Shenzhen Hi-Link Electronic Co., Ltd.

# HLK-LD2412
# Human presence sensor module
# User manual




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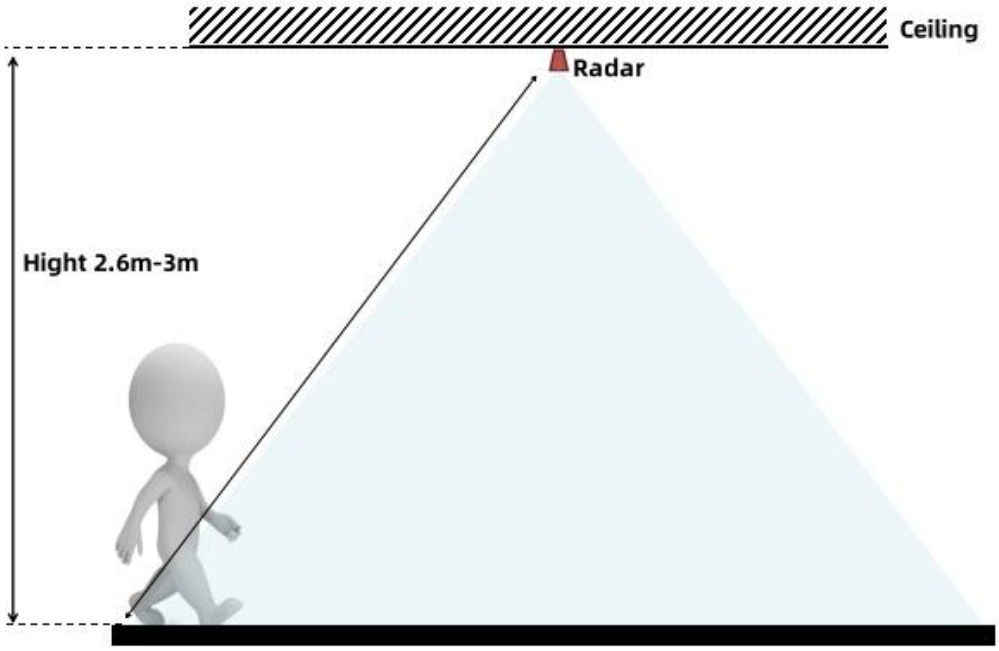
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# 1. Product Introduction

LD2412 is a high sensitivity 24GHz human presence sensing module developed by Hi-Link. Its working principle is to use FMCW FM continuous wave to detect the human body target in the set space, combined with radar signal processing and accurate human body sensing algorithm, to achieve highly sensitive human presence state sensing, can identify the human body in motion and static state, and can calculate the distance of the target and other auxiliary information.

This product is mainly used in indoor scenes, sensing whether there is movement or micromovement of the human body in the area, real-time output of detection results. The maximum sensing distance can reach 9 meters, and the distance resolution is 0.75m. Provide visual configuration tools, which can easily configure the induction distance range, induction sensitivity of different intervals and unmanned delay time, etc., to adapt to different specific application requirements.

Support GPIO and UART output, plug and play, can be flexibly applied to different intelligent scenarios and end products.



