ZWLD-01

USER MANUAL

V1.0.0 2024.12

Leishen Intelligent System Co., Ltd. **http://www.lslidar.com/**

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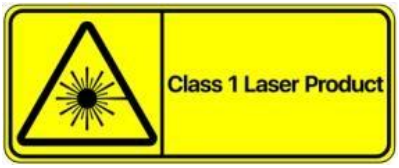
1. Safety Regulations

1.1. Operation Safety

Before using this product, in order to avoid accidents to you or others, as well as damage to the equipment and violation of warranty terms, please be sure to carefully read and follow the operation and specifications in this manual. This manual covers important information and data for the use of the product, and the user must strictly comply with its provisions to ensure the normal operation of the product.

1) **Laser Safety:** The laser safety level of this product complies with IEC 60825-1:2014 standard.



2) **Explosion-proof Safety:** The product explosion-proof safety level is based on: *GB/T3836.2-2021 Explosive atmosphere-Part 2: Equipment protection by flameproof enclosures "d"*, it has passed the Ex d IIC T6 Gb explosion-proof grade certification.

3) **High-temperature Attention:** watch out for surface overheating markings to prevent accidents.

4) **Retention Reminder:** Please retain all safety and operating instructions for future reference.

5) **Caution Warning:** The products described in this manual have been developed, manufactured, tested and archived with the relevant safety standards in mind. In order to ensure the user's personal safety when using and maintaining this product, and to avoid damage to property, there are cautions and warning messages in this manual, which are shown by specific icons with corresponding explanatory text. The icons used in this manual are shown in the table below.

Icon	Descriptions
	Note Mark and Information- Indicates general information to remind the user during the use of the product, or sections of this manual that require general attention.
	Caution Mark and Information- Indicates important information to be aware of during the use of the product, or sections of this manual that require special attention.
	Warning Mark and Information-Indicates that failure to observe proper safety measures in the use of the product will result in the instrument failing to measure correctly, and in particularly serious cases may result in accidents involving significant personal injury or property damage.

1.2. Operation Requirements

The use of this product have certain requirements for the basic professional knowledge and other related qualifications of the operator. Our company will not be responsible for any damage, injury, or loss caused to the product or the property of any person due to improper operation by untrained personnel without basic knowledge or training.

1) Please thoroughly read the product manual before operation.

2) The operator must be trained before starting work and have construction qualifications for the relevant types of work.

3) The operator should have basic knowledge of the computer data connection and electrical, etc.

4) It is recommended to inspect the operating environment of the product at least once a month.

5) Prohibition of unauthorized operation.

1.3. Violation Operation

Please use the product according to regulations, otherwise it may cause damage to the product, property damage and injury to personnel. Operation in violation of the regulations is at the user's own risk.

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

2) It is prohibited to use unregulated power supplies and accessories.

3) Please avoid abnormal operation such as dropping, collision and burning.

4) If you find the appearance of the product is damaged (curved protection shield), please stop using it immediately;

5) If you find the product working abnormally, etc., please stop using it immediately and contact our technicians in time.

2. Product Profile

2.1. Working Mechanism

The ZWLD-01 lidar adopts the Time of Flight (ToF) method. The lidar starts timing (t_1) when the laser pulses are sent out. And when the laser encounters the target object and the light returns to the sensor unit, the receiving end stops timing (t_2).

$$\text{Distance} = \text{Speed of Light}^*(t_2 - t_1)/2$$

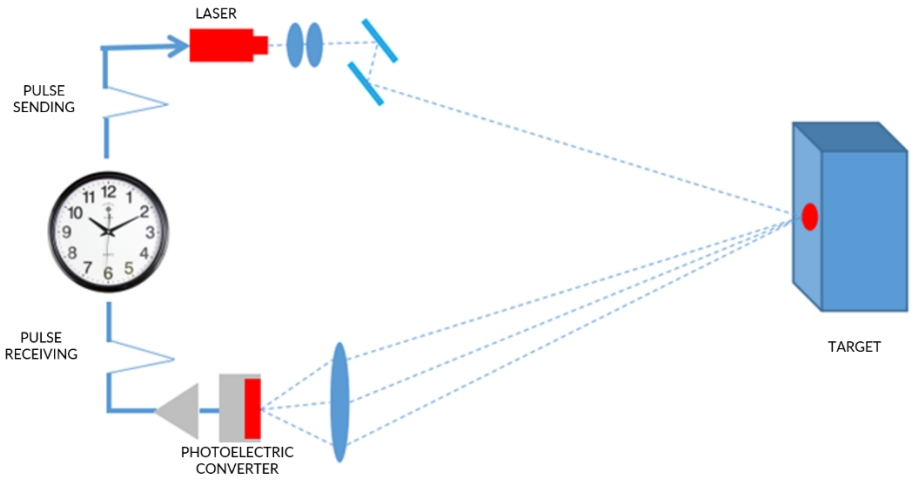


Figure 2.1 Time of Flight

2.2. Specifications

Table 2.1 Specifications of ZWLD-01

Model	ZWLD-01
Laser Beam	16
Enclosure Exclusion Proof	Ex d IIC T6 Gb
Wavelength	905 nm
Laser Safety	Class 1 (Eye Safe)
Ranging Distance (@0 klx)	70 m~200 m
Ranging Accuracy	± 3 cm
Data Point Generated In Single Echo Mode (Dual Echo)	320,000 pts/sec (640,000 pts/sec)
Horizontal FoV (Field of View)	360°
Horizontal Angular Resolution	5 Hz: 0.09°/10 Hz: 0.18°/20 Hz: 0.36°
Vertical FoV	-15~+15° (no horizontal 0° laser beam)

Vertical Angular Resolution	Uniform 2°
Frame Rate	5Hz/10Hz/20Hz
Operating Temperature	-20℃~+60℃ (B-type) -40℃~+60℃ (D-type)
Storage Temperature	-40℃~+85℃
Communication Interface	Ethernet/PPS
Power Supply	+9 V~+32 V DC
IP Grade	IP67 (Aviation connector: IP 50)
Dimensions	Φ180 mm*110.4 mm
Shock	500 m/sec^2, lasting for 11 ms
Vibrations	5 Hz~2000 Hz, 3G rms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1) Ranging accuracy is based on 50% NIST diffuse reflective panels as a target, the test results will be affected by the environment, including but not limited to the ambient temperature, the distance to the target and other factors, and the accuracy of the value applies to most of the channels, and some of the channels may differ from each other.

2) The product power consumption test results will be affected by the external environment, including but not limited to the ambient temperature, the distance of the target, the target reflective intensity and other factors.

3) The product operating temperature is affected by the external environment, including but not limited to the lighting environment, airflow changes.

2.3. Mechanical Structure

There are spare location holes and explosion-proof aviation connector on the bottom of the lidar. The lidar spins in a clockwise direction.

