PIR Digital Sensor

BM22S4021-1/BM22S4022-1
BM22S4023-1/BM22S4024-1

Revision: V1.00 Date: November 15, 2022

www.bestmodulescorp.com

Table of Contents

Features

- Operating voltage: 2.7V~5.5V
- Intelligent signal recognition algorithm
- Interface: UART
- Adjustable function
  - 8th order adjustable sensitivity
  - Custom trigger modes: Single mode or Continuous mode
  - Trigger output time: 1~6553.5ms
  - Low voltage detection: 2.7/3.0/3.3/3.6/4.0V
- Intelligent temperature sensor
- Factory-calibrated

General Description

The BM22S402x-1 series of modules are digital output human body infrared sensors, which fully integrate a passive infrared (PIR) sensor, a high-performance Analog Front End circuit and an A/D Converter. These hardware functions when combined with appropriate algorithms give the module the characteristics of high performance, high integration and small size. All modules are factory calibrated with the calibrated data stored in the memory to ensure that the module can be used directly without requiring software calibration.

Regarding the communication, the module has one standard interface, the UART interface. The modules are suitable for use in safety protection products, power saving devices and IoT terminal devices.

Applications

- IoT device
- Security products (intrusion-detection system, surveillance cameras)
- Energy saving (lighting, fan, air-conditioner, ext.)

Selection Table

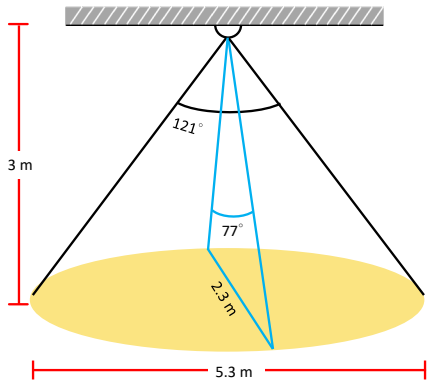
Ta=25°C

Part No.	Lens Type	Viewing Angle H/V	Detect Range	Interface
BM22S4021-1	Ceiling mounted	121°/77°	3 meters	UART
BM22S4022-1		86°/75°	4 meters	UART
BM22S4023-1	Wall mounted	91°/10°	4 meters	UART
BM22S4024-1		10°/20°	10 meters	UART

