60G millimeter-wave radar

R60ATR1 Single-Person Trajectory Radar

Data Book v1.1

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1. Product introduction

1.1 Product introduction

The R60ATR1 radar module employs the millimeter-wave radar technology to realize distance, angle and speed sensing of human motion. Based on the 1T3R FMCW (frequency modulated continuous wave) signal processing mechanism, this module performs real-time trajectory tracking on multiple targets in the detection range of specific areas via the synchronous sensing technology that detects motion orientation and chest expansion parameters, and is able to lock the coordinates of static persons.

Radar frequency band	60G millimeter-wave radar
Number of antennas	1T3R
Detection mechanism	FMCW
Active detection	Detection of chest expansion with breath
	Distance / angle / speed measurement
Parameter settings	N/A

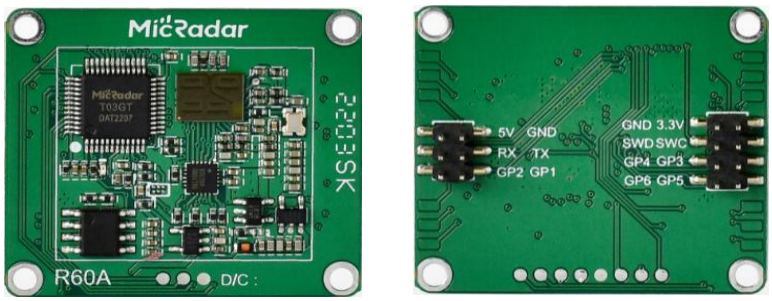

Fig. 1: Front and back sides of the radar

1.2 Theory of operation

The radar antenna transmits electromagnetic wave signals, and synchronically receives reflected echo signals. Then, the radar analyzes the phase difference and energy change between waveform parameters of the echo signals from varying antennas, and gives feedback on distance, orientation, speed, motion power, and other information of the target. making it possible to detect the status and trajectory of moving objects.

1.3 Function description

Motion detection amplitude

- Motion information output, such as walking and minor arm swings, can be detected within the range of the radar, upon which the human presence state will be triggered

Breath 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.

Distance / angle detection

- In the detection range, the radar is able to detect the real-time change in angles and distance of a moving target, and further detect the real-time trajectory of moving people based on such information.

1.4 Applications

- House intelligence
- Smart appliances (TVs, ACs, loudspeakers, etc.)
- Office energy conservation (ACs / lighting)
- Speed / distance / orientation measurement
- Home security
- IPC triggering
- Smart fresh air systems (wind follow-up)
- Smart loudspeaker applications (sound follow-up)
- Smart high-end TV applications (sound follow-up / viewing distance control)

2. Product encapsulation diagram

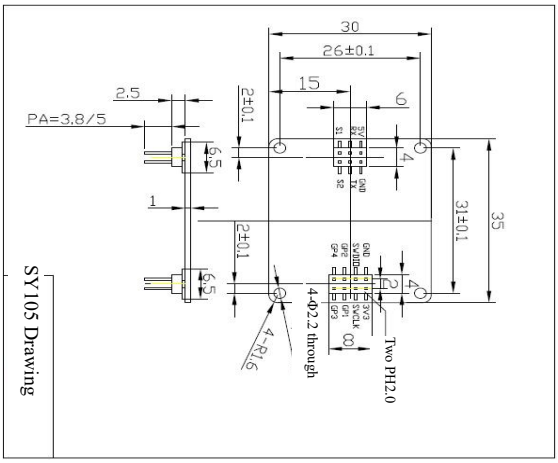

Fig. 2: Schematic diagram for radar module frame

- Volume: 35 mm × 31 mm × 7.5 mm
- Interface: Pitch 2.0 mm dual-row connector. 2 connectors in total: 2*3 and 2*4

3. Pin parameter explanation

3.1 Pin explanation

Interface	Pin	Description	Typical value	Notes
Interface 1	1	5V	5.0V	Power input positive
	2	GND		Ground
	3	RX	3.3v	Serial port reception
	4	TX	3.3v	Serial port send
	5	GP2	3.3V/0V	Presence / Non-presence
	6	GP1	3.3V/0V	Active / Still
Interface 2	1	3V3	3.3V	Output power
	2	GND		Ground
	3	SL		Reserved
	4	SD		Reserved
	5	GP3		Spare extension pin
	6	GP4		Spare extension pin

	7	GP5		Spare extension pin
	8	GP6		Spare extension pin

Note: 1) The output signals from this interface are all 3.3 V in level.

