Data Sheet for Bioradar Sensor SYH24A1 (V1.0)

Features

✧24GHz millimeter wave radar sensor;

✧2 × 8 microstrip antenna;

✧Based on enhanced Doppler radar technology, to realize the perception function of people in two dimensions;

✧Realize the synchronous sensing function of sports personnel and stationary personnel;

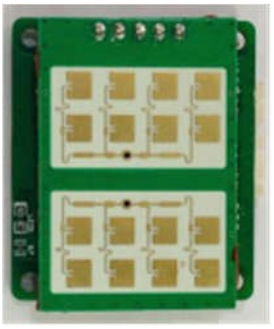
✧Maximum distance for motion perception: ≥20 meters;

✧Maximum human perception distance: ≥5 meters;

✧Antenna beam width: 80 ° / 30 °;

✧Not affected by temperature, humidity, noise, airflow, dust, light, etc., suitable for harsh environments;

✧The output power is small, which is not harmful to the human body;



Applications

✧Smart appliances (TV, projection, speakers, etc.)

✧Office energy saving (air conditioning, lighting)

✧Zone Security

✧Automatic doors, elevators

✧Smart street lights, etc.

Product package

✧Volume: 37mm × 32mm × 8mm

✧Interface: SMT 1.25mm connector

Contents

1. Overview

SYH24A1 radar module is a radar detection module based on millimeter wave Doppler radar system to realize human biological motion perception and human biological perception. This module is based on the enhanced Doppler radar signal processing system, and realizes wireless perception of the status of personnel in a specific place through synchronous sensing technology of Doppler parameters of personnel movement and physiological parameters of personnel.

This module has the following working characteristics:

✧This module restricts the detection object to personnel (moving or stationary) and eliminates interference from other inanimate objects in the environment;

✧This module realizes the synchronous sensing function of people in motion and people in stationary;

✧This module effectively eliminates interference from non-living objects and can also detect non-living moving objects;

✧The output power is small and does not pose a danger to the human body;

✧It is not affected by environmental factors such as temperature, light and dust, has a long detection distance, high sensitivity, and has a wide range of applications.

