# RX671 Group

## RX671 Capacitive Touch Evaluation System Sample Code

### Introduction

This document describes the sample code for the RX671 Capacitive Touch Evaluation System.

### Target Device

RX671 (R5F5671EHDFP)

### Contents

# 1. Overview

This sample code is software that operates with capacitive touch in the RX671 Capacitive Touch Evaluation system.

The following is added to the project created by e$^2$ 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) of Capacitive Touch Evaluation Application Board.
2. Press the capacitive touch buttons, slider and wheel to control the LEDs on Capacitive Touch Evaluation Application Board.
3. Enables USB serial interface to control serial communication and supports QE serial monitor and serial tuning. For more information on serial monitoring and serial tuning, refer to QE Help and "7. [Additional function] Serial communication monitor setting using UART" in Using QE and FIT to Develop Capacitive Touch Applications.
4. LED control is performed in conjunction with the push button on CPU board. Pressing SW2, LED 2 lights up. Pressing SW3, LED3 lights up.

# 2. Environment for Confirming Operation

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

**Table 2-1 Operating Environment**

| Item | Description |
|---|---|
| MCU | RX671 (R5F5671EHDFP) |
| Operating frequency | 120MHz<br>(HOCO 20MHz * PLL Circuit (Divide by 1/2 * Multiply by 12)) |
| Operating voltage | 3.3V (The supply voltage to the CPU board is 5.0V) |
| Evaluation board | RX671 Capacitive Touch Evaluation System<br>(Product No：RTK0EG0044S01001BJ)<br>• RX671 CPU Board（Product No：RTK0EG0043C01001BJ）<br>• Capacitive Touch Evaluation Application Board<br>— Self-Capacitance Buttons / Wheel / Slider Board<br>(Product No：RTK0EG0019B01002BJ) |
| Integrated development environment | e$^2$ studio Version 2022-10 (22.10.0) |
| C Compiler | CC-RX V3.04.00 |
| Development Assistance Tool for Capacitive Touch Sensors | QE for Capacitive Touch V3.1.0 |
| Emulator | Renesas E2 Emulator Lite |

