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MR24FDB1

24GHz mmWave Radar Sensor – Fall Detection Module Datasheet

Product features

- Stationary body detection

- Vital signs detection

- 24GHz millimetre wave radar sensor

- Realisation of the radar scanning area person sensing function based on Doppler radar technology.

- Simultaneous sensing of moving and stationary persons

- Maximum distance for motion sensing: ≤ 12 m

- Maximum distance for micro–motion sensing: ≤ 5 m

- Maximum distance for human body sensing: ≤ 3 m

- Maximum distance for fall detection: ≤1.5 m

- Antenna beamwidth MR24FDB1: Horizontal 90°/vertical 60° sector beam

- Scene recognition capability, identify occupied/unoccupied and personnel activity status, output body movement

- unaffected by temperature, humidity, noise, airflow, dust, light, etc., suitable for harsh environments

- low output power, no harm to human body for long time irradiation.

- Detection time from unoccupied to occupied: within 0.5 seconds

- Detection time from man to man: more than 1 minute

Description of Models

The MR24FDB1 is a highly accurate narrow beam fall detection radar sensor of 90/60 degree sector, and it is more suitable within a 6-meter range.

Product Applications

For human detection:

- Healthcare

- Intelligent household appliances (TV, Yuba, security, etc.)

- Office energy saving (air conditioning, lighting)

- Sleep monitoring (sleep curve)

- Home security

- Automatic doors, elevators, etc

Fall detection applications

The detection of falls in wet and slippery environments, such as the kitchen and toilet, as well as places where there may be fall hazards.

Product Packaging

Volume: ≤ 35MM x 30MM x 5MM

Interface: PITCH 2.0MM interface, double row of pins

CONTENTS

1. Overview

The MR24FDB1 radar module uses millimeter-wave radar technology to detect humans' motion and biological features. Based on enhanced Doppler radar signal processing technology, this module provides wireless detection and reports the presence and fall status of personnel in real-time through synchronized scanning technology based on Doppler parameters of movement and physiological parameters of the personnel.

This is a two-array element antenna module. This wide beam radar module is primarily suitable for top mounting to achieve detection over a wide area. If the radar is mounted horizontally or inclinedly, it is necessary to consider the occlusion of the actual scene in order to attain a greater detection range.

This radar module has the following characteristics:
1. Achieve synchronized detection function between moving and static personnel (sitting still and sleeping);
2. The sensor can detect static personnel and provide real-time information.
3. This radar is capable of detecting fall state of personnel in specific locations and providing real-time feedback.
4. It can quickly report how far or near a target is.
5. Real-time monitoring of motion amplitudes with numerical output.
6. Detecting only biological objects (moving or stationary) and eliminating the interference of other inanimate objects in the environment;
7. This module has the ability to eliminate the interference caused by nonliving objects as well as to detect nonliving moving objects;
8. It is suitable for secondary development and can be customized;
9. Providing a universal interface for UART communication
10. Four I/O groups are reserved for user-defined applications and simple interface simulation.
11. Low output power, no harm to the human body
12. Temperature, light, dust, and other environmental factors do not affect the radar's performance. Yet it is very sensitive and has a wide range of applications.

2. Electrical characteristics and parameters

2.1. Detection angle and distance

Parameter content	Minimum value	Typical values	Maximum value	Unit
MR24FDB1 (8–point narrow beam antenna)				
Movement personnel detection distance	–	–	13	meter
Distance perceived by stationary/slightly mobile personnel	–	–	5	meter

Parameter content	Minimum value	Typical values	Maximum value	Unit
Sleeper perception distance	–	–	2.5	meter
Fall state sensing distance			1.5	meter
Radar detection angle (horizontal)	–	90	–	degree
Radar detection angle (pitch)	–	60	–	degree

2.2. Electrical characteristics

Operating parameters	Minimum value	Typical values	Maximum value	Unit
Operating voltage (VCC)	4.5	5.0	6	V
Operating current (ICC)	90	93	100	mA
Operating I\O Inflow/Output Current (IIO)	–	8	20	mA
Operating temperature (TOP)	–20	–	+60	℃
Storage temperature (TST)	–40	–	+80	℃

