

Capacitive Sensor MCU

QE for Capacitive Touch Advanced Mode Parameter Guide

Introduction

QE for Capacitive Touch is a tool that generates tuning data which is used by Renesas MCU which have the CTSU peripheral (Capacitive Touch Sensing Unit).

By default, QE for Capacitive Touch generates tuning data via "Auto Tuning" mode. However, to optimize touch performance and to mitigate against unwanted behavior from environmental effects such as electrical noise, QE for Capacitive Touch supports an "Advanced mode" Tuning.

This application note describes "Advanced mode" Tuning and the CTSU parameters which can be adjusted.

If you are developing a Capacitive Touch for the first time, it is recommended that you read the Capacitive Touch Introduction Guide beforehand.

Capacitive Sensor Microcontrollers CTSU Capacitive Touch Introduction Guide (renesas.com)

Target Device

CTSU mounted RX family, RA family, RL78 family MCU, Renesas Synergy ™

(CTSU includes CTSU2, CTSU2L, CTSU2SL, etc.)



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1. Outline

QE for Capacitive Touch measures the parasitic capacitance of the user's touch sensor and performs autotuning to optimize the parameters. For more information about QE for Capacitive Touch, see Web page below.

Capacitive Sensor Microcontrollers CTSU Capacitive Touch Introduction Guide (renesas.com)

Auto tuning with QE for Capacitive Touch generates basic CapTouch parameters. If the required specifications are not met in evaluations using these parameter, perform manual tuning with CapTouch parameters. If further adjustment is required, perform "Advanced mode" Tuning. Figure 1-1 shows the tuning procedure in QE for Capacitive Touch.

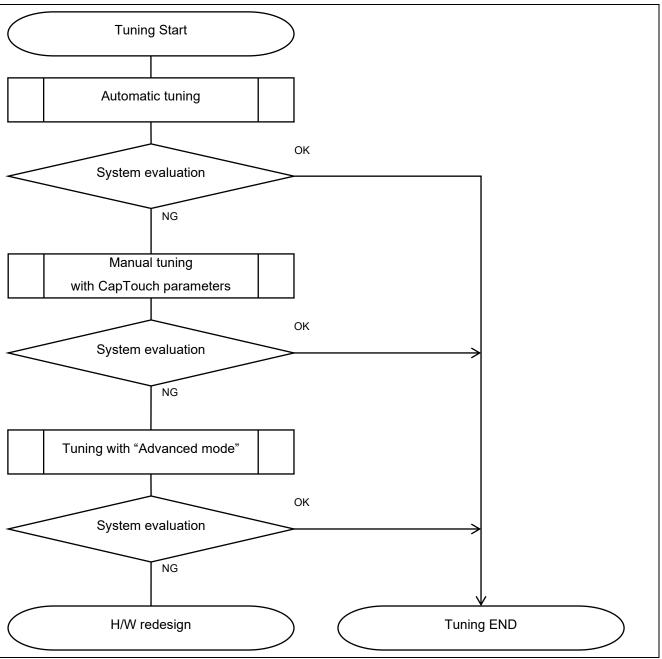


Figure 1-1 Tuning Flowchart



Table 1-1 lists the parameters that can be adjusted with Auto Tuning /Manual tuning with CapTouch parameters /"Advanced mode" Tuning.

| Table 1-1 | Tuning-ad | justable | parameters |
|-----------|-----------|----------|------------|
| | | | |

| Parameter | Auto tuning ^{*1} | Manual tuning with CapTouch parameters ^{*2} | Tuning with "Advanced mode" |
|---|---------------------------|---|-----------------------------|
| Measurement frequency | 1 | - | 1 |
| Offset | ✓ | - | - |
| Touch threshold | 1 | ✓ <i>✓</i> | - |
| Hysteresis | 1 | ✓ <i>✓</i> | - |
| Drift correction interval | - | ✓ <i>✓</i> | - |
| Long press cancel cycle | - | 1 | - |
| Positive noise filter cycles | - | ✓ | - |
| Cycle of the negative noise filter | - | ✓ | - |
| Depth of the moving average filter | - | ✓ | - |
| Number of Measurements/Number of Time | - | _*4 | 1 |
| Target value of Offset Tuning | - | _*4 | 1 |
| Measured Current Range *3 | - | - | 1 |
| Non-Measured Channel Output Select ^{*3} | - | - | 1 |
| Multi-Clock Measuring/Multiplier Rate ^{*3} | - | _*4 | 1 |
| Transmit Terminal Power | - | - | 1 |
| Automatic Correction (Hardware) ^{*3} | - | - | 1 |

✓: Supported

Note: 1. In Auto tuning, QE for Capacitive Touch automatically adjusts parameter values and outputs the adjustment results to a source file.

Note: 2. For manual tuning with CapTouch parameters, see "CapTouch Parameters (QE)" in QE for Capacitive Touch for a list of parameters that can be changed. For details, please refer to "7.2 Manually Tuning with CapTouch Parameters" in the following document.

Capacitive Sensor Microcontrollers CTSU Capacitive Touch Introduction Guide (renesas.com)

Note: 3. This function can be adjusted only for CTSU2/CTSU2L/CTSU2La/CTSU2SL. For CTSU2La/CTSU2L from the next page, refer to CTSU2. Also, please refer to the Introduction Guide for the difference between each capacitive touch sensor and compatible products. Capacitive Sensor Microcontrollers CTSU Capacitive Touch Introduction Guide (renesas.com)

Note: 4. The registers can be set from the "CapTouch Parameters (QE)", but do not change them, as they are parameters adjusted by the software to follow the environment.

If the "Auto tuning" or "Manual tuning with CapTouch parameters" does not meet the user's requirements for sensitivity/noise immunity, you can adjust the parameters in "Advanced mode".



1.1 Auto tuning

Figure 1-2 shows the flow of Auto tuning.

| | ■ Automatic Tuning Processing × | | | |
|---------------------------------------|--|--|--|--|
| | QE is beginning the tuning process. | | | |
| Preparing for | During the tuning process, please do not touch the sensors on the target board until instructed by the QE Tuning Program. | | | |
| adjustment | and instacted by the QL furning Program. | | | |
| dujuotinent | Cancel | | | |
| | | | | |
| | Automatic Tuning Processing X | | | |
| Measuring | QE is measuring the parasitic capacitance for all touch sensors. During this measurement process, please do not touch the sensors on the target | | | |
| parasitic | board. | | | |
| capacitance | | | | |
| | Cancel <u>H</u> elp | | | |
| \sim | a Automatic Tuning Processing | | | |
| | QE is adjusting offset values for each sensor.(config01) | | | |
| Adjusting | During the adjustment process, please do not touch the sensors on the target board. | | | |
| the offset | Button00, TS00 35329 | | | |
| | | | | |
| | Cancel Help | | | |
| \sim | Automatic Tuning Processing X | | | |
| | QE is now starting sensitivity measurement for each of the touch sensors when not | | | |
| Measuring | touched.(config01) | | | |
| sensitivity | During this step, please do not touch the sensors on the target board. | | | |
| (while not touched) | | | | |
| | | | | |
| | Cancel | | | |
| | Automatic Tuning Processing X | | | |
| · · · · · · · · · · · · · · · · · · · | QE will now measure touch sensitivity for (Button00, TS00 @ config01). | | | |
| | In this step please use maximum touch pressure on the sensor with a metal conductor. Press any key on the PC keyboard to accept the sensitivity | | | |
| Measuring | measurement. | | | |
| sensitivity | Button00, TS00 @ config01: 15265 | | | |
| (while touched) | | | | |
| | Cancel Help | | | |
| | | | | |
| | Automatic Tuning Processing × The automatic tuning process is now complete. If overflow or warning/errors are | | | |
| ~ | indicated, those sensors can be retried. If there are continued overflows or | | | |
| | warning/errors, please consult the Renesas application notes for Capacitive Touch for guidance. | | | |
| Result of | Select the target Method Kind Name Touch Sensor Threshold Overflow Warning / Error | | | |
| the tuning | config01 Button0 TS00 65535 | | | |
| the taning | | | | |
| | Retry Continue the Tuning Process | | | |
| | Cancel <u>H</u> elp | | | |
| | | | | |

Figure 1-2 Flow of Auto tuning with QE for Capacitive Touch

Auto tuning adjusts the sensitivity of touch sensor detection to determine the optimal parameters. First, the capacitance at touch OFF is measured, and the measurement frequency is set according to the measurement result. Also, adjust the offset according to the target value of offset tuning. Then, the capacitance of the touch ON/OFF status is measured, touch thresholds, etc. are set, and the tuning result is output to the source file.



1.2 Manual tuning with CapTouch parameters

For Manual tuning with CapTouch parameters, software parameters can be changed from "CapTouch Parameters (QE)". The touch behavior and the effect of changing the parameter values can be viewed in real time.

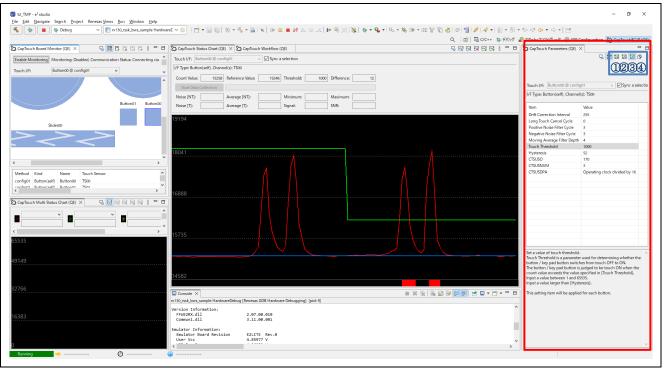


Figure 1-3 Manual Tuning with QE for Capacitive Touch

For Manual tuning, use the "CapTouch Parameters (QE)" in QE for Capacitive Touch (in red box in Figure 1-3). You can change the parameter and check the operation after adjusting it from the "CapTouch Status Chart (QE)" in real time. Parameters adjusted in this view can also be reflected in the source file. Refer to Table 1-2 for explanations of the functions of the "CapTouch Parameters (QE)" tool bar (in the blue frame in Figure 1-3) used when performing manual tuning. Parameters can be read and written to the application via the CapTouch Parameter icons.

| | | Icon Description | Feature Overview |
|---|-----|------------------------------------|--|
| 1 | | Read from target board | Reads parameter values from the target board. |
| 2 | | Write to target board | Write the value of the edited parameter to the target board. |
| 3 | 100 | Write to target board in real time | Toggle button to switch whether the numerical value of the parameter is reflected to the target in real time. |
| 4 | 3 | Generate a parameter file | The parameter file is output based on the parameter information adjusted in this view. |

"Generate parameter file" outputs the source file under the qe_gen folder. Table 1-3 shows the output source file. After outputting the source file, the operation of adjusted parameters can be checked by building and debugging.

Table 1-3 Source file output by "Generating a Parameter File"

| File name | Description |
|-------------------|--|
| qe_touch_config.c | File that holds parameter settings for each configuration (method) |

Please refer to the QE for Capacitive Touch "Help" for details.



1.3 "Advanced mode" Tuning

In the "Advanced mode" Tuning, it is possible to adjust mainly hardware parameters such as the sensor drive pulse output for measuring capacitance. For details on the parameters that can be adjusted, please refer to the table below 2.3 Correspondence table for each capacitive touch sensor.

Figure 1-4 shows the Cap Touch workflow (QE). Tuning can be performed from "2. Tuning Touch Sensors". Tuning by checking the "Advanced mode" checkbox under "Start Tuning".

| Oreparation Tuning | Coding Monitoring | | |
|-----------------------------|--|--|--|
| 1.Preparation - | Note on Use | | |
| Select a Project | | | |
| Prepare a Configuration | If you are tuning using emulator connection, you do not need to tune using serial | | |
| 2.Tuning Touch Sensors 🗸 🔻 | connection. | | |
| Start Tuning (Emulator) | Start Tuning | | |
| Start Tuning (Serial) | Start Tuning | | |
| Output Parameter Files | QE will automatically perform tuning | | |
| 3.Coding - | processing for each touch sensor. Connect your target board and PC via an | | |
| Implement Program | emulator. | | |
| 4.Monitoring - | | | |
| Start Monitoring (Emulator) | To Start Tuning | | |
| Start Monitoring (Serial) | Follow instructions in the dialog. | | |
| | Start Tuning | | |

Figure 1-4 Tuning with "Advanced mode"

When tuning with "Advanced mode" Tuning is started, a window as shown in Figure 1-5 is displayed and each parameter can be adjusted. After desired parameters are adjusted, click the "Start the Tuning Process" button in the blue frame in Figure 1-5 to start tuning.

| Multi-Clock Measuring Multiplier Rate 1 Multiplier Rate 2 Multiplier Rate 3 Automatic Correction (Hardware) Judgement Type System 3 Frequencies 64 55 73 Enable Default | |
|---|--|
| | |
| Method Kind Name Touch Sensor Number of Measurements / Number of Time Measurement Frequency config01 Button(self) Button00 TS08 Auto Auto | |

Figure 1-5 "Advanced mode" Tuning window

The parameters that can be adjusted in "Advanced mode" Tuning vary depending on the device. For details, see 2.3 Correspondence table for each capacitive touch sensor.



After tuning in the "Advanced mode", you can reflect the results of parameter adjustment in the source file by clicking the "Output Parameter Files" button shown in Figure 1-6 from the "To Output Parameter Files" menu.

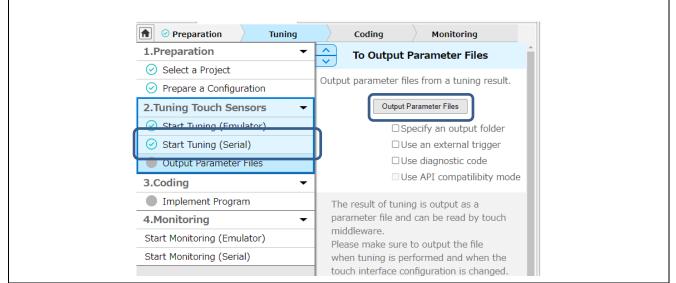


Figure 1-6 To Output Parameter Files

Click the Output File button to output the source file under the "qe_gen" folder. Table 1-4 Source files output by the "Output Parameter Files" button

| Table 1-4 Source files | output by the "Output | t Parameter Files" button |
|------------------------|-----------------------|---------------------------|
| | output by the output | |

| File name Description | | | |
|-------------------------------|--|--|--|
| qe_touch_define.h | Macro information file used by the touch middleware | | |
| qe_touch_config.h | Files to include from user programs | | |
| qe_touch_config.c | File that holds parameter settings for each configuration (method) | | |

After outputting the source file, the operation of adjusted parameters can be checked by building and debugging.

Setting these values incorrectly or without a clear understanding may result in poor adjustment results. Adjust the value after sufficiently evaluating it to suit the environment in which it is used.



