G3_IO3, USART3_RTS	ADC_IN9
20	28	G6	PB2	I/O	FT		LPTIM1_OUT, TSC_G3_IO4	LCD_VLCD1
21	29	G7	PB10	I/O	FT		LCD_SEG10, TIM2_CH3, TSC_SYNC, USART3_TX, SPI2_SCK, I2C2_SCL	
22	30	H7	PB11	I/O	FT		EVENTOUT, LCD_SEG11, TIM2_CH4, TSC_G6_IO1, USART3_RX, I2C2_SDA	
23	31	D6	VSS	S				
24	32	E6	VDD	S				

Table 14. STM32L053x6/8 pin definitions (continued)

Pin number			Pin name (function after reset)	Pin type	I/O structure	Notes	Alternate functions	Additional functions
LQFP48	LQFP64	TFBGA64						
25	33	H8	PB12	I/O	FT		SPI2_NSS/I2S2_WS, LCD_SEG12, USART3_RTS, TSC_G6_IO2, I2C2_SMBA, EVENTOUT	LCD_VLCD2
26	34	G8	PB13	I/O	FTf		SPI2_SCK/I2S2_CK, LCD_SEG13, TSC_G6_IO3, USART3_CTS, I2C2_SCL, TIM21_CH1	
27	35	F8	PB14	I/O	FTf		SPI2_MISO/I2S2_MCK, LCD_SEG14, RTC_OUT, TSC_G6_IO4, USART3_RTS, I2C2_SDA, TIM21_CH2	
28	36	F7	PB15	I/O	FT		SPI2_MOSI/I2S2_SD, LCD_SEG15, RTC_REFIN	
-	37	F6	PC6	I/O	FT		TIM22_CH1, LCD_SEG24, TSC_G8_IO1	
-	38	E7	PC7	I/O	FT		TIM22_CH2, LCD_SEG25, TSC_G8_IO2	
-	39	E8	PC8	I/O	FT		TIM22_ETR, LCD_SEG26, TSC_G8_IO3	
-	40	D8	PC9	I/O	FT		TIM21_ETR, LCD_SEG27, USB_OE, TSC_G8_IO4	
29	41	D7	PA8	I/O	FT		MCO, LCD_COM0, USB_CRS_SYNC, EVENTOUT, USART1_CK	
30	42	C7	PA9	I/O	FT		MCO, LCD_COM1, TSC_G4_IO1, USART1_TX	
31	43	C6	PA10	I/O	FT		LCD_COM2, TSC_G4_IO2, USART1_RX	
32	44	C8	PA11	I/O	FT		SPI1_MISO, EVENTOUT, TSC_G4_IO3, USART1_CTS, COMP1_OUT	USB_DM

Table 14. STM32L053x6/8 pin definitions (continued)

Pin number			Pin name (function after reset)	Pin type	I/O structure	Notes	Alternate functions	Additional functions
LQFP48	LQFP64	TFBGA64						
33	45	B8	PA12	I/O	FT		SPI1_MOSI, EVENTOUT, TSC_G4_IO4, USART1_RTS, COMP2_OUT	USB_DP
34	46	A8	PA13	I/O	FT		SWDIO, USB_OE	
35	47	D5	VSS	S				
36	48	E5	VDD_USB	S				
37	49	A7	PA14	I/O	FT		SWCLK, USART2_TX	
38	50	A6	PA15	I/O	FT		SPI1_NSS, LCD_SEG17, TIM2_ETR, EVENTOUT, USART2_RX, TIM2_CH1	
-	51	B7	PC10	I/O	FT		USART3_TX, LCD_COM4/LCD_SEG28/ LCD_SEG40	
-	52	B6	PC11	I/O	FT		USART3_RX, LCD_COM5/LCD_SEG29/ LCD_SEG41	
-	53	C5	PC12	I/O	FT		LCD_COM6/LCD_SEG30/ LCD_SEG42	
-	54	B5	PD2	I/O	FT		USART3_RTS, LCD_COM7/LCD_SEG31/ LCD_SEG43	
39	55	A5	PB3	I/O	FT		SPI1_SCK, LCD_SEG7, TIM2_CH2, TSC_G5_I01, EVENTOUT	COMP2_INN
40	56	A4	PB4	I/O	FT		SPI1_MISO, LCD_SEG8, EVENTOUT, TSC_G5_IO2, TIM22_CH1	COMP2_INP
41	57	C4	PB5	I/O	FT		SPI1_MOSI, LCD_SEG9, LPTIM1_IN1, I2C1_SMBA, TIM22_CH2	COMP2_INP
42	58	D3	PB6	I/O	FTf		USART1_TX, I2C1_SCL, LPTIM1_ETR, TSC_G5_IO3	COMP2_INP

Table 14. STM32L053x6/8 pin definitions (continued)

Pin number			Pin name (function after reset)	Pin type	I/O structure	Notes	Alternate functions	Additional functions
LQFP48	LQFP64	TFBGA64						
43	59	C3	PB7	I/O	FTf		USART1_RX, I2C1_SDA, LPTIM1_IN2, TSC_G5_IO4	COMP2_INP, PVD_IN
44	60	B4	BOOT0	I	B			
45	61	B3	PB8	I/O	FTf		LCD_SEG16, TSC_SYNC, I2C1_SCL	
46	62	A3	PB9	I/O	FTf		LCD_COM3, EVENTOUT, I2C1_SDA, SPI2_NSS/I2S2_WS	
47	63	D4	VSS	S				
48	64	E4	VDD	S				

1. PA4 offers a reduced touch sensing sensitivity. It is thus recommended to use it as sampling capacitor I/O.



Table 15. Alternate function port A

Port	AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7
	SPI1/TIM21/SYS_A F/EVENTOUT/	LCD	USB/TIM2/ EVENTOUT/	TSC/ EVENTOUT	USART1/2/3	TIM2/21/22	EVENTOUT	COMP1/2
Port A	PA0			TIM2_CH1	TSC_G1_IO1	USART2_CTS	TIM2_ETR	COMP1_OUT
	PA1	EVENTOUT	LCD_SEG0	TIM2_CH2	TSC_G1_IO2	USART2_RTS	TIM21_ETR	
	PA2	TIM21_CH1	LCD_SEG1	TIM2_CH3	TSC_G1_IO3	USART2_TX		COMP2_OUT
	PA3	TIM21_CH2	LCD_SEG2	TIM2_CH4	TSC_G1_IO4	USART2_RX		
	PA4	SPI1_NSS			TSC_G2_IO1	USART2_CK	TIM22_ETR	
	PA5	SPI1_SCK		TIM2_ETR	TSC_G2_IO2		TIM2_CH1	
	PA6	SPI1_MISO	LCD_SEG3		TSC_G2_IO3	LPUART_CTS	TIM22_CH1	EVENTOUT _OUT
	PA7	SPI1_MOSI	LCD_SEG4		TSC_G2_IO4		TIM22_CH2	EVENTOUT COMP2_OUT
	PA8	MCO	LCD_COM0	USB_CRD_SYNC	EVENTOUT	USART1_CK		
	PA9	MCO	LCD_COM1		TSC_G4_IO1	USART1_TX		
	PA10		LCD_COM2		TSC_G4_IO2	USART1_RX		
	PA11	SPI1_MISO		EVENTOUT	TSC_G4_IO3	USART1_CTS		COMP1_OUT
	PA12	SPI1_MOSI		EVENTOUT	TSC_G4_IO4	USART1_RTS		COMP2_OUT
	PA13	SWDIO		USB_OE				
	PA14	SWCLK				USART2_TX		
PA15	SPI1_NSS	LCD_SEG17	TIM2_ETR	EVENTOUT	USART2_RX	TIM2_CH1		

Table 16. Alternate function port B

Port	AF0	AF1	AF2	AF3	AF4	AF5	AF6	
	SPI1/SPI2/I2S2/ USART1/ EVENTOUT/	I2C1/LCD	LPUART/LPTIM /TIM2/SYS_AF/ EVENTOUT	I2C1/TSC	I2C1/TIM22/ EVENTOUT/ LPUART	SPI2/I2S2/I2C2	I2C2/TIM21/ EVENTOUT	
Port B	PB0	EVENTOUT	LCD_SEG5		TSC_G3_IO2			
	PB1		LCD_SEG6		TSC_G3_IO3	LPUART_RTS		
	PB2			LPTIM1_OUT	TSC_G3_IO4			
	PB3	SPI1_SCK	LCD_SEG7	TIM2_CH2	TSC_G5I_O1	EVENTOUT		
	PB4	SPI1_MISO	LCD_SEG8	EVENTOUT	TSC_G5_IO2	TIM22_CH1		
	PB5	SPI1_MOSI	LCD_SEG9	LPTIM1_IN1	I2C1_SMBA	TIM22_CH2		
	PB6	USART1_TX	I2C1_SCL	LPTIM1_ETR	TSC_G5_IO3			
	PB7	USART1_RX	I2C1_SDA	LPTIM1_IN2	TSC_G5_IO4			
	PB8		LCD_SEG16		TSC_SYNC	I2C1_SCL		
	PB9		LCD_COM3	EVENTOUT		I2C1_SDA	SPI2_NSS/I2S2_ WS	
	PB10		LCD_SEG10	TIM2_CH3	TSC_SYNC	LPUART_TX	SPI2_SCK	I2C2_SCL
	PB11	EVENTOUT	LCD_SEG11	TIM2_CH4	TSC_G6_IO1	LPUART_RX		I2C2_SDA
	PB12	SPI2_NSS/I2S2_WS	LCD_SEG12	LPUART_RTS	TSC_G6_IO2		I2C2_SMBA	EVENTOUT
	PB13	SPI2_SCK/I2S2_CK	LCD_SEG13		TSC_G6_IO3	LPUART_CTS	I2C2_SCL	TIM21_CH1
	PB14	SPI2_MISO/I2S2_MCK	LCD_SEG14	RTC_OUT	TSC_G6_IO4	LPUART_RTS	I2C2_SDA	TIM21_CH2
PB15	SPI2_MOSI/I2S2_SD	LCD_SEG15	RTC_REFIN					



Table 17. Alternate function port C

Port		AF0	AF1	AF2	AF3
		LPUART/LPTIM/ TIM21/12/ EVENTOUT/	LCD	SPI2/I2S2/USB/ LPUART/ EVENTOUT	TSC
Port C	PC0	LPTIM1_IN1	LCD_SEG18	EVENTOUT	TSC_G7_IO1
	PC1	LPTIM1_OUT	LCD_SEG19	EVENTOUT	TSC_G7_IO2
	PC2	LPTIM1_IN2	LCD_SEG20	SPI2_MISO/I2S2_MCK	TSC_G7_IO3
	PC3	LPTIM1_ETR	LCD_SEG21	SPI2_MOSI/I2S2_SD	TSC_G7_IO4
	PC4	EVENTOUT	LCD_SEG22	LPUART_TX	
	PC5		LCD_SEG23	LPUART_RX	TSC_G3_IO1
	PC6	TIM22_CH1	LCD_SEG24		TSC_G8_IO1
	PC7	TIM22_CH2	LCD_SEG25		TSC_G8_IO2
	PC8	TIM22_ETR	LCD_SEG26		TSC_G8_IO3
	PC9	TIM21_ETR	LCD_SEG27	USB_OE	TSC_G8_IO4
	PC10	LPUART_TX	LCD_COM4/LCD_SEG28		
	PC11	LPUART_RX	LCD_COM5/LCD_SEG29		
	PC12		LCD_COM6/LCD_SEG30		
	PC13				
	PC14				
PC15					

Table 18. Alternate function port D

Port		AF0	AF1
		LPUART	LCD
Port D	PD2	LPUART_RTS	LCD_COM7/LCD_SEG31



Table 19. Alternate function port H

Port		AF0
		USB
Port H	PH0	USB_CR_S_SYNC
	PH1	-

6 Electrical characteristics

6.1 Parameter conditions

Unless otherwise specified, all voltages are referenced to V_{SS} .

6.1.1 Minimum and maximum values

Unless otherwise specified the minimum and maximum values are guaranteed in the worst conditions of ambient temperature, supply voltage and frequencies by tests in production on 100% of the devices with an ambient temperature at $T_A = 25\text{ }^\circ\text{C}$ and $T_A = T_{Amax}$ (given by the selected temperature range).

Data based on characterization results, design simulation and/or technology characteristics are indicated in the table footnotes and are not tested in production. Based on characterization, the minimum and maximum values refer to sample tests and represent the mean value plus or minus three times the standard deviation ($\text{mean} \pm 3\sigma$).

6.1.2 Typical values

Unless otherwise specified, typical data are based on $T_A = 25\text{ }^\circ\text{C}$, $V_{DD} = 3.6\text{ V}$ (for the $1.65\text{ V} \leq V_{DD} \leq 3.6\text{ V}$ voltage range). They are given only as design guidelines and are not tested.

Typical ADC accuracy values are determined by characterization of a batch of samples from a standard diffusion lot over the full temperature range, where 95% of the devices have an error less than or equal to the value indicated ($\text{mean} \pm 2\sigma$).

6.1.3 Typical curves

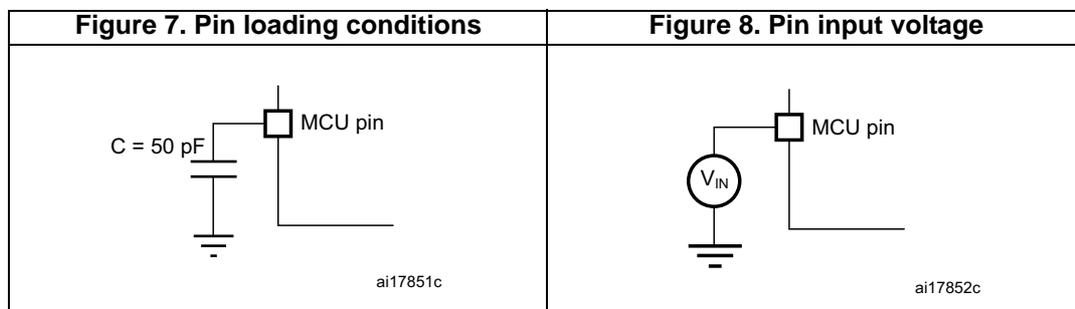
Unless otherwise specified, all typical curves are given only as design guidelines and are not tested.

6.1.4 Loading capacitor

The loading conditions used for pin parameter measurement are shown in [Figure 7](#).

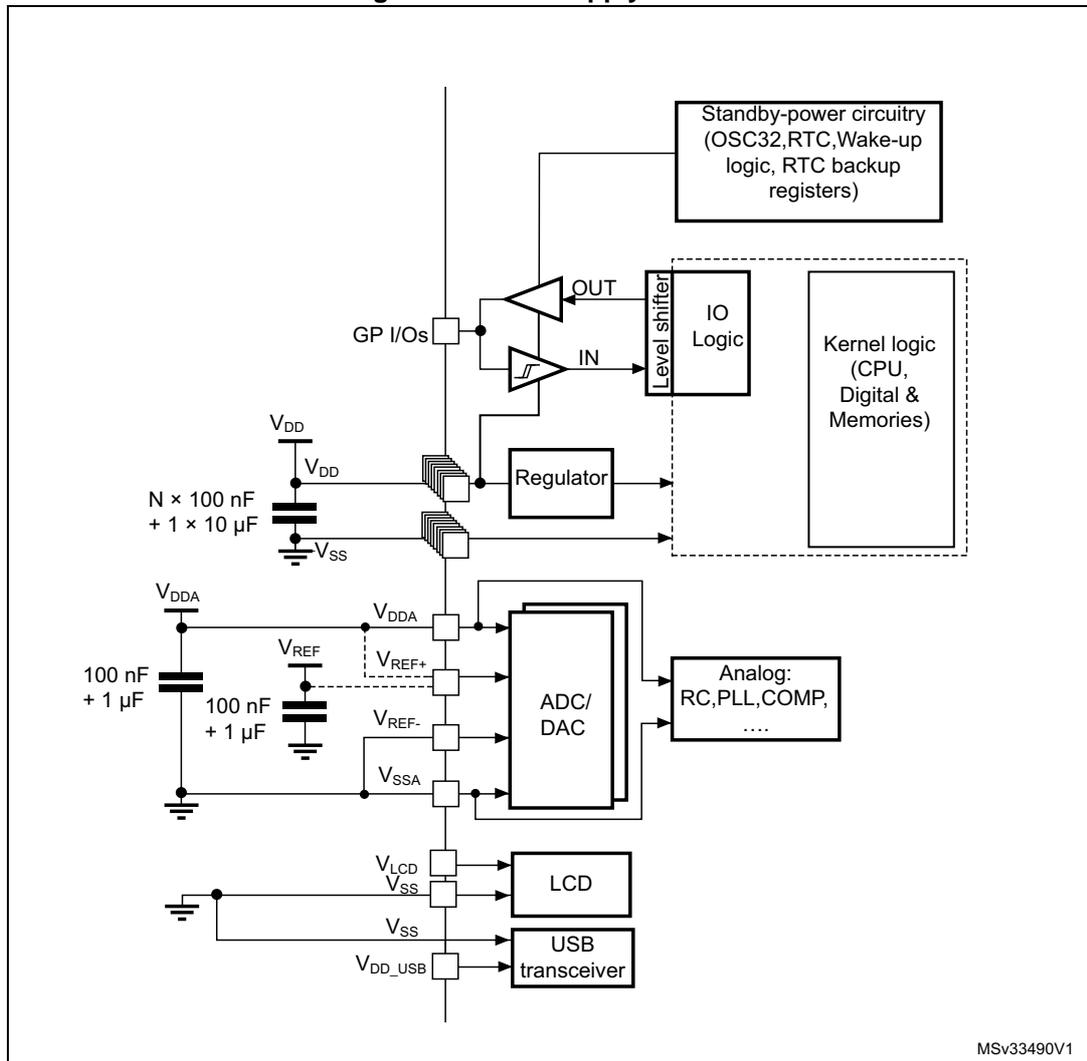
6.1.5 Pin input voltage

The input voltage measurement on a pin of the device is described in [Figure 8](#).



6.1.6 Power supply scheme

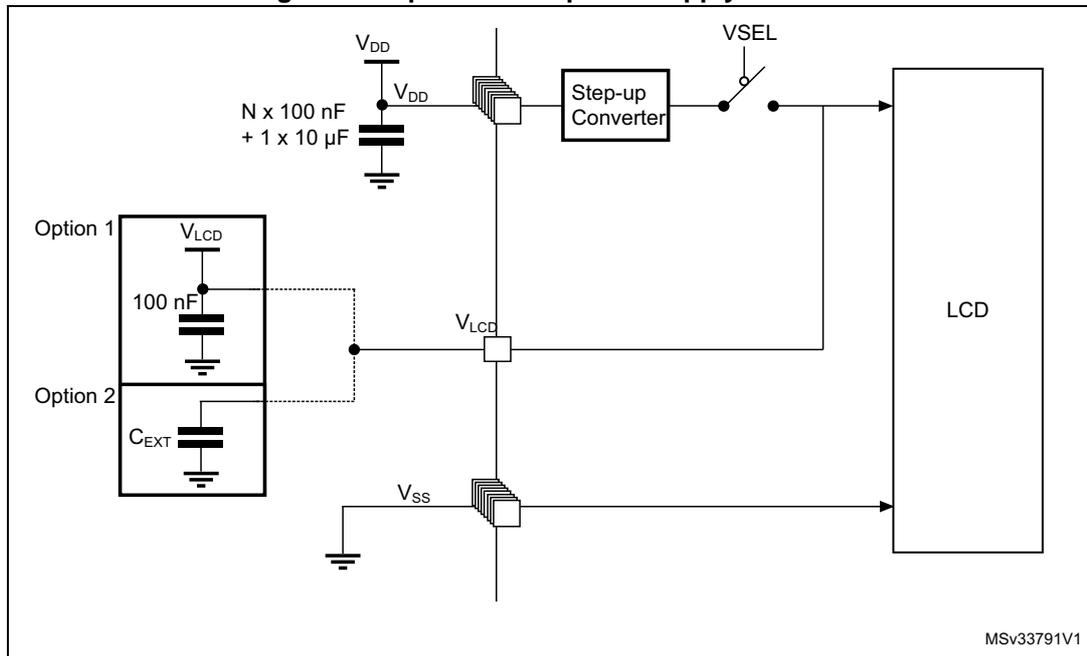
Figure 9. Power supply scheme



MSv33490V1

6.1.7 Optional LCD power supply scheme

Figure 10. Optional LCD power supply scheme



1. Option 1: LCD power supply is provided by a dedicated VLCD supply source, VSEL switch is open.
2. Option 2: LCD power supply is provided by the internal step-up converter, VSEL switch is closed, an external capacitance is needed for correct behavior of this converter.

6.1.8 Current consumption measurement

Figure 11. Current consumption measurement scheme

6.2 Absolute maximum ratings

Stresses above the absolute maximum ratings listed in [Table 20: Voltage characteristics](#), [Table 21: Current characteristics](#), and [Table 22: Thermal characteristics](#) may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

Table 20. Voltage characteristics

Symbol	Ratings	Min	Max	Unit
$V_{DD}-V_{SS}$	External main supply voltage (including V_{DDA} and V_{DD}) ⁽¹⁾	-0.3	4.0	V
V_{IN} ⁽²⁾	Input voltage on five-volt tolerant pin	$V_{SS} - 0.3$	$V_{DD} + 4.0$	
	Input voltage on any other pin	$V_{SS} - 0.3$	4.0	
$ \Delta V_{DD} $	Variations between different V_{DD} power pins	-	50	mV
$ \Delta V_{SS} $	Variations between all different ground pins	-	50	
$V_{REF+} - V_{DDA}$	Allowed voltage difference for $V_{REF+} > V_{DDA}$	-	0.4	V
$V_{ESD(HBM)}$	Electrostatic discharge voltage (human body model)	see Section 6.3.11		

1. All main power (V_{DD} , V_{DDA}) and ground (V_{SS} , V_{SSA}) pins must always be connected to the external power supply, in the permitted range.
2. V_{IN} maximum must always be respected. Refer to [Table 21](#) for maximum allowed injected current values.

Table 21. Current characteristics

Symbol	Ratings	Max.	Unit
$I_{VDD(\Sigma)}$	Total current into sum of all V_{DD} power lines (source) ⁽¹⁾	100	mA
$I_{VSS(\Sigma)}$ ⁽²⁾	Total current out of sum of all V_{SS} ground lines (sink) ⁽¹⁾	100	
$I_{VDD(PIN)}$	Maximum current into each V_{DD} power pin (source) ⁽¹⁾	70	
$I_{VSS(PIN)}$	Maximum current out of each V_{SS} ground pin (sink) ⁽¹⁾	-70	
I_{IO}	Output current sunk by any I/O and control pin	25	
	Output current sourced by any I/O and control pin	-25	
$\Sigma I_{IO(PIN)}$	Total output current sunk by sum of all IOs and control pins ⁽²⁾	60	
	Total output current sourced by sum of all IOs and control pins ⁽²⁾	-60	
$I_{INJ(PIN)}$ ⁽³⁾	Injected current on five-volt tolerant I/O ⁽⁴⁾	-5/+0	
	Injected current on any other pin ⁽⁵⁾	± 5	
$\Sigma I_{INJ(PIN)}$	Total injected current (sum of all I/O and control pins) ⁽⁶⁾	± 25	

1. All main power (V_{DD} , V_{DDA}) and ground (V_{SS} , V_{SSA}) pins must always be connected to the external power supply, in the permitted range.
2. This current consumption must be correctly distributed over all I/Os and control pins. The total output current must not be sunk/sourced between two consecutive power supply pins referring to high pin count LQFP packages.
3. Negative injection disturbs the analog performance of the device. See note in [Section 6.3.21](#).

4. Positive current injection is not possible on these I/Os. A negative injection is induced by $V_{IN} < V_{SS}$. $I_{INJ(PIN)}$ must never be exceeded. Refer to [Table 20](#) for maximum allowed input voltage values.
5. A positive injection is induced by $V_{IN} > V_{DD}$ while a negative injection is induced by $V_{IN} < V_{SS}$. $I_{INJ(PIN)}$ must never be exceeded. Refer to [Table 20: Voltage characteristics](#) for the maximum allowed input voltage values.
6. When several inputs are submitted to a current injection, the maximum $\Sigma I_{INJ(PIN)}$ is the absolute sum of the positive and negative injected currents (instantaneous values).

