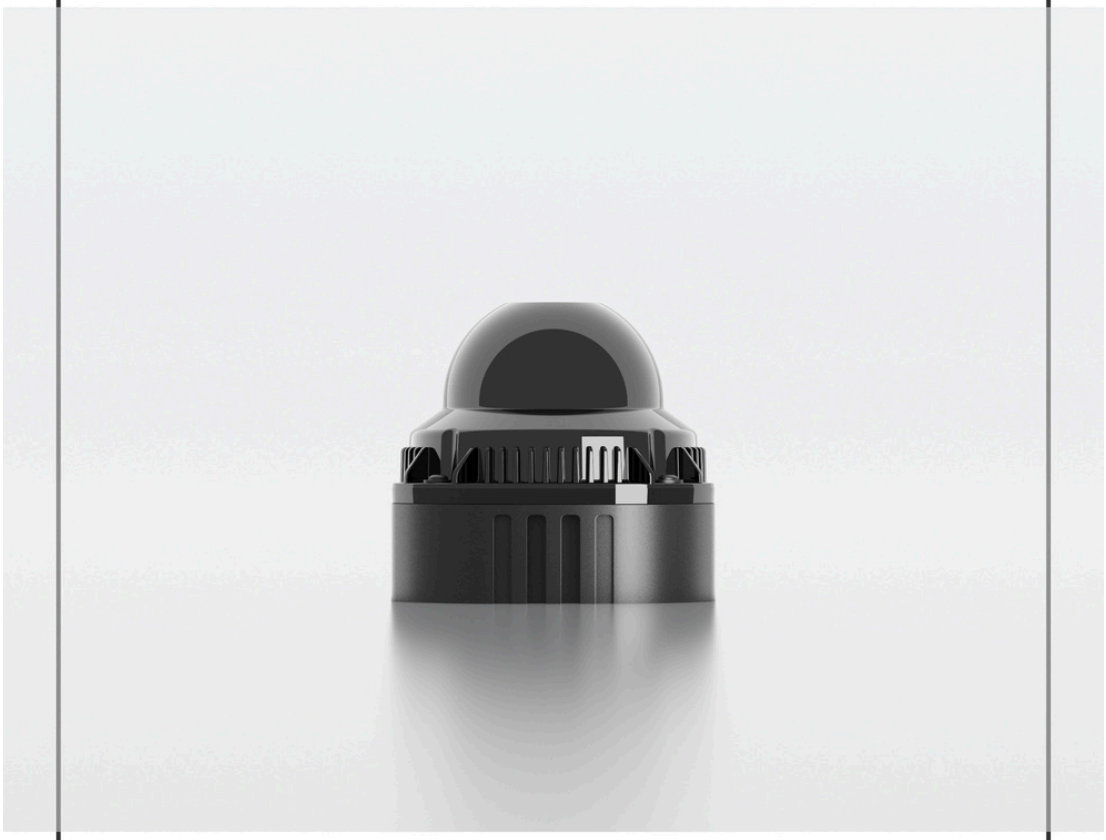
robosense

Airy Lite

User Guide



Version 1.0

Change Description

Version	Revision Date	Description
1.0	2026/1/14	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.

ⓘ Note: 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.ai/en/resources

More Information

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Contents

1 SafetyNotices

1.1 Legal Statement

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1.2 User Guidelines

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

1) Pleasestrictlyabidebyrelevantnationallasersafetylawsandregulations;
2) Pleasereadthisproductmanualindetailbeforeusingtheproduct;
3) Pleaseusethisproductonlyintherelevantfieldofapplication;
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 accompanying accessories);

2) Non-specified power supply and accompanying accessories are prohibited;
3) Please avoid abnormal operations such as dropping, colliding, burning, etc.;
4) If you notice any damage to the appearance of the device (arc protection cover), 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) Pleasereadtheproductmanualindetailbeforeusingthedevice;
2) Prohibitillegaloperations;
3) Before working, personnel must undergo training and obtain relevant construction qualifications;
4) Havesomebasicknowledgeofcomputerdataconnection,electrical,andso on.

1.5 Work Safety and Special Hazards

⚠ To avoid risks of accidents, damage to sensors 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 ProductDescription

2.1 Product Overview

Airy Lite is a new type of low-cost 3D LiDAR specifically designed by RoboSense to eliminate blind spots. It is primarily used in commercial, industrial, and consumer robotics applications.

Airy Lite features an ultra-short minimum detection distance of 0.1 meters, while offering a wide field of view (FOV) of 360°(H) × 45°(V) and a maximum ranging capability of 60 meters, enabling effective detection of various short-range obstacles over a large area. The entire unit weighs less than 250 grams, with its exposed part boasting a compact structure of only φ44×20mm. This significantly reduces space occupation, allows flexible and convenient installation, and enables easy integration into various devices. Relying on RoboSense's digital platform, it adopts an innovative chip-based transceiver solution, digital architecture, and signal processing technology, achieving high performance while balancing cost optimization and reliability assurance.

2.2 Product Structure

The structure diagram of Airy Lite is shown in Figure 1 .

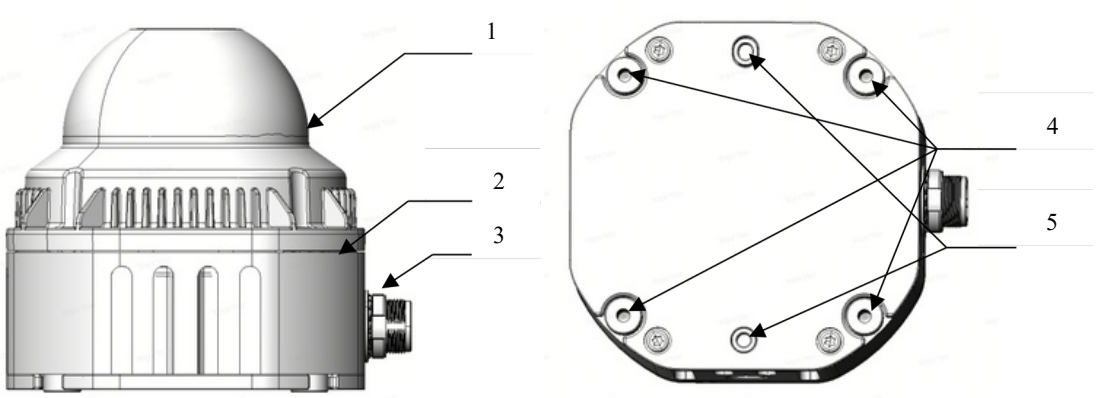


Figure 1 Product Structure Description

It mainly includes the following components:

1) ProtectiveCover

Both the emitted laser and returned laser need to pass through the specially designed

arc-shaped protective cover. Therefore, any obstruction within the laser's field of view (FOV) is strictly prohibited.

2) Base

The base unit of Airy Lite incorporates a bottom vent membrane, screw mounting holes, positioning holes, and a cable outlet port.

3) AviationConnector

The electrical interface of the LiDAR. For detailed interface definitions, refer to Section 3.3.

4) M3ScrewMountingHoles

Used to secure the LiDAR to the mounting bracket with M3 screws.

5) MountingHoles

Used to support and fix the position and orientation between the LiDAR and the bracket, and to enhance installation efficiency and accuracy.

For the detailed dimensions and parameters of the above structure, refer to the structural drawing section in Appendix D.

2.3 FOV Distribution

Airy Lite's FOV ranges from 0 to 360° horizontally and from -11.5° to +33.5° vertically, with a vertical angular interval of approximately 1.96°. The correspondence between the 24 channels and the true vertical angles is illustrated in Figure 2.

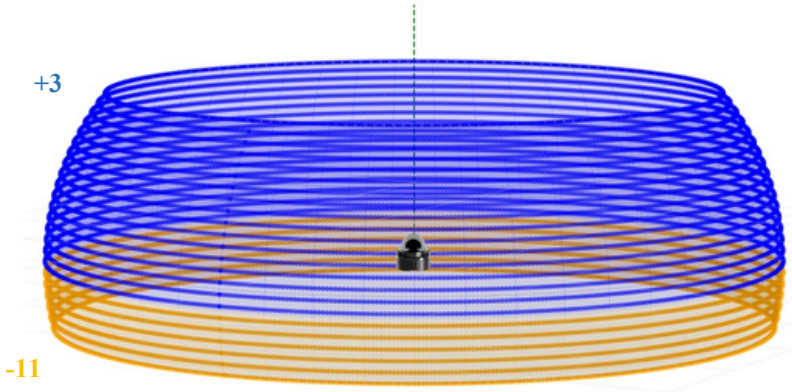


Figure 2 FOV Illustration

Airy Lite's design architecture and scanning sequence result in a point cloud with an

approximate 30° gap in every set of 10 frames.

