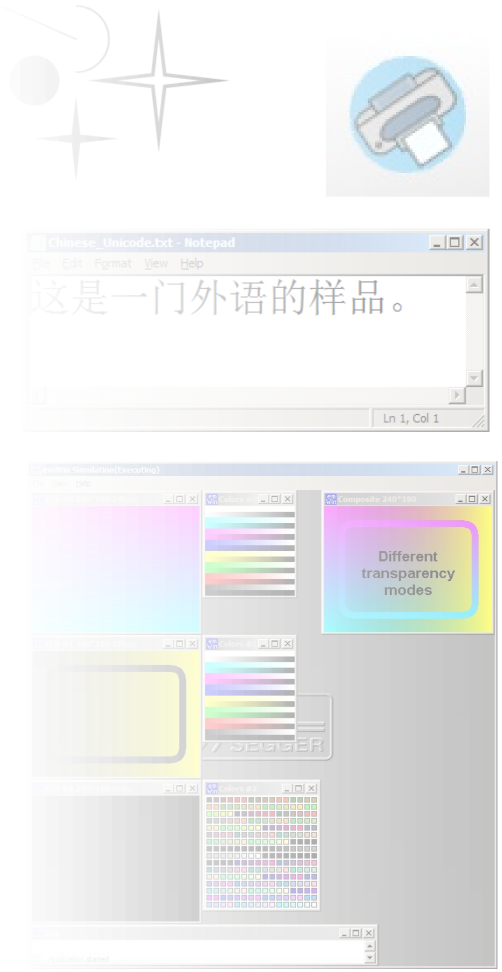
emWin Training

Content

emWin now supports
Skinning
Alphablending
SEGGER


Chinese_Unicode.txt - Notepad
这是一门外语的样品。
Ln 1, Col 1
Different transparency modes

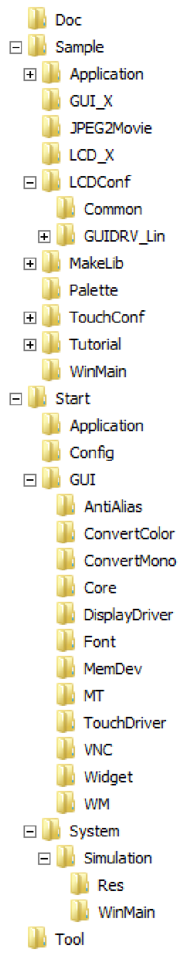
The shipment - Doc, Samples

Doc:

- **Documentation**
- **Release notes**
- **Migration guide** for older versions
- Explanation how to create a **custom widget**

Samples:

- **Tutorial** and application **samples**
- Sample routines for setting up timing and multitasking
- Samples for **indirect display controller access**, **configuration examples** for the display driver(s)
- Batch files for generating libraries
- Samples for a **custom simulation**



```
Doc
Sample
  Application
  GUI_X
  JPEG2Movie
  LCD_X
  LCDConf
    Common
    GUIDRV_Lin
  MakeLib
  Palette
  TouchConf
  Tutorial
  WinMain
Start
  Application
  Config
  GUI
    AntiAlias
    ConvertColor
    ConvertMono
    Core
    DisplayDriver
    Font
    MemDev
    MT
    TouchDriver
    VNC
    Widget
    WM
  System
    Simulation
      Res
      WinMain
Tool
```

The shipment

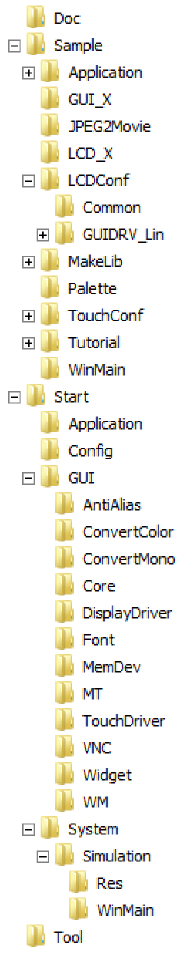
Start:

- **Simulation project**
- A kind of 'Hello World' application
- The **source code of the GUI library**
- Simulation in binary form

Tool:

- All tools which are part of the license

Hint: Most of the upcomming questions of an emWin newbie could be cleared up by a looking into the samples and the documentation.



```
Doc
⊟ Sample
  ⊞ Application
    GUI_X
    JPEG2Movie
    LCD_X
  ⊟ LCDConf
      Common
    ⊞ GUIDRV_Lin
  ⊞ MakeLib
    Palette
  ⊞ TouchConf
  ⊞ Tutorial
    WinMain
⊟ Start
    Application
    Config
  ⊟ GUI
      AntiAlias
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      DisplayDriver
      Font
      MemDev
      MT
      TouchDriver
      VNC
      Widget
      WM
  ⊟ System
    ⊟ Simulation
        Res
        WinMain
Tool
```

Simulation project

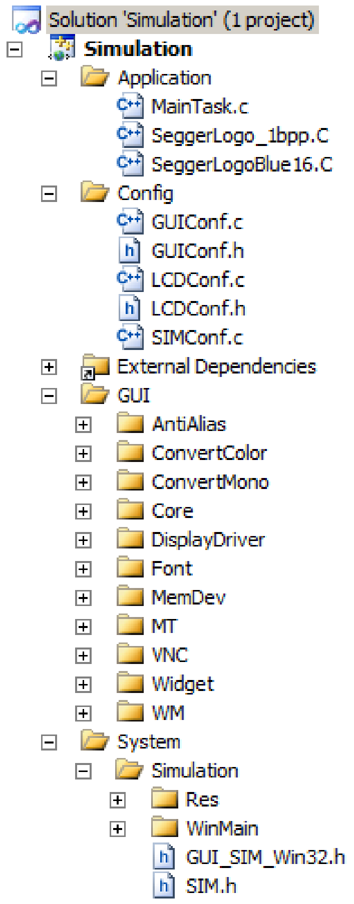
The project contains:

- Sample application files
- Configuration files
- GUI-files
- Simulation related files

The GUI group consists of the following folders:

- **Optional** antialiasing
- **Optional** color conversion routines
- Core package
- Display driver
- Standard fonts
- **Optional** memory devices
- **Optional** MultiTouch
- **Optional** VNC
- **Optional** window manager and widget library

Each project is preconfigured and shows the content which is part of the emWin license. **PNG**- and **FreeType** support could be added from our website. The link can be found in the documentation.



```
Solution 'Simulation' (1 project)
⊟ Simulation
    ⊟ Application
          MainTask.c
          SeggerLogo_1bpp.C
          SeggerLogoBlue16.C
    ⊟ Config
          GUIConf.c
          GUIConf.h
          LCDConf.c
          LCDConf.h
          SIMConf.c
    ⊞ External Dependencies
    ⊟ GUI
        ⊞ AntiAlias
        ⊞ ConvertColor
        ⊞ ConvertMono
        ⊞ Core
        ⊞ DisplayDriver
        ⊞ Font
        ⊞ MemDev
        ⊞ MT
        ⊞ VNC
        ⊞ Widget
        ⊞ WM
    ⊟ System
        ⊟ Simulation
            ⊞ Res
            ⊞ WinMain
              GUI_SIM_Win32.h
              SIM.h
```

'Hello World' with emWin

The **application entry point** in the simulation is:

```
void MainTask(void) {
  ...
}
```

Keep source of hardware project identical to the simulation. Call `MainTask()` from within the `main()` function or start it as a separate task:

```
OS_CREATETASK(&TCB, "MainTask",
              MainTask, 100, Stack);
```

Only one include file is required (for the core functions):

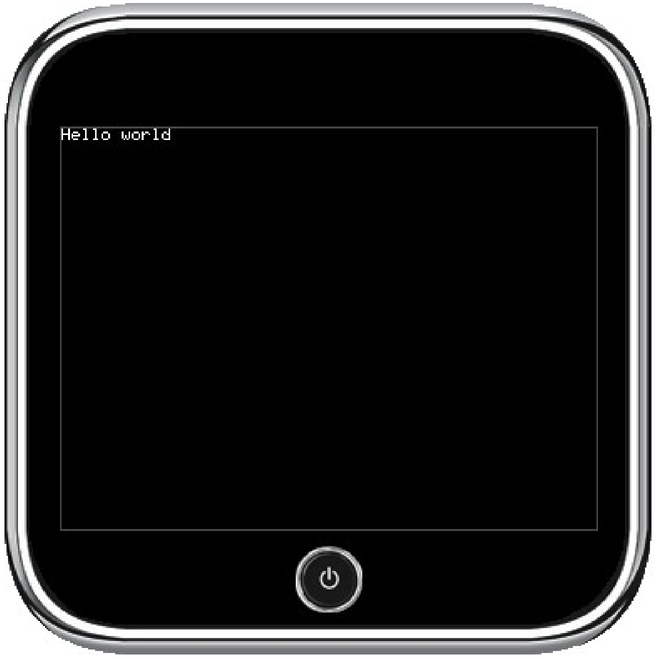
```
#include „GUI.h“
```

It is required to call `GUI_Init()` at first.

A loop is required to keep the application alive:

```
while(1) {
  GUI_Delay(10);
}
```

```
#include "GUI.h"

void MainTask(void) {
  GUI_Init();
  GUI_DispString("Hello world");
  while (1) {
    GUI_Delay(10);
  }
}
```



Color management

How does emWin work with colors?

- Color information 32bpp
- Config switch **GUI_USE_ARGB** for AGBR or ARGB format
- Color conversion into '**Index Values**' and vice versa
- `LCD_X_Config()` must set up the right color conversion
- A 'Fixed Palette Mode' is recommended
- A 'Custom Palette' could degrade performance

Alpha channel

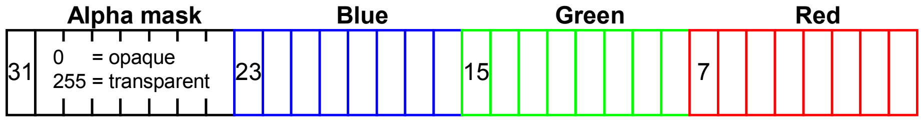
- **GUI_USE_ARGB = 0**:
  0 means opaque, 255 means 100% transparent
- **GUI_USE_ARGB = 1**:
  0 means 100% transparent, 255 means opaque

TrueColor - 8 bits for each component (24 or 32bpp)

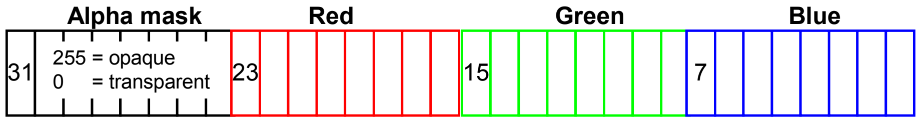
HighColor - 5 bits blue, 6 bits green, 5 bits red (16bpp)

Note: Changing the color format within a project could lead into wrong colors.

GUI_USE_ARGB = 0

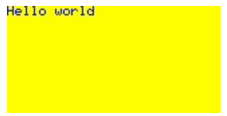


GUI_USE_ARGB = 1



```
#include "GUI.h"

void MainTask(void) {
  GUI_Init();
  #if (GUI_USE_ARGB == 0)
    GUI_SetBkColor(0x00FFFF);
    GUI_SetColor(0xFF0000);
  #else
    GUI_SetBkColor(0xFFFFFF00);
    GUI_SetColor(0xFF0000FF);
  #endif
  GUI_Clear();
  GUI_DispString("Hello world");
  while (1) {
    GUI_Delay(10);
  }
}
```

```
#include "GUI.h"

void MainTask(void) {
  GUI_Init();
  GUI_SetBkColor(GUI_YELLOW);
  GUI_SetColor(GUI_BLUE);
  GUI_Clear();
  GUI_DispString("Hello world");
  while (1) {
    GUI_Delay(10);
  }
}
```



```
Hello world
```

Introduction summary

You should now be able to answer the following questions:

- **What is the difference between 'Color' and 'Index' values?**
- **What is the application entry point of the simulation?**
- **What exactly is the difference between GUI_USE_ARGB = 0 and GUI_USE_ARGB = 1?**
- **Which optional packages are available?**
- **How could PNG and TrueType support be added?**
- **What is the difference between 'fixed palette mode' and 'custom palette mode'?**

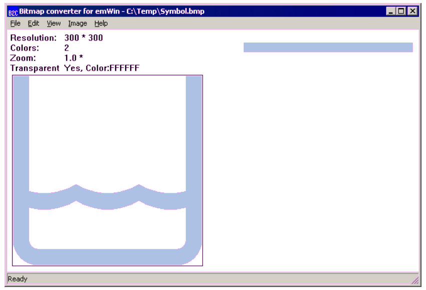
Tools overview

Basic:

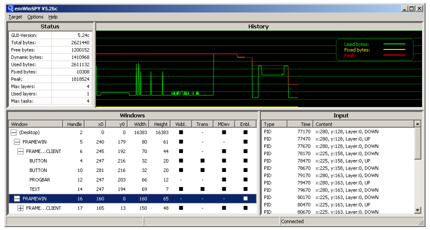
- **Bitmap converter**
  Tool for converting images and saving them as C-files or streamed bitmaps.
- **emWinView**
  To be used to view the content of the display while stepping through the debugger of the simulation.
- **emWinSPY**
  Shows runtime information of the embedded target on a PC.
- **emVNC**
  VNC client to be used for VNC connections with or without emWin.
- **Bin2C**
  Can be used for converting any kind of file into byte arrays which then can be used within a C file.
- **U2C**
  Used for converting UTF8-text into C-code.
- **JPEG2Movie**
  Used for creating emWin movie files in conjunction with FFMPEG.

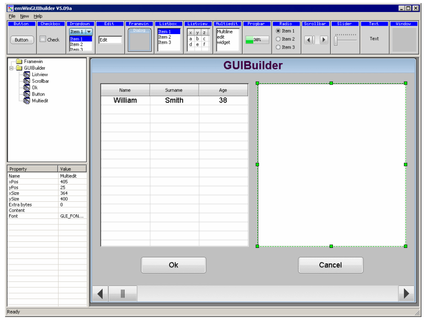
Optional:

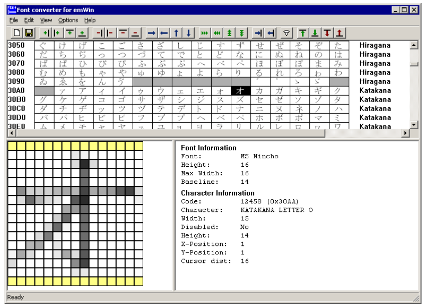
- **Font converter**
  Can be used for converting any font installed on the host system into emWin compatible formats.
- **GUIBuilder**
  Used to generate dialog based applications without writing any line of code.


Bitmap converter for emWin - C:\Temp\Symbol.bmp
File Edit View Image Help
Ready

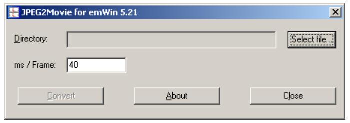
Resolution: 300 * 300
Colors: 2
Zoom: 1.0 *
Transparent Yes, Color:FFFFFF







Font Information
Font: MS Mincho
Height: 16
Max Width: 16
Baseline: 14
Character Information
Code: 12458 (0x30AA)
Character: KATAKANA LETTER O
Width: 15
Disabled: No
Height: 14
X-Position: 1
Y-Position: 1
Cursor dist: 16



Directory:
ms / Frame: 40

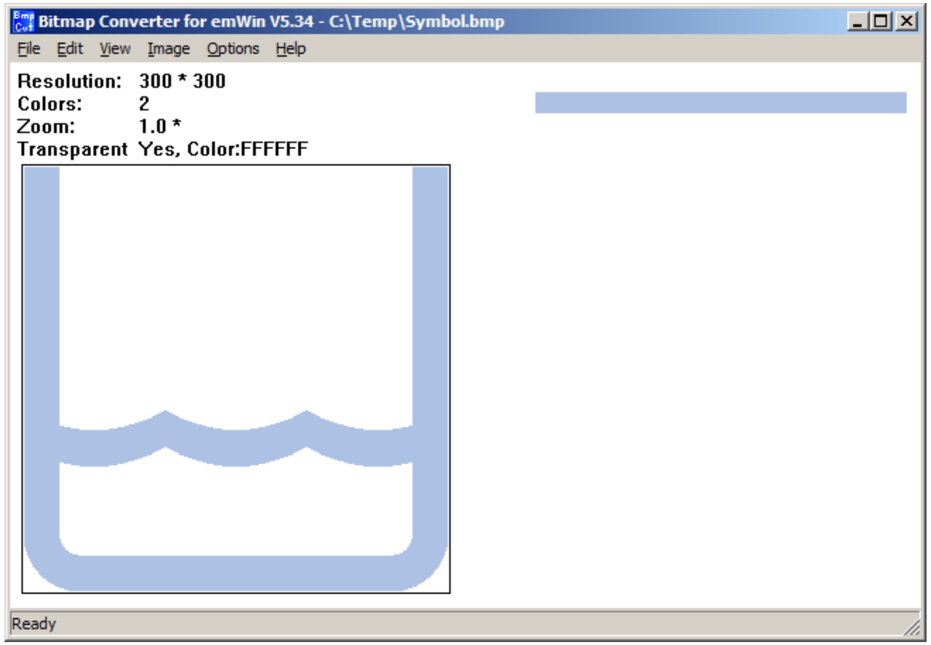
BitmapConverter - Supported image formats

Input formats:

- **BMP** files
- **GIF** files without animation
- **PNG** files with alpha channel support

Output formats:

- **C files**
  Could be compiled and linked within the project. **Most** recommended and **flexible** image format in case of enough addressable ROM.
- **Streamed bitmaps**
  If system is short on adressable ROM, images can be saved as streamed bitmaps.
  Functions are available to create real emWin bitmaps from streamed bitmaps.
  Accessed by `GetData()` function passed by the customer.
- **BMP-, GIF and PNG**
  Images could also be saved as GIF-, BMP or PNG files.


Bitmap Converter for emWin V5.34 - C:\Temp\Symbol.bmp
File Edit View Image Options Help
Ready

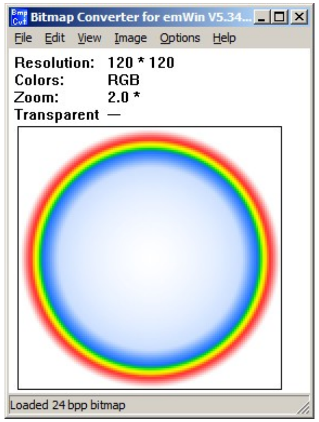
Resolution: 300 * 300
Colors: 2
Zoom: 1.0 *
Transparent Yes, Color:FFFFFF

BitmapConverter - Color conversion and color reduction

The bitmap converter offers a wide range of possible image transformations.

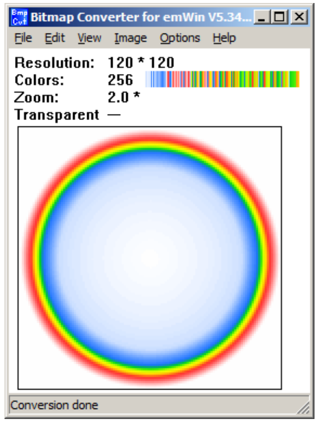
- **Color conversion**
  Use '**Image\Convert Into\...**' to convert the image to the right format for the hardware.
- **Dithering**
  Use '**Image\Dither into\...**' to dither the image into the desired format.
- **Color reduction**
  Use '**Image\Reduce Colors\...**' to reduce the color depth.
- **Flipping, rotating, inverting and scaling**
  Use '**Image\Flip, Rotate, Invert and Scale**'

Important: When saving images in high color format, the format should fit **exactly** to the layer configuration. Otherwise color conversion is required for each pixel during the drawing operation which degrades the performance significantly.



