RA2L1 Group

Capacitive Touch Low Power Guide

Introduction

This application note explains Capacitive Touch measurement that uses the Asynchronous General-Purpose Timer (AGT) function and Low power mode (Software Standby mode, Snooze mode) installed in RA2L1.

Target Device

RA2L1

Contents

1. Specification

1.1 Project description

Sample code that this application note describes is confirmed to operate on the Capacitive Touch Evaluation System for RA2L1 MCU Group (RTK0EG0022S01001BJ). The setting of this project is adjusted to R7FA2L1AB2DFP implemented on Capacitive Touch Evaluation System for RA2L1 Group. Modify the device setting in the project when you use the other device.

1.2 Used Peripherals

Table 1-1 lists the used peripherals in the sample code.

Table 1-1 Peripherals in the sample code

Used Peripherals	Functions
Capacitive Touch Sensing Unit (CTSU)	- Measures electrostatic capacitance of the touch sensor.
Data Transfer Controller (DTC)	- Transfers CTSUSO setting value in RAM to CTSU register. - Transfers CTSUSC counter in CTSU register to RAM.
Asynchronous General-Purpose Timer (AGT)	- Timer used to cancel Software Standby mode.
Event Link Controller (ELC)	- Starts CTSU measurement by Snooze entry.

1.3 CPU Operation Mode

Table 1-2 lists CPU mode used in this sample code.

Table 1-2 CPU operation mode

CPU operation mode	Transition condition
Snooze mode	- Transition from AGT counter underflow in Software Standby mode
Normal mode (Touch measurement End process and Touch On/Off detection process and Touch measurement Start process)	- Transition from CTSU measurement end interrupt in Snooze mode
Software Standby mode	- Transition by API of r_lpm driver

1.4 CTSU Operation Status

Table 1-3 lists CTSU operation status used in this sample code.

Table 1-3 CTSU Operation status

CTSU Operation Status	Transition condition
Operating	- Touch measurement start
Suspended	- Touch measurement stop

1.5 Register settings

Register settings changed from the reset value are shown below.

Table 1-4 Register settings

Function	Register	Value	Remarks
I/O Ports	P108PFS	0x00000000	
	P110PFS	0x00000000	
	P112PFS	0x00000000	
	P201PFS	0x00000000	
	P204PFS	0x00000000	
	P300PFS	0x00000000	
	P304PFS	0x00000000	
	P306PFS	0x00000000	
Realtime Clock (RTC)	RCR2	0x00	Set according to 22.6.7 “Initialization Procedure When RTC Is Not to Be Used” in RA2L1 Group User’s Manual: Hardware
	RCR4	0x01	RCKSEL bit (Count Source Select in normal operation mode): 1 LOCO is selected
Low Power Modes	SBYCR	0x8000	SSBY bit (Software Standby Mode Select): 1 Software Standby mode
	SNZCR	0x82	RXDREQEN bit (RXD0 Snooze Request Enable): 0 Ignore RXD0 falling edge in Software Standby mode SNZDTCEN bit (DTC Enable in Snooze mode): 1 Enable DTC operation SNZE (Snooze mode Enable): 1 Enable Snooze mode
Clock Generation Circuit	SOSCCR	0x01	SOSTP bit (Sub Clock Oscillator Stop): 1 Stop the sub-clock oscillator

1.6 File Configuration

Table 1-5 lists the file added or changed in the sample code generated by RA configurator and QE for Capacitive Touch.

Table 1-5 Files added or changed in the sample code

Name	Outline	Remarks
qe_touch_sample.c	Main processing	Changed file

2. Operation Conditions

This application note confirms operation based on the items and conditions stated below.

Table 2-1 Operation Conditions

Item	Description
MCU	R7FA2L1AB2DFP (RA2L1 Group)
Operating frequency	32MHz High-speed on-chip oscillator (HOCO) 32KHz Low-speed on-chip oscillator (LOCO)
Operating voltage	5.0V
Target board	RA2L1 MCU Group Capacitive Touch Evaluation System (RTK0EG0022S01001BJ)
Integrated development environment	e^2 studio (2021-10)
C compiler	GCC Arm Embedded (9.3.1.20200408)
Endian	Little endian
Operation mode	Single chip mode
Debugger	E2 Emulator Lite
FSP Version	Ver.3.4.0
Sample code Version	Ver.1.00

3. Software Description

The sample code operates as follows by using the FSP driver and middleware functions.

1. After reset release by power on, the sample code opens rm_touch middleware.
2. Transit to Software Standby mode.
3. Transit to Snooze mode by AGT counter underflow and start CTSU measurement by Snooze entry.
4. Transit to Normal mode from Snooze mode by CTSU measurement end interrupt.
5. When Touch-On is detected, user LED (LED3) is lit.
6. Repeat from step 2 to step 5.

3.1 Operation image

Figure 3-1 shows CPU operation mode and CTSU operation status according to the process in the sample code.

