

Capacitive Controller ICs

Capacitive Switch Controller ICs

BU21079F

General Description

BU21079F is a capacitive switch controller used for operating switches. Low power consumption is achieved using the intermittent operation mode. In addition to a regular simple switch, it supports matrix switches which are arranged in the matrix sensors. If external noise and temperature drift are detected, the automatic self-calibration is activated.

Key Specifications

| | |
|-------------------------------|---------------|
| ■ Input voltage range | 3.0V to 5.5V |
| ■ Operating temperature range | -25°C to 85°C |
| ■ Operating current | 2.5mA (Typ) |
| ■ Detect cycle | 6msec (Typ) |

Packages

BU21079F :

Features

- 8 capacitive sensor ports
- Supports matrix switches. Maximum of 16 switches.
- Automatic self-calibration
- Continued touch detection
- Sends an interrupt when there is a detected result of switch operation
- 2-wire serial bus interface
- 3.3V or 5.0V single power supply
- Built-in Power-On-Reset and Oscillator



SOP16
10.00 mm×6.20 mm×1.71 mm

Applications

- Electronic devices with multiple switches.
- Information appliances such as printers.
- AV appliances such as digital TV and HDD recorder.
- Notebook PC.
- Air-conditioner. Refrigerator. Electrical rice cooker.

Typical Application Circuit

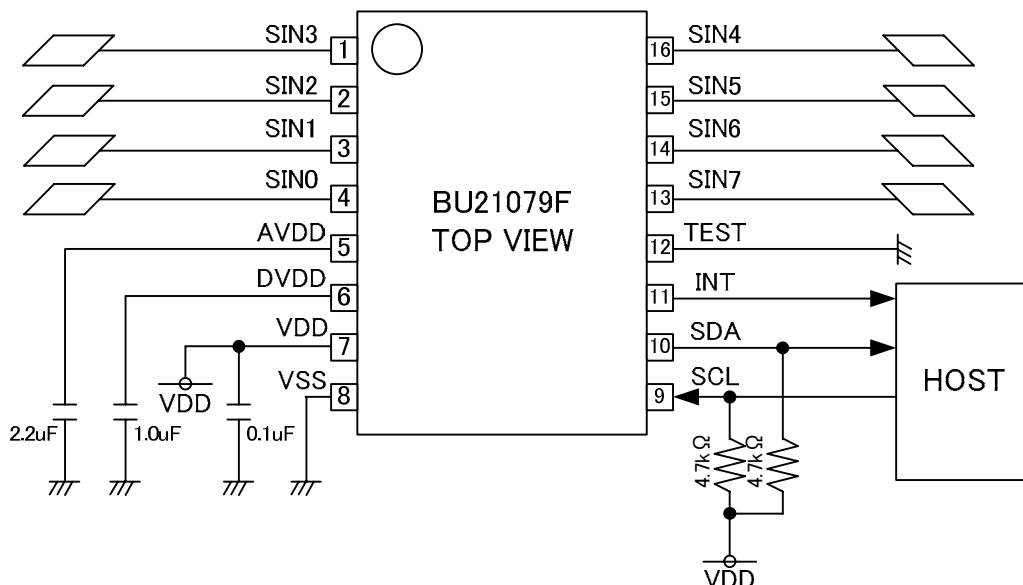


Figure 1. Typical Application Circuit

OVERVIEW

BU21079F is a capacitive sensor controller for switch operation.

BU21079F has the following blocks: AFE (Analog Front End) detecting capacitance, A/D converter, MPU, 2-wire serial bus interface compatible with I2C protocol, power-on-reset, and oscillator. It is operated with a 3.0V to 5.5V single power supply.

The results detected during switch operations (Touch/Release/Hold) are stored in a register. An interrupt is sent from INT port to the host when a register is updated during operations. If external noise and temperature drift are detected, automatic self-calibration is activated. When continuous monitoring of the host is unnecessary, the load of the host will be reduced.

Intermittent operation

When touch ON is detected, its operation shifts from intermittent operation to normal operation. When touch OFF is detected, its operation shifts from normal operation to intermittent operation, and the operating power is decreased. Sensing during intermittent operation is called "check sensing" and sensing during normal operation is called "normal sensing".

Simple switch

One sensor is assigned to one switch. Each simple switch has the registers for the detected Touch/Release/Hold operations. Simple switches support multi-detect Touch/Release/Hold. It is possible to mask unused switches.

Matrix switches

The cross points of the sensors which are arranged in a matrix can be assigned to individual switches. Each matrix switch has registers for detected Touch/Release/Hold operations. Matrix switches do not support multi-detect Touch/Release/Hold. It is possible to mask unused matrix switches. BU21079F supports 16 matrix switches configured by 4x4 sensors.

Automatic self-calibration

BU21079F checks the status of the sensors based on the detected result. If external noise and temperature drift are detected, the automatic self-calibration is activated in order to get stable detection.

Host interface

BU21079F is slave device for the host device. 2-wire serial bus is compatible with I2C protocol. Slave Address Is 0x5C.

Pin Configurations

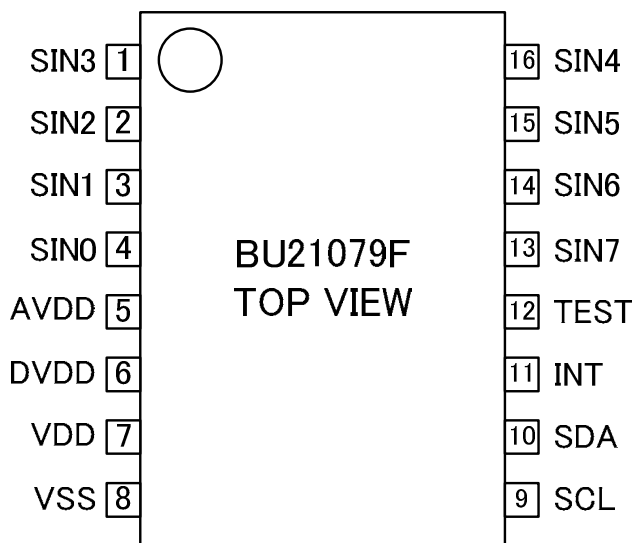


Figure 2. Pin configuration of BU21079F

Pin Descriptions

| Pin Number | Pin Name | Type | Function | Note | Power | Initial condition | I/O Equivalence circuit |
|------------|----------|-------|-------------------------------|---------------------------------|-------|-------------------|-------------------------|
| 1 | SIN3 | Ain | Capacitive Touch Sensor 3 | | AVDD | Hi-Z | Fig.3 |
| 2 | SIN2 | Ain | Capacitive Touch Sensor 2 | | AVDD | Hi-Z | Fig.3 |
| 3 | SIN1 | Ain | Capacitive Touch Sensor 1 | | AVDD | Hi-Z | Fig.3 |
| 4 | SIN0 | Ain | Capacitive Touch Sensor 0 | | AVDD | Hi-Z | Fig.3 |
| 5 | AVDD | Power | LD0 output for analog blocks | | — | — | — |
| 6 | DVDD | Power | LD0 output for digital blocks | | — | — | — |
| 7 | VDD | Power | Power | | — | — | — |
| 8 | VSS | GND | Ground | | — | — | — |
| 9 | SCL | In | Host I/F:SCL input pin | | VDD | Hi-Z | Fig.4 |
| 10 | SDA | InOut | Host I/F:SDA input/output pin | | VDD | Hi-Z | Fig.4 |
| 11 | INT | Out | Interrupt output | Interrupt "H" | VDD | L | Fig.4 |
| 12 | TEST | In | Test input | Fix "L" at the normal operation | VDD | — | Fig.5 |
| 13 | SIN7 | Ain | Capacitive Touch Sensor 7 | | AVDD | Hi-Z | Fig.3 |
| 14 | SIN6 | Ain | Capacitive Touch Sensor 6 | | AVDD | Hi-Z | Fig.3 |
| 15 | SIN5 | Ain | Capacitive Touch Sensor 5 | | AVDD | Hi-Z | Fig.3 |
| 16 | SIN4 | Ain | Capacitive Touch Sensor 4 | | AVDD | Hi-Z | Fig.3 |

I/O Equivalent Circuits

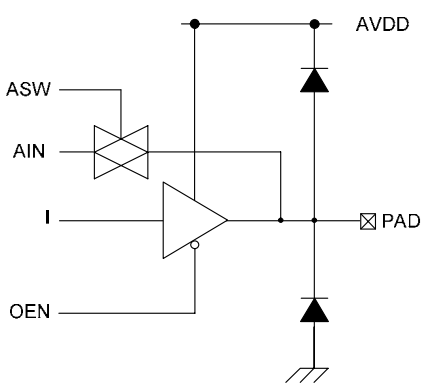


Figure 3. I/O equivalent circuit (a)

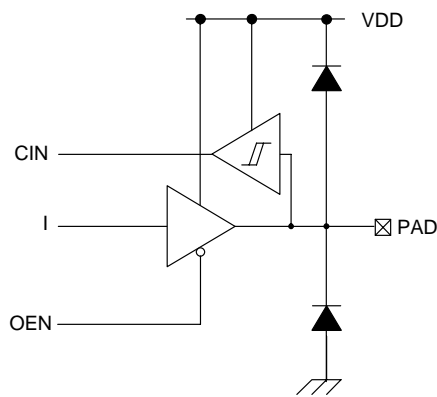


Figure 4. I/O equivalent circuit (b)

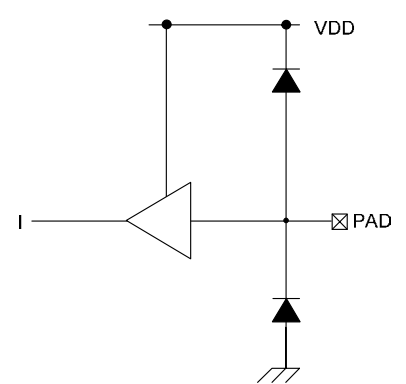


Figure 5. I/O equivalent circuit (c)

Block Diagram

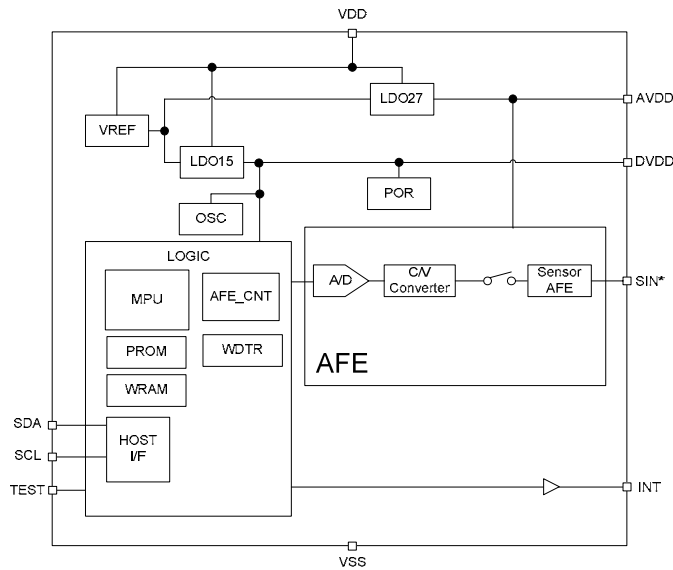


Figure 6. Block Diagram

Description of Blocks

Sensor AFE、C/V Converter

Converts capacitance from the sensors to voltage.

A/D

Converts the voltage from C/V Converter to digital.

LDO27

2.7V output LDO for Sensor AFE, C/V Converter and A/D.

LDO15

1.5V output LDO for OSC and digital blocks.

OSC

Ring oscillator used for the system clock.

POR

Power-On-Reset monitoring LDO15 for system reset.

MPU

Controls switch operations based on the sensing results and run Auto-calibration.

INT port informs the host that switch operations are detected.

PROM

Programmable ROM for the built-in MPU.

WRAM

Work RAM for the built-in MPU.

HOST I/F

2-wire serial bus interface compatible with I2C protocol.

AFE_CNT

Sequencer of Sensor AFE, C/V converter and A/D.

WDTR

Watchdog Timer Reset. It operates as the system resets. If MPU hangs-up, Watchdog Timer Reset can reset the IC.

Absolute Maximum Ratings (Ta = 25°C)

| Parameter | Symbol | Rating | Unit |
|------------------------------|-------------------|--------------------|------|
| Power supply voltage | VDD | -0.5 to 7.0 | V |
| Input voltage | V _{IN} | -0.5 to VDD + 0.3 | V |
| Storage temperature range | T _{stg} | -55 to 125 | °C |
| Permissible loss | P _d | 0.30 ^{*1} | W |
| Maximum junction temperature | T _{jmax} | 125 | °C |

*1 Derate by 3.00mW/°C when operating above Ta =25°C. (IC only).

When mounted in a Rohm standard board (70mm x 70mm x 1.6t mm), Pd is 0.50W, and it reduces in 5.00mW/°C over Ta=25°C.

