E54-24LD12A User Manual

24GHz Human Micro-Motion Millimeter Wave Sensor



成都亿佰特电子科技有限公司
Chengdu Ebyte Electronic Technology Co.,Ltd.

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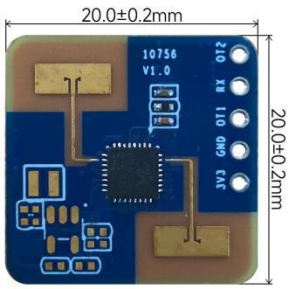
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Chapter 1 Product Overview



E54-24LD12A is a wide coverage human body micro-motion millimeter wave sensor of Ebyte millimeter wave radar series , including a very simplified 24GHz Sensor hardware and human body micro-motion sensing intelligent algorithm firmware.

Hardware AIoT Millimeter wave sensor, high performance 24GHz One transmit and one receive antenna and peripheral circuits ; the human body micro - motion sensing algorithm uses millimeter wave radar distance measurement technology and advanced proprietary radar signal processing technology to achieve accurate perception of moving, micro-moving and standing human bodies.

The human micro-motion sensing intelligent algorithm firmware is mainly used in indoor scenes to sense whether there is a moving or micro-moving human body in the area , and refresh the detection results in real time. The maximum sensing distance of E54-24LD12A for moving human bodies is 10m , and the sensing distance range , trigger and hold thresholds in different intervals, and unattended reporting time can be easily configured . E54-24LD12A supports GPIO and UART interfaces , plug and play , and can be flexibly applied to different smart scenes and terminal products.

1.1 Features

- Equipped with single-chip intelligent millimeter wave sensor SoC and intelligent algorithm firmware ;
- Ultra-small sensor size: 20mm×20mm ;
- Load the default human body sensing configuration , plug and play ;
- 24GHz ISM frequency band , can pass FCC , CE , and RF spectrum regulation certification ;
- 3.3V power supply , supports 3.0V~3.6V wide voltage range ;
- Average working current 50mA ;
- The detection target is the moving or slightly moving human body ;
- Report detection results in real time ;
- Provides visualization tools to support configuration of detection distance interval and target disappearance delay time ;
- Support automatic generation of detection thresholds ;
- Supports sensing range division , completely shielding any interference outside the range ;
- Close distance sensing of 0.2m , no detection blind area ;
- The maximum distance of motion human body sensing is 10m ;
- Large detection angle , covering range up to ±60° ;
- Supports multiple installation methods such as ceiling hanging and wall hanging ;
- The trigger and hold states are configured independently , with strong anti-interference capability .

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1. 2 Application Scenario

The E54-24LD12A wide coverage human body micro-motion millimeter wave sensor can detect and identify moving, standing and stationary human bodies. It is widely used in various AIoT scenarios , covering the following types:

- Smart Home

Sense the presence and distance of human body and report the detection results for the main control module to intelligently control the operation of home appliances.

- Smart Security

Induction access control, building intercom, electronic cat's eye, etc.

- Smart Lighting

Identify and sense the human body , accurately detect the position , and can be used for lighting equipment in public places (induction lamps, bulbs, etc.).

- Smart Business

Identify when a person is approaching or moving away within the set distance range; light up the screen in time and keep the device lit when a person is present.

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Chapter 2 System Description

E54-24LD12A is a wide coverage human body micro-motion millimeter wave sensor developed based on millimeter wave sensor chip. FMCW Frequency modulated continuous wave , combined with radar signal processing and built-in intelligent human body sensing algorithm , detects human targets in a set space and updates the detection results in real time. Using E54-24LD12A , users can quickly develop their own precise human micro-motion sensing products.

The hardware mainly consists of a fully integrated intelligent mmWave sensor SoC , a 24 GHz transmit-receive antenna and a main control MCU The software part is composed of the intelligent micro -motion human body sensing firmware and visual configuration tool released by Ebyte , which can realize the human body sensing function with flexible configuration of sensing distance, trigger and hold threshold and unattended reporting time.

2.1 Specifications

parameter	Minimum	Typical Value	Maximum	unit	Remark
Specifications					
Supported frequency bands	24	-	24.25	GHz	conform to FCC、CE , non-committee certification standards
Supports maximum sweep bandwidth	-	0.25	-	GHz	
Maximum equivalent isotropic radiated power	-	1 2	-	dBm	-
Supply voltage	3.0	3.3	3.6	V	-
size	-	20 * 20	-	mm	±0.2mm
Ambient temperature	-40	-	85	℃	-
System Performance					
Detection range (wall mounted)	-	10	-	m	Sports human target
	-	6	-	m	Micro-motion human target
Detection range (ceiling mounted)	-	5	-	m	Sports human target
	-	4	-	m	Micro-motion human target
Detection accuracy	-	0.15	-	m	Moving target within 10 m of the sensor
Average operating current	-	50	-	mA	-
Data refresh cycle	-	100	-	ms	-
weight	-	1.2	-	g	±0.2g

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Chapter 3 Hardware Description

3.1 Dimensions

Figure 3-1 shows the mechanical dimensions of hardware E54-24LD12A , all units are in mm. The board thickness of hardware E54-24LD12 is 1.2mm , with a tolerance of ± 0.2mm .

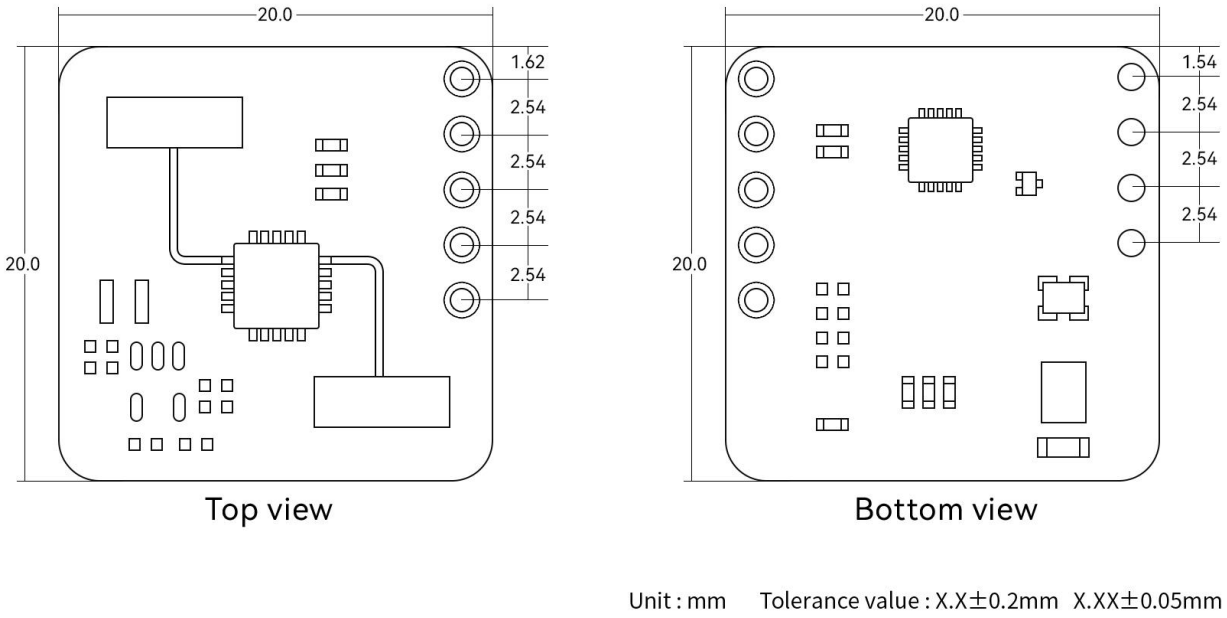


Figure 3-1 Mechanical dimensions

3.2 Pin Definition

The millimeter wave radar module has five reserved pin holes (not equipped with pins when leaving the factory) called J1 , which are used for power supply and communication ; J1 is the SWD interface , which is used for MCU program burning and debugging.