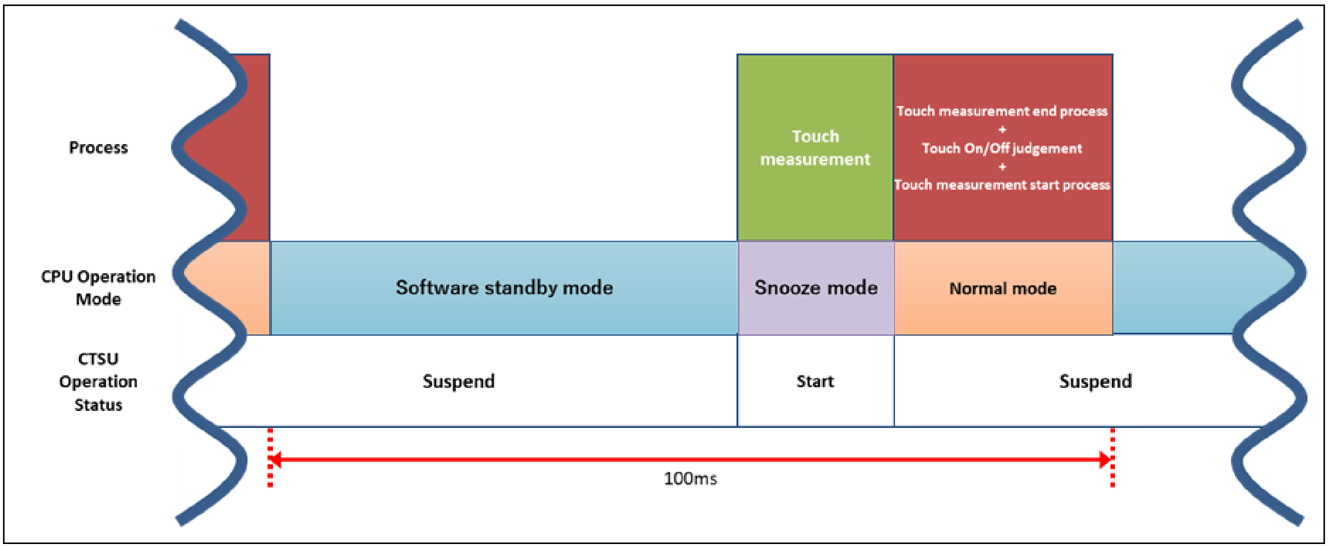

Figure 3-1 Operation image

3.2 FSP driver and middleware

Table 3-1 lists FSP driver and middleware used in the sample code.

Table 3-1 FSP driver and middleware used in the sample code

FSP driver, middleware	Version
Board Support Package (BSP)	3.4.0
CTSU Driver (r_ctsu)	3.4.0
Capacitive Touch Middleware (rm_touch)	3.4.0
I/O Port Driver (r_ioport)	3.4.0
Timer Driver (r_agt)	3.4.0
Low Power Mode Driver (r_lpm)	3.4.0
Event Link Controller (r_elc)	3.4.0

3.3 List of Variables

Variables added and changed in this sample code are shown below.

Table 3-2 Variables (qe_touch_sample.c)

Attribute	Variable name	Description
uint64_t	button_status	Result of Touch On/Off detection

3.4 List of Functions

The specification for functions added or changed in this sample code are shown below.

3.4.1 qe_touch_main ()

qe_touch_main ()	
Outline	Control Touch measurement and low power mode.
Declaration	void qe_touch_main (void)
Description	Controls CTSU measurement and transition to Low power mode. 1. Open r_agt driver. 2. Open r_lpm driver. 3. Open r_elc driver. 4. Enable Event Link. 5. Disable Realtime Clock. 6. When Touch-On is detected, user LED (LED3) is lit. 7. Set external trigger to CTSU Measurement Operation Start Trigger and start CTSU measurement. 8. Start count of AGT. 9. Transit to Software Standby mode and transit to Snooze mode by AGT counter underflow and start CTSU measurement by Snooze entry. 10. Transit to Normal mode from Snooze mode by CTSU measurement end interrupt. 11. Stop count of AGT. 12. Repeat from step6 to step 11.
Argument	-
Return value	-

3.4.2 r_captouch_low_power_scan

r_captouch_low_power_scan ()	
Outline	Control touch measurement
Declaration	void r_captouch_low_power_scan (void)
Description	Controls touch measurement. 1. Start touch measurement. 2. Start count of AGT. 3. Transit to Software Standby mode. 4. Stop AGT count.
Argument	-
Return value	-

3.4.3 r_captouch_low_power_disable_rtc

r_captouch_low_power_disable_rtc ()	
Outline	Disable RTC
Declaration	void r_captouch_low_power_disable_rtc (void)
Description	Initialize RTC registers.
Argument	-
Return value	-

4. Flowcharts

4.1 qe_touch_main ()

Flowchart is shown below.

