RA4L1 Group

Smart Wakeup Solution

Introduction

This application note explains the software that operates with low power consumption on the RA4L1 Capacitive Touch Evaluation System.

Target Device

RA4L1 (R7FA4L1BD4CFP)

Related Documents

1. RA4L1 Group Capacitive Touch Evaluation System User's Manual (R12UZ0162EJ0110)

Contents

1. Outline

This application note describes the automatic judgment function and the multi-electrode connection function of CTSU2SLa in RA4L1 for providing low-power touch operation.

This software has two modes: "standby mode" and "active mode". In standby mode, touch detection with any button is performed, and then the mode transitions to active mode. When the non-touch state continues in active mode, the mode transitions to standby. The system loops through this behavior.

In this application note, this system is referred to as the "Smart Wakeup Solution."

2. Operation Environment

Table 2.1 shows the confirmed operation environment of this software.

Table 2.1 Confirmed operation environment

Item	Contents
MCU (parts common with e2 studio projects)	RA4L1 capacitive touch evaluation system (RTK0EG0057S01001BJ) • RA4L1 CPU board (RTK0EG0056C01001BJ) • Application board for capacitive touch evaluation − Self-Capacitance Buttons / Wheels / Slider Board (RTK0EG0019B01002BJ v1.1b)
MCU	R7FA4L1BD4CFP (RA4L1 MCU Group)
Operating frequency	24MHz
Operating voltage	5V
Integrated development environment	e^2 Studio 2025-04
C compiler	GCC 13.2.1.arm-12-24
OCD emulator	E2 emulator Lite
QE for Capacitive Touch	V4.1.0

3. Software Functions

The smart wakeup solution is designed to optimize the return from low-power status to active mode. This design uses input to touch sensors as triggers to transition to the active operating status. It minimizes standby power consumption while providing quick response when needed.

Figure 3.1 shows the software operation image.

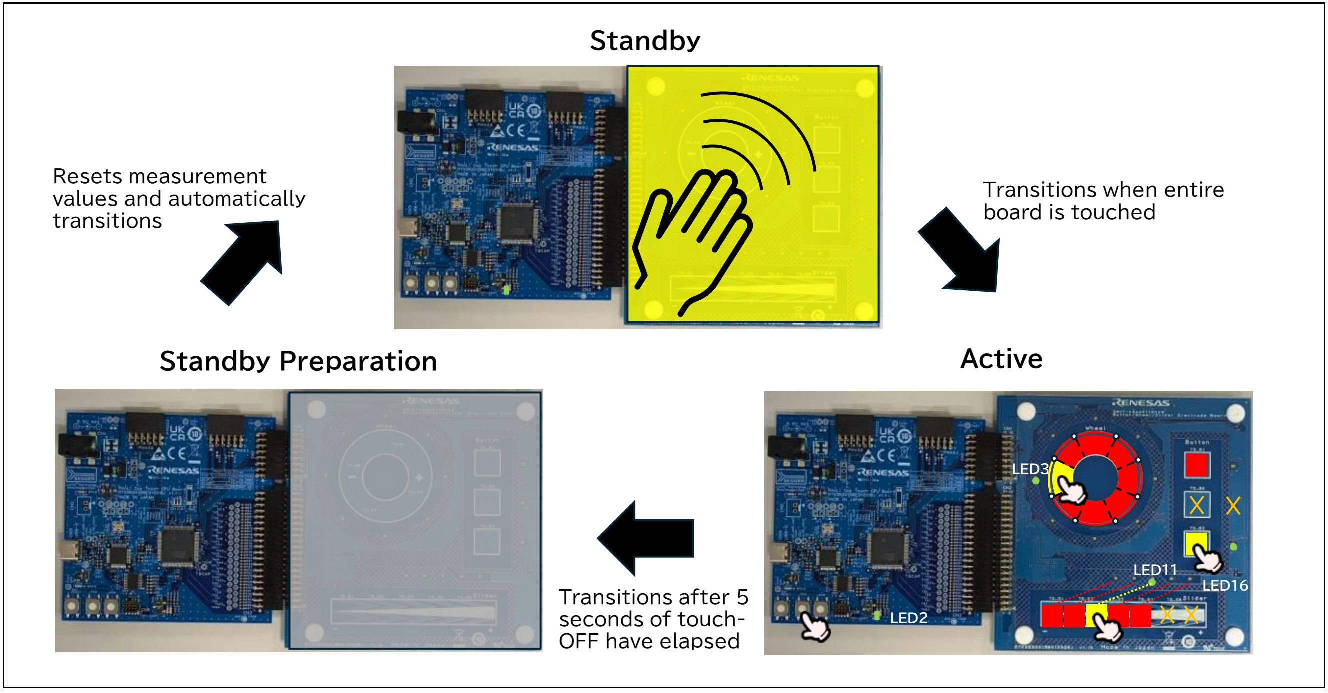

Figure 3.1 Software operation image

*Electrodes labeled with X are not operable as they are not assigned to a TS pin on RA4L1.

Refer to the following sections for details regarding each state:

- 5.7 Standby preparation
- 5.8 Standby
- 5.9 Active

4. Capacitive Touch Settings

The software's touch interface configuration, configuration (method) settings, and tuning results using the QE tuning function are provided in this section.

4.1 Touch Interface Configuration

Figure 4.1 shows the touch interface configuration.

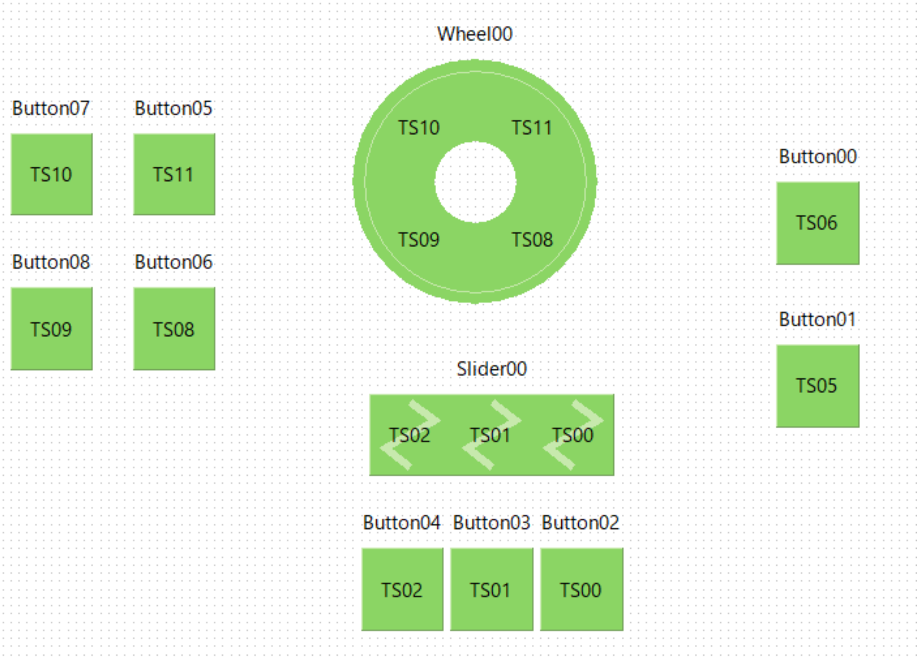

Figure 4.1 Touch interface configuration

4.2 Configuration (method) Settings

Figure 4.2 shows the touch interface settings. Each setting is described in detail below.

mec setting: This sets all buttons and is used during standby mode measurement (see Figure 3.1). This enables the automatic judgment function for measurements in standby mode, and the multi-electrode connection function for measurements in low-power mode.

bsw setting: This sets two buttons, a slider and a wheel, and is used during active mode measurement (see Figure 3.1). After automatic touch judgment, it sets the touch interface configuration assuming use of slider and wheel.

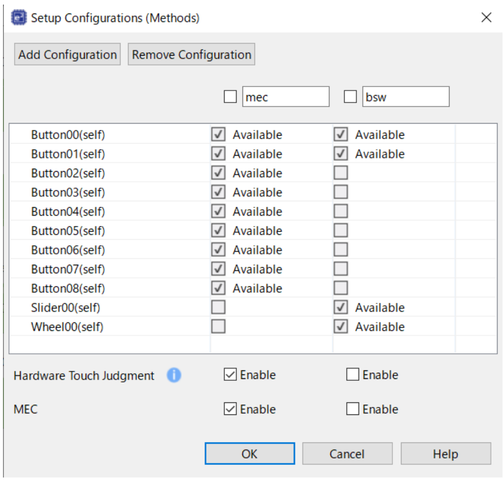

Figure 4.2 Configuration (method) settings

5. Software Specification

5.1 Software Structure

The following modules are added to create an application by using QE for Capacitive Touch and FSP. The software structure diagram is shown below.

