

Introduction

This document introduces the reference design of ICLM intelligent screen management mmWave sensor XenD103HP, including its basic functions, hardware specification, software configuration, and installing condition etc.

The goal of this document is to guide users to get started with XenD103HP intelligent screen management sensor quickly and easily, so that users can sort out suitable parameters for specified scenarios, and can design both precise and customized human presence detection sensors.

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1. XenD103HP Overview

The XenD103HP is an intelligent screen management reference design of ICLM EZ Sensor series. It contains a minimalist 24 GHz radar sensor hardware XenD103 and an intelligent algorithm firmware HPS01.

The XenD103 hardware incorporates an AIoT mmWave sensor SoC S3KM111L, high-performance 24 GHz 1T1R antennas, and peripheral circuits. The intelligent algorithm firmware HPS01 applies FMCW waveform and S3KM111L specified advanced signal processing technology. This reference design is mainly applied to common indoors scenarios such as home, office and hotels for human presence detection.

The XenD103 hardware adopts extreme narrow frame design which empowers it with excellent performance and ultra-compact size. XenD103HP applies intelligent range measurement algorithm for further improving the range accuracy, and its maximum range for human presence detection is 6 m. The reference design provides a visualization tool that allows users to modify radar key parameters such as maximum detectable range, sensibility of each range gate, and absence report delay (refer to 9 Important Tips). XenD103HP works in two modes: when a target is detected, its report frequency is 10 Hz so as to sense the target continuously; when there is no target in the detection range, its report frequency is 1 Hz so as to save power. XenD103HP supports the UART interface and also supports Plug and Play.

The main features of XenD103HP are listed below:

- 24 GHz ISM bandwidth
- Integrate single-chip smart mmWave sensor S3KM111L and intelligent algorithm firmware
- Precise indoors human presence and range measurement
- Compact module size: 7 mm × 35 mm
- 3.3 V single power supply, support a wide voltage range of 3.0 V ~ 3.6 V
- Average operating current of 33 mA@10 Hz report frequency
- Average operating current of 3.4 mA@1 Hz report frequency
- Load default setting of human presence detection, support Plug and Play
- Provide a visualization tool, support configuring detection range and sensibility of each range gate
- Maximum human presence detection range up to 6 m
- Azimuth angle $\pm 45^\circ$, pitch angle $\pm 60^\circ$
- Wall mounted

XenD103HP intelligent screen management sensor can detect motion, micro-motion and motionless human body. It can be widely applied to various AIoT scenarios, and they are as follows:

- **Smart Home**
Detecting human presence, reporting results in real time, enabling the MCU to control smart domestic appliances accordingly.
- **Smart Business**
Detecting human approach or leaving in specified range to turn on/off devices, keeping devices on when human presence is detected.
- **Intelligent Security**
Entrance control, building intercom, visual doorbell etc.
- **Intelligent Lighting**
Detecting human body presence and location precisely, applicable to public lighting, various motion-sensor lights, LED bulbs etc.
- **Medical and Aged Care**
Detecting vital signs such as respiration and heartbeats and the human presence in real time.

2. System Characteristics

XenD103HP is an intelligent screen management sensor reference solution developed based on ICLM mmWave sensor chip S3KM111L. It detects human in specified range and reports detection results in real time by incorporating FMCW, radar signal processing, and built-in intelligent human presence detection algorithm. With this reference solution, users can quickly develop customized human presence detection products with high precision.

The systematic characteristics of XenD103HP are shown in Table 2-1:

Table 2-1 XenD103HP characteristics

Parameter	Condition	Min.	Typ.	Max.	Unit
XenD103 Hardware Characteristics					
Supporting frequency		24	-	24.25	GHz
Max. bandwidth	Configurable on host PC side	-	0.25	-	GHz
Power supply		3.0	3.3	3.6	V
Size		-	7 × 35	-	mm × mm
Environment temperature		-40	-	85	°C
XenD103HP System Characteristics					
Detection range	Motion/motionless human target	-	6	-	m
Range resolution	Motion/motionless human target	-	0.75	-	m
Detection accuracy		-	0.15	-	m
Operating frequency	In accordance with FCC, CE and RC certification standards	24.025	-	24.24	GHz
Bandwidth		-	0.215	-	GHz
EIRP		-	14	-	dBm
Average operating current	Report cycle 100 ms	-	33	-	mA
Average operating current	Report cycle 1 ms	-	3.4	-	mA

3. Hardware Overview

Device maps of hardware XenD103HP are shown in Figure 3-1. XenD103 hardware reserves 4 pins (default without contact pin) called J1 for power supply and communication; 3 pins called J2 for programming the MCU. Please pay attention to the connection of the RW pins before programming the board.