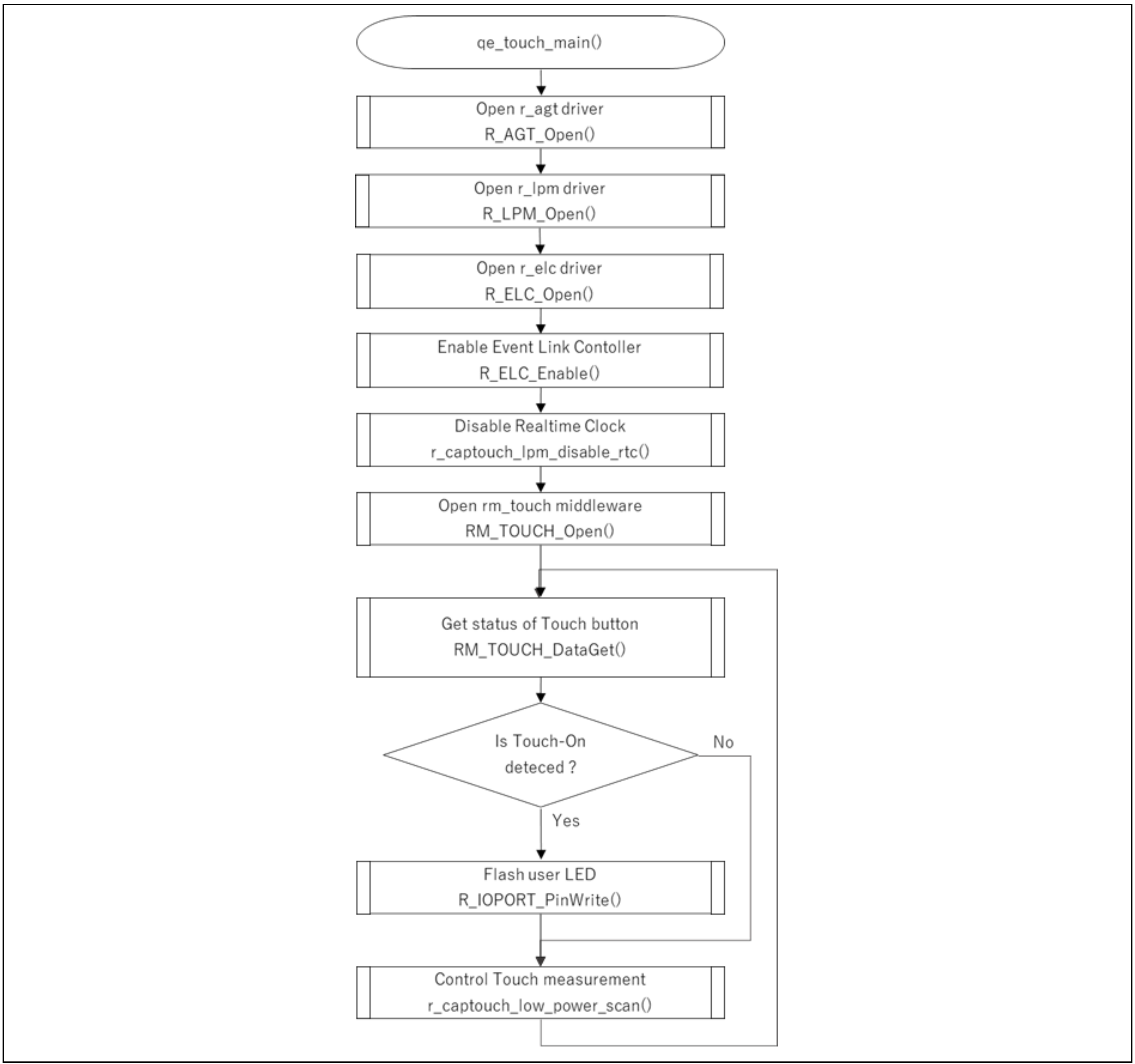

Figure 4-1 qe_touch_main ()

4.2 r_captouch_low_power_scan ()

Flowchart is shown below.

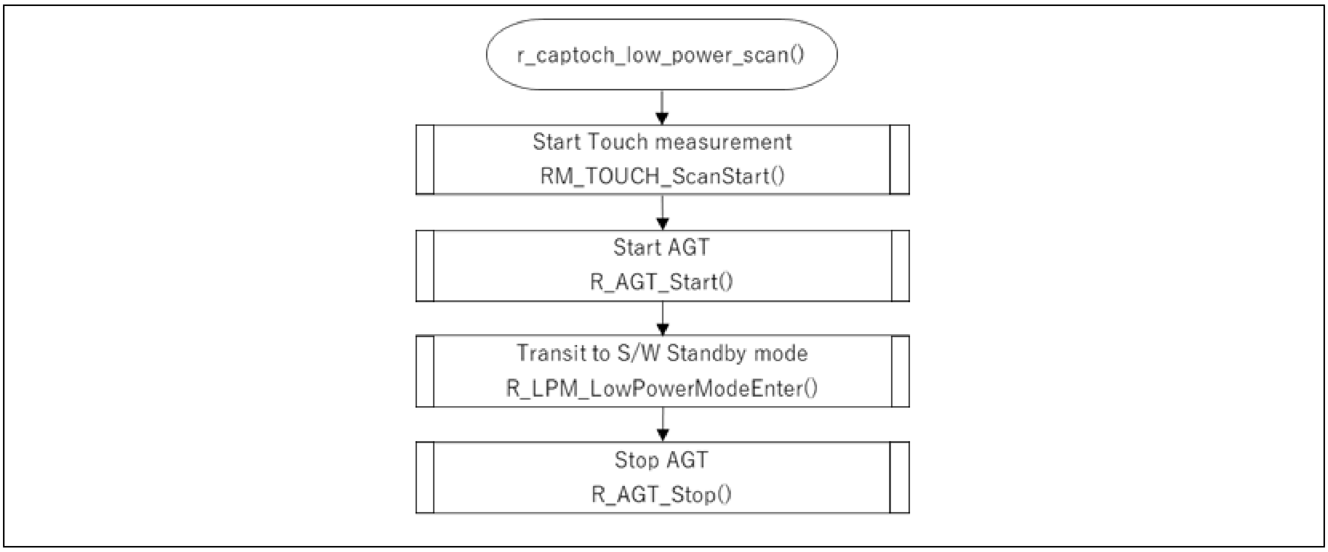

Figure 4-2 r_captouch_low_power_scan ()

4.3 r_captouch_low_power_disable_rtc ()

Flowchart is shown below.

