

## RL78/L23

### Capacitive Touch with segment LCD display Sample Code

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#### Introduction

This application note describes the RL78/L23 Capacitive Touch Evaluation System and the contents of the sample code displaying the detected position of the Capacitive Touch on the LCD panel.

#### Target Device

RL78/L23

When using this application note with other Renesas MCUs, careful evaluation is recommended after making modifications to comply with the alternate MCU.

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## 1. Overview

This sample code is software that display the detected position of the capacitive touch on the LCD panel with the RL78/L23 Capacitive Touch Evaluation System (RSSK-RL78L23) and the LCD module.

The following is added to the project.

- Components generated by the Smart Configurator
- Capacitive touch configuration files and applications tuning with QE for Capacitive Touch (QE)
- LED control application
- LCD control application (Note: Because the LCD is an optional function, you need to configure to use.)

### 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 SW1, LED1 lights up. Pressing SW2, LED2 lights up.

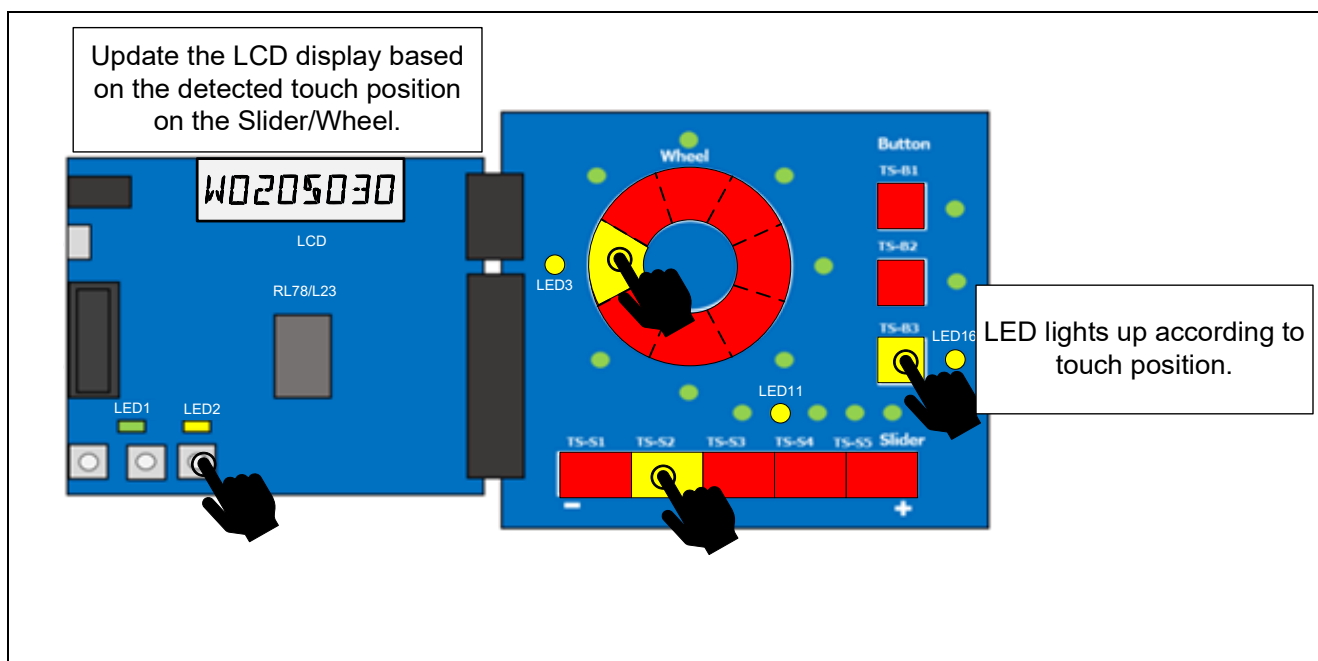


図 1-1 Description of the function

## 2. Operation Confirmation Conditions

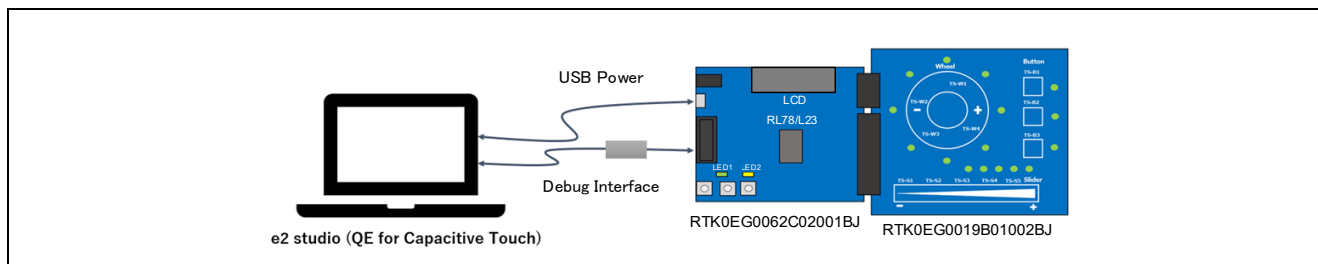
The operation of this sample code has been confirmed the following environment.

**Table 2-1 Operation Confirmation Conditions**

| Item                                                       | Contents                                                                                                                                                                                                                                                                                                                         |
|------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MCU                                                        | RL78/L23 (R7F100LPL3CFB)                                                                                                                                                                                                                                                                                                         |
| Operating frequency                                        | 32MHz (HOCO 32MHz)                                                                                                                                                                                                                                                                                                               |
| Operating voltage                                          | 3.3V<br>LVD0 detection voltage : Reset mode<br>At rising edge TYP. 2.97V(TYP) (2.88V to 3.06V)<br>At falling edge TYP. 2.91V(TYP) (2.82V to 3.00V)                                                                                                                                                                               |
| Evaluation board                                           | Capacitive Touch Evaluation System for RL78/G23 (Product No: RTK0EG0063S01001B)<br><ul style="list-style-type: none"> <li>RL78/L23 CPU Board (Product No: RT0EG0062C01001BJ)</li> <li>Capacitive Touch Evaluation Application Board Self-Capacitance Buttons / Wheels / Slider Board (Product No: RTK0EG0019B01002BJ)</li> </ul> |
| LCD(Note)                                                  | Varitronix VIM-878-DP-FC-S-LV<br>16 segments x8 digits<br>Header : 36-pin (18 x 2 rows) x 1<br>Operating voltage condition : 3V to 4.6V (When using the module with operating voltage other than 3.3V, remove the LCD panel.)                                                                                                    |
| Integrated development environment (e <sup>2</sup> studio) | e <sup>2</sup> studio Version 2025-07<br>from Renesas Electronics Corporation                                                                                                                                                                                                                                                    |
| C Compiler (e <sup>2</sup> studio)                         | CC-RL V1.15.01<br>from Renesas Electronics Corporation                                                                                                                                                                                                                                                                           |
| Integrated development environment (CS+)                   | CS+ for CC V8.14.00<br>from Renesas Electronics Corporation                                                                                                                                                                                                                                                                      |
| C Compiler (CS+)                                           | CC-RL V1.15.01<br>from Renesas Electronics Corporation                                                                                                                                                                                                                                                                           |
| Smart Configurator                                         | RL78 Smart Configurator V1.14.0<br>from Renesas Electronics Corporation                                                                                                                                                                                                                                                          |
| Development Assistance Tool for Capacitive Touch Sensors   | QE for Capacitive Touch V4.2.0                                                                                                                                                                                                                                                                                                   |
| Board support package (BSP)                                | V1.91 from Renesas Electronics Corporation                                                                                                                                                                                                                                                                                       |
| Emulator                                                   | Renesas E2Emulator Lite (RTE0T0002LKCE00000R)                                                                                                                                                                                                                                                                                    |

Note: This board doesn't come with any LCD.

Figure 2-1 shows device connection diagram.



