

## Capacitive Sensor Control IC Series

# Capacitive Sensor Switch Control IC



No.09048EBT03

### BU21009MUV

#### Description

BU21009MUV is the capacitive sensor controller for the switch function and slider function with 16 channels sensors.

All channels are calibrated for the slider functions. So this is useful for 16 switches application, too.

LED driver is available (No PWM function).

#### Features

- 1) Slider function
- 2) LED driver available
- 3) 2 wire serial interface
- 4) Power supply = 2.5V to 3.3V, I/O power supply = 1.7V to 3.3V
- 5) Integrated 10bit AD converter, clock and reset
- 6) Package VQFN032V5050

#### Applications

It is possible to use it widely as a switch/slider such as a Mobile phone, Portable equipment, and Audiovisual apparatuses.

#### Absolute Maximum Ratings (Ta=25°C)

| PARAMETER                 | SYMBOL | RATING |          | UNIT |
|---------------------------|--------|--------|----------|------|
|                           |        | MIN    | MAX      |      |
| APPLIED VOLTAGE           | AVDD   | -0.3   | 4.5      | V    |
|                           | DVDD   | -0.3   | 4.5      |      |
| INPUT VOLTAGE             | VAIN   | -0.3   | AVDD+0.3 | V    |
|                           | VDIN   | -0.3   | DVDD+0.3 |      |
| STORAGE TEMPERATURE RANGE | Tstg   | -55    | 125      | °C   |
| POWER DISSIPATION         | Pd     | 304    |          | mW   |

Ambient temperature reduces a permission loss by 3.1mW per case more than 25 degrees Celsius, 1 degree Celsius.

#### Recommended Operating conditions

| PARAMETER                   | SYMBOL | RATING |     |     | UNIT |
|-----------------------------|--------|--------|-----|-----|------|
|                             |        | MIN    | TYP | MAX |      |
| APPLIED VOLTAGE             | AVDD   | 2.5    | 3.0 | 3.3 | V    |
|                             | DVDD   | 1.7    | 3.0 | 3.3 | V    |
| OPERATING TEMPERATURE RANGE | Topr   | -40    | 25  | 85  | °C   |

●Electrical characteristics(Especially, Topr=25 °C and AVDD=DVDD=0 as long as it doesn't specify it.)

| PARAMETER             | SYMBOL          | RATING   |     |          | UNIT | Condition                                                            |
|-----------------------|-----------------|----------|-----|----------|------|----------------------------------------------------------------------|
|                       |                 | MIN      | TYP | MAX      |      |                                                                      |
| H INPUT VOLTAGE       | VIHIO           | DVDDx0.8 | -   | DVDD+0.3 | V    |                                                                      |
| L INPUT VOLTAGE       | VILIO           | DVSS-0.3 | -   | DVDDx0.2 | V    |                                                                      |
| Output "H" voltage    | VOHIO           | DVDD-0.7 | -   | DVDD     | V    | I <sub>OH</sub> =-2[mA]. Overshoot is excluded.                      |
| Output "L" voltage    | VOLLED          | AVSS     | -   | 0.5      | V    | I <sub>OL</sub> =8[mA]. Undershoot is excluded. LED output.          |
|                       | VOLTxD          | DVSS     | -   | 0.5      |      | I <sub>OL</sub> =3[mA]. Undershoot is excluded. SDA/TXD application. |
|                       |                 |          |     | DVDDx0.3 |      |                                                                      |
|                       | VOLINT          | DVSS     | -   | 0.5      |      | I <sub>OL</sub> =2[mA]. Undershoot is excluded. INT application.     |
| Input leakage current | IIZ             | -1       | -   | 1        | μA   |                                                                      |
| Off leakage current   | I <sub>OZ</sub> | -1       | -   | 1        | μA   |                                                                      |
| Standby current       | I <sub>ST</sub> | -        | -   | 2        | μA   | Shutdown (SDN="L")                                                   |
| Current of operation  | I <sub>DD</sub> | -        | 300 | -        | μA   |                                                                      |

