

# 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)

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## 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)<br>LVD0 detection voltage : Reset mode<br>At rising edge TYP. 2.67V(TYP) (2.59V to 2.75V)<br>At falling edge TYP. 2.62V(TYP) (2.54V to 2.70V)                                                                                                                                                                                 |
| Evaluation board                                         | Capacitive Touch Evaluation System for RL78/G23<br>(Product No : RTK0EG0030S01001BJ) <ul style="list-style-type: none"><li>• RL78/G23 CPU Board(Product No : RTK0EG0029C01001BJ)</li><li>• Capacitive Touch Evaluation Application Board<br/>— Self-Capacitance Buttons / Wheels / Slider Board<br/>(Product No :RTK0EG0019B01002BJ)</li></ul> |
| Integrated development environment                       | e² studio Version 2024-04                                                                                                                                                                                                                                                                                                                      |
| C Compiler                                               | CC-RL V1.13.00<br>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.

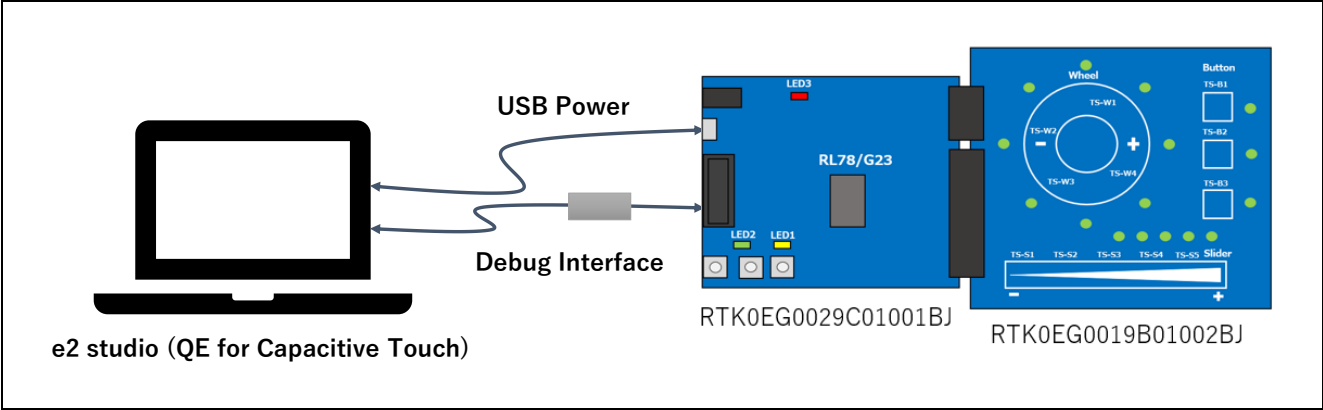
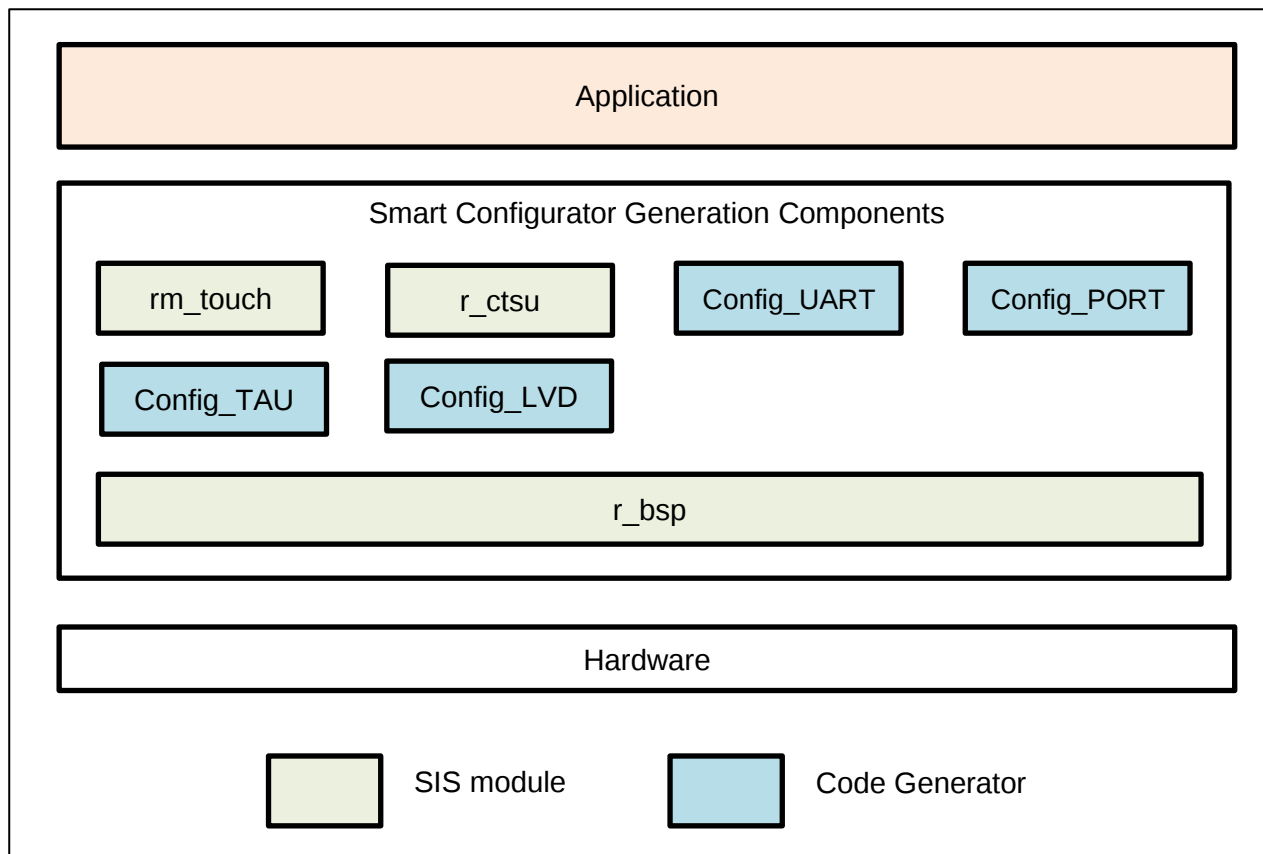