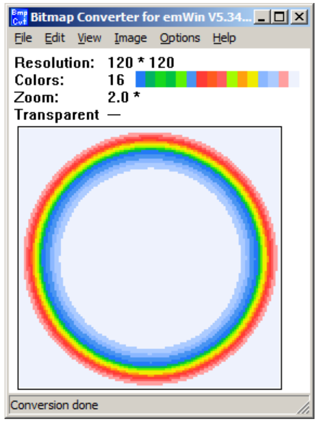
Resolution: 120 * 120
Colors: RGB
Zoom: 2.0 *
Transparent —

Loaded 24 bpp bitmap



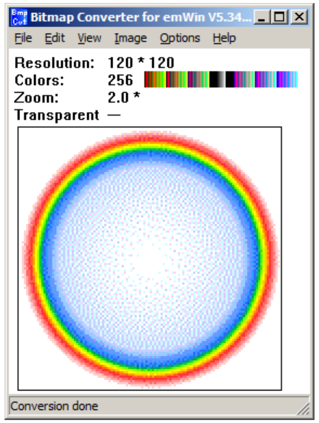
Resolution: 120 * 120
Colors: 256
Zoom: 2.0 *
Transparent —

Conversion done



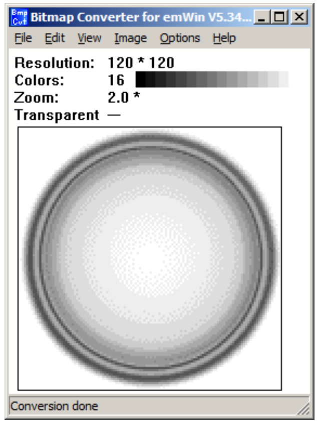
Resolution: 120 * 120
Colors: 16
Zoom: 2.0 *
Transparent —

Conversion done



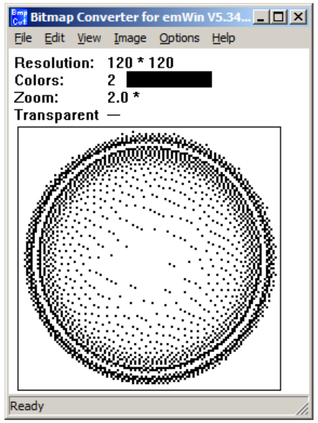
Resolution: 120 * 120
Colors: 256
Zoom: 2.0 *
Transparent —

Conversion done



Resolution: 120 * 120
Colors: 16
Zoom: 2.0 *
Transparent —

Conversion done



Resolution: 120 * 120
Colors: 2
Zoom: 2.0 *
Transparent —

Ready

BitmapConverter - Transparency

Meaning of transparency:

- Supported for palette based bitmaps (1-8bpp)
- Pixel data are index values into the palette of the bitmap
- Index value 0 means pixel is transparent
- Not to be mixed up with alpha blending

Creating transparent images:

- **Selecting the color of palette based bitmaps**

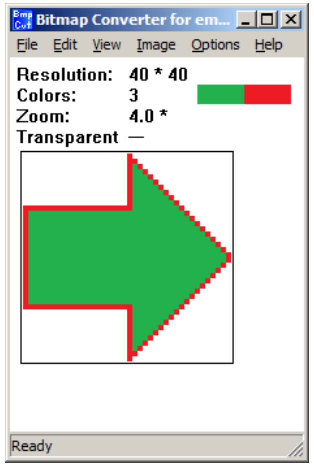
  Use 'Image\Transparency...' for selecting the color to be treated as transparent.

  → (see right side in the upper sample)

- **Converting PNG files**

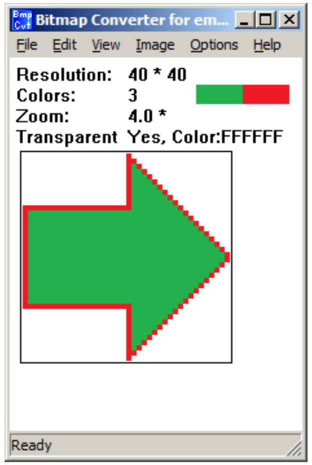
  Use 'Image\Convert to\Best palette + transparency'.

  → (see right side in the lower sample)



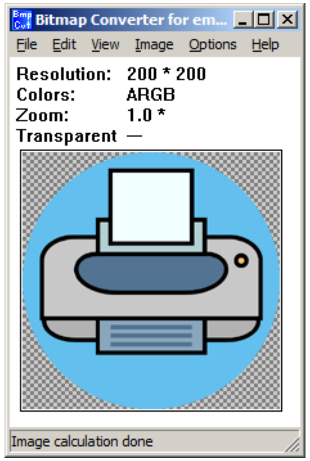
Resolution: 40 * 40
Colors: 3
Zoom: 4.0 *
Transparent —

Ready



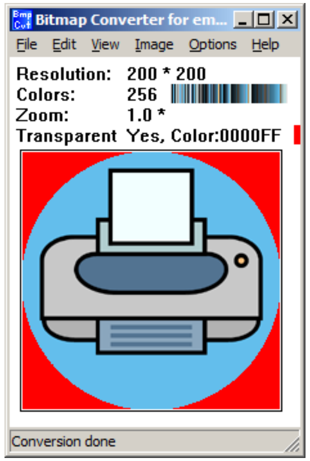
Resolution: 40 * 40
Colors: 3
Zoom: 4.0 *
Transparent Yes, Color:FFFFFF

Ready



Resolution: 200 * 200
Colors: ARGB
Zoom: 1.0 *
Transparent —

Image calculation done



Resolution: 200 * 200
Colors: 256
Zoom: 1.0 *
Transparent Yes, Color:0000FF

Conversion done

BitmapConverter - Alpha blending

Alpha blending is a method of combining a foreground image with the background to create the appearance of semi transparency. An alpha value determines how much of a pixel should be visible and how much of the background should show through.

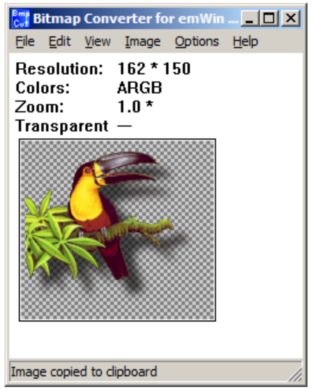
- **PNG files with alpha mask**

  The easiest method to use bitmaps with alpha blending is to load PNG files and to save them as 'True color bitmap with alpha channel'

- **Alpha mask bitmaps**

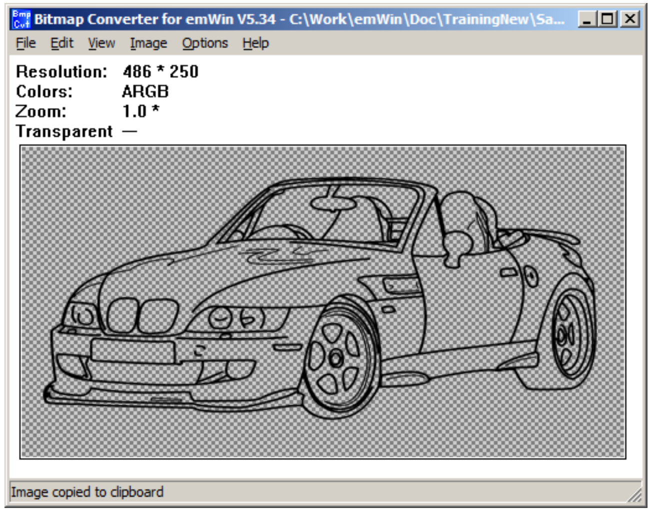
  Sometimes it could be useful to have only the alpha mask to be able to draw the shape of the image in different colors. Can be done by saving only the alpha mask as 'Alpha channel, compressed'. The images are drawn with the currently selectet foreground color.

Note: Alpha mask bitmaps are the most effective way to achieve smooth shapes or outlines which could be drawn in different colors.


Bitmap Converter for emWin ...
File Edit View Image Options Help

```
Resolution:  162 * 150
Colors:      ARGB
Zoom:        1.0 *
Transparent  —
```

Image copied to clipboard


Bitmap Converter for emWin V5.34 - C:\Work\emWin\Doc\TrainingNew\Sa...
File Edit View Image Options Help

```
Resolution:  486 * 250
Colors:      ARGB
Zoom:        1.0 *
Transparent  —
```

Image copied to clipboard

FontConverter

The font converter is able to convert any installed font of the host system into emWin compatible formats.

- Converts **any installed font** of the host system.
- Supports different font **types**: STD, EXT, AA2, ...
- Supports different font **formats**: C, XBF, SIF, BDF.
- C-font files can be loaded and changed.
- C-font files can be merged to existing data.
- **Pattern files** can be used to select characters.

Insert pixel line to character

Delete pixel line from character

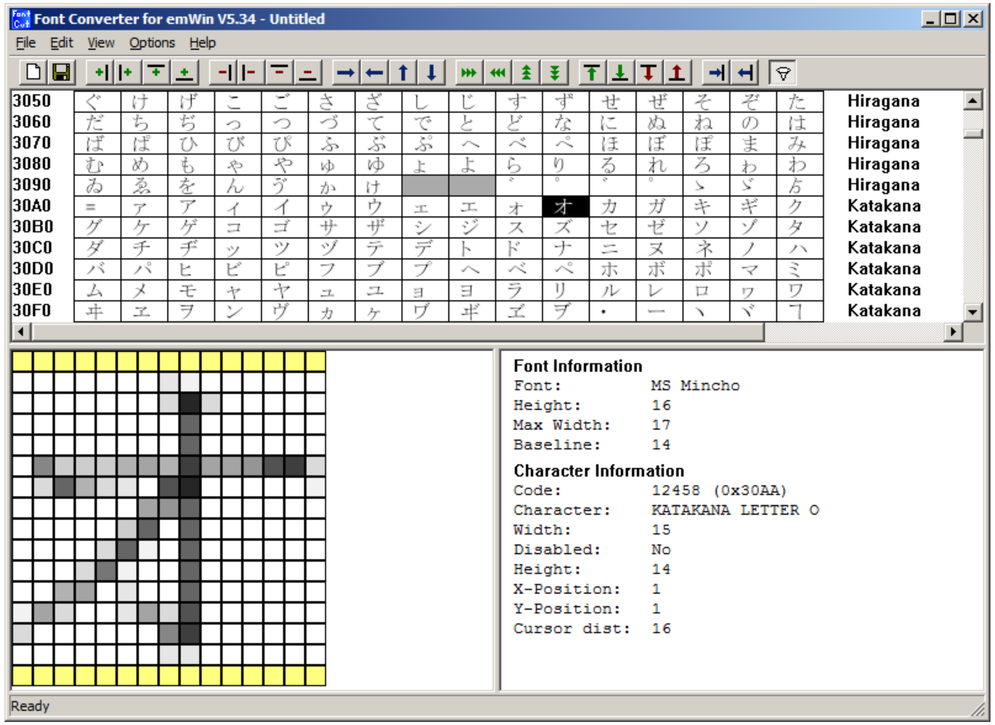
Shift content of character

Move position of character

Insert/delete pixel line to font

Increase/decrease cursor increment

Filter for showing only blocks with content


Font Converter for emWin V5.34 - Untitled
File Edit View Options Help

3050	ぐ	け	げ	こ	ご	さ	ざ	し	じ	す	ず	せ	ぜ	そ	ぞ	た	Hiragana
3060	だ	ち	ぢ	っ	つ	づ	て	で	と	ど	な	に	ぬ	ね	の	は	Hiragana
3070	ば	ぱ	ひ	び	ぴ	ふ	ぶ	ぷ	へ	べ	ぺ	ほ	ぼ	ぽ	ま	み	Hiragana
3080	む	め	も	ゃ	や	ゅ	ゆ	ょ	よ	ら	り	る	れ	ろ	ゎ	わ	Hiragana
3090	ゐ	ゑ	を	ん	ゔ	ゕ	ゖ			゙	゚	゛	゜	ゝ	ゞ	ゟ	Hiragana
30A0	゠	ァ	ア	ィ	イ	ゥ	ウ	ェ	エ	ォ	オ	カ	ガ	キ	ギ	ク	Katakana
30B0	グ	ケ	ゲ	コ	ゴ	サ	ザ	シ	ジ	ス	ズ	セ	ゼ	ソ	ゾ	タ	Katakana
30C0	ダ	チ	ヂ	ッ	ツ	ヅ	テ	デ	ト	ド	ナ	ニ	ヌ	ネ	ノ	ハ	Katakana
30D0	バ	パ	ヒ	ビ	ピ	フ	ブ	プ	ヘ	ベ	ペ	ホ	ボ	ポ	マ	ミ	Katakana
30E0	ム	メ	モ	ャ	ヤ	ュ	ユ	ョ	ヨ	ラ	リ	ル	レ	ロ	ヮ	ワ	Katakana
30F0	ヰ	ヱ	ヲ	ン	ヴ	ヵ	ヶ	ヷ	ヸ	ヹ	ヺ	・	ー	ヽ	ヾ	ヿ	Katakana

Font Information

```
Font:          MS Mincho
Height:        16
Max Width:     17
Baseline:      14
```

Character Information

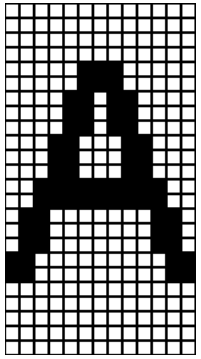
```
Code:          12458 (0x30AA)
Character:     KATAKANA LETTER O
Width:         15
Disabled:      No
Height:        14
X-Position:    1
Y-Position:    1
Cursor dist:   16
```

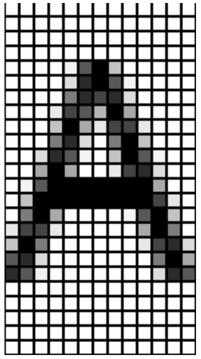
Ready

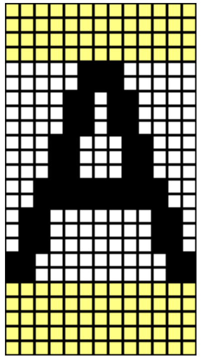
FontConverter - Font types

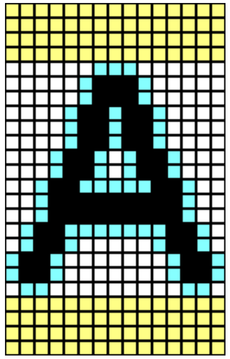
- **Standard fonts (obsolete)**
  Format, does not support compound characters required for languages like Thai or Arabic.
- **Antialiased, 2bpp and 4bpp (obsolete)**
  Antialiasing font format, replaced by the 'Extended' fonts.
- **Extended**
  Successor of the 'Standard fonts' with support for compound characters.
- **Extended, Framed**
  To be used on undetermined backgrounds.
- **Extended, antialiased, 2 and 4bpp**
  Successor of 'Antialiased, 2bpp and 4bpp' with support for compound characters.

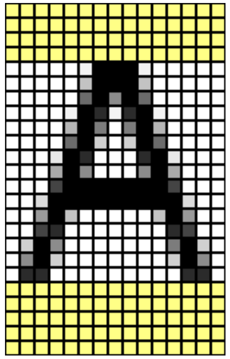
Note: Support for 'Standard' fonts is implemented for reasons of compatibility. A better quality could be achieved with 'Extended' fonts.


(obsolete)


(obsolete)







FontConverter - Font formats

- **C file format**

  Easy to use font format which can be simply compiled and linked with the project. Needs to reside in addressable memory area.

- **SIF file format**
  (**S**ystem **I**ndependent **F**ont)

  Contains exactly the same information as the C file format, but in binary form. Needs to be loaded into addressable memory area before it can be used. Same performance as C files.

- **XBF file format**
  (E**x**ternal **B**inary **F**ont)

  Binary file format with fast character access. Can reside on any media. Recommended for fonts with a large number of character areas.

- **BDF file format**
  (**B**itmap **D**istribution **F**ormat)

  The font converter suppors reading of font files in BDF format which is defined by Adobe. A large number of BDF font files exist in the UNIX-world.

+ Easy usage, simply compile and link
- Performance degrades with big fonts

- Must be loaded completely into memory
- Performance degrades with big fonts

+ Could reside on any media
- File system with cache recommended

FontConverter - Chinese language sample

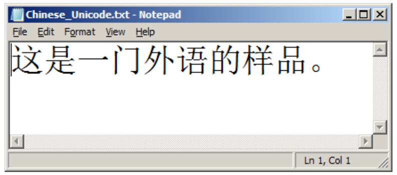
Unicode support should be enabled once at the beginning of the application:

```
GUI_Init();
GUI_UC_SetEncodeUTF8(); // Enable UTF8 support
```

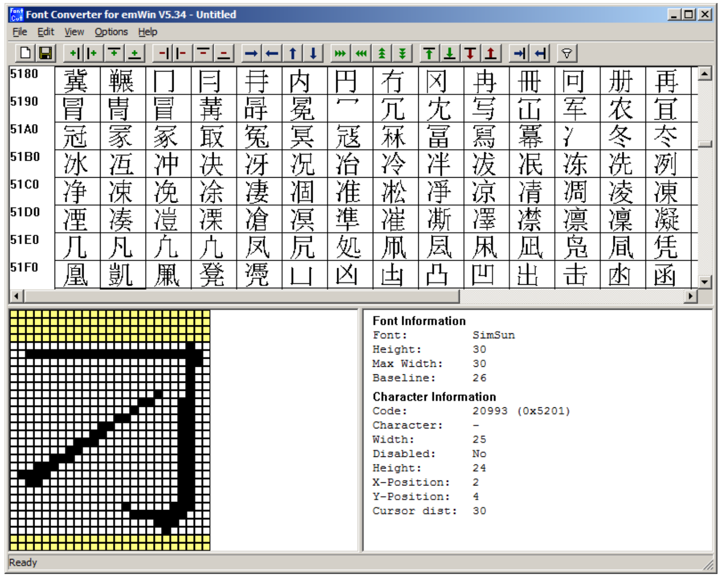
The following shows the steps for getting a Chinese text sample on the display:

- Save text file in UTF8 and Unicode format.
- Create a new font of desired size and type.
- Disable all characters.
- Read pattern file with desired characters.
- Save font file.
- Convert UTF8 text file into C code.
- Include font and text into project.

Note: Unicode support of emWin is based on UTF-8 encoding.



这是一门外语的样品。


Font Converter for emWin V5.34 - Untitled
File Edit View Options Help
Ready

5180	冀	冁	冂	冃	冄	内	円	冇	冈	冉	冊	冋	册	再
5190	冐	冑	冒	冓	冔	冕	冖	冗	冘	写	冚	军	农	冝
51A0	冠	冡	冢	冣	冤	冥	冦	冧	冨	冩	冪	冫	冬	冭
51B0	冰	冱	冲	决	冴	况	冶	冷	冸	冹	冺	冻	冼	冽
51C0	净	凁	凂	凃	凄	凅	准	凇	凈	凉	凊	凋	凌	凍
51D0	凐	凑	凒	凓	凔	凕	凖	凗	凘	凙	凚	凛	凜	凝
51E0	几	凡	凢	凣	凤	凥	処	凧	凨	凩	凪	凫	凬	凭
51F0	凰	凱	凲	凳	凴	凵	凶	凷	凸	凹	出	击	凼	函

```
Font Information
Font:          SimSun
Height:        30
Max Width:     30
Baseline:      26

Character Information
Code:          20993 (0x5201)
Character:     -
Width:         25
Disabled:      No
Height:        24
X-Position:    2
Y-Position:    4
Cursor dist:   30
```

```
static char acText[] = "\xe8\xbf\x99\xe6\x98\xaf\xe4\xb8\x80\xe9\x97\xa8\xe5\xa4\x96"
                       "\xe8\xaf\xad\xe7\x9a\x84\xe6\xa0\xb7\xe5\x93\x81\xe3\x80\x82";

void MainTask(void) {
  GUI_Init();
  GUI_UC_SetEncodeUTF8();
  GUI_SetFont(&GUI_FontChinese_30);
  GUI_DispString(acText);
  while (1) {
    GUI_Delay(100);
  }
}
```

FontConverter - Using XBF files

XBF format should be used for large fonts.

Large: Fonts with many characters and **many gaps**.

- Interface between an XBF file and emWin is the **GetData**() function.
- **GUI_XBF_CreateFont()** should be used to create the font structure.
- The **void* pointer** is **passed to GetData**().
- **GetData() has to copy** the requested **data** of the file into the given buffer.
- Return value is 0 on success.

Note: Unlike in C and SIF format, where the character access depends on the codepoint of the character, XBF fonts contain an access table which makes sure that each character can be accessed with only 2 _GetData() accesses.

