

Introduction

This document primarily describes the basic functions, hardware specifications, software configurations, and installation requirements of ICLEGEND MICRO(ICL) high-precision 24 GHz mmWave sensor reference design, XenG101G. It aims to assist developers in quickly getting started with the XenG101G-based wave gesture recognition mmWave sensor, enabling convenient parameter configuration tailored to specific application scenarios. This allows users to develop their own high-accuracy human proximity sensing and wave gesture recognition control sensors.

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1. XenG101G Overview

XenG101G is a Hand Gesture Recognition mmWave sensor of ICL EZ Sensor series, integrating the ultra-simplified 24 GHz radar sensor hardware Xen101 and intelligent hand-gesture recognition algorithm firmware.

The sensor hardware consists of a mmWave radar chip, a high-performance one-transmit-one-receive microstrip antenna, an MCU, and peripheral auxiliary circuits. This product adopts FMCW operation mode along with target detection and ranging algorithms, enabling accurate recognition of hand gestures (1–20 cm) and human presence detection (0.2–4 m). It facilitates proximity wake-up and gesture control functions for smart devices, making it suitable for applications such as smart displays, smart home systems, smart appliances, and intelligent kitchen/bathroom solutions.

2. System Characteristics

XenG101G is a Hand Gesture Recognition reference solution developed based on ICL's S1 series chip. The sensor employs FMCW waveform and integrates the MCU's dedicated radar signal processing with built-in intelligent sensing algorithms, enabling it to detect and recognize gestures within a specified area while reporting results in real time. Based on this reference design, users can rapidly develop corresponding sensing products

The systematic characteristics of XenG101G are shown in Table 2-1.

Table 2-1 XenG101G characteristics

Parameter	Min.	Typ.	Max.	Unit
Operating Frequency	24.00	-	24.25	GHz
Sweeping Bandwidth	-	-	0.25	GHz
Max. EIRP (Equivalent Isotropically Radiated Power)	-	11	-	dBm
Power Supply	3.0	3.3	3.6	V
Refresh Cycle	-	50	-	ms
Size	-	20 × 20	-	mm ²
Ambient Temperature	-40	-	85	°C
Human Detection Range	0.2	-	4	m
Ranging Accuracy	-	±20	-	cm
Wave Recognition Range	0.01	-	0.20	m
Field of View	-	±75° × ±75°(H×E)	-	-

3. Hardware Overview

Figure 3-1 shows the top and bottom views of the Xen101 hardware. The board reserves 5 pin headers (pins not included by default) labeled J2 for power supply and communication. J1 is the SWD interface for MCU program flashing and debugging. The pin pitch is compatible with both 2.54 mm and 2.00 mm spacing standards.

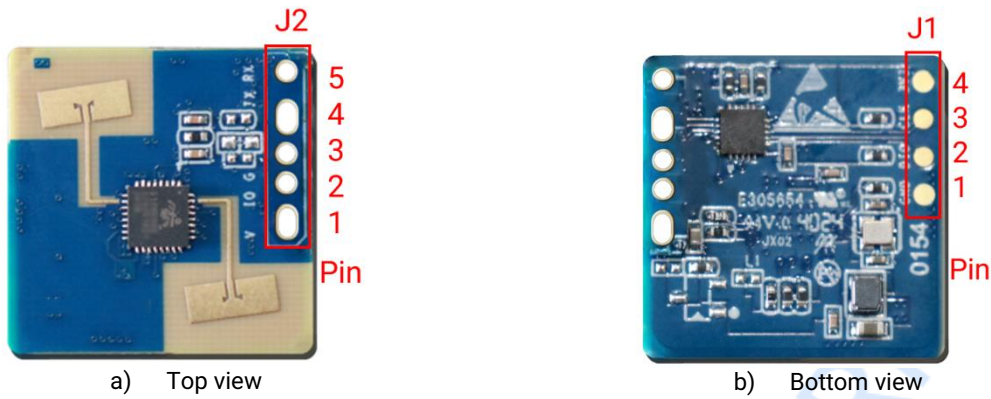


Figure 3-1 Xen102_V2 device map

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 interface	0 ~ 3.3 V
J1Pin3	CLK	SWD clock interface	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	V	Power input	3.0 V ~ 3.6 V, Typ. 3.3 V ¹
J2Pin2	IO	Reserved	0 ~ 3.3 V
J2Pin3	G	Ground	-
J2Pin4	TX	UART_TX	0 ~ 3.3 V
J2Pin5	RX	UART_RX	0 ~ 3.3 V

