镭神智能
LeiShen Intelligent System

LS LIDAR

C16 V3.2 Manual

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1. LiDAR Introduction

1.1 Description

1. All the illustrations in this instruction are for reference only and shall be subject to the latest products.

2. In order to avoid violating the warranty terms, it is not allowed to disassemble the LiDAR. For the relevant operation, please consult LeiShen Intelligent's after-sales technical staff.

1.2 Operation Principles

The ranging principle of C16-channel hybrid solid-state LiDAR (hereinafter referred to as C16) is Time of flight measurement.

Time of flight(TOF): As the laser transmitter emits a laser pulse, the internal timer starts to calculate the time (t_1) and stops (t_2) when the laser receiver receives the partial energy of the laser wave bouncing off any objects

Distance = Light Speed × (t_2-t_1)/2

1.3 Product Description

Inside the LiDAR enclosure are 16 pairs of laser-emitting and receiving devices mounted on the bearings. A 360° panoramic scanning is done by rotating the internal motor at 5Hz (or 10Hz, 20Hz).

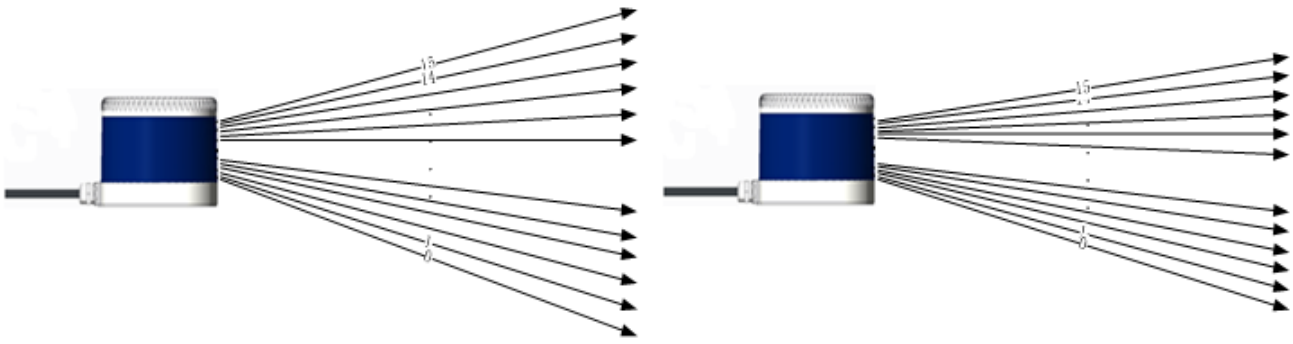


Figure 1.1 C16 's beams distribution: 2° (Left） and 1.33° (Right)

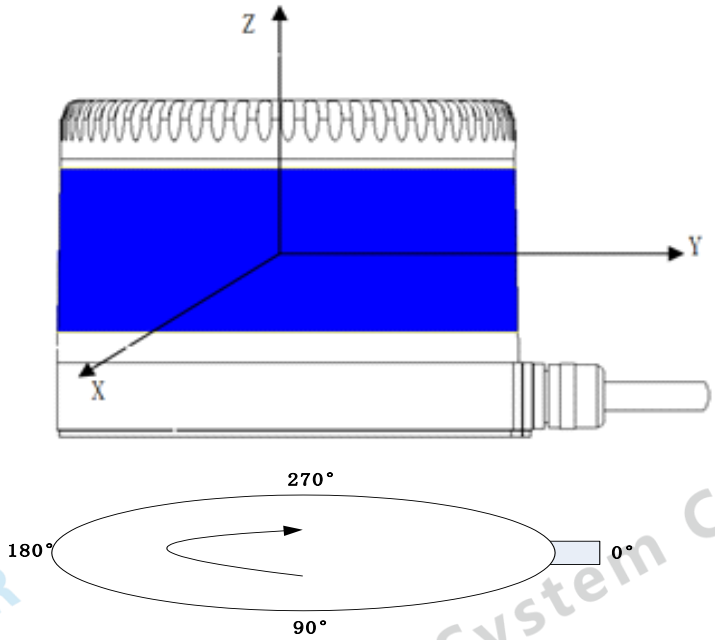


Figure 1.2 C16 Coordinate system and scanning direction

2. Product Specification

2.1 Specification parameter

Table 2.1 : Specifications of C16-xxxB

Model		C16-xxxB/C16 -xxxD
Detecting way		Pulsed Laser
Laser band		905nm
Laser class		Class 1 (eye-safe)
Laser channel		16-channel
Detecting range		70~200m
Range accuracy		±3cm
Data acquisition speed (Dual return mode)		320,000 pts/sec (640,000 pts/sec)
FOV	Vertical	-15°~ +15°
	Horizontal	360°
Angular Resolution	Vertical	Equal 2°
	Horizontal	5Hz: 0.09º / 10Hz: 0.18º / 20Hz: 0.36º
Scanning speed		5Hz, 10Hz, 20Hz(optional)
Communication interface		Ethernet external communication, PPS
Supply scope		+9V～+36VDC
Operating temperature		-20℃～+60℃(B)/ -40℃～+60℃
Storage temperature		-40℃～+85℃
Impact		500 m/sec², for 11 ms
Vibration		5Hz～2000Hz,3G rms
IP Grade		IP67
Dimension		Φ102mm*78mm
Weight		1050g(including 1.2m cable)/840g(lightweight, including 1.2m cable)

Table 2.2: Specifications of C16-xxxC

Mode	C16-xxxC/ C16-xxxE
Detecting way	Pulsed Laser
Laser band	905nm
Laser class	Class 1 (eye-safe)
Laser channel	16-channel
Detecting range	70m~200m

Range accuracy		±3cm
Data acquisition speed (Dual return mode)		320,000 pts/sec (640,000 pts/sec)
Viewing Angle	Vertical	-10°~+10°
	Horizontal	360°
Angle Resolution	Vertical	Equal 1.33°
	Horizontal	5Hz: 0.09º / 10Hz: 0.18º / 20Hz: 0.36º
Scanning speed		5Hz, 10Hz, 20Hz(optional)
Communication interface		Ethernet external communication, PPS
Supply scope		+9V～+36VDC
Operating temperature		-10℃～+60℃
Storage temperature		-40℃～+85℃
Impact		500 m/sec², for 11 ms
Vibration		5Hz～2000Hz,3G rms
IP Grade		IP67
Dimension		Φ102mm*81mm
Weight		1050g(standard)/840g(lightweight)

2.2 External Dimensions and Installation

There are 2 positioning holes and 4 M4 screw mounting holes at the bottom of the LiDAR. The data line interface position is 0° (Or 180°, Please contact sale manger)horizontal angle of the LiDAR, and the LiDAR rotates clockwise.

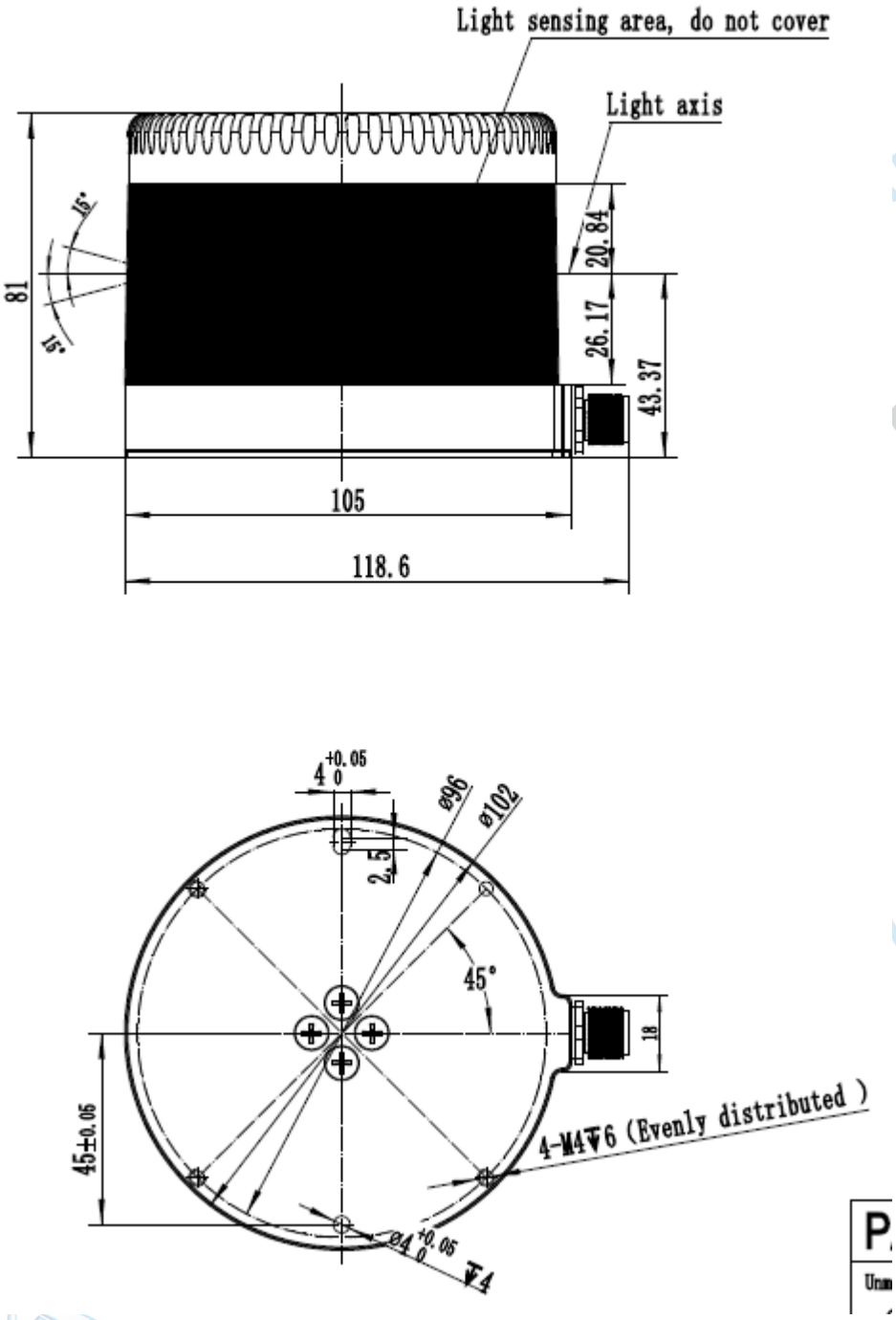


Figure 2.1 Structure size of 16-line small lidar

3. Electrical Interface

3.1 Device Power Supply

Device power supply input range: 9VDC - 36VDC, use of input voltage 12VDC recommended.(If using other DC power supply, the recommended output voltage of the power supply: 12VDC, the maximum output current: ⩾3A. Output ripple noise: <120mVp-p, output voltage accuracy.