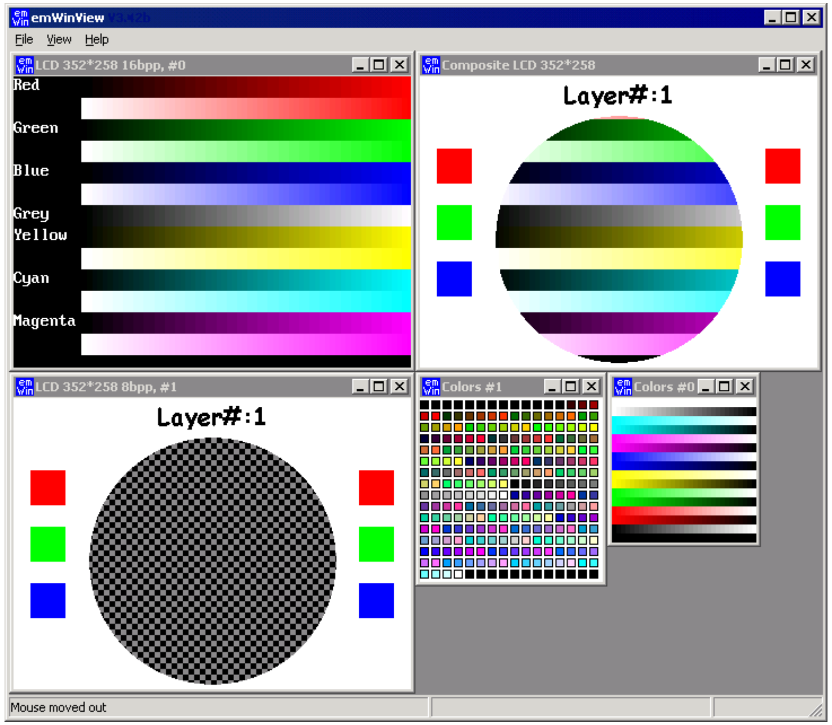
```c
#include <windows.h>

#include "GUI.h"

/*********************************************************************
*
*       _cbGetData
*
* Parameters:
*   Off      - Position of XBF file to be read
*   NumBytes - Number of requested bytes
*   pVoid    - Application defined pointer
*   pBuffer  - Pointer to buffer to be filled by the function
*/
static int _cbGetDataXBF(U32 Off, U16 NumBytes, void * pVoid, void * pBuffer) {
  DWORD NumBytesRead;
  HANDLE hFile;

  hFile = *(HANDLE *)pVoid;
  // Set file pointer to the requested position
  if (SetFilePointer(hFile, Off, 0, FILE_BEGIN) == 0xFFFFFFFF) {
    return 1; // Error
  }
  // Read font data
  if (!ReadFile(hFile, pBuffer, NumBytes, &NumBytesRead, 0)) {
    return 1; // Error
  }
  if (NumBytesRead != NumBytes) {
    return 1; // Error
  }
  return 0; // Ok
}

/*********************************************************************
*
*       MainTask
*/
void MainTask(void) {
  HANDLE       hFile;
  GUI_FONT     Font;
  GUI_XBF_DATA XBF_Data;

  GUI_Init();
  // Get file handle
  hFile = CreateFile(Filename, GENERIC_READ, 0, 0, OPEN_EXISTING, FILE_ATTRIBUTE_NORMAL, 0);
  // Create XBF font
  GUI_XBF_CreateFont(&Font,                 // Pointer to GUI_FONT structure in RAM
                     &XBF_Data,             // Pointer to GUI_XBF_DATA structure in RAM
                     GUI_XBF_TYPE_PROP_EXT, // Font type to be created
                     _cbGetDataXBF,         // Pointer to callback function
                     (void *)&hFile);       // Pointer to be passed to GetData function
  // Draw some text
  GUI_DispStringHCenterAt("Hello world!", 160, 80);
  while (1) {
    GUI_Delay(100);
  }
}
```

SAMPLE: FontConverter\GetData_XBF.c

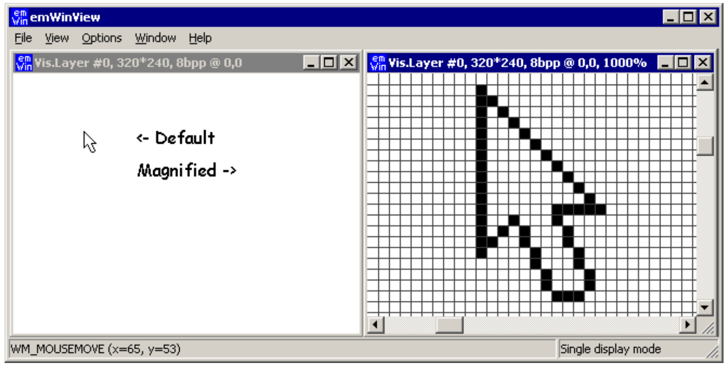
emWinView

The viewer can be used to view the content of the display during stepping through the debugger.

- **Magnification** of each layer window
- **Watching** the whole **virtual layer** in one window
- **Composite view** with multiple layers
- Content **visible** even **if** the **debugger stops**
- Visibility can be **always on top**
- **Touch events** are passed to the simulation



Mouse moved out


emWinView
File
View
Options
Window
Help
Vis.Layer #0, 320*240, 8bpp @ 0,0
Vis.Layer #0, 320*240, 8bpp @ 0,0, 1000%
<- Default
Magnified ->

WM_MOUSEMOVE (x=65, y=53)

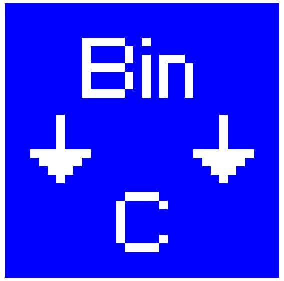
Single display mode

Bin2C - Converts binary files into C code

Its often useful to get a binary file into the target without having a file system available. In this case the Bin2C tool can be used. It can be used to convert any file into a C array.

Without a file system it offers the following features:

- **Direct drawing of image files**
- **Use of XBF font files**
- **Use of TrueType font files**

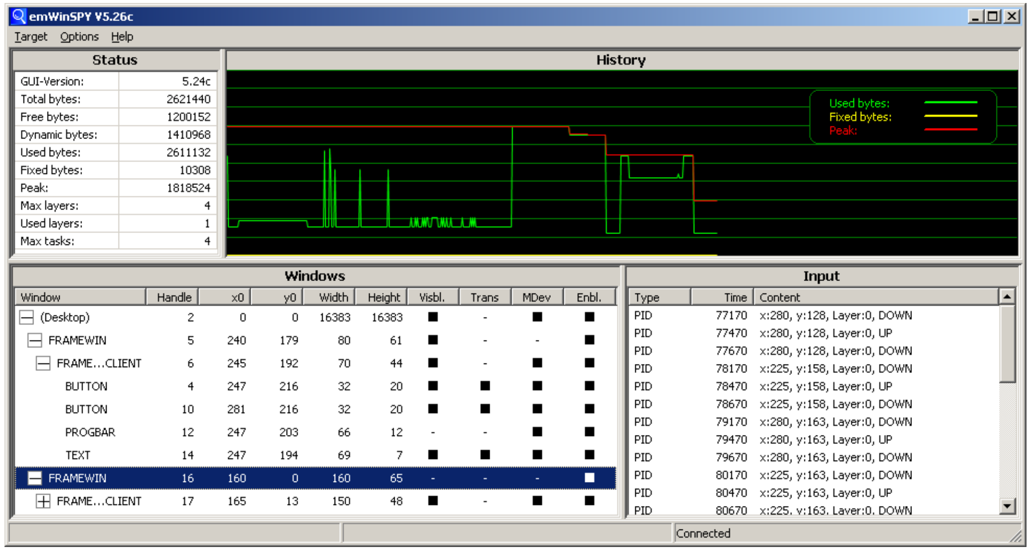


```
#include "GUI.h"

static unsigned char _acFontABC_16_EXT_XBF[] = {
  0x47, 0x55, 0x49, 0x58, 0x10, 0x00, 0x10, 0x00, 0x0D, 0x00, 0x07, 0x00, 0x0A,
  0x00, 0x41, 0x00, 0x43, 0x00, 0x24, 0x00, 0x00, 0x00, 0x20, 0x00, 0x44, 0x00,
  0x00, 0x00, 0x16, 0x00, 0x5A, 0x00, 0x00, 0x00, 0x16, 0x00, 0x09, 0x00, 0x09,
  0x00, 0x0A, 0x00, 0x00, 0x00, 0x03, 0x00, 0x02, 0x00, 0x08, 0x00, 0x14, 0x00,
  0x14, 0x00, 0x14, 0x00, 0x22, 0x00, 0x22, 0x00, 0x7F, 0x00, 0x41, 0x00, 0x80,
  0x80, 0x80, 0x80, 0x09, 0x00, 0x07, 0x00, 0x0A, 0x00, 0x01, 0x00, 0x03, 0x00,
  0x01, 0x00, 0xFC, 0x82, 0x82, 0x82, 0xFC, 0x82, 0x82, 0x82, 0x82, 0xFC, 0x09,
  0x00, 0x07, 0x00, 0x0A, 0x00, 0x01, 0x00, 0x03, 0x00, 0x01, 0x00, 0x38, 0x44,
  0x82, 0x80, 0x80, 0x80, 0x80, 0x82, 0x44, 0x38, 0x00
};

static int _cbGetDataXBF(U32 Off, U16 NumBytes, void * pVoid, void * pBuffer) {
  U8 * p;

  p = (U8 *)pVoid;
  //
  // Copy data
  //
  memcpy(pBuffer, p + Off, NumBytes);
  return 0; // Ok
}

void MainTask(void) {
  GUI_FONT     Font;
  GUI_XBF_DATA XBF_Data;

  GUI_Init();
  //
  // Create XBF font
  //
  GUI_XBF_CreateFont(&Font,                          // Pointer to GUI_FONT structure
                     &XBF_Data,                      // Pointer to GUI_XBF_DATA structure
                     GUI_XBF_TYPE_PROP_EXT,          // Font type to be created
                     _cbGetDataXBF,                  // Pointer to callback function
                     (void *)_acFontABC_16_EXT_XBF); // Pointer to be passed to GetData
  //
  // Draw some text
  //
  GUI_DispStringHCenterAt("ABC", 160, 80);
  while (1) {
    GUI_Delay(100);
  }
}
```

emWinSPY - Runtime information of target system

Shows runtime information of a target system on the PC:

- Current state of **memory usage** including the peak.
- History of **fixed** and **dynamic** memory usage.
- Current **state of the window manager** with information about each window like handle, position, size, visibility, transparency, memory device flag and enabled state.
- Input of **PID** and **MultiTouch** events including timestamp, position, layer and type (UP, DOWN and MOVE in case of MultiTouch).
- **Keyboard input** including key code, timestamp and type (UP and DOWN).
- **Screenshots** could be taken directly from the target.
- Could be used in simulation by GUI_SPY_X_StartServer().
- Comunicates via **TCP/IP** or **RTT** (Real Time Transfer).
- Configuration example shows how to start the SPY-server on the target hardware using TCP/IP or RTT.
- Detailed **information about RTT on www.segger.com**.



Status

GUI-Version:	5.24c
Total bytes:	2621440
Free bytes:	1200152
Dynamic bytes:	1410968
Used bytes:	2611132
Fixed bytes:	10308
Peak:	1818524
Max layers:	4
Used layers:	1
Max tasks:	4

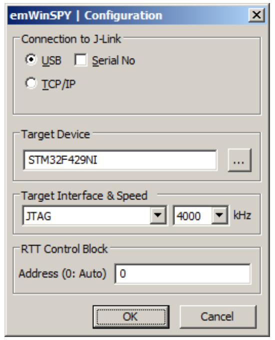
Windows

Window	Handle	x0	y0	Width	Height	Visbl.	Trans	MDev	Enbl.
(Desktop)	2	0	0	16383	16383	■	-	■	■
FRAMEWIN	5	240	179	80	61	■	-	-	■
FRAME...CLIENT	6	245	192	70	44	■	-	■	■
BUTTON	4	247	216	32	20	■	■	■	■
BUTTON	10	281	216	32	20	■	■	■	■
PROGBAR	12	247	203	66	12	-	-	■	■
TEXT	14	247	194	69	7	■	■	■	■
FRAMEWIN	16	160	0	160	65	-	-	-	■
FRAME...CLIENT	17	165	13	150	48	■	-	■	■

Input

Type	Time	Content
PID	77170	x:280, y:128, Layer:0, DOWN
PID	77470	x:280, y:128, Layer:0, UP
PID	77670	x:280, y:128, Layer:0, DOWN
PID	78170	x:225, y:158, Layer:0, DOWN
PID	78470	x:225, y:158, Layer:0, UP
PID	78670	x:225, y:158, Layer:0, DOWN
PID	79170	x:280, y:163, Layer:0, DOWN
PID	79470	x:280, y:163, Layer:0, UP
PID	79670	x:280, y:163, Layer:0, DOWN
PID	80170	x:225, y:163, Layer:0, DOWN
PID	80470	x:225, y:163, Layer:0, UP
PID	80670	x:225, y:163, Layer:0, DOWN

Connected

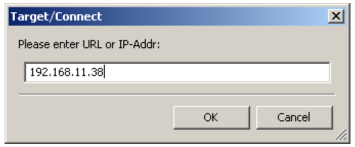


Connection to J-Link
(● USB) ☐ Serial No
○ TCP/IP

Target Device: STM32F429NI

Target Interface & Speed: JTAG 4000 kHz

RTT Control Block
Address (0: Auto) 0



Please enter URL or IP-Addr: 192.168.11.38

emVNC - emWin VNC client

Could be used to establish an **RFB** (**R**emote **F**rame **B**uffer) connection between a MS windows system and a VNC server.

It is part of the basic package of emWin. The server is optional.

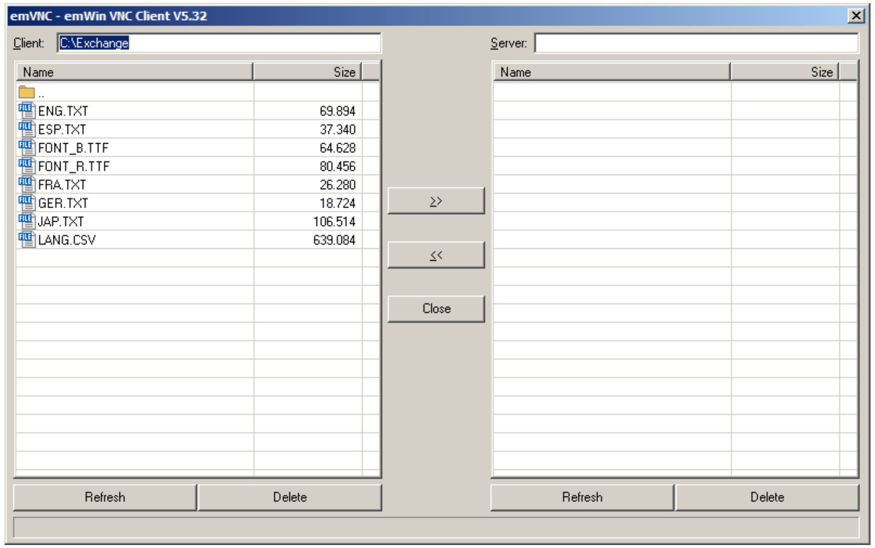
File Transfer

If file transfer (FT) between the emWin target and the VNC viewer is required, only emVNC could be used as client. FT operations are not part of the RFB standard.

Opening FT window of viewer

To spare a constantly visible menu we added that option to the system menu which is accessible with <ALT>+<SPACE> or by clicking the application logo of the title bar.

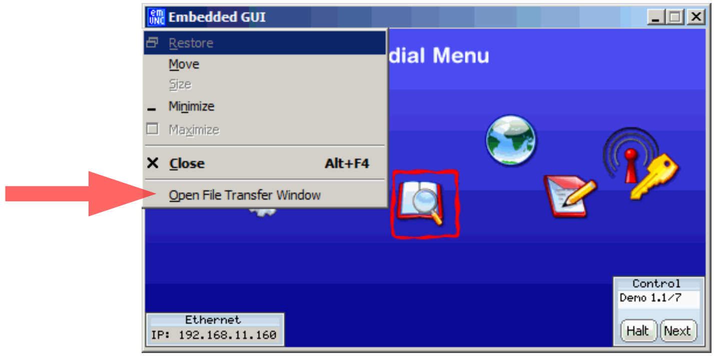
Note: 'Open File Transfer Window' is shown only if the connected target has file transfer options enabled.


emVNC - emWin VNC Client V5.32

Client: C:\Exchange

Server:

Name	Size
..	
ENG.TXT	69.894
ESP.TXT	37.340
FONT_B.TTF	64.628
FONT_R.TTF	80.456
FRA.TXT	26.280
GER.TXT	18.724
JAP.TXT	106.514
LANG.CSV	639.084



Tools summary

You should now be able to answer the following questions:

- **What must be considered to achieve the best performance when drawing high color bitmaps on 16bpp layers?**
- **What exactly is a transparent bitmap?**
- **What is the most recommended bitmap format for smooth shapes and outlines?**
- **What is the recommended font format to be used for example for Chinese fonts with many characters and gaps?**
- **Which encoding is used to write Unicode text?**
- **Which VNC client needs to be used if file transfer is required?**
- **Which kind of communication is used for emWinSPY?**

Configuration

Compile time configuration (.h files):

- **GUIConf.h**

  Configuration of available features

- **LCDConf.h**

  Display driver configuration (obsolete)

Runtime configuration (.c files):

- **GUIConf.c**

  Configuration of dynamic memory

- **LCDConf.c**

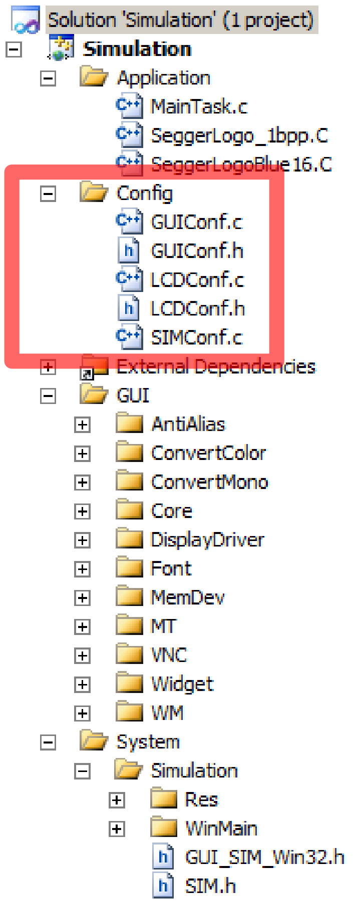
  Display driver configuration and initialization

- **SIMConf.c**

  Configuration of simulator

- **GUI_X.c / GUI_X_embOS.c**

  Not required in simulation



```
Solution 'Simulation' (1 project)
⊟ Simulation
  ⊟ Application
      MainTask.c
      SeggerLogo_1bpp.C
      SeggerLogoBlue16.C
  ⊟ Config
      GUIConf.c
      GUIConf.h
      LCDConf.c
      LCDConf.h
      SIMConf.c
  ⊞ External Dependencies
  ⊟ GUI
    ⊞ AntiAlias
    ⊞ ConvertColor
    ⊞ ConvertMono
    ⊞ Core
    ⊞ DisplayDriver
    ⊞ Font
    ⊞ MemDev
    ⊞ MT
    ⊞ VNC
    ⊞ Widget
    ⊞ WM
  ⊟ System
    ⊟ Simulation
      ⊞ Res
      ⊞ WinMain
        GUI_SIM_Win32.h
        SIM.h
```

Configuration - GUIConf.h

Compile time configuration of emWin:

- **GUI_NUM_LAYERS**
  Defines the maximum number of available layers
- **GUI_OS**
  Enables multitasking support
- **GUI_SUPPORT_TOUCH**
  Enables optional touch screen support
- **GUI_DEFAULT_FONT**
  Default font to be used, runtime configuration routine also available.
- **GUI_WINSUPPORT**
  Enables use of optional window manager
- **GUI_SUPPORT_MEMDEV**
  Enables use of optional memory devices

```
#ifndef GUICONF_H
#define GUICONF_H

/*********************************************************************
*
*       Multi layer/display support
*/
#define GUI_NUM_LAYERS            1    // Maximum number of available layers

/*********************************************************************
*
*       Multi tasking support
*/
#define GUI_OS                   (0)   // Compile with multitasking support

/*********************************************************************
*
*       Configuration of touch support
*/
#define GUI_SUPPORT_TOUCH        (0)   // Support a touch screen (req. win-manager)

/*********************************************************************
*
*       Default font
*/
#define GUI_DEFAULT_FONT          &GUI_Font6x8

/*********************************************************************
*
*         Configuration of available packages
*/
#define GUI_WINSUPPORT                1    /* Use window manager */
#define GUI_SUPPORT_MEMDEV            1    /* Memory device package available */

#endif  /* Avoid multiple inclusion */
```

Configuration - GUIConf.c

`GUI_X_Config()` is the very first routine called during the process of initialization. Main task here is assigning memory to the dynamic memory management system of emWin:

- **GUI_ALLOC_AssignMemory()**

  Passes a pointer to a memory block and its size in bytes to the memory manager.

