E54-24LD12B User Manual

24GHz Presence Sensing Millimeter Wave Sensor



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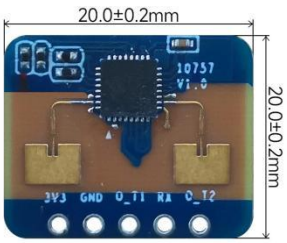
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1 Introduction



Human presence sensing is a technology that detects biometric features such as breathing and heartbeat in the detection zone without the need for physical movement, and is especially suitable for detecting static human bodies, such as sleeping people.

The E54-24LD12B is an outstanding life presence sensing sensor reference design in the EBYTE millimeter wave radar series, which combines the highly efficient 24GHz millimeter wave sensor hardware E54-24LD12B with the intelligent algorithm firmware HPS01.

The sensor hardware consists of an AIoT millimeter-wave sensor chip, a high-performance one-transmitter-one-receiver microstrip antenna, an MCU, and supporting peripheral auxiliary circuits. The smart algorithm firmware HPS01 utilizes FMCW waveforms and the chip's proprietary advanced signal processing technology. This solution is mainly designed for regular indoor environments, such as homes, offices and hotels, to realize accurate presence sensing of the human body.

The E54-24LD12B has a maximum detection distance of 4.5 meters. Through the intuitive visualization tool interface, users can easily configure key parameters such as the maximum sensing distance, the sensing sensitivity of different distance segments, and the duration of unoccupied time (see Chapter IX for details). In addition, this solution supports GPIO and UART interfaces to realize the rapid reporting of sensing results, truly realizing plug-and-play.

1.1 Features

- 24GHz ISM band operation;.
- Integrated smart millimeter wave sensor single chip with smart algorithmic firmware.
- Accurate life presence sensing and distance detection in indoor environments.
- Ultra-compact module size 18mm x 15mm.
- Adopts 3.3V single power supply, voltage range 3.0V~3.6V.
- Continuous working average current 50mA @10Hz reporting frequency.
- The farthest distance of human presence sensing can be up to 4.5m.
- Azimuth and tilt angle are ±45°, to meet a variety of installation requirements.
- Supports automatic loading of the default configuration, plug and play.
- Provide visualization tools to flexibly configure the detection distance range and adjust the sensitivity according to the distance gate.
- Supports ceiling-mounted, wall-mounted and other installation methods to adapt to different scenarios

1.2 Application

The E54-24LD12B human presence sensing sensor is capable of accurately detecting and recognizing the human body in motion, standing and at rest, and is widely used in various AIoT scenarios, including but not limited to.

- Smart Home

Sensing the presence and distance of the human body, and intelligently controlling the operation of home appliances.

- Smart Business

Zone sensing, realizing intelligent lighting and long-lighting control of equipment.

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- Intelligent Security

Access control system, building intercom and electronic cat eyes.

- Intelligent Lighting

Precise location detection to optimize lighting management in public places.

- Medical care for the elderly

Real-time monitoring of respiratory heartbeat and other vital signs.

2 System description

E54-24LD12B is a millimeter wave sensor based on EBYTE's millimeter wave sensor chip to create a reference solution for life presence sensing. It utilizes FMCW waveform and MCU's unique millimeter wave sensor signal processing technology, combined with built-in intelligent presence sensing algorithms, to achieve accurate detection and real-time reporting of targets in a specified area. With this reference solution, users can quickly develop efficient presence sensing products to meet diversified application requirements.

The specifications of E54-24LD12B are shown in Table 2-1.

Table 2-1 Specifications

Parameter	Remarks	Minimum	Typical	Maximum	Unit
Hardware Specifications					
Supported Frequency Bands	-	24	-	25	GHz
Maximum swept bandwidth	-	-	0.25	1	GHz
Maximum equivalent omni-directional radiated power	-	-	-	15	dBm
Supply Voltage	-	3.0	3.3	3.6	V
Dimension	±0.2mm	-	18×15	-	mm
Weight	±0.2g	-	1.2	-	g
Ambient Temperature	-	-40	-	85	℃
System Performance					
Distance Detection Range	Motion and Stationary TargetsBody Targets	1.5	4	4.5	m
Distance resolution	Motion and Stationary Target Human Target	0.75	-	-	m
Distance Measuring Accuracy	-Conforms to FCC, CE, and NRC certification standards.	-	0.15	-	m
Frequency band	Conforms to FCC, CE, No Commission certification standards	24	-	24.25	GHz
Sweep bandwidth		-	-	0.25	GHz
Average working current	100ms reporting cycle	-	50	-	mA

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3 Hardware Description

3.1 External Dimension

Figure 7-1 shows the mechanical dimensions of the E54-24LD12B hardware PCB, and all dimensions in the figure are in millimeters (mm).The E54-24LD12B hardware board thickness is 1.6 mm, and the board thickness tolerance is ±0.2 mm.

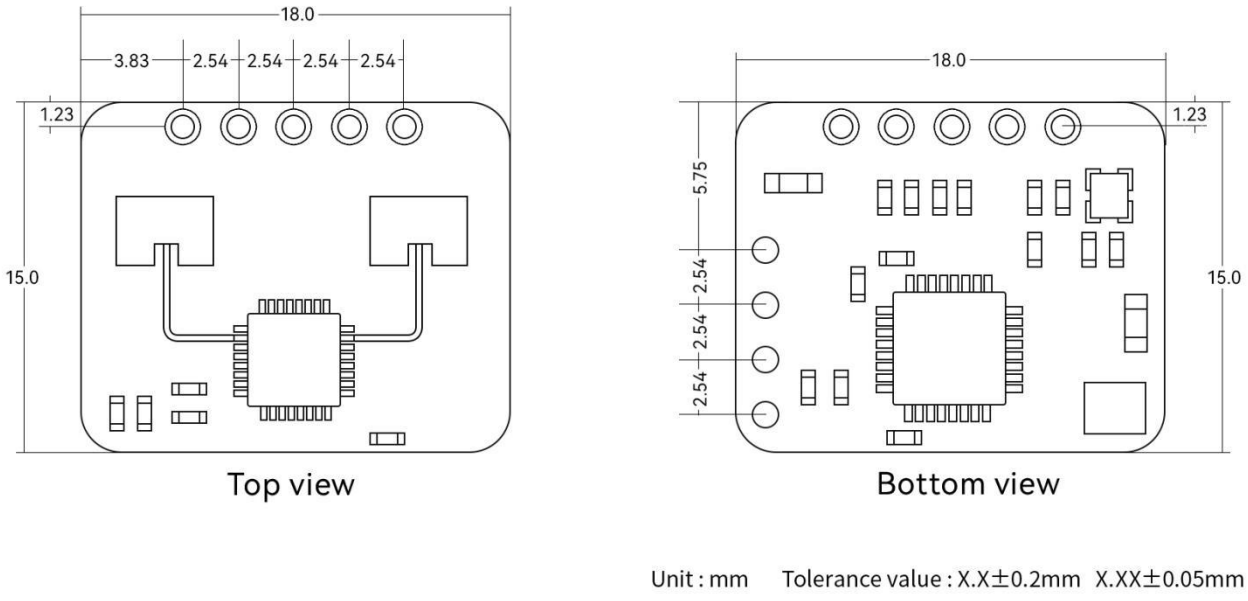


Figure 7-1 E54-24LD12B Hardware Mechanical Dimension Drawing

3.2 Pin Definitions

Figure 3-1 shows a physical diagram of the E54-24LD12B hardware. The hardware has 5 reserved pin holes (not equipped with pins from the factory), labeled J1, for the power and communication interfaces. The millimeter wave sensor burn-in port is labeled J2, so please follow the corresponding pin name to connect it when burning.

