Renesas RA Family

Getting Started with GUIX Thermostat Application

Introduction

This application, which is a Thermostat application, provides a reference for developing complex multi-threaded applications with a touch screen graphical Human Machine Interface (HMI) by using Renesas FSP and Azure RTOS GUIX. It describes steps to create a basic GUIX for FSP, integrates touch driver, handles multiple hardware accesses, system updates, and event handling.

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 Azure RTOS GUIX library and Azure RTOS. In addition, FSP also provides Ethernet, USB, File System and other middleware stacks as well. 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 Azure RTOS. This application note makes use of RTOS features such as threads and semaphores. Prior experience in using Azure RTOS would be helpful for easy understanding of the provided application project. For more detailed information on Azure RTOS features, refer to the Azure RTOS User Manual.

The Graphics application is developed using the Renesas e^2 studio Integrated Solution Development Environment (IDE). e^2 studio is integrate with the FSP platform installer, which can be downloaded from Renesas website. The intuitive configurators and code generators in e^2 studio and FSP will help the application developers in creating such complex multi-threaded graphics applications very quickly. This application note walks you through all the necessary steps in creating, building and running a complex graphics project, including the following:

- Board setup.
- Install tools.
- Build and run application.
- Azure RTOS GUIX Studio project integration.
- Setup Azure RTOS GUIX Studio project.
- Add Touch Driver.
- Create FSP GUIX project.
- Hardware Setup.
- Using the General Purpose Timer to drive a PWM backlight control signal.

Required Resources

Development tools and software

- e^2 studio IDE 2025-04.1
- Renesas Flexible Software Package (FSP) v6.0.0
- Azure RTOS GUIX Studio V6.4.0.0

Hardware

- Renesas EK-RA6M3G kit (RA6M3 MCU Group)

Reference Manuals

- RA Flexible Software Package Documentation Release v6.0.0
- Azure RTOS GUIX and GUIX Studio v6.4.0.0
- Renesas RA6M3 Group User's Manual Rev.1.20
- EK-RA6M3G-v1.0 Schematics

Contents

1. Installing Tools

1.1 Overview

In this section you will copy the application note (AN) materials to your PC and install e² studio v2025-04.1/FSP v6.0.0 and Azure RTOS GUIX Studio v6.4.0.0.

1.2 Procedural Steps

1. If you already have e² studio v2025-04.1 with FSP v6.0.0, you can skip this step. Otherwise, you can download RA Flexible Software Package (FSP).
2. You can get Azure RTOS GUIX Studio v6.4.0.0 or greater. If it goes well, you will see the window in the next step on the web browser.
   Note: It needs Microsoft Store to work on your PC to install Azure RTOS GUIX Studio.
3. Click **Get** to start installing Azure RTOS GUIX Studio.

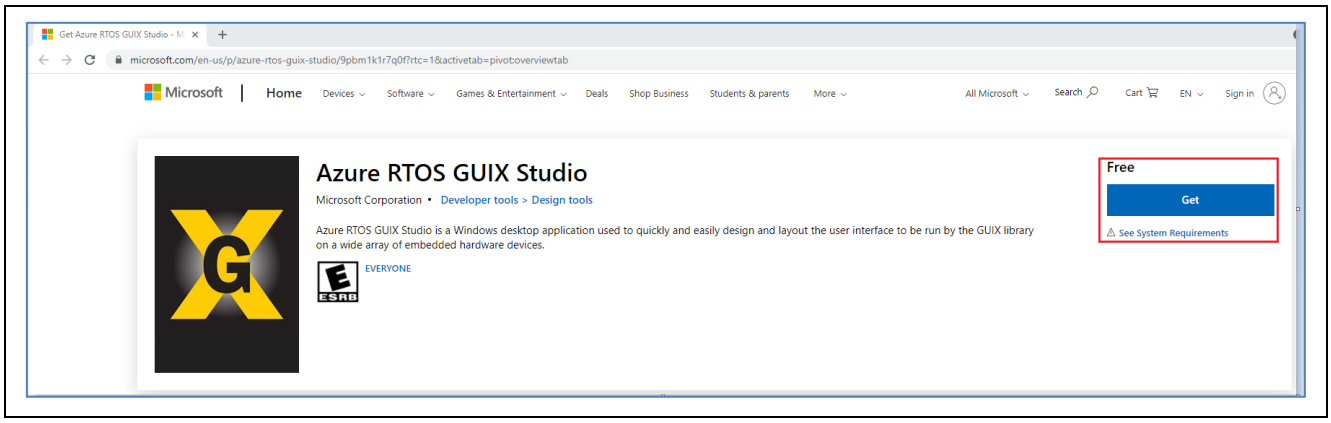

Figure 1. Clicking Get to Start Installing Azure RTOS GUIX

4. Click **Open Microsoft Store** to continue installing Azure RTOS GUIX Studio.

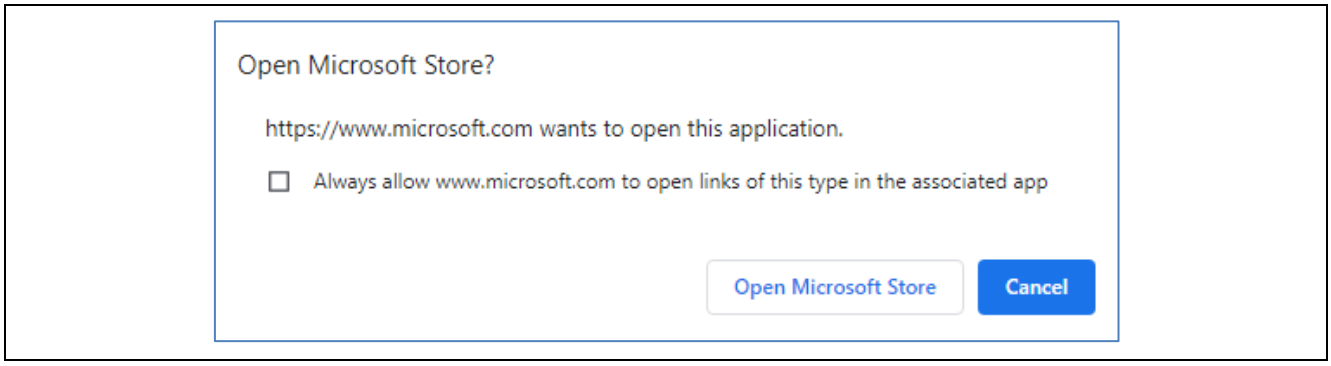

Figure 2. Clicking Open Microsoft Store

5. Click **Install** to continue. A window shows up to ask for a Microsoft account, which is seen in the next step.

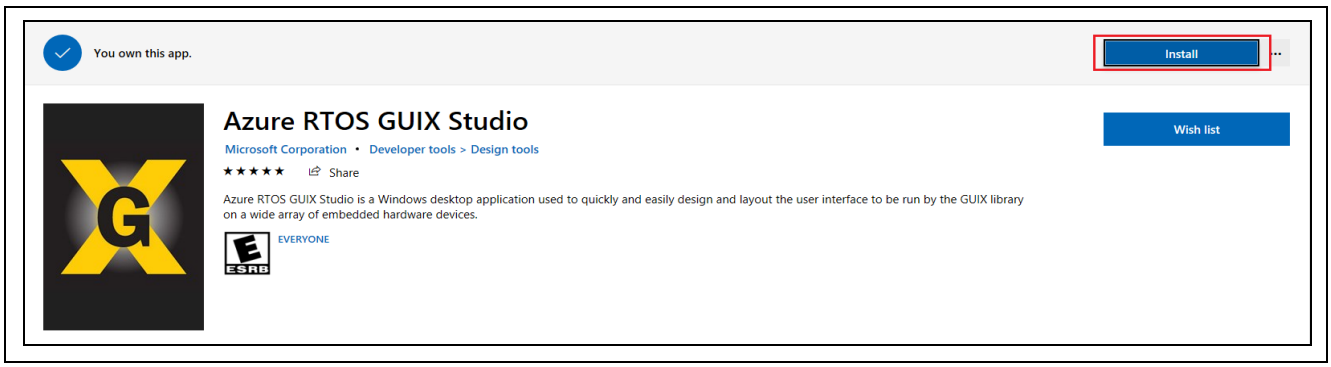

Figure 3. Installing Azure RTOS GUIX

6. Ignore it by clicking “X” on the top-right to close this pop-up window and continue Azure RTOS GUIX Studio installation.

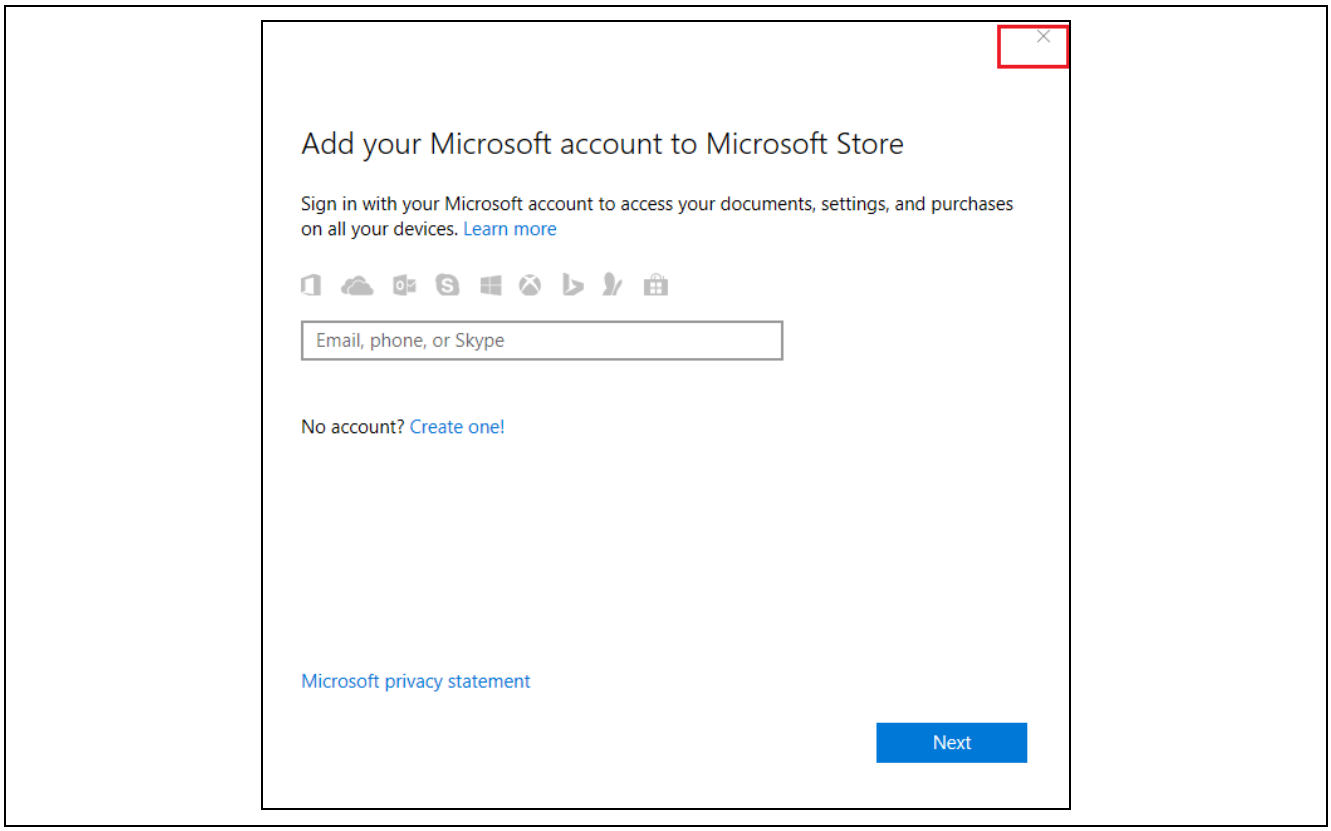

Figure 4. Closing Pop-up Window to Continue Installing Azure RTOS GUIX

7. Downloading and installation of Azure RTOS GUIX Studio starts.

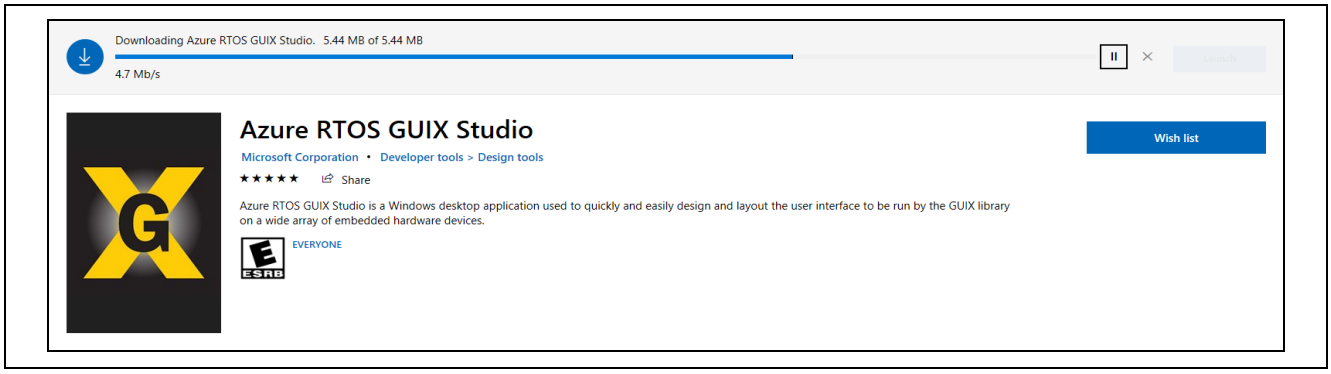

Figure 5. Starting of Downloading and Installation

8. Click **Launch** to launch Azure RTOS GUIX Studio.

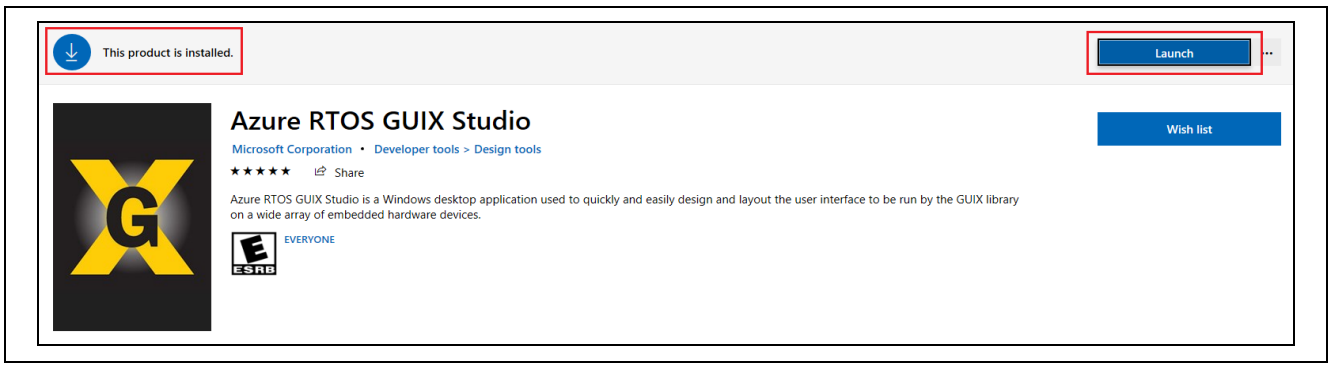

Figure 6. Launching to Start Azure RTOS GUIX Studio

9. **Azure RTOS GUIX Studio** launched.

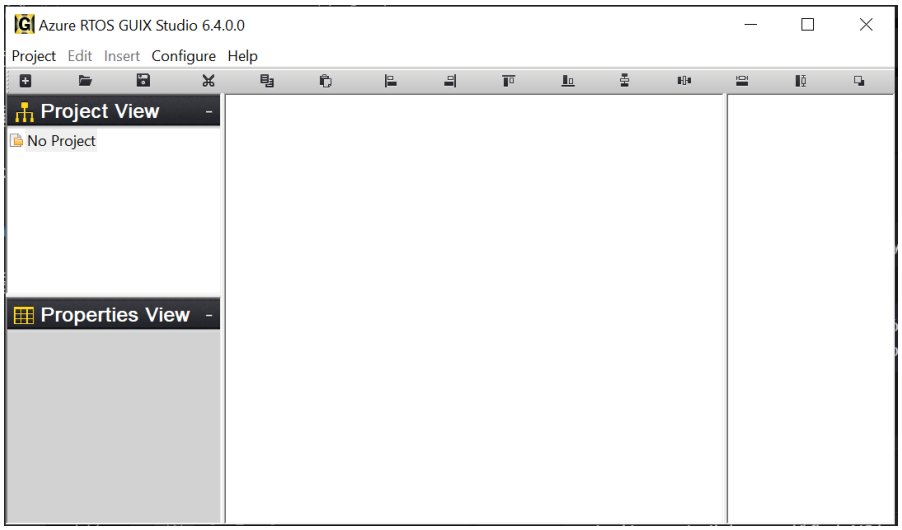

Figure 7. Azure RTOS GUIX Studio Launched

10. Close Azure RTOS GUIX Studio, for now, you will open it again later.

2. Create Application Note Project

2.1 Overview

In this section, you will create a project to which you will add pre-written source code and integrate it with a pre-created Azure RTOS GUIX Studio project.

