UM10025
XenD106L User Manual

Rev.1.2 User Manual

Introduction

This document introduces the basic functions, hardware specifications, software configurations, and installation conditions of the ICLEGEND MICRO(ICL) battery-powered ultra-low power consumption human presence mmWave sensor, XenD106L. It aims to assist developers in quickly getting started with the XenD106L ultra-low power consumption human presence mmWave sensor, facilitating the configuration of parameters best suited to their application scenarios, and creating personalized ultra-low power consumption human sensing sensors.

Table of Contents

1. XenD106L Overview

XenD106L is a battery-powered ultra-low power consumption human presence mmWave sensor from ICL EZ Sensor series. It incorporates a highly simplified 24 GHz sensor hardware, Xen106, along with low power consumption intelligent firmware for human presence sensing.

The hardware, Xen106, is equipped with the the AIoT mmWave sensor SoC ICL1112, a high-performance 24 GHz single-transmit-single-receive antenna and peripheral circuitry. The low power consumption intelligent human sensing algorithm adopts mmWave sensor ranging technology and the advanced proprietary radar signal processing and low power consumption control technologies of the ICL1112 chip, achieving precise perception of moving/micro-moving and static sitting/lying human bodies.

The low power consumption intelligent firmware for human presence sensing is primarily applied in indoor scenarios. It senses the presence of moving or micro-moving human bodies within the detection area in low power consumption mode and refreshes the detection results in real time.

XenD106L has a maximum trigger distance of 6 m for moving human bodies. It allows for easy configuration of the sensing distance range, trigger and hold thresholds for different intervals, target human distance reporting frequency and human absence reporting time. Supporting GPIO and UART interfaces, XenD106L is plug-and-play and can be flexibly applied to various smart scenarios and end products.

The key features of XenD106L are as follows:

- Equipped with a single-chip intelligent mmWave sensor SoC and intelligent algorithm firmware.
- Compact Size: Sensor dimensions of 19 mm × 16 mm.
- Preloaded with default sensing configurations for plug-and-play use.
- Operates in the 24 GHz ISM band, compliant with FCC, CE, and SRRC.
- Supports 3.3 V power supplies, compatible with a wide voltage range of 3.0~3.6 V.
- Typical operating current as low as 56 μA with a sensing delay of 250 ms.
- Effectively detects moving, micro-moving, and stationary sitting, stationary lying humans.
- Real-time reporting of detection results.
- Provides visualization tools for flexible configuration of detection distance ranges and target disappearance delay times, supporting automatic generation of detection thresholds.
- Supports sensing range division to effectively neglect interference from outside the designated area.
- Capable of sensing from a close distance of 0.35 m, no blind zone detection.
- Maximum trigger distance of 6 m for moving human bodies.
- Wide detection angle with ±60° horizontal coverage for wall-mounted installation.
- Supports various installation methods, including ceiling and wall mounting.
- Supports IAP (In-Application Programming) online upgrade

The XenD106L battery-powered ultra-low power consumption human presence mmWave sensor can detect, recognize, and identify moving, micro-moving, stationary sitting, stationary lying humans, making it widely applicable in various AIoT scenarios, including:

- **Smart Homes**
  Senses the presence and distance of humans, reporting detection results for intelligent control of home appliances by the main control module.
- **Smart Commerce**
  Recognizes human approach or departure within set distance intervals; promptly activates screens and keeps devices illuminated in the presence of humans.
- **Smart Security**
  Used in smart door locks, access control, building intercoms, electronic peepholes, etc.
- **Smart Lighting**

  Identifies and senses humans, with precise location detection, suitable for public lighting equipment (sensor lights, bulb lights, etc.).

2. System Characteristics

The XenD106L is a battery-powered ultra-low power consumption human presence sensor developed based on ICL1112 mmWave sensor chip. The sensor employs FMCW (Frequency Modulated Continuous Wave) technology, combined with radar signal processing and built-in intelligent low power consumption human sensing algorithms, to detect human targets within a designated space and update detection results in real-time. With XenD106L, users can rapidly develop their own precise low power consumption human presence sensing products.

The hardware Xen106 mainly consists of a fully integrated ICL1112 AIoT mmWave sensor, a 24 GHz single-transmit-single-receive antenna, and a main MCU. The software component is complemented by ICL low power consumption human presence sensing firmware and a visualization tool, enabling flexible configuration of sensing distance, trigger and hold thresholds, and human absence reporting times and data refresh rate for human sensing functionality. It also supports spatial echo energy scanning to automatically determine detection thresholds.

The specifications and parameters of XenD106L are shown in Table 2-1.

Table 2-1 XenD106L characteristics

Parameter	Min.	Typ.	Max.	Unit	Description
Hardware Xen106 Characteristics					
Supporting frequency	24	-	24.25	GHz	FCC, CE, and SRRC compliant
Sweeping bandwidth	-	0.25	-	GHz	
Max. EIRP	-	10	-	dBm	-
Power supply	3.0	3.3	3.6	V	-
Size	-	19 × 16	-	mm^2	-
Environment temperature	-40	-	85	°C	-
XenD106L System Characteristics					
Distance detection range(Wall-mounted, 1.5 m installation height)	-	6	-	m	Detection for moving human Target
		5		m	Detection for micro-moving human target
	-	4	-	m	Detection for motionless human target
Typical Operating Current	-	56	-	μA	
Sensing delay time	-	250	-	ms	-
Data report cycle	-	1	-	s	Configurable

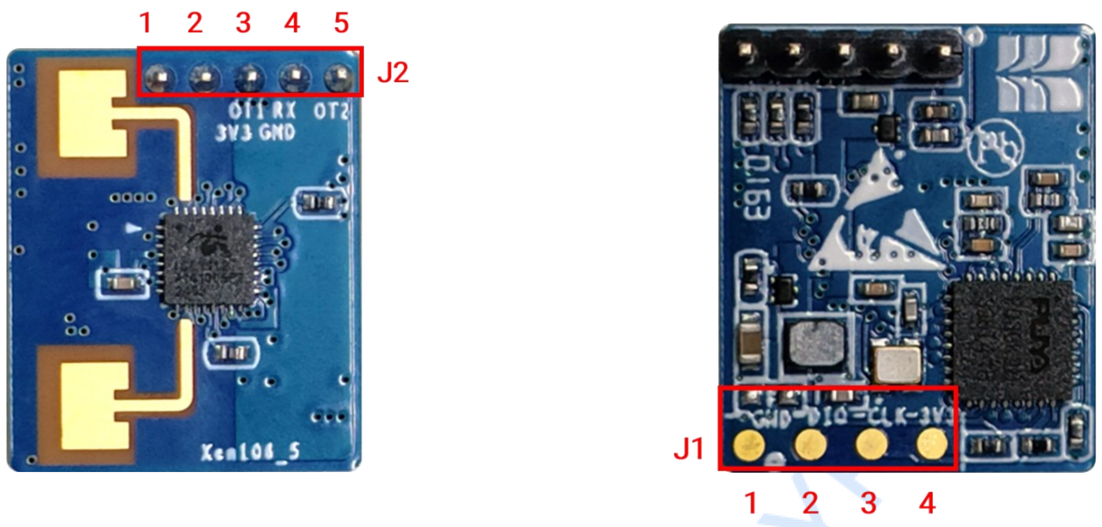
3. Hardware Overview

This chapter introduces the hardware Xen106 and its two matching power supply boards.

3.1 Hardware Xen106

Figure 3-1shows the top and bottom photos of the hardware Xen106. The hardware Xen106 reserves 5 pin holes (without pins provided at the factory) labeled as J2[1], which are used for power supply and communication. J1 is the SWD interface, used for MCU program burning and debugging.

[1] Note: J2 is a pin header socket with 2 mm pitch.



(a) Top (b) Bottom

Figure 3-1 XenD106L device map

Details of J1 and J2 pins are listed in Table 3-1 and Table 3-2.

