RL78/F25

Capacitive Touch Evaluation System Sample Code

Introduction

This document describes the contents of the sample code for the RL78/F25 Capacitive Touch Evaluation System.

Target Device

RL78/F25 (R7F125FPL)

Contents

1. Overview

This sample code is software that operates with capacitive touch in the RL78/F25 Capacitive Touch Evaluation system. The following is added to the project created by e^{2}studio.

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

1.1 Function

The functions of this software are shown below.

1. When the power is turned on and started, the LED test is performed. First, turn on LED2 and LED3 on the CPU board. After that, the LEDs on the electrode board are turned on and off in the order of buttons, slider, and wheel. (See Figure 1-1.)
2. The LEDs are controlled in conjunction with the operation of the three buttons, wheel, and slider on the touch electrode board. (See Figure 1-2). LED control is performed in conjunction with the push button on CPU board. Pressing SW2, LED2 lights up. Pressing SW3, LED3 lights up. (See Figure 1-2)

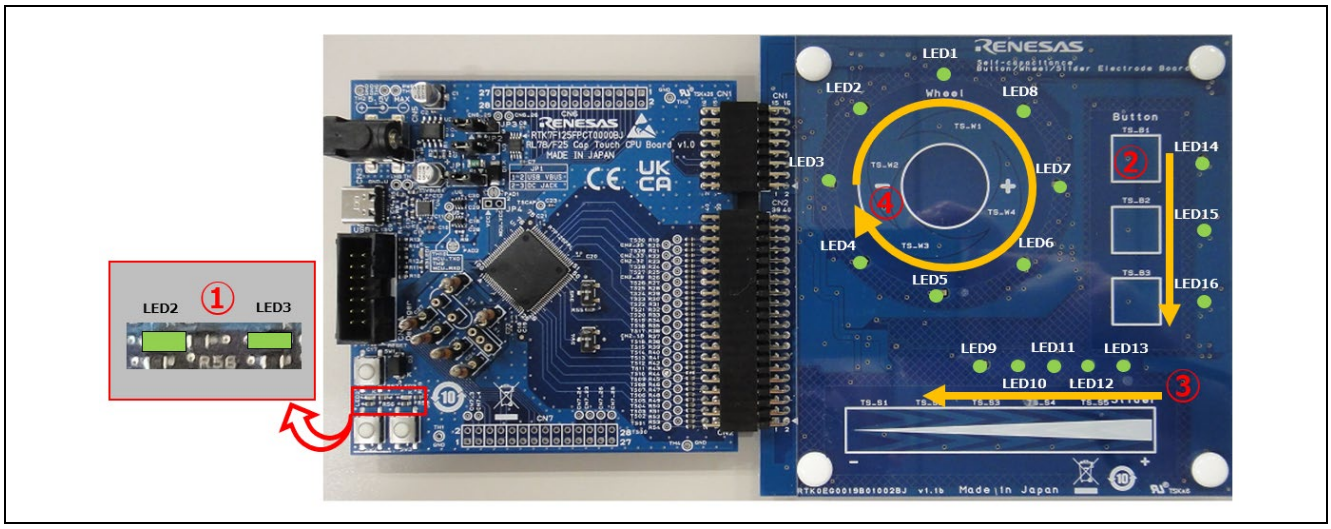

Figure 1-1 LED Testing During Software Startup

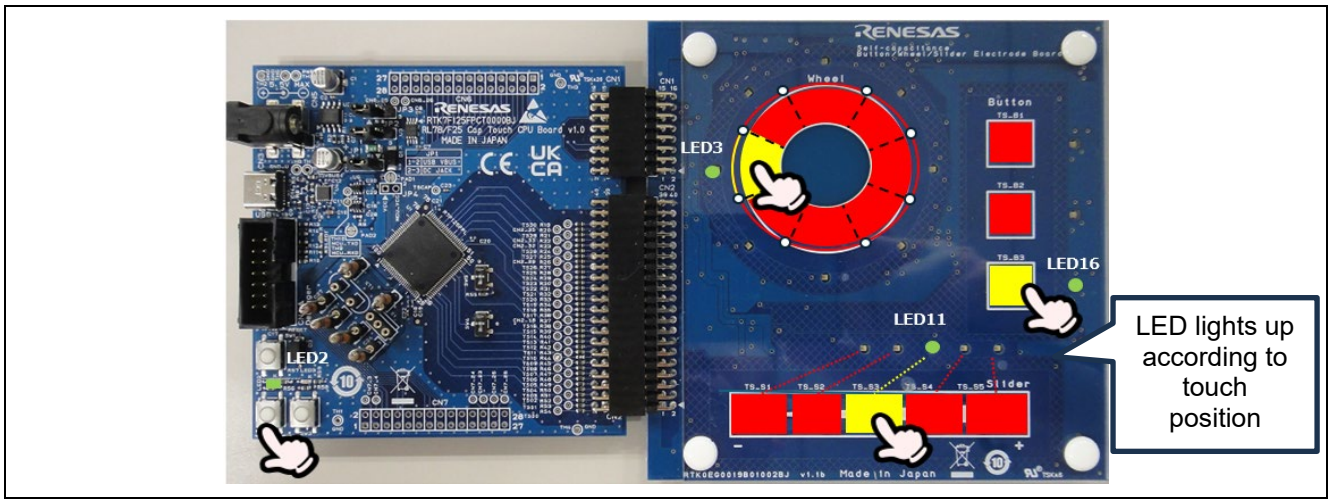

Figure 1-2 LED Control in Conjunction with Capacitive Touch Buttons, Slider, and Wheel Movements

