AN3128
Application note

STM32 embedded graphic objects/touchscreen library

Introduction

This library is a firmware package which contains a collection of routines, data structures, and macros covering the main features of a graphic library and supporting a HID device to interact with the graphic objects (touchscreen, joystick, and pushbutton).

The library is general purpose and can be executed on any CPU, 8/16/32-bit, to guarantee the maximum portability of any architecture or LCD controller, and it provides a graphical user interface (GUI) for any application that operates with a graphical LCD.

While the firmware library functions with all currently available STM32 microcontrollers, (STM32F10xxx, STM32L1xx and STM32F2xx series), this document describes the firmware library through the implementation of a graphic library for embedded systems based on the STM32F10xxx microcontroller family.

It can easily be used in the user application without an in-depth study of STM32 registers, SPI, and I^2C read/write operation steps. As a result, using the firmware library saves significant time that would otherwise be spent in coding, while at the same time reducing the application development and integration costs.

The firmware architecture is developed in separate layers and the HAL (hardware abstraction layer) makes it independent from the microcontroller used in the final application.

A set of fonts is included: 8x12 and 16x24.

Even though the firmware library source code is developed in 'ANSI-C', the code architecture follows an OOP (object oriented programming) approach.

Section 1 describes the document and library rules.

Section 2 highlights the features of the STMPE811 and explains its hardware interface with a device microcontroller (STM32 in this case).

Section 3 and *4* describe the library features, its architecture and its exported APIs (application programming interfaces) in detail.

Section 5 contains an example application source code describing how to configure and use the library.

Section 6 contains information about the embedded GUI resource editor application.

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1 Document and library rules

This document uses the conventions described in the sections below.

1.1 Acronyms

The following table lists the acronyms used in this document.

Table 1. List of acronyms

Acronym	Meaning
API	Application programming interface
HAL	Hardware abstraction layer
MCU	Microcontroller unit
I^2C	Inter-integrated circuit
SPI	Serial peripheral interface
OOP	Object oriented programming

2 Touchscreen controller hardware description

2.1 Description

In this section we describe an example device that could be used for the touchscreen management. This device is present on both STM3210C-EVAL and STM32100E-EVAL demonstration board. The STMPE811 is a GPIO (general purpose input/output) port expander able to interface a main digital ASIC via the two-line bi-directional bus (I^2C). A separate GPIO expander is often used in mobile multimedia platforms to solve the problem regarding the limited amount of GPIOs typically available on the digital engine.

The STMPE811 offers great flexibility, as each I/O can be configured as input, output, or specific functions. The device has been designed with very low quiescent current and includes a wake-up feature for each I/O, to optimize the power consumption of the device.

A 4-wire touchscreen controller is built into the STMPE811. The touchscreen controller is enhanced with a movement tracking algorithm (to avoid excessive data), a 128 x 32-bit buffer and programmable active window feature.

2.2 Features

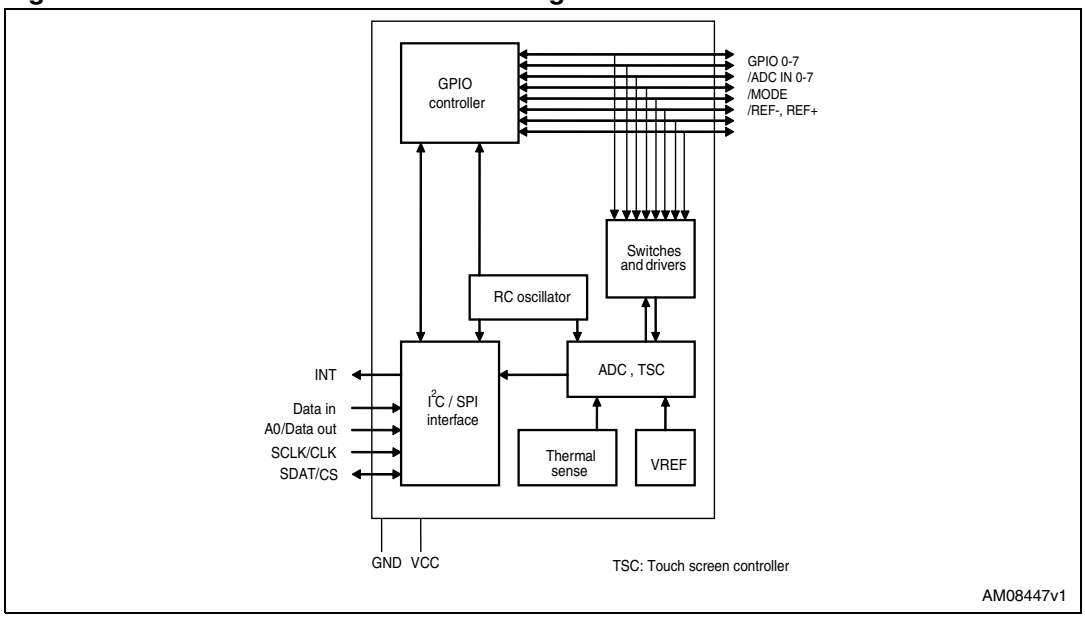
- 8 GPIOs
- 1.8 - 3.3 V operating voltage
- Integrated 4-wire touchscreen controller
- Interrupt output pin
- Wake-up feature on each I/O
- SPI and I^2C interface
- Up to 2 devices sharing the same bus in I^2C mode (1 address line)
- 8-input 12-bit ADC
- 128-depth buffer touchscreen controller
- Touchscreen movement detection algorithm
- 25 kV air-gap ESD protection (system level)
- 4 kV HBM ESD protection (device level).

2.3 STMPE811 functional overview

The STMP811 consists of the following blocks:

- I^2C and SPI interface
- Analog-to-digital converter (ADC)
- Touchscreen controller (TSC)
- Driver and switch control unit
- Temperature sensor
- GPIO controller.

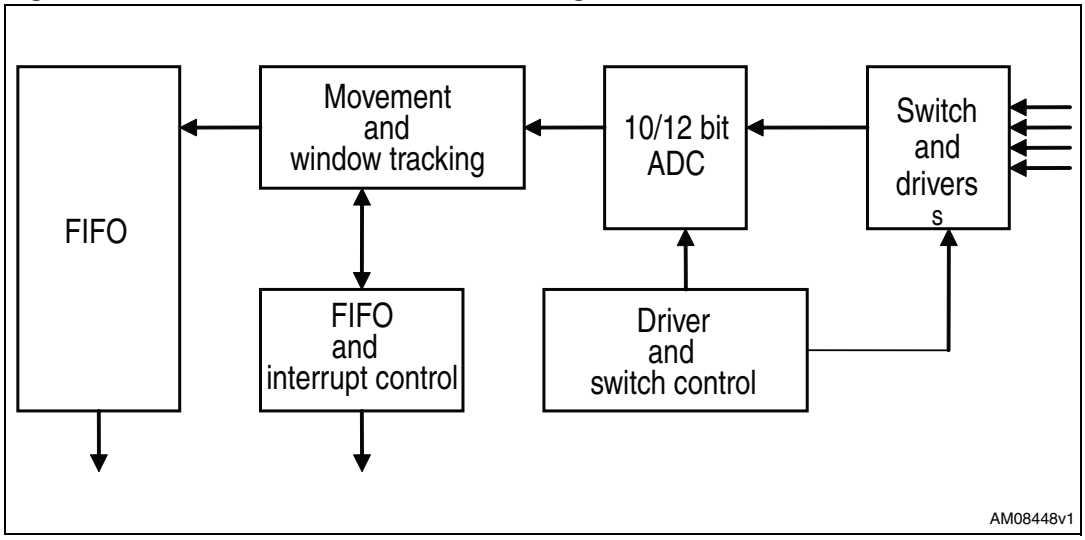
Figure 1. STMPE811 functional block diagram



2.4 Touchscreen controller

The STMPE811 is integrated with a hard-wired touchscreen controller for a 4-wire resistive type touchscreen. The touchscreen controller is able to operate completely autonomously, and interrupts the connected CPU only when a pre-defined event occurs.

Figure 2. Touchscreen controller block diagram

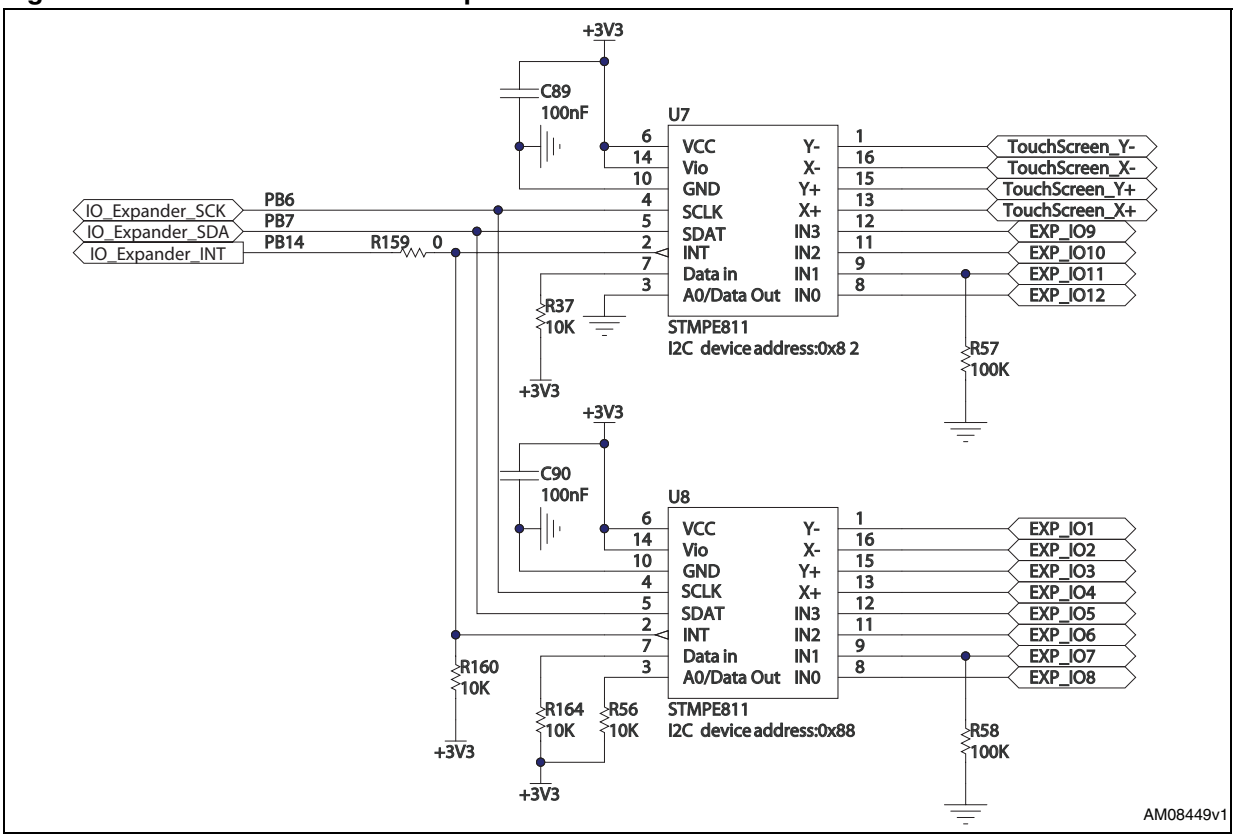


2.5 Interfacing touchscreen with microcontroller with the STMPE811 via I2C

The STMPE811 has a simple 2-wire I^2C digital serial interface which allows the user to access the data in the touchscreen controller register at any time. It communicates via the serial interface with a master controller.

Figure 3 shows how the STM32F10xxx microcontroller (master device) must be connected to the STMPE811 device.

Figure 3. Two STMPE811s in IOExpander mode



For more information on the touchscreen controller, refer to the STMPE811, datasheet, where it is possible to find details about the registers concerning the data of the touched points on the touchscreen.

3 Multi-input embedded GUI library

3.1 Introduction

The library supports touchscreen features and includes a low level driver which handles the analog input (for 12-bit ADC), and a function for the touchscreen calibration based on an algorithm using 5 points.

The multi-input embedded GUI firmware library is fully developed in 'ANSI-C' following an OOP approach. This means that the final application uses instances of page and graphic objects according to their public methods and properties. In the end the PageObj is a structure containing public properties (data fields) and methods (functions pointers). The OOP encapsulation feature is assured.

The library can be included in the final application as a library file (multi-input embedded GUI library.a) and used as a black box through its exported public API, or included in the final application as source files (.c and .h) if the user wants to debug the library itself, and/or change the HAL functions in order to port the library on an LCD different (in model and resolution).

The calibration process is part of the post-processing layer. The touchscreen must be calibrated at first power-on and/or upon user request.

Once the calibration is done, on future power-on of the board it does not have to be run again because the calibration parameters are saved on the Flash memory.

3.2 Graphic object introduction

This solution enables designers, comfortable with the use of standard microcontrollers, to create higher-end “look and feel” human interfaces by replacing conventional electromechanical switches with touch sensing controls.

Designers can combine touch sensing functions using multiple configurations (touchscreen, joystick, and keys) with traditional MCU features (communication, LED control, beeper, LCD control, etc.).

The multi-input embedded GUI library is part of the application firmware.

Maturity, robustness, flexibility, and performance, with good time-to-market, make this solution simple to implement to develop any kind of application.

The graphic objects are a set of controls that can be printed on the screen and associated to an action when pressed.

The library has been developed and tested on an LCD panel of QVGA resolution (320x240) which is the default, but the library is independent to the LCD resolution, although it has not been tested with others.

The library has been designed to have the minimum memory footprint possible.

The reserved Flash memory footprint requirement depends on the application configuration. It is therefore not possible to specify a precise value, but normally for a “typical” user application, 64 Kbytes of Flash memory are needed (the images are stored in ROM).

It is the same as far as the RAM usage is concerned: the user can calculate the space required by the application considering the heap space required by each graphic object used in their own application. For a typical application, 32 KB of RAM are required.

Table 2 shows the ROM usage (Flash memory) of the bitmap images for each type of graphic object using IAR 5.5 and high optimization for size:

Table 2. ROM usage of graphic objects

Graphic object type	ROM (Flash)	Note
Label	0 bytes	Totally
Button	2.904 bytes	Totally
Checkbox	1.736 bytes	Totally
RadioButton	1.736 bytes	Totally
ComboBox	4.144 bytes	Totally
Switch	2.904 bytes	Totally
Icon	0 bytes	Totally
Slidebar	944 bytes	Totally
Histogram	0 bytes	Totally
Graph chart	0 bytes	Totally

Table 3 shows the RAM usage of each type of graphic object:

Table 3. RAM usage of graphic objects

Graphic object type	RAM (Heap)	Note
Label	101 bytes	Each
Button	70 bytes	Each
Checkbox	79 bytes	Each
RadioButtonGrp	40 bytes	Each
RadioOption	48 bytes	Each
ComboBoxGrp	90 bytes	Each
ComboOption	29 bytes	Each
Switch	86 bytes	Each
Icon	53 bytes	Each
Slidebar	79 bytes	Each
Histogram	156 bytes	Each
Graph chart	257 bytes	Each
Page	162 bytes	Each

Table 4 shows the ROM usage (Flash memory) of the font sets:

Table 4. ROM usage of font sets

Font set	ROM (Flash)	Note
Font 16x24	4.560 bytes	Totally
Font 8x12	2.688 bytes	Totally

All the graphic objects are allocated dynamically, in a typical application the heap size should be about 16 KB, and the stack should be about 2 KB.

3.3 Library package

The library was developed supporting Raisonance Ride Kit ARM, IAR the IAR EWARM, Atollic TrueSTUDIO, Keil MDK-ARM , TASKING VX-toolset for ARM Cortex-M3 and the related workspace/project files are included in the delivered package.

The “Libraries” folder contains all the subdirectories and files that make up the core of the library.

Embedded_GUI_HAL contains all files and subdirectories that makes the hardware abstraction layer (HAL). The developer has to modify only these files if he needs to port the library to other board with other TSC/LCD/JOYSTICK controller, and set the defined constant into the file “hw_config.h” contained under the folder “./Embedded_GUI_Example/inc”:

- inc: sub-folder contains the HAL header files.
  - LcdHal.h: HAL layer file; contains all the LCD function prototypes whose implementation depends on the LCD used. The final user should change this file in order to re-use this library with other LCDs.
  - JoyHal.h: HAL layer file; contains all the joystick function prototypes whose implementation depends on the joystick controller used by the application. The user need only change these function implementations in order to re-use this code with other joystick controllers.
  - TscHal.h: HAL layer file; contains all the touchscreen function prototypes whose implementation depends on the TSC controller used by the application. The user need only change these function implementations in order to re-use this code with other TSC controllers.
  - touchscreen.h: contains all the function prototypes for the touchscreen firmware driver.
- src: sub-folder contains the HAL source files.
  - LcdHal.c: HAL layer file; contains all the LCD function declarations whose implementation depends on the LCD used and the MCU (STM32 for this delivery). The final user should change this file in order to re-use this library with other LCDs.
  - JoyHal.c: HAL layer file; contains all the joystick management function declarations whose implementation depends on the joystick controller used by the application. The user only needs to change these functions implementations in order to re-use this code with other joystick controllers.

  - TscHal.c: HAL layer file; contains all the touchscreen management function declarations whose implementation depends on the TSC controller used by the application. The user only needs to change these functions implementations in order to re-use this code with other TSC controllers.
  - touchscreen.c: contains all the function declarations for the touchscreen firmware driver.

Embedded_GUI_Library contains all files and subdirectories that makes the graphic objects core:

- inc: sub-folder contains the firmware library header files
  - cursor.h: contains all the function prototypes and basic structure for the cursor pointer (arrow header).
  - gl_fonts.h: contains all the LCD fonts size definition exported declarations.
  - GraphicObject.h: API layer file; contains all the function prototypes for the graphic objects; the API functions are declared in this file.
  - GraphicObjectTypes.h: API layer file; contains all the defined types used by GraphicObject.c file and related to the graphic objects structures; and the structure parameters for the LCD, touchscreen, joystick and push button.
  - images.h: contains all the Hex dumps of the various images used by the application.
- src: sub-folder contains the firmware library source files.
  - cursor.c: API layer file; contains the exported public API (application programming interface) and the related private internal functions for the cursor pointer (arrow header). No direct reference to the hardware and micro firmware library occurs in this file.
  - gl_fonts.c: contains all the LCD font size definitions.
  - GraphicObject.c: API layer file; contains the entire exported public API (application programming interface) and the related private internal functions for the graphic objects and touchscreen calibration; no direct reference to the hardware and microcontroller firmware library occurs in this file.
  - images.c: contains all the Hex dumps of the various images used by the library application.

STM32F10x_StdPeriph_Driver, STM32L1xx_StdPeriph_Driver and STM32F2xx_StdPeriph_Driver sub-folders contain respectively the STM32F10xxxV3.5.0, STM32L1xxV1.0.0 and STM32F2xxV1.0.0 firmware library files. If the final user wants to use another microcontroller library version, he can replace the updated library folder and check the HAL types and the microcontroller library function calls inside the HAL layer files (TscHal.c, TscHal.h, JoyHal.h, JoyHal.c, LcdHal.c, LcdHal.h).

CMSIS sub-folder contains the STM32F10xxx, STM32L1xx and STM32F2xx CMSIS files: device peripheral access layer and core peripheral access layer.

The “Project” folder contains all the subdirectories and files that make up the library demonstration.

- Embedded_GUI_Example sub-folder contains the STM32F10xxx Graphic library demonstration:
  - inc: sub-folder contains the graphic library demonstration header files
  - src: sub-folder contains the graphic library demonstration header source files
  - EWARM sub-folder contains the IAR EWARM workspace and project files
  - RIDE sub-folder contains the Raisonance Ride workspace and project files

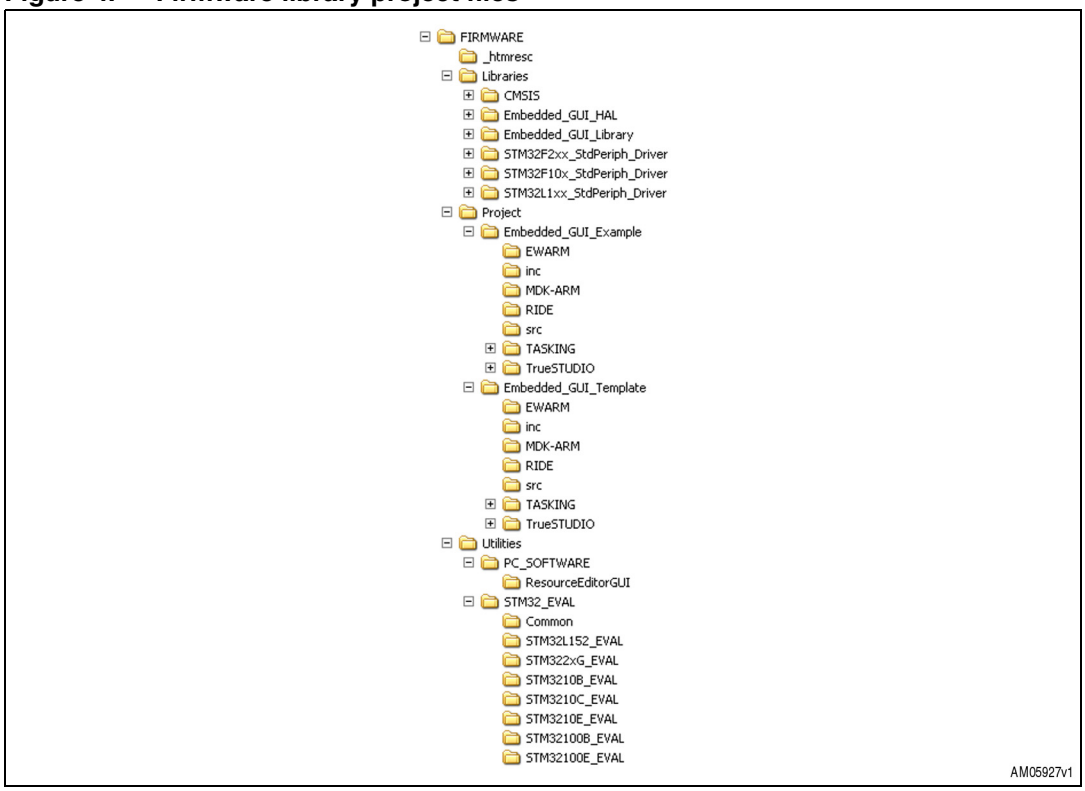
  - MDK-ARM sub-folder contains the Keil MDK-ARM workspace and project files
  - TrueSTUDIO sub-folder contains the Atollic TrueSTUDIO workspace and project files
  - TASKING sub-folder contains the TASKING VX-toolset for ARM Cortex-M3 workspace and project files
- Embedded_GUI_Template sub-folder contains the STM32 Graphic library template for Resource Editor (PC Software) output files:
- inc : sub-folder where to place generated header files from Resource Editor PC software (uiappuser.h, uiframework.h, uiappuser.h).
- src : sub-folder where to place generated source files from Resource Editor PC software (uiframework.c, pictures.c, uiappuser.c).
- EWARM sub-folder contains the IAR EWARM workspace and project files
- RIDE sub-folder contains the Raisonance Ride workspace and project files
- MDK-ARM sub-folder contains the Keil MDK-ARM workspace and project files
- TrueSTUDIO sub-folder contains the Atollic TrueSTUDIO workspace and project files
- TASKING sub-folder contains the TASKING VX-toolset for ARM Cortex-M3 workspace and project files

The “Utilities” folder contains all the subdirectories and files that make up the STMicroelectronics demonstration board drivers.

