RL78/G23

RL78/G23 Capacitive Touch Low Power Guide (SMS function)

Introduction

This application note explains how to use the SNOOZE Mode Sequencer (SMS) to achieve low power consumption with capacitive touch measurement.

Target Device

RL78/G23

When applying the contents of this application note to other MCUs, please change them according to the specifications of the MCUs and perform a thorough evaluation.

Contents

1. Outline

This application note shows the reference current consumption when the capacitive touch measurement using the SNOOZE mode sequencer (SMS) function of the RL78/G23 is operated intermittently in 100ms cycles.

By using SMS function, the touch on/off status of several electrodes can be determined during SNOOZE mode, enabling low power consumption.

※ SNOOZE Mode Sequencer (SMS)

This function sequentially executes up to 32 processes from 21 types of processing such as arithmetic processing, branch processing, and control of peripheral functions (timer, serial communication, etc.). SMS is activated by the interrupt-request signal of the peripheral function or the output signal of ELCL, and the process can be executed independently of CPU. Therefore, SMS can operate even when CPU is in stand-by. In addition, since the operating current of SMS is smaller than that of CPU, CPU can be replaced by a process to reduce power consumption.

2. Used Peripherals

Table 2-1 lists the used peripherals in the sample code.

Table 2-1 Peripherals in the sample code

Used Peripherals	Functions
Capacitive Sensing Unit (CTSU2L)	Measures electrostatic capacitance of the touch sensor.
32-bit interval timer (TML32)	Timer to release STOP mode and transition to SNOOZE mode (measurement cycle: 100 ms). It can also be switched and used as a timer (measurement cycle: 20ms) for periodic touch measurement.
Logic and Event Link Controller (ELCL)	Use ELCL to link the interrupt signal of the 32-bit interval timer and the measurement start trigger of the capacitance sensor unit.
SNOOZE Mode Sequencer (SMS)	A request from a capacitive sensor unit or an SMS event output is used as a trigger to transfer the program executed by SMS using DTC.
Data transfer controller (DTC)	
Timer array unit (TAU)	Timer for LED output (measurement cycle: 4 ms)
Port	Initialize port input/output

3. Operation Environment / Conditions

Table 3.1 lists the operating conditions, Table 3.2 lists the operating conditions, and Figure 3.1 shows CTSU measurement touch sensor, sensor drive pulse frequency, and CTSU measurement times.

Note: In QE for Capacitive Touch V3.5.0, the display of the threshold of the button of config01 in Figure 3.1 is incorrect. Out of the three displayed threshold, the correct value is twice the first threshold.

Table 3.1 Operation environment

Item	Contents
MCU	RL78/G23 (R7F100GSN2DFB)
Operating voltage	5.0V LVD0 detection voltage: Reset mode At rising edge TYP. 2.67V (2.59 V～2.75 V) At falling edge TYP. 2.62V (2.54 V～2.70 V)
Target board	RL78/G23 capacitive touch evaluation system (RTK0EG0030S01001BJ)
Integrated development environment	e^2 studio (2024-04)
Smart Configurator	V24.4.0
C compiler	CC-RL V1.13.00
QE for Capacitive Touch	V3.5.0
Debugger	E2 emulator Lite

Table 3.2 Operation conditions

Item	Contents
High-speed on-chip oscillator clock (fIH)	12MHz *Note
CPU/peripheral hardware clock (fCLK)	12MHz *Note
Low-speed on-chip oscillator clock (fIL)	32.768 kHz
Low-speed peripheral clock (fSXP)	32.768 kHz
Capacitive Touch measurement cycle	20 ms (Normal mode)/100 ms (Low power consumption mode)
Capacitance measurement terminal	TS06
Measurement Mode Select 1	Self-capacitance method
Measurement Mode Select 0	Multi-scan mode
Measurement Start Trigger Select	External trigger
SNOOZE Enable	Enables the SNOOZE mode
Analog Adjustment 0	Measurement power-supply voltage = 1.5 V (Normal voltage operating mode)
Analog Adjustment 1	40 μA
Sensor Stabilization Wait Time Setting	64 μs (Recommended value)
Multi-clock x Enable	3 frequencies (MCA0, MCA1, MCA2: Available)

Note : Operation is not supported when fIH or fCLK is set to 4 MHz or lower.

Automatic judgment measurement using SMS supports only button touch detection (slider/wheel touch position detection is not supports). This sample program measures one button electrode.

Method	Kind	Name	Touch Sensor	Parasitic Capacitance[pF]	Sensor Drive Pulse Frequency[MHz]	Threshold	Scan Time[ms]	Overflow
config01	Button(self)	Button00	TS06	22.868	2.0	704, 601, 806	0.576	None

Figure 3.1 CTSU measurement Touch sensor and Sensor Drive Pulse Frequency and CTSU Scan Time

4. Capacitive touch settings

4.1 Touch interface configuration

Figure 4.1 shows the touch interface configuration. Measuring TS06 terminal by self-capacitance method.

Figure 4.1 Touch interface configuration

4.2 Method settings

Figure 4.2shows the touch interface configuration method settings.

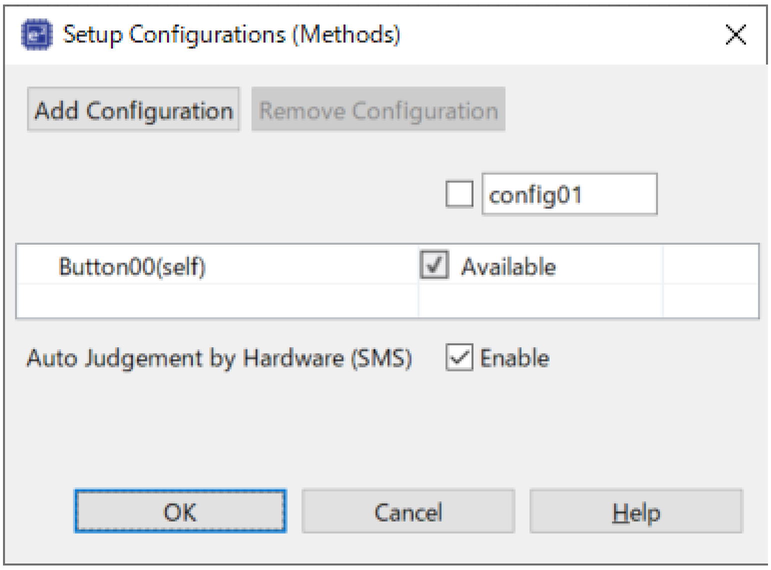


Figure 4.2 Method settings

Note: If you want to enable Auto Judgement by Hardware (SMS) using CTSU driver V1.50, please set the touch interface configuration in config01.

5. Used components

Figure 5.1 shows the components used in Smart Configurator.

Selected components:

Component	Version	Configuration
Board Support Packages. - v1.62 (r_bsp)	1.62	r_bsp(used)
Capacitive Sensing Unit driver. (r_ctsu)	1.50	r_ctsu(used)
Interval Timer	1.4.0	Config_TAU0_1(TAU0_1: used), Config_ITL000(ITL000: used)
Ports	1.4.1	Config_PORT(PORT: used)
Touch middleware. (rm_touch)	1.50	rm_touch(used)
Voltage Detector	1.3.0	Config_LVD0(LVD0: used)

Figure 5.1 Components of Smart Configurator

6. Option Byte Settings

Table 6.1shows the components used in Smart Configurator.

Table 6.1 Option Byte Settings

Address	Setting Value	Contents
000C0H/040C0H	11101111B (0xEF)	Disables the watchdog timer. (Counting stopped after reset)
000C1H/040C1H	11111100B (0xFC)	LVD0 detection voltage: reset mode At rising edge TYP. 2.67V (2.59 V～2.75 V) At falling edge TYP. 2.62V (2.54 V～2.70 V)
000C2H/040C2H	11100001B (0xE1)	HS mode, High-speed on-chip oscillator clock: 12 MHz
000C3H/040C3H	10000100B (0x84)	Enables on-chip debugging

Figure 6.1 shows the screen to check the build options.

To set the option byte, open the project properties (ALT+Enter) after code generation, "C/C++ Build" -> "Settings" -> "Tool Settings" -> "Linker" -> "Device" -> "User option byte value" and "On-chip debug control value".

