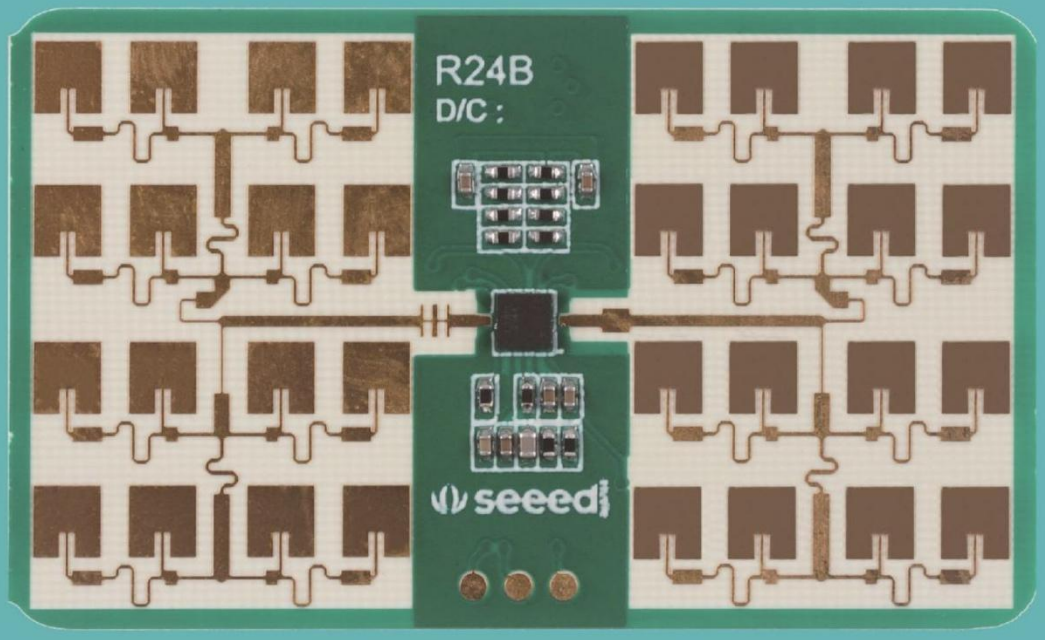
MR24BSD1

Respiratory sleep detection



Product features

- Stationary Body Detection
- Vital signs detection
- 24GHz millimetre wave radar sensor
- Based on Doppler radar technology, enabling radar scanning area person sensing functions.
- Realisation of simultaneous sensing functions for moving and stationary persons.
- Maximum distance for human sleep quality monitoring: ⩽ 2.75m
- Maximum distance for human breathing rate detection: ⩽ 1.5m
- Antenna beamwidth R24BBD1: Horizontal 40°/vertical 40° 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

Model description

Type description R24BBD1 – Narrow beam body sensing radar sensor, 40°/40° sector beam (high measurement accuracy, recommended for use at a distance of 6 m)

Product Applications

Sleep detection applications: Sleep monitoring (sleep profiles)

Breath detection applications: Respiratory rate monitoring

Product Packaging

Volume: ⩽ 46MM x 27.5MM x 5MM

Interface: PITCH 2.0MM interface, double row of pins

CONTENTS

1. Overview

The MR24BSD1 radar module uses millimeter-wave radar technology for bio-awareness and human motion detection. The module is based on an improved Doppler radar signal processing mechanism, enabling wireless sensing and reporting of a person's presence and fall status in a location by simultaneously sensing the Doppler of a person's movement and physiological parameters.

The module has a wide beam radar of thirty-two-array antenna format. Wide beam radar modules are mainly suitable for top-mounted mode for achieving a wide range of radar detection; if used for horizontal or inclined installation, you need to pay attention to obscurations in actual scenes in order to achieve a more extended range of radar detection function.

This radar module has the following operating characteristics:

- It simultaneously detects moving and stationary humans (sitting, sleeping).
- It detects stationary humans in real-time.
- Accurate fall detection in specific locations and guaranteed real-time output.
- Rapid output of the target's distance from the radar in terms of distance and proximity.
- It detects a wide range of movements and outputs numerical status in real-time.
- It eliminates inanimate objects' interference in the environment by limiting detection to humans (whether they are moving or still).
- It effectively rejects interference from non-living objects and enables the detection of moving non-living things.
- The system supports secondary development that can be adapted to numerous scenarios and applications.
- A communication interface based on the universal UART standard protocol.
- It has 4 groups of I\O reserved for user-defined input and out or simple interface simulation.
- It has a low power output, posing no danger to the human body.
- A robust module that can be used in a range of sensitive applications since it is not affected by extreme temperatures, light, and dust.

