Renesas RA Family

Getting Started with the Graphics Application

Introduction

This application note describes creation of an application that uses Graphical User Interfaces with an EK-RA6M3G kit, referred to as ‘graphics application. This application is geared towards providing a reference for developing complex multi-threaded applications with a touch screen graphical Human Machine Interface (HMI) by using the Renesas Flexible Software Package (FSP) and SEGGER AppWizard.

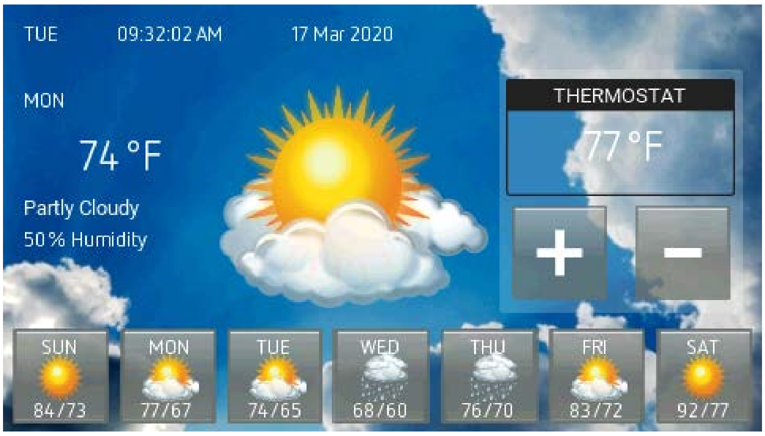


Figure 1. Weather Panel of the Graphics Application on Renesas EK-RA6M3G

This application is developed using the Renesas RA Flexible Software Package (FSP), which provides a quick and versatile way to build secure connected Internet of Things (IoT) devices using the Renesas RA family of Arm microcontrollers (MCUs). RA FSP provides production ready peripheral drivers to take advantage of the RA FSP ecosystem along with SEGGER emWin library and FreeRTOS. In addition, Ethernet, USB, file system stacks support are also available. This powerful suite of tools provides a comprehensive, integrated framework for rapid development of complex embedded applications.

This application note assumes that you are familiar with the concepts associated with writing multi-threaded applications under a Real Time Operating System (RTOS) environment, such as FreeRTOS. This application note makes use of RTOS features such as threads and semaphores. Knowledge on operating these with FreeRTOS can help in understanding the supplied application project in source. For more detailed information on FreeRTOS features, refer to the FreeRTOS User Manual.

The Graphics application is developed using the Renesas Synergy e^2 studio Integrated Solution Development Environment (ISDE). This e^2 studio is a free application that you can download from Renesas website. While building applications under the Renesas FSP Platform is considerably faster than developing similar applications in other environments, there is still a learning curve to understand the steps necessary to construct complex multi-threaded HMI applications quickly. This application note walks you through all the steps necessary, including the following:

- Board setup
- Application overview
- Detailed explanation of the graphical screens uses
- SEGGER AppWizard project integration
- SEGGER AppWizard interactions setup
- Adding an emWin widget that is not yet available in AppWizard
- FSP configuration
- Application design highlights
- Using the General Purpose Timer to drive a PWM backlight control signal
- Importing Loading and running the project.

Required Resources

Development tools and software

- e^2 studio ISDE v7.8.0 or greater
- Renesas Flexible Software Package (FSP) v1.2.0 or later
- AppWizard V1.04a_6.14a or later

Hardware

- Renesas EK-RA6M3G kit (RA6M3 MCU Group)
  (https://www.renesas.com/us/en/products/software-tools/boards-and-kits/eval-kits/ek-ra6m3g.html)

Reference Manuals

- RA Flexible Software Package Documentation Release v1.2.0
- AppWizard User Guide & Reference Manual Software Version 1.04
- emWin User Guide & Reference Manual Software Version 6.12
- Renesas RA6M3 Group User's Manual Rev.1.00
- EK-RA6M3G-v1.0 Schematics

Contents

1. Board Setup

The EK-RA6M3G kit contains a few switch settings which must be configured prior to running the application associated with this application note. In addition to these switch settings, the boards also contain a USB debug port and connectors to access the J-Link® programming interface.

Table 1. Switch settings for EK-RA6M3G

Switch	Setting
J8	Jumper on pins 1-2
J9	Open

The EK-RA6M3G kit consists of two boards: the EK-RA6M3 board featuring the RA6M3 MCU with an on-chip Graphics LCD Controller and a Graphics Expansion Board featuring a 4.3-inch 480- x 272-pixel TFT color LCD with capacitive touch overlay. The GPIO port pin driving the backlight controller is capable of PWM output using a timer peripheral in the MCU. As a result, the intensity of the LED backlight can be adjusted by the RA6M3 MCU.

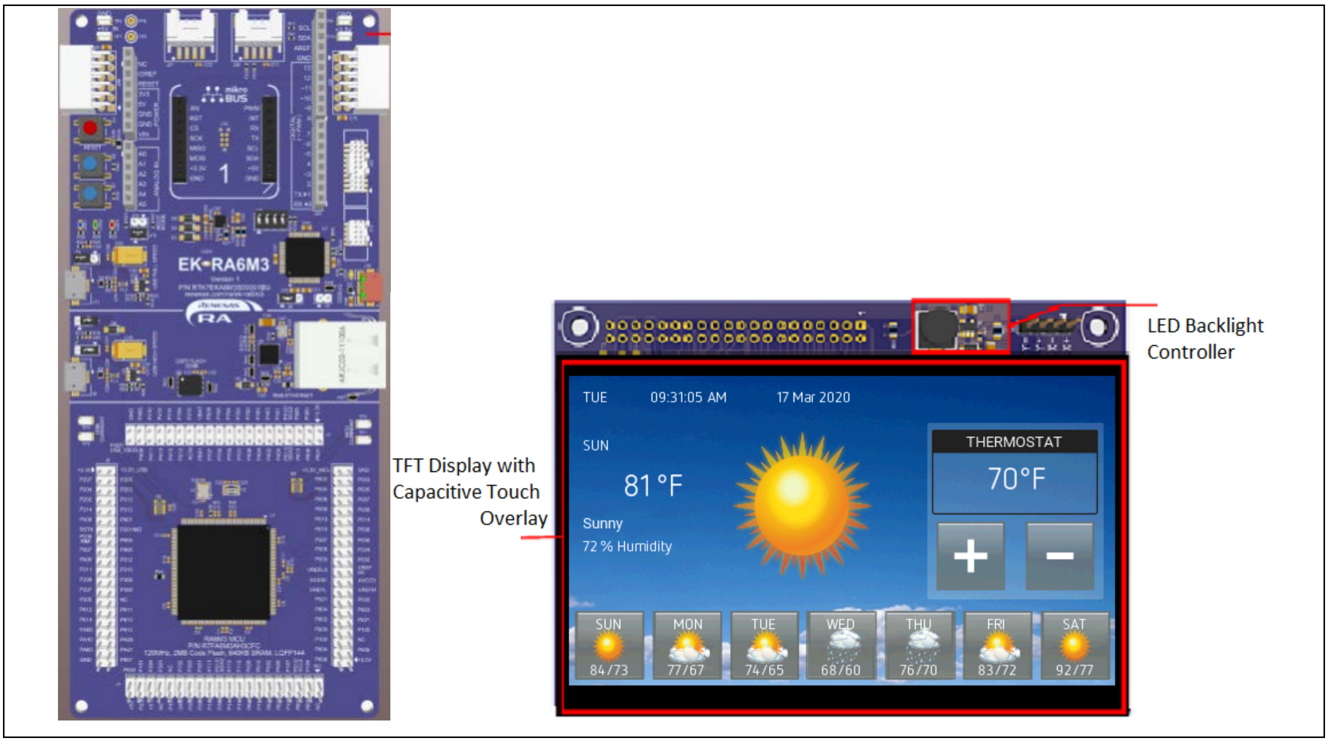


Figure 2. EK-RA6M3G Kit

2. Application Overview

One of the key goals of the provided graphics application is to demonstrate how to build applications which require complex HMI screens using SEGGER AppWizard and emWin library. The following list highlights all the key features of the graphics application:

- Complex HMI design using AppWizard
- Multi-threaded applications using the FreeRTOS
  - Semaphore object.
- GLCDC configuration
  - Framebuffer configuration
  - TCON configuration
- Touch Panel, I2C touch controller driver ft5x06
  - External IRQ mapping required

In any software design, there are many ways to solve the same problem. The solution given in this application note is one approach.

2.1 RA6M3 MCU Peripherals used by the Graphics Application

The graphics application is fairly complex and it uses the Renesas RA6M3 MCU. This MCU is built around an ARM Cortex-M4 device. Developing complex microcontroller based applications is usually a multi-step process:

1. The first step usually involves gathering the application requirements and performing a high-level system design that maps the requirements onto the set of hardware components. The components are necessary to fulfill those including the target MCU that will be used in the design, the tool chains required to build/debug the applications, and so forth.
2. The next step usually determines which on-board peripherals of the target MCU are used. In this step, it is often necessary to spend a considerable amount of time understanding the register map of the on-board peripherals and writing lower level driver code necessary to expose the peripheral to the upper level application code. Most of this work has already been done in the FSP, considerably streamlining application development.
3. In addition to the on-board peripherals of the target MCU, the design often encompasses external hardware and how it is controlled. As an example, the EK-RA6M3G has the Graphics Expansion board, that controlled directly by the on-chip Graphics LCD Controller (GLCDC) of the RA6M3 MCU.
4. The last step usually details how an application will be structured on top of the selected hardware to accomplish the initial requirements.

   The graphics application requirements were first mapped to the on-board peripherals of the EK-RA6M3G kit. Figure 3 shows all the internal hardware peripherals used by the Graphics application. This application note describes how each of these peripherals is configured using the FSP, and the considerations that were used for each peripheral as the application is being developed.

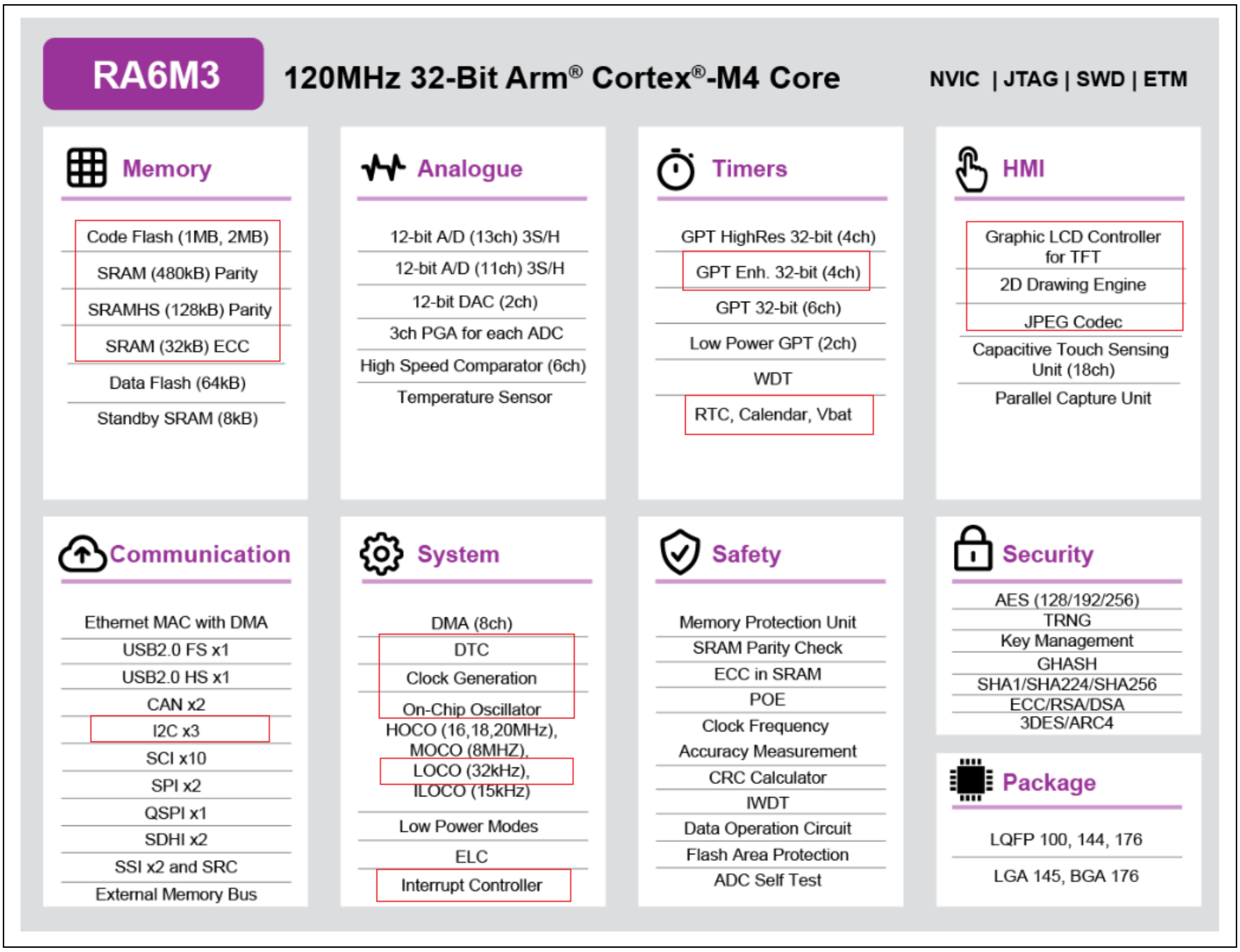


Figure 3. RA6M3 MCU Peripherals Used in the Graphics Application

2.2 Human-Machine Interface (HMI)

In many HMI applications, the most daunting task may be the GUI itself. In applications requiring a graphical HMI, it is generally considered best practice to separate the business logic from presentation. This abstracts th the GUI from making decisions on what to display. Instead, it is now only concerned about how to display it. It relies on external logic to tell it what to display and when to display it.

Once you have gathered the requirements, achieved a top-level design, and identified the hardware necessary to implement that design, it is often beneficial to construct a GUI (Graphical User Interface) to help quickly communicate the look and feel of the system to others. This is where the SEGGER AppWizard comes into play.

The FSP natively supports the use of AppWizard and emWin library from SEGGER. You may choose to use emWin primitive calls directly in your application or choose to use the AppWizard to design your screens. AppWizard is a stand-alone tool that provides a point and click environment for generating all the screens necessary for your embedded application. Once designed, the tool outputs `.c` and `.h` files, which you then include into your application. All the application screens in the graphics application were built using the AppWizard.

2.3 Graphics Application Panels

The Graphics application consists of two graphical panels, **Weather Panel**, and **Logging Panel**. In this application, we build separate static display designs for these two panels. The screen resolution on the EK-RA6M3G kit is 480 x 272 pixels.

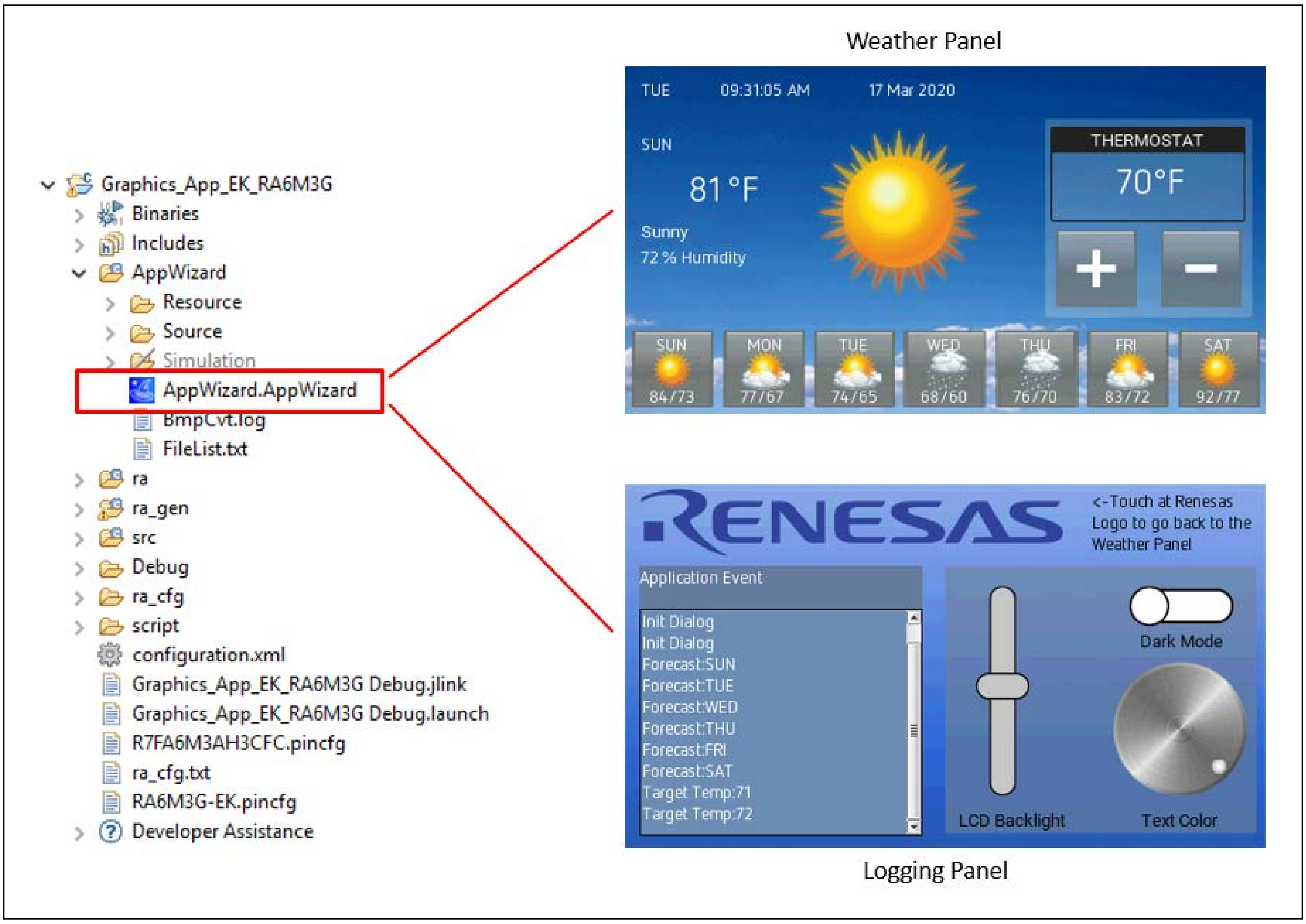


Figure 4. Screenshot of the Graphics Application

Weather Panel	This is the first screen that appears on the kit on boot up. It shows Weather forecasts by selecting days or increase/decrease Temperature.
Logging Panel	Show events occurred in the **Weather Panel**, adjust LCD backlight, or text color and background color of the Logging Editor.