Figure 2-1 shows device connection diagram

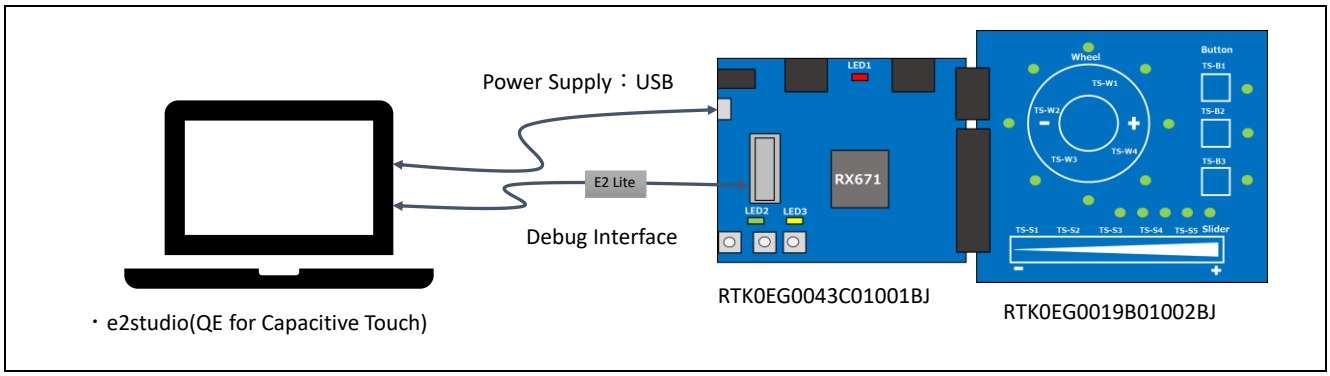



**Figure 2-1 Device Connection Diagram**

# 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.

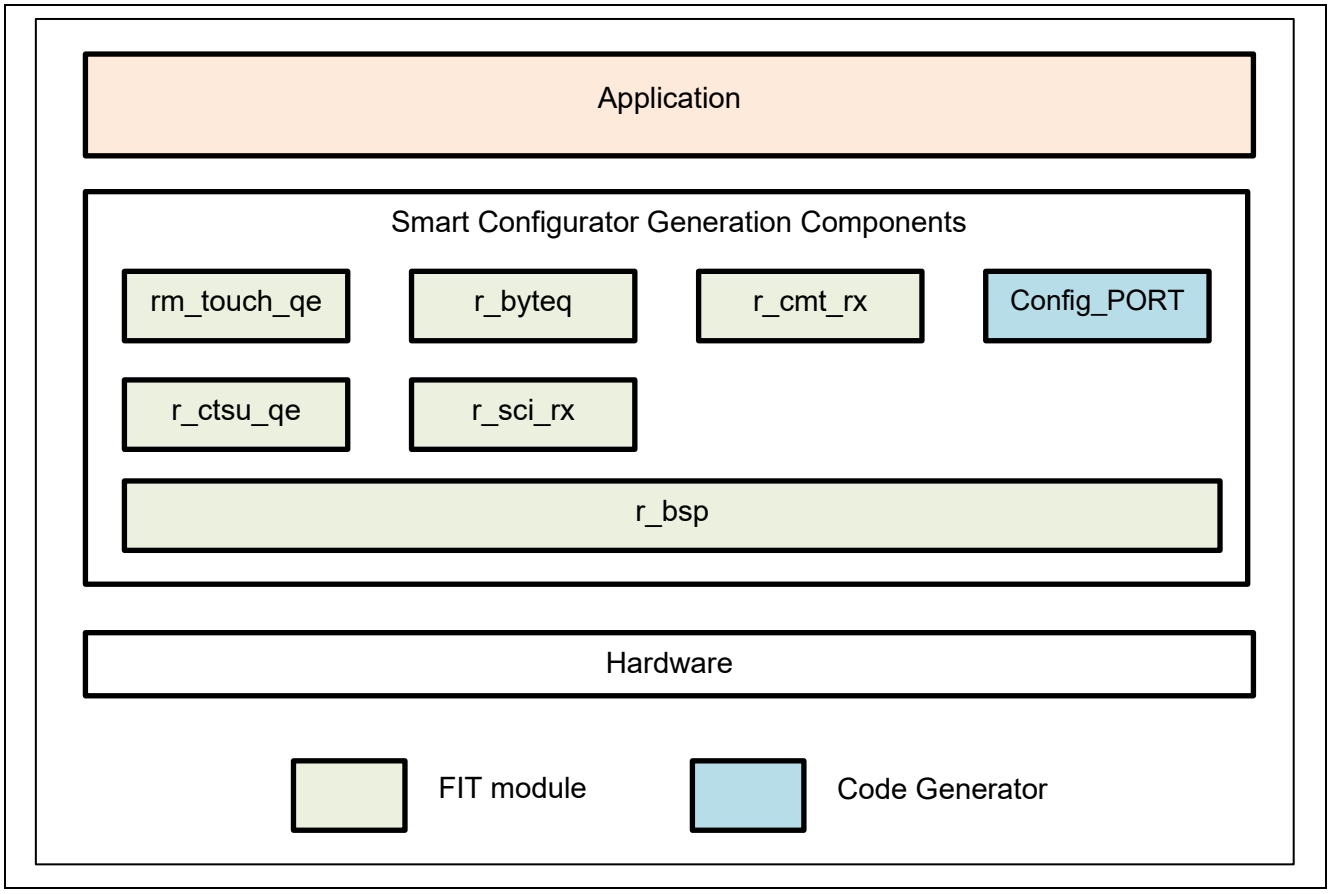



**Figure 3-1 Software structure diagram**

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. (r_bsp) | 7.20 | r_bsp(used) |
| Byte-based circular buffer library. (r_... | 2.00 | r_byteq(used) |
| CMT driver (r_cmt_rx) | 5.20 | r_cmt_rx(used) |
| CTSU QE API (r_ctsu_qe) | 2.10 | r_ctsu_qe(used) |
| DTC driver (r_dtc_rx) | 4.10 | r_dtc_rx(used) |
| Ports | 2.4.0 | Config_PORT(PORT: used) |
| SCI Driver (r_sci_rx) | 4.40 | r_sci_rx(used) |
| Touch QE API (rm_touch_qe) | 2.10 | rm_touch_qe(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.

```
Rx671_rssk_sample
 |
 ├──QE-Touch
 |    qe_tuning20221129173925.log      ・・・QE Tuning log
 |    rx671_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
   |  rx671_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
     ├──general                            ・・・general setting folde
     ├──rm_touch_qe                        ・・・TOUCH FIT folder
     ├──r_bsp                              ・・・BSP folder
     ├──r_byteq                            ・・・BYTEQ FIT folder
     ├──r_cmt_rx                           ・・・CMT FIT folder
     ├──r_config                           ・・・FIT configuration folder
     ├──r_ctsu_qe                          ・・・CTSU FIT folder
     ├──r_pincfg                           ・・・PIN configuration folder
     └──r_sci_rx                           ・・・SCI FIT folder
```

## 3.3 Constants

Table 3-2 lists the constants.

**Table 3-2 List of Constant**

| Constant Name | Value | Description |
|---|---|---|
| File Name : qe_touch_sample.c | | |
| TOUCH_SCAN_INTERVAL_EXAMPLE | (20) | Software delay value<br>[unit : msec] |
| File Name : r_rssk_switch_led.c | | |
| RSSK_SW2_PORT | (PORTJ.PIDR.BIT.B3) | Pointer to port control register connected to SW2 |
| RSSK_SW3_PORT | (PORT3.PIDR.BIT.B2) | Pointer to port control register connected to SW3 |
