



Rd-03E Specification

Version V1.0.0

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1. Product overview

Rd-03E is a radar module developed by Shenzhen Ai-Thinker Technology Co., LTD. It is equipped with silicon micro-S3KM111L chip. S3KM111L is an integrated single-chip millimeter-wave sensor SoC based on FMCW radar transceiver technology. It operates in the 24 GHz k band with up to 1 GHz modulation bandwidth per frequency. The module adopts FMCW waveform and advanced signal processing technology proprietary to S3 series chips. Combined with MCU's proprietary radar signal processing and built-in intelligent presence sensing algorithm, it can realize accurate human body sensing distance measurement and gesture recognition. Developers can display distance information and gesture information in real time through the host computer tool.

The Rd-03E module can detect and identify moving and micro-moving human bodies, and report real-time distances. It can detect targets and gestures in designated areas and report results in real time. It is widely used in various AIoT scenarios. This module has the characteristics of strong real-time performance, high ranging accuracy, large ranging range, and flexible configuration of algorithm parameters.

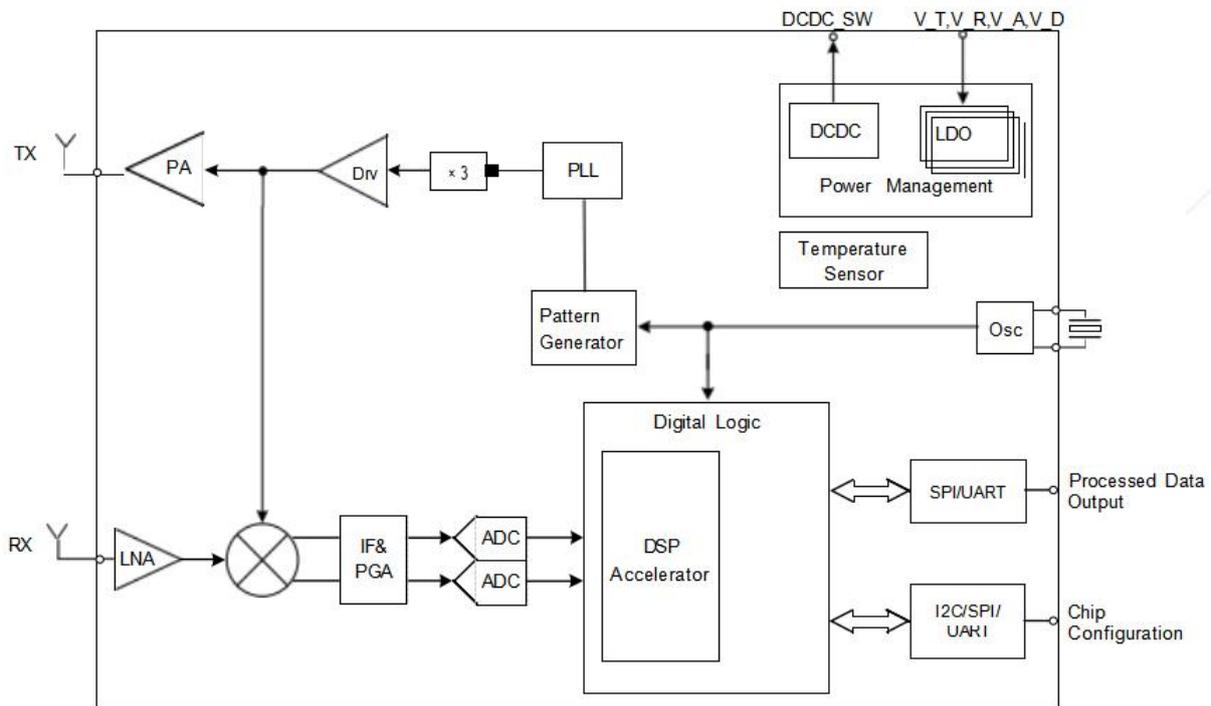


Figure 1 S3KM111L architecture diagram

1.1. Characteristic

- DIP package, standard 2.54mm pin
- Radar support 24 GHZ ISM frequency band
- Precise indoor and outdoor human movement, micro-motion sensing and distance, gesture recognition detection
- The radar antenna supports 1 receive and 1 transmit, antenna beam narrow, high resolution, frequency bandwidth, strong anti-interference
- Provides visual tools to support configuration of detection distance intervals and setting sensitivity by range gate
- The longest distance for sensing a moving human body is 6 m, and the longest distance for sensing a slight human body is 3.5 m
- High precision ranging: 30 cm~350 cm ± 5 cm; 350cm~600 cm $\pm 5\%$
- Accurate distance measurement, detection range of human body sensor module $\pm 20^\circ$ in azimuth, $\pm 45^\circ$ in elevation
- Gesture recognition detection range: azimuth angle $\pm 20^\circ$, elevation angle $\pm 40^\circ$
- Automatically load the default configuration, plug and play
- Support UART. Intelligent parameter adjustment of the radar can be realized through the serial port, which is convenient and fast
- 5V single power supply
- Wall mount
- Typical application scenarios:
 - ✓ Smart home appliances
 - ✓ Intelligent business
 - ✓ Smart Security
 - ✓ Smart lighting