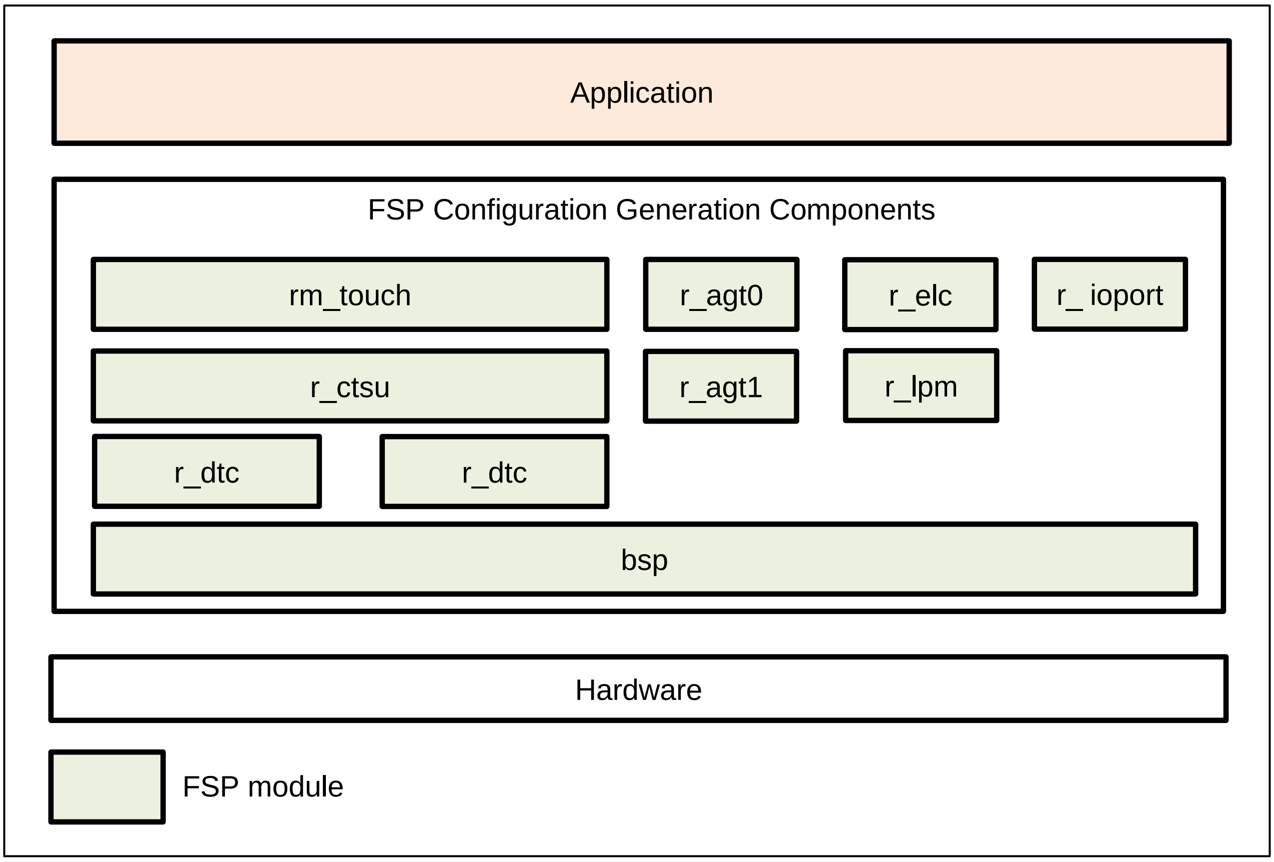

Figure 5.1 Software structure diagram

Table 5.1 shows the list of components. Refer to the Smart Configurator for component settings.

Table 5.1 Component list

Selected software components

Board Support Package Common Files	v5.9.0
Asynchronous General Purpose Timer	v5.9.0
Capacitive Touch Sensing Unit	v5.9.0
Data Transfer Controller	v5.9.0
Event Link Controller	v5.9.0
I/O Port	v5.9.0
Low Power Modes	v5.9.0
Touch	v5.9.0
Arm CMSIS Version 6 - Core (M)	v6.1.0+fsp.5.9.0
RSSK-RA4L1 Board Support Files	v5.9.0
Board support package for R7FA4L1BD4CFP	v5.9.0
Board support package for RA4L1	v5.9.0
Board support package for RA4L1 - FSP Data	v5.9.0
Board support package for RA4L1 - Events	v5.9.0

5.2 File Structure

Figure 5.2 shows the source file tree. Note that Smart Configurator files have been omitted for brevity.

```
├── 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
|      hal_entry.c    ・・・・・・・・・main file
|      r_board_control.c ・・・・・・・Board control source file
|      r_board_control.h ・・・・・・・Board control header file
|      r_rssk_touch_led.c・・・・・・・Touch electrode LED processing source
|      r_rssk_touch_led.h・・・・・・・Touch electrode LED processing header
├── QE-Touch
       smart_wakeup_ra4l1_rssk.tifcfg・・・Touch I/F structure file
       smart_wakeup_ra4l1_rssk_log_tuning20250416210442.log・・・QE tuning log
```

Figure 5.2 Source file tree

Table 5.2 shows the list of source files.

Table 5.2 Source files

File name	Contents
hal_entry.c	Main source file
r_board_control.c	Board control source file
qe_touch_config.c	Touch QE configuration definition source file
qe_touch_sample.c	Touch QE application file

Table 5.3 shows the list of header files.

Table 5.3 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
r_board_control.h	Board control header file
r_rssk_touch_led.h	Touch electrode LED processing header

5.3 List of Constants

Table 5.4 shows the list of constants.

Table 5.4 List of constants

Constant name	Setting value	Description
File name: qe_touch_sample.c		
BASELINE_SET_TIME	(33)	Specifies the baseline setting time (1msec) required for automatic judgment in Hz
SOFTWARE_MODE_TIME	(3326)	Specifies the AGT underflow value (100msec) during standby mode in Hz
NORMAL_MODE_TIME	(655)	Specifies the AGT underflow value (20msec) during active mode in Hz
AJINTC_BIT_INDEX	(9U)	AJINTC bit of CTSUOP
LED_ROW0	BSP_IO_PORT_05_PIN_13	COL0 control port definition
LED_ROW1	BSP_IO_PORT_00_PIN_04	COL1 control port definition
LED_ROW2	BSP_IO_PORT_00_PIN_03	COL2 control port definition
LED_ROW3	BSP_IO_PORT_00_PIN_02	COL3 control port definition
LED_COL0	BSP_IO_PORT_04_PIN_08	ROW0 control port definition
LED_COL1	BSP_IO_PORT_04_PIN_07	ROW1 control port definition
LED_COL2	BSP_IO_PORT_04_PIN_10	ROW2 control port definition
LED_COL3	BSP_IO_PORT_04_PIN_09	ROW3 control port definition
BUTTON_OFF_STATE	(0x0000)	Value when button is in non-touch state
SLIDER_OFF_STATE	(0xFFFF)	Value when slider is in non-touch state
WHEEL_OFF_STATE	(0xFFFF)	Value when wheel is in non-touch state
TOUCH_OFF_PERIOD	(250U)	Non-touch judgment count (20ms * 250 = 5sec)
WAKEUP_TIME_BASELINE	(32)	Number of measurements for standby preparation
File name: r_rssk_touch_led.c		
LED_COL0	(BSP_IO_PORT_05_PIN_13)	COL0 control port definition
LED_COL1	(BSP_IO_PORT_00_PIN_04)	COL1 control port definition
LED_COL2	(BSP_IO_PORT_00_PIN_03)	COL2 control port definition
LED_COL3	(BSP_IO_PORT_00_PIN_02)	COL3 control port definition
LED_ROW0	(BSP_IO_PORT_04_PIN_08)	ROW0 control port definition
LED_ROW1	(BSP_IO_PORT_04_PIN_07)	ROW1 control port definition
LED_ROW2	(BSP_IO_PORT_04_PIN_10)	ROW2 control port definition
LED_ROW3	(BSP_IO_PORT_04_PIN_09)	ROW3 control port definition

LED_COL_MAX	(4)	Number of COL signals
LED_ROW_MAX	(4)	Number of ROW signals
LED_COL_OFF	(BSP_IO_LEVEL_LOW)	COL signal OFF
LED_COL_ON	(BSP_IO_LEVEL_HIGH)	COL signal ON
LED_ROW_OFF	(BSP_IO_LEVEL_HIGH)	ROW signal OFF
LED_ROW_ON	(BSP_IO_LEVEL_LOW)	ROW signal ON
SLIDER_LED_NUM	(5U)	Number of slider LEDs
SLIDER_RESOLUTION	(100)	Slider touch result: maximum value
WHEEL_LED_NUM	(8U)	Number of wheel LEDs
WHEEL_LED_MSB	(1U << (WHEEL_LED_NUM - 1))	Wheel control bit MSB
WHEEL_RESOLUTION_DEGREE	(360)	Wheel touch result: maximum value (in degrees)
WHEEL_POSITION_OFFSET_DEGREE	(112)	Wheel touch position: offset (in degrees)
ALL_LED_NUM	(16U)	Number of touch board LEDs
LED_TEST_INTERVAL	(100U)	LED lighting interval time
DUMMY_BUTTON02	(2)	Dummy judgment button for LED 15 lighting
File name: r_board_control.c		
LED1	BSP_IO_PORT_06_PIN_01	CPU LED2 control port definition

5.4 List of Functions

Table 5.5 shows the list of functions.

