

RX140 Group

CTSU Application Example: 3D Gesture Electrode Board Sample Software

Introduction

RX140 Group is equipped with the hardware called “Capacitive Touch Sensing Unit2 (CTSU2)” that detects human touch by measuring capacitance generated between touch electrodes and the human hand.

This application note describes the software specification of the 3D Gesture Electrode Board (RTK0EG0023B01002BJ) as a sample application of mutual capacitance method used in CTSU2. This product is used in combination with the CPU board of the Capacitive Touch Evaluation System.

Target Device

RX140 Group

Related Documentation

1. RX Family Using QE and FIT to Develop Capacitive Touch Applications (R01AN4516)
2. RX140 Capacitive Touch Evaluation System User's Manual (R12UZ0102)
3. RX130 Group CTSU Application Example: 3D Gesture Demo Set Small version (Hardware) (R01AN4320)
4. RX231 Group CTSU Application Example: 3D Gesture Demo Set (Hardware) (R01AN4219)
5. RX Family CTSU 3D Gesture Demo Set Sample Software (R01AN4101)
6. RX Family CTSU 3D Gesture Demo Set Evaluation Tool '3D Monitor' (R20AN0501)
7. RA2L1 Group 3D Gesture Electrode Board (Hardware) (R01AN6126)

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1. Overview

This application note describes the sample software running on RX140 Cap Touch CPU board (RTK0EG0038C01001BJ) and 3D Gesture Electrode Board (RTK0EG0023B01002BJ). For hardware information, see the related documentation, RA2L1 Group 3D Gesture Electrode Board Hardware (R01AN6126)

1.1 Function

Performs CTSU measurement, detects gestures in a space 5cm away from 3D gesture electrode board, and notifies 3D position calculation result and gesture recognition result.

The 3D position calculation and gesture recognition results can be confirmed with the evaluation tool '3D Monitor'. For detail, please refer to the related document "RX Family CTSU 3D Gesture Demo Set Evaluation Tool '3D Monitor' (R20AN0501)".

2. Operating Environment

Table 2-1 lists the software operating environments.

Table 2-1 Operating environment

| Item | Description |
|---|--|
| Evaluation board | RX140 Cap Touch CPU (RTK0EG0038C01001BJ) (RX140 Capacitive Touch Evaluation System (RTK0EG0039S01001BJ) Accessories) |
| MCU used | R5FA51406ADFN(Renesas RX140 MCU group) |
| Operating frequency | 48MHz |
| Operating voltage | 5.0V |
| Integrated Development Environment | Renesas e ² studio Version: 2022-07 (22.07.0) |
| C compiler | Renesas CC-RX V3.04.00 |
| Smart Configurator e ² studio plugin | V2.14.0 |
| Capacitance touch IDE | QE for Capacitive Touch V3.1.0 |
| Emulator | Renesas E2 Emulator Lite |
| Driver package | RX Driver Package V1.36 |

Figure 2-1 shows the connection diagram for the 3D Gesture Electrode Board.

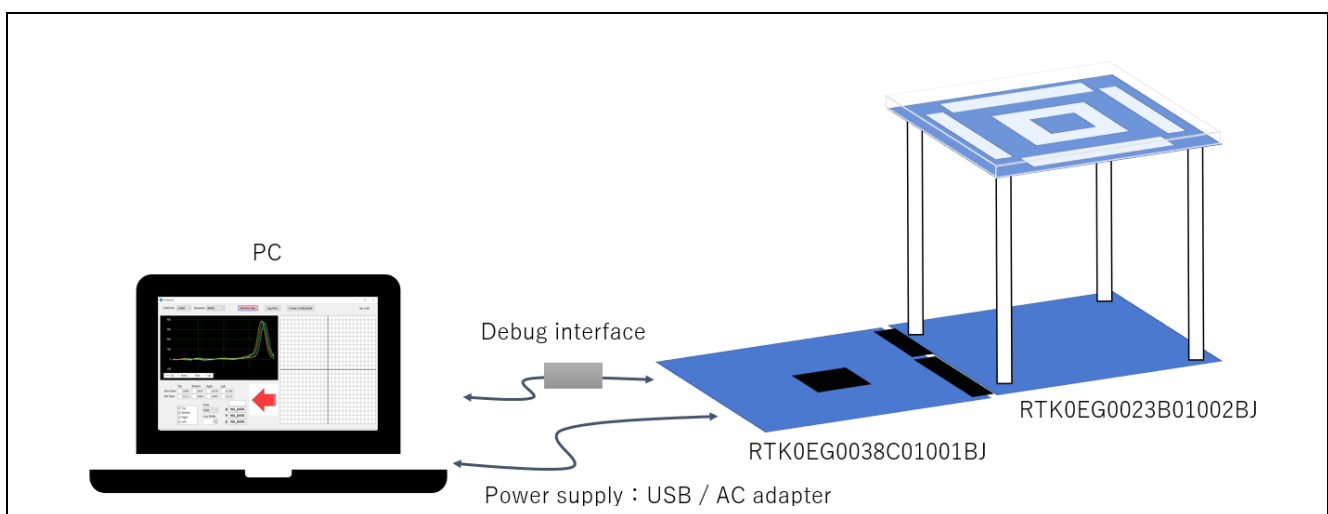


Figure 2-1 3D Gesture Electrode Board Connection Diagram

3. Sample software

This section describes the sample software.

3.1 Outline of Operation

Figure 3-1 shows the overall processing flow of the sample software.

The 3D Gesture sample application has been added based on the QE Touch module application file `qe_touch_sample.c`.

