UM10036
XenD/P108Y User Manual

Rev.1.1 User Manual

Introduction

This document mainly introduces the basic functions, hardware specifications, software configuration, and installation conditions of the ICLEGEND MICRO (ICL) miniaturized high-precision liquid and material level detection reference design XenD/P108Y. It aims to help developers quickly get started with this reference design, and conveniently configure parameters suitable for actual application scenarios, so as to create customized high-precision liquid and material level detection sensors.

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1. XenD/P108Y Overview

XenD/P108Y is a miniaturized high-precision liquid and material level detection mmWave sensor of the ICL EZ Sensor series. It integrates a streamline 24 GHz mmWave sensor hardware Xen108 and an intelligent high-precision liquid and material level detection algorithm firmware.

The hardware Xen108 features a compact design that delivers excellent performance while remaining small size. It incorporates AIoT mmWave sensor SoC S5KM312CL, high-performance 24 GHz 1T1R microstrip antenna, MCU, and peripheral circuits. The intelligent high-precision liquid and material level detection algorithm achieves accurate detection by adopting FMCW waveform and S5KM312CL specified advanced radar signal processing technology.

The detection range of XenD/P108Y is from 0.15 m to 10 m. with a precision of 0.03 mm ~ 0.15 mm and an accuracy of 0.5 mm[1]. With a visualization tool specially designed for XenD/P108Y, users can configure the sensor parameters such as report period easily. Additionally, this solution is plug-and-play by supporting real-time reporting detection results through the UART interface.

The main features of XenD/P108Y are as follows:

- Equipped with a single-chip smart mmWave sensor SoC and intelligent algorithm firmware
- High-precision liquid and material level detection
- Compact size of 44 mm × 36 mm
- 3.3 V single power supply, supporting a wide voltage range of 3.0 V~3.6 V
- Average operating current 6 mA @ 1 s report period (report period reconfigurable)
- Provides a visualization tool, supports distance calibration and report period configuration
- Report detection results in real time
- Beamwidth ≤ ±12°@ -6 dB (round trip)

In practical applications, the XenD/P108Y miniaturized high-precision liquid and material level detection sensor enables non-contact measurement of the liquid and material level in closed or open containers despite the influence of various environmental factors (such as temperature, pressure, and dust). This makes it promising for a wide range of applications in the following fields:

- **Industrial Application**

Non-contact continuous detection of the material/liquid level of chemical materials, corrosive liquids, etc., stored in tanks, ensuring safe production.

- **Smart Appliances**

Real-time high-precision monitoring of water levels in smart water dispensers, coffee machines, and other household appliances to prevent overflow, dry burning, and other safety issues.

- **Hydrological Monitoring**

Real-time observing of water levels in reservoirs, rivers, lakes, and other natural water bodies, providing support for water resource management.

- **Intelligent Cities**

Real-time monitoring of city drains and underground water levels, assisting in solving urban drainage problems.

2. System Characteristics

XenD/P108Y is a miniaturized high-precision liquid and material level detection sensor developed based on the ICL S5KM312CL SoC. It accurately detects the level of target in the specified range and reports the results in real time by adopting FMCW waveform and applying radar signal processing with the built-in liquid and material level detection algorithm. With this reference design, users can develop customized miniaturized and high-precision liquid and material level detection products conveniently.

[1] When measuring long distances, the precision and accuracy may fluctuate due to potential interference from surrounding objects.

The Xen108 hardware is mainly composed of a fully integrated ICL S5KM312CL smart mmWave sensor SoC, high-performance 24 GHz 1T1R antenna, and a main control MCU. The software part includes an intelligent high-precision liquid and material level detection algorithm firmware, and a visualization tool that allows users to configure the data report period flexibly and check the detection results in real time.

The specification parameters of XenD/P108Y are shown in Table 2-1.

Table 2-1 XenD/P108Y specifications

Parameter	Min.	Typ.	Max.	Unit	Condition
Hardware Xen108					
Operating frequency	23	-	27	GHz	-
Sweep bandwidth	-	4	-	GHz	
Beam width	-12	-	12	°	-6 dB (round trip)
Max. EIRP	-	11	-	dBm	When equipped with the radome
Power supply	3.0	3.3	3.6	V	-
Size	-	44 × 36	-	mm^2	-
Environment temperature	-40	-	85	°C	-
XenD/P108Y System					
Detection range	0.15	-	10	m	When detecting water surface and large corner reflector
Precision	0.03	-	0.15	mm	
Accuracy	-	0.5	-	mm	
Report Period	50	1,000	60,000	ms	Reconfigurable, refer to 9.5 for details
Average operating current	-	6	-	mA	@1 s report period
	-	15	-		@160 ms report period

3. Hardware Overview

Figure 3-1 shows the physical front and back views of the Xen108 hardware. There are 5 pin holes reserved on the hardware (pins not included by default), labeled as J1, used for power supply and communication. Interface J2 is the SWD (Single Wire Debug) interface used for burning and debugging MCU programs. When burning the firmware, please make sure to connect according to the corresponding pin names.

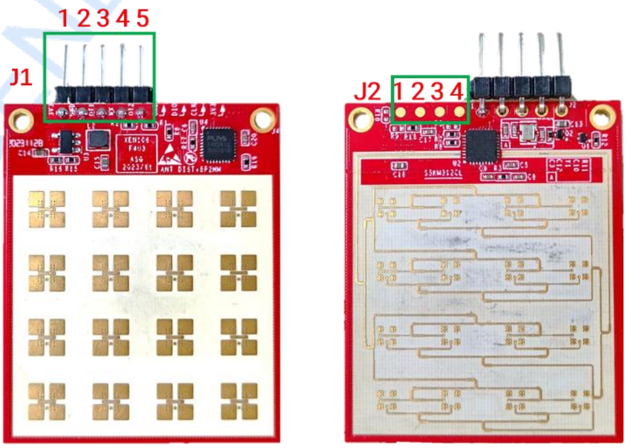


Figure 3-1 Front and back view of Xen108

Pin descriptions of J1 and J2 please refer to Table 3-1 and Table 3-2, respectively.

