Renesas RA Family

# QE for Capacitive Touch usage for IAR EWARM

## Introduction

This document will demonstrate how to generate QE code for Capacitive Touch in e² studio and copy the QE code to IAR EW for ARM using Renesas RA Microcontrollers.

## Target Device

Capacitive Touch Evaluation System for RA2L1 (RSSK RA2L1)

## Operating Environment

| | |
|---|---|
| **IDE** | IAR Embedded Workbench for Arm version 9.20.2 or later<br>e² studio version 2021-10 is used for Capacitive Touch tuning and code generation |
| **Configuration Tool** | RA Smart Configurator (RA SC) v2021-10 and FSP v3.5.0 |
| **Toolchains** | GNU Arm Embedded Toolchain: 10.3-2021.10<br>(GNU ARM Embedded 10.3.1.20210824) |
| **QE** | Renesas QE for Capacitive Touch v3.0.1 |

**Note: Please download and install tools from the following URL in advance.**

- Renesas QE download site:
  https://www.renesas.com/software-tool/qe-tools-particular-applications
- FSP with e² studio installer download site:
  https://github.com/renesas/fsp/releases
- IAR EW for ARM download site:
  https://www.iar.com/products/architectures/arm/iar-embedded-workbench-for-arm

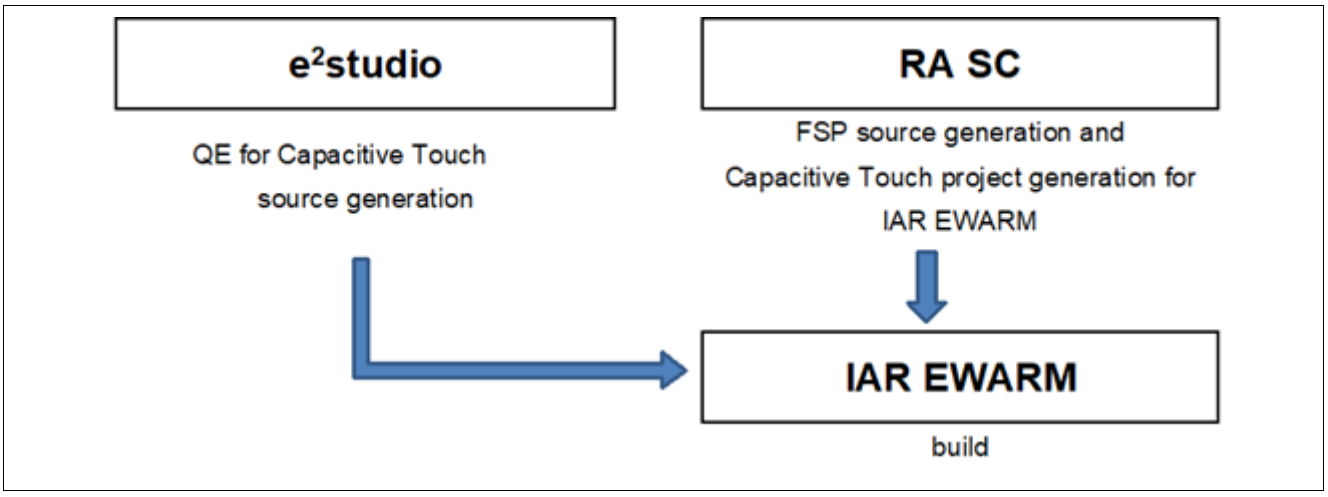



**Figure 1. Configuration diagram when using QE for Capacitive Touch with IAR EWARM**

## Contents

# 1. Creating a project in e² studio

A project generation wizard is available in e² studio to generate an RA project with a project name and the associated device and board, including board-level drivers.

Start the e² studio application and choose a workspace folder in the Workspace Launcher. To create a new RA project, follow these steps:

1. Select F**ile > New > C/C++ Project**.
2. Select the **Renesas RA: Renesas RA C/C++ Project** template. Click **Next** to continue.

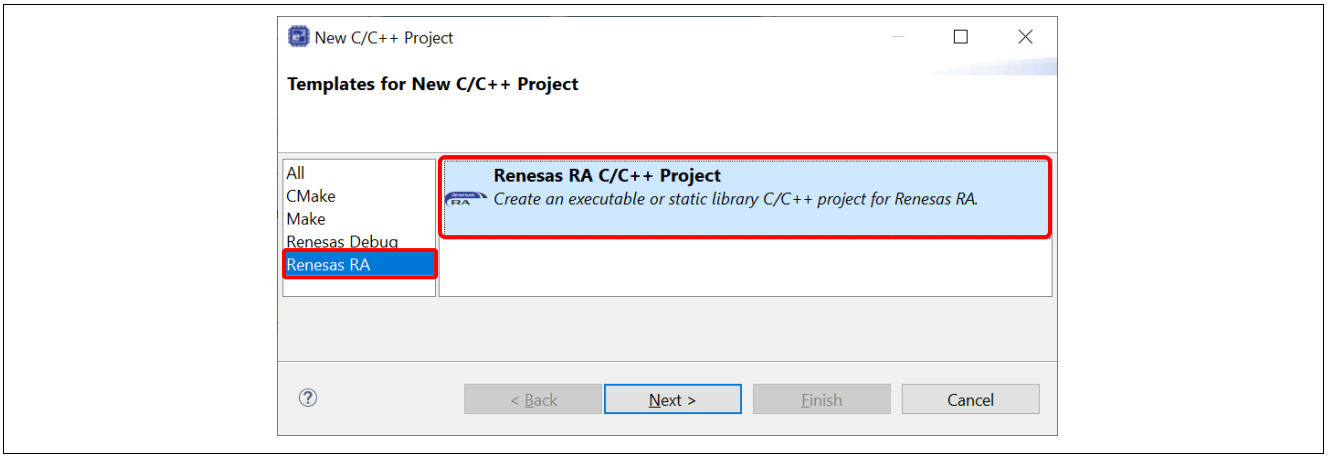



**Figure 2. Template Selection**

3. In the next dialog box, enter a project name and click **Next**.

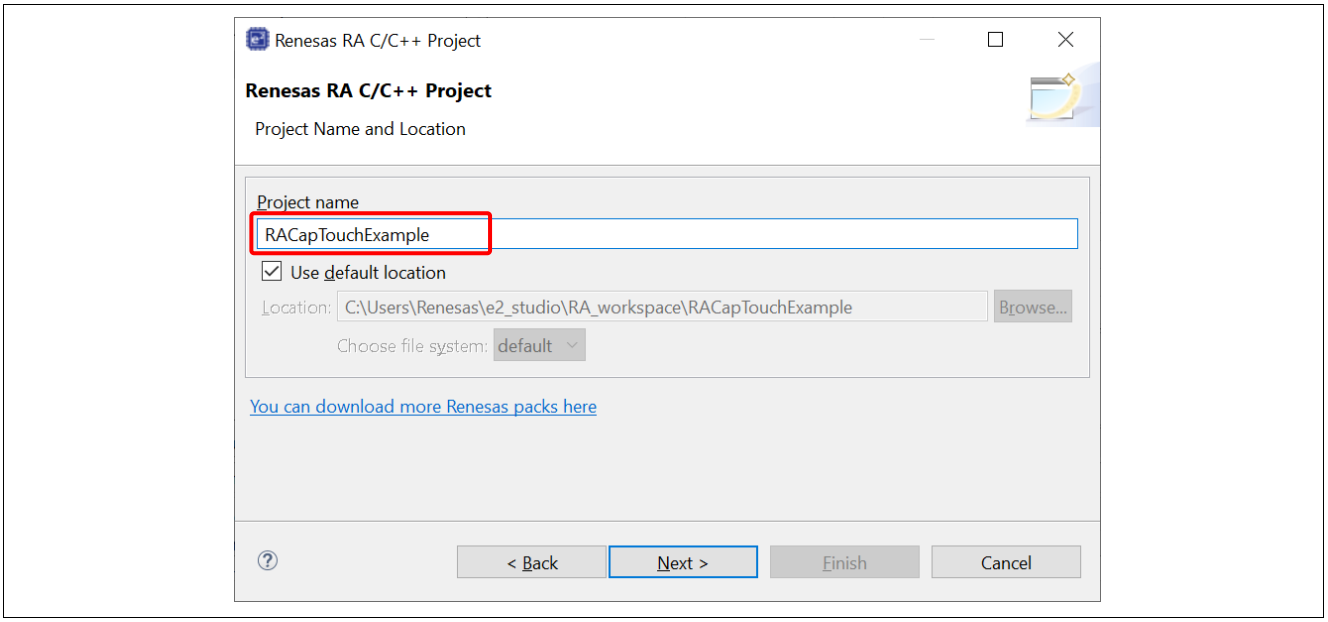



**Figure 3. Project Name and Location**

4. In the device selection dialog, enter device and tool information:
   - FSP version: **3.5.0**
   - Board: **RSSK-RA2L1**
   - Device: Auto selected
   - Language: **C**
   - Toolchain version: Latest GNU Arm Embedded Toolchain approved for use with Renesas RA. (for example, GCC ARM Embedded 10.3.1.20210824)
   - Debugger: **J-Link ARM**
   - Click **Next** to continue.

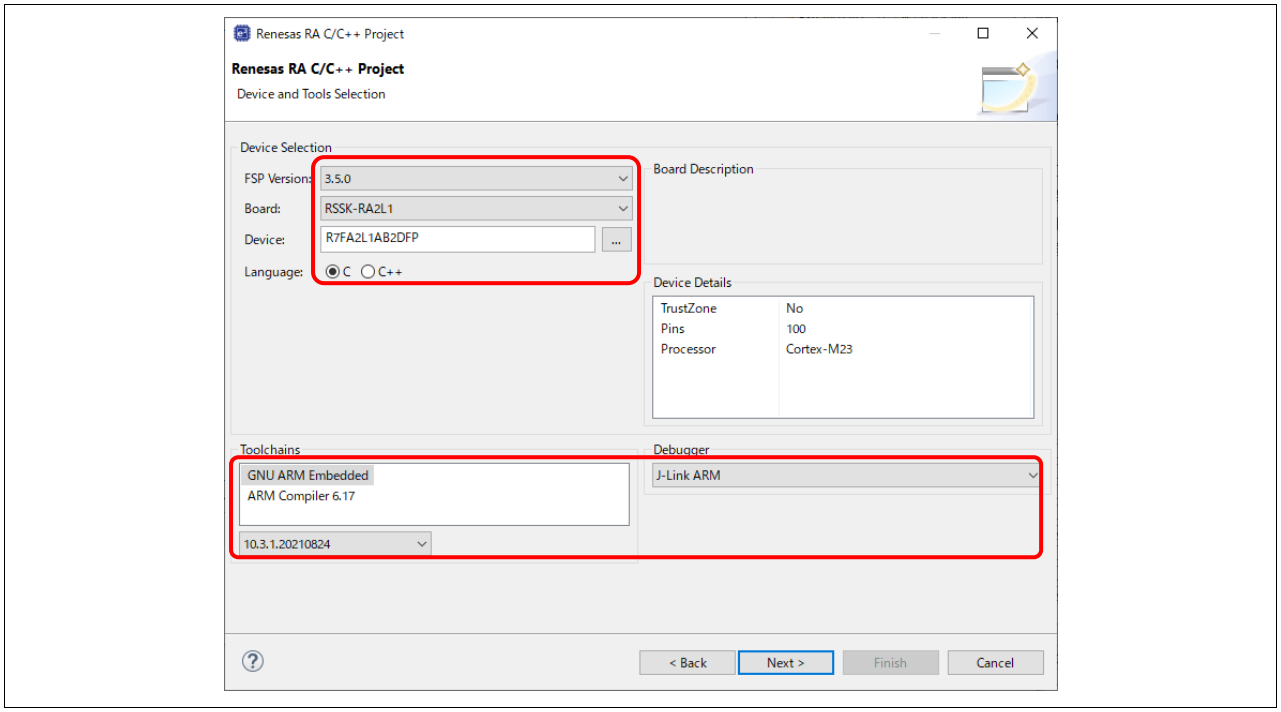



**Figure 4. Create New Project for RSSK-RA2L1**

5. Build Artifact Selection: **Executable**
   RTOS Selection: **No RTOS**

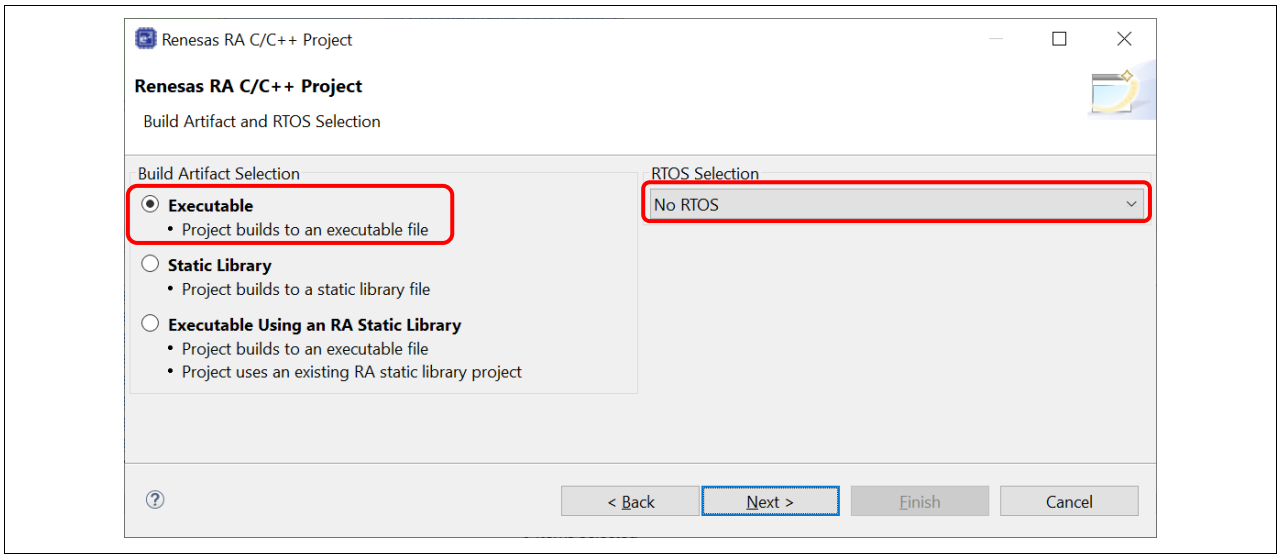



**Figure 5. Build Artifact and RTOS Selection**

6. In the project template dialog, select **Bare Metal - Minimal** and click **Finish.**

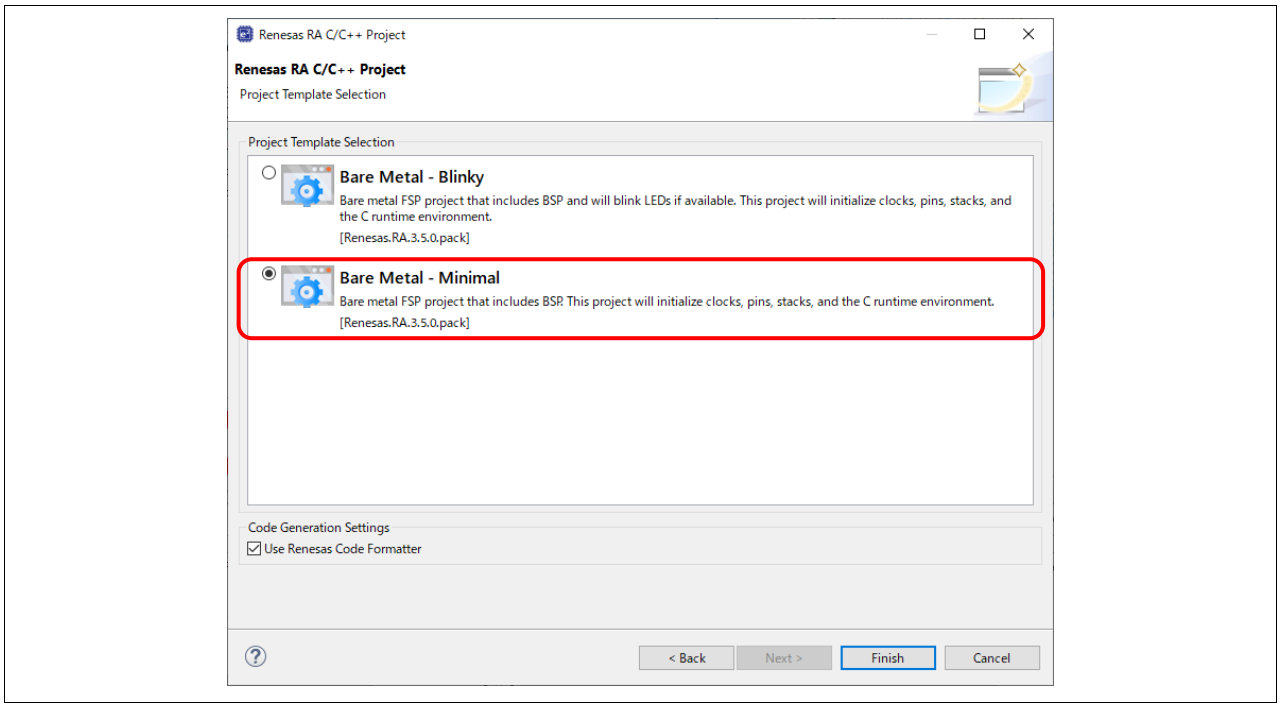



**Figure 6. Project Template Selection**

7. Once complete, e$^2$ studio creates a new project with the “FSP Configuration” perspective open and ready for project configuration.

