Renesas RA Family

RA6M2 Group Capacitive Touch Evaluation System Example Project

Introduction

This document describes the sample code for the RA6M2 Capacitive Touch Evaluation System.

Target Device

RA6M2 (R7FA6M2AF3CFB)

Contents

1. Overview

   This sample code is software that operates with capacitive touch in the RA6M2 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	RA6M2 (R7FA6M2AF3CFB)
Operating frequency	120MHz (Main Click Oscillator 12MHz, PLL 240MHz)
Operating voltage	5V
Evaluation board	RA6M2 Capacitive Touch Evaluation System (Product No : RTK0EG0021S01001BJ) • RA6M2 CPU Board (Product No : RTK0EG0017C01001BJ) • Capacitive Touch Evaluation Application Board (Product No : RTK0EG0019B01002BJ)
Integrated development environment	e^2 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

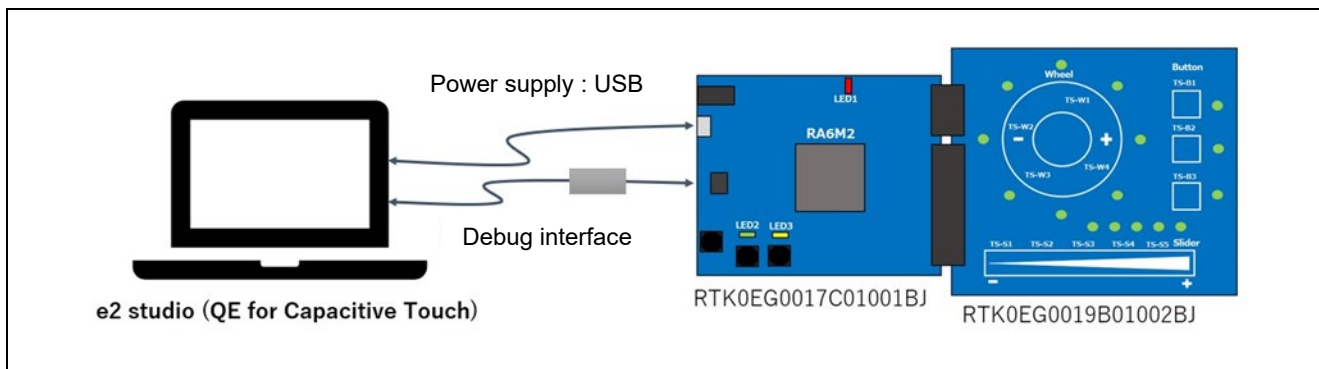Figure 2-1 shows device connection diagram