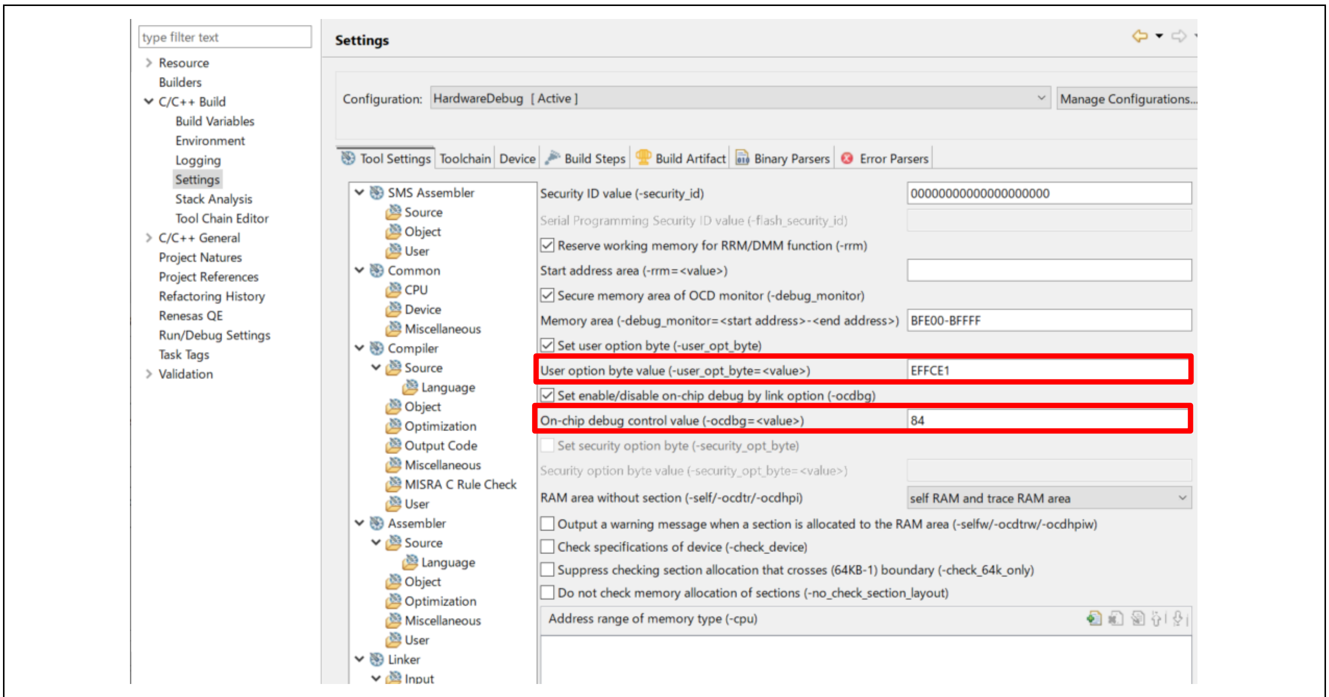


Figure 6.1 Option byte setting screen

7. Operation description

This section describes the sample project operation overview.

===== Up to initial offset tuning ===

1. Executes RM_TOUCH_Open function. After the reset is released by power-on, CTSU is initialized.
2. ELCL sets CTSU as the link destination for the compare match of the event source 32-bit interval timer.
3. Execute RM_TOUCH_ScanStart to set the touch measurement and wait for external trigger.
4. When STOP instruction is executed, the unit transits to STOP.
5. After 100ms an interrupt of 32-bit interval timer is generated, touch measurement is started by an external trigger from ELCL.
6. When the end of measurement is detected by an interrupt, the touch measurement results are obtained.
7. To check the output of the touch position display LED, turn on the LEDs in order.
8. Transition to Low Power Consumption mode (9).

===== Touch-Measurement Using SMS (Low Power Consumption mode) ===========

9. After initial offset tuning, turn off the LED and stop the timer (timer array unit) for touch position display control.
10. Set a 32-bit interval timer (measurement cycle: 100ms) to generate an external trigger to start touch measurement.
11. Set SMS by executing RM_TOUCH_SmsSet.
12. The touch measurement setting and SNOOZE function are enabled by executing RM_TOUCH_ScanStart function. Then, the external trigger wait status is set.
13. When STOP instruction is executed, the unit transits to STOP.
14. After 100ms an interrupt of 32-bit interval timer is generated, touch measurement is started by entering SNOOZE mode by an external trigger from ELCL.
15. When a measurement end interrupt is occurs, touch on/off judgment is made by SMS while in SNOOZE mode.
16. The 32-bit interval timer is stopped and transits to Normal mode (17) at touch-on judgment. When touch-off judgment is made, the display returns to 13.

===== Touch measurement of buttons (Normal mode) =============================

17. Turns off the touch position display LED and starts counting the touch position display control timer (cycle: 4ms).
18. Set a 32-bit interval timer (measurement cycle: 20ms) to generate an external trigger to start touch measurement.
19. Execute RM_TOUCH_ScanStart to set the touch measurement and wait for external trigger.
20. After 20ms an interrupt of 32-bit interval timer is generated, touch measurement is started by an external trigger from ELCL.
21. When a measurement end interrupt occurs, touch on/off judgment is made by the acquired touch measurement result.
22. When button 1 is touch-on, the button 1 LED turns on. When button 1 is touch-off, the button 1 LED turns off.
23. If button 1 is not performed for 3 seconds, the timer for touch position display control and the 32-bit interval timer are stopped, and the device transitions to Low Power Consumption mode (9). It returns to 20 until 3 seconds have elapsed.

7.1 Operation Image of CPU and CTSU

Figure 7.1 shows an image of CPU operation and CTSU operation status during touch measurement using SMS.

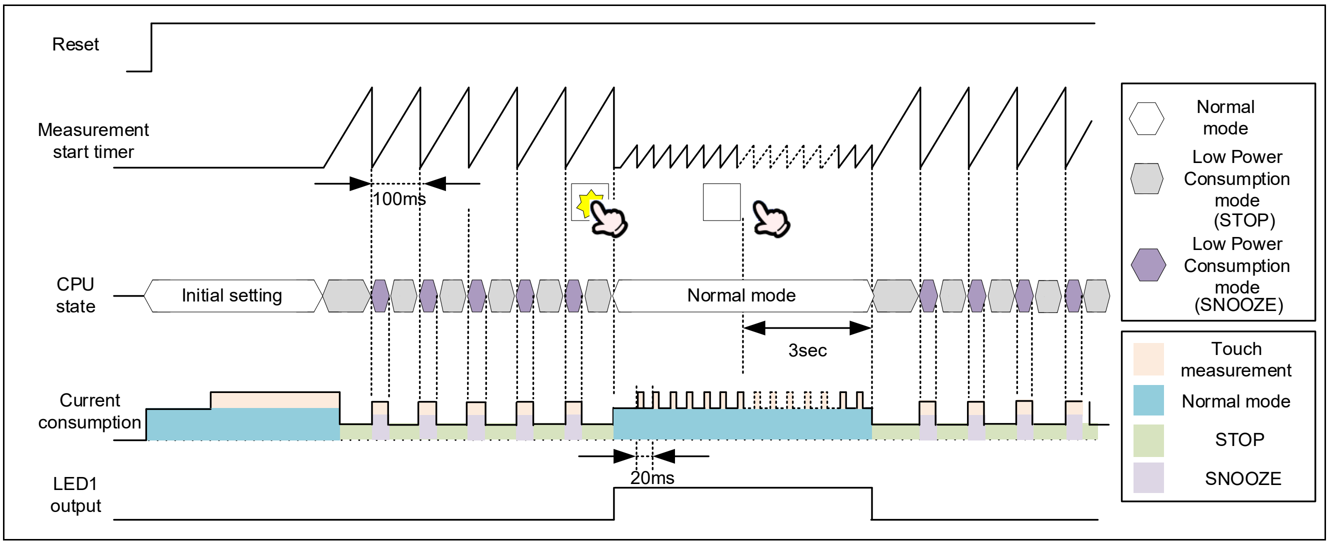


Figure 7.1 Operation image during touch measurement using SMS

8. Current measurement software flow chart

The flow chart of the sample project is described below.

8.1 Main processing

Figure 8.1 shows the flowchart of main processing.

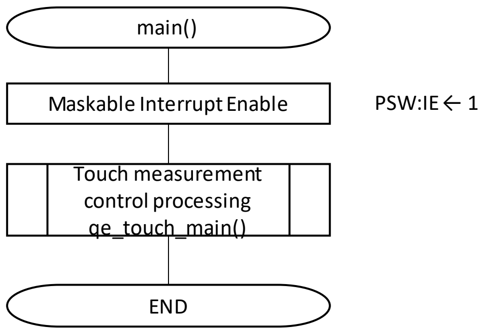


Figure 8.1 Flowchart of main processing

8.2 Touch measurement control processing

Figure 8.2shows the flowchart of touch measurement control processing.

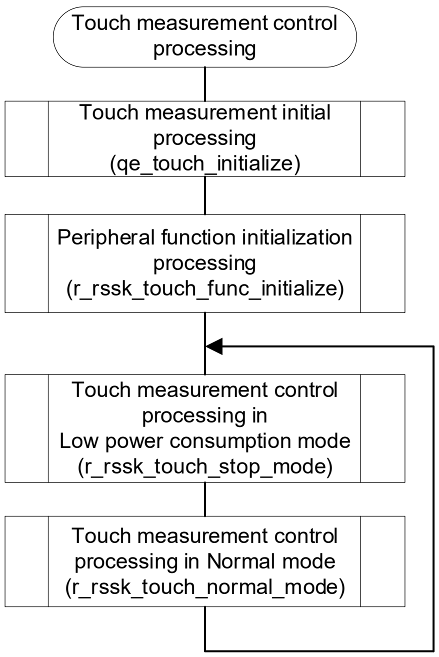


Figure 8.2 Flowchart of Touch measurement control processing

8.3 Touch measurement initial processing

Figure 8.1 Figure 8.3 and Figure 8.4 and Figure 8.5 shows the flowchart of touch measurement initial processing.