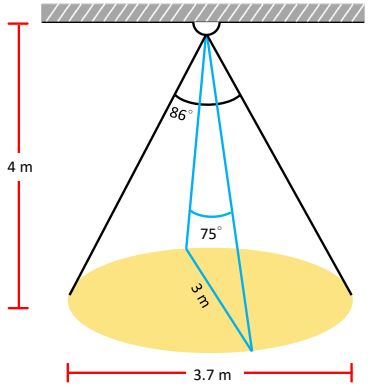
Sensing Range

Ceiling mounted

BM22S4021-1



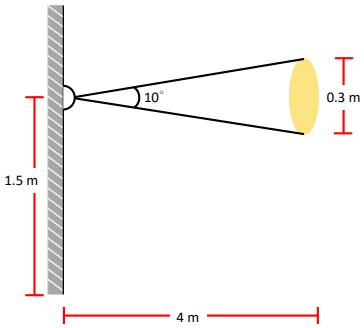
BM22S4022-1



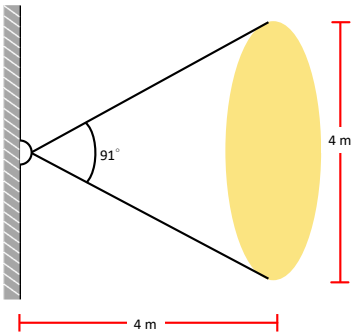
Wall Mounted

BM22S4023-1

Side View

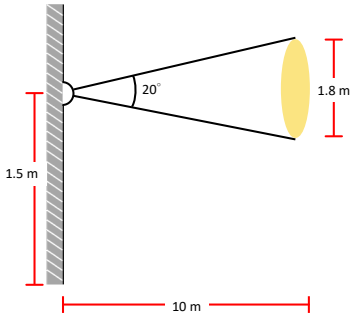


TOP View

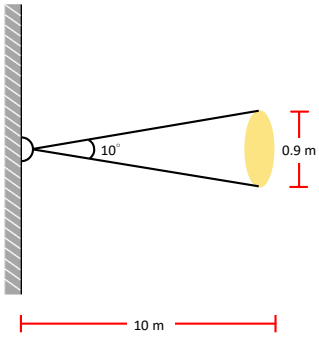


BM22S4024-1

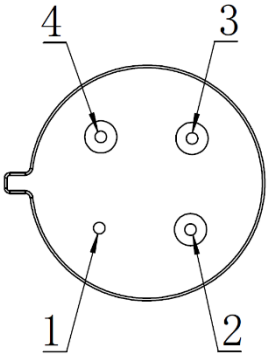
Side View



TOP View



Pin Assignment



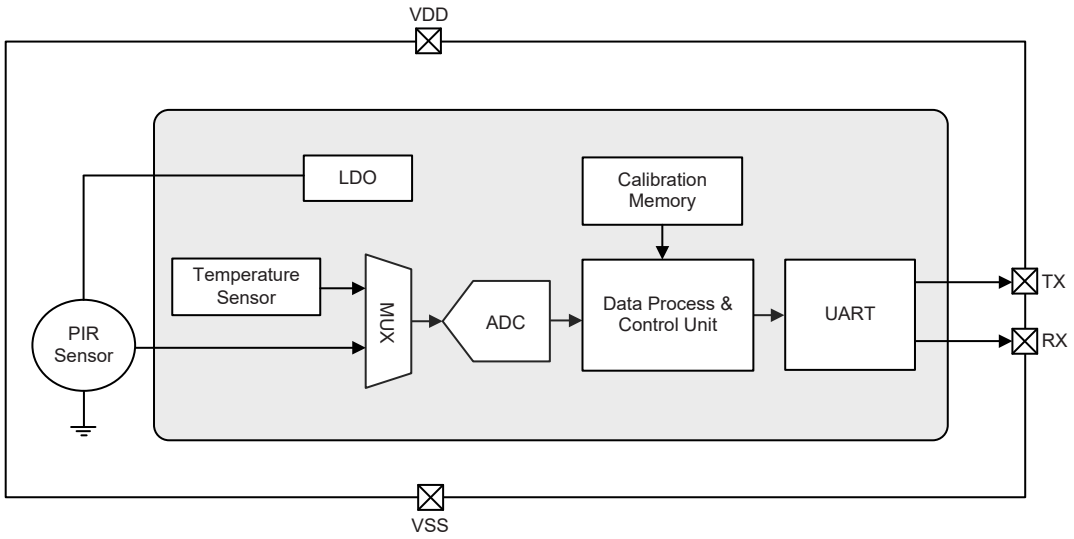
Bottom View

Pin Description

Pin No.	Function	Type	Description
1	GND	PWR	Negative power supply, GND
2	VDD	PWR	Positive power supply
3	RX	I	UART RX pin
4	TX	O	UART TX pin

Legend: PWR: Power; I: Digital Input; O: Digital Output

Block Diagram



Absolute Maximum Ratings

Supply Voltage ..... V_{SS}-0.3V to V_{SS}+5.5V

Input Voltage ..... V_{SS}-0.3V to V_{DD}+0.3V

Storage Temperature..... -40°C to 80°C

Operating (Ambient) Temperature ..... -10°C to 60°C

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. Characteristics

Ta=25°C, V_{DD}=5V

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V_{DD}	Conditions				
V_{DD}	Supply Voltage	—	—	2.7	5.0	5.5	V
I_{DD}	Normal Current	3.3V	Normal mode	—	1.8	—	mA
		5V		—	2.53	—	
	Standby Current	3.3V	Sleep mode	—	—	1	μA
		5V		—	—	1	
V_{IL}	Input Low Voltage	2.7V~5.5V	—	0	—	0.2V_{DD}	V
V_{IH}	Input High Voltage	2.7V~5.5V	—	0.8V_{DD}	—	V_{DD}	V
V_{LVR}	Low Voltage Reset Voltage	—	—	-5%	2.55	+5%	V
V_{LVD}	Low Voltage Detect Voltage	—	LVD enable, voltage select 2.7V	-5%	2.7	+5%	V
		—	LVD enable, voltage select 3.0V		3.0		
		—	LVD enable, voltage select 3.3V		3.3		
		—	LVD enable, voltage select 3.6V		3.6		
		—	LVD enable, voltage select 4.0V		4.0		

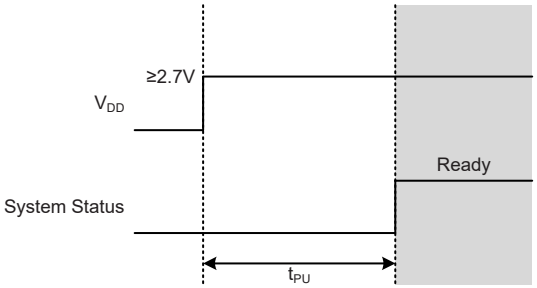
A.C. Characteristics

System Timing

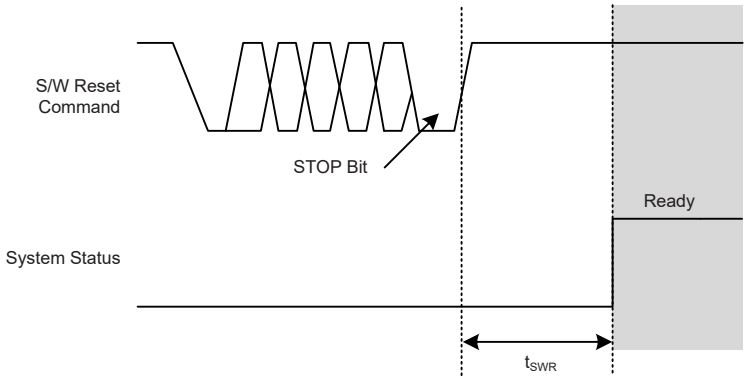
Ta=25°C, V_{DD}=5V

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
t_{PU}	Power-up Time	When V_{DD} ≥ 2.7V, until the first communication can be performed	—	60	—	ms
t_{SWR}	Software Reset Time	Time from reset to PIR detection	—	30	—	s
t_{PWU}	PIR Warm-up Time	PIR warm-up	—	30	—	s
t_{WU}	System Wake-up Time	Time from wake-up to receive commands	—	15	—	μs
t_{WR}	WRITE Command Response Time	Time from executing WRITE command to respond	—	—	9	ms
t_{RR}	READ Command Response Time	Time from executing READ command to respond	—	350	—	μs
t_{SR}	SETUP Command Response Time	Time from executing SETUP command to respond	—	350	—	μs
t_{CI}	Command Interval Time	—	10	—	—	ms

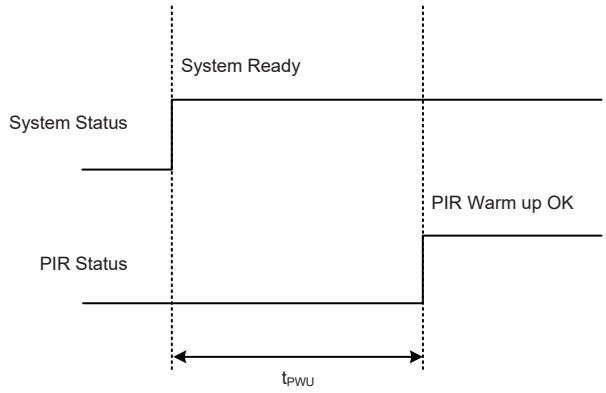
Note: The System Ready signal indicates that the system initialisation has completed and the sensor is ready to receive commands sent by the master device.