2.2 Procedural Steps

1. Create a new **Renesas RA C/C++ project**. Name it as Thermostat_GUIX_EK_RA6M3G.

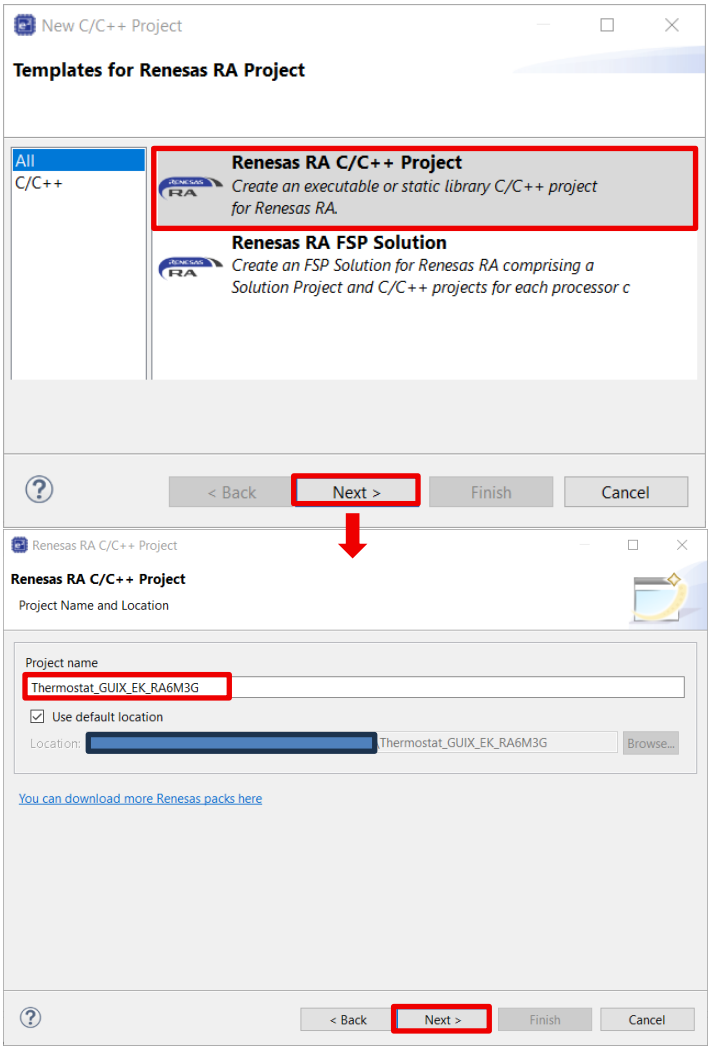

Figure 8. Creating New RA C/C++ Project

2. Set board to EK-RA6M3G.

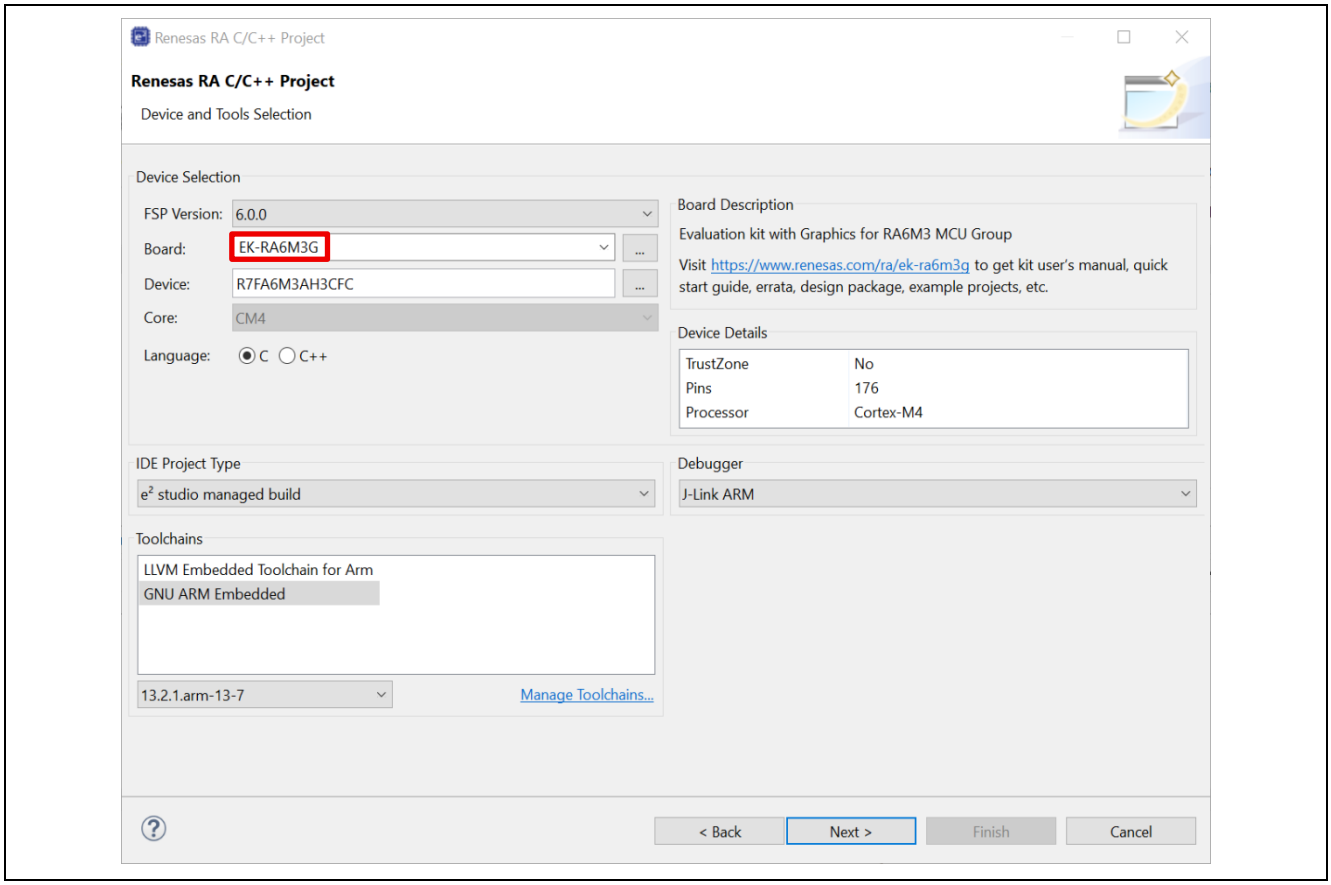

Figure 9. Setting Board to EK-RA6M3G

3. Select Preceding project or Smart Bundle.

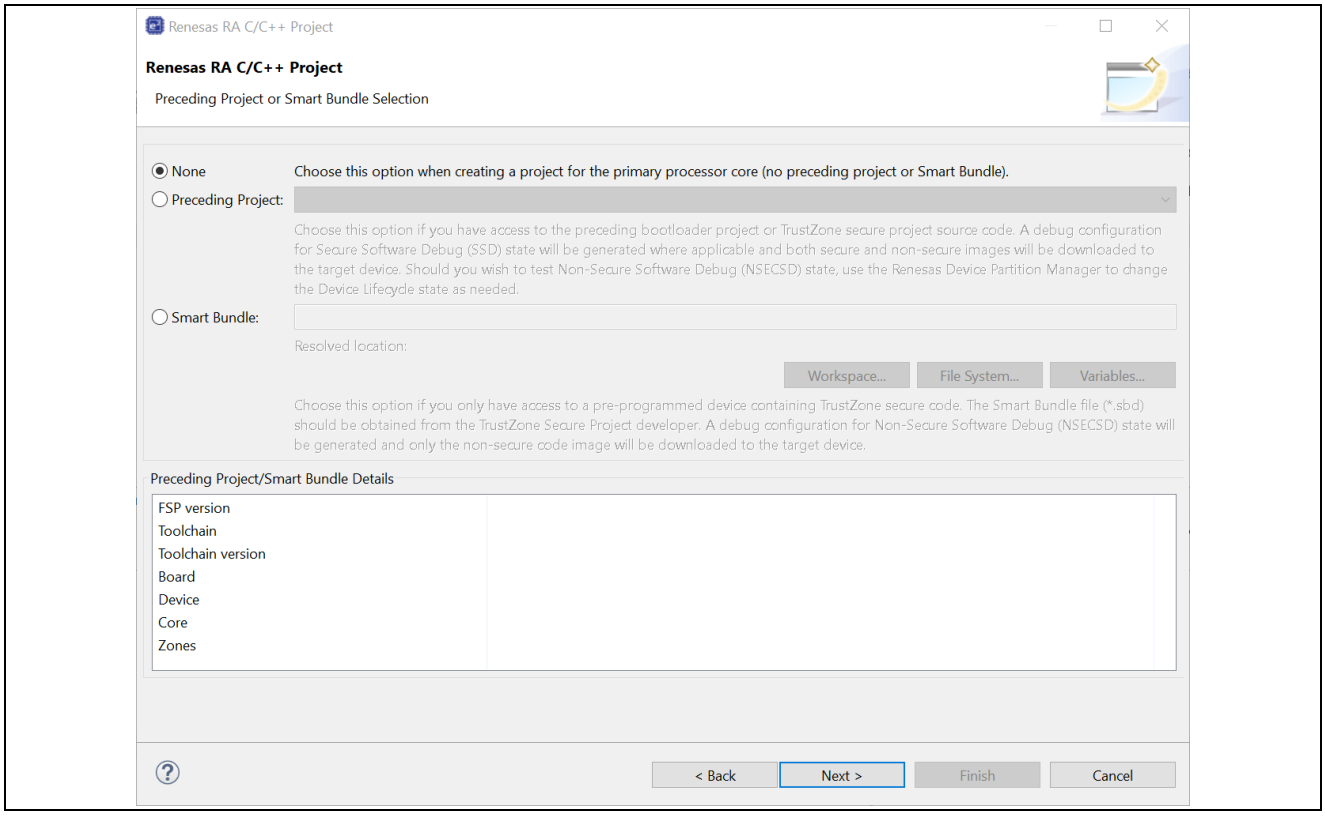

Figure 10. Preceding project or Smart Bundle Selection

4. Select Azure RTOS ThreadX (v6.4.0+fsp.6.0.0).

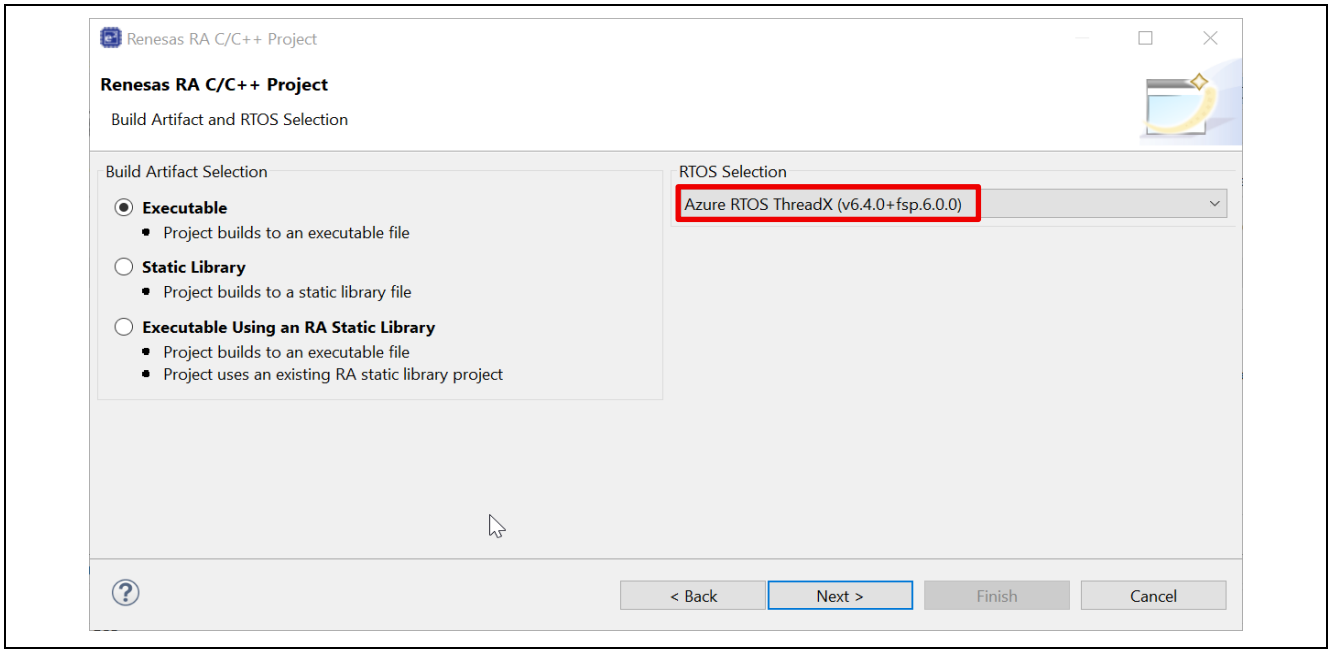

Figure 11. Selecting Azure RTOS ThreadX

5. Use Azure RTOS ThreadX-Minimal template.

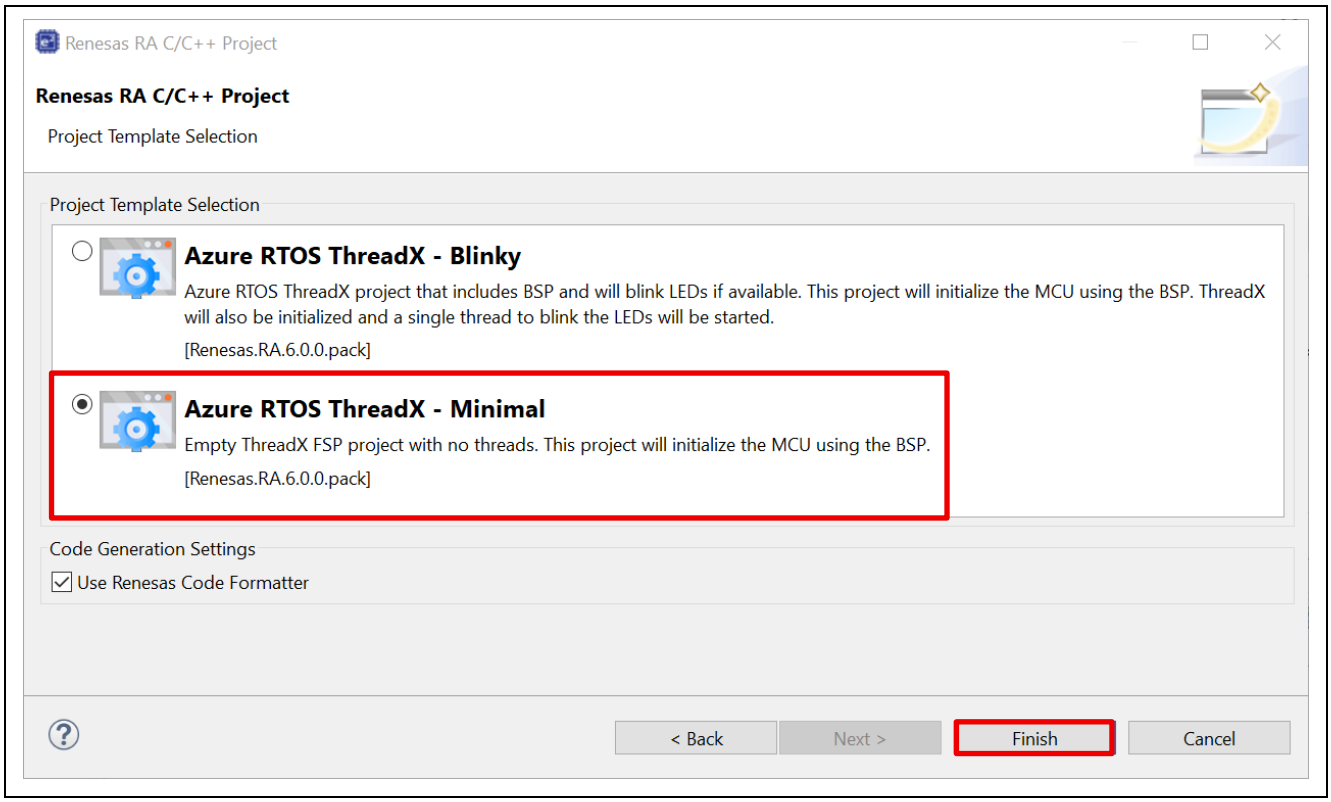

Figure 12. Selecting Azure RTOS ThreadX – Minimal Template

6. Open project configuration, go to **BSP** tab, change Heap size to 0x2000.

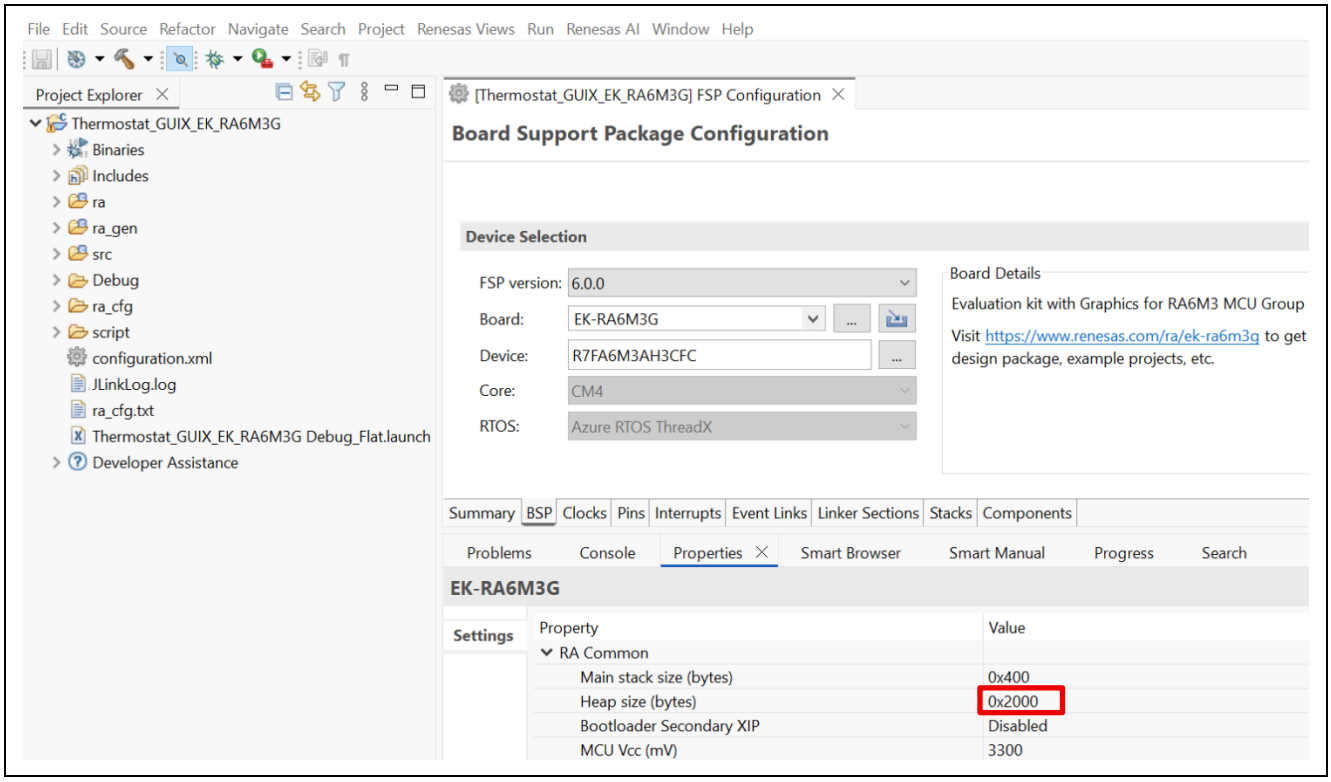

Figure 13. Changing Heap size (bytes) in Project Configuration

7. You can remove **Azure RTOS ThreadX Port** if you want.

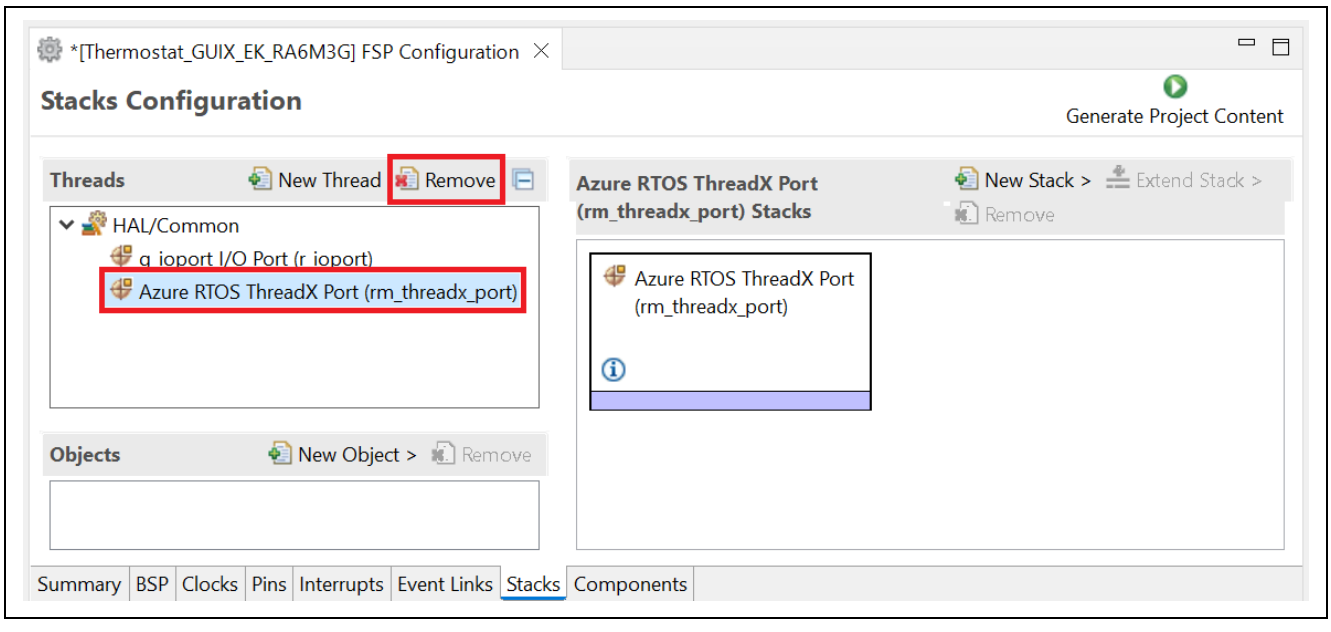

Figure 14. Remove Azure RTOS ThreadX Port

8. Add a **New Thread** and name it as **System Thread** with the following settings.

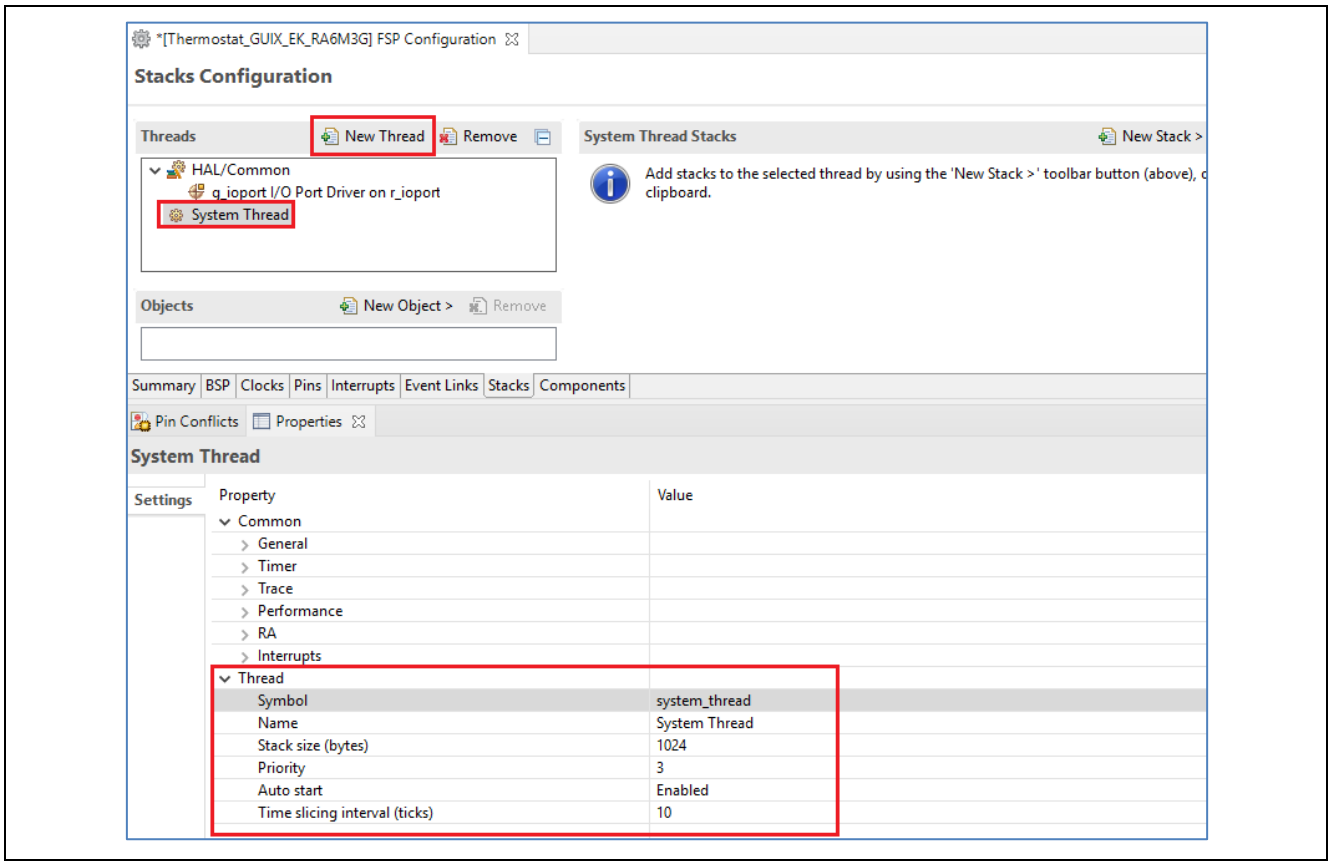

Figure 15. Adding a New Thread and Naming it System Thread

9. Add **Azure RTOS GUIX** to **System Thread**.

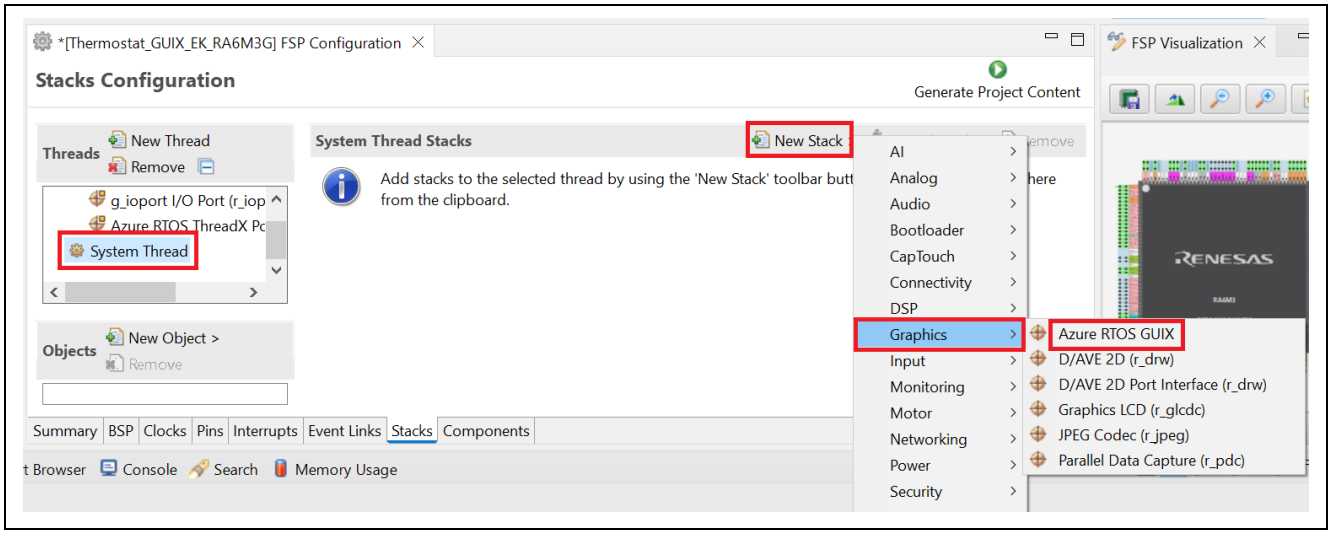

Figure 16. Adding Azure RTOS GUIX to System Thread

10. Property settings for the **g_display0 Graphics LCD on r_glcdc.**

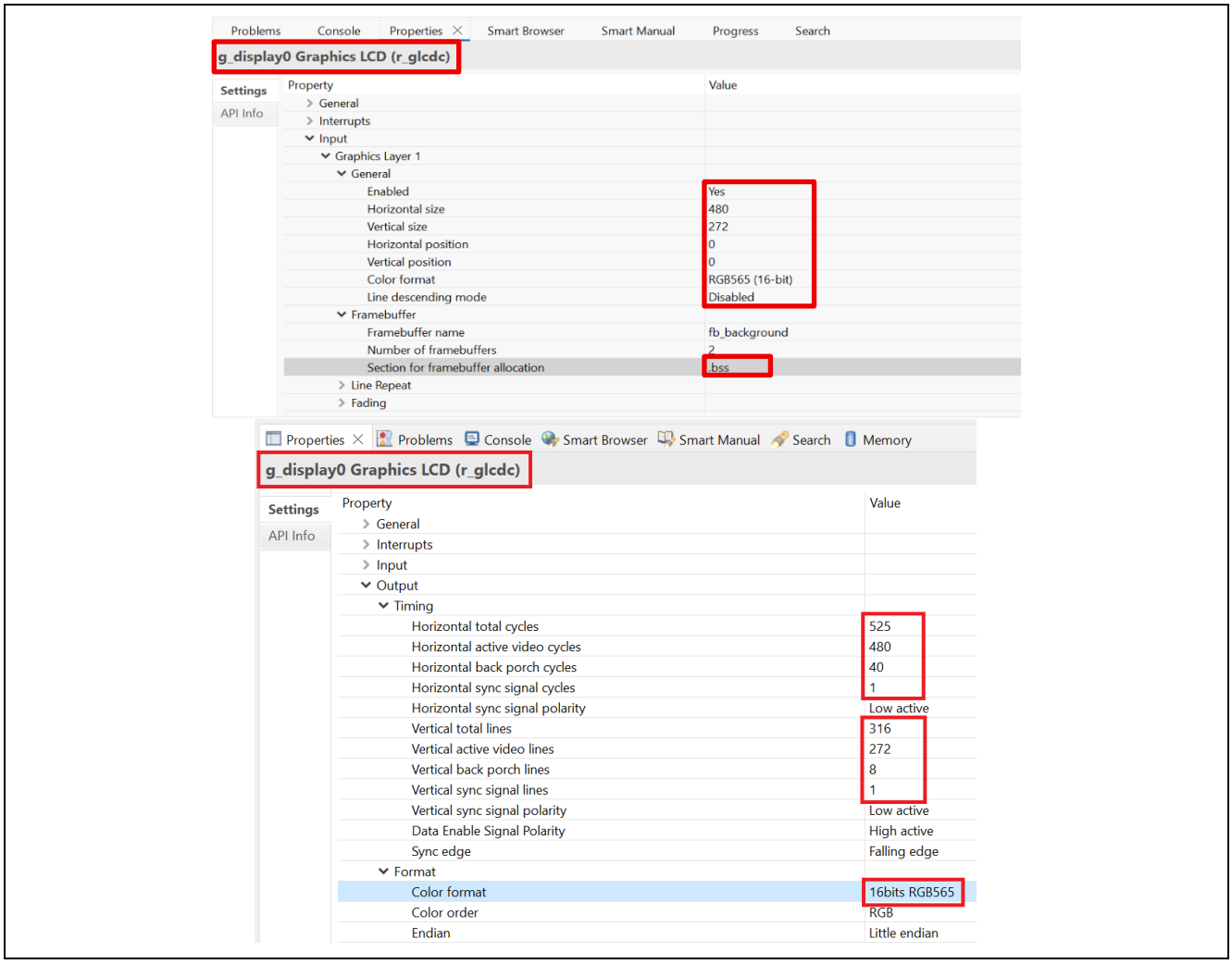

Figure 17. Graphics LCD Display Driver Configuration

11. Configure the Hsync, Vsync, Data Enable pins and clock as shown.

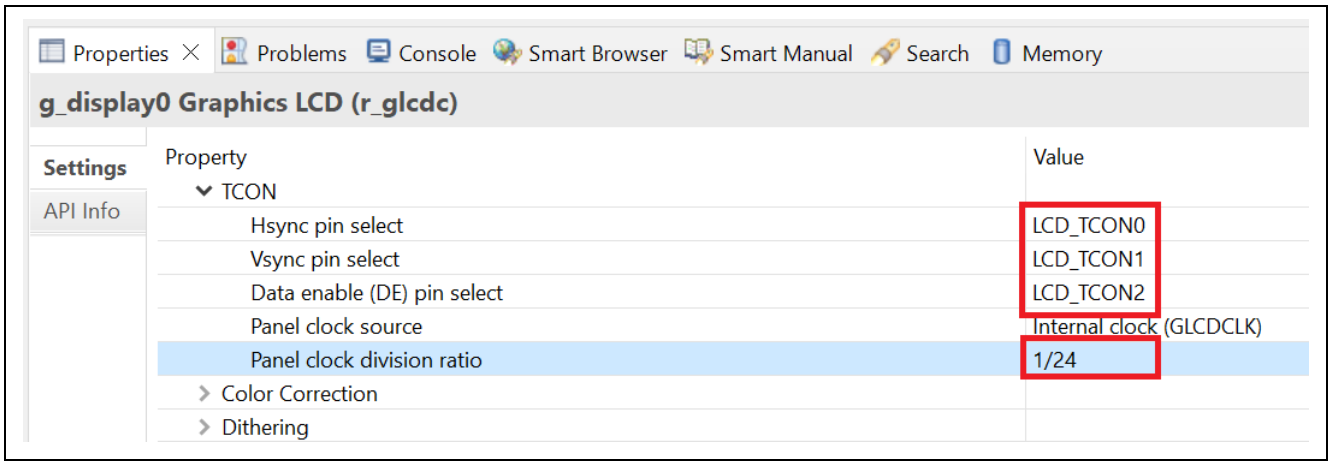

Figure 18. TCON Properties

12. In **Pin Configuration**, change P603's mode to **Output mode (Initial high)** to enable LCD panel backlight.