3.2 Definition of Device Lead Output Interface

C16 body leads cable (8-core shielded wire with serial number shown as below) from the side at the lower side.

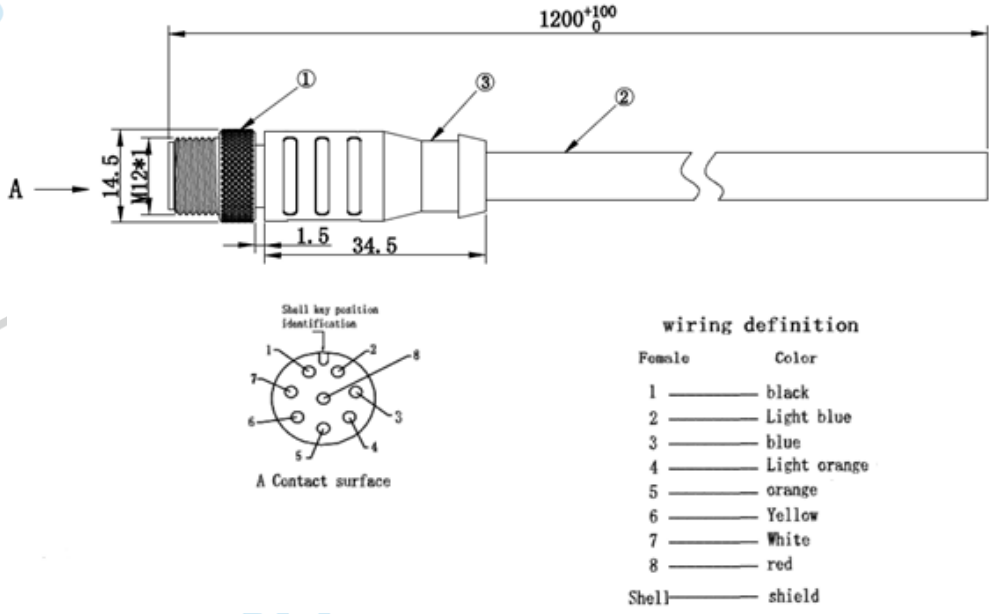


Figure 3.1 A-side interface of lidar base cable

The cable leading out from the terminal box is connected to the aviation plug (male head). The cable is an 8-core shielding cable, as shown in the figure below.

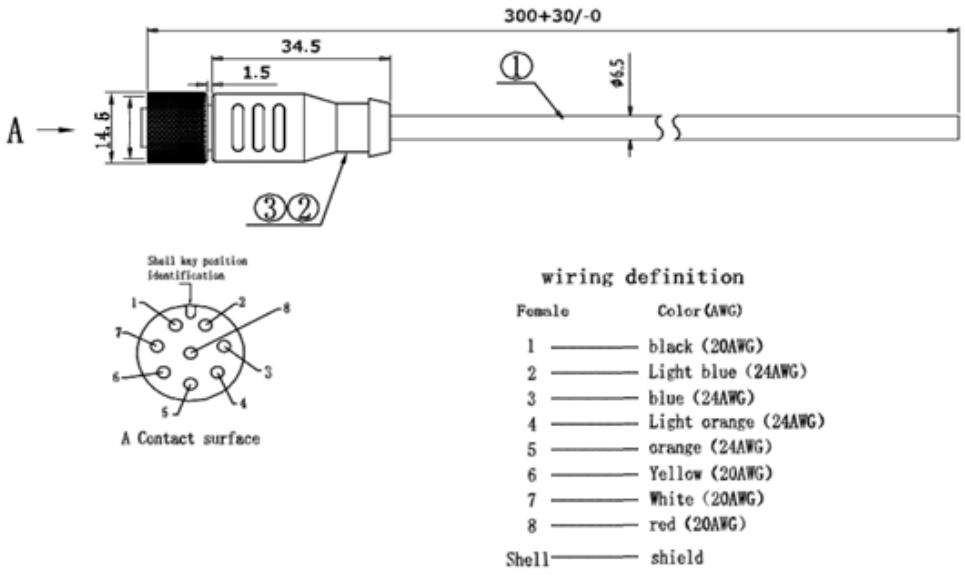


Figure 3.2 A-side interface of lidar junction box

8 core cable defined as follows：

S/N	Cable color and specifications	Definition	Description
1	Red（20AWG）	VCC	Positive power supply
2	Light blue（24AWG）	TD_N	Negative Ethernet transmitter differential
3	Blue（24AWG）	TD_P	Positive Ethernet transmitter differential
4	Light orange（24AWG）	RD_N	Negative Ethernet receiver differential
5	Orange（24AWG）	RD_P	Positive Ethernet receiver differential
6	Yellow（20AWG）	GPS_PPS	GPS synchronous second pulse / external synchronous second pulse
7	White（20AWG）	GPS_Rec	GPS timing receiving
8	Black（20AWG）	GND	Negative power supply (GND)

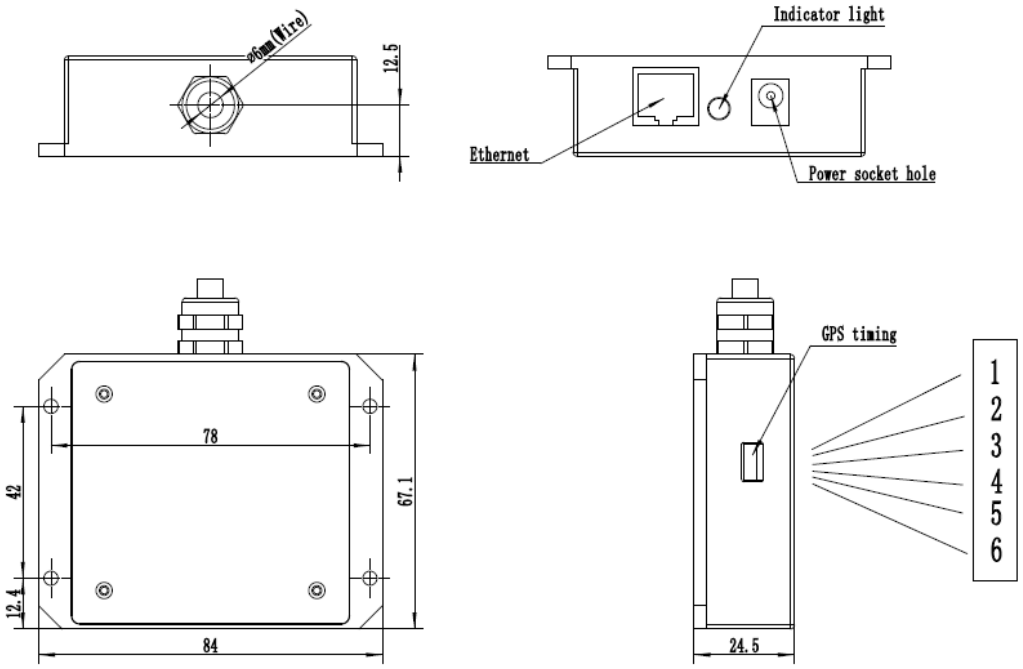
The function of cable box is to facilitate the computer to use the power adapter attached to the lidar and connect the Ethernet cable directly to the lidar test. If no connection box is needed, it can be usedRemove the 8-core terminal wire from the junction box by yourself and connect the power supply, Ethernet interface and GPS device interface separately. Just disconnect the junction box shell.Disconnect the welding position of the 8-core connector and take out the 8-core terminal connector from the junction box.

C16 factory default connection junction box, from the LiDAR to junction box line length is divided into two sections, cable which connected to the LiDAR part of 1.5 meters,

the connection junction box line length of 0.3 meters, the middle aviation plug connection, as shown.

Figure 3.3 Connection between Adapter Box and LiDAR

The adapter box for the C16 series multi-line LiDAR has external interfaces including: 2.1MM DC socket, indicator, 100M Ethernet RJ45 port, and the 6-pin connector GPS timing interface.