3. AppWizard Overview

This section provides an overview of how graphical screens are designed and integrated into an FSP application using the AppWizard and emWin library. It is not meant as a replacement for the AppWizard or emWin documentation. When designing graphical interfaces for the Renesas FSP platform, you are encouraged to refer the documentation for the AppWizard and emWin library.

The AppWizard presents a graphical, point and click environment that allows you to quickly create all the screens needed for your embedded application. You can specify the screen resolution, color depth, and various other parameters such that what you see in the AppWizard that is running on your PC is what you will get on your embedded screens.

The AppWizard comes as a standard with some fonts and basic graphics for interfaces such as button controls, rotary, and slider. During your screen creation phase, you may provide the AppWizard with your own external images and font files to make your displays as fancy as needed.

Figure 5. Screen Snapshot of the Weather Panel being designed in the AppWizard

The organization of the AppWizard is straightforward. The top center window, known as the **Editor** window, contains the screen being designed. On the upper left corner, you will find the **Add Object** window. This window shows the supported window objects in the AppWizard. It allows you to click on the object icons, drag and place them in the Editor window. On the center left is **Hierarchic Tree** window. The order in which you add items in the same level/parent determines the order that they are drawn in the final screens, so some planning is necessary but you still can change the order by using drag and drop or the **Move Up** and **Move Down** buttons. As is the case with most graphical design environments, screens are laid out in a hierarchy where the main window is usually the parent and all graphical objects contained in the window are children of that parent. The **Properties** window on the right side displays properties associated with a selected object. You may select objects from the **Hierarchic Tree** window or from the **Editor** window.

The bottom left of the AppWizard screen contains **Quick Access Buttons** for managing resources such as Texts, Fonts, Images, and Variables you used to create and interact with the screens. AppWizard supports multi-language designs as well.

The key to making any graphical design interactive is to associate events like button touches with the event handling code that implements the appropriate functionality. The **Interactions** window on the bottom center make it easy for you to define the application's behavior on certain actions. These interactions can be done without any extra code but AppWizard allows you to add your code to handle these actions and respond to GUI events.

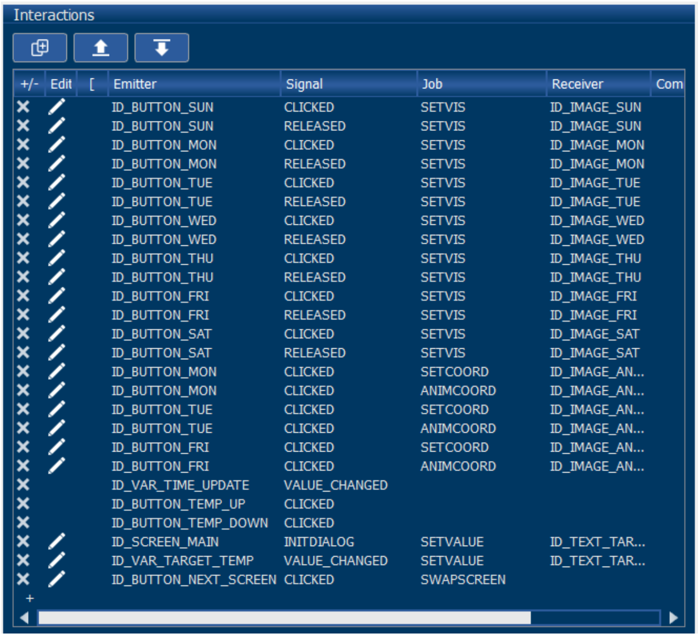


Figure 6. AppWizard Interaction Window

3.1 Create New Project Using the AppWizard

This presents you with the **Create New Project** dialog box as shown in Figure 7. This dialog box is where you specify the project specific information such as the basic display settings as well as the path information for where AppWizard locates the files that result from the **Export & Save** process. The AppWizard also generates a simulation project in the folder `\Simulation` located in the project folder.

When you do **Export & Save**, the AppWizard creates `.c` and `.h` files that contain all the information necessary to render the screens you built with AppWizard on the LCD in your embedded application. The **Project Path** is where you specify the default output directory for the Source, Header, and Resource files.

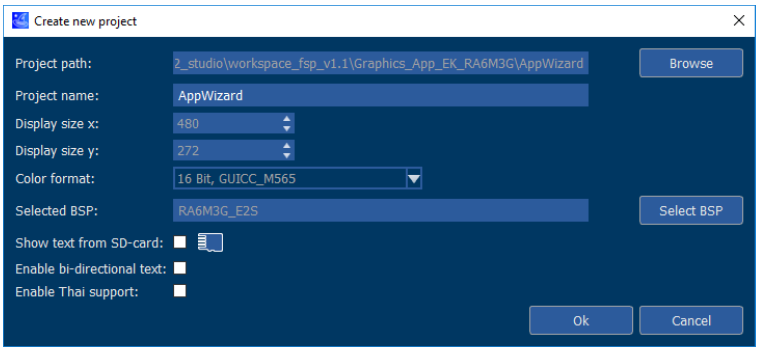


Figure 7. Create New Project Dialog Box

It is a good practice to save the Source, Header, and Resource files relative to the e² studio location. This makes it easy to move projects from one location to another or from one PC to another. In the case of the Graphics application, you can see that all the directories are located under the AppWizard folder in the project directory created by e² studio. We recommend creating the e² studio project first, then creating the AppWizard folder as an e² studio source folder before creating an AppWizard project named AppWizard under the e² studio project folder.

After generated the AppWizard, you should exclude the Simulation and Target folders from Build before building the e² studio project. All of the necessary library and header files for the target board are generated after you finish adding the emWin stack to your e² studio project.

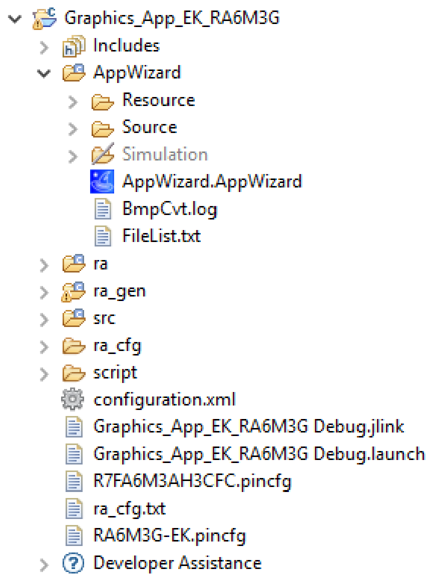


Figure 8. AppWizard Project File View in the Graphics Application Folder

Go to **Project>Properties>C/C++ Build>Settings>GNU ARM Cross C Compiler>Includes** to add the newly created AppWizard folder and its subfolders to the e2studio project include path as shown in Figure 9.

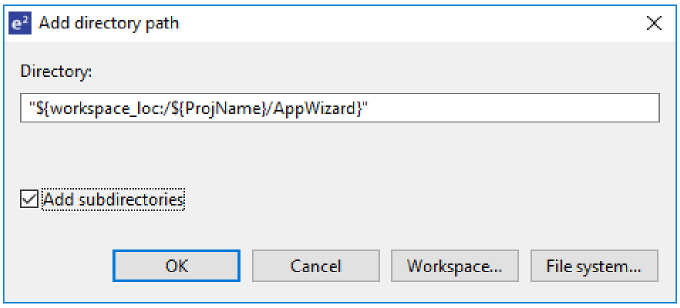


Figure 9. Adding the AppWizard Folder to the e² studio Project Include Path

3.2 Design Weather Panel Buttons Using AppWizard

The AppWizard ser Manual and Quick Start Guide cover basic designs. The **Logging Panel** buttons, on the other hand, are more complex and are the target of this Application Note. These buttons grouped in a Windows widget that including multiple-objects. For example, the window ID_WINDOW_SUN consist of:

- ID_WINDOW_SUN
  — Window widget. The place holder to group the other widgets.
- ID_MAGE_SUN_PRESSED
  — Image widget. Visible when the ID_BUTTON_SUN pressed, invisible when the ID_BUTTON_SUN released. Set bitmap using `bottom_button_trans_pressed.png`.

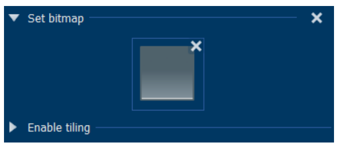


Figure 10. ID_MAGE_SUN_PRESSED Bitmap Setting

- ID_IMAGE_SUN
  — Image widget. Invisible when the ID_BUTTON_SUN is pressed, visible when the ID_BUTTON_SUN released. Set bitmap using `bottom_button_trans.png`.

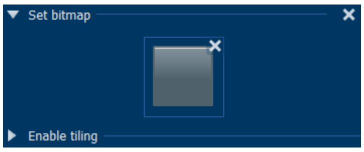


Figure 11. ID_MAGE_SUN Bitmap Setting

- ID_IMAGE_SUNNY_SUN
  — Image widget. Sunny icon. Set bitmap using `icon_sunny.png`.

Figure 12. ID_IMAGE_SUNNY_SUN Bitmap Setting

- ID_TEXT_SUN
  — Text widget. The “SUN” text.
- ID_TEXT_SUN_RANGE
  — Text widget. Shows temperature range.
- ID_BUTTON_SUN
  — Button widget. A transparent button without a bitmap image, placed on top of the other widgets. Some AppWizard interaction setups have to be in place to create button pressed/release impression.

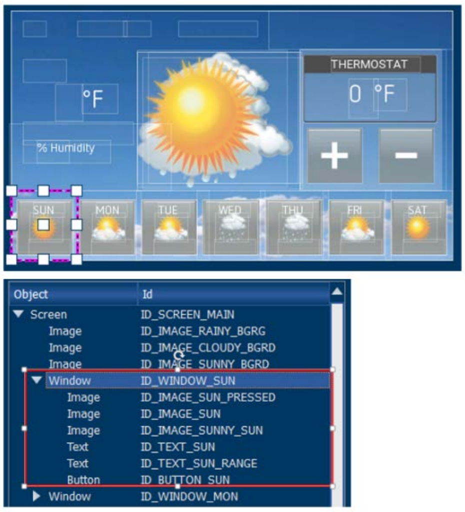


Figure 13. Design of the Sun Button Group

3.3 Setup AppWizard Interactions

Set the following interaction for the ID_BUTTON_SUN to create the button pressed/release as mentioned earlier in the Weather Panel Button Design section:

- • The ID_IMAGE_SUN widget is invisible when the transparent ID_BUTTON_SUN pressed.
- • The ID_IMAGE_SUN widget is visible when the transparent ID_BUTTON_SUN released.

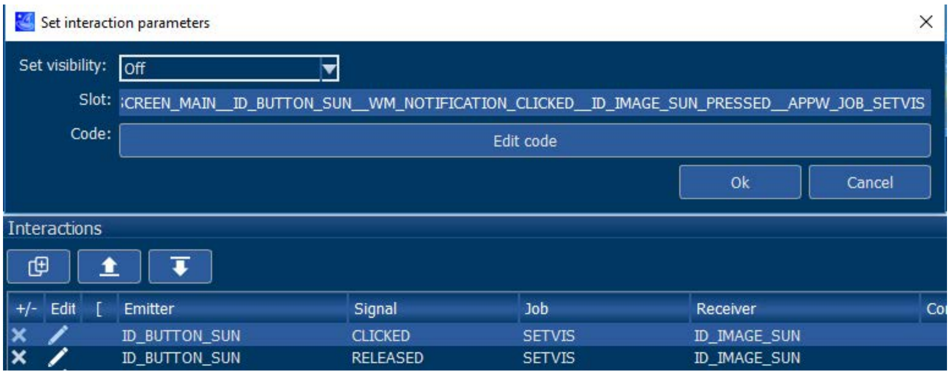


Figure 14. ID_BUTTON_SUN Interaction When Clicked

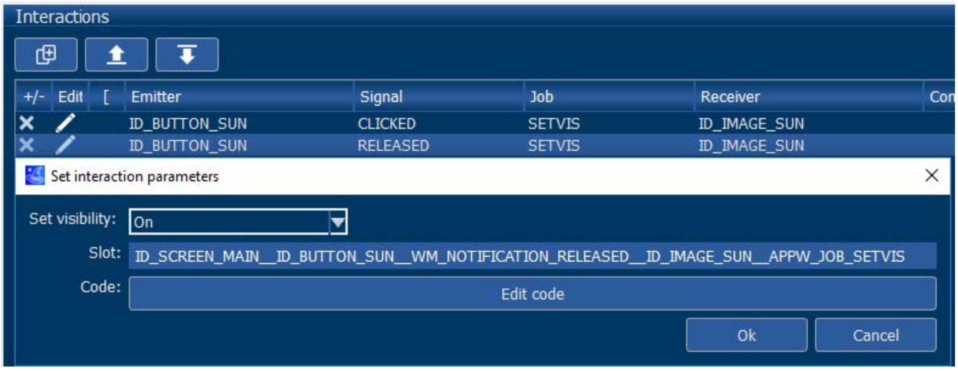


Figure 15. ID_BUTTON_SUN Interaction When Released

3.4 Add emWin Widget to AppWizard Project

Often, you may need to use an emWin widget that is not yet supported by the AppWizard. The AppWizard allows that capability via the emWin API calls.

The **Logging Panel** in this Graphics application features a Logging dialog created by using the Multiline Text widget, which not supported by AppWizard V1.06a_6.14a.

The steps to add an emWin widget to AppWizard project as following:

- Create an emWin widget by using emWin APIs in the slot routine for the AppWizard screen in the CustomCode folder.
- Handle GUI events/message if needed via slot routines in the file `<ScreenID>_Slots.c` located in the `\AppWizard\Source\CustomCode` folder.
- Figure 16 shows the function that creates the Multiline Text widget by using `MULTIEDIT_CreateEx` API and other APIs.

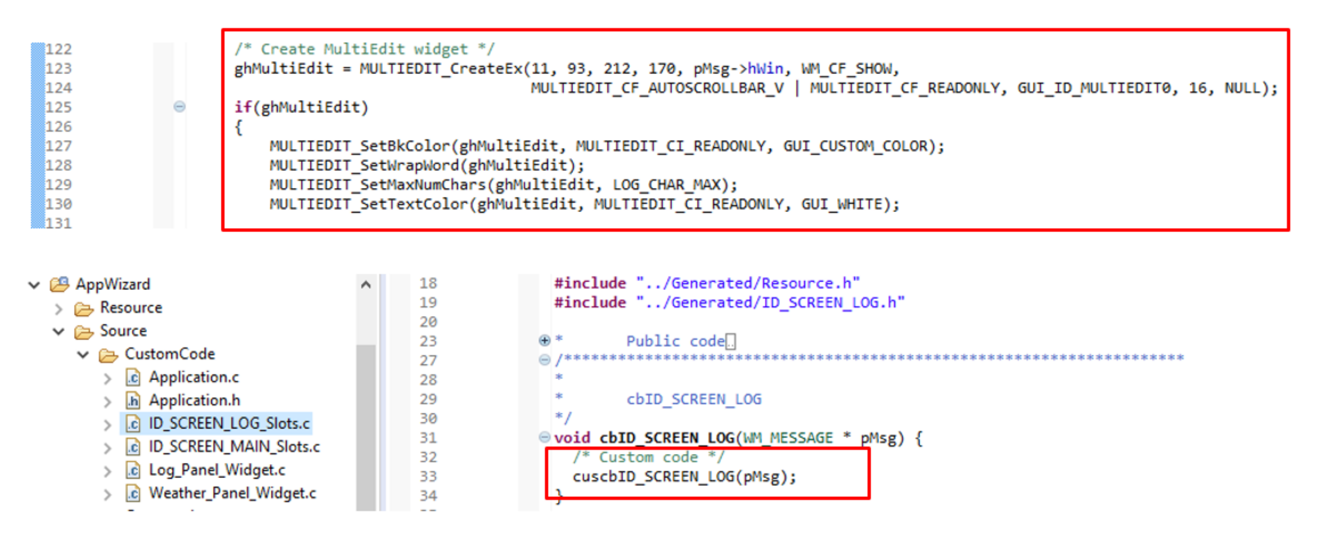


Figure 16. Adding Multiline Text Widget to AppWizard Application by using emWin APIs

4. Understanding the Graphics Application

While the HMI is certainly a large part of understanding any HMI application, there are many other areas that you must understand while developing with the Renesas FSP applications. These include how the project is physically structured in e^2 studio, how threads and thread resources are added to the project, how threads communicate, the state machine design, and how state data is shared among cooperating threads, and especially emWin thread.

4.1 Source Code Layout

Prior to diving into the actual application code, it is best to first understand the overall source code layout of an FSP project. Renesas FSP applications generally consist of two different types of code, your code, and auto-generated code. The auto-generated code can be further broken down into two sub-categories, code that is auto-generated by the FSP, and code that is auto-generated by AppWizard.

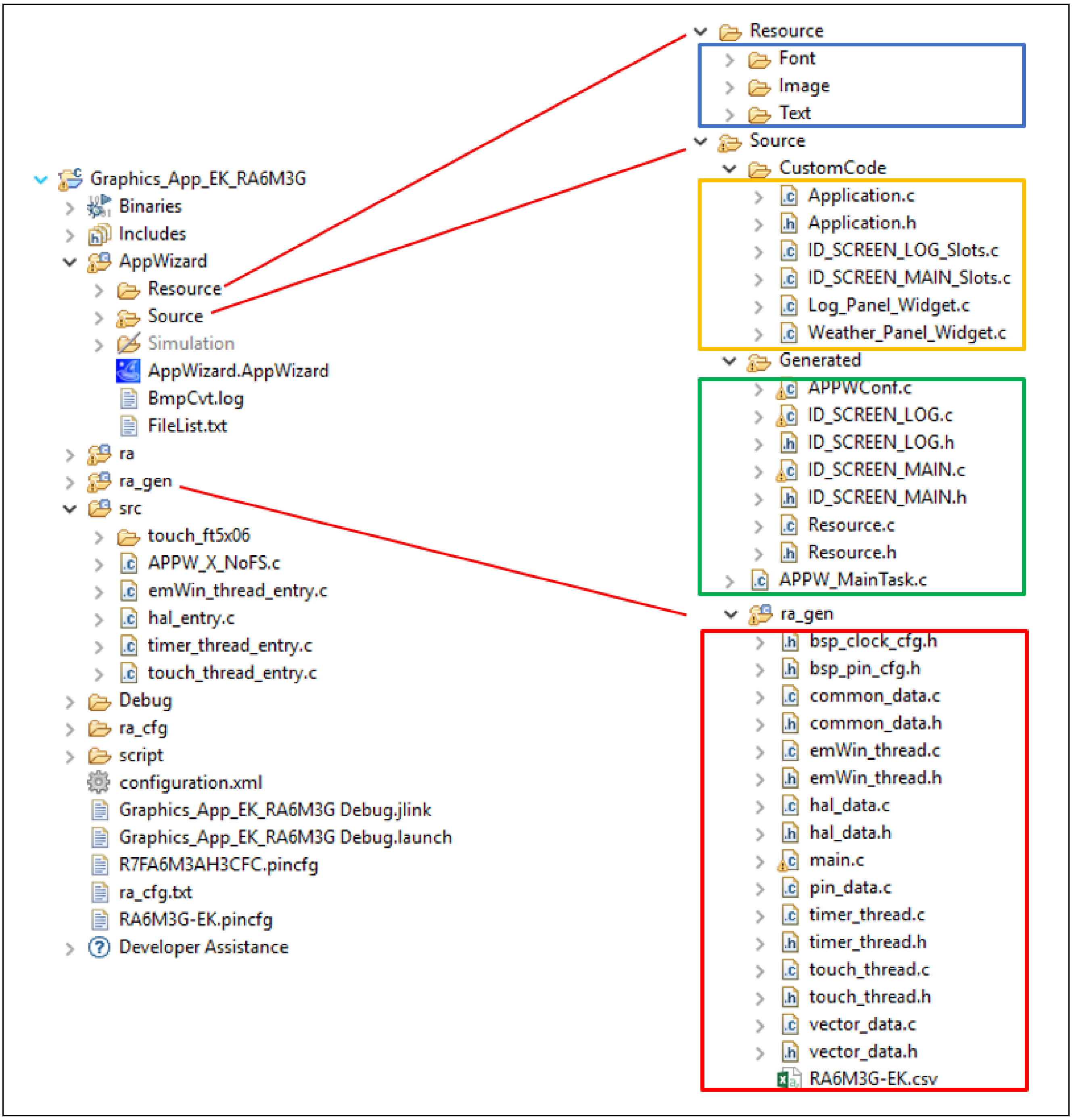


Figure 17. Graphics Application Project Source File Layout

Figure 17 above shows the source code layout for the EK-RA6M3G board. FSP auto-generated code is in the `ra_gen` folder, AppWizard auto-generated code is highlighted in the `Generated` folder, and the code you generated is in the `CustomCode` folder.