Table 3-1 J1 pin description

J#Pin#	Name	Function	Operating Range
J1 Pin1	3V3	Power input	3.0 V~3.6 V, Typ. 3.3 V
J1 Pin2	OT1	Ground	-
J1 Pin3	GND	UART_TX	0~3.3 V
J1 Pin4	RX	UART_RX	0~3.3 V
J1 Pin5	OT2	IO port	0~3.3 V

Table 3-2 J2 pin description

J#Pin#	Name	Function	Operating Range
J2 Pin1	3V3	Power input	3.0 V~3.6 V, Typ. 3.3 V
J2 Pin2	CLK	Clock signal	0~3.3 V
J2 Pin3	DIO	Data port	0~3.3 V
J2 Pin4	GND	Ground	-

The XenD/P108Y supports programming hex file or bin file using the Keil5 IDE. It is recommended to use a programmer such as J-Link (V9 or later) or CMSIS-DAP to download the program. Before programming, ensure the MCU driver Puya.PY32F4xx_DFP.0.0.1.pack is installed.

4. Software Overview

This chapter introduces the debugging of the firmware and the use of the visualization tool of the XenD/P108Y miniaturized high-precision liquid and material level detection sensor.

XenD/P108Y is released with pre-burned system firmware, and the firmware version is detailed on the external packaging of the sensor. ICL provides a visualization tool software to configure XenD/P108Y, allowing developers to conveniently customize the parameters according to practical scenarios and obtain optimized sensing effects.

4.1 Firmware Debugging

This section introduces how to debug the firmware of the XenD/P108Y with a third-party serial tool software. Follow these steps to debug the firmware:

Step 1: Connect the mmWave sensor with the host PC using a USB-TTL serial transfer board. The pin connection method is as shown in Table 4-1 and Figure 4-1.

Table 4-1 Correspondence of pins when connecting the sensor to the USB-TTL adapter

mmWave Sensor	USB Serial Board
RX	TXD
OT1	RXD
GND	GND
3V3	VCCIO

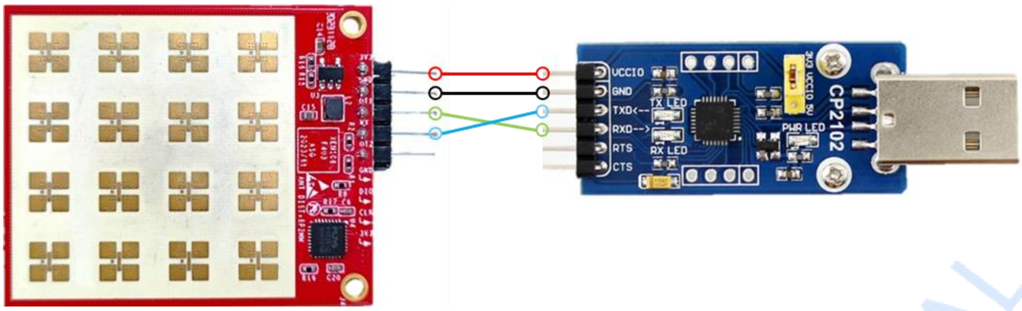


Figure 4-1 Illustration of the connection between XenD/P108Y and USB-TTL adapter

Step 2: Open the **Device Manager** of the host PC, obtain the serial COM number of the sensor.

Step 3: Open the third-party serial port tool, type in or select the sensor serial COM number, and set the baud rate to 115,200;

Step 4: Click the **Open Serial Port** (or other of the same function) button to view the current sensor's detection results on the third-party serial port tool interface.

For details about the format and parsing method of the detection results output by the third-party serial port tool, see 5.3 Report Data.

4.2 Visualization Tool Guide

For the convenience of understanding, obtaining, and configuring the parameters of the sensor, ICL provides a visualization tool *ICL_XenD/P108Y_Tool*.

Note: The third-party debugging tool and visualization tool cannot be used at the same time!

4.2.1 Connecting the Sensor to the Visualization Tool

Before using the visualization tool, users should first connect the XenD/P108Y with the visualization tool, following these steps:

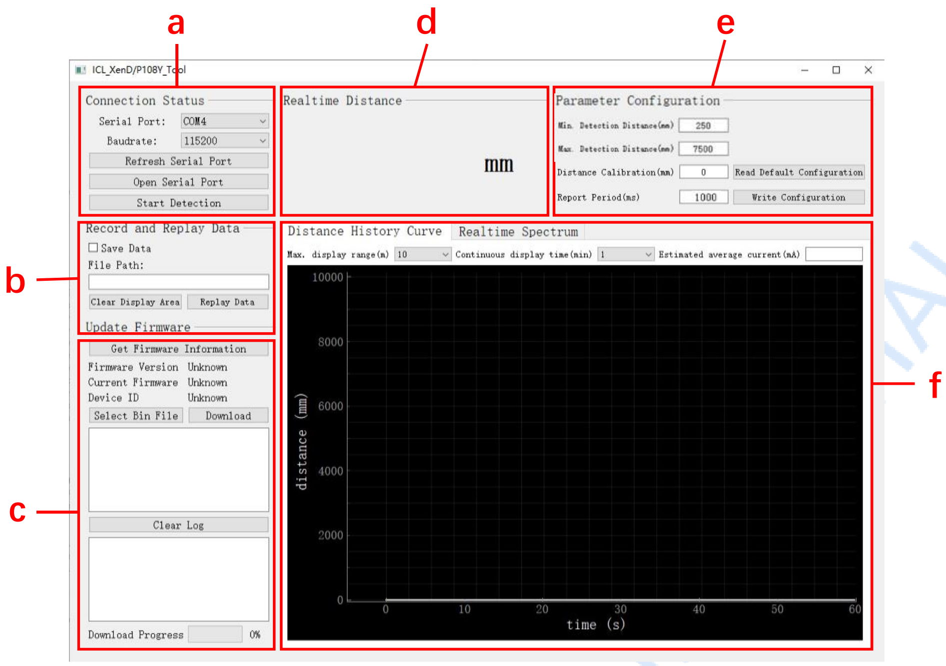
Step 1: Obtain the visualization tool *ICL_XenD/P108Y_Tool* from ICL website.