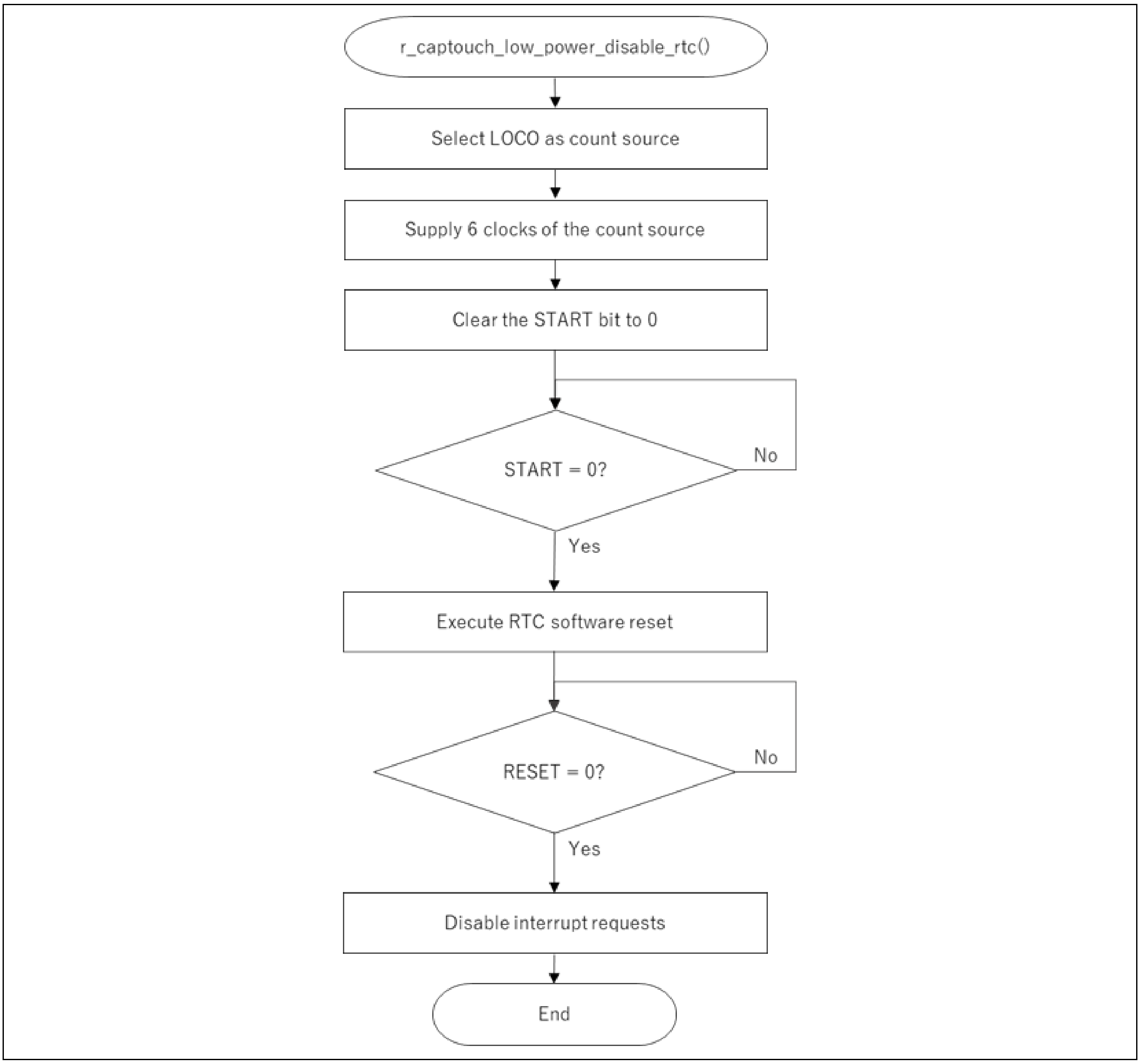

Figure 4-3 r_captouch_low_power_disable_rtc ()

5. Current consumption

The system configuration in the following red box shows a model of the electrostatic capacitive touch low power consumption operation described in this application note.

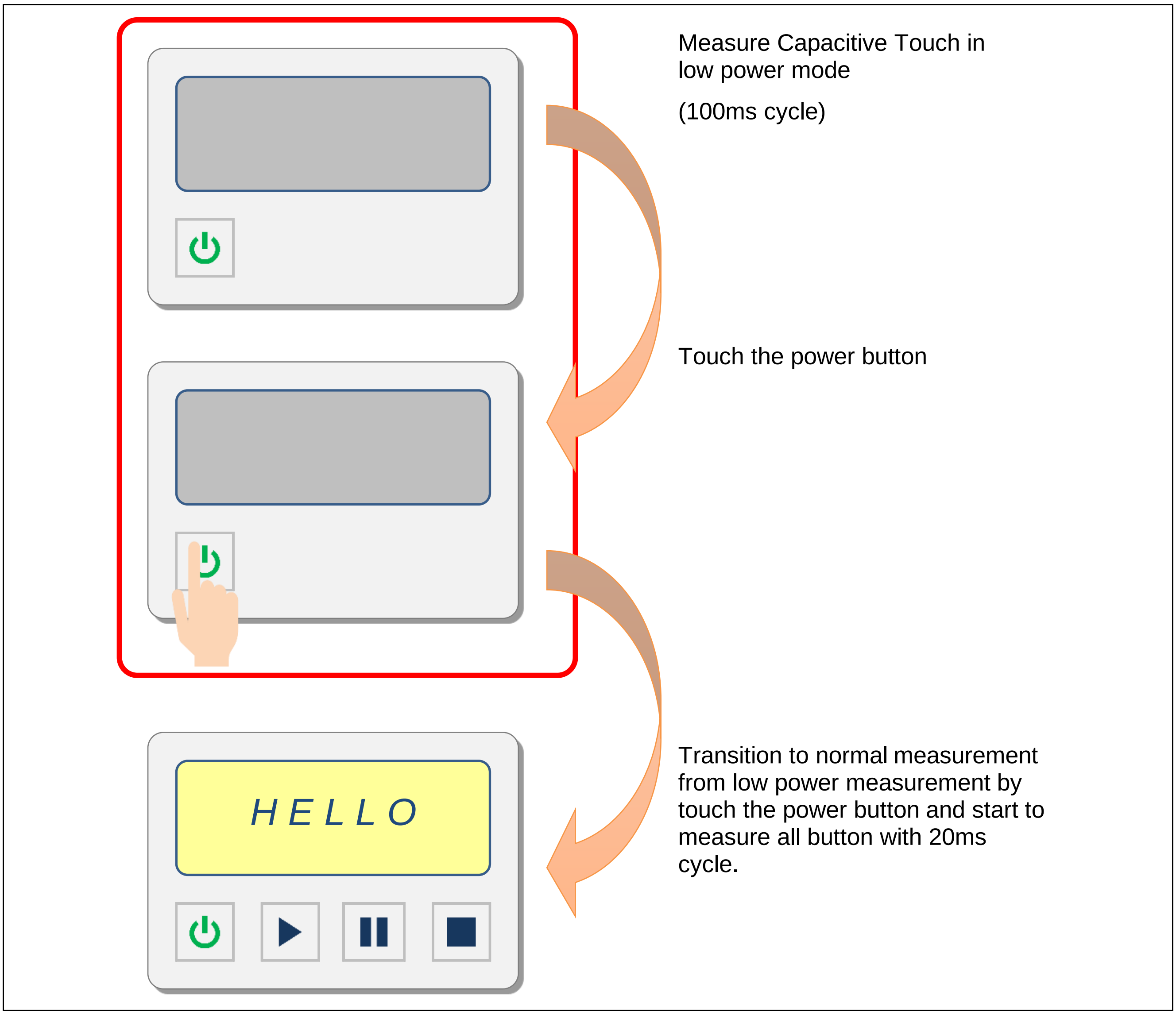

Figure 5-1 Model of the electrostatic capacitive touch low power consumption operation

5.1 Operation Conditions

Table 5-1 shows operation condition.

