Renesas Synergy™ Platform

User Button/CTSU Button Application for S1/S3/S5 Target Board Kits

Introduction

This application note provides a brief introduction to the Capacitive Touch Sensing Unit (CTSU) peripheral on the Synergy Microcontrollers and implementation details of the User Button/CTSU application project provided for the Synergy Target Board Kits.

This application note also provides step-by-step instructions to:

1. Import and build the application project using the Synergy Software Package and e² studio Integrated Solutions Development Environment (ISDE) or IAR Embedded Workbench® for Renesas Synergy™ (IAR EW for Synergy).
2. Download and execute the application on Synergy Target Board Kits.
3. Recreate, generate, and build the application with any modifications that you intend to make in the application provided.

Required Resources

To build and run the application, you need the following:

	Hardware	Software and Development Tools
System	**Host PC** • At least 8 GB of RAM • At least 2 GB of free hard disk space • One USB 2.0 (or later) port	**Operating system** • Windows® 7 (or later)
Embedded	**One of the following Target Board Kits**	
	TB-S3A6, TB-S5D5, TB-S3A3	• e² studio ISDE v5.4.0.023 or later • IAR EW for Synergy v7.71.3 or later • Synergy Software Package (SSP) v1.3.0 or later • Synergy Standalone Configurator (SSC) v5.4.0.023 or later
	TB-S3A1	• e² studio ISDE v6.2 or later • IAR EW for Synergy v8.2 or later • Synergy Software Package (SSP) v1.4.0 or later • Synergy Standalone Configurator (SSC) v6_2_0_R20180102 or later
	TB-S1JA, TB-S5D3	• e² studio ISDE v6.2.1 or later • IAR EW for Synergy v8.23.1 or later • Synergy Software Package (SSP) v1.5.0 or later • Synergy Standalone Configurator (SSC) v6_2_1 _R20180629 or later

Estimated time required is 45 minutes (assuming all the necessary hardware is available, software is installed and ready to use).

Prerequisites and Assumptions

Software and Tool readiness: It is assumed that the Synergy Software Package, J-Link drivers, and development tools are installed on the Windows® PC. The software and tools are bundled and can be downloaded using one of the two platform installers:

A. **e² studio Platform Installer** installs Synergy Software Package and e² studio for Synergy IDE with IAR complier and J-Link USB drivers.
Download from www.renesas.com/synergy/e2studio.

B. **IAR Platform Installer** installs Synergy Software Package and IAR Embedded Workbench® for Renesas Synergy™ IDE with IAR complier and J-Link USB drivers.
Download from www.renesas.com/synergy/ewsynergy.

Synergy Standalone Configurator (SSC) (Optional)
SSC can be used with IAR Embedded Workbench® for Renesas Synergy™ IDE and can be downloaded from www.renesas.com/synergy/ssc.

Tool experience: It is assumed that the user has prior experience working with embedded development environments such as the e² studio Integrated Solutions Development Environment (ISDE).

Subject knowledge: It is assumed that the user has basic knowledge about the Synergy Software Package and principles of capacitive touch operation.

Note: It is recommended that you first refer to the Quick Start Guide for your Target Board Kit to become familiar with the hardware. It is also recommended that you refer to the *Out-of-Box (OoB) Demonstration (Blinky) Application for S1/S3/S5 Target Board Kits* application note to familiarize yourself with Synergy Software Package and using the development tools. Both documents can be downloaded from the Target Board Kit webpage (www.renesas.com/synergy/tb-sXXX).

For example, TB-S5D5 Target Board Kit webpage is at www.renesas.com/synergy/tb-s5d5.

Contents

1. Application Project Overview

This application project introduces the basic usage model of the Capacitive Touch Sensing Unit (CTSU) button functionality on the Renesas Synergy™ Target boards with the following key elements that work together in a typical design: ThreadX® RTOS, CTSU Framework, and the CTSU device driver for the Renesas Synergy Platform.

1.1 CTSU Architecture

The CTSU measures the electrostatic capacitance of a touch sensor. Changes in electrostatic capacitance are determined by software which enables the CTSU to detect whether a finger is in contact with the touch sensor. Electrostatic capacitance is detected by self-capacitance and mutual capacitance methods. This application uses self-capacitance single-scan mode for the slider and button functionality.

Figure 1 shows the CTSU and its control blocks (status, trigger, clock, channel, and port), measurement block, interrupt block, sensor drive pulse generator, along with the I/O registers. With support from the SSP CTSU framework, you do not need to control the module at the block and register level.

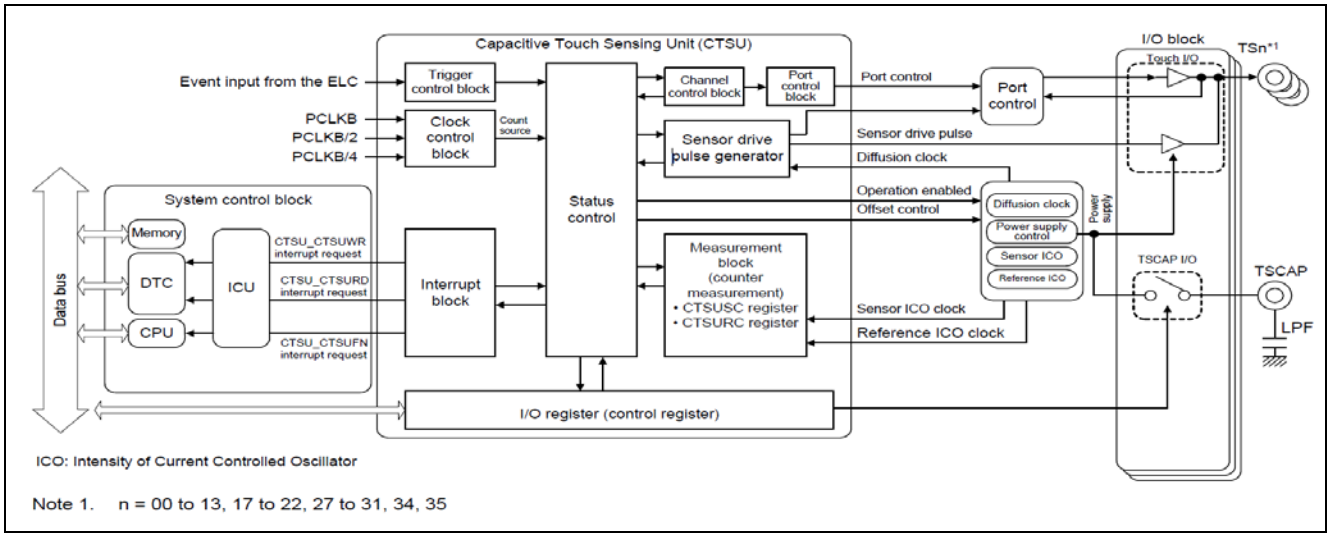

Figure 1. CTSU Block Diagram

1.1.1 Resources Used in the Capacitive Touch SSP Framework

Table 1. Resources Used in the CTSU Framework Interface

Resources	ISDE Tab	Selection
Framework CTSU Driver	Threads	**Framework > Input >Cap Touch Framework on** `sf_touch_ctsu`

Table 2. Additional Resources Used in the CTSU Framework Interface

Resources	ISDE Tab	Selection
Framework CTSU Button Driver	Threads	**Framework > Input >Cap Touch Framework on** `sf_touch_ctsu`
CTSU	Threads	-

Table 3 lists the SSP CTSU button framework events that are generated after touch data processing.