Step 2: Connect the XenD/P108Y to the host PC using a serial port adapter board, as shown in Figure 4-1.

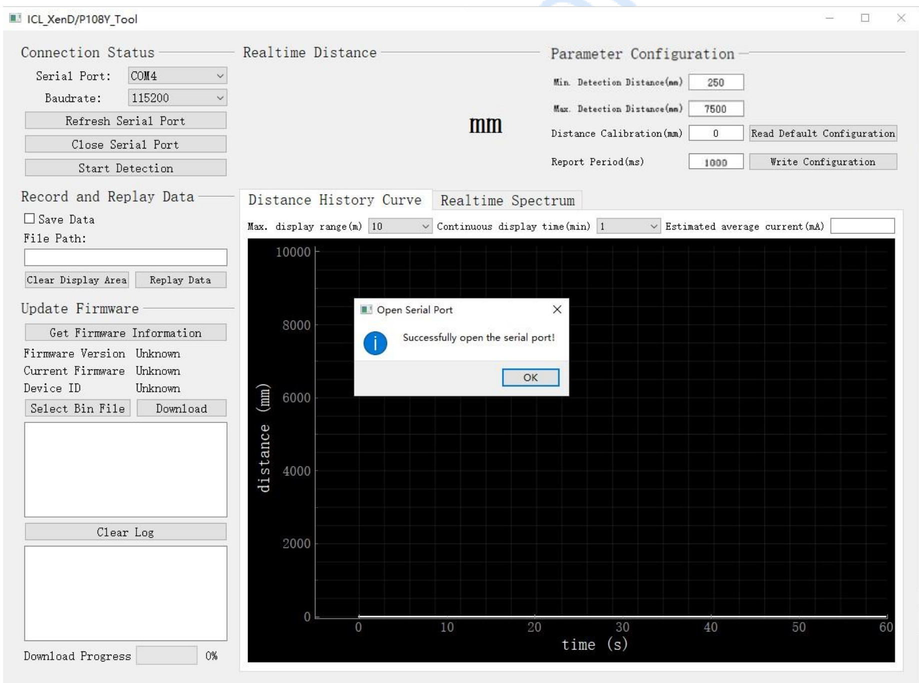
Step 3: Open the visualization tool (see Figure 4-2 (a)), click the **Refresh Serial Port** button, select the sensor's serial port number from the Serial Port drop-down box, ensure the Baudrate is 115200, and click the **Open Serial Port** button to start connecting the host PC to the sensor.

After successful connection, a pop-up window will appear with the message "Successfully open the serial port!", and the text on the original "Open Serial Port" button will switch to "Close Serial Port", as shown in Figure 4-2 (b).

If the connection is not successful, please confirm whether the host PC has correctly installed the driver for the serial port adapter and ensure that the serial port adapter is correctly connected to the sensor.



(a) Before connecting with the mmWave sensor



(b) After connecting with the mmWave sensor

Figure 4-2 ICL_XenD/P108Y_Tool

As shown in Figure 4-2 (a), the interface of ICL_XenD/P108Y_Tool can be partitioned into 5 zones: (a) Connection Status zone, (b) Record and Replay Data zone, (c) Update Firmware zone, (d) Realtime Distance zone, (e) Parameter Configuration zone, and (f) Distance History Curve zone.

4.2.2 Parameter Configuration

Once the sensor is successfully connected to the host computer tool, users can configure parameters in zone (e) of the interface to meet application requirements. Users can modify parameter values in the corresponding text boxes and click "Write Configuration" to successfully configure the parameter. Users can also click "Read Default Configuration" to display the default parameter values, and then click "Write configuration" to restore the default configuration. After the configuration is complete, click the "Start Detection" button in zone (a) to activate the distance detection function.

The minimum and maximum detection distances of XenD/P108Y are set to 250 mm and 7500 mm respectively by default. The calibration distance is set to 0 mm by default. The report period is set to 1000 ms by default.

- **Read Configuration**

The steps to read the default configuration using the host computer tool are as follows: Connect XenD/P108Y to the host computer tool (with the serial port open) and ensure that it is in the stopped detection state. Then, click the "Read Default Configuration" button to display the corresponding default parameter values in the text box.

- **Write Configuration**

The steps to write configuration through the host computer tool are as follows:

Step 1: Connect XenD/P108Y to the host computer tool with the serial port open and ensure it is in the stopped detection state. Then, input the corresponding parameter values into the "Minimum Detection Distance (mm)", "Maximum Detection Distance (mm)", "Distance Calibration Value (mm)", and "Reporting Period (ms)" text boxes. The range for the minimum and maximum detection distances is "150 mm to 10500 mm", the distance calibration value range is "-100 mm to 100 mm", and the reporting period configuration range is "50 ms to 60000 ms". All parameter values support only integer values.

Step 2: Click the "Write Configuration" button to configure.

Upon successful write configuration, a pop-up window will appear with the message “Successfully Write Configuration!”, as shown in Figure 4-3.