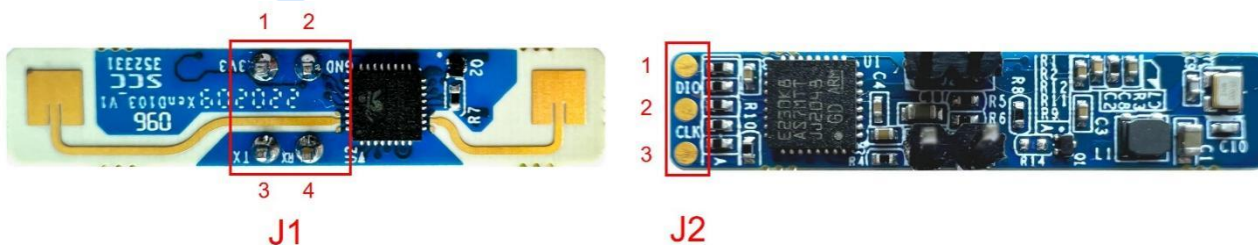


Figure 3-1 Top and bottom device map of XenD103HP

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

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	GND	Ground	-
J1 Pin3	TX	UART_TX.	0 ~ 3.3 V
J1 Pin4	RX	UART_RX	0 ~ 3.3 V

Table 3-2 J2 pin description

J#PIN#	Name	Function	Operating Range
J2 Pin1	GND	Ground	-
J2 Pin2	DIO	Data port	0~3.3V
J2 Pin3	CLK	Clock signal	0~3.3V

XenD103 supports Keil5 IDE programming, and either hex or source project can be programmed via a programmer such as J-Link (revisions no earlier than V9) and CMSIS-DAP. Make sure you have installed [GigaDevice.GD32E23x_DFP.1.0.1.pack](#) and [ARM.CMSIS.5.6.0.pack](#), or later versions.

4. Software Overview

XenD103HP is released with firmware HPS01 programmed into the system. ICLM provides a visualization software tool that can configure XenD103HP from the host PC, users can optimize detection results by adjusting parameters according to the applied scenarios.

4.1 Firmware Description

XenD103HP radar reference design can detect the human presence (motion & motionless) up to 6 m by default setting. Default parameters are listed in Table 4-1, and users can configure these parameters according to actual scenarios.

Table 4-1 XenD103HP default parameter description

Parameter	Operating Range	Default Value	Description
Max. range gate	2 ~ 8	8	75 cm per range gate
Absence report delay	0 ~ 65535 s	5 s	
Motion Sensibility	1 ~ 100	0 ~ 1 range gate: 50 2 ~ 5 range gate: 40 6 ~ 8 range gate: 30	
Motionless Sensibility	1 ~ 100	0 ~ 1 range gate: 0 2 ~ 5 range gate: 40 6 ~ 8 range gate: 15	By default, there is no motionless target detect in range gate 0 ~ 1

The default output data from the radar contains target state, radial range (motion & motionless), and energy value (motion & motionless). Users can send Enable Engineering Mode to the radar by ticking Engineering Mode on the visualization tool or sending the command via serial port (see [5.2.6 Enable Engineering Mode](#)). Then, in addition to the basic information listed above, radar will report energy value of each range gate, which is called engineering data. For details of radar output data protocol please refer to [5.3 Output Protocol](#).

4.2 Visualization Tool Description

4.2.1 Visualization Tool Overview

The ICLM_XenD103Tool is a portable software specially developed for XenD103, it displays and records radar data after connecting XenD103 with the host PC, and allows users to configure radar parameters.

Instructions for using the visualization tool are as follows:

Step 1: Download [ICLM_XenD103Tool.zip](#) from [ICLM website](#), unzip the pack with an unzip software such as 7z, and enter the directory;

Step 2: Connect the XenD103HP module with the host PC via a serial port tool, as shown in Figure 4-1;

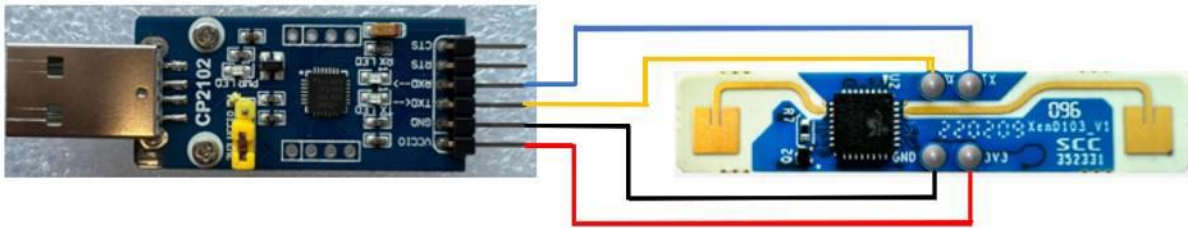


Figure 4-1 Connection of serial port tool and XenD103

Step 3: Double click **ICLM_XenD103Tool.exe** under the directory **XenD103Tool/**, the graphical user interface (GUI) will appear as shown in Figure 4-2.



Figure 4-2 GUI of the ICLM_XenD103Tool

The GUI can be partitioned into 5 zones, they are Serial Port and Data Format (Zone 1), Parameter Information (Zone 2), Sensibility Statistics (Zone 3), Target Information (Zone 4), and Engineering Mode (Zone 5). The function of each zone is described as follows:

Serial Port and Data Format	obtain the serial port number of the radar, configure the baud rate and data format (Engineering Mode);
Parameter Information	configure and display radar parameters, including Maximum Range Gate (motion & motionless), Absence Report Delay, sensibility statistics of each

	range gate (motion & motionless), and Duration of Range Detection (s/m/h);
Sensibility Statistics	display the largest energy value of all range gates (motion & motionless) for each frame of radar data and update in real-time;
Target Information	display the basic information of the target, including the presence state (motion / motionless / absent) and the distance to the radar;
Engineering Mode Display	when Engineering Mode is ticked, this zone will display the energy value of each range gate in curves for both motion target and motionless target; the real-time energy value is depicted in red curve, and sensibility is depicted in a green curve; when the sensibility configuration is modified, the green curve will update accordingly; in the Detected Distance graph, the yellow curve represents the radial distance of the target detected in the latest 120 s, and the background color of the chart represents the motion state of the target, with red represents motion target, and green represents the motionless target.

