RX140 Group

Smart Wakeup Solution (Touchless Demo)

Introduction

This application note describes a touchless demonstration applying the RX140 Group Smart Wakeup Solution.

Target Device

RX140 (R5F51406ADFN)

Related Documents

1. RX140 Group Capacitive Touch Evaluation System User's Manual (r12uz0102ej0100)
2. RX140 Group Smart Wakeup Solution (r11an0613jj0100)
3. RA2L1 Group Touchless Button Demo Solution (Hardware) (r01an5812ej0101)

Contents

1. Outline

This software performs standby with low power consumption by using the automatic judgment function of CTSU2SL and the multi-electrode connection (All TS Pin Output Control bit: enabled) function installed in RX140. After waking up from the low power consumption standby mode, the LED lights up according to the touch operation. Figure 1.1 shows software operation image.

- Multiple electrode connection function:

This function can measure as one electrode by connecting multiple self-capacitance electrodes inside the MCU. Since multiple electrodes can be measured at one time, measurement time can be shortened, and power consumption can be reduced. An example of use is a system that waking up from the low power consumption mode by any button, and usability can be improved by changing the conventional system that waking up only with the power button to a system that waking up with multiple buttons.

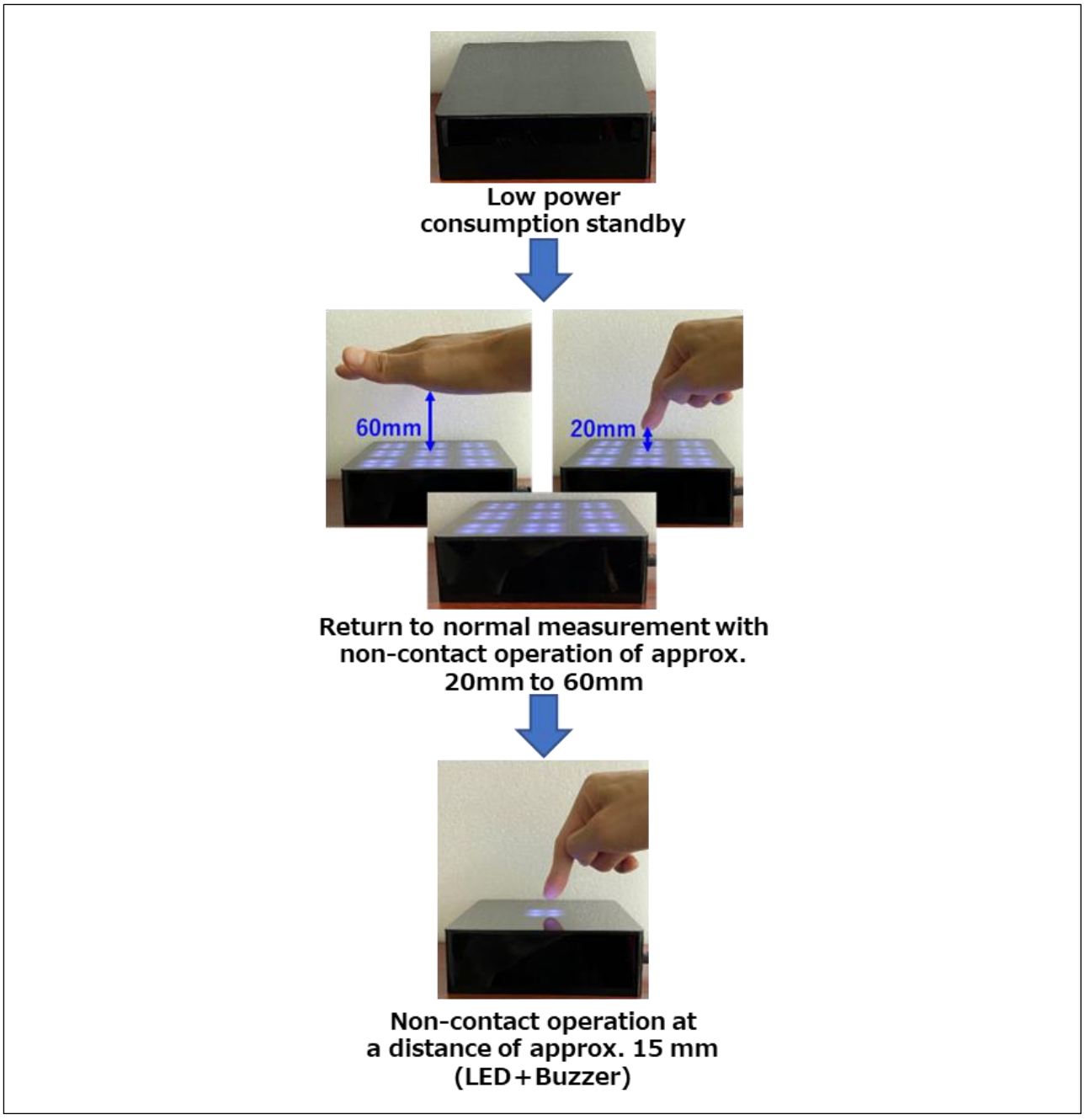


Figure 1.1 Software operation image

2. Operation Environment

Table 2.1 shows confirmed operation environment of this software.

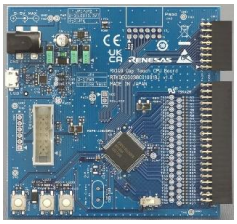
Table 2.1 Operation confirmed environment

Item	Contents
MCU	R5F51406ADFN (RX140 MCU Group)
Operating frequency	48MHz
Operating voltage	5V
Integrated development environment	e^2 Studio 2022-04
C compiler	CC-RX v3.04.00
OCD emulator	E2 emulator Lite
QE for Capacitive Touch	V3.10
CTSU QE API (r_ctsu_qe) [QE CTSU module Firmware Integration Technology]	V2.10