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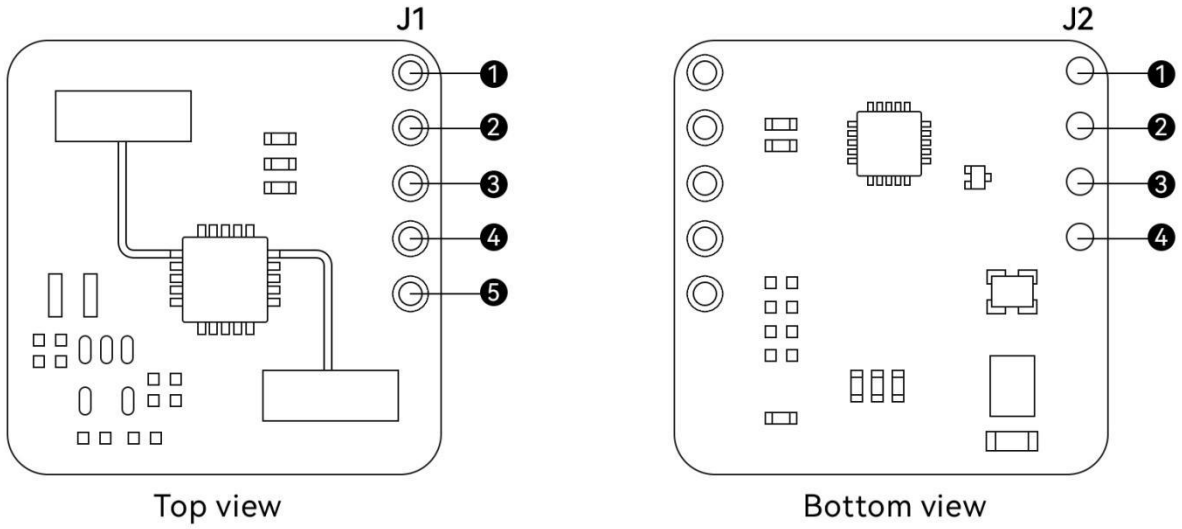


Figure 3-2 E54-24LD12A pin definition

Table 3-1 J1 , J2 pin description

J1	Name	Function	illustrate
1	OT2	IO , used to report detection status: high level means someone is there , low level means no one is there	0~3.3V
2	RX	UART_RX	0~3.3V
3	OT1	UART_TX	0~3.3V
4	GND	Grounding	-
5	3V3	Power Input	3.0V~ 3.6V , Typ.3.3V
J 2	Name	Function	illustrate
1	3V3	Power Input	3.0V~3.6V
2	CLK	SWD interface clock line	0~3.3V
3	DIO	SWD interface data cable	0~3.3V
4	GND	Grounding	-

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Chapter 4 Software Description

This chapter introduces the firmware debugging of the E54-24LD12A wide coverage human body micro-motion millimeter-wave sensor and the use of configuration software tools.

E54-24LD12A has burned system firmware before leaving the factory. Ebyte provides a visual configuration tool software for the E54-24LD12A hardware , which is convenient for developers to configure the parameters of the E54-24LD12A according to the usage scenario and optimize the sensing effect.

4.1 Firmware Debugging

This section describes how to use the serial port tool software to debug the E54-24LD12A mmWave sensor firmware.

Step 1: Connect the configuration software and the millimeter wave sensor through the USB to TTL serial port adapter board . The pin connection method is shown in the figure below :

The corresponding relationship between the pins when the sensor is connected to the USB serial port adapter board	
Sensor	**Serial port adapter board**
RX	TXD
OT1	RxD
GND	GND
3V3	VCC

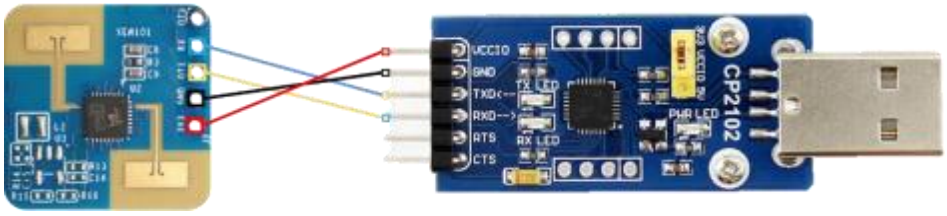


Figure **4-1** Connection between **E54-24LD12A** and **USB to serial port adapter board**

Step 2: Open the device manager of the configuration software and check the serial port number of the millimeter wave sensor .

Step 3. Open the third-party serial port tool , select the serial port number of the millimeter wave sensor , set the serial port baud rate to 115200 , and then click the " Open Serial Port " (or equivalent) button to view the current millimeter wave sensor detection results at the output end of the tool interface .

4.2 Configuration software tool description

This section introduces the use of the configuration software tool that comes with the E54-24LD12A millimeter wave sensor to help users understand the meaning of related parameters and how to obtain them .

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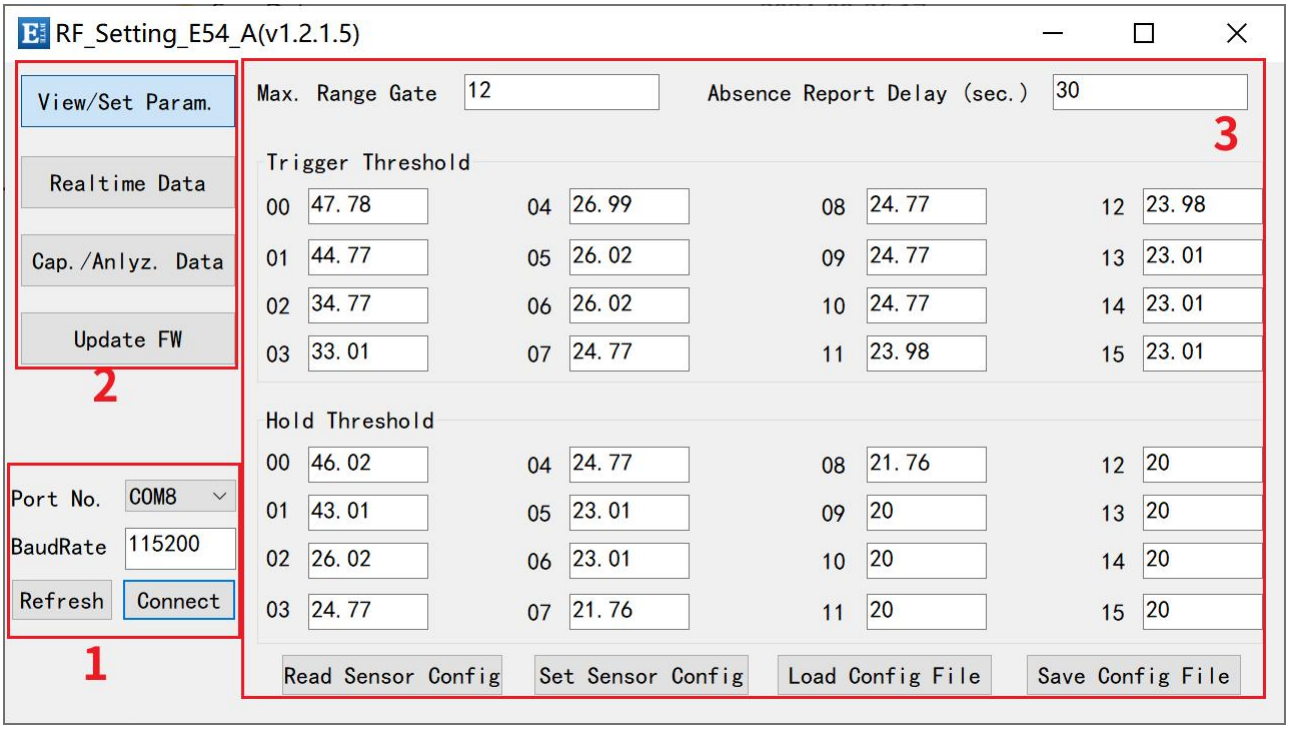
Note: The configuration software tool and the third-party serial port tool cannot be used at the same time!

Before using the functions of the the configuration software, the user should first connect E54-24LD12A to the configuration software. The steps are as follows:

Step 1: Get the the configuration software tool " RF_Setting_E54_A_V1.2.1.5 " for E54-24LD12A from the official website of Ebyte ;

Step 2: Use the serial port adapter board to connect the millimeter wave sensor and the the configuration software according to Figure 4-1 ;

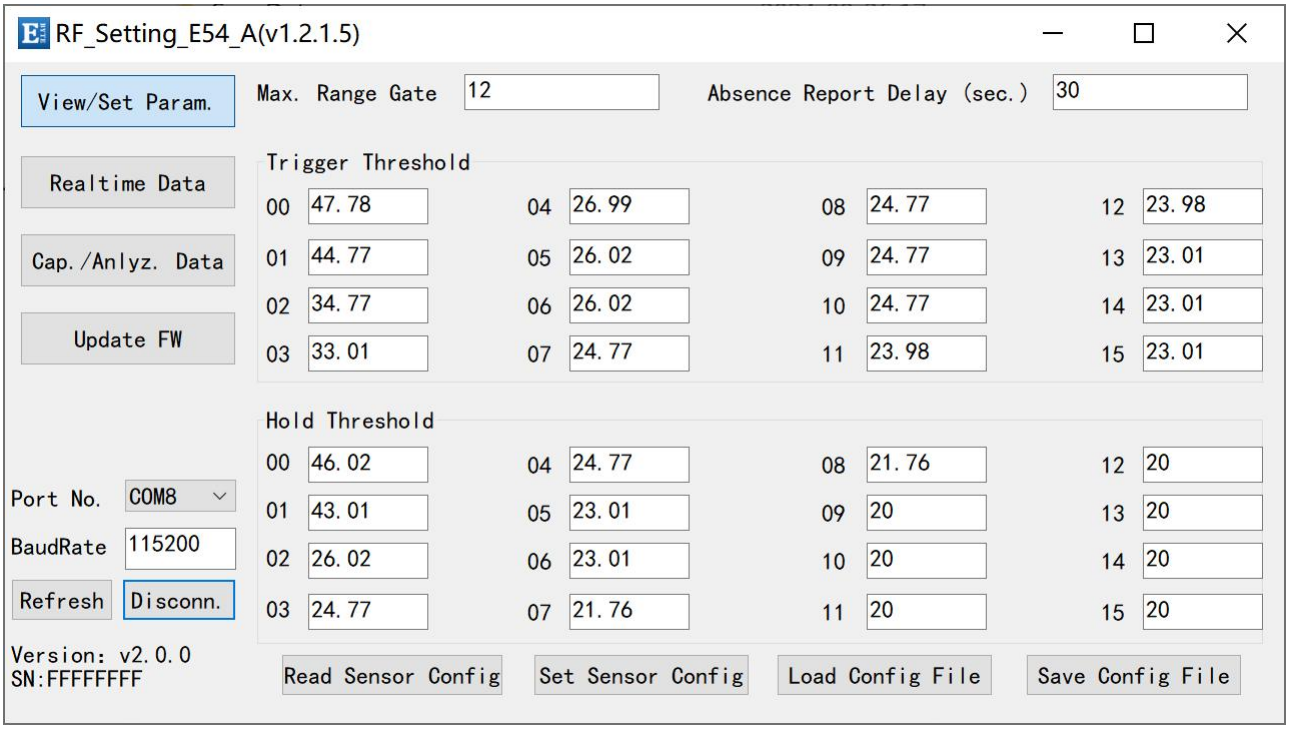
Step 3. Open the configuration software tool, click the "Refresh" button, select the serial port number of the millimeter wave sensor in the "Serial Port Number" drop-down box, confirm that the "Baud Rate" is 115200 , and click the " Connect Device " button to start connecting the configuration software and the millimeter wave sensor .