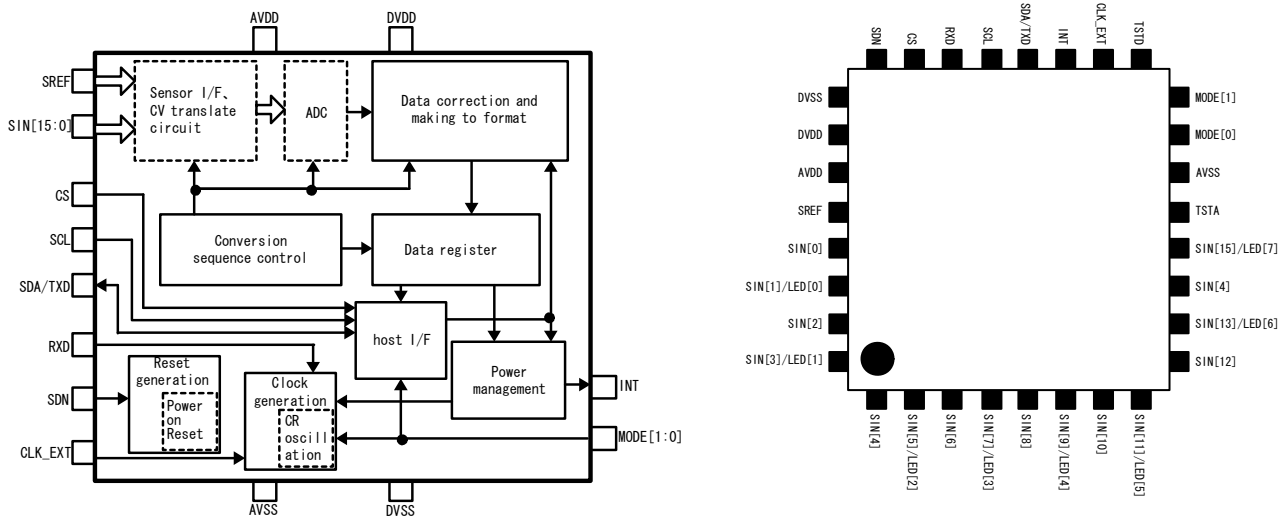
●A/D Converter

| PARAMETER                      | SYMBOL            | RATING    |     |           | UNIT | Condition                  |
|--------------------------------|-------------------|-----------|-----|-----------|------|----------------------------|
|                                |                   | MIN       | TYP | MAX       |      |                            |
| Resolution                     |                   | -         | 10  | -         | bit  |                            |
| Analog Input voltage           | V <sub>AIN</sub>  | AVSS      | -   | AVDD      | V    |                            |
| change clock frequency         | f <sub>adck</sub> | 0.2       | -   | 2.0       | MHz  |                            |
| change time                    | t <sub>tim</sub>  | -         | 77  | -         | μsec | f <sub>adck</sub> = 1[MHz] |
| Zero scale voltage             |                   | -         | -   | AVSS+0.07 | V    |                            |
| full scale voltage             |                   | AVDD-0.07 | -   | -         | V    |                            |
| differential Non line accurate | DNL               | -         | -   | ±3        | LSB  |                            |
| Integrate Non line accurate    | INL               | -         | -   | ±3        | LSB  |                            |

●CR Oscillator characteristic

| PARAMETER             | SYMBOL          | RATING |     |     | UNIT | Condition |
|-----------------------|-----------------|--------|-----|-----|------|-----------|
|                       |                 | MIN    | TYP | MAX |      |           |
| Frequency Oscillation | f <sub>cr</sub> | 0.4    | 1.1 | 2.0 | MHz  |           |

## ●Block Diagram, Pin configuration



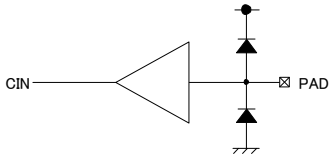
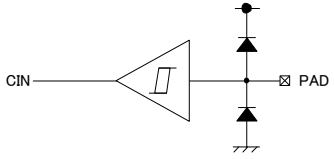
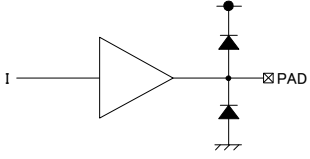
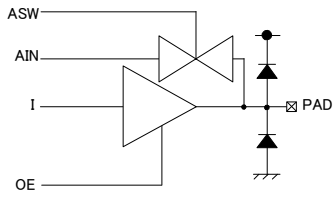
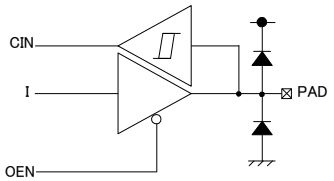
- **Sensor I/F CV translate circuit**  
This module selects between sensor inputs. The selection sequences between all 16 channels.
- **AD Conversion**  
The voltage into which CV is converted is converted into a digital value.  
Conversion is 10 bit and full scale corresponds to AVDD.
- **Conversion sequence control**  
Performs timing generation for the analogue circuitry and a sequencer circuit for selection of the sensor channel for conversion.
- **Data correction and making to format**  
This module provides the digital intelligence of the sensor.  
The block includes, amongst other things, scaling, adding offsets and input filtering for de-bouncing.  
Registers are formatted to simplify usage by the software application.  
The block implements auto-calibration to manage drift in temperature, process variation, voltage variation and aging effects.
- **Data register**  
This stores the results for the software application. Please refer to the register map for details.
- **HOST I/F**  
2 wire serial interface.
- **Power management**  
The power management block provides smart power control.  
When the sensors are not in use, the Controller automatically transitions into a low-power mode.  
When a sensor is touched, then the device automatically wakes up and enters its normal operation.  
The chip drives an INT pin for alerting the controller device in this case.
- **Reset generation**  
The circuit is initialized by a either a soft reset command or by the external SDN pin.
- **Clock generation**  
The device has an internal oscillator.  
Provision is also made if the application would like to make use of an external clock input.