Touch QE API (rm_touch_qe) [QE TOUCH module Firmware Integration Technology]	V2.10

3. Regarding the Demonstration

3.1 Demonstration Configuration

This demonstration consists of the RA2L1 CPU board mounted on the touchless button demonstration (model name: RTK0EG0036D01001BJ) replaced with the RX140 CPU board (model name: RTK0EG0038C01001BJ).

RX140 Capacitive Touch Evaluation System
(RTK0EG0022S01001BJ)

Figure 3.1 CPU board

3.2 operation procedures

The demonstration is started by supplying power to the USB connector in the blue boxed area in Figure 3.2.

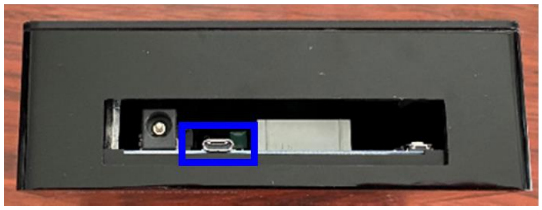



Figure 3.2 Power supply unit

4. Software Functions

The software operates as follows.

1. Low power consumption standby using automatic judgment function and multi-electrode connection function
2. Normal operation after waking up (LED lights up according to the touch operation)

4.1 Low Power Consumption Standby

Use the CTSU2SL module, the DTC module, the LPC module, the LPT module and the ELC module.

- Use the LPC to transition MCU(R5FA51406ADFN) to low power consumption mode.
- Set the measurement start trigger to the external trigger of the LPT compare match interrupt (event input from ELC), and measure CTSU2SL at 100 msec intervals during software standby mode.
- DTC is used for CTSU measurement operation in snooze mode.
- By using the automatic judgment function of CTSU2SL, if the touch ON judgment is not detected because of CTSU measurement during snooze mode, the software standby is entered again without starting the CPU.
- By using the multiple electrode connection function of CTSU2SL, 9ch can be measured at once to reduce power consumption.
- The following non-contact operation shifts the device from the low-power standby mode to the normal operation mode.
  - Finger close to one button: approx. 20 mm
  - 9 buttons palm: approx. 60 mm