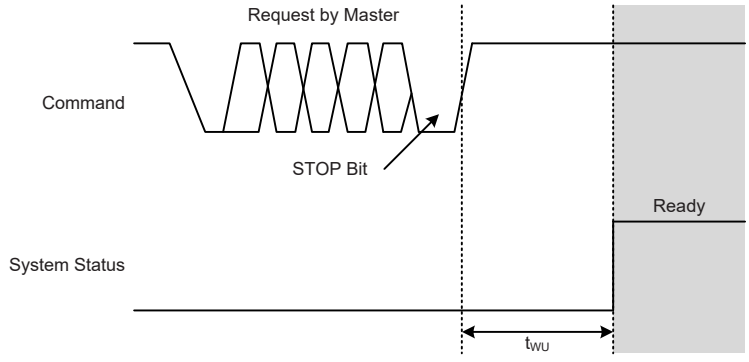
System Power-up Timing Chart



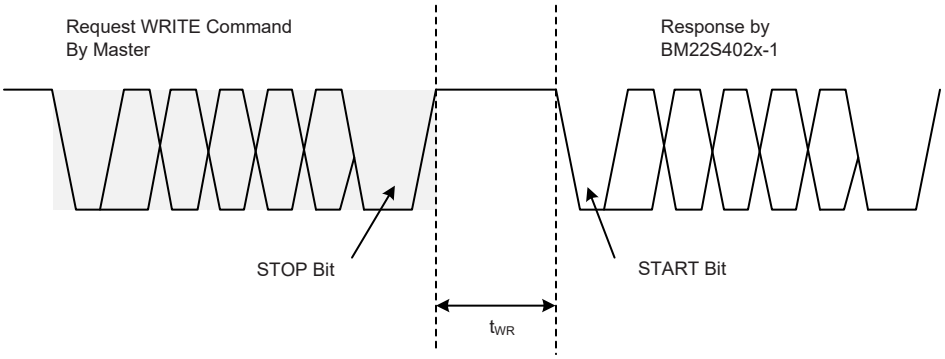
Software Reset Timing Chart



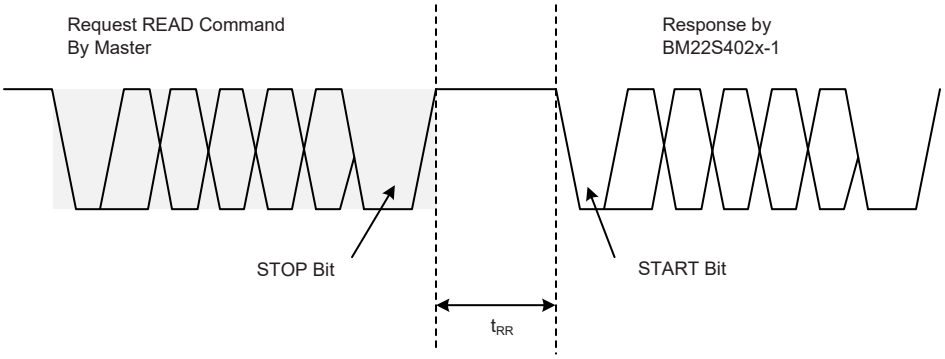
PIR Warm-up Time



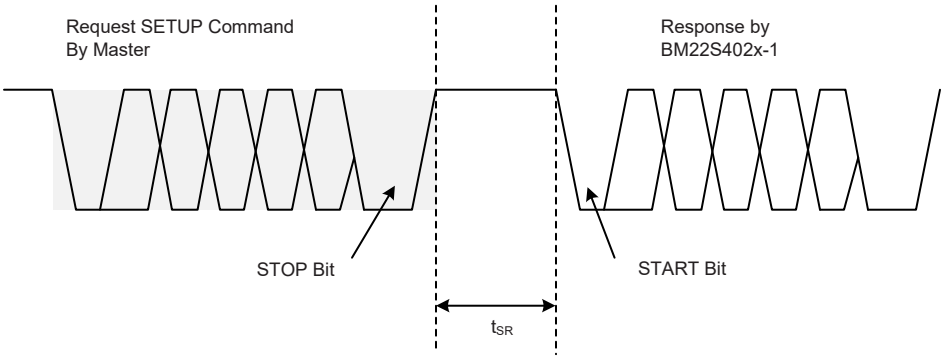
System Wake-up Time



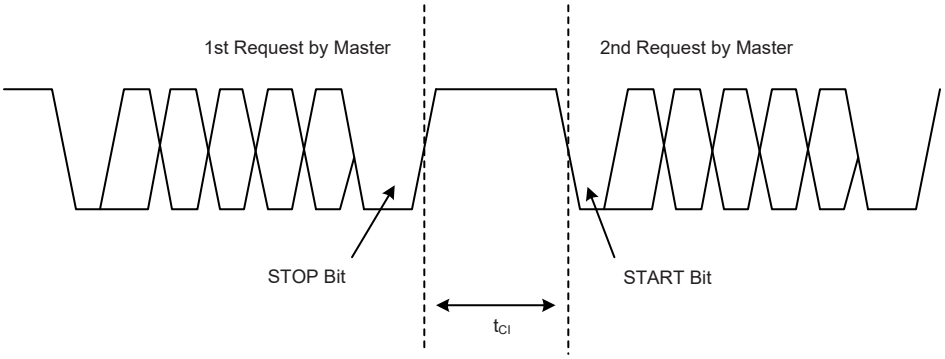
WRITE Command Response Time



READ Command Response Time



SETUP Command Response Time

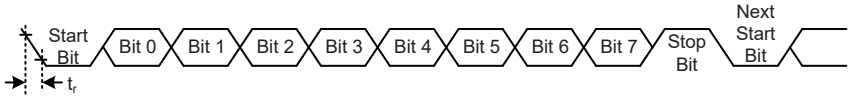


Command Interval Time

UART Interface

V_{DD}=5V, Ta=25°C

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
BDR	UART Baud Rate	—	—	38400	—	bps
t_r	Rising or Falling Time	—	—	—	0.3	μs



UART Timing Chart

Sensor Characteristics

PIR Sensor

V_{DD}=5V, Ta=25°C, unless otherwise specified

Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Sensing Element Size	—	—	2×1	—	mm^2
Responsivity	Ta=100°C, 1Hz	3.8	4.3	—	kV/W
Match	Ta=100°C, 1Hz	—	—	15%	—
Noise	Ta=25°C, 0.3Hz~3Hz	—	33	80	μVp-p
Fov. H	No lens	—	135°	—	—
Fov. V	No lens	—	123°	—	—

Temperature Sensor

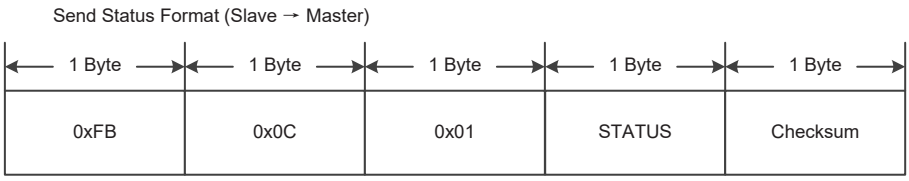
Parameter	Test Conditions		Min.	Typ.	Max.	Unit
	V_{DD}	Conditions				
Sensing Range	2.7V~5.5V	—	-20	—	80	°C
Resolution	2.7V~5.5V	—	—	0.1	—	°C
Accuracy	5V	Ta=0°C~60°C	—	±1	—	°C
		Ta=-20°C~0°C and Ta=60°C~80°C	—	±3	—	°C