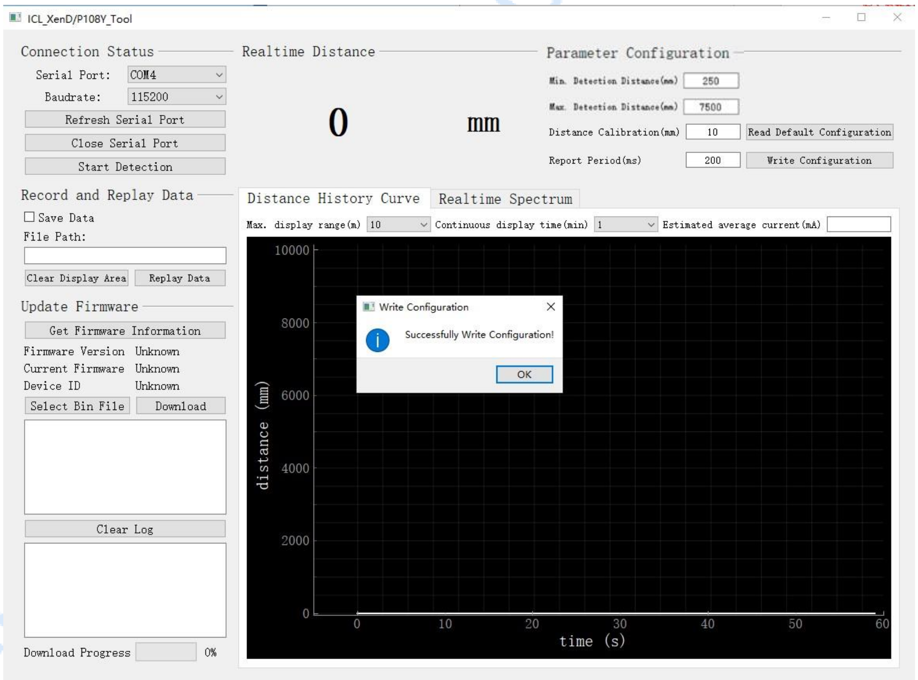


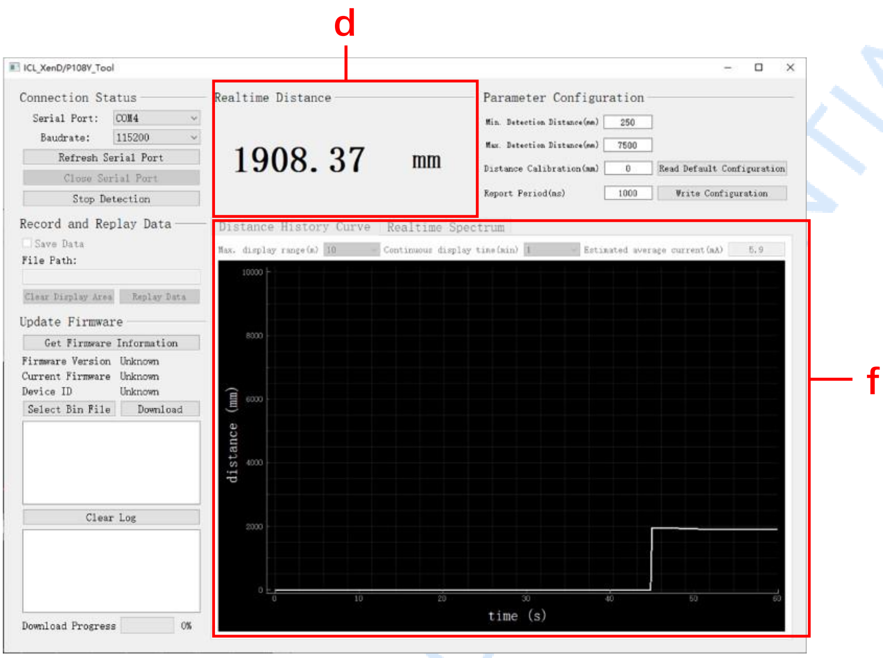
Figure 4-3 Successfully Write Configuration

4.2.3 Detection Information Display

Zone (d) and zone (f) of the visualization tool are used to present real-time detection information.

Zone (d) displays the current detection distance in millimeters (mm), with values shown to two decimal places. zone (f) , page 1, presents the distance history curve, where users can adjust the maximum display distance and duration using the "Max Display Distance (m)" and "Continuous Display Time (min)" dropdown menus. The text box above the curve also displays the estimated average current (mA) under the current configuration. zone (f), page 2, shows the real-time waveform: the white curve represents the waveform, the red curve indicates the detection threshold, and the area between the green lines represents the detection range.

Once the sensor is successfully connected to the host computer tool (with the serial port open), clicking the "Start Detection" button initiates the detection process. Figure 4-4 (a) is the distance history curve. The detection distance is 1893.56mm, the maximum display distance is 10 m, the continuous display time is 1 min, and the current estimated average current is 5.9 mA. Users can switch the real-time spectrum display by clicking the real-time spectrum page title in zone (f), as shown in Figure 4-4 (b).



(a) Distance History Curve

(b) Realtime Spectrum

Figure 4-4 Detection information display

4.2.4 Record and Replay Data

Zone (b) of the host computer tool interface provides the function to save and replay detection distances. This feature supports saving and replaying detection distances only and does not support saving and replaying real-time waveform data. Therefore, users need to switch zone (f) to the distance history curve interface for saving and replaying data.

- **Recording Data**

The steps to save detection data are as follows:

Step 1: After connecting the XenD/P108Y to the host computer tool (with the serial port open), check the "Save Data" checkbox.

Step 2: In the popped up "Select Path" page, choose the desired directory for saving the data; and the selected path will be displayed in the "File Path" textbox.

Step 3: Click the **Start Detection** button to save the data while detecting.

The saved data file is named by default as "Data_year_month_day_hour_minute_second.dat."

- **Clear Display Area**

Click the **Clear Display Area** button to erase the distance history curve and the currently displayed distance value.

- **Replay Data**

The steps to playback detection data are as follows:

Step 1: After connecting the XenD/P108Y to the host computer tool (with the serial port open), click the **Replay Data** button.

Step 2: On the popped-up “Select Path” page, choose a previously saved detection data file.

Once the selection is completed, users can view the detection results on the visualization tool interface.

4.2.5 Update Firmware

The steps to update the sensor firmware through the visualization tool are as follows:

Step 1: After successfully connecting the XenD/P108Y to the visualization tool (with the serial port open), click the **Get Firmware Information** button. The firmware version and device ID of the sensor will be displayed below.