Figure 4.1 shows an image of the CPU operating mode and CTSU operating status

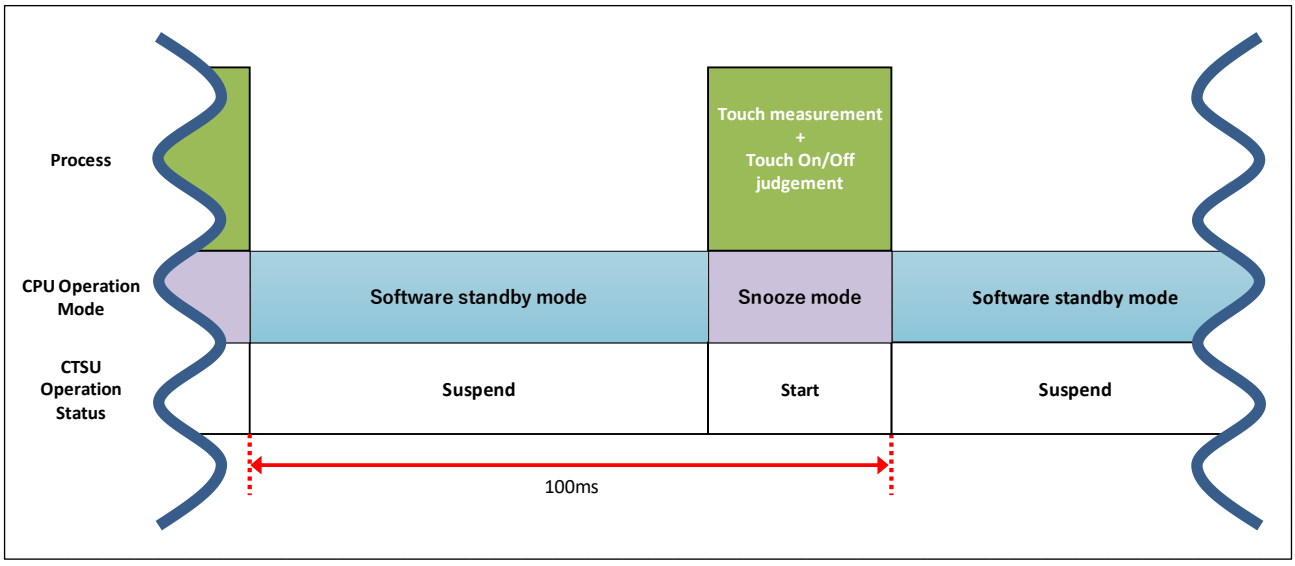


Figure 4.1 Image of CPU operating mode and CTSU operating status

4.2 Normal Operation After Waking up

The software uses the CTSU2SL module.

- LED lighting and buzzer sound are output by non-contact operation of approx. 15 mm for each button.
- The normal operation mode is shifted to the low-power-consumption standby mode after 15 seconds in the non-touch state or by recognizing two diagonal buttons simultaneously for 3 seconds as shown in Figure 4.2.