Functional Instruction

Functional Description

PIR Detection

The BM22S402x-1 modules provide object movement detection function and can select whether to enable this function, which can be freely controlled by the user in different environments. If the function is enabled, when the sensor detects an object in the command mode, the sensor will automatically send the STATUS[7:0] bits to inform the master.



Send Status Format

Sensitivity

The BM22S402x-1 modules provide an 8-order sensitivity adjustment function for different detection distances to adapt to various operating environments. Use the UART communication for adjustment. Refer to the Command Table.

Trigger Mode

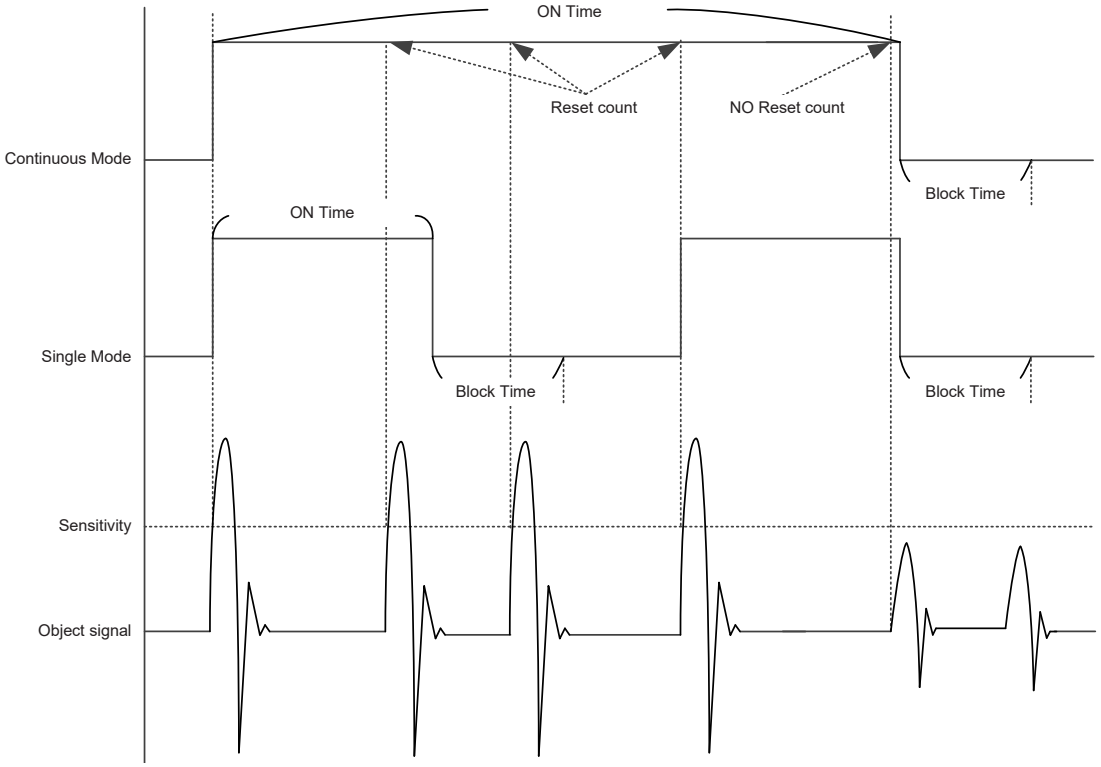
The BM22S402x-1 modules provide two trigger modes, single shot and continuous trigger. The single trigger is to detect an object movement within the detection range and trigger a signal. Even if an object passes within the ON time, the ON time will not be increased. The sensor will not trigger again until the ON time and block time have elapsed. Continuous trigger means that the object moves within the ON time. The ON time will be recalculated until no object moves within the detection range. More details refer to the Single/Continuous Mode Description.