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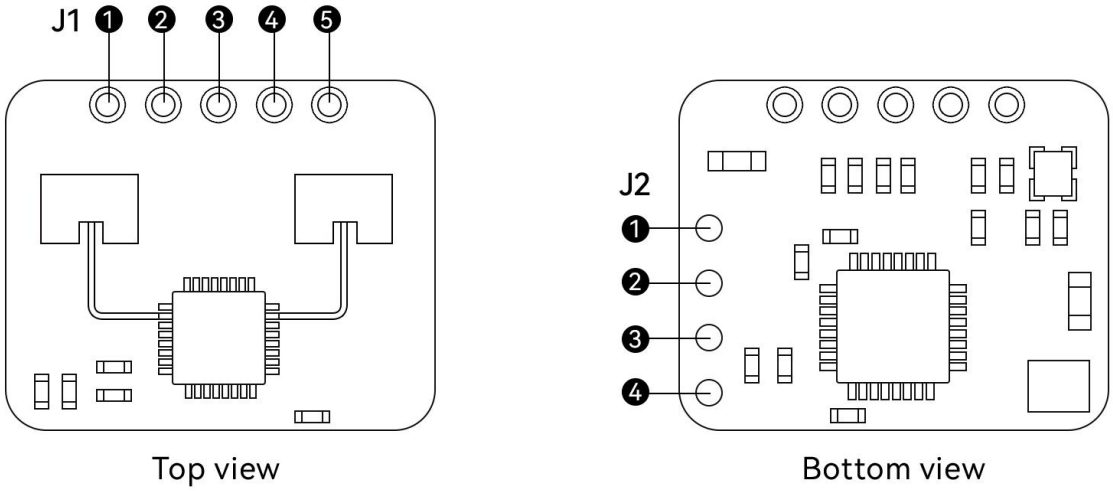


Figure 3-1 Front and Back View of Hardware

Table 3-1 J1 and J2 Pin Descriptions

J1	Name	Function	Description
1	O_T2	IO is used to report the detection status: a high level indicates presence, and a low level indicates absence	0~3.3V
2	RX	UART_RX	0~3.3V
3	O_T1	UART_TX	0~3.3V
4	GND	Grounding	-
5	3V3	Power Input	3.0V~3.6V,Typ.3.3V
J2	Name	Functions	clarification
1	3V3	Power input	1.8~3.6V, Typical 3.3V
2	CLK	Clock signal	0~3.3V
3	DIO	Data Port	0~3.3V
4	GND	Grounding	-

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4 Software Description

The E54-24LD12B is shipped with pre-installed system firmware HPS01. Meanwhile, EVERBUILD provides a visual uplink configuration tool software specially designed for the E54-24LD12B hardware, which allows users to configure the parameters of the millimeter wave sensor module intuitively and conveniently according to the actual application scenarios, in order to optimize the sensing effect and meet the diversified usage requirements.

4.1 Firmware Description

Based on the E54-24LD12B millimeter wave sensor presence sensing reference design, in the default configuration, its maximum detection distance up to 4.5 meters (moving and stationary targets). The default configuration of the firmware is shown in Table 4-1, users can flexibly adjust the parameters according to the actual needs to achieve the best sensing results.

Table 4-1 E54-24LD12B Parameter Description

Parameter name	Configurable Range	Default Configuration	Description
Maximum Detection Distance Gate	2~6	6	Distance from door 75cm
Unoccupied Duration	0~65535s	5s	-
Motion Sensitivity	1~100	20	-
Stationary sensitivity	1~100	25	-

The default output data of the millimeter wave sensor includes target status, target distance (moving and stationary targets) and target energy value (moving and stationary targets). In the visualization tool, the user can add the energy value information of each distance gate to the millimeter wave sensor output data by checking the engineering mode or sending the enable engineering mode command through the serial port. The millimeter wave sensor output data at this time is called engineering data. Please refer to 5.3 Millimeter Wave Sensor Data Output Protocol for the specific millimeter wave sensor output protocol.

4.2 Visual Configuration Tool Description

4.2.1 Introduction to the Visual Configuration Tool

RF_Setting_E54_B_V1.0 is a visual configuration tool developed specifically for the E54-24LD12B millimeter wave sensor module. The tool seamlessly connects with the millimeter-wave sensor module, displays and records millimeter-wave sensor data in real time, and allows users to easily configure millimeter-wave sensor parameters to optimize the millimeter-wave sensor's sensing effect to meet the needs of various application scenarios.

To connect the visualization tool with the millimeter wave sensor module, please follow the steps below.

Step 1: Get the “RF_Setting_E54_B_V1.0.zip” package from EVERBUILT website, use 7z or other decompression

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software to decompress the package, open the package directory and enter the “RF_Setting_E54_B_V1.0” path. Open the package directory and enter the “RF_Setting_E54_B_V1.0” path.

Step 2: Connect the millimeter wave sensor module to the computer using the serial-to-USB connection board, as shown in Figure 4-1.

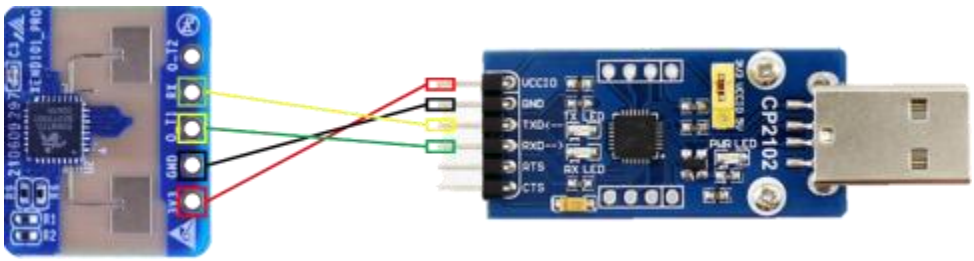


Figure 4-1 Example of connecting the E54-24LD12B to a computer via a serial port utility

Step 3: In the path of “RF_Setting_E54_B_V1.0”, double-click the executable file “RF_Setting_E54_B_V1.0.exe”, you can start the interface of the visual configuration tool. As shown in Figure 4-2.