Table 3. CTSU Button States

Name	Description
TOUCH_BUTTON_STATE_RELEASED	Button is in the released state
TOUCH_BUTTON_STATE_PRESSED	Button is in the pressed state
TOUCH_BUTTON_STATE_LONG_HOLD	Button is pressed down for a long time (duration in sf_touch_ctsu_button_config.h)
TOUCH_BUTTON_STATE_STUCK	Button is pressed down for a short time (duration in sf_touch_ctsu_button_config.h)
TOUCH_BUTTON_STATE_INITIAL	Button has been initialized successfully
TOUCH_BUTTON_STATE_CLOSING	Button has been disabled and will no longer generate events
TOUCH_BUTTON_STATE_MULTI_TOUCH	More than one touch element is being touched
TOUCH_BUTTON_STATE_DISABLED	Button is disabled from being updated

1.1.2 CTSU Configuration Data

The sample project includes a set of CTSU configuration data in the src\captouch_configs\ folder. The CTSU configuration data is specific to Renesas Synergy Target Boards. Be sure to copy the \captouch_configs folder to any new application you create for a Renesas Synergy Target Board.

1.2 Application Software Architecture

Figure 2 shows the main software components of the Button/CTSU application:

- Button thread
- LED thread
- CTSU thread

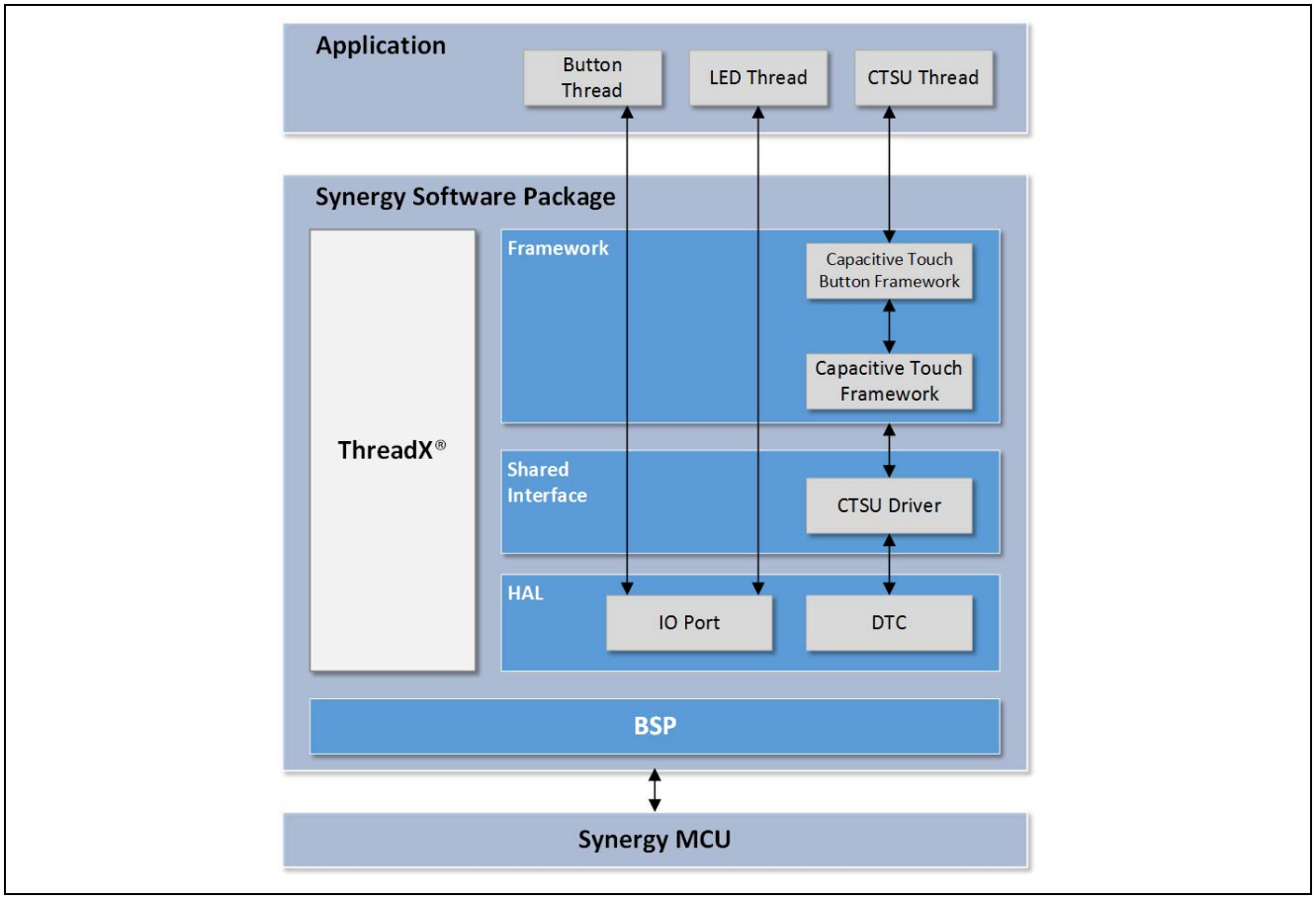

Figure 2. Button/CTSU Application Software Architecture

1.2.1 Button Thread

The button thread processes button events using an interrupt mechanism. When the user presses the button, it generates an interrupt and the `pb_switch_event_callback` is invoked. The button event is then processed, and the button trigger event is sent to **CTSU** and **LED Threads** through the ThreadX® message queue API.

1.2.2 LED Thread

The LED thread receives button events from the CTSU, or button thread, when a user touches/releases the Capacitive Touch button or presses/releases the user button with their finger. Once the button event is received, it toggles the user LED ON/OFF.