Table 5.5 List of functions

Function name	Processing outline
File name: qe_touch_sample.c	
qe_touch_main	Main function
init_peripheral_function	Initialization of peripheral functions
agt_led_control_callback	LED control callback function
r_rssk_touch_led_control	LED control function
File name: r_rssk_touch_led.c	
r_rssk_touch_led_test	Touch board LED test processing
r_rssk_touch_led_control	Touch board LED control processing
File name: r_board_control.c	
r_rssk_touch_led_control	Touch board LED control processing

5.5 Overall Processing

Figure 5.3 provides the overall processing flowchart.

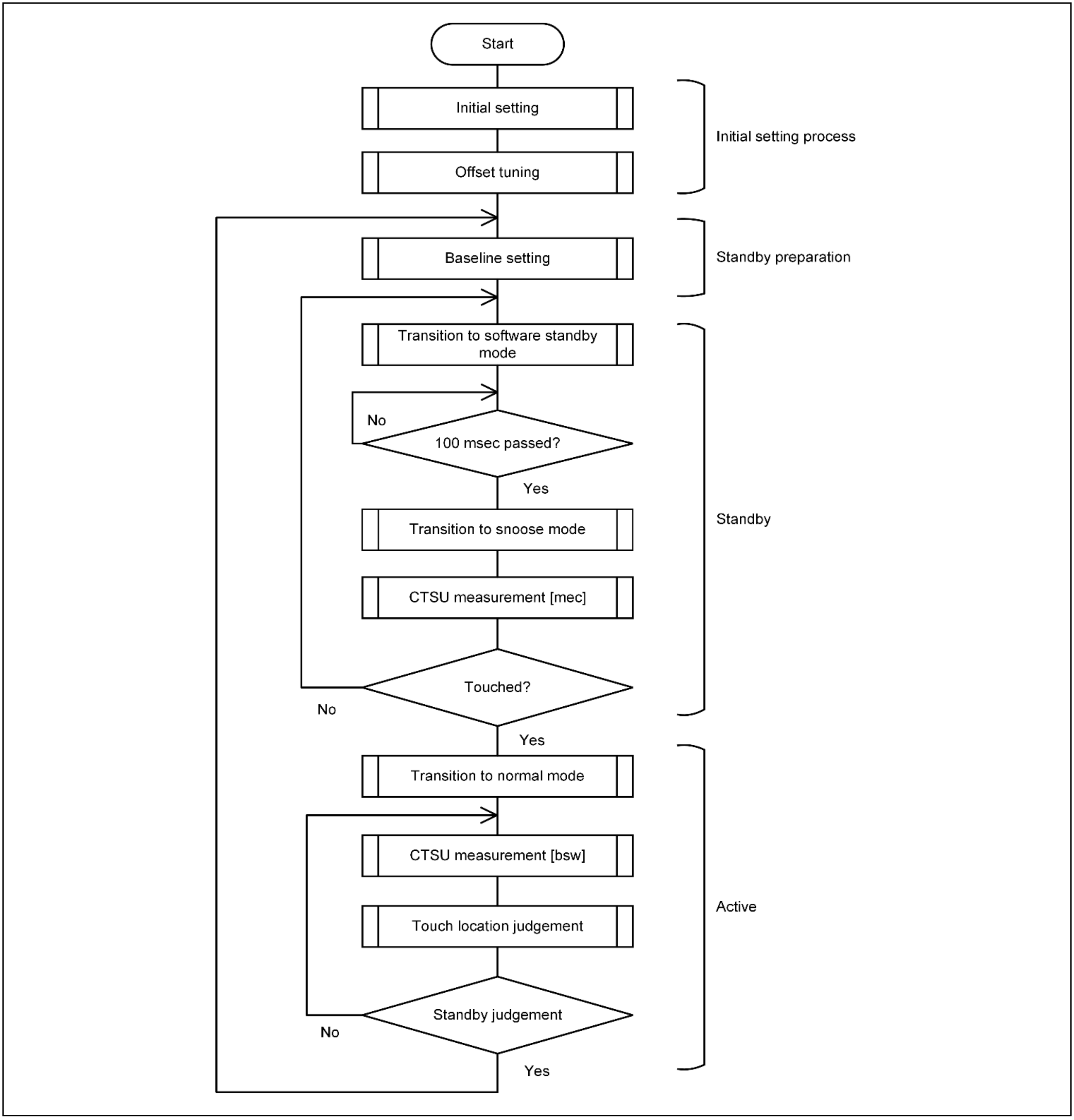

Figure 5.3 Overall processing flowchart

LEDs are controlled with interrupt functions. For details, see 5.9 Active.

The following shows the transitioning flow from standby mode to active mode, and then back to standby mode. This flow is explained based on the operation explanation in Figure 3.1, focusing on the states of the two configurations (mec and bsw).

State	Standby Preparation	Reset the measurement value and transition automatically	Standby	Transition when entire board is touched	Active	Transitions after 5 seconds of touch-off have elapsed	Standby Preparation	Start Standby	Standby	…
mec	Measurement in progress	Number of baseline average measurements completed	Measurement in progress	Touch ON	Measurement stop	Measurement stop	Measurement in progress	Number of baseline average measurements completed	Measurement in progress	…
bsw	Measurement stop	Measurement stop	Measurement stop	Measurement stop	Measurement in progress	Touch OFF for 5 seconds	Measurement stop	Measurement stop	Measurement stop	…

Figure 5.4 State transition image

Refer to the following sections for details regarding each state:

- 5.7 Standby preparation
- 5.8 Standby
- 5.9 Active

The smart wake-up solution loops between standby and active modes. If the parasitic capacitance changes significantly during each mode due to environmental changes, the baseline update process cannot function properly in a touch interface configuration that is not in operation. As a result, the touch threshold may be exceeded without touch, leading to incorrect or failed touch judgment. In such cases, a system reset will be required, so caution should be taken when using the device in environments that experience significant changes.

5.6 Initial Setting Processing

Figure 5.5 shows the initial setting processing flowchart.

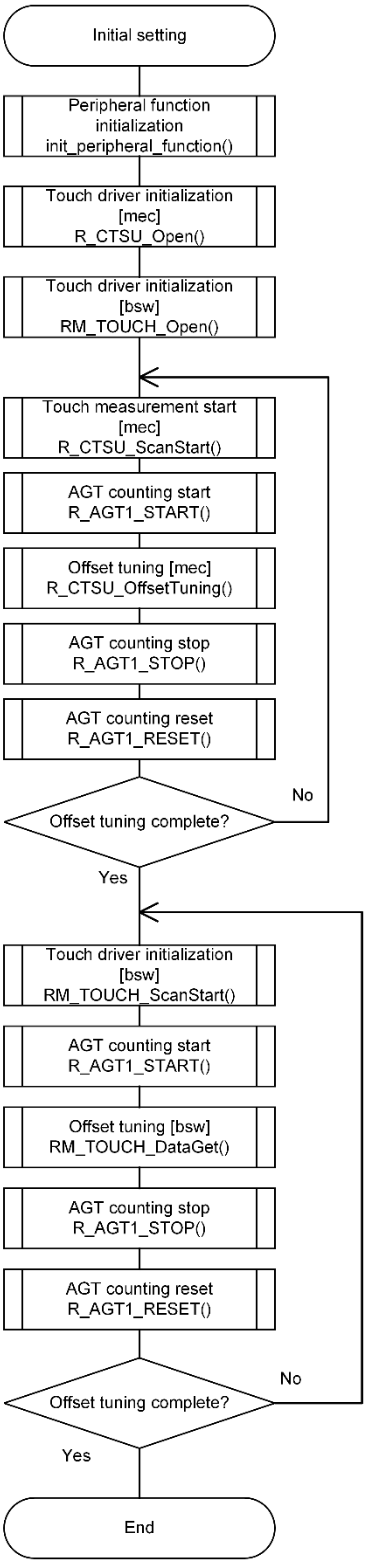

Figure 5.5 Initial setting processing flowchart

5.7 Standby preparation

This state prevents false touch judgment when transitioning from active mode to standby mode.