Recommended Operating Conditions

| Parameter | Symbol | Rating | Unit |
|-----------------------------|------------------|------------|------|
| Power supply voltage | VDD | 3.0 to 5.5 | V |
| Operating temperature range | T _{opr} | -20 to 85 | °C |

Electrical Characteristics (Ta = 25°C , VDD = 3.3V , VSS = 0V)

| Parameter | Symbol | Rating | | | Unit | Condition |
|--------------------------------|-------------------|-----------|------|-----------|------|--|
| | | Min. | Typ. | Max. | | |
| Input High voltage | V _{IH} | VDD x 0.7 | - | VDD + 0.3 | V | |
| Input Low voltage | V _{IL} | VSS - 0.3 | - | VDD x 0.3 | V | |
| Output High voltage | V _{OH} | VDD - 0.5 | - | VDD | V | I _{OH} = -4mA |
| Output Low voltage | V _{OL} | VSS | - | VSS + 0.5 | V | I _{OL} = 4mA |
| Oscillator clock frequency1 | f _{OSC1} | 45 | 50 | 55 | MHz | |
| Oscillator clock frequency2 | f _{OSC2} | 51.2 | 64 | 76.8 | KHz | |
| DVDD LDO output voltage | V _{DVDD} | 1.35 | 1.50 | 1.65 | V | |
| AVDD LDO output voltage | V _{AVDD} | 2.61 | 2.71 | 2.81 | V | |
| Full scan operating current | I _{BD} | - | 2.5 | - | mA | No load of sensors. |
| Intermittent operating current | I _{INT} | | 75 | | uA | Intermittent operation cycle 200m s |

Register Map (OSC = 50MHz, unless otherwise noted.)
 No accessing to the reserved areas is allowed

| Group | Address | Name | R/W | Ini | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|----------------|----------|-------------------|------|------|------------|------------|-----------|-----------|-----------|-----------|-----------|-----------|
| Detect value | 0x00 | SIN_DATA0 | R | 0x00 | SD_SIN0 | | | | | | | |
| | 0x01 | SIN_DATA1 | R | 0x00 | SD_SIN1 | | | | | | | |
| | 0x02 | SIN_DATA2 | R | 0x00 | SD_SIN2 | | | | | | | |
| | 0x03 | SIN_DATA3 | R | 0x00 | SD_SIN3 | | | | | | | |
| | 0x04 | SIN_DATA4 | R | 0x00 | SD_SIN4 | | | | | | | |
| | 0x05 | SIN_DATA5 | R | 0x00 | SD_SIN5 | | | | | | | |
| | 0x06 | SIN_DATA6 | R | 0x00 | SD_SIN6 | | | | | | | |
| | 0x07 | SIN_DATA7 | R | 0x00 | SD_SIN7 | | | | | | | |
| | 0x08 | SIN_DATA8 | R | 0x00 | SD_SIN8 | | | | | | | |
| | 0x09-0F | reserved | R | 0x00 | - | | | | | | | |
| Detect result | 0x10 | INTERRUPT | R | 0x00 | CONDET | OFFDET | ONDET | PERCAL | WDT | ERCAL | CAL | INI |
| | 0x11 | SIN_STATE | R | 0x00 | SIN7_STAT | SIN6_STAT | SIN5_STAT | SIN4_STAT | SIN3_STAT | SIN2_STAT | SIN1_STAT | SIN0_STAT |
| | 0x12 | Reserved | R | 0x00 | - | | | | | | | |
| | 0x13 | DETECT_SW_ON | R | 0x00 | SW7_ON | SW6_ON | SW5_ON | SW4_ON | SW3_ON | SW2_ON | SW1_ON | SW0_ON |
| | 0x14 | DETECT_SLIDER_ON | R | 0x00 | SLIDER_ON | SLIDER_CNT | | | | | | |
| | 0x15 | DETECT_MAT_ON | R | 0x00 | MAT_ON | - | | | KEY_ON | | | |
| | 0x16 | DETECT_SW_OFF | R | 0x00 | SW7_OFF | SW6_OFF | SW5_OFF | SW4_OFF | SW3_OFF | SW2_OFF | SW1_OFF | SW0_OFF |
| | 0x17 | DETECT_SLIDER_OFF | R | 0x00 | SLIDER_OFF | - | | | | | | |
| | 0x18 | DETECT_MAT_OFF | R | 0x00 | MAT_OFF | - | | | KEY_OFF | | | |
| | 0x19 | DETECT_SW_CONT | R | 0x00 | SW7_CONT | SW6_CONT | SW5_CONT | SW4_CONT | SW3_CONT | SW2_CONT | SW1_CONT | SW0_CONT |
| | 0x1A | Reserved | R | 0x00 | - | | | | | | | |
| | 0x1B | DETECT_MAT_CONT | R | 0x00 | MAT_CONT | - | | | KEY_CONT | | | |
| | 0x1C | STATE | R | 0x00 | E_CALIB | - | - | - | - | - | INTVL | CALIB |
| | 0x1D | Reserved | R | 0x00 | - | | | | | | | |
| | 0x1E | RACT | R | 0x00 | RACT | | | | | | | |
| 0x1F-84 | Reserved | R | 0x00 | - | | | | | | | | |
| Reset setting | 0x85 | SOFTRESET0 | R/W | 0x00 | SRST[7:0] | | | | | | | |
| | 0x86-89 | Reserved | - | - | reserved | | | | | | | |
| | 0x8A | SOFTRESET1 | R/W | 0x00 | SRST[15:8] | | | | | | | |
| - | 0x8B-BF | Reserved | - | - | reserved | | | | | | | |
| Sensor setting | 0xC0 | CFG_SIN_1_0 | R/W | 0x00 | GA_SIN1 | | ON_SIN1 | | GA_SIN0 | | ON_SIN0 | |
| | 0xC1 | CFG_SIN_3_2 | R/W | 0x00 | GA_SIN3 | | ON_SIN3 | | GA_SIN2 | | ON_SIN2 | |
| | 0xC2 | CFG_SIN_5_4 | R/W | 0x00 | GA_SIN5 | | ON_SIN5 | | GA_SIN4 | | ON_SIN4 | |
| | 0xC3 | CFG_SIN_7_6 | R/W | 0x00 | GA_SIN7 | | ON_SIN7 | | GA_SIN6 | | ON_SIN6 | |
| | 0xC4 | CFG_SIN_x_8 | R/W | 0x00 | - | | - | | GA_SIN8 | | ON_SIN8 | |
| | 0xC5-C7 | Reserved | R/W | 0x00 | - | | | | | | | |
| | 0xC8 | GAIN_1_0 | R/W | 0x00 | GA1 | | | | GA0 | | | |
| | 0xC9 | GAIN_x_2 | R/W | 0x00 | - | | | | GA2 | | | |
| | 0xCA | ON_TH0 | R/W | 0x00 | ON0 | | | | | | | |
| | 0xCB | ON_TH1 | R/W | 0x00 | ON1 | | | | | | | |
| | 0xCC | ON_TH2 | R/W | 0x00 | ON2 | | | | | | | |
| | 0xCD | OFF_TH | R/W | 0x00 | - | OFF | | | | | | |
| | 0xCE | OVERSAMPLES | R/W | 0x00 | OST | | | | - | | | |
| | 0xCF | CONTTIMES | R/W | 0x00 | CONTSSEL | - | CONT | | | | | |

Register Map (OSC = 50MHz, unless otherwise specified).
 Access to reserved areas is restricted.

| Group | Address | Name | R/W | Ini | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|----------------|---------------|-----------------------|------|---------------|----------------|--------------|--------------|---------------|---------------|--------------|--------------|--------------|
| Mask setting | 0xD0 | MSK_DETECT_SW | R/W | 0x00 | MSK_SW7 | MSK_SW6 | MSK_SW5 | MSK_SW4 | MSK_SW3 | MSK_SW2 | MSK_SW1 | MSK_SW0 |
| | 0xD1 | Reserved | R/W | 0x00 | - | | | | | | | |
| | 0xD2 | MSK_DETECT_MAT0 | R/W | 0x00 | MSK_KEYH | MSK_KEYG | MSK_KEYF | MSK_KEYE | MSK_KEYD | MSK_KEYC | MSK_KEYB | MSK_KEYA |
| | 0xD3 | MSK_DETECT_MAT1 | R/W | 0x00 | MSK_KEYP | MSK_KEYO | MSK_KEYN | MSK_KEYM | MSK_KEYL | MSK_KEYK | MSK_KEYJ | MSK_KEYI |
| | 0xD4-D8 | Reserved | R/W | 0x00 | - | | | | | | | |
| | 0xD9 | EN_SLIDER | R/W | 0x00 | EN_SLID_SIN7 | EN_SLID_SIN6 | EN_SLID_SIN5 | EN_SLID_SIN4 | EN_SLID_SIN3 | EN_SLID_SIN2 | EN_SLID_SIN1 | EN_SLID_SIN0 |
| | 0xDA | KEEP_SENS_NUM | R/W | 0x00 | KEEP_SENS_NUM | | | | | | | |
| | 0xDB | UNIT_SENS_NUM | R/W | 0x00 | - | | | | UNIT_SENS_NUM | | | |
| | 0xDC | TH_SLEEP_H | R/W | 0x00 | TH_SLEEP[15:8] | | | | | | | |
| | 0xDD | TH_SLEEP_L | R/W | 0x00 | TH_SLEEP[7:0] | | | | | | | |
| | 0xDE | OUTPUT_OFFSET | R/W | 0x00 | OUTPUT_OFFSET | | | | | | | |
| 0xDF | MSK_INTERRUPT | R/W | 0x00 | - | - | - | MSK_PERCAL | MSK_WDT | MSK_ERCAL | MSK_CAL | - | |
| Analog setting | 0xE0 | MODE_CONFIG0 | R/W | 0x00 | - | - | FIX_BASE_CYC | FIX_SNS_CYC | - | SLID_LOOP | EN_DSLP | EN_SLP |
| | 0xE1 | MODE_CONFIG1 | R/W | 0x00 | DIS_SIN8 | - | - | PERCAL_DIS | RET_DIS | HOP_DIS | ERROR_DIS | DRIFT_DIS |
| | 0xE2 | EN_SIN | R/W | 0x00 | EN_SIN7 | EN_SIN6 | EN_SIN5 | EN_SIN4 | EN_SIN3 | EN_SIN2 | EN_SIN1 | EN_SIN0 |
| | 0xE3 | SENS_NUM | R/W | 0x00 | SENS_NUM | | | | | | | |
| | 0xE4 | SENS_RD_TIME | R/W | 0x00 | SENS_RD_TIME | | | | | | | |
| | 0xE5 | SENS_RST_TIME | R/W | 0x00 | SENS_RST_TIME | | | | | | | |
| | 0xE6 | SENS_IRST_TIME | R/W | 0x00 | SENS_IRST_TIME | | | | | | | |
| | 0xE7 | CHK_NUM | R/W | 0x00 | CHK_NUM | | | | | | | |
| | 0xE8 | CHK_RD_TIME | R/W | 0x00 | CHK_RD_TIME | | | | | | | |
| | 0xE9 | CHK_RST_TIME | R/W | 0x00 | CHK_RST_TIME | | | | | | | |
| | 0xEA | CHK_IRST_TIME | R/W | 0x00 | CHK_IRST_TIME | | | | | | | |
| | 0xEB | DIG_GAIN | R/W | 0x00 | CHK_DIG_GAIN | | | | SENS_DIG_GAIN | | | |
| | 0xEC | CHK_WAIT_TIME | R/W | 0x00 | CHK_WAIT_TIME | | | | | | | |
| | 0xED | SENS_WAIT_TIME | R/W | 0x00 | SENS_WAIT_TIME | | | | | | | |
| | 0xEE | CALIB_CONFIG0 | R/W | 0x00 | RET_NUM | | | | | | | |
| 0xEF | CALIB_CONFIG1 | R/W | 0x00 | PRECAL_PERIOD | | | | DRIFT_SIN_NUM | | | | |
| Control | 0xF0 | CLR_INT | R/W | 0x00 | - | - | - | C_PERCAL | C_WDT | C_ERCAL | C_CAL | C_INI |
| | 0xF1 | CLR_DETECT_SW_ON | R/W | 0x00 | C_SW7_ON | C_SW6_ON | C_SW5_ON | C_SW4_ON | C_SW3_ON | C_SW2_ON | C_SW1_ON | C_SW0_ON |
| | 0xF2 | Reserved | R/W | 0x00 | - | | | | | | | |
| | 0xF3 | CLR_DETECT_MAT_ON | R/W | 0x00 | C_MAT_ON | - | - | - | - | - | - | - |
| | 0xF4 | CLR_DETECT_SW_OFF | R/W | 0x00 | C_SW7_OFF | C_SW6_OFF | C_SW5_OFF | C_SW4_OFF | C_SW3_OFF | C_SW2_OFF | C_SW1_OFF | C_SW0_OFF |
| | 0xF5 | CLR_DETECT_SLIDER_OFF | R/W | 0x00 | C_SLIDER_OFF | - | - | - | - | - | - | - |
| | 0xF6 | CLR_DETECT_MAT_OFF | R/W | 0x00 | C_MAT_OFF | - | - | - | - | - | - | - |
| | 0xF7 | CLR_DETECT_SW_CONT | R/W | 0x00 | C_SW7_CONT | C_SW6_CONT | C_SW5_CONT | C_SW4_CONT | C_SW3_CONT | C_SW2_CONT | C_SW1_CONT | C_SW0_CONT |
| | 0xF8 | Reserved | R/W | 0x00 | - | | | | | | | |
| | 0xF9 | CLR_DETECT_MAT_CONT | R/W | 0x00 | C_MAT_CONT | - | - | - | - | - | - | - |
| | 0xFA-FD | Reserved | R/W | 0x00 | - | | | | | | | |
| | 0xFE | WACT | R/W | 0x00 | WACT | | | | | | | |
| | 0xFF | CONTROL | R/W | 0x00 | FRCLS | CALOVF | - | CALMOD | - | CFG | CAL | ACT |

[0x00-0x08 : Sensor Data]

Name: SIN_DATA
 Address: 0x00-0x08
 Description: This register shows the 8bit ADC values for each sensor.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|--------------|------------|------------|------------|------------|------------|------------|------------|------------|
| 0x00 | SD_SIN0[7] | SD_SIN0[6] | SD_SIN0[5] | SD_SIN0[4] | SD_SIN0[3] | SD_SIN0[2] | SD_SIN0[1] | SD_SIN0[0] |
| 0x01 | SD_SIN1[7] | SD_SIN1[6] | SD_SIN1[5] | SD_SIN1[4] | SD_SIN1[3] | SD_SIN1[2] | SD_SIN1[1] | SD_SIN1[0] |
| 0x02 | SD_SIN2[7] | SD_SIN2[6] | SD_SIN2[5] | SD_SIN2[4] | SD_SIN2[3] | SD_SIN2[2] | SD_SIN2[1] | SD_SIN2[0] |
| 0x03 | SD_SIN3[7] | SD_SIN3[6] | SD_SIN3[5] | SD_SIN3[4] | SD_SIN3[3] | SD_SIN3[2] | SD_SIN3[1] | SD_SIN3[0] |
| 0x04 | SD_SIN4[7] | SD_SIN4[6] | SD_SIN4[5] | SD_SIN4[4] | SD_SIN4[3] | SD_SIN4[2] | SD_SIN4[1] | SD_SIN4[0] |
| 0x05 | SD_SIN5[7] | SD_SIN5[6] | SD_SIN5[5] | SD_SIN5[4] | SD_SIN5[3] | SD_SIN5[2] | SD_SIN5[1] | SD_SIN5[0] |
| 0x06 | SD_SIN6[7] | SD_SIN6[6] | SD_SIN6[5] | SD_SIN6[4] | SD_SIN6[3] | SD_SIN6[2] | SD_SIN6[1] | SD_SIN6[0] |
| 0x07 | SD_SIN7[7] | SD_SIN7[6] | SD_SIN7[5] | SD_SIN7[4] | SD_SIN7[3] | SD_SIN7[2] | SD_SIN7[1] | SD_SIN7[0] |
| 0x08 | SD_SIN8[7] | SD_SIN8[6] | SD_SIN8[5] | SD_SIN8[4] | SD_SIN8[3] | SD_SIN8[2] | SD_SIN8[1] | SD_SIN8[0] |
| R/W | R | R | R | R | R | R | R | R |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0x10 : Interrupt factor]

Name: INTERRUPT
 Address: 0x10
 Description: This register shows the interrupt factors. Port INT outputs this register's OR operation.
 INI : Initialization finish.