2.3. RF Performance

Launching parameters				
Operating frequency (fTX)	24.0	–	24.25	GHz
Transmitted power (Pout)	–	–	6	dBm

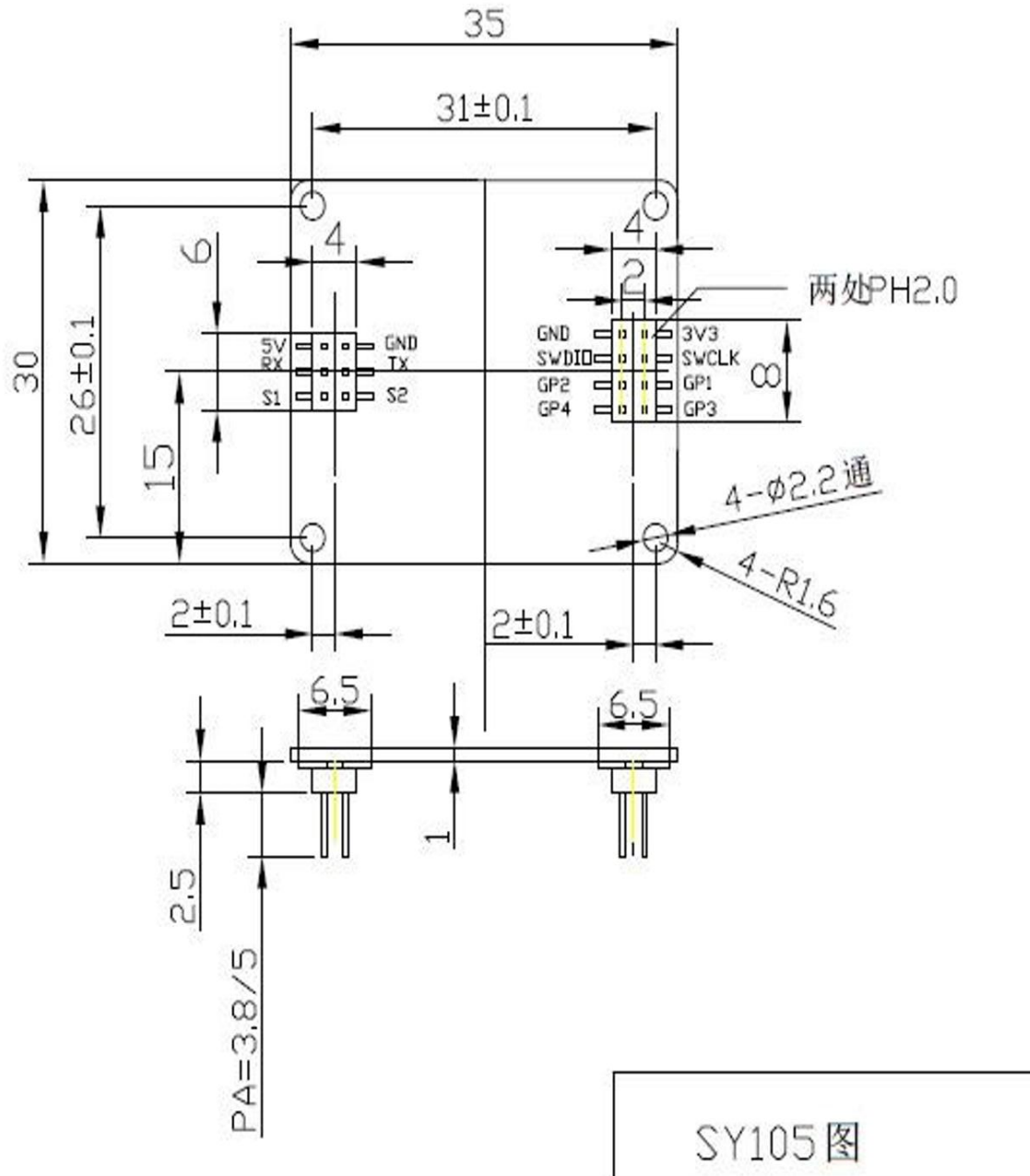# 3. Module dimensions and pin description