ON Time

When the sensor detects an object movement, the duration after triggering the signal is the ON time. The BM22S402x-1 modules provide a time range of 1sec to 6553.5sec with an interval of 0.1sec by sending a command, making the application more flexible.

Block Time

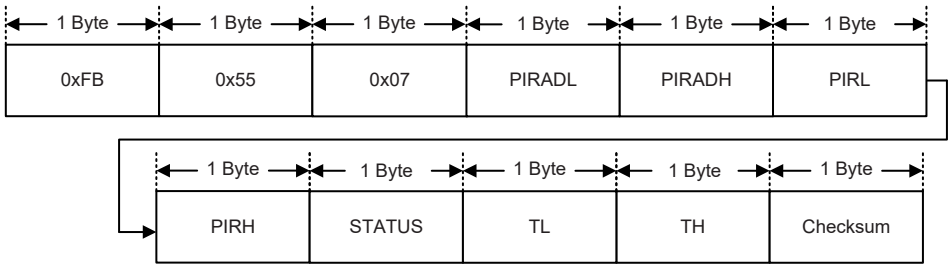
After the end of the sensor ON time, the time elapsed until the next trigger is the block time. Providing a time range of 0.2sec to 51sec with an interval of 0.2sec.



Single/Continuous Mode Description

PIR Data output – Auto Mode

The BM22S402x-1 modules provide two data output modes, command mode and automatic output, which can be configured by the AUTO bit in the PIR configuration register. The command mode is one request and one response for communication. For more command details, refer to the Command Table. Automatic output is continuously output the signal, temperature, status and other relevant information to the master, with an interval of 50ms, so that the master can master the relevant information of the sensor without sending commands all the time. The output format is 11-byte. The format is as follows:



Auto Mode Format

In this mode, it will execute the corresponding action, end the automatic output and enter the command mode after receiving the master command. If the master command is received during the data transmission, the above actions will be performed after the remaining data is sent.

Checksum = (0x55+0x07+PIRADL+PIRADH+PIRL+PIRH+STATUS+TL+TH)

Low Voltage Monitoring

This series of modules provide Low Voltage Detect (LVD) and Low Voltage Reset (LVR) mechanisms for low voltage conditions. The master device can poll the LVDO flag in the STATUS register for low voltage monitoring. The LVDO flag is set high when V_{DD} is less than 2.7V and cleared to zero after the master device reads the STATUS register. The LVR function will reset the system when V_{DD} is less than the 2.55V voltage threshold.

Function	Condition	Reaction
LVD on	—	LVDEN=1
LVD	V_{DD}<2.7V	LVDO=1
LVR	V_{DD}<2.55V	System reset

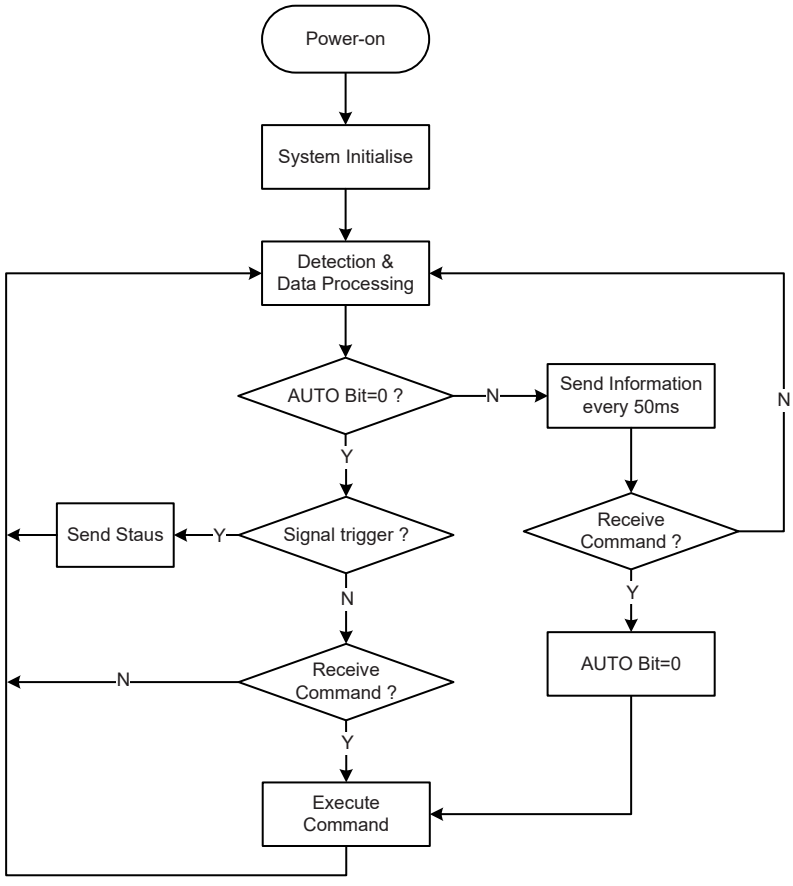
System Flow Description

The BM22S402x-1 modules use the UART 8-N-1 standard as the digital output mode. The default command is one request and one response. A time of t_{PWU} time is required after the system initialisation, the system will continue to detect. If an object passes and meets the trigger conditions, the sensor will send a status signal to the master. Refer to the Response Format for the relevant format. If there is no trigger, the system will wait for the master to ask. The commands are divided into three types, READ, WRITE and SETUP. For more command details, refer to the Command Table.