Figure 2-1 Device Connection Diagram

### 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.

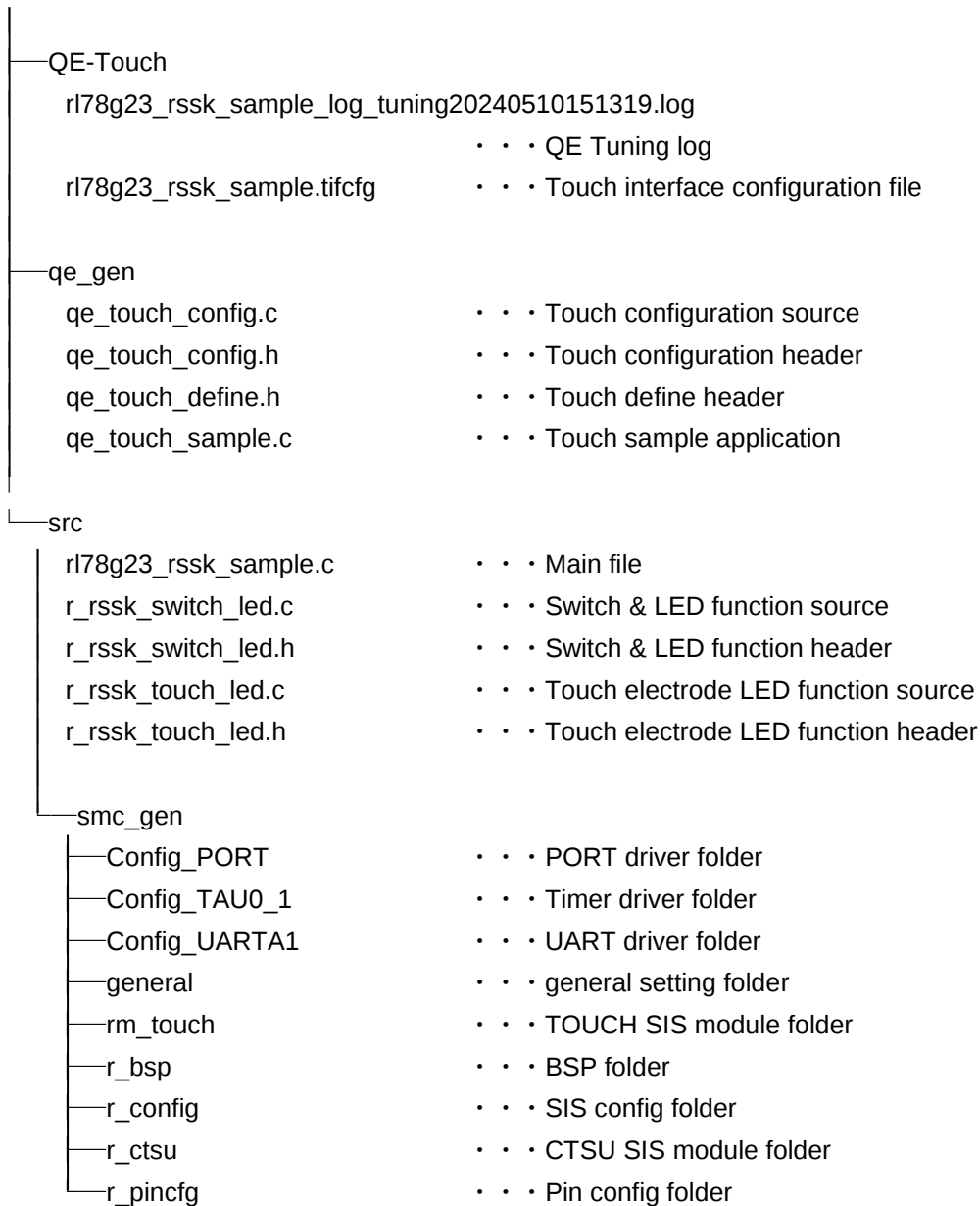
**Table 3-1 Components and versions list**