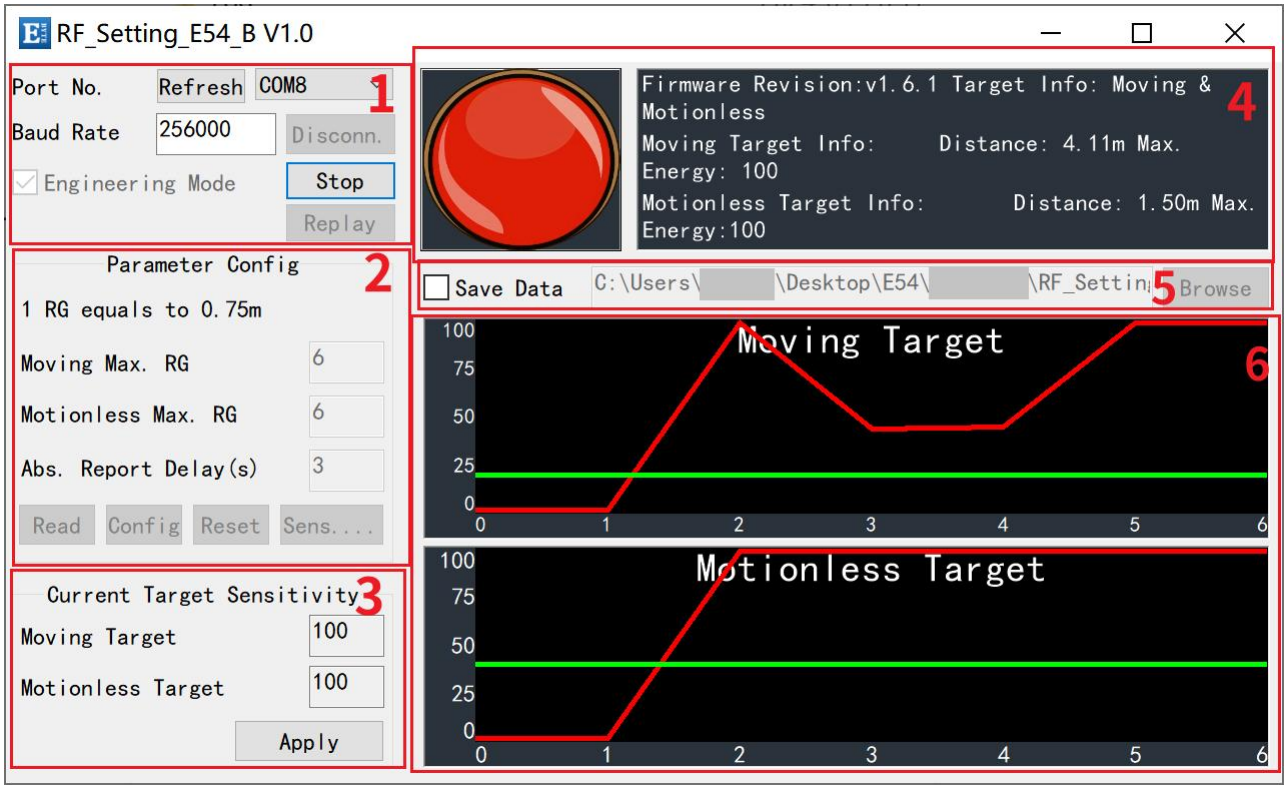


Figure 4-2 Visualization Tool Interface

The interface of the visualization tool is mainly divided into “Serial port and data format area (1)”, “Parameter information area (2)”, “Sensitivity statistics area (3)”, “Target and version information area (4)”, “Save data area (5)”, and “Project mode display area (6)”. “Target and version information area (4)”, ‘Save data area (5)’, and ‘Project mode display area (6)’. The functions of each area are as follows.

Serial Port and Data Format Area

Get the port number of the millimeter wave sensor serial tool, configure the baud rate and data format (i.e. engineering mode).

Parameter Area Information

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Configure or display millimeter wave sensor parameters, including detection of the farthest distance gate (moving and stationary targets), unoccupied duration, and the sensitivity of each distance gate (moving and stationary targets).

Sensitivity Statistics Area

Real-time display of the maximum energy value in all distance gates (moving and stationary targets) for each frame of data sent by the millimeter wave sensor, and continuously updated.

Target and Version Information Area

Display the millimeter wave sensor firmware version number, the basic information of the target, including the presence of the target, target status, target distance (motion and stationary targets), target energy value (motion and stationary targets).

Save Data Area

After checking “Save Data”, click “Select Path” button to set the path for saving millimeter wave sensor data. When the sensor starts to detect again, the upper computer tool will automatically save the real-time data.

Working Mode Display Area

After checking the “Working Mode”, this area will display the energy value of the sensor at each distance gate, and present it in the form of curve plotting. The red curve represents the target energy value updated in real time; the green curve is the sensitivity.

4.2.2 Use of visualization tools

The visualization tool provides operations including “Device Connection”, “Start/Stop Data Receiving”, “Parameter Reading/Configuration”, “Sensitivity Configuration Sensitivity Configuration”, and ‘Millimeter Wave Sensor Data Save & Playback’ operations.

Device Connection

Step 1: After the sensor module is powered on, use the serial port to USB connection board to connect the millimeter wave sensor module to the computer as shown in Figure 4-1.

Step 2: Open the RF_Setting_E54_B_V1.0 software package, double-click and run “RF_Setting_E54_B_V1.0.exe” to enter the visualization tool interface, as shown in Figure 4-2.

Step 3: Click “Refresh” button to get the serial port number; if there are more than one port number, select the one that communicates with the millimeter wave sensor.

Step 4: Set the baud rate consistent with the millimeter wave sensor firmware baud rate, click the “Connect Device” button to establish the connection. Start/Stop Data Receiving

Step 1: After successful connection, click the “Start” button, and the text on the button changes to “Stop”. Areas (2)~(4) of the visualization interface will display the detailed information of the target. If the “Engineering Mode” checkbox of the visualization is checked, area (5) will show the specific energy values for each distance gate (moving and stationary targets). The tool is not able to send configuration parameters at this time.

Step 2: Click on the “Stop” button to stop parsing the data. At this point the user can configure and read the parameters.

Parameter Reading/Configuration

Step 1: After successful connection, and the “Start/Stop” button is in the “Start” state, click the “Read” button to get the current configuration parameters, sensitivity and other data of the millimeter wave sensor. Step 2: Modify the millimeter wave sensor's current configuration parameters, sensitivity and other data.

Step 2: There are two ways to modify the millimeter wave sensor parameters, users can choose the appropriate way according to demand.

If you need to change the millimeter-wave sensor parameters, in the visualization tool area (2) of the text box, type the new parameter values, click “Set”, “OK” button.

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To restore the default parameter settings of the millimeter wave sensor, click on the “Reset” and “OK” buttons.

Sensitivity Configuration

Step-:After successful connection, click “Sensitivity Configuration” button to enter the “Sensitivity Setting” interface, as shown in Figure 4-3. Users can set

The user can set the sensitivity of each distance gate (motion and stationary target) on the interface.

Step 2: There are three ways to modify the sensitivity of distance gates, users can choose the appropriate way according to their needs.

If you want to set the sensitivity (motion and stationary target) of all the distance gates to the same value, key in the target value at the bottom of the “Sensitivity Setting” interface, and then click the “Set” and “OK” buttons to set the new sensitivity to the same value. Click the “Set” and “OK” buttons to send the new parameters to the millimeter wave sensor.

If you want to reset the sensitivity of all distance gates (moving and stationary targets) to the default value, click the “Reset” and “OK” buttons in turn, and the host computer tool will send the default parameters to the millimeter wave sensor.