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.
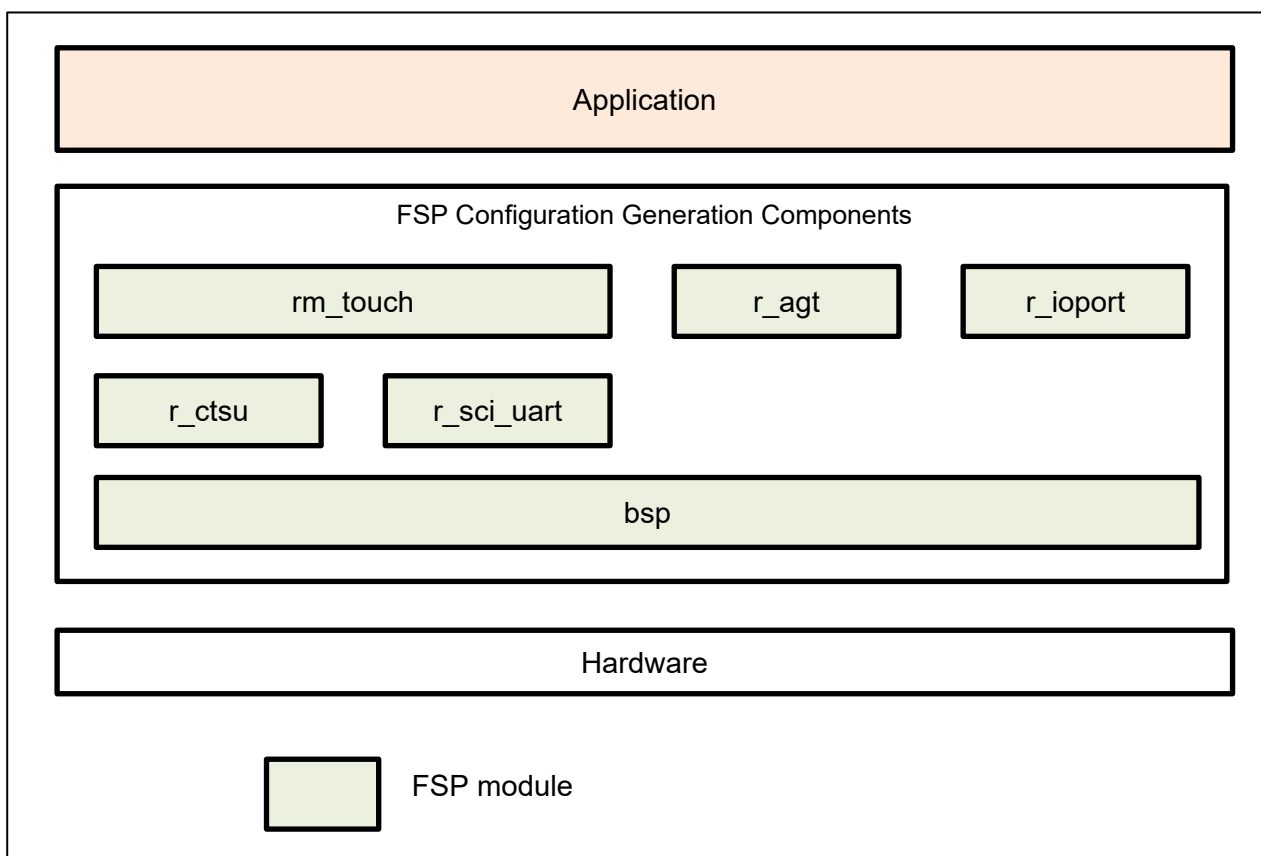

Figure 3-1 Software structure diagram

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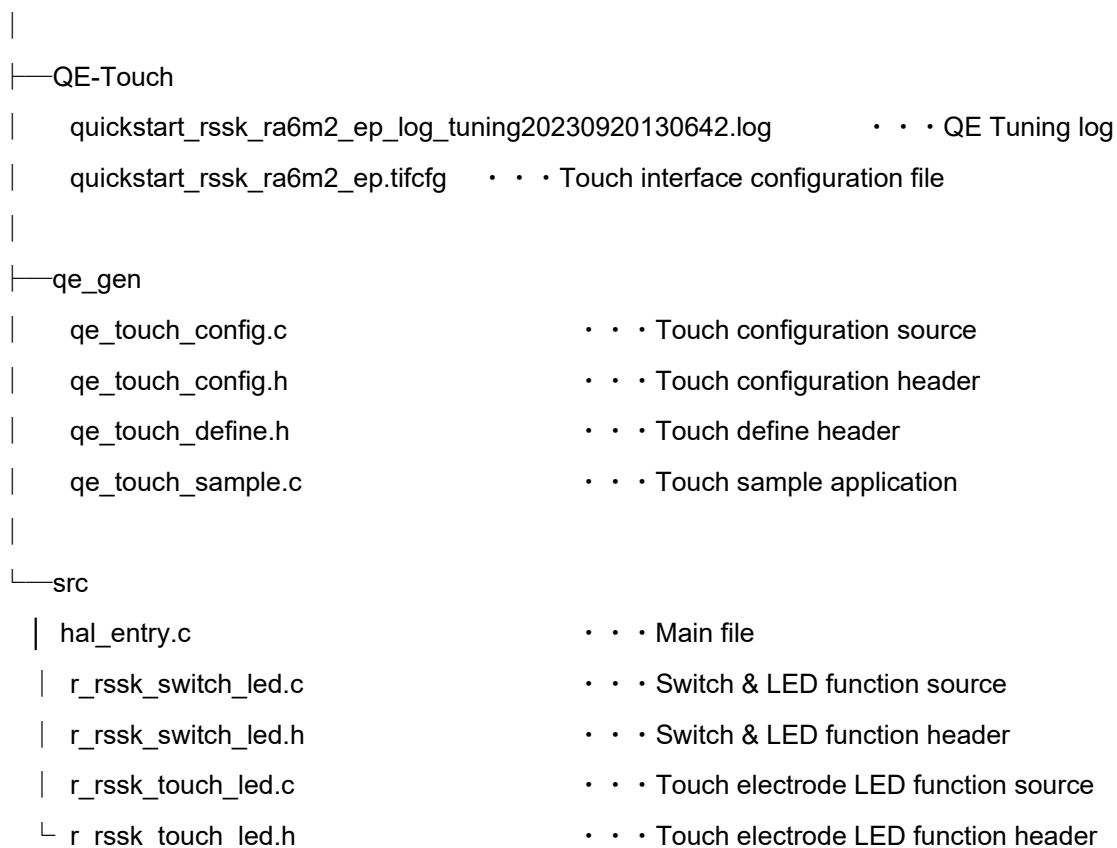
Table 3-1 Components and versions list

