5.8GHz Radar Sensor Module

BM22S4422-1

Revision: V1.00 Date: December 30, 2024

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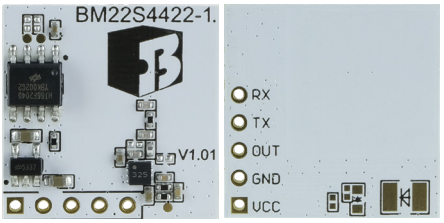
Features



- Operating frequency band: 5.8GHz ISM
- Operating voltage: 4V~12V
  (UART voltage: 3.3V)
- Current
  - Sleep current: 0.4mA @ 5V
  - Operating current: 13mA @ 5V
- 2m high mounted on the wall, horizontal forward sensing distance (5V, 25℃): 20m
- 3m suspension height, sensing radius to ground (5V, 25℃): 5.5m
- Operating temperature: -40℃~85℃
- Supports standard UART serial port protocol
- Reserves light sensing component positions, must not be used simultaneously with serial port communication
- Interface: 5-pin straight hole, pitch=2.54mm
- Size: 20.0mm(L)×20.0mm(W)×3.2mm(H)

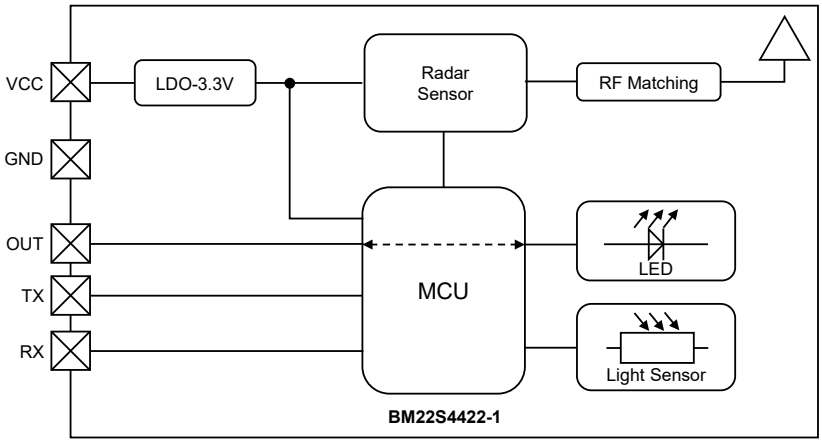
General Description

The BM22S4422-1 is a 5.8GHz radar human movement sensing module for moving object detection. The radar sensing is triggered when an object moves within the detection range. The module's small size, penetration of non-metallic substances and wide detection range make it suitable for different application scenarios without compromising the integrity and aesthetics of the projects. The module performance can be flexibly adjusted with UART serial communication, the sensing distance is up to 20m, and the photoresistor and test LED component positions are reserved.

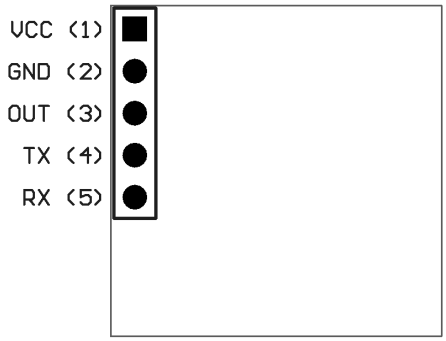
Applications

- Smart lighting
- Smart home
- Anti-intrusion detection

Block Diagram



Pin Assignment



Pin Description

Pin	Function	Type	Description
1	VCC	PWR	Positive power supply
2	GND	PWR	Negative power supply, ground
3	OUT	DO	Radar sensing trigger output
4	TX	DO	UART TX serial data output
5	RX	DI	UART RX serial data input

Legend: PWR: Power; DI: Digital Input; DO: Digital Output

Technical Specifications

Absolute Maximum Ratings

Supply Voltage ..... V_{SS}-0.3V~V_{SS}+12V

Input Digital Voltage ..... V_{SS}-0.3V~3.3V+0.3V

Storage Temperature..... -60℃~150℃

Operating (Ambient) Temperature ..... -40℃~85℃

ESD HBM ..... >±2kV

Note: This module is ESD sensitive. HBM (Human Body Mode) is based on MIL-STD-883.