READ: Read sensor data such as temperature value and register status, etc.

WRITE: Setup parameter such as sensitivity, ON time and Block time, etc.

SETUP: Control the sensor operations, including sleep mode entry and system reset.



System Flow Chart

Command Description

In the communication, the BM22S402x-1 modules are used as slave devices, using one request and one response command mode.

The sensor uses UART 8-N-1 standard with baud rate of 38400 to communicate with the master. The relevant commands are as shown in the following table.

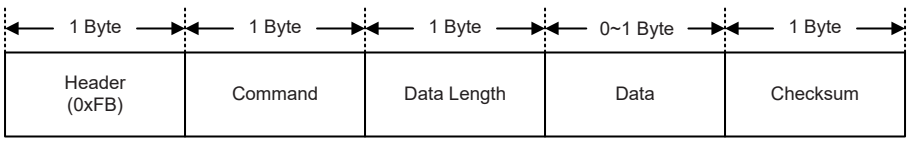
Request: Master → Slave

Response: Slave → Master

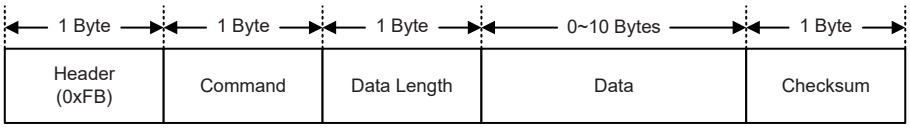
Command Format

- **Command Table**

No.	Command Type	Command Code	Functional Description	Data (Byte)
1	READ	0x01	Request to read PIR original signal	—
			Respond with PIR original signal	2
2	READ	0x02	Request to read PIR filtering signal	—
			Respond with PIR filtering signal	2
3	READ	0x03	Request to read device module name	—
			Respond with device module name	10
4	READ	0x04	Request to read PIR configuration register	—
			Respond with PIR configuration register	1
5	WRITE	0x05	Setup PIR configuration register	1
			Respond with WRITE information	1
6	READ	0x06	Request to read sensitivity register	—
			Respond with sensitivity register	1
7	WRITE	0x07	Setup sensitivity register	1
			Respond with WRITE information	1
8	READ	0x08	Request to read PIR time delay interval	—
			Respond with PIR ON time interval	2
9	WRITE	0x09	Setup PIR ON time interval	2
			Respond with WRITE information	2
10	READ	0x0A	Request to read PIR block time interval	—
			Respond with PIR block time interval	1
11	WRITE	0x0B	Setup PIR block time interval	1
			Respond with WRITE information	1
12	READ	0x0C	Request to read PIR STATUS register	—
			Respond with PIR STATUS register	1
13	SETUP	0x0D	Request device to enter Sleep mode	—
			Respond with SETUP information	1
14	SETUP	0x0F	Reset the device	—
			Respond with SETUP information	1
15	READ	0x10	Request to read temperature data (Unit: 0.1°C)	—
			Respond with temperature data (Unit: 0.1°C)	2



Request Format (Master → Slave)



Response Format (Slave → Master)

Header (1 Byte): Start code, fixed at 0xFB

Command (1 Byte): Command code, refer to the Command Table above

Data Length (1 Byte): Refer to the Command Table above

Data: Refer to the Command Table above

Checksum (1 Byte): Checksum = Command+Data Length+Data

Note: The Data field needs to be omitted if the master device sets the Data Length of the command to 0x00, thereby the packet length of the request is 4-byte.

Format

Error Code Response

When the READ/WRITE/SETUP command receiving from the master is in error, the sensor will respond the error code to inform the master. The format is shown below:

0xFB	0xAB	0x00	0xAB

Error Code Response Format

PIR Filtering Signal (2 Bytes)

The PIR filtering signal output is in a form of HEX code. Each transfer includes 2 bytes with the low byte first and the high byte last. Its calculation is shown below:

PIR Filtering Signal = (PIRH×256+PIRL)

Legend: PIRH = PIR Filtering Signal Value High Byte
PIRL = PIR Filtering Signal Value Low Byte

PIRL	PIRH

PIR Filtering Signal Output Format

Temperature Data (2 Bytes)

The Temperature value output is in a form of HEX code. Each transfer includes 2 bytes with the low byte first and the high byte last. Its calculation is shown below:

Temperature Value = (TH×256+TL)/10 (Unit: °C)

Legend: TH = Temperature Value High Byte
TL = Temperature Value Low Byte

TL	TH

Temperature Data Output Format

PIR Original Signal (2 Bytes)

The PIR original signal is composed of 2 bytes. Each transfer includes 2 bytes with the low byte first and the high byte last. The original signal is signed, which is judged by the highest bit of PIRADH. It is positive when the bit is low and it is negative when the bit is high.

PIR Original Signal Positive Value = (PIRADH×256+PIRADL)

PIR Original Signal Negative Value = (PIRADH×256+PIRADL)-65535

Legend: PIRADH = PIR Original Signal High Byte
PIRADL = PIR Original Signal Low Byte

PIR Original Signal Output Format

Device Information

The device information is composed of 10-byte ASCII code as shown below:

Part Number	B	M	2	2	S	4	0	2	x	-1
Value	42	4D	32	32	53	34	30	32	78	31

B: 42h M: 4Dh 2: 32h 2: 32h S: 53h 4: 34h 0: 30h
2: 32h x: 78h -1: 31h

Register Description

- **STATUS Register (Command code: READ: 0x0C)**

Bit	7	6	5	4	3	2	1	0
Name	—	—	STABLE	LVDO	PIRDF	—	BTF	TF
R/W	—	—	R	R	R	—	R	R
POR	—	—	0	0	1	—	0	0

Bit 7~6 Unimplemented

Bit 5 **STABLE**: PIR stable flag
0: PIR unstable
1: PIR stable
The STABLE flag will be set high after a time of t_{SWR} or t_{PWU} has elapsed.