2.4 Specifications

Table 1 Airy Lite Specifications

Specifications[1]			
Number of Channels	24	Horizontal FieldofView (FOV)[2]	0°~360°
Laser Safety Level	Class1Eye-Safety	Vertical Field ofView (FOV)[3]	-11.5°~+33.5 °
Measurement Range[4]	Max Range: 60m Upper/Lower FOV (-11.5° ~ -0.25° & +22.25° ~+33.5°): 30m@10% NIST Central FOV (-0.25 ~ +22.25°) : 40m@10% NIST		
Horizontal Angular Resolution	0.6°	Vertical Angular Resolution	1.96°
BlindZone	<0.1m	Accuracy (Typical)[5]	7-18Ch:0-10m:0.5cm;10-40m:1cm 1-6&19-24Ch:0-30m:1cm;30-40m:1.5cm
OutputPoints	144,000pts/s	FrameRate	10Hz
DataInterface	100Base-Tx		
OutputDataProtocol	UDPPacketsOverEthernet		
LiDAR Data Packet Content	Distance, Reflectivity, Timestamp, etc.		
OperatingVoltage	9V-24V	ReturnMode	SingleReturn:StrongestReturn
ProductPower[6]	6W	Dimensions (HxWxD)	65*64*72.5mm (Including cable outletport) (Protective cover: Φ 44mm*20 mm)
Weight	<250g(LiDAR Body)	Operating Temperature[7]	-20℃~+60℃

[1] The following data applies only to mass-produced products. Any samples, prototypes, or other non-mass-produced versions may not be applicable to these specification data. If you have any questions, please contact Robosense;

[2] Approximatelyoneframeoutofevery10pointcloudsshowsagapofabout30°;

[3] Theverticalangleexhibitssomefluctuation;

[4] The test conditions are normal temperature, 100 klux illumination, and a 10% NIST diffuse reflection board as thetarget;
Measurement Accuracy is based on a 50% NIST diffuse reflection target, and the test results may be affected by environmental factors, including ambient temperature and target distance. The accuracy value applies to most channels,butvariationsmayexistbetweencertainchannels;

[6] Device Power Consumption test results are influenced by external environmental factors, including ambient temperature,targetdistance,andtargetreflectivity;

[7] Device Operating Temperature may be affected by external environmental factors, including lighting conditions and airflow variations.

Time Synchronization	GPS & gPTP & Storage PTP	Temperature	-40 ℃ ~+85 ℃
ProductModel	AiryLite	Protection Level	IP67

2.5 Product Principle

2.5.1 Coordinate Mapping

As the LiDAR data packet contains only horizontal rotation angles and distance parameters, to present a three-dimensional point cloud, the polar coordinates (angle and distance) are transformed into Cartesian coordinates (x, y, z) according to the following equations:

$$\begin{cases} x = r\cos(\omega)\sin(\alpha) + \mathrm{R}\cos(\alpha); \\ y = r\cos(\omega)\cos(\alpha) + \mathrm{R}\sin(\alpha); \\ z = r\sin(\omega) + \mathrm{Z}; \end{cases}$$

where r is the measured distance, ω is the laser's vertical angle, α is the laser's horizontal rotation angle, R is the plane radius from the optical center to the origin, Z is the height from the optical center to the origin, and x, y, z are the coordinates projected onto the Cartesian X, Y, Z axes.

2.5.2 Reflectivity Interpretation

Airy Lite LiDAR provides reflectivity information to characterize the reflectance of measured objects. In Airy Lite data, the calibrated reflectivity range is from 1 to 255 (This range is a custom value defined by RoboSense products representing the reflectivity of detected target).

2.5.3 Return Mode

Airy Lite only supports the Strongest Return mode.

2.5.4 Time Synchronization Method

Airy Lite supports three synchronization methods: GPS, PTP (IEEE 1588 V2

protocol), and gPTP (IEEE 802.1AS protocol).

2.5.4.1 GPSTimeSynchronizationPrinciple

The GPS module continuously sends GPRMC data and PPS synchronization pulse signals to the product. The PPS pulse length is between 20 and 200 ms. The GPRMC data must be transmitted 10 ms after the falling edge of the PPS synchronization pulse. The timing diagram is shown in Figure 3.

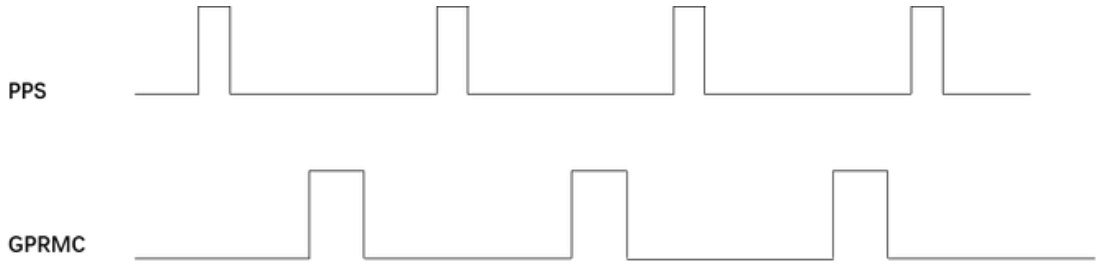


Figure 3 GPS Time Synchronization Timing Diagram

Note:

To ensure the accuracy of time synchronization, set the PPS pulse width between 20 and 200 ms, with a transmission cycle of 1 second. Transmit the PPS pulse first. Use the time information from the subsequent GPRMC data to determine the master time of the previously transmitted PPS pulse.

2.5.4.2 GPS Time Synchronization Usage

The GPS interface of Airy Lite adopts the RS232 protocol. Refer to Table 2 for the pin definition.

Table 2 Product Time Synchronization Pin Definitions

Communication	**Receiving Pin Definition**	
	GPS_GPRMC	**GPS_PPS**
RS232	RS232 Receives serial data with RS232 electrical level standard output from the GPS module	Receives positive synchronization pulse signal output from the GPS module, with a voltage requirement of 3.3 V

The external GPS module needs to set the output serial port baud rate to 9600 bps, 8 data bits, no parity bit, and 1 stop bit. Airy Lite only reads GPRMC-formatted data sent by the GPS module. The standard format is as follows:

$ GPRMC,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12> * hh

<1> UTC time

<2> Positioning status: A = valid positioning, V = invalid positioning

<3> Latitude

<4> Latitude hemisphere N (Northern Hemisphere) or S (Southern Hemisphere)

<5> Longitude

<6> Longitude hemisphere E (Eastern Longitude) or W (Western Longitude)

<7> Ground speed

<8> Ground course

<9> UTC date

<10> Magnetic declination

<11> Magnetic declination direction: E (East) or W (West)

<12> Mode indication (A = Autonomous positioning, D = Differential, E = Estimated, N = Data invalid)

*hh at the end represents the XOR sum of characters from $ to *

Note:

1) TheGPS_RECinterfacespecificationontheAiryLitepowerboxisSM2.54male connector. The pin definitions are shown in Figure 6;

2) Theintervalforsending1PPSpulseshouldbecontrolledwithin1s±200us;

3) Foryearsintherangeof00to69,theyareinterpretedas2000to2069;for years in the range of 70 to 99, they are interpreted as 1970 to 1999;

4) The status bit in the GPRMC message must be valid for A to allow time synchronization;

5) Airy Lite is compatible with most GPRMC message formats from GPS modules available in the market. If any compatibility issues are found during usage, please contact RoboSense.

2.5.4.3 PTPSynchronizationPrinciple

PTP (Precision Time Protocol, IEEE 1588V2 protocol) is a time synchronization protocol used for high-precision time synchronization between devices. It can also be

used for frequency synchronization between devices. Compared to various existing time synchronization mechanisms, PTP offers the following advantages:

1) Compared to NTP (Network Time Protocol), PTP can meet higher precision time synchronization requirements. NTP generally achieves sub-millisecond level time synchronization accuracy, while PTP can reach sub-microsecond level accuracy;

2) ComparedtoGPS(GlobalPositioningSystem),PTPhaslowerconstructionand maintenance costs.

2.5.4.4 gPTPSynchronizationPrinciple

gPTP (general Precise Time Protocol, IEEE 802.1AS protocol) is a derivative protocol of PTP in Time-Sensitive Networking (TSN). The synchronization mechanism uses the same P2P peer delay mechanism as the PTP protocol and adopts Ethernet L2 layer communication. Unlike PTP, gPTP requires the use of hardware-based timestamps, i.e., hardware timestamps, so the requirements for switches and master clocks are more stringent, complying with the IEEE 802.1AS protocol.

2.5.4.5 PTP/gPTPWiringMethod

To use PTP/gPTP synchronization, the following preparations are required. Refer to Section 3.4 for connection details:

1) SelectPTP/gPTPmodeintheWebinterface.SeeSection4.2fordetails;
2) Ethernetswitch;
3) DevicesthatsupportPTP/gPTPprotocolsandneedtimesynchronization.

Note:

1) The PTP Master device is a third-party device and is not included in the RoboSense shipment. The user needs to purchase it separately;
2) RoboSenseproducts,asSlavedevices,onlyreceivetimefromtheMasterand do not judge the accuracy of the Master's clock source. If there are sudden changes in the time when parsing LiDAR point cloud data, please check if the time provided by the Master is accurate;
3) AfterLiDARsynchronization,whentheMasterisdisconnected,thetimeinthe

point cloud data packet will be accumulated based on the LiDAR's internal clock. The time will be reset when the LiDAR is powered off and restarted;

4) The LiDAR defaults to gPTP mode. To select PTP/GPS synchronization mode, configuration can be done via the diagnostic protocol. For details on configuring the diagnostic protocol, please contact RoboSense technical support.