D.C. Electrical Characteristics

Ta=25°C, V_{CC}=5.0V, with matching circuit and antenna, unless otherwise specified

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_{CC}	Supply Voltage	—	4	5.0	12	V
V_{IL}	I/O Low Level Input Voltage	—	0	—	0.6	V
V_{IH}	I/O High Level Input Voltage	—	2.6	—	3.3	V
T_{OP}	Operating Temperature	—	-40	—	85	°C
Current Consumption						
I_{SLP}	Sleep Current	WDT Off RF Sleep mode	—	0.4	—	mA
I_{DD}	Operating Current	RF CW mode 3dBm	—	13	—	mA
I_{OL}	I/O Port Sink Current	—	5	10	—	mA
I_{OH}	I/O Port Source Current	—	-0.5	-1.0	—	mA
R_{PH}	I/O Port Pull-High Resistor	—	20	60	100	kΩ

A.C. Electrical Characteristics

Ta=25°C, V_{CC}=5.0V, with matching circuit and antenna, unless otherwise specified

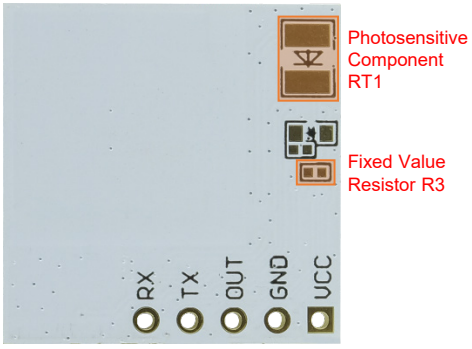
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
f_{RF}	RF Frequency	—	5767	5800	5833	MHz
P_{OUT}	Output Power	—	-8.5	3	4.5	dBm
	Power-On Settling Time	—	—	1.2	—	s
	Sensing Distance	Horizontal forward, 2m above the ground	—	—	20	m
		High to ground, 3m above the ground	—	—	5.5	m
S.E.$_{TX}$	TX Spurious Emission Power	f<1GHz	—	—	-36	dBm
		47MHz<f<74MHz	—	—	-54	dBm
		87.5MHz<f<118MHz				dBm
		174MHz<f<230MHz				dBm
		470MHz<f<862MHz				dBm
		2nd, 3rd harmonic	—	—	-30	dBm
		1.8GHz~1.9GHz	—	—	-47	dBm
		5.1GHz~5.3GHz	—	—	-47	dBm

Software Default Parameters

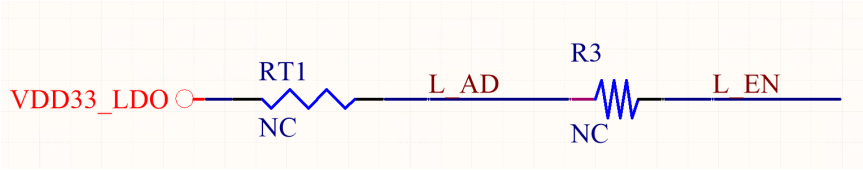
Parameter	Default Value
TX Frequency	5800MHz
Horizontal Forward Sensing Distance	20m
Sensing Radius with 3m Suspension Height	5.5m
OUT Pin Output Level	Outputs 0V in silence and outputs 3.3V when sensing
Sensing Output Delay	3s
Light Sensing Function	Disabled
Light Sensing Method	Triggered when the sampling value is less than the threshold
Light Sensing Threshold (AD Value)	37
TX Power	3dBm
AMP Gain	44dB
Radar Sensing Threshold	6

Light Sensing Circuit Principle

Enable light sensing: Radar sensing can only be triggered after the light sensing is triggered. This allows the module to trigger radar sensing only in dark/light environments. As shown in the following figure, the module has reserved component positions for the light sensing circuit, where users can solder a photosensitive component and a resistor to form a light sensing circuit.