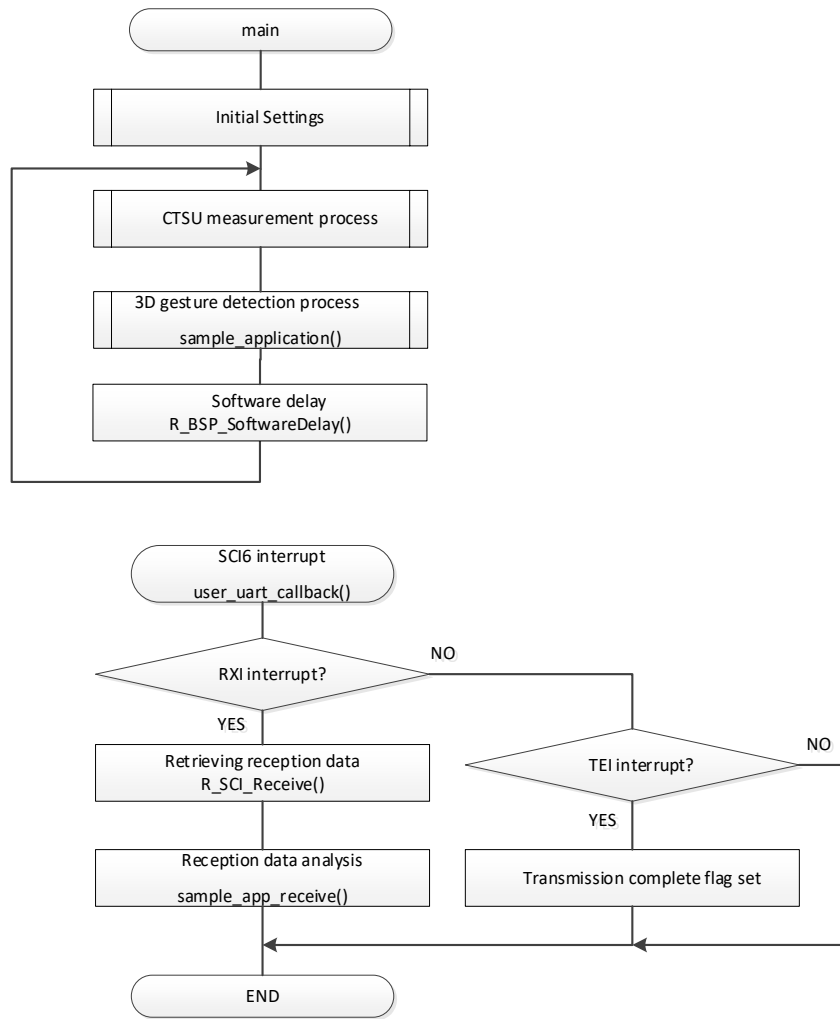


Figure 3-1 Processing flow

1. Initial Settings

The initialization process is as follows.

- CTSU initialization process

Pinning and initialization are performed using CTSU drivers.

- Peripheral function initialization process

Use `init_peripheral_function()` to initialize SCI6 using SCI drivers.

Table 3-1 shows SCI6 settings.

Table 3-1 SCI6 setting

| Setting | Set value |
|--------------|-----------|
| Baud rate | 38400bps |
| Data length | 8bit |
| Parity | None |
| Stop bit | 1bit |
| Flow control | None |

- 3D Gesture Electrode Board Initialization Process

Initialization is performed by `sample_initialize()` using 3D position calculation software.

2. CTSU measurement process

Perform CTSU measurement with `RM_TOUCH_ScanStart()`, use `RM_TOUCH_DataGet()` to check if the measurement was successful, and then use `R_CTSU_DataGet()` to obtain the touch count.

3. 3D gesture-detection process

Using the count value obtained by CTSU measurement, 3D position calculation is acquired to 3D Monitor using SCI drivers by using `R_CAPPOS_Read()`, and the gesture recognition result is acquired by `R_GESTURE_Detect()`.

4. Software delay

Adjusts the period of CTSU measurement. The default setting is 5msec.

You can change the rate at which 3D gestures are detected by adjusting CTSU measurement period.

Increase software delay → supports detection of slow gestures

Shorten software delay → support fast gesture detection

5. SCI6 interrupt handling

In SCI6 interrupt handling, when a reception completion interrupt (RXI) occurs, the received data from 3D Monitor is analyzed.

When the "Monitor Start" command is received, 3D position calculation result and the gesture recognition result are sent to the tool. Transmission is stopped when the "Monitor Stop" command is received. For the communication format with 3D Monitor, refer to "7 Sample Application" in "RX Family CTSU 3D Gesture Demo Set Sample Software" (R01AN4101).

When a transmit end interrupt (TEI) occurs, the transmit end flag is set.

3.2 Software structure

Figure 3-2 shows the software structure diagram.

Capacitance measurement with CTSU2 uses the Development Assistance Tool for Capacitive Touch Sensors QE for Capacitive Touch and software generated by the Smart Configurator (QE Touch Module, QE CTSU Module).

The gesture recognition library analyzes changes in this 3D position to recognize gestures.

The application communicates USB with PC to notify the user of 3D position calculation and gesture recognition results.