3 ProductInstallation

3.1 Accessory Description

The standard accessories included with Airy Lite LiDAR are listed in Table 3 for reference.

Table 3 Standard Accessory List

No.	Accessory Name	Specification	Quantity
1	LiDAR	Airy Lite	4
2	Screw Pack(optional)	M3*8	1
3	Aviation Connector Cable(optional)	1.5m	1
4	Power Adapter(optional)	DC12 V * 3.34 A / 40 W	1
5	Power Cable(optional)	1.2m	1
6	Ethernet Cable(optional)	1.5m	1
7	Product Packing List and Shipment Inspection Report	/	

Note:

For specific requirements, please contact RoboSense or just refer to the commercial agreement.

3.2 Mechanical Installation

The installation diagram of the LiDAR is shown in Figure 4 .

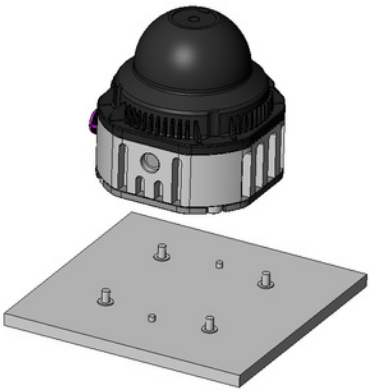


Figure 4 LiDAR Structure Installation Diagram

1) Screw Specifications:

a) GB/T70.1,M3×8,hexsocketcaphead,strengthgradenotlowerthan 8.8;

2) Installation and Positioning Requirements:

a) The bracket and LiDAR are positioned as shown in Figure 4; it is recommended to use the positioning posts on the bottom of the LiDAR for alignment;

b) Itisrecommendedtousesmallbossesnearthe4mountingholesonthe bottom bracket to engage with the LiDAR. The overall flatness of the bosses must be within 0.05 mm;

c) Use4M3screwstoinstallonthebase,4~5mmoutoftheinstallation surface. Recommended tightening torque is 6.6 ±0.5 kgf·cm;

d) Use2 Φ2.5positioningpinsonthebaseforinstallationalignment,with the height not exceeding 1.5mm above the installation surface;

e) When installing the LiDAR, if both the top and bottom of the LiDAR have contact surfaces, ensure the distance between the surfaces is greater than the height of the LiDAR to avoid compressing it;

f) Theprotectivecoverisanopticalcomponentmadeofplasticmaterial. During installation or usage, avoid applying force to it;

g) As the LiDAR requires a cable harness for external communication, insufficient routing space or an excessively small bending radius will adversely affect the cable's service life and signal quality. The installation requirements for the cable harness are as follows:

i. WheninstallingandroutingtheLiDAR,avoidexcessivetensionon the connecting cable. Ensure the cable has a certain degree of slack；

ii. Wireharnessdiameteris6mm;withaminimumbendingradiusofthe wire harness of 5 times its diameter.

3) Bracket Stiffness and Strength Requirements:

The mounting bracket must possess sufficient rigidity to securely install and fix the LiDAR, maintaining its stable position under various operating conditions. The design requirements are as follows:

a) ItisrecommendedthattheLiDARmountingbracketmaintainsacertain level of rigidity, with specific boundary requirements determined by

user perception-side needs assessment;

b) The LiDAR will undergo various random vibrations and mechanical shocks during use. Under these conditions, the bracket needs to withstand significant loads, so it also requires sufficient strength. Under mechanical shock conditions, the maximum stress of the bracket shall be less than 2/3 of the tensile strength. Under random vibration conditions, the 1 sigma RMS stress of the bracket shall be less than 1/5 of the tensile strength.

4) Heat Dissipation Requirements:

Airy Lite may experience moderate temperature rise during operation. Factors such as nearby heat sources, ambient temperature, and solar radiation may exacerbate this condition. RoboSense provides thermal simulationanalysisand optimization recommendations based on specific design schemes. General thermal management guidelines include:

a) TheambienttemperaturearoundtheLiDARmustbemaintainedwithin its operating temperature range (- 20℃ ~ + 60℃);

b) Thebracketmaterialisrecommendedtobemadeofaluminumalloy with a thermal conductivity greater than 90 W/m · K. Some heat dissipation fins should be added to the bracket, with reasonable spacing, height, and direction of the fins to increase the heat dissipation area. The direction should align with the air convection direction for more effective heat dissipation. The bracket surface area shall be no less than 10000 mm^2;

c) Ensure that the LiDAR base or top cover is not covered with non-metallic materials to avoid affecting the overall heat dissipation, leading to excessive temperature rise of the LiDAR;

d) Itisrecommendedtoaddathermalinterfacematerial(withathermal conductivity of 3W/mK or higher) between the LiDAR base and the underlying metal bracket to improve heat transfer efficiency from the LiDAR to the bracket.

5) Ventilation Requirements:

The Airy Lite base has ventilation holes. The surrounding components of the LiDAR must not obstruct these ventilation holes.

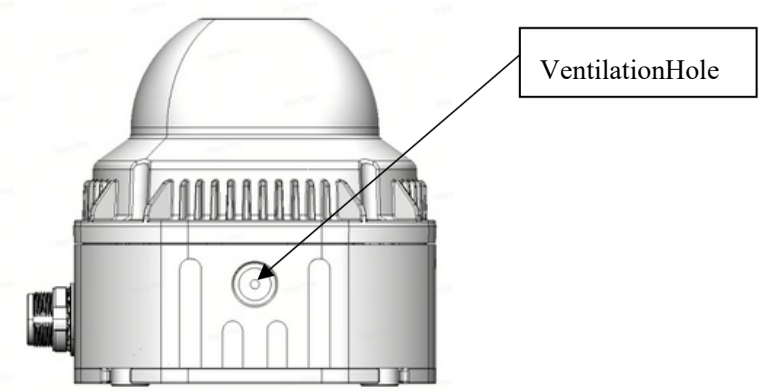


Figure 5 LiDAR Base Ventilation Hole Location Diagram

3.3 Interface Description

3.3.1 Aviation Plug Interface and Definitions

The cable aviation plug on the Airy Lite LiDAR side is shown in Figure 6.

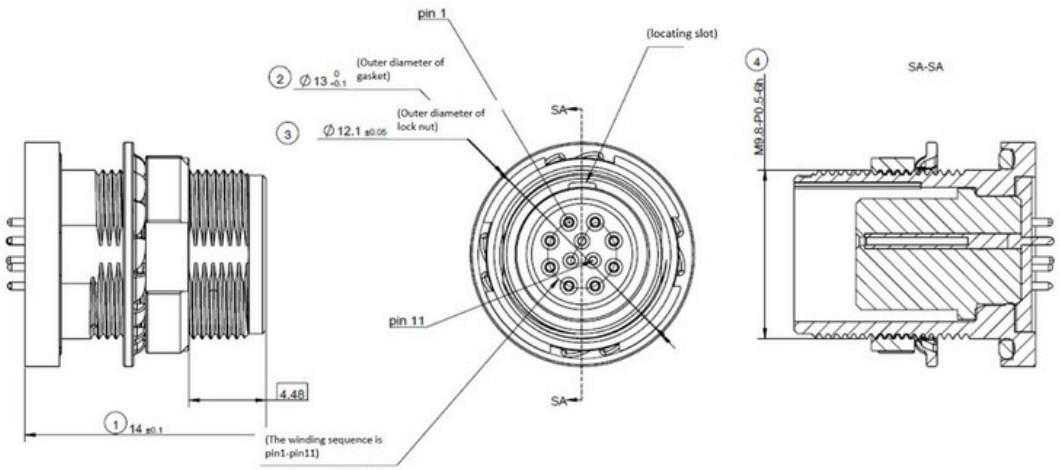


Figure 6 Aviation Plug Interface Pin Numbers

The specific pin definitions of the aviation plug interface on the LiDAR side are shown in Table 4.

