

## Renesas RA Family

## QE for Capacitive Touch usage for Keil® MDK

### Introduction

This document will demonstrate how to generate QE code for Capacitive Touch in e<sup>2</sup> studio and copy QE code to Keil® MDK for ARM using Renesas RA Microcontrollers.

### Target Device

Capacitive Touch Evaluation System for RA2L1 (RSSK RA2L1)

### Operating Environment

<b>IDE</b>	Keil® Microcontroller Development Kit Version 5.36 or later e <sup>2</sup> studio version 2021-10 is used for Capacitive Touch tuning and code generation
<b>Configuration Tool</b>	RA Smart Configurator (RA SC) v2021-10 and FSP v3.5.0
<b>Toolchains</b>	GNU Arm Embedded Toolchain: 10.3-2021.10 (GNU ARM Embedded 10.3.1.20210824)
<b>QE</b>	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 e<sup>2</sup> studio installer download site:  
<https://github.com/renesas/fsp/releases>
- Keil® MDK Getting Started site:  
<https://www2.keil.com/mdk5/install>

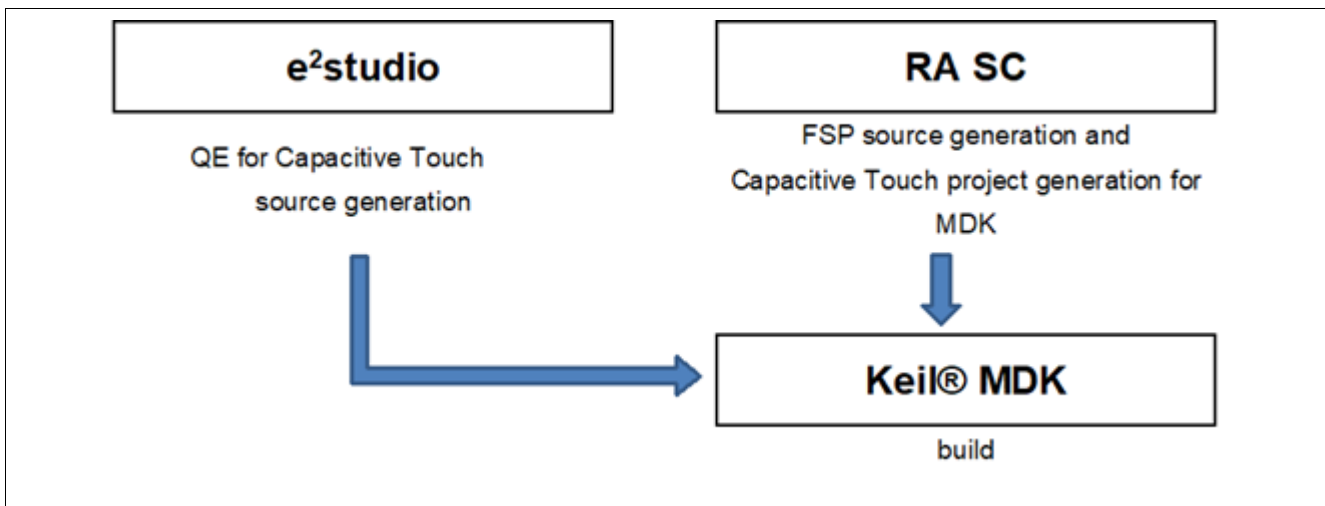


Figure 1. Configuration diagram when using QE for Capacitive Touch with Keil® MDK

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## 1. Creating a project in e<sup>2</sup> studio

A project generation wizard is available in e<sup>2</sup> studio to generate an RA project with a project name and the associated device and board, including board-level drivers.

Start the e<sup>2</sup> studio application and choose a workspace folder in the Workspace Launcher. To create a new RA project, follow these steps:

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

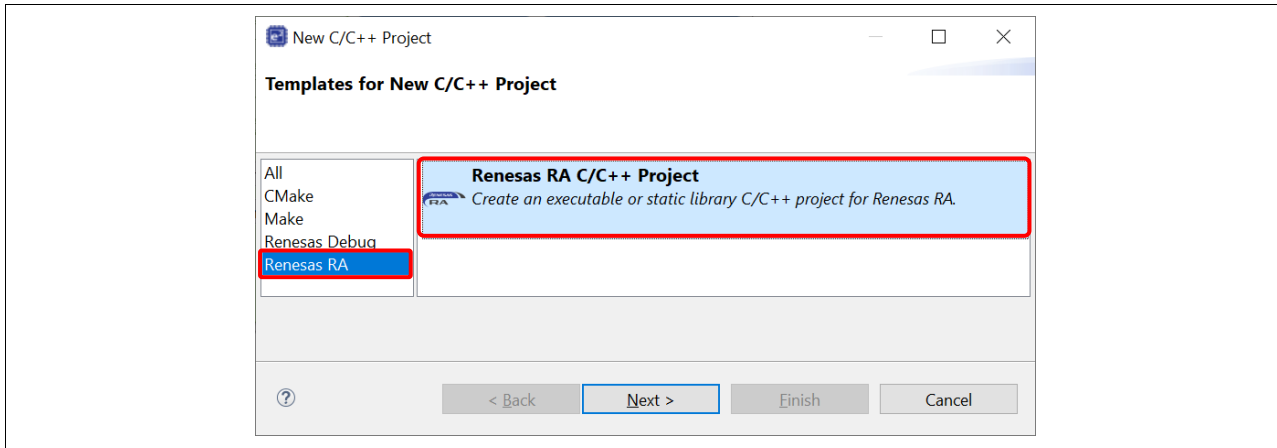


Figure 2. Templates Selection

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

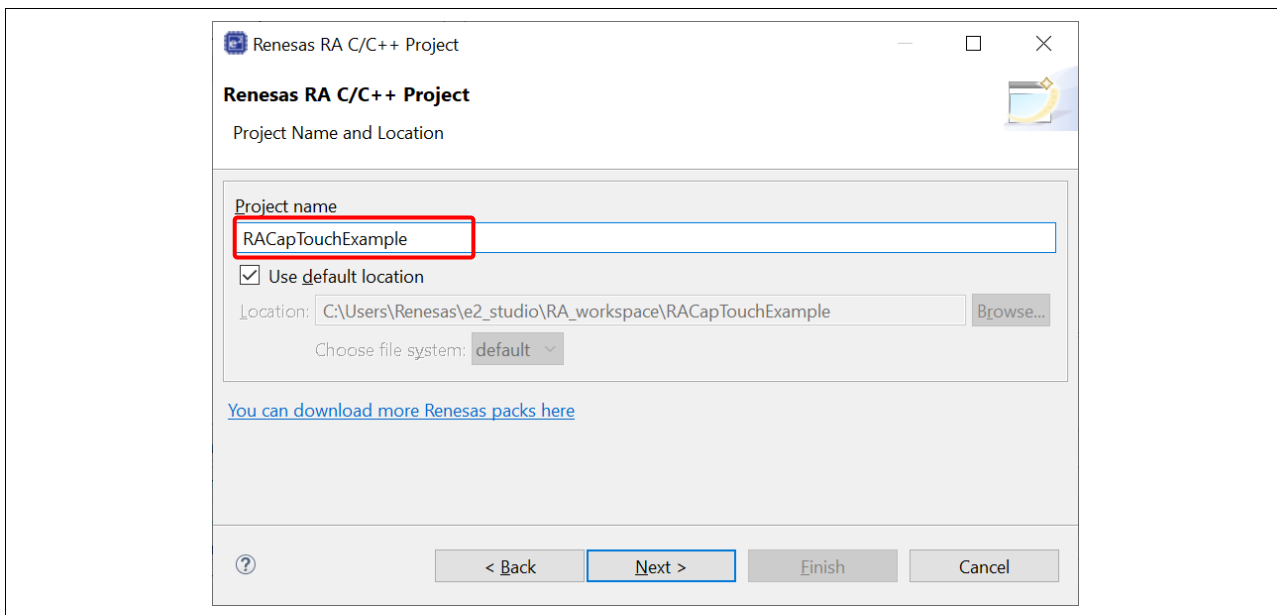


Figure 3. Project Name and Location

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

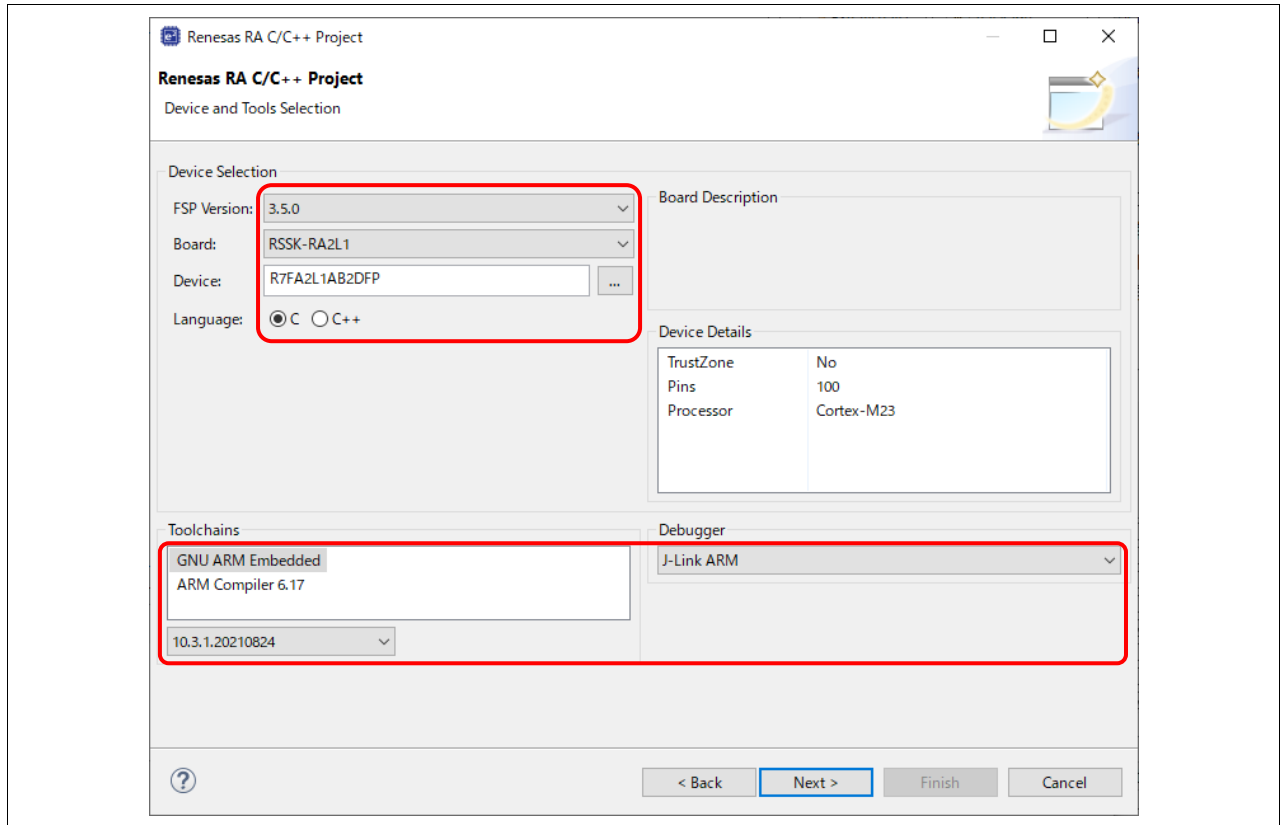


Figure 4. Create New Project for RSSK-RA2L1

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

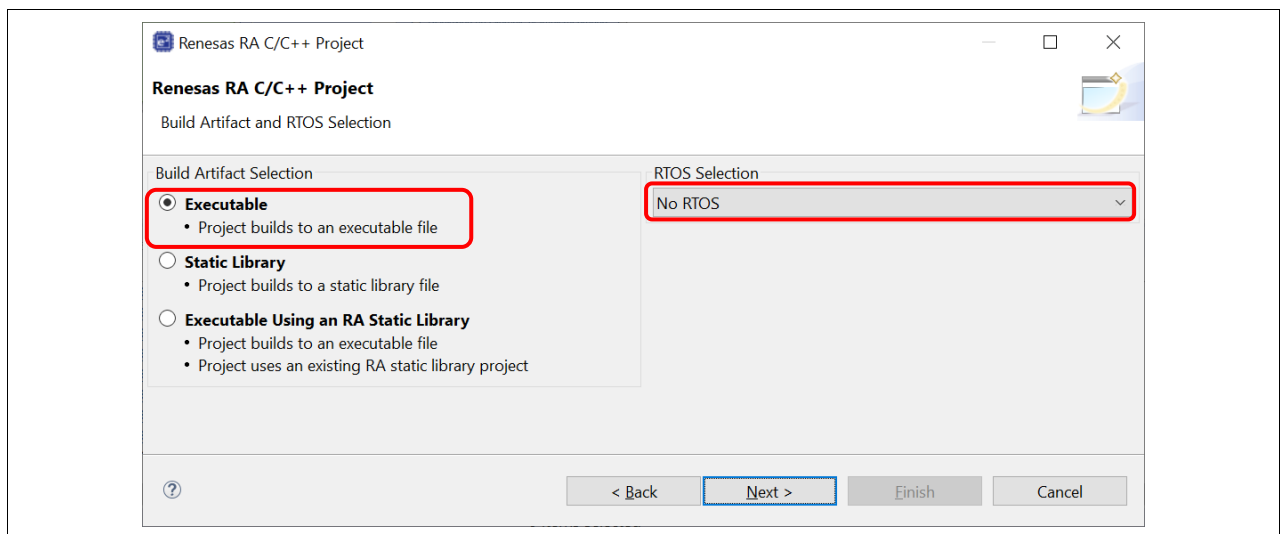
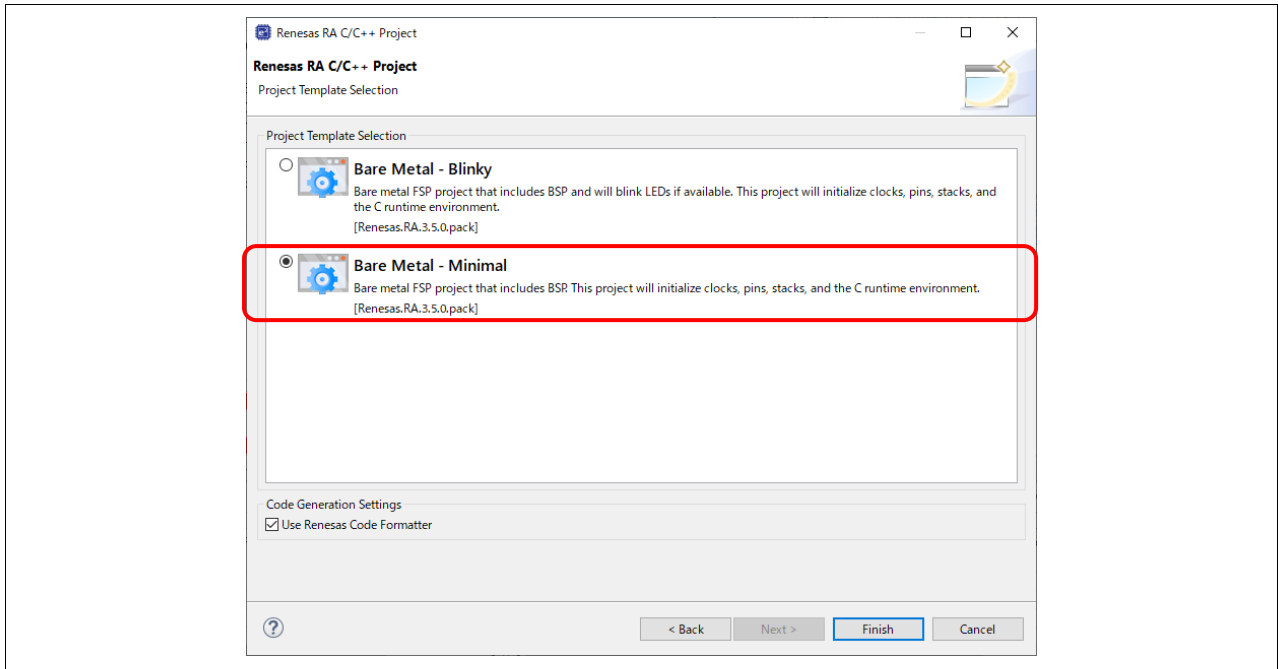