| 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



### 3.3 Setting of Option Byte

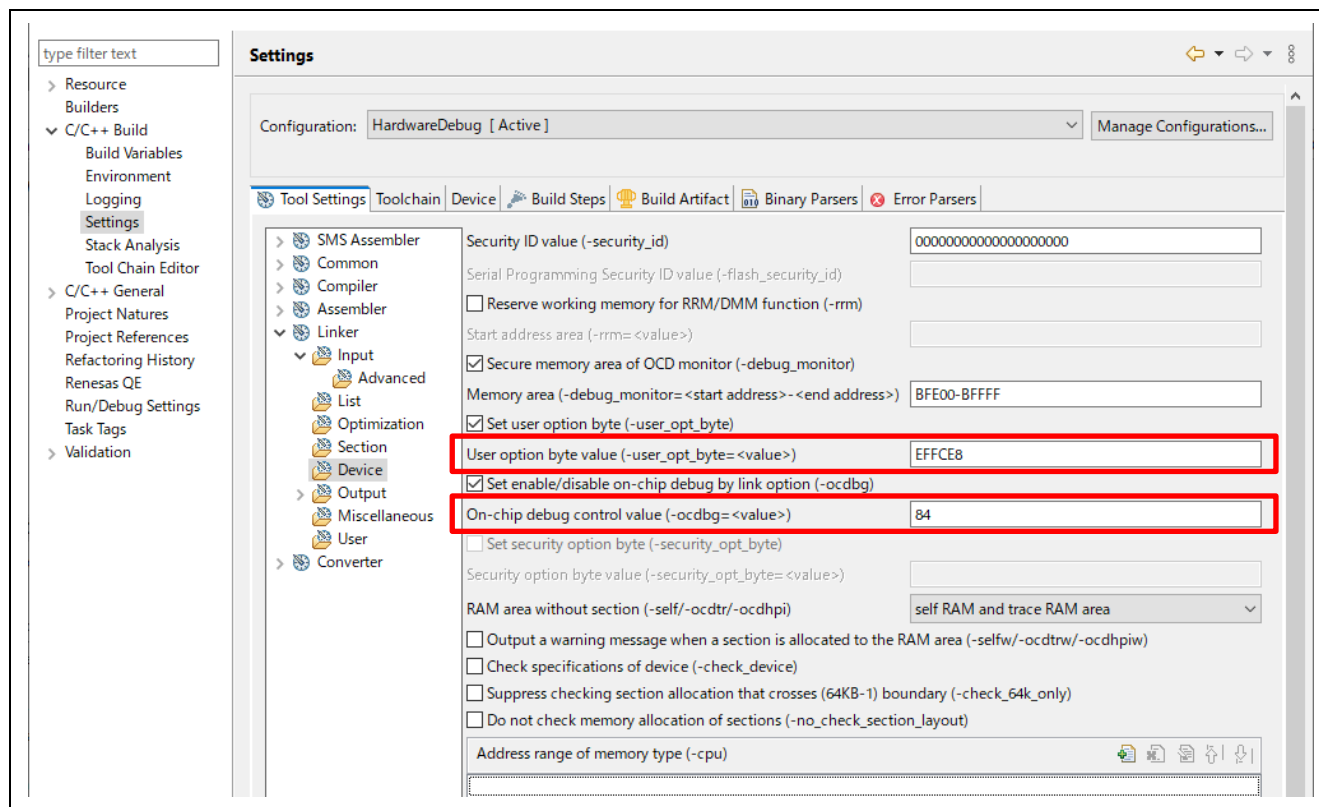
Table 3-2 shows the option byte settings.

**Table 3-2 Option Byte Settings**

| Address         | Setting Value    | Contents                                                                                                                                   |
|-----------------|------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| 000C0H / 040C0H | 1110 1111b(0xEF) | Disables the watchdog timer.<br>(Counting stopped after reset)                                                                             |
| 000C1H / 040C1H | 1111 1100b(0xFC) | LVD0 detection voltage : Reset mode<br>At rising edge TYP. 2.67V(TYP) (2.59V to 2.75V)<br>At falling edge TYP. 2.62V(TYP) (2.54V to 2.70V) |
| 000C2H / 040C2H | 1110 1000b(0xE8) | HS (high-speed main) mode<br>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                                         |
|----------------------------------------|------------------------------|-----------------------------------------------------|
| <b>File Name : qe_touch_sample.c</b>   |                              |                                                     |
| TOUCH_SCAN_INTERVAL_EXAMPLE            | (20 * 1000)                  | Software delay value<br>[unit: $\mu$ s]             |
| TEST_INTERVAL_EXAMPLE                  | (1 * 1000)                   | Initial LED software delay value<br>[unit: $\mu$ s] |
| <b>File Name : r_rssk_switch_led.c</b> |                              |                                                     |
| 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                                    |
| <b>File Name : r_rssk_touch_led.c</b>  |                              |                                                     |
| 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<br>[unit : degree]       |

## List of Constant (Continue)

| Constant Name                         | Setting Value | Description                                    |
|---------------------------------------|---------------|------------------------------------------------|
| <b>File Name : r_rssk_touch_led.c</b> |               |                                                |
| WHEEL_POSITION_OFFSET_DEGREE          | (112U)        | Wheel touch position offset<br>[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 rsk\_sw\_status\_t enum.