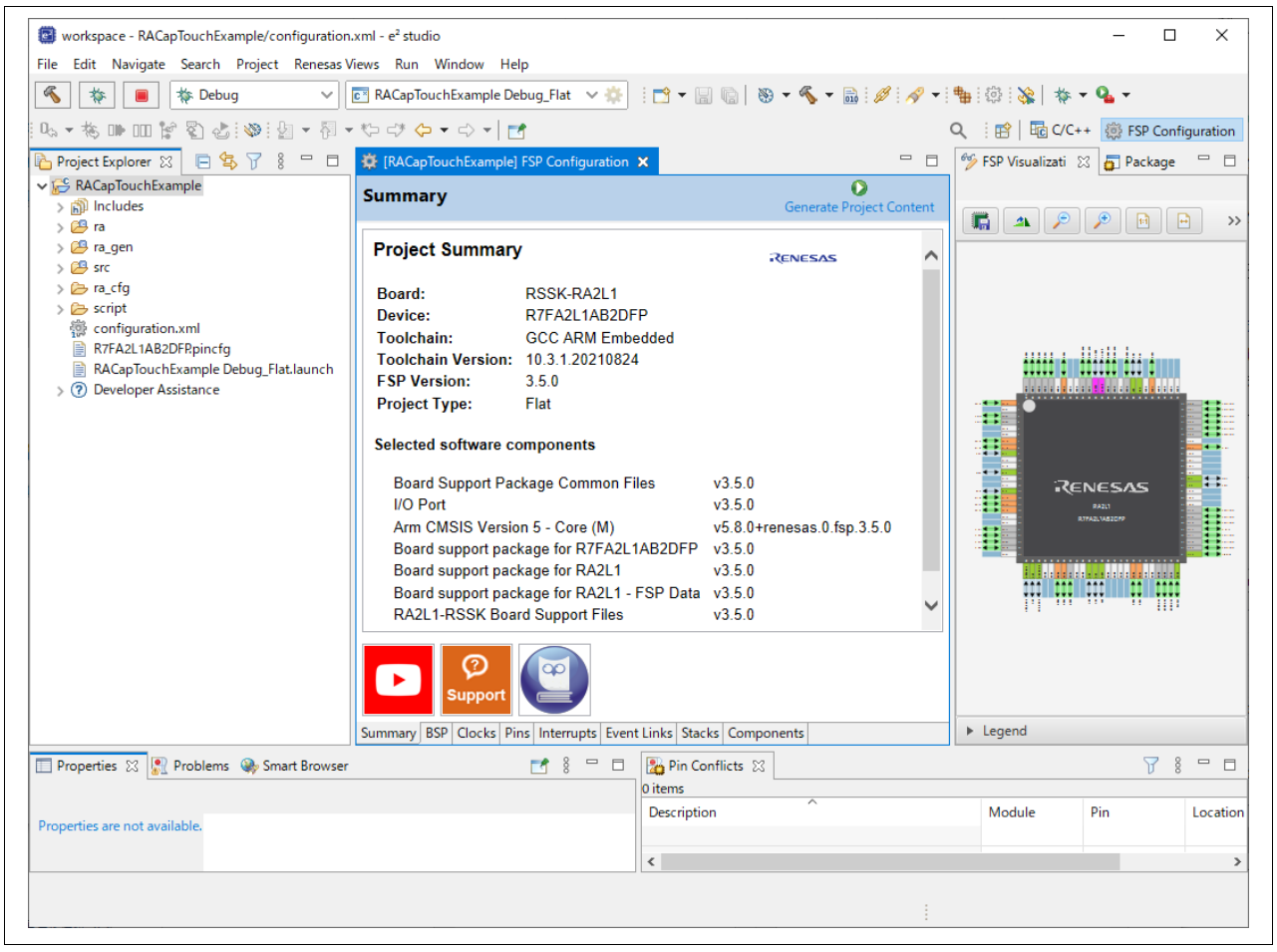



**Figure 7. New Project for RSSK RA2L1**

## 2. Create Capacitive Touch Configuration in e² studio

1. If you have not installed the **QE for Capacitive Touch**, select **Renesas Views > Renesas Software Installer** from the menu of e² studio to install it**.**
2. In the **Renesas Software Installer** dialog box, select **Renesas QE**, then click **Next**.
3. Select **QE for Capacitive Touch** and click **Finish** to install it.

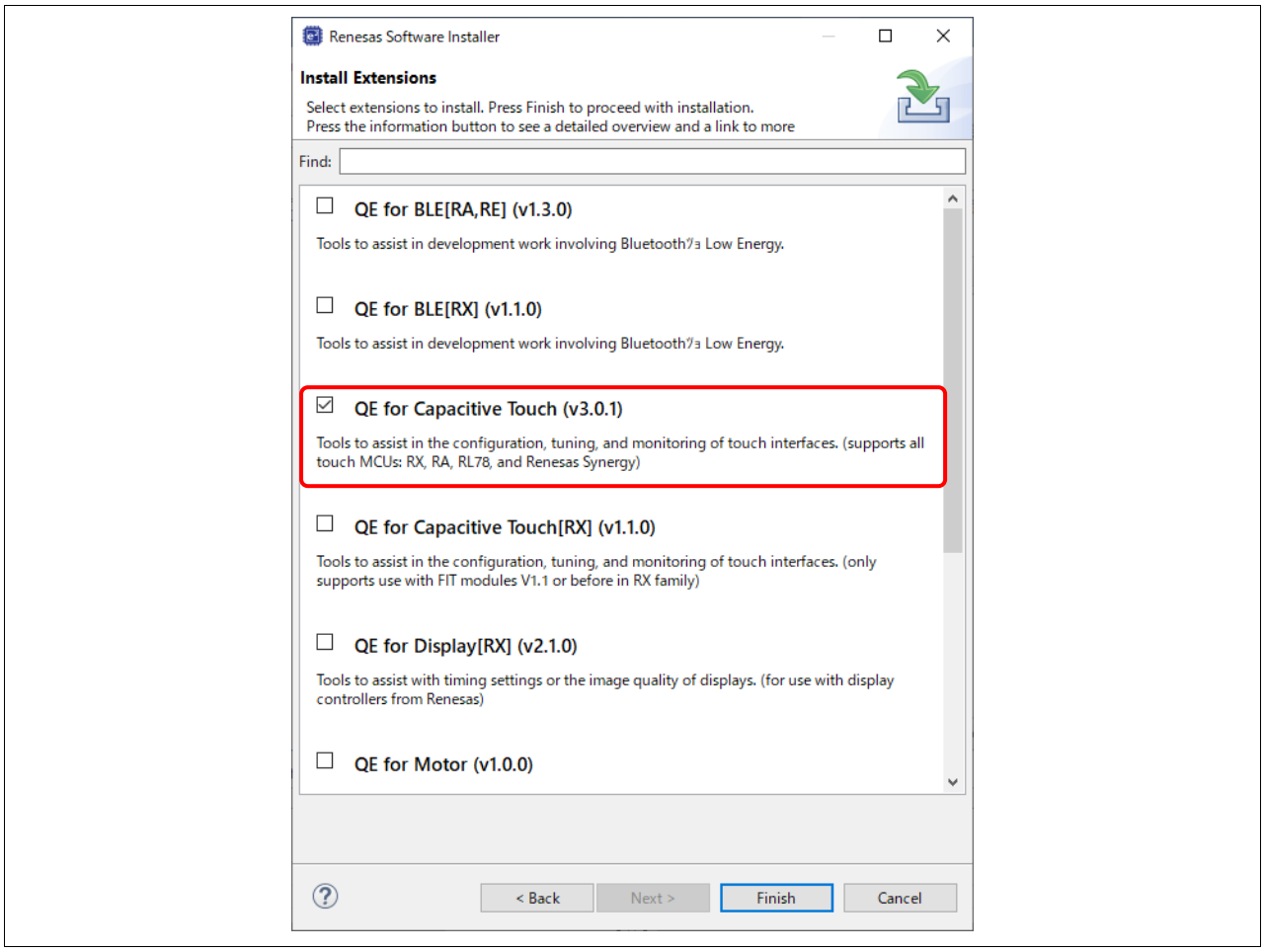



**Figure 8. Install QE for Capacitive Touch**

4. From the menu of e² studio, select **Renesas Views > Renesas QE > CapTouch Main (QE)** to open the main perspective for configuring capacitive touch to the project.

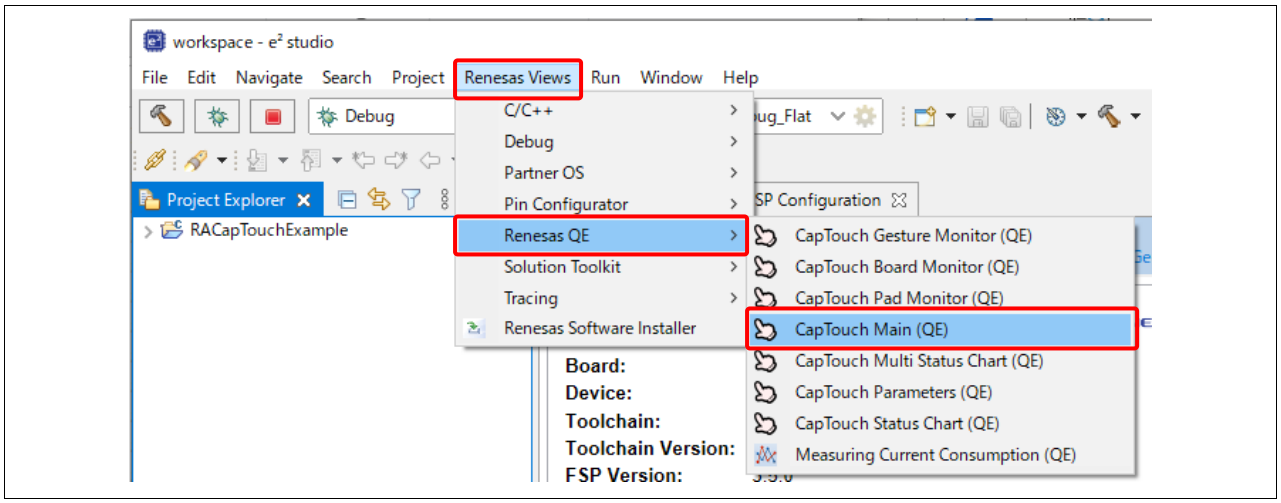



**Figure 9. Open CapTouch Main (QE)**

5. In the **CapTouch Main (QE)** pane, select the project to configure the Touch interface for by using the pull-down tab and selecting the **RACapTouchExample** project as shown below.

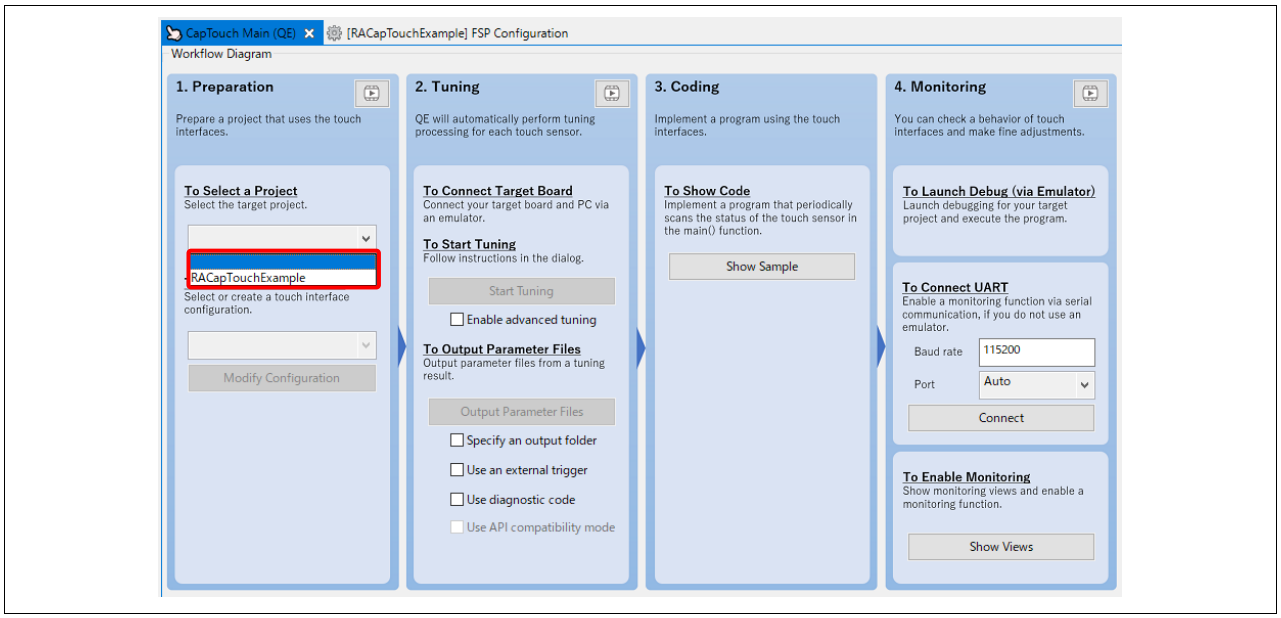



**Figure 10. Select Project**

6. Create a new Touch configuration by using the lower pull-down and selecting **Create a new configuration.**

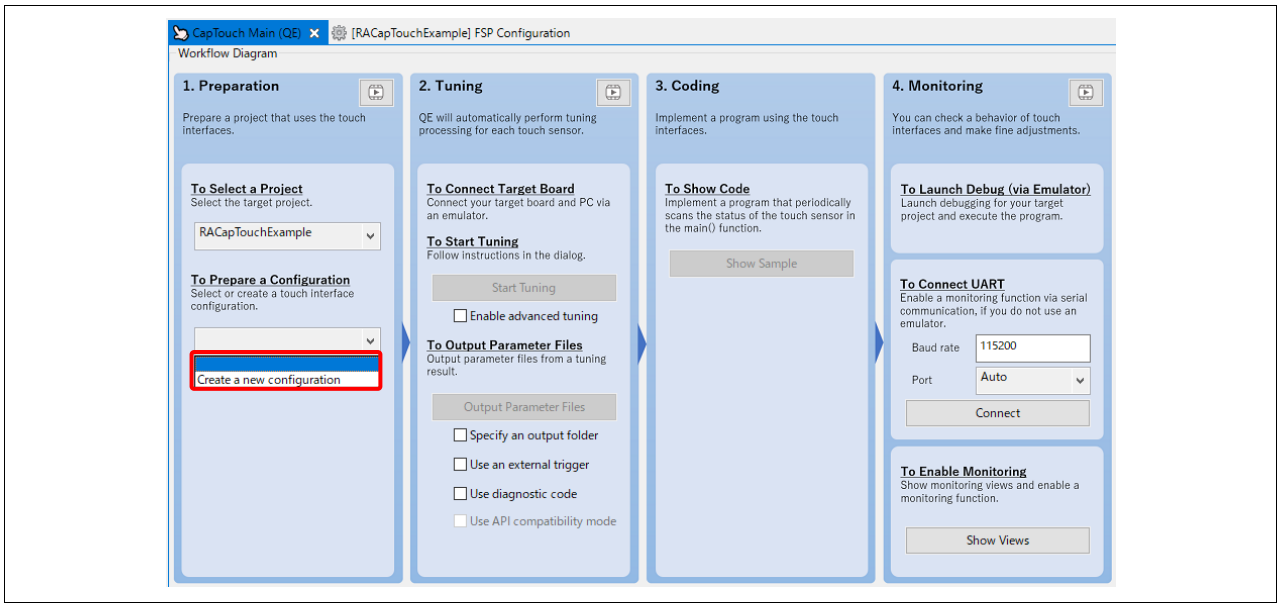



**Figure 11. Create New Touch Configuration**

7. A new menu window will open with the default blank canvas for creating the Touch Interface.

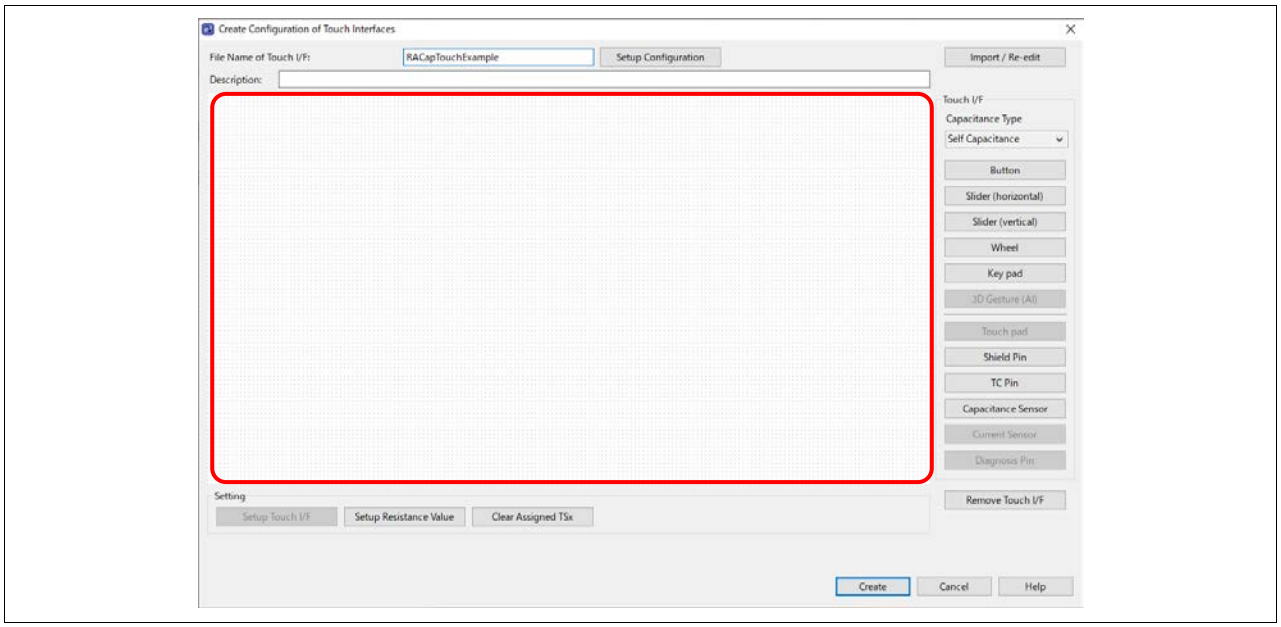



**Figure 12. Blank Canvas**

8. Add 3 buttons to the canvas by:
   a. Selecting the **Button** menu item from the right-hand side and moving the mouse onto the canvas.
   b. Click the left-hand mouse button to drop the button icon. Do this three times to add three buttons.
   c. Press the **ESC** key to exit once the three buttons are added.

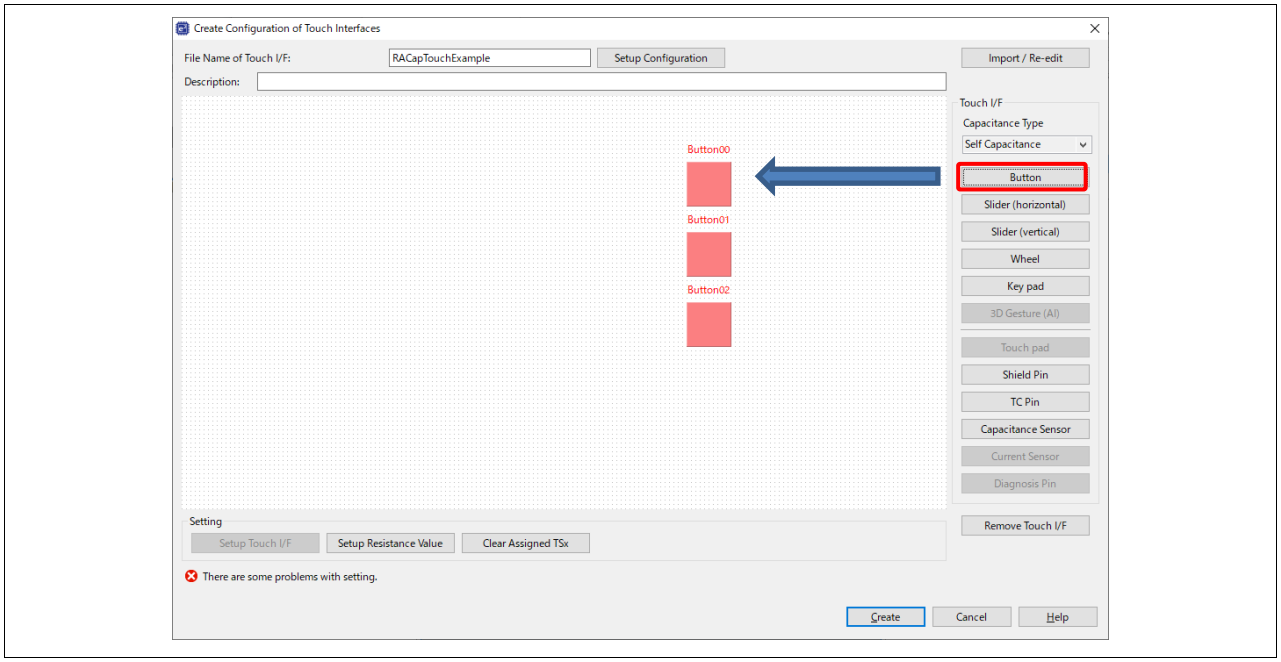



**Figure 13. Create New Touch Button**

9. Assign Touch Sensor to buttons:
   a. Double click on **Button00** and a dialog box will appear. Rename it to TS_B1. Using the pull-down and select **TS11** as the MCU sensor to assign to this button.
   b. Double click on **Button01** and a dialog box will appear. Rename it to TS_B2. Using the pull-down and select **TS10** as the MCU sensor to assign to this button.
   c. Double click on **Button02** and a dialog box will appear. Rename it to TS_B3. Using the pull-down and select **TS09** as the MCU sensor to assign to this button.