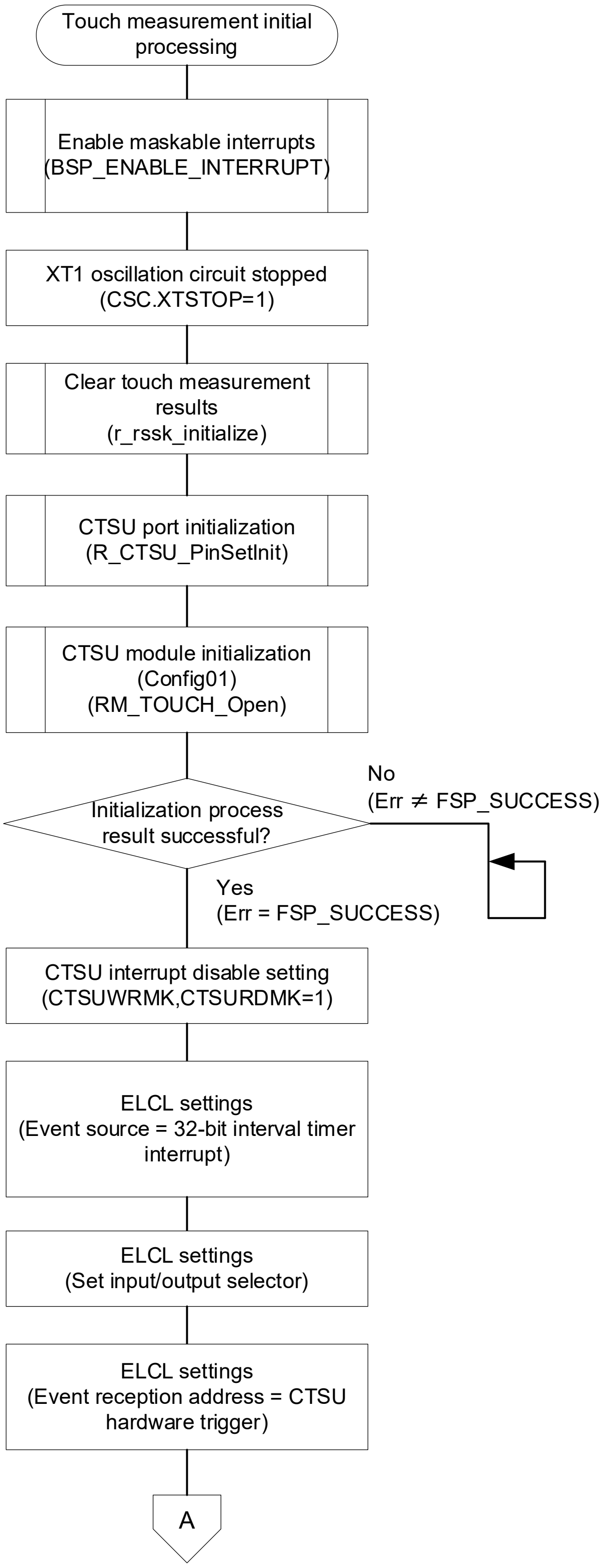


Figure 8.3 Flowchart of Touch measurement initial processing (1/3)

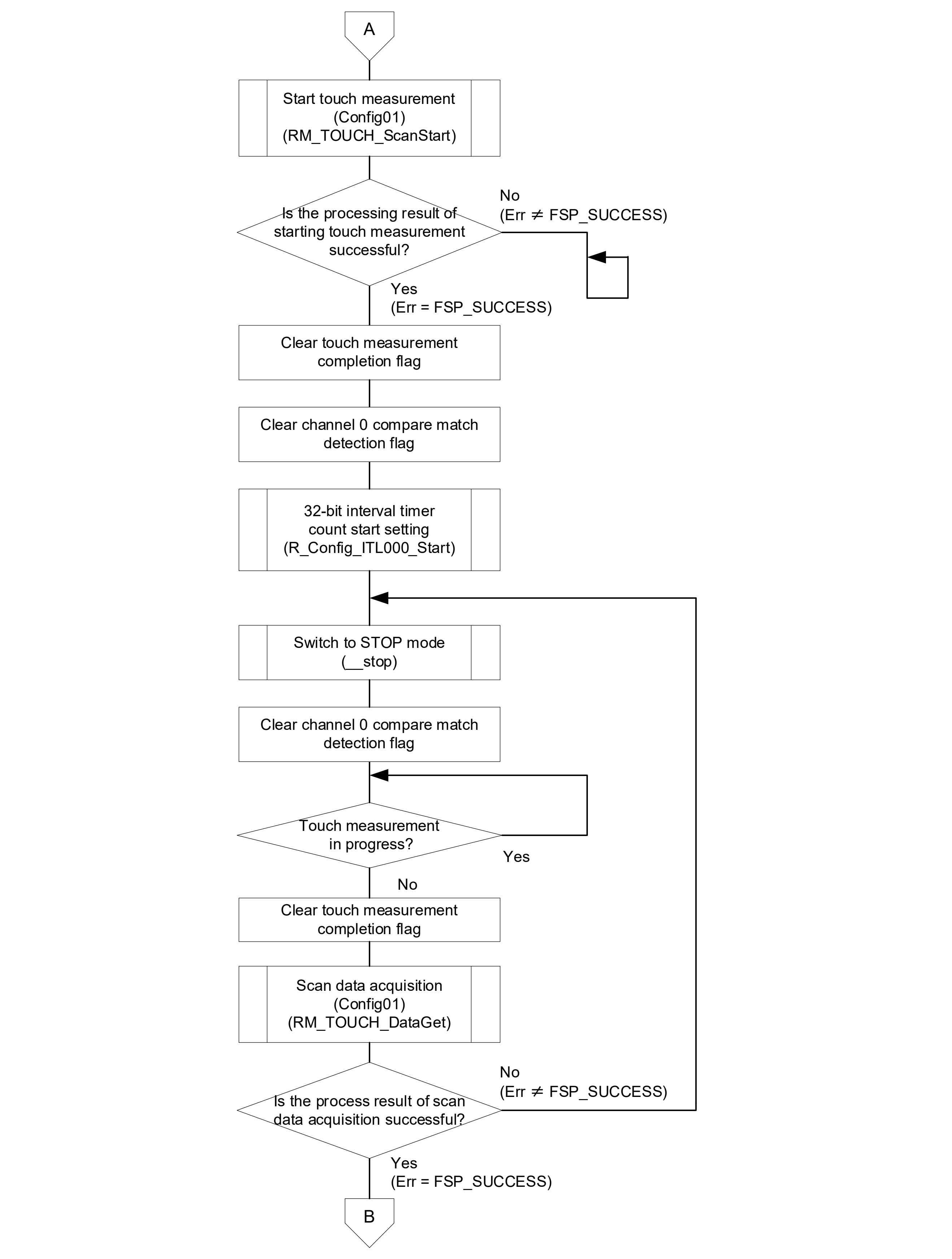


Figure 8.4 Flowchart of Touch measurement initial processing (2/3)

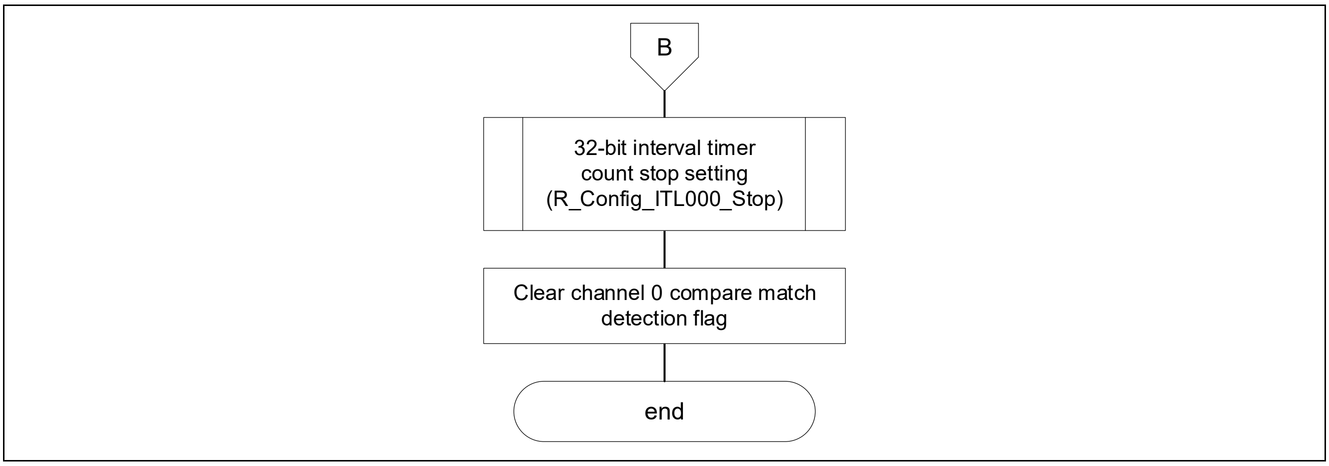


Figure 8.5 Flowchart of Touch measurement initial processing (3/3)

8.4 Peripheral function initialization processing

Figure 8.6shows the flowchart of peripheral function initialization processing.