## ●Pin Description

| Pin No. | Name       | I/O      | Function                                                | Note                                             | Supply Reference | Reset Level | I/O Pad |
|---------|------------|----------|---------------------------------------------------------|--------------------------------------------------|------------------|-------------|---------|
| 1       | SIN4       | AIIn     | sensor input4                                           | -                                                | AVDD             | "Hi-Z"      | ④       |
| 2       | SIN5/LED2  | AIIn/Out | sensor input 5<br>/PW Drive LEDcontrol output 2         | sensor input ,<br>LED drive select               | AVDD             | "Hi-Z"      | ④       |
| 3       | SIN6       | AIIn     | sensor input6                                           | -                                                | AVDD             | "Hi-Z"      | ④       |
| 4       | SIN7/LED3  | AIIn/Out | sensor input 7<br>/PWM Drive LED control output 3       | sensor input ,<br>LED drive select               | AVDD             | "Hi-Z"      | ④       |
| 5       | SIN8       | AIIn     | sensor input8                                           | -                                                | AVDD             | "Hi-Z"      | ④       |
| 6       | SIN9/LED4  | AIIn/Out | sensor input 9<br>/LED control output 4                 | sensor input ,<br>LED drive select               | AVDD             | "Hi-Z"      | ④       |
| 7       | SIN10      | AIIn     | sensor input10                                          | -                                                | AVDD             | "Hi-Z"      | ④       |
| 8       | SIN11/LED5 | AIIn/Out | sensor input 11<br>/LED control output 5                | sensor input ,<br>LED drive select               | AVDD             | "Hi-Z"      | ④       |
| 9       | SIN12      | AIIn     | sensor input12                                          | -                                                | AVDD             | "Hi-Z"      | ④       |
| 10      | SIN13/LED6 | AIIn/Out | sensor input 13<br>/LED control output 6                | sensor input ,<br>LED drive select               | AVDD             | "Hi-Z"      | ④       |
| 11      | SIN14      | AIIn     | sensor input14                                          | -                                                | AVDD             | "Hi-Z"      | ④       |
| 12      | SIN15/LED7 | AIIn/Out | sensor input 15<br>/LED control output 7                | sensor input ,<br>LED drive select               | AVDD             | "Hi-Z"      | ④       |
| 13      | TSTA       | AIIn     | Test input for analog block                             | NC on the substrate is recommended.              | AVDD             | "Hi-Z"      | ④       |
| 14      | AVSS       | Ground   | Analog ground                                           | -                                                | -                | -           | -       |
| 15      | MODE[0]    | In       | Mode selection, input0                                  | 00 = 2wires serial,<br>internal clock            | DVDD             | -           | ①       |
| 16      | MODE[1]    | In       | Mode selection, input1                                  |                                                  | DVDD             | -           | ①       |
| 17      | TSTD       | In       | Digital part test input                                 | Usually must be tide to "L"                      | DVDD             | -           | ①       |
| 18      | CLK_EXT    | In       | External system clock input                             | Usually tide to "L"                              | DVDD             | -           | ①       |
| 19      | INT        | Out      | Output of interrupt                                     | "L" : Active mode<br>"H" : Idle mode ※2          | DVDD             | "L"         | ③       |
| 20      | SDA/TXD    | In/Out   | Communication data sending and receiving(2wires serial) | -                                                | DVDD             | "Hi-Z"<br>- | ⑤<br>②  |
| 21      | SCL        | In       | Communication synchronous clock input                   | -                                                | DVDD             | -           | ②       |
| 22      | RXD        | In       | system clock input (2wires serial)                      | "L" : Internal clock<br>"H" : external clock     | DVDD             | -           | ②       |
| 23      | CS         | In       | Slave address selection (2wires serial mode)            | "L" : 5Ah<br>"H" : 5Bh                           | DVDD             | -           | ②       |
| 24      | SDN        | In       | Shutdown input                                          | "L" : Halt condition<br>"H" : state of operation | DVDD             | -           | -       |
| 25      | DVSS       | Ground   | Digital part ground                                     | -                                                | -                | -           | -       |
| 26      | DVDD       | Power    | Digital part Power supply                               | -                                                | -                | -           | -       |
| 27      | AVDD       | Power    | Analog part Power supply                                | -                                                | -                | -           | ④       |
| 28      | SREF       | AIIn     | Standard capacitor input                                | -                                                | AVDD             | "Hi-Z"      | ④       |
| 29      | SIN0       | AIIn     | sensor input 0                                          | -                                                | AVDD             | "Hi-Z"      | ④       |
| 30      | SIN1/LED0  | AIIn/Out | sensor input 1<br>/PWM Drive LEDcontrol output 0        | sensor input ,<br>LED drive select               | AVDD             | "Hi-Z"      | ④       |
| 31      | SIN2       | AIIn     | sensor input 2                                          | -                                                | AVDD             | "Hi-Z"      | ④       |
| 32      | SIN3/LED1  | AIIn/Out | sensor input 3<br>/PWM Drive LEDcontrol output 1        | sensor input ,<br>LED drive select               | AVDD             | "Hi-Z"      | ④       |