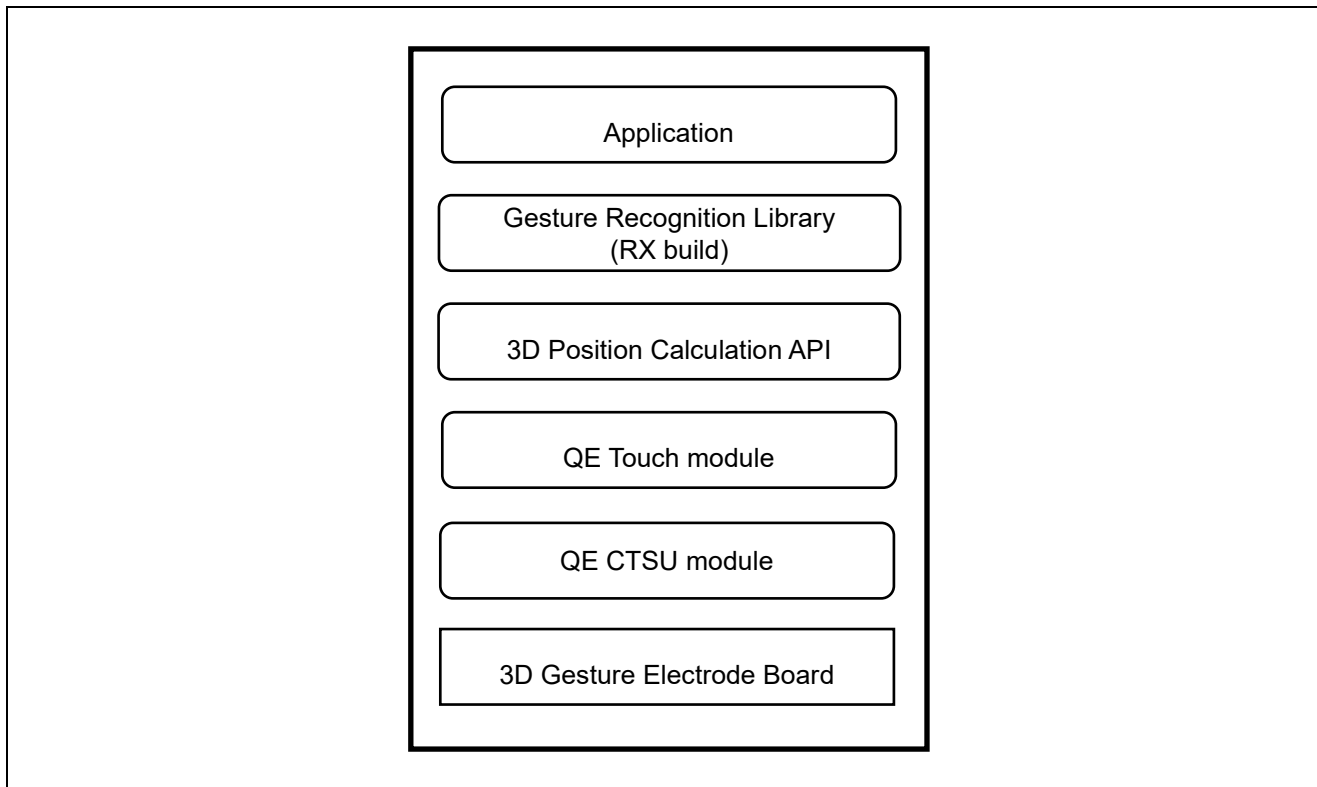


Figure 3-2 Software Structure

3.3 File Configuration

Table3-2 shows the file configuration. The source file/header file generated by the Smart Configurator, such as QE Touch module, is omitted.

Table3-2 File Configuration

| Folder/file name | Overview |
|--|--|
| 3d_gesture_electrode_sample_project_rx140 | Project folder |
| .cproject | C project file |
| .project | Project file |
| 3d_gesture_electrode_sample_project_rx140 .launch | Debug configuration file |
| 3d_gesture_electrode_sample_project_rx140.scfg | Smart Configurator configuration file |
| Gesture_Recognition_RXv2.lib | Gesture recognition library |
| qe_gen | Source/header file storage folder |
| qe_touch_config.c | QE Touch configuration definition source file |
| qe_touch_config.h | QE Touch configuration definition header file |
| qe_touch_define.h | QE Touch configuration definition header file |
| qe_touch_sample.c | Application file |
| src | |
| r_cap_position.c | 3D position calculation API source file |
| r_cap_position_config.h | 3D position calculation API config file |
| r_cap_position_measure.h | 3D position calculation API pre-measurement file |
| r_cap_position_if.h | 3D position calculation API interface file |
| r_cap_position.h | 3D position calculation API header file |
| r_cap_gesture_if.h | Gesture recognition interface file |
| 3d_gesture_electrode_sample_project_rx140.c | Main source file |
| QE-Touch | QE for Capacitive Touch generated folder |
| 3d_gesture_electrode_sample_project_rx140.tifcfg | Touch I/F configuration file |

3.4 List of Peripheral Functions and Pins Used

Table 3-3 lists the peripheral functions used by this sample software, Table 3-4 lists the pins used, and Table 3-5 lists the unused pins and remedies.

Table 3-3 List of peripheral functions to be used

| Peripheral functions | Use |
|----------------------|-------------------------------|
| CTSU、DTC | CTSU measurement |
| SCI6 | Communicating with 3D Monitor |

Table 3-4 List of Pins Used

| Pin number | Terminal name | I/O | Use |
|------------|---------------|-----|-------------------------------|
| 17 | TS01 | I | CTSU measurement |
| 25 | TS05 | I | |
| 29 | TS07 | I | |
| 31 | TS09 | I | |
| 61 | TS35 | I | |
| 38 | TSCAP | I | |
| 65 | PD1/RXD6 | I | Communicating with 3D Monitor |
| 66 | PD0/TXD6 | O | |

Table 3-5 List of unused pins and remedies

| Pin number | Terminal name | I/O | Unused measures |
|---------------------------|---------------|-----|--|
| 1 | P06 | O | Low output |
| 2 | P03 | O | Low output |
| 4 | VCL | I | Connected to GND via a capacitor (4.7uF) |
| 6 | MD | I | Input |
| 9 | RES# | I | Connected to the reset circuit |
| 14 | NMI | I | Input |
| 15 | IRQ4 | I | Input |
| 77 | AVCC0 | I | Connected to GND via a capacitor (0.1uF) |
| 19 | AVSS0 | I | Connect to GND |
| Pins other than the above | | - | Open, Low output |

The peripheral function settings using the smart configurator are shown below.

- CTSU、DTC (CTSU measurement)

Use CTSU to perform touch measurement. DTC is used to set the register of CTSU and to acquire the measurement result.

Table 3-6 and Table 3-7 show the settings of each peripheral function.