2. "Advanced mode" settings

2.1 Sensitivity improvement adjustment flow

Figure 2-1 shows the adjustment steps to improve sensitivity through "Advanced mode" Tuning.

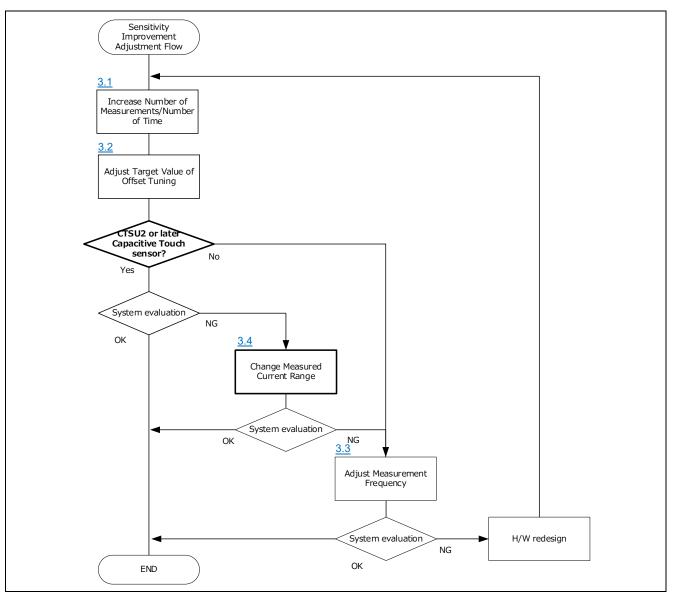


Figure 2-1 Sensitivity improvement adjustment flow



2.2 Noise suppression adjustment flow

Figure 2-2 shows the adjustment steps for improving noise immunity through "Advanced mode" Tuning.

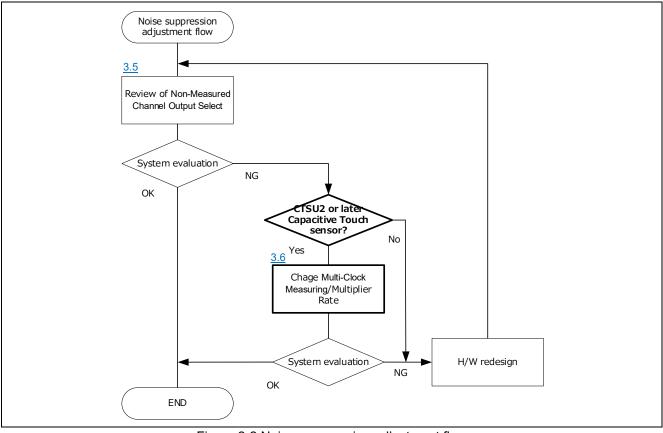


Figure 2-2 Noise suppression adjustment flow



2.3 Correspondence table for each capacitive touch sensor

Table 2-1 Correspondence table of capacitive touch sensors

| | Parameter | Purpose | CTSU2SL | CTSU2 | CTSU1 | Feature Overview |
|---|--|--|----------|-------|-------|---|
| 1 | <u>Number of</u> <u>Measurements/Number</u> <u>of Time</u> | Improved sensitivity | 1 | 5 | 5 | Set the number of measurements and determine the measurement time. The signal value can be improved by integrating the number of measurements. |
| 2 | <u>Target value of Offset</u> <u>Tuning</u> | Improved sensitivity | 1 | 1 | 1 | Set the target value (%) of the offset current so that the measured value at touch OFF becomes the target value. Adjust this when the measurement time is changed. |
| 3 | <u>Measurement</u> <u>frequency</u> | Improved sensitivity | ~ | 1 | 1 | Sets the frequency division ratio of the frequency output to the touch sensor. The higher the measurement frequency, the better the sensitivity can be seen. However, a measurement error occurs when the parasitic capacitance is large. |
| 4 | Measured Current Range | Improved sensitivity | 1 | 1 | - | Sets the power supply capability from VDC and determines the current mirror ratio between the measured power supply current and the input current of the current-controlled oscillator. Setting a low measuring current range increases the sensitivity. This is because CCO input current at touch ON increases. |
| 5 | <u>Non-Measured</u> <u>Channel Output Select</u> | Noise Suppression | v | 1 | - | These bits set the handling of non-measurement terminals other than the measurement terminals during the measurement interval of the terminals set in TS terminal. Noise suppression can be achieved by appropriately processing the non-measurement terminals. |
| 6 | <u>Multi-Clock</u> <u>Measuring/Multiplier</u> <u>Rate</u> | Noise Suppression | \$ | 1 | - | Set the number of times to be measured in multi- Clock measurement and the multiplier rate of multiple types of frequencies to be used for measurement. Multi-Clock Measurement allows you to measure multiple drive frequencies to avoid synchronous noise |
| 7 | <u>Transmit Terminal</u> <u>Power</u> | Terminal Setting | 1 | 1 | J | Selects I/O power supply of the terminals set to the transmit terminals when the mutual capacitance method is used or the active-shield is used. This value uses the default setting and should not be changed. |
| 8 | Automatic Correction (Hardware) | Process reduction Low power consumption | <i>√</i> | - | - | Sets whether to process the compensation computation with CTSU peripheral. Hardware processing eliminates the need for wake-up for each measurement and contributes to power consumption reduction. |

Table 2-1 Correspondence table of capacitive touch sensors.

✓: Supported



3. Overview of each parameter

3.1 Number of Measurements/Number of Time

In "Number of Measurements/Number of Time", you can set how many times the charge/discharge is accumulated repeatedly to perform one touch detection, and determine the measurement time for one touch detection. By increasing the number of measurements, the signal value* can be increased, leading to improved sensitivity. However, since measurement time is also extended at the same time, adjustment according to the user's specifications is required. In addition, adjust the offset tuning target by the target value of offset tuning to prevent overflow when the number of measurements is changed. Refer to 3.2 Target value of Offset Tuning for details of offset tuning target adjustment.

Note: The signal value indicates the difference value at touch ON/OFF.

Figure 3-1 shows the image of the measurement times by the number of measurements and the measured value at the time of touch ON/OFF.

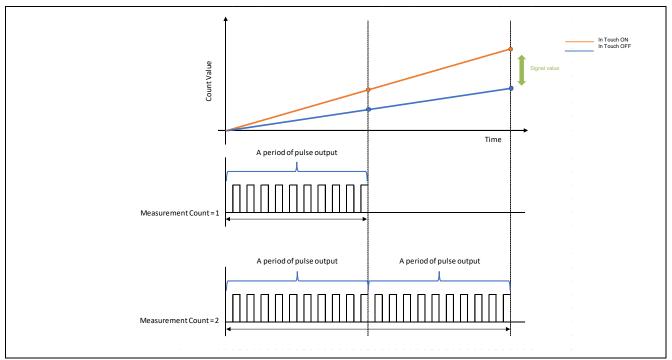


Figure 3-1 Image of measurement time and measurement value based on the number of measurements

Table 3-1 shows the default number of measurements.

| Table 3-1 Default "Number of measurements" Setti | ng |
|--|----|
|--|----|

| | Measurement frequency (sensor drive pulse frequency) | Number of measurements *1 | Measurement time [µs] |
|---------------------------------|---|------------------------------|--------------------------|
| CTSU1 | 4 MHz | 8 | |
| (Sample RX130) | 2 MHz | 4 | 526 |
| | 1 MHz | 2 | 520 |
| | 0.5 MHz | 1 | |
| CTSU2/CTSU2SL (Sample RX140) | - | 8 | 128 ^{*2} |

Note: 1. Refer to the respective capacitive touch sensor hardware manual for more information on SNUM. By CTSU2/CTSU2SL, the number of measurements is fixed at 8.

Note: 2. The measurement time of one frequency is described.



The stabilization wait time and measurement time also vary depending on the number of measurements. The formulas for calculating the stabilization wait time and measurement time for CTSU1, CTSU2/CTSU2SL are shown below.

• CTSU1 (RX130)

Stabilization wait time $[\mu s] = 34 \times (1/\text{sensor drive pulse frequency})$

Measurement time [µs] = 263 × (1/sensor drive pulse frequency) × (number of measurements)

Table 3-2 shows a typical example of the measurement time and stabilization wait time when the self-capacitance method is used in RX130 as a typical CTSU1.

Table 3-2 Stabilization Wait Time and measurement time when using self-capacitance method on RX130

| Sensor drive pulse frequency [MHz] | Number of measurements | Stabilization wait time [µs] | Measurement time [µs] | Total (Stabilization wait time + Measurement time) [µs] |
|---------------------------------------|---------------------------|---------------------------------|--------------------------|--|
| 4 | 8 | 8.5 | 526 | 534.5 |
| 2 | 4 | 17 | 526 | 543 |
| 1 | 2 | 34 | 526 | 560 |
| 0.5 | 1 | 68 | 526 | 594 |

Note: Recommended CTSUPRRTIO, CTSUPRMODE are used. Changing this value is deprecated. For details, refer to the hardware manual of each capacitive touch sensor.

• CTSU2/CTSU2SL (RX140)

Stabilization wait time [µs] = (64 × 3 [for 3 frequency measurement])

Measurement time [µs] = (16 × (number of measurements) × 3 [for 3 frequency measurement])

Table 3-3 shows a typical CTSU2/CTSU2SL for the measurement time and stabilization wait time when the self-capacitance method is used in RX140.

Table 3-3 Stabilization wait time and measurement time when using self-capacitance method with RX140 (3 frequency measurement)

| Number of measurements | Stabilization wait | Measurement time | Total (Stabilization wait time + |
|-----------------------------|--------------------|------------------|----------------------------------|
| | time [µs] | [µs] | Measurement time) [µs] |
| 8 [(STCLK cycle* 8) * 8] | 192 [64 × 3] | 384 [128 × 3] | 576 [384 + 192] |

Note: STCLK cycling is a reference clock for measuring times. It is set to the recommended 0.5MHz (2µs).

The stabilization wait time and measurement time when each capacitive touch sensor is used vary depending on the operation clock. Please refer to the hardware manual of each capacitive touch sensor and the following documents.

RX Family QE CTSU Module Using Firmware Integration Technology Rev.2.20 (renesas.com)



Figure 3-2 shows a window example when setting "Number of Measurements/Number of Time" with "Advanced mode".

