

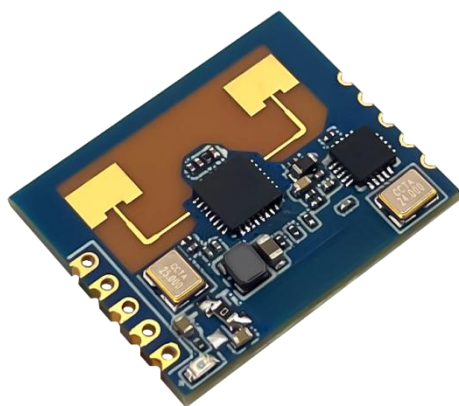


Shenzhen Hi-Link Electronic Co.,Ltd

HLK-LD2401

Human presence sensor module

Datasheet



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1 Product Introduction

HLK-LD2401 is a highly sensitive 24GHz human presence sensing module developed by Hi-Link Electronics. Its working principle is to use FMCW frequency modulated continuous wave to detect human targets in a set space, and combine radar signal processing and precise human body sensing algorithm to achieve highly sensitive human presence sensing, which can identify human bodies in motion and at rest, and calculate auxiliary information such as the distance to the target.

This product is mainly used in indoor scenes to sense whether there is a moving or slightly moving human body in the area and output the detection results in real time. The maximum sensing distance can reach 6 meters, and the distance resolution is 0.75m. It provides a visual configuration tool that can easily configure the sensing distance range, sensing sensitivity in different intervals, and unmanned delay time, etc., to meet different specific application needs.

Supports GPIO and UART output, plug and play, and can be flexibly applied to different smart scenarios and terminal products.

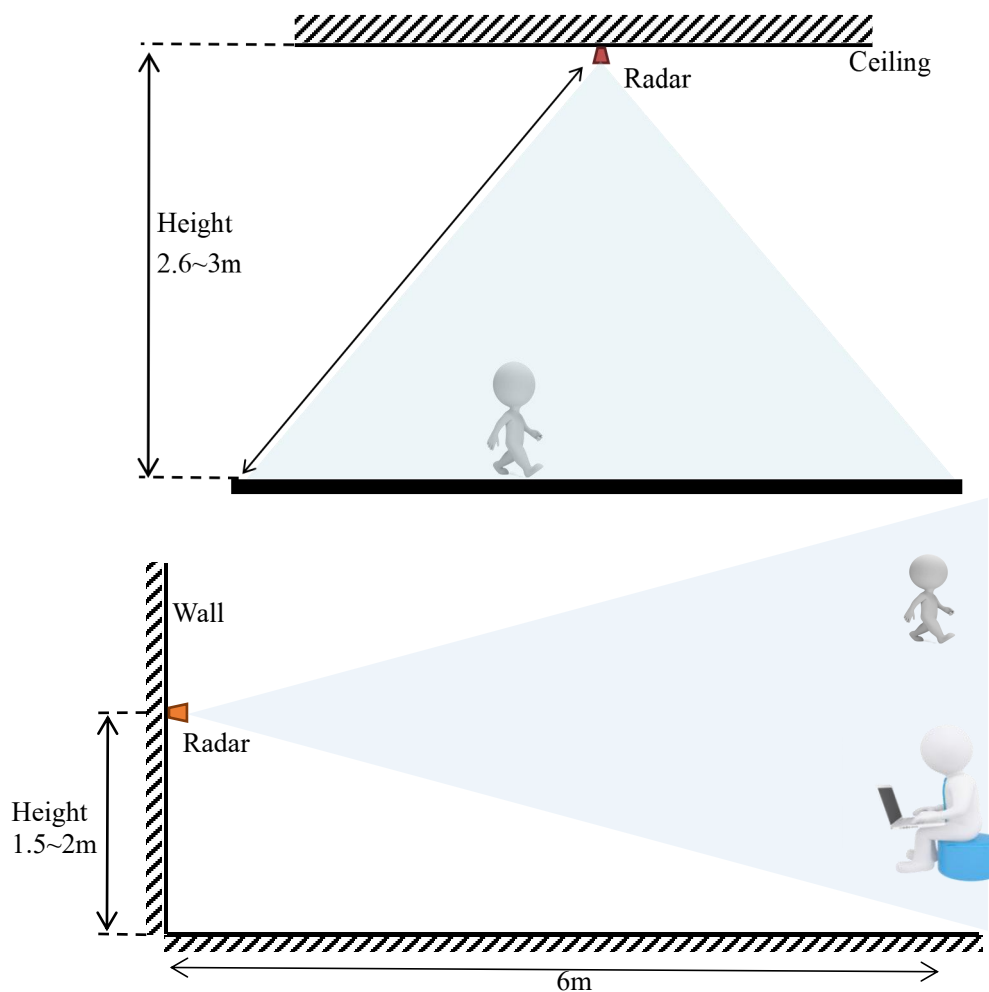


Figure 1 Usage diagram

2 Product Features and Advantages

2.1 Features

- Plug and play, easy assembly
- The maximum sensing distance is up to 6 meters
- Large detection angle, coverage range up to ± 60 degrees
- Accurately identify within the interval, support sensing range division, and shield interference outside the interval
- Multi-level intelligent parameter adjustment can be achieved through Bluetooth or serial port to meet the needs of scene changes
- Visual debugging and configuration tools
- Supports multiple installation methods such as ceiling hanging and wall hanging
- 24GHz ISM band, certified to FCC and CE spectrum regulations
- The ultimate cost-effective choice