- STM32_EVAL sub-folder contains STM32 demonstration board drivers
- PC_SOFTWARE sub-folder contains Resource Editor

The “_htmresc” folder contains all package html page resources.

Figure 4. Firmware library project files



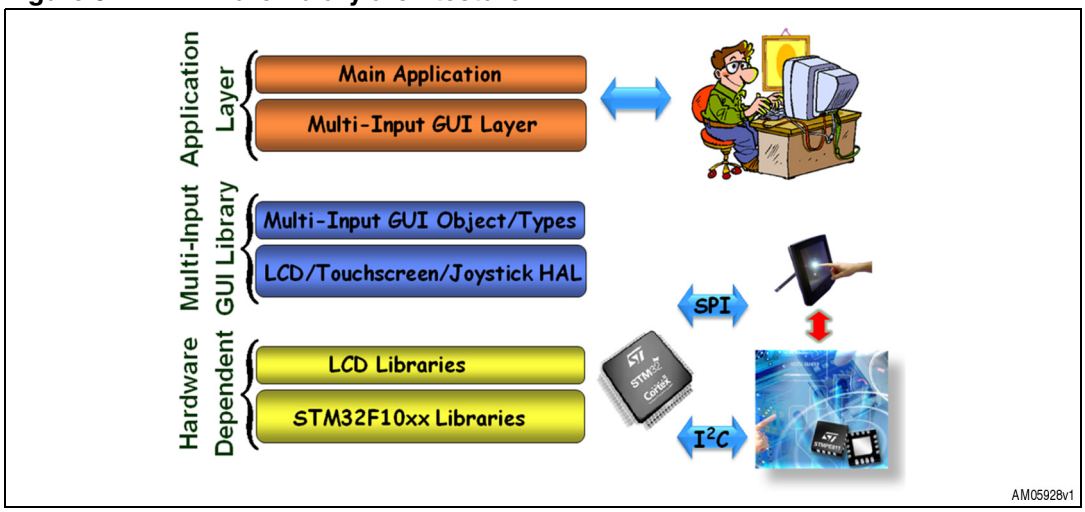
3.4 Library architecture

Library architecture is thought out and developed in two separate layers:

- API layer
- HAL layer

This layer architecture improves the code re-usability splitting the application programming interface code (fully portable and re-usable) from the hardware abstraction layer code (hardware dependent and written upon the LCD library).

Figure 5. Firmware library architecture



3.4.1 API layer

The application programming interface layer allows the final application to use the library as a black-box. The library firmware encapsulation feature and exported API allow a full control of the LCD and touchscreen without knowing, in-depth, LCD registers and SPI/I^2C read/write operation steps for the LCD and touchscreen respectively.

- The API layer includes the following files:
  - graphicObject.h
  - graphicObject.c
  - graphicObjectTypes
  - cursor.c
  - cursor.h

See *Section 4.1* for a more detailed description.

3.4.2 HAL layer

The hardware abstraction layer is directly built into the specific LCD firmware library and allows the build-upon layers, like the API layer, to implement its functions without knowing, in-depth, the LCD, MCU and touchscreen controller used. This improves the library code re-

usability and guarantees an easy portability on other LCDs, MCUs and touchscreen controllers.

- The HAL layer includes the following files:
  - LcdHal.h
  - LcdHal.c
  - TscHal.h
  - TscHal.c
  - JoyHal.h
  - JoyHal.c
  - Touchscreen.h
  - Touchscreen.c

See *Section 4.4* for a more detailed description.

4 Multi-input embedded GUI library firmware

This section describes the API and HAL layer implementation. Each library firmware function is described in detail. An example of how to use API functions is provided. No example is provided for the HAL function, because the final application should manage the graphic objects through the API layer functions only, without any direct access to the HAL functions.

The functions are described in the following format:

Table 5. Function description format

Name	Description
Function name	The name of the function
Function prototype	Prototype declaration of the function
Behavior description	Brief explanation of how the function is executed
Input parameter {x}	Description of the input parameters
Output parameter {x}	Description of the output parameters
Return value	Value returned by the function
Required preconditions	Requirements before calling the function
Called functions	Other library functions called

4.1 Graphic object API functions

The application programming interface layer allows the final application to create pages of graphic objects and easy use of the STMPE811 touchscreen controller. An OOP approach is used, so it's possible for the application developer to create and use one or more instances of a graphic object and work with pages of object without writing the code to display the graphic objects every time the application changes the focus on another page.

Graphic object structures are seen by the application as objects with encapsulated properties and methods. In the end, they are advanced structures containing:

- Properties as data fields
- Methods as function pointers

In this way each API function belongs to the related graphic object instance and so, many graphic objects can be managed without any conflicts.

Every type of graphic object has a pre-event function that provides the process to change its visualization on the screen and the internal status of the object; for example in a ComboBox, when the user hits the “Down Arrow” the pre-event function changes the image associated showing the one associated to Image2_PTR for a few moments, and sets the next option in the list as active. This function is predefined for each type of object and very useful in order to minimize the developer workload. In this way, the developer need only place graphic objects on the screen page and write a function event that is called after the pre-event function, when a touch/click event occurs between the object coordinates area.

The library exports the following public API global functions in order to create the graphic objects type structure instance and set/get the relative properties:

- NewLabel function
- NewButton function
- NewSwitch function
- NewCheckbox function
- NewIcon function
- NewRadioButtonGrp function
- AddRadioOption function
- NewSlidebar function
- NewHistogram function
- NewGraphChart function
- NewComboBoxGrp function
- AddComboOption function
- Create_PageObj function
- AddPageControlObj function
- DestroyPageControl function
- DestroyPage function
- Set_Label function
- Get_Label function
- Get_SlidebarValue function
- SetGraphChartPoints function
- SetHistogramPoints function
- GetObjStatus function
- GetComboOptionActive function
- ResetComboOptionActive function
- GetComboOptionLabel function
- SetComboOptionLabel function
- SetIconImage function
- ShowPage function
- RefreshPage function
- RefreshPageControl function
- ChangePage function.

4.1.1 NewLabel API global function

Table 6 describes the NewLabel function:

Table 6. NewLabel API function

Name	Description
Function name	NewLabel
Function prototype	GL_PageControls_TypeDef* NewLabel (char* oName, char* Label, GL_Direction_direction, GL vu8 FontSize, GL vuint16_t color)
Behavior description	Create and initialize a new Label Object (a C structure)
Input parameter {x}	oName: object name Label: text on a Label Object Direction: the direction to follow printing the Label FontSize: the size of the font: FONT_BIG or FONT_SMALL Color: color of the Label text
Output parameter {x}	None
Return value	The created object pointer or null if the object cannot be created
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );

/* Declares and initiates a Label Object and add it with specified coordinates to a
Page Object */
GL_PageControls_TypeDef* pageLabel = NewLabel("pageLabel","Graphic Library",
                                                GL_HORIZONTAL, GL_FONT_BIG, GL_Blue);
AddPageControlObj((uint16_t)((LCD_Width/11)*9),(uint8_t)(LCD_Height/11),pageLabel,
                  &page1);
```

Once a Label Object instance is created using the NewLabel function, the Label Object itself provides all its features through its internal function pointers.

Figure 14, *15*, *16*, show, in detail, the Label Object properties and methods which the final application can use to interact with.

4.1.2 NewButton API global function

The button object is the most used and its graphical look changes temporarily during the interaction between the touchscreen or the joystick. In fact there are two looks for the button as well as for the majority of the others objects.

When the button is pressed, its “graphical look” changes for a few moments and then returns to the starting aspect.

Inside the button, it's possible to insert a text Label, by which the button width itself depends. The library automatically fits the width and places the text in the center.

Figure 6. Button graphical layout

Table 7 describes the NewButton function:

Table 7. NewButton API function

Name	Description
Function name	NewButton
Function prototype	GL_PageControls_TypeDef* NewButton (char* oName, char* Label, void* (*pEventHandler)(void))
Behavior description	Create and initialize a new button object (a C structure)
Input parameter {x}	oName: object name Label: Label on button pEventHandler: pointer to function associated to its touch event
Output parameter {x}	None
Return value	The created object pointer or null if the object cannot be created
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );

/* Declares & initiates a Button Object and add it with specified coordinates to a
Page Object */
GL_PageControls_TypeDef* TestBtn = NewButton("TestBtn", "Test Button", TestBtnFunc);
AddPageControlObj((uint16_t)((LCD_Width/10)*6), (uint8_t)((LCD_Height/9)*4),
                  TestBtn, &page1);
```

Once a button object instance is created using the NewButton function, the button object itself provides all its features through its internal function pointers.

Figure 14, *15*, *16*, show, in detail, the button object properties and methods which the final application can use to interact with.

4.1.3 NewCheckbox API global function

The checkbox object follows a Boolean principle so its value can be defined in a binary way (0/1).

A typical example of this kind of object could be enable/disable a variable concerning a specified feature/option.

Figure 7. Checkbox graphical layout

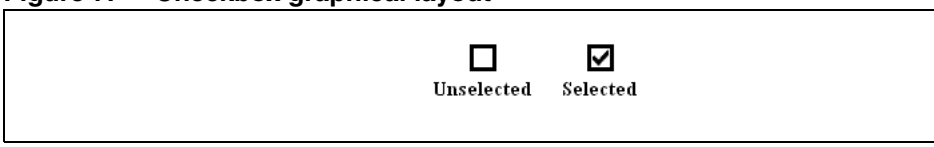


Table 8 describes the NewCheckbox function:

Table 8. NewCheckbox API function

Name	Description
Function name	NewCheckbox
Function prototype	GL_PageControls_TypeDef* NewCheckbox (char* oName, char* Label, void* (*pEventHandler)(void))
Behavior description	Create and initialize a new Label Object (a C structure)
Input parameter {x}	oName: object name Label: Label for the checkbox pEventHandler: pointer to function associated to its touch event
Output parameter {x}	None
Return value	The created object pointer or null if the object cannot be created
Required preconditions	None
Called functions	No API/HAL layer functions

Example

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );

/* Declares and initiates a Checkbox Object and add it with specified coordinates to
a Page Object */
GL_PageControls_TypeDef* CheckBox = NewCheckbox("CheckBox", "Enable", CheckboxFunc);
AddPageControlObj((uint16_t)((LCD_Width/10)*7),(uint8_t)((LCD_Height/9)*4),CheckBox,
                  &page1);
```

Once a checkbox object instance is created using the NewCheckbox function, the checkbox object itself provides all its features through its internal function pointers.

Figure 14, *15*, *16*, show, in detail, the Checkbox object properties and methods which the final application can use to interact with.

4.1.4 NewSwitch API global function

The switch object or SwitchButton is very similar to the button object and actually contains all its features, the only difference being that when this object is stimulated through the touchscreen or the joystick, its state, and then its graphical look, change permanently until a new press event.

The most obvious function of this object is to change the status of a Boolean/Binary variable (0/1) and so enable/disable something.

Figure 8. Switch graphical layout

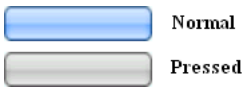


Table 9 describes the NewSwitch function:

Table 9. NewSwitch API function

Name	Description
Function name	NewSwitch
Function prototype	GL_PageControls_TypeDef* NewSwitch (char* oName, char* Label_1, char* Label_2, void* (*pEventHandler)(void))
Behavior description	Create and initialize a new Label Object (a C structure)
Input parameter {x}	oName: object name Label_1: Label on not clicked switch button Label_2: Label on clicked switch button pEventHandler: pointer to function associated to its touch event
Output parameter {x}	None
Return value	The created object pointer or null if the object cannot be created
Required preconditions	None
Called functions	No API/HAL layer functions

Example

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );

/* Declares and initiates a Switch Object and add it with specified coordinates to a
Page Object */
GL_PageControls_TypeDef* EnDisBtn = NewSwitch("EnDisBtn","Enable","Disable",MyFunc);
AddPageControlObj((uint16_t)((LCD_Width/10)*6),(uint8_t)((LCD_Height/9)*4),EnDisBtn,
                  &page1);
```

Once a switch object instance is created using the NewSwitch function, the switch object itself provides all its features through its internal function pointers.

Figure 14, *15*, *16*, show, in detail, the switch object properties and methods which the final application can use to interact with.

4.1.5 NewIcon API global function

This object allows the user to show an arbitrary image on the LCD, stored in the Flash memory of the MCU, and associate the press event of the image itself through the touchscreen or the joystick.

Table 10 describes the NewIcon function:

Table 10. NewIcon API function

Name	Description
Function name	NewIcon
Function prototype	GL_PageControls_TypeDef* NewIcon (char* oName, GL_uint8_t* Image_PTR, GL_uint16_t Width, GL_uint8_t Height, void* (*pEventHandler)(void))
Behavior description	Create and initialize a new icon object (a C structure)
Input parameter {x}	oName: object name Image_PTR: icon image pointer Width: image width Height: image height pEventHandler: pointer to function associated to its touch event
Output parameter {x}	None
Return value	The created object pointer or null if the object cannot be created
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );

/* Declare and initiate a Icon Object and add it with specified coordinates to a Page
Object */
GL_PageControls_TypeDef* MyIcon = NewIcon ("MyIcon", NULL, 90, 90, NullFunc);
AddPageControlObj( (uint16_t)((LCD_Width/2)+45),(uint8_t)((LCD_Height/2)+45),MyIcon,
                   &page1 );
```

Once an icon object instance is created using the icon function, the icon object itself provides all its features through its internal function pointers.

Figure 14, *15*, *16*, show, in detail, the icon object properties and methods which the final application can use to interact with.

4.1.6 NewRadioButtonGrp API global function

The radio button (sometimes called the option button) is a special kind of button that allows the user to choose only one of a predefined set of alternatives. Its name derives from the old car radio, where this button was used to select the preset stations. The major difference with the ordinary button is that the radio buttons are arranged in groups where the group acts as a big switchboard. In a group, only one radio button must be selected at most. Then, if in a group, the first radio button is in the selected state, and suddenly the second radio button is pressed, the first one must be immediately released going back to the normal state, and the second passes to the selected state.

Figure 9. Radio button graphical layout

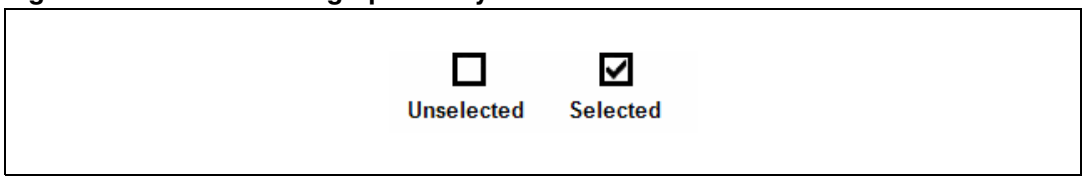


Table 11 describes the NewRadioButtonGrp function:

Table 11. NewRadioButtonGrp API function

Name	Description
Function name	NewRadioButtonGrp
Function prototype	GL_RadioButtonGrp_TypeDef* NewRadioButtonGrp (char* oName)
Behavior description	Create and initialize a new RadioButtonGrp object (a C structure)
Input parameter {x}	oName: object name
Output parameter {x}	None
Return value	The created object pointer or null if the object cannot be created
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
/* Declares and initiates a RadioButtonGrp Object */
GL_RadioButtonGrp_TypeDef* RadioButtonGrp = NewRadioButtonGrp("RadioButtonGrp");
```

4.1.7 AddRadioOption API global function

Table 12 describes the AddRadioOption function:

Table 12. AddRadioOption API function

Name	Description
Function name	AddRadioOption
Function prototype	GL_PageControls_TypeDef* AddRadioOption (GL_RadioButtonGrp_TypeDef* pThis, char* Label, void* (*pEventHandler)(void))
Behavior description	Create and initialize a new Label Object (a C structure)

Table 12. AddRadioOption API function (continued)

Name	Description
Input parameter {x}	GL_RadioButtonGrp_TypeDef*: pThis Label: Label for RadioButton option pEventHandler: pointer to function associated to its touch event
Output parameter {x}	None
Return value	The created object pointer or null if the object cannot be created
Required preconditions	NewRadioButtonGrp must have been called before
Called functions	No API/HAL layer functions

Example:

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );

/* Declares and initiates a RadioButton Group Object */
GL_RadioButtonGrp_TypeDef* RButtonGrp = NewRadioButtonGrp("RButtonGrp");

/* Declare/initiate a RadioOption Object and add it with specified coordinates to a
Page Object */
GL_PageControls_TypeDef* ROption_a = RADIO_BUTTON_ADD(RButtonGrp,"Option1",RBtnFunc1);
GL_PageControls_TypeDef* ROption_b = RADIO_BUTTON_ADD(RButtonGrp,"Option2",RBtnFunc2);
AddPageControlObj((uint16_t)(LCD_Width/2),(uint8_t)((LCD_Height/9)*3),ROption_a,
                  &page1);
AddPageControlObj((uint16_t)(LCD_Width/2),(uint8_t)((LCD_Height/9)*4),ROption_b,
                  &page1);
```

Note: As can be seen from the code above, to simplify the adding of a radio option the user should not directly use the function "AddRadioOption()", but must use the following macro instead:

```
#define RADIO_BUTTON_ADD(RadioButtonGrpName, Label, Function) \
RadioButtonGrpName->AddRadioOption(RadioButtonGrpName,Label,Function);
```

Once a RadioOption object instance is created using the AddRadioOption function, the RadioOption object itself provides all its features through its internal function pointers.

Figure 14, *15*, *16*, show, in detail, the RadioOption object properties and methods which the final application can use to interact with.

4.1.8 NewComboBoxGrp API global function

This kind of object allows the user to choose an option from a list of alternatives that can be scrolled by selecting the up/down arrows.

Figure 10. Combobox graphical layout

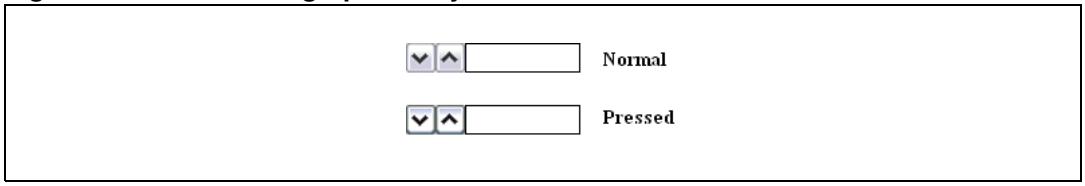


Table 13 describes the NewComboBoxGrp function:

Table 13. NewComboBoxGrp API function

Name	Description
Function name	NewComboBoxGrp
Function prototype	GL_PageControls_TypeDef* NewComboBoxGrp (char* oName)
Behavior description	Create and initialize a new ComboBoxGrp object (a C structure)
Input parameter {x}	oName: object name
Output parameter {x}	None
Return value	The created object pointer or null if the object cannot be created
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );

/* Declares and initiates a ComboBoxGroup Object and add it with specified
coordinates to a Page Object */
GL_PageControls_TypeDef* MyComboGrp = NewComboBoxGrp("MyComboGrp");
AddPageControlObj((uint16_t)((LCD_Width/10)*8),(uint8_t)(LCD_Height/2),MyComboGrp,
                  &page1);
```

Once a ComboBoxGrp object instance is created using the NewComboBoxGrp function, the ComboBoxGrp object itself provides all its features through its internal function pointers.

Figure 14, *15*, *16*, show, in detail, the ComboBoxGrp object properties and methods which the final application can use to interact with.

4.1.9 AddComboOption API global function

Table 14 describes the AddComboOption function:

Table 14. AddComboOption API function

Name	Description
Function name	AddComboOption
Function prototype	GL_ErrStatus AddComboOption (GL_ComboBoxGrp_TypeDef* pThis, char* Label, void* (*pEventHandler)(void))
Behavior description	Create and initialize a new ComboBoxOption object (a C structure)
Input parameter {x}	GL_ComboBoxGrp_TypeDef*: pThis Label: Label for RadioButton option pEventHandler: pointer to function associated to its touch event
Output parameter {x}	None
Return value	GL_OK if successful, GL_ERROR otherwise

Table 14. AddComboOption API function (continued)

Name	Description
Required preconditions	NewComboBoxGrp must have been called before
Called functions	No API/HAL layer functions

Example:

```
GL_ErrStatus errStatus;
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );
/* Declare and initiate a ComboBoxGroup with its ComboOptions Object and add it with
specified coordinates to a Page Object */
GL_PageControls_TypeDef* MyComboGrp = NewComboBoxGrp("MyComboGrp");
AddComboOption (MyComboGrp ->objPTR, "Option1", MyComboboxFunc);
AddComboOption (MyComboGrp ->objPTR, "Option2", MyComboboxFunc);
AddComboOption (MyComboGrp ->objPTR, "Option3", MyComboboxFunc);
AddComboOption (MyComboGrp ->objPTR, "Option4", MyComboboxFunc);
AddPageControlObj((uint16_t)((LCD_Width/10)*8),(uint8_t)(LCD_Height/2),MyComboGrp,
                  &page1);
```

Once a ComboBoxGrp object and its combo option instances are created using the NewComboBoxGrp and AddComboOption functions, ComboBoxGrp and combo option objects themselves provide all their features through their internal function pointers.