Table 22. Thermal characteristics

Symbol	Ratings	Value	Unit
T _{STG}	Storage temperature range	-65 to +150	°C
T _J	Maximum junction temperature	150	°C

6.3 Operating conditions

6.3.1 General operating conditions

Table 23. General operating conditions⁽¹⁾

Symbol	Parameter	Conditions	Min	Max	Unit
f _{HCLK}	Internal AHB clock frequency	-	0	32	MHz
f _{PCLK1}	Internal APB1 clock frequency	-	0	32	
f _{PCLK2}	Internal APB2 clock frequency	-	0	32	
V _{DD}	Standard operating voltage	BOR detector disabled	1.65	3.6	V
		BOR detector enabled, at power on	1.8	3.6	
		BOR detector disabled, after power on	1.65	3.6	
V _{DDA} ⁽²⁾	Analog operating voltage (ADC and DAC not used)	Must be the same voltage as V _{DD} ⁽³⁾	1.65	3.6	V
	Analog operating voltage (ADC or DAC used)		1.8	3.6	
V _{IN}	Input voltage on FT pins ⁽⁴⁾	2.0 V ≤ V _{DD} ≤ 3.6 V	-0.3	5.55	V
		1.65 V ≤ V _{DD} ≤ 2.0 V	-0.3	5.25	
	Input voltage on BOOT0 pin	-	0	5.5	
	Input voltage on any other pin	-	-0.3	V _{DD} +0.3	
P _D	Power dissipation at T _A = 85 °C (range 6) or T _A = 105 °C (range 7) ⁽⁵⁾	TFBGA64 package	-	327	mW
		LQFP64 package	-	444	
		LQFP48 package	-	363	

Table 23. General operating conditions⁽¹⁾ (continued)

Symbol	Parameter	Conditions	Min	Max	Unit
T _A	Temperature range	Maximum power dissipation (range 6)	-40	85	°C
		Maximum power dissipation (range 7)	-40	105	
		Low-power dissipation (range 7) ⁽⁶⁾	-40	125	
T _J	Junction temperature range (range 6)	-40 °C ≤ T _A ≤ 85 °	-40	105	°C
	Junction temperature range (range 7)	-40 °C ≤ T _A ≤ 105 °C	-40	125	

1. TBD stands for "to be defined".
2. When the ADC is used, refer to [Table 57: ADC characteristics](#).
3. It is recommended to power V_{DD} and V_{DDA} from the same source. A maximum difference of 300 mV between V_{DD} and V_{DDA} can be tolerated during power-up and normal operation.
4. To sustain a voltage higher than V_{DD}+0.3V, the internal pull-up/pull-down resistors must be disabled.
5. If T_A is lower, higher P_D values are allowed as long as T_J does not exceed T_J max (see [Table 76: Thermal characteristics on page 115](#)).
6. In low-power dissipation state, T_A can be extended to this range as long as T_J does not exceed T_J max (see [Table 76: Thermal characteristics on page 115](#)).

6.3.2 Embedded reset and power control block characteristics

The parameters given in the following table are derived from the tests performed under the ambient temperature condition summarized in [Table 23](#).

Table 24. Embedded reset and power control block characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
t _{VDD} ⁽¹⁾	V _{DD} rise time rate	BOR detector enabled	0	-	∞	µs/V
		BOR detector disabled	0	-	1000	
	V _{DD} fall time rate	BOR detector enabled	20	-	∞	
		BOR detector disabled	0	-	1000	
T _{RSTTEMPO} ⁽¹⁾	Reset temporization	V _{DD} rising, BOR enabled	-	2	3.3	ms
		V _{DD} rising, BOR disabled ⁽²⁾	0.4	0.7	1.6	
V _{POR/PDR}	Power on/power down reset threshold	Falling edge	1	1.5	1.65	V
		Rising edge	1.3	1.5	1.65	
V _{BOR0}	Brown-out reset threshold 0	Falling edge	1.67	1.7	1.74	
		Rising edge	1.69	1.76	1.8	
V _{BOR1}	Brown-out reset threshold 1	Falling edge	1.87	1.93	1.97	
		Rising edge	1.96	2.03	2.07	
V _{BOR2}	Brown-out reset threshold 2	Falling edge	2.22	2.30	2.35	
		Rising edge	2.31	2.41	2.44	

Table 24. Embedded reset and power control block characteristics (continued)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{BOR3}	Brown-out reset threshold 3	Falling edge	2.45	2.55	2.6	V
		Rising edge	2.54	2.66	2.7	
V_{BOR4}	Brown-out reset threshold 4	Falling edge	2.68	2.8	2.85	
		Rising edge	2.78	2.9	2.95	
V_{PVD0}	Programmable voltage detector threshold 0	Falling edge	1.8	1.85	1.88	
		Rising edge	1.88	1.94	1.99	
V_{PVD1}	PVD threshold 1	Falling edge	1.98	2.04	2.09	
		Rising edge	2.08	2.14	2.18	
V_{PVD2}	PVD threshold 2	Falling edge	2.20	2.24	2.28	
		Rising edge	2.28	2.34	2.38	
V_{PVD3}	PVD threshold 3	Falling edge	2.39	2.44	2.48	
		Rising edge	2.47	2.54	2.58	
V_{PVD4}	PVD threshold 4	Falling edge	2.57	2.64	2.69	
		Rising edge	2.68	2.74	2.79	
V_{PVD5}	PVD threshold 5	Falling edge	2.77	2.83	2.88	
		Rising edge	2.87	2.94	2.99	
V_{PVD6}	PVD threshold 6	Falling edge	2.97	3.05	3.09	
		Rising edge	3.08	3.15	3.20	
V_{hyst}	Hysteresis voltage	BOR0 threshold	-	40	-	mV
		All BOR and PVD thresholds excepting BOR0	-	100	-	

1. Guaranteed by characterization, not tested in production.
2. Valid for device version without BOR at power up. Please see option "D" in Ordering information scheme for more details.

6.3.3 Embedded internal reference voltage

The parameters given in [Table 26](#) are based on characterization results, unless otherwise specified.

Table 25. Embedded internal reference voltage calibration values

Calibration value name	Description	Memory address
VREFINT_CAL	Raw data acquired at temperature of 30 °C V _{DDA} = 3 V	0x1FF8 0078 - 0x1FF8 0079

Table 26. Embedded internal reference voltage

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V _{REFINT_out} ⁽¹⁾	Internal reference voltage	-40 °C < T _J < +105 °C	1.202	1.224	1.242	V
I _{REFINT}	Internal reference current consumption	-	-	1.4	2.3	μA
T _{VREFINT}	Internal reference startup time	-	-	2	3	ms
V _{VREF_MEAS}	V _{DDA} and V _{REF+} voltage during V _{REFINT} factory measure	-	2.99	3	3.01	V
A _{VREF_MEAS}	Accuracy of factory-measured V _{REF} value ⁽²⁾	Including uncertainties due to ADC and V _{DDA} /V _{REF+} values	-	-	±5	mV
T _{Coef} ⁽³⁾	Temperature coefficient	-40 °C < T _J < +105 °C	-	20	50	ppm/°C
		0 °C < T _J < +50 °C	-	-	20	
A _{Coef} ⁽³⁾	Long-term stability	1000 hours, T = 25 °C	-	-	1000	ppm
V _{DDCoef} ⁽³⁾	Voltage coefficient	3.0 V < V _{DDA} < 3.6 V	-	-	2000	ppm/V
T _{S_vrefint} ⁽³⁾⁽⁴⁾	ADC sampling time when reading the internal reference voltage	-	5	10	-	μs
T _{ADC_BUF} ⁽³⁾	Startup time of reference voltage buffer for ADC	-	-	-	10	μs
I _{BUF_ADC} ⁽³⁾	Consumption of reference voltage buffer for ADC	-	-	13.5	25	μA
I _{VREF_OUT} ⁽³⁾	VREF_OUT output current ⁽⁵⁾	-	-	-	1	μA
C _{VREF_OUT} ⁽³⁾	VREF_OUT output load	-	-	-	50	pF
I _{LPBUF} ⁽³⁾	Consumption of reference voltage buffer for VREF_OUT and COMP	-	-	730	1200	nA
V _{REFINT_DIV1} ⁽³⁾	1/4 reference voltage	-	24	25	26	% V _{REFINT}
V _{REFINT_DIV2} ⁽³⁾	1/2 reference voltage	-	49	50	51	
V _{REFINT_DIV3} ⁽³⁾	3/4 reference voltage	-	74	75	76	

1. Tested in production.

2. The internal V_{REF} value is individually measured in production and stored in dedicated EEPROM bytes.

3. Guaranteed by design, not tested in production.
4. Shortest sampling time can be determined in the application by multiple iterations.
5. To guarantee less than 1% VREF_OUT deviation.

6.3.4 Supply current characteristics

The current consumption is a function of several parameters and factors such as the operating voltage, temperature, I/O pin loading, device software configuration, operating frequencies, I/O pin switching rate, program location in memory and executed binary code. The current consumption is measured as described in [Figure 11: Current consumption measurement scheme](#).

All Run-mode current consumption measurements given in this section are performed with a reduced code that gives a consumption equivalent to Dhrystone 2.1 code if not specified otherwise.

The current consumption values are derived from the tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in [Table 23: General operating conditions](#) unless otherwise specified.

The MCU is placed under the following conditions:

- All I/O pins are configured in analog input mode
- All peripherals are disabled except when explicitly mentioned
- The Flash memory access time and prefetch is adjusted depending on fHCLK frequency and voltage range to provide the best CPU performance unless otherwise specified.
- When the peripherals are enabled $f_{APB1} = f_{APB2} = f_{APB}$
- When PLL is ON, the PLL inputs are equal to HSI = 16 MHz (if internal clock is used) or HSE = 16 MHz (if HSE bypass mode is used)
- The HSE user clock applied to OSCI_IN input follows the characteristic specified in [Table 36: High-speed external user clock characteristics](#)
- For maximum current consumption $V_{DD} = V_{DDA} = 3.6$ V is applied to all supply pins
- For typical current consumption $V_{DD} = V_{DDA} = 3.0$ V is applied to all supply pins if not specified otherwise

The parameters given in [Table 44](#), [Table 23](#) and [Table 24](#) are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in [Table 23](#).

Table 27. Current consumption in Run mode, code with data processing running from Flash⁽¹⁾⁽²⁾

Symbol	Parameter	Conditions	f _{HCLK}	Typ	Max ⁽³⁾	Unit		
I _{DD} (Run from Flash)	Supply current in Run mode, code executed from Flash	f _{HSE} = f _{HCLK} up to 16 MHz included, f _{HSE} = f _{HCLK} /2 above 16 MHz (PLL ON) ⁽⁴⁾	Range 3, V _{CORE} =1.2 V	1 MHz	165	TBD	μA	
				2 MHz	300	TBD		
				4 MHz	580	-		
			4 MHz	Range 3, V _{CORE} =1.2 V, CoreMark ⁽⁵⁾	585	-		
				Range 3, V _{CORE} =1.2 V, Fibonacci ⁽⁵⁾	505	-		
				Range 3, V _{CORE} =1.2 V, while(1) ⁽⁵⁾	360	-		
			Range 3, V _{CORE} =1.2 V, running while(1), 1WS, prefetch OFF ⁽⁵⁾	TBD	TBD			
			Range 2, V _{CORE} =1.5 V	4 MHz	0.685	TBD		mA
				8 MHz	1.35	TBD		
				16 MHz	2.6	TBD		
		Range 1, V _{CORE} =1.8 V,	8 MHz	1.6	TBD			
			16 MHz	3.1	TBD			
			32 MHz	6	TBD			
		32 MHz	Range 1, V _{CORE} =1.8 V, CoreMark ⁽⁵⁾	6.1	-			
			Range 1, V _{CORE} =1.8 V, Fibonacci ⁽⁵⁾	5.65	-			
			Range 1, V _{CORE} =1.8 V, while(1) ⁽⁵⁾	5.1	-			
			Range 1, V _{CORE} =1.8 V, while(1) ⁽⁵⁾ , prefetch OFF	4.45	-			
		HSI16 clock source (16 MHz)	Range 2, V _{CORE} =1.5 V	16 MHz	2.55	TBD		
			Range 1, V _{CORE} =1.8 V	32 MHz	6.15	TBD		
		MSI clock, 65 kHz	Range 3, V _{CORE} =1.2 V	65 kHz	36.5	TBD	μA	
MSI clock, 524 kHz	524 kHz	100		TBD				
MSI clock, 4.2 MHz	4.2 MHz	245		TBD				

1. TBD stands for “to be defined”.
2. CoreMark, Fibonacci and while(1) conditions are given for current consumption estimates compared to Dhrystone.
3. Based on characterization, not tested in production, unless otherwise specified.
4. Oscillator bypassed (HSEBYP = 1 in RCC_CR register).
5. CoreMark, Fibonacci and while(1) conditions are given for current consumption estimate vs. Dhrystone

The following current consumption curves will be provided in next revision of this datasheet:

- I_{DD} vs V_{DD} , at $T_A = -40\text{ }^\circ\text{C}/25\text{ }^\circ\text{C}/85\text{ }^\circ\text{C}$, Run mode, code running from Flash memory, Range 2, HSE, 1WS
- I_{DD} vs V_{DD} , at $T_A = -40\text{ }^\circ\text{C}/25\text{ }^\circ\text{C}/85\text{ }^\circ\text{C}$, Run mode, code running from Flash memory, Range 2, HSI 1WS

Table 28. Current consumption in Run mode, code with data processing running from RAM⁽¹⁾

Symbol	Parameter	Conditions	f_{HCLK}	Typ	Max ⁽²⁾	Unit				
I_{DD} (Run from RAM)	Supply current in Run mode, code executed from RAM, Flash switched off	$f_{HSE} = f_{HCLK}$ up to 16 MHz, included $f_{HSE} = f_{HCLK}/2$ above 16 MHz (PLL ON) ⁽³⁾	Range 3, $V_{CORE}=1.2\text{ V}$	1 MHz	TBD	TBD	μA			
				2 MHz	TBD	TBD				
				4 MHz	TBD	TBD				
					Range 3, $V_{CORE}=1.2\text{ V}$, CoreMark		TBD	-	μA	
					Range 3, $V_{CORE}=1.2\text{ V}$, Fibonacci	4 MHz	445	-		
					Range 3, $V_{CORE}=1.2\text{ V}$, while(1)		405	-		
					Range 2, $V_{CORE}=1.5\text{ V}$	4 MHz	TBD	TBD	mA	
						8 MHz	TBD	TBD		
						16 MHz	TBD	TBD		
					Range 1, $V_{CORE}=1.8\text{ V}$	8 MHz	TBD	TBD		
						16 MHz	TBD	TBD		
						32 MHz	TBD	TBD		
					Range 1, $V_{CORE}=1.8\text{ V}$, CoreMark		TBD	-	mA	
					Range 1, $V_{CORE}=1.8\text{ V}$, Fibonacci	32 MHz	5.10	-		
					Range 1, $V_{CORE}=1.8\text{ V}$, while(1)		3.95	-		
					HSI16 clock source (16 MHz)	Range 2, $V_{CORE}=1.5\text{ V}$	16 MHz	TBD	TBD	mA
						Range 1, $V_{CORE}=1.8\text{ V}$	32 MHz	TBD	TBD	
					MSI clock, 65 kHz	Range 3, $V_{CORE}=1.2\text{ V}$	65 kHz	TBD	TBD	μA
		MSI clock, 524 kHz	524 kHz	TBD	TBD					
		MSI clock, 4.2 MHz	4.2 MHz	TBD	TBD					

1. TBD stands for "to be defined".
2. Based on characterization, not tested in production, unless otherwise specified.
3. Oscillator bypassed (HSEBYP = 1 in RCC_CR register).

Table 29. Current consumption in Sleep mode⁽¹⁾

Symbol	Parameter	Conditions	f _{HCLK}	Typ	Max ⁽²⁾	Unit	
I _{DD} (Sleep)	Supply current in Sleep mode, Flash OFF	f _{HSE} = f _{HCLK} up to 16 MHz included, f _{HSE} = f _{HCLK} /2 above 16 MHz (PLL ON) ⁽³⁾	Range 3, V _{CORE} =1.2 V	1 MHz	49.4	TBD	μA
				2 MHz	78.5	TBD	
				4 MHz	140	TBD	
			Range 2, V _{CORE} =1.5 V	4 MHz	160	TBD	
				8 MHz	295	TBD	
				16 MHz	570	TBD	
			Range 1, V _{CORE} =1.8 V	8 MHz	380	TBD	
				16 MHz	710	TBD	
				32 MHz	1600	TBD	
		HSI16 clock source (16 MHz)	Range 2, V _{CORE} =1.5 V	16 MHz	645	TBD	
			Range 1, V _{CORE} =1.8 V	32 MHz	1700	TBD	
		MSI clock, 65 kHz	Range 3, V _{CORE} =1.2 V	65 kHz	18	TBD	
		MSI clock, 524 kHz		524 kHz	32.5	TBD	
	MSI clock, 4.2 MHz	4.2 MHz		145	TBD		
	Supply current in Sleep mode, Flash ON	f _{HSE} = f _{HCLK} up to 16 MHz included, f _{HSE} = f _{HCLK} /2 above 16 MHz (PLL ON) ⁽³⁾	Range 3, V _{CORE} =1.2 V	1 MHz	59.5	TBD	
				2 MHz	89	TBD	
				4 MHz	150	TBD	
			Range 2, V _{CORE} =1.5 V	4 MHz	170	TBD	
				8 MHz	310	TBD	
				16 MHz	580	TBD	
			Range 1, V _{CORE} =1.8 V	8 MHz	380	TBD	
				16 MHz	710	TBD	
				32 MHz	1600	TBD	
HSI16 clock source (16 MHz)		Range 2, V _{CORE} =1.5 V	16 MHz	660	TBD		
		Range 1, V _{CORE} =1.8 V	32 MHz	1700	TBD		
Supply current in Sleep mode, code executed from Flash		MSI clock, 65 kHz	Range 3, V _{CORE} =1.2V	65 kHz	29	TBD	
		MSI clock, 524 kHz		524 kHz	43	TBD	
	MSI clock, 4.2 MHz	4.2 MHz		160	TBD		

1. TBD stands for "to be defined".
2. Based on characterization, not tested in production, unless otherwise specified.
3. Oscillator bypassed (HSEBYP = 1 in RCC_CR register)



Table 30. Current consumption in Low-power Run mode⁽¹⁾

Symbol	Parameter	Conditions			Typ	Max ⁽²⁾	Unit
I _{DD} (LP Run)	Supply current in Low-power run mode	All peripherals OFF, code executed from RAM, Flash switched OFF, V _{DD} from 1.65 V to 3.6 V	MSI clock, 65 kHz f _{HCLK} = 32 kHz	T _A = -40 °C to 25 °C	8.55	TBD	μA
				T _A = 85 °C	TBD	TBD	
				T _A = 105 °C	TBD	TBD	
			MSI clock, 65 kHz f _{HCLK} = 65 kHz	T _A = -40 °C to 25 °C	12.5	TBD	
				T _A = 85 °C	TBD	TBD	
				T _A = 105 °C	TBD	TBD	
			MSI clock, 131 kHz f _{HCLK} = 131 kHz	T _A = -40 °C to 25 °C	23	TBD	
				T _A = 55 °C	TBD	TBD	
				T _A = 85 °C	TBD	TBD	
		All peripherals OFF, code executed from Flash, V _{DD} from 1.65 V to 3.6 V	MSI clock, 65 kHz f _{HCLK} = 32 kHz	T _A = -40 °C to 25 °C	22	TBD	
				T _A = 85 °C	TBD	TBD	
				T _A = 105 °C	TBD	TBD	
			MSI clock, 65 kHz f _{HCLK} = 65 kHz	T _A = -40 °C to 25 °C	27.5	TBD	
				T _A = 85 °C	TBD	TBD	
				T _A = 105 °C	TBD	TBD	
			MSI clock, 131 kHz f _{HCLK} = 131 kHz	T _A = -40 °C to 25 °C	39.5	TBD	
				T _A = 55 °C	TBD	TBD	
				T _A = 85 °C	TBD	TBD	
T _A = 105 °C	TBD	TBD	TBD				
	TBD	TBD	TBD				
	TBD	TBD	TBD				
	TBD	TBD	TBD				
I _{DD} max (LP Run)	Max allowed current in Low-power run mode	V _{DD} from 1.65 V to 3.6 V	-	-	-	TBD	

1. TBD stands for "to be defined".
2. Based on characterization, not tested in production, unless otherwise specified.

The following current consumption curve will be provided in next revision of this datasheet:

- I_{DD} vs V_{DD}, at T_A= -40 °C/25 °C/55 °C/ 85 °C, Low-power run mode, code running from RAM, Range 3, MSI (Range 0) at 64 KHz, 0 WS

Table 31. Current consumption in Low-power Sleep mode⁽¹⁾

Symbol	Parameter	Conditions		Typ	Max ⁽²⁾	Unit	
I _{DD} (LP Sleep)	Supply current in Low-power sleep mode	All peripherals OFF, V _{DD} from 1.65 V to 3.6 V	MSI clock, 65 kHz f _{HCLK} = 32 kHz Flash OFF	T _A = -40 °C to 25 °C	4.65	TBD	μA
				T _A = -40 °C to 25 °C	17	TBD	
			MSI clock, 65 kHz f _{HCLK} = 32 kHz Flash ON	T _A = 85 °C	19	TBD	
				T _A = 105 °C	TBD	TBD	
				T _A = -40 °C to 25 °C	17	TBD	
			MSI clock, 65 kHz f _{HCLK} = 65 kHz, Flash ON	T _A = 85 °C	TBD	TBD	
				T _A = 105 °C	TBD	TBD	
				T _A = -40 °C to 25 °C	19.5	TBD	
			MSI clock, 131 kHz f _{HCLK} = 131 kHz, Flash ON	T _A = 55 °C	TBD	TBD	
				T _A = 85 °C	TBD	TBD	
				T _A = 105 °C	TBD	TBD	
			I _{DD} max (LP Sleep)	Max allowed current in Low-power sleep mode	V _{DD} from 1.65 V to 3.6 V	-	

1. TBD stands for "to be defined".
2. Based on characterization, not tested in production, unless otherwise specified.

Table 32. Typical and maximum current consumptions in Stop mode⁽¹⁾

Symbol	Parameter	Conditions		Typ	Max ⁽²⁾	Unit	
I _{DD} (Stop with RTC)	Supply current in Stop mode with RTC enabled	RTC clocked by LSI, regulator in LP mode, HSI, LSE and HSE OFF (no independent watchdog)	LCD OFF	T _A = -40°C to 25°C V _{DD} = 1.8 V	1.1	TBD	μA
				T _A = -40°C to 25°C	1.35	TBD	
				T _A = 55°C	TBD	TBD	
				T _A = 85°C	TBD	TBD	
				T _A = 105°C	TBD	TBD	
			LCD ON (static duty) ⁽³⁾	T _A = -40°C to 25°C	1.65	TBD	
				T _A = 55°C	TBD	TBD	
				T _A = 85°C	TBD	TBD	
			LCD ON (1/8 duty) ⁽⁴⁾	T _A = 105°C	TBD	TBD	
				T _A = -40°C to 25°C	4.05	TBD	
				T _A = 55°C	TBD	TBD	



Table 32. Typical and maximum current consumptions in Stop mode⁽¹⁾ (continued)