| | Select se | etting valu | es for ea | ch method | / touch in | nterface. | | | | | | | | | |
|--|---|---|---|--|--|--|---------------------------------|-------------------|------------------|-------------|---------|--------|--------------|------------|-----|
| | | - | | | | | مع المعالمات | | | | | | | | |
| | | 1 | | tently or witho | | | | | - | | | | | _ | |
| | Method | Capacitance | | Shield Termin | al Target Val Auto | ue of Offset Ti | uning Trar ∨ Aut | nsmit Te | rminal P | ower | | | | | |
| | config01 | Self-Capacita | nce method | None | Auto | | V Aut | .0 | | | ~ | | | | |
| | Method | Kind | Name | Touch Sensor | Number of M | leasurements | / Number of | fTime | Measu | ement Fre | equenci | v | | -1 | |
| | config01 | | Button00 | TS08 | Auto | reasurements | / Number of | v | Auto | ementin | | y • | | | |
| | | | | | Auto | | | ^ | | | | | | | |
| | | | 1 | | 1 | | | | | | | | | | |
| | Start the T | uning Process |] | | 3 | | | | | | | | | | |
| | | | | | 5 | | | | | 6 | 1 | - | 11-1- | | |
| | | | | | Z Z | | | | | Can | cei | | <u>H</u> elp | | |
| | | | | | C | CTSU1 | | | | | | | | | |
| Automatic | Tuning Process | sina | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| elect sett | ing values | for each me | thod / tou | ch interface. | | | | | | | | | | | |
| 🔒 If you will | l set these value | es inadvertently or | without clear | understanding, it c | ould lead to poor | r tuning results. | | | | | | | | | |
| | | | |)ffset Tuning Me | | | asured Channe | -l Output | Select 1 | ransmit Pin | Power | | | | |
| | elf Capacitance | | uto | v Au | | ✓ Auto | asurea enanne | louput | ✓ A | | v | | | | |
| | | | | | | | | | | | | | | | |
| Mu | ulti-Clock Measu | uring Multiplier | Rate 1 Multi | olier Rate 2 Multi | iplier Rate 3 Jud | gement Type | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| System 3 Fr | requencies | 64 | 55 | 73 | Det | ault | | | | | | | | | |
| System 3 Fr | requencies | 64 | 55 | 73 | Det | ault | | | | | | | | | |
| Method K | ind Na | ame Touch S | ienso Numb | 73 er of Measurement | | me Neasureme | ent Frequency | | | | | | | | |
| Method K | | ame Touch S | ienso Numb Auto | | | | ent Frequency | | | | | | | | |
| | ind Na | ame Touch S | ienso Numb Auto Auto (STCLK | er of Measurement cycle * 8) * 1 | | me Neasureme | ent Frequency | | | | | | | | |
| Method Ki config01 B | ind Na iutton(self) Bu | ame Touch S | ienso Numb Auto (STCLK (STCLK | er of Measurement cycle * 8) * 1 cycle * 8) * 2 | | me Neasureme | ent Frequency | | | | | | | | |
| Method K | ind Na iutton(self) Bu | ame Touch S | ensc Numb Auto (STCLK (STCLK (STCLK | er of Measurement cycle * 8) * 1 cycle * 8) * 2 cycle * 8) * 3 cycle * 8) * 4 | | me Neasureme | ent Frequency | | | | | | | | |
| Method Ki config01 B | ind Na iutton(self) Bu | ame Touch S | ienso Numb Auto (STCLK (STCLK (STCLK (STCLK (STCLK | er of Measurement cycle * 8) * 1 cycle * 8) * 2 cycle * 8) * 3 | | me Neasureme | ent Frequency | | | | | | Cancel |] — н | -lp |
| Method Ki config01 B | ind Na iutton(self) Bu | ame Touch S | Auto Auto (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK) | cycle * 8) * 1 cycle * 8) * 2 cycle * 8) * 3 cycle * 8) * 3 cycle * 8) * 4 cycle * 8) * 5 | ts / Number of Tin | me Measureme v Juto | ent Frequency | | | | | | Cancel |) <u>H</u> | :lp |
| Method Ki config01 B | ind Na iutton(self) Bu | ame Touch S | Auto Auto (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK) | er of Measurement cycle * 8) * 1 cycle * 8) * 2 cycle * 8) * 3 cycle * 8) * 4 cycle * 8) * 5 cycle * 8) * 6 | ts / Number of Tin | me Neasureme | ent Frequency | | | | | (| Cancel | | łp |
| Method K config01 B Start the Tuni | ind Na iutton(self) Bu ing Process | ame Touch S utton00 TS11 | Auto Auto (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK) | er of Measurement cycle * 8) * 1 cycle * 8) * 2 cycle * 8) * 3 cycle * 8) * 4 cycle * 8) * 5 cycle * 8) * 6 | ts / Number of Tin | me Measureme v Juto | ent Frequency | | | | | | Cancel |) <u>H</u> | łlp |
| Method K config01 B Start the Tuni | ind Na iutton(self) Bu | ame Touch S utton00 TS11 | Auto Auto (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK) | er of Measurement cycle * 8) * 1 cycle * 8) * 2 cycle * 8) * 3 cycle * 8) * 4 cycle * 8) * 5 cycle * 8) * 6 | ts / Number of Tin | me Measureme v Juto | ent Frequency | | | | | | Cancel | Ш | łlp |
| Method K config01 B Start the Tuni | ind Na iutton(self) Bu ing Process | ame Touch S atton00 TS11 | Auto Auto (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK)) | er of Measurement cycle * 8) * 1 cycle * 8) * 2 cycle * 8) * 3 cycle * 8) * 4 cycle * 8) * 5 cycle * 8) * 6 | ts / Number of Tin | me Measureme v Juto | ent Frequency | | | | | | Cancel |) H | łþ |
| Method K config01 B Start the Tunio | ind Na autton(self) Bu ing Process c Tuning Process ting values | ame Touch S rtton00 TS11 | enso Numb Auto (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK)) (STCLK | er of Measurement cycle * 8) * 1 cycle * 8) * 2 cycle * 8) * 3 cycle * 8) * 3 cycle * 8) * 4 cycle * 8) * 5 cycle * 8) * 6 cycle * 8) * 7 | ts / Number of Tir | Auto | ent Frequency | | | | | | Cancel |] <u> </u> | łþ |
| Method K config01 B Start the Tuni Start the Tuni Automatie elect sett | ind Na hutton(self) Bu ing Process c Tuning Process ting values ill set these value | ame Touch S utton00 TS11 ssing for each me es inadvertently o | enso Numb Auto (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK)) (STCLK) (ST | er of Measurement cycle * 8) * 1 cycle * 8) * 2 cycle * 8) * 3 cycle * 8) * 3 cycle * 8) * 4 cycle * 8) * 6 cycle * 8) * 7 cycle * | ts / Number of Tin | r tuning results. | ~ | el Outout | Select 1 | ransmit Pir | Power | | Cancel |) <u>H</u> | łlp |
| Method K config01 B Start the Tuni Automatic elect sett A If you will Method C | ind Na autton(self) Bu ing Process c Tuning Process ting values Il set these valu Capacitance Typ | ame Touch S titton00 TS11 ising for each me es inadvertently o re Shield Pin 1 | enso Numb Auto (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK)) (STCLK) (ST | er of Measurement cycle * 8) * 1 cycle * 8) * 2 cycle * 8) * 3 cycle * 8) * 3 cycle * 8) * 5 cycle * 8) * 6 cycle * 8) * 6 cycle * 8) * 7 - + * * * | ts / Number of Tin | r tuning results. | ~ | el Output | Select 1 | | Power | | Cancel | | łþ |
| Method K config01 B Start the Tuni Automatic elect sett A If you will Method C | ind Na hutton(self) Bu ing Process c Tuning Process ting values ill set these value | ame Touch S titton00 TS11 ising for each me es inadvertently o re Shield Pin 1 | enso Numb Auto Auto (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK) | cycle * 8) * 1 cycle * 8) * 2 cycle * 8) * 2 cycle * 8) * 3 cycle * 8) * 4 cycle * 8) * 4 cycle * 8) * 5 cycle * 8) * 6 cycle * 8) * 7 cycle | ts / Number of Tin | Tuto | ~ | el Output | | | | | Cancel |) <u>H</u> | ŀlp |
| Method K config01 B Start the Tuni Automatic elect sett Method C config01 S | ind Na iutton(self) Bu ing Process c Tuning Process ting values Il set these valu Capacitance Typ Self Capacitance | ame Touch S atton00 TS11 sing for each me es inadvertently o re Shield Pin 1 2 None A | Auto Auto (STCLK) (STC | cycle * 8) * 1 cycle * 8) * 2 cycle * 8) * 2 cycle * 8) * 3 cycle * 8) * 4 cycle * 8) * 4 cycle * 8) * 5 cycle * 8) * 6 cycle * 8) * 7 cycle | ts / Number of Tir Could lead to poor easured Current R ito | r tuning results. Range Non-Me > Auto | vasured Channe | | ✓ A | | | | Cancel | | łþ |
| Method K config01 B Start the Tuni Automatic elect sett Method C config01 S | ind Na iutton(self) Bu ing Process c Tuning Process ting values ill set these valu Capacitance Typ Self Capacitance | ame Touch S atton00 TS11 sing for each me es inadvertently o re Shield Pin 1 2 None A | Auto Auto (STCLK) (STC | er of Measurement cycle * 8) * 1 cycle * 8) * 2 cycle * 8) * 3 cycle * 8) * 4 cycle * 8) * 4 cycle * 8) * 6 cycle * 8) * 7 tch interface. understanding, it o Dffset Tuning M v Au | ts / Number of Tir Could lead to poor easured Current R ito | r tuning results. Range Non-Me v Auto | easured Channe | | v A nent Type | | | | Cancel | Н | łlp |
| Method K config01 B Start the Tuni Automatie elect sett A If you wil Method C config01 S | ind Na iutton(self) Bu ing Process c Tuning Process ting values ill set these valu Capacitance Typ Self Capacitance | ame Touch S atton00 TS11 | enso Numb Auto Auto (STCLK (STCLK (STCLK) (STC | er of Measurement cycle * 8) * 1 cycle * 8) * 2 cycle * 8) * 2 cycle * 8) * 3 cycle * 8) * 5 cycle * 8) * 6 cycle * 8) * 6 cycle * 8) * 7 cycle * 7 cyc | ts / Number of Tin could lead to poor easured Current R itto | r tuning results. Range Non-Me v Auto | easured Channe | Judgen | v A nent Type | | | | Cancel | | łp |
| Method K config01 B Start the Tuni Automatie elect sett A If you wil Method C config01 S | ind Na autton(self) Bu ing Process c Tuning Process ting values ill set these valu Capacitance Typ Self Capacitance ulti-Clock Meas requencies | ame Touch S atton00 TS11 | enso Numb Auto (STCLK (STCLK) | er of Measurement cycle * 8) * 1 cycle * 8) * 2 cycle * 8) * 2 cycle * 8) * 3 cycle * 8) * 5 cycle * 8) * 6 cycle * 8) * 6 cycle * 8) * 7 cycle * 7 cyc | ts / Number of Tin Could lead to poor easured Current R ito iplier Rate 3 Aut v Ena | rtuning results. Auto tomatic Correction tomatic Correction total Correc | easured Channe | Judgen | v A nent Type | | | | Cancel | | łþ |
| Method K config01 B Start the Tuni Start the Tuni Automatic elect sett A If you wit Method C config01 S System 3 F Method k | ind Na autton(self) Bu ing Process c Tuning Process ting values ill set these valu Capacitance Typ Self Capacitance ulti-Clock Meas requencies | ame Touch S atton00 TS11 | enso Numb Auto Auto (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK) (STC | er of Measurement cycle * 8) * 1 cycle * 8) * 2 cycle * 8) * 2 cycle * 8) * 4 cycle * 8) * 5 cycle * 8) * 6 cycle * 8) * 7 cycle * 7 cyc | ts / Number of Tin Could lead to poor easured Current R ito iplier Rate 3 Aut v Ena | rtuning results. Auto tomatic Correction tomatic Correction total Correc | easured Channe | Judgen Default | v A nent Type | | | | Cancel | | łþ |
| Method K config01 B Start the Tuni Start the Tuni Start the Tuni Automatic elect sett Automatic elect sett Method C config01 S System 3 F Method k | ind Na iutton(self) Bu ing Process c Tuning Process ting values Il set these valu Capacitance Typ Self Capacitance ulti-Clock Meas requencies | ame Touch S atton00 TS11 | enso Numb Auto Auto (STCLK) (S | er of Measurement cycle * 8) * 1 cycle * 8) * 2 cycle * 8) * 2 cycle * 8) * 3 cycle * 8) * 5 cycle * 8) * 6 cycle * 8) * 7 cycle * 7 cyc | ts / Number of Tin Could lead to poor easured Current R ito iplier Rate 3 Aut v Ena | r tuning results. Range Non-Me > Auto tomatic Correctionable | vasured Channe on (Hardware) | Judgen Default | v A nent Type | | | | Cancel | | łp |
| Method K config01 B Start the Tuni Start the Tuni A If you will Method C config01 S System 3 Fi Method K config01 E | ind Na iutton(self) Bu ing Process c Tuning Process ting values Il set these valu Capacitance Typ Self Capacitance ulti-Clock Meass requencies Kind N Button(self) B | ame Touch S atton00 TS11 | enso Numb Auto (STCLK) | er of Measurement cycle * 8) * 1 cycle * 8) * 2 cycle * 8) * 2 cycle * 8) * 4 cycle * 8) * 5 cycle * 8) * 6 cycle * 8) * 7 cycle * 8) * 1 cycle * 8) * 1 cycle * 8) * 1 cycle * 8) * 1 cycle * 8) * 2 | ts / Number of Tin Could lead to poor easured Current R ito iplier Rate 3 Aut v Ena | r tuning results. Range Non-Me > Auto tomatic Correctionable | vasured Channe on (Hardware) | Judgen Default | v A nent Type | | | | Cancel | | Hp. |
| Method K config01 B Start the Tuni Start the Tuni A If you will Method C config01 S System 3 Fi Method K config01 E | ind Na iutton(self) Bu ing Process c Tuning Process ting values Il set these valu Capacitance Typ Self Capacitance ulti-Clock Meass requencies Kind N Button(self) B | ame Touch S atton00 TS11 | enso Numb Auto (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK)) (STCL) (STCL (STCL) (STCL) (STCL (STCLK)) | er of Measurement cycle * 8) * 1 cycle * 8) * 2 cycle * 8) * 3 cycle * 8) * 3 cycle * 8) * 5 cycle * 8) * 6 cycle * 8) * 7 | ts / Number of Tin Could lead to poor easured Current R ito iplier Rate 3 Aut v Ena | r tuning results. Range Non-Me > Auto tomatic Correctionable | vasured Channe on (Hardware) | Judgen Default | v A nent Type | | | | Cancel | | |
| Method K config01 B Start the Tuni Start the Tuni Start the Tuni Automatic elect sett Method C config01 S System 3 Fi Method k | ind Na iutton(self) Bu ing Process c Tuning Process ting values Il set these valu Capacitance Typ Self Capacitance ulti-Clock Meass requencies Kind N Button(self) B | ame Touch S atton00 TS11 | enso Numb Auto (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK (STCLK) (STCLK) (STCLK) (STCLK) (STCLK) Sensor Numb Auto Auto (STCL (STCL) (STCL (STCL) (STCL) (STCL (STCL) (STCL) (STCL) (STCL) (STCL) (STCL) (STCL) | er of Measurement cycle * 8) * 1 cycle * 8) * 2 cycle * 8) * 2 cycle * 8) * 4 cycle * 8) * 5 cycle * 8) * 6 cycle * 8) * 7 cycle * 8) * 1 cycle * 8) * 1 cycle * 8) * 1 cycle * 8) * 1 cycle * 8) * 2 | ts / Number of Tin Could lead to poor easured Current R ito iplier Rate 3 Aut v Ena | r tuning results. Range Non-Me > Auto tomatic Correctionable | vasured Channe on (Hardware) | Judgen Default | v A nent Type | | | | Cancel | | elp |

Figure 3-2 Setting of "Number of Measurements/Number of Time"

For the set value, the value of Number of measurements -1 is reflected to "snum" of the qe_touch_config.c. If "(STCLK Cycle* 8) * 8" is selected in "Number of Measurements/Number of Time", it is set as "snum = 0x07".

```
const ctsu_element_cfg_t g_qe_ctsu_element_cfg_config01[] =
{
    {
        { .ssdiv = CTSU_SSDIV_4000, .so = 0x12B, .snum = 0x07, .sdpa = 0x07 },
};
```

Note: Refer to the respective capacitive touch sensor hardware manual for more information on SNUM.



3.1.1 Impact on sensitivity and precautions due to changes in the Number of measurements/Number of time

Table 3-4 shows the measurement values (actual measurement examples) when RX140 mounted capacitance touch evaluation system is used when the number of measurements/Number of Time is changed.

Table 3-4 Measurement values when the number of measurements/Number of Time is changed (actual measurement example)

| Capacitance | Capacitance Touch Evaluation System with CTSU2SL(RX140) | | | | | | | | |
|---|---|-------|-------|------|------|--------|--|--|--|
| Self-capacitance | Self-capacitance method, Measurement frequency: 2MHz, measurement current range: 40µA, button 1ch (averaged five times) | | | | | | | | |
| Number of measurements Target value Avg. at touch Avg. at touch Signal value Avg. at touch Stabilization wait time Number of measurements for offset OFF ON (Difference of touch ON/OFF) OFF + Number of measurements A B B - A Noise value Measurement time | | | | | | | | | |
| 8 | 37.5% | 15388 | 17186 | 1798 | 17.8 | 576 µs | | | |
| 12 | 25% | 15354 | 18279 | 2925 | 30.4 | 768 µs | | | |
| 15 | 20% | 15339 | 19124 | 3785 | 36 | 912 µs | | | |

Note: The actual measurement was obtained from QE for Capacitive Touch's "CapTouch Status Chart (QE) View" function. For more information, refer to e²studio "Help".

Accumulation of the number of measurements increases the signal value. At the same time, however, the measurement value may overflow or the measurement time may not satisfy the user's required specifications. In such cases, please consider adjusting the target value of offset adjustment, reducing the number of measurements, or changing the measurement current range or frequency. These can be adjusted individually.

Also, increasing the number of measurements can cause CTSU to consume more power during low-power operation. Please adjust the number of measurements after thorough evaluation according to the specifications required by the user.



3.1.2 Necessity of Offset Tuning Adjustment when Changing Number of Measurements

When the number of measurements is changed, the sensor counter register becomes 0x0FFFF and the measurement value exceeds 65535. In order to prevent overflow, offset-tuning must be adjusted and the measurement value adjusted. Refer to 3.2 Target value of Offset Tuning for offset tuning adjustment.