3.1. Module size package

Fig. 1 Schematic diagram of the radar module structure

3.2. Pin descriptions

Interface	Pins	Description	Typical values	Description
Interface 1	1	5V	5.0V	Positive power input
	2	GND		Ground
	3	RX		Serial port reception
	4	TX		Serial port send
	5	S1	3.3V/0V	occupied/unoccupied
	6	S2	3.3V.0V	Stationary / Active
Interface 2	1	3V3	3.3V	Output power
	2	GND		Ground
	3	SL		Reserved
	4	SD		Reserved
	5	GP1		Spare expansion pins
	6	GP2		Spare expansion pins
	7	GP3		Spare expansion pins
	8	GP4		Spare expansion pins

Notes

1. S1 output: high level - occupied, low level - unoccupied.
2. S2 output: high level - active, low level - stationary.
3. GP1 to GP4 are parameter selection controls, which can be redefined according to user requirements.
4. The output signals of this interface are all at 3.3V level.
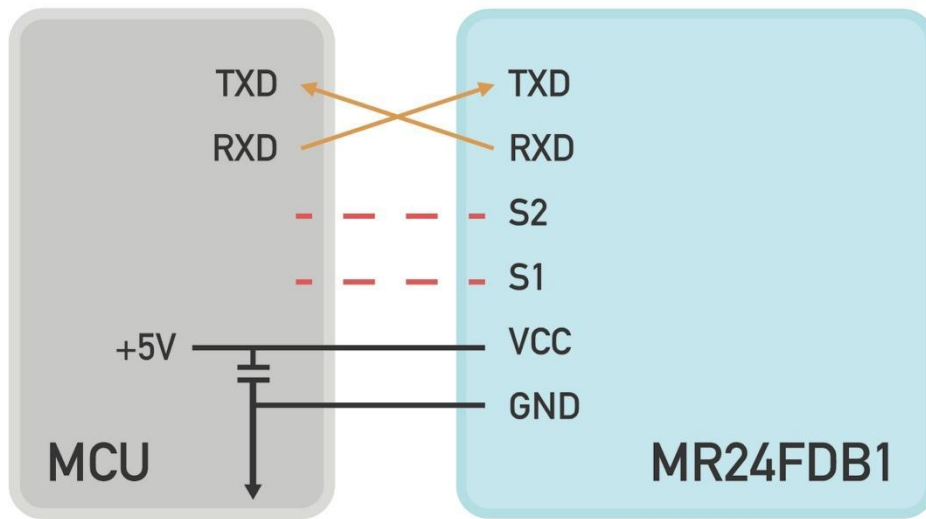
3.3. Using the wiring diagram

Fig. 2 Schematic diagram of the radar module and peripheral connections

4. Main operating performance

4.1 Radar module operating range

Figure 4 illustrates the beam coverage of the MR24FDB1 radar module. Basically, it covers a three-dimensional area with a horizontal angle of 90° and 60° inclined.
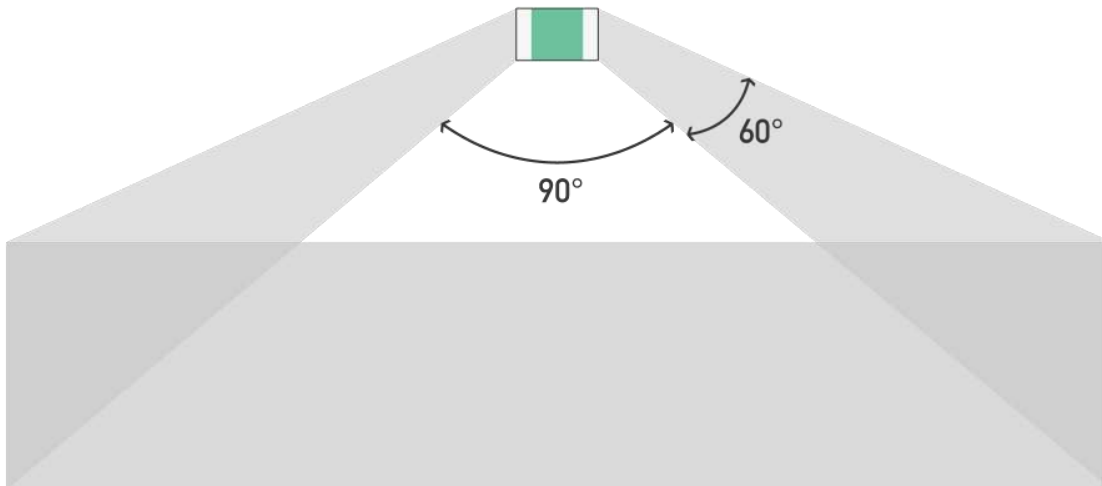