**Figure 2-1 Device Connection Diagram**

### 3. Hardware configuration

The LCD is optional in the RL78/L23 Capacitive Touch Evaluation System. You must configure RL78/L23 CPU Board (No: RT0EG0062C02001BJ) properly to enable its use.

#### 3.1 Connect wires to LCD

Since the LCD is not connected in the initial state, switch the wiring using Short-PAD/Open-PAD to use the LCD.

The LCD drive power supply settings need to be changed. This application note uses the capacitance division method.

For details on the wiring to be switched and its settings, refer to the "RL78/L23 Renesas Solution Starter Kit Capacitive Touch Evaluation System User's Manual (R12UZ0175)."

#### 3.2 LCD connection

To connect to the LCD, installation of the LCD connection socket on the CPU board is required. After that, you can use the LCD. You can refer to "RL78/L23 LCD display(Clock demo)(R01AN7852)" for more details.

#### 3.3 Jumper wires configuration

The sample code accompanying this application note has been run and confirmed under the conditions of Table 3-1. The LCD used in this note operates at 3.0V to 4.6V, so power must be supplied through LDO.

**Table 3-1 Jumper Settings for CPU Board**

| Jumper | Configuration | Contents                 |
|--------|---------------|--------------------------|
| JP4    | Short 1-2     | Supplied from USB        |
| JP1    | Short 2-3     | Using 3.3V LDO           |
| JP2    | Short 2-3     |                          |
| SW6    | Short 2-3     | TS16 is connected to CN2 |

4. Software Specification

4.1 Software Structure Diagram

Figure 4-1 shows the software structure diagram of this sample code.  
This software uses components generated by the Smart Configurator.

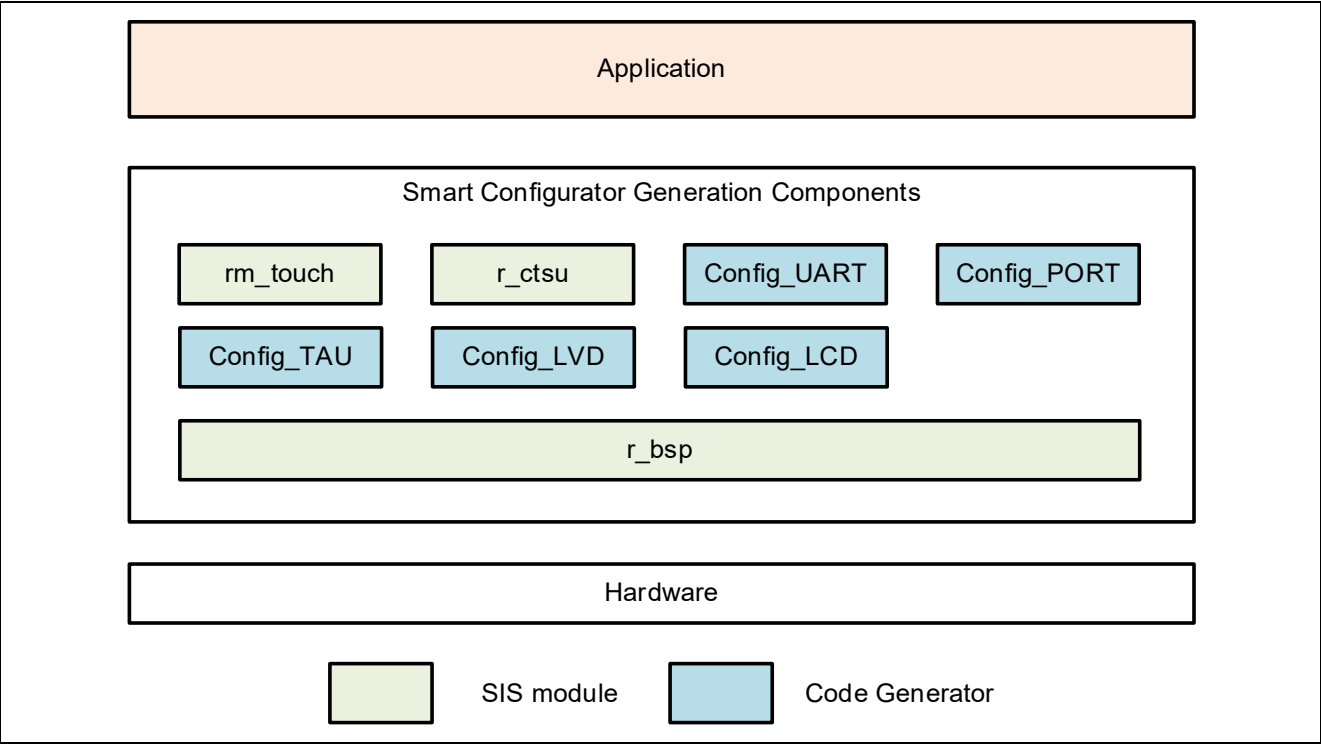


Figure 4-1 Software structure diagram

Figure 4-2 shows a list of components and their versions.  
Refer to the smart configurator for component settings.

| Component                                | Version | Configuration                                                                         |
|------------------------------------------|---------|---------------------------------------------------------------------------------------|
| Board Support Packages. - v1.91 (r_bsp)  | 1.91    | r_bsp(used)                                                                           |
| Capacitive Sensing Unit driver. (r_ctsu) | 2.20    | r_ctsu(used)                                                                          |
| Interval Timer                           | 1.8.0   | Config_TAU0_2(TAU0_2: used), Config_TAU0_1(TAU0_1: used), Config_TAU0_3(TAU0_3: used) |
| LCD Controller                           | 1.1.0   | Config_LCD(LCD: used)                                                                 |
| Ports                                    | 1.8.0   | Config_PORT(PORT: used)                                                               |
| Touch middleware. (rm_touch)             | 2.20    | rm_touch(used)                                                                        |
| UART Communication                       | 1.10.0  | Config_UART2(UART2: used)                                                             |
| Voltage Detector                         | 1.6.1   | Config_LVD0(LVD0: used)                                                               |

Figure 4-2 Components and their versions list

## 4.2 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.

**Table 4-1 File structure of this sample code**

| Folder and file name    | Description                           | Smart Configurator Usage |
|-------------------------|---------------------------------------|--------------------------|
| rl78l23_rssk_lcd <DIR>  | Sample code folder                    |                          |
| QE-Touch <DIR>          | QE structure folder                   |                          |
| rl78l23_rssk_lcd.tifcfg | Touch interface configuration file    |                          |
| qe_gen                  | QE generated folder                   |                          |
| 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 <DIR>               | Source Folder                         |                          |
| rl78l23_rssk_lcd.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 & LDE function source |                          |
| r_rssk_touch_led.h      | Touch electrode & LDE function header |                          |
| r_rssk_touch_lcd.c      | Touch electrode & LCD function source |                          |
| r_rssk_touch_lcd.h      | Touch electrode & LCD function header |                          |
| smc_gen <DIR>           | Smart Configuration generated folder  | ✓                        |
| Config_LCD <DIR>        | LCD driver folder                     | ✓                        |
| Config_LVD <DIR>        | LVD driver folder                     | ✓                        |
| Config_PORT <DIR>       | PORT driver folder                    | ✓                        |
| Config_TAU0_1 <DIR>     | TAU0_1 driver folder                  | ✓                        |
| Config_TAU0_2 <DIR>     | TAU0_2 driver folder                  | ✓                        |
| Config_TAU0_3 <DIR>     | TAU0_3 driver folder                  | ✓                        |
| r_ctsu <DIR>            | CTSU SIS module folder                | ✓                        |
| rm_touch <DIR>          | TOUCH SIS module folder               | ✓                        |

