RL78/G23

Capacitive Touch Evaluation System Sample Code

Introduction

This document describes the contents of the sample code for the RL78/G23 Capacitive Touch Evaluation System.

Target Device

RL78/G23 (R7F100GSN2DFB)

Contents

1. Overview

This sample code is software that operates with capacitive touch in the RL78/G23 Capacitive Touch Evaluation system.

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

- Components generated by the Smart Configurator
- 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. LED control linked to capacitive touch buttons, sliders, and wheels.

3. Enable 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”8. [Additional function] Setting the serial communication monitor using UART” in “Application Note RL78 Family Using QE and SIS to Develop Capacitive Touch Applications (R01AN5512)”.
   When performing serial monitoring and serial tuning of QE, set the serial communication bit rate to 115200bps.

4. LED control linked to CPU board push buttons. Pressing SW3, LED2 lights up. Pressing SW4, LED1 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	Contents
MCU	RL78/G23 (R7F100GSN2DFB)
Operating frequency	32MHz (HOCO 32MHz)
Operating voltage	5.0V (USB power) LVD0 detection voltage：Reset mode At rising edge TYP. 2.67V(TYP) (2.59V to 2.75V) At falling edge TYP. 2.62V(TYP) (2.54V to 2.70V)
Evaluation board	Capacitive Touch Evaluation System for RL78/G23 (Product No : RTK0EG0030S01001BJ) • RL78/G23 CPU Board(Product No : RTK0EG0029C01001BJ) • Capacitive Touch Evaluation Application Board — Self-Capacitance Buttons / Wheels / Slider Board (Product No :RTK0EG0019B01002BJ)
Integrated development environment	e² studio Version 2024-04
C Compiler	CC-RL V1.13.00 Compile options of optimization: -Odefault
Development Assistance Tool for Capacitive Touch Sensors	QE for Capacitive Touch V3.5.0
Emulator	Renesas E2 Emulator Lite

Figure 2-1 shows device connection diagram.

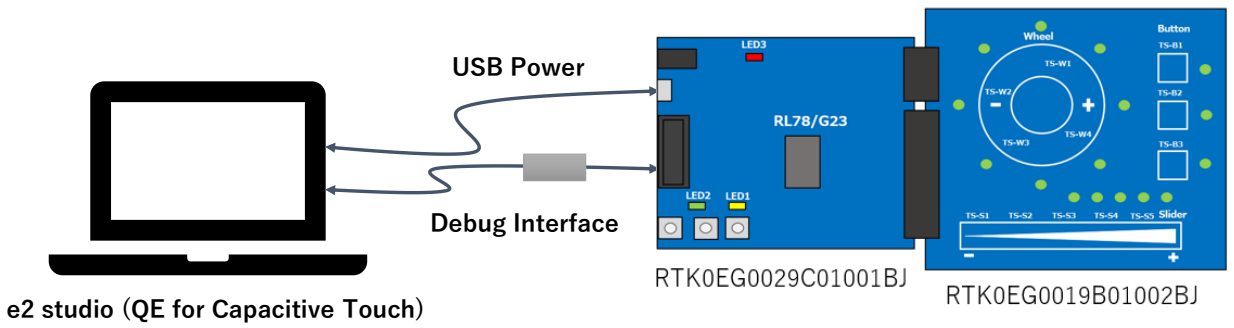

Figure 2-1 Device Connection Diagram

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.

