Rd-03_V2_User Manual

Version V1.0.0

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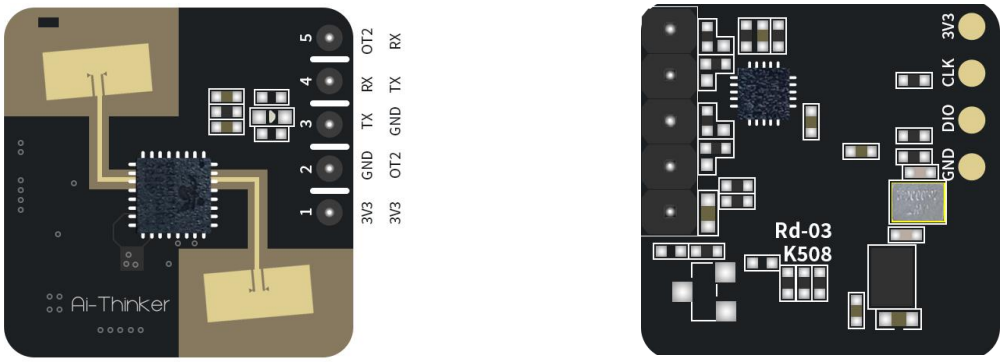
Document Resume

Version	date	Develop/Revise Content	Formulate	Approval
V1.0.0	2025/9/30	First Edition	Qian Zekai	Xu Hong

Content

1. introduce

This document mainly describes the basic usage of the Ai-Thinker Rd-03_V2 version, including hardware wiring, use and configuration of the visual configuration tool (host computer), installation instructions and precautions, all aimed at helping developers quickly get started with the Rd-03_V2 version and configure the parameters most suitable for user application scenarios.



Front Back

Figure 1 Pin diagram

2. Hardware wiring

The Rd-03_V2 module has a total of 5 pins , as shown in the pin diagram. The pin function definition table is the interface definition.

Table 1. Rd-03_V2 version TTL connection (default interface sorting)

Rd-03_V2 version	USB to TTL
3.3V	3.3V
GND	GND
TX	RXD
RX	TXD
OT2	Output high or low level based on the test result; no wiring required.

3. The use and configuration of visualization tools

The Rd-03_V2 module comes pre-programmed with the relevant factory firmware . Ai-Thinker provides a visual host computer configuration tool for the Rd-03_V2 module, allowing developers to easily configure parameters and optimize sensing performance according to their usage scenarios.

1. Obtain the visual host computer configuration tool from the Rd-03_V2 version of the radar module series on the Ai-Thinker official website .
2. Connect to Rd-03_V2 using the serial-to-USB (TTL) adapter as shown in Table 1. Note: The visual configuration tool and the serial port tool cannot be used simultaneously.
3. Run the visual configuration tool.
4. Click the "Refresh" button, select the corresponding serial port number, set the baud rate to 115200 , and click " Connect Device ".

Figure 2. Visual configuration tool interface (after connection)

The visualization tool interface is divided into three areas:

1. Device Operation Area (Zone1) : Displays the firmware version number (Ver: xxxx) and serial number (SN: XXXX) of Rd-03_V2.
2. Function button area (Zone2) : Displays four buttons to switch between function pages.
3. Functional page area (Zone3) : Displays the functions of the corresponding interface.

3.1. Parameter View/Setting

The "Parameter View/Setting" page of the host computer tool is shown in Figure 3. It allows users to view the current parameters of the radar and modify the specified parameter configurations to meet the needs of specific application scenarios.

The steps to read radar parameters using host computer tools are as follows:

- After connecting the Rd-03_V2 module to the visualization configuration tool, click the "Read Sensor Settings" button on the function page. A "Successfully Read Parameters" prompt window will pop up and display all the current parameter values of the radar. Click "OK" to close the prompt window.

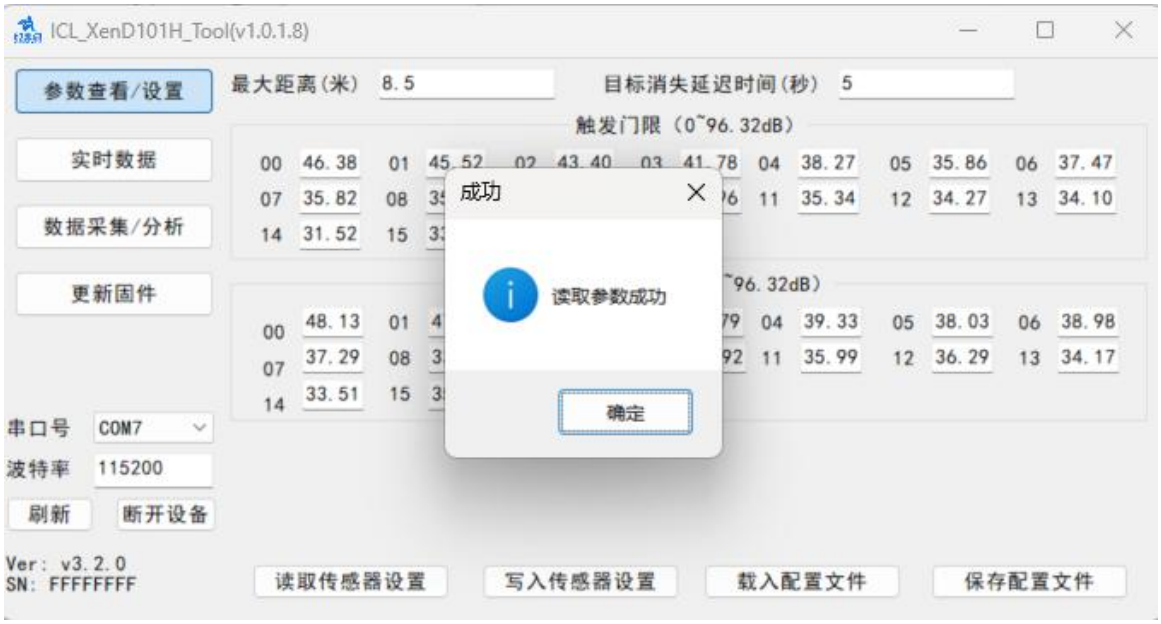


Figure 3. Interface for reading radar parameters from the host computer

The steps to change one or more radar parameters using the host computer tool are as follows:

- After connecting the Rd-03_V2 module with the visual configuration tool, enter new parameter values for all parameters that need to be changed on the function page.
- Click the "Write Sensor Settings" button on the function page. The host computer will write the parameter values in the current interface to the radar module. A "Successfully Written Parameters" prompt window will pop up. Click "OK" to complete the parameter settings.

For a detailed explanation of the parameters on the "Parameter Settings" page of the host computer tool, please refer to Table 2.