In order to transition to standby mode in a non-touch state, measurements are conducted for the number of baseline averages in standby mode. If all measurements are non-touch, the system transitions to standby mode. For details regarding standby mode, refer to section 5.7.

The following chart shows the standby preparation process flow.

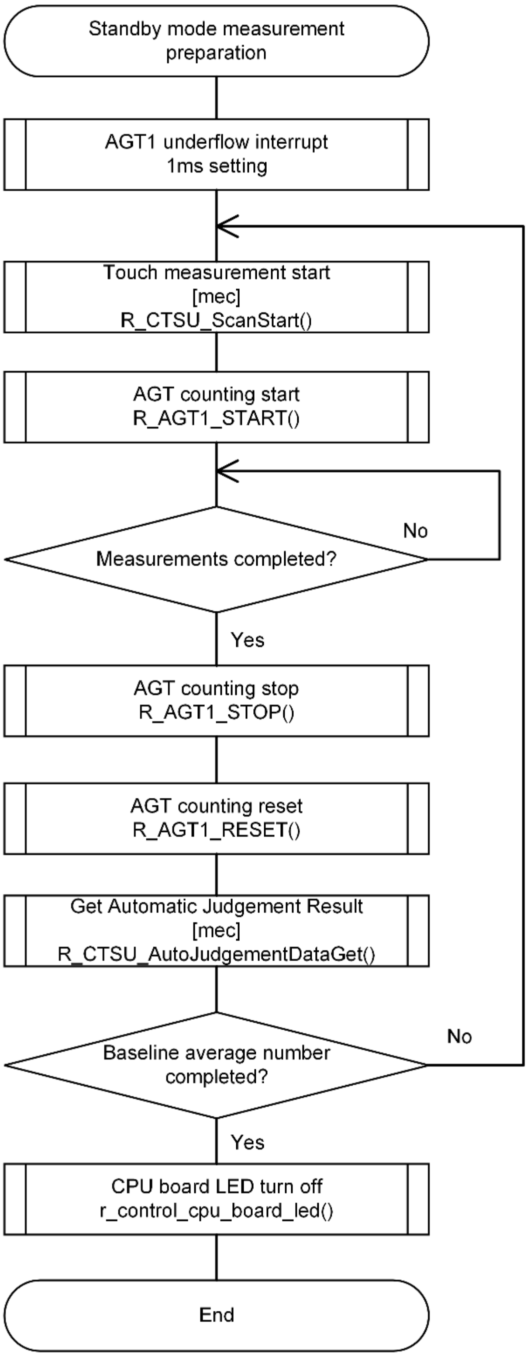

Figure 5.6 Standby preparation flowchart

5.7.1 Number of baseline averages

The number of baseline averages is determined using the following formula.

Number of baseline averages = 2^ (ajbmat+1)

For this explanation, the setting value for ajbmat is 4, so the number of baseline averages is 32.

5.7.2 Role of baseline setting

In this application, the baseline is set in the standby preparation processing before the auto touch judgement is performed.

This transition can be expressed in measured values as follows.

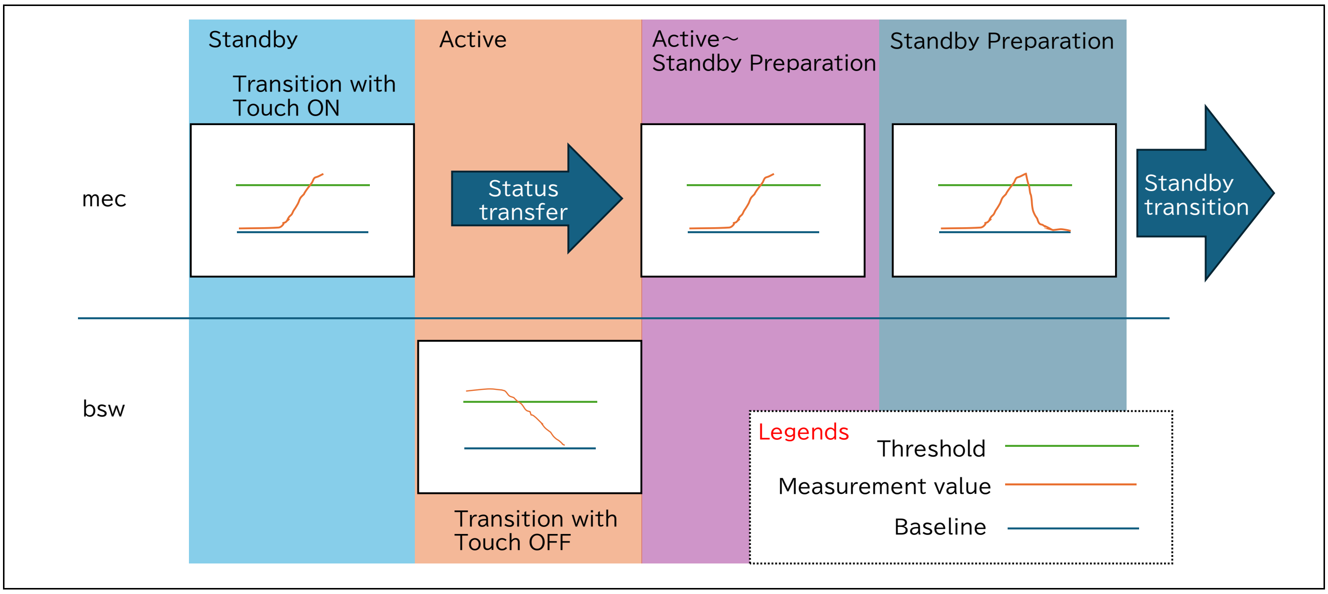

Figure 5.7 Measurement value transition image

This setting has the following role:

・Idle running process to prevent touch judgment malfunction

In this process, the measurement is repeated until the touch judgment of the MEC is turned off, and the measurement of the number of baseline acquisitions is completed in the standby preparation status.

Based on the driver specifications, baseline updates must be performed in the active state before transitioning to the first standby. This process also serves as a baseline update.

5.8 Standby

The CPU is set to a low-power mode and touch measurement is performed using the automatic judgment function and the multiple electrode connection function. By using the multiple electrode connection (MEC) function, 9 channels can be measured at one time to reduce power consumption.

The following shows an image of CPU operating mode and CTSU operating status

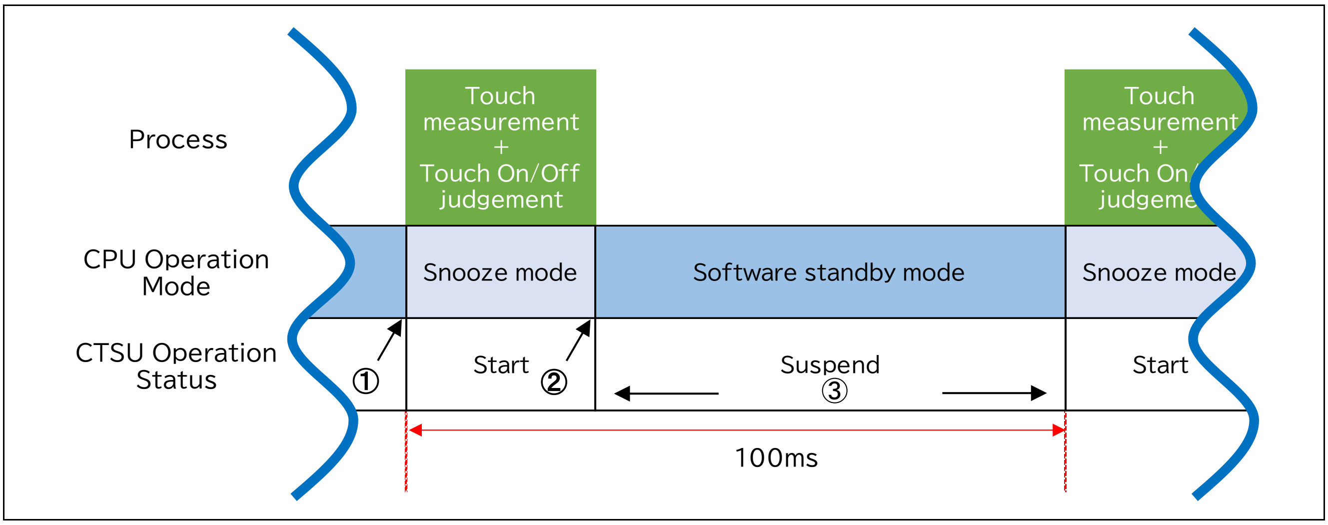

Figure 5.8 Image of CPU operating mode and CTSU operating status

The above figure shows the flow in which the AGT underflow interrupt is set as an LPM snooze request, and the CTSU starts the measurement after receiving the snooze entry. The numbers indicated within the figure are described below.

