24G millimeter-wave radar

R24ATC1-S

Multi-Person Trajectory Radar

Data Book V1.0

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1. Product introduction

1.1 Product introduction

The R24ATC1 radar module employs the millimeter-wave radar technology to realize distance, angle and speed sensing of human motion. Based on the 1T4R FMCW (frequency modulated continuous wave) signal processing mechanism, this module performs trajectory tracking on 2 targets in specific areas via the synchronous sensing technology that detects parameters such as motion orientation change and slight chest expansion, and is able to lock the coordinates of static persons.

Radar frequency band	24G millimeter-wave radar
Number of antennas	1T4R
Radar system	FMCW
Active detection	Body movement parameter and static presence
	Trajectory tracking

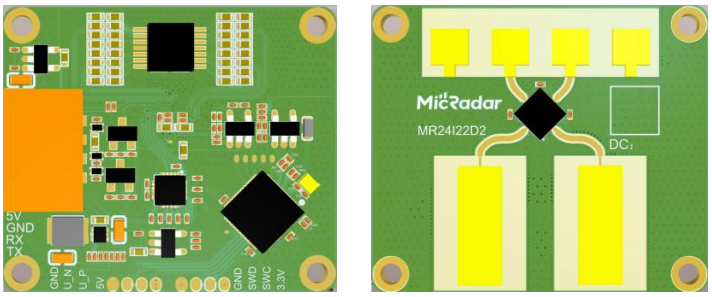

Fig. 1 Front and back sides of the radar

1.2 Theory of operation

The radar antenna transmits electromagnetic wave signals, and synchronically receives reflected echo signals. Then, the radar analyzes the waveform parameter of the echo signals received by different antennas, to detect the motion state and trajectory position of the moving object.

1.3 Function description

- Motion detection: Motion information output, such as walking and minor arm swings, can be detected and triggered within the range of the radar.
- Static human presence detection: When someone stays still in the detection range of the radar, his/her subtle motion arising from breath, such as chest expansion, can be detected, and the state of human presence will remain.

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- Trajectory movement detection: Within the detection range of the radar, the real-time movement trajectory of the moving target can be detected, the 2D coordinates (x, y) of the moving or static target can be output.

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1.4 Product applications

- Smart household appliances
- Office energy conservation (ACs/lighting)
- Regional human detection
- Elderly care/Babysitting
- Home security
- Fan and air supply systems

2. Product encapsulation diagram

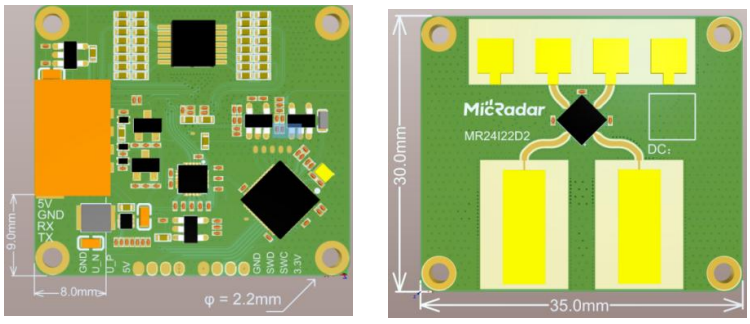

Fig. 2 Radar Module Size Diagram

- Volume: 35mm×30mm
- Interface: Pitch 2.00mm-4PIN female terminal, with the size specifications as shown in the figure below

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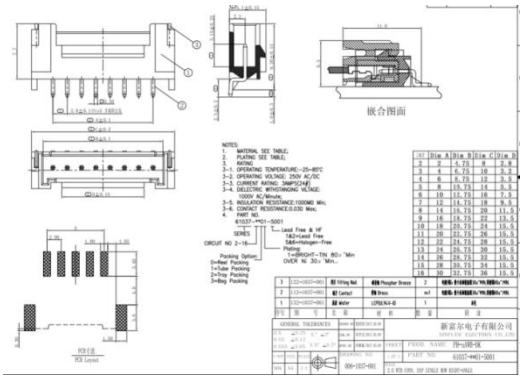

Fig. 3 Radar Module Interface Terminal Encapsulation Diagram

3. Pin parameters explanation

3.1 Pin explanation

Interface	Pin	Description	Typical value	Notes
Interface	1	5V	5V	Power input positive
	2	GND	0V	Power input ground
	3	RX		Serial port reception, 3.3V TTL level
	4	TX		Serial port transmission, 3.3V TTL level

3.2 Serial port output parameters

- Presence/Non-presence
- Active/Still
- Real-time trajectory orientation data (x, y)
- Product Info