Interface S/N	Description
1	NC
2	GND
3	GPS_REC

4	GND
5	+5V
6	GPS_PPS

Figure 3.4 Terminal Block Definition

4. Quick guide

4.1 Connect the lidar

Standard Ethernet port and computer host port connected to lidar with network cable

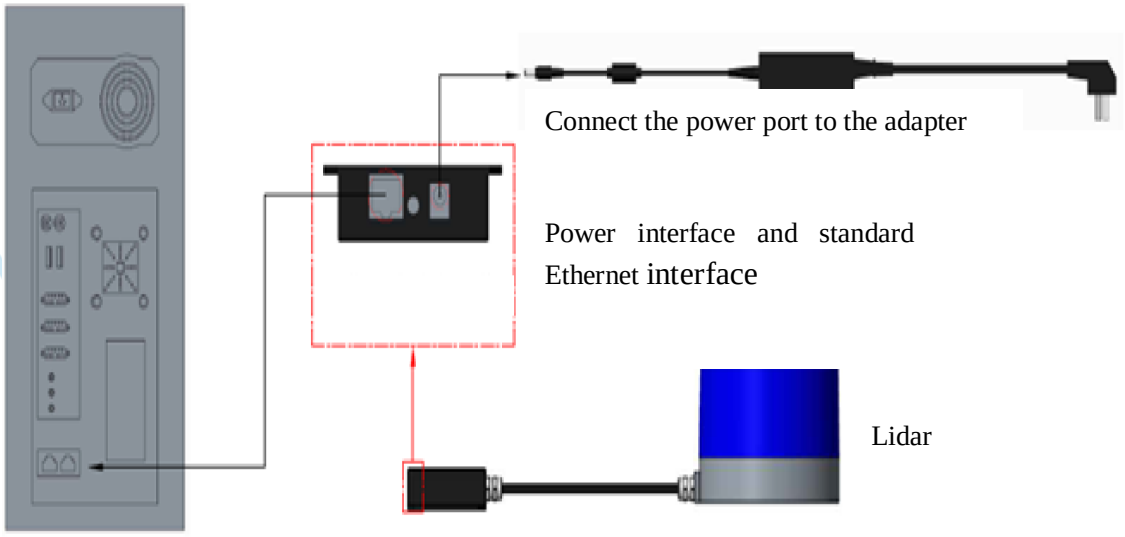


Figure 4.1 Connect the lidar to the computer

4.2 Windows Software display and LiDAR config

The point cloud display software provides parsing data package and Device package information, and displays 3D point cloud data. Through the visual window, users can reset LiDAR parameters. For detailed operation process, please refer to the point cloud display software section

LiDAR IP and port：

Table 4.1 LiDAR Default Network Configuration

	IP Address	UDP Equipment Port	UDP Parsing Port
LiDAR	192.168.1.200	2368（Fixed unmatchable）	2369（Fixed unmatchable）
Computer	192.168.1.102	2369	2368

Note:When setting the LiDAR IP, LiDAR IP and the Computer IP cannot be set to the same IP, otherwise the LiDAR will not work properly; In lidar multicast mode, both destination ports are set to the same port number

When connecting the lidar, the computer and lidar IP in different network segments, need to set up the gateway; When the same network segment, set different IP, for example, IP: 192.168.1.x, and subnet mask: 255.255.255.0. If the device's network configuration information is unknown, wireshark is used for the connecting device to capture the device's ARP packet for analysis after the LiDAR is powered on. For the characteristics of the ARP packet, see the figure below.

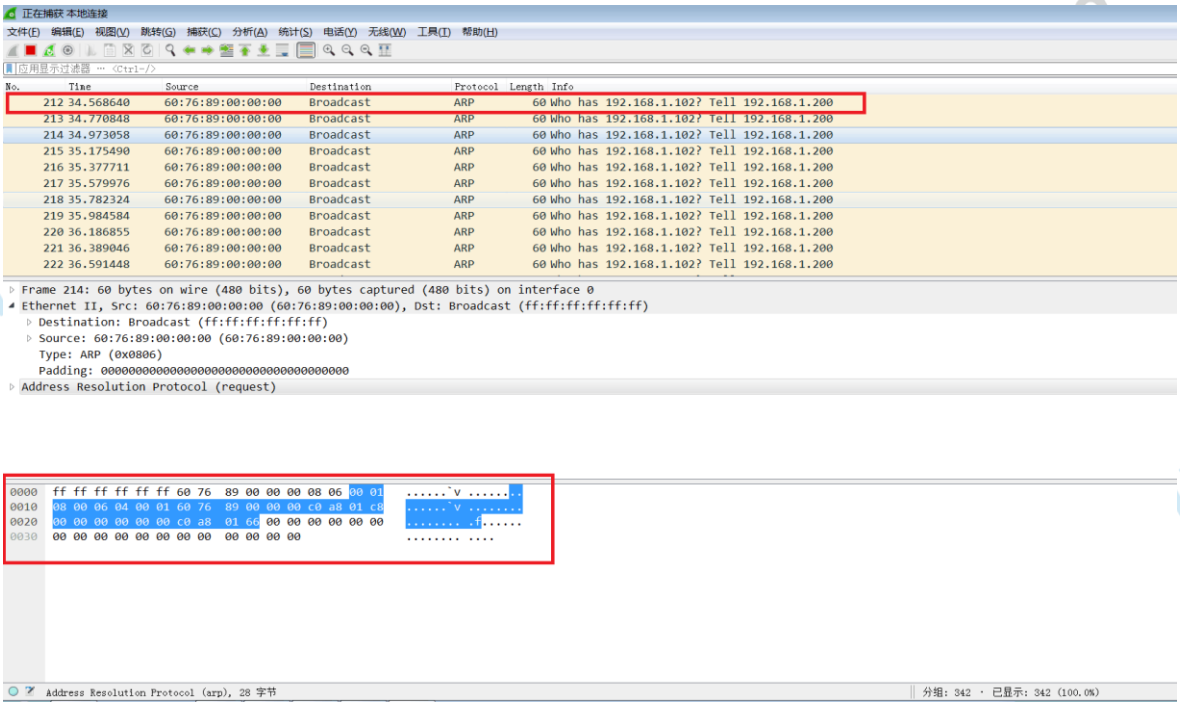


Figure 4.2 Wireshark ARP

Note: Wireshark software is third-party software. Copyright and commercial disputes caused by customers during use are not related to LeiShen.

4.3 Parse point cloud data

If the user needs to parse the lidar data, follow the following steps:

1) Analyze data packets to obtain the relative horizontal Angle, ranging information, strength data and microsecond timestamp information of each line;

2) Read the device package and obtain information such as horizontal correction Angle value, UTC time (GPS or NTP timing) and device current state configuration;

3) Obtain the vertical Angle of each line according to the lidar beam distribution;

4) Obtain the XYZ coordinate value according to the ranging value, vertical Angle and calculated horizontal Angle of point cloud data;

5) Calculate the exact time of the point cloud data through UTC time, microsecond time stamp, luminescence time of each lidar line and single-double echo mode if necessary;

6) Reconfigure Ethernet, PPS synchronization horizontal Angle, speed and other information as required, and package and configure packet protocol.

5. Communication Protocol

The LiDAR data output and configuration use the 100M Ethernet UDP / IP communication protocol. There are 3 UDP packet protocols with a packet length of 1248 bytes (42 bytes Ethernet header and 1206 bytes payload). The LiDAR supports unicast, broadcast, and multicast communications.

1）**MSOP**(Main data Stream Output Protocol)，Output data include : measured distance, angle, intensity and other information；

2）**DIFOP**(Device Information Output Protocol)，Output data include: LiDAR configuration information；

3）**UCWP**(User Configuration Write Protocol)， Setting LiDAR Config parameter

Table 5.1 UDP packet

(Protocol/packet) Name	Abbreviation	Function	Packet Size	Transmission Interval
Main data Stream Output Protocol	MSOP	**Output measurement data and timestamp**	1248bytes	1.2ms/0.6ms
Device Information Output Protocol	DIFOP	**Output parameter configuration and status information**		0.33s
User Configuration Write Protocol	UCWP	**Inputting user configured device parameters**		INF

5.1 MOSP Protocol

Measurement data such as Angle value, distance value, strength value and time stamp of packet output point cloud The data of packet adopts small terminal mode. The packet

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

5.1.1 MOSP format

The 16-chanel LiDAR data supports primary and secondary echoes. The recent echo value of single echo measurement, the recent echo value of double echo measurement and the sub-near echo value (time axis). When using the primary echo mode,, all primary echo data is transmitted in all 12 data blocks; two emissions from 16 lasers are included in one data block, Sequence information. Each packet contains data for 24 transmit sequences. Each data block returns only one azimuth. See the picture below:

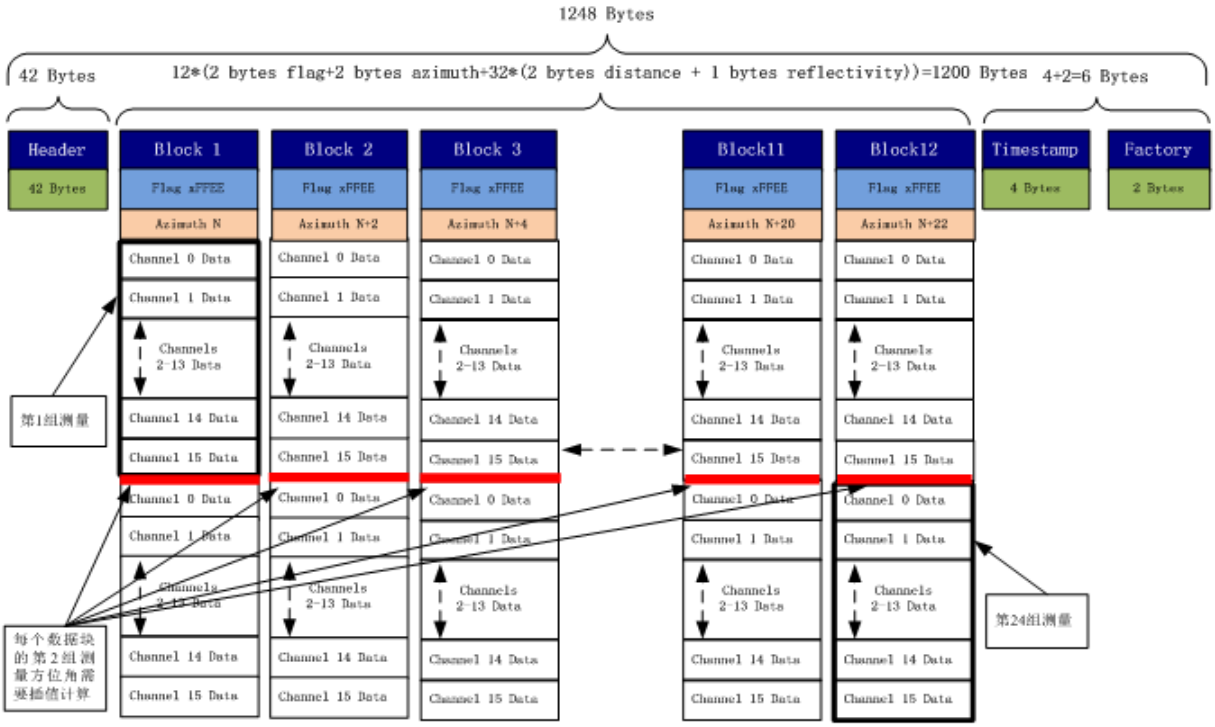


Figure 5.1 Single Echo Packet Data Structure Form

When dual echo mode is used, a single point laser emission measures the echo data twice. The packet contains 6 odd and even data block pairs, and each 2 data blocks contains 2 groups of 16 channel echo values measured in packaging order. Block(1,2) data Block refers to the two echo data of the first 2 groups of 16 point cloud data, the odd Block refers to the first echo data, and the even Block refers to the second echo data. Block (3,4) data block is the two echo data of the next 2 groups of 16 point cloud data... And so on. Each parity block pair returns only one azimuth. See the following figure:

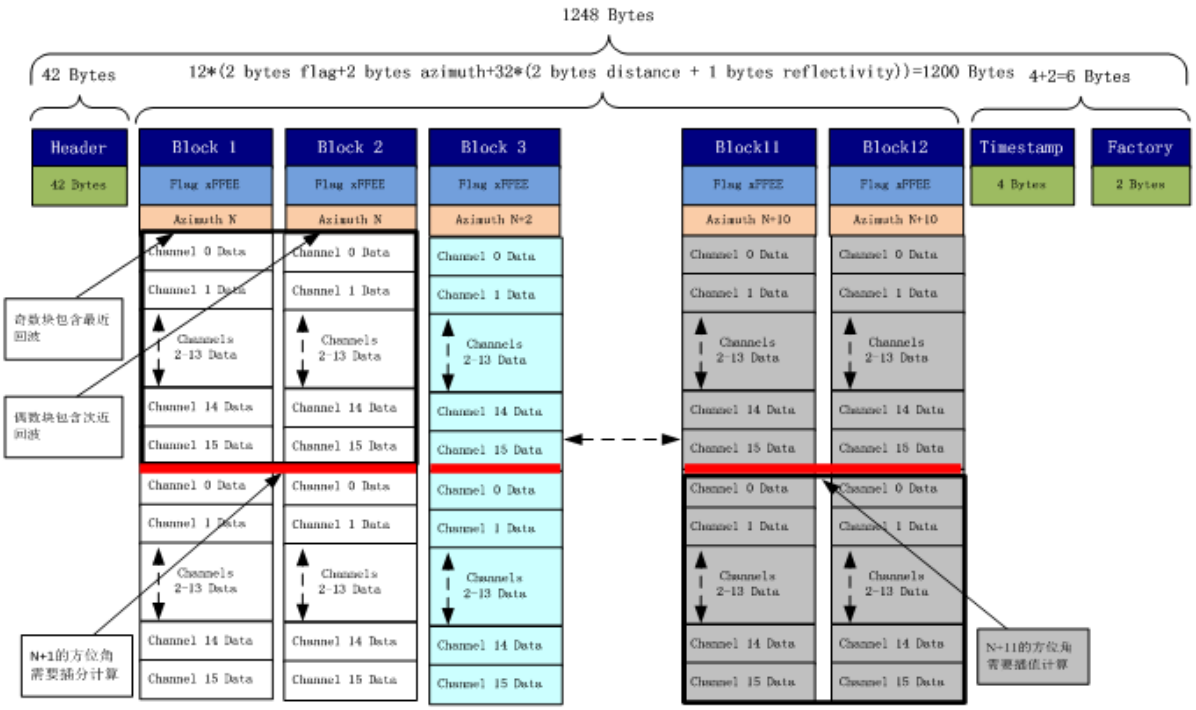


Figure 5.2 Second Echo Packet Data Structure Form

5.1.2 Ethernet Header

The Ethernet Header have 42byte:

Ethernet Header: 42Bytes				
NAMED	**Number**	**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 Protocol port	4	LiDAR Port(0x0941, represent 2369)	34	2
	5	Computer Port(0x0940, represent 2368)	36	2
UDP Protocol Length and check	6	Length(0x04BE, represent:1214 bytes)	38	2
	7	Sum Check	40	2

5.1.3 Data Block

The measurement data is 1200 bytes in total. It consists of 12 data blocks (each block is 100 bytes)。

A data block include：

2 byte 0xffee :Fixed flag value；

2 byte Azimuth :relative horizontal angle information；

Point cloud data of 2 groups of 16 channels (3 bytes per channel). Each group of 16-channel channel data (UDP packet encapsulation order) corresponds to the measurement data of a LiDAR 16-channel laser at different launch times.（Attention）

Attention: The channel data is packaged in an increasing order, which may not be consistent with the vertical angle distribution order of the channel and the laser emission measurement time order of the channel, but has a fixed one-to-one correspondence (see Chapter 7 Vertical angles and Chapter 8 Channel Luminescence time).

5.1.3.1 Azimutu

Azimuth represents the angle value when the first laser ranging of two groups of 16 laser shots is measured, that is, the angle of the first channel 0 of the data block, the unit is 0.01°. The resolution of the horizontal angle value corresponds to the motor speed (5Hz, 10Hz, 20Hz) (0.09 °, 0.18 °, 0.36 °).

5.1.3.2 Channel Data

Channel data is an unsigned integer, the upper 2 bytes are the distance, and the lower 1 byte is the intensity, as shown in the following table.

Table 5.2 Channel data

Channel N data（3Bytes）		
Byte3	Byte2	Byte1
Distance	Distance	Intensity

The unit of distance is 0.25cm. The echo intensity indicates the energy reflection characteristics of the measured object, and the intensity value represents the intensity of 0-255 different reflective objects, etc.

5.1.4 Additional Information

The additional information is 6 bytes in length, including the 4-byte microsecond timestamp and the 2 bytes Factory.

Table 5.3 Additional Information

Additional Information：**6Bytes**			
Name		**Length（Byte）**	**Function**
Timestamp		4	Timestamp，Unit: us
Factory	Echo information	1	0x37 Represents the strongest echo，0x38 Represents the last echo，0x39 Represents the return echo
	Vendor information	1	0x10 represent C16 LiDAR，0x20 represent C32 LiDAR

When the NTP service synchronous timing is enabled, the timestamp is synchronized with the NTP server time, and the range of the timestamp is 0-999999 (us)，

If the NTP service synchronization time is invalid:

1) When GPS input PPS, a timestamp is generated for the periodic timing according to the PPS time, and the time stamp ranges from 0 to 999999 (us);

2) When there is an external synchronization input PPS, a time stamp is generated for the periodic timing according to the external synchronization PPS time, and the time stamp ranges from 0-999999 (us);

3) When there is no synchronous input PPS, the internal LiDAR generates a time stamp with a period of 1 hour. The time stamp ranges from 0-3599_999_999 (us).

5.2 Device Packet Protocol

The device package outputs read-only parameters and status information such as

version number, Ethernet configuration, motor speed and running status, and fault diagnosis. The data of the device package uses big-endian mode.

The device packet includes 42-byte Ethernet header and a 1206-byte payload with a length of 1248 bytes. The payload consists of an 8-byte frame header, 1196-byte data Data and a 2-byte frame tail.

Table 5.4 Data format of the device package

Ethernet header: 42Bytes				
NAMED	**Number**	**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 Protocol port	4	LiDAR Port(0x0941, represent 2369)	34	2
	5	Computer Port(0x0940, represent 2368)	36	2
UDP Protocol Length and check	6	Length(0x04BE, Represent:1214 bytes)	38	2
	7	Sum Check	40	2
1206Bytes				
NAMED	**Number**	**Information**	**Offset**	**Length（Byte）**
Header	0	Device packet identification header	0	8
Data	1	Motor speed	8	2
	2	Ethernet configuration	10	22
	3	Misalignment angle	32	2
	4	Reserve	34	2
	5	UTC time	36	6
	6	Reserve	42	2
	7	PPS alignment angle value	44	2
	8	LiDAR rotation / stationary	46	2
	9	Reserve	48	2
	10	Device flow packet interval	50	2
	11	Reserve	52	160
	12	Latitude and longitude	212	22
	13	Reserve	234	424
	14	Gateway address	658	4
	15	Subnet mask	662	4
	16	Reserve	666	532
	17	Version number (dd / mm / yy)	1198	4

	18	VERSION_SUBVERSION	1202	2
Tail	19	End of frame	1204	2

Header is a device packet identification header, which is fixed to 0xA5,0xFF, 0x00,0x5A, 0x11,0x11,0x55,0x55, where the first 4 bytes can be used as the packet inspection sequence. The tail of the frame is fixed to 0x0F, 0xF0.

5.3 Configuration Packet Protocol

The configuration packet protocol configures the LiDAR's Ethernet, PPS alignment angle, motor and other parameters. The data of the configuration packet adopts 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 consists of an 8-byte header, 1238-byte Data, and a 2-byte Tail.

Note: It is recommended that users configure the LiDAR through the Win point cloud software. It is forbidden for customers to package and configure the LiDAR parameters by themselves. Except for the Ethernet configuration, gateway, and subnet mask that require the LiDAR to restart to take effect, other configurations take effect immediately.

Table 5.5 Configure Packet Data Format

Ethernet header:42 Bytes				
NAMED	**Mumber**	**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 Protocol port	4	LiDAR Port(0x0941, represent 2369)	34	2
	5	Computer Port(0x0940, represent 2368)	36	2
UDP Protocol Length and check	6	Length(0x04BE, Represent:1214 bytes)	38	2
	7	Sum Check	40	2
Payload:1206 Bytes				
Named	**Number**	**information**	**Offset**	**Length（byte）**
Header	0	Configure packet identification header	0	8
Data	1	Motor speed	8	2

	2	Ethernet configuration	10	22
	3	Reserve	16	12
	4	PPS alignment angle value	44	2
	6	LiDAR rotation / stationary	46	2
	7	Reserve	48	2
	8	Device flow packet interval	50	2
	9	Reserve	52	640
	10	Gateway address	692	4
	11	Subnet mask	696	4
	12	Reserve	700	504
Tail	13	End of frame	1204	2

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

5.4 Configuration Parameters and Status Description

5.4.1 Motor speed

Motor speed（2Bytes）		
Number	Byte1	Byte2
Function	Speed:5Hz/10Hz/20Hz	

Configure the motor speed, the motor rotates clockwise, you can set three kinds of speed: when set to 0x04B0, the speed is 1200rpm; when set to 0x04B0, 0x0258, the speed is 600rpm; when set to 0x012C, the speed is 300rpm. No other setting data is supported.