① CPU transitions to snooze mode upon detecting an external trigger.

② CTSU measurement in snooze mode is judged based on touch detected an automatic judgment function using DTC. If the touch-on decision is not detected, the system transitions to software standby again. When the touch-on judgment is detected, the system transitions from standby mode to active mode.

③ Use LPM to transition the CPU to software standby mode. CTSU will be suspended.

The following figure shows the standby flowchart.

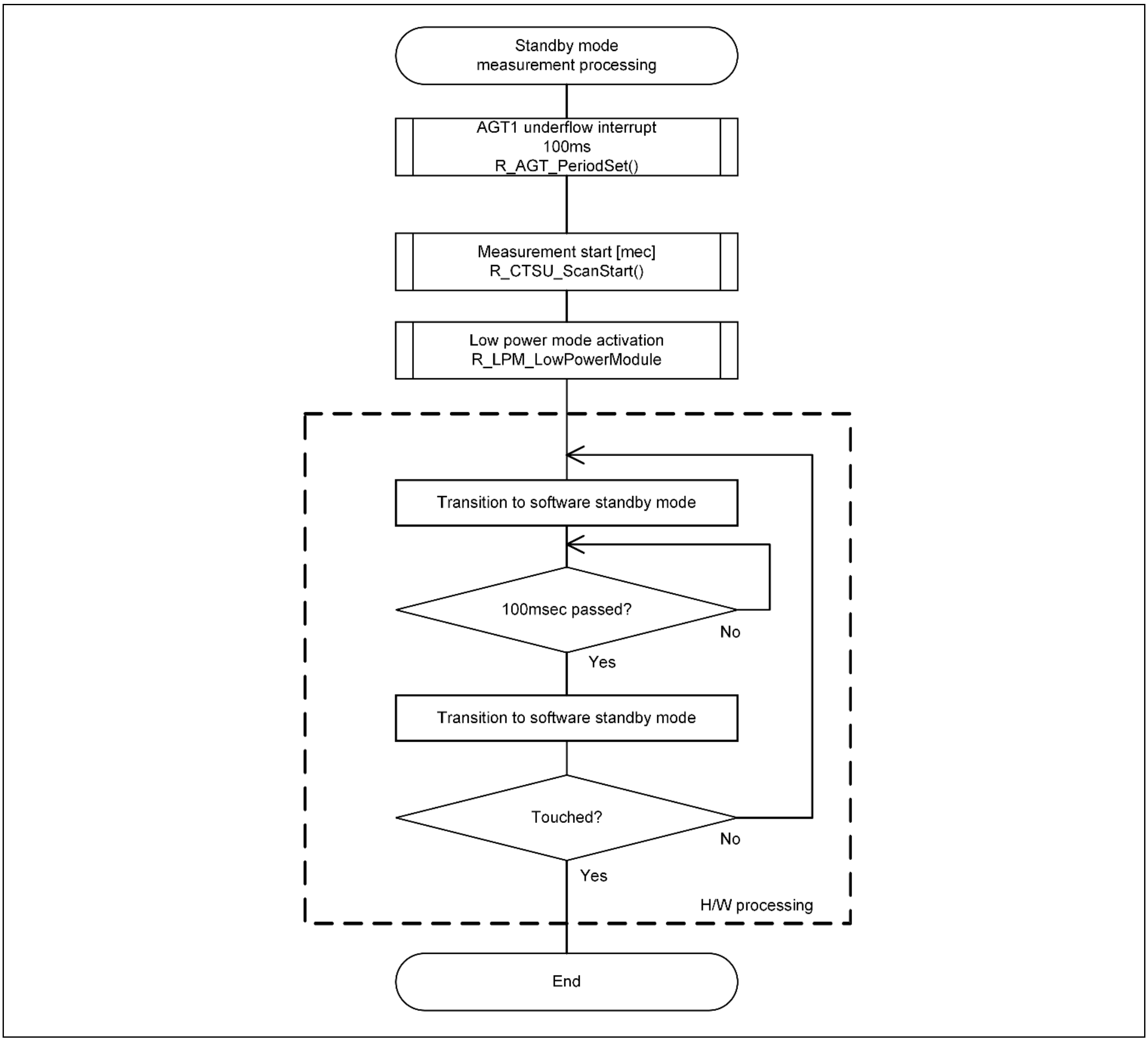

Figure 5.9 Standby flowchart

5.8.1 Transition to software standby mode

The LPM module API function R_LPM_LowPowerModeEnter is executed to transition to software standby mode.

5.8.2 Transition to snooze mode

An external trigger (an AGT underflow interrupt) is used to transition from software standby mode to snooze mode.

5.8.3 Branch out from snooze mode

CTSU measurement in snooze mode uses the automatic judgment function and MEC.

Non-touch judgment: system transitions to software standby mode

Touch judgment: system transitions to active mode

5.9 Active

This mode operates the 2 buttons, 3 slider electrodes, and wheel on the touch board.

- When the touch board is touched, the corresponding LEDs lights up. When no touch is detected, the LEDs remain off. See Figure 3.1 for details on which LEDs respond to touch.
- When 5 seconds elapse in the non-touch state, the system transitions from active mode to standby mode.

The following is the flowchart for the active mode measurements.

