UM10047
XenD109M User Manual

Rev.0.9 User Manual

Introduction

This document introduces the basic functions, hardware specifications, and usage of the ICLEGEND MICRO (ICL) mmWave sensor reference design XenD109M, aiming to help users quickly get started with the compact, easy-to-develop AiP mmWave human detection sensor solution.

Table of Contents

1. XenD109M Overview

The XenD109M is a minimalist AiP human detection mmWave sensor reference solution developed based on the ICL111A chip. This solution utilizes FMCW waveform technology and incorporates proprietary human detection algorithms within the chip, enabling the detection of motion and micro-movement of human targets within a specified area and outputting detection results in real-time via pins. Based on this reference design, users can rapidly develop human detection products.

The hardware of XenD109M, Xen109, consists of the mmWave radar chip ICL111A and peripheral auxiliary circuits, available in two versions[1]: Xen109_S (square) and Xen109_L (rectangular), which are flexible for various applications such as wall-mounted and ceiling-mounted installations.

The main features of XenD109M include:

- Operating frequency band: 24 GHz ISM band
- Integrated intelligent mmWave radar AiP chip ICL111A with human detection algorithm
- Multiple operating modes: 2 distance modes, 6 detection range gates
- Extremely compact module size: 10 x 10 mm² (S version), 6 x 25 mm² (L version)
- Operating temperature: -40°C to 85°C
- Power supply: 3.3 V single power supply

2. System Characteristics

XenD109M offers two operating modes:

- Mode 1: With a maximum detection range of approximately 1.5 meters, it offers four distance detection settings: 0.6 meters, 0.9 meters, 1.2 meters, and 1.5 meters. Please note that the actual trigger distance may vary due to distance accuracy issues.
- Mode 2: With a maximum detection range of approximately 4.9 meters, it provides two distance detection settings: 3.6 meters and 4.9 meters. Similarly, the actual trigger distance may also vary due to distance accuracy issues.

The detection results for different range gates are indicated by corresponding pins in both operating modes.

The specifications of XenD109M are shown in Table 2-1.

Table 2-1 XenD109M characteristics

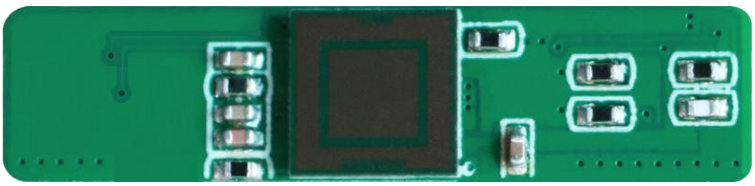
Parameter	Min.	Typ.	Max.	Unit	Description
Xen109 Hardware Characteristics					
Supporting frequency	24.00	-	24.25	GHz	FCC, CE, SRRC compliant
Max. sweeping bandwidth	-	250	-	GHz	-
Power supply	3.0	3.3	3.6	V	-
Size	-	10 × 10(S) 6 × 25(L)	-	mm^2	-
Ambient temperature	-40	-	85	°C	-
XenD109M System Characteristics					

[1] The functions and usage methods of the two hardware versions are the same; only the appearance differs.

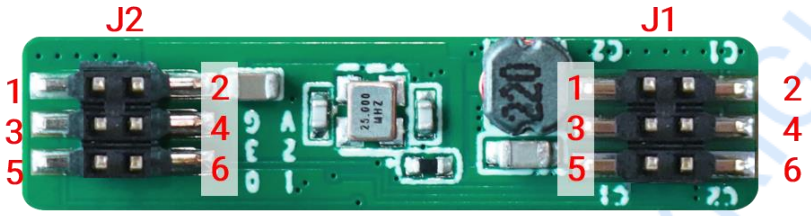
Mode 1 range gate	-	0.6/0.9/1.2/1.5	-	m	-
Mode 1 micro-motion detection range	-	1.5	-	m	-
Mode 1 motion detection range	-	1.5	-	m	-
Mode 1 field of view	-45	-	45	°	-
Mode 1 average current	-	85	-	mA	-
Mode 1 off time	-	2	-	s	-
Mode 2 range gate	-	3.6/4.9	-	m	-
Mode 2 micro-motion detection range	-	4	-	m	-
Mode 2 motion detection range	-	5	-	m	-
Mode 2 field of view	-60	-	60	°	-
Mode 2 average current	-	80	-	mA	-
Mode 2 off time	-	30	-	s	-
Note: In Mode 1, the distance accuracy is approximately 20 centimeters, and in Mode 2, the distance accuracy is approximately 40 centimeters. The actual trigger distance for the corresponding distance levels fluctuates around the typical values.					