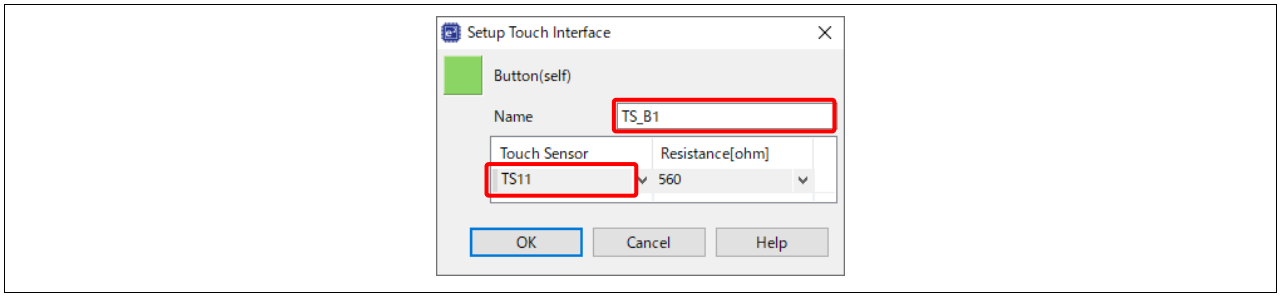



**Figure 14. Assign Touch Sensor to Button**

10. Select the **Wheel** menu item from the right-hand side and add it onto the canvas. Press **ESC** once completed.
11. Double click on **Wheel00** and a dialog box will appear. Using the pull-down and select **TS21, TS18, TS32, TS23** as the MCU sensors to assign to this wheel.

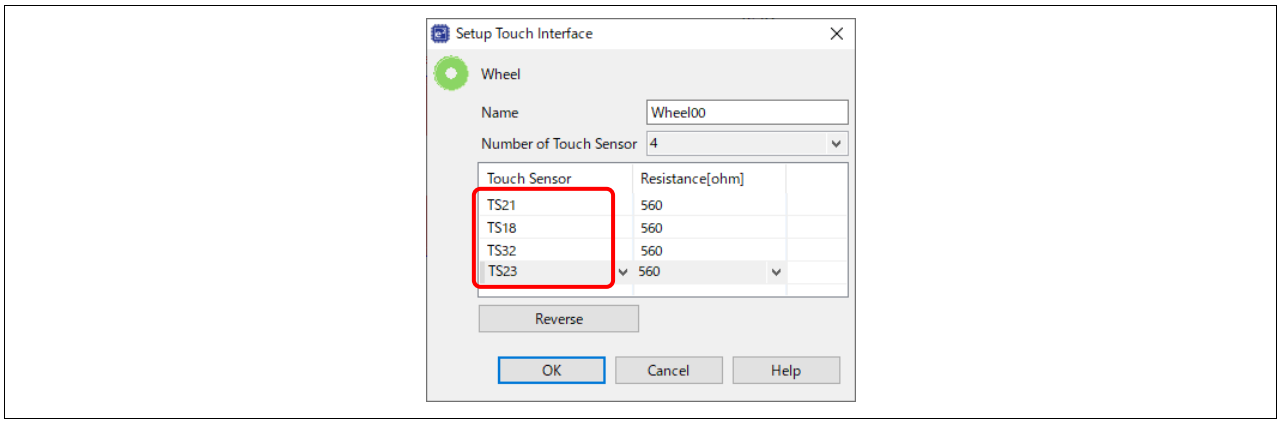



**Figure 15. Assign Touch Sensor to Wheel**

12. Selecting the **Slider (horizontal)** menu item from the right-hand side and add it onto the canvas. Press **ESC** once completed.
13. Double click on **Slider00** and a dialog box will appear.
   a. Select **Number of Touch Sensor**: **5**.
   b. Use the pull-down and select **TS06**, **TS07**, **TS05**, **TS02**, and **TS04** as the MCU sensors to assign to this slider.

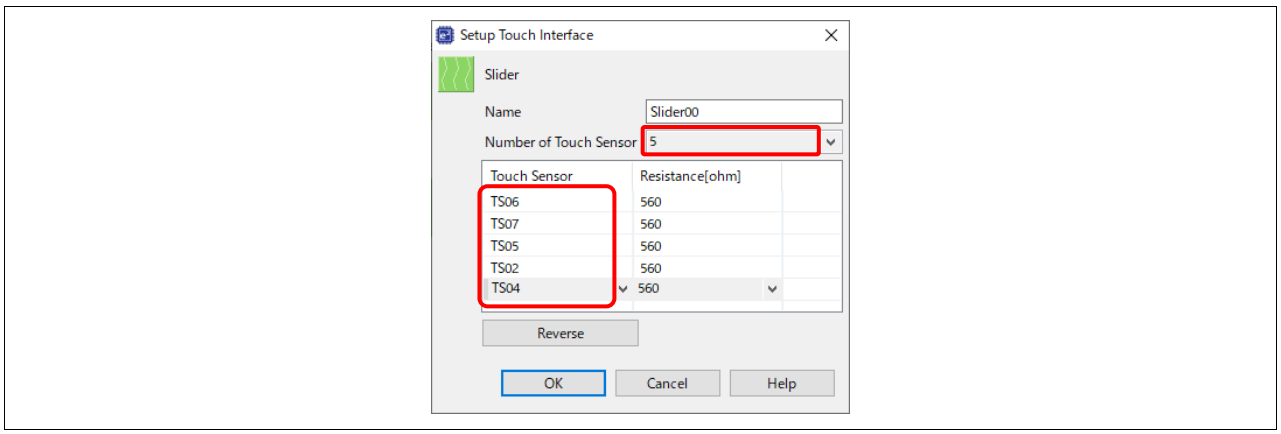



**Figure 16. Assign Touch Sensor to Slider**

14. Select the **Shield Pin** menu item from the right-hand side.
    a. Add the 1st shield to the canvas to cover the three buttons.
    b. Add the 2nd shield to the canvas to cover the wheel.
    c. Add the 3rd shield to the canvas to cover the slider.
    d. Press **ESC** once completed.
15. Assign Touch Sensor to shields.
    a. Double click on **Shield00** and a dialog box will appear. Assign **TS00** to this shield.
    b. Double click on **Shield01** and a dialog box will appear. Assign **TS14** to this shield.
    c. Double click on **Shield02** and a dialog box will appear. Assign **TS08** to this shield.
16. This completes the addition of the Touch interface like shown below **Figure 17**.

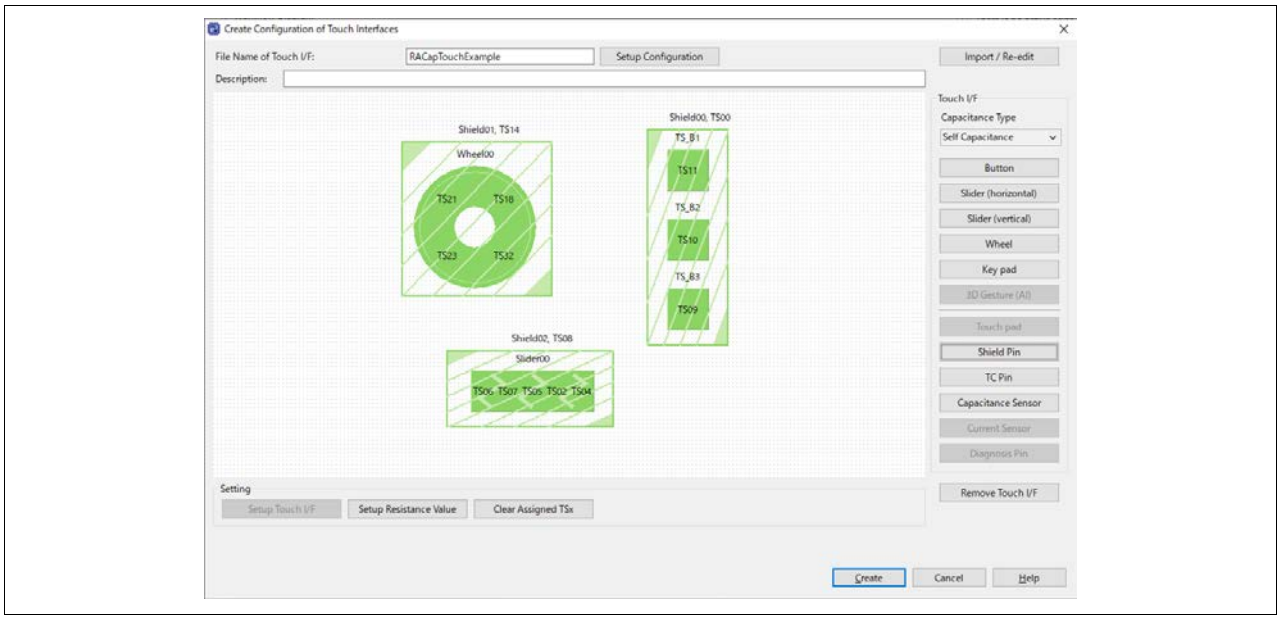



**Figure 17. Complete New Touch Interface**

17. Next, set the touch interface configuration. Press **Setup Configuration** button to open the **Setup Configuration (methods)** dialog and set the three active shields.

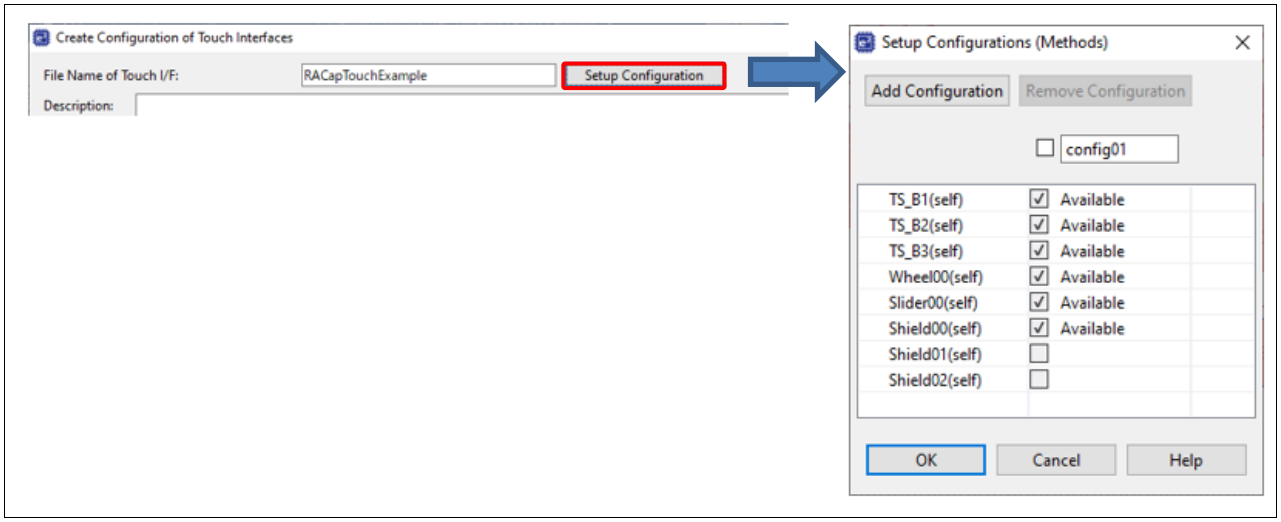



**Figure 18. Setup Configuration**

18. The following steps to configure like **Figure 19**.
    a. Uncheck **Wheel00(self)** and **Slider00(self)** to compose **Shield00(self)** with **TS_B1(self), TS_B2(self)** and **TS_B3(self)** as **config01**.
    b. Press **Add Configuration**, **config02** is added.
    c. Uncheck **TS_B1(self)**, **TS_B2(self)**, **TS_B3(self)**, **Slider00(self)**, **Shield00(self)** and **Shield02(self)** to compose **Shield01(self)** with **Wheel00(self)** and **Shield01(self)** as **config02**.
    d. Press **Add Configuration**, **config03** is added.
    e. Uncheck **TS_B1(self)**, **TS_B2(self)**, **TS_B3(self)**, **Wheel00(self)**, **Shield00(self)** and **Shield01(self)** to compose **Shield02(self)** with **Slider00(self)** and **Shield02(self)** as **config03**.
    f. Click **OK** to close the dialog box.

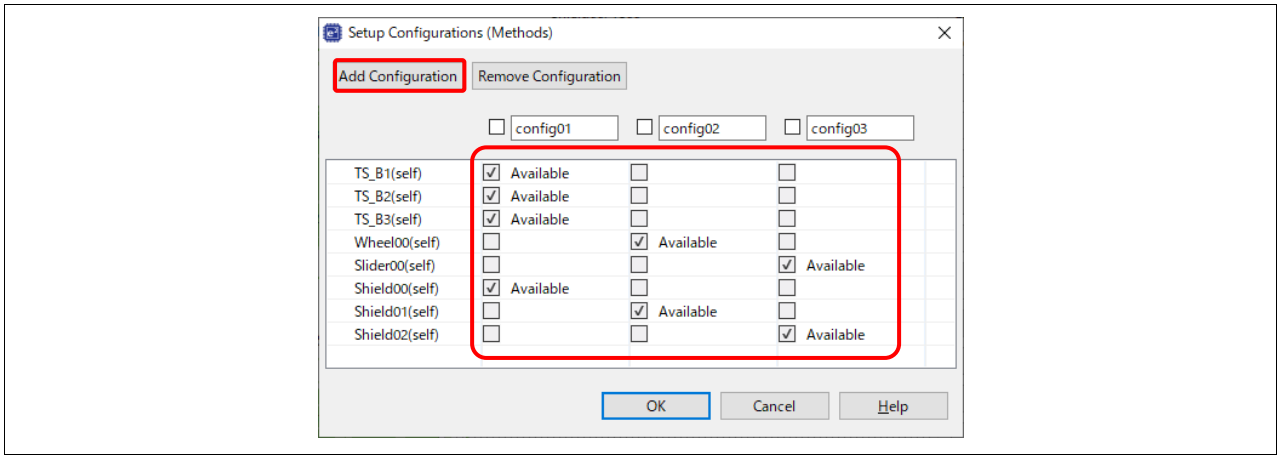
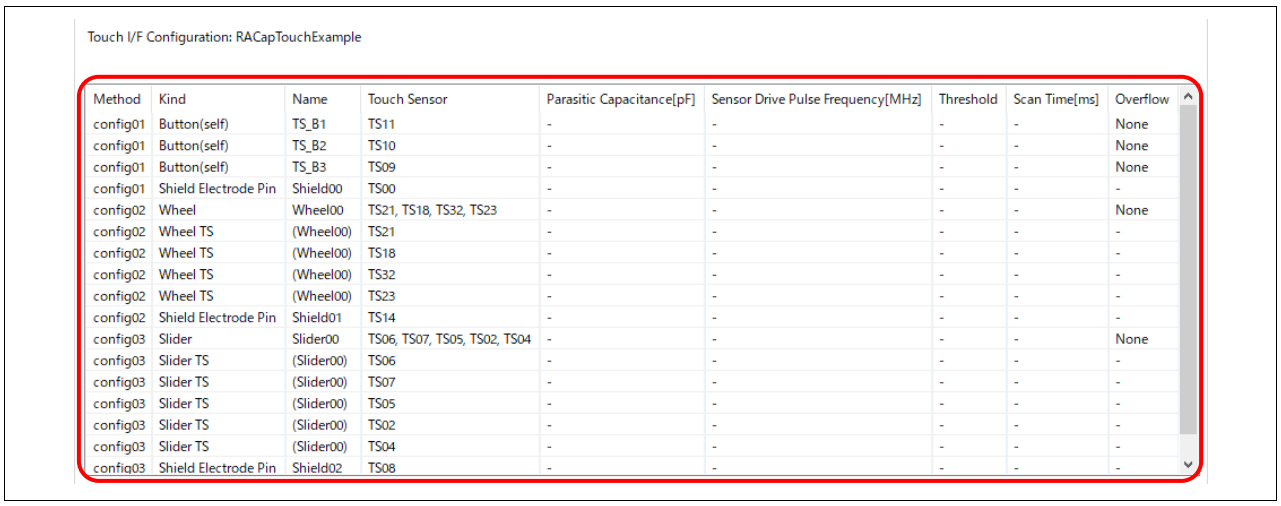



**Figure 19. Setting Setup Configurations (Methods)**

19. This is the final Touch Interface. Click **Create** button bottom right of the **Configuration of Touch Interfaces** window to set up the Touch Interface.
20. The CapTouch Main (QE) will now display the configuration of the touch interface in the main view pane.




| Method | Kind | Name | Touch Sensor | Parasitic Capacitance[pF] | Sensor Drive Pulse Frequency[MHz] | Threshold | Scan Time[ms] | Overflow |
|---|---|---|---|---|---|---|---|---|
| config01 | Button(self) | TS_B1 | TS11 | - | - | - | - | None |
| config01 | Button(self) | TS_B2 | TS10 | - | - | - | - | None |
| config01 | Button(self) | TS_B3 | TS09 | - | - | - | - | None |
| config01 | Shield Electrode Pin | Shield00 | TS00 | - | - | - | - | - |
| config02 | Wheel | Wheel00 | TS21, TS18, TS32, TS23 | - | - | - | - | None |
| config02 | Wheel TS | (Wheel00) | TS21 | - | - | - | - | - |
| config02 | Wheel TS | (Wheel00) | TS18 | - | - | - | - | - |
| config02 | Wheel TS | (Wheel00) | TS32 | - | - | - | - | - |
| config02 | Wheel TS | (Wheel00) | TS23 | - | - | - | - | - |
| config02 | Shield Electrode Pin | Shield01 | TS14 | - | - | - | - | - |
| config03 | Slider | Slider00 | TS06, TS07, TS05, TS02, TS04 | - | - | - | - | None |
| config03 | Slider TS | (Slider00) | TS06 | - | - | - | - | - |
| config03 | Slider TS | (Slider00) | TS07 | - | - | - | - | - |
| config03 | Slider TS | (Slider00) | TS05 | - | - | - | - | - |
| config03 | Slider TS | (Slider00) | TS02 | - | - | - | - | - |
| config03 | Slider TS | (Slider00) | TS04 | - | - | - | - | - |
| config03 | Shield Electrode Pin | Shield02 | TS08 | - | - | - | - | - |