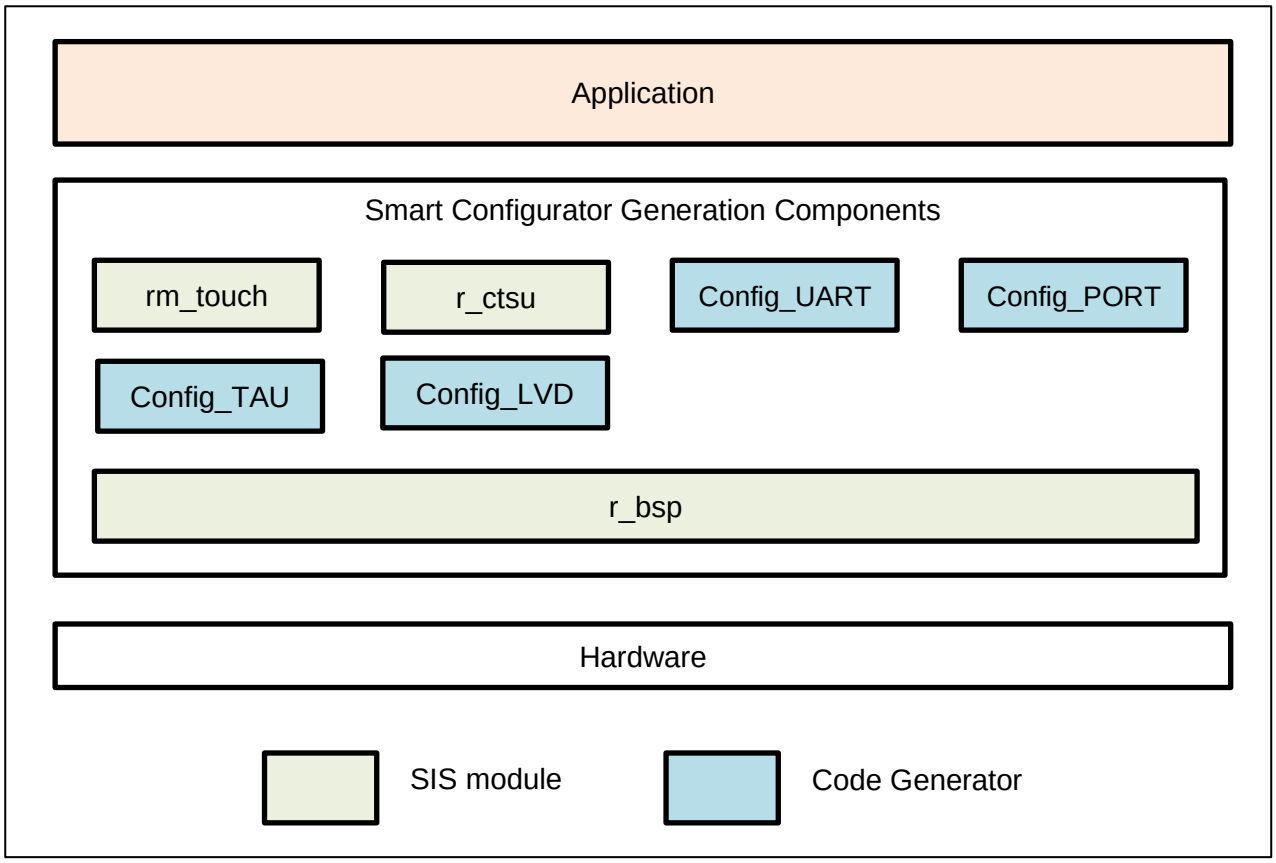

Figure 3-1 Software structure diagram

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

Component	Version	Configuration
Board Support Packages. - v1.62 (r_bsp)	1.62	r_bsp(used)
Capacitive Sensing Unit driver. (r_ctsu)	1.50	r_ctsu(used)
Interval Timer	1.4.0	Config_TAU0_1(TAU0_1: used)
Ports	1.4.1	Config_PORT(PORT: used)
Touch middleware. (rm_touch)	1.50	rm_touch(used)
UART Communication	1.6.0	Config_UARTA1(UARTA1: used)
Voltage Detector	1.3.0	Config_LVD0(LVD0: used)

3.2 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.

```
rl78g23_rssk_sample
├─QE-Touch
│    rl78g23_rssk_sample_log_tuning20240510151319.log
│                                        ・・・QE Tuning log
│    rl78g23_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
     rl78g23_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_UARTA1                   ・・・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
```

3.3 Setting of Option Byte

Table 3-2 shows the option byte settings.

Table 3-2 Option Byte Settings

Address	Setting Value	Contents
000C0H / 040C0H	1110 1111b(0xEF)	Disables the watchdog timer. (Counting stopped after reset)
000C1H / 040C1H	1111 1100b(0xFC)	LVD0 detection voltage：Reset mode At rising edge TYP. 2.67V(TYP) (2.59V to 2.75V) At falling edge TYP. 2.62V(TYP) (2.54V to 2.70V)
000C2H / 040C2H	1110 1000b(0xE8)	HS (high-speed main) mode High-speed on-chip oscillator clock: 32 MHz
000C3H / 040C3H	1000 0100b(0x84)	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.