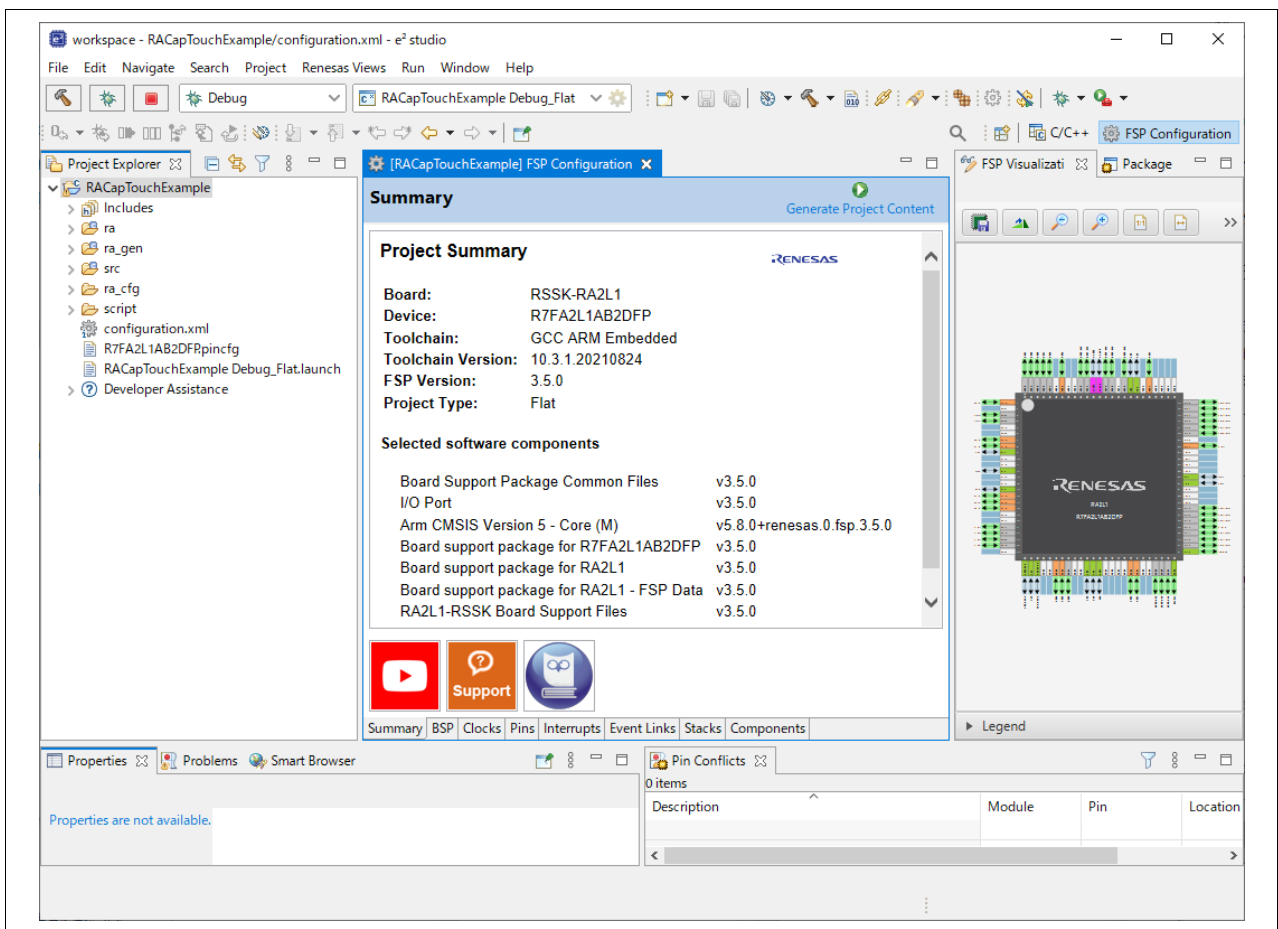
Figure 5. Build Artifact and RTOS Selection

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



**Figure 6. Project Template Selection**

7. Once template selection is complete, e<sup>2</sup> 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 e<sup>2</sup> studio

1. If you have not installed the QE for Capacitive Touch, select **Renesas Views > Renesas Software Installer** from the menu of e<sup>2</sup> 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.

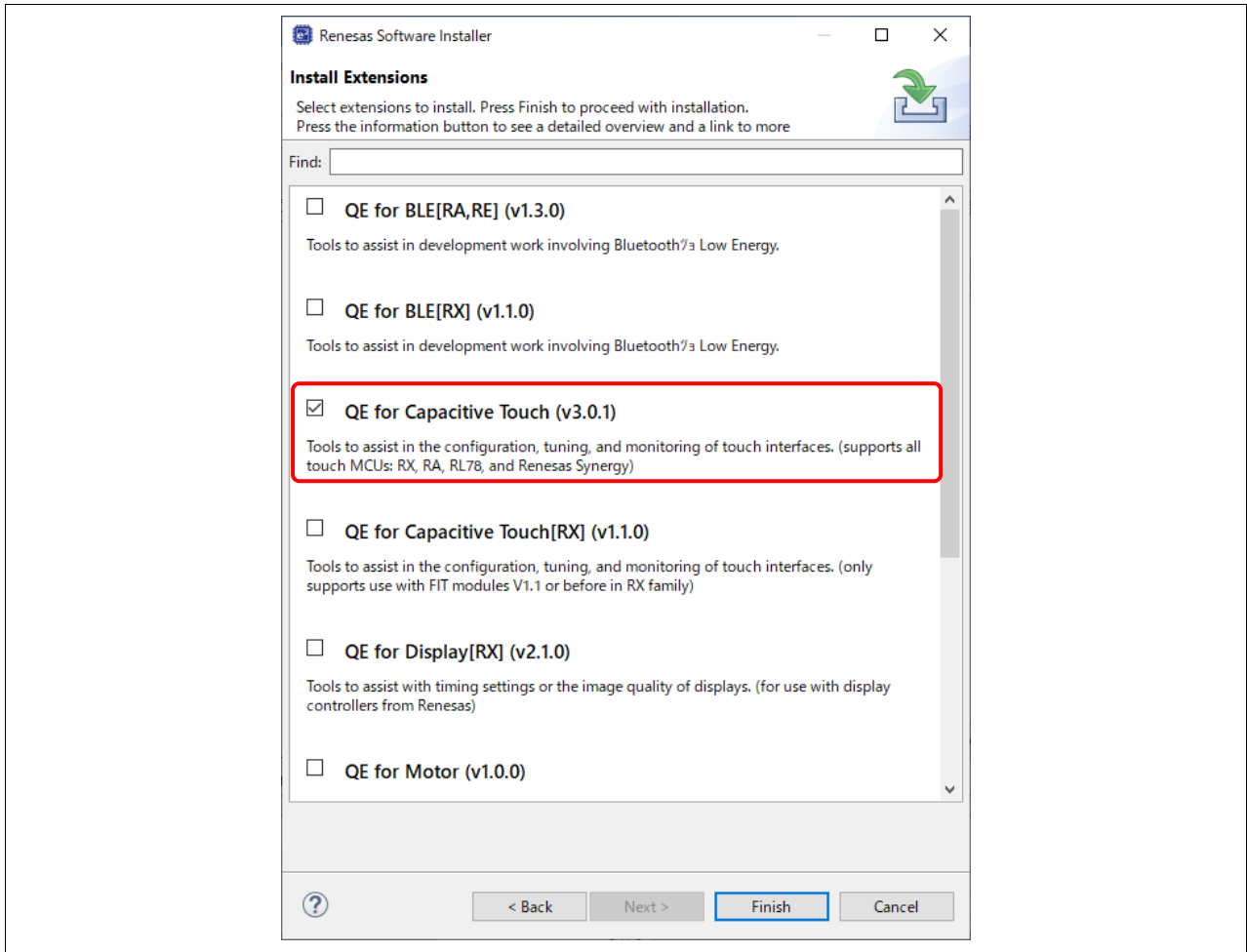


Figure 8. Install QE for Capacitive Touch

4. From the menu of e<sup>2</sup> studio, select **Renesas Views > Renesas QE > CapTouch Main (QE)** to open the main perspective for configuring Capacitive Touch to the project.

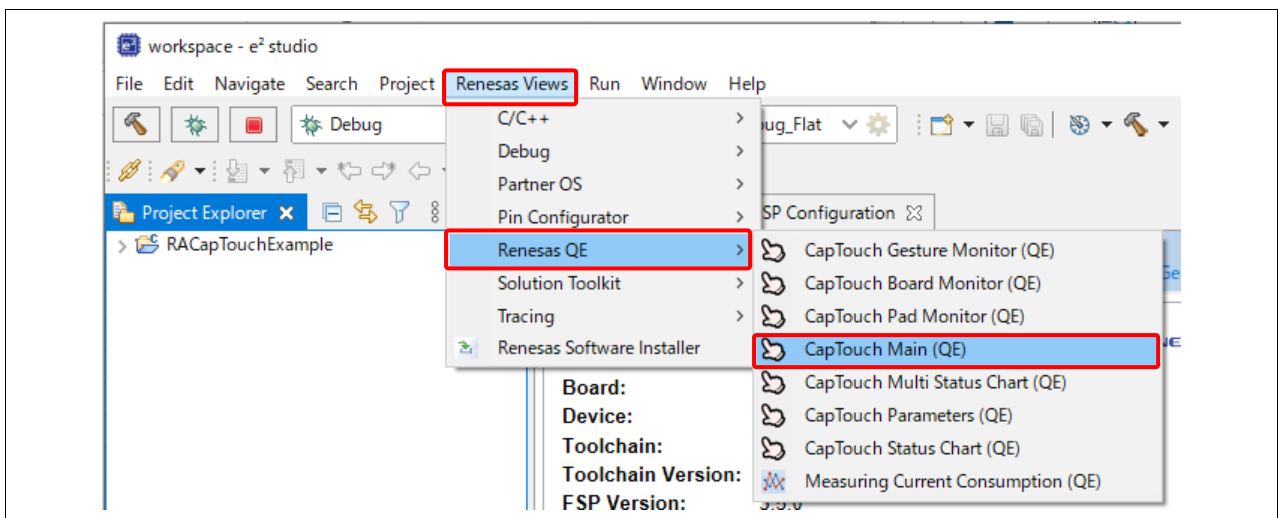


Figure 9. Open CapTouch Main (QE)

- 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.

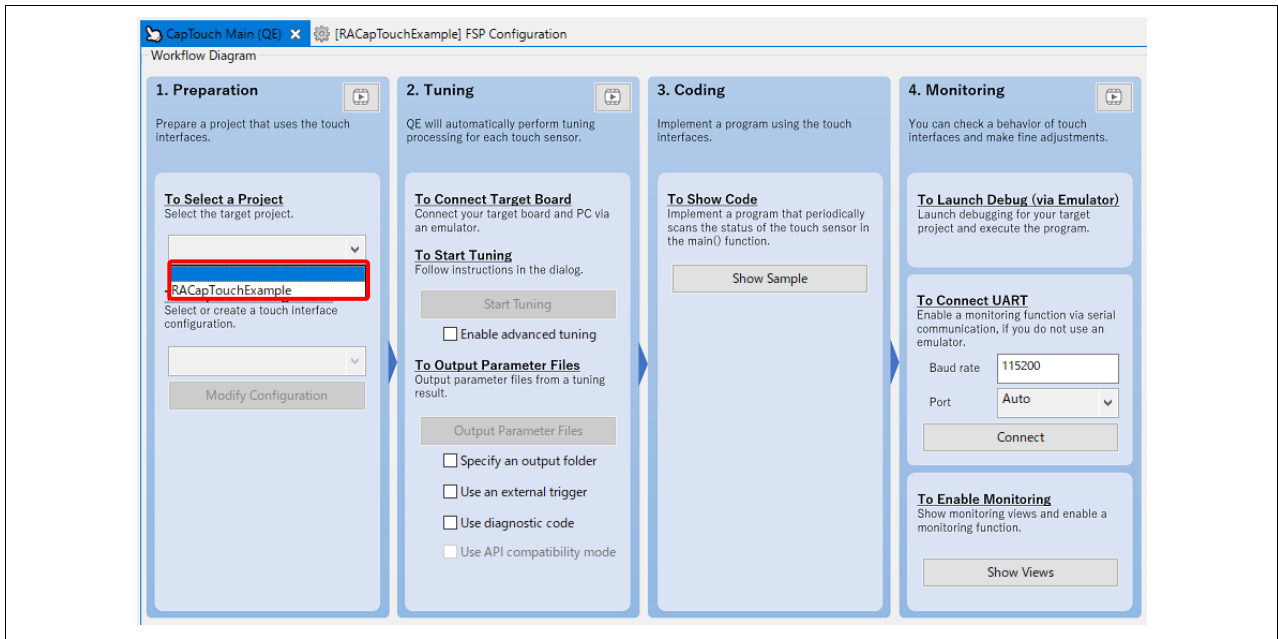


Figure 10. Select Project

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

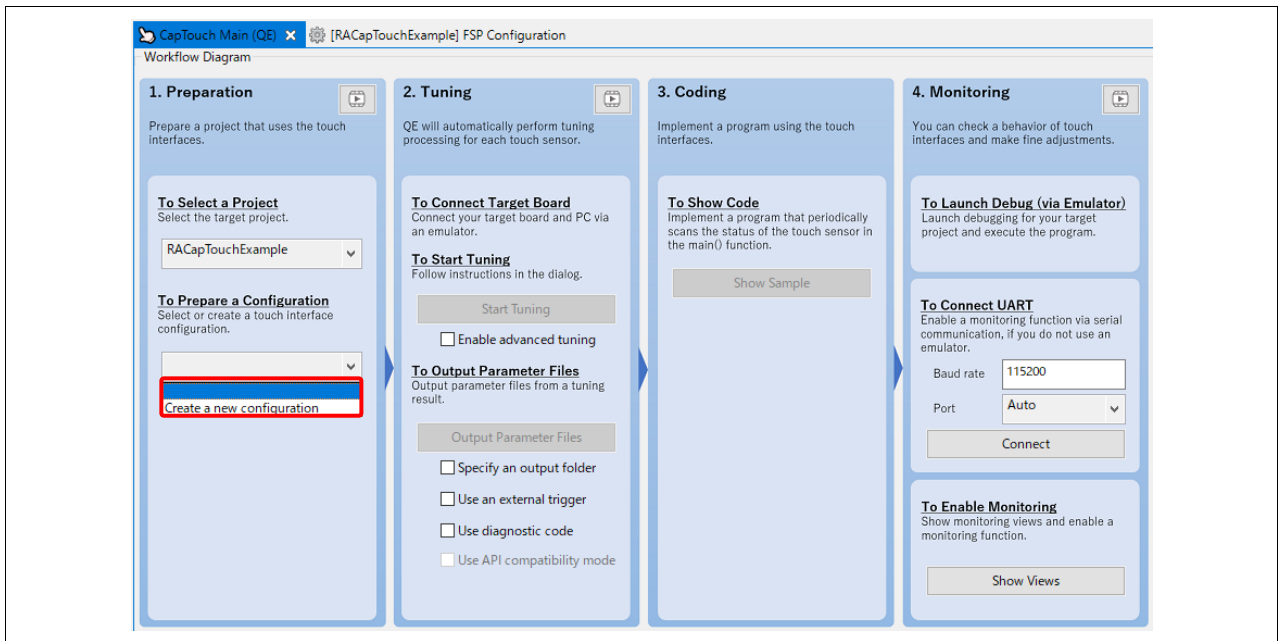


Figure 11. Create New Touch Configuration

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

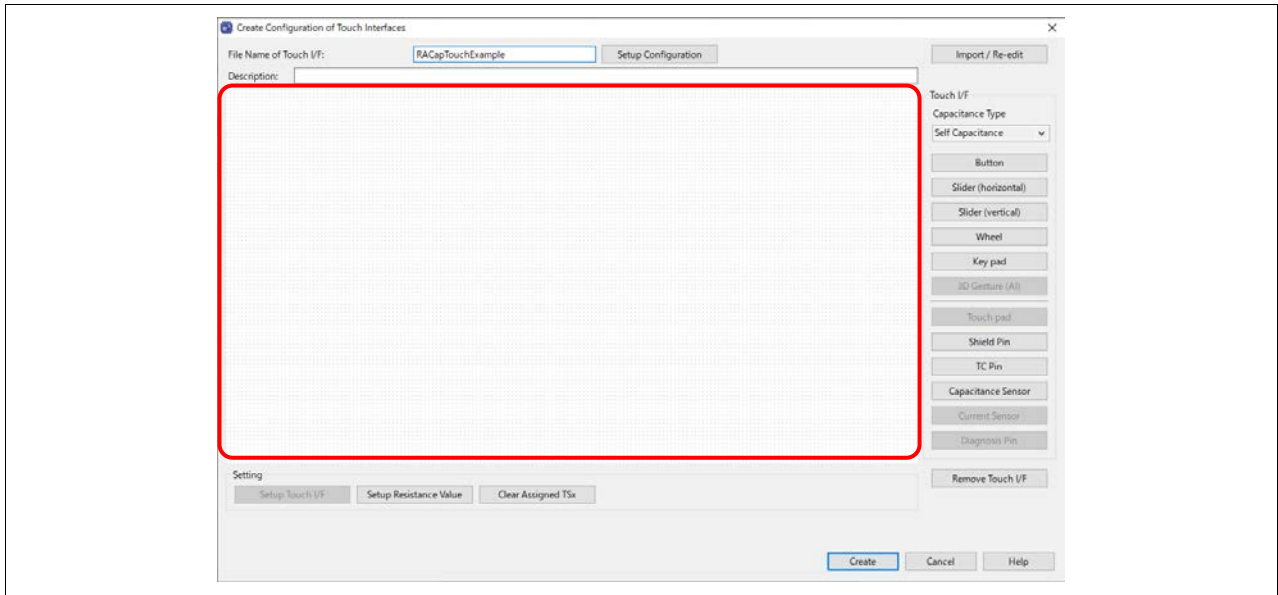


Figure 12. Blank Canvas

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.

