

## Renesas Synergy

Using QE and SSP to Develop Capacitive Touch Applications

## Introduction

This document will demonstrate the necessary steps for creating an application example that integrates capacitive touch sensing using Renesas Synergy Microcontrollers.

## **Target Device**

Renesas Synergy family MCUs with Capacitive Touch Sensing Unit (CTSU)



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## 1. Application Example Overview

This document will demonstrate how to implement capacitive touch sensing functions using Renesas S3A MCUs based on the following methods:

- Create a project using the Synergy Smart Configurator with the S3A7 MCU board
- Create a cap touch interface with QE for Capacitive Touch [RA, RL78, Synergy] for tuning and monitoring

## 2. Related Documents

This application example is intended to give the user a short introduction to creating a working RA capacitive touch sensing project. A thorough review of all the applicable documentation for the e2 studio/Synergy Smart Configurator, Synergy Software Package (SSP) drivers/middleware, and QE for Capacitive Touch [RA, RL78, Synergy] plug-in help (contained within the e2 studio IDE help index) is strongly suggested to answer any questions or for more details on usage of any of the tools utilized in this application example.

## 3. High Level Integration Steps

The following high-level steps will give the reader an overview of the steps required to integrate touch detection into this project. These same steps should apply to any typical user development application.

- 1. Create a new project with the  $e^2$  studio project creation wizard.
- 2. Use the Synergy Smart Configurator to add the required modules to the created e<sup>2</sup> studio project.
- 3. Use the QE for Capacitive Touch [RA, RL78, Synergy] e<sup>2</sup> studio plug-in to create the capacitive touch interface.
- 4. Use the QE for Capacitive Touch [RA, RL78, Synergy] e<sup>2</sup> studio plug-in to tune the application project.
- 5. Add the needed SSP module API calls to the user project to enable capacitive touch sensing operations in the application.
- 6. Monitor the application project using QE for Capacitive Touch [RA, RL78, Synergy] e<sup>2</sup> studio plug-in to demonstrate capacitive touch sensing detection.

## 4. Required Development Tools and Software Components

This project utilizes the following development environment:

 Table 1.
 Development Environment

Development Tool Software Components	S3A7(CTSU)
Board kit	Application Example for Capacitive Touch (AE-CAP1) (YSAECAP1S11)
	• AE-CAP1-S3 V1.1
	Self-capacitance Button/Wheel/Slider Board (referred to as
	"BWS" in this document)
Renesas e <sup>2</sup> studio Integrated	2021-04 or later
Development Environment (IDE)	
GNU ARM Embedded compiler	9.2.1.20191025 or later
Renesas QE for Capacitive Touch	1.4.0 or later
[RA, RL78, Synergy]	
Synergy Software Package (SSP)	2.0.0 or later



## 5. Application Example Overview

In the main loop of the application example, the following processing is performed.

A code listing of the completed application example after modifications is provided in "7. qe\_touch\_sample.c Listing After Modifications" for review.



## 6. Capacitance Touch Application Development Procedure

## 6.1 Project Creation

- 1. On your PC, start the e<sup>2</sup> studio IDE using the **Windows -> Start** menu or the icon on your desktop. When the dialog appears, create the Workspace wherever you like.
- 2. Start a new project by clicking **File -> New -> Renesas Synergy** from the e<sup>2</sup> studio menu.
- 3. When the New Synergy C/C++ Project dialog box opens, select "Renesas Synergy C Executable Project", then click Next
- In the Project Configuration (Synergy C Executable Project) dialog, enter a project name in Project Name (any name can be used).
   The example here uses Capacitive\_Touch\_Project\_Example. When you have entered your project name, click Next.
- 5. Next, in the **Project Configuration (Synergy C Executable Project)** dialog, select the following:

Item	S3A7(CTSU)
SSP version	V2.0.0 or later
Board	Custom User Board (Any Device)
Device	R7FS3A77C3A01CFB
Toolchain	GNU ARM Embedded
Toolchain version	9.2.1.20191025 or later
Debugger	J-Link ARM

Note: To select the Device, press the ellipsis (...) and chose from the displayed list.

Select the board you will be using from: S3 > S3A7 > S3A7 – 144Pin.



e2 studio - Project Configuration (Synergy C Executable Project)	– 🗆 X
e2 studio - Project Configuration (Synergy C Executable Project) Select the board support that you require.	
Device Selection SSP version: 2.0.0 Board: Custom User Board (Any Device) Device: R7FS3A77C3A01CFB	
Select Tools Toolchain: GNU ARM Embedded Toolchain version: 9.2.1.20191025 Debugger: J-Link ARM	Available Tools Solution of the second state
? < Back Next >	Finish Cancel

Figure 1. Device and Toolchain Selection

- 6. Once complete, click Next.
- 7. When the **e**<sup>2</sup> **studio Project Configuration (Synergy C Executable Project)** dialog displays, check "BSP" and click **Finish**.

Once complete, the Synergy Smart Configurator perspective will appear in the e<sup>2</sup> studio default window, ready for project configuration. This completes the new project creation process.



## 6.2 Using Synergy Smart Configurator to Add Modules

1. Using the tabs in the lower-middle pane of the e<sup>2</sup> studio, select the **BSP** tab to display the Board Support Package (BSP) configuration.

Summary BSP Clocks Pins Threads Messaging Components

Figure 2. BSP Tab

 To set the power supply, select the following from the lower-left of the e<sup>2</sup> studio screen: Properties -> Settings -> Synergy Common -> MCU Vcc (mV). For this example, the MCU Vcc (mV) will be set to 3300mV.

stom Us	ser Board (Any Device)			
	Voltage Detection 0 Level	1.90 V		
tings	HOCO OScillation Disable	HOCO oscillation is enabled after reset		
	MPU - Enable or disable PC Region 0	Disabled		
	MPU - PC0 Start	0x000FFFFC		
	MPU - PC0 End	0x000FFFFF		
	MPU - Enable or disable PC Region 1	Disabled		
	MPU - PC1 Start	0x000FFFFC		
	MPU - PC1 End	0x000FFFFF		
	MPU - Enable or disable Memory Region 0	Disabled		
	MPU - Memory Region 0 Start	0x000FFFFC		
	MPU - Memory Region 0 End	0x000FFFFF		
	<ul> <li>Synergy Common</li> </ul>			
	Main stack size (bytes)	0x800		
	Process stack size (bytes)	0		
	Heap size (bytes) - A minimum of 4K (0x100	0x1000		
	MCU Vcc (mV)	3300		
	MCU Analog Power Supply AVCC0 (mV)	3300		
	Parameter checking	Enabled		
	Assert Failures	Return SSP_ERR_ASSERTION		
	Error Log	No Error Log		
	ID Code Mode	Unlocked (Ignore ID)		
	ID Code (32 Hex Characters)	FFFFFFFFFFFFFFFFFFFFFFFFFFFF		

Figure 3. BSP Tab - Power Supply Voltage Setting



3. Select the **Clocks** tab from the lower-middle middle pane of  $e^2$  studio to display the clock settings.

Summary BSP Clocks Pins Threads Messaging Components	

Figure 4. Clocks Tab

4. For this example, the following settings are used.

### Table 3.Clocks Configuration

Clock	S3A7 (CTSU)
PLL Src	XTAL
Clock Src	PLL
PCLKB	PCLKB Div /2

Clocks Configurati	on			
XTAL 12MHz			> ICLK Div /1	✓ → ICLK 48MHz
	PLL Src: XTAL	3	→ PCLKA Div /1	✓ → PCLKA 48MHz
	PLL Div /2	·	→ PCLKB Div /2	✓ → PCLKB 24MHz
	PLL Mul x8 \	·	→ PCLKC Div /1	✓ → PCLKC 48MHz
	PLL 48MHz	→ Clock Src: PLL	✓ <> PCLKD Div /1	✓ → PCLKD 48MHz
	UCLK 48MHz		SCLK Div /2	→ BCLK 24MHz
HOCO 24MHz V			BCK/2	→ BCLKout 12MHz
LOCO 32768Hz			→ FCLK Div /2	✓ → FCLK 24MHz
MOCO 8MHz				
SUBCLK 32768Hz				

Figure 5. Clocks Tab – Clocks Configuration



5. Next, select the **Pins** tab. Assign the pins to connect the sensor port of the MCU to the BWS Board.

Note: Depending on the selections made in Device Selection -> Board when creating the project, the sensor port may be assigned to the TS pin by default.

Summary         BSP         Clocks         Pins         Threads         Messaging         Components							
	Summary	BSP Clock	s Pins	Threads	Messaging	Components	
				-			

Figure 6. Pins Tab

6. Under **Pin Selection**, expand **Peripherals**. Open **Input:CTSU** and select **CTSU0**.

Pin Sele	ection	
type fil	ter text	
> ✓	Ports	^
~ ~	Peripherals	
>	Analog:ACMP	
>	Analog:ADC	
>	Analog:ANALOG	
>	Analog:DAC	
>	Analog:OPAMP	
>	Connectivity:CAN	
>	Connectivity:IIC	
>	Connectivity:SCI	
>	Connectivity:SPI	
>	Connectivity:SSI	
>	Connectivity:USB	
>	Graphics:SLCDC	
~	Input:CTSU	
	laputiCU	
>	InputiCO	
	Monitoring:CAC	
(	Storage:OSPI	
	Storage:SDHI	
Ś	System:BUS	
Ś	System:CGC	
	✓ System:DEBUG	
>	System:SYSTEM	~
Summary	BSP Clocks Pins Threads	Messaging

Figure 7. Pins Tab - Select Peripherals



7. In **Pin Configuration**, change the **Operation Mode** from "Disabled" to "Enabled".

n Sel	ection	Pin Configuration				
ype fi	lter text					a a
~ ~	Ports	<ul> <li>Module name:</li> </ul>		CTSU0		^
>	Peripherals Analog:ACMP	Operation Mode:		Enabled	~	
>	Analog:ADC Analog:ANALOG	Input/Output				
>	Analog:DAC	TSCAP:	~	P205	$\sim$	
>	Analog:OPAMP Connectivity:CAN	TS00:		None	~	
>	Connectivity:IIC	TS01:		None	$\sim$	
>	Connectivity:SCI Connectivity:SPI	TS03:		None	~	<del></del>
>	Connectivity:SSI	TS04:		None	$\sim$	
>	Graphics:SLCDC	TS05:		None	~	
~	<ul> <li>✓ Input:CTSU</li> <li>✓ CTSU0</li> </ul>	TS06:		None	~	
>	Input:ICU	TS07:		None	~	

Figure 8. Pins Tab - Operation Mode

- 8. In this application example, only one button is created. In this case, the setting for the TS pins listed below, which will be used for cap touch interface, must be changed from "None", and the port set from the pull-down menu.
  - TSCAP pin
  - TS31pin

TSCAP:	✓ P205	$\sim$	$\Rightarrow$
TS00:	None	~	
TS01:	None	~	

Figure 9. TS Pin Configurations



9. Click Pin Selection --> Peripherals --> Connectivity:SCI, and select SCI9.

NOTE: Steps 9 and 10 should only be set when using serial communication for monitoring. Otherwise, skip to Step 11.

type filter text   >    Ports      Peripherals   Analog:ACMP   Analog:ADC
<ul> <li>Ports</li> <li>Peripherals</li> <li>Analog:ACMP</li> <li>Analog:ADC</li> </ul>
Peripherals     Analog:ACMP     Analog:ADC
> Analog:ACMP > Analog:ADC
Angle ANALOG
> Analog:ANALOG
> Analog:DAC
> Analog:OPAMP
> Connectivity:IIC
<ul> <li>Connectivity:SCI</li> </ul>
SCIO
SCI1
SCI2
SCI4
SCI9
> Connectivity:SPI
Connectivity: ISB

Figure 10. Pins Tab – Select Peripheral SCI9



10. Select **Pin Configuration -> Operation Mode**, then change "Disabled" to "Asynchronous UART". Also make sure **TXD** is set to "P203" and **RXD** is set to "P202".

Module name:	SCI9		
Usage:	When using Simple I2C mo drain. When switching between I2	de, ensure port pins output type is n-ch open 2C and other modes, first disable.	
Pin Group Selection:	Mixed	$\sim$	
Operation Mode:	Asynchronous UART	$\sim$	
Input/Output			
TXD:	✓ P203	~	-[
RXD:	✓ P202	~	-[
SCK:	None	$\checkmark$	-[
CTS:	None	~	-[
SDA:	None	~	-[
601	N		[

Figure 11. Pins Tab - Operation Mode

11. Next, move on to the **Threads** tab.

Summary BSP Clocks Pins Threads Messaging Components
Figure 12. Threads Tab

12. Select **New Stack**, then **Framework -> input -> Cap Touch Framework on sf\_touch\_ctsuv2**. This will add the CTSU driver and DTC middleware

IAL/Common Stacks	New Stack	: <u></u>	Extend Stack > Priver	Rer	nove		
g_cgc CGC Driver on	g_elc ELC Driver or	Fr	ramework	>	Input	> 🕀	Cap Touch Framework on sf_touch_ctsuv2
r_cgc	r_elc	X	-Ware	>	Services	> +01	<sup>2</sup> ( )
<b>i</b>	<u>(</u> )	🔗 Se	earch			P403 C	
						P406	

Figure 13. Threads Tab - Add CTSU Driver and Middleware



13. **HAL/Common Stacks** will appear as shown in the figure below. The selected Stacks will be highlighted in gray.

Cap Touch Framework on sf_touch_ctsuv2	
<b>i</b>	
▲	
CTSU Driver on r_ctsuv2	Add SCI UART Driver for monitor of QE
۵	
Add DTC Driver for Transmission [Recommended but optional] [Recommended optional]	r for d but
	<ul> <li>Cap Touch Framework on sf_touch_ctsuv2</li> <li>CTSU Driver on r_ctsuv2</li> <li>Add DTC Driver for Transmission [Recommended but optional]</li> </ul>

Figure 14. HAL/Common Stacks (after CTSU is added)



14. Next, click the CTSU Driver on r\_ctsu2 module to display Properties.

NOTE: Steps 14 to 17 should only be set when using the Data Transfer Controller (DTC). Use the DTC to transfer data between memory and registers without going through the CPU. When not using the DTC, skip to Step 18.



Figure 15. CTSU Driver on r\_ctsu2 Module

15. Set the DTC from **Properties** at the bottom-left of the screen. Change the **Support for using DTC** setting from "Disabled" to "Enabled".

Propert	ties 🔀 🏟 Smart Browser		<b>7</b> 8 🗆 🗖
CTSU D	river on r_ctsuv2		
Settings	Property V Common	Value	
Artimo	Parameter Checking	Default (RSP)	
	Support for using DTC	Enabled	
	Interrupt priority level	Priority 12	

Figure 16. Support for using DTC



16. Click the **Add DTC Driver for Transmission** module and select the **New -> Transfer Driver on r\_dtc** to add the DTC driver for transmission.



Figure 17. Add DTC Driver for Transmission (CTSU)

17. In the same manner, click the **Add DTC Driver for Reception** module and select the **New -> Transfer Driver on r\_dtc** to add the DTC driver for reception.

CTSU Driver on r_ctsuv2	Add SCI UART Driver for monitor of QE
<b>(i)</b>	P702 C P703 C P704 C P705 C
<ul> <li>         ⊕ g_transfer0 Transfer         Driver on r_dtc CTSU         WRITE         <ul> <li></li></ul></li></ul>	VBATT [ VCL [ P215 [ P214 [ VSS [ P213 ]
	lew >  Transfer Driver on r_dtc

Figure 18. Add DTC Driver for Reception (CTSU)



18. Select Cap Touch Framework on sf\_touch\_ctsuv2 to display Properties.

NOTE: Steps 18 to 23 should only be set when using serial communication for monitoring. Otherwise, skip to Step 24.



Figure 19. Cap Touch Framework on sf\_touch\_ctsuv2 Module

At the bottom left of the screen, select Properties -> Settings -> Common -> Support for QE monitoring using UART and change "Disabled" to "Enabled".

Propert	es 🔀 🏟 Smart Browser	
Cap Tou	ch Framework on sf_touch_ctsuv2	
Settings	Property ✔ Common	Value
AFTINO	Parameter Checking	Default (BSP)
	Support for QE monitoring using UART	Enabled

Figure 20. Support for QE monitoring using UART



20. Click Add SCI UART Driver monitor of QE and select New -> UART Driver on r\_sci\_uart to add the UART driver.



Figure 21. Add UART Driver

## 21. Click g\_uart\_qe UART Driver on r\_sci\_uart to display Properties.



Figure 22 g\_uart\_qe UART Driver on r\_sci\_uart Module



22. Set the SCI channel. At the bottom-left of the screen, select **Properties -> Settings -> Module** g\_uart\_qe UART Driver on r\_sci\_uart] -> Channel and change the channel setting from "0" to "9".

Propert	ies 💥 🏟 Smart Browser		000	
g_uart_q	e UART Driver on r_sci_uart			
Settings	Property ✔ Common	Value		^
APIInto	External RTS Operation	Disable		
	Reception	Enable		
	Transmission	Enable		
	Parameter Checking	Default (BSP)		
	<ul> <li>Module g_uart_qe UART Driver on r_sci_uart</li> </ul>			
	Name	🔒 g_uart_qe		
	Channel	9		
	Baud Rate	9600		
	Data Bits	🔒 8bits		
	Parity	🔒 None		
	Stop Bits	🔒 1bit		

Figure 23. Channel

23. Set the DTC. Click Add DTC Driver for Reception and select New -> Transfer Driver on r\_dtc to add the DTC driver for reception.

NOTE: Only carry out this step when using the Data Transfer Controller (DTC). Use the DTC to transfer data between memory and registers without going through the CPU.



Figure 24. Add DTC Driver for Reception (UART)

24. At this point, all application modules necessary for capacitive touch operations have been added. The final step is to generate the application code modules necessary for the project. Click **Generate Project Content** icon at the upper-right of the screen.



Figure 25. Generate Project Content Button



## 6.3 Creating the Capacitive Touch Interface

1. From the e<sup>2</sup> studio menu, use **Renesas Views -> Renesas QE -> CapTouch Main / Sensor Tuner RA, RL78, Synergy (QE)** to open the main perspective for configuring capacitive touch to the project.



Figure 26. CapTouch Main / Sensor Tuner RA, RL78, Synergy (QE) Menu

2. In the **CapTouch Main / Sensor Tuner RA, RL78, Synergy (QE)** pane, select the project you want to configure for touch interface by using the pull-down tab under **To Select Project** and selecting "Capacitive\_Touch\_Project\_Example" as shown below.

1. Preparing	
Capacitive_Touch_Project_Example Select of create a coden interface configuration.	

Figure 27 Select a Project



3. Next, create a new touch interface configuration by using the **To Prepare a Configuration** pull-down menu and selecting **Create a new configuration**.

To Prepare a Configuration Select or create a touch interface configuration.
Create a new configuration Modify Configuration

Figure 28. Create Configuration of Touch Interfaces Dialog Box

4. The **Create Configuration of Touch Interfaces** dialog box will open, showing the area for positioning the touch interface (default blank canvas).

scription:		
		Touch I/F
		Capacitance Type
		Self Capacitance
		Button
		Slider (horizontal)
		Slider (vertical)
		Wheel
		Key pad
		Touch pad
		Shield Pin
		TC Pin
		Capacitance Sensor
		Current Sensor
		Remove Touch I/F
tting		
Setup Touch I/F Se	tup Resistance Value Clear Assigned TSx	

Figure 29. Create Configuration of Touch Interfaces Dialog Box



5. Add a button to the touch interface area by selecting **Button** on the right side of the **Create Configuration of Touch Interfaces** dialog box, and then clicking on the blank canvas.

Press the ESC key on your keyboard or select **Button** again to complete the step. The added button will remain red (indicating setting error), as shown in the figure below, as it has not been assigned a touch sensor yet.

Name of Touch yr.	Capacitive_Touch_Pr	oject_Example	Setup Configuration	Import / Re-edit
cription:				
				Touch I/F
				Capacitance Type
				Self Capacitance
		Button00		Button
				Slider (horizontal)
				Slider (vertical)
				Wheel
				Key pad
				Touch pad
				Shield Pin
				TC Pin
				Capacitance Sensor
				Current Sensor
				Remove Touch I/F
ting				
Setup Touch I/F	Setup Resistance Value	Clear Assigned TSx		

Figure 30. Add a Button



6. Double click "Button00" in the touch interface canvas to display the **Setup Touch Interface** dialog box. From the pull-down menu, select MCU sensor port TS31 to assign to this button.

When a sensor port that has been enabled by the Synergy Smart Configurator is correctly assign to the button, the setting error will disappear and the button will turn green, indicating it has been set.

Button00				
	Setup Touch Interface	•	×	]
	Button(self)			
	Name	Button00		
	Touch Sensor	Resistance[ohm]		
	TS31	✓ 560	~	
	OK	Cancel Help	)	
				J

Figure 31. Setup Touch Interface (button)

7. Click the **Create** button in the **Create Configuration of Touch Interfaces dialog box** to complete the touch interface settings.

Remove Touch I/F
Create Cancel Help

Figure 32. Create Button

8. The **CapTouch Main / Sensor Tuner RA**, **RL78**, **Synergy (QE)** window will now display the configuration of the touch interface in the **Tuning** pane.

uning									
		o	Design Designed Fr	ample					
ouch I/F (	Configuration:	Capacitive_I	ioucn_Project_Ex	ample					
ouch I/F (	Configuration:	Capacitive_I	ioucn_Project_Ex	ampie					
ouch I/F (	Configuration:	Capacitive_I	ioucn_Project_Ex	lampie					
ouch I/F ( Method	Configuration: Kind	Name	Touch Sensor	Parasitic Capacitance[pF]	Sensor Drive Pulse Frequency[MHz]	Threshold	Scan Time[ms]	Overflow	

Figure 33. Tuning Pane



9. Build the project using the hammer icon in the upper left-hand side of the e<sup>2</sup> studio screen. The project should build without any errors or warnings.

e v	orkspace_QE_APN_pic - e² studio	
File	Edit Navigate Search Project R	Renesas N
R	🎄 🔳 🔆 Debug	~[

Figure 34. Build Button



## 6.4 Modifying Debug Session for Capacitive Touch Tuning

 The debug configuration needs to be modified slightly so that a special tuning kernel can be downloaded into the MCU RAM after the debug session starts. Enter the Debug Configuration by clicking the **Gear** icon in the upper right-hand side of the Workspace

🖸 w	orkspa	ce_QE_AF	PN_pic - e²	studio						
File	Edit	Source	Refactor	Navigate	Search	Project	Renesas Views	Run	Window	Help
3	*		🎋 Deb	ug	~	c* Capac	itive_Touch_Proj	ect_Exa	ample 🗸 🐇	) on:

Figure 35. Debug Configuration Editing Button

2. Select the **Startup** tab.

📄 Main 🕸 Debugger 🕨 Startup 🔲 Common 🧤 Source	
Initialization Commands	
Reset and Delay (seconds): 0	

Figure 36. Startup Tab

3. Ensure the two check boxes **Set breakpoint at:** and **Resume** are checked and look as follows in the Runtime Options. You may need to scroll down in the dialog box to see these check boxes

Runtime Options
Set program counter at (hex):
✓ Set breakpoint at: main
- Run Commands

Figure 37. Runtime Option

4. Click **OK** to use these modified settings. This completes the project configuration and debug setup for tuning.



## 6.5 Tuning the Capacitive Touch Interface Using QE for Capacitive Touch [RA, RL78, Synergy] Plug-in

- 1. Make sure the emulator is connected correctly to the board and PC.
- 2. To start the automatic tuning process, click the **Start Tuning** button in the **CapTouch Main / Sensor Tuner RA, RL78, Synergy (QE)** e<sup>2</sup> studio IDE.



Figure 38. Start Tuning

3. At the start of the first debug session, e<sup>2</sup> studio may display a message regarding a switch to the Debug perspective. Click the **Remember my decision** check box and **Yes** to continue the Debug session and the QE for Capacitive Touch [RA, RL78, Synergy] automatic tuning.

	This kind of lower his configured to some the Debug personation when it even and			
	This kind of launch is configured to open the Debug perspective when it suspends.			
$\sim$	This Debug perspective supports application debugging by providing views for			
	displaying the debug stack, variables and breakpoints.			
	Switch to this perspective?			
Ren	nember my decision			

Figure 39. Confirm Perspective Setting



4. QE for Capacitive Touch [RA, RL78, Synergy] automatic tuning will now begin. Please carefully read the **Automatic Tuning Processing** dialog windows 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.

Automatic Tuning Processing	×
1/6: QE is beginning the tuning process. During the tuning process, please do not touc until instructed by the QE Tuning Program.	h the sensors on the target board
	Cancel Help

Figure 40. Automatic Tuning Processing Dialog (now preparing)

5. After several automated steps, a dialog box with information similar to what is shown below will appear. This is the touch sensitivity measurement step of the tuning process.

As the first interactive step of the tuning process, press "Button00/TS31" (sensor) using normal touch pressure as indicated in the dialog box. When pressing the self-capacitance sensor, the bar graph will increase to the right and the touch counts will increase numerically. While continuing to apply pressure to the sensor, press any key on the PC keyboard to accept the measurement

Automatic Tuning Processing	×
5/6: QE will now measure touch sensitivi In this step please use normal touch pre key on the PC keyboard to accept the se Button00, TS31 @ config01: 15283	ty for (Button00, TS31 @ config01). ssure on the sensor for once. Press any ensitivity measurement.
	Cancel Help

Figure 41. Automatic Tuning Processing Dialog (now measuring)



6. Once tuning is complete, a dialog like the following will appear allowing threshold confirmation. This is the detection threshold that is used by the middleware to determine if a touch event has occurred.

The automation indicated, tho warning/error for guidance.	c tuning ose senso rs, please	proce ors can e consu	ss is nov be retri ult the R	v complete. ed. If there enesas app	If overflo are conti lication n	ow or wa inued ov otes for	arning/errors verflows or Capacitive Te	are ouch
Select the target	Method config01	Kind Button	Name Button00	Touch Sensor TS31	Threshold 817	Overflow	Warning / Error	
Retry Continue	the Tuning	Process						

Figure 42. Automatic Tuning Processing (tuning complete)

7. 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 board. This should return you to the default **Cap Touch Main / Sensor Tuner RA**, **RL78**, **Synergy (QE)** screen in the e<sup>2</sup> studio IDE.

Select the target	Method	Kind	Nam
	config01	Button	Butt
Retry Continue	the Tuning	Process	

Figure 43. Continue the Tuning Process Button

8. In this example, the final step is to output the tuning parameter files by clicking the **Output Parameter Files** button.

Follow instructions in the dialog.	
Start Tuning	
Enable Advanced Tuning	
Generate parameter Files Generate parameter files from a tuning result.	
Output Parameter Files	
Change Output Settings	

Figure 44. Output Parameter Files



9. In the **Project Explorer** window under folder **qe\_gen**, confirm that **qe\_touch\_config.c**, **qe\_touch\_config.h** and **qe\_touch\_define.h** files have been added. These contain the tuning information necessary for enabling touch detection with drivers.



Figure 45. Generated Parameter Files

10. Build the project using the hammer icon in the upper left-hand side of the e<sup>2</sup> studio IDE. Confirm that the build results shown in the **Console** window do not show any errors.



## 6.6 Adding qe\_touch\_main() middleware to the Application Example

1. To implement a program (code) that will scan and report the state of the touch sensor, click the **Show Sample** button in the **CapTouch Main / Sensor Tuner RA, RL78, Synergy (QE)** e<sup>2</sup> studio IDE.



Figure 46. Show Sample Code

2. The **Show Sample Code** window will open which shows the sample code in text. Click the **Output to a File** button to output the sample code. Finally, click **OK** to close the window.

Sample code of main() function:			
/*******	*********		^
*			
* FILE : qe_sample_main.c			
* DATE: 2021-03-11			
* DESCRIPTION : Main Program			
* NOTE THIS IS A TYDICAL EXAMPLE			
*			
*****	********		
#include "qe_touch_config.h"			
#define TOUCH_SCAN_INTERVAL_EXA	AMPLE (20) /* milliseconds */		
void qe_touch_main(void);			
uint64 t button status:			
#if (SE TOUCH CTSU CEG NUM SUD	(FRS != 0)		
uint16 t slider position[SE TOUCH C	TSU CEG NUM SLIDERSI		
#endif			
#if (SF_TOUCH_CTSU_CFG_NUM_WHI	EELS != 0)		
uint16_t wheel_position[SF_TOUCH_C	TSU_CFG_NUM_WHEELS];		
#endif			
unid an truck and (unid)			
void de_touch_main(void)			
ssp.err.terr			
ssp_en_een,			×
<		-	>
Copy to the Clipboard	Output to a File	Show the Applicat	ion Note

Figure 47. Show Sample Code Window



3. Confirm that the new qe\_touch\_sample.c file has been created in **Project Explorer** in the **qe\_gen** folder.

Project Explorer 🛛
✓ ☑ Capacitive_Touch_Project_Example (in test) [Debug]
> 🐉 Binaries
> 🔊 Includes
✓ 😕 qe_gen
> c qe_touch_config.c
> h qe_touch_config.h
> h ae touch define.h
ic qe_touch_sample.c
> 😕 src
> 😕 synergy
> 📂 Debug
> 🥟 QE-Touch
> 🗁 script
> 🗁 synergy_cfg
Capacitive_Touch_Project_Example Debug.jlink
💮 configuration.xml
R7FS3A77C3A01CFB.pincfg
synergy_cfg.txt
📄 test Debug.launch
> (?) Developer Assistance

Figure 48. qe\_touch\_sample.c

4. In the **src** folder, open hal\_entry.c.

Add the code to call the **qe\_touch\_main()** function in the qe\_touch\_main() function declaration and in the hal\_entry() function.



Figure 49. Add Call to hal\_entry.c

5. This completes all the necessary code modifications required for this application example. Build the code to confirm that there are no errors or warning.



# 6.7 Monitoring Touch Performance Using e<sup>2</sup>studio Expressions Window and QE for Capacitive Touch [RA, RL78, Synergy]

1. Start a Debug session by clicking the **Bug** icon in the upper left-hand corner of e<sup>2</sup> studio.

The debugger session will stop at the hal\_entry () function call. This is the first code entry point in the main() function

2. Select hal\_entry () function to open the declaration.



Figure 50. Open Declaration (hal\_entry function)

3. In the hal\_entry(), select the **qe\_touch\_main()** function and open the declaration.



Figure 51. Open Declaration (qe\_touch\_main function)



 Scroll down the qe\_touch\_main.c file in the while (true) loop and display g\_qe\_touch\_instance\_config01.p\_api->dataGet(). With the argument "button\_status" selected, right click and select Add Watch Expression.



Figure 52. Add Watch Expression Menu / Dialog

5. Right click in the **Expressions** window to select **Enable Real-time Refresh** and enable real-time refresh in the added variable.

Expression	Туре	Value		Address	Name : button Details:0	_status	$\sim$
(×)= button_status	uint64_t	0		Nv 200005a8		Ctrl+A	
Add new expression			<b>F</b>	Const Francis		Cul+A	
				Copy Expression	ons	Ctrl+C	
			×	Remove			
			X	Remove All			
				Number Form	at	>	
				Add Expressio	n Group	>	
				Find		Ctrl+F	
				Show Details A	٩s	>	
			<b>e</b>	Add Watch Ex	pression		
				Disable	Monitor expres	sion in real-	time
				Enable			
				Edit Watch Ex	pression		
			ଙ୍କ	Add Watchpo	int (C/C++)		
			0	Cast To Type			
			×U	Display As Arr	av		
			<u>_</u>	Enable Real-ti	me Refresh		
				Real-time Refr	esh	>	
			x+y	Watch			
			=Y.	watch			J

Figure 53. Enable Real-time Refresh Menu

6. Click the **Resume** (green arrow) button, located near the middle of the e<sup>2</sup> studio tool bar, to continue code execution.



7. Press the TS31 sensor on the board which was configured as "Button00" in Section 6.3 **Creating Capacitive Touch Interface**. When pressed, the "button\_status" value in the Expressions window will change from '0' to '1', confirming the touch with a binary indication

(x)= Variables 💁 Breakp	🛋 Modules	Projec	🙀 Expres 🛛 🧉
Expression	Туре	Value	Address
🎄 button_status	uint64_t	1	x200005a8
🕂 Add new expression			

Figure 54. Touch Status Confirmation in Expressions Window

8. Click the Show Views button in the Monitoring pane of CapTouch Main / Sensor Tuner RA, RL78, Synergy (QE) to startup the CapTouch Board Monitor RA, RL78, Synergy (QE) pane



Figure 55. Show Views Button

9. The CapTouch Board Monitor RA, RL78, Synergy (QE) pane should appear like the image below.

🖏 CapTouch Board M	Nonitor RA, RL78, Synergy (QE) 🛛	5		G .	000
Enable Monitoring	Monitoring: Enabled, Communicat	tion Status: Con	necting via	OCD em	ulator
Touch I/F:		~			
	Button00				

Figure 56. CapTouch Board Monitor RA, RL78, Synergy (QE) Window

10. [Click the **Enable Monitoring** button. The dialog text will change from "Monitoring: Disabled" to "Monitoring: Enabled.

CapTouch Board M	Nonitor RA, RL78, Synergy (QE) 🔀	
Enable Monitoring	Monitoring: Enabled, Communicat	ation St
Touch I/F:		¥

Figure 57. Enable Monitoring Function

11. Touch "Button00" ("TS31") on the **BSW**. The **CapTouch Board Monitor RA, RL78, Synergy (QE)** will show a touch with a finger image on the button like the below image.



Figure 58. Touch Status Confirmation in CapTouch Board Monitor RA, RL78, Synergy (QE) Window



12. To see a graphical representation of the 'touch counts' from the board, open the **CapTouch Status Chart RA, RL78, Synergy (QE)** window.

	,			 _		
					20 DQ DR DR	
Touch I/F:	✓ Syn	nc a selection				
Touch Position	Reference Valuer	Threshold	Difference			
			Difference			
Start Data Collection	n					
Noise [NT]:	Average [NT]:	Minimum:	Maximum:			
Noise [T]:	Average [T]:	Signal:	SNR:			
65535						
40140						
49149						
49149						
49149						
49149						
49149						
32766						
32766						
32766						
32766						
32766						
32766						
32766 16383						
32766 16383						
32766 16383						

Figure 59. CapTouch Status Chart RA, RL78, Synergy (QE) Window

13. Using the Touch I/F pulldown, select "Button00 @ config01".

Sync a selection				5.63.64.6
Sync a selection				
ilue: Threshold:	Difference:			
]: Minimum:	Maximum:			
Signal:	SNR:			
T	alue: Threshold:	'alue:     Threshold:     Difference:       T]:     Minimum:     Maximum:       :     Sional:     SNR:	alue: Threshold: Difference:	'alue:     Threshold:     Difference:       T]:     Minimum:     Maximum:       :     Signal:     SNR:

Figure 60. Touch I/F Configuration



14. The graph will begin to display running values. Touch "Button00" (TS31) on the board to view the touch counts shown as a step change on the running graph. The green line is the touch threshold, which the SPP middleware uses to determine whether a button is actuated/touched. The red blocks at the bottom of the graph are a visual indication to the user that the touch counts have exceeded the threshold and a touch is detected.



Figure 61. Confirm Touch Status in CapTouch Status Chart RA, RL78, Synergy (QE) Window



### Note: Steps 15 to 18 must be set when displaying and measuring standard deviation.

15. Next, measure the standard deviation. Click the **Start Data Collection** button. While collecting data in the **touch-off state**, don't touch the electrode. The green bar is the data collection rate. When the green bar goes all the way to the right, the data collection in the touch-off state is complete.

Touch I/F: Button00 @ co	nfig01 v Sync a selection
I/F Type: Button(self), Char	nel(s): TS31
Count Value: 1525 Start Data Collection	Reference Value: 15369 Threshold: 919 Difference: -118
Noise [NT]:	Average [NT]: Minimum: Maximum:
Noise [T]:	Average [T]:     Signal:     SNR:

Figure 62. Start Data Collection Button (touch-off state))

16. When the green bar goes all the way to the right, click the **Stop Data Collection** button.

Touch I/F: Bu	tton00 @ conf	ig01	✓ 🗌 Sync a	selection			
I/F Type: Butto	n(self), Channe	el(s): TS31					
Count Value:	15333	Reference Value:	15361	Threshold:	919	Difference:	-28
Stop Data	Collection						
Noise [NT]:	40	Average [NT]:	15353	Minimum:	15061	Maximum:	15457
Noise [T]:		Average [T]:		Signal:		SNR:	

Figure 63. Stop Data Collection Button (touch-off state)



17. Next, touch the electrode in order to collect data in the touch-on state. Click the **Start Data Collection** button while touching the electrode.



Figure 64. Start Data Collection Button (touch-on state)

18. When the green bar goes all the way to the right, click the **Stop Data Collection** button. The SNR is displayed when data collection is complete.

Touch I/F: Button00 @ config01							
I/F Type: Butto	on(self), Chann	el(s): TS31					
Count Value:	15305	Reference Value:	15342	Threshold:	919	Difference:	-37
Start Data	Collection						
Noise [NT]:	40	Average [NT]:	15358	Minimum:	15126	Maximum:	15462
Noise [T]:	46	Average [T]:	17187	Signal:	1829	SNR:	5

Figure 65. Stop Data Collection Button (touch-on state)



# 6.8 Monitoring Touch Performance with QE for Capacitive Touch [RA, RL78, Synergy] Using Serial Communication

1. When monitoring is in operation, click the **Enable Monitoring** button. The dialog text will change from "Monitoring: Enabled" to "Monitoring: Disabled".

Enable Monitoring Monitoring: Disabled, Communication	🖏 CapTouch Board Monitor RA, RL78, Synergy (QE) 🛛
Touch I/F:	Enable Monitoring Monitoring: Disabled, Communic
	Touch I/F:

Figure 66. Disable Monitoring Function

- 2. To finish the debug session, click the **Stop** icon at the top-right of the e2 studio window.
- 3. Disconnect the emulator from the PC and the AE-CAP1-S3 V1.1 board. Confirm that the USB cable is correctly connected to the target board and PC.

Note: Although operations can be carried out with the emulator connected, the emulator is removed in this step to confirm successful monitoring without the emulator.

4. Reset the AE-CAP1-S3 V1.1 board by pressing the **RESET** switch.



 Open the CapTouch Main / Sensor Tuner RA, RL78, Synergy (QE) pane. Make sure following folder/file are selected:

To Select a Project: "Capacitive\_Touch\_Project\_Example"

To Prepare a Configuration: "Capacitive\_Touch\_Project\_Example.tifcfg"



Figure 67. Select Project / Configuration

6. In the **CapTouch Main / Sensor Tuner RA, RL78 (QE)** pane under **Monitoring**, select **Connect** to enable monitoring using serial communication.



Figure 68. Connect Button



7. "Connected to COM*n*" should appear at the bottom of Console window. Confirm the message to make sure the connection is successful.

Note: The COM port number for connection varies depending on the PC environment.

📮 Console 🛛		
OE for Capacitive Touch		
Connected to \\.\COM84.		
1		

Figure 69. Console Window Output

8. The rest of the process is the same as Step 6.7 on in Section 6.7 Monitoring Touch Performance Using e<sup>2</sup>studio Expressions Window and QE for Capacitive Touch [RA, RL78, Synergy]



## 

#include "qe\_touch\_config.h"
#define TOUCH\_SCAN\_INTERVAL\_EXAMPLE (20) /\* milliseconds \*/

void qe\_touch\_main(void);

uint64\_t button\_status;

#if (SF\_TOUCH\_CTSU\_CFG\_NUM\_SLIDERS != 0)

uint16\_t slider\_position[SF\_TOUCH\_CTSU\_CFG\_NUM\_SLIDERS];

#if (SF\_TOUCH\_CTSU\_CFG\_NUM\_WHEELS != 0)

```
uint16_t wheel_position[SF_TOUCH_CTSU_CFG_NUM_WHEELS];
```

```
#endif
```

#endif

void qe\_touch\_main(void)

## {

```
ssp_err_t err;
```

/\* Open Touch middleware \*/

```
err = g_qe_touch_instance_config01.p_api->open(g_qe_touch_instance_config01.p_ctrl, g_qe_touch_instance_config01.p_cfg);
```

```
if (SSP_SUCCESS != err)
{
     while (true) 0
```

while (true) {}

```
}
```

## /\* Main loop \*/ while (true)

.

{

/\* for [CONFIG01] configuration \*/

 $err = g_qe_touch\_instance\_config01.p\_api->scanStart(g_qe\_touch\_instance\_config01.p\_ctrl);$ 



```
if (SSP_SUCCESS != err)
        {
            while (true) {}
        }
        while (0 == g_qe_touch_flag) {}
        g_qe_touch_flag = 0;
        err = g_qe_touch_instance_config01.p_api->dataGet(g_qe_touch_instance_config01.p_ctrl,
&button_status, NULL, NULL);
        if (SSP_SUCCESS == err)
        {
            /* TODO: Add your own code here. */
        }
        /* FIXME: Since this is a temporary process, so re-create a waiting process yourself. */
        R_BSP_SoftwareDelay(TOUCH_SCAN_INTERVAL_EXAMPLE,
BSP_DELAY_UNITS_MILLISECONDS);
    }
}
```



## Website and Support

**Renesas Electronics Website** 

https://www.renesas.com/

## Capacitive Touch Sensing Unit related pages

https://www.renesas.com/solutions/touch-key https://www.renesas.com/ssp https://www.renesas.com/ge-capacitive-touch

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## **Revision History**

		Description		
Rev.	Date	Page	Summary	
1.00	Jun.23.21	-	First edition issued	



# 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 is supplied until the 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.

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