Table 3-4 rsk\_sw\_status\_t

| Member                                 | Value | Description      |
|----------------------------------------|-------|------------------|
| <b>File Name : r_rssk_switch_led.h</b> |       |                  |
| RSSK_SW_OFF                            | 0x00  | Switch OFF state |
| RSSK_SW_ON                             | 0x01  | Switch ON state  |

## 3.6 Global Variables

Table 3-5 lists the global variables.

Table 3-5 List of Global Variable

| Variable Name                         | Types    | Description                                 |
|---------------------------------------|----------|---------------------------------------------|
| <b>File Name : qe_touch_sample.c</b>  |          |                                             |
| button_status                         | uint64_t | Button status                               |
| slider_position[1]                    | uint16_t | Slider touch position information           |
| wheel_position[1]                     | uint16_t | Wheel touch position information            |
| <b>File Name : r_rssk_touch_led.c</b> |          |                                             |
| 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                                                     |
|----------------------------------------|-----------------------------------------------------------------|
| <b>File Name : qe_touch_sample.c</b>   |                                                                 |
| 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                                         |
| <b>File Name : r_rssk_switch_led.c</b> |                                                                 |
| 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 in Table 3-11.

**Table 3-11 Voltage Detector Setting**

| Item                                               | Setting    |
|----------------------------------------------------|------------|
| Operation mode                                     | Reset mode |
| Detection level<br>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 <sub>IHP</sub>                                   |
| Clock Source                        | f <sub>SEL</sub>                                   |
| 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<br>Reception error : Enable |

- Interval Timer

Use TAU0\_1 for LED control. Table 3-13 shows the TAU0\_1 settings.

**Table 3-13 TAU0 Setting**

| Item                     | Setting                                                                   |
|--------------------------|---------------------------------------------------------------------------|
| Operation clock          | CK03                                                                      |
| Clock source             | f <sub>CLK</sub> /2 <sup>10</sup>                                         |
| Interval value (16 bits) | 5 ms                                                                      |
| Interrupt setting        | End of timer channel1 count, generate an interrupt (INTTM01H)<br>: 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.

