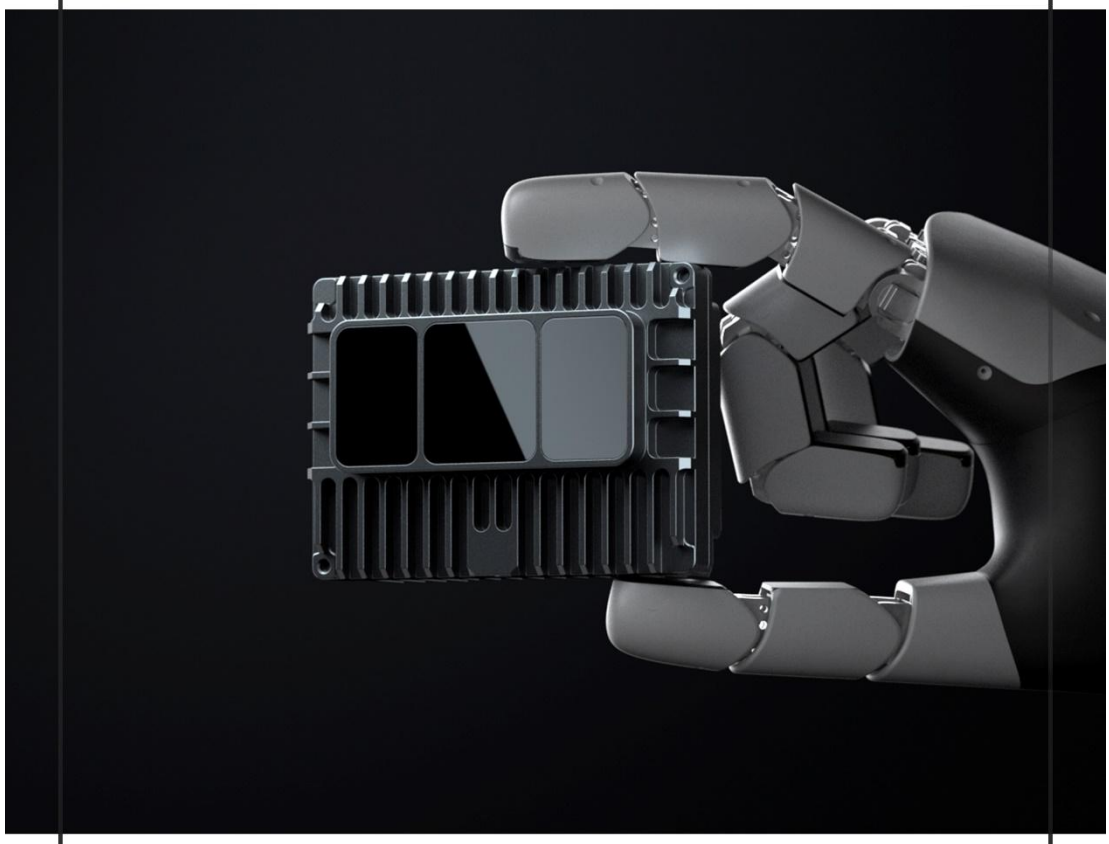
robosense

E1R

User Guide



Version 1.0

Change description

Version	Revision Date	Description
1.0	2025/01/02	Initial release

Reading Prompt

Symbolic instructions

⚠ Warning: The usage process should be strictly followed, otherwise it may lead to potential dangerous situations such as minor injuries or property damage.

! Important: The usage process should be observed, otherwise it may cause potential harmful situations such as product damage.

ⓘ Tip: The usage process should be valued sufficiently to achieve maximum value of the product efficiently and smoothly.

Resource Download

Please click the following link to download the latest product manual, RSview and other resources:

https://www.robosense.cn/resources

More Information

Manufacturer: Suteng Innovation Technology Co., Ltd. (RoboSense).

Website: https://www.robosense.cn/

FAE: support@robosense.cn

Address: Building 9, Block 2, Zhongguan Honghualing Industry Southern District, 1213 Liuxian Avenue, Taoyuan Street, Nanshan District, Shenzhen, China

Phone: 0755-86325830

Email: service@robosense.cn (new email address)

Working Hours: Monday to Friday, 9:00 AM to 6:00 PM (GMT/UTC +8)

Content

1 Safety Notices

1.1 Legal Statement

⚠ Unless otherwise stated, all rights (including copyrights, trademarks, patents, trade secrets, and other related rights) in RoboSense's products, technologies, software, programs, data, and other information (including text, icons, photographs, audio, video, graphics, color combinations, layout design, etc.) are owned by RoboSense and its licensors.

⚠ No one may use any content contained in this manual in any unauthorized manner without the prior written consent of RoboSense.

⚠ The words "RoboSense", "速腾聚创", and other logos and product and service names are owned by RoboSense. If you need to use them for any advertising or display purposes, you must obtain prior written authorization from RoboSense.

1.2 User Guidelines

⚠ Please use this product in accordance with the following requirements:

1) Please strictly abide by relevant national laser safety laws and regulations;
2) Please read this product manual in detail before using the product;
3) Please use this product only in the relevant field of application;
4) Please avoid using this product in environments that are explosive, highly corrosive, or beyond the IP protection level of the equipment.

1.3 Illegal Operation

⚠ Please use this product in accordance with the regulations, otherwise it may cause product damage, property loss, and personal injury. Users are responsible for risk arising from unauthorized operations.

1) Do not disassemble or modify this product (including accessories);

2) Do not use power supplies and accessories that exceed specifications;
3) Please avoid abnormal operations such as dropping, colliding, burning, etc.;
4) If you notice any damage to the appearance of the device, please immediately stop using it;
5) If you notice any abnormal operation of the product, please immediately stop using it and contact RoboSense in a timely manner.

1.4 Requirements for Operating Personnel

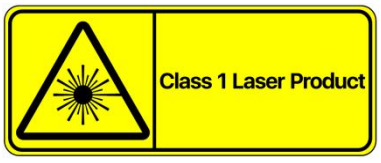
⚠ The use of this product requires certain basic professional knowledge and other related requirements for operating personnel. Unreasonable operations performed by personnel without basic knowledge or training do not constitute a fault of RoboSense and may cause damage to equipment and personal property.

1) Please read the product manual in detail before using the device;
2) Prohibit illegal operations;
3) Before working, personnel must undergo training and obtain relevant construction qualifications;
4) Have some basic knowledge of computer data connection, electrical, and so on.

1.5 Work Safety and Special Hazards

⚠ To avoid risks of accidents, damage to sensor or violating of your product warranty, please read and follow the instructions in this manual carefully before operating the product.

1) Laser Safety: This product meets the following standards for laser products: IEC 60825-1:2014;：



2) High temperature warning: Please pay attention to the overheating sign on

the LiDAR surface to avoid a hot LiDAR surface that may lead to sensor failure or undesirable consequences.

3) Retain Instructions: The safety and operating instructions should be retained for future reference.
4) Heed Warnings: All warnings on the product and in the operating instructions should be adhered to.
5) Servicing: Except for what's described in this manual, the sensor has no field serviceable parts. For servicing, please contact RoboSense sales or the authorized distributors.

2 Product Description

2.1 Product Structure

The shape and size diagram of E1R is shown in Figure 1 .