Table 3-6 CTSU setting

| Item | Setting |
|-----------------------------|----------|
| Data transfer by interrupt | DTC |
| Automatic judgment function | Disabled |

Table 3-7 DTC setting

| Item | Setting |
|------------------------|---|
| DTCER control | All DTCER registers are cleared by the open-function. |
| Address mode | Full address mode |
| DTC transfer read skip | Enabled |
| Sequence transfer | Not used |

- SCI6

SCI6 is used to communicate with 3D Monitor. SCI6 settings are shown in Table 3-8.

Table 3-8 SCI6 setting

| Item | Setting |
|-----------------------------|-------------|
| Mode to use | ASYNCR Mode |
| Channels to be used | Channel 6 |
| Transfer complete interrupt | Enabled |

3.5 Software configuration

3.5.1 File Configuration

Table 3-9 shows the source files.

Table 3-9 Source file

| File name | Description | Notes |
|-------------------|------------------|-------|
| qe_touch_sample.c | Application file | - |

3.5.2 Constants

Table 3-10 shows the constants of the qe_touch_sample.c.

Table 3-10 Constants (qe_touch_sample.c)

| Constant name | Setting value | Description |
|-----------------------------|--|--|
| TOUCH_SCAN_INTERVAL_EXAMPLE | (5) | Software delay value [msec units] |
| LOG_SEND_DATA_SIZE | (0x1C) | Data size to be sent from a single CTSU measurement |
| LOG_RECV_DATA_SIZE | (0x04) | Receive data size from 3D Monitor |
| LOG_HEADER | (0x55) | Value indicating the header of the log communication data format |
| LOG_DELIMITER | (0x0A) | Value indicating the delimiter of the log communication data format |
| LOG_COMMAND_START | (0x01) | Indicates START of the command. |
| LOG_COMMAND_STOP | (0x02) | Indicates STOP of the command. |
| LOG_COMMAND_DATA | (0x03) | Indicates DATA of the command. |
| LOG_ON | (0x01) | Value indicating that log transmission is valid |
| LOG_OFF | (0x00) | Value indicating that log transmission is disabled |
| LOG_ID_MAX | (0xFF) | ID Maximum value |
| LOG_INDEX_HEADER | (0) | Value indicating the index of the header of the log communication data format |
| LOG_INDEX_ID | (1) | Indicates the indexes of ID in the log communication data format. |
| LOG_INDEX_COMMAND | (2) | Value indicating the index of the command in the log communication data format |
| LOG_SEND_COUNT | (2) | CTSU count required for logging transmission |
| BUF_SIZE_SND | (LOG_SEND_DATA_SIZE * LOG_SEND_COUNT) | Transmit data buffer size |
| BUF_SIZE_DATA | (8) | CTSU measured value storage buffer size |
| SCI_BAUDRATE | (38400) | SCI6 baud rate setting |
| SCI_INT_PRIORITY | (1) | SCI6 interrupt priority setting |
| SCI_RECV_DATA_SIZE | (1) | SCI6 Received data size |

3.5.3 Functions

Table 3-11 shows the functions.

Table 3-11 Functions

| Function Name | Processing overview |
|---------------------------------------|---|
| <code>qe_touch_sample.c</code> | |
| <code>qe_touch_main</code> | Main function |
| <code>init_peripheral_function</code> | Peripheral function initialization processing |
| <code>sample_initialize</code> | 3D Gesture Electrode Board Initialization Process |
| <code>sample_application</code> | 3D gesture-detection process |
| <code>sample_app_receive</code> | Receive-data analysis process from 3D Monitor |
| <code>user_uart_callback</code> | SCI6 interrupt callback |

For further API specifics, please refer to the application notes of the individual modules.

3.6 3D Position Computation Software Specifications

3.6.1 File Configuration

Table 3-12 shows the source file used in this sample software.

Table 3-12 Source file

| File name | Description | Notes |
|-------------------------------|---|-------|
| <code>r_cap_position.c</code> | 3D position calculation API source file | - |

Table 3-13 shows the header files.

Table 3-13 Header files

| File name | Description | Notes |
|---------------------------------------|--|--|
| <code>r_cap_position_config.h</code> | 3D position calculation API config file | - |
| <code>r_cap_position_measure.h</code> | 3D position calculation API pre-measurement file | - |
| <code>r_cap_position_if.h</code> | 3D position calculation API interface file | - |
| <code>r_cap_position.h</code> | 3D position calculation API header file | For use in 3D position calculation API |

3.6.2 Constants

Table 3-14 shows the `r_cap_position_if.h` constants.

Table 3-14 Constants (`r_cap_position_if.h`)

| Constant name | Setting value | Description |
|------------------------------|---------------|--|
| <code>CAPPOS_NODETECT</code> | (0x3FFF) | Value displayed when no 3D position calculation results are detected |
| <code>CAPPOS_SUCCESS</code> | (0x00) | 3D position calculation API completed normally |
| <code>CAPPOS_ERROR</code> | (0x01) | 3D position calculation API error occurred |
| <code>CAPPOS_NORMAL</code> | (0x00) | Value displayed when result of noise environment is normal |
| <code>CAPPOS_NOISY</code> | (0x01) | Value displayed when result of noise environment is noise detection |

Table 3-15 shows the `r_cap_position_config.h` constants.

The default setting value is the value for the 3D Gesture Electrode Board; change as necessary to fit the usage environment.

Table 3-15 Constants (`r_cap_position_config.h`)

| Constant name | Setting value | Description |
|------------------------|---------------|---|
| CAPPOS_CNF_MOVAVG_NUM | (15) | Moving average setting value |
| CAPPOS_CNF_DRIFT_NUM | (150) | Drift measurement number |
| CAPPOS_CNF_DRIFT_THR | (25) | Drift threshold |
| CAPPOS_CNF_RESUME_NUM | (25) | Resume measurement number |
| CAPPOS_CNF_RESUME_THR | (20) | Resume threshold |
| CAPPOS_CNF_NOISE_THR_A | (150) | Noise threshold A (difference with reference value) |
| CAPPOS_CNF_NOISE_THR_B | (50) | Noise threshold B (difference with past value) |
| CAPPOS_CNF_MAX_X | (100) | X direction calculation range [mm] |
| CAPPOS_CNF_MAX_Y | (100) | Y direction calculation range [mm] |

Table 3-16 shows the `r_cap_position_measure.h` constants.