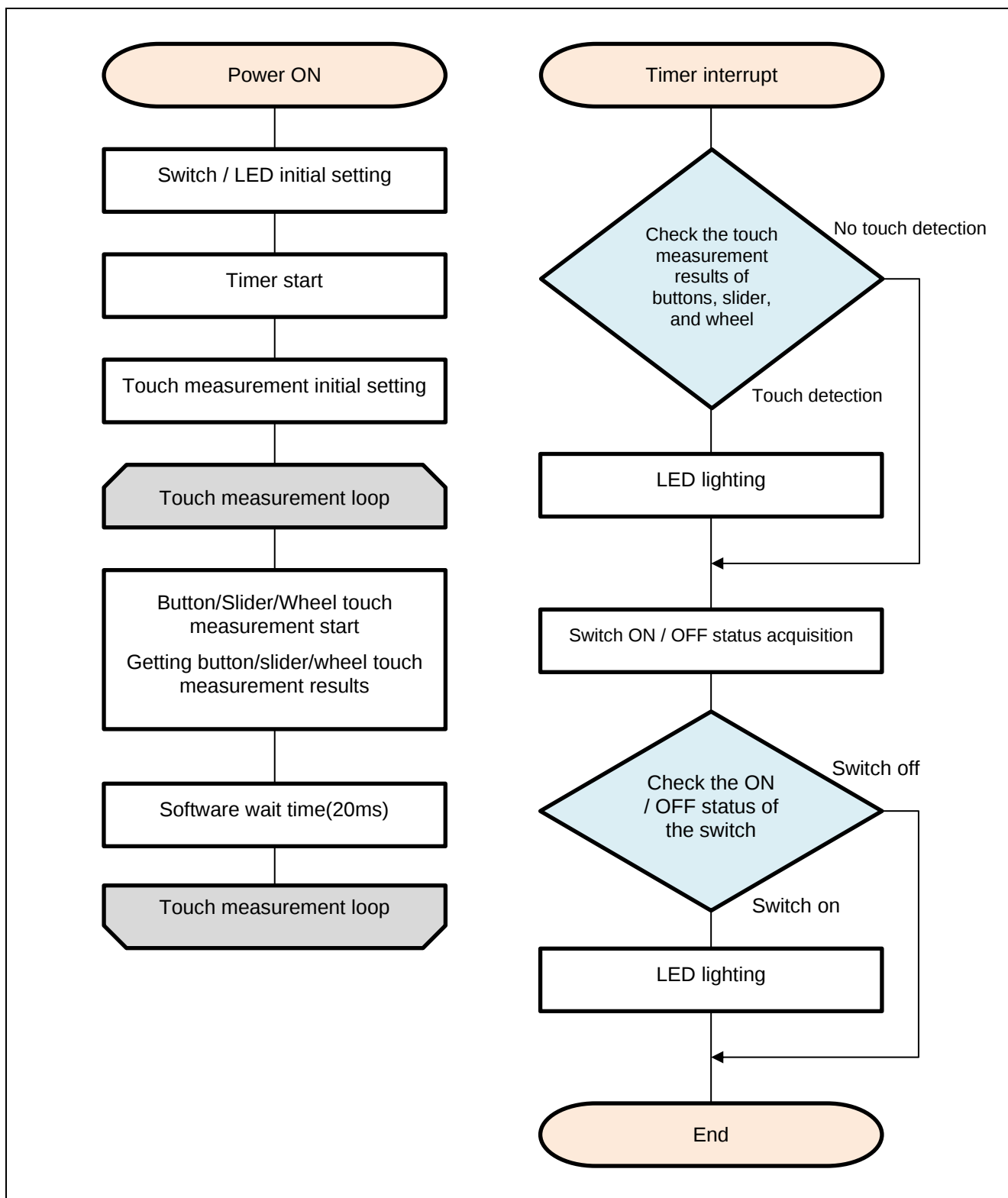


Figure 3-3 Processing Flowchart (Self-Capacitance Buttons / Wheel / Slider Board)