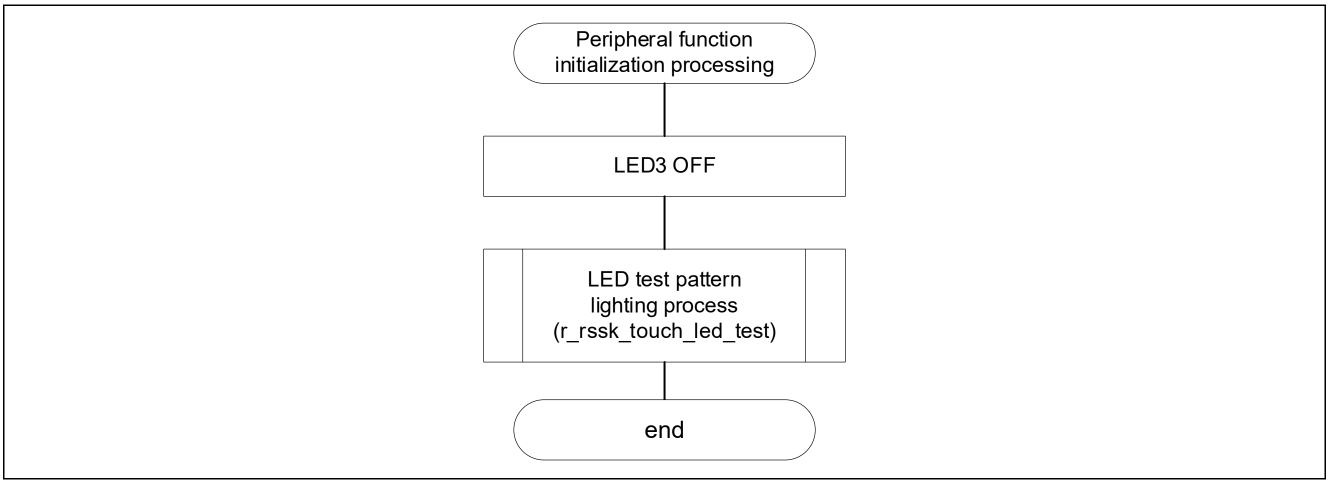


Figure 8.6 Flowchart of peripheral function initialization processing

8.5 Touch measurement control processing in Low power consumption mode

Figure 8.7 and Figure 8.8 and Figure 8.9 shows the flowchart of touch measurement control processing in low power consumption mode. Figure 8.10 shows the flowchart of SMS processing in SNOOZE mode.

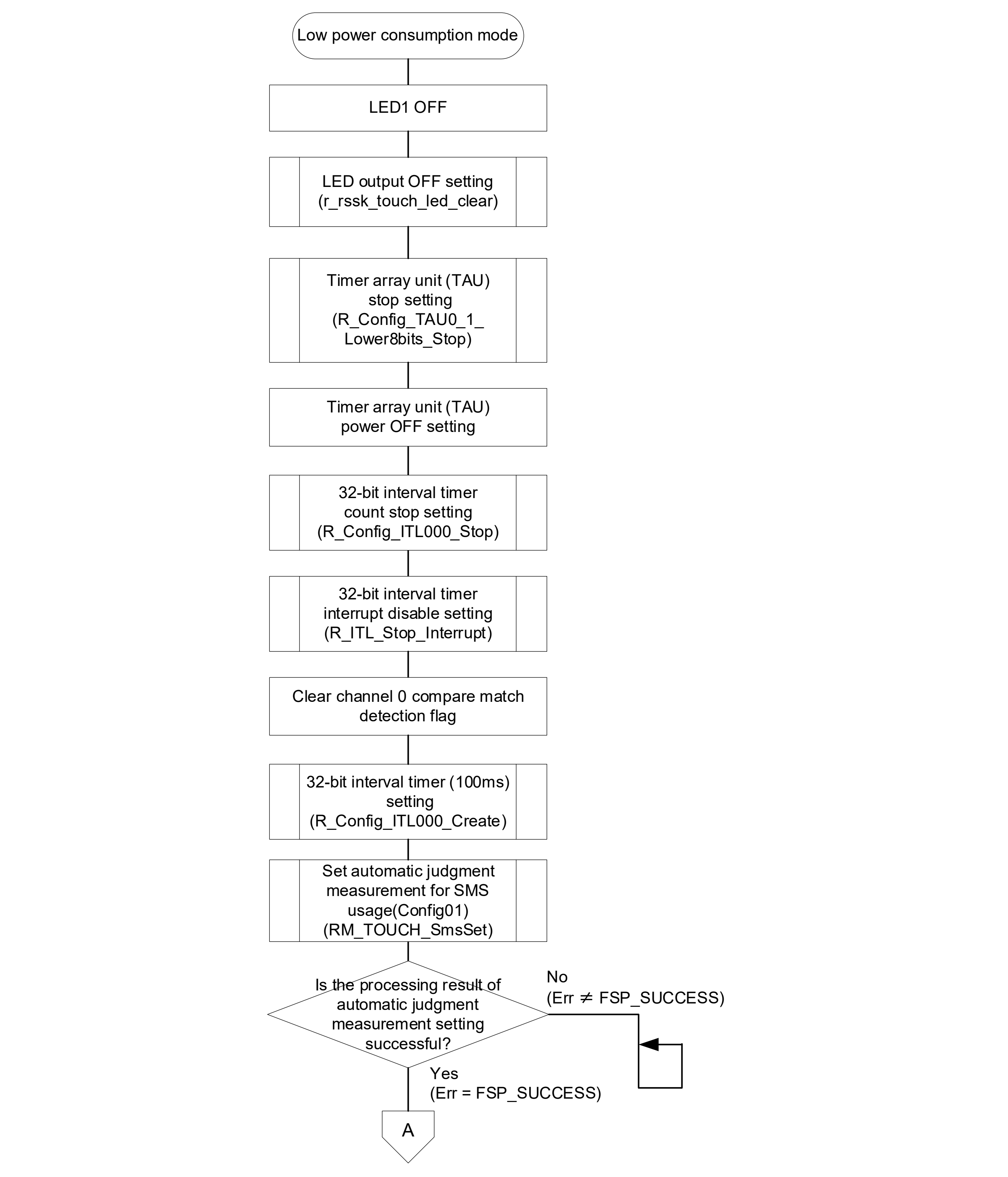


Figure 8.7 Flowchart of Touch measurement control processing in Low power consumption mode (1/3)

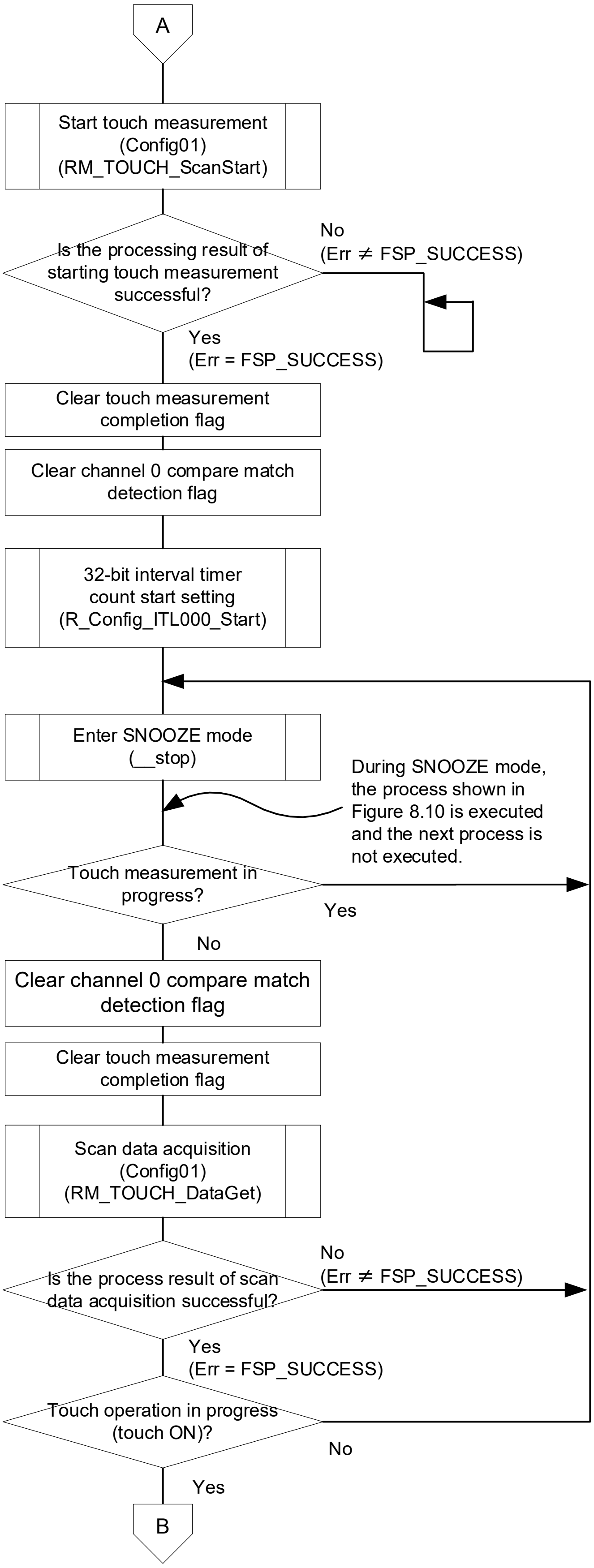


Figure 8.8 Flowchart of Touch measurement control processing in Low power consumption mode (2/3)