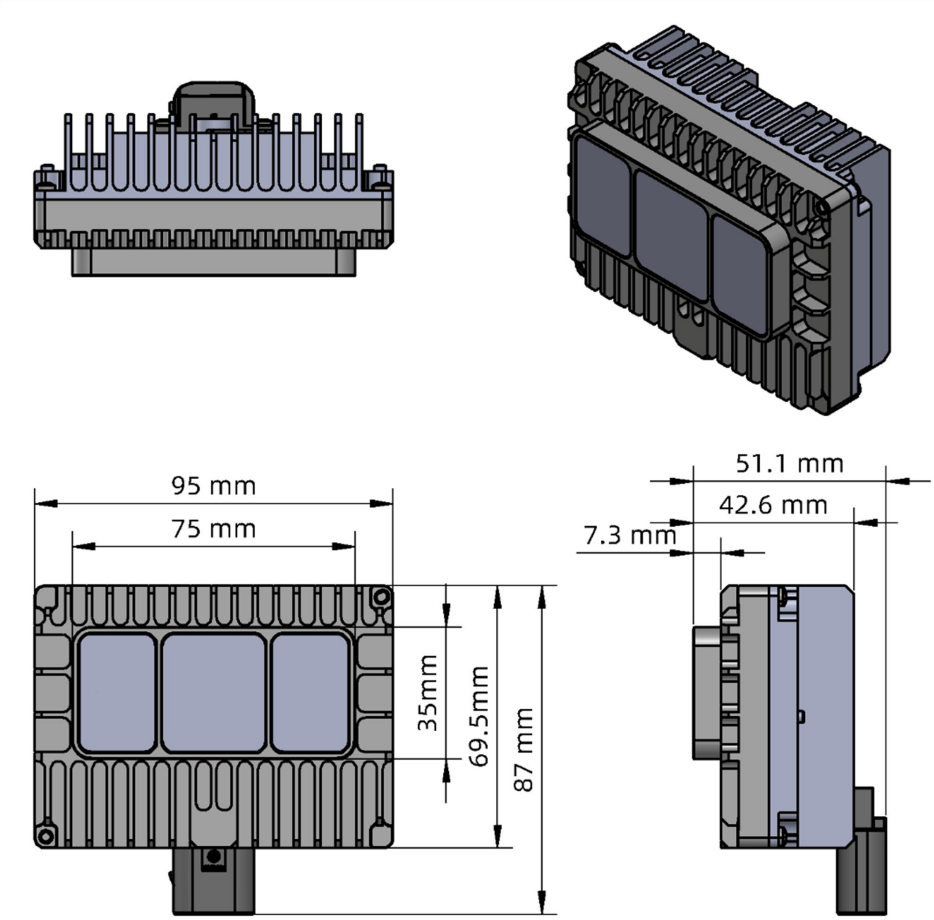


Figure 1 E1R shape and size diagram

2.2 Optical Envelope FOV Definition

The optical envelope of the E1R is shown in Figure 2 . After all limits are accumulated, the optical envelope of the LiDAR cannot be blocked by exterior parts of the vehicle, such as LiDAR cover, roof panel, engine hood, and front bumper, which may block the field of view (FOV) of some parts. Figure 3 shows the FOV diagram of E1R.

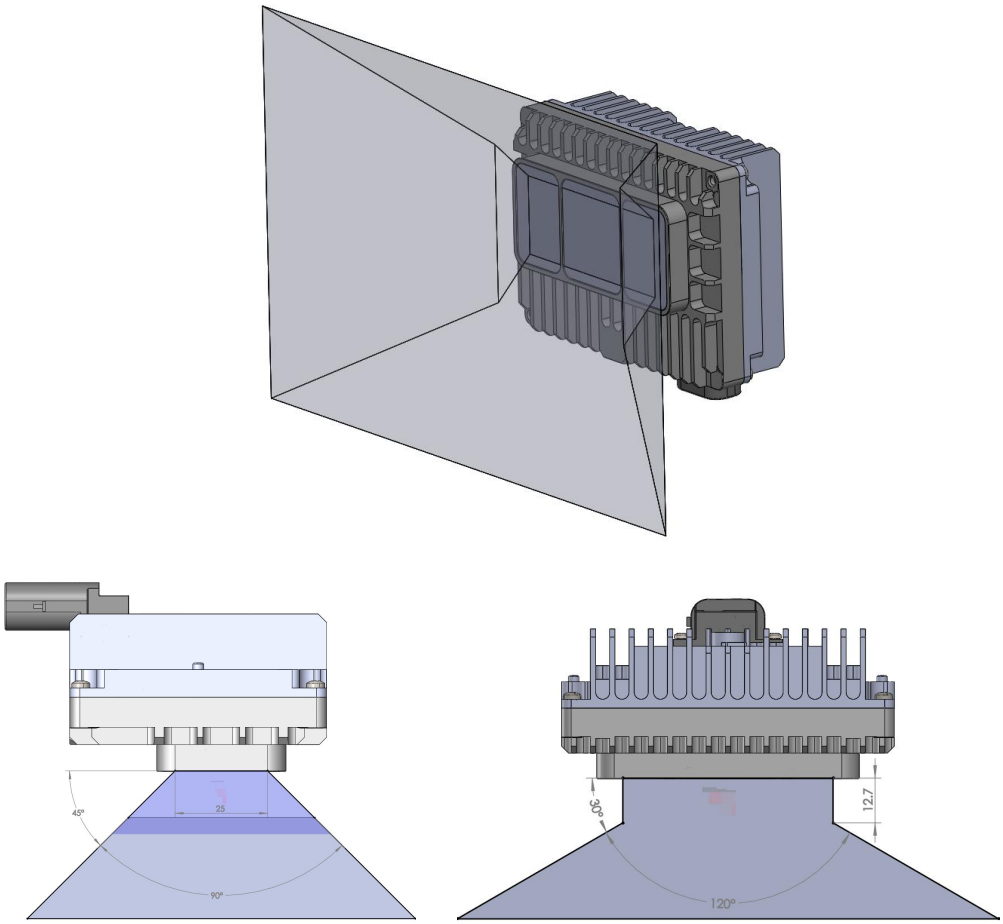


Figure 2 E1R FOV

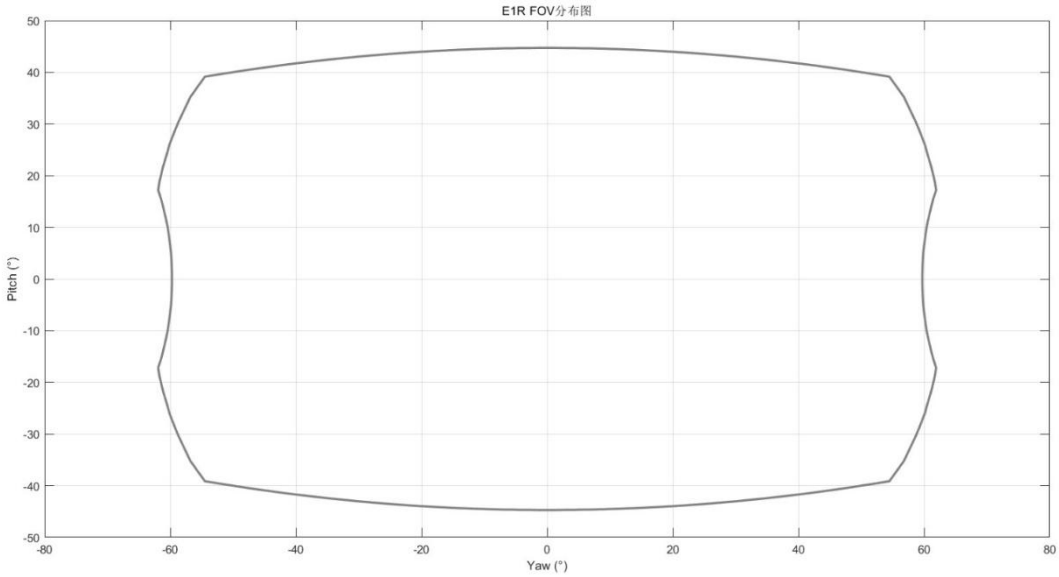


Figure 3 E1R FOV diagram

2.3 Product Specifications

The E1R uses a flash scanning method to measure distances up to 30 meters. Each frame produces a high number of points, at a rate of 26,000 points. The horizontal range of the scan is 120° (-60.0° to +60.0°), while the vertical range is 90° (-45° to +45°). For more details, please refer to Table 1.