Symbol	Parameter	Conditions		Typ	Max ⁽²⁾	Unit	
I _{DD} (Stop with RTC)	Supply current in Stop mode with RTC enabled	RTC clocked by LSE external quartz (32.768kHz), regulator in LP mode, HSI/HSE OFF (no independent watchdog ⁽⁵⁾⁽⁶⁾)	LCD OFF	T _A = -40°C to 25°C V _{DD} = 1.8V	0.82	-	μA
				T _A = -40°C to 25°C V _{DD} = 3.0V	1	-	
				T _A = -40°C to 25°C V _{DD} = 3.6V	1.15	-	
				T _A = 55°C	TBD	TBD	
				T _A = 85°C	TBD	-	
				T _A = 105°C	TBD	-	
				T _A = 125°C	TBD	-	
			LCD OFF, LSE high drive	T _A = -40°C to 25°C	1.4	-	
				T _A = 55°C	TBD	-	
				T _A = 85°C	TBD	-	
				T _A = 105°C	TBD	-	
			LCD ON (static duty) ⁽³⁾	T _A = -40°C to 25°C	1.3	-	
				T _A = 55°C	TBD	-	
				T _A = 85°C	TBD	-	
				T _A = 105°C	TBD	-	
			LCD ON (1/8 duty) ⁽⁴⁾	T _A = -40°C to 25°C	3.7	-	
T _A = 55°C	TBD	-					
T _A = 85°C	TBD	-					
T _A = 105°C	TBD	-					

Table 32. Typical and maximum current consumptions in Stop mode⁽¹⁾ (continued)

Symbol	Parameter	Conditions	Typ	Max ⁽²⁾	Unit	
I _{DD} (Stop)	Supply current in Stop mode (RTC disabled)	Reg in LP mode, LSE/HSI/HSE OFF, independent watchdog with LSI enabled	T _A = -40°C to 25°C	TBD	TBD	μA
			TBD	TBD		
			TBD	TBD		
			TBD	TBD		
		LPTIM1 enabled, regulator in LP mode, HSI/HSE/LSE/LSI OFF (no independent watchdog), 0 Hz external clock on LPTIM1_IN1	T _A = -40°C to 25°C	0.415	TBD	
		LPTIM1 enabled, regulator in LP mode, HSI/HSE/LSE/LSI OFF (no independent watchdog), 100 Hz external clock on LPTIM1_IN1	T _A = -40°C to 25°C	0.42	TBD	
		LPTIM1 enabled, regulator in LP mode, HSI/HSE/LSE/LSI OFF (no independent watchdog), 100 KHz external clock on LPTIM1_IN1	T _A = -40°C to 25°C	1.2	TBD	
		LPTIM1 enabled, regulator in LP mode, HSI/HSE/LSE/LSI OFF (no independent watchdog), 1 MHz external clock on LPTIM1_IN1	T _A = -40°C to 25°C	5.6	TBD	
		LPUART1 enabled and clocked by LSE external quartz at 32,768 kHz, regulator in LP mode, HSI/HSE/LSI OFF (no independent watchdog), LSE Low drive	T _A = -40°C to 25°C	0.785	TBD	
		LPUART1 enabled and clocked by LSE external quartz at 32,768 kHz, regulator in LP mode, HSI, HSE, and LSI OFF (no independent watchdog), LSE High drive	T _A = -40°C to 25°C	TBD	TBD	
		LPUART1 enabled and clocked by LSE ⁽⁷⁾ 32,768 kHz, regulator in LP mode, HSI/HSE/LSI OFF (no independent watchdog)	T _A = -40°C to 25°C	TBD	TBD	
		LPTIM1 and LPUART1 enabled and clocked by LSE ⁽⁷⁾ , LSE bypass, regulator in LP mode, HSI/HSE/LSI OFF (no independent watchdog)	T _A = -40°C to 25°C	TBD	TBD	
		Regulator in Low power mode, LSI/LSE/HSI/HSE OFF (no independent watchdog)	T _A = -40°C to 25°C	0.415	TBD	
			T _A = 55°C	TBD	TBD	
			T _A = 85°C	TBD	TBD	
T _A = 105°C	TBD		TBD ⁽⁸⁾			

Table 32. Typical and maximum current consumptions in Stop mode⁽¹⁾ (continued)

Symbol	Parameter	Conditions	Typ	Max ⁽²⁾	Unit	
I _{DD} (Stop)	Supply current in Stop mode (LPTIM1 enabled)	Regulator in Low power mode, HSI/HSE OFF, LSE Bypass and independent watchdog with LSI enabled	T _A = -40°C to 25°C	TBD	TBD	μA
			T _A = 55°C	TBD	TBD	
			T _A = 85°C	TBD	TBD	
			T _A = 105°C	TBD	TBD	
		Regulator in Low power mode, LSI/HSI/HSE OFF, LSE Bypass (no independent watchdog)	T _A = -40°C to 25°C	TBD	TBD	
			T _A = 55°C	TBD	TBD	
			T _A = 85°C	TBD	TBD	
			T _A = 105°C	TBD	TBD	
	Supply current in Stop mode (LPUART1 enabled)	Regulator in Low power mode, HSI/HSE OFF, LSE Bypass and independent watchdog with LSI enabled	T _A = -40°C to 25°C	TBD	TBD	
			T _A = 55°C	TBD	TBD	
			T _A = 85°C	TBD	TBD	
			T _A = 105°C	TBD	TBD	
Regulator in Low power mode, LSI/HSI/HSE OFF, LSE Bypass (no independent watchdog)		T _A = -40°C to 25°C	TBD	TBD		
		T _A = 55°C	TBD	TBD		
		T _A = 85°C	TBD	TBD		
		T _A = 105°C	TBD	TBD		
I _{DD} (WU from Stop)	Supply current during wakeup from Stop mode	MSI = 4.2 MHz	T _A = -40°C to 25°C	TBD	-	mA
		MSI = 1.05 MHz		TBD	-	
		MSI = 65 kHz ⁽⁹⁾		TBD	-	
		HSI16 = 16 MHz		TBD	-	
		HSI16/4 = 4 MHz		TBD	-	

- TBD stands for "to be defined".
- Based on characterization, not tested in production, unless otherwise specified.
- LCD enabled with external VLCD, static duty, division ratio = 256, all pixels active, no LCD connected.
- LCD enabled with external VLCD, 1/8 duty, 1/3 bias, division ratio = 64, all pixels active, no LCD connected.
- Based on characterization done with a 32.768 kHz crystal (MC306-G-06Q-32.768, manufacturer JFVNY) with two 6.8 pF loading capacitors.
- LSE Low drive unless otherwise specified.
- Oscillator bypassed (LSEBYP = 1 in RCC_CSR register).
- Tested in production.
- When MSI = 64 kHz, the RMS current is measured over the first 15 μs following the wakeup event. For the remaining part of the wakeup period, the current corresponds the Run mode current.

The following current consumption curve will be provided in next revision of this datasheet:

- I_{DD} vs V_{DD}, at T_A = -40 °C/25 °C/55 °C/ 85 °C, Stop mode with RTC enabled, all clocks OFF
- I_{DD} vs V_{DD}, at T_A = -40 °C/25 °C/55 °C/ 85 °C, Stop mode with RTC disabled, all clocks OFF

Table 33. Typical and maximum current consumptions in Standby mode⁽¹⁾

Symbol	Parameter	Conditions	Typ	Max ⁽²⁾	Unit	
I_{DD} (Standby with RTC)	Supply current in Standby mode with RTC enabled	RTC clocked by LSI (no independent watchdog)	$T_A = -40\text{ °C to }25\text{ °C}$, $V_{DD} = 1.8\text{ V}$	0.93	TBD	μA
			$T_A = -40\text{ °C to }25\text{ °C}$	1.2	TBD	
			$T_A = 55\text{ °C}$	TBD	TBD	
			$T_A = 85\text{ °C}$	TBD	TBD	
			$T_A = 105\text{ °C}$	TBD	TBD	
			$T_A = 125\text{ °C}$	TBD	TBD	
		RTC clocked by LSI (with independent watchdog)	$T_A = -40\text{ °C to }25\text{ °C}$, $V_{DD} = 1.8\text{ V}$	TBD	TBD	
			$T_A = -40\text{ °C to }25\text{ °C}$	TBD	TBD	
			$T_A = 55\text{ °C}$	TBD	TBD	
			$T_A = 85\text{ °C}$	TBD	TBD	
			$T_A = 105\text{ °C}$	TBD	TBD	
			$T_A = 125\text{ °C}$	TBD	TBD	
		RTC clocked by LSE (no independent watchdog), oscillator bypassed ⁽³⁾	$T_A = -40\text{ °C to }25\text{ °C}$	TBD	TBD	
			$T_A = -40\text{ °C to }25\text{ °C}$, $V_{DD} = 1.8\text{ V}$	TBD	TBD	
		RTC clocked by LSE 32.768 KHz external quartz (no independent watchdog), LSE low drive ⁽³⁾	$T_A = -40\text{ °C to }25\text{ °C}$, $V_{DD} = 1.8\text{ V}$	0.655	TBD	
			$T_A = -40\text{ °C to }25\text{ °C}$	0.845	TBD	
			$T_A = 55\text{ °C}$	TBD	TBD	
			$T_A = 85\text{ °C}$	TBD	TBD	
			$T_A = 105\text{ °C}$	TBD	TBD	
			$T_A = 125\text{ °C}$	TBD	TBD	
		RTC clocked by LSE 32.768 KHz external quartz (no independent watchdog), LSE high drive ⁽³⁾	$T_A = -40\text{ °C to }25\text{ °C}$, $V_{DD} = 1.8\text{ V}$	1	-	
			$T_A = -40\text{ °C to }25\text{ °C}$	1.2	-	
			$T_A = 55\text{ °C}$	TBD	-	
			$T_A = 85\text{ °C}$	TBD	-	
$T_A = 105\text{ °C}$	TBD		-			
$T_A = 125\text{ °C}$	TBD		-			
I_{DD} (Standby)	Supply current in Standby mode (RTC disabled)	Independent watchdog and LSI enabled	$T_A = -40\text{ °C to }25\text{ °C}$	TBD	TBD	
			$T_A = 55\text{ °C}$	TBD	TBD	
			$T_A = 85\text{ °C}$	TBD	TBD	
			$T_A = 105\text{ °C}$	TBD	TBD	

Table 33. Typical and maximum current consumptions in Standby mode⁽¹⁾ (continued)

Symbol	Parameter	Conditions		Typ	Max ⁽²⁾	Unit
I _{DD} (Standby)	Supply current in Standby mode (RTC disabled)	Independent watchdog and LSI OFF	T _A = -40 °C to 25 °C	0.29	TBD	μA
			T _A = 55 °C	TBD	TBD	
			T _A = 85 °C	TBD	TBD	
			T _A = 105 °C	TBD	TBD	
			T _A = 125 °C	TBD	TBD	
I _{DD} (WU from Standby)	Supply current during wakeup time from Standby mode	-	T _A = -40 °C to 25 °C	TBD	-	mA

1. TBD stands for "to be defined".
2. Based on characterization, not tested in production, unless otherwise specified
3. Based on characterization done with a 32.768 kHz crystal (MC306-G-06Q-32.768, manufacturer JFVNY) with two 6.8pF loading capacitors.

On-chip peripheral current consumption

The current consumption of the on-chip peripherals is given in the following table. The MCU is placed under the following conditions:

- all I/O pins are in input mode with a static value at V_{DD} or V_{SS} (no load)
- all peripherals are disabled unless otherwise mentioned
- the given value is calculated by measuring the current consumption
 - with all peripherals clocked off
 - with only one peripheral clocked on

Table 34. Peripheral current consumption⁽¹⁾⁽²⁾

Peripheral		Typical consumption, V _{DD} = 3.0 V, T _A = 25 °C				Unit
		Range 1, V _{CORE} = 1.8 V VOS[1:0] = 01	Range 2, V _{CORE} = 1.5 V VOS[1:0] = 10	Range 3, V _{CORE} = 1.2 V VOS[1:0] = 11	Low-power sleep and run	
APB1	LCD1	TBD	TBD	TBD	TBD	μA/MHz (f _{HCLK})
	WWDG	TBD	TBD	TBD	TBD	
	SPI2	TBD	TBD	TBD	TBD	
	USART2	TBD	TBD	TBD	TBD	
	LPUART	TBD	TBD	TBD	TBD	
	I2C1	TBD	TBD	TBD	TBD	
	I2C2	TBD	TBD	TBD	TBD	
	USB	TBD	TBD	TBD	TBD	
DAC1	TBD	TBD	TBD	TBD		

Table 34. Peripheral current consumption⁽¹⁾⁽²⁾ (continued)

Peripheral		Typical consumption, V _{DD} = 3.0 V, T _A = 25 °C				Unit
		Range 1, V _{CORE} = 1.8 V VOS[1:0] = 01	Range 2, V _{CORE} = 1.5 V VOS[1:0] = 10	Range 3, V _{CORE} = 1.2 V VOS[1:0] = 11	Low-power sleep and run	
APB2	COMP1	TBD	TBD	TBD	TBD	μA/MHz (f _{HCLK})
	COMP2	TBD	TBD	TBD	TBD	
	ADC1 ⁽³⁾	TBD	TBD	TBD	TBD	
	SPI1	TBD	TBD	TBD	TBD	
	USART1	TBD	TBD	TBD	TBD	
	TIM2	TBD	TBD	TBD	TBD	
	TIM21	TBD	TBD	TBD	TBD	
	TIM22	TBD	TBD	TBD	TBD	
Cortex-M0+ core I/O port	GPIOA	TBD	TBD	TBD	TBD	μA/MHz (f _{HCLK})
	GPIOB	TBD	TBD	TBD	TBD	
	GPIOC	TBD	TBD	TBD	TBD	
	GPIOD	TBD	TBD	TBD	TBD	
	GPIOH	TBD	TBD	TBD	TBD	
AHB	CRC	TBD	TBD	TBD	TBD	μA/MHz (f _{HCLK})
	FLASH	TBD	TBD	TBD	TBD	
	DMA1	TBD	TBD	TBD	TBD	
All enabled		TBD	TBD	TBD	TBD	
SYSCFG & RI		TBD	TBD	TBD	TBD	μA/MHz (f _{HCLK})
PWR		TBD	TBD	TBD	TBD	
I _{DD} (RTC)		TBD				μA
I _{DD} (LCD)		TBD				
I _{DD} (ADC) ⁽⁴⁾		TBD				
I _{DD} (DAC) ⁽⁵⁾		TBD				
I _{DD} (COMP1)		TBD				
I _{DD} (COMP2)	Slow mode	TBD				
	Fast mode	TBD				
I _{DD} (PVD / BOR) ⁽⁶⁾		TBD				
I _{DD} (IWDG)		TBD				

1. Data based on differential I_{DD} measurement between all peripherals OFF and one peripheral with clock enabled, in the following conditions: f_{HCLK} = 32 MHz (range 1), f_{HCLK} = 16 MHz (range 2), f_{HCLK} = 4 MHz (range 3), f_{HCLK} = 64kHz (Low-power run/sleep), f_{APB1} = f_{HCLK}, f_{APB2} = f_{HCLK}, default prescaler value for each peripheral. The CPU is in Sleep mode in both cases. No I/O pins toggling. Not tested in production.

2. TBD stands for "to be defined".
3. HSI oscillator is OFF for this measure.
4. Data based on a differential I_{DD} measurement between ADC in reset configuration and continuous ADC conversion (HSI consumption not included).
5. Data based on a differential I_{DD} measurement between DAC in reset configuration and continuous DAC conversion of $V_{DD}/2$. DAC is in buffered mode, output is left floating.
6. Including supply current of internal reference voltage.

6.3.5 Wakeup time from low-power mode

The wakeup times given in the following table are measured with the MSI or HSI16 RC oscillator. The clock source used to wake up the device depends on the current operating mode:

- Sleep mode: the clock source is the clock that was set before entering Sleep mode
- Stop mode: the clock source is either the MSI oscillator in the range configured before entering Stop mode, the HSI16 or HSI16/4.
- Standby mode: the clock source is the MSI oscillator running at 2.1 MHz

All timings are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in [Table 23](#).

Table 35. Low-power mode wakeup timings

Symbol	Parameter	Conditions	Typ	Max ⁽¹⁾	Unit
$t_{WUSLEEP}$	Wakeup from Sleep mode	$f_{HCLK} = 32 \text{ MHz}$	TBD	-	μs
$t_{WUSLEEP_LP}$	Wakeup from Low-power sleep mode, $f_{HCLK} = 262 \text{ kHz}$	$f_{HCLK} = 262 \text{ kHz}$ Flash enabled	TBD	-	
		$f_{HCLK} = 262 \text{ kHz}$ Flash switched OFF	TBD	-	
t_{WUSTOP}	Wakeup from Stop mode, regulator in Run mode	$f_{HCLK} = f_{MSI} = 4.2 \text{ MHz}$	TBD	-	
		$f_{HCLK} = f_{HSI} = 16 \text{ MHz}$	TBD	-	
		$f_{HCLK} = f_{HSI}/4 = 4 \text{ MHz}$	TBD	-	
	Wakeup from Stop mode, regulator in low-power mode	$f_{HCLK} = f_{MSI} = 4.2 \text{ MHz}$ Voltage range 1 and 2	TBD	TBD	
		$f_{HCLK} = f_{MSI} = 4.2 \text{ MHz}$ Voltage range 3	TBD	TBD	
		$f_{HCLK} = f_{MSI} = 2.1 \text{ MHz}$	TBD	TBD	
		$f_{HCLK} = f_{MSI} = 1.05 \text{ MHz}$	TBD	TBD	
		$f_{HCLK} = f_{MSI} = 524 \text{ kHz}$	TBD	TBD	
		$f_{HCLK} = f_{MSI} = 262 \text{ kHz}$	TBD	TBD	
		$f_{HCLK} = f_{MSI} = 131 \text{ kHz}$	TBD	TBD	
		$f_{HCLK} = f_{MSI} = 65 \text{ kHz}$	TBD	TBD	
		$f_{HCLK} = f_{HSI} = 16 \text{ MHz}$	TBD	-	
		$f_{HCLK} = f_{HSI}/4 = 4 \text{ MHz}$	TBD	-	
Wakeup from Stop mode, regulator in low-power mode, code running from RAM	$f_{HCLK} = f_{HSI} = 16 \text{ MHz}$	TBD	TBD		
	$f_{HCLK} = f_{HSI}/4 = 4 \text{ MHz}$	TBD	TBD		
	$f_{HCLK} = f_{MSI} = 4.2 \text{ MHz}$	TBD	TBD		
$t_{WUSTDBY}$	Wakeup from Standby mode FWU bit = 1	$f_{HCLK} = f_{MSI} = 2.1 \text{ MHz}$	TBD	TBD	
	Wakeup from Standby mode FWU bit = 0	$f_{HCLK} = f_{MSI} = 2.1 \text{ MHz}$	TBD	TBD	ms

1. Based on characterization, not tested in production, unless otherwise specified

6.3.6 External clock source characteristics

High-speed external user clock generated from an external source

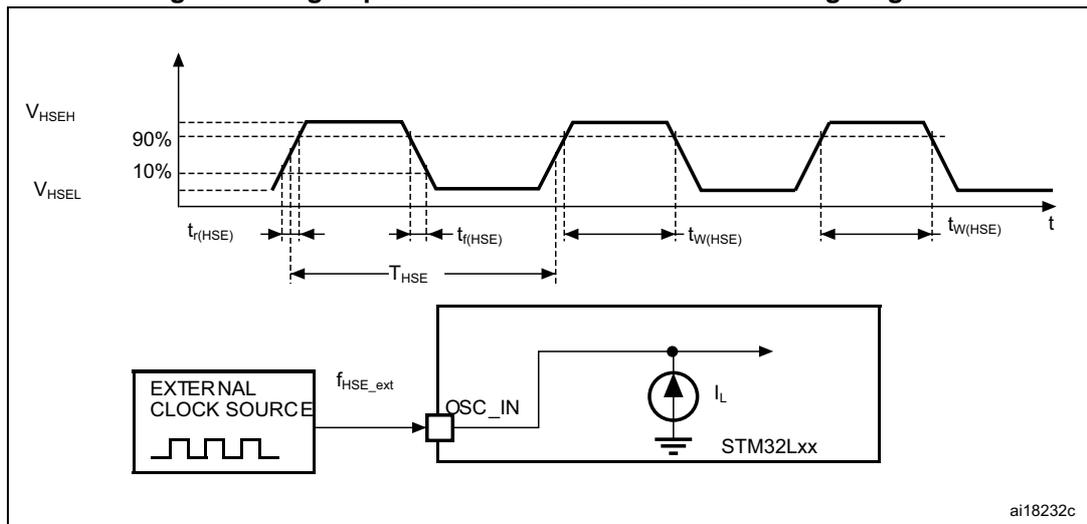
In bypass mode the HSE oscillator is switched off and the input pin is a standard GPIO. The external clock signal has to respect the I/O characteristics in [Section 6.3.12](#). However, the recommended clock input waveform is shown in [Figure 12](#).

Table 36. High-speed external user clock characteristics⁽¹⁾

Symbol	Parameter	Conditions	Min	Typ	Max	Unit	
f_{HSE_ext}	User external clock source frequency	CSS is on or PLL is used	1	8	32	MHz	
		CSS is off, PLL not used	0	8	32	MHz	
V_{HSEH}	OSC_IN input pin high level voltage	-	$0.7V_{DD}$	-	V_{DD}	V	
V_{HSEL}	OSC_IN input pin low level voltage		V_{SS}	-	$0.3V_{DD}$		
$t_{w(HSE)}$ $t_{w(HSE)}$	OSC_IN high or low time		12	-	-	ns	
$t_{r(HSE)}$ $t_{f(HSE)}$	OSC_IN rise or fall time		-	-	20		
$C_{in(HSE)}$	OSC_IN input capacitance		-	2.6	-		pF
$DuCy_{(HSE)}$	Duty cycle			45	-	55	%
I_L	OSC_IN Input leakage current		$V_{SS} \leq V_{IN} \leq V_{DD}$	-	-	± 1	μA

1. Guaranteed by design, not tested in production.

Figure 12. High-speed external clock source AC timing diagram



Low-speed external user clock generated from an external source

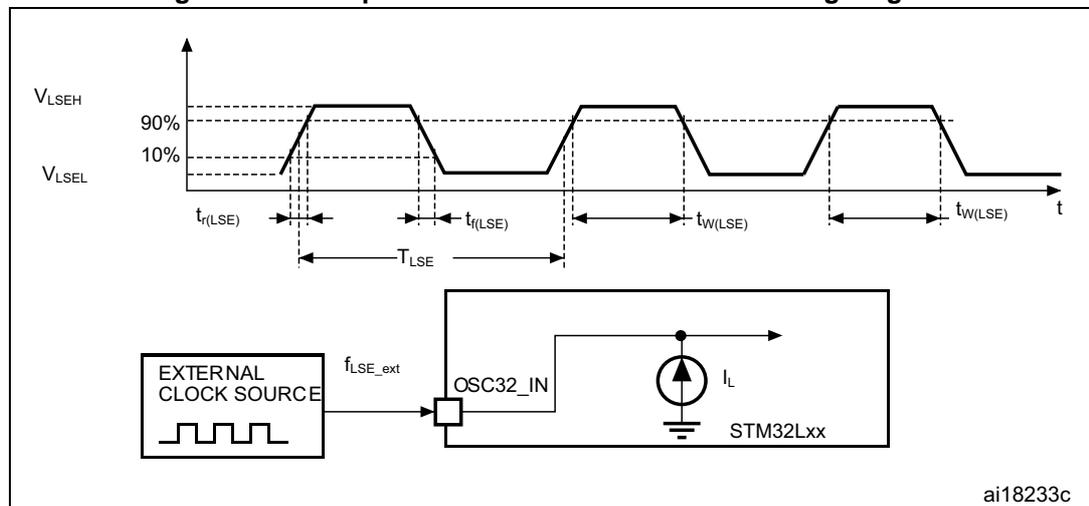
The characteristics given in the following table result from tests performed using a low-speed external clock source, and under ambient temperature and supply voltage conditions summarized in [Table 23](#).