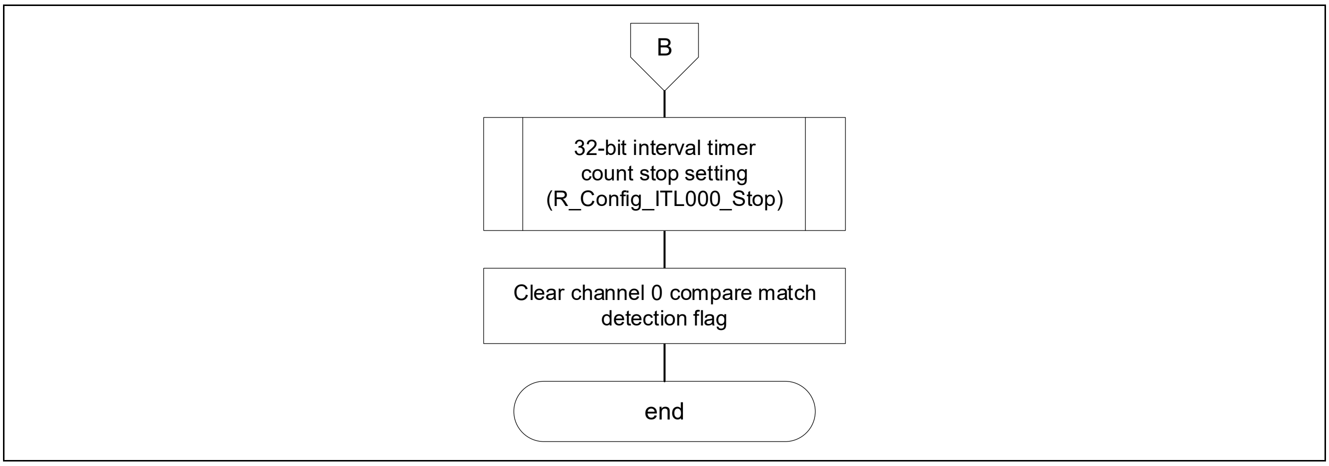


Figure 8.9 Flowchart of Touch measurement control processing in Low power consumption mode (3/3)

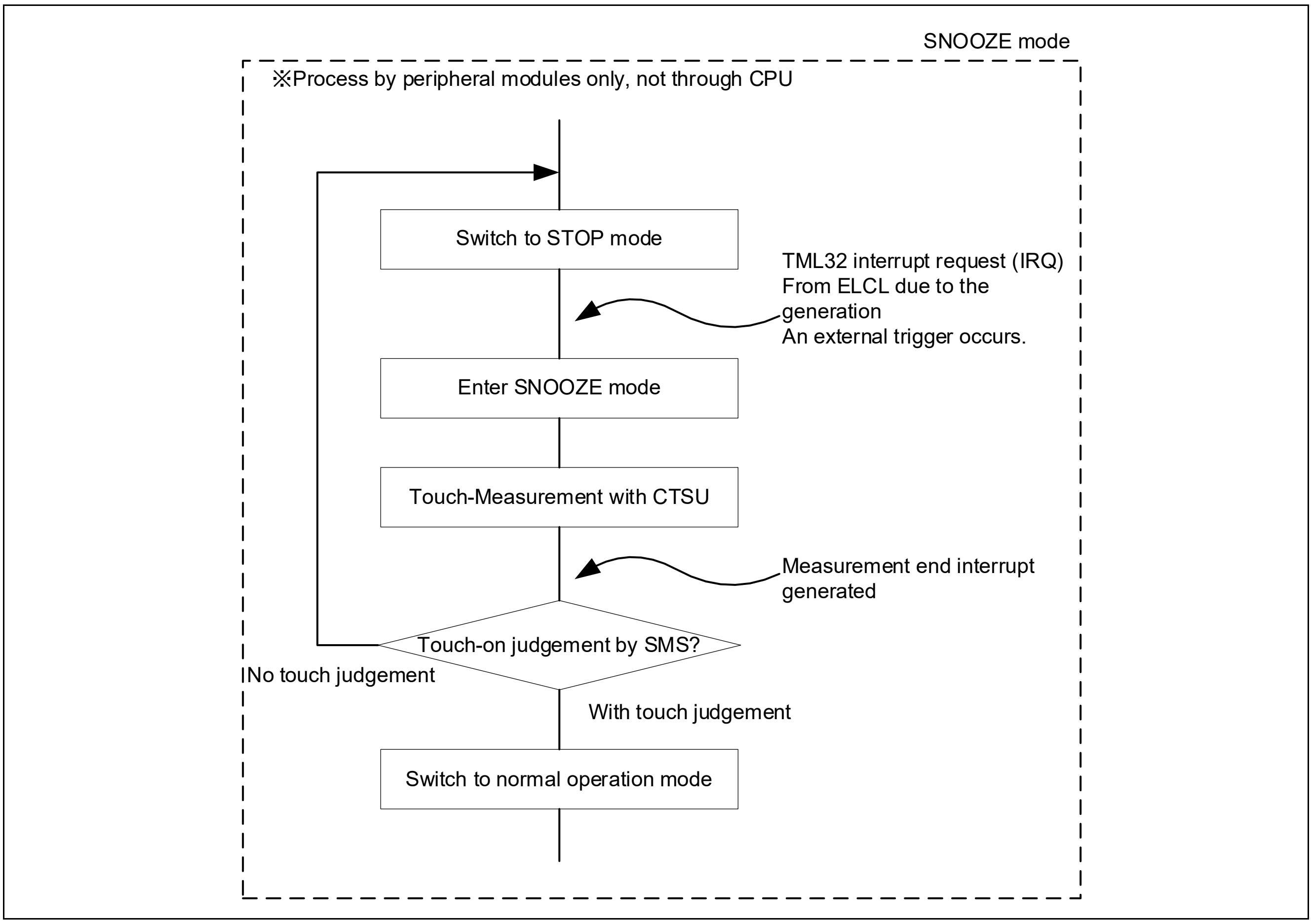


Figure 8.10 Flowchart of SMS processing in SNOOZE mode

8.6 Touch measurement control processing in Normal mode

Figure 8.11 and Figure 8.12 and Figure 8.13 shows the flowchart of touch measurement control processing in Normal mode.

Figure 8.11 Flowchart of Touch measurement control processing in Normal mode (1/3)