The default setting value is the value for the 3D Gesture Electrode Board; change as necessary to fit the usage environment.

Table 3-16 Constants (`r_cap_position_measure.h`)

| Constant name | Setting value | Description |
|----------------|---------------|---|
| CAPPOS_MEAS_Z0 | (10) | Measured Z direction position [mm] Set to 1 or higher. |
| CAPPOS_MEAS_Z1 | (20) | Measured Z direction position [mm] Set to a value higher than CAPPOS_MEAS_Z0 |
| CAPPOS_MEAS_Z2 | (30) | Measured Z direction position [mm] Set to a value higher than CAPPOS_MEAS_Z1 |
| CAPPOS_MEAS_Z3 | (40) | Measured Z direction position [mm]. Set to a value higher than CAPPOS_MEAS_Z2. If positions were measured in 3 locations, set to 0 for this constant and all "CAPPOS_MEAS_*_3" constants. |
| CAPPOS_MEAS_Z4 | (50) | Measured Z direction position [mm]. Set to a value higher than CAPPOS_MEAS_Z3. If positions were measured in 4 locations, set to 0 for this constant and all "CAPPOS_MEAS_*_4" constants. |
| CAPPOS_MEAS_Z5 | (60) | Measured Z direction position [mm]. Set to a value higher than CAPPOS_MEAS_Z4. If positions were measured in 5 locations, set to 0 for this constant and all "CAPPOS_MEAS_*_5" constants. |
| CAPPOS_MEAS_Z6 | (70) | Measured Z direction position [mm]. Set to a value higher than CAPPOS_MEAS_Z5. If positions were measured in 6 locations, set to 0 for this constant and all "CAPPOS_MEAS_*_6" constants. |
| CAPPOS_MEAS_Z7 | (80) | Measured Z direction position [mm]. Set to a value higher than CAPPOS_MEAS_Z6. If positions were measured in 7 locations, set to 0 for this constant and all "CAPPOS_MEAS_*_7" constants. |

| | | |
|------------------|---------|---|
| CAPPOS_MEAS_Z8 | (90) | Measured Z direction position [mm]. Set to a value higher than CAPPOS_MEAS_Z7. If positions were measured in 8 locations, set to 0 for this constant and all "CAPPOS_MEAS_*_8" constants. |
| CAPPOS_MEAS_Z9 | (100) | Measured Z direction position [mm]. Set to a value higher than CAPPOS_MEAS_Z8. If positions were measured in 9 locations, set to 0 for this constant and all "CAPPOS_MEAS_*_9" constants. |
| CAPPOS_MEAS_X | (60) | Measured X direction position [mm] If the X direction is not measured, set to 0 for this constant. |
| CAPPOS_MEAS_Y | (0) | Measured Y direction position [mm] If the Y direction is not measured, set to 0 for this constant. |
| CAPPOS_MEAS_TOP | (15284) | Top electrode count value when nothing is in vicinity of board |
| CAPPOS_MEAS_BTM | (14017) | Bottom electrode count value when nothing is in vicinity of board |
| CAPPOS_MEAS_RGT | (11991) | Right electrode count value when nothing is in vicinity of board |
| CAPPOS_MEAS_LFT | (11348) | Left electrode count value when nothing is in vicinity of board |
| CAPPOS_MEAS_TOP0 | (13615) | Top electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z0) |
| CAPPOS_MEAS_TOP1 | (14451) | Top electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z1) |
| CAPPOS_MEAS_TOP2 | (14791) | Top electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z2) |
| CAPPOS_MEAS_TOP3 | (14967) | Top electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z3) |
| CAPPOS_MEAS_TOP4 | (15060) | Top electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z4) |
| CAPPOS_MEAS_TOP5 | (15117) | Top electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z5) |
| CAPPOS_MEAS_TOP6 | (15165) | Top electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z6) |
| CAPPOS_MEAS_TOP7 | (15206) | Top electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z7) |
| CAPPOS_MEAS_TOP8 | (15215) | Top electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z8) |
| CAPPOS_MEAS_TOP9 | (15239) | Top electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z9) |
| CAPPOS_MEAS_BTM0 | (12637) | Bottom electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z0) |
| CAPPOS_MEAS_BTM1 | (13297) | Bottom electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z1) |
| CAPPOS_MEAS_BTM2 | (13565) | Bottom electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z2) |
| CAPPOS_MEAS_BTM3 | (13717) | Bottom electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z3) |
| CAPPOS_MEAS_BTM4 | (13801) | Bottom electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z4) |
| CAPPOS_MEAS_BTM5 | (13852) | Bottom electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z5) |
| CAPPOS_MEAS_BTM6 | (13894) | Bottom electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z6) |
| CAPPOS_MEAS_BTM7 | (13926) | Bottom electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z7) |
| CAPPOS_MEAS_BTM8 | (13950) | Bottom electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z8) |
| CAPPOS_MEAS_BTM9 | (13976) | Bottom electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z9) |
| CAPPOS_MEAS_RGT0 | (10725) | Right electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z0) |
| CAPPOS_MEAS_RGT1 | (11347) | Right electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z1) |
| CAPPOS_MEAS_RGT2 | (11597) | Right electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z2) |
| CAPPOS_MEAS_RGT3 | (11729) | Right electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z3) |
| CAPPOS_MEAS_RGT4 | (11805) | Right electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z4) |
| CAPPOS_MEAS_RGT5 | (11852) | Right electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z5) |
| CAPPOS_MEAS_RGT6 | (11890) | Right electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z6) |
| CAPPOS_MEAS_RGT7 | (11918) | Right electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z7) |
| CAPPOS_MEAS_RGT8 | (11930) | Right electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z8) |
| CAPPOS_MEAS_RGT9 | (11950) | Right electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z9) |
| CAPPOS_MEAS_LFT0 | (10229) | Left electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z0) |
| CAPPOS_MEAS_LFT1 | (10785) | Left electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z1) |
| CAPPOS_MEAS_LFT2 | (11009) | Left electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z2) |
| CAPPOS_MEAS_LFT3 | (11124) | Left electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z3) |
| CAPPOS_MEAS_LFT4 | (11192) | Left electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z4) |
| CAPPOS_MEAS_LFT5 | (11230) | Left electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z5) |