Your generated code `/AppWizard/Source/CustomCode` is mainly for HMI event handling. Your code in the `/src` folder is related to MCU peripherals and other functionalities.

4.2 Application Block Diagram

As mentioned, the Graphics application consists of two panels, the **Weather Panel** and the **Logging Panel**. The two application panels interface with the graphics framework through interaction such as touch events, and data (variables) changes. It communicates with FSP and HAL drivers to send and receive touch sensing data, GPT PWM duty cycle, and RTC date and time.

The graphics framework includes the SEGGER AppWizard framework, emWin library, emWin RA port, and interfaces with several HAL drivers such as GLCDC, JPEG CODEC, and D/AVE 2D. Figure 18 shows the application diagram.

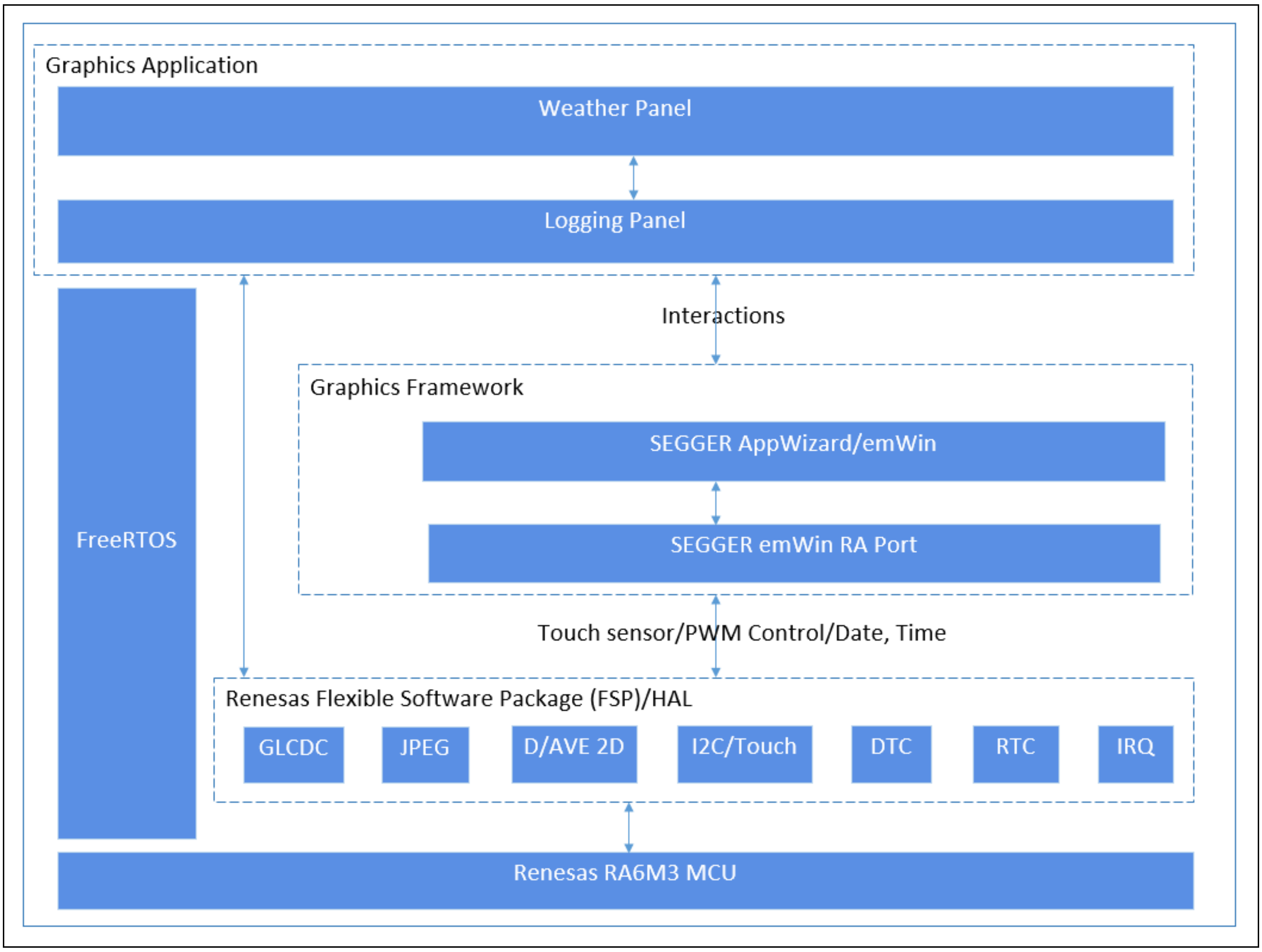


Figure 18. Application Block Diagram

4.3 Thread Overview

As mentioned in the introduction, the Graphics application is a multi-threaded application, running under FreeRTOS. There are two types of threads found in an FSP application, those created by you, and those created automatically to support operation of FSP. While it is obvious as to what threads you created, it is not always obvious as to what threads are created by FSP. The Graphics application uses both user-created threads and FSP threads. Threads communicate through the emWin messages and the FreeRTOS messaging framework. The emWin thread processes window events and touch messages, that are sent by the Touch thread. The FSP Configuration section details how to add your threads to your application. Figure 9 shows a high-level design of the threads and messaging running on the Graphics application. Notice the distinction between your threads and FSP threads.

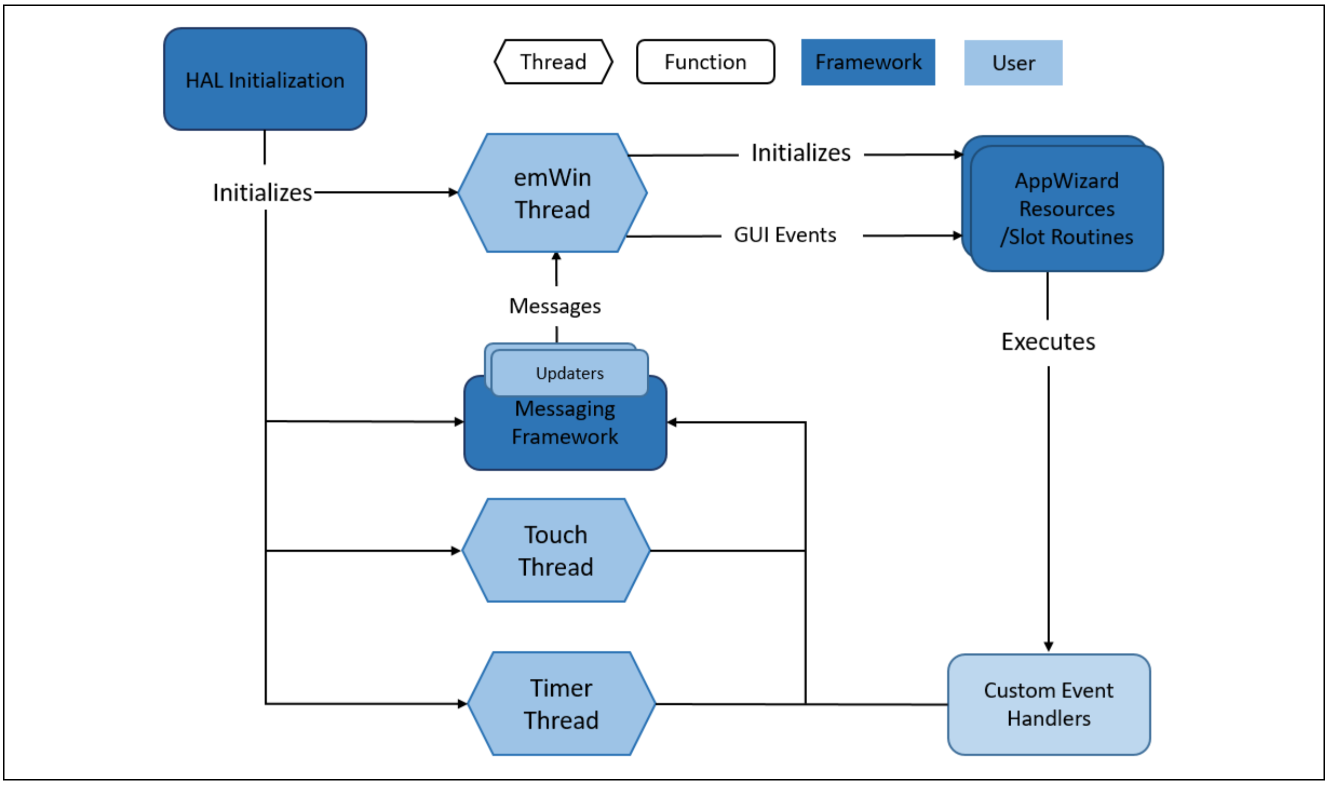


Figure 19. Graphics Application Message Sequence Flow

4.3.1 emWin Thread

The emWin thread is an HMI thread, which initializes various services and resources used by the Graphics application. Once this initialization is complete, the emWin thread processes touch messages, and window events. If any of these inputs result in a change to the system state, the emWin invokes the AppWizard Slot routines, which are the callback routines, resulting in changes to the graphical HMI. The flowchart in Figure 20 gives the high-level view of the emWin Thread.

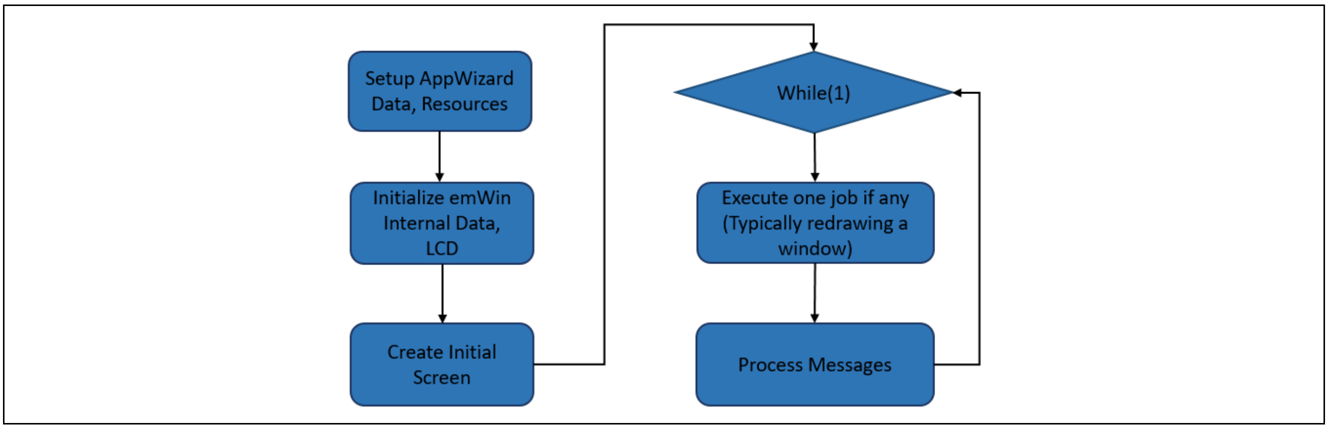


Figure 20. High-Level View of the emWin Thread

4.3.2 Touch Thread

A separate touch thread is created to read the touch sensor data. The touch sensor IC signals an event, such as a user interaction, on the LCD screen by toggling a pin connected to the MCU. In response, the touch thread reads the information from the touch sensor IC registers. Figure 21 shows the flowchart of the Touch thread.

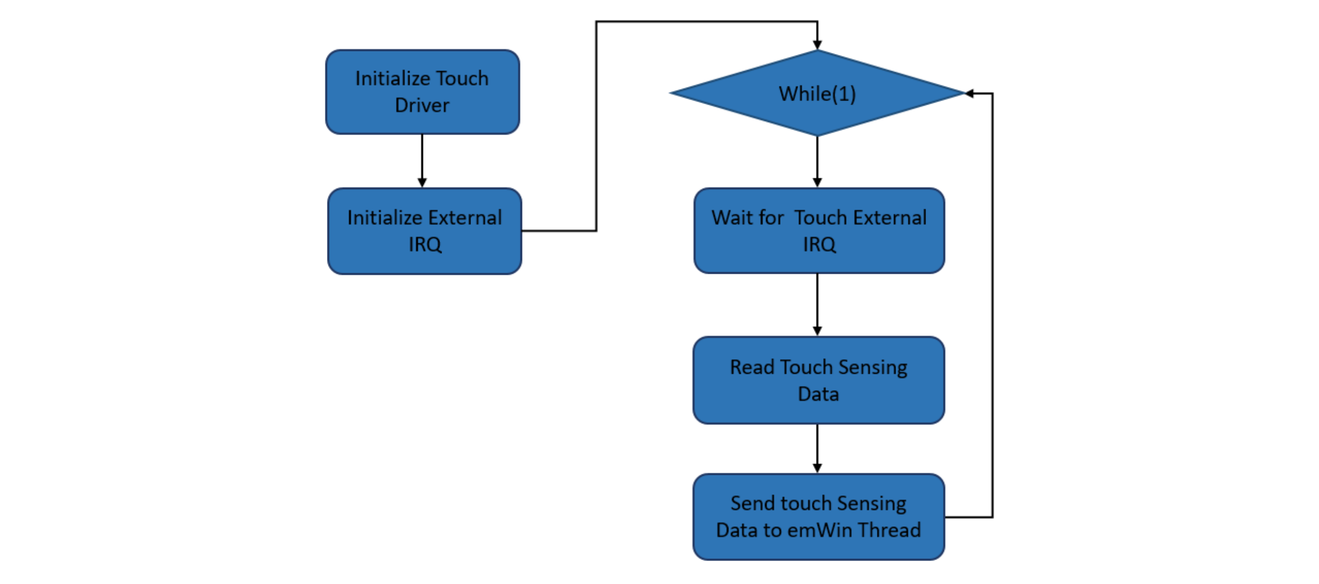


Figure 21. Touch Thread Flowchart

5. FSP Configuration

One of the first things you must do when writing an FSP application is to configure the FSP. To properly configure the FSP, you must have detailed knowledge of both the software design that you will be implementing, along with the specific hardware it will be running on. For the hardware, this includes the types of peripherals to be used on the hardware, the pins they are mapped to, if they are internal or external to the MCU, and so on. From the software perspective, you need to decide how many threads will be used, which threads need access to what hardware components, and what additional software objects like semaphores, queues, and so on that each thread will require. Once you have this information, you will be ready to successfully configure the FSP for your specific application needs.

In the **Weather Panel** application, the FSP configuration is stored in a file named `configuration.xml`. Double clicking on this file brings up the **RA Configuration** tab for the project.

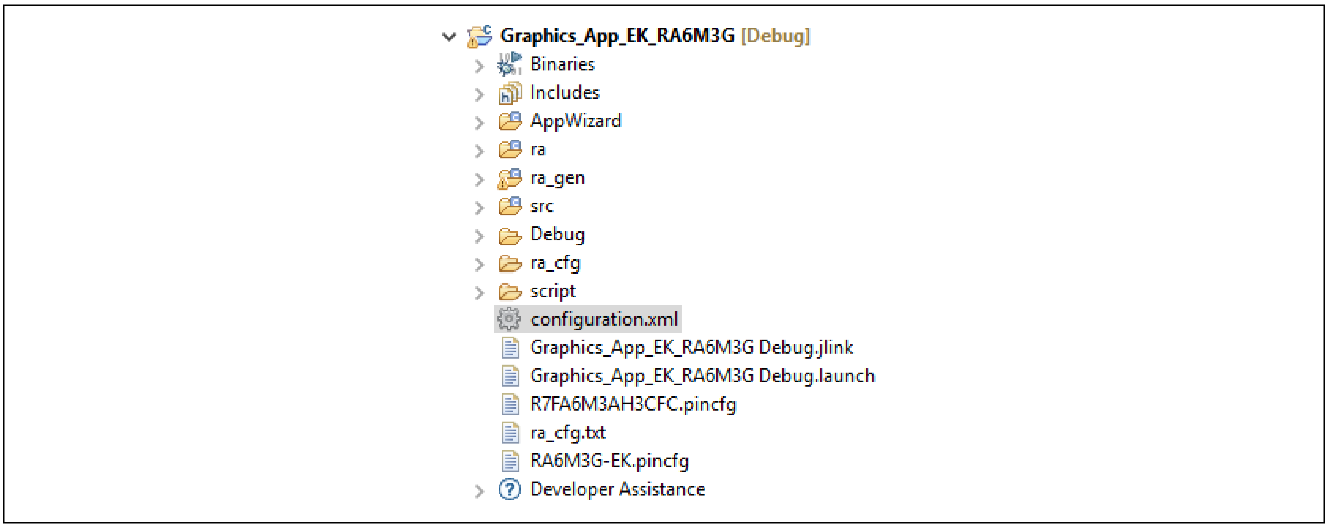


Figure 22. configuration.xml on the Project Plane

When a project is built from scratch, this configuration tab is where you will perform the initial configuration of the FSP. As you can see in Figure 23, the RA Configuration pane contains a **Summary** screen highlighting the items you may configure, along with a scrolling window that lists all the software components currently selected for this project. Below this scrolling window are tabs that allow you to tailor the FSP to the needs of your specific application.