2. Main parameters

Table 1 Main parameters

Model	Rd-03E
Package	DIP-5
Size	28.0*24.0(±0.2)mm
Antenna	On-board antenna
Frequency	24G ~24.25GHz
Operation temperature	-40℃~ 85℃
Storage environment	-40℃~ 125℃, < 90%RH
Power supply	Support voltage 4.5V ~5.5V, power supply current $\geq 200\text{mA}$
Interfaces	UART
UART rate	Default 256000 bps

2.1. Static electricity requirements

Rd-03E is an electrostatic sensitive equipment, special precautions should be taken during handling.



Figure 2 ESD anti-static diagram

2.2. Electrical characteristics

Table 2 Electrical Characteristics Table

Parameter	Condition	Min.	Typical value	Max.	Unit
Power supply	VDD	4.5	5	5.5	V
I/O	VIL	-	0	1.4	V
	VIH	-	1.9	VDD	V
	VOL	-	0	0.1	V
	VOH	-	2.8	VDD	V

2.3. Radar sensing range

Table 3 Radar induced range

Installation	Min.	Typical	Max.	Unit
Wall-mounted method ($\pm 20^\circ$ range) accurate ranging	-	6	-	m
Inclined installation (inclined 45°)	-	2.2	-	m

Notice:

- The above sensing distance is measured based on the open space of Ai-Thinker, for reference only
- The radar sensing distance is greatly affected by surrounding walls, ceilings, large-sized objects, and installation methods. The actual measurement data of the installation environment shall prevail

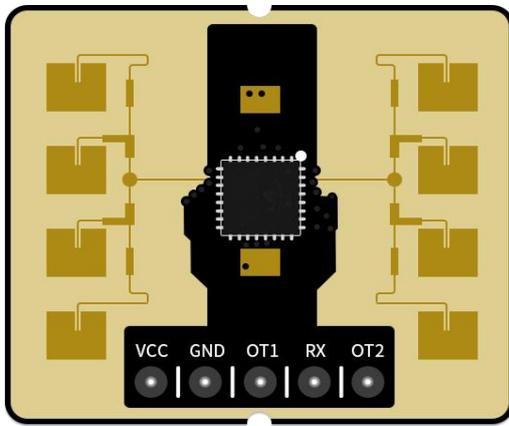
2.4. Power

The following power consumption data is based on a 5V power supply and an ambient temperature of 25°C .