Fig. 3 MR24FDB1 Radar coverage area Schematic diagram

Due to the characteristics of the radar's beam, it has a long-range coverage in the direction normal to the antenna surface but a short-range if it deviates from the normal direction of the antenna surface.

Additionally, the radar's range will be reduced when it is mounted on top or angled. This is due to the effect of the beam and effective radiation space. It is important to consider this when using the device.

4.2. Main functions and performance

The main functions of this radar module are:
   a. Motion detection function

  i. Maximum detection distance: ≤ 13m (adult);

  ii. Detection sensitivity: ≤ 0.2m/s;

  iii. Reaction time: ≤ 100ms;

   b. Micro motion detection;

  i. Maximum detection distance: ≤ 5m;

  ii. Reaction time: ≤ 1s;

   c. Breath detection function;

  i. Maximum detection distance: ≤ 2.5m;

  ii. Reaction time: ≤ 60s;

   d. Fall detection function:

  i. Maximum detection distance: ≤ 1.5m;

  ii. Accurate detection of movement: rapid fall movement;
  iii. Reaction time: 1s;

   e. Environmental status assessment function;
   f. Early warning design function.

# 5. Radar installation and mode

5.1. Installation methods

There are three recommended installation methods for radar modules: horizontal, inclined and overhead. (when it's necessary to use the fall function, it can only be installed on top, and the installation is only for wet and slippery areas like the kitchen and toilet where there is a risk of falling.)

5.1.1. Top–mounted installation

Figure 4 illustrates how it is installed on top. This installation method is typically used to monitor human bodies (e.g. in a bedroom, nursing home, or hospital bed), determine fall

hazards in wet and slippery environments, and to detect people who are asleep.

In order to ensure adequate coverage of the detection area, the radar installation height should be set at *2.75M, with the horizontal deviation angle set at 3°. There is no obvious shelter or cover in front of the radar. According to the radar installation height and radar range, the maximum detection distance of moving human bodies is L3 * 6.5m, that of human sitting/inching is L2 * 3m, and that of human sleeping is L1 ≈ 1.8m.

According to radar installation height, radar beam range, and calculation logic of the fall-related model, the maximum fall detection distance of the human body is L4 ≈ 1.5m..