It is set at the time the initialization of the MPU is completed.
 There is no corresponding mask register. The clear register is 0xF0 [0].
 It is also set when initialization by WDT occurs.

CAL : Software-calibration finish.
 It is set at the time the calibration is finished.
 The corresponding mask register is 0xDF [1], and the clear register is 0xF0 [1].

ERCAL : Self-calibration finish.
 It is set at the time the calibration is ended by an error. There are four errors in calibration (Drift calibration, Calib-error calibration, Hopping calibration, and Return calibration).The corresponding mask register is 0xDF [2] and the clear register is 0xF0 [2].

WDT : Watch Dog Timer interrupt generation
 It is WDT interruption generation time.
 If WDT interrupt occurs again without clearing WDT, HW reset will start, all are initialized, and INIT interruption of 0x10 [0] is active (low).
 The corresponding mask register is 0xDF [3], and the clear register is 0xF0 [3].
 The clearance of the WDT counter by MPU is not performed other than the time of a sense.
 Therefore, in the state of deep sleep (0xE0 [1] =0), a WDT interrupt occurs periodically.
 * The initial state is deep sleep.

PERCAL : Periodic calibration finish.
 It is set at the time the periodic calibration is completed.
 The corresponding mask register is 0xDF [4], and the clear register is 0xF0 [4].

ONDET : Detection of switch-on.
 The value of this register is '1' when it detects "ON" switch operation. This register is cleared by clearing every bit of the "Detection Switch-On" register. (0x13, 0x15)

OFFDET : Detection of switch-off.
 The value of this register is '1' when it detects "OFF" switch operation. This register is cleared by clearing every bit of the "Detection Switch-Off" register.(0x16, 0x18)

CONTDDET : Detection of continued touch.
 The value of this register is '1' when it detects a continued touch switch operation. This register is cleared by clearing every bit of the "Detection continued touch" register.(0x19, 0x1B)

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|--------------|----------|--------|-------|--------|------|-------|------|------|
| 0x10 | CONTDDET | OFFDET | ONDET | PERCAL | WDT | ERCAL | CAL | INI |
| R/W | R | R | R | R | R | R | R | R |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0x11 : Sensor State]

Name: SIN_STATE

Address: 0x11

Description: This register indicates the state of each sensor.

1 : Switch-on.(Register "SIN" > Register "ON") 0 : switch-off. (Register "SIN" < Register "OFF")

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 0x11 | SIN7_STAT | SIN6_STAT | SIN5_STAT | SIN4_STAT | SIN3_STAT | SIN2_STAT | SIN1_STAT | SIN0_STAT |
| R/W | R | R | R | R | R | R | R | R |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0x13, 0x15 : Detection Switch-On]

Name: DETECT_ON

Address: 0x13, 0x15

Description: This register indicates the transition from Off state to On state of every switch.

Since SW 0-7 supports multiple presses, each switch has bit recognition. And the matrix key does not support multiple detection, so matrix switch is indicated by 1 bit for ON detection (MAT) and 4 bits (KEY switch). Logical OR of each SW and MAT will be ONDET interrupt source register.

1: Detect On. 0: No detect.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|--------|--------|--------|--------|-----------|-----------|-----------|-----------|
| 0x13 | SW7_ON | SW6_ON | SW5_ON | SW4_ON | SW3_ON | SW2_ON | SW1_ON | SW0_ON |
| 0x15 | MAT_ON | - | - | - | KEY_ON[3] | KEY_ON[2] | KEY_ON[1] | KEY_ON[0] |
| R/W | R | R | R | R | R | R | R | R |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0x14 : Detection slider On]

Name: DETECT_SLIDER_ON

Address: 0x14

Description: SLIDER_ON: The value of this register is "1" when SLIDER is detected.

1: Detect On. 0: No detect.

SLIDER_CNT[6:0] : The detected amount of movement is shown in 2's complement. The amount of movement detected in order of SIN0→SIN1→SIN2→……→SIN7 is expressed by a positive value, and the amount of the movement detected in a reverse order is expressed by a negative value. The amount of the movement is 2 when center of gravity moves to the next sensor, and when center of gravity comes between 2 sensors, the amount of the movement is 1. It loops when the range where the detected amount of movement that can be shown is exceeded. The next of 63(0111111) become -64(1000000).

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|-----------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 0x14 | SLIDER_ON | SLIDER_CNT[6] | SLIDER_CNT[5] | SLIDER_CNT[4] | SLIDER_CNT[3] | SLIDER_CNT[2] | SLIDER_CNT[1] | SLIDER_CNT[0] |
| R/W | R | R | R | R | R | R | R | R |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0x16, 0x18 : Detection Switch-Off]

Name: DETECT_OFF

Address: 0x16, 0x18

Description: This register indicates the transition from On state to Off state of every switch.

Since SW 0-7 supports multiple presses, each switch has bit recognition. And the matrix key does not support multiple detection, so matrix switch is indicated by 1 bit for ON detection (MAT) and 4 bits (KEY switch). Logical OR of each SW and MAT will be OFFDET interrupt source register.

1 : Detect Off. 0 : No detect.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|---------|---------|---------|---------|------------|------------|------------|------------|
| 0x16 | SW7_OFF | SW6_OFF | SW5_OFF | SW4_OFF | SW3_OFF | SW2_OFF | SW1_OFF | SW0_OFF |
| 0x18 | MAT_OFF | - | - | - | KEY_OFF[3] | KEY_OFF[2] | KEY_OFF[1] | KEY_OFF[0] |
| R/W | R | R | R | R | R | R | R | R |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0x17 : Detection slider Off]

Name: DETECT_SLIDER_OFF
Address: 0x17

Description: It is set when IC detects that the slider is in the off state. It is necessary to clear this flag to detect. The corresponding clear register is 0xF5 [7]. 1 : Detect Off. 0 : No detect.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|------------|------|------|------|------|------|------|------|
| 0x17 | SLIDER_OFF | - | - | - | - | - | - | - |
| R/W | R | R | R | R | R | R | R | R |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0x19, 0x1B : Detection continued touch]

Name: DETECT_CONT
Address: 0x19, 0x1B

Description: This register indicates the detection of continued touch for every switch.
Since SW 0-7 supports multiple presses, each switch has bit recognition. And the matrix key does not support multiple detection, so matrix switch is indicated by 1 bit for ON detection (MAT) and 4 bits(KEY switch). Logical OR of each SW and MAT will be CONTDDET interrupt source register.
1 : Detect continued touch. 0 : No detect.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|----------|----------|----------|----------|-------------|-------------|-------------|-------------|
| 0x19 | SW7_CONT | SW6_CONT | SW5_CONT | SW4_CONT | SW3_CONT | SW2_CONT | SW1_CONT | SW0_CONT |
| 0x1B | MAT_CONT | - | - | - | KEY_CONT[3] | KEY_CONT[2] | KEY_CONT[1] | KEY_CONT[0] |
| R/W | R | R | R | R | R | R | R | R |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0x1C : State of IC]

Name: STATE
Address: 0x1C

Description: This register indicates the state of IC.

CALIB : Indicates whether the IC is in calibration or not.

1: In calibration 0: Not in calibration

INTVL : Indicates whether the IC is in Intermittent Operation or not.

1: Intermittent Operation 0: Not in Intermittent Operation

E_CALIB : When the calibration fails for three consecutive times, it is set.

1: Calibration Error 0: No Error

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|---------|------|------|------|------|------|-------|-------|
| 0x1C | E_CALIB | - | - | - | - | - | INTVL | CALIB |
| R/W | R | - | - | - | - | - | R | R |
| Initial val. | 0 | - | - | - | - | - | 0 | 0 |

[0x1E : Read register for operation check of MPU]

Name: RACT
Address: 0x1E

Description: This register is a read register for operational check of the IC. The value written to the write register for operation check (Address is 0xFE) is copied to this register. If the write value and the read value is equal, MPU and I/F are operating normally.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| 0x1E | RACT[7] | RACT[6] | RACT[5] | RACT[4] | RACT[3] | RACT[2] | RACT[1] | RACT[0] |
| R/W | R | R | R | R | R | R | R | R |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0x85, 0x8A : Software Reset]

Name: SRST
 Address: 0x85, 0x8A
 Description: These registers are used for hardware reset. If register 0x85=55h and register 0x8A=AAh, then a hardware reset will be done.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|--------------|----------|----------|----------|----------|----------|----------|---------|---------|
| 0x85 | SRST[7] | SRST[6] | SRST[5] | SRST[4] | SRST[3] | SRST[2] | SRST[1] | SRST[0] |
| 0x8A | SRST[15] | SRST[14] | SRST[13] | SRST[12] | SRST[11] | SRST[10] | SRST[9] | SRST[8] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xC0 – 0xC4 : Select a setting for Gain and Threshold for “Off→On”]

Name: CFG_SIN
 Address: 0xC0 – 0xC4
 Description: You can set 3 values for gain and set 3 values for threshold to the “Off → On” registers of this IC. These registers are used to select a setting for gain and threshold for every sensor. There are three available settings.
 Gain : GA_SIN*[1:0] = 0x0 : Select GA0.
 0x1 : Select GA1.
 0x2 : Select GA2.
 0x3 : Select GA0.
 Threshold : ON_SIN*[1:0] = 0x0 : Select ON0.
 0x1 : Select ON1.
 0x2 : Select ON2.
 0x3 : Select ON0.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|--------------|------------|------------|------------|------------|------------|------------|------------|------------|
| 0xC0 | GA_SIN1[1] | GA_SIN1[0] | ON_SIN1[1] | ON_SIN1[0] | GA_SIN0[1] | GA_SIN0[0] | ON_SIN0[1] | ON_SIN0[0] |
| 0xC1 | GA_SIN3[1] | GA_SIN3[0] | ON_SIN3[1] | ON_SIN3[0] | GA_SIN2[1] | GA_SIN2[0] | ON_SIN2[1] | ON_SIN2[0] |
| 0xC2 | GA_SIN5[1] | GA_SIN5[0] | ON_SIN5[1] | ON_SIN5[0] | GA_SIN4[1] | GA_SIN4[0] | ON_SIN4[1] | ON_SIN4[0] |
| 0xC3 | GA_SIN7[1] | GA_SIN7[0] | ON_SIN7[1] | ON_SIN7[0] | GA_SIN6[1] | GA_SIN6[0] | ON_SIN6[1] | ON_SIN6[0] |
| 0xC4 | - | - | - | - | GA_SIN8[1] | GA_SIN8[0] | ON_SIN8[1] | ON_SIN8[0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xC8 – 0xC9 : Value of GAIN]

Name: GA0, GA1, GA2
 Address: 0xC8 – 0xC9
 Description: This register is used for setting the gain of AFE. The smaller the value of GA, the higher the gain will be. You can set 3 values for gain. These values are assigned to each sensor by register GA_SIN including CFG_SIN.
 The settable range : $0x1 \leq GA \leq 0xF$

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|--------------|--------|--------|--------|--------|--------|--------|--------|--------|
| 0xC8 | GA1[3] | GA1[2] | GA1[1] | GA1[0] | GA0[3] | GA0[2] | GA0[1] | GA0[0] |
| 0xC9 | - | - | - | - | GA2[3] | GA2[2] | GA2[1] | GA2[0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xCA – 0xCC : Value of the threshold for "Off → On"]

Name: ON0, ON1, ON2
 Address: 0xCA – 0xCC
 Description: These registers are used for setting the threshold of the “Off → On” operation. You can set 3 values for threshold. If the 8bit ADC value of each sensor (register SENS_DATA) is larger than this value, then the “Off → On” operation of the sensor is valid. These values are assigned to each sensor by register GA_SIN including ON_SIN.
 The settable range : $0x00 < OFF < ON < 0xFF$

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|--------------|--------|--------|--------|--------|--------|--------|--------|--------|
| 0xCA | ON0[7] | ON0[6] | ON0[5] | ON0[4] | ON0[3] | ON0[2] | ON0[1] | ON0[0] |
| 0xCB | ON1[7] | ON1[6] | ON1[5] | ON1[4] | ON1[3] | ON1[2] | ON1[1] | ON1[0] |
| 0xCC | ON2[7] | ON2[6] | ON2[5] | ON2[4] | ON2[3] | ON2[2] | ON2[1] | ON2[0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

【0xCD : Value of the threshold for "On → Off"】

Name: OFF
 Address: 0xCD
 Description: This register is used for setting the threshold for "On → Off" operation. If the 8bit ADC value of each sensor (register SENS_DATA) is smaller than this value, then the "On → Off" operation of the sensor is enabled.
 The setting range : 0x00 < OFF < ON < 0xFF

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|------|---------|---------|---------|---------|---------|---------|---------|
| 0xCD | - | OFF [6] | OFF [5] | OFF [4] | OFF [3] | OFF [2] | OFF [1] | OFF [0] |
| R/W | - | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

【0xCE :Chattering cancel】

Name: OVERSAMPLES
 Address: 0xCE
 Description: OST[3:0] : This register has the number of times of over sampling for canceling chattering in the "ON" or "OFF" operation.
 The continuous button level of over sampling frequency + three times or less is disregarded.
 If the register value is 0, then the number of times of over sampling is 1.
 Sampling rate : About 6msec.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|--------|--------|--------|--------|------|------|------|------|
| 0xCE | OST[3] | OST[2] | OST[1] | OST[0] | - | - | - | - |
| R/W | R/W | R/W | R/W | R/W | - | - | - | - |
| Initial val. | 0 | 0 | 0 | 0 | - | - | - | - |

【0xCF :Long press】

Name: CONTTIMES
 Address: 0xCF
 Description: CONTSEL : The output pattern of an interrupt generated after recognizing long press is set up.
 1 : Every continuous touch period.
 0 : First detect only.
 CONT[5:0] : Continuous touch period is about 0.036 [sec] x CONT.
 If the setting value is 0x0, continuous touch function is invalid.
 (0.036sec ≤ Continuous touch period ≤ 2.3sec)