| RSSK_LED2_PORT | (PORT0.PODR.BIT.B7) | Pointer to port control register connected to LED2 |
| RSSK_LED3_PORT | (PORT0.PODR.BIT.B5) | 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 | (0x01U) | Turn on the LED |
| RSSK_LED_OFF | (0x00U) | Turn off the LED |
| File Name : r_rssk_touch_led.c | | |
| LED_COL0 | (PORTE.PODR.BIT.B4) | Pointer to port control register connected to COL0 |
| LED_COL1 | (PORTE.PODR.BIT.B3) | Pointer to port control register connected to COL1 |
| LED_COL2 | (PORTE.PODR.BIT.B0) | Pointer to port control register connected to COL2 |
| LED_COL3 | (PORTA.PODR.BIT.B7) | Pointer to port control register connected to COL3 |
| LED_ROW0 | (PORT4.PODR.BIT.B6) | Pointer to port control register connected to ROW0 |
| LED_ROW1 | (PORT4.PODR.BIT.B7) | Pointer to port control register connected to ROW1 |
| LED_ROW2 | (PORT4.PODR.BIT.B4) | Pointer to port control register connected to ROW2 |
| LED_ROW3 | (PORT4.PODR.BIT.B5) | Pointer to port control register connected to ROW3 |
| LED_COL_MAX | (4) | Number of COL signals |
| LED_COL_ON | (0x01U) | COL signal ON |
| LED_COL_OFF | (0x00U) | COL signal OFF |
| LED_ROW_OFF | (0x01U) | 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 - 1)) | Wheel LED control bit MSB |
| WHEEL_RESOLUTION_DEGREE | (360U) | Maximum wheel touch result |
| WHEEL_POSITION_OFFSET_DEGREE | (112) | 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 |

## 3.4 Enumerations

Table 3-3 lists the rssk_sw_status_t enum

**Table 3-3 rssk_sw_status_t**

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

## 3.5 Variables

Table 3-4 lists the global valiables

**Table 3-4 List of Global Valiable**

| Variable Name | Types | Description |
|---|---|---|
| File Name : qe_touch_sample.c | | |
| gs_cmt_ch | uint32_t | Use channel of CMT |
| File Name : r_rssk_switch_led.c | | |
| rssk_get_sw2_status | uint8_t | State of switch SW2 |
| rssk_get_sw3_status | uint8_t | State of switch SW3 |
| File Name : r_rssk_touch_led.c | | |
| g_led_drive_colmun | uint8_t | Touch electrode board LED drive information |
| g_button_idx[] | uint8_t | Button index array |

