Capacitive Sensor Control IC Series

Capacitive Sensor Switch Control IC

BU21008MUV

No.09048EBT04

●Description

BU21008MUV are the capacitive sensor controller with 16 channels respectively. Half of sensor ports are available to use to LED driver with PWM function. PWM function can control light ambient. Also gesture function can recognize the short touch, long touch and finger motion.

●Features

1) Gesture function
2) LED driver with PWM 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 such as a Mobile phone, Portable equipment, and Audiovisual apparatuses.

●Absolute Maximum Ratings (Ta=25℃)

PARAMETER	SYMBOL	RATING		UNIT
		MIN	MAX	
APPLIED VOLTAGE	AVDD	-0.3	4.5	V
	DVDD	-0.3	4.5	
INPUT VOLTAGE	V_{AIN}	-0.3	AVDD+0.3	V
	V_{DIN}	-0.3	DVDD+0.3	
STORAGE TEMPERATURE RANGE	T_{stg}	-55	125	℃
POWER DISSIPATION	P_d	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
OPERATINGTEMPERATURE RANGE	T_{opr}	-40	25	85	℃

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

PARAMETER	SYMBOL	RATING			UNIT	Condition	
		MIN	TYP	MAX			
H INPUT VOLTAGE	V_{IHIO}	DVDDx0.8	-	DVDD+0.3	V		
L INPUT VOLTAGE	V_{ILIO}	DVSS-0.3	-	DVDDx0.2	V		
Output "H" voltage	V_{OHIO}	DVDD-0.7	-	DVDD	V	I_{OH}=-2[mA]. Overshoot is excluded.	
Output "L" voltage	V_{OLLED}	AVSS	-	0.5	V	I_{OL}=8[mA]. Undershoot is excluded. LED output.	
	V_{OLTXD}	DVSS	-	0.5		I_{OL}=3[mA]. Undershoot is excluded. SDA/TXD application.	DVDD > 2[V]
				DVDDx0.3			DVDD ≦ 2[V]
	V_{OLINT}	DVSS	-	0.5		I_{OL}=2[mA]. Undershoot is excluded. INT application.	
Input leakage current	I_{IZ}	-1	-	1	μA		
Off leakage current	I_{OZ}	-1	-	1	μA		
Standby current	I_{ST}	-	-	2	μA	Shutdown (SDN＝”L”)	
Current of operation	I_{DD}	-	300	-	μA		