1.2.3 CTSU Thread

The example project implements the **slider** and **button callback functions** in the `ctsu_thread_entry.c`, that is in the sample project **`\src`** folder. The Synergy Configurator generates `ctsu_thread_entry.c`. Table 4 lists key functions implemented in `ctsu_thread_entry.c`. With the SSP Button Framework, you create a typical button application using these functions.

Table 4. Functions in ctsu_thread_entry.c

Functions	Description
`g_button_framework_user_callback`	Button touch callback function (defined with the Synergy configurator) implementation.
`CB_self_Button_TS04/CB_self_Button_TS35`	Sub function called from `g_button_framework_user_callback` activated when a Capacitive Touch button is pressed. Implements a response to the events listed in the table.

2. Powering up the Board

Power up the Target Board by connecting it to the USB port on the PC using the USB Type-A to USB Micro-B cable. Connect the Micro USB end of the cable to connector J11 (DEBUG USB located in the DEBUG area) on the Target Board. Connect the other end of the cable to the USB port of a host PC. LED2 (PWR) on the Target Board lights up solid green indicating that the Target Board is powered on.

Note: The Target Board uses SEGGER J-Link® On-board (OB) as the debug interface. Make sure that the J-Link drivers are installed on your computer by checking for them in the Windows Device Manager. If J-Link drivers are not installed on the PC, LED2 (DEBUG) blinks orange. If J-Link drivers are installed on the PC and detected by the Target Board, the LED2 (DEBUG) blinks orange with a very small duty cycle that is barely noticeable.

3. Importing, Building, and Downloading the Application Project

Refer to the *SSP Import Guide* (r11an0023eu0121-synergy-ssp-import-guide.pdf) for instructions on importing the bundled application project into e^2 studio ISDE or IAR EW, to build and run the project. The SSP Import Guide is included in the zipped folder along with this application note.

Note: You need to select the **Button_CTSU_AP_TBxxx Debug GDB Hardware Debugging** configuration based on the kit for debugging.

4. Running the Application Project

Once the application is running, press the S1 user button or place your finger on the CTSU BTN on the Target Board. Every time the S1 button is pressed/released or the CTSU BTN is touched/released, the LED1 toggles ON/OFF.

5. Recreating, Generating, and Building the Application Project

You can make modifications to the source code of the provided application project if needed. The procedures for recreating, generating, and building the project using the e^2 studio ISDE are explained in the following sections.

5.1 Recreating the Application Project

Step 1. Creating a new project with RTOS included.

1. Create a new Synergy project by clicking **File->New-> Synergy C/C++ Project**.
2. For IAR EW for Synergy, click **Renesas Synergy -> New Synergy Project**. Select the name as described in the figure that follows and select the license file and SSC version.
3. Choose **Renesas Synergy C Executable Project** and click **Next** (see Figure 3).

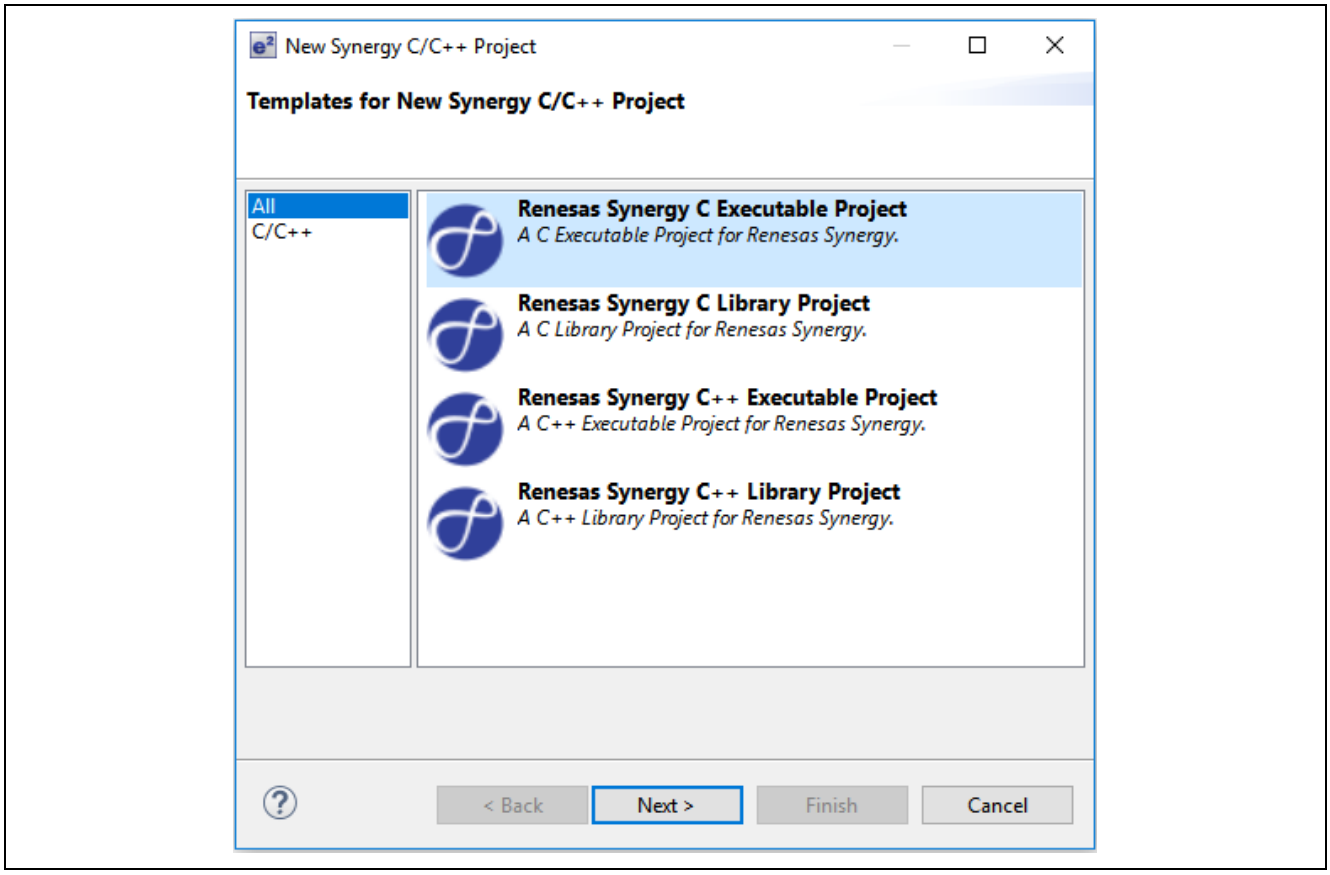

Figure 3. Choose “Renesas Synergy C Executable Project”

For TB-S1JA Boards using e² studio, in order to build the project, you need to install the IAR compiler. You can install this as a plugin as referenced by the document, “Installing IAR Compiler into e² studio,” available at www.renesas.com. Follow the instructions and select the IAR Toolchain for ARM –(8.x), as shown in the following graphic.