## 3.6 Functions

Table 3-5 lists the functions

**Table 3-5 List of Function**

| Function Name | Description |
|---|---|
| qe_touch_sample.c | |
| qe_touch_main | Main function |
| r_rssk_initialize | Initialization processing of Capacitive Touch Evaluation System |
| r_rssk_led_test | LED test processing for Capacitive Touch Evaluation System |
| r_rssk_timer_callback | CMT interrupt callback |
| 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 |
| r_rssk_led2_on | CPU board LED2 lights up |
| r_rssk_led2_off | CPU board LED2 lights off |
| r_rssk_led3_on | CPU board LED3 lights up |
| r_rssk_led3_off | CPU board LED3 lights off |
| r_rssk_touch_led.c | |
| r_rssk_touch_led_test | Touch electrode board LED test processing |
| r_rssk_touch_led_control | Touch electrode board LED control processing |

## 3.7 List of Peripheral Functions Used and Pins Used

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

**Table 3-6 List of Peripheral Functions Used**

| Peripheral Function | Usage |
|---|---|
| CTSU, DTC | CTSU measurement |
| SCI12 | QE serial monitoring |
| CMT | LED control trigger |
| PORT | LED control |

**Table 3-7 List of used pins**

| Pin No. | Pin Name | I/O | Usage |
|---|---|---|---|
| 16 | TS00 | I/O | CTSU measurement |
| 17 | TS01 | I/O | |
| 21 | TS02 | I/O | |
| 22 | TS03 | I/O | |
| 23 | TS04 | I/O | |
| 24 | P24 [Note] | O | |
| 25 | P23 [Note] | O | |
| 26 | TS07 | I/O | |
| 27 | TS08 | I/O | |
| 28 | TS09 | I/O | |
| 41 | P53 [Note] | O | |
| 46 | TS13 | I/O | |
| 47 | TS14 | I/O | |
| 48 | TSCAP | - | |
| 51 | TS15 | I/O | |
| 52 | TS16 | I/O | |
| 38 | TSCAP | I | |
| 76 | PE2/RXD12 | I | QE serial monitoring |
| 77 | PE1/TXD12 | O | |
| 4 | PJ3 | I | LED control |
| 18 | P32 | I | |
| 63 | PA7 | O | |
| 74 | PE4 | O | |
| 75 | PE3 | O | |
| 78 | PE0 | O | |
| 87 | P47 | O | |
| 88 | P46 | O | |
| 89 | P45 | O | |
| 90 | P44 | O | |
| 98 | P07 | O | |
| 100 | P05 | O | |

Note : Low level fixed for shiled electrode

**Table 3-8 List of Handling of Unused Pins**

| Pin No. | Pin Name | I/O | Handling |
|---|---|---|---|
| 1 | AVCC1 | O | Connect the pin to GND via a capacitor (0.1uF). |
| 2 | EMLE | I | Connect the pin to GND via a register (4.7Kohm). |
| 3 | AVSS1 | I | Connect the pin to GND. |
| 5 | VCL | I | Connect the pin to GND via a capacitor (4.7uF). |
| 6 | VBATT | I | Connect the pin to VCC. |
| 7 | MD/FINED | I/O | Connect the pin to VCC or GND via a register (4.7Kohm). |
| 8 | XCIN | - | Open |
| 9 | XCOUT | - | Open |
| 10 | RES# | I | Connect the pin to reset citcuit |
| 14 | NMI | I | Connect the pin to VCC via a register (10Kohm). |
| 45 | UB | I | Connect the pin to GND via a register (4.7Kohm). |
| 94 | VREFL0 | I | Connect the pin to GND. |
| 96 | VREFH0 | I | Connect the pin to GND via a capacitor (0.1uF). |
| 97 | AVCC0 | I | Connect the pin to GND via a capacitor (0.1uF). |
| 98 | AVSS0 | I | Connect the pin to GND. |
| Pins than the above | | - | Low output |

The peripheral function settings using Smart Configurator are shown below.

- CTSU, DTC (CTSU measurement)

CTSU is used for touch measurement. DTC is used to acquire CTSU register settings and measurement results.

Table 3-9 and Table 3-10 shows the settings of each peripheral function.

**Table 3-9 CTSU Setting**

| Item | Setting |
|---|---|
| Data transfer by interrupt | DTC |

**Table 3-10 DTC Setting**

| Item | Setting |
|---|---|
| DTCER control | Clear all DTCER registers with open function |
| Address mode | Full-address mode |
| DTC transfer read skip enable | Enabled |
| Sequence transfer | Disabled |

- SCI12

Use SCI12 for serial monitoring of QE for Capacitive Touch. Table 3-11 shows the SCI12 settings.