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

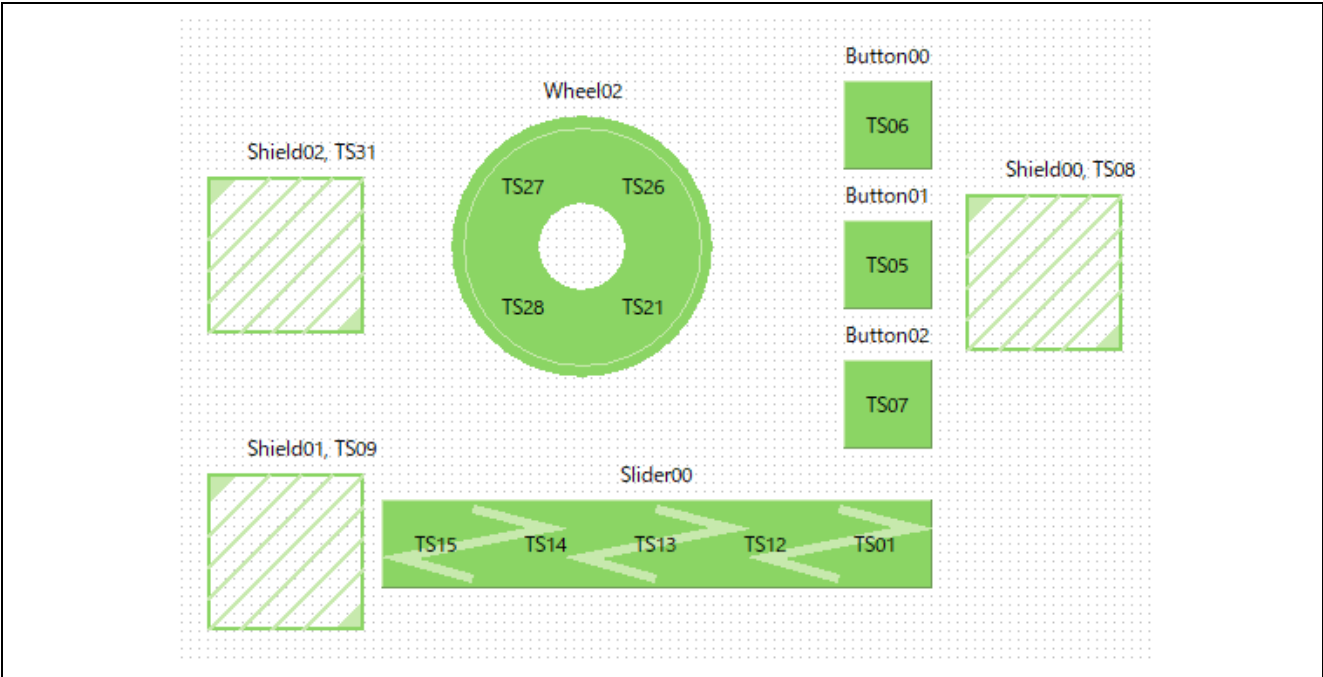


Figure 4-1 Touch interface configuration (Self-Capacitance Buttons / Wheel / Slider Board)

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.