\*1 Initial State When internal organs power-on reset is effective  
Halt condition SDN="L"

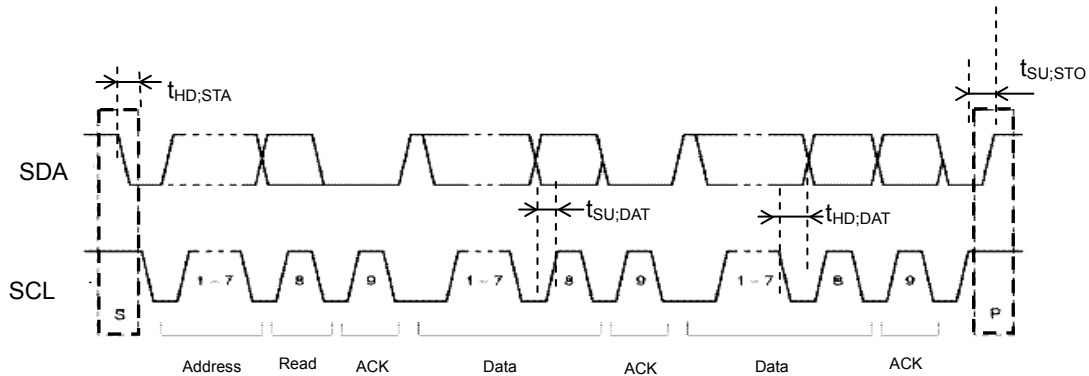
● I/O Circuit

| ①CMOS INPUT                                                                       | ②CMOS Schmitt INPUT                                                                | ③CMOS OUTPUT                                                                        |
|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|  |  |  |
| ④CMOS 3state OUTPUT with ANALOG-SW                                                | ⑤CMOS Schmitt INOUT                                                                |                                                                                     |
|  |  |                                                                                     |

### ●HOST I/F

- 2 wire serial, BUS (Pin configuration, MODE [1:0] =00b)  
Slave mode only  
Slave Address = 5Ch,5Dh selection possible.  
Normal (Normal mode. 100kHz Transfer rate)  
Fs mode (Fast mode. 400kHz Transfer rate) also.  
Not adapting sequential read / write.

### 【Data format】



| Parameter                                                                      | Standard mode |      | High Speed mode |     | Unit |
|--------------------------------------------------------------------------------|---------------|------|-----------------|-----|------|
|                                                                                | MIN           | MAX  | MIN             | MAX |      |
| fSCL : SCL Clock Freq                                                          | 0             | 100  | 0               | 400 | kHz  |
| t <sub>HD;STA</sub> : START condition hold time                                | 4.0           | -    | 0.6             | -   | μsec |
| t <sub>LOW</sub> : SCL "L"                                                     | 4.7           | -    | 1.3             | -   | μsec |
| t <sub>HIGH</sub> : SCL "H"                                                    | 4.0           | -    | 0.6             | -   | μsec |
| t <sub>HD;DAT</sub> : Data hold time                                           | 0.1           | 3.45 | 0.1             | 0.9 | μsec |
| t <sub>SU;DAT</sub> : Data setup time                                          | 0.25          | -    | 0.1             | -   | μsec |
| t <sub>SU;STO</sub> : START condition hold time                                | 4.0           | -    | 0.6             | -   | μsec |
| t <sub>BUF</sub> : Free time of bus between STOP condition and START condition | 4.7           | -    | 1.3             | -   | μsec |