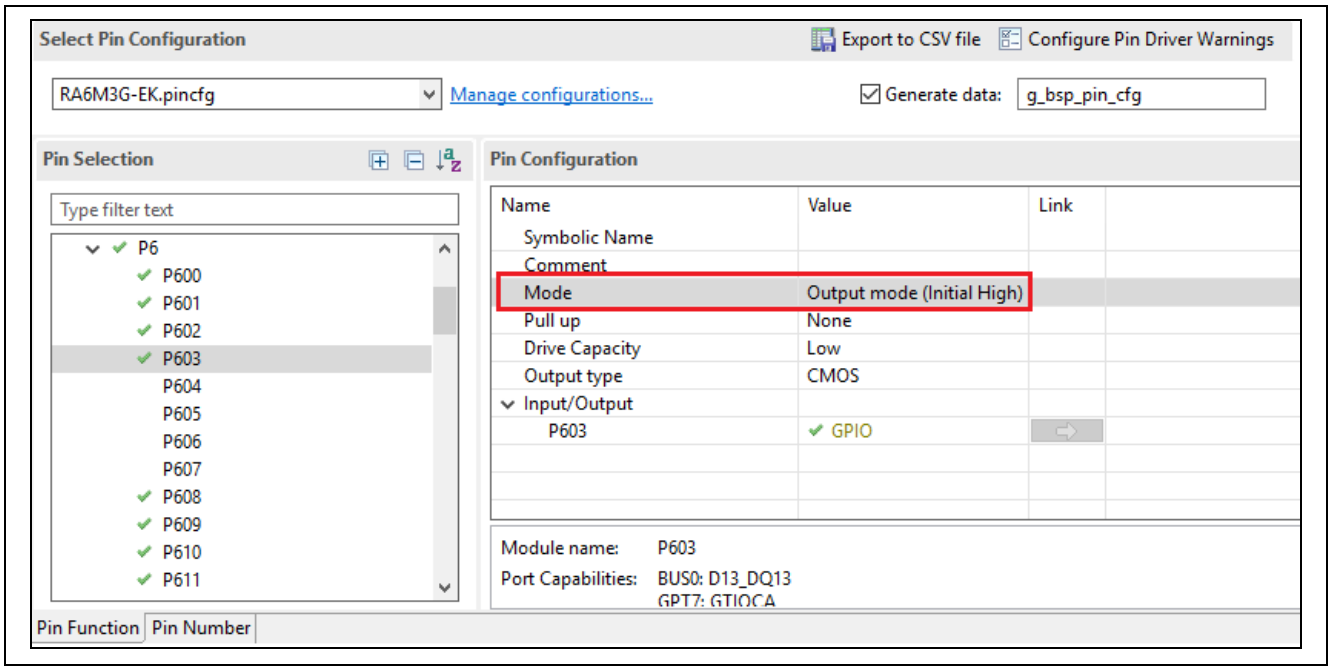

Figure 19. Changing Pin Configuration Mode to Enable LCD Panel Backlight

13. In RA Configurator, click 

to generate project content. Make sure project is active, click  to build the project. It may take a long period of time to finish building an Azure RTOS/GUIX project on your PC.

14. Copy Azure RTOS GUIX Studio project to e² studio project (Themostat_GUIX_EK_RA6M3G) by copying **"guix_studio"** folder in the application note (**AN**) folder (FSP_GUIX_Thermostat) and pasting it in the Themostat_GUIX_EK_RA6M3G project.

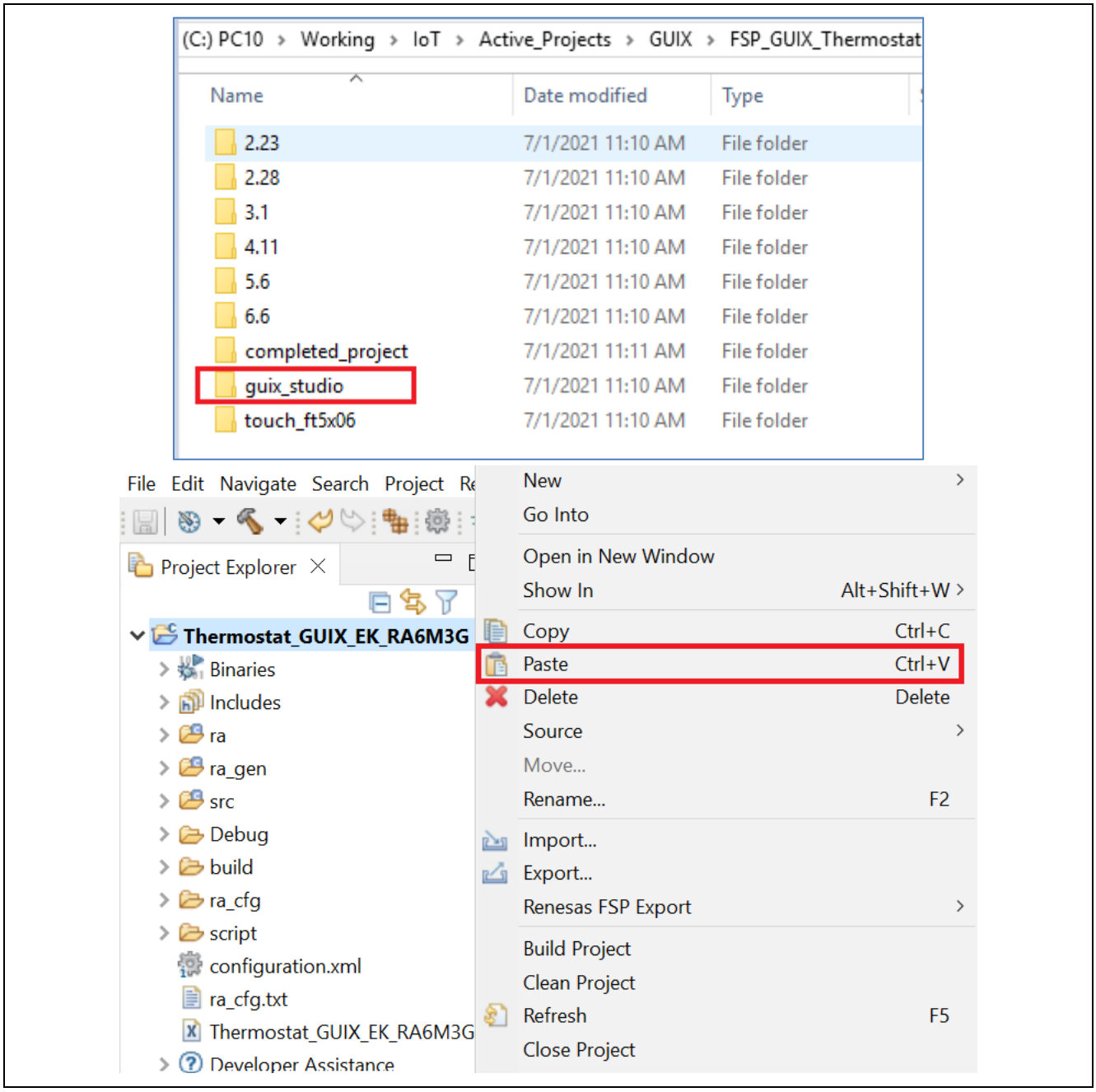

Figure 20. Copying the Azure RTOS GUIX Studio Project to e² studio

15. GUIX Studio project is now in Thermostat_GUIX_EK_RA6M3G project. In e^2 studio, right-click the "**guix_studio**" folder and exclude it from the build since it contains the Azure GUIX Studio project, which will not be built by FSP.

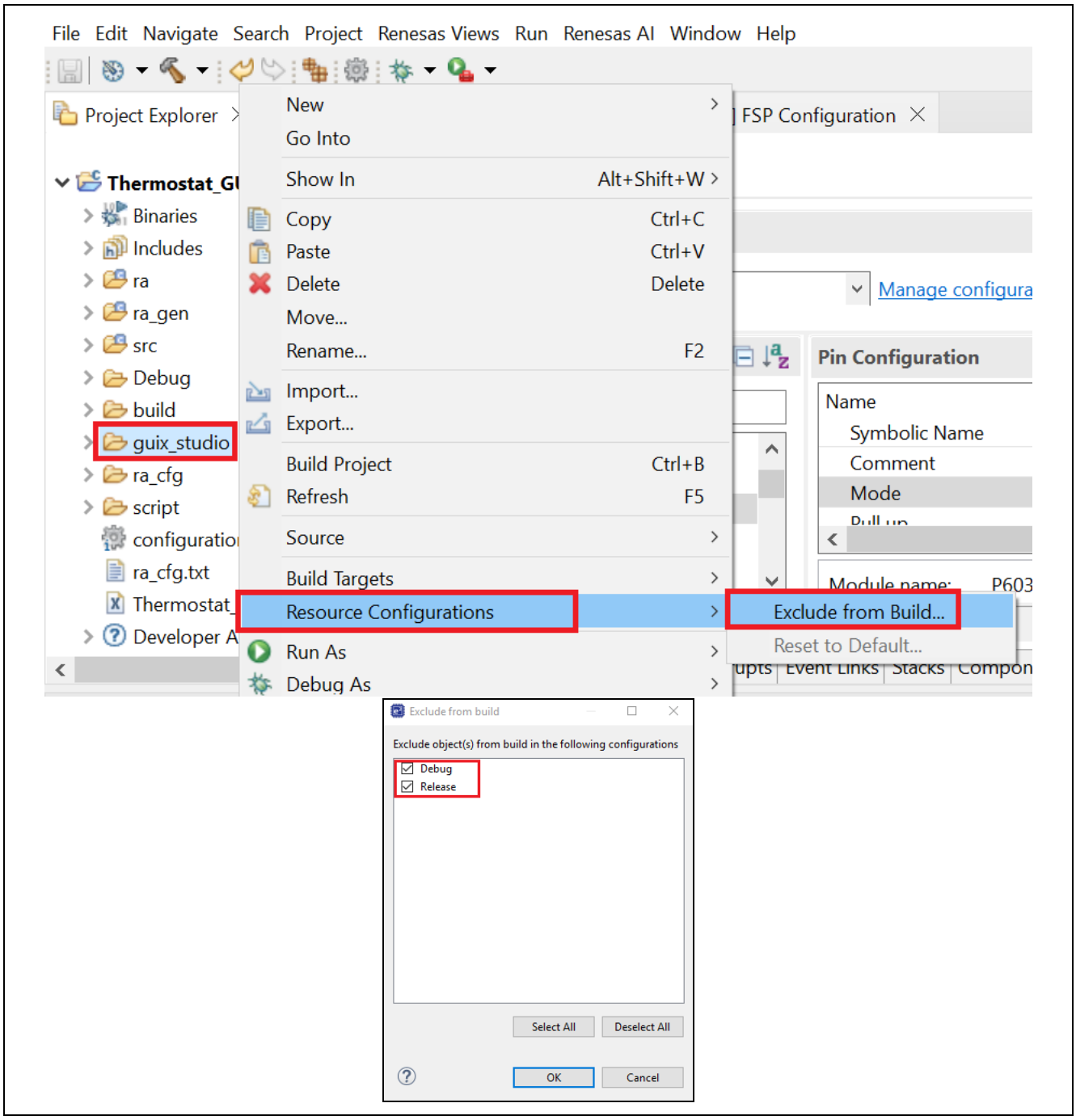

Figure 21. Excluding guix_studio Folder from the Build

16. Get to Thermostat_GUIX_EK_RA6M3G project folder by right clicking the e² studio project and select "**System Explorer**" as shown below.

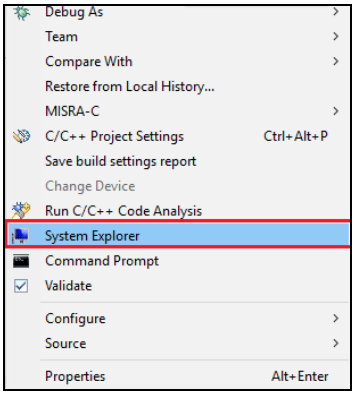

Figure 22. Selecting System Explorer

17. Open **thermostat.gpx** project file in "**guix_studio>GNU**" sub-folder in your Thermostat_GUIX_EK_RA6M3G folder. If you have several GUIX Studio versions in your system, make sure you choose the right one, which is **v6.4.0.0 or later**.

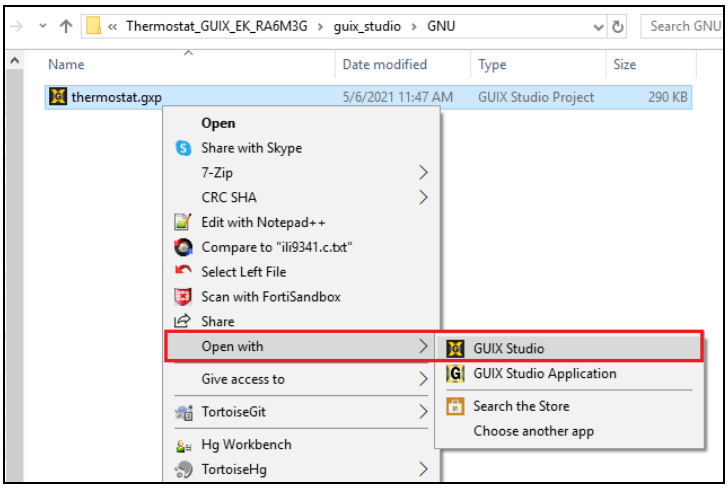

Figure 23. Opening the Project File

18. This GUIX Studio project has a complete design of this Thermostat application. The next several steps describe the process to generate resources, application code and integrate them with an e² studio project.