2.2 Solution Advantages

The HLK-LD2401 human body sensing module uses 24GHz millimeter wave radar sensor technology. Compared with other solutions, it has obvious advantages in human body sensing applications:

1. In addition to being sensitive to moving human bodies, it can also be sensitive to static, slightly moving, sitting and lying human bodies that cannot be identified by traditional solutions;
2. It has good environmental adaptability, and the sensing effect is not affected by the surrounding environment such as temperature, brightness, humidity and light fluctuations;
3. It has good shell penetration and can be hidden inside the shell to work without opening holes on the product surface, which improves the product's aesthetics;
4. The maximum sensing distance and the sensitivity of each distance gate can be flexibly configured to achieve flexible and detailed personalized configuration;
5. With Bluetooth function, you can directly use the APP to debug radar parameters without connecting to the serial port.

	Infrared Solution	Visual Solution	Ultrasound	Li DAR	Millimeter wave radar
Application flexibility	●	●	●	●	●
Resistant to environmental influences (weather, light, etc.)	●	●	●	●	●
Detection speed	●	●	●	●	●
Detection accuracy	●	●	●	●	●
Resolution	●	●	●	●	●
Directionality	●	●	●	●	●
Detection distance	●	●	●	●	●
Ability to penetrate materials	●	●	●	●	●
Dimension	●	●	●	●	●
Cost	●	●	●	●	●

● Good ● Generally ● Bad

Figure 2 Comparison between millimeter wave radar solution and other solutions

3 Application

The HLK-LD2401 human body sensing module can detect and identify moving, slightly moving, standing, sitting or lying human bodies. It supports multi-level parameter adjustment and can be widely used in various AIoT scenarios. Common types are as follows:

- **Human body sensor light control**

It can sense whether there are people in the space and automatically control the lights, such as public lighting equipment, various sensor lights, and bulb lights.

- **Human body induction wake-up for advertising screens and other equipment**

It turns on automatically when someone comes, and goes into sleep mode when no one is around to save power, making information delivery more accurate and efficient.

- **Life safety protection**

UV light working protection to prevent the UV lamp from turning on when there are people around and causing harm to people.

Automatic detection and alarm in dangerous places prevent people from entering specific high-

risk spaces, such as high-risk places entered by personnel engaged in coal mine blasting.

● Smart Home Appliances

If no one is in the room for a long time, electrical appliances such as TV and air conditioner will be automatically turned off, which is energy-saving and safe.

● Smart Security

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

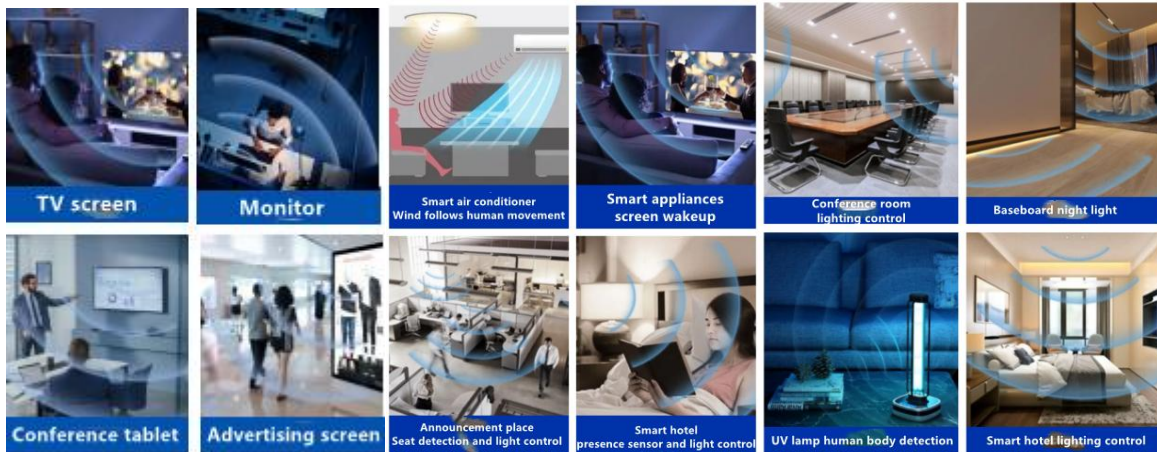


Figure 3 Application areas

4 Hardware Description

4.1 Dimension

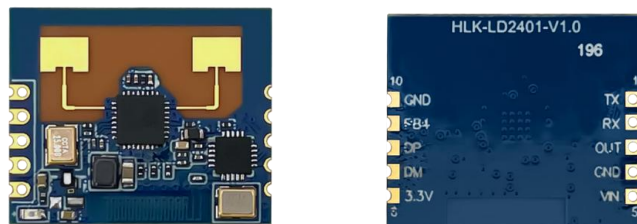


Figure 4 Module pictures

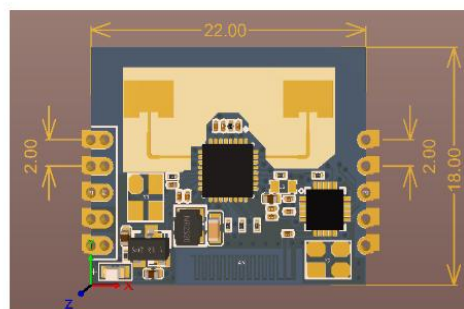


Figure 5 Module dimension

Module size: 18mmx22mm, 5 pin holes reserved in hardware (no pins are provided by default)