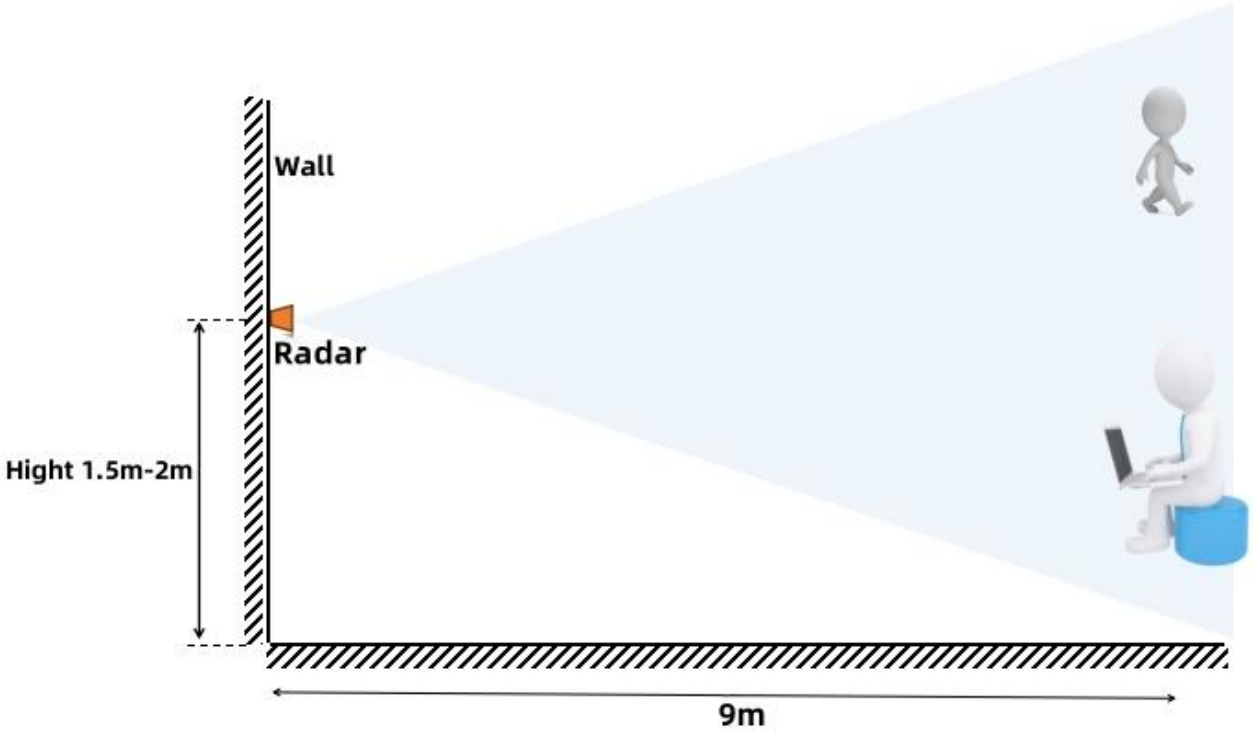



Figure 1 **Diagram of usag**

## 2. Product features and benefits

2.1 Features

- Plug and play, simple assembly method
- The longest sensing distance is up to 9m, configurable nearest and farthest detection distance
- Large detection angle, coverage range up to ±75 degrees
- Multi-level intelligent parameter adjustment to meet the needs of scene changes
- Visual debugging and configuration tools
- Compact and simplified, supports multiple installation methods such as ceiling-mounted and wall-mounted
- 24GHz ISM band, certified to FCC and CE spectrum regulations
- The ultimate cost-effective choice

2.2 Solution advantages

LD2412 human sensing module adopts 24GHz millimeter wave radar sensor technology, which has obvious advantages in human sensing applications compared with other solutions:

1. In addition to being sensitive to the moving human body, it can also be sensitive to the stationary, micro-moving, sitting and lying human body that cannot be identified by traditional solutions;

2. Good environmental adaptability, the induction effect is not affected by the surrounding environment such as temperature, brightness, humidity and light fluctuations;

3. Good shell penetration, can be hidden in the shell inside the work, no need to open holes on the surface of the product, improve the product beauty;

The maximum sensing distance and sensitivity on each distance door can be flexibly configured to achieve flexible and fine personalized configuration;

| | Infrared solution | Visual scheme | Ultrasound | Lidar | Millimeter wave radar |
|---|---|---|---|---|---|
| Application flexibility | 🔴 | 🔴 | 🔴 | 🔴 | 🟢 |
| Resistant to environmental influences (weather, light, etc.) | 🔴 | 🔴 | 🔴 | 🔵 | 🟢 |
| Detection speed | 🔴 | 🔵 | 🔵 | 🟢 | 🟢 |
| Detection accuracy | 🔴 | 🔵 | 🟢 | 🟢 | 🟢 |
| Resolution | 🔴 | 🟢 | 🟢 | 🟢 | 🟢 |
| Directionality | 🔴 | 🔵 | 🔴 | 🟢 | 🟢 |
| Detection distance | 🔵 | 🔴 | 🔴 | 🟢 | 🟢 |
| Ability to penetrate materials | 🔴 | 🔴 | 🔴 | 🔴 | 🟢 |
| size | 🟢 | 🔴 | 🟢 | 🔴 | 🟢 |
| cost | 🟢 | 🔴 | 🟢 | 🔴 | 🔵 |

🟢 Good 🔵 Common 🔴 Weak

Figure2 Comparison between millimeter wave radar solution and other solutions

## 3. Application scenarios

The LD2412 human body sensing module can detect and identify the human body in motion, micro-movement, standing and sitting, and supports multi-level adjustment. It can be widely used in various scenarios of AIoT. The common types are as follows:

- **Human body induction light control**

Sensing the presence of people in the space, automatic control of lighting, such as lighting equipment in public places, various induction lights, bulb lights, etc.

- **Human body induction awakening of advertising screen and other devices**

Automatically turns on when someone comes, automatically sleeps when no one is around to save power, and information delivery is more accurate and efficient.

- **Life safety protection**

UV lamp work protection, to prevent the UV lamp from being turned on when there are peoplearound and causing personal injury;

Automatic detection and alarm of dangerous places to prevent people from entering specifichighrisk spaces, such as high-risk places entered by personnel from coal mine blasting;

- **Smart home appliances**

When there is no one in the room for a long time, the TV, air conditioner and other electrical appliances are automatically turned off, saving energy and safety.

- **Intelligent security**

Detection and identification of people intruding, staying, etc. within the specified range.