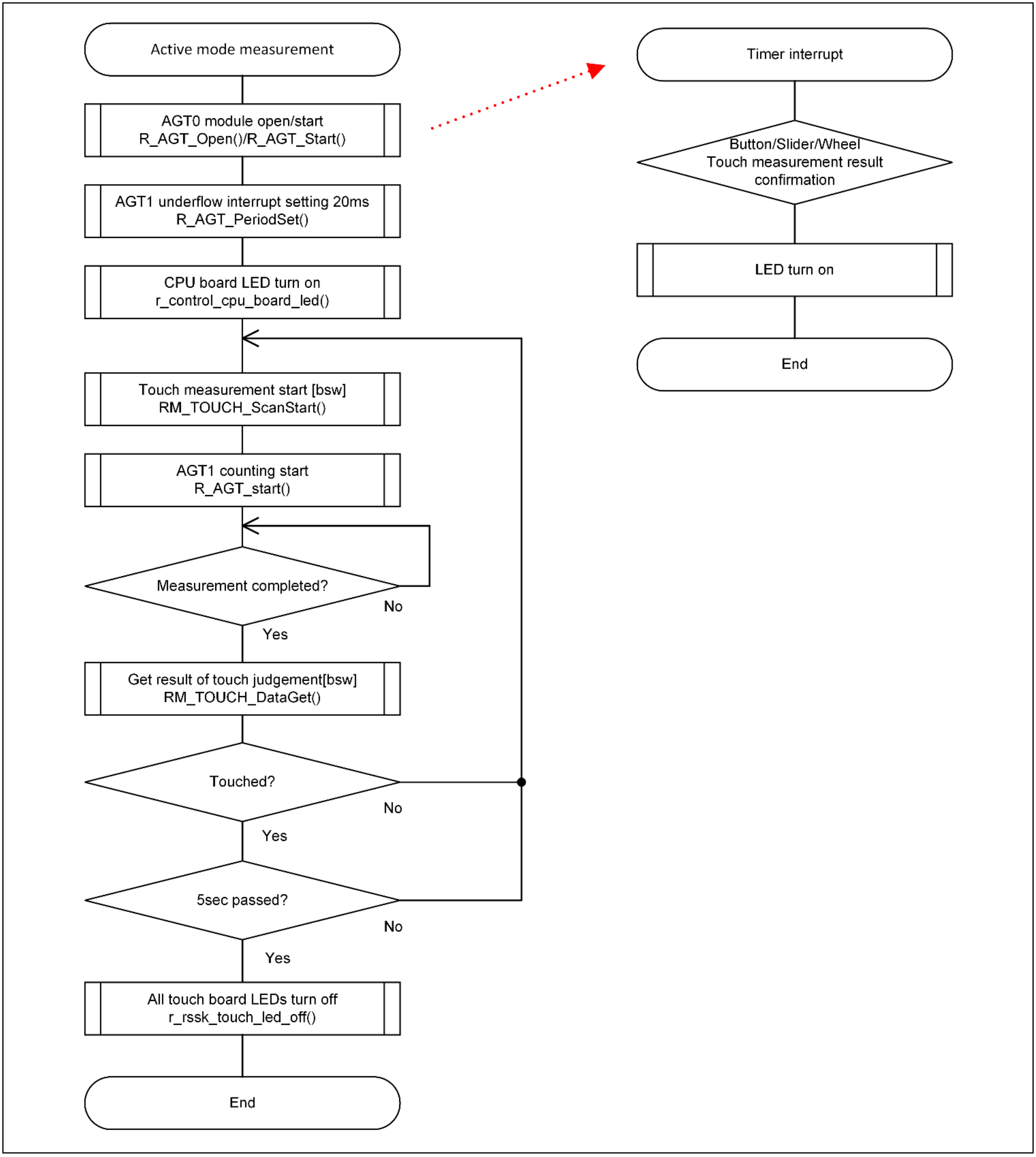

Figure 5.10 Active mode measurement processing flowchart

5.9.1 Active to standby preparation

CTSU measurement is performed in active, and if there is standby judgment, the system transitions to standby mode.

・The CTSU measurement uses an AGT timer cycle of 20msec and bsw for the pin configuration

・Standby judgment occurs when the following operating condition is met, triggering a transition to standby mode.

For non-touch: 5 seconds elapse in non-touch state

5.9.2 Active operations

Active mode performs the following operations.

1. Perform CTSU measurement with bsw to measure buttons/slider/wheel touch.
2. Corresponding LED turns on while position is touched (button/slider/wheel).
   *For details on which LED corresponds to each electrode, see Figure 5.11.
3. LED2 of the CPU turns on.

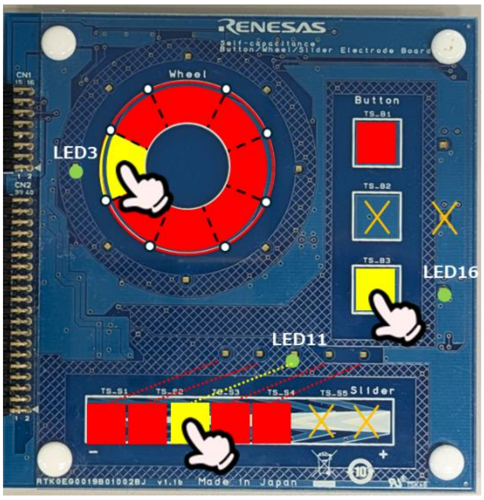

Figure 5.11 Example operating range of touch button electrode

6. Tuning Results

The following table lists the QE tuning results, with the software operating under the settings shown in the list.

This software changes the “snum” of mec to 0x03 in the advanced settings during QE tuning.

Table 6.1 Tuning results

Configuration	Name	Touch sensor	Parasitic capacitance [pF]	Sensor drive pulse frequency [MHz]	Touch threshold	Measurement time [ms]	so	snum	sdpa
mec	mec00	TS00	163.743	0.5	92;79;104	0.064	0x2D3	0x03	0x1F
bsw	Button00	TS12	20.632	2	1062	0.128	0x11C	0x07	0x07
bsw	Button01	TS11	19.09	2	1036	0.128	0x12C	0x07	0x07
bsw	Slider00	TS03	18.09	2	720	0.128	0x0F6	0x07	0x07
bsw	Slider00	TS01	19.174	2	720	0.128	0x11A	0x07	0x07
bsw	Slider00	TS04	21.757	2	720	0.128	0x13A	0x07	0x07
bsw	Wheel00	TS33	29.938	1	402	0.128	0x09F	0x07	0x0F
bsw	Wheel00	TS35	28.917	1	402	0.128	0x079	0x07	0x0F
bsw	Wheel00	TS27	24.146	1	402	0.128	0x081	0x07	0x0F
bsw	Wheel00	TS30	22.889	1	402	0.128	0x09C	0x07	0x0F

so : Variables for sensor offset setting
snum : Variables for measurement period setting
sdpa : Variables for clock frequency setting

Note 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.

Note 2: To reduce power consumption, a part of the " g_qe_ctsu_cfg_mec " setting in "qe_touch_config.c" was changed manually, as follows.

tlot (Non-touch criteria) = 2 → 1

thot (Touch criteria) = 2 → 1

ajbmat (Number of baseline averages) = 7 → 4

7. Power Consumption Measurement

7.1 Standby Mode Operating Conditions

Table 7.1 shows the operating conditions for standby mode.

Table 7.1 Standby mode operating conditions

Item	Description
CPU operating frequency	24MHz High-speed on-chip oscillator (HOCO) 3.2768KHz Low-speed on-chip oscillator (LOCO)
System clock (ICLK)	6 MHz
Peripheral module clock A (PCLKA)	6 MHz
Peripheral module clock B (PCLKB)	6 MHz
Peripheral module clock C (PCLKC)	6 MHz
Peripheral module clock D (PCLKD)	6 MHz
FlashIF clock (FCLK)	6 MHz
Touch measurement cycle	100ms
Sensor drive pulse frequency	0.5MHz
CTSU Measurement Mode	Self-capacitance method (MD1 = 0)
CTSU Scan Mode	Multi-scan mode (MD0 = 1)
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 (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 Control	3 frequencies (MCA0, MCA1, MCA2: available)
CTSU Measurement Count	64µs (SNUM= 3)

7.2 Current Measuring Equipment and Software

Table 7.2 shows the measuring equipment and software used in current consumption measurement.

Table 7.2 Current measuring equipment and software

Type	Name	Use
Digital multi meter	KEITHLEY/DMM7510	Measure current consumption
Power supply	KENWOOD/PA18-1.2A	Supply power to RA4L1 CPU board
Software	KEITHLEY/KickStar Software	Get result of current consumption measurement from Keithley DM7510 and output the result to log-file.

7.3 RA4L1 CPU Board

The following figure shows the front of the RA4L1 CPU board.

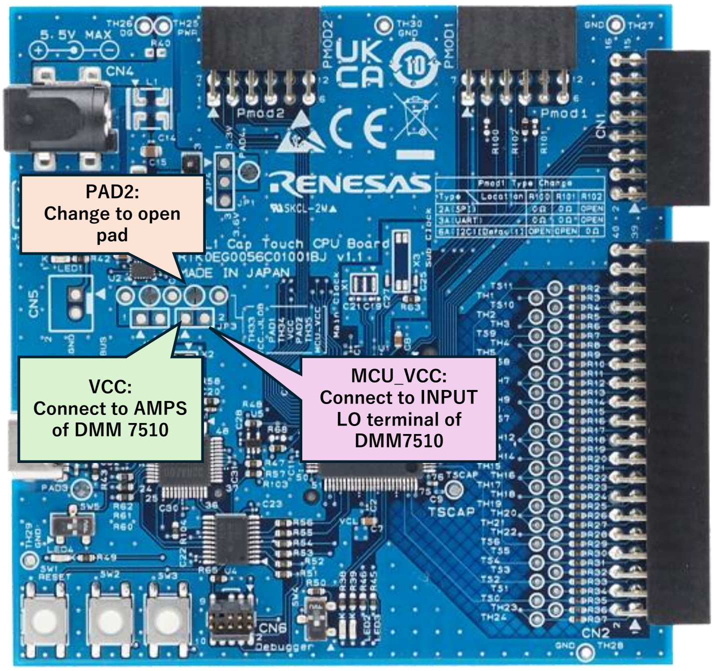

Figure 7.1 RA4L1 CPU board (front side)

Cut the bridge pattern between the pads for the default short PAD3. The following figure shows the shape of the jumper pad.

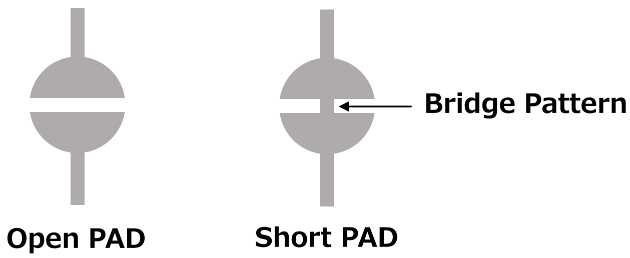

Figure 7.2 Jumper pad shape

7.4 RA4L1 CPU Board Jumper Settings

Table 7.3 shows the jumper settings of the RA4L1 CPU board for measuring current consumption.