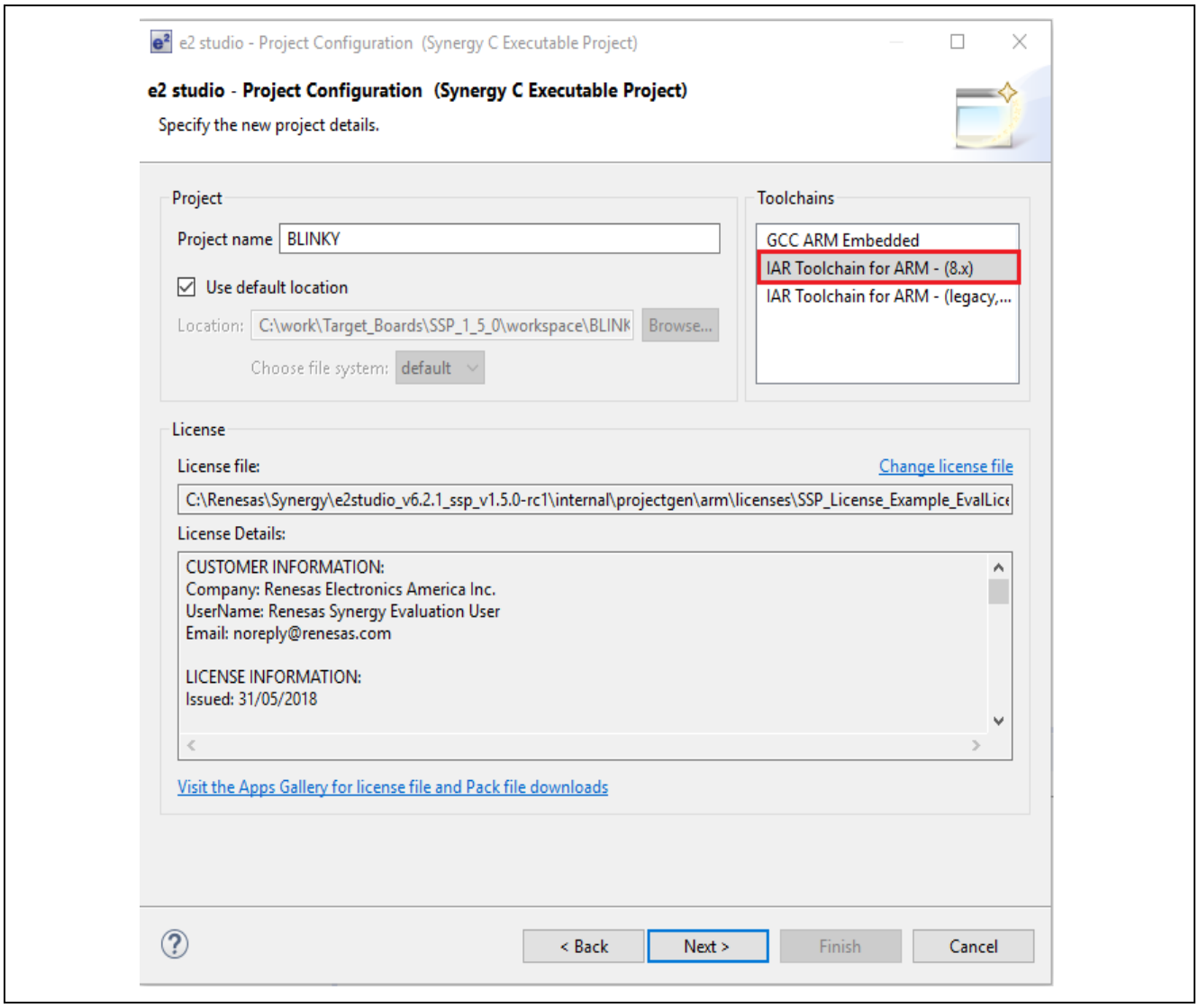

Figure 4. e² studio IAR Compiler Selection Window

4. Enter the project name and then set up the **Synergy license** file.
5. Toolchain: GCC ARM Embedded (for TB-S3A1, TB-S3A3, TB-S3A6, TB-S5D3, TB-S5D kits).
6. Toolchain: IAR Toolchain for ARM (8.x) (for TB-S1JA kit).
7. Choose the target board (for example, in case of TB-S3A6, choose **S3A6 TB** (see Figure 5)).
8. Choose **SSP version** (In case of SSP 1.3.0, choose **1.3.0** (see Figure 5)).

9. Choose the **BSP** option in the project template selection window.

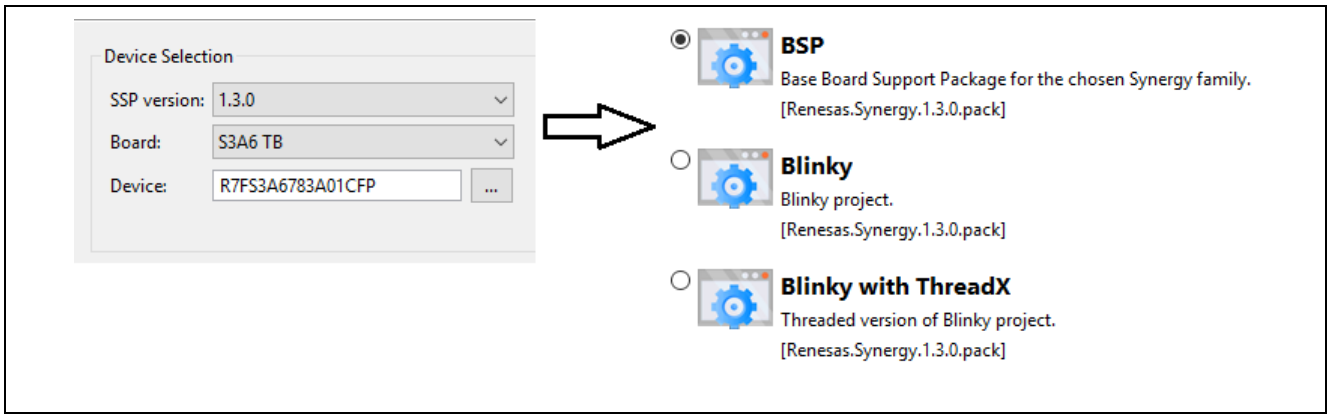

Figure 5. Synergy Project Creation

Step 2. Creating the CTSU thread.