Pin hole diameter 0.8mm, pin spacing 2.00mm

4.2 Pin Definition

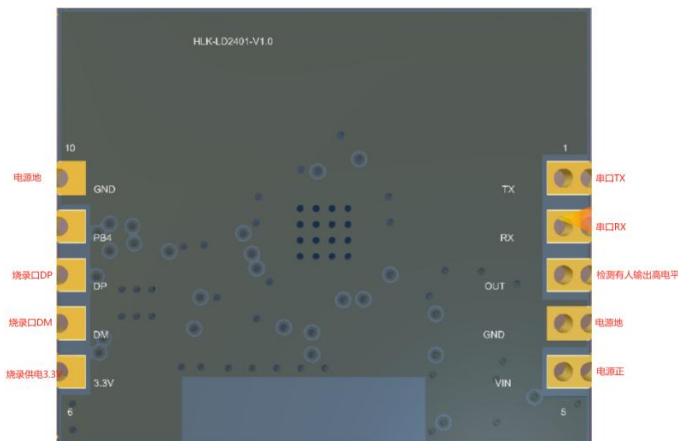


Figure 6 Module pin definition

Pin	Symbol	Name	Function
1	UART_Tx	Serial port Tx	Serial port Tx pin
2	UART_Rx	Serial port Rx	Serial port Rx pin
3	OUT	Target status output	Detecting the presence of a human body: output high level No human body present: output low level
4	GND	Power ground	Power ground
5	VCC	Power input	Power input 3.3V

Table 1 Pin definition

Pin	Symbol	Name	Function
1	GND	Power ground	Power ground
2	PB4	Reserve	
3	DP	Program download port	Program download
4	DM	Program download port	Program download
5	3.3V	Burning power supply	Burning power input 3.3V

Table 2 Burning pin definition

5 Using and Configuration

5.1 Typical Application Circuit

The HLK-LD2401 module directly outputs the detected target status through an IO pin (high level if someone is there, low level if no one is there). It can also output the detection result data through the serial port according to the specified protocol. The serial port output data contains the target status and distance auxiliary information, etc. Users can use it flexibly according to specific application scenarios.

The module power supply voltage is 3.3V, and the power supply capacity of the input power supply is required to be greater than 200mA.

The module IO output level is 3.3V. The default baud rate of the serial port is 256000, 1 stop bit, and no parity bit.

5.2 Configuration Parameters

Users can modify the configuration parameters of the module through the serial port of HLK-LD2401 to adapt to different application requirements, and the configuration content will not be lost when power is off.

The configurable parameters include the following:

Maximum detection distance

Set the farthest detectable distance. Only human targets within this farthest distance will be detected and the results will be output.

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

Including the farthest distance gate for motion detection and the farthest distance gate for static detection, which can be set in the range of 1 to 8. For example, if the farthest distance gate is set to 2, only human beings within 1.5m will be effectively detected and the results will be output.

Sensitivity

The target is considered to exist only when the detected target energy value (range 0-100) is greater than the sensitivity value, otherwise it is ignored.

The sensitivity value can be set in the range of 0-100. Each range gate can set the sensitivity independently, which can accurately adjust the detection within different distance ranges, local accurate detection or filtering of interference sources in specific areas.

In addition, if the sensitivity of a range gate is set to 100, the effect of not identifying the target under this range gate can be achieved. For example, if the sensitivity of range gates 3 and 4 is set to

20, and the sensitivity of other range gates is set to 100, it can be achieved that only the human body within the range of 2.25-3.75m of the range module can be detected.

No one duration

When the radar outputs the result from someone to no one, it will continue to report someone. If no one is in the radar test range during this period, the radar will report no one. If the radar detects someone during this period, it will refresh this time in seconds. It is equivalent to the no one delay time. After the person leaves, the no one status will be output only after the no one status exceeds this duration.