Table 7.3 Jumper settings

Position	Jumper setting	Use
JP3	Open	Measure current consumption
JP4	2-3 pins closed	Power supply from DC jack

Other jumper settings and switch settings are factory-default.

7.5 Current Consumption Measurement Environment

The following figure shows the environment necessary for measuring current consumption.

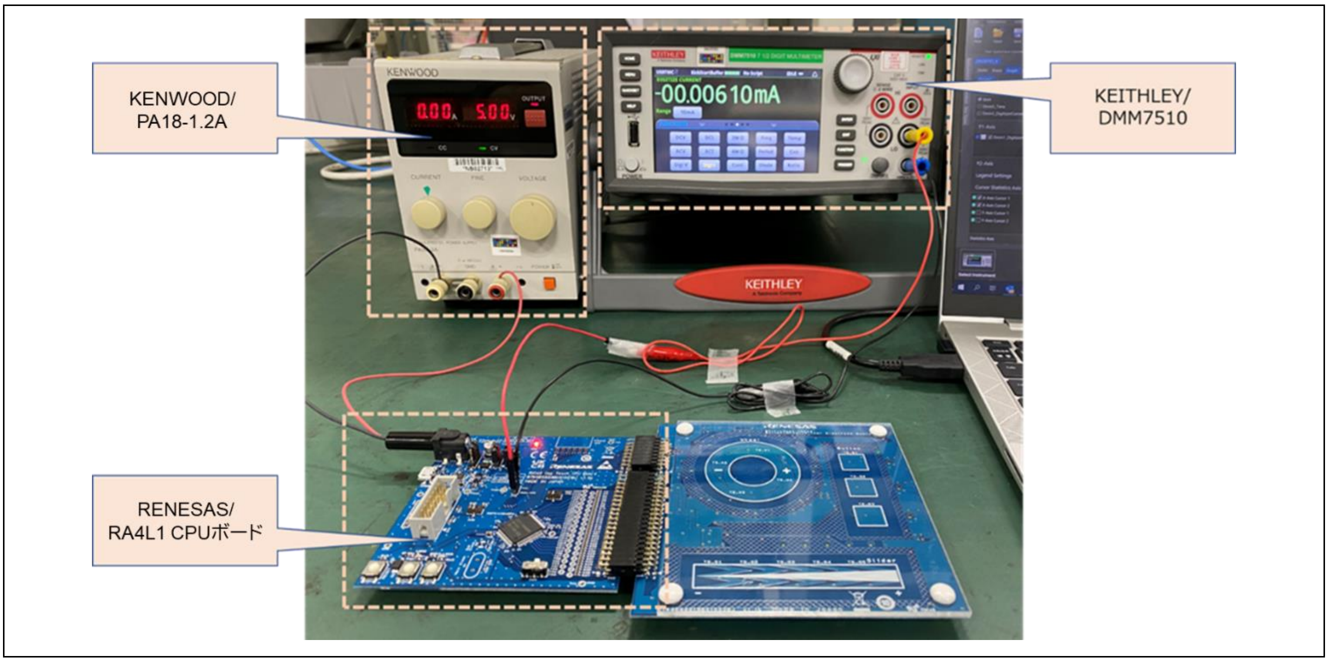

Figure 7.3 Current Consumption Measurement Environment

7.6 Current Consumption Measurement Settings

The following figure shows the Keithley KickStart settings for measuring current consumption.

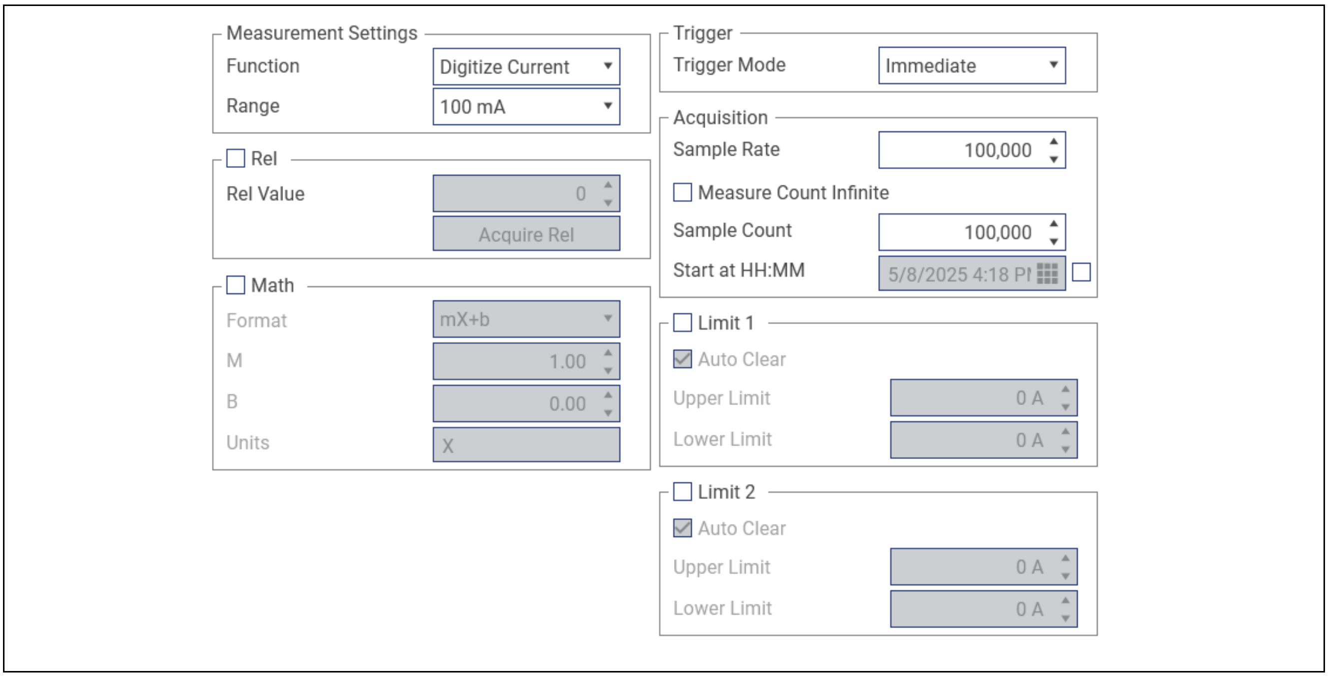

Figure 7.4 Keithley KickStart settings for current consumption measurement

7.7 Current Consumption Measurement Results

Figure 7.5 and Figure 7.6 show the current consumption waveforms of the operation when the CPU operation mode transitions to the software standby mode and snooze mode (touch measurement processing, touch on / off judgment processing).