Table 3-1 J1 pin description

J#PIN#	Name	Function	Operating Range
J1Pin1	GND	Ground	-
J1Pin2	DIO	SWD data	0 ~ 3.3 V
J1Pin3	CLK	SWD clock	0 ~ 3.3 V
J1Pin4	3V3	Power input	3.0 V ~ 3.6 V, Typ. 3.3 V

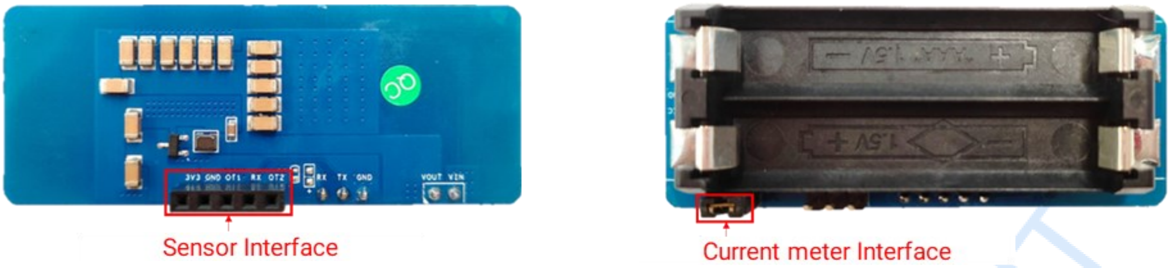
Table 3-2 J2 pin description

J#PIN#	Name	Function	Operating Range
J2Pin1	3V3	Power input	3.0 V ~ 3.6 V, Typ. 3.3 V
J2Pin2	GND	Ground	-
J2Pin3	OT1	UART_TX	0 ~ 3.3 V
J2Pin4	RX	UART_RX	0 ~ 3.3 V
J2Pin5	OT2	IO, for reporting detection status: High level indicates the presence of human, while low level indicates no human.	0 ~ 3.3 V

XenD106L supports programming hex files or source code projects using the Keil 5 IDE. Programs can be downloaded using programmers such as J-Link (version V9 or above) or CMSIS-DAP. Before programming, please ensure that the Puya.PY32F0xx_DFP.1.2.0.pack has been installed.

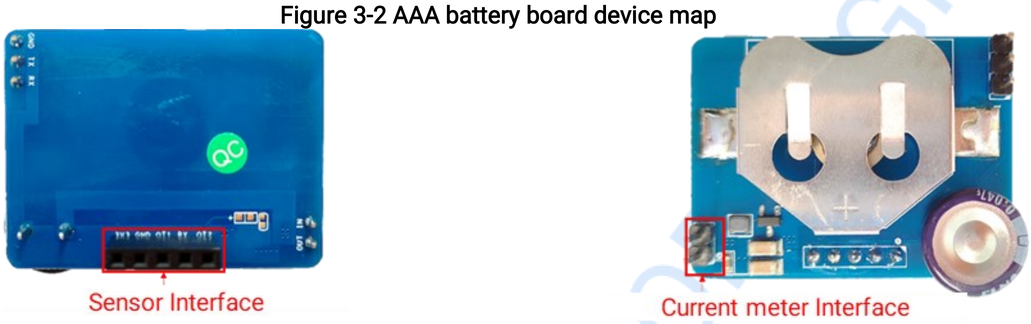
3.2 Matching Battery Board

XenD106L is equipped with dedicated battery boards to provide current testing functionality. Developers can measure the operating current of the mmWave sensor in real time using a high-precision multimeter or ammeter. Figure 3-2 and Figure 3-3 show the physical photos of the battery boards powered by AAA batteries and CR2450 coin cells, respectively. The jumper shunt on the back of the battery board serves as the current test interface, and developers need to connect the ammeter in series with the circuit when measuring the current.



(a) Top (b) Bottom

Figure 3-2 AAA battery board device map



(a) Top (b) Bottom

Figure 3-3 Button battery board device map

4. Visualization Tool

This chapter introduces the firmware debugging of XenD106L and the usage of the visualization tool. For debugging or using the mmWave sensor, power can be supplied via a USB-to-serial adapter board, with the sensor's TX, RX and GND pins connected to the corresponding pins of the adapter board (see Table 4-1 for the pin correspondence when connecting the sensor to the serial port adapter). Alternatively, power can be supplied by a battery board, with the battery board's TX, RX and GND pins connected to the corresponding pins of the USB-to-serial adapter board (the TX, RX and GND pins of the battery board are connected to the homonymous pins of the sensor). Since the connection methods for the two power supply modes are similar, this chapter only introduces the method using power supply from the host computer.

XenD106L is pre-programmed with the low power consumption firmware for human presence sensing at the factory, and the firmware version is detailed on the sensor's outer packaging. ICL provides a visualization configuration tool for the hardware Xen106, allowing developers to configure the parameters of XenD106L according to application scenarios and optimize the sensing effect.

4.1 Firmware Configuration

This section introduces how to use a third-party serial port tool to debug the firmware of the XenD106L sensor.

Step 1: Connect the host computer and the mmWave sensor through a USB-to-TTL serial port adapter board. The pin connections are shown in Table 4-1and Figure 4-1.

Table 4-1 Pin correspondence when connecting the sensor to USB serial port adapter

Sensor Pin Name	Serial Port Pin Name
RX	TXD
OT1	RXD
GND	GND
3V3	VCCIO

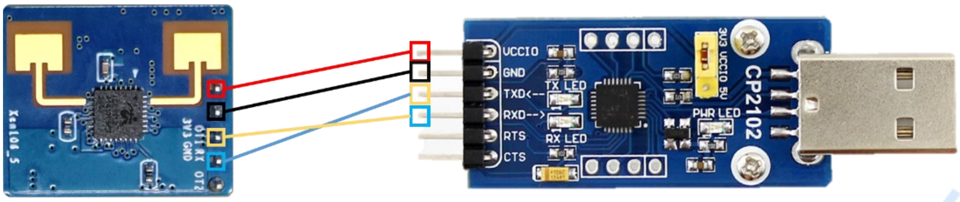


Figure 4-1 Connection of Xen106 and USB serial port tool

Step 2: Open the Device Manager on the host computer to check the serial port number of the mmWave sensor.

Step 3: Open the third-party serial port tool, select the serial port number of the mmWave sensor, set the serial port baud rate to 115200, and then click the "Open Serial Port" (or similar function) button to view the current detection results of the mmWave sensor in the output section of the tool interface.

4.2 Visualization Tool Instructions

This section introduces the use of the visualization tool that accompanies the XenD106L mmWave sensor to help users understand the meanings of relevant parameters and the methods for obtaining them.

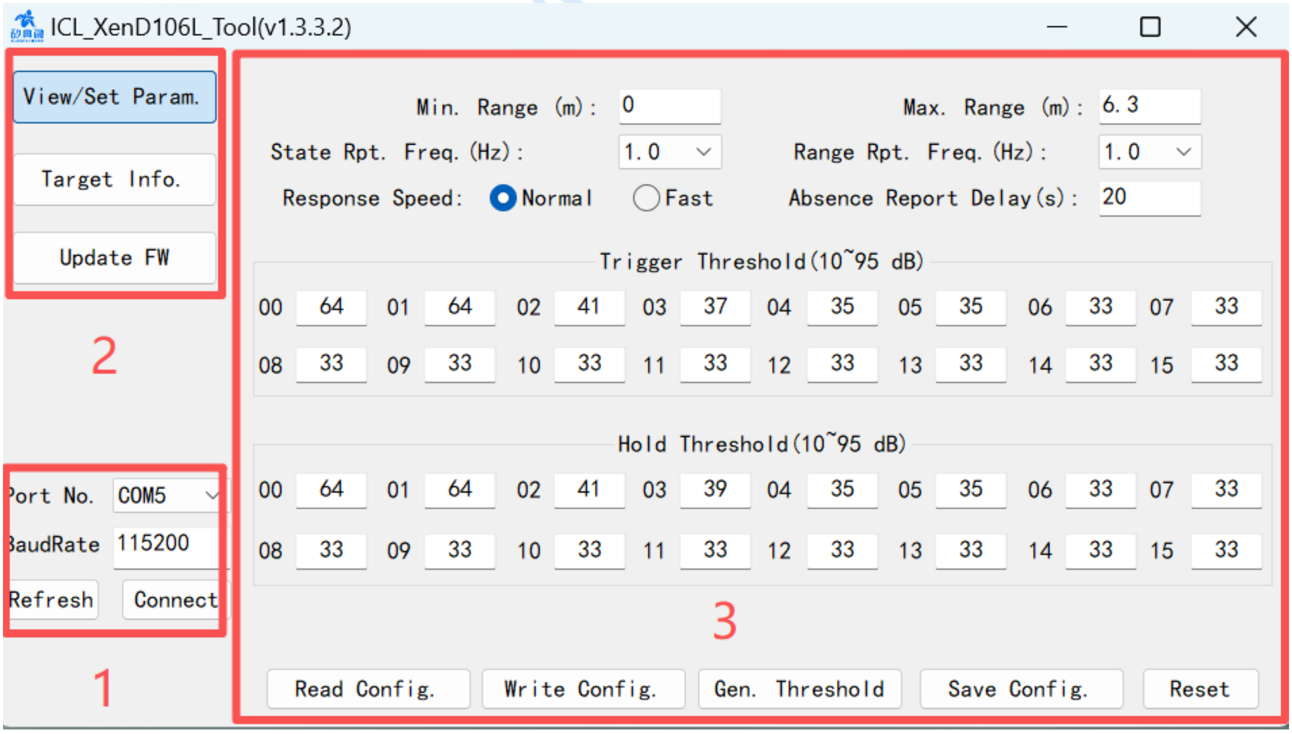
Note: The visualization tool and the third-party serial port tool cannot be used simultaneously!