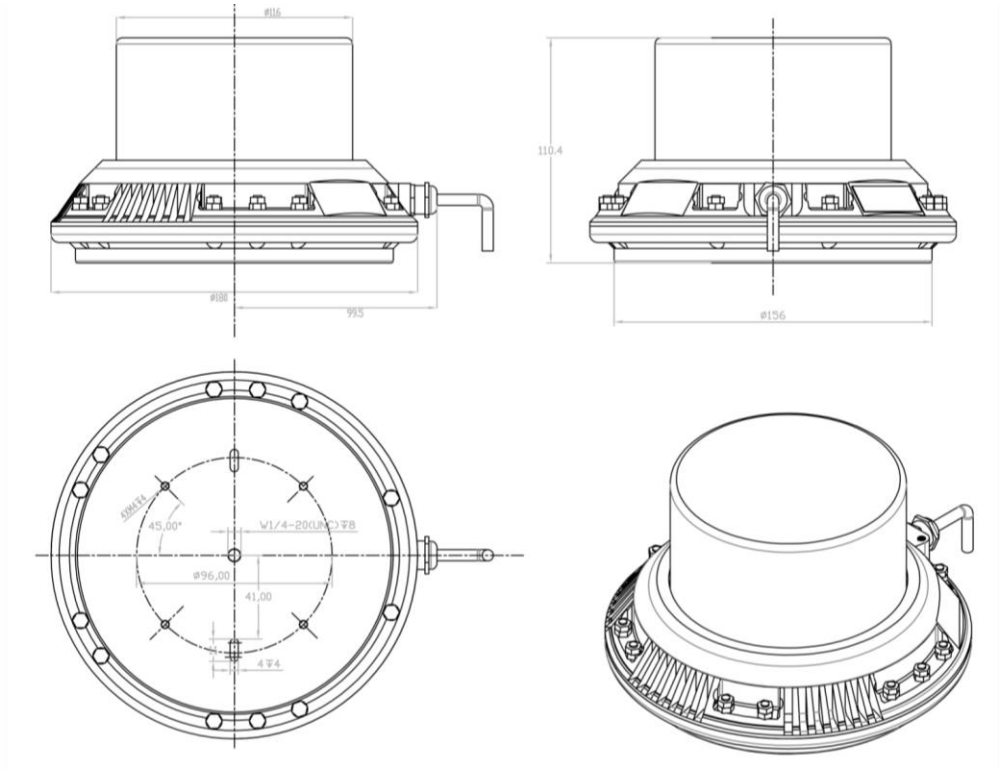
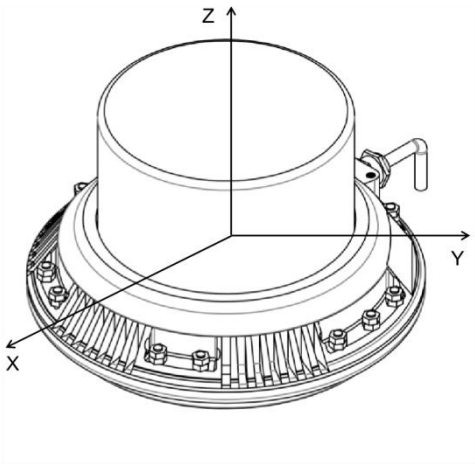


Figure 2.2 Lidar Mechanical Drawing



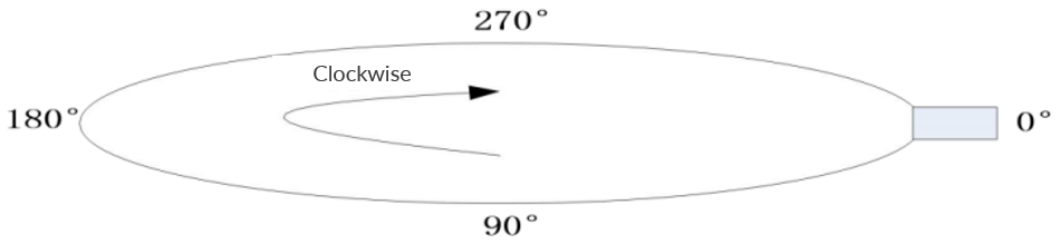


Figure 2.3 Lidar Rotation Direction

The lidar is equipped with 16 pairs of laser transmitter and receiver modules. Its motor is driven at a rotation speed of 5 Hz/10 Hz/20 Hz to cover a 360° scan range. And the vertical FoV is -15° to +15°.

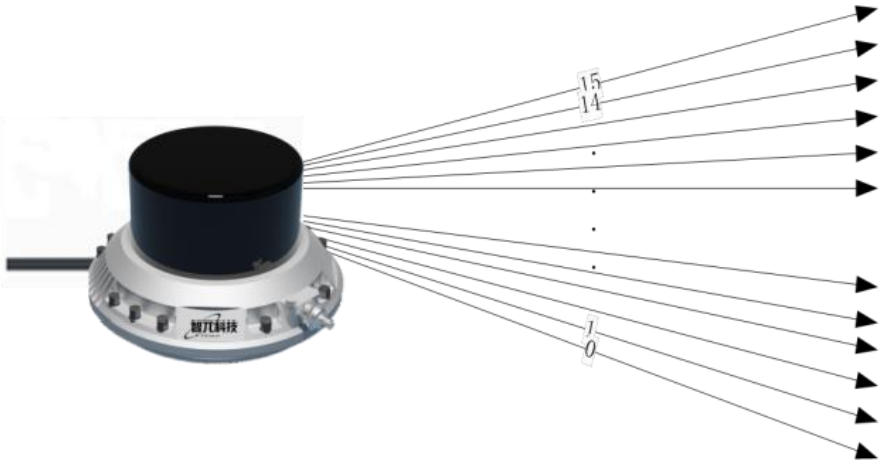
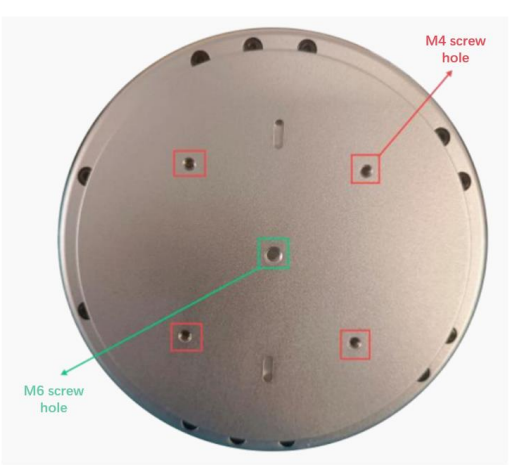


Figure 2.4 Lidar Laser Beam Distribution

2.4. Installation Requirements

Please read this manual carefully before installation, so as not to damage the product by wrong installation and affect the use of the product.



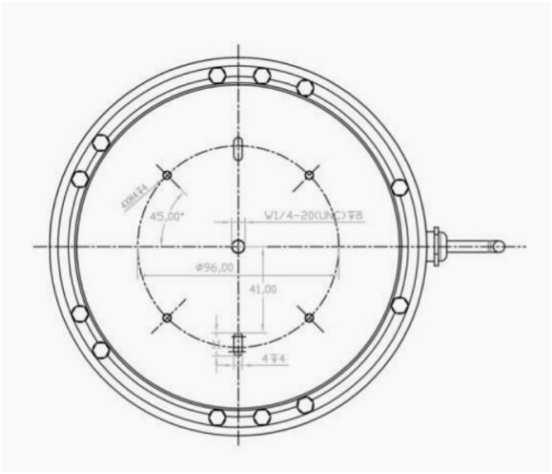


Figure 2.5 Lidar Base

Installation Steps:

1) Fix the mounting bracket;

2) Install the lidar to the mounting bracket;

3) Power on the lidar;

4) Adjust the bracket rotation direction.

1) The explosion-proof lidar transmits laser beams and receives laser echoes are required to pass through the curved special shield, therefore, it is strictly prohibited to block the field of view of the laser dispersion range.
2) When installing the fixed mounting bracket, please be careful not to damage the safety guarantee structure of the building.
3) Please ensure that the spacing between mounting surfaces is greater than the size of the equipment to avoid crushing the equipment.
4) Please ensure that the spacing between mounting surfaces is greater than the size of the equipment to avoid crushing the equipment.
5) The cables between parts should be connected tightly, and when deploy the cables, please make sure that cable has a certain amount of slack (there should be an installation allowance of more than 2 cm).
6) In the installation process, it needs to take into account the stiffness, strength and heat dissipation ability of the bracket when installing the it, and it is recommended to use aluminium alloy (thickness of 4 mm or more) or galvanized steel (thickness of 2 mm or more) with a thermal conductivity of more than 50 W/m-K.
7) The installation surface flatness should be better than 0.2 mm.
8) The base is installed with four pieces of M4 screws (M4x12, hexagonal socket head cap, strength grade of 10.9, nylonpatch) and one M6 screw (M6x12, hexagonal socket head cap, strength grade 10.9, nylonpatch), and it's recommended to be 4~ 5mm above the mounting surface. The recommended tightening torque is 13±1 kgf.cm.

2.5. Shipping List

The standard shipping list is shown below for reference only, please refer to the

actual package.

Table 2.2 Shipping List

No.	Accessory Name	Spec	Qty.
1	Explosion-proof lidar	ZWLD-01	1
2	Interface box	Length: 0.3 m	1
3	Power adapter	DC 12 V/36 W	1
4	Power cable (optional)	1.2 m	1
5	Ethernet cable	1.5 m	1
6	Cleaning cloth	1 piece	1
7	Extension cable (optional)	/	1
8	Product package list and outgoing inspection report	/	1

3. Electrical Interface

3.1. Power Supply

This lidar's power input range is 9 V~36 V DC. If other DC power supply is adopted, the recommended output voltage is 12 V. The output current should be no less than 3 A (the lidar requires a large instantaneous current to start, and a small starting current may cause its failure to start normally). The output ripple noise should be less than 120 mVp-p and output voltage accuracy should be less than 5%.