5.4.2 Ethernet Configuration

Table 5.6 Ethernet Configuration

Ethernet configuration（22Bytes）								
Number	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7	Byte8
Function	IP_SRC				IP_DEST			
Number	Byte9	Byte10	Byte11	Byte12	Byte13	Byte14	Byte15	Byte16
Function	MAC_ADDR						Data port1	
Number	Byte17	Byte18	Byte19	Byte20	Byte21	Byte22		
Function	Device Port2		NTP Service Address					

LiDAR IP address IP_SRC, length 4 Bytes; Computer IP address IP_DEST, length 4

Bytes; each LiDAR has a fixed MAC address MAC_ADDR, which cannot be configured by the user; port1 is the UDP data port number, port2 is the UDP device port number; NTP server address, length 4Byte The internal time of the LiDAR can be synchronized from the server address through the NTP protocol.

5.4.3 PPS Align horizontal angle

The PPS signal input from an external device controls the LiDAR to scan to a specific horizontal angle.The configuration package sets the pps alignment angle, the unit is 0.01°. For example, the alignment angle is 90°, the setting value is 9000, and the conversion into hexadecimal is 0x2328, corresponding to byte2 = 23h, byte1 = 28h.

PPS Angle value（2Bytes）		
Number	Byte1	Byte2
Function	Configuration PPS alignment angle	

The device package outputs the PPS synchronization time, and the unit of the alignment angle error is 0.01°. valid is 0, which means that the second pulse signal is valid; angle_err [14: 0] is the alignment angle error value, a signed integer ranging from -18000 to 18000, that is, between -180° and 180°.

Attention: The default value of this parameter is 0, which is defined as not turning on PPS Angle alignment by default. If the client needs PPS second pulse to temporarily align 0 degree, this parameter can be set to a small amount greater than 0, such as 0.01 or 1.

Align horizontal angle error（2Bytes）		
Number	Byte1	Byte2
Function	valid	angle_err[14:0]

5.4.4 UTC Time

When NTP server timing is enabled, UTC time is synchronized with NTP server time; When NTP is turned off, the LiDAR receives GPS signals, parses $ GPRMC, and UTC time synchronizes GPS; When there is no NTP and GPS time, UTC time is all 0.

The device packet output UTC time, error is 1s, GPS time data format.

UTC TIME（6Bytes）						
Number	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6

Function	Year	Month	Day	Hour	Min	Sec
	0~255 correspond to 2000~2255	1~12 month	1~31 day	0~23 hour	0~59 min	0~59 sec

5.4.5 LiDAR Rotation / Stationary

LiDAR rotation / stationary（2Bytes）		
Number	Byte1	Byte2
Function	0：rotation；1：stationary	

0x0000 LiDAR rotation, 0x0001 LiDAR stationary, LiDAR default is rotation scan.

5.4.6 DIFOP Packet Interval

DIFOP Packet Interval（2Byes）		
Number	Byte1	Byte2
Function	0:Same as packet interval; other values: one packet per second;	

Configuration 0x0000 means that the device packet interval is the same as the data packet, and the other parameters mean 1 packet per second. The default value is 0x0001.

5.4.7 Latitude and longitude

The bety Latitude and longitude（22BytesRead only）								
Number	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7	Byte8
Function	Reserve	Latitude						
Number	Byte9	Byte10	Byte11	Byte12	Byte13	Byte14	Byte15	Byte16
Function		Longitude						
Number	Byte17	Byte18	Byte19	Byte20	Byte21	Byte22		
Function					N/S	W/E		

Latitude and longitude, output in ASCII code.

5.4.8 Network Address

Network Address（4Bytes）				
Number	Byte1	Byte2	Byte3	Byte4

Function	Network Address

5.4.9 Subnet Mask

Subnet mask（4Bytes）				
Number	Byte1	Byte2	Byte3	Byte4
Function	Subnet mask			

5.5 Configuration Package Example

The client resets the speed, IP address, device port number, NTP server address, PPS alignment angle value, LiDAR rotation / static, etc. According to the definition of the configuration package, the payload of 1206 bytes is set as follows:

Info	Content	Config	Length（byte）
Header		0xAA,0x00,0xFF,0x11, 0x22,0x22,0xAA,0xAA	8
Speed	1200rpm	0x04,0xB0	2
LiDAR IP （IP_SRC）	192.168.1.105	0xC0,0xA8,0x01,0x69	4
Computer IP （IP_DEST）	192.168.1.225	0xC0,0xA8,0x01,0xE1	4
Device （MAC_ADDR）	XXXX（Read only)	0xxxxx	6
Data（port1）	XXXX	0xxxxx	2
Device（port2）	8899	0x22,0xC3	2
NTP SER Address	192.168.1.106	0xC0,0xA8,0x01,0x6A	4
reserved	XXXX	0xxxxx	12
PPS alignment	1.28°	0x00,0x80	2
LiDAR rotation / static	rotation	0x00,0x00	2
reserved	XXXX	0xxxxx	2
Device Packet Interval	3 Packet	0x00,0x00	2
reserved	XXXX	0xxxxx	640
Network	192.168.1.1	0xC0,0xA8,0x01,0x01	4
Subnet mask	255.255.255.0	0xFF,0xFF,0xFF,0x00	4
reserved	XXXX	0xxxxx	504
Tail	Fixed value	0x0F,0xF0	2

Configuration package encapsulation must be completely written into the entire package of data.

6. Time Synchronization

There are 3 ways to synchronize LiDAR with external devices: GPS synchronization, NTP synchronization, and external PPS synchronization. If there is no external synchronization input, timing information is generated inside the LiDAR. The absolute precise time of the point cloud data is obtained by adding a 4-byte time stamp (accurate to microseconds) of the data packet and a 6-byte UTC time (accurate to seconds) of the device packet.

6.1 GPS Synchronization

GPS synchronization: The LiDAR receiving the PPS second pulse, the LiDAR uses microsecond us as the unit, and the time value is output as the time stamp of the data packet. The LiDAR extracts UTC information from GPS's $ GPRMC information as the UTC time output of the device package, with accuracy to seconds.

6.1.1 GPS

GPS timing synchronization, marking and calculating the precise emission measurement time of each pointcloud. LiDAR accurate point cloud data time can be matched with GPS / inertial measurement system's pitch, roll, yaw, latitude, longitude, and altitude.

The serial configuration baud rate of the LiDAR receiving GPS data output by default is 9600, 8N1. PPS high pulse width requirements are greater than 40ns.

The standard format of GPRMC information is as follows:

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

The serial number	Define name	Description/Format
1	UTC time	hhmmss（hours/minutes/seconds）
2	Positioning state	A=Effective positioning，V=invalid positioning
3	Latitude	ddmm.mmmm（° /”）
4	Latitude hemisphere	N（the Northern Hemisphere）或 S（the Southern Hemisphere）
5	Longitude	dddmm.mmmm（° /”）
6	Longitude hemisphere	E（east longitude）或 W（west longitude）
7	Ground speed	000.0~999.9 节

8	Course of the ground	000.0~359.9°, Take due north as reference
9	UTC date	ddmmyy（day/month/year）
10	Magnetic declination	000.0~180.0°
11	The direction of magnetic declination	E（east）或 W（west）
12	Mode indication	Only ouput NMEA0183 3.00 version，A=autonomic positioning，D = difference，E = estimate，N = The data is invalid

The 16-line LIdar is compatible with GPS interface of multiple data formats, and the GPRMC data format meets the following two requirements: the minute and second information of data after the first comma separator.

The data after the ninth comma separator is date information.

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 NTP

NTP synchronization: The LiDAR periodically obtains the NTP server time ,The time is used as the timestamp of the data packet, and the extracted UTC time is output as the UTC (GMT) time of the device envelope. The LiDAR sends a time request to the NTP server every 4 seconds. After receiving the request, the server sends time information to the LiDAR according to the NTP protocol.

6.3 External synchronization

External synchronization: The LiDAR obtain PPS signal input by the external device, the LiDAR uses microsecond us as the time unit, and time is output as the time stamp 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 is invalid.

The PPS level of the external synchronization signal is 3.3 ~ 5V, which is triggered by the rising edge of the LiDAR. The PPS high pulse width is required to be greater than 40ns.

6.4 Internal synchronization

In the absence of GPS and other equipment synchronization, the lidar takes 1 hour (360*106 US) as the cycle, takes microsecond US as the unit of timing, and counts the time value as the timestamp output of the packet. There is no UTC time baseline. If UTC time is required, it must be written through the configuration package, or the UTC time

output information for the device package is invalid.

7. LiDAR data calculations of Angles and Coordinates

7.1 Vertical Angle

The 16-line miniaturized lidar has two different vertical angle distributions, and the data of each channel corresponds to the fixed vertical angle, see the table below:

Table 7.1 16 lines uniform 2° vertical angle distribution

UDP Package Chanel	Vertical Angle
Chanel 0 Data	-15°
Chanel 1 Data	1°
Chanel 2 Data	-13°
Chanel 3 Data	3°
Chanel 4 Data	-11°
Chanel 5 Data	5°
Chanel 6 Data	-9°
Chanel 7 Data	7°
Chanel 8 Data	-7°
Chanel 9 Data	9°
Chanel 10 Data	-5°
Chanel 11 Data	11°
Chanel 12 Data	-3°
Chanel 13 Data	13°
Chanel 14 Data	-1°
Chanel 15 Data	15°

Table 7.2 16 lines uniform 1.33° vertical angle distribution

UDP Package Chanel	Vertical Angle
Chanel 0 Data	-10°
Chanel 1 Data	0.665°
Chanel 2 Data	-8.665°
Chanel 3 Data	2°
Chanel 4 Data	-7.33°

Chanel 5 Data	3.33°
Chanel 6 Data	-6°
Chanel 7 Data	4.665°
Chanel 8 Data	-4.665°
Chanel 9 Data	6°
Chanel 10 Data	-3.33°
Chanel 11 Data	7.33°
Chanel 12 Data	-2°
Chanel 13 Data	8.665°
Chanel 14 Data	-0.665°
Chanel 15 Data	10°

By querying the table above, you can get the vertical angle of the 16-channel data.