4. Communication Protocol

The XenG101G module outputs monitoring status information via UART, with default settings of 115200 bps baud rate, 8 data bits, 1 stop bit, and no parity/flow control (NONE). Each frame consists of 6 bytes, with the frame format detailed in Table 4-1. This module supports configuration and retrieval of parameters such as maximum human detection range, gesture recognition distance, and baud rate. The parameter configuration protocol and configuration response protocol are specified in Table 4-2 and Table 4-3, respectively

¹ When an LDO regulator is added, the power supply voltage range is 4.5–5.5 V (Typ. 5 V)

Table 4-1 Definitions of the sensor's output data

Sequence	Value	Descriptions
Byte[0]	0xAA	Frame header
Byte[1]	0x00~0xFF	0x00: human target absence >0x00: human target detected, and the value represents target range ²
Byte[2]	Bit0	0: no wave gesture detected 1: wave gesture detected
	Bit4~7	The number of consecutive hand waves
Byte[3]	0x00	Reserved bit
Byte[4]	Byte[1]+Byte[2]+ Byte[3]	Checksum (if overflow occurs, keep the lower byte)
Byte[5]	0x55	Frame trailer

Table 4-2 Definitions of the sensor's parameter configuration command

Sequence	Frame Header	Command ID	Command Content		Checksum	Frame Trailer
	Byte[0]	Byte[1]	Byte[2]	Byte[3]	Byte[4]	Byte[5]
1	0xAB	Set detection distance --0xB1	Gesture detection distance ³ --0x00/0x01	Human detection distance ⁴ --0x00~0xA0	Byte[1]+ Byte[2]+ Byte[3]	0x55
2	0xAB	Get Current Detection Distance --0xB2	Reserved --0x00	Reserved --0x00	Same as above	0x55
3	0xAB	Restore Default Configuration --0xB3	Reserved --0x00	Reserved --0x00	Same as above	0x55
4	0xAB	Query Current Software Version --0xB4	Reserved --0x00	Reserved --0x00	Same as above	0x55
5	0xAB	Set UART Baud Rate --0xB5	Reserved --0x00	0x00: 9600 0x01: 19200 0x02: 38400 0x03: 57600 0x04: 115200	Same as above	0x55

² This byte indicates the detected target distance (unit: cm). If the output is 0x8C, the target distance equals $140 * 2.5 = 350$ cm.

³ This byte represents gesture detection distance. 0x00: >90% recognition probability for hand waves within 10 cm, <5% probability beyond 20 cm; 0x01: >90% recognition probability for hand waves within 20 cm, <5% probability beyond 30 cm.

⁴ This byte sets the maximum human detection range (unit: cm). When set to 0x8C, the maximum human detection range is $140 * 2.5 = 350$ cm. The maximum configurable value is 0xA0 (400 cm).

Table 4-3 Definitions of the sensor's configuration response

Sequence	Frame Header	Response ID	Response Content		Checksum	Frame Trailer
	Byte[0]	Byte[1]	Byte[2]	Byte[3]	Byte[4]	Byte[5]
1	0xAB	Response to Set Detection Distance --0xB1	Gesture detection distance --0x00/0x01	Human detection distance --0x00~0xA0	Byte[1]+ Byte[2]+ Byte[3]	0x55
2	0xAB	Response to Current Detection Distance --0xB2	Gesture detection distance --0x00/0x01	Human detection distance --0x00~0xA0	Same as above	0x55
3	0xAB	Response to Restore Default Configuration --0xB3	Configuration successful --0x01	Configuration successful --0x01	Same as above	0x55
4	0xAB	Response to Query Current Software Version ⁵ --0xB4	Main version --0x00~0xFF	Sub. version --0x00~0xFF	Same as above	0x55
6	0xAB	Response to UART Baud Rate --0xB5	Reserved --0x00	0x00: 9600 0x01: 19200 0x02: 38400 0x03: 57600 0x04: 115200	Same as above	0x55

5. Hand Gesture Recognition Demo Tool

ICL provides a hand gesture recognition demo tool for XenG101G.

The Xen101 hardware operates at 3.3 V power supply. When connecting the hardware to a serial tool, ensure:

- The hardware's TX pin is connected to the tool's RX pin
- The RX pin is connected to the tool's TX pin
- Use jumper caps to set the adapter board's output power to 3.3 V

If using other serial tools, similarly ensure 3.3 V power supply. Refer to Figure 5-1 for the connection diagram.