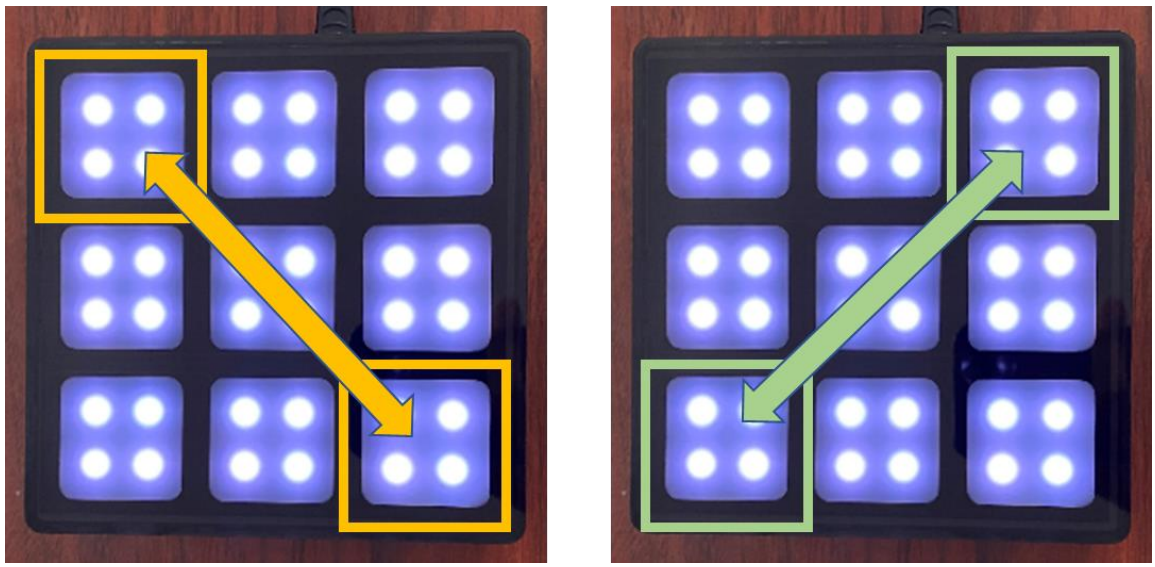


Figure 4.2 How to transition to low power consumption standby mode by operation

5. Software Specifications

5.1 Software Structure

Figure 5.1 shows the software structure diagram.

By using QE for Capacitive Touch and RX Smart Configurator, the following modules are added to create an application.