Table 5-1 Operation Conditions

Item	Description
Operating frequency	32MHz High-speed on-chip oscillator (HOCO) 32KHz Low-speed on-chip oscillator (LOCO)
System clock (ICLK)	1MHz
Peripheral module clock B (PCLKB)	1MHz
Peripheral module clock D (PCLKD)	1MHz
Internal Clock Supply Architecture Type	Internal Clock Supply Architecture Type B
Capacitive Touch measurement cycle	100ms
Sensor drive pulse frequency	2MHz
Capacitance measurement pin	TS11-CFC
Active shield control pin	TS00
CTSU Measurement Mode	Self-capacitance method
CTSU Scan Mode	Multi-scan mode
CTSU Measurement Operation Start Trigger Select	External trigger
CTSU Wait State Power-Saving Enable	Enable power-saving function during wait state
CTSU Power Supply Operating Mode	Normal voltage operating mode
CTSU Current Range Adjustment	40μA
CTSU Non-Measured Channel Output	Output a pulse in phase with the transmit channel
Wait Time Sensor Stabilization	64μs (Recommended value)
CTSU Measurement Count	7 times

5.2 Equipment and Software

Table 5-2 shows equipment and software used in current consumption measurement.

Table 5-2 Equipment and software

Type	Name	Use
Digital multi meter	Keithley DM7510	Measure current consumption
Power supply	KENWOOD PA18-1.2A	Supply power to RA2L1 Cap Touch CPU board
Software	Keithley KickStart Software	Get result of current consumption measurement from Keithley DM7510 and output the result to log-file.

5.3 RA2L1 Cap Touch CPU board jumper settings

Table 5-3 shows jumper settings of RA2L1 Cap Touch CPU board to measure current consumption.

Table 5-3 Jumper settings

Position	Circuit group	Jumper	Use
JP2	Power	Close 1-2 pin	Power supply from DC jack
JP3	Power	Open	Measure current consumption

5.4 RA2L1 Cap Touch CPU board

The front and back of RA2L1 Cap Touch CPU board are as follows.

5.4.1 RA2L1 Cap Touch CPU board - front

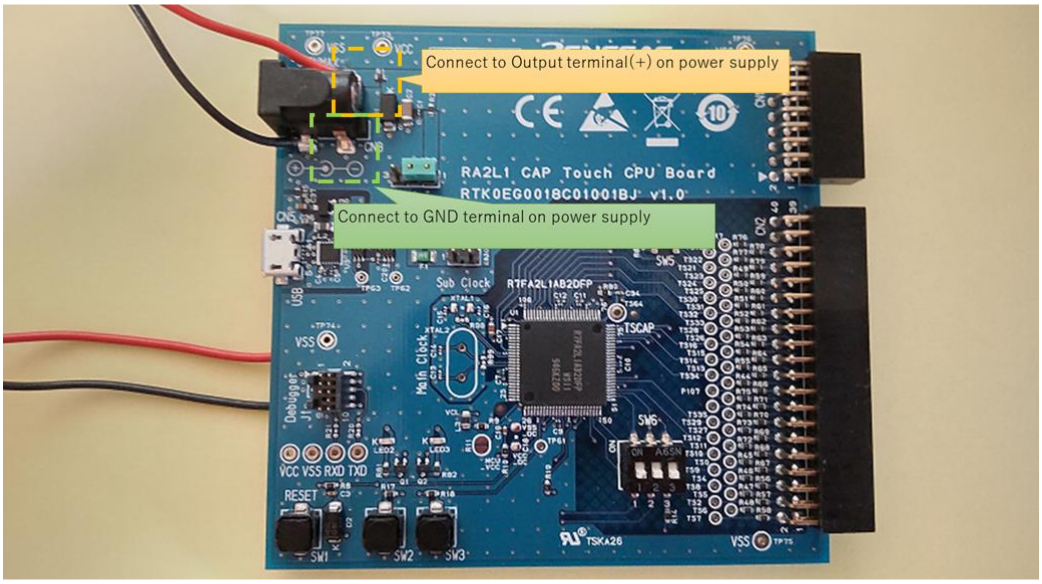

Figure 5-2 RA2L1 Cap Touch CPU board - front

5.4.2 RA2L1 Cap Touch CPU board - back

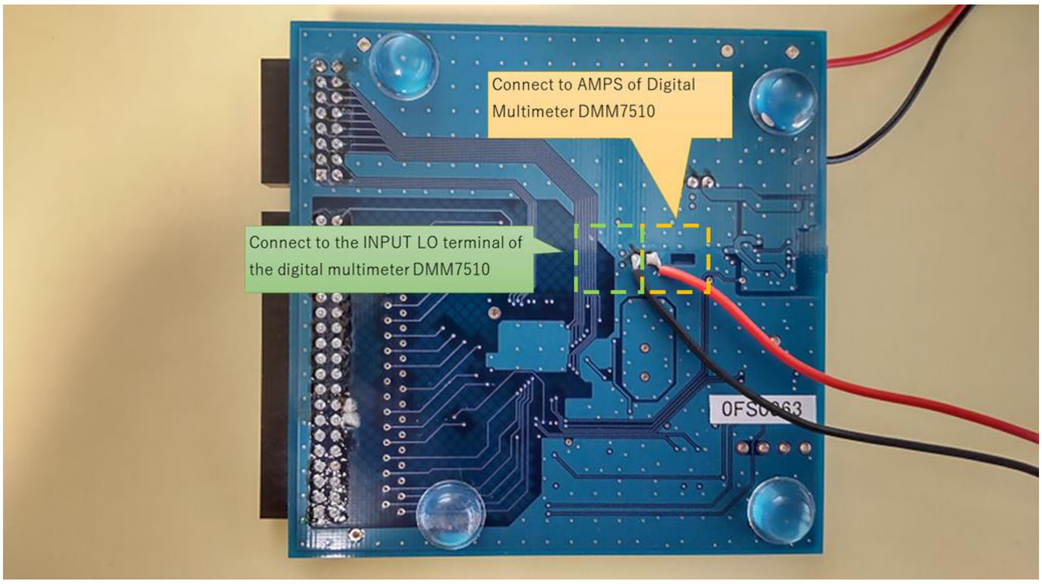

Figure 5-3 RA2L1 Cap Touch CPU board - back

5.5 Environment to measure current consumption

Figure 5-4 shows environment to measure current consumption.