(a) Before connecting the device

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(b) After the device is connected

Figure 4-2 RF_Setting_E54_A_V1.2.1.5

Figure 4-2 (a) , the the configuration software tool interface can be divided into three areas: device operation area (Zone1) , function button area (Zone2) , and function page area (Zone3).

After the configuration software tool is successfully connected to the millimeter wave sensor, the firmware version number (format is Version : ...) and serial number (format is SN: ... , when the serial number is not burned , the configuration software will display FFFFFFFF) of the millimeter wave sensor will be displayed in the Zone 1 area of the interface , and the current parameter values of the millimeter wave sensor will be displayed in the "Parameter View/Set" function page area , as shown in Figure 4-2 (b).

4.2.1 Parameter View/Setting

"Parameter View/Set" page of the configuration software tool is shown in Figure 4-3 , which allows users to view the current parameters of the millimeter wave sensor and modify the parameters.

The number of configurations can be customized to meet the needs of specific application scenarios.

The steps to read the millimeter wave sensor parameters through the configuration software tool are as follows:

- After connecting E54-24LD12A to the configuration software tool , click the " Read sensor settings " button on the function page . A " Read parameters successfully " prompt window will pop up on the page and display all the current parameter values of the millimeter wave sensor. Click " OK " to close the prompt window .

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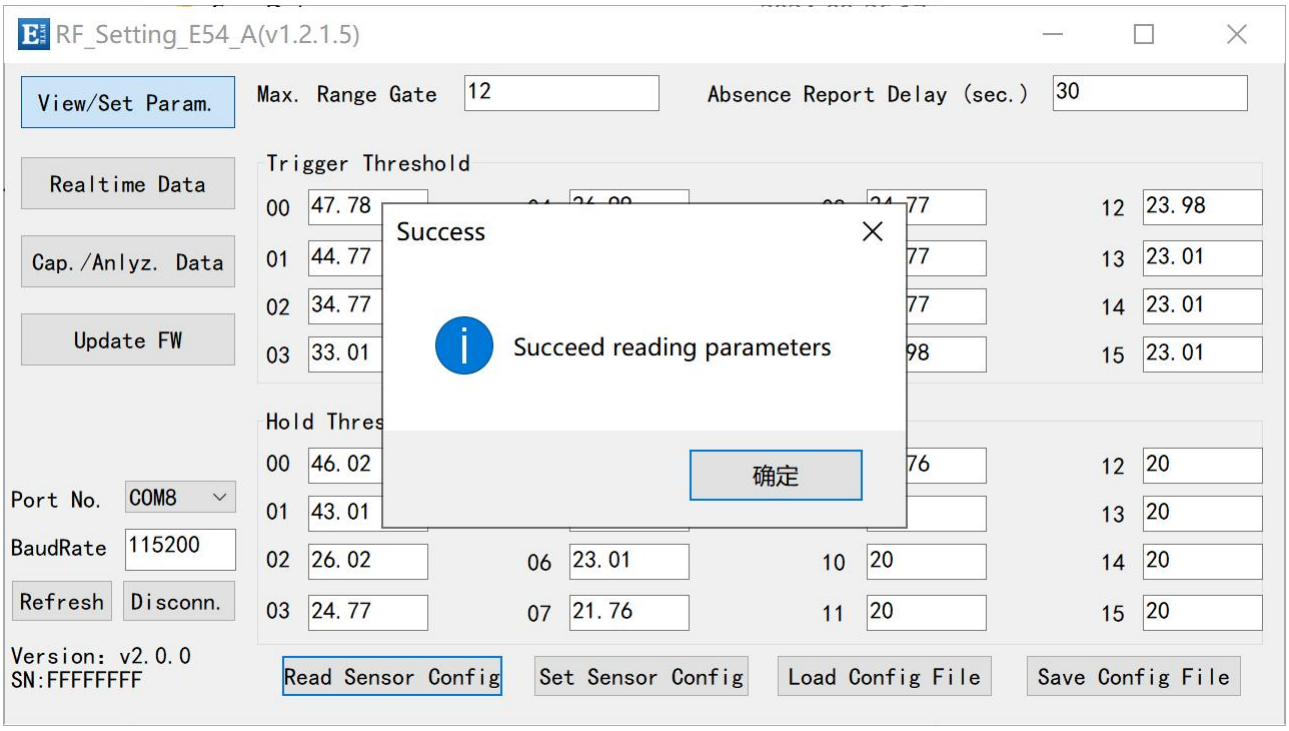


Figure 4-3 Reading millimeter wave sensor parameters interface

The steps to change one or more mmWave sensor parameters through the configuration software tool are as follows:

Step 1: After connecting E54-24LD12A to the configuration software tool , enter new parameter values for all parameters that need to be changed on the function page ;

Step 2. Click the "Write Sensor Settings" button on the function page. The configuration software will write the parameter values in the current interface to the millimeter wave sensor. The page will pop up a "Write Parameters Successfully" prompt window. Click "OK" to complete the parameter setting.

Explanation of the parameters on the "Parameter Setting" page of the configuration software tool, see Table 4-2

Table 4-2 Parameter explanation of the configuration software tool interface

Parameter name	Explanation	Parameter range
Maximum distance gate	Used to set the maximum effective detection distance of the millimeter wave sensor ; The length of one distance door is 70cm.	0~15
Target disappears Delay time (s)	There is a delay of T for the target state to switch from occupied to unoccupied . During this period , if someone is detected , the timing of this period will be restarted. The millimeter wave sensor will only switch to the unoccupied state and report that no one is there after detecting that the unoccupied state has lasted for a full T period of time .	0~65535
Trigger threshold (dB)	Used to set the energy value threshold from unmanned to manned state, which can be calculated through the "Generate Threshold" function	0~65535
Hold Threshold (dB)	The energy threshold used to detect human micro-movement and maintain human presence can be calculated using the "Generate Threshold" function.	0~65535

The configuration software tool supports saving and loading the parameter configuration of the millimeter wave sensor:

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Click the "Save Configuration File" button and select the path you want to save . The configuration software tool will save the current parameter configuration of the millimeter wave sensor in the form of an .xml file in the configuration software. The default save address is the folder where the configuration software tool is located .

Click the "Load Configuration File" button , and the configuration software tool will open the millimeter wave sensor parameter configuration file in the path specified by the user and read in the millimeter wave .

4.2.2 Real-time data

"Real-time Data" page of the configuration software is shown in Figure 4-4 . Its function page is mainly divided into target information area a, function button area b and real-time data area c . The detailed introduction is shown in Table 4-3.



Figure **4-4** Real-time data page

Table **4-3** Function description of each area on the "Real-time data" page

Page Area		Function	illustrate
a	Lantern Icon	The color of the light indicates the presence of human targets in the detection area.	Red means someone is there ; green means no one is there
	Target information text box	Displays the detected target distance information	Displays the straight-line distance between the human target and the sensor.
b	Start / Pause toggle button	Start / stop sensor for human presence detection	-
	Generate Gate button	hold threshold" of each range gate based on the threshold generation coefficient	Refer to Table 4-2 for the definition of trigger threshold and hold threshold .

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c	"Relative power VS time" real-time detection data display	Real-time display of the motion energy value of each distance gate (green line), trigger threshold (red line) Line) and hold threshold (yellow line)	A black background indicates that the range gate is within the valid detection range, and a gray background indicates that the range gate is within the invalid detection range.
	"Distance VS Time" real-time detection data display	Real-time display of the distance change of the target human body detected by the millimeter wave sensor in the past 60 seconds	The gray background area indicates that the sensor detects the target person in this time period, and the black background area indicates that the sensor does not detect the target person in this time period.