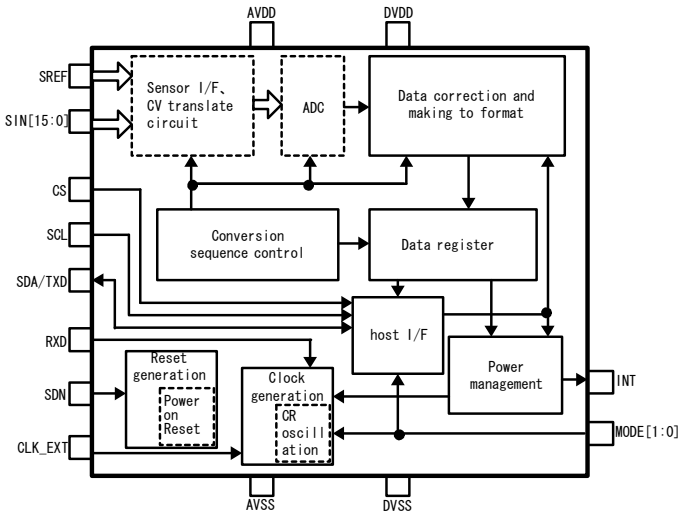
●A/D Converter

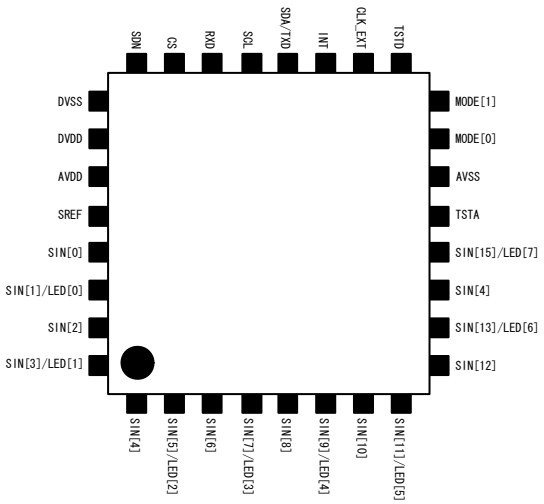
PARAMETER	SYMBOL	RATING			UNIT	Condition
		MIN	TYP	MAX		
Resolution		-	10	-	bit	
Analog Input voltage	V_{AIN}	AVSS	-	AVDD	V	
change clock frequency	f_{adck}	0.2	-	2.0	MHz	
change time	f_{tim}	-	77	-	μsec	f_{adck} = 1[MHz]
Zero scale voltage		-	-	AVSS+0.07	V	
full scale voltage		AVDD-0.07	-	-	V	
differential 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_{cr}	0.4	0.8	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.

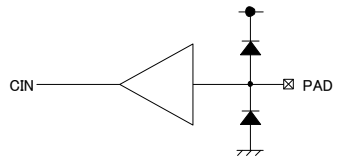
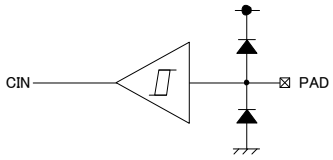
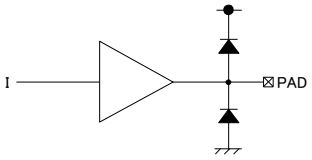
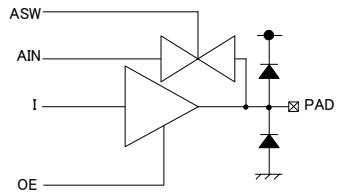
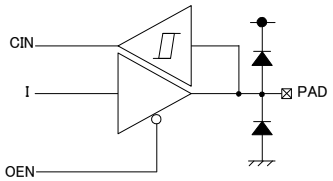
・Clock generation
The device has an internal oscillator.
Provision is also made if the application would like to make use of an external clock input.

●Pin Description

Pin No.	Name	I/O	Function	Note	Supply Reference	Reset Level	I/O Pad
1	SIN4	AIn	sensor input4	-	AVDD	"Hi-Z"	④
2	SIN5/LED2	AIn/Out	sensor input 5 /PW Drive LEDcontrol output 2	sensor input , LED drive select	AVDD	"Hi-Z"	④
3	SIN6	AIn	sensor input6	-	AVDD	"Hi-Z"	④
4	SIN7/LED3	AIn/Out	sensor input 7 /PWM Drive LED control output 3	sensor input , LED drive select	AVDD	"Hi-Z"	④
5	SIN8	AIn	sensor input8	-	AVDD	"Hi-Z"	④
6	SIN9/LED4	AIn/Out	sensor input 9 /LED control output 4	sensor input , LED drive select	AVDD	"Hi-Z"	④
7	SIN10	AIn	sensor input10	-	AVDD	"Hi-Z"	④
8	SIN11/LED5	AIn/Out	sensor input 11 /LED control output 5	sensor input , LED drive select	AVDD	"Hi-Z"	④
9	SIN12	AIn	sensor input12	-	AVDD	"Hi-Z"	④
10	SIN13/LED6	AIn/Out	sensor input 13 /LED control output 6	sensor input , LED drive select	AVDD	"Hi-Z"	④
11	SIN14	AIn	sensor input14	-	AVDD	"Hi-Z"	④
12	SIN15/LED7	AIn/Out	sensor input 15 /LED control output 7	sensor input , LED drive select	AVDD	"Hi-Z"	④
13	TSTA	AIn	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, 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 "H" : Idle mode ※2	DVDD	"L"	③
20	SDA/TXD	In/Out	Communication data sending and receiving(2wires serial)	-	DVDD	"Hi-Z" -	⑤ ②
21	SCL	In	Communication synchronous clock input	-	DVDD	-	②
22	RXD	In	system clock input (2wires serial)	"L" : Internal clock "H" : external clock	DVDD	-	②
23	CS	In	Slave address selection (2wires serial mode)	"L" : 5Ah "H" : 5Bh	DVDD	-	②
24	SDN	In	Shutdown input	"L" : Halt condition "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	AIn	Standard capacitor input	-	AVDD	"Hi-Z"	④
29	SIN0	AIn	sensor input 0	-	AVDD	"Hi-Z"	④
30	SIN1/LED0	AIn/Out	sensor input 1 /PWM Drive LEDcontrol output 0	sensor input , LED drive select	AVDD	"Hi-Z"	④
31	SIN2	AIn	sensor input 2		AVDD	"Hi-Z"	④
32	SIN3/LED1	AIn/Out	sensor input 3 /PWM Drive LEDcontrol output 1	sensor input , LED drive select	AVDD	"Hi-Z"	④