### 4.3 Setting of Option Byte

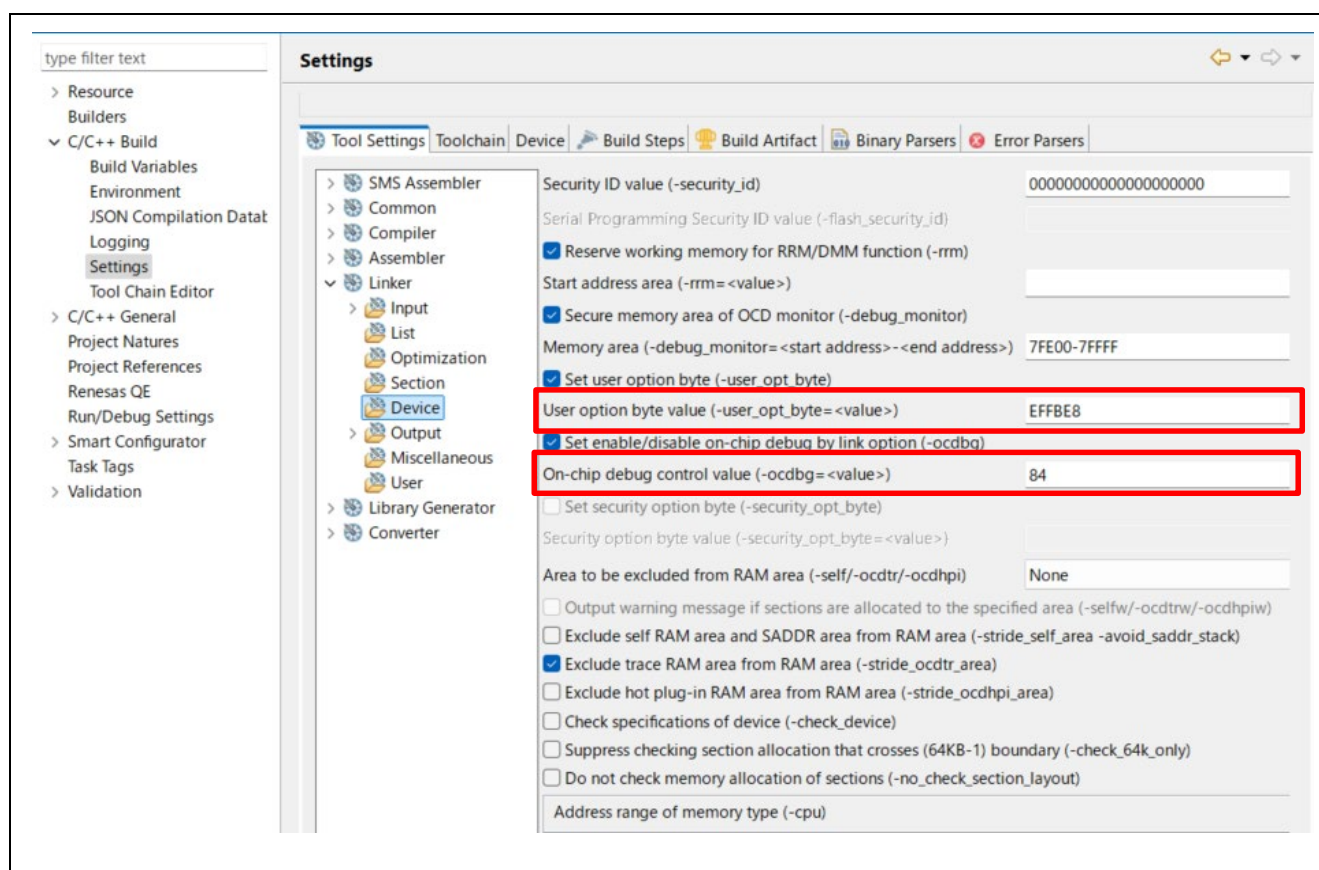
Table 4-2 shows the option byte settings.

**Table 4-2 Option Byte Settings**

| Address         | Setting Value    | Content                                                                                                                                    |
|-----------------|------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| 000C0H / 040C0H | 1110 1111b(0xEF) | Disables the watchdog timer.<br>(Counting stopped after reset)                                                                             |
| 000C1H / 040C1H | 1111 1011b(0xFB) | 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 4-3 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 4-3 User Option Byte Value and On-chip Debug Control Value**

#### 4.4 Constants

Table 4-3, Table 4-4 lists the constants.

**Table 4-3 List of Constant (1/2)**

| Constant Name                   | Setting Value | Description                                        |
|---------------------------------|---------------|----------------------------------------------------|
| File name : qe_touch_main.c     |               |                                                    |
| TOUCH_SCAN_INTERVAL_EXAMPLE     | (20 * 1000)   | Software delay value [unit: $\mu$ s]               |
| TEST_INTERVAL_EXAMPLE           | (1 * 1000)    | Initial LED software delay value [unit: $\mu$ s]   |
| File name : r_rssk_switch_led.c |               |                                                    |
| RSSK_SW1_PORT                   | (P6_bit.no0)  | Pointer to port control register connected to SW1  |
| RSSK_SW2_PORT                   | (P6_bit.no1)  | Pointer to port control register connected to SW2  |
| RSSK_LED1_PORT                  | (P6_bit.no4)  | Pointer to port control register connected to LED1 |
| RSSK_LED2_PORT                  | (P6_bit.no5)  | Pointer to port control register connected to LED2 |
| RSSK_SW1_PORT_MODE              | (PM6_bit.no0) | Pointer to port mode register connected to SW1     |
| RSSK_SW2_PORT_MODE              | (PM6_bit.no1) | Pointer to port mode register connected to SW2     |
| RSSK_LED1_PORT_MODE             | (PM6_bit.no4) | Pointer to port mode register connected to LED1    |
| RSSK_LED2_PORT_MODE             | (PM6_bit.no5) | Pointer to port mode register connected to LED2    |
| 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.no0) | Pointer to port control register connected to COL0 |
| LED_COL1                        | (P8_bit.no4)  | Pointer to port control register connected to COL1 |
| LED_COL2                        | (P8_bit.no3)  | Pointer to port control register connected to COL2 |
| LED_COL3                        | (P8_bit.no2)  | Pointer to port control register connected to COL3 |
| LED_ROW0                        | (P2_bit.no1)  | Pointer to port control register connected to ROW0 |
| LED_ROW1                        | (P2_bit.no0)  | Pointer to port control register connected to ROW1 |
| LED_ROW2                        | (P8_bit.no1)  | Pointer to port control register connected to ROW2 |
| LED_ROW3                        | (P8_bit.no0)  | 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                                     |

Table 4-4 List of Constant (2/2)

| Constant Name                  | Setting Value                | Description                                   |
|--------------------------------|------------------------------|-----------------------------------------------|
| File name : r_rssk_touch_led.c |                              |                                               |
| SLIDER_LED_NUM                 | (5U)                         | Number of slider LED                          |
| SLIDER_RESOLUTION              | (100U)                       | Maximum slider touch result                   |
| WHEEL_LED_NUM                  | (8U)                         | Wheel LED control bit MSB                     |
| WHEEL_LED_MSB                  | (1U << (WHEEL_LED_NUM - 1U)) | Wheel LED control bit MSB                     |
| WHEEL_RESOLUTION_DEGREE        | (360U)                       | Maximum wheel touch result<br>[unit: degree]  |
| 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                    |
| File Name : r_rssk_touch_lcd.c |                              |                                               |
| TOUCH_BUTTON1_ONLY_ON          | (0x02)                       | Enable only touch button 1                    |
| TOUCH_BUTTON2_ONLY_ON          | (0x04)                       | Enable only touch button 2                    |
| TOUCH_BUTTON3_ONLY_ON          | (0x01)                       | Enable only touch button 3                    |
| LCD_STATE_OFF                  | (0)                          | LCD display OFF state                         |
| LCD_STATE_ON                   | (1)                          | LCD display ON state                          |
| LCD_STATE_BLINK_150MS          | (2)                          | LCD display blinking at 150ms intervals       |
| LCD_STATE_BLINK_250MS          | (3)                          | LCD display blinking at 250ms intervals       |

## 4.5 Enumerations

Table 4-5 lists the `rssk_sw_status_t` enum.