**Figure 20. Main View Pane Displays the Touch Configuration**

21. Build the project by clicking the hammer icon. The project should build without any errors or warnings.

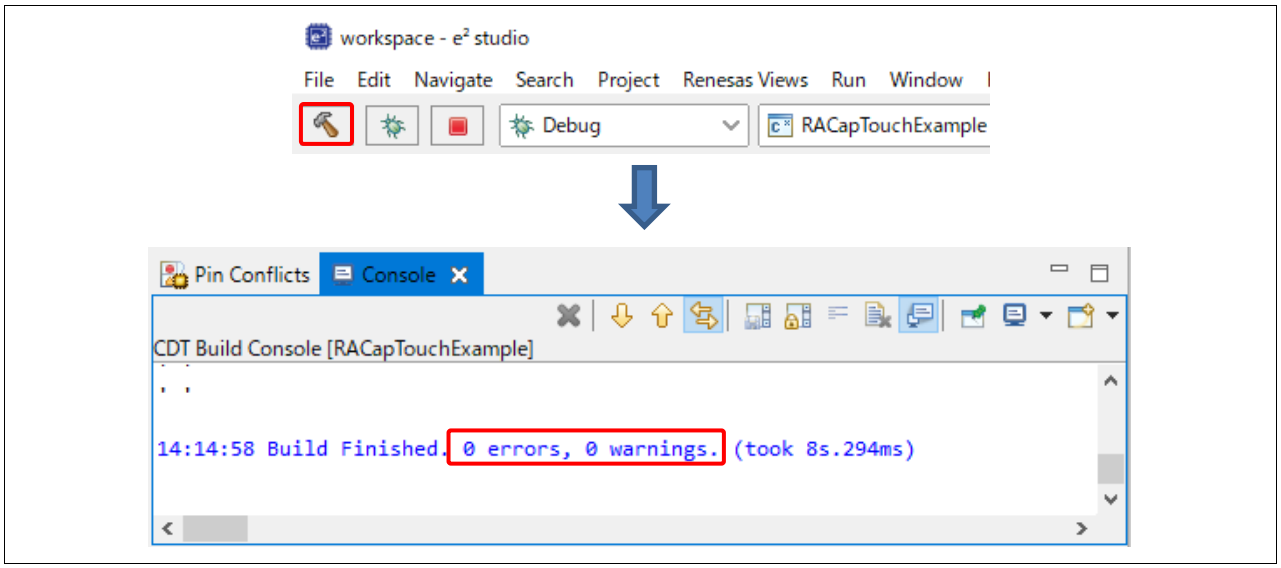



**Figure 21. Build Project**

## 3. Capacitive Touch Tuning in e² studio

1. Connect the board with a PC. Refer to the **Figure 53** for how to connect.
2. To start the automatic tuning process, click the button **Start Tuning** in the **CapTouch Main (QE)**.

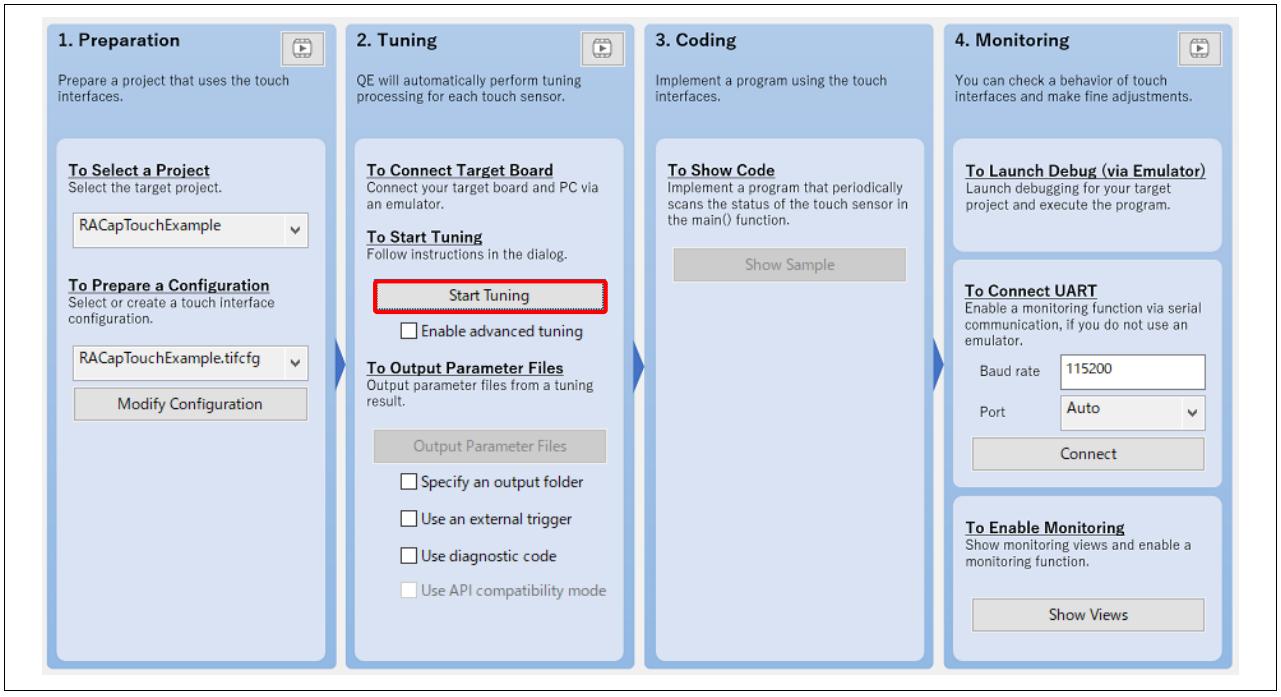



**Figure 22. Start Tuning**

3. At the start of the first debug session, e$^2$ studio may display a message indicating that is will switch to the Debug perspective. Click the **Remember my decision** check box and **Switch** to continue the Debug process and the QE for Capacitive Touch automatic tuning.

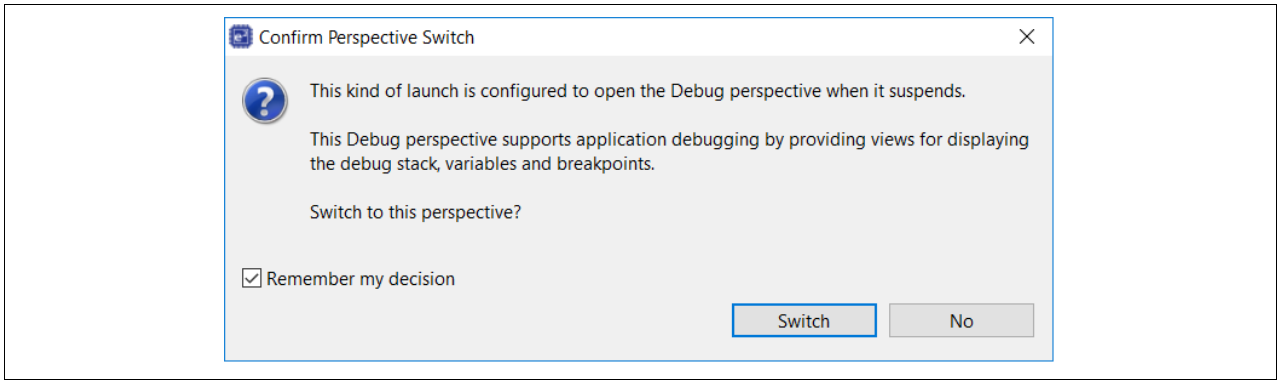



**Figure 23. Switch Perspective**

4. The QE for Capacitive Touch RA automatic tuning will now begin. Please read the tuning dialog windows carefully as they will guide you through the tuning process. An example screen is shown below. Typically, no interaction is required during the initial tuning process steps.

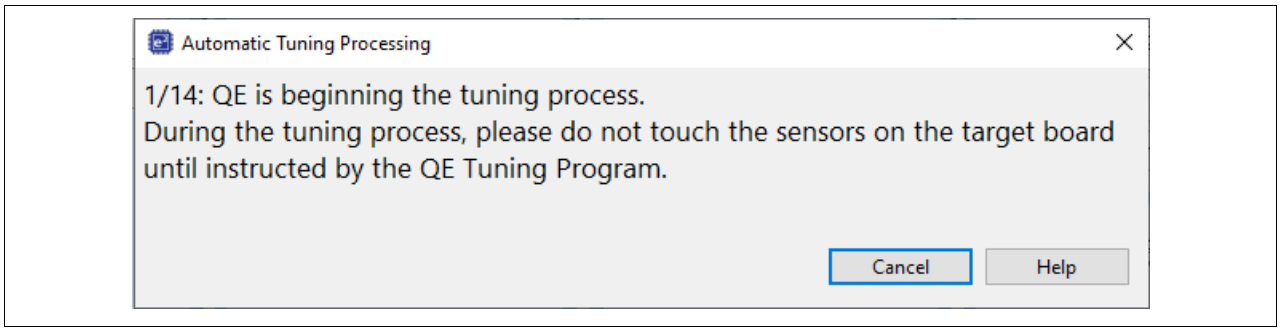



**Figure 24. Tuning Dialog Window**

5. After several automated steps, you will arrive at the dialog box with information like what is shown below. This is the Touch sensitivity measurement step of the tuning process. Press using **normal Touch pressure** on the sensor being indicated in the dialog box (TS_B3, TS09). When you press, the bar graph will increase to the right and the Touch counts go numerically up. While holding that pressure, **press any key on the PC keyboard** to accept the measurement.

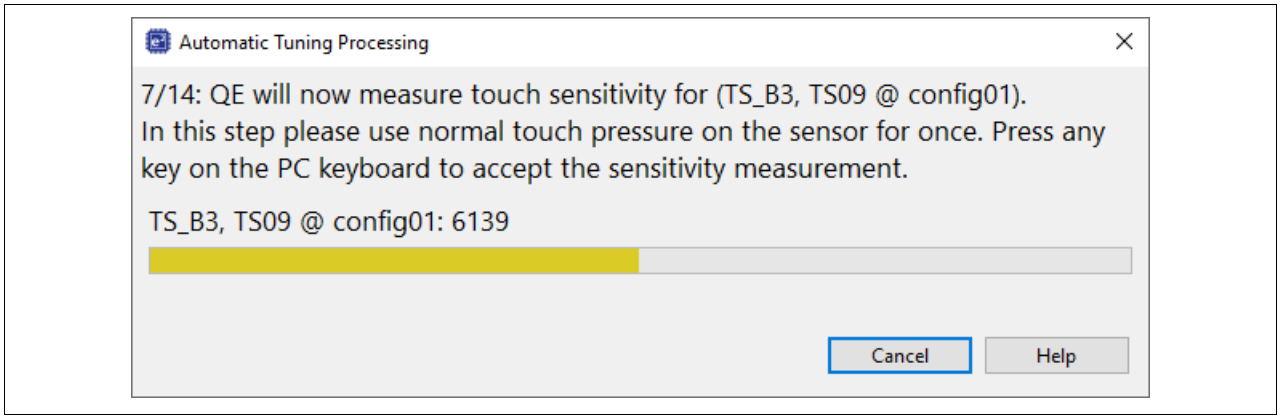



**Figure 25. Measure Touch Button TS_B3**

6. Repeat the process for buttons TS_B2 and TS_B1.

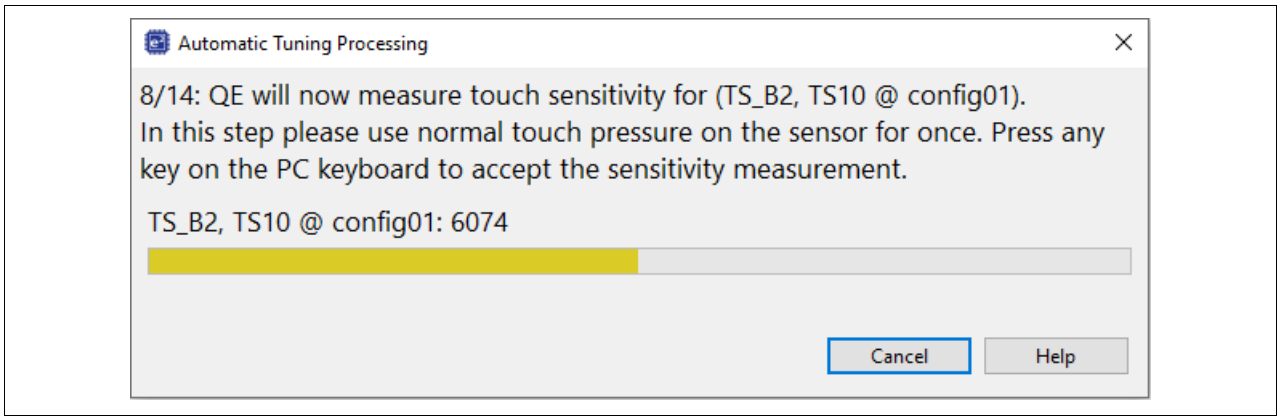



**Figure 26. Measure Touch Button TS_B2**

7. Next, we will measure the sensitivity of the wheel. Move your finger across the wheel sensors 3-4 times. After that, **press any key on the PC keyboard** to accept the measurement.

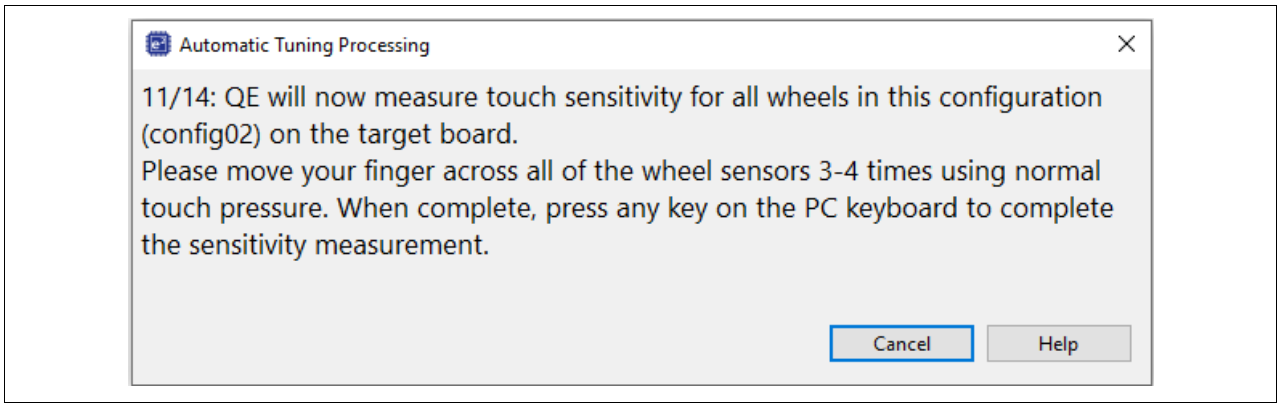



**Figure 27. Repeat Measurement 3 Times**

8. Next, we will adjust the slider. Move your finger across the slider 3-4 times. After that, **press any key on the PC keyboard** to accept the measurement.

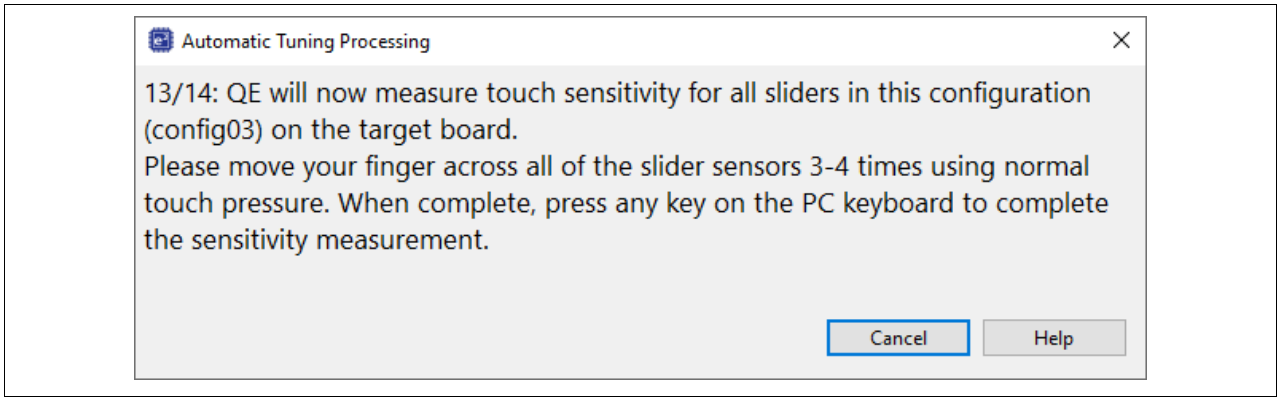



**Figure 28. Repeat Measurement 3 Times**

9. Once complete, you will see a screen like what is shown below. This is the detection threshold that is used by the middleware to determine if a Touch event has occurred.

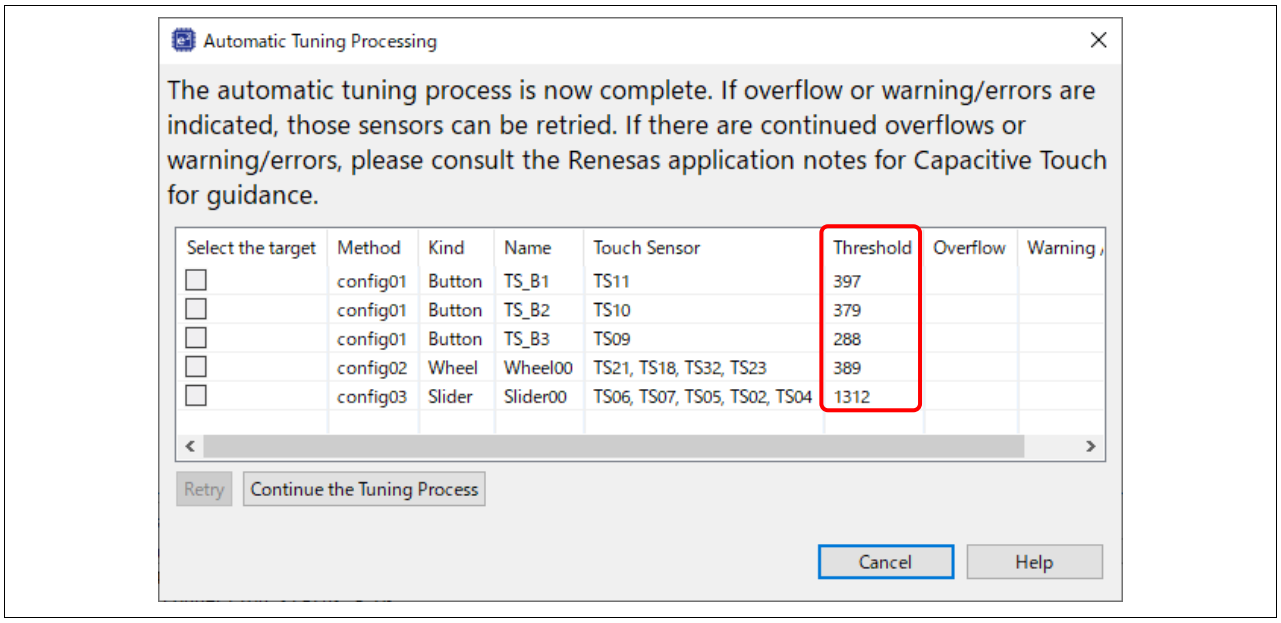



**Figure 29. Threshold for Touch Event**

10. Click the **Continue the Tuning Process** button in the dialog box shown. This will exit the tuning process and disconnect from the Debug session on the target. You should return to the default **CapTouch Main (QE)** screen in the e$^2$ studio IDE.