Table 37. Low-speed external user clock characteristics⁽¹⁾

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{LSE_ext}	User external clock source frequency		1	32.768	1000	kHz
V_{LSEH}	OSC32_IN input pin high level voltage	-	$0.7V_{DD}$	-	V_{DD}	V
V_{LSEL}	OSC32_IN input pin low level voltage		V_{SS}	-	$0.3V_{DD}$	
$t_{w(LSE)}$ $t_{w(LSE)}$	OSC32_IN high or low time		465	-	-	ns
$t_{r(LSE)}$ $t_{r(LSE)}$	OSC32_IN rise or fall time	-	-	10		
$C_{IN(LSE)}$	OSC32_IN input capacitance	-	-	0.6	-	pF
$DuCy_{(LSE)}$	Duty cycle	-	45	-	55	%
I_L	OSC32_IN Input leakage current	$V_{SS} \leq V_{IN} \leq V_{DD}$	-	-	± 1	μA

1. Guaranteed by design, not tested in production

Figure 13. Low-speed external clock source AC timing diagram



High-speed external clock generated from a crystal/ceramic resonator

The high-speed external (HSE) clock can be supplied with a 1 to 24 MHz crystal/ceramic resonator oscillator. All the information given in this paragraph are based on characterization results obtained with typical external components specified in [Table 38](#). In the application, the resonator and the load capacitors have to be placed as close as possible to the oscillator pins in order to minimize output distortion and startup stabilization

time. Refer to the crystal resonator manufacturer for more details on the resonator characteristics (frequency, package, accuracy).

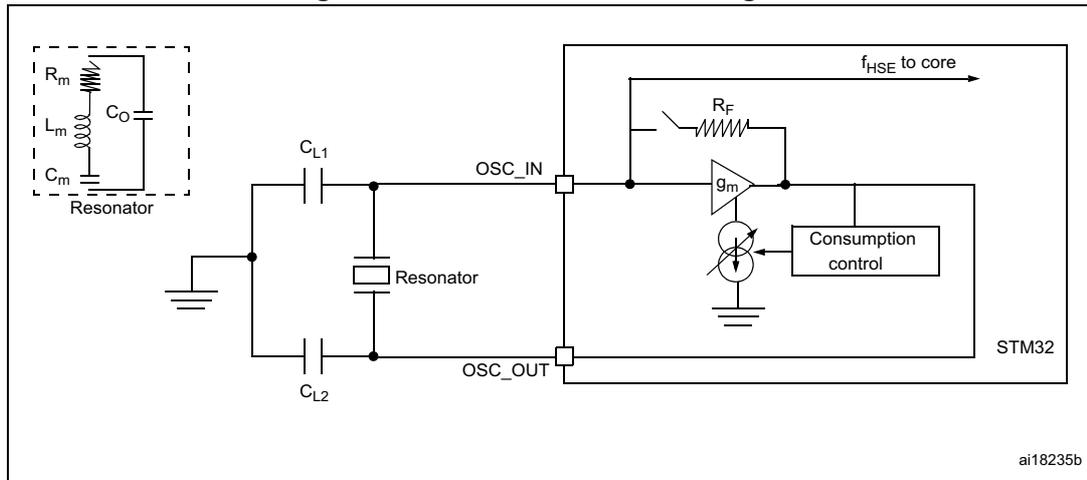
Table 38. HSE oscillator characteristics⁽¹⁾⁽²⁾

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{OSC_IN}	Oscillator frequency	-	1		24	MHz
R_F	Feedback resistor	-	-	200	-	k Ω
C	Recommended load capacitance versus equivalent serial resistance of the crystal (R_S) ⁽³⁾	$R_S = 30 \Omega$	-	20	-	pF
I_{HSE}	HSE driving current	$V_{DD} = 3.3 V$, $V_{IN} = V_{SS}$ with 30 pF load	-	-	3	mA
$I_{DD(HSE)}$	HSE oscillator power consumption	C = 20 pF $f_{OSC} = 16 MHz$	-	-	2.5 (startup) 0.7 (stabilized)	mA
		C = 10 pF $f_{OSC} = 16 MHz$	-	-	2.5 (startup) 0.46 (stabilized)	
g_m	Oscillator transconductance	Startup	3.5	-	-	mA /V
$t_{SU(HSE)}^{(4)}$	Startup time	V_{DD} is stabilized	-	1	-	ms

1. Resonator characteristics given by the crystal/ceramic resonator manufacturer.
2. Based on characterization results, not tested in production.
3. The relatively low value of the RF resistor offers a good protection against issues resulting from use in a humid environment, due to the induced leakage and the bias condition change. However, it is recommended to take this point into account if the MCU is used in tough humidity conditions.
4. $t_{SU(HSE)}$ is the startup time measured from the moment it is enabled (by software) to a stabilized 8 MHz oscillation is reached. This value is measured for a standard crystal resonator and it can vary significantly with the crystal manufacturer.

For C_{L1} and C_{L2} , it is recommended to use high-quality external ceramic capacitors in the 5 pF to 25 pF range (typ.), designed for high-frequency applications, and selected to match the requirements of the crystal or resonator (see [Figure 14](#)). C_{L1} and C_{L2} are usually the same size. The crystal manufacturer typically specifies a load capacitance which is the series combination of C_{L1} and C_{L2} . PCB and MCU pin capacitance must be included (10 pF can be used as a rough estimate of the combined pin and board capacitance) when sizing C_{L1} and C_{L2} . Refer to the application note AN2867 "Oscillator design guide for ST microcontrollers" available from the ST website www.st.com.

Figure 14. HSE oscillator circuit diagram



1. R_{EXT} value depends on the crystal characteristics.

Low-speed external clock generated from a crystal/ceramic resonator

The low-speed external (LSE) clock can be supplied with a 32.768 kHz crystal/ceramic resonator oscillator. All the information given in this paragraph are based on characterization results obtained with typical external components specified in [Table 39](#). In the application, the resonator and the load capacitors have to be placed as close as possible to the oscillator pins in order to minimize output distortion and startup stabilization time. Refer to the crystal resonator manufacturer for more details on the resonator characteristics (frequency, package, accuracy).

Table 39. LSE oscillator characteristics ($f_{LSE} = 32.768$ kHz)

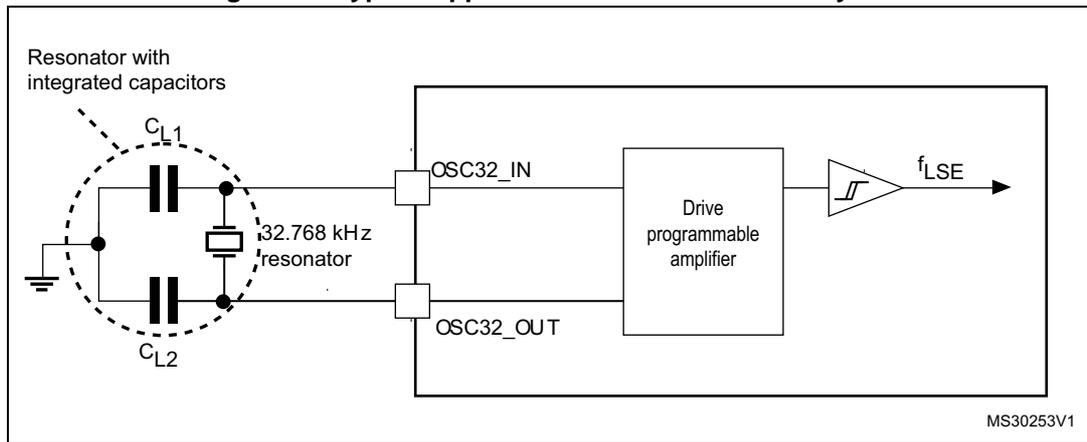
Symbol	Parameter	Conditions ⁽¹⁾	Min ⁽²⁾	Typ	Max ⁽²⁾	Unit
I_{DD}	LSE current consumption	LSEDRV[1:0]=00 lower driving capability	-	0.5	0.9	μA
		LSEDRV[1:0]= 01 medium low driving capability	-	-	1	
		LSEDRV[1:0] = 10 medium high driving capability	-	-	1.3	
		LSEDRV[1:0]=11 higher driving capability	-	-	1.6	
g_m	Oscillator transconductance	LSEDRV[1:0]=00 lower driving capability	5	-	-	$\mu A/V$
		LSEDRV[1:0]= 01 medium low driving capability	8	-	-	
		LSEDRV[1:0] = 10 medium high driving capability	15	-	-	
		LSEDRV[1:0]=11 higher driving capability	25	-	-	
$t_{SU(LSE)}^{(3)}$	Startup time	V_{DD} is stabilized	-	2	-	s

1. Refer to the note and caution paragraphs below the table, and to the application note AN2867 "Oscillator design guide for ST microcontrollers".

- 2. Guaranteed by design, not tested in production.
- 3. $t_{SU(LSE)}$ is the startup time measured from the moment it is enabled (by software) to a stabilized 32.768 kHz oscillation is reached. This value is measured for a standard crystal and it can vary significantly with the crystal manufacturer

Note: For information on selecting the crystal, refer to the application note AN2867 "Oscillator design guide for ST microcontrollers" available from the ST website www.st.com.

Figure 15. Typical application with a 32.768 kHz crystal



Note: An external resistor is not required between OSC32_IN and OSC32_OUT and it is forbidden to add one.

6.3.7 Internal clock source characteristics

The parameters given in [Table 40](#) are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in [Table 23](#).

High-speed internal 16 MHz (HSI16) RC oscillator

Table 40. 16 MHz HSI16 oscillator characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{HSI16}	Frequency	$V_{DD} = 3.0\text{ V}$	-	16	-	MHz
$TRIM^{(1)(2)}$	HSI16 user-trimmed resolution	Trimming code is not a multiple of 16	-	± 0.4	0.7	%
		Trimming code is a multiple of 16	-	-	± 1.5	%
$ACC_{HSI16}^{(2)}$	Accuracy of the factory-calibrated HSI16 oscillator	$V_{DDA} = 3.0\text{ V}, T_A = 25\text{ }^\circ\text{C}$	-1 ⁽³⁾	-	1 ⁽³⁾	%
		$V_{DDA} = 3.0\text{ V}, T_A = 0\text{ to }55\text{ }^\circ\text{C}$	-1.5	-	1.5	%
		$V_{DDA} = 3.0\text{ V}, T_A = -10\text{ to }70\text{ }^\circ\text{C}$	-2	-	2	%
		$V_{DDA} = 3.0\text{ V}, T_A = -10\text{ to }85\text{ }^\circ\text{C}$	-2.5	-	2	%
		$V_{DDA} = 3.0\text{ V}, T_A = -10\text{ to }105\text{ }^\circ\text{C}$	-4	-	2	%
		$V_{DDA} = 1.65\text{ V to }3.6\text{ V}$ $T_A = -40\text{ to }105\text{ }^\circ\text{C}$	-4	-	3	%
$t_{SU(HSI16)}^{(2)}$	HSI16 oscillator startup time	-	-	3.7	6	μs
$I_{DD(HSI16)}^{(2)}$	HSI16 oscillator power consumption	-	-	100	140	μA

1. The trimming step differs depending on the trimming code. It is usually negative on the codes which are multiples of 16 (0x00, 0x10, 0x20, 0x30...0xE0).
2. Based on characterization, not tested in production.
3. Tested in production.

High-speed internal 48 MHz (HSI48) RC oscillator

Table 41. HSI48 oscillator characteristics⁽¹⁾⁽²⁾

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{HSI48}	Frequency		-	48	-	MHz
TRIM	HSI48 user-trimming step		0.09 ⁽³⁾	0.14	0.2 ⁽³⁾	%
$DuCy_{(HSI48)}$	Duty cycle		45 ⁽³⁾	-	55 ⁽³⁾	%
ACC_{HSI48}	Accuracy of the HSI48 oscillator (factory calibrated)	$T_A = -40\text{ to }105\text{ }^\circ\text{C}$	TBD	-	TBD	%
		$T_A = -10\text{ to }85\text{ }^\circ\text{C}$	TBD	-	TBD	%
		$T_A = 0\text{ to }70\text{ }^\circ\text{C}$	TBD	-	TBD	%
		$T_A = 25\text{ }^\circ\text{C}$	TBD	-	TBD	%
$t_{su(HSI48)}$	HSI48 oscillator startup time		-	-	TBD	μs
$I_{DDA(HSI48)}$	HSI48 oscillator power consumption		-	TBD	TBD	μA

1. $V_{DDA} = 3.3\text{ V}$, $T_A = -40\text{ to }105\text{ °C}$ unless otherwise specified.
2. TBD stands for “to be defined”.
3. Guaranteed by design, not tested in production.

Low-speed internal (LSI) RC oscillator

Table 42. LSI oscillator characteristics

Symbol	Parameter	Min	Typ	Max	Unit
$f_{LSI}^{(1)}$	LSI frequency	26	38	56	kHz
$D_{LSI}^{(2)}$	LSI oscillator frequency drift $0\text{ °C} \leq T_A \leq 85\text{ °C}$	-10	-	4	%
$t_{su(LSI)}^{(3)}$	LSI oscillator startup time	-	-	200	μs
$I_{DD(LSI)}^{(3)}$	LSI oscillator power consumption	-	400	510	nA

1. Tested in production.
2. This is a deviation for an individual part, once the initial frequency has been measured.
3. Guaranteed by design, not tested in production.

Multi-speed internal (MSI) RC oscillator

Table 43. MSI oscillator characteristics

Symbol	Parameter	Condition	Typ	Max	Unit
f_{MSI}	Frequency after factory calibration, done at $V_{DD} = 3.3\text{ V}$ and $T_A = 25\text{ °C}$	MSI range 0	65.5	-	kHz
		MSI range 1	131	-	
		MSI range 2	262	-	
		MSI range 3	524	-	
		MSI range 4	1.05	-	MHz
		MSI range 5	2.1	-	
		MSI range 6	4.2	-	
ACC_{MSI}	Frequency error after factory calibration	-	± 0.5	-	%
$D_{TEMP(MSI)}^{(1)}$	MSI oscillator frequency drift $0\text{ °C} \leq T_A \leq 85\text{ °C}$	-	± 3	-	%
$D_{VOLT(MSI)}^{(1)}$	MSI oscillator frequency drift $1.65\text{ V} \leq V_{DD} \leq 3.6\text{ V}$, $T_A = 25\text{ °C}$	-	-	2.5	%/V
$I_{DD(MSI)}^{(2)}$	MSI oscillator power consumption	MSI range 0	0.75	-	μA
		MSI range 1	1	-	
		MSI range 2	1.5	-	
		MSI range 3	2.5	-	
		MSI range 4	4.5	-	
		MSI range 5	8	-	
		MSI range 6	15	-	

Table 43. MSI oscillator characteristics (continued)

Symbol	Parameter	Condition	Typ	Max	Unit
$t_{SU(MSI)}$	MSI oscillator startup time	MSI range 0	30	-	μs
		MSI range 1	20	-	
		MSI range 2	15	-	
		MSI range 3	10	-	
		MSI range 4	6	-	
		MSI range 5	5	-	
		MSI range 6, Voltage range 1 and 2	3.5	-	
$t_{STAB(MSI)}^{(2)}$	MSI oscillator stabilization time	MSI range 0	-	40	μs
		MSI range 1	-	20	
		MSI range 2	-	10	
		MSI range 3	-	4	
		MSI range 4	-	2.5	
		MSI range 5	-	2	
		MSI range 6, Voltage range 1 and 2	-	2	
$f_{OVER(MSI)}$	MSI oscillator frequency overshoot	Any range to range 5	-	4	MHz
		Any range to range 6	-	6	

1. This is a deviation for an individual part, once the initial frequency has been measured.
2. Based on characterization, not tested in production.

6.3.8 PLL characteristics

The parameters given in [Table 44](#) are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in [Table 23](#).

Table 44. PLL characteristics

Symbol	Parameter	Value			Unit
		Min	Typ	Max ⁽¹⁾	
f _{PLL_IN}	PLL input clock ⁽²⁾	2	-	24	MHz
	PLL input clock duty cycle	45	-	55	%
f _{PLL_OUT}	PLL output clock	2	-	32	MHz
t _{LOCK}	Worst case PLL lock time PLL input = 2 MHz PLL VCO = 96 MHz	-	TBD	TBD	μs
Jitter	Cycle-to-cycle jitter	-		± 600	ps
I _{DDA} (PLL)	Current consumption on V _{DDA}	-	220	450	μA
I _{DD} (PLL)	Current consumption on V _{DD}	-	120	150	

1. Based on characterization, not tested in production.
2. Take care of using the appropriate multiplier factors so as to have PLL input clock values compatible with the range defined by f_{PLL_OUT}.

6.3.9 Memory characteristics

The characteristics are given at T_A = -40 to 105 °C unless otherwise specified.

RAM memory

Table 45. RAM and hardware registers

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
VRM	Data retention mode ⁽¹⁾	STOP mode (or RESET)	1.65	-	-	V

1. Minimum supply voltage without losing data stored in RAM (in Stop mode or under Reset) or in hardware registers (only in Stop mode).

Flash memory and data EEPROM

Table 46. Flash memory and data EEPROM characteristics

Symbol	Parameter	Conditions	Min	Typ	Max ⁽¹⁾	Unit
V _{DD}	Operating voltage Read / Write / Erase	-	1.65	-	3.6	V
t _{prog}	Programming time for word or half-page	Erasing	-	3.28	3.94	ms
		Programming	-	3.28	3.94	
I _{DD}	Average current during the whole programming / erase operation	T _A = 25 °C, V _{DD} = 3.6 V	-	TBD	TBD	µA
	Maximum current (peak) during the whole programming / erase operation		-	TBD	TBD	mA

1. Guaranteed by design, not tested in production.

Table 47. Flash memory and data EEPROM endurance and retention

Symbol	Parameter	Conditions	Value			Unit
			Min ⁽¹⁾	Typ	Max	
N _{CYC} ⁽²⁾	Cycling (erase / write) Program memory	T _A = -40°C to 105 °C	10	-	-	kcycles
	Cycling (erase / write) EEPROM data memory		100	-	-	
t _{RET} ⁽²⁾	Data retention (program memory) after 10 kcycles at T _A = 85 °C	T _{RET} = +85 °C	30	-	-	years
	Data retention (EEPROM data memory) after 100 kcycles at T _A = 85 °C		30	-	-	
	Data retention (program memory) after 10 kcycles at T _A = 105 °C	T _{RET} = +105 °C	10	-	-	
	Data retention (EEPROM data memory) after 100 kcycles at T _A = 105 °C		10	-	-	

1. Based on characterization not tested in production.

2. Characterization is done according to JEDEC JESD22-A117.

6.3.10 EMC characteristics

Susceptibility tests are performed on a sample basis during device characterization.

Functional EMS (electromagnetic susceptibility)

While a simple application is executed on the device (toggling 2 LEDs through I/O ports), the device is stressed by two electromagnetic events until a failure occurs. The failure is indicated by the LEDs:

- **Electrostatic discharge (ESD)** (positive and negative) is applied to all device pins until a functional disturbance occurs. This test is compliant with the IEC 61000-4-2 standard.
- **FTB: A Burst of Fast Transient voltage** (positive and negative) is applied to V_{DD} and V_{SS} through a 100 pF capacitor, until a functional disturbance occurs. This test is compliant with the IEC 61000-4-4 standard.

A device reset allows normal operations to be resumed.

The test results are given in [Table 48](#). They are based on the EMS levels and classes defined in application note AN1709.

Table 48. EMS characteristics

Symbol	Parameter	Conditions	Level/Class
V_{FESD}	Voltage limits to be applied on any I/O pin to induce a functional disturbance	$V_{DD} = 3.3\text{ V}$, LQFP100, $T_A = +25\text{ }^\circ\text{C}$, $f_{HCLK} = 32\text{ MHz}$ conforms to IEC 61000-4-2	2B
V_{EFTB}	Fast transient voltage burst limits to be applied through 100 pF on V_{DD} and V_{SS} pins to induce a functional disturbance	$V_{DD} = 3.3\text{ V}$, LQFP100, $T_A = +25\text{ }^\circ\text{C}$, $f_{HCLK} = 32\text{ MHz}$ conforms to IEC 61000-4-4	4A

Designing hardened software to avoid noise problems

EMC characterization and optimization are performed at component level with a typical application environment and simplified MCU software. It should be noted that good EMC performance is highly dependent on the user application and the software in particular.

Therefore it is recommended that the user applies EMC software optimization and prequalification tests in relation with the EMC level requested for his application.

Software recommendations

The software flowchart must include the management of runaway conditions such as:

- Corrupted program counter
- Unexpected reset
- Critical data corruption (control registers...)

Prequalification trials

Most of the common failures (unexpected reset and program counter corruption) can be reproduced by manually forcing a low state on the NRST pin or the oscillator pins for 1 second.

To complete these trials, ESD stress can be applied directly on the device, over the range of specification values. When unexpected behavior is detected, the software can be hardened to prevent unrecoverable errors occurring (see application note AN1015).

Electromagnetic Interference (EMI)

The electromagnetic field emitted by the device are monitored while a simple application is executed (toggling 2 LEDs through the I/O ports). This emission test is compliant with IEC 61967-2 standard which specifies the test board and the pin loading.

Table 49. EMI characteristics

Symbol	Parameter	Conditions	Monitored frequency band	Max vs. frequency range			Unit
				4 MHz voltage range 3	16 MHz voltage range 2	32 MHz voltage range 1	
S _{EMI}	Peak level	V _{DD} = 3.3 V, T _A = 25 °C, LQFP100 package compliant with IEC 61967-2	0.1 to 30 MHz	3	-6	-5	dBμV
			30 to 130 MHz	18	4	-7	
			130 MHz to 1GHz	15	5	-7	
			SAE EMI Level	2.5	2	1	-

6.3.11 Electrical sensitivity characteristics

Based on three different tests (ESD, LU) using specific measurement methods, the device is stressed in order to determine its performance in terms of electrical sensitivity.

Electrostatic discharge (ESD)

Electrostatic discharges (a positive then a negative pulse separated by 1 second) are applied to the pins of each sample according to each pin combination. The sample size depends on the number of supply pins in the device (3 parts × (n+1) supply pins). This test conforms to the JESD22-A114/C101 standard.

Table 50. ESD absolute maximum ratings

Symbol	Ratings	Conditions	Class	Maximum value ⁽¹⁾	Unit
V _{ESD(HBM)}	Electrostatic discharge voltage (human body model)	T _A = +25 °C, conforming to JESD22-A114	2	2000	V
V _{ESD(CDM)}	Electrostatic discharge voltage (charge device model)	T _A = +25 °C, conforming to ANSI/ESD STM5.3.1.	II	500	

1. Based on characterization results, not tested in production.



Static latch-up

Two complementary static tests are required on six parts to assess the latch-up performance:

- A supply overvoltage is applied to each power supply pin
- A current injection is applied to each input, output and configurable I/O pin

These tests are compliant with EIA/JESD 78A IC latch-up standard.

Table 51. Electrical sensitivities

Symbol	Parameter	Conditions	Class
LU	Static latch-up class	T _A = +105 °C conforming to JESD78A	II level A

6.3.12 I/O current injection characteristics

As a general rule, current injection to the I/O pins, due to external voltage below V_{SS} or above V_{DD} (for standard pins) should be avoided during normal product operation. However, in order to give an indication of the robustness of the microcontroller in cases when abnormal injection accidentally happens, susceptibility tests are performed on a sample basis during device characterization.

Functional susceptibility to I/O current injection

While a simple application is executed on the device, the device is stressed by injecting current into the I/O pins programmed in floating input mode. While current is injected into the I/O pin, one at a time, the device is checked for functional failures.

The failure is indicated by an out of range parameter: ADC error above a certain limit (higher than 5 LSB TUE), out of conventional limits of induced leakage current on adjacent pins (out of -5 µA/+0 µA range), or other functional failure (for example reset occurrence oscillator frequency deviation, LCD levels).

The test results are given in the [Table 52](#).

Table 52. I/O current injection susceptibility

Symbol	Description	Functional susceptibility		Unit
		Negative injection	Positive injection	
I _{INJ}	Injected current on all 5 V tolerant (FT) pins	-5 ⁽¹⁾	+0	mA
	Injected current on any other pin	-5 ⁽¹⁾	+5	

1. It is recommended to add a Schottky diode (pin to ground) to analog pins which may potentially inject negative currents.