Step 2: Click the **Select Bin File** button to choose the target bin file on the "Select Bin File" page. Then the bin file path will be shown in the information box below.

Step 3: Click the **Download** button to start the firmware upgrade. The "Download Progress" progress bar below will display the download progress in real-time.

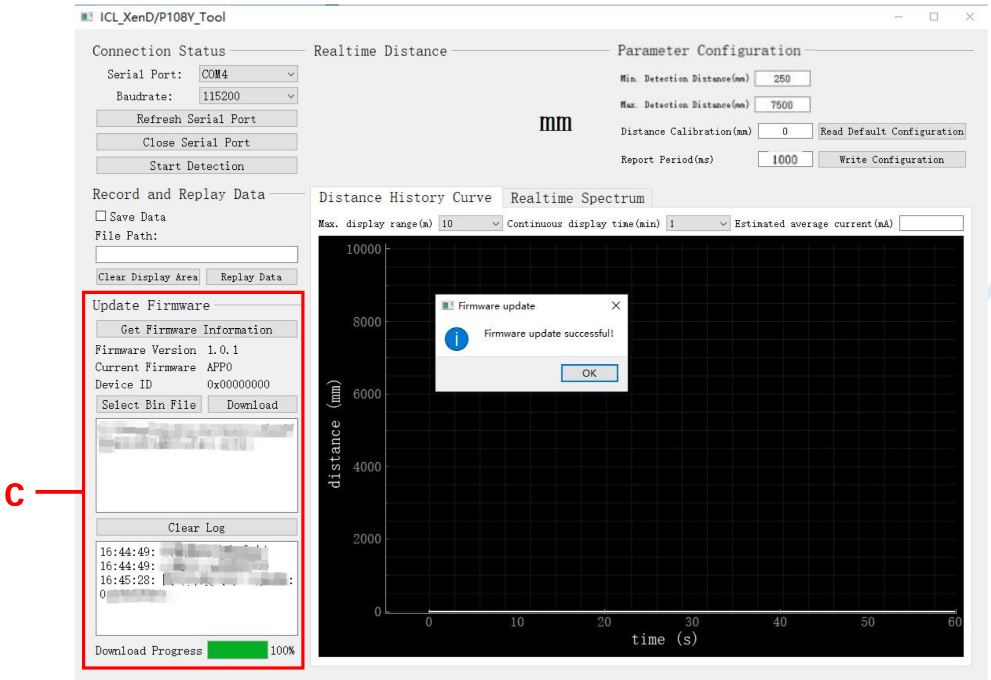


Figure 4-5 Firmware update successful

Upon successful firmware upgrade, a pop-up window will appear with the message "Firmware upgrade successful!", as shown in Figure 4-5. If the firmware upgrade fails, the error message will be displayed in the prompt box.

5. Communication Protocol

This communication protocol is primarily for users who are engaged in secondary development without visual tools. The XenD/P108Y compact high-precision liquid level mmWave sensor communicates with the outside world via serial port (TTL level). Both data output and parameter configuration commands of the sensor are conducted under this protocol. The default baud rate of the sensor serial port is 115,200, with 1 stop bit and no parity bit.

This chapter outlines this communication protocol in three sections:

1) **Protocol Format**

- Introduces the formats of protocol data frames and command frames.

2) **Command and ACK Format**

- Command Format: Details the format of command frames sent to the sensor;
- ACK Format: Specifies the frame format for each command replied by the sensor.

3) **Report Data Format**

- Introduces the format of the data frames sent by the mmWave radar to the upper computer tool.

5.1 Protocol Format

5.1.1 Protocol Data Format

The data communication of XenD/P108Y uses little-endian format, and all data in the following table are hexadecimal.

5.1.2 Protocol Command Format

The formats of configuration commands and ACK defined by the protocol are shown in Table 5-1 and Table 5-3, respectively.

Table 5-1 Command frame format

Header	Length of Intra-Frame Data	Intra-frame Data	Trailer
FD FC FB FA	2 bytes	Refer to Table 5-2	04 03 02 01

Table 5-2 Intra-frame data format

Command ID (2 bytes)	Command Parameter (N bytes)

Table 5-3 Sensor ACK frame format

Header	Length of Intra-Frame Data	Data Intra-Frame Data	Trailer
FD FC FB FA	2 bytes	Refer to Table 5-4	04 03 02 01

Table 5-4 Data format of the ACK frame

ACK ID (2 bytes)	Command Status (2 bytes)	Return Value (N bytes)

5.2 Command and ACK

The basic process for configuring and retrieving sensor parameters using commands is as follows:

1. Enter command mode (refer to 5.2.2 Enable Configuration Command);

2. Send configuration parameter command/get parameter command (refer to 5.2.1, and 5.2.4~5.2.10);

3. Exit command mode (refer to 5.2.3 End Configuration Command).

Below are detailed descriptions of each command and its corresponding ACK.

5.2.1 Read Firmware Version Command

This command reads the mmWave sensor firmware version number.

Command word: 0x0000

Command value: None

Return value: Version number length (2 bytes) + 2 bytes major version number + 2 bytes minor version number + 2 bytes patch version number

Sending data:

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

ACK (Succeed, the firmware version is an example):

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

5.2.2 Enable Configuration Command

This command is used to enable the configuration mode of the sensor. Any other command sent to the sensor must be executed after this command is issued, otherwise it will be invalid.

Command word: 0x00FF

Command value: 0x0001

Return value: 2-byte ACK status (0 succeeded, 1 failed)

Sending data:

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

ACK(Succeed):

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

5.2.3 End Configuration Command

After executing the End Configuration Command, the sensor resumes normal operation mode. To send other commands again, you need to first send the Enable Configuration Command.

Command word: 0x00FE

Command value: None

Return value: 2-byte ACK status (0 succeeded, 1 failed)

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 Switching the Distance History Curve Command

This command is used for switching the distance history curve.