Before using the various functions of the visualization tool, users should first connect the XenD106L to the host computer, following these steps:

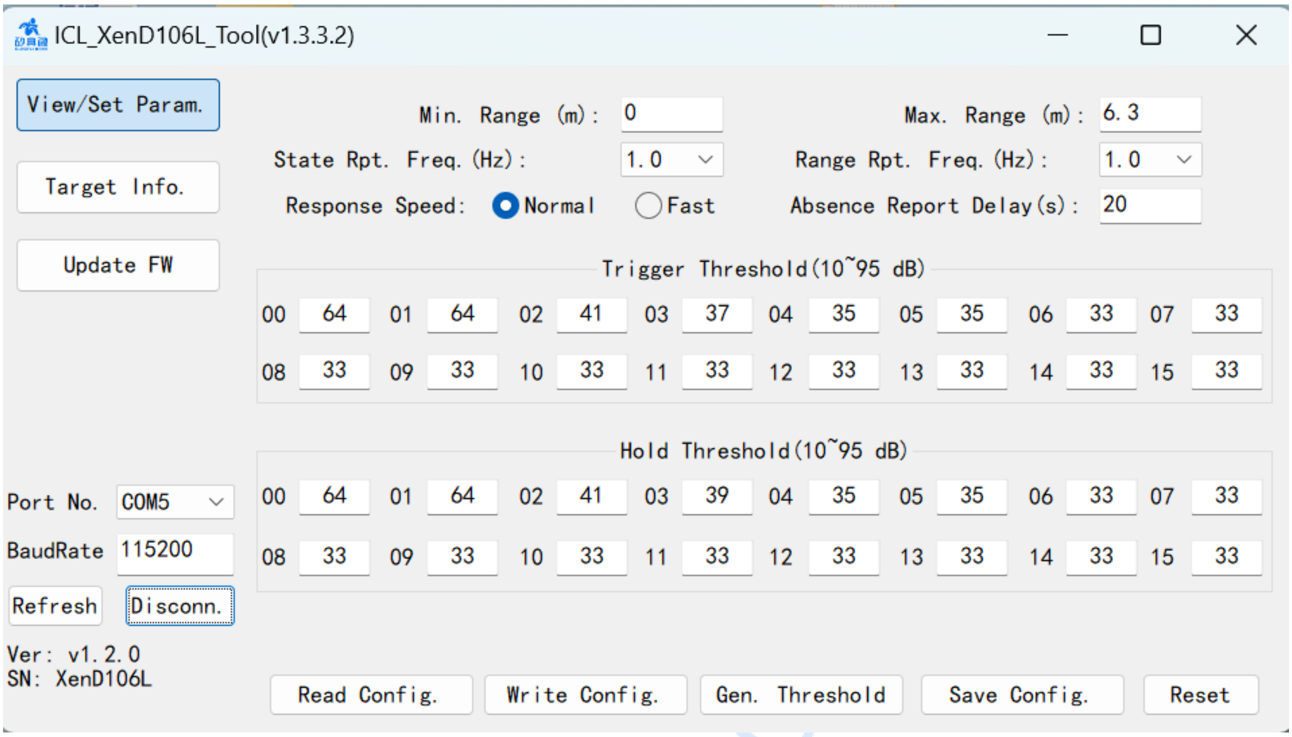
Step 1: Obtain the "ICL_XenD106L_Tool" from the ICL official website, which is released together with the XenD106L.

Step 2: Connect the mmWave sensor and the host computer using a serial port adapter board as shown in Figure 4-1.

Step 3: Open the visualization tool, click the **"Refresh"** button, select the serial port number of the mmWave sensor in the **"Port No."** dropdown box, confirm that the **"BaudRate"** is 115200, and then click the **"Connect"** button to start connecting the host computer to the mmWave sensor.



(a) Before connecting to sensor



(b) After connecting to sensor

Figure 4-2 ICL_XenD106L_Tool

As shown in Figure 4-2(a), the the visualization tool interface can be divided into three zones: Zone 1 for device operation, Zone 2 for functional buttons, and Zone 3 for functional pages.

Upon successful connection between the visualization tool and the sensor, the firmware version number (formatted as "**Ver: …**") and serial number (formatted as "**SN: …**"; the default SN of the sensor is XenD106L) of the sensor will be displayed in Zone 1. The functional page area for " **View/Set Param.**" displays the current parameter values of the sensor, as shown in Figure 4-2(b).

4.2.1 View/Set Parameters

The **View/Set Param.** page of the visualization tool is shown in Figure 4-2, it displays the parameter values of the mmWave sensor and allows users to modify each parameter for actual scenarios and generate automatic detection thresholds.

Descriptions of the parameters on the GUI are listed in Table 4-2.

Table 4-2 Descriptions of parameters on GUI

Parameter	Description	Range	Unit
Min. Range	For setting the minimum valid detection range of the mmWave sensor.	0~8.4	m
Max. Range	For setting the maximum valid detection range of the mmWave sensor.	0.7~8.4	m
State Rpt. Freq.	Frequency of the sensor reporting human presence/absence status	1~8	Hz
Range Rpt. Freq.	Frequency of the sensor reporting target distance when a human is present	1~8	Hz
Response Speed	Response speed of the sensor from human absence to presence in the detection area	Normal / Fast	-

Absence Report Delay	Delay time for the sensor to switch the reported target status from human present to human absent	10~120	s
Trigger Threshold	Absolute energy threshold of 0~15 range bins when switching from human absence to presence	10~95	dB
Hold Threshold	Absolute energy threshold of 0~15 range bins for detecting stationary humans and maintaining human presence status	10~95	dB

4.2.1.1 Parameter Configuration

Parameter configuration operations include Read Configuration, Write Configuration, Reset Configuration and Save Configuration, with their operation steps described as follows:

Read Configuration

After connecting the XenD106L with the visualization tool, in the View/Set Param.function buttons zone, click **"Read Config"** button, a window writing **"Succeed reading parameters**" will appear, and the function page will display the parameters of the mmWave sensor, click "**OK"** to close the prompt window.

Write Configuration

Step 1: After connecting the XenD106L with the visualization tool, type in the new values for desired parameters;

Step 2: Click "**Write Config"** button, the visualization tool will send all the new values to the mmWave sensor, and a prompt window writing **"Succeed setting parameters"** will appear, click "**OK"** button to finish the process.

Reset Configuration

Step 1: After connecting the XenD106L with the visualization tool, click the "**Reset"** button on the View/Set Parameters page. the visualization tool will reset all configuration parameters to their default values.

Step 2: Click the Write Config button to complete the parameter reset. A prompt window "**Succeed setting parameters"** will appear, click **"OK"** button to finish the process, and the visualization tool will display the latest parameters.

Save Configuration

Step 1: After connecting the XenD106L with the visualization tool, click the "**Save Config"** button on the View/Set Parameters page. the visualization tool will save the current parameter configuration to the **appConfig.xml** file in the same directory as the application program.