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 R7FA6M2AF3CFB	v4.6.0
Board support package for RA6M2	v4.6.0
Board support package for RA6M2 - FSP Data	v4.6.0
Custom 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_RA6M2_ep
 │
 ├──QE-Touch
 │     quickstart_rssk_ra6m2_ep_log_tuning20230920130642.log        ・・・QE Tuning log
 │     quickstart_rssk_ra6m2_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_05_PIN_02)	SW2 control port definition
RSSK_SW3_PORT	(BSP_IO_PORT_05_PIN_01)	SW3 control port definition
RSSK_LED2_PORT	(BSP_IO_PORT_00_PIN_06)	LED2 control port definition
RSSK_LED3_PORT	(BSP_IO_PORT_00_PIN_05)	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_01_PIN_03)	COL0 control port definition
LED_COL1	(BSP_IO_PORT_05_PIN_03)	COL1 control port definition
LED_COL2	(BSP_IO_PORT_05_PIN_04)	COL2 control port definition
LED_COL3	(BSP_IO_PORT_05_PIN_06)	COL3 control port definition
LED_ROW0	(BSP_IO_PORT_00_PIN_08)	ROW0 control port definition
LED_ROW1	(BSP_IO_PORT_00_PIN_07)	ROW1 control port definition
LED_ROW2	(BSP_IO_PORT_00_PIN_14)	ROW2 control port definition
LED_ROW3	(BSP_IO_PORT_00_PIN_09)	ROW3 control port definition
LED_COL_MAX	(4U)	Number of COL signals
LED_ROW_MAX	(4U)	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	(112U)	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
create_led_bitstring_button	Touch electrode board LED control (Button)
create_led_bitstring_wheel	Touch electrode board LED control (Wheel)
create_led_bitstring_slider	Touch electrode board LED control (Slider)

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
45	TSCAP	I	CTSU measurement
44	TS00	I/O	
42	TS01	I/O	
41	TS02	I/O	
36	TS03	I/O	
34	TS05	I/O	
33	TS06	I/O	
32	TS07	I/O	
31	TS08	I/O	
30	TS09	I/O	
29	TS10	I/O	
26	TS13	I/O	
25	TS14	I/O	
24	TS15	I/O	
23	TS16	I/O	
22	TS17	I/O	
88	P613/TXD7	O	QE serial communication
89	P614/RXD7	I	
114	P501	I	LED control (CPU Board)
115	P502	I	
135	P005	O	
134	P006	O	
133	P007	O	LED control (Electrode Board)
132	P008	O	
131	P009	O	
124	P014	O	
119	P506	O	
117	P504	O	
116	P503	O	
105	P103	O	