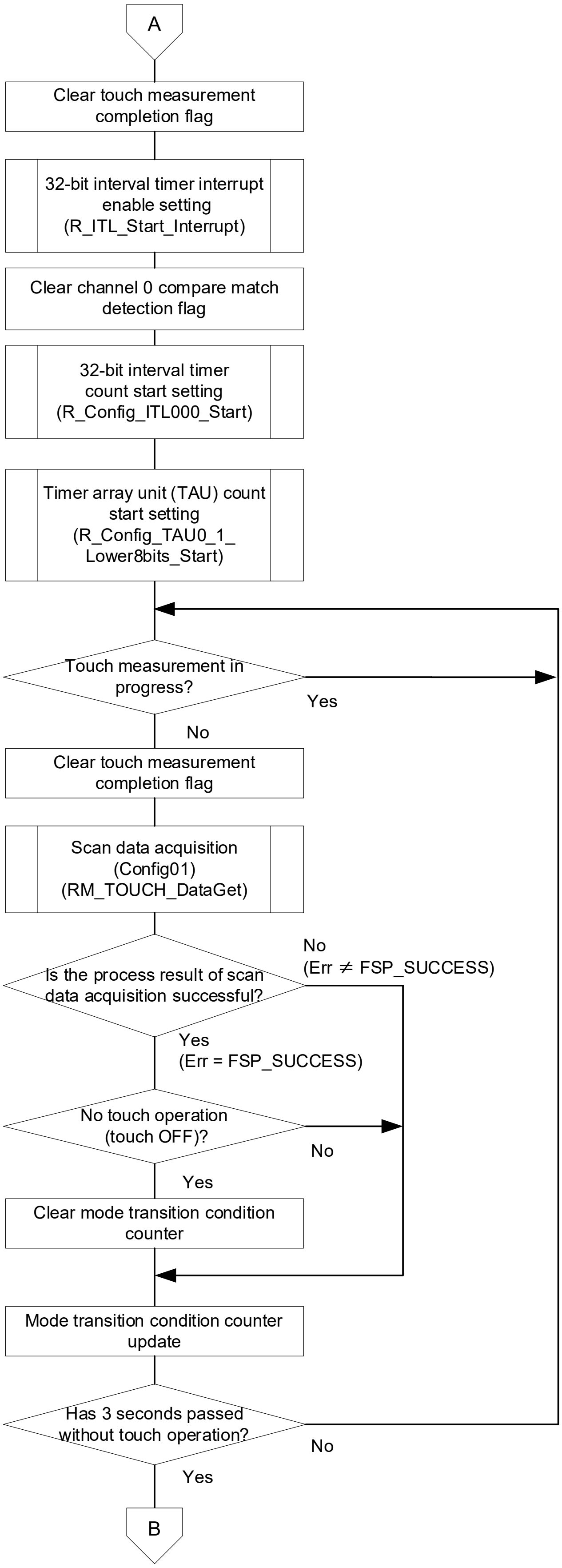


Figure 8.12 Flowchart of Touch measurement control processing in Normal mode (2/3)

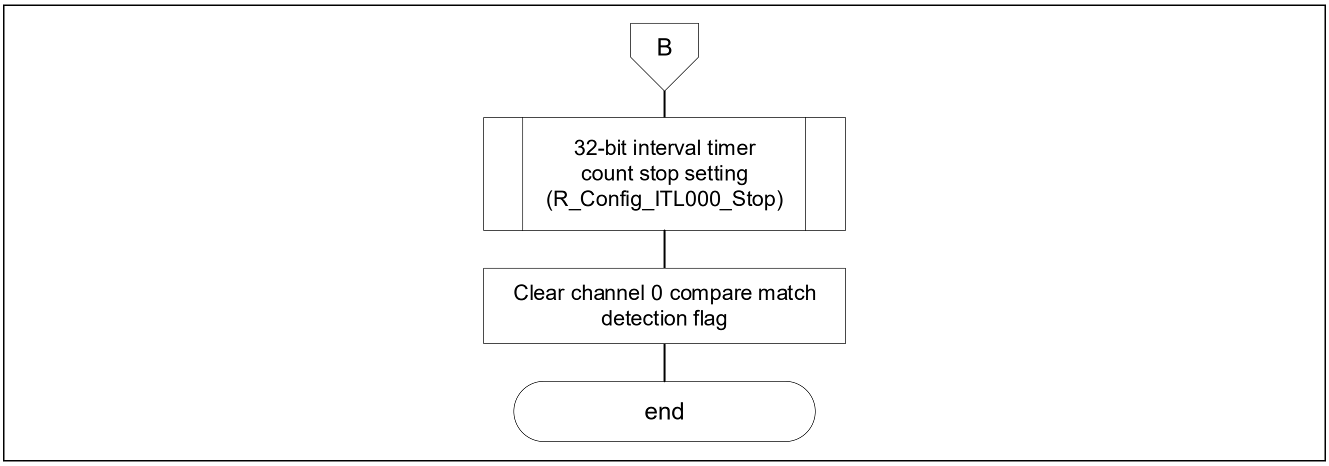


Figure 8.13 Flowchart of Touch measurement control processing in Normal mode (3/3)

9. How to measure current consumption

9.1 Environment to Measure Current Consumption

Figure 9.1 shows environment to measure current consumption.

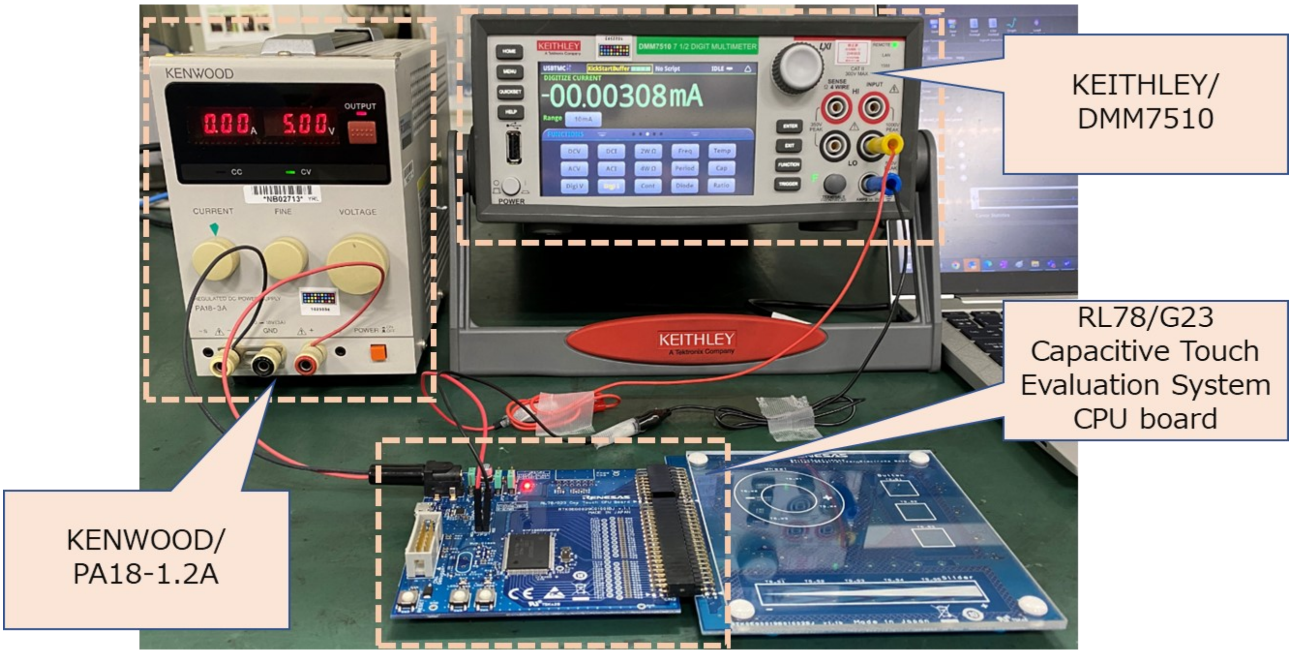


Figure 9.1 Environment to measure current consumption

9.2 Equipment and Software

Table 9.1 shows equipment and software used in current consumption measurement.

Table 9.1 Current measuring equipment and Software

Type	Name	Use
Digital multi meter	KEITHLEY/DMM7510	Measure current consumption.
Stable power suppl	KENWOOD/PA18-1.2A	Supply power to RL78/G23 Capacitive Touch Evaluation System CPU board.
Software	KEITHLEY/KickStart Software	Get result of current consumption measurement from Keithley DMM7510 and output the result to log-file.

9.3 How to connect the target board and each equipment

Figure 9.2 shows how to connect the RL78/G23 capacitive touch evaluation system CPU board and each equipment, and Figure 9.3 shows the power supply system diagram for the RL78/G23 capacitive touch evaluation system CPU board.