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|---------|------|---------|---------|---------|---------|---------|---------|
| 0xCF | CONTSEL | - | CONT[5] | CONT[4] | CONT[3] | CONT[2] | CONT[1] | CONT[0] |
| R/W | R/W | - | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | - | 0 | 0 | 0 | 0 | 0 | 0 |

【0xD0, 0xD2, 0xD3 : Mask switch operation】

Name: MSK_SW_KEY
 Address: 0xD0, 0xD2, 0xD3
 Description: This register is used for masking the operation of each matrix switches and each simple switches. The masked switches are excluded from the interrupt factor. It is prohibited to assign one sensor to both matrix switch and a simple switch. Unused switches must be masked.
 1 : Masked. 0 : Unmasked.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|----------|----------|----------|----------|----------|----------|----------|----------|
| 0xD0 | MSK_SW7 | MSK_SW6 | MSK_SW5 | MSK_SW4 | MSK_SW3 | MSK_SW2 | MSK_SW1 | MSK_SW0 |
| 0xD2 | MSK_KEYH | MSK_KEYG | MSK_KEYF | MSK_KEYE | MSK_KEYD | MSK_KEYC | MSK_KEYB | MSK_KEYA |
| 0xD3 | MSK_KEYP | MSK_KEYO | MSK_KEYN | MSK_KEYM | MSK_KEYL | MSK_KEYK | MSK_KEYJ | MSK_KEYI |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xD9 : Slider]

Name: EN_SLIDER
 Address: 0xD9
 Description: EN_SLID_SIN [7:0]: It is used for enabling a sensor for a slider.
 The sensor by which 1 was set is enabled as a slider. The order is SIN0, 1, 2, 3, 4, 5, 6, and 7, and the disabled sensor is skipped. For example, when only SIN1, 2, 5, and 6 are enabled, the order is SIN1, 2, 5, 6. Moreover, when SLIDER_LOOP (0xE0 2) is enabled, SIN7 and SIN0 are processed as a consecutive sensor. When touch is detected in any of the sensors operating in intermittent mode, all enabled sensors start sensing.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| 0xD9 | EN_SLID_SIN7 | EN_SLID_SIN6 | EN_SLID_SIN5 | EN_SLID_SIN4 | EN_SLID_SIN3 | EN_SLID_SIN2 | EN_SLID_SIN1 | EN_SLID_SIN0 |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xDA : Keep intermittent sensing]

Name: KEEP_SENS_NUM
 Address: 0xDA
 Description: KEEP_SENS_NUM[7:0] : This is used for setting how long sensing operates from last intermittent operation.
 It works only in the intermittent operation.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| 0xDA | KEEP_SENS_NUM[7] | KEEP_SENS_NUM[6] | KEEP_SENS_NUM[5] | KEEP_SENS_NUM[4] | KEEP_SENS_NUM[3] | KEEP_SENS_NUM[2] | KEEP_SENS_NUM[1] | KEEP_SENS_NUM[0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xDB : Frequency of normal sensing during check sensing]

Name: UNIT_SENS_NUM
 Address: 0xDB
 Description: UNIT_SENS_NUM[3:0] : It is used to set the number of times normal sensing is done during check sensing for intermittent return. It works only in the intermittent operation. The number of times normal sensing is done is equal to the set value + 1.
 For example, when 3 is set up, it becomes check -> Normal -> Normal -> Normal -> Normal -> check -> Normal -> Normal --.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|------|------|------|------|-------------------|-------------------|-------------------|-------------------|
| 0xDB | - | - | - | - | UNIT_SENS_NUM [3] | UNIT_SENS_NUM [2] | UNIT_SENS_NUM [1] | UNIT_SENS_NUM [0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xDC : Intermittent operation return threshold setting]

Name: TH_SLEEP_H
 Address: 0xDC
 Description: TH_SLEEP[15:8] : It is the upper 8 bits of the return threshold value from intermittent operation to normal operation. The lower 8 bits is register 0xDD. When the result of check sensing shifts from the median and more than this threshold value, that sensor is returned from intermittent operation and normal sensing operates.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|--------------|--------------|--------------|--------------|--------------|--------------|-------------|-------------|
| 0xDC | TH_SLEEP[15] | TH_SLEEP[14] | TH_SLEEP[13] | TH_SLEEP[12] | TH_SLEEP[11] | TH_SLEEP[10] | TH_SLEEP[9] | TH_SLEEP[8] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xDD : Intermittent sensing return threshold setting]

Name: TH_SLEEP_L
 Address: 0xDD
 Description: TH_SLEEP[7:0] : It is the lower 8 bits of the return threshold value from intermittent operation to normal operation. Please refer to register 0xDC.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| 0xDD | TH_SLEEP[7] | TH_SLEEP[6] | TH_SLEEP[5] | TH_SLEEP[4] | TH_SLEEP[3] | TH_SLEEP[2] | TH_SLEEP[1] | TH_SLEEP[0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

【0xDE : Sensor value offset setting】

Name: OUTPUT_OFFSET
Address: 0xDE

Description: OUTPUT_OFFSET[7:0] : The offset added to the sensor value output to SD_SIN0-SD_SIN8(0x00-0x08) is set. When the calibration is completed, these sensor values reach the value of about 0. Therefore, it is shown as 0, and doesn't acquire an accurate value when swinging to negative. When offset is added, monitoring data at the minus side and acquiring an accurate value becomes possible.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| 0xDE | OUTPUT_OFFSET[7] | OUTPUT_OFFSET[6] | OUTPUT_OFFSET[5] | OUTPUT_OFFSET[4] | OUTPUT_OFFSET[3] | OUTPUT_OFFSET[2] | OUTPUT_OFFSET[1] | OUTPUT_OFFSET[0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

【0xDF : Mask interrupt】

Name: MSK_INTERRUPT
Address: 0xDF

Description: This register is for masking the interrupt factor. The masked interrupt factor is not shown on the register "Interrupt factor (address 0x10)", so it does not affect the output port INT.
1 : Masked. 0 : Unmasked.

MSK_CAL : Mask for Software-calibration finish.

This bit is used for masking the interrupt of Software-calibration finish (the bit CAL in the register INTERRUPT(address 0x10)).

MSK_ERCAL : Mask for Self-calibration finish.

This bit is used for masking the interrupt of Self-calibration finish (the bit ERCAL in the register INTERRUPT(address 0x10)).

MSK_WDT : Mask for watch dog timer.

This bit is used for masking the interrupt of initialization by WDT.
WDT of register interrupt factor (address 0x10) is masked.

MSK_PERCAL : Mask for Periodic calibration finish.

This bit is used for masking the interrupt of Periodic calibration finish (the bit PERCAL in the register INTERRUPT(address 0x10)).

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|------|------|------|------------|----------|-----------|---------|------|
| 0xDF | - | - | - | MSK_PERCAL | MSK_WDT- | MSK_ERCAL | MSK_CAL | - |
| R/W | - | - | - | R/W | R/W | R/W | R/W | - |
| Initial val. | - | - | - | 0 | -0 | 0 | 0 | - |

【0xE0 : Operation mode setting0】

Name: MODE_CONFIG0
Address: 0xE0

Description: FIX_BASE_CYC : Sensing frequency is changed at the time of calibration failure, and returns the error occurrence time. The noise measure function is disabled.

FIX_SNS_CYC : The noise measures function to change the frequency of sensing to each sensing is invalidated.

SLID_LOOP : Process which treats CH recognized as a slider like a sensor continuous like SIN6->SIN7->SIN0 and SIN1 ->SIN0 ->SIN7 is enabled.

EN_DSLP : The main clock is stopped when the main clock is not necessary while intermittent is operating and the operating current is lowered.

EN_SLP : Intermittent operation is activated and the operating current is lowered.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|------|------|--------------|-------------|------|-----------|---------|--------|
| 0xE0 | - | - | FIX_BASE_CYC | FIX_SNS_CYC | - | SLID_LOOP | EN_DSLP | EN_SLP |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xE1 : Operation mode setting1]

Name: MODE_CONFIG1

Address: 0xE1

Description: DIS_SIN8: Disables SIN8 for noise detection. Since sensing is not done when it is disabled, the operating current decreases.

RERCAL_DIS : Disables regular calibration.

RET_DIS : Disables return calibration. 1: disable function.

HOP_DIS : Disables hopping calibration. 1: disable function.

ERROR_DIS : Disables error calibration. 1: disable function.

DRIFT_DIS : Disables drift calibration. 1: disable function.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|----------|------|------|------------|---------|---------|-----------|-----------|
| 0xE1 | DIS_SIN8 | - | - | RERCAL_DIS | RET_DIS | HOP_DIS | ERROR_DIS | DRIFT_DIS |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xE2 : Effective sensor setting]

Name: EN_SIN

Address: 0xE2

Description: EN_SIN[7:0]: Enables sensors

The sensor by which 1 was set is enabled. Sensing is done only when the sensor is enabled. Disabling unnecessary sensors can lower current consumption.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 0xE2 | EN_SIN[7] | EN_SIN[6] | EN_SIN[5] | EN_SIN[4] | EN_SIN[3] | EN_SIN[2] | EN_SIN[1] | EN_SIN[0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xE3 : Data compare frequency setting]

Name: SENS_NUM

Address: 0xE3

Description: SENS_NUM[7:0] : The number of times data comparison is performed during 1 time of sensing .

Increasing the value also increases the accuracy but time and its current consumption also increases.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| 0xE3 | SENS_NUM[7] | SENS_NUM[6] | SENS_NUM[5] | SENS_NUM[4] | SENS_NUM[3] | SENS_NUM[2] | SENS_NUM[1] | SENS_NUM[0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xE4 : Normal sensing timing setting 1]

Name: SENS_RD_TIME

Address: 0xE4

Description: SENS_RD_TIME [7:0] : Comparator initial waiting time at normal sensing.

The time of one normal sensing increases by increasing the value.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 0xE4 | SENS_RD_TIME[7] | SENS_RD_TIME[6] | SENS_RD_TIME[5] | SENS_RD_TIME[4] | SENS_RD_TIME[3] | SENS_RD_TIME[2] | SENS_RD_TIME[1] | SENS_RD_TIME[0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xE5 : Normal sensing timing setting 2]

Name: SENS_RST_TIME

Address: 0xE5

Description: SENS_RST_TIME [7:0] : Setting of normal sensing at impressed time.
The time of normal sensing increases by increasing the value.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| 0xE5 | SENS_RST_TIME[7] | SENS_RST_TIME[6] | SENS_RST_TIME[5] | SENS_RST_TIME[4] | SENS_RST_TIME[3] | SENS_RST_TIME[2] | SENS_RST_TIME[1] | SENS_RST_TIME[0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xE6 : Normal sensing timing setting 3]

Name: SENS_IRST_TIME

Address: 0xE6

Description: SENS_IRST_TIME [7:0] : Setting of normal sensing at initial impressed time.
The time of normal sensing increases by increasing the value.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| 0xE6 | SENS_IRST_TIME[7] | SENS_IRST_TIME[6] | SENS_IRST_TIME[5] | SENS_IRST_TIME[4] | SENS_IRST_TIME[3] | SENS_IRST_TIME[2] | SENS_IRST_TIME[1] | SENS_IRST_TIME[0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xE7 : Datacompare frequency setting at check sensing]

Name: CHK_NUM

Address: 0xE7

Description: CHK_NUM[7:0] : Frequency of data comparison by check sensing and one time of calibration sensing.
Increasing the value also increases the accuracy but sensing time and its current consumption also increases.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|------------|------------|------------|------------|------------|------------|------------|------------|
| 0xE7 | CHK_NUM[7] | CHK_NUM[6] | CHK_NUM[5] | CHK_NUM[4] | CHK_NUM[3] | CHK_NUM[2] | CHK_NUM[1] | CHK_NUM[0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xE8 : Check sensing timing setting1]

Name: CHK_RD_TIME

Address: 0xE8

Description: CHK_RD_TIME [7:0] :Setting of comparator initial waiting time for check sensing and calibration sensing.
Increasing the value also increases the time for one sensing.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| 0xE8 | CHK_RD_TIME[7] | CHK_RD_TIME[6] | CHK_RD_TIME[5] | CHK_RD_TIME[4] | CHK_RD_TIME[3] | CHK_RD_TIME[2] | CHK_RD_TIME[1] | CHK_RD_TIME[0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xE9 : Check sensing timing setting 2]

Name: CHK_RST_TIME

Address: 0xE9

Description: CHK_RST_TIME [7:0] : Setup time setting for check sensing and calibration sensing.
Increasing the value also increases the time for one sensing.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 0xE9 | CHK_RST_TIME[7] | CHK_RST_TIME[6] | CHK_RST_TIME[5] | CHK_RST_TIME[4] | CHK_RST_TIME[3] | CHK_RST_TIME[2] | CHK_RST_TIME[1] | CHK_RST_TIME[0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

【0xEA : Check sensing timing setting 3】

Name: CHK_IRST_TIME

Address: 0xEA

Description: CHK_IRST_TIME [7:0] : Setup time setting for check sensing and calibration sensing. The value also increases the time for one sensing.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| 0xEA | CHK_IRST_TIME[7] | CHK_IRST_TIME[6] | CHK_IRST_TIME[5] | CHK_IRST_TIME[4] | CHK_IRST_TIME[3] | CHK_IRST_TIME[2] | CHK_IRST_TIME[1] | CHK_IRST_TIME[0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

【0xEB : Digital gain setting】

Name: DIG_GAIN

Address: 0xEB

Description: CHK_DIG_GAIN [3:0]: The digital gain result at the time of check sensing and calibration sensing is shifted to the right only by the set value. The sensor value obtained with 0x00-0x08 is the value after the digital gain is applied.

SENS_DIG_GAIN [3:0]: Digital gain at the time of normal sensing

The result is shifted to the right only by the set value.

Moreover, the sensor value obtained with 0x00-0x08 is the value after the digital gain is applied.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|-----------------|-----------------|-----------------|-----------------|------------------|------------------|------------------|------------------|
| 0xEB | CHK_DIG_GAIN[3] | CHK_DIG_GAIN[2] | CHK_DIG_GAIN[1] | CHK_DIG_GAIN[0] | SENS_DIG_GAIN[3] | SENS_DIG_GAIN[2] | SENS_DIG_GAIN[1] | SENS_DIG_GAIN[0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

【0xEC : Setting at intermittent operation time】

Name: CHK_WAIT_TIME

Address: 0xEC

Description: CHK_WAIT_TIME [7:0] : It decides the execution interval between the check sensing and the next check sensing. Corresponds to check intervals when all sensors are judged OFF through touch judgement of check sensing. Check interval = (set value + 1) X 4 ms

When ON judgment is done, the check sensing interval is decided by the sensing execution interval.