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

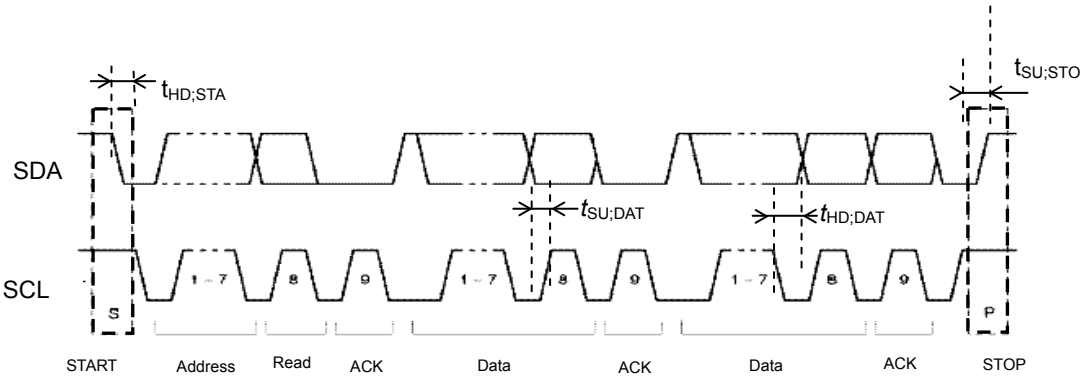
●I/O Circuit

①CMOS INPUT	②CMOS Schmitt INPUT	③CMOS OUTPUT
		
④CMOS 3stute 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 = 5Ah,5Bh 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
$t_{HD;STA}$: START condition hold time	4.0	-	0.6	-	µsec
t_{LOW} : SCL “L”	4.7	-	1.3	-	µsec
t_{HIGH} : SCL “H”	4.0	-	0.6	-	µsec
$t_{HD;DAT}$: Data hold time	0.1	3.45	0.1	0.9	µsec
$t_{SU;DAT}$: Data setup time	0.25	-	0.1	-	µsec
$t_{SU;STO}$: START condition hold time	4.0	-	0.6	-	µsec
t_{BUF} : Free time of bus between STOP condition and START condition	4.7	-	1.3	-	µsec

【PROTOCOL】

・Write Protocol

S	SLAVE ADDRESS	W	A	REGISTER ADDRESS	A	WRITE DATA	A	P
	7bit = 5Ah or 5Bh			8bit		8bit		

・Read Protocol

S	SLAVE ADDRESS	W	A	REGISTER ADDRESS	A	S	SLAVE ADDRESS	R	A	READ DATA	N	P
	7bit = 5Ah or 5Bh			8bit			7bit = 5Ah or 5Bh			8bit		

	from Master to Slave
	from Slave to Master

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.
32h, 33h	BTN	R	2byte	Button On/Off.
35h	BTN_STATE	R	1byte	Button state data.
4*h	OFFSET	R	1byte / channel	Offset correction data. One for each channel.
60h, 61h	GES_VEL	R	2byte	Gesture duration.
62h	GES_DIR	R	1byte	Gesture direction.
E0h	FEAD_CTL	W	1byte	PWM control setting.
E1h	FEAD_CLK	W	1byte	PWM clock setting.
E2h	GES_CLR	W	1byte	Gesture clear control.
E3h	GES_CTL	W	1byte	Gesture control.
E4h	GES_CLK	W	1byte	Gesture clock setting.
E5h	GES_TIMEOUT	W	1byte	Gesture time-out data setting.
E6h	GES_TEST	W	1byte	Gesture test function.
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

【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

【35h : Button State Data】

Name: BTN_STATE
Address: 35h
Description: This provides information about the press.

CH[3:0] : Effective channel :
This indicates which button is dominant.

SIMUL : Button effective :
This indicates that the effective channel corresponds to a valid button press according to the thresholds. 1 : On. 0 : Off.