3.2. Connectors

The side of the lidar base lead out the cable with a self-locking connector (male, model: CNT07-TGG-1B-008HC62D-0D).

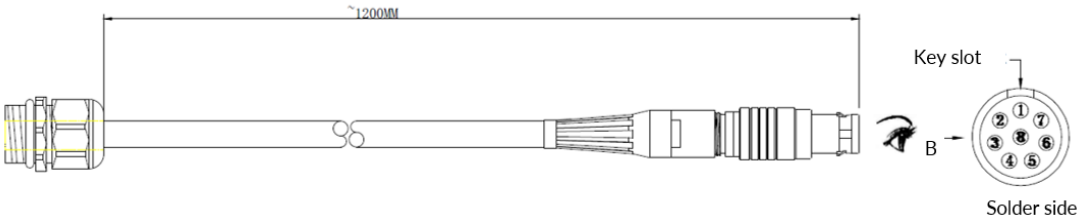


Figure 3.1 Lidar Cable and Connector

The interface box leads out a cable with a self-locking connector (female, model: CNT07-MHG-1B-008HC62D-0D).

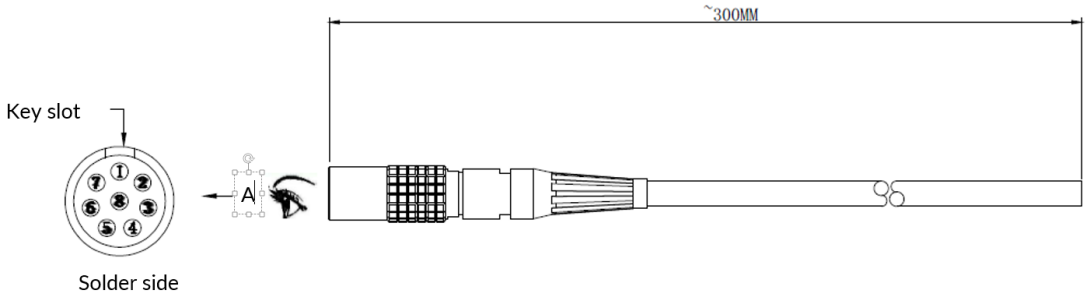


Figure 3.2 Interface Cable and Connector

Table 3.1 Pin Definition of the 8-pin Female Connector

No.	Color	Definition	Descriptions
1	Green	GPS_PPS	GPS Sync Pulse/External Sync Pulse
2	Red&Yellow	VCC	Power+

3	Orange	TD_N	Ethernet TX-
4	White&Black	PGND&SGND	Power-&GPS signal ground
5	Orange/White	TD_P	Ethernet TX+
6	Blue	GPS_Rec	GPS latitude & longitude, hour/minute/second
7	Brown	RD_N	Ethernet RX-
8	Brown/White	RD_P	Ethernet RX+
Shell	Shield	PE	PE

To facilitate the testing and connection of connectors, the lidar can also be equipped with an interface box, which is not a necessary accessory for lidar operation. On the interface box, there is a Φ5.5*2.1 mm DC socket, an indicator light, an RJ45 network port and a 6-pin GPS port, as shown in the figure below.

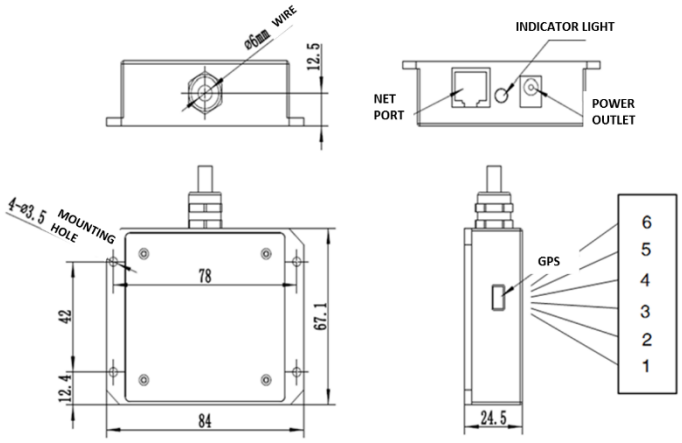


Figure 3.3 Interface Box

Table 3.2 GPS PIN Descriptions

PIN No.	Descriptions
1	NC
2	GND
3	GPS_REC
4	GND
5	+5 V
6	GPS_PPS

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When the “ground” of the ZWLD-01 is connected to the external system, the negative (“ground”) terminal of the external system power supply and the “ground” of the GPS system must be a non-isolated common ground system.

4. Get Ready

4.1. Lidar Connection

To get ready for the lidar operation, please connect the lidar to the computer as shown in Figure 4.1.

1) The lidar is connected to the interface box through the aviation connector.

2) The host computer is connected to the interface box through the RJ 45 Ethernet port.

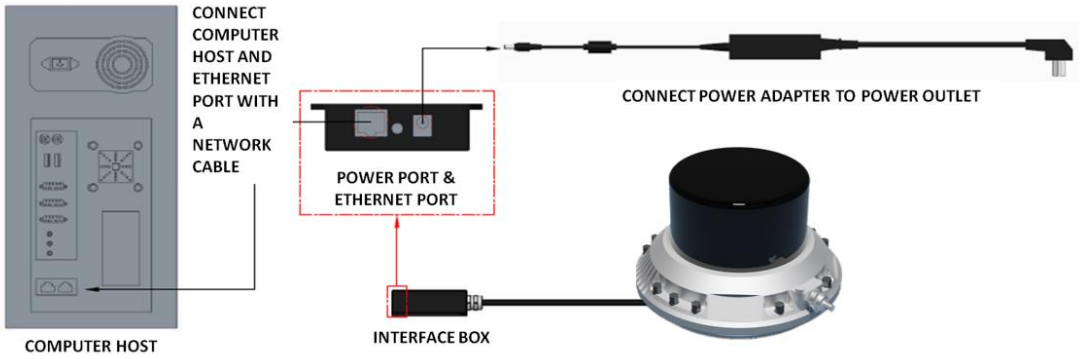

Figure 4.1 Connecting Lidar and Computer

4.2. Software Preparation

The lidar can be operated under both Windows operating system and Linux operating system. Software needed is as follows:

Wireshark: to capture the ARP (Address Resolution Protocol) packets.

Note: Wireshark is a third-party software that you need to download by yourself. Leishen Intelligent bears no responsibility to any copyright and commercial disputes caused by the use of this software.

To view the point cloud data generated by the lidar, you can either use the Upper **Computer Platform** (Windows Client) or the **ROS Driver Program.**

Upper Computer Platform: a host computer software to view point cloud image under Windows operating system, which is also referred to as “point cloud

display software".

- Software Acquisition

This Upper Computer Platform has been pre-stored in the Service Pack provided along with the lidar. It can also be obtained from the sales or technical support personnel.

- Operating Environment

This software can only run under the Windows x64 operating system at present. The computer configuration requirements for installing the software are: CPU: Intel(R) Core(TM) i5 or higher; Graphics Card: NVIDIA GeForce GTX750 or higher achieves the best effect, otherwise the display of the point cloud may be affected. And the computer graphics card must support OpenGL 2 or higher graphics acceleration to display the point cloud normally.

- Supplemental Software

To use the Upper Computer Platform, it is necessary to install the **Npcap** third-party library, which is also included in the Upper Computer Platform installation files package.

ROS Driver Program (optional): to view the point cloud data under Linux operating system. This program has been included in the customer service package which can be obtained from the sales or technical support personnel.

4.3. Operation under Windows OS

4.3.1. Lidar Configuration

The default IP address and port number of the lidar network are as follows:

Table 4.1 Default Lidar Network Configuration

	IP Address	UDP Device Package Port Number	UDP Data Package Port Number
Lidar	192.168.1.200	2368 (Fixed)	2369 (Fixed)
Computer	192.168.1.102	2369	2368

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The lidar IP (local IP) and the computer IP (destination IP) cannot be set to the same, otherwise the lidar will not work normally.

In the multicast mode, no two destination ports should be set to the same port number.