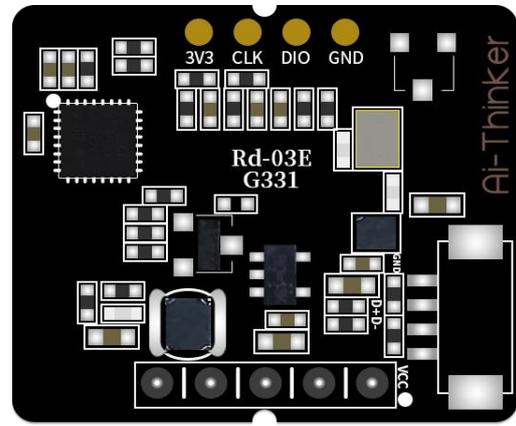
Table 4 Power Consumption Table

Model	Min.	AVG	Max.	Unit
working status	-	44	-	mA

3. Appearance size

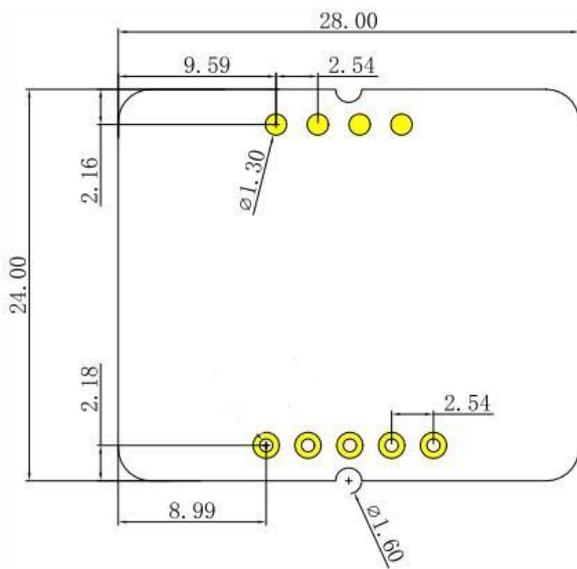


Front

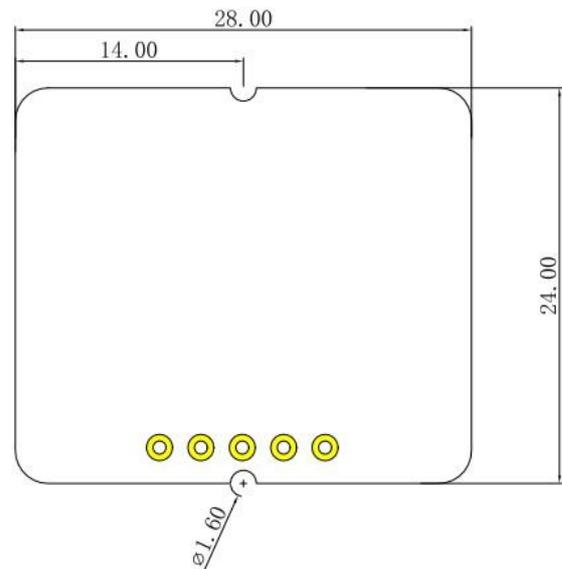


Back

Figure 3 Appearance diagram (rendering diagram is for reference only, subject to the actual object)



Front



Back

Figure 4 Size chart

4. Pin definition

Rd-03E connects to a total of 5 interfaces, for example, the pin diagram, the pin function definition table is the interface definition.

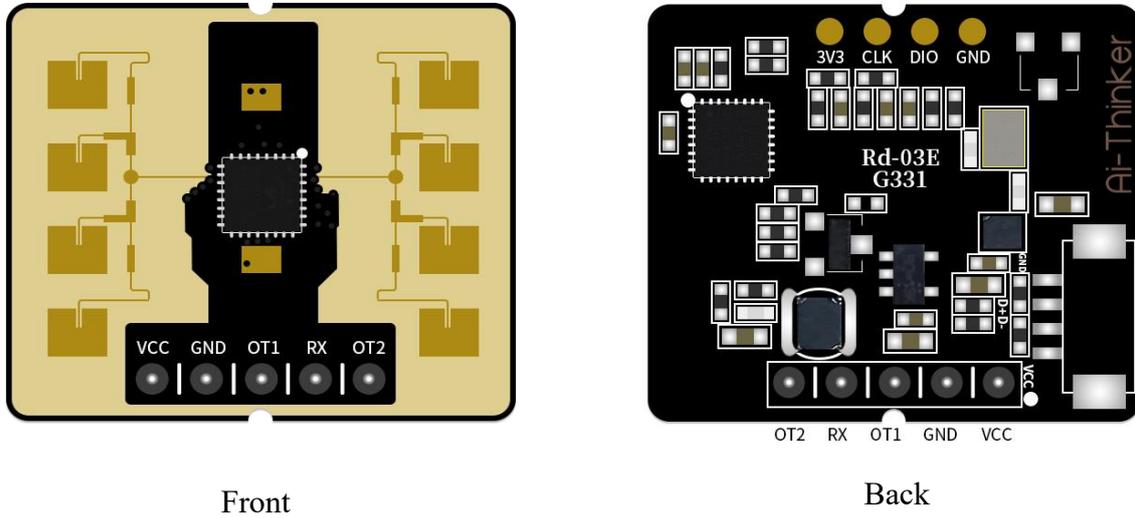


Figure 5 Pin diagram

Table 5 Definition table of pin functions

No.	Name	Function
1	VCC	Input power 5V
2	GND	Ground
3	OT1	UART_TX
4	RX	UART_RX
5	OT2	Reserved interface, function to be determined