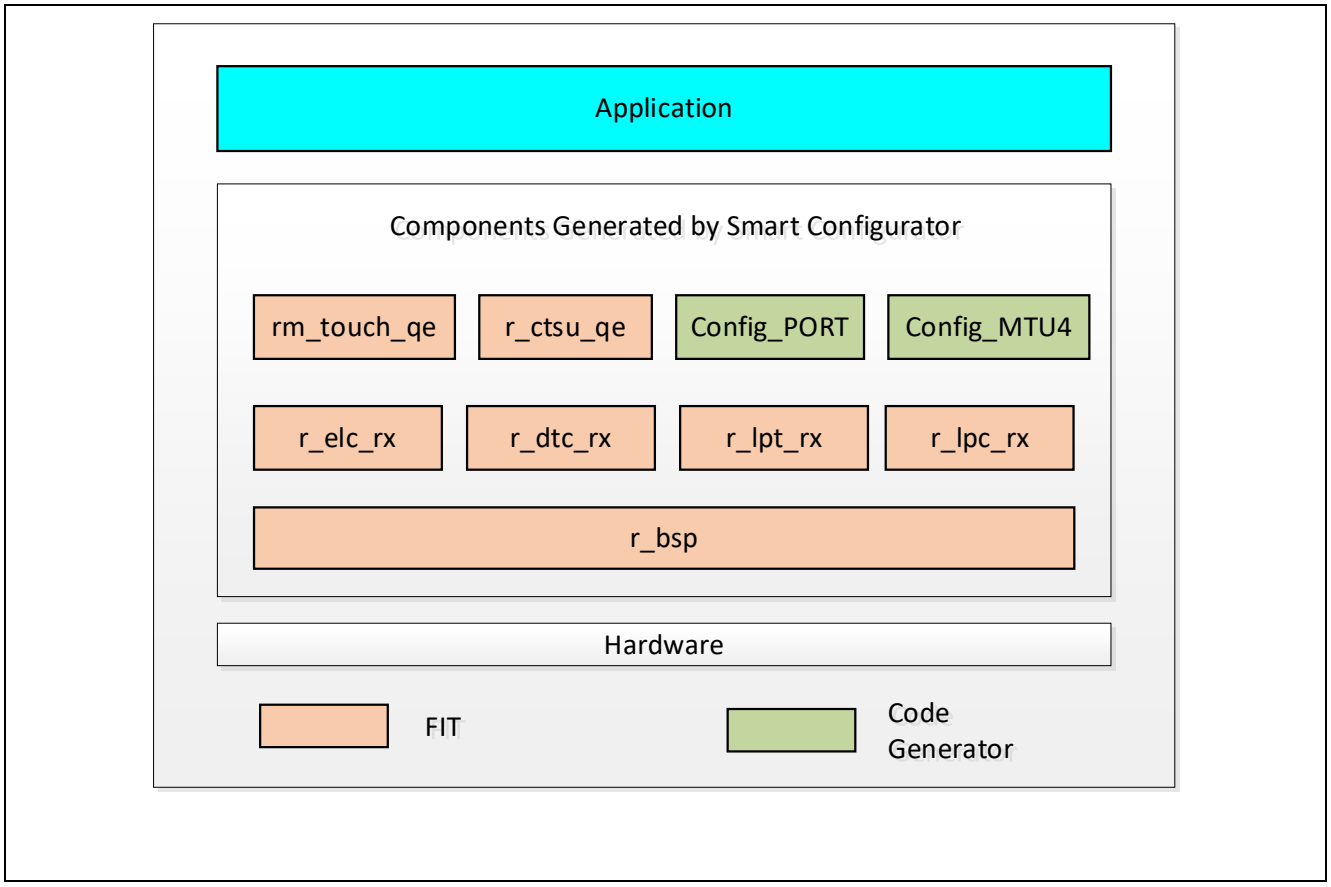


Figure 5.1 Software structure diagram

The component is shown in Table 5.1. See the Smart Configurator for component settings.

Table 5.1 Component

Component	Version
r_bsp	7.10
r_lpc_rx	2.03
r_ctsu_qe	2.10
r_dtc_rx	3.90
r_elc_rx	2.01
r_lpt_rx	3.01
rm_touch_qe	2.10
Config_PORT	2.3.0
Config_MTU4	1.11.0

5.2 File Structure

Figure 5.2 shows the source file tree. (Omit the smart configurator file.)

```
├── qe_gen
│       qe_touch_config.c ・・・・・・・・・Touch QE Configuration definition source file
│       qe_touch_config.h ・・・・・・・・・Touch QE Configuration definition header file
│       qe_touch_define.h ・・・・・・・・・Touch QE Configuration definition header file
│       qe_touch_sample.c ・・・・・・・・・Touch QE Application file
├── src
│       r_board_control.c ・・・・・・・・・Board control source file
│       r_board_control.h ・・・・・・・・・Board control header file
│       smart_wakeup_rx140_touchless.c・・Main source file
│
├── QE-Touch
      smart_wakeup_rx140_touchless.tifcfg・Configuration file
```

Figure 5.2 Source file tree

Table 5.2 shows the source files.

Table 5.2 The source files

File name	Contents
smart_wakeup_rx140_touchless.c	Main source file
r_board_control.c	Board control source file
qe_touch_config.c	Touch QE Configuration definition header file
qe_touch_sample.c	Touch QE Application file

Table 5.3 shows the header files.

Table 5.3 The header files

File name	Contents
r_board_control.h	Board control header file
qe_touch_config.h	Touch QE Configuration definition header file
qe_touch_define.h	Touch QE Configuration definition header file

6. Capacitive Touch Setting

The Capacitive touch setting of this software is shown.

6.1 Touch Interface Configuration

Figure 6.1 shows the touch interface configuration.