2. Operation Confirmation Conditions

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

Table 2-1 Operation Confirmation Conditions

Item	Contents
MCU	RL78/F25 (R7F125FPL)
Operating frequency	40MHz
Operating voltage	5.0V (USB power) LVD0 detection voltage：Reset mode At rising edge: 2.97V, 3.96V (2 step) At falling edge: 2.91V, 3.88V (2 step)
Evaluation board	Capacitive Touch Evaluation System for RL78/F25 (Product No: RTK7F125FPST0000BJ) • RL78/F25 CPU Board (Product No: RTK7F125FPCT0000BJ) • Capacitive Touch Evaluation Application Board — Self-Capacitance Buttons / Wheel / Slider Board (Product No: RTK0EG0019B01002BJ)
Integrated development environment	e² studio Version 2025-07
C Compiler	CC-RL V1.15.00 Compile options of optimization: -Odefault
Development Assistance Tool for Capacitive Touch Sensors	QE for Capacitive Touch V4.2.0
Emulator	Renesas E2 Emulator Lite

Figure 2-1 shows device connection diagram.

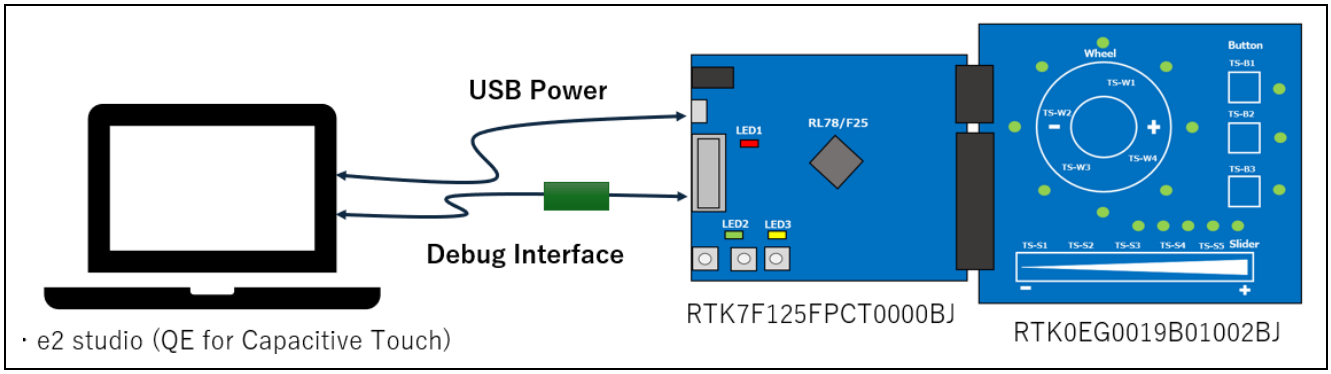

Figure 2-1 Device Connection Diagram

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 Smart Configurator.