5. Schematic diagram

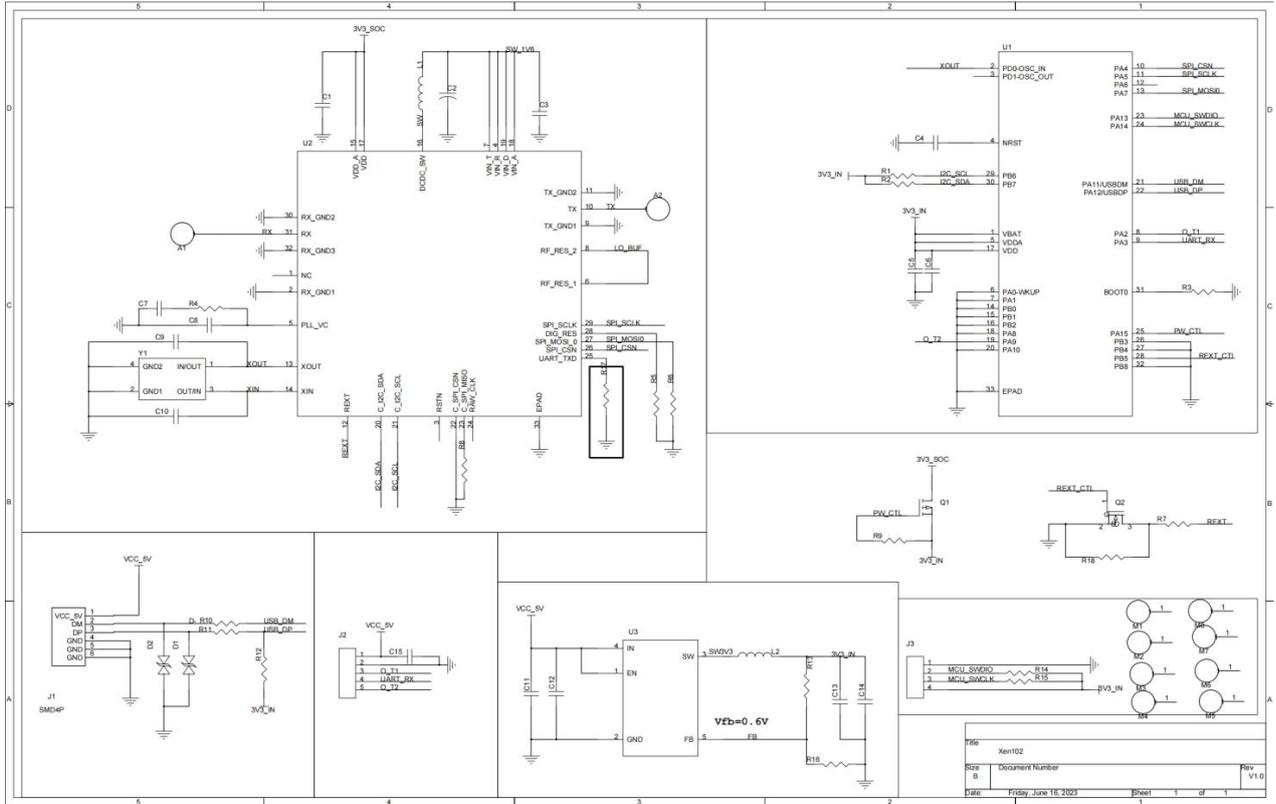


Figure 6 Schematic diagram

6. Design guidance

6.1. Application guide circuit

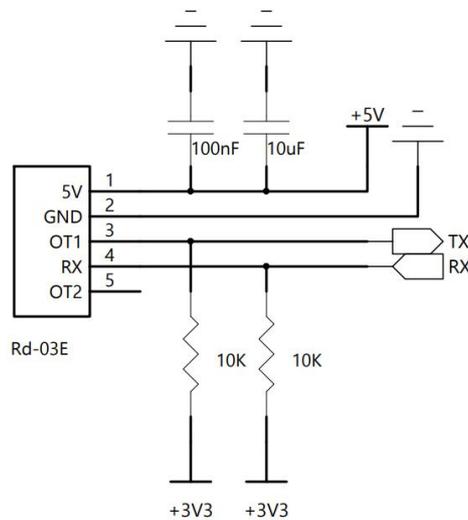


Figure 7 Application guide circuit

7. Precautions for radar installation

- In motherboard installation position, it is recommended that the following several ways:
 - ✓ As far as possible to ensure that the radar antenna is opposite to test area, and the antenna around open without sunscreen.
 - ✓ Ensure that the radar installation position is firm, stable, shaking will influence the effect of detection of radar itself.
 - ✓ Ensure that there won't be on the back of radar object movement or vibration. Due to the penetrating nature of radar waves, the antenna signal back lobe may detect moving objects on the back of the radar. A metal shield or metal backplane can be used to shield the radar back flap to weaken the influence of objects on the back of the radar.
 - ✓ The theoretical range accuracy of radar is obtained by special algorithm on the basis of the physical resolution of 0.75m. As target size, condition, different, such as RCS target distance accuracy will fluctuate; And the farthest distances fluctuate a little bit.
- In order to meet the performance of on-board antenna, antenna surrounding prohibited, metal pieces, far away from the high frequency components.
- The power input voltage range is 5V, and the power supply ripple is required to have no obvious frequency peak within 100kHz. Users need to consider the corresponding electromagnetic compatibility design such as ESD and lightning surges.

7.1. Installation environment requirements

This product needs to be installed in a suitable environment. If it is used in the following environments, the detection effect will be affected:

- Induction of continuous movement in the area of nonhuman objects, such as animals, sustained oscillation of the curtain, is the outlet of the large strain of green plant, etc.
- Induction area exists the strong reflector of large area, strong reflector is of the radar antenna can cause interference.
- When mounting the wall, need to consider the top of the indoor air conditioning, electric fan etc. External interference factors.