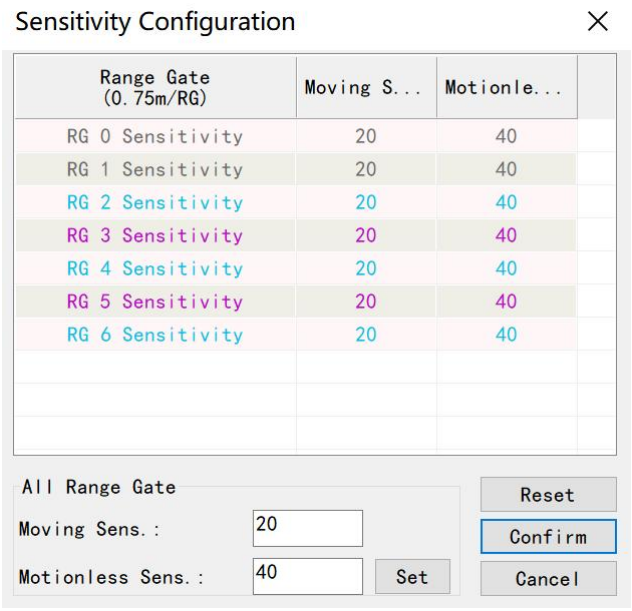
If you want to set the sensitivity of other distance gates except 0 and 1, double click the corresponding data in the interface table, type in the value of the target parameter, and click the “OK” button.

Once the parameters have been read or configured, click the Start button and the millimeter wave sensor will operate with the new parameter configuration and report data information about the target.

Each time the “Start” button is clicked in the visualization tool interface, a log is generated in the “Log/” folder under its path for user analysis.

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Millimeter wave sensor data saving and playback

XenD101ProTool program default open “save data” function, set the millimeter wave sensor data saving steps are as follows: Step 1: after the connection is successful, the check box and button in the area (5) are operable; Step 2: Make sure the “Save Data” check box is checked, click the “Select Path” button to set the storage path of the sensor data; Step 3: Click the “Save Data” button to set the storage path of the sensor data.

Step 2: Ensure that the “Save Data” check box is checked, click on the “Select Path” button to set the storage path of the sensor data; Step 3: Click on the “Select Path” button to set the storage path of the sensor data; Step 4: Click on the “Save Data” button to set the storage path of the sensor data.

Step 3: Click the “Start/Stop” button to start the millimeter wave sensor detection.

Step 4: Click “Start/Stop” button to stop the detection, users can find the millimeter wave sensor data file named “XenDProTool_YYYY_MM_DD_HH_MM_SS.dat” under the data storage path set in Step 2, where YYYY_MM_DD_HH_MM_SS is the data file for saving the millimeter wave sensor data. MM_SS is the timestamp when the data is saved.

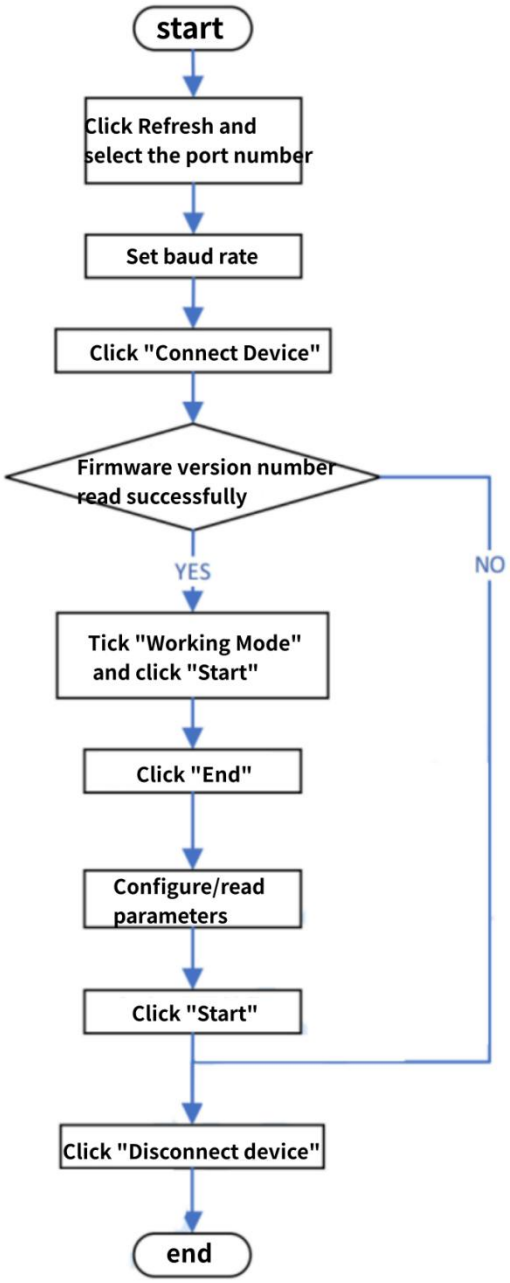
The steps of using XenD101ProTool to playback the millimeter wave sensor data file are as follows.

Step 1: After successful connection, click the “Play/Stop” button, select the millimeter wave sensor data file you want to play back, and the interface area (4) and area (6) will start to play back the target information in the data file; Step 2: Click the “Play/Stop” button again, and select the millimeter wave sensor data file you want to play back.

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Step 2: Click the “Play/Stop” button again to interrupt the data playback; the user can also wait for the end of the data playback, and then carry out other operations. Please refer to Figure 4-4 for the basic operation flow of the visualization tool in the upper computer.



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5 Communications protocol

This communication protocol is designed for users who are not using visualization tools for secondary development.The E54-24LD12B millimeter wave sensor communicates with the outside world through the serial port (TTL level), and the data output and parameter configuration follow this protocol. The default baud rate of the sensor serial port is 256000, with 1 stop bit and no parity bit.

5.1 Protocol Format

5.1.1 Protocol Data Format

The E54-24LD12B data communication is in small-end format, and all protocol data is in hexadecimal format.

5.1.2 Command Protocol Frame Format

See Table 5-1 and Table 5-3 for the protocol-defined millimeter wave sensor configuration commands and ACK command formats, respectively.

Table 5-1 Send Command Protocol Frame Format

Frame	Length of data in frame	In-frame data	End of frame
FD FC FB FA	2 Bytes	See Table 5-2	04 03 02 01

Table 5-2 Transmit In-Frame Data Format

Command word (2 bytes)	Command value (N bytes)

Table 5-3 ACK Command Protocol Frame Format

header	In-frame data length	in-frame data	end of frame
FD FC FB FA	2 bytes	See Table 5-4	04 03 02 01

Table 5-4 ACK In-Frame Data Format

Send command word & 0x0100 (2 bytes)	Return value (N bytes)

5.2 Send command with ACK

5.2.1 Read Firmware Version Command

This command is used to read the firmware version information of the millimeter wave sensor.

Command word:0x0000

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Command value:None

Return Value:2 bytes ACK status(0 success,1 failure) + 2 bytes product type(0x8004) + 2 bytes firmware type(0x0000) + 2 bytes major version number + 2 bytes minor version number + 2 bytes patch version number Sending Data.

Byte 1 ~ 4	Byte 5, 6	Byte 7, 8	Byte 9 ~ 12
FD FC FB FA	02 00	00 00	04 03 02 01

Millimeter wave sensor ACK (success)

Byte 1 ~ 4	Byte 5, 6	Byte 7, 8	Byte 9, 10	Byte 11, 12	Byte 13, 14	Byte 15, 16	Byte 17, 18	Byte 19, 20	Byte 21 ~ 24
FD FC FB FA	0E 00	00 01	00 00	04 80	00 00	0x2 00	0x 00	0x 00	04 03 02 01

5.2.2 Enable Configuration Commands

This command is used to enable the configuration mode, any other commands issued to the millimeter wave sensor must be issued after this command to take effect.