Step 2: When the visualization tool is closed and reopened, it will read the configuration information from the xml file and display it on the View/Set Parameters page.

4.2.1.2 Auto Threshold Generation

The steps for generating automatic thresholds using the visualization tool are as follows:

Step 1: After connecting the XenD106L with the visualization tool, click the "**Gen. Thresholds**" button on the "**View/Set Param.** "page; a Threshold Generation window as shown in Figure 4-3 Threshold Generation Dialog will pop up.

Step 2: Enter the trigger/hold threshold generation coefficients and scan duration. Two scan duration options are available: 30s and 120s. Select 30s if the scanning environment is complex and maintaining absence of personnel for an extended period is impractical; otherwise, select 120s. Click the "**Start"** button to begin threshold generation. The progress bar at the bottom of the window displays the generation progress in real time. Ensure no personnel are present in the detection range throughout the entire threshold generation process.

Step 3: A text prompt "**Threshold Generation Succeeded**" will be displayed at the bottom left of the window upon completion. After closing the **“Threshold Generation”** window, the generated automatic thresholds can be viewed in the trigger/hold threshold area on the View/Set Parameters page.

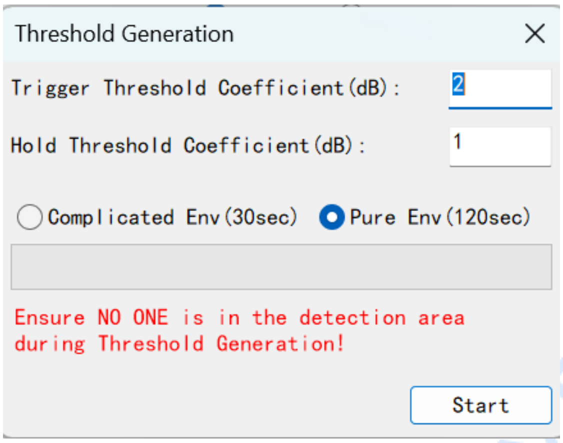


Figure 4-3 Threshold Generation Dialog

4.2.2 Target Information

The “**Target Info.”** page of the visualization tool displays human presence detection results and real-time data, and provides operations for saving millimeter-wave sensor detection data.

As shown in Figure 4-4, the “**Target Info.** “page is divided into five functional areas:

- a: Target Result Display Area
- b: Function Button Area
- c: Real-Time Energy Value Display Area
- d: Real-Time Distance/Status Information Display Area
- e: Data Save Operation Area

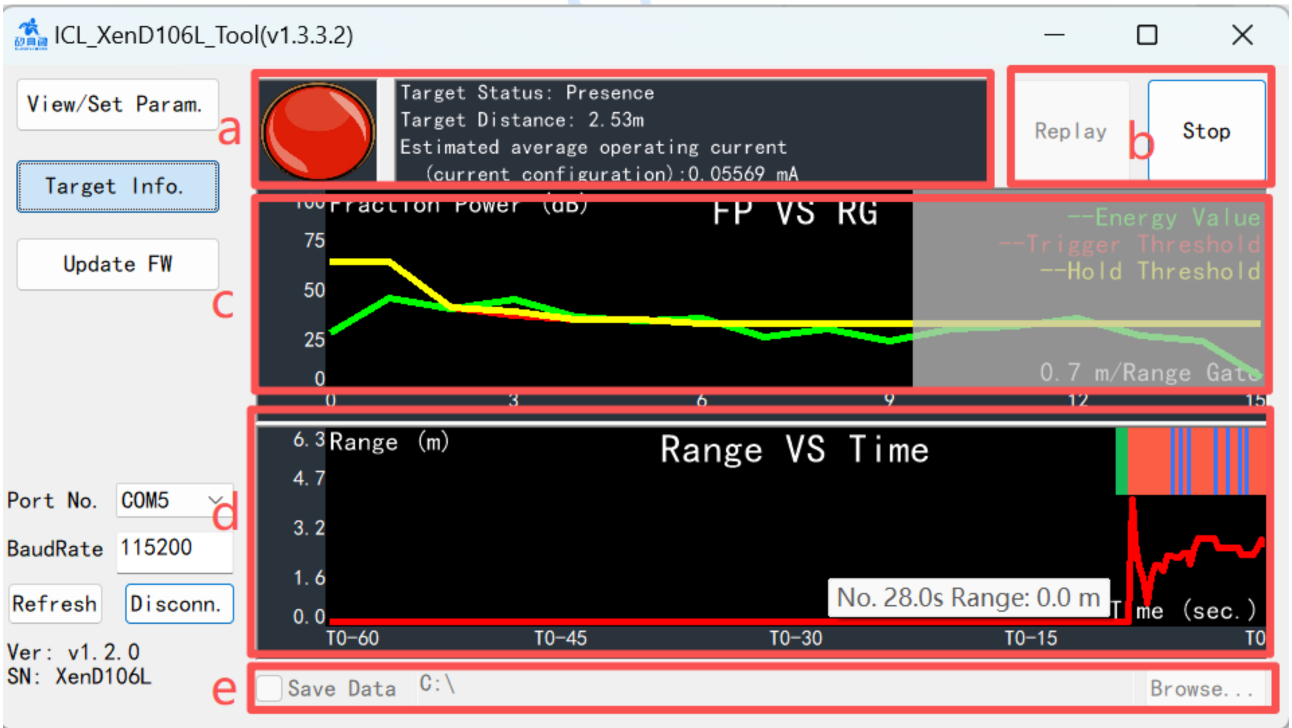


Figure 4-4 The Target Info. Page of the visualization Tool

The functional areas of the Target Information page are described in Table 4-3:

Table 4-3 Description of each zone on Realtime Data page

Zone		Function	Description
a	Light icon	The color of the light icon represents human target motion/micro-motion/ absence status in the detection area.	Green: no human Red: human present Blue: human stationary, accompanied by "heart" icon
	Target Information Text Box	Displays detected target information.	Displays the presence/ absence of human targets and their motion status, the linear distance (m) between the human body and the sensor, and the estimated average operating current (mA) in the current state
b	"Replay/Stop"Toggle Button	Replays or stops displaying specified detection data.	This button is clickable when the "Start/Stop" toggle button displays "Start"; otherwise, the button is grayed out and disabled.
	"Start/Stop" Toggle Button	Enables or pauses human presence detection.	-
c	"FP vs. RG" Real-Time Detection Data Display	Displays real-time energy values and threshold information for each distance gate within the detection range.	-
d	"Range vs. Time" Real-Time Detection Data Display	Displays presence/absence information detected by the sensor within the last 60 seconds, and range information of detected human targets.	The colored progress bar above the coordinate displays real-time presence/ absence status in the detection area: green indicates no human, red indicates human present, blue indicates human present and stationary. The red curve below the coordinate graph displays the historical linear distance data between the target and the sensor within the last 60 s.
e	Save Data	Allows users to select whether to save detection data and configure the save path.	This area is operable only when the "Start/Stop" button in area b displays "Start". After selecting the "Save Data" option, click the "Browse…" button to choose a custom save path; if no path is selected, detection data is saved to the directory where the visualization software is located.

The **"Target Info."** page supports users to view, save, and replay detection data, with the corresponding operation steps described as follows:

View Detection Data

Step 1: After connecting the XenD106L with the visualization tool, click the "**Target Info."** button to switch to this function page; the visualization tool will automatically enable the detection function of the mmWave sensor (the "**Start/Stop"** toggle button displays **Stop**), and Zones a, c and d will start displaying the corresponding target information in real time.

Step 2: Click the "**Start/Stop"** toggle button again to pause the detection of the mmWave sensor.

Save Detection Data

Step 1: After connecting the XenD106L with the visualization tool, click the" **Target Info."** button to switch to this function page; the visualization tool will automatically enable the detection function of the mmWave sensor .

Step 2: Click the "**Start/Stop"** toggle button to stop the detection function of the sensor; the data saving function controls in Zone e will become accessible.

Step 3: Check the check box before **"Save Data"** to enable the data saving function.

Step 4: (Optional) Click the **Browse…** button to select a path for saving the detection data..