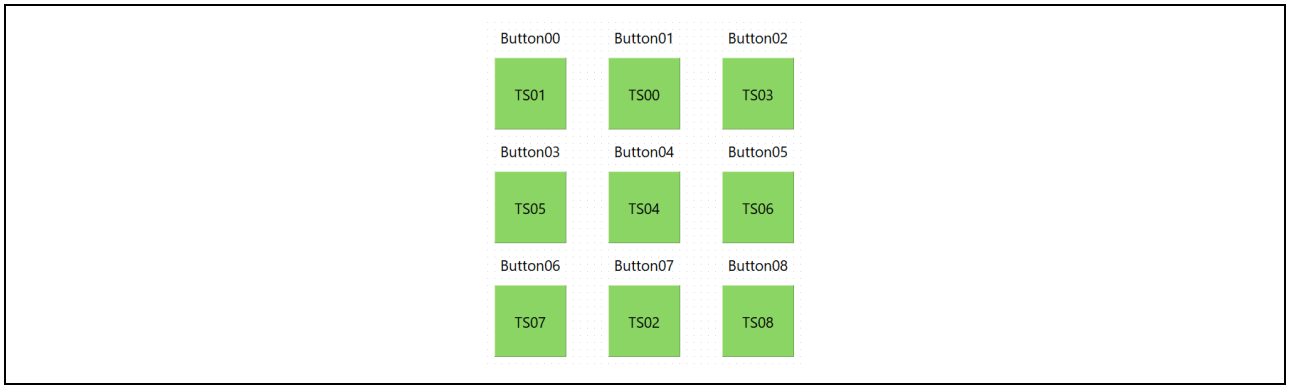


Figure 6.1 Touch interface configuration

6.2 Configuration (method) Setting

Figure 6.2 shows the touch interface settings.

Both config01 and config02 are set as all buttons. The automatic judgment function and multiple electrode connection are set to enable only for config01.

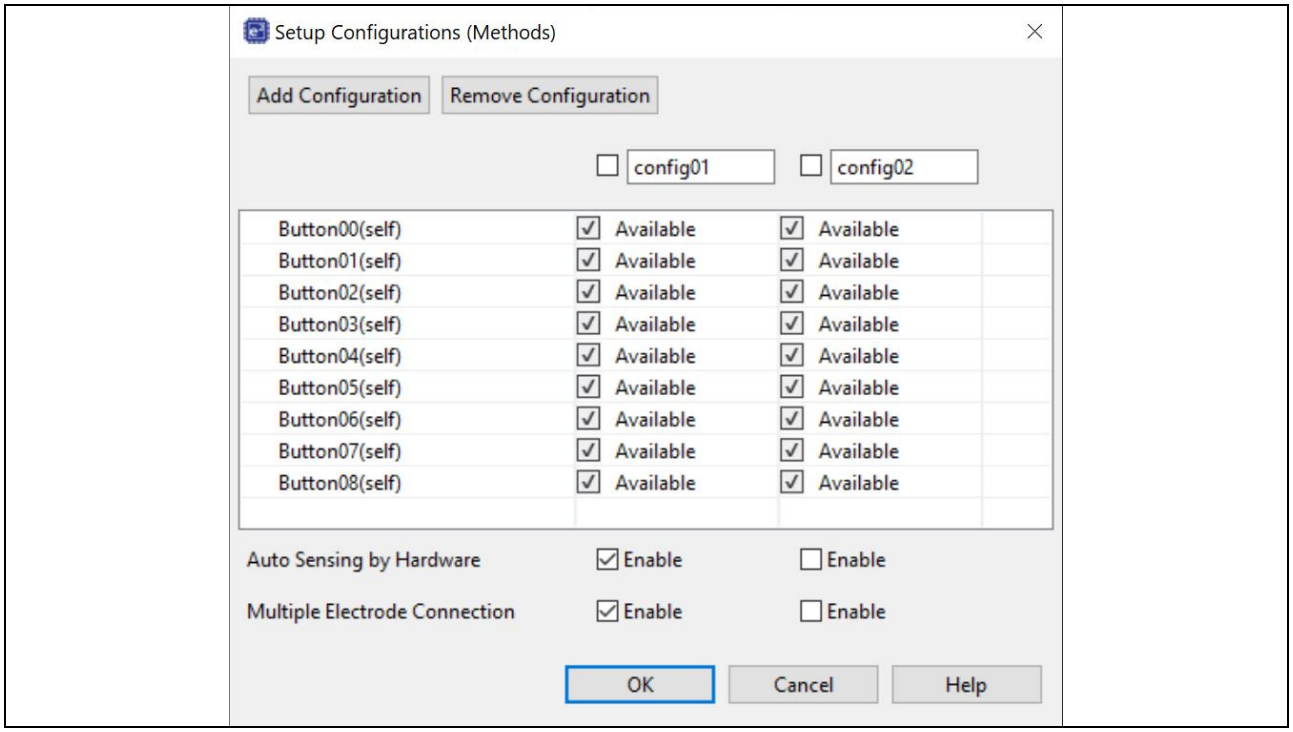


Figure 6.2 Touch Interface setting

6.3 Tuning Result

Tabel 6.1 shows the tuning result of QE. This software operates with the settings shown in Table 6.1.