4.2.2 Visualization Tool Guide

The visualization tool provides multiple operations, including Connect Device, Start/Stop Data Transmission, Read/Configure Parameter, and Configure Sensibility.

Connect Device

Step 1: Connect the radar module with host PC using a USB serial port tool, as shown in Figure 4-1. Double click **ICLM_XenD103Tool.exe** and the GUI will appear as shown in Figure 4-2.

Step 2: Click the **Refresh** button and select the serial port number of the radar. If there is more than one serial port number in the list, choose the one that communicates with the radar module.

Step 3: Type in the baud rate in the **Baud Rate** text box; please note that the baud rate must match the radar firmware baud rate, see [Chapter 9](#) for more details.

Step 4: Click the **Connect Device** button; after the connection is successfully established, the Start button appears clickable.

Start/Stop Data Transmission

Step 1: After the Connect Device operation, click the **Start/Stop** toggle button to start the data transmission with the radar. Zone 2 ~ Zone 4 will display information about the detected target.

If Engineering Mode is ticked, Zone 5 will display the energy value of each range gate (motion & motionless).

Please note that during data transmission, users cannot modify radar parameters.

Step 2: Click the **Start/Stop** toggle button to stop receiving and parsing data, and the visualization tool is available for users to configure radar parameters.

Read/Configure Parameter

Step 1: Make sure the radar is successfully connected to the host PC and the **Start/Stop** toggle button displays Start (if not, click the **Start/Stop** toggle button to stop receiving and parsing data);

Step 2: Read, modify, or reset radar parameters:

- To read radar parameters, click the **Read** button;
- To modify radar parameters, type in desired values in Zone 2, and click the **Config** button, then the host PC will send the new parameters to the radar.
- To reset radar parameters back to default settings, click the **Reset** button and the host PC will send default settings to the radar.

Configure Sensibility

Step 1: After the Connect Device operation, click the **Sensi...** button and a Sensibility Configuration window will appear, as shown in Figure 4-3.

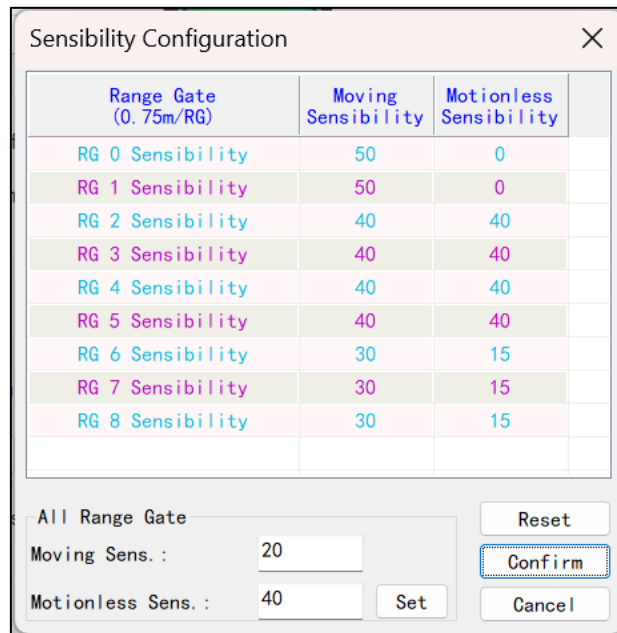


Figure 4-3 Sensibility Configuration

Step 2: There are 3 different ways to set the sensibility values of all the range gates:

- To set all the sensibility values (motion & motionless) to an identical value,
 - type the desired values in the two text boxes at the bottom of the window;
 - click the **Set** button to save the data;
 - click the **Confirm** button to send the new settings to the radar.
- To set all sensibility values (motion & motionless) back to default settings;
 - click the **Reset** button to replace current settings with default ones;
 - click the **Confirm** button to send the new settings to the radar.
- To set different sensibility values to different range gates,
 - double click the table cell that needs to be modified;
 - type in the desired value;
 - click the **Confirm** button to send the new settings to the radar.

After reading or configuring radar parameters, click the **Start/Stop** toggle button on the visualization GUI, and the radar will work with updated parameters and report detecting results in real-time.

Each time users start the data transmission, the visualization tool will generate a log file under **Log** directory for further development.

The working flow of the visualization tool is presented in Figure 4-4.

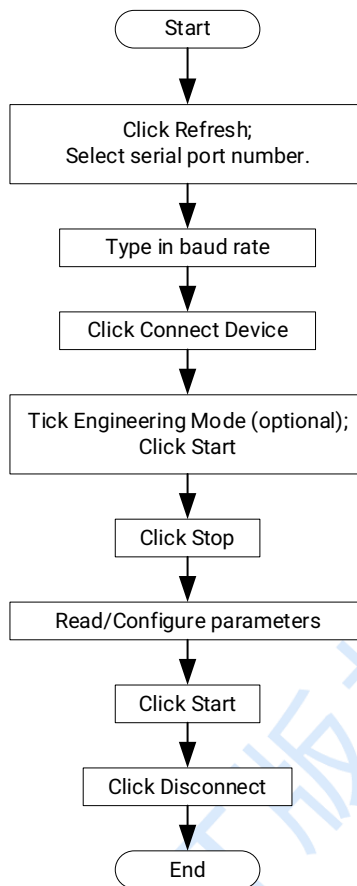


Figure 4-4 Work flow of operations on visualization tool

5. Communication Protocol

This communication protocol is mainly for users who need to develop products without the visualization tool. Users can build communication with XenD103 via serial port (TTL electrical level). The baud rate of the radar serial port is 256000 by default with 1 stop bit and no parity check digit.