7.2. Installation mode and induction range

- Precise distance measurement wall-mounted installation method

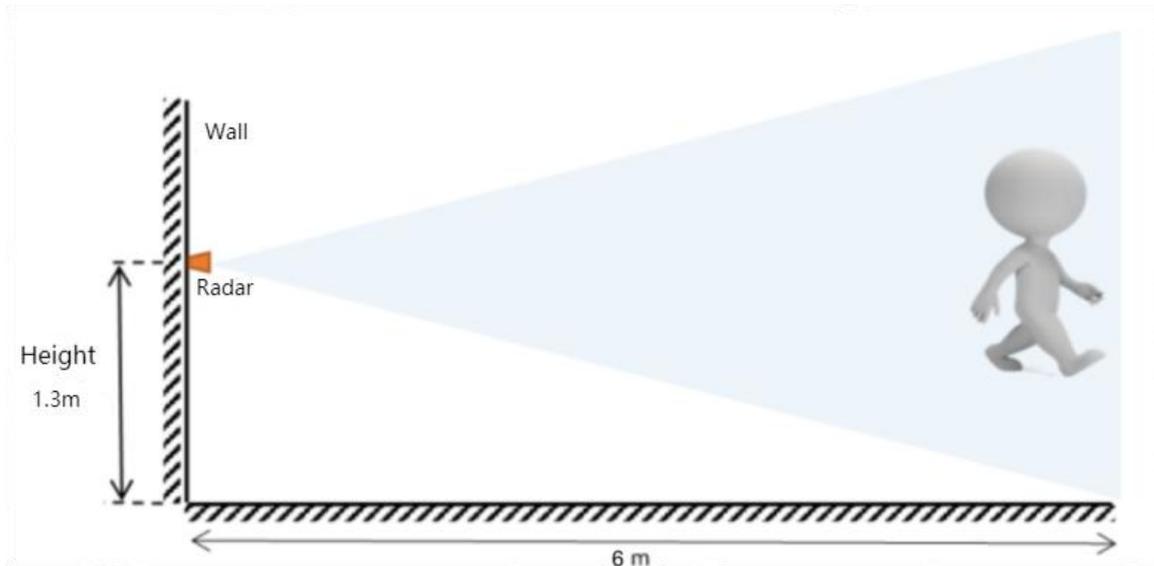


Figure 8 Schematic diagram of mounting the roof

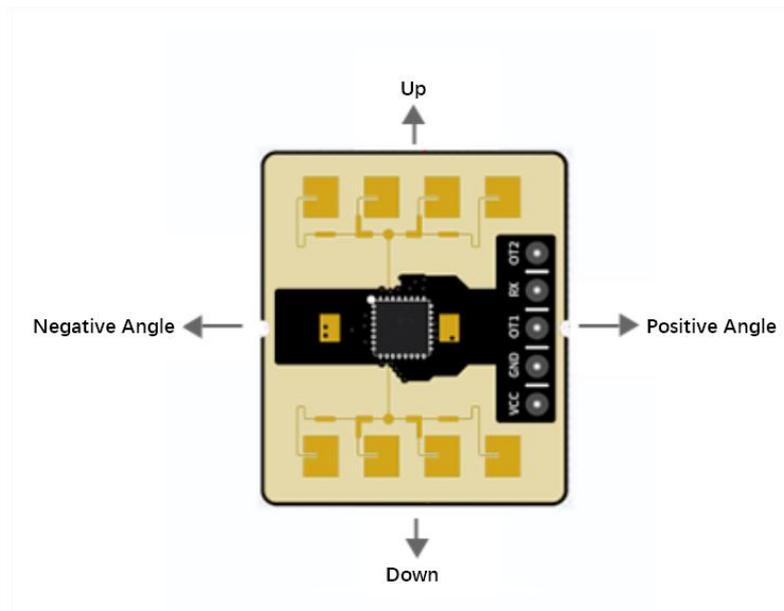


Figure 9 Schematic diagram of the direction of the ceiling

Note: The positive and negative directions are azimuth angles, and the up and down directions are pitch angles

- Accurate ranging detection range azimuth $\pm 20^\circ$, elevation angle $\pm 45^\circ$