Mobile Trigger

Static micro-movement hold

Fall Detection
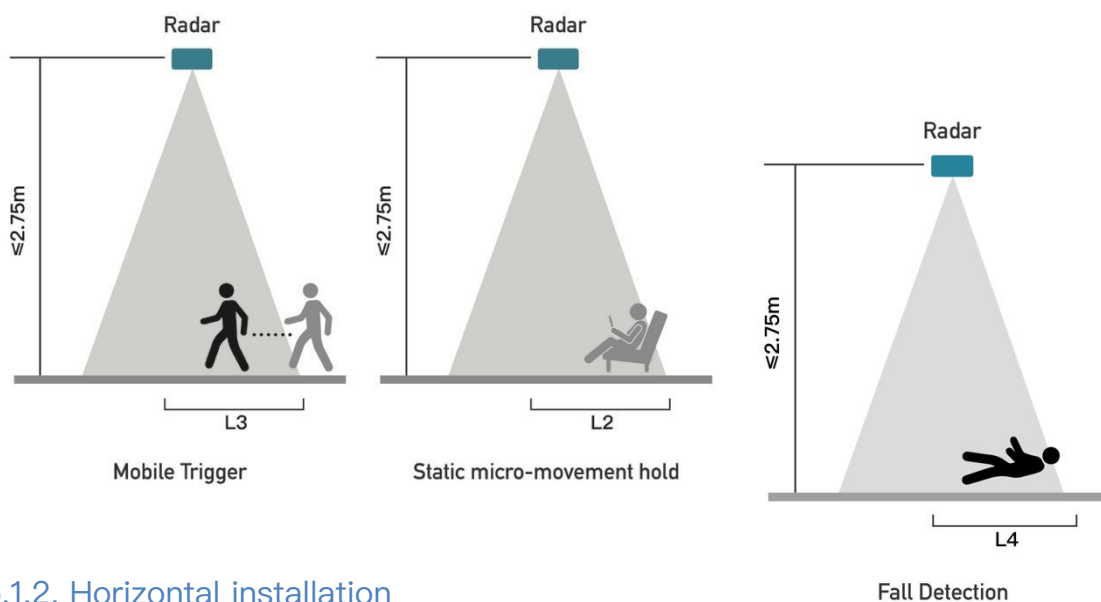
5.1.2. Horizontal installation

Figure 4 shows the horizontal installation method. The method is primarily used to detect the presence of the human body in a standing or sitting position, such as in a living room, home appliance applications, and other situations.

The recommended installation height for the radar is between 1 and 1.5 meters. The radar should be installed horizontally and forward, with an inclination of ≤± 5o. There should be no obvious interfering objects or covering in front of the radar.

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

The maximum detection range of moving human bodies is L3 ≤12m; The maximum distance of detection for seated or inching humans is L2 ≤ 5m; The maximum distance of detection of sleeping humans is L1 ≤ 2.5m;

The maximum effective range will be affected by deviations from the normal direction of the radar. The millimeter-wave band electromagnetic field has certain penetration characteristics for non-metallic materials and can penetrate common glass, wood, screen, and thin partition walls, as well as to detect moving objects behind the shelter; however, a thick bearing wall and a metal door cannot be penetrated.
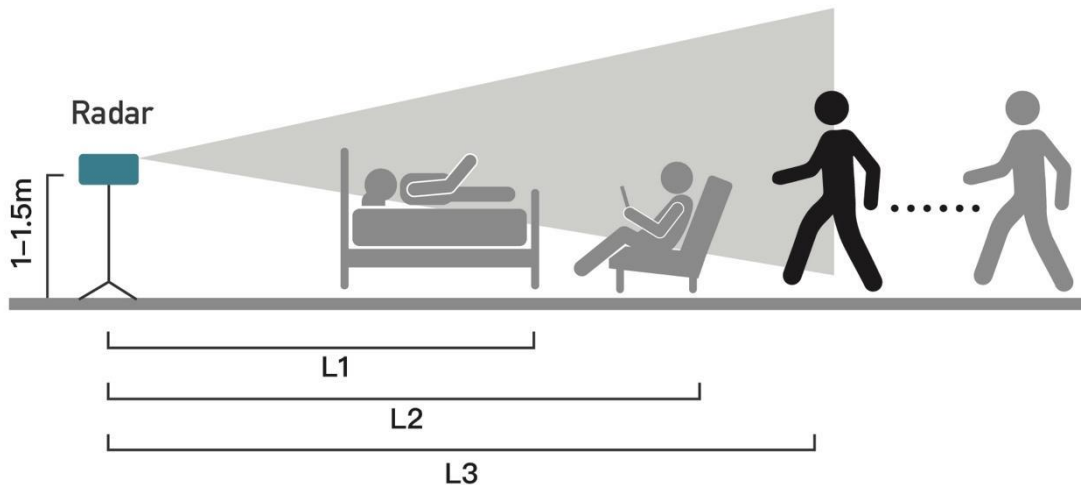
5.1.3 Tilt mounting