Table 4 Aviation Plug Interface Pin Definitions

Pin No.	Spec	Signal
1	26AW	2P(RX+)
2	G	2N(RX-)
3	26AW	1P(TX+)
4	G	1N(TX-)
5	26AW	GND
6	G	VIN
7	26AW	VIN
8	G	GND
9	26AW	GPS PPS
10	G	RESERVED
11	26AW	GPS GPRMC
	G	
	26AW	
	G	
	26AW	
	G	
	30AW	
	G	
	30AW	
	G	
	30AW	
	G	

3.3.2 Interface Cable (Optional)

The optional accessory Interface cable for Airy Lite is shown in the Figure 7 below:

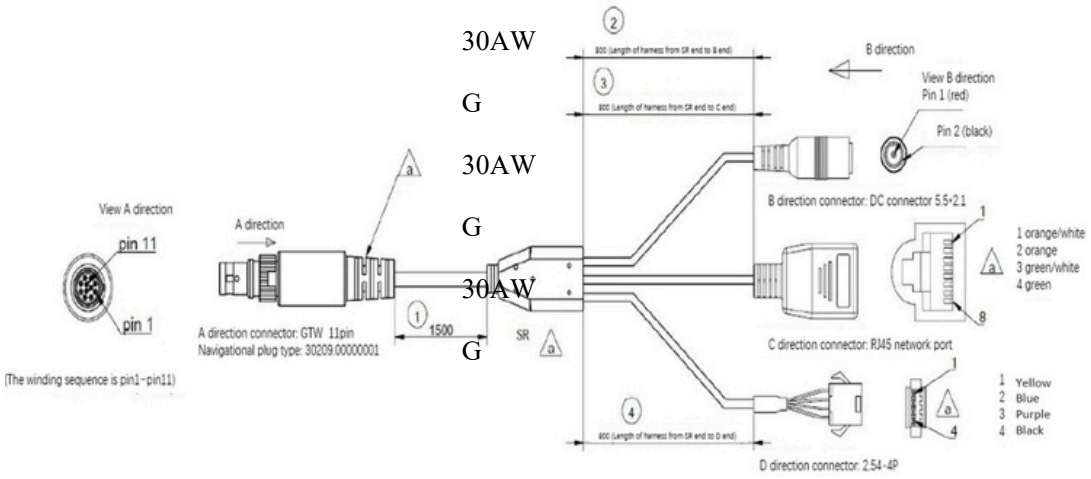


Figure 7 Interface Cable

For detailed specifications of the interfaces on the Interface cable, please refer to Table 5.

Table 5 Interface Cable Interface Specifications

AEnd No.	WireSpec	Wire Definition	AE ndB	EndC No.	EndD No.	End No.	Color
1	26AWG	2P(RX+)	Orange-white	\	1	\	\
2	26AWG	2N(RX-)	Orange	\	2	\	\
3	26AWG	1P(TX+)	Green-white	\	3	\	\
4	26AW	1N(TX-)	Green	\	6	\	\
5	G	GND	Black	2	\	\	\
6	26AW	VIN	Red Red	1	\	\	\
7	G	VIN	Black	1	\	\	\ Black
8	26AW	GND	Purple	2	\	4	Purple
9	G	GPS PPS	Blue	\	\	3	Blue
10	26AW	Reserved	Yellow	\	\	2	Yello
11	G	GPS GPRMC		\	\	1	w
	26AW						
	G						
	30AW						
	G						
	30AW						
	G						
	30AW						
	G						

3.3.3 Power Interface

The Airy Lite power interface uses a standard DC 5.5 - 2.1 interface.

If the LiDAR motor does not rotate after connecting the power supply, it may be due to a damaged cable. In this case, please contact RoboSense.

3.3.4 RJ45 Ethernet Port

The Airy Lite Ethernet interface follows the EIA/TIA568B standard.

3.3.5 Sync Interface

The Airy Lite sync interface is defined as follows: GPS GPRMC is for GPRMC signal input, and GPS PPS is for PPS signal input.

! Important:

When connecting the "Ground" of Airy Lite to an external system, the power supply negative pole ("Ground") of the external system and the GPS system's "Ground" must

be non-isolated and connected together.

3.4 Quick Connection

The Airy Lite network parameters can be configured, and the default factory setting uses fixed IP and port number mode, as shown in Table 6.

Table 6 Default Factory Network Configuration Table

Device	IP Address	MSOP Package Port Number	DIFOP Package Port Number	IMU Package Port Number
Airy Lite	192.168.1.200	6699	7788	6688
Computer	192.168.1.102			

When using the product, the user needs to set the computer's IP address to be in the same subnet as the product, for example, 192.168.1.x (where x can be any value between 1 and 254), and the subnet mask is 255.255.255.0. For unknown product network configuration information, please connect the product and use Wireshark to capture the output package of the product for analysis. The IP configuration and connection methods are as follows:

1) ConnectingtheLiDAR

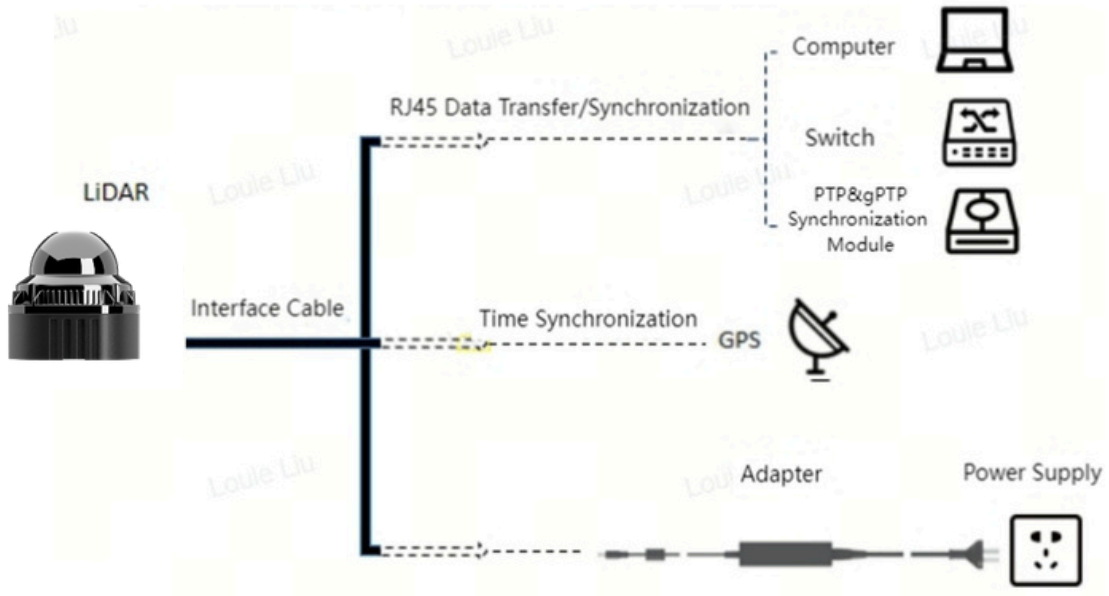


Figure 8 Interface Cable Connection Diagram

The connection method is shown in Figure 8.

a) ConnecttheLiDARusingtheaviationplug;

b) ConnectthePCandLiDARusingtheRJ45Ethernetport;

c) Afterpoweringon,theLiDARcanworknormally.

2) ByusingWiresharktocapturepackets,analyzetheARPmessagestoperform local IP configuration

a) PerformthefollowingstepsaftertheLiDARandPCareconnected:Start Wireshark (a third-party network analysis tool) and select the correct network interface to begin capturing packet;

b) UsethesearchboxinWiresharkandenter"arp"tosearchforthemutual addressing packets between the LiDAR and PC, as shown in Figure 9;

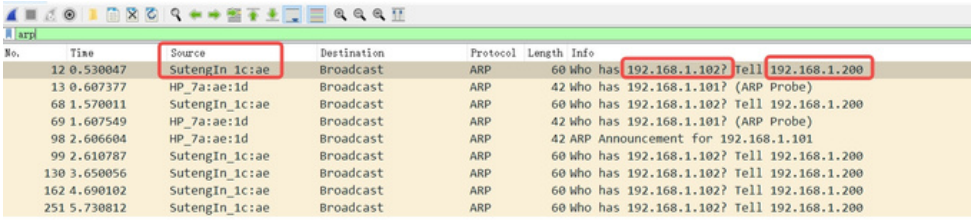


Figure 9 Analyzing ARP Packets

c) In Figure 9 , the "SutengIn" in the Source column indicates the source information of the LiDAR, indicating that the Source IP is 192.168.1.200, which is the LiDAR's IP. The request is accessing 192.168.1.102, which is the PC's IP. If the local IP is not the requested access IP, then configure the PC's local IP as 192.168.1.102 as shown in step 3. If the access is successful, proceed to step 4.

3) Configuring the PC's Local IP

a) In the Control Panel, go to "Network and Internet" and then "Network and Sharing Center." In the "View your active networks" section, click on the corresponding Ethernet connection to enter the corresponding "Ethernet Status," and then click on "Properties";

b) Double-click"InternetProtocolVersion4(TCP/IPv4)"toentertheIP information settings and use a static IP for configuration;

c) SetthelocalIPaddressto192.168.1.102,subnetmaskto255.255.255.0, and click "OK" to complete the PC's static IP setting.

4) Connection Completed

Note:

1) Thetimesynchronizationmodule(PTP&gPTP,GPStimesynchronizationmodule) is not included as a standard product. If you need to use these features, please purchase them separately and follow the connection method shown in Figure 8;
2) TheconfigurationofthelocalstaticIPprovidedaboveisonlyanexample for Windows operating systems. For other operating systems, please refer to the actual instructions.

4 Product Usage

4.1 Product Coordinate System

The coordinates and rotation direction of the product are shown in Figure 10 .