3.3 Output protocol

3.4 Naming conventions of models

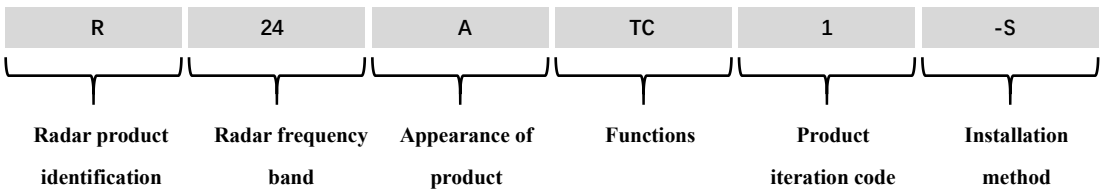

Fig. 5 Naming conventions of models

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4. Product features

The R24ATC1-S radar module is a wide-beam radar module featuring single patch antennas including 1 transmitting and 4 receiving antennas. It mainly applies to inclined installation and realizes the detection of human presence trajectory and sleep state over a wide range.

This radar module features the following:

- The product supports secondary development, making it applicable to a variety of scenarios;
- The module adopts universal UART communication interface and universal protocol provided;
- The module is of small output power and hence harmless to health;
- The module is easy to install, with positioning holes for free fixation and terminals for proper wiring;
- The module can perform real-time multi-target trajectory tracking, with the number of targets ≤ 2;
- The module is immune to temperature, lighting, dust and other factors while bearing high sensitivity, making it applicable in a variety of scenarios.

5. Electrical characteristics and parameters

5.1 Detection angle and distance

Parameter details	Minimum	Typical value	Maximum	Unit	Installation method
R24ATC1					
Mounting height of radar	2.3	2.4	2.5	m	Inclined installation downward, with the angle between the antenna surface and the wall surface being 150°
Human trajectory and tracking distance (Horizontal FOV ± 50°)	-	-	5	m	
Sensing distance for positions of static persons (Horizontal FOV ± 40°)	-	-	4	m	
Angle of radar detection (horizontal)	-	100	-	Degree(s)	
Angle of radar detection (inclined)	-	80	-	Degree(s)	

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5.2 Electrical characteristics

Working Parameters	Minimum	Typical value	Maximum	Unit
Working voltage (VCC)	4.5	5.0	5.5	V
Average current (ICC)	—	—	130	mA
Peak current (IPEAK)	—	—	200	mA
Working temperature (TOP)	-20	-	+70	℃
Storage temperature (TST)	-40	-	+85	℃

5.3 RF performance

Transmission parameter	Minimum	Typical value	Maximum	Unit
Working frequency (fTX)	24.0	-	24.25	GHz
Transmission power (Pout)	-	6	9.5	dBm
Antenna gain (G_{ANT})		5		dBi

5.4 Response time and others

Response time	Minimum	Typical value	Maximum	Unit
Motion detection sensitivity (m/s)	—	—	0.5	m/s
Output time of motion detection (ms)	—	500	—	ms
Non-presence (s)	—	30	120	s
Distance precision	—	—	0.3	m
Horizontal angle accuracy	—	10	—	°

6. Main functions and performance

6.1 Radar module coverage

The beam coverage of the radar module is shown in Fig. 5. The coverage of the radar is a three-dimensional sector 100° horizontally and 80° vertically.

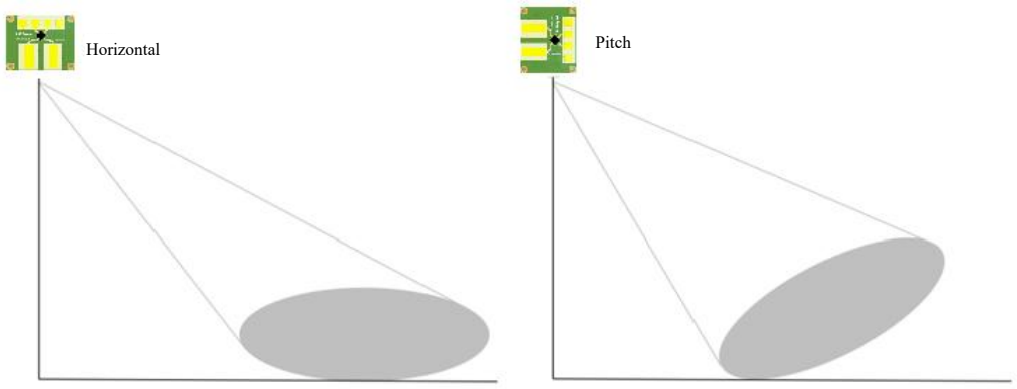

Fig. 6 Coverage of radar

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Affected by the characteristics of radar beams, the operating distance along the normal line to the antenna face is greater, while the one displacing from it is smaller.

Attention should be paid that when the radar is top-mounted, the range of the radar will be reduced as a result of radar beam coverage and effective radiation space.

7. Installation method and working modes

7.1 Installation method

This radar module is recommended to be installed in an inclined manner or at a 150° angle to the vertical wall surface.