Figure 14, *15*, *16*, show, in detail, the ComboBoxOption object properties and methods which the final application can use to interact with.

4.1.10 NewSlidebar API global function

This kind of object is composed of a rectangular shaped 3D image and a thin cursor that can be moved using the joystick or touchscreen pressing the cursor itself laterally. The variance is established in a percentage from 0 to 100, and the minimum step is fixed at 5%.

A typical example of the application of this object could be the volume variation of the audio output in an MP3 player.

It is possible to read the current value of the cursor position through the function “Get_SlidebarValue” defined in the following pages, therefore easily integrating such an object in the application.

The slidebar can be chosen to be printed horizontally or vertically, as shown in *Figure 11*.

Figure 11. Slidebar graphical object

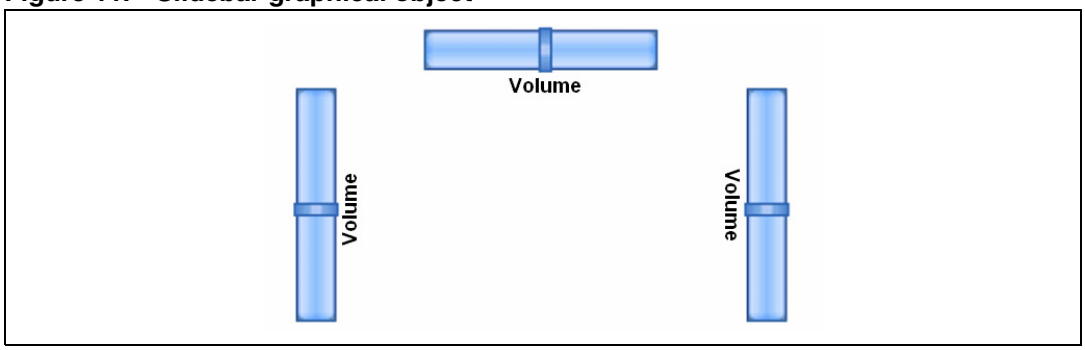


Table 15 describes the NewSlidebar function:

Table 15. NewSlidebar API function

Name	Description
Function name	NewSlidebar
Function prototype	GL_PageControls_TypeDef* NewSlidebar (char* oName, char* Label, GL_Direction, void* (*pEventHandler)(void))
Behavior description	Create and initialize a new slidebar object (a C structure)
Input parameter {x}	oName: object name Label: Label for slidebar meaning direction: the printing orientation. The parameters can be GL_Vertical or GL_Horizontal pEventHandler: pointer to function associated to its touch event
Output parameter {x}	None
Return value	The created object pointer or null if the object cannot be created
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );

/* Declares and initiates a Slidebar Object and add it with specified coordinates to
a Page Object */
GL_PageControls_TypeDef* MySlidebar = NewSlidebar("MySlidebar", "Volume",
                                                  GL_Horizontal, MySlidebarFunc);
AddPageControlObj((uint16_t)((LCD_Width/10)*7),(uint8_t)(LCD_Height/2),MySlidebar,
                  &page1);
```

Once a slidebar object instance is created using the NewSlidebar function, the slidebar object itself provides all its features through its internal function pointers.

Figure 14, *15*, *16*, show, in detail, the slidebar object properties and methods which the final application can use to interact with.

4.1.11 NewHistogram API global function

This kind of object is composed of two axes (X & Y) with the relative values printed to the side, and a certain number of blue columns representing the real distribution of respective values. The values are saved in a vector of decimal numbers.

A typical example of the application of this object may be reading the distribution of measured values concerning changing data.

It is possible to change the values of the vectors through the function “SetHistogramPoints” defined in the following pages, therefore easily integrating such an object into the application.

Figure 12. Histogram graphical object

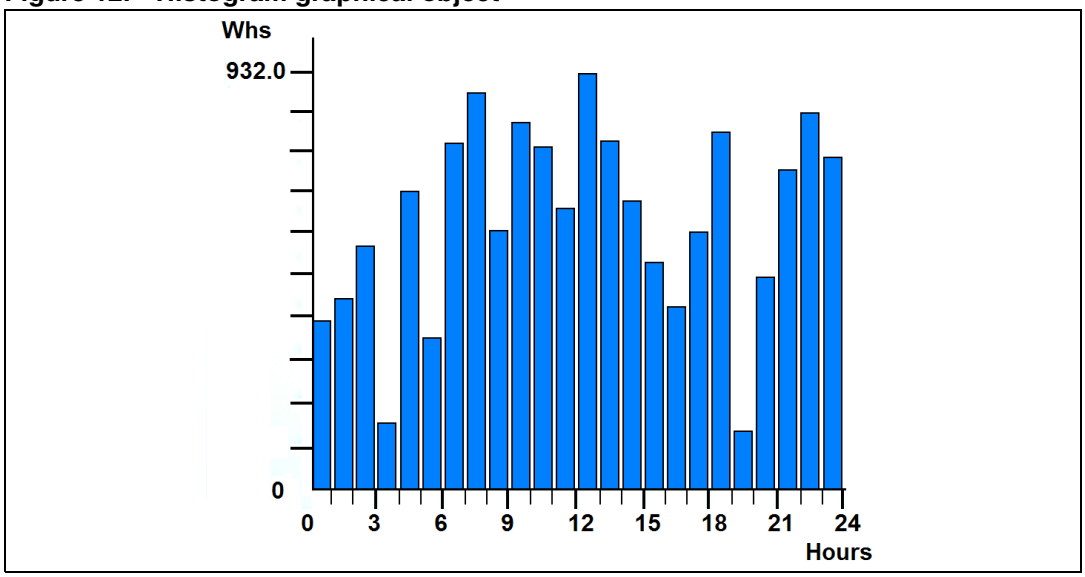


Table 16 describes the NewHistogram function:

Table 16. NewHistogram API function

Name	Description
Function name	NewHistogram
Function prototype	GL_PageControls_TypeDef* NewHistogram (char* oName, char* LabelX, char* LabelY, int16_t data_points[], GL_uint8_t n_points);
Behavior description	Create and initialize a new histogram object (a C structure)
Input parameter {x}	oName: object Name LabelX: Label for the X axis LabelY: Label for the Y axis data_points[]: the array of points to be plotted on the LCD pointer to function associated to its touch event n_points: number of points to be plotted
Output parameter {x}	None
Return value	The created object pointer or null if the object cannot be created

Table 16. NewHistogram API function (continued)

Name	Description
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );
/* Declares and initiates a Histogram Object and add it with specified coordinates to
a Page Object */
int16_tMyHistPoints[24];
MyHistPoints = {1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24};
GL_PageControls_TypeDef* MyHistogram = NewHistogram("MyHistogram", "Hours", "Wh",
                                                    MyHistPoints, 24 );
AddPageControlObj( 0, 0, MyHistogram, &page1 );
```

Once a histogram object instance is created using the NewHistogram function, the histogram object itself provides all its features through its internal function pointers.

Figure 14, *15*, *16*, show, in detail, the histogram object properties and methods which the final application can use to interact with.

4.1.12 NewGraphChart API global function

This kind of object is made up of two axes (X and Y) with the relative values printed to the side, and a certain number of blue columns representing the real distribution of respective values. The values are saved in a vector of decimal numbers.

A typical example of the application of this object may be reading the distribution of measured values concerning changing data.

It is possible to change the values of the vectors through the function “SetGraphChartPoints” defined in the following pages, therefore easily integrating such an object into the application.

Figure 13. GraphChart graphical object

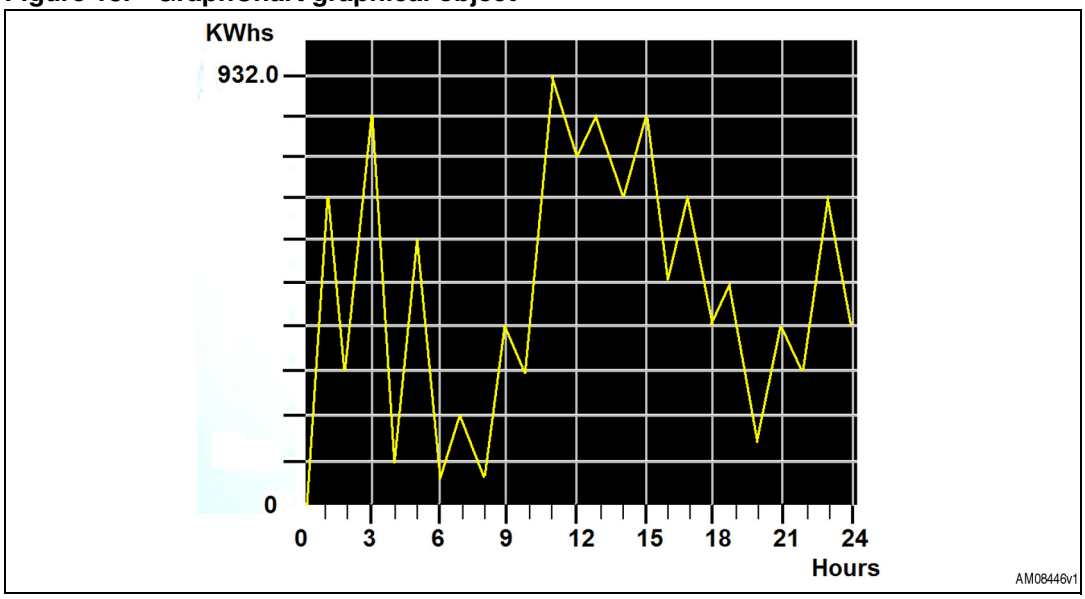


Table 17 describes the NewGraphChart function:

Table 17. NewGraphChart API function

Function name	NewGraphChart
Function prototype	GL_PageControls_TypeDef* NewGraphChart (char* oName, char* LabelX, char* LabelY, int16_tdata_points[], GL_uint8_t n_points, GL_bool Background)
Behavior description	Create and initialize a new GraphChart object (a C structure)
Input parameter {x}	oName: object Name LabelX: Label for the X axis LabelY: Label for the Y axis data_points[]: the array of points to be plotted on the LCD pointer to function associated to its touch event n_points: number of points to be plotted Background: select if black background has to be used. This parameter can be GL_TRUE or GL_FALSE
Output parameter {x}	None

Table 17. NewGraphChart API function (continued)

Function name	NewGraphChart
Return value	The created object pointer or null if the object cannot be created
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );

/* Declares & initiates a GraphChart Object and add it with specified coordinates to
a Page Object */
int16_tMyChartPoints[24];
MyChartPoints = {1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24};
GL_PageControls_TypeDef* MyGraphChart = NewGraphChart("MyGraphChart", "Hours", "Wh",
                                                      MyChartPoints, 24);
AddPageControlObj( 0, 0, MyGraphChart, &page1 );
```

Once a GraphChart object instance is created using the NewGraphChart function, the GraphChart object itself provides all its features through its internal function pointers.

Figure 14, *15*, *16*, show, in detail, the GraphChart object properties and methods which the final application can use to interact with.

4.1.13 AddPageControlObj API global function

Table 18 describes the AddPageControlObj function:

Table 18. AddPageControlObj API function

Name	Description
Function name	AddPageControlObj
Function prototype	GL_ErrStatus AddPageControlObj (GL_uint16_t PosX, GL_uint8_t PosY, GL_PageControls_TypeDef* objPTR, GL_Page_TypeDef* pagePTR)
Behavior description	Add a new control object to the page
Input parameter {x}	PosX & PosY: max and min coordinates for X and Y axis *objPTR: pointer to object structure *pagePTR: pointer to page structure
Output parameter {x}	None
Return value	GL_OK if successful, GL_ERROR otherwise
Required preconditions	NewXXX must have been called before, where XXX represents a kind of graphical object
Called functions	No API/HAL layer functions

The values of PosX and PosY parameters represent the coordinates of the top-left corner of the object according to the origin coordinates placed in the top-right corner of the LCD.

Example:

```
GL_ErrStatus errStatus;
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );
. . . . . .
/* Adding an object with specified coordinates to a Page Object */
errStatus =
AddPageControlObj((uint16_t)((LCD_Width/10)*7.5),(uint8_t)(LCD_Height/2),
                  MyGraphicObject, &page1);
```

Once a PageControl object instance is created using the AddPageControlObj function, the PageControl object itself provides all its features through its internal function pointers.

Figure 14, *15*, *16*, show, in detail, the PageControl object properties and methods which the final application can use to interact with.

4.1.14 DestroyPageControl API global function

Table 19 describes the DestroyPageControl function:

Table 19. DestroyPageControl API function

Name	Description
Function name	DestroyPageControl
Function prototype	GL_ErrStatus DestroyPageControl (GL_Page_TypeDef* pPage, char* objName)
Behavior description	Free the allocated memory for a PageControl object
Input parameter {x}	*pPage: pointer to page structure objName: name of the object
Output parameter {x}	None
Return value	GL_OK if successful, GL_ERROR otherwise
Required preconditions	NewXXX must have been called before, where XXX represents a kind of graphical object
Called functions	No API/HAL layer functions

Example:

```
GL_ErrStatus errStatus;
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );
...
/* Adding an object with specified coordinates to a PageControl Object */
errStatus = AddPageControlObj((uint16_t)(LCD_Width/2),(uint8_t)(LCD_Height/2),
                              MyGraphObj,&page1);

/* De-allocate a Page Object */
DestroyPageControl(page1, "MyGraphicObject");
```

Once a PageControl object instance is created, it can be destroyed at any time using the DestroyPageControl function, and its pointer is set to NULL.

4.1.15 DestroyPage API global function

Table 20 describes the DestroyPage function:

Table 20. DestroyPage API function

Name	Description
Function name	DestroyPage
Function prototype	GL_ErrStatus DestroyPage (GL_Page_TypeDef * pPage)
Behavior description	Free the allocated memory for all the PageControl objects belonging to a page
Input parameter {x}	*pPage: pointer to page structure
Output parameter {x}	None
Return value	GL_OK if successful, GL_ERROR otherwise
Required preconditions	NewXXX must have been called before, where XXX represents a kind of graphical object
Called functions	No API/HAL layer functions

Example:

```
GL_ErrStatus errStatus;
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );
. . . . . .

/* Adding an object with specified coordinates to a PageControl */
errStatus = AddPageControlObj( (uint16_t)(LCD_Width/2), (uint8_t)(LCD_Height/2),
                                MyGraphicObject, &page1);

/* De-allocate all the Object belonging to a Page */
DestroyPage(&page1);
```

Once a page object instance is created, it can be destroyed at any time using the DestroyPage function, and its pointer is set to NULL.

4.1.16 Set_Label API global function

Table 21 describes the Set_Label function:

Table 21. Set_Label API function

Name	Description
Function name	Set_Label
Function prototype	GL_ErrStatus Set_Label (GL_Page_TypeDef* pPage, char* objName, char* Label)
Behavior description	Modify the Label in a Label Object

Table 21. Set_Label API function (continued)

Name	Description
Input parameter {x}	pPage: pointer to page structure objName: name of the object Label: text on a Label Object
Output parameter {x}	None
Return value	GL_OK if successful, GL_ERROR otherwise
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );

/* Declares and initiates a Label Object and add it with specified coordinates to a
Page Object */
GL_PageControls_TypeDef* pageLabel = NewLabel("pageLabel", "Graphic Library",
                                                GL_HORIZONTAL, GL_FONT_BIG, GL_Blue);
AddPageControlObj((uint16_t)((LCD_Width/11)*9), (uint8_t)(LCD_Height/11), pageLabel,
                  &page1);

/* Modify the label in a "Label Object" */
Set_Label(&page1, "pageLabel", "Graphic Library New")
```

Figure 14, *15*, *16*, show, in detail, the Label Object properties and methods which the final application can use to interact with.

4.1.17 Get_Label API global function

Table 22 describes the Get_Label function:

Table 22. Get_Label API function

Name	Description
Function name	Get_Label
Function prototype	GL_ErrStatus Get_Label (GL_Page_TypeDef* pPage, char* objName, char* Label)
Behavior description	Return the Label of a Label Object
Input parameter {x}	*pPage: pointer to page structure objName: name of the object
Output parameter {x}	Label: this is the variable where the Label of a Label Object is copied into
Return value	GL_OK if successful, GL_ERROR otherwise
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );

/* Declares and initiates a Label Object and add it with specified coordinates to a
Page Object */
GL_PageControls_TypeDef* pageLabel = NewLabel("pageLabel", "Graphic Library",
                                                GL_HORIZONTAL, GL_FONT_BIG, GL_Blue);
AddPageControlObj((uint16_t)((LCD_Width/11)*9),(uint8_t)(LCD_Height/11),pageLabel,
                  &page1);

/* Modify the label in a "Label Object" */
Set_Label(&page1, "pageLabel", "Graphic Library New")

/* Get the label in a "Label Object" */
Char* label;
Get_Label(&page1, "pageLabel", label)
```

Figure 14, *15*, *16*, show, in detail, the Label Object properties and methods which the final application can use to interact with.

4.1.18 GetComboOptionLabel API global function

Table 23 describes the GetComboOptionLabel function:

Table 23. GetComboOptionLabel API function

Name	Description
Function name	GetComboOptionLabel
Function prototype	char* GetComboOptionLabel(GL_Page_TypeDef* pPage, char* objName)
Behavior description	Return the active combo option Label
Input parameter {x}	*pPage: pointer to page structure objName: name of the object
Output parameter {x}	None
Return value	char* Label: the active combo option Label if the object was found GL_NULL: if the object was not found
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );

/* Declares and initiates a Label Object and add it with specified coordinates to a
Page Object */
AddPageControlObj((uint16_t)((LCD_Width/11)*9),(uint8_t)(LCD_Height/11),pageLabel,
                  &page1);

/* Declares and initiates a Combobox object */
GL_PageControls_TypeDef* ComboBoxGrp1 = NewComboBoxGrp("ComboBoxGrp1");
```

```
AddComboOption (ComboBoxGrp1->objPTR, "Option1", ComboboxFunc);
AddComboOption (ComboBoxGrp1->objPTR, "Option2", ComboboxFunc);
AddComboOption (ComboBoxGrp1->objPTR, "Option3", ComboboxFunc);
AddPageControlObj((uint16_t)((LCD_Width/10)*7),(uint16_t)(LCD_Height/2),ComboBoxGrp1,
&page1);

/* Modify the label in a "Label Object by the active combobox option label" */
Set_Label( &page1, "pageLabel", GetComboOptionLabel(&page1, "ComboBoxGrp1") );
```

Figure 14, *15*, *16*, show, in detail, the Combobox object properties and methods which the final application can use to interact with.

4.1.19 SetComboOptionLabel API global function

Table 24 describes the SetComboOptionLabel function:

Table 24. SetComboOptionLabel API function

Name	Description
Function name	SetComboOptionLabel
Function prototype	GL_ErrStatus SetComboOptionLabel(GL_Page_TypeDef* pPage, char* objName, char* Label)
Behavior description	Set the Label for the active ComboOption
Input parameter {x}	*pPage: pointer to page structure objName: name of the object Label: new Label for the active ComboOption object
Output parameter {x}	None
Return value	GL_OK if successful, GL_ERROR otherwise
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );

/* Declares and initiates a Label Object and add it with specified coordinates to a
Page Object */
GL_PageControls_TypeDef* pageLabel = NewLabel("pageLabel", "Graphic Library",
                                                GL_HORIZONTAL, GL_FONT_BIG, GL_Blue);
AddPageControlObj((uint16_t)((LCD_Width/11)*9),(uint8_t)(LCD_Height/11),pageLabel,
                  &page1);

/* Declares and initiates a Combobox object */
GL_PageControls_TypeDef* ComboBoxGrp1 = NewComboBoxGrp("ComboBoxGrp1");
AddComboOption (ComboBoxGrp1->objPTR, "Option1", ComboboxFunc);
AddComboOption (ComboBoxGrp1->objPTR, "Option2", ComboboxFunc);
AddComboOption (ComboBoxGrp1->objPTR, "Option3", ComboboxFunc);
AddPageControlObj((uint16_t)((LCD_Width/10)*7),(uint16_t)(LCD_Height/2),ComboBoxGrp1,
                  &page1);
...
/* Modifying the active combobox option label" */
SetComboOptionLabel(&page1, "ComboBoxGrp1", "NewLabel");
```

Figure 14, *15*, *16*, show, in detail, the Combobox object properties and methods which the final application can use to interact with.

4.1.20 ResetComboOptionActive API global function

Table 25 describes the ResetComboOptionActive function:

Table 25. ResetComboOptionActive API function

Name	Description
Function name	ResetComboOptionActive
Function prototype	GL_ErrStatus ResetComboOptionActive(GL_Page_TypeDef* pPage, char* objName)
Behavior description	Reset the active combo option to the first one
Input parameter {x}	*pPage: pointer to page structure objName: name of the object
Output parameter {x}	None
Return value	GL_OK if successful, GL_ERROR otherwise
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );

/* Declares and initiates a Label Object and add it with specified coordinates to a
Page Object */
GL_PageControls_TypeDef* pageLabel = NewLabel("pageLabel", "Graphic Library",
                                                GL_HORIZONTAL, GL_FONT_BIG, GL_Blue);
AddPageControlObj(((LCD_Width/11)*9),(LCD_Height/11),pageLabel,&page1);
/* Declares and initiates a Combobox object */
GL_PageControls_TypeDef* ComboBoxGrp1 = NewComboBoxGrp("ComboBoxGrp1");
AddComboOption (ComboBoxGrp1->objPTR, "Option1", ComboboxFunc);
AddComboOption (ComboBoxGrp1->objPTR, "Option2", ComboboxFunc);
AddComboOption (ComboBoxGrp1->objPTR, "Option3", ComboboxFunc);
AddPageControlObj(((LCD_Width/10)*7),(LCD_Height/2),ComboBoxGrp1, &page1 );
...
void ChangeFirstComboLabel(void)
{
  if (page1.Page_Active == GL_TRUE)
  {
      page1.ShowPage(&page1, GL_FALSE);
      ResetComboOptionActive(&page1, "ComboBoxGrp1");
      /* Modify the active combobox option label" */
      SetComboOptionLabel(&page1, "ComboBoxGrp1", "Option1_New");
      page1.ShowPage(&page1, GL_TRUE);
  }
}
```

Figure 14, *15*, *16*, show, in detail, the Combobox object properties and methods which the final application can use to interact with.