**Table 4-5 `rssk_sw_status_t`**

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

## 4.6 Global Variables

Table 4-6 lists the global variables.

**Table 4-6 List of Global Variable**

| Variable Name                                 | Types                      | Description                                         |
|-----------------------------------------------|----------------------------|-----------------------------------------------------|
| File Name : <code>qe_touch_sample.c</code>    |                            |                                                     |
| <code>button_status</code>                    | <code>uint64_t</code>      | Button Status                                       |
| <code>slider_position[1]</code>               | <code>uint16_t</code>      | Slider touch position information                   |
| <code>wheel_position[1]</code>                | <code>uint16_t</code>      | Wheel touch position information                    |
| File Name : <code>r_rssk_touch_led.c</code>   |                            |                                                     |
| <code>s_led_drive_colmun</code>               | <code>uint8_t</code>       | Touch electrode board LED drive information         |
| <code>s_button_idx[3]</code>                  | <code>uint8_t</code>       | Button index array                                  |
| File Name : <code>r_rssk_touch_lcd.c</code>   |                            |                                                     |
| <code>s_lcd_state</code>                      | <code>uint8_t</code>       | LCD display state                                   |
| <code>s_lcd_blink_150ms_on</code>             | <code>uint8_t</code>       | LCD blinking at 150ms intervals                     |
| <code>s_lcd_blink_250ms_on</code>             | <code>uint8_t</code>       | LCD blinking at 250ms intervals                     |
| <code>s_lcd_display_array[8]</code>           | <code>uint8_t</code>       | Array to store characters displayed on the LCD      |
| File Name : <code>r_rssk_lcd_segdata.c</code> |                            |                                                     |
| <code>g_show_segdata[41][4]</code>            | <code>const uint8_t</code> | Segment values for displaying characters on the LCD |
| <code>g_digit_segdata[8][4]</code>            | <code>const uint8_t</code> | Number of digits on the LCD for displaying          |

## 4.7 Functions

Table 4-7 lists the functions.

**Table 4-7 List of Function**

| Function Name                   | Description                                                     |
|---------------------------------|-----------------------------------------------------------------|
| File Name : qe_touch_main.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_sw1_status             | SW1 state response processing                                   |
| rssk_get_sw2_status             | SW2 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                                         |
| 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                    |
| File Name : r_rssk_touch_lcd.c  |                                                                 |
| r_rssk_lcd_init                 | Display on the LCD at the beginning                             |
| r_rssk_touch_lcd_control        | Touch board LCD control processing                              |
| r_rssk_blink_150ms_callback     | Callback for LCD display blinking at 150ms intervals            |
| r_rssk_blink_250ms_callback     | Callback for LCD display blinking at 250ms intervals            |
| lcd_update_display              | Update LCD display                                              |
| lcd_clear_display               | Clear LCD display                                               |
| lcd_show_array                  | Display character array on the LCD                              |
| lcd_show                        | Displays a character on the LCD                                 |
| touch_button1_lcd               | Touch detection processing for touch button 1                   |
| touch_button2_blink_150ms       | Touch detection processing for touch button 2                   |
| touch_button3_blink_250ms       | Touch detection processing for touch button 3                   |
| timer_stop_blink                | Stop LCD display blinking timers                                |
| timer_start_blink_150ms         | Start LCD display blinking timer at 150ms intervals             |
| timer_start_blink_250ms         | Start LCD display blinking timer at 250ms intervals             |
| update_lcd_wheel_value          | Update the value of wheel on the LCD                            |
| update_lcd_slider_value         | Update the value of slider on the LCD                           |

#### 4.8 List of Peripheral Functions Used and Pins Used

Table 4-8 and Table 4-9 show a list of used pins, and Table 4-10 shows a list of handling of unused pins in this sample software.

**Table 4-8 List of used pins (1/2)**

| Pin No. | Pin Name      | I/O | Usage                   |
|---------|---------------|-----|-------------------------|
| 34      | TS03          | I/O | CTS measurement         |
| 35      | TS04          | I/O |                         |
| 36      | TS05          | I/O |                         |
| 37      | TS06          | I/O |                         |
| 39      | TS07          | I/O |                         |
| 40      | TS08          | I/O |                         |
| 75      | TS09          | I/O |                         |
| 74      | TS10          | I/O |                         |
| 43      | TS11          | I/O |                         |
| 44      | TS12          | I/O |                         |
| 56      | TS21          | I/O |                         |
| 69      | TS32          | I/O |                         |
| 70      | TS33          | I/O |                         |
| 71      | TS34          | I/O |                         |
| 72      | TS35          | I/O |                         |
| 51      | TSCAP         | -   |                         |
| 42      | RxD2          | I   | QE serial communication |
| 41      | TxD2          | O   |                         |
| 22      | P60/SW1       | I   | Switch input            |
| 23      | P61/SW2       | I   |                         |
| 24      | P64/LED1      | O   | LED Control             |
| 25      | P65/LED2      | O   |                         |
| 99      | P21/LED_ROW0  | O   |                         |
| 100     | P20/LED_ROW1  | O   |                         |
| 68      | P81/LED_ROW2  | O   |                         |
| 73      | P80/LED_ROW3  | O   |                         |
| 1       | P140/LED_COL0 | O   |                         |
| 49      | P84/LED_COL1  | O   |                         |
| 50      | P83/LED_COL2  | O   |                         |
| 67      | P82/LED_COL3  | O   |                         |

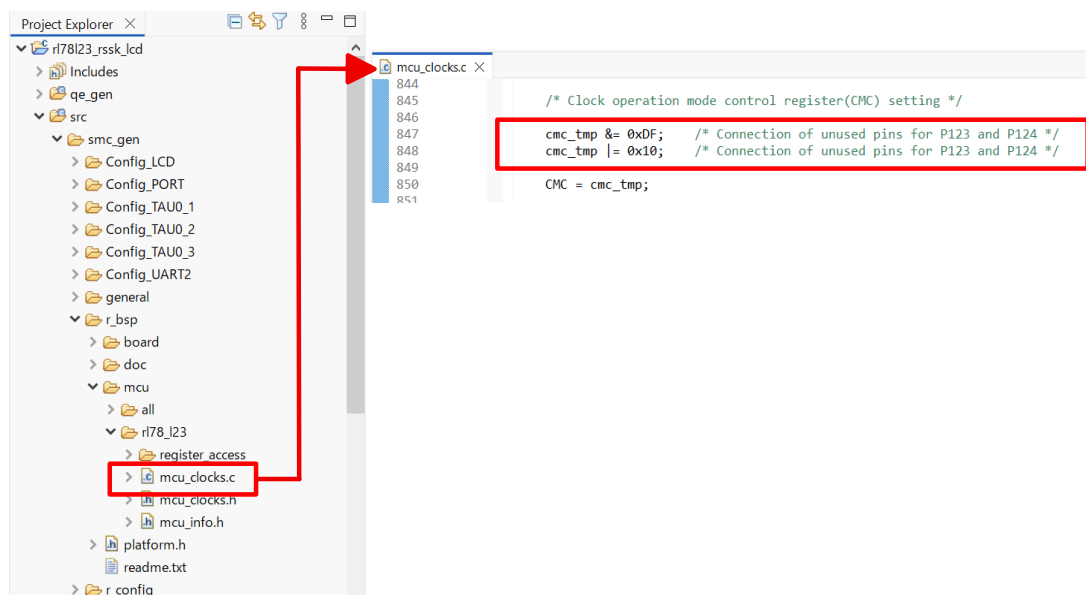
Table 4-9 List of used pins(2/2)

| Pin No. | Pin Name | I/O | Usage       |
|---------|----------|-----|-------------|
| 62      | SEG00    | O   | LCD Control |
| 61      | SEG01    | O   |             |
| 60      | SEG02    | O   |             |
| 59      | SEG03    | O   |             |
| 46      | SEG14    | O   |             |
| 45      | SEG15    | O   |             |
| 4       | SEG26    | O   |             |
| 3       | SEG27    | O   |             |
| 2       | SEG28    | O   |             |
| 98      | SEG29    | O   |             |
| 97      | SEG30    | O   |             |
| 93      | SEG31    | O   |             |
| 92      | SEG32    | O   |             |
| 91      | SEG33    | O   |             |
| 90      | SEG34    | O   |             |
| 87      | SEG35    | O   |             |
| 86      | SEG36    | O   |             |
| 85      | SEG37    | O   |             |
| 84      | SEG38    | O   |             |
| 83      | SEG39    | O   |             |
| 82      | SEG40    | O   |             |
| 81      | SEG41    | O   |             |
| 80      | SEG42    | O   |             |
| 79      | SEG43    | O   |             |
| 78      | SEG44    | O   |             |
| 77      | SEG45    | O   |             |
| 76      | SEG46    | O   |             |
| 96      | SEG51    | O   |             |
| 95      | SEG52    | O   |             |
| 94      | SEG53    | O   |             |
| 89      | SEG54    | O   |             |
| 88      | SEG55    | O   |             |
| 66      | COM0     | O   |             |
| 65      | COM1     | O   |             |
| 64      | COM2     | O   |             |
| 63      | COM3     | O   |             |