The light sensing circuit principle is shown below:



RT1: a photosensitive component; if using an ambient light sensor, pay attention to the current direction;

R3: a fixed value resistor, must be ≥27kΩ;

VDD33_LDO: 3.3V voltage, which is also the reference voltage for ADC;

L_AD: ADC sampling point;

L_EN: light sensing enable pin; L_EN=0V when light sensing is enabled, L_EN=3.3V when light sensing is disabled.

Note: 1. The A/D converter resolution is 12-bit, with a maximum value of 4095.

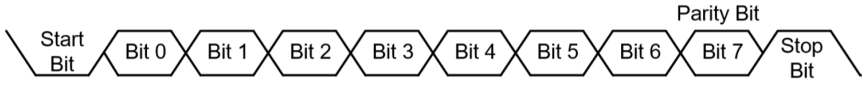
2. L_AD sampling value = R3/(RT1+R3)×4095 = L_AD voltage/VDD33_LDO voltage×4095
3. The light sensing trigger conditions such as trigger mode and trigger threshold are configurable, refer to the UART Communication section. Users can flexibly adjust the trigger conditions according to the component specifications actually used and the ambient brightness.

Software Parameter Adjustment Method

UART Communication

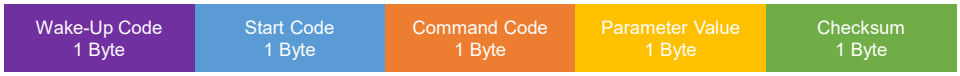
Power on the module and wait for 1.2s, then use an external MCU or serial port assistant to set the module software parameters through UART communication. Note that the MCU communication pin high level or the serial port assistant voltage should be 3.3V. The software parameters will take effect in real time after being set. Except for a few special parameters, the setting values of most parameters will be stored, therefore, there is no need to re-configure them when the module is powered on again.

UART waveform: the baud rate is 4800bps using an 8-bit data format with the LSB first.



8-bit data format

Packet format: 5-byte, the interval between two consecutive bytes should be greater than 0.4ms and less than 8ms. The host must wait for the module to reply before sending the next data packet.



Wake-up code: 0x00

Start code: 0x42(write), 0x43(read)

Command code: refer to the following table

Parameter value: the parameter values for write operations are shown below; the parameter values for read operations can be any value, but the checksum must be correct.

Checksum: command code + parameter value + 4; if the calculation result exceeds 8 bits, take the lowest 8 bits.

Item	Command Code	Parameter Value	Default Value	Note
OUT Pin Output Mode	0x02	1, 2	2	1: Outputs a low level when moving object is detected, outputs a high level when not detected 2: Outputs a high level when moving object is detected, outputs a low level when not detected
OUT Pin Output Delay	0x03	1~250	3	Unit: s
Light Sensing Function Enable	0x04	1, 2	1	1: Disable light sensing function 2: Enable light sensing function
Trigger Method of Light Sensing Function	0x05	1, 2	1	1: Light sensing is triggered when the AD sampling value is less than the threshold 2: Light sensing is triggered when the AD sampling value is greater than the threshold
Light Sensing Threshold Lower 8 Bits	0x06	0~255	37	The combined 16-bit parameter value has a range of 0~4095
Light Sensing Threshold Higher 8 Bits	0x07	0~15	0	
TX Frequency	0x08	1~31	16	5767+(n-1)×2.2(MHz)
TX Power	0x0D	1~10	2	4.5, 3, 2, 1.5, 0.5, -0.5, -1, -3, -5, -8.5 (dBm)
AMP Gain	0x0E	1~8	1	44, 40, 36, 32, 28, 24, 20, 0 (dBm)
Radar Sensing Threshold Lower 8 Bits	0x0F	0~255	6	The combined 16-bit parameter value has a range of 0~4095
Radar Sensing Threshold Higher 8 Bits	0x10	0~15	0	
RF Function Enable	0x14	1, 2	—	The RF function is enabled by default after power-on. This parameter setting takes effect only when the module is in use and will not be saved. 1: Disable RF function 2: Enable RF function
Module Firmware Version	0x15	0x10~0xFF	—	Read only; if the data read back is 0x10, the firmware version is V1.0
Slow Movement Detection Enable	0x16	1, 2	1	1: Normal detection mode 2: Slow movement detection mode