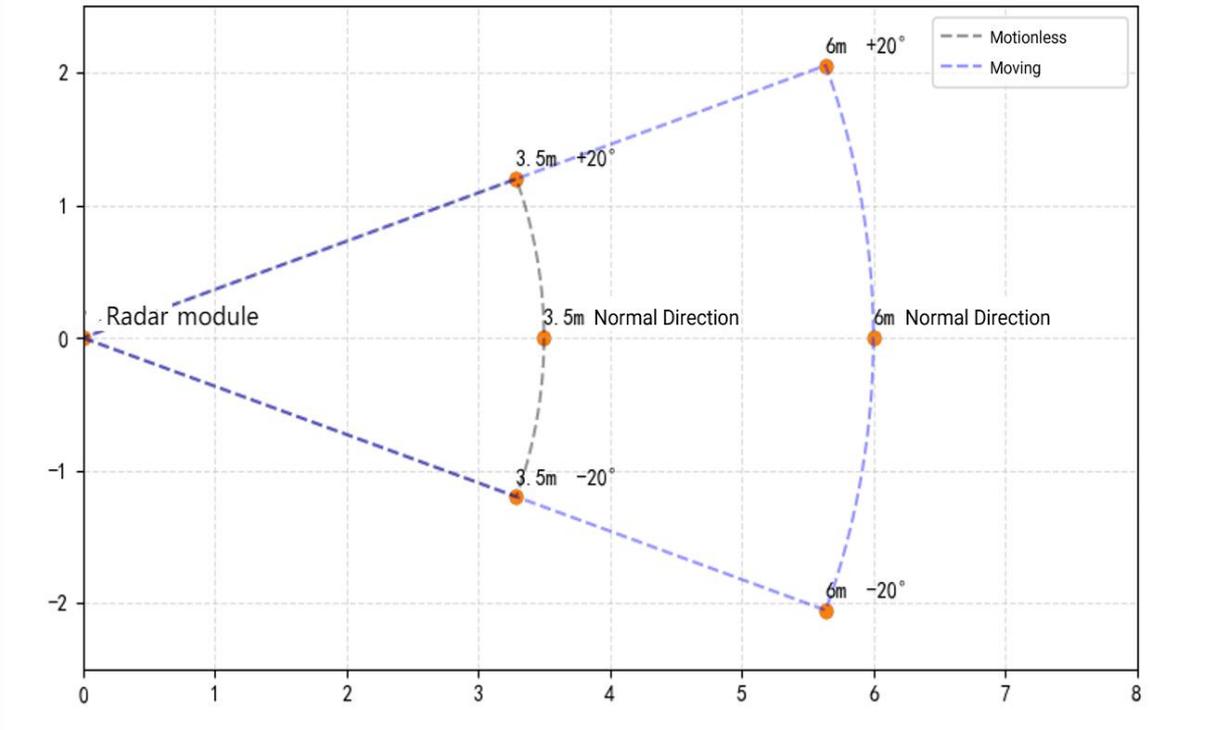


Figure 10 Power map of precision ranging wall-mounted radar

Note:

- The angle range of moving human recognition is $\pm 20^\circ$ in direction angle, $\pm 45^\circ$ in pitch angle, and the detection range is 0.3m~6m
- The angular range of micro-motion human body detection is direction angle $\pm 20^\circ$, pitch angle $\pm 45^\circ$, and detection range is 0.3m~3.5m

■ Gesture recognition tilt installation method

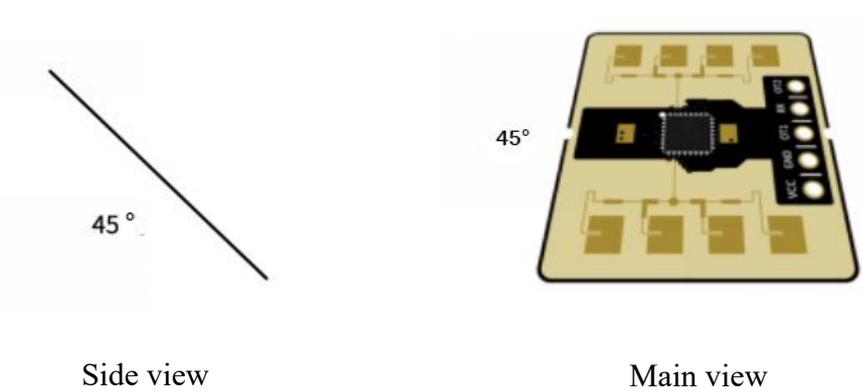


Figure 11 Schematic diagram of tilted installation for gesture recognition

Note:

- The module is installed at an angle of 45°

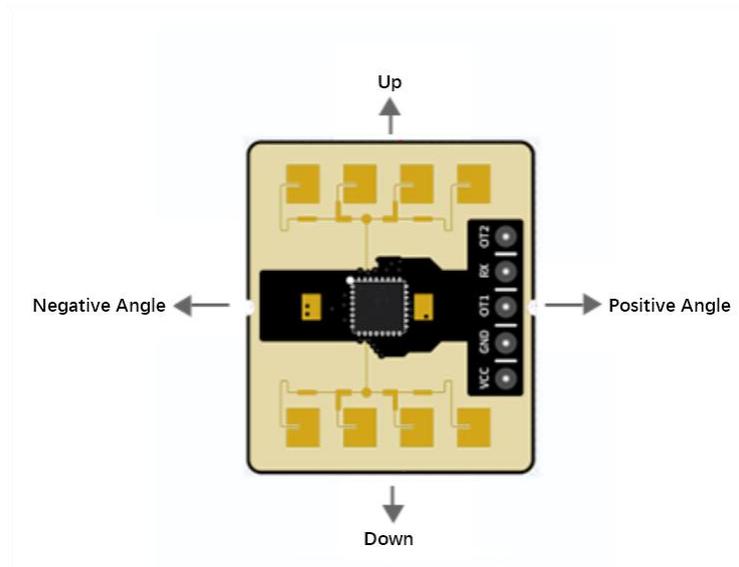


Figure 12 Schematic diagram of gesture recognition detection range

Note: The positive and negative directions are azimuth angles, and the up and down directions are pitch angles