Intermittent sensing is applied only when it is enabled.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| 0xEC | CHK_WAIT_TIME[7] | CHK_WAIT_TIME[6] | CHK_WAIT_TIME[5] | CHK_WAIT_TIME[4] | CHK_WAIT_TIME[3] | CHK_WAIT_TIME[2] | CHK_WAIT_TIME[1] | CHK_WAIT_TIME[0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

【0xED : Setting at normal sensing waiting time】

Name: SENS_WAIT_TIME

Address: 0xED

Description: SENS_WAIT_TIME [7:0] : Waiting time until the next sensing starts.

Normal sensing interval = set value x 4 ms

When 0 is set, the next sensing starts after the MPU calculation ends.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| 0xE0 | SENS_WAIT_TIME[7] | SENS_WAIT_TIME[6] | SENS_WAIT_TIME[5] | SENS_WAIT_TIME[4] | SENS_WAIT_TIME[3] | SENS_WAIT_TIME[2] | SENS_WAIT_TIME[1] | SENS_WAIT_TIME[0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xEE : Calibration setting 0]

Name: CALIB_CONFIG0
 Address: 0xEE
 Description: RET_NUM[7:0] : Frequency setting for Calibration
 The return calibration starts when the sensing that touch detection is not performed and it is operated continuously more than the setting value after returning from intermittent operation to normal operation.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|------------|------------|------------|------------|------------|------------|------------|------------|
| 0xE0 | RET_NUM[7] | RET_NUM[6] | RET_NUM[5] | RET_NUM[4] | RET_NUM[3] | RET_NUM[2] | RET_NUM[1] | RET_NUM[0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xEF : Calibration setting 1]

Name: CALIB_CONFIG1
 Address: 0xEF
 Description: PRECAL_PERIOD [7:4]: Setting at cyclic calibration execution intervals
 When either of the next conditions is filled, a cyclic calibration is executed.
 Sleep function disabled and (setting value +1) x 500 >= the number of sensing
 Sleep function enabled and (setting value +1) x 50 >= the number of check sensing
 DRIFT_SIM_NUM[3:0]: Number of drift calibration detection sensor channels
 When the drift detected with the sensor channel is more than this setting value, the drift calibration is activated.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|-------------------|-------------------|-------------------|-------------------|------------------|------------------|------------------|------------------|
| 0xE0 | PRECAL_PERIOD [7] | PRECAL_PERIOD [6] | PRECAL_PERIOD [5] | PRECAL_PERIOD [4] | DRIFT_SIM_NUM[3] | DRIFT_SIM_NUM[2] | DRIFT_SIM_NUM[1] | DRIFT_SIM_NUM[0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xF0 : Clear interrupt]

Name: CLR_INTERRUPT
 Address: 0xF0
 Description: Clear Interrupt Register
 C_INI : Clear Interrupt of Initialization finish.
 Clears the INI interrupt by writing '0' in this register.
 C_CAL : Clear Interrupt of Software-calibration finish.
 Clears the CAL interrupt by writing '0' in this register.
 C_ERCAL : Clear Interrupt of Self-calibration finish.
 Clears the ERCAL interrupt by writing '0' in this register.
 C_WDT : '0' is set when clearing the bit WDT of the interrupt factor register.
 C_PERCAL : Clear Interrupt of Periodic calibration finish.
 Clears the PERCAL interrupt by writing '0' in this register.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|------|------|------|----------|-------|---------|-------|-------|
| 0xF0 | - | - | - | C_PERCAL | C_WDT | C_ERCAL | C_CAL | C_INI |
| R/W | - | - | - | R/W | R/W | R/W | R/W | R/W |
| Initial val. | - | - | - | 0 | 0 | 0 | 0 | 0 |

[0xF1, 0xF3 : Clear Switch-ON]

Name: CLR_DETECT_ON
 Address: 0xF1, 0xF3
 Description: DETECT_ON Clear Register. Clear the DETECT_ON by writing '0' in these registers. If you write '1', the operation is disabled. SW 0-15 has individual clear bit because SW 0-15 supports multiple presses. The matrix key's DETECT_ON clear bit is 1bit for MAT because the matrix key does not support multiple press.
 1 : Invalid. 0 :Clear.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|----------|----------|----------|----------|----------|----------|----------|----------|
| 0xF1 | C_SW7_ON | C_SW6_ON | C_SW5_ON | C_SW4_ON | C_SW3_ON | C_SW2_ON | C_SW1_ON | C_SW0_ON |
| 0xF3 | C_MAT_ON | - | - | - | - | - | - | - |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xF4, 0xF6 : Clear Switch-OFF]

Name: CLR_DETECT_OFF
 Address: 0xF4, 0xF6

Description: DETECT_OFF Clear Register. Clears the DETECT_OFF by writing '0' in these registers. If you write '1', the operation is disabled. SW 0-7 has individual clear bit because SW 0-7 supports multiple press. The matrix key's DETECT_OFF clear bit is 1bit for MAT because the matrix key does not support multiple press.
 1 : Invalid. 0 :Clear.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 0xF4 | C_SW7_OFF | C_SW6_OFF | C_SW5_OFF | C_SW4_OFF | C_SW3_OFF | C_SW2_OFF | C_SW1_OFF | C_SW0_OFF |
| 0xF6 | C_MAT_OFF | - | - | - | - | - | - | - |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xF5 : Slider Off recognition clear]

Name: CLR_DETECT_SLIDER_OFF
 Address: 0xF5

Description: C_SLIDER_OFF: Clear Slider off detection flag
 SLIDER_OFF (0x17 7) is cleared by writing 0. The next slider is not detected until this flag is cleared.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|--------------|------|------|------|------|------|------|------|
| 0xF4 | C_SLIDER_OFF | - | - | - | - | - | - | - |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xF7-0xF9 : Clear continuous touch]

Name: CLR_DETECT_CONT
 Address: 0xF7-0xF9

Description: DETECT_CONT Clear Register. Clears the DETECT_CONT by writing '0' in these registers. If you write '1', the operation is disabled. SW 0-7 has individual clear bit because SW 0-7 supports multiple press. The matrix key's DETECT_CONT clear bit is 1bit for MAT because the matrix key does not support multiple press.
 1 : Invalid. 0 :Clear.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|------------|------------|------------|------------|------------|------------|------------|------------|
| 0xF7 | C_SW7_CONT | C_SW6_CONT | C_SW5_CONT | C_SW4_CONT | C_SW3_CONT | C_SW2_CONT | C_SW1_CONT | C_SW0_CONT |
| 0xF9 | C_MAT_CONT | - | - | - | - | - | - | - |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xFE : Write register for operation check of MPU]

Name: WACT
 Address: 0xFE

Description: This register is a write register for operational check of the IC. The value written to this register is copied to the register for operation check (Address is 0x1E). If the write value with the read value is equal then the MPU and I/F are operating normally.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| 0xFE | WACT[7] | WACT[6] | WACT[5] | WACT[4] | WACT[3] | WACT[2] | WACT[1] | WACT[0] |
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Initial val. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[0xFF : AFE control]

Name: CNT
 Address: 0xFF
 Description: This register is for controlling AFE.

ACT : Scan Enable :

This bit is the scan enable for sensors. 1:Normal Scan Enable. 0:Normal Scan Disable.

CAL : Act Software-calibration :

The calibration is operated by setting '1'.

CFG : Enable Configuration Value :

Writing '1' to this bit renew the values of Sensor Configuration (Address 0xC0-0xCF), Mask Configuration except for 0xDF(Address 0xD0-0xDE), Analog setting Configuration (Address 0xE0-0xEF), FRCRLS and CALOVF. Also It affect the IC's operation.

CALMOD : Select Software-calibration mode :

0: All sensors are the targets for software-calibration. If some sensor has the value more than the threshold for "Off→On", the sensors are changed to OFF, and DETECT_OFF registers are enabled. (default)
 1: Sensors with value more than the threshold for "Off→On are not included"

CALOVF : Select Self-calibration mode detected overflow :

When the periodic calibration is active, it selects whether to activate self-calibration or not to activate in the case that the sensor values are over the dynamic range of included ADC.
 0: Deactivate self-calibration (default) 1: Activate self-calibration.

FRCRLS : Select Force OFF at continued touch :

When the continued touch is active, select whether to activate force OFF or not in the case that the max value after detect continued touch minus the current sensor value is more than the threshold for "Off→On".
 0: Deactivate force OFF(default) 1:Activate force OFF.
 The continued touch sensor is changed to OFF, and DETECT_OFF register is enabled.

| | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---------------------|--------|--------|------|--------|------|------|------|------|
| 0xFF | FRCRLS | CALOVF | - | CALMOD | - | CFG | CAL | ACT |
| R/W | R/W | R/W | - | R/W | - | R/W | R/W | R/W |
| Initial val. | 0 | 0 | - | 0 | - | 0 | 0 | 0 |

Timing Charts

•Host interface

2-wire serial bus.
 Compatible with I2C protocol.
 Supports slave mode only.
 Slave Address = 0x5C
 Supports Standard-mode (data transfer rate is 100 kbit/s) and Fast-mode (data transfer rate is 400 kbit/s).
 Supports sequential read.

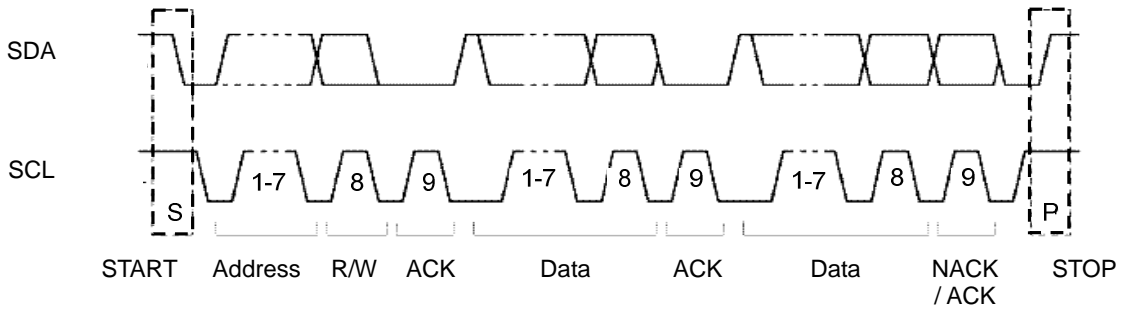


Fig 7. 2-wire serial bus data format

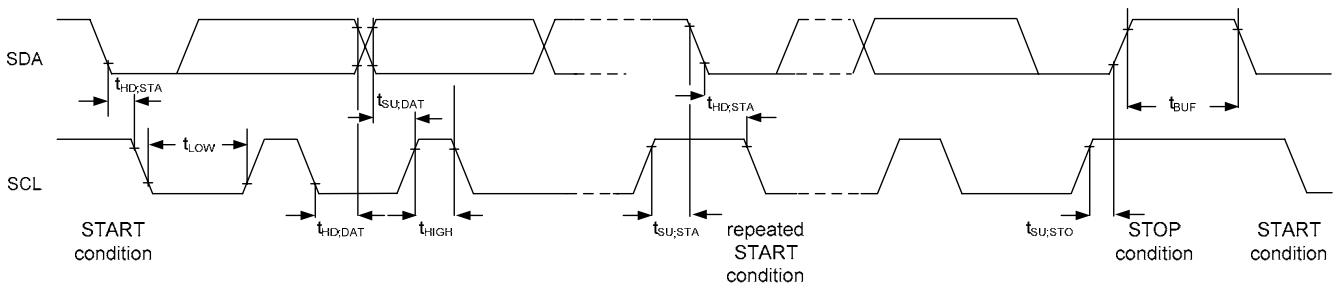
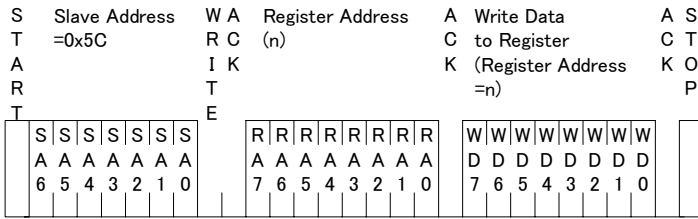


Fig 8. 2-wire serial bus timing chart

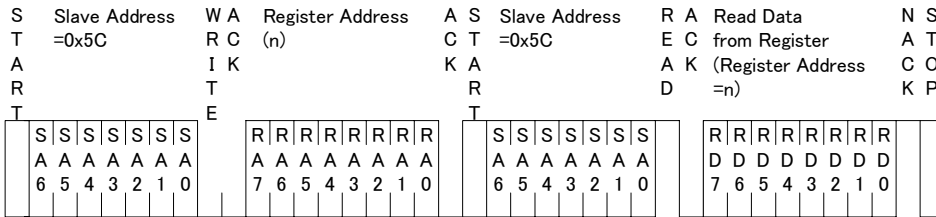
| Parameter | Symbol | Standard-mode | | Fast-mode | | Unit |
|--|--------------|---------------|------|-----------|-----|-----------|
| | | MIN | MAX | MIN | MAX | |
| Hold time (repeated) START condition | f_{SCL} | 0 | 100 | 0 | 400 | kHz |
| LOW period of the SCL clock | $t_{HD,STA}$ | 4.0 | - | 0.6 | - | μ sec |
| HIGH period of the SCL clock | t_{LOW} | 4.7 | - | 1.3 | - | μ sec |
| Data hold time | t_{HIGH} | 4.0 | - | 0.6 | - | μ sec |
| Data set-up time | $t_{HD,DAT}$ | 0.1 | 3.45 | 0.1 | 0.9 | μ sec |
| Set-up time for a repeated START condition | $t_{SU,DAT}$ | 0.25 | - | 0.1 | - | μ sec |
| Set-up time for STOP condition | $t_{SU,STA}$ | 4.7 | - | 0.6 | - | μ sec |
| Bus free time between a STOP and START condition | $t_{SU,STO}$ | 4.0 | - | 0.6 | - | μ sec |
| Hold time (repeated) START condition | t_{BUF} | 4.7 | - | 1.3 | - | μ sec |

●Byte Write



SA : Slave Address
 RA : Register Address
 RD : Read Data
 WD : Write Data

●Random Read



●Sequential Read

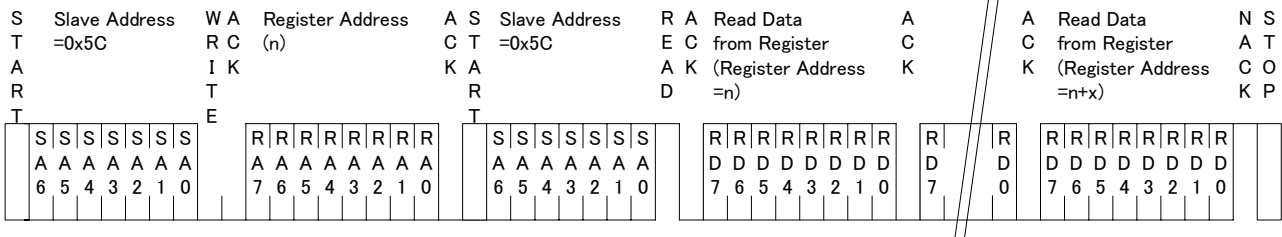


Figure 9. 2-wire serial bus protocol

Scan rate

After scanning each sensor in time series, MPU converts the detected results to switch operations. One scan rate is about 6msec at typical.