5.3 Visual Configuration Tool Description

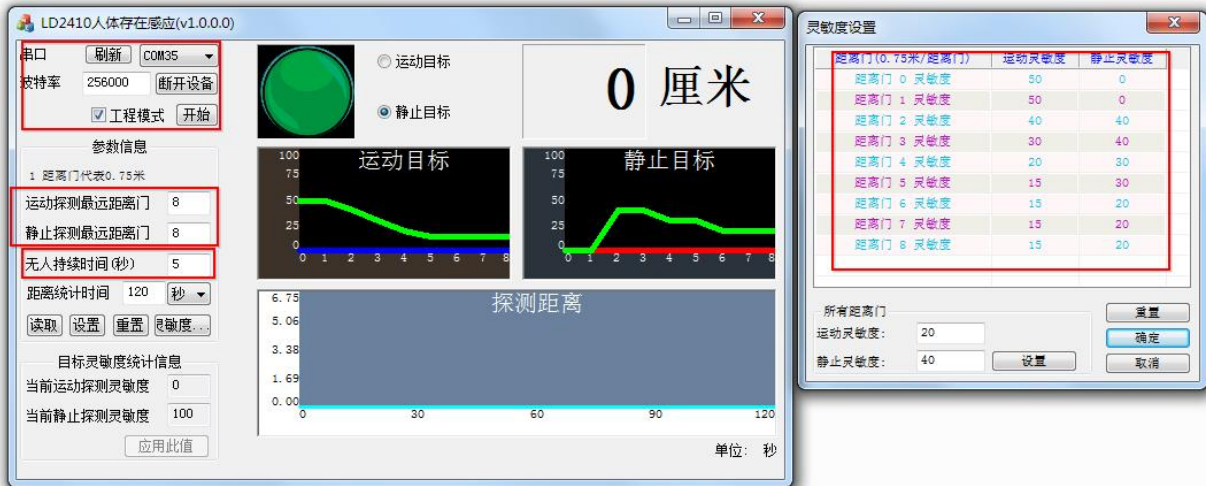
In order to facilitate users to test and configure the module quickly and efficiently, a PC-side host configuration tool is provided. Users can use this tool software to connect to the serial port of the module, read and configure the module parameters, and receive the detection result data reported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

Use of the host tool:

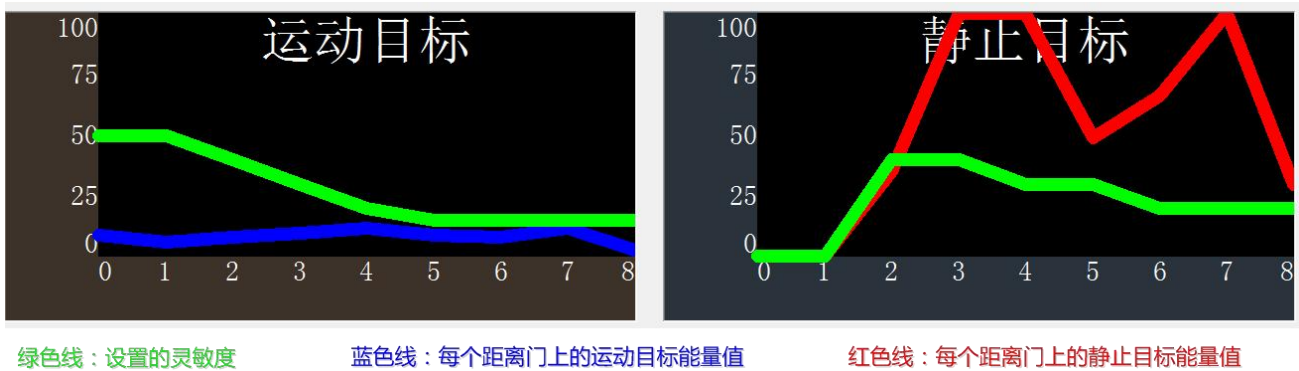
1. Use the USB to serial port tool to correctly connect the module serial port;
2. Select the corresponding serial port number in the host tool, set the baud rate to 256000, select the engineering mode, and click Connect Device;
3. After the connection is successful, click the Start button, and the graphical interface on the right will display the test results and data;
4. After the connection is established, if the Start button is not clicked, or if Stop is clicked after starting, the mode parameter information can be read or set;

Note: After clicking Start, the parameters cannot be read and configured, and they must be stopped before configuration can be performed.

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



The ball is the target status output indicator: red represents a moving target, purple represents a stationary target and green represents no one.