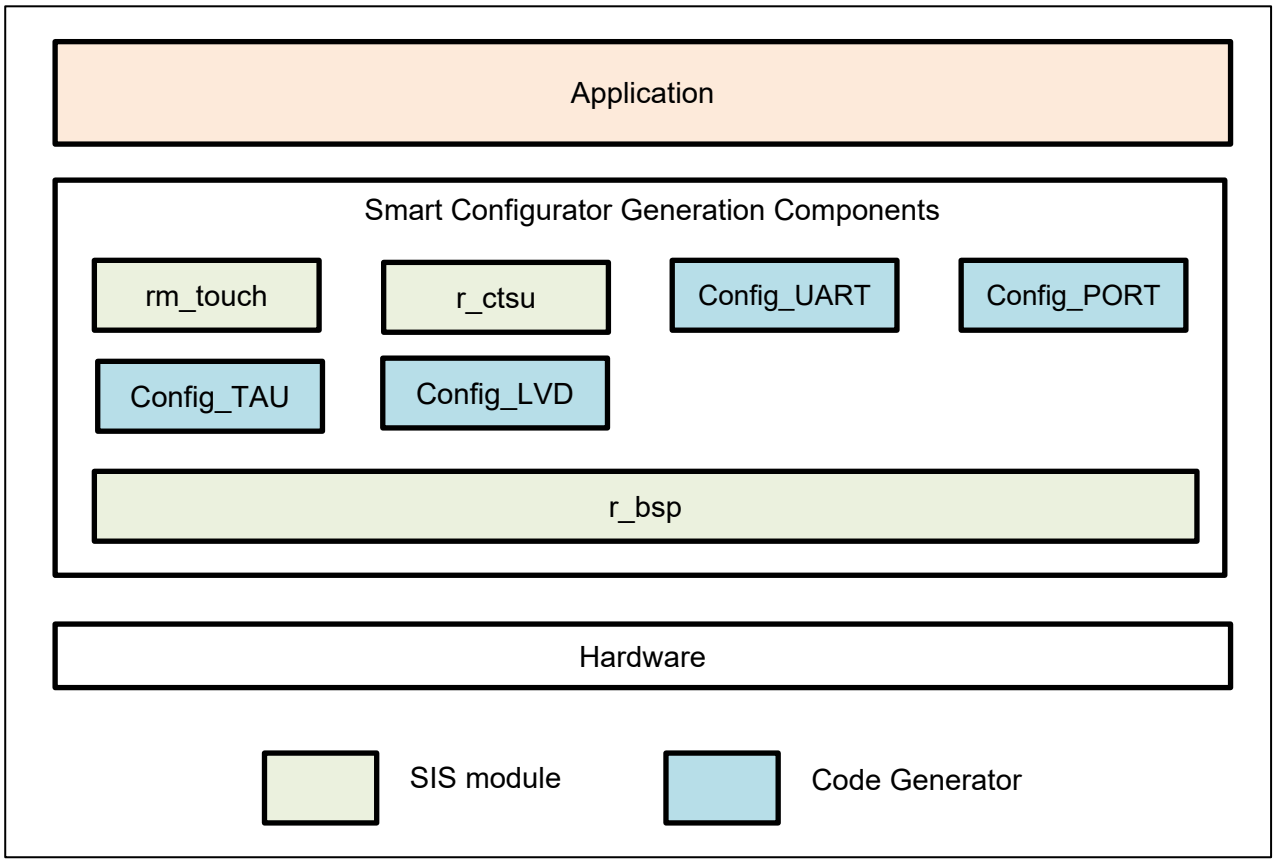

Figure 3-1 Software structure diagram

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

Table 3-1 Components and versions list

Selected components:

Component	Version	Configuration
Board Support Packages. - v1.91 (r_bsp)	1.91	r_bsp(used)
Capacitive Sensing Unit driver. (r_ctsu)	2.20	r_ctsu(used)
Interval Timer	1.8.0	Config_TAU0_1(TAU0_1: used)
Ports	1.8.0	Config_PORT(PORT: used)
Touch middleware. (rm_touch)	2.20	rm_touch(used)
UART Communication	1.10.0	Config_UART1(UART1: used)
Voltage Detector	1.6.1	Config_LVD0(LVD0: used)

3.2 List of Peripheral Functions Used and Pins Used

The peripheral function settings using Smart Configurator are shown below.

Table 3-2 shows a list of peripheral functions used.

Table 3-2 List of Peripheral Functions Used

Peripheral Function	Usage
TOUCH	Touch control
CTSU	CTSU measurement
UART1	QE serial monitoring and serial tuning
TAU0	LED control trigger
PORT	LED control
LVD0	Voltage Detector

- Touch middleware(rm_touch).

Use rm_touch for touch control. Table 3-3 shows the rm_touch settings. This setting enables QE serial monitoring and serial tuning.

Table 3-3 Touch middleware(rm_touch) Setting

Item	Setting
Support QE monitor using UART	Enable
Support QE tuning using UART	Enable
UART channel	UART1
Type of chattering suppression	TypeA

- CTSU (r_ctsu).

Use CTSU to run touch measurement. Table 3-7 shows the TS terminal settings. The CTSU setting is the default setting without the TS terminal settings.

- Voltage Detector

The reset generation voltage settings are shown inTable 3-4.

Table 3-4 Voltage Detector Setting

Item	Setting
Operation mode	Reset mode
Detection level Reset generation voltage(VLVD0)	 2.91V

➢ UART communication

Use UART1 for serial monitoring of QE for Capacitive Touch. Table 3-5 shows the UART1 settings.

Table 3-5 UART1 Setting

Item	Setting
Operation clock	CK10
Clock Source	fCLK/2
Transfer mode setting	Single transfer mode
Data length setting	8 bits
Transfer direction setting	LSB
Parity setting	Parity bit None
Stop bit length setting	1 bit
Transfer data level setting	None-reverse
Transfer rate setting	115200 bps
Interrupt- setting: Transmit	Transmit end interrupt priority(INTST1): Level 3 (low)
Interrupt- setting: Receive	Reception end interrupt priority(INTSR1): Level 3 (low)
Callback function setting: Transmit	Transmission end: Enable
Callback function setting: Receive	Reception end: Enable

➢ Interval Timer

Use TAU0_1 for LED control. Table 3-6 shows the TAU0_1 settings.