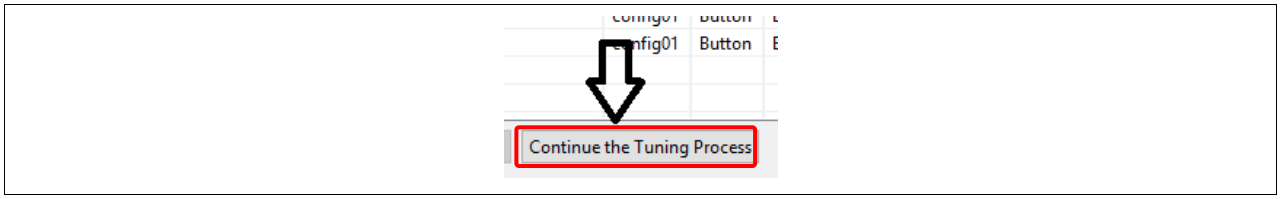



**Figure 30. Continue the Tuning Process**

11. After the tuning process is completed, the default view of the **CapTouch Main (QE)** presented here will be the results of the tuning process for the sensors in the configuration. This gives the user a quick way to examine the tuning results.

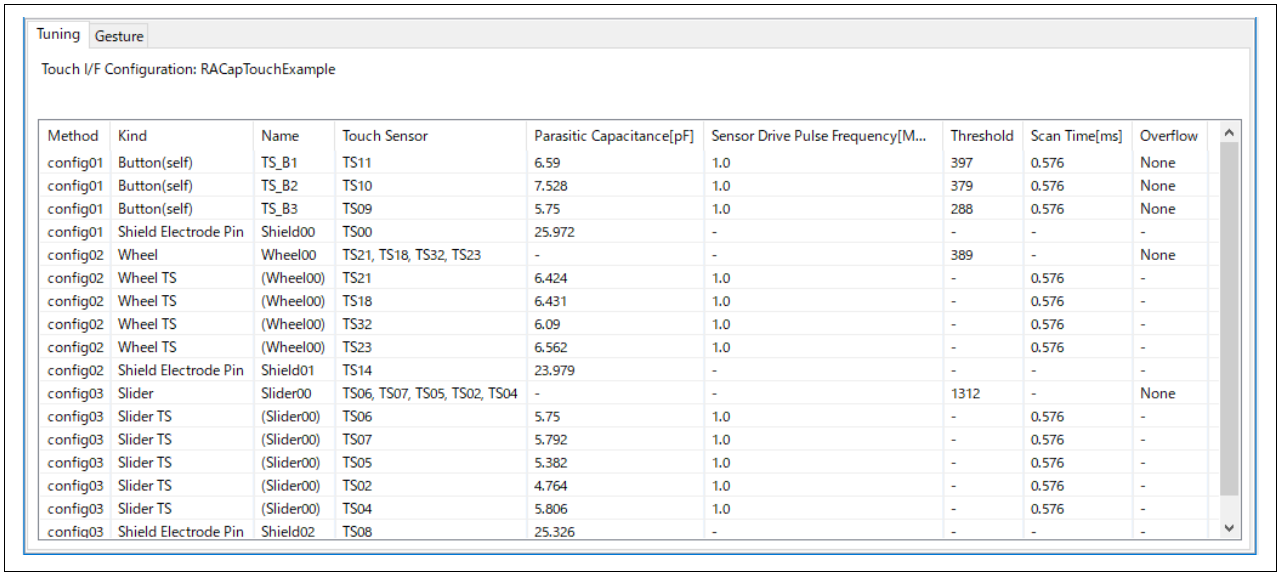



**Figure 31. Tuning Result**

12. Finally, output the tuning parameter files. Click the button **Output Parameter Files**.

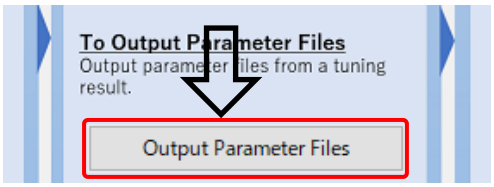



**Figure 32. Continue The Tuning Process**

**13.** Look at the **Project Explorer** window and you will see that files have been added. These contain the needed tuning information to enable Touch detection using the **r_ctsu** and **rm_touch** FSP modules.

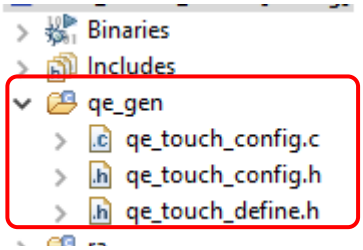



**Figure 33. Output Parameter Files**

## 4. Creating a project in IAR EWARM

1. Install the IAR Embedded Workbench for ARM version 9.20.2 from https://www.iar.com/products/architectures/arm/iar-embedded-workbench-for-arm.
2. Install the RA Smart Configurator (RA SC) from https://www.renesas.com/smart-configurator.
   Note: Please check the version of the RA Smart Configurator installer. If the FSP is not v3.5.0, download and install the latest version from https://github.com/renesas/fsp/releases.
3. To create a third-party IDE project with the RA Smart Configurator, run the “rasc.exe” application. In the “New Renesas RA FSP Project” wizard, enter the **Project name** and **Location**.

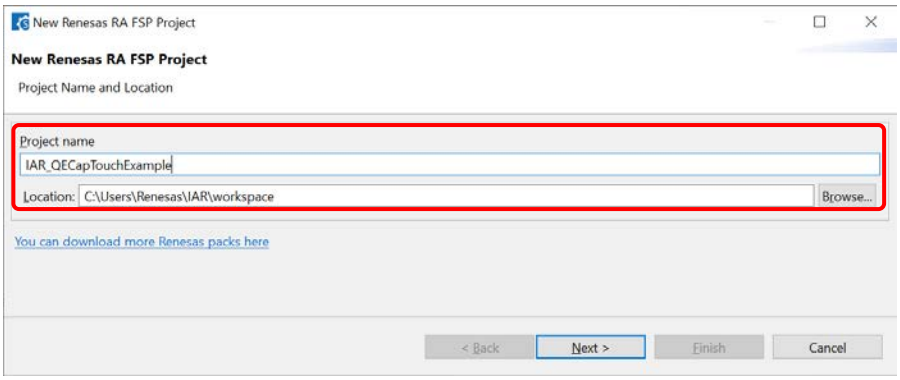



**Figure 34. Project Name And Location**

4. Board: **RSSK-RA2L1**

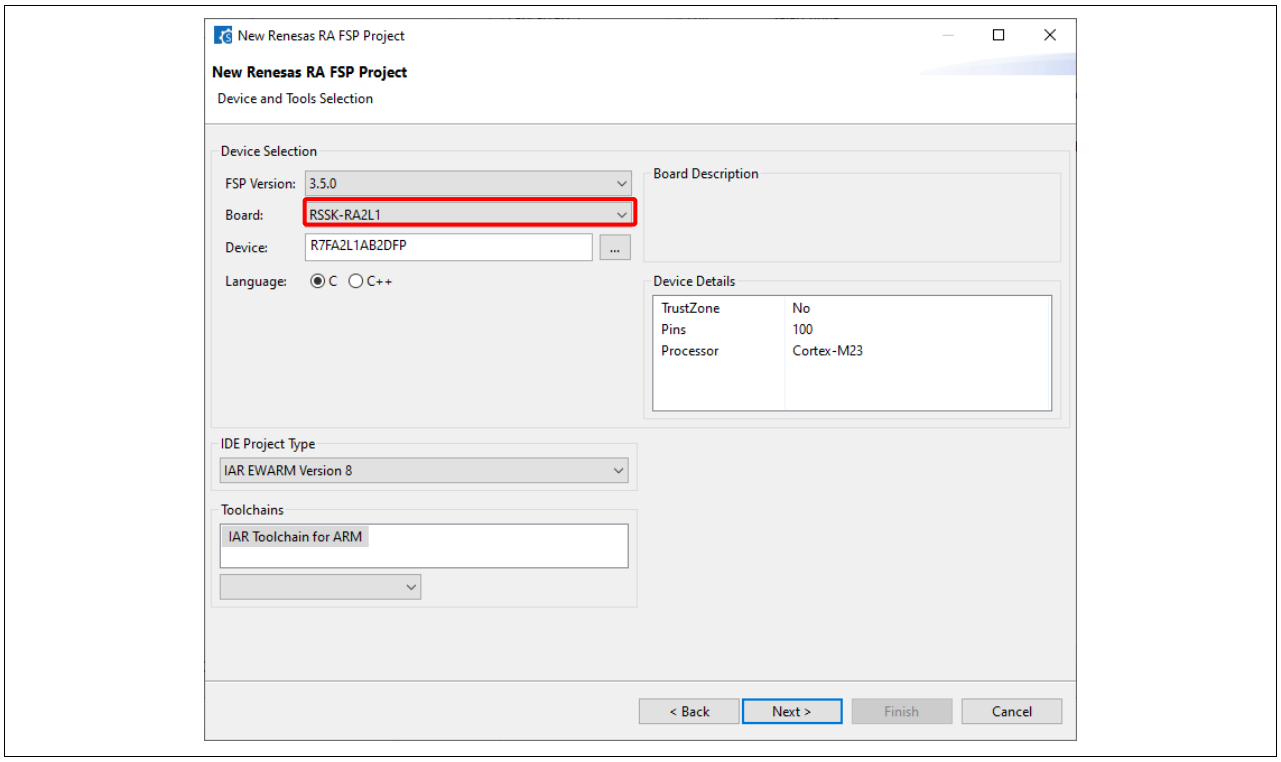



**Figure 35. Board Selection for RSSK RA2L1**

5. RTOS Selection: **No RTOS**

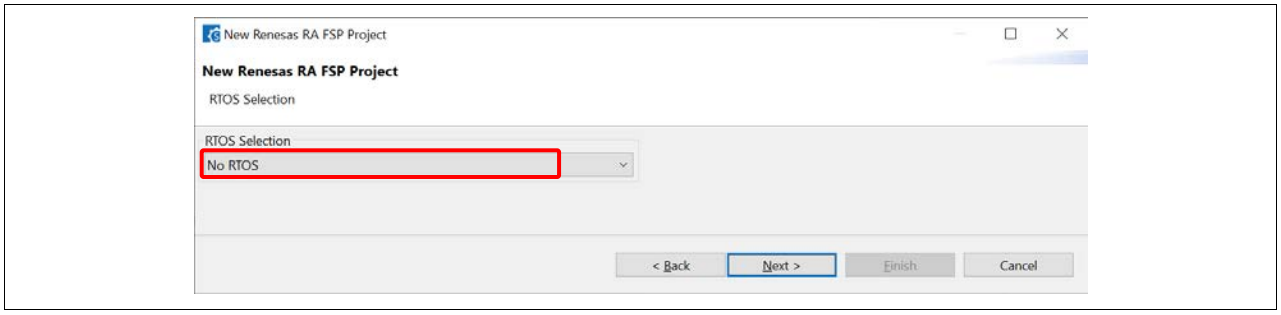



**Figure 36. RTOS Selection**

6. Project Template Selection: **Bare Metal – Minimum**. Click **Finish** to create project.

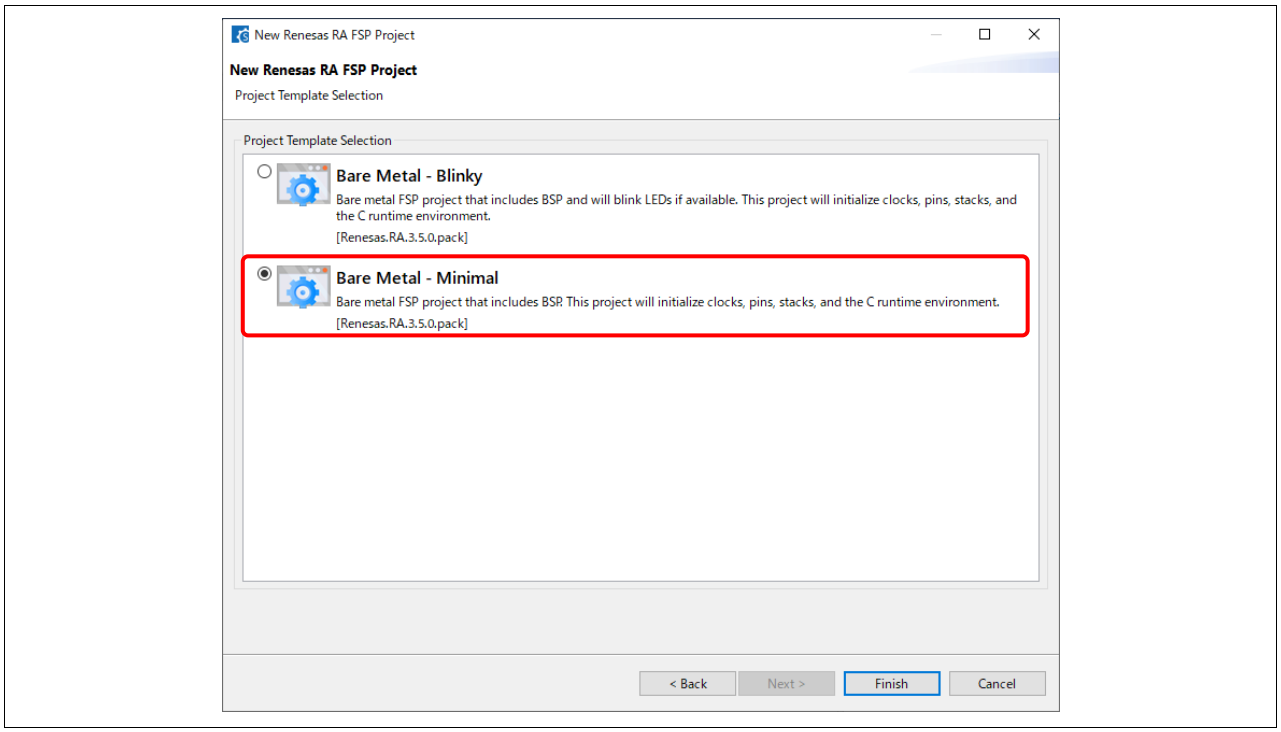



**Figure 37. Template Selection**

7. After the project is created, the **DDSC Smart Configurator** window will pop-up.

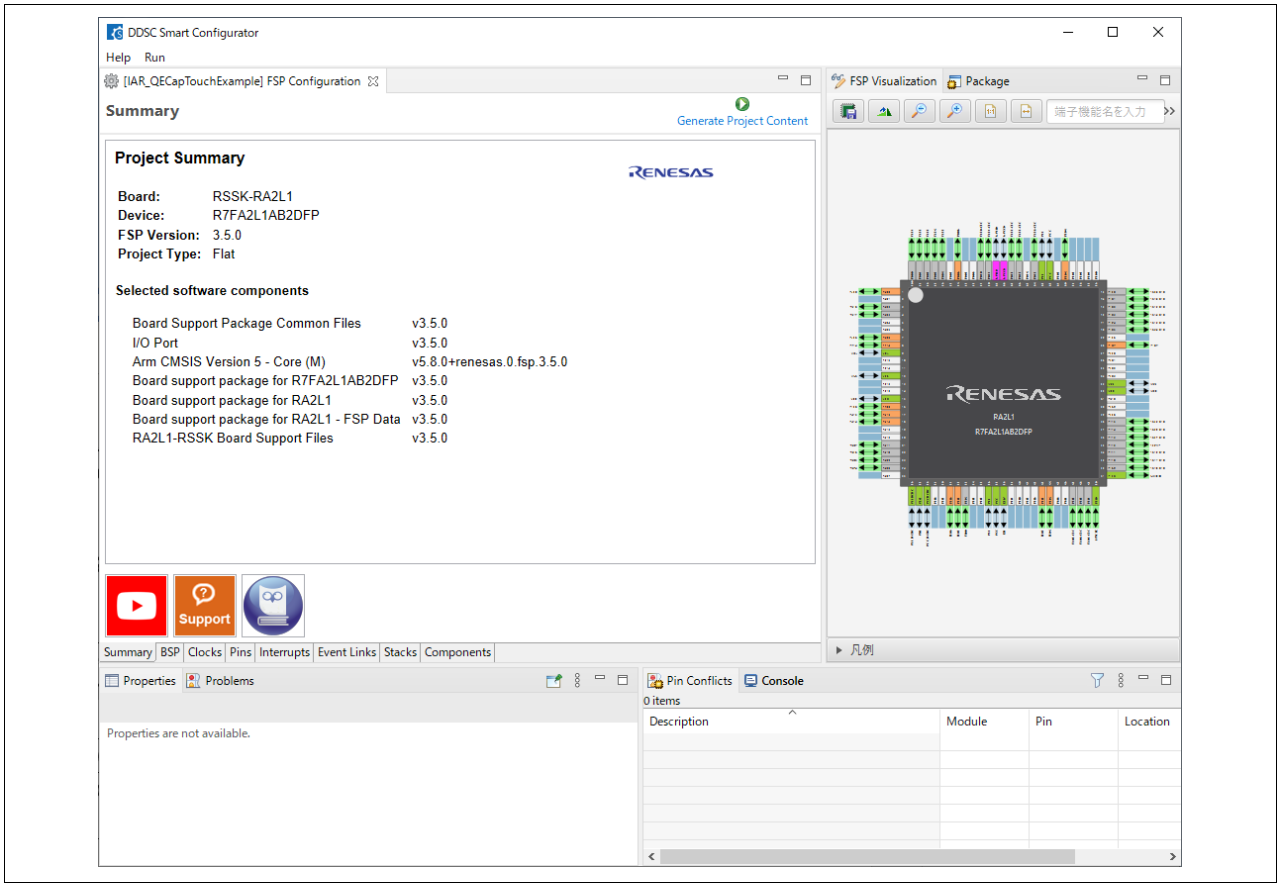



**Figure 38. Smart Configurator Window**

8. Navigate to the project location in Windows Explorer and double-click on the main workspace (IAR EWARM *.eww file) to open the project.