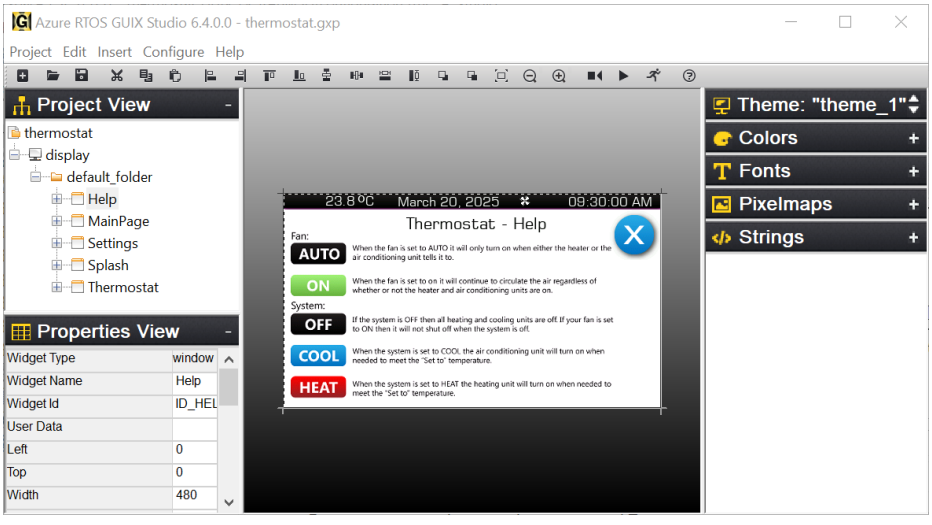

Figure 24. GUIX Studio Thermostat Application View

19. The Azure RTOS GUIX Studio project consists of 5 screens, including Splash, Main Page, Settings, Thermostat and Help from top to bottom:

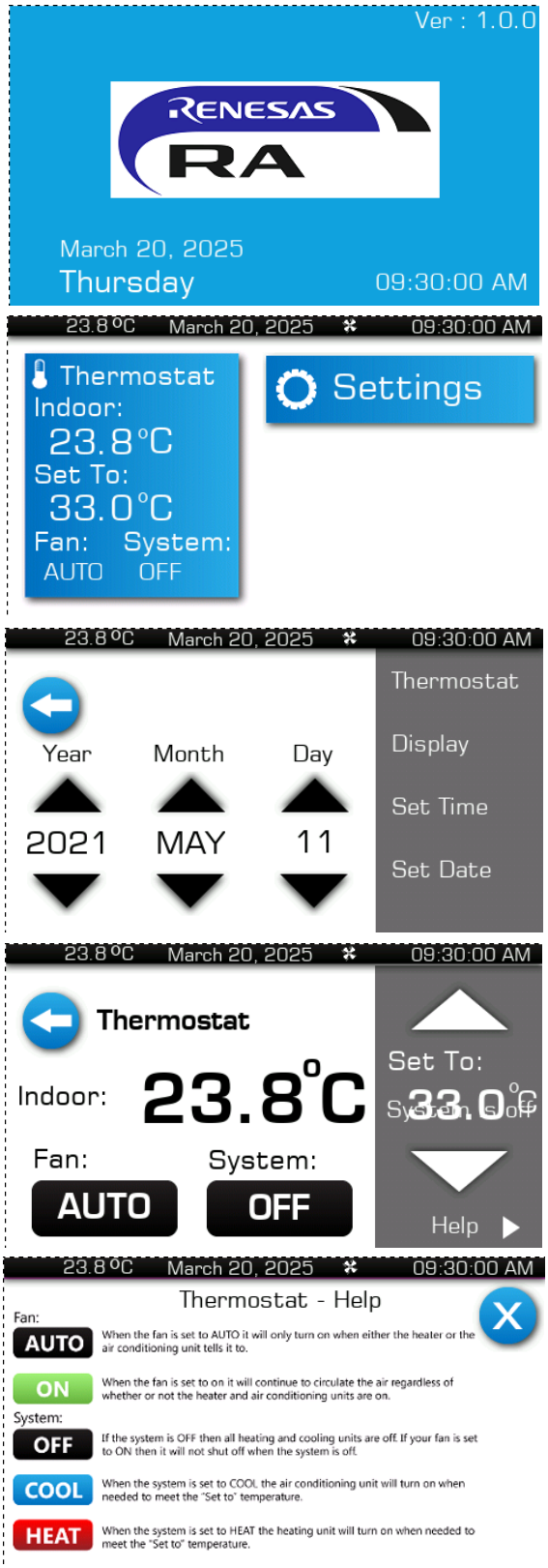

Figure 25. Azure RTOS GUIX Studio Project Screens

20. Click “**Configure→Project/Display**” and confirm the following settings.

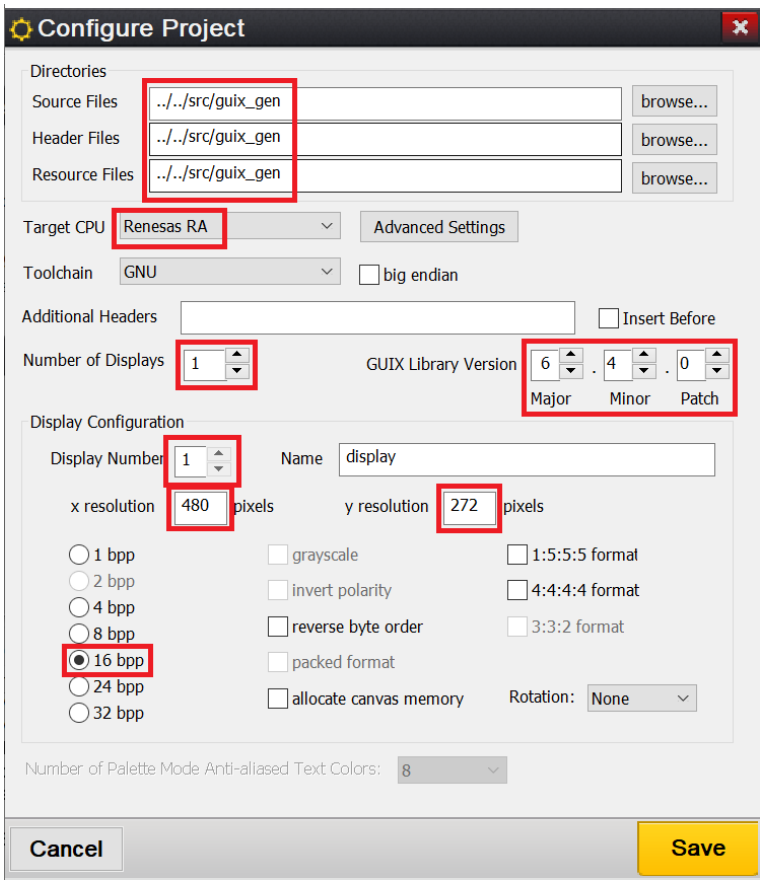

Figure 26. Configure Project Settings

21. Go back e² studio project (Thermostat_GUIX_EK_RA6M3G), right click “**src**”, then select “**New→Folder**” and create a folder named “**guix_gen**”.

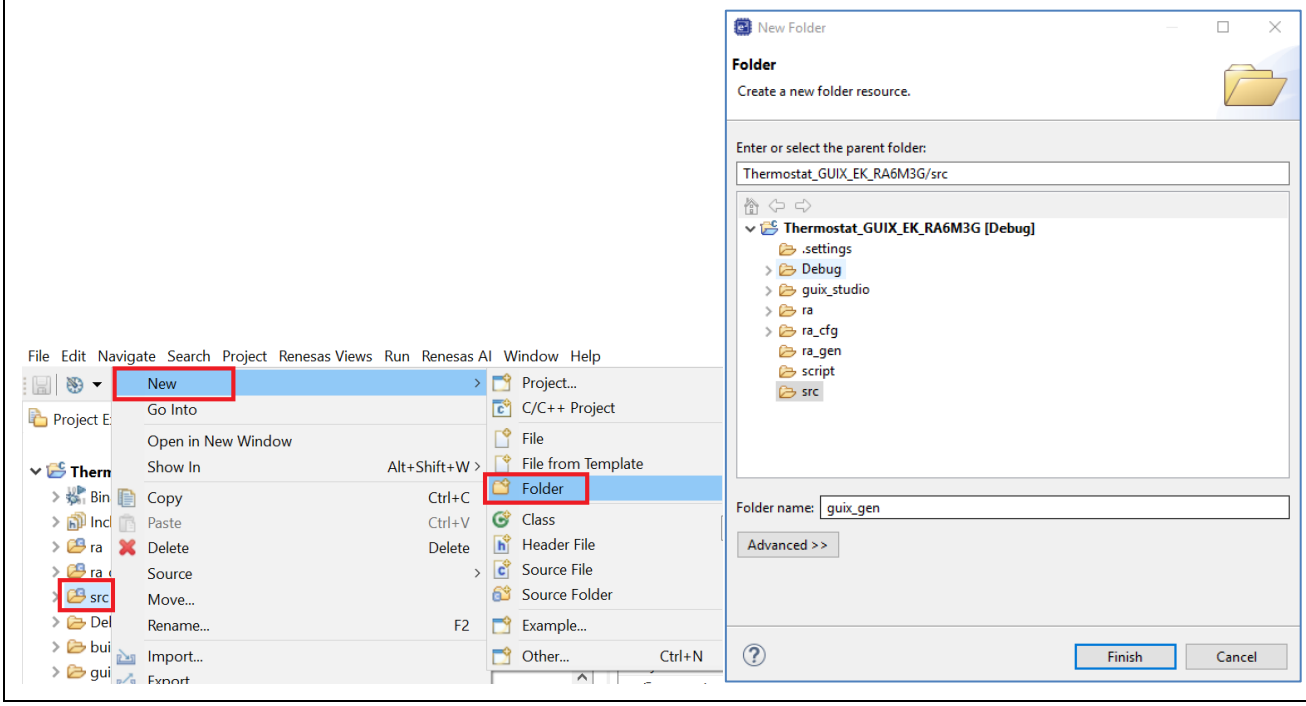

Figure 27. Creating a “guix_gen” in e²studio Project

22. Confirm “guix_gen” is created before moving to next step.

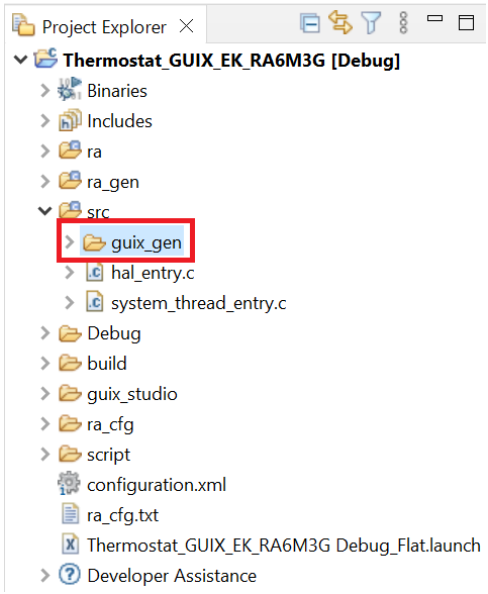

Figure 28. Confirming Creation of “guix_gen”

23. In Azure RTOS GUIX Studio, click **Project→Generate All Output Files** to generate resource files, header files and source files of this GUIX design.

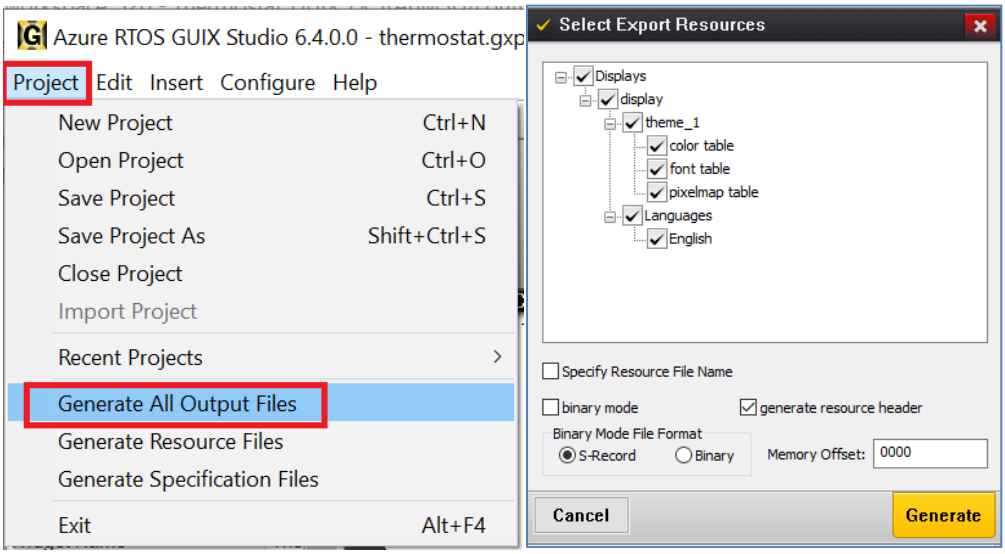

Figure 29. Clicking Generate All Output Files

Click **Generate** to generate all output files. If succeeded, you will see below notification.

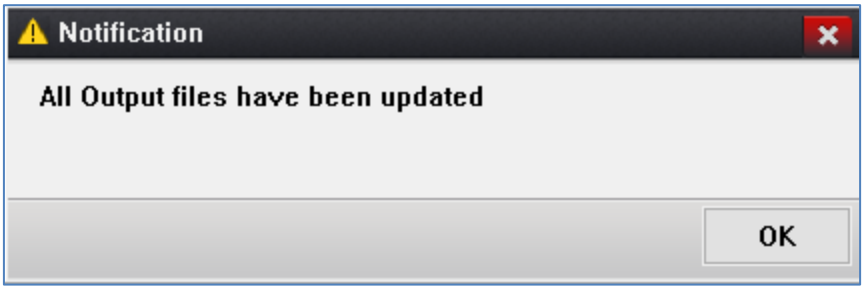

Figure 30. All Output Files Updated Notification

24. All output files are now in “**guix_gen**” folder.

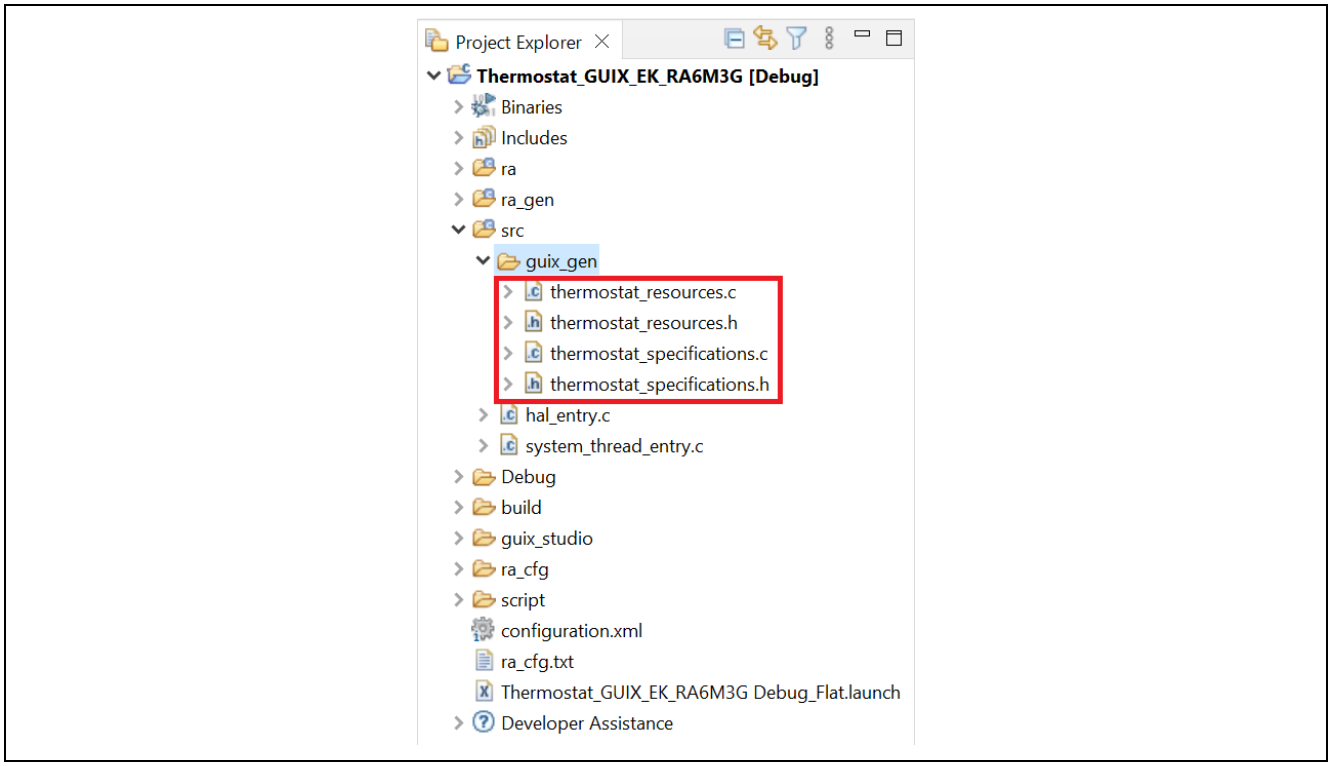

Figure 31. Location of Output Files

25. In **the Azure RTOS GUIX Studio Project**, click **“Splash”** and pick up “**Widget Name**” and “**Event Function**” definitions. These definitions are used to create a screen and handle it in **the e2studio/FSP project**. The other windows have similar definitions.

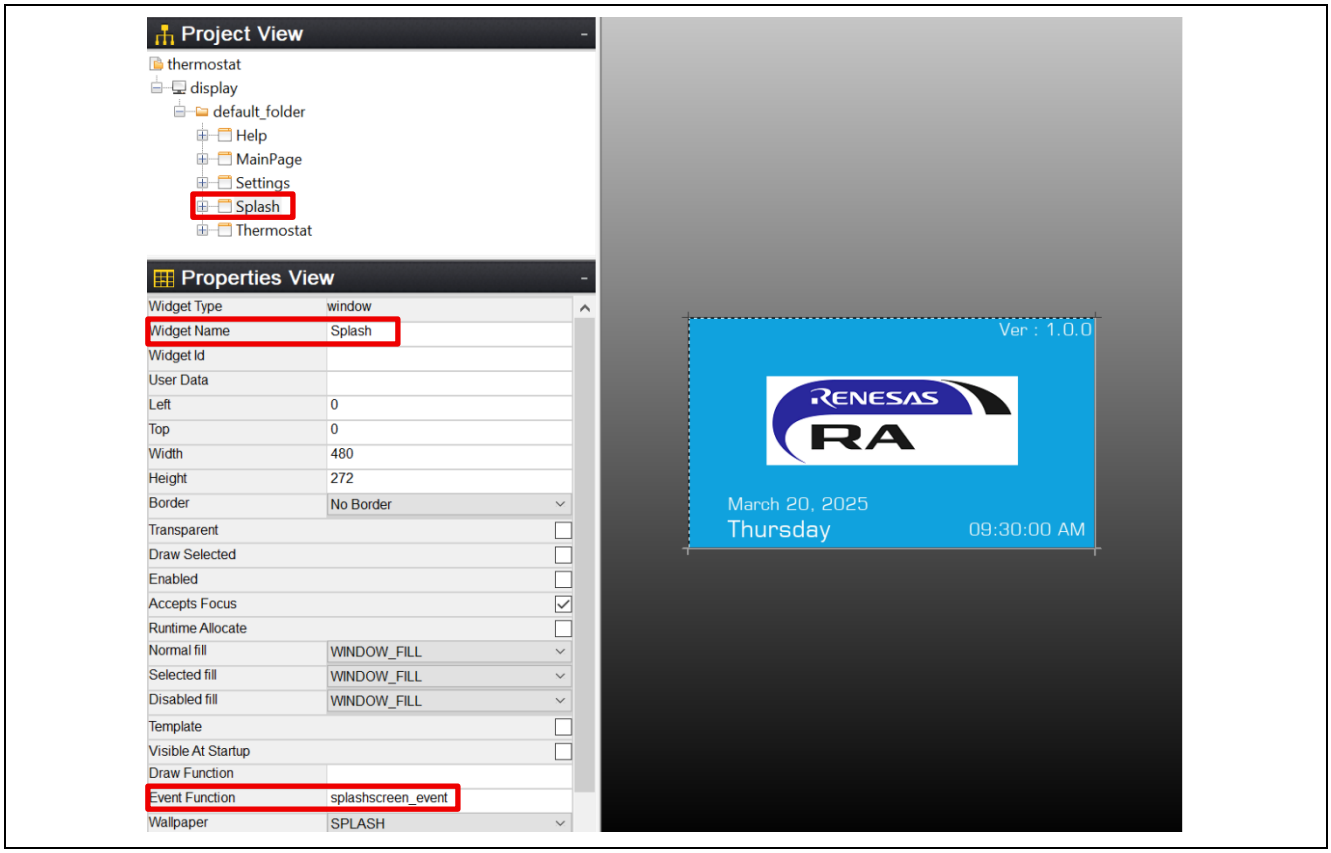

Figure 32. Definitions in the Azure RTOS GUIX Studio Project

26. Copy and replace the files in **"src"** folder in e^2 studio project with the files in **"2.23"** folder in the AN folder:
    - hmi_event_handler.c
    - system_thread_entry.c

    Build Thermostat_GUIX_EK_RA6M3G project you will see several warnings, but we will address them in later steps.
27. **Code highlight:** The following example creates a screen based on Widget Name in GUIX project and attached it to the root window. In this case, it is the "Splash" screen. Refer to system_thread_entry.c for more details.

```
/* Create the widget and attached to root window.*/
gx_err = gx_studio_named_widget_create("Splash", (GX_WIDGET *) p_root, (GX_WIDGET **) &p_splash_screen);
if(GX_SUCCESS != gx_err)
{
    APP_ERR_TRAP(FSP_ERR_ASSERTION);
}
```

28. **Code highlight:** An event function associated with a screen needs to be defined to handle events on that screen. Refer to hmi_event_handler.c for more details. All event functions are empty at this point.

```
/*****************************************************************************************************************//**
 * @brief   Handles all events on the splash screen.
 *
 * @param[in]   widget      Pointer to the widget that caused the event
 * @param[in]   event_ptr   Pointer to event that needs handling
 *
 * @retval      GX_SUCCESS
 *****************************************************************************************************************/
UINT splashscreen_event(GX_WINDOW *widget, GX_EVENT *event_ptr)
{
    UINT gx_err = GX_SUCCESS;

    return gx_err;
}
```

29. Get your EK-RA6M3G ready to run the project. Connect LCD board to **Graphics Expansion** connector on EK-RA6M3 as shown below.