Table 3-5 and Figure 3-3 show the measurements of "measurement count/measurement time" in RX130 as a typical CTSU1.

| Table 3-5 Measurement value for | "Number of Measurements/Number of Time" | with RX130 (theoretical |
|---------------------------------|---|-------------------------|
| value) | | |

| Capacitance Touch Evaluation System with CTSU1(RX130) | | | | | | | |
|---|--|-----------------------|----------------------------|---------------------|--|--|--|
| Self-Capacitance System PC | Self-Capacitance System PCLKB:32MHz Driving Pulse Frequency: 2MHz Target value of Offset Tuning: 37.5% Key 1ch | | | | | | |
| Number of | stabilization wait time [µs] | Measurement time [µs] | Total (stable waiting time | Measurement value | | | |
| measurements | | | + measurement time) [µs] | (theoretical value) | | | |
| 1 | 17 | 131.5 | 148.5 | 3840 | | | |
| 2 | 17 | 263 | 280 | 7680 | | | |
| 3 | 17 | 394.5 | 411.5 | 11520 | | | |
| 4 | 17 | 526 | 543 | 15360 | | | |
| 5 | 17 | 657.5 | 674.5 | 19200 | | | |
| 6 | 17 | 789 | 806 | 23040 | | | |
| : | : | | : | : | | | |

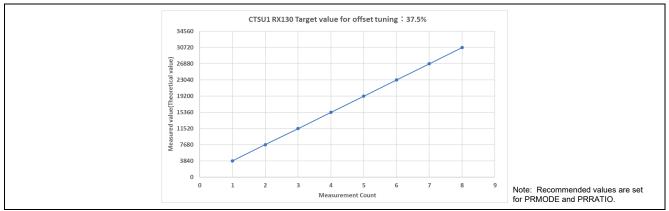


Figure 3-3 Measurement value (theoretical value) for "Number of Measurements/Number of Time" with RX130

For instance, if the number of measurements is increased to eight by the self-capacitance method, the measurement value at touch OFF will be around 30720. Increasing the number of measurements may cause overflow of measurements during touch ON. The offset-tuning target value must be adjusted so that the measurement value is within the range of good output-linearity characteristics of the current-controlled oscillator (CCO).



Table 3-6 and Figure 3-4 show typical measurements for "Number of Measurements/Number of Time" in RX140 as a CTSU2/CTSU2SL.

| Table 3-6 measurement value for | "Number of Measurements/Number of Time" | with RX140 (theoretical |
|---------------------------------|---|-------------------------|
| value) | | |

| Capacitance Touch Evaluation System with CTSU2SL(RX140) | | | | | | | |
|---|--|-----------------------|----------------------------|---------------------|--|--|--|
| Self-Capacitance System PCI | Self-Capacitance System PCLKB:32MHz Driving Pulse Frequency: 2MHz Target value of Offset Tuning: 37.5% Key 1ch | | | | | | |
| Number of | stabilization wait time [µs] | Measurement time [µs] | Total (stable waiting time | Measurement value | | | |
| measurements | | | + measurement time) [µs] | (theoretical value) | | | |
| 1 [(STCLK cycle* 8) * 1] | 192 | 48 | 240 | 1920 | | | |
| 2 [(STCLK cycle* 8) * 2] | 192 | 96 | 288 | 3840 | | | |
| 3 [(STCLK cycle* 8) * 3] | 192 | 144 | 336 | 5760 | | | |
| : | : | • | : | ••• | | | |
| 8 [(STCLK cycle* 8) * 8] | 192 | 384 | 576 | 15360 | | | |
| : | | | : | | | | |
| 16 [(STCLK cycle* 8) * 16] | 192 | 768 | 960 | 30720 | | | |
| : | : | : | : | : | | | |

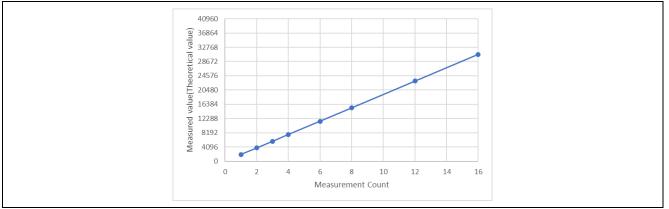


Figure 3-4 Measurement value (theoretical value) for "Number of Measurements/Number of Time" with RX140

For instance, if the number of measurements is increased to 16 when using the self-capacitance method, the measurement value at touch OFF will be around 30720. Increasing the number of measurements may cause overflow of measurements during touch ON. It is necessary to adjust the target value of offset tuning so that the measurement value fits within the good range of the output linearity characteristic of the current controlled oscillator (CCO).



3.2 Target value of Offset Tuning

In "Target value of Offset Tuning", adjust the offset current setting for each method so that the measurement value at touch OFF becomes the target value. This adjustment is made when the measurement time is changed and the measurement value overflows, or when the parasitic capacitance is large and the measurement value does not reach the target value for measurement value when the active shield is used. For details, refer to "2.2.2 Measurement Range" in the following document. Capacitive Sensor Microcontrollers CTSU Capacitive Touch Introduction Guide (renesas.com)

Figure 3-5 shows an image of offset-tuning when using the self-capacitance method in RX130.

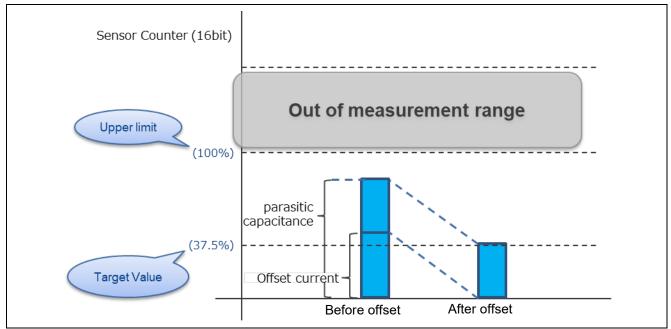


Figure 3-5 Offset Tuning Process of Self-Capacitance Method

Table 3-7 shows the target values for the default number of measurements. For the default "number of measurements" see Table 3-1 setting.

| Table 3-7 Detault "Target value of () | ffset Tuning" Setting for Each Method |
|---------------------------------------|---------------------------------------|
| | |

| | When self-capacitance method is used | When using mutual capacitance method | When using active shield |
|----------------|--------------------------------------|--------------------------------------|--------------------------|
| CTSU1 | 15360 (37.5%) | 10240 (25%) | - |
| CTSU2/CTSU2SL* | 15360 (37.5%) | 10240 (25%) | 6144 (15%) |

Note: In the actual measurement, the sum of the two adopted frequency measurement results out of the three frequency measurement results $(128 + 128 = 256 \ \mu s)$ is the final measurement result. Offset tuning uses the value of the measurement time doubled at the first frequency $(128 \times 2 = 256 \ \mu s)$ for tuning.



Target values are shown in Table 3-8 for setting the target value during offset-tuning in CTSU1.

| Target value of Offset Tuning | Target value |
|-------------------------------|--------------|
| 25.0% | 10240 |
| 30.0% | 12288 |
| 35.0% | 14336 |
| 37.5% | 15360 |
| 40.0% | 16384 |
| 45.0% | 18432 |
| 50.0% | 20480 |

Table 3-8 Target value for "Target Value of Offset tuning" in CTSU1

Target values are shown in Table 3-9. for setting the target value during offset-tuning in CTSU2/CTSU2SL.

Table 3-9 Target value for "Target Value of Offset Tuning" in CTSU2/CTSU2SL

| Target value of Offset Tuning | Target value* |
|-------------------------------|---------------|
| 10.0% | 4096 |
| 15.0% | 6144 |
| 20.0% | 8192 |
| 25.0% | 10240 |
| 30.0% | 12288 |
| 35.0% | 14336 |
| 37.5% | 15360 |
| 40.0% | 16384 |
| 45.0% | 18432 |
| 50.0% | 20480 |

Note: The value after the two-frequency sum of the three-frequency measurement results.



Figure 3-6 shows an example window for setting "Target value of Offset Tuning" with "Advanced mode".

| | you will set these | values inadver | tently or witho | ut clear unde | rstanding, it could le | ad to poor tur | ning results. | | |
|--|--|--|-------------------|------------------------|--------------------------------|----------------|---------------------------------|-----------------|--------------|
| Meth | od Capacitance | е Туре | Shield Termin | nal Target V | alue of Offset Tuning | Transmit Te | erminal Power | | |
| conf | ig01 Self-Capaci | tance method | None | Auto Auto | | ✓ Auto | | * | |
| Meth | od Kind | Name | Touch Sensor | 25.0% | | er of Time | Measurement Free | uepcy/ | |
| conf | | | TS08 | 35.0% | | a or nine | Auto | lucity | |
| | | | | 40.0% | | | | | |
| Start | the Tuning Proces | is | | 45.0% 50.0% | | | | | |
| | | | | | | | | | |
| | | | | | | | Cance | el <u>H</u> elp |] |
| | | | | | CTSU1 | | | | |
| Automatic Tuning | Processing | | | | 01001 | | | | |
| | lues for each n | nethod / tou | ich interface | | | | | | |
| | | | | | an huning an other | | | | |
| - | e values inadvertently | | | | - | Channel Outer | Coloret Terrorite D' D | | |
| onfig01 Self Capa | ce Type Shield Pin | Target Value of Auto | | leasured Curren uto | t Range Non-Measured V Auto | Channel Output | Select Transmit Pin P V Auto | ower | |
| singer sereapa | Numee Home | Auto | | | | | | | |
| Multi-Cloc | Measuring Multip | | ul | tiplier Rate 3 | udgement Type | | | | |
| ystem 3 Frequenc | es 64 | 20.0% 25.0% | | | Default | | | | |
| | | 30.0% 35.0% | - | | | | | | |
| lethod Kind | Name Touc | 37.5% | ier | nts / Number of | | quency | | | |
| onfig01 Button(se | f) Button00 TS11 | 40.0% 45.0% | | | Auto | | | | |
| | | 20.0% | | | | | | | |
| art the Tuning Proc | 255 | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | Cancel | <u>H</u> elp |
| | | | | | CTSU2 | | | | |
| | | | | | 01002 | | | | |
| Automatic Tuning | | | | | | | | | |
| | alues for each i | method / too | uch interface | | | | | | |
| elect setting v | se values inadvertent | ly or without clear | understanding, it | could lead to p | oor tuning results. | | | | |
| | | Target Value of | Offset Tuning | leasured Curren | t Range Non-Measured | Channel Output | | wer | |
| If you will set the | nce Type Shield Pin | Auto | ∨ A | uto | ✓ Auto | | ✓ Auto | ~ | |
| If you will set the | | | | 1 | | | | | |
| If you will set the Method Capacita config01 Self Cap | acitance None | Auto 10.0% | | tiplier Rate 3 | Automatic Correction (Har | - | | | |
| If you will set the Method Capacita config01 Self Cap Multi-Close | k Measuring Multip | 10.0% i 15.0% | ul | | | | | | |
| If you will set the Method Capacita config01 Self Cap | k Measuring Multip | 10.0% i 15.0% 20.0% 25.0% | ul | | nable | Default | | | |
| Method Capacite config01 Self Cap System 3 Frequen | citance None k Measuring Multip cies 64 | 10.0% 115.0% 20.0% 25.0% 30.0% 35.0% | | E | | | | | |
| L If you will set the Method Capacita config01 Self Cap System 3 Frequen Method Kind | k Measuring Multip k Measuring 64 Name Tou | 10.0% 15.0% 20.0% 25.0% 30.0% 35.0% 37.5% | | E | Time Measurement Freq | | | | |
| Method Capacite config01 Self Cap System 3 Frequen | k Measuring Multip k Measuring 64 Name Tou | 10.0% 15.0% 20.0% 30.0% 35.0% 137.5% 40.0% | | E | | | | | |
| L If you will set the Method Capacita config01 Self Cap System 3 Frequen Method Kind | k Measuring Multip its 64 Name Tou Button00 TS0 | 10.0% 15.0% 20.0% 30.0% 35.0% 37.5% 40.0% | | E | Time Measurement Freq | | | | |

Figure 3-6 Setting of "Target value of Offset Tuning"

The settings are reflected in the qe_touch_config.c. The following is an example of target values for the self capacitance method/mutual capacitance method when RX130 is used. It is not recommended to rewrite this value directly.

```
#if (CTSU_TARGET_VALUE_CONFIG_SUPPORT == 1)
   .tuning_self_target_value = 15360,
   .tuning_mutual_target_value = 10240,
```



3.2.1 Effect of Target value of Offset Tuning and Number of measurements Change on Measurement Value

The number of measurements can be changed only with CTSU2/CTSU2SL. The measurement value changes according to the number of times of measurement, and if the number of times of measurement is set to double the default setting, the measurement value is also doubled.

Measurement value = (Target value of Offset Tuning [%] × 40960*)/100 ×

(number of measurements/default number of measurements)

Note: 40960 is the value when the Target value of Offset Tuning is 100%.

Table 3-10 and Figure 3-7 show the measurement values (theoretical values) at touch OFF with respect to the setting of the target value at offset tuning when the Number of measurements in CTSU2/CTSU2SL.

Table 3-10 Measurement values for "Target values of offset tuning" when the number of measurements is changed (theoretical values)

| Target value of Offset | Torgot voluo* | Measurement value at tou value)* | ich OFF (theoretical |
|------------------------|---------------|--|----------------------------|
| Tuning | Target value* | Number of measurements: 8 (default) | Number of measurements: 16 |
| 10.0% | 4096 | 4096 | 8192 |
| 15.0% | 6144 | 6144 | 12288 |
| 20.0% | 8192 | 8192 | 16384 |
| 25.0% | 10240 | 10240 | 20480 |
| 30.0% | 12288 | 12288 | 24576 |
| 35.0% | 14336 | 14336 | 28672 |
| 37.5% | 15360 | 15360 | 30720 |
| 40.0% | 16384 | 16384 | 32768 |
| 45.0% | 18432 | 18432 | 36864 |
| 50.0% | 20480 | 20480 | 40960 |

Note: The value after the 2 frequency sum of the 3 frequency measurement results.



Figure 3-7 Measurement value (theoretical value) with respect to "Target value of Offset Tuning" when the number of measurements is changed



Changing the offset tuning target value may cause the count value to overflow. Set the target value and measurement time so that the measurement value at the maximum capacitance-added state* assumed when the system (product) is operating falls within the good range of output linearity characteristics of the current-controlled oscillator (CCO). If there is no particular need to change, set the target value and measurement time for offset tuning to the target value for each method, referring to Table 3-7.

Change the number of measurements. If the measurement value differs from the expected value, refer to Table 3-10 to set the target value for offset tuning. Set the target value for offset tuning lower than the default setting when the measurement value is larger than the target value, and higher than the default setting when the measurement value is smaller than the target value. When the parasitic capacitance of the electrode is small or the active shield is used, set these target values again when it does not reach the target value set by the offset tuning process.

Note: As an example, assume the maximum possible capacity addition state, including non-normal operation, when water is spilled over the touch buttons.



3.3 Measurement frequency

"Measurement frequency" (sensor drive pulse frequency) sets the frequency division of the frequency output to the touch sensor. The higher the measurement frequency, the better the sensitivity will be. However, measurement errors will occur if the parasitic capacitance is large.