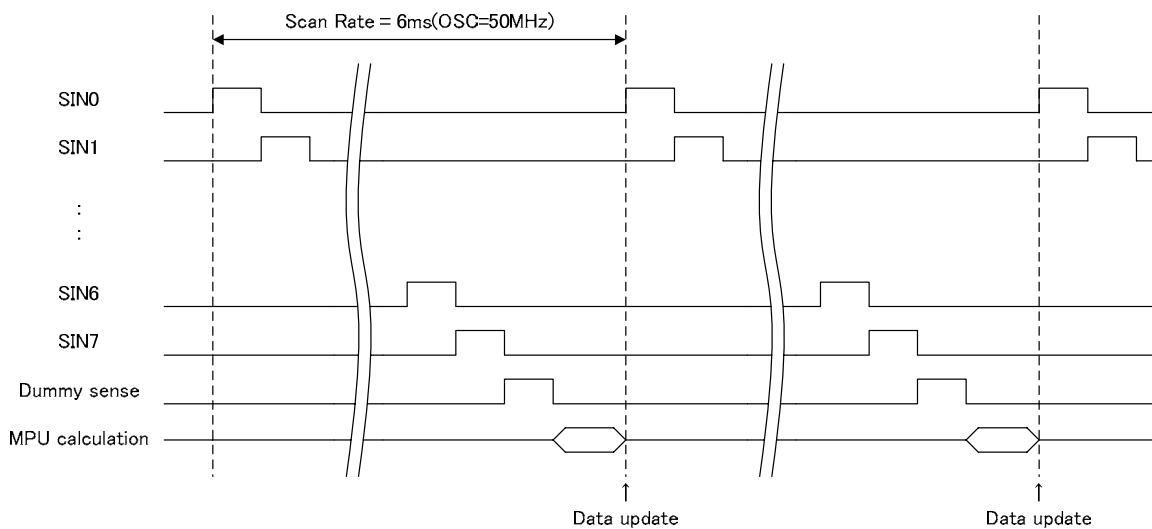


Figure 10. Timing chart of scan rate

Power on sequence

The power supply pin is only VDD. Because AVDD and DVDD are generated by a built-in LDO, there is no need for an external supply. The internal reference voltage is started up by the VDD supply, and DVDD starts up continuously. Power-on reset is released when DVDD reaches the required voltage.

Recommended value of external capacitors

| | | |
|----------------|-------|---------------------------|
| C ₁ | 0.1μF | VDD decoupling capacitor |
| C ₂ | 1.0μF | DVDD decoupling capacitor |
| C ₃ | 2.2μF | AVDD decoupling capacitor |

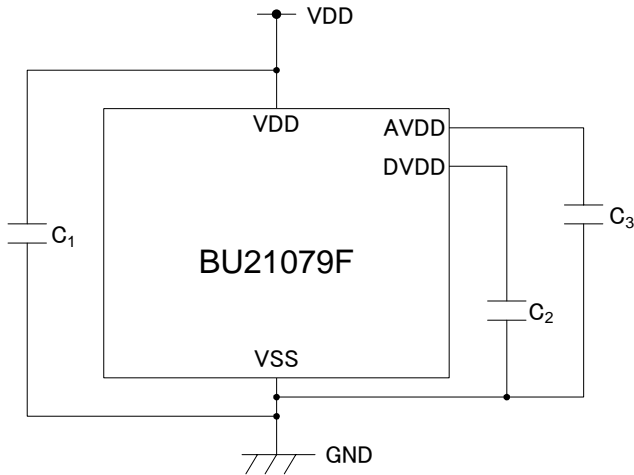


Figure 11. Arrangement of external decoupling capacitors

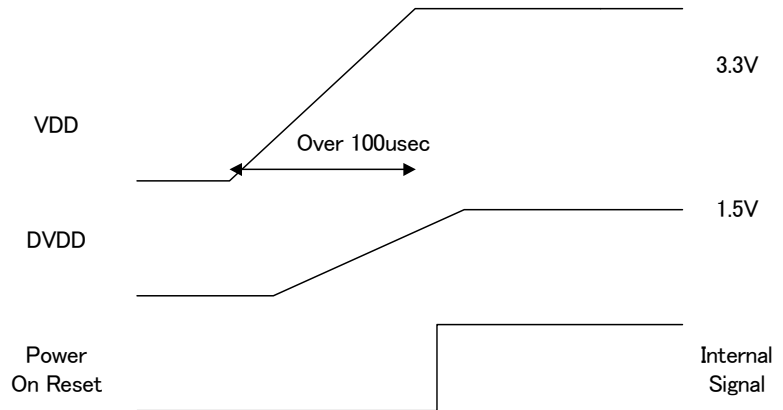


Figure 12. Power on sequence

When power-on-reset is released, MPU starts initial sequence. INT port informs the host that the initialization has been completed. After verifying if the initialization is completed, the host will need to send the command to the IC. In the case that WDTR is released as well, MPU starts initial sequence. If WDTR is released, all registers have been initialized so the host will need to resend the command to the IC.

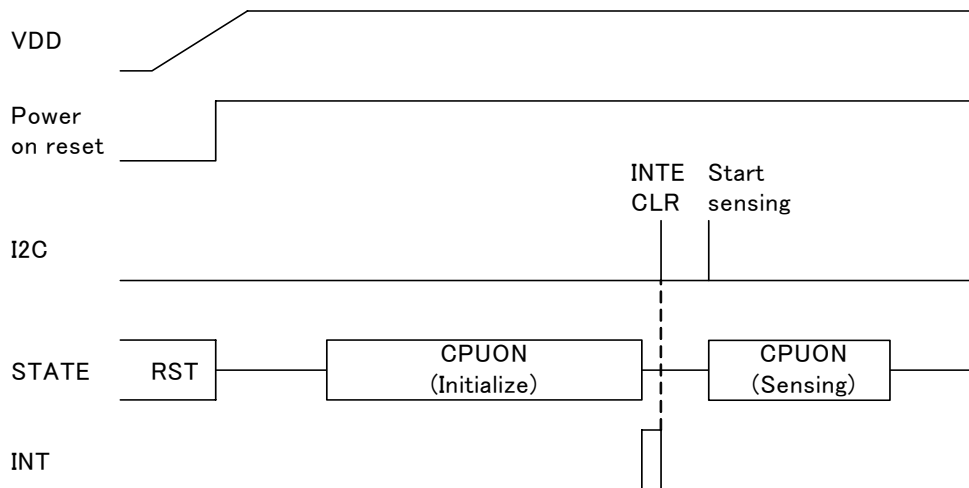


Figure 13. Timing chart of initialization

Operational mode

This IC has three operational modes, [Stop mode], [Intermittent mode], and [Normal mode].

【Stop mode】

It is the state where detection is disabled.

Detection is stopped by setting '0' to ACT of the sensor motion control register CNT (address 0xFF).

A detection process is stopped and consumption current decreases by performing the power down of AFE.

【Normal mode】

In normal mode, detection is continuous.

Sensing is started by setting '1' to ACT of the sensor motion control register CNT (address 0xFF).

Starting detection and soft calibration is operated simultaneously.

Sensing in normal mode is defined as normal sensing.

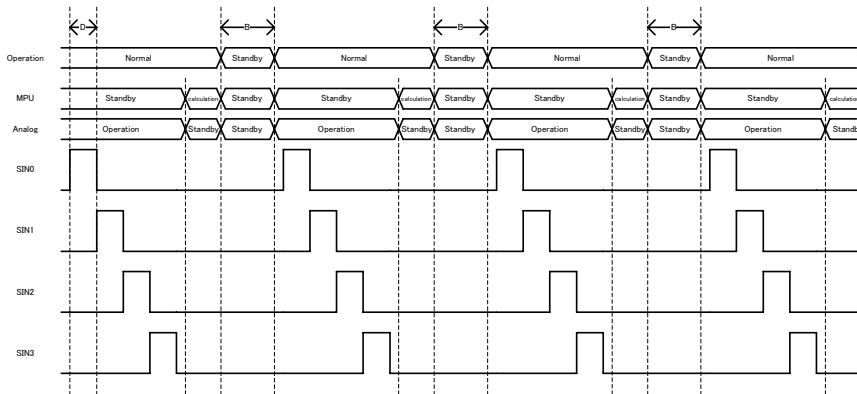
【Intermittent mode】

Detection is thinned out. If the touch detection beyond a definite period of time is not recognized, it will shift to intermittent operation. In this state, since the frequency of sensing is low, current consumption can be reduced.

Sensing in intermittent operation is defined as check sensing.

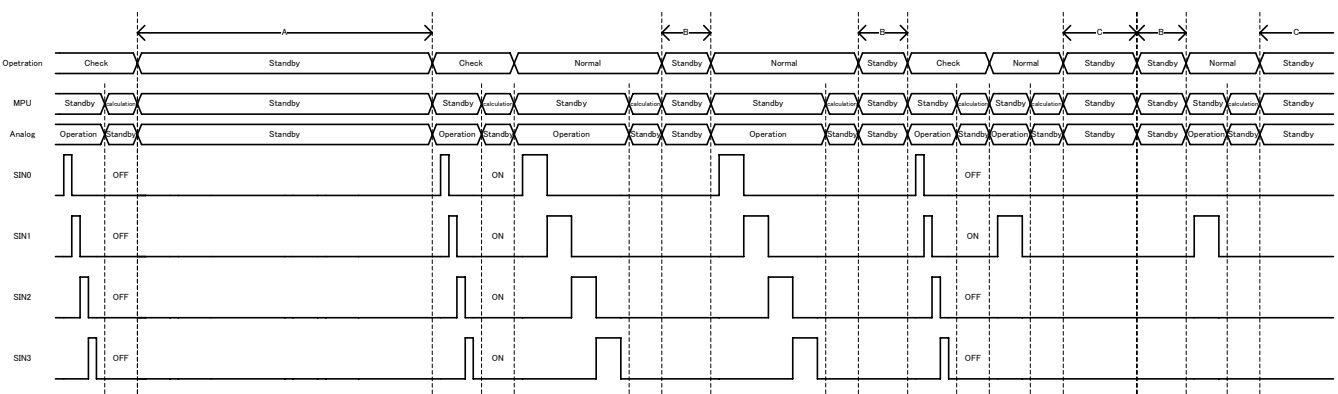
【 Normal operation 】

①An effective sensor is sensing by the SENS setting.



【 Intermittent operation 】

- ①All sensors are checked sensing by each CHK setting of the register.
- ②The sensor of ON judgment is done normal sensing by the check sensing result, and it uses it for the touch judgment that outputs only the result.
- ③It stands by until time equal with all channel sensing when sensors of ON judgment are less than 8 channels in the check sensing result.
- ④It stands by at time that even the next check timing was set when there is no sensor of ON judgment in the check sensing result.
- ⑤The frequency of the sensor while check sensing is operated is specified by the register. Minimum is 1 time. (A below figure is shown twice.)



- A: Check waiting time. It is possible to set it at CHK_WAIT_TIME. (About 4 to 1024ms)
- B: Sense waiting time. It is possible to set it at SENS_WAIT_TIME. (About 0 to 1020ms)
- C: Sense adjustment time. It changes according to the number of sensors in which not sensing. (About 4ms unit)
- D: Sensing time of each sensor

Figure14. Operation sequence of normal operation and intermittent operation

Initialized operation

This IC is initialized and all registers are cleared by Power-on reset, WDT time-out reset, and Software reset command. When initialization is complete, the register INI is '1' and I/O port INT is "H". After the IC is initialized, write the configuration values to registers. After setting configuration values, the next action is sensor calibration. Set '1' to the registers ACT, CFG and CAL on Address 0xFF, and calibration sequence is performed.

The initialization process after the ROM hardware reset

- Power activation
- WDT timeout
- Software reset

Also in the case of hardware reset by any, all the register is cleared.

Since reset to MPU is also operated, MPU follows the firmware in Program ROM and initializes IC.

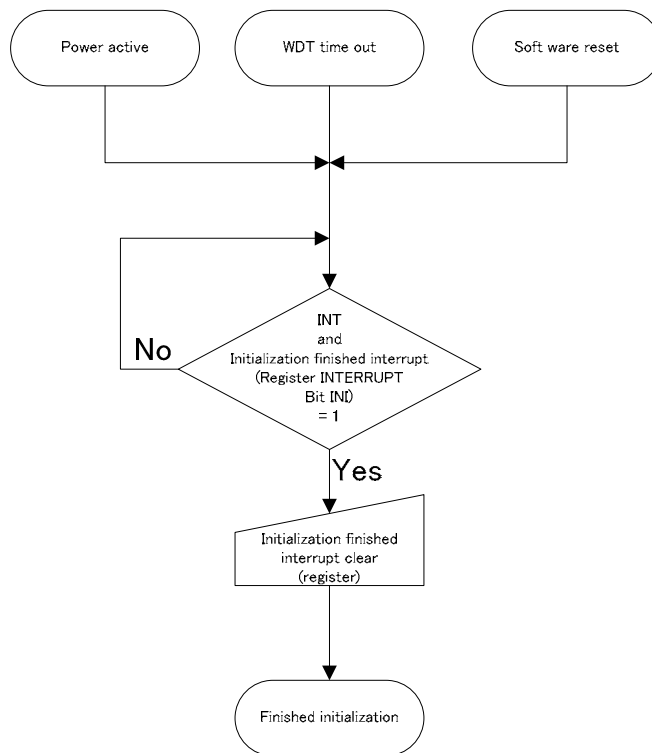


Figure15. The initialization process after hardware reset

The relation of sequence after power on and interrupt

After power on, a system reset is performed by the power-on-reset circuit inside the IC, and download of firmware from ROM is started. When downloading of the firmware is completed, the initialization is finished. Since interrupt is active, please send an interrupt clear command. Calibration starts to setup CNT (0xFF) =03h. Since interrupt is active after finishing, please send an interrupt clear command.