The lidar IP range are forbidden to be set to

1) Class D IP address (multicast address: i.e. 224.0.0.0~ 239.255.255.255)

2) Class E IP address (reserved address: i.e. 240.0.0.0~ 255.255.255.254)

3) Broadcast address (i.e. 255.255.255.255 and xx.x.255 for each network segment)

4) Special class IP address (0.x.xx and 127.xxx)

The lidar destination IP are forbidden to be set to

1) Class E IP address (i.e. 240.0.0.0 to 255.255.255.254)

2) Special class address (0.x.xx and 127.x.x.x)

When connecting to the lidar, if the computer IP and the lidar IP are in different network segments, the gateway is needed to be set; if they are in the same network segment, only different IPs are needed to be set, for example: 192.168.1.x, and the subnet mask is 255.255.255.0. If you need to find the Ethernet configuration information of the lidar, please connect the lidar to the computer and use “Wireshark” to capture the ARP packet of the device for analysis. For the feature identification of the ARP packet, see the figure below.

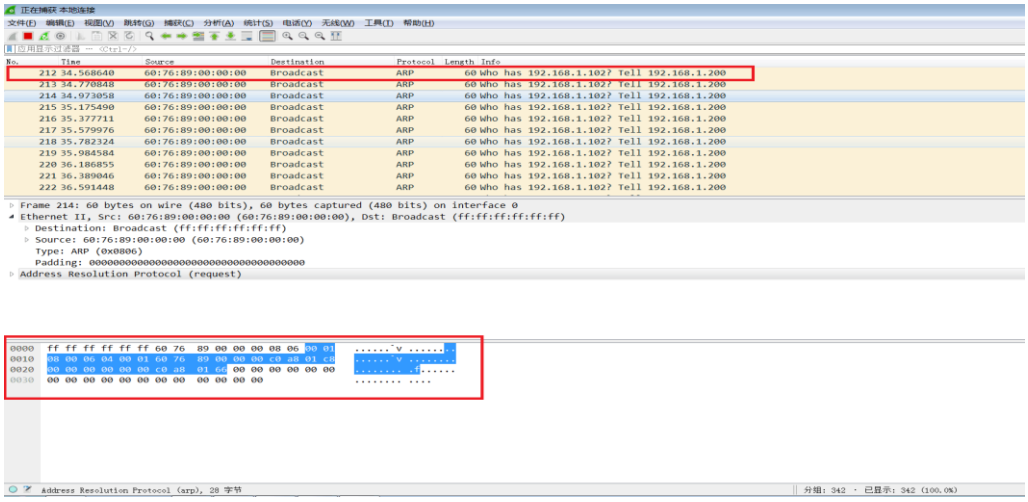

Figure 4.2 Wireshark Captures ARP Packet


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Note: Wireshark is a third-party software, and you may need to download it by yourself. Leishen Intelligent bears no responsibility for any copyright and commercial disputes caused by users' use of the software.

4.3.2. Upper Computer Platform

Upper Computer Platform (Windows Client), which is also referred to as "point cloud display software". Simple functions like parameter configuration, lidar test and fault detection can be realized through the software, too.

For more information on how to use the software, please refer to the software operation manual included in the LiDAR service package or click on the icon  in the upper right corner of the software to jump to the software operation.

4.3.3. Point Cloud Data Parsing

If you need to parse lidar data, please follow the steps below:

Step 1. Parse the data package to obtain the relative horizontal angle, ranging information, intensity data and timestamp information of each laser;

Step 2. Read the device package to obtain information such as the UTC (GPS or NTP time service) and the current configuration of the device;

Step 3. Obtain the vertical angle of each line according to the laser beam distribution;

Step 4. According to the distance measurement value, vertical angle and the calculated horizontal angle of the point cloud data, the XYZ coordinate values are obtained;

Step 5. If necessary, calculate the precise time of the point cloud data through UTC, timestamp, light-emitting time of each laser, as well as single and dual echo modes;

Step 6. Reconfigure information such as Ethernet, PPS synchronization horizontal angle, motor speed and other information as needed, and pack the configuration package protocol.