2. Electrical characteristics and parameters

2.1. detection angle and distance

Parameter content	Minimum value	Typical values	Maximum value	Unit
R24BBD1 (32–point narrow beam antenna)				
Sleeper perception distance	–	–	2.75	meter
Fall state sensing distance	0.5		1.5	meter
Radar detection angle (horizontal)	–	90	–	meter
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

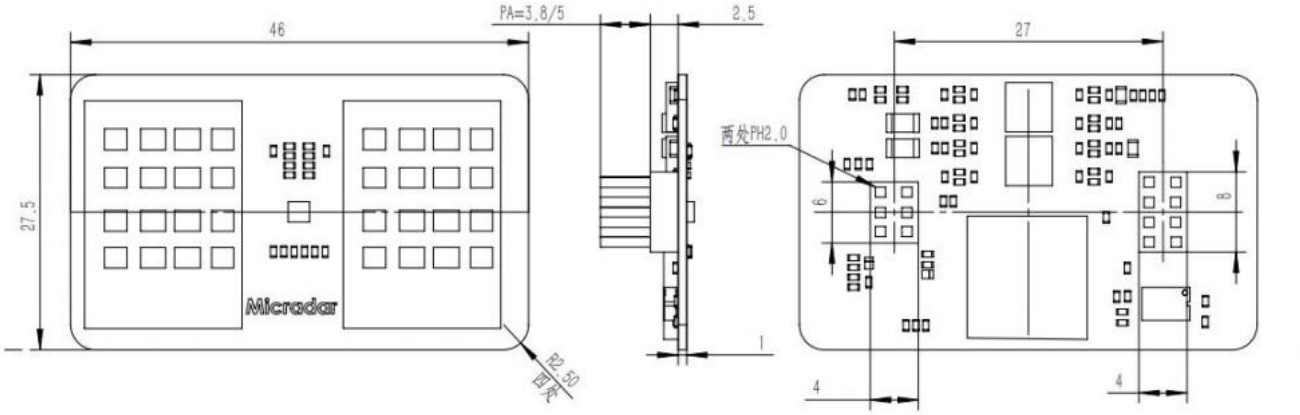


Fig. 1 Schematic diagram of the radar module structure

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

Interface	Pins	Description	Typical values	Description
	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

- S1 output: high level – occupied; low level – unoccupied.
- S2 output: high level – active; low level – stationary
- GP1 to GP4 are parameter selection controls, which can be redefined according to user requirements.
- The output signals of the interface are all at 3.3V.

3.3. using the wiring diagram

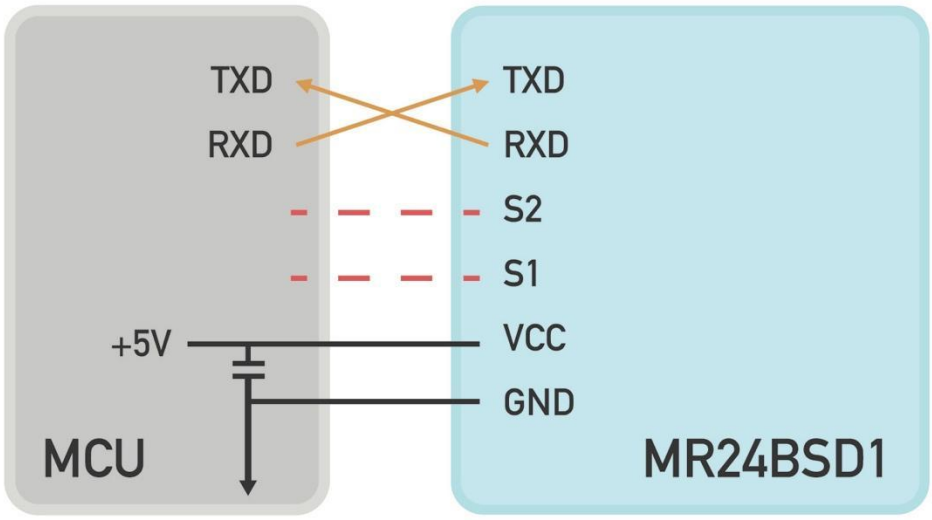


Fig. 2 Schematic diagram of the radar module and peripheral connections

4. Main operating performance

4.1 Radar module operating range

Figure 4 illustrates MR24BSD1 radar beam coverage. It has a 3D coverage of 40° horizontally and 40° tilted.