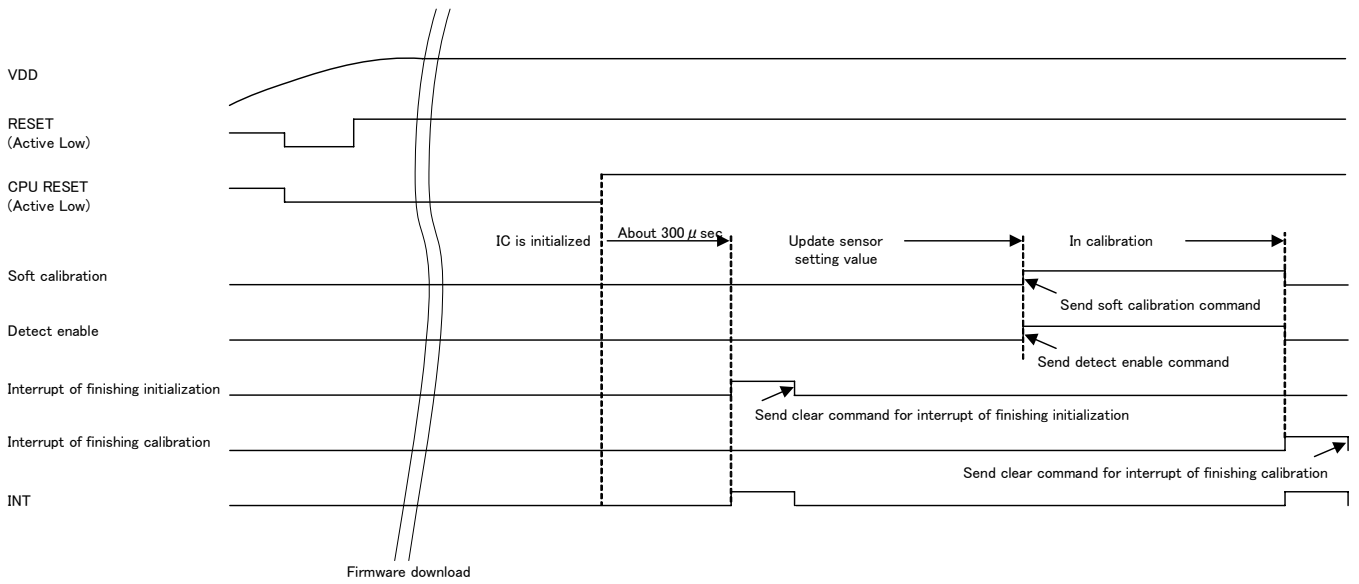


Figure16. The setting processes after a system reset and interrupt, and interrupt clear.

Calibration

There are three kinds of calibration: soft calibration, period calibration and recalibration according to error.

There are four kinds of recalibration according to error: drift calibration, calib-error calibration, hopping calibration and return calibration.

Soft calibration (CAL)

When the sensor setting value is changed, it is necessary to execute a soft calibration.

When a soft calibration ends, soft calibration end interrupt bit is '1' and INT (interrupt) pin is active.

Interrupt by soft calibration completion have mask function. (0: Off mask 1: On mask).

Bit of the soft calibration end interrupt is cleared by writing '0'.

When a soft calibration is operated, the register by the result of detecting the sensor value and the switch operation that has been detected is cleared.

IC doesn't update sensor value during calibration, therefore, the sensor operation is also disabled.

The calibration is operated by the next sampling while a soft calibration is sent during the sensor sampling.

0xFF(CALMOD) can set soft calibration execution for ON detection sensor in touch.

Period calibration (PERCAL)

The execution of self calibration can be selected at each passage at a fixed time. The selection of the execution/non-execution selects registers 0xE1[4] (PERCAL_DIS 0: Execute period calibration, 1: disable period calibration)

Calibration is not done for ON detection sensor in touch even when the period calibration is executed.

When the finger does not touch the sensor, the calibration is executed.

Whenever the period calibration is executed, an interrupt factor PERCAL is set '1' and INT (interrupt) pin is active.

Interrupt by period calibration completion have mask function (0: MASK Off , 1: MASK On).

Recalibration according to error (ERCAL)

When the next four situations are generated, the calibration is automatically executed. The completion of the recalibration can be identified through the INT interrupt.

The mask function is prepared in the interrupt factor recalibration completion. (0: MASK Off, 1: MASK On).

The completion interrupt bit of the recalibration is cleared by writing '0'.

1. Drift calibration

When the IC detects the drift condition, the IC activates self-calibration. When calibration is complete, the interrupt factor register CAL is '1' and I/O port INT is "H". When there is a sensor with a value more than the threshold for "Off→On", IC does not detect drift condition.

2. Calib-error calibration

When the finger is on the sensor at the calibration, the sensor base state is with the finger. Without the finger, the sensor value is under the base state value. This abnormal condition is defined to be an incorrect operation. When incorrect operation is detected, the IC activates self-calibration.

3. Hopping calibration

When the IC detects noise, the IC changes the scan rate so it does not synchronize with the noise, and the IC activates self-calibration. When calibration is complete, the Interrupt factor register CAL is '1' and I/O port INT is "H".

4. Return calibration

Though it returned to normal operation from intermittent operation, when sensing not on detected is more than the regulated frequency, self-calibration is executed, recalibration end interrupt bit become '1' and INT is output.

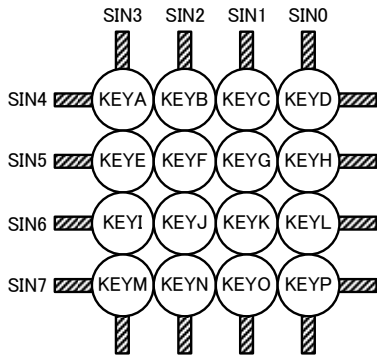
The frequency can be set by register 0xEE.

Matrix Switch

The cross points of the sensors which are arranged in a matrix can be assigned to individual switches. The matrix layout of the sensors is shown in Figure 17.

Each matrix switch has the registers of detected Touch (DETECT_ON) / Release (DETECT_OFF) / Hold (DETECT_COND) operations. It is recommended to mask unused matrix switches. If there are unstructured matrix switches (in the case that under 4x4 matrix layout), it is a must that the unstructured matrix switches are masked.

Matrix switches do not support multi-detect Touch/Release/Hold. The condition of acceptable matrix switch operation is that every sensor's value is under the threshold for "On→Off" and DETECT_OFF register of matrix switch is cleared. It is a must that the matrix switches that are made by the sensor assigned to a simple switch are masked.



| | |
|------------------------|------------------------|
| KEYA : KEY[3:0] = 0x00 | KEYI : KEY[3:0] = 0x08 |
| KEYB : KEY[3:0] = 0x01 | KEYJ : KEY[3:0] = 0x09 |
| KEYC : KEY[3:0] = 0x02 | KEYK : KEY[3:0] = 0x0A |
| KEYD : KEY[3:0] = 0x03 | KEYL : KEY[3:0] = 0x0B |
| KEYE : KEY[3:0] = 0x04 | KEYM : KEY[3:0] = 0x0C |
| KEYF : KEY[3:0] = 0x05 | KEYN : KEY[3:0] = 0x0D |
| KEYG : KEY[3:0] = 0x06 | KEYO : KEY[3:0] = 0x0E |
| KEYH : KEY[3:0] = 0x07 | KEYP : KEY[3:0] = 0x0F |

Figure 17. Layout for matrix switch

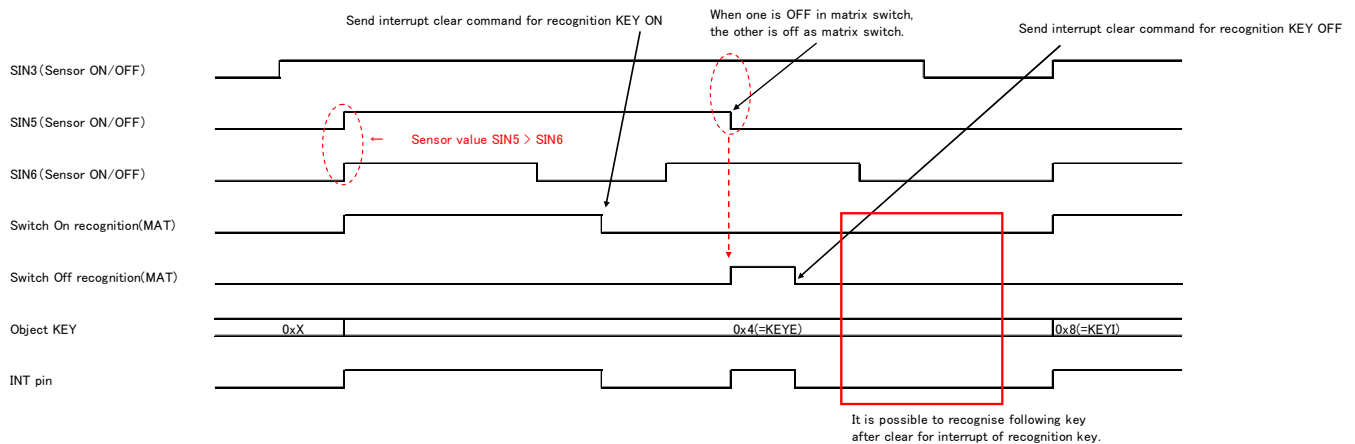


Figure 18. Interrupt of matrix switch (1)

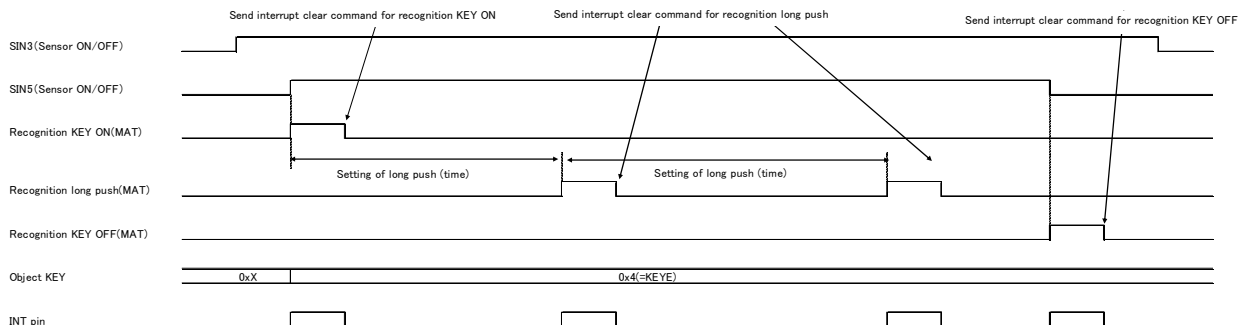
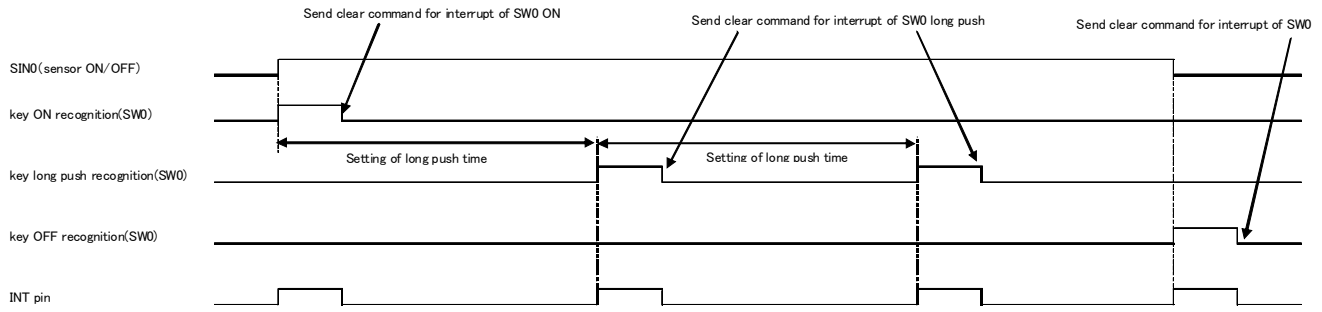


Figure 19. Interrupt of matrix switch (2)

Simple Switch

Every sensor is used for simple switch. Each simple switch has the registers of detected Touch/Release/Hold operations. Simple switches support multi-detect Touch/Release/Hold. It is possible to mask each switch.