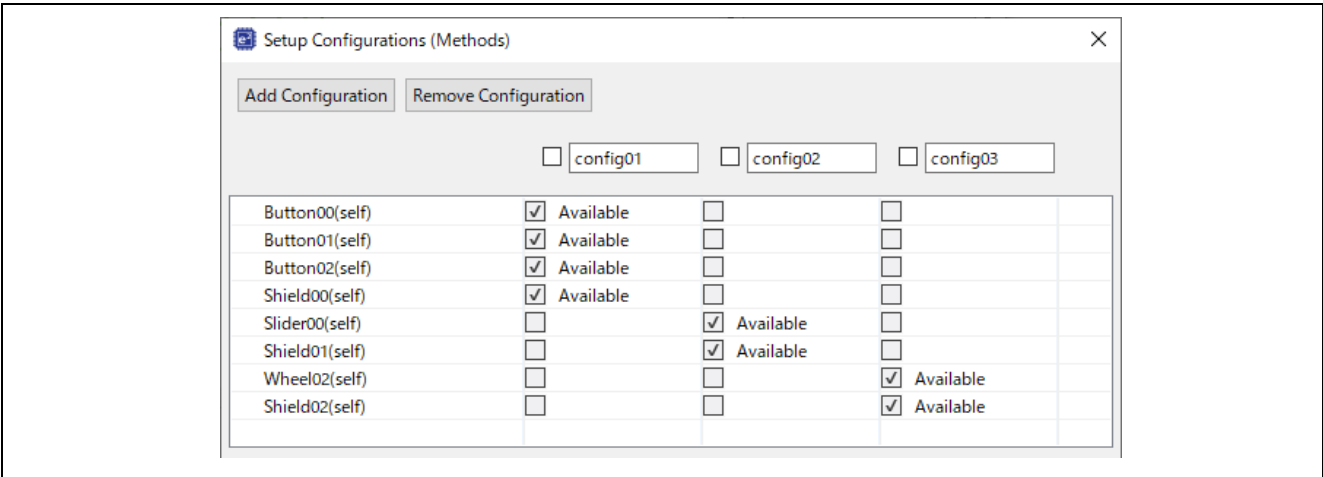


Figure 4-2 Configuration (methods) setting

### 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 sensor | 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

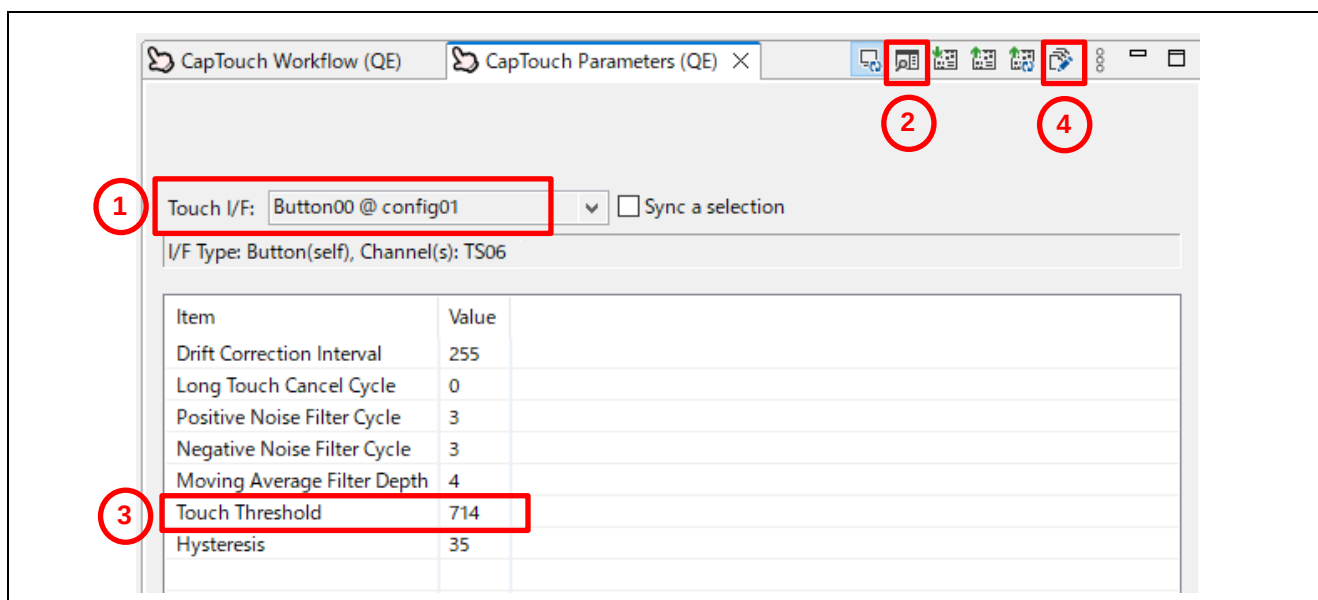
Follow the tutorial from the "CapTouch Workflow (QE)" of QE for Capacitive Touch.

- 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](https://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](https://renesas.com/en/document/apn/rl78-family-using-qe-and-sis-develop-capacitive-touch-applications)

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## 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."<br>Added "1. Overview" and "1.1 Function".                                                                                                                                                                                                                                                         |
|      |             | 3           | Changed the contents of "2. Operation Confirmation Conditions" and "Table 2-1 Operation Confirmation Conditions".<br>- Updated the description of the version used.<br>- Added a description of LVD0 detection voltage to operating voltage.<br>- Added optimization level options to C compiler.<br>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"<br>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           | Added "3.8 List of Peripheral Functions Used and Pins Used"<br>Added Table 3-7 and Table 3-8 List of used pins"                                                                                                                                                                                                                                   |
|      |             | 10          | Added "Table 3-9 List of Handling of Unused Pins".<br>Added "Table 3-10 List of Peripheral Functions Used".<br>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"<br>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<br>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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## Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,  
Koto-ku, Tokyo 135-0061, Japan  
[www.renesas.com](http://www.renesas.com)

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