Further initialization functions available to be used here:

- **GUI_SetDefaultFont()**

  Sets the default font to be used.

- **GUI_SetSignalEventFunc()**
  GUI_SetWaitEventFunc()
  GUI_SetWaitEventTimedFunc()

  Optional to be used to put the GUI task into sleep mode until PID- or keyboard input occurs. Default is calling GUI_X_ExecIdle() located in GUI_X.c

Note: Memory must be accessible 8- 16- and 32 bit wise. Memory access is checked during initialization (in debug mode).

```
/*********************************************************************
*
*       Defines
*
**********************************************************************
*/
//
// Define the available number of bytes available for the GUI
//
#define GUI_NUMBYTES  0x200000

/*********************************************************************
*
*       Public code
*
**********************************************************************
*/
/*********************************************************************
*
*       GUI_X_Config
*
* Purpose:
*   Called during the initialization process in order to set up the
*   available memory for the GUI.
*/
void GUI_X_Config(void) {
  //
  // 32 bit aligned memory area
  //
  static U32 aMemory[GUI_NUMBYTES / 4];
  //
  // Assign memory to emWin
  //
  GUI_ALLOC_AssignMemory(aMemory, GUI_NUMBYTES);
  //
  // Set default font
  //
  GUI_SetDefaultFont(GUI_FONT_6X8);
}
```

Configuration - LCDConf.c

`LCD_X_Config()`, display driver configuration:

Called immediately after `GUI_X_Config()` has been executed. Main task here is creating and configuring a display driver for each layer:

- **GUI_DEVICE_CreateAndLink()**

  Creates the driver device and links it into the device chain

- **LCD_SetSizeEx() / LCD_SetVSizeEx()**

  Display size configuration

- **LCD_SetVRAMAddrEx()**

  Required in case of linear addressable memory

`LCD_X_DisplayDriver()`, driver callback routine:

- Called by the driver for several tasks, important when using advanced features like multiple buffers, smooth scrolling or virtual pages. Must return 0 after successful initialization.

Note: LCD_X_DisplayDriver() Must return 0 after successful initialization.

LCD_X_Config:

```
void LCD_X_Config(void) {
  //
  // Set display driver and color conversion for 1st layer
  //
  GUI_DEVICE_CreateAndLink(DISPLAY_DRIVER, COLOR_CONVERSION, 0, 0);
  //
  // Display driver configuration, required for Lin-driver
  //
  if (LCD_GetSwapXY()) {
    LCD_SetSizeEx (0, YSIZE_PHYS, XSIZE_PHYS);
    LCD_SetVSizeEx(0, YSIZE_PHYS * NUM_VSCREENS, XSIZE_PHYS);
  } else {
    LCD_SetSizeEx (0, XSIZE_PHYS, YSIZE_PHYS);
    LCD_SetVSizeEx(0, XSIZE_PHYS, YSIZE_PHYS * NUM_VSCREENS);
  }
  LCD_SetVRAMAddrEx(0, (void *)VRAM_ADDR);
}
```

LCD_X_DisplayDriver:

```
int LCD_X_DisplayDriver(unsigned LayerIndex, unsigned Cmd, void * pData) {
  int r;

  switch (Cmd) {
  case LCD_X_INITCONTROLLER: {
    //
    // Called during the initialization process in order to set up the
    // display controller and put it into operation. If the display
    // controller is not initialized by any external routine this needs
    // to be adapted by the customer...
    //
    // …
    _InitLCDController();
    return 0;
  }
  . . .
  default:
    r = -1;
  }
  return r;
}
```

Configuration - Single task / Multiple tasks

One of the files **GUI_X.c** or **GUI_X_embOS.c** is required to be included into the target system.

- **GUI_X.c – Single task execution**

  Should be used in a single task environment. 'Single task' means that the project uses emWin only from within one single task.
  Main Purpose is to supply emWin with a timing base.

- **GUI_X_embOS.c – Multi task execution**

  If emWin is used by multiple tasks this file contains additional routines required for synchronizing multiple tasks.

Note 1:	If timing routines are used OS_TimeMS needs to be incremented each ms.
Note 2:	Multitasking systems need additional task synchronization routines as available in GUI_X_embOS.c.

GUI_X.c:

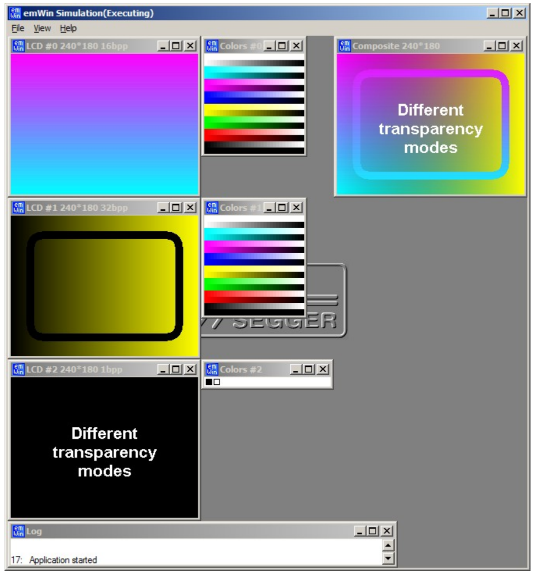
```
#include "GUI.h"

volatile int OS_TimeMS;

int GUI_X_GetTime(void) {
  return OS_TimeMS;
}

void GUI_X_Delay(int ms) {
  int tEnd = OS_TimeMS + ms;
  while ((tEnd - OS_TimeMS) > 0);
}
...
```

GUI_X_embOS.c:

```
int GUI_X_GetTime(void) {
  return OS_GetTime();
}

void GUI_X_Delay(int Period) {
  OS_Delay(Period);
}

void GUI_X_ExecIdle(void) {
  OS_Delay(1);
}

void GUI_X_InitOS(void)    { OS_CreateRSema(&_RSema);    }
void GUI_X_Unlock(void)    { OS_Unuse(&_RSema); }
void GUI_X_Lock(void)      { OS_Use(&_RSema);  }
U32  GUI_X_GetTaskId(void) { return (U32)OS_GetTaskID(); }

void GUI_X_WaitEvent(void)    {
  _pGUITask = OS_GetpCurrentTask();
  OS_WaitEvent(1);
}

void GUI_X_SignalEvent(void)    {
  if (_pGUITask) {
    OS_SignalEvent(1, _pGUITask);
  }
}

void GUI_X_WaitEventTimed(int Period) {
  static OS_TIMER Timer;
  static int Initialized;

  if (Period > 0) {
    if (Initialized != 0) {
      OS_DeleteTimer(&Timer);
    }
    Initialized = 1;
    OS_CreateTimer(&Timer, GUI_X_SignalEvent, Period);
    OS_StartTimer(&Timer);
    GUI_X_WaitEvent();
  }
}
```

Configuration - Multiple layers and transparency

- Each layer needs to be configured separately
- Different layer sizes are supported
- Different transparency modes are available
- Each layer shown separately in simulator and viewer
- Composite view available in simulator and viewer
- Number of layers not limited



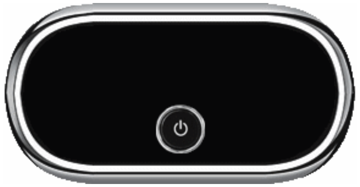
```
17:  Application started
```

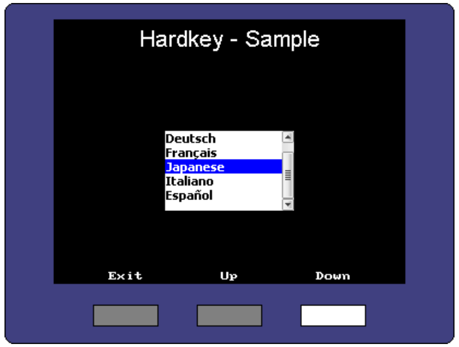
```
void LCD_X_Config(void) {
  int Layer;
  const GUI_DEVICE_API     * apDeviceAPI[] = {
    GUIDRV_LIN_24,       // Layer 0: 24bpp
    GUIDRV_LIN_8,        // Layer 1:  8bpp
    GUIDRV_LIN_1         // Layer 2:  1bpp
  };
  const LCD_API_COLOR_CONV * apColorConvAPI[] = {
    GUICC_888,           // Layer 0: 24bpp
    GUICC_8666,          // Layer 1:  8bpp
    GUICC_1              // Layer 2:  1bpp
  };
  void * apVRAM_Addr[] = {
     (void *)0x20000000, // Address of frame buffer layer 0
     (void *)0x2004B000, // Address of frame buffer layer 1
     (void *)0x2005DC00, // Address of frame buffer layer 2
  };

  for (Layer = 0; Layer < 3; Layer++) {
    GUI_DEVICE_CreateAndLink(apDeviceAPI[Layer], apColorConvAPI[Layer], 0, Layer);
    LCD_SetSizeEx (Layer, XSIZE_PHYS, YSIZE_PHYS);
    LCD_SetVSizeEx(Layer, XSIZE_PHYS, YSIZE_PHYS);
    LCD_SetVRAMAddrEx(Layer, apVRAM_Addr[Layer]);
  }
}


void SIM_X_Config() {
  int xSize, ySize;

  xSize = LCD_GetXSizeEx(0);
  ySize = LCD_GetYSizeEx(0);
  SIM_GUI_SetCompositeSize(xSize, ySize);
  SIM_GUI_SetTransMode(1, GUI_TRANSMODE_PIXELALPHA);
  SIM_GUI_SetTransMode(2, GUI_TRANSMODE_ZERO);
}


void MainTask(void) {
  int xSize, ySize;

  GUI_Init();
  xSize = LCD_GetXSize();
  ySize = LCD_GetYSize();
  GUI_SetLayerVisEx(0, 1);
  GUI_SetLayerVisEx(1, 1);
  GUI_SetLayerVisEx(2, 1);
  GUI_DrawGradientV(0, 0, xSize, ySize, GUI_MAGENTA, GUI_CYAN);
  GUI_SelectLayer(1);
  GUI_DrawGradientH(0, 0, xSize, ySize, 0xFF000000, 0x0000FFFF);
  GUI_SetColor(GUI_TRANSPARENT);
  GUI_DrawRoundedFrame(20, 20, xSize - 20, ySize - 20, 20, 10);
  GUI_SelectLayer(2);
  GUI_SetBkColorIndex(0);
  GUI_Clear();
  GUI_SetColor(GUI_WHITE);
  GUI_SetFont(GUI_FONT_24B_ASCII);
  GUI_DispStringHCenterAt("Different\ntransparency\nmodes", xSize / 2, ySize / 3);
  while (1) {
    GUI_Delay(100);
  }
}
```

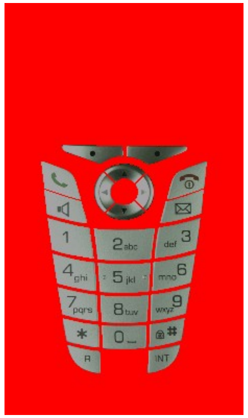
Configuration - Device simulation

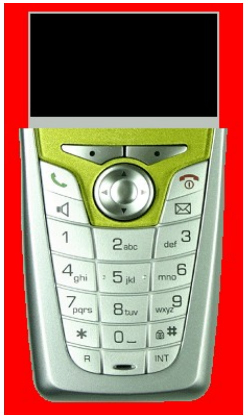
Multiple simulation modes available:

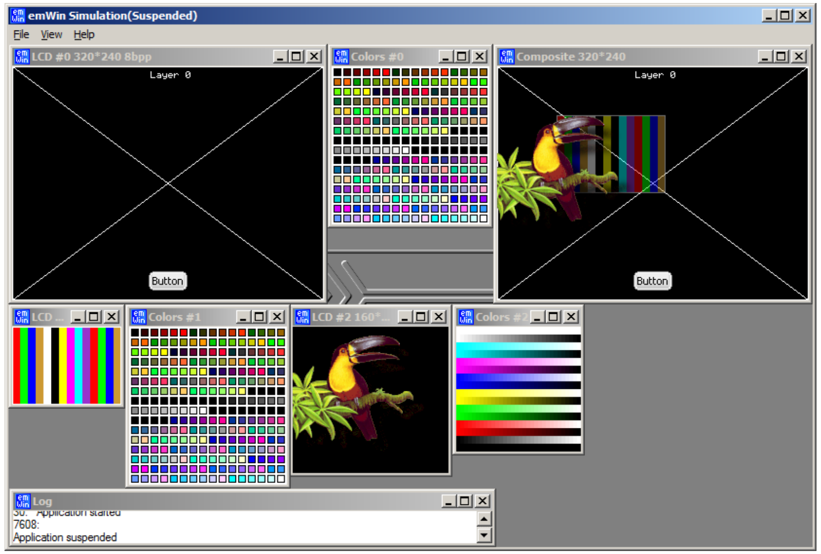
- **Generated frame view**
  Automatically generated frame surrounding the display with a small close button.
- **Custom bitmap view**
  Supports any number and any form of buttons.
- **Window view**
  Default view in multiple layer mode.
- **Magnification**
  Display can be magnified.











```
30:  Application started
7608:
Application suspended
```

```
SAMPLES:  Configuration\SIMConf_*.c
          Configuration\Device_*.bmp
```

Configuration - Multiple buffering

Several methods are available:

Double buffering:

- Hides the process of drawing operations
- Requires memory for a second frame buffer
- Does not avoid tearing effects

Tripple buffering:

- Requires memory for three frame buffers
- Requires an 'END_OF_FRAME' interrupt
- Avoids tearing effects

Usage:

- Early configuration
  `GUI_MULTIBUF_Config()`
- Automatic usage by window manager
  `WM_MULTIBUF_Enable()`
- Manual usage is also possible
  `GUI_MULTIBUF_Begin()`
  `GUI_MULTIBUF_End()`

```
/*********************************************************************
*
*       _LCD_CopyBuffer
*/
static void _LCD_CopyBuffer(int LayerIndex, int IndexSrc, int IndexDst) {
  U32 BufferSize, BaseAddr, AddrSrc, AddrDst;

  GUI_USE_PARA(LayerIndex);
  BufferSize = ((_XSIZE * _YSIZE * LCD_BITSPERPIXEL) >> 3);
  BaseAddr   = ((U32)&_aVRAM[0] + OFFSET_VRAM);
  AddrSrc    = BaseAddr + BufferSize * IndexSrc;
  AddrDst    = BaseAddr + BufferSize * IndexDst;
  GUI_MEMCPY((void *)AddrDst, (void *)AddrSrc, BufferSize);
}

/*********************************************************************
*
*       _ISR_EndOfFrame
*/
static void _ISR_EndOfFrame(void) {
  U32 Addr;

  if (_PendingBuffer >= 0) {
    Addr     = ((U32)&_aVRAM[0] + _XSIZE * _YSIZE * _PendingBuffer * (LCD_BITSPERPIXEL >> 3));
    SFR_ADDR = Addr;
    GUI_MULTIBUF_Confirm(_PendingBuffer);
    _PendingBuffer = -1;
  }
}

/*********************************************************************
*
*       LCD_X_DisplayDriver
*/
int LCD_X_DisplayDriver(unsigned LayerIndex, unsigned Cmd, void * p) {
  switch (Cmd) {
  ...
  case LCD_X_SHOWBUFFER: {
      LCD_X_SHOWBUFFER_INFO * pData;

      pData = (LCD_X_SHOWBUFFER_INFO *)p;
      _PendingBuffer = pData->Index;
    }
    break;
  ...
  }
  return 0;
}

/*********************************************************************
*
*       LCD_X_Config
*/
void LCD_X_Config(void) {
  GUI_MULTIBUF_Config(NUM_BUFFERS);
  GUI_DEVICE_CreateAndLink(DISPLAY_DRIVER, COLOR_CONVERSION, 0, 0);
  LCD_SetDevFunc(0, LCD_DEVFUNC_COPYBUFFER, (void (*)())_LCD_CopyBuffer);
  LCD_SetSizeEx (0, LCD_XSIZE,  LCD_YSIZE);
  LCD_SetVSizeEx(0, LCD_VXSIZE, LCD_VYSIZE);
  LCD_SetVRAMAddrEx(0, (void *)((U32)&_aVRAM[0]));
}
```

Configuration - Display orientation

Several capabilities for setting the display orientation are available. It depends on the used driver which kind of determining the display orientation should be used.

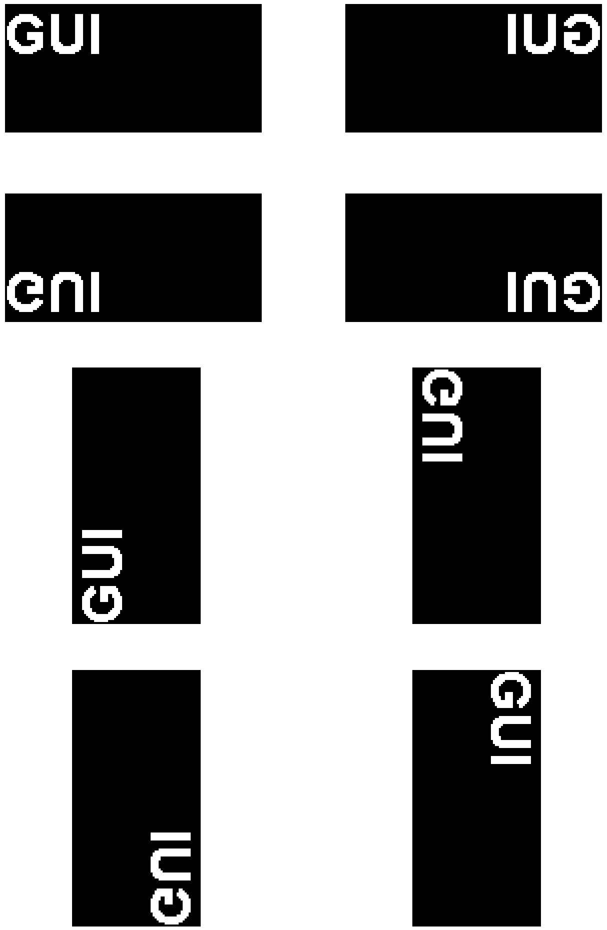
- **Display driver selection (recommended)**
  Some driver like GUDRV_Lin consists of different modules for certain display orientations. Selecting the right driver determines the display orientation.

- **Display driver configuration (recommended)**
  Some drivers like the `GUIDRV_FlexColor` contain configuration functions for setting the orientation.

- **Orientation device (less performance, more RAM load)**
  If the used driver does not support the required orientation an orientation device can simply be used by `GUI_SetOrientation()`.

- **Touch orientation**
  Can be determined by calling the function `GUI_TOUCH_SetOrientation()`.

- **Compile time configuration**
  Only some very rarely used drivers require configuration at compile time.