4.4. ROS Driver Operation under Linux OS

4.4.1. Hardware Connection and Test

Step 1. Connect the lidar to the internet and power supply

Step 2. Set the computer wired IP according to the destination IP of the lidar, (whether the computer wired IP is set successfully can be checked by the ifconfig command, as shown in the figure, the destination IP is 192.168.1.102).

```
ls@ls-Inspiron-15-3511:~$ ifconfig
enxf8e43b292f8c: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 192.168.1.102  netmask 255.255.255.0  broadcast 192.168.1.255
        inet6 fe80::898a:1bfd:a729:2f4e  prefixlen 64  scopeid 0x20<link>
        ether f8:e4:3b:29:2f:8c  txqueuelen 1000  (以太网)
        RX packets 254127  bytes 313581906 (313.5 MB)
        RX errors 254118  dropped 3  overruns 0  frame 254118
        TX packets 76  bytes 9406 (9.4 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

Figure 4.3 ifconfig Command Feedback

Note: The default destination IP of the lidar is 192.168.1.102, and the computer must be configured according to the actual lidar destination IP. After setting the IP for the first time, please restart the lidar.

Step 3. After the lidar is powered on and restarted, check the wired connection icon of the computer to see whether it is connected properly.

Step 4. Open the terminal: ping the lidar IP, and test whether the hardware is connected normally. If the ping is successful, then the data is received, otherwise check the hardware connection.

Step 5. Use “sudo tcpdump -n -i eth0” (here eth0 is the name of the wired network device, see the device name of ifconfig wired connection display for details) to view the data packets sent by the lidar (as shown in the figure, there are 1206-byte data packets sent by the lidar to the destination, which means that the lidar data is sent normally).

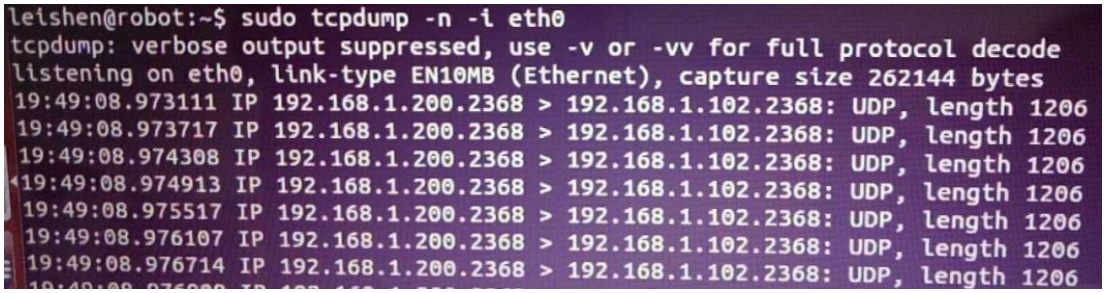

Figure 4.4 sudo tcpdump -n -i eth0 Command Feedback

4.4.2. Software Operation Example

All the commands in the following examples are for reference only, please refer to the README file in the ROS driver included in the Service Package for details.

Step 1. Establish a workspace and build a compilation environment

mkdir -p ~/leishen_ws/src

cd ~/leishen_ws

Note: The workspace can be named arbitrarily. For example, “leishen_ws” can be changed to any name.

Step 2. Download the Lidar ROS driver

The ROS driver can also be obtained directly from our website or customer service. Copy the obtained driver file to the newly created workspace “src”, and

decompress it.

Step 3. Compile and package

cd ~/leishen_ws

catkin_make

Step 4. Run the program

source devel/setup.bash

roslaunch lslidar_driver lslidar.launch

Note 1): If the lidar destination port and motor speed are modified, please open "lslidar.launch" to modify the configuration accordingly. The default data packet port is 2368, device packet port is 2369, IP address is 192.168.1.200.

Note 2): If timeout appears, it means that the driver has no data reception. Please check the hardware connection.

Note 3): If steps 1, 2, and 3 have been completed, next time after the "Displays Window" is reopened, start directly from Step 4.

Step 5. Display the lidar's point cloud data

Check the point cloud data in the pop-up RVIZ window.

Step 6. Modify configuration

You can modify the configuration parameters in the launch file. For specific parameter descriptions, see the decompressed README.md document.

5. Communication Protocol

The data output and configuration of the lidar are through Fast Ethernet UDP/IP communication protocol. There are 3 UDP packet protocols, among which MOSP packet length is 1254 bytes (42 bytes Ethernet header and 1212 bytes payload). DIFOP and UCWP are 1248 bytes (42 bytes Ethernet header and 1206 bytes payload) lidar supports unicast, broadcast and multicast communication.

The communication protocols of the lidar are:

Main data Stream Output Protocol (MSOP): outputting the distance, angle, intensity and other information measured by the lidar;

Device Information Output Protocol (DIFOP): outputting the current status of lidar and accessory equipment and various configuration information;

User Configuration Write Protocol (UCWP): setting the configuration parameters of the lidar.

Table 5.1 UDP Packet Protocol

Protocol Name	Abbr.	Function	Length	Transmission Interval
Main data Stream Output Protocol	MSOP	Outputting measured data and timestamp	1212 bytes	About 1.2 ms/0.6 ms
Device Information Output Protocol	DIFOP	Outputting parameter configuration and status information	1206 bytes	1s (1 packet consecutively)
User Configuration Write Protocol	UCWP	Inputting user configured device parameters	1206 bytes	not fixed

5.1. MSOP Protocol

The data package outputs measured data such as the angle value, distance value, intensity value, and timestamp of the point cloud. The data of the package adopts Little-Endian mode.

The data package includes a 42-byte Ethernet header and a 1212-byte payload, with a total length of 1254 bytes. The payload consists of 1200 bytes of point cloud data (12 data blocks of 100 bytes) and 12 bytes of additional information (6 bytes of UTC, 4 bytes of Timestamp and 2 bytes of Factory).

5.1.1. Data Format

The lidar supports single and dual echo modes. Single echo mode measures the most recent echo value, and dual echo mode measures the most recent echo and the second recent echo value.

In the single echo mode, one echo data is measured after a single-point laser emission. A point cloud data package contains 12 data blocks, and each data block contains 2 set of 16-channel point cloud data measured in the packing order. Each data block returns only one azimuth angle. See the picture below:

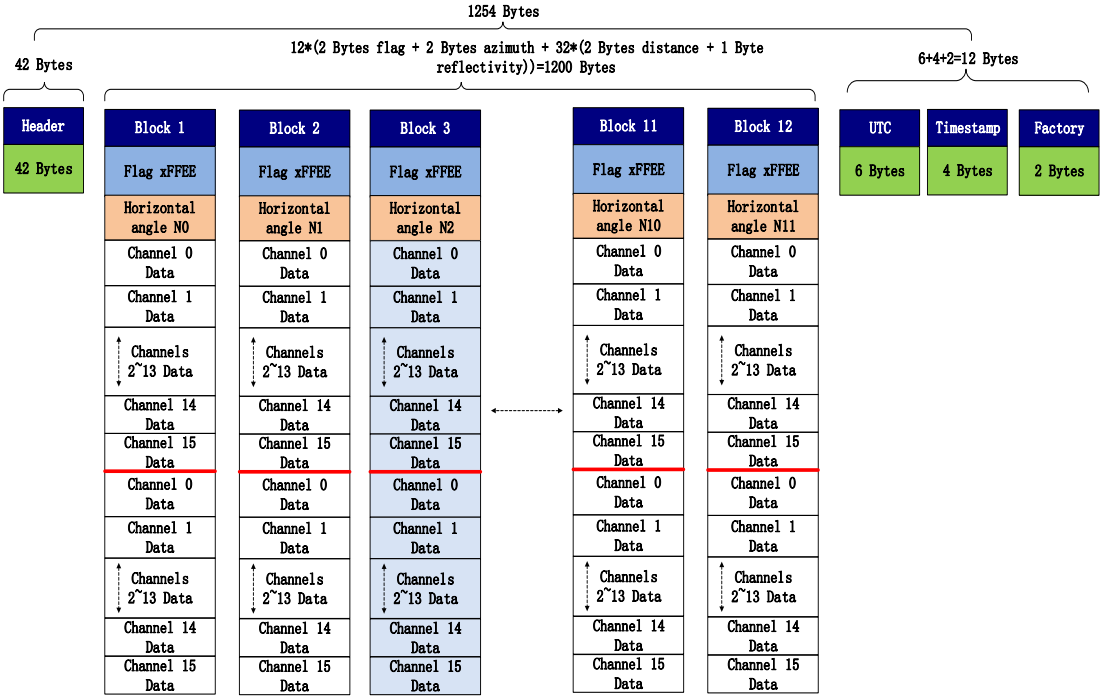

Figure 5.1 Data Format of the Single Echo Mode

When dual echo mode is adopted, two echo data are measured after a single-point laser emission. The data package contains 6 parity data block pairs, and

every 2 data blocks contain 2 set of two echo values of 16 channels measured in the packing order. Block (1, 2) is the two echo data of the first 2 sets of 16 point cloud data. The odd block is the first echo data, and the even block is the second echo data; Block (3, 4) is the two echo data of the next 2 sets of 16 point cloud data, ..., and so on. Only one azimuth angle is returned for each parity data block pair. See the picture below:

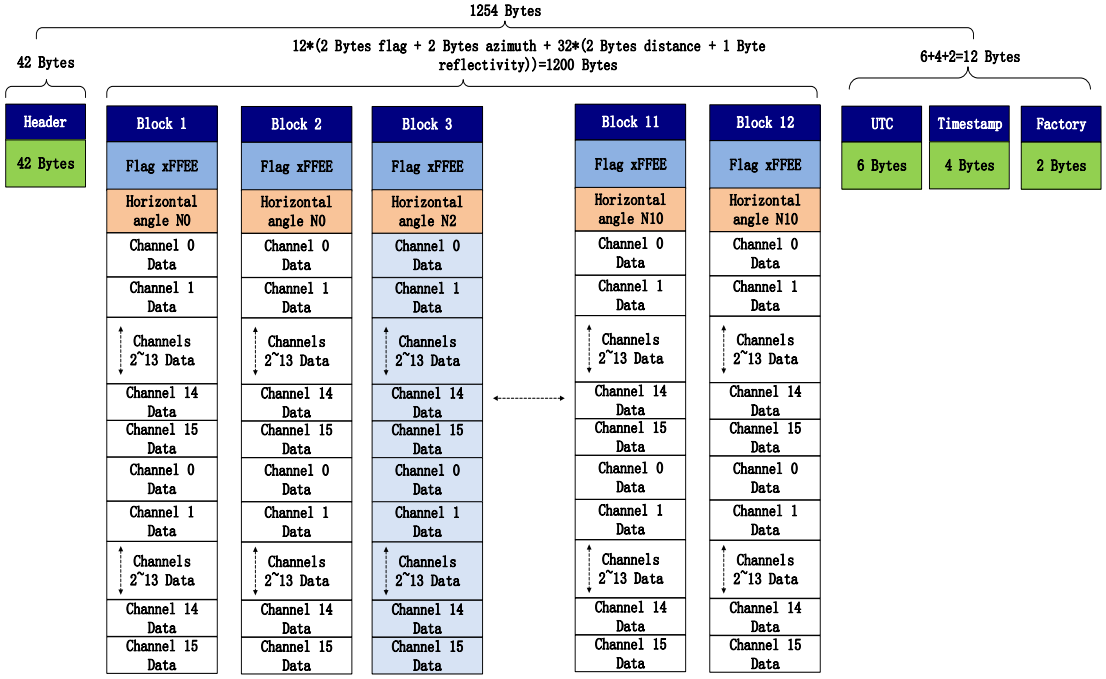

Figure 5.2 Data Format of the Dual Echo Mode

5.1.2. Data Package Parameter Description

Ethernet Header

The Ethernet header has a total of 42 bytes, as shown in the table below.

Ethernet Header: 42 bytes				
Name	S/N	Information	Offset	Length (byte)
Ethernet II MAC	0	Destination	0	6
	1	Source	6	6
Ethernet Packet Type	2	Type	12	2
Internet Protocol	3	Version, Header Length, Differentiated Services, Field, Total Length, Identification, Flags, Fragment Offset, Time to Live, Protocol, Header, Checksum, Source IP Address, Destination IP Address	14	20

UDP Port Number	4	Lidar Port (0x0941, represent 2369)	34	2
	5	Computer Port (0x0940, represent 2368)	36	2
UDP Length & Sum Check	6	Length (0x04BE, represent 1214 bytes)	38	2
	7	Sum Check	40	2

Data Block

The measured data has a total of 1200 bytes, which is composed of 12 data blocks, and each data block is 100 bytes in length.

A data block includes:

- 2 bytes 0xffee fixed value flag bit;
- 2 bytes of Azimuth's relative horizontal angle information;
- 2 sets of 16-channel point cloud data (each channel 3 bytes). Each set of 16-channel data (UDP packet encapsulation sequence) corresponds to a 16-channel laser measurement data of the lidar at a certain launch time.