**Table 3-11 SCI12 Setting**

| Item | Setting |
|---|---|
| Mode | ASYNC mode |
| Channel | Channel 12 |
| Transmit end interrupt | Enable |

## 3.8 Processing Flowchart

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

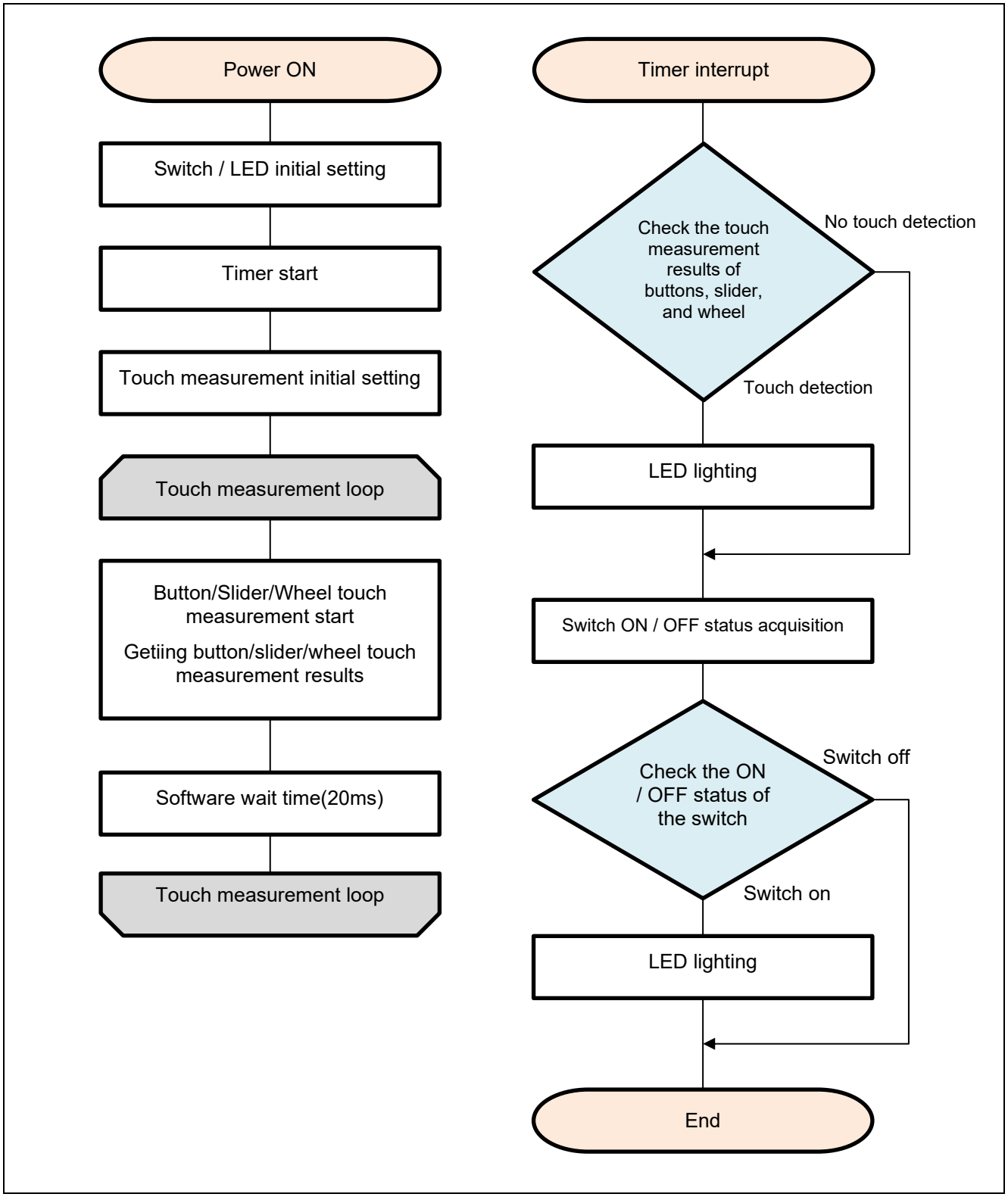



**Figure 3-2 Processing Flowchart (Self-Capacitance Buttons / Wheel / Slider Board)**