Configuration summary

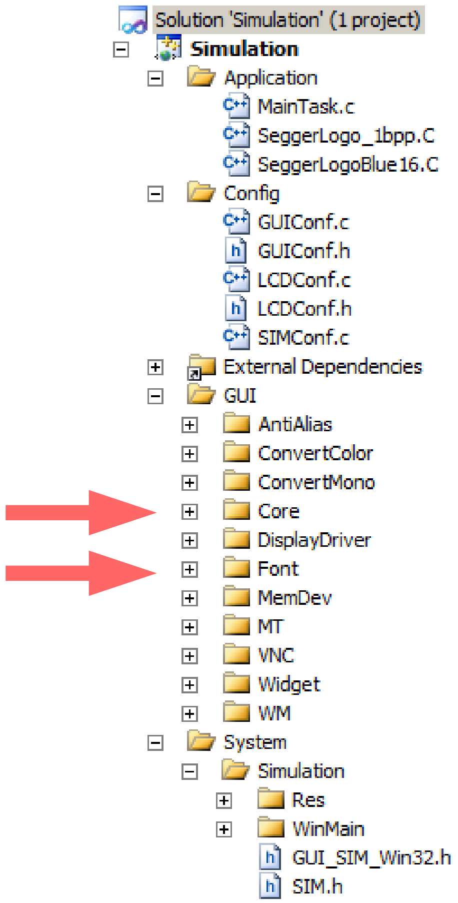
You should now be able to answer the following questions:

- **Which routine is called first during GUI_Init() and what needs to be done there?**
- **What is the purpose of GUIConf.h**
- **Which configuration routine is called for setting up the display drivers for the layers?**
- **What is the advantage of tripple buffering in comparison to double buffering?**
- **What is the most recommended way for setting up the display orientation?**

Core functions

The following features are covered by the base package:

- Image file support for BMP, GIF and JPEG
- Drawing of images and fonts from non addressable media
- LTR, RTL and bidirectional text support
- Software alpha blending
- Sprites and cursors, animated
- Drawing primitives
- Support for non antialiased font formats
- Drawing of text and values (dec, bin, hex, float)
- Multiple buffering
- Animations
- Drawing of QR codes
- Touch screen support
- Language support
- Standard font package (ASCII and ISO 8859-1)



```
Solution 'Simulation' (1 project)
⊟ Simulation
  ⊟ Application
      MainTask.c
      SeggerLogo_1bpp.C
      SeggerLogoBlue16.C
  ⊟ Config
      GUIConf.c
      GUIConf.h
      LCDConf.c
      LCDConf.h
      SIMConf.c
  ⊞ External Dependencies
  ⊟ GUI
    ⊞ AntiAlias
    ⊞ ConvertColor
    ⊞ ConvertMono
    ⊞ Core
    ⊞ DisplayDriver
    ⊞ Font
    ⊞ MemDev
    ⊞ MT
    ⊞ VNC
    ⊞ Widget
    ⊞ WM
  ⊟ System
    ⊟ Simulation
      ⊞ Res
      ⊞ WinMain
        GUI_SIM_Win32.h
        SIM.h
```

Core functions - Drawing image files

Multiple capabilities for drawing images:

- **BMP file support**

  No decompression required
- **GIF file support**

  Requires app. 16KByte RAM for decompression
- **JPEG file support**

  Requires app. 33KByte + xSize * 80 bytes
- **PNG file support** (free available on www.segger.com)

  Requires app. 21KByte + (xSize * ySize) * 4
- **DTA file support**

  Streamed bitmaps of bitmap converter
- **Drawing from non addressable areas**

  _GetData() functions are required

```
/**********************************************************************
*
*       _GetData0: BMP, JPEG, GIF
*/
static int _GetData0(void * p, const U8 ** ppData, unsigned NumBytesReq, U32 Off) {
  static char acBuffer[0x200];
  HANDLE    * phFile;
  DWORD       NumBytesRead;

  phFile = (HANDLE *)p;
  //
  // Check buffer size
  //
  if (NumBytesReq > sizeof(acBuffer)) {
    NumBytesReq = sizeof(acBuffer);
  }
  //
  // Set file pointer to the required position
  //
  SetFilePointer(*phFile, Off, 0, FILE_BEGIN);
  //
  // Read data into buffer
  //
  ReadFile(*phFile, acBuffer, NumBytesReq, &NumBytesRead, NULL);
  //
  // Set data pointer to the beginning of the buffer
  //
  *ppData = acBuffer;
  //
  // Return number of available bytes
  //
  return NumBytesRead;
}

/**********************************************************************
*
*       _GetData1: DTA, PNG
*/
static int _GetData1(void * p, const U8 ** ppData, unsigned NumBytesReq, U32 Off) {
  HANDLE * phFile;
  DWORD    NumBytesRead;
  U8     * pData;

  pData  = (U8 *)*ppData;
  phFile = (HANDLE *)p;
  //
  // Set file pointer to the required position
  //
  SetFilePointer(*phFile, Off, 0, FILE_BEGIN);
  //
  // Read data into buffer
  //
  ReadFile(*phFile, pData, NumBytesReq, &NumBytesRead, NULL);
  //
  // Return number of available bytes
  //
  return NumBytesRead;
}
```

```
SAMPLES:  ImageFiles\GetData_*.c
          ImageFiles\MainTask_DrawingImageFile.c
```

Core functions - Bidirectional text

Drawing Arabic or Hebrew text with emWin is quite easy and is supported automatically in each text based function. It only needs to be enabled once.

- UTF8 encoding needs to be enabled

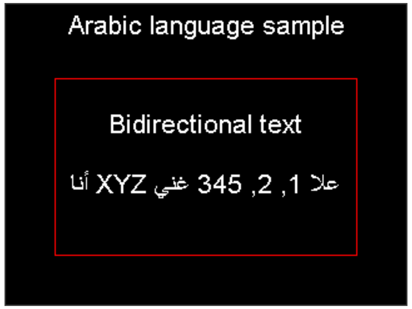
  Should be done by `GUI_UC_SetEncodeUTF8()`.
- Bidirectional text needs to be enabled

  Should be done by `GUI_UC_EnableBIDI()`.
- Font file needs to be available

  The FontConverter or TTF support is required because emWin does not contain Arabic or Hebrew fonts.
- Once enabled all text based functions support bidirectional text

Note: Bidirectional text support require app. 60 Kbyte additional ROM.

```
GUI_CONST_STORAGE GUI_FONT GUI_FontArabic24 = {…};

static char * _apText[] = {
  { "\nBidirectional text\n\n\xd8\xb9\xd9\x84\xd8\xa7 1, 2, 345 "
    "\xd8\xba\xd9\x86\xd9\x8a XYZ \xd8\xa3\xd9\x86\xd8\xa7"},
  { "\nBeautiful\n\n\xd8\xac\xd9\x80\xd9\x85\xd9\x8a\xd9\x84"},
  { "\nI'm from Lebanon.\n\n\xd8\xa3\xd9\x86\xd8\xa7 \xd9\x85"
    "\xd9\x86 \xd9\x84\xd8\xa8\xd9\x86\xd8\xa7\xd9\x86"},
  { "\nI'm from Canada.\n\n\xd8\xa3\xd9\x86\xd8\xa7 \xd9\x85"
    "\xd9\x86 \xd9\x83\xd9\x86\xd8\xaf\xd8\xa7"},
  { "\nIsn't it like that?\n\n\xd8\xa3\xd9\x84\xd9\x8a\xd8"
    "\xb3 \xd9\x83\xd8\xb0\xd8\xa7\xd9\x84\xd9\x83\xd8\x9f"},
  { "\nDo you work?\n\n\xd9\x87\xd9\x84 \xd8\xaa\xd8\xb9\xd9"
    "\x85\xd9\x84\xd8\x9f"},
  { "\nThe book is heavy.\n\n\xd8\xa7\xd9\x84\xd9\x83\xd8\xaa"
    "\xd8\xa7\xd8\xa8 \xd8\xab\xd9\x82\xd9\x8a\xd9\x84"},
};

static void _ShowArabicTextSamples(void) {
  GUI_RECT Rect = {40, 60, 279, 199};
  GUI_SetFont(&GUI_FontArabic24); /* Set Arabic font */
  while (1) {
    int i;
    GUI_SetColor(GUI_RED);
    GUI_DrawRect(Rect.x0 - 1, Rect.y0 - 1, Rect.x1 + 1, Rect.y1 + 1);
    GUI_SetColor(GUI_WHITE);
    for (i = 0; i < GUI_COUNTOF(_apText); i++) {
      GUI_DispStringInRectWrap(_apText[i], &Rect, GUI_TA_HCENTER, GUI_WRAPMODE_WORD);
      GUI_Delay(2000);
      GUI_ClearRectEx(&Rect);
    }
  }
}

void MainTask(void) {
  GUI_Init();
  GUI_UC_SetEncodeUTF8();          /* Enable UTF8 decoding */
  GUI_UC_EnableBIDI(1);            /* Enable bidirectional text */
  GUI_SetFont(&GUI_FontArabic24); /* Select font with required characters */
  GUI_DispStringHCenterAt("Arabic language sample", 160, 5);
  _ShowArabicTextSamples();
}
```



```
Arabic language sample

Bidirectional text

علا 1, 2, 345 غني XYZ أنا
```

Core functions - Alpha blending

Different capabilities of alpha blending:

- **Setting of alpha value**

  GUI_SetAlpha() can be used to set the alpha value for subsequent drawing operations.

- **Automatic alpha blending**

  GUI_EnableAlpha() can be used to enable automatic alpha blending. The upper 8 bits of the current color are then used for alpha blending. Should be disabled after use.

- **PNG file support**

  GUI_PNG_Draw() can be used to draw PNG files with alpha value.

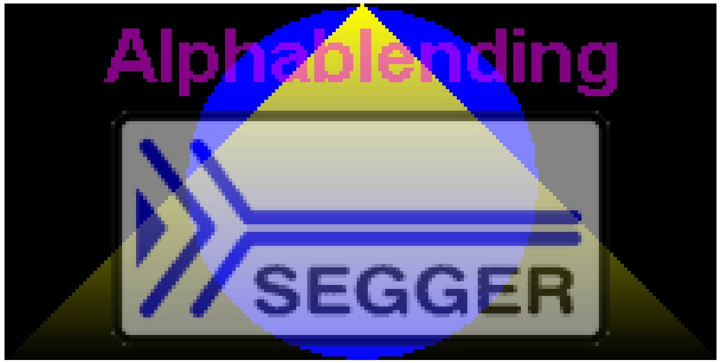
- **True color bitmaps with alpha channel**

  BitmapConverter supports conversion of PNG files to 32bpp bitmaps with alpha channel.

- **Compressed alpha channel bitmaps**

  Uses the alpha mask to draw the image in the current color.

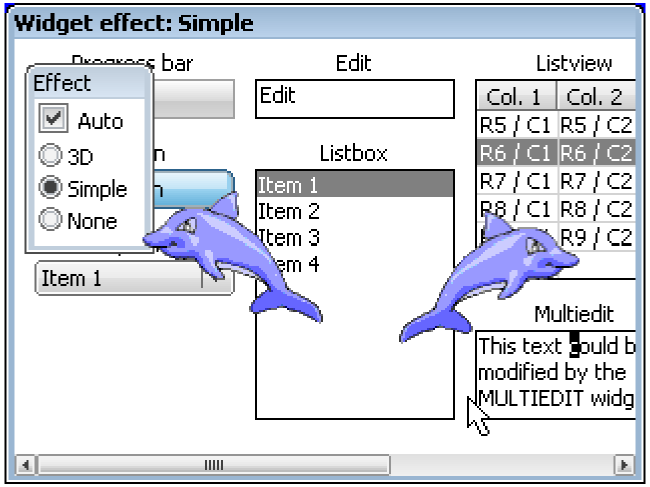
```
/*********************************************************************
*
*       MainTask
*/
void MainTask(void) {
  U32 Alpha;
  int i;

  GUI_Init();
  GUI_EnableAlpha(1);
  GUI_SetColor(GUI_BLUE);
  GUI_FillCircle(100, 50, 49);
  for (i = 0; i < 100; i++) {
    Alpha = (i * 255 / 100) << 24;
    GUI_SetColor(GUI_YELLOW | Alpha);
    GUI_DrawHLine(i, 100 - i, 100 + i);
  }
  GUI_SetAlpha(0x80);
  GUI_DrawBitmap(&_LogoBitmap, 30, 30);
  GUI_SetAlpha(0);
  GUI_SetColor(GUI_MAGENTA | 0x80000000);
  GUI_SetFont(&GUI_Font24B_ASCII);
  GUI_SetTextMode(GUI_TM_TRANS);
  GUI_DispStringHCenterAt("Alphablending", 100, 3);
  GUI_EnableAlpha(0);
  while (1) {
    GUI_Delay(100);
  }
}
```



Core functions - Sprites and cursors

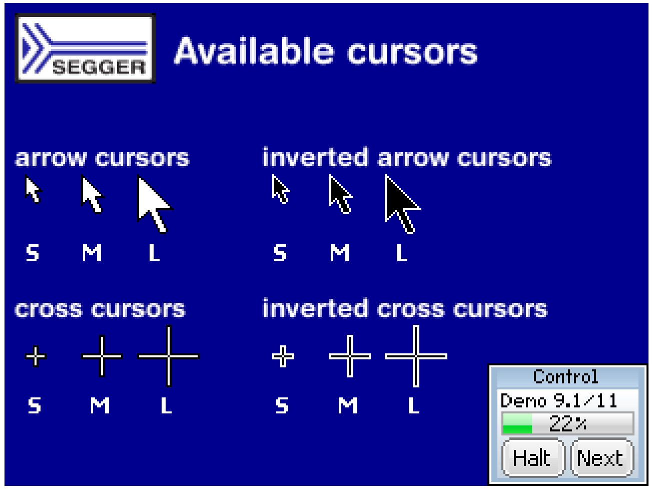
Software sprites

- Index based bitmaps and alpha bitmaps can be used
- Sprites manage the background automatically



Cursors

- Cursors are based on sprites
- Window manager automatically manages position



Core functions - Animated Sprites and Cursors

Cursors can be animated:

- **GUI_CURSOR_SetAnim()**

  Only one line of code required. The function gets a pointer to an array of bitmaps to be used, the position of the hot spot and the period to be used. Optional an array for the period values can be used.

Sprites can be animated:

- **GUI_SPRITE_CreateAnim()**

  Similar to animated cursors sprites can be animated by the above function. The function gets a pointer to an array of bitmaps to be used, the position of the sprite and the period to be used. Optional an array for the period values can be used.

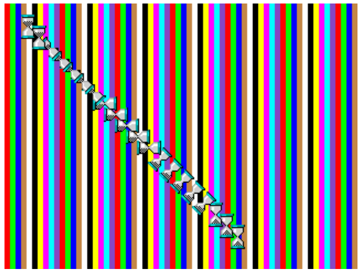
Note: All bitmaps must have the same size.

Animated Cursor

```
GUI_BITMAP const * _apbmHourGlassM[] = {
  ...
}

static void _DrawStripes(void) {
  ...
}

void MainTask(void) {
  GUI_Init();
  _DrawStripes();
  GUI_CURSOR_SetAnimEx(_apbmHourGlassM, 11, 11, 50, NULL, GUI_COUNTOF(_apbmHourGlassM), 0);
  GUI_CURSOR_SetPosition(100, 100);
  while (1) {
    GUI_Delay(100);
  }
}
```

Animated Sprites

```
GUI_BITMAP const * _apbmHourGlassM[] = {
  ...
}

static void _DrawStripes(void) {
  ...
}

void MainTask(void) {
  int i;
  GUI_HSPRITE ahSprite[20];

  GUI_Init();
  _DrawStripes();
  for (i = 0; i < GUI_COUNTOF(ahSprite); i++) {
    ahSprite[i] = GUI_SPRITE_CreateAnim(_apBM, 10 + i * 10, 10 + i * 10, 50, NULL, GUI_COUNTOF(_apBM));
    GUI_Delay(5);
  }
  while (1) {
    GUI_Delay(100);
  }
}
```



Core functions - Drawing QR-codes

Basic routines for QR (Quick Response) codes are available.

Steps to show a QR code:

- **Create** QR code bitmap
- **Draw** QR code bitmap
- **Delete** QR code bitmap (if no longer used)

Terms:

- **Error correction**
  QR codes contain Reed-Solomon code blocks for error correction. The higher the level, the better the correction.
- **Module**
  One 'pixel' is called a Module.
- **Version**
  QR code capacity depends on version (1-40).
  Version could be calculated automatically.

Note: emWin supports QR codes in byte encoding.

```c
#include "GUI.h"

#define PIXEL_SIZE 4

static const char sText[] = "www.segger.com";

void MainTask(void) {
  GUI_HMEM hQR;

  GUI_Init();
  hQR = GUI_QR_Create(sText, PIXEL_SIZE, GUI_QR_ECLEVEL_H, 0);
  GUI_QR_Draw(hQR, 50, 50);
  GUI_QR_Delete(hQR);
  while (1) {
    GUI_Delay(100);
  }
}
```

```
Size of bitmap:    100
Number of modules: 25
Version:           2
```

Core functions - Text and language resource files

Text could be 'outsourced' from code to text files. Language support API could be used to access these files.

- Use of **different languages.**
- Files could reside in **RAM or any non addressable medium** like a file system accessed by a **GetData()** function.
- TXT and CSV files are supported.

If system is **low on RAM**:

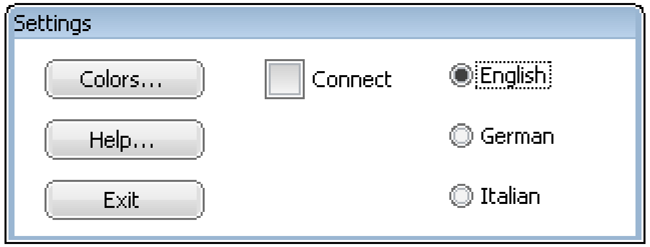
- **GUI_LANG_GetTextBuffered..()** copies the text into the given buffer.

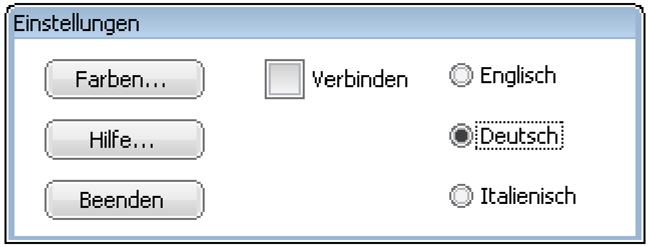
  Advantage: RAM usage is constant.
  Disadvantage: Buffer managment overhead.

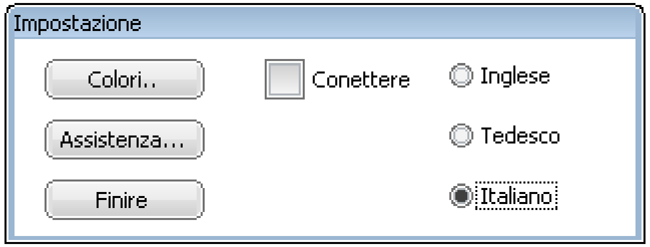
If system has **enough RAM** for the used text:

- **GUI_LANG_GetText..()** returns a pointer to the requested string which remains in RAM.

  Advantage: Text pointers remain valid
  Disadvantage: Text usage increases RAM usage.







Core functions - Text and language resource file format

Different formats are supported:

- **TXT file support**
  One language per file. Multiple TXT files can be used simultaneously.
- **CSV file support**
  Multiple languages in one file. Only one CSV file can be used simultaneously.

TXT file format

```
日本語
emWin
は様々な
言語に
対応しています
```

CSV file format

```
"Deutsch","English"
"emWin","emWin"
"unterstÃ¼tzt","supports"
"verschiedene","different"
"Sprachen","languages"
```

```c
#include "GUI.h"

#define GERMAN  0
#define ENGLISH 1

static int _GetData(void * pVoid, const U8 ** ppData, unsigned NumBytes, U32 Off) {
  ...
}

static char * _pFileName = "GUI_LANG_CSV_Ger_Eng.csv";

void MainTask(void) {
  int NumLanguages, i, Language, NumItems;
  const char * pString;

  GUI_Init();
  //
  // Enable UTF8 encoding (if required)
  //
  GUI_UC_SetEncodeUTF8();
  //
  // Read CSV file
  //
  NumLanguages = GUI_LANG_LoadCSVEx(_GetData, _pFileName);
  //
  // Set language
  //
  Language = GERMAN;
  GUI_LANG_SetLang(Language);
  GUI_LANG_GetNumItems(Language);
  NumItems = GUI_LANG_GetNumItems(GERMAN);
  //
  // Draw all
  //
  for (i = 0; i < NumItems; i++) {
    pString = GUI_LANG_GetText(i);
    GUI_DispString(pString);
    GUI_DispNextLine();
  }
}
```

Core functions - Animations

emWin animations support multiple independend animated items.