### 【PROTOCOL】

- Write Protocol



- Read Protocol



- |   |                                  |
|---|----------------------------------|
| S | = START condition                |
| P | = STOP condition                 |
| R | = data direction READ (SDA HIGH) |
| W | = data direction WRITE (SDA LOW) |
| A | = acknowledge (SDA LOW)          |
| N | = not acknowledge (SDA HIGH)     |

## ●Register map

| Address  | Register name | R/W | Length          | Explanation                                                                               |
|----------|---------------|-----|-----------------|-------------------------------------------------------------------------------------------|
| 1*h      | SENS_DATA     | R   | 1byte / channel | Sensor output data. One for each channel.                                                 |
| 30h      | POSX          | R   | 1byte           | X positional value axially.                                                               |
| 31h      | POSY          | R   | 1byte           | Y positional value axially.                                                               |
| 32h, 33h | BTN           | R   | 2byte           | Button On/Off.                                                                            |
| 4*h      | OFFSET        | R   | 1byte / channel | Offset correction data. One for each channel.                                             |
| ECh      | POS_MODE      | W   | 1byte           | XY matrix setting.                                                                        |
| EDh      | RESET         | W   | 1byte           | Soft reset execution.                                                                     |
| EEh      | CALIB         | W   | 1byte           | Soft calibration execution.                                                               |
| EFh      | DONE          | W   | 1byte           | Setting done command.                                                                     |
| F0h, F1h | SENS_CH       | W   | 2byte           | Sensor channel enables.                                                                   |
| F2h      | LED_CH        | W   | 1byte           | LED channel enables.                                                                      |
| F3h, F4h | IDLE_CH       | W   | 2byte           | Idle mode release control.                                                                |
| F5h      | LED_LINK      | W   | 1byte           | LED linkage to sensor input.                                                              |
| F6h      | TIMES         | W   | 1byte           | Defines the sampling interval and number of samples required to recognize a button press. |
| F7h      | TH_ON2        | W   | 1byte           | A second threshold value in the detection of a button going from OFF state to ON state.   |
| F8h, F9h | TH_ON2_CH     | W   | 2byte           | Per channel selection of whether to use TH_ON or TH_ON2.                                  |
| FAh      | CMD           | W   | 1byte           | Simultaneous press and idle mode entry.                                                   |
| FBh      | GAIN_FILTER   | W   | 1byte           | Gain setting, filter function.                                                            |
| FCh      | TH_ON         | W   | 1byte           | A threshold value in the detection of a button going from OFF state to ON state.          |
| FDh      | TH_OFF        | W   | 1byte           | A threshold value in the detection of a button going from ON state to OFF state.          |
| FEh      | DLED          | W   | 1byte           | Register to allow simple writing to LEDs.                                                 |

**【1\*h : Sensor Output Data】**

Name: SENS\_DATA

Address: 1\* h (one byte per sensor channel)

Description: The sensor output that converts to 10bit. Scaling, offsets and filtering (when enabled) are applied.  
The most significant 8 bits are presented to the software with this register.

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

**【30h : X positional value axially】**

Name: POSX

Address: 30h

Description: This represents the X-position of the press. The value is calculated differently depending on the matrix arrangement. For example when:

- When POS\_MODE[0]=0 : Value interprets SIN[0:7]
- When POS\_MODE[0]=1 : Value interprets SIN[10:5]

|     | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|-----|------|------|------|------|------|------|------|------|
| 30h | 0    | 0    | D5   | D4   | D3   | D2   | D1   | D0   |
| R/W | R    | R    | R    | R    | R    | R    | R    | R    |

**【31h : Y positional value axially】**

Name: POSY

Address: 31h

Description: This represents the Y-position of the press. The value is calculated differently depending on the matrix arrangement. For example when:

- When POS\_MODE[0]=0 : Value interprets SIN[8:15]
- When POS\_MODE[0]=1 : Value interprets SIN[11:4:12:3:13:2:14:1:15:0]

|     | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|-----|------|------|------|------|------|------|------|------|
| 31h | 0    | D6   | D5   | D4   | D3   | D2   | D1   | D0   |
| R/W | R    | R    | R    | R    | R    | R    | R    | R    |

**【32h / 33h : Button ON/OFF】**

Name: BTN

Address: 32h, 33h

Description: This is the state of the sensor when considered as an ON/OFF button. Here 1 : On. 0 : Off.

|              | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|--------------|------|------|------|------|------|------|------|------|
| 32h          | CH7  | CH6  | CH5  | CH4  | CH3  | CH2  | CH1  | CH0  |
| 33h          | CH15 | CH14 | CH13 | CH12 | CH11 | CH10 | CH9  | CH8  |
| R/W          | R    | R    | R    | R    | R    | R    | R    | R    |
| Initial val. | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    |

**【4\* h : Offset Correction Data】**

Name: OFFSET

Address: 4\* h (one byte per sensor channel)

Description: This is the offset required to correct the sense data to half scale during the calibration procedure.

