



**VCSEL Proximity Sensing Digital Sensor**

**BM32S212x-1**

Revision: V1.10 Date: November 21, 2024

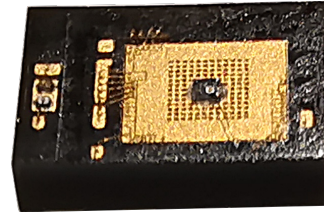
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## Features

- Short distance detection application
- Operating voltage: 2.0V~5.0V
- Integrated modules: VCSEL, Photodiode (PD) and signal conditioning MCU
- Low power consumption
- Operating distance range:
  - ♦ BM32S2122-1:  $\leq 10\text{cm}$
  - ♦ BM32S2123-1:  $\leq 30\text{cm}$
- Factory-calibrated
- Detection distance learning function
- Output type: I<sup>2</sup>C & IRQ
- Package type: Surface-mount OLGA-8
- Dimensions: 4.0×3.0×0.9mm



## General Description

The devices are infrared proximity sensing modules, which are designed for object detection applications. When an object enters the detection range, the reflected energy of the infrared will change. Proximity is determined by detecting changes in reflection. The modules have small sizes, support detection of objects at a distance of up to 30cm and have the low operation current consumption of 10 $\mu$ A at 3.3V, allowing the module to meet the requirements of a large number of product applications with varying power designs.

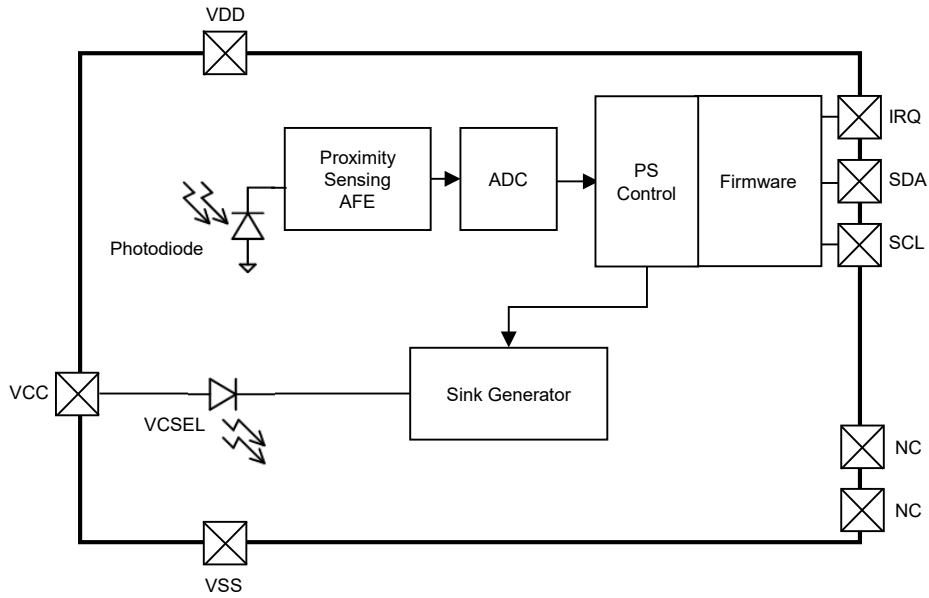
## Applications

- Wearable
- Consumer electronics
- Sanitary ware
- Urinal

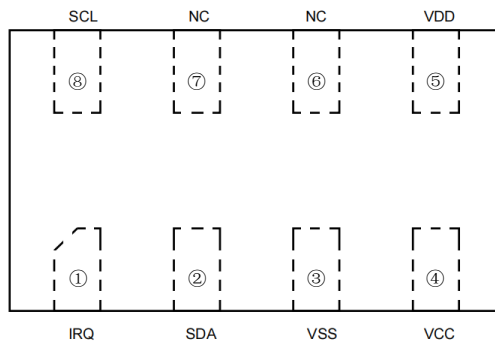
## Selection Table

Part No.	Description
BM32S2122-1	Detection distance $\leq 10\text{cm}$
BM32S2123-1	Detection distance $\leq 30\text{cm}$

### Block Diagram



### Pin Assignment



### Pin Description

Pin	Function	Type	Description
1	IRQ	DO	Output a low level when proximity triggering
2	SDA	DI/DO	I <sup>2</sup> C data line
3	VSS	P	Ground
4	VCC	P	VCSEL power
5	VDD	P	Sensor power
6, 7	NC	—	No-connect
8	SCL	DI/DO	I <sup>2</sup> C clock line