Table 2 Configuration Parameters for Rd-03_V2

Parameter name	explain	Parameter range
Maximum distance gate	Used to set the maximum effective detection range of the millimeter-wave sensor; a distance gate is 10 cm long.	0~10.5M, accurate to 0.1M
Target disappearance delay time (seconds)	The target state needs a delay of T before switching from occupied to unoccupied. During this period, if someone is detected, the timing restarts. The millimeter-wave sensor will only switch to unoccupied state and report that no one	0~65535

	is present after the unoccupied state has been detected for a full time T.	
Trigger threshold (dB)	The energy threshold used to set the transition from an unmanned to a manned state can be calculated using the "Generate Threshold" function.	0~96.32 , accurate to 0.1 .
Micro-motion & stationary thresholds (dB)	The energy threshold used to detect the human body's micro-movement and static states can be calculated using the "Generate Threshold" function.	0~96.32 , accurate to 0.1

The host computer tool supports saving and loading radar parameter configurations:

- Click the "Save Configuration File" button, select the desired save path, and the host computer tool will save the current radar parameter configuration in the host computer as a .xml file; the default save location is the folder where the host computer tool is located, but users can set the save path themselves.

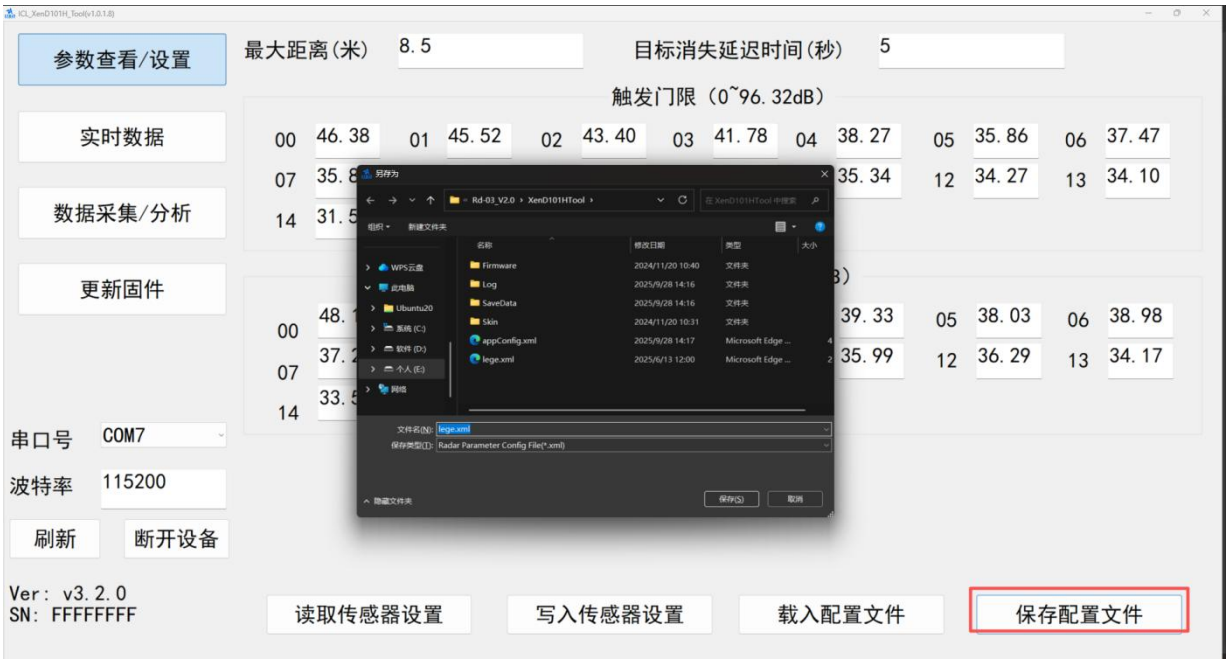


Figure 4. Configuration file saving interface

- Clicking the "Load Configuration File" button will open the radar parameter configuration file located in the user-specified path and read in the radar parameters. Clicking the "Write Sensor Settings" button will write the parameters in the configuration file into the radar module.

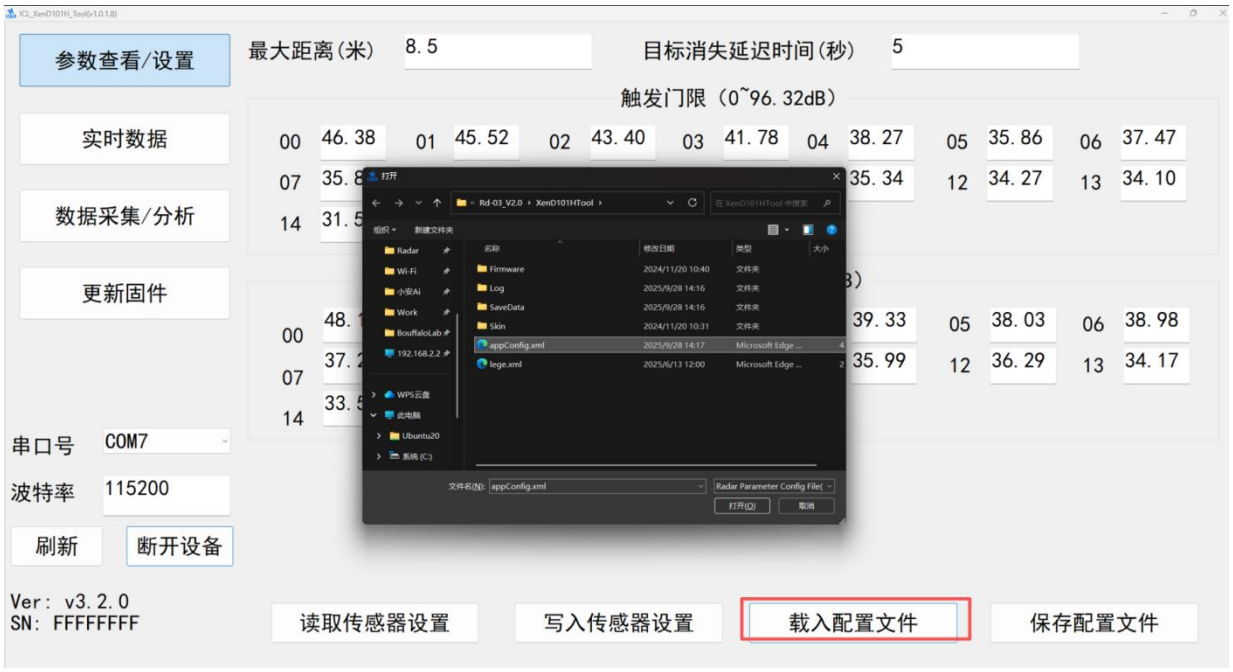


Figure 5 Loading configuration file interface

3.2. Real-time data

The host computer's "Real-time Data" page is shown in Figure 6. Its functional page is mainly divided into target information area a, function button area b, and real-time data area c, as detailed in Table 3.