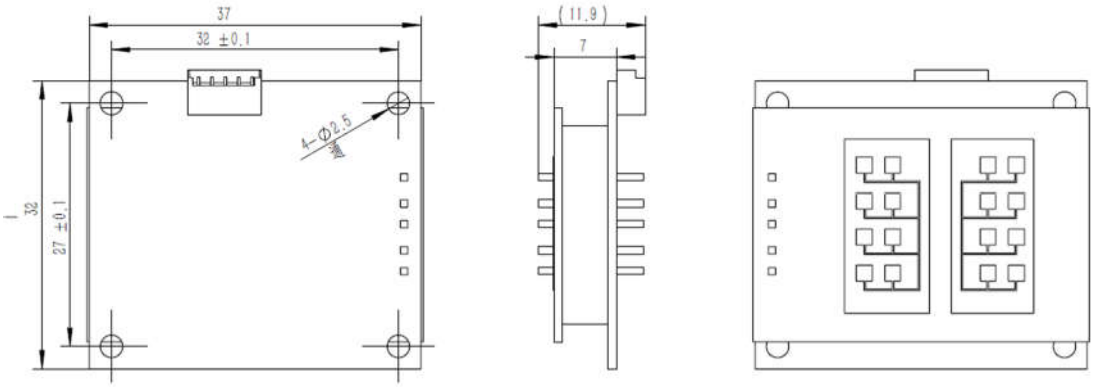
2. Electrical parameters

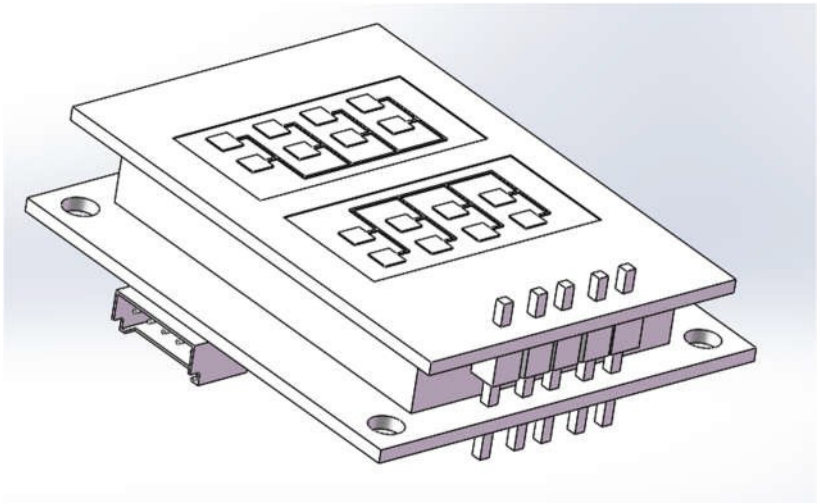
Parameters	Minimum	Typical	Max	Unit
Performance				
Detection range of people in motion		15	20	m
Induction speed sensitivity		0.25		m/s
Perceived distance for stationary		4.5	5	m
Working parameter				
Voltage（VCC）	5.0	5.0	5.5	V
Current（I_{CC}）	90	93	100	mA
Operating temperature（T_{OP}）	-20		+60	℃
Storage temperature（T_{ST}）	-40		+80	℃
Launch parameters				
Working frequency（f_{TX}）	24.0	24.1	24.25	GHz
Transmit power（P_{out}）	+8	+10	+12	dBm
Antenna parameters				
Antenna gain（G_{ANT}）		11.6		dBi
Horizontal beam（-3dB）		80		°
Vertical beam（-3dB）		30		°

Note：There is a certain correlation between the detection distance of the stationary human body and the scene environment.

3. Size and pin

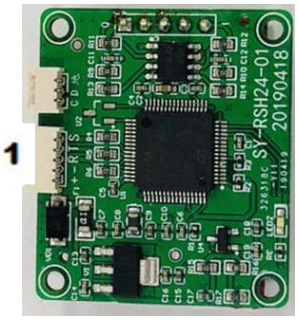
3.1. Size





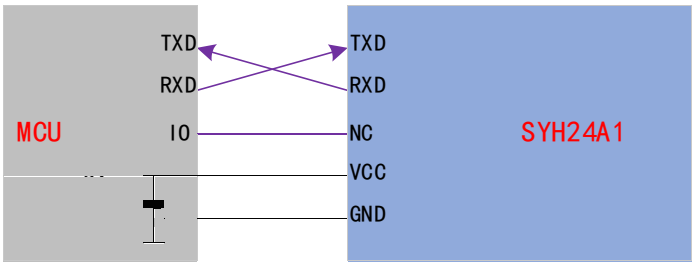
3.2. Pin description

Pin	Desciption	Typical	Desciption
1	VCC	5V DC	Power
2	GND	Ground	Ground
3	ST		Status word
4	TX	Interface, TTL level	
5	RX		



Note: When the device detects someone, the ST output is high; otherwise, the ST output is low when there is no one.

3.3. Wiring diagram



4. Operating mode

4.1. Working range

The beam coverage of this radar module is shown in Figure 1. Radar coverage is a three-dimensional sector with a horizontal 80 ° and a pitch of 30 °. It can sense people and other moving objects in the coverage area in real time.

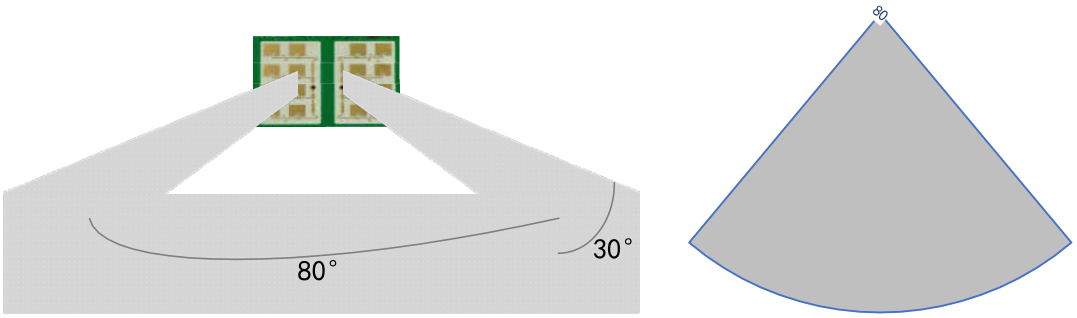


Figure 1 Schematic diagram of radar coverage area

Affected by the characteristics of the radar beam, the radar has a longer operating distance in the direction of the normal of the antenna surface, but the operating distance deviating from the direction of the antenna normal will be shortened.