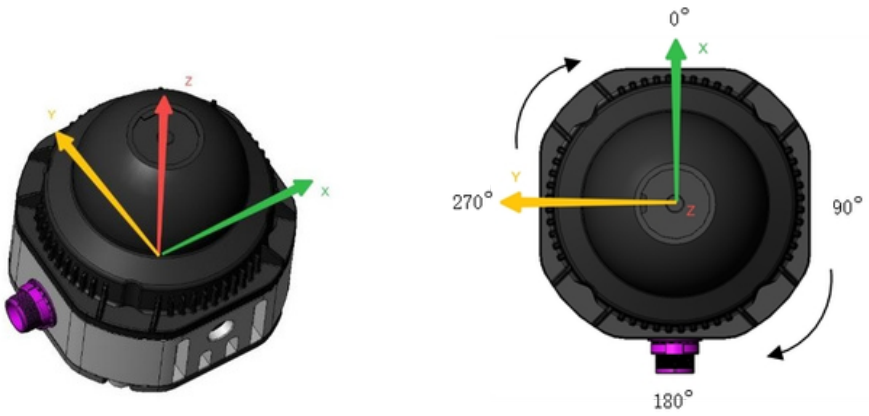


Figure 10 LiDAR Coordinate and Rotation Direction Illustration

Note:
The origin of the coordinates for the LiDAR is defined at the center of the LiDAR base.

4.2 RSView Usage

For data visualization with Airy Lite, you can use free tools such as Wireshark and tcp-dump to obtain raw data. RSView can provide a more convenient way to visualize the raw data.

4.2.1 Software Functions

RSView enables real-time visualization of Airy Lite data. It can also replay data saved in ".pcap" file format, but does not support ".pcapng" files at the moment.

In RSView, the distance measurement values obtained by Airy Lite are displayed as points. It supports various custom colors to display data, such as reflection intensity, time, distance, horizontal angle, and laser beam index. The displayed data can be exported and saved in ".csv" format, and RSView version 3.1.3 and later versions support exporting data in ".las" format.

RSView includes the following features:

1) Real-timedisplayofdataviaEthernet;

2) Savereal-timedataasPCAPfiles;

3) ReplaydatafromrecordedPCAPfiles;

4) Variousvisualizationmodes,suchasdistance,time,horizontalangle,etc;

5) Displaypointdataintabularformat;

6) ExportpointclouddataasCSVfiles;

7) Distancemeasurementtool;

8) Displaymultipleframesofreplayeddatasimultaneously;

9) ShoworhideindividuallaserbeamsfromAiryLite;

10) Cropping display.

4.2.2 Installing RSView

RSView can be run on Windows 64-bit and Ubuntu 18.04 or higher operating systems. Please contact RoboSense technical support to obtain the latest version of the Airy Lite RSView software package. The software extraction path should not contain Chinese characters. No installation is required; simply extract the files and run the executable to use the software normally.

4.3 Communication Protocols

Airy Lite uses the UDP protocol, and its output content is primarily divided into two categories. For details, refer to Table 7.

Table 7 Protocol Overview

Protocol Name	**Abbreviation**	**Function**	**Packet Size**	**Send Interval**
Main data Stream Output Protocol	MSOP	Point Cloud Data	1280 bytes	Approximately 2.667 ms Approximately 100 ms Approximately 5ms
Device Information Output Protocol	DIFOP	LiDA R Information Output	540 bytes	
IMU Output Protocol	IMU	Inertial Sensor Information	51 bytes	

Note:

1) Section 4.3 of the product manual describes and defines the payload of the protocols;
2) TheMainDataStreamOutputProtocol(MSOP)encapsulatesthelaserscanning data, including distance, angle, and reflection intensity, into packets for output;
3) The Device Information Output Protocol (DIFOP) outputs various configuration information about the current state of LiDAR;
4) TheIMUOutputProtocol(IMU)outputstheLiDAR's6-axisaccelerationand angular velocity information;
5) Thismanualdoesnotincludedescriptionsofupgradeordiagnosticprotocols. For further information, please contact RoboSense technical support.

4.3.1 Output Data Structure

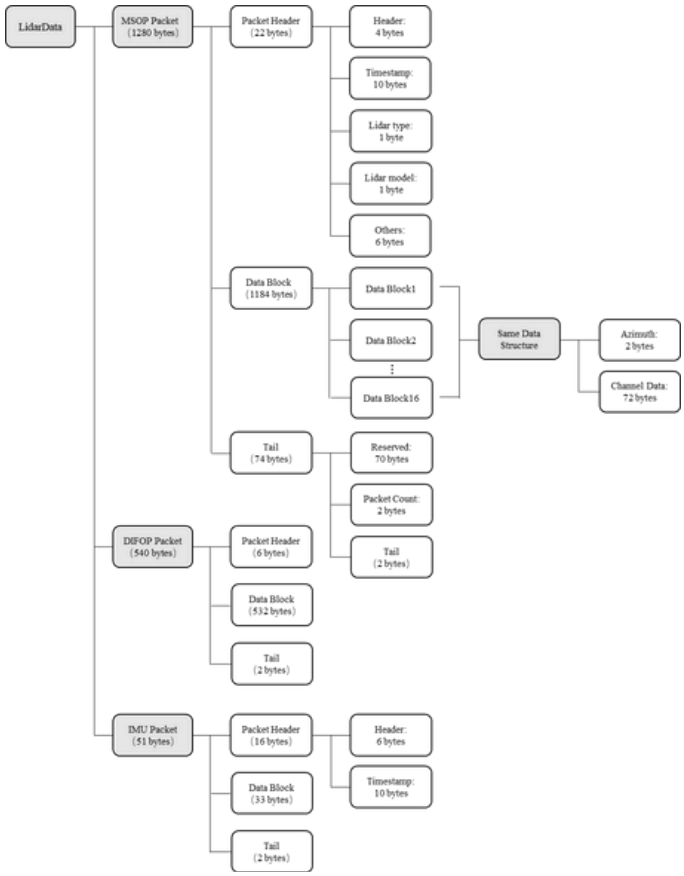


Figure 11 LiDAR Data Structure Diagram

4.3.2 Main Data Stream Output Protocol (MSOP)

Main data Stream Output Protocol, abbreviated as MSOP.

I/O Type: Product output, computer parsing.

4.3.2.1 Header

The frame header (Header) is 22 bytes in total and is used to identify the start position of the data. For details on the data structure, refer to Table 8.

Table 8 MSOP Header Data Table

Information	Offset	Length (byte)	Description	Total Length(byte)
pkt_head	0	4	0x5AFF55AA	22
Reserved	4	1		
Data Type	5	1	Value 3, indicating status information	
timestamp	6	10	Timestamp, first 6 bytes indicate seconds, last 4 bytes indicate microseconds	
lidar_type	16	1	0x0C： Airy Lite Network Platform Edition	
lidar_model	17	1	0x04：24 beams	
Reserved	18	4		

Note:

The defined timestamp is used to record the system time with a resolution of 1 μs.

4.3.2.2 Data Block

As shown in Table 9, Data block is the part of sensor measurement value in MSOP package, with a total of 1184 bytes. It consists of 16 data blocks, with each block having a length of 74 bytes.

Each Data block contains 2 bytes for Azimuth, representing horizontal rotation angle information. Each angle information corresponds to 24 channel data.

Table 9 Data Block Definition

Information	Offset	Length （byte）	Definition	Total Length(byte)

Azimuth	0	2	Horizontalangleinpolar coordinates, resolution 0.01	74
Channel data 1	2	2	Range (Lower 14 bits used for measurement; upper 2 bits reserved for rain, occlusion,and contamination points markers (customer-specific use))	
	4	1	Reflectivity	
Channeldata2	5	3	Sameasdata1	
Channeldata3	8	3	Sameasdata1	
...	...	...	...	
Channeldata23	68	3	Sameasdata1	
Channeldata24	71	3	Sameasdata1	

1) AngleValueDefinition

In each Block, the angle value output by Airy Lite is the Azimuth angle at which the first channel laser range finding occurs. This angle value is derived from the angle encoder, where the zero position of the angle encoder is the zero point of the angle. The resolution for horizontal rotation angle values is 0.01°.

2) ChannelDataDefinition

Channel data is 3 bytes, with the high two bytes used to represent distance information and the low one byte used to represent reflectivity information, as shown in Table 10 .

Table 10 Channel Data

Channel Data (3 bytes)	
2 bytes Distance	1 byte Reflectivity
Lower 14 bits for data, upper 2 bits reserved for rain, occlusion, and contamination points markers	Reflectivity

Note:
Distance is 2 bytes ，resolution is 0.5 cm.

4.3.2.3 Tail

Frame tail (Tail) is 74 bytes in total, consisting of two parts: 2 bytes of fixed characters for Tails and 72 bytes of reserved space.

4.3.3 Device Info Output Protocol (DIFOP)

Device Info Output Protocol, abbreviated as DIFOP.

I/O Type: Product output, computer parsing.

DIFOP is an "output-only" protocol designed to periodically send information such as product serial number (S/N), firmware version, calibration angles, and operational status, etc. to the user. By reading the DIFOP, users can interpret specific parameters of the product in use.

A complete DIFOP packet has a data format structure of DIFOP header, data area, and tail. Every packet has 540 bytes totally. The basic structure of the data packet is shown in Table 11.