For the purposes of this application note, we will highlight a few of the details of the FSP configuration such as SEGGER emWin, the r_glcdc driver, touch controller, and PWM timer as they pertain to the graphics application. For additional details, refer to the Renesas Flexible Software Package (FSP) v1.2.0 User's Manual on how to configure the FSP.

When you have configured the project appropriately, click the **Generate Project Content**, the green arrow button above the summary screen, to build all the auto-generated files necessary to implement the components you defined.

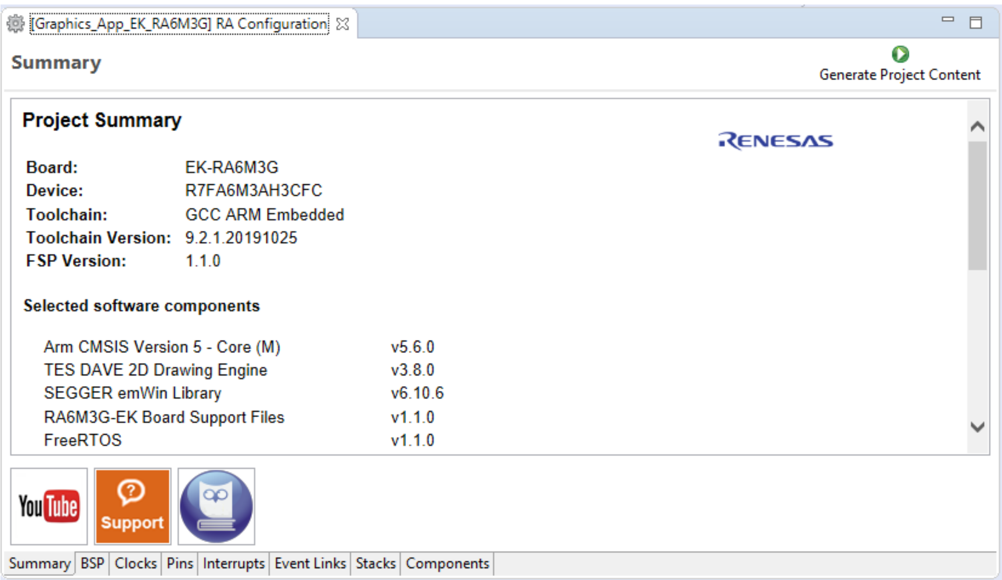


Figure 23. Summary of the Graphics Application Configuration

5.1 Components Tab

Even though the **Components** tab is the last tab showing, it is one of the first things you should configure. Selecting components first makes them available in subsequent operations such as mapping hardware resources to specific threads in the **Stacks** tab. One of the advantages of the FSP is that it will only compile in the components you choose, thereby reducing the size of your overall application. As shown in Figure 24, components are broken down into seven categories.

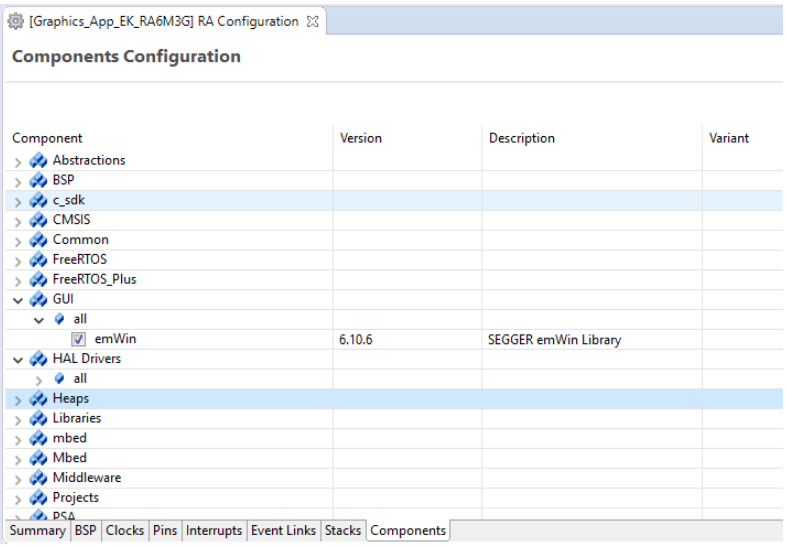


Figure 24. Components Tab Categories

You may expand any of the categories by clicking the arrow to the left of the category name.

The following table highlights the selections used for the Graphics application.

Table 2. Components Used in the Graphics Application

Category	Component	Version	Description
BSP	ra6m3g_ek	1.2.0	RA6M3G-EK Board Support Package Files
CMSIS	CoreM	5.6.0	Arm CMSIS Version5 - Core (M)
Common	fsp_common	1.2.0	Board Support Package Common Files
GUI	emWin	6.12.12	SEGGER emWin Library
HAL Drivers	r_drw	1.2.0	TES D/AVE 2D Port
	r_dtc	1.2.0	Data Transfer Controller
	r_glcdc	1.2.0	Graphics LCD Controller
	r_icu	1.2.0	External Interrupt
	r_iic_master	1.2.0	I2C Master Interface
	r_ioport	1.2.0	I/O Port
	r_jpeg	1.2.0	JPEG Codec
	r_rtc	1.2.0	Real Time Clock
	r_ioport	1.2.0	I/O Port
Heaps	heap_4	1.2.0	FreeRTOS - Memory Management – Heap 4
Middleware	rm_emwin_port	1.2.0	SEGGER emWin RA Port
RTOS	FreeRTOS	1.2.0	FreeRTOS
TES	dave2d	3.8.0	TES DAVE 2D Drawing Engine

5.2 Stacks Tab

The **Stacks** tab is where you can add and configure the threads that the FSP automatically creates for your application. You define a new thread by clicking the  button and then entering a unique name for your new thread. Once you add a new thread, you must define the Modules that the thread will use along with any thread objects that will be used by your thread.

As an example, if you click the **Threads** and then single click on the **emWin Thread**, you should see something like the screen capture shown in Figure 25. This shows that the emWin thread requires multiple modules, for exam[ple, the GLCDC driver which is used to control the LCD screen on the Graphics expansion board of the EK-RA6M3G kit.

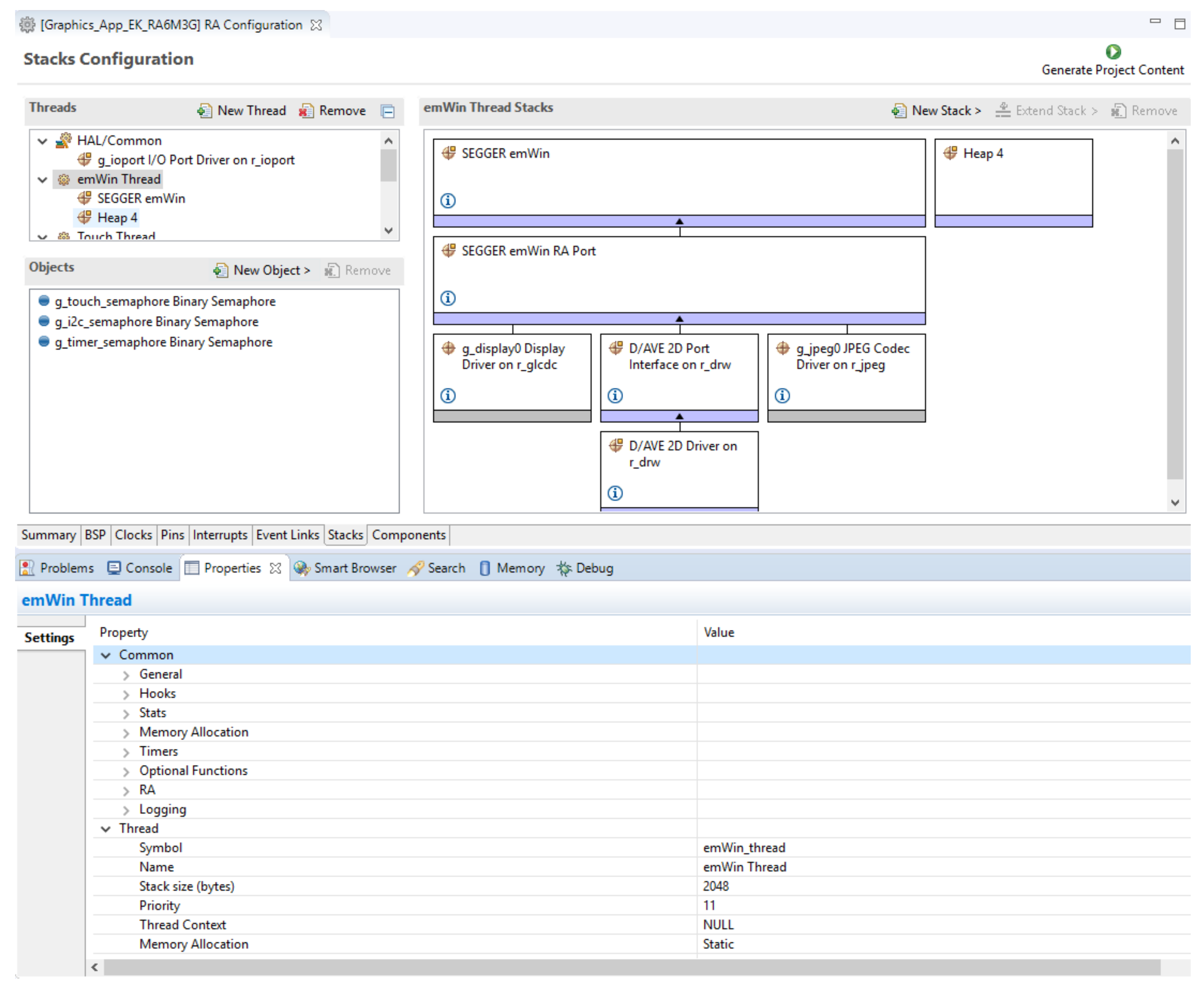


Figure 25. emWin Thread Properties and Modules Using for the Graphics Application

You can add additional Modules to any thread by clicking the button. If you have chosen the appropriate components prior to adding Modules to your threads, you should not receive any errors. As an example, Figure 26 shows you how to add a GPT timer to the Timer Thread. The timer is added by choosing **(+) New Stack** > **Driver** > **Timers** > **Timer Driver on r_gpt**.

If you pick a Module that you have not preselected, the appropriate component for first, the FSP automatically selects the component for you. If the FSP detects errors with the Module addition, it prefaces the Module with an error. You may examine the errors by hovering over the Module name.

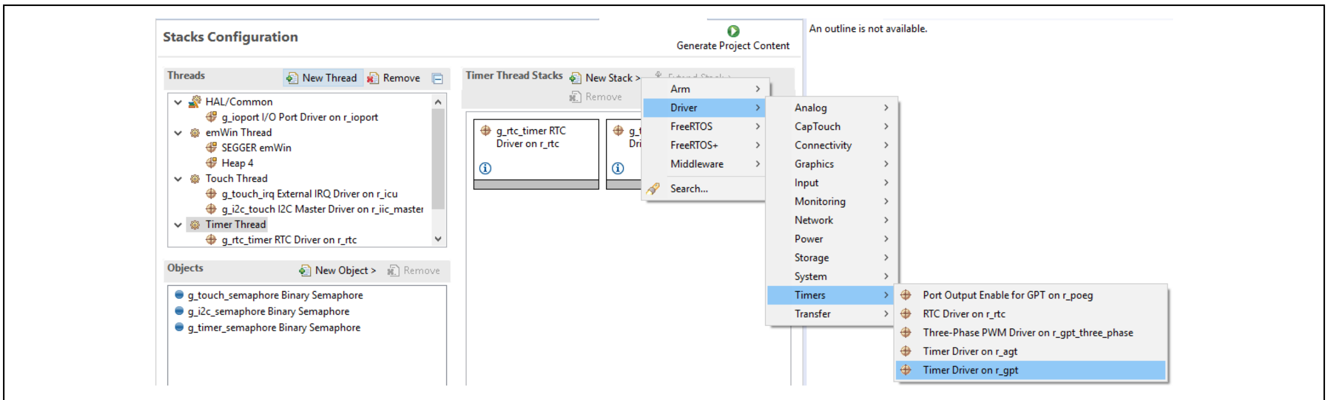


Figure 26. Screenshot of Weather Panel being designed in AppWizard

5.3 Thread Objects

FreeRTOS supports various objects such as Mutexes, Queues, Semaphores, and Timer. In the **Objects** window, you will see that there are three semaphore objects, **g_touch_semaphore**, **g_i2c_semaphore**, **g_timer_semaphore** created for this application.

You can allocate additional thread objects by clicking on the button next to the **Objects** window. As you can see in Figure 27, after clicking the button in the **Objects** window, you are presented with a drop-down list that allows you to add the standard thread objects supported by FreeRTOS.

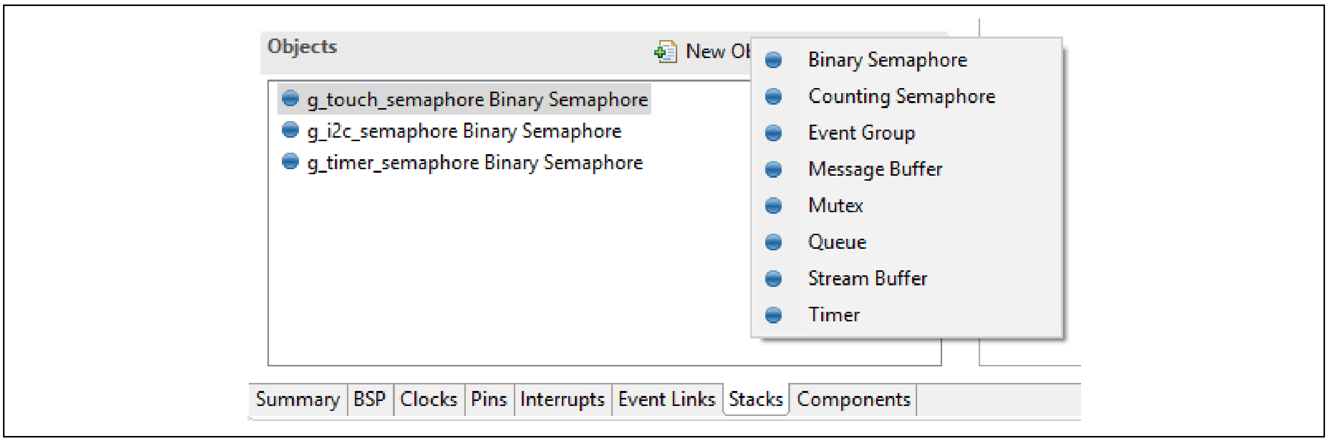


Figure 27. Screenshot of Weather Panel being designed in AppWizard

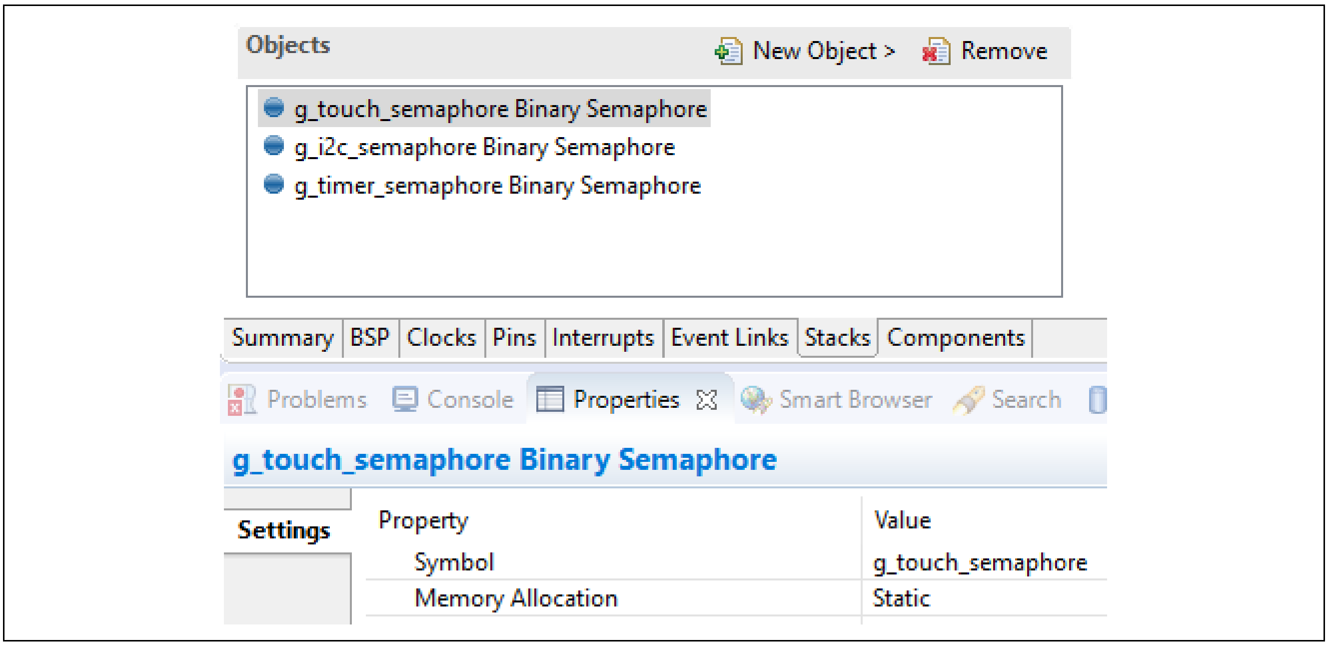


Figure 28. g_touch_semaphore Properties

5.4 Module Configuration

Once you have added a module to your project, you need to configure its properties. The properties are dependent on the module(s) that you have added. Use the **Properties** tab to configure them. The graphics application adds the `r_glcd` driver module as part of SEGGER emWin stack. This module is used to configure the GLCDC peripheral of the Renesas RA6M3 MCU.

5.4.1 GLCDC Configuration

As you can see in Figure 29, selecting the `g_display0 Display Driver` on the `g_glcdc` module under the emWin Thread Modules dialog brings up the associated properties under the **Properties** tab. The first thing you will notice is that it is a lengthy list of properties within the Module group. The Module group is where you configure the GLCDC controller. These properties can be a bit daunting at first but can be broken down. First, you will notice a few broad categories inside the Module grouping.