| | | |
|--------------------|---------|--|
| CAPPOS_MEAS_LFT6 | (11261) | Left electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z6) |
| CAPPOS_MEAS_LFT7 | (11279) | Left electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z7) |
| CAPPOS_MEAS_LFT8 | (11297) | Left electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z8) |
| CAPPOS_MEAS_LFT9 | (11317) | Left electrode count value measured when coordinates are (0, 0, CAPPOS_MEAS_Z9) |
| CAPPOS_MEAS_X_RGT0 | (10956) | Right electrode count value measured when coordinates are (CAPPOS_MEAS_X, 0, CAPPOS_MEAS_Z0) |
| CAPPOS_MEAS_X_RGT1 | (11417) | Right electrode count value measured when coordinates are (CAPPOS_MEAS_X, 0, CAPPOS_MEAS_Z1) |
| CAPPOS_MEAS_X_RGT2 | (11640) | Right electrode count value measured when coordinates are (CAPPOS_MEAS_X, 0, CAPPOS_MEAS_Z2) |
| CAPPOS_MEAS_X_RGT3 | (11760) | Right electrode count value measured when coordinates are (CAPPOS_MEAS_X, 0, CAPPOS_MEAS_Z3) |
| CAPPOS_MEAS_X_RGT4 | (11828) | Right electrode count value measured when coordinates are (CAPPOS_MEAS_X, 0, CAPPOS_MEAS_Z4) |
| CAPPOS_MEAS_X_RGT5 | (11869) | Right electrode count value measured when coordinates are (CAPPOS_MEAS_X, 0, CAPPOS_MEAS_Z5) |
| CAPPOS_MEAS_X_RGT6 | (11905) | Right electrode count value measured when coordinates are (CAPPOS_MEAS_X, 0, CAPPOS_MEAS_Z6) |
| CAPPOS_MEAS_X_RGT7 | (11924) | Right electrode count value measured when coordinates are (CAPPOS_MEAS_X, 0, CAPPOS_MEAS_Z7) |
| CAPPOS_MEAS_X_RGT8 | (11948) | Right electrode count value measured when coordinates are (CAPPOS_MEAS_X, 0, CAPPOS_MEAS_Z8) |
| CAPPOS_MEAS_X_RGT9 | (11956) | Right electrode count value measured when coordinates are (CAPPOS_MEAS_X, 0, CAPPOS_MEAS_Z9) |
| CAPPOS_MEAS_X_LFT0 | (11123) | Left electrode count value measured when coordinates are (CAPPOS_MEAS_X, 0, CAPPOS_MEAS_Z0) |
| CAPPOS_MEAS_X_LFT1 | (11198) | Left electrode count value measured when coordinates are (CAPPOS_MEAS_X, 0, CAPPOS_MEAS_Z1) |
| CAPPOS_MEAS_X_LFT2 | (11232) | Left electrode count value measured when coordinates are (CAPPOS_MEAS_X, 0, CAPPOS_MEAS_Z2) |
| CAPPOS_MEAS_X_LFT3 | (11257) | Left electrode count value measured when coordinates are (CAPPOS_MEAS_X, 0, CAPPOS_MEAS_Z3) |
| CAPPOS_MEAS_X_LFT4 | (11278) | Left electrode count value measured when coordinates are (CAPPOS_MEAS_X, 0, CAPPOS_MEAS_Z4) |
| CAPPOS_MEAS_X_LFT5 | (11290) | Left electrode count value measured when coordinates are (CAPPOS_MEAS_X, 0, CAPPOS_MEAS_Z5) |
| CAPPOS_MEAS_X_LFT6 | (11307) | Left electrode count value measured when coordinates are (CAPPOS_MEAS_X, 0, CAPPOS_MEAS_Z6) |
| CAPPOS_MEAS_X_LFT7 | (11308) | Left electrode count value measured when coordinates are (CAPPOS_MEAS_X, 0, CAPPOS_MEAS_Z7) |
| CAPPOS_MEAS_X_LFT8 | (11327) | Left electrode count value measured when coordinates are (CAPPOS_MEAS_X, 0, CAPPOS_MEAS_Z8) |
| CAPPOS_MEAS_X_LFT9 | (11332) | Left electrode count value measured when coordinates are (CAPPOS_MEAS_X, 0, CAPPOS_MEAS_Z9) |
| CAPPOS_MEAS_Y_TOP0 | (0) | Top electrode count value measured when coordinates are (0, CAPPOS_MEAS_Y, CAPPOS_MEAS_Z0) |
| CAPPOS_MEAS_Y_TOP1 | (0) | Top electrode count value measured when coordinates are (0, CAPPOS_MEAS_Y, CAPPOS_MEAS_Z1) |
| CAPPOS_MEAS_Y_TOP2 | (0) | Top electrode count value measured when coordinates are (0, CAPPOS_MEAS_Y, CAPPOS_MEAS_Z2) |
| CAPPOS_MEAS_Y_TOP3 | (0) | Top electrode count value measured when coordinates are (0, CAPPOS_MEAS_Y, CAPPOS_MEAS_Z3) |
| CAPPOS_MEAS_Y_TOP4 | (0) | Top electrode count value measured when coordinates are (0, CAPPOS_MEAS_Y, CAPPOS_MEAS_Z4) |