Table 1 E1R Product Specifications

E1R Product Specifications			
Ranging principle	Time of Flight	FOV(horizontal)	120°（-60.0°~+60.0°）
Wavelength	940 nm	FOV(vertical)	90°（-45°~+45°）
safety class	Class1 eye safe	Angular resolution(horizontal)	average 0.625°[1]
Ranging distance [2]	30m @10% NIS, 100klux direct sunlight	Angular resolution(vertical)	
Blind area	0.1 m	Ranging Precision[3]	±5cm@1 sigma
Count of the points	~260,000 points/second	Ethernet transmission rate	1000Base-T1 Gigabit Ethernet
Time Synchronization	gPTP（IEEE-802.1AS） PTP E2E L2（IEEE-1588）	Operating Voltage	9V - 16V
Frame rate	10 Hz	Weight	330 g±20 g (only LiDAR)
Power Consumption[4]	<10 W	Storage Temperature:	- 40℃ ~ + 105℃
Operating Temperature [5]	- 40℃ ~ + 85℃	Protection Rating	IP67 / IP6K9K

[1] The vertical & horizontal angular resolution is not uniform in the entire FOV. The angular resolution is 0.625° in the center of the FOV and 0.7° at the edges of the FOV;
[2] The ranging capability of 30meters is measured with the 10% NIST diffuse reflector as the target, the test results may be affected by the environment conditions, including but not limited to factors such as ambient temperature and lights;
[3] The ranging precision is tested in the range of 10m~30m with 50% NIST diffuse reflector as the target. The test results may be affected by the environment conditions, including but not limited to factors such as ambient temperature and target distance. The precision value is applicable to most channels, but difference may exist between some channels.
[4] The test results of product power consumption will be affected by external environment, including but not limited to environmental temperature, distance of target object, reflection intensity of target object and other factors;
[5] The operating temperature of the product may be affected by the external environment, including but not limited to the lighting environment, air flow changes and other factors;

Table 1 (Continued table)

Size	Name	length（mm）	width（mm）	height（mm）
Size	Outer Contour	95	42.6	69.5
	Outer contour of main body with connector and installation position contour	95	51.1	87

2.4 Product Principle

2.4.1 Accurate Time Synchronization Protocol

The default firmware of E1R uses the gPTP (IEEE 802.1AS) time synchronization method.

2.4.1.1 Principle of gPTP synchronization

gPTP (general Precision Time Protocol) is a derived protocol from PTP (Precision Time Protocol) in Time-Sensitive Networking. The synchronization mechanism uses the same P2P end-delay mechanism as PTP, and it adopts communication at the Layer 2 of Ethernet. Unlike PTP, gPTP requires hardware timestamping, which imposes strict requirements on switches and master clocks (IEEE 802.1AS protocol is required).

2.4.1.2 gPTP wiring Method

To use the gPTP synchronization method, you need to make the following preparations, and then connect according to the connection method shown in the Figure 3 。

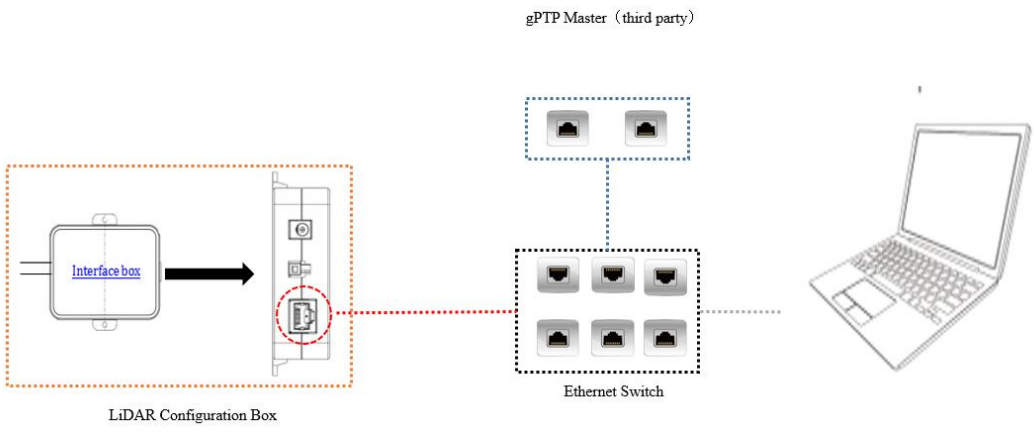


Figure 4 gPTP Connecting Diagram

1) Prepare a gPTP Master timing host (plug and play, no additional configuration required);
2) Ethernet switch;
3) Device supporting gPTP protocol.

Note

1) The Master timing equipment is a third-party equipment that needs to be purchased by the user independently, which is not included in the RoboSense standard product shipping package.;
2) RoboSense devices, as Slave devices, only obtain the time from the Master and do not judge the accuracy of the Master clock source. If there are sudden changes in the time resolution of the LiDAR point cloud, please check if the provided time by the Master is accurate.
3) After the LiDAR is synchronized, the Master is disconnected, and the time in the point cloud data packet will be superimposed according to the LiDAR's internal clock, and it will be reset after the LiDAR is powered off and restarted.

2.4.2 Use Linuxptp tool to verify time synchronization

Connect the E1R power cable and network cable to the Interface Box, and then connect the other end of the network cable to the upper computer. The operating system (OS) of the upper computer must be a Linux system, and here we take Ubuntu as an example.

1) Use the command $ifconfig to check the network card name. As shown in the figure, the network card name is enp2s0.

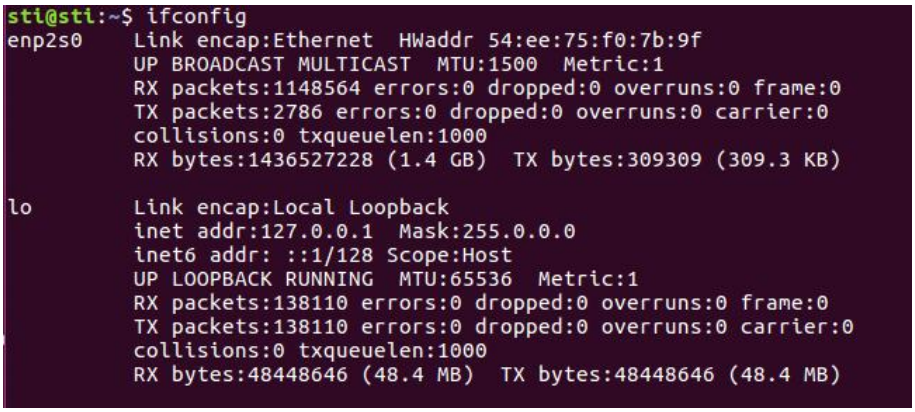


Figure 5 Illustration of Finding Network Card Name

2) Use the command $ ethtool -T enp2s0 (the network card name obtained in the previous step), you can check if this card supports PTP hardware. For gPTP synchronization, hardware support is required, and the PTP Hardware Clock option requires a value other than none.

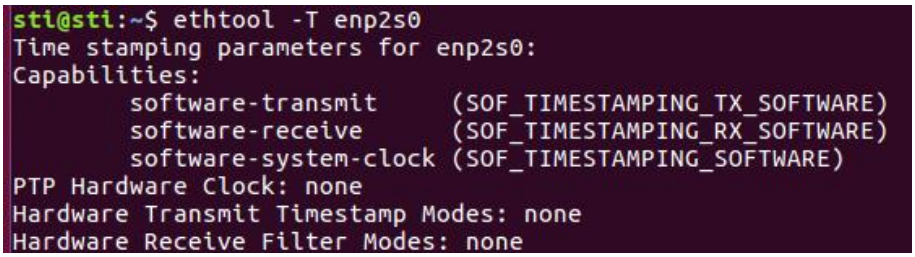


Figure 6 Illustration of checking PTP hardware support

3) Download and install the linuxptp tool.

$sudo git clone git://git.code.sf.net/p/linuxptp/code linuxptp

$cd linuxptp

$sudo make

$sudo make install

$reboot

4) The use of the ptp4l command.

Here are some options for using the ptp4l command:

a) Delay mechanism options

-A Automatic mode, automatically selects the E2E delay mechanism when receiving a peer delay request and switches to P2P mode.

-E E2E mode, request-response delay mechanism (default)

-P P2P mode, end-to-end delay mechanism

b) Network transport options

-2 IEEE 802.3

-4 UDP IPV4 (default)

-6 UDP IPV6

c) Timestamp options

-H Hardware timestamp (default)

-S Software simulation timestamp

-L The old hardware timestamp", and LEGACY_HW requires cooperation with PHC devices.

d) Other options

-f [file] Read configuration from the specified file. By default, no configuration file is read.