6.3.13 I/O port characteristics

General input/output characteristics

Unless otherwise specified, the parameters given in [Table 53](#) are derived from tests performed under the conditions summarized in [Table 23](#). All I/Os are CMOS and TTL compliant.

Table 53. I/O static characteristics⁽¹⁾

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V _{IL}	Input low level voltage	Standard I/O, and FT I/O	-	-	0.3V _{DD} ⁽²⁾	V
		BOOT0 I/O	-	-	TBD	
V _{IH}	Input high level voltage	Standard I/O	0.7 V _{DD}	-	-	
		FT I/O		-	-	
		BOOT0 I/O	TBD	-	-	
V _{hys}	I/O Schmitt trigger voltage hysteresis ⁽³⁾	Standard I/O	-	10% V _{DD} ⁽⁴⁾	-	
		FT I/O Schmitt trigger hysteresis	-	TBD	-	
I _{lkg}	Input leakage current ⁽⁵⁾	V _{SS} ≤ V _{IN} ≤ V _{DD} I/Os with LCD	-	-	±50	nA
		V _{SS} ≤ V _{IN} ≤ V _{DD} I/Os with analog switches	-	-	±50	
		V _{SS} ≤ V _{IN} ≤ V _{DD} I/Os with analog switches and LCD	-	-	±50	
		V _{SS} ≤ V _{IN} ≤ V _{DD} I/Os with USB	-	-	250	
		V _{SS} ≤ V _{IN} ≤ V _{DD} Standard I/Os	-	-	±50	
		FT I/O V _{DD} ≤ V _{IN} ≤ 5 V	-	-	±10	μA
R _{PU}	Weak pull-up equivalent resistor ⁽⁶⁾⁽²⁾	V _{IN} = V _{SS}	30	45	60	kΩ
R _{PD}	Weak pull-down equivalent resistor ⁽⁶⁾	V _{IN} = V _{DD}	30	45	60	kΩ
C _{IO}	I/O pin capacitance	-	-	5	-	pF

1. TBD stands for "to be defined".

2. Tested in production

3. Hysteresis voltage between Schmitt trigger switching levels. Based on characterization, not tested in production.

4. With a minimum of 200 mV. Based on characterization, not tested in production.

5. The max. value may be exceeded if negative current is injected on adjacent pins.

6. Pull-up and pull-down resistors are designed with a true resistance in series with a switchable PMOS/NMOS. This MOS/NMOS contribution to the series resistance is minimum (~10% order).

Output driving current

The GPIOs (general purpose input/outputs) can sink or source up to ±8 mA, and sink or source up to ±20 mA with the non-standard V_{OL}/V_{OH} specifications given in [Table 54](#).

In the user application, the number of I/O pins which can drive current must be limited to respect the absolute maximum rating specified in [Section 6.2](#):

- The sum of the currents sourced by all the I/Os on V_{DD} , plus the maximum Run consumption of the MCU sourced on V_{DD} , cannot exceed the absolute maximum rating $I_{VDD(\Sigma)}$ (see [Table 21](#)).
- The sum of the currents sunk by all the I/Os on V_{SS} plus the maximum Run consumption of the MCU sunk on V_{SS} cannot exceed the absolute maximum rating $I_{VSS(\Sigma)}$ (see [Table 21](#)).

Output voltage levels

Unless otherwise specified, the parameters given in [Table 54](#) are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in [Table 23](#). All I/Os are CMOS and TTL compliant.

Table 54. Output voltage characteristics

Symbol	Parameter	Conditions	Min	Max	Unit
$V_{OL}^{(1)(2)}$	Output low level voltage for an I/O pin	$I_{IO} = +8 \text{ mA}$ $2.7 \text{ V} < V_{DD} < 3.6 \text{ V}$	-	0.4	V
$V_{OH}^{(3)(2)}$	Output high level voltage for an I/O pin		$V_{DD}-0.4$	-	
$V_{OL}^{(3)(4)}$	Output low level voltage for an I/O pin	$I_{IO} = +4 \text{ mA}$ $1.65 \text{ V} < V_{DD} < 2.7 \text{ V}$	-	0.45	
$V_{OH}^{(3)(4)}$	Output high level voltage for an I/O pin		$V_{DD}-0.45$	-	
$V_{OL}^{(1)(4)}$	Output low level voltage for an I/O pin	$I_{IO} = +20 \text{ mA}$ $2.7 \text{ V} < V_{DD} < 3.6 \text{ V}$	-	1.3	
$V_{OH}^{(3)(4)}$	Output high level voltage for an I/O pin		$V_{DD}-1.3$	-	
$V_{OLFM+}^{(4)}$	Output low level voltage for an FTf I/O pin in Fm+ mode	TBD	-	TBD	

1. The I_{IO} current sunk by the device must always respect the absolute maximum rating specified in [Table 21](#) and the sum of I_{IO} (I/O ports and control pins) must not exceed I_{VSS} .
2. Tested in production.
3. The I_{IO} current sourced by the device must always respect the absolute maximum rating specified in [Table 21](#) and the sum of I_{IO} (I/O ports and control pins) must not exceed I_{VDD} .
4. Based on characterization data, not tested in production.

Input/output AC characteristics

The definition and values of input/output AC characteristics are given in [Figure 16](#) and [Table 55](#), respectively.

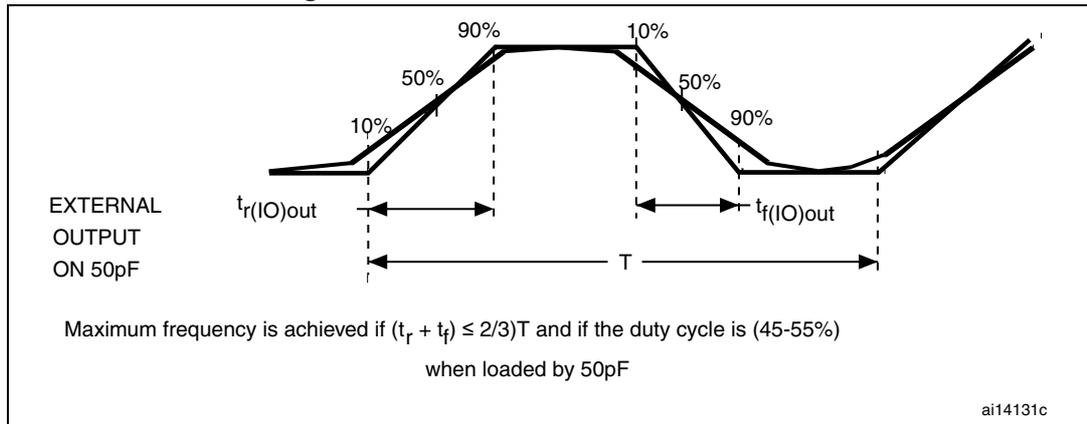
Unless otherwise specified, the parameters given in [Table 55](#) are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in [Table 23](#).

Table 55. I/O AC characteristics⁽¹⁾

OSPEEDRx [1:0] bit value ⁽¹⁾	Symbol	Parameter	Conditions	Min	Max ⁽²⁾	Unit
00	$f_{\max(\text{IO})\text{out}}$	Maximum frequency ⁽³⁾	$C_L = 50 \text{ pF}, V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$	-	400	kHz
			$C_L = 50 \text{ pF}, V_{DD} = 1.65 \text{ V to } 2.7 \text{ V}$	-	400	
	$t_{f(\text{IO})\text{out}}$ $t_{r(\text{IO})\text{out}}$	Output rise and fall time	$C_L = 50 \text{ pF}, V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$	-	625	ns
			$C_L = 50 \text{ pF}, V_{DD} = 1.65 \text{ V to } 2.7 \text{ V}$	-	625	
01	$f_{\max(\text{IO})\text{out}}$	Maximum frequency ⁽³⁾	$C_L = 50 \text{ pF}, V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$	-	2	MHz
			$C_L = 50 \text{ pF}, V_{DD} = 1.65 \text{ V to } 2.7 \text{ V}$	-	1	
	$t_{f(\text{IO})\text{out}}$ $t_{r(\text{IO})\text{out}}$	Output rise and fall time	$C_L = 50 \text{ pF}, V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$	-	125	ns
			$C_L = 50 \text{ pF}, V_{DD} = 1.65 \text{ V to } 2.7 \text{ V}$	-	250	
10	$F_{\max(\text{IO})\text{out}}$	Maximum frequency ⁽³⁾	$C_L = 50 \text{ pF}, V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$	-	10	MHz
			$C_L = 50 \text{ pF}, V_{DD} = 1.65 \text{ V to } 2.7 \text{ V}$	-	2	
	$t_{f(\text{IO})\text{out}}$ $t_{r(\text{IO})\text{out}}$	Output rise and fall time	$C_L = 50 \text{ pF}, V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$	-	25	ns
			$C_L = 50 \text{ pF}, V_{DD} = 1.65 \text{ V to } 2.7 \text{ V}$	-	125	
11	$F_{\max(\text{IO})\text{out}}$	Maximum frequency ⁽³⁾	$C_L = 30 \text{ pF}, V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$	-	50	MHz
			$C_L = 50 \text{ pF}, V_{DD} = 1.65 \text{ V to } 2.7 \text{ V}$	-	8	
	$t_{f(\text{IO})\text{out}}$ $t_{r(\text{IO})\text{out}}$	Output rise and fall time	$C_L = 30 \text{ pF}, V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$	-	5	ns
			$C_L = 50 \text{ pF}, V_{DD} = 1.65 \text{ V to } 2.7 \text{ V}$	-	30	
Fm+ configuration ⁽⁴⁾	$f_{\max(\text{IO})\text{out}}$	Maximum frequency ⁽³⁾	CL = 50 pF	-	TBD	MHz
	$t_{f(\text{IO})\text{out}}$	Output fall time		-	TBD	
	$t_{r(\text{IO})\text{out}}$	Output rise time		-	TBD	
-	$t_{\text{EXTI}pw}$	Pulse width of external signals detected by the EXTI controller	-	8	-	ns

1. The I/O speed is configured using the OSPEEDRx[1:0] bits. Refer to the line reference manual for a description of GPIO Port configuration register.
2. Guaranteed by design. Not tested in production.
3. The maximum frequency is defined in [Figure 16](#).
4. When Fm+ configuration is set, the I/O speed control is bypassed. Refer to the line reference manual for a detailed description of Fm+ I/O configuration.

Figure 16. I/O AC characteristics definition



6.3.14 NRST pin characteristics

The NRST pin input driver uses CMOS technology. It is connected to a permanent pull-up resistor, R_{PU} (see [Table 56](#))

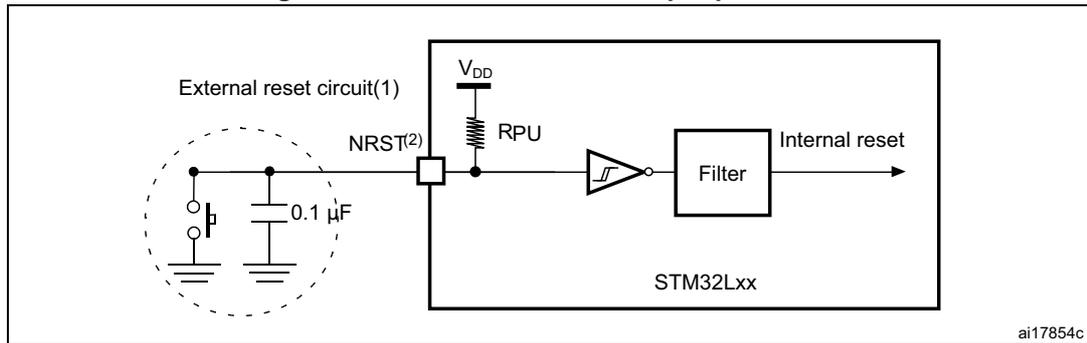
Unless otherwise specified, the parameters given in [Table 56](#) are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in [Table 23](#).

Table 56. NRST pin characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{IL(NRST)}^{(1)}$	NRST input low level voltage	-	V_{SS}	-	0.8	V
$V_{IH(NRST)}^{(1)}$	NRST input high level voltage	-	1.4	-	V_{DD}	
$V_{OL(NRST)}^{(1)}$	NRST output low level voltage	$I_{OL} = 2 \text{ mA}$ $2.7 \text{ V} < V_{DD} < 3.6 \text{ V}$	-	-	0.4	
		$I_{OL} = 1.5 \text{ mA}$ $1.65 \text{ V} < V_{DD} < 2.7 \text{ V}$	-	-		
$V_{hys(NRST)}^{(1)}$	NRST Schmitt trigger voltage hysteresis	-	-	$10\%V_{DD}^{(2)}$	-	mV
R_{PU}	Weak pull-up equivalent resistor ⁽³⁾	$V_{IN} = V_{SS}$	30	45	60	k Ω
$V_{F(NRST)}^{(1)}$	NRST input filtered pulse	-	-	-	50	ns
$V_{NF(NRST)}^{(1)}$	NRST input not filtered pulse	-	350	-	-	ns

1. Guaranteed by design, not tested in production.
2. 200 mV minimum value
3. The pull-up is designed with a true resistance in series with a switchable PMOS. This PMOS contribution to the series resistance is around 10%.

Figure 17. Recommended NRST pin protection



1. The reset network protects the device against parasitic resets.
2. The user must ensure that the level on the NRST pin can go below the $V_{IL(NRST)}$ max level specified in [Table 56](#). Otherwise the reset will not be taken into account by the device.

6.3.15 12-bit ADC characteristics

Unless otherwise specified, the parameters given in [Table 57](#) are preliminary values derived from tests performed under ambient temperature, f_{PCLK} frequency and V_{DDA} supply voltage conditions summarized in [Table 23: General operating conditions](#).

Note: It is recommended to perform a calibration after each power-up.

Table 57. ADC characteristics⁽¹⁾

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{DDA}	Analog supply voltage for ADC ON		2.4	-	3.6	V
$I_{DDA(ADC)}$	Current consumption of the ADC ⁽²⁾	1.14 Msps	-	TBD	-	mA
		10 ksps	-	TBD	-	
f_{ADC}	ADC clock frequency		0.6	-	16	MHz
$f_S^{(3)}$	Sampling rate		0.05	-	1.14	MHz
$f_{TRIG}^{(3)}$	External trigger frequency	$f_{ADC} = 16$ MHz	-	-	941	kHz
			-	-	17	$1/f_{ADC}$
V_{AIN}	Conversion voltage range		0	-	V_{DDA}	V
$R_{AIN}^{(3)}$	External input impedance	See Equation 1 and Table 58 for details	-	-	50	k Ω
$R_{ADC}^{(3)}$	Sampling switch resistance		-	-	1	k Ω
$C_{ADC}^{(3)}$	Internal sample and hold capacitor		-	-	8	pF
$t_{CAL}^{(3)}$	Calibration time	$f_{ADC} = 16$ MHz	5.2			μ s
			83			$1/f_{ADC}$

Table 57. ADC characteristics⁽¹⁾ (continued)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
W _{LATENCY}	ADC_DR register write latency	ADC clock = HSI14	1.5 ADC cycles + 2 f _{PCLK} cycles	-	1.5 ADC cycles + 3 f _{PCLK} cycles	-
		ADC clock = PCLK/2	-	4.5	-	f _{PCLK} cycle
		ADC clock = PCLK/4	-	8.5	-	f _{PCLK} cycle
t _{latr} ⁽³⁾	Trigger conversion latency	f _{ADC} = f _{PCLK} /2 = 16 MHz	0.172			µs
		f _{ADC} = f _{PCLK} /2	5.5			1/f _{PCLK}
		f _{ADC} = f _{PCLK} /4 = 8 MHz	0.172			µs
		f _{ADC} = f _{PCLK} /4	10.5			1/f _{PCLK}
		f _{ADC} = f _{HSI16} = 16 MHz	TBD	-	TBD	µs
Jitter _{ADC}	ADC jitter on trigger conversion	f _{ADC} = f _{HSI14}	-	1	-	1/f _{HSI14}
t _s ⁽³⁾	Sampling time	f _{ADC} = 16 MHz	0.093	-	15	µs
			1.5	-	239.5	1/f _{ADC}
t _{STAB} ⁽³⁾	Power-up time		0	0	1	µs
t _{CONV} ⁽³⁾	Total conversion time (including sampling time)	f _{ADC} = 16 MHz	1		15.75	µs
			14 to 252 (t _s for sampling + 12.5 for successive approximation)			1/f _{ADC}

1. TBD stands for "to be defined".
2. During conversion of the sampled value (12.5 x ADC clock period), an additional consumption of 100 µA on I_{DDA} and 60 µA on I_{DD} should be taken into account.
3. Guaranteed by design, not tested in production.

Equation 1: R_{AIN} max formula

$$R_{AIN} < \frac{T_S}{f_{ADC} \times C_{ADC} \times \ln(2^{N+2})} - R_{ADC}$$

The formula above ([Equation 1](#)) is used to determine the maximum external impedance allowed for an error below 1/4 of LSB. Here N = 12 (from 12-bit resolution).

Table 58. R_{AIN} max for f_{ADC} = 14 MHz

T _s (cycles)	t _s (μs)	R _{AIN} max (kΩ) ⁽¹⁾
1.5	0.11	0.4
7.5	0.54	5.9
13.5	0.96	11.4
28.5	2.04	25.2
41.5	2.96	37.2
55.5	3.96	50
71.5	5.11	NA
239.5	17.1	NA

1. Guaranteed by design, not tested in production.

Table 59. ADC accuracy⁽¹⁾⁽²⁾⁽³⁾⁽⁴⁾

Symbol	Parameter	Test conditions	Typ	Max ⁽⁵⁾	Unit
ET	Total unadjusted error	f _{PCLK} = 32 MHz, f _{ADC} = 6 MHz, R _{AIN} < 10 kΩ V _{DDA} = V _{REF+} = 3.3 V T _A = 25 °C	±1.3	TBD	LSB
EO	Offset error		±0.4	TBD	
EG	Gain error		±0.4	TBD	
ED	Differential linearity error		±1	TBD	
EL	Integral linearity error		±1.6	TBD	
ET	Total unadjusted error	f _{PCLK} = 32 MHz, f _{ADC} = 6 MHz, R _{AIN} < 10 kΩ V _{DDA} = V _{REF+} = 1.8 to 3.6 V T _A = -40 to 105 °C	±2.9	TBD	LSB
EO	Offset error		±1.2	TBD	
EG	Gain error		±1.7	TBD	
ED	Differential linearity error		±1	TBD	
EL	Integral linearity error		±1.6	TBD	
ET	Total unadjusted error	f _{PCLK} = 32 MHz, f _{ADC} = 6 MHz, R _{AIN} < 10 kΩ V _{DDA} = V _{REF+} = 1.8 to 3.6 V T _A = 25 °C	±2.5	TBD	LSB
EO	Offset error		±0.9	TBD	
EG	Gain error		±1.2	TBD	
ED	Differential linearity error		±1	TBD	
EL	Integral linearity error		±1.6	TBD	

- ADC DC accuracy values are measured after internal calibration.
- ADC Accuracy vs. Negative Injection Current: Injecting negative current on any of the standard (non-robust) analog input pins should be avoided as this significantly reduces the accuracy of the conversion being performed on another analog input. It is recommended to add a Schottky diode (pin to ground) to standard analog pins which may potentially inject negative current. Any positive injection current within the limits specified for I_{INJ(PIN)} and ΣI_{INJ(PIN)} in [Section 6.3.12](#) does not affect the ADC accuracy.
- Better performance may be achieved in restricted V_{DDA}, frequency and temperature ranges.
- TBD stands for "to be defined".
- Data based on characterization results, not tested in production.

Figure 18. ADC accuracy characteristics

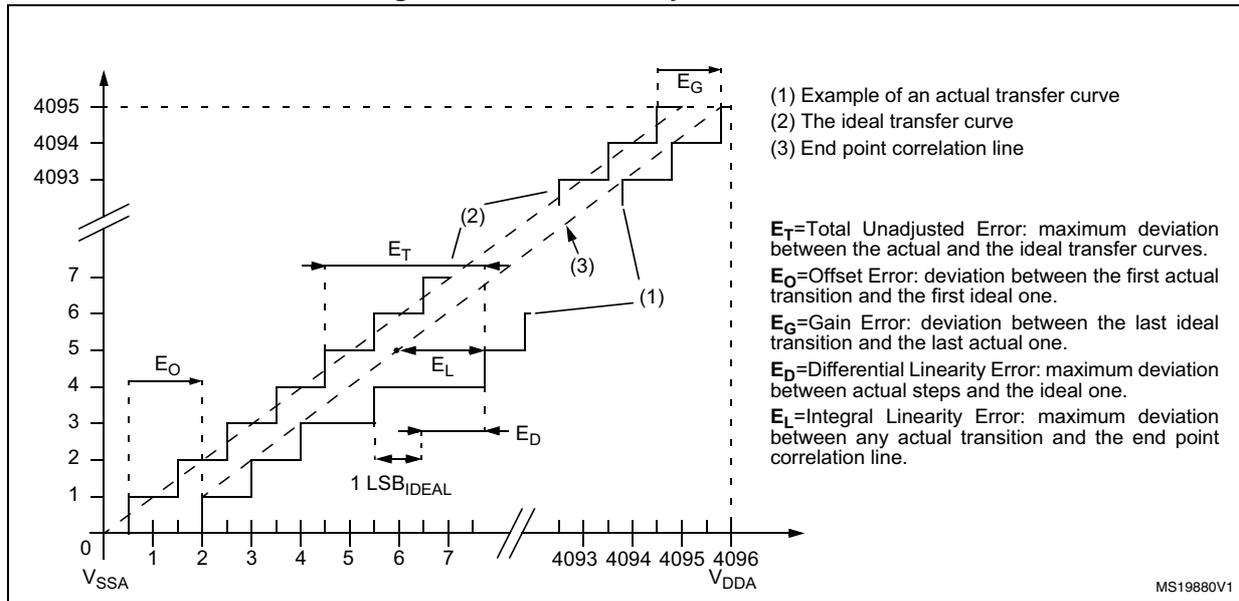
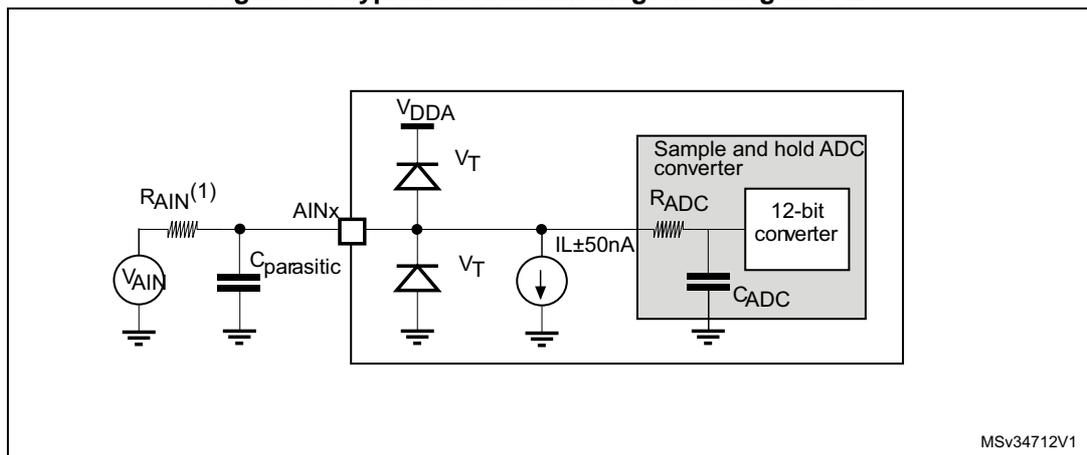


Figure 19. Typical connection diagram using the ADC



1. Refer to [Table 57: ADC characteristics](#) for the values of R_{AIN} , R_{ADC} and C_{ADC} .
2. $C_{parasitic}$ represents the capacitance of the PCB (dependent on soldering and PCB layout quality) plus the pad capacitance (roughly 7 pF). A high $C_{parasitic}$ value will downgrade conversion accuracy. To remedy this, f_{ADC} should be reduced.