# 4. Capacitive Touch Setting

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

## 4.1 Touch Interface Configuration

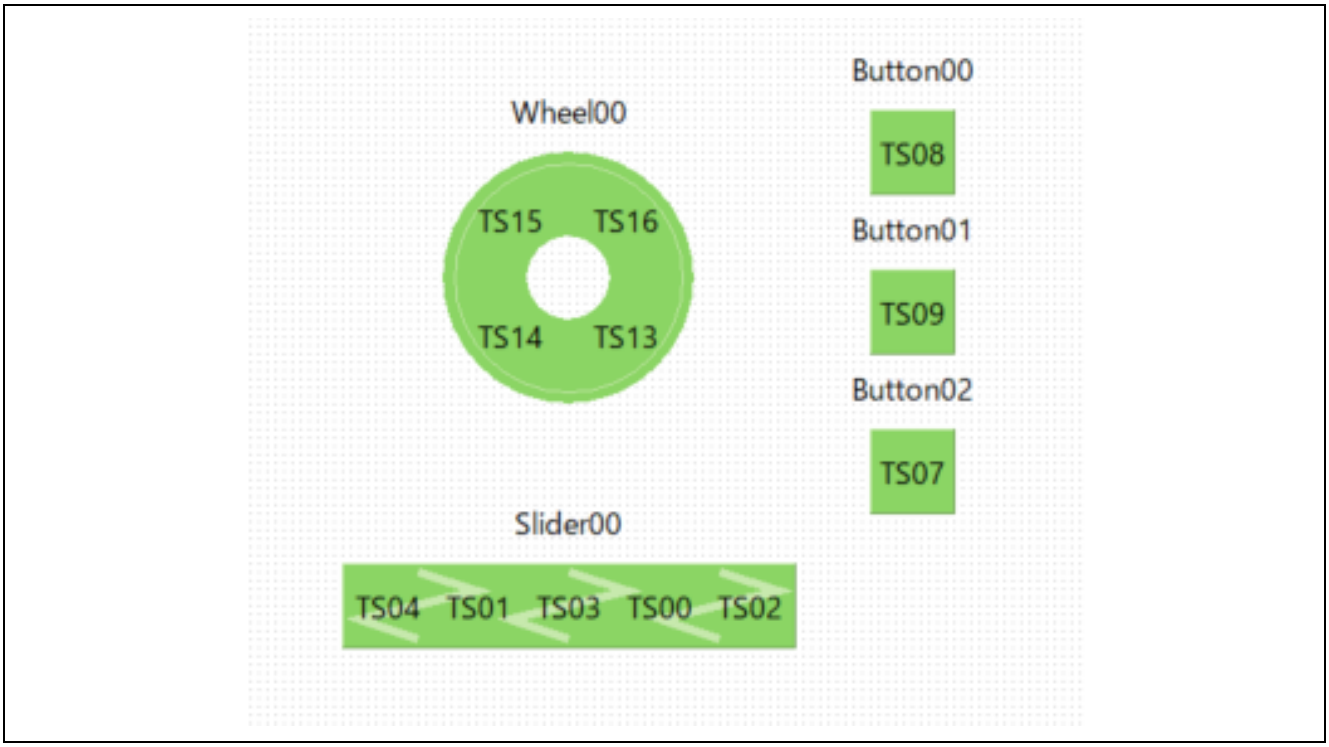



**Figure 4-1 Touch interface configuration (Self-Capacitance Buttons / Wheel / Slider Board)**

## 4.2 Configuration (methods) Settings

config01 sets 3 buttons, Wheel and Slider.