CTSU outputs a sensor drive pulse from TS terminal and measures the capacitance from the charge current. For details, refer to the following document.

Capacitive Sensor Microcontrollers CTSU Capacitive Touch Introduction Guide (renesas.com)

The measurement frequency is set to an appropriate frequency in Auto tuning by the parasitic capacitance and the set damping resistance. In addition, the measurement frequency varies depending on the operation clock. For details, refer to the hardware manual of each capacitive touch sensor. Figure 3-8 shows the relation between the parasitic capacitance/damping resistor of RX130 set by auto tuning and the measurement frequency. A typical example of CTSU1 is shown below.

| pF_Q | 10 12 15 18 22 27 33 39 47 | 56 68 82 100 | 150 2 | 200 220 | 240 270 | 300 | 330 | 360 39 | 90 430 | 470 | 510 | 560 | 620 | 680 | 750 8 | 20 91 | 0 1000 |
|----------|----------------------------|--------------|-------|---------|---------|-----|-----|--------|--------|-----|-----|-----|-----|-----|-------|-------|--------|
| 10 12 | | | | | | | | | | | | | | | | | |
| 15 18 | + | | | | | | | | | | | | | | | | |
| 22 | 2MHz | | | | | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | | | | | | |
| 39 | 4 | | | | | | | | | | | | | | | | |
| 42 | + | 1MH | z | | | | | | | | | | | | | | |
| 51 | | | | | | | | | | | | | | | | | |
| 56 62 | 4 | | | | | | | | | | | | | | | | |
| 68 | 4 | | | | _ | | | | | | | | | | | | |
| 75 82 | 4 | | | | 0.5M | Hz | | | | | | | | | | | |
| 91 | | | | | | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | | | | | | |

Figure 3-8 Parasitic capacitance/damping resistance of RX130 (receiving electrode 1.6V) vs. measurement frequency

Figure 3-9 shows the relation between the parasitic capacitance/damping resistor of RX140 and the measurement frequency. A typical example of CTSU2/CTSU2SL is shown below.

| pF_Q | 10 | 12 | 15 | 18 | 22 | 27 | 33 | 39 | 47 | 56 | 68 | 82 | 100 | 150 | 200 | 220 | 240 | 270 | 300 | 330 | 360 | 390 | 430 | 470 | 510 | 560 | 620 | 680 | 750 | 820 | 910 | 1000 |
|------|----|-----|----|----|----|----|----|-----|----|----|----|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | | 4MF | lz | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 27 | | | | | | | 21 | IHz | | | | | | | | | | | | | | | | | | | | | | | | |
| 33 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 42 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 47 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 51 | | | | | | | | | | | | 1.0.4 | | | | | | | | | | | | | | | | | | | | |
| 56 | | | | | | | | | | | | 1 M | IHZ | | | | | | | | | | | | | | | | | | | |
| 62 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 75 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 82 | | | | | | | | | | | | | | | | | 0.1 | 5МН | 7 | | | | | | | | | | | | | |
| 91 | | | | | | | | | | | | | | | | | 0 | | | | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Figure 3-9 Parasitic capacitance/damping resistance of RX140 (receiving electrode 1.5V) vs. measurement frequency

The higher the parasitic capacitance, the lower the measurement frequency is set. If the measurement frequency is set to a high value when the parasitic capacitance is large, the charge/discharge may not be satisfactorily performed and measurement error may occur when outputting sensor drive pulses from TS terminal. In Auto-tuning sets the optimum measurement frequency where no measurement error occurs.

In addition, in CTSU2/CTSU2SL, the frequency set in "Measurement frequency" is determined as the 1st frequency in multi-clock measurement. Refer to 3.6 Multi-Clock Measuring/Multiplier Rate for the setting method of the 2nd/3rd Frequency.



Figure 3-10 shows a window example for setting "Measurement Frequency" with "Advanced mode".

| | Select se | etting valu | es for ea | ch method | / touch interfac | e. | | | | | |
|--|--|--|--|---|--|--|--|--|--|---|----------------|
| | | - | | | , it clear understanding, | | to pear tw | aina results | | | |
| | | | | | | | | | | | |
| | Method | Capacitance Self-Capacita | | Shield Termina | Auto | | Auto | erminal Power | ~ | | |
| | conngor | Self-Capacita | nce method | None | , allo | · | , lato | | | | |
| | Method | Kind | Name | Touch Sensor | Number of Measurem | ents / Numb | ber of Time | Measurement | Frequency | | |
| | config01 | Button(self) | Button00 | TS08 | Auto | | ~ | Auto | | v | |
| | | | | | | | | Auto Operating clo | ck divided l | A by 2 | _ |
| | Start the T | Funing Process |] | | | | | Operating clo Operating clo Operating clo Operating clo Operating clo Operating clo | ck divided l ck divided l ck divided l ck divided l ck divided l | by 4 by 6 by 8 by 10 by 12elp | |
| | | | | | CTSU | 1 | | | | | |
| Automatic | : Tuning Process | sing | | | | | | | | | |
| | | | thod / tou | ch interface | | | | | | | |
| | - | | | ch interface. | | | | | | | |
| - | | | | | uld lead to poor tuning res | | | | | | |
| | | | irget Value of (ito | Offset Tuning Mea ✓ Auto | asured Current Range Nor | | nannel Output | Select Transmit V Auto | Pin Power | | |
| onfig01 S | elf Capacitance | None A | 10 | V Aut | → Auto | 0 | | ✓ Auto | Ý | | |
| | ulti-Clock Measu | uring Multiplier | Rate 1 Multi | olier Rate 2 Multin | lier Rate 3 Judgement Typ | pe | | | | | |
| Mi | | in generation of the second se | | | | | | | | | |
| | requencies | 64 | 55 | 73 | Default | | | | | | |
| | | 64 | 55 | 73 | | | | | | | |
| ystem 3 F Method K onfig01 B | irequencies | 64 ame Touch S itton00 TS11 | | r of Measurements | / Number of Time Measu Auto SUCLK SUCLK SUCLK SUCLK | divided by 1 divided by 2 divided by 3 divided by 4 divided by 5 | ency | | | | |
| ystem 3 F Aethod K onfig01 B | requencies (ind Na Button(self) Bu | ame Touch S | ensor Numb | | / Number of Time Measu Auto SUCLK SUCLK SUCLK SUCLK SUCLK | divided by 1 divided by 2 divided by 3 | ~ | | | Cancel | Hel |
| ystem 3 F Method K onfig01 B | requencies (ind Na Button(self) Bu | ame Touch S | ensor Numb | | / Number of Time Measu Auto SUCLK SUCLK SUCLK SUCLK SUCLK | divided by 1 divided by 2 divided by 3 divided by 4 divided by 5 divided by 6 divided by 7 | ~ | | | Cancel | Hel |
| 4ethod K onfig01 B art the Tun | requencies (ind Na Button(self) Bu | ame Touch S atton00 TS11 | ensor Numb | | / Number of Time Measu Auto SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK | divided by 1 divided by 2 divided by 3 divided by 4 divided by 5 divided by 6 divided by 7 | ~ | | | Cancel | Hel |
| 3 F Method K onfig01 B tart the Tun | requencies | ame Touch S atton00 TS11 | Auto | er of Measurements | / Number of Time Measu Auto SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK | divided by 1 divided by 2 divided by 3 divided by 4 divided by 5 divided by 6 divided by 7 | ~ | | | Cancel | Hel |
| 3 F lethod K onfig01 B art the Tun Automatic | ing Process c Tuning Process ting values | ame Touch S htton00 TS11 | ensor Numb Auto | er of Measurements | / Number of Time Measu Auto SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK | divided by 1 divided by 2 divided by 3 divided by 4 divided by 5 divided by 6 divided by 7 2 | ~ | | | Cancel | Hel |
| 3 F fethod K onfig01 B art the Tun Automatic lect set1 I fyou wi | requencies iind Na kutton(self) Bu iing Process c Tuning Process ting values Il set these value | ame Touch S atton00 TS11 | thod / tou | er of Measurements | / Number of Time Auto SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK | divided by 1 divided by 2 divided by 3 divided by 4 divided by 5 divided by 5 divided by 7 divided by 7 2 2 | | | | Cancel | Hel |
| Automatic lethod K ponfig01 B art the Tun Automatic lect sett b If you wi Aethod C | requencies ind Na kutton(self) Bu ing Process c Tuning Process ting values Il set these value Capacitance Type | sing for each me e Shield Pin T. | thod / tou without clear urget Value of 0 | er of Measurements Ich interface. understanding, it cc | A Number of Time Measu Auto Succk Su | divided by 1 divided by 2 divided by 3 divided by 4 divided by 5 divided by 6 divided by 7 2 ults. | | | | Cancel | Hel |
| 3 F Method K onfig01 B art the Tun Automatic lect sett I fyou wi Method O | requencies iind Na kutton(self) Bu iing Process c Tuning Process ting values Il set these value | sing for each me e Shield Pin T. | thod / tou | er of Measurements | A Number of Time Measu Auto Succk Su | divided by 1 divided by 2 divided by 3 divided by 4 divided by 5 divided by 6 divided by 7 2 ults. | | Select Transmit v Auto | Pin Power | Cancel | Help |
| 3 F Method K Method K art the Turn Automatic lect sett Method C onfig01 S | ing Process c Tuning Process c Tuning Process iting values Il set these value Capacitance Type Self Capacitance | ame Touch S ttton00 TS11 sing for each me es inadvertently or e Shield Pin T. None A | thod / tou without clear arget Value of tuto | er of Measurements Ich interface. understanding, it cc Offset Tuning Me V Aut | V Number of Time Measu Auto SUCLK SUCK SUCK SUCK SUCK SUCK SUCK SUCK SUC | divided by 1 divided by 2 divided by 3 divided by 3 divided by 4 divided by 5 divided by 6 divided by 7 2 ults. | nannel Output | ∀ Auto | | Cancel | Hel |
| Automatic Automatic Iect sett If you wi Automatic Iect sett Method (onfigot S | ing Process c Tuning Process c Tuning Process iting values Il set these value Capacitance Type Self Capacitance | ame Touch S ttton00 TS11 sing for each me es inadvertently or e Shield Pin T. None A | thod / tou without clear arget Value of tuto | er of Measurements Ich interface. understanding, it cc Offset Tuning Me V Aut | A Number of Time Measu Auto Succk Su | divided by 1 divided by 2 divided by 3 divided by 3 divided by 4 divided by 5 divided by 6 divided by 7 2 ults. | nannel Output | ✓ Auto nent Type | | Cancel |] <u>H</u> ely |
| Automatic Automa | requencies | ame Touch S ttton00 TS11 sing for each me es inadvertently or e Shield Pin T. None A uring Multiplier | thod / tou without clear reget Value of to thou Rate 1 Multi 55 | er of Measurements Ich interface. understanding, it cc Difset Tuning Mea plier Rate 2 Multip | / Number of Time Measu Auto SUCLK SUCK SUCK SUCK SUCK SUCK SUCK SUCK SUC | divided by 1 divided by 2 divided by 3 divided by 3 divided by 4 divided by 5 divided by 6 divided by 7 2 ults. | nannel Output vare) Judgen v Default | ✓ Auto nent Type | | Cancel |] Hely |
| 3 F 4ethod Kathod Kathod Kathod I Automatia I Automatia I fyou wi Method Config01 Signature I fyou wi Method Gonfig01 Signature Method Method Method Method Method | requencies | ame Touch S ttton00 TS11 for each me es inadvertently or None A urring Multiplier V 64 ame Touch S | thod / tou without clear reget Value of to thou Rate 1 Multi 55 | er of Measurements Ich interface. understanding, it cc Difset Tuning Mea v Aut plier Rate 2 Multip v 73 | A Number of Time Measu Auto SUCLK SU | divided by 1 divided by 2 divided by 3 divided by 4 divided by 5 divided by 5 divided by 7 2 2 ults. n-Measured CP o rection (Hardw | vanel Output vare) Judgen v Default | ✓ Auto nent Type | | Cancel | |
| stem 3 F lethod K art the Tun Automatic lett sett lf you wi dethod (onfig01 5 M ystem 3 F Aethod k | requencies (ind Na kutton(self) Bu ing Process c Tuning Process ting values ting values ulti-Clock Measu requencies Kind Na | ame Touch S ttton00 TS11 for each me es inadvertently or None A urring Multiplier V 64 ame Touch S | thod / tou without clear rarget Value of ta Rate 1 Multi S5 | er of Measurements Ich interface. understanding, it cc Difset Tuning Mea v Aut plier Rate 2 Multip v 73 | Auto Auto Auto SUCLK | divided by 1 divided by 2 divided by 3 divided by 4 divided by 5 divided by 5 divided by 5 divided by 7 2 ults. n-Measured Ch o rection (Hardw arement Freque divided by 1 | nannel Output vare) Judgen v Default | ✓ Auto nent Type | | Cancel | |
| 3 F Method K Martine K Automatic Iect sett Method C onfig01 S Method M ystem S F Method M onfig01 S Method F Method F Martine S | requencies | ame Touch S ttton00 TS11 for each me es inadvertently or None A urring Multiplier V 64 ame Touch S | thod / tou without clear rarget Value of ta Rate 1 Multi S5 | er of Measurements Ich interface. understanding, it cc Difset Tuning Mea v Aut plier Rate 2 Multip v 73 | / Number of Time Auto SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK Auto Auto Auto Auto SUCLK | divided by 1 divided by 2 divided by 3 divided by 3 divided by 3 divided by 5 divided by 5 divided by 7 2 2 2 2 2 3 4 5 5 5 5 5 5 5 5 5 5 | vanel Output vare) Judgen v Default | ✓ Auto nent Type | | Cancel | |
| 3 F Method K Martine K Automatic Iect sett Method C onfig01 S Method M ystem S F Method M onfig01 S Method F Method F Martine S | requencies (ind Na kutton(self) Bu ing Process c Tuning Process ting values ting values ulti-Clock Measu requencies Kind Na | ame Touch S ttton00 TS11 for each me es inadvertently or None A urring Multiplier V 64 ame Touch S | thod / tou without clear rarget Value of ta Rate 1 Multi S5 | er of Measurements Ich interface. understanding, it cc Difset Tuning Mea v Aut plier Rate 2 Multip v 73 | / Number of Time Auto SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK SUCLK Auto Auto Auto Auto SUCLK | divided by 1 divided by 2 divided by 3 divided by 4 divided by 5 divided by 5 divided by 5 divided by 7 2 ults. n-Measured Ch o rection (Hardw arement Freque divided by 1 | vanel Output vare) Judgen v Default | ✓ Auto nent Type | | Cancel | |

Figure 3-10 Setting of "Measurement Frequency"

The setting is reflected in "sdpa" of the qe_touch_config.c. For instance, when the Capacitance Touch Evaluation System with RX140 is used, if "8 division of SUCLK" is selected for the measurement frequency, "sdpa = 0x07" is set.

const ctsu_element_cfg_t g_qe_ctsu_element_cfg_config01[] = { { .ssdiv = CTSU_SSDIV_4000, .so = 0x12B, .snum = 0x07, .sdpa = 0x07 }, };

Note: Refer to the respective capacitive touch sensor hardware manual for more information on SDPA.