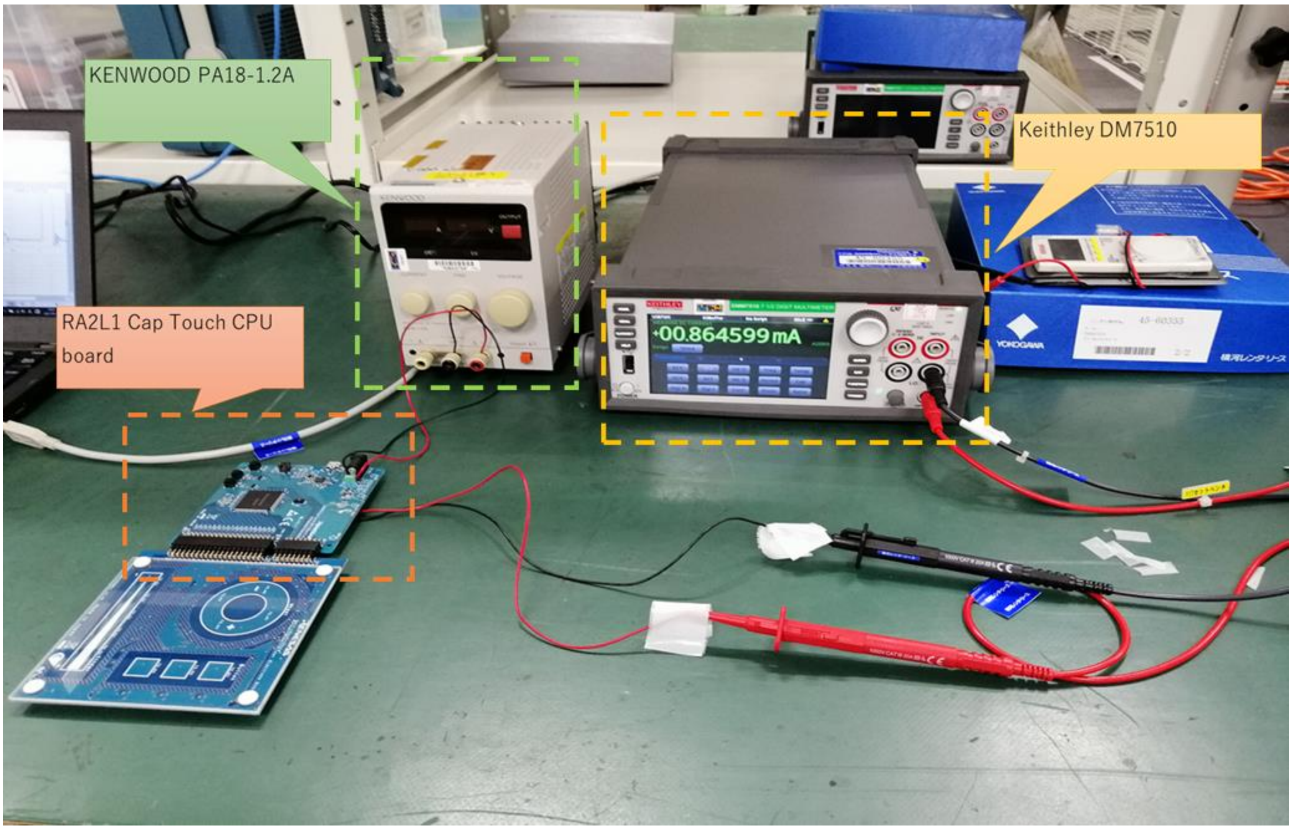

Figure 5-4 Environment to measure current consumption

5.6 Setting to measure current consumption

Figure 5-5 shows settings of Keithley KickStart to measure current consumption.

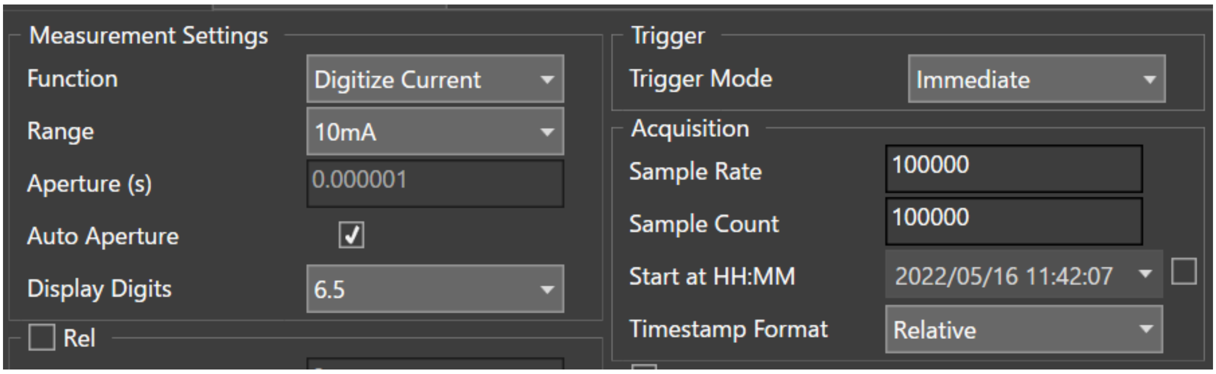

Figure 5-5 Settings of Keithley KickStart to measure current consumption

5.7 Current Consumption Measurement Results

Figure 5-6 to Figure 5-7 show the current consumption waveforms for a series of operations in which the CPU operation mode transitions to Software Standby mode, Snooze mode (touch measurement processing), and Normal mode (Touch measurement end processing and Touch On/Off judgment processing).Figure 5-6 and Figure 5-7 show the touch measurement at TS pin 1 channel.