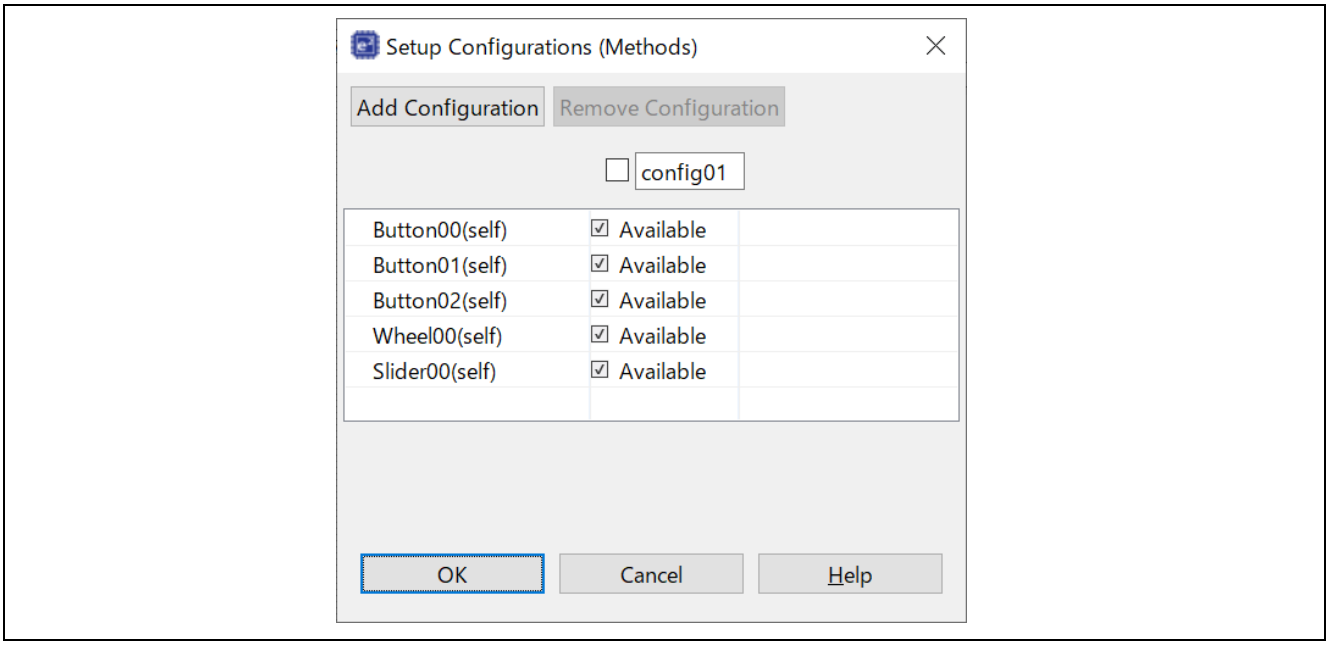



**Figure 4-2 Configuration (methods) setting**

## 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 | 25.046 | 0.943 (BASE:1.0) | 501 | 0.526 | 0x057 | 0x01 | 0x0E |
| config01 | Button01 | TS09 | 23.281 | 0.943 (BASE:1.0) | 529 | 0.526 | 0x04B | 0x01 | 0x0E |
| config01 | Button02 | TS07 | 19.327 | 1.768(BASE:1.875) | 1026 | 0.561 | 0x0A2 | 0x03 | 0x07 |
| config01 | Slider00 | TS00 | 20.454 | 1.768(BASE:1.875) | 659 | 0.561 | 0x0B1 | 0x03 | 0x07 |
| config01 | Slider00 | TS01 | 19.506 | 1.768(BASE:1.875) | 659 | 0.561 | 0x0A5 | 0x03 | 0x07 |
| config01 | Slider00 | TS02 | 21.834 | 1.768(BASE:1.875) | 659 | 0.561 | 0x0C2 | 0x03 | 0x07 |
| config01 | Slider00 | TS03 | 19.223 | 1.768(BASE:1.875) | 659 | 0.561 | 0x0A1 | 0x03 | 0x07 |
| config01 | Slider00 | TS04 | 16.477 | 1.768(BASE:1.875) | 659 | 0.561 | 0x07A | 0x03 | 0x07 |
| config01 | Wheel00 | TS13 | 24.047 | 0.943(BASE:1.0) | 562 | 0.526 | 0x050 | 0x01 | 0x0E |
| config01 | Wheel00 | TS14 | 22.58 | 0.943(BASE:1.0) | 562 | 0.526 | 0x045 | 0x01 | 0x0E |
| config01 | Wheel00 | TS15 | 24.732 | 0.943(BASE:1.0) | 562 | 0.526 | 0x055 | 0x01 | 0x0E |
| config01 | Wheel00 | TS16 | 26.658 | 0.943(BASE:1.0) | 562 | 0.526 | 0x064 | 0x01 | 0x0E |