The steps to view real-time data through the configuration software are as follows:

Step 1. After connecting E54-24LD12A to the configuration software tool, click the "Real-time Data" button to switch to the function page. At this time, the configuration software tool automatically turns on the detection function of the millimeter wave sensor, the "Start/Pause" switch button displays "Pause", and the two line graphs on the configuration software function page begin to display the corresponding real-time data information;

Step 2 (optional): Click the "Start/Pause" switch button to pause the detection function of the millimeter wave sensor. The colored light on the function page turns green, the target distance displays "0.00 meters", and the two line graphs below stop updating.

The steps to generate sensor detection thresholds through the configuration software tool are as follows:

Step 1: On the "Real-time Data" page, click the "Generate Threshold" button, and the "Threshold Generation" window will appear;

The trigger and hold threshold generation coefficients are displayed at the top of the "Threshold Generation" window. The threshold generation coefficient is proportional to the sensitivity of the millimeter wave sensor and has a value range of 1.0~20.0. The threshold generation progress bar and text of the specific generation progress are displayed at the bottom (the text is visible during the threshold generation process).

Step 2: After entering the trigger and hold threshold generation coefficients in the "Threshold Generation" window, click the "Start/Close" switch button. The configuration software tool will start to automatically generate thresholds. The progress bar and the text below will display the generation progress in real time, as shown in Figure 4-5.

Step 3. When the threshold generation is completed, the text in the lower left corner displays "Threshold Generation Successful" and the "Start/Close" switch button displays "Close"; click the "Close" button to complete the threshold generation.

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

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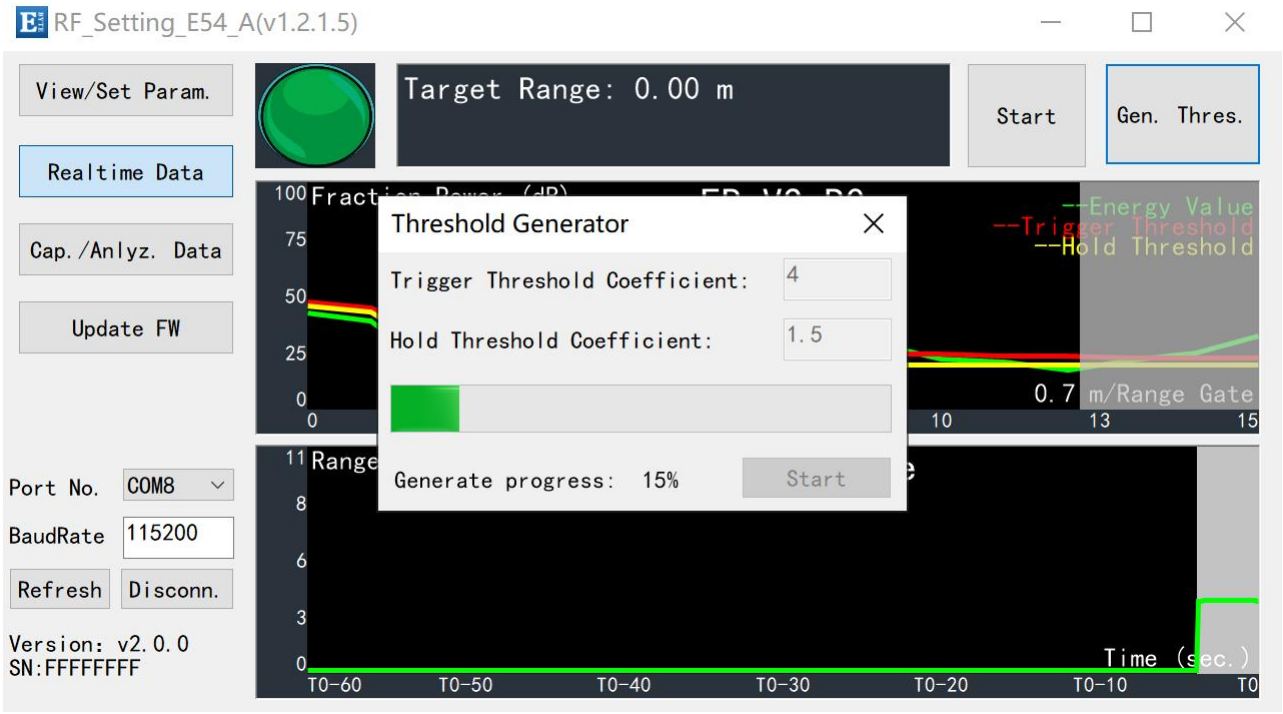


Figure **4-5** Threshold generation page

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4.2.3 Data collection/analysis

"Data Collection/Analysis" page of the configuration software is shown in Figure 4-6 . Its function page can be divided into data operation area a and data display area b . The detailed introduction is shown in Table 4-4.

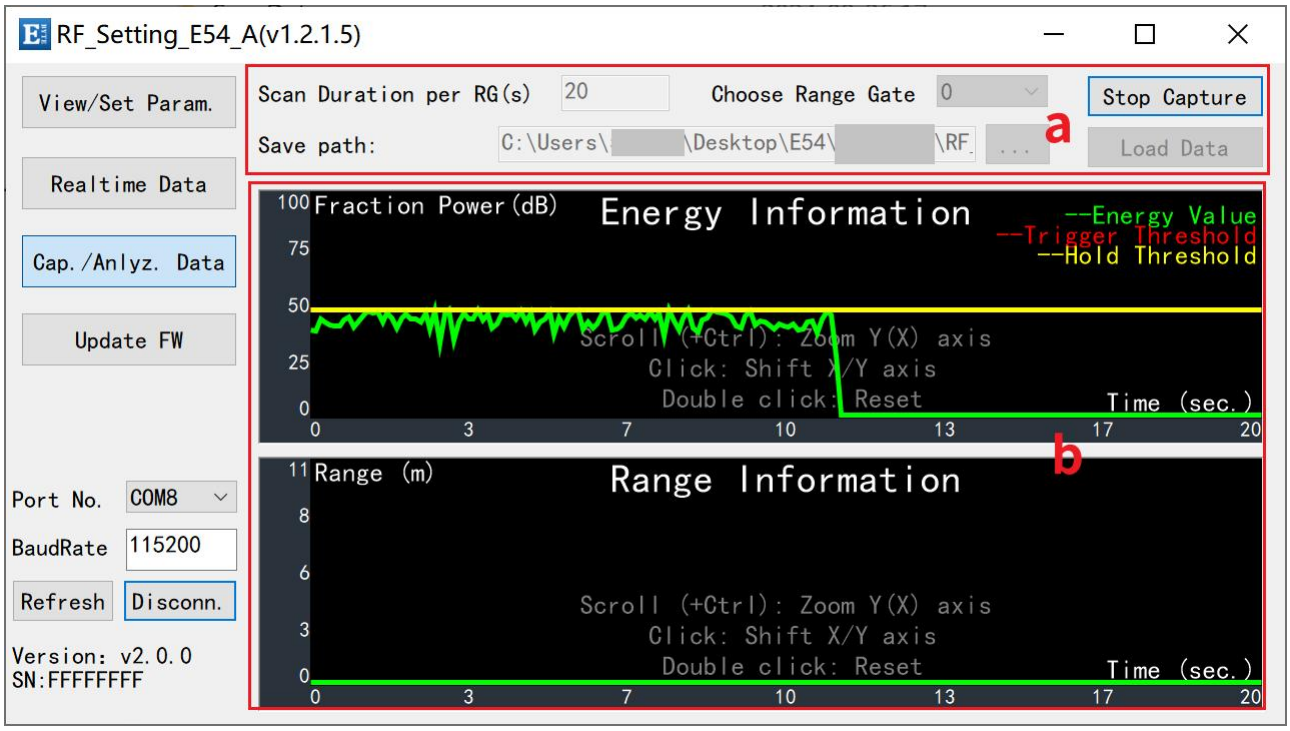


Figure **4-6** Collect / Analyze Data Page

surface **4-4** Functional description of each area on the " Data Collection / Analysis " page

Page Area		Function	Description
a	Range gate scan time (seconds)	time for each range gate	The default value is 20 seconds and the value range is 0~ 65535 .
	File save path	Set the save path for the collected data	Displays the straight-line distance (meters) between the human target and the sensor.
	Select Display Range Gate	Select the range gate you want to view	The optional range is 0~15 .
	" Collect data / stop collecting Set toggle button	Starting and stopping data collection	After stopping data collection , users can see .data type files with file names starting with RadarData and ending with timestamp in the set file save path .
	Load Data button	Open the saved data for users to view and analyze	-
b	Energy Information line chart	value, trigger threshold and hold threshold on the user-selected range gate	The horizontal axis is time , and the vertical axis is relative power to represent energy information.
	Distance Information line chart	the distance information of human targets detected within the detection range of the millimeter wave sensor	The horizontal axis is time and the vertical axis is distance.