Table 3-6 TAU0 Setting

Item	Setting
Operation clock	CK02
Clock source	fCLK/2^12
Operation Mode	Upper 8 bits
Interval value (16 bits)	5 ms
Interrupt setting	End of timer channel1 count, generate an interrupt (INTTM01H) : Enable Priority: Level 3 (low)

➢ Ports.

Table 3-7 and Table 3-8 show lists of used pins, and Table 3-9 shows a list of handling of unused pins in this sample software.

Table 3-7 List of used pins (1)

Pin No.	Pin Name	I/O	Usage
24	TS00	I/O	CTSU measurement
25	TS01	I/O	
26	TS02	I/O	
27	TS03	I/O	
28	TS04	I/O	
29	TS05	I/O	
30	TS06	I/O	
31	TS07	I/O	
39	TS08	I/O	
40	TS09	I/O	
57	TS20	I/O	
64	TS26	I/O	
66	TS28	I/O	
57	TS29	I/O	
68	TS30	I/O	
62	TSCAP	-	

Table 3-8 List of used pins (2)

Pin No.	Pin Name	I/O	Usage
41	P75/RxD1	I	QE serial communication
42	P74/TxD1	O	
16	P137/SW2	I	Switch Input
55	P31/SW3	I	
70	P106/LED2	O	LED Control
69	P107/LED3	O	
98	P01/LED_ROW0	O	
95	P02/LED_ROW1	O	
97	P126/LED_ROW2	O	
96	P127/LED_ROW3	O	
34	P00/LED_COL0	O	
48	P03/LED_COL1	O	
49	P32/LED_COL2	O	
50	P30/LED_COL3	O	

Table 3-9 List of Handling of Unused Pins

Pin No	Pin Name	I/O	Handling
19	REGC	-	-
22	VDD		
23	EVDD0		
53	EVDD1		
20	VSS		
21	EVSS0		
43	EVSS1		
74	AVSS		
11	P41	I	Set to input port.
14	P124/XT2	I	
15	P123/XT1	I	
17	X2	I	
18	X1	I	
Pins than the above		-	Low output

3.3 File Structure

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

```
rl78f25_rssk_sample
├─QE-Touch
│    rl78f25_rssk_sample_tuning.log   ・・・QE Tuning log
│    rl78f25_rssk_sample.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
     rl78f25_rssk_sample.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
     └─smc_gen
          ├─Config_PORT               ・・・PORT driver folder
          ├─Config_TAU0_1             ・・・Timer driver folder
          ├─Config_UART1              ・・・UART driver folder
          ├─general                   ・・・general setting folder
          ├─rm_touch                  ・・・TOUCH SIS module folder
          ├─r_bsp                     ・・・BSP folder
          ├─r_config                  ・・・SIS config folder
          ├─r_ctsu                    ・・・CTSU SIS module folder
          └─r_pincfg                  ・・・Pin config folder
```

3.4 Setting of Option Byte

Table 3-10 shows the option byte settings.

Table 3-10 Option Byte Settings

Address	Setting Value	Contents
000C0H / 040C0H	1110 1111b(0xEF)	Disables the watchdog timer. (Counting stopped after reset)
000C1H / 040C1H	0111 1011b(0x7B)	LVD0 detection voltage : Reset mode At rising edge: 2.97V, 3.96V (2 step) At falling edge: 2.91V, 3.88V (2 step)
000C2H / 040C2H	1110 1000b(0xE8)	HS (high-speed main) mode High-speed on-chip oscillator clock: 40MHz
000C3H / 040C3H	1010 0100b(0xA4)	Enables on-chip debugging

Figure 3-2 shows the screen to check with the build options.

The setting value of the option byte can be checked from the project properties after code generation. Open the project properties (Alt+Enter) and select “C/C++ Build” -> “Settings” to open a “Tool Settings” tab, and select “Linker” -> “Device” and the “User option byte value” and “On-chip debug control value” are displayed.