Replied data:

Item	Replied Data	Note
Write Operation	0x65	Communication is failed
	0x6A	Communication is successful
Read Operation	Wake-up code + start code + command code + parameter value + checksum	Parameter value indicates the current module state

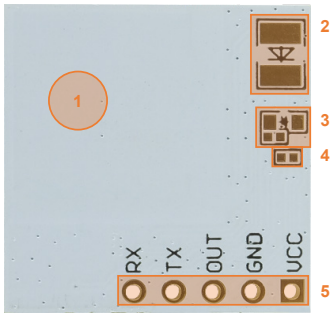
Software Parameter Introduction

1. **OUT pin output mode**: used to set the OUT pin output level when a moving object is detected.
2. **OUT pin output delay**: used to set the delay time of the OUT pin valid output after the module does not detect a moving object.
3. **Light sensing function enable**: used to control whether the module needs to turn on the light sensing function. The light sensing function cannot be used independently and only works when the RF function is turned on.
4. **Trigger method of light sensing function**: used to set that the light sensing function is triggered when the AD sampling value is greater than or less than the threshold.
5. **Light sensing threshold lower 8 bits**: used to set the lower eight bits of the light sensing trigger threshold, which is combined with the light sensing threshold higher eight bits to form a 16-bit data ranging from 0 to 4095.

6. **Light sensing threshold higher 8 bits**: used to set the higher eight bits of the light sensing trigger threshold, which is combined with the light sensing threshold lower eight bits to form a 16-bit data ranging from 0 to 4095.
7. **TX frequency**: used to set the TX frequency of the module. There are 32 frequency points for users to select: (n-1)×2.2+5767MHz (n=1~31). Users need to set this parameter according to the actual requirements such as regulations.
8. **TX power**: used to set the TX power of the module. The higher the power, the farther the sensing distance, but also the more power consumption.
9. **AMP gain**: used to set the gain of the module's IF signal amplifier. The greater the gain, the farther the sensing distance, but also the more power consumption.
10. **Radar sensing threshold lower 8 bits**: used to set the radar sensing trigger threshold lower eight bits, which is combined with the radar sensing trigger threshold higher eight bits to form a 16-bit data ranging from 0 to 4095.
11. **Radar sensing threshold higher 8 bits**: used to set the radar sensing trigger threshold higher eight bits, which is combined with the radar sensing trigger threshold lower eight bits to form a 16-bit data ranging from 0 to 4095.
12. **RF function enable**: used to turn on/off the RF function. This parameter value is not stored and takes effect only when the module is running. The RF function is turned on by default after the module is powered on.
13. **Module firmware version**: used to read the current firmware version of the module, not writable. For example, if 0x10 is read, the current firmware version is V1.0.
14. **Slow movement detection enable**: used to detect the slow movement of small objects in close proximity. The required threshold for this mode will be greater than the threshold for normal mode and the maximum sensing distance will also be shorter.