Step 5: Click the "**Start/Stop**" toggle button to restart the detection function of the sensor. After the detection is completed, users can view the saved detection data in the path set in Step 4; if no path is set, the detection data will be saved to the **Save Data** directory in the same directory as the application program by default.

Replay Detection Data

Step 1: After connecting the XenD106L with the visualization tool, click the "**Target Info.**" button to switch to this function page; the visualization tool will automatically enable the detection function of the mmWave sensor .

Step 2: Click the "**Start/Stop**" toggle button to stop the detection function of the sensor; the "**Replay/Stop**" button will become clickable.

Step 3: Click the "**Replay /Stop**" button and select the path where the detection data to be played back is located. After completion, the function page of the visualization tool will start playing the detection data, and the text on the "**Replay /Stop**" button will switch to "**Stop**".

Step 4: (Optional) Click the "**Replay /Stop**" toggle button to stop data playback; users can also wait for the replay process to complete before performing other operations.

4.2.3 Update Firmware

The "**Update FW**" page of the visualization tool is shown in Figure 4-5, with its operation steps as follows:

Step 1: After connecting the XenD106L with the visualization tool, click the "**Update Fw.** "function button to switch to this function page.

Step 2: Click the "**Obtain Firmware Info.**" button; the current device ID information and firmware information will be displayed in the prompt information below and to the right of the button.

Step 3: Click the "**Choose bin File Path**" button to select the required .bin file.

Step 4: Click the "**Flash**" button to start updating the firmware; the prompt information box on the right will display the download result in real time, and the bin file information and current download progress will be displayed at the bottom.

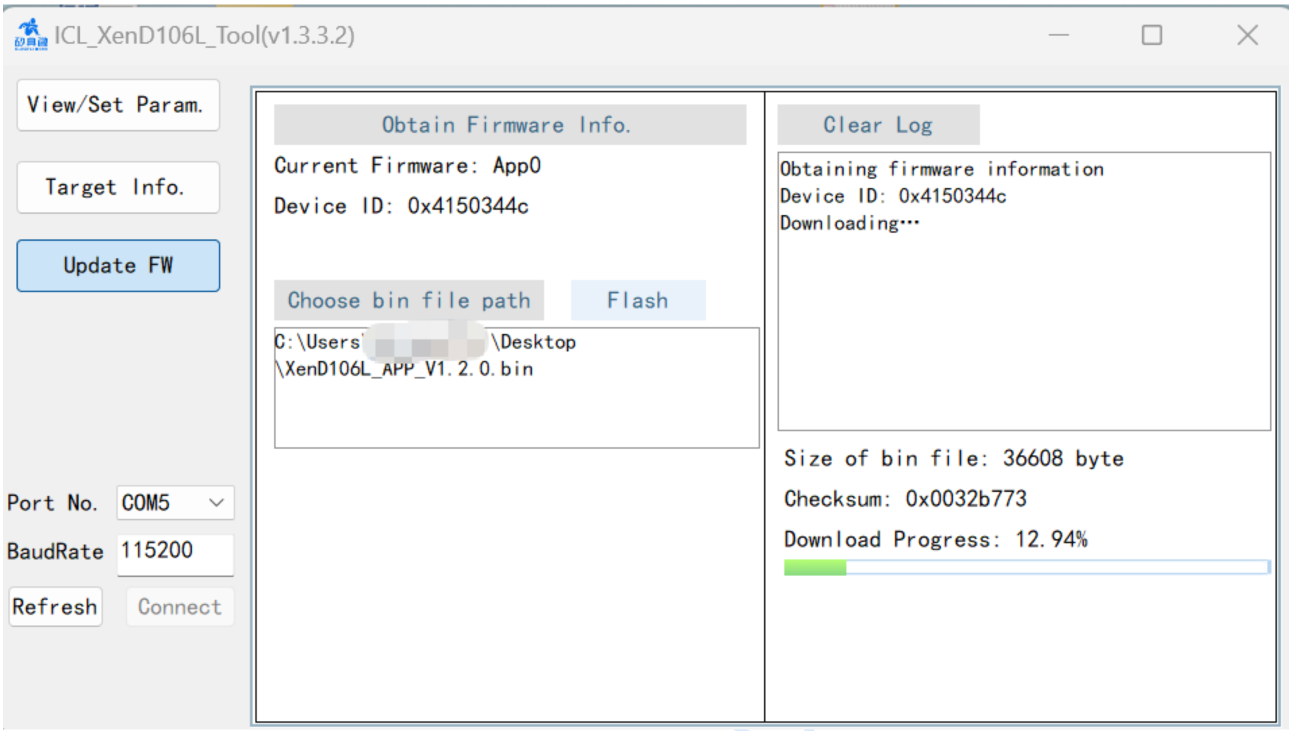


Figure 4-5 Firmware Upgrade Page of the visualization Tool

A prompt **Download Successful!** will be displayed in the page prompt information box upon successful firmware upgrade. Corresponding error information will be displayed in the prompt information box if the firmware upgrade fails.

5. Communication Protocol

This communication protocol is mainly for users who need to conduct further development without the visualization tool. he XenD106L battery-powered ultra-low power consumption human presence mmWave sensor communicates with the outside via the serial port (TTL level). Both the data output and parameter configuration follow this protocol. The default serial port baud rate is 115200, with 1 stop bit and no parity bit.

Steps for using commands to configure the mmWave sensor are as follows:

1. Enter command mode;
2. Send the command for configuring/reading the parameter;
3. Exit command mode.

XenD106L adopts MSB for data communication, and all the data in the tables of the following sections are hexadecimal.

5.1 Report Data Format

Table 5-1 shows the format of the sensor's report data. XenD106L supports three types of report data formats: Lite Data Report Format, Standard Data Report Format and Auto-Threshold Progress Report Format. The sensor defaults to the Lite Data format; the Standard Data format is used when paired with the visualization tools; the Auto-Threshold Progress format is used exclusively during auto-threshold generation.

Table 5-1 Report Data Format

Lite Data	Header	Target Status	Target Range	Trailer
	6E	1 byte(0/1 = Unoccupied; 2/3 = Occupied)	2 bytes(Unit: cm)	62

Standard Data	Header	In-Frame Data Length	Data Type	Target Status	Target Range	Reserved Bits	RG Energy Value	Trailer
	F4 F3 F2 F1	2 bytes	0x01	1 byte (0/1=Unoccupied 2/3 = Occupied)	2 bytes (Unit: cm)	2 bytes	64 bytes	F8 F7 F6 F5
Auto-Threshold Progress	Header	In-Frame Data Length	Data Type	Threshold Generation Progress				Trailer
	F4 F3 F2 F1	2 bytes	0x03	2 bytes: Progress × 100				F8 F7 F6 F5

5.2 Command and ACK

5.2.1 Read Firmware Version Command

This command reads the mmWave sensor firmware version number.

Command word: 0x0000

Command value: NA

Return value: major version number (2 bytes) + Minor version number (2 bytes) + Patch version number (2 bytes)

Sending data:

Header	Intra-frame Data Length	Command Word	Trailer
FD FC FB FA	02 00	00 00	04 03 02 01

ACK (Succeed):

Header	Intra-frame Data Length	Command Word	Major ver.	Minor ver.	Patch Ver.	Trailer
FD FC FB FA	08 00	00 01	0x[2] 00	0x 00	0x 00	04 03 02 01

5.2.2 Enable Configuration Command

This command enables the mmWave sensor to enter configuration mode. All the other commands should be sent after this command, otherwise the command will be invalid.

Command word: 0x00FF

Command value: 0x0001

Return value: 2 bytes protocol version number (0x0001)

Sending data:

Header	Intra-frame Data Length	Command Word	Command Value	Trailer
FD FC FB FA	04 00	FF 00	01 00	04 03 02 01

ACK(Succeed):

Header	Intra-frame Data Length	Command Word	ACK	Protocol Ver.	Buffer Size	Trailer
FD FC FB FA	08 00	FF 01	00 00	03 00	80 00	04 03 02 01

5.2.3 End Configuration Command

This command enables the mmWave sensor to exit configuration mode. After successfully conducting this command, the mmWave sensor will return to normal working mode. If another mmWave sensor command

[2] Note: In this table, X denotes the version number.

needs to be conducted, an Enable Configuration Command needs to be sent beforehand.