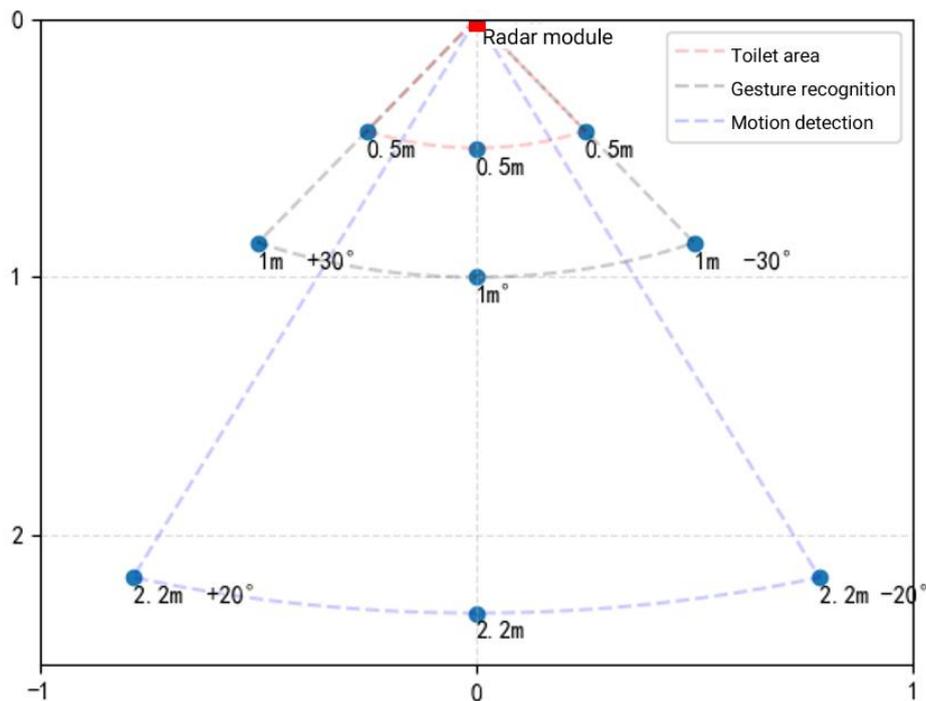


Figure 13 Gesture recognition hanging wall radar power diagram

Note:

- Motion recognition detection range direction angle $\pm 20^\circ$, pitch angle $\pm 40^\circ$, detection distance range is a sector area of 0.3~2.2m
- Gesture recognition and micro-motion human examination range direction angle $\pm 30^\circ$, pitch angle $\pm 40^\circ$, detection distance range 0.5~1m sector area

7.3. Power supply

- Recommended voltage is 5V and the peak current is above 200mA.
- Recommended to use LDO as power supply ; If using DC-DC, it is recommended to control ripple within 30mV.
- DC-DC power supply circuit suggested the reserved capacitance position, dynamic response can be large changes in load and optimize the output ripple.
- 5V power supply interface increases ESD device is recommended.

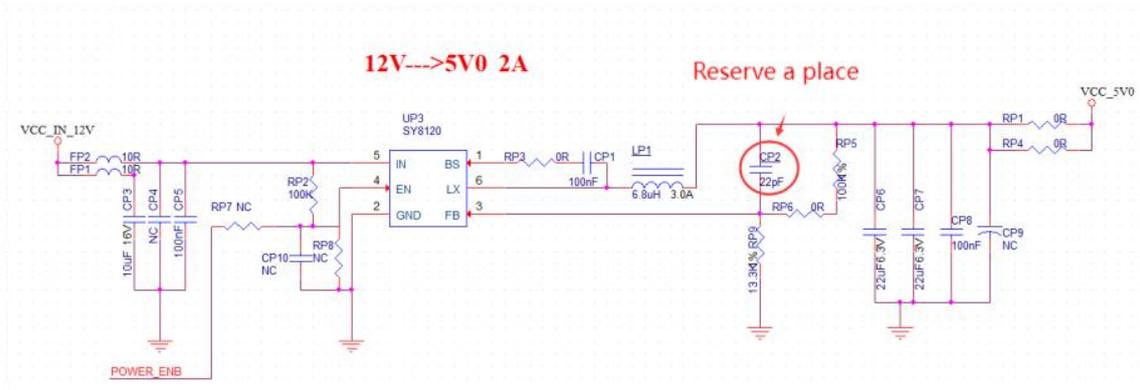


Figure 14 DC-DC step-down circuit diagram

7.4. GPIO

- Some IO ports are drawn from the periphery of the module. If necessary, it is recommended to use 10-100 ohm resistors in series on the IO ports. It can suppress overshoot, so make level both sides more smoothly. It helps EMI and ESD.
- Special IO mouth pull up or down, need to refer to instructions on the use of the specification, here will affect the launch configuration module.
- Module IO port is 3.3 V if the master IO mouth level does not match with module, need to increase the level conversion circuit.
- If IO mouth directly connected to the peripheral interface, or terminal, such as row needles, and Suggestions on the IO mouth line near the terminal obligate ESD device.