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

**【ECh : XY matrix setting】**

Name: POS\_MODE

Address: ECh

Description: Setting when two or more sensor are displayed to the first origin and position is detected.

XY : This selects between two matrix configurations.

1 = X axis → SIN [10 : 5] , Y axis → SIN [11:4:12:3:13:2:14:1:15:0]

0 = X axis → SIN [0 : 7] , Y axis → SIN [8:15]

POS\_EN : The position tracking enable

Enables the condition under which the position tracking is made effective.

1=When either of sensor exceeds the threshold, the data of the position tracking is made effective.

If all registers do not exceed the threshold, the data of the position tracking is (POSX, POSY) = (0,0).

0=the position is detected regardless of the level of the sensor data, and data is made effective.

Initial state: When either of sensor exceeds the threshold, the positional detection data is made effective (=1).

|              | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1   | Bit0 |
|--------------|------|------|------|------|------|------|--------|------|
| ECh          | -    | -    | -    | -    | -    | -    | POS_EN | XY   |
| R/W          | -    | -    | -    | -    | -    | -    | W      | W    |
| Initial val. | -    | -    | -    | -    | -    | -    | 1      | 1    |

**【EEh : Soft Calibration】**

Name: CALIB

Address: EEh

Description: This forces a chip re-calibration when a 1 is written and returns to 0 afterward automatically. Please note that one should always re-calibrate after changing the gain adjustment value.

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

**【EFh : Setting Done, Detect Start】**

Name: DONE

Address: EFh

Description: This register should be written to following register updates.

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

**【F0h / F1h : Sensor Channel Setting】**

Name: SENS\_CH

Address: F0h / F1h

Description: Individual enabling and disabling of sensor channels. 1 : Effective 0 : Not in use

|              | Bit7  | Bit6  | Bit5  | Bit4  | Bit3  | Bit2  | Bit1 | Bit0 |
|--------------|-------|-------|-------|-------|-------|-------|------|------|
| F0h          | SIN7  | SIN6  | SIN5  | SIN4  | SIN3  | SIN2  | SIN1 | SIN0 |
| F1h          | SIN15 | SIN14 | SIN13 | SIN12 | SIN11 | SIN10 | SIN9 | SIN8 |
| R/W          | W     | W     | W     | W     | W     | W     | W    | W    |
| Initial val. | 0     | 0     | 0     | 0     | 0     | 0     | 0    | 0    |

**【F2h : LED Channel Setting】**

Name: LED\_CH

Address: F2h

Description: Enables and disables the channels to be used as LED outputs. Valid for the 8 LED outputs.

1 : Effective 0 : Not in use

|              | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|--------------|------|------|------|------|------|------|------|------|
| F2h          | LED7 | LED6 | LED5 | LED4 | LED3 | LED2 | LED1 | LED0 |
| R/W          | W    | W    | W    | W    | W    | W    | W    | W    |
| Initial val. | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    |

**【F3h / F4h : Idle Exit Condition】**

Name: IDLE\_CH

Address: F3h / F4h

Description: Defines which channels cause the device to wake up – i.e.  
go from idle mode to normal operation on a key press. Selection is made on a per channel basis.  
1 : Effective 0 : Not used

|              | Bit7  | Bit6  | Bit5  | Bit4  | Bit3  | Bit2  | Bit1 | Bit0 |
|--------------|-------|-------|-------|-------|-------|-------|------|------|
| F3h          | SIN7  | SIN6  | SIN5  | SIN4  | SIN3  | SIN2  | SIN1 | SIN0 |
| F4h          | SIN15 | SIN14 | SIN13 | SIN12 | SIN11 | SIN10 | SIN9 | SIN8 |
| R/W          | W     | W     | W     | W     | W     | W     | W    | W    |
| Initial val. | 1     | 1     | 1     | 1     | 1     | 1     | 1    | 1    |

**【F5h : LED to Sensor Linkage】**

Name: LED\_LINK

Address: F5h

Description: Allows the LED outputs to be automatically linked to the input channels without need for any software control.  
1 : It synchronizes with the button. 0 : It synchronizes with data (The register name: DLED) from host.

|              | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|--------------|------|------|------|------|------|------|------|------|
| F5h          | LED7 | LED6 | LED5 | LED4 | LED3 | LED2 | LED1 | LED0 |
| R/W          | W    | W    | W    | W    | W    | W    | W    | W    |
| Initial val. | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    |

**【F6h : Sampling Interval】**

Name: TIMES

Address: F6h

Description: Defines the sampling interval.