3. Hardware Overview

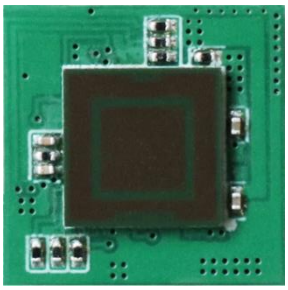
Figure 3-1 shows the top and bottom photos of the hardware Xen109_L and Xen109_S. The hardware reserves two interfaces, J1 and J2, where J1 is used for power supply and output detection results, and J2 is used for mode switching.



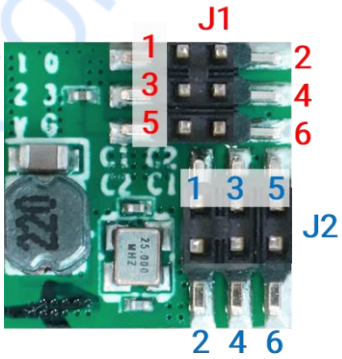
Xen109_L Top



Xen109_L Bottom



Xen109_S Top



Xen109_S Bottom

Figure 3-1 Photos of hardware Xen109_L and Xen109_S

Refer to Table 3-1 for the pin assignment of J1.

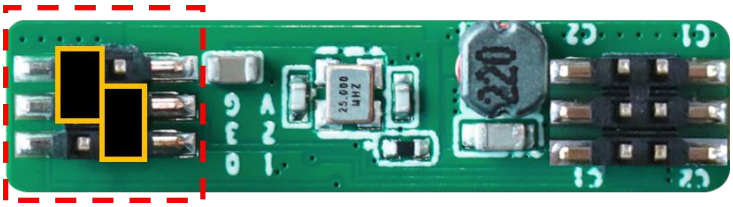
Table 3-1 J1 pin description

J#PIN#	Name	Function	Operating Range
J1Pin1	1	Mode 1: Indicate the detection results of range gate 2	High level means human presence is detected; Low level means no human is detected.
J1Pin2	0	Mode 1: Indicate the detection results of range gate 1	
J1Pin3	2	Mode 1: Indicate the detection results of range gate 3 Mode 2: Indicate the detection results of range gate 1	
J1Pin4	3	Mode 1: Indicate the detection results of range gate 4 Mode 2: Indicate the detection results of range gate 2	
J1Pin5	V	Power input	0 ~ 3.3 V
J1Pin6	G	Ground	-

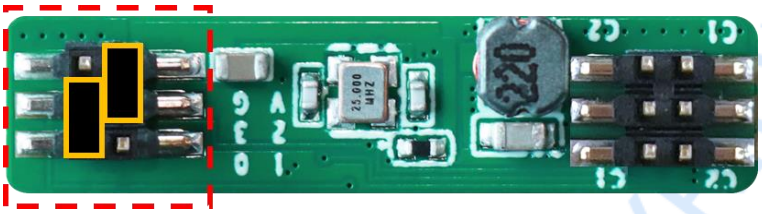
By connecting different pin combinations on J2 using jumpers, the operating mode of XenD109M can be switched:

- Connect pin 1 and pin 3, and pin 4 and pin 6 to enter operating mode 1;
- Connect pin 3 and pin 5, and pin 2 and pin 4 to enter operating mode 2.

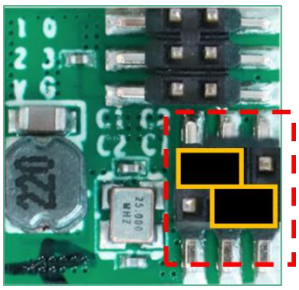
The specific connection methods are illustrated in Figure 3-2.