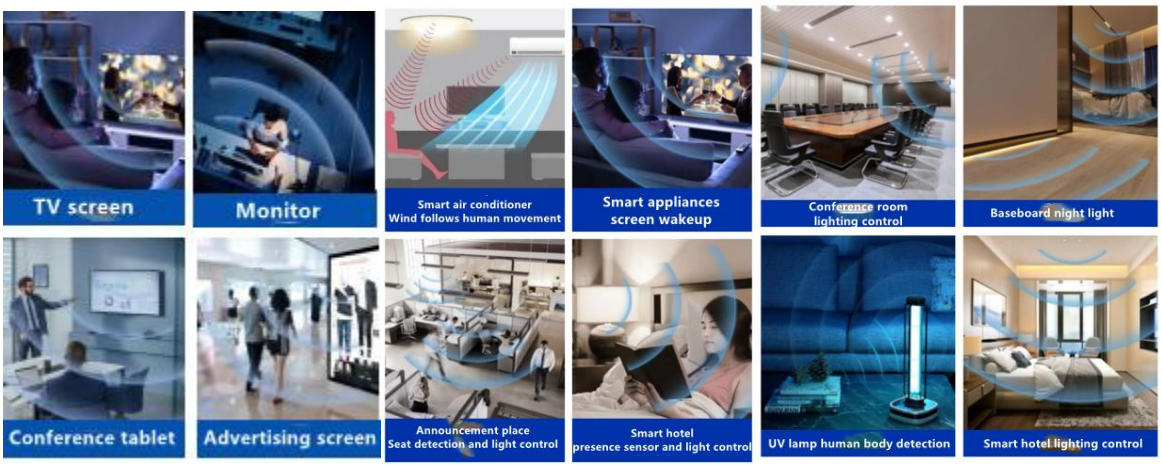



Figure 3 Application Scenario

# 4. Hardware description

## 4.1 Dimensions




Figure4 Module physical picture

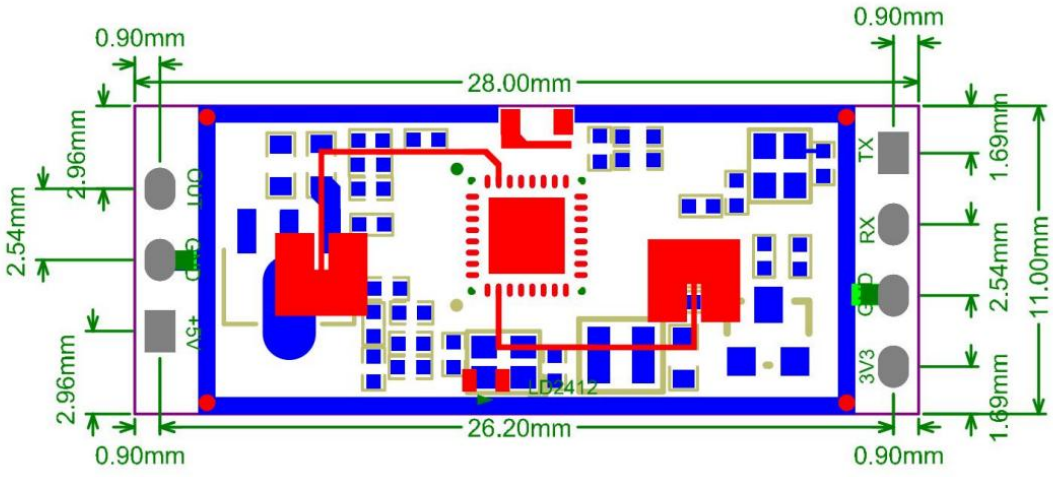



Figure5 Module size drawing

Module size: 11mmx28mm
Pin Spacing: 2.54mm

## 4.2 Pin definition

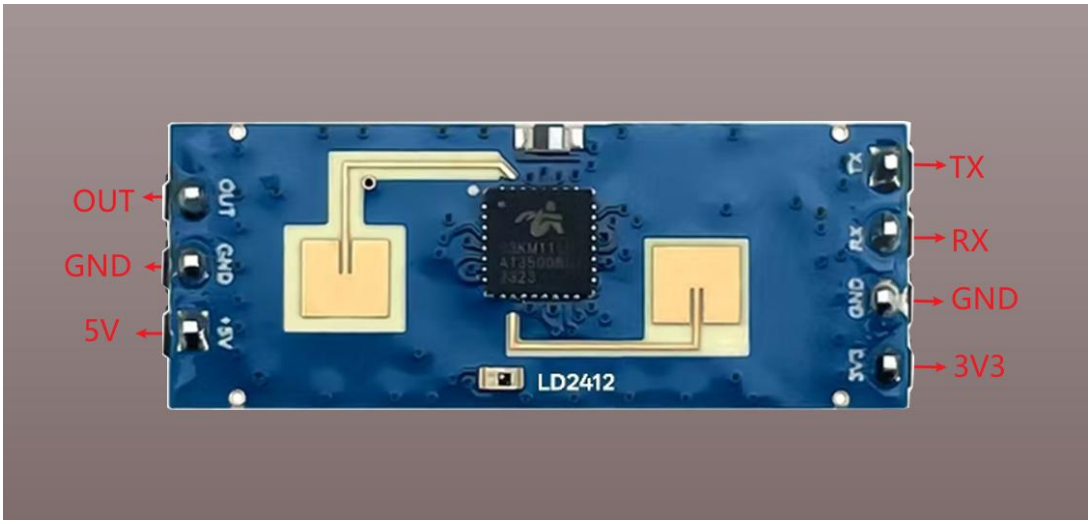



Figure6 Module pin definition diagram

| Pin | Name | Function |
|---|---|---|
| OUT | Target state output | The default is<br>Human presence detected: output high level<br>No human body exists: output low level<br>Output levels are configurable via commands |
| Tx | Serial Tx | Serial port Tx pin |
| RX | Serial port Rx | Serial Rx pin |
| +5V | 5V power input | The power supply input is 5V; you can choose between 5V and 3.3V power supply. |
| 3V3 | 3.3V power input | Power supply input is 3.3V; either 5V or 3.3V power supply can be selected |
| GND | power ground | power ground |
| G | power ground | power ground |

**Table1 Pin definition**

## 4.3 Use and configuration

### 4.3.1 Typical application circuit

LD2412 module directly output the detected target state through an IO pin (the level can be configured, the default is a high level of human, no low level), and can also output the detection result data through the serial port according to the specified protocol, the serial port output data contains the target state and distance auxiliary

information, etc., users can flexibly use according to the specific application scenario.

The power supply voltage of the module can be 5V or 3.3V, and the power supply capacity of the input power supply must be greater than 200mA.

Module IO output level is 3.3V. The serial port has a default baud rate of 115200, 1 stop bit and no parity bit.

#### 4.3.2 The role of configuration parameters

Users can modify the configuration parameters of the module through the serial port of LD2412 to adapt to different application needs.

Configurable radar detection parameters include the following:

**Maximum distance door**

Set the maximum detection distance. Only human targets appearing within this maximum distance will be detected and the results will be output.

Set in units of distance gates, each distance gate is 0.75m.

The settable range is 1 to 14. For example, if the farthest distance door is set to 2, the result will only be effectively detected and output if there is a human body within 1.5m.

**Minimum distance gate**

Set the nearest detection distance. The human target will not be detected and the result will be output until the radar module is greater than this distance.