-i [dev] Select the PTP interface device, such as eth0 (can be specified multiple times). The dev parameter must be used with this option or a port is specified in the configuration file.

-p [dev] This option is used to specify the PHC device to be used on older Linux kernels (such as /dev/ptp0 clock device), the default is auto, ignoring both software/ LEGACY_HW time stamps (not recommended to use this option)

-s SlaveOnly mode, overrides the clock mode from the configuration file

-t Transparent clock mode

-l [num] Set the logging level to 'num', the default is 6

-m Print messages to stdout

-q Don't print messages to syslog

-v Print software version and exit

-h Help command

Additionally, here are some simple commands for synchronizing E1R using the PTP protocol:

1) PTP E2E (L2 layer) command:

   $sudo ptp4l -E -S -2 -m -i enp2s0(the name of the network card)

   The device requires hardware support for PTP Hardware Clock, and it is not a "none" value. In this case, you can use "-H" instead of "-S".

2) The gPTP command:

   $sudo ptp4l -i enp4s0 -m -H -2 -f gptp-master.cfg

   The device requires hardware support for PTP Hardware Clock, which is not a "none" value. In this case, gptp-master.cfg is the gPTP master clock configuration file.

   Create a new gptp-master.cfg file on the host, and copy the following content into this file, then save the file:

```
# 802.1AS example configuration containing those attributes which
# differ from the defaults.    See the file, default.cfg, for the
# complete list of available options.
[global]
domainNumber            0
logSyncInterval         -3
syncReceiptTimeout      3
neighborPropDelayThresh     800
path_trace_enabled 1
follow_up_info          1
transportSpecific   0x1
ptp_dst_mac         01:80:C2:00:00:0E
#p2p_dst_mac        01:1B:19:00:00:00
network_transport   L2
delay_mechanism         P2P
masterOnly          1
BMCA                noop
asCapable                   true
inhibit_announce    1
inhibit_delay_req   1
```

Note

For devices without hardware support, you can use -S instead of -H for gPTP synchronization simulation. However, the synchronization accuracy cannot be guaranteed.

2.4.3 GPS Time Synchronization

If you need to synchronize the E1R with a GPS module, first you need to enable the GPS module to provide time synchronization to the gPTP Master. The specific interface and synchronization method needs to be clear with the gPTP master provider. Unless there are special requirements, RoboSense will not provide related technical support.

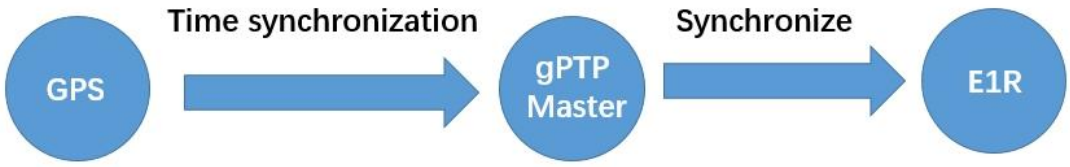


Figure 7 Topology Diagram of GPS Synchronization

3 Product Installation Recommendations

3.1 Interface Description

3.1.1 E1R Platform Connector

The TE 2397179-1 connector scheme is recommended for the E1R platform, Custom connector models are not accepted, and the bending radius of the wiring harness is greater than 30 mm, and the specific connector scheme can be seen in Table 2.

Table 2 Connector Scheme

Connector Scheme	Connection Type	Model	Picture	Function
TE Bow-mount Type (Two-in-one plug, 6+2pin)	LiDAR End Connector	TE 2397179-1		Power + Gigabit Ethernet

3.1.2 Connection Installation Requirements

1) The waterproof ring of the wire harness end connector should be well-compatible with the wire material and meet IP67 and IP6K9K waterproof levels;
2) The outgoing cable location of the wire harness end connector at the end should have a hand-preserved space of at least 70mm around the environment.

3.1.3 Whole Car Wire Harness End Installation Requirements

1) The material of the Ethernet wire harness should use STP wires that meet 1000BASE-T1;
2) It is recommended to use Dacra 686-3 (bending radius 25mm) or GG X9305 (bending radius 12mm) for the whole car wire harness;
3) The total length of the Ethernet wire harness is recommended to be less than 15m, and the number of connectors should not exceed 3 pairs (including wire pairs);

4) Ethernet signal lines should be routed in the entire car, and it is recommended to avoid moving sections and high-temperature areas;
5) Power supply needs to consider cable length, wire diameter, and impedance, and the LiDAR working voltage on the power line should remain above 9V;

3.2 The Connection of Interface Box

3.2.1 Vehicle Ethernet Harness Interface and Definition

The E1R uses a car Ethernet and power 2-in-1 connector, and the wiring harness is shown in Figure 8.

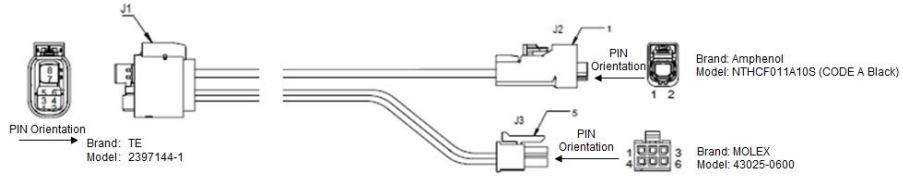
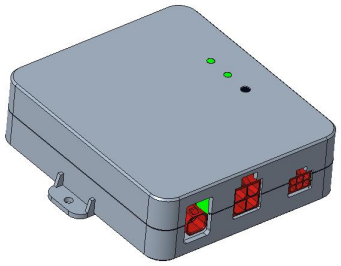


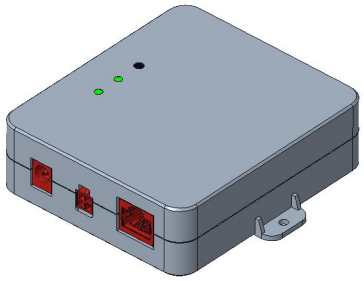
Figure 8 Direct Connection between LiDAR Equipment and Host Computer

3.2.2 Interface Box Interface

The connection description of E1R interface box is shown in Table 3:

Table 3 Wiring Description

Wiring Description	TE Interface Box Structure Diagram
Connecting to the LiDAR side	

Connecting to the power supply and host computer side	

3.2.3 Power Interface

The E1R interface box uses standard DC 5.5-2.1 interfaces.

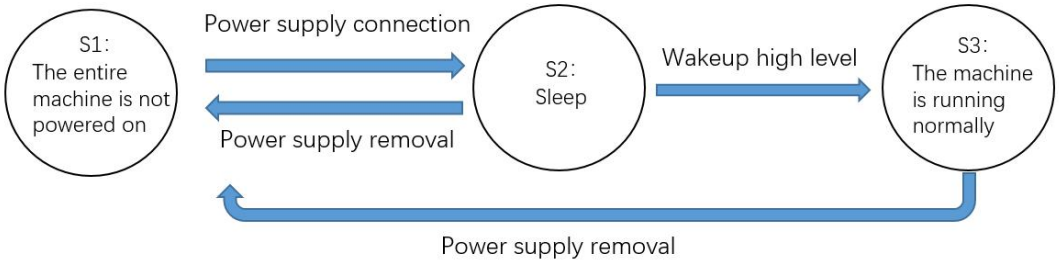
When the power supply is normal, the green indicator of the power supply box is steady on. When the green indicator is off, check whether the power input is normal. If the power input is normal, the interface box may be damaged. Contact RoboSense.

3.2.4 RJ45 network port

The E1R body supports only 1000BASE-T1 on-board Ethernet. When the interface box is used, the network interface uses the standard RJ45 interface. The interface box supports only Gigabit Ethernet.

3.3 LiDAR State Machine

Refer to Figure 9 for the description of the LiDAR state machine. When the wake-up pin inputs a high level of 9-16V, the LiDAR wakes up.



The description of the overall machine state machine:
S1: The entire machine is not powered on.
S2: The entire machine is sleeping
S3: The entire machine is running normally

Figure 9 LiDAR State Machine Description

3.4 Installation and positioning methods recommendation

E1R doesn't include installation ears, and it is recommended to use installation brackets to fix it.