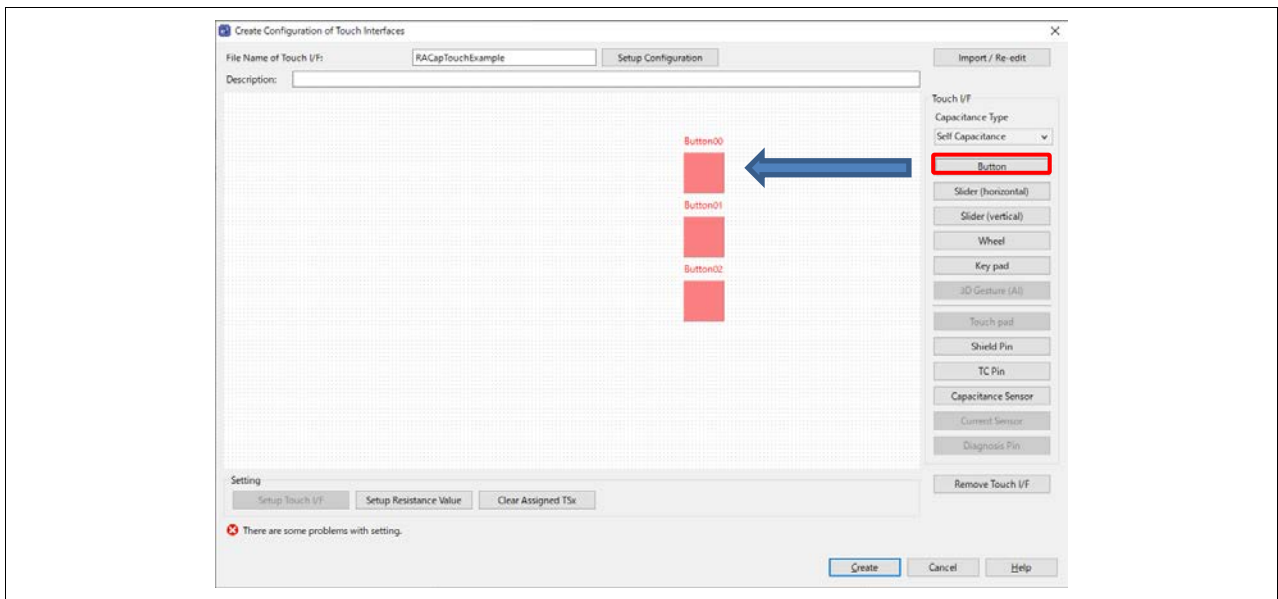


Figure 13. Create New Touch Button



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.

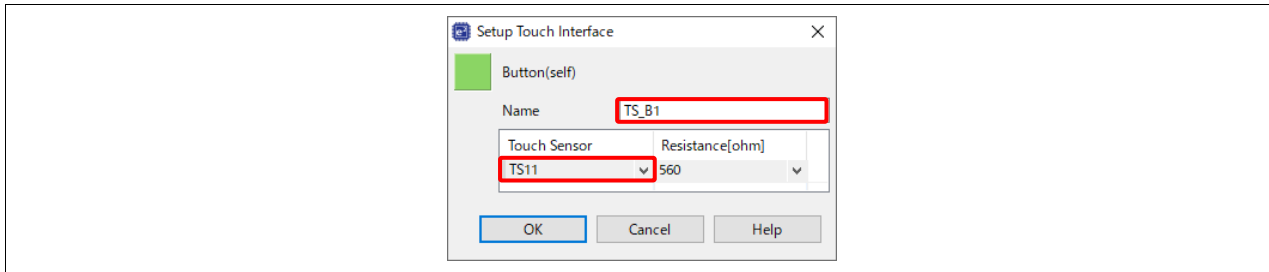


Figure 14. Assign Touch Sensor to Button

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.

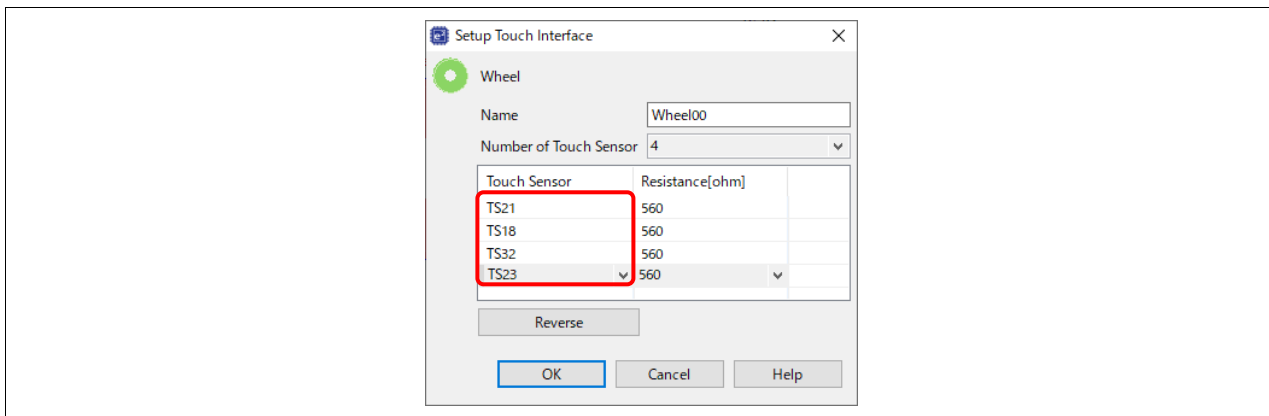


Figure 15. Assign Touch Sensor to Wheel

12. Select 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. Using the pull-down and select TS06, TS07, TS05, TS02 and TS04 as the MCU sensors to assign to this slider.

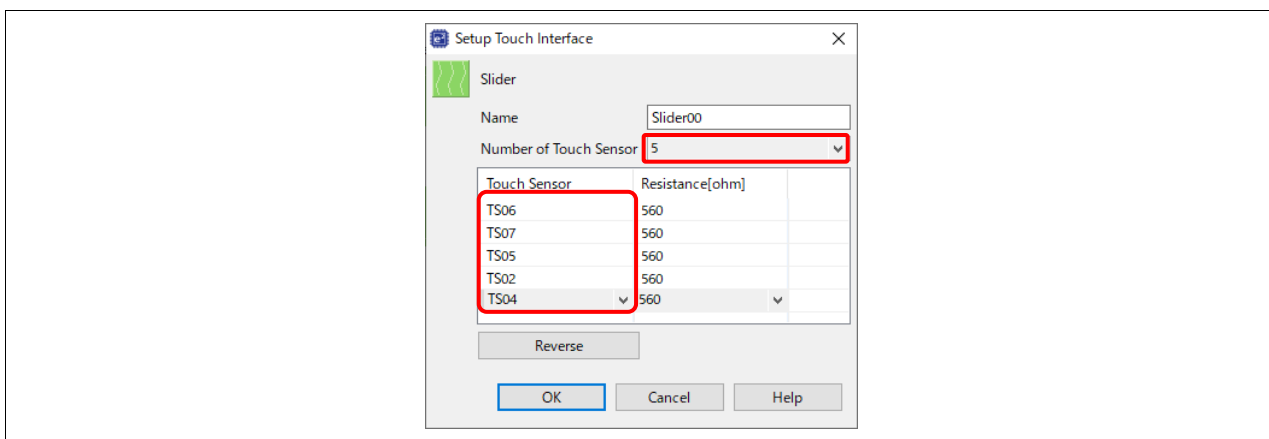
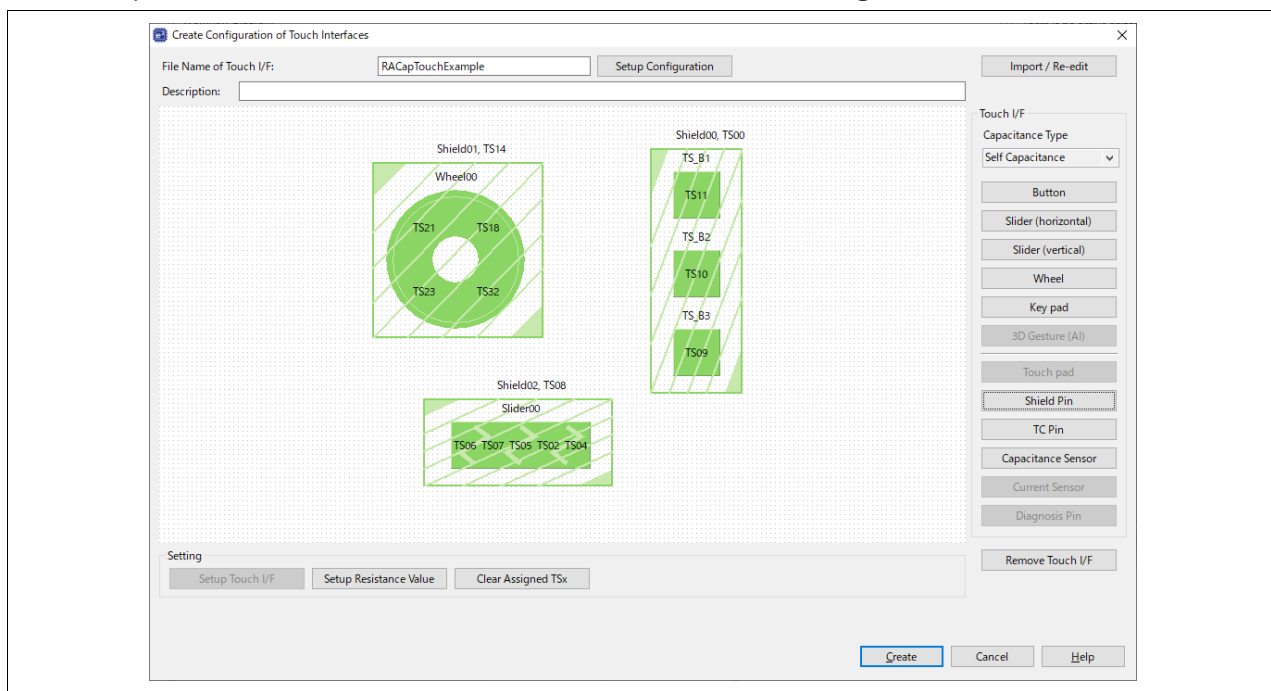


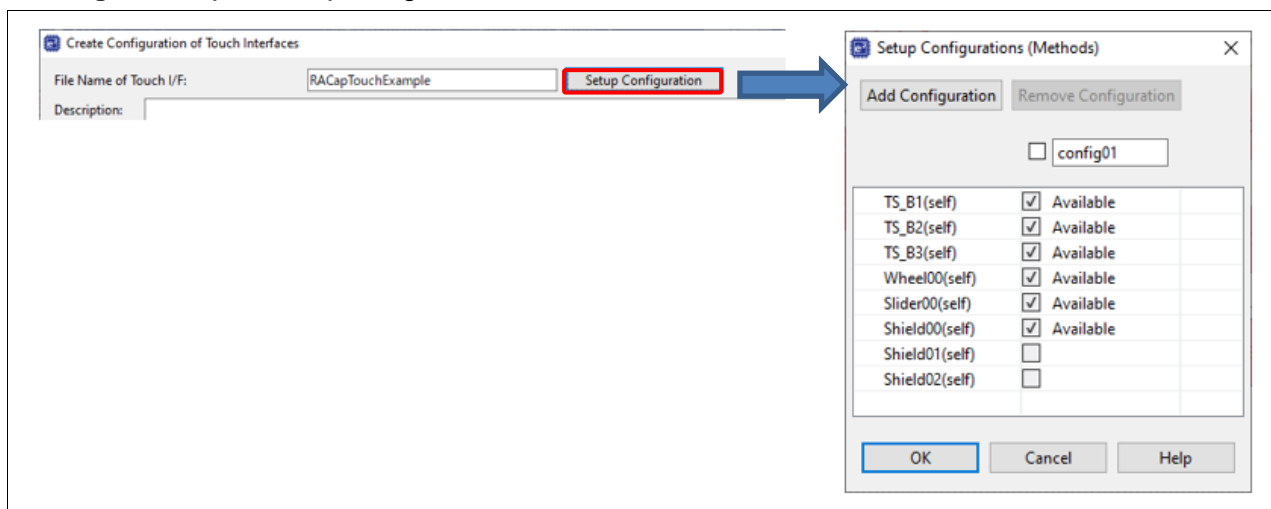
Figure 16. Assign Touch Sensor to Slider

14. Select the **Shield Pin** menu item from the right-hand side.
  - a. Add the 1st shield to canvas to cover the 3 buttons.
  - b. Add the 2nd shield to canvas to cover the wheel.
  - c. Add the 3rd shield to 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**.



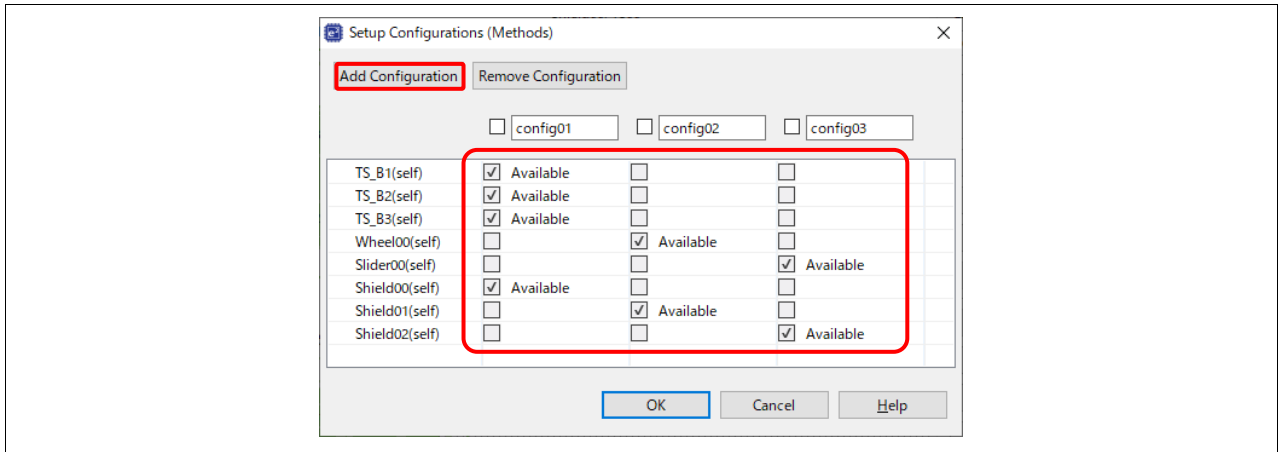
**Figure 17. Complete New Touch Interface**

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 Configurations (Methods)**

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.

Touch I/F Configuration: RACapTouchExample

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.