Legend: DI/DO=Digital input/output; P=Power

## Technical Specifications

### Absolute Maximum Ratings

Supply Voltage .....	$V_{SS}-0.3V$ to $V_{SS}+5.5V$
Input Voltage .....	$V_{SS}-0.3V$ to $V_{DD}+0.5V$
Storage Temperature.....	$-40^{\circ}C$ to $85^{\circ}C$
Total Power Dissipation .....	500mW

Note: These are stress ratings only. Stresses exceeding the range specified under “Absolute Maximum Ratings” may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

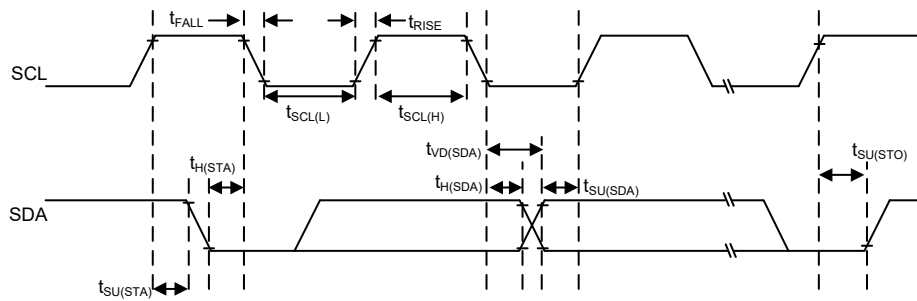
### D.C. Electrical Characteristics

Ta=25°C

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V <sub>DD</sub>	Conditions				
V <sub>DD</sub>	Operating Voltage	—	—	2.0	—	5.0	V
V <sub>CC</sub>	VCSEL Forward Voltage	—	12mA	0.7	—	5.0	V
I <sub>VCSEL</sub>	VCSEL Driving Current	3.3V	—	—	11	14	mA
I <sub>STB</sub>	Operation Current	3.3V	Scanning time=512ms	—	10	20	μA
		5V		—	15	35	

### I<sup>2</sup>C Interface Characteristics

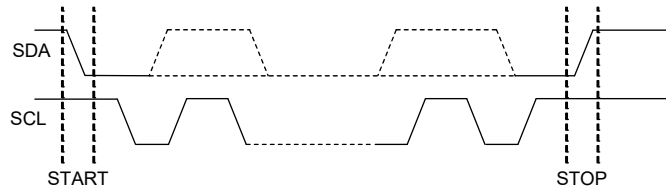
Symbol	Parameter	VDD	Min.	Typ.	Max.	Unit
t <sub>SCL(H)</sub>	SCL Clock High Time	3V/5V	65	—	—	μs
t <sub>SCL(L)</sub>	SCL Clock Low Time	3V/5V	65	—	—	μs
t <sub>FALL</sub>	SCL and SDA Fall Time	3V/5V	—	—	4.5	μs
t <sub>RISE</sub>	SCL and SDA Rise Time	3V/5V	—	—	4.5	μs
t <sub>SU(SDA)</sub>	SDA Data Setup Time	3V/5V	25	—	—	μs
t <sub>H(SDA)</sub>	SDA Data Hold Time	3V/5V	25	—	—	μs
t <sub>VD(SDA)</sub>	SDA Data Valid Time	3V/5V	25	—	—	μs
t <sub>SU(STA)</sub>	Start Condition Setup Time	3V/5V	35	—	—	μs
t <sub>H(STA)</sub>	Start Condition Hold Time	3V/5V	35	—	—	μs
t <sub>SU(STO)</sub>	Stop Condition Setup Time	3V/5V	20	—	—	μs
T <sub>BR</sub>	Data Transfer Rate	—	—	—	7.5	kbps
T <sub>TO</sub>	Time-Out Period	—	—	70	—	ms