Table 11 Data Format Structure of DIFOP Packet

Information	Offset	Length (byte)	Description
pkt_head	0	4	Packet Start Flag Fixed Value: 0x5A 0xFF 0x55 0xAA
Reserved	4	1	
Data Type	5	1	Value 3, indicating status information
Mainboard Firmware Version	6	4	Appendix B.1
Baseboard Firmware Version	10	4	Appendix B.2
Motor Firmware Version	14	4	Appendix B.3
Ethernet Source IP Address	18	4	Appendix B.4
Ethernet Destination IP Address	22	4	
LiDAR MAC Address	26	6	
MSOP Port	32	2	
DIFOP Port	34	2	
IMU Port Number	36	2	
Reserved	38	10	
Reserved	48	1	
Product SN Number	49	6	Appendix B.5
Reserved	55	39	
Time Sync Mode Setting	94	1	Appendix B.6

Time Sync Status	95	1	
Time	96	10	Appendix B.7
GPRMC Baud Rate in GPS Synchronization Mode (default baud rate is 9600)	106	1	The baud rate values are as follows: 0x00:1200 0x01:2400 0x02:4800 0x03:9600 0x04:14400 0x05:19200 0x06:38400 0x07:43000 0x08:57600 0x09:76800 0x0A:115200 0x0B:128000 0x0C:230400 0x0D:256000 0x0E:460800 0x0F:921600 0x10:1382400
Reserved	107	204	
FOV Start Angle	311	2	The range is 0-359，the precision is 0.01°
FOV End Angle	313	2	The range is 0-359，the precision is 0.01°
Phase-Locked Angle	315	2	The range is 0-360，the precision is 1°
Reserved	317	25	
Real-time Motor Speed	342	2	Appendix B.8
Reserved	344	4	
Vertical Angle Calibration	348	48	Appendix B.9
Vertical Angle Calibration Positive/Negative Sign	396	3	
Horizontal Angle Calibration	399	48	Appendix B.10
Horizontal Angle Calibration Positive/Negative Sign	447	3	
Reserved	450	23	
IMU Extrinsic Calibration Data	473	4	Appendix B.11
	477	4	
	481	4	
	485	4	
	489	4	

	493	4	
	497	4	
Reserved	501	35	
Mainboard Total Input Voltage	508	2	Appendix 12
Reserved	510	16	
Baseboard External Power Supply Input Voltage	526	2	Appendix 13
Reserved	528	10	
FrameTail	538	2	0x0F 0xF0

Note:

1) The Header (DIFOP Identification Header) consists of the bytes 0x5A, 0xFF, 0x55, 0xAA, and can be used as a check sequence for the packet;
2) The Tail contains the bytes 0x0F, 0xF0;
3) The definition and usage of each item's registers can be found in detail in Appendix B of the product manual. The corresponding relationship is specified in the Remarks column of Table 11.

4.3.4 IMU Data Stream Output Protocol

I/O Type: Product output, computer parsing.

The IMU output is the attitude information of IMU in the product, which can be used to adjust the external parameters of the customer’s products. Each packet contains 51 bytes. The basic structure of the packet is shown in Table 12.

Table 12 IMU Data Format Structure

Information	Offset	Length (byte)	Remarks
IMU Header	0	4	0x5A 0xFF 0x55 0xAA
Reserved	4	1	
Data Type	5	1	Value 2, indicating IMU data
timestamp	6	10	UTC time format. The first 6 bytes are second timestamps, and the last 4 bytes are microsecond timestamps.
AccelX	16	4	X-axis acceleration value, float, unit: m/s²

AccelY	20	4	Y-axis acceleration value, float, unit: m/s²
AccelZ	24	4	Z-axis acceleration value, float, unit: m/s²
GyroX	28	4	X-axis angular velocity, float, unit: rad/s
GyroY	32	4	Y-axis angular velocity, float, unit: rad/s
GyroZ	36	4	Z-axis angular velocity, float, unit: rad/s
Internal Temperature	40	4	IMU internal temperature (-40~105°C), signed, resolution: 0.01°
ODR	44	1	Data Output Frequency 0:25Hz 1:50Hz 2:100Hz 3:200Hz (Default Value)
AccelFsr	45	1	Accelerometer Range 0: +/- 2g 1: +/- 4g (Default Value) 2: +/- 8g 3: +/- 16g
GyroFsr	46	1	Gyroscope Range 0: +/- 250 dps 1: +/- 500 dps (Default Value) 2: +/- 1000 dps 3: +/- 2000 dps
Packet Count	47	2	Packet Sequence Number u16 0~0xFFFF
Tails	49	2	CRC16 (calculated from pkt_head to packet count section)

5 ProductMaintenance

5.1 Transportation and Logistics

! Important:

Improper transportation can cause product damage!

1) The product should be packaged with shockproof and moisture-proof materials to avoid damage during transportation. It is recommended to use the original packaging;

2) Handlewithcareduringtransportationtoavoidimpactordropping;

3) Whenreceivingthegoods,carefullycheckthedeliverylistforanydamages (including the product and packaging);

4) If there is any transportation damage, refuse to accept the delivery and contact RoboSense promptly.

5.2 Storage

! Important:

Improper storage may cause product damage!

1) Storetheproductinanindoorenvironmentwithnormaltemperatureanddry conditions;

2) Handletheproductgentlytoavoidimpactordropping;

3) The product should be stored in a safe environment to avoid corrosion, mechanical impact, or exposure to environments exceeding the protection level;

4) Regularly inspect the condition of all components and packaging, and it is recommended to check every three months.

5.3 Product Cleaning

To ensure accurate perception of the surrounding environment, keep the RS-LiDAR’s circular protective cover clean.

5.3.1 Precautions

! Before cleaning the RS-LiDAR, carefully read and understand the content of this section. Improper cleaning may damage the product.

! When using the LiDAR in harsh environmental conditions, clean the surface regularly to keep the LiDAR clean. Otherwise, it may affect the normal operation of the LiDAR.

5.3.2 Required Materials

1) Cleananddust-freecloth;

2) Neutralsolutionatmoderatetemperature(suchassoapywater,distilledwater, 99% concentration of ethanol, etc.).

5.3.3 Cleaning Method

1) IftheLiDARsurfaceisonlycoveredwithsomedust:

a) Use a clean and dust-free cloth, dip it in a small amount of neutral solution;

b) Gently wipe the LiDAR surface;

c) Dry it with a clean and dry dust-free cloth.

2) IftheLiDARsurfaceiscoveredwithmudorothersolidforeignobjects:

a) First, spray clean water on the dirty part of the LiDAR surface to remove the mud or foreign objects (Note: Do not directly wipe off the mud with a dust-free cloth, as it may scratch the surface, especially the protective cover);

b) Then spray warm soapy water on the dirty part. The lubricating effect of the soapy water helps to remove the foreign objects. Gently wipe the LiDAR surface with a fiber cloth, but be careful not to scratch the surface;

c) Finally, rinse off the residual soap on the LiDAR surface with clean water (if there is still residue, clean it again with 99% ethanol) and dry it with a clean and dry dust-free cloth.

6 FaultDiagnosis

This chapter lists some common problems encountered during the use of the product and their corresponding troubleshooting methods. For details, refer to Table 13.

Table 13 Common Fault Troubleshooting Methods

Fault Phenomenon	Solution
The Product Motor Does Not Rotate	Check whether the connector cable on the aviation plug power/product side is loose or if the wiring harness is damaged.
The Product Keeps Restarting During Startup	Check the input power connection and polarity; Check if the voltage and current of the input power meet the requirements; Check if the installation plane of the product is level or if the screws on the bottom of the LiDAR are tightened too tightly.
The Product Internally Rotates, But There Is No Data	Check if the LiDAR emits light normally; Check if the network connection is normal; Confirm if the computer-side network configuration is correct; Use other software (such as Wireshark) to check if the data is received; Disable the firewall and other security software that may block the network; Check if the power supply is normal; Try restarting the product. Close the computer's firewall and run RSView through the firewall;
Wireshark Can Receive Data, But RSView Does Not Display Point Cloud	Confirm that the computer's IP configuration matches the destination address set in the product; Confirm that the Sensor Network Configuration in RSView is set correctly; Confirm that the installation directory or configuration file storage directory of RSView does not contain any Chinese characters; Confirm that the data packets received by Wireshark are of the MSOP type.
The Product Has Frequent Data Loss	Confirm if there is a large number of other network packets or network conflicts in the network; Confirm if there are other network products sending a large amount of data in broadcast mode, causing sensor data

	blocking; Confirm if the computer's performance and interface performance meet the requirements; Remove all other network products and directly connect to the computer to confirm if data loss occurs.
Unable to Synchronize GPS/PTP/gPTP Time	Confirm if the synchronization mode has been switched to the correct mode on the web page; Under the GPS time synchronization mode: Confirm if the GPS module's baud rate is 9600 bps, 8 data bits, no parity bit, and 1 stop bit; Confirm if the GPS module outputs 3.3V TTL or RS232 level; Confirm if the 1PPS pulse is continuous and the wiring is correct; Confirm if the NMEA message format of GPRMC is correct; Confirm if the GPS module and interface box share the same ground; Confirm if the GPS module receives a valid fix; Confirm if the GPS module is validly positioned (outdoors); Under the PTP / gPTP time synchronization mode: Confirm if the PTP / gPTP Master synchronization protocol complies with the current PTP / gPTP protocol; Confirm if the PTP / gPTP Master is working properly. Close the DHCP function of the router or set the IP address of the sensor to the correct IP address internally in the router.
No Data Output After Passing Through The Router	This phenomenon is normal. It occurs because the ROS driver splits the data into fixed packages for frame display.
ROS Driver Displays A Fixed Blank Area Rotating When Showing Point Cloud	The blank part of the data will be displayed in the next frame. For Windows 10 systems, set RSView to run in Windows 7 compatibility mode to resolve the issue.
RSView Software Outputs Point Clouds As A Single Ray	

Note:

If the above troubleshooting steps fail to resolve the issue, please contact RoboSense for further assistance.