General PCB design guidelines

Power supply decoupling should be performed as shown in [Figure 20](#) or [Figure 21](#), depending on whether V_{REF+} is connected to V_{DDA} or not. The 10 nF capacitors should be ceramic (good quality). They should be placed as close as possible to the chip.

Figure 20. Power supply and reference decoupling (V_{REF+} not connected to V_{DDA})

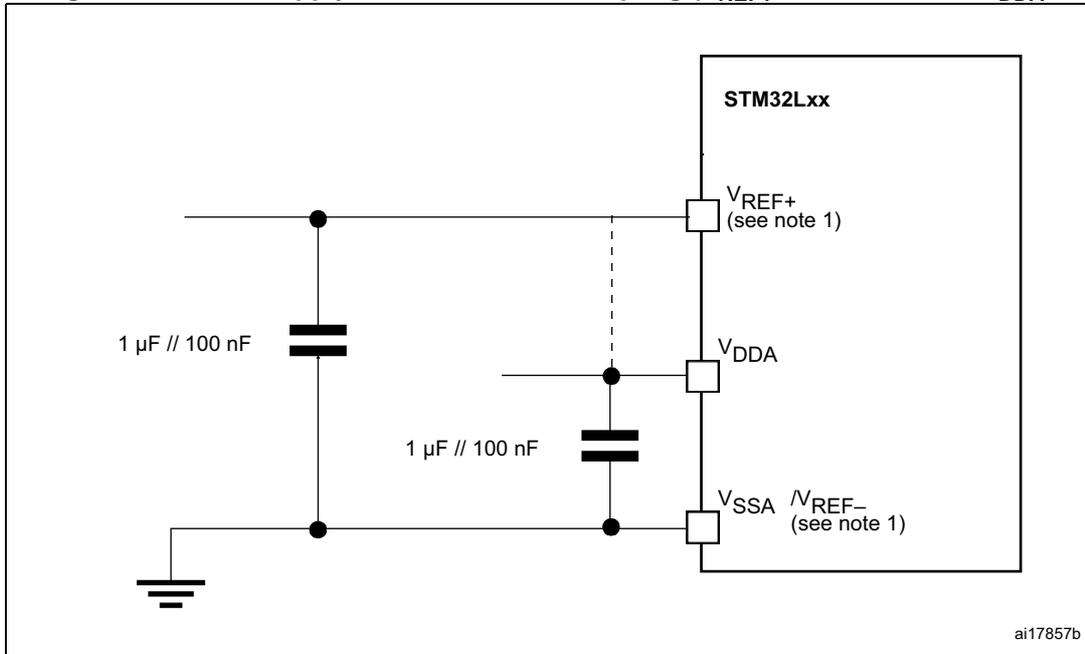
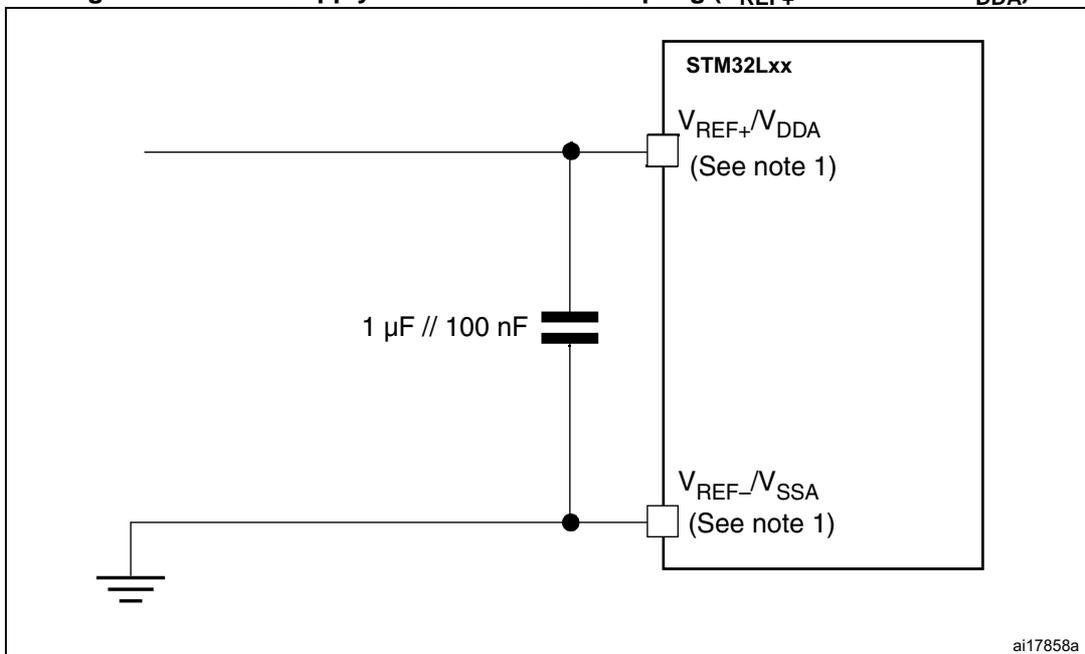


Figure 21. Power supply and reference decoupling (V_{REF+} connected to V_{DDA})



6.3.16 DAC electrical specifications

Data guaranteed by design, not tested in production, unless otherwise specified.

Table 60. DAC characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{DDA}	Analog supply voltage		1.8	-	3.6	V
V_{REF+}	Reference supply voltage	V_{REF+} must always be below V_{DDA}	1.8	-	3.6	V
V_{REF-}	Lower reference voltage		V_{SSA}			V
$I_{DDVREF+}^{(1)}$	Current consumption on V_{REF+} supply $V_{REF+} = 3.3$ V	No load, middle code (0x800)	-	130	220	μ A
		No load, worst code (0x000)	-	220	350	
$I_{DDA}^{(2)}$	Current consumption on V_{DDA} supply $V_{DDA} = 3.3$ V	No load, middle code (0x800)	-	340	540	μ A
		No load, worst code (0xF1C)	-	540	870	
$R_L^{(2)}$	Resistive load	DAC output buffer ON	5	-	-	k Ω
$C_L^{(2)}$	Capacitive load		-	-	50	pF
R_O	Output impedance	DAC output buffer OFF	6	8	10	k Ω
V_{DAC_OUT}	Voltage on DAC_OUT output	DAC output buffer ON	0.2	-	$V_{DDA} - 0.2$	V
		DAC output buffer OFF	0.5	-	$V_{REF+} - 1LSB$	mV
$DNL^{(2)}$	Differential non linearity ⁽³⁾	$C_L \leq 50$ pF, $R_L \geq 5$ k Ω DAC output buffer ON	-	1.5	3	LSB
		No R_{LOAD} , $C_L \leq 50$ pF DAC output buffer OFF	-	1.5	3	
$INL^{(2)}$	Integral non linearity ⁽⁴⁾	$C_L \leq 50$ pF, $R_L \geq 5$ k Ω DAC output buffer ON	-	2	4	
		No R_{LOAD} , $C_L \leq 50$ pF DAC output buffer OFF	-	2	4	
Offset ⁽²⁾	Offset error at code 0x800 ⁽⁵⁾	$C_L \leq 50$ pF, $R_L \geq 5$ k Ω DAC output buffer ON	-	± 10	± 25	
		No R_{LOAD} , $C_L \leq 50$ pF DAC output buffer OFF	-	± 5	± 8	
Offset1 ⁽²⁾	Offset error at code 0x001 ⁽⁶⁾	No R_{LOAD} , $C_L \leq 50$ pF DAC output buffer OFF	-	± 1.5	± 5	

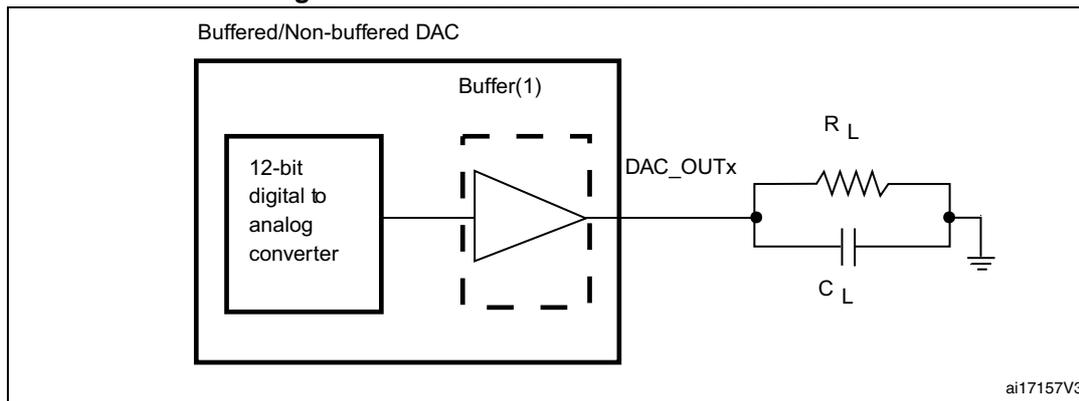
Table 60. DAC characteristics (continued)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
dOffset/dT ⁽²⁾	Offset error temperature coefficient (code 0x800)	V _{DDA} = 3.3V V _{REF+} = 3.0 V T _A = 0 to 50 °C DAC output buffer OFF	-20	-10	0	μV/°C
		V _{DDA} = 3.3V V _{REF+} = 3.0V T _A = 0 to 50 °C DAC output buffer ON	0	20	50	
Gain ⁽²⁾	Gain error ⁽⁷⁾	C _L ≤ 50 pF, R _L ≥ 5 kΩ DAC output buffer ON	-	+0.1 / -0.2%	+0.2 / -0.5%	%
		No R _{LOAD} , C _L ≤ 50 pF DAC output buffer OFF	-	+0 / -0.2%	+0 / -0.4%	
dGain/dT ⁽²⁾	Gain error temperature coefficient	V _{DDA} = 3.3V V _{REF+} = 3.0V T _A = 0 to 50 °C DAC output buffer OFF	-10	-2	0	μV/°C
		V _{DDA} = 3.3V V _{REF+} = 3.0V T _A = 0 to 50 °C DAC output buffer ON	-40	-8	0	
TUE ⁽²⁾	Total unadjusted error	C _L ≤ 50 pF, R _L ≥ 5 kΩ DAC output buffer ON	-	12	30	LSB
		No R _{LOAD} , C _L ≤ 50 pF DAC output buffer OFF	-	8	12	
t _{SETTLING}	Settling time (full scale: for a 12-bit code transition between the lowest and the highest input codes till DAC_OUT reaches final value ±1LSB)	C _L ≤ 50 pF, R _L ≥ 5 kΩ	-	7	12	μs
Update rate	Max frequency for a correct DAC_OUT change (95% of final value) with 1 LSB variation in the input code	C _L ≤ 50 pF, R _L ≥ 5 kΩ	-	-	1	Msp/s
t _{WAKEUP}	Wakeup time from off state (setting the ENx bit in the DAC Control register) ⁽⁸⁾	C _L ≤ 50 pF, R _L ≥ 5 kΩ	-	9	15	μs
PSRR+	V _{DDA} supply rejection ratio (static DC measurement)	C _L ≤ 50 pF, R _L ≥ 5 kΩ	-	-60	-35	dB

1. Data based on characterization results.

2. Connected between DAC_OUT and V_{SSA}.
3. Difference between two consecutive codes - 1 LSB.
4. Difference between measured value at Code i and the value at Code i on a line drawn between Code 0 and last Code 4095.
5. Difference between the value measured at Code (0x800) and the ideal value = V_{REF+}/2.
6. Difference between the value measured at Code (0x001) and the ideal value.
7. Difference between ideal slope of the transfer function and measured slope computed from code 0x000 and 0xFFFF when buffer is OFF, and from code giving 0.2 V and (V_{DDA} - 0.2) V when buffer is ON.
8. In buffered mode, the output can overshoot above the final value for low input code (starting from min value).

Figure 22. 12-bit buffered/non-buffered DAC



6.3.17 Temperature sensor characteristics

Table 61. Temperature sensor calibration values

Calibration value name	Description	Memory address
TS_CAL1	TS ADC raw data acquired at temperature of 30 °C, V _{DDA} = 3 V	0x1FF8 007A - 0x1FF8 007B
TS_CAL2	TS ADC raw data acquired at temperature of 130 °C, V _{DDA} = 3 V	0x1FF8 007E - 0x1FF8 007F

Table 62. Temperature sensor characteristics

Symbol	Parameter	Min	Typ	Max	Unit
T _L ⁽¹⁾	V _{SENSE} linearity with temperature	-	±1	±2	°C
Avg_Slope ⁽¹⁾	Average slope	1.48	1.61	1.75	mV/°C
V ₁₃₀	Voltage at 130°C ±5°C ⁽²⁾	654	670	686	mV
I _{DDA(TEMP)} ⁽³⁾	Current consumption	-	3.4	6	µA
t _{START} ⁽³⁾	Startup time	-	-	10	µs
T _{S_temp} ⁽⁴⁾⁽³⁾	ADC sampling time when reading the temperature	10	-	-	

1. Guaranteed by characterization, not tested in production.
2. Measured at V_{DD} = 3 V ±10 mV. V₁₃₀ ADC conversion result is stored in the TS_CAL2 byte.

3. Guaranteed by design, not tested in production.
4. Shortest sampling time can be determined in the application by multiple iterations.

6.3.18 Comparators

Table 63. Comparator 1 characteristics

Symbol	Parameter	Conditions	Min ⁽¹⁾	Typ	Max ⁽¹⁾	Unit
V _{DDA}	Analog supply voltage	-	1.65		3.6	V
R _{400K}	R _{400K} value	-	-	400	-	kΩ
R _{10K}	R _{10K} value	-	-	10	-	
V _{IN}	Comparator 1 input voltage range	-	0.6	-	V _{DDA}	V
t _{START}	Comparator startup time	-	-	7	10	μs
t _d	Propagation delay ⁽²⁾	-	-	3	10	
V _{offset}	Comparator offset	-	-	±3	±10	mV
d _{Voffset/dt}	Comparator offset variation in worst voltage stress conditions	V _{DDA} = 3.6 V V _{IN+} = 0 V V _{IN-} = V _{REFINT} T _A = 25 °C	0	1.5	10	mV/1000 h
I _{COMP1}	Current consumption ⁽³⁾	-	-	160	260	nA

1. Based on characterization, not tested in production.
2. The delay is characterized for 100 mV input step with 10 mV overdrive on the inverting input, the non-inverting input set to the reference.
3. Comparator consumption only. Internal reference voltage not included.

Table 64. Comparator 2 characteristics

Symbol	Parameter	Conditions	Min	Typ	Max ⁽¹⁾	Unit
V _{DDA}	Analog supply voltage	-	1.65	-	3.6	V
V _{IN}	Comparator 2 input voltage range	-	0	-	V _{DDA}	V
t _{START}	Comparator startup time	Fast mode	-	15	20	μs
		Slow mode	-	20	25	
t _{d slow}	Propagation delay ⁽²⁾ in slow mode	1.65 V ≤ V _{DDA} ≤ 2.7 V	-	1.8	3.5	
		2.7 V ≤ V _{DDA} ≤ 3.6 V	-	2.5	6	
t _{d fast}	Propagation delay ⁽²⁾ in fast mode	1.65 V ≤ V _{DDA} ≤ 2.7 V	-	0.8	2	
		2.7 V ≤ V _{DDA} ≤ 3.6 V	-	1.2	4	
V _{offset}	Comparator offset error		-	±4	±20	mV
dThreshold/dt	Threshold voltage temperature coefficient	V _{DDA} = 3.3V T _A = 0 to 50 °C V ₋ = V _{REFINT} , 3/4 V _{REFINT} , 1/2 V _{REFINT} , 1/4 V _{REFINT}	-	15	30	ppm /°C

Table 64. Comparator 2 characteristics (continued)

Symbol	Parameter	Conditions	Min	Typ	Max ⁽¹⁾	Unit
I _{COMP2}	Current consumption ⁽³⁾	Fast mode	-	3.5	5	μA
		Slow mode	-	0.5	2	

1. Based on characterization, not tested in production.
2. The delay is characterized for 100 mV input step with 10 mV overdrive on the inverting input, the non-inverting input set to the reference.
3. Comparator consumption only. Internal reference voltage (necessary for comparator operation) is not included.

6.3.19 Timer characteristics

TIM timer characteristics

The parameters given in the [Table 65](#) are guaranteed by design.

Refer to [Section 6.3.13: I/O port characteristics](#) for details on the input/output alternate function characteristics (output compare, input capture, external clock, PWM output).

Table 65. TIMx⁽¹⁾ characteristics

Symbol	Parameter	Conditions	Min	Max	Unit
t _{res(TIM)}	Timer resolution time		1	-	t _{TIMxCLK}
		f _{TIMxCLK} = 32 MHz	31.25	-	ns
f _{EXT}	Timer external clock frequency on CH1 to CH4		0	f _{TIMxCLK} /2	MHz
		f _{TIMxCLK} = 32 MHz	0	16	MHz
Res _{TIM}	Timer resolution	-		16	bit
t _{COUNTER}	16-bit counter clock period when internal clock is selected (timer's prescaler disabled)		1	65536	t _{TIMxCLK}
		f _{TIMxCLK} = 32 MHz	0.0312	2048	μs
t _{MAX_COUNT}	Maximum possible count		-	65536 × 65536	t _{TIMxCLK}
		f _{TIMxCLK} = 32 MHz	-	134.2	s

1. TIMx is used as a general term to refer to the TIM2, TIM6, TIM21, and TIM22 timers.

6.3.20 Communications interfaces

I²C interface characteristics

The I²C interface meets the timings requirements of the I²C-bus specification and user manual rev. 03 for:

- Standard-mode (Sm) : with a bit rate up to 100 kbit/s
- Fast-mode (Fm) : with a bit rate up to 400 kbit/s
- Fast-mode Plus (Fm+) : with a bit rate up to 1 Mbit/s.

The I²C timing requirements are guaranteed by design when the I²C peripheral is properly configured (refer to the reference manual for details). The SDA and SCL I/O requirements are met with the following restrictions: the SDA and SCL I/O pins are not "true" open-drain. When configured as open-drain, the PMOS connected between the I/O pin and VDDIOx is disabled, but is still present. Only FTf I/O pins support Fm+ low level output current maximum requirement (refer to [Section 6.3.13: I/O port characteristics](#) for the I2C I/Os characteristics).

All I²C SDA and SCL I/Os embed an analog filter (see [Table 66](#) for the analog filter characteristics).

Table 66. I2C analog filter characteristics⁽¹⁾

Symbol	Parameter	Min	Max	Unit
t _{AF}	Maximum pulse width of spikes that are suppressed by the analog filter	50 ⁽²⁾	260 ⁽³⁾	ns

1. Guaranteed by design, not tested in production.
2. Spikes with widths below t_{AF(min)} are filtered.
3. Spikes with widths above t_{AF(max)} are not filtered

ISPI characteristics

Unless otherwise specified, the parameters given in the following table are derived from tests performed under ambient temperature, f_{PCLKx} frequency and V_{DD} supply voltage conditions summarized in [Table 23](#).

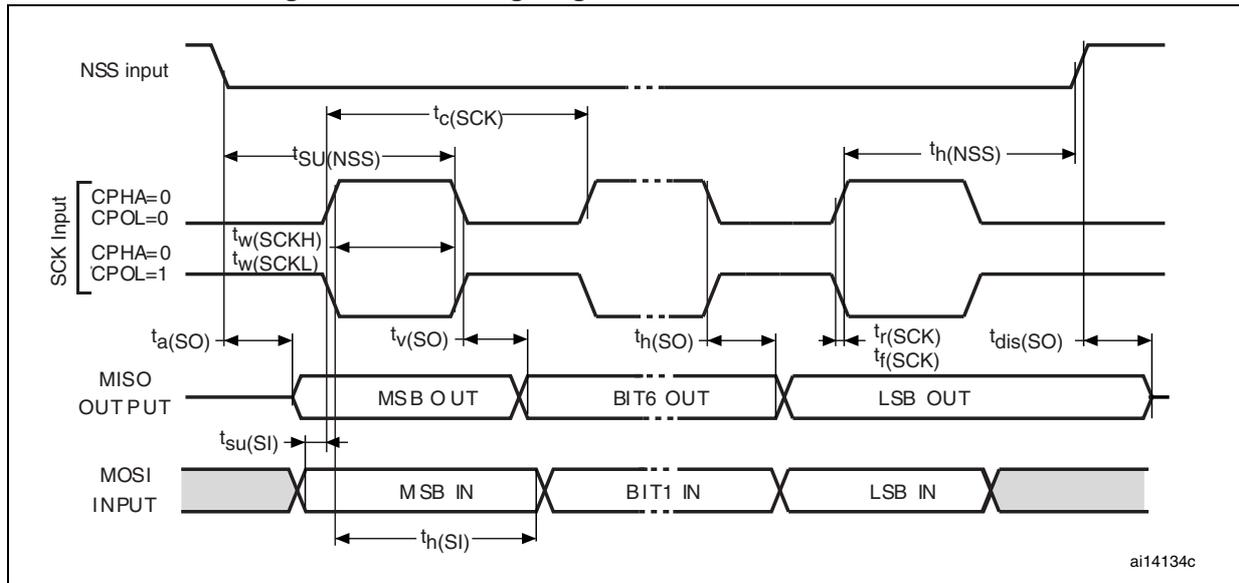
Refer to [Section 6.3.12: I/O current injection characteristics](#) for more details on the input/output alternate function characteristics (NSS, SCK, MOSI, MISO).

Table 67. SPI characteristics⁽¹⁾⁽²⁾⁽³⁾

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{SCK} $1/t_{c(SCK)}$	SPI clock frequency	Master mode	-	-	16	MHz
		Slave mode receiver			16	
		Slave mode Transmitter $1.65 V < V_{DD} < 3.6 V$	-	-	TBD ⁽⁴⁾	
		Slave mode Transmitter $2.7 V < V_{DD} < 3.6 V$	-	-	16 ⁽⁴⁾	
Duty _(SCK)	Duty cycle of SPI clock frequency	Slave mode	30	50	70	%
$t_{su(NSS)}$	NSS setup time	Slave mode, SPI presc = 2	4* T_{pclk}	-	-	
$t_{h(NSS)}$	NSS hold time	Slave mode, SPI presc = 2	2* T_{pclk}	-	-	
$t_{w(SCKH)}$ $t_{w(SCKL)}$	SCK high and low time	Master mode	$T_{pclk}-2$	T_{pclk}	$T_{pclk}+2$	
$t_{su(MI)}$	Data input setup time	Master mode	TBD	-	-	
$t_{su(SI)}$		Slave mode	TBD	-	-	
$t_{h(MI)}$	Data input hold time	Master mode	TBD	-	-	
$t_{h(SI)}$		Slave mode	TBD	-	-	
$t_{a(SO)}$	Data output access time	Slave mode	TBD	-	TBD	
$t_{dis(SO)}$	Data output disable time	Slave mode	TBD	-	TBD	
$t_{v(SO)}$	Data output valid time	Slave mode $1.65 V < V_{DD} < 3.6 V$	-	29	TBD	
		Slave mode $2.7 V < V_{DD} < 3.6 V$	-	22	TBD	
$t_{v(MO)}$		Master mode	-	10	TBD	
$t_{h(SO)}$	Data output hold time	Slave mode	TBD	-	-	
$t_{h(MO)}$		Master mode	TBD	-	-	

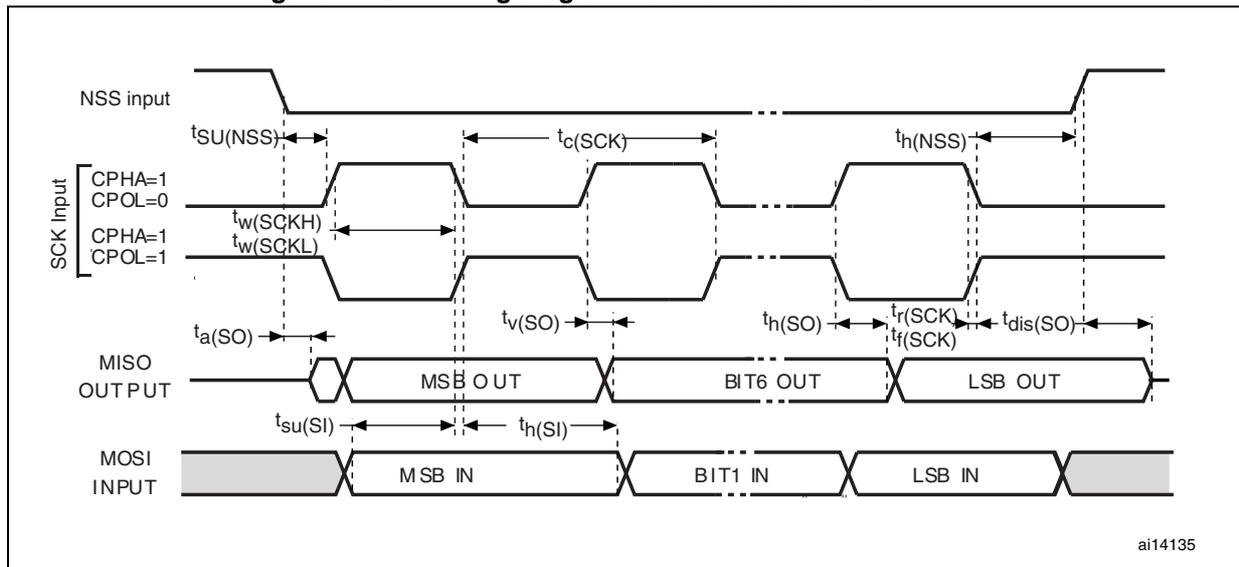
1. The characteristics above are given for voltage range 1.
2. Based on characterization, not tested in production.
3. TBD stands for "to be defined".
4. The maximum SPL clock frequency in slave transmitter mode is determined by the sum of $t_{v(SO)}$ and $t_{su(MI)}$ which has to fit into SCK low or high phase preceding the SCK sampling edge. This value can be achieved when the SPI communicates with a master having $t_{su(MI)} = 0$ while $Duty_{(SCK)} = 50\%$.