Figure 33. Connecting LCD Board to Graphics Expansion Connector of EK-RA6M3

30. Connect EK-RA6M3G kit to your PC using **J10**. **Download and Run** Thermostat_GUIX_EK_RA6M3G project, you will see a black screen.

31. Add the following code to **splashscreen_event** function in **hmi_event_handler.c** to show Splash screen. **Build** the e² studio project.

```
switch (event_ptr->gx_event_type)
{
    case GX_EVENT_SHOW:
        gx_err = gx_window_event_process(widget, event_ptr);
        if(GX_SUCCESS != gx_err) {
            while(1);
        }
        break;
    default:
        gx_err = gx_window_event_process(widget, event_ptr);
        if(GX_SUCCESS != gx_err) {
            while(1);
        }
        break;
}
```

Please refer to splashscreen_event function in hmi_event_handler.c in "**2.28**" folder in the AN folder.

32. **Download and Run** the project, you will see the Splash screen on LCD panel.

Figure 34. Splash Screen View on LCD

3. Using GUIX Widget Timer to Trigger a Screen Transition

3.1 Overview

In this section, you will implement a simple use of GUIX Widget timer, which is to trigger a screen transition.

3.2 Procedural Steps

1. Copy and replace the files in **"src"** folder in e² studio project with the files in **"3.1"** folder in the AN folder:

   hmi_event_handler.c

   system_thread_entry.c

2. **Code highlight**: The following code in splashscreen_event function starts a GUIX Widget timer and trigger a screen transition that hides Splash screen and shows Main Page screen.

```
switch (event_ptr->gx_event_type)
{
    case GX_EVENT_TIMER:
        gx_system_timer_stop(widget, 10);
        toggle_screen(p_mainpage_screen,p_splash_screen);
        break;
    case GX_EVENT_SHOW:
        gx_system_timer_start(widget, 10 , SPLASH_TIMEOUT,
SPLASH_TIMEOUT);
        gx_err = gx_window_event_process(widget, event_ptr);
        if(GX_SUCCESS != gx_err) {
            while(1);
        }
        break;
    default:
        gx_err = gx_window_event_process(widget, event_ptr);
        if(GX_SUCCESS != gx_err) {
            while(1);
        }
        break;
}
```

3. **Build, Download, and Run** the project, you will see the transition from Splash screen to Main Page screen in about 3 seconds.

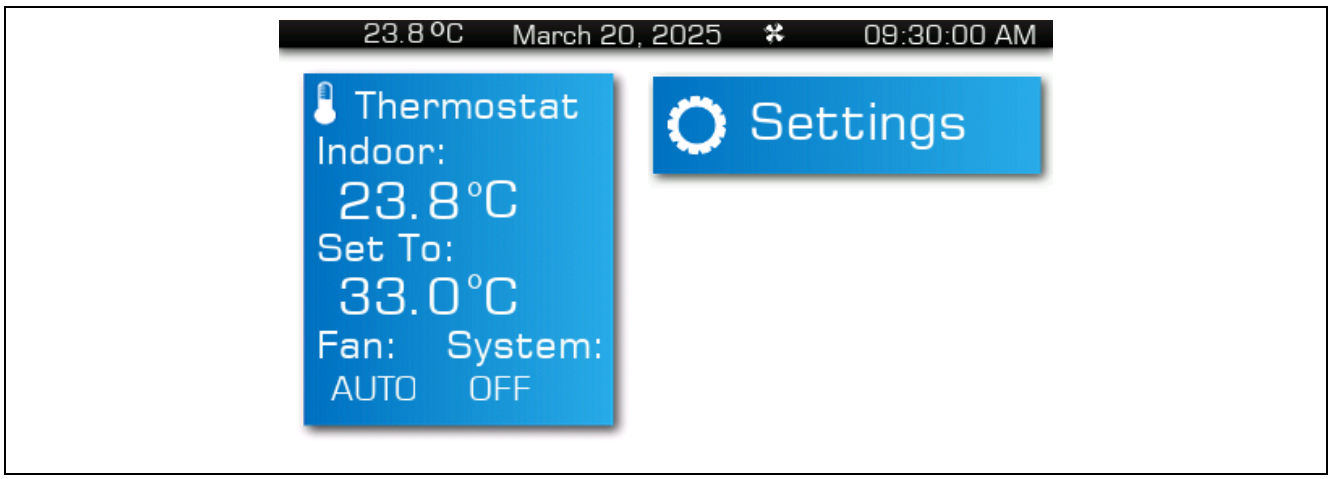

Figure 35. Main Page Screen

4. Add Touch Driver to Thermostat_GUIX_EK_RA6M3G Project

4.1 Overview

In this section, you will add the ft5x06 touch driver to the project to handle touch events on LCD panel.

4.2 Procedural Steps

1. In Thermostat_GUIX_EK_RA6M3G project, create a folder by right-clicking **"src",** then select **"New→Folder".**

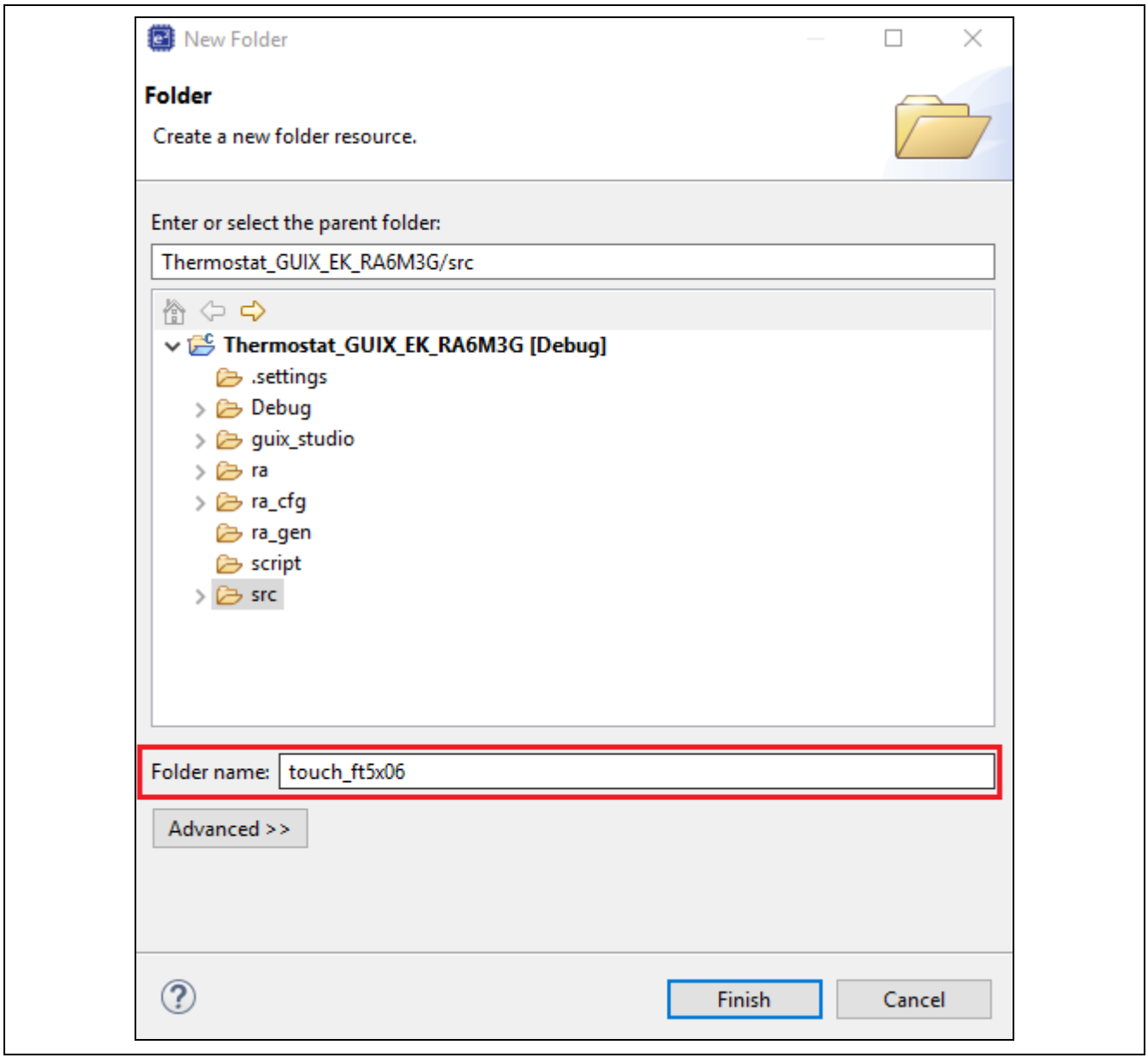

Figure 36. Creating New Folder in Thermostat_GUIX_EK_RA6M3G Project

Click **Finish** to create **"touch_ft5x06"** folder.

2. Copy `touch_ft5x06.c` and `touch_ft5x06.h` from “touch_ft5x06” folder in the Lab folder to the one in e² studio project.

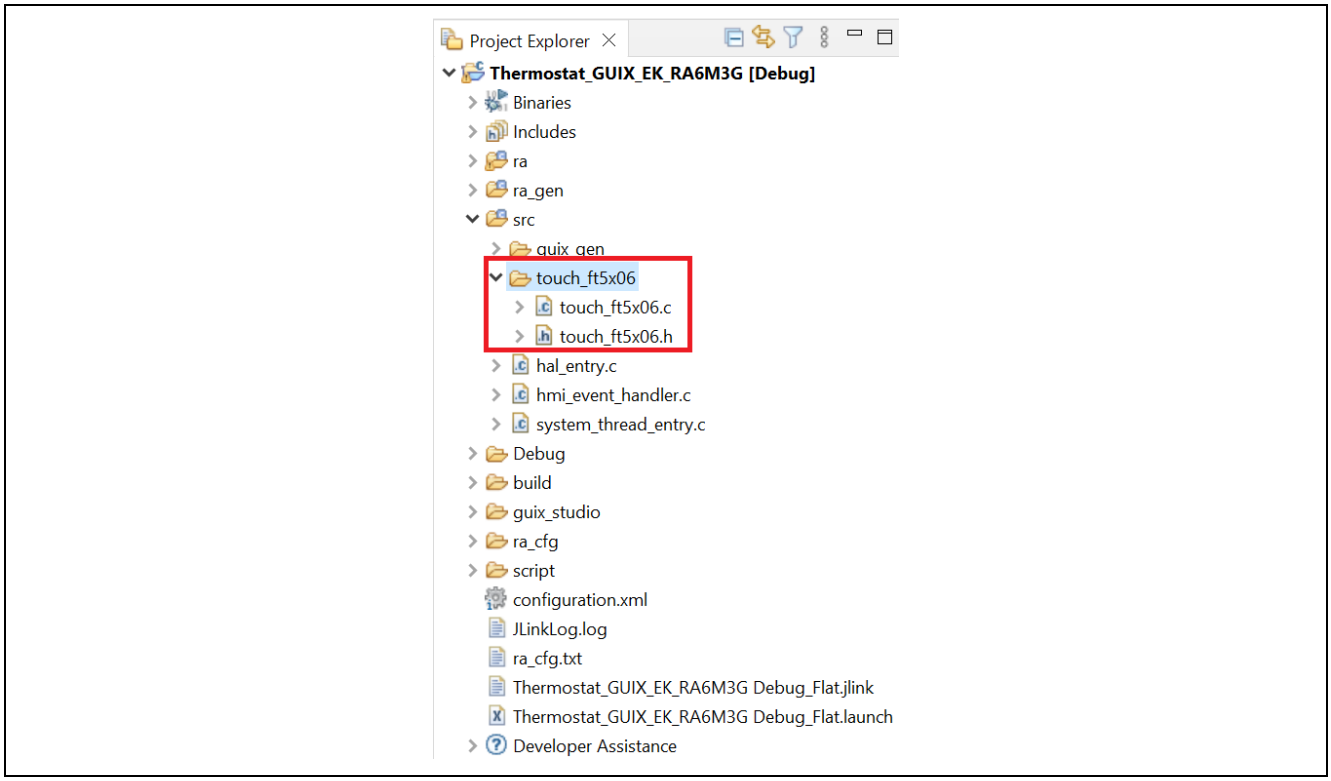

Figure 37. Copying files to the e² studio Project

3. Open project configuration and create **Touch Thread** with the settings below.

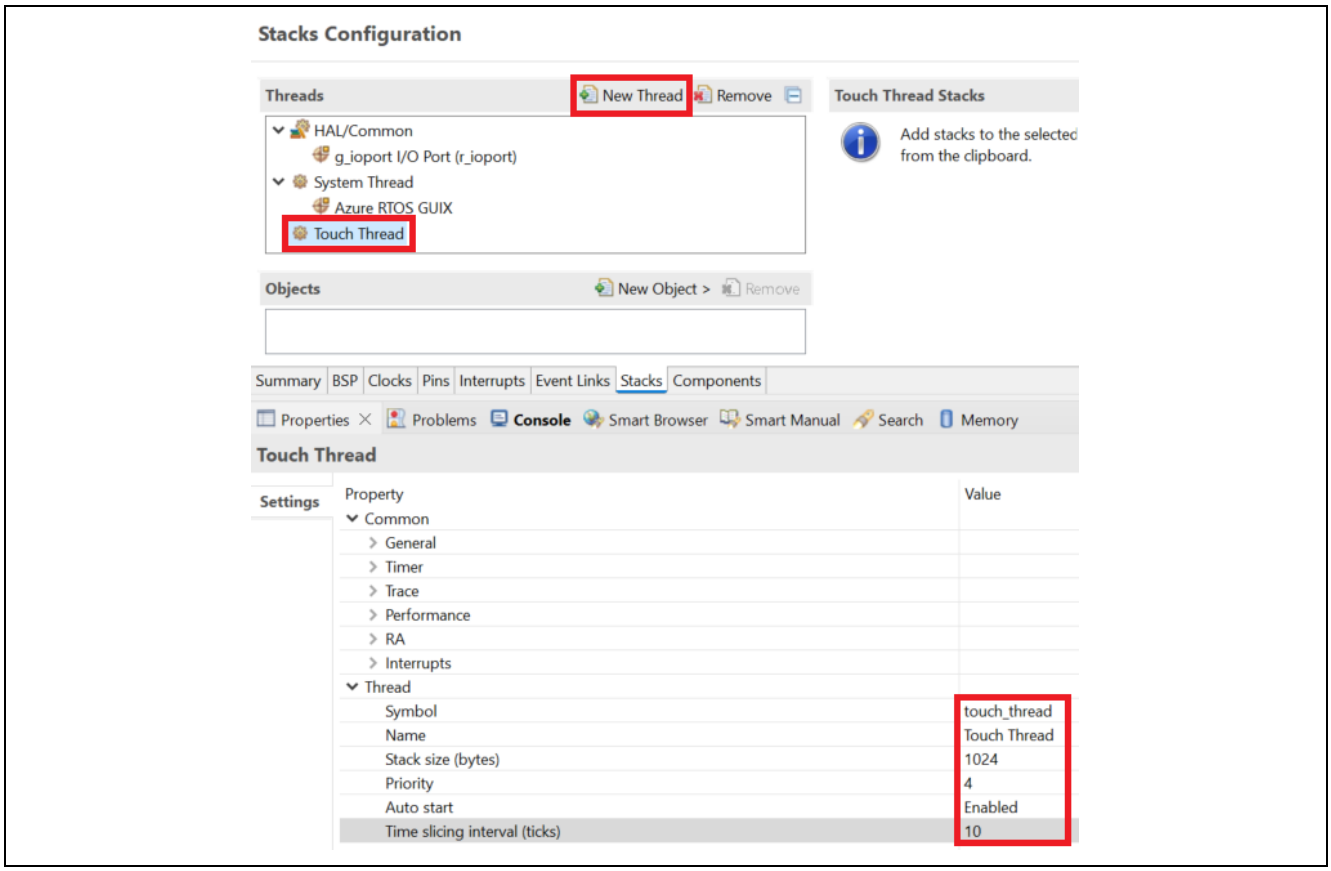

Figure 38. Creating Touch Thread

4. The pins marked in red below are used for touch panel controller on the LCD board:
   - IRQ0 interrupt (P206) is used to trigger touch events.
   - I2C channel 2 (P512, P511) is used to read and write data to the touch controller. P304 is used to reset the touch controller.

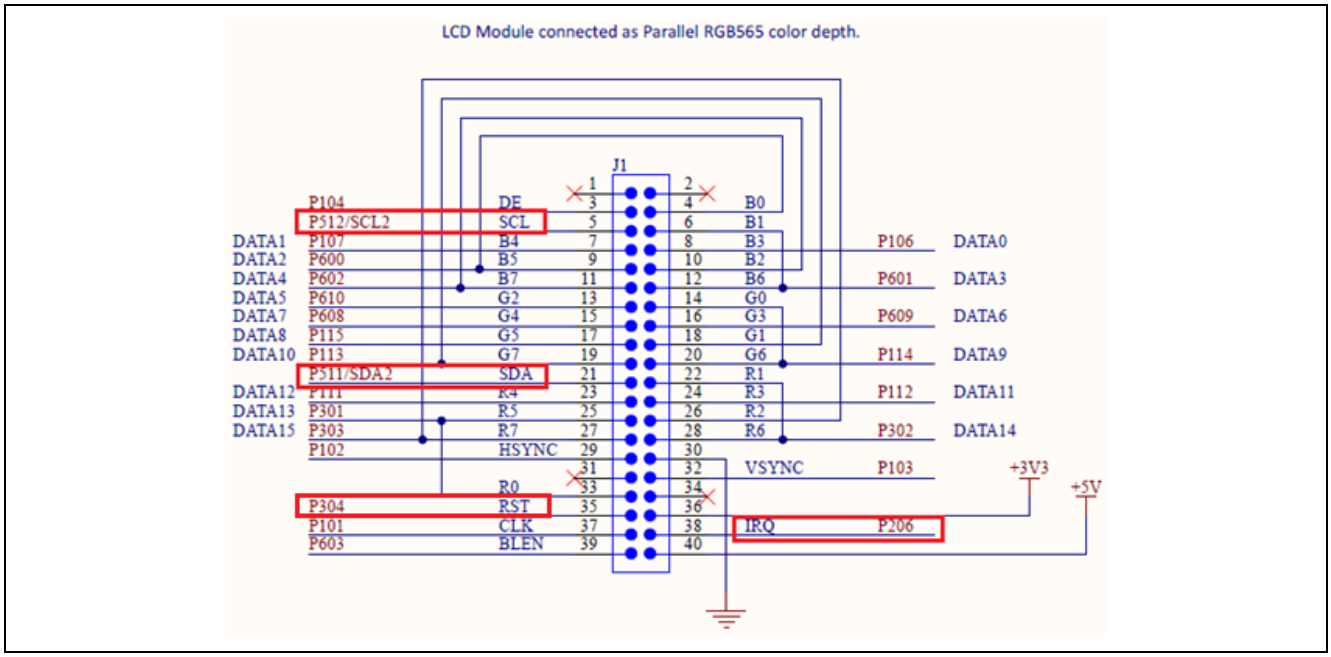

Figure 39. Pins Used in Touch Panel Controller (marked in red)

5. Since the IRQ0 (P206) needs a pull-up to function properly with the LCD board, do not change the setting that was done by FSP, as shown below.

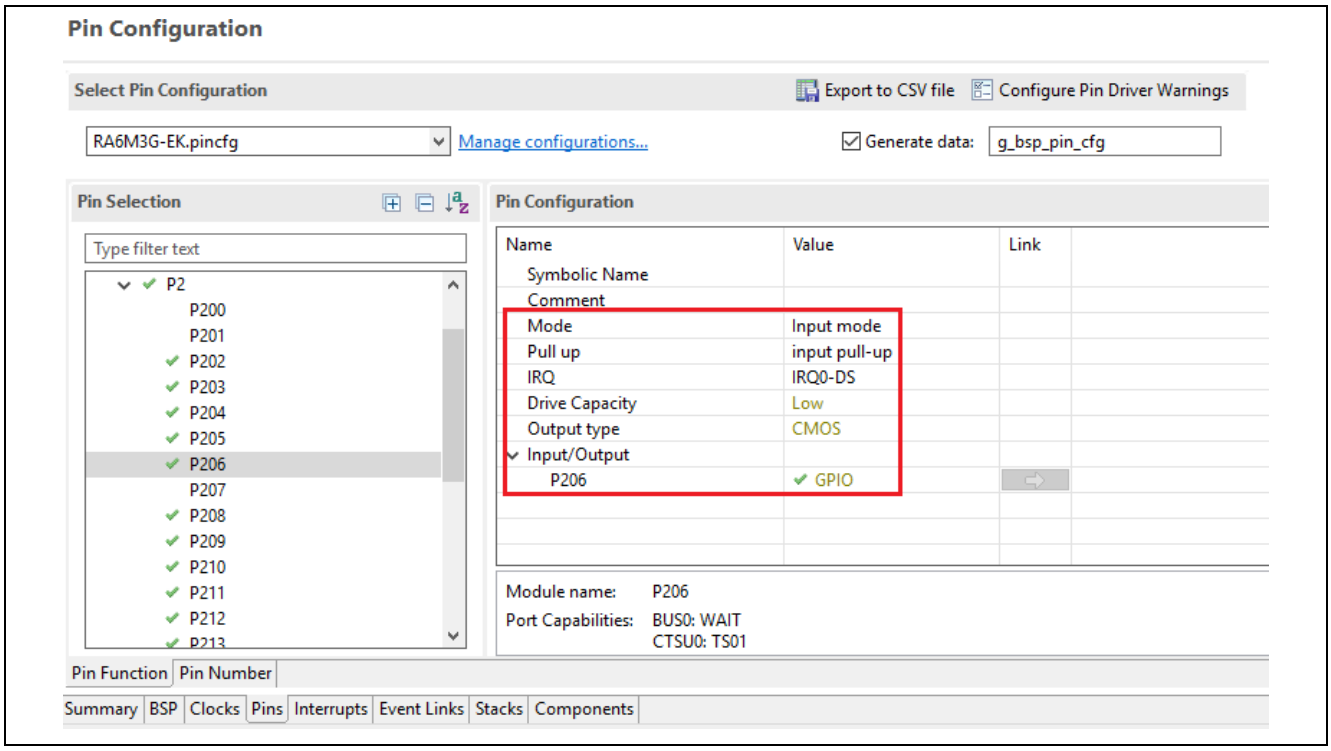

Figure 40. FSP Setting

6. In e² studio project configuration, add **External IRQ Driver on r_icu** to **Touch Thread** with the following settings.