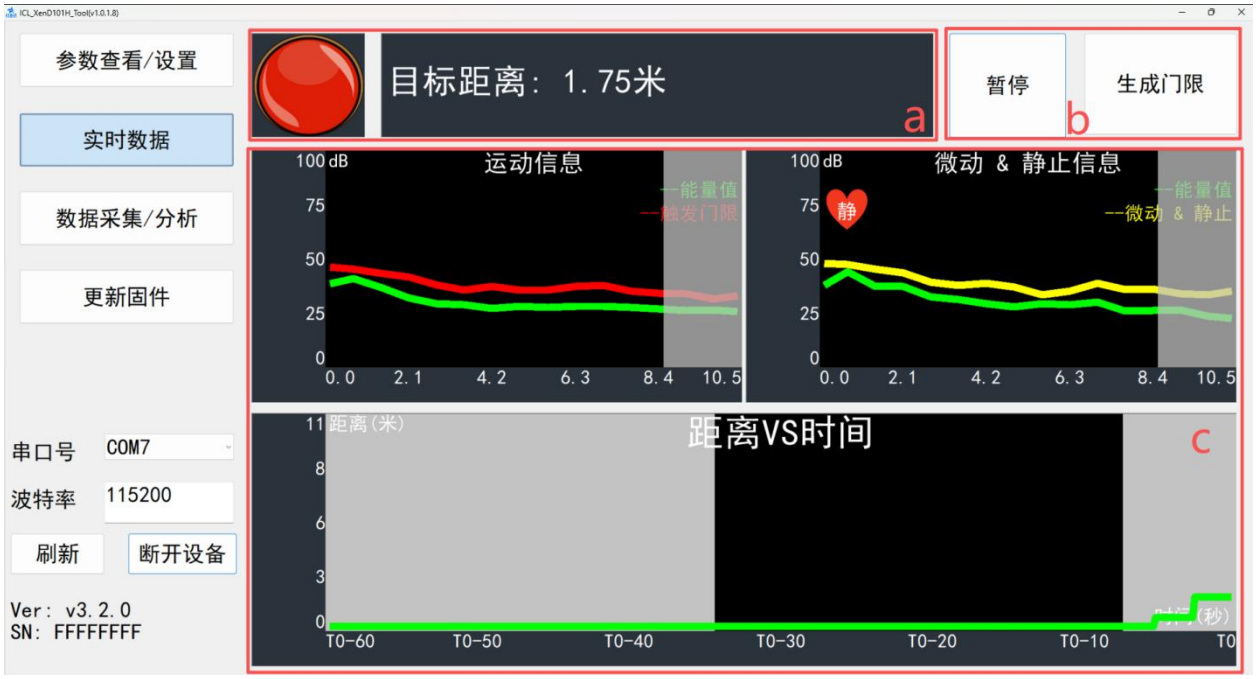


Figure 6 Real-time data page

Table 3. Function Descriptions of Each Area on the "Real-time Data" Page

Page area		Function	illustrate
a	Colored light icon	The color of the colored light indicates the presence of human targets within the detection area.	Red indicates someone is present; green indicates no one is present.
	Target information text box	Displays the distance information of the detected target.	Displays the straight-line distance between the human target and the sensor.
b	"Start/Pause" toggle button	Start/stop human presence detection sensor	-----
	"Generate Threshold" button	Scan the ambient noise and calculate the "trigger threshold" and "hold threshold" for each distance gate based on the threshold generation coefficient.	Refer to Table 2 for the definitions of trigger threshold and micro-motion/static threshold.
c	Real-time monitoring and display of "Sports Information/ Micro-motion & Sports Information "	The system displays the motion energy value (green line) and threshold value (red line) for each distance gate in real time.	A black background indicates that the distance gate is within the effective detection range, while a gray background indicates that the distance gate is within the invalid detection range.
	Real-time monitoring data of "Distance VS Time"	Real-time display of distance changes of a target human body detected by a millimeter-wave sensor over the past 60 seconds.	A gray background area indicates that the sensor detected a human body during that time period, while a black background area indicates that the sensor did not detect a human body during that time period.

The steps to view real-time data via a host computer are as follows:

Step 1: After connecting Rd-03_V2 to the host computer tool, click the "Real-time Data" button to switch to this function page. At this time, the host computer tool will automatically start the millimeter-wave sensor detection function, the "Start/Pause" switch button will display "Pause", and the two line graphs on the host computer function page will start displaying the corresponding real-time data information.

Step 2 (optional): Click the "Start/Pause" switch button to pause the millimeter-wave sensor's

detection function. The colored light on the function page will turn green, the target distance will be displayed as "0.00 meters", and the two line graphs below will stop updating.

3.3. Automatic threshold generation

The steps to generate sensor detection thresholds using host computer tools are as follows:

1. On the "Real-time Data" page, clicking the "Generate Threshold" button will bring up the "Threshold Generation" window;

   The “Threshold Generation” window displays the trigger and hold threshold generation coefficients at the top. The threshold generation coefficients are proportional to the sensitivity of the millimeter-wave sensor and range from 1.0 to 20.0. Below, a threshold generation progress bar and text indicating the specific generation progress are displayed (the text is visible during the threshold generation process).

2. After entering the trigger and hold threshold generation coefficients in the "Threshold Generation" window, click the "Start/Close" toggle button. The host computer tool will start automatically generating the threshold, and the progress bar and the text below will display the generation progress in real time, as shown in Figure 7.
3. When threshold generation is complete, the text "Threshold generation successful." will be displayed in the lower left corner, and the "Start/Close" toggle button will display "Close"; click the "Close" button to complete threshold generation.

After the threshold is successfully generated, the sensor automatically saves the generated threshold value, and the host computer tool automatically reads and applies the newly generated threshold.