Command word: 0x00FE

Command value: NA

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

Sending data:

Header	Intra-frame Data Length	Command Word	Trailer
FD FC FB FA	02 00	FE 00	04 03 02 01

ACK(Succeed):

Header	Intra-frame Data Length	Command Word	ACK	Trailer
FD FC FB FA	04 00	FE 01	00 00	04 03 02 01

5.2.4 Write Serial Number Command

This command writes the serial number into the mmWave sensor.

Command word: 0x0010

Command value: Length of SN (2 bytes) + SN (8 bytes)

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

Sending data (Example: SN = 12345678):

Header	Intra-frame Data Length	Command Word	Length of SN	SN	Trailer
FD FC FB FA	0C 00	10 00	08 00	31 32 33 34 35 36 37 38	04 03 02 01

ACK(Succeed):

Header	Intra-frame Data Length	Command Word	ACK	Trailer
FD FC FB FA	04 00	10 01	00 00	04 03 02 01

5.2.5 Read Serial Number Command

This command reads the serial number of the mmWave sensor.

Command word: 0x0011

Command value: NA

Return value: 2 bytes ACK status (0 for success, 1 for failure)+ Length of SN (2 bytes) + SN (8 bytes)

Sending data:

Header	Intra-frame Data Length	Command Word	Trailer
FD FC FB FA	02 00	11 00	04 03 02 01

ACK(Succeed, the SN here is an example):

Header	Intra-frame Data Length	Command Word	ACK	Length of SN	SN	Trailer
FD FC FB FA	0E 00	11 01	00 00	08 00	31 32 33 34 35 36 37 38	04 03 02 01

5.2.6 Write General Parameters Command

This command sets the general parameters of the sensor.

Command word: 0x7000

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

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

Sending data (Example: Max Range Gate[3]= 12; Min Range Gate = 0; Absence Report Delay (s) = 40; Status Rpt. Freq.[4]= 1Hz; Range Rpt. Freq. = 1Hz; Response Speed = Normal):

Header	Intra-frame Data Length	Command Word	Max Range Gate	Min Range Gate
FD FC FB FA	26 00	70 00	05 00 0C 00 00 00	0A 00 00 00 00 00
Absence Report Delay (s)	**Status Rpt. Freq.**	**Range Rpt. Freq.**	**Response Speed**	**Trailer**
06 00 28 00 00 00	02 00 0A 00 00 00	0C 00 0A 00 00 00	0B 00 0A 00 00 00	04 03 02 01

ACK(Succeed):

Header	Intra-frame Data Length	Command Word	ACK	Trailer
FD FC FB FA	04 00	70 01	00 00	04 03 02 01

The definitions of parameter IDs and value ranges for general parameters are shown in Table 5-2.

Table 5-2 Parameter Identifier Definitions and Value Range Encodings

Parameter	Parameter ID	Range of Parameter Value	Unit
Max Range Gate	05	1~16	-
Min Range Gate	0A	0~16	-
Absence Report Delay	06	10 ~ 120	s
Status Rpt. Freq.	02	1 ~ 8 (1 step)	Hz
Range Rpt. Freq.	0C	1 ~ 8 (1 step)	Hz
Response Speed	0B	10(Norma)/ 20(Fast)	-

5.2.7 Read General Parameters Command

This command reads the configuration parameters of the sensor.

Command word: 0x7100

Command value: (2 bytes parameter ID) * N

Return value: (4 bytes parameter value) * N

Sending data:

Header	Intra-frame Data Length	Command Word	Max Range Gate	Min Range Gate
FD FC FB FA	0E 00	71 00	05 00	0A 00
Absence Report Delay (s)	**Status Rpt. Freq.**	**Range Rpt. Freq.**	**Response Speed**	**Trailer**
06 00	02 00	0C 00	0B 00	04 03 02 01

ACK(Succeed, Example: Max Range Gate=12; Min Range Gate = 0; Absence Report Delay(s)= 40; Status Rpt. Freq.= 1Hz; Range Rpt. Freq.= 1Hz; Response Speed = Normal):

Header	Intra-frame Data Length	Command Word	ACK	Max Range Gate	Min Range Gate
FD FC FB FA	1A 00	71 01	00 00	0C 00 00 00	00 00 00 00
Absence Report Delay (s)	**Status Rpt. Freq.**	**Range Rpt. Freq.**		**Response Speed**	**Trailer**
28 00 00 00	0A 00 00 00	0A 00 00 00		0A 00 00 00	04 03 02 01

[3] One range gate unit corresponds to 0.7 m.

[4] In this protocol, the parameter value for the state/range reporting frequency is the corresponding frequency×10.

5.2.8 Write Trigger Threshold Parameters Command

This command configures the trigger threshold parameters of 0~15 range gate of the sensor.

Command word: 0x7200

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

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

Sending data (Example：Trigger Threshold = [50, 46, 34, 32, 32, 32, 32, 32, 50, 46, 34, 32, 32, 32, 32, 32]):

Header	In-frame Data Length	Command Word	Range Gate 0 Hold Threshold	Range Gate 1 Hold Threshold	Range Gate 2 Hold Threshold	Range Gate 3 Hold Threshold
FD FC FB FA	62 00	72 00	00 00 32 00 00 00	01 00 2E 00 00 00	02 00 2E 00 00 00	03 00 20 00 00 00
Range Gate 4 Hold Threshold	Range Gate 5 Hold Threshold	Range Gate 6 Hold Threshold	Range Gate 7 Hold Threshold	Range Gate 8 Hold Threshold	Range Gate 9 Hold Threshold	Range Gate 10 Hold Threshold
04 00 20 00 00 00	05 00 20 00 00 00	06 00 20 00 00 00	07 00 20 00 00 00	08 00 32 00 00 00	09 00 2E 00 00 00	0A 00 20 00 00 00
Range Gate 11 Hold Threshold	Range Gate 12 Hold Threshold	Range Gate 13 Hold Threshold	Range Gate 14 Hold Threshold	Range Gate 15 Hold Threshold	Trailer	
0B 00 1E 00 00 00	0C 00 1E 00 00 00	0D 00 1E 00 00 00	0E 00 1E 00 00 00	0F 00 1E 00 00 00	04 03 02 01	

ACK (Succeed):

Header	Intra-frame Data Length	Command Word	ACK	Trailer
FD FC FB FA	04 00	72 01	00 00	04 03 02 01

5.2.9 Read Trigger Threshold Parameters Command

This command reads the trigger threshold parameters of 0~15 range bins of the sensor.

Command word: 0x7300

Command value: (2 bytes parameter ID) * N

Return value: (4 bytes parameter value) * N

Sending data:

Header	In-frame Data Length	Command Word	Range Gate 0 Hold Threshold	Range Gate 1 Hold Threshold	Range Gate 2 Hold Threshold	Range Gate 3 Hold Threshold
FD FC FB FA	62 00	72 00	00 00 32 00 00 00	01 00 2E 00 00 00	02 00 2E 00 00 00	03 00 20 00 00 00
Range Gate 4 Hold Threshold	Range Gate 5 Hold Threshold	Range Gate 6 Hold Threshold	Range Gate 7 Hold Threshold	Range Gate 8 Hold Threshold	Range Gate 9 Hold Threshold	Range Gate 10 Hold Threshold
04 00 20 00 00 00	05 00 20 00 00 00	06 00 20 00 00 00	07 00 20 00 00 00	08 00 32 00 00 00	09 00 2E 00 00 00	0A 00 20 00 00 00
Range Gate 11 Hold Threshold	Range Gate 12 Hold Threshold	Range Gate 13 Hold Threshold	Range Gate 14 Hold Threshold	Range Gate 15 Hold Threshold	Trailer	
0B 00 1E 00 00 00	0C 00 1E 00 00 00	0D 00 1E 00 00 00	0E 00 1E 00 00 00	0F 00 1E 00 00 00	04 03 02 01	

ACK (Succeed, Example：Trigger Threshold = [50, 46, 34, 32, 32, 32, 32, 32, 50, 46, 34, 32, 32, 32, 32, 32]):

Header	In-frame Data Length	Command Word	ACK	Range Gate 0 Hold Threshold	Range Gate 1 Hold Threshold	Range Gate 2 Hold Threshold
FD FC FB FA	44 00	73 01	00 00	32 00 00 00	2E 00 00 00	22 00 00 00
Range Gate 3 Hold Threshold	Range Gate 4 Hold Threshold	Range Gate 5 Hold Threshold	Range Gate 6 Hold Threshold	Range Gate 7 Hold Threshold	Range Gate 8 Hold Threshold	Range Gate 9 Hold Threshold
20 00 00 00	20 00 00 00	20 00 00 00	20 00 00 00	20 00 00 00	32 00 00 00	2E 00 00 00
Range Gate 10 Hold Threshold	Range Gate 11 Hold Threshold	Range Gate 12 Hold Threshold	Range Gate 13 Hold Threshold	Range Gate 14 Hold Threshold	Range Gate 15 Hold Threshold	Trailer
20 00 00 00	1E 00 00 00	1E 00 00 00	1E 00 00 00	1E 00 00 00	1E 00 00 00	04 03 02 01

5.2.10 Write Hold Threshold Command

his command writes the hold threshold parameters of 0~15 range bins of the sensor.