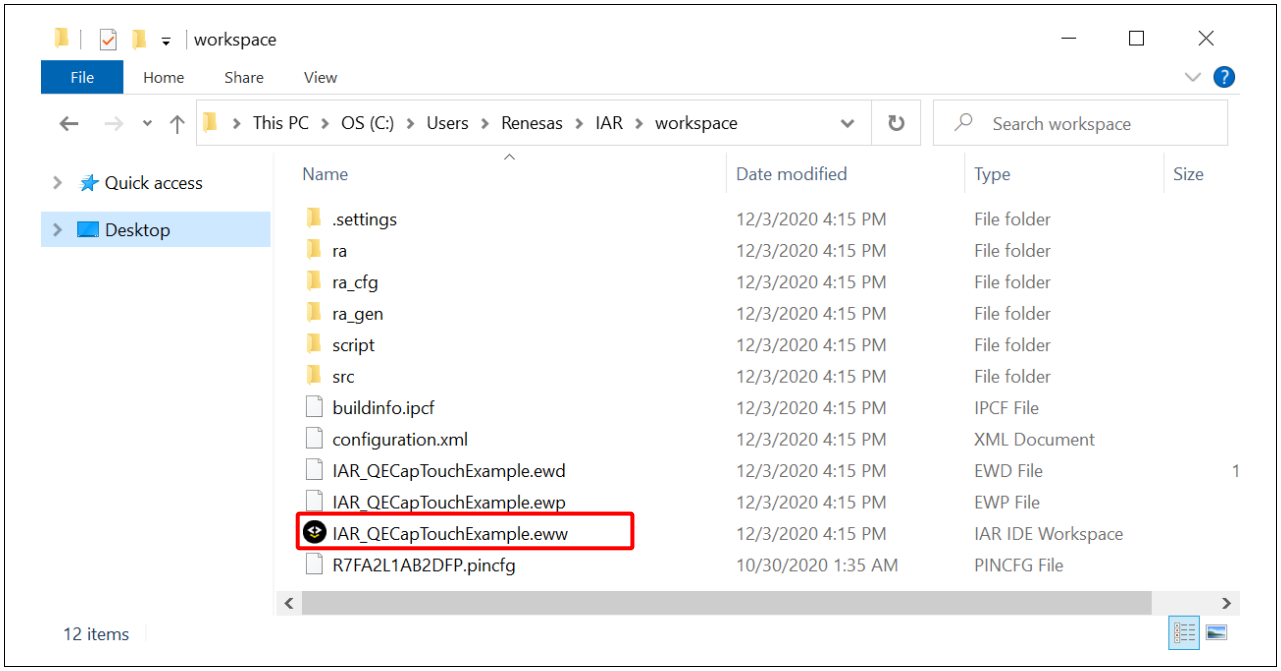



**Figure 39. Project Location**

**9.** The project is opened by IAR EWARM. Right-click on the project and select Rebuild All. The project should be built without error.

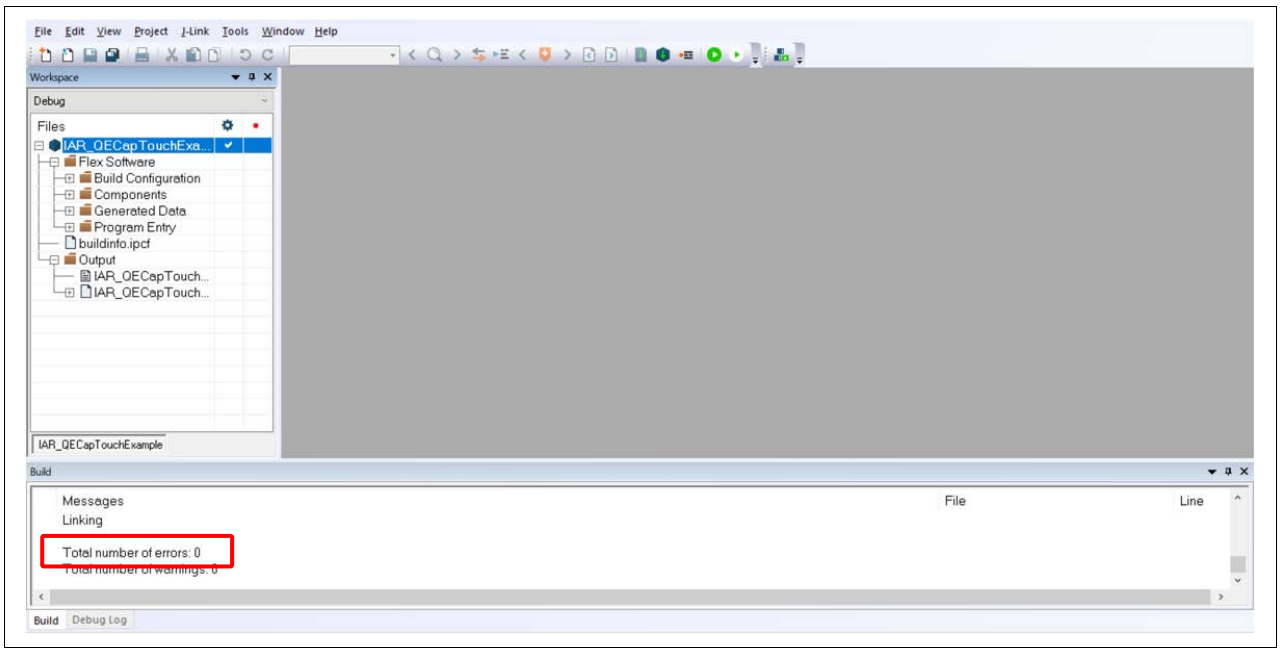



**Figure 40. Project is Built Successfully**

10. After a project created with the RA Smart Configurator has been opened in IAR EWARM, its FSP configuration can be changed by relaunching the RA Smart Configurator from the IDE. Follow the instructions below to reopen the RA Smart Configurator.

11. In the menu of IAR EWARM, select **Tools > Configure Tools…** Then, select **New** and fill in the fields as follows.
    Menu Text: **RA Smart Configurator**
    Command: Select "**Browse…**" and navigate to "**rasc.exe**"
    Argument: **-compiler IAR configuration.xml**
    Initial Directory: **$PROJ_DIR$**

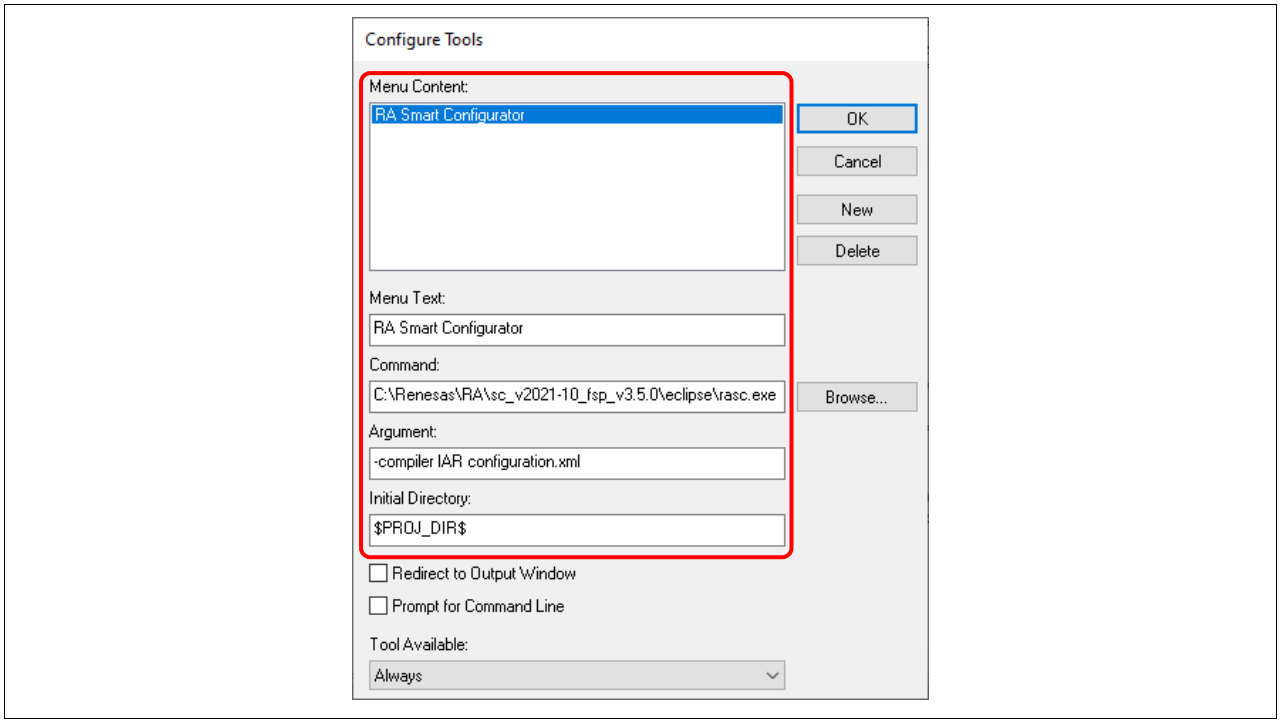



**Figure 41. How to Use RA Smart Configurator in IAR EWARM**

**12.** Now, a FSP configuration of a created project can be reopened by select **Tool > RA Smart Configurator** in IAR EWARM.

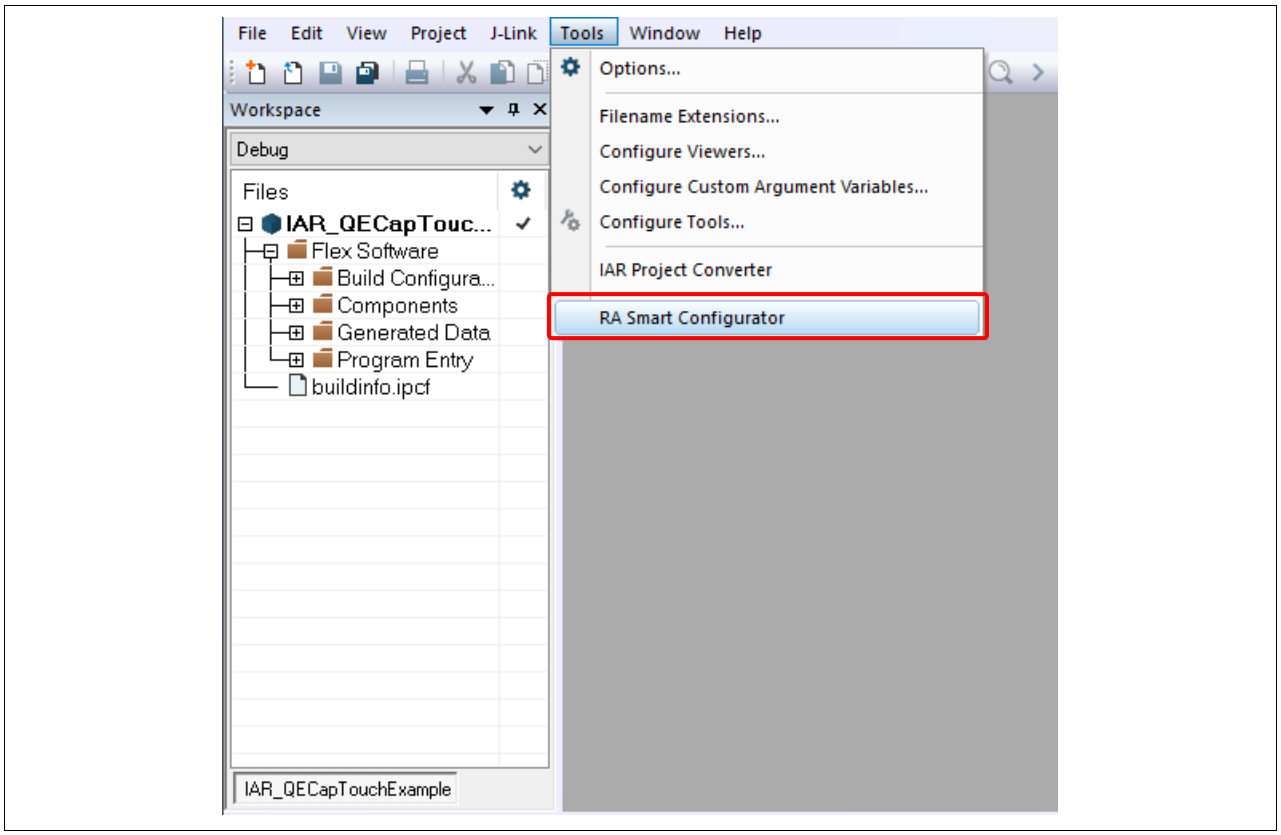



**Figure 42. RA Smart Configurator Has Been Added**

## 5. Adding TOUCH Driver in IAR EWARM

1. In Smart Configurator, select the **Pins** tab at the bottom of the pane. Type **ctsu** in the search box and select the **CTSU0** pin in the search result.

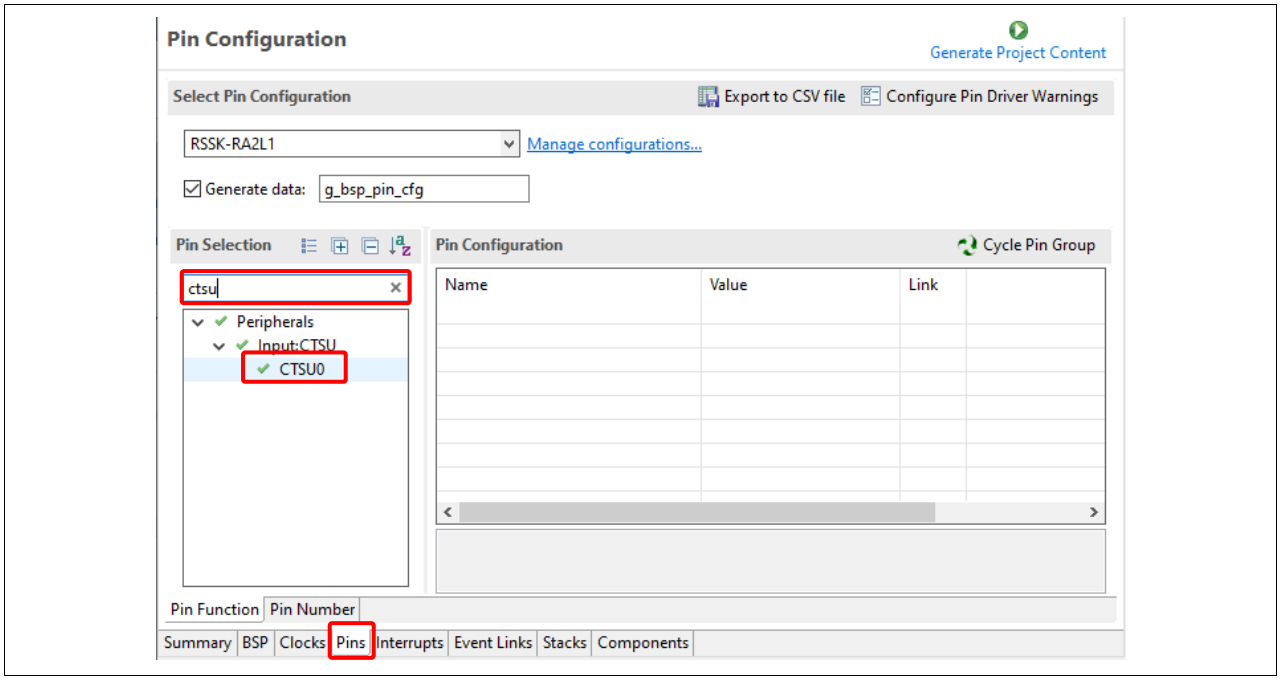



**Figure 43. Select Pin CTSU0**

2. Ensure that the **Operation Mode** and the **TS pins** below are enabled:
   TSCAP, TS00, TS04, TS05, TS06, TS07, TS18, TS21, TS23, TS02-CFC, TS08-CFC, TS09-CFC, TS10-CFC, TS11-CFC, TS14-CFC, and TS32-CFC.

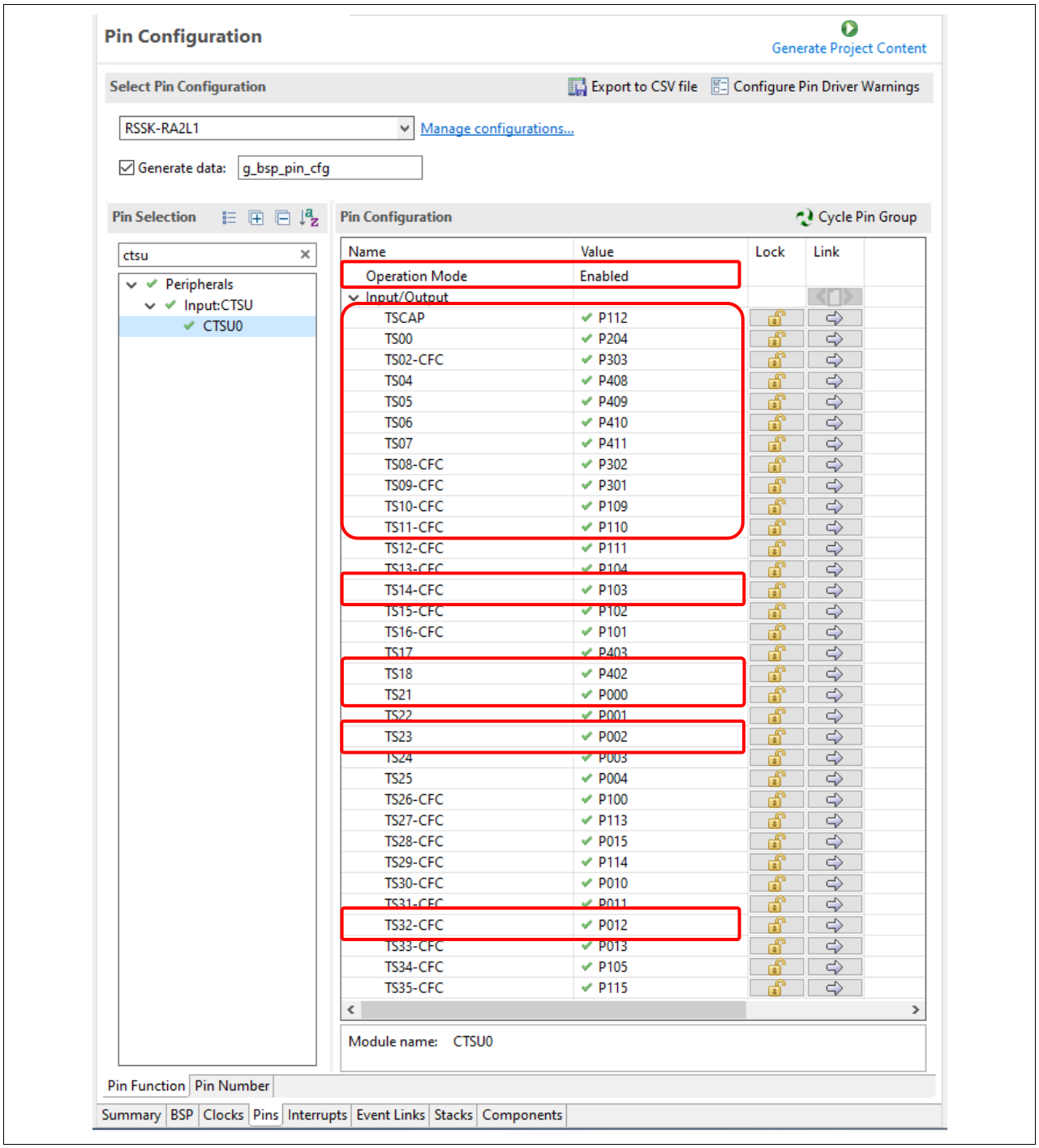



**Figure 44. Enable TS Pins for RSSK-RA2L1**

3. Move to the **Stacks** tab. Add the Capacitive Touch middleware by clicking **New Stack > CapTouch > Touch (rm_touch)**.

