

60G millimeter-wave radar
R60ABD1 Breath & sleep radar
Data Book v1.1

1. Product introduction

1.1 Product introduction

The R60ABD1 radar module employs 60 G millimeter-wave radar technology to realize breath & heartbeat sensing and sleep assessment. Established on the FMCW radar system, this module reports the sleep status and history of people in time based on the breath and heartbeat frequency output of people in specific places in combination with the sleep posture and body movement data collected over a long period of time.

Radar frequency band	60G millimeter-wave radar
Number of antennas	1T3R
Detection mechanism	FMCW
Active detection	Detection of chest expansion with breath and heartbeat
	Subtle motion amplitude detection
Parameter settings	N/A

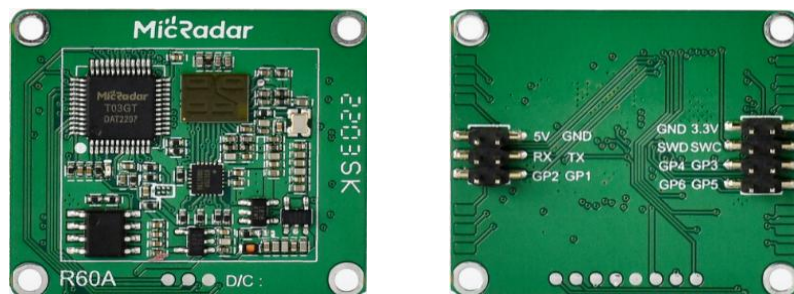


Fig. 1: Front and back sides of the radar

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 subtle motion power change, distance, orientation, speed, and other

information of the target. This makes it possible to detect the motion state and chest expansion frequency / status of the target.

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.

Breath & heartbeat frequency acquisition

- When someone stays still in the detection range of the radar, his / her subtle motion arising from breath and heartbeat, such as chest expansion, can be detected and summarized for outputting the respiration and heartbeat rates per minute.

Applications

- House intelligence
- Smart appliances (TVs, ACs, loudspeakers, etc.)
- Regional human detection
- Sleep care

2. Product encapsulation diagram

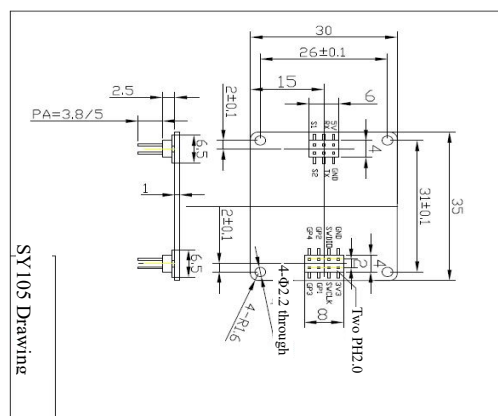


Fig. 2: Schematic diagram for radar module frame

- 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) GP3 - GP6 are control ends of parameter selection, and can be redefined as required by the user.
2) 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
- In / Out of bed
- Sleep status: Awake / Light Sleep / Deep Sleep
- Sleep score
- Sleep quality analysis
- Respiratory rate

- Respiratory waveform
- Heartbeat frequency
- Heartbeat waveform
- Product Info

3.3 Settable parameters

- Human presence switch
- Breath detection switch
- Heartbeat detection switch
- Sleep detection switch
- Detection mode switch (real-time detection / sleep modes)

3.4 Output protocol

- Standard serial port protocol
- Tuya protocol

3.5 Naming conventions of models

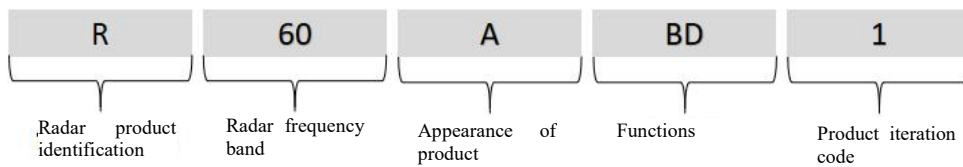


Fig. 3: Naming conventions of models

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4. Product features

The R60ABD1 radar module is in the form of 1 transmit and 3 receive antenna elements: The wide-beam radar module is mainly applicable to top mounting. It controls the angle and coverage via algorithms, and accurately scans the full-body motion tomography to realize sleep detection of people who are static and moving as well as acquisition of breath & heartbeat data under different postures.