Table 4-10 List of Handling of Unused Pins

| Pin No.             | Pin Name                 | I/O | Handling                                                                                                                                                                                                    |
|---------------------|--------------------------|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 19                  | REGC                     | I   | Connect the pin to GND via a capacitor (1uF)                                                                                                                                                                |
| 21                  | VDD                      | I   | Connect the pin to GND via a capacitor (0.1uF)                                                                                                                                                              |
| 20                  | VSS                      | I   | Connect the pin to GND                                                                                                                                                                                      |
| 38                  | EVSS                     | I   |                                                                                                                                                                                                             |
| 16                  | P137                     | I   | Connect the pin to V <sub>DD</sub> via a register (10kohm)                                                                                                                                                  |
| 15                  | P124/XT2 <sup>Note</sup> | I   | Set the EXCLKS bit to 0 and the OSCSELS bit to 1 in the clock operation mode control register (CMC), set the XTSTOP bit in the clock operation status control register (CSC) to 1, and leave the pins open. |
| 14                  | P123/XT1 <sup>Note</sup> | I   |                                                                                                                                                                                                             |
| pins than the above |                          | -   | Low output                                                                                                                                                                                                  |

Note: The CMC register is set by the mcu\_clock\_setup function in mcu\_clocks.c as shown in Figure 4-4.



**Caution** If you change the version of the "r\_bsp" component in the Smart Configurator, mcu\_clocks.c will be overwritten and any code added by the user will be erased. Therefore, whenever you change the version of the "r\_bsp" component, you will need to add the code for the above settings.

Figure 4-4 Edit mcu\_clocks.c

Table 4-11 shows a list of peripheral functions used.

**Table 4-11 List of Peripheral Functions Used**

| Peripheral Function | Usage                                                       |
|---------------------|-------------------------------------------------------------|
| LVD                 | Low Voltage Detection                                       |
| CTSU                | CTSU measurement                                            |
| UART2               | QE serial monitoring and serial tuning                      |
| TAU0_1              | LED control trigger                                         |
| TAU0_2              | Trigger for LCD display blinking control at 150ms intervals |
| TAU0_3              | Trigger for LCD display blinking control at 250ms intervals |
| LCD                 | LCD control                                                 |
| PORT                | LED control                                                 |

The peripheral function settings using Smart Configurator are shown below.

- Voltage Detector

The reset generation voltage settings are shown in Table 4-12.

**Table 4-12 Voltage Detector**

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

- UART communication

Use UARTA1 for serial monitoring of QE for Capacitive Touch. Table 4-13 shows the UART2 settings.

**Table 4-13 UART2 setting**

| Item                       | Setting              |
|----------------------------|----------------------|
| Operation clock            | CK10                 |
| Clock Source               | $f_{CLK}/2^2$        |
| Transfer mode setting      | Single transfer mode |
| Data length setting        | 8 bits               |
| Transfer direction segging | LSB                  |
| Parity setting             | None                 |
| Stop bit length setting    | 1 bit                |
| Transfer rate setting      | Non-reverse          |
| Transfer rate setting      | 115200               |
| Interrupt setting          | level 3              |
| Callback function setting  | Transmission end     |

- Interval Timer

Use TAU0\_1 for LED control. Table 4-14 shows the TAU0\_1 settings.

**Table 4-14 TAU0\_1 Setting**

| Item                         | Setting                                                                             |
|------------------------------|-------------------------------------------------------------------------------------|
| Operation clock              | CK03                                                                                |
| Clock source                 | $f_{CLK}/2^{10}$                                                                    |
| Interval value (higher 8bit) | 5ms                                                                                 |
| Interrupt setting            | End of timer channel1 count, generate an interrupt (INTTM01H)<br>: Enable (level 3) |

Use interval timer "TAU0\_2" to control the LCD display blinking at 150 ms intervals. Table 4-15 shows the TAU0\_2 settings.

**Table 4-15 TAU0\_2 Settings**

| Item                    | Setting                                                                             |
|-------------------------|-------------------------------------------------------------------------------------|
| Operation clock         | CK00                                                                                |
| Clock source            | $f_{CLK}/2^{10}$                                                                    |
| Interval value (16 bit) | 150ms                                                                               |
| Count start interrupt   | Generates INTTM02 when counting is started: Enable                                  |
| Interrupt setting       | End of timer channel 2 count, generate an interrupt (INTTM02)<br>: Enable (Level 3) |

Use interval timer "TAU0\_3" to control the LCD display blinking at 250 ms intervals. Table 4-16 shows the TAU0\_3 settings.

**Table 4-16 TAU0\_3 Settings**

| Item                    | Setting                                                                             |
|-------------------------|-------------------------------------------------------------------------------------|
| Operation clock         | CK00                                                                                |
| Clock source            | $f_{CLK}/2^{10}$                                                                    |
| Interval value (16 bit) | 250ms                                                                               |
| Count start interrupt   | Generates INTTM03 when counting is started: Enable                                  |
| Interrupt setting       | End of timer channel 3 count, generate an interrupt (INTTM03)<br>: Enable (Level 3) |

- LCD

Use LCD. Table 4-17 shows LCD setting.

**Table 4-17 LCD Setting**

| Item                            | Setting                                           |
|---------------------------------|---------------------------------------------------|
| Display waveform setting        | Type A waveform                                   |
| Drive voltage generator setting | Capacitor split method for the $V_{DD}$ reference |
| Display mode setting            | Number of time slices: 4(1/3 bias mode)           |
| Display data area setting       | A-pattern area data                               |
| Clock source                    | $f_{IL}$                                          |
| Frequency divider               | $f_{IL}/2^7$                                      |
| Frame frequency                 | 64Hz                                              |

- Ctsu middleware (r\_ctsu)

Use r\_ctsu for touch control. Table 4-18 shows r\_ctsu setting.

**Table 4-18 r\_ctsu Setting**

| Item                                            | Setting           |
|-------------------------------------------------|-------------------|
| Data Transfer of INTCTSUWR and INTCTSURD        | Interrupt handler |
| DTC setting                                     | Setting in r_ctsu |
| Auto-judgment function in Snooze mode using SMS | Disable           |
| Interrupt level for INTCTSUWR                   | Level 2           |
| Interrupt level for INTCTSURD                   | Level 2           |
| Interrupt level for INTCTSUFN                   | Level 2           |

- Touch middleware (rm\_touch)

Use rm\_touch for touch control. Table 4-19 shows rm\_touch setting. This setting

Enables QE serial monitoring and serial tuning.

**Table 4-19 rm\_touch Setting**

| Item                          | Setting |
|-------------------------------|---------|
| Support QE monitor using UART | Enable  |
| Support QE tuning using UART  | Enable  |
| UART channel                  | UART2   |

#### 4.9 Processing Flowchart

Figure 4-5 shows processing flowchart of this sample code.