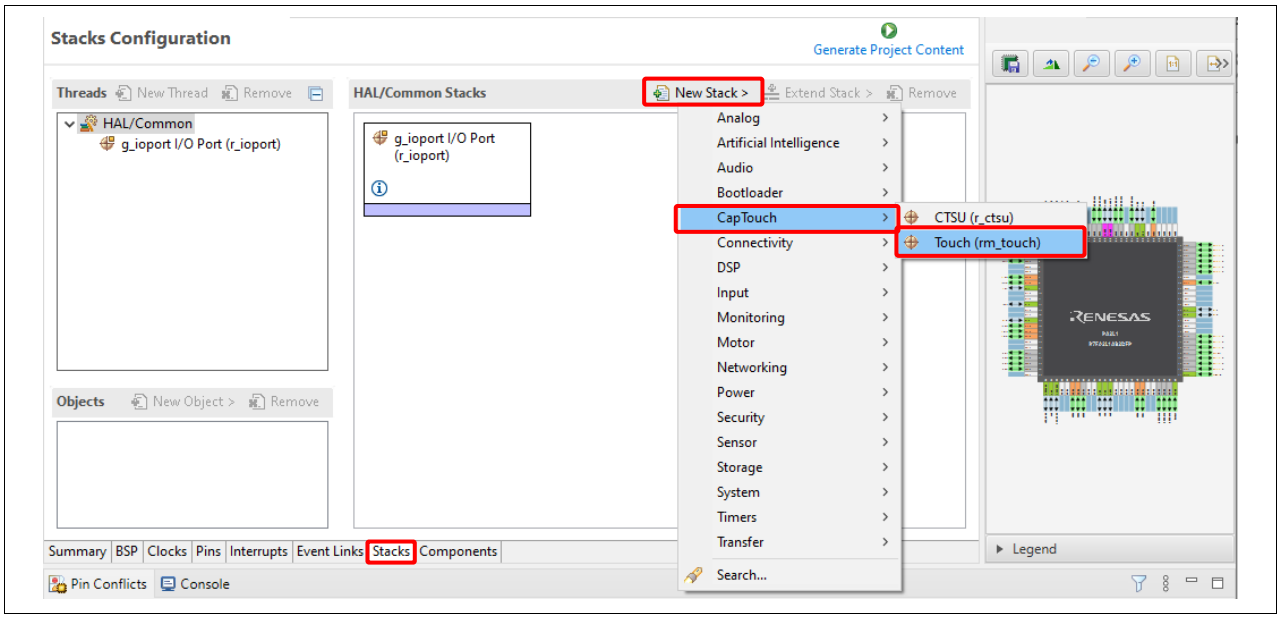
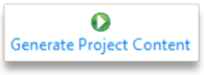



**Figure 45. Add TOUCH Driver**

4. Click on the  button to generate the source files.


5. In IAR EWARM, right-click on the project and select **Rebuild All**. The project should be built without error.

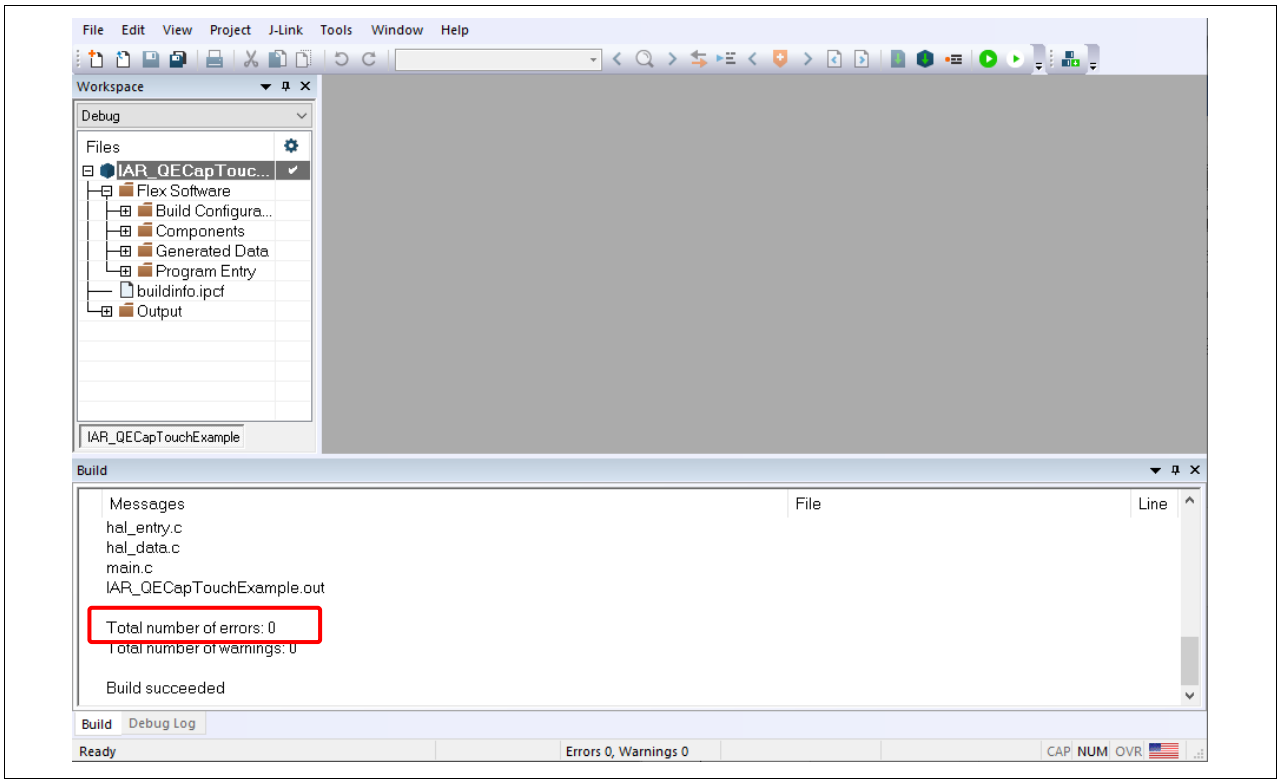



**Figure 46. Fix Errors**

## 6. Copying QE files to IAR EWARM

1. Copy the qe_gen folder in e$^2$ studio and paste it to the IAR EWARM project folder.

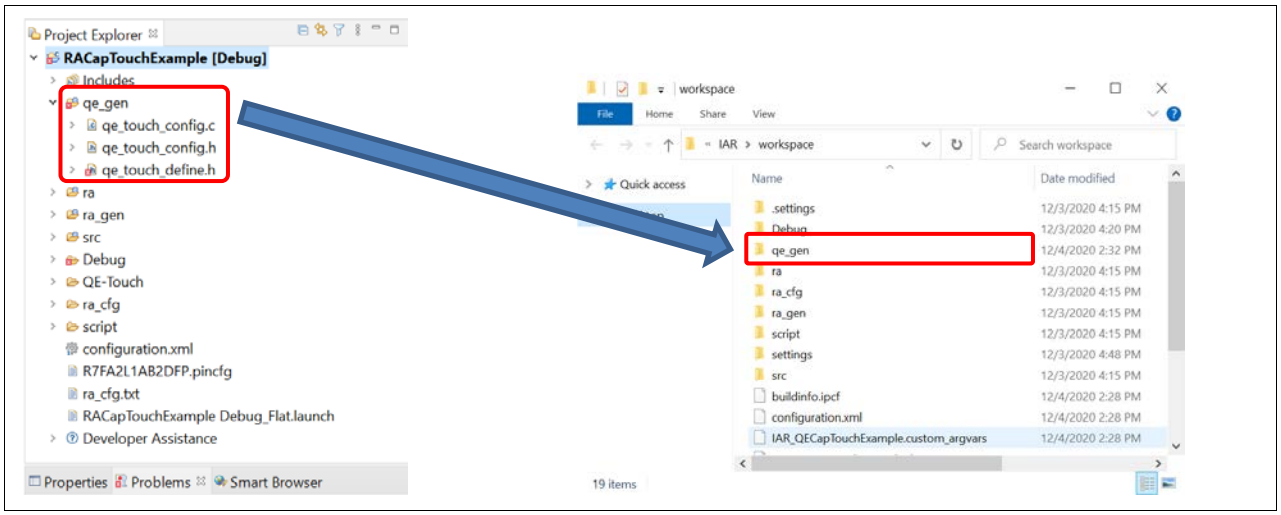



**Figure 47. Copy qe_gen Folder To IAR**

2. In IAR EWARM, right-click on the project name and select **Add > Add Group…**. Enter the group name qe_gen and click **OK**.

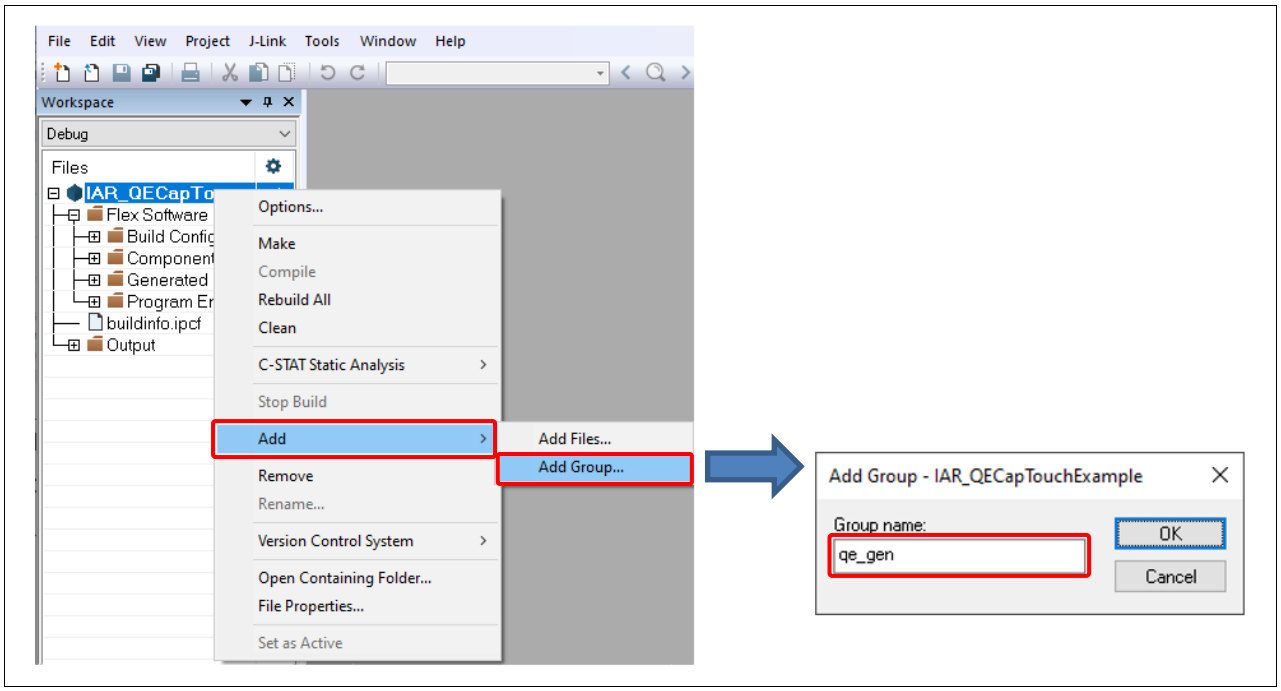



**Figure 48. Create New Group**

3. Right-click on qe_gen group and select **Add > Add Files…**. Select all the source files inside the qe_gen folder and click **Open** to add them to the project.

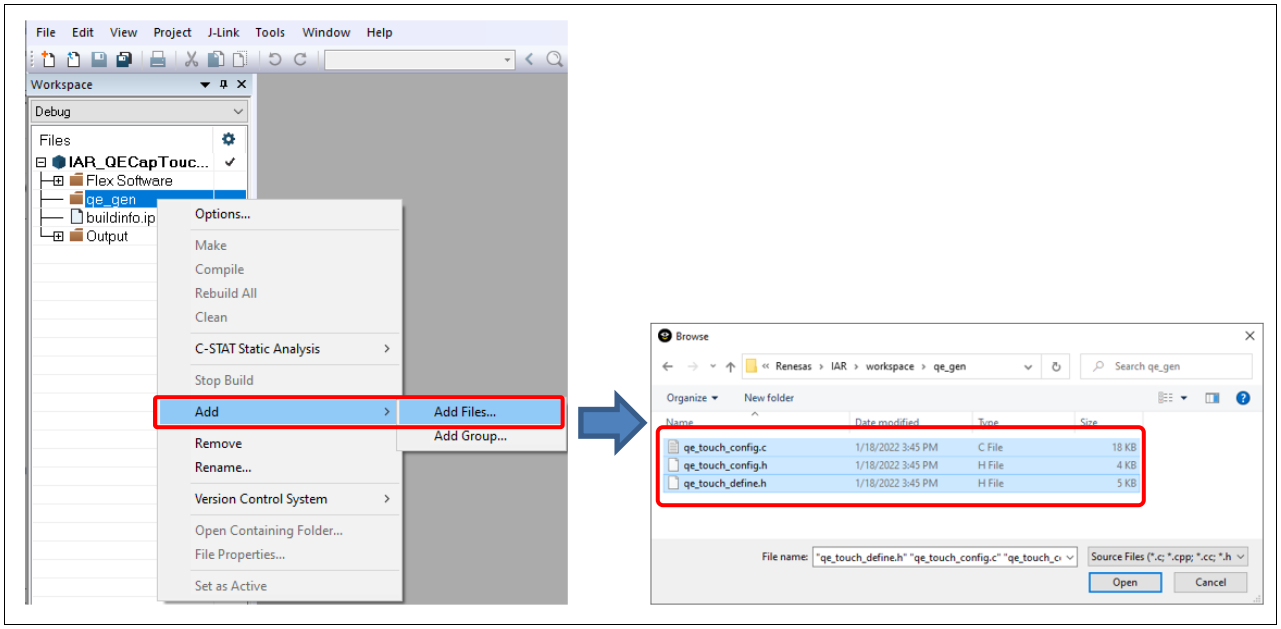



**Figure 49. Add Source Files**

4. Right-click on the project name and select **Options…**. In the **Options** dialog, select **C/C++ Compiler > Preprocessor**. Click on the **[…]** button to add include directory.

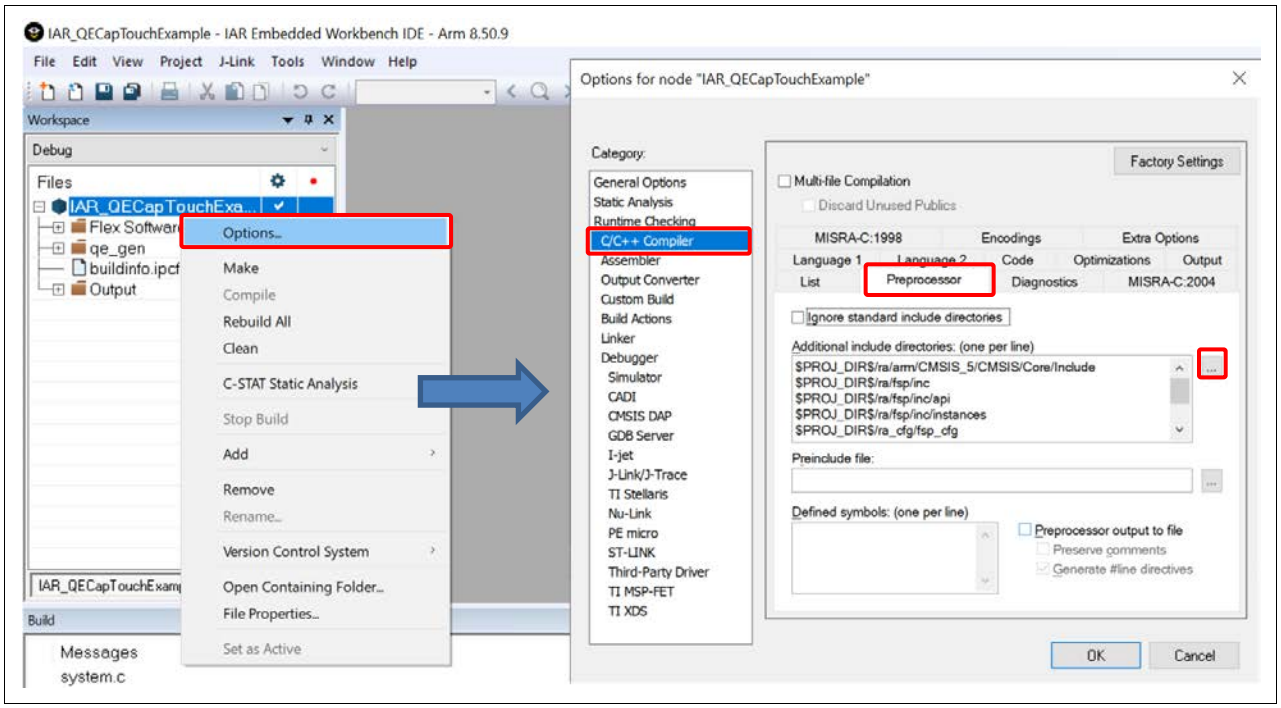



**Figure 50. Open Project Option**

5. Click on the empty row and add the qe_gen folder to the list of include directories. The triangle button can be used to change the absolute path to a relative path. Click **OK** to close the dialog.