Case1 Long push setting **CONTSEL = 1**



Case2 Long push setting **CONTSEL = 0**

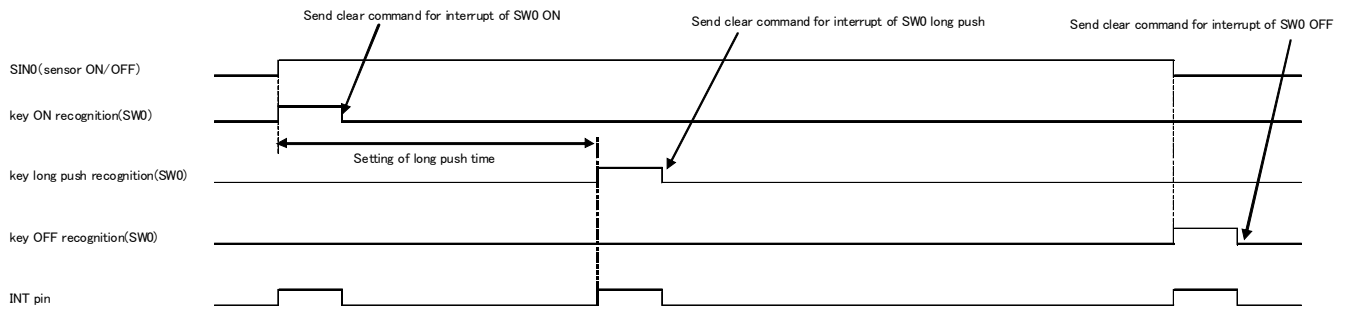


Figure 20. Interrupt of simple switch (1)

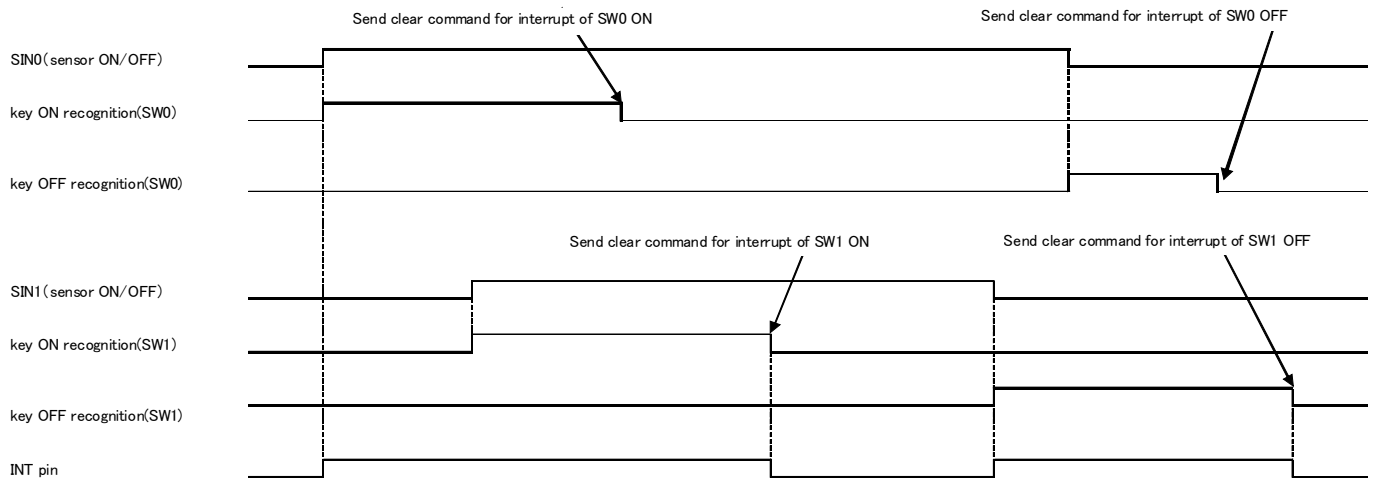


Figure 21. Interrupt of simple switch (2)

Application Examples

BU21079F offers 2 methods of switch. One method is simple switch, another method is matrix switch. The maximum number of matrix switches that BU21079F can handle is 16.

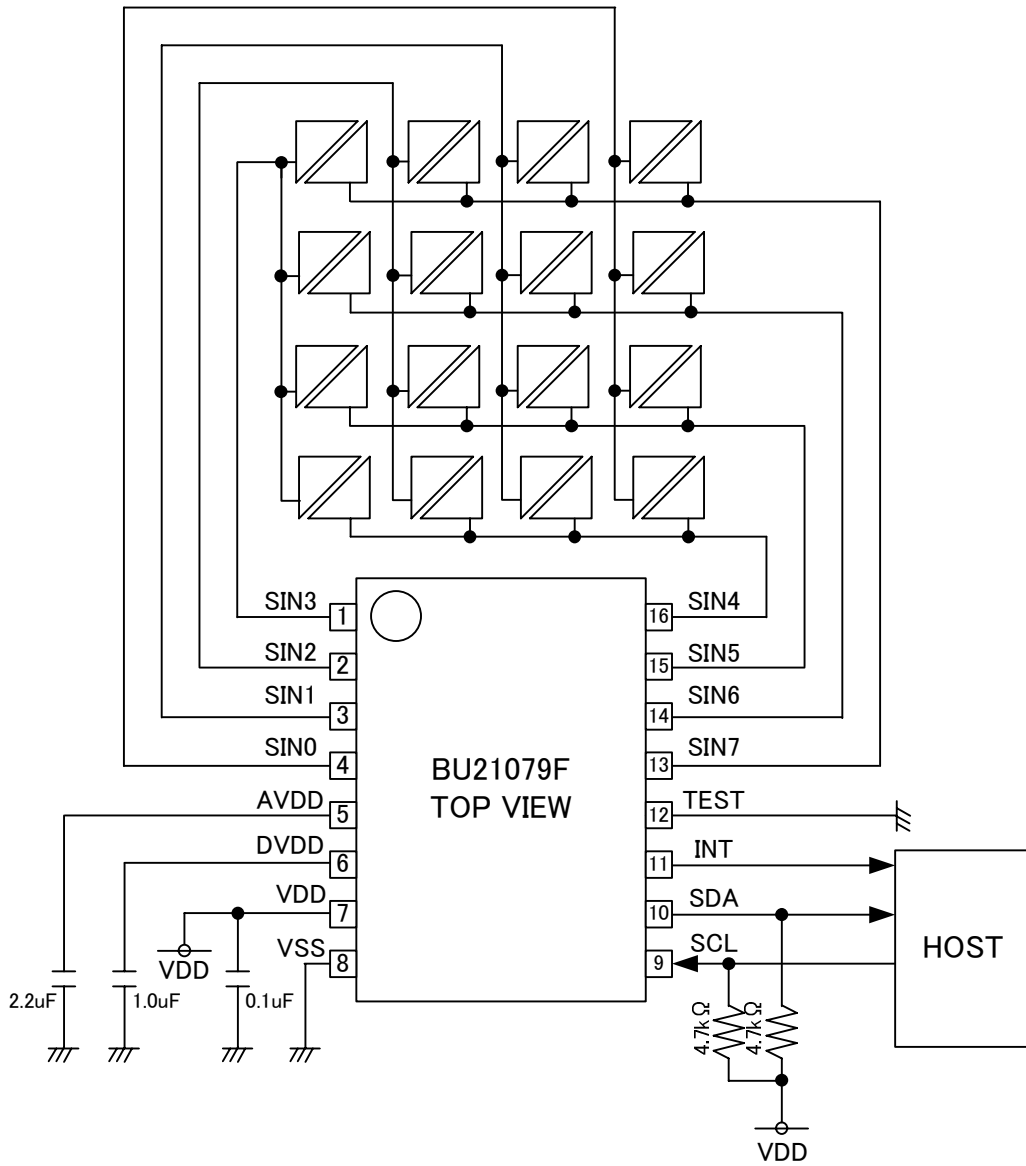


Figure 22. Application example 1. (Matrix 4 x 4 composition by BU21079F)

Operational Notes**(1) Absolute Maximum Ratings**

An excess in the absolute maximum ratings, such as supply voltage, temperature range of operating conditions, etc., can break down the device, thus making it impossible to identify the reason for breakdown such as a short circuit or an open circuit. If any special mode exceeding the absolute maximum ratings is assumed, consideration should be given and apply safety measures including the use of fuses, etc.

(2) Operating conditions

These conditions represent the range within which characteristics can be provided approximately as expected. The electrical characteristics are guaranteed under these conditions for each parameter.

(3) Reverse connection of power supply connector

The reverse connection of power supply can break down the IC. Take protective measures against the breakdown due to the reverse connection by using methods such as mounting an external diode between the power supply and the IC's power supply terminal.

(4) Power supply line

Design PCB trace to provide low impedance for the wiring between the power supply and the GND lines. In this regard, for the digital block power supply and the analog block power supply, even though these power supplies has the same level of potential, separate the power supply trace for the digital block from that of the analog block, thus suppressing the diffraction of digital noises to the analog block power supply resulting from impedance common to the trace. For the GND line, give consideration to design the trace in a similar manner.

Furthermore, for all power supply terminals of the ICs, mount a capacitor between the power supply and the GND terminal. At the same time, when using an electrolytic capacitor, be sure that the characteristics of the capacitor to be used will introduce no problem including the occurrence of capacity dropout at a low temperature, thus determining the constant.

(5) GND voltage

Set the potential of the GND terminal so that it will be maintained at the minimum in any operating state. Furthermore, ensure that no terminals are at a potential lower than the GND voltage including transient conditions.

(6) Short circuit between terminals and erroneous mounting

When mounting ICs on a PCB, pay attention to the orientation of the ICs. Erroneous mounting can break down the ICs. Furthermore, if a short circuit occurs due to foreign objects entering between terminals or between the terminal and the power supply or the GND terminal, the ICs can break down.

(7) Operation in strong electromagnetic field

Please note that using the ICs in the presence of a strong electromagnetic field can cause malfunction.

(8) Inspection with set PCB

On the inspection with the set PCB, if a capacitor is connected to a low-impedance IC terminal, the IC can suffer stress. Therefore, be sure to discharge capacitors connected to the set PCB after each process. Furthermore, in mounting or dismounting the set PCB to/from the jig for the inspection process, be sure to turn OFF the power supply and then mount the set PCB to the jig. After the completion of the inspection, be sure to turn OFF the power supply and then dismount it from the jig. In addition, for protection against static electricity, establish a ground for the assembly process and pay thorough attention to the transportation and the storage of the set PCB.

(9) Input terminals

In terms of the construction of IC, parasitic elements are inevitably formed in relation to potential. The operation of the parasitic element can cause interference with circuit operation, thus resulting in a malfunction and then breakdown of the input terminal. Therefore, pay thorough attention not to handle the input terminals, such as to apply to the input terminals a voltage lower than the GND respectively, so that any parasitic element will operate. Furthermore, do not apply a voltage to the input terminals when no power supply voltage is applied to the IC. In addition, even if the power supply voltage is applied, apply to the input terminals a voltage lower than the power supply voltage or within the guaranteed value of electrical characteristics.

(10) Ground wiring pattern

If small-signal GND and large-current GND are provided it is recommended to separate the large-current GND trace from the small-signal GND trace and establish a single ground at the reference point of the set PCB so that resistance to the wiring pattern and voltage fluctuations due to a large current will cause no fluctuations in voltages of the small-signal GND. Pay attention not to cause fluctuations in the GND wiring pattern of external parts as well.

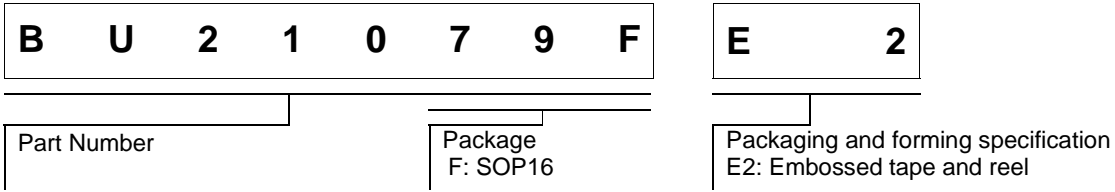
(11) External capacitor

When using a ceramic capacitor as the external capacitor, determine the value while also considering the degradation in the nominal capacitance due to DC bias and changes in the capacitance due to temperature, etc.

(12) Rush current

When supplying power to the IC, a rush of current may occur due to the procedure and delay at power-on. Pay attention to the capacitance of the coupling capacitors and the wiring pattern width and routing of the power supply and the GND lines.

Ordering Information

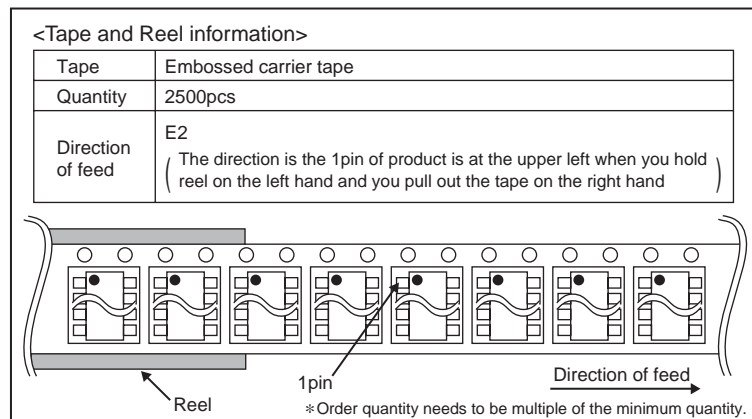
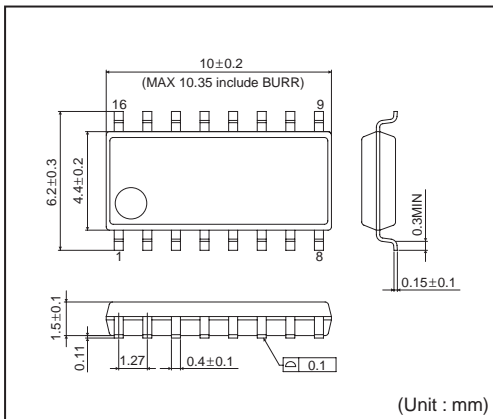


Line-up

| Sensor ports | Package | Orderable Part Number |
|--------------|---------|-----------------------|
| 8ch | SOP16 | BU21079F-E2 |

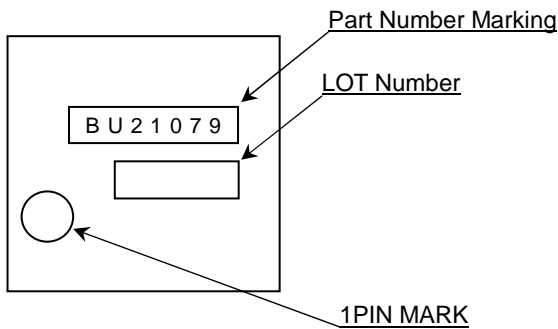
Physical Dimension Tape and Reel Information

SOP16



Marking Diagrams (TOP VIEW)

SOP16 (TOP VIEW)



Revision History

| Date | Revision | Changes |
|-----------|----------|---------|
| 2013.9.25 | Rev.001 | New |
| — | — | — |

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|-----------|-----------|------------|-----------|
| CLASS III | CLASS III | CLASS II b | CLASS III |
| CLASS IV | | CLASS III | |

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 - Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl₂, H₂S, NH₃, SO₂, and NO₂
 - Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
 - Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
 - Sealing or coating our Products with resin or other coating materials
 - Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
 - Use of the Products in places subject to dew condensation
- The Products are not subject to radiation-proof design.
- Please verify and confirm characteristics of the final or mounted products in using the Products.
- In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse. is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.
- De-rate Power Dissipation (Pd) depending on Ambient temperature (Ta). When used in sealed area, confirm the actual ambient temperature.
- Confirm that operation temperature is within the specified range described in the product specification.
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 - [b] the temperature or humidity exceeds those recommended by ROHM
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