5.4 Installation and Sensing Range

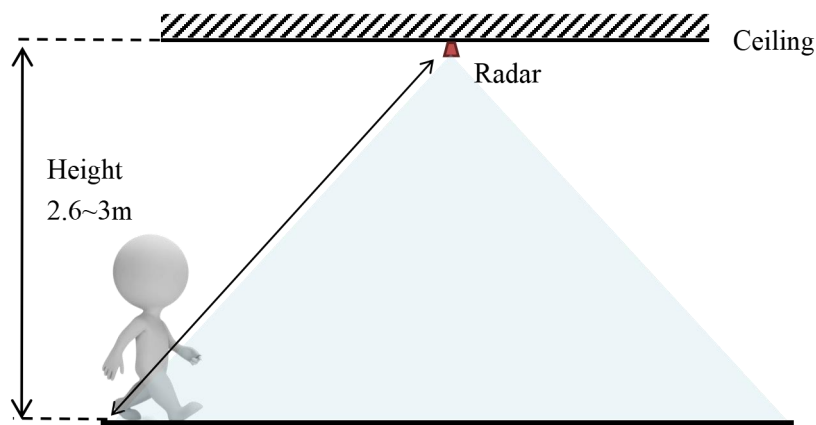
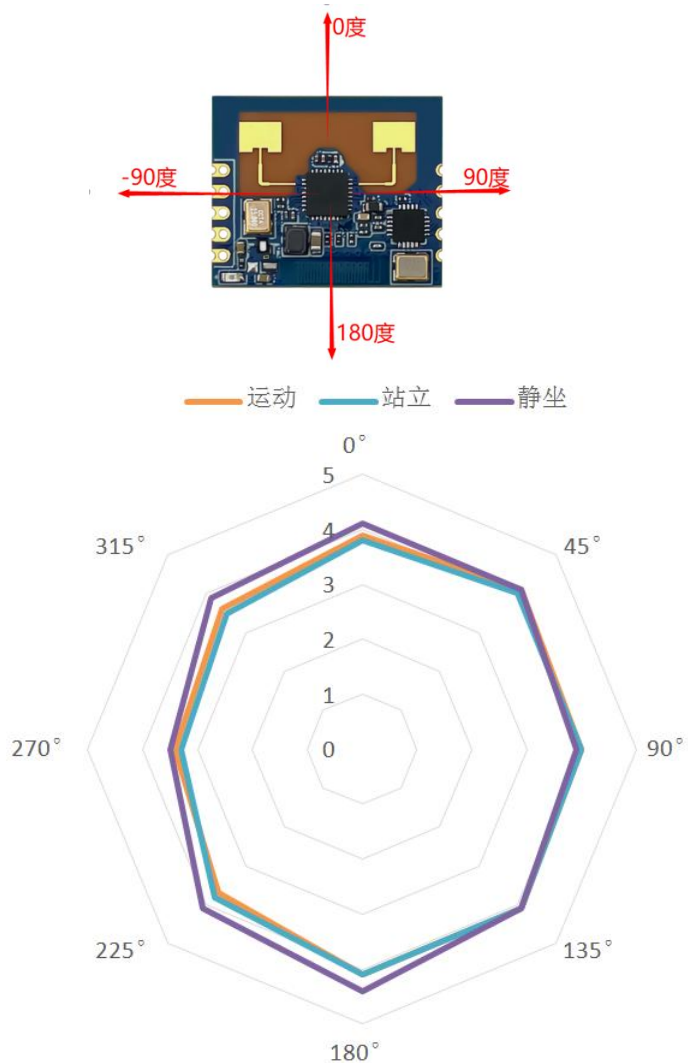
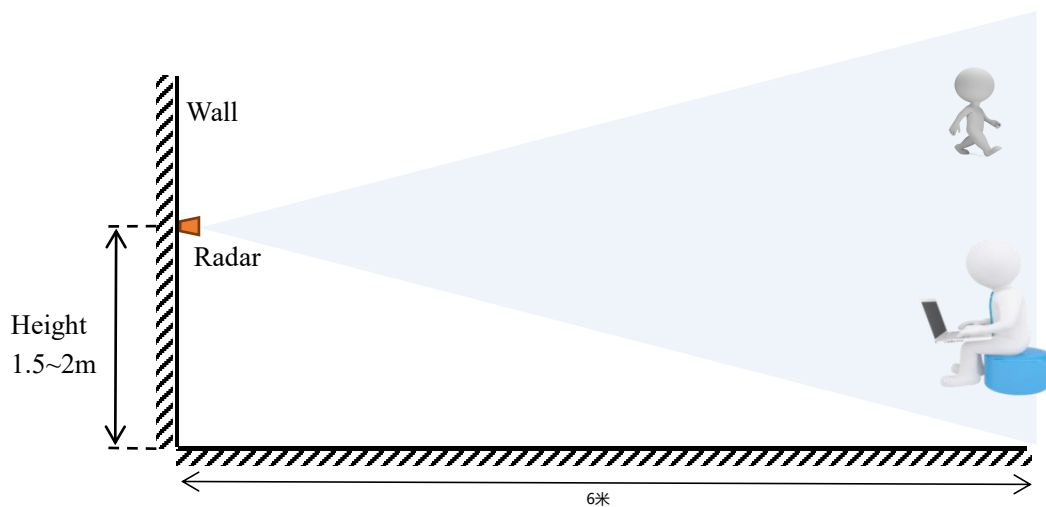


Figure 7 Ceiling installation



(Distance unit: meter, angle unit: degree)

Figure 8 Detection range diagram (ceiling height 3 meters)



(Distance unit: meter, angle unit: degree)