Command word:0x00FF

Command value:0x0001

Return value: 2 bytes ACK status (0 success, 1 failure) + 2 bytes protocol version (0x0001) + 2 bytes buffer size (0x0040)

2 x in this table indicate the version number.

Sending data.

Byte 1 ~ 4	Byte 5, 6	Byte 7, 8	Byte 9, 10	Byte 11 ~ 14
FD FC FB FA	04 00	FF 00	01 00	04 03 02 01

Millimeter wave sensor ACK (success).

Byte 1 ~ 4	Byte 5, 6	Byte 7, 8	Byte 9, 10	Byte 11, 12	Byte 13, 14	Byte 15 ~ 18
FD FC FB FA	08 00	FF 01	00 00	01 00	40 00	04 03 02 01

5.2.3 End Configuration Commands

This command is used to end the configuration mode and enable the millimeter wave sensor to resume the working mode.

Command word:0x00FE

Command value:None

Return Value:2 bytes ACK Status(0 Success,1 Failure) Sending Data.

Byte 1 ~ 4	Byte 5, 6	Byte 7, 8	Byte 9 ~ 12
FD FC FB FA	02 00	FE 00	04 03 02 01

Millimeter wave sensor ACK (success)：

Byte 1 ~ 4	Byte 5, 6	Byte 7, 8	Byte 9, 10	Byte 11 ~ 14

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FD FC FB FA	04 00	FE 01	00 00	04 03 02 01

5.2.4 Maximum Distance Gate and Unoccupied Duration Parameter Configuration Commands

This command is used to set the maximum detection distance gate (motion and stationary target) of the millimeter wave sensor (configuration range 2~6), and the unoccupied duration parameter (configuration range 0~65535 seconds). Please refer to Table 5-5 for specific parameter words.

Command word:0x0060

Command value: 2-byte maximum motion distance gate word + 4-byte maximum motion distance gate parameter + 2-byte maximum standstill distance gate word + 4-byte maximum standstill distance gate parameter + 2-byte unoccupied duration word + 4-byte unoccupied duration parameter

Return value: 2-byte ACK status (0 success, 1 failure)

Table 5-5 0x0060 Protocol Parameter Words

Parameter name	parameterized character
Maximum movement distance door	0x0000
Maximum stationary distance door	0x0001
Unoccupied duration	0x0002

Transmit data: Maximum distance to gate 6 (moving and stationary targets), unmanned duration 5 sec.

Byte 1 ~ 4	Byte 5, 6	Byte 7, 8	Byte 9, 10	Byte 11 ~ 14	Byte 15, 16	Byte 17 ~ 20	Byte 21, 22	Byte 23 ~ 26	Byte 27 ~ 30
FD FC FB FA	14 00	60 00	00 00	06 00 00 00	01 00	06 00 00 00	02 00	05 00 00 00	04 03 02 01

Millimeter wave sensor ACK (successful)

Byte 1 ~ 4	Byte 5, 6	Byte 7, 8	Byte 9, 10	Byte 11 ~ 14
FD FC FB FA	04 00	60 01	00 00	04 03 02 01

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5.2.5 Read Parameter Command

This command is used to read the current configuration parameters of the millimeter wave sensor.

Command word:0x0061

Command value:None

Return Value:2 bytes ACK Status(0 Success, 1 Failure) + Header(0xAA) + Max Distance Gate N (0x06)) + Configure Max Motion Distance Gate + Configure Max Stationary Distance Gate + Distance Gate 0 Motion Sensitivity + ... + Distance gate N Motion sensitivity + Distance gate 0 Stationary sensitivity + ... + distance gate N standstill sensitivity + unoccupied duration (2 bytes)

Sending data.

Byte 1 ~ 4	Byte 5, 6	Byte 7, 8	Byte 9 ~ 12
FD FC FB FA	02 00	61 00	04 03 02 01

Millimeter wave sensor ACK: (successful, max distance gate 6, configured motion distance gate 5, stationary distance gate 4, motion sensitivity 20, stationary sensitivity 25, unoccupied duration 3s)

Byte 1 ~ 4	Byte 5 6	Byte 7 8	Byte 9 10	Byte 11	Byte 12	Byte 13	Byte 14	Byte 15	Byte 16	Byte 17	Byte 18
FD FC FB FA	18 00	61 01	00 00	AA	06	05	04	14	14	14	14

Byte 19	Byte 20	Byte 21	Byte 22	Byte 23	Byte 24	Byte 25	Byte 26	Byte 27	Byte 28	Byte 29 30	Byte 31 ~ 34
14	14	14	19	19	19	19	19	19	19	03 00	04 03 02 01

5.2.6 Enable Engineering Mode Command

This command is used to turn on the millimeter wave sensor engineering mode. In engineering mode, the data reported by the sensor will contain the energy value of each distance gate, please refer to 5.3.2 Target Data Composition for detailed format.

Command word:0x0062

Command value:None

Return value:2 bytes ACK status (0 success, 1 failure)

Transmit data.

Byte 1 ~ 4	Byte 5, 6	Byte 7, 8	Byte 9 ~ 12
FD FC FB FA	02 00	62 00	04 03 02 01

Millimeter wave sensor ACK (success)

Byte 1 ~ 4	Byte 5, 6	Byte 7, 8	Byte 9, 10	Byte 11 ~ 14
FD FC FB FA	04 00	62 01	00 00	04 03 02 01

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5.2.7 Close Engineering Mode Command

This command turns off the millimeter wave sensor engineering mode. Please refer to 5.3.2 Target Data Composition for the reported data format of the sensor after turning off.

Command word:0x0063

Command value:None

Return Value:2 bytes ACK Status (0 Success, 1 Failure) Sending Data.

Byte 1 ~ 4	Byte 5, 6	Byte 7, 8	Byte 9 ~ 12
FD FC FB FA	02 00	63 00	04 03 02 01

Millimeter wave sensor ACK (success)

Byte 1 ~ 4	Byte 5, 6	Byte 7, 8	Byte 9, 10	Byte 11 ~ 14
FD FC FB FA	04 00	63 01	00 00	04 03 02 01

5.2.8 Distance Gate Sensitivity Configuration Commands

This command is used to configure the sensitivity of sensor distance gates, and supports configuring each distance gate individually, or configuring all distance gates uniformly. If the sensitivity of all distance gates needs to be set to the same value, you need to set the distance gate value to 0x

If all the distance gates need to be set to the same sensitivity value, the distance gate value should be set to 0xFFFF, please refer to Table 5-6 for the specific parameter words. command word: 0x0064

Command value: 2 bytes of distance gate word + 4 bytes of distance gate value + 2 bytes of motion sensitivity word + 4 bytes of motion sensitivity value + 2 bytes of standstill sensitivity word + 4 bytes of standstill sensitivity value

Return value: 2 bytes ACK status (0 success, 1 failure)

Table 5-6 0x0064 Protocol Parameter Words

Parameter name	parameterized character
Distance gate	0x0000
Motion sensitivity word	0x0001
Stationary sensitivity word	0x0002

Transmit data: Configure the distance to door 3 with motion sensitivity 15 and static sensitivity 25

Byte 1 ~ 4	Byte 5, 6	Byte 7, 8	Byte 9, 10	Byte 11 ~ 14	Byte 15, 16	Byte 17 ~ 20	Byte 21, 22	Byte 23 ~ 26	Byte 27 ~ 30
FD FC FB FA	14 00	64 00	00 00	03 00 00 00	01 00	0F 00 00 00	02 00	19 00 00 00	04 03 02 01