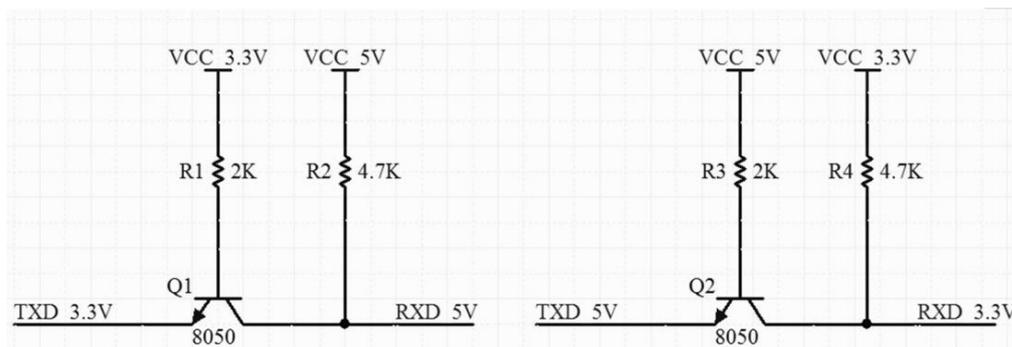


Figure 15 Level switching circuit

8. Storage conditions

- Products sealed in moisture-proof bags should be stored in a non-condensing atmosphere at $<40^{\circ}\text{C}/90\%\text{RH}$.
- The module's moisture sensitivity level MSL is level 3.
- After the vacuum bag is unwrapped, it must be used within 168 hours at $25 \pm 5^{\circ}\text{C}/60\%\text{RH}$. Otherwise, it needs to be baked before it can be put on line again.

9. Reflow welding curve diagram

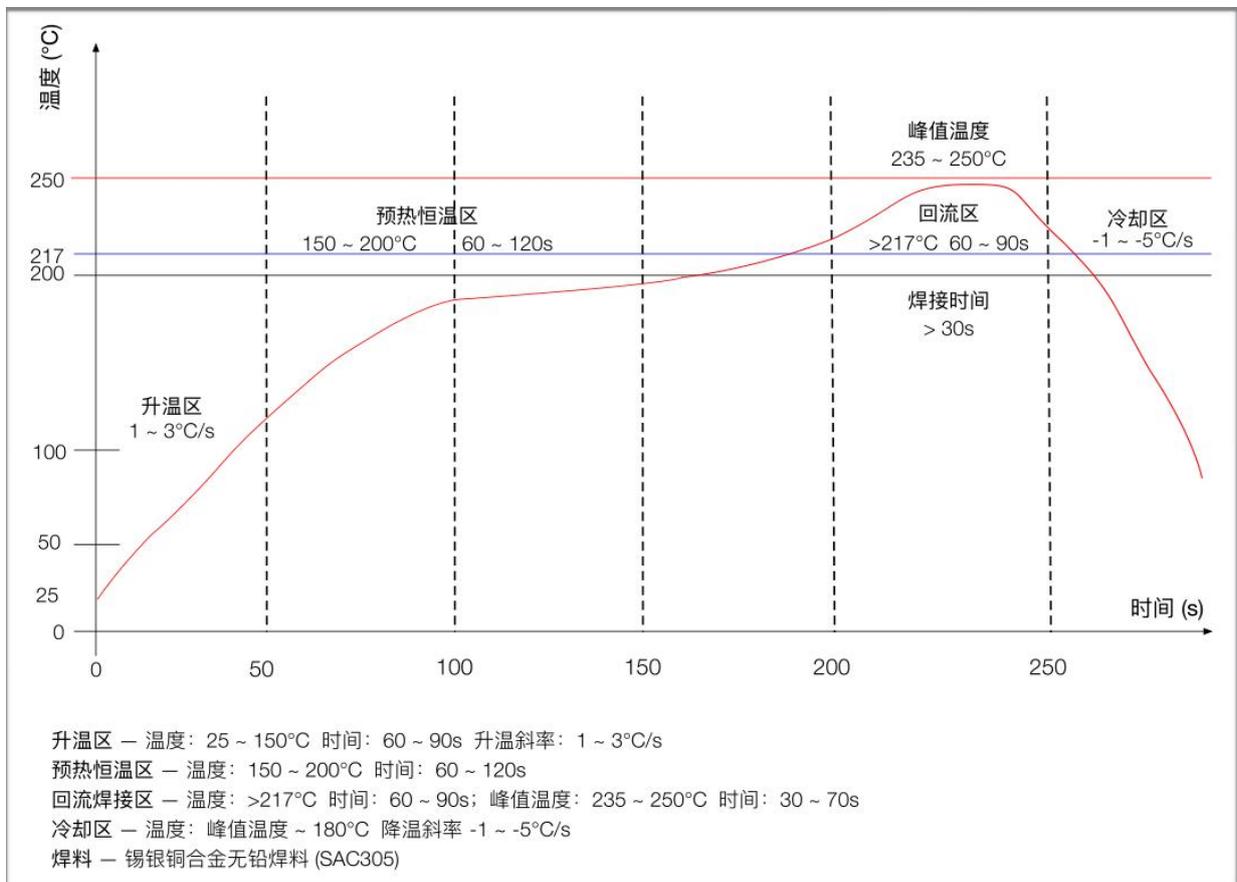


Figure 16 Reflow welding curve

10. Product package information

Rd-03E module is packed in tape, 150pcs/tray. As shown below:



Figure 17 Packaging and taping diagram

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