- **Name:** The name given to this instance of the module `g_display0` by default.
- **Interrupts:** You set the Line Detect interrupt and other interrupts here.
- **Input:** This block of module properties defines the input to the graphics controller, most notably, the framebuffer name and the number of the framebuffers, the memory address where the frame buffer is located, and others.
- **Output:** This is the area where you define the output properties of the GLCD. This includes properties such as the total Horizontal and Video Cycles, the active video cycles, both horizontal and vertical, front and back porch duration, and so on.
- **TCON:** You use these lines in conjunction with the **Pins** tab, to map the Horizontal Sync (Hsync), Vertical Sync (Vsync), and Data Enable signals. You can specify the LCD Panel clock divisor that divides the clock input to the GCLD. This divisor ratio currently ranges from 1/1 to 1/32.
- **Color Correction:** This is where you can add various levels of color correction, for example, brightness, contrast and gamma to your display. Color, contrast, and gamma correction of LCD screens are outside the scope of this application note, but this is the area where you would do that type of adjustment.

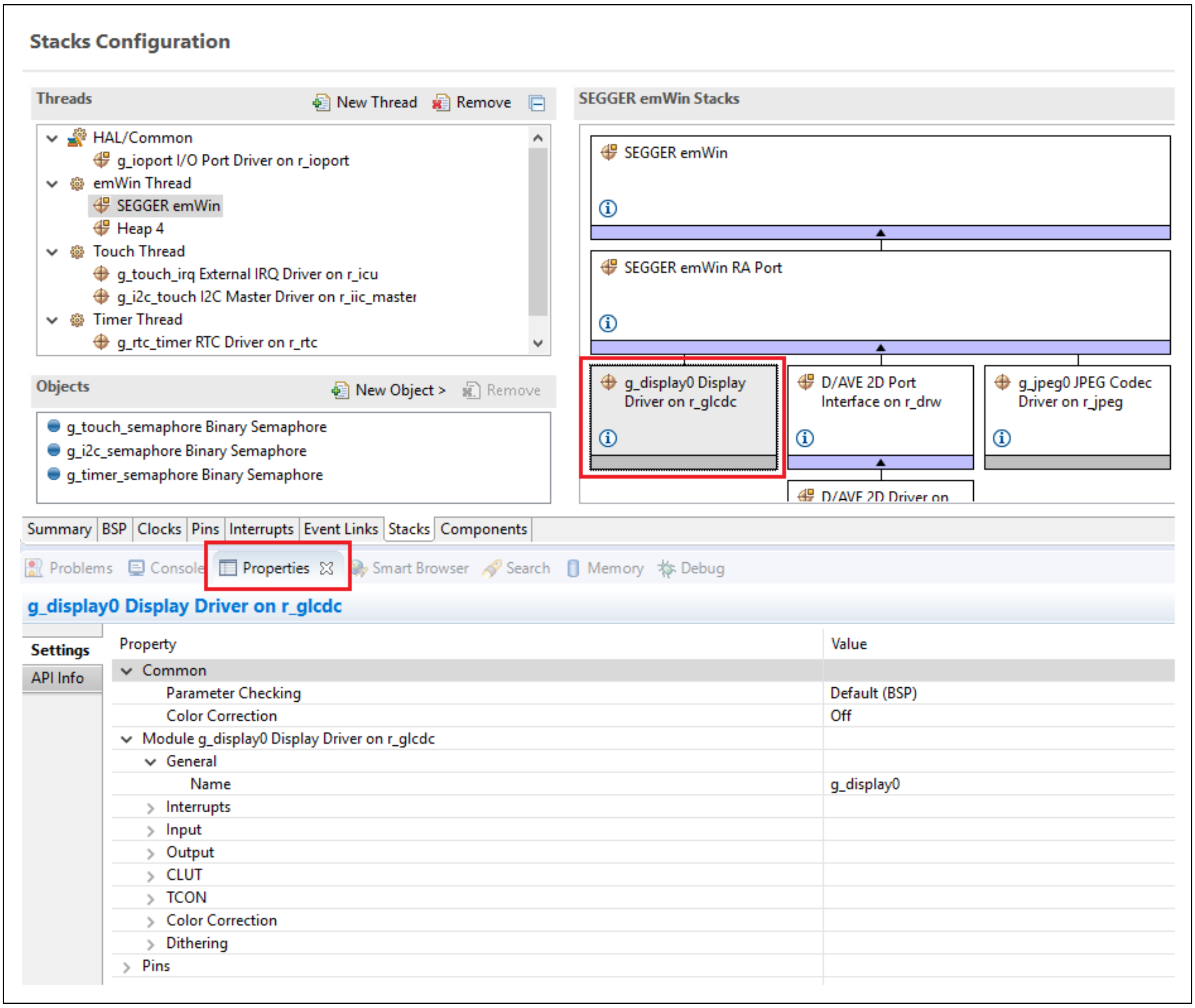


Figure 29. GLCD Properties Configuration using the Properties Tab

5.4.2 TCON Configuration

If you scroll down a little further in the **Properties** tab, you will see four TCON properties. One of these is associated with the Panel clock division ratio. This allows additional division of the pixel clock that is driven directly from the PLLOUT branch of the clock tree. The other three are associated with the LCD sync signals. These three signals can be confusing to new users, so how these signals map to the physical pins they are connected to, is discussed here.

TCON	
Hsync pin select	LCD_TCON0
Vsync pin select	LCD_TCON1
Data enable (DE) pin select	LCD_TCON2
Panel clock source	Internal clock (GLCDCLK)
Panel clock division ratio	1/24

Figure 30. TCON Configuration for EK-RA6M3G Kit

To provide flexibility, the GLCD controller of the RA6M3 MCU provides two pin grouping options. Each option uses different pins on the MCU to drive the data lines connected to the LCD display. It is up to the hardware designer to pick the group of pins they want to use. Picking one or the other may free up MCU pins that are necessary in some other part of the hardware design.

If you look at the schematics for the EK-RA6M3G kit, you can see the pins header for the LCD board. You will also notice the three pins connected to the sync signals that are highlighted in red. The data lines chosen by the hardware designer must match one of the two pin groupings available under the GLCD module.

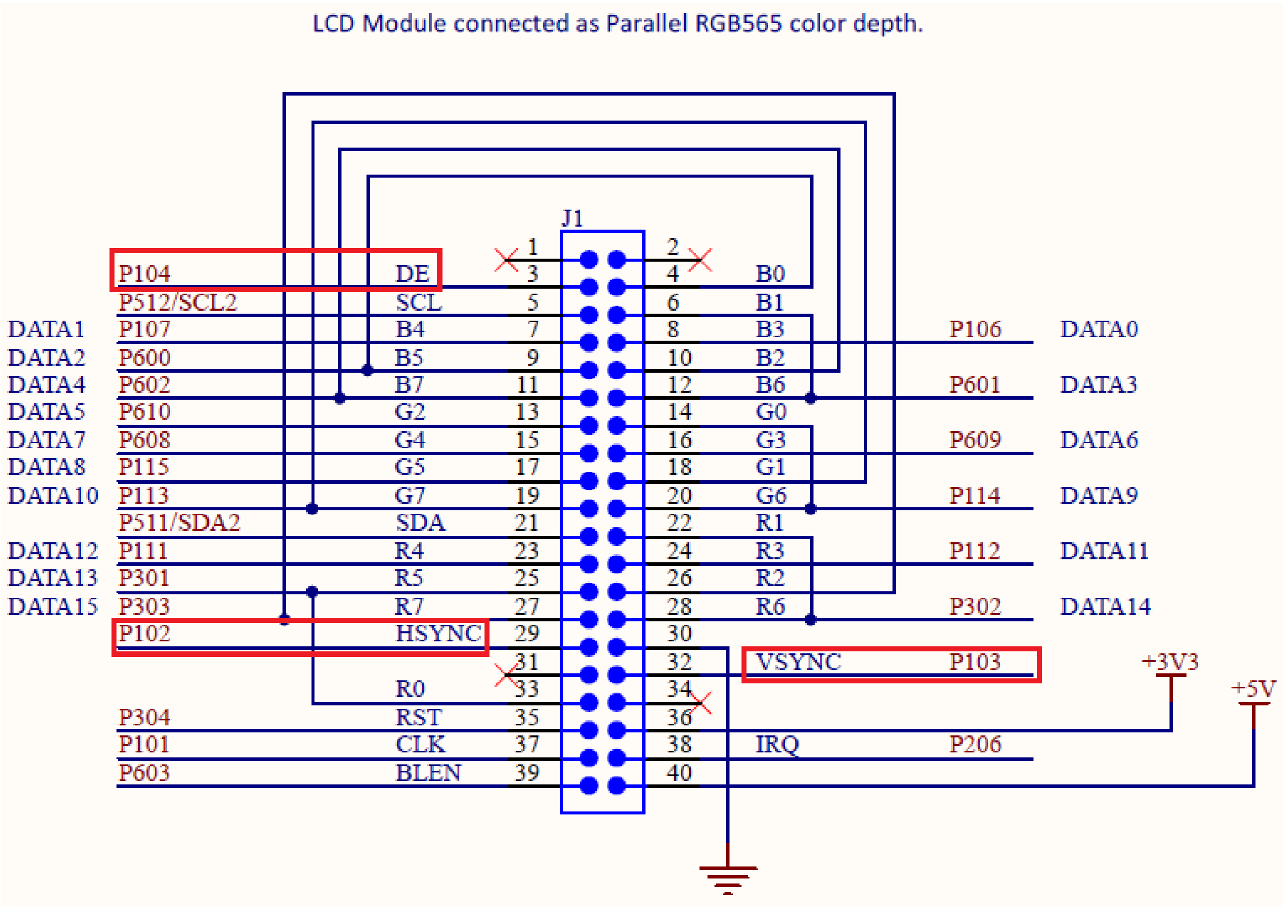


Figure 31. EK-RA6M3G LCD-Specific Signals from the Schematics

The easiest way to understand this is to go to the **Pins** tab in the RA Configuration window. You will see selections for **Ports**, **Peripherals**, and **Other Pins**, as shown in Figure 32. If you expand the **Peripherals** dialog, you will see all the various MCU peripherals that can be configured from this screen.

If you scroll down to the **Graphics:GLCDC** entry and click to expand it, you will see two options **GLCD0 Pin Group Selection A** and **GLCD0 Pin Group Selection B**. In case of EK-RA6M3G kit, the **GLCD0 Pin Group Selection A** selected to drive the LCD display.

Notice that TCON0 is associated with the Port 1 Pin 02 (P102). On the schematic (P102) we see that it is connected to HSYNC, which is the horizontal synchronization pin for this LCD screen. Referring to Figure 30, we see TCON0 has been selected to drive the HSYNC signal.

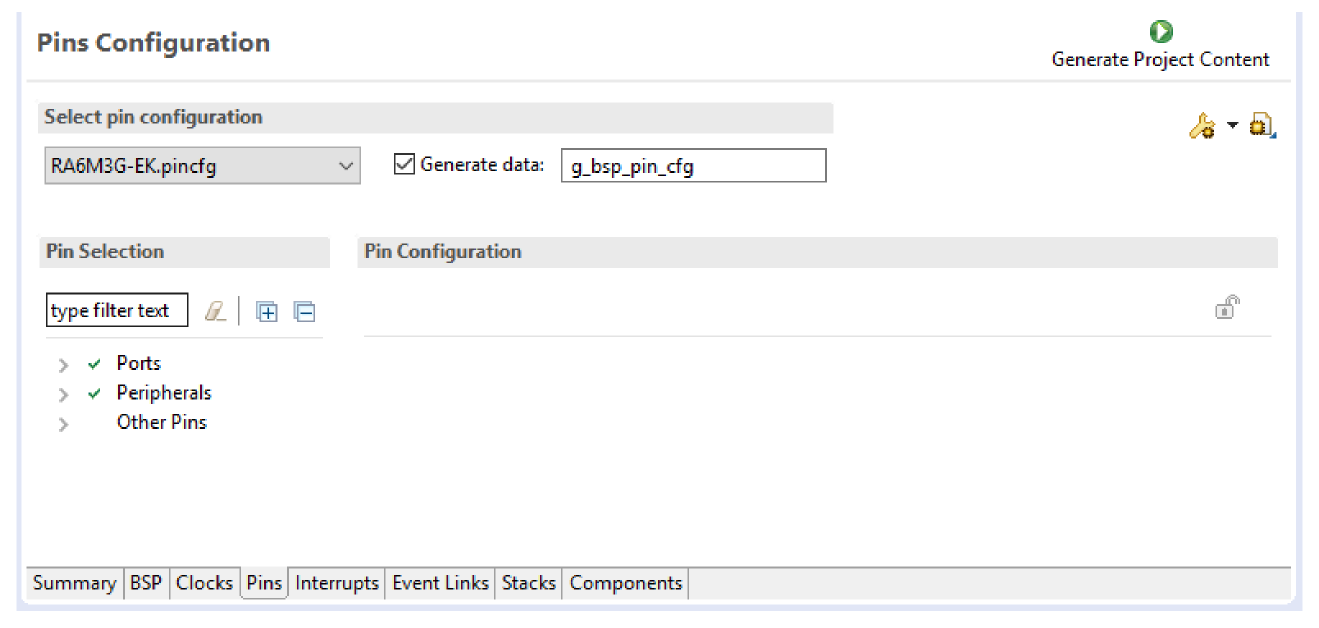


Figure 32. Pin Configuration Tab

If you look at all the LCD data lines such as LCD_DATA_DATA00, and the pins they are connected to, they should match the pins they are connected to on the schematic. Clicking on the arrow to the right of the pin brings you directly to the associated **Pin Configuration** dialog just as if you had selected the **Ports Group**, and then the specific port and pin that you are interested in.

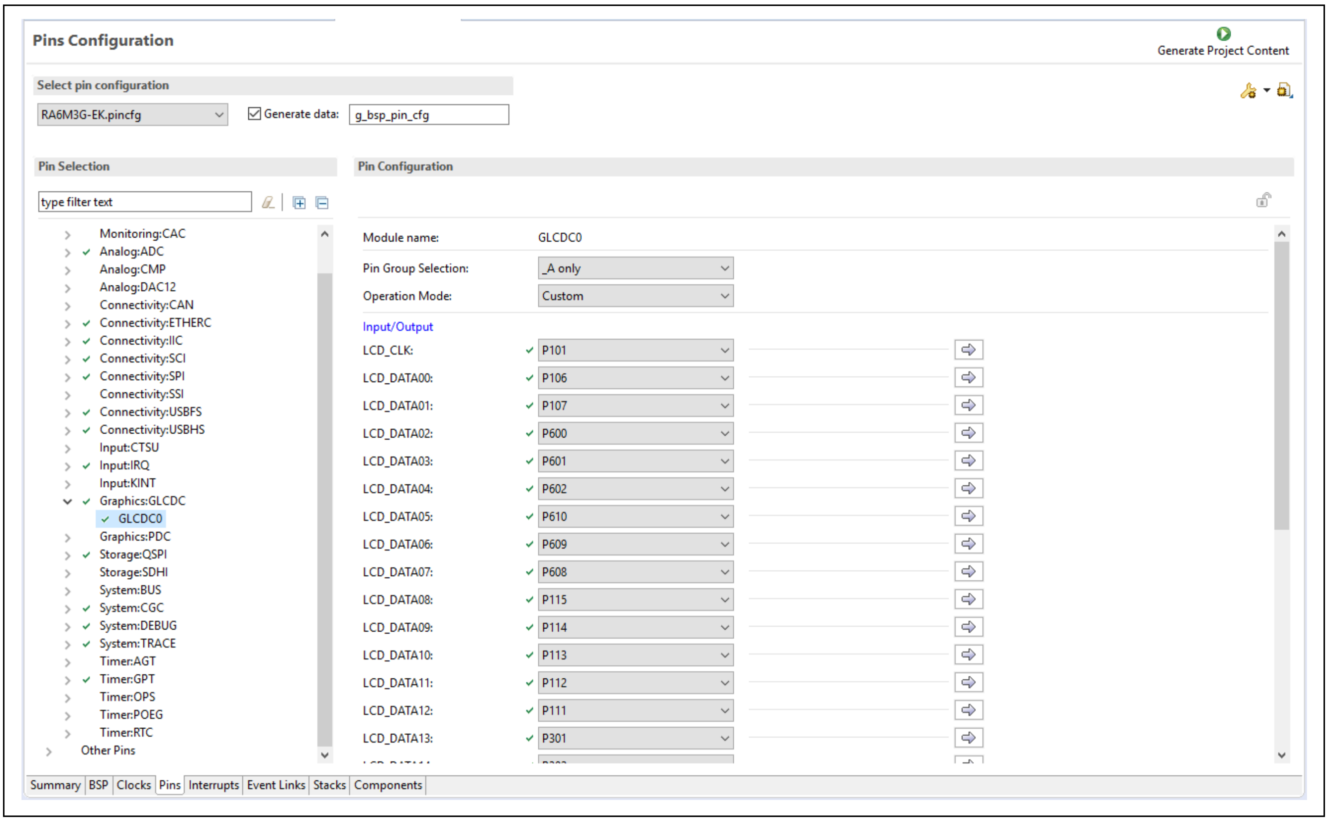


Figure 33. LCD Pin Configuration Using Configurator

For example, clicking on this arrow next to the LCD_TCON0 pin should bring you to the **Pin Selection Screen** that looks like Figure 34. Notice that the pin is appropriately set to the **Peripheral mode**. At the time of writing this application note, the pins default to no Pull Up, High Drive Capacity, and CMOS output type. Clicking on the arrow button to the right of this screen brings you back to the associated peripheral screen.

Note: At the time of writing this application note, when you select option A or B of the **Graphics:GLCDC** peripheral, you must manually enable each pin connected to your display. Using the arrow button to toggle back and forth between the **Peripheral** screen and the **Pin Configuration** screen makes this process easier.

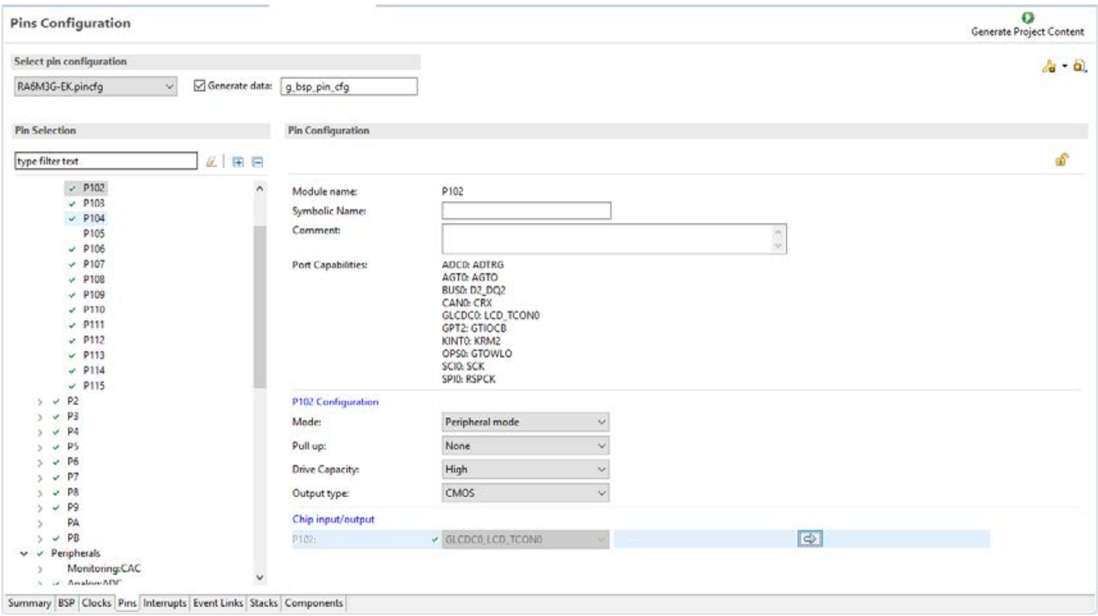


Figure 34. LCD_TCON0 Settings in Pin Configuration Tab

5.4.3 Touch Controller Configuration

The touch event on the LCD screen is sensed by the RA6M3 MCU external IRQ pin, and touch sensor is read via I2C master.