I<sup>2</sup>C Timing Diagram

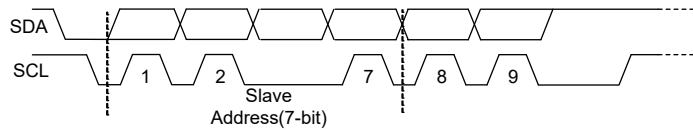
## I<sup>2</sup>C Interface

### START and STOP Conditions

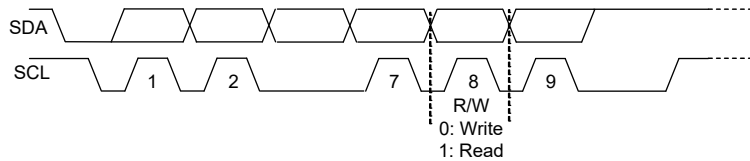


### Slave Address

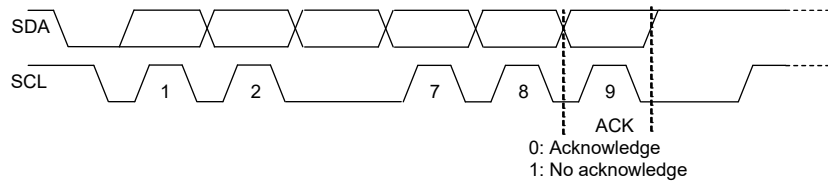
After the START signal, a 7-bit slave address will be transmitted. The slave address is 0x50. (slave address + R/W = 0xA1 or 0xA0)



### Read or Write Control

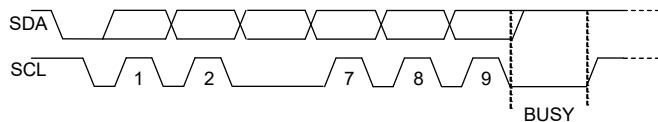


### Acknowledge

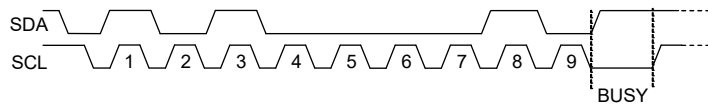


### Slave Busy

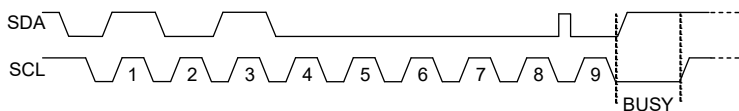
After a data byte (8-bit+ACK) is transmitted, the slave device is busy with processing the received data (slave busy) and cannot receive the next data byte. At this time the SCL line is pulled down and the master can continue to transmit the data until the SCL line is pulled high again.



### Master Read



### Master Write

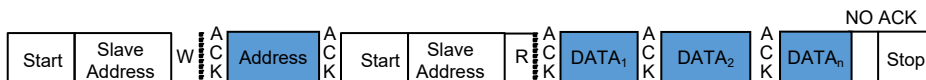


### Read Setting Register

The master read a setting byte of the sensor.



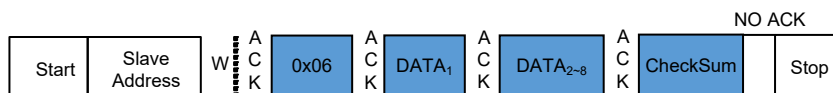
The master read n setting bytes of the sensor.



### Write Setting Register

When the master writes the setting byte to the BM32S21xx-1, it must write all data bytes consecutively, starting with 0x06, and the last byte is the checksum.

Checksum (8-bit):  $DATA1_{(06)} + DATA2_{(07)} + \dots + DATA8_{(0D)}$



When the setting is changed, the sensor will be reset. For about 0.8s later the sensor can normally operate after reset.

### I<sup>2</sup>C Register Map

Address	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access
00	SENSOR_STATUS	CALF3	CALF2	CALF1	STU3	STU2	STU1	PROXF2	PROXF1	R/W
01	PROX_LEVEL	Proximity Level								R
02	REF_DATA_LOW	Reference Data Low								R
03	REF_DATA_HIGH	0				Reference Data High				R
04	NOW_DATA_LOW	Now Data Low								R
05	NOW_DATA_HIGH	0				Now Data High				R
06	—	0								R/W
07	—	0								R/W
08	STATUS_DBC	Proximity Debounce Times								R/W
09	CURRENT	VCSEL Driving Current								R/W
0A	PROX_THR	Proximity Threshold								R/W
0B	LEAVE_THR	Leaving Threshold								R/W
0C	OPTION	MODE	0	Maximum Hold Time			Proximity Scan Cycle			R/W
0D	CALIBRATE_TIME	0				Calibration Period				R/W
0E	CHECK SUM	Check Sum								R/W
0F	FW_VER	0x02								R

• **SENSOR\_STATUS (Address: 0x00)**

Address	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access
00	SENSOR_STATUS	CALF3	CALF2	CALF1	STU3	STU2	STU1	PROXF2	PROXF1	R/W

I<sup>2</sup>C protocol for starting a learning calibration: 0xa0+0x00+SENSOR\_STATUS

**CALF3:** Proximity Sensing AFE calibration

- 0: None
- 1: Calibrating

**CALF2:** Power-on calibration

- 0: None
- 1: Calibrating

**CALF1:** Moving calibration

- 0: None
- 1: Calibrating

**STU3:** Distance learning mode (no covered plate + with object)

- 0: Normal operation
- 1: Start the current learning

The threshold remains unchanged after the learning has started, the current value is automatically adjusted to be able to detect objects. Within 1.5 seconds of power-on, pull the IRQ pin down for more than 0.4 seconds and then pull the IRQ pin high, this bit will be set high.