1. Under the **Thread** tab, click the **New Thread** button to create a new thread.
2. Set the property of the new thread (see Figure 6).

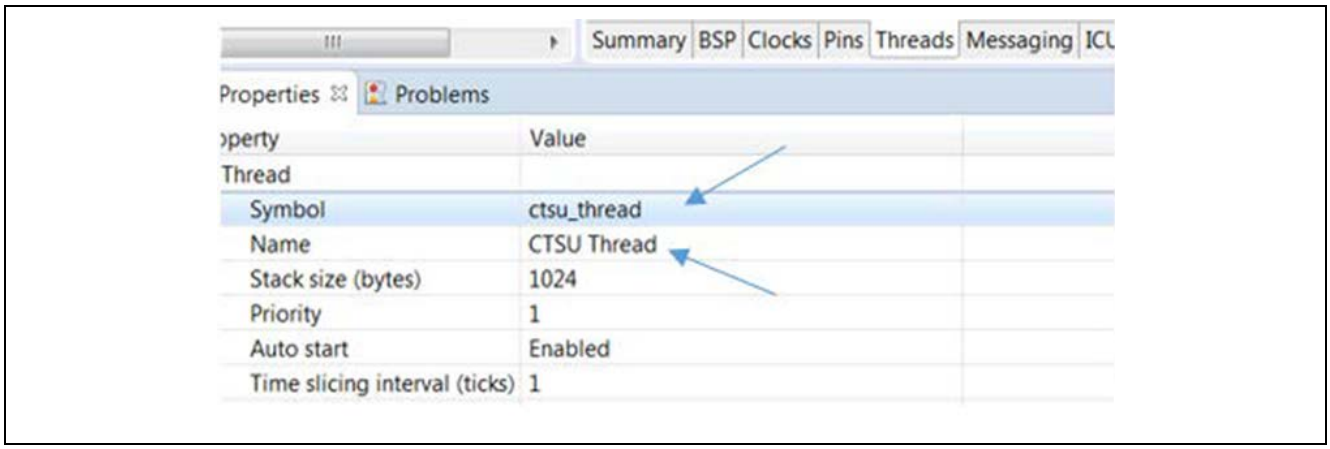

Figure 6. CTSU Thread Properties

Step 3. Adding the CTSU button framework.

1. In the **CTSU Thread Stacks** window, click the **New Stack** button to add the Cap Touch Button Framework.
2. Click on the box `g_sf_touch_button0` Cap Touch Button Framework on `sf_touch_ctsu_button` and change the **Number of Buttons** to 1.

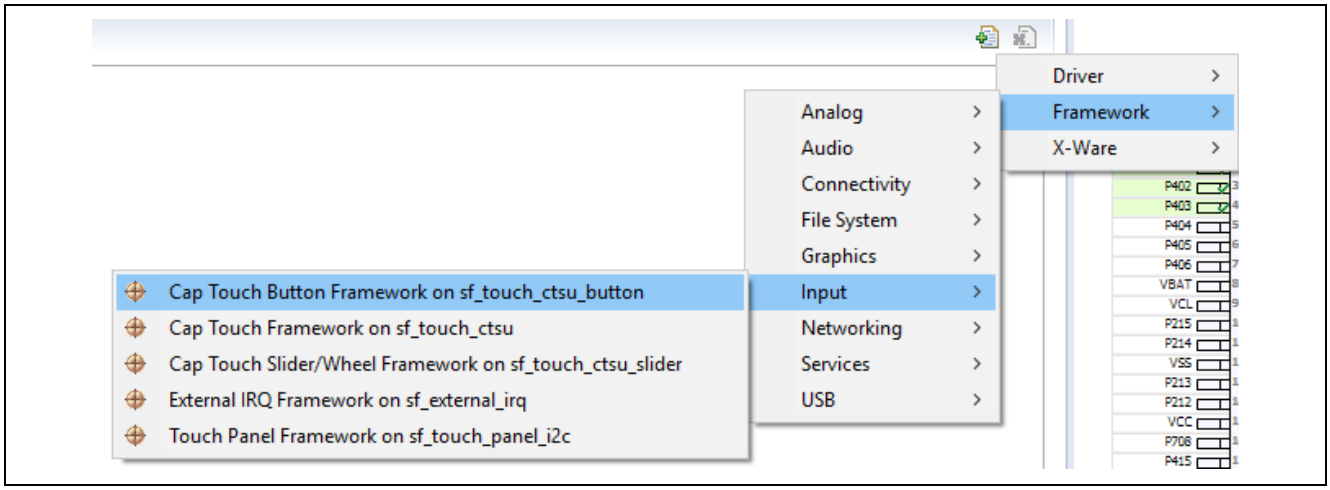

Figure 7. Adding CTSU Button Framework

3. Click on the `g_ctsu0` CTSU Driver on the `r_ctsu` properties and update the **Write Interrupt Priority**, **Read Interrupt Priority**, **End Interrupt Priority to Priority 1**, and the **CTSU configuration** used.