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

## 4.4 Sensitivity adjustment

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

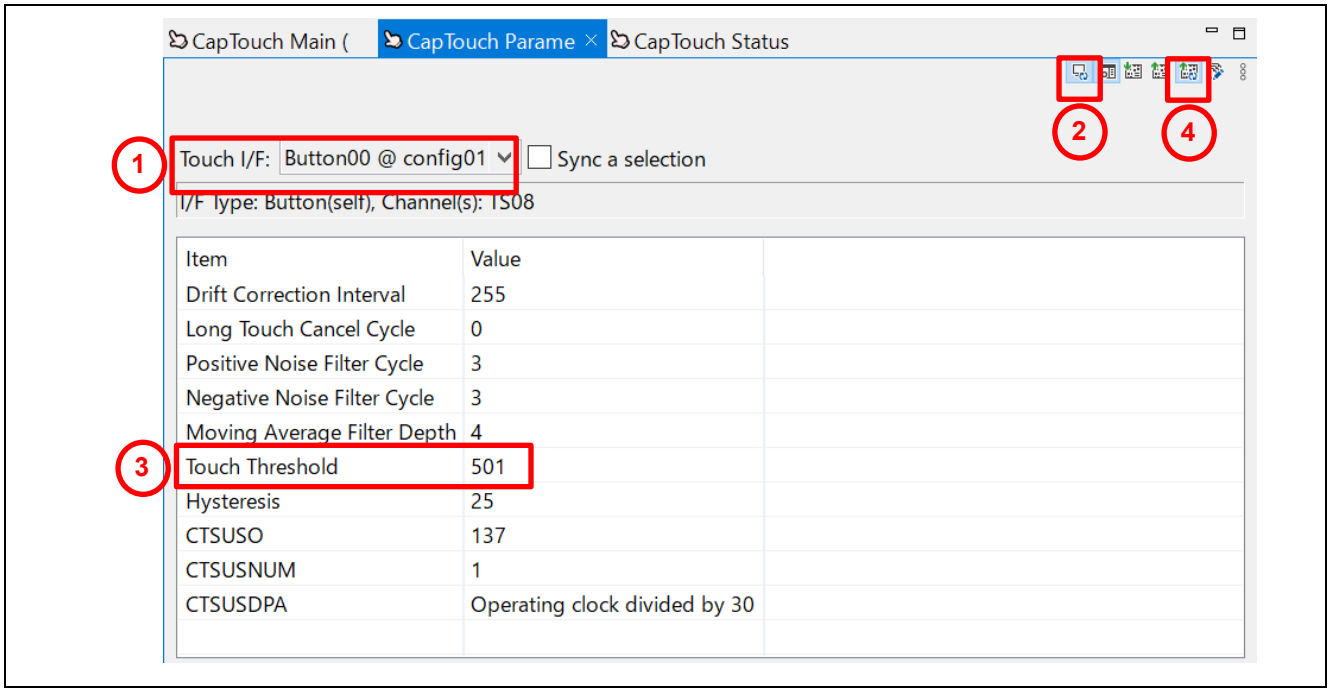
- The method using monitoring function of QE for Capacitive Touch

  Follow the tutorial from the QE for Capacitive Touch main window (Cap Touch Main).

- 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.




- How to change the code manually

  It can be adjusted by changing the member variable of the structure variable “g_qe_touch_button_cfg_config01” in qe_touch_config.c.

  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

| | |
|---|---|
| RX671 Capacitive Touch Evaluation System | renesas.com/rssk-touch-rx671 |
| QE for Capacitive Touch | renesas.com/qe-capacitive-touch |
| Renesas support | renesas.com/support |

RX Family Using QE and FIT to Develop Capacitive Touch Applications

renesas.com/document/apn/rx-family-using-qe-and-fit-develop-capacitive-touch-applications?language=en

## Revision History

| Rev. | Date | Description | |
|---|---|---|---|
| | | Page | Summary |
| 1.0 | 16.Dec.2022 | - | 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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