Demo Board Operation

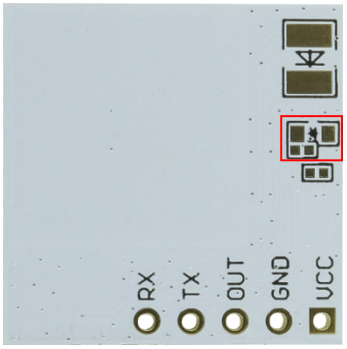
Demo Board Introduction



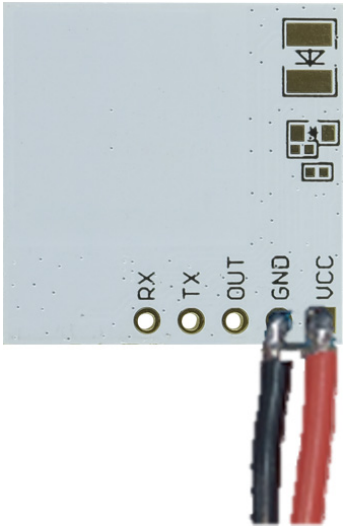
1. **Radar antenna**: the antenna must face the detection area.
2. **Reserved position for photosensitive component**: used for soldering a photosensitive component to implement the light sensing function of the module.
3. **Reserved position for test LED and current limiting resistor**: after the components are soldered, power can be supplied to the module to test the module function, and the LED will be illuminated when the module detects a moving object.
4. **Voltage divider resistor of the light sensing circuit**: this resistor and the photosensitive component form the light sensing circuit. Refer to the Light Sensing Circuit Principle section for more details.
5. **5-pin header**: power input (4V~12V), OUT pin output, serial port connection.

Moving Object Detection

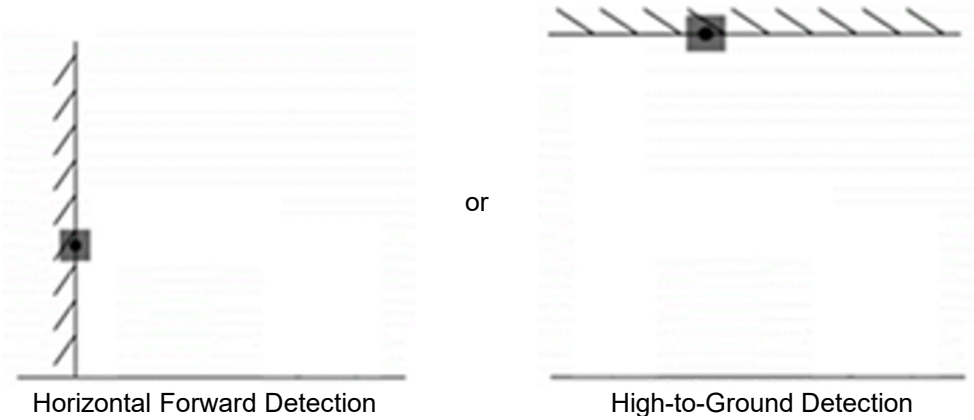
1. Solder the test LED and current limiting resistor on the reserved position of the module, or connect the module to the user's test board through the pin header.



2. Connect power to the module.

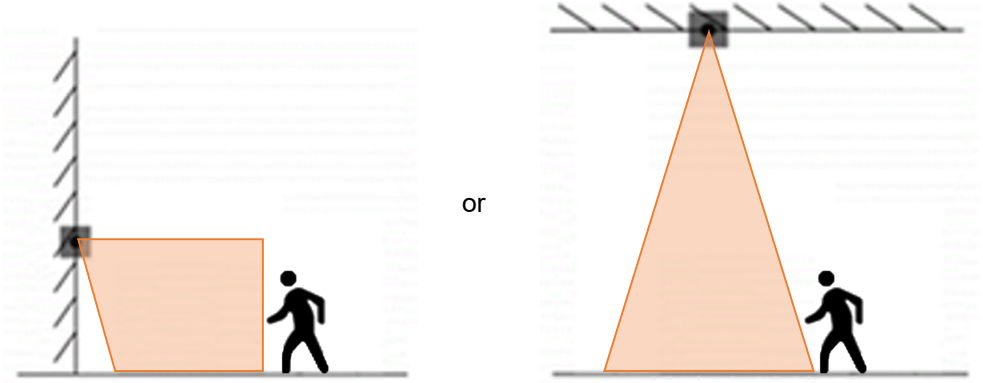


3. Use a double-sided sponge tape or similar adhesive tape to attach the module to a wall, ceiling or stable object (refer to the Considerations section when installing), and make the module antenna face the test area.



Horizontal Forward Detection　　High-to-Ground Detection

4. Turn on the power switch to power the module. Move an object within the test area, the LED is on when the radar module detects the moving object. When the moving object leaves the detection area or the object stops moving, the radar module will no longer detect the moving object and the LED will be turned off after a period of time, this delay time is adjustable.