**STU2:** Learning mode after a plate has been covered (no object)

- 0: Normal operation
- 1: Start the current learning

After the learning has started, the current value is automatically adjusted so that the current A/D value is less than 3072.

**STU1:** Distance learning mode after a plate has been covered (with object)

- 0: Normal operation
- 1: Start the threshold learning

The current value remains unchanged after the learning has started, the threshold is automatically adjusted to be able to detect objects.

**PROXF2:** Real-time proximity status (Without debounce)

- 0: No proximity
- 1: Proximity detected

**PROXF1:** Proximity status after debounce (Determine by PROX\_THR)

- 0: No proximity
- 1: Proximity detected

• **PROX\_LEVEL (Address: 0x01)**

Address	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access
01	PROX_LEVEL	Proximity Level								R

**Proximity Level:** Proximity level of an object

- 00000000: No proximity
- 00000001: Farthest
- ⋮
- 01100100: Nearest

• **REF\_DATA\_LOW (Address: 0x02)**

Address	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access
02	REF_DATA_LOW	Reference Data Low								R

**Reference Data Low:** A/D value low bits of VCSEL without emission

- 00000000~11111111 : 0~255



• **REF\_DATA\_HIGH (Address: 0x03)**

Address	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access
03	REF_DATA_HIGH	0				Reference Data High				R

**Reference Data High:** A/D value high bits of VCSEL without emission  
 0000~1111: 0~15

• **NOW\_DATA\_LOW (Address: 0x04)**

Address	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access
04	NOW_DATA_LOW	Now Data Low								R

**Now Data Low:** A/D value low bits of VCSEL emission  
 00000000~11111111: 0~255

• **NOW\_DATA\_HIGH (Address: 0x05)**

Address	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access
05	NOW_DATA_HIGH	0				Now Data High				R

**Now Data High:** A/D value high bits of VCSEL emission  
 0000~1111: 0~15

• **STATUS\_DBC (Address: 0x08)**

Address	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access
08	STATUS_DBC	Proximity Debounce Times								R/W

**Proximity Debounce Times:** Determine proximity trigger (PROXF) debounce times  
 00000001~00010000: When level is bigger than threshold and exceeds  
 debounce times, PROXF=1 (Default 10)

• **CURRENT (Address: 0x09)**

Address	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access
09	CURRENT	VCSEL Driving Current								R/W

**VCSEL Driving Current:** Setting VCSEL Driving Current  
 00000001~0000000B: 2~12mA (Default 0x0A=11mA)

• **PROX\_THR (Address: 0x0A)**

Address	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access
0A	PROX_THR	Proximity Threshold								R/W

**Proximity Threshold:** Determine proximity trigger (PROXF) level  
 00000100~00100000: When level is bigger than threshold and exceeds  
 debounce times, PROXF=1 (Default 8)

• **LEAVE\_THR (Address: 0x0B)**

Address	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access
0B	LEAVE_THR	Leaving Threshold								R/W

**Leaving Threshold:** Determine leaving threshold level  
 00000100~00100000: When level is smaller than threshold and exceeds  
 debounce times, PROXF=0 (Default 6)

• **OPTION (Address: 0x0C)**

Address	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access
0C	OPTION MODE	0	Maximum Hold Time			Proximity Scan Cycle			R/W	

**MODE:** Touch mode selection

- 0: Reference mode
- 1: Absolute mode

In absolute mode, the maximum trigger output time and the automatic calibration function are disabled.

**Maximum Hold Time:** Maximum trigger output time

- 000: Disable (Default)
- 001: 2s
- 010: 4s
- 011: 8s
- 100: 16s
- 101: 32s
- 110: 64s
- 111: 128s

**Proximity Scan Cycle:** Proximity scanning period

- 000: 8ms
- 001: 16ms
- 010: 32ms
- 011: 64ms
- 100: 128ms
- 101: 256ms
- 110: 512ms (Default)
- 111: 1024ms

• **CALIBRATE\_TIME (Address: 0x0D)**

Address	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access
0D	CALIBRATE_TIME	0			Calibration Period			R/W		

**Calibration Period:** Calibration period

- 0000: 0.5s
- 0001: 1.0s
- 0010: 1.5s
- 0011: 2.0s (Default)
- ⋮
- 1111: 8.0s

Plus 0.5s for all settings when [Proximity Scan Cycle] = 111.