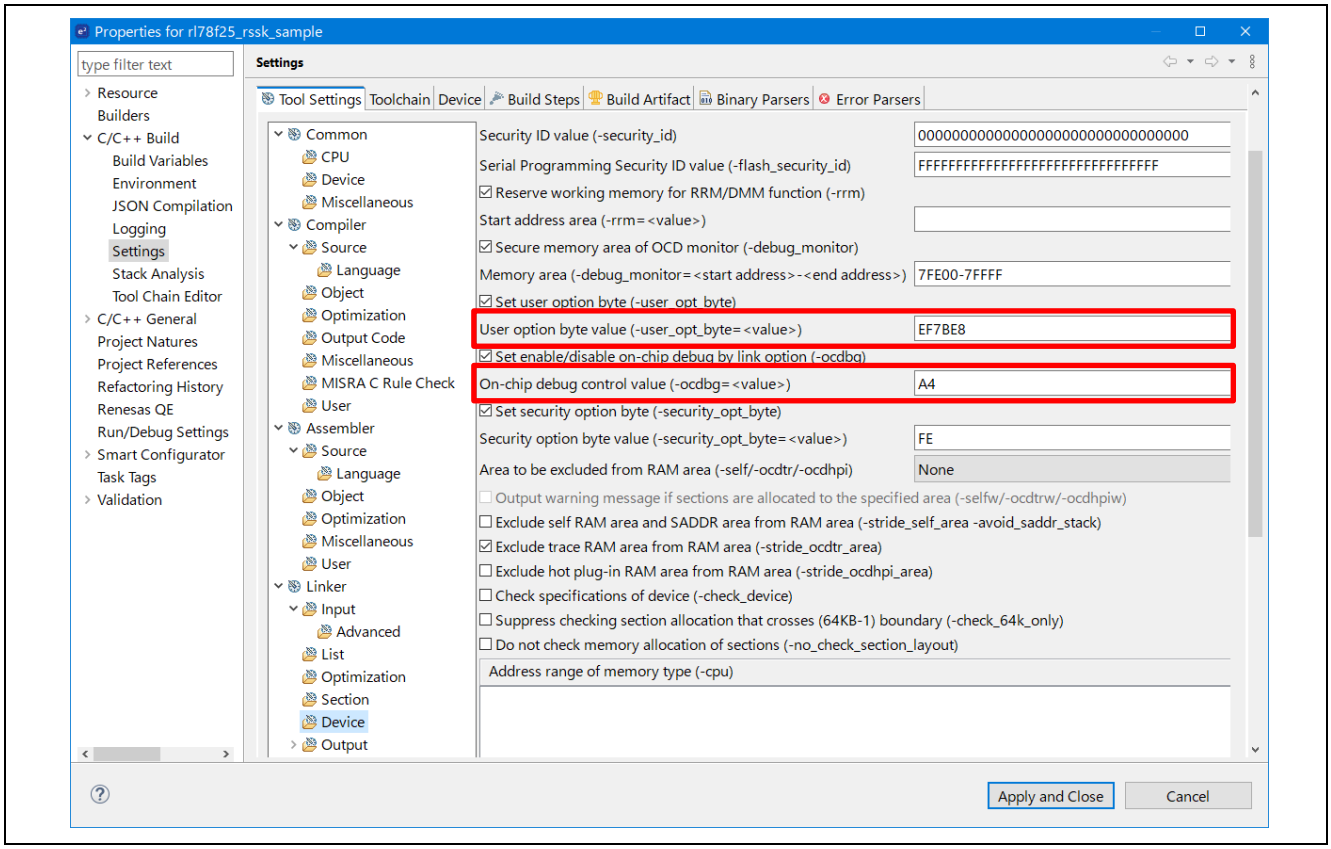

Figure 3-2 User Option Byte Value and On-chip Debug Control Value

3.5 Constants

Table 3-11 lists the constants.

Table 3-11 List of Constant

Constant Name	Setting Value	Description
File Name : qe_touch_sample.c		
TOUCH_SCAN_INTERVAL_EXAMPLE	(20U)	Software delay value [unit: ms]
File Name : r_rssk_switch_led.c		
RSSK_SW2_PORT	(P13_bit.no7)	Pointer to port control register connected to SW2
RSSK_SW3_PORT	(P3_bit.no1)	Pointer to port control register connected to SW3
RSSK_LED2_PORT	(P10_bit.no6)	Pointer to port control register connected to LED2
RSSK_LED3_PORT	(P10_bit.no7)	Pointer to port control register connected to LED3
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	(0x00U)	Turn on the LED
RSSK_LED_OFF	(0x01U)	Turn off the LED
File Name : r_rssk_touch_led.c		
LED_COL0	(P0_bit.no0)	Pointer to port control register connected to COL0
LED_COL1	(P0_bit.no3)	Pointer to port control register connected to COL1
LED_COL2	(P3_bit.no2)	Pointer to port control register connected to COL2
LED_COL3	(P3_bit.no0)	Pointer to port control register connected to COL3
LED_ROW0	(P0_bit.no1)	Pointer to port control register connected to ROW0
LED_ROW1	(P0_bit.no2)	Pointer to port control register connected to ROW1
LED_ROW2	(P12_bit.no6)	Pointer to port control register connected to ROW2
LED_ROW3	(P12_bit.no7)	Pointer to port control register connected to ROW3
LED_COL_MAX	(4U)	Number of COL signals
LED_COL_ON	(1U)	COL signal ON
LED_COL_OFF	(0U)	COL signal OFF
LED_ROW_OFF	(1U)	ROW signal OFF
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 – 1U))	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)	Total number of touch electrode board LEDs
LED_TEST_INTERVAL	(100U)	LED lighting interval time [unit: ms]

3.6 Enumerations

Table 3-12 lists the rssk_sw_status_t enum.

Table 3-12 rssk_sw_status_t

Member	Value	Description
File Name : r_rssk_switch_led.h		
RSSK_SW_OFF	0x00	Switch OFF state
RSSK_SW_ON	0x01	Switch ON state

3.7 Global Variables

Table 3-13 lists the global variables.