4.1.21 GetComboOptionActive API global function

Table 26 describes the GetComboOptionActive function:

Table 26. GetComboOptionActive API function

Name	Description
Function name	GetComboOptionActive
Function prototype	GL_uint8_t GetComboOptionActive(GL_Page_TypeDef* pPage, char* objName)
Behavior description	Return the active combo option number
Input parameter {x}	*pPage: pointer to page structure objName: name of the object
Output parameter {x}	None
Return value	j: the active combo option index if the object was found GL_NULL: if the object was not found
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );

/* Declares and initiates a ComboBoxGroup with its ComboOptions Object and add it
with specified coordinates to a Page Object */
GL_PageControls_TypeDef* MyComboBoxGrp = NewComboBoxGrp("MyComboBoxGrp");
AddComboOption (MyComboBoxGrp ->objPTR, "Option1", MyComboboxFunc);
AddComboOption (MyComboBoxGrp ->objPTR, "Option2", MyComboboxFunc);
AddComboOption (MyComboBoxGrp ->objPTR, "Option3", MyComboboxFunc);

AddPageControlObj(((LCD_Width/10)*7),(LCD_Height/2),MyComboBoxGrp,&page1);

void MyComboboxFunc(void)
{
  if (page1.Page_Active == GL_TRUE)
  {
    if( GetComboOptionActive( &page1, "MyComboBoxGrp" ) == 1 )
    {
      GL_DisplayAdjStringLine( (uint16_t)(LCD_Height/2), (uint16_t)(LCD_Width),
                               "You've chosen option1", GL_TRUE );
    }
    else if( GetComboOptionActive( &page1, "MyComboBoxGrp" ) == 2 )
    {
      GL_DisplayAdjStringLine( (uint16_t)(LCD_Height/2), (uint16_t)(LCD_Width),
                               "You've chosen option2", GL_TRUE );
    }
    else if( GetComboOptionActive( &page1, "MyComboBoxGrp" ) == 3 )
    {
      GL_DisplayAdjStringLine( (uint16_t)(LCD_Height/2), (uint16_t)(LCD_Width),
                               "You've chosen option3", GL_TRUE );
    }
  }
}
```

4.1.22 SetIconImage API global function

Table 27 describes the SetIconImage function:

Table 27. SetIconImage API function

Name	Description
Function name	SetIconImage
Function prototype	GL_ErrStatus SetIconImage (GL_Page_TypeDef* pPage, char* objName, GL_uint8_t* pImage)
Behavior description	Return the image pointer of the icon object
Input parameter {x}	*pPage: pointer to page structure objName: name of the object pImage: pointer to the image Width: image width Height: image height
Output parameter {x}	None
Return value	GL_OK if successful, GL_ERROR otherwise
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
...
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );

/* Declares and initiates a Icon Object and add it with specified coordinates to a
Page Object */
GL_PageControls_TypeDef* MyIcon = NewIcon("MyIcon",(GL_uint8_t*)myImage1,90,90,
                                          IconFunc);
AddPageControlObj((uint16_t)((LCD_Width/2)+45),(uint8_t)((LCD_Height/2)+45),MyIcon,
                  &page1);
...

void IconFunc(void)
{
  if (page1.Page_Active == GL_TRUE)
  {
    GL_uint8_t* ptrBitmap = GL_NULL;
    ptrBitmap = (GL_uint8_t*)myImage2;
    SetIconImage( &page1, "MyIcon", ptrBitmap, 90, 90);
    RefreshPage( &page1 );
  }
}
```

4.1.23 Get_SlidebarValue API global function

Table 28 describes the Get_SlidebarValue function:

Table 28. Get_SlidebarValue API function

Name	Description
Function name	Get_SlidebarValue
Function prototype	uint8_t Get_SlidebarValue (GL_Page_TypeDef* pPage, char* objName)
Behavior description	Return the current value of cursor position in a slidebar object
Input parameter {x}	*pPage: pointer to page structure objName: name of the object
Output parameter {x}	None
Return value	The cursor position value (0-100 percentage)
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );

/* Declares and initiates a Slidebar Object and add it with specified coordinates to
a Page Object */
GL_PageControls_TypeDef* MySlidebar = NewSlidebar("MySlidebar", "Volume",
                                                  GL_Horizontal, MySlidebarFunc);
AddPageControlObj((uint16_t)((LCD_Width/10)*7),(uint8_t)((LCD_Height/9)*3),
                  MySlidebar,&page1);

...

uint8_t slidebarValue = Get_SlidebarValue(&page1, "MySlidebar" );
```

Figure 14, *15*, *16*, show, in detail, the slidebar object properties and methods which the final application can use to interact with.

4.1.24 SetHistogramPoints API global function

Table 29 describes the SetHistogramPoints function:

Table 29. SetHistogramPoints API function

Name	Description
Function name	SetHistogramPoints
Function prototype	GL_ErrStatus SetHistogramPoints(GL_Page_TypeDef* pPage,char* objName,int16_tdata_points[],GL_uint8_t n_points)
Behavior description	Modify the points array of the histogram object
Input parameter {x}	*pPage: pointer to page structure objName: name of the object data_points[]: the array of points to be plotted on the LCD n_points: number of points to be plotted
Output parameter {x}	None
Return value	GL_OK if successful, GL_ERROR otherwise
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );

/* Declares and initiates a Histogram Object and add it to a Page Object */
MyHistogram = NewHistogram ("MyHistogram", "Hours", "Watt", points, 24);
AddPageControlObj( 0, 0, MyHistogram, &page1 );
...
MyHistogramPoints ={1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24};

SetHistogramPoints( &page1, "MyHistogram", MyHistogramPoints, 24 );
```

Figure 14, *15*, *16*, show, in detail, the histogram object properties and methods which the final application can use to interact with.

4.1.25 SetGraphChartPoints API global function

Table 30 describes the SetGraphChartPoints function:

Table 30. SetGraphChartPoints API function

Name	Description
Function name	SetGraphChartPoints
Function prototype	GL_ErrStatus SetGraphChartPoints(GL_Page_TypeDef* pPage,char* objName,int16_tdata_points[],GL_uint8_t n_points);
Behavior description	Modify the points array of the GraphChart object

Table 30. SetGraphChartPoints API function (continued)

Name	Description
Input parameter {x}	*pPage: pointer to page structure objName: name of the object data_points[]: the array of points to be plotted on the LCD n_points: number of points to be plotted
Output parameter {x}	None
Return value	GL_OK if successful, GL_ERROR otherwise
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );

/* Declares and initiates a GraphChart Object and add it to a Page Object */
MyGraphChart = NewGraphChart("MyGraphChart", "Hours", "Watt", points, 24, GL_TRUE);
AddPageControlObj( 0, 0, MyGraphChart, &page1 );
...
MyGraphChartPoints={1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24};
SetGraphChartPoints( &page1, "MyGraphChart", MyGraphChartPoints, 24 );
```

Figure 14, *15*, *16*, show, in detail, the GraphChart object properties and methods which the final application can use to interact with.

4.1.26 GetObjStatus API global function

Table 31 describes the GetObjStatus function:

Table 31. GetObjStatus API function

Name	Description
Function name	GetObjStatus
Function prototype	GL_bool GetObjStatus(GL_Page_TypeDef* pThis, char* objName)
Behavior description	Return the status of the object: – GL_FALSE: the object is not Hit – GL_TRUE: the object has been Hit – NULL: represents that there are no objects with that name (objName).
Input parameter {x}	*pPage: pointer to page structure objName: name of the object
Output parameter {x}	None
Return value	GL_FALSE, GL_TRUE, or NULL in case no object is defined
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );

/* Declares and initiates a Checkbox Object and add it with specified coordinates to
a Page Object */
GL_PageControls_TypeDef* CheckBox = NewCheckbox("CheckBox", "Enable", CheckboxFunc);
AddPageControlObj( (uint16_t)((LCD_Width/10)*7), (uint8_t)((LCD_Height/9)*3),
                   CheckBox, &page1);

...

GL_bool checkboxStatus = GetObjStatus( &page1, "CheckBox" );
```

4.1.27 ShowPage API global function

Table 32 describes the ShowPage function:

Table 32. ShowPage API function

Name	Description
Function name	ShowPage
Function prototype	GL_ErrStatus ShowPage(GL_Page_TypeDef* pPage, GL_bool bVal)
Behavior description	GL_TRUE show / GL_FALSE hide the page
Input parameter {x}	*pPage: pointer to page structure bVal: GL_TRUE or GL_FALSE
Output parameter {x}	None
Return value	GL_OK if successful, GL_ERROR otherwise
Required preconditions	None
Called functions	No API/HAL layer functions

Example

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );
GL_PageControls_TypeDef* pageLabel = NewLabel( "pageLabel", "Graphic Library",
                                               GL_HORIZONTAL, GL_FONT_BIG, GL_Blue);
AddPageControlObj((uint16_t)((LCD_Width/11)*9),(uint8_t)(LCD_Height/11),pageLabel,
                  &page1);

GL_PageControls_TypeDef* Button1 = NewButton( "Button1", "BUTTON1", NullFunc );
AddPageControlObj((uint16_t)((LCD_Width/10)*6),(uint8_t)((LCD_Height/9)*5), Button1,
                  &page1);

GL_PageControls_TypeDef* Button2 = NewButton( "Button2", "BUTTON2", NullFunc );
AddPageControlObj((uint16_t)((LCD_Width/10)*6),(uint8_t)((LCD_Height/9)*7), Button2,
                  &page1);
...
GL_Clear(White);
GL_SetTextColor(GL_Blue);
page1.ShowPage( &page1, GL_TRUE );
```

4.1.28 RefreshPage API global function

Table 33 describes the RefreshPage function:

Table 33. RefreshPage API function

Name	Description
Function name	RefreshPage
Function prototype	void RefreshPage (GL_Page_TypeDef* pPage)
Behavior description	Refresh the page if the status of any object was changed.
Input parameter {x}	*pPage: pointer to page structure
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );
GL_PageControls_TypeDef* pageLabel = NewLabel("pageLabel", "Graphic Library",
                                                GL_HORIZONTAL, GL_FONT_BIG, GL_Blue);
AddPageControlObj((uint16_t)((LCD_Width/11)*9),(uint8_t)(LCD_Height/11), pageLabel,
                  &page1 );
GL_PageControls_TypeDef* Button1 = NewButton("Button1","BUTTON1", NullFunc );
AddPageControlObj((uint16_t)((LCD_Width/10)*6),(uint8_t)((LCD_Height/9)*5),Button1,
                  &page1 );

GL_PageControls_TypeDef* Button2 = NewButton( "Button2", "BUTTON2", NullFunc );
AddPageControlObj((uint16_t)((LCD_Width/10)*6),(uint8_t)((LCD_Height/9)*7),Button2,
                  &page1);
...
GL_Clear(White);
GL_SetTextColor(GL_Blue);
page1.ShowPage( &page1, GL_TRUE );
/* Modify the label in a "Label Object" */
Set_Label(&page1, "pageLabel", "Graphic Lib New")
RefreshPage(&page1);
```

4.1.29 RefreshPageControl API global function

Table 34 describes the RefreshPageControl:

Table 34. RefreshPage API function

Name	Description
Function name	RefreshPageControl
Function prototype	GL_ErrStatus RefreshPageControl (GL_Page_TypeDef* pPage, char* objName)
Behavior description	Refresh the visualization of a page control object.
Input parameter {x}	*pPage: pointer to page structure objName: name of the object
Output parameter {x}	None
Return value	GL_OK if successful, GL_ERROR otherwise
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
/* Declares and initiates a Page Object */
GL_Page_TypeDef page1;
Create_PageObj( &page1 );

GL_PageControls_TypeDef* pageLabel = NewLabel("pageLabel", "Graphic Library",
GL_HORIZONTAL, GL_FONT_BIG, GL_Blue);
AddPageControlObj((uint16_t)((LCD_Width/11)*9),(uint8_t)(LCD_Height/11), pageLabel,
                  &page1);

GL_PageControls_TypeDef* Button1 = NewButton( "Button1", "BUTTON1", NullFunc );
AddPageControlObj((uint16_t)((LCD_Width/10)*6),(uint8_t)((LCD_Height/9)*5),Button1,
                  &page1);

GL_PageControls_TypeDef* Button2 = NewButton( "Button2", "BUTTON2", NullFunc );
AddPageControlObj((uint16_t)((LCD_Width/10)*6),(uint8_t)((LCD_Height/9)*7),Button2,
                  &page1);

...

GL_Clear(White);
GL_SetTextColor(GL_Blue);
page1.ShowPage( &page1, GL_TRUE );

/* Modify the label in a "Label Object" */
Set_Label(&page1, "pageLabel", "Graphic Lib New")

RefreshPageControl(&page1, "pageLabel");
```

4.1.30 ChangePage API global function

Table 35 describes the ChangePage function:

Table 35. ChangePage API function

Name	Description
Function name	ChangePage
Function prototype	void ChangePage(GL_Page_TypeDef* pPageOld, GL_Page_TypeDef* pPageNew)
Behavior description	Change the current page shown on the LCD
Input parameter {x}	*pPageOld: pointer to page structure of the current page *pPageNew: pointer to page structure of the new page
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
int void main(void)
{
 /* Declares and initiates a Page Object */
 GL_Page_TypeDef page1, page2;
 Create_PageObj( &page1 );
 Create_PageObj( &page2 );

 GL_PageControls_TypeDef* pageLabel = NewLabel("pageLabel", "Graphic Library",
 GL_HORIZONTAL, GL_FONT_BIG, GL_Blue);
 AddPageControlObj((uint16_t)((LCD_Width/11)*9),(uint8_t)(LCD_Height/11),pageLabel,
                   &page1);
 GL_PageControls_TypeDef* Button1 = NewButton( "Button1", "BUTTON1", NextPageFunc );
 AddPageControlObj((uint16_t)((LCD_Width/10)*6),(uint8_t)((LCD_Height/9)*5),Button1,
                   &page1);

 GL_PageControls_TypeDef* Button2 = NewButton( "Button2", "BUTTON2", BackPageFunc );
 AddPageControlObj((uint16_t)((LCD_Width/10)*6),(uint8_t)((LCD_Height/9)*7),Button2,
                   &page2);

...

 GL_Clear(White);
 GL_SetTextColor(GL_Blue);
 page1.ShowPage( &page1, GL_TRUE );
}


void NextPageFunc(void)
{
   ChangePage(&page1, &page2);
}

void BackPageFunc(void)
{
   ChangePage(&page2, &page1);
```

4.1.31 Set_LCD_Resolution API global function

Table 36 describes the Set_LCD_Resolution function:

Table 36. Set_LCD_Resolution API global function

Name	Description
Function name	Set_LCD_Resolution
Function prototype	void Set_LCD_Resolution (uint16_t Lcd_Width, uint16_t Lcd_Height)
Behavior description	Set LCD panel resolution
Input parameter {x}	uint16_t Lcd_Width: width of the LCD Panel uint16_t Lcd_Height: height of the LCD Panel
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
int main(void)
{
  ...
  Set_LCD_Resolution( 640, 480 );
  GL_LCD_Init();
  GL_Clear(White);
  ...
}
```

4.1.32 Set_LastFlashMemoryAddress API global function

Table 37 describes the Set_LastFlashMemoryAddress function:

Table 37. Set_LastFlashMemoryAddress API global function

Name	Description
Function name	Set_LastFlashMemoryAddress
Function prototype	void Set_LastFlashMemoryAddress (uint32_t address)
Behavior description	Set the last Flash memory address. This address is used to calculate the penultimate Flash memory page, where the calibration parameters are saved.
Input parameter {x}	uint32_t address: pointer to the last memory location
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
int main(void)
{
  ...
  Set_LastFlashMemoryAddress( 0x08040000 );
  ...
}
```

The address of the Flash memory page, where the calibration parameters are saved, is calculated by subtracting from the last Flash memory address, the size of one memory page corresponding to “1024” (if a page is “1024 bytes”) and the size in bytes of a memory pointer, “4” (32-bit), just to align the address to the start of a memory page location. Therefore, if the Flash memory size is 256 KB and the ROM start address is 0x08000000, it is necessary to subtract 0x0400+0x0004=0x0404 (1024+4=1028 in decimal) from 0x08040000 that is the last Flash memory address. The result is: 0x0803EFD8.

4.1.33 CursorInit API global function

The cursor is composed of two essential elements. The first is a data structure which gathers all the necessary variables for regular cursor operations including user-defined settings, and secondly a graphic appearance displayed on a screen, letting the user know about its position as a main purpose of it.

In the meantime, the cursor seems to act as a graphic object, but it is different because it is not involved in the user events management.

Although the actual implementation of the cursor can manage only the input from the joystick, its structure also supports the input from the mouse connected to a USB port (this feature is to be available in a future release).

The cursor data structure gathers all variables needed for the regular functioning of service routines, such as coordinates, press state, pointer to the cursor bitmap mask, and array of background pixel color. This array, together with a pixels pointer mask serves as storage for pixels located behind an actual pointer mark. They must be saved before the cursor is displayed, in order to allow the removal of the cursor when just these stored pixels are employed to overdraw an old-positioned cursor. Therefore, no information is lost by cursor drawing (moving).

The CursorInit function initializes a cursor, allocating the memory for the cursor data structure and afterwards allocating the memory for behind data pixels regarding the number of pixels listed in the pointer mark header. *Table 38* describes the CursorInit function:

Table 38. CursorInit API global function

Name	Description
Function name	CursorInit
Function prototype	ErrorStatus CursorInit (GL_uint8_t *PointerMark)
Behavior description	Initiate the cursor including allocating memory for structure and behind array.
Input parameter {x}	*PointerMark: pointer to the cursor mask
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
int main(void)
{
  LCD_HW_Parameters_TypeDef* pLcdParam = NewLcdHwParamObj ();
  TSC_HW_Parameters_TypeDef* pTscParam = NewTscHwParamObj ();
  JOY_HW_Parameters_TypeDef* pJoyParam = NewJoyHwParamObj ();
  BTN_HW_Parameters_TypeDef* pBtnParam = NewBtnHwParamObj ();

  ...

  /* Touch Screen Init */
  TSC_Init();

  /* Joystick Init */
  GL_JoyStickConfig_GPIO();

  ...

  CursorInit( GL_NULL );
  ...
}
```

4.1.34 CursorShow API global function

The function CursorShow sets an initial value of the Cursor position. *Table 39* describes the CursorShow function:

Table 39. CursorShow API function

Name	Description
Function name	CursorShow
Function prototype	void CursorShow (GL_uint16_t Xpos, GL_uint16_t Ypos)
Behavior description	Show the cursor at the specified position.
Input parameter {x}	Xpos: specifies the X position of cursor Ypos: specifies the Y position of cursor
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	No API/HAL layer functions

Example:

```
int main(void)
{
  LCD_HW_Parameters_TypeDef* pLcdParam = NewLcdHwParamObj ();
  TSC_HW_Parameters_TypeDef* pTscParam = NewTscHwParamObj ();
  JOY_HW_Parameters_TypeDef* pJoyParam = NewJoyHwParamObj ();
  BTN_HW_Parameters_TypeDef* pBtnParam = NewBtnHwParamObj ();

  ...

  /* Touch Screen Init */
  TSC_Init();

  /* Joystick Init */
```

```
  GL_JoyStickConfig_GPIO();

  ...