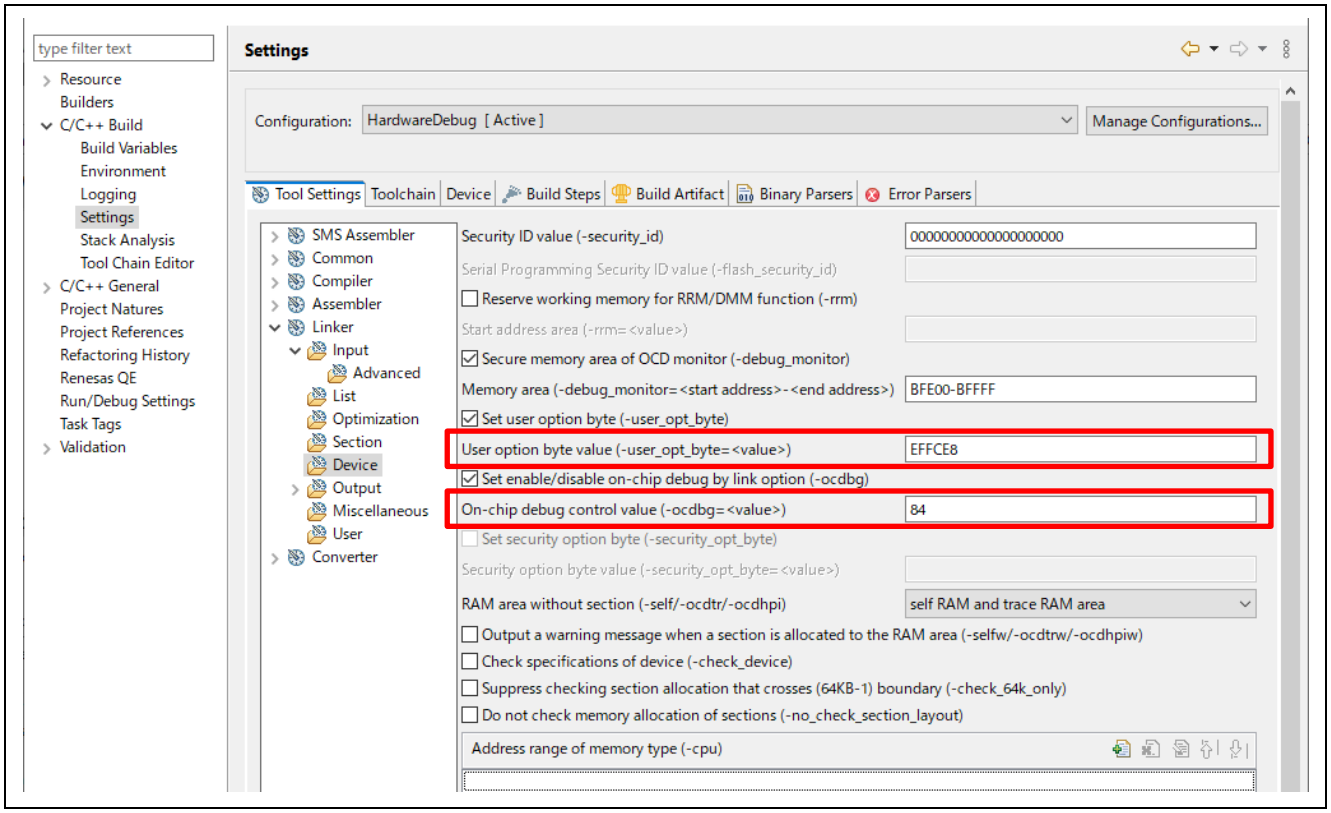

Figure 3-2 User Option Byte Value and On-chip Debug Control Value

3.4 Constants

Table 3-3 lists the constants.