Millimeter wave sensor ACK (success)

Byte 1 ~ 4	Byte 5, 6	Byte 7, 8	Byte 9, 10	Byte 11 ~ 14
FD FC FB FA	04 00	64 01	00 00	04 03 02 01

Transmit data: Configure motion sensitivity 15, static sensitivity 25 for all distance doors

Byte 1 ~ 4	Byte 5,	Byte 7,	Byte 9,	Byte 11 ~ 14	Byte	Byte 17 ~ 20	Byte	Byte 23 ~ 26	Byte 27 ~ 30

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	6	8	10		15, 16		21, 22		
FD FC FB FA	14 00	64 00	00 00	FF FF 00 00	01 00	0F 00 00 00	02 00	19 00 00 00	04 03 02 01

Millimeter wave sensor ACK (successful)

Byte 1 ~ 4	Byte 5, 6	Byte 7, 8	Byte 9, 10	Byte 11 ~ 14
FD FC FB FA	04 00	64 01	00 00	04 03 02 01

5.2.9 MCU reset command

This command is used to configure MCU software reset. Note that the reset is not executed immediately, but triggered when the end configuration command is received or when no other command is sent for more than 3 seconds after the reset command is sent.

Command word:0x0065

Command value:None

Return Value:2 bytes ACK Status(0 Success, 1 Failure) Sending Data.

Byte 1 ~ 4	Byte 5, 6	Byte 7, 8	Byte 9, 10
FD FC FB FA	02 00	65 00	04 03 02 01

Millimeter wave sensor ACK (success)

Byte 1 ~ 4	Byte 5, 6	Byte 7, 8	Byte 9, 10	Byte 11, 12
FD FC FB FA	04 00	65 01	00 00	04 03 02 01

5.3 Millimeter-wave sensor data output protocol

E54-24LD12B millimeter wave sensor through the serial port output detection results, data output format according to the different operating modes. Under normal operating mode, the sensor outputs the basic information of the target, including target status, motion energy value, stationary energy value, motion distance, stationary distance and other information; and under the engineering mode, it will additionally output the energy value of each distance gate.

5.3.1 MCU reset command

The frame format of the reported message is divided into two parts: the frame header and data content, the frame header is used to identify the beginning of the packet and the type, and the data content contains the specific detection results, as shown in Table 5-7 and Table 5-8. Normal mode and engineering mode frame format is different, the two modes of operation corresponding to the definition of the data type values as shown in Table 5-9

Table 5-7 Reporting data frame format

header	In-frame data length	in-frame data	end of frame
F4 F3 F2 F1	2 Bytes	Table 5-8	F8 F7 F6 F5

Table 5-8 Intraframe Data Frame Format

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data type	head	Target data	rear or tail section	calibration
1 byte	0xAA	See tables 5-10 and 5-12	0x55	0x00

Table 5-9 Description of Data Types

data type value	clarification
0x01	Engineering model data
0x02	Target basic information data

5.3.2 Target data composition

The target data consists of several fields, including target status, motion/static energy value, distance, etc. In normal operating mode, only this basic information is output; in engineering mode, energy values for each distance gate are also appended to each target data. These energy values are useful for in-depth analysis of target characteristics and behavior.

The composition of the target data reported by the millimeter wave sensor in the normal operating mode is shown in Table 5-10, and the definition of the target state values is shown in Table 5-11. Engineering mode target data frame composition is shown in Table 5-12.

Table 5-10 Composition of target data frame

target state	Movement target distance (cm)	Exercise target energy value	Distance to stationary target (centimeters)	Static target energy value
1 byte	2 bytes	1 byte	2 bytes	1 byte

Table 5-11 Description of Target Status Values

target state value	Description
0x00	No target
0x01	Moving target
0x02	Stationary target
0x03	Motion and Stationary Targets

Table 5-12 Target Data (Engineering Mode) Frame Composition

...	Stationary target distance	Stationary Target Scale Energy value	Maximum movement distance Door N	Maximum resting distance door N	Movement distance gate 0 energy value	...	Motion distance gate N energy value	Static distance gate 0 energy value	...	Static distance gate N energy value
...	2 bytes	1 byte	1 byte	1 byte	1 byte	...	1 byte	1 byte	...	1 byte

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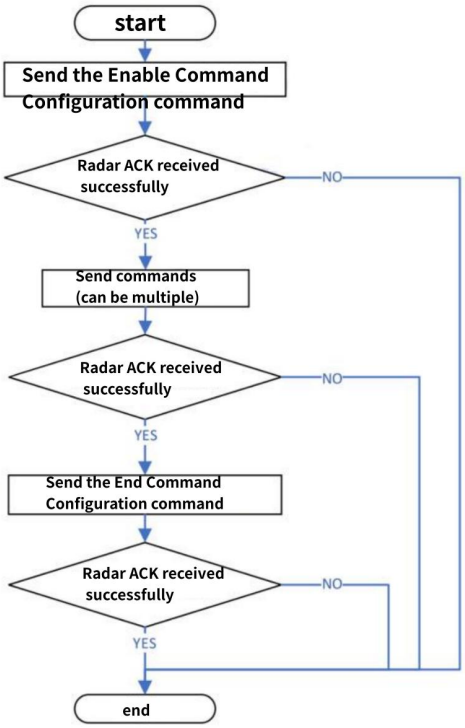
5.4 Millimeter-wave Sensor Command Configuration Method

Configuring a millimeter wave sensor requires following certain steps and precautions to ensure correct and effective configuration.

5.4.1 Millimeter-wave Sensor Command Configuration Procedure

Configuring a millimeter wave sensor typically involves sending a configuration command and receiving an ACK response. Before sending any configuration commands, an “enable configuration” command must be sent to allow subsequent configuration operations. After the configuration is completed, the “end configuration” command should be sent to notify the sensor configuration is complete and return to normal operating mode.

For example, to read the configuration parameters of the sensor, you should first send the “enable configuration” command, send the “read parameters” command after receiving the ACK response, and then send the “end configuration” command after receiving the ACK again. Send “End Configuration” command after receiving ACK again (see 5.4.2 Millimeter-wave Sensor Configuration Precautions). During the whole process, if the sensor does not return ACK or fails to return ACK, the configuration fails. The millimeter wave sensor command configuration flow is shown in Figure 5-1.



5.4.2 Millimeter-wave Sensor Configuration Considerations

When configuring a millimeter wave sensor, the following points should be noted.

Timeout mechanism: Before sending configuration commands to the sensor, you need to send the “enable configuration” command.

After sending the “Enable Configuration” command, the sensor will enter a 3-second command configuration phase.

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Multiple configuration commands can be sent during this phase, and each command will restart the timer for 3 seconds. If no command is received within 3 seconds, the sensor will automatically exit configuration mode and resume normal operation. Therefore, when configuring, make sure that all necessary configuration operations are completed within 3 seconds.

Error Handling: If a failed ACK response is received during configuration or if no response is received after the timeout period, you should check the correctness of the configuration commands and the sensor's operating status, and try to resend the configuration commands or perform troubleshooting.