This radar module features the following:

- Realizing radar detection through FWCW (frequency modulated continuous wave);
- Realizing synchronous sensing of breath and heart rate of human bodies;
- Recording history of sleep quality;
- Max. detection distance for sleep quality monitoring: ≤ 1.5 m;
- Max. distance for breath & heart rate detection: ≤ 1.5 m;
- An output power no greater than 0.5 W for radar module, applicable to tasks requiring long-term power supply;
- Free from the influences of temperature, humidity, noise, air flow, dust, lighting, etc.
- The product supports secondary development, making it applicable to a variety of scenarios;
- Universal UART communication interface, with universal protocol provided;
- Time from presence to non-presence detection (reporting): Automatic detection based on algorithms.
Typical value: 30 s;
- 4 sets of I/O are reserved, allowing the user to define input and output as needed or perform simple interface simulation.

5. Electrical characteristics and parameters

5.1 Detection angle and distance

Parameter details	Minimum	Typical value	Maximum	Unit
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R60ABD1				
Detection distance of sleep (chest)	0.4		2.5	m
Detection distance of breath and heartbeat (chest)	0.4		1.5	m
Measurement accuracy of breath		90		%
Measurement range of breath	10		25	times / min
Measurement accuracy of heartbeat		95		%
Measurement range of heartbeat	60	80	100	times / min
Refresh time	1	3	30	S
Establishment time of detection		30		S

5.2 Electrical characteristics

Working Parameters	Minimum	Typical value	Maximum	Unit
Working voltage (VCC)	4.6	5	6	V
Working current (ICC)	90	93	100	mA
Working temperature (TOP)	-20	-	+60	°C
Storage temperature (TST)	-40	-	+105	°C

5.3 RF performance

Transmission parameter	Minimum	Typical value	Maximum	Unit
Working frequency (fTX)	61		61.5	GHz
Transmission power (Pout)			6	dBm

5.4 Parameters of antenna

Parameters of antenna	Minimum	Typical value	Maximum	Unit
Antenna gain (GANT)		4		dBi
Horizontal beam (-3 dB)	-20		20	o
Vertical beam (-3 dB)	-20		20	o

5.4 Application wiring diagram

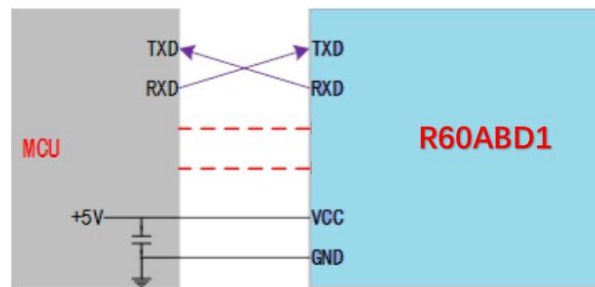


Fig. 4: Schematic diagram for connection between radar module and peripherals

6. Main functions and performance

6.1 Radar module coverage

The beam coverage of the radar module is shown in Fig. 5. The coverage of the radar is a three-dimensional sector 40° horizontally and 40° vertically.

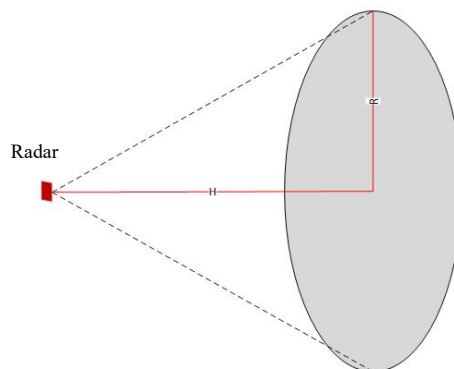


Fig. 5 Diagram for coverage of radar beams

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 mounted inclined, 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:

- Sleep detection

a.Distance of detection: ≤ 2.5 m (detection distance between people and the face of radar antenna)

b.Sleep quality assessment: Awake / Light Sleep / Deep Sleep

c.Sleep time recording: Temporal data output on sleep quality

d.In bed state: In / Out of bed

- Breath detection

a.Distance of detection: $0.4 \text{ m} \leq x \leq 1.5 \text{ m}$ (detection distance between chest and the face of radar antenna)

b.Accuracy: $\geq 90\%$

- Heartbeat detection

a.Distance measurement: $0.4 \text{ m} \leq x \leq 1.5 \text{ m}$ (detection distance between chest and the face of radar antenna)

b.Accuracy: $\geq 95\%$

- Presence sensing

a.Distance of detection: ≤ 2.5 m (detection distance between people and the face of radar antenna)

b.Accuracy: $\geq 90\%$

- Motion detection

a.Motion triggering

b.Motion orientation and position sensing

7. Installation method and working modes

7.1 Installation method

We recommend to inclined-install this radar module and keep the distance parallel to the scan face ≤ 1.5 m.