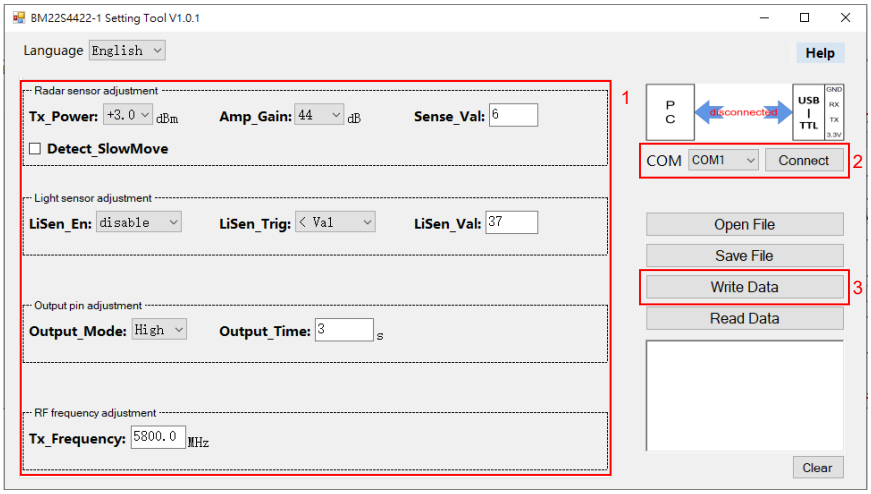


Horizontal Forward Detection　　High-to-Ground Detection

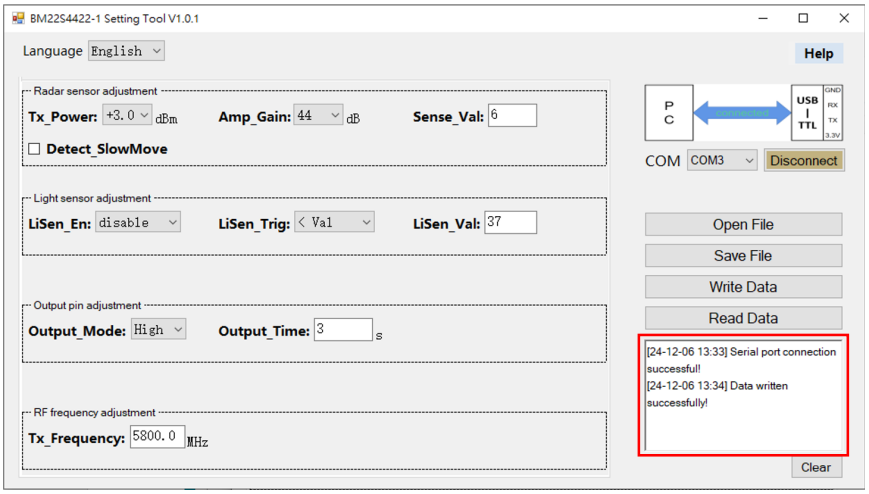
Software Parameter Adjustment

1. Connect the USB serial port assistant to the computer. Remove the module and use Dupont lines to connect the USB serial port assistant and module. The connection diagram is shown in the figure:

2. Open the BM22S4422-1 Setting Tool software. First, configure the desired module parameters on the interface, or click “Open File” to load a parameter file previously saved, or click “Help” →“Example” to select the desired example parameters. Then select the COM port and click “Connect”. Finally, click “Write Data”.



3. After the display area displays “Data written successfully!”, remove the module and power the module with a battery for normal test.



Detection Range

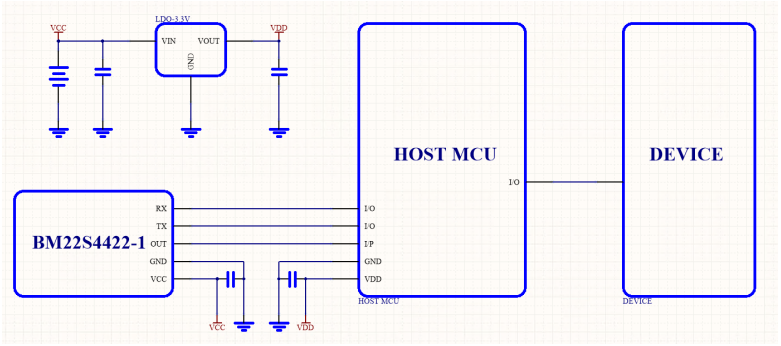
The following figure shows the horizontal forward detection range of the radar module, with a sensitivity of 20m. The detection range varies with different sensitivities. The area within the red line is the strong sensing area, and the area between the red and orange lines is the weak sensing area.