As shown in Figure 37, the interrupt signal of the Touch Controller on the LCD screen connected to P206 on header J1 of the EK-RA6M3 board, which is MCU IRQ channel 0. The `r_icu` and `r_iic_master` drivers are adding to a Touch Thread to handle the IRQ channel 0 and I2C Master Channel 2, respectively.

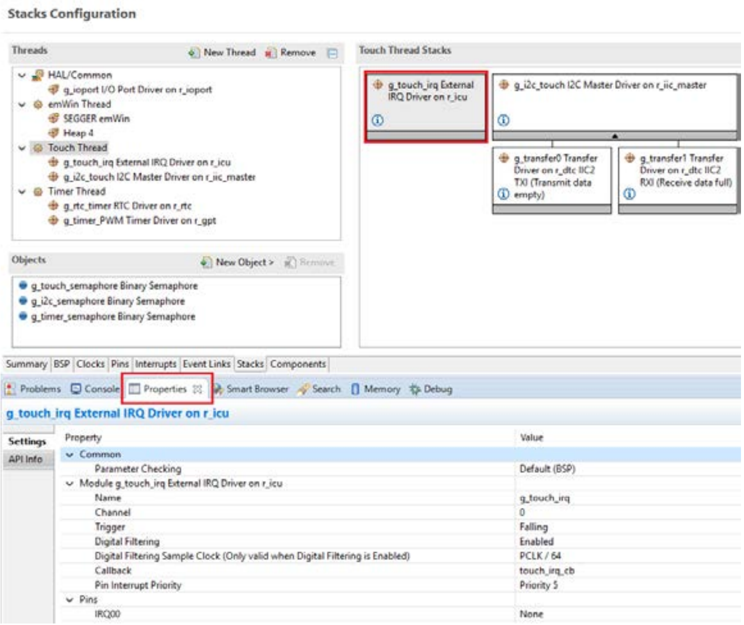


Figure 35. External Interrupt Configuration

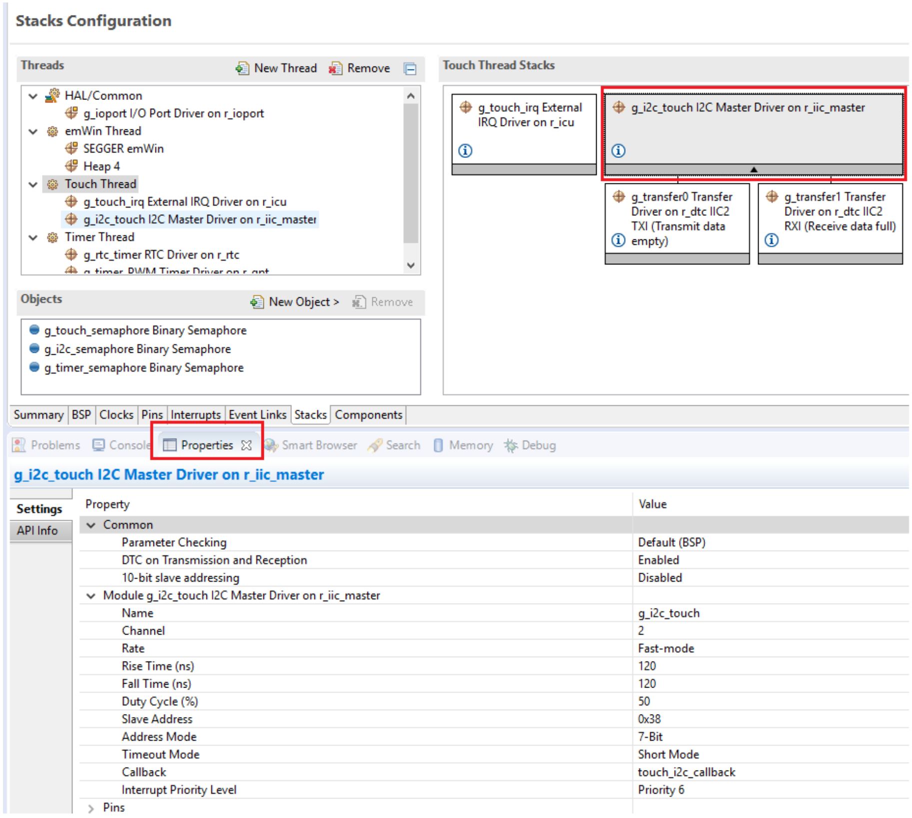


Figure 36. I2C Master Driver Configuration

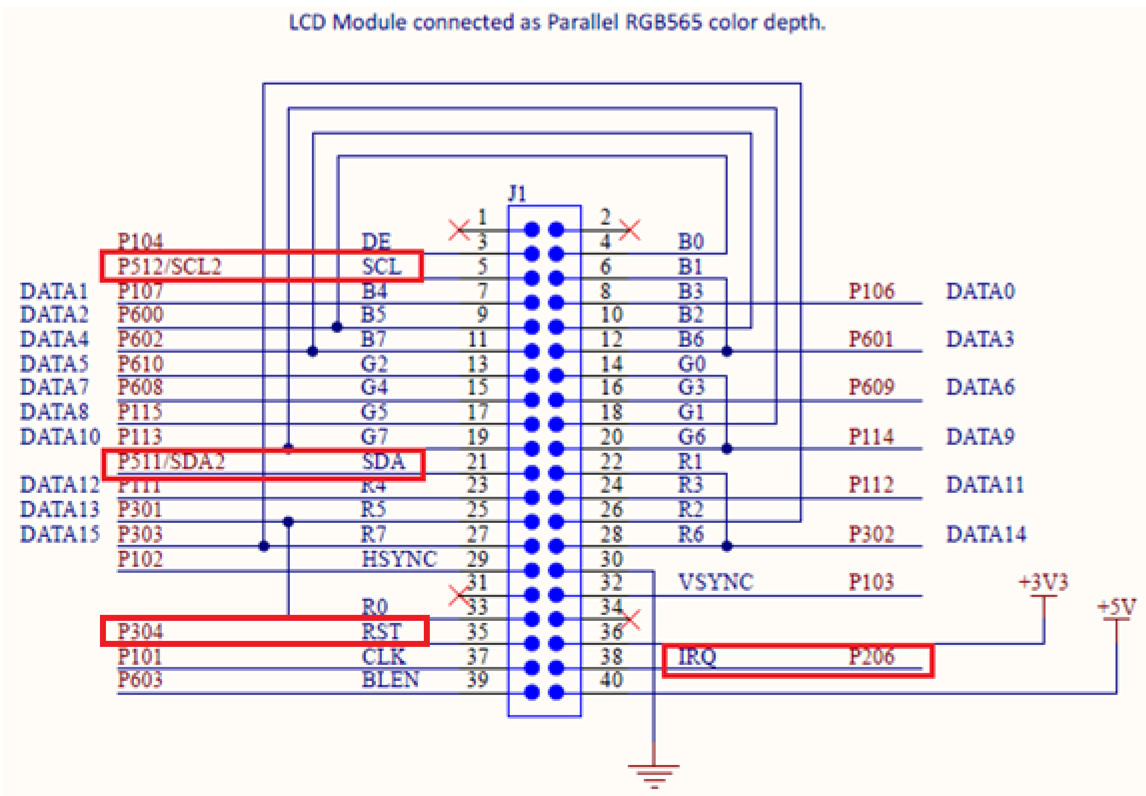


Figure 37. Touch Controller Signals

The EK-RA6M3G User Manual r20ut4629eu0101-ek-ra6m3g-v1-um.pdf recommends the touch interrupt input must have the internal pull-up feature enabled. Use Ports Configuration for this setting instead of Peripherals Configuration.

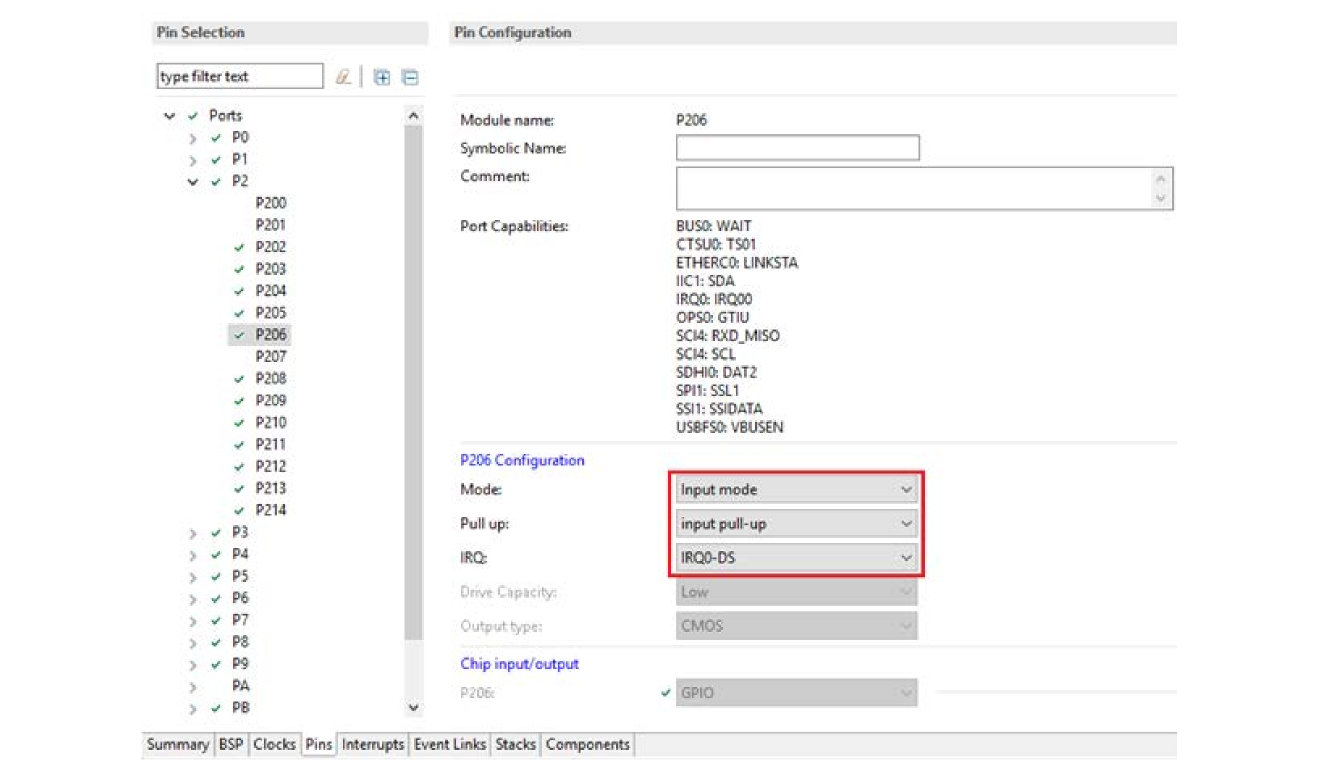


Figure 38. Touch Controller Interrupt Configuration

When creating a project from scratch, you must add the touch driver to your project by copying the `touch_ft5x06` folder to the new project. Go to **Project>Properties>C/C++ Build>Settings>GNU ARM Cross C Compiler>Includes** to add its Include Path.

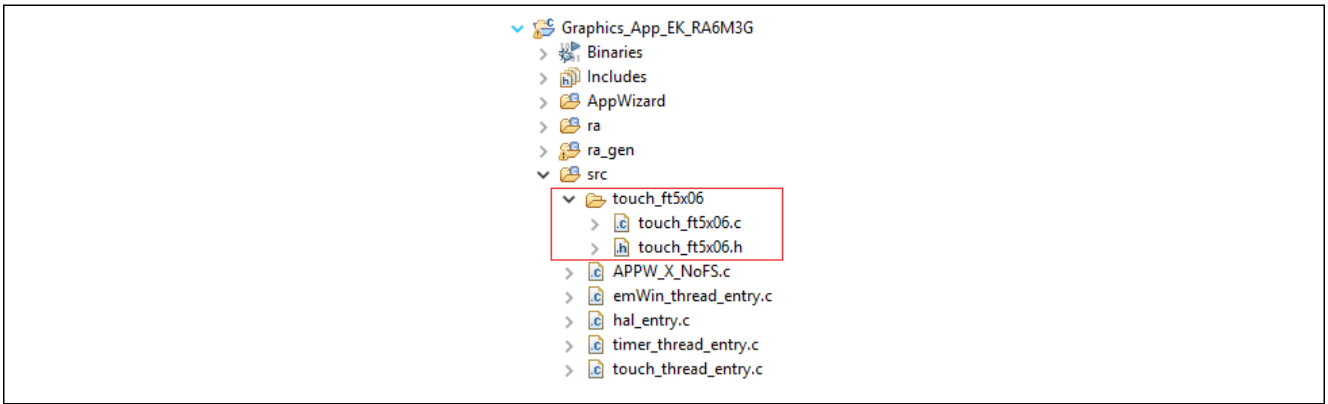


Figure 39. Backlight Control Pin on EK-RA6M3G

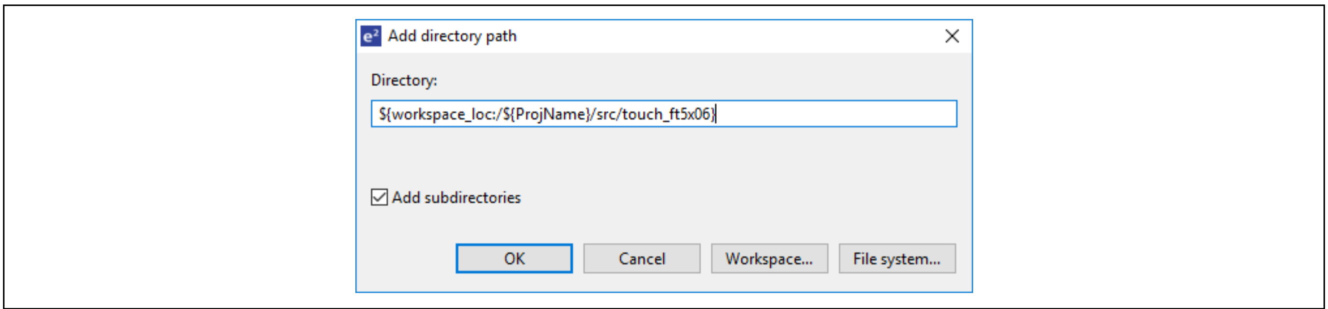


Figure 40. Add Touch Driver Folder to the List of Include Paths

5.4.4 PWM Configuration

The LCD_BLEN signal (Blanking Enable), which is connected to the P603 on the RA6M3 MCU, is configuring in PWM mode to control the intensity of LCD backlight. Figure 41 shows an excerpt from the Graphics Expansion board schematic, which shows the LCD_BLEN signal connected to the backlight controller.

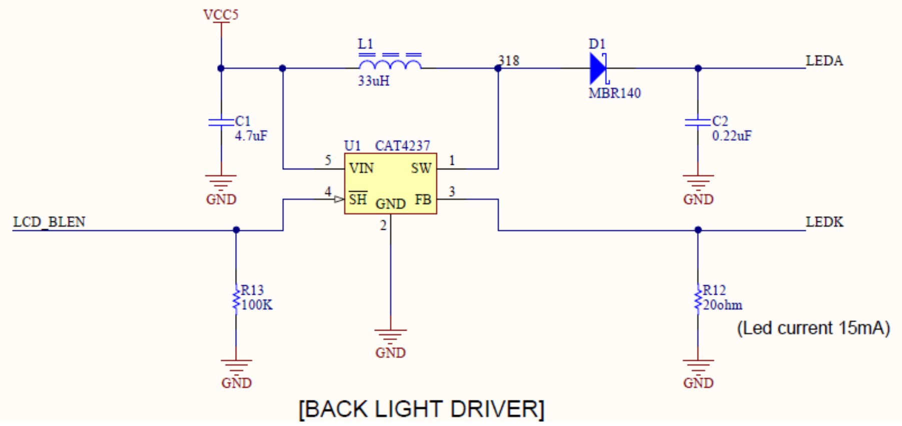


Figure 41. Backlight Control Pin on EK-RA6M3G

In Pin Selection Configuration set P206 as GTIOCA output of the GPT channel 7, the **Pin Group Selection** is set as mixed and the **Operation Mode** operation as GTIOCA or GTIOCB.

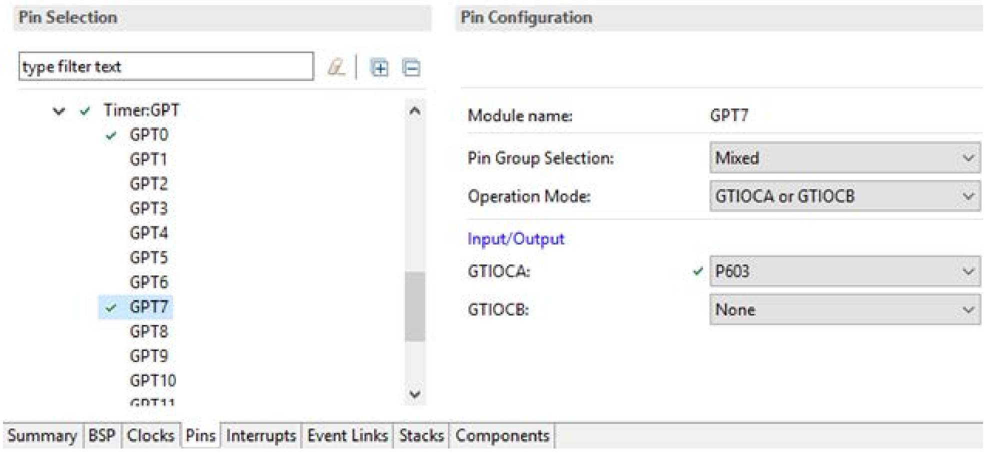


Figure 42. GPT PWM Channel 7 Pin Configuration

The `r_gpt` in the Timer thread is set in PWM mode to modulate LCD backlight intensity. In this graphics application, moving a slider in the **Logging Panel** will generate a duty cycle percentage that will be calculated into the GPT timer period and write to the counter register.