3.2 Serial port output parameters

- Presence / Non-presence
- Active / Still
- Physical sign parameter
- Real-time orientation data (x, y, z)
- Product Info

3.4 Output protocol

- Standard serial port protocol
- Standard protocol of Tuya

3.5 Naming conventions of models

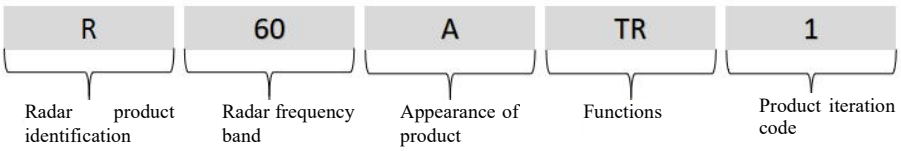

Fig. 3: Naming conventions of models

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4. Product features

The R60ATR1 radar module is in the form of 1 transmit and 3 receive antenna elements: the wide-beam radar module controls the angle to a certain range via algorithms, scans accurately the real-time changes in orientation and distance of the target, and refreshes the 3D data (X/Y/Z) of the target in real time.

This radar module features the following:

- Realizing radar detection through FWCW (frequency modulated continuous wave);
- Realizing real-time trajectory tracking and position detection for the target;
- Max. detection radius of motion trajectory tracking: ≤ 1.5 m (height for top mounting 2.4 m);
- Max. detection radius of static position locking: ≤ 1.5 m (height for top mounting 2.4 m);
- Limiting detection to humans that bear biological features (moving or static) while eliminating the interference from other inanimate objects in the same place;
- The module is capable of eliminating interference from inanimate objects as well as realizing detection of inanimate moving objects;
- The product supports secondary development, making it applicable to a variety of scenarios;
- Universal UART communication interface, with universal protocol provided
- 4 sets of I/O are reserved, allowing the user to define input and output as needed or perform simple interface simulation
- An output power no greater than 0.5 W for radar module, applicable to tasks requiring long-term power supply;
- 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

R60ATR2					
Mounting height of radar	1.0	1.4	1.5	m	Horizontal mounting
Detection distance for motion trajectory tracking	-	-	5	m	Horizontal mounting
Sensing distance for positions of static persons	-	-	4	m	Horizontal mounting
Angle of radar detection (horizontal)	-	100	-	Degree(s)	
Angle of radar detection (inclined)	-	100	-	Degree(s)	

Note: [1][2][3] Hanging height of radar 2.8 m. Radius of radar projection.

5.2 Electrical characteristics

Working Parameters	Minimum	Typical value	Maximum	Unit
Working voltage (VCC)	4.5	5.0	6	V
Working current (ICC)	90	93	100	mA
Working temperature (TOP)	-20	-	+60	℃
Storage temperature (TST)	-40	-	+105	℃

5.3 RF performance

发射参数	最小值	典型值	最大值	单位
Transmission parameter	**Minimum**	**Typical value**	**Maximum**	**Unit**
Working frequency (fTX)	61	-	61.5	GHz

5.4 Application wiring diagram

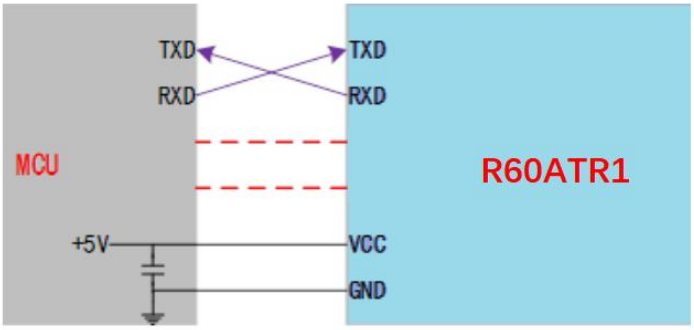
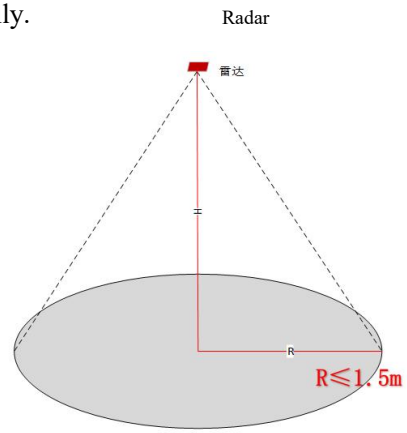


Fig. 4: Schematic diagram for connection between radar module and peripherals

6. Main functions and performance

6.1 Radar module coverage

The beam coverage of the radar module is as illustrated. The coverage of the radar is a three-dimensional sector 100° horizontally and 100° vertically.