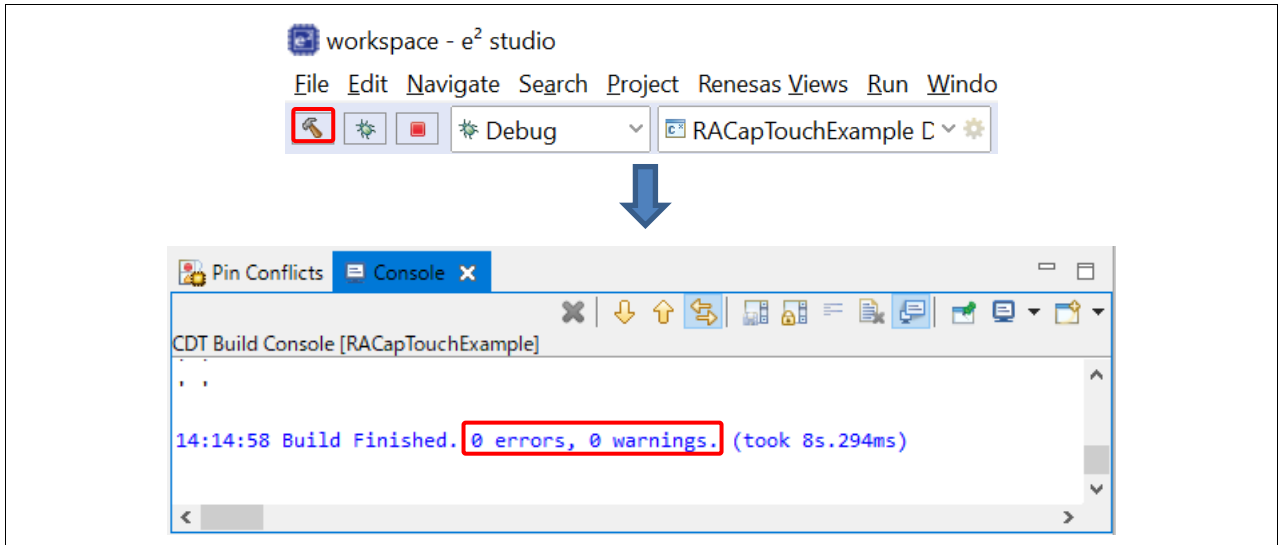


Figure 21. Build Project

### 3. Capacitive Touch Tuning in e<sup>2</sup> 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 CapTouch Main (QE).

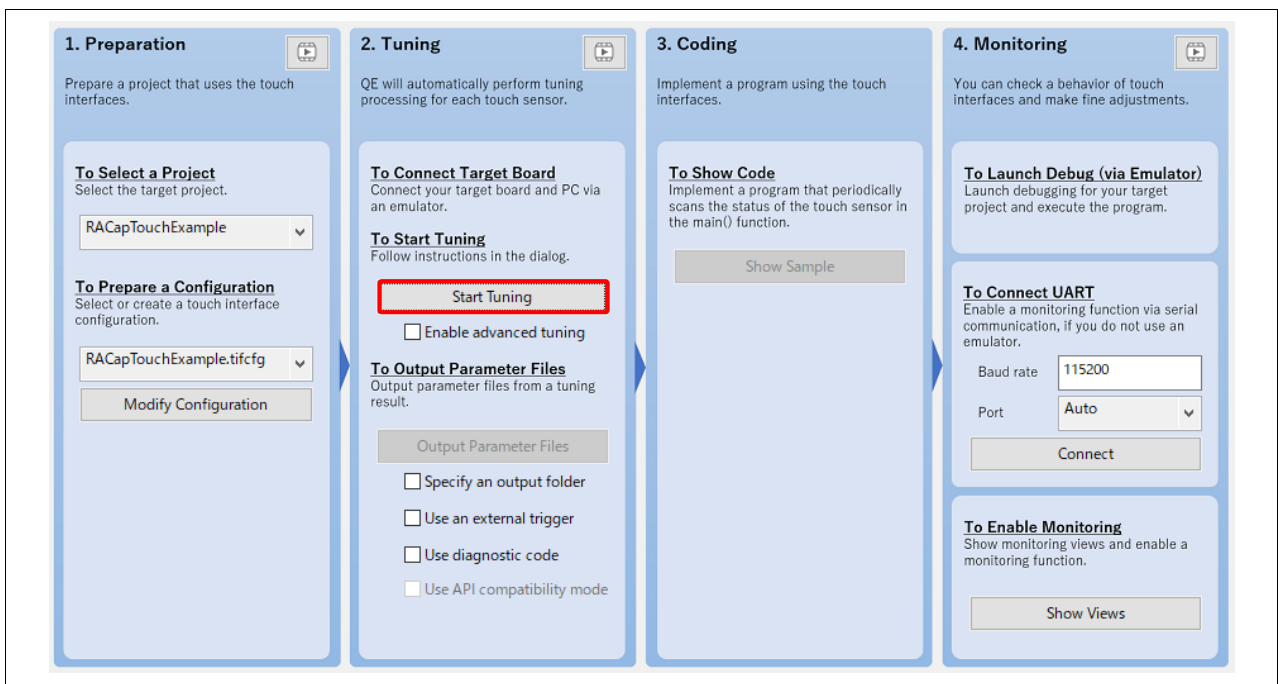
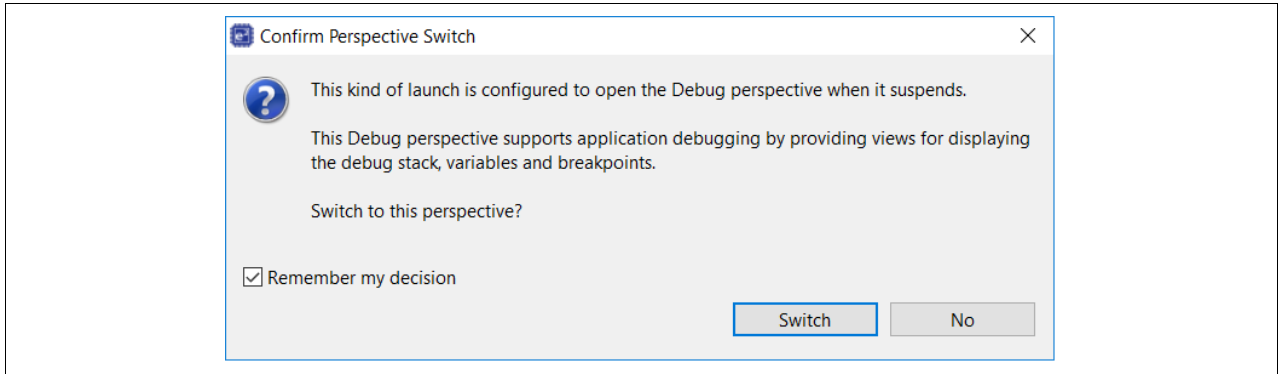


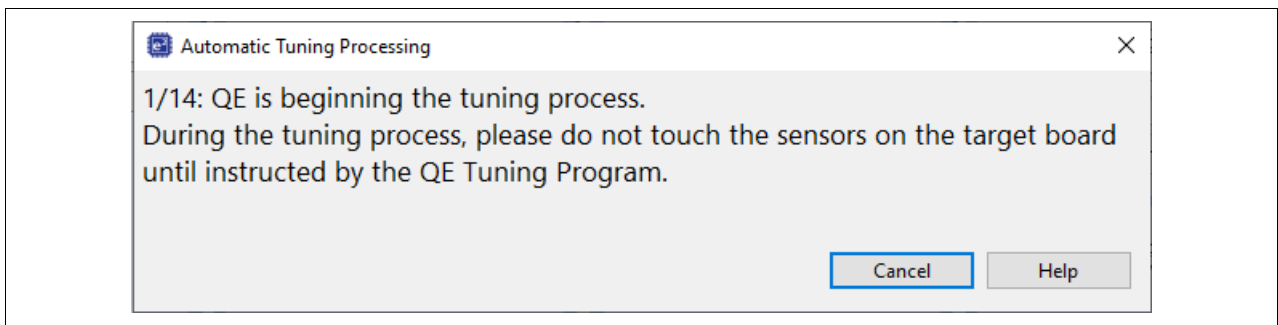
Figure 22. Start Tuning

- At the start of the first debug session, e<sup>2</sup> studio may display a message indicating the Debug perspective will be switched to. Click the **Remember my decision** check box and **Switch** to continue the Debug process and the QE for Capacitive Touch automatic tuning.



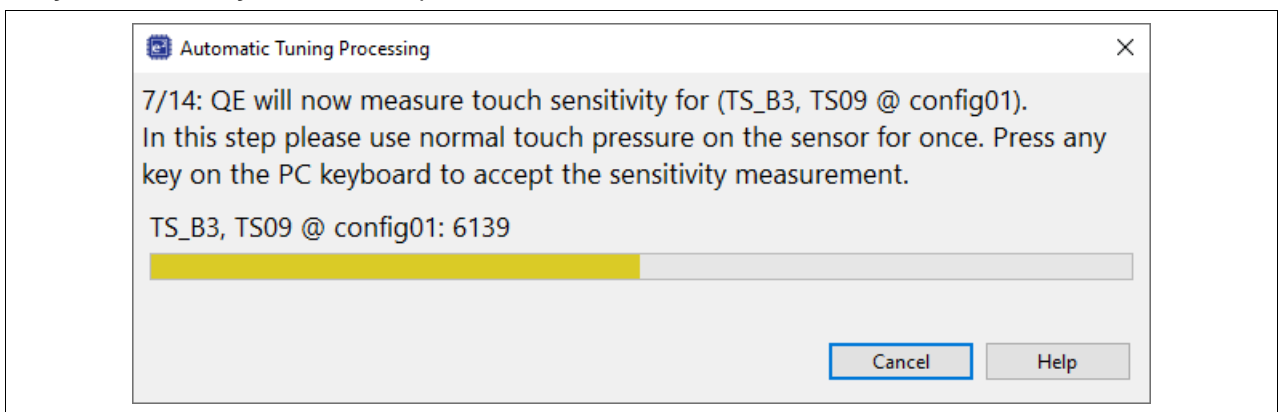
**Figure 23. Switch Perspective**

- QE for Capacitive Touch 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**

- 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 pressing 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.

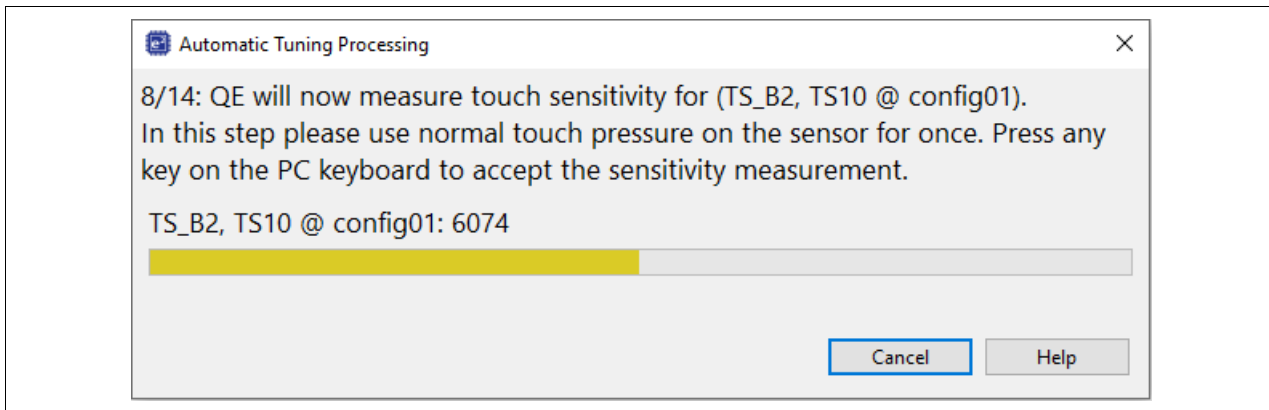


Figure 26. Measure Touch Button TS\_B2

- 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.

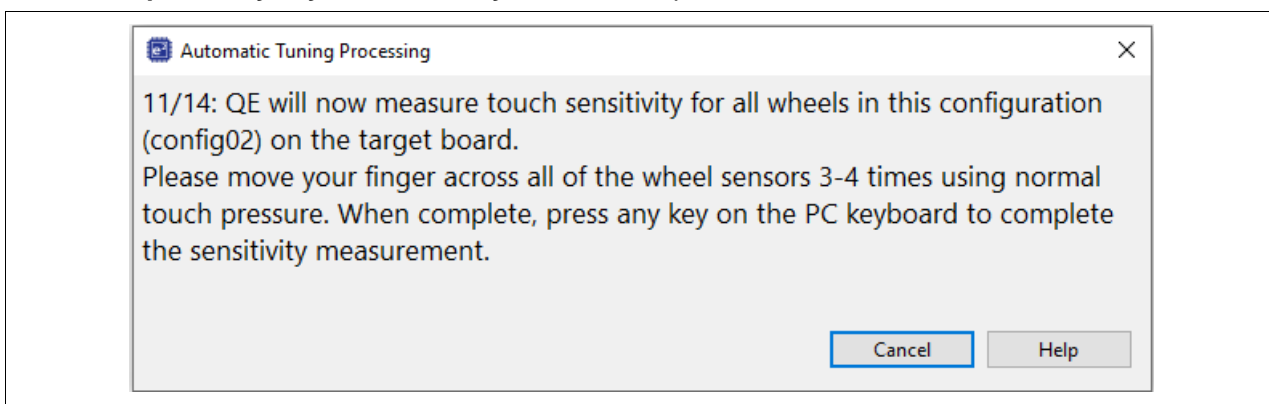


Figure 27. Repeat Measurement 3 Times

- 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.

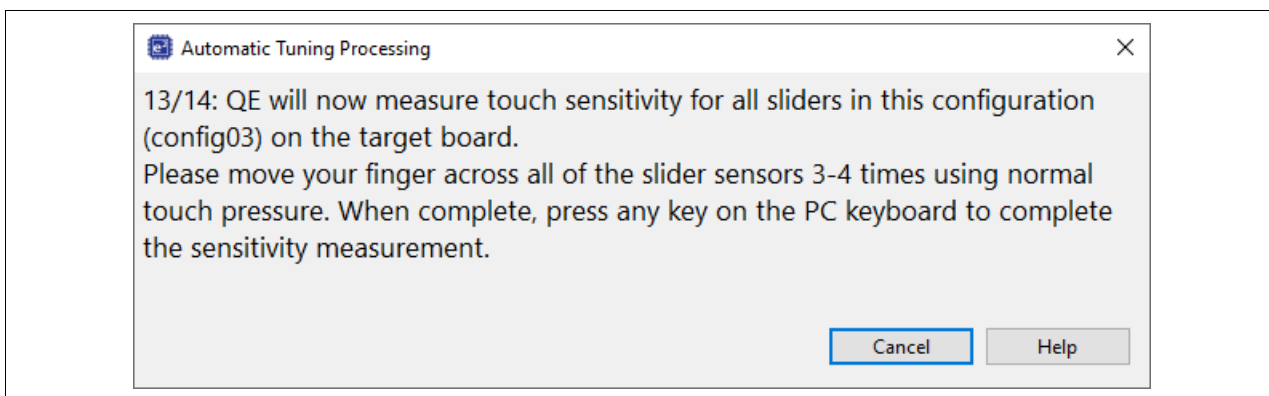


Figure 28. Repeat Measurement 3 Times

- 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.

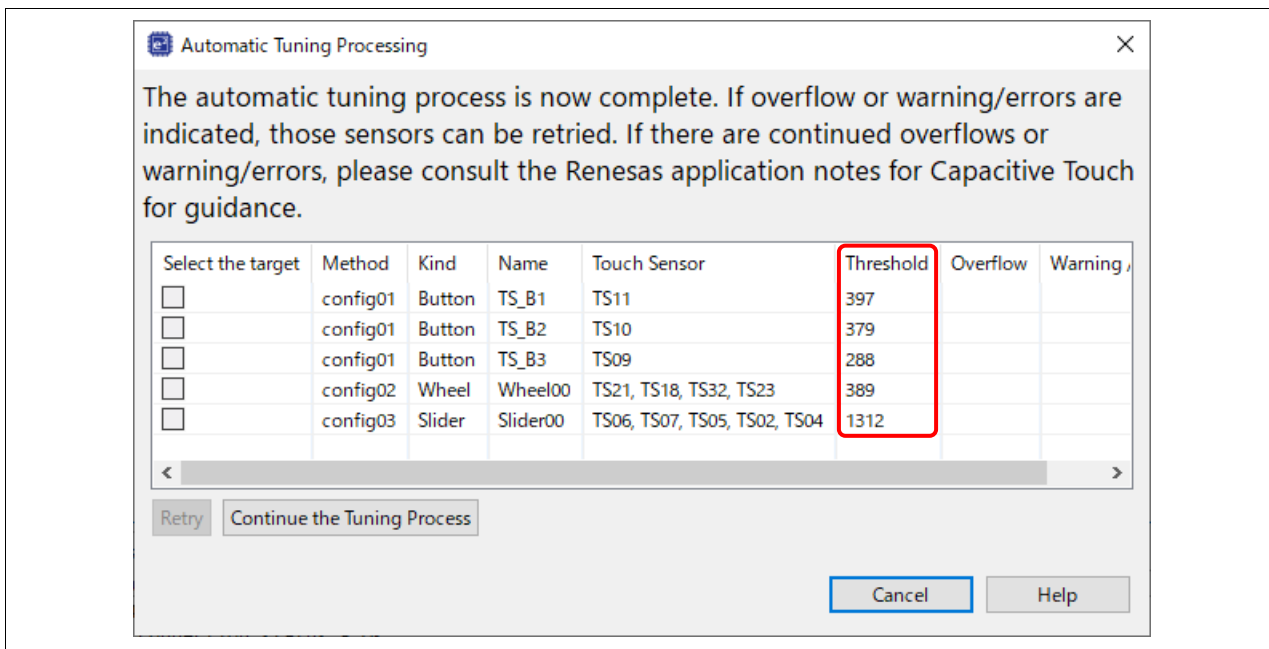


Figure 29. Threshold for Touch Event

- 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<sup>2</sup> studio IDE.