Figure 9 Wall installation

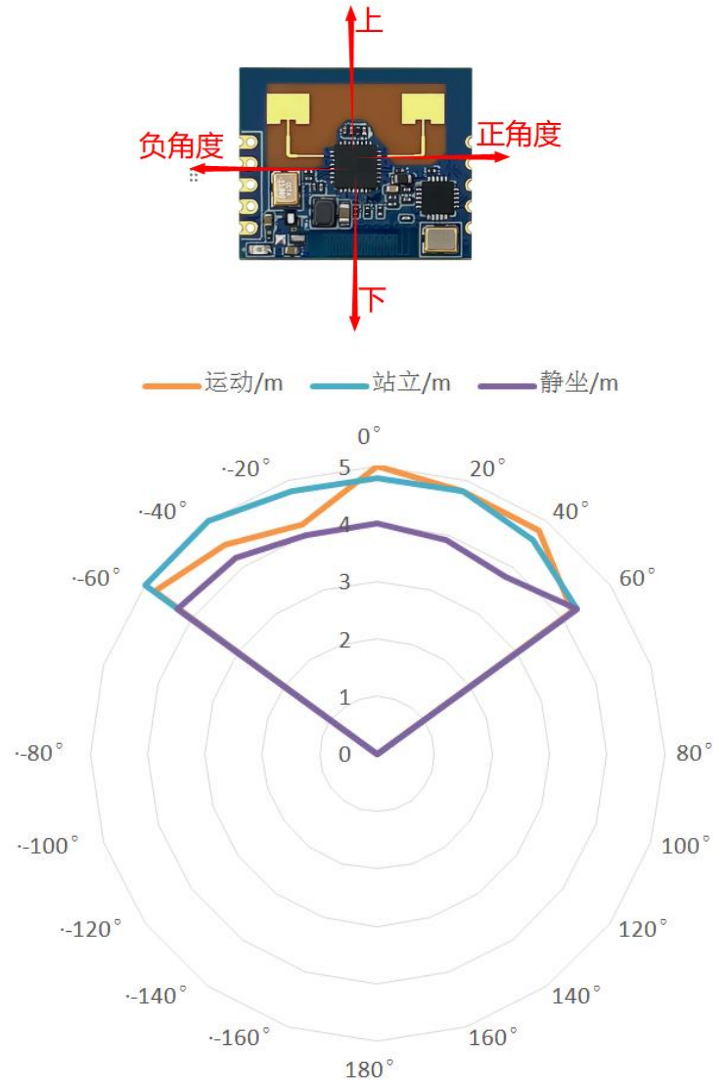


Figure 10 Detection range diagram (wall height 1.5 meters)

5.5 Installation conditions

Confirm the minimum installation clearance

If the radar needs to be installed in a casing, the casing must have good wave transmission properties at 24 GHz and cannot contain metal materials or materials that have a shielding effect on electromagnetic waves.

Installation environment requirements

- This product needs to be installed in a suitable environment. If used in the following environments, the detection effect will be affected:
- There are non-human objects in continuous motion in the sensing area, such as animals, continuously swinging curtains, large green plants facing the air outlet, etc.

- There are large areas of strong reflectors in the sensing area, and strong reflectors facing the radar antenna will cause interference.
- When wall-mounted, external interference factors such as air conditioners and electric fans on the top of the room need to be considered.

Precautions during installation

- Try to ensure that the radar antenna is facing the area to be detected, and the antenna is open and unobstructed.
- Ensure that the sensor is installed firmly and stably. The shaking of the radar itself will affect the detection effect.
- Ensure that there is no movement or vibration of objects on the back of the radar. Because radar waves are penetrating, the back lobe of the antenna signal may detect moving objects on the back of the radar. Metal shielding covers or metal back plates can be used to shield the radar back lobe to reduce the impact of objects on the back of the radar.
- The theoretical distance accuracy of the radar is obtained by special algorithm processing based on a physical resolution of 0.75 meters. Due to the different size, state, RCS, etc. of the target, the target distance accuracy will fluctuate; at the same time, the maximum distance will also fluctuate slightly.

6 Bluetooth Instructions

6.1 Install the software

Currently the APP supports Android and IOS platforms and can be downloaded from this link:

<https://www.hlktech.com/Mobile/App/12.html>

You can also go to major app stores to search for "HLKRadarTools" and install it.