Configuration	Name	Touch Sensor	Parasitic capacitance [pF]	Sensor drive pulse frequency [MHz]	Touch Threshold	Measurement time [ms]	so	snum	sdpa
config01	mec00	TS00	219.208	0.5	120	0.064	0x3BE	0x03	0x1F
config02	Button00	TS01	32.757	1	120	0.128	0x0C3	0x07	0x0F
config02	Button01	TS00	30.819	1	120	0.128	0x0B7	0x07	0x0F
config02	Button02	TS03	28.354	1	120	0.128	0x09F	0x07	0x0F
config02	Button03	TS05	32.576	1	120	0.128	0x0C7	0x07	0x0F
config02	Button04	TS04	29.708	1	120	0.128	0x0AC	0x07	0x0F
config02	Button05	TS06	29.347	1	120	0.128	0x0A7	0x07	0x0F
config02	Button06	TS07	30.965	1	120	0.128	0x0B6	0x07	0x0F
config02	Button07	TS02	27.889	1	120	0.128	0x09A	0x07	0x0F
config02	Button08	TS08	29.806	1	120	0.128	0x0AC	0x07	0x0F

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

*1: The values in the result list depend on the operating environment at the time of QE tuning, so these values may change when QE tuning is performed again.

*2: The value of the yellow marker part was changed manually.

*3: Manually changed a part of the setting of "g_qe_ctsu_cfg_config01" in "qe_touch_config.c".

tlot = 2 → 1 / thot = 2 → 1 / ajbmat = 7 → 4

7. Power Consumption Measurement

7.1 Operating Conditions of Low Power Consumption Standby

Table 7.1 shows the operation condition of low power consumption standby.

Table 7.1 Operating conditions of low power consumption standby

Item	Description
Operating frequency	24MHz High-speed on-chip oscillator（HOCO） 32KHz Low-speed on-chip oscillator（LOCO）
System clock (ICLK)	6MHz
Peripheral module clock B（PCLKB）	6MHz
Peripheral module clock D（PCLKD）	6MHz
Capacitive Touch measurement cycle	100ms
Sensor drive pulse frequency	0.5MHz
CTSU Measurement Mode	Self-capacitance method (MD1 = 1)
CTSU Scan Mode	Multi-scan mode (MD0 = 0)
CTSU Measurement Operation Start Trigger Select	External trigger (CAP = 1)
CTSU Wait State Power-Saving Enable	Enable power-saving function during wait state (SNZ = 1)
CTSU Power Supply Operating Mode	Normal voltage operating mode (ATUNE0 = 0)
CTSU Current Range Adjustment	40µA (ATUNE1 = 1, ATUNE2 = 0)
CTSU Non-measurement Channel Output Select (POSEL)	GPIO LOW Output (POSEL = 0)
CTSU Sensor Drive Pulse Select (SDPSEL)	High resolution pulse mode (SDPSEL =1)
CTSU Sensor Stabilization Wait Time Setting (SST)	64µs (Recommended value) (SST = 0x1F)
CTSU Multi-Clock	3 frequencies (MCA0, MCA1, MCA2: Available)
CTSU Measurement Count	64µs (SNUM= 3)

7.2 Current Consumption Measurement

For information on how to measure and calculate current consumption, refer to "6. Current Consumption Measurement" in "RX140 Group Smart Wakeup Solution (r11an0613ej0100)".

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Jul.29.22	-	First edition issued

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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.
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   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.
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   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.).
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(Rev.5.0-1 October 2020)

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