| | | |
|--------------------|-----|---|
| CAPPOS_MEAS_Y_TOP5 | (0) | Top electrode count value measured when coordinates are (0, CAPPOS_MEAS_Y, CAPPOS_MEAS_Z5) |
| CAPPOS_MEAS_Y_TOP6 | (0) | Top electrode count value measured when coordinates are (0, CAPPOS_MEAS_Y, CAPPOS_MEAS_Z6) |
| CAPPOS_MEAS_Y_TOP7 | (0) | Top electrode count value measured when coordinates are (0, CAPPOS_MEAS_Y, CAPPOS_MEAS_Z7) |
| CAPPOS_MEAS_Y_TOP8 | (0) | Top electrode count value measured when coordinates are (0, CAPPOS_MEAS_Y, CAPPOS_MEAS_Z8) |
| CAPPOS_MEAS_Y_TOP9 | (0) | Top electrode count value measured when coordinates are (0, CAPPOS_MEAS_Y, CAPPOS_MEAS_Z9) |
| CAPPOS_MEAS_Y_BTM0 | (0) | Bottom electrode count value measured when coordinates are (0, CAPPOS_MEAS_Y, CAPPOS_MEAS_Z0) |
| CAPPOS_MEAS_Y_BTM1 | (0) | Bottom electrode count value measured when coordinates are (0, CAPPOS_MEAS_Y, CAPPOS_MEAS_Z1) |
| CAPPOS_MEAS_Y_BTM2 | (0) | Bottom electrode count value measured when coordinates are (0, CAPPOS_MEAS_Y, CAPPOS_MEAS_Z2) |
| CAPPOS_MEAS_Y_BTM3 | (0) | Bottom electrode count value measured when coordinates are (0, CAPPOS_MEAS_Y, CAPPOS_MEAS_Z3) |
| CAPPOS_MEAS_Y_BTM4 | (0) | Bottom electrode count value measured when coordinates are (0, CAPPOS_MEAS_Y, CAPPOS_MEAS_Z4) |
| CAPPOS_MEAS_Y_BTM5 | (0) | Bottom electrode count value measured when coordinates are (0, CAPPOS_MEAS_Y, CAPPOS_MEAS_Z5) |
| CAPPOS_MEAS_Y_BTM6 | (0) | Bottom electrode count value measured when coordinates are (0, CAPPOS_MEAS_Y, CAPPOS_MEAS_Z6) |
| CAPPOS_MEAS_Y_BTM7 | (0) | Bottom electrode count value measured when coordinates are (0, CAPPOS_MEAS_Y, CAPPOS_MEAS_Z7) |
| CAPPOS_MEAS_Y_BTM8 | (0) | Bottom electrode count value measured when coordinates are (0, CAPPOS_MEAS_Y, CAPPOS_MEAS_Z8) |
| CAPPOS_MEAS_Y_BTM9 | (0) | Bottom electrode count value measured when coordinates are (0, CAPPOS_MEAS_Y, CAPPOS_MEAS_Z9) |

3.6.3 Structures

Table 3-17 shows the `st_position_result_t` structures.

Table 3-17 `st_cappos_result_t` Structures

| Type | Member | Description |
|----------------------|----------------------|---------------------------------------|
| <code>int16_t</code> | <code>coord_x</code> | x position calculation result [mm] |
| <code>int16_t</code> | <code>coord_y</code> | y position calculation result [mm] |
| <code>int16_t</code> | <code>coord_z</code> | z position calculation result [mm] |
| <code>uint8_t</code> | <code>noise</code> | Result of noise environment detection |

Table 3-18 shows the `st_captouch_data_t` structures.

Table 3-18 `st_captouch_data_t` Structures

| Type | Member | Description |
|-----------------------|------------------|------------------------------|
| <code>uint16_t</code> | <code>top</code> | Top electrode count value |
| <code>uint16_t</code> | <code>btm</code> | Bottom electrode count value |
| <code>uint16_t</code> | <code>rgt</code> | Right electrode count value |
| <code>uint16_t</code> | <code>lft</code> | Left electrode count value |

3.7 API Function Specification

For API function specification, refer to "5.4 API function specification" in "RX Family CTSU 3D Gesture Demo Set Sample Software" (R01AN4101).

3.8 Gesture Recognition Library Specifications

3.8.1 File Configuration

Table 3-19 shows the library files.

Table 3-19 Library file

| File name | Description |
|------------------------------|---|
| Gesture_Recognition_RXv2.lib | Gesture recognition library file (RX build) |

Table 3-20 shows the header file.

Table 3-20 Header file

| File name | Description |
|--------------------|--|
| r_cap_gesture_if.h | Gesture recognition API interface file |

3.8.2 Constants

Table 3-21 shows the constants. These are defined by enumerated type `e_gesture_result_t`.

Table 3-21 Constants

| Constant name | Setting value | Description |
|----------------------------|---------------|---------------------------------------|
| GESTURE_RESULT_NONE | (0) | No recognition |
| GESTURE_RESULT_RIGHT_SWIPE | (1) | Right swipe |
| GESTURE_RESULT_LEFT_SWIPE | (2) | Left swipe |
| GESTURE_RESULT_FRONT_SWIPE | (3) | Front swipe |
| GESTURE_RESULT_BACK_SWIPE | (4) | Back swipe |
| GESTURE_RESULT_DOWN_SWIPE | (5) | Push |
| GESTURE_RESULT_CW_SLOW | (6) | Draw circle (Clockwise, Slow) |
| GESTURE_RESULT_CW_FAST | (7) | Draw circle (Clockwise, Fast) |
| GESTURE_RESULT_RESERVE | (8) | Reserved |
| GESTURE_RESULT_CCW_SLOW | (9) | Draw circle (Counter clockwise, Slow) |
| GESTURE_RESULT_CCW_FAST | (10) | Draw circle (Counter clockwise, Fast) |
| GESTURE_RESULT_RESERVE2 | (11) | Reserved2 |

3.8.3 Structures

Table 3-22 shows the `st_cappos_input_t` structure.