Set in units of distance gates, each distance gate is 0.75m.

The value range ranges from 1 to 14. For example, if the farthest distance door is set to 2, the system can effectively detect and output the result only when there is a human body within 1.5m.

**Sensitivity**

Only when the detected target energy value (range 0~100) is greater than the sensitivity value will it be determined that the target exists, otherwise it will be ignored.

The sensitivity value can be set in the range of 0 to 100. The sensitivity of each

distance gate can be set independently, which can accurately adjust the detection within different distance ranges, accurately detect local areas or filter interference sources in specific areas.

In addition, if the sensitivity of a certain distance gate is set to 100, the effect of not recognizing targets under this distance gate can be achieved. For example, if the sensitivity of distance gate 3 and distance gate 4 is set to 20, and the sensitivity of other distance gates is set to 100, then only human bodies within the range of 2.25 to 3.75 meters from the distance module can be detected.

**No one duration**

When the radar outputs results from occupied to unmanned, it will continue to report that there is someone for a period of time. If there is no one within the radar test range during this time period, the radar will report that there is no one; if the radar detects someone during this time period, it will refresh again. This time, in seconds, the minimum value is 5. It is equivalent to the unmanned delay time. After the person leaves, the status will be output as unmanned after the duration of the time has elapsed.

## 4.4 Visual configuration tool description

In order to facilitate the user to test and configure the module quickly and efficiently, the host computer configuration tool on the PC is provided. Users can use this tool software to connect the serial port of the module, read and configure the parameters of the module, receive the detection result data reported by the module, and perform real-time visual display, which greatly facilitates the use of users.

How to use the host computer tools:

1. Use the USB to serial port tool to correctly connect the module serial port;

2. Select the corresponding serial port number in the host computer tool, set the baud rate to 115200, select the engineering mode, and click to connect the device;