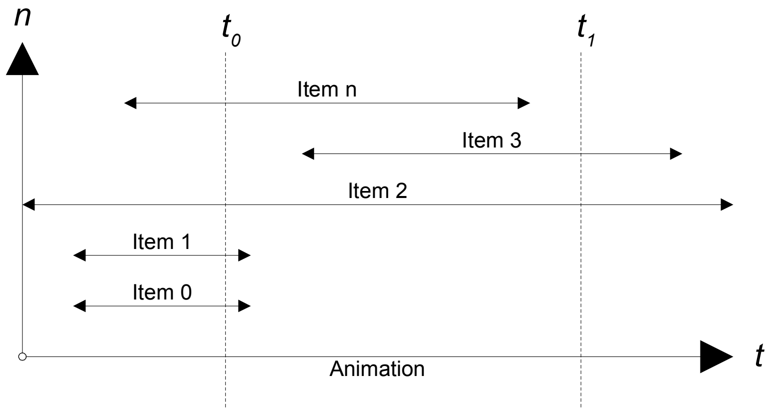
- Multiple items on the timeline
- Each item has its own period

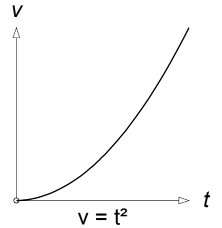
Within the period of an item emWin calculates a position value.

- Predefined position calculations available
- Custom position calculation possible

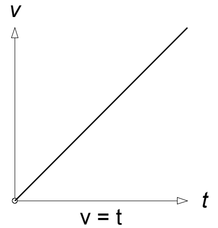
Using animations:

- **Create** animation **object** with GUI_ANIM_Create()
- **Add items** with GUI_ANIM_AddItem()
- **Start animation** with GUI_ANIM_Start()
- **Call GUI_ANIM_Exec()** periodically and check **return code**
- If return code is 1 the animation is at the end. Now it could be restarted with GUI_ANIM_Start() or deleted with GUI_ANIM_Delete()

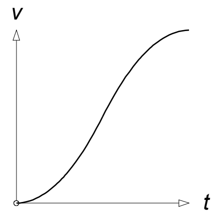




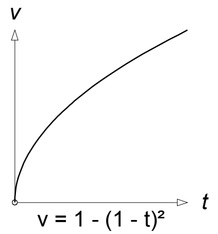
ANIM_ACCEL



ANIM_LINEAR



ANIM_ACCELDECEL



ANIM_DECEL

Core functions summary

You should now be able to answer the following questions:

- **Which character sets are included in the standard fonts shipped with emWin?**
- **What needs to be done to support BiDi text automatically in the application?**
- **What means 'Automatic alpha blending'?**
- **What is the difference between GUI_LANG_GetText() and GUI_LANG_GetTextBuffered()?**
- **What should be considered when using GUI_EnableAlpha()?**

Memory devices

How do they work?

Drawing operations can be passed to a memory device instead to the display. A memory device is a hardware independent destination device for drawing operations.

What can they be used for?

- Preventing flickering
- Container for decompressed images
- Scaling and rotating
- Fading operations
- Window animations
- Transparency effects

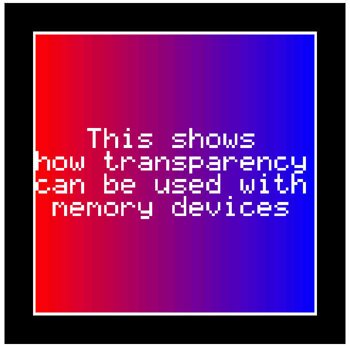
What means 'transparency' here?

Memory devices with transparency 'know' the pixels which have been accessed. One additional bit is required per pixel for storing this information. Supported by 1, 8 and 16bpp memory devices.

Do memory devices support alpha blending?

Yes, 32bpp memory devices support alpha blending, but not 'transparency'.

```
#include "GUI.h"

void MainTask(void) {
  GUI_MEMDEV_Handle hMem;
  GUI_RECT Rect = { 10, 10, 109, 109 };

  GUI_Init();
  hMem = GUI_MEMDEV_Create(Rect.x0, Rect.y0, Rect.x1 - Rect.x0 + 1, Rect.y1 - Rect.y0 + 1);
  GUI_DrawGradientH(Rect.x0, Rect.y0, Rect.x1, Rect.y1, GUI_RED, GUI_BLUE);
  GUI_MEMDEV_Select(hMem);
  GUI_DrawRectEx(&Rect);
  GUI_SetTextMode(GUI_TM_TRANS);
  GUI_DispStringInRect("This shows\n"
                       "how transparency\n"
                       "can be used with\n"
                       "memory devices"
                       , &Rect
                       , GUI_TA_HCENTER | GUI_TA_VCENTER);
  GUI_MEMDEV_Select(0);
  GUI_MEMDEV_Write(hMem);
  while (1) {
    GUI_Delay(100);
  }
}
```

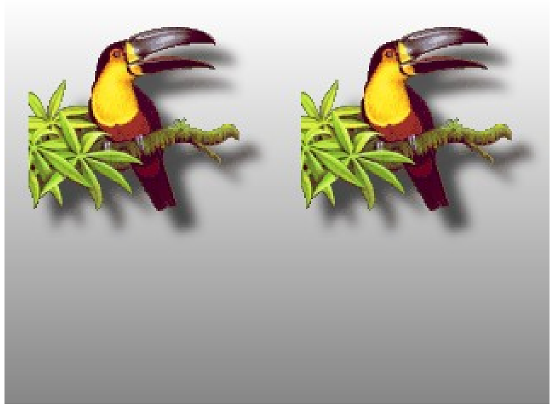


```
This shows
how transparency
can be used with
memory devices
```

Memory devices - Using as image container

If drawing of the same image **is required multiple times** and if enough memory is available, using memory devices as image container offers the following advantages:

- Decompression only required one time
- Alpha blending support (32bpp memory devices)
- Fast drawing operations



```
#include <windows.h> // Required only for file handling

#include "GUI.h"

/*********************************************************************
*
*       _GetData1: DTA, PNG
*/
static int _GetData1(void * p, const U8 ** ppData, unsigned NumBytesReq, U32 Off) {
  HANDLE * phFile;
  DWORD    NumBytesRead;
  U8     * pData;

  pData  = (U8 *)*ppData;
  phFile = (HANDLE *)p;
  //
  // Set file pointer to the required position
  //
  SetFilePointer(*phFile, Off, 0, FILE_BEGIN);
  //
  // Read data into buffer
  //
  ReadFile(*phFile, pData, NumBytesReq, &NumBytesRead, NULL);
  //
  // Return number of available bytes
  //
  return NumBytesRead;
}


/*********************************************************************
*
*       MainTask
*/
void MainTask(void) {
  GUI_MEMDEV_Handle hMem;
  HANDLE hFile;

  GUI_Init();
  GUI_DrawGradientV(0, 0, 319, 239, GUI_BLUE, 0);
  hMem = GUI_MEMDEV_CreateFixed(0, 0, 162, 150,
                                GUI_MEMDEV_NOTRANS, GUI_MEMDEV_APILIST_32, GUICC_8888);
  hFile = CreateFile("IMAGE.png", GENERIC_READ, 0, NULL, OPEN_EXISTING, FILE_ATTRIBUTE_NORMAL, NULL);
  GUI_MEMDEV_Select(hMem);
  GUI_SetBkColor(GUI_TRANSPARENT);
  GUI_Clear();
  GUI_PNG_DrawEx(_GetData1, (void *)&hFile, 0, 0);
  GUI_MEMDEV_Select(0);
  CloseHandle(hFile);
  GUI_MEMDEV_WriteAt(hMem, 0, 0);
  GUI_MEMDEV_WriteAt(hMem, 160, 0);
  while (1) {
    GUI_Delay(100);
  }
}
```

SAMPLE: MemoryDevices\MainTask_MemDevImageContainerPNG.c

Memory devices - Scaling and rotating images

A set of functions optimized for several purposes are available:

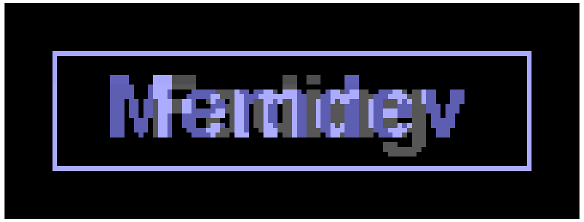
- **GUI_MEMDEV_Rotate()**
  Fast routine using 'nearest neighbour' method
- **GUI_MEMDEV_RotateAlpha()**
  Fast routine using with additional alpha value
- **GUI_MEMDEV_RotateHQ()**
  Uses high quality method (bilinear)
- **GUI_MEMDEV_RotateHQAlpha()**
  Uses high quality method with additional alpha value
- **GUI_MEMDEV_RotateHQHR()**
  Uses high quality method and high resolution
- **GUI_MEMDEV_RotateHQT()**
  Uses high quality method optimized for images with a large amount of transparent pixels

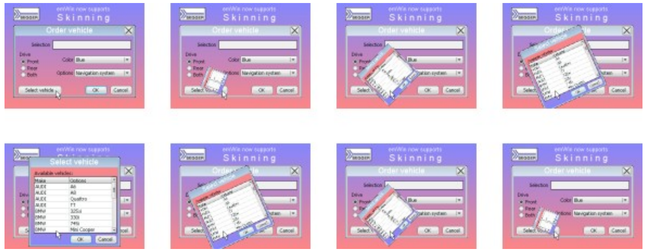
```c
#include <windows.h>

#include "GUI.h"

#define TIME_MIN 20

static int _GetData1(void * p, const U8 ** ppData, unsigned NumBytesReq, U32 Off) {
  HANDLE * phFile;
  DWORD    NumBytesRead;
  U8     * pData;

  pData  = (U8 *)*ppData;
  phFile = (HANDLE *)p;
  SetFilePointer(*phFile, Off, 0, FILE_BEGIN);
  ReadFile(*phFile, pData, NumBytesReq, &NumBytesRead, NULL);
  return NumBytesRead;
}

void MainTask(void) {
  GUI_MEMDEV_Handle hMemImage, hMemWork, hMemBk;
  HANDLE hFile;
  I32 a1000, Add, TimeStart, Time0, TimeUsed;

  GUI_Init();
  GUI_DrawGradientV(0, 0, 319, 239, GUI_WHITE, GUI_GRAY);
  hMemImage = GUI_MEMDEV_CreateFixed(10, 10, 50, 50,
                                     GUI_MEMDEV_NOTRANS, GUI_MEMDEV_APILIST_32, GUICC_8888);
  hMemWork  = GUI_MEMDEV_CreateFixed(10, 10, 50, 50,
                                     GUI_MEMDEV_NOTRANS, GUI_MEMDEV_APILIST_32, GUICC_8888);
  hMemBk    = GUI_MEMDEV_CreateFixed(10, 10, 50, 50,
                                     GUI_MEMDEV_NOTRANS, GUI_MEMDEV_APILIST_32, GUICC_8888);
  hFile = CreateFile("IMAGE.png", GENERIC_READ, 0, NULL, OPEN_EXISTING, FILE_ATTRIBUTE_NORMAL, NULL);
  GUI_MEMDEV_Select(hMemImage);
  GUI_SetBkColor(GUI_TRANSPARENT);
  GUI_Clear();
  GUI_PNG_DrawEx(_GetData1, (void *)&hFile, 10, 10);
  GUI_MEMDEV_Select(0);
  CloseHandle(hFile);
  GUI_MEMDEV_CopyFromLCD(hMemBk);
  a1000 = Add = 0;
  TimeStart = GUI_GetTime();
  while (1) {
    Time0 = GUI_GetTime();
    GUI_MEMDEV_Select(hMemWork);
    GUI_MEMDEV_Write(hMemBk);
    GUI_MEMDEV_RotateHQ(hMemImage, hMemWork, 0, 0, -a1000, 1000); // High quality
    a1000 = (GUI_GetTime() - TimeStart) * 90 - Add;
    if (a1000 > 360000) {
      Add   += 360000;
      a1000 -= 360000;
    }
    GUI_MEMDEV_CopyToLCD(hMemWork);
    TimeUsed = GUI_GetTime() - Time0;
    if (TIME_MIN > TimeUsed) {
      GUI_X_Delay(TIME_MIN - TimeUsed);
    }
  }
}
```

Memory devices - Fading and animation functions

Animations can be used to inject some life into the application.
They will always help to let the users eye smoothly capture what happens in the application.

- Automatic fading function available
- Animation functions require window manager





```
#include "GUI.h"

void MainTask(void) {
  GUI_MEMDEV_Handle hMem0, hMem1;
  GUI_RECT Rect = { 10, 10, 109, 34 };

  GUI_Init();
  hMem0 = GUI_MEMDEV_CreateFixed(Rect.x0, Rect.y0,
                                 Rect.x1 - Rect.x0 + 1, Rect.y1 - Rect.y0 + 1,
                                 GUI_MEMDEV_NOTRANS, GUI_MEMDEV_APILIST_32, GUICC_8888);
  hMem1 = GUI_MEMDEV_CreateFixed(Rect.x0, Rect.y0,
                                 Rect.x1 - Rect.x0 + 1, Rect.y1 - Rect.y0 + 1,
                                 GUI_MEMDEV_NOTRANS, GUI_MEMDEV_APILIST_32, GUICC_8888);
  GUI_SetFont(GUI_FONT_20B_ASCII);
  GUI_MEMDEV_Select(hMem0);
  GUI_SetColor(GUI_LIGHTBLUE);
  GUI_DrawRectEx(&Rect);
  GUI_DispStringInRect("Memdev", &Rect, GUI_TA_HCENTER | GUI_TA_VCENTER);
  GUI_MEMDEV_Select(hMem1);
  GUI_SetColor(GUI_WHITE);
  GUI_DrawRectEx(&Rect);
  GUI_DispStringInRect("Fading", &Rect, GUI_TA_HCENTER | GUI_TA_VCENTER);
  while (1) {
    GUI_MEMDEV_FadeDevices(hMem0, hMem1, 500);
    GUI_MEMDEV_FadeDevices(hMem1, hMem0, 500);
  }
}

#include <stddef.h>

#include "DIALOG.h"

void _cbBk(WM_MESSAGE * pMsg) {
  switch (pMsg->MsgId) {
  case WM_PAINT:
    GUI_DrawGradientV(0, 0, 319, 239, GUI_BLUE, GUI_MAGENTA);
  }
}

void MainTask(void) {
  WM_HWIN hWin;

  GUI_Init();
  WM_SetCallback(WM_HBKWIN, _cbBk);
  WM_Exec();
  FRAMEWIN_SetDefaultSkin(FRAMEWIN_SKIN_FLEX);
  FRAMEWIN_SetDefaultFont(GUI_FONT_20B_ASCII);
  FRAMEWIN_SetDefaultTextColor(FRAMEWIN_CI_ACTIVE,   GUI_DARKGRAY);
  FRAMEWIN_SetDefaultTextColor(FRAMEWIN_CI_INACTIVE, GUI_DARKGRAY);
  FRAMEWIN_SetDefaultTextAlign(GUI_TA_HCENTER);
  hWin = FRAMEWIN_CreateEx(60, 60, 200, 120, WM_HBKWIN, WM_CF_SHOW, 0, 0, "FRAMEWIN", NULL);
  while (1) {
    GUI_MEMDEV_FadeInWindow  (hWin, 400);
    GUI_Delay(400);
    GUI_MEMDEV_FadeOutWindow (hWin, 400);
    GUI_MEMDEV_MoveInWindow  (hWin,   0, 240,  45, 400);
    GUI_Delay(400);
    GUI_MEMDEV_MoveOutWindow (hWin, 320, 240, -45, 400);
    GUI_MEMDEV_ShiftInWindow (hWin, 400, GUI_MEMDEV_EDGE_TOP);
    GUI_Delay(400);
    GUI_MEMDEV_ShiftOutWindow(hWin, 400, GUI_MEMDEV_EDGE_BOTTOM);
  }
}
```

```
SAMPLES:  MemoryDevices\MainTask_MemDevFading.c
          MemoryDevices\MainTask_NestedModal.c
```

Memory devices summary

You should now be able to answer the following questions:

- **What is the difference between 'transparency' and alpha blending in the context of memory devices?**
- **What could be done to avoid multiple decompression when showing PNGs or JPEGs?**

Antialiasing

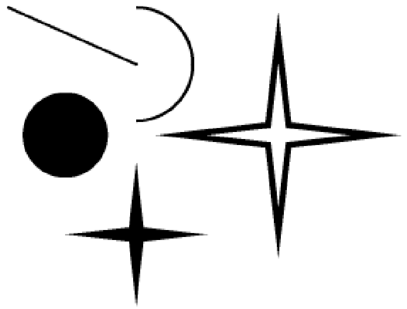
Antialiasing smoothes curves and diagonal lines by "blending" the background color with that of the foreground.

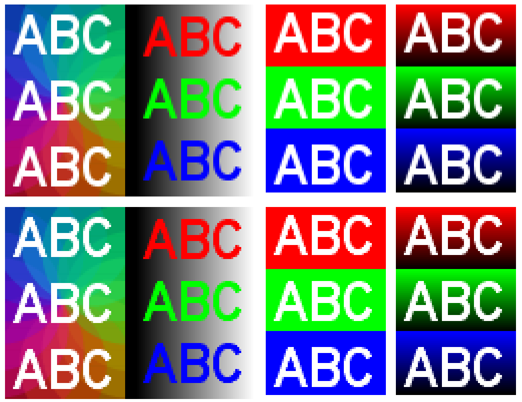
emWin supports antialiased drawing of

- **Text**
  Font converter is required for creating AA fonts.
- **Arcs**
  `GUI_AA_DrawArc()`
- **Circles**
  `GUI_AA_FillCircle()`
- **Lines**
  `GUI_AA_DrawLine()`
- **Polygons**
  `GUI_AA_DrawPolyOutline()`
  `GUI_AA_FillPolygon()`

Note: Performance of antialiased drawing operations degrades significantly in comparison to non antialiased drawing operations.

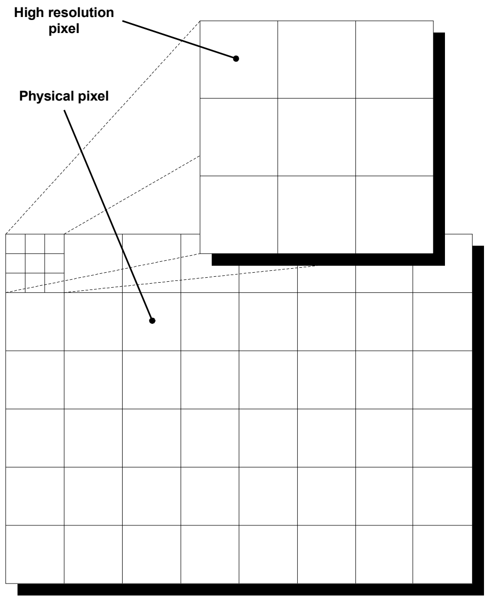
```
#include "GUI.h"

static GUI_POINT _aPoint[] = {
  {  -5,  -5 }, {   0, -50 }, {   5,  -5 }, {  50,   0 },
  {   5,   5 }, {   0,  50 }, {  -5,   5 }, { -50,   0 },
};

void MainTask(void) {
  GUI_Init();
  GUI_SetBkColor(GUI_WHITE);
  GUI_SetColor(GUI_BLACK);
  GUI_Clear();
  GUI_SetPenSize(2);
  GUI_AA_DrawLine(10, 10, 100, 50);
  GUI_AA_DrawArc(100, 50, 40, 40, 270, 450);
  GUI_AA_FillCircle(50, 100, 30);
  GUI_AA_DrawPolyOutline(_aPoint, GUI_COUNTOF(_aPoint), 4, 200, 100);
  GUI_AA_FillPolygon(_aPoint, GUI_COUNTOF(_aPoint), 100, 170);
  while (1) {
    GUI_Delay(100);
  }
}
```





Antialiasing - High resolution antialiasing

High resolution antialiasing of emWin uses the virtual space determined by the antialiasing factor and the display size. The advantage is that items can be placed not only at physical positions of your display but also "between" them.