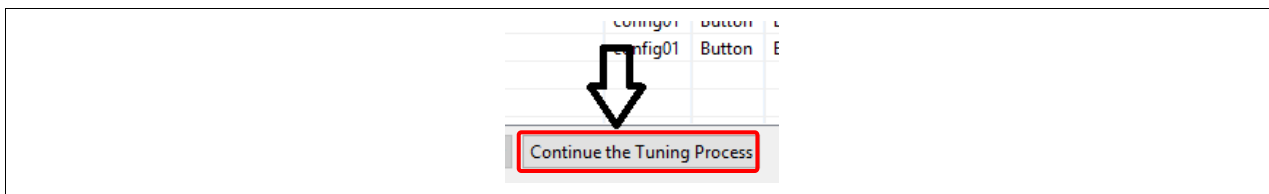


Figure 30. Continue the Tuning Process

- 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.

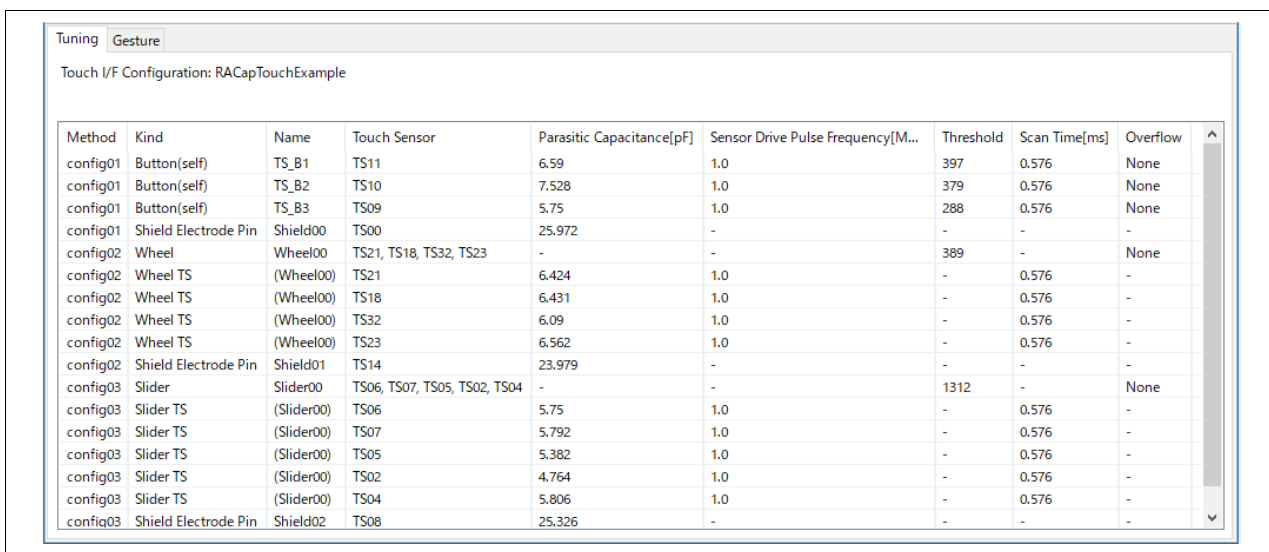
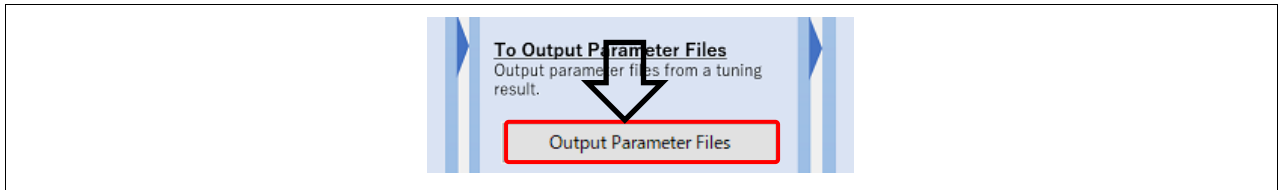


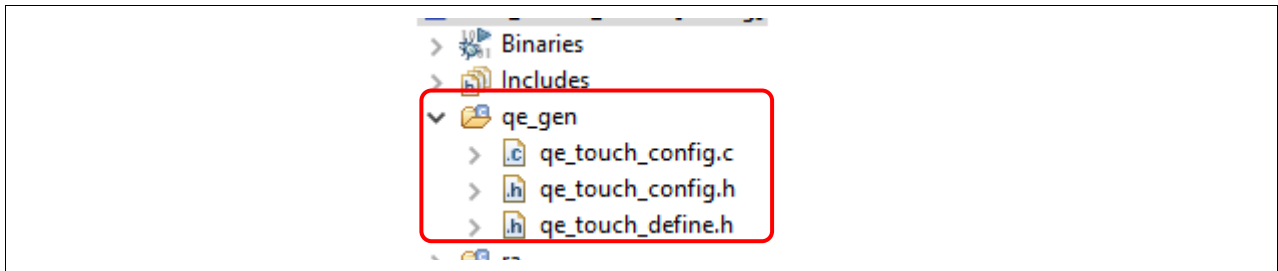
Figure 31. Tuning Result

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



**Figure 32. Continue the Tuning Process**

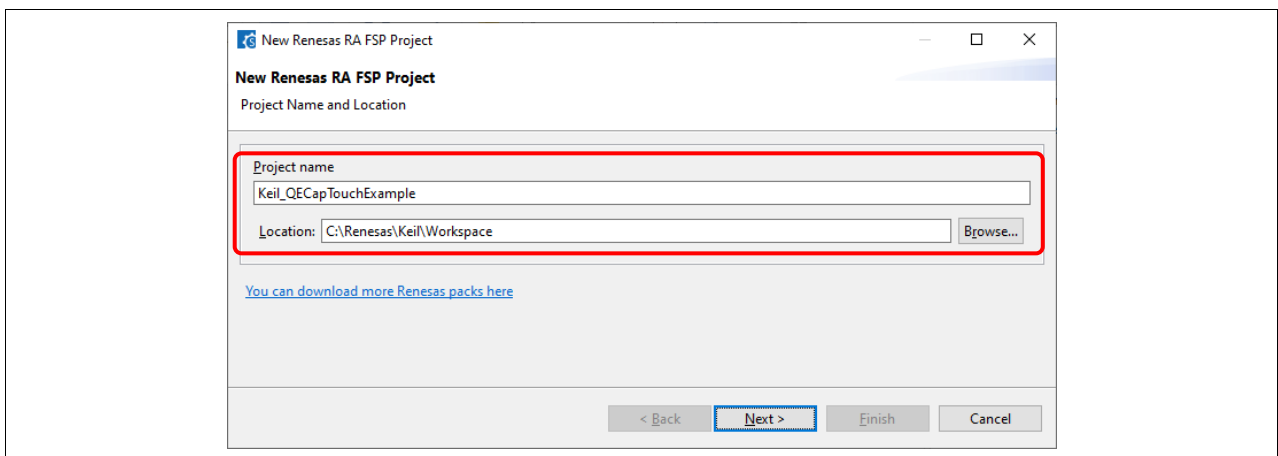
13. Look at the **Project Explorer** window and you will see that files have been added. These contain the needed tuning information to enable Touch detection using the **r\_ctsu** and **rm\_touch** FSP modules.



**Figure 33. Output Parameter Files**

#### 4. Creating new project in Keil® MDK

1. Install the Keil® Microcontroller Development Kit version 5.36 or later (for RA device support) from <https://www2.keil.com/mdk5/install>.
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. Import the RA device pack. See “2.6.2 Using RA Smart Configurator with Keil MDK” in the Renesas Flexible Software Package (FSP) User’s Manual for details.  
<https://www.renesas.com/us/en/software-tool/flexible-software-package-fsp#document>
4. 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**



- 5. Device and Tools Selection.
  - Board: **RSSK-RA2L1**
  - Device: Auto selected
  - Language: **C**IDE Project Type: **Keil MDK Version 5**  
Toolchains: **ARM Compiler 6**

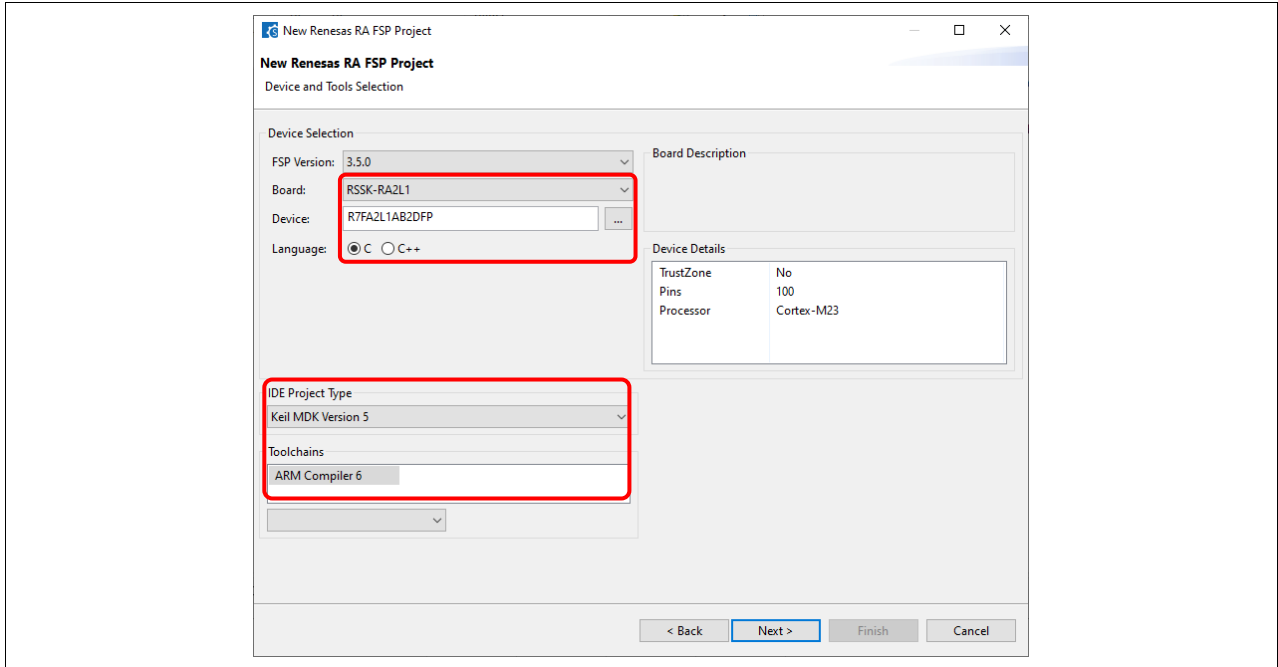


Figure 35. Board Selection for RSSK RA2L1

- 6. RTOS Selection: **No RTOS**.

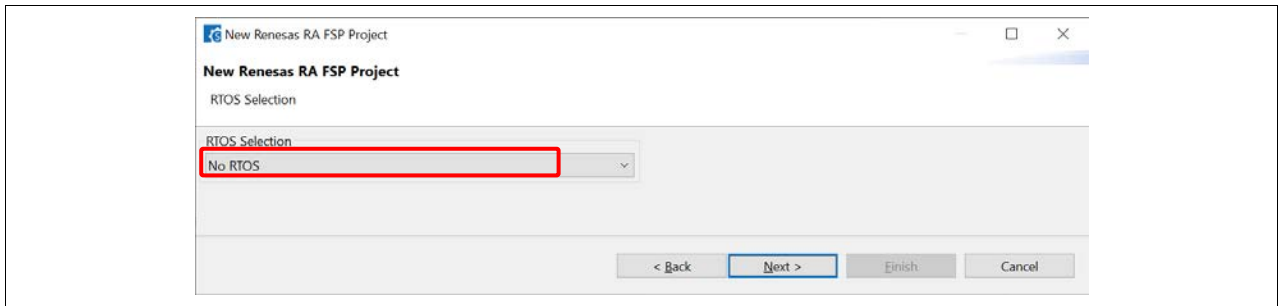


Figure 36. RTOS Selection

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

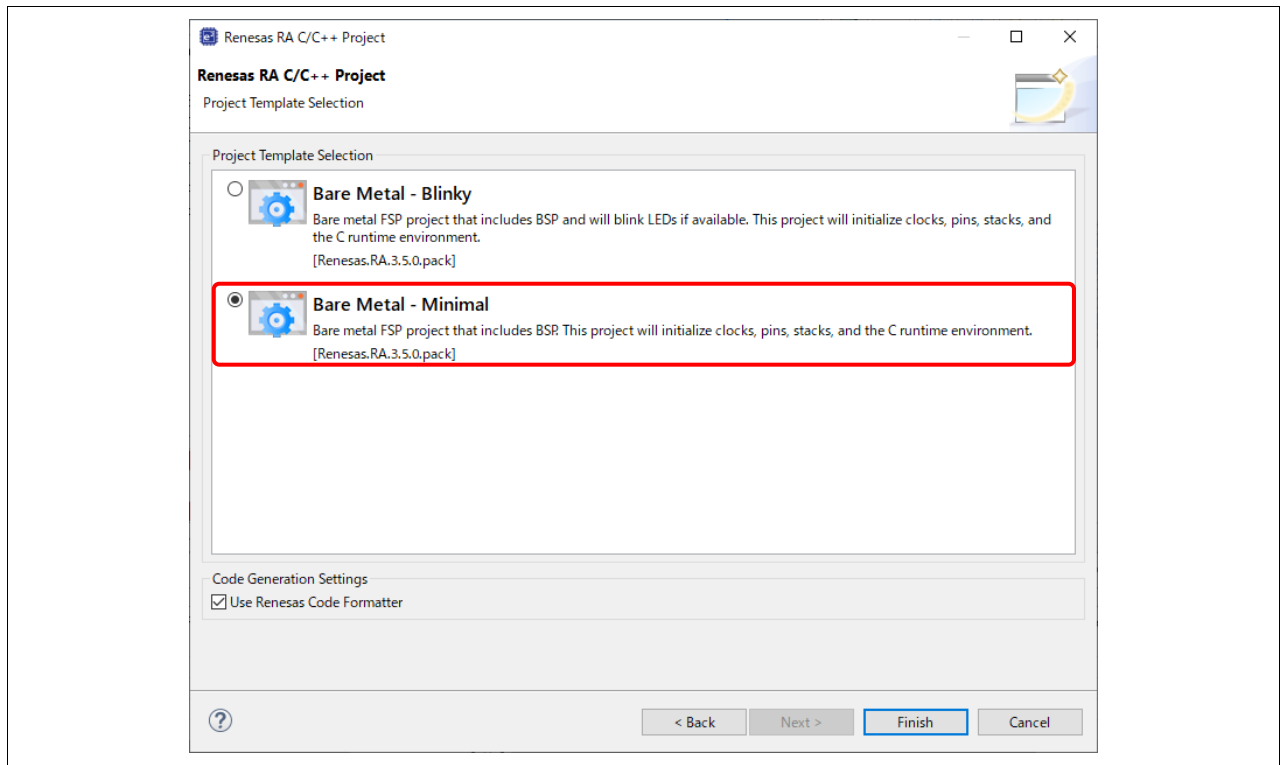
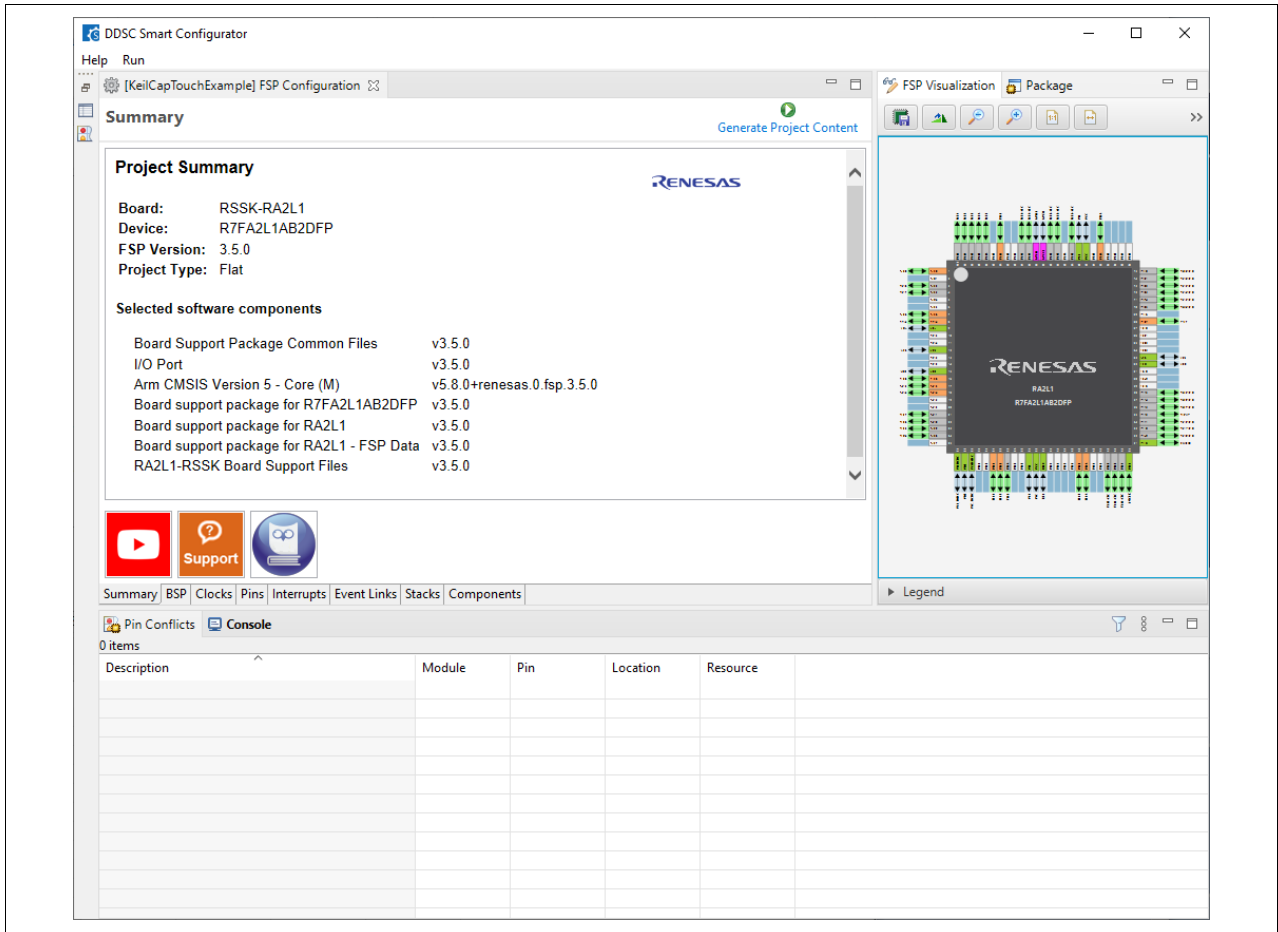