Note: The packing order of channel data increases in order. This order may be inconsistent with the vertical angle distribution order of the channel and the laser emission measurement time order of the channel, but there is a fixed one-to-one correspondence. (Refer to the Vertical Angle in Chapter 7 and the Channel Light-Emitting Time in Chapter 8)

Azimuth

The horizontal angle value—Azimuth represents the angle of the first channel 0 of the data block, which is a relative value and its unit is 0.01°. To calculate the absolute horizontal value, please refer to Chapter 7.2. The resolution of the horizontal angle value corresponds to 0.09°, 0.18° and 0.36° according to the motor speed 5 Hz, 10 Hz and 20 Hz.

Channel Data

Channel data is an unsigned integer, the 2 high bytes are distance, and the 1 low

byte is intensity, as shown in the following table.

Channel N Data (3 bytes)		
Byte3	Byte2	Byte1
Distance		Intensity

The unit of distance is 0.4 cm. The echo intensity represents the energy reflection characteristics of the measured object, and the intensity value represents the intensity level of 0~255 different reflectors.

Related Calculation Example:

1) Horizontal angle value Azimuth: The obtained byte is in HEX: 0x12; 0x34, then the corresponding decimal DEC is: 18; 52

-> The actual angle obtained: (52 * 256 + 18) * 0.01 = 133.30°;

2) Distance: The bytes obtained are in HEX: 0x56; 0x78, then the corresponding decimal DEC is: 86; 120

-> Actual obtained distance: (120* 256 + 86) * 0.004 = 123.224 m;

3) Intensity: The obtained byte is in HEX: 0x90, then the corresponding decimal DEC is: 144

-> Actual obtained strength value 144;

4) Timestamp: The bytes obtained are in HEX: 0x78; 0x56; 0x34; 0x12; then the corresponding decimal DEC is: 120; 86; 52; 18

-> Timestamp = $(18*2^{24} + 52*2^{16} + 86*2^{8} + 120*2^{0})$ = 305419896 ns.

Additional Information

The additional information is 12 bytes in length, including 6 bytes of UTC, 4 bytes of Timestamp and 2 bytes of Factory.

Additional Information: 12 bytes		
Name	Length (byte)	Function
UTC	6	year/month/day/hour/minute/second, add 2000 to the value of year

Timestamp		4	Timestamp (ns), the least significant value in the sequence is stored first, at the lowest storage address while the most significant value is stored at the highest storage address.
Factory	Echo information	1	0x37 represents the strongest echo, 0x38 the last echo, 0x39 the dual echo
	Vendor information	1	0x10 represents C16 lidar, 0x20 represents C32 lidar

1) When there is a GPS device inputting PPS signal to the lidar, the timestamp is generated with the PPS time as the cycle time, and the range of the timestamp is 0-999,999,999 (ns);

2) When there is an external synchronization device inputting PPS signal, the timestamp is generated with the external synchronization PPS time as the cycle time, and the range of the timestamp is 0-999,999,999 (ns);

3) When there is no synchronization device inputting PPS signal, the lidar generates timestamps with a period of 1 second. The range of the timestamp is 0-999,999,999 (ns).

5.2. DIFOP Protocol

The device package outputs read-only parameters and status information such as version number, Ethernet configuration, motor speed and operating status, and fault diagnosis. The data of the device package adopts Big-Endian mode. That is the most significant value in the sequence is stored first, at the lowest storage address while the least significant value is stored at the highest storage address. The device package includes a 42-byte Ethernet header and a 1206-byte payload, with a length of 1248 bytes. The payload is composed of 8-byte frame header, 1196-byte data and 2-byte frame tail.

Figure 5.2 Data Format of the Device Package

Ethernet Header: 42 bytes				
Name	S/N	Information	Offset	Length (byte)
Ethernet II MAC	0	Destination	0	6
	1	Source	6	6

Ethernet Packet Type	2	Type	12	2
Internet Protocol	3	Version, Header Length, Differentiated Services, Field, Total Length, Identification, Flags, Fragment Offset, Time to Live, Protocol, Header, Checksum, Source IP Address, Destination IP Address	14	20
UDP Port Number	4	Lidar Port (0x0940, represent 2368)	34	2
	5	Computer Port (0x0941, represent 2369)	36	2
UDP Length & Sum Check	6	Length (0x04BE, represent 1214 bytes)	38	2
	7	Sum Check	40	2
Payload: 1206 bytes				
Name	S/N	Information	Offset	Length (byte)
Header	0	Device Package Identification Header	0	8
Data	1	Motor Speed	8	2
	2	Ethernet Configuration 1	10	22
	3	Ethernet Configuration 2	32	8
	4	Lidar Rotation / Stationary	40	2
	5	Reserved	42	2
	6	Clock Source Selection	44	2
	7	PPS Alignment Horizontal Angle Value	46	2
	8	Monitor PPS Alignment Angle Error	48	2
	9	Reserved	50	2
	10	UTC Time	52	6
	11	Latitude and Longitude	58	22
	12	APD Board Temperature	80	2
	13	LD Board Temperature	82	2
	14	APD High Voltage	84	2
	15	LD Emitting High Voltage	86	2
	16	No. 3 Plate Temperature	88	2
	17	No. 3 Plate Humidity	90	2
	18	GPS Status	92	1
	19	PPS Status	93	1
	20	High Temperature Suspension	94	2
	21	Cover Dirty Count	96	1
	22	Cover Dirty Alarm Message	97	1
	23	Cover Dirty Energy Value	98	2
	24	Threshold Adjustment Value	100	1
	25	Input Voltage Value	101	2
	26	Input Current Value	103	2
	27	Length of Work	105	4
	28	Reserved	109	1095
Tail	29	Frame Tail	1204	2

Header is the device packet identification header, which is fixed as 0xA5, 0xFF, 0x00, 0x5A, 0x11, 0x11, 0x55, 0x55, and the first 4 bytes can be used as the packet inspection sequence. Tail is fixed at 0x0F, 0xF0.

5.3. UCWP Protocol

The UCWP configures the lidar's Ethernet, PPS alignment angle, motor speed and other parameters, and the data of the configuration package adopts the Big-Endian mode.

The configuration packet includes a 42-byte Ethernet header and a 1206-byte payload, with a length of 1248 bytes. The payload is composed of 8-byte Header, 1196-byte Data, and 2-byte Tail.

Note: It is recommended to configure the lidar through the Upper Computer Platform. Please not package or configure the lidar parameters by yourself. The configurations take effect immediately.

Figure 5.3 Data Format of the Configuration Package

Ethernet Header: 42 bytes				
Name	S/N	Information	Offset	Length (byte)
Ethernet II MAC	0	Destination	0	6
	1	Source	6	6
Ethernet Packet Type	2	Type	12	2
Internet Protocol	3	Version, Header Length, Differentiated Services, Field, Total Length, Identification, Flags, Fragment Offset, Time to Live, Protocol, Header, Checksum, Source IP Address, Destination IP Address	14	20
UDP Port Number	4	Lidar Port (0x0941, represent 2369)	34	2
	5	Computer Port (0x0940, represent 2368)	36	2
UDP Length & Sum Check	6	Length (0x04BE, represent 1214 bytes)	38	2
	7	Sum Check	40	2
Payload: 1206 bytes				
Name	S/N	Information	Offset	Length (byte)
Header	0	Configuration Package Identification Header	0	8
Data	1	Motor Speed	8	2
	2	Ethernet Configuration 1	10	22
	3	Ethernet Configuration 2	32	8
	4	Lidar Rotation / Stationary	40	2
	5	Reserved	42	2
	6	Clock Source Selection	44	2
	7	PPS Alignment Horizontal Angle Value	46	2

	8	Reserved	48	1156
Tail	9	Frame Tail	1204	2

Header is the configuration packet identification header, which is fixed as 0xAA,0x00,0xFF,0x11,0x22,0x22,0xAA,0xAA, and the first 4 bytes are used as the packet inspection sequence. The Tail of the frame is fixed at 0x0F, 0xF0.

5.3.1. Configuration Parameters and Status Description

Here below are the configuration parameters and status description of specific lidar information.