7 After-salesService

If the solutions provided in Chapter 6 of the troubleshooting guide do not solve the problem, please promptly contact RoboSense.

Official Website: https://www.robosense.cn/en/contact

Email: support@robosense.cn

Phone: +86-0755-86325830 / +86-15338772453

Note:

1) Please wait for a confirmation response from RoboSense after-sales service before sending the product back;

2) When sending the product back, please use the original packaging or an equivalent cushioned and moisture-resistant packaging.

AppendixA ROS&ROS2Package

rslidar_sdk is the LiDAR driver SDK under the ROS/ROS2 platform. The specific details are as follows:

1) rslidar_sdkreliesonrs_driver,whichisthebasicdriverofRoboSense;

2) IfROS2isused,rslidar_sdkalsoreliesonrslidar_msg,whichisthemsg definition file;

3) The driver SDK download package contains rich usage guidelines. Please read the README file and doc folder in the file before using the driver SDK.

Please contact RoboSense technical support department to obtain the above file directly.

AppendixB DIFOPDataDefinitions

This appendix supplements the definitions of each item in the DIFOP protocol outlined in Section 4.3.3, facilitating user understanding for product use and development. For calculations, big-endian mode is used, and "Value" represents the decimal number derived from the corresponding offset bytes.

B.1 Mainboard Firmware Version (TOP_FRM)

Table 14 Mainboard Firmware Version

Mainboard Firmware Version (4 bytes)				
No.	byte 1	byte2	byte3	byte 4
Fun.	TOP_FRM			

Register Description:

1) This register is used to read the mainboard firmware version number;
2) Forexample,ifbyte1=0x00,byte2=0x10,byte3=0x04,byte4=0x0c, and byte 5 = 0x00, then the firmware version number is: 00 10 04 0c.

B.2 Baseboard Firmware Version (BOT_FRM)

Table 15 Baseboard Firmware Version

Baseboard Firmware Version（4 bytes）				
No.	byte 1	byte2	byte3	byte 4
Fun.	BOT_FRM			

Register Description:

1) This register is used to read the baseboard firmware version number;
2) Forexample,ifbyte1=0x00,byte2=0x10,byte3=0x04,byte4=0x0c, then the firmware version number is: 00 10 04 0c.

B.3 Motor Firmware Version (MOT_FRM)

Table 16 Motor Firmware Version

Motor Firmware Version（4 bytes）				
No.	byte 1	byte 2	byte 3	byte 4

Fun.	MOT_FRM

Register Description:

1) This register is used to read the motor firmware version number;
2) Forexample,ifbyte1=0x00,byte2=0x24,byte3=0x12,byte4=0x12, then the firmware version number is: 00 24 12 12.

B.4 Ethernet (ETH)

Table 17 Ethernet

Register of Ethernet (30 bytes)								
No.	byte 1	byte2	byte3	byte4	byte 5	byte6	byte7	byte8
Fun.	LIDAR_IP				DEST_PC_IP			
No.	byte 9	byte10	byte11	byte12	byte 13	byte14	byte15	byte16
Fun.	MAC_ADDR						MSOP	
No.	byte17	byte18	byte19	byte20	byte 21	byte22	byte23	byte24
Fun.	DIFOP		IMU		RESERVED			
No.	byte25	byte26	byte27	byte28	byte 29	byte30	\	\
Fun.	RESERVED						\	

Register Description:

1) LiDAR_IP is the source IP address of the LiDAR, occupying 4 bytes;
2) DEST_PC_IP is the destination PC's IP address, occupying 4 bytes;
3) MAC_ADDRistheMACaddressoftheLiDAR;
4) MSOP,DIFOPandIMUeachoccupies2bytes,andthesourceanddestination port numbers are required to be identical.

B.5 Product Serial Number

Table 18 Serial Number Information

Serial Number (6 bytes)						
No.	byte 1	byte 2	byte 3	byte 4	byte 5	byte 6
Fun.	SN					

Register Description:

1) This register is used for the device serial number;

2) Similar to a MAC address, it consists of 6 bytes, representing the product serial number in hexadecimal.

B.6 Time Sync Mode Setting (TIME_SYNC_INFO)

Table 19 Time Sync Information

Time Sync Information (2 bytes)		
No.	byte 1	byte 2
Fun.	Time_Sync_Mode	Time_Sync_State

Register Description:

1) This register is used to read time synchronization information;
2) Byte1isthetimesynchronizationmodestatusbit,definedasfollows:0x00: GPS; 0x01: E2E-L4; 0x02: P2P; 0x03: gPTP; 0x04: E2E-L2;
3) Byte 2 is the time synchronization success status bit, defined as follows:0x00: Not synchronized; 0x01: Synchronized successfully.

B.7 Time (UTC_TIME)

Table 20 Time Information

Register of Time (10 bytes)										
No.	byte 1	byte 2	byte3	byte4	byte 5	byte 6	byte 7	byte8	byte9	byte10
Fun.	sec						μs			

Register Description:

1) This register is used to read time information;
2) The range of the microsecond (us) value: 0 ~ 999,999.

B.8 Real-time Motor Speed (REALTIME_ROTATION_SPEED)

Table 21 Real-time Motor Speed

Real-time Motor Speed (2 bytes)		
No.	byte1	byte2
Fun.	REALTIME_ROTATION_SPEED	

Register Description:

1) This register is used to read the real-time speed value of the motor, with the unit being 0.1 RPM.

2) For example, if byte 1 = 0x17 and byte 2 = 0x70, then Value = 6000. The real-time speed is calculated as 6000 × 0.1 RPM = 600 RPM.

B.9 Vertical Angle Calibration Sign Bits

Table 22 Vertical Angle Calibration Bits

Vertical Angle Calibration Register (48bytes)				
No.	byte1 byte2	byte3 byte4	byte5 byte6	byte7 byte8
Fun.	Channel 1 Vertical Angle	Channel 2 Vertical Angle	Channel 3 Vertical Angle	Channel 4 Vertical Angle
No.	...			
Fun.	...			
No.	byte41 byte42	byte43 byte44	byte45 byte46	byte47 byte48
Fun.	Channel 21 Vertical Angle	Channel 22 Vertical Angle	Channel 23 Vertical Angle	Channel 24 Vertical Angle

Table 23 Vertical Angle Calibration Sign Bits

Vertical Angle Calibration Sign Bit Register (3bytes)			
No.	byte1	byte2	byte3
Fun.	Sign Bits Corresponding to 24-Channel Vertical Angles		

Register Description:

1) The vertical calibration angle for each channel must be calculated by combining the Vertical Angle Calibration value with the Vertical Angle Calibration Sign Bits;
2) As shown in Table 10, the vertical angle value for each channel is represented by 2 bytes, with an angular resolution of 0.01°;
3) As shown in Table 2, the 24 channels collectively use 3 bytes (24 bits) to represent the sign bits of each channel. Each bit indicates the sign of the vertical calibration angle for the corresponding channel (0 for positive, 1 for negative). Bit 1 of Byte 1 corresponds to Channel 1, Bit 2 of Byte 1 corresponds to Channel 2, etc.;
4) Example:ForChannel1inTable22,theregistervalueisByte1=0x01, Byte 2 = 0x71. Converted to decimal, this gives 369. Multiplying by the angular resolution yields 3.69°. Meanwhile, in Table 23, the sign bit for Channel 1 is Bit 1 of Byte 1, with a value of 0 indicating a positive sign.

Therefore, the vertical angle value for Channel 1 is 3.69 ° .

B.10 Horizontal Angle Calibration and Horizontal Angle Calibration Sign Bits

Table 24 Horizontal Angle Calibration Bits

Horizontal Angle Calibration Register (48bytes)								
No.	byte1	byte2	byte3	byte4	byte5	byte6	byte7	byte8
Fun.	Channel 1 Horizontal Angle		Channel 2 Horizontal Angle		Channel 3 Horizontal Angle		Channel 4 Horizontal Angle	
No.	...							
Fun.	...							
No.	byte41	byte42	byte43	byte44	byte45	byte46	byte47	byte48
Fun.	Channel 21 Horizontal Angle		Channel 22 Horizontal Angle		Channel 23 Horizontal Angle		Channel 24 Horizontal Angle	

Table 25 Horizontal Angle Calibration Sign Bits

Horizontal Angle Calibration Sign Bits Register (3bytes)			
No.	byte1	byte2	byte3
Fun.	Sign Bits Corresponding to 24-Channel Horizontal Angles		

Register Description:

1) Thecalculationmethodforhorizontalanglecalibrationisthesameasthat for vertical angle calibration. For details, refer to Appendix B.09.