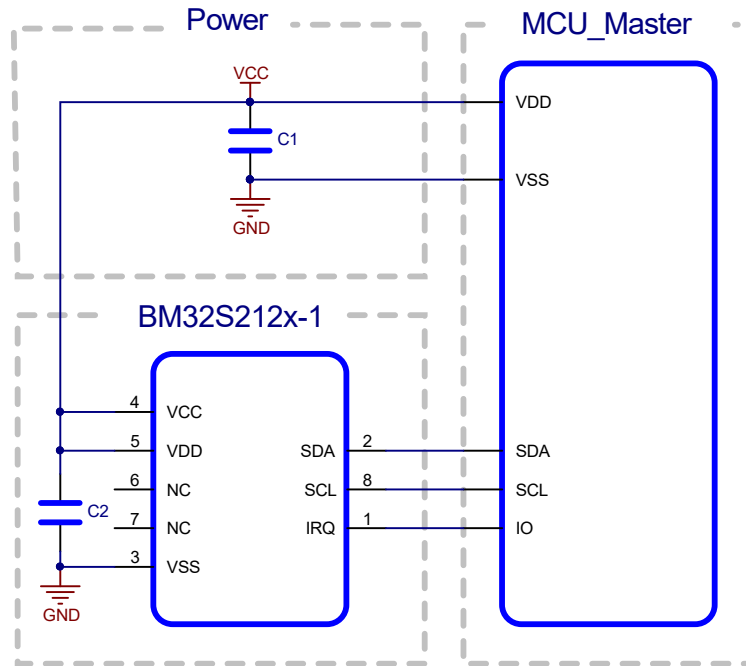
• **CHECK SUM (Address: 0x0E)**

Address	Name	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Access
0E	CHECK SUM	Check Sum							R/W	

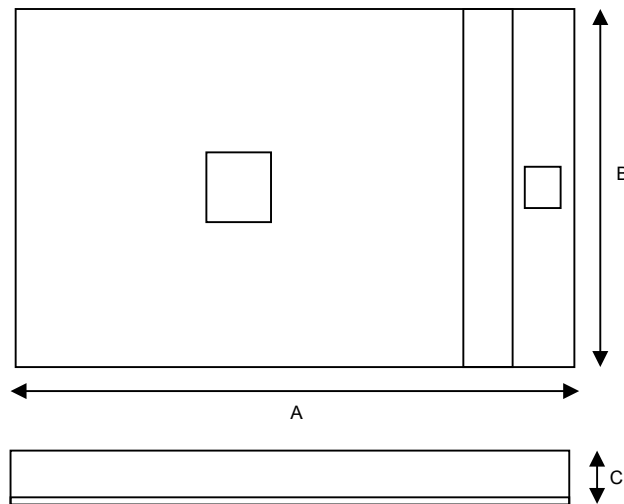
**Check Sum:** After the checksum is successfully written, the data will be stored in the EEPROM, and the IC will automatically reset

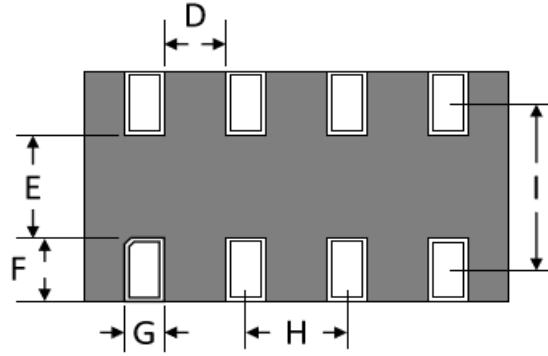
**Check Sum (8-bit):** DATA1<sub>(06)</sub> + DATA2<sub>(07)</sub> + ... + DATA8<sub>(0D)</sub>

### Application Circuits



### Dimensions





Symbol	Unit	
	mm	inch
A	4.00	0.157
B	3.00	0.118
C	0.90	0.035
D	0.53	0.021
E	1.50	0.059
F	0.70	0.028
G	0.40	0.016
H	0.93	0.037
I	2.20	0.087

## Reference Information

### Revision History

Date	Author	Issue	Modification Information
2024.11.18	姚尊宇	V1.00	First version

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