3.4.1 Position of installation bracket

The back shell of LiDAR has four M4 screw holes or through holes, as well as two positioning pillars, as shown in Figure 10 . The positioning pillar of the back shell and the bracket positioning hole match, and the bracket sets four fixed holes, which are connected by the four threaded holes of the back shell. Finally, the bracket is further fixed to the body metal by other holes.

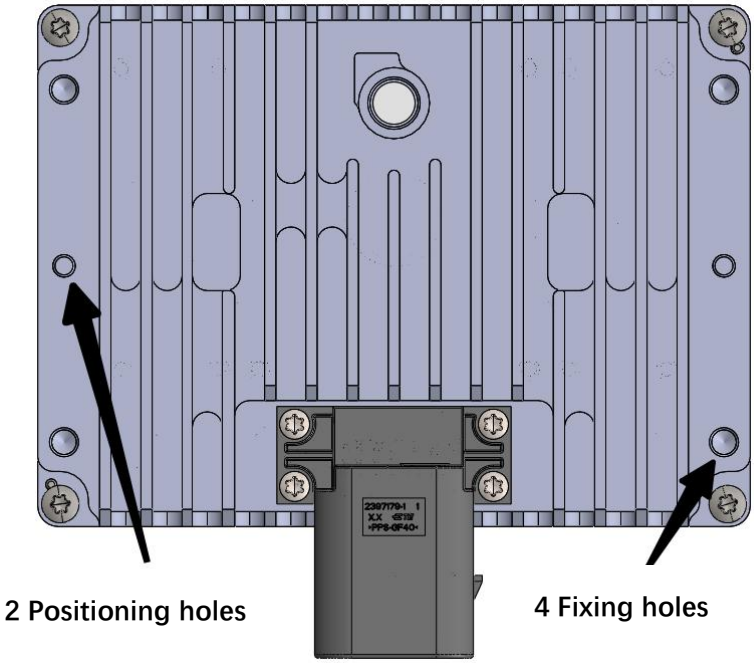


Figure 10 Position of bracket installation and fixation

3.4.2 Installation bracket positioning and fastening requirements

1) It is recommended to use the positioning method of the rear wing panel positioning hole/positioning column;
2) Four M4 screws (which can be selected based on actual design requirements)

should be used for the rear wing panel side ears;

3) The LiDAR bracket is recommended to use small concave platforms near the four installation holes to cooperate with the LiDAR, and the overall plane accuracy of the concave platform should be within 0.2mm;
4) The pitch of the M4 screw hole is 1mm;
5) The strength grade of the screws is recommended to be above 8.8 level;
6) The recommended torque is 5±10% N·m;
7) The recommended length of the screw is T + 4.5mm for the thickness of the bracket;
8) The recommended bracket thicknesses are: steel plate 2-2.5mm, aluminum alloy die-casting 3-5mm, and the bracket thickness should be determined according to design verification.

3.5 Design and requirements for installation bracket

The fixed bracket needs to have good rigidity for installing and fixing the LiDAR, and to keep the LiDAR in a stable state under various working conditions. The design requirements are as follows:

1) The first-order modal frequency of the LiDAR and its fixed bracket should be greater than 50 Hz as a whole, and low stiffness of the fixed bracket will lead to large displacement of the LiDAR rigid body, affecting the point cloud accuracy;
2) The LiDAR and its fixed bracket must ensure no resonance at 780 Hz, and if it is really impossible to avoid the resonant zone, the customer needs to provide the acceleration PSD response spectrum of the LiDAR installation under random road excitation (simulation, measured, or estimated data), and Robosense will compare and identify whether there is a risk based on the LiDAR's fixed-frequency anti-vibration ability curve;
3) During use, the LiDAR will experience various random vibration, mechanical impact, etc. Working conditions, where the bracket needs to bear

a large load. Therefore, the bracket also needs to have enough strength, and it is recommended to have double safety factors;

4) At the same time, increase strengthening ribs, convexity, bending and other designs in all directions to improve its stiffness and strength;
5) Try to avoid structures with sharp angles or corners smaller than 0.3mm that easily generate stress concentration such as those with rounded corners or gaps;
6) It is recommended to avoid overlap between the LiDAR bracket and crash barrier in height, which will increase the difficulty of pedestrian protection design. The contradiction lies in pedestrian protection requiring collapse while the LiDAR bracket requires good rigidity;
7) The plane accuracy and coplanarity of the installation plane should be less than 0.5mm;
8) It is recommended to provide the installation bracket model and installation environment information to Robosense for structural simulation confirmation.

3.6 Cooling requirements for installation brackets

1) Cooling requirements: During the use of E1R, there will be some heat, and the radiation from the body's own heat source may aggravate the temperature rise of E1R, and the heat dissipation requirements are as follows:
   a) The installation bracket for E1R should be an excellent heat transfer material and should avoid being enclosed in the bracket as much as possible;
   b) The front and rear ends of E1R are the main heat dissipation surfaces;
   c) The bracket is recommended to use aluminum alloy with a thermal conductivity coefficient of more than 50 W/m·K or galvanized steel plate, etc.;
   d) Some cooling fins should be added to the bracket and the fin spacing/height/direction should be controlled reasonably to increase the

cooling area as much as possible, consistent with the air flow direction;

e) It is recommended to provide the installation bracket model and installation environment information to Robosense for thermal simulation confirmation.

2) Working temperature requirements.

a) There should be a gap between E1R and surrounding components (greater than 5mm), and the installation parts should not completely enclose the LiDAR, but rather open some holes to ensure better air flow;

b) In principle, as long as the ambient temperature around E1R does not exceed 85°C under any conditions, it can meet the working temperature requirements.

4 LiDAR Usage

4.1 Coordinate System

The coordinate system definition of E1R is shown in Figure 11.

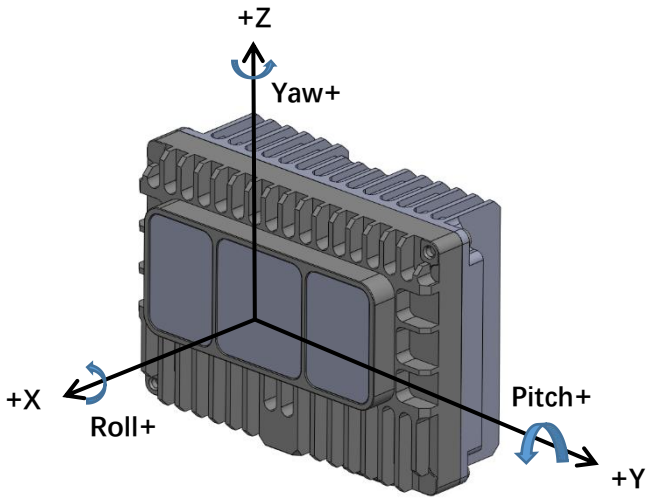


Figure 11 E1R Coordinate System Definition

4.2 RSView

In the detection of data from E1R, free tools such as Wireshark and tcp-dump can be used to obtain raw data. Meanwhile, RSView can assist users in visualizing raw data more conveniently.

4.2.1 Software Features

RSView provides real-time visualization of any RoboSense LiDAR data. RSView can also review pre-recorded data stored in “pcap” (Packet Capture) files, but RSView still does not support playing “.pcapng” files.

RSView displays distance measurements from a RoboSense LiDAR as point data. It supports custom-colored display of variables such as intensity-of-return, time, distance, azimuth, and laser ID. The data can be exported in ‘.csv format’. The

RSView 4.3.11 or later version supports generating LAS format point cloud files.

Functionality and features of RSView include:

1) Visualize live streaming sensor data over Ethernet
2) Record live sensor data to pcap files
3) Visualize sensor data from a recorded pcap file
4) Different types of visualization modes, such as distance, time, azimuth, etc.
5) Display point data in a spreadsheet
6) Export point cloud data in CSV format
7) Distance measurement tool
8) Display multiple frames of data simultaneously (Trailing Frames)
9) Crop views

4.2.2 Install RSView

RSView supports running on Windows 64-bit, Ubuntu 18.04 or higher operating systems. You can download the latest installer from RoboSense website (http://www.robosense.ai/resource). Launch the downloaded installer and follow the instructions to finish the installation. After installation is completed, a shortcut will be generated on the desktop. Make sure the installation path only contains English characters.