Table 3-3 List of Constant

Constant Name	Setting Value	Description
File Name : qe_touch_sample.c		
TOUCH_SCAN_INTERVAL_EXAMPLE	(20 * 1000)	Software delay value [unit: μs]
TEST_INTERVAL_EXAMPLE	(1 * 1000)	Initial LED software delay value [unit: μs]
File Name : r_rssk_switch_led.c		
RSSK_SW3_PORT	(P5_bit.no7)	Pointer to port control register connected to SW3
RSSK_SW4_PORT	(P1_bit.no6)	Pointer to port control register connected to SW4
RSSK_LED1_PORT	(P6_bit.no0)	Pointer to port control register connected to LED1
RSSK_LED2_PORT	(P6_bit.no1)	Pointer to port control register connected to LED2
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	(P14_bit.no1)	Pointer to port control register connected to COL0
LED_COL1	(P14_bit.no0)	Pointer to port control register connected to COL1
LED_COL2	(P3_bit.no7)	Pointer to port control register connected to COL2
LED_COL3	(P3_bit.no6)	Pointer to port control register connected to COL3
LED_ROW0	(P10_bit.no4)	Pointer to port control register connected to ROW0
LED_ROW1	(P12_bit.no0)	Pointer to port control register connected to ROW1
LED_ROW2	(P10_bit.no6)	Pointer to port control register connected to ROW2
LED_ROW3	(P10_bit.no5)	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]

List of Constant (Continue)

Constant Name	Setting Value	Description
File Name : r_rssk_touch_led.c		
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

3.5 Enumerations

Table 3-4 lists the rssk_sw_status_t enum.

Table 3-4 rssk_sw_status_t

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

3.6 Global Variables

Table 3-5 lists the global variables.

Table 3-5 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

3.7 Functions

Table 3-6 lists the functions.

Table 3-6 List of Function

Function Name	Description
File Name : qe_touch_sample.c	
qe_touch_main	Main function
qe_touch_delay	Software delay
r_rssk_initialize	Initialization processing of Capacitive Touch Evaluation System
r_rssk_led_test	LED test processing for Capacitive Touch Evaluation System
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_sw3_status	SW3 state response processing
rssk_get_sw4_status	SW4 state response processing
r_rssk_led1_on	CPU board LED1 turn on
r_rssk_led1_off	CPU board LED1 turn off
r_rssk_led2_on	CPU board LED2 turn on
r_rssk_led2_off	CPU board LED2 turn off

List of Function(Continue)

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

3.8 List of Peripheral Functions Used and Pins Used

Table 3-7 and Table 3-8 shows a list 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
67	TS00	I/O	CTSU measurement
41	TS01	I/O	
53	TS02	I/O	
52	TS03	I/O	
51	TS04	I/O	
50	TS05	I/O	
49	TS06	I/O	
48	TS07	I/O	
47	TS08	I/O	
46	TS09	I/O	
55	TS10	I/O	
54	TS11	I/O	
42	TS12	I/O	
43	TS13	I/O	
44	TS14	I/O	
45	TS15	I/O	
115	TS20	I/O	
114	TS21	I/O	
113	TS22	I/O	
112	TS23	I/O	
111	TS24	I/O	
110	TS25	I/O	
125	TS26	I/O	
124	TS27	I/O	
123	TS28	I/O	
122	TS29	I/O	
109	TS30	I/O	
108	TS31	I/O	
107	TS32	I/O	
106	TS33	I/O	
105	TS34	I/O	
104	TS35	I/O	
66	TSCAP	-	

Table 3-8 List of used pins(2)

Pin No.	Pin Name	I/O	Usage
9	P33/RXDA1	I	QE serial communication (SW4 : Left)
8	P34/TXDA1	O	
74	P57/SW3	I	Switch Input
76	P16/SW4	I	
37	P60/LED1	O	LED Control
38	P61/LED2	O	
2	P141/LED_ROW0	O	
3	P140/LED_ROW1	O	
5	P37/LED_ROW2	O	
6	P36/LED_ROW3	O	
13	P104/LED_COL0	O	
4	P120/LED_COL1	O	
11	P106/LED_COL2	O	
12	P105/LED_COL3	O	

Table 3-9 List of Handling of Unused Pins

Pin No	Pin Name	I/O	Handling
32	REGC	I	Connect the pin to GND via a capacitor (1uF).
35	VDD	I	Connect the pin to GND via a capacitor (0.1uF).
36	EVDD0	I	
57	EVDD1	I	
33	VSS	I	Connect the pin to GND.
34	EVSS0	I	
56	EVSS1	I	
29	P137	I	Connect the pin to VDD via a register (10kohm).
27	P124/XT2	I	Leave open
28	P123/XT1	I	
Pins than the above		-	Low output

Table 3-10 shows a list of peripheral functions used.