Figure 23. SPI timing diagram - slave mode and CPHA = 0



ai14134c

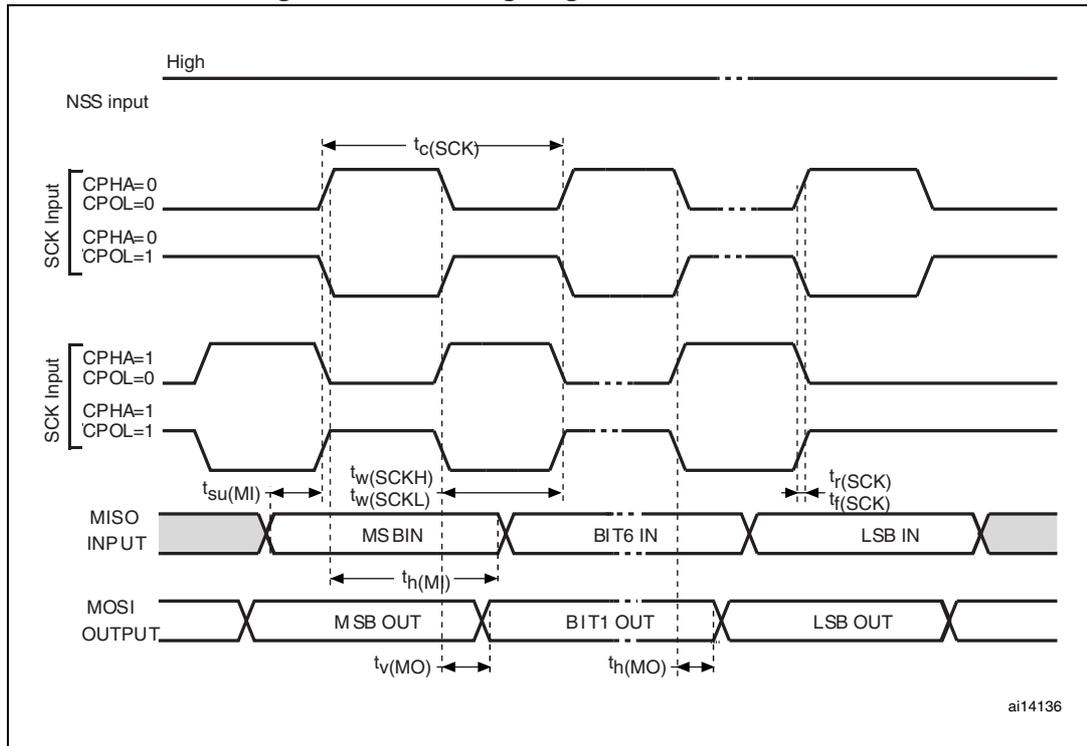
Figure 24. SPI timing diagram - slave mode and CPHA = 1⁽¹⁾



ai14135

1. Measurement points are done at CMOS levels: 0.3V_{DD} and 0.7V_{DD}.

Figure 25. SPI timing diagram - master mode⁽¹⁾



1. Measurement points are done at CMOS levels: $0.3V_{DD}$ and $0.7V_{DD}$.

I2S characteristics

Table 68. I2S characteristics⁽¹⁾⁽²⁾

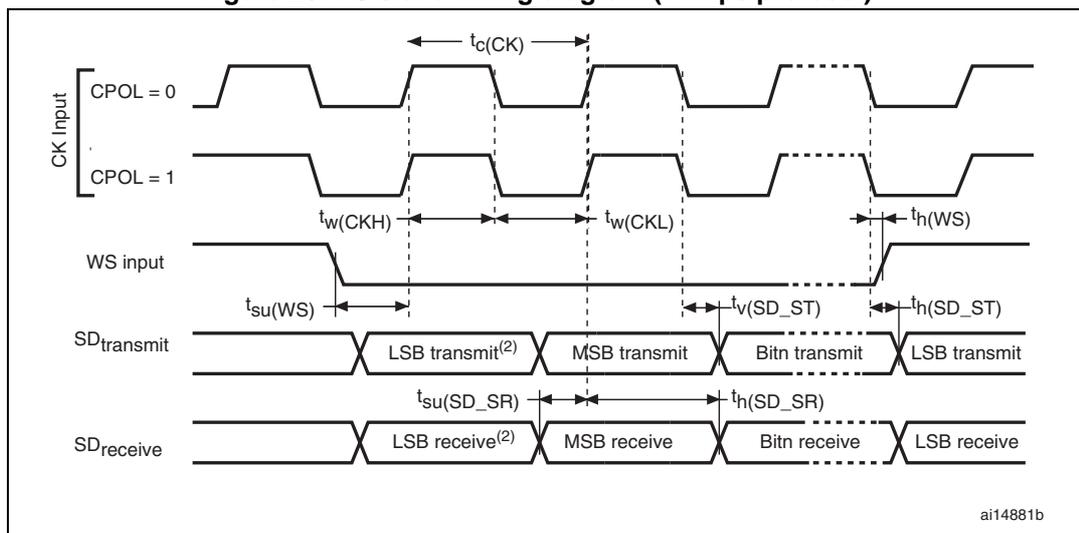
Symbol	Parameter	Conditions	Min	Max	Unit
f _{MCK}	I2S Main clock output	-	256 x 8K	256xFs ⁽³⁾	MHz
f _{CK}	I2S clock frequency	Master data: 32 bits	-	64xFs	MHz
		Slave data: 32 bits	-	64xFs	
D _{CK}	I2S clock frequency duty cycle	Slave receiver	30	70	%
t _{v(WS)}	WS valid time	Master mode	-	TBD	ns
t _{h(WS)}	WS hold time	Master mode	TBD	-	
t _{su(WS)}	WS setup time	Slave mode	TBD	-	
t _{h(WS)}	WS hold time	Slave mode	TBD	-	
t _{su(SD_MR)}	Data input setup time	Master receiver	TBD	-	
t _{su(SD_SR)}		Slave receiver	TBD	-	
t _{h(SD_MR)}	Data input hold time	Master receiver	TBD	-	
t _{h(SD_SR)}		Slave receiver	0	-	
t _{v(SD_ST)}	Data output valid time	Slave transmitter (after enable edge)	-	TBD	
t _{v(SD_MT)}		Master transmitter (after enable edge)	-	TBD	
t _{h(SD_ST)}	Data output hold time	Slave transmitter (after enable edge)	TBD	-	
t _{h(SD_MT)}		Master transmitter (after enable edge)	TBD	-	

1. Based on characterization, not tested in production.
2. TBD stands for "to be defined".
3. The maximum for 256xFs is 8 MHz

Note: Refer to the I2S section of the product reference manual for more details about the sampling frequency (Fs), f_{MCK}, f_{CK} and D_{CK} values. These values reflect only the digital peripheral behavior, source clock precision might slightly change them. DCK depends mainly on the ODD bit value, digital contribution leads to a min of (I2SDIV/(2*I2SDIV+ODD)) and a max of (I2SDIV+ODD)/(2*I2SDIV+ODD). Fs max is supported for each mode/condition.

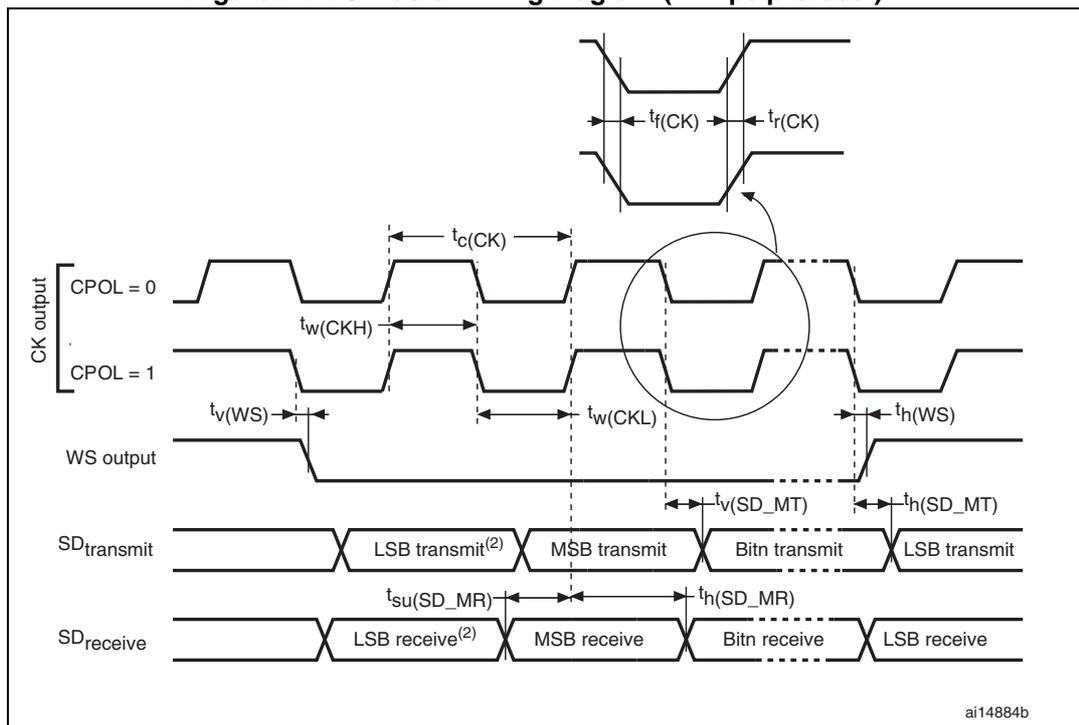


Figure 26. I²S slave timing diagram (Philips protocol)⁽¹⁾



1. Measurement points are done at CMOS levels: $0.3 \times V_{DD}$ and $0.7 \times V_{DD}$.
2. LSB transmit/receive of the previously transmitted byte. No LSB transmit/receive is sent before the first byte.

Figure 27. I²S master timing diagram (Philips protocol)⁽¹⁾



1. Based on characterization, not tested in production.
2. LSB transmit/receive of the previously transmitted byte. No LSB transmit/receive is sent before the first byte.

USB characteristics

The USB interface is USB-IF certified (full speed).

Table 69. USB startup time

Symbol	Parameter	Max	Unit
$t_{STARTUP}^{(1)}$	USB transceiver startup time	1	μs

1. Guaranteed by design, not tested in production.

Table 70. USB DC electrical characteristics

Symbol	Parameter	Conditions	Min. ⁽¹⁾	Max. ⁽¹⁾	Unit
Input levels					
V_{DD}	USB operating voltage	-	3.0	3.6	V
$V_{DI}^{(2)}$	Differential input sensitivity	I(USB_DP, USB_DM)	0.2	-	V
$V_{CM}^{(2)}$	Differential common mode range	Includes V_{DI} range	0.8	2.5	
$V_{SE}^{(2)}$	Single ended receiver threshold	-	1.3	2.0	
Output levels					
$V_{OL}^{(3)}$	Static output level low	R_L of 1.5 k Ω to 3.6 V ⁽⁴⁾	-	0.3	V
$V_{OH}^{(3)}$	Static output level high	R_L of 15 k Ω to $V_{SS}^{(4)}$	2.8	3.6	

1. All the voltages are measured from the local ground potential.
2. Guaranteed by characterization, not tested in production.
3. Tested in production.
4. R_L is the load connected on the USB drivers.

Figure 28. USB timings: definition of data signal rise and fall time

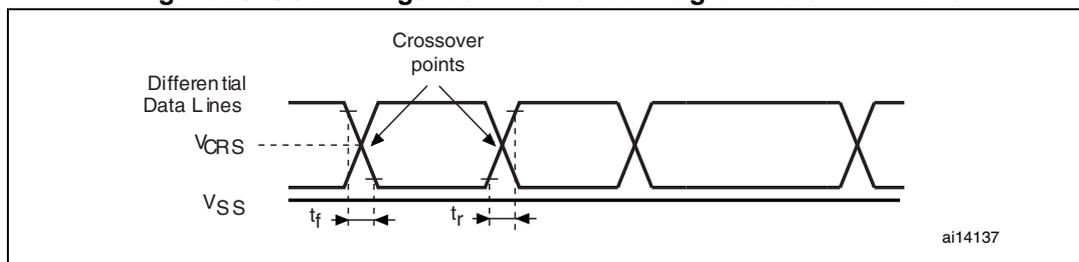


Table 71. USB: full speed electrical characteristics

Driver characteristics ⁽¹⁾					
Symbol	Parameter	Conditions	Min	Max	Unit
t_r	Rise time ⁽²⁾	$C_L = 50 \text{ pF}$	4	20	ns
t_f	Fall Time ⁽²⁾	$C_L = 50 \text{ pF}$	4	20	ns
t_{rfm}	Rise/ fall time matching	t_r/t_f	90	110	%
V_{CRS}	Output signal crossover voltage		1.3	2.0	V

1. Guaranteed by design, not tested in production.
2. Measured from 10% to 90% of the data signal. For more detailed informations, please refer to USB Specification - Chapter 7 (version 2.0).

6.3.21 LCD controller

The devices embed a built-in step-up converter to provide a constant LCD reference voltage independently from the V_{DD} voltage. An external capacitor C_{ext} must be connected to the V_{LCD} pin to decouple this converter.

Table 72. LCD controller characteristics

Symbol	Parameter	Min	Typ	Max	Unit
V_{LCD}	LCD external voltage	-	-	3.6	V
V_{LCD0}	LCD internal reference voltage 0	-	2.6	-	
V_{LCD1}	LCD internal reference voltage 1	-	2.73	-	
V_{LCD2}	LCD internal reference voltage 2	-	2.86	-	
V_{LCD3}	LCD internal reference voltage 3	-	2.98	-	
V_{LCD4}	LCD internal reference voltage 4	-	3.12	-	
V_{LCD5}	LCD internal reference voltage 5	-	3.26	-	
V_{LCD6}	LCD internal reference voltage 6	-	3.4	-	
V_{LCD7}	LCD internal reference voltage 7	-	3.55	-	
C_{ext}	V_{LCD} external capacitance	0.1	-	2	μF
$I_{LCD}^{(1)}$	Supply current at $V_{DD} = 2.2 \text{ V}$	-	3.3	-	μA
	Supply current at $V_{DD} = 3.0 \text{ V}$	-	3.1	-	
$R_{Htot}^{(2)}$	Low drive resistive network overall value	5.28	6.6	7.92	$\text{M}\Omega$

Table 72. LCD controller characteristics (continued)

Symbol	Parameter	Min	Typ	Max	Unit
$R_L^{(2)}$	High drive resistive network total value	192	240	288	kΩ
V_{44}	Segment/Common highest level voltage	-	-	V_{LCD}	V
V_{34}	Segment/Common 3/4 level voltage	-	$3/4 V_{LCD}$	-	V
V_{23}	Segment/Common 2/3 level voltage	-	$2/3 V_{LCD}$	-	
V_{12}	Segment/Common 1/2 level voltage	-	$1/2 V_{LCD}$	-	
V_{13}	Segment/Common 1/3 level voltage	-	$1/3 V_{LCD}$	-	
V_{14}	Segment/Common 1/4 level voltage	-	$1/4 V_{LCD}$	-	
V_0	Segment/Common lowest level voltage	0	-	-	
$\Delta V_{XX}^{(3)}$	Segment/Common level voltage error $T_A = -40$ to 85 °C	-	-	± 50	mV

1. LCD enabled with 3 V internal step-up active, 1/8 duty, 1/4 bias, division ratio= 64, all pixels active, no LCD connected.
2. Guaranteed by design, not tested in production.
3. Based on characterization, not tested in production.

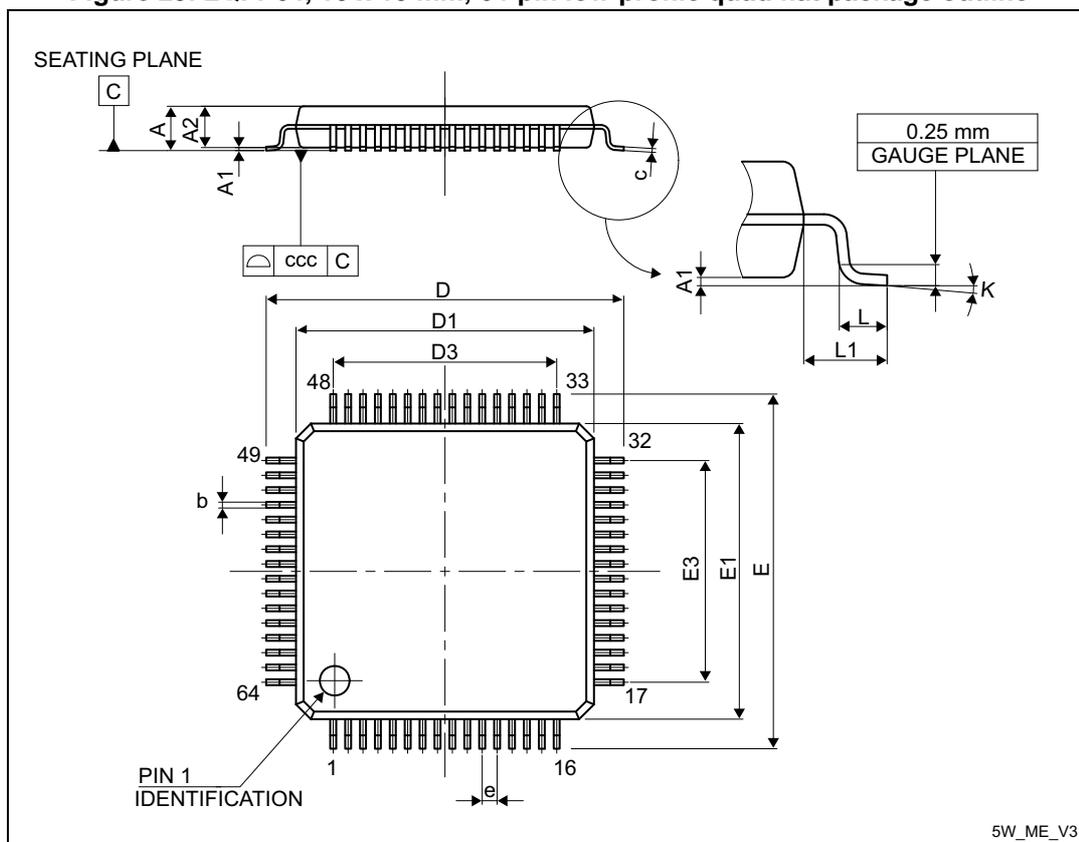
7 Package characteristics

7.1 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: www.st.com. ECOPACK® is an ST trademark.

7.1.1 LQFP64 10 x 10 mm low profile quad flat package

Figure 29. LQFP64, 10 x 10 mm, 64-pin low-profile quad flat package outline



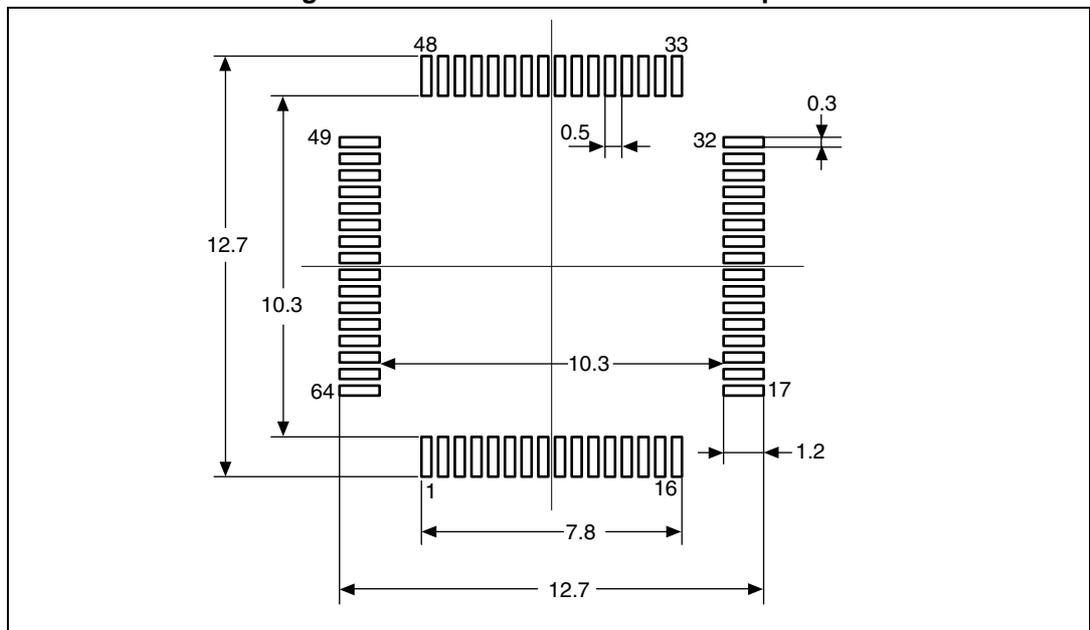
1. Drawing is not to scale.