**SAMP[1:0] : Sampling Interval :**

Given by the following equation :

Sampling interval = system clock x  $2^{13}$  x SAMP (Example: system clock 1[MHz] time : About 8.2[msec]).

|              | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1    | Bit0    |
|--------------|------|------|------|------|------|------|---------|---------|
| F6h          | -    | -    | -    | -    | -    | -    | SAMP[1] | SAMP[0] |
| R/W          | -    | -    | -    | -    | -    | -    | W       | W       |
| Initial val. | -    | -    | -    | -    | -    | -    | 0       | 0       |

**【F7h : Button OFF→ON Threshold】**

Name: TH\_ON2

Address: F7h

Description: A second threshold value for determining a button off→on judgment of sensor.  
The sensor output value of 8bit (register SENS\_DATA) is compared with 128+ ON2 [6:0],  
and if it is larger, the button is determined active.

|              | Bit7 | Bit6   | Bit5   | Bit4   | Bit3   | Bit2   | Bit1   | Bit0   |
|--------------|------|--------|--------|--------|--------|--------|--------|--------|
| F7h          | -    | ON2[6] | ON2[5] | ON2[4] | ON2[3] | ON2[2] | ON2[1] | ON2[0] |
| R/W          | -    | W      | W      | W      | W      | W      | W      | W      |
| Initial val. | -    | 0      | 0      | 1      | 0      | 0      | 0      | 0      |

**【F8h / F9h : Button OFF→ON Threshold Selection】**

Name: TH\_ON2\_CH

Address: F8h / F9h

Description: This register is used to relate either threshold TH\_ON or TH\_ON2 to particular sensor channels  
for button press activity determination.  
1 : TH\_ON2 is applied 0 : TH\_ON is applied

|              | Bit7  | Bit6  | Bit5  | Bit4  | Bit3  | Bit2  | Bit1 | Bit0 |
|--------------|-------|-------|-------|-------|-------|-------|------|------|
| F8h          | SIN7  | SIN6  | SIN5  | SIN4  | SIN3  | SIN2  | SIN1 | SIN0 |
| F9h          | SIN15 | SIN14 | SIN13 | SIN12 | SIN11 | SIN10 | SIN9 | SIN8 |
| R/W          | W     | W     | W     | W     | W     | W     | W    | W    |
| Initial val. | 0     | 0     | 0     | 0     | 0     | 0     | 0    | 0    |

**【FAh : Simultaneous Press and Idle Mode Entry】**

Name: CMD

Address: FAh

Description:

**INTERMIT\_EN : Intermittent and the drive are enable. :**

Whether intermittent is driven at the idol mode is selected.

1 : Intermittent is driven. 0 : Intermittent is not driven. Initial state : Intermittent is driven.

**IDLE\_T[3:0] : non-detect time-out setting :**

This sets the time the chip takes to go from normal mode to idle mode in a period key inactivity.

Duration = system clock x  $2^{19}$  x IDLE\_T (Example of system clock 1[MHz]time : About 520[msec])

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

**【FBh : Gain Setting, Filter Function】**

Name: GAIN\_FILTER

Address: FBh

Description: Gain adjustment and setting of noise filter function.

**GAIN[2:0] : gain setting :**

It uses it for the gain adjustment in eight stages. Initial adjustment value : x1

| GAIN[2:0]        | 000 | 001    | 010   | 011    | 100  | 101  | 110  | 111  |
|------------------|-----|--------|-------|--------|------|------|------|------|
| Adjustment value | x 1 | x 4.22 | x 8.4 | x 16.5 | x 23 | x 46 | x 69 | x 92 |

**FILTER\_EN : Filter enable :**

Enables/disables setting of noise filter function

1 : enabled 0 : disabled Initial state : disabled

**DELTA[3:0] : Filter follow count setting :**

The follow count to which the noise filter function is effective is set.

|              | Bit7    | Bit6    | Bit5    | Bit4      | Bit3     | Bit2     | Bit1     | Bit0     |
|--------------|---------|---------|---------|-----------|----------|----------|----------|----------|
| FBh          | GAIN[2] | GAIN[1] | GAIN[0] | FILTER_EN | DELTA[3] | DELTA[2] | DELTA[1] | DELTA[0] |
| R/W          | W       | W       | W       | W         | W        | W        | W        | W        |
| Initial val. | 0       | 0       | 0       | 0         | 0        | 0        | 1        | 0        |

**【FCh : Switch OFF -> ON Threshold】**

Name: TH\_ON

Address: FCh

Description: This register provides a threshold value for determining if a sensor has transitioned from OFF to ON.  
 This is relative value from reference value (128d). So the absolute value of threshold is 128d + ON[6:0].  
 It makes a threshold value between TH\_ON and TH\_OFF.  
 TH\_ON must be bigger than TH\_OFF (TH\_ON >= TH\_OFF)  
 Maximum threshold is 256d and minimum value is 128d.