4.2.3 Use RSView

For details on using RSView for operation, please refer to the RS-LiDAR User Guide by pressing the F1 button, or clicking the Help option in menu bar.

4.3 Communication Protocol

The communication between E1R and the computer is through Ethernet, and uses UDP protocol. There are two types of output packets: MSOP packet and DIFOP packet.

All MSOP packets involved in this document are with fixed length of 1200 bytes,

DIFOP packets are with fixed length of 256 bytes. E1R network parameters are configurable, and the factory default IP and fixed client port number are set as listed in the Table 4:

Table 4 Factory default network configuration

	IP Address	MSOP Port Number	DIFOP Port Number
E1R	192.168.1.200	6699	7788
Computer	192.168.1.102	6699	7788

The default MAC address of the LiDAR is initially set at the factory, and the MAC address of each LiDAR is unique.

When using the LiDAR in unicast mode, you need to set the computer's IP to the same network segment as the LiDAR, for example, 192.168.1.x (the range of x is 1~254), and the subnet mask as 255.255.0.0. If you don't know the network configuration information of the LiDAR, please set the host computer subnet mask to 255.255.0.0 to connect to the LiDAR and use Wireshark to capture the LiDAR output packet for analysis.

The communication protocol between E1R and the computer is mainly divided into two categories. See the Table 5 for the protocol list.

The main data stream output protocol (MSOP), encapsulates the distance, angle, reflectivity and other information measured by the LiDAR into a package and outputs it to the computer.

LiDAR information output protocol (DIFOP), outputs various configuration information of the LiDAR currently in use to the computer.

Table 5 List of communication protocols

Protocol	Abbreviation	Function	Type	Packet size
Main Data Stream Output Protocol	MSOP	Output measured data	UDP	1200 Bytes
Device Information Output Protocol	DIFOP	Output device information	UDP	256 Bytes

4.3.1 Main Data Stream Output Protocol (MSOP)

Main data Stream Output Protocol is abbreviated as MSOP.

I/O type: LiDAR output, computer analysis.

Default port number: 6699.

The MSOP packets output three-dimensional measurement related data, including laser ranging value, return reflectivity value, vertical angle, horizontal angle and time stamp.The payload length of the MSOP packet is 1200 bytes, which consists of a synchronization header of 32 bytes, a data packet of 1152 bytes (a total of 96 data blocks of 12 bytes), and a tail of 16 bytes.

The basic structure of the MSOP packet is as shown in the figure below:

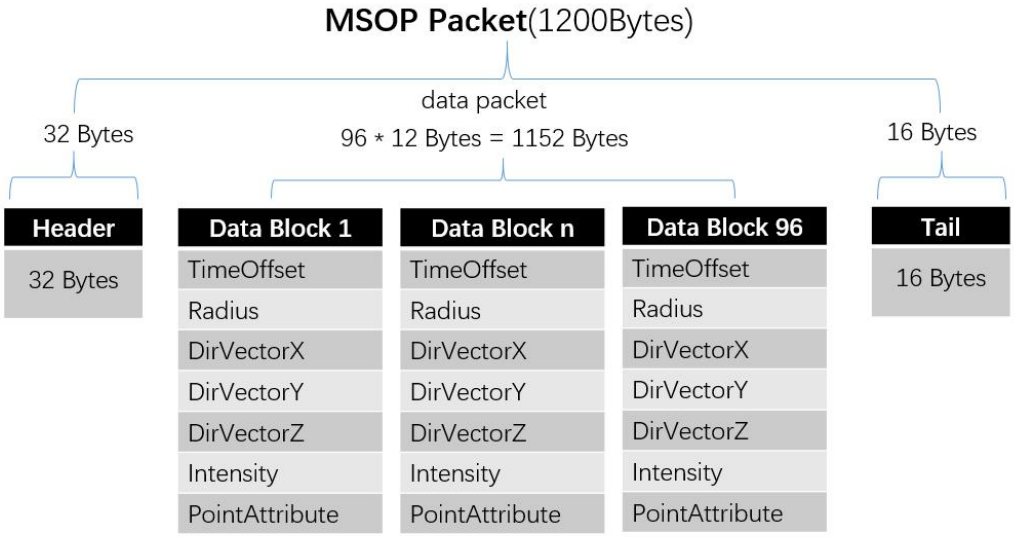


Figure 12 MSOP Packet Structure

4.3.1.1 Header

The header is 32-bytes long, and is used for identification of the starting position of data, packet counting, UDP communication reservation, and time stamp storage. The detailed definition is as follows:

Table 6 MSOP Header

Header(32Bytes)				
Sync	PktCnt	Ver	ReturnMode	TimeMode
4 Bytes	2 Bytes	2 Bytes	1 Byte	1 Byte

Timestamp	FrameSync	Res0	LidarType	LidarTmp
10 Bytes	1 Byte	9 Bytes	1 Byte	1 Byte

Sync: can be used as a packet inspection sequence, and the identification header is 0x55, 0xaa, 0x5a, 0xa5.

PktCnt: Packets Sequence Number, packet counting in a circular counting manner, the count value of the first data packet of each frame is 0, the count value of the last data packet of each frame is the maximum value.

Ver: version number of the UDP communication protocol.

ReturnMode: return mode flag, 4 means strongest return, which is fixed.

TimeMode: Time synchronization mode:

0x00: currently using the LiDAR internal timing.

0x02: currently using PTP E2E time synchronization mode.

0x03: currently using gPTP time synchronization mode.

Timestamp: store timestamps. The defined timestamp is used to record the system. time. The high 6 bytes are the second bits, and the low 4 bytes are the microsecond bits.

FrameSync: frame synchronization state（0x00:no 0x01:yes）

Res0: reserved bit

LidarType: the type of LiDAR, default is 0x62.

LidarTmp: LiDAR's temperature, Temp = LidarTmp – 80

4.3.1.2 Data Packet

The data packet in the MSOP packet stores the data measured by the LiDAR, it has a total of 1152 bytes consisting of 96 data blocks, each data block has 12 bytes

The detailed definition is as follows:

Table 7 Definition of data block in MSOP packet

Data block (12Bytes)			
content	offset	byte	instruction
TimeOffset	0	2	The time offset of all points in the block relative to the timestamp of the packet,

			the time of this group of points equals to Timestamp + time_offset
Radius	2	2	In the polar coordinate system, the radial distance value of the points, the distance resolution is 5mm
DirVectorX	4	2	Unit direction vector X axis component of channel 1, the value ranges from -32768 to 32767, and divides by 2^15 to float.
DirVectorY	6	2	Unit direction vector Y axis component of channel 1, the value ranges from -32768 to 32767, and divides by 2^15 to float.
DirVectorZ	8	2	Unit direction vector Z axis component of channel 1, the value ranges from -32768 to 32767, and divides by 2^15 to float.
Intensity	10	1	Reflection intensity value of the channel 1 points, the value range is 0~255
PointAttribute	11	1	Attribute of the channel 1 point, 1 indicates normal, 2 indicates noisy point,

Related calculation specification:

Calculation of the radial distance: (Radius is 2-byte long, the unit is millimeter, and the resolution is 5mm.)

Get the hexadecimal number of the radius value of a charnel in the data packet: R1 is 0x03, R2 is 0xfc

0x03 is the high digit of the distance, converted to decimal is 3, 0xfc is the low digit of the distance, converted into decimal is 252.

Therefore: the radial distance of this channel=R1*256+R2=3*256+252=1020.

According to the resolution of the coordinates, it is converted to meters: 1020 *0.005=5.10m.

Therefore, the radial distance of this channel in the corresponding elevation and azimuth direction is 5.1 m.