Table 3-8 List of Handling of Unused Pins

Pin No	Pin Name	I/O	Handling
14	VBATT	I	Backup power pin
15	VCL0	-	Connect the pin to GND via a capacitor (0.1µF).
16	XCIN	I	Connect a crystal resonator between XCOUT and XCIN.
17	XCOUT	O	
19	XTAL	O	An external clock signal can be input through the EXTAL
20	EXTAL	I	pin.
37	VSS_USB	I	USB ground pin
38	USB_DM	I/O	D- I/O pin of the USB on-chip transceiver.
39	USB_DP	I/O	D+ I/O pin of the USB on-chip transceiver.
40	VCC_USB	I	USB transceiver input supply voltage
55	RES	I	Connect to the reset circuit
56	MD	I	Connect the pin to VCC or GND via a register (1.5Kohm).
92	VCL	-	Connect the pin to GND via a capacitor (0.1µF).
125	VREFL	I	Analog reference ground pin.
126	VREFH	I	Analog reference voltage supply pin.
127	AVCC0	I	Supply this pin with the same voltage as the VCC pin.
128	AVSS0	I	Supply this pin with the same voltage as the VSS pin.
129	VREFL0	I	Analog reference ground pin.
130	VREFH0	I	Analog reference voltage supply pin.
18	VSS	I	Ground pin. Connect to the system power supply (0 V).
48			
67			
82			
91			
100			
112			
122			
141			
21	VCC	I	Power supply pin. Connect this pin to VSS by a 0.1-µF capacitor.
49			
68			
81			
90			
99			
111			
121			
142			
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	7

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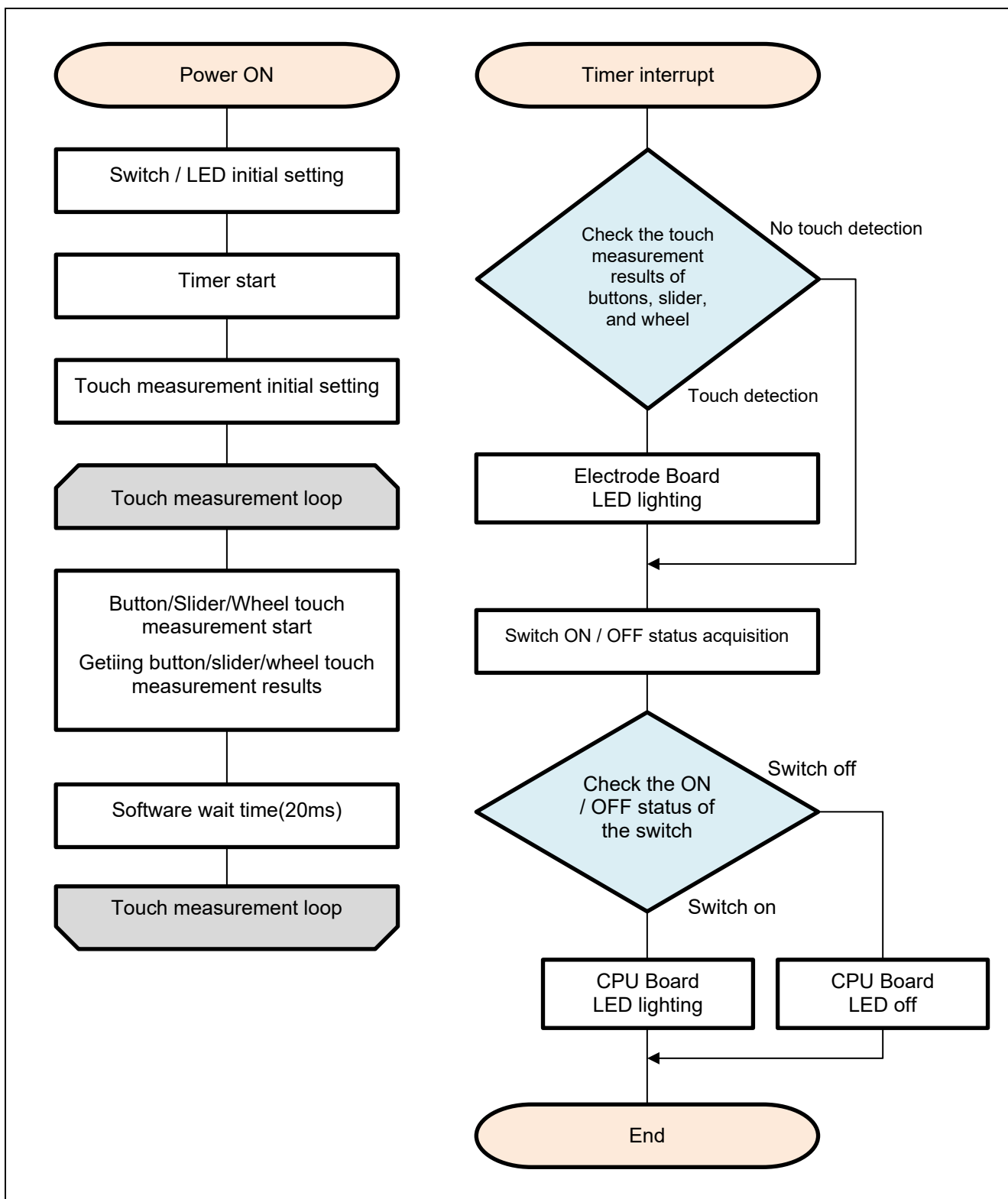
Figure 3-2   Processing Flowchart (Self-Capacitance Buttons / Wheel / Slider Board)