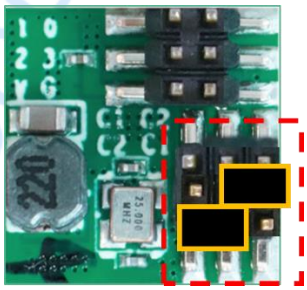
Xen109_L Mode 1



Xen109_L Mode 2



Xen109_S Mode 1



Xen109_S Mode 2

Figure 3-2 J2 pin connection methods for two operating modes

4. Application Instructions

XenD109M can directly output detection results via pins based on the built-in human detection algorithm. Users can connect the sensor module with the accompanying light board provided by ICL to observe the detection results. A physical image of the light board is shown in Figure 4-1. The connection methods for both hardware versions with the light board and serial tools are illustrated in Figure 4-2.

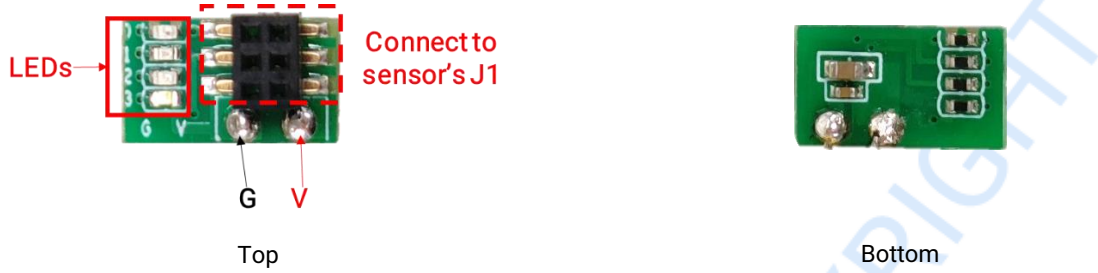
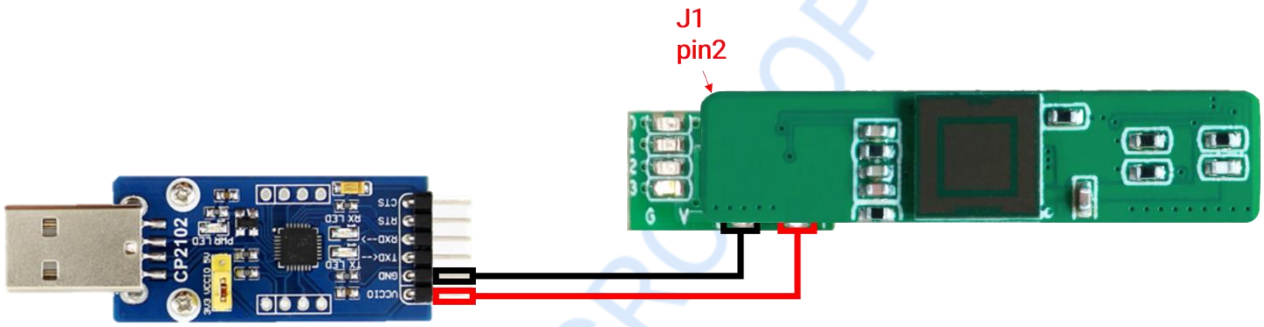
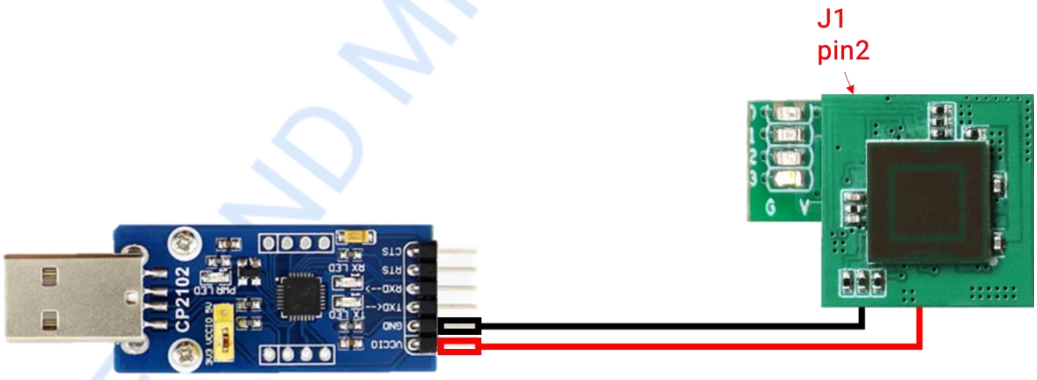