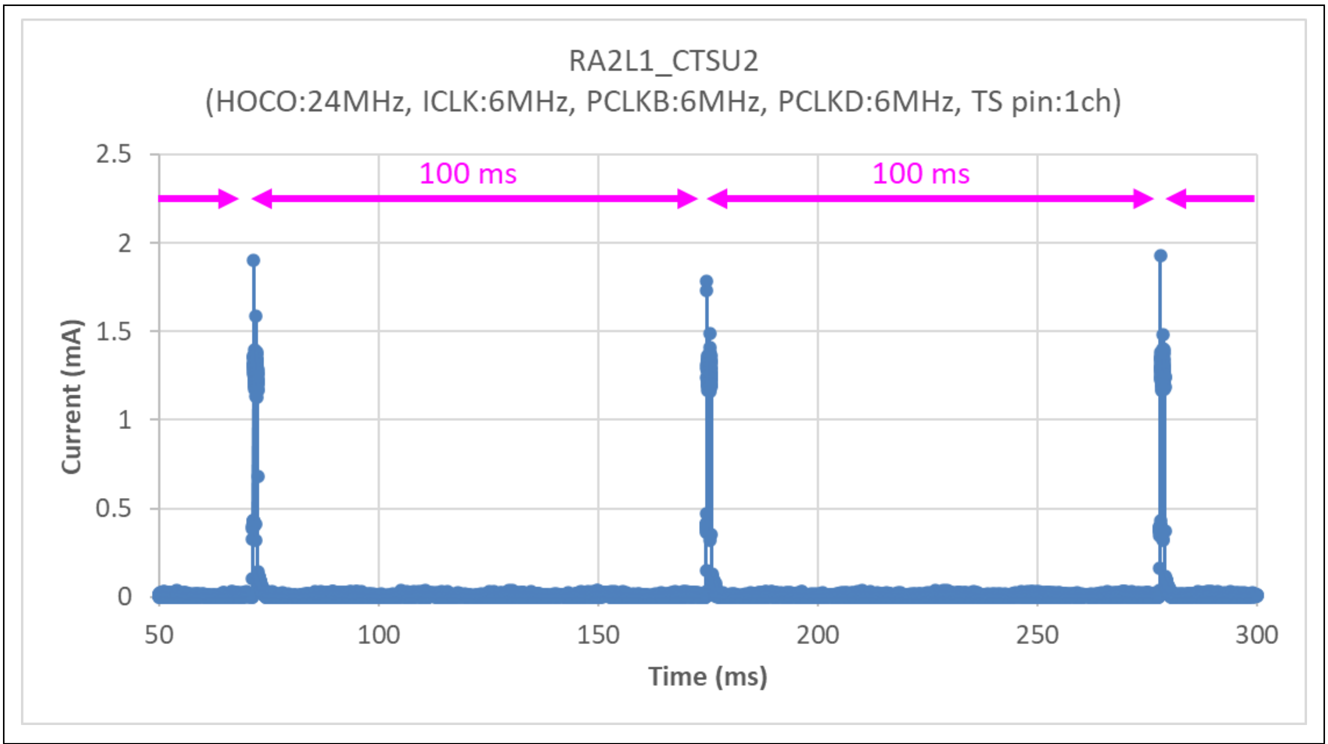

Figure 5-6 Current consumption waveform: TS pin 1ch measurement (1/2)

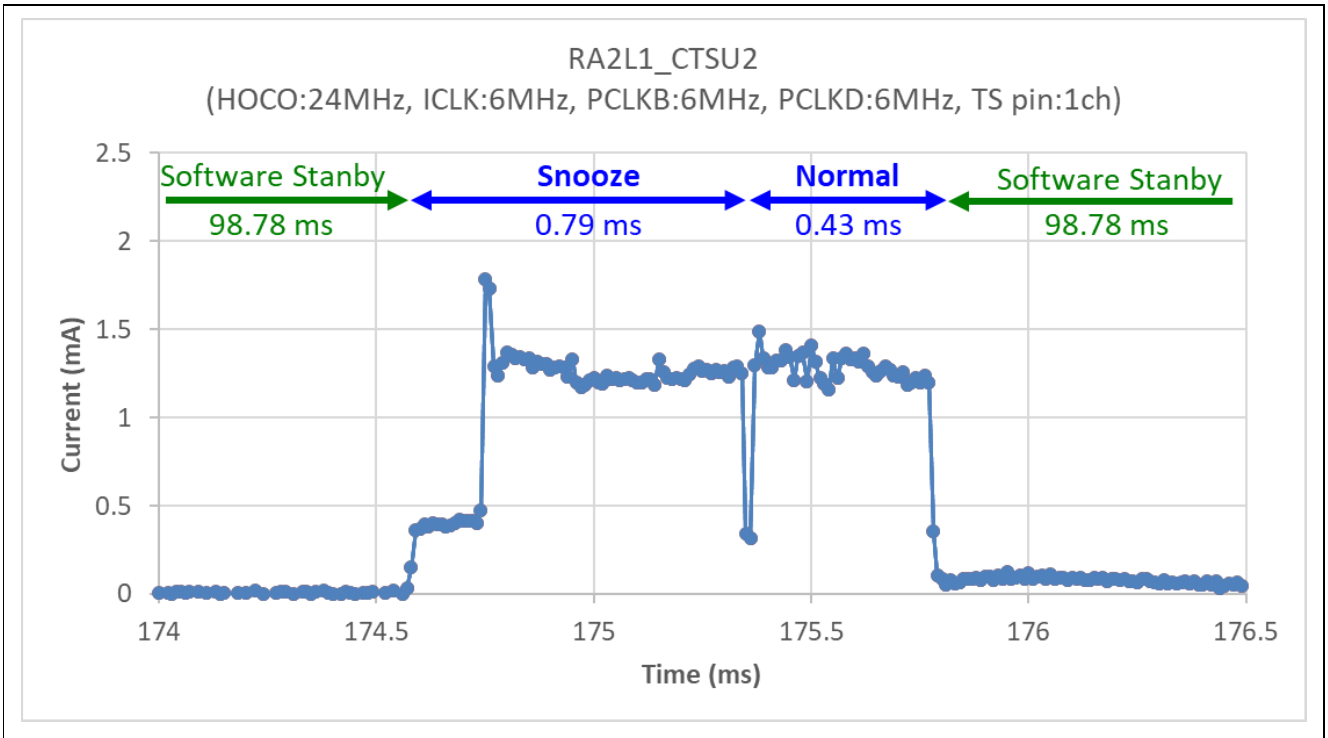

Figure 5-7 Current consumption waveform: TS pin 1ch measurement (2/2)

5.8 Current Consumption Calculation Results

The average current consumption of TS pin 1 channel measured with a touch measurement cycle of 100ms is shown below (Figure 5-8).