Command word: 0x7600

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

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

Sending data (Example: Trigger Threshold = [15, 15, 15, 15, 15, 15, 15, 15, 09, 09, 09, 09, 09, 09, 09, 09]):

Header	In-frame Data Length	Command Word	Range Gate 0 Hold Threshold	Range Gate 1 Hold Threshold	Range Gate 2 Hold Threshold	Range Gate 3 Hold Threshold
FD FC FB FA	62 00	76 00	00 00 0F 00 00 00	01 00 0F 00 00 00	02 00 0F 00 00 00	03 00 0F 00 00 00
Range Gate 4 Hold Threshold	Range Gate 5 Hold Threshold	Range Gate 6 Hold Threshold	Range Gate 7 Hold Threshold	Range Gate 8 Hold Threshold	Range Gate 9 Hold Threshold	Range Gate 10 Hold Threshold
04 00 0F 00 00 00	05 00 0F 00 00 00	06 00 0F 00 00 00	07 00 0F 00 00 00	08 00 09 00 00 00	09 00 09 00 00 00	0A 00 09 00 00 00
Range Gate 11 Hold Threshold	Range Gate 12 Hold Threshold	Range Gate 13 Hold Threshold	Range Gate 14 Hold Threshold	Range Gate 15 Hold Threshold	Trailer	
0B 00 09 00 00 00	0C 00 09 00 00 00	0D 00 09 00 00 00	0E 00 09 00 00 00	0F 00 09 00 00 00	04 03 02 01	

ACK(Succeed):

Header	Intra-frame Data Length	Command Word	ACK	Trailer
FD FC FB FA	04 00	76 01	00 00	04 03 02 01

5.2.11 Read Hold Threshold Parameters Command

This command reads the hold threshold parameters of 0~15 range bins of the sensor.

Command word: 0x7700

Command value: (2 bytes parameter ID) * N

Return value: (4 bytes parameter value) * N

Sending data:

Header	In-frame Data Length	Command Word	Range Gate 0 Hold Threshold	Range Gate 1 Hold Threshold	Range Gate 2 Hold Threshold	Range Gate 3 Hold Threshold
FD FC FB FA	22 00	77 00	00 00	01 00	02 00	03 00
Range Gate 4 Hold Threshold	Range Gate 5 Hold Threshold	Range Gate 6 Hold Threshold	Range Gate 7 Hold Threshold	Range Gate 8 Hold Threshold	Range Gate 9 Hold Threshold	Range Gate 10 Hold Threshold
04 00	05 00	06 00	07 00	08 00	09 00	0A 00
Range Gate 11 Hold Threshold	Range Gate 12 Hold Threshold	Range Gate 13 Hold Threshold	Range Gate 14 Hold Threshold	Range Gate 15 Hold Threshold	Trailer	
0B 00	0C 00	0D 00	0E 00	0F 00	04 03 02 01	

ACK(Succeed, Example: Trigger Threshold = [15, 15, 15, 15, 15, 15, 15, 15, 09, 09, 09, 09, 09, 09, 09, 09]):

Header	In-frame Data Length	Command Word	ACK	Range Gate 0 Hold Threshold	Range Gate 1 Hold Threshold	Range Gate 2 Hold Threshold
FD FC FB FA	44 00	77 01	00 00	0F 00 00 00	0F 00 00 00	0F 00 00 00
Range Gate 3 Hold Threshold	Range Gate 4 Hold Threshold	Range Gate 5 Hold Threshold	Range Gate 6 Hold Threshold	Range Gate 7 Hold Threshold	Range Gate 8 Hold Threshold	Range Gate 9 Hold Threshold
0F 00 00 00	0F 00 00 00	0F 00 00 00	0F 00 00 00	0F 00 00 00	09 00 00 00	09 00 00 00
Range Gate 10 Hold Threshold	Range Gate 11 Hold Threshold	Range Gate 12 Hold Threshold	Range Gate 13 Hold Threshold	Range Gate 14 Hold Threshold	Range Gate 15 Hold Threshold	Trailer
09 00 00 00	09 00 00 00	09 00 00 00	09 00 00 00	09 00 00 00	09 00 00 00	04 03 02 01

6. Installation and Detection Range

The recommended installation method for the XenD106L is wall-mounted installation. For wall-mounted installation, the orientation of the millimeter-wave sensor is shown in Figure 6-1.The X-axis direction is 0°, the Z-axis direction is 90°, and the Y-axis is perpendicular to the X-Z plane (also referred to as the normal direction).

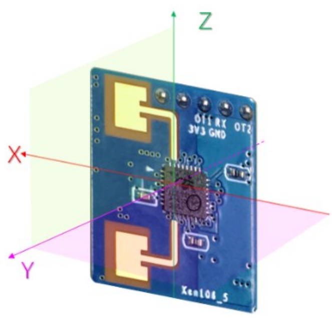


Figure 6-1 Sensor Orientation Diagram

The recommended installation height for wall mounting method is 1.5 ~ 2 m. The motion detection range of sensor XenD106L under default setting is a conic area formed within the sensor's radial distance of 6 m, azimuth and elevation angle of ±60°, as shown in Figure 6-2.

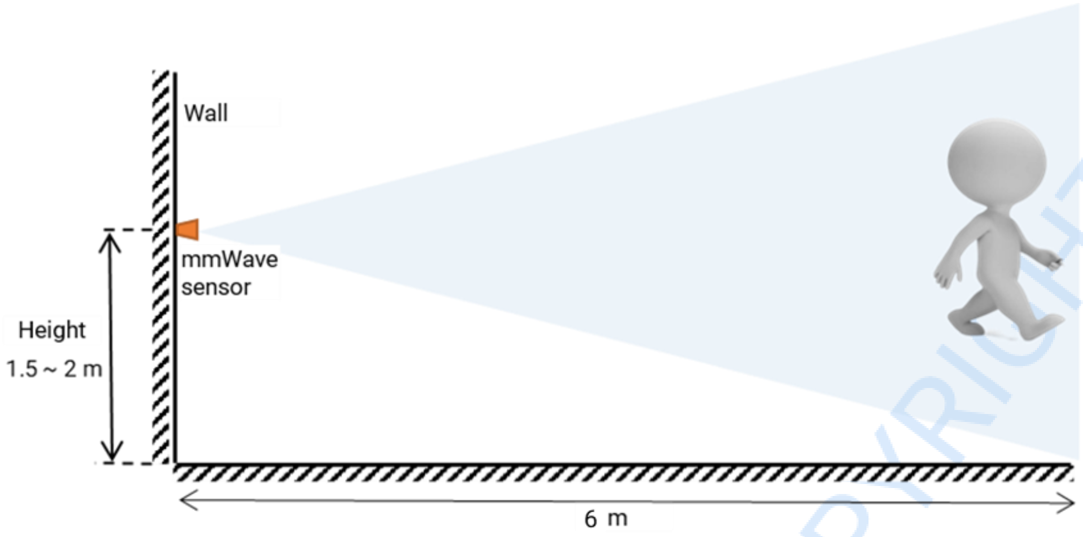


Figure 6-2 Illustration of wall mounted XenD106L detection range

The detailed detection ranges of the XenD106L in all directions are shown in Figure 6-3, when applying wall mounted with the height of 1.5 m.