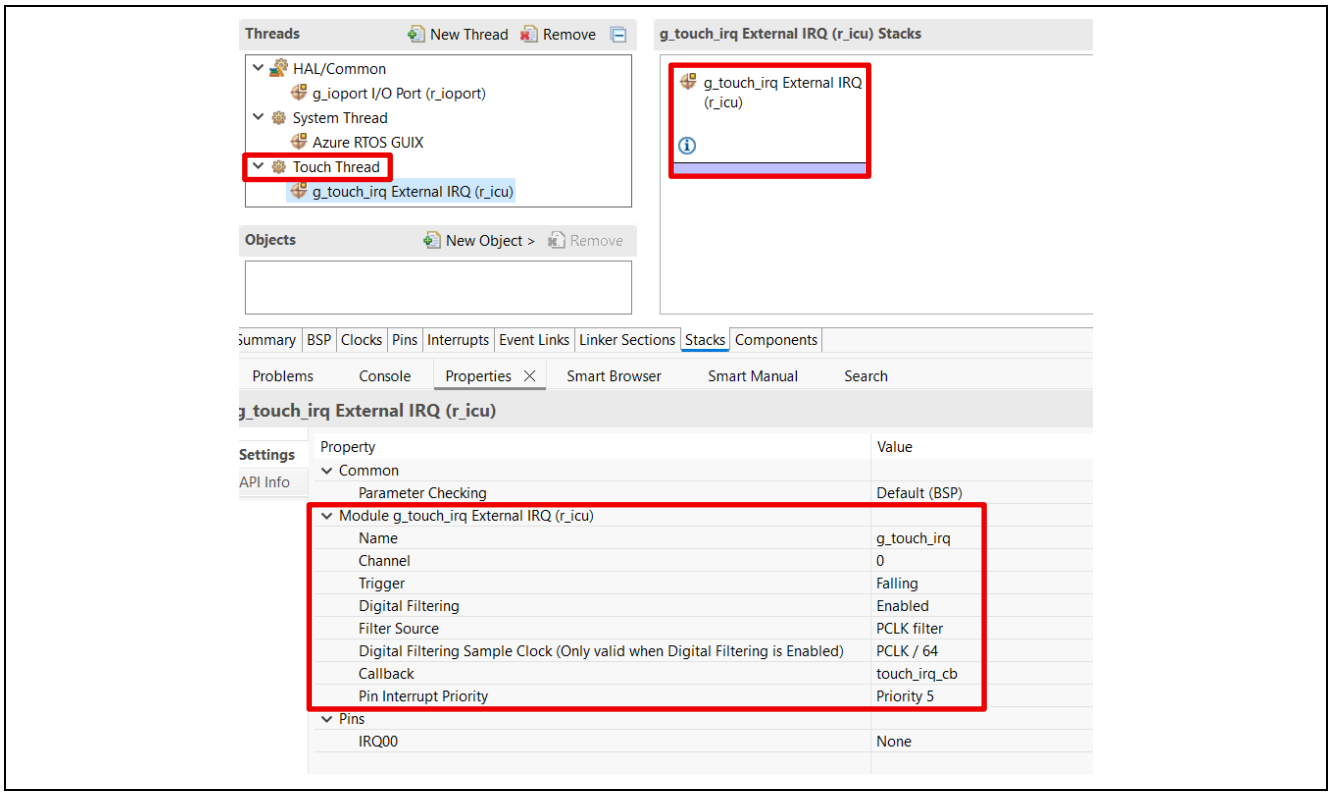

Figure 41. Adding External IRQ Driver on r_icu to Touch Thread

7. In project configuration, add **I2C Master Driver on r_iic_master** to **Touch Thread** with below settings.

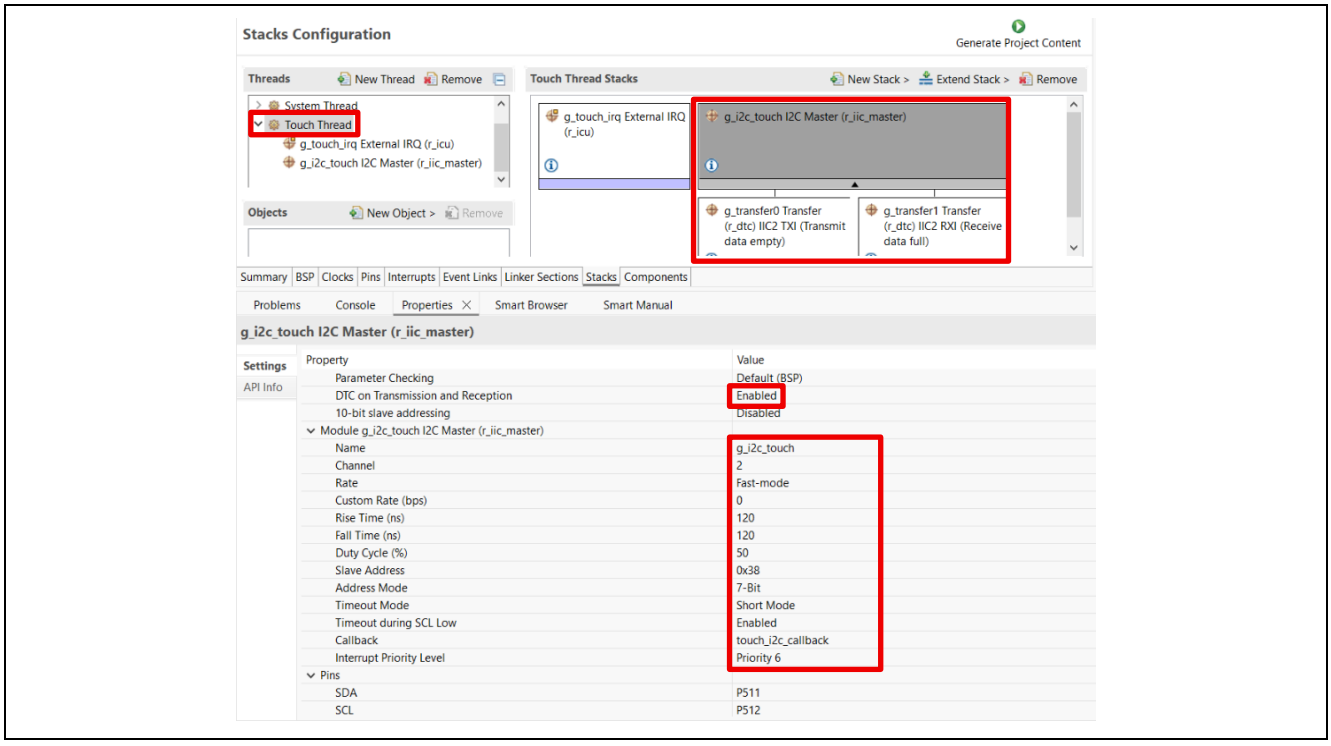

Figure 42. Adding I2C Master Driver on r_iic_master to Touch Thread

8. In project configuration, add **Touch Semaphore** as shown below. We use this semaphore to signal the Touch thread when a touch event occurs. The Touch thread then sends the touch event to GUIX.

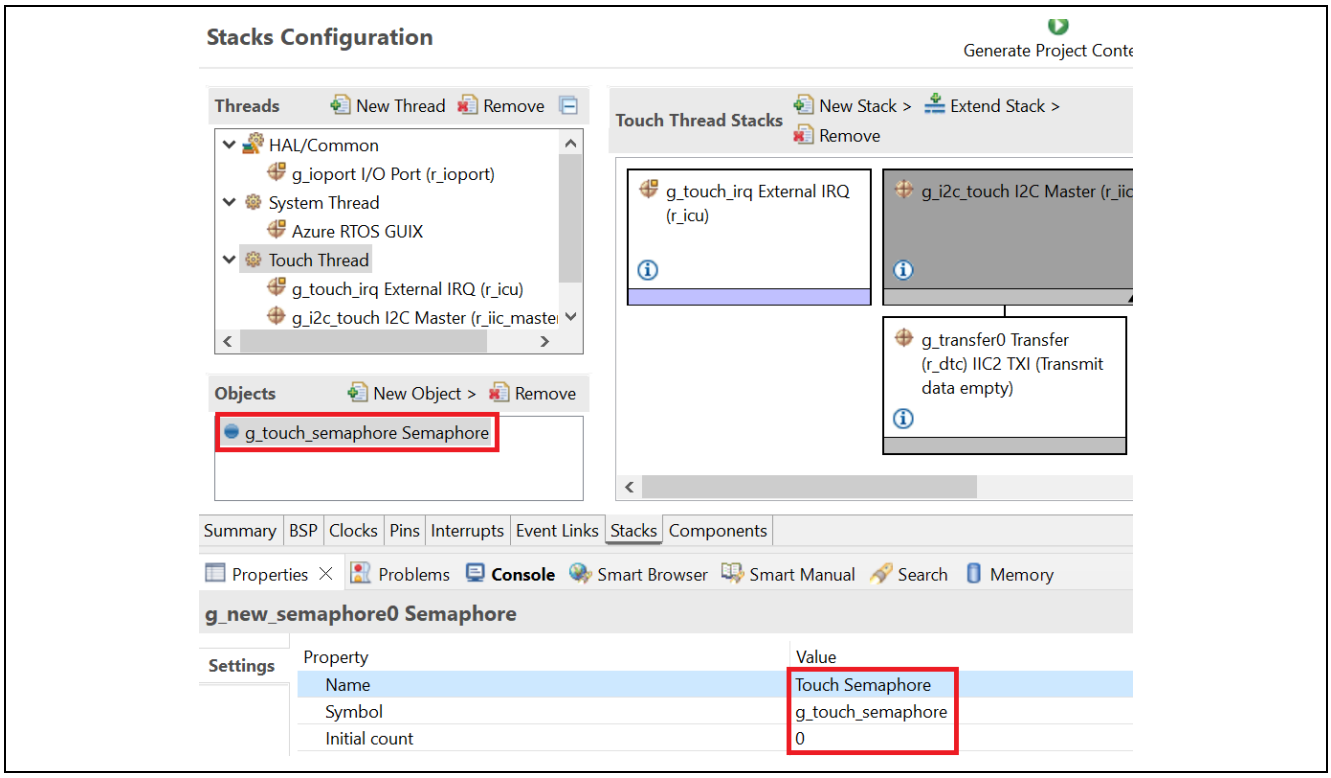

Figure 43. Adding Touch Semaphore

9. In project configuration, add **I2C Semaphore** as shown below. This semaphore is used in the ft5x06 driver to trigger data reading when a touch-panel interrupt occurs.

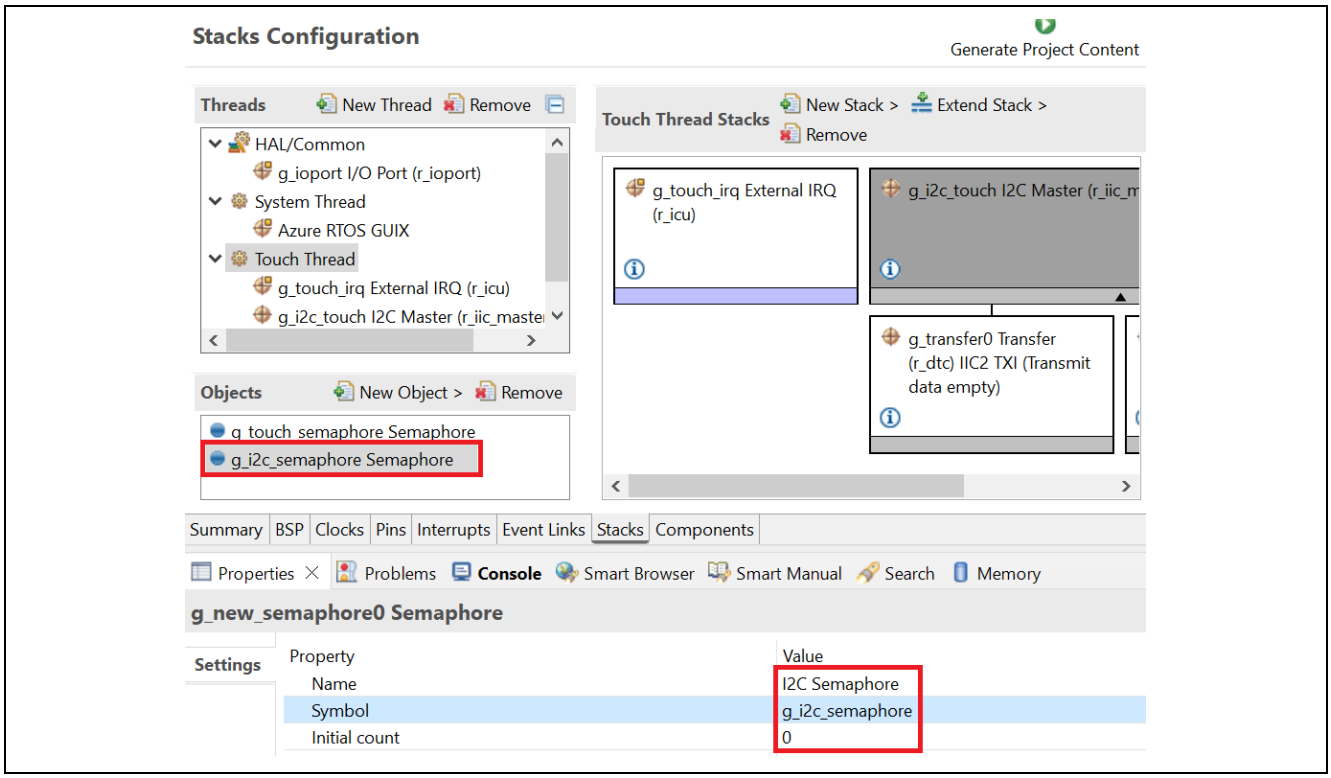

Figure 44. Adding I2C Semaphore

10. In RA Configurator, click 

to generate project content.
11. Copy and replace the files in **"src"** folder in the e² studio project with the files in **"4.11"** folder in the AN folder:
    - hmi_event_handler.c
    - system_thread_entry.c
    - touch_thread_entry.c

12. **Code highlight:** Below code in touch_thread_entry.c get touch data and send touch event to GUIX.

```
/* Get touch data from the FT5X06 */
ft5x06_payload_get(&touch_data);
/* Send touch data*/
if(1 == touch_data.num_points)
{
  gxe.gx_event_payload.gx_event_pointdata.gx_point_x      = touch_data.point[0].x;
  gxe.gx_event_payload.gx_event_pointdata.gx_point_y      = touch_data.point[0].y;
  gxe.gx_event_type = GX_EVENT_PEN_DOWN;
  gx_system_event_send(&gxe);
}
else if (GX_EVENT_PEN_DOWN == gxe.gx_event_type)
{
  gxe.gx_event_type = GX_EVENT_PEN_UP;
  gx_system_event_send(&gxe);
}
```

13. All the screens designed in the Azure RTOS GUIX Studio project are now created in system_thread_entry.c

```
/* Create a screen and attached  it to root window.*/
gx_err = gx_studio_named_widget_create("Splash", (GX_WIDGET *) p_root, (GX_WIDGET **) &p_splash_screen);
if(GX_SUCCESS != gx_err)
{
    APP_ERR_TRAP(FSP_ERR_ASSERTION);
}

gx_err = gx_studio_named_widget_create ("Settings", GX_NULL, (GX_WIDGET **) &p_settings_screen);
if(GX_SUCCESS != gx_err)
{
    APP_ERR_TRAP(FSP_ERR_ASSERTION);
}
gx_err = gx_studio_named_widget_create ("MainPage", GX_NULL, (GX_WIDGET **) &p_mainpage_screen);
if(GX_SUCCESS != gx_err)
{
    APP_ERR_TRAP(FSP_ERR_ASSERTION);
}

gx_err = gx_studio_named_widget_create ("Thermostat", GX_NULL, (GX_WIDGET **) &p_thermostat_screen);
if(GX_SUCCESS != gx_err)
{
    APP_ERR_TRAP(FSP_ERR_ASSERTION);
}

gx_err = gx_studio_named_widget_create ("Help", GX_NULL, (GX_WIDGET **) &p_help_screen);
if(GX_SUCCESS != gx_err)
{
    APP_ERR_TRAP(FSP_ERR_ASSERTION);
}
```

The code marked in red in hmi_event_handler.c handle touch event when Thermostat button and Settings button are clicked. Refer to hmi_event_handler.c for more details.

```
UINT mainpage_event(GX_WINDOW *widget, GX_EVENT *event_ptr)
{
    UINT gx_err = GX_SUCCESS;
    switch (event_ptr->gx_event_type)
    {
        case GX_SIGNAL(ID_THERMO_BUTTON, GX_EVENT_CLICKED):
            /** Shows the thermostat control screen. */
            toggle_screen (p_thermostat_screen, p_mainpage_screen);
            break;
        case GX_SIGNAL(ID_SETTINGS_BUTTON, GX_EVENT_CLICKED):
            /** Shows the settings screen and saves which screen the user is currently viewing. */
            toggle_screen (p_settings_screen, widget);
            break;
        case GX_EVENT_SHOW:
            gx_err = gx_window_event_process(widget, event_ptr);
            if(GX_SUCCESS != gx_err) {
                while(1);
            }
            break;
        default:
            gx_err = gx_window_event_process(widget, event_ptr);
            if(GX_SUCCESS != gx_err) {
                while(1);
            }
            break;
    }
    return gx_err;
}
```

```
UINT settings_screen_event(GX_WINDOW *widget, GX_EVENT *event_ptr)
{
    UINT gx_err = GX_SUCCESS;
    switch (event_ptr->gx_event_type)
    {
        case GX_SIGNAL(ID_BACK_BUTTON, GX_EVENT_CLICKED):
            /** Returns to main screen. */
            toggle_screen (p_mainpage_screen, widget);
            break;
        case GX_EVENT_SHOW:
            gx_err = gx_window_event_process(widget, event_ptr);
            if(GX_SUCCESS != gx_err) {
                while(1);
            }
            break;
        default:
            gx_err = gx_window_event_process(widget, event_ptr);
            if(GX_SUCCESS != gx_err) {
                while(1);
            }
            break;
    }
    return gx_err;
}
```

14. **Build, Download, and Run** the e^2 studio project. Then, you will be able to go back and forth from the Main Page screen to Thermostat screen and Settings screen using **Thermostat** and **Settings** buttons on Main Page screen and "**Back**" button on the other two screens.

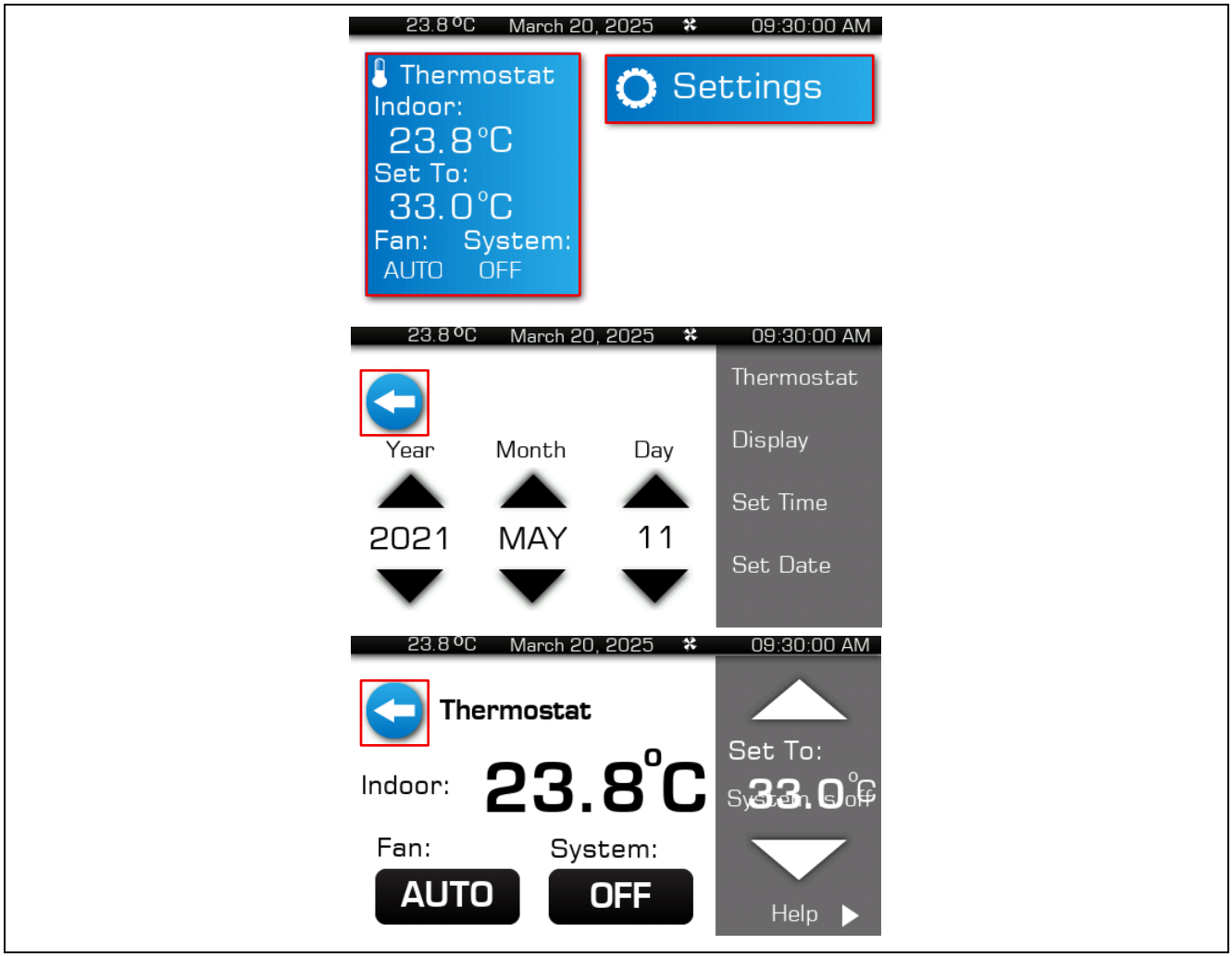

Figure 45. Navigating between Main Page Screen and Thermostat Screen

5. Control LCD Backlight

5.1 Overview

In this section, you will use a PWM output pin of a GPT timer to control the intensity (brightness) of LCD backlight.