Calculation of XYZ coordinates:

XYZ coordinates can be calculated from the following equations:

$$\begin{cases} X = radius * (DirVectorX / (2^{15})) \\ Y = radius * (DirVectorY / (2^{15})) \\ Z = radius * (DirVectorZ / (2^{15})) \end{cases}$$

4.3.1.3 Tail

The frame tail contains parameters used by LiDAR E2E Profile4, The detailed definition is as follows:

Table 8 Definition of tail in MSOP packet

content	offset	byte	instruction
Res1	1184	4	Reserved
DataLength	1188	2	04 B0
Counter	1190	2	00 00~FF FF
DataId	1192	4	00 00 0E 5C
Crc32	1196	4	

4.3.2 LiDAR Information Output Protocol (DIFOP)

LiDAR Information Output Protocol is abbreviated as DIFOP

I/O type: LiDAR output, computer read.

Default port number: 7788.

DIFOP is an "output-only" protocol to periodically send the LiDAR serial number (S/N), firmware version information, host computer driver compatibility information, network configuration information, calibration information, operating status, and fault

diagnosis information to users. By reading DIFOP, users can learn specific information of various parameters of the LiDAR currently in use.

The detailed definition is as follows:

Table 9 Definition of DIFOP packet

DIFOP Packet(256Bytes)			
content	offset	byte	instruction
DifopHeader	0	8	DIFOP recognition head
Res0	8	8	Reserved
SW Version	16	3	LIDAR SW version information
Res1	19	1	Reserved
SN	20	6	Serial number
Res2	26	18	Reserved
LocalIP	44	4	LIDAR IP source address
NetMask	48	4	Subnet mask
MacAddress	52	6	LIDAR IP local Mac address
MsopRemoteIp	58	4	Msop remote IP address
MsopLocalPort	62	2	Msop local port number
MsopRemotePort	64	2	Msop Remote port number
DifopRemoteIp	66	4	Difop Remote IP address
DifopLocalPort	70	2	Difop Local port number
DifopRemotePort	72	2	Difop Remote port number
Res3	74	25	Reserved
FrequecySetting	99	1	LIDAR frame rate setting
ReturnMode	100	1	LIDAR echo information： 0x00: FarthestWave 0x04: StrongestWave (Default) 0x07: NearestWave 0x08: 2ndStrongestWave 0x09: StrongestFarthestWave

			0x0A: NearestFarthestWave 0x0B: Strongest2ndStrongestWave
TimesyncMode	101	1	Time Synchronization Mode: 0x0: Internal 0x2: E2E L2 0x3: GPTP
TimesyncStatus	102	1	Time Syne Status: 0x00: failed 0x01: success 0x02: timeout
TimeStatus	103	10	Timestamp: 0-5bytes: Second 6-9bytes: MicroSecond
PHYMode	113	1	PHY Mode: 0x00: auto-negotiation 0x01: master 0x02: slave other: same as 0x00
Res4	114	142	Reserved

5 Product Maintenance

5.1 Transportation and Logistics

! Important

Improper transportation can cause damage to the equipment!

1) The products should be packaged with shock-proof and moisture-proof materials to avoid damage during transportation. It is recommended to use original packaging;
2) During transportation, please handle the products carefully to avoid dangerous behaviors such as bumping and dropping;
3) Upon receiving each shipment, please thoroughly check the delivery list and product packaging for any damage (including physical damage to the products);
4) If there is any transportation damage, please refuse to accept the goods and contact RoboSense in a timely manner.

5.2 Storage

! Important

Storage Inadequate can lead to equipment damage!

1) Please store the equipment in an indoor environment with normal temperature and dryness;
2) Handle the equipment carefully to avoid collisions, drops, and other dangerous behaviors;
3) The products should be stored in a safe environment to prevent corrosion, mechanical impact, and exposure to environments above the protective level;
4) Regularly check the status of all components and packaging. It is recommended to conduct inspections every 3 months.

5.3 Cleaning

In order to be able to accurately sense the surrounding environment, E1R needs to be kept clean, especially the window.

5.3.1 Attention

! Please read the contents of this chapter carefully and completely before cleaning your E1R, otherwise improper operation may damage the sensor.

! When the LiDAR is used in a harsh environment, it is necessary to clean up the dirt on the surface in time to keep the LiDAR clean, otherwise it will affect the normal use of the LiDAR.

5.3.2 Required Materials

1) Clean, dust-free cloths
2) Neutral solution at moderate temperature (such as soap water, distilled water, 99% alcohol concentration, etc.)

5.3.3 Cleaning Method

1) If only some dust/dust particles have adhered to the surface of the LiDAR:
    a) First, use a clean, dust-free cloth to dip into a small amount of neutral solution;
    b) Then, gently wipe and clean the LiDAR surface;
    c) Finally, use a dry, clean, dust-free cloth to wipe it dry.
2) If mud or other blocky foreign objects have adhered to the surface of the LiDAR:
    a) First, clean water should be sprayed on the surface of the dirty part of the LiDAR to remove foreign objects such as mud (Note: the mud cannot be wiped off directly with a dust-free cloth, which may scratch the surface, especially the surface of the window)
    b) Then, spray warm soap water on the dirty area to accelerate the

removal of the foreign objects. Gently wipe the LiDAR surface with a fiber cloth, but be careful not to scratch the surface;

c) Finally, rinse the LiDAR surface with clean water to remove any soap residue (if there are still traces left, you can use 99% alcohol to clean it again), and dry it with a dry, clean, dust-free cloth.

6 After-sale service

If you encounter any problems that cannot be solved during use, please contact RoboSense company in time.

Official website: https://www.robosense.cn/contact

Email: support@robosense.cn

Telephone: 0755-86325830/15338772453

Note

1) Only after receiving confirmation of xx company's after-sales service, return the device;

2) The device can only be returned with the original packaging or equivalent moisture-proof packaging.

Appendix A Driver & SDK

A.1 Compile and Install rs_ driver

RS Driver provides a cross-platform LiDAR driver kernel for RoboSense LiDAR products, which is convenient for users to re-develop and use. The driver kernel of v1.5.10 and later versions already support analysis and transformation of E1R point cloud. Users can download the rs_driver package from our official account on GitHub : https://github.com/RoboSense-LiDAR/rs_driver

rs_driver currently supports the following systems and compilers:

1) Windows:
   a) MSVC (VS2017 & VS2019 tested)
   b) Mingw-w64 (x86_64-8.1.0-posix-seh-rt_v6-rev0 tested)
2) Ubuntu (16.04, 18.04, 20.04):
   gcc (4.8+)

A.1.1 Install Dependent Libraries

rs_driver depends on the following third-party libraries, which need to be installed before compilation:

1) Boost
2) Pcap
3) PCL (not required, can be ignored if visualization tools are not needed)
4) Eigen3 (not required, can be ignored if built-in coordinate transformation is not needed)

Install the above dependent libraries in Ubuntu:

$sudo apt-get install libboost-dev libpcap-dev libpcl-dev libeigen3-dev

Install the above dependent libraries in Windows:

1) Boost

   The Boost library needs to be compiled from source code under Windows,

please refer to the official guide:

(https://www.boost.org/doc/libs/1_67_0/more/getting_started/windows.html)

After compiling and installing, add the path of Boost to the system environment variable BOOST_ROOT, see Figure 13 below. If you use MSVC, you can also choose to directly download the pre-compiled installation package of the corresponding version.

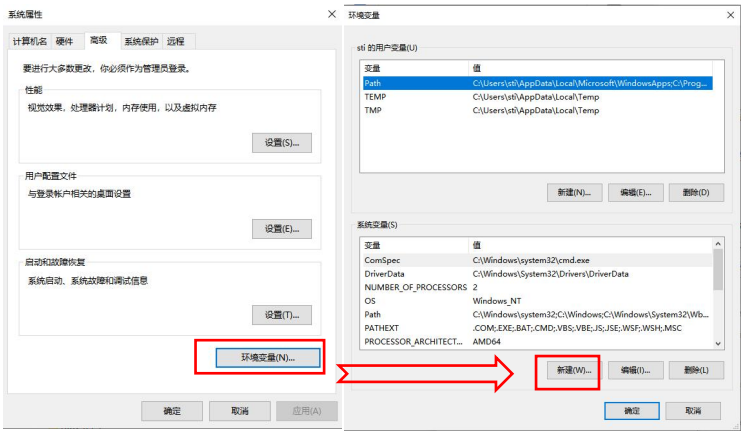


Figure 13 Add environment variables

2) Pcap

First, install the Pcap runtime library:

(https://www.winpcap.org/install/bin/WinPcap_4_1_3.exe).