6 Installation and Detection Range

The E54-24LD12B millimeter wave sensor offers two typical mounting methods: wall-mounted and ceiling-mounted. When wall mounted, the E54-24LD12B can provide precise area settings with a range accuracy of ±15cm; when ceiling mounted, the radial sensing distance of the E54-24LD12B varies due to the height of the wall, the height of the person, the size and posture of the person. When using the default configuration, the maximum radial sensing distance of the sensor is 4.5m in both installation methods.

Since the E54-24LD12B is a wide-beam millimeter-wave sensor, ceiling mounting can achieve a larger range of detection, so the recommended mounting height range is 2.6~3 m. Wall mounting needs to take into account the application of the scene of the obstruction and the top of the interference, so the recommended mounting height range is 1.5~2 m. The E54-24LD12B can be mounted on the top of the wall, so the recommended mounting height range is 1.5~2 m. The E54-24LD12B can be mounted on the top of the wall.

6.1 Ceiling mounting and detection range

Figure 6-1 illustrates the ceiling mounting of the E54-24LD12B millimeter wave sensor. When mounted on the roof, the antenna of the millimeter-wave sensor is oriented at 0°, i.e., directly below. The left side of the sensor has a negative angle of illumination and the right side has a positive angle, as shown in Figure 6-2.

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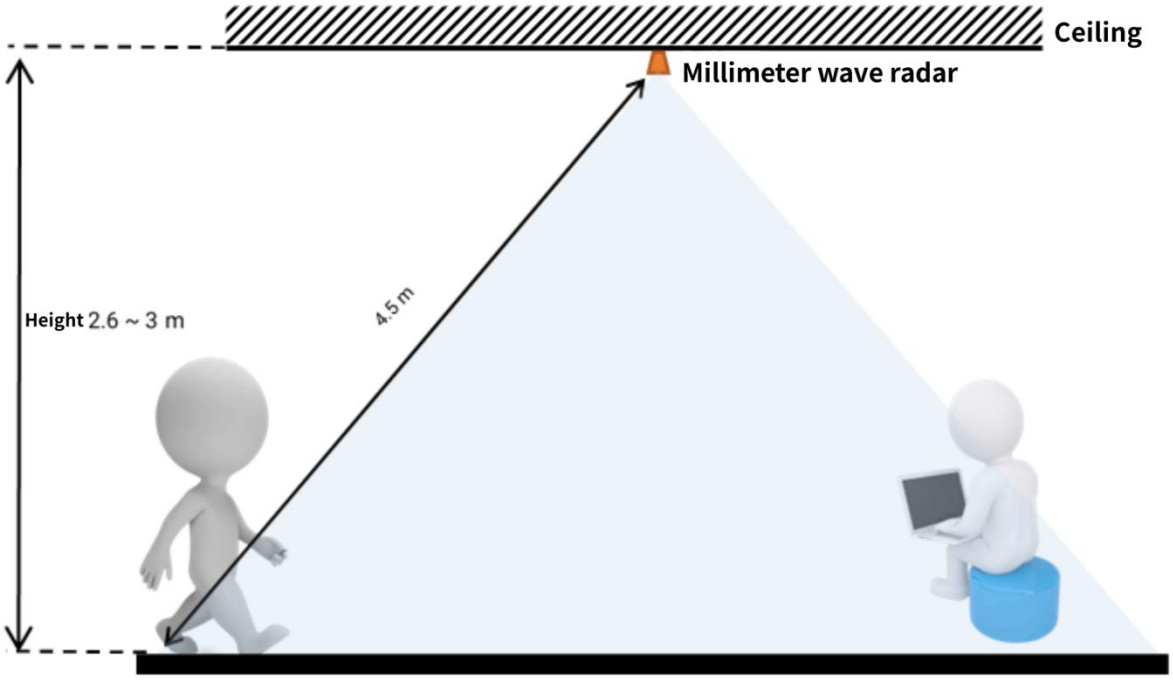


Figure 6-1 Schematic diagram of ceiling mounting

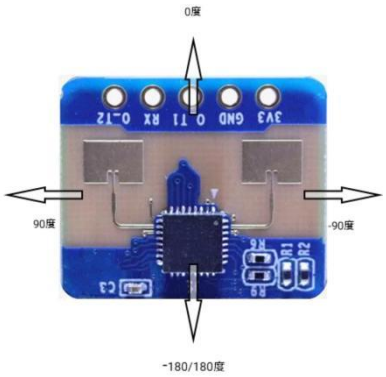
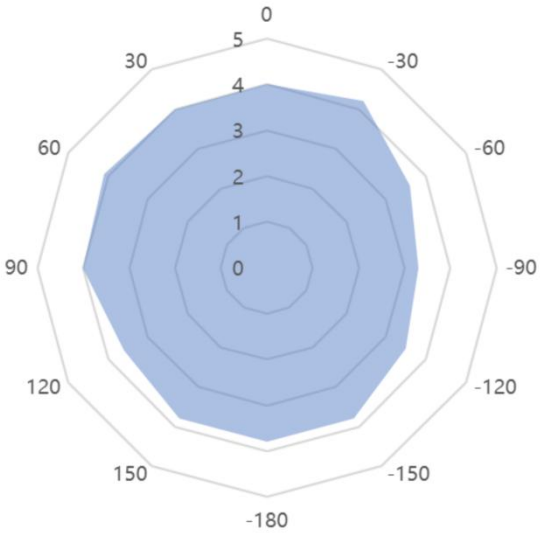


Figure 6-2 Millimeter-wave Sensor Ceiling Mount Angle Identification

Figure 6-3 shows the detection range of the reference solution when the ceiling mounting height is 2.7m. As can be seen from the figure, the millimeter wave sensor can cover a large circle-like area when mounted on the ceiling, and its maximum radial sensing distance can reach 4.5 m. This kind of mounting method is suitable for halls, conference rooms and other scenarios that require a large range of detection.



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Figure 6-3 Schematic of the detection range of a millimeter-wave sensor for ceiling mounting (length in m, angle in °)

6.2 Wall mounting and detection range

Figure 6-4 illustrates the wall mounting of the E54-24LD12B millimeter wave sensor. For wall mounting, the millimeter wave sensor is also oriented at 0°, i.e., directly in front of the sensor. The left side of the sensor has a negative azimuth angle and the right side has a positive azimuth angle, as shown in Figure 6-5.