Note: The vertical angle corresponding to the increment of channel number does not increase from bottom to top, because the channel packaging order of packet is consistent with the luminous time order of each channel, while the luminous time is not from bottom to top. For details, see the description of 16-line luminous time.

7.2 Horizontal angle

The horizontal Angle value of each channel of the packet needs to be calculated according to the lighting time of the 16 channels.

7.2.1 Calculation of horizontal Angle of single echo mode

In the single-echo packet, each data block has only one horizontal Angle value, which represents the horizontal Angle value corresponding to the first transmitting measurement channel 0 of this data block, and the corresponding angles of the other 2 groups of 16 channels need to be interpolated. As the lidar rotates at a constant speed, each channel of the data block has the same luminous time interval. Therefore, interpolation is carried out for two adjacent angles (Azimuth N and Azimuth (N+2). Then, according to the luminous time of each channel, the horizontal Angle corresponding to the remaining 31 laser luminous times of the data block can be calculated. The data block structure of 16-line single-echo packet is as follows:

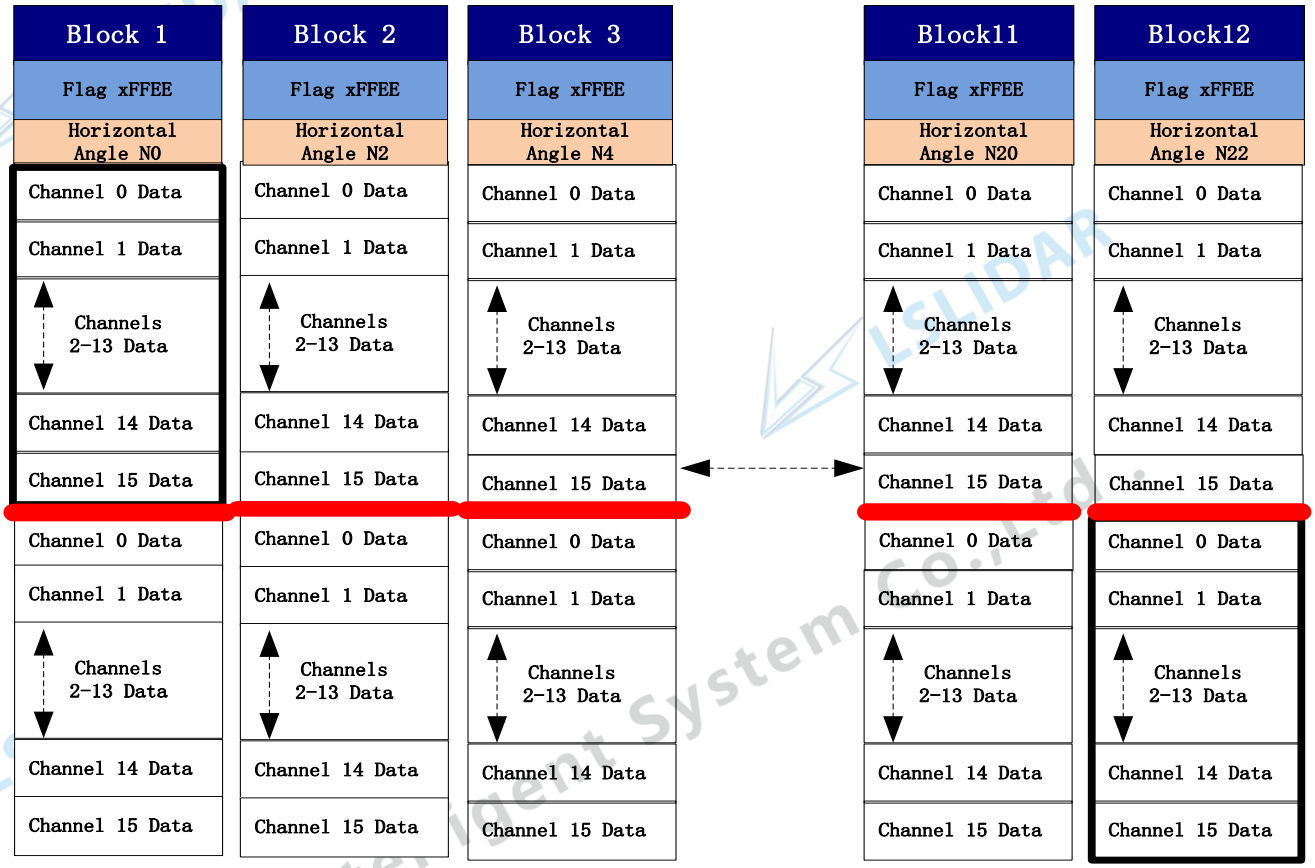


Figure 7.1 Single echo data structure

7.2.2 Calculation of horizontal Angle of double echo mode

Double echo packet, one single point laser emission measurement twice echo data. Each pair of odd-even data blocks contains two measurements of 16 channels of 2 sets of transmitting time series, and each pair of odd-even data blocks returns only one azimuth.The Angle values provided by the Nth odd block and even block are the horizontal Angle values corresponding to channel 0 of the last emission measurement, and the Angle values corresponding to the other 31 channels need to be interpolated. The data block structure of the 16-line double-echo packet is as follows:

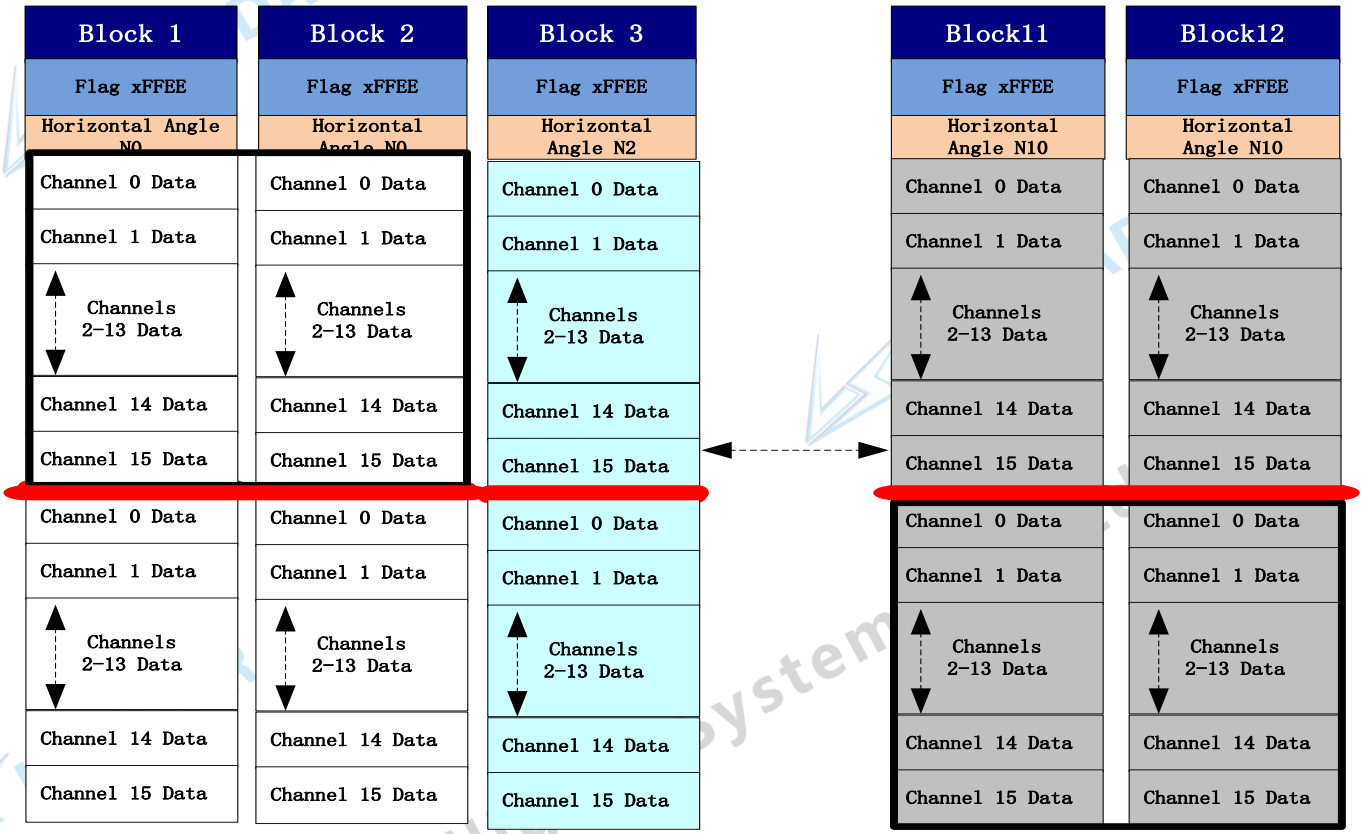


Figure 7.2 Dual echo data block structure

7.3 Calculation of distance

Distance calculation of channel data: Get the 2-byte channel distance of packet small-end mode, assuming as (0x72,0x06), hexadecimal number denoted as 0x0672, convert to decimal number as 1650, unit 0.25cm, namely 1650x0.25cm = 412.cm.

7.4 Cartesian coordinates

Obtain the vertical angle, horizontal angle, and distance parameters of the LiDAR, and convert the angle and distance information in polar coordinates to the x, y, and z coordinates in the right-hand Cartesian coordinate system. The conversion relationship is shown in the following formula:

$$\begin{cases} x = r\cos\alpha\cos\theta; \\ y = r\cos\alpha\sin\theta; \\ z = r\sin\alpha \end{cases}$$

The r is the distance, α is the vertical angle, θ is the horizontal rotation angle (the horizontal correction angle needs to be considered in the calculation), and x, y, and z are

the coordinates of the polar projection onto the x, y, and z axes.