5.2 Procedural Steps

1. In LCD board schematics below, the LCD_BLEN signal, which is connected to the P603 on the RA6M3 MCU, is configured in PWM mode to control the intensity of LCD backlight.

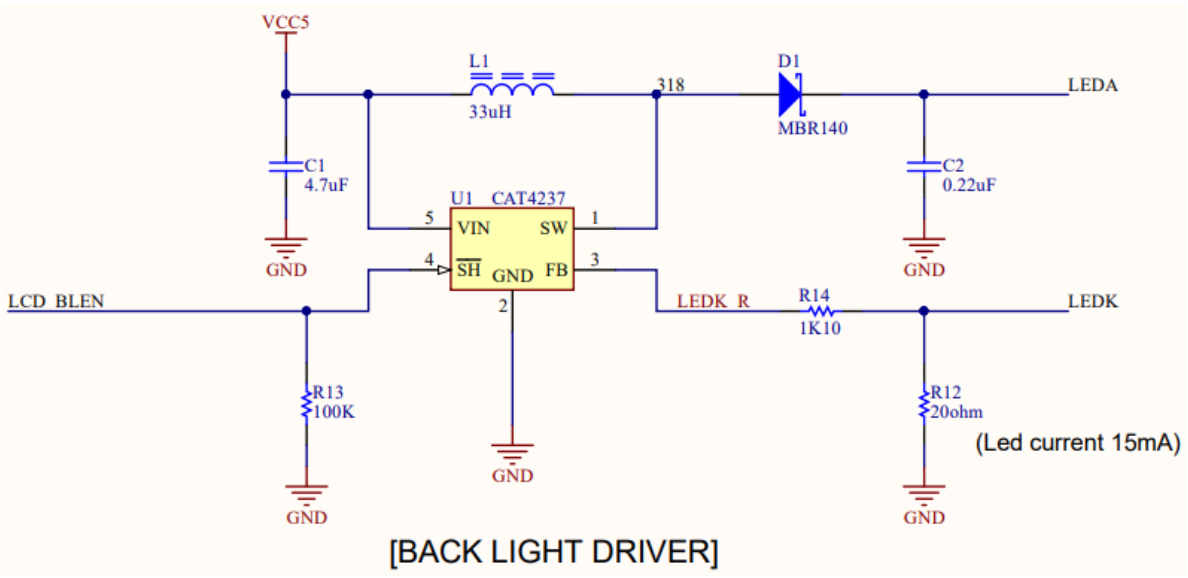

Figure 46. LCD Board Schematic

2. To configure P603 in PWM output mode, we disable it in Pin Configuration at first. **Save this change before moving to the next step.**

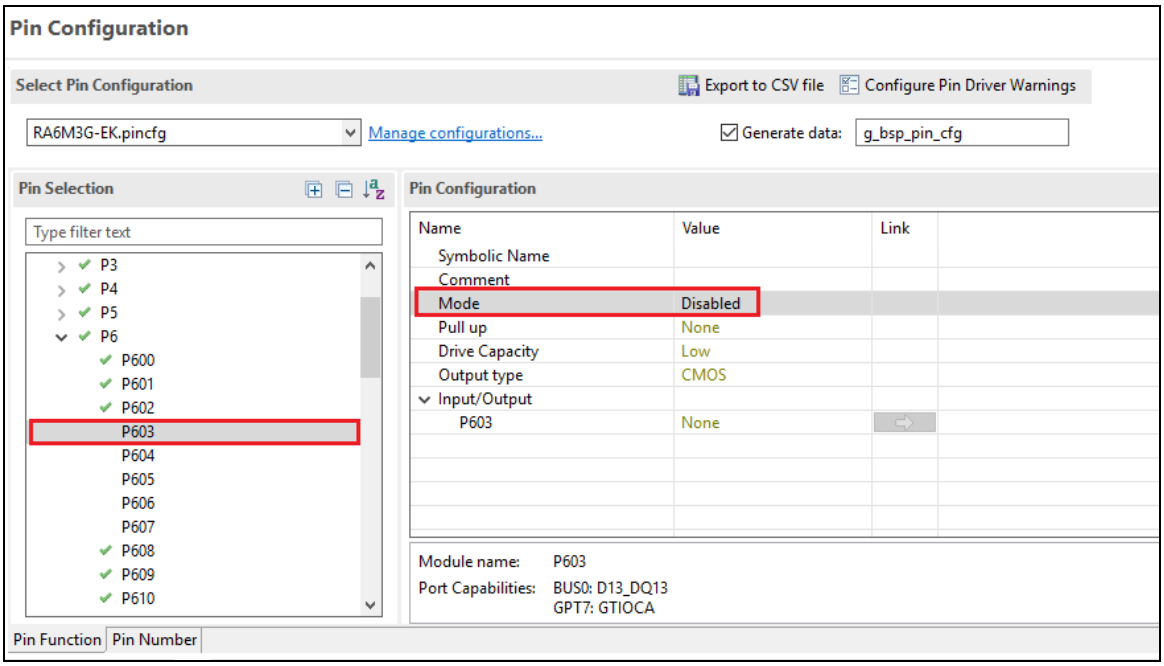

Figure 47. Disabling P603 in Pin Configuration

3. In Pin Configuration, set P603 as GPT7 GTIOCA output.

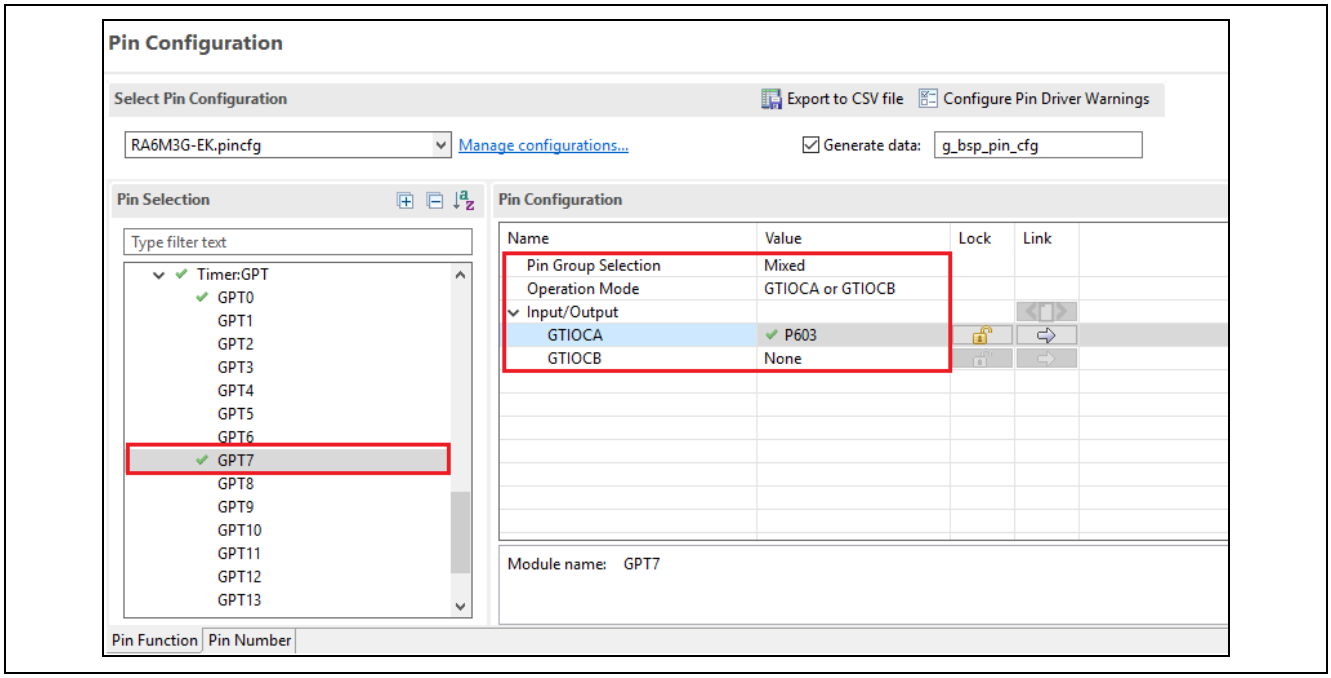

Figure 48. Setting P603 as GPT7 GTIOCA Output in Pin Configuration

4. In project configuration, add **Timer Driver on r_gpt** to **System Thread** with below settings.

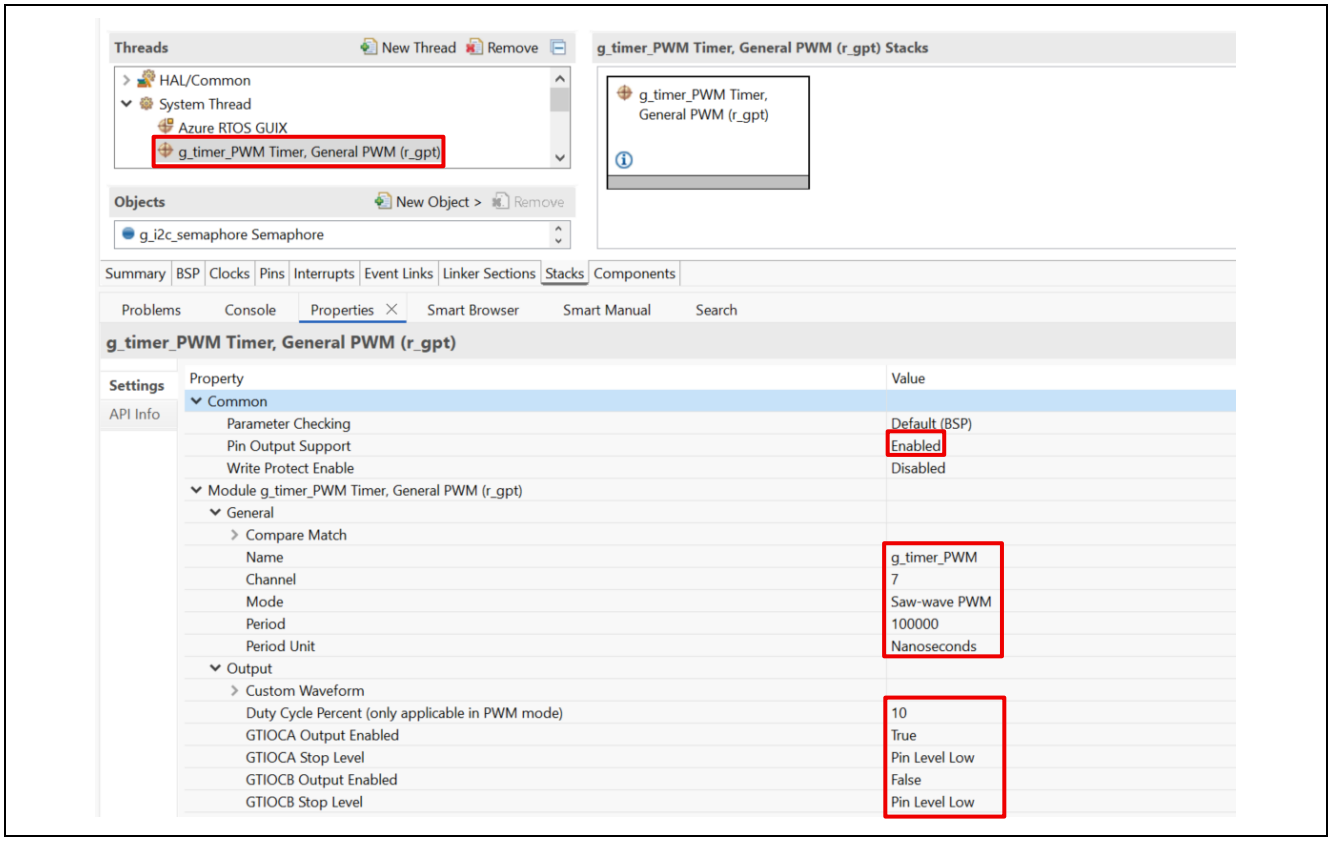

Figure 49. Adding Timer Driver on r_gpt to System Thread

Even though the duty cycle of PWM output is purposely set to **10%** here, it will be changed to **50%** later in the code.

5. In RA Configurator, click 

to generate project content.

6. Copy and replace the files in "**src**" folder in e^2 studio project with the files in "**5.6**" folder in the AN folder:
   - hmi_event_handler.c
   - system_thread_entry.c
   - brightness.c
   - brightness.h
   - system_api.h
   - system_cfg.h
7. brightness_up and brightness_down functions in brightness.c are used to set the PWM duty cycle, as shown below:

```
/* Get the current period setting. */
R_GPT_InfoGet(&g_timer_PWM_ctrl, &info);
/* Calculate the desired duty cycle based on the current period. */
duty_cycle_count = (uint32_t) ((info.period_counts *
brightness)/GPT_PWM_MAX_PERCENT);
err = R_GPT_DutyCycleSet(&g_timer_PWM_ctrl, duty_cycle_count,
GPT_IO_PIN_GTIOCA);
```

8. Looking at gpt_timer_PWM_Setup function in `system_thread_entry.c`, you will see brightness (**duty cycle of PWM output**) is set to 50 percent.

```
static fsp_err_t gpt_timer_PWM_setup(void)
{
    fsp_err_t err = FSP_SUCCESS;
    /* Open GPT */
    err = R_GPT_Open(&g_timer_PWM_ctrl, &g_timer_PWM_cfg);
    if(FSP_SUCCESS != err)
    {
        return err;
    }
    /* Enable GPT Timer */
    err = R_GPT_Enable(&g_timer_PWM_ctrl);
    /* Handle error */
    if (FSP_SUCCESS != err)
    {
        return err;
    }
    /* Start GPT timer */
    err = R_GPT_Start(&g_timer_PWM_ctrl);;
    if(FSP_SUCCESS != err)
    {
        return err;
    }

    /* Set brightness (LCD backlight) level: 50 = (45+5) */
    g_gui_state.brightness = 45;
    brightness_up(&g_gui_state.brightness);

    return err;
}
```

9. **Build, Download, and Run** the e² studio project. By clicking the **Settings** button on **Main Page** screen, you can access **Settings** screen.

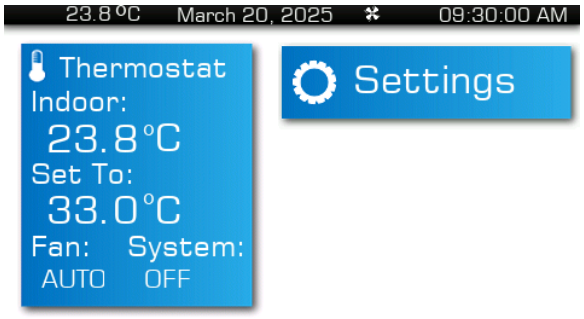

Figure 50. Settings Button on Main Page Screen

10. PWM output measured on pin P603 with brightness is set to 50%.

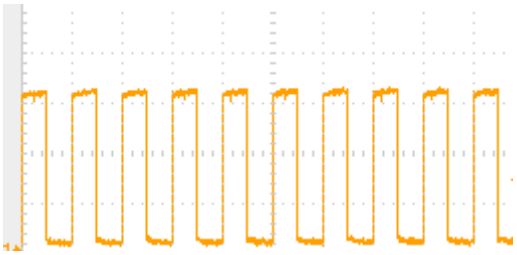

Figure 51. PWM Output on P603 at 50% Brightness

11. Click "**Display**" menu on **Settings** screen, you can use "**Up**" and "**Down**" buttons to change the brightness of LCD backlight.

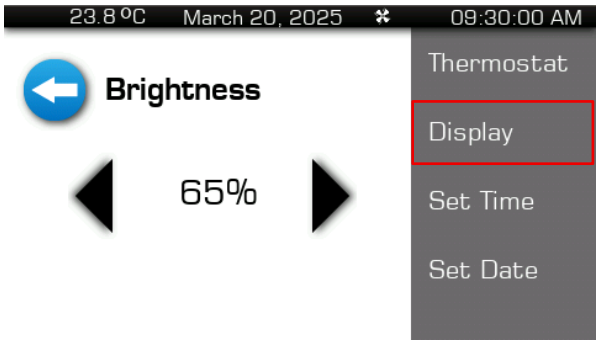

Figure 52. Display on Settings Screen

12. PWM output measured on pin P603 after changing brightness to **65%**.

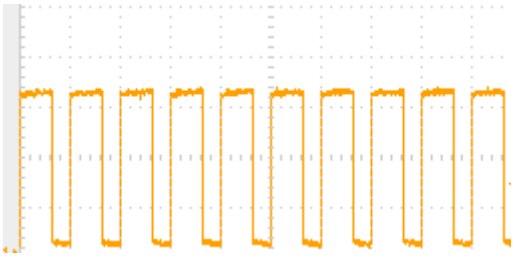

Figure 53. PWM Output on P603 at 65% Brightness

6. Update Date/Time and Temperature

6.1 Overview

In this section, you will enable RTC controller as a timekeeper and one ADC channel to read the MCU die's temperature sensor and use it as Thermostat temperature data.