Note: The higher the factor the better the quality. Factor should be between 2 and 8.

```
#include "GUI.h"

#define TIME_MIN         20
#define TIME_PER_TURN 40000
#define DURATION           (TIME_PER_TURN / 16)

typedef struct {
  void (* pFunc)(const GUI_POINT * pPoints, int NumPoints, int x0, int y0);
  int Factor;
} PARA;

static GUI_POINT _aPoint[] = { ... };

static void _MagnifyPoints(const GUI_POINT * pPointSrc, GUI_POINT * pPointDest, int NumPoints, int Factor) {
  int i;
  for (i = 0; i < NumPoints; i++) {
    (pPointDest + i)->x = (pPointSrc + i)->x * Factor;
    (pPointDest + i)->y = (pPointSrc + i)->y * Factor;
  }
}

static void _Loop(void (* pFunc)(const GUI_POINT * pPoints,
                  int NumPoints, int x0, int y0), int Factor, GUI_MEMDEV_Handle hMem, int x, int y) {
  GUI_POINT aPoint   [GUI_COUNTOF(_aPoint)];
  GUI_POINT aPointRot[GUI_COUNTOF(_aPoint)];
  int TimeStart, Time0, TimeUsed;
  float a;
  GUI_AA_SetFactor(Factor);
  _MagnifyPoints(_aPoint, aPoint, GUI_COUNTOF(_aPoint), Factor);
  TimeStart = GUI_GetTime();
  do {
    Time0 = GUI_GetTime();
    a = (float)(Time0 - TimeStart) / TIME_PER_TURN * 3.1415f * 2;
    GUI_RotatePolygon(aPointRot, aPoint, GUI_COUNTOF(_aPoint), a);
    GUI_Clear();
    GUI_DispStringHCenterAt("Factor: ", x - 5, 10);
    GUI_DispDecMin(Factor);
    pFunc(aPointRot, GUI_COUNTOF(_aPoint), x * Factor, y * Factor);
    GUI_MEMDEV_CopyToLCD(hMem);
    TimeUsed = GUI_GetTime() - Time0;
  } while ((Time0 - TimeStart) < DURATION);
}

void MainTask(void) {
  int xSize, ySize, i;
  GUI_MEMDEV_Handle hMem;
  PARA aPara[] = {
    {(void (*)(const GUI_POINT * pPoints, int NumPoints, int x0, int y0))GUI_FillPolygon,    1},
    {(void (*)(const GUI_POINT * pPoints, int NumPoints, int x0, int y0))GUI_AA_FillPolygon, 2},
    {(void (*)(const GUI_POINT * pPoints, int NumPoints, int x0, int y0))GUI_AA_FillPolygon, 4},
    {(void (*)(const GUI_POINT * pPoints, int NumPoints, int x0, int y0))GUI_AA_FillPolygon, 8},
  };
  GUI_Init();
  xSize = LCD_GetXSize();
  ySize = LCD_GetYSize();
  hMem = GUI_MEMDEV_Create(0, 0, xSize, ySize);
  GUI_MEMDEV_Select(hMem);
  GUI_AA_EnableHiRes();
  while (1) {
    for (i = 0; i < GUI_COUNTOF(aPara); i++) {
      _Loop(aPara[i].pFunc, aPara[i].Factor, hMem, xSize / 2, ySize / 2);
    }
  }
}
```

Antialiasing summary

You should now be able to answer the following questions:

- **What is the difference between antialiasing and high resolution antialiasing?**

Window manager

What is the **W**indow **M**anager?

- **Management system for a hierarchic window structure**

  Each layer has its own desktop window. Each desktop window can have its own hierarchic tree of child windows.

- **Callback mechanism based system**

  Communication is based on an event driven callback mechanism. **All** drawing operations should be done within the `WM_PAINT` event.

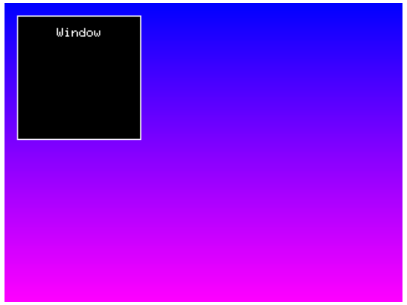
- **Foundation of widget library**

  All widgets are based on the functions of the WM.

Basic capabilities:

- **Automatic clipping**
- **Automatic use of multiple buffers**
- **Automatic use of memory devices**
- **Automatic use of display driver cache**
- **Motion support**

```
#include "WM.h"

void _cbWin(WM_MESSAGE * pMsg) {
  int xSize, ySize;

  switch (pMsg->MsgId) {
  case WM_PAINT:
    xSize = WM_GetWindowSizeX(pMsg->hWin);
    ySize = WM_GetWindowSizeY(pMsg->hWin);
    GUI_Clear();
    GUI_DrawRect(0, 0, xSize - 1, ySize - 1);
    GUI_DispStringHCenterAt("Window", xSize / 2, 10);
    break;
  default:
    WM_DefaultProc(pMsg);
  }
}

void _cbBk(WM_MESSAGE * pMsg) {
  switch (pMsg->MsgId) {
  case WM_PAINT:
    GUI_DrawGradientV(0, 0, 319, 239, GUI_BLUE, GUI_MAGENTA);
    break;
  default:
    WM_DefaultProc(pMsg);
    break;
  }
}

void MainTask(void) {
  WM_HWIN hWin;

  GUI_Init();
  WM_SetCallback(WM_HBKWIN, _cbBk);
  hWin = WM_CreateWindowAsChild(10, 10, 100, 100, WM_HBKWIN, WM_CF_SHOW, _cbWin, 0);
  while (1) {
    GUI_Delay(100);
  }
}
```



Window manager - Callback mechanism

Window management is based on a callback mechanism.

That requires a **callback routine** for each window which **should support at least** the following:

- **Painting**

  Each window has to draw itself. This should be done when receiving a `WM_PAINT` message.

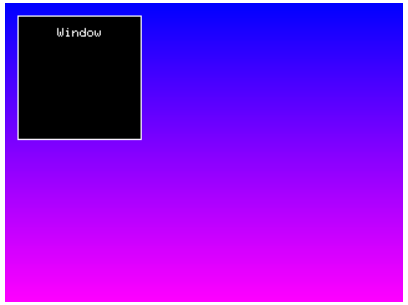
- **Default message handling**

  Plain windows need to call the function `WM_DefaultProc()` to avoid undefined behavior of the window.

WM needs to 'stay alive'. This can be done within a simple loop after creating the windows. It has nothing to do but calling `GUI_Delay()` which does the following:

- **Window (re)drawing**
- **PID management**
- **Key input management**
- **Timer management**

```
#include "WM.h"

void _cbWin(WM_MESSAGE * pMsg) {
  int xSize, ySize;

  switch (pMsg->MsgId) {
  case WM_PAINT:
    xSize = WM_GetWindowSizeX(pMsg->hWin);
    ySize = WM_GetWindowSizeY(pMsg->hWin);
    GUI_Clear();
    GUI_DrawRect(0, 0, xSize - 1, ySize - 1);
    GUI_DispStringHCenterAt("Window", xSize / 2, 10);
    break;
  default:
    WM_DefaultProc(pMsg);
  }
}

void _cbBk(WM_MESSAGE * pMsg) {
  switch (pMsg->MsgId) {
  case WM_PAINT:
    GUI_DrawGradientV(0, 0, 319, 239, GUI_BLUE, GUI_MAGENTA);
    break;
  default:
    WM_DefaultProc(pMsg);
    break;
  }
}

void MainTask(void) {
  WM_HWIN hWin;

  GUI_Init();
  WM_SetCallback(WM_HBKWIN, _cbBk);
  hWin = WM_CreateWindowAsChild(10, 10, 100, 100, WM_HBKWIN, WM_CF_SHOW, _cbWin, 0);
  while (1) {
    GUI_Delay(100);
  }
}
```



Window manager - Keyboard and PID input

Communication between the application and the user is mostly done by keyboard and/or **P**ointer **I**nput **D**evices. The following functions are available for that:

- **GUI_StoreKeyMsg()**

  If a keyboard event occurs (pressing or unpressing a key) it should be passed to this routine.

- **GUI_PID_StoreState()**

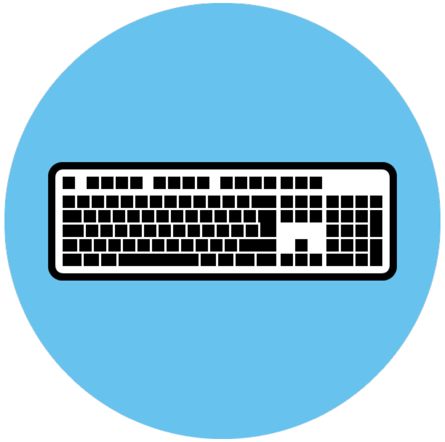
  If a PID event occurs (pressed, unpresed or moving) it should be passed to this routine.

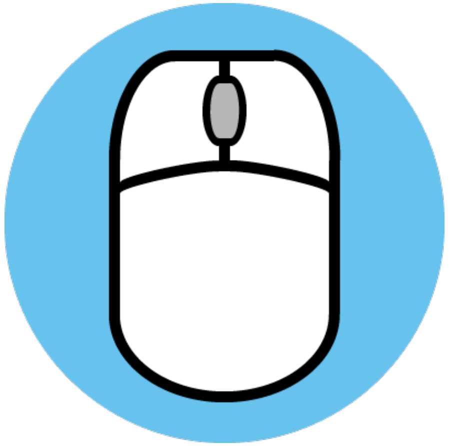
The WM automatically polls the keyboard and the PID buffer.

Keyboard input is passed to the **currently focussed window**.

PID input is passed to the **uppermost window of event position**.

Note: The above routines can also be called from within an interrupt or from a separate task without the multitasking option.





Window manager - Invalidating and rendering

Invalidating instead of drawing

If things need to be redrawn the most recommended way is changing the values to be drawn immediately when the event occurs and invalidating the window (or a part of it). The WM sends `WM_PAINT` messages automatically to each invalid window.

- **WM_InvalidateWindow()**

  Invalidates the complete window. Easy and most often used for invalidation.

- **WM_InvalidateRect()**

  Invalidates only a rectangular part of the window.

Note: Invalidating transparent windows causes invalidation of the window behind to make sure the background is (re)drawn.

Note: It is highly recommended to draw things only within the WM_PAINT event.

```
#include "WM.h"

void _cbWin(WM_MESSAGE * pMsg) {
  int xSize, ySize;
  static int Value;
  WM_KEY_INFO * pInfo;

  switch (pMsg->MsgId) {
  case WM_PAINT:
    xSize = WM_GetWindowSizeX(pMsg->hWin);
    ySize = WM_GetWindowSizeY(pMsg->hWin);
    GUI_Clear();
    GUI_DrawRect(0, 0, xSize - 1, ySize - 1);
    GUI_DispStringHCenterAt("Window", xSize / 2, 10);
    GUI_GotoXY(xSize / 2, 50);
    GUI_SetTextAlign(GUI_TA_HCENTER);
    GUI_DispDecMin(Value);
    break;
  case WM_KEY:
    pInfo = (WM_KEY_INFO *)pMsg->Data.p;
    if (pInfo->PressedCnt) {
      switch (pInfo->Key) {
      case GUI_KEY_UP:
        Value++;
        break;
      case GUI_KEY_DOWN:
        Value--;
        break;
      }
      WM_InvalidateWindow(pMsg->hWin);
    }
    break;
  default:
    WM_DefaultProc(pMsg);
  }
}

void _cbBk(WM_MESSAGE * pMsg) {
  switch (pMsg->MsgId) {
  case WM_PAINT:
    GUI_DrawGradientV(0, 0, 319, 239, GUI_BLUE, GUI_MAGENTA);
  }
}

void MainTask(void) {
  WM_HWIN hWin;

  GUI_Init();
  WM_SetCallback(WM_HBKWIN, _cbBk);
  hWin = WM_CreateWindowAsChild(10, 10, 100, 100, WM_HBKWIN, WM_CF_SHOW, _cbWin, 0);
  WM_SetFocus(hWin);
  while (1) {
    GUI_Delay(100);
  }
}
```

Window manager - Invalidation of transparent windows

The following should be observed with transparent windows:

- Invalidating a transparent window causes invalidation of the background window.
- Many widgets with skinning are transparent per default.
- Background invalidation is done to make sure, the content of the whole window is redrawn.
- The window manager invalidates as long as an opaque window is found.

If the **shape** of the window to be invalidated **remains constant**, the **background does not need to be invalidated**. That could be achieved by setting the flag `WM_CF_CONST_OUTLINE`.

The following functions are available:

- `WM_SetTransState()`
- `WM_CreateWindow...()`

Useful for example for a keyboard keys with constant outlines.

`WM_CF_CONST_OUTLINE`

Could avoid unnecessary invalidations of background windows

Window manager - Software timer

Timers can be used for triggering periodic or individual events.

- Unlimited number of timers
- Only one line of code required for creation

The callback routine of the window receives a `WM_TIMER` message after the period is expired.

For periodic use it should be restarted.

- **WM_TIMER**
  The message gets the timer handle in the pMsg->Data.v variable. It can be used to restart the timer.
- **WM_CreateTimer()**
  Used to create a timer.
- **WM_RestartTimer()**
  Should be used to restart the timer. The period can be changed.
- **WM_DeleteTimer()**
  Should be used to delete any unused timer.

Note: Timers should be deleted if they are not used anymore.

Create timer

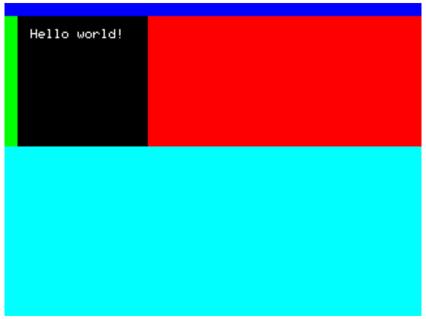
Receive WM_TIMER messages

Restart timer for periodic use

Delete timer if no longer used

Window manager - Tiling algorithm

Default behaviour of the WM is '**early clipping**'. That means clipping is done before WM_PAINT is send. An overlapped window then receives more than one paint message. It is drawn tile by tile:



Under certain circumstances it could make sense to use '**late clipping**'. In this case each drawing operation manages the clipping by itself. This could be done by using the flag WM_CF_LATE_CLIP.

Note: Normally early clipping provides the better performance.

The following messages are used:

- **WM_PRE_PAINT**
  Send before the first WM_PAINT message is send
- **WM_PAINT**
  One or more WM_PAINT messages for the drawing
- **WM_POSTPAINT**
  Send immediately after the last WM_PAINT message

```
#include "WM.h"

void _cbBk(WM_MESSAGE * pMsg) {
  GUI_COLOR aColor[] = { GUI_BLUE, GUI_GREEN, GUI_RED, GUI_CYAN, GUI_MAGENTA, GUI_YELLOW };
  static int Index;

  switch (pMsg->MsgId) {
  case WM_PAINT:
    GUI_SetBkColor(aColor[Index++]);
    if (Index == GUI_COUNTOF(aColor)) {
      Index = 0;
    }
    GUI_Clear();
    break;
  default:
    WM_DefaultProc(pMsg);
  }
}

void _cbWin(WM_MESSAGE * pMsg) {
  switch (pMsg->MsgId) {
  case WM_PAINT:
    GUI_Clear();
    break;
  default:
    WM_DefaultProc(pMsg);
  }
}

void MainTask(void) {
  WM_HWIN hWin;

  GUI_Init();
  WM_SetCallback(WM_HBKWIN, _cbBk);
  hWin = WM_CreateWindowAsChild(10, 10, 100, 100, WM_HBKWIN, WM_CF_SHOW, _cbWin, 0);
  while (1) {
    GUI_Delay(100);
  }
}
```

Window manager - Preventing flickering effects

The WM is able to use the following mechanisms to prevent flickering effects:

- **Multiple buffering**

  If multiple buffers are available the WM redirects all drawing operations to the back buffer before it starts working and makes it visible after it has finished.

- **Display driver cache**

  Some drivers, normally those with an indirect interface, are able to use a cache. This cache will be locked before it draws the invalid windows and unlocked at the end.

- **Memory devices**

  The WM creates and selects a memory device before sending the WM_PAINT event to a window. After that the content of the memory device is drawn at once.

Note: Memory devices can only prevent flickering operations 'per window'. Each widget is a window and the progress of drawing the screen can be noticed anyhow.

Multiple buffering

Most recommended method with **direct addressable** frame buffer

Display driver cache

Most recommended method with **indirect addressable** frame buffer

Memory devices

Less recommended method if other methods could not be used

Window manager - Window animations

Window animation functions are available for the following effects:

- **Moving in and out**

  Any widget/window can be moved in/out from a determined position. The window will be enlarged/shrinked and moved/turned to its final position.

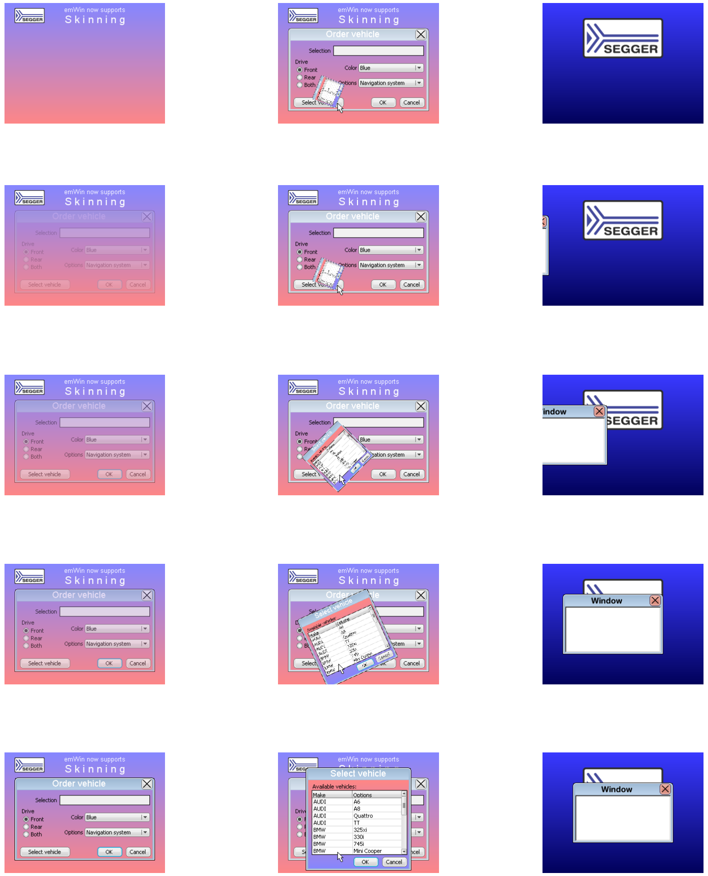
- **Shifting in and out**

  The given window is shifted in/out from/to a determined edge of the display.

- **Fading in and out**

  As the name implies the window the effect fades in/out the given window.

Note 1:	The functions require RAM for up to 3 whole screen memory devices (32bpp).
Note 2:	The animation functions are only available in conjunction with memory devices.
Note 3:	Recommended on fast systems only.



SAMPLE: MemoryDevices\MainTask_MemDevAnimation.c

Window manager - Adding user data

Application defined data attached to a window could avoid global variables. The following functions exist:

- **WM_CreateWindowAsChild()**

  Last parameter defines the number of bytes for user data.

- **WM_SetUserData()**

  Adds user data to a window object.

- **WM_GetUserData()**

  Retrieves the data from the window object.

Note: User data allows custom defined object related data and helps to avoid global variables.