4.2. Installation method

The recommended installation methods of this radar module include horizontal installation, inclined installation and top installation.

4.2.1. Horizontal installation

Figure 2 shows the horizontal installation method. This installation method is mainly used to detect the human body in a standing or sitting position. It is mainly used in living room and home appliance applications.

The installation height of the radar is recommended to be 1 m to 1.5 m. The radar is installed horizontally and in a forward direction. The installation inclination angle is $\leqslant \pm 5^{\circ}$. There is no obvious obstruction or cover in front of the radar.

The normal direction of the radar is aligned with the main detection position to ensure that the main beam of the radar antenna covers the detection area and the radar beam covers the airspace of human activity.

In this installation mode, the maximum distance for detecting a moving human body is L ⩾ 10 meters; the maximum distance for detecting a stationary human body is L ≈ 5 meters, and the effective distance is generally 3 to 4 meters.

Limited by the range of the radar antenna beam, if it deviates from the position of the radar normal direction, the effective working distance will be reduced.

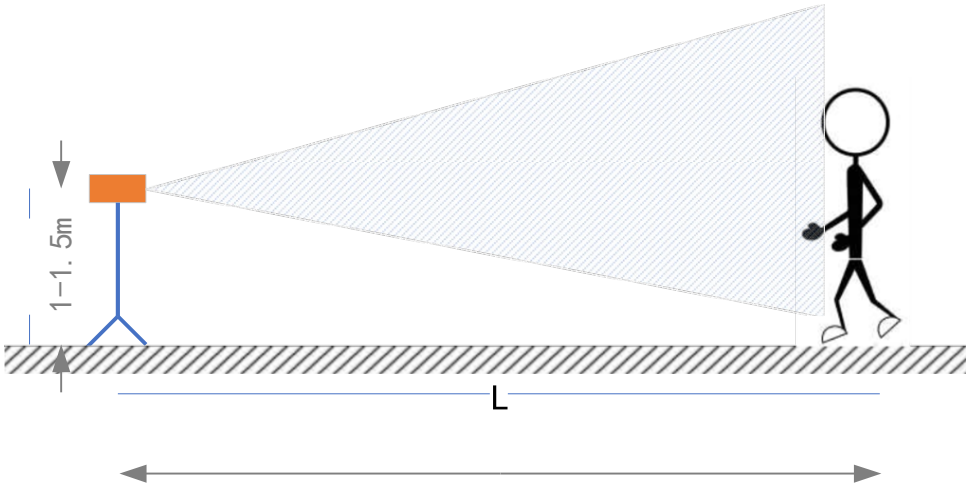


Figure 2 Horizontal installation

4.2.2. Inclined installation

Figure 3 shows an inclined installation. This installation method is mainly used to detect the movement of people in the room, and is mainly applicable to hotels, halls and other places.

The installation height of the radar is recommended to be 2-3 meters; the range of the downward tilt angle of the radar is 10 ° ~ 30 °, and there is no obvious obstruction or cover in front of the radar.

The normal direction of the radar is aligned with the main detection position to ensure that the main beam of the radar antenna covers the detection area and the radar beam covers the airspace of human activity.

In this installation mode, the maximum distance for detection of a moving human body is L ⩾ 10 meters; the

maximum distance for detection of a stationary human body is ⩽ 5 meters, and the effective distance is generally 3 to 4 meters;

In this mode, there may be blind spots in the surveillance area directly below the radar. As the downward tilt increases, the static human detection distance will be significantly compressed.