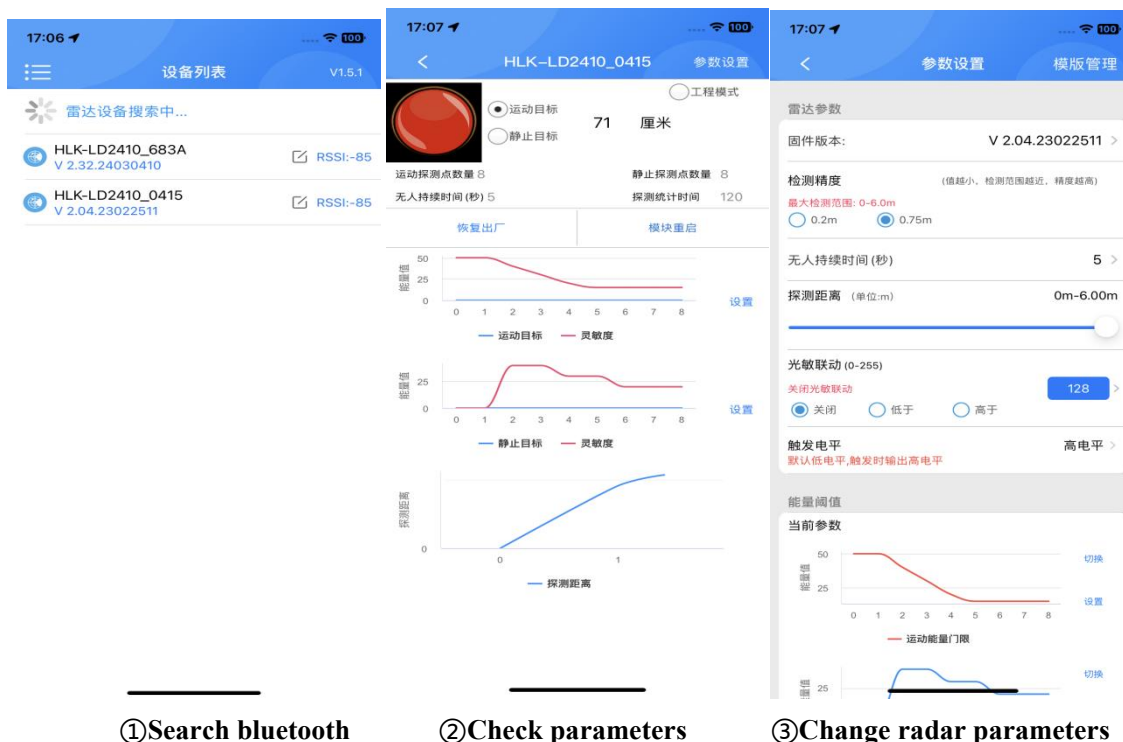


App

6.2 Using Methods

Open the app, and the app searches for nearby radar devices. The device's broadcast name is "HLK-LD2401_xxxx" (xxxx is the last four digits of the mac address). After successfully connecting to the module, you can view the radar's information, or debug and save parameters.

The use distance of the APP should not exceed the Bluetooth signal range (within 4 meters).



The process of modifying radar parameters by Bluetooth APP is the same as that by PC host tool.

6.3 Bluetooth password

When the APP is connected for the first time, you must enter the password before controlling it. **The default password is HiLink**, which can be modified in Parameter Settings->Control Password. The password is fixed to 6 bytes.



Note: Only versions V1.07.22091516 or later support the password function.

6.4 OTA upgrade

When the device firmware is updated, the word "upgradeable" will appear on the firmware version. Long press the version number to enter the upgrade interface. Only versions V1.07.22091516 or later support upgrades.

参数设置		OTA升级	
固件版本:	V 1.07.22091516(可升级)	设备ID: 5D:FE:89:52:F8:2E	当前版本: V 1.07.22091516 最新版本: V 1.07.22091516 固件大小: 0.47MB 提示: 为提高升级速度, 尽量将手机靠近设备, 且升级过程中, 保证APP处于前台运行, 不要锁屏! 否则可能会出现升级异常等情况! 开始升级
距离门分辨率:	☐ 0.2m ☒ 0.75m		
控制密码:	HiLink 设置		
无人持续时间(s):	5 设置		
距离门数量:	<input type="range" value="8"/>		

Long press the red circle to enter the upgrade

Enter OTA upgrade

OTA升级
设备ID: B7:9D:E9:6E:23:14 当前版本: V 1.07.22091516 最新版本: V 1.07.22091516 固件大小: 0.47MB 提示: 为提高升级速度, 尽量将手机靠近设备, 且升级过程中, 保证APP处于前台运行, 不要锁屏! 否则可能会出现升级异常等情况! 升级中... ✓ 准备固件 ✓ 固件下载成功 ✓ 进入升级状态 ✓ 准备校验 ✓ 校验成功 - 正在升级 <input type="range" value="16%"/>

Upgrading

The overall upgrade time takes 1 to 3 minutes. The upgrade must be performed within 3 meters of the module, otherwise the upgrade will fail due to poor Bluetooth signal.

Do not power off or restart the module before the upgrade is completed, and do not force exit the APP, otherwise the upgrade will fail. If the upgrade fails, the radar program of HLK-LD2401 will become invalid and radar detection will not be possible.

If the device upgrade fails, please restart the device and reconnect the APP. A "waiting for upgrade" prompt will appear on the device list:



Waiting upgrade

Upgrade successfully

Click the device to be upgraded and upgrade it again. The radar function can only be restored after the upgrade is successful.

6.5 Bluetooth communication protocol

HLK-LD2401 acts as a slave and is only allowed to be connected by one host.

UUID	Operation Permissions	Function Definition
0000fff1-0000-1000-8000-00805f9b34fb	Read/Notify	Module send, APP receive
0000fff2-0000-1000-8000-00805f9b34fb	Write Without Response	APP send, Module receive

When the app and HLK-LD2401 Bluetooth connection and password verification are successful, the module will start transparent transmission of radar data. The data transmitted by Bluetooth is exactly the same as the serial port protocol. Please refer to the document "HLK-LD2401 Serial Port Communication Protocol.pdf".

When the app is successfully connected, a Bluetooth password will be sent to the module for verification. Only when the password is correct will the module start transparent transmission of data. For details, see the "Get Bluetooth Permissions" section of "**HLK-LD2401 Serial Port Communication Protocol.pdf**".

6.6 Opening Bluetooth Again

The Bluetooth function of HLK-LD2401 is enabled by default. You can turn Bluetooth off or on through the serial port protocol "**HLK-LD2401 Serial Port Communication Protocol .pdf**". If Bluetooth is turned off or the serial port cannot be used, you can turn Bluetooth on again by powering off and on the module more than 5 times within 2~3s.