CONTINU : A push and hold is effective :
Indicates that the button was pressed and held for more than push/hold judgment time. 1 : On. 0 : Off.

	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
35h	CONTINU	-	-	SIMUL	CH[3]	CH[2]	CH[1]	CH[0]
R/W	R	-	-	R	R	R	R	R
Initial val.	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

【60h / 61h : Gesture Duration】

Name: GES_VEL
Address: 60h, 61h
Description: Indicates the duration of the gesture in number of internal clocks. The count is a clock set with 0xE4(GES_CLK). It is possible to count up to 0～4095 clocks.
Gesture duration＝(gesture sampling interval) * VEL [sec]

	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
60h	VEL[7]	VEL[6]	VEL[5]	VEL[4]	VEL[3]	VEL[2]	VEL[1]	VEL[0]
61h	-	-	-	-	VEL[11]	VEL[10]	VEL[9]	VEL[8]
R/W	R	R	R	R	R	R	R	R
Initial val.	0	0	0	0	0	0	0	0

【62h : Gesture Direction Judgment】

Name: GES_DIR
Address: 62h
Description: Gesture direction judgment

DIR_A : gesture direction A
0xE3(GES_CTL) reference
DIR_B : gesture direction B
0xE3(GES_CTL) reference

	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
62h	-	-	-	-	-	-	DIR_B	DIR_A
R/W	-	-	-	-	-	-	R	R
Initial val.	-	-	-	-	-	-	0	0

【E0h : PWM Control Setting】

Name: FEAD_CTRL
Address: E0h
Description: The following LEDs can be output as PWM-LED0, LED1, LED2, and LED3.

EN : enable
When the LED port is used as PWM, 1 is written. LED0 = EN[0], LED 1= EN[1], LED2 = EN[2], LED3 = EN[3].

MODE : mode
The mode of PWM is selected from four kinds.

mode	MODE		Fade in	Fade out
1	0	0	None	Fig 1
2	0	1	Fig 2	Fig 1
3	1	0	None	Fig 3
4	1	1	Fig 4	Fig 3

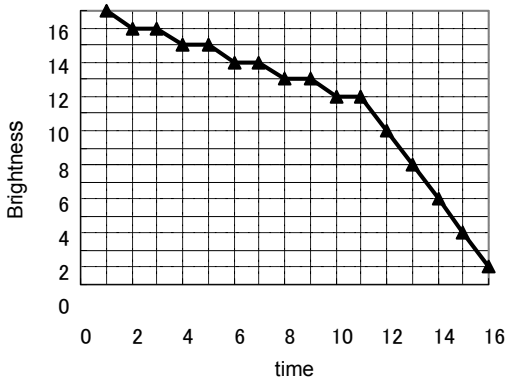


Fig 1.

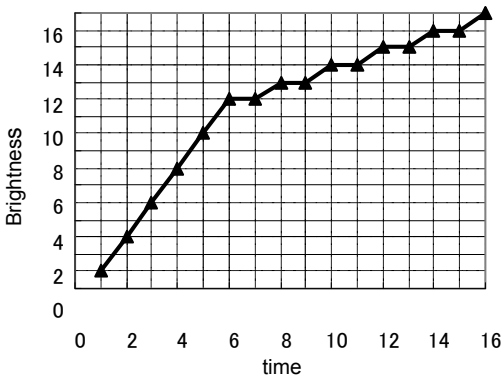


Fig 2.

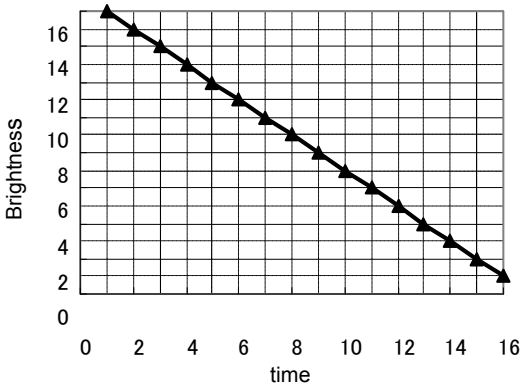


Fig 3.