Table 3-22 `st_cappos_input_t` Structures

| Type | Member | Description |
|---------|---------|---------------------------------------|
| int16_t | coord_x | x position calculation result [mm] |
| int16_t | coord_y | y position calculation result [mm] |
| int16_t | coord_z | z position calculation result [mm] |
| uint8_t | noise | Result of noise environment detection |

3.9 API Function Specification

For API function specification, refer to "6.4 API function specification" in "RX Family CTSU 3D Gesture Demo Set Sample Software" (R01AN4101).

4. Capacitance Touch Settings

This section describes the sample application. The 3D Gesture sample application has been added based on the QE Touch module application file `qe_touch_sample.c`.

4.1 Touch Interface Configuration

In this software, TS pins are configured as shown in Figure 4-1.

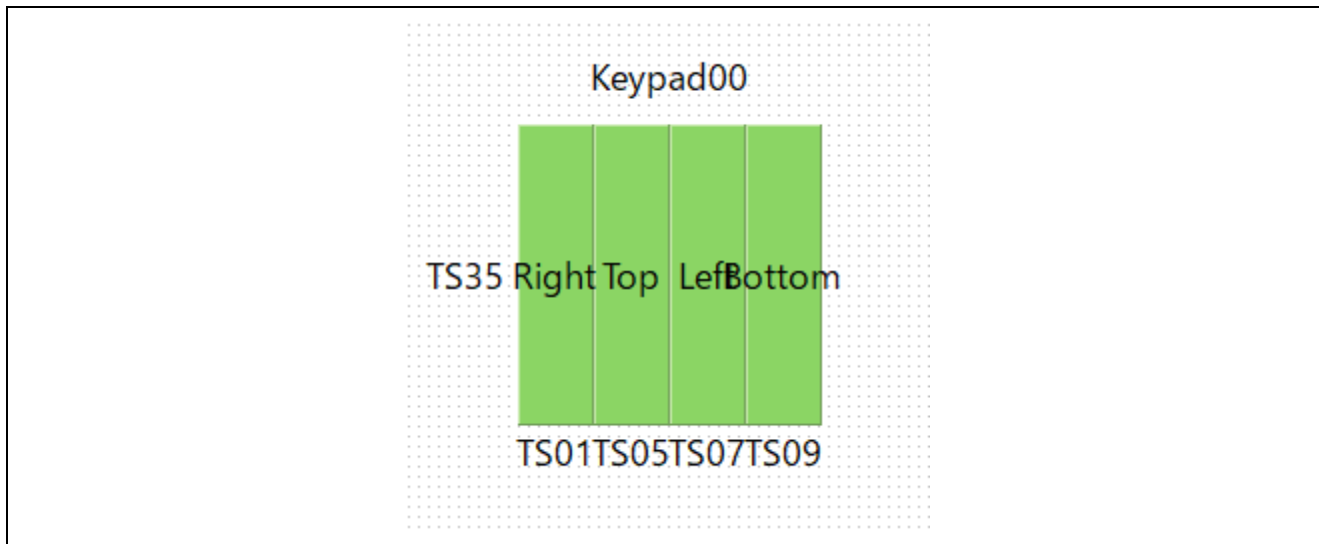


Figure 4-1 Touch Interface Configuration

4.2 Configuration (method) settings

Config01 is set to the keypad.

4.3 Tuning result

The following shows the tuning results in QE tuning. This program operates with the setting values shown in the results list.

Since the values in the result list depend on the operating environment at the time of QE tuning, these values may change when QE tuning is performed again.

Table 4-1 QE Tuning Results

| Method | Name | Touch sensor | Parasitic capacitance [pF] | Drive pulse frequency [MHz] | Threshold | Measuring time [ms] | so | snum | sdpa |
|----------|--------|--------------|----------------------------|-----------------------------|-----------|---------------------|-------|------|------|
| config01 | right | TS01 | 26.924 | 1 | 86 | 0.576 | 0x000 | 0x07 | 0x0F |
| config01 | top | TS03 | 26.924 | 1 | 80 | 0.576 | 0x000 | 0x07 | 0x0F |
| config01 | left | TS05 | 26.924 | 1 | 97 | 0.576 | 0x000 | 0x07 | 0x0F |
| config01 | bottom | TS09 | 26.924 | 1 | 110 | 0.576 | 0x000 | 0x07 | 0x0F |

so : Sensor Offset Setting Variables
snum : Variables for the measurement period setting
sdpa : Clock division setting variable

4.4 Sensitivity adjustment method

Use QE for Capacitive Touch to adjust the sensitivity. There are the following methods for adjusting the sensitivity.

- How to use the tune function of QE for Capacitive Touch

Follow the tutorial from the main window (Cap Touch main) of QE for Capacitive Touch.

5. Calculating 3D position

Refer to Section 4 of RX Family CTSU 3D Gesture Demonstration Set Sample Software (R01AN4101) for information on calculating 3D position.

Revision History

| Rev. | Date | Description | |
|------|-----------|-------------|-----------------------|
| | | Page | Summary |
| 1.00 | Nov.11.22 | - | First edition release |
| | | | |

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)

A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity.

Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.

2. Processing at power-on

The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.

3. Input of signal during power-off state

Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.

4. Handling of unused pins

Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.

5. Clock signals

After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.

6. Voltage application waveform at input pin

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).

7. Prohibition of access to reserved addresses

Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.

8. Differences between products

Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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