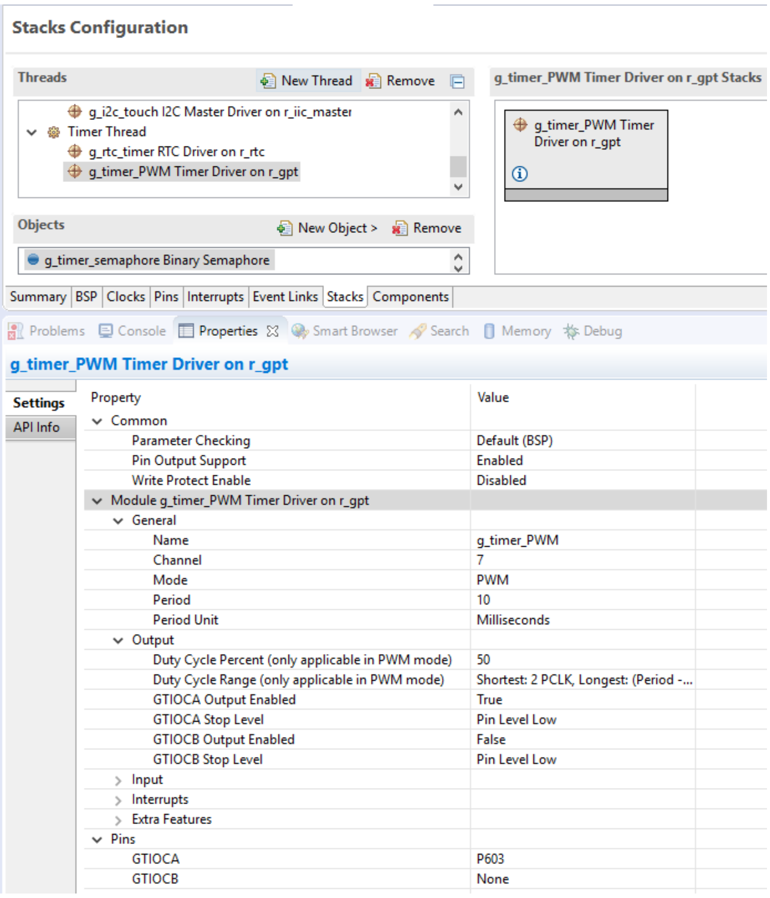


Figure 43. GPT Driver Configuration in PWM Mode

Figure 44 and Figure 45 show the AppWizard Configuration for the Backlight Slider. Its range limits are from 5 to 100. Some interactions and custom code are needed to control the duty cycle of PWM output as well.

Figure 44. Slider Setup to Control LCD Backlight Intensity

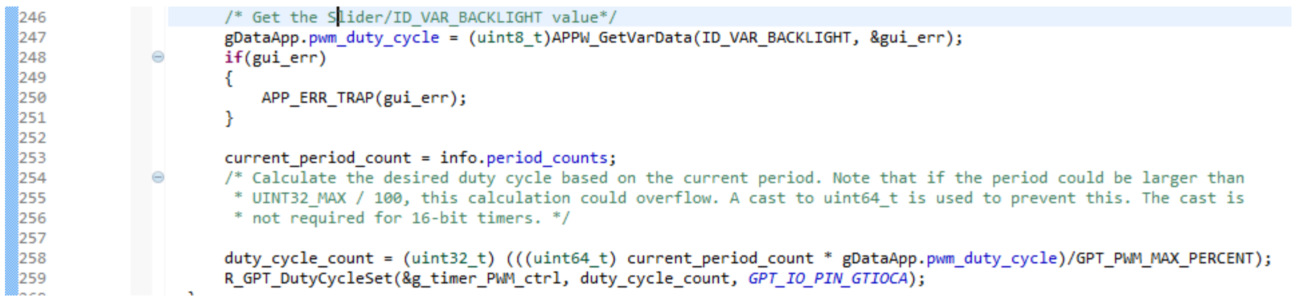


Figure 45. Custom Code Controls PWM Update GPT Timer Duty Cycle

5.4.5 e² studio Tricks

The e² studio ISDE has a handy feature that you can use to ensure that the images you are seeing on your LCD screen are coming from your framebuffer. To use this feature, make sure to connect the e² studio to your board and run the program under the debugger. Ensure that your **Memory** tab is open in the **Console** window, normally located to the bottom of the screen in **Debug** view. Click the small green plus (**+**) sign to add a memory monitor. You should see a **Monitor Memory** dialog as shown in Figure 46. Enter the Framebuffer **fb_background[0]** or **fb_background[1]** and click the **OK** key.

A new tab should now appear under the **Memory** tab that displays the contents of the memory area you specified for the memory monitor.

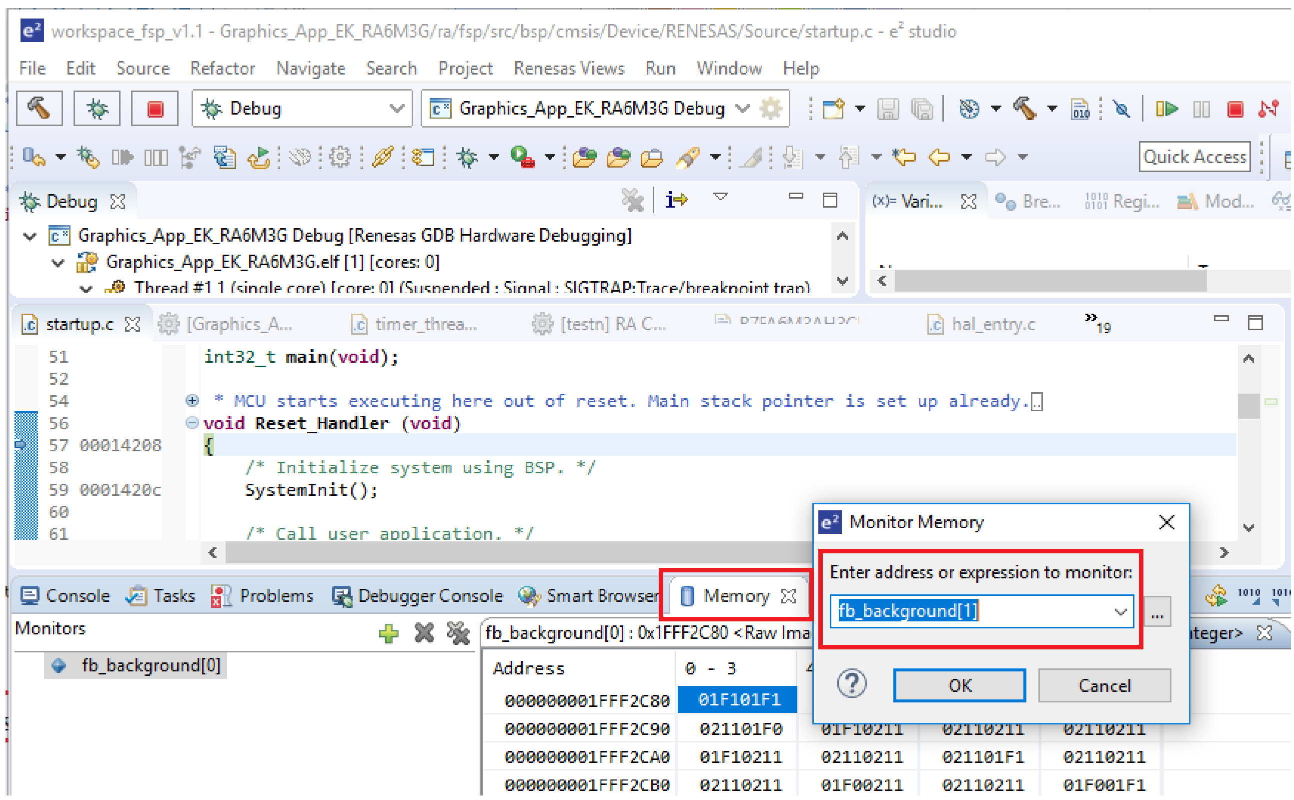


Figure 46. Using the Memory Monitor to Display the Framebuffer Contents

You should now see the contents of the selected framebuffer memory area displayed in the memory monitor you just created. If you know what the hex value of every pixel should be on your display, you would be able to use this memory monitor to definitively say that your image is being stored in the Framebuffer. However, as most of us do not know the hex values associated with our pixels, we will let the memory monitor do the work for us.

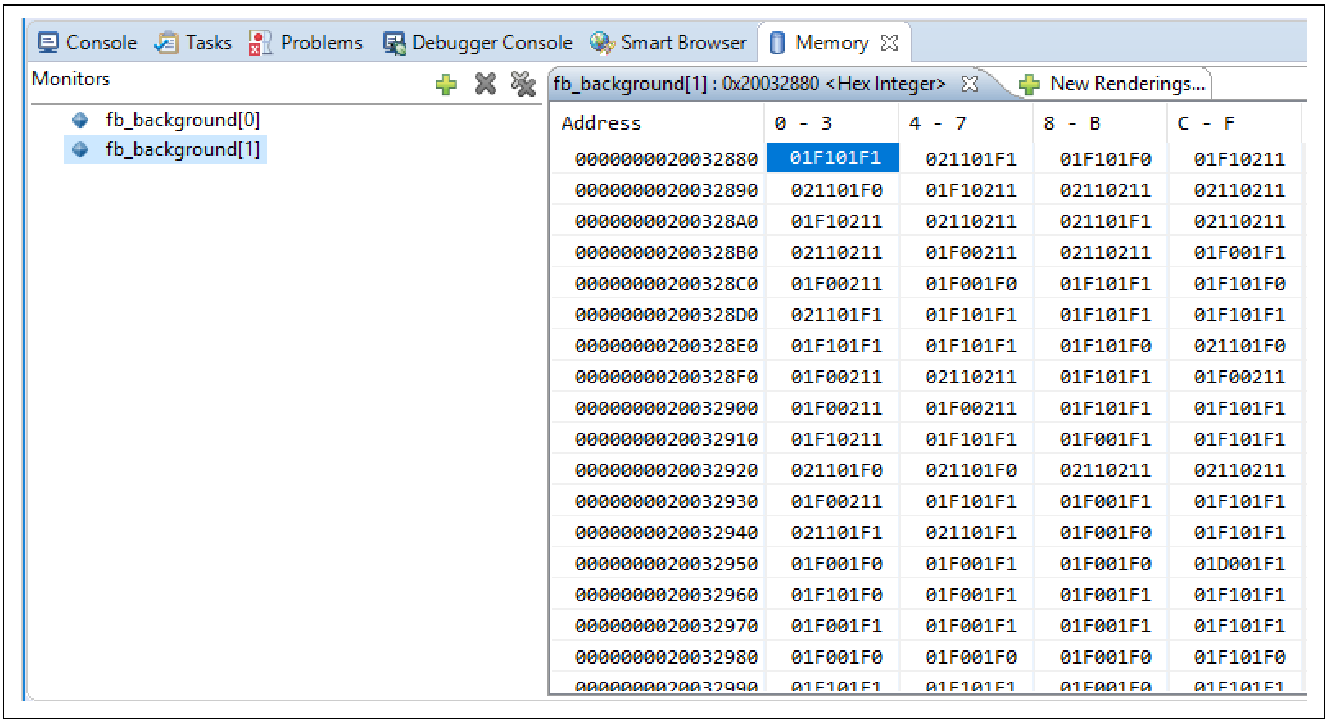


Figure 47. Framebuffer 1 Contents

Select the **New Renderings** tab next to the memory monitor you just created, select **Raw Image** type from the list of options, and press the **Add Rendering(s)** button off to the right side of the screen.

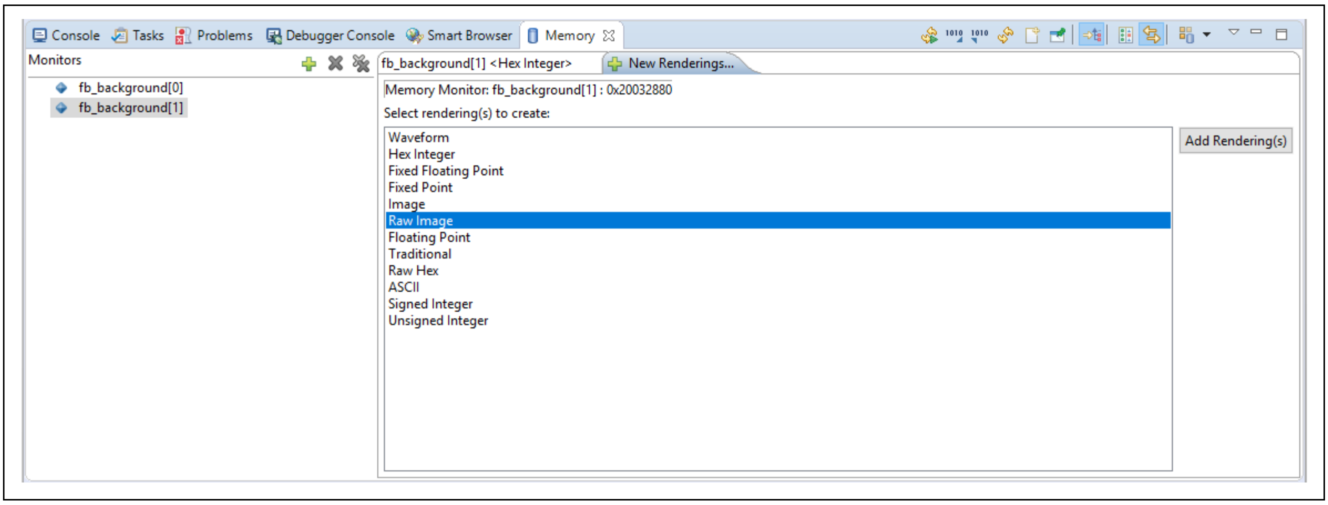


Figure 48. Rendering Format Selection

The **Raw Image Format** dialog box appears, that lets you enter the screen resolution Width and Height, along with the Encoding that is 16 bpp (5:6:5), in our case.

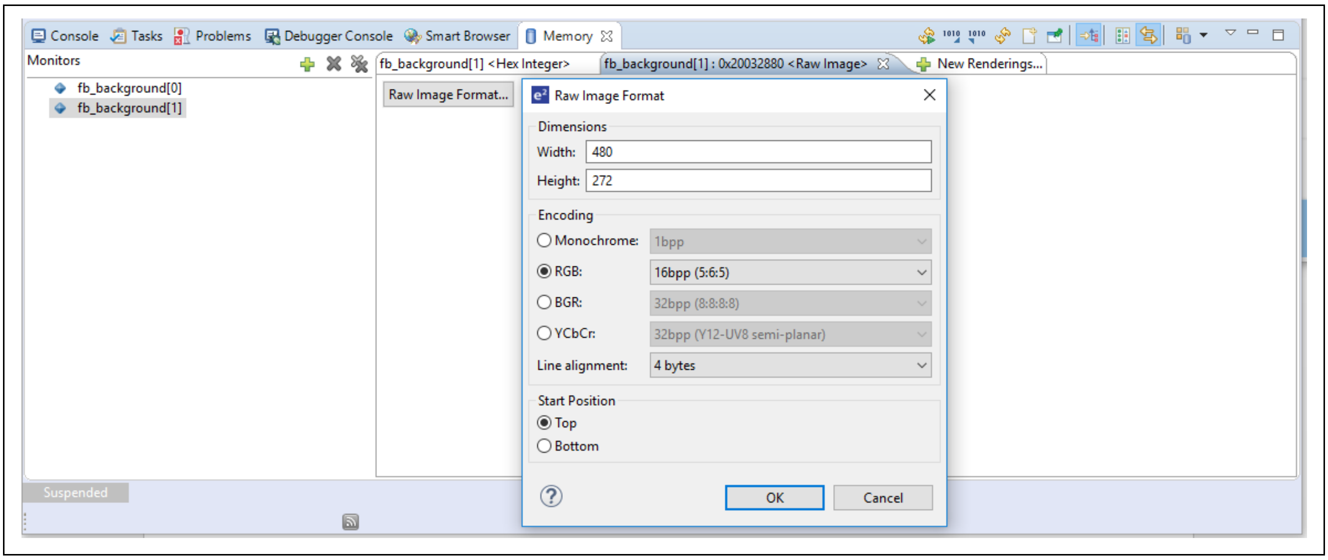


Figure 49. Raw Image Format for Graphics Application on EK-RA6M3G

Once you press the **OK** key, the memory monitor presents you with the image that would be displayed at that memory address, based on the parameters you entered.

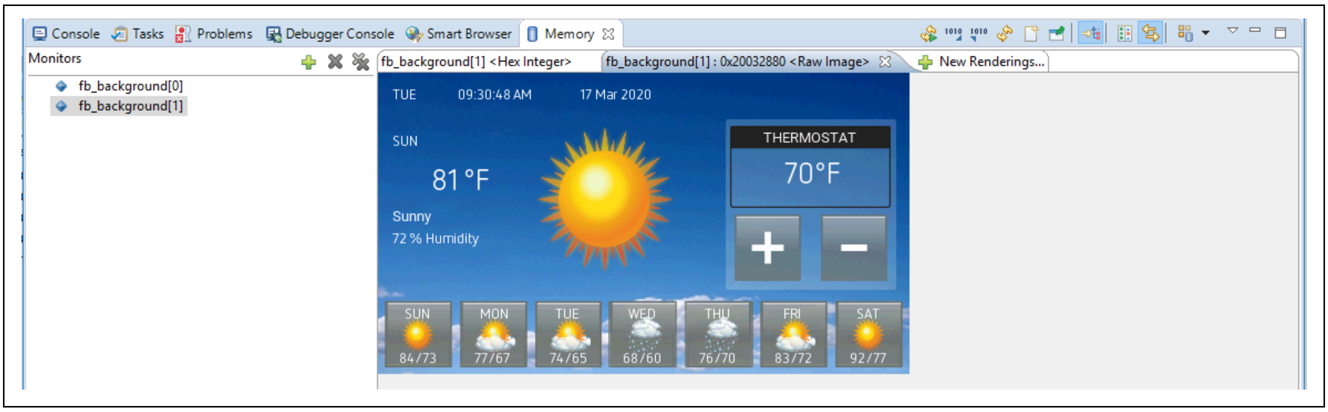


Figure 50. Image Rendering Using Seen Using e2 studio Memory Monitor

6. Application Code Highlights

This section details the highlights of the graphics application. The goal of the graphics application is to show you how to develop more complex multi-threaded HMI applications using the FSP, AppWizard, and emWin library.

The key goal of the FSP is to abstract much of the complexity of interfacing with various Renesas peripherals and to quickly get you to the point where you can simply focus on constructing more complex applications as quickly as possible.