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.
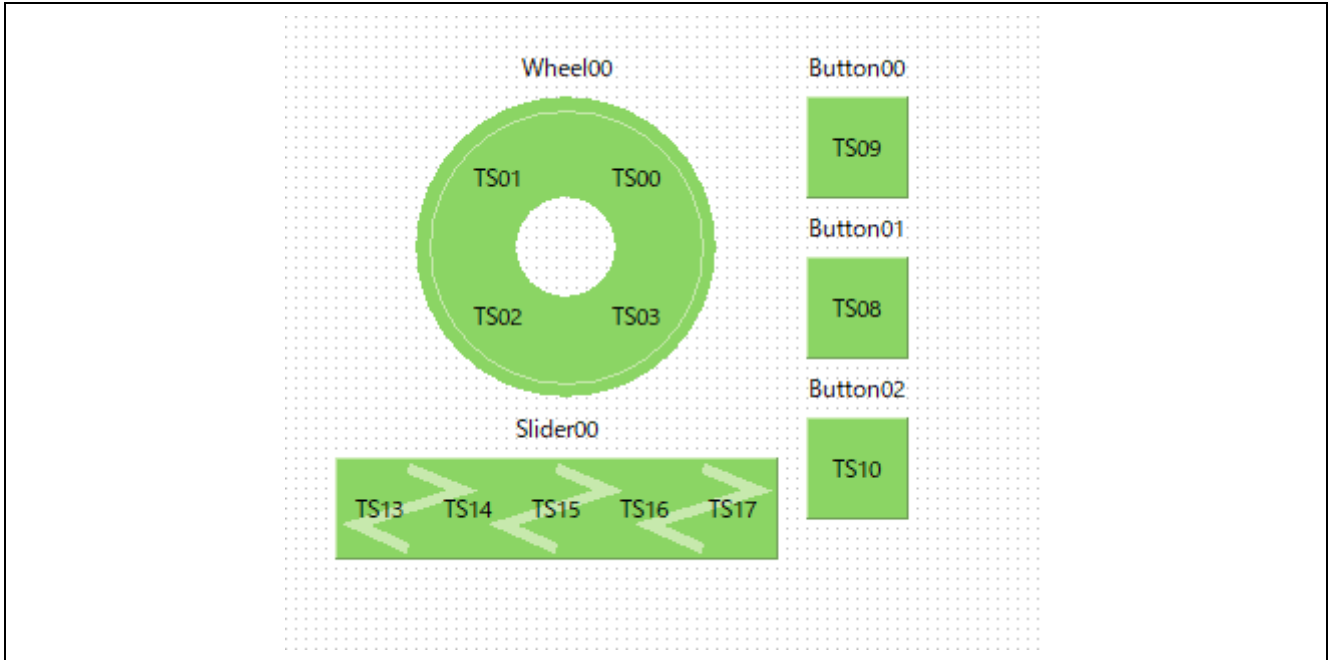
4.1   Touch Interface Configuration