Command word: 0x0076

Command value: None

Return value: 2 bytes ACK status (0 succeeded, 1 failed)

Sending data:

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

5.2.5 Switching the Realtime Spectrum Command

This command is used to switching the real-time spectrum.

Command word: 0x0077

Command value: None

Return value: 2-byte ACK status (0 succeeded, 1 failed)

Sending data (Example): Report period = 500 ms

Header	Intra-frame Data Length	Command Word	Command Value	Trailer

FD FC FB FA	04 00	77 00	F4 01	04 03 02 01

ACK(Succeed):

Header	Intra-frame Data Length	Command Word	ACK	Trailer
FD FC FB FA	04 00	77 01	00 00	04 03 02 01

5.2.6 Configure Minimum Detection Range Command

This command is used to configure the minimum detection range, with a range of 150 mm~10,500 mm (only supporting integer values).

Command word: 0x0074

Command value: 2-byte parameter number (small-endian format after detection range conversion to hexadecimal)

Return value: 2-byte ACK status (0 succeeded, 1 failed)

Sending data (Example): Minimum detection range = 200 mm

Header	Intra-frame Data Length	Command Word	Command Value	Trailer
FD FC FB FA	04 00	74 00	C8 00	04 03 02 01

ACK(Succeed):

Header	Intra-frame Data Length	Command Word	ACK	Trailer
FD FC FB FA	04 00	74 01	00 00	04 03 02 01

5.2.7 Configure Maximum Detection Range Command

This command is used to configure the maximum detection range, with a range of 150 mm~10,500 mm (only supporting integer values).

Command word: 0x0075

Command value: 2-byte parameter number (Little-endian format after detection range conversion to hexadecimal)

Return value: 2-byte ACK status (0 succeeded, 1 failed)

Sending data (Example): Maximum detection range = 1000 mm

Header	Intra-frame Data Length	Command Word	Command Value	Trailer
FD FC FB FA	04 00	75 00	E8 03	04 03 02 01

ACK(Succeed):

Header	Intra-frame Data Length	Command Word	ACK	Trailer
FD FC FB FA	04 00	75 01	00 00	04 03 02 01

5.2.8 Configure Report Period Command

This command is used to configure the report period, with a range of 50 ms~60,000 ms (only supporting integer values).

Command word: 0x0071

Command value: 2-byte parameter number (small-endian format after frame period conversion to hexadecimal)

Return value: 2-byte ACK status (0 succeeded, 1 failed)

Sending data (Example): Report period = 500 ms

Header	Intra-frame Data Length	Command Word	Command Value	Trailer
FD FC FB FA	04 00	71 00	F4 01	04 03 02 01

ACK(Succeed):

Header	Intra-frame Data Length	Command Word	ACK	Trailer
FD FC FB FA	04 00	71 01	00 00	04 03 02 01

5.2.9 Read Report Period Command

This command used to read the report period.

Command word: 0x0070

Command value: None

Return value: 4-byte report period

Sending data (Example):

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

ACK (Succeed): Report period = 1,000 ms

Header	Intra-frame Data Length	Command Word	Report Period	Trailer
FD FC FB FA	06 00	70 01	E8 03 00 00	04 03 02 01

5.2.10 Configure Distance Calibration Command

This command is used for distance calibration, with a range of -100 mm to 100 mm (only supporting integer values).

Command word: 0x0073

Command value: 1-byte absolute value of the distance calibration + 1-byte sign of the distance calibration (0x00 positive sign, 0x01 negative sign)

Return value: 2-byte ACK status (0 succeeded, 1 failed)

Sending data (Example): Distance calibration value = -100 mm

Header	Intra-frame Data Length	Command Word	Command Value	Trailer
FD FC FB FA	**04 00**	**73 00**	**64 01**	**04 03 02 01**

ACK(Succeed):

Header	Intra-frame Data Length	Command Word	ACK	Trailer
FD FC FB FA	04 00	73 01	00 00	04 03 02 01

5.3 Report Data

The factory firmware of XenD/P108Y defaults to output distance detection results in millimeters via the serial port. In command-line mode, users can modify the reporting data format by issuing a command to switch to display real-time waveform, thereby outputting distance detection results and waveform data.

When displaying the distance history curve interface, the reporting data format is as shown in Table 5-5.

Table 5-5 Report data format (distance history curve)

Header	Intra-frame Data Length	Detection Result	Trailer
F4 F3 F2 F1	2 bytes	4 bytes (Float)	F8 F7 F6 F5

Figure 5-1 shows an example of a data frame transmitted through the serial port when in the distance history curve display.

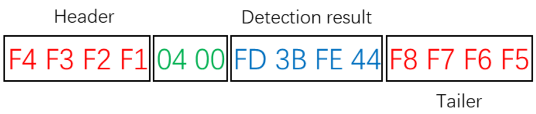


Figure 5-1 Example of reported frame

When displaying the real-time waveform interface, the reporting data format is as shown in Table 5-6.

Table 5-6 Report data format (real-time spectrum)

Header	Intra-frame Data Length	Detection Result	Spectrum Data	Trailer
F4 F3 F2 F1	2 bytes	4 bytes (Float)	512 x 4 bytes (Float)	F8 F7 F6 F5

Figure 5-2 shows an example of a data frame transmitted through the serial port when in the real-time spectrum display.

Figure 5-2 Example of reported frame

In the example:

- **Data Length:** Indicates the number of bytes occupied by the detection result.
- **Detection result:** Indicates the distance between the target and the mmWave sensor at the current moment.

Therefore, an example of data frame interpretation in Figure 5-1 is as follows:

- **Data length:** 00 04, indicating that the number of bytes reported from the distance detection result is 4;
- **Range Detection result:** The distance detection result stored in little-endian format FD 3B FE 44, after conversion to single-precision floating-point number, is 2033.87 (rounded to two decimal places), which means the target distance to the mmWave sensor at the current moment is 2033.87 mm.
- **Spectrum data**: The spectrum data stored in little-endian format.