Motor Speed

Motor Speed (2 bytes)		
S/N	Byte1	Byte2
Function	Speed: 5Hz/10Hz/20Hz	

The motor rotates clockwise. Three speeds can be set: when it is set to 0x04B0, the speed is 1200 rpm, 20 Hz; when it is set to 0x0258, the speed is 600 rpm, 10 Hz; when it is set to 0x012C, the speed is 300 rpm, 5 Hz. Other setting data is not supported.

Ethernet Configuration

The length of the source IP address “IP_SRC” is 4 bytes and the length of the destination IP address “IP_DEST” is 4 bytes. Each lidar has a fixed MAC address “MAC_ADDR”, which cannot be configured by users. Port1 is the UDP data port number and port2 is the UDP device port number. 4 bytes are reserved.

Ethernet Configuration 1 (22 bytes)								
S/N	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7	Byte8
Function	IP_SRC				IP_DEST			
S/N	Byte9	Byte10	Byte11	Byte12	Byte13	Byte14	Byte15	Byte16
Function	MAC_ADDR (Read Only)						Data Port: Port1	
S/N	Byte17	Byte18	Byte19	Byte20	Byte21	Byte22		
Function	Device Port: Port2		Reserved					

Ethernet Configuration (8 bytes)				
S/N	Byte1	Byte2	Byte3	Byte4

Function	Gateway Address			
S/N	Byte 1	Byte 2	Byte 3	Byte 4
Function	Subnet Mask			

Lidar Rotation & Stationary

Lidar Rotation & Stationary (2 bytes)		
S/N	Byte 1	Byte 2
Function	0: Rotation； 1: Stationary	

0x0000 indicates that the lidar is rotating, and 0x0001 indicates that the lidar is stationary, and the default value of the lidar is rotating scan.

Clock Source Selection

Clock Source Selection (2 bytes)		
S/N	Byte 1	Byte 2
Function	0: GPS; 1: PTP (the unit of timestamp is ns); 0x0000 indicates GPS time service, 0x0001 indicates PTP time service	

PPS Alignment Horizontal Angle

When the lidar obtains the PPS signal input by the external device, it controls the lidar to scan to a specific horizontal angle at the moment. The configuration package sets the PPS alignment angle value, the unit of which is 0.01°. For example, if the alignment angle is 90°, the setting value should be 9,000, and the hexadecimal number is 0x2328, corresponding to byte2 = 23h, byte1 = 28h.

PPS Alignment Angle Value (2 bytes)		
S/N	Byte1	Byte2
Function	Configure the PPS Alignment Horizontal Angle	

The device package outputs the PPS synchronization time. The unit of the alignment angle error, which is the difference between the actual scanning horizontal angle of the lidar and the set PPS alignment angle value, is 0.01°. “Valid is 0” indicates that the second pulse signal is valid. Angle_err[14:0] is the alignment angle error value, which is a signed integer with a range of -18,000~18,000, that is, between -180° and 180°.

PPS Alignment Angle Error (2 bytes Read only)		
S/N	Byte 1	Byte 2
Function	valid	angle_err [14:0]

5.3.2. Configuration Package Example

If parameters like motor speed, IP address, lidar device port number, NTP server address, PPS alignment angle value, lidar rotation/stationary, etc. need to be reset, according to the definition of the configuration package, the 1206-byte payload is set as follows:

Table 5.4 Configuration Package Example

Info	Content	Configuration	Start Position	Length (byte)
Header	-	0xAA,0x00,0xFF,0x11, 0x22,0x22,0xAA,0xAA	0	8
Motor Speed	1200 RPM	0x04,0xB0	8	2
Lidar IP (IP_SRC)	192.168.1.105	0xC0,0xA8,0x01,0x69	10	4
Computer IP (IP_DEST)	192.168.1.225	0xC0,0xA8,0x01,0xE1	14	4
Device (MAC_ADDR)	XXXX (Read Only)	0xxxxx	18	6
Data Port (port 1)	XXXX	0xxxxx	24	2
Device Port (port 2)	8899	0x22,0xC3	26	2
NTP Server Address (Reserved)	192.168.1.106	0xC0,0xA8,0x01,0x6A	28	4
Gateway	192.168.1.1	0xC0,0xA8,0x01,0x01	32	4
Subnet Mask	255.255.255.0	0xFF,0xFF,0xFF,0x00	36	4
Lidar Rotation or Stationary	Rotation	0x00,0x00	40	2
Reserved			42	2
Clock Source Selection	PTP	0x00,0x01	44	2
PPS Alignment Angle Value	1.28°	0x00,0x80	46	2
Reserved	XXXX	0xxxxx	48	1156
Tail	Fixed Value	0x0F,0xF0	1204	2

Note: When encapsulating the configuration package, the entire package data must be written completely.

6. Time Synchronization

There are two ways to synchronize the lidar and external equipment: GPS synchronization and external PPS synchronization. If there is no external synchronization input, the lidar internally generates timing information. The absolute accurate time of the point cloud data is obtained by adding the 6-byte UTC (accurate to seconds) of the data packet and the 4-byte timestamp (accurate to nanoseconds).

6.1. GPS Synchronization

When GPS synchronization is employed, the lidar will start timing in nanoseconds after receiving the PPS second pulse, and the time value will be output as the timestamp of the data packet. The lidar extracts UTC information from the $GPRMC of the GPS as the UTC time (accurate to the second) output of the device package.

There are two types of lidar GPS_REC interface level protocols, namely TTL level standard and RS232 level standard; the GPS_REC interface specification on the power box is SH1.0-6P female socket. The two protocols differ in two aspects, respectively:

TTL level pin definition:

Pin GPS_REC receives the standard serial port data of the TTL level output from GPS module;

Pin GPS_PPS receives the positive TTL synchronous pulse signal output by the GPS module;

RS232 pin definition:

Pin GPS_REC receives the standard serial data of the R232 level output from the GPS module;

Pin GPS_PPS receives the positive synchronization pulse signal output by the GPS module, and the level is required to be 3.0 V~15.0 V.

If the GPS you use outputs according to the RS232 serial port protocol, and the lidar receives data according to the TTL protocol, then a RS232 to TTL conversion module is needed.

The GPS equipment is time-synchronized to mark and calculate the precise emission and data measurement time of each laser. The precise time of the lidar point cloud can be matched with the pitch, roll, yaw, latitude, longitude and height of the GPS/inertial measurement system.

The default serial configuration baud rate of the GPS data output received by the lidar is 9600, 8N1. The PPS high pulse width is required to be more than 1 ms.

The standard format of the GPRMC information is as follows:

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

Table 6.1 The Standard Format of GPRMC Information

S/N	Name	Description/Format
1	UTC Time	hhmmss (hour/minute/second)
2	Positioning State	A=Effective Positioning, V=Invalid Positioning
3	Latitude	ddmm.mmmm (degree/minute)
4	Latitude Hemisphere	N (Northern Hemisphere) or S (Southern Hemisphere)
5	Longitude	dddmm.mmmm (degree/minute)
6	Longitude Hemisphere	E (East Longitude) or W (West Longitude)
7	Ground Speed	000.0~999.9 knot
8	Ground Direction	000.0~359.9 degree, take true north as the reference datum
9	UTC Date	ddmmyy (day/month/year)
10	Magnetic Declination	000.0~180.0 degree
11	Direction of Magnetic Declination	E (East) or W (West)
12	Mode Indication	Only NMEA0183 version 3.00 output, A= autonomic positioning, D= difference, E=estimation, N=invalid data

The lidar is compatible with GPS interfaces of multiple data formats. The GPRMC data format only needs to meet the following two requirements: the

data after the first comma separator is hour, minute and second information; the data after the ninth comma separator is date information. The following two formats can be used normally:

1)
$GPRMC,072242,A,3027.3680,N,11423.6975,E,000.0,316.7,160617,004.1,W*67;

2) $GPRMC,065829.00,A,3121.86377,N,12114.68162,E,0.027,,160617,,,A*74.

6.2. External Synchronization