Figure 4-1 Light board top and bottom photos



Connection of Xen109_L to the light board and the serial port tool



Connection of Xen109_S to the light board and the serial port tool

Figure 4-2 Connection methods of Xen109 to the light board and the serial port tool

By connecting the XenD109M module through the serial port tool to the host computer, power can be supplied to the module, and all four LED lights on the light board will light up simultaneously. Once all the lights on the light board go out, the module's detection results will begin to be displayed. The relationship between the light patterns and the module's detection results are indicated in Table 4-1.

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

Operating Mode	Range Gate	Red	Green	Blue	White
Mode 1	Range gate 1 (0~0.6 m)	✔	✔	✔	✔
	Range gate 2 (0~0.9 m)	-	✔	✔	✔
	Range gate 3 (0~1.2 m)	-	-	✔	✔
	Range gate 4 (0~1.5 m)	-	-	-	✔
Mode 2	Range gate 1 (0~3.6 m)	-	-	✔	✔
	Range gate 2 (0~4.9 m)	-	-	-	✔

5. Installation Method

As shown in Figure 5-1, the typical installation method for XenD109M is wall-mounted, with a recommended installation height range of 1.5 to 2 meters. In this scenario, the maximum detection range is 4.9 m. During installation, it is necessary to consider potential obstructions and interferences in the application environment. For specific installation precautions, please refer to Chapter 7 Installation Requirements.

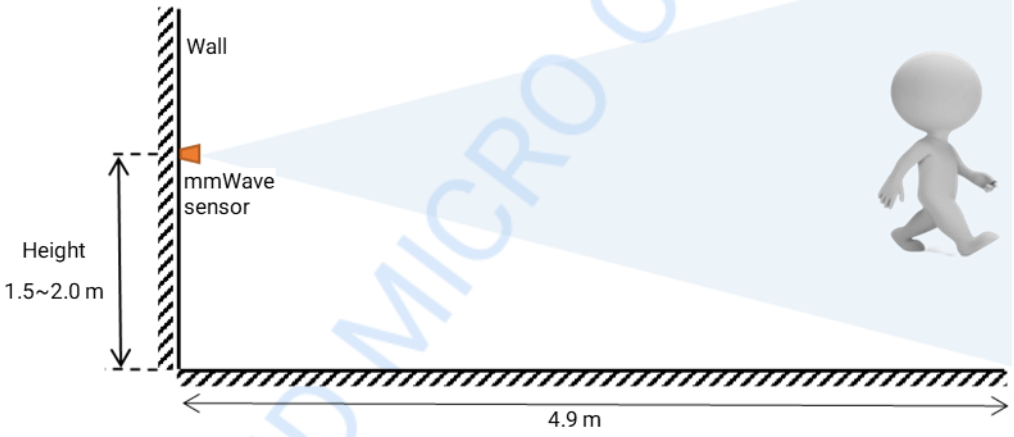
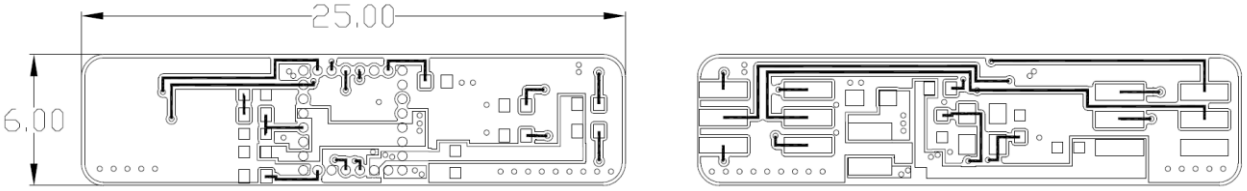


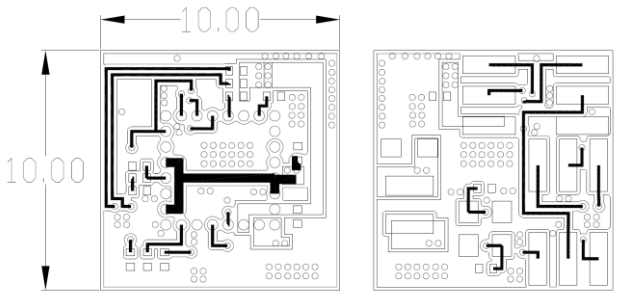
Figure 5-1 Illustration of XenD109M detection range when wall-mounted

6. Mechanical Size

The PCB mechanical dimensions of the two hardware versions of XenD109M are shown in Figure 6-1, with all dimensions in millimeters. The hardware board thickness is 1.00 mm, with a thickness tolerance of ±10%.