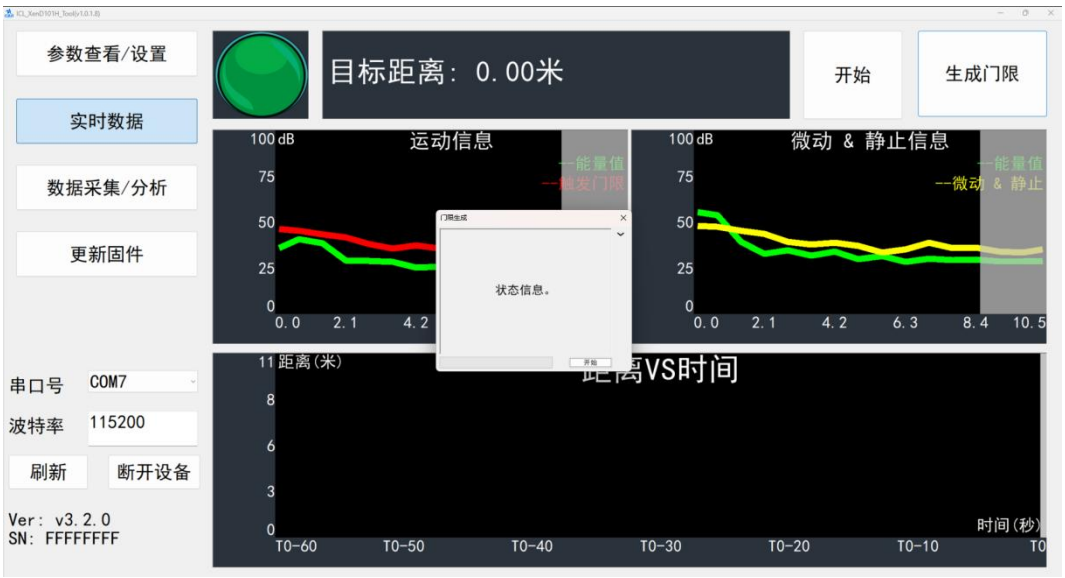


Figure 7 Threshold generation interface

During threshold generation, the environment within the detection range must be kept open. If

there is significant human movement during generation, the host computer will provide a prompt after generation is complete. If there is significant interference in the environment that prevents the module from even performing basic motion detection, the system will prompt for threshold regeneration, as shown in Figure 8. If there is minor interference in the environment that causes a decrease in the module's detection performance, the system will indicate the distance of the interference, and the user can choose whether to regenerate the threshold, as shown in Figure 9 .

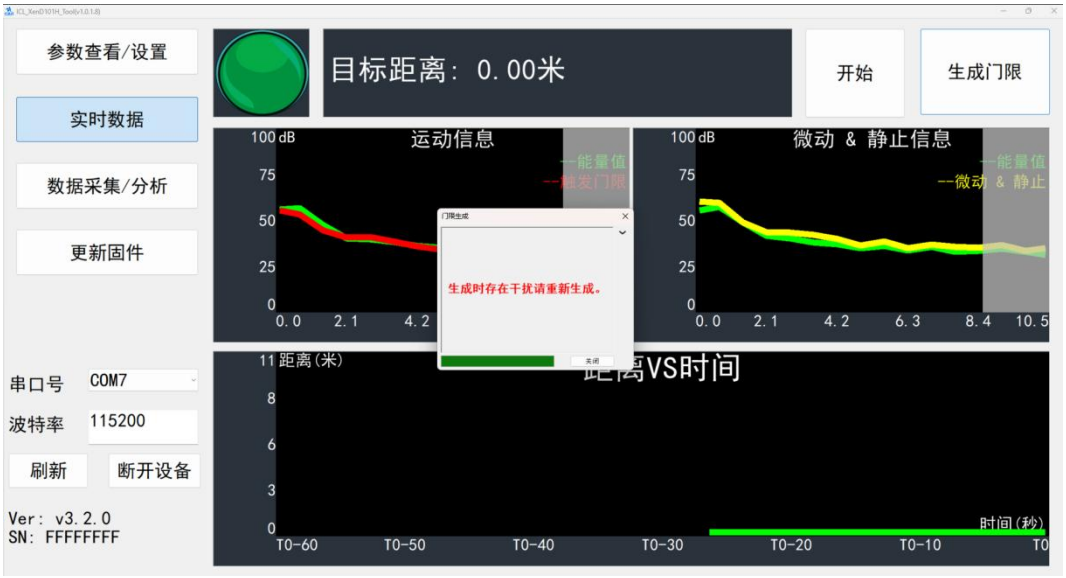


Figure 8 shows a page with obvious moving human interference during generation.

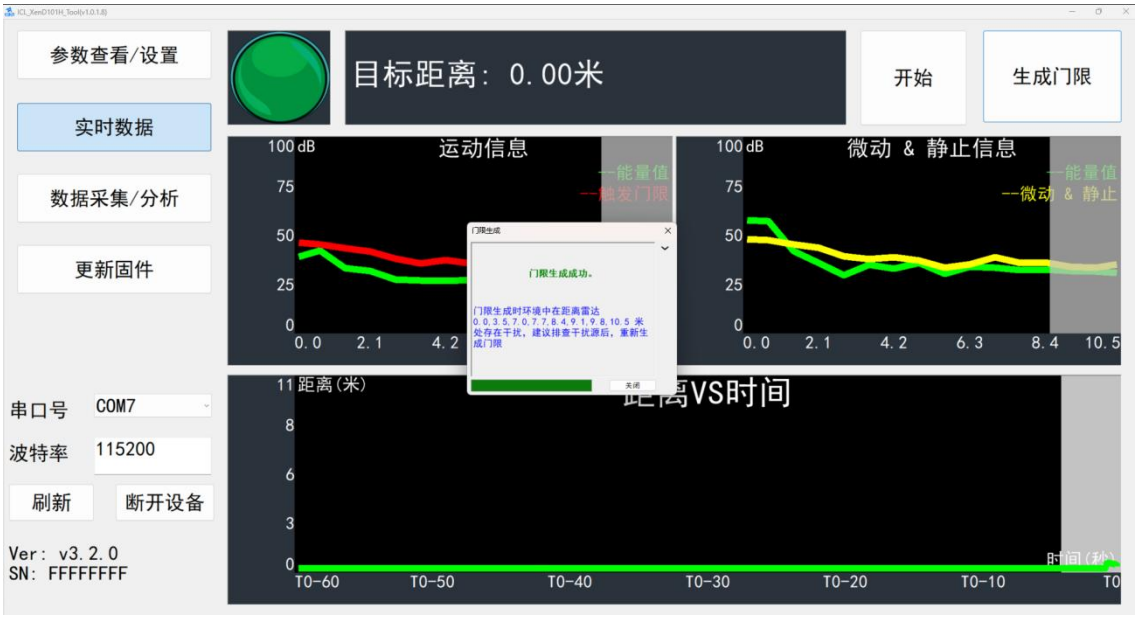


Figure 9 shows a page indicating obvious human movement interference during generation.

3.4. Power interference warning

After the sensor module is powered on, it will perform a self-test on the power supply. If there is obvious interference in the power supply, it will give a prompt through the host computer (the absence of a prompt from the host computer does not mean that there is no interference in the power supply), as shown in Figure 10 .