6. Installation and Detection Range

The recommended installation method for the XenD/P108Y miniaturized high-precision liquid and material level detection sensor is to mount it on the ceiling inside storage tanks or barrels, with the antenna facing towards the material or liquid being measured, and the sensor's normal direction perpendicular to the cross-section or surface of the material or liquid being measured. By default, the XenD/P108Y has a range of 0.15 m to 10 m, with a precision of 0.03 mm ~ 0.15 mm and a typical ranging accuracy of 0.5 mm.

The orientation definitions of the XenD/P108Y mmWave sensor are 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 known as the normal direction).

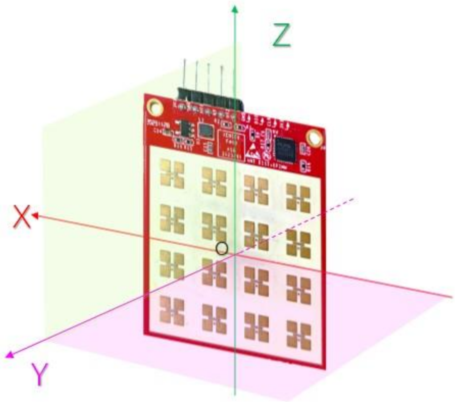
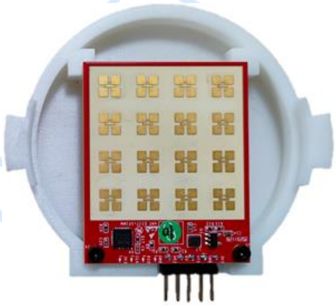


Figure 6-1 Illustration of the directions of XenD/P108Y

Assembly of the XenD/P108Y mmWave sensor with a fully transparent radome is shown in Figure 6-2, where the antenna cover mainly serves as a mounting fixture.

(a) Sensor equipped with a fully transparent radome



(b) Illustration of the sensor fixated inside the radome

Figure 6-2 Illustration of XenD/P108Y assembly with a radome

If the material to be measured is inside a storage tank or barrel, it is recommended to mount the XenD/P108Y sensor on the ceiling, as shown in Figure 6-3.

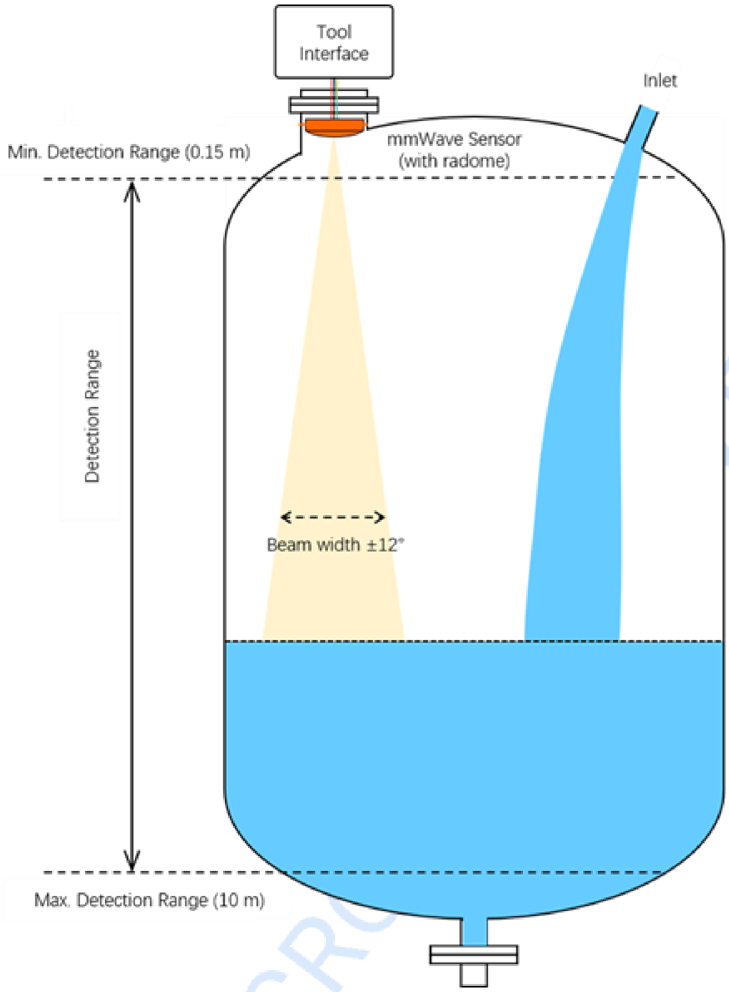


Figure 6-3 Illustration of XenD/P108Y installation inside a storage tank

When adjusting the sensor position, please note:

(1) The antenna surface (i.e., the XOZ plane in Figure 6-1) should be parallel to the surface or cross-section of the object to be measured;

(2) Avoid installing the sensor above the inlet;

(3) Maintain a certain distance between the storage tank wall and the sensor in the horizontal direction, with the recommended minimum safe distance being 1/5 of the maximum detection distance inside the tank;

(4) Avoid installing any internal devices within the ±12°beam range.

7. Mechanical Size

Figure 7-1 presents the mechanical size of Xen108 hardware, with all units in millimeters. The board thickness is 2 mm, with a tolerance of ±10%.