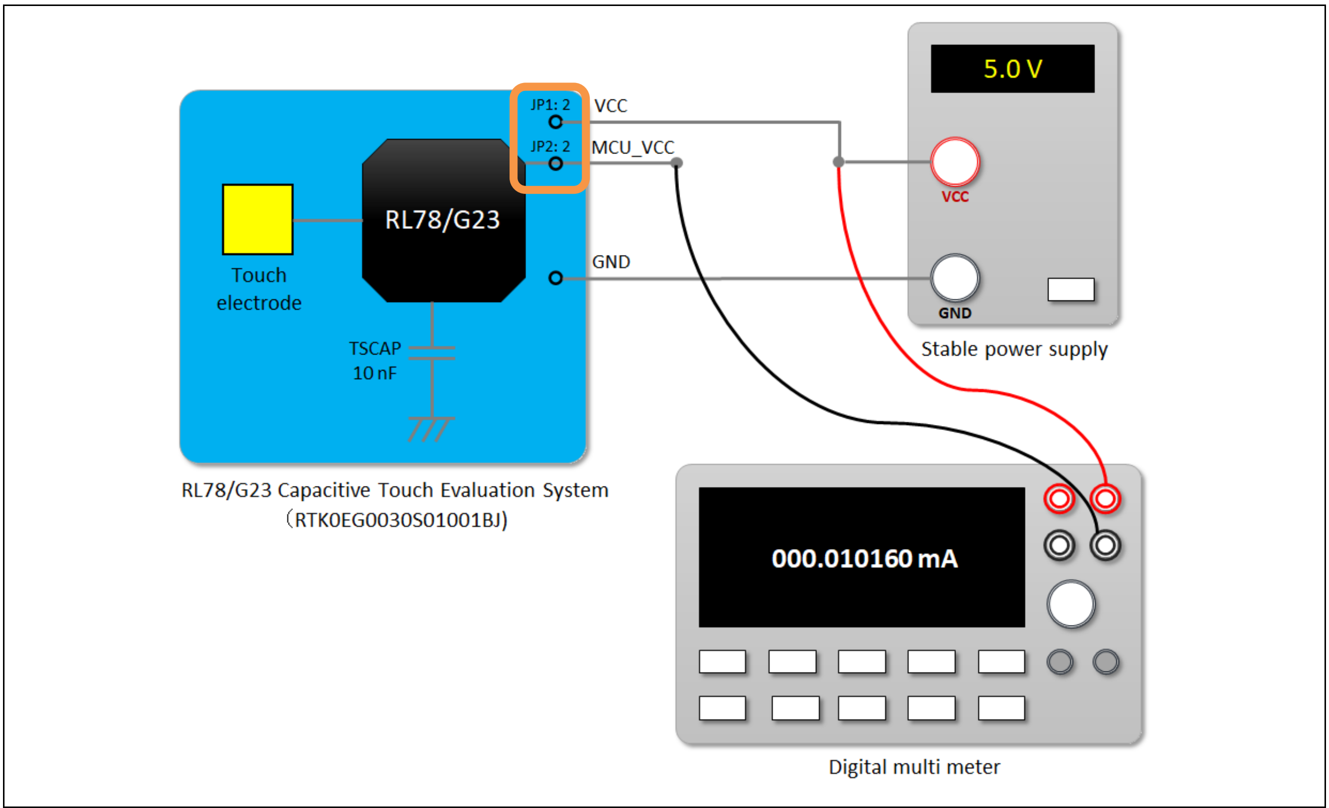


Figure 9.2 Connect the RL78/G23 capacitive touch evaluation system CPU board and each equipment

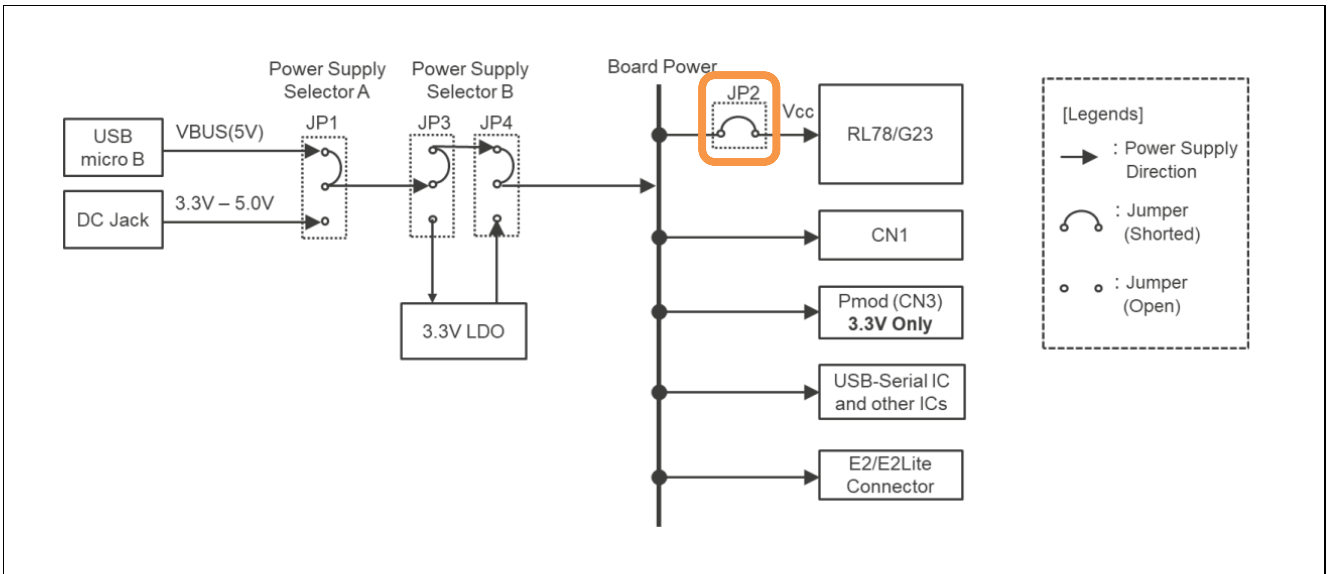


Figure 9.3 Power supply system diagram for the RL78/G23 capacitive touch evaluation system CPU board

9.4 RL78/G23 Capacitive Touch Evaluation System CPU Board

Figure 9.4 shows the pins of the RL78/G23 capacitive touch evaluation system CPU board connected to the digital multimeter, and Table 9.2 shows the jumper settings of the RL78G23 capacitive touch evaluation system CPU board.

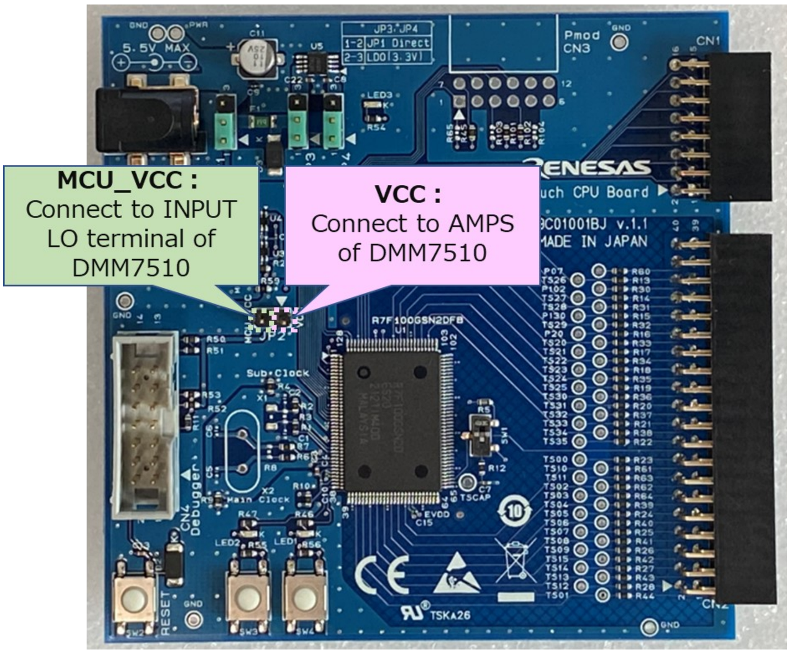


Figure 9.4 Pins of CPU board connected to the digital multimeter

Table 9.2 CPU board jumper settings

Position	Circuit group	Jumper setting	Use
JP1	VCC power	Open	Power supply from JP1: 2
JP2	MCU_VCC power	Open	Measure current consumption
JP3	Power supply jumper	Shorted pin 1-2	-
JP4	Power supply jumper	Shorted pin 1-2	-

9.5 Settings of current measuring software

Figure 9.5 shows settings of KEITHLEY/KickStart software to measure current consumption.

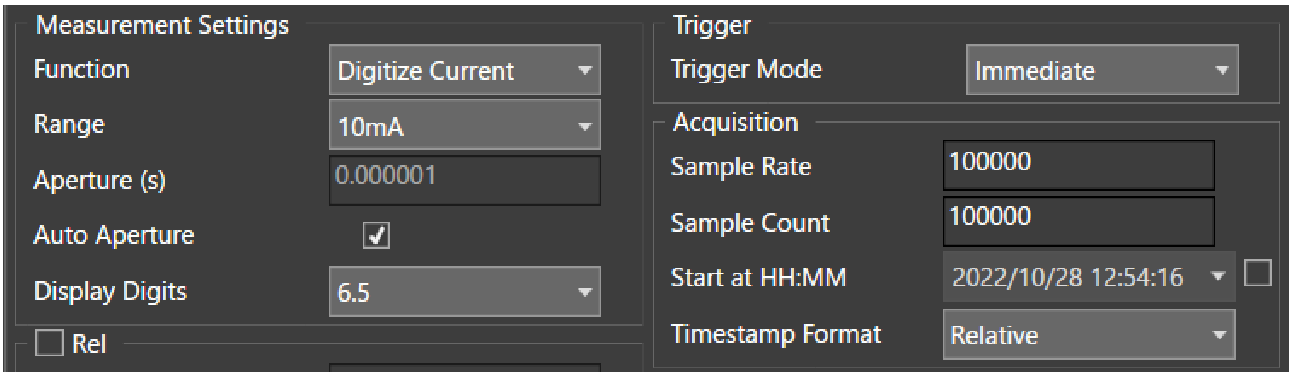


Figure 9.5 Settings of KEITHLEY/KickStart software

10. Current consumption measurement result

10.1 Current consumption waveform in intermittent operation

Figure 10.1 shows the Current consumption waveform in intermittent operation with touch measurement every 100ms.