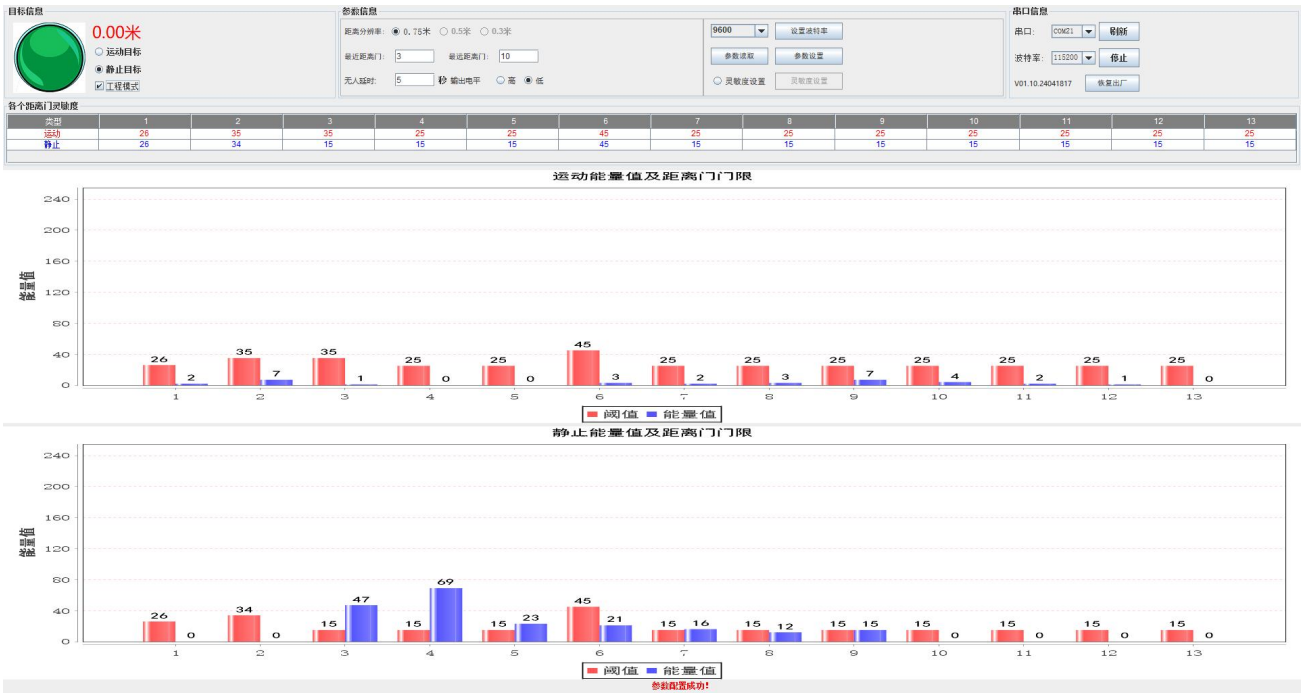
3. After the connection is successful, click the start button, and the graphical interface on the right will display the test results and data;

4. After connecting, the mode parameter information can be read or set without clicking the start button, or by clicking stop after starting;

Note: Parameters cannot be read and configured after clicking Start. You must stop before configuring.

When the module is first powered on, there is a cumulative process for static energy detection. Therefore, there may be no static energy on the host computer in the first 5 to 10 seconds after the module is powered on. The energy value display is stopped, which is a normal phenomenon;

The interface and common functions of the host computer tool are as follows:




## 4.5 Installation method and sensing range

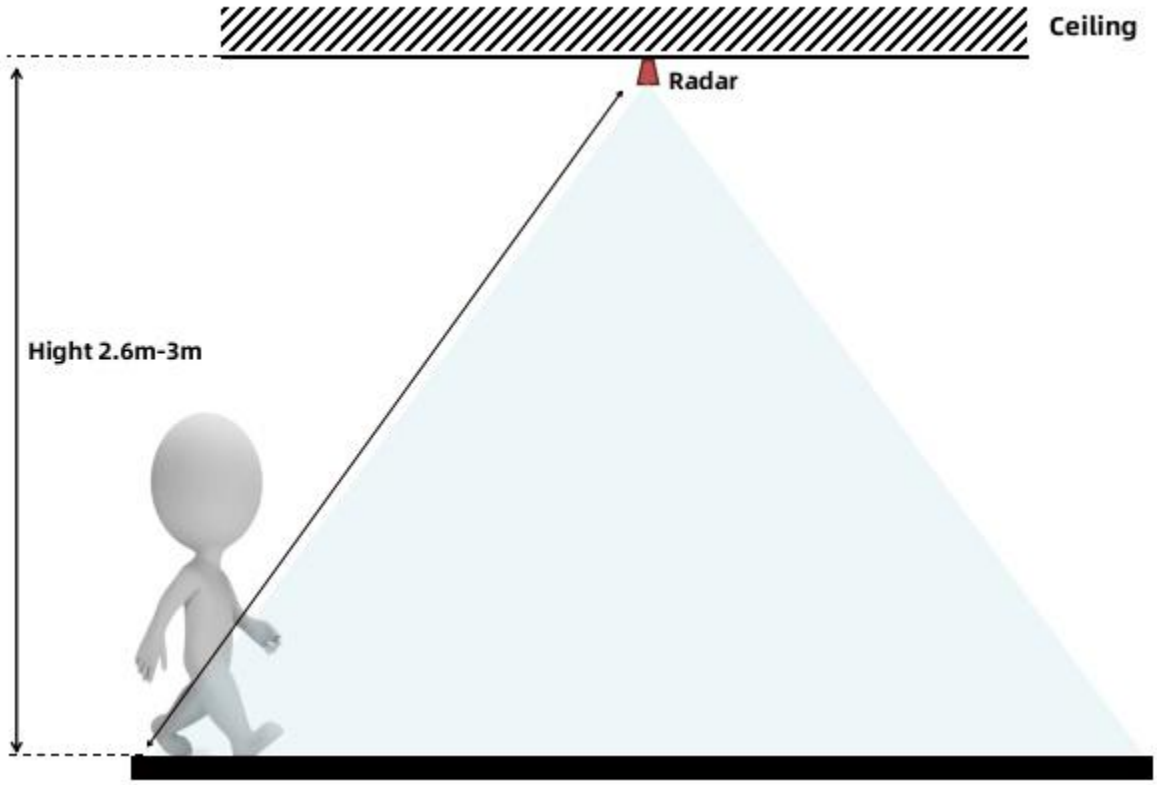
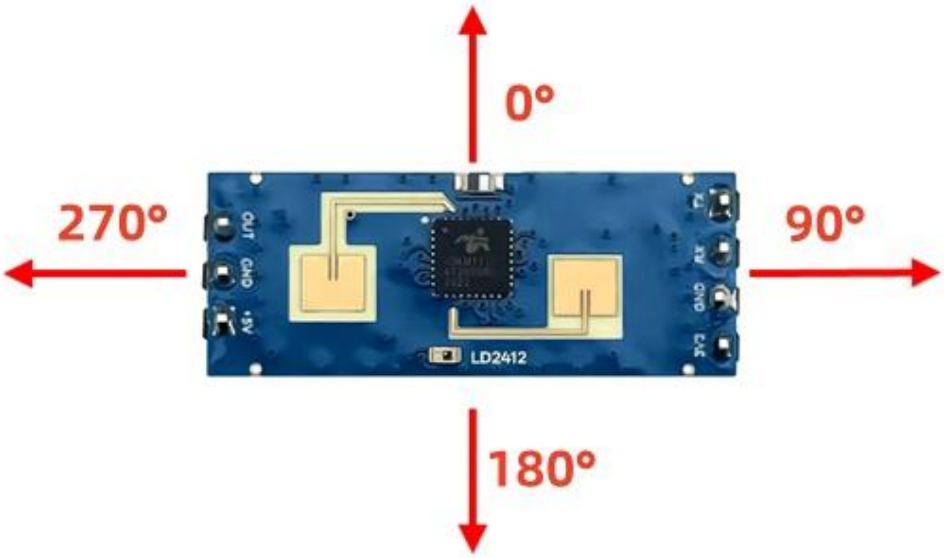
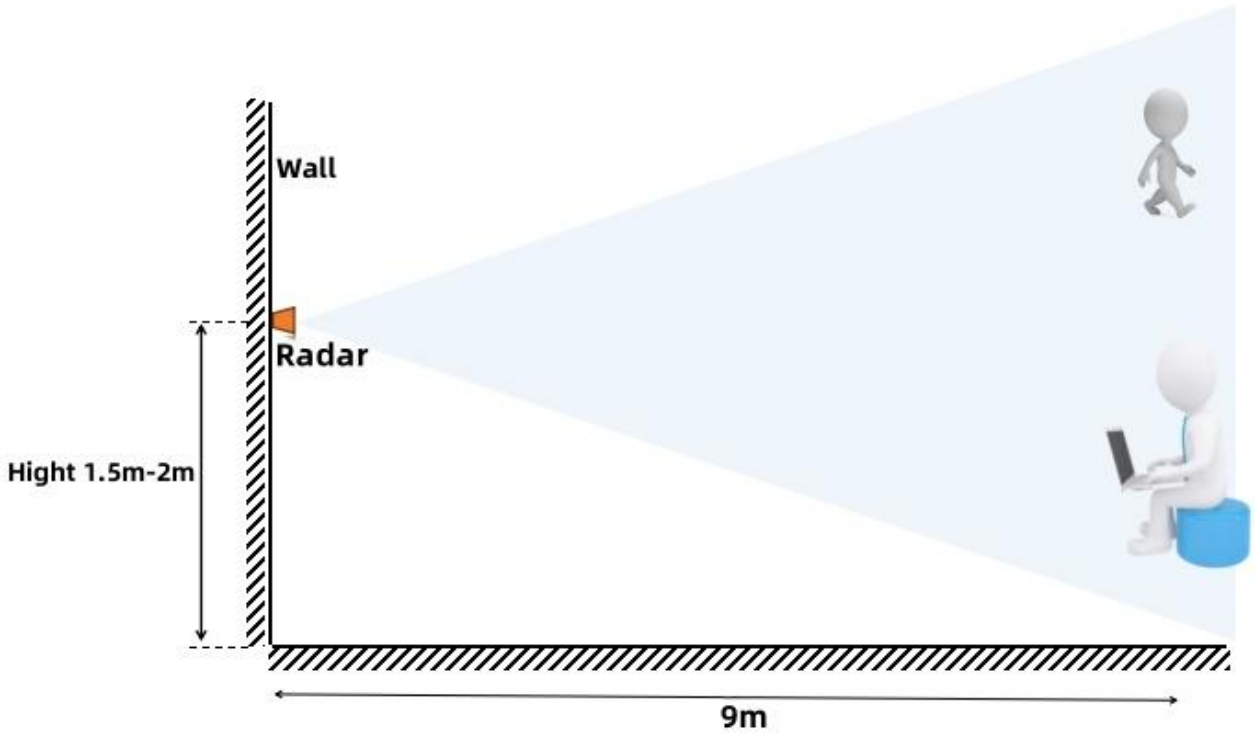



Figure7 Ceiling installation diagram






(Distance unit: meters, angle unit: degrees)

Figure8 Wall installation diagram




## 4.6 Installation conditions

**Confirm minimum installation clearance**

If the radar needs to be installed with a shell, the shell must have good wave transmission properties at 24GHz and cannot contain metal or materials that can shield electromagnetic waves.