Xen109_L



Xen109_S

Figure 6-1 Hardware Xen109 mechanical size

7. Installation Requirements

7.1 Enclosure Requirements (if installation is needed)

If the sensor requires an enclosure, the enclosure must have good wave transmission characteristics in the 24 GHz frequency band. The enclosure material must not contain metals or substances that shield electromagnetic waves. For more considerations regarding enclosure design, please refer to the mmWave Sensor Radome Design Guide.

7.2 Installation Environment Requirements

This product must be installed in a suitable environment. Detection effectiveness will be compromised if used in the following environments:

- Continuous movement of non-human objects within the sensing area, such as animals, persistently swaying curtains, and large green plants directly facing air vents.
- Presence of large reflective surfaces within the sensing area, as objects with strong reflectivity facing the antenna may cause interference.
- When installing on a wall, external interference factors such as air conditioners and ceiling fans located at the indoor ceiling should be considered.

7.3 Precautions During Installation

- Ensure that the antenna faces the area to be detected and that the surroundings around the antenna are unobstructed.
- The installation position of the mmWave sensor must be secure and stable, as any movement of the sensor itself will affect detection effectiveness.

- Ensure that no objects are moving or vibrating behind the mmWave sensor. Due to mmWave's penetrating nature, the back lobe of the antenna may detect moving objects behind the sensor. A metal shield or metal backplate can be used to shield the back lobe of the antenna and reduce the impact of objects behind the sensor.
- In the presence of multiple 24 GHz mmWave sensors, avoid installing them with their beams facing each other and try to keep them far apart to prevent possible mutual interference.

7.4 Power Supply Precautions

A power input of 3.3 V is recommended. Please refer to Chapter 3 of this document for hardware specifications. Additionally, this design serves as a reference, and users need to consider corresponding electromagnetic compatibility designs for ESD and lightning surge protection.

8. Revision History

Revision	Date	Modification
0.9	2024/12/18	Initial draft.

Important Notice

ICLEGEND MICRO provides technical and reliability data (including Datasheets), design resources (including reference designs), application or other design advice, web tools, safety information, and other resources (hereinafter referred to as “these resources”) “as is” and with all faults, and disclaims all warranties, express and implied, including without limitation any implied warranties of merchantability, fitness for a particular purpose or non-infringement of third-party intellectual property rights.

ICLEGEND MICRO reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

These resources are intended for skilled developers designing with ICLEGEND MICRO products. You are solely responsible for (1) selecting the appropriate ICLEGEND MICRO products for your application, (2) designing, validating and operation of your applications and products throughout the lifecycles, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice.

ICLEGEND MICRO grants you permission to use these resources only for development of the application that uses ICLEGEND MICRO products described in this resource. Without the permission of ICLEGEND MICRO, any company or individual shall not extract or copy part or all of the content of these resources, shall not disseminate it in any form. No license is granted to any other ICLEGEND MICRO intellectual property right or to any third party intellectual property right. ICLEGEND MICRO disclaims responsibility for, and you will fully indemnify ICLEGEND MICRO and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

ICLEGEND MICRO products are provided subject to ICLEGEND MICRO’s Terms of Sale or other applicable terms. ICLEGEND MICRO’s provision of these resources does not expand or otherwise alter ICLEGEND MICRO’s applicable warranties or warranty disclaimers for ICLEGEND MICRO products.

附录

（供内部评审参考，发布时请将本页删除！）

模版版本变更记录

模板版本	模版负责人	修订时间	修订内容
V2.0	杜琼琼	2023/11/16	添加附录。

文档版本变更记录

文档版本	文档负责人	修订时间	修改记录
0.9	杜琼琼	2024/12/18	初稿。