The steps for collecting energy data through the configuration software are as follows:

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Step 1: After connecting E54-24LD12A to the configuration software tool , click the " Data Collection / Analysis " function button to switch to the function page ;

Step 2: Enter the "range gate scanning time" and set the "file saving path" 2. After ensuring that there is no one in the detection range of the millimeter wave sensor within a scanning cycle: click the "collect data/stop collection" switch button to start collecting data ;

2It is recommended to set the "File Save Path" to the SaveData folder in the same path as RF_Setting_E54_A_V1.2.1.5.exe .

Step 3: After starting to collect data , the user can wait for the configuration software tool to automatically stop collecting after the scan is completed , or click "Collect Data/Stop Collecting" to stop collecting data.

In both cases, the collected data will be stored in the file save path set in step 2.

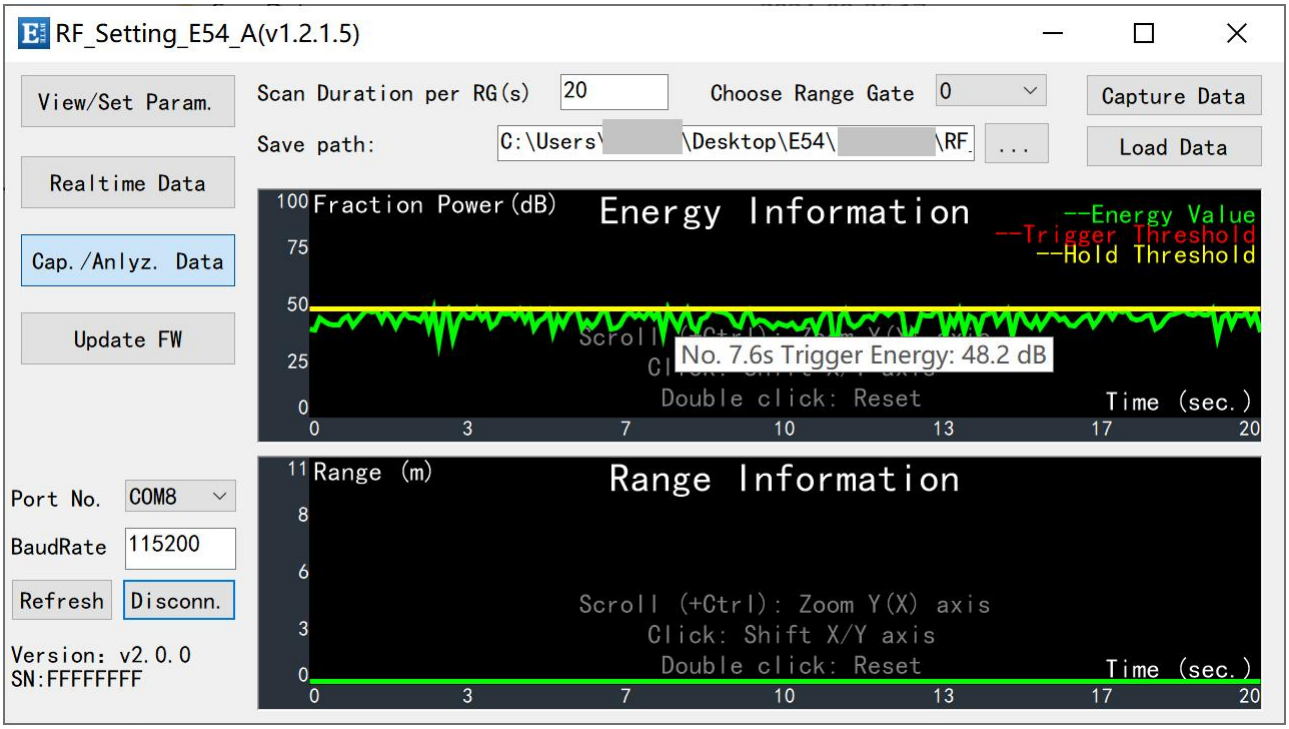
The steps for analyzing energy data through the configuration software are as follows:

Step 1: After connecting E54-24LD12A to the configuration software tool , click the "Data Collection/Analysis" function button to switch to the function page ;

Step 2. Click the "Load Data" button and select the data you want to view;

Step 3. Select the range gate you want to view , and the user can see the energy information and distance information of the range gate in the data file on two line graphs ;

Step 4. If you want to view the specific data of a certain point on the curve, place the mouse cursor at the position of interest on the curve. A floating box will appear near the cursor to display the energy value or distance information at that location, as shown in Figure 4-7.



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Figure **4-7** When viewing data on the data viewing page , users can zoom, pan, and restore the line chart:

- Zoom the horizontal axis: Place the mouse cursor on the graphic canvas , press the Ctrl key on the keyboard and scroll the mouse wheel to zoom in (scroll the mouse wheel up) or zoom out (scroll the mouse wheel down) the graphic on the horizontal axis ;
- Pan data graph: Place the mouse cursor on the graph canvas , press the left mouse button and move the mouse to move the graph accordingly , and the horizontal and vertical coordinates will also change synchronously ;
- Restore graphics: Place the mouse cursor on the graphics canvas and double-click the left mouse button to restore the graphics to the default display settings.

4.2.4 Update Firmware

The "Update Firmware" page of the configuration software is shown in Figure 4-8. The steps to update the mmWave sensor firmware through the configuration software are as follows:

Step 1: After connecting E54-24LD12A to the configuration software tool , click the "Update Firmware" function button to switch to the function page ;

Step 2 [3.] 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 ;

Step 3. Click the "Select bin file path" button , select the required .bin file , and click the "Download" button to start upgrading the firmware . The prompt information box on the right will display the download results in real time , and the bin file information and current download progress will be displayed below.

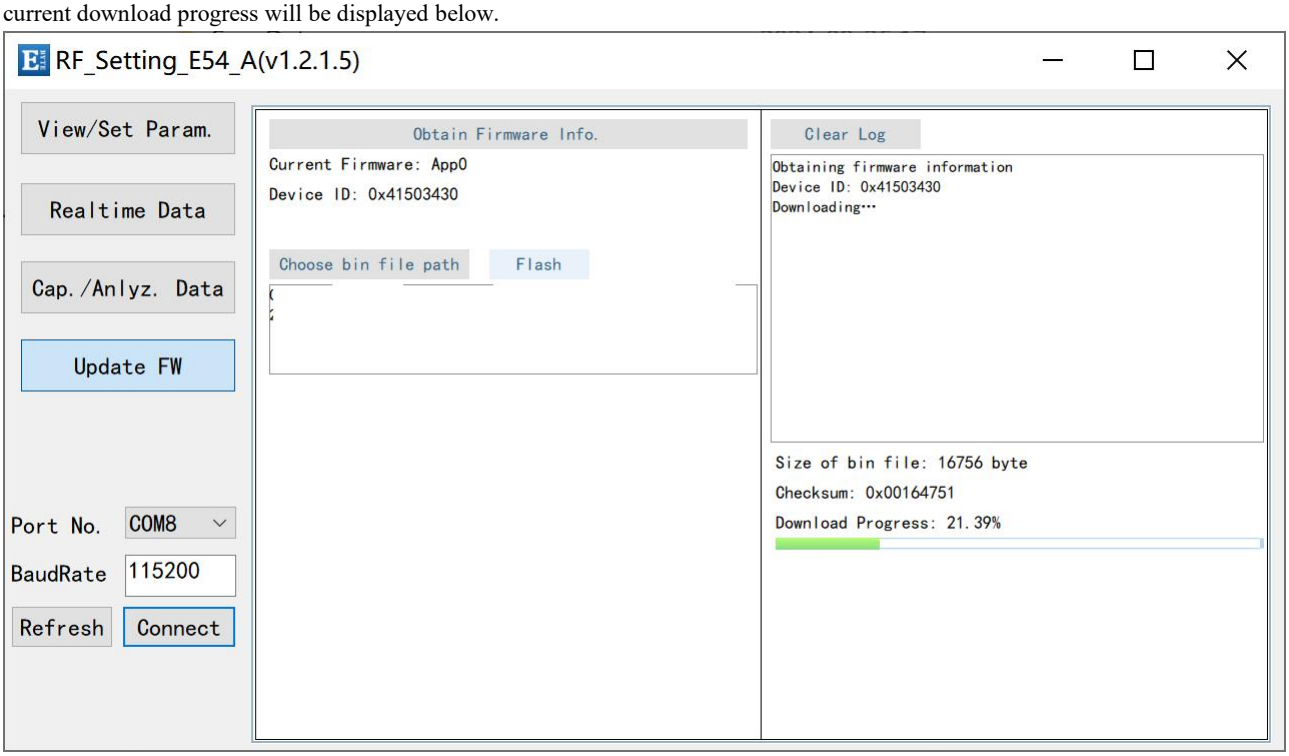


Figure **4-8** Firmware upgrade page

After the firmware upgrade is successful, the page prompt box will display "Download Successful!". If the firmware upgrade fails, the prompt box will display the corresponding error message.

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[3] This step is mandatory and cannot be skipped when the user uses the configuration software interface to update the firmware.