5.1 Format

5.1.1 Data Format

XenD103HP adopts the little-endian data format, and all the data presented in the following tables are hexadecimal.

5.1.2 Command Frame Format

Radar configuration and ACK command frame formats are defined as shown in Table 5-4.

Table 5-1 Configuration command frame

Head	Data Length	Data Value	Tail
FD FC FB FA	2 bytes	Refer to Table 5-2	04 03 02 01

Table 5-2 Data format inside the configuration command

Command Word	Command Value
2 bytes	N bytes

Table 5-3 ACK command frame

Head	Data Length	Data Value	Tail
FD FC FB FA	2 bytes	Refer to Table 5-4	04 03 02 01

Table 5-4 Data format inside the ACK

Command Word & 0x0100	Return Value
2 bytes	N bytes

5.2 Command and ACK

5.2.1 Read Firmware Version

This command is for reading the firmware revision information of the radar.

Command Word: 0x0000

Command Value: None

Return Value: 2 bytes ACK state (0-succeed, 1-fail) + 2 bytes product type(0x8004) + 2 bytes firmware type (0x0000) + 2 bytes major revision number + 2 bytes minor revision number + 2 bytes patch revision number

Sending data:

Head	Byte 5, 6	Byte 7, 8	Tail
FD FC FB FA	02 00	00 00	04 03 02 01

ACK from radar(succeed):

Head	Byte 5, 6	Byte 7, 8	Byte 9, 10	Byte 11, 12	Byte 13, 14	Byte 15, 16	Byte 17, 18	Byte 19, 20	Tail
FD FC FB FA	0E 00	00 01	00 00	04 80	00 00	0x1 00	0x 00	0x 00	04 03 02 01

5.2.2 Enable Configuration

Before sending any other commands, an Enable Command should be sent. Otherwise, these commands will be ineffective.

Command word: 0x00FF

Command value: 0x0001

Return value: 2 bytes ACK state (0-succeed, 1-fail) + 2 bytes protocol revision (0x0001) + 2 bytes buffer size(0x0040)

Sending data:

Head	Byte 5, 6	Byte 7, 8	Byte 9, 10	Tail
FD FC FB FA	04 00	FF 00	01 00	04 03 02 01

ACK from radar(succeed):

Head	Byte 5, 6	Byte 7, 8	Byte 9, 10	Byte 11, 12	Byte 13, 14	Tail
FD FC FB FA	08 00	FF 01	00 00	01 00	40 00	04 03 02 01

5.2.3 End Configuration

After sending the End Command, no other command will be effective until an Enable Command is sent again.

Command word: 0x00FE

¹ x in this table represents revision number.

Command value: None

Return value: 2 bytes ACK state (0-succeed, 1-fail)

Sending data:

Head	Byte 5, 6	Byte 7, 8	Tail
FD FC FB FA	02 00	FE 00	04 03 02 01

ACK from radar(succeed):

Head	Byte 5, 6	Byte 7, 8	Byte 9, 10	Tail
FD FC FB FA	04 00	FE 01	00 00	04 03 02 01

5.2.4 Configure Maximum Range Gate and Absence Report Delay

This command configures radar maximum range gate (motion & motionless) (parameter range 2 ~ 6), and the absence report delay (parameter range 0 ~ 65535 s). For more details please refer to Table 5-5.

Command word: 0x0060

Command value: 2 bytes maximum motion range gate word + 4 bytes maximum motion range gate parameter + 2 bytes maximum motionless range gate word + 4 bytes maximum motionless range gate parameter + 2 bytes absence report delay word + 4 bytes absence report delay parameter

Return value: 2 bytes ACK state (0-succeed, 1-fail)

Table 5-5 Parameter Word Description

Parameter Name	Parameter Word
Maximum Motion Range Gate	0x0000
Maximum Motionless Range Gate	0x0001
Absence Report Delay	0x0002

Sending data: Maximum Range Gate (motion & motionless) is 6, Absence Report Delay is 5 s

Head	Byte 5, 6	Byte 7, 8	Byte 9, 10	Byte 11 ~ 14	Byte 15, 16	Byte 17 ~ 20	Byte 21, 22	Byte 23 ~ 26	Tail
FD FC FB FA	14 00	60 00	00 00	06 00 00 00	01 00	06 00 00 00	02 00	05 00 00 00	04 03 02 01

ACK from radar(succeed):

Head	Byte 5, 6	Byte 7, 8	Byte 9, 10	Tail
FD FC FB FA	04 00	60 01	00 00	04 03 02 01

5.2.5 Read Radar Parameter

This command reads the current configuration parameters of the radar.