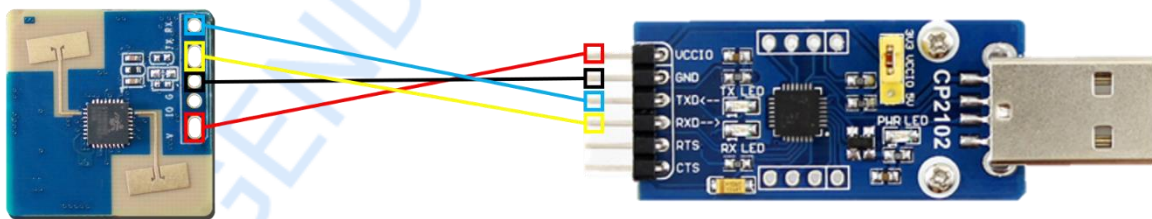


Figure 5-1 Connection of XenG101G and serial port tool

5.1 Quick Start

After correctly connecting the cables as shown in Figure 5-1, double-click to open the "Hand Gesture Recognition Demo Tool". The interface appears as shown in Figure 5-2.

1. In the "Port No." dropdown menu, select the serial port corresponding to the sensor
2. Verify the baud rate is set to 115200
3. Click the "Refresh" button followed by the "Connect" button

⁵ Example: If the version query returns 01 02, it indicates the software version: V1.2.

4. The interface will then display human detection and gesture recognition results:

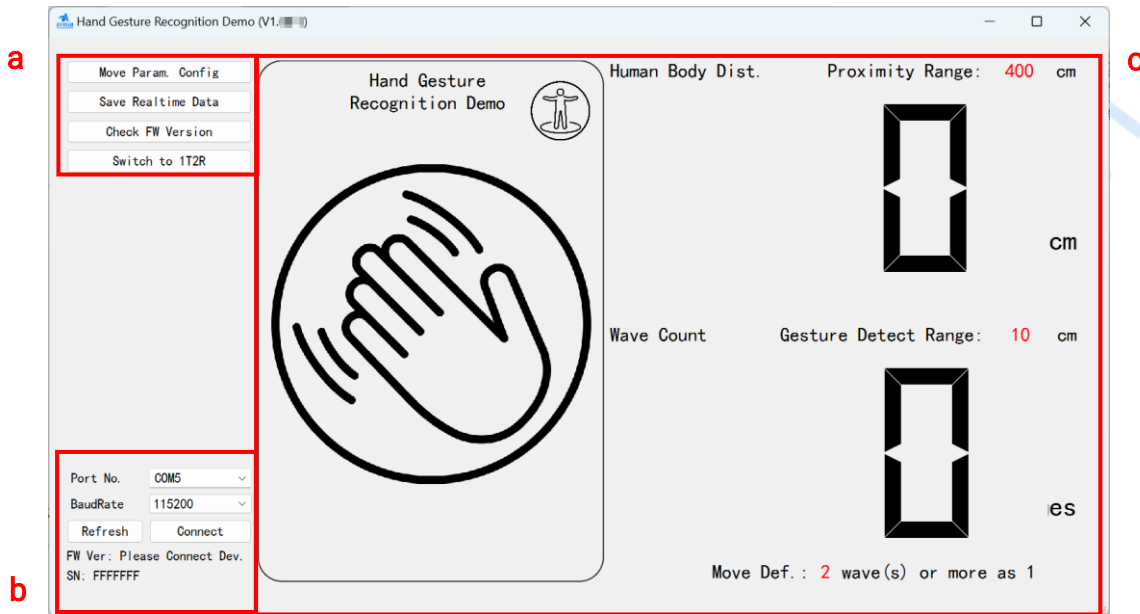


Figure 5-2 Demonstration tool of XenG101G

The main interface of the Hand Gesture Recognition Demo Tool is divided into three functional areas:

a) Function Button Area: Provides operational buttons for:

- Viewing/configuring sensor parameters
- Starting/stopping real-time data recording
- Querying firmware version information

b) Connection Display Area:

Manages hardware connections and displays information:

- Select the sensor's COM port
- Set communication baud rate (default: 115200)
- Connect/disconnect devices

Displays below:

- Sensor firmware version
- Hardware serial number (SN; user-definable, factory default: FFFFFFFF)

c) Real-Time Display Area:

Shows live detection results:

- Human Presence:
 - Icon background changes from gray to blue
 - Right panel displays detected distance (see Figure 5-3)
- Hand Wave Detection:
 - Wave icon background changes from blue to orange
 - Right panel shows wave counts within recognition time window (see Figure 5-4)

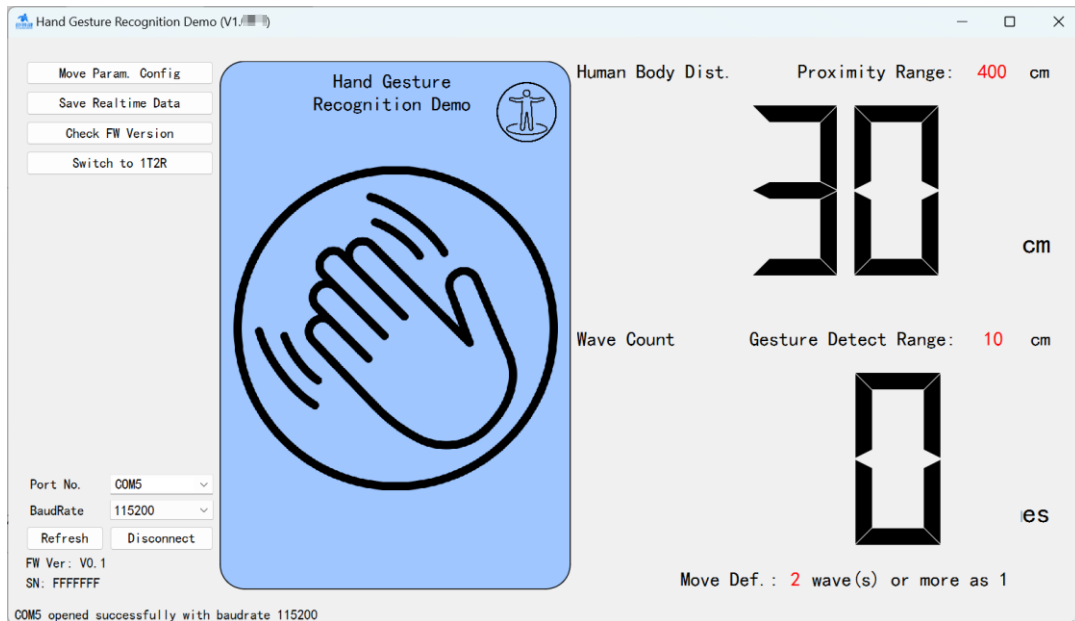


Figure 5-3 Tool interface when human presence is detected

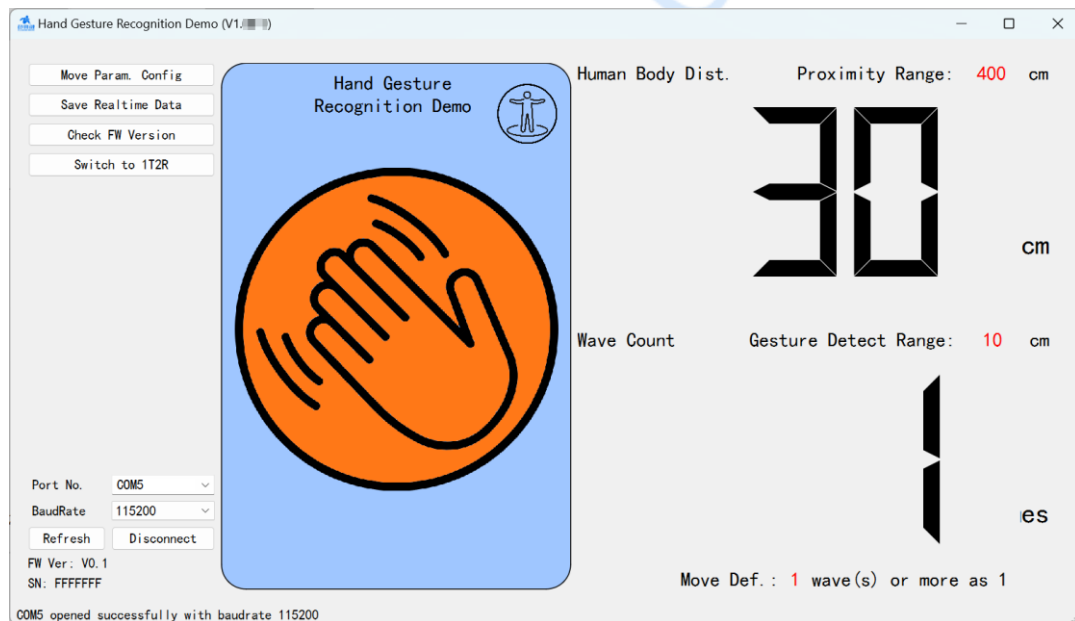


Figure 5-4 Tool interface when human presence and wave gestures are detected

5.2 Wave Gesture Configuration

Click the "Move Param. Config" button to access the "Parameters Configuration" page, where you can configure human detection and gesture recognition parameters for the current sensor, as shown in Figure 5-5.

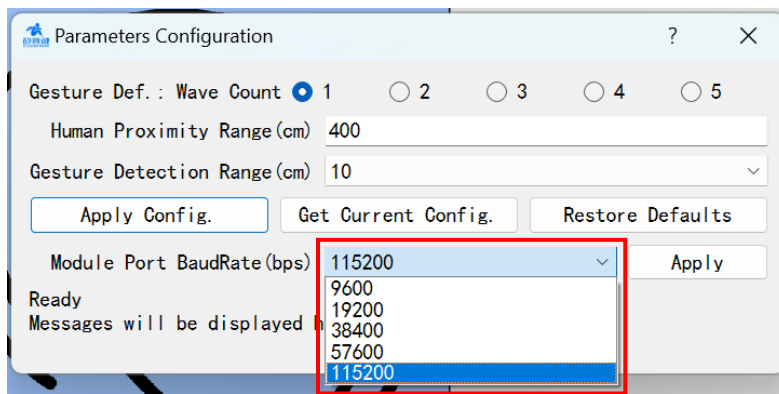


Figure 5-5 Parameters Configuration page

- Gesture Definition and Detection Range:
 - **Gesture Def.:** Allows users to set the minimum number of hand waves required to trigger reporting. Users can configure this based on their application scenario. For example, when this parameter is set to 3, the demo tool will only display wave counts when 3 or more waves are detected; otherwise, it shows "0 times".
 - **Human Proximity Range:** Allows users to define the maximum human detection distance (configurable from 20-400 cm in integer values).
 - **Gesture Detection Range:** Allows users to select the detection distance range for hand gestures (20 cm or 40 cm options).
- View/Modify/Restore Configuration:
 - **Apply Config.:** Writes user-defined parameters to the sensor.
 - **Get Current Config.:** Displays the sensor's current parameter settings.
 - **Restore Defaults:** Resets all parameters to factory default values.
- **Module Port BaudRate:** Allows users to select from multiple baud rate options. Click "Apply" button to activate the selected baud rate.

5.3 Save Realtime Data

- To save real-time detection data:
 1. Click the "Save Realtime Data" button in the main interface's function area (Area-a in Figure 5-2)
 2. The software will begin recording detection results
 3. The button text will change to "Stop Saving"
 4. The interface footer will display "Starting saving realtime data..." (see Figure 5-6)
- To stop data recording:
 1. Click the "Stop Saving" button
 2. The interface footer will show: "Realtime data saved to [Desktop]\[Radar Data]\YYYY-MM-DD_HH-MM-SS.txt"
 3. The button text will revert to "Save Realtime Data" (see Figure 5-7)
- Default log save path: [Desktop]\[Radar Data]\