In external synchronization, the lidar receives the PPS signal input by other external devices and times it in nanoseconds, and the timing value is output as the timestamp of the data packet. At this time, there is no UTC time reference. If UTC time is required, it must be written in the configuration package, otherwise the UTC time output information of the device package is invalid.

The PPS level of the external synchronization signal is 3.3 V~ 5 V, and the lidar receives the rising edge trigger, and the PPS high pulse width is required to be more than 1 ms.

6.3. PTP/gPTP Synchronization

Precise Time Protocol (PTP) is used for high-precision time synchronization between devices in an accuracy within sub-microsecond for measurement and control systems.

Generalized Precise Time Protocol (gPTP) is derived from Precise Time Protocol (PTP) and is used to synchronize the time of individual devices within a local area network with high precision.

This series of lidar supports PTP/gPTP timing synchronization. Before synchronizing the lidar via PTP/gPTP, the time source needs to be set to “PTP”

in the lidar's point cloud display software.

The steps are as follows: open the point cloud display software, click on "  " to bring up the parameter modification window, select "PTP" from the "Source Selection" drop-down list as shown in the figure below.

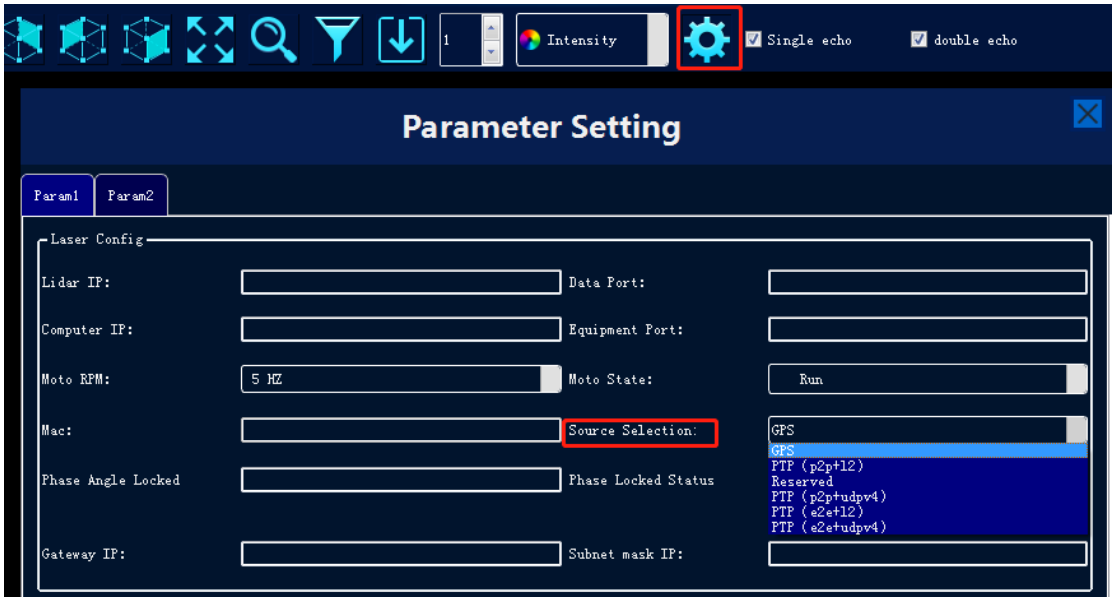

Figure 6.1 Source Selection on the Software

Note:

When "PTP" is selected as the clock source, the lidar no longer outputs GPS packets and the time unit changes to nanoseconds (ns). The Timestamp and Date & Time in the point cloud packets will be synchronized strictly according to the time signal provided by the PTP/gPTP master clock.

If PTP/gPTP has been selected as the time source and no PTP/gPTP master clock is currently available, the lidar will start timing from the internal default start time (00:00:00 on 1 January 2000); if a PTP/gPTP time source is provided and then interrupted, the lidar will continue timing from the time of the interruption.

6.4. Lidar Internal Timing

When there is no GPS and other equipment to synchronize, the lidar uses 1 second ($1*10^9$ ns) as the cycle, with nanosecond as the timing unit, and the

timing value is output as the timestamp of the data packet. At this time, there is no UTC time reference. If UTC time is required, it must be written through the configuration package, otherwise the UTC time output information of the device package will be invalid.

Appendix A. Maintenance

Shipping Requirements

The lidar use packaging materials specially customized by our company, which can resist certain vibrations and impacts. For long-distance transportation, special packaging materials must be used to avoid irreversible damage during transportation.

Installation

Use screws that meet the specifications to fix the lidar base, and make sure the base has good heat dissipation. Wear powder-free clean gloves during installation to avoid optical cover contamination and mechanical damage.

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Storage Conditions

It is recommended to store the products in a ventilated and dry place. Do not store in environments where humidity, pH, etc. exceed the protection level.

1) Improper storage may result in product damage.
2) Please check the condition of all components and packaging regularly, the recommended inspection cycle is 3 months.

Dirt Treatment

If the mask is dirty during use, such as with fingerprints, muddy water, dry leaves or insect corpses, etc., the lidar's ranging effect will be directly affected. Please clean it according to the following steps:

Tools: PVC gloves, clean cloth, absolute ethanol (99%)

Environment: ventilated and dry, away from fire

1) Put on PVC gloves and fix the lidar base with your fingers; if it is not stubborn stains, use a dust-free cloth or dry air to gently remove the stains;

2) For stubborn stains, evenly spray the ethanol in the spray bottle on the location to be cleaned and wait for the stain to be dissolved. Then use a dustless cloth dipped in ethanol solvent, and gently wipe the mask. If the cloth is contaminated, please replace it in time. After cleaning the stain, use a new dustless cloth to remove any remaining liquid.

Appendix B. Troubleshooting

For any of the following problems during the use of the lidar, please refer to the corresponding solutions for troubleshooting. If you are unable to implement the following steps, or if you are still unable to solve the problem after implementing the steps, please contact our technical support.

Problem	**Solution**
The indicator light on the interface box is not working	Confirm: ● power supply meets electrical requirements ● interface box is in good condition with no damage ● power cord contact is good and undamaged; power adapter is working properly ● re-power the lidar to see if the fault disappears
Motor is not running	Confirm: ● power supply meets electrical requirements ● good contact between interface box and the lidar ● re-power the lidar to see if the fault disappears
Motor running but no data output on the host PC or Wireshark	Confirm: ● power supply meets electrical requirements ● the network cable is well connected ● the IP address of the computer matches the destination IP address of the lidar ● your computer's firewall and other security software that may affect Ethernet broadcasts is turned off ● if the lidar emits laser beam with an IR camera or IR card ● re-power the lidar to see if the fault disappears
Wireshark has data but the host PC has no data	Confirm: ● your computer's firewall is turned off ● the IP address of the computer matches the destination IP address of the lidar ● data port and device port in the host computer are set correctly ● lidar port is not occupied by another process ● Npcap plugin is installed ● re-power the lidar to see if the fault disappears
Point cloud missing	Confirm: ● lidar housing is clean and free of stains ● horizontal FOV setting in the host computer ● the number of packets received by the lidar is normal ● whether the lidar emits laser beams, this can be checked with an IR camera or an IR card ● whether there are network conflicts ● whether there is a network blockage caused by other devices transmitting large amounts of data ● connect the PC to the lidar only and observe if the point cloud is missing

	● re-power the lidar to see if the fault disappears
Abnormal point cloud image on the host PC (flickering point cloud; irregular point cloud alignment)	Confirm: ● the lidar housing is clean and free of stains ● lidar surroundings are not complex ● horizontal FOV setting in the host computer ● whether the network is blocked by other devices transmitting data
Error occurs when running the Windows Client, no interface display	Confirm: ● the graphics card is used correctly, discrete graphics card is recommended ● the graphics card meets the minimum configuration requirements ● the driver for the graphics card is correctly installed
Crash or no response of the Windows Client when modifying lidar parameters	Confirm: ● Npcap plugin is installed ● the device package port number is correctly filled in ● the computer memory is not full

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The inspection work must be performed by technicians with specialized training or knowledge of instrument operation and control (e.g., automation technology), and care should be taken to ensure the safety of personnel and equipment by operating in accordance with electrical inspection specifications.

Revision History

Rev.	Release Date	Revised Content	Issued/Revised By
V1.0.0	2024-12-11	Initial Version	Leishen