3.3.1 Influence on Sensitivity by Changing Measurement Frequency

Table 3-11 shows the measurement values (actual measurement examples) when RX140 mounted capacitance touch evaluation system is used when the measurement frequency is changed.

| Table 3-11 Measurement values when the measurement frequency is changed (actual measurement | |
|---|--|
| example) | |

| Capacitanc | Capacitance Touch Evaluation System with CTSU2SL(RX140) | | | | | | | | | | | |
|---------------------------|---|-------|-------|-------------|--|--|--|--|--|--|--|--|
| Self-capacitanc | Self-capacitance method, Number of measurements: 8, Measurement current range: 40µA, Target value of Offset Tuning: 37.5% (averaged five times) | | | | | | | | | | | |
| | Avg. at touch Avg. at touch Signal value Avg. at touch | | | | | | | | | | | |
| | Measurement OFF ON (Difference of touch ON/OFF) OFF | | | | | | | | | | | |
| Frequency | Α | В | В - А | Noise value | | | | | | | | |
| 4MHz | 15359 | 18914 | 3555 | 30.2 | | | | | | | | |
| 2MHz | 15408 | 17217 | 1809 | 18.2 | | | | | | | | |
| 1MHz 15371 16306 935 14.2 | | | | | | | | | | | | |
| 0.5MHz | 10882 | 11357 | 475 | 12.6 | | | | | | | | |

Note: The actual measurement was obtained from QE for Capacitive Touch's "CapTouch Status Chart (QE) View" function. For more information, refer to e²studio "Help".

When the measurement frequency is increased, the difference in the touch ON/OFF can be seen to be large. However, when the measurement frequency is increased, overflow may occur during touch ON. If the measurement frequency is increased forcibly when the parasitic capacitance is large, a measurement error may occur.

Figure 3-11 shows the image of CTSU measurement when the parasitic capacitance is large and the measurement frequency is increased. If the output of the pulse is faster than the charging time and the parasitic capacitance is large at a higher frequency, charging/discharging may not be performed sufficiently. As a result, measurement errors may occur. Therefore, it is necessary to set the measurement frequency to match the parasitic capacitance.

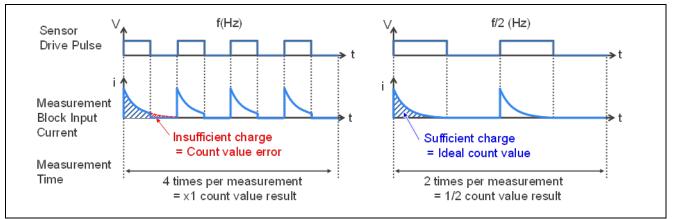


Figure 3-11 Image of CTSU measurement

When set to 0.5MHz, if the parasitic capacitance is small, the average value at touch OFF may not be set near the offset tuning target value. The reason is that the measurement value does not reach the target value because the current supplied from VDC is small because the parasitic capacitance is small and the current supplied to the current mirror circuit is also small. In this case, increase the measurement frequency or decrease the Target value of Offset Tuning.

In addition, considering that the charge/discharge times should be sufficiently secured, set the measurement frequency to be less than 4MHz.

Please make adjustments after sufficiently evaluating it in accordance with the specifications required by the user.



3.3.2 How to adjust the measurement frequency using Advanced Mode

Automatic tuning sets the optimum measurement frequency where no measurement error occurs. Although the final measurement frequency is determined from the default 4 measurement frequencies, 4MHz, 2MHz, 1MHz, 0.5MHz by the parasitic capacitance, the margin of the measurement frequency set for the parasitic capacitance may be too large. In such a case, it is possible to change to a more detailed measurement frequency by using the advanced mode. Figure 3-12 shows the relation between parasitic capacitance and SDPA when a damping resistor of 560 Ω is used in RX130 that is CTSU1.

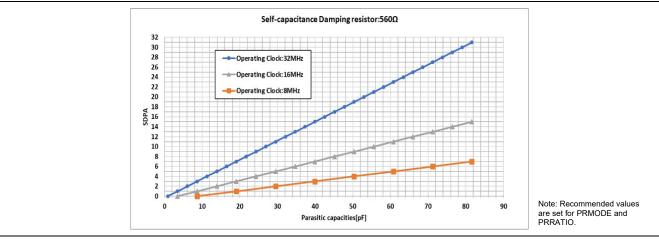
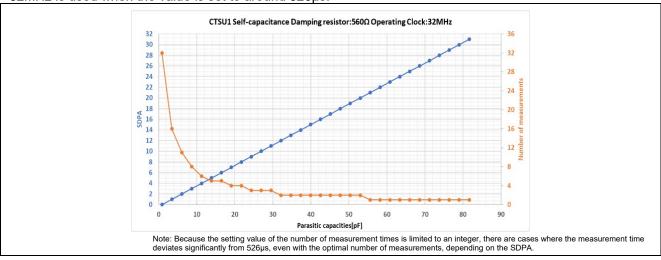


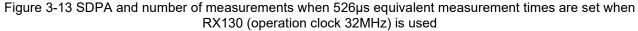
Figure 3-12 Parasitic capacitance that can be measured when RX130 is used

When the parasitic capacitance is 30pF and the operating clocks (CTSUCLK) are 32MHz, the optimal SDPA is 11. The measurement frequency is calculated by the following formula. Measurement frequency = CTSUCLK / ((SDPA + 1) × 2)

When the operating clock (CTSUCLK) is 32MHz and SDPA is 11, the measurement frequency is as follows. Measurement frequency: $32[MHz] / ((11 + 1) \times 2) = 1.333MHz$

In RX130, the measurement time is set to be 526µs as the result of auto-tuning. However, if the measurement frequency is manually changed using this Advanced mode, the measurement time also changes. For details, please see 3.1 Number of Measurements/Number of Time. Figure 3-13 shows the relation between SDPA and the number of measurements when the operating clock 32MHz is used when the value is set to around 526µs.





When changing the measurement time, adjust it to the user's required specifications to prevent an overflow error from occurring. Depending on the operation clock, the setting may be set to other than 4/2/1/0.5MHz depending on the auto-tuning. For instance, if the operating clocks are 30MHz, they cannot be set to 4/2MHz because of the frequency division relation. In such cases, 4/2MHz is set to a lower 3.75/1.875MHz.



Figure 3-14 shows the parasitic capacitance versus SDPA when the default setting of "Multi-frequency measurement/multiplication ratio" is used in RX140 that is CTSU2 and the damping resistor 560 Ω is used.

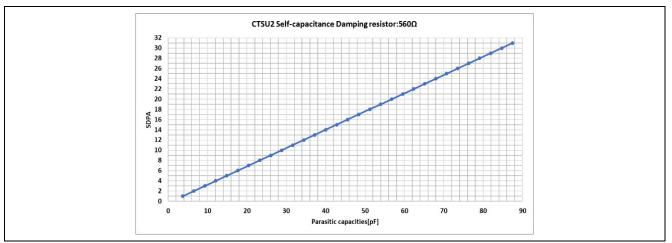


Figure 3-14 Parasitic capacitance that can be measured when RX140 is used

When the parasitic capacitance is 25pF, the optimal SDPA is 9. The measurement frequency is calculated by the following formula. Measurement frequency = (SUCLK* / 2) / (SDPA + 1)

Note: SUCLK = STCLK[0.5MHz] × SUMULTI is shown. For details on STCLK and SUMULTI, refer to the hardware manual for each capacitive touch sensor.

When SDPA is 9, the frequency at 3-frequency measurement is as follows. Measurement frequency (multiplied by 64) : (32 [MHz] / 2) / (9 + 1) = 1.6MHz Measurement frequency (multiplied by 55) : (27.5[MHz] / 2) / (9 + 1) = 1.38MHz Measurement frequency (multiplied by 73) : (36.5[MHz] / 2) / (9 + 1) = 1.83MHz

Please make adjustments after sufficiently evaluating it in accordance with the specifications required by the user.



3.4 Measured Current Range

The "Measured Current Range" setting can be changed only with CTSU2/CTSU2SL.

In "Measured Current Range", the current mirror ratio between the current supplied from the measurement VDC and the current flowing through the current controlled oscillator (CCO) via the current mirror circuit is set for each method. Setting a low "Measuring Current Range" increases the sensitivity. This is because CCO input current at the time of touch ON increases.

CTSU measures the capacitance by outputting a sensor drive pulse from TS terminal and measuring the charge/discharge current. The following equation is established.

I = F C V

Here, the current I is the sum of the current I1 supplied from the measurement VDC and the current I2 supplied from the offset current (DAC). For details, refer to "2.2.1 Principles of Detection" in the following documents.

Capacitive Sensor Microcontrollers CTSU Capacitive Touch Introduction Guide (renesas.com)

A current IOUT proportional to CCO is applied to the current I1 supplied from the measurement VDC through the current mirror. Set the power supply capability from VDC and the current mirror ratio is automatically determined according to the setting. Increasing the measurement current range increases the current I1 supplied from VDC for measurement.

Figure 3-15 shows the measurement image when "Measured Current Range" is changed.

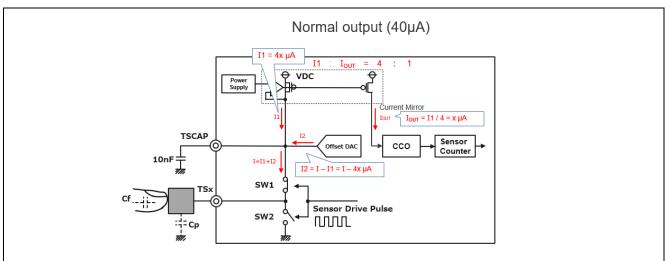


Figure 3-15 Measurement image when normal current (40µA) is used

Table 3-12 shows the default settings.

Table 3-12 Default "Measured Current Range" settings

| | When self-capacitance method is used | When using mutual capacitance method |
|---------------|--------------------------------------|--------------------------------------|
| CTSU2/CTSU2SL | Normal current (40µA) | High current (80µA) |

In addition to the defaults, CTSU2/CTSU2SL can be set to low current (20µA) or high current (160µA).



Figure 3-16 shows an example window for setting "Measured Current Range" with "Advanced mode".

| Automatic Tuning Processing | | | | × | | | | | |
|--|---|--|----------------------------------|---------------------|--|--|--|--|--|
| Select setting values for each method / t | touch interface | | | ^ | | | | | |
| | | | | | | | | | |
| If you will set these values inadvertently or without cl Method Capacitance Type Shield Pin Target Value | | - | Output Select Transmit Pin Power | | | | | | |
| config01 Self Capacitance None Auto | | Non-Measured Channel Auto | V Auto V | | | | | | |
| | Auto Low-current output(20u | A) | | | | | | | |
| Multi-Clock Measuring Multiplier Rate 1 M System 3 Frequencies 64 55 | Aultiplier Rate 2 M Normal output(40uA) | (AL | | | | | | | |
| | umber of Measurements / Number of Time uto | Measurement Frequency Auto | | | | | | | |
| Start the Tuning Process Cancel Help | | | | | | | | | |
| | CT | SU2 | | | | | | | |
| Automatic Tuning Processing Select setting values for each method / 1 If you will set these values inadvertently or without c Method Capacitance Type Shield Pin Target Value config01 Self Capacitance None Auto | clear understanding, it could lead to poor tur e of Offset Tuning Measured Current Rang | - | Output Select Transmit Pin Power | X | | | | | |
| | Auto Low-current output(200 Normal output(40uA) 55 Very high-current output(80 Very high-current output(80 | n (Hardware) JA) | Judgement Type Default | | | | | | |
| | lumber of Measurements / Number of Time uuto | Measurement Frequency Auto | | | | | | | |
| Start the Tuning Process | | | | Cancel <u>H</u> elp | | | | | |
| | CTS | U2SL | | | | | | | |

Figure 3-16 Setting of "Measured Current Range"

The settings are reflected in the qe_touch_config.c. Normal current (40µA) is shown below.

.atune12= CTSU_ATUNE12_40UA,

Note: Refer to the respective capacitive touch sensor hardware manual for more information on ATUNE.



3.4.1 Effects on Sensitivity by Changing the Measured Current Range

Table 3-13 shows the measurement values (actual measurement examples) when RX140 mounted capacitance touch evaluation system is used when the Measured Current Range is changed.

Table 3-13 Measurement values when the Measured Current Range is changed (actual measurement example)

| Capacitance Touch | Capacitance Touch Evaluation System with CTSU2SL(RX140) | | | | | | | | | | |
|---|---|-------|-------|-------------|--|--|--|--|--|--|--|
| Self-capacitance method, Measurement frequency: 2MHz, easurement count: 8, Target value of Offset Tuning: 37.5% (averaged five times) | | | | | | | | | | | |
| Avg. at touch Avg. at touch Signal value Avg. at touch | | | | | | | | | | | |
| Measured Current Range | | | | | | | | | | | |
| | А | В | B - A | Noise value | | | | | | | |
| 20µA | 15363 | 18897 | 3534 | 34.2 | | | | | | | |
| 40µA | 15429 | 17214 | 1785 | 19.4 | | | | | | | |
| 80µA 15372 16255 883 11 | | | | | | | | | | | |
| 160µA | 10834 | 11271 | 437 | 8.2 | | | | | | | |

Note: The actual measurement was obtained from QE for Capacitive Touch's "CapTouch Status Chart (QE) View" function. For more information, refer to e²studio "Help".

When the measured current range is low, the difference in the touch ON/OFF can be seen to be large, but when the current range is low, overflow may occur during touch ON. Perform adjustment after sufficiently evaluating the offset tuning to meet the user's required specifications. Also, if the current-mode is too large when the parasitic capacitance is small, the mean value at touch OFF may not be set near the offset-tuning target value. The reason is that the measurement value does not reach the target value because the current supplied from VDC is small because the parasitic capacitance is small and the current supplied to the current mirror circuit is also small. In this case, lower the measured current range or decrease the target value of the measurement value.

Figure 3-17 shows, as an example, the current I1 supplied from the VDC for measurement and the current I2 supplied from the offset current (DAC) to the target offset tuning value when the measurement current range is normal current $(40\mu A)$ / high current ($160\mu A$) when the measurement frequency is 2MHz and an electrode with a parasitic capacitance of approximately 18.8pF is used. current I2 supplied from the current (DAC) and the current value lout flowing in the CCO are shown below.