Generally, this installation method is intended to detect movement in a room, and it is primarily applicable to hotels, halls and other public spaces.
The recommended installation height of the radar is 2 - 2.75m; The radar's downward inclination angle range is 10 - 30 degrees, and there is no obvious shelter or cover in front of the radar.
The normal direction of the radar is aligned with the radar's main detection area to ensure the radar antenna's main beam covers the detection area and the radar beam covers the human activity airspace.
This installation mode allows the maximum detection distance of a moving human body, denoted as L3, to be about ~7 meters; while the maximum detection distance for human sitting and inching, denoted as L2, is ~4 meters, and the maximum detection distance for human sleep L1 is ~ 3 meters.
When operating in this mode, there may be a blind area under the radar and adjacent to it. As the dip angle increases, the detection distance of the static human body will be significantly reduced. Depending on the radiation characteristics of the radar antenna, the range of the radar will be reduced if it deviates from the normal direction of the radar.

Caution.
   A. In the various installation methods above, the radar's main beam should cover the human body's main activity area and face the normal direction as much as possible.

B. When it is installed obliquely, the horizontal action distance will be correspondingly reduced due to the change in the horizontal projection of the coverage area.
C. When the module is working, metal objects should not be placed on its surface.
D. Affected by the transmission characteristics of electromagnetic waves, the radar range is related to the RCS of the target, the material, and the thickness of the target cover; the radar effective range will change to a certain extent.
E. In the case of a human being in a static state, varying body positions would affect the radar range, and the radar could not guarantee that every state would reach the maximum range.

5.2 Radar module operating modes

After analyzing and processing the statistical data, the radar module provides a comprehensive evaluation of persons' status in the current detection area, and the data can be directly used by the users.

● Status operation mode

In this mode, the radar module periodically reports the presence and movement status of humans in the current radar detection area. The main statuses include
  1) unoccupied.
  2) occupied, stationary.
  3) occupied, active.
During the status operation mode, the radar module performs internal logic discrimination to determine the environmental status's accuracy. The radar module status output logic is as follows;

a. Radar can only produce a corresponding state output when it detects the change in state; otherwise, it remains inactive.

b. The radar rapidly switches from an unmanned to a manned state (moving, approaching, and far away), and the switching time is ≤ 1 second.

c. Whenever the radar is switched from manned to an unmanned mode, it needs to be confirmed many times, and the switching time is ≥ 1 minute;

The fall detection mode

In this mode, the radar module detects whether a falling action state occurs within the detection range in real-time and reports the falling action state alarm in real-time. The main states are

1. Assessment of suspected falling state;
2. Fall state judgment;
3. long-term evaluation of alarm state;

When the fall detection mode is in use, the radar module must be installed on top, at a

height ≤ 2.75m, and in wet and slippery environments such as toilets and kitchens where

falls may occur.

6. Typical application mode

This module has many applications, including house appliances, energy-saving light control, health care, and others. Following are a few examples of typical applications.

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6.1. Smart appliance applications

The radar is installed inside the home appliance equipment and records the status of the personnel working on the appliance equipment in real-time. By adjusting the equipment's working mode (working, low power consumption, standby, shutdown, etc.) in real-time or quasi-real-time based on the status of the working face (manned/unmanned, active/static, close / far away), the appliance becomes intelligent.

The radar is installed inside the appliance and monitors the working surface of the appliance in real-time. The appliance adjusts its operating mode (working, low power consumption, standby, off, etc.) in real-time or quasi-real-time based on information based on the working surface personnel (occupied/unoccupied, active/stationary, close/away).

Radar is installed on the equipment in this scenario. As part of the routine operation of the equipment, the radar is installed horizontally or obliquely to guarantee that the radar beam covers the main work area.
Conventional household appliances include

● Smart TVs

● Smart speakers

● Smart air conditioners

- Other smart home appliances

6.2. Home applications

For places such as homes, hotels, offices, and bathrooms, real-time detection is needed to enable security, electric control, staff monitoring, and a lot more, while at the same time avoiding privacy concerns. When installed in the room, the radar can monitor in real-time whether a target is moving, what direction people are moving, the presence of people, etc. By using IoT transmission methods and means with the relevant IoT support platform, we will be able to maximize the effectiveness in other relevant applications. The radar is applicable to the following areas.