  CursorInit( GL_NULL );
  CursorShow(195, 60);
  ...
}
```

Figure 14. Firmware library API types

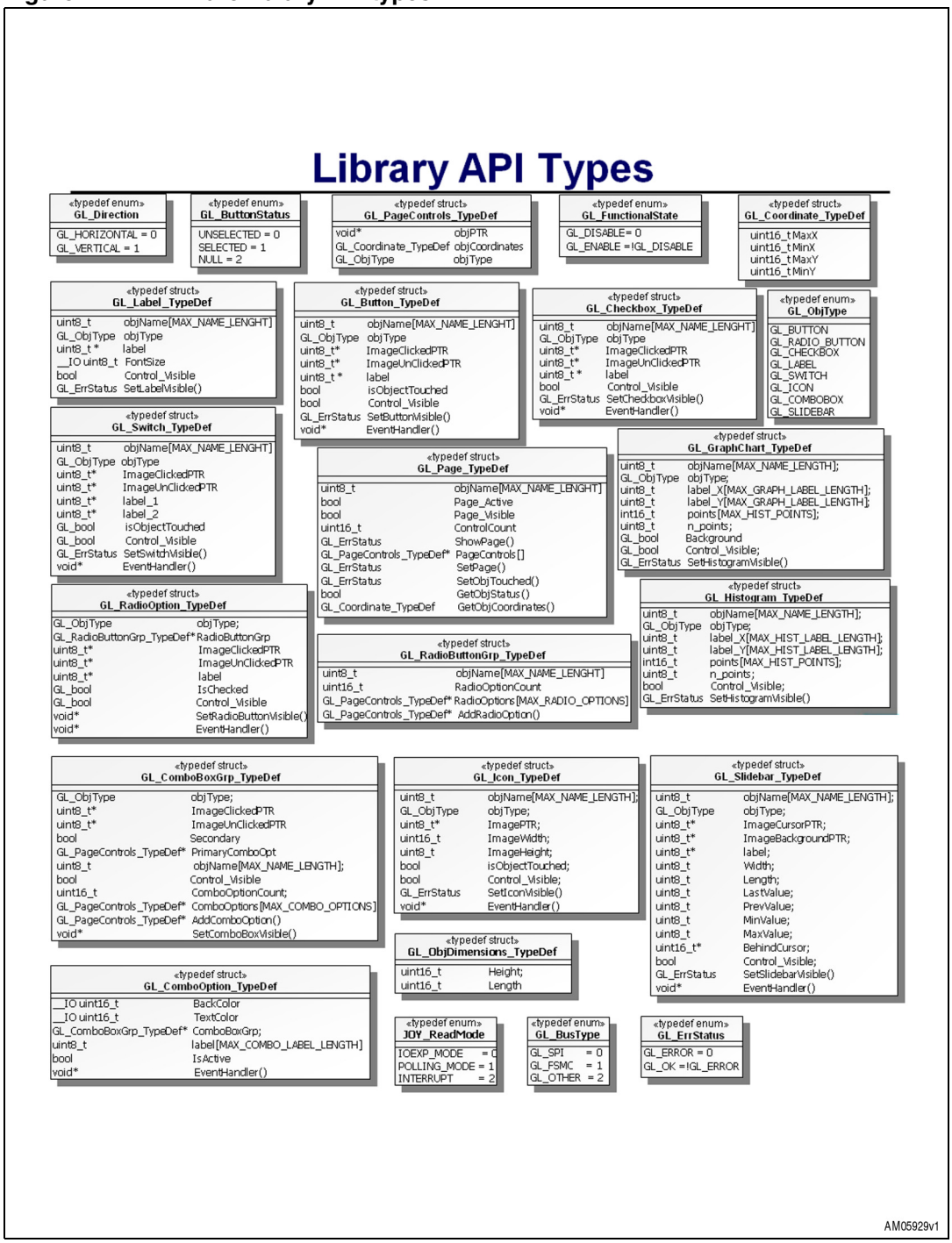


Figure 15. Firmware library API functions

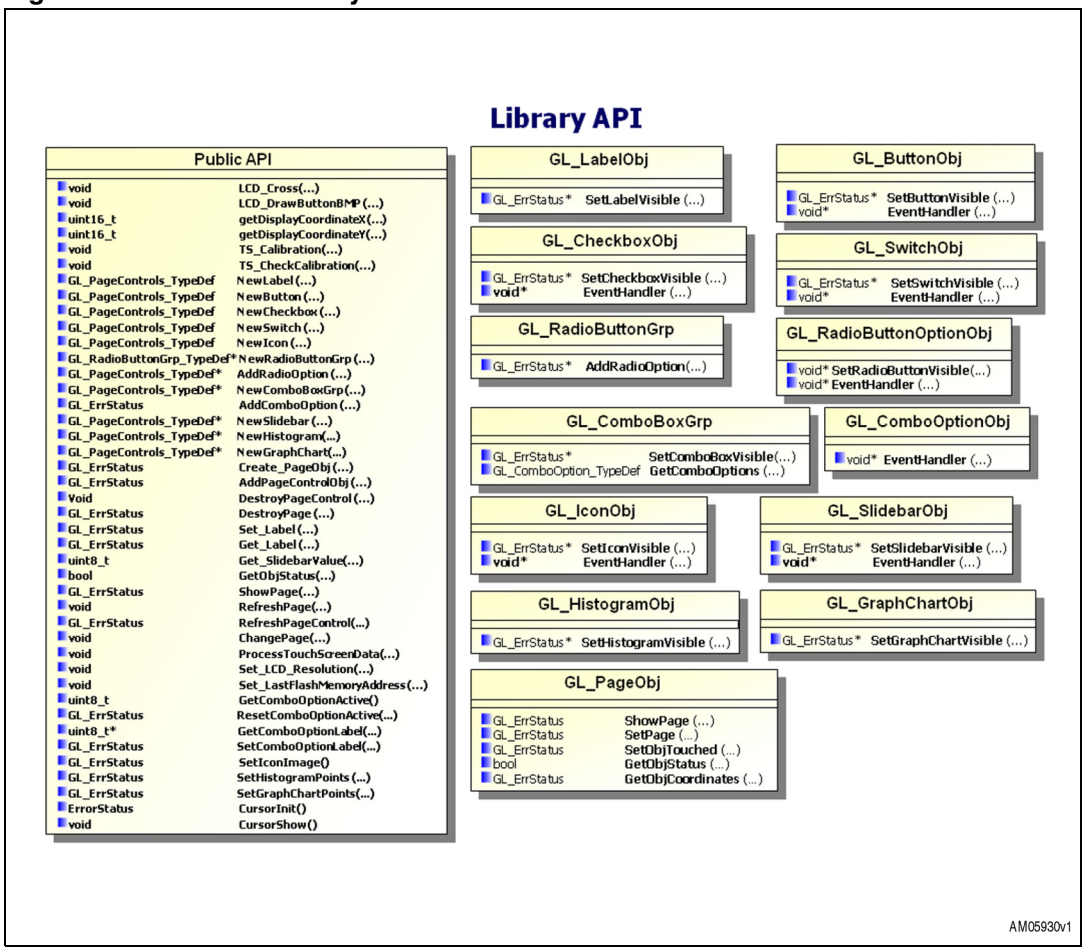
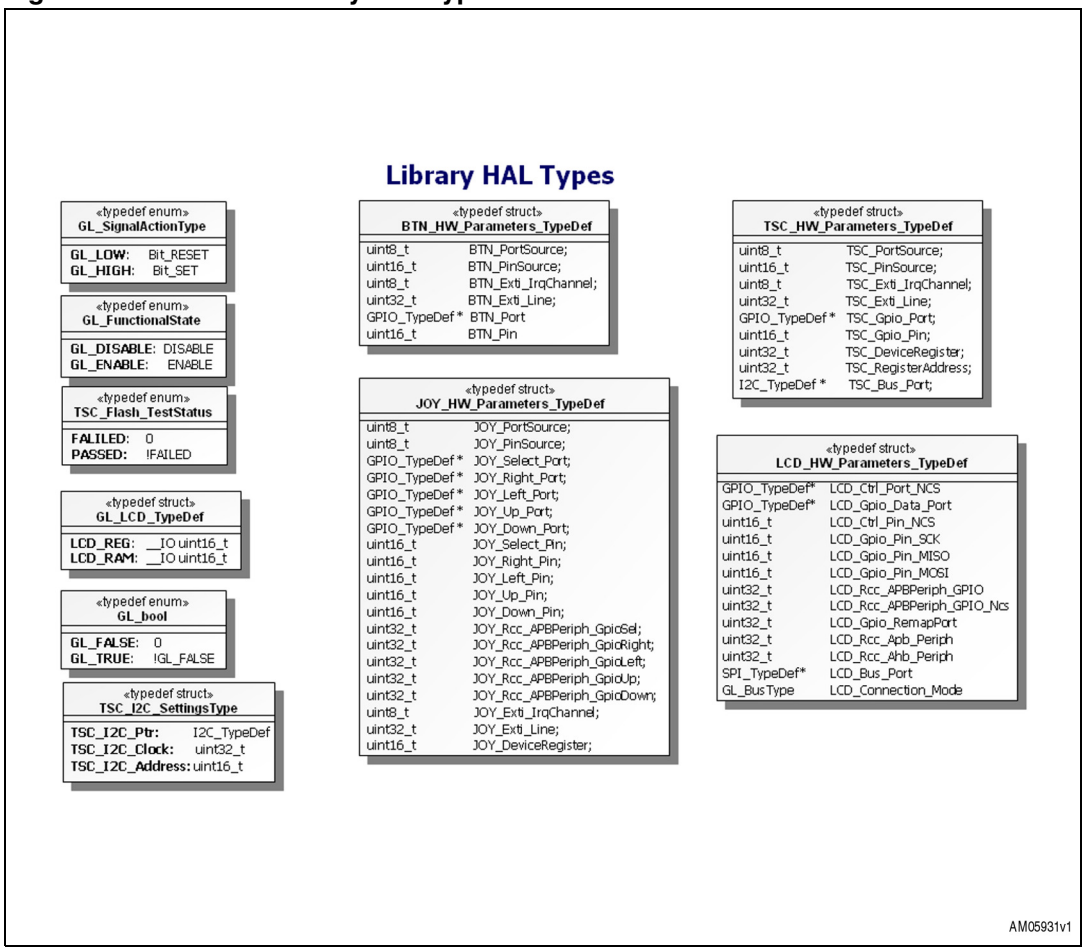


Figure 16. Firmware library HAL types



4.2 Graphic objects API types

This section describes the graphic object structures, and all their exported API functions and defined types. See *Figure 14*, *15*, *16*.

Here is a description of the defined types used by graphic object source code and a description of its properties and methods. All API layer types are defined in the file GraphicObjectTypes.h.

The following structure types can be considered as OOP classes including private/public properties and public methods. The final graphic objects are instances of these defined structures.

These structure fields' parameters must not be directly accessed by the final application and Getxxx/Setxxx methods should be used instead. Obviously the final application could access these private members, but it should never do so.

The final application must interact with this library using the following public properties and methods only, as described in the following sections.

4.2.1 GL_ErrStatus type

```
/* Error status types */
typedef enum {
    GL_ERROR = 0,
    GL_OK = !GL_ERROR
} GL_ErrStatus;
```

4.2.2 GL_Direction type

```
/* Direction of LCD orientation */
typedef enum {
    GL_HORIZONTAL = 0,
    GL_VERTICAL
} GL_Direction;
```

4.2.3 GL_ButtonStatus type

```
/* Status value type */
typedef enum {
    UNSELECTED = 0,
    SELECTED = 1,
    NULL = 2
} GL_ButtonStatus;
```

4.2.4 GL_ObjType type

```
/* Enumerator for Graphic Object types */
typedef enum{
    GL_BUTTON,
    GL_RADIO_BUTTON,
    GL_CHECKBOX,
    GL_LABEL,
    GL_SWITCH,
    GL_ICON,
    GL_COMBOBOX,
    GL_SLIDEBAR
}GL_ObjType;
```

4.2.5 GL_Coordinate_TypeDef type

```
/* Display Coordinates for the Graphic Object */
typedef struct
{ GL_uint16_t MaxX;
  GL_uint16_t MinX;
  GL_uint16_t MaxY;
  GL_uint16_t MinY;
}GL_Coordinate_TypeDef;
```

4.2.6 GL_PageControls_TypeDef type

```
/* Object type */

/* Forward declaration for circular typedefs */
typedef struct GL_PageControlsObj GL_PageControls_TypeDef;
struct GL_PageControlsObj
{
  void*                  objPTR;
  GL_Coordinate_TypeDef  objCoordinates;
  GL_ObjType             objType;
};
```

4.2.7 GL_Label_TypeDef type

```
/* Object type */

/* Forward declaration for circular typedefs */
typedef struct GL_LabelObj GL_Label_TypeDef;
struct GL_LabelObj
{
  const uint8_t
  GL_ObjType     objType;
  const uint8_t  label[MAX_LABEL_LENGTH];
  __IO uint8_t   FontSize;
  GL_bool        Control_Visible;
  GL_ErrStatus   (*SetLabelVisible)(GL_Label_TypeDef* pThis, GL_Coordinate_TypeDef
                  objCoordinates);
};
```

4.2.8 GL_Button_TypeDef type

```
/* Object type */

/* Forward declaration for circular typedefs */
typedef struct GL_ButtonObj GL_Button_TypeDef;
struct GL_ButtonObj
{
  const uint8_t  objName[MAX_NAME_LENGHT];
  GL_ObjType     objType;
  GL_uint8_t*    ImageClickedPTR;
  GL_uint8_t*    ImageUnClickedPTR;
  const uint8_t  label[MAX_BUTTON_LABEL_LENGTH];
  GL_bool        isObjectTouched;
  GL_bool        Control_Visible;
  GL_ErrStatus   (*SetButtonVisible)(GL_Button_TypeDef* pThis, GL_Coordinate_TypeDef
                 objCoordinates);
  void*        (*EventHandler)(void);
};
```

4.2.9 GL_CheckboxObj_TypeDef type

```
/* Object type */

/* Forward declaration for circular typedefs */
typedef struct GL_ CheckboxObj GL_CheckboxObj_TypeDef;
struct GL_ButtonObj
{
  char         objName[MAX_NAME_LENGHT];
  GL_ObjType   objType;
  GL_uint8_t*  ImageClickedPTR;
  GL_uint8_t*  ImageUnClickedPTR;
  char         label[MAX_CHECKBOX_LABEL_LENGTH];
  GL_bool      IsChecked;
  GL_bool      Control_Visible;
  GL_ErrStatus (*SetCheckboxVisible)(GL_Checkbox_TypeDef* pThis,
                GL_Coordinate_TypeDef objCoordinates);
  void*        (*EventHandler)(void);
};
```

4.2.10 GL_SwitchObj_TypeDef type

```
/* Object type */

/* Forward declaration for circular typedefs */
typedef struct GL_SwitchObj GL_Switch_TypeDef;
struct GL_SwitchObj
{
  char          objName[MAX_NAME_LENGHT];
  GL_ObjType    objType;
  GL_uint8_t*   ImageClickedPTR;
  GL_uint8_t*   ImageUnClickedPTR;
  char          label_1[MAX_SWITCH_LABEL_LENGTH];
  char          label_2[MAX_SWITCH_LABEL_LENGTH];
  GL_bool       isObjectTouched;
  GL_bool       Control_Visible;
  GL_ErrStatus  (*SetSwitchVisible)(GL_Switch_TypeDef* pThis, GL_Coordinate_TypeDef
                objCoordinates);
  void*         (*EventHandler)(void);
};
```

4.2.11 GL_RadioButtonGrp_TypeDef type

```
/* Object type */

/* Forward declaration for circular typedefs */
typedef struct GL_RadioButtonGrp GL_RadioButtonGrp_TypeDef;
struct GL_RadioButtonGrp
{
  const uint8_t            objName[MAX_NAME_LENGTH];
  GL_uint16_t              RadioOptionCount;
  GL_PageControls_TypeDef* RadioOptions[MAX_RADIO_OPTIONS];
  GL_PageControls_TypeDef* (*AddRadioOption)( GL_RadioButtonGrp_TypeDef* pThis,
                            const* uint8_t label, void* (*pEventHandler)(void) );
};
```

4.2.12 GL_RadioButton_TypeDef type

```
/* Object type */

/* Forward declaration for circular typedefs */
typedef struct GL_RadioButtonOptionObj GL_RadioOption_TypeDef;
struct GL_RadioButtonOptionObj
{
  GL_ObjType                 objType;
  GL_RadioButtonGrp_TypeDef* RadioButtonGrp;
  GL_uint8_t*                ImageCheckedPTR;
  GL_uint8_t*                ImageUnCheckedPTR;
  char                       label[MAX_RADIO_OPTION_LABEL_LENGTH];
  GL_bool                    IsChecked;
  GL_bool                    Control_Visible;
  GL_ErrStatus               (*SetRadioButtonVisible)(GL_RadioOption_TypeDef* pThis,
                             GL_Coordinate_TypeDef objCoordinates);
  void*                      (*EventHandler)(void);
};
```

4.2.13 GL_ComboBoxGrp_TypeDef type

```
/* Object type */

/* Forward declaration for circular typedefs */
typedef struct GL_ComboBoxGrp GL_ComboBoxGrp_TypeDef;
struct GL_ComboBoxGrp
{
  GL_ObjType                objType;
  GL_uint8_t*               ImageClickedPTR;
  GL_uint8_t*               ImageUnClickedPTR;
  GL_bool                   Secondary;
  GL_PageControls_TypeDef*  PrimaryComboOpt;
  char                      objName[MAX_NAME_LENGTH];
  GL_bool                   Control_Visible;
  GL_uint16_t               ComboOptionCount;
  GL_ComboOption_TypeDef*   ComboOptions[MAX_COMBO_OPTIONS];
  GL_ErrStatus              (*AddComboOption)(GL_ComboBoxGrp_TypeDef* pThis, char*
                            label, void* (*pEventHandler)(void) );
  GL_ErrStatus              (*SetComboBoxVisible)(GL_ComboBoxGrp_TypeDef* pThis,
                            GL_Coordinate_TypeDef objCoordinates);
};
```

4.2.14 GL_ComboOption_TypeDef type

```
/* Object type */

/* Forward declaration for circular typedefs */
typedef struct GL_ComboOptionObj GL_ComboOption_TypeDef;
struct GL_ComboBoxGrp
{
  __IO uint16_t           BackColor;
  GL_vuint16_t            TextColor;
  GL_ComboBoxGrp_TypeDef* ComboBoxGrp;
  char                    label[MAX_COMBO_LABEL_LENGTH];
  GL_bool                 IsActive;
  void*                   (*EventHandler)(void);
};
```

4.2.15 GL_Icon_TypeDef type

```
/* Object type */

/* Forward declaration for circular typedefs */
typedef struct GL_IconObj GL_Icon_TypeDef;
struct GL_IconObj
{
  char         objName[MAX_NAME_LENGTH];
  GL_ObjType   objType;
  GL_uint8_t*  ImagePTR;
  GL_uint16_t  ImageWidth;
  GL_uint8_t   ImageHeight;
  GL_bool      isObjectTouched;
  GL_bool      Control_Visible;
  GL_ErrStatus (*SetIconVisible)(GL_Icon_TypeDef* pThis, GL_Coordinate_TypeDef
                objCoordinates);
  void*        (*EventHandler)(void);
};
```

4.2.16 GL_Slidebar_TypeDef type

```
/* Object type */

/* Forward declaration for circular typedefs */
typedef struct GL_SlidebarObj GL_Slidebar_TypeDef;
struct GL_SlidebarObj
{
  char           objName[MAX_NAME_LENGTH];
  GL_ObjType     objType;
  GL_uint8_t*    ImageCursorPTR;
  GL_uint8_t*    ImageBackgroundPTR;
  char           label[MAX_SLIDE_LABEL_LENGTH];
  GL_Direction   Direction;
  GL_uint8_t     Width;
  GL_uint8_t     Length;
  GL_uint8_t     LastValue;
  GL_uint8_t     PrevValue;
  GL_uint8_t     MinValue;
  GL_uint8_t     MaxValue;
  GL_uint16_t*   BehindCursor;
  GL_bool        Control_Visible;
  GL_ErrStatus   (*SetSlidebarVisible)(GL_Slidebar_TypeDef* pThis,
                 GL_PageControls_TypeDef* pControl);
  void*          (*EventHandler)(void);
};
```

4.2.17 GL_Histogram_TypeDef type

```
/* Object type */

/* Forward declaration for circular typedefs */
typedef struct GL_HistogramObj GL_Histogram_TypeDef;
struct GL_HistogramObj
{
  char           objName[MAX_NAME_LENGTH];
  GL_ObjType     objType;
  char           label_X[MAX_HIST_LABEL_LENGTH];
  char           label_Y[MAX_HIST_LABEL_LENGTH];
  int16_t        points[MAX_HIST_POINTS];
  GL_uint8_t     n_points;
  GL_bool        Control_Visible;
  GL_ErrStatus   (*SetHistogramVisible)(GL_Histogram_TypeDef* pThis);
};
```

4.2.18 GL_GraphChart_TypeDef type

```
/* Object type */

/* Forward declaration for circular typedefs */
typedef struct GL_GraphChartObj GL_GraphChart_TypeDef;
struct GL_GraphChartObj
{
  char           objName[MAX_NAME_LENGTH];
  GL_ObjType     objType;
  char           label_X[MAX_GRAPH_LABEL_LENGTH];
  char           label_Y[MAX_GRAPH_LABEL_LENGTH];
  int16_t        points[MAX_GRAPH_POINTS];
  GL_uint8_t     n_points;
  GL_bool        Background;
  GL_bool        Control_Visible;
  GL_ErrStatus   (*SetGraphChartVisible)(GL_GraphChart_TypeDef* pThis);
};
```

4.2.19 GL_ObjDimensions_TypeDef type

```
/* Object type */

typedef struct
{ GL_uint16_t Height;
  GL_uint16_t Length;
}GL_ObjDimensions_TypeDef;
```

4.2.20 GL_Page_TypeDef type

```
/* Object type */

/* Forward declaration for circular typedefs */
typedef struct GL_PageObj GL_Page_TypeDef;
struct GL_PageObj
{
  char                    objName[MAX_NAME_LENGTH];
  GL_bool                 Page_Active;
  GL_bool                 Page_Visible;
  GL_uint16_t             ControlCount;
  GL_ErrStatus            (*ShowPage)(GL_Page_TypeDef* pThis, GL_bool bVal);
  GL_PageControls_TypeDef* PageControls[MAX_CTRL_X_PAGE];
  GL_ErrStatus            (*SetPage)(GL_Page_TypeDef* pThis, GL_bool bVal);
  GL_bool                 (*GetObjStatus)(GL_Page_TypeDef* pThis, char* objName);
  GL_Coordinate_TypeDef   (*GetObjCoordinates)(GL_Page_TypeDef* pThis, char*
                           objName);
};
```

4.2.21 GL_BusType type

```
/* Communication Bus Type enumeration */
typedef enum
{
  GL_SPI   = 0,
  GL_FSMC  = 1,
  GL_OTHER = 2
}GL_BusType;
```

4.2.22 LCD_HW_Parameters_TypeDef type

```
/* Object type */
typedef struct   /* It contains the Hardware Parameter for the LCD (Bus, Port, Pins)
*/
{
  GL_PortType *  LCD_Ctrl_Port_NCS;
  GL_PortType *  LCD_Gpio_Data_Port;
  GL_uint16_t    LCD_Ctrl_Pin_NCS;
  GL_uint16_t    LCD_Gpio_Pin_SCK;
  GL_uint16_t    LCD_Gpio_Pin_MISO;
  GL_uint16_t    LCD_Gpio_Pin_MOSI;
  GL_uint32_t    LCD_Rcc_APBPeriph_GPIO;
  GL_uint32_t    LCD_Rcc_APBPeriph_GPIO_Ncs;
  GL_uint32_t    LCD_Gpio_RemapPort;
  GL_uint32_t    LCD_Rcc_Apb_Periph;
  GL_uint32_t    LCD_Rcc_Ahb_Periph;
  GL_SPIType *   LCD_Bus_Port;
  GL_BusType     LCD_Connection_Mode;
}LCD_HW_Parameters_TypeDef;
```

4.2.23 TSC_HW_Parameters_TypeDef type

```
/* Object type */
typedef struct /* It contains the Hardware Parameter for the Touchscreen Controller
(Bus, Port, Pins) */
{
  GL_uint8_t     TSC_PortSource;
  GL_uint16_t    TSC_PinSource;
  GL_uint8_t     TSC_Exti_IrqChannel;
  GL_uint32_t    TSC_Exti_Line;
  GL_PortType *  TSC_Gpio_Port;
  GL_uint16_t    TSC_Gpio_Pin;
  GL_uint16_t    TSC_DeviceRegister;
  GL_I2CType *   TSC_Bus_Port
}TSC_HW_Parameters_TypeDef;
```

4.2.24 JOY_HW_Parameters_TypeDef type

```
/* Object type */
typedef struct   /* It contains the Hardware Parameter for the Joystick (Bus, Port,
Pins) */
{
  GL_uint8_t     JOY_PortSource;
  GL_uint8_t     JOY_PinSource;
  GL_PortType *  JOY_Select_Port;
  GL_PortType *  JOY_Right_Port;
  GL_PortType *  JOY_Left_Port;
  GL_PortType *  JOY_Up_Port;
  GL_PortType *  JOY_Down_Port;
  GL_uint16_t    JOY_Select_Pin;
  GL_uint16_t    JOY_Right_Pin;
  GL_uint16_t    JOY_Left_Pin;
  GL_uint16_t    JOY_Up_Pin;
  GL_uint16_t    JOY_Down_Pin;
  GL_uint32_t    JOY_Rcc_APBPeriph_GpioSel;
  GL_uint32_t    JOY_Rcc_APBPeriph_GpioRight;
  GL_uint32_t    JOY_Rcc_APBPeriph_GpioLeft;
  GL_uint32_t    JOY_Rcc_APBPeriph_GpioUp;
  GL_uint32_t    JOY_Rcc_APBPeriph_GpioDown;
  GL_uint8_t     JOY_Exti_IrqChannel;
  GL_uint32_t    JOY_Exti_Line;
  GL_uint16_t    JOY_DeviceRegister;
}JOY_HW_Parameters_TypeDef;
```

4.2.25 JOY_ReadMode type

```
/* Joystick Reading Mode */
typedef enum   /* It contains the Reading Mode Parameter for the Joystick (Polling
Mode, IOExpander) */
{
  IOEXP_MODE    = 0,
  POLLING_MODE  = 1,
  INTERRUPT     = 2
}JOY_ReadMode;
```

4.2.26 BTN_HW_Parameters_TypeDef type

```
/* Object type */
typedef struct   /* It contains the Hardware Parameter for the Push Button (i.e.
Port, Pin) */
{
  GL_uint8_t     BTN_PortSource;
  GL_uint16_t    BTN_PinSource;
  GL_uint8_t     BTN_Exti_IrqChannel;
  GL_uint32_t    BTN_Exti_Line;
  GL_PortType *  BTN_Port
  GL_uint16_t    BTN_Pin
  GL_PortType *  BUTTON_Port;
  GL_uint16_t    BUTTON_Pin;
}BTN_HW_Parameters_TypeDef;
```

4.3 Graphic object API properties

4.3.1 Graphics controls:: properties

Below are some DEFINES that are useful for some of the graphic object parameters.