Fig. 7 shows the inclined installation method, which applies to position detection of walking or seated targets, such as air conditioning systems and household appliance applications in places such as living rooms and bedrooms.

The radar is recommended to be installed at a height of 2.4±0.1 m, with the radar antenna surface inclining at an angle of 150° to the vertical wall surface.

The front of the radar should not be blocked or covered whatsoever.

The normal line of the radar should be aligned with the main point of detection to ensure the main beam of the radar antenna covers the detection area and the airspace of body activities.

Under this installation mode, the max. distance of trajectory tracking for moving targets is L3 ≤ 5 m; and the max. distance of position detection for static targets is L2 ≤ 4 m.

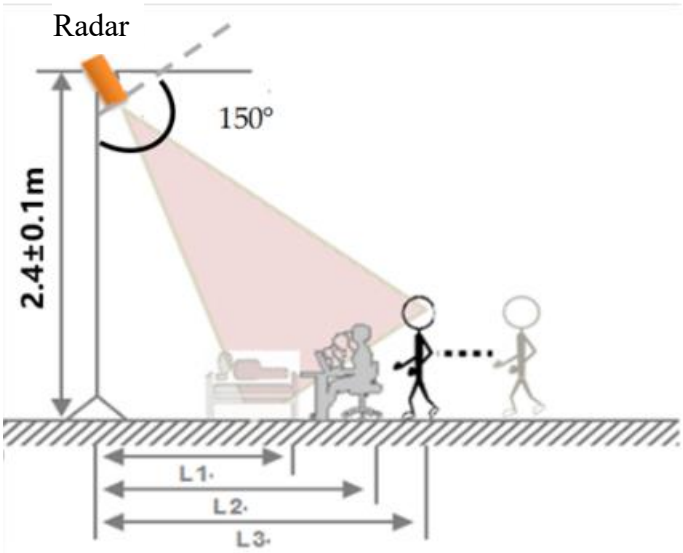

Fig. 7 Diagram of inclined mounting

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8. Related documents

- User Manual: Links to be updated
- Start Guide: Links to be updated

9. Notes

9.1 Start-up time

The module needs to fully reset its internal circuits and performs a full assessment on ambient noise when it is powered on and starts to work, so as to ensure the module can work properly. As a result, the module requires a stabling time ≥ 30 s upon powering on to ensure the effectiveness of parameters output subsequently.

9.2 Effective distance of detection

The distance of detection of the radar module depends mainly on target RCS and environmental factors, and might vary with the environment and the target. This module is not provided with distance measurement feature for now, and hence it's normal for the effective distance of detection to fluctuate in a certain range.

9.3 Bio-detection performance of radar

For static human presence, the detection is more effective when human chest is facing the radar. However, when a person turns sideways or backward during detection, there is a risk that the radar may not detect chest movement, leading to the possibility of not detecting the person.

Due to the fact that the biological features of human bodies are characteristic signals of super low frequency and weak reflection, long-period accumulation is required for radar processing. However, a number of factors might affect the parameters of the radar during the course. On this account, it's normal that detection fails sporadically.

9.4 Power source

1) The radar module has requirements higher than regular low-frequency circuits on power source quality. When supplying power to the module, the power source is required to be free from any threshold glitches or ripples, and can effectively shield power supply noise from accessories.

2) The radar module requires proper grounding. Ground noise from other circuits might compromise the performance or even cause an anomaly in the module. A reduced distance of detection or increased false alarm rate is one of the commonest.

3) To ensure the VCO circuit inside the module works properly, power supply to this module should be +4.5V - +5.5V, with ripple voltage ≤ 100 mV. External power supply must be able to provide sufficient current output and transient response capacity.

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2) To avoid any harm, disaster, or social damage caused by the malfunction of our millimeter-wave products, customers are advised to implement safety designs such as fail-safe designs, redundancy designs, fire prevention designs and fault tolerance designs, to ensure the safety of their equipment.

3) Please contact our sales office in advance, if this product is used in the following equipment that requires particularly high reliability:

for example, aerospace equipment, submarine equipment, power generation control equipment (nuclear, thermal, hydro, etc.), life-support medical equipment, disaster/crime prevention equipment, movable object control equipment (cars, planes, trains, ships, etc.), and other safety equipment.

4) If you intend to use this product under conditions different from our recommendations, please provide a separate certificate of compliance with technical standards or construction designs for your system.

5) When operating this product, you must take anti-static measures, such as grounding the measurement system and grounding the human body. In addition, when this product is placed in a reflow oven, please handle it according to the MSL classifications.

6) Please note that applying stress to the external form of this product may affect local oscillation frequencies. When multiple modules are used in the same area, please consider preventing interference.

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13. Revision History

Revision	Release Data	Summary	Author
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