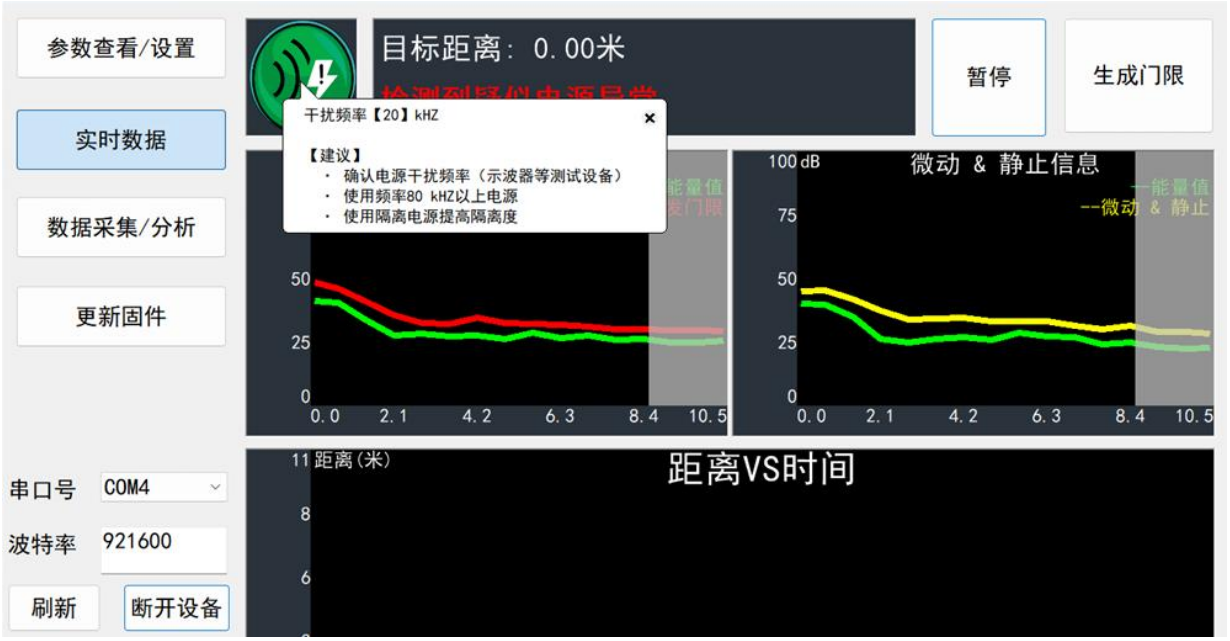


Figure 10 Power Interference Warning Page

3.5. Data Acquisition/Analysis

The "Data Acquisition/Analysis" page of the host computer is shown in Figure 11. Its function pages are described below:

- "Distance gate scan time (seconds)": This setting determines the environmental noise scan duration for each distance gate. The default value is 20 seconds, and the value range is 0~65535.
- "File save path": Used to set the save path for the collected data.
- "Select Display Distance Gate": Used to select the distance gate to view; the selectable range is 0~15.
- The "Acquire Data/Stop Acquisition" toggle button is used to start and stop data acquisition. After stopping data acquisition, users can find a .bat file with the filename starting with RadarData and ending with a timestamp in the set file save path.
- The "Load Data" button opens saved radar scan data for users to view and analyze.
- The "Energy Information" line graph displays the scanned energy value at the user-selected distance gate, trigger threshold, and hold threshold. The horizontal axis represents time, and the vertical axis represents the energy information in terms of relative

power.

- The "Distance Information" line graph displays the distance information of human targets detected within the radar's detection range. The horizontal axis represents time, and the

vertical axis represents distance.

Figure 11 Data Acquisition/Analysis Page

The steps for collecting energy data via a host computer are as follows:

1. After connecting the module and the host computer, click the "Data Acquisition/Analysis" function button to switch to the function page.
2. Enter the "Distance Gate Scan Time", set the "File Save Path", and ensure that no one is within the radar detection range during one scan cycle. Then, click the "Acquire Data/Stop Acquisition" toggle button to start data acquisition.
3. After data collection begins, users can wait for the host computer tool to automatically stop collection after the scan is complete, or they can click the "Collect Data/Stop Collection" toggle button to stop data collection in advance; in both cases, the data collected by the host computer will be stored in the file save path set in step 2.

The steps for analyzing energy data using a host computer are as follows:

1. After connecting the module and the host computer tool, click the "Data Acquisition/Analysis" function button to switch to that function page.
2. Click the "Load Data" button and select the data you want to view.
3. By selecting the desired distance gate, users can view the energy and distance information for that particular distance gate in the data file on two line graphs.
4. To view specific data at a point on the curve, place the mouse cursor over the location of interest on the curve. A pop-up window will appear at the cursor position displaying the energy value or distance information at that point, as shown in Figure 12.

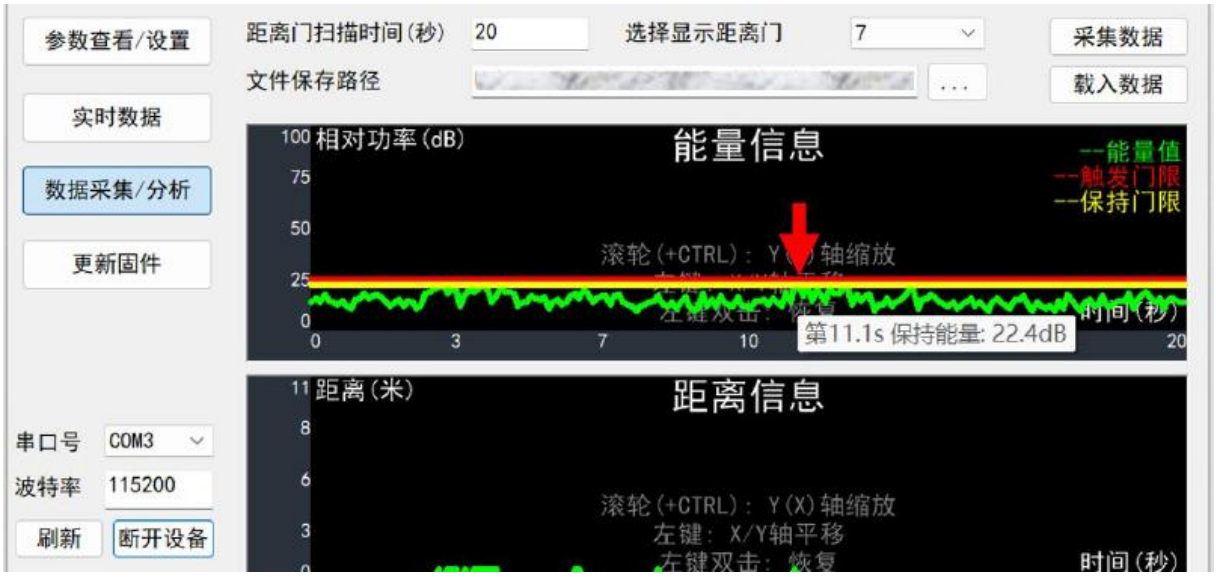


Figure 12 Host computer data viewing page

3.6. Update firmware

The "Update Firmware" page on the host computer is shown in Figure 13. The steps to update the millimeter-wave sensor firmware via the host computer are as follows:

1. After connecting Rd-03_V2 to the host computer tool, click the "Update Firmware" button to switch to this function page;
2. Click the "Get Firmware Information" button on the function page, and the ID information of the current device will be displayed in the prompt information box on the right.
3. Click the "Select bin file path" button, select the required .bin file, and click the "Download" button to start upgrading the firmware. The download results will be displayed in real time in the right-hand prompt box, and the bin file information and current download progress will be displayed below.