Table 3-10 List of Peripheral Functions Used

Peripheral Function	Usage
CTSU	CTSU measurement
UARTA1	QE serial monitoring and serial tuning
TAU0	LED control trigger
PORT	LED control

The peripheral function settings using Smart Configurator are shown below.

- Voltage Detector

The reset generation voltage settings are shown inTable 3-11.

Table 3-11 Voltage Detector Setting

Item	Setting
Operation mode	Reset mode
Detection level Reset generation voltage(VLVD0)	 2.62V

- UART communication

Use UARTA1 for serial monitoring of QE for Capacitive Touch. Table 3-12 shows the UARTA1 settings.

Table 3-12 UARTA1 Setting

Item	Setting
Operation clock	f_{IHP}
Clock Source	f_{SEL}
Transfer mode setting	Continuous transmission by polling
Usable channel	UARTA1
Transfer rate setting	115200 bps
Callback function setting: Transmit	Transmission end : Enable
Callback function setting : Receive	Reception end : Enable Reception error : Enable

- Interval Timer

Use TAU0_1 for LED control. Table 3-13 shows the TAU0_1settings.

Table 3-13 TAU0 Setting

Item	Setting
Operation clock	CK03
Clock source	f_{CLK}/2^10
Interval value (16 bits)	5 ms
Interrupt setting	End of timer channel1 count, generate an interrupt (INTTM01H) : Enable

- Touch middleware(rm_touch).

Use rm_touch for touch control. Table 3-14 shows the rm_touch settings. This setting enables QE serial monitoring and serial tuning.

Table 3-14 Touch middleware(rm_touch) Setting.

Item	Setting
Support QE monitor using UART	Enable
Support QE tuning using UART	Enable
UART channel	UARTA1