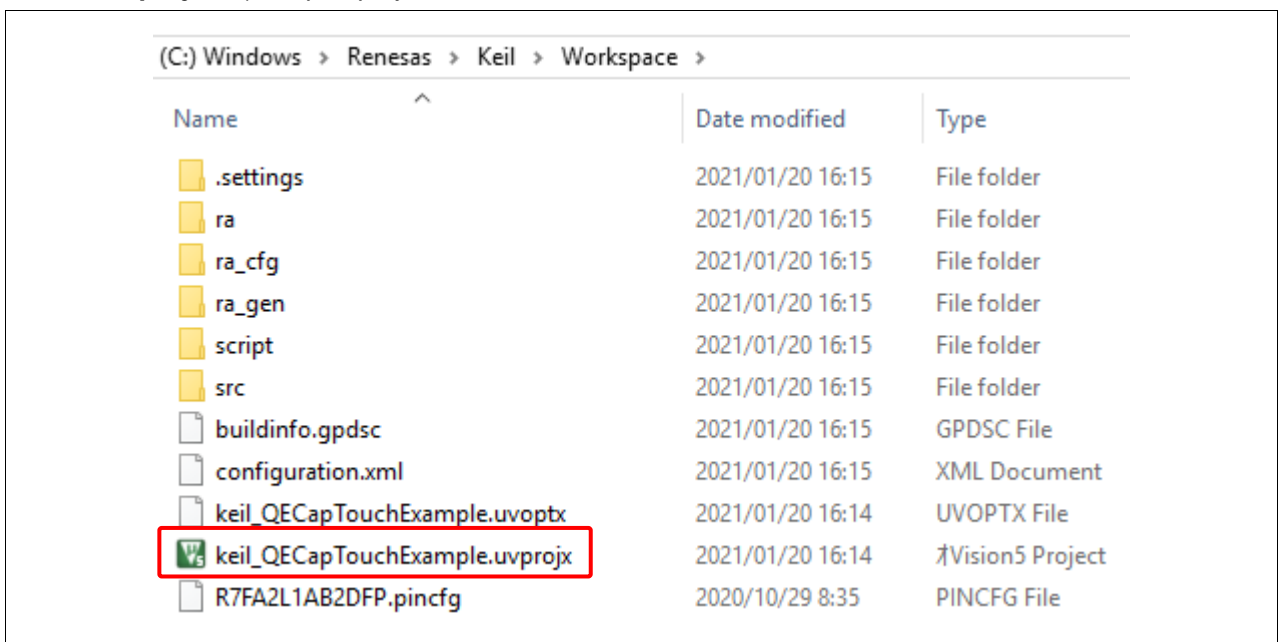
Figure 37. Template Selection

8. After creating the project, the **DDSC Smart Configurator** window will pop-up.



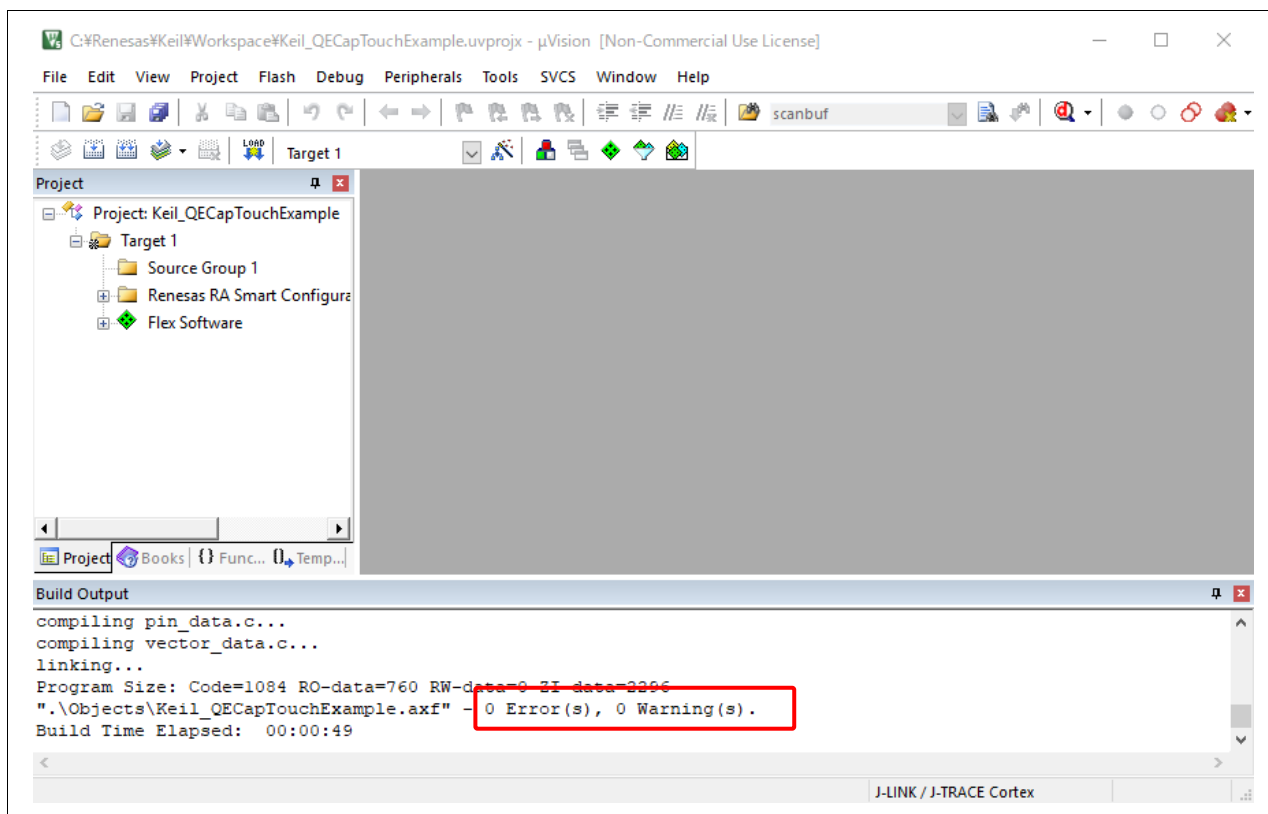
**Figure 38. Smart Configurator Window**

9. Navigate to the project location in Windows Explorer and double-click on the main workspace (Keil® MDK \*.uvprojx file) to open project.



**Figure 39. Project Location**

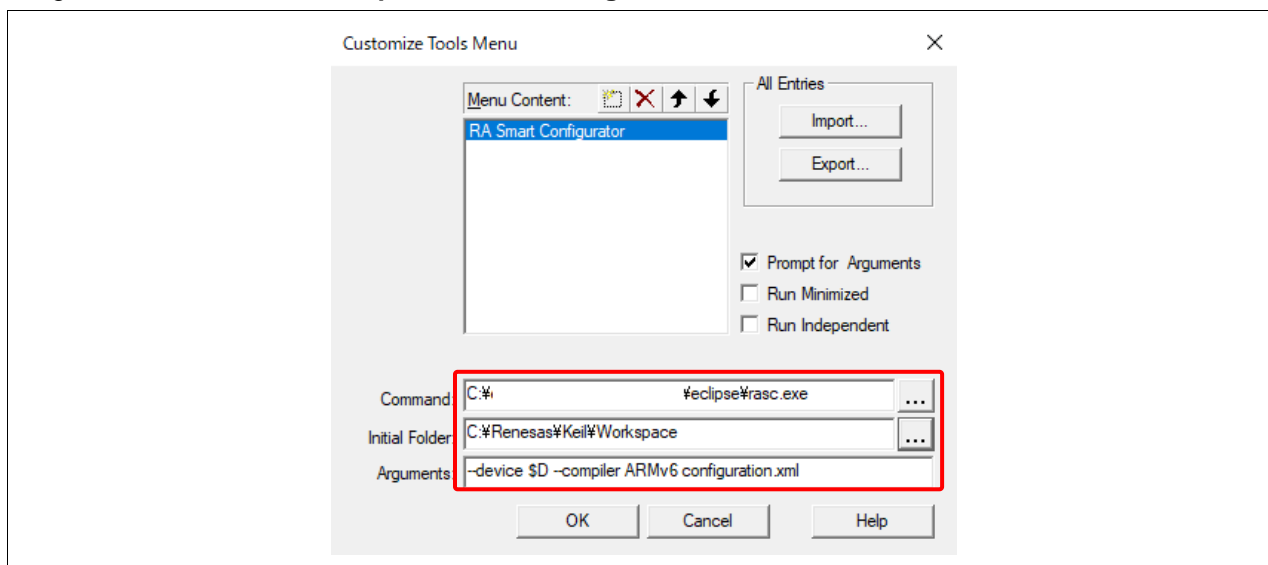
- Project is opened by Keil® MDK. Right-click on the project and select **Rebuild all target files**. The project should be built without error.



**Figure 40. Project is Built Successfully**

- After a project created with the RA Smart Configurator has been opened in Keil® MDK, 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.
- In the menu of Keil® MDK, select **Tools > Configure Tools Menu...** Then, select **New** and fill in the fields as follows.

Menu Text: **RA Smart Configurator**  
 Command: Select **Browse...** and navigate to **rasc.exe**  
 Initial Folder: Select **Browse...** and navigate to **Workspace**  
 Argument: **--device \$D --compiler ARMv6 configuration.xml**



**Figure 41. How to Use RA Smart Configurator in Keil® MDK**

- Now, an FSP configuration of a created project can be reopened by selecting **Tool > RA Smart Configurator** in Keil® MDK.