```
#define MAX_CTRL_X_PAGE 30 /* Defines the Max number of graphic objects per page */
#define MAX_NAME_LENGTH 22 /* Defines the Max name length for graphic objects */
#define MAX_LABEL_LENGTH 46 /* Defines the Max length for Label (Label objects) */
#define MAX_BUTTON_LABEL_LENGTH 16 /*Defines the Max Label length of Button objects*/
#define MAX_CHECKBOX_LABEL_LENGTH 25 /* Defines the Max Label length for Checkbox */
#define MAX_RADIO_OPTION_LABEL_LENGTH 12 /* Defines the Max Label length of
RadioButton */
#define MAX_RADIO_OPTIONS 3 /* Defines the Max options number of RadioButton group */
#define MAX_COMBO_OPTIONS 10 /* Defines the Max values number of ComboBox objects */
#define MAX_COMBO_LABEL_LENGTH 16 /* Defines the Max Label length for the ComboBox */
#define MAX_SWITCH_LABEL_LENGTH 12 /* Defines the Max Label length for the Switch */
#define MAX_SLIDE_LABEL_LENGTH 16 /* Defines the Max Label length for the Slidebar */
#define MAX_HIST_LABEL_LENGTH 7  /* Defines the Max Label length for the Histogram */
#define MAX_GRAPH_LABEL_LENGTH 7 /* Defines the Max Label length for the GraphChart */
#define MAX_HIST_POINTS 50 /* Defines the Max number of points for the Histogram */
#define MAX_GRAPH_POINTS 100 /* Defines the Max number of points for the GraphChart */
```

4.3.2 Graphic Object:: PagesList array

The GraphicObject.h library file exports the following public property:

```
extern GL_Page_TypeDef* PagesList[];
```

PagesList contains the array of page pointers created statically by the application. This object has been left as public for utility means.

4.3.3 LCD:: pLcdParam API properties

LcdHal.c exports the following public structure variable:

```
LCD_HW_Parameters_TypeDef * pLcdParam; /* LCD Hardware Parameters Structure */
```

pLcdParam hardware properties allow the final application to set the hardware communication parameter (Bus GPIO port, GPIO pins).

- LCD_Ctrl_Port_NCS is the GPIO port that contains the GPIO pin which the LCD control pin is connected to
- LCD_Gpio_Data_Port is the GPIO port dedicated to data transfer

- LCD_Ctrl_Pin_NCS is the GPIO pin which the LCD control pin is connected to
- LCD_Gpio_Pin_SCK is the SPI clock pin needed by the SPI interface for the communication between LCD and micro
- LCD_Gpio_Pin_MISO is the SPI MISO pin needed by the SPI interface for the communication between LCD and micro
- LCD_Gpio_Pin_MOSI is the SPI MOSI pin needed by the SPI interface for the communication between LCD and micro
- LCD_Gpio_RemapPort specifies eventually the SPI alternate function mapping
- LCD_Rcc_APBPeriph_GPIO specifies the IO port clock for the LCD data transfer, the APB peripheral that gates the clock
- LCD_Rcc_APBPeriph_GPIO_Ncs specifies the IO port clock for the NCS control port of the LCD
- LCD_Rcc_Apb_Periph selects the APB peripheral bus that gates the clock
- LCD_Rcc_Ahb_Periph selects the AHB peripheral bus that gates the clock
- LCD_Bus_Port is the communication interface port used by the LCD (i.e. SPI/I2C)
- LCD_Connection_Mode indicates the way in which the LCD is connected (i.e. FSMC/SPI/OTHER).

Some examples are listed below:

File: hw_config.h

```
//LCD Controller DEFINES
#define LCD_CTRL_PORT_NCS            GPIOB
#define LCD_GPIO_DATA_PORT           GPIOC
#define LCD_CTRL_PIN_NCS             GPIO_Pin_2
#define LCD_GPIO_PIN_SCK             GPIO_Pin_10
#define LCD_GPIO_PIN_MISO            GPIO_Pin_11
#define LCD_GPIO_PIN_MOSI            GPIO_Pin_12
#define LCD_GPIO_RCC_APB_PERIPH      RCC_APB2Periph_GPIOC
#define LCD_GPIO_RCC_APB_PERIPH_NCS  RCC_APB2Periph_GPIOB
#define LCD_GPIO_REMAP_PORT          GPIO_Remap_SPI3
#define LCD_RCC_APB_PERIPH           RCC_APB1Periph_SPI3
#define LCD_SPI_PORT                 SPI3

#define LCD_CONNECTION_MODE          GL_FSMC

LCD_HW_Parameters_TypeDef* pLcdParam;
File: hw_config.c

void HWConfig_SetHardwareParams(void)

{
 ...
    pLcdParam = NewLcdHwParamObj();

    /* Assign the following values for LCD Controller Parameters Structure */
    pLcdParam->LCD_Ctrl_Port_NCS          = LCD_CTRL_PORT_NCS;
    pLcdParam->LCD_Gpio_Data_Port         = LCD_GPIO_DATA_PORT;
    pLcdParam->LCD_Ctrl_Pin_NCS           = LCD_CTRL_PIN_NCS;
    pLcdParam->LCD_Ctrl_Pin_NWR           = LCD_CTRL_PIN_NWR;
    pLcdParam->LCD_Ctrl_Pin_RS            = LCD_CTRL_PIN_RS;
    pLcdParam->LCD_Gpio_Pin_SCK           = LCD_GPIO_PIN_SCK;
    pLcdParam->LCD_Gpio_Pin_MISO          = LCD_GPIO_PIN_MISO;
    pLcdParam->LCD_Gpio_Pin_MOSI          = LCD_GPIO_PIN_MOSI;
    pLcdParam->LCD_Gpio_RemapPort         = LCD_GPIO_REMAP_PORT;
    pLcdParam->LCD_Rcc_APBPeriph_GPIO     = LCD_GPIO_RCC_APB_PERIPH;
    pLcdParam->LCD_Rcc_APBPeriph_GPIO_Ncs = LCD_GPIO_RCC_APB_PERIPH_NCS;
```

```
    pLcdParam->LCD_Rcc_Apb_Periph          = LCD_RCC_APB_PERIPH;
    pLcdParam->LCD_Rcc_Ahb_Periph          = LCD_RCC_AHB_PERIPH;
    pLcdParam->LCD_Bus_Port                = LCD_SPI_PORT;
    pLcdParam->LCD_Connection_Mode         = LCD_CONNECTION_MODE;
    ...
}
```

4.3.4 Touchscreen:: pTscParam API properties

TscHal.c exports the following public structure variable:

```
TSC_HW_Parameters_TypeDef * pTscHwParam; /* Touchscreen Hardware Parameters
Structure */
```

pTscParam properties allow setting the hardware communication parameters (Bus GPIO port, GPIO pins).

- TSC_PortSource selects the GPIO port to be used as source for event output for the touchscreen controller
- TSC_PinSource is the GPIO pin for the event output
- TSC_Exti_IrqChannel selects the external line interrupts
- TSC_Exti_Line selects the external interrupt line which the touchscreen controller is connected to
- TSC_Gpio_Port is the GPIO port needed for the communication between the touchscreen controller and micro
- TSC_Gpio_Pin is the GPIO pin needed for the communication between the touchscreen controller and micro
- TSC_DeviceRegister selects the touchscreen controller if two STMPE811s are connected to be used as the IO expander
- TSC_Bus_Port is the communication interface channel for the communication between the touchscreen controller and the microcontroller.

Some examples are listed below:

File: hw_config.h

```
// Touchscreen Controller DEFINES
#define TSC_GPIO_PORT_SOURCE      GPIO_PortSourceGPIOB
#define TSC_GPIO_PIN_SOURCE       GPIO_PinSource14
#define TSC_EXTI_IRQ_CHANNEL      EXTI15_10_IRQn
#define TSC_EXTI_LINE             EXTI_Line14
#define TSC_GPIO_PORT             GPIOA
#define TSC_GPIO_PIN              GPIO_Pin_14
#define TSC_I2C_DEVICE_REGISTER   0x82
#define TSC_I2C_PORT              I2C1

TSC_HW_Parameters_TypeDef* pTscParam;
File: hw_config.c

void HWConfig_SetHardwareParams(void)

{
  ...
  pTscParam = NewTscHwParamObj();
  /* Assign the following value for Touchscreen Controller
  Parameters Structure */
  pTscParam->TSC_PortSource           = GL_GPIO_TSC_PORT_SOURCE;
  pTscParam->TSC_PinSource            = GL_GPIO_TSC_PIN_SOURCE;
  pTscParam->TSC_Exti_IrqChannel      = TSC_EXTI_IRQ_CHANNEL;
  pTscParam->TSC_Exti_Line            = TSC_EXTI_LINE;
```

```
  pTscParam->TSC_Gpio_Port            = TSC_GPIO_PORT;
  pTscParam->TSC_Gpio_Pin             = TSC_GPIO_PIN;
  pTscParam->TSC_DeviceRegister       = TSC_I2C_DEVICE_REGISTER;
  pTscParam->TSC_Bus_Port             = TSC_I2C_PORT;
}
```

4.3.5 Joystick:: pJoyParam API properties

JoyHal.c exports the following public structure variable:

```
JOY_HW_Parameters_TypeDef* pJoyParam; /*Joystick Hardware Parameters Structure */
```

pJoyHwParam properties allow setting the hardware communication parameters (Bus GPIO port, GPIO pins).

- JOY_PortSource selects the GPIO port to be used as source for event output for the joystick
- JOY_PinSource is the GPIO pin for the event output
- JOY_Select_Port selects the GPIO port to be used for the select command on the joystick
- JOY_Select_Pin selects the GPIO pin to be used for the select command on the joystick
- JOY_Right_Port selects the GPIO port to be used for the right command on the joystick
- JOY_Right_Pin selects the GPIO pin to be used for the right command on the joystick
- JOY_Left_Port selects the GPIO port to be used for the left command on the joystick
- JOY_Left_Pin selects the GPIO pin to be used for the left command on the joystick
- JOY_Up_Port selects the GPIO port to be used for the up command on the joystick
- JOY_Up_Pin selects the GPIO pin to be used for the up command on the joystick
- JOY_Down_Port selects the GPIO port to be used for the down command on the joystick
- JOY_Down_Pin selects the GPIO pin to be used for the down command on the joystick
- JOY_Rcc_APBPeriph_GpioSel selects the APB peripheral bus that gates the select port of the joystick
- JOY_Rcc_APBPeriph_GpioRight selects the APB peripheral bus that gates the right port of the joystick
- JOY_Rcc_APBPeriph_GpioLeft selects the APB peripheral bus that gates the left port of the joystick
- JOY_Rcc_APBPeriph_GpioUp selects the APB peripheral bus that gates the up port of the joystick
- JOY_Rcc_APBPeriph_GpioDown selects the APB peripheral bus that gates the down port of the joystick
- JOY_Exti_IrqChannel selects the external line interrupts
- JOY_Exti_Line selects the external interrupt line which the joystick is connected to
- JOY_DeviceRegister if the joystick is connected to an IO expander (i.e. STMPE811) it selects the STMPE811 device if, for example, two STMPE811s are connected to be used as the IO expander.

Some examples are listed below:

File: hw_config.h

```
/* Joystick DEFINES */
#define GL_GPIO_JOY_PORT_SOURCE   GPIO_PortSourceGPIOB
#define GL_GPIO_JOY_PIN_SOURCE    GPIO_PinSource14
#define JOY_GPIO_SELECT_PORT      GPIOG
#define JOY_GPIO_SELECT_PIN       GPIO_Pin_7
#define JOY_GPIO_RIGHT_PORT       GPIOG
#define JOY_GPIO_RIGHT_PIN        GPIO_Pin_13
#define JOY_GPIO_LEFT_PORT        GPIOG
#define JOY_GPIO_LEFT_PIN         GPIO_Pin_14
#define JOY_GPIO_UP_PORT          GPIOG
#define JOY_GPIO_UP_PIN           GPIO_Pin_15
#define JOY_GPIO_DOWN_PORT        GPIOD
#define JOY_GPIO_DOWN_PIN         GPIO_Pin_3
#define JOY_GPIO_RCC_APB_PERIPH1  RCC_APB2Periph_GPIOG
#define JOY_GPIO_RCC_APB_PERIPH2  RCC_APB2Periph_GPIOG
#define JOY_GPIO_RCC_APB_PERIPH3  RCC_APB2Periph_GPIOG
#define JOY_GPIO_RCC_APB_PERIPH4  RCC_APB2Periph_GPIOG
#define JOY_GPIO_RCC_APB_PERIPH5  RCC_APB2Periph_GPIOD
#define JOY_EXTI_IRQ_CHANNEL      EXTI15_10_IRQn
#define JOY_EXTI_LINE             EXTI_Line14
#define JOY_I2C_DEVICE_REGISTER   0x88

JOY_HW_Parameters_TypeDef * pJoyParam;
File: hw_config.c

void HWConfig_SetHardwareParams(void)

{
  ...
  /* Assign the following value for Joystick Parameters Structure */
  pJoyParam->JOY_PortSource              = GL_GPIO_JOY_PORT_SOURCE;
  pJoyParam->JOY_PinSource               = GL_GPIO_JOY_PIN_SOURCE;
  pJoyParam->JOY_Select_Port             = JOY_GPIO_SELECT_PORT;
  pJoyParam->JOY_Select_Pin              = JOY_GPIO_SELECT_PIN;
  pJoyParam->JOY_Right_Port              = JOY_GPIO_RIGHT_PORT;
  pJoyParam->JOY_Right_Pin               = JOY_GPIO_RIGHT_PIN;
  pJoyParam->JOY_Left_Port               = JOY_GPIO_LEFT_PORT;
  pJoyParam->JOY_Left_Pin                = JOY_GPIO_LEFT_PIN;
  pJoyParam->JOY_Up_Port                 = JOY_GPIO_UP_PORT;
  pJoyParam->JOY_Up_Pin                  = JOY_GPIO_UP_PIN;
  pJoyParam->JOY_Down_Port               = JOY_GPIO_DOWN_PORT;
  pJoyParam->JOY_Down_Pin                = JOY_GPIO_DOWN_PIN;
  pJoyParam->JOY_Rcc_APBPeriph_GpioSel   = JOY_GPIO_RCC_APB_PERIPH1;
  pJoyParam->JOY_Rcc_APBPeriph_GpioRight = JOY_GPIO_RCC_APB_PERIPH2;
  pJoyParam->JOY_Rcc_APBPeriph_GpioLeft  = JOY_GPIO_RCC_APB_PERIPH3;
  pJoyParam->JOY_Rcc_APBPeriph_GpioUp    = JOY_GPIO_RCC_APB_PERIPH4;
  pJoyParam->JOY_Rcc_APBPeriph_GpioDown  = JOY_GPIO_RCC_APB_PERIPH5;
  pJoyParam->JOY_Exti_IrqChannel         = JOY_EXTI_IRQ_CHANNEL;
  pJoyParam->JOY_Exti_Line               = JOY_EXTI_LINE;
  pJoyParam->JOY_DeviceRegister          = JOY_I2C_DEVICE_REGISTER;
  ...
}
```

4.3.6 Push user button:: pBtnParam API properties

JoyHal.c exports the following public structure variable:

```
BTN_HW_Parameters_TypeDef* pBtnParam; /*Push Button Hardware Parameters Structure */
```

pBtnParam properties allow setting the hardware communication parameters (GPIO port, GPIO pins).

- BTN_PortSource selects the GPIO port to be used as source for event output for the push button
- BTN_PinSource is the GPIO pin for the event output
- BTN_Exti_IrqChannel selects the external line interrupts
- BTN_Exti_Line selects the external interrupt line which the push button is connected to
- BTN_Port is the GPIO port needed for the communication between push button and micro
- BTN_Pin is the GPIO pin needed for the communication between push button and micro

Some examples are listed below:

File: hw_config.h

```
// Push Button DEFINES
#define BUTTON_GPIO_PORT   GPIOG
#define BUTTON_GPIO_PIN    GPIO_Pin_8

BTN_HW_Parameters_TypeDef * pBtnParam;

File: hw_config.c

void HWConfig_SetHardwareParams(void)

{
    ...
    pBtnParam = NewBtnHwParamObj ();

    /* Assign the following values for Button Parameters structure*/
    pBtnParam->BTN_Port = USER_BUTTON_PORT;
    pBtnParam->BTN_Pin  = USER_BUTTON_PIN;
    ...
}
```

4.4 HAL layer firmware overview

The following section describes the hardware abstraction layer function used by the upper API layer described in the previous section. All the library microcontroller hardware dependent functions and related defined types are described in this section. See *Figure 14*, *15*, *16*.

The final application should never directly use these HAL functions, and it should only manage LCD, touchscreen, and joystick through API layer functions as described above.

4.5 HAL types

4.5.1 GL_bool type

```
/* Boolean Definition Type */

typedef enum
{
   GL_FALSE = 0,
   GL_TRUE  = !GL_FALSE,
}GL_bool;
```

4.5.2 GL_FlagStatus/GL_ITStatus type

```
/* Flag/IT Status Type */
typedef enum /* It contains the status parameter of LCD Flags/Interrupts
                (GL_RESET, GL_SET) */
{
  GL_RESET    = 0,
  GL_SET      = !GL_RESET,
}GL_FlagStatus, GL_ITStatus;
```

4.5.3 GL_SignalActionType type

```
/* Signal state enumeration */
typedef enum
{
  GL_LOW   = Bit_RESET,
  GL_HIGH  = Bit_SET
}GL_SignalActionType;
```

4.5.4 GL_FunctionalState type

```
/* Error status types */
typedef enum {
    GL_DISABLE = 0,
    GL_ENABLE = GL_DISABLE
} GL_FunctionalState;
```

4.5.5 TSC_I2C_SettingsType type

```
/* The TouchScreen I2C Peripheral settings */
typedef struct
{
  GL_I2CType *        TSC_I2C_Ptr;
  GL_uint32_t         TSC_I2C_Clock;
  GL_uint16_t         TSC_I2C_Address;
}TSC_I2C_SettingsType;
```

4.5.6 TSC_Flash_TestStatus type

```
/* For Flash Programming */
typedef enum {FAILED = 0, PASSED = !FAILED} TSC_Flash_TestStatus;
```

4.5.7 GL_LCD_TypeDef type