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

**【FDh : Switch ON -> OFF Threshold Value】**

Name: TH\_OFF

Address: FDh

Description: This register provides a threshold value for transitioning from ON to OFF.  
 This is relative value from reference value (128d). So absolute value of threshold is 128d + OFF[6:0].  
 It makes a threshold value between TH\_ON and TH\_OFF.  
 TH\_OFF must be smaller than TH\_ON (TH\_OFF ≤ TH\_ON)  
 Maximum value is 256d and minimum value is 128d.

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

**【FEh : LED Port Data】**

Name: DLED

Address: FEh

Description: When LED is not linked with the sensor, it becomes a simple digital output that controls the LED.  
 1 : Light. 0 : Turned off.

|              | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|--------------|------|------|------|------|------|------|------|------|
| FEh          | D7   | D6   | D5   | D4   | D3   | D2   | D1   | D0   |
| R/W          | W    | W    | W    | W    | W    | W    | W    | W    |
| Initial val. | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    |

**● Operation mode**

This IC has a normal mode, idle mode and a shutdown mode as states of operation.

**【Normal mode】**

This is the normal operation of the device. Output pin INT="L".

**【Idle mode】**

This is the mode when the normal mode times out due to inactivity on the keys. In this mode the control interface is still alive.

\*Usually time-out is aimed at about 200msec or less.

\*Transition between normal and idle modes is automatic and without software control.

**【Shutdown mode】**

In this mode the device is completely stopped – and reset. This is achieved by making the terminal SDN L. All analog circuits and the logic circuits are stopped. The return from the shutdown mode returns by making the terminal SDN H.

\*After shut-down all registers have their default values.

**● Interface and system clock selection**

I/F selection with MODE [1:0] pin. System clock selection by RXD.

**【Using 2wires serial bus mode (MODE [1:0] =00b)】**

The 2wires serial bus is used for host I/F.

RXD=0 in the system clock: Built-in oscillator is used.

RXD=1 in the system clock: The clock input from CLK\_EXT is used.

**● Initialization procedure**

A normal power on sequence is:

- (1) Power on
  - (2) Setup the registers
  - (3) Write '1' to 0xEF (done register)
- <sensing operation begins after auto-calibration occurs>

**● Power supply turning on procedure**

You should always power on DVDD at the same time as AVDD or before AVDD.

- Ordering part number

|   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
| B | U | 2 | 1 | 0 | 0 | 9 |
|---|---|---|---|---|---|---|

Part No

Part No

|   |   |   |
|---|---|---|
| M | U | V |
|---|---|---|

## Package

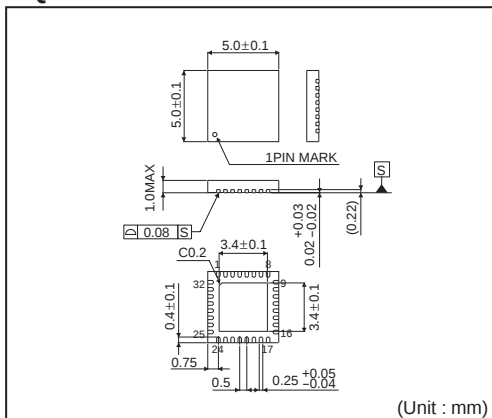
MUV : VQFN032V5050

|   |   |
|---|---|
| E | 2 |
|---|---|

### Packaging and forming specification

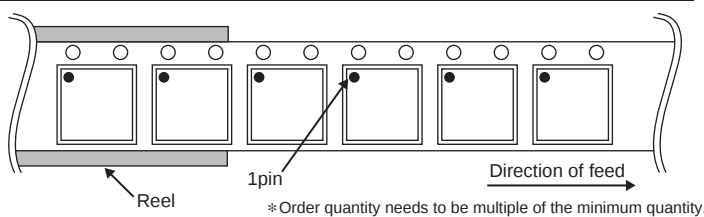
E2 : Embossed tape and reel

**VQFN032V5050**



<Tape and Reel information>

|                   |                                                                                                                                                  |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| Tape              | Embossed carrier tape                                                                                                                            |
| Quantity          | 2500pcs                                                                                                                                          |
| Direction of feed | E2<br>(The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand |



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