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Chapter 5 Communication Protocol

This communication protocol is mainly used by users who need to perform secondary development without visualization tools. The E54-24LD12A wide coverage human body micro-motion millimeter wave sensor communicates with the outside world through the serial port (TTL level). The data output and parameter configuration commands of the millimeter wave sensor are all carried out under this protocol. The default baud rate of the millimeter wave sensor serial port is 115200 , 1 Stop bit , no parity bit.

This chapter mainly introduces this communication protocol from three parts:

- Protocol format: including protocol data format and command frame format;
- Configuration command package format: including command package format and command return package format ;
- Upload data frame format: including the upload data frame format of the debug mode and the upload data frame format of the report mode.

The basic process of using commands to configure parameters is:

1. Enter command mode ;
2. Configure parameter command / get parameter command ;
3. Exit command mode.

5.1 Protocol Format

5.1.1 Protocol data format

E54-24LD12A uses the little-endian format . All data in the following table are in hexadecimal.

5.1.2 Command protocol frame format

The millimeter wave sensor configuration command and ACK command formats defined by the protocol are shown in Table 5-1 and Table 5-3 .

Table **5-1** Send command protocol frame format

Frame Header	Data length in frame	Intra-frame data	Frame end
FD FC FB FA	2 byte	See table 5-2	04 03 02 01

Table **5-2** Data format in the transmission frame

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

Table **5-3 ACK** command protocol frame format

Frame Header	Data length in frame	Intra-frame data	Frame end
FD FC FB FA	2 bytes	See Table 5-4	04 03 02 01

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Table **5-4 ACK** frame data format

Send command word (2 bytes)	Command execution status (2 bytes)	Return value (N bytes)

5.2 Sending Commands and ACK

5.2.1 Read firmware version command

This command reads the mmWave sensor firmware version information.

Command word: 0x0000

Command value: None

Return value: version number length (2 bytes) + version number byte string Send data:

Frame Header	Data length in frame	Command word	Frame end
FD FC FB FA	02 00	00 00	04 03 02 01

ACK (successful , data is an example):

Frame Header	Data length in frame	Command word	ACK	Version number length	Version Number	Frame end
FD FC FB FA	0C 00	00 01	00 00	06 00	76 31 2E 35 2E 35	04 03 02 01

5.2.2 Enable Configuration Command

Any other commands sent to the millimeter wave sensor must be executed after this command is sent , otherwise they will be invalid.

Command word: 0x00FF

Command value: 0x0001

Return value: 2 bytes ACK Status(0 Success , 1 Failed) + 2 bytes protocol version (0x0002) + 2 bytes buffer size (0x0020) Send data:

Frame Header	Data length in frame	Command word	Command Value	Frame end
FD FC FB FA	04 00	FF 00	01 00	04 03 02 01

ACK(Success):

Frame Header	Data length in frame	Command word	**ACK**	Protocol Version	Buffer size	Frame end
FD FC FB FA	08 00	FF 01	00 00	02 00	20 00	04 03 02 01

5.2.3 End configuration command

After executing the end configuration command, the millimeter wave sensor resumes working mode. If you need to send other commands again , you need to send the enable configuration command first.

Command word: 0x00FE

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Command value: None

Return value: 2 bytes ACK Status(0 Success , 1 Failed) Send data:

Frame Header	Data length in frame	Command word	Frame end
FD FC FB FA	02 00	FE 00	04 03 02 01

ACK(Success):

Frame Header	Data length in frame	Command word	**ACK**	Frame end
FD FC FB FA	04 00	FE 01	00 00	04 03 02 01

5.2.4 Read serial number command

This command reads the serial number of the mmWave sensor.

Command word: 0x0011

Command value: None

Return value: 2-byte ACK status (0 success , 1 failure) + SN length (2 bytes) + SN (2 bytes) Send data:

Frame Header	Data length in frame	Command word	Frame end
FD FC FB FA	02 00	11 00	04 03 02 01

ACK (success , SN is an example):

Frame Header	Data length in frame	Command word	**ACK**	**SN** length	**SN**	Frame end
FD FC FB FA	08 00	11 01	00 00	02 00	CD AB	04 03 02 01

5.2.5 Write serial number command

This command writes the serial number of the mmWave sensor.

Command word: 0x0010

Command value: SN length (2 bytes) + SN byte string (2 bytes) Return value: 2 bytes ACK status (0 success , 1 failure)

Send data (example):

Frame Header	Data length in frame	Command word	**SN** length	**SN**	Frame end
FD FC FB FA	06 00	10 00	02 00	CD AB	04 03 02 01

ACK(Success):

Frame Header	Data length in frame	Command word	**ACK**	Frame end
FD FC FB FA	04 00	10 01	00 00	04 03 02 01

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5.2.6 Read sensor register command

This command reads the registers of the mmWave sensor.

Command word: 0x0002

Command value: 2-byte chip address + (2-byte register address) * N Return value: (2-byte register data) * N

Send data (example):

Frame Header	Data length in frame	Command word	Chip Address	Register Address	Frame end
FD FC FB FA	06 00	02 00	40 00	40 00	04 03 02 01

ACK (success , data is example):

Frame Header	Data length in frame	Command word	**ACK**	Register data	Frame end
FD FC FB FA	06 00	02 01	00 00	07 02	04 03 02 01

5.2.7 Configure sensor register commands

This command writes to the register of the millimeter wave sensor. Command word: 0x0001

Command value: 2-byte chip address + (2-byte register address + 2-byte register data) * N

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

Send data (example):

Frame Header	Data length in frame	Command word	Chip Address	Register Address	Register data	Frame end
FD FC FB FA	08 00	01 00	40 00	40 00	07 42	04 03 02 01

ACK(Success):

Frame Header	Data length in frame	Command word	**ACK**	Frame end
FD FC FB FA	04 00	01 01	00 00	04 03 02 01

5.2.8 Read sensor parameter configuration command

This command can read the current configuration parameters of the sensor.

Command word: 0x0008

Command value: (2-byte parameter ID)*N

Return value: (4-byte parameter value)*N Send data (example):

Frame Header	Data length in frame	Command word	Parameter **ID**	Frame end
FD FC FB FA	04 00	08 00	01 00	04 03 02 01

ACK (success , maximum distance gate 12):

Frame Header	Data length in frame	Command word	**ACK**	Parameter Value	Frame end

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FD FC FB FA	08 00	08 01	00 00	0C 00 00 00	04 03 02 01

5.2.9 Configure sensor parameter commands

This command sets the parameters of the millimeter wave sensor. For specific parameter words, please refer to Table 5-5 .

Table **5-5** Sensor parameter table

Parameter name	Parameter word	Parameter range
Minimum distance gate	0x0000	0~15
Maximum distance gate	0x0001	0~15
Target disappearance delay	0x0004	0~65535 units seconds
Trigger threshold	0x0010~0x001F	0~232-1 , is the square of the modulus value
Keep Threshold	0x0020~0x002F	0~232-1 , is the square of the modulus value

Command word: 0x0007

Command value: (2-byte parameter ID + 4-byte parameter value)*N

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

Send data (example: maximum distance gate 12):

Frame Header	Data length in frame	Command word	Parameter **ID**	Parameter Value	Frame end
FD FC FB FA	08 00	07 00	01 00	0C 00 00 00	04 03 02 01

ACK(Success):

Frame Header	Data length in frame	Command word	**ACK**	Frame end
FD FC FB FA	04 00	07 01	00 00	04 03 02 01

5.2.10 Configuration system parameter commands

This command can configure the mmWave sensor system parameters.

Command word: 0x0012

Command value: (2-byte parameter ID + 4-byte parameter value)*N

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

Send data (example):

Frame Header	Data length in frame	Command word	Parameter **ID**	Parameter Value	Frame end
FD FC FB FA	08 00	12 00	00 00	04 00 00 00	04 03 02 01

ACK(Success):

Frame Header	Data length in frame	Command word	**ACK**	Frame end
FD FC FB FA	04 00	12 01	00 00	04 03 02 01

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5.2.11 Start automatic threshold generation command

This command sets the parameters for automatic threshold generation and enables the MCU to start automatic threshold calculation . For specific parameter words, please refer to Table 5-6.

Table **5-6** Automatic threshold generation parameter table

Parameter name	Parameter range	illustrate
Trigger threshold generation coefficient	0x000A~0x00C8	10 times magnification factor , for example, when the factor is 2 , the parameter value is 0x0014
Keep threshold generation coefficient	0x000A~0x00C8	10 times magnification factor , for example, when the factor is 2 , the parameter value is 0x0014

Command word: 0x0009

Command value: 4-byte parameter value

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

Send data (for example: the trigger threshold generation factor is 4 , and the hold threshold generation factor is 1.5):

Frame Header	Data length in frame	Command word	Parameter Value	Frame end
FD FC FB FA	06 00	09 00	28 00 0f 00	04 03 02 01

ACK(Success):

Frame Header	Data length in frame	Command word	**ACK**	Frame end
FD FC FB FA	04 00	09 01	00 00	04 03 02 01

5.2.12 Automatic threshold progress query command

This command can query the progress of automatic threshold generation . The return value contains the progress percentage . When the percentage is 100, it means that the threshold generation is complete. Command word: 0x000A

Command value: None

Return value: 2 bytes ACK status (0 success , 1 failure) + 2 bytes percentage of sent data:

Frame Header	Data length in frame	Command word	Frame end
FD FC FB FA	02 00	0A 00	04 03 02 01

ACK (successful , example: the percentage is 60%):

Frame Header	Data length in frame	Command word	**ACK**	percentage	Frame end
FD FC FB FA	06 00	0A 01	00 00	3C 00	04 03 02 01

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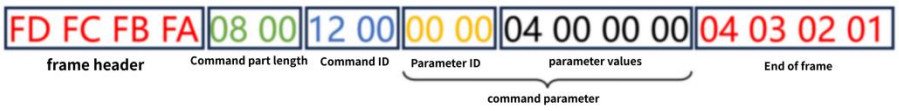
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5.3 Reporting Data

The normal working mode of the E54-24LD12A factory firmware outputs the detection results through the serial port . The output results are ON/OFF strings and target distance gates. In special modes , the host machine obtains the data during the millimeter wave sensor processing . Therefore, the firmware provides two additional transmission formats in the command line mode , namely debug mode and report mode.