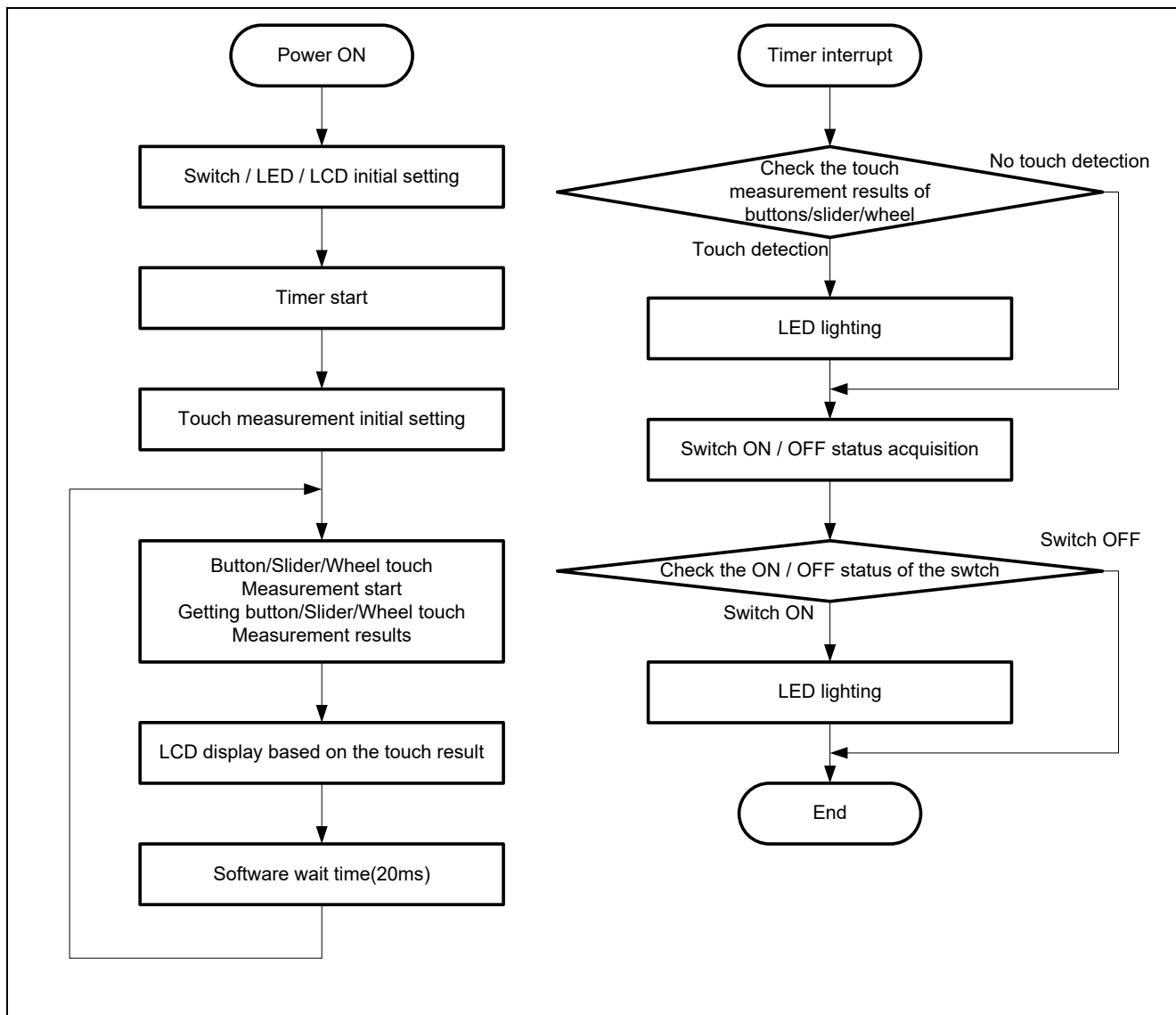


Figure 4-5 Processing Flowchart (Self-Capacitance Buttons / Wheel / Slider Board)

#### 4.10 LCD Display Details

Figure 4-6 shows the detail of how LCD display works in this sample code.

Upon power-on, display "WHEE" on the leftmost 4 LCD digits and "SLID" on the rightmost 4 digits.

- Wheel  
When a touch event is detected, display W and the detected position (1 to 360) on the leftmost 4 LCD digits. When missing any touch subsequently, display "W---" on the same digits.
- Slider  
When a touch event is detected, display S and the detected position (1 to 100) on the rightmost 4 LCD digits. When missing any touch subsequently, display "S---" on the same digits.

The changing display by Wheel and Slider is executed independently.

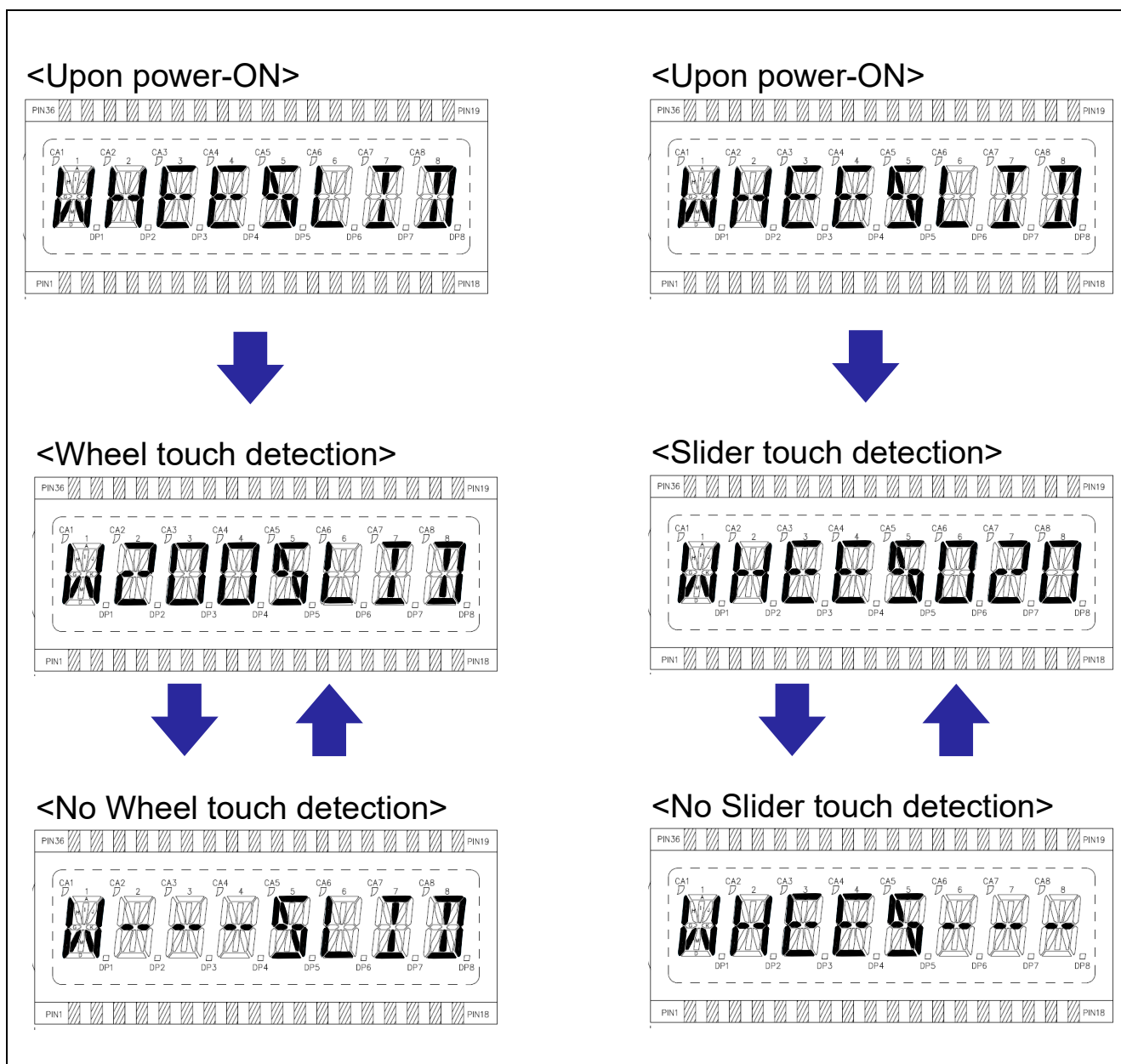


Figure 4-6 LCD Display Details

When a touch event is detected on a touch button, control the LCD display according to the specific button pressed. Figure 4-7 shows examples of touch button.