7.1.1 Inclined mounting

For detection of sleep breath and heartbeat, the radar should be mounted inclined (as shown in Fig. 6) and 1 m right above the head of the bed. The tilt angle should be 45° downwards to align it with the bed center. Keep the radar-chest distance within 1.5 m to make sure the radar can detect breath and heartbeat and sleep-related parameters properly.

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 area of sleep detection.

Limited by the beam coverage of the radar antenna, the effective working distance will be reduced if displaced from the normal line direction of the radar.

Electromagnetic waves in millimeter-wave frequency band can penetrate non-metallic matters - common glass, wooden boards, screens, and thin partition walls - to a certain degree, and hence can detect moving objects behind such obstacles. However, thick load-bearing walls, metal doors, and the like are not penetrable.

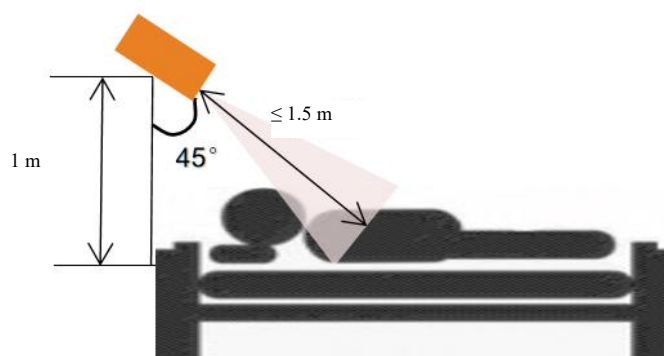


Fig. 6 Diagram of Inclined mounting at the head of bed

7.2 Work modes of radar

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

Real-time state running mode

In this mode, the radar module periodically gives feedback on the presence and motion states of persons in current detection area, which mainly include:

- Absence;
- Presence, static / active;
- Heart rate / respiratory rate;

In order to ensure accuracy of environmental condition judgement in state running mode, the radar module performs logical judgement internally. Below is the state output logic of radar module:

- only when a change in states is detected will the radar output corresponding state. In the other cases, the radar will remain silent;

- The change from presence state to non-presence state (moving / approaching / leaving away) by the radar is a fast switch, time of which ≤ 1 s;
- The radar will go through state confirmation several times before changing presence state to non-presence state. Switching time ≤ 1 min.;
- The radar collects in real time the frequency and signal states of breath / heart rate of static bodies. The refresh rate for breath & heart rate frequency is 3 s. Signal states are output when a change occurs;

Sleep detection mode

In this mode, the radar module periodically gives feedback on the sleep status and respiratory rate of persons in current detection area, which mainly include:

- Sleep quality assessment: Awake / Deep Sleep / Light Sleep;
- In / Out of bed judgement;
- Breath / heart rate frequency statistics;

In order to ensure accurate judgement on sleep-related states in sleep detection mode, specific method and height limit are required for the mounting of the radar module:

- The radar should be mounted inclined and 1 m right above the head of the bed. The tilt angle should be 45° downwards to align the radar with the bed center. The radar-body distance should be kept within 1.5 m to make sure the detection range covers the sleep area properly.

8. Related documents

- User Manual
- Tutorial
- Development board

9. Typical application mode

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

9.1 Installation and applications in bedrooms

To give relevant information on people lying in bed in certain cases, e.g. presence / non-presence, sleep states, depth of sleep, motion information, etc., so as to realize specific applications. The radar should be top-mounted in this mode. Applications realizable based on this mode include

- Care for the aged
- Health care
- Home automation
- Home health

9.2 Healthy life applications

Based on the detection features on sleep states and respiratory rate of sleeping people, this radar is quite applicable to healthy life scenarios, which include:

- Linkage to intelligent health products
- Appliance powering

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 stabiling time ≥ 30 s upon powering on to ensure the effectiveness of parameters output subsequently.

10.2 Limits on breath & heartbeat detection scenarios

The radar is a kind of non-contact devices. To detect the breath and heartbeat of the target, it needs to lock the position of the target before collecting and calculating the intensity and values of breath and heartbeat of the target. On this account, the target detection should be in appropriate detection range and should stay still to avoid influencing on locking by the radar and thus on breath and heartbeat detection.

10.3 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.

10.4 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.

10.5 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

To our best knowledge, the description in the document is accurate when it was released. Considering the technical complexity of products and the differences in working environments, it's impracticable to eliminate each and every inaccurate or imperfect description. On this account, this document is for reference by the user only. We reserve the right to make any changes to the product without a prior notice to the user. We make no commitments nor guarantees on the legal level. We encourage the customers to give valuable opinions on the latest update on the product and its supportive tools.

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13.Contact

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14. Revision History

Revision	Release Data	Summary	Author
V1.0_0215	2/16/2023	First draft	Mark
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