User data instead of global variables

```
#include "WM.h"

void _cbWin(WM_MESSAGE * pMsg) {
  int xSize, ySize;
  GUI_COLOR * pColor;

  switch (pMsg->MsgId) {
  case WM_PAINT:
    xSize = WM_GetWindowSizeX(pMsg->hWin);
    ySize = WM_GetWindowSizeY(pMsg->hWin);
    WM_GetUserData(pMsg->hWin, &pColor, sizeof(GUI_COLOR *));
    GUI_DrawGradientV(0, 0, xSize - 1, ySize - 1, *(pColor + 0), *(pColor + 1));
    break;
  default:
    WM_DefaultProc(pMsg);
  }
}

void MainTask(void) {
  WM_HWIN hWin;
  GUI_COLOR aColor[] = { GUI_MAGENTA, GUI_BLUE };
  GUI_COLOR * pColor = aColor;

  GUI_Init();
  WM_SetDesktopColor(GUI_BLACK);
  hWin = WM_CreateWindowAsChild(10, 10, 100, 100, WM_HBKWIN, WM_CF_SHOW, _cbWin, sizeof(GUI_COLOR *));
  WM_SetUserData(hWin, &pColor, sizeof(GUI_COLOR *));
  while (1) {
    GUI_Delay(100);
  }
}
```

Window manager - Motion support

The content of a window (or the window itself) can simply be moved by wiping over the touch screen.

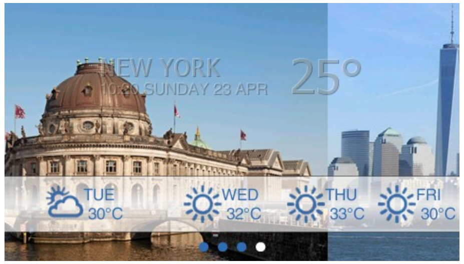
- Snapping supported
- Configurable motion properties
- Manual motion functions available

Enabling motion support for a window:

- Enable motion support with `WM_MOTION_Enable()`
- Create window with `WM_CF_MOTION_X/Y` flag

Detailed configuration can be done in the callback routine on `WM_MOTION_INIT` message.

WM sends `WM_MOTION` messages to be used for moving custom defined data.



...moving the window content

The most recommended and flexible way of use. Window position remains and only custom defined data is moved.

- Managing `WM_MOTION` messages required
- Custom defined drawing

...moving the window itself

The less recommended way of use. The window is moved automatically and the redrawing is done by the WM.

Window manager summary

You should now be able to answer the following questions:

- **What needs to be done to 'keep the WM alive'?**
- **What could avoid unnecessary invalidation of transparent windows with constant shapes?**
- **What influences the number of WM_PAINT messages required for redrawing?**
- **What could be done to reduce the number of WM_PAINT messages if required?**
- **Which methods are available to avoid flickering effects?**
- **How much memory is required to be able to use the window animation functions?**
- **What could be done to assign application defined data to a window object?**
- **Which basical methods of motion support are available?**
- **How is keyboard- and PID-input managed by the MW?**

Widget library

Widget = **Wi**ndow + Ga**dget**

Each widget is a window with special behavior.

Window manager functions could be used with widgets.

Creating a widget can be done with one line of code. There are basically 2 ways of creating a widget:

- **Direct creation**

  For each widget there exist creation functions:

  - `<WIDGET>_CreateEx()`
    Creation without user data.
  - `<WIDGET>_CreateUser()`
    Creation with user data.

- **Indirect creation**

  Indirect means here using a dialog box creation function and a `GUI_WIDGET_CREATE_INFO` structure which contains a pointer to the indirect creation routine:

  - `<WIDGET>_CreateIndirect()`
    Creation by dialog box creation function.

Direct creation

```
void MainTask(void) {
  WM_HWIN hWin;

  GUI_Init();
  hWin = FRAMEWIN_CreateEx(10, 10, 100, 50, WM_HBKWIN, WM_CF_SHOW, 0, 0, "Window", NULL);
  while (1) {
    GUI_Delay(100);
  }
}
```

Indirect creation

```
static const GUI_WIDGET_CREATE_INFO _aDialogCreate[] = {
  { FRAMEWIN_CreateIndirect, "Window", 0, 10, 10, 100, 50 }
};

void MainTask(void) {
  WM_HWIN hWin;

  GUI_Init();
  hWin = GUI_CreateDialogBox(_aDialogCreate, GUI_COUNTOF(_aDialogCreate), NULL, 0, 0, 0);
  while (1) {
    GUI_Delay(100);
  }
}
```

Button, Checkbox, Dropdown, Edit, Framewin, Graph, Header, Iconview, Image, Knob, Listbox, Listview, Listwheel, Menu, Multiedit, Multipage, Progbar, Radio, Scrollbar, Slider, Spinbox, Swipelist, Text, Treeview, Window

Widget library - Extended widget initialisation

Range of parameters of the creation functions is limited.

Widgets often need further initialization.

The WM sends a message when using indirect creation:

- **WM_INIT_DIALOG**

  Send immediately to the client window of the dialog after it has been created.

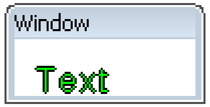
Within that event the function `WM_GetDialogItem()` can be used to get the handle of a child widget.

Independent of this message the widget properties can also be modified at any other point of code.

Note: This message is only available in conjunction with indirect creation functions

Initialization

```
#include "DIALOG.h"

static const GUI_WIDGET_CREATE_INFO _aDialogCreate[] = {
  { FRAMEWIN_CreateIndirect, "Window", 0,           10, 10, 100, 50 },
  { TEXT_CreateIndirect,     "Text",   GUI_ID_TEXT0, 10, 10,  50, 20 },
};

void _cbFrame(WM_MESSAGE * pMsg) {
  WM_HWIN hItem;

  switch (pMsg->MsgId) {
  case WM_INIT_DIALOG:
    hItem = WM_GetDialogItem(pMsg->hWin, GUI_ID_TEXT0);
    TEXT_SetFont(hItem, GUI_FONT_20F_ASCII);
    TEXT_SetTextColor(hItem, GUI_GREEN);
    break;
  }
}

void MainTask(void) {
  WM_HWIN hWin;

  GUI_Init();
  hWin = GUI_CreateDialogBox(_aDialogCreate, GUI_COUNTOF(_aDialogCreate), _cbFrame, 0, 0, 0);
  while (1) {
    GUI_Delay(100);
  }
}
```



Widget library - Transparent widgets

A non transparent window has to draw its complete window area. A transparent window lets the background shine through.

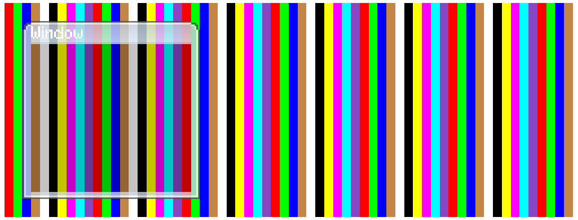
To make a widget looking (semi)transparent the transparency flag need to be set. This can be done by the following ways:

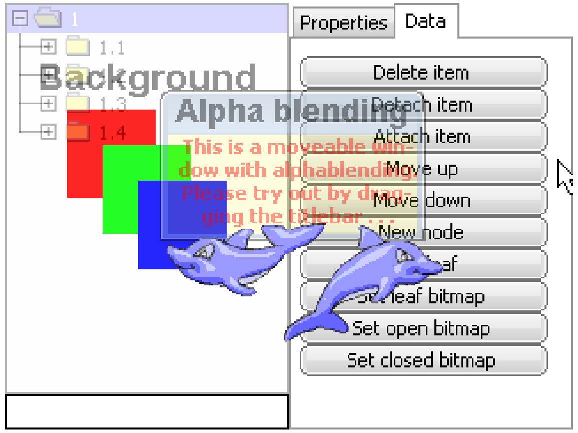
- **WM_CF_HASTRANS**

  This transparency flag can be used when creating the window.

- **WM_SetHasTrans()**

  This function can be used after the window has been created





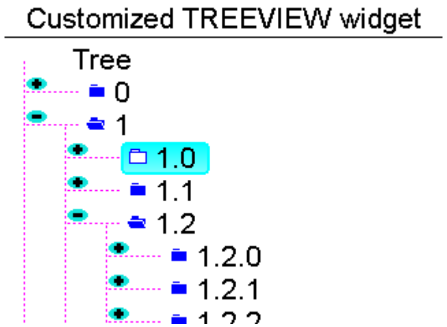
Note: Invalidating a transparent window causes also redrawing of the window behind the transparent window

Widget library - Custom drawing routines

Owner drawing

Sometimes the default API functions do not allow customizing the widgets exactly to the designers vision. For that case several widgets (Graph, Listbox, Listwheel, Treeview) support owner drawing routines `<WIDGET>_SetOwnerDraw()`.

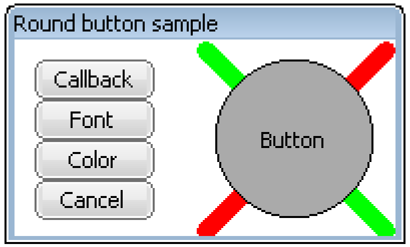
Method supported by several widgets



Overwriting the callback function

If the owner drawing function do not offer the required functionality or if there is no owner drawing routine available, the callback routine of the widget can be overwritten with `WM_SetCallback()`.

Works with each kind of window



Widget library - Skinning

Skinning is used to change the appearance of one or multiple widgets. Currently emWin supports 2 skins:

- **Classic skin**

  Old classic style. Look can be changed by using the API functions described in the 'Widget' chapter of the documentation.

- **FLEX_SKIN (default)**

  Flexible skin, can easily be modified by custom skinning routines.

The default skin for each kind of widget can be set by:

```
<WIDGET>_SetDefaultSkin()
```

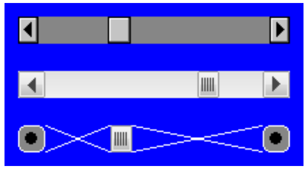
The skin of each single wigdet can be set by:

```
<WIDGET>_SetSkin()
```

Properties of FLEX_SKIN can be fetched / set by:

```
<WIDGET>_GetSkinFlexProps()
<WIDGET>_SetSkinFlexProps()
```

```
#include "DIALOG.h"

static int _ScrollbarSkinCust(const WIDGET_ITEM_DRAW_INFO * pDrawItemInfo) {
  switch (pDrawItemInfo->Cmd) {
  case WIDGET_ITEM_CREATE:
    WM_SetHasTrans(pDrawItemInfo->hWin);
    break;
  case WIDGET_ITEM_DRAW_BUTTON_L:
  case WIDGET_ITEM_DRAW_BUTTON_R:
    GUI_SetColor(GUI_GRAY);
    GUI_FillRoundedRect(pDrawItemInfo->x0, pDrawItemInfo->y0,
                        pDrawItemInfo->x1, pDrawItemInfo->y1, 4);
    GUI_SetColor(GUI_WHITE);
    GUI_DrawRoundedRect(pDrawItemInfo->x0, pDrawItemInfo->y0,
                        pDrawItemInfo->x1, pDrawItemInfo->y1, 4);
    GUI_SetColor(GUI_BLACK);
    GUI_FillCircle((pDrawItemInfo->x1 + pDrawItemInfo->x0) / 2,
                   (pDrawItemInfo->y1 + pDrawItemInfo->y0) / 2, 4);
    break;
  case WIDGET_ITEM_DRAW_SHAFT_L:
  case WIDGET_ITEM_DRAW_SHAFT_R:
    GUI_SetColor(GUI_WHITE);
    GUI_DrawLine(pDrawItemInfo->x0, pDrawItemInfo->y0, pDrawItemInfo->x1, pDrawItemInfo->y1);
    GUI_DrawLine(pDrawItemInfo->x0, pDrawItemInfo->y1, pDrawItemInfo->x1, pDrawItemInfo->y0);
    break;
  default:
    return SCROLLBAR_DrawSkinFlex(pDrawItemInfo);
  }
  return 0;
}

void MainTask(void) {
  WM_HWIN hWin0, hWin1, hWin2;

  WM_SetCreateFlags(WM_CF_MEMDEV);
  GUI_Init();
  WM_SetDesktopColor(GUI_BLUE);
  SCROLLBAR_SetDefaultSkinClassic();
  hWin0 = SCROLLBAR_CreateEx(10, 10, 200, 20, WM_HBKWIN, WM_CF_SHOW, 0, GUI_ID_SCROLLBAR0);
  SCROLLBAR_SetDefaultSkin(SCROLLBAR_SKIN_FLEX);
  hWin1 = SCROLLBAR_CreateEx(10, 50, 200, 20, WM_HBKWIN, WM_CF_SHOW, 0, GUI_ID_SCROLLBAR1);
  hWin2 = SCROLLBAR_CreateEx(10, 90, 200, 20, WM_HBKWIN, WM_CF_SHOW, 0, GUI_ID_SCROLLBAR2);
  SCROLLBAR_SetSkin(hWin2, _ScrollbarSkinCust);
  SCROLLBAR_SetValue(hWin0, 30);
  SCROLLBAR_SetValue(hWin1, 70);
  SCROLLBAR_SetValue(hWin2, 30);
  while (1) {
    GUI_Delay(100);
  }
}
```



Widget library summary

You should now be able to answer the following questions:

- **What is the difference between direct- and indirect widget creation?**
- **Which message is intended to be used for extended widget initialization within a dialog?**
- **What is the difference between 'owner drawing', 'overwriting callback' and 'skinning'?**
- **Why it is possible to use most of the window manager functions with widgets?**

GUI-Builder

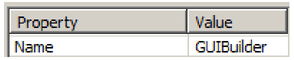
Tool for creating dialogs without knowledge of the C language.

Basic usage:

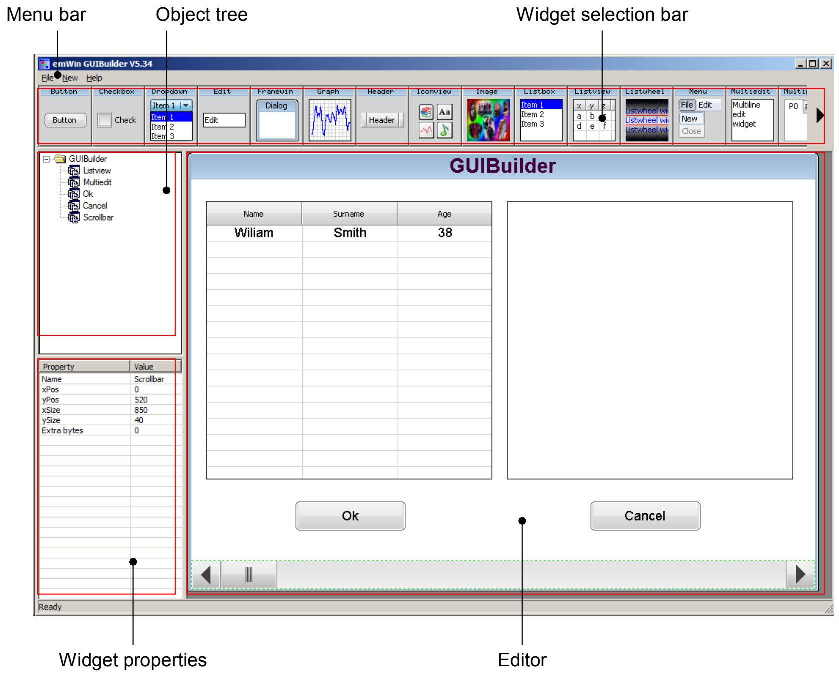
- **Check project path in** `GUIBuilder.ini`
  Located in the application folder.
- **Start GUI-Builder**
- **Start with** `FRAMEWIN` **or** `WINDOW` **widget**
  Only these widgets could serve as dialog parent window.
- **Place widgets within the parent window**
  Placed and size widgets by moving them with the mouse and/or by editing the properties in the property window.
- **Configure the widgets**
  The context menu shows the available options.
- **Save dialog**
  Each dialog is saved in a separate file. The filenames are generated automatically by the name of the parent window.

The filenames are automatically generated by the name of the parent window:

`<WindowName>Dlg.c`



Property	Value
Name	GUIBuilder



Property	Value
Name	Scrollbar
xPos	0
yPos	520
xSize	850
ySize	40
Extra bytes	0

Name	Surname	Age
Wiliam	Smith	38

- Files can be opened by **drag and drop**
- **Multiple dialogs** allowed simultaneously
- Each dialog is saved in a separate file
- **Filenames** are generated **automatically**

GUI-Builder - Filenames and code sections

Filenames

The project path contains one C file for each parent widget. The filenames are automatically generated by the names of the parent windows:

```
<WindowName>Dlg.c
```

Creation routine

The file contains a creation routine for the dialog. The routine name includes the name of the parent window:

```
WM_HWIN Create<WindowName>(void);
```

Simply call this routine to create the dialog:

```
hWin = CreateFramewin();
```

User defined code

The generated code contains a couple of comments to add user code between them. To be able to read back the file with the GUI-Builder the code must be between these comments.

Note: Adding code outside the user code comments makes the file unreadable for the GUI-Builder.

```
/*********************************************************************
. . . Header
*/

// USER START (Optionally insert additional includes)
// USER END

#include "DIALOG.h"

/*********************************************************************
*       Defines
**********************************************************************
*/

. . . ID definitions

// USER START (Optionally insert additional defines)
// USER END

/*********************************************************************
*       Static data
**********************************************************************
*/

// USER START (Optionally insert additional static data)
// USER END

/*********************************************************************
*       _aDialogCreate
*/
. . . Resource table

/*********************************************************************
*       Static code
**********************************************************************
*/

// USER START (Optionally insert additional static code)
// USER END

/*********************************************************************
*       _cbDialog
*/
. . . Callback routine

/*********************************************************************
*       Public code
**********************************************************************
*/
/*********************************************************************
*       CreateXXX
*/
. . . Creation routine

/*************************** End of file ****************************/
```

GUI-Builder - Callback routine

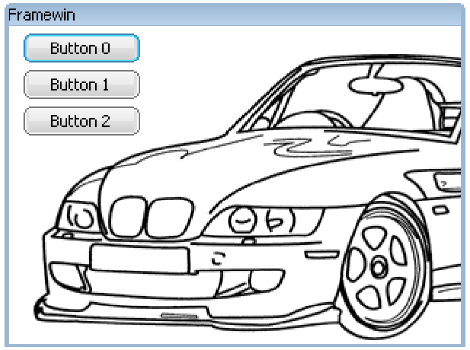
Main part of the generated file is the callback routine. It normally contains the following message handlers:

- **WM_INIT_DIALOG**

  The widget initialization is done here immediately after creating all widgets of the dialog. The user code area can be used to add further initialization.

- **WM_NOTIFY_PARENT**

  Contains (empty) message handlers to be filled with user code. For each notification of the widget there is one message handler.
  Further reactions on notification messages can be added.



```
/*********************************************************************
*
*       _cbDialog
*/
static void _cbDialog(WM_MESSAGE * pMsg) {
  WM_HWIN hItem;
  int Id, NCode;
  // USER START (Optionally insert additional variables)
  // USER END

  switch (pMsg->MsgId) {
  case WM_INIT_DIALOG:
    //
    // Initialization of 'Button'
    //
    hItem = WM_GetDialogItem(pMsg->hWin, ID_BUTTON_0);
    BUTTON_SetFont(hItem, GUI_FONT_20_ASCII);
    // USER START (Optionally insert additional code for further widget initialization)
    // USER END
    break;
  case WM_NOTIFY_PARENT:
    Id    = WM_GetId(pMsg->hWinSrc);
    NCode = pMsg->Data.v;
    switch(Id) {
    case ID_BUTTON_0: // Notifications sent by 'Button'
      switch(NCode) {
      case WM_NOTIFICATION_CLICKED:
        // USER START (Optionally insert code for reacting on notification message)
        // USER END
        break;
      case WM_NOTIFICATION_RELEASED:
        // USER START (Optionally insert code for reacting on notification message)
        // USER END
        break;
      // USER START (Optionally insert additional code for further notification handling)
      // USER END
      }
      break;
    // USER START (Optionally insert additional code for further Ids)
    // USER END
    }
    break;
  // USER START (Optionally insert additional message handling)
  // USER END
  default:
    WM_DefaultProc(pMsg);
    break;
  }
}
```

GUI-Builder summary

You should now be able to answer the following questions:

- **Which kinds of widgets could be used for starting a dialog?**
- **Which file should be used to set up the project path?**
- **What needs to be observed when adding user code?**
- **How the file names are generated when saving the project?**