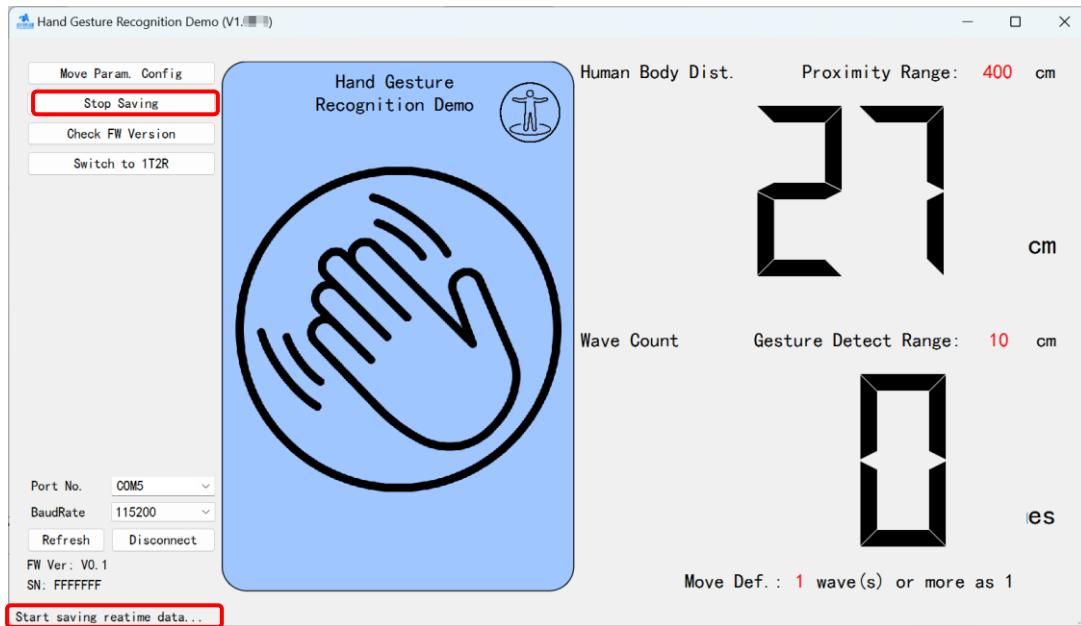


Figure 5-6 Start saving realtime data

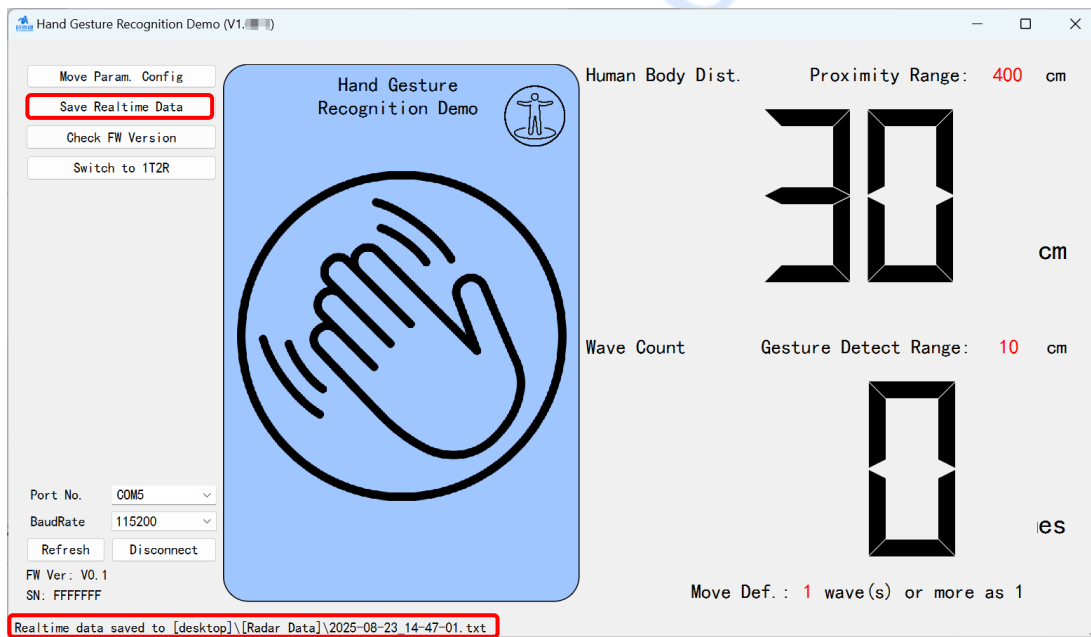


Figure 5-7 Stop saving realtime data

5.4 Check FW Version

Click the "Check FW Version" button on the interface to view the sensor firmware version information in the bottom-left corner, as shown in Figure 5-8.