- Touch button 1  
Transition to LCD display ON state.  
When it's already LCD display ON state, transitions to LCD display OFF state.
- Touch button 2  
Transition to LCD display blinking at 150ms intervals state.  
When it's already LCD display blinking at 150ms intervals state, transitions to LCD display ON state.
- Touch button 3  
Transition to LCD display blinking at 250ms intervals state.  
When it's already LCD display blinking at 250ms intervals state, transitions to LCD display ON state.

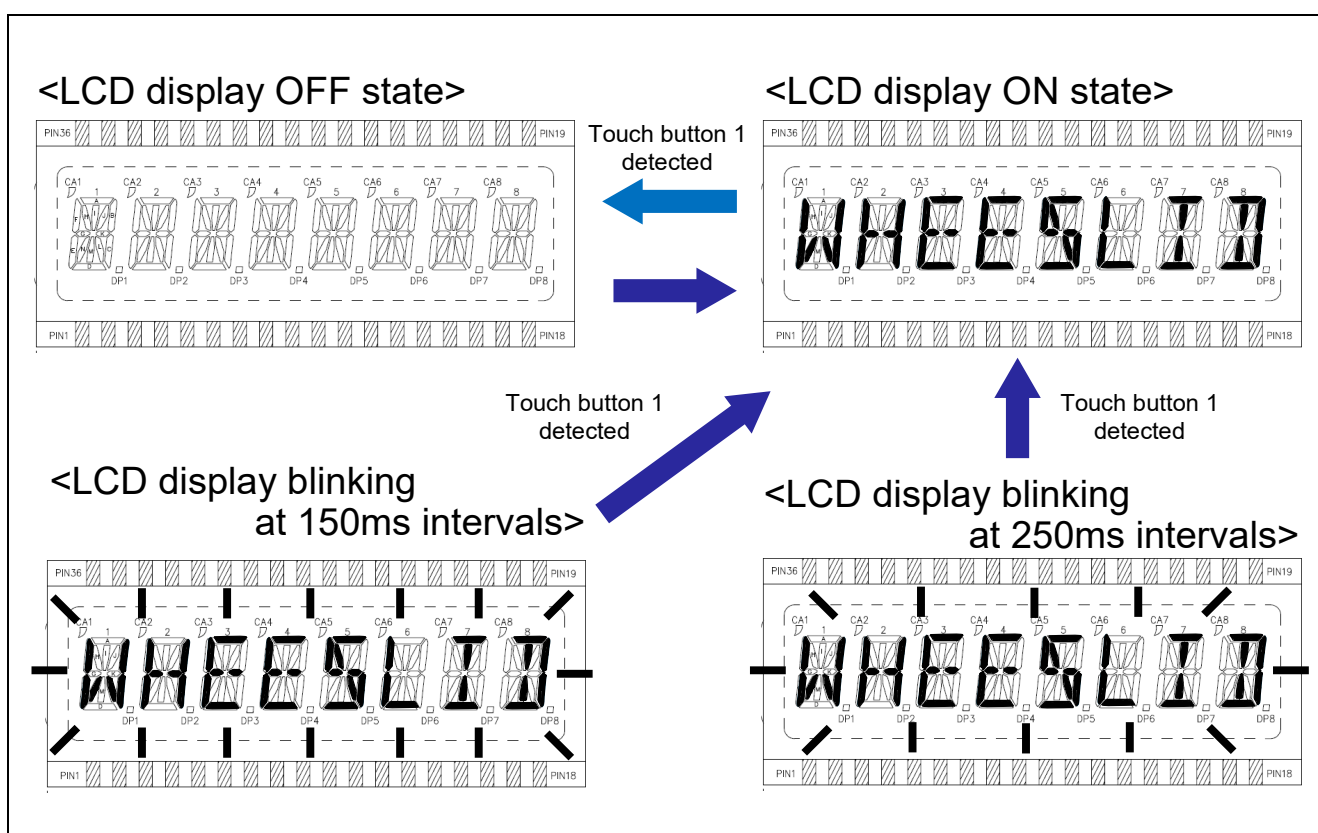


Figure 4-7 Example of LCD display controlled by touch button 1 detection

5. 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.

5.1 Touch Interface Configuration

Figure 5-1 shows the setting of the touch interface configuration in this sample code.

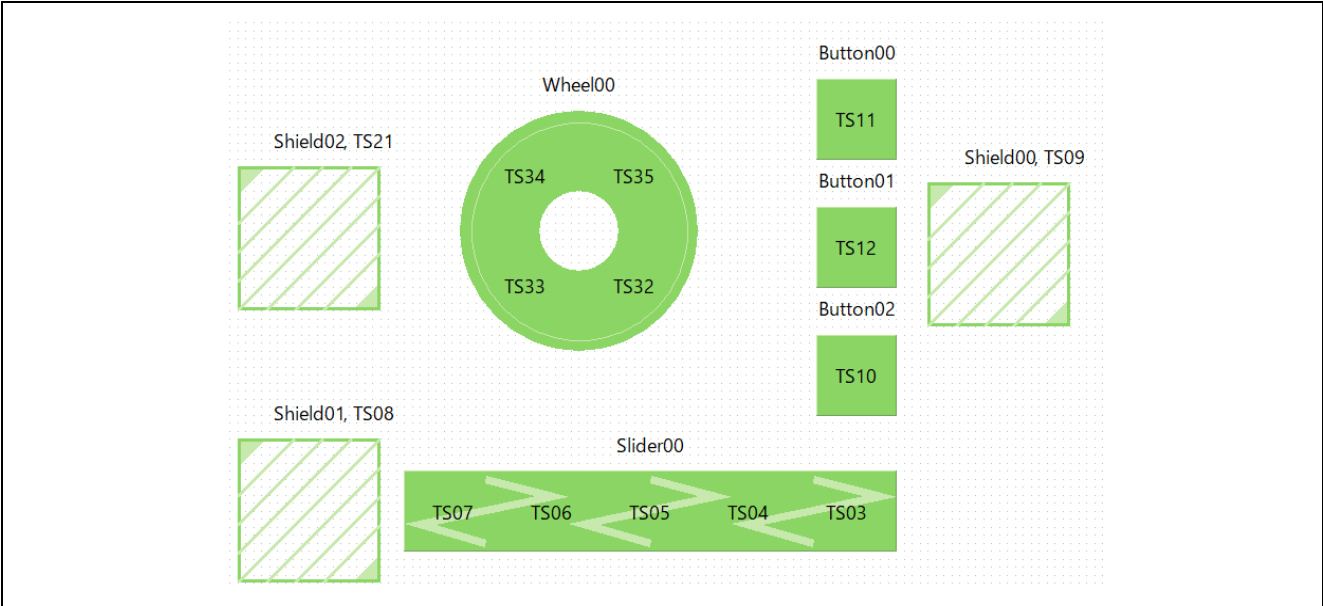


Figure 5-1 Touch interface configuration (Self-Capacitance Buttons / Wheel / Slider Board)

5.2 Configuration (methods) Settings

Figure 5-2 shows configuration (methods) of this sample code. 3 buttons and a shield00 are set enabled in config01. Slider and a shield01 are set enabled in config02. Wheel and a shield02 are set enabled in config03.