Considerations

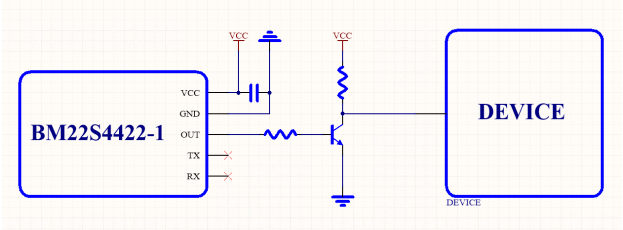
1. When using or installing the module, the module antenna should face the detection area.
2. Large metal equipment or pipelines should not be placed in front of the module antenna.
3. During the product installment, metal shells/components or components that are prone to shaking should not be placed in front of the module antenna.
4. Non-metallic obstructions can be placed in front of the module antenna but a suitable clearance area must be reserved in front of the antenna with a distance of at least 5mm.
5. The module should be as far as possible from components with strong radiation interference. This can avoid coupling interference signals into the IF signal so as to prevent false triggers.
6. Although the module has a filtering function for the power frequency signals, it is still necessary to avoid the interference of the power frequency signals as much as possible.

Application Circuits

Control with MCU

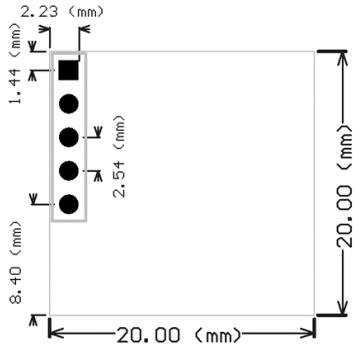


Control without MCU

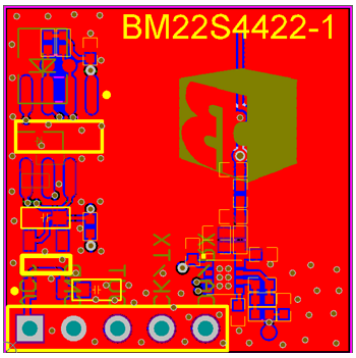


Layout Description

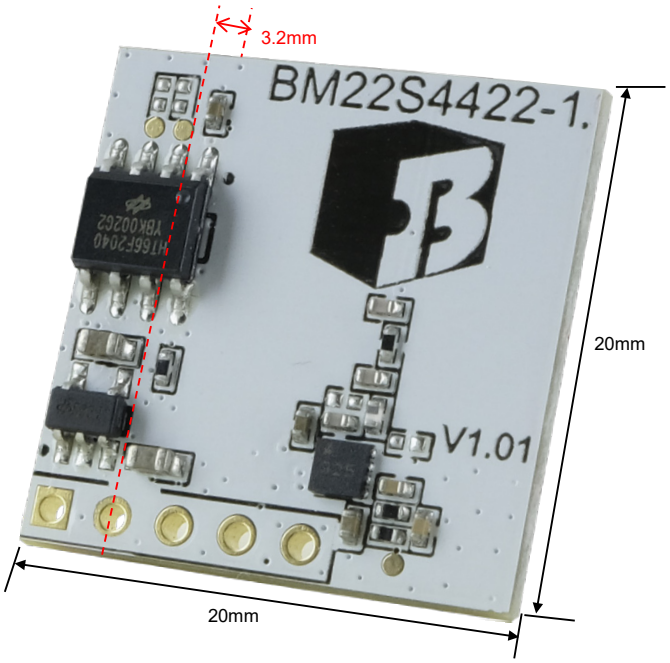
PCB Footprint



Layout Example



Dimensions



Reference Information

Modification History

Date	Author	Issue	Modification Information
2024.11.26	苏运猛	V1.00	First version

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