3.9 Processing Flowchart

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

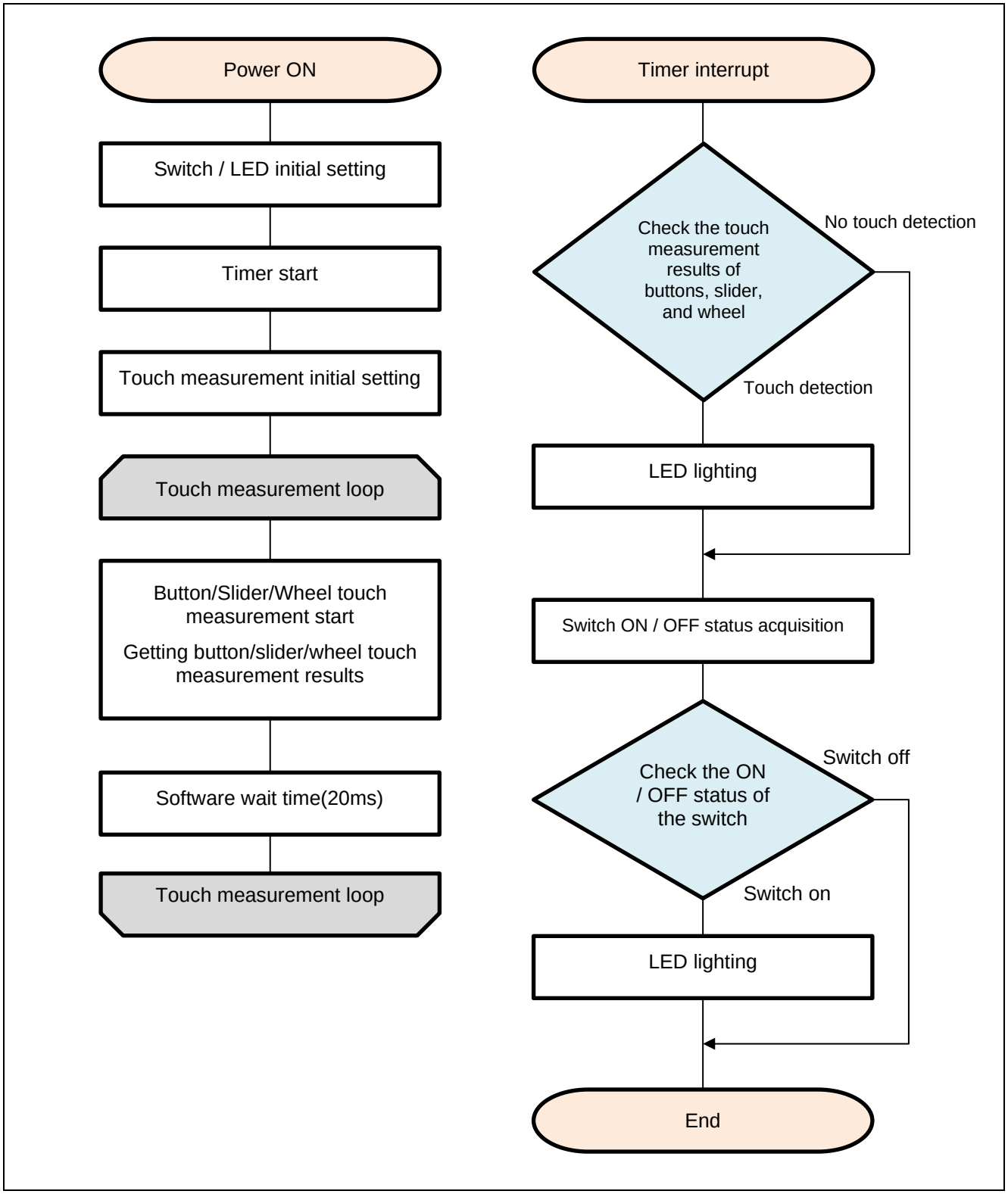

Figure 3-3 Processing Flowchart (Self-Capacitance Buttons / Wheel / Slider Board)

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

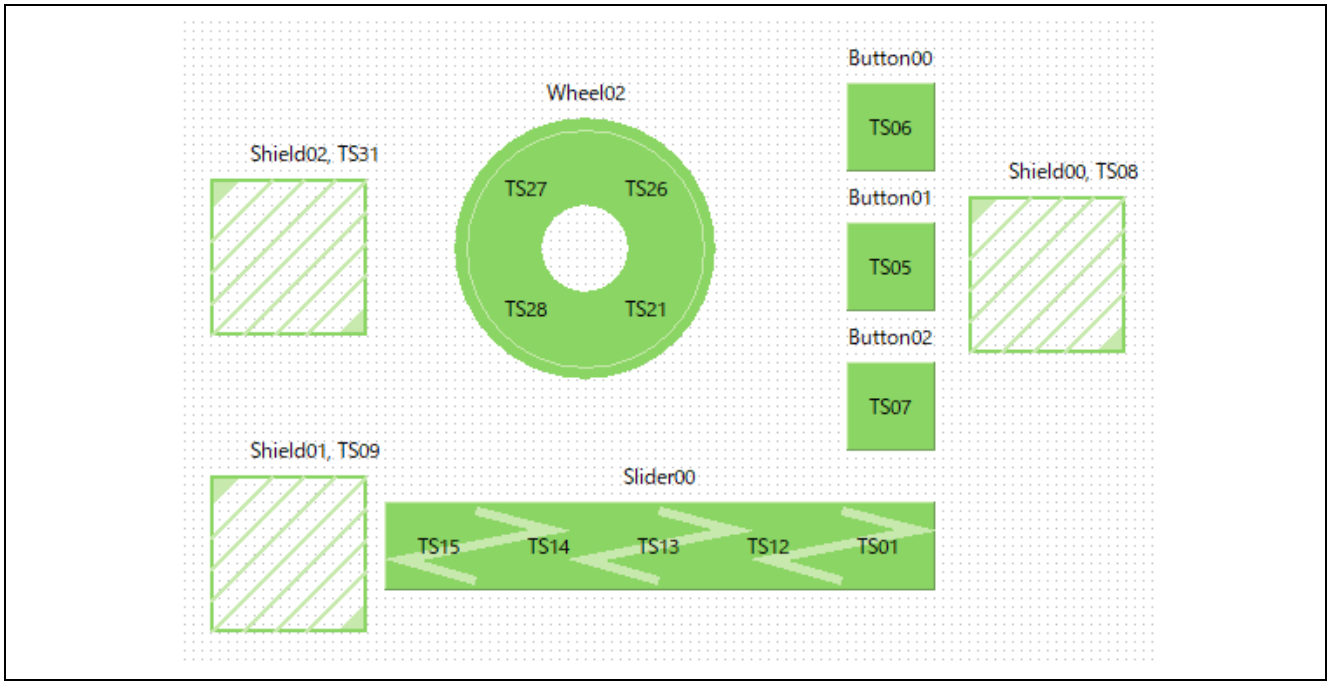

Figure 4-1 Touch interface configuration (Self-Capacitance Buttons / Wheel / Slider Board)

4.2 Configuration (methods) Settings

Figure 4-2 shows configuration (methods) of this sample code. 3 buttons and a shield 0 are set enabled in config01. Slider and a shield 1 are set enabled in config02. Wheel and a shield 2 are set enabled in config02.