Bit 4 **LVDO**: Low voltage detect output flag
0: No low voltage detected
1: Low voltage detected
The LVDO flag will be set high when the system voltage is less than 2.7V and cleared to zero after the master device reads the STATUS register.

Bit 3 **PIRDF**: PIR detection flag
0: Detection function disabled
1: Detection function enabled
The PIRDF bit is the detection function flag. This bit is used to determine whether the detection function has been enabled or not.

Bit 2 Unimplemented

Bit 1 **BTF**: PIR block time flag
0: No block time entered
1: Block time entered
This bit is used to determine whether the sensor has been entered the block time or not.

Bit 0 **TF**: PIR signal trigger flag
0: Without signal triggered
1: Signal triggered
This bit is used to determine whether the sensor has been triggered by signal or not. After the ON time, this bit will be cleared to “0”.

• PIR Configuration Register (Command code: READ: 0x04, WRITE: 0x05)

This register is used to enable the sensor LVD function, trigger mode selection and LVD voltage selection.

Bit	7	6	5	4	3	2	1	0
Name	VLVD2	VLVD1	VLVD0	LVDEN	PIREN	—	TRIG	AUTO
R/W	R/W	R/W	R/W	R/W	R/W	—	R/W	R/W
POR	u	u	u	u	u	—	u	0

Bit 7~5 **VLVD2~VLVD0**: LVD voltage selection
000~011: 2.7V (default selection is 011)
100: 3.0V
101: 3.3V
110: 3.6V
111: 4.0V

Bit 4 **LVDEN**: LVD function control
0: Disable (Default)
1: Enable

Bit 3 **PIREN**: PIR Detection function control
0: Disable
1: Enable (Default)

Bit 2 Unimplemented

Bit 1 **TRIG**: PIR trigger mode control
0: Single shot
1: Continous trigger (Default)

Bit 0 **AUTO**: PIR Auto mode control
0: Commande mode
1: Automatic data output (Default)

Note: "u" stands for unchanged. The parameter in the system will remain unchanged after power on reset or software reset.

• Sensitivity Register (Command code: READ: 0x06, WRITE: 0x07)

This register is used to select the sensor sensitivity.

Bit	7	6	5	4	3	2	1	0
Name	—	—	—	—	—	SEN2	SEN1	SEN0
R/W	—	—	—	—	—	R/W	R/W	R/W
POR	—	—	—	—	—	u	u	u

Bit 7~3 Unimplemented

Bit 2~0 **SEN2~SEN0**: Sensitivity selection
000: Level 1 (Default)
001: Level 2
010: Level 3
011: Level 4
100: Level 5
101: Level 6
110: Level 7
111: Level 8

Level 1 is the longest distance. The closer the distance, the higher the level.

Note: "u" stands for unchanged. The parameter in the system will remain unchanged after power on reset or software reset.

• **ON Time Registers (Command code: READ: 0x08, WRITE: 0x09)**

These two registers are used to configure the ON time of the sensor.

Bit	7	6	5	4	3	2	1	0
Name	OT15	OT14	OT13	OT12	OT11	OT10	OT9	OT8
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
POR	u	u	u	u	u	u	u	u

Bit 7~0 **OT15~OT8**: ON time high byte bit 15~bit 8

Bit	7	6	5	4	3	2	1	0
Name	OT7	OT6	OT5	OT4	OT3	OT2	OT1	OT0
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
POR	u	u	u	u	u	u	u	u

Bit 7~0 **OT7~OT0**: ON time low byte bit 7~bit 0

Note: "u" stands for unchanged. The parameter in the system will remain unchanged after power on reset or software reset.

Use the ON time register to set the ON time to 3sec. The setting range is from 1sec to 6553.5sec, the minimum is 1sec and the interval is 0.1sec. When the OT[15:0] bits are range from 0x0000 to 0x000A, it will be regarded as 1sec. Its calculation is shown below:

OT[15:0] = User's required seconds×10 (Unit: sec)

• **Block Time Register (Command code: READ: 0x0A, WRITE: 0x0B)**

This register is used to configure the block time of the sensor.

Bit	7	6	5	4	3	2	1	0
Name	BT7	BT6	BT5	BT4	BT3	BT2	BT1	BT0
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
POR	u	u	u	u	u	u	u	u

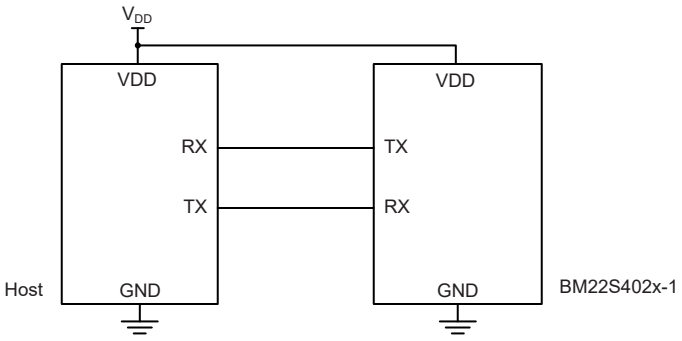
Bit 7~0 **BT7~BT0**: Block time bit 7~bit 0

Note: "u" stands for unchanged. The parameter in the system will remain unchanged after power on reset or software reset.