Affected by the radiation characteristics of the radar antenna, if it deviates from the normal position of the radar, the effective range of the radar will decrease.

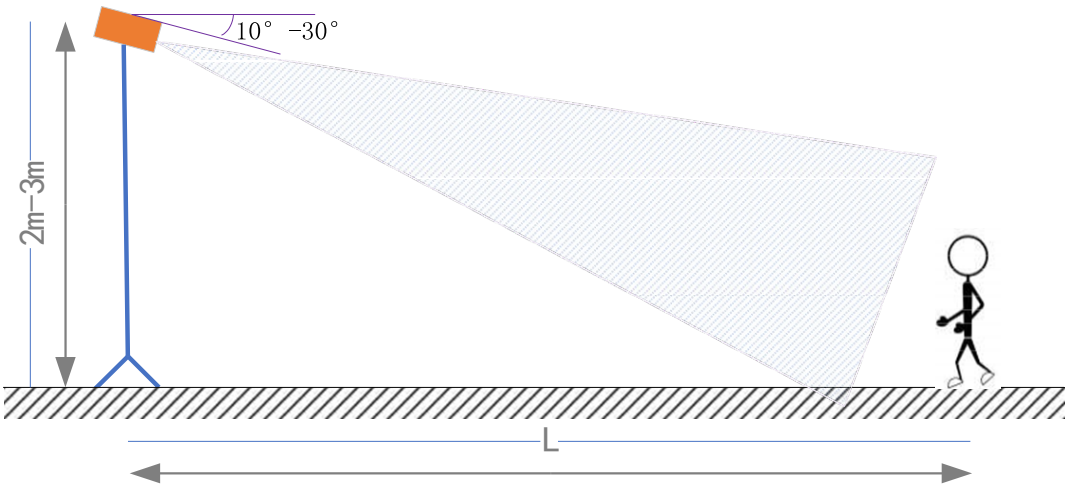


Figure 3 Inclined installation

4.2.3. Top installation

Figure 4 shows the top-mounted installation. This installation method is mainly used for human monitoring in a lying state, such as bedrooms, nursing homes, and hospital beds.

The radar is installed vertically and the horizontal deviation angle is ≤5 ° to ensure that the main beam of the radar covers the detection area. The installation height of the radar is recommended to be 2-3 meters. There is no obvious obstruction and cover in front of the radar.

Affected by the radar installation height and radar beam range, the length of the horizontally acting area L ≈ 3 m to 5 m.

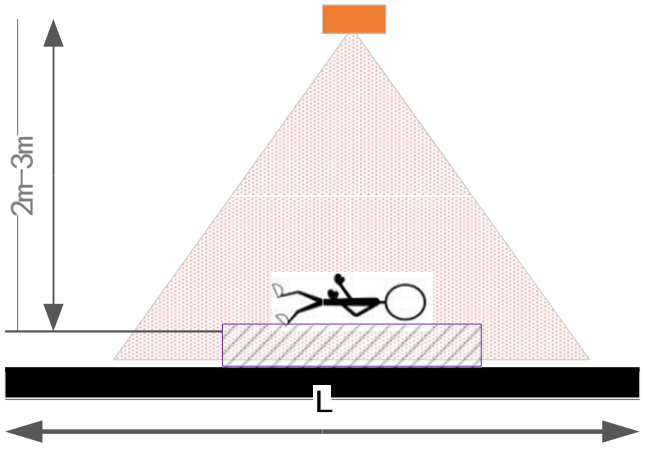


Figure 4 Top installation

Note:

A. The above-mentioned different installation methods all need the radar main beam to cover the main active area of the human body, and face the normal direction as much as possible;

B. When installed obliquely, the horizontal working distance will be correspondingly reduced due to the change in the horizontal projection of the coverage area;

C. When the module is working, the surface of the module should not be covered by metal objects;

D. Affected by the electromagnetic wave transmission characteristics, the radar's working distance is related to the target RCS, the material and thickness of the target covering, and the radar's effective working distance will change to some extent.

E. Corresponding to the detection of the human body in the stationary state, different positions will affect the radar's working distance, and it is not guaranteed that all states will reach the maximum working distance.