In command line mode , the data format reported by the serial port can be controlled by adjusting the working mode parameters in the command packet . Figure 5-1 shows a command packet.

Example.



picture **5-1** Command packet format example

In this command packet , the parameter value of the command parameter can determine the working mode of the millimeter wave sensor: 0x0000 is the debugging mode , 0x0004 is the reporting mode , and 0x0064 is the normal mode. Table 5-7 shows the data frame format of the debugging mode. The RDMAP modulus value data transmitted in the debugging mode is sent according to the data of all range gates of each chirp , that is , the modulus value data of the 16 range gates of the first chirp is sent first , and then the modulus value data of the 16 range gates of the second chirp is sent , and so on.

Table **5-7** Data frame format for debug mode

Frame Header	Intra-frame data	Frame end
AA , BF , 10 , 14	RDMAP : 20 (Doppler) * 16 (range gate) * 4 (square of modulus)	FD , FC , FB , FA

Table **5-8** Data frame format of reporting mode

Frame Header	length	Test results	Target distance	Energy value of each range gate	Frame end
F4 , F3 , F2 , F1	2 bytes , the total number of bytes of detection results, target distance and energy values of each range gate	1 byte , 00 unmanned 01 Someone	2 bytes	32 bytes 16 (total number of range gates) * 2 bytes	F8 , F7 , F6 , F5

Figure 5-2 shows an example of a data frame transmitted from the serial port in reporting mode .

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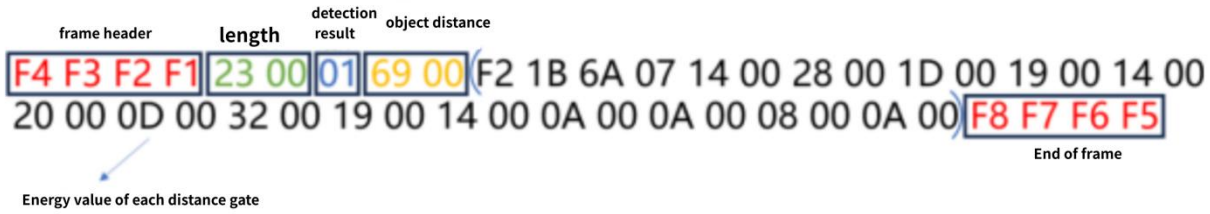


Figure **5-2** Example of a data frame in reporting mode

In the example , the meaning of each part of the data is as follows:

- Length field: indicates the total number of bytes occupied by the reported detection result + target distance + energy value of each range gate ;
- Detection result: indicates whether there is a target in the current scene ;
- Target distance: indicates the distance between the target in the scene and the millimeter wave sensor ;
- Energy value of each range gate: indicates the energy value of each range gate from 0 to 15 range gates .

Therefore, the data frame analysis example in Figure 2 is as follows:

- Length field: 0023 , indicating the total number of bytes occupied by the reported detection result + target distance + energy value of each range gate = 35
- Detection result: 01 , indicating that someone is currently detected in the scene
- Target distance: 0069 , means target distance = 105cm
- Energy value of each range gate:

Range Gate 0 Energy = 1BF2 Range Gate 2 Energy = 0014

Range Gate 1 Energy = 076A Range Gate 3 Energy = 0028

Range Gate 4 Energy = 001D Range Gate 5 Energy = 0019

Range Gate 6 Energy = 0014 Range Gate 7 Energy = 0020

Range Gate 8 Energy = 000D Range Gate 9 Energy = 0032

Range Gate 10 Energy = 0019 Range Gate 11 Energy = 0014

Range Gate 12 Energy = 000A Range Gate 13 Energy = 000A

Range Gate 14 Energy = 0008 Distance Gate 15 Energy = 000A

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Chapter 6 Installation and Detection Range

The E54-24LD12A wide-coverage human body micro-motion millimeter-wave sensor supports two installation methods : ceiling-mounted and wall-mounted . The recommended method is ceiling-mounted installation.

The direction definition of the E54-24LD12A millimeter wave sensor is shown in Figure 6-1. Among them , the X-axis direction is 0° , the Z-axis direction is 90° , and the Y-axis is perpendicular to the XZ plane (also called the normal direction).

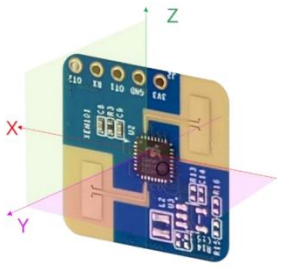


Figure **6-1 E54-24LD12A** direction definition diagram

6.1 Ceiling Installation

The recommended ceiling installation height is 2.7~3.0m. The maximum motion sensing range of the ceiling-mounted E54-24LD12A is 5m at the bottom radius in the default configuration .

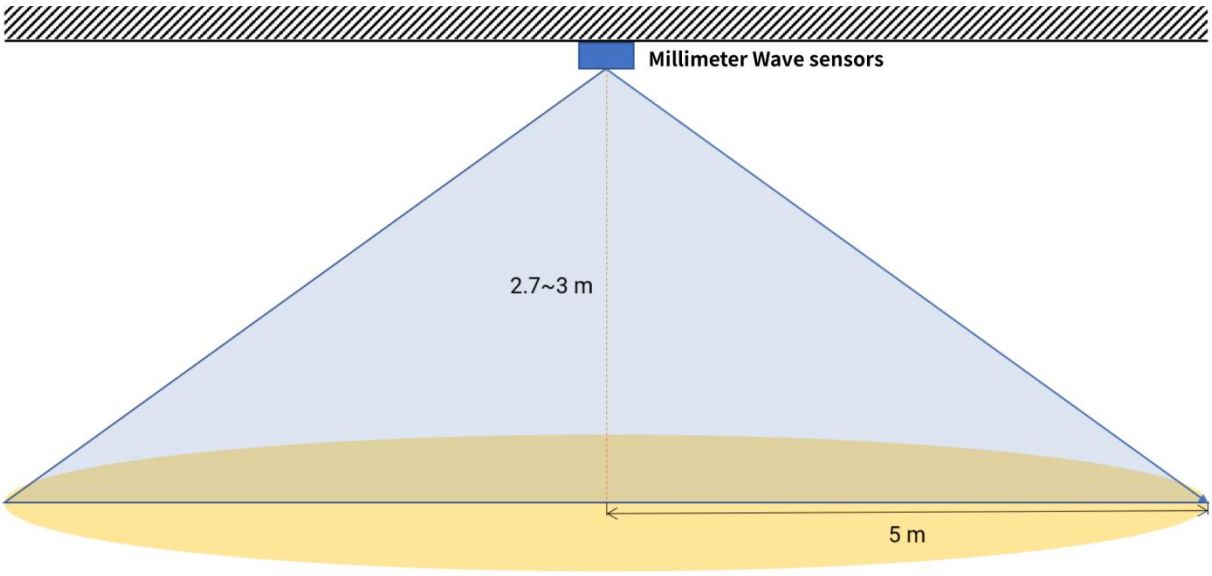


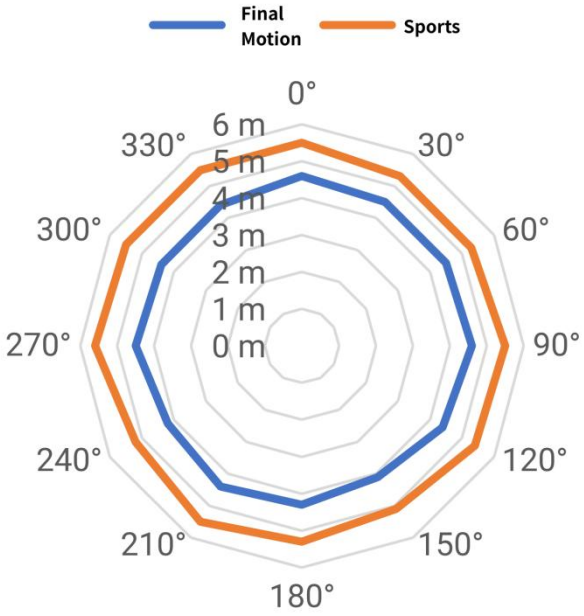
Figure **6-2** Schematic diagram of the detection range of **E54-24LD12A** ceiling installation

The schematic diagram of the motion and micro-motion detection range of this reference scheme when the ceiling installation height is 2.7m is shown in Figure 6-3.