Use the block time register to set the block time to 1sec. The setting range is from 0.2sec to 6553.5sec, the minimum is 0.2sec and the interval is 0.1sec. When the BT[7:0] bits are set to 0x00, it will be regarded as 0.2sec. Its calculation is shown below:

BT[7:0] = User's required seconds×5 (Unit: sec)

Application Circuits



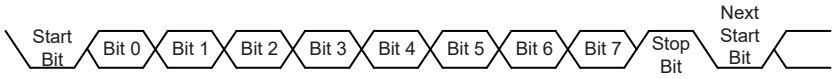
UART Interface

The BM22S402x-1 modules contain an integrated full-duplex asynchronous serial communications UART interface that enables communication with external devices that contain a serial interface. The UART function has many features and can transmit and receive data serially by transferring a frame of data with eight data bits per transmission.

The integrated UART function contains the following features:

- Full-duplex, asynchronous communication
- 8 bits character length
- No parity function
- One stop bit
- Fixed baud rate of 38400bps
- RX pin wake-up function

Baud Rate	Real Rate	Miss Rate
38400bps	38461bps	0.16%



8-bit Data Format

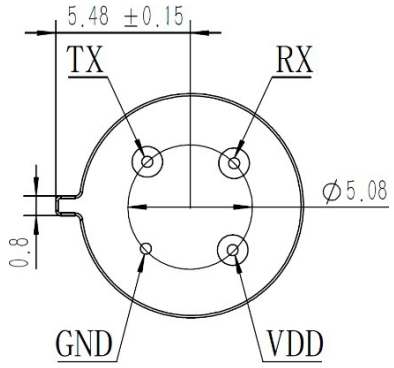
UART External Pins

To communicate with an external serial interface, the internal UART has two external pins known as TX and RX, which are the UART transmitter and receiver pins respectively.

Dimensions

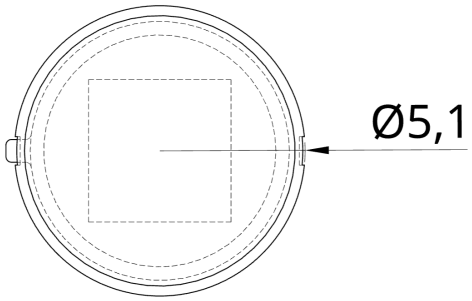
Bottom View

(Unit: mm)



Top View

(Unit: mm)



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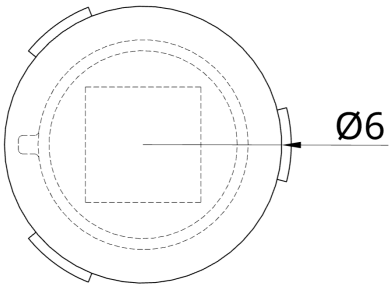
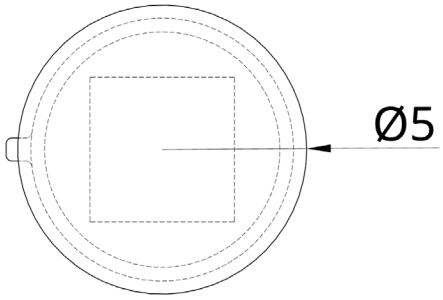
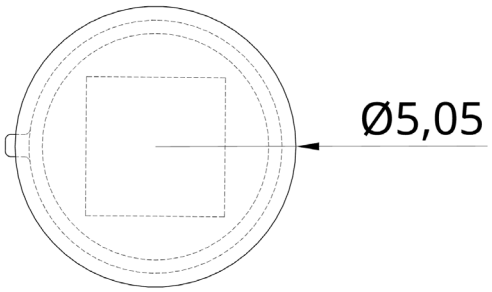


BM22S4022-1



BM22S4023-1



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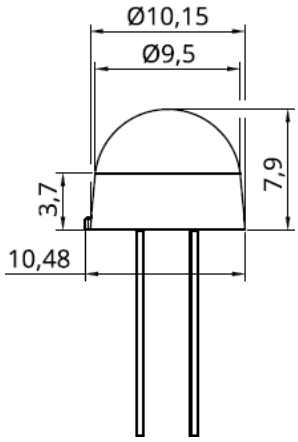
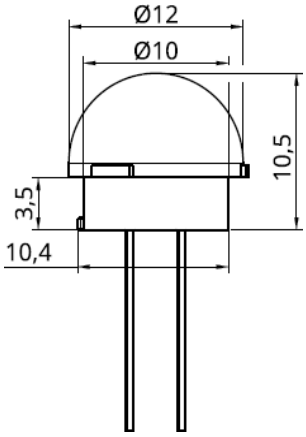
Side View

(Unit: mm)



BM22S4021-1



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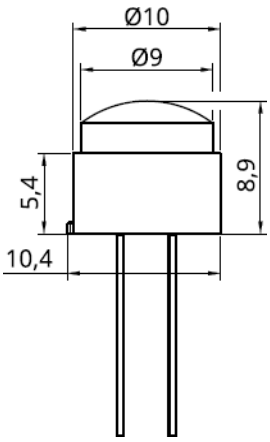
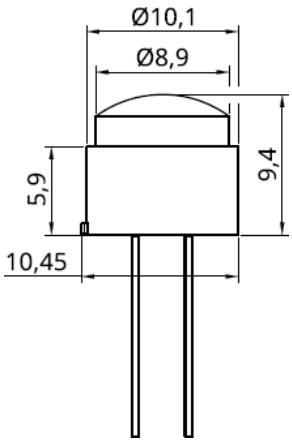


BM22S4023-1



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