Figure 13 Upper computer firmware upgrade

After a successful firmware upgrade, a message box will display "Download successful!". If the firmware upgrade fails, the message box will display the corresponding information.

4. Radar installation and detection range

The Rd-03_V2 wide-coverage human body micro-motion millimeter-wave sensor supports both ceiling-mounted and wall-mounted installation, with ceiling-mounted installation being the recommended method. The orientation definition of the Rd-03_V2 millimeter-wave sensor is shown in Figure 14. The X-axis is 0° , the Z-axis is 90° , and the Y-axis is perpendicular to the XZ plane (also called the normal direction).

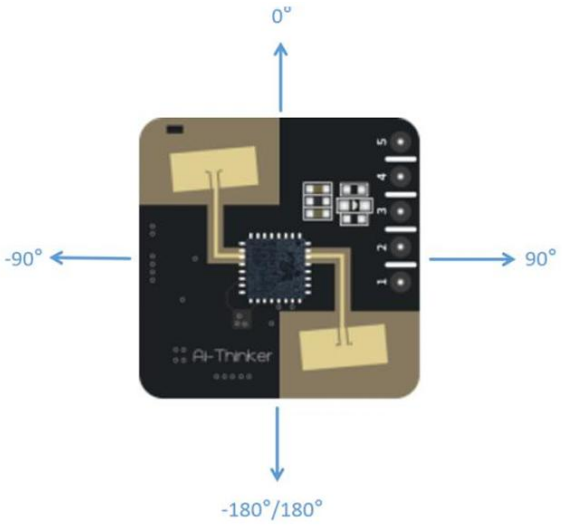


Figure 14 Schematic diagram of direction definition

4.1. Radar installation method

■ Ceiling mounting method

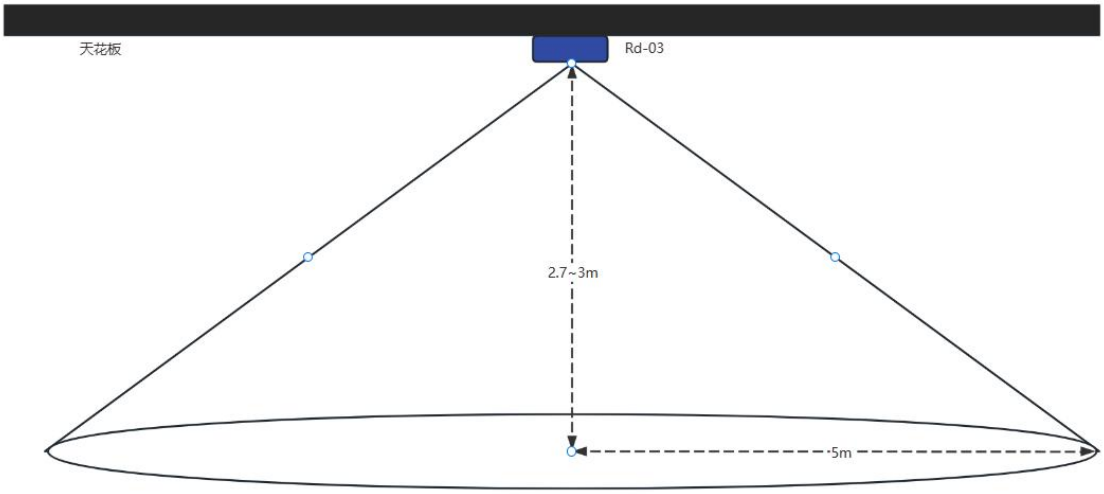


Figure 1.5 Schematic diagram of ceiling installation inspection range

It should be noted that as the installation height decreases, the maximum sensing range gradually shrinks, as shown in Figure 16.

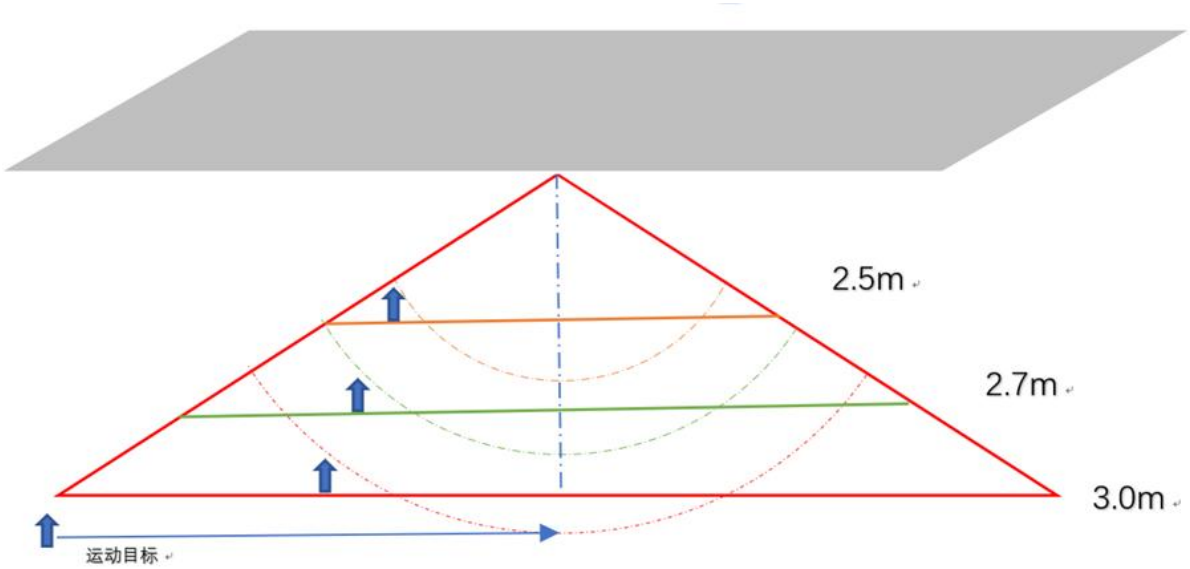


Figure 1. Schematic diagram of the relationship between ceiling installation height and detection range.