4.3. Working mode

This radar module can realize parameter operation mode or state operation mode under the parameter setting control.

✧Parameter operation mode: The parameter operation mode directly sees the output of radar detection parameters. Users can develop related applications based on the output parameters.

✧Status operation mode: The status operation mode is that the radar module comprehensively evaluates the status of personnel in the current detection area after statistical analysis and processing. The user can directly use the result.

Parameter operation mode

In this mode, the radar output parameters are shown in the following table:

	Output parameters	Parameter Description	Note
1	Speed of movement	When there is a moving target, the moving target speed and moving direction are output in real time. Refresh rate: ≥10Hz	
2	Biometric	When there is personnel activity in the detection area, the personnel status value will be output. Refresh rate: ≈9s / times	

The user can evaluate the movement status of personnel in the current radar detection area based on the real-time output parameters of the target and the specific application of the user.

Status operation mode

In this mode, the radar module periodically gives the existence status and movement status of the perso nnel in the current detection area. The main statuses include:

(1) No one's situation;
(2) Someone's condition-static state (sleep state);
(3) Someone's condition-active state;
(4) Someone's condition-approaching state;
(5) Someone's situation-stay away.

In the state running mode, in order to determine the accuracy of the environmental status, the radar module has performed logic discrimination. The status output logic of the radar module is as follows:
A. Only when the radar device detects a state change, the radar will have a corresponding status output; otherwise, the radar remains silent;
B. The radar switches from an unmanned state to a manned state (moving, approaching, or distant), which is a fast switching state. The switching time is ⩽1s;
C. The radar switches from a human state to an unmanned state, which requires multiple state confirmations. The switching time is ⩾2min.

Note: In extreme cases, some users have high electromagnetic noise in the use environment, which can easily cause misjudgment of the status. In the case of the current harsh environment, the internal algorithm of the module supports the learning and adaptation of the existing environment characteristics in an unmanned scenario to reduce the misjudgment caused by the module detection in a harsh environment. The learning process needs to be powered on in an unmanned environment. Run for about 2 hours.

5. Typical application mode

This module is mainly used in home, home appliances, energy-saving light control and other scenarios. The application modes of typical scenarios are described below.

5.1. Smart Appliances

The radar is installed inside the home appliance and will monitor the working conditions of the home appliance in real time.
The device will adjust the working mode of the device (working, low power consumption, standby, shutdown, etc.) in real time or near real time according to the status of the working personnel (manned / unmanned, active / static, approaching / away), so as to realize intelligent home appliances.

In this application scenario, the radar is installed on the equipment radar. Depending on the normal nature of the equipment, the radar is installed horizontally or tilted to ensure that the radar beam can cover the main area of the equipment.

Conventional appliances include:

Smart TV

Smart speaker

Smart air conditioner

Other smart home appliances

5.2. Home place applications

In homes, hotels, offices, bathrooms and other places, it is necessary to detect the presence or absence of people in the place or whether the people in the place are in motion in real time, so as to achieve purposes such as security, electrical control, and personnel monitoring. We need a product that can avoid privacy leakage, this radar device can achieve these functions.

It can be installed in a room to monitor the presence of moving targets, the direction of movement of people, and the presence of people in the room in real time. And through the Internet of things transmission methods and means, combined with the relevant Internet of Things support platform, to achieve effective applications in relevant places.

This radar can be applied in the following areas:

Home Security

Hotel Management and Monitoring

Community Rehabilitation Staff Monitoring

Office monitoring

5.3. Installation and application in the bedroom

For specific applications, real-time monitoring of bedridden related information, such as presence / absence, sleep status, sleep depth, exercise information, etc., and then provide relevant data to achieve specific applications. In this mode, the radar needs to be mounted on the ceiling.

Based on this mode application, you can implement applications including

Elderly care

Health care

Hotel application

Family health

5.4. Energy-saving control applications

Based on the functions of moving target detection and biometric detection, this radar can have better applications in energy-saving control. The main application modes are as follows:

Home appliance energy saving

Office appliances energy-saving control

Energy saving control of street lights

6. Module interface protocol

6.1. Interface introduction

The radar module and the host computer use the serial communication mode. The serial communication is defined as follows:

Interface level: TTL

Baud rate: 9600

Stop bits: 1

Data bits: 8

Parity: None

6.2. Frame structure and description

The frame structure of radar communication is shown in the following table.