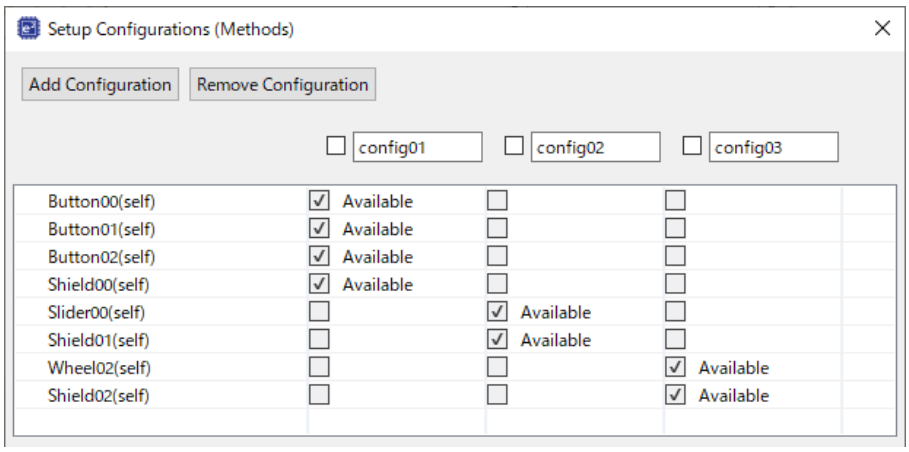

Figure 4-2 Configuration (methods) setting

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	TS06	9.889	1 (BASE:1.0)	738	0.576	0x037	0x0F	0x0B
config01	Button01	TS05	10.056	1 (BASE:1.0)	783	0.576	0x035	0x0F	0x0B
config01	Button02	TS07	9.417	1 (BASE:1.0)	771	0.576	0x032	0x0F	0x0B
config01	Shield00	TS08	48.472	-	-	-	-	-	-
config02	Slider00	TS15	8.507	1 (BASE:1.0)	648	0.576	0x029	0x0F	0x0B
config02	Slider00	TS14	7.417	1 (BASE:1.0)	648	0.576	0x018	0x0F	0x0B
config02	Slider00	TS13	7.951	1 (BASE:1.0)	648	0.576	0x020	0x0F	0x0B
config02	Slider00	TS12	8.049	1 (BASE:1.0)	648	0.576	0x025	0x0F	0x0B
config02	Slider00	TS01	9.639	1 (BASE:1.0)	648	0.576	0x031	0x0F	0x0B
config02	Shield01	TS09	48.965	-	-	-	-	-	-
config03	Wheel00	TS27	9.229	1 (BASE:1.0)	785	0.576	0x031	0x0F	0x0B
config03	Wheel00	TS26	10.132	1 (BASE:1.0)	785	0.576	0x039	0x0F	0x0B
config03	Wheel00	TS21	12.91	1 (BASE:1.0)	785	0.576	0x053	0x0F	0x0B
config03	Wheel00	TS28	10.854	1 (BASE:1.0)	785	0.576	0x041	0x0F	0x0B
config03	Shield02	TS31	43.668	-	-	-	-	-	-