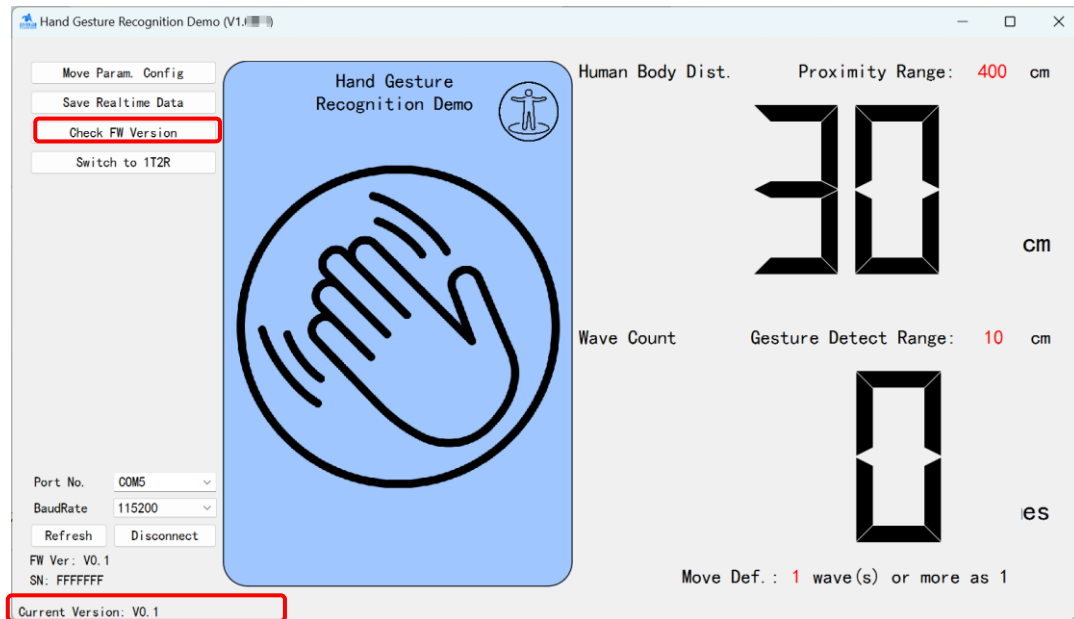


Figure 5-8 Succeed checking firmware version

6. Installation and Detection Instructions

6.1 Installation and Detection Range

The XenG101G sensor recommends wall-mounted installation. After installation, the sensor module plane should be perpendicular to the horizontal plane - the module's orientation does not affect human presence detection or gesture recognition performance. The recommended mounting height is 1.7 m.

The detection range after installation is as follows:

The XenG101G sensing area forms a sector pattern (see Figure 6-1):

Human motion detection area: 4 m radius sector centered on the sensor, with $\pm 75^\circ$ horizontal and elevation angles relative to radar normal

Gesture recognition area: 0.2 m radius sector centered on the sensor, with $\pm 75^\circ$ horizontal and elevation angles

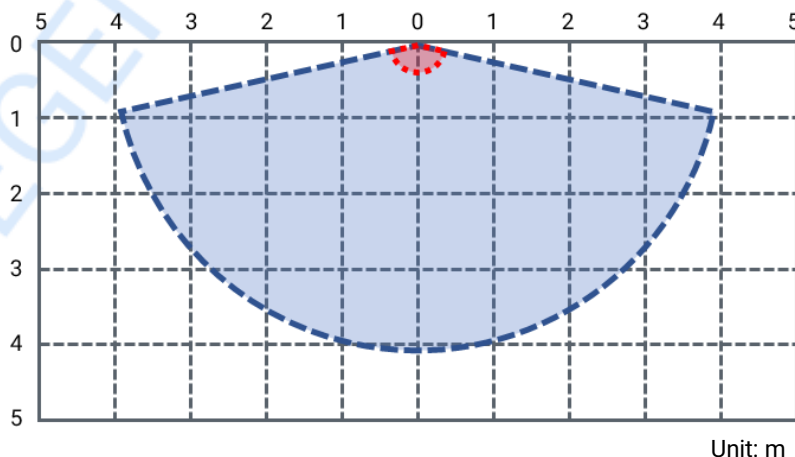


Figure 6-1 Sensor human motion detection range (blue area) and gesture recognition range (red area)

6.2 Hand Gesture Recognition Instructions

When using the mmWave sensor's gesture recognition function, note:

- Recognition distance: 10 cm or 20 cm
- Wave gesture requirements:
 - Palm facing radar directly
 - Horizontal wave span ≥ 30 cm (15 cm each side)
- Counting rules:
 - Waves detected within 1.5 sec are counted as one action (cumulative counting for continuous waves)
 - If wave interval > 1.5 sec, counting resets

6.3 Human Presence Detection Function

The mmWave sensor supports configurable human detection range: Maximum: 4 m, Minimum: 0.2 m

When a target enters detection range: Presence signal and distance output within 0.5 sec

After target leaves: Presence signal maintains for ~ 6 sec

7. Mechanical Size

Figure 7-1 shows the mechanical dimensions of the XenG101G hardware, with all units in millimeters (mm). The board thickness is 1.0 mm with a tolerance of $\pm 10\%$.