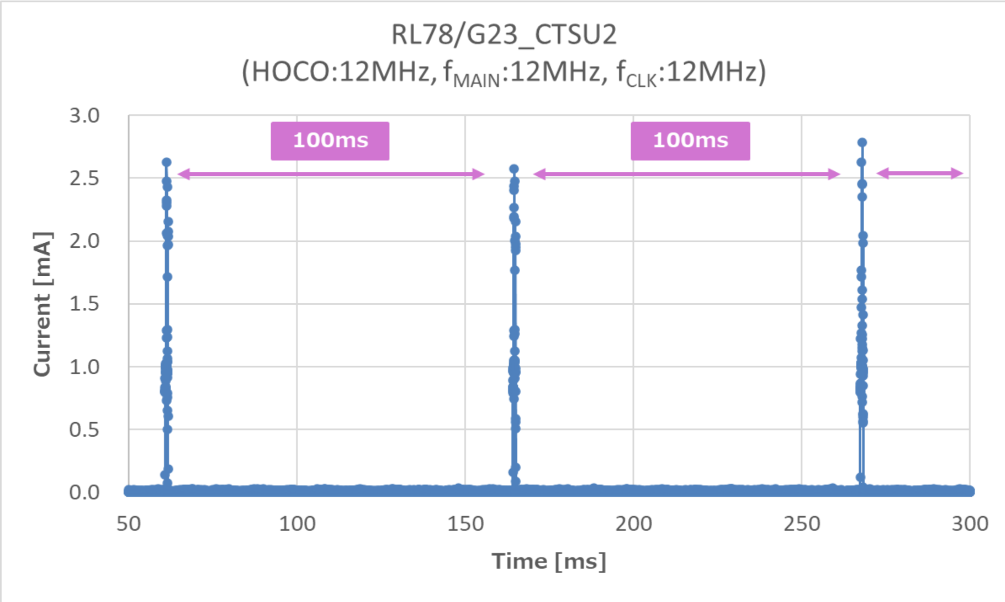


Figure 10.1 Current waveform in intermittent operation with touch measurement every 100ms

10.2 Current consumption waveform during CPU state transition (Touch measurement using SMS)

Figure 10.2 shows the current consumption waveform when the CPU operation mode transitions to STOP mode and SNOOZE mode (touch measurement processing + touch on/off determination processing).

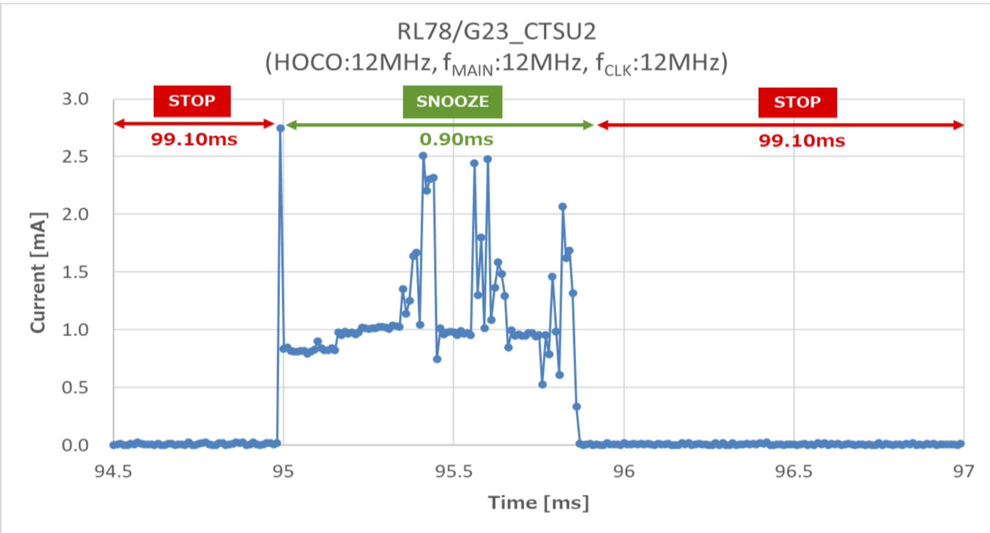
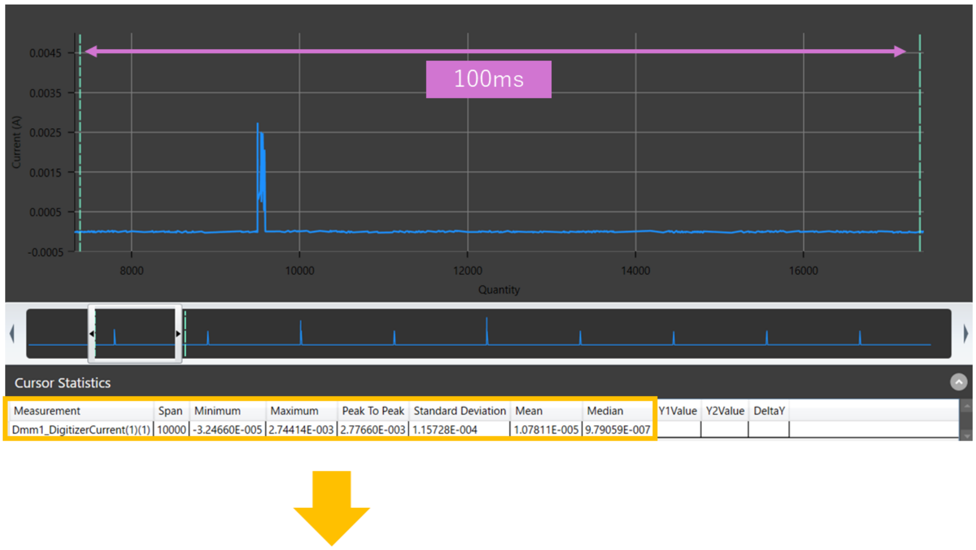


Figure 10.2 Current consumption waveform 1ch measurement (Touch measurement using SMS)

10.3 Calculation result of current consumption (Touch measurement using SMS)

Figure 10.3 shows the average current consumption of 100ms cycle by the KEITHLEY/KickStart software.



Measurement	Span	Minimum	Maximum	Peak To Peak	Standard Deviation	Mean	Median
Dmm1_DigitizerCurrent(1)(1)	10000	-3.24660E-005	2.74414E-003	2.77660E-003	1.15728E-004	1.07811E-005	9.79059E-007

Figure 10.3 Current consumption result by the KEITHLEY/KickStart (touch measurement using SMS)

Current consumption (touch measurement cycle of 100ms) = **10.7811 μA**

11. Related Document

RL78/Gxx User’s Manual: Hardware
- RL78/G23 User’s Manual: Hardware (R01UH0896)

RL78 Family User's Manual: Software (R01US0015)
(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 Environments
(The latest version can be downloaded from the Renesas Electronics website.)

User's Manual：RL78/G23 Capacitive Touch Evaluation System（RTK0EG0030S01001BJ)
(The latest version can be downloaded from the Renesas Electronics website.)

Application Note RL78 Family Capacitive Touch Sensing Unit (CTSU2L) Operation Explanation (R01AN5744)
Application Note RL78 Family
Using QE and SIS to Develop Capacitive Touch Applications (R01AN5512)
Application Note RL78 Family CTSU Module Software Integration System (R11AN0484)
Application Note RL78 Family TOUCH Module Software Integration System (R11AN0485)
Application Note Capacitive Sensor Microcontrollers CTSU Capacitive Touch Electrode Design Guide (R30AN0389)
(The latest version can be downloaded from the Renesas Electronics website.)

Website and Support

Renesas Electronics Website
http://www.renesas.com/

Capacitive Sensing Unit related page
https://www.renesas.com/solutions/touch-key
https://www.renesas.com/qe-capacitive-touch

Inquiries
http://www.renesas.com/contact/

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Oct.31.22	-	First edition issued
1.10	May.31.24	1	Related documents moved to P.24
		3	1. Overview The comparison with "RL78 Family RL78/G23 Capacitive Touch Low Power Consumption Guide (SNOOZE Function)" has been deleted. 2. Peripheral functions Added description.
		4	3. Operation Environment/Conditions Table 3-1 Operation environment Added LVD0 description to operating voltage and updated the version of the tool used. Table 3-2 Operation conditions Changed the item name in the table, changed the description of touch measurement period, and changed the description method.
		5	4.2 Method settings Added description. 5. Components used Change the version used, add voltage detection circuit.
		6	6. Option Byte settings Added description.
		7	7. Operation description Changed the operation of the sample program and changed the description content.
		8	7.1 Operation Image of CPU and CTSU Changed description of operation image diagram Deleted description of touch measurement without SMS (operation image)
		9 - 18	8. Current measurement software flowchart The comparison with "RL78 Family RL78/G23 Capacitive Touch Low Power Consumption Guide (SNOOZE Function)" has been deleted. Changed the operation of the sample program and changed the description content.
		22	Deleted description of touch measurement without SMS results.

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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