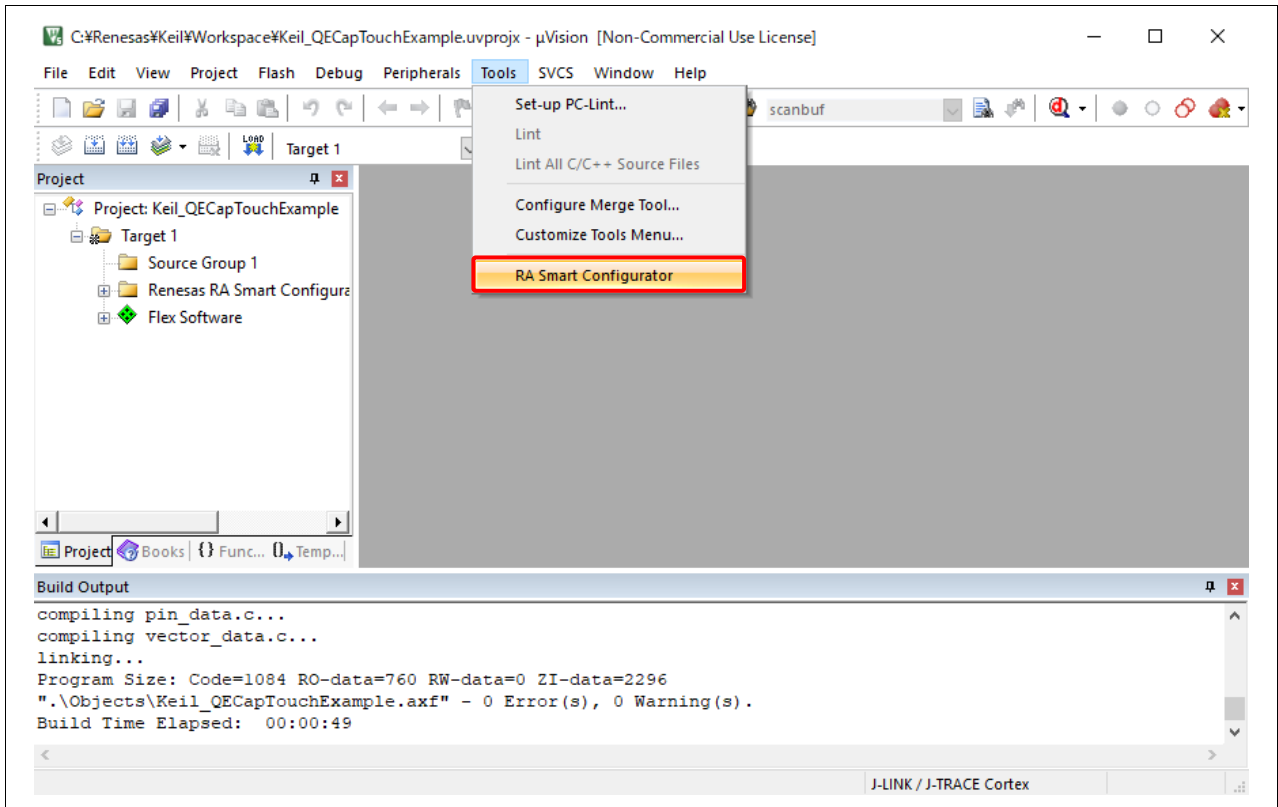


Figure 42. RA Smart Configurator Has Been Added

## 5. Adding TOUCH Driver in Keil® MDK

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

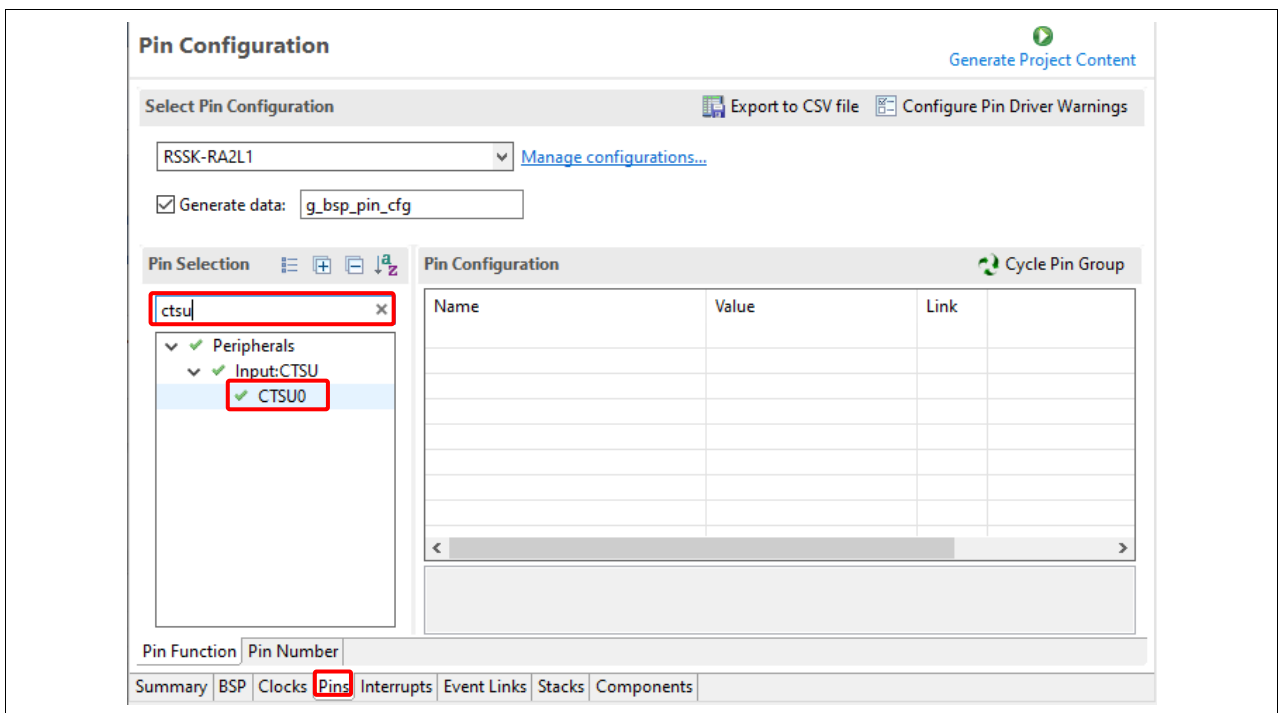


Figure 43. Select Pin CTSU0

- Make sure the **Operation Mode** and the following **TS pins** 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.

The screenshot shows the 'Pin Configuration' window for the RSK-RA2L1 device. The 'Operation Mode' is set to 'Enabled'. The 'Input/Output' section is expanded, showing a list of TS pins. The following pins are highlighted with red boxes in the original image:

Name	Value	Lock	Link
Operation Mode	Enabled		
TSCAP	✓ P112	🔒	🔗
TS00	✓ P204	🔒	🔗
TS02-CFC	✓ P303	🔒	🔗
TS04	✓ P408	🔒	🔗
TS05	✓ P409	🔒	🔗
TS06	✓ P410	🔒	🔗
TS07	✓ P411	🔒	🔗
TS08-CFC	✓ P302	🔒	🔗
TS09-CFC	✓ P301	🔒	🔗
TS10-CFC	✓ P109	🔒	🔗
TS11-CFC	✓ P110	🔒	🔗
TS12-CFC	✓ P111	🔒	🔗
TS13-CFC	✓ P104	🔒	🔗
TS14-CFC	✓ P103	🔒	🔗
TS15-CFC	✓ P102	🔒	🔗
TS16-CFC	✓ P101	🔒	🔗
TS17	✓ P403	🔒	🔗
TS18	✓ P402	🔒	🔗
TS21	✓ P000	🔒	🔗
TS22	✓ P001	🔒	🔗
TS23	✓ P002	🔒	🔗
TS24	✓ P003	🔒	🔗
TS25	✓ P004	🔒	🔗
TS26-CFC	✓ P100	🔒	🔗
TS27-CFC	✓ P113	🔒	🔗
TS28-CFC	✓ P015	🔒	🔗
TS29-CFC	✓ P114	🔒	🔗
TS30-CFC	✓ P010	🔒	🔗
TS31-CFC	✓ P011	🔒	🔗
TS32-CFC	✓ P012	🔒	🔗
TS33-CFC	✓ P013	🔒	🔗
TS34-CFC	✓ P105	🔒	🔗
TS35-CFC	✓ P115	🔒	🔗

The 'Module name' is set to 'CTS00'. The 'Pin Selection' pane on the left shows 'CTS00' selected under 'Input:CTS0'. The bottom navigation bar includes 'Summary', 'BSP', 'Clocks', 'Pins', 'Interrupts', 'Event Links', 'Stacks', and 'Components'.

Figure 44. Enable TS Pins for RSK-RA2L1

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

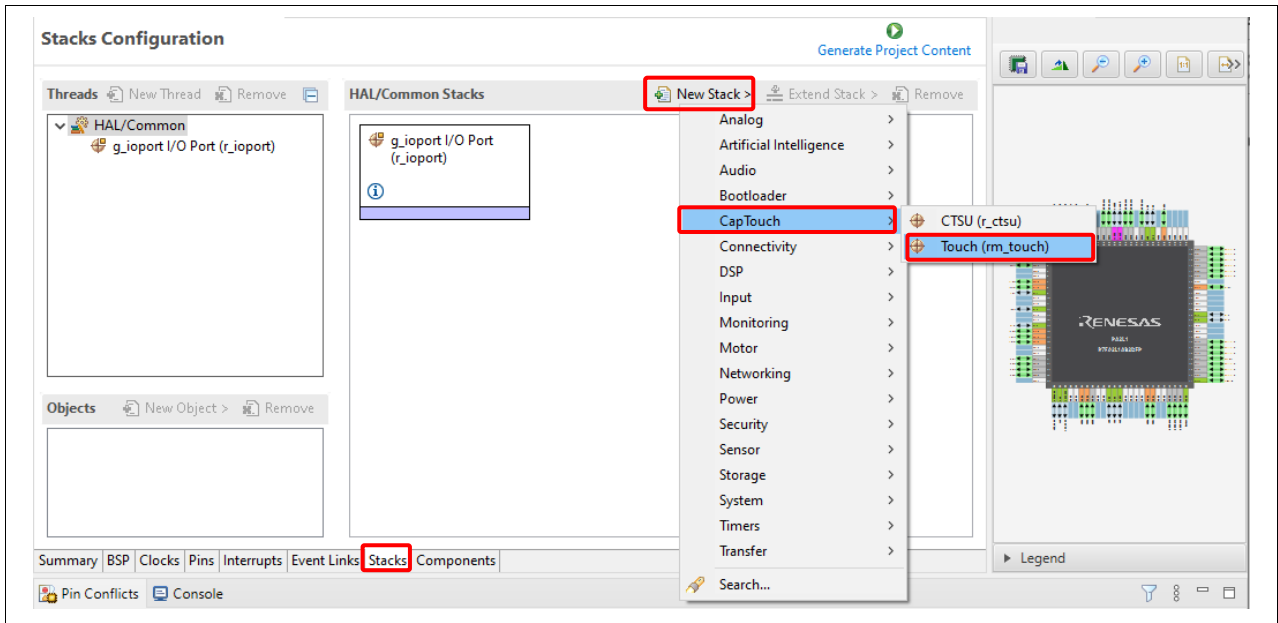


Figure 45. Add TOUCH Driver

4. Click on the  button to generate source file.

## 6. Copying QE files to Keil® MDK

1. Copy the **qe\_gen** folder in e<sup>2</sup> studio and paste it to the Keil® MDK project folder.

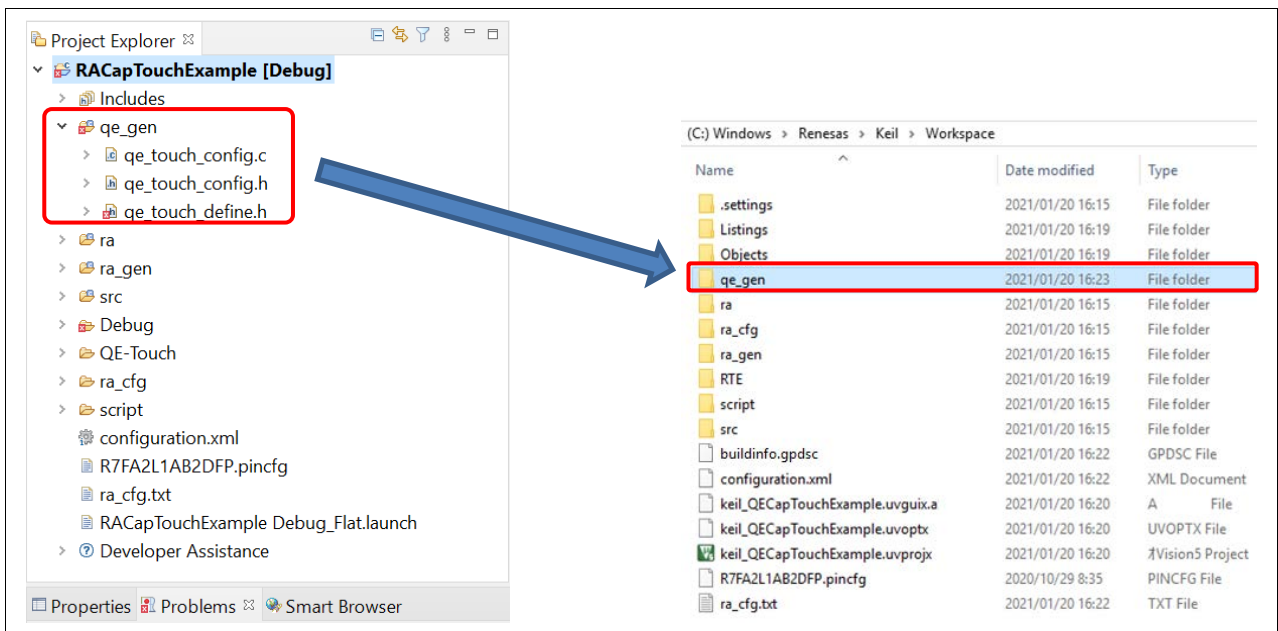


Figure 46. Copy qe\_gen Folder to Keil® MDK

- In Keil® MDK, click on the **Source Group 1**. Rename the group name **qe\_gen**.

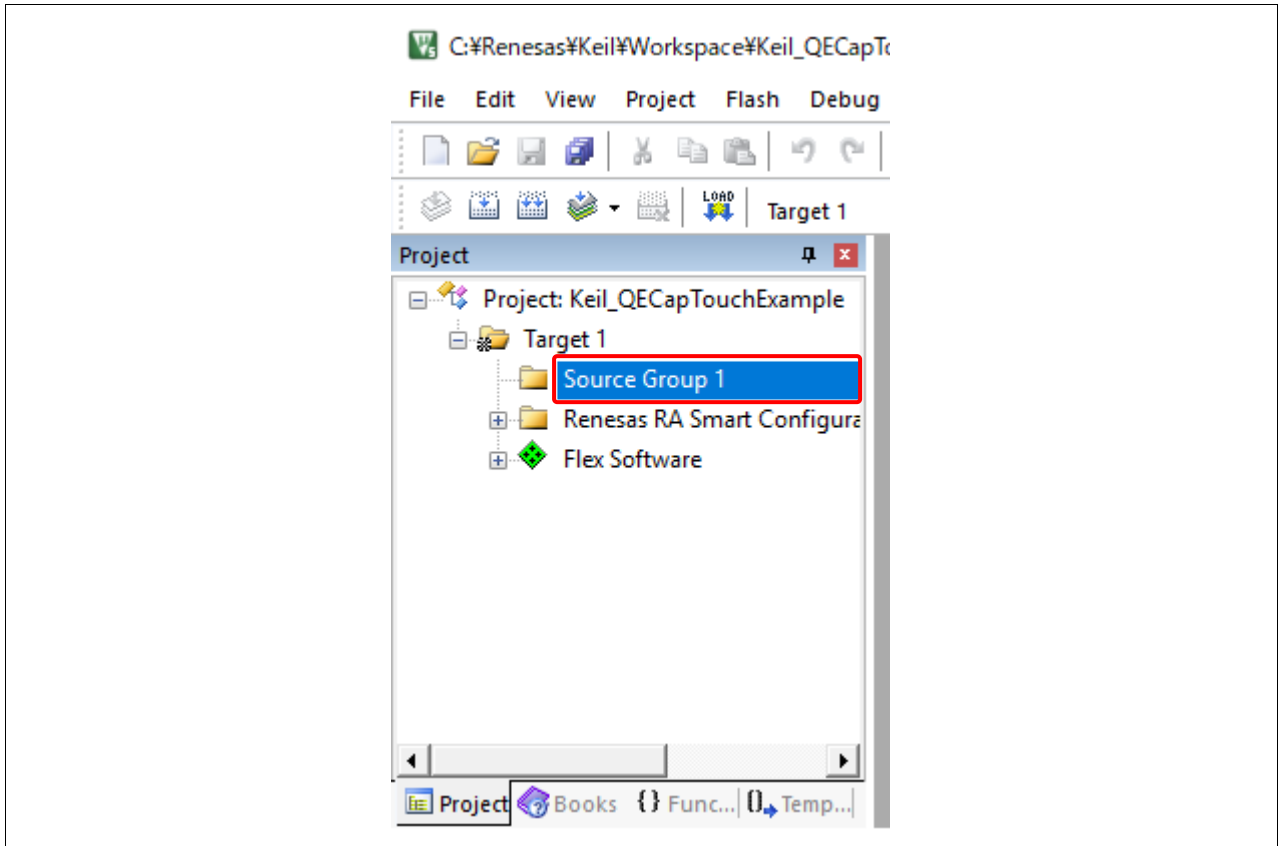


Figure 47. Create New Group

- Right-click on **qe\_gen** group and select **Add Existing Files to Group 'qe\_gen'...**. Select all the source files inside the **qe\_gen** folder and click **Add** to add them to the project.

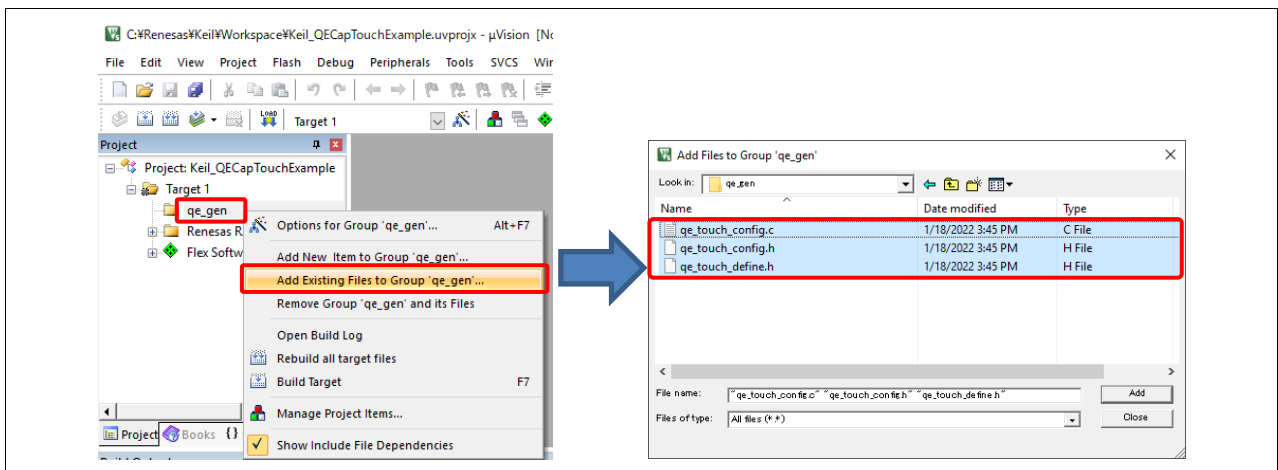


Figure 48. Add Source Files



- Right click on project name and select **Options for Target 'Target 1'...** In the **Options** dialog, select **C/C++ (AC6)**. Click on the [...] button to add include directory.