**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:

• There are continuously moving non-human objects in the sensing area, such as animals, continuously swinging curtains, large green plants facing the air outlet, etc.

• There is a large area of strong reflectors in the sensing area. The strong reflectors will cause interference to the radar antenna.

• When installing on the wall, you need to consider external interference factors such as air conditioners and electric fans at the top of the room.

**Things to note when installing**

• Try to ensure that the radar antenna is facing the area to be detected and that the surrounding area of the antenna is open and unobstructed

• Ensure that the installation position of the sensor is firm and stable. The shaking of the radar itself will affect the detection effect.

• Make sure there is no movement or vibration on the back of the radar. Due to the penetrating nature of radar waves, the antenna signal back lobe may detect moving objects behind the radar. Metal shields or metal back plates can be used to shield the radar back lobe and reduce the impact of objects on the back of the radar.

• The theoretical distance accuracy of radar is the result of special algorithm processing based on the distance resolution. Due to the different size, status, RCS, etc. of the target, the target distance accuracy will fluctuate; at the same time, the farthest distance will also fluctuate slightly.

# 5. Performance and electrical parameters

| | |
|---|---|
| **Working frequency** | 24GHz~ 24.25GHz<br>Comply with FCC, CE, non-committee certification standards |
| **Power supply requirements** | DC 5V or DC 3.3V,Power supply capacity>200mA |
| **Average working current** | 90mA |
| **Modulation** | FMCW |
| **Interface** | One GPIO, IO level 3.3V<br>One UART |
| **Target application** | Human body presence sensor |
| **Detection distance** | Distance resolution=0.75m: 0.75m ~ 9m, adjustable |
| **Detection angle** | ±75° |
| **Distance resolution** | 0.75m |
| **Sweep bandwidth** | 250MHz<br>Comply with FCC, CE, non-committee certification standards |
| **Environment temperature** | -40 ~85℃ |
| **Dimensions** | 11mm x28mm |

Table2 Performance and electrical parameters table

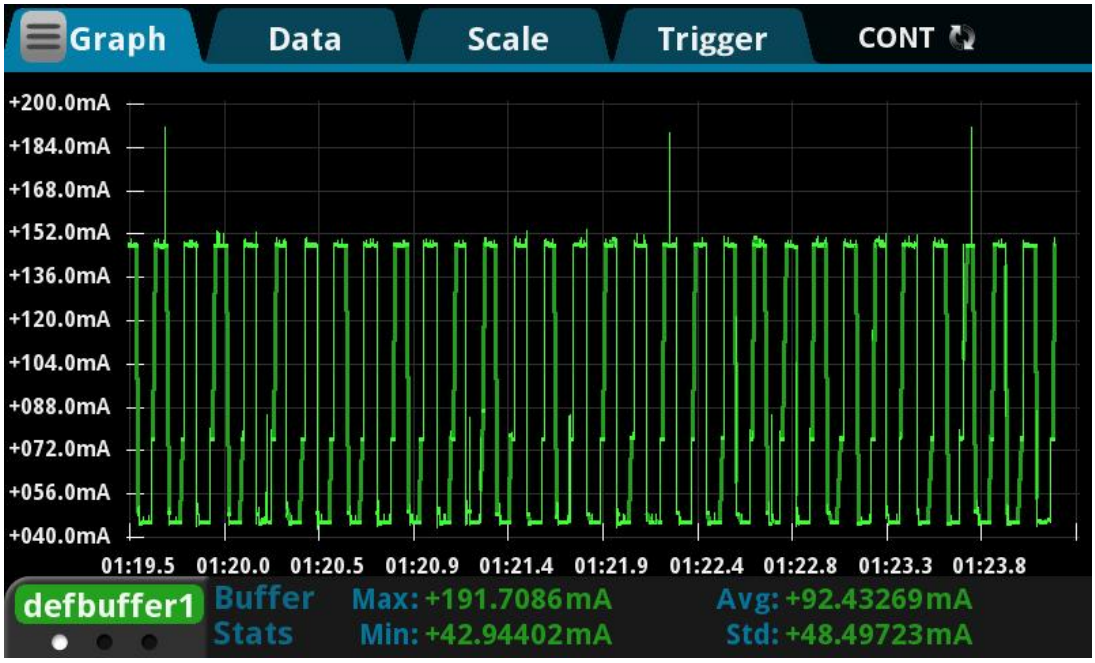
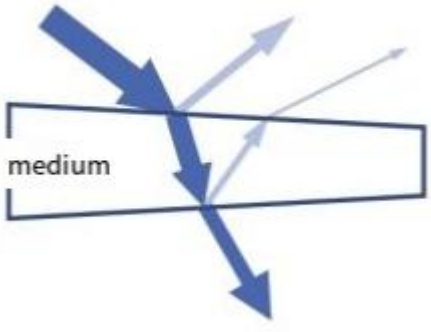