```
/* LCD Structure definition */
typedef enum
{
  __IO uint16_t LCD_REG;
  __IO uint16_t LCD_RAM;
} GL_LCD_TypeDef;
```

4.6 HAL functions

4.6.1 NewLcdHwParamObj HAL function

Table 40 describes the NewLcdHwParamObj function of the hardware abstraction layer.

Table 40. NewLcdHwParamObj

Name	Description
Function name	NewLcdHwParamObj
Function prototype	LCD_HW_Parameters_TypeDef* NewLcdHwParamObj (void)
Behavior description	Create and initialize a new LCD Hw parameter structure object
Input parameter {x}	None
Output parameter {x}	None
Return value	The created object pointer
Required preconditions	None
Called functions	None

4.6.2 GL_SetTextColor HAL function

Table 41 describes the GL_SetTextColor function of the hardware abstraction layer.

Table 41. GL_SetTextColor

Name	Description
Function name	GL_SetTextColor
Function prototype	void GL_SetTextColor (__IO uint16_t TextColor)
Behavior description	Sets the text color
Input parameter {x}	Color: specifies the text color code RGB (5-6-5)
Output parameter {x}	TextColor: text color global variable used by GL_DrawChar and GL_DrawPicture functions
Return value	None

Table 41. GL_SetTextColor (continued)

Name	Description
Required preconditions	None
Called functions	LCD_SetTextColor (TextColor)

4.6.3 GL_SetBackColor HAL function

Table 42 describes the GL_SetBackColor function of the hardware abstraction layer.

Table 42. GL_SetBackColor

Name	Description
Function name	GL_SetBackColor
Function prototype	void GL_SetBackColor (__IO uint16_t BackColor)
Behavior description	Sets the background color
Input parameter {x}	Color: specifies the background color code RGB(5-6-5)
Output parameter {x}	BackColor: background color global variable used by GL_DrawChar and GL_DrawPicture functions
Return value	None
Required preconditions	None
Called functions	LCD_SetBackColor (BackColor)

4.6.4 GL_Clear HAL function

Table 43 describes the GL_Clear function of the hardware abstraction layer.

Table 43. GL_Clear

Name	Description
Function name	GL_Clear
Function prototype	void GL_Clear (GL_uint16_t color)
Behavior description	Clears the whole LCD
Input parameter {x}	Color: the color of the background
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	LCD_Clear (Color)

4.6.5 GL_LCD_DrawCharTransparent HAL function

Table 44 describes the GL_LCD_DrawCharTransparent function of the hardware abstraction layer.

Table 44. GL_LCD_DrawCharTransparent HAL function

Name	Description
Function name	GL_LCD_DrawCharTransparent
Function prototype	void GL_LCD_DrawCharTransparent (uint8_t Xpos, uint16_t Ypos, uc8 *c) //8bit char
Behavior description	Draws a character on the LCD without background
Input parameter {x}	Xpos: the line where the character shape is displayed. This parameter can be one of the following values: - Linex: where x is 0..9 Ypos: start column address. c: pointer to the character data
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	None

4.6.6 GL_LCD_DrawChar HAL function

Table 45 describes the GL_LCD_DrawChar function of the hardware abstraction layer.

Table 45. GL_LCD_DrawChar HAL function

Name	Description
Function name	GL_LCD_DrawChar
Function prototype	void GL_LCD_DrawChar (uint8_t Xpos, uint16_t Ypos, uc8 *c) //8bit char
Behavior description	Draws a character on the LCD with background color
Input parameter {x}	Xpos: the line where the character shape is displayed. This parameter can be one of the following values: Linex: where x is 0..9 Ypos: start column address. c: pointer to the character data
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	None

4.6.7 GL_DisplayAdjStringLine HAL function

Table 46 describes the GL_DisplayAdjStringLine function of the hardware abstraction layer.

Table 46. GL_DisplayAdjStringLine

Name	Description
Function name	GL_DisplayAdjStringLine
Function prototype	void GL_DisplayAdjStringLine (GL_uint8_t Line, GL_uint16_t Column, GL_uint8_t *ptr, GL_bool Transparent_Flag)
Behavior description	Displays a maximum of 20 char on the LCD
Input parameter {x}	Line: the line where the character shape is displayed *ptr: pointer to the string to display on LCD
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	None

4.6.8 GL_LCD_DisplayChar HAL function

Table 47 describes the GL_LCD_DisplayChar function of the hardware abstraction layer.

Table 47. GL_LCD_DisplayChar

Name	Description
Function name	GL_LCD_DisplayChar
Function prototype	void GL_LCD_DisplayChar (uint8_t Line, uint16_t Column, uint8_t Ascii, GL_bool Transparent_Flag)
Behavior description	Displays one character (16 dots width, 24 dots height)
Input parameter {x}	Line: the line where the character shape is displayed. This parameter can be one of the following values: Linex: where x can be 0..9 Column: start column address Ascii: character ascii code, must be between 0x20 and 0x7E GL_bool Trasparent_Flag, if TRUE it does not print a BackColor
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	GL_LCD_DrawCharTransparent or GL_LCD_DrawChar

4.6.9 GL_SetDisplayWindow HAL function

Table 48 describes the GL_SetDisplayWindow function of the hardware abstraction layer.

Table 48. GL_SetDisplayWindow

Name	Description
Function name	GL_SetDisplayWindow
Function prototype	void GL_SetDisplayWindow (GL_uint8_t Xpos, GL_uint16_t Ypos, GL_uint8_t Height, GL_uint16_t Width)
Behavior description	Sets a display window
Input parameter {x}	Xpos: specifies the X bottom left position Ypos: specifies the Y bottom left position Height: display window height. Width: display window width.
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	LCD_SetDisplayWindow(Xpos, Ypos, Height, Width)

4.6.10 GL_DrawLine HAL function

Table 49 describes the GL_DrawLine function of the hardware abstraction layer.

Table 49. GL_DrawLine

Name	Description
Function name	GL_DrawLine
Function prototype	void GL_DrawLine (GL_uint8_t Xpos, GL_uint16_t Ypos, GL_uint16_t Length, GL_uint8_t Direction)
Behavior description	Displays a line
Input parameter {x}	Xpos: specifies the X position. Ypos: specifies the Y position. Length: line length. Direction: line direction. This parameter can be one of the following values: Vertical or Horizontal.
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	LCD_DrawLine (Xpos, Ypos, Length, Direction)

4.6.11 GL_DrawBMP HAL function

Table 50 describes the GL_DrawBMP function of the hardware abstraction layer.

Table 50. GL_DrawBMP

Name	Description
Function name	GL_DrawBMP
Function prototype	void GL_DrawBMP (GL_uint8_t* ptrBitmap)
Behavior description	Displays a bitmap picture
Input parameter {x}	BmpAddress: Bmp picture address
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	None

4.6.12 GL_SetFont HAL function

Table 51 describes the GL_SetFont function of the hardware abstraction layer.

Table 51. GL_SetFont

Name	Description
Function name	GL_SetFont
Function prototype	void GL_SetFont (GL_uint8_t uFont)
Behavior description	Sets the font (big or small)
Input parameter {x}	uFont: specifies the font (GL_FONT_BIG or GL_FONT_SMALL)
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	None

4.6.13 GL_BackLightSwitch HAL function

Table 52 describes the GL_BackLightSwitch function of the hardware abstraction layer.

Table 52. GL_BackLightSwitch

Name	Description
Function name	GL_BackLightSwitch
Function prototype	void GL_BackLightSwitch (GL_uint8_t uint8_t_State)
Behavior description	Switches the backlight either ON or OFF
Input parameter {x}	State: ON or OFF

Table 52. GL_BackLightSwitch (continued)

Name	Description
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	None

4.6.14 GL_BUSConfig HAL function

Table 53 describes the GL_BUSConfig function of the hardware abstraction layer.

Table 53. GL_BUSConfig

Name	Description
Function name	GL_BUSConfig
Function prototype	void GL_BUSConfig (GL_BusType busType)
Behavior description	Configures the BUS communication interface
Input parameter {x}	Bus type: GL_SPI or GL_FSMC
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	None

4.6.15 GL_LCD_Init HAL function

Table 54 describes the GL_LCD_Init function of the hardware abstraction layer.

Table 54. GL_LCD_Init

Name	Description
Function name	GL_LCD_Init
Function prototype	void GL_LCD_Init (void)
Behavior description	Initializes the LCD
Input parameter {x}	None
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	LCD_Setup()

4.6.16 NewTscHwParamObj HAL function

Table 55 describes the NewTscHwParamObj function of the hardware abstraction layer.

Table 55. NewTscHwParamObj

Name	Description
Function name	NewTscHwParamObj
Function prototype	TSC_HW_Parameters_TypeDef* NewTscHwParamObj (void)
Behavior description	Create and initialize a new touchscreen Hw parameter structure object used by the micro in order to manage the touchscreen controller device
Input parameter {x}	None
Output parameter {x}	None
Return value	The created object pointer
Required preconditions	None
Called functions	None

4.6.17 NewJoyHwParamObj HAL function

Table 56 describes the NewJoyHwParamObj function of the hardware abstraction layer.

Table 56. NewJoyHwParamObj

Name	Description
Function name	NewJoyHwParamObj
Function prototype	JOY_HW_Parameters_TypeDef* NewJoyHwParamObj (void)
Behavior description	Create and initialize a new joystick Hw parameter structure object used by the micro in order to manage the joystick device
Input parameter {x}	None
Output parameter {x}	None
Return value	The created object pointer
Required preconditions	None
Called functions	None

4.6.18 NewBtnHwParamObj HAL function

Table 57 describes the NewBtnHwParamObj function of the hardware abstraction layer.

Table 57. NewBtnHwParamObj HAL

Name	Description
Function name	NewBtnHwParamObj
Function prototype	BTN_HW_Parameters_TypeDef* NewBtnHwParamObj (void)

Table 57. NewBtnHwParamObj HAL (continued)

Name	Description
Behavior description	Create and initialize a new button Hw parameter structure object used by the micro in order to manage the push button device
Input parameter {x}	None
Output parameter {x}	None
Return value	The created object pointer
Required preconditions	None
Called functions	None

4.6.19 GL_GPIO_Init HAL function

Table 58 describes the GL_GPIO_Init function of the hardware abstraction layer.

Table 58. GL_GPIO_Init

Name	Description
Function name	GL_GPIO_Init
Function prototype	void GL_GPIO_Init (GPIO_TypeDef* GPIOx, GL_GPIO_InitTypeDef* GPIO_InitStruct)
Behavior description	Initializes the GPIOx peripheral according to the specified parameters in the GPIO_InitStruct
Input parameter {x}	GPIOx: where x can be 1, 2, 3, … to select the GPIO port. GPIO_InitStruct: pointer to GPIO_InitTypeDef structure that contains the configuration information for the specified GPIO peripheral
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	GPIO_Init (GPIOx, GPIO_InitStruct)

4.6.20 GL_SPI_Init HAL function

Table 59 describes the GL_SPI_Init function of the hardware abstraction layer.

Table 59. GL_SPI_Init

Name	Description
Function name	GL_SPI_Init
Function prototype	void GL_SPI_Init (SPI_TypeDef* SPIx, GL_SPI_InitTypeDef* SPI_InitStruct)
Behavior description	Initializes the SPIx peripheral according to the specified parameters in the SPI_InitStruct.

Table 59. GL_SPI_Init (continued)

Name	Description
Input parameter {x}	SPIx: where x can be 1, 2 or 3 to select the SPI peripheral. SPI_InitStruct: pointer to a SPI_InitTypeDef structure that contains the configuration information for the specified SPI peripheral.
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	SPI_Init (SPIx, &tmp)

4.6.21 GL_NVIC_SetVectorTable HAL function

Table 60 describes the GL_NVIC_SetVectorTable function of the hardware abstraction layer.

Table 60. GL_NVIC_SetVectorTable

Name	Description
Function name	GL_NVIC_SetVectorTable
Function prototype	void GL_NVIC_SetVectorTable (GL_uint32_t NVIC_VectTab, GL_uint32_t Offset)
Behavior description	Sets the vector table location and offset
Input parameter {x}	NVIC_VectTab: specifies if the vector table is in RAM or Flash memory. This parameter can be one of the following values: – NVIC_VectTab_RAM – NVIC_VectTab_FLASH Offset: vector table base offset field. This value must be a multiple of 0x100.
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	NVIC_SetVectorTable (NVIC_VectTab, Offset)

4.6.22 GL_NVIC_Init HAL function

Table 61 describes the GL_NVIC_Init function of the hardware abstraction layer.

Table 61. GL_NVIC_Init

Name	Description
Function name	GL_NVIC_Init
Function prototype	void GL_NVIC_Init (GL_NVIC_InitTypeDef* NVIC_InitStruct)
Behavior description	Initializes the NVIC peripheral according to the specified parameters in the NVIC_InitStruct
Input parameter {x}	NVIC_InitStruct: pointer to a NVIC_InitTypeDef structure that contains the configuration information for the specified NVIC peripheral.

Table 61. GL_NVIC_Init (continued)

Name	Description
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	NVIC_Init (NVIC_InitStruct);

4.6.23 GL_NVIC_PriorityGroupConfig HAL function

Table 62 describes the GL_NVIC_PriorityGroupConfig function of the hardware abstraction layer.

Table 62. GL_NVIC_PriorityGroupConfig

Name	Description
Function name	GL_NVIC_PriorityGroupConfig
Function prototype	void GL_NVIC_PriorityGroupConfig (GL_uint32_t NVIC_PriorityGroup)
Behavior description	Configures the priority grouping: pre-emption priority and subpriority
Input parameter {x}	NVIC_PriorityGroup: specifies the priority grouping bits length. This parameter can be one of the following values: – NVIC_PriorityGroup_0: 0 bits for pre-emption priority, 4 bits for subpriority – NVIC_PriorityGroup_1: 1 bits for pre-emption priority, 3 bits for subpriority – NVIC_PriorityGroup_2: 2 bits for pre-emption priority, 2 bits for subpriority – NVIC_PriorityGroup_3: 3 bits for pre-emption priority, 1 bits for subpriority – NVIC_PriorityGroup_4: 4 bits for pre-emption priority, 0 bits for subpriority
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	NVIC_PriorityGroupConfig (NVIC_PriorityGroup)

4.6.24 GL_EXTI_DeInit HAL function

Table 63 describes the GL_EXTI_DeInit function of the hardware abstraction layer.

Table 63. GL_EXTI_DeInit

Name	Description
Function name	GL_EXTI_DeInit
Function prototype	void GL_EXTI_DeInit (void)
Behavior description	Deinitializes the EXTI peripheral registers to their default reset values
Input parameter {x}	None
Output parameter {x}	None
Return value	None

Table 63. GL_EXTI_DeInit (continued)

Name	Description
Required preconditions	None
Called functions	EXTI_DeInit()

4.6.25 GL_EXTI_Init HAL function

Table 64 describes the GL_EXTI_Init function of the hardware abstraction layer.

Table 64. GL_EXTI_Init

Name	Description
Function name	GL_EXTI_Init
Function prototype	void GL_EXTI_Init (GL_EXTI_InitTypeDef* EXTI_InitStruct)
Behavior description	Initializes the EXTI peripheral according to the specified parameters in the EXTI_InitStruct.
Input parameter {x}	EXTI_InitStruct: pointer to an EXTI_InitTypeDef structure that contains the configuration information for the EXTI peripheral
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	EXTI_Init (EXTI_InitStruct)

4.6.26 GL_GPIO_EXTILineConfig HAL function

Table 65 describes the GL_GPIO_EXTILineConfig function of the hardware abstraction layer.

Table 65. GL_GPIO_EXTILineConfig

Name	Description
Function name	GL_GPIO_EXTILineConfig
Function prototype	void GL_GPIO_EXTILineConfig (GL_uint8_t GPIO_PortSource, GL_uint8_t GPIO_PinSource)
Behavior description	Selects the GPIO pin used as the EXTI Line
Input parameter {x}	GPIO_PortSource: selects the GPIO port to be used as source for EXTI lines. This parameter can be GPIO_PortSourceGPIOx where x can be (A..G). GPIO_PinSource: specifies the EXTI line to be configured. This parameter can be GPIO_PinSourcex where x can be (0..15).
Output parameter {x}	None
Return value	None

Table 65. GL_GPIO_EXTILineConfig (continued)

Name	Description
Required preconditions	None
Called functions	GPIO_EXTILineConfig (GPIO_PortSource, GPIO_PinSource)

4.6.27 GL_EXTI_TSC_IRQHandler HAL function

Table 66 describes the GL_EXTI_TSC_IRQHandler function of the hardware abstraction layer.

Table 66. GL_EXTI_TSC_IRQHandler

Name	Description
Function name	GL_EXTI_TSC_IRQHandler
Function prototype	void GL_EXTI_TSC_IRQHandler (void)
Behavior description	This function handles external lines interrupt request for the touchscreen
Input parameter {x}	None
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	None

4.6.28 GL_TSC_Interface_Init HAL function

Table 67 describes the GL_TSC_Interface_Init function of the hardware abstraction layer.

Table 67. GL_TSC_Interface_Init

Name	Description
Function name	GL_TSC_Interface_Init
Function prototype	GL_uint32_t GL_TSC_Interface_Init (void)
Behavior description	Initializes the IO expander registers
Input parameter {x}	None
Output parameter {x}	None
Return value	0: if all initializations are OK
Required preconditions	None
Called functions	TSC_IOExpander_Init()

4.6.29 GL_JOY_Interface_Init HAL function

Table 68 describes the GL_JOY_Interface_Init function of the hardware abstraction layer.

Table 68. GL_JOY_Interface_Init

Name	Description
Function name	GL_JOY_Interface_Init
Function prototype	GL_uint32_t GL_JOY_Interface_Init (void)
Behavior description	Initializes the IO expander registers
Input parameter {x}	None
Output parameter {x}	None
Return value	0: if all initializations are OK
Required preconditions	None
Called functions	JOY_IOExpander_Init()

4.6.30 GL_JoyStickConfig_IOExpander HAL function

Table 69 describes the GL_JoyStickConfig_IOExpander function of the hardware abstraction layer.

Table 69. GL_JoyStickConfig_IOExpander

Name	Description
Function name	GL_JoyStickConfig_IOExpander
Function prototype	void GL_JoyStickConfig_IOExpander(void)
Behavior description	Initializes the IO expander for joystick operations
Input parameter {x}	None
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	None

4.6.31 GL_JoyStickConfig_GPIO HAL function

Table 70 describes the GL_JoyStickConfig_ GPIO function of the hardware abstraction layer.

Table 70. GL_JoyStickConfig_GPIO

Name	Description
Function name	GL_JoyStickConfig_GPIO
Function prototype	void GL_JoyStickConfig_GPIO(void)
Behavior description	Configures the GPIO ports pins concerned with the joystick.

Table 70. GL_JoyStickConfig_GPIO (continued)

Name	Description
Input parameter {x}	None
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	None

4.6.32 GL_JoyStickStateIOEXP HAL function

Table 71 describes the GL_JoyStickStateIOEXP function of the hardware abstraction layer.

Table 71. GL_JoyStickStateIOEXP

Name	Description
Function name	GL_JoyStickStateIOEXP
Function prototype	uint32_t GL_JoyStickStateIOEXP(void)
Behavior description	Return the joystick status
Input parameter {x}	None
Output parameter {x}	None
Return value	The code of the joystick key pressed
Required preconditions	None
Called functions	None

4.6.33 GL_JoyStickStatePolling HAL function

The state acquisition of the joystick is implemented by reading the relative pins with a period of 50 ms in order to easily recognize if one of the joystick commands has been activated for a long period of time.

Table 72 describes the GL_JoyStickStatePolling function of the hardware abstraction layer.

Table 72. GL_JoyStickConfig_GPIO

Name	Description
Function name	GL_JoyStickStatePolling
Function prototype	uint32_t GL_JoyStickStatePolling (void)
Behavior description	Return the joystick status
Input parameter {x}	None
Output parameter {x}	None
Return value	The code of the joystick key pressed
Required preconditions	None
Called functions	None

4.6.34 GL_Delay HAL function

The delay routine employs the SysTick processor internal circuit. It is a very simple down-counting counter which is clocked by a processor clock, in this case 72 MHz. The counter width is 24 bits, so it operates over a range from 16,777,215 to 0. Each working cycle starts with a counter preloading by the entered scaler which determines a time of counting at the end of which the SysTick interrupt handler is launched, in order to handle an underflow event. The handler decrements an intended number of working cycles and reloads the counter which continues in this manner, setting a number of working cycles generates a variation of the total time latency.

The second important issue regarding this portion is interrupt handling.

Throughout all the families of diverse microprocessors, the interrupt feature is integrated into a core behavior as an essential property in order to make it possible to handle some circumstances time adequately, or better, as soon as possible. The interrupts are very often closely linked with the data transfers where a regular time characteristic of protocols must be accomplished or with purely timing business where a need of immediate treatment is clear.

The library, as well as every ordinary project which employs this library, contains a file of interrupt handler routines. According to a STM32 start-up vector file, which, among others, sets a vector table entry with exception handler addresses (this means that it defines the names of all handlers), a handler must be defined for every possible exception-interrupt source even if that may be empty and unused.

Therefore, the file of the handler routines comprises also the handlers of peripherals which are not involved in the application.

The GL_Delay(uint32_t nCount) function stops the code execution of the processor in an empty “while-loop” for a defined time delay. There is a global variable TimingDelay and another complementing routine called TimingDelay_Decrement, which must be taken into account at the process of comprehension. The delay routine, first of all, sets TimingDelay with an entered nCount number, enables the SysTick counter and then it sticks at while-loop, waiting until the TimingDelay is equal to zero. The TimingDelay value is decremented by routine, as its name suggests, decrement TimeDelay, which is launched by SysTick interrupt handler every time the counter reaches zero. Therefore, the nCount variable multiplied by a SysTick period (which is fixed to 10 ms) is the total time latency caused by delay procedure.

Table 73 describes the GL_Delay function of the hardware abstraction layer.

Table 73. GL_Delay

Name	Description
Function name	GL_Delay
Function prototype	void GL_Delay (uint32_t nCount)
Behavior description	Inserts a delay time
Input parameter {x}	nCount: specifies the delay time length (time base 10 ms)
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	None

4.6.35 TSC_Read HAL function

Table 74 describes the TSC_Read function of the hardware abstraction layer.

Table 74. TSC_Read

Name	Description
Function name	TSC_Read
Function prototype	void TSC_Read (void)
Behavior description	Reads the coordinates of the point touched and assigns their value to the variables uint32_t_TSXCoordinate and uint32_t_TSYCoordinate
Input parameter {x}	None
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	None

4.6.36 TSC_FLASH_Unlock HAL function

Table 75 describes the TSC_FLASH_Unlock function of the hardware abstraction layer.

Table 75. TSC_FLASH_Unlock

Name	Description
Function name	TSC_FLASH_Unlock
Function prototype	void TSC_FLASH_Unlock (void)
Behavior description	Unlocks the Flash program erase controller
Input parameter {x}	None
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	None

4.6.37 TSC_FLASH_ClearFlag HAL function

Table 76 describes the TSC_FLASH_ClearFlag function of the hardware abstraction layer.

Table 76. TSC_FLASH_ClearFlag

Name	Description
Function name	TSC_FLASH_ClearFlag
Function prototype	void TSC_FLASH_ClearFlag (uint16_t FLASH_FLAG)
Behavior description	Clears the Flash's pending flags.

Table 76. TSC_FLASH_ClearFlag (continued)

Name	Description
Input parameter {x}	FLASH_FLAG: specifies the Flash flags to clear. This parameter can be any combination of the following values: – TSC_FLASH_FLAG_PGERR: Flash program error flag – TSC_FLASH_FLAG_WRPRTERR: Flash write protected error flag – TSC_FLASH_FLAG_EOP: Flash end of operation flag
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	None

4.6.38 TSC_FLASH_ErasePage HAL function

Table 77 describes the TSC_FLASH_ErasePage function of the hardware abstraction layer.

Table 77. TSC_FLASH_ErasePage

Name	Description
Function name	TSC_FLASH_ErasePage
Function prototype	TSC_FLASH_Status TSC_FLASH_ErasePage (GL_uint32_t Page_Address)
Behavior description	Erases a specified Flash page.
Input parameter {x}	Page_Address: the page address to be erased.
Output parameter {x}	None
Return value	TSC_FLASH_Status: the returned value can be: FLASH_BUSY, FLASH_ERROR_PG, FLASH_ERROR_WRP, FLASH_COMPLETE or FLASH_TIMEOUT.
Required preconditions	None
Called functions	None

4.6.39 TSC_FLASH_ProgramWord HAL function

Table 78 describes the TSC_FLASH_ProgramWord function of the hardware abstraction layer.

Table 78. TSC_FLASH_ProgramWord

Name	Description
Function name	TSC_FLASH_ProgramWord
Function prototype	TSC_FLASH_Status TSC_FLASH_ProgramWord (GL_uint32_t Address, GL_uint32_t Data)
Behavior description	Programs a word at a specified address.

Table 78. TSC_FLASH_ProgramWord (continued)

Name	Description
Input parameter {x}	Address: specifies the address to be programmed. Data: specifies the data to be programmed
Output parameter {x}	None
Return value	TSC_FLASH_Status: the returned value can be: FLASH_BUSY, FLASH_ERROR_PG, FLASH_ERROR_WRP, FLASH_COMPLETE or FLASH_TIMEOUT.
Required preconditions	None
Called functions	None

4.6.40 GL_GPIO_ReadInputDataBit HAL function

Table 79 describes the GL_GPIO_ReadInputDataBit function of the hardware abstraction layer.

Table 79. GL_GPIO_ReadInputDataBit

Name	Description
Function name	GL_GPIO_ReadInputDataBit
Function prototype	GL_uint8_t GL_GPIO_ReadInputDataBit (GL_PortType * GPIOx, GL_uint16_t GPIO_Pin)
Behavior description	Reads the specified input port pin.
Input parameter {x}	GPIOx: where x can be (A..G) to select the GPIO peripheral. GPIO_Pin: specifies the port bit to read. This parameter can be GPIO_Pin_x where x can be (0..15).
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	None

4.6.41 GL_LCD_CtrlLinesWrite HAL function

Table 80 describes the GL_LCD_CtrlLinesWrite function of the hardware abstraction layer.

Table 80. GL_LCD_CtrlLinesWrite

Name	Description
Function name	GL_LCD_CtrlLinesWrite
Function prototype	void GL_LCD_CtrlLinesWrite (GL_PortType* GPIOx, uint16_t CtrlPins, GL_SignalActionType BitVal)
Behavior description	Sets or resets LCD control lines.

Table 80. GL_LCD_CtrlLinesWrite (continued)

Name	Description
Input parameter {x}	GPIOx: where x can be B or D to select the GPIO peripheral. CtrlPins: the control line. This parameter can be: – LCD_CtrlPin_NCS: chip select pin (PB.02) – CtrlPin_NWR: read/write selection pin (PD.15) – CtrlPin_RS: register/RAM selection pin (PD.07) BitVal: specifies the value to be written to the selected bit. This parameter can be: – GL_LOW: to clear the port pin – GL_HIGH: to set the port pin
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	None

4.6.42 GL_LCD_ReadRAM HAL function

Table 81 describes the GL_LCD_ReadRAM function of the hardware abstraction layer.

Table 81. GL_LCD_ReadRAM

Name	Description
Function name	GL_LCD_ReadRAM
Function prototype	GL_uint16_t GL_LCD_ReadRAM (void)
Behavior description	Reads the LCD RAM
Input parameter {x}	None
Output parameter {x}	None
Return value	LCD RAM value.
Required preconditions	None
Called functions	None

4.6.43 GL_RCC_APBPeriphClockCmd HAL function

Table 82 describes the GL_RCC_APBPeriphClockCmd function of the hardware abstraction layer.

Table 82. GL_RCC_APBPeriphClockCmd

Name	Description
Function name	GL_RCC_APBPeriphClockCmd
Function prototype	void GL_RCC_APBPeriphClockCmd (GL_uint32_t RCC_APBPeriph, GL_FunctionalState NewState, uint8_t APB_Selector)

Table 82. GL_RCC_APBPeriphClockCmd (continued)

Name	Description
Behavior description	Enables or disables the high speed APB (APB1 or APB2) peripheral clock.
Input parameter {x}	RCC_APBPeriph: specifies the APB peripheral to gate its clock. NewState: new state of the specified peripheral clock. This parameter can be: Enable or Disable. APB_Selector: this parameter selects the APB bus, 1 for APB1 and 2 for APB2.
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	None

4.6.44 GL_RCC_AHBPeriphClockCmd HAL function

Table 83 describes the GL_RCC_AHBPeriphClockCmd function of the hardware abstraction layer.

Table 83. GL_RCC_AHBPeriphClockCmd

Name	Description
Function name	GL_RCC_AHBPeriphClockCmd
Function prototype	void GL_RCC_AHBPeriphClockCmd (GL_uint32_t RCC_AHBPeriph, GL_FunctionalState NewState);
Behavior description	Enables or disables the AHB peripheral clock.

Table 83. GL_RCC_AHBPeriphClockCmd (continued)

Name	Description
Input parameter {x}	- RCC_AHBPeriph: specifies the AHB peripheral to gate its clock. For @b STM32_Connectivity_line_devices, this parameter can be any combination of the following values: – RCC_AHBPeriph_DMA1 – RCC_AHBPeriph_DMA2 – RCC_AHBPeriph_SRAM – RCC_AHBPeriph_FLITF – RCC_AHBPeriph_CRC – RCC_AHBPeriph_OTG_FS – RCC_AHBPeriph_ETH_MAC – RCC_AHBPeriph_ETH_MAC_Tx – RCC_AHBPeriph_ETH_MAC_Rx For @b other_STM32_devices, this parameter can be any combination of the following values: – RCC_AHBPeriph_DMA1 – RCC_AHBPeriph_DMA2 – RCC_AHBPeriph_SRAM – RCC_AHBPeriph_FLITF – RCC_AHBPeriph_CRC – RCC_AHBPeriph_FSMC – RCC_AHBPeriph_SDIO – NewState: new state of the specified peripheral clock. This parameter can be: Enable or Disable
Output parameter {x}	None
Return value	None
Required preconditions	None
Called functions	None

5 Getting started with the system

5.1 Example application - main.c

An example of a main application is given below. The main function contains an example of the Graphic library initialization/configuration and implements the classic operations:

```
/* Includes ------------------------------------------------------------------*/
#include "main.h"
#include "hw_config.h"
#include "menu.h"
#include "cursor.h"
#include "pictures.h"
#include <stdio.h>

/* Main_Private_Macros --------------------------------------------------------*/

#ifdef __GNUC__
/* With GCC/RAISONANCE, small printf (option LD Linker->Libraries->Small printf
   set to 'Yes') calls __io_putchar() */
#define PUTCHAR_PROTOTYPE int __io_putchar(int ch)

#endif /* __GNUC__ */

/**
  * @brief  Main program.
  * @param  None
  * @retval None
  */
int main(void)
{
  RCC_ClocksTypeDef RCC_Clocks;

  uint32_t time_out = 0xFFF;

  /* Setup the microcontroller system. Initialize the Embedded Flash Interface,
  initialize the PLL and update the SystemFrequency variable. */
  SystemInit();

  /* Setup SysTick Timer for 10 msec interrupts  */
  RCC_GetClocksFreq(&RCC_Clocks);
  if (SysTick_Config(RCC_Clocks.SYSCLK_Frequency / 100))
  {
     /* Capture error */
     while (1);
  }

  /* Set HW structure parameters */
  HWConfig_SetHardwareParams();

  /* Set the Vector Table base location at 0x08000000 */
  NVIC_SetVectorTable(NVIC_VectTab_FLASH, 0x0000);

  /* If the LCD Panel has a resolution of 320x240 this command is not needed, it's
  set by default */
  /* Set_LCD_Resolution( 320, 240 ); */

  /* Initialize the LCD */
  GL_LCD_Init();
```

```
  /* Touch Screen Init */
  TSC_Init();

  /* Joystick Init */
  GL_JoyStickConfig_IOExpander();

  /* Set the last Flash Memory address */
  Set_LastFlashMemoryAddress( 0x08040000 );

  /* If key is pressed - Start Calibration */
  while( GPIO_ReadInputDataBit(USER_BUTTON_PORT, USER_BUTTON_PIN) && (time_out>0) )
     time_out--;
  if (time_out>0)
    TS_Calibration();

  GL_Clear(GL_White);
  ...

  /* Check if Calibration has been done*/
  TS_CheckCalibration();

  /*Initialize cursor*/
  GL_Clear(White);
  CursorInit(GL_NULL);

  /* Menu Initialization*/
  Show_Menu();

  CursorShow( LCD_Height/2, LCD_Width/2 );

  /* Infinite main loop -------------------------------------------------------*/
  while (1)
  {
    /* Catching touch events */
    if ( calibration_done )
    {
      ProcessInputData ();
    }

    /*Time out calculate for power saving mode*/
    TimeOutCalculate();

    CursorReadJoystick(POLLING_MODE);
    TSC_Read();
  }
}
```

The initialization process is in charge of preparing the basic mechanism of the system. The clock distribution and the interrupt settings are two components that are strongly dependent on the target project. An example of clock rate may be 72 MHz as the maximum speed of the current STM32 microcontroller. It can be decreased to reduce the power consumption. Special attention should be paid to the SysTick counter and its related delay routine which generates a variable time latency in multiples of 10 ms. The clock rate assumptions are:

- System HCLK - 72 MHz
- Low speed peripheral PCLK1 - 36 MHz
- High speed peripheral PCLK2 - 72 MHz

The interrupt setting situation is very similar to clock distribution. The library functions involved with interrupt managing do not take care of the priorities, they only perform very

necessary and absolutely common settings to make them serviceable. The developer who designs the final project and who decides to include the graphic library must consider the relation between all the possible interrupts, and consequently must assess the priority levels. Default characters of the interrupt controller are:

- Vector table base address is set to 0x08000000
- Priority group identifier takes 2 bits.

The goal of this document is not to give an exhaustive description of this issue. The processor reference manual and the firmware library are comprehensive information resources where lots of examples can be found as the clock distribution is an integral task of every application.

6 Embedded GUI resource editor application

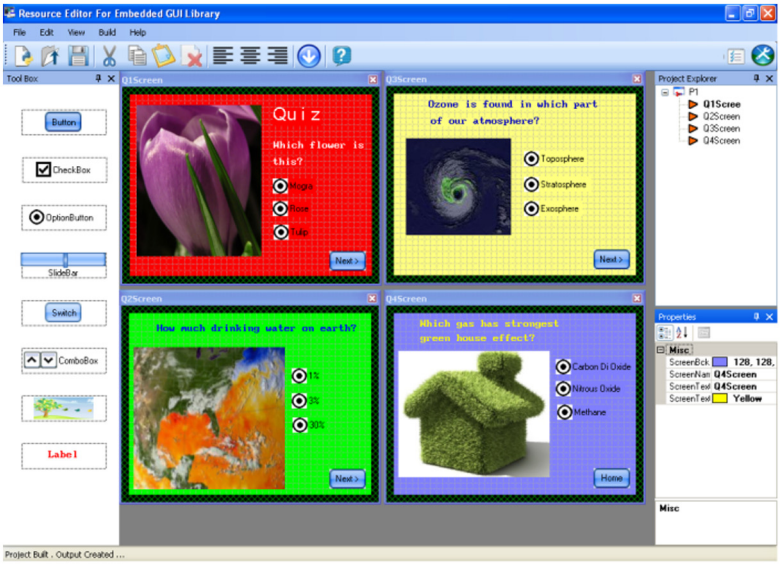
6.1 Introduction

The “Resource Editor for STM32 embedded graphic objects/touchscreen library” is a software application to leverage the features of the multi-input GUI library developed on the microcontroller platform.

Traditionally, the generation of touchscreen UIs requires writing a lot of redundant code and painful mapping of screen coordinates to the interface. In absence of any WYSIWYG tool, perfecting such an interface requires numerous time consuming iterations. The GUI library is a part of the embedded UI generation ecosystem. It comprises the embedded GUI library running on the firmware and the resource editor application running on the PC. The resource editor GUI provides one common unified user interface to implement all the interface design functionality, so that it becomes possible to make the changes visually and generate the C code targeting the embedded GUI library in a few mouse clicks. The user can include this code in their application and burn on the firmware.

The GUI allows the user to develop their own screens using the controls provided by the library. The user simply drags and drops the controls from the tool box and changes the control properties as required. After finishing the layout, the user is able to generate the source code (header and c file) which can be integrated into the firmware application.

Figure 17. Creating a GUI application

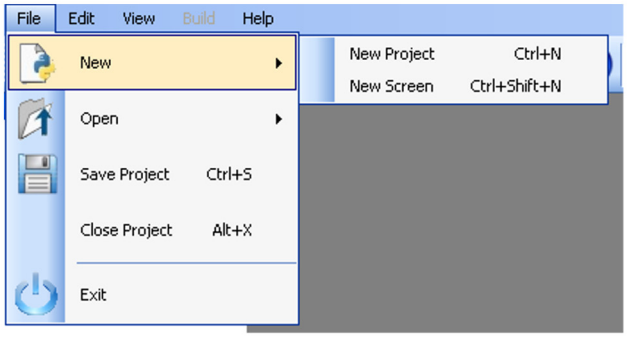


6.2 Resource editor application: quick start

Follow these simple steps for getting the first project run.

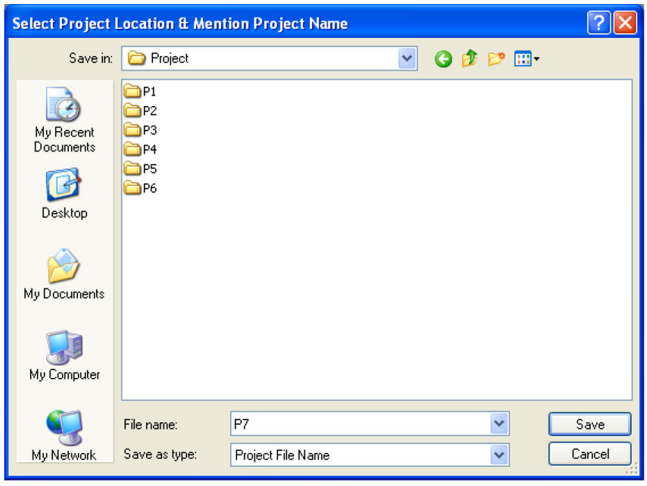
Click on New-->New Project to start the new project.

Figure 18. Creating a new GUI project



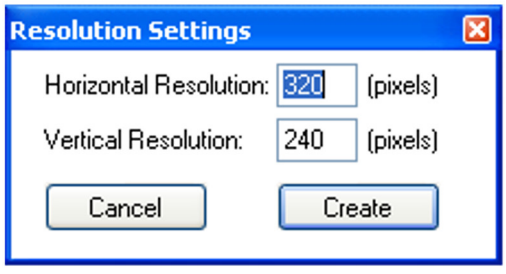
This opens the save dialog in which you must choose the path and the name of the project.

Figure 19. Choosing the project file location



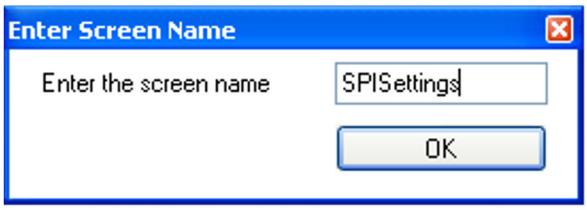
This opens the resolution settings window, which asks for the resolution of the screen.

Figure 20. Set the screen resolution



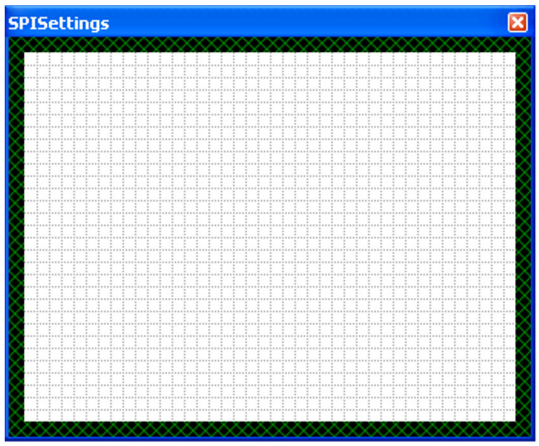
This opens the screen name window, which asks for the name of the screen.

Figure 21. Set the screen name



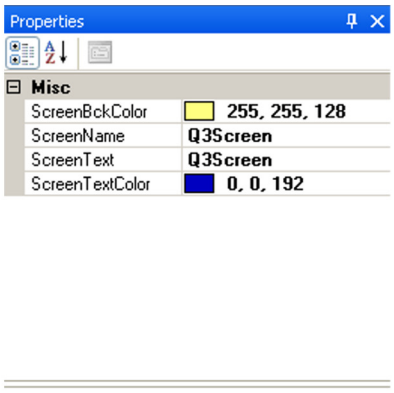
The project is started now, select the control from the tool box and drag and drop it into the screen opened.

Figure 22. Screen workspace



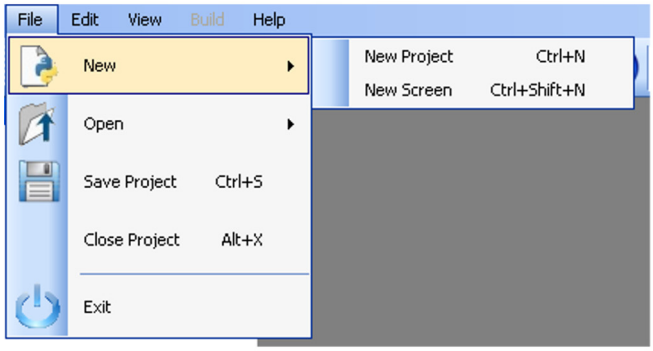
You can create the any number of controls and change their properties in the property window.

Figure 23. Screen properties



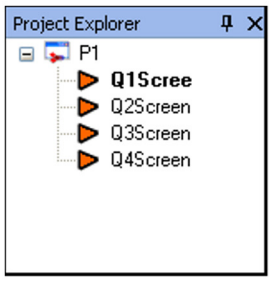
You can add more screens by selecting the New-->New Screen button on the menu bar.

Figure 24. Creating a new screen



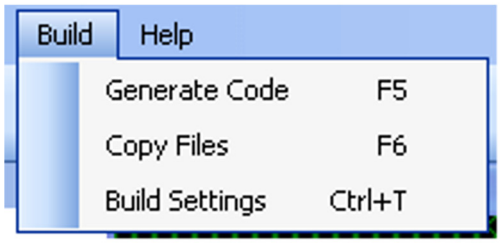
The Project Explorer window shows all the screens in the project.

Figure 25. Screens list



Finally, build the project by clicking on “Generate Code” to generate the code. Build operation automatically saves the project.

Figure 26. Building the project source code



The generate files are located at “project path\project name\output”.

Figure 27. Set the include/source file paths

The resource editor application has an easy integration feature. Open the Tools--> Build Settings dialog box and select the Include and Source file paths for your embedded project and save.

Now, after generating the files, just click the “Copy Files” option and the files are automatically copied from the resource editor output folder to the embedded project source and include folders. Add these files to the embedded project in the IAR embedded workbench (or any other IDE you are using).

After these steps are performed, it becomes very easy to make any changes to the resource editor project. Just make the required changes, click “Generate Files” followed by “Copy Files” and the changes are immediately reflected in the embedded workspace.

6.3 Description of the generated files

The resource editor GUI generates the following six files as the output of the project:

Image files

- Pictures.c:
  - contains several arrays of all images used in the GUI in the 5-6-5 format
- Pictures.h:
  - contains the declaration of all the images used in the GUI

App user files

- uiappuser.c:
  - contains the definition of all the events for the control used in the GUI e.g. event for button click
- uiappuser.h:
  - contains the declaration of all the events for the control used in the GUI

UI framework files

- uiframework.c:
  - contains all the information required by the embedded GUI library to create the object. All the objects used in the GUI have their object creation modules with the user defined settings in this file
  - contains functions to:

1. Create and configure embedded GUI library objects
2. Display and update screens

- uiframework.h:
  - contains the declaration of all the functions and constants used in the uiframework.c.

In the resource editor GUI, the user can set the output path of the files. When the output is generated, it is dumped in the specified folders.

For the first time the user needs to change the main.c of his project.

The files are formatted and commented to enable the Doxygen tool to generate documentation for the files. To work with the output files generated by the GUI, the developer must make a few changes:

- The user must include all three header files in the main.c file
- The user must call Show_HomeScreen() after all the initialization has taken place on the hardware
- The user needs to compile the updated source code and burn it on the firmware.

6.4 Integration with the embedded project

The user must include the following generated files in the project:

- pictures.c
- pictures.h
- uiappuser.c
- uiappuser.h
- uiframework.c
- uiframework.h

The user also needs to include the embedded GUI library files in the project. The GUI library can either be in the form of source files or the object file (along with the header) depending on the distribution. The joystick and/or the touchscreen should also be configured in the main.c.

To start the GUI, call the function Show_HomeScreen() in the user application. The user can write functions to call their code in event handlers present in uiappuser.c. A sample project, configured to work with an embedded GUI library, is provided with the distribution for reference purposes.

7 References

1. STMPE811, datasheet
2. TN0074, technical note
3. RM0008, reference manual
4. STM32F10xFWLib 3.4.0, help file.

8 Revision history

Table 84. Document revision history

Date	Revision	Changes
13-May-2010	1	Initial release.
26-Nov-2010	2	– The following figures have been added: *Figure 12* and *13* – Modified: title on cover page and *Section 7* – The following figures have been modified: *Figure 1*,*2*, *3*, *5* – The following functions have been added: *NewHistogram API global function* (…) *NewGraphChart API global function* (…) *RefreshPageControl API global function* (…) *SetHistogramPoints API global function* (…) *SetGraphChartPoints API global function* (…) *GetComboOptionLabel API global function* (…) *SetComboOptionLabel API global function* (…) *ResetComboOptionActive API global function* (…) – The following functions have been modified: *DestroyPage API global function* (…) *DestroyPageControl API global function* (…) *NewLabel API global function*(…)
09-Dec-2010	3	Modified: examples
22-Mar-2011	4	– The following figures have been added: *Figure 15*, *16*, *17*, *19*, *20*, *21*, *22*, *23*, *24*, *25*, *26*, and *27* – *Section 6* has been added. – Title of the document has been modified
21-Jun-2011	5	– Modified: *Figure 4* – Modified: *Section 3.3*