B.11 IMU Calibration Data

Table 26 IMU Data

IMU Calibration Data (28 bytes)								
No.	byte 1	byte2	byte3	byte 4	byte 5	byte6	byte7	byte 8
Fun.	q_x				q_y			
No.	byte 9	byte10	byte11	byte 12	byte 13	byte14	byte15	byte 16
Fun.	q_z				q_w			
No.	byte 17	byte18	byte19	byte 20	byte 21	byte22	byte23	byte 24
Fun.	x				y			
No.	byte 25	byte26	byte27	byte 28				
Fun.	z							

Register Description:

1) Theregisterisusedtoreadthecalibrationdataofthe IMUrelativeto

the LiDAR coordinate system;

2) This calibration data includes pose estimation and position offset, and the data type is 32-bit float (conforming to the IEEE 754 standard);

3) For example, the current bytes of x (byte 17~byte20) are 3b 8b 43 96, and its calculation method is as follows:

a) First,combinethefourbytesinto32binarynumbers,thatis,00111011 10001011 01000011 10010110;

b) Separatethesignbit,theexponentfieldandthemantissafield.Among them, the sign bit is 31 bits, that is, 0, the exponent field is 23 to 30 bits, that is, 01110111, and the mantissa field is 0 to 22 bits, that is,00010110100001110010110;

c) Calculate the values of each domain, according to IEEE 754. Here, the sign domain is 0, indicating a positive number. The exponent domain is 01110111, which converts to 119 in decimal, and the actual exponent is 119 - 127 = -8. The mantissa domain is 00010110100001110010110. Therefore, it is first converted to a decimal fraction, approximately 0.086. The actual mantissa calculation is: 1 + 0.086 = 1.086;

d) Floating-point number, using the formula: Float32= $(-1)^{\blacksquare\blacksquare\blacksquare\blacksquare\blacksquare\blacksquare\blacksquare\blacksquare\blacksquare\blacksquare}$* mantissadomain*$2^{\blacksquare\blacksquare\blacksquare\blacksquare\blacksquare\blacksquare\blacksquare\blacksquare\blacksquare\blacksquare\blacksquare\blacksquare\blacksquare\blacksquare}$ = $-1^{0} * 1.086 * 2^{-8} = 0.00424$.

B.12 Mainboard Input Voltage (MAINBOARD_VOLTAGE)

Table 27 Mainboard Input Voltage

Mainboard Input Voltage (2 bytes)		
No.	byte 1	byte 2
Fun.	Mainboard Voltage	

Register Description:

1) Thisregisterisusedtoreadthemainboardinputvoltageofthedevice;

2) Unit:V.Thevoltagevalueconsistsof2bytes.Thecalculationformula is: Mainboard Voltage = Value / 100.

B.13 Baseboard External Power Supply Input Voltage

（VOLTAGE_BOT_BUS）

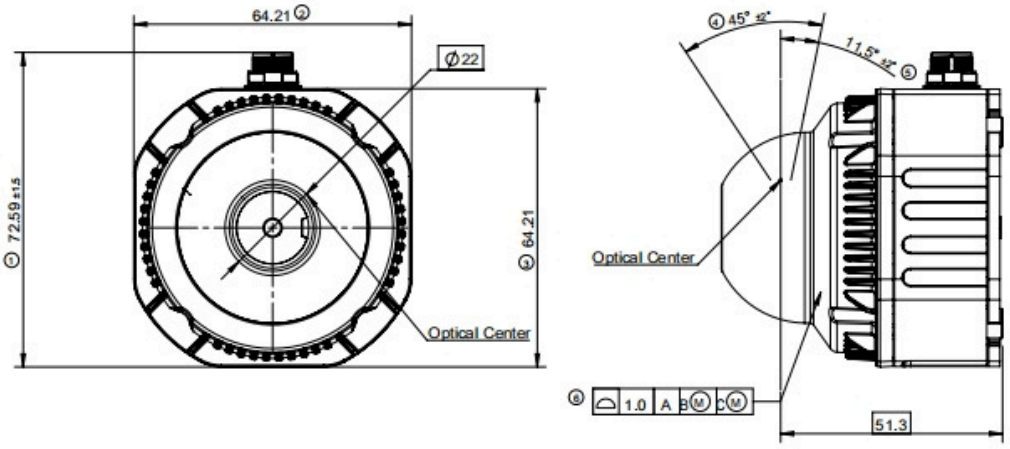
Table 28 Baseboard External Power Supply Input Voltage

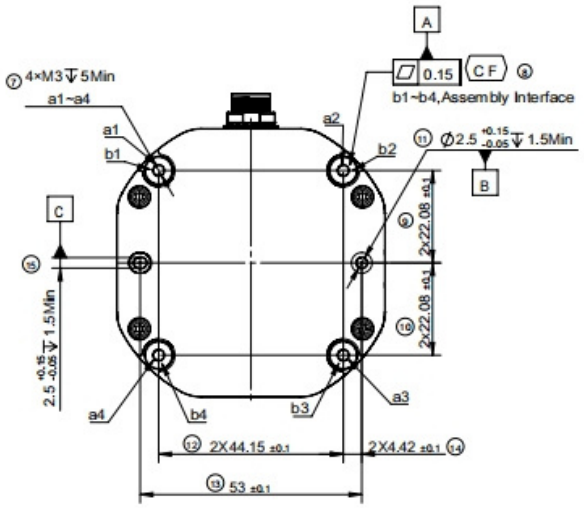
Baseboard External Power Supply Input Voltage (2 bytes)		
No.	byte 1	byte 2
Fun.	Machine Voltage	

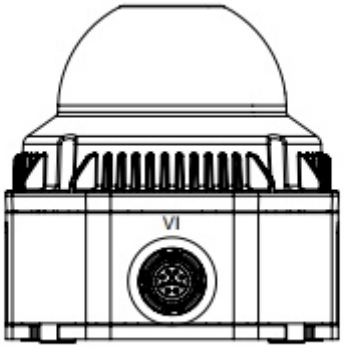
Register Description:

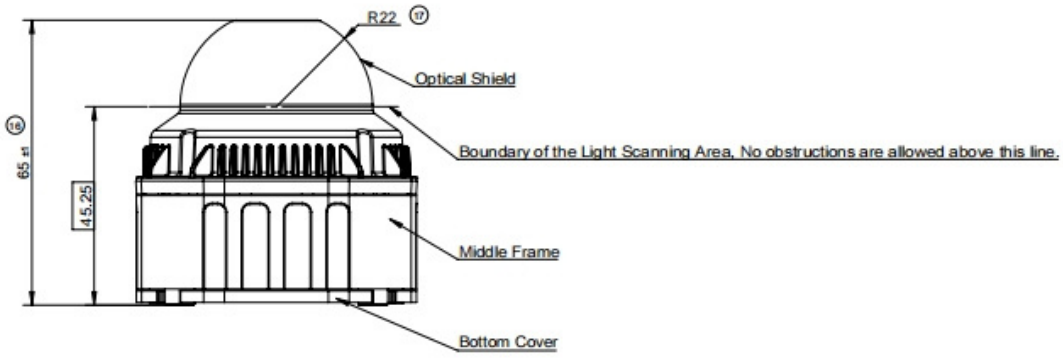
1) ThisregisterisusedtoreadtheBaseboardExternalPowerSupplyInput Voltage of the device;
2) Unit:V.Thevoltagevalueconsistsof2bytes.Thecalculationformula is: Mainboard Voltage = Value / 100.

AppendixC StructuralDrawings









Technical Requirements:
1. Unspecified fillet radius: R0.2 mm; Unspecified chamfer: C0.2 mm.
2.Unspecified dimensions refer to the 3D model. Tolerances for unspecified linear and angular dimensions shall conform to GB/T 1804 grade C. Tolerances for unspecified geometrical characteristics shall conform to GB/T 1184 grade L.
3.The product shall have good appearance, free from defects such as deformation, short shots, etc., which may adversely affect product performance.
4.The protective cover is an optical component. Any friction or collision with other parts is strictly prohibited.
5.It is recommended to use M3 screws with a strength grade not lower than 8.8 for a1~a4. Tightening torque: 0.5~0.7 N·m.
6.Flatness of the mating surface on the base for the counterpart component: ≤ 0.05 mm.
7.Thermal conductivity of the base for the counterpart component: ≥ 96 W/m·K. Heat dissipation surface area: ≥ 20000 mm².
8.Compliance with the latest requirements of relevant laws, regulations, and their amendments, such as the U.S. TSCA Act and the new national VOCs standards, is required

AppendixD EmissionDelayTableperChannel

Table 29 Emission Delay Table per Channel

Channel Number	Emission Delay (μ s)	Channel Number	Emission Delay (μ s)
00-05	0	12-17	64
06-11	21	18-23	107

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