Note: R is the radius of fall detection

Fig. 5 Coverage of radar

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.

6.2 Main functions and performance

The main functions of this radar module include:

- Motion detection (top-mounted)

  a.Max. sensing radius for motion: 2 m (common motion amplitude of adults);

  b.Triggering time for motion: ≤ 0.5 s;

- Static detection (top-mounted)

  a.Sensing radius for static human bodies: 2 m;

  b.Time of detection for non-presence: ≤ 40 s;

- Real-time tracking and detection of single-person trajectories (top-mounted)

  a.Mounting height: 2.4 m (fixed height)

b.Max. tracking diameter of motion trajectories: 3 m (moving radially to / from radar);

c.Max. detection diameter of static positions: 3 m;

d.Precision of distance measurement: ≤ 0.3 m;

e.Precision of angle measurement: ≤ 5°; (target ≥ 2 m)

f.Refresh rate of motion detection: ≥ 10 Hz;

7. Installation method and working modes

7.1 Installation method

This radar module is recommended to be top-mounted.

Top mounting is as shown in Fig. 4. This mounting method is mainly for real-time detection of people's trajectories in scenarios such as home automation.

The radar is installed vertical with a horizontal deviation angle of ≤ 3° to make sure the main beam of the radar covers the detection area. The recommended height of installation is 2.4 m without noticeable obstacles and coverings in front.

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.

Depending on the height of installation and the coverage of radar beams, under this installation mode, the max. diameter of real-time trajectory tracking is L3 ≈ 3 m, and the max. distance of static position detection is L2 ≈ 3 m.

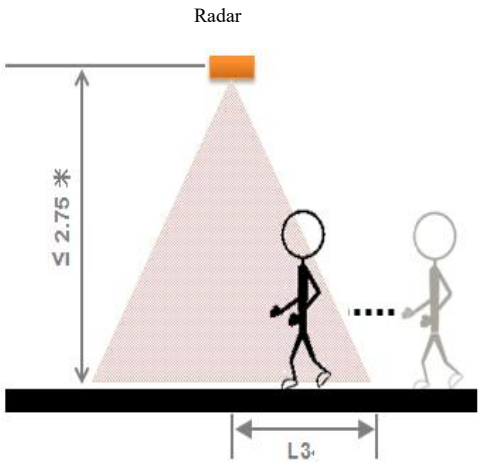


Fig. 4 Top mounting

7.2 Work modes of radar

Upon statistical analysis, the radar module will perform a comprehensive assessment over the real-time position states of persons in current detection area, results of which are readily usable by the user.

Real-time trajectory tracking mode

In this mode, the radar module periodically gives feedback on real-time trajectory tracking information of persons in current detection area. Main states include:

- Real-time angle variation;
- Real-time distance variation;

8. Related documents

- User Manual
- Tutorial
- Development board

9. Typical application mode

This module is mainly applicable to scenarios such as home appliance powering. Below are the details on the applications in typical scenarios.

9.1 Applications in smart appliances

For specific applications, the product outputs information on trajectories and static positions of people in real time, and fulfilled the intended purposes with the relevant data. The radar should be top-mounted in this mode. Applications realizable based on this mode include

- Fresh air systems for kitchens
- Fresh air systems for homes
- Home automation

10. Notes

10.1 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.

10.2 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.

10.3 Bio-detection performance of radar

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.

10.4 Power source

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.

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.

To ensure the VCO circuit inside the module works properly, power supply to this module should be +5V - +6V, with ripple voltage ≤ 100 mV.

External power supply must be able to provide sufficient current output and transient response capacity.

11. Disclaimer

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14. Revision History

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V1.1_0313	3/13/2023	Adjusted the composition of the front portion of the document	Mark