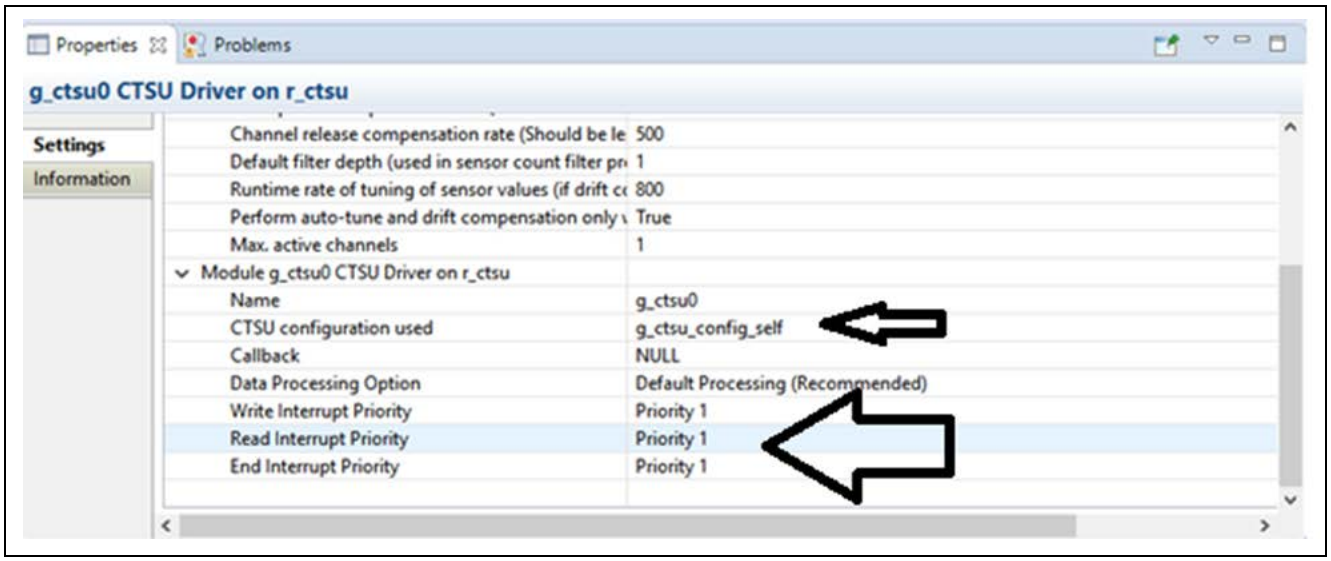

Figure 8. CTSU Driver Properties

Step 4. Creating the button processing thread.

1. Go to the new **Thread** tab and click the **New Thread** button plus (+) sign to create the `button_processing_thread`.
2. In the **Property** of this new thread, update the **Symbol Name** to `button_processing_thread` (see Figure 9).
3. Include the **External IRQ Driver on `r_icu`** module by clicking the **New Stack** button (+) sign in the **HAL/Common Stacks** window and go to **Driver** > **Input** > **External IRQ Driver on** r_icu (see Figure 9).

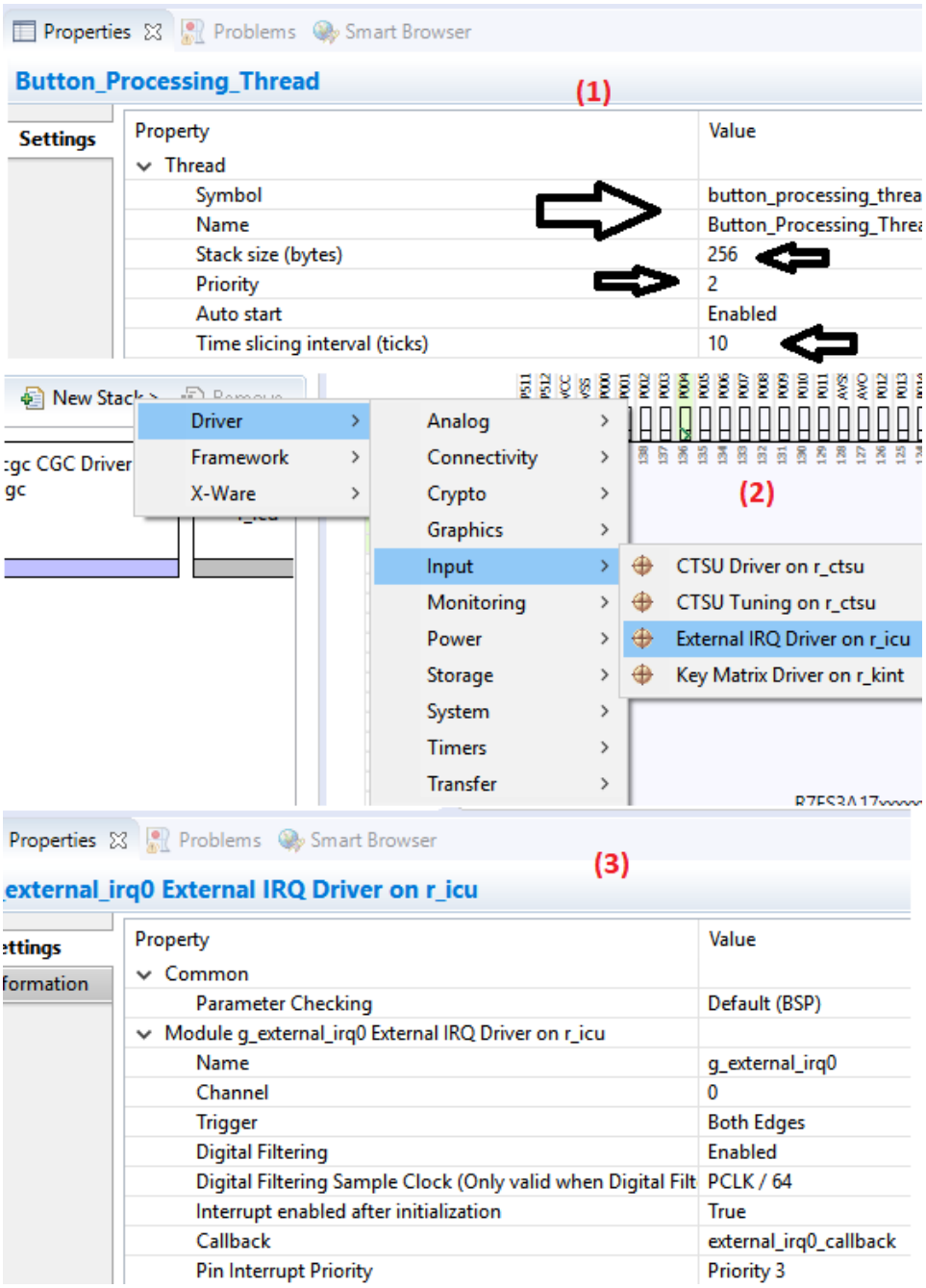

Figure 9. Adding External IRQ Driver Module

4. Click the **New Object** button in the **Button_Processing_Thread Objects** window. Create the thread object (see Figure 10).