Figure9 Module operating current measurement data

# 6. Radome design guide

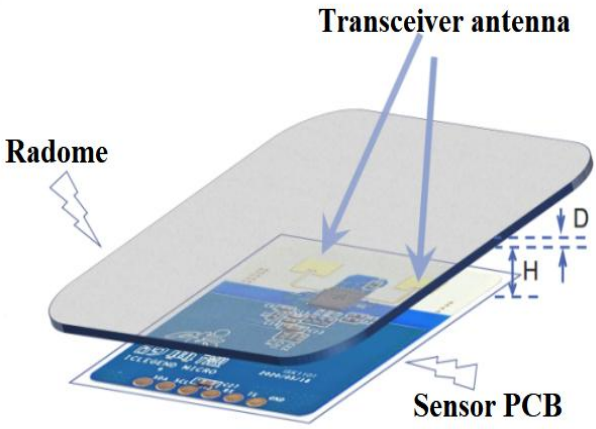
## 6.1 The impact of radomes on millimeter wave sensor performance




- Radar waves are reflected at the boundary of the radome
  - The total power radiated or received by the radar is lost
  - The reflected wave enters the receiving channel and affects the isolation between the transmitting and receiving channels
  - The reflection may make the antenna's standing wave worse and further affect the antenna gain
- Radar wave propagation in the medium will cause loss, theoretically speaking, the higher the frequency of the loss will be greater
- Electromagnetic wave will produce a certain degree of refraction when passing through the medium
  - The radiation pattern of the antenna is affected, which in turn affects the coverage of the sensor

## 6.2 Design Principles of radomes

- Structural shape of the radome
- The surface is smooth and flat, and the thickness is uniform. Such as plane or spherical surface, can not be uneven.
- If there is a surface coating, it must not contain metals or conductive materials.
- Directly above the antenna, the radome is parallel to the antenna plane.
- Height H from the antenna to the inner surface of the radome
- The ideal height is an integer multiple of the half wavelength of the electromagnetic wave in the air.
- $H = \frac{m}{2} * \frac{C_0}{f}$ ,where m is a positive integer,Co is the speed of light in vacuum, and f is the working center frequency.
- For example, the center frequency of 24.125GHz, its half wavelength in air is about 6.2mm.
- Radome thickness D
- The ideal thickness is an integer multiple of the half wavelength of the electromagnetic wave in the medium.
- $D = \frac{m}{2} * \frac{C_0}{f\sqrt{\epsilon r}}$ ,where m is a positive integer and $\epsilon r$ is the relative permittivity of the radome material.
- For example, a certain ABS material $\epsilon r$=2.5, its half wavelength is about 3.92mm.



6.3 Common materials

• Understand the material and electrical characteristics of the radome before designing

• The table on the right is for reference only, the actual value should be confirmed with the supplier

• Height H from the antenna to the inner surface of the radome

• If there is enough space, it is preferred to recommend 1 times or 1.5 times the wavelength

• For example, 12.4 or 18.6mm is recommended for 24.125GHz

• Error control: ±1.2mm

• Radome thickness D

• Recommended half wavelength, error control±20%

• If the thickness requirement of half wavelength cannot be met

• It is recommended to use low materials

• Thickness recommended 1/8 wavelength or thinner

• Influence of heterogeneous materials or multi-layer composite materials on radar performance, it is recommended to make experimental adjustments during design

**Common material properties (based on 24.125GHz)**

| Medium | $\epsilon_r$ Typical value | Half wavelength (mm) | 1/8 wavelength (mm) | 1/10 wavelength (mm) |
|---|---|---|---|---|
| Air | 1.00 | 6.20 | 1.55 | 1.24 |
| ABS1 | 1.50 | 5.06 | 1.27 | 1.01 |
| ABS2 | 2.50 | 3.92 | 0.98 | 0.78 |
| PC material | 3.00 | 3.58 | 0.89 | 0.72 |
| PMMA acrylic 1 | 2.00 | 4.38 | 1.10 | 0.88 |
| PMMA acrylic 2 | 5.00 | 2.77 | 0.69 | 0.55 |
| PVC hard | 4.00 | 3.10 | 0.78 | 0.62 |
| PVC soft | 8.00 | 2.19 | 0.55 | 0.44 |
| High density PE | 2.40 | 4.00 | 1.00 | 0.80 |
| Low density PE | 2.30 | 4.09 | 1.02 | 0.82 |
| Quartz glass | 5 | 2.77 | 0.69 | 0.55 |

Table 3 Common Material Properties of Radomes

## 7. Revision history

| Date | Version | Modify content |
|---|---|---|
| 2024-4-18 | 1.01 | Test version |
| | | |
| | | |
| | | |
| | | |

## 8. Technical support and contact information

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