Figure 17 shows a schematic diagram of the motion and micro-motion detection range of this reference scheme when the ceiling installation height is 2.7m.

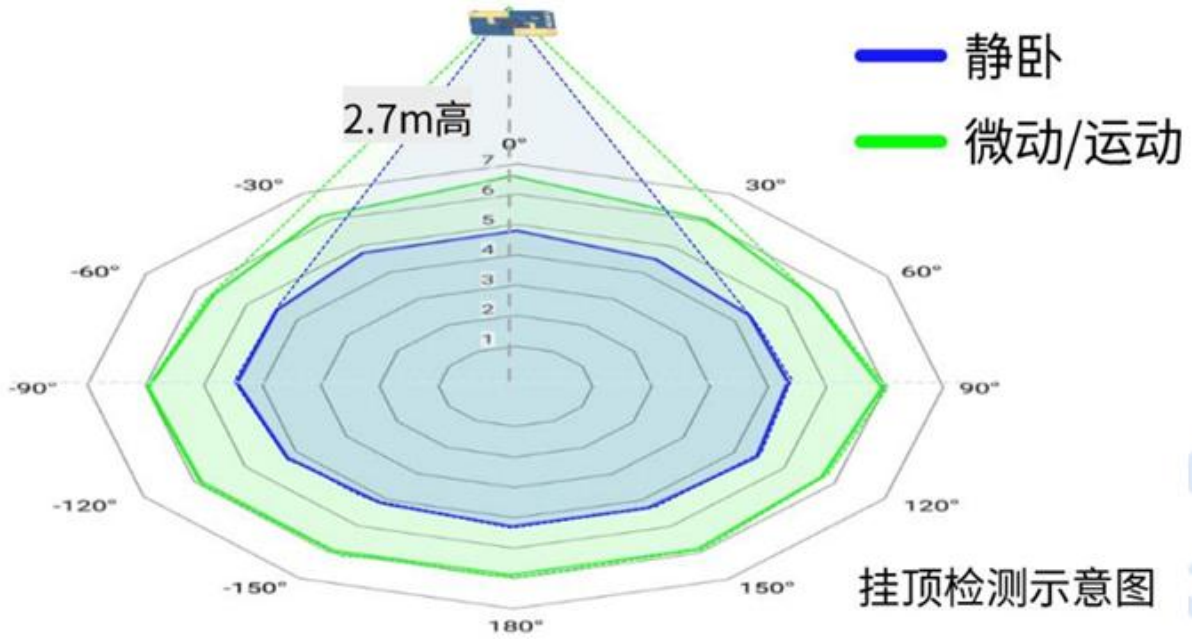


Figure 17 Ceiling-mounted sensor range

■ Wall-mounted installation method

The recommended wall-mounting height is 1.5~2m. When wall-mounted, the X-axis (reference) of the millimeter-wave sensor should point horizontally, the Z-axis upwards, and the Y-axis pointing towards the detection area. Under default configuration, the maximum motion sensing range of the wall-mounted Rd-03_V2 version is a conical space within ±60' of the sensor normal and the angle between the horizontal and pitch directions, as shown in Figure 18.

Figure 19 shows a schematic diagram of the detection range of this reference scheme when the wall-mounted installation height is 1.5 m.

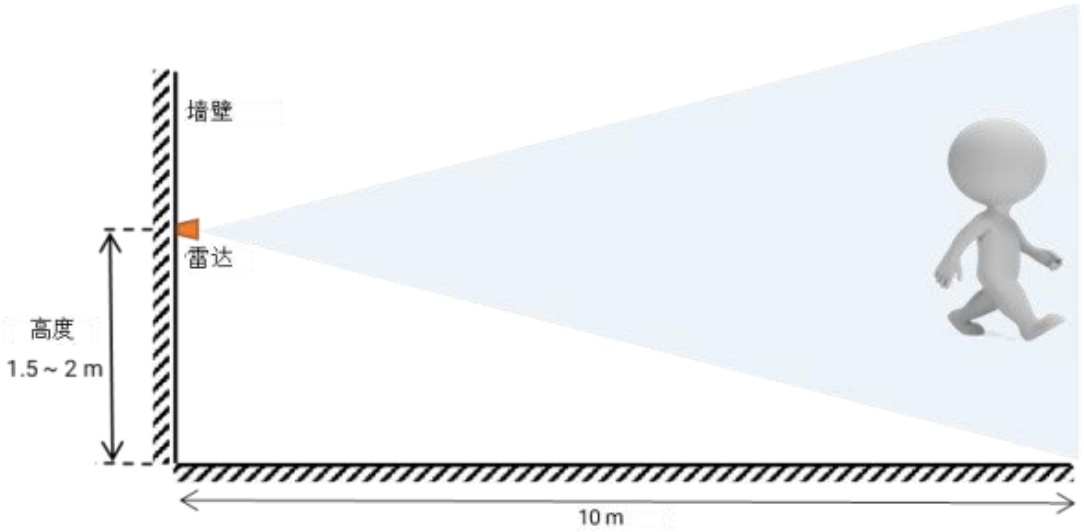


Figure 18 Schematic diagram of the wall-mounted installation testing range

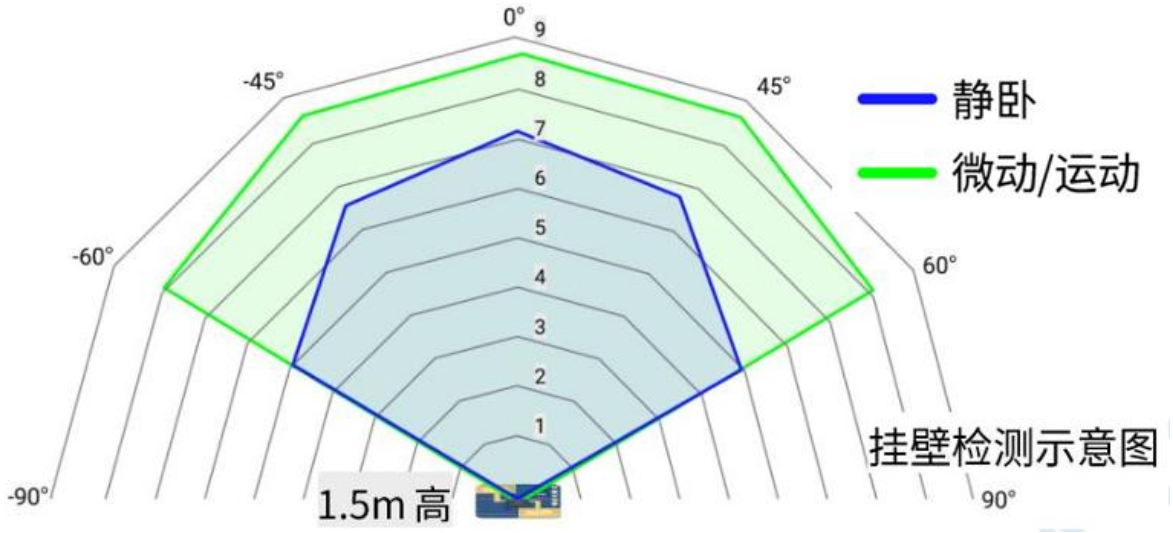


Figure 1.9 Wall -mounted installation sensing range

4.2. Radar detection range test

The test methods for triggering and maintaining the detection range of millimeter-wave sensors are described below:

Triggering range : When a target human body approaches the millimeter-wave sensor from a distance while the sensor reports no one, and stops moving forward when the sensor starts reporting someone, the current position is the boundary of the millimeter-wave sensor's triggering detection range ; the area enclosed by the detection boundaries in each direction is the millimeter-wave sensor's triggering detection range .

Maintaining range : When the target human body maintains a small movement at the test position, such as shrugging or raising its hand, while the millimeter-wave sensor reports a person, if the millimeter-wave sensor continues to report a person within 60 seconds, the current position is within the maintaining detection range of the millimeter-wave sensor; otherwise, the detection position is outside the maintaining detection range.

5. Radar Installation Instructions

5.1. Millimeter-wave sensor housing requirements

If the radar requires a housing, the housing must have good wave transmission characteristics at 24 GHz and must not contain metallic materials or materials that shield electromagnetic waves . Refer to the millimeter-wave sensor radome design guidelines.

5.2. Installation environment requirements

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

- The sensing area contains continuously moving non-human objects, such as animals, continuously swaying curtains, and large green plants facing the wind vent.
- There is a large area of highly reflective plane in the sensing area, and if the highly reflective object is directly facing the antenna, it will cause interference.
- When wall-mounting, external interference factors such as air conditioners and electric fans on the ceiling need to be considered.

5.3. Installation Precautions

- Try to ensure that the antenna is directly facing the area to be detected, and that the area around the antenna is open and unobstructed.
- To ensure the millimeter-wave sensor is securely and stably installed, any movement of the sensor itself will affect the detection results.
- It is essential to ensure that there is no moving or vibrating object behind the millimeter-wave sensor. Because millimeter waves have penetrating power, the antenna back lobe may detect moving objects behind the sensor. A metal shield or metal backplate can be used to shield the antenna back lobe, reducing the impact of objects behind the sensor.
- When multiple 24 GHz band millimeter-wave sensors are present, do not point the beams directly at each other and install them as far apart as possible to avoid potential mutual interference.

6. Precautions

- Maximum detection range

The maximum range for radar target detection is a radial distance of 8 meters. Within this detection range, the radar reports the straight-line distance between the target and the radar.

- Maximum distance and accuracy

In theory, the radar ranging accuracy of this reference scheme is ±0.15 m. However, due to differences in the size, state, and RCS of human targets, the ranging accuracy will fluctuate, and the maximum detection distance will also fluctuate to some extent.

- Target disappearance delay time

When the radar module detects no human presence within the target area, it does not immediately report a "no one" status, but rather there is a delay. The mechanism for this delayed reporting is as follows : once no human target is detected within the test range, the radar module starts a timer, the duration of which is the "no one" status. If no one is detected within the timer, a "no one" status is reported after the timer ends . If someone is detected within this time period, the timer is immediately stopped, updated, and the target information is reported.

- Micro-motion detection range

The detection range of millimeter-wave sensors for micro-motions of the human body is inversely proportional to the angle between the normal of the human body and the normal of the sensor. Therefore, in micro-motion detection scenarios, it is recommended that when installing millimeter-wave sensors, their position and angle should be adjusted to minimize the angle between their normal and the normal of the human body being detected, thereby improving detection accuracy and range.

- Optimization of automatic threshold generation function

This optimization of the automatic threshold generation function improves the overall performance of Rd-03_V2 , providing users with a better experience. Specific optimizations are as follows :

  - Reduce on-site commissioning workload

With its automatic threshold generation function, the system can automatically calculate and set appropriate threshold values, significantly reducing the workload of on-site debugging. This avoids the drawback of engineers manually adjusting the threshold values of each millimeter-wave sensor during traditional product deployment, making large-scale deployment more efficient and convenient. It improves deployment efficiency and reduces the risk of human error.

  - Improve detection accuracy

The automatic threshold generation function can automatically calculate the most suitable threshold value for the current environment through precise environmental perception and data

analysis. This method reduces the interference of manual adjustment and ensures that the sensor maintains optimal detection accuracy in various complex environments. Whether it is stable detection of static targets or rapid response to dynamic targets, the Rd-03_V2 version can provide accurate and reliable results, bringing users a superior experience.

- Simplify the installation process

The automatic threshold generation function simplifies the sensor installation process. Users only need to complete the basic installation steps, and the sensor can automatically optimize the threshold settings without the need for complex manual adjustments.

- Reduce maintenance costs

The sensor can automatically adjust its threshold values in real time according to environmental changes, reducing the need for periodic manual adjustments due to environmental variations. This reduces the workload of maintenance personnel, improves system operating efficiency and stability, and thus saves users maintenance costs.

- Flexible triggering methods

To meet the needs of different users and application scenarios, we provide two flexible automatic trigger threshold generation methods : external triggering and automatic sensor-based determination of start conditions.

External trigger : Users can trigger the automatic generation of thresholds via external signals. This method allows users to manually control the timing of threshold generation according to the needs of the actual application scenario.

Automatic sensor start condition determination : For users requiring a higher level of automation , we offer a feature that allows the sensor to automatically determine the start condition. This feature, based on the sensor's built-in intelligent algorithm, automatically determines when to begin generating threshold values. Note that custom firmware may be required to implement this feature. Users can choose flexibly based on their specific needs and application scenarios.

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Ai-Thinker official website Official Forum Develop DOCS

Ai-Thinker LinkedIn Tmall flagship store Taobao Shop

Alibaba International Station

Technical support email: support@aithinker.com

Domestic business cooperation: sales@aithinker.com Overseas business cooperation: overseas@aithinker.com

Company Address: Room 403, 408-410, Building C, Huafeng Smart Innovation Port, Gushu, Xixiang, Bao'an District, Shenzhen

Contact number: 0755-29162996

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