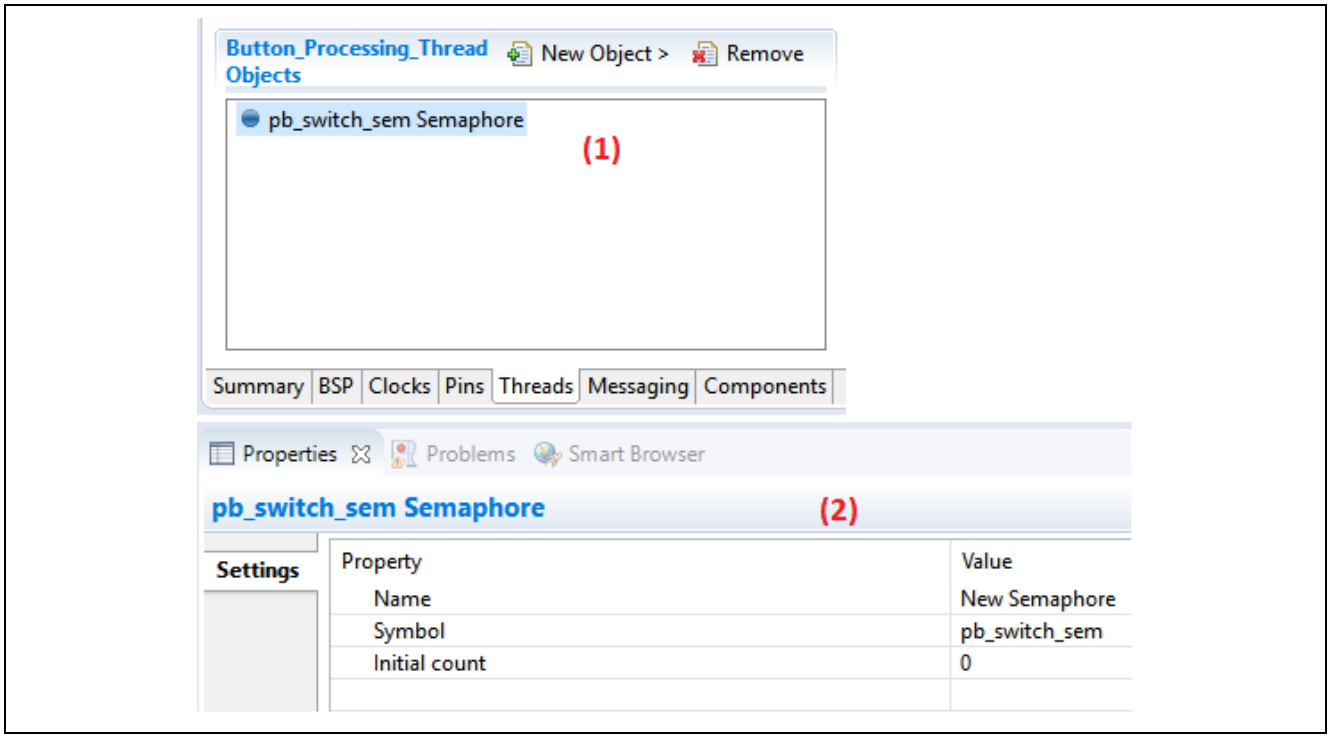

Figure 10. Button Thread Object Properties

Step 5. Creating an LED thread.

1. Go to **LED Thread** tab, click the **New Thread** button to create a new thread.
2. Set the **Property** of this new thread (see Figure 11).

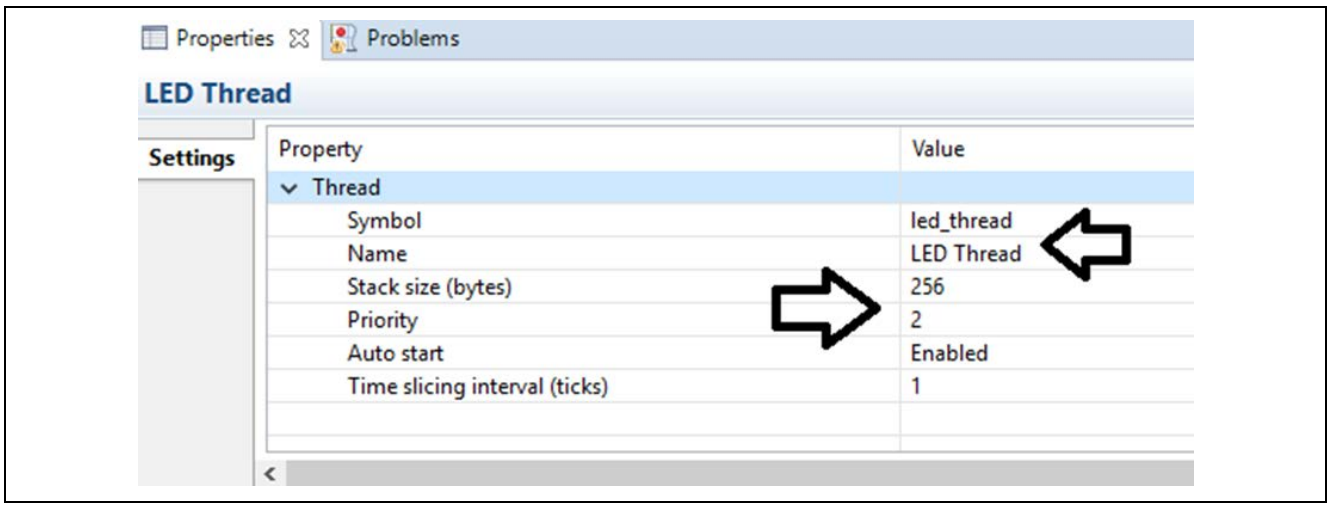

Figure 11. LED Thread Properties

3. Go to **LED Thread Objects** tab. Click the **New Object** button to create the queue for this thread and set its **Properties** (see Figure 12).