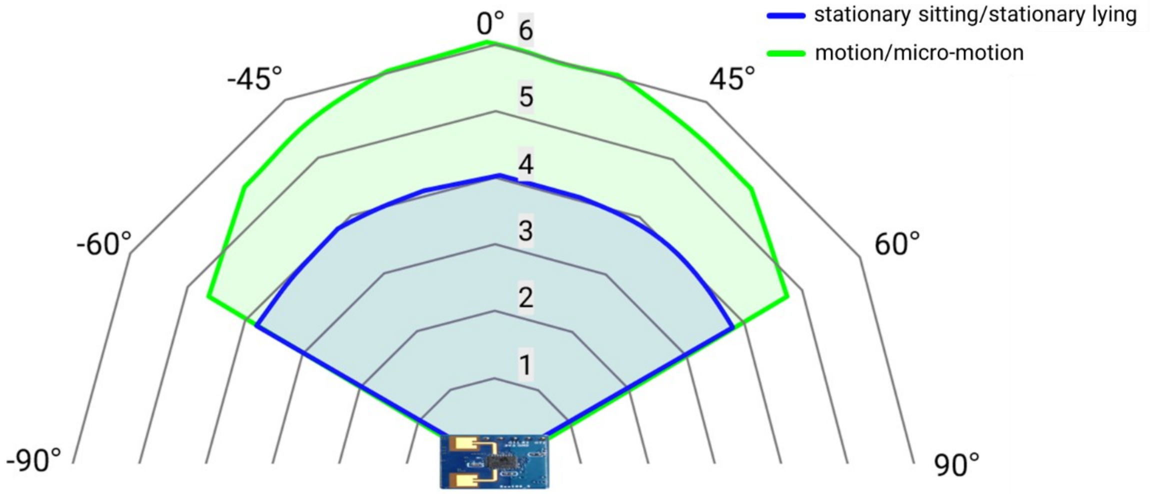


Figure 6-3 Detection range of wall mounted XenD106L

7. Mechanical Size

Figure 7-1 presents the mechanical size of hardware Xen106, all the unit is mm. The board thickness Of Xen106 is 1.3 mm with a tolerance of ±10%.

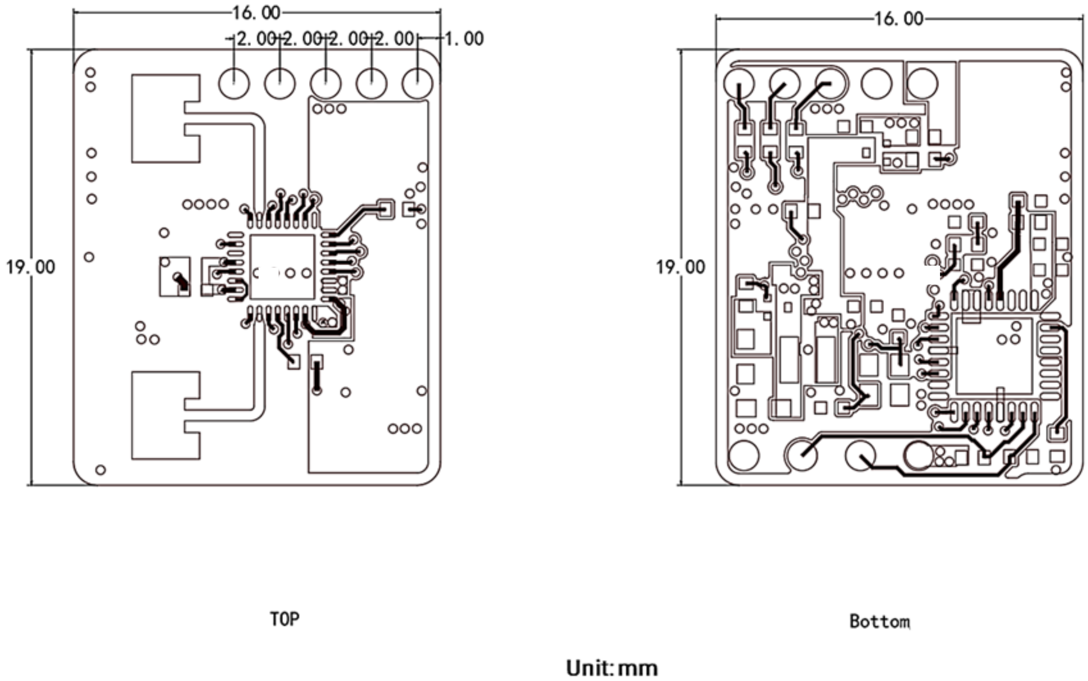


Figure 7-1 Mechanical size of hardware Xen106

8. Installation Requirement

Radome Requirements

If there is a need to install a radome, the material selected must have good transparency for 24 GHz wave, and do not contain any material that may block electromagnetic wave such as metal. More details please refer to mmWave Radar Sensor Antenna Radome Design Guide .

Before installing the mmWave sensor, it is required to try out the minimum mounting clearance between the antennas and the cover. It is recommended to maintain the gap within 4 ~ 6 mm, because the mmWave sensor will reach saturation if the cover is too close to the antenna. The minimum mounting clearance varies with respect to the material, thickness and shape of the cover.

Installation Environment

When installing the product, certain requirements should be taken into consideration in case the detection performance is interfered. Features of unsuitable environment are listed below.

- Continuous moving non-human objects in detection area, such as moving animals, swinging curtains, big shaking plants in front of an active vent etc.
- Large strong reflectors will interfere with detection performance when put in front of the antennas.
- Interferences of on-ceiling home appliances such as air-conditioners, fans, etc. should be taken into consideration while top mounted.

Important Requirements

- Ensure the antennas are facing squarely to desired detection area with a clear field of view.
- Ensure the installation position of the mmWave sensor is solid and stable. Motion of the mmWave sensor itself can hugely impact signal processing.
- Ensure there is no object moving or vibrating behind the mmWave sensor. Motion behind the antennas can also be detected due to the penetrability of mmWave, thus interferes detection accuracy. It is

recommended to use a radome or a backplane to reduce the interference.

- When there are multiple 24 GHz mmWave sensors installed in close areas, ensure their beamforms do not face to each other, try to separate them as far as possible to avoid interference.

Power Supply

The XenD106L supports power supply from 3.3 V to 3.6 V. The power ripple should show no obvious spectral peaks within 100 kHz. Additionally, developers should take EMC design such as ESD and lightning surge into consideration.

9. Important Tips

Maximum Detection Range

The maximum trigger range of the XenD106L sensor for target detection is a radial distance of 6 m, and the detection range can reach 8.4 m. Within this range, the mmWave sensor reports the direct distance of the detected moving target.

Modifying Firmware Baud Rate

The default baud rate of sensor XenD106L is 115200. It can be modified through the macro USART0_BAUDRATE defined under engineering directory \platform\py32\inc\py32_uart.h.

Maximum Detection Range and Range Accuracy

Theoretically, the range accuracy of sensor XenD106L is ±0.35cm. However, the value together with the maximum range may vary according to human target size, pose, and RCS.

Absence Report Dela

When human absence is detected in detection area, the mmWave sensor will delay the absence report. The delay mechanism works as such: once no human target is detected in detection area, the mmWave sensor will start a timer whose duration is the parameter absence report delay, and if there is no target showing up during this timing the mmWave sensor will end the timer and send the non-human report; however, if a human target is detected in detection area during the timing, the mmWave sensor will end and refresh the timer before sending the target information.

10. Revision History

Revision	Date	Modification
1.0	2023/10/20	Initial release.
1.1	2024/01/15	Firmware updated to v1.1.1, added automatic threshold generation function; Updated sensor communication protocol; The visualization tool updated to v1.3.0.1 with synchronized updates to operation procedures and accompanying figures; Updated supporting battery board, synchronized updates to Figure 3-2 and Figure 3-3.
1.2	2024/11/26	Firmware Updated to V1.2.0 with further firmware optimizations; Visualization Tool Updated to v1.3.3.2 with synchronized updates to user documentation and illustrations; Hardware revisions implemented, corresponding illustrations updated accordingly.

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