Command word: 0x0061

Command value: None

Return value: 2 bytes ACK state (0-succeed, 1-fail) + head (0xAA) + maximum motion range gate parameter + maximum motionless range gate parameter + motion range gate 0 sensibility + motion range gate 1 sensibility + ... + motion range gate N sensibility + motionless range gate 0 sensibility + motionless range gate 1 sensibility + ... + motionless range gate N sensibility + absence report delay (2 bytes)

Sending data:

Head	Byte 5, 6	Byte 7, 8	Tail
FD FC FB FA	02 00	61 00	04 03 02 01

ACK from radar: (succeed, maximum range gate is 6, range gate for motion target is 5, range gate for motionless target is 4, sensibility of motion target is 20, sensibility of motionless target 25, absence report delay is 3 s)

Head		Byte 5, 6	Byte 7, 8	Byte 9, 10	Byte 11	Byte 12	Byte 13	Byte 14	Byte 15	Byte 16	Byte 17	Byte 18					
FD	FC	FB	FA	18	00	61	01	00	00	AA	06	05	04	14	14	14	14
Byte 19	Byte 20	Byte 21	Byte 22	Byte 23	Byte 24	Byte 25	Byte 26	Byte 27	Byte 28	Byte 29, 30	Tail						
14	14	14	19	19	19	19	19	19	19	03	00	04	03	02	01		

5.2.6 Enable Engineering Mode

This command switches on Engineering Mode for the radar. In this mode, the radar additionally reports energy values for each range gate. For more details, please refer to [5.3.2 Target Data Composition](#).

Command word: 0x0062

Command value: None

Return value: 2 bytes ACK state (0-succeed, 1-fail)

Sending data:

Head	Byte 5, 6	Byte 7, 8	Tail								
FD	FC	FB	FA	02	00	62	00	04	03	02	01

ACK from radar(succeed):

Head	Byte 5, 6	Byte 7, 8	Byte 9, 10	Tail									
FD	FC	FB	FA	04	00	62	01	00	00	04	03	02	01

5.2.7 Disable Engineering Mode

This command switches off Engineering Mode. For more details related to radar report data format, please refer to [5.3.2 Target Data Composition](#).

Command word: 0x0063

Command value: None

Return value: 2 bytes ACK state (0-succeed, 1-fail)

Sending data:

Head	Byte 5, 6	Byte 7, 8	Tail								
FD	FC	FB	FA	02	00	63	00	04	03	02	01

ACK from radar(succeed):

Head	Byte 5, 6	Byte 7, 8	Byte 9, 10	Tail									
FD	FC	FB	FA	04	00	63	01	00	00	04	03	02	01

5.2.8 Configure Range Gate Sensibility

This command configures sensibilities for each range gate. It can either configure individual range gate or configure the sensibility of multiple range gates to the same value. When setting multiple range gates to the same value, please configure the Range Gate Value as 0xFFFF. Parameter words refer to Table 5-6.

Command word: 0x0064

Command value: 2 bytes range gate word + 4 bytes range gate value + 2 bytes motion sensibility word + 4 bytes motion sensibility value + 2 bytes motionless sensibility word + 4 bytes motionless sensibility value

Return value: 2 bytes ACK state (0-succeed, 1-fail)

Table 5-6 Parameter word for sensibility configuration

Parameter Name	Parameter Word
Range Gate	0x0000
Motion Sensibility Word	0x0001
Motionless Sensibility Word	0x0002

Sending data: range gate 3, motion sensibility 15, motionless sensibility 25

Head	Byte 5, 6	Byte 7, 8	Byte 9, 10	Byte 11 ~ 14	Byte 15, 16	Byte 17 ~ 20	Byte 21, 22	Byte 23 ~ 26	Tail
FD FC FB FA	14 00	64 00	00 00	03 00 00 00	01 00	0F 00 00 00	02 00	19 00 00 00	04 03 02 01

ACK from radar(succeed):

Head	Byte 5, 6	Byte 7, 8	Byte 9, 10	Tail
FD FC FB FA	04 00	64 01	00 00	04 03 02 01

Sending data: for all range gates, motion sensibility 15, motionless sensibility 25

Head	Byte 5, 6	Byte 7, 8	Byte 9, 10	Byte 11 ~ 14	Byte 15, 16	Byte 17 ~ 20	Byte 21, 22	Byte 23 ~ 26	Tail
FD FC FB FA	14 00	64 00	00 00	FF FF 00 00	01 00	0F 00 00 00	02 00	19 00 00 00	04 03 02 01

ACK from radar(succeed):

Head	Byte 5, 6	Byte 7, 8	Byte 9, 10	Tail
FD FC FB FA	04 00	64 01	00 00	04 03 02 01

Return Value: 2 bytes ACK state (0-succeed, 1-fail)

5.3 Output Protocol

XenD103HP outputs the detection results through the serial port. By default, it reports the basic information of the target, including target state, motion target energy, motionless target energy, motion target distance, and motionless target distance. When the Engineering Mode is ticked, it will report the energy level of each range gate (motion & motionless) at the same time. All radar data frame is reported in accordance with the protocol.

5.3.1 Output Report Format

According to the protocol, the report data frame formats of the radar are shown in Table 5-7 and Table 5-8. The data type values for normal mode and Engineering Mode are presented in Table 5-9.