- Home security

- Hotel management and monitoring

- Community recreation personnel monitoring

- Office monitoring

6.3. Applications and installations for bedrooms

Specific applications are enabled by providing real-time information about the person in bed, such as presence/absence, sleep status, sleep depth, movement information, etc. In this mode, the radar must be mounted above the bed.

This mode can be used to implement a variety of applications, which include

- Elderly care

- Health care

- Hotel applications

- Home health

6.4. Energy–saving control applications

The radar's motion target and biometric detection capability enable it to have much better applications in energy-saving control. The main application modes are as follows.

- Home appliance energy saving

- Energy–saving control of office appliances

- Street lighting energy–saving control

6.5. Health care applications

Due to the radar's ability to detect sleep state and respiratory rate, it can be used to monitor a person's health. The main application modes are as follows

- An intelligent health appliance linkage application

7. Notes

7.1. Start–up time

To ensure the smooth operation of the module after the initial power-on, it is necessary

to completely reset the internal circuit of the device and evaluate the environmental

noises. Therefore, when the module is initially powered on, it needs to be powered on for

a stable time ≥ 30s to ensure the effectiveness of subsequent output parameters.

7.2. Effective detection distance

For the time being, this radar module does not feature a ranging function. Its range of detection is closely related to the RCS of the target and the environment in which it operates. Therefore, the effective detection range may change depending on the environment and the target. So, it is normal for the effective range of detection to change within a certain range.

7.3 Radar biodetection performance

Since human biological characteristics are characterized by ultra-low frequencies and weak reflections, the accumulation process of the radar will be relatively lengthy.In the process of accumulation, many factors can influence the radar parameters. It is therefore normal for accidental detection failure to occur.

7.4. Power supply

This radar module has a higher power quality requirement than conventional low-frequency circuits. The power supply must be free of threshold burr and ripple and protect the module from power noise from accessories.

The radar module should be well-grounded. As a result of ground noise caused by other circuits, the radar module may perform poorly or even malfunction. In most cases, the detection distance becomes closer, or the false alarm rate increases.

The module's power supply must be with +5v ~ +6v and a voltage ripple of 100mV to ensure the normal operation of the module's VCO circuit.

External power supplies must provide sufficient current output and transient response capability.

8. Common problems

Interference factors

The radar is an electromagnetic wave sensor, and the presence of an active nonliving object will result in a false alarm. Metal and liquid will cause the radar to make an incorrect judgment. An electric fan, a pet within range of the radar, or the sway of the curtain can all cause miscalculations. Therefore, the installation angle of the radar should be considered.

Non-interference factors

The radar's electromagnetic waves can penetrate human clothing, curtains, veneers, and glass. The installation angle and performance of the radar should be determined according to the intended use.

Semi-interference factors

The radar detects the presence of a human body, which is not ideal for facing the air conditioner directly. This is due to the internal motor of the air conditioner causing the radar to misjudge. The radar is not necessary to be directed at the air conditioner.

9. Disclaimers

When publishing documents, we believe that the description should be as accurate as possible. Given the technical complexity of the product and the differences in the

working environment, it is still difficult to exclude the possibility of inaccurate or incomplete descriptions. Therefore, this document is intended only as a user guide. We reserve the right to make changes to the product without notifying the user. Our company does not make any legal commitment or guarantee. Encourage customers to provide feedback regarding the latest updates to products and support tools.

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11. Historical version update notes

Revision	Release Data	Summary
V1.0_1012	2020/10/12	First draft
V1.1_1126	2020/11/26	Added close to away and scene modes
V1.2_1209	2020/12/9	Take the proximity away from the ambient state
V1.3_1214	2020/12/14	1: added the heartbeat packet specific environment parameter to 2: modified the fixed character near the away from parameter to 0x01 0x01 3: Modified the interval definition of the motion sign parameter
V1.4_0106	2021/1/6	Passive reporting of scenario setting data bit fix errors
V1.5_0317	2021/03/17	Overall perfection