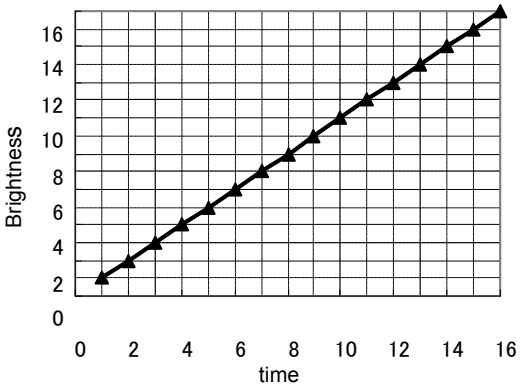


Fig 4.

	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
E0h	-	-	MODE[1]	MODE[0]	EN[3]	EN[2]	EN[1]	EN[0]
R/W	-	-	W	W	W	W	W	W
Initial val.	-	-	0	0	1	1	1	1

【E1h : PWM Clock Setting】

Name: FEAD_CLK
Address: E1h
Description: This register defines the divide ratio of the clock used for PWM.
This also relates to the fade-in and fade-out time according to the following relationship.

Fead in/out =1 / ((Internal oscillation frequency) / (2 * 16 * 16 * 16 * (F_DIV+1) * 16)) [sec]
For example with an internal clock of 1.1MHz possible range is 0.119～1.906 [sec]

	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
E1h	-	-	-	-	F_DIV[3]	F_DIV[2]	F_DIV[1]	F_DIV[0]
R/W	-	-	-	-	W	W	W	W
Initial val.	-	-	-	-	0	1	1	1

【E2h : Gesture Clear】

Name: GES_CLR
Address: E2h
Description: This register when written to clears GES_VEL and GES_DIR.
It is cleared by one, and it returns to 0 by the automatic operation.

	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
E2h	CLR	-	-	-	-	-	-	-
R/W	W	-	-	-	-	-	-	-
Initial val.	0	-	-	-	-	-	-	-

【E3h : Gesture Function Setting】

Name: GES_CTL
Address: E3h
Description: This register controls what key-press sequence is recognized as a gesture.
Only 4 channels may be used-SIN0, SIN2, SIN4, and SIN6.

EN : enable

These are the enable bits. One is provided for each of the 4 sense inputs used for gesture. EN[0] is for SN0, EN[1] is for SN2, EN[2] is for SN4 and EN[3] is for SN6. 1 is to enable and 0 is for disable.

MODE : mode

0 : Requires all sensors to be present in the sequence before the gesture is recognized.(All detection mode)
1 : Allows one or more of the keys to be missed in the sequence.(Verbose mode)

The condition and the direction of detection that can be detected in each mode are as follows.

mode	MODE	Direction(GES_DIR)	Detected
All detection	0	DIR_A	1)SIN0→SIN2→SIN4→SIN6
		DIR_B	1)SIN6→SIN4→SIN2→SIN0
Verbose	1	DIR_A	1)SIN0→SIN2→SIN4 2)SIN0→SIN2→ SIN6 3) SIN2→SIN4→SIN6 4)SIN0→ SIN4 5) SIN2→ SIN6
		DIR_B	1)SIN6→SIN4→SIN2 2)SIN6→SIN4→ SIN0 3) SIN4→SIN2→SIN0 4)SIN6→ SIN2 5) SIN4→ SIN0

	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
E3h	-	-	-	MODE	EN[3]	EN[2]	EN[1]	EN[0]
R/W	-	-	-	W	W	W	W	W
Initial val.	-	-	-	1	1	1	1	1

【E4h : Gesture Clock Setting】

Name: GES_CLK
Address: E4h
Description: This register allows setting of the time base for the gesture detection. It sets a divide ratio of the clock used. The maximum judgment time and the sampling interval of the gesture can be set by changing this clock.

Gesture sampling interval =
1 / ((Internal oscillation frequency) / (2 * 16 * 16) * 1 [sec] … G_DIV = 0
1 / ((Internal oscillation frequency) / (2 * 16 * 16) * 2 [sec] … G_DIV = 1
1 / ((Internal oscillation frequency) / (2 * 16 * 16) * 4 [sec] … G_DIV = 2
1 / ((Internal oscillation frequency) / (2 * 16 * 16) * 8 [sec] … G_DIV = 3

Gesture maximum judgment time＝(Gesture sampling interval) * TO * 16 [sec]
For example with an internal clock of 1.1MHz

G_DIV	Gesture sampling interval[msec]	Gesture maximum judgment time[sec]
0	0.46	1.90
1	0.93	3.81
2	1.86	7.62
3	3.72	15.2

	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
E4h	-	-	-	-	-	-	G_DIV[1]	G_DIV[0]
R/W	-	-	-	-	-	-	W	W
Initial val.	-	-	-	-	-	-	1	0

【E5h : Gesture Timeout Data Setting】

Name: GES_TIMEOUT
Address: E5h
Description: The maximum judgment time of the gesture is set.
A key sequence which exceeds this time is not recognized.