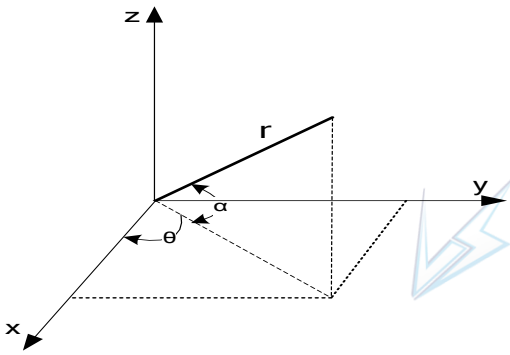


Figure 7.3 Coordinate

8. Pointcloud Data Time Calculation

To accurately calculate the time of point cloud data, you need to obtain the data packet timestamp and device package UTC time output by the LiDAR. The time stamp and UTC time come from the same synchronization source, such as a GPS or NTP server.

The measurement time interval of a group of data in each data block of 16-LiDAR is 50us. The data packet has 12 data blocks, and one data block contains two groups of 16-channel data.

A data packet has (16 * 2) * 12 = 384 channels of data in total, and the packet packing time is about (50us * 2) * 12 = 1.2ms. The data rate is 1s / 1.2ms = 833.3 data packets / second. Double-echo mode data rate doubles.

8.1 Packet end time calculation

The timestamp in the data packet is a relative time of microseconds, which is defined as the packaging time (data packet end time) of the last channel of laser measurement data in the data packet, which is less than 1 second, So to calculate the absolute time of the end of the data packet, you need to first Get the 4-byte microsecond timestamp in the data packet, and then get the UTC time (greater than 1 second) from the device packet. Adding the two is the exact time at which the data packet ends.

EXACT TIME = DIFOP TIEM + MOSP TIMESTAMP

8.2 Channel Data Time Calculation

Obtain the exact time of the end of the data packet. Each UDP contains 12 data blocks. And each data block contains 2 groups of 16 channels of light emitting time and the light emitting time interval of each channel. The precise measurement time of each channel data can be calculated.

8.2.1 Data block time

Each data block of C16 LiDAR contains 2 groups of 16 channel measurement data. The end time interval of each group of channels in each data block is 50us, each data block (single echo mode) or each parity block pair (Double echo mode) The end time interval is 2 * 50us = 100us. Assuming that the absolute time of the end of the data packet is TPacket_end, the steps to calculate the end time of the data block TBlock_end (N) are as follows:

1）Single Echo Mode

The data packet contains 12 data blocks, each data block includes two sets of single measurement data of 16 laser channels. The end time of each data block is the end time of all 2 groups of 16 channels. Calculate the end time of each data block as follows TBlock_end(N) = (TPacket_end – 100*(12-N))us,（N = 1,2，...,12）

$T_{Block\_end}(N)$ represents the end time of the N th data block

2）Dual Echo Mode

$T_{Block\_end}(2N) = T_{Block\_end}(2N-1) = (T_{Packet\_end} – 100*(6-N))us$, （N = 1,2，...,6）

其中 $T_{Block\_end}(M)$ represents the end time of the N th data block, M=2N or(2N-1)

8.2.2 Pointcloud Data Time Calculation

The C16 LiDAR 2° / 1.33° type fixed the time interval of each channel as: T = 50us / 16 = 3.125us. There is a fixed correspondence between the lighting time and the UDP packet encapsulation order. Assuming that the lighting time of Channel 0 is T0, the corresponding lighting time of 16 channels is shown in the table below:

Table 8.1 C16 LiDAR Channel Glowing Time

UDP (Channel)	Vertical Angle	Glowing moment （T=3.125us）
Channel 0 Data	**-15°**	T_0
Channel 1 Data	**1°**	T_0+(1*T)
Channel 2 Data	**-13°**	T_0+(2*T)

Channel 3 Data	**3°**	T_0+(3*T)
Channel 4 Data	**-11°**	T_0+(4*T)
Channel 5 Data	**5°**	T_0+(5*T)
Channel 6 Data	**-9°**	T_0+(6*T)
Channel 7 Data	**7°**	T_0+(7*T)
Channel 8 Data	**-7°**	T_0+(8*T)
Channel 9 Data	**9°**	T_0+(9*T)
Channel 10 Data	**-5°**	T_0+(10*T)
Channel 11 Data	**11°**	T_0+(11*T)
Channel 12 Data	**-3°**	T_0+(12*T)
Channel 13 Data	**13°**	T_0+(13*T)
Channel 14 Data	**-1°**	T_0+(14*T)
Channel 15 Data	**15°**	T_0+(15*T)

After the end time of each data block is obtained, the precise measurement time of the point cloud data of each channel in the data block can be calculated according to the correspondence between the channel data packing order and the light emission time in the table above.

9. Appendix (ROS DRIVER PACKAGE)

The github address of the ROS driver package:

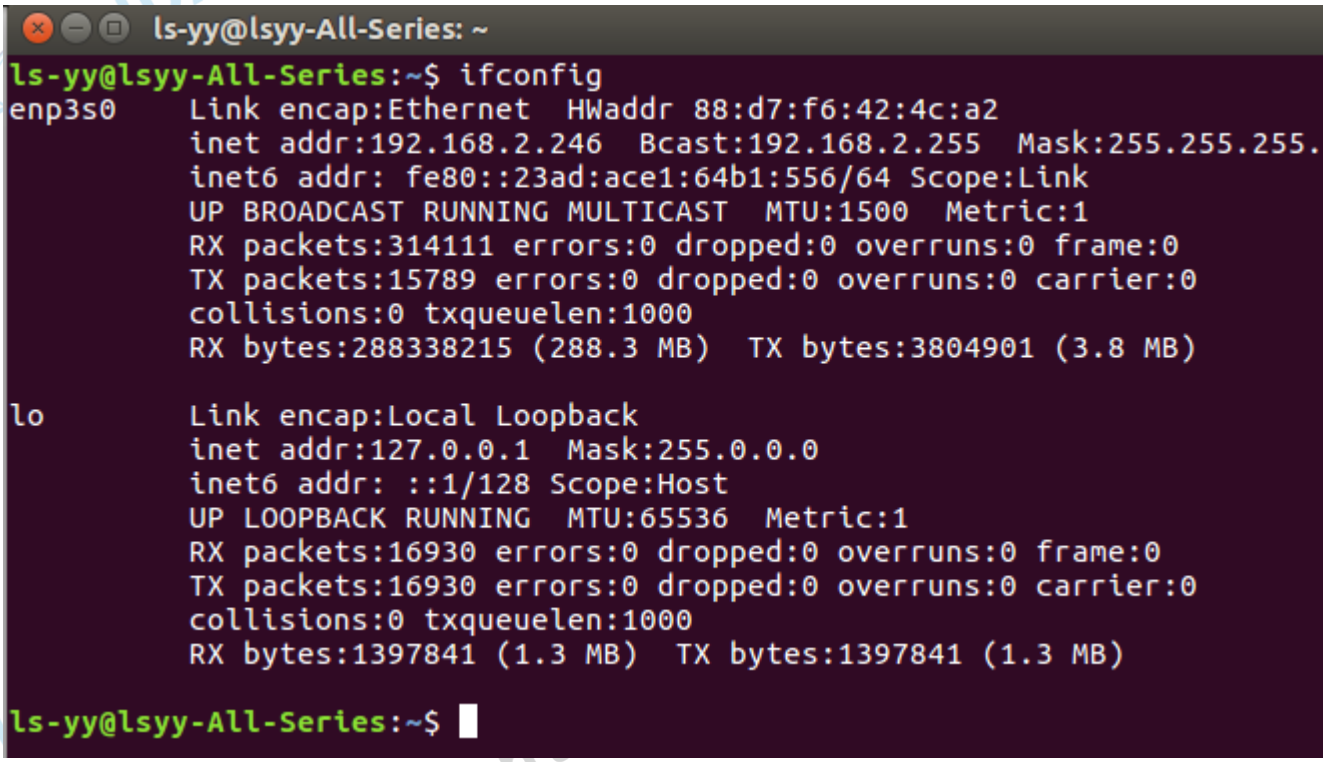
https://github.com/LS-Technical-Supporter/LS-LIDAR-C16ROS

The github address of the ROS2 driver package:

https://github.com/LS-Technical-Supporter/LS-LIDAR-C16ROS2

9.1 Hardware Connection and Testing

Connect LiDAR network interface and power cord Set the computer IP based on the target IP on LiDAR (use the if config command to see if the computer IP has been set successfully, as shown in the target IP 192.168.1.102)

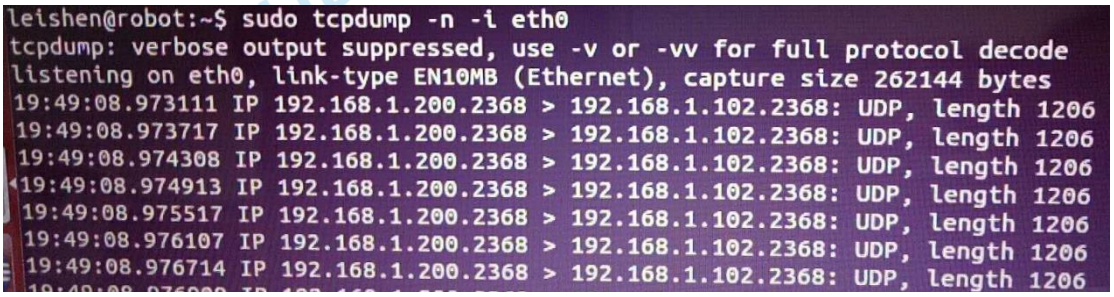


Note: LiDAR factory set IP:192.168.1.102 as original, please configure LiDAR IP according to the actual IP on the computer.

After the LiDAR is powered on, observe whether the computer's wired connection icon is connected properly or not.

Open terminal: ping LiDAR IP, test whether the hardware connection is normal. if the ping dose not show well, check the hardware connection.