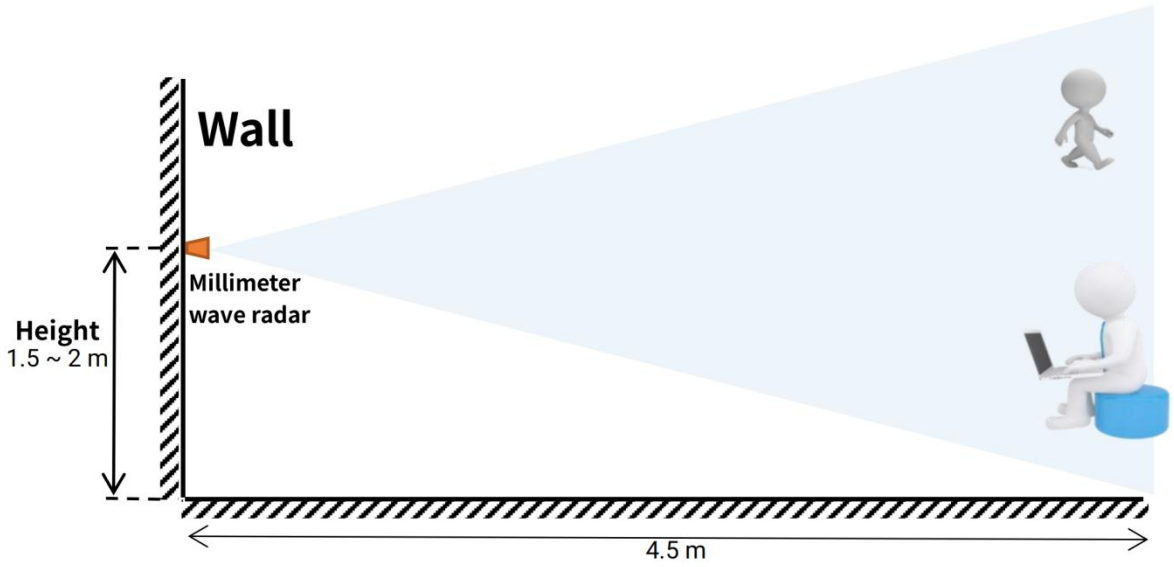


Figure 6-4 Wall Mounting Schematic

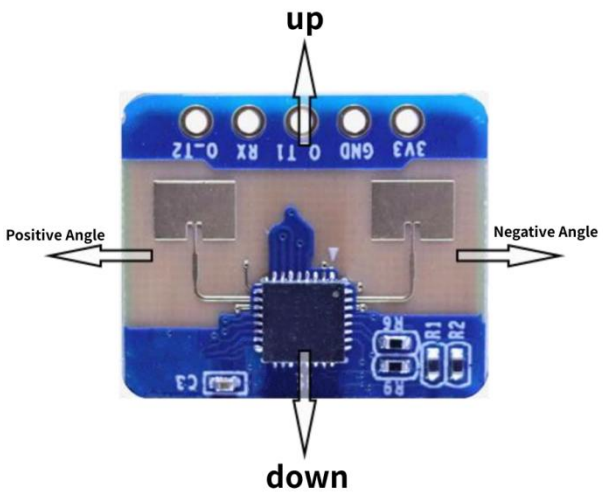


Figure 6-5 Millimeter-wave Sensor Wall Mounting Angle Identification

Figure 6-6 shows the detection range of the reference solution at a wall height of 1.5 meters. In the case of wall mounting, due to the limitations of the mounting position and angle, the detection range is relatively small, but the accuracy is higher. The detection angle range is ±45° centered on the normal direction of the millimeter wave sensor antenna, and the

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maximum detection distance is 4.5 m. This type of installation is suitable for corridors, doorways, and other scenarios that require accurate detection and area control.

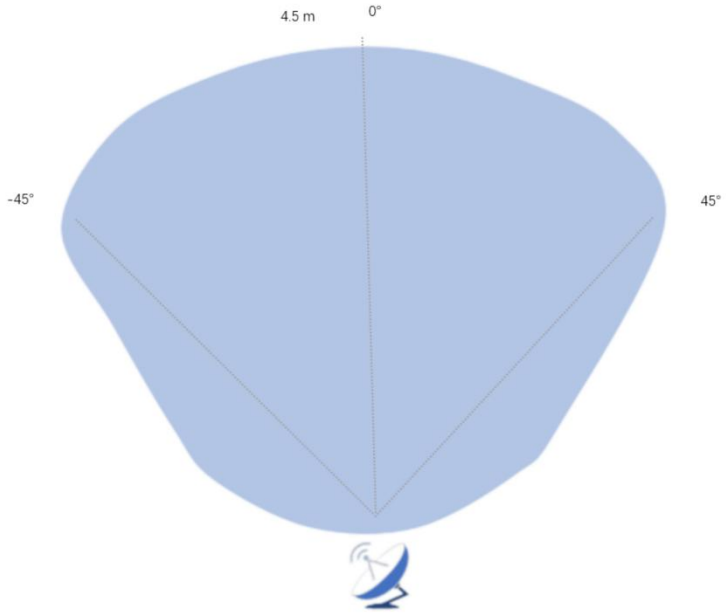


Figure 6-6 Schematic of the detection range of a millimeter-wave sensor for wall mounting

7 Installation Instructions

When installing the E54-24LD12B millimeter wave sensor, follow these instructions to ensure proper installation and optimum performance.

Verify the minimum mounting clearance

- If the sensor requires an enclosure, the enclosure material must have good wave-transmission characteristics in the 24 GHz band.
- Metals or materials that are shielding against electromagnetic waves should not be used.

Installation environment requirements

- Avoid the presence of non-human objects in the sensing area that are in constant motion, such as animals, curtains or greenery, etc., which may affect the detection effect.
- Avoid large areas of strong reflections in the sensing area, which may interfere with the normal operation of the millimeter wave sensor.
- When wall-mounted, pay attention to the air conditioner on the top of the room, electric fans and other possible external interference.

Installation Precautions

- Ensure that the millimeter wave sensor antenna is facing the area to be detected and that there is no obstruction around the antenna.
- The sensor should be mounted in a firm and stable position to avoid shaking, resulting in a decrease in the detection effect.
- There should be no object movement or vibration on the back of the sensor to avoid back flap signal interference.

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If necessary, a metal shield or back plate can be used for shielding.

- If there are more than one 24GHz band millimeter wave sensors, their beams should be avoided directly opposite each other; when mounted on the ceiling, the neighboring sensors should be spaced at least 3m apart in order to reduce mutual interference.

Power supply precautions

- The power supply input voltage should be kept in the range of 3.0~3.6V, and make sure the power supply ripple is within 100kHz without obvious spectral peaks.
- As this program is a reference design, users need to consider the ESD and lightning surge and other electromagnetic compatibility design.

8 Caution

Maximum Detection Distance

- The millimeter wave sensor has a maximum detection distance of 4.5m in a straight line.
- The sensor can accurately report target distances in the range of 1.5m to 4.5m. However, due to the influence of the DC signal, the target distance within 1.5m may not be accurate, in which case the sensor will report the distance as 1.5m.

Start-up time

- After the millimeter wave sensor is powered on, it can report the moving target information after 2s, and the stationary target information after 3s.

Maximum distance and accuracy

- The theoretical range accuracy of the millimeter wave sensor of this reference program is 0.15m, but it may fluctuate in actual use due to the characteristics of the target (body type, state, RCS, etc.).
- The maximum detection range of the sensor may also vary slightly depending on target characteristics and environmental conditions.

Burn-in time limitations

- needs to send the enable command configuration command before burning the program to the millimeter wave sensor module. Please make sure that the whole burning process is completed within 3s.

Unoccupied Duration

- When the millimeter wave sensor module detects that there is no human body in the target area, it will not report the “unoccupied” status immediately, but will wait for a certain period of time, which is called unoccupied duration.
- If no human body is detected during the waiting period, the “unoccupied” status will be reported; if a human being is detected during the waiting period, the waiting period will be ended immediately and the timing will be updated, and the target information will be reported at the same time.

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9 Related Models

Model	chip solution	Package form	Size mm	Communications interface
E54-24LD12A	-	DIP	20.0*20.0	UART/GPIO

Revision history

Version	Date	Description	Issued by
1.0	2024.10.31	Initial version	Bin
1.1	2025.11.03	Modify pin description	Bin
1.2	2026.4.29	Modify the detection range	Ning

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