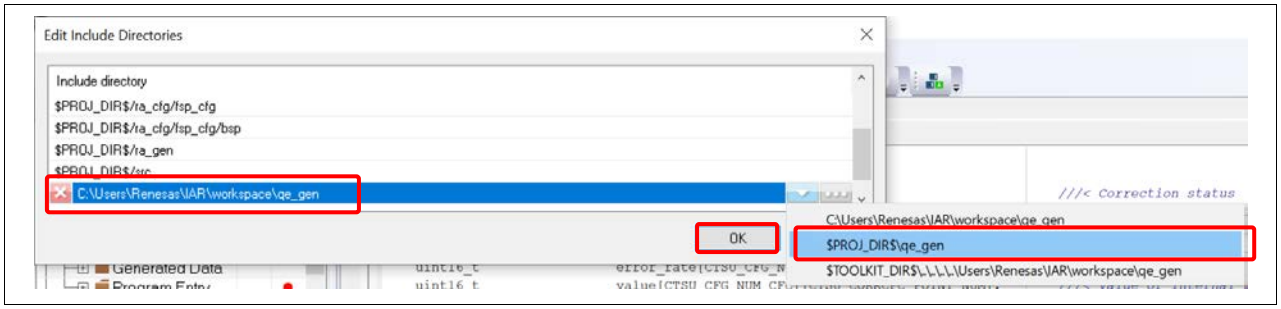



**Figure 51. Add qe_gen To List Of Include Directories**

6. Right-click on the project and select **Rebuild All**. The project should be built without error.

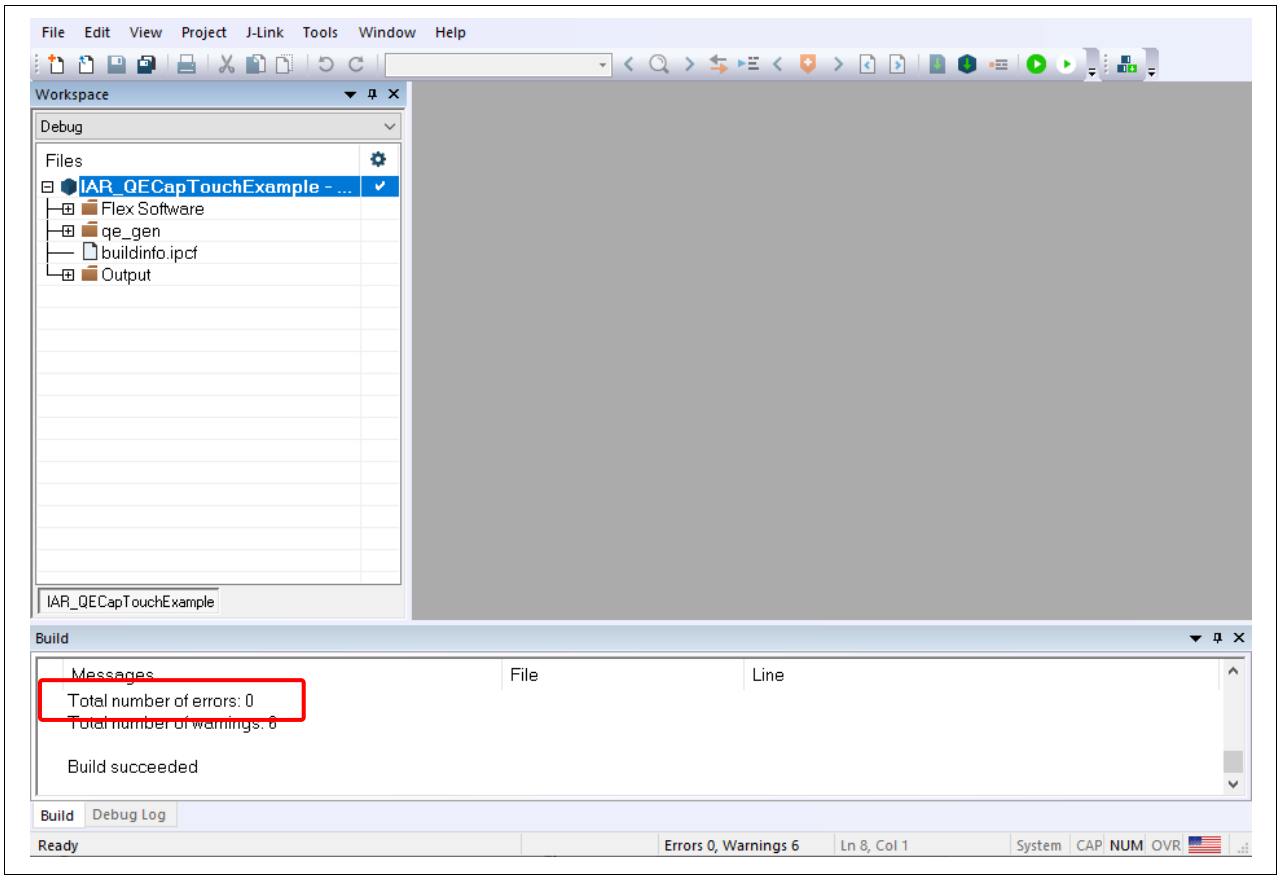



**Figure 52. Build Successfully**

## 7. Run Capacitive Touch Project in IAR EWARM

1. USB connection for power:
   Connect CN5 on RSSK-RA2L1 board to the USB port of the host PC using the USB cable.
2. Debugger connection:
   Connect the debugger cable from the Debugger port (J1) of RSSK-RA2L1 board to the J-Link. Connect the other side of J-Link to the host PC using a USB cable.
   The picture below shows the connection between the host PC and the RSSK-RA2L1 board.

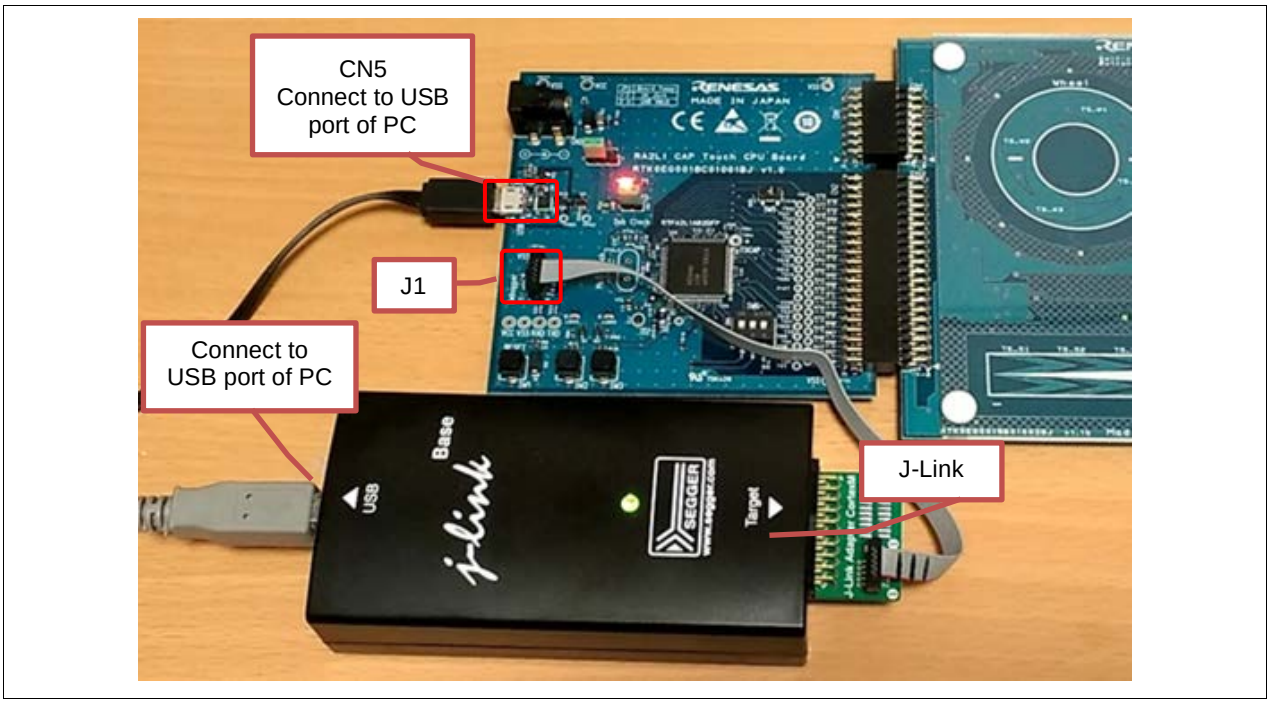



**Figure 53. Connection Between PC & RSSK-RA2L1 Board**

3. Right-click on the project and select **Options…**.

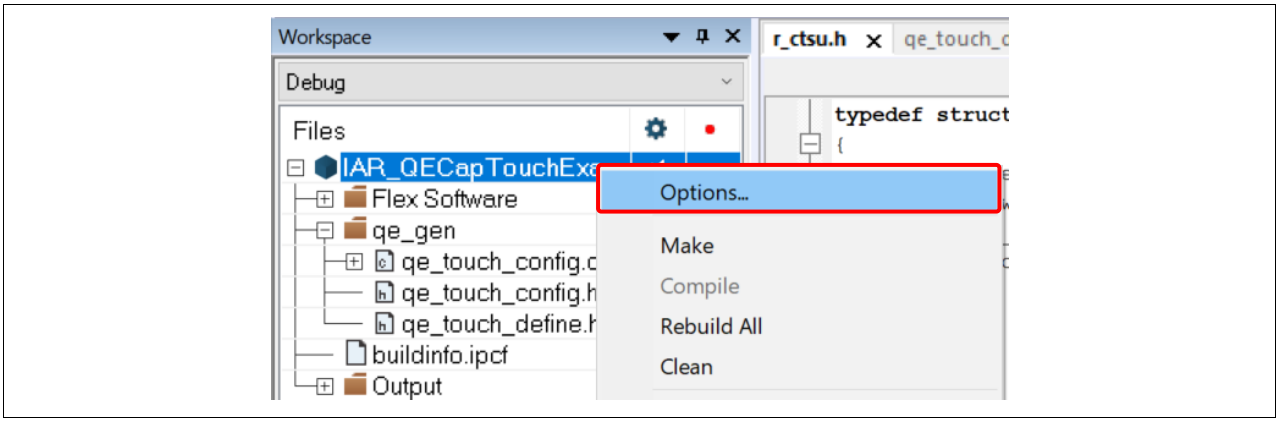



**Figure 54. Open Project Option**

4. In the **Options** dialog, select **Debugger > Setup**. Click on the **Driver** menu to select **J-Link/J-Trace**. Click **OK** to save the settings.

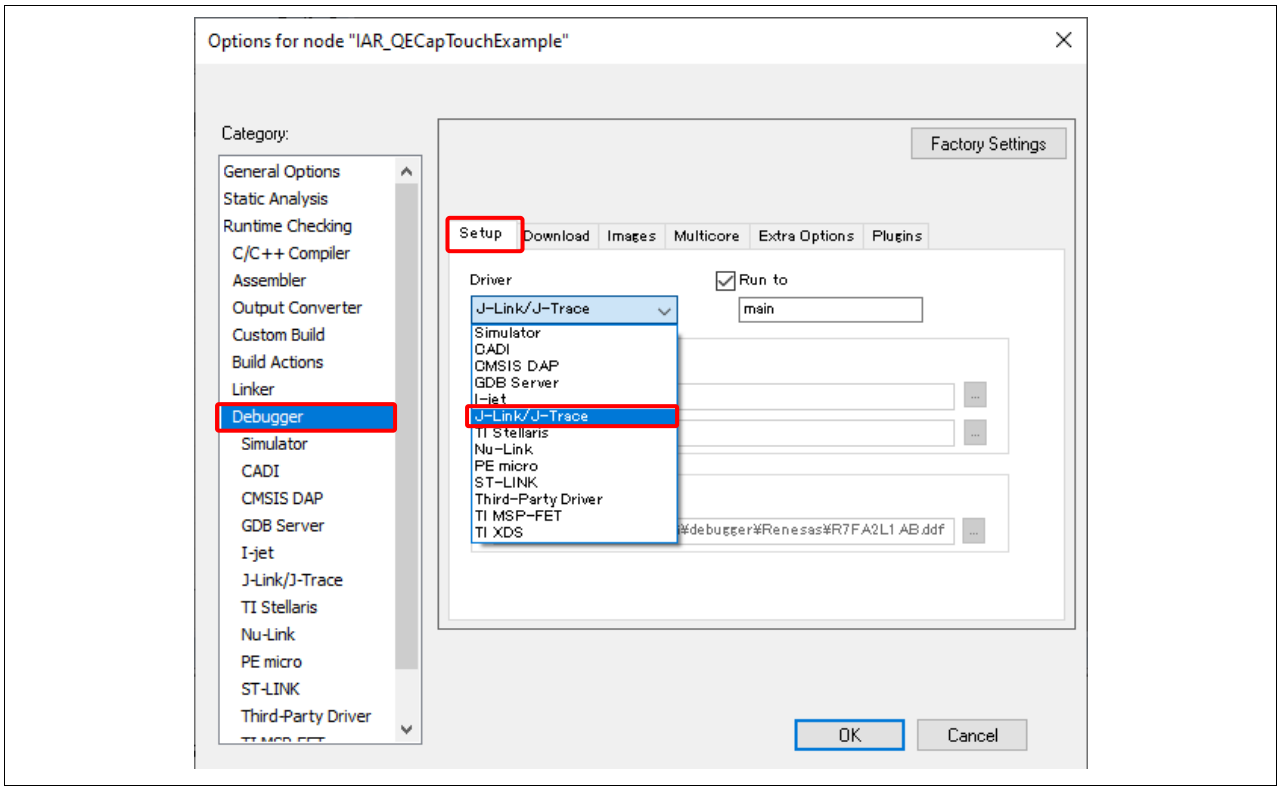



**Figure 55. Setting Project Option**

5. Click **Project**, select **Download and Debug**.

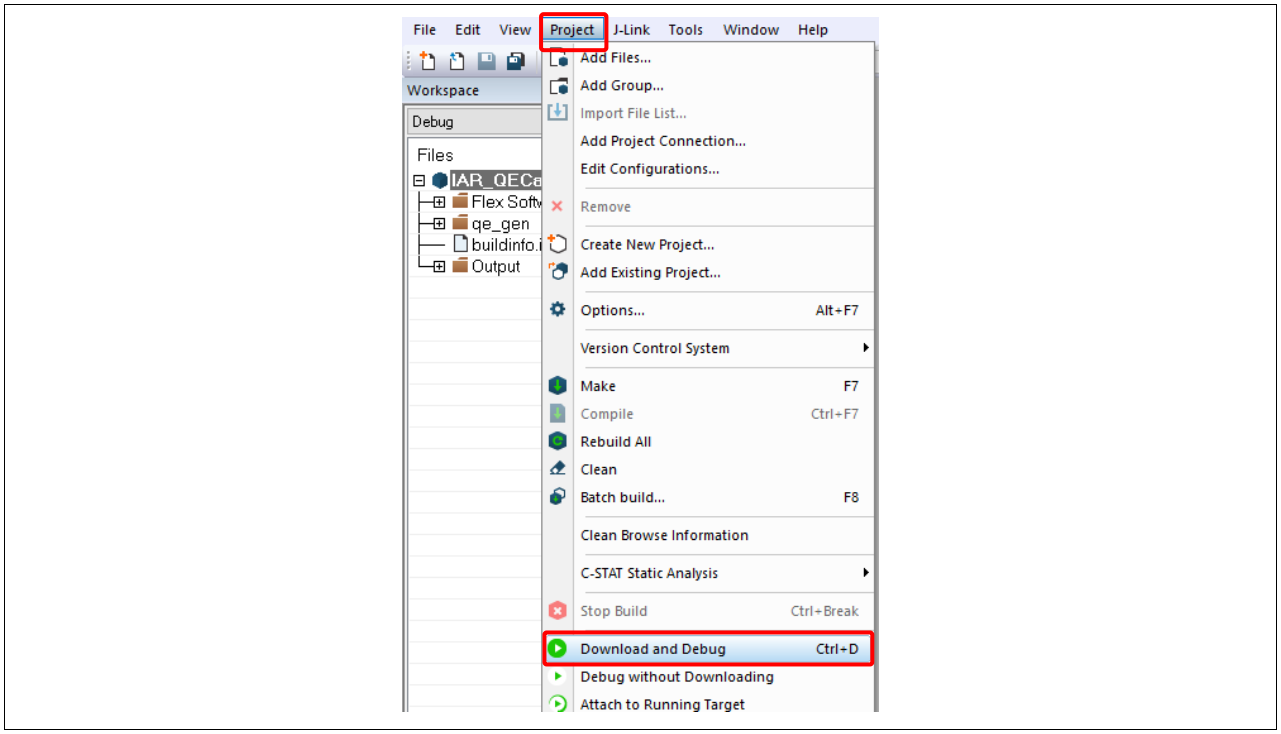



**Figure 56. Download & Debug Project**

6. The **Disassembly** window will pop up and the project should run smoothly.

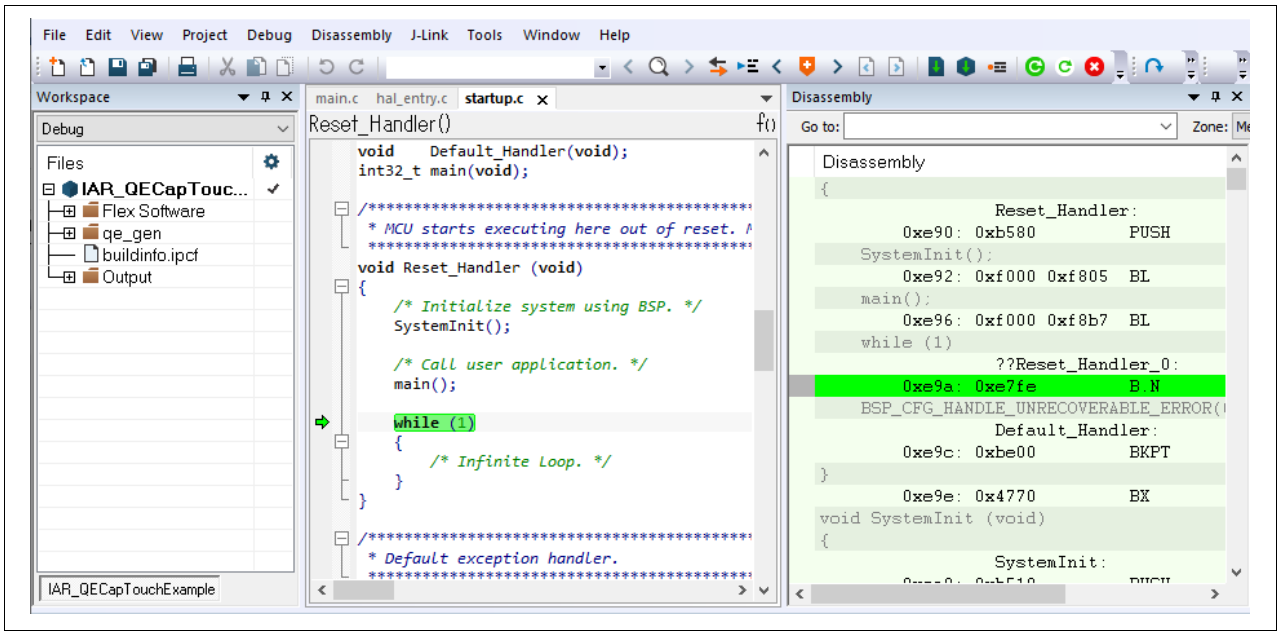



**Figure 57. Run Project**

## 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 |
| 1.00 | Feb.25.21 | — | First release document |
| 1.10 | Jan.25.22 | 1 | Update to Operating Environment |
| | | — | Changed version FSP to v3.5.0 |
| | | — | Changed version QE for Capacitive Touch to v3.0.1 |
| | | 4, 27, 28 | Changed debugger to J-Link |
| | | 10 | Added Setup Configuration |
| | | | |

# 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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