Table 5-7 Output report format

Head	Data Length	Data Value	Tail
F1 F2 F3 F4	2 bytes	Refer to Table 5-8	F5 F6 F7 F8

Table 5-8 Data frame format

Data Type	Head	Target Data	Tail	Check
1 byte (refer to Table 5-9)	0xAA	Refer to Table 5-10 and Table 5-12	0x55	0x00

Table 5-9 Description of data type

Data Type Value	Description
0x01	Engineering mode data
0x01	Target basic information data

5.3.2 Target Data Composition

Radar report data changes based on whether it is in Enable Engineering Mode. The radar reports the target basic information by default, and when it is in Enable Engineering Mode, the radar will additionally report the energy level of each range gate. This means that the target's basic information is always reported, while the energy levels of each range gate are only reported when the radar is in Enable Engineering Mode command.

The data format of the basic information of the target is shown in Table 5-10, the definition of Target State Value is shown in Table 5-11, and the data format of the reported data in Engineering Mode is shown in Table 5-12.

Table 5-10 Composition of target data

Target State	Motion Target Distance (cm)	Motion Target Energy	Motionless Target Distance(cm)	Motionless Target Energy
1 byte	2 bytes	1 byte	2 bytes	1 byte

Table 5-11 Description of target state value

Target State Value	Description
0x00	No target detected.
0x01	Motion target detected.
0x02	Motionless target detected.
0x03	Motion and motionless targets detected.

Table 5-12 Composition of target data in engineering mode

...	Motionless Target Distance	Energy of Motionless Target	Max. Motion Range Gate N	Max. Motionless Range Gate N	Energy of Motion Range Gate 0	...	Energy of Motion Range Gate N	Energy of Motionless Range Gate 0	...	Energy of Motionless Range Gate N
...	2 bytes	1 byte	1 byte	1 byte	1 byte	...	1 byte	1 byte	...	1 byte

5.4 Guide to Configure the Radar

5.4.1 Steps of Configuration

A complete process of carrying out a command consists of the radar receiving a command and sending an ACK message back. If no ACK message or a failed ACK is sent from the radar, that means the radar failed to implement the latest command.

Before sending any command to the radar, users must send an Enable Command. Then users should send configuration command(s) within in predefined time window (refer to [5.4.2 Notifications of Configuration](#)). After sending all the configuration commands, an End Command should be sent to the radar to end the configuration process.

For example, to read the configuration of the radar, there are 3 steps:

Step 1: Send an **Enable Command** to the radar, users should receive a successful ACK from the radar;

Step 2: Send the **Read Parameter Command**, users should receive the second successful ACK;

Step 3: Send an **End Command**, users should receive a third successful ACK.

The flow chart of the communication process is shown in Figure 5-1.

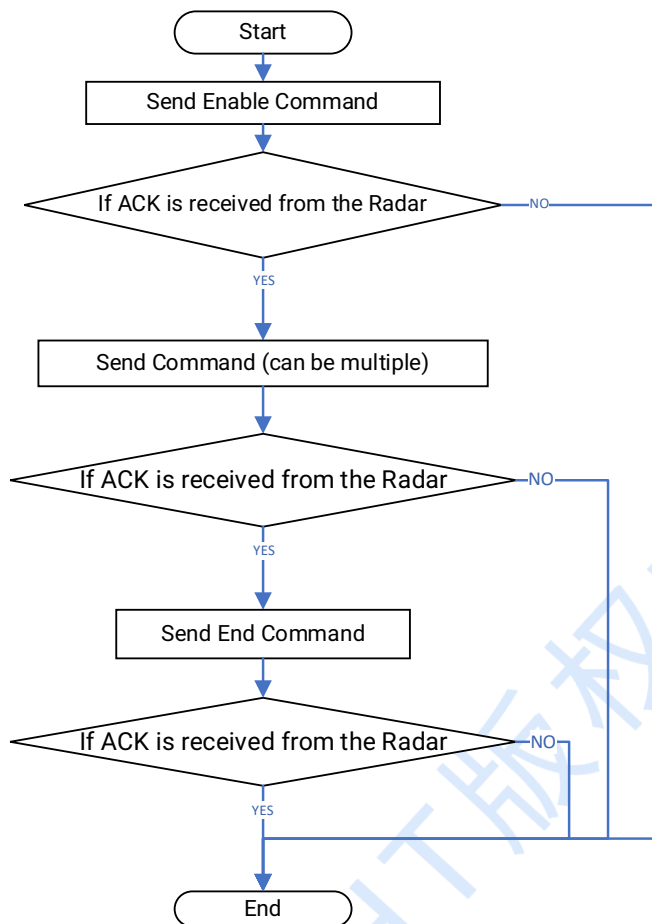


Figure 5-1 Flow chart of configuring or commanding the radar

5.4.2 Notifications of Configuration

Timeout: Before sending any command to the radar, an Enable Command should be sent. As soon as the radar receives this command, a timer of 3 s will start when the radar is waiting for the commands. When the timer is running, the radar receives and implements configuration command(s), and each time a command is received, the timer will restart timing. During this time, the radar only responds to configuration commands and does not report detection data. When no command is received before the 3 s timer ends, the radar will automatically exit the configuration process and start detecting targets and reporting detection results. If there is a need to configure the radar again, another Enable Command should be sent to the radar.

6. Installation and Detection Range

The typical installation method of XenD103HP is wall mounted, the range detection accuracy is ± 15 cm, and the maximum detection range is 6 m with default setting.

The recommended installation height of wall mounted method is 0.7 ~ 2 m.