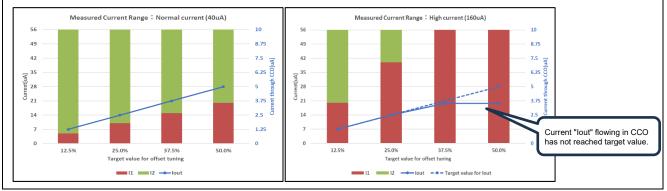


Figure 3-17 Current value when the target offset tuning value and measured current range are changed

The current flowing through the CCO is $1.25 \sim 10 \mu$ A, and 10μ A flows when the offset tuning target value is 100%.

When the normal current (40 μ A) is used, I1 = approx. 15 μ A, I2 = approx. 41 μ A when the offset-tuning target is 37.5%. The current IOUT flowing through CCO is determined by the current mirror rate with the current I1 supplied from VDC for measurement, and is therefore calculated as IOUT = I1 / 4 = 3.75 μ A.

When high current (160 μ A) is used, I1 = approx. 56 μ A, I2 = 0 μ A when offset-tuning target is 37.5%. Since the current IOUT flowing through CCO is determined by the current mirror rate with the current I1 supplied from the measurement VDC, IOUT = I1/16 is approximately 3.5 μ A.

If the current mode is too large when the parasitic capacitance is small in this way, the current supplied to the current mirror circuit will also be small and the measurement value will not reach the target value.

Adjust the target value for current range and offset tuning after fully evaluating to the user's required specifications.



3.5 Non-Measured Channel Output Select

The setting of "Non-Measured Channel Output Select" can be changed only with CTSU2/CTSU2SL. In "Non-Measured Channel Output Select", the processing of non-measurement terminals other than the measurement terminals during the measurement period is set for each method.

Noise suppression is possible by appropriately processing non-measurement terminals. It is recommended to set TS terminal which is not measured to GPIO Low output for noise-suppression. In order to shield the external influence while suppressing the increase of the parasitic capacitance when using the active shield, set the non-measurement terminal to the common-mode pulse output which is the setting to output the shield signal in the same phase as the sensor drive pulse during the measurement period. Table 3-14 shows the default settings.

Table 3-14 Default "Non-Measured Channel Output Select" setting.

| | When self-capacitance method is used | When using mutual capacitance method | When using active shield |
|---------------|--------------------------------------|--------------------------------------|---|
| CTSU2/CTSU2SL | Output low thorough GPIO | Output low thorough GPIO | Same phase pulse output as transmission channel through the power setting |

Figure 3-19 shows an image of TS terminal measurement in a touch interface configuration as shown in Figure 3-18. Since the active shield is set for the behavior of TS terminal during config01 measurement period, the other terminal TS01,TS02 is in-phase pulsing while TS00 is being measured. During config02 measurement, TS04 that TS03 is being measured is turned Low.

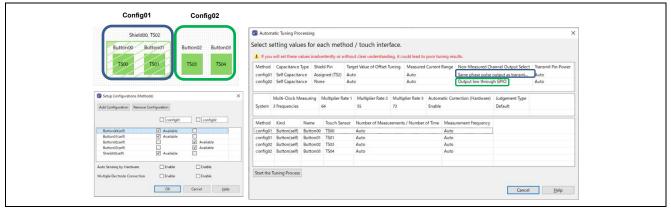


Figure 3-18 Example touch interface configuration

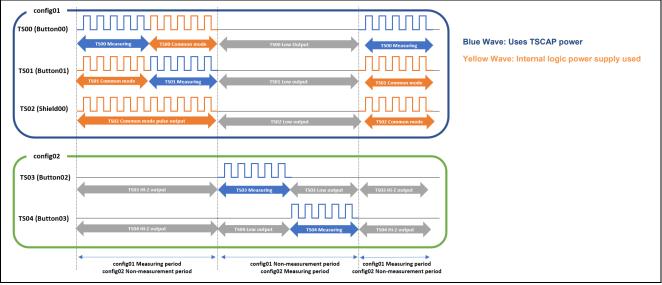


Figure 3-19 Image of TS terminal measurement

This is an example of a Non-Measured Channel Output Select. Please refer to the following documents. RL78 Family Capacitive Touch Sensing Unit (CTSU2L) Operation Explanation Rev.1.00 (renesas.com)



Table 3-15 shows an overview of each process setting.

Table 3-15 Overview of processing settings

| Non-Measured Channel Output Select setting | Overview |
|--|--|
| Output low thorough GPIO | This setting is used to output a Low from the non-measurement terminal during measurement. |
| Hi-Z | This setting is used to output a Hi-Z from the non-measurement terminal during measurement. |
| Same phase pulse output as transmission channel through the power setting | This setting outputs a shield signal in phase with the sensor drive pulse from the non-measurement terminal during the measurement period. |

Figure 3-20 shows an example window for setting "Non-Measured Channel Output Select" with "Advanced mode".

| | tic Tuning Drov | | | | | | | | | | | |
|---|---|--|--|--|---|--|---|----------------------|--------------------------|-------------|-----------|--------------|
| | tic Tuning Pro | - | | | | | | | | | | |
| elect set | tting value | es for ea | ach method | / touch inter | face. | | | | | | | |
| 🛓 lf you w | vill set these va | alues inadv | ertently or withou | ıt clear understandi | ing, it could lead to | poor tur | ing results. | | | | | |
| | Capacitance 1 | 21 | | lue of Offset Tunin | - | rent Rang | e Non-Measured Channe | | | | | |
| onfig01 | Self Capacitar | nce Nor | e Auto | | ✓ Auto | | ✓ Auto Auto | <u>`</u> | / Auto | ~ | | |
| N | Aulti-Clock Me | anguring | Multiplier Rate 1 | Multiplier Rate 2 | Multiplier Rate 3 | Judgen | Output low through GP | 10 | | | | |
| | Frequencies | - | 64 | 55 | 73 | Default | Output low through the | | | gh the powe | r setting | |
| Vethod | Kind | Name | Touch Sensor | Number of Measu | irements / Number | of Time | Measurement Frequency | | | | | |
| config01 | Button(self) | Button00 | TS11 | Auto | | | Auto | | | | | |
| | | 1 | | | | | | | | | | |
| tart the Tu | uning Process | | | | | | | | | | | |
| | | | | | | | | | | | Cancel | <u>H</u> elp |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | СТ | SU2 | | | | | |
| Automat | atic Tuning Pro | cessing | | | | СТ | SU2 | | | | | |
| | - | - | ach method | / touch inter | face | СТ | SU2 | | | | | |
| elect set | etting valu | es for e | | / touch inter | | | - | | · | | | |
| elect set | etting valu | es for e | ertently or witho | ut clear understandi | ing, it could lead to | poor tun | ing results. | Output Select | Transmit Din Dea | | | |
| elect set If you w Method | etting valu will set these v Capacitance | es for ea values inadv Type Shie | ertently or without eld Pin Target Va | | ing, it could lead to | poor tun | ing results. | - | Transmit Pin Por Auto | wer v | | |
| elect set L If you w Method | etting valu | es for ea values inadv Type Shie | ertently or without eld Pin Target Va | ut clear understandi | ing, it could lead to g Measured Curr | poor tun | Non-Measured Channel Auto | ¥ | | | | |
| elect set If you w Method config01 | etting valu will set these v Capacitance | es for ea values inadv Type Shia ince Nor | ertently or without eld Pin Target Va | ut clear understandi alue of Offset Tunin | ing, it could lead to g Measured Curr | poor tun rent Range | ng results. Non-Measured Channel Auto Output low through GPI tHi-Z | 0 | Auto | | | |
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| A lf you w Method config01 System 3 Method | etting valu will set these v Capacitance Self Capacita Multi-Clock M | es for en ralues inadv Type Shie Ince Nor | ertently or without a constraint of the second seco | ut clear understandi alue of Offset Tunin Multiplier Rate 2 55 | ing, it could lead to g Measured Curr V Auto Multiplier Rate 3 | poor tun rent Range Automa Enable | Ing results. Non-Measured Channel Auto Output low through GPI te Hi-Z Output low through the | O power setting (| Auto prohibited item) | ~ | setting | |
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| A If you w Method config01 System 3 Method config01 | etting valu will set these v Capacitance Self Capacita Multi-Clock M 3 Frequencies Kind Button(self) | es for en alues inadv Type Shir ince Nor leasuring Name Button00 | ertently or without a constraint of the second seco | ut clear understandi alue of Offset Tunin Multiplier Rate 2 55 Number of Measu | Multiplier Rate 3 | poor tun rent Range Automa Enable | Ing results. Non-Measured Channel Auto Output low through GPI tr Hi-Z Output low through the Same phase pulse output Measurement Frequency | O power setting (| Auto prohibited item) | ~ | setting | |
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| Method Config01 System 3 Method Config01 | etting valu will set these v Capacitance Self Capacita Multi-Clock M 3 Frequencies Kind Button(self) | es for en alues inadv Type Shir ince Nor leasuring Name Button00 | ertently or without a constraint of the second seco | ut clear understandi alue of Offset Tunin Multiplier Rate 2 55 Number of Measu | Multiplier Rate 3 | poor tun rent Range Automa Enable | Ing results. Non-Measured Channel Auto Output low through GPI tr Hi-Z Output low through the Same phase pulse output Measurement Frequency | O power setting (| Auto prohibited item) | * | setting | <u>H</u> elp |

Figure 3-20 Setting of "Non-Measured Channel Output Select"

The settings are reflected in the qe_touch_config.c. Below is an example of setting from GPIO to L-output.

.posel = CTSU_POSEL_LOW_GPIO,

Note: Refer to the respective capacitive touch sensor hardware manual for more information on POSEL.



3.6 Multi-Clock Measuring/Multiplier Rate

The "Multi-Clock Measuring/Multiplier Rate" setting can be changed only with CTSU2/CTSU2SL. In "Multi-Clock Measuring/Multiplier Rate", the number of times of measurement and measurement frequency in multi-clock measurement are set from the multiplier rate.

Multi-Clock Measuring can be performed at multiple drive frequencies to avoid synchronous noise. By default, the instrument measures three frequencies and makes a majority decision on the result at the three frequencies to determine the measurement value. For 3-frequency measurement, the frequency set in "Measurement frequency" (sensor drive pulse frequency) is used as the first frequency, and the multiplying ratio of the 2nd/3rd frequencies can be changed to any value. For details, refer to the following document. Capacitive Sensor Microcontrollers CTSU Capacitive Touch Introduction Guide (renesas.com)

Figure 3-21 shows an image of multi-clock measurement (3-frequency measurement).

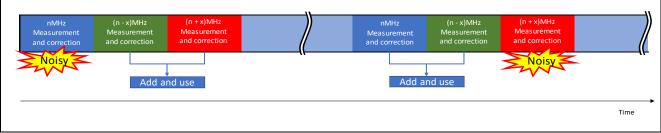


Figure 3-21 Image of multi-clock measurement (3-frequency measurement)

Table 3-16 lists the default settings.

Table 3-16 Default "Multi-Clock Measuring/Multiplier Rate" Settings

| | Multi-Clock Measuring | 1st frequency | 2nd frequency | 3rd frequency |
|---------------|-----------------------|-----------------|-----------------|-----------------|
| | Frequency | Multiplier Rate | Multiplier Rate | Multiplier Rate |
| CTSU2/CTSU2SL | 3 Frequencies | 64 | 55 | 73 |

The number of multi-clock measurements can be set at 1 frequency or 3 frequencies. Since majority operation is not performed when 1 frequency measurement is set, the measurement value is half that of 3 frequency measurement. For 3-frequency measurement, the multiplier rate of the 2nd/3rd frequency can be set within the range of 32 to 80. The multiplier rate of the 1st frequency is fixed at 64, and the frequency set in "Measurement frequency" is used. Refer to 3.3 Measurement frequency for details. The measurement frequency according to the set multiplier rate is displayed as shown in Figure 3-22.

| | Multi-Clock M 3 Frequencies | | Multiplier Rate 1 64 | Multiplier Rate 2 55 | | Automa Enable | tic Correction (Hardware) | Judgement Type Default |
|--------------------|--------------------------------|------------------|-------------------------|-------------------------|--------------------|------------------|---|---------------------------|
| Method config01 | Kind 1 Button(self) | Name Button00 | | Number of Measu Auto | rements / Number o | | Measurement Frequency 2.000 MH: 1.719 MH: 2.28 | 1 MHz |

Figure 3-22 Measurement Frequency by Setting the Multiplier Rate

The formulas for calculating the measurement frequencies of the 2nd and 3rd frequencies when the multiplier rate is changed are shown below.

Measurement frequency [2nd frequency] = Measurement frequency [1st frequency] × Multiplier rate [2nd frequency]/Multiplier rate [1st frequency]

Measurement frequency [3rd frequency] = Measurement frequency [1st frequency] × Multiplier rate [3rd frequency]/Multiplier rate [1st frequency]

Increasing the frequency difference for 3-frequency measurement tends to increase the dispersion of the measurement value.

In addition, the multiplier rate should be set so that the measurement value does not overflow. The multiplier rate should be set after thorough evaluation.