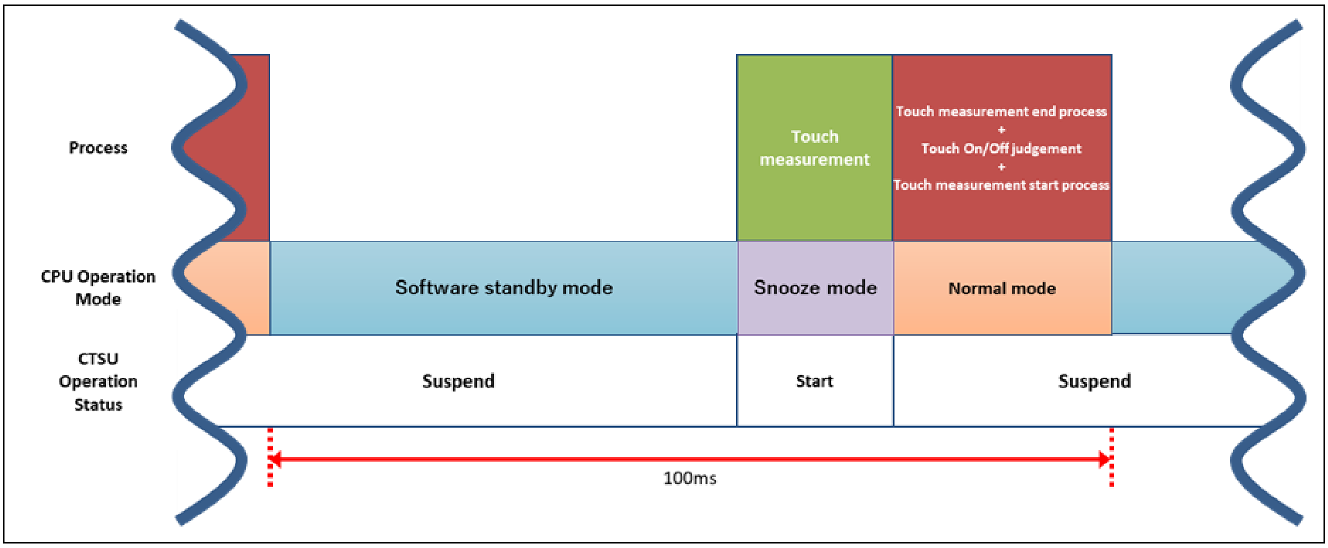

Figure 5-8 Operation timing of CTSU

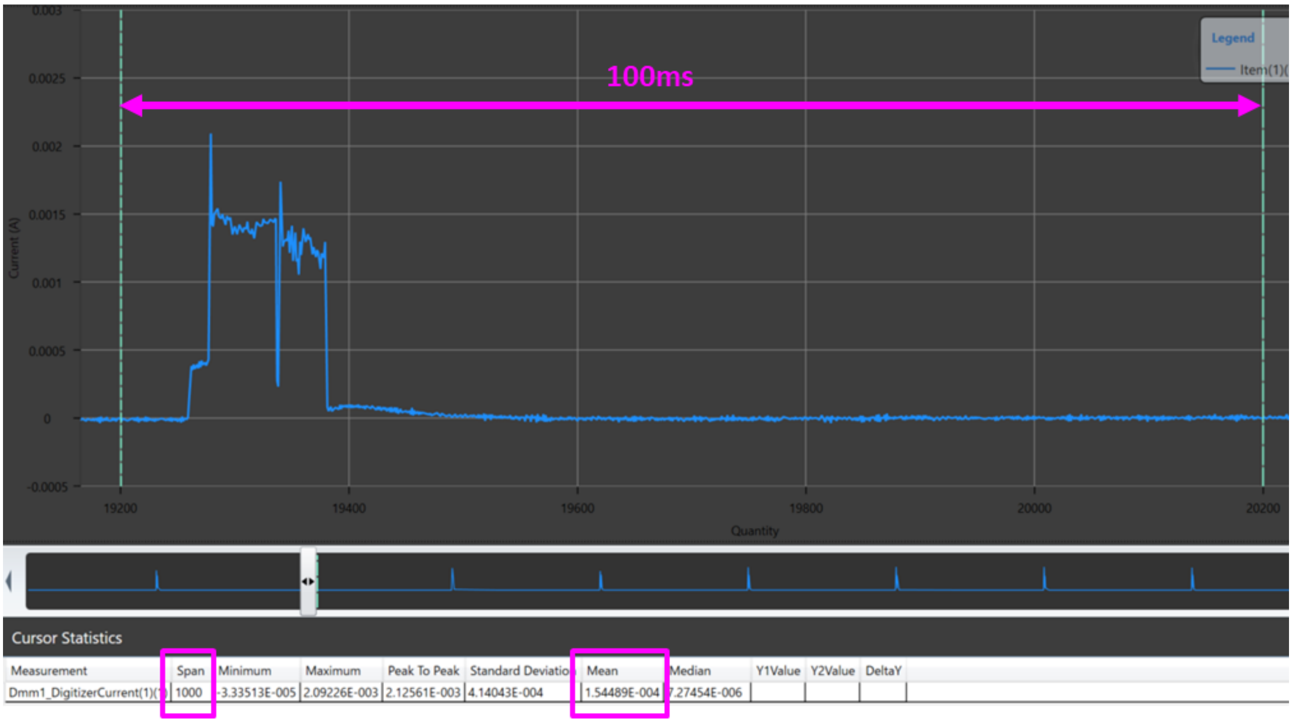

Figure 5-9 Current consumption results (TS pin 1ch measurement)

Current consumption (touch measurement cycle of 100ms) = **15.4489 uA**

6. References

User's Manual: Hardware

RA2L1 User's Manual Hardware R01UH0853

(The latest version can be downloaded from the Renesas Electronics website.)

Technical Update/Technical News

(The latest version can be downloaded from the Renesas Electronics website.)

User's Manual: Development Tools

(The latest version can be downloaded from the Renesas Electronics website.)

User's Manual: RA2L1 MCU Group Capacitive Touch Evaluation System

(The latest version can be downloaded from the Renesas Electronics website.)

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Dec.17.21	-	First edition issued
1.10	May.17.22	16,17,18,19	Changed the current measurement method

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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