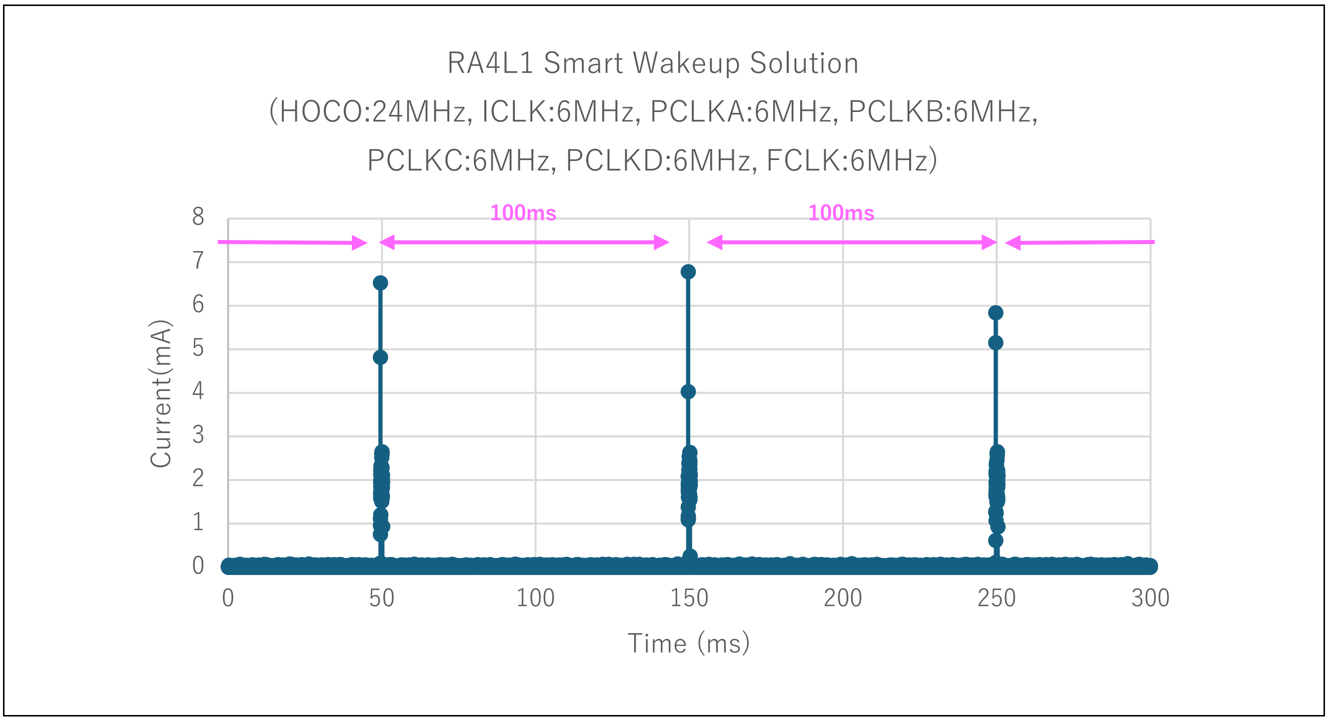

Figure 7.5 Current consumption waveform during standby mode (1/2)

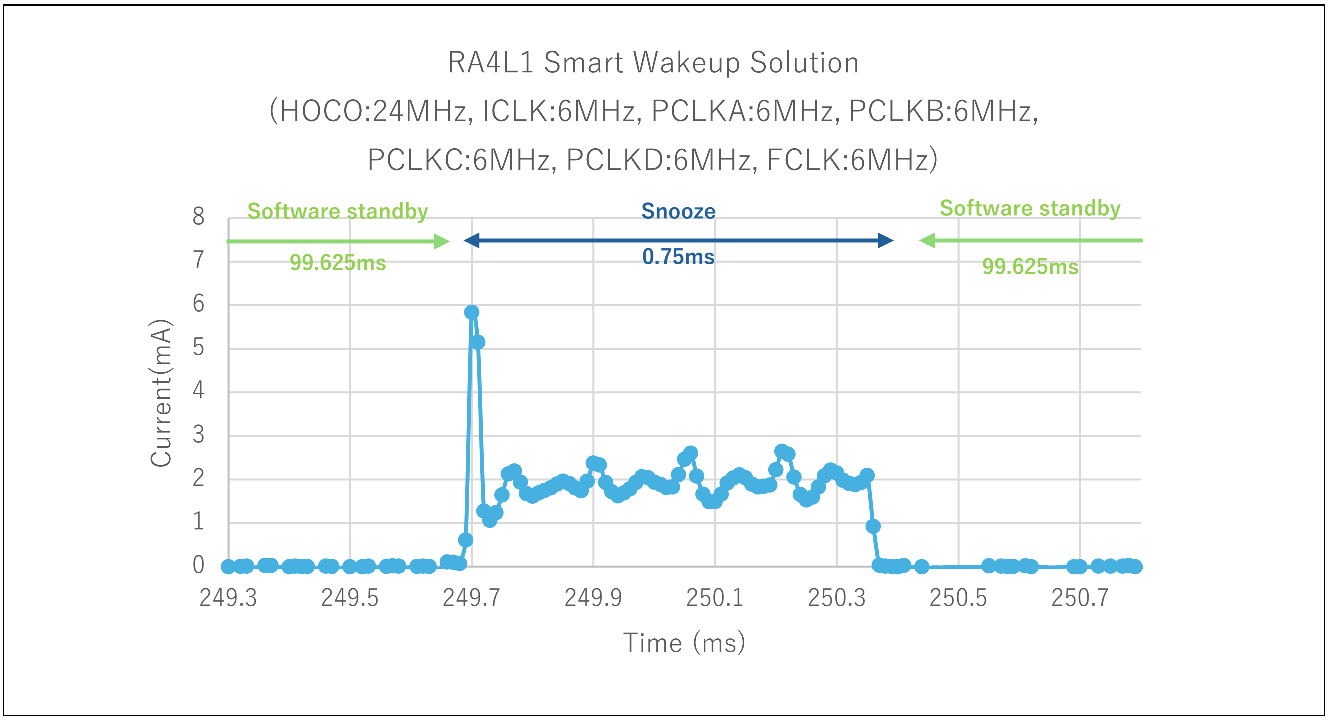

Figure 7.6 Current consumption waveform during standby mode (2/2)

7.8 Average Current Consumption Calculation Results

The following figure shows the average current measured in a touch measurement cycle of 100ms in standby mode with the automatic judgment function and multiple electrode connection function.

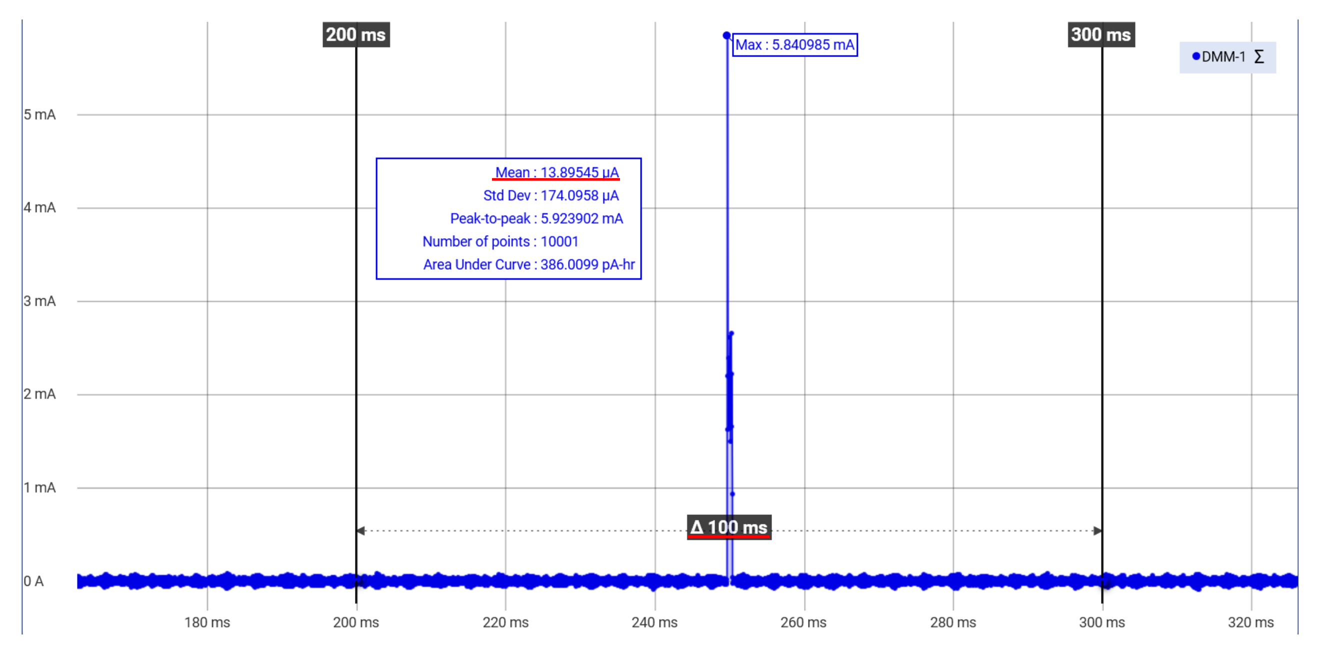

Figure 7.7 Average current of 100ms cycle in standby mode

Average current consumption (touch measurement cycle of 100ms) **= 13.89545 µA**

*When the clock settings are changed as shown in the table below, the average current consumption (touch measurement cycle of 100ms) is 52.89462 µA.

Table 7.4 Change conditions for clock settings

Item	Description
CPU operating frequency	80MHz High-speed on-chip oscillator (HOCO) 3.2768KHz Low-speed on-chip oscillator (LOCO)
System clock (ICLK)	80 MHz
Peripheral module clock A (PCLKA)	80 MHz
Peripheral module clock B (PCLKB)	40 MHz
Peripheral module clock C (PCLKC)	40 MHz
Peripheral module clock D (PCLKD)	80 MHz
FlashIF clock (FCLK)	40 MHz
Touch measurement cycle	100ms
Sensor drive pulse frequency	0.5MHz

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	May.28.25	-	Initial version

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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