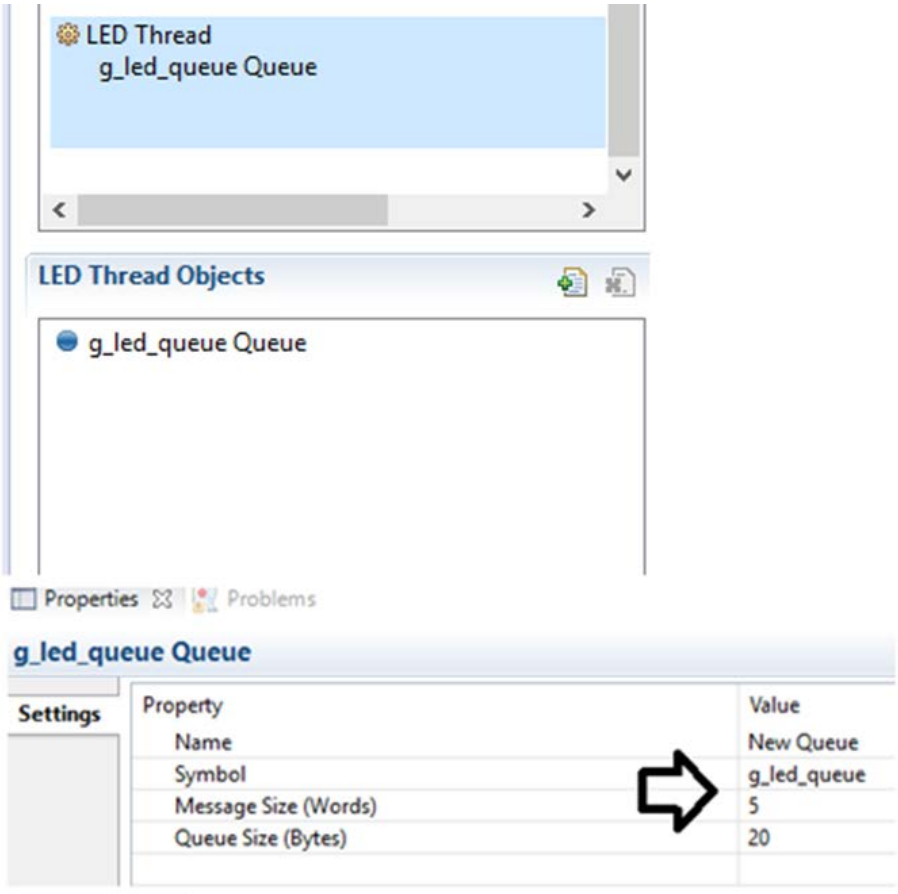

Figure 12. LED Thread Object Properties

5.2 Generating the Project Content

Click the **Generate Project Content** button. The project files are generated with the configuration options you selected. Your new project is now created, configured, and ready to build.

Figure 13. Generate Project Content Button

5.3 Setting up the Application Project Files

1. After the e² studio ISDE generates the application project files for the configuration chosen, go to the **Project Explorer** window under your project, open the `src` folder to view the files generated for this application project.

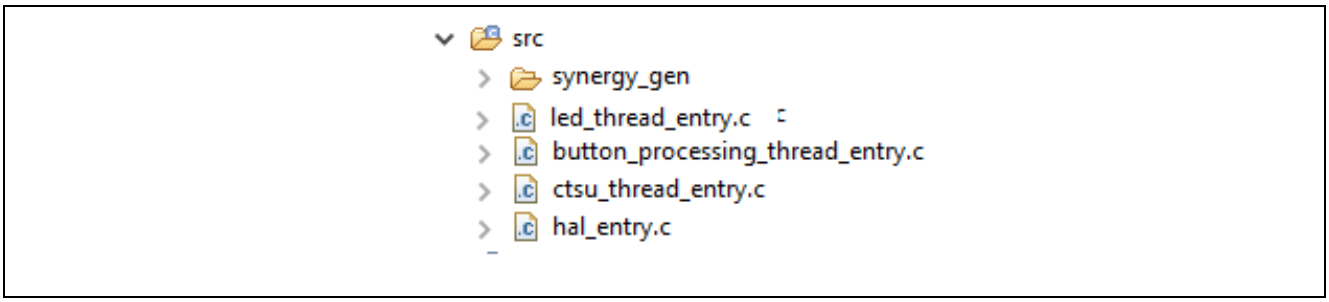

Figure 14. Generated Files

These files are place holders for adding your application code.

2. You can either write your own application functions for these threads or copy the existing Button/CTSU Button application project source files to recreate this demonstration.

- LED_thread_entry.c
- Button_processing_thread_entry.c
- Common.h
- Board configuration file (for example, Config_s3a6.h)
- Ctsu_button.h
- Ctsu_thread_entry.c
- Push_button_switch.h
- Util.h
- Captouch_configs (folder)

5.4 Building the Project

Build the application project by clicking the hammer  icon as shown in the following graphic.

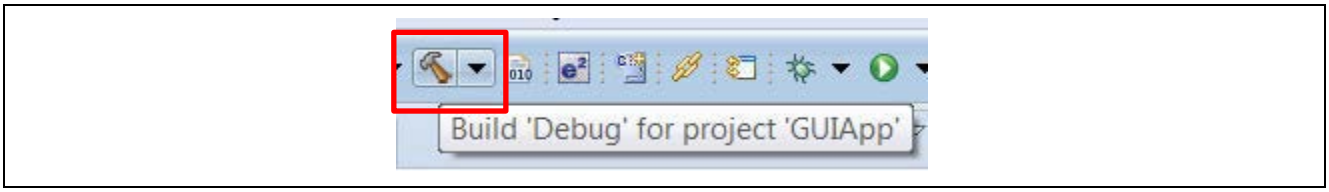

Figure 15. Build Button

5.5 Running the Application

Run the project and verify the functionality as per the modifications performed in the source code of the provided application project.

6. Next Steps

1. **Learn more about the Target Board Kit.**
   Visit the Target Board Kit webpage (www.renesas.com/synergy/tb-sXXX) to learn more about the kit and download documentation, schematics, design files, and so forth.
   For example, the TB-S5D5 Target Board Kit webpage is at www.renesas.com/synergy/tb-s5d5.
2. **Explore existing application projects for the Target Board Kit.**
   Renesas provides several application projects to demonstrate different capabilities of the S1/S3/S5 MCU Series. These application projects can also serve as a good starting point for you to develop your custom application. Application projects available for the Target Board Kit are listed on the Target Board Kit webpage (www.renesas.com/synergy/tb-sXXX).
   For example, TB-S5D5 Target Board Kit webpage is at www.renesas.com/synergy/tb-s5d5.
3. **Learn more about the Synergy Platform.**
   Visit the following URLs to learn about the following elements of the Synergy Platform and download different components:
   - Synergy Software: www.renesas.com/synergy/software
   - Synergy Hardware: www.renesas.com/synergy/hardware
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7. Limitations and Assumptions

None

Website and Support

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

Synergy Software	www.renesas.com/synergy/software
Synergy Software Package	www.renesas.com/synergy/ssp
Software add-ons	www.renesas.com/synergy/addons
Software glossary	www.renesas.com/synergy/softwareglossary
Development tools	www.renesas.com/synergy/tools
Synergy Hardware	www.renesas.com/synergy/hardware
Microcontrollers	www.renesas.com/synergy/mcus
MCU glossary	www.renesas.com/synergy/mcuglossary
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Synergy Solutions Gallery	www.renesas.com/synergy/solutionsgallery
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Forums	www.renesas.com/synergy/forum
Training	www.renesas.com/synergy/training
Videos	www.renesas.com/synergy/videos
Chat and web ticket	www.renesas.com/synergy/resourcelibrary

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Aug.28.17	-	Initial release
1.01	Oct.16.17	1 7	Updated kits and software versions. Modified steps to create a button processing thread.
1.02	Oct.26.17	-	Updated to SSP 1.3.2
1.03	Feb.23.18	-	Added support for TB-S3A1
1.04	Sep.17.18	-	Added support for TB-S1JA and TB-S5D3
1.05	Feb.08.19	14	Updated Website and Support URLs

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