Start code	Data length		Function code	Data	Check code	
0x55	ID_L	ID_H	COMMAND	DATA	CRC16_L	CRC16_H
1BYTE	1BYTE	1BYTE	1BYTE	nBYTE	1BYTE	1BYTE

Explanation:

A. Start code: Fixed at 0x55.

B. Data length: 2Byte.

Length = data length (2Bytes) + function code (1Byte) + data (nBytes) + check code (2Bytes)

C. Function code: 1Byte

Upper four bits: reserved (default is 0) read command-0x01

Write command-0x02

Control command-0x03

Active report command-0x04

Test mode: 0x05, factory verification mode.

D. Data: data address + data information

6.3. Frame data details

This module communication includes two parts: uplink communication (the radar module outputs to the host computer) and downlink communication (the host computer outputs to the radar module).

6.3.1. Downlink communication

✧ Host computer sends control instructions to radar module

Control commands 0x03			
Data address	Content	Data information	Note
0x02	Sleep mode	No	
0x04	Stop working	No	
0x05	Parameter operation mode	No	Default mode
0x06	State operation mode	No	

✧ Host computer sends read command to radar module

Read command 0x01			
Data address	Content	Data information	Note
0x01	Read device ID	No	
0x02	Read working status	No	
0x04	Read environmental status	No	
0x08	Read parameter information		
0x05	Equipment type Manufacturer ID Software version Protocol version		Each tag identifies two bytes, a total of eight bytes

6.3.2. Uplink communication

✧ Radar module returns data

Radar output data 0x02					
Data address	Content	Data information	Content	Data	Note
0x01	Output device ID	ID		4Bytes	
0x02	Output working status	0x01		No	
		0x02		No	
0x04	Environmental status information	0x00 unmanned	Parameter operation mode	No	Default output status
		0x01 Stationary state		0x01	
		0x04 Active status		0x04	
		0x08 Keep		0x08	
		0x10 Keep away		0x10	
	Parameter information	0x20 Speed of movement	State mode	4Byte	32bit floating point
		0x40 Biological strength		4Byte	

0x08	Output parameter	No		No	
0x05	Output version information	Equipment type, Manufacturer ID Software version, Protocol version			8Byte

✧ Radar module returns data

Active report command 0x04			
Data address	Content	Data information	Note
0x02	Power-on status report after accidental power failure	10byte	The specific report content is described in the following table

✧ Radar reports other information-0x02:

Data number	Data information	Content	Note
Data1-4	4Bytes	Device ID	
Data5	0x01or0x02	Working condition	
Data7	0xxx/0x01/0x02/0x04/0x08/0x10	Environmental status	
Data7-10	Reserve	Reserve	

✧ Radar module test data

Test mode 0x05			
Data address	Content	Data information	Note
0x01	Person sensor enters self-test mode (reserved)	No	Send from other hosts
0x02	Device returns self-test result (reserved)	error code 0- normal; 1-255 failure;	Personnel sensor return

6.4. Frame check

- ✧CRC-16 / MODBUS x16 + x15 + x2 + 1 for verification
- ✧Width: 16 bits, Poly: 0x8005,
- ✧Inti: 0xffff (CRC from start code to command value).