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Figure **6-3 E54-24LD12A** ceiling installation sensing range



6.2 Wall Mounting

The recommended wall mounting height is 1.5~2m. When mounted on a wall , the X-axis (reference) of the millimeter wave sensor points horizontally , the Z-axis points upward , and the Y-axis points to the detection area. The maximum motion sensing range of the wall-mounted E54-24LD12A in the default configuration is a conical space within 10m normal to the sensor and within ±60° in the horizontal and pitch directions , as shown in Figure 6-4.

the wall-mounted installation height is 1.5m is shown in Figure 6-5.

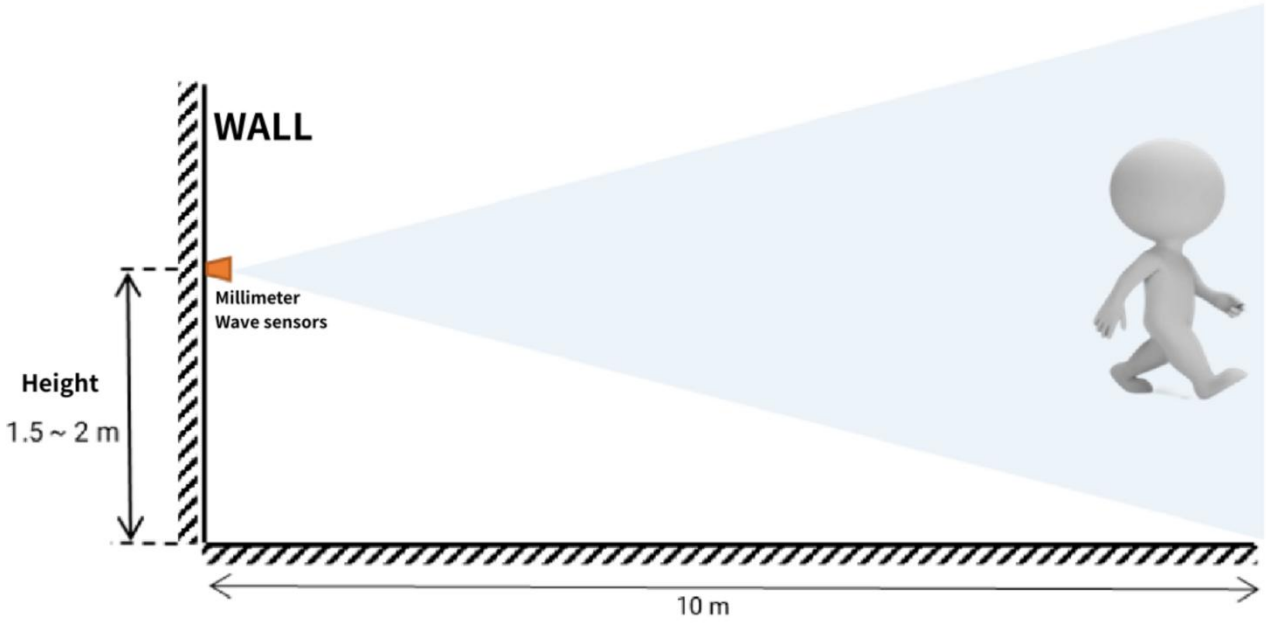


Figure **6-4** Schematic diagram of the detection range of **the E54-24LD12A** wall-mounted installation

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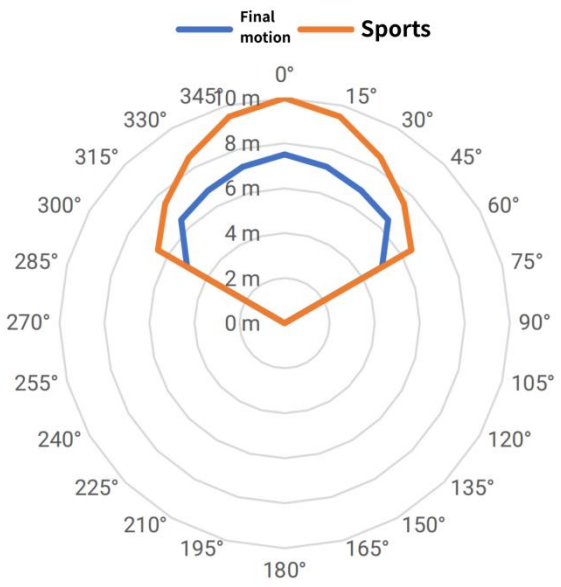


Figure **6-5 E54-24LD12A** wall-mounted sensing range

6.3 Detection range test

The test methods for triggering and maintaining the detection range of the millimeter wave sensor are introduced as follows:

- Trigger range: When the target person approaches the sensor from a distance while the millimeter wave sensor reports that there is no one , and stops moving when the sensor starts to report that there is someone , the current position is the boundary of the millimeter wave sensor's trigger detection range ; the area surrounded by the detection boundaries in all directions is the millimeter wave sensor's trigger detection range ;

- Holding range: When the millimeter wave sensor reports that there is a person, the target person keeps a small movement at the position to be detected , such as shrugging or raising the hand . If the millimeter wave sensor continues to report that there is a person within 60 seconds , the current position is within the holding detection range of the millimeter wave sensor ; otherwise , the detection position is outside the holding detection range.

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Chapter 7 Installation Instructions

7.1 Millimeter wave sensor housing requirements

If the millimeter wave sensor needs to be installed in a housing , the housing must have good wave transmission characteristics in the 24GHz frequency band and cannot contain metal or materials that have a shielding effect on electromagnetic waves. For more precautions, please refer to the " Millimeter Wave Sensor Antenna Cover Design Guide "

7.2 Installation environment requirements

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

- There are non-human objects that are constantly moving in the sensing area , such as animals , continuously swinging curtains, and large green plants facing the air vents.
- There is a large area of strong reflective plane in the sensing area , and the strong reflective object facing the antenna will cause interference.
- When wall-mounted , external interference factors such as air conditioners and electric fans on the ceiling of the room need to be considered.

7.3 Notes on installation

- Try to ensure that the antenna is facing the area to be detected and that there is an open area around the antenna without any obstructions.
- It is necessary to ensure that the installation position of the millimeter wave sensor is firm and stable ; the shaking of the sensor itself will affect the detection effect.
- Make sure that there is no movement or vibration on the back of the millimeter wave sensor. Since millimeter waves are penetrating , the antenna back lobe may detect moving objects on the back of the sensor. A metal shield or metal back plate can be used to shield the antenna back lobe to reduce the impact of objects on the back of the sensor.
- When there are multiple 24 GHz band millimeter wave sensors , do not face each other with their beams and install them as far away as possible to avoid possible mutual interference.

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7.4 Power Supply Considerations

- The power input voltage range is 3.0V~3.6V , and the power ripple has no obvious spectrum peak within 100kHz . This solution is a reference design , and users need to consider the corresponding electromagnetic compatibility design such as ESD and lightning surge.

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Chapter 8 Notes

8.1Maximum detection distance

The maximum range of the millimeter wave sensor to detect a target is 10 meters in radial distance. Within the detection range , the millimeter wave sensor will report the straight-line distance of the target from the millimeter wave sensor.

8.2 Maximum distance and accuracy

Theoretically , the ranging accuracy of the millimeter wave sensor in this reference solution is 0.35m . Due to the differences in body shape, state, and RCS of human targets , the ranging accuracy will fluctuate , and the maximum detection distance will also fluctuate to a certain extent.

8.3 Target disappearance delay time

When a person stands relaxed and looks straight ahead, the direction of sight is the normal "no one" state of the person, but there is a delay. The delayed reporting mechanism is: once no human target is detected within the test range , the millimeter wave sensor will start timing , the duration is the duration of no one , if no one is detected during the timing, then the "no one" state will be reported after the timing ends; if someone is detected during this time period, the timing will be immediately ended and updated , and the target information will be reported.

8.4 Micro motion detection range

The detection range of the millimeter wave sensor for micro-motion of the human body is inversely proportional to the angle between the normal direction of the human body and the normal direction of the sensor. Therefore, in the micro-motion detection scenario, it is recommended to adjust the position and angle of the millimeter wave sensor when installing it so that the angle between its normal direction and the normal direction of the detected human body is as small as possible , thereby improving the detection accuracy and range.

---

4 When a person stands relaxed and looks straight ahead, the direction of the line of sight is the direction of the body.

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Related Models

Product Model	Chip Solution	Package	Product size mm	Communication interface
E54-24LD12B	-	Plugins	1 8.0 * 15.0	UART/GPIO

Revision History

Version	Revision Date	Revision Notes	Maintainer
V1.0	2024-10-31	First edition	Bin

About Us

Sales hotline: 4000-330-990
Technical support: support@cdebyte.comOfficial
website: https://www.cdebyte.com
Company Address: Building B2, No. 199, Xiqu Avenue, West Hi-Tech Zone, Chengdu , Sichuan

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