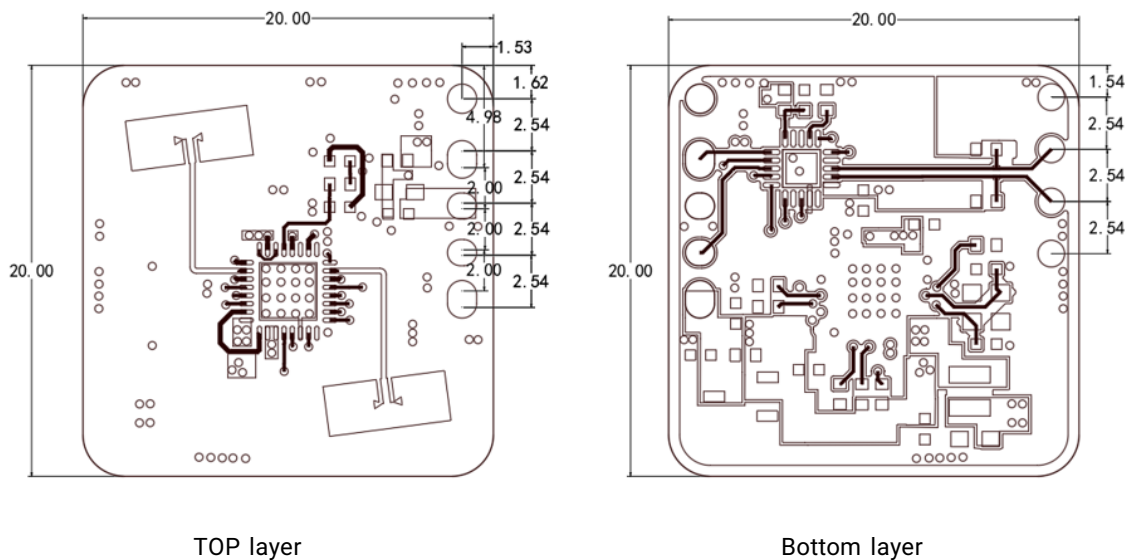


Figure 7-1 Mechanical size of hardware Xen101

8. Important Tips

8.1 Enclosure and Material Requirements

- The radar housing must provide good wave transparency in the 24 GHz band. Metal or electromagnetic shielding materials are prohibited.

- Do not apply conformal coating to the antenna area. If protection is necessary, avoid the antenna radiation surface.
- For additional design details, refer to the [mmWave Sensor Radome Design Guide⁶](#).

8.2 Installation Environment Requirements

Avoid the following interference-prone environments:

- Continuous movement of non-target objects (e.g., pets, swaying curtains, plants facing air vents) within the detection zone.
- Large-area, highly reflective surfaces (e.g., mirrors, metal plates) in the detection zone.
- When wall-mounted, avoid dynamic interference sources such as overhead air conditioners or fans.

8.3 Installation Guidelines

- Antenna Orientation: Face the detection area directly with no obstructions.
- Stability: Ensure secure mounting to prevent sensor vibration.
- Rear Interference:
 - Keep moving objects or vibrations at least 10 cm away from the radar's rear.
 - A metal backplate/shield may be added to suppress backlobe false detections.
- Multi-Radar Deployment: Avoid direct beam alignment and maintain spacing to reduce mutual interference.

8.4 Power and Electrical Requirements

- Voltage Range: 3.0–3.6 V or 4.5–5.5 V (with LDO regulator).
- Power Quality: Ripple must show no significant spectral peaks within 100 kHz; supports 180 mA peak current.
- EMC: Additional ESD protection and surge suppression circuits are required.

8.5 Gesture-Specific Notes

- Gesture Recognition: Excessively slow or deliberately static hand movements may fail to trigger detection.
- False Trigger Risk: Rapid lateral movement (e.g., a person crossing within 30 cm) may be misinterpreted as a hand wave.

9. Revision History

Revision	Date	Modification
1.0	2025/05/07	Initial release.
1.1	2025/10/15	Added Refresh Cycle to Table 2-1; Updated the GUI to V1.0.0.1.

⁶ If you need to obtain this document, you can download it from the official website or contact the corresponding sales personnel.

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