7 Performance and Electrical Parameters

Working frequency band	24GHz~ 24.25GHz Comply with FCC, CE, and NFPA certification standards
Power supply requirements	DC 3.3V, power supply >200mA
Average operating current	79 mA
Modulation	FMCW
Connector	GPIO*1, IO level 3.3V UART*1
Target application	Human presence sensor
Detection distance	0.75m ~ 6m (adjustable)
Detection angle	±60 °
Detection resolution	0.75m
Sweep bandwidth	250MHz Comply with FCC, CE, and NFPA certification standards
Working temperature	-40 ~ 85°C
Dimension	18mm * 22 mm

Table 3 Performance and electrical parameters table

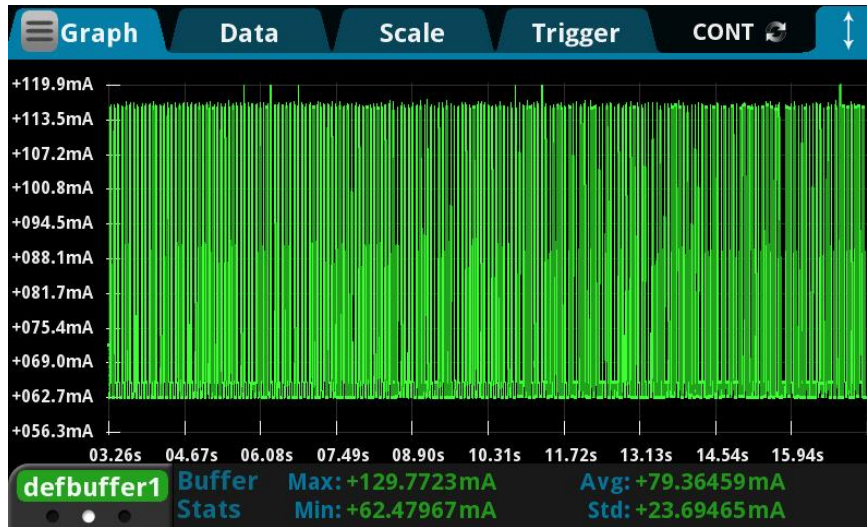
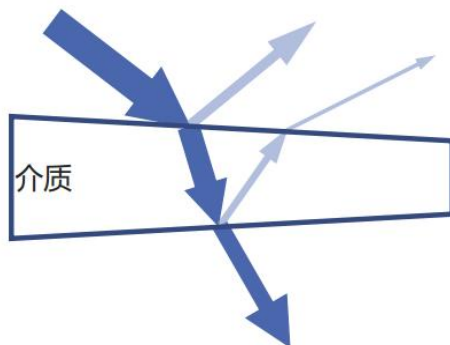


Figure 11 Module operating current measured data

8 Radome Design Guidelines

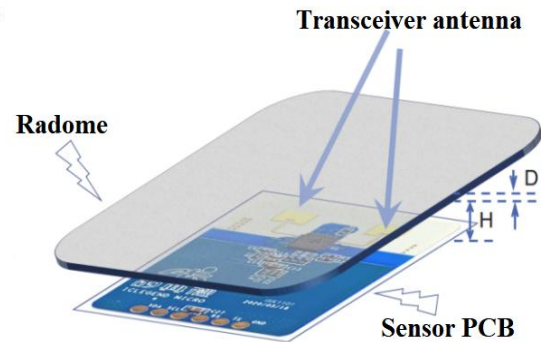
8.1 Effect of Radome on Millimeter Wave Sensor Performance

- Radar waves are reflected on the boundary of the radome
- The total power radiated or received by the radar is lost
- The reflected wave enters the receiving channel, affecting the isolation between the transmitting and receiving channels
- Reflection may deteriorate the standing wave of the antenna, further affecting the antenna gain
- Radar waves will lose power when propagating in the medium. Theoretically, the higher the frequency, the greater the loss
- Electromagnetic waves will refract to a certain extent when passing through the medium
- Affect the radiation pattern of the antenna, thereby affecting the coverage of the sensor



8.2 Radome design principles

- 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.
- $H = \frac{m}{2} \cdot \frac{c_0}{f}$, where m is a positive integer, c_0 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.
- $D = \frac{m}{2} \cdot \frac{c_0}{f \sqrt{\epsilon_r}}$, where m is a positive integer and ϵ_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.



8.3 Common Materials

- Before designing, first understand the material and electrical characteristics of the radome
- The table on the right is for reference only. Please confirm the actual value with the supplier
- The height H from the antenna to the inner surface of the radome
- When space permits, 1 or 1.5 times the wavelength is recommended
- For example, 12.4 or 18.6mm is recommended for 24.125GHz
- Error control: $\pm 1.2\text{mm}$
- Radome thickness D
- Half wavelength is recommended, error control $\pm 20\%$
- If the half-wavelength thickness requirement cannot be met
- Low ϵ_r materials are recommended
- Thickness recommended is 1/8 wavelength or thinner
- The impact of uneven materials or multi-layer composite materials on radar performance is recommended to be experimentally adjusted during design

Tale 4 Common material properties of radomes

Medium	ϵ_r type 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

9 Revision History

Date	Version	Modifications
2022-5-26	1.01	Test version
2022-6-8	1.02	Perfect data
2022-6-29	1.03	Update data
2022-8-19	1.04	Bluetooth description modified
2022-9-20	1.05	OTA and Bluetooth password content increased
2022-10-28	1.06	Supplementary Bluetooth instructions
2023-6-2	1.07	Change company address
2024-7-9	1.08	Modify APP screenshots
2024-10-8	1.09	Modify the App download address

10 Technical support and contact information



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