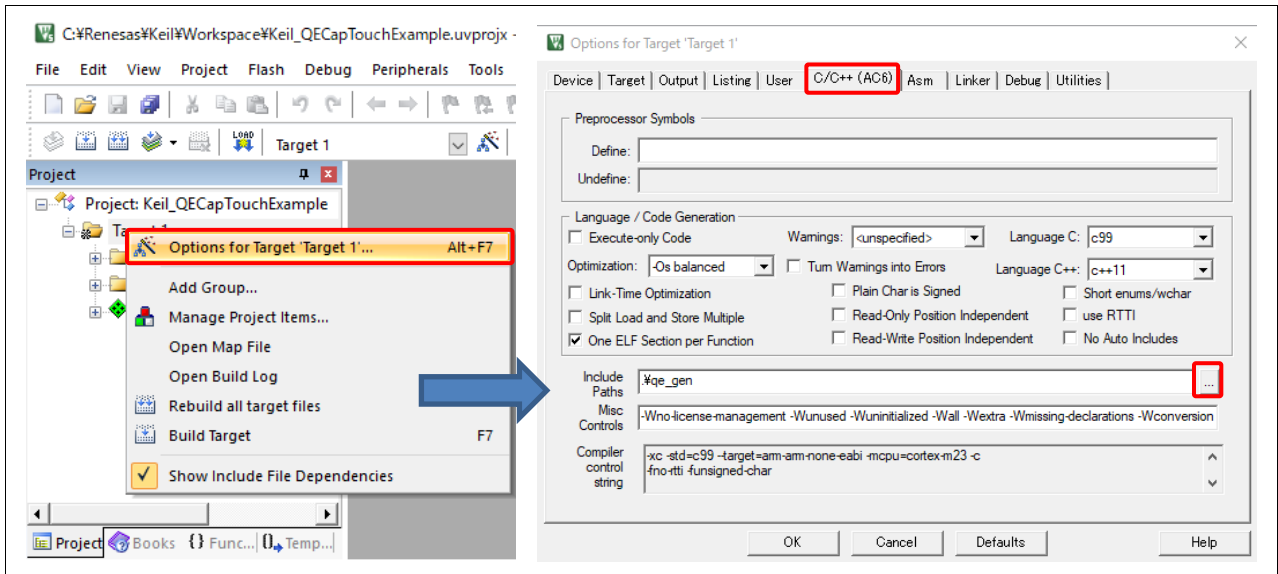


Figure 49. Open Project Option

- 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 relative path. Click OK to close the dialog.

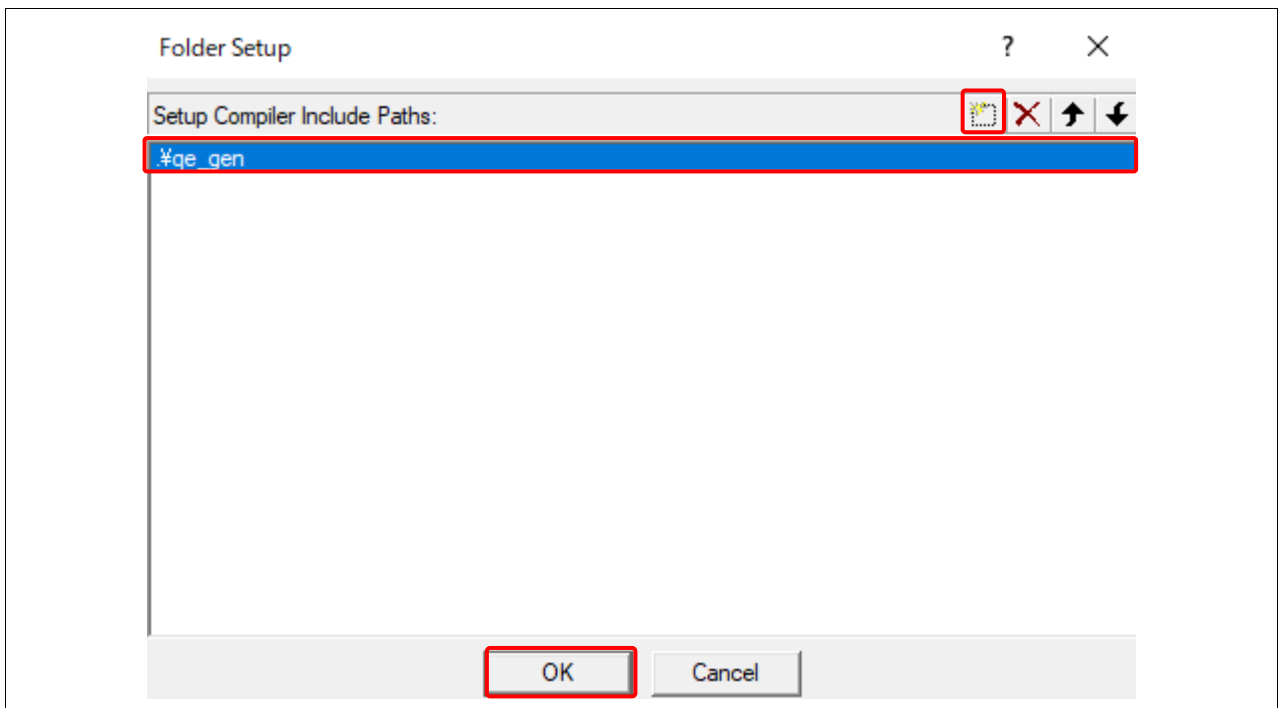


Figure 50. Add qe\_gen To List of Include Directories

- Right-click on the project and select **Rebuild all target files**. The project should be built without error.

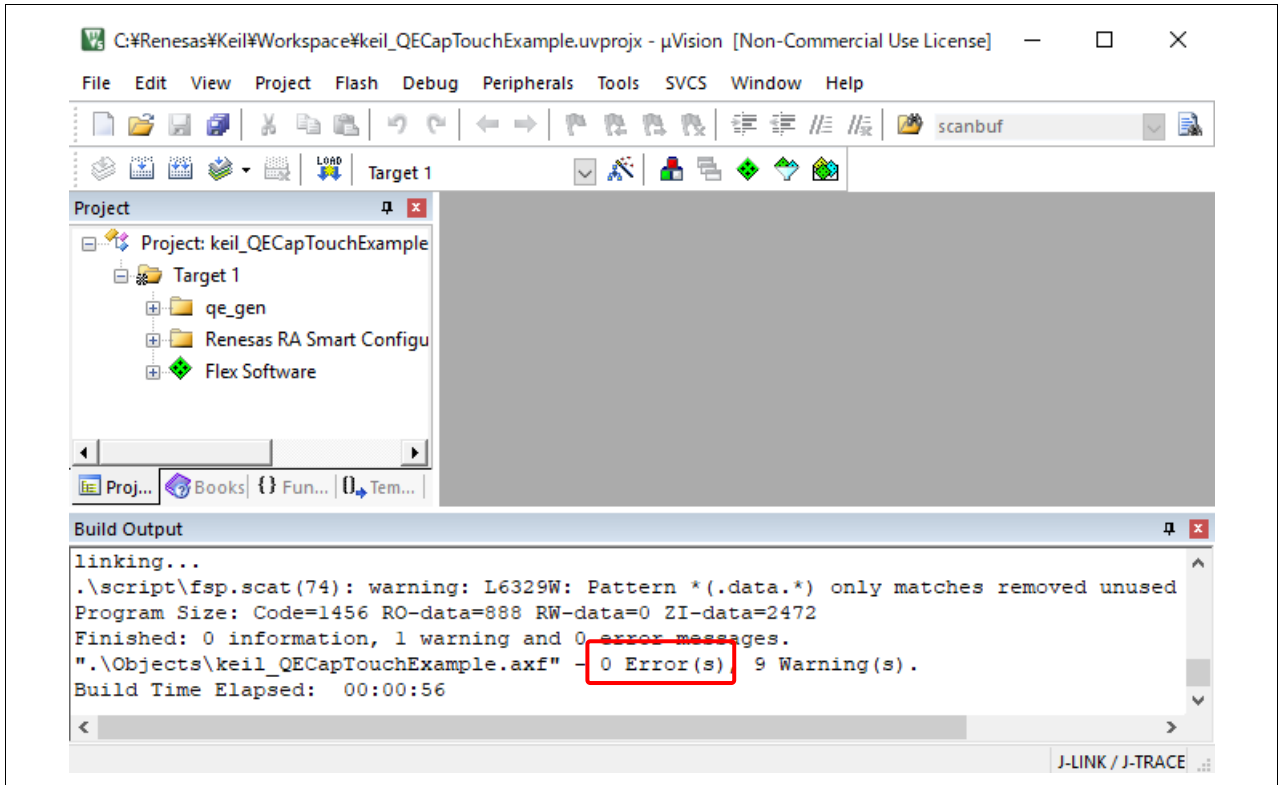


Figure 51. Build Successfully

## 7. Run Capacitive Touch Project in Keil® MDK

- Connect the board to the target PC using the USB cable connected to CN5 on the board.

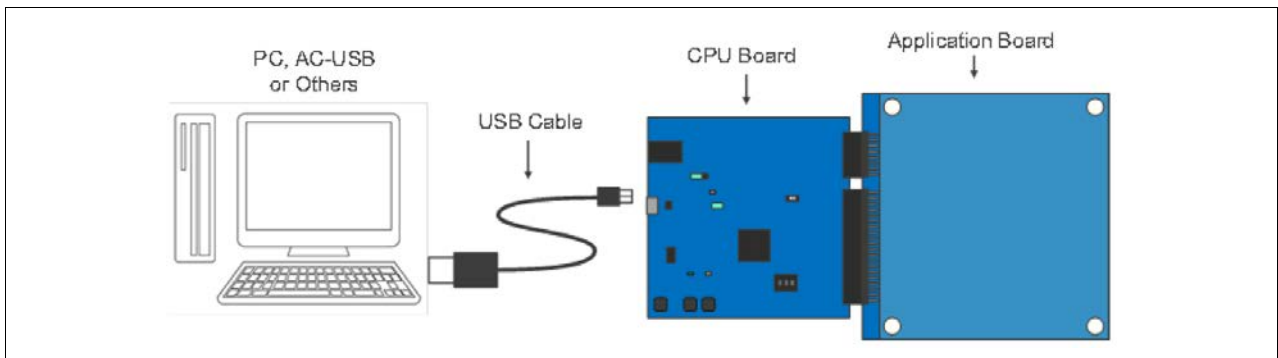


Figure 52. Power Supply to Board

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.

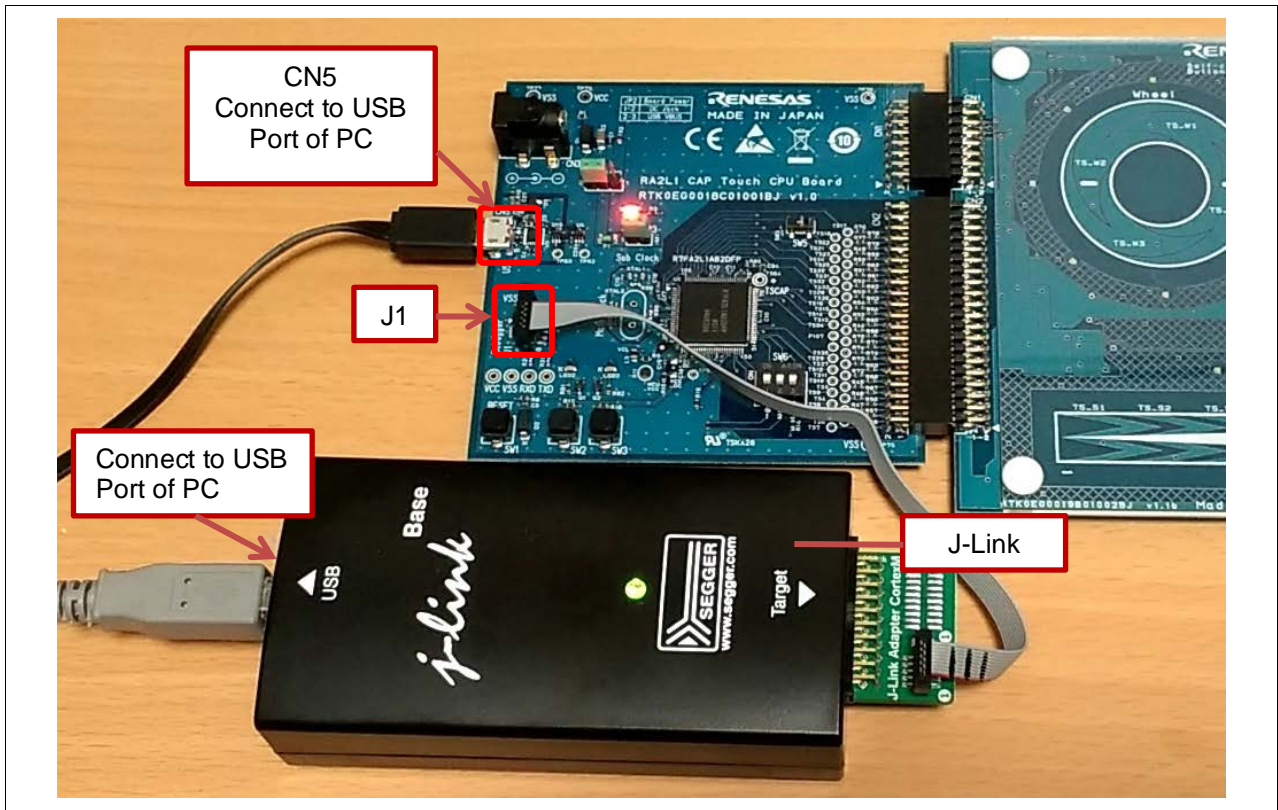


Figure 53. Debug Connection

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

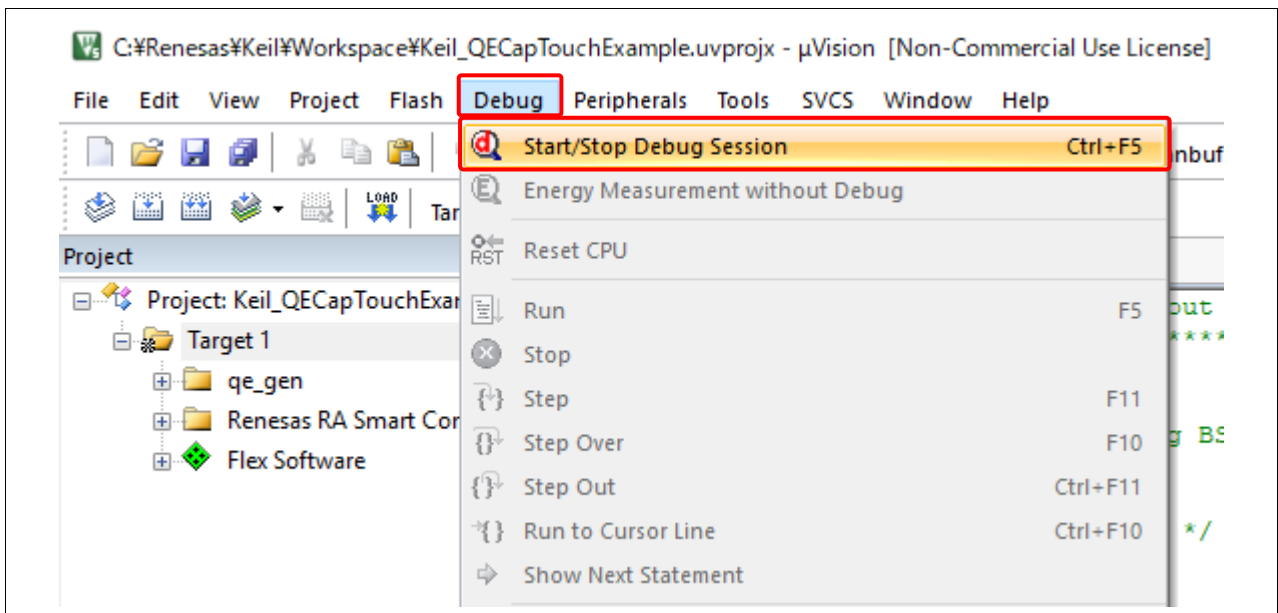


Figure 54. Download & Debug Project



**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	<a href="http://www.renesas.com/ra">www.renesas.com/ra</a>
RA Product Support Forum	<a href="http://www.renesas.com/ra/forum">www.renesas.com/ra/forum</a>
RA Flexible Software Package	<a href="http://www.renesas.com/FSP">www.renesas.com/FSP</a>
Renesas Support	<a href="http://www.renesas.com/support">www.renesas.com/support</a>

**Revision History**

Rev.	Date	Description	
		Page	Summary
1.0.0	Feb 26, 2021	-	First release
1.10	Jan 26, 2022	1	Update to Operating Environment
		-	Changed version FSP to v3.5.0
		-	Changed version QE for Capacitive Touch to v3.0.1
		4	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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