Table 73. LQFP64, 10 x 10 mm 64-pin low-profile quad flat package mechanical data

Symbol	millimeters			inches ⁽¹⁾		
	Min	Typ	Max	Min	Typ	Max
A	-	-	1.600	-	-	0.0630
A1	0.050	-	0.150	0.0020	-	0.0059
A2	1.350	1.400	1.450	0.0531	0.0551	0.0571
b	0.170	0.220	0.270	0.0067	0.0087	0.0106
c	0.090	-	0.200	0.0035	-	0.0079
D	11.800	12.000	12.200	0.4646	0.4724	0.4803
D1	9.800	10.000	10.200	0.3858	0.3937	0.4016
D3	-	7.500	-	-	0.2953	-
E	11.800	12.000	12.200	0.4646	0.4724	0.4803
E1	9.800	10.000	10.200	0.3858	0.3937	0.4016
E3	-	7.500	-	-	0.2953	-
e	-	0.500	-	-	0.0197	-
L	0.450	0.600	0.750	0.0177	0.0236	0.0295
L1	-	1.000	-	-	0.0394	-
ccc	-	-	0.080	-	-	0.0031
K	0.0	3.5	7.0	0.0	3.5	7.0

1. Values in inches are converted from mm and rounded to 4 decimal digits.

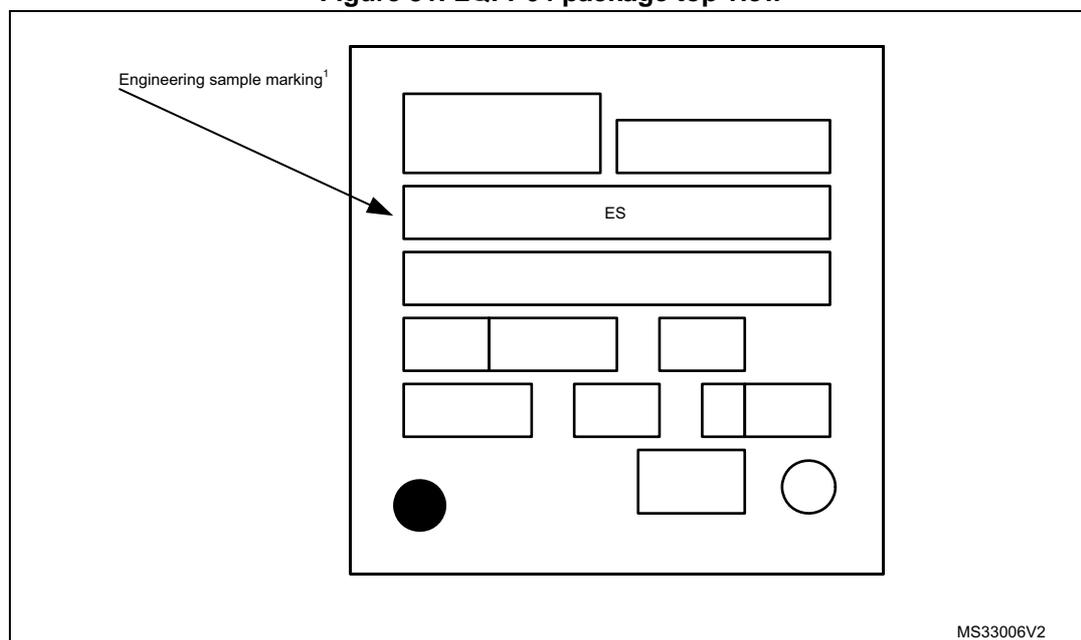
Figure 30. LQFP64 recommended footprint



1. Dimensions are expressed in millimeters

Marking of engineering samples

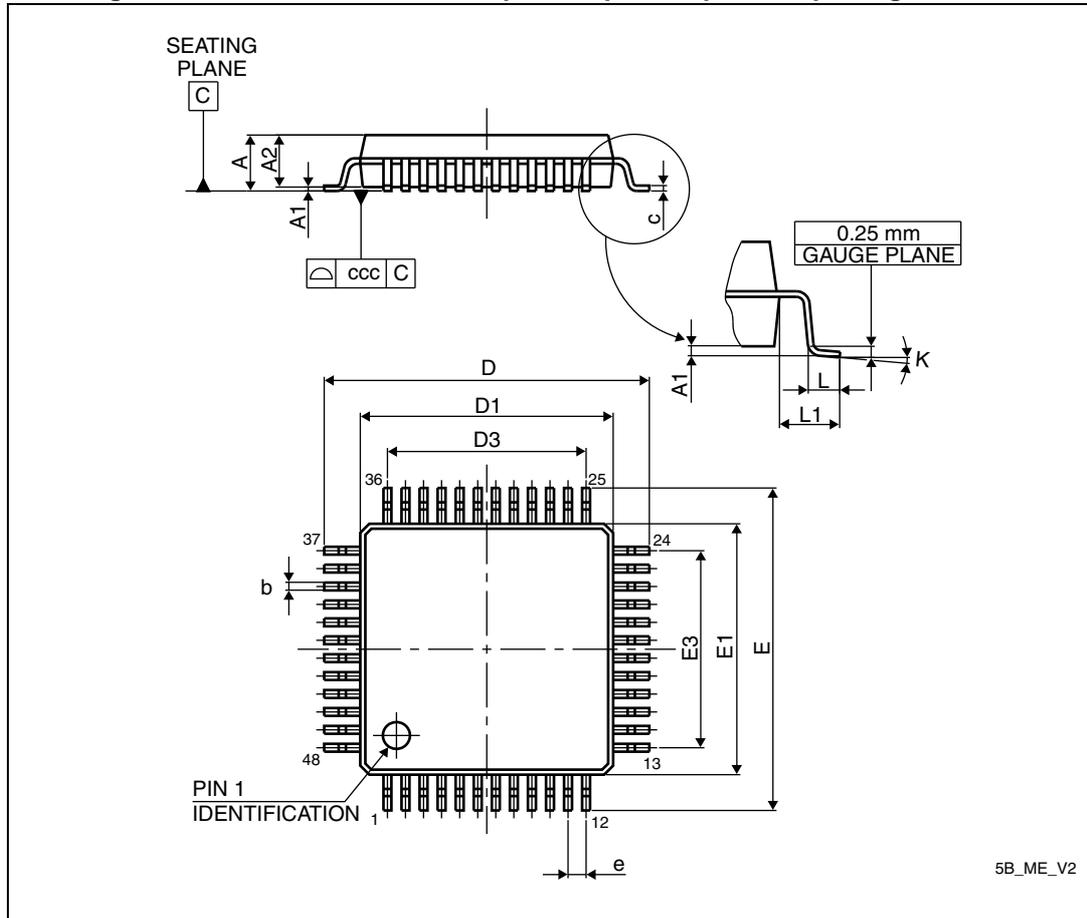
Figure 31. LQFP64 package top view



1. Samples marked "ES" are to be considered as "Engineering Samples": i.e. they are intended to be sent to customer for electrical compatibility evaluation and may be used to start customer qualification where specifically authorized by ST in writing. In no event ST will be liable for any customer usage in production. Only if ST has authorized in writing the customer qualification Engineering Samples can be used for reliability qualification trials.

7.1.2 LQFP48 7 x 7 mm low profile quad flat package

Figure 32. LQFP48, 7 x 7 mm, 48-pin low-profile quad flat package outline



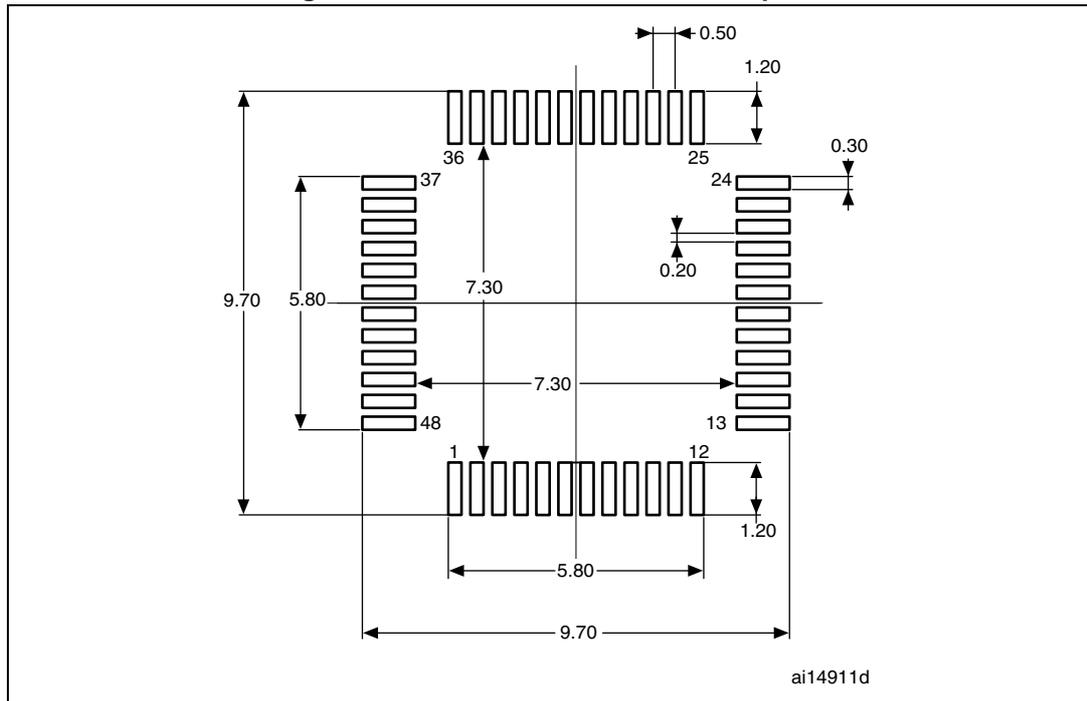
1. Drawing is not to scale.

Table 74. LQFP48, 7 x 7 mm, 48-pin low-profile quad flat package mechanical data

Symbol	millimeters			inches ⁽¹⁾		
	Min	Typ	Max	Min	Typ	Max
A	-	-	1.600	-	-	0.0630
A1	0.050	-	0.150	0.0020	-	0.0059
A2	1.350	1.400	1.450	0.0531	0.0551	0.0571
b	0.170	0.220	0.270	0.0067	0.0087	0.0106
c	0.090	-	0.200	0.0035	-	0.0079
D	8.800	9.000	9.200	0.3465	0.3543	0.3622
D1	6.800	7.000	7.200	0.2677	0.2756	0.2835
D3	-	5.500	-	-	0.2165	-
E	8.800	9.000	9.200	0.3465	0.3543	0.3622
E1	6.800	7.000	7.200	0.2677	0.2756	0.2835
E3	-	5.500	-	-	0.2165	-
e	-	0.500	-	-	0.0197	-
L	0.450	0.600	0.750	0.0177	0.0236	0.0295
L1	-	1.000	-	-	0.0394	-
k	0°	3.5°	7°	0°	3.5°	7°
ccc	-	-	0.080	-	-	0.0031

1. Values in inches are converted from mm and rounded to 4 decimal digits.

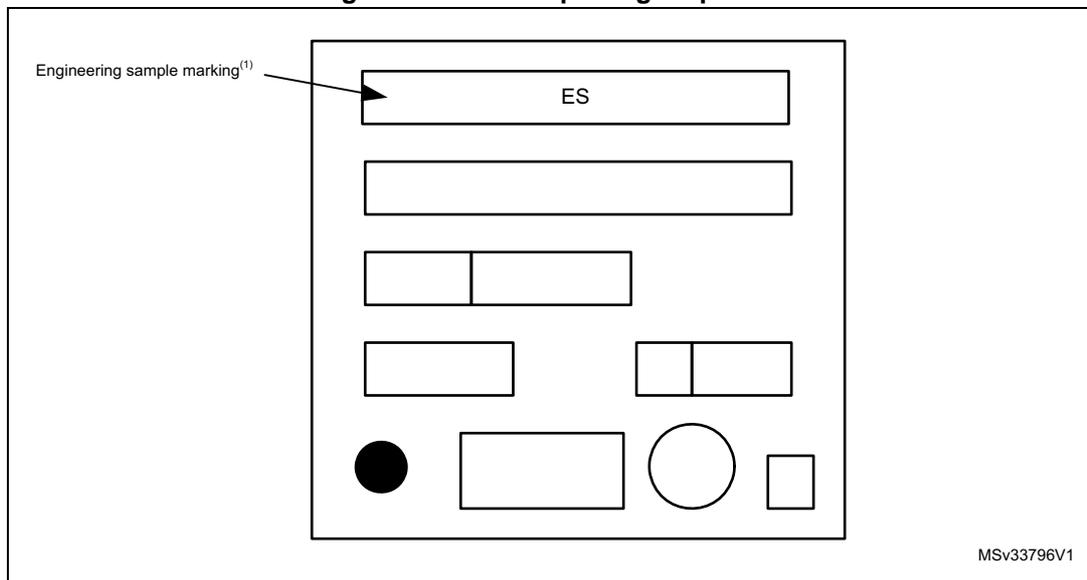
Figure 33. LQFP48 recommended footprint



1. Dimensions are expressed in millimeters.

Marking of engineering samples

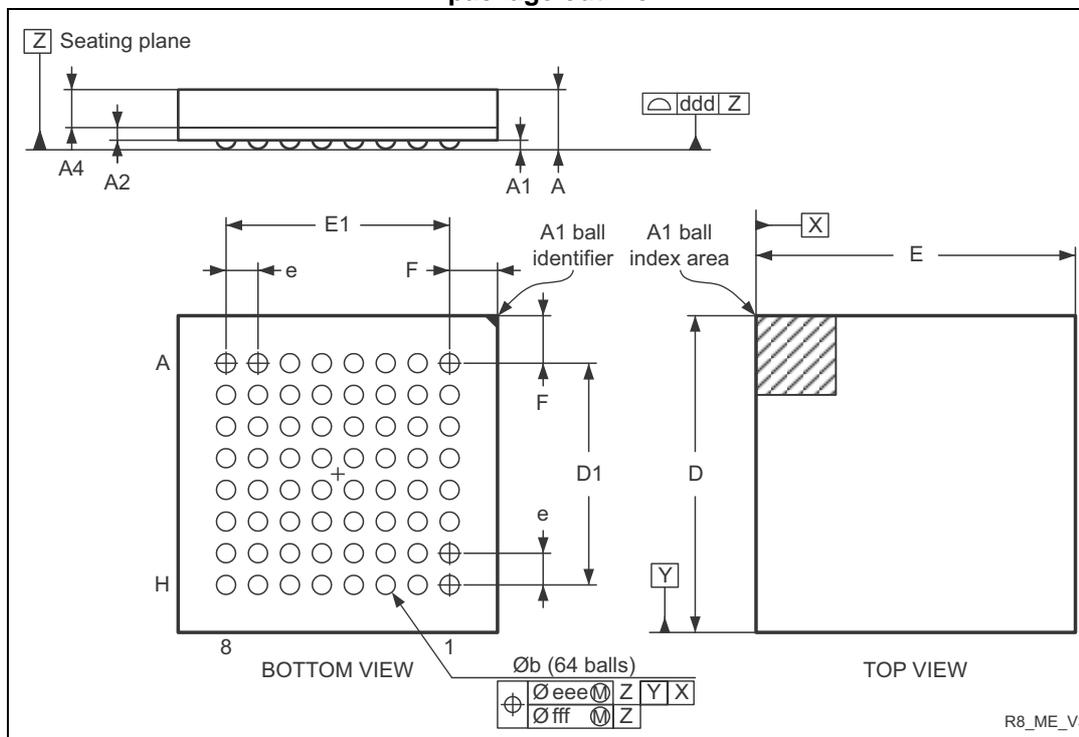
Figure 34. LQFP48 package top view



1. Samples marked "ES" are to be considered as "Engineering Samples": i.e. they are intended to be sent to customer for electrical compatibility evaluation and may be used to start customer qualification where specifically authorized by ST in writing. In no event ST will be liable for any customer usage in production. Only if ST has authorized in writing the customer qualification Engineering Samples can be used for reliability qualification trials.

7.1.3 TFBGA64 5 x 5 mm thin profile fine pitch ball grid array package

Figure 35. TFBGA64, 5 x 5 mm, 64-bump thin profile fine pitch ball grid array package outline



1. Drawing is not to scale.

Table 75. TFBGA64, 5 x 5 mm, 64-bump thin profile fine pitch ball grid array package mechanical data

Symbol	millimeters			inches ⁽¹⁾		
	Min	Typ	Max	Min	Typ	Max
A	-	-	1.200	-	-	0.0472
A1	0.150	-	-	0.0059	-	-
A2	-	0.200	-	-	0.0079	-
A4	-	-	0.600	-	-	0.0236
b	0.250	0.300	0.350	0.0098	0.0118	0.0138
D	4.850	5.000	5.150	0.1909	0.1969	0.2028
D1	-	3.500	-	-	0.1378	-
E	4.850	5.000	5.150	0.1909	0.1969	0.2028
E1	-	3.500	-	-	0.1378	-
e	-	0.500	-	-	0.0197	-
F	-	0.750	-	-	0.0295	-
ddd	-	-	0.080	-	-	0.0031

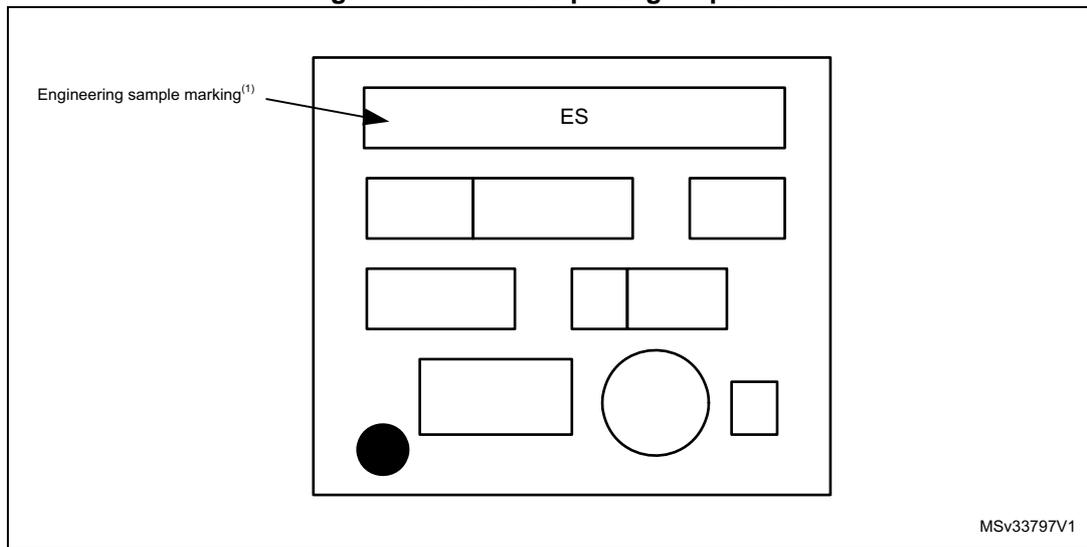
Table 75. TFBGA64, 5 x 5 mm, 64-bump thin profile fine pitch ball grid array package mechanical data (continued)

Symbol	millimeters			inches ⁽¹⁾		
	Min	Typ	Max	Min	Typ	Max
eee	-	-	0.150	-	-	0.0059
fff	-	-	0.050	-	-	0.0020

1. Values in inches are converted from mm and rounded to 4 decimal digits.

Marking of engineering samples

Figure 36. TFBGA64 package top view



1. Samples marked "ES" are to be considered as "Engineering Samples": i.e. they are intended to be sent to customer for electrical compatibility evaluation and may be used to start customer qualification where specifically authorized by ST in writing. In no event ST will be liable for any customer usage in production. Only if ST has authorized in writing the customer qualification Engineering Samples can be used for reliability qualification trials.

7.2 Thermal characteristics

The maximum chip-junction temperature, $T_J \text{ max}$, in degrees Celsius, may be calculated using the following equation:

$$T_J \text{ max} = T_A \text{ max} + (P_D \text{ max} \times \Theta_{JA})$$

Where:

- $T_A \text{ max}$ is the maximum ambient temperature in °C,
- Θ_{JA} is the package junction-to-ambient thermal resistance, in °C/W,
- $P_D \text{ max}$ is the sum of $P_{INT} \text{ max}$ and $P_{I/O} \text{ max}$ ($P_D \text{ max} = P_{INT} \text{ max} + P_{I/O} \text{ max}$),
- $P_{INT} \text{ max}$ is the product of I_{DD} and V_{DD} , expressed in Watts. This is the maximum chip internal power.

$P_{I/O} \text{ max}$ represents the maximum power dissipation on output pins where:

$$P_{I/O} \text{ max} = \Sigma (V_{OL} \times I_{OL}) + \Sigma (V_{DD} - V_{OH}) \times I_{OH},$$

taking into account the actual V_{OL} / I_{OL} and V_{OH} / I_{OH} of the I/Os at low and high level in the application.

Table 76. Thermal characteristics

Symbol	Parameter	Value	Unit
Θ_{JA}	Thermal resistance junction-ambient TFBGA64 - 5 x 5 mm / 0.5 mm pitch	61	°C/W
	Thermal resistance junction-ambient LQFP64 - 10 x 10 mm / 0.5 mm pitch	45	
	Thermal resistance junction-ambient LQFP48 - 7 x 7 mm / 0.5 mm pitch	55	

7.2.1 Reference document

JESD51-2 Integrated Circuits Thermal Test Method Environment Conditions - Natural Convection (Still Air). Available from www.jedec.org.

8 Ordering information

Table 77. STM32L053x6/8 ordering information scheme

Example:	STM32	L	053	R	8	T	6	D	xxx
Device family	<div style="border-left: 1px solid black; border-right: 1px solid black; border-bottom: 1px solid black; height: 100%; position: relative;"> <div style="position: absolute; top: 0; left: 0; right: 0; border-bottom: 1px solid black; height: 100%;"></div> </div>								
STM32 = ARM-based 32-bit microcontroller									
Product type									
L = Low power									
Device subfamily									
053 = USB + LCD									
Pin count									
C = 48 pins									
R = 64 pins									
Flash memory size									
6 = 32 Kbytes									
8 = 64 Kbytes									
Package	<div style="border-left: 1px solid black; border-right: 1px solid black; border-bottom: 1px solid black; height: 100%; position: relative;"> <div style="position: absolute; top: 0; left: 0; right: 0; border-bottom: 1px solid black; height: 100%;"></div> </div>								
T = LQFP									
H = TFBGA									
Temperature range	<div style="border-left: 1px solid black; border-right: 1px solid black; border-bottom: 1px solid black; height: 100%; position: relative;"> <div style="position: absolute; top: 0; left: 0; right: 0; border-bottom: 1px solid black; height: 100%;"></div> </div>								
6 = Industrial temperature range, -40 to 85 °C									
7 = Industrial temperature range, -40 to 105 °C									
Options	<div style="border-left: 1px solid black; border-right: 1px solid black; border-bottom: 1px solid black; height: 100%; position: relative;"> <div style="position: absolute; top: 0; left: 0; right: 0; border-bottom: 1px solid black; height: 100%;"></div> </div>								
No character = V _{DD} range: 1.8 to 3.6 V and BOR enabled									
D = V _{DD} range: 1.65 to 3.6 V and BOR disabled									
Packing	<div style="border-left: 1px solid black; border-right: 1px solid black; border-bottom: 1px solid black; height: 100%; position: relative;"> <div style="position: absolute; top: 0; left: 0; right: 0; border-bottom: 1px solid black; height: 100%;"></div> </div>								
TR = tape and reel									
No character = tray or tube									

For a list of available options (speed, package, etc.) or for further information on any aspect of this device, please contact your nearest ST sales office.

9 Revision history

Table 78. Document revision history

Date	Revision	Changes
07-Feb-2013	1	Initial release.

Please Read Carefully:

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST's terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

UNLESS OTHERWISE SET FORTH IN ST'S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

ST PRODUCTS ARE NOT DESIGNED OR AUTHORIZED FOR USE IN: (A) SAFETY CRITICAL APPLICATIONS SUCH AS LIFE SUPPORTING, ACTIVE IMPLANTED DEVICES OR SYSTEMS WITH PRODUCT FUNCTIONAL SAFETY REQUIREMENTS; (B) AERONAUTIC APPLICATIONS; (C) AUTOMOTIVE APPLICATIONS OR ENVIRONMENTS, AND/OR (D) AEROSPACE APPLICATIONS OR ENVIRONMENTS. WHERE ST PRODUCTS ARE NOT DESIGNED FOR SUCH USE, THE PURCHASER SHALL USE PRODUCTS AT PURCHASER'S SOLE RISK, EVEN IF ST HAS BEEN INFORMED IN WRITING OF SUCH USAGE, UNLESS A PRODUCT IS EXPRESSLY DESIGNATED BY ST AS BEING INTENDED FOR "AUTOMOTIVE, AUTOMOTIVE SAFETY OR MEDICAL" INDUSTRY DOMAINS ACCORDING TO ST PRODUCT DESIGN SPECIFICATIONS. PRODUCTS FORMALLY ESCC, QML OR JAN QUALIFIED ARE DEEMED SUITABLE FOR USE IN AEROSPACE BY THE CORRESPONDING GOVERNMENTAL AGENCY.

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

© 2014 STMicroelectronics - All rights reserved

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

www.st.com