Frame check c language code

C implementation of CRC16 check used in this protocol: The initial check code used in this protocol is 0xffff,
The function qioucrc16 (0xffff, xx, xx) is directly called when the CRC16 check value of n bytes is obtained, and the return value of this function is the CRC16 check value requested.

```
/*------------------------------------------------
Function description: find the CRC check code of the data crc is the initial check code, * buf is the initial address, and x is the number requested
------------------------------------------------*/
unsigned int qioucrc16(unsigned int crc,unsigned char *buf,unsigned int x)
{
    unsigned char hi,lo;
    unsigned int i;
    for (i=0;i<x;i++)
    {
        crc=calccrc(*buf,crc);
        buf++;
    }
    hi=crc%256;
    lo=crc/256;
    crc=(hi<<8)|lo;
    return crc;
}
/*------------------------------------------------
How to call : unsigned int calccrc(uchar crcbuf,uint crc)
Function description: find the CRC code of CRCBUF based on crc
------------------------------------------------*/
unsigned int calccrc(unsigned char crcbuf,unsigned int crc)
{
    unsigned char i;
    unsigned char chk;
    crc=crc ^ crcbuf;
    for(i=0;i<8;i++)
    {
      chk=crc&1;
      crc=crc>>1;
      crc=crc&0x7fff;
      if(chk==1)
      crc=crc^0xa001;
      crc=crc&0xffff;
```

```
}
return crc;       }
```

6.5. Protocol routines

6.5.1. Control commands（0x03）

✧ Control commands - Operating mode

	Start code	Data length		Function	Data address	CRC16	
Host sends	55	06	00	03	05	E9	B4
Device return	55	06	00	03	05	E9	B4

✧ Control commands - Sleep mode

	Start code	Data length		Function	Data address	CRC16	
Host sends	55	06	00	03	02	A9	B5
Device return	55	06	00	03	02	A9	B5

6.5.2. Read command（0x01）

✧ Read command - Read device ID E.g：701D0801

	Start code	Data length		Function	Data address	Data information	CRC16	
Host sends	55	06	00	01	01	No	E8	D4
	Start code	Data length		Function	Data address	Data information	CRC16	
Device return	55	0A	00	02	02 01	70 1D 08 01	7D	38

✧ Read command - Read environmental status E.g: Someone / moderate exercise

	Start code	Data length		Function	Data address	Data information	CRC16	
Host sends	55	06	00	01	04	No	28	D7
	Start code	Data length		Function	Data address	Data information	CRC16	
Device return	55	07	00	02	04	04	4F	1C

6.5.3. The slave actively reports the command（0x04）

✧ Information reported by personnel sensors—0x02

E.g: Device ID：701d0801，working state, slight movement

	Start code	Data length		Function	Data address	Data1	Data2	Data3
Send from the	55	10	00	04	02	70	1D	08

Data4	Data5	Data6	Data7	Data8	Data9	Data10	CRC16	
01	01	04	00	00	00	00	49	93

7. Precautions

7.1. Start Time

When the module starts to work when it is initially powered on, it is necessary to completely reset the internal circuit of the module and fully evaluate the environmental noise to ensure the normal operation of the module. Therefore, when the module is initially powered on, it needs a startup stability time of ⩾30s to ensure the validity of subsequent output parameters.

7.2. Effective detection distance

The detection range of the radar module is greatly related to the target RCS and environmental factors. The effective detection range may change with changes in the environment and the target. This module does not have a ranging function for the time being, so it is normal for the effective detection range to fluctuate within a certain range.

7.3. Radar biological detection performance

Because human biological characteristics belong to ultra-low frequency and weak reflection characteristic signals, radar processing requires a relatively long cumulative processing. During the cumulative process, many factors may affect the radar parameters, so occasional detection failure is normal.

7.4. Power

The radar module requires higher power quality than conventional low-frequency circuits. When powering the module, it is required that the power supply has no threshold glitches or ripples and that it effectively shields the power supply noise caused by accessory equipment.

The radar module needs to be well grounded. Due to the ground noise brought by other circuits, the performance of the radar module may even be reduced or even work abnormally; the most common cause is a shorter detection distance or an increased false alarm rate.
In order to ensure the normal operation of the VCO circuit inside the module, the power supply requirement for this module is + 5V- + 6V power supply, especially the power supply voltage cannot be lower than 5V.

The external power supply must provide sufficient current output capability and transient response capability. The supply current must be at least 150mA.

8. FAQ

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9. Disclaimer

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11. Version

Version	Content	Date	Producer
V0.1	Adjust output format	2019-8-15	
V0.2	Radar module unmanned state output delay	2019-10-22	
V0.3	Increase radar IO output	2019-11-21	
V1.0	Increase radar mounting angle	2019-12-3	