Figure 3-23 shows a window example for setting "Multi-Clock Measuring/Multiplier Rate" with "Advanced mode".

| Automatic Tuning Processing | × |
|---|--|
| Select setting values for each method / touch interface. | |
| A If you will set these values inadvertently or without clear understanding, it could lead to poor tur | ning results. |
| Method Capacitance Type Shield Pin Target Value of Offset Tuning Measured Current Range config01 Self Capacitance None Auto V Auto | |
| Multi-Clock Measuring Multiplier Rate 1 Multiplier Rate 2 Multiplier Rate 3 Judgen System 8 Frequencies 64 55 v 73 v Default I Frequency 64 55 v 73 v Default | |
| Method Anno Anno Touch Sensor Number of Measurements / Number of Time config01 Button(self) Button00 TS11 Auto | Measurement Frequency Auto |
| Start the Tuning Process | Cancel <u>H</u> elp |
| atomate Luing Processing X | Construct: Inside Proceeding Select setting values for each method / touch interface. |
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| light Butterickett Butterickett Butterickett Big Auto | 64 |
| the Tuning Process C Cancel Life | Start the Tuning Process 65 67 69 69 69 60 60 60 60 60 60 60 60 60 60 60 60 60 |
| | SU2 |
| Select setting values for each method / touch interface. A If you will set these values inadvertently or without clear understanding, it could lead to poor tur Method Capacitance Type Shield Pin Target Value of Offset Tuning Measured Current Rang config0t Self Capacitance None Auto v Auto | ge Non-Measured Channel Output Select Transmit Pin Power |
| Multi-Clock Measuring Multiplier Rate 1 Multiplier Rate 2 Multiplier Rate 3 Autom System 3 frequencies v 55 v 73 v Enable 1 frequency 54 55 v 73 v Enable | |
| Image: Street under S | Measurement Frequency Auto |
| Start the Tuning Process | Cancel Help |
| | X Select setting values for each method / touch interface. Argo will set flow values for each method / touch interface. Argo will set flow values inderstanding 8 could lead to poor tuning multi. Method: Genetarce Type: Select flow Type Values (The Tuning Masseed Caret Rage: Non-Masseed Caret Values (Tuning Masseed Caret Values (Tuning Massee |
| Centigo) Self Capacitance None Auto o | Multi-Clock Measuring Multiplier Rate 1 Multiplier Rate 2 Multiplier Rate 3 Justomatic Correction (Hardware) Judgement Type |
| Multi-Clock Measuring Multiplier Kate Multiplier Kate 2 Multiplier Kate 3 Automatic Correction (Hardware) Judgement type | System 3 Frequencies v 64 55 73 v nable v Default v |
| System 3 Frequencies v 64 73 v Faultier Othalt v Method Kind Name Tourk Servation Faultier Method Method Material Method Material Method Method Material Method | Method End Name Total Sensor Number of Mag 40 Method End Name Total Sensor Number of Mag 40 Confight Batton(arth Batton(arth |
| Spitem 3 Frequencies v 64 55 v 73 v Enable Default v Method Kind Name Tour Smooth Fig. | Method Kord Average TouckServer Number of Meek Kord Control Average Control Average Control Co |

Figure 3-23 Setting of "Multi-Clock Measuring/Multiplier Rate"

The settings are reflected in the qe_touch_define.h. The following is an example of the default setting when 3-frequency measurement is used.

| #define | CTSU_CFG_NUM_SUMULTI | (3) |
|---------|----------------------|--------|
| #define | CTSU_CFG_SUMULTIO | (0x3F) |
| #define | CTSU_CFG_SUMULTI1 | (0x36) |
| #define | CTSU_CFG_SUMULT12 | (0x48) |

Note: Refer to the respective capacitive touch sensor hardware manual for more information on SUMULTI.



3.7 Transmit Terminal Power

When the mutual capacitance method is used, I/O power supply of the terminals set in the transmit terminal is selected for each method in the "Transmit Terminal Power". The selected power supply is also used for the self-capacitance active shield electrode.

This value uses the default setting and should not be changed. For details, refer to the following document.

RL78 Family Capacitive Touch Sensing Unit (CTSU2L) Operation Explanation Rev.1.00 (renesas.com)

Table 3-17 lists the default settings.

Table 3-17 Default "Transmit Terminal Power" settings

| | When self-capacitance method is used | When using mutual capacitance method | When using active shield |
|---------------|---|---|--|
| CTSU1 | VCC | VCC | - |
| CTSU2/CTSU2SL | VCC | VCC (private) | Internal logic power supply (Power supply for active shield) |

Table 3-18 outlines the settings in CTSU1.

Table 3-18 Overview of "Transmit Terminal Power " settings for CTSU1

| | Power setting of transmit terminal | TXVSEL | Overview |
|---|------------------------------------|--------|---|
| When self-capacitance method is used | VCC | 0 | Only the receive terminal is used during measurement and the transmit terminal is not used. The receiving terminal uses TSCAP power supply. |
| When using mutual capacitance method | VCC | 0 | The transmission terminal is also used during measurement. Sensitivity changes depending on the voltage of the transmission terminal. The receiving terminal uses TSCAP power supply. |

When using CTSU1, do not set TXVSEL = 1.

Table 3-19 outlines the settings in CTSU2/CTSU2SL.

Table 3-19 Overview of "Transmit Terminal Power " settings for CTSU2/CTSU2SL

| | Power setting of transmit terminal | TXVSEL | TXVSEL2 | Overview |
|--------------------------------------|---|--------|---------|---|
| When self-capacitance method is used | VCC | 0 | 0 | Only the receive terminal is used during measurement and the transmit terminal is not used. The receiving terminal uses TSCAP power supply. |
| When using mutual capacitance method | VCC (private) | 0 / 1 | 1 | The transmission terminal is also used during measurement. Sensitivity changes depending on the voltage of the transmission terminal. The receiving terminal uses TSCAP power supply. |
| When using active shield | Internal logic power supply (Power supply for active shield) RX,RA:VCL RL:REGC | 1 | 0 | The transmit terminal is used for the output of the shield pulse. It can act as a shield by outputting pulses of the same phase and potential as the receiving terminal from the transmitting terminal. The receiving terminal uses TSCAP power supply. |

Note: For details, refer to "2.3.1 Principles of Detection" in the following documents.

Capacitive Sensor Microcontrollers CTSU Capacitive Touch Introduction Guide (renesas.com)



Figure 3-24 shows an example window for setting "Transmit Terminal Power" with "Advanced mode".

| I you will not have values inductivent you will have of Offers than it will be read in the next series of the second read o | | Se | lect se | tting value | s for eac | ch method / | touch int | erface. | |
|--|--|---------------------------------------|------------------|--------------------|---------------|--|------------------|------------------------|---------------------------|
| | | 4 | lf you 🕯 | will set these val | ues inadver | tently or without | clear understa | nding, it could lead | d to poor tuning results. |
| Improve the service of the service | | | Method | Capacitance Ty | /pe | Shield Terminal | Target Value | of Offset Tuning | Transmit Terminal Power |
| Implementation of the server in number of Measurements / Number o | | | onfig01 | Self-Capacitan | ce method | None | Auto | | |
| icentifys1 Button(self) Buttonion 1500 Auto Start the Tuning Process Curved Help Curv | | | | | | | | | VCC |
| Image: Concert in the procession Image: Concert in the proces prophy (Proceen supphy for eactive the proc | | | | | | | | asurements / Num | |
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| fyrovell set these values inadvertently or without clear understanding, it could lead to poor tuning result. Method Capacitance System 3 frequencies Sut the Tuning Processing If yow will set these values inadvertently or without clear understanding, it could lead to poor tuning results. Multi-Clock Measuring Multi-Clock Measuring Multiplier Rate 1 Multi-Clock Measuring Multiplier Rate 2 Multi-Clock Measuring Multiplier Rate 3 Mathod Kind Mathod Mathod Mathod Mathod Mathod Mathod Mathod Mathod Mathod Mathod Mathod Mathod Mathod Mathod Mathod Mathod Mathod Mathod Mathod Mathod Mathod Mathod Mathod | | | | a ch m a th | 1/+ | interfe | | | |
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| config01 Self Capacitance None Auto Auto Auto Auto Auto Auto Auto Auto | 🛓 lf you | will set these v | alues inad | vertently or witho | ut clear und | erstanding, it could | lead to poor tu | ning results. | |
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| Multiplier Rate 1 Multiplier Rate 2 Multiplier Rate 3 Judgement Type Method Kind Name Touch Sensor Number of Measurements / Number of Time Measurement Frequency Auto Auto Auto Cancel Help Start the Tuning Process Cancel Help Cancel Help Forguencies 64 So Auto Start the Tuning Process Cancel Help Cancel Help Help Forguencies Cancel Help Automatic Tuning Processing Cancel Help Sett these values insolvertently or without clear understanding, it could lead to poor tuning results. Auto Multiplier Rate 1 Multiplier Rate 1 Auto Auto Auto Auto Auto Auto Auto Auto Auto Auto Auto Auto Multiplier Rate 1 Multiplier Rate 1 Multiplier Rate 3 Automatic Correction (Hardward) Auto System 3 Frequencies 64 S5 S5 S S S System 3 Fre | config01 | Self Capacita | nce No | ne Auto | | ✓ Auto | | ✓ Auto | |
| System 3 Frequencies 64 55 73 Default UCC[private] Method Kind Name Touch Sensor Number of Measurements / Number of Time Measurement frequency Start the Tuning Process Auto Auto Auto Auto Start the Tuning Process Cancel Help Chromotic Tuning Processing Elect setting values for each method / touch interface. Method Cancel Image: Start the Tuning Processing Elect setting values for each method / touch interface. Multiplier Rate 1 Multiplier Rate 2 Auto Non-Measured Channel Output Select Tansmit Pin Power supply (Power supply for active shite configo) System 3 Frequencies 64 55 73 Enable Udgement Time Time Power supply (Power supply for active shite VCC[private) System 3 Frequencies 64 55 73 Enable Udgement Time Time Power supply (Power supply for active shite VCC[private) System 3 Frequencies 64 55 73 Enable Udgement Time Time Power supply (Power supply for active shite VCC[private) VCC[private] System 3 Frequencies 64 55 73 Enable | | Multi-Clock M | easuring | Multiplier Rate 1 | Multiplier | Rate 2 Multiplier | Rate 3 Judger | nent Type | |
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| config01 Button(self) Button00 T511 Auto Auto Start the Tuning Process | | | | | | | | | |
| Start the Tuning Process Start the Tuning Process Cancel Help CTSU2 Automatic Tuning Processing Lect setting values for each method / touch interface. f you will set these values inadvertently or without clear understanding, it could lead to poor tuning results. Method Capacitance Type Shield Pin Target Value of Offset Tuning Measured Current Range Non-Measured Channel Output Selet Tansmit Pin Power Auto Auto Auto Auto Multiplier Rate 1 Multiplier Rate 2 Multiplier Rate 2 Automatic Correction (Hardware) Judgement 1 Internal logic power supply for active shie System 3 Frequencies Auto Multiplier Rate 1 Multiplier Rate 1 Multiplier Rate 2 Auto Auto Auto Start the Tuning Process Start the Tuning Process | | | | | | Measurements / N | umber of Time | | uency |
| Cancel Help Cancel Lep Automatic Tuning Processing Elect setting values for each method / touch interface. If you will set these values inadvertently or without clear understanding, it could lead to poor tuning results. Method Capacitance Type Shield Pin Target Value of Offset Tuning Measured Current Range Non-Measured Channel Output Select Value Auto Auto Auto Multi-Clock Measuring Multiplier Rate 1 Multiplier Rate 1 Size 2 Target Value of Measurements / Number of Time Measurement Frequency Auto Auto Method Kind Name Touch Sensor Number of Measurements / Number of Time Auto Auto Auto Auto Start the Tuning Process Start the Tuning Process | config01 | Button(self) | Button00 |) TS11 | Auto | | | Auto | |
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| config01 Button(self) Button00 TS08 Auto Auto | Method config01 | | | | | M | | Manager | |
| Start the Tuning Process | Method config01 System | 3 Frequencies | | Truck C | March 1 | Measurements / N | umber of Lime | weasurement Freque | Jency |
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| | Method config01 System Method | 3 Frequencies Kind | Name | | | Websurements / W | | Auto | |
| Cancel Help | Method config01 System Method config01 | 3 Frequencies Kind Button(self) | Name Button00 | | | Webstrements / N | | Auto | |
| | Method config01 System Method config01 | 3 Frequencies Kind Button(self) | Name Button00 | | | inclusion inclusion in the second sec | | Auto | |

Figure 3-24 Setting of "Transmit Terminal Power"



The settings are reflected in the qe_touch_config.c.

Below is a sample of CTSU1.

When self-capacitance method/mutual capacitance method used

 txvsel = CTSU_TXVSEL_VCC,

Below is a sample of CTSU2/CTSU2SL.

- When self-capacitance method is used
 - .txvsel = CTSU_TXVSEL_VCC,
 - .txvsel2= CTSU_TXVSEL_MODE,
- When mutual capacitance method is used . txvsel = CTSU_TXVSEL_VCC,

.txvsel2= CTSU_TXVSEL_VCC_PRIVATE,

When active shield is used
 .txvsel = CTSU_TXVSEL_INTERNAL_POWER,

.txvsel2= CTSU_TXVSEL_MODE,



3.8 Automatic Correction (Hardware)

The "Automatic Correction (Hardware)" setting can be changed only in CTSU2SL. In "Automatic Correction (Hardware)", it is set whether to process the correction computation with CTSU peripheral. CTSU has built-in circuitry to compensate for the potential small variations in the current controlled oscillator (CCO) MCU manufacturing process. CTSU drivers or software temporarily shift to the compensation process at initialization after power-on. In the correction process, a correction circuit is used to generate a correction factor to ensure accurate sensor measurements. In the correction calculation, correction is calculated for the measurement value obtained by using this correction coefficient.

Hardware processing of correction calculation eliminates the need for wake-up for each measurement and contributes to power consumption reduction. For details, refer to the following document.

RX Family QE CTSU Module Using Firmware Integration Technology Rev.2.20 (renesas.com)

Enabled is the default setting. If it is set to "Disable", the correction calculation is executed by software.

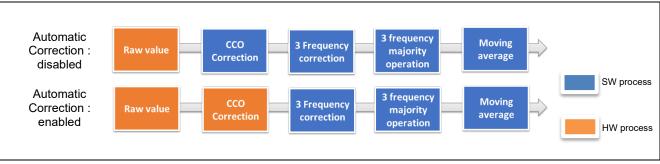


Figure 3-25 shows the image of Automatic Correction (Hardware) disabled/enabled.

Figure 3-25 Operation image with Automatic Correction disabled/enabled

Figure 3-26 shows an example window for setting "Automatic Correction (Hardware)" with "Advanced mode".

| | Capacitance | iype : | shield Pin | Target Va | alue of Offset Tunin | 9 | Measured Curre | ent Range | Non-Measured Channe | l Output Select | Transmit Pin Power | | |
|--------------------|------------------------------|----------------|--------------|------------|-------------------------|---------|----------------|---|-------------------------------|--------------------------|--------------------|---|--|
| onfig01 | Self Capacita | nce l | None | Auto | | ۷ | Auto | ~ | Auto | * | Auto 🗸 | / | |
| | Multi-Clock M Frequencies | | Multip 64 | ier Rate 1 | | N 73 | 3 🗸 | Automati Enable Enable Disable | c Correction (Hardware) V | Judgement Typ Default | v v | | |
| Method :onfig01 | Kind Button(self) | Name Buttor | | h Sensor | Number of Measu Auto | iren | | | Acusarement Frequency Auto | | | | |

Figure 3-26 Setting of "Automatic Correction (Hardware)"

The settings are reflected in the qe_touch_define.h. The following is an example when Automatic Correction (Hardware) is enabled.

#define CTSU_CFG_AUTO_CORRECTION_ENABLE (1)



Revision History

| | | Description | |
|------|-----------|-------------|--|
| Rev. | Date | Page | Summary |
| 1.00 | Jun.20.23 | - | First edition issued |
| 2.00 | Dec.25.23 | P26 | Added explanation on how to adjust measurement frequency |
| | | P30 | Added an image diagram of the amount of current change relative to the offset target value when the measured current range is changed. |
| | | P38 | Added image diagrams when Automatic Correction (Hardware) is enabled/disabled. |



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 is supplied until the power is supplied until the power reaches the level at which reseting 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 systemevaluation test for the given product.

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