The screenshot shows a configuration interface with two buttons at the top: 'Add Configuration' and 'Remove Configuration'. Below these are three checkboxes for 'config01', 'config02', and 'config03'. The main part of the interface is a table with the following components listed on the left:

|                |                                     |                          |                                     |                                     |
|----------------|-------------------------------------|--------------------------|-------------------------------------|-------------------------------------|
| Button00(self) | <input checked="" type="checkbox"/> | Available                | <input type="checkbox"/>            | <input type="checkbox"/>            |
| Button01(self) | <input checked="" type="checkbox"/> | Available                | <input type="checkbox"/>            | <input type="checkbox"/>            |
| Button02(self) | <input checked="" type="checkbox"/> | Available                | <input type="checkbox"/>            | <input type="checkbox"/>            |
| Shield00(self) | <input checked="" type="checkbox"/> | Available                | <input type="checkbox"/>            | <input type="checkbox"/>            |
| Slider00(self) | <input type="checkbox"/>            | <input type="checkbox"/> | <input checked="" type="checkbox"/> | Available                           |
| Shield01(self) | <input type="checkbox"/>            | <input type="checkbox"/> | <input checked="" type="checkbox"/> | Available                           |
| Wheel00(self)  | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input checked="" type="checkbox"/> |
| Shield02(self) | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input checked="" type="checkbox"/> |

At the bottom, there are two rows of settings, each with three checkboxes:

- Touch Judgment (SMS) : ☐ Enable, ☐ Enable, ☐ Enable
- MEC: ☐ Enable, ☐ Enable, ☐ Enable

Figure 5-2 Configuration (methods) setting

### 5.3 Tuning Results

Table 5-1 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 5-1 QE tuning result list (Self-Capacitance Buttons / Wheel / Slider Board)**

| method   | Button name | Touch sensor | Parasitic capacitance [pF] | Drive pulse frequency [MHz] | Threshold | Scan time [ms] | so    | snum | sdpa |
|----------|-------------|--------------|----------------------------|-----------------------------|-----------|----------------|-------|------|------|
| Config01 | Button00    | TS11         | 12.688                     | 0.988                       | 709       | 0.576          | 0x03B | 0x07 | 0x0D |
| Config01 | Button01    | TS12         | 12.458                     | 0.988                       | 727       | 0.576          | 0x041 | 0x07 | 0x0D |
| Config01 | Button02    | TS10         | 12.201                     | 0.988                       | 711       | 0.576          | 0x03F | 0x07 | 0x0D |
| Config01 | Shield00    | TS09         | 49.701                     | -                           | -         | -              | -     | -    | -    |
| Config02 | Slider00    | TS07         | 11.396                     | 0.99                        | 382       | 0.576          | 0x038 | 0x07 | 0x0D |
| Config02 | Slider00    | TS06         | 10.604                     | 0.99                        | 382       | 0.576          | 0x030 | 0x07 | 0x0D |
| Config02 | Slider00    | TS05         | 10.806                     | 0.99                        | 382       | 0.576          | 0x030 | 0x07 | 0x0D |
| Config02 | Slider00    | TS04         | 10.799                     | 0.99                        | 382       | 0.576          | 0x02F | 0x07 | 0x0D |
| Config02 | Slider00    | TS03         | 11.84                      | 0.99                        | 382       | 0.576          | 0x036 | 0x07 | 0x0D |
| Config02 | Shield01    | TS08         | 49.611                     | -                           | -         | -              | -     | -    | -    |
| Config03 | Wheel00     | TS34         | 12.549                     | 1.067                       | 955       | 0.576          | 0x04D | 0x07 | 0x0C |
| Config03 | Wheel00     | TS35         | 12.417                     | 1.067                       | 955       | 0.576          | 0x046 | 0x07 | 0x0C |
| Config03 | Wheel00     | TS32         | 13.417                     | 1.067                       | 955       | 0.576          | 0x046 | 0x07 | 0x0C |
| Config03 | Wheel00     | TS33         | 12.812                     | 1.067                       | 955       | 0.576          | 0x043 | 0x07 | 0x0C |
| Config03 | Shield02    | TS21         | 45.896                     | -                           | -         | -              | -     | -    | -    |

so : Variables for sensor offset settings

snum : Variables for setting the measurement period

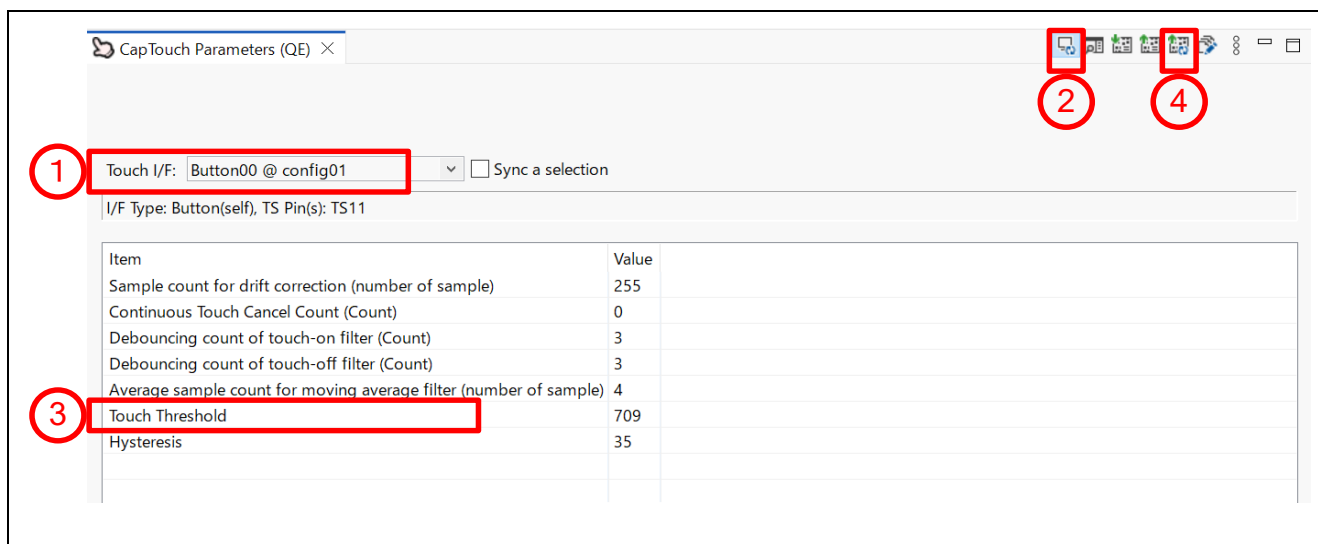
sdpa : Clock division setting variable

## 5.4 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 5-3



**Figure 5-3 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

## 6. Documents for Reference

RL78/L23 User's Manual: Hardware (R01UH1082)

RL78/L23 Renesas Solution Starter Kit Capacitive Touch Evaluation System User's Manual (R12UZ0175)

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

RL78/L23 LCD display (Clock demo) (R01AN7852)

(The latest versions of the documents are available on the Renesas Electronics Web site.)

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## Web site and Support

Renesas Electronics Web site

<http://www.renesas.com/>

Capacitive Sensing Unit related pages

<https://www.renesas.com/solutions/touch-key>

<https://www.renesas.com/qe-capacitive-touch>

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**Revision History**

| Rev. | Date      | Description |                      |
|------|-----------|-------------|----------------------|
|      |           | Page        | Summary              |
| 1.00 | Aug.27.25 | -           | First edition issued |
|      |           |             |                      |

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

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## 1. Precaution against Electrostatic Discharge (ESD)

A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.

## 2. Processing at power-on

The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.

## 3. Input of signal during power-off state

Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.

## 4. Handling of unused pins

Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.

## 5. Clock signals

After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.

## 6. Voltage application waveform at input pin

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between  $V_{IL}$  (Max.) and  $V_{IH}$  (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between  $V_{IL}$  (Max.) and  $V_{IH}$  (Min.).

## 7. Prohibition of access to reserved addresses

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