Table 3-13 List of Global Variable

Variable Name	Types	Description
File Name : qe_touch_sample.c		
button_status	uint64_t	Button status
slider_position[1]	uint16_t	Slider touch position information
wheel_position[1]	uint16_t	Wheel touch position information
File Name : r_rssk_touch_led.c		
g_led_drive_colmun	uint8_t	Touch electrode board LED drive information
g_button_idx[3]	uint8_t	Button index array

3.8 Functions

Table 3-14 lists the functions.

Table 3-14 List of Function

Function Name	Description
File Name : qe_touch_sample.c	
qe_touch_main	Main function
r_rssk_led_test	LED test processing for Capacitive Touch Evaluation System
r_rssk_initialize	CPU board initialization processing
r_rssk_timer_callback	TAU0 interrupt callback
File Name : r_rssk_switch_led.c	
r_rssk_switch_led_init	CPU board LED initialization processing
r_rssk_switch_led_control	CPU board LED control processing
rssk_get_sw2_status	SW2 state response processing
rssk_get_sw3_status	SW3 state response 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
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	Create Button LED bit strings
create_led_bitstring_wheel	Create Wheel LED bit strings
create_led_bitstring_slider	Create Slider LED bit strings

3.9 Processing Flowchart

Figure 3-3 shows processing flowchart of this software.

- Initialization

① 1. Initial setting of switches / touch electrodes / LEDs, performing LED tests
2. Touch measurement initial setting, open touch middleware
3. Timer activation for touch measurement loops

- Touch measurement loop (main loop)

② 1. Touch measurement of buttons, slider, wheel → Waiting for measurement results
→ Acquisition of measurement results
2. Software wait (wait 20ms after processing 1.)

- Timer interrupt processing (5ms Interval)

③ LED control of the touch electrode board (The LEDs are configured in a 4x4 matrix, so they are controlled by a dynamic lighting method, with four interrupts per row.)

④ LED control corresponding to the switch on the CPU board (To prevent chattering, the LED will light up if the switch input is judged to be ON three times in a row.)