6.1 Threads and Main

In the FSP, `main()` is an auto-generated file which looks like the following code. The threads and objects specified during the FSP configuration are initialized in the `main()`.

```
int main(void)
{
    g_fsp_common_thread_count = 0;
    g_fsp_common_initialized = false;

    /* Create semaphore to make sure common init is done before threads start running. */
    g_fsp_common_initialized_semaphore =
#if configSUPPORT_STATIC_ALLOCATION
            xSemaphoreCreateCountingStatic(
#else
            xSemaphoreCreateCounting (
#endif
                                    256,
                                    1
#if configSUPPORT_STATIC_ALLOCATION
                                    , &g_fsp_common_initialized_semaphore_memory
#endif
                                    );

    if (NULL == g_fsp_common_initialized_semaphore)
    {
        rtos_startup_err_callback (g_fsp_common_initialized_semaphore, 0);
    }

    /* Init RTOS tasks. */
    emWin_thread_create ();
    touch_thread_create ();
    timer_thread_create ();

    /* Start the scheduler. */
    vTaskStartScheduler ();
    return 0;
}
```

Figure 51. The main () function in FSP with FreeRTOS Enabled

When you create a thread using the **New Threads** tab, the FSP creates several files. As an example, when the **emWin Thread** is added, the FSP created three files for you: `emWin_thread.h`, `emWin_thread.c`, and `emWin_thread_entry.c`, as shown in Figure 52.

The first two files are auto-generated and therefore put into the `ra_gen` folder. The `emWin_thread_entry.c` file is the entry point for the **emWin Thread**, and this is where you put your application code. Auto-generated files should not be updated by the user since they will be re-generated every time you build the project or click the **Generate Project Content** button. Auto-generated files always contain some form of **do not edit** message at the top of the file.

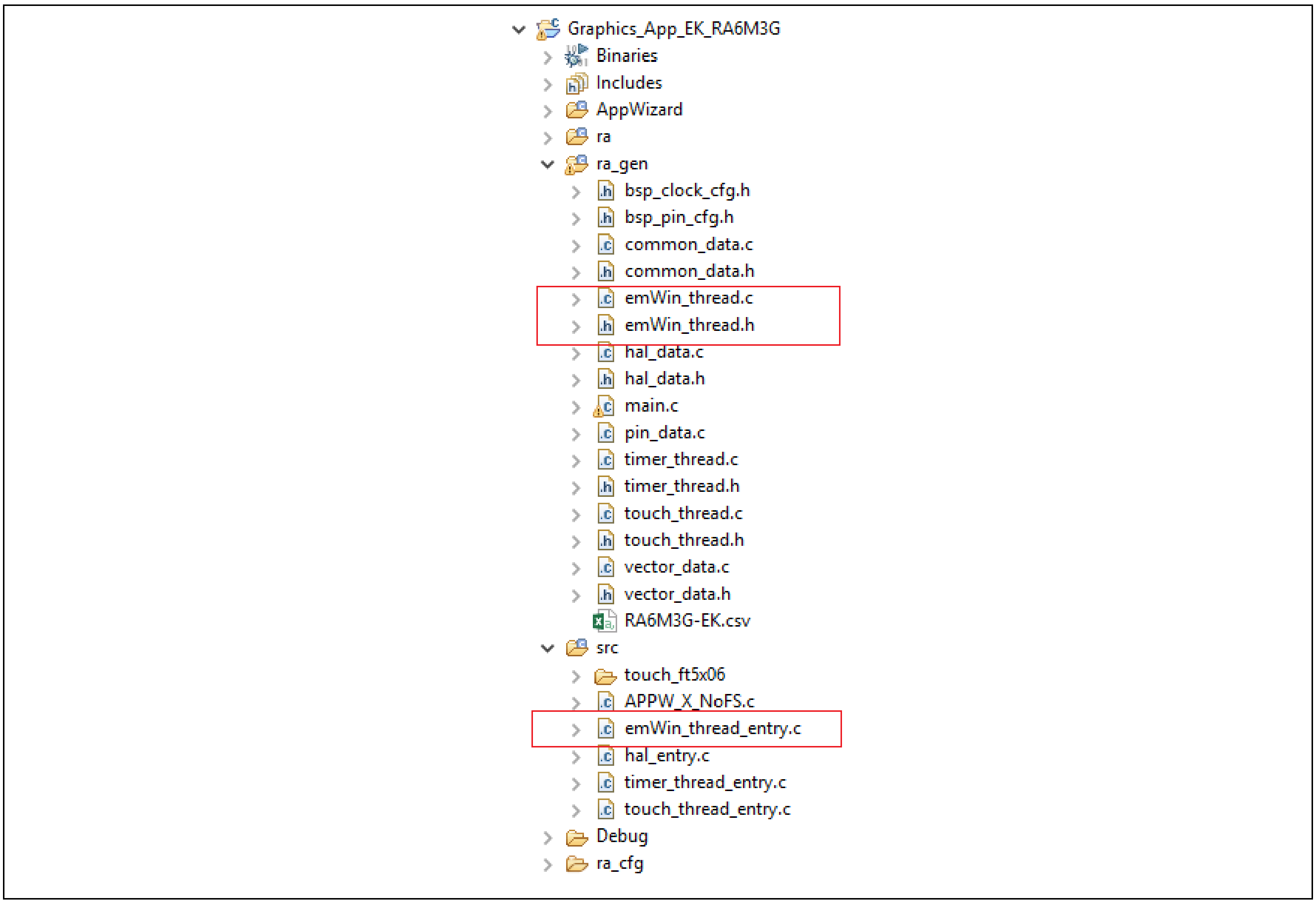


Figure 52. FSP Generated Source File Organization

6.1.1 AppWizard/emWin Initialization

The FSP does not automatically initialize the AppWizard system. To initialize it, simply include `GUI.h` and add the `MainTask()` API call to `emWin_thread_entry()` located in the `emWin_thread_entry.c` file.

```
#include "emWin_thread.h"
#include "GUI.h"
/* emWin thread entry function */
/* pvParameters contains TaskHandle_t */
void emWin_thread_entry(void *pvParameters)
{
    FSP_PARAMETER_NOT_USED (pvParameters);

    MainTask();

    while (1)
    {
        vTaskDelay (1);
    }
}
```

Figure 53. Backlight Control Pin on EK-RA6M3G

6.1.2 emWin Events and Messages

Touching the screen in the graphics application causes emWin to invoke the specific callback function generated for that screen in the AppWizard. AppWizard provides the callback function with specific information about the window that caused the event, and the actual event that occurred. These events are defined in `CM.h`.

You can add your code to Slot routines in the file `<ScreenID>_Slots.c` located in the `\AppWizard\Source\CustomCode` folder to handle window events. The Slot routines are actual Callback routines generated by AppWizard.

```
 * @brief       Custom code for cbID_SCREEN_MAIN in ID_SCREEN_MAIN_Slots.c
void cuscbID_SCREEN_MAIN(WM_MESSAGE * pMsg) {
    int wId                     = 0;
    int wMsg                    = 0;

    switch(pMsg->MsgId) {
        case WM_INIT_DIALOG:
            /* Get and store Images's handles */
            if(ImageHandleGet(pMsg))
            {
                APP_ERR_TRAP(FSP_ERR_INVALID_POINTER);
            }
            /* Set default weather forecast */
            if(WeatherForecastInit(pMsg))
             {
                 APP_ERR_TRAP(FSP_ERR_INVALID_POINTER);
             }
            /* Set Thermostat target temperature */
            APPW_SetVarData(ID_VAR_TARGET_TEMP, gDataApp.thermo_target_temp);
            /* Save logging */
            LogDataAppend(gDataLog, sizeof(gDataLog),"\n%s", "Init Dialog");
            /* Create timer to control effects/animation*/
            ghTimer = WM_CreateTimer(pMsg->hWin, 0, ANIM_TIMER_PERIOD, 0);
            break;
        case WM_TIMER:
            /* Rainy effect*/
            if(SYS_WEATHER_RAINY == gDataApp.sys_weather_type)
            {
                if(0 == AnimRainyState)
                {
                    /* Hide 1st animation image, show 2nd animation image */
                    WM_HideWindow(hImageAnimBGRD[gDataApp.sys_weather_type]);
                    WM_ShowWindow(hImageAnimBGRD[IMAGE_ANIM_RAINY_BGRD_2]);
```

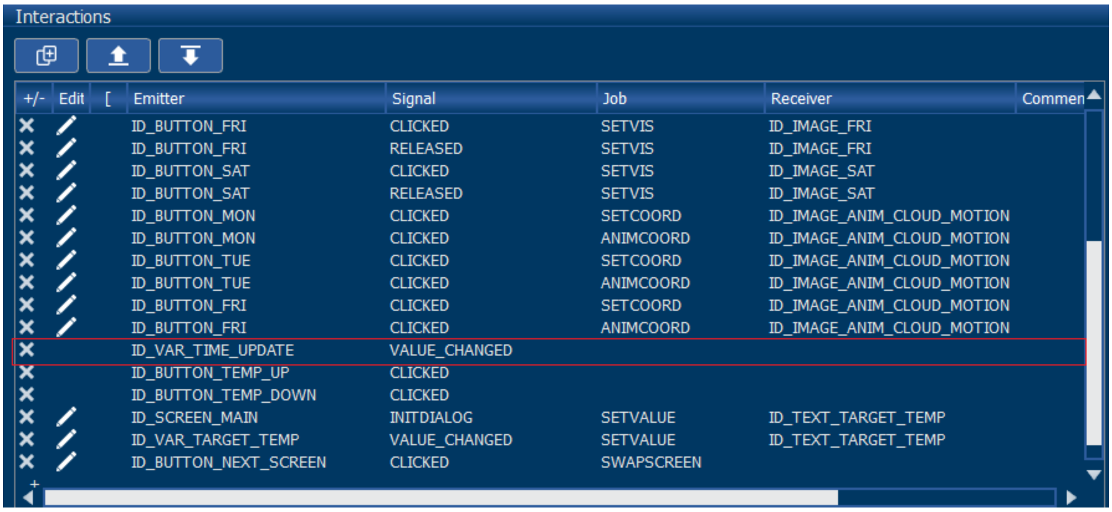
Figure 54. Custom Code for The Slot Routine cb_ID_SCREEN_MAIN

6.1.3 AppWizard Variables

Variables in the AppWizard can be used to store a value. They can be accessed and changed by the application or from outside of the application. The application can react on a change of a variable using interactions. One of typical uses is update the variables in a non-GUI thread to trigger data exchange between the AppWizard and non-GUI threads.

```
/* Timer Thread entry function */
/* pvParameters contains TaskHandle_t */
void timer_thread_entry(void *pvParameters)
{
    FSP_PARAMETER_NOT_USED (pvParameters);

    /* Set up GPT/PWM timer using for LCD back light control */
    if(gpt_timer_PWM_setup())
    {
        APP_ERR_TRAP(FSP_ERR_ASSERTION);
    }

    /* Set up RTC timer */
    if(rtc_timer_setup())
    {
        APP_ERR_TRAP(FSP_ERR_ASSERTION);
    }

    while (1)
    {
        /* Wait for interrupt from RTC timer */
        xSemaphoreTake(g_timer_semaphore, portMAX_DELAY);

        /* Get date, time */
        R_RTC_CalendarTimeGet(&g_rtc_timer_ctrl, &RtcTimeCurrent);
        /* Trigger GUI update*/
        APPW_SetVarData(ID_VAR_TIME_UPDATE, 1);

        vTaskDelay (1);
    }
}
```

Figure 55. AppWizard Variable Update in Timer Thread



Interactions

+/-	Edit	[	Emitter	Signal	Job	Receiver	Commen
			ID_BUTTON_FRI	CLICKED	SETVIS	ID_IMAGE_FRI	
			ID_BUTTON_FRI	RELEASED	SETVIS	ID_IMAGE_FRI	
			ID_BUTTON_SAT	CLICKED	SETVIS	ID_IMAGE_SAT	
			ID_BUTTON_SAT	RELEASED	SETVIS	ID_IMAGE_SAT	
			ID_BUTTON_MON	CLICKED	SETCOORD	ID_IMAGE_ANIM_CLOUD_MOTION	
			ID_BUTTON_MON	CLICKED	ANIMCOORD	ID_IMAGE_ANIM_CLOUD_MOTION	
			ID_BUTTON_TUE	CLICKED	SETCOORD	ID_IMAGE_ANIM_CLOUD_MOTION	
			ID_BUTTON_TUE	CLICKED	ANIMCOORD	ID_IMAGE_ANIM_CLOUD_MOTION	
			ID_BUTTON_FRI	CLICKED	SETCOORD	ID_IMAGE_ANIM_CLOUD_MOTION	
			ID_BUTTON_FRI	CLICKED	ANIMCOORD	ID_IMAGE_ANIM_CLOUD_MOTION	
			ID_VAR_TIME_UPDATE	VALUE_CHANGED			
			ID_BUTTON_TEMP_UP	CLICKED			
			ID_BUTTON_TEMP_DOWN	CLICKED			
			ID_SCREEN_MAIN	INITDIALOG	SETVALUE	ID_TEXT_TARGET_TEMP	
			ID_VAR_TARGET_TEMP	VALUE_CHANGED	SETVALUE	ID_TEXT_TARGET_TEMP	
			ID_BUTTON_NEXT_SCREEN	CLICKED	SWAPSCREEN		

Figure 56. Setup Null Interaction for ID_VAR_Time to Implement Date, Time Update in emWin Thread

7. Importing and Building the Project

To bring the Graphics application into the e^2 studio ISDE, follow these steps:

1. Launch e^2 studio ISDE.
2. In the workspace launcher, browse to the workspace location of your choice.
3. Close the **Welcome** window.
4. In the ISDE go to **File** > **Import.**
5. In the Import Dialog Box pick **Existing Projects into Workspace.**
6. Select the Root directory of your workspace (where you placed the project).
7. Select the project you wish to import and click **Finish**.
8. Click on **Generate Project Content** on the FSP configurator window.
9. Now build the project.

8. Downloading the Executable to the EK-RA6M3G Kit

To connect and run the code, follow these steps:

1. Refer to the Quick Start Guide for EK-RA6M3G r20qs0013eu0101-ek-ra6m3g-qsg.pdf to setup the J-Link debugger connection from your PC to the J-Link connectors on the target board.
2. Go to **Run > Debug configurations.**
3. Click **Debug**. The program will break at the reset handler.
4. Click **Yes** to switch to the **Debug perspective** when prompted by the ISDE.
5. Click **Resume** twice.
6. The **Weather Panel** will show as below. You can select Forecast day or adjust the thermostat temperature. Touch at the top left corner to move to the **Logging Panel**.

Figure 57. The Weather Panel

The **Logging Panel** allows you to adjust the LCD backlight using the slider or change **Logging Dialog** text color and background color using the rotary and the switch, respectively. The logging buffer resets when it reaches the limit of 256 bytes. Touch the Renesas logo to go back to the **Weather Panel**.

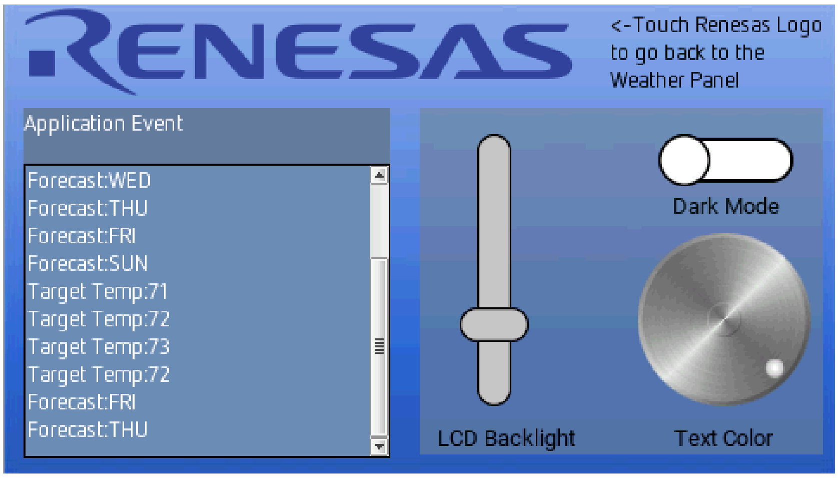


Figure 58. The Logging Panel

9. Known Issues

The JPEG decoder in RA6M3 MCU requires JPEG data to be aligned to an 8-byte boundary, but JPEG data files generated by AppWizard do not support this alignment As a result, an 8-byte aligned attribute will be manually added to JPEG data array as shown in Figure 59. Although the FSP has a software solution to skip this 8-byte data alignment, it is recommended since it improves performance and reduces SRAM usage.

AppWizard will overwrite image data files every time you re-generate the AppWizard project by using **Export & Save** under its **File** menu, so you have to manually add the 8-byte aligned attribute to the JPEG data files named `bg_sunny.c`, `bg_rainy.c`, `bg_partlycloudy.c`, and `Simple_blue_green_gradient_480x272.c` in the `/AppWizard/Resource/Image` folder.

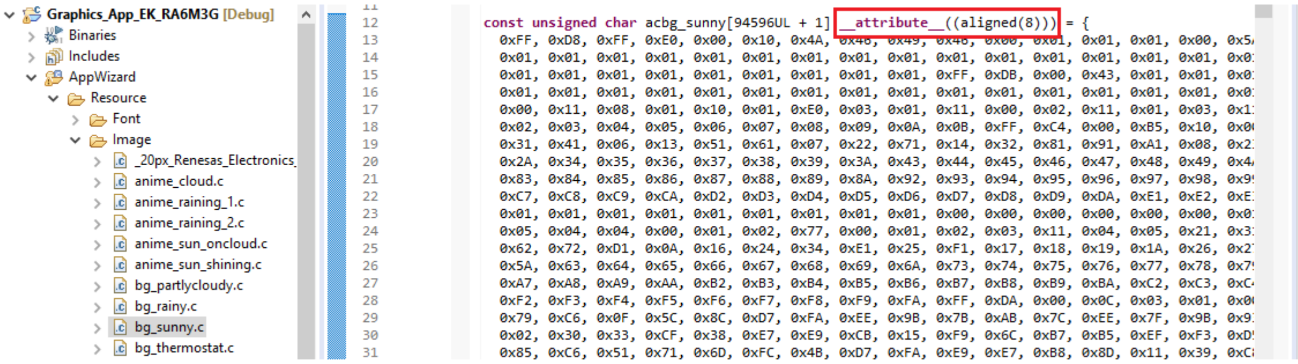


Figure 59. Adding 8-Byte Aligned Attribute to JPEG Data Array

Website and Support

Visit the following vanity URLs to learn about key elements of the RA family, download components and related documentation, and get support.

RA Product Information	www.renesas.com/ra
RA Product Support Forum	www.renesas.com/ra/forum
RA Flexible Software Package	www.renesas.com/FSP
Renesas Support	www.renesas.com/support

Revision History

Rev.	Date	Description	
		Page	Summary
1.0	Jul13.20	-	Initial version

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