6.2 Procedural Steps

1. In project configuration, create **Temperature Time Thread**.

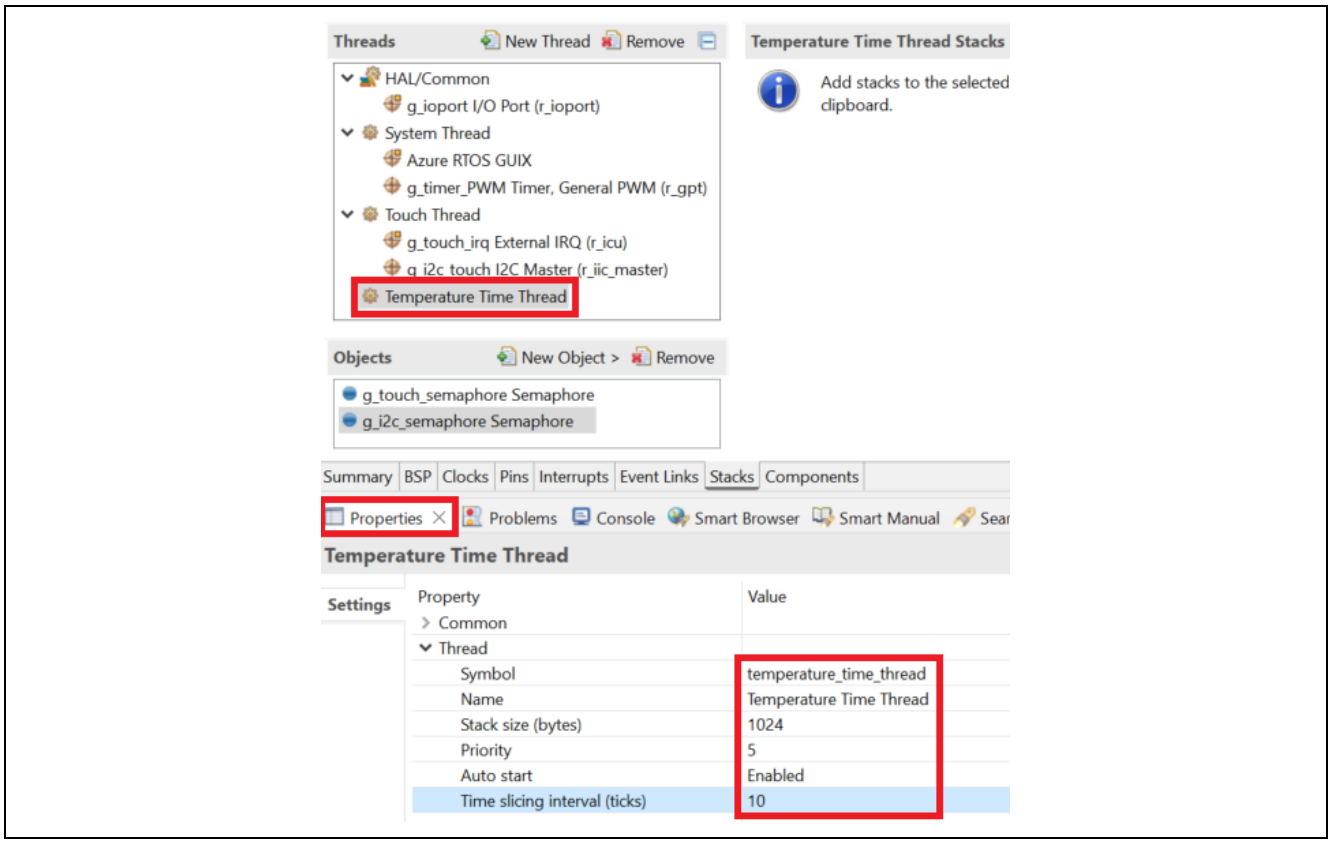

Figure 54. Create Temperature Time Thread

2. In project configuration, add **RTC Driver on g_rtc** to **Temperature Time Thread**.

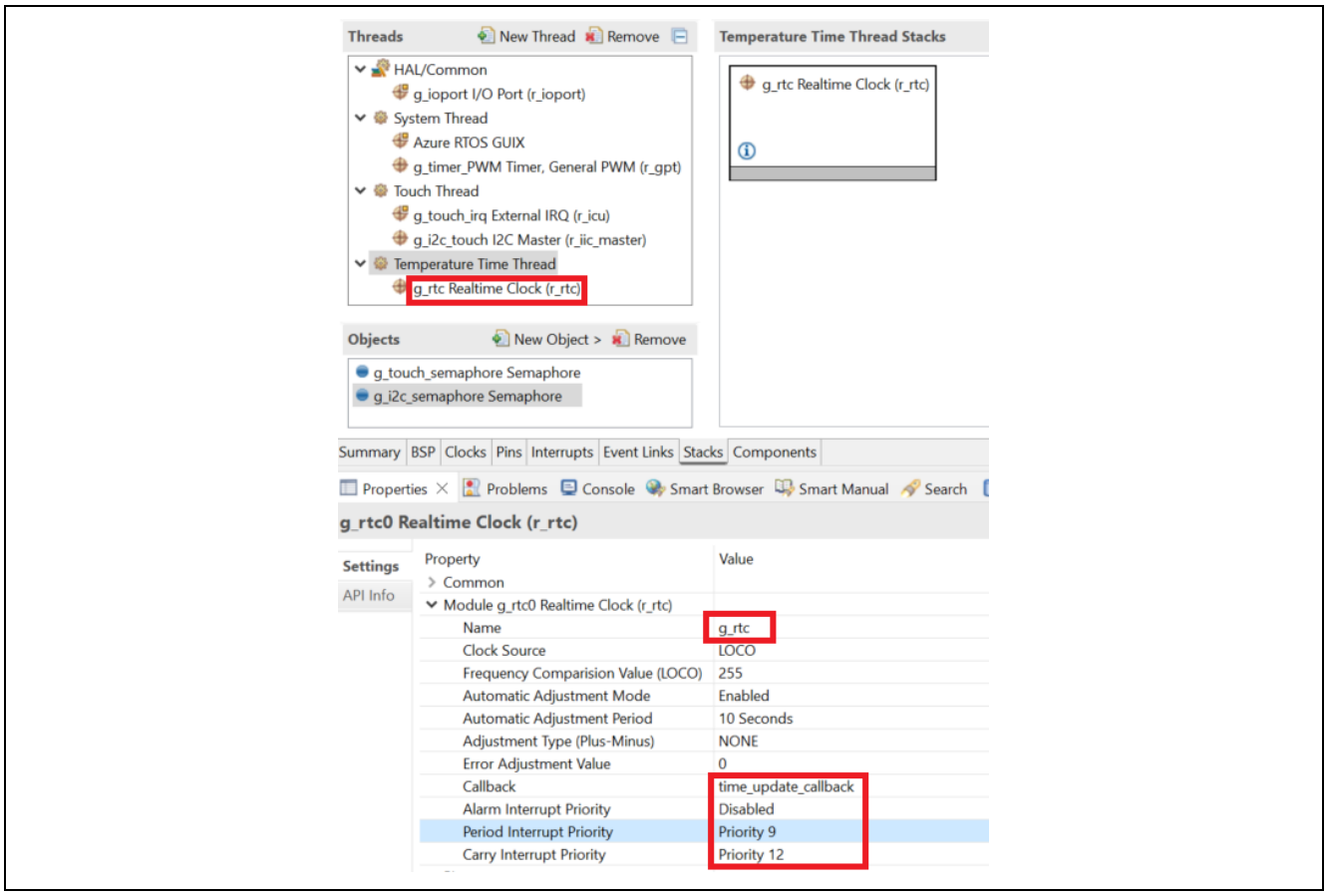

Figure 55. Adding RTC Driver on g_rtc to Temperature Time Thread

3. In project configuration, add **ADC Driver on r_adc** to **System Thread**.

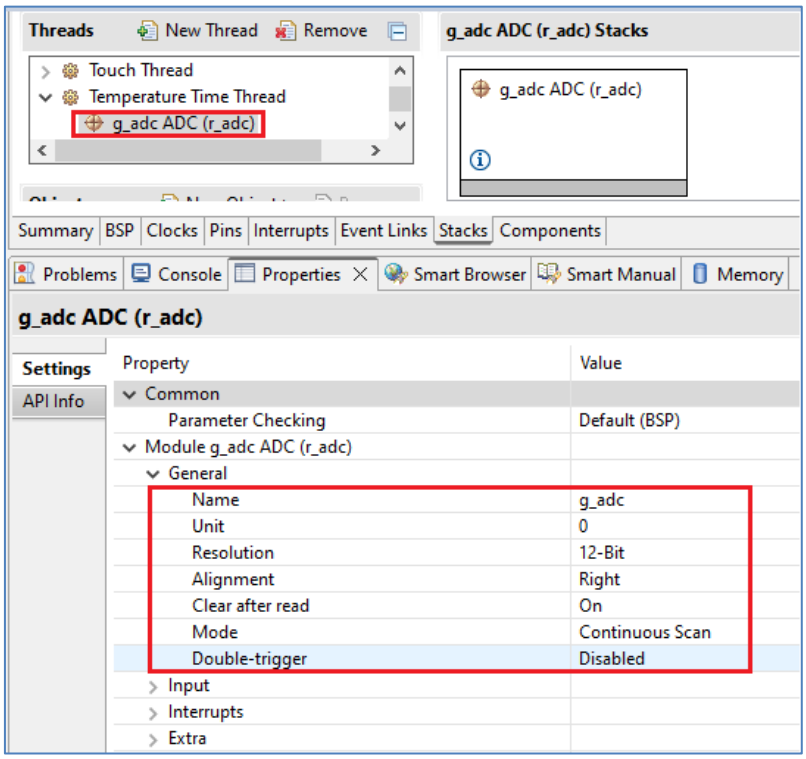

Figure 56. Adding ADC Driver on r_adc to System Thread

4. Select **Temperature Sensor** as input source for g_adc module.

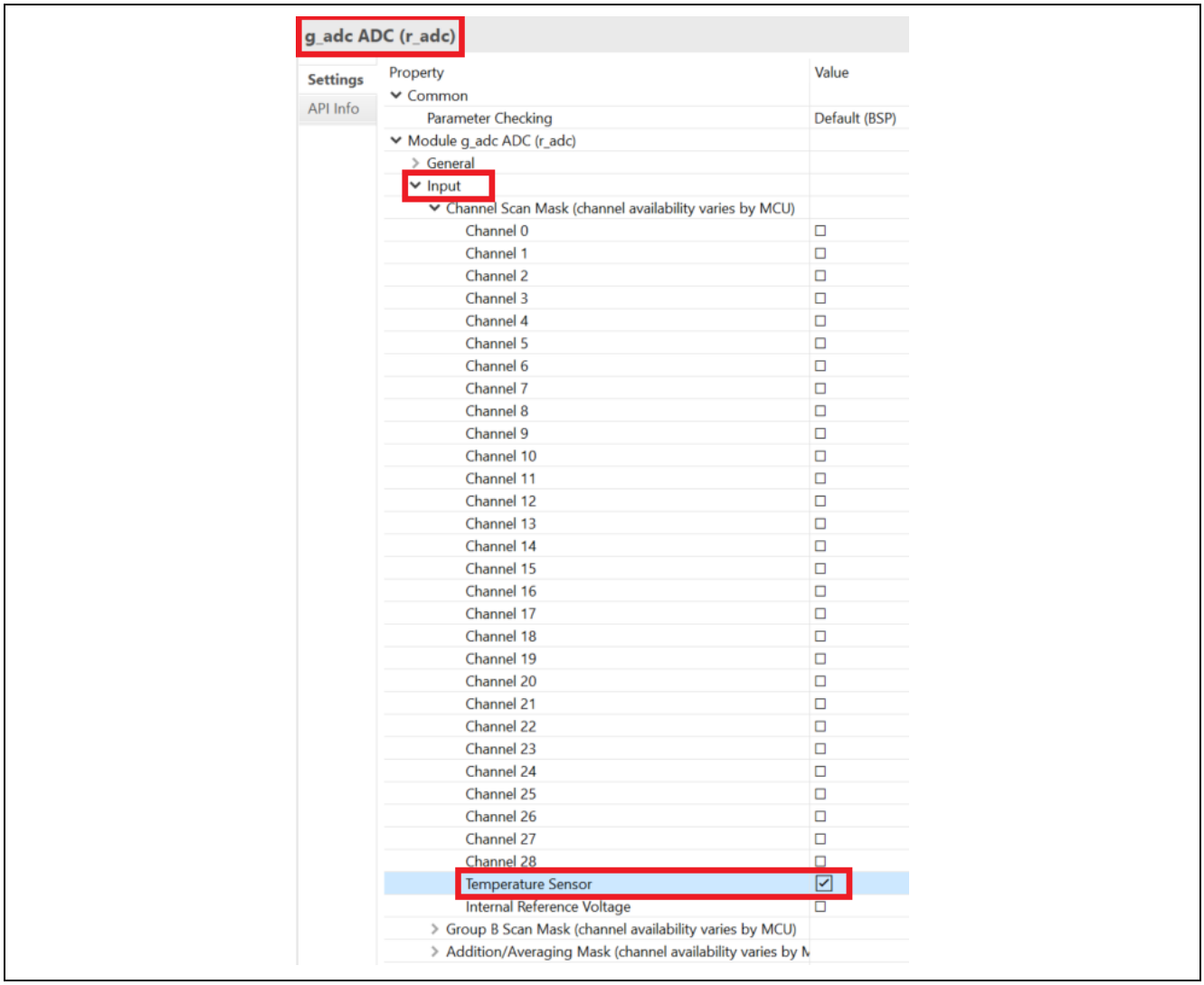

Figure 57. Selecting Temperature Sensor as Input Source for g_adc

5. Create **g_timer_semaphore** with the following settings. We use this semaphore to trigger the date and time update every second.

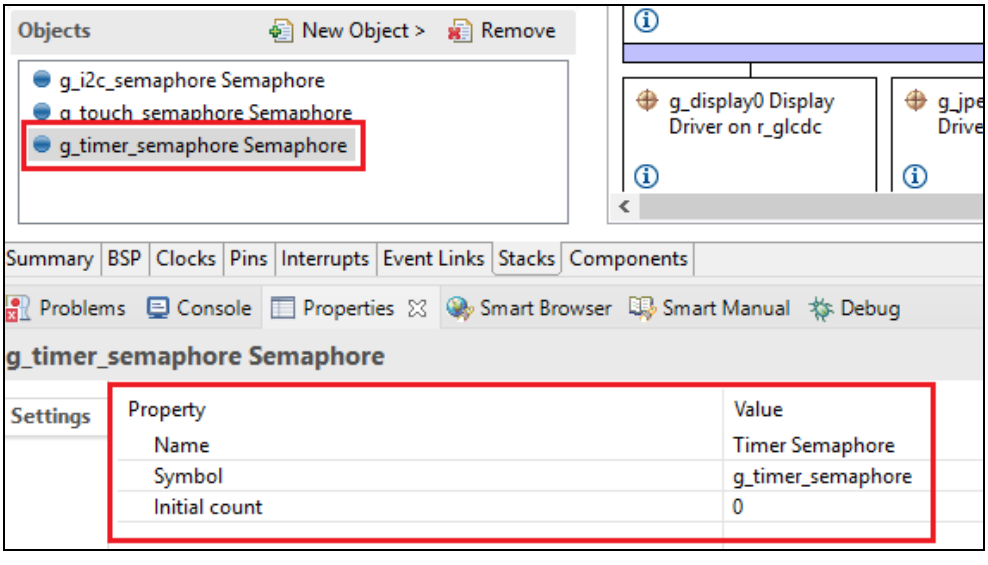

Figure 58. Creating g_timer_semaphore

6. In RA Configurator, click 

to generate project content.
7. Copy and replace the files in **"src"** folder in e^2 studio project with the files in **"6.6"** folder in the Lab folder:
   - hmi_event_handler.c
   - system_thread_entry.c
   - system_time.c
   - system_time.h
   - system_api.h
8. In System Thread, date/time data and temperature data get updated every second. It then sends out events to trigger GUIX updates.

```
while (1)
{
    /* Wait for RTC interrupt. */
    status = tx_semaphore_get(&g_timer_semaphore, TX_WAIT_FOREVER);
    if(TX_SUCCESS != status)
    {
        APP_ERR_TRAP(FSP_ERR_ASSERTION);
    }
    /* Get date, time */
    R_RTC_CalendarTimeGet(&g_rtc_ctrl, &g_gui_state.time);
    /* Send GUIX event to update time */
    send_hmi_message(GXEVENT_MSG_TIME_UPDATE);;

    /* Delay and update temperature*/
    tx_thread_sleep (10);
    /* Read die temperature */
    err = R_ADC_Read(&g_adc_ctrl, ADC_CHANNEL_TEMPERATURE, &adc_temp_data);
    /* Handle error */
    if (FSP_SUCCESS != err)
    {
        APP_ERR_TRAP(err);
    }

    /* Conversion of ADC temperature in celsius */
    g_gui_state.temp_c = ADCTEMP_AS_C(adc_temp_data);

    /* Send GUIX event to update time */
    send_hmi_message(GXEVENT_MSG_UPDATE_TEMPERATURE);
    tx_thread_sleep (1);
}
```

9. The following is an example of handling temperature and time update events in the Main Page screen event handler.

```
UINT mainpage_event(GX_WINDOW *widget, GX_EVENT *event_ptr)
{
    UINT gx_err = GX_SUCCESS;
    switch (event_ptr->gx_event_type)
    {
        case GXEVENT_MSG_UPDATE_TEMPERATURE:
            /** Update temperature text. */
            update_local_temp_string();
            update_text((GX_WIDGET *) widget, ID_TEMP_TEXT, g_local_temp_str);
            update_text((GX_WIDGET *) widget, ID_TEMP_TEXT_2, g_local_temp_str);
            break;
        case GXEVENT_MSG_TIME_UPDATE:
            update_time ((GX_WIDGET *) widget, &g_gui_state);
            update_date((GX_WIDGET *) widget, &g_gui_state);
            break;
        case GX_SIGNAL(ID_THERMO_BUTTON, GX_EVENT_CLICKED):
            /** Shows the thermostat control screen. */
            toggle_screen (p_thermostat_screen, p_mainpage_screen);
            break;
        case GX_SIGNAL(ID_SETTINGS_BUTTON, GX_EVENT_CLICKED):
            /** Shows the settings screen and saves which screen the user is currently viewing. */
            toggle_screen (p_settings_screen, widget);
            break;
        case GX_EVENT_SHOW:
            gx_err = gx_window_event_process(widget, event_ptr);
            if(GX_SUCCESS != gx_err) {
                while(1);
            }
            break;
        default:
            gx_err = gx_window_event_process(widget, event_ptr);
            if(GX_SUCCESS != gx_err) {
                while(1);
            }
            break;
    }
    return gx_err;
}
```

10. **Build, Download, and Run** the e² studio project. You will see time and temperature get updated every second.

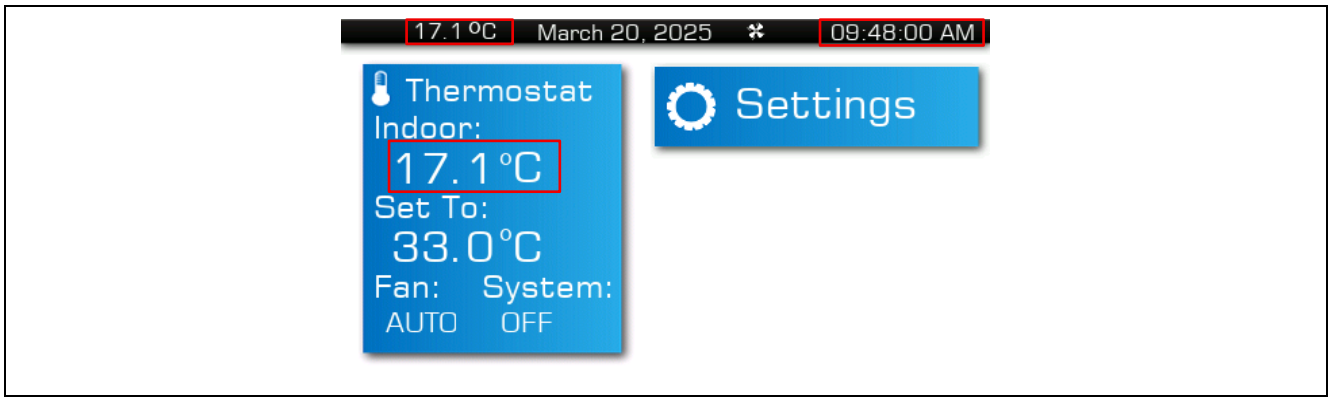

Figure 59. Time, Temperature on Main Page Screen

7. Setting Date/Time in A Full Function Project

7.1 Overview

In this section, you will import and run the complete Thermostat project that enables the settings of date and time. Upon user press date and time buttons on the settings screen, a message will be sent to the system thread to update the date and time, then the system thread will send a GUIX event to trigger time display update on screens.

7.2 Procedural Steps

1. You can try the completed project in "**completed_project**" folder that has a full function Thermostat application. Use "**Rename & Import Existing C/C++ Project into Workspace**" feature of **Import** menu in e² studio to do so since you already had a project with the same in the workspace.

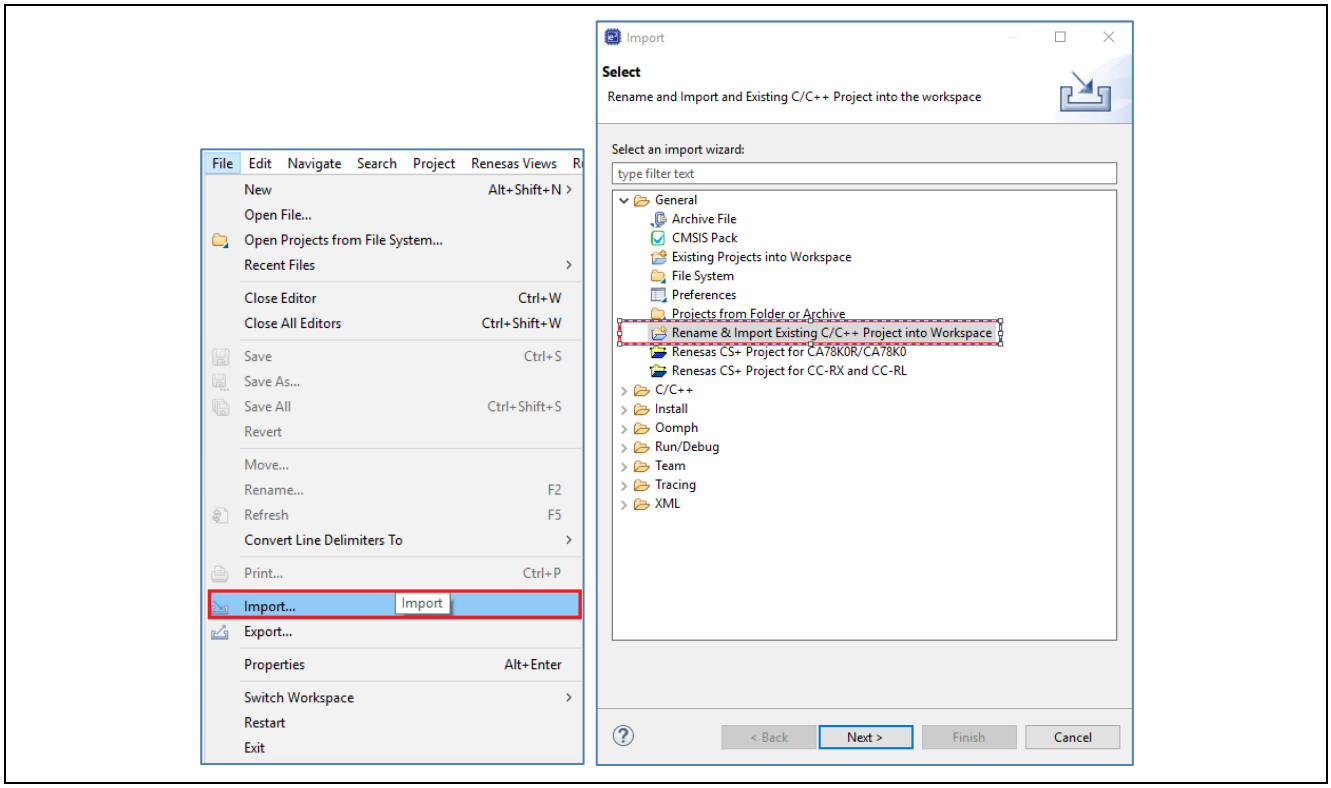

Figure 60. Rename & Import Existing C/C++ Project into Workspace on Import Menu

8. Website and Support

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

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

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Mar.31.23	—	Initial release
1.01	Jul.17.23	—	Updated for FSP v4.4.0.
1.02	Jun.03.24	—	Updated for FSP v5.2.0.
1.03	Jul.08.25	—	Updated for FSP v6.0.0.

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)

   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on

   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.
3. Input of signal during power-off state

   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.
4. Handling of unused pins

   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.
5. Clock signals

   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.
6. Voltage application waveform at input pin

   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).
7. Prohibition of access to reserved addresses

   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products

   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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