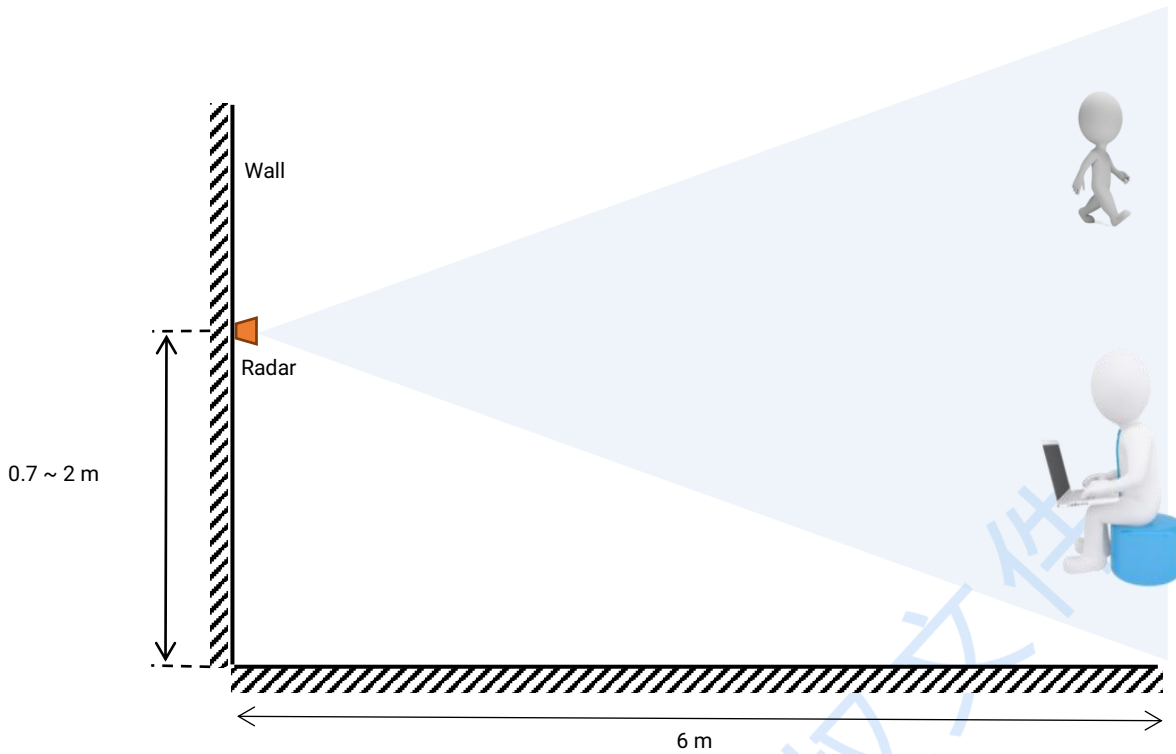


Figure 6-1 Illustration of wall-mounted installation

When wall mounted, as shown in Figure 6-1, the normal direction of the radar antennas is defined as 0° , the angle of its left side is positive, and the right side is negative, as shown in Figure 6-2.

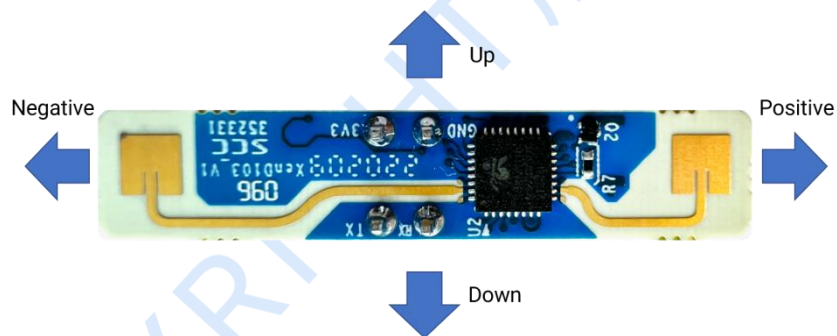


Figure 6-2 Radar direction definition when wall mounted

Figure 6-3 shows the detection range of the radar with an installation height of 1.5 m (the tester is 1.72 m and medium-sized). The field of view is $\pm 60^\circ$, and the maximum detection range is 6 m.

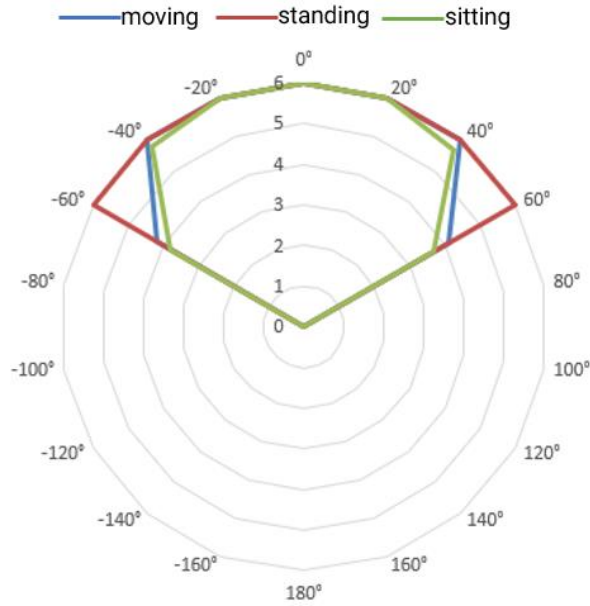


Figure 6-3 The detection range of the radar when wall mounted (range unit m)

7. Mechanical Size

Figure 7-1 presents the mechanical size of XenD103 hardware. The board thickness is 1.6 mm with a tolerance of $\pm 10\%$.