Gesture Maximum Judgment Time＝(Gesture sampling interval) * TO * 16 [sec]

	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
E5h	TO[7]	TO[6]	TO[5]	TO[4]	TO[3]	TO[2]	TO[1]	TO[0]
R/W	W	W	W	W	W	W	W	W
Initial val.	1	1	1	1	1	1	1	1

【E6h : Gesture Test Setting】

Name: GES_TIMEOUT
Address: E6h
Description: When this test bit is enabled (1) then the lower 4 bits of 0xFE(DLED) are used for the gesture recognition instead of the sensor inputs.

	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
E6h	-	-	-	-	-	-	-	TEST
R/W	-	-	-	-	-	-	-	W
Initial val.	-	-	-	-	-	-	-	0

【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 and Number of Samples Used for Button Press】

Name: TIMES
Address: F6h
Description: Defines the sampling interval and number of samples required to recognise as a button press.

CONT_T[3:0] : Push and hold judgment time :
Governs how long it is before the chip decides it is push and hold. Given by the following equation:
Push-Hold Time = system clockx2^{19}xCONT_T (Example: system clock 1[MHz] time : About 520[msec]).
SAMP[3:0] : Sampling Interval :
Given by the following equation:
Sampling interval = system clockx2^{13}xSAMP (Example: system clock 1[MHz] time : About 8.2[msec]).

	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
F6h	CONT_T[3]	CONT_T[2]	CONT_T[1]	CONT_T[0]	SAMP[3]	SAMP[2]	SAMP[1]	SAMP[0]
R/W	W	W	W	W	W	W	W	W
Initial val.	0	0	0	0	0	0	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:

SIMUL_SEL : Simultaneous push judgment element choice :
In the case of simultaneous key press a decision must be made to select the dominant channel. The chip allows for two alternative methods. Either it can be based on whichever key press was first, or the priority can be based on the highest signal level.
1 : A level of a sensor gives priority 0 : Give priority to the channel pushed earliest
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 clockx2^{19}xIDLE_T (Example of system clock 1[MHz]time : About 520[msec])

	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
FAh	SIMUL_SEL	-	-	INTERMIT_EN	IDLE_T[3]	IDLE_T[2]	IDLE_T[1]	IDLE_T[0]
R/W	W	-	-	W	W	W	W	W
Initial val.	0	-	-	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	8	M	U	V	-	E	2

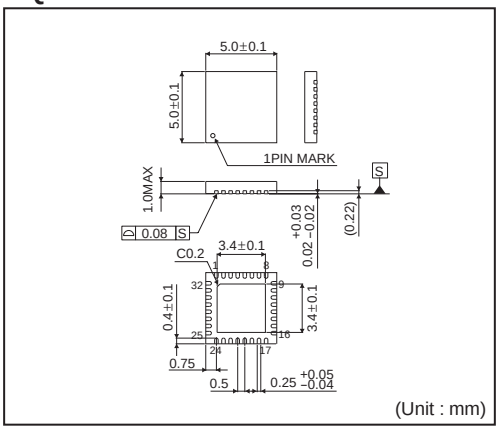
Part No

Part No

Package
MUV : VQFN032V5050

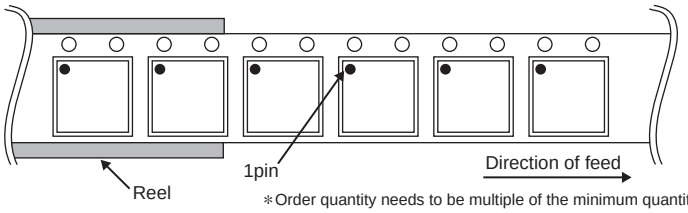
Packaging and forming specification
E2 : Embossed tape and reel

VQFN032V5050



<Tape and Reel information>

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 (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)



∗Order quantity needs to be multiple of the minimum quantity.

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