You can further use: sudo tcpdump-n-i eth0, (where eth0 is the name of the wired network device.Please refer to the name of the display device which is connected by ifconfig wired) to check the LiDAR data packets (as shown in the diagram showing the LiDAR sending 1206 bytes to the destination packet which means the LiDAR data is transmitted successfully).



Note: after setting up IP for the first time, please restart the LiDAR.

9.2 Software Operation Example

1)Create a workspace and build a compilation environment

```
mkdir -p ~/leishen_ws/src
cd ~/leishen_ws
```

> Remarks:
>
> The workspace can be named arbitrarily, for example, leishen_ws can be changed to any name.

Download LiDAR drive and dependency packets

> Remarks:
>
> The driver is provided in the C16 ser package, copy the obtained rosdriver.tar to the newly created working space XXX_ws / src, and extract the .tar file.

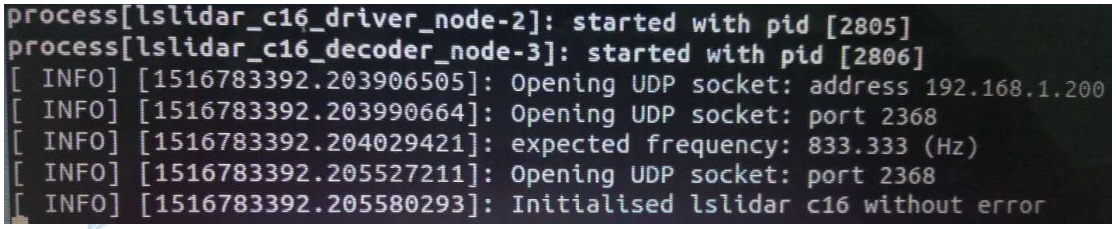
2)Compile Package

```
cd ~/leishen_ws
catkin_make
```

3)Running Program

```
source ~/leishen_ws /devel/setup.bash
roslaunch lslidar_c16_decoder lslidar_c16.launch --screen
```

Note: if you have modified the LiDAR destination port and speed, please open the lsLiDAR_c16.launch to modify the configuration, the default port is 2368, the speed of 10hz is 2000 points.



Note: if the timeout indicates that the driver has no data, please check the hardware connection. Open a terminal again and execute the following command:

```
rosrun rviz rviz
```

4) Display the data detected by LiDAR in the pop-up displays window

Please change the value of "Fixed Frame" to “laser_link”, click the “add” button, and click “pointcloud2” under “by topic” to add the multi-lines point cloud.

10. Appendix (Windows system software)

10.1 Introduction

This document is intended to guide users and developers how to use the 16-line LiDAR of LeiShen Intelligent System Co., Ltd. and the matching 16-line LiDAR display software.

10.2 Application Scope

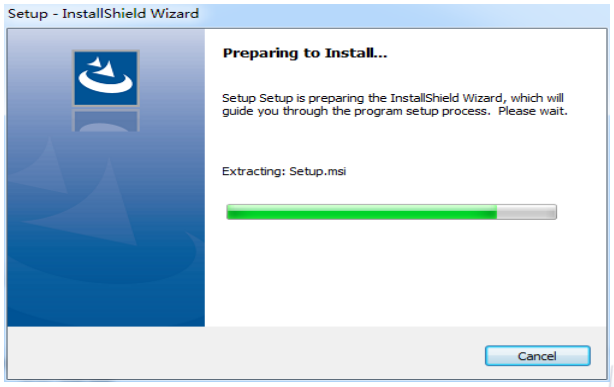
The multi-line LiDAR display software of LeiShen Intelligent is applicable for the 16-line LiDAR of LeiShen Intelligent and compatible with the related operations of 16-line single and second echo LiDAR of Velodyne.

10.3 Software

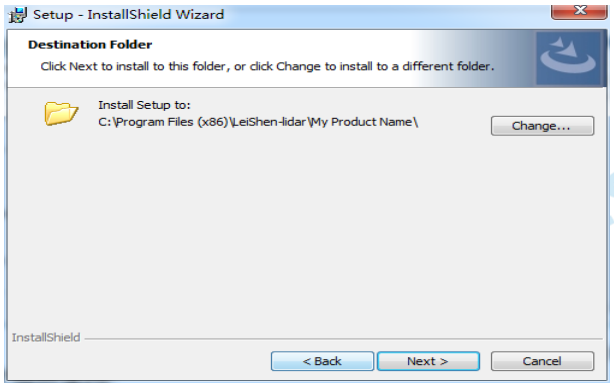
10.3.1 Installation Environment

This software is currently only applicable in the Windows x64 system operating platform. The configuration requirements for the computer installing the software are: CPU: Intel (R) Core(TM) i5 or above, GPU: NVDIA GeForce GTX750 or above (most desirable), or it may influence the software display effect. After installing Leishen's multi-lines software, it still needs to install WinPcap, from the third-party library, which is enclosed in Leishen's multi-lines software.

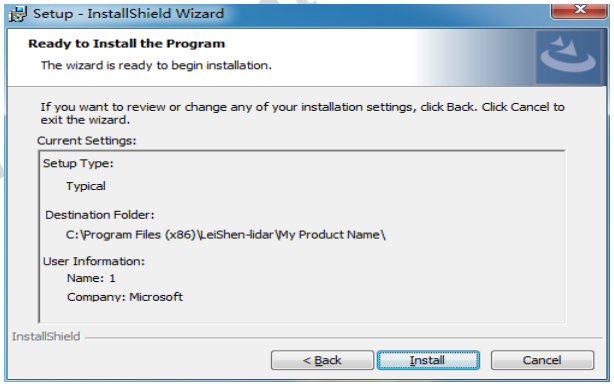
(1)Insert the CD-ROM for software installation included with the LiDAR into the CD/DVD drive. Open the CD-ROM and double-click  to install the file and the installation interface will pop up.

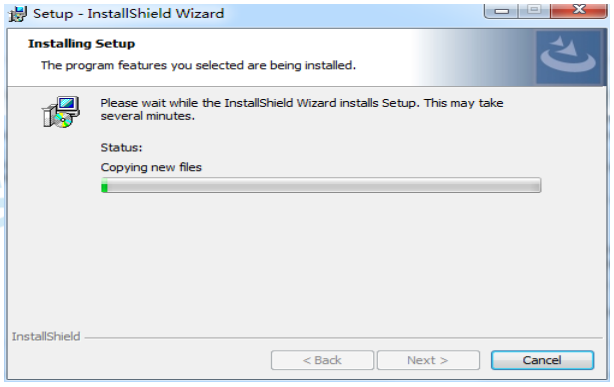


(2)Click next to enter the installation path selection interface.



(3)After customizing the installation path (do not use a path in Chinese), click next to enter the installation interface and click the install button. Wait until the installation is completed.

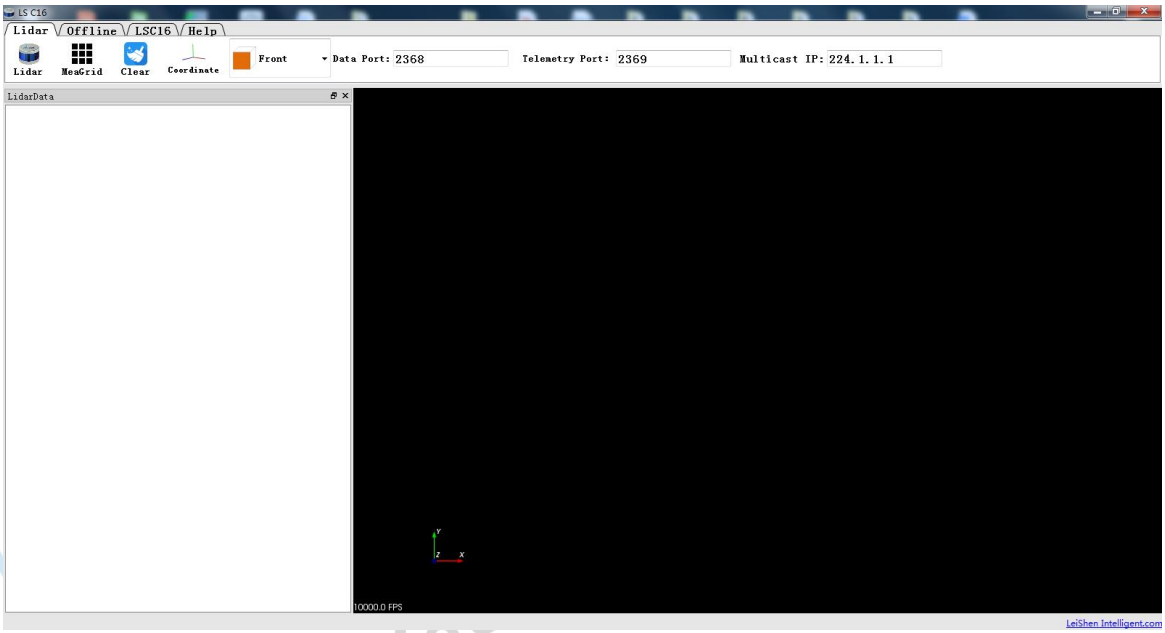




10.4 Introduction and Use of Related Functions

Operation of multi-line LiDAR display system of LeiShen Intelligent.

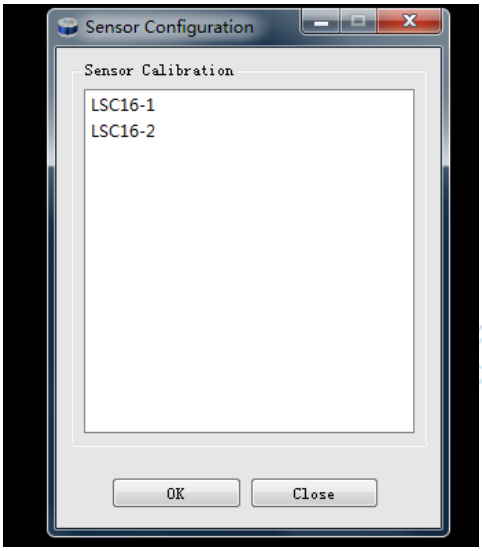
Double-click the shortcut icon on the desktop:  The initial interface is shown below:

