Renesas RA Family

RA2L1 Group Capacitive Touch Evaluation System Example Project

Introduction

This document describes the sample code for the RA2L1 Capacitive Touch Evaluation System.

Target Device

RA2L1 (R7FA2L1AB2DFP)

Contents

1. Overview

This document describes the sample code included in the Example Project of the RA2L1 Capacitive Touch Evaluation System.

The following is added to the project created by e2 studio.

- Components generated by the FSP Configuration
- Capacitive touch configuration files and applications tuning with QE for Capacitive Touch (QE)
- LED control application

1.1 Function

The functions are shown below.

1. Capacitive touch function operates all electrodes (3 buttons, slider, wheel, shield) of Capacitive Touch Evaluation Application Board.
2. Press the capacitive touch buttons, slider and wheel to control the LEDs on Capacitive Touch Evaluation Application Board.
3. Enables USB serial interface to control serial communication and supports QE serial monitor and serial tuning. For more information on serial monitoring and serial tuning, refer to”6. Capacitance Touch Application Development Procedure” in “Using QE and FSP to Develop Capacitive Touch Applications”
4. LED control is performed in conjunction with the push button on CPU board. Pressing SW2, LED 2 lights up. Pressing SW3, LED3 lights up.

2. Operation confirmation conditions

The operation of this sample code has been confirmed the following environment.

Table 2-1 Operation confirmation conditions

Item	Description
MCU	RA2L1 (R7FA2L1AB2DFP)
Operating frequency	48MHz (HOCO 48MHz)
Operating voltage	5V
Evaluation board	RA2L1 Capacitive Touch Evaluation System (Product No : RTK0EG0022S01001BJ) • RA2L1 CPU Board (Product No : RTK0EG0018C01001BJ) • Capacitive Touch Evaluation Application Board (Product No : RTK0EG0019B01002BJ)
Integrated development environment	e² studio Version 2023-07 (23.07.0)
C Compiler	GCC Arm Embedded 10.3-2021.10
Development Assistance Tool for Capacitive Touch Sensors	QE for Capacitive Touch V3.3.0
Emulator	Renesas E2 Emulator Lite
Software Package	FSP v4.6.0

Figure 2-1 shows device connection diagram

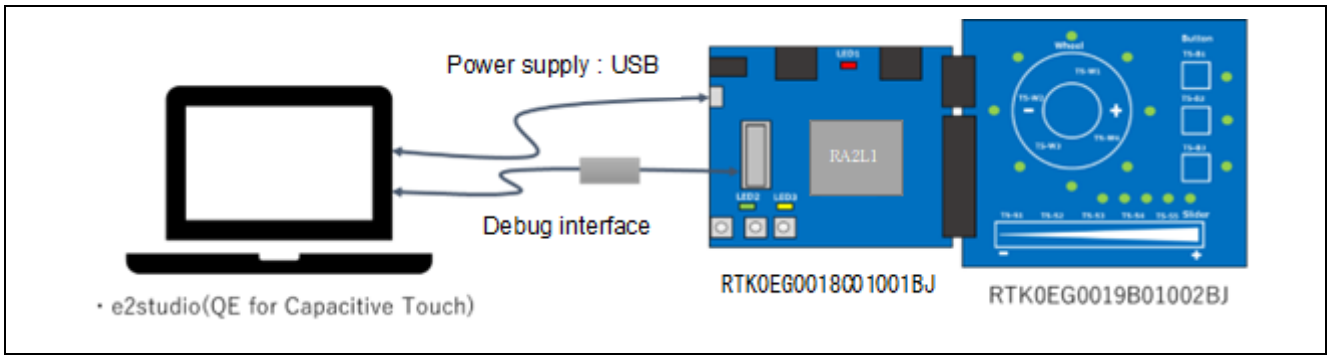


Figure 2-1 Device Connection Diagram

3. Software specification

3.1 Software structure diagram

Figure 3-1 shows the software structure diagram of this sample code. This software uses components generated by the FSP Configuration.

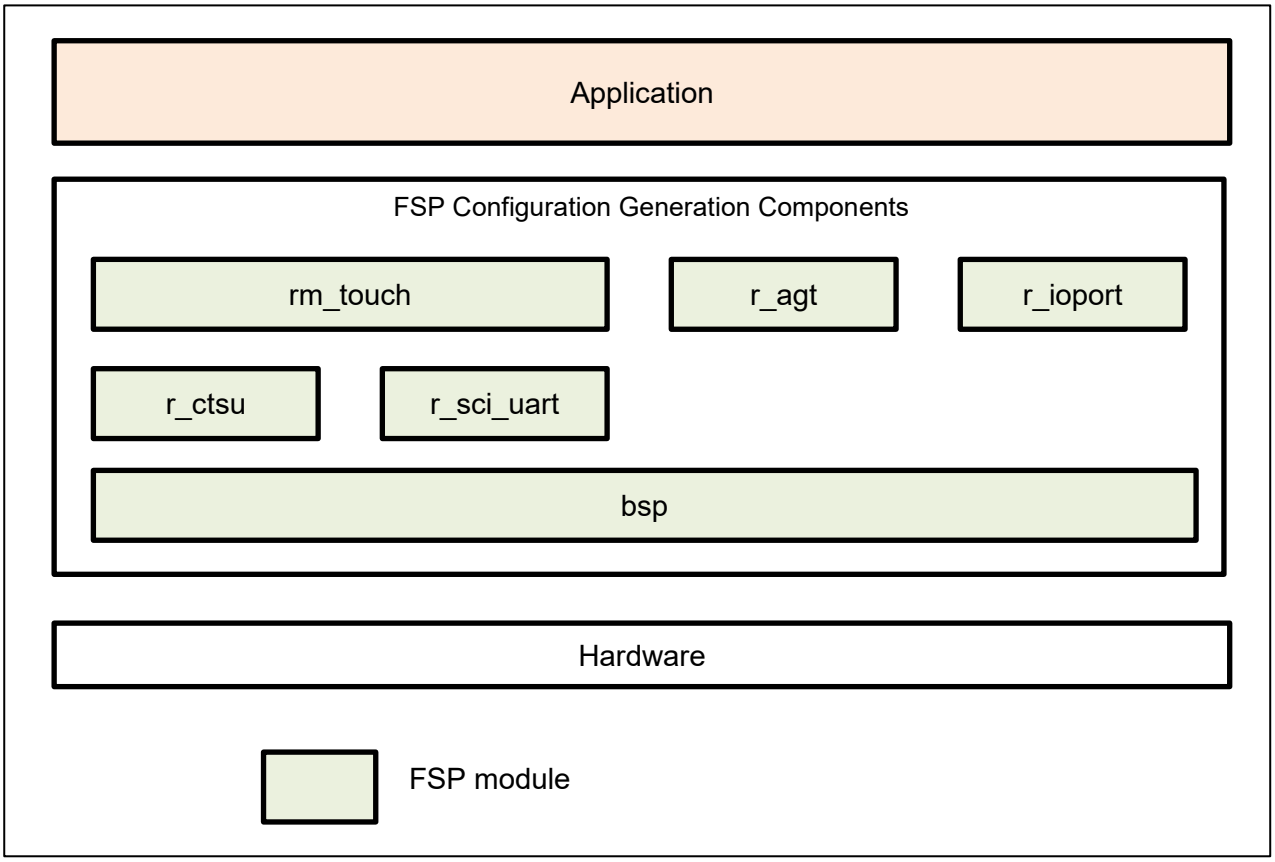


Figure 3-1 Software structure diagram

Table 3-1 shows a list of components and versions. Refer to the FSP configuration for component settings.

Table 3-1 Components and versions list

Selected software components

Board Support Package Common Files	v4.6.0
I/O Port	v4.6.0
Arm CMSIS Version 5 - Core (M)	v5.9.0+renesas.0.fsp.4.6.0
Board support package for R7FA2L1AB2DFP	v4.6.0
Board support package for RA2L1	v4.6.0
Board support package for RA2L1 - FSP Data	v4.6.0
RA2L1-RSSK Board Support Files	v4.6.0
Asynchronous General Purpose Timer	v4.6.0
Capacitive Touch Sensing Unit	v4.6.0
SCI UART	v4.6.0
Touch	v4.6.0

3.2 File structure

This is the file structure of this sample code. The project configuration file and FSP configuration generation file of the development environment are omitted.

```
quickstart_rssk_ra2l1_ep
│
├──QE-Touch
│     qe_tuning20230221103059.log      ・・・QE Tuning log
│     quickstart_rssk_ra2l1_ep.tifcfg  ・・・Touch interface configuration file
│
├──qe_gen
│     qe_touch_config.c                ・・・Touch configuration source
│     qe_touch_config.h                ・・・Touch configuration header
│     qe_touch_define.h                ・・・Touch define header
│     qe_touch_sample.c                ・・・Touch sample application
│
└──src
   │ hal_entry.c                       ・・・Main file
   │  r_rssk_switch_led.c              ・・・Switch & LED function source
   │  r_rssk_switch_led.h              ・・・Switch & LED function header
   │  r_rssk_touch_led.c               ・・・Touch electrode LED function source
   └ r_rssk_touch_led.h                ・・・Touch electrode LED function header
```

3.3 Constants

Table 3-2 lists the constants.

Table 3-2 List of Constant

Constant Name	Setting Value	Description
File Name : qe_touch_sample.c		
TOUCH_SCAN_INTERVAL_EXAMPLE	(20)	Software delay value [Unit : msec]
File Name : r_rssk_switch_led.c		
RSSK_SW2_PORT	(BSP_IO_PORT_02_PIN_06)	SW2 control port definition
RSSK_SW3_PORT	(BSP_IO_PORT_02_PIN_05)	SW3 control port definition
RSSK_LED2_PORT	(BSP_IO_PORT_03_PIN_05)	LED2 control port definition
RSSK_LED3_PORT	(BSP_IO_PORT_03_PIN_04)	LED3 control port definition
SW_EDGE_RIZE	(0x07U)	Switch rising judgment
SW_EDGE_FALL	(0x08U)	Switch falling judgment
SW_EDGE_BIT_MASK	(0x0FU)	Switch state judgement mask
RSSK_LED_ON	(0x01U)	Turn on the LED
RSSK_LED_OFF	(0x00U)	Turn off the LED
File Name : r_rssk_touch_led.c		
LED_COL0	(BSP_IO_PORT_05_PIN_04)	COL0 control port definition
LED_COL1	(BSP_IO_PORT_04_PIN_00)	COL1 control port definition
LED_COL2	(BSP_IO_PORT_07_PIN_14)	COL2 control port definition
LED_COL3	(BSP_IO_PORT_04_PIN_06)	COL3 control port definition
LED_ROW0	(BSP_IO_PORT_04_PIN_14)	ROW0 control port definition
LED_ROW1	(BSP_IO_PORT_00_PIN_06)	ROW1 control port definition
LED_ROW2	(BSP_IO_PORT_07_PIN_08)	ROW2 control port definition
LED_ROW3	(BSP_IO_PORT_04_PIN_15)	ROW3 control port definition
LED_COL_MAX	(4)	Number of COL signals
LED_ROW_MAX	(4)	Number of ROW signals
LED_COL_OFF	(BSP_IO_LEVEL_LOW)	COL signal OFF
LED_COL_ON	(BSP_IO_LEVEL_HIGH)	COL signal ON
LED_ROW_OFF	(BSP_IO_LEVEL_HIGH)	ROW signal OFF
LED_ROW_ON	(BSP_IO_LEVEL_LOW)	ROW signal ON
SLIDER_LED_NUM	(5U)	Number of slider LED
SLIDER_RESOLUTION	(100U)	Maximum slider touch result
WHEEL_LED_NUM	(8U)	Number of wheel LED
WHEEL_LED_MSB	(1U << (WHEEL_LED_NUM - 1))	Wheel LED control bit MSB
WHEEL_RESOLUTION_DEGREE	(360U)	Maximum wheel touch result [unit : degree]
WHEEL_POSITION_OFFSET_DEGREE	(112)	Wheel touch position offset [unit : degree]
ALL_LED_NUM	(16U)	Number of touch electorode board LEDs
LED_TEST_INTERVAL	(100U)	LED lighting interval time

3.4 Enumerations

Table 3-3 lists the rssk_sw_status_t enum.

Table 3-3 rssk_sw_status_t

Member	Value	Description
RSSK_SW_OFF	0x00	Switch OFF state
RSSK_SW_ON	0x01	Switch ON state

3.5 Global Variables

Table 3-4 lists the global variables.

Table 3-4 List of Global Variable

Variable Name	Types	Description
File Name : r_rssk_touch_led.c		
g_led_column[]	bsp_io_port_pin_t	Touch electrode board LED column control port array
g_led_row[]	bsp_io_port_pin_t	Touch electrode board LED row control port array
g_led_drive_colmun	uint8_t	Touch electrode board LED drive information
g_button_idx[]	uint8_t	Button index array

3.6 Functions

Table 3-5 lists the functions.

Table 3-5 List of Function

Function Name	Description
File Name :qe_touch_sample.c	
qe_touch_main	Main function
r_rssk_initialize	Initialization processing of Capacitive Touch Evaluation System
r_rssk_led_test	LED test processing for Capacitive Touch Evaluation System
timer0_callback	AGT interrupt callback
File Name :r_rssk_switch_led.c	
r_rssk_switch_led_control	CPU board LED initialization processing
r_rssk_led2_on	CPU board LED2 turn on
r_rssk_led2_off	CPU board LED2 turn off
r_rssk_led3_on	CPU board LED3 turn on
r_rssk_led3_off	CPU board LED3 turn off
rssk_get_sw2_status	CPU board SW2 status check
rssk_get_sw3_status	CPU board SW3 status check
File Name :r_rssk_touch_led.c	
r_rssk_touch_led_test	Touch electrode board LED test pattern processing
r_rssk_touch_led_control	Touch electrode board LED control processing

3.7 List of Peripheral Functions Used and Pins Used

Table 3-6 shows a list of peripheral functions used, Table 3-7 shows a list of used pins and Table 3-8 shows a list of handling of unused pins in this sample software.

Table 3-6 List of Peripheral Functions Used

Peripheral Function	Usage
CTSU	CTSU measurement
SCI	QE serial monitoring and serial tuning
AGT	LED control trigger
IOPORT	LED control

Table 3-7 List of used pins

Pin No	Pin Name	I/O	Usage
3	TS18	I/O	CTSU measurement
4	TS17	I/O	
21	TS07	I/O	
22	TS06	I/O	
23	TS05	I/O	
24	TS04	I/O	
33	TS00	I/O	
47	TS02	I/O	
48	TS08	I/O	
49	TS09	I/O	
52	TS10	I/O	
53	TS11	I/O	
54	TS12	I/O	
56	TS27	I/O	
57	TS29	I/O	
58	TS35	I/O	
70	TS34	I/O	
71	TS13	I/O	
72	TS14	I/O	
73	TS15	I/O	
74	TS16	I/O	
75	TS26	I/O	
84	TS28	I/O	
86	TS33	I/O	
87	TS32	I/O	
90	TS31	I/O	
91	TS30	I/O	
96	TS25	I/O	
97	TS24	I/O	
98	TS23	I/O	
99	TS22	I/O	
100	TS21	I/O	
55	TSCAP	I	
34	P203/TXD9	O	QE serial communication
35	P202/RXD9	I	
31	P206	I	LED control
32	P205	I	
1	P400	O	
7	P406	O	
8	P714	O	
16	P708	O	
17	P415	O	
18	P414	O	
43	P305	O	
44	P304	O	
80	P504	O	
94	P006	O	

Table 3-8 List of Handling of Unused Pins

Pin No	Pin Name	I/O	Handling
9	VCL	-	Connect the pin to GND via a capacitor (4.7uF).
10	XCIN	-	Open
11	XCOUT	-	Open
12	VSS	-	Ground pin. Connect it to the system power supply (0V).
15	VCC	-	Power supply pin. Connect it to the system power supply.
26	VSS_DCDC	-	Switching regulator ground pin. Connect it to the system power supply (0V).
27	VLO	-	Switching regulator pin
28	VCC_DCDC		Switching regulator power supply pin
36	VSS	-	Ground pin. Connect it to the system power supply (0V).
37	VCC	-	Power supply pin. Connect it to the system power supply.
38	RES	I	Connect to the reset circuit
39	MD	-	Connect the pin to VCC or GND via a register (1.5Kohm).
40	NMI	I	Connect the pin to VCC via a register (4.7Kohm).
50	SWCLK	-	Serial wire clock pin
51	SWDIO	-	Serial wire debug data input/output pin
62	VCC	-	Power supply pin. Connect it to the system power supply.
63	VSS	-	Ground pin. Connect it to the system power supply (0V).
82	VCC	-	Power supply pin. Connect it to the system power supply.
83	VSS	-	Ground pin. Connect it to the system power supply (0V).
88	AVCC0	-	Connect the pin to GND via a capacitor (0.1uF).
89	AVSS0	-	Connect the pin to GND
Pins than the above		-	Low output

The peripheral function settings using FSP Configuration are shown below.

- CTSU (CTSU measurement)

Use CTSU to run touch measurement. The CTSU setting is the default setting.

- SCI

Use SCI for serial monitoring of QE for Capacitive Touch. Table 3-9 shows the SCI settings.

Table 3-9 SCI Setting

Item	Setting
Usable mode	Asynchronous UART
Usable channel	9

- AGT

Use AGT for LED control. Table 3-10 shows the AGT settings.

Table 3-10 AGT Setting

Item	Setting
Interval	5ms
Usable channel	0

- IOPORT

Use IOPORT for LED control. The IOPORT setting is the default setting.

3.8 Processing Flowchart

Figure 3-2 shows processing flowchart of this sample code.

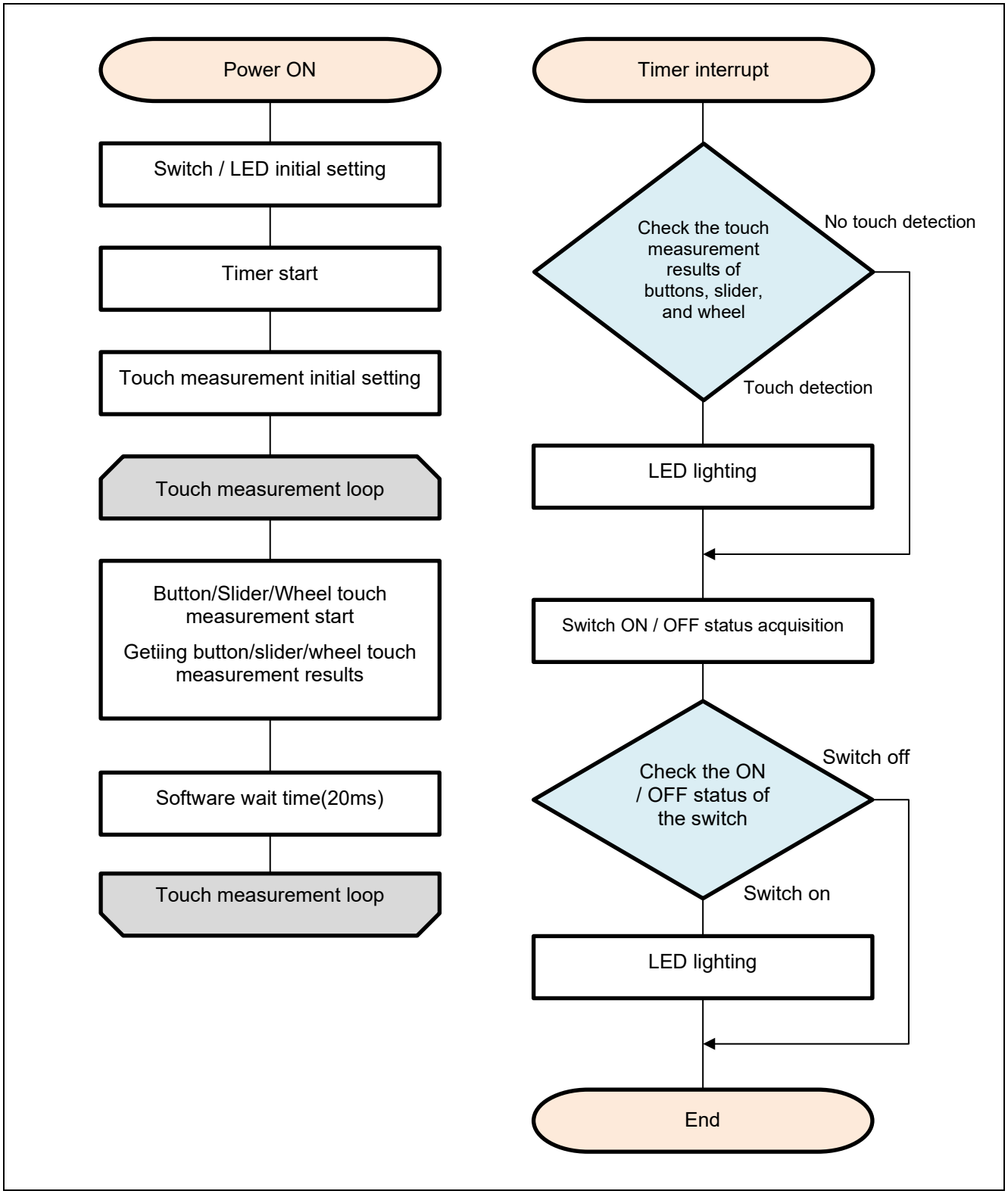


Figure 3-2 Processing Flowchart (Self-Capacitance Buttons / Wheel / Slider Board)

4. Capacitive Touch Setting

These are the touch interface configuration, configuration (method) settings and tuning results of this sample code. These use the tuning function of QE.

4.1 Touch Interface Configuration

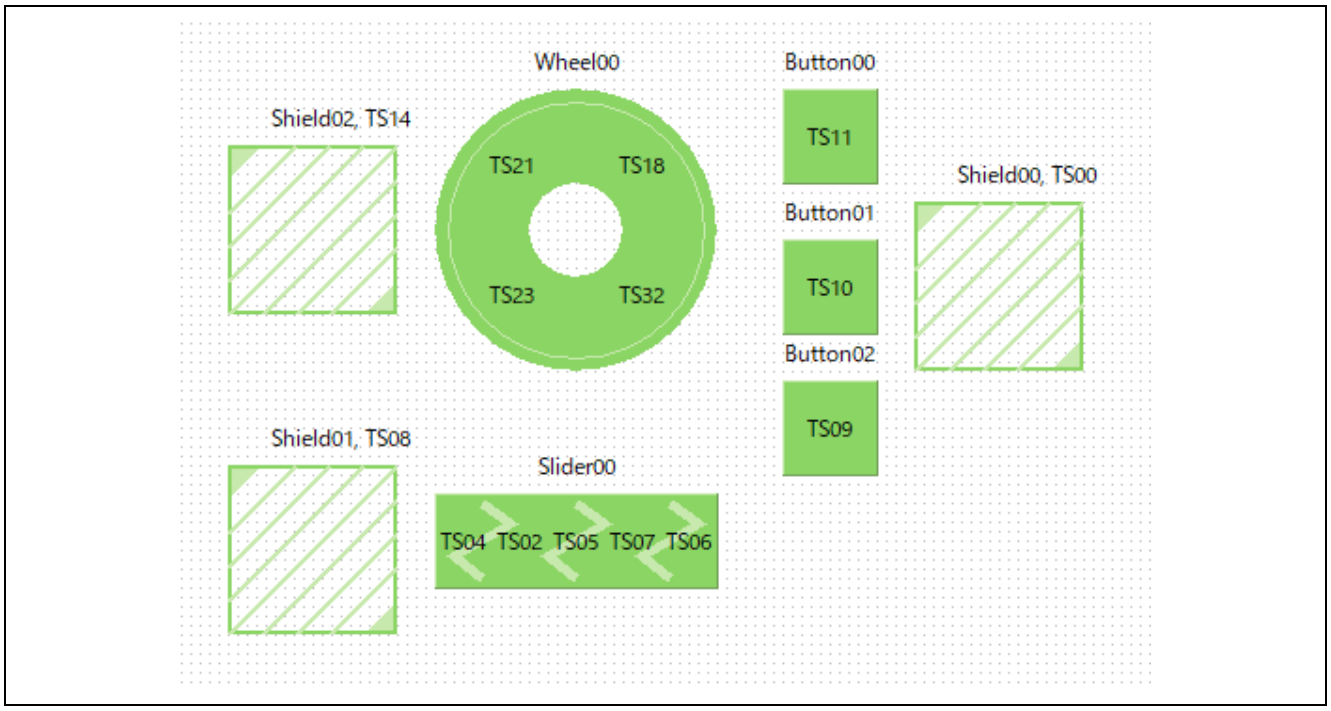


Figure 4-1 Touch interface configuration (Self-Capacitance Buttons / Wheel / Slider Board)

4.2 Configuration (methods) Settings

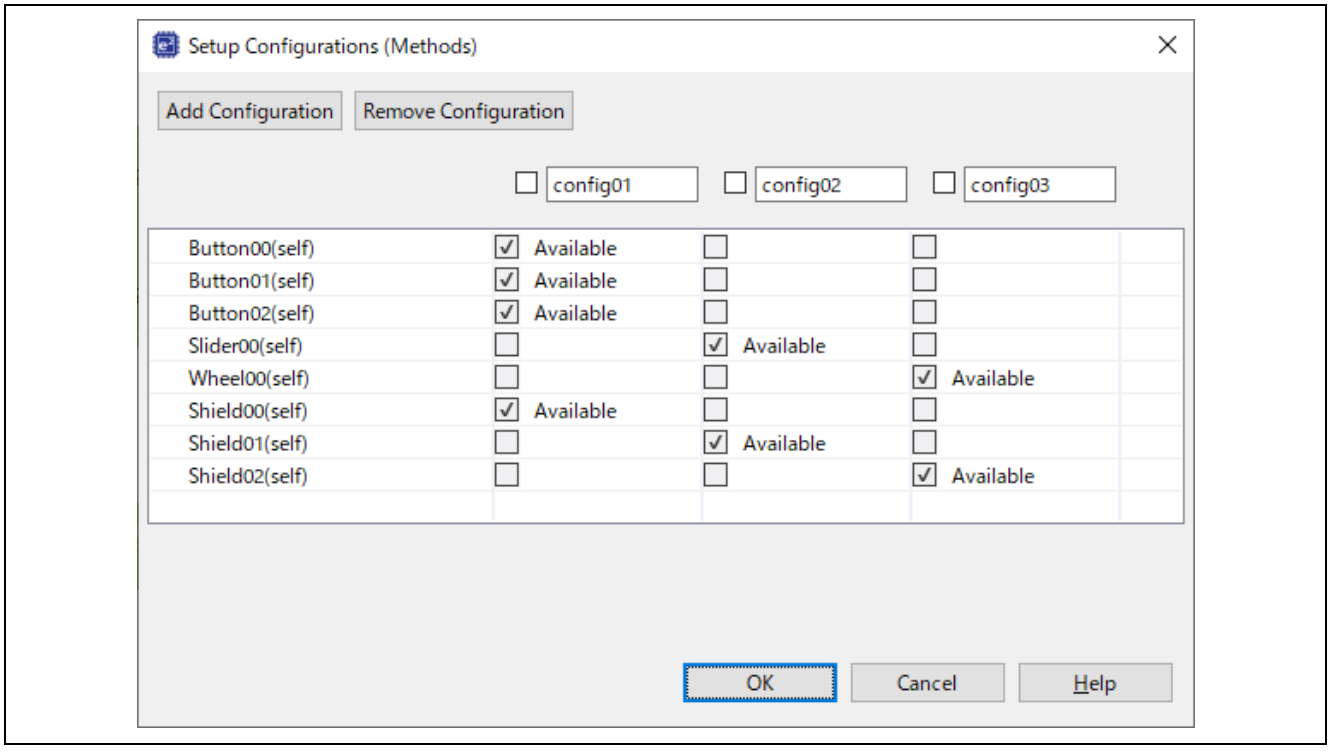


Figure 4-2 Configuration (methods) setting

4.3 Tuning results

Table 4-1 shows tuning results in QE tuning. Sample code operates with the setting values shown in the QE tuning result list.

Since the values in QE tuning result list depend on the operating environment at QE tuning, these values may change at QE tuning again.

Table 4-1 QE tuning result list (Self-Capacitance Buttons / Wheel / Slider Board)

methods	Button name	Touch senser	Parasitic capacitance [pF]	Drive pulse frequency [MHz]	Threshold	Scan time [ms]	so	snum	sdpa
config01	Button00	TS11	12.736	1 (BASE:1.0)	501	0.576	0x03D	0x07	0x0F
config01	Button01	TS10	14.528	1 (BASE:1.0)	525	0.576	0x04E	0x07	0x0F
config01	Button02	TS09	11.174	1 (BASE:1.0)	508	0.576	0x02F	0x07	0x0F
config01	Shield00	TS00	47.736						
config02	Slider00	TS04	11.41	1 (BASE:1.0)	609	0.576	0x030	0x07	0x0F
config02	Slider00	TS02	9.701	1 (BASE:1.0)	609	0.576	0x021	0x07	0x0F
config02	Slider00	TS05	10.896	1 (BASE:1.0)	609	0.576	0x02C	0x07	0x0F
config02	Slider00	TS07	11.743	1 (BASE:1.0)	609	0.576	0x033	0x07	0x0F
config02	Slider00	TS06	11.556	1 (BASE:1.0)	609	0.576	0x032	0x07	0x0F
config02	Shield01	TS08	48.16						
config03	Wheel00	TS21	12.493	1 (BASE:1.0)	655	0.576	0x03A	0x07	0x0F
config03	Wheel00	TS18	12.66	1 (BASE:1.0)	655	0.576	0x03B	0x07	0x0F
config03	Wheel00	TS32	11.903	1 (BASE:1.0)	655	0.576	0x034	0x07	0x0F
config03	Wheel00	TS23	12.826	1 (BASE:1.0)	655	0.576	0x03E	0x07	0x0F
config03	Shield02	TS14	44.708						

so : Variables for sensor offset settings
snum : Variables for setting the measurement period
sdpa : Clock division setting variable

4.4 Sensitivity adjustment

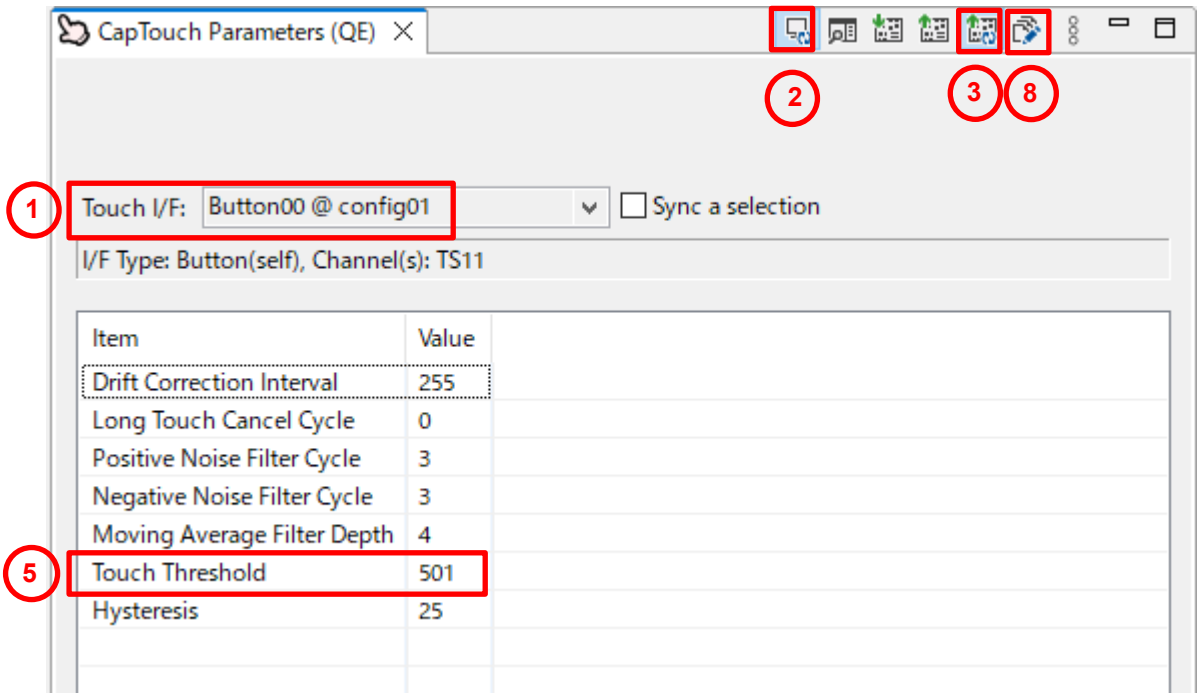
Button sensitivity adjustment uses QE for Capacitive Touch. The sensitivity adjustment method is as follows.

- The method using monitoring function of QE for Capacitive Touch

Follow the tutorial from the "CapTouch Workflow (QE)" of QE for Capacitive Touch.

- Real-time change method using monitoring function of QE for Capacitive Touch

1. Display the Cap Touch parameter list of QE for Capacitive Touch and adjust it by the following steps.
2. Select the touch I/F that corresponds to the button you want to adjust.
3. Click Enable Monitoring to start monitoring.
4. Once monitoring is enabled, the CapTouch parameter list items will be displayed.
5. Click [Write to target board in real time] to enable it.
6. Change the [Touch Threshold] value.
7. Repeat step 4 to adjust the sensitivity.
8. After completing the sensitivity adjustment, reflect the adjustment results in the source code using the following steps.
9. Click [Generate parameter file].
10. Build the project with an IDE (e2 studio, etc.).
11. Write the program to the MCU using an IDE (e2 studio, etc.).



- How to change the code manually

It can be adjusted by changing member variables of structure variable g_qe_touch_button_cfg_config01, g_qe_touch_slider_cfg_config02 or g_qe_touch_wheel_cfg_config03.

The variables to change are:

- threshold : Touch detection threshold

5. Support

For information on capacitive touch, download tools and documentation, and technical support, please visit the website below.

RA2L1 Capacitive Touch Evaluation System

https://www.renesas.com/rssk-touch-ra2l1

RA Family Using QE and FSP to Develop Capacitive Touch Applications (R01AN4934)

renesas.com/us/en/document/apn/using-qe-and-fsp-develop-capacitive-touch-applications?r=1398061

QE for Capacitive Touch	renesas.com/qe-capacitive-touch
Renesas support	renesas.com/support

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Nov.16.20	-	First edition issued
2.00	Mar.03.23	-	Support for FSP v4.3.0 Support for QE for Capacitive Touch V3.2.0 Added Software Specification
2.01	Oct.27.23	2	Updated operating frequencies and versions used (e2 studio, QE for Capacitive Touch, software packages) in Table 2.1.
		4	Table 3.1 Updated the versions used in the component list. 3.2 Update QE tuning log file name in file configuration。
		11	Table 4 1 Changed numerical data in QE tuning result list
		14	"4.4 Sensitivity adjustment method" Added the procedure and information linking the numbers in the figure.

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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