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

4.2   Configuration (methods) Settings
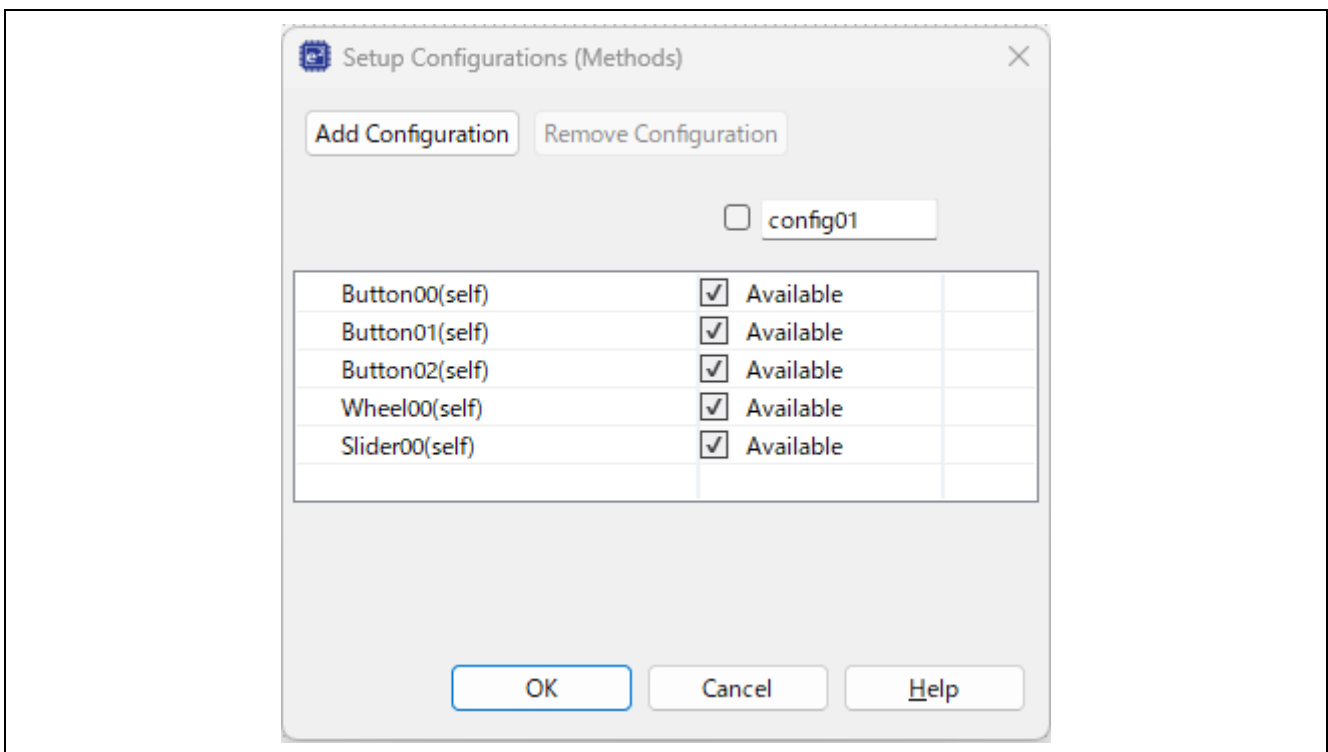
Figure 4-2 Configuration (methods) setting

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	TS09	21.854	1.768 (BASE:1.875)	1364	0.594	0x0E1	0x03	0x07
config01	Button01	TS08	19.918	1.768 (BASE:1.875)	1051	0.594	0x0C8	0x03	0x07
config01	Button02	TS10	20.019	1.768 (BASE:1.875)	1053	0.594	0x0C9	0x03	0x07
config02	Slider00	TS13	16.939	0.943 (BASE:1.0)	598	0.592	0x02D	0x01	0x0E
config02	Slider00	TS14	18.565	0.943 (BASE:1.0)	598	0.592	0x038	0x01	0x0E
config02	Slider00	TS15	18.919	0.943 (BASE:1.0)	598	0.592	0x03B	0x01	0x0E
config02	Slider00	TS16	19.746	0.943 (BASE:1.0)	598	0.592	0x041	0x01	0x0E
config02	Slider00	TS17	22.998	0.943 (BASE:1.0)	598	0.592	0x054	0x01	0x0E
config03	Wheel00	TS01	24.658	0.943 (BASE:1.0)	677	0.592	0x064	0x01	0x0E
config03	Wheel00	TS00	24.732	0.943 (BASE:1.0)	677	0.592	0x063	0x01	0x0E
config03	Wheel00	TS03	25.791	0.943 (BASE:1.0)	677	0.592	0x054	0x01	0x0E
config03	Wheel00	TS02	22.482	0.943 (BASE:1.0)	677	0.592	0x06C	0x01	0x0E

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

Display the Cap Touch parameter list of QE for Capacitive Touch and adjust it by the following steps.

1. Select the touch I/F corresponding to the button you want to adjust.
2. Click [Enable Monitoring] icon to start monitoring.
   When monitoring is enabled, the CapTouch parameter item is displayed.
3. Click [Write Value to the Target Board] to enable.
4. Change the value of [Touch Threshold].
5. Repeat steps 4 to adjust the sensitivity.

After completing the sensitivity adjustment, reflect the adjustment result in the source code by the following steps.

6. Click [Output Parameter Files] to generate the parameter file.
7. Build the project using the IDE (e^2 studio as an example).
8. Write the program to the MCU using the IDE (e^2 studio as an example).
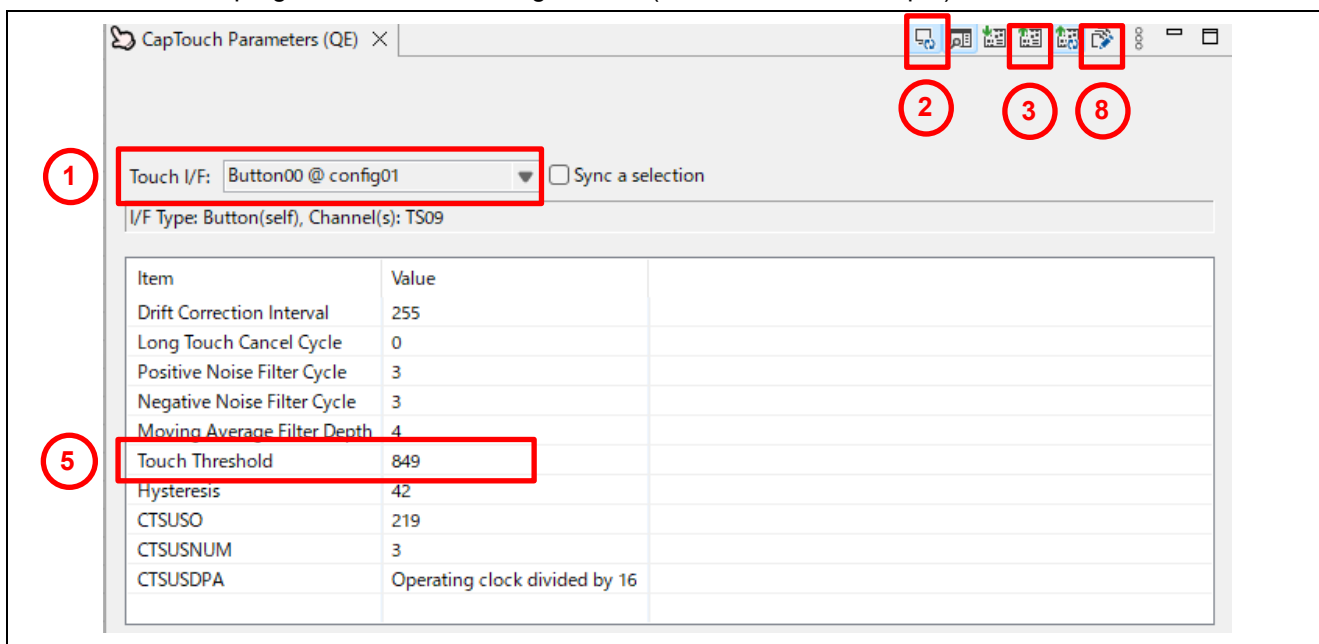
- How to change the code manually

It can be adjusted by changing member variables of structure variable g_qe_touch_button_cfg_config01.

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.

RA6M2 Capacitive Touch Evaluation System

https://www.renesas.com/rssk-touch-RA6M2

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

		Description	
Rev.	Date	Page	Summary
1.00	Nov.16.20	-	First edition issued
2.00	Dec.25.23	-	Support for FSP v4.6.0
			Support for QE for Capacitive Touch V3.3.0
			Added Software Specification

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

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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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(Rev.5.0-1 October 2020)

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