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

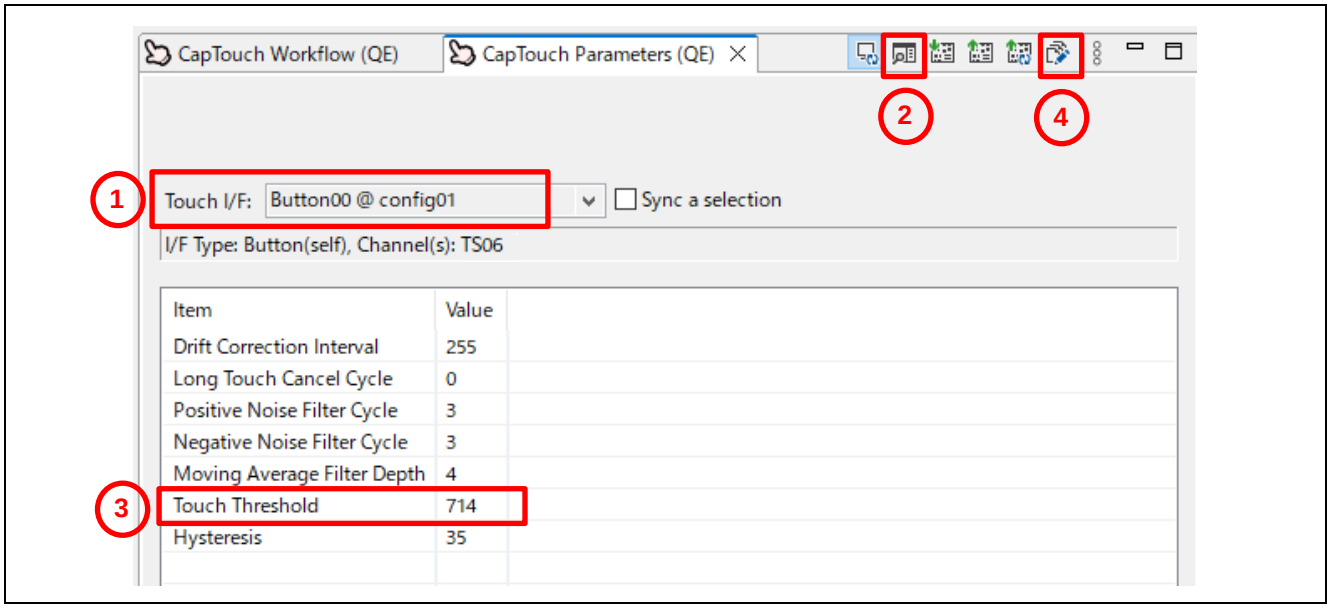

Figure 4-3 Sensitivity adjustment window using the monitoring function

- 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

5. Support

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

RL78/G23 Capacitive Touch Evaluation System	renesas.com/rssk-touch-rl78g23

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	8.Sep.2021	-	First edition issued
2.00	21.Aug.2023	2	Deleted the description of “1. Specification. Added “1. Overview” and “1.1 Function”.
		3	Changed the contents of "2. Operation Confirmation Conditions" and "Table 2-1 Operation Confirmation Conditions ". - Updated the description of the version used. - Added a description of LVD0 detection voltage to operating voltage. - Added optimization level options to C compiler. Added “Figure 2 1 Device Connection Diagram”
		3	Deleted “3. Usage notes”
		4	Deleted “4. Sample Code” and “5. Reference Documents”.
		4	Added “3. Software Specification” and “Figure 3 1 Software structure diagram” Updated component versions in Table 3-1 and added voltage detectors to the component list.
		5	Added “3.2 File Structure”
		6	Added “3.3 Setting of Option Byte”
		7	Added “3.4 Constants”
		8	Added “3.5 Enumerations”, “3.6 Global Variables”, and “3.7 Functions”
		9 10	Added “3.8 List of Peripheral Functions Used and Pins Used” Added Table 3-7 and Table 3-8 List of used pins” Added “Table 3-9 List of Handling of Unused Pins”. Added “Table 3-10 List of Peripheral Functions Used”. Added descriptions for voltage detector settings, UART communication settings, interval timer settings and touch middleware settings.
		12	Added “3.9 Processing Flowchart”
		13	Added “4. Capacitive Touch Setting” Added “4.1 Touch Interface Configuration” and “4.2 Configuration (methods) Settings”
		14	Added “4.3 Tuning Results”
		15	Added “4.4 Sensitivity Adjustment”
3.00	31.May.2024	3	Updated “2-1 Operation Confirmation Conditions” version
		4	Add “Config_LVD” component to Figure 3-1 Updated “Table 3-1 Components and version list”
		5	Updated QE Tuning log file name
		13	Modified “Figure 4-1 Touch interface configuration”
		14	Updated “Table 4-1 QE tuning result list”

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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(Rev.5.0-1 October 2020)

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