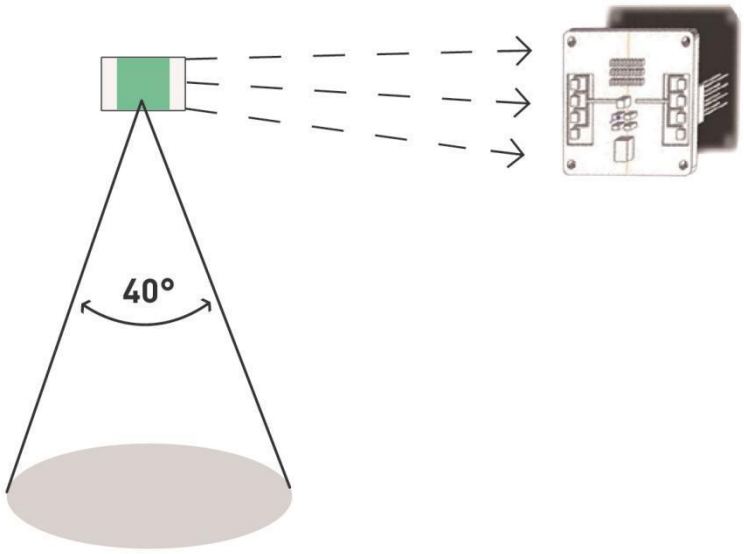


Fig. 4 Diagram of the MR24BSD1 radar coverage area

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.

In addition, when the radar is mounted on top or inclined, its range will be reduced. This is due to the influence of its beam and effective radiation space. This should be put into consideration during usage.

4.2. main functions and performance

The main functions of the radar module include
A. Breath detection.

(1) Maximum detection distance: ≤ 2.75 m.

(2) Reflection time: ≤ 60s.

B. Respiratory rate statistics function.

(3) Maximum detection distance: ≤ 1.5 m.

(4) Maximum respiratory detection frequency: ≤ 30 times

(5) Minimum respiratory detection frequency: ≥ 12 times.

C. Sleep quality assessment function.
D. Sleep time recording function.
E. Environmental status assessment function.
F. Early warning design function.

5. works and installation

5.1. installation methods

It is recommended to select the appropriate installation mode for each function of this radar module

5.1.1 Respiratory rate statistics function

For the respiration frequency statistics function, it is necessary to keep the distance between the radar and the chest within 0.5m-1.5m, and expose the chest within the range of the radar's antenna. (It is recommended that the radar be mounted on top or in an incline position).

5.1.2 Sleep quality assessment function

In the case of the sleep detection radar that is intended to measure sleep quality and time of sleep, the installation method can only be top or inclined position. The radar installation height should not exceed 2.75 meters and is suitable only for resting areas such as above the bed in a bedroom.
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 unmanned mode, it needs to be confirmed many times, and the switching time is ≥ 1 minute;

- Sleep detection mode.

In this mode, the radar module periodically reports the sleeping state and respiratory rate of personnel in the radar area of detection. The main states include

4) Sleep quality assessment: awake, deep sleep, light sleep;
5) In- and out-of-bed judgments
6) Respiratory rate statistics
7) Respiratory signal judgment: abnormal breath-holding, good, abnormal exercise, abnormal rapid breathing.

For the sleep detection mode, the radar module has specific installation methods and height restrictions for judging the accuracy of the sleep-related states:

d. The installation method can only be top-mounted or inclined to implement the respiratory rate statistics function in the sleep function. The distance between the radar and the chest should be maintained between 0.5m and 1.5m
e. In the case of the sleep detection radar intended to measure sleep quality and record time of sleep, the installation method can only be top-mounted or inclined. The radar installation height should not exceed 2.75 meters. Installation of the scene is only suitable for rest areas, such as above the bed in a bedroom

6. Typical application scenarios

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

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 range

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.

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