Download the developer package:

(https://www.winpcap.org/install/bin/WpdPack_4_1_2.zip) to any location,

Then, add the path of WpdPack_4_1_2/WpdPack to the environment variable PATH, as shown in Figure 13 .

3) PCL (not required, can be ignored if visualization tools are not needed)

a) MSVC

If you are going to use the MSVC compiler, please install the official installation package provided by PCL.

Select "Add PCL to the system PATH for xxx" during installation:

Figure 14 PCL Set up PCL

b) Mingw-w64

PCL does not provide the official mingw compilation library, users need to compile PCL from source code and install it according to the official tutorial.

A.1.2 Use of rs_Driver

A.1.2.1 rs_Driver Installation and Use

Take the Linux environment as an example for driver compilation (rs_driver currently does not support installation and use in windows system), execute the following codes to install the driver

```
$cd rs_driver
$mkdir build && cd build
$cmake .. && make -j4
$sudo make install
```

A.1.2.2 Use as a Submodule

When rs_driver is used as a submodule, the following commands need to be added to the CMakeLists.txt file. (add rs_driver as a submodule to the project, use the find_package() instruction to find rs_driver, and then link the relevant library)

```
add_subdirectory(${PROJECT_SOURCE_DIR}/rs_driver)
find_package(rs_driver REQUIRED)
include_directories(${rs_driver_INCLUDE_DIRS})
target_link_libraries(project ${rs_driver_LIBRARIES})
```

A.1.3 Demo Programs & Visualization Tools

A.1.3.1 Demo Programs

rs_driver provides two demo programs. Users can refer to the demo programs to write code, call interfaces and store them in rs_driver/demo:

1) demo_online.cpp
2) demo_pcap.cpp

To compile the two demo programs, users can add the parameters when executing the CMake configuration.

$cmake -DCOMPILE_DEMOS=ON ..

A.1.3.2 Visualization Tools

rs_driver provides a point cloud visualization tool based on PCL, which is stored in rs_driver/tool:

1) rs_driver_viewer.cpp

To compile the two demo programs, users can add the parameters when executing the CMake configuration

$cmake -DCOMPILE_TOOLS=ON ..

A.1.4 Coordinate Transformation

rs_driver provides a built-in coordinate transformation feature, which can directly output the point cloud after coordinate transformation, which saves users the time-consuming extra operations of coordinate transformation on the point cloud. If you want to enable this feature, add the parameters when executing CMake configuration:

$cmake -DENABLE_TRANSFORM=ON ..

A.2 Compile and Install rslidar_sdk

rslidar _sdk is the ROS-based driver SDK. You can download it from the RoboSense GitHub repository or contact RoboSense for access.

1) rslidar_sdk depends on rs_driver, which is the basic RoboSense driver. Download rs_driver from the GitHub platform.
2) If you are using ROS2, rslidar_sdk also depends on rslidar_msg, which defines the message format. Download the msg file from the GitHub platform.
3) The SDK package contains comprehensive usage guidelines. Before using the driver SDK, please read the README file and documentation under the doc folder.

Note:

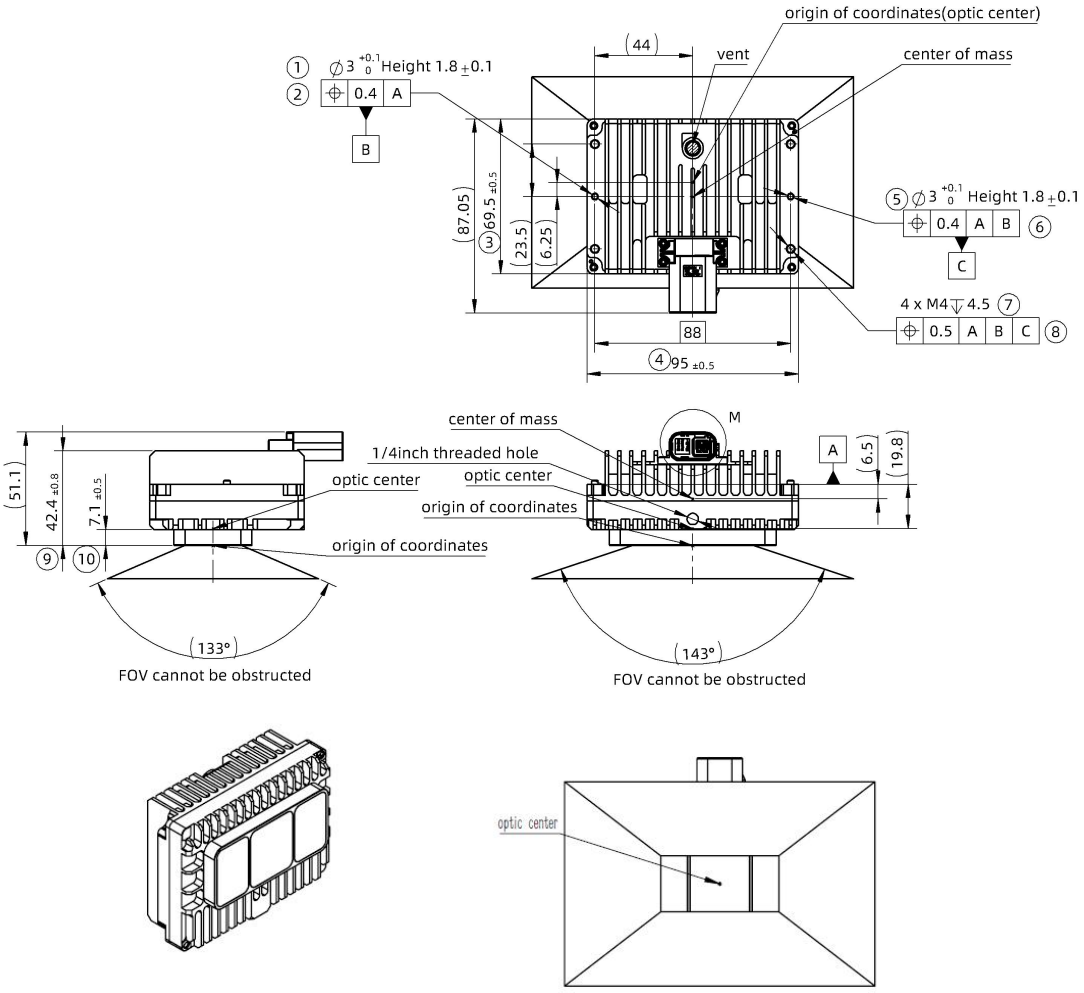
SDK Download Link: https://github.com/RoboSense-LiDAR/rslidar_sdk

rs_driver Download Link: https://github.com/RoboSense-LiDAR/rs_driver

msg Download Link: https://github.com/RoboSense-LiDAR/rslidar_msg

Appendix B Mechanical Drawings

Drawing of LiDAR with TE Connector:



Definition of TE-Pins:

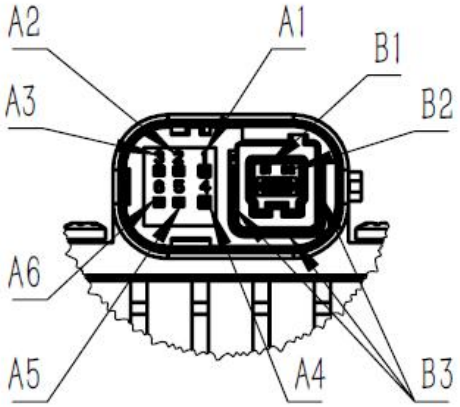


Table 10 Pin definitions for connectors

Pin number	number	Pin definition	Connector model
A1	1	Battery+	TE-2397179-1
A2	2	Wakeup(KL15)	
A3	3	NC	
A4	4	GND	
A5	5	NC	
A6	6	NC	
B1	D1	TRX_N(1000Base-T1)	
B2	D2	TRX_P(1000Base-T1)	
B3	/	SHIELD	

Building 9, Block 2, Zhongguan Honghualing Industry Southern District, 1213 Liuxian Avenue, Taoyuan Street, Nanshan District, Shenzhen, China
www.robosense.ai