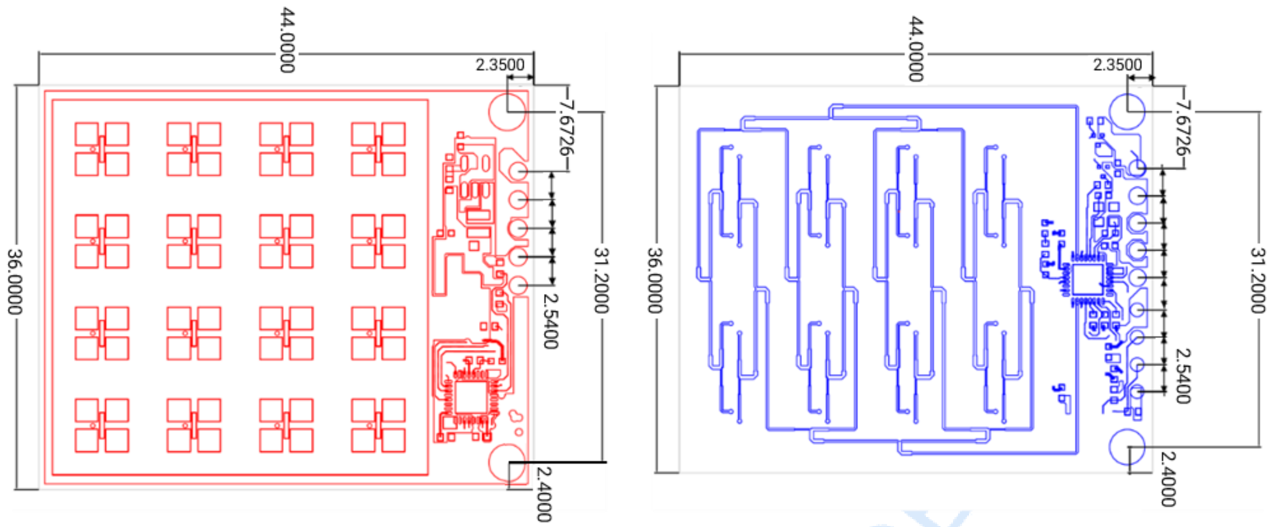


Figure 7-1 Mechanical size of Xen108 hardware

8. Installation Requirement

8.1 Radome Requirements

The XenD/P108Y mmWave sensor is equipped with a fully transparent radome, which is mainly used for mounting and fixing.

If a different shape of housing is required for the sensor, the housing must have good wave transmission characteristics in the 24 GHz band and must not contain metal or materials that shield electromagnetic waves. For more considerations, please refer to the mmWave Sensor Antenna Radome Design Guide[2].

8.2 Installation Environment Requirements

This product needs to be installed in a suitable environment. Detection will be affected if it is installed in the following environments:

- Avoid the presence of continuously moving non-human objects within the detection area, such as animals, curtains, or plants, as they may affect detection performance.
- Avoid the presence of large reflective objects within the detection area, as these reflections may interfere with the normal operation of the mmWave sensor.

8.3 Installation Requirements

- Ensure that the sensor antenna faces directly towards the area to be detected, with unobstructed surroundings around the antenna.
- Ensure that the installation position of the sensor is firm and stable; movement of the sensor itself will affect detection performance.
- Ensure that there is no movement or vibration on the back of the sensor. Due to the penetrative nature of radar waves, movement of objects behind the sensor may be detected by the antenna backlobe. Metal shielding or a metal backplate can be used to shield the radar backlobe and reduce the impact of objects behind the sensor.

[2] Currently, only Chinese version is available.

- When multiple radar systems operating in the 24 GHz frequency band are present in the working environment, avoid beam alignment and install as far away as possible to avoid potential mutual interference.

8.4 Power Supply

The power input voltage range is 3.0 V to 3.6 V, with no significant spectral peaks in the power supply ripple within 2 MHz. This scheme is a reference design; users should consider corresponding electromagnetic compatibility designs such as ESD and lightning surge protection.

9. Important Tips

9.1 Detection Range

The detection range of XenD/P108Y is from 0.15 m to 10 m. Within this detection range, the mmWave sensor will report the straight-line distance between the target and the sensor.

9.2 Modifying Firmware Baud Rate

The default serial port baud rate of the sensor is 115,200. Developers can modify the baud rate by changing the UART_BAUDRATE macro definition in the project directory \platform\py32\inc\py32_uart.h.

9.3 Maximum Detection Range and Precision

The ranging precision within the ±12° beam width range, without interference, is characterized by the standard deviation of the measured values when measuring specific fixed distances. The ranging precision within the detection range of this reference design is 0.03 mm ~ 0.15 mm, which is obtained from actual measurements of rigid body targets with strong reflection.

Cases where the 0.03 mm ~ 0.15 mm ranging precision does not apply include:

- Distance measurement of targets beyond the detection range;
- Distance measurement of targets that undergo unstable distance displacement;
- Presence of multiple adjacent strong scattering points near the detected target.

When the detected target is a large angle reflector, the sensor can detect up to 4.5 m; when the detected target is a hard ground or an open water area, the sensor can detect up to 10 m. Due to differences in target size, motion status, and RCS (Radar Cross Section), the ranging precision of the sensor may fluctuate, and the maximum detection distance may also fluctuate.

9.4 Response Time

The response time is defined as the time it takes for the sensor's output distance to first reach 90% of the stable value after the distance of the detected target undergoes a sudden change. The response time of the mmWave sensor is positively correlated with the report period. For example, if the report period is set to 160 ms, the response time will be 2.4 s.

9.5 Influence of Report Period on Average Operating Current

The default report period of XenD/P108Y is 1 second, during which the average operating current is 6 mA. Users can flexibly configure different report periods using the visualization tool according to actual needs, thereby adjusting the power consumption of the sensor. For specific correspondence between average operating current and report period, please refer to Table 9-1.

Table 9-1 Correspondence between Average Operating Current and Report Period

Report Period (s)	Average Operating Current (mA)
0.05	38.8

0.1	21.5
0.16	15
0.2	12.8
0.5	7.7
1 (default)	6
2	5.1
5	4.5
10	4.4

9.6 Reporting Period Explanation

The reporting period configured in the XenD/P108Y host computer interface represents the time interval for reporting only distance detection results (with the display interface set to the distance history curve). When switching the interface to real-time waveform, the actual reporting period will be longer than the configured reporting period, and the actual average operating current will increase accordingly.

10. Revision History

Revision	Date	Modification
1.0	2024/4/7	Initial draft.

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