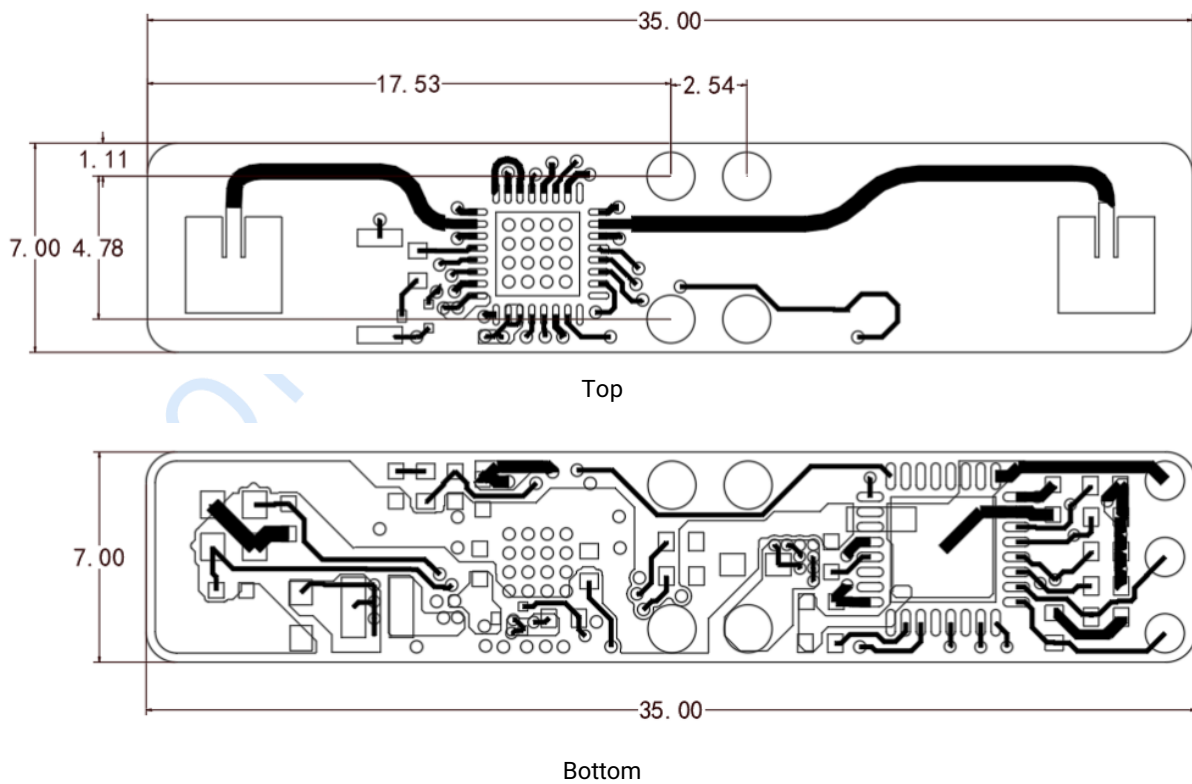


Figure 7-1 XenD103 mechanical size

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. For more details please refer to [Guide of mmWave Sensor Antenna Radome Design](#)² .

Installation Environment

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

- Continuous moving non-human objects in the 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 radar antennas are facing squarely to desired detection area with a clear field of view.
- Ensure the installation position of the sensor is solid and stable. The motion of the radar itself can hugely impact signal processing.
- Ensure there is no object moving or vibrating behind the radar. Motion behind antennas can also be detected due to the penetrability of radar RF wave, thus interfering with detection accuracy. It is recommended to use a radome or a backplane to reduce interference.
- When there are multiple 24 GHz radars installed in close areas, make sure their beamforming does not face each other, and try to separate them as far as possible to avoid interference.

Power Supply

XenD103HP supports power voltage ranges of 3.0 V ~ 3.6 V, and the power ripple should show no obvious spectral peaks within 100 kHz. Additionally, developers should take EMC designs such as ESD and lightning surge into consideration.

9. Important Tips

Maximum Detection Range

The maximum detection range of XenD103HP is 6 m. Within this range, the radar will report the direct distance of the target (both motion and motionless). While within 1.5 m, radar only reports the distance of the motion target instead of the motionless target.

Modifying Firmware Baud Rate

XenD103HP default baud rate 256000. It can be modified through the macro USART_BAUDRATE defined under the engineering directory \Middleware\platform\gd32\inc\gd32_uart.h.

Start-up Time

After the radar starts up, it is able to report a motion target within 200 ms, and it is able to report a motionless target within 3 s.

² Currently, only Chinese version is available.

Range Accuracy

Theoretically, the range accuracy of the XenD103HP reference design is 0.15 cm (as a result of specialized algorithmic processing based on 0.75 m physical resolution). The range accuracy may slightly fluctuate due to the size, motion state, and RCS of the target.

Time Limit for Programming

It is suggested to finish the programming process of XenD103 within 3 s after powering up, or after sending the Enable Configuration Command to the radar.

Absence Report Delay

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

10. Revision History

Revision	Date	Modification
1.1	2023/4/17	Initial release.
1.2	2023/6/1	Add EULA to the visualization tool; update the figures of the visualization tool.

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