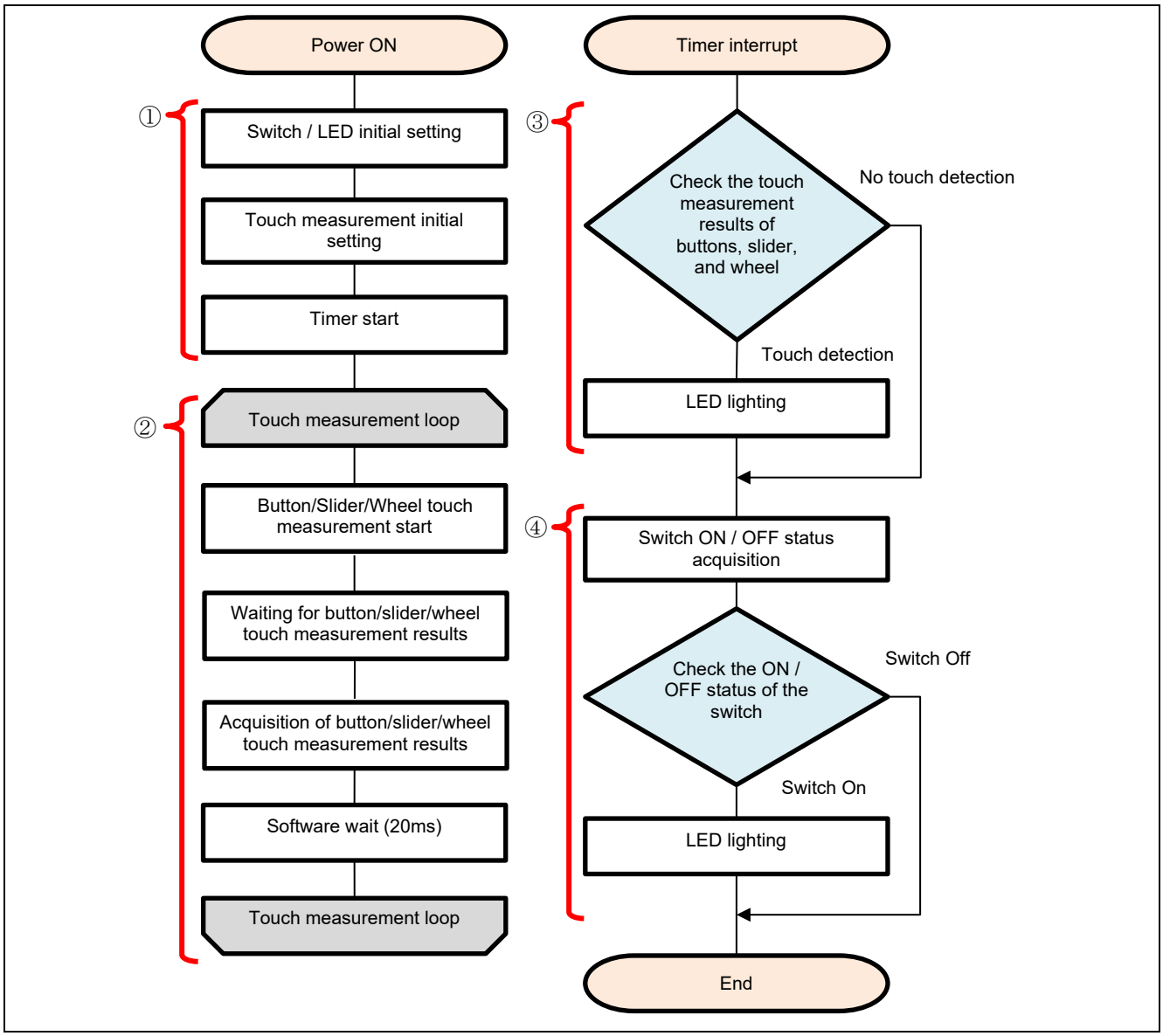

Figure 3-3 Processing Flowchart

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

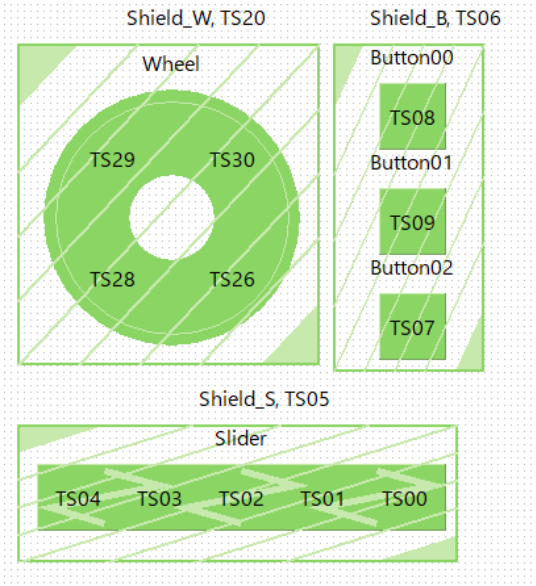

Figure 4-1 Touch interface configuration (Self-Capacitance Buttons / Wheel / Slider Board)

4.2 Configuration (methods) Settings

Figure 4-2 shows configuration (methods) of this sample code. 3 buttons and Shield00 are set enabled in config01. Slider and Shield01 are set enabled in config02. Wheel and Shield02 are set enabled in config03.

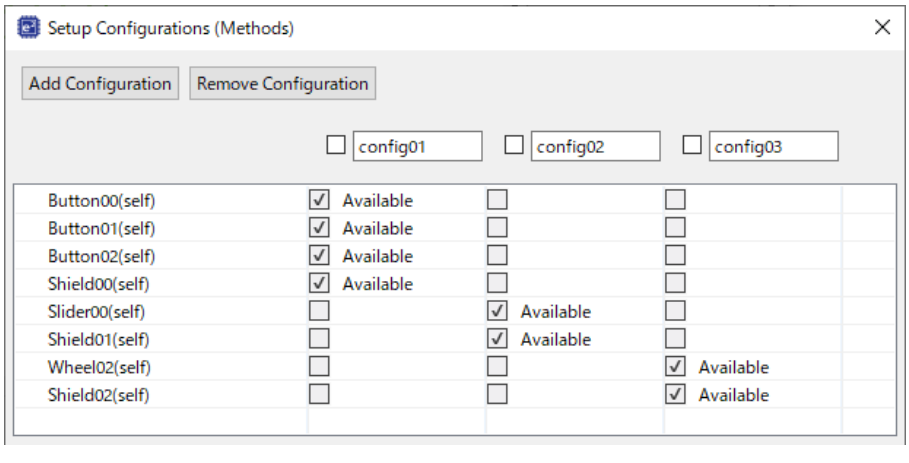

Figure 4-2 Configuration (methods) setting

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	TS08	11.839	1.014 (BASE:1.0)	587	0.576	0x03B	0x07	0x11
config01	Button01	TS09	9.924	1.014 (BASE:1.0)	604	0.576	0x02D	0x07	0x11
config01	Button02	TS07	10.153	1.014 (BASE:1.0)	595	0.576	0x030	0x07	0x11
config01	Shield00	TS06	48.382	-	-	-	-	-	-
config02	Slider00	TS04	9.778	1.035 (BASE:1.0)	573	0.576	0x037	0x07	0x11
config02	Slider00	TS03	7.75	1.035 (BASE:1.0)	573	0.576	0x028	0x07	0x11
config02	Slider00	TS02	9.95	1.035 (BASE:1.0)	573	0.576	0x02B	0x07	0x11
config02	Slider00	TS01	9.208	1.035 (BASE:1.0)	573	0.576	0x01C	0x07	0x11
config02	Slider00	TS00	11.25	1.035 (BASE:1.0)	573	0.576	0x02E	0x07	0x11
config02	Shield01	TS05	47.382	-	-	-	-	-	-
config03	Wheel00	TS29	8.576	1.097 (BASE:1.0)	718	0.576	0x03B	0x07	0x10
config03	Wheel00	TS30	9.583	1.097 (BASE:1.0)	718	0.576	0x03B	0x07	0x10
config03	Wheel00	TS26	10.722	1.097 (BASE:1.0)	718	0.576	0x027	0x07	0x10
config03	Wheel00	TS28	10.924	1.097 (BASE:1.0)	718	0.576	0x030	0x07	0x10
config03	Shield02	TS20	44.597	-	-	-	-	-	-

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.
3. When the item is displayed, change the value of [Touch Threshold].
4. Click [Enable Auto Writing] to change the touch threshold.
5. Repeat steps 3 to 4 to adjust the sensitivity.

The settings for steps 1 to 4 above are performed in steps ① to ④ in Figure 4-3.

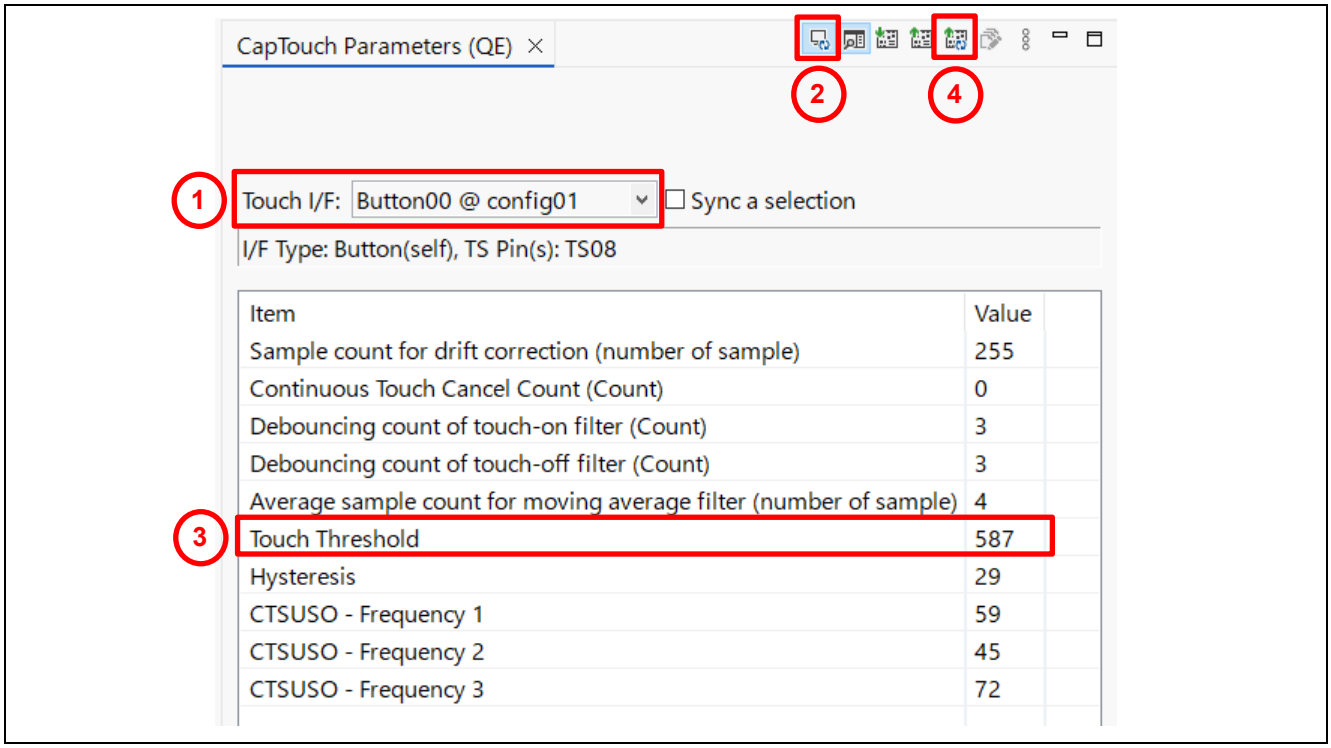

Figure 4-3 Sensitivity adjustment window using the monitoring function

- How to change the code manually

It can be adjusted by changing member variables of structure variable g_qe_touch_button_cfg_config01 to 03.

The variables to change are:

- threshold : Touch detection threshold

QE for Capacitive Touch also supports the Serial Monitor and Serial Tuning features.
For more details on the Serial Monitor and Serial Tuning, please refer to the QE Help and Section 8, "[Additional Feature] Setting Up Serial Communication Monitor Using UART" in RL78 Family Using QE and SIS to Develop Capacitive Touch Applications Rev.4.00.

5. Support

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

RL78/F25 Capacitive Touch Evaluation System	renesas.com/rssk-touch-rl78f25

Application Note RL78 Family Using QE and SIS to Develop Capacitive Touch Applications (R01AN5512)

renesas.com/en/document/apn/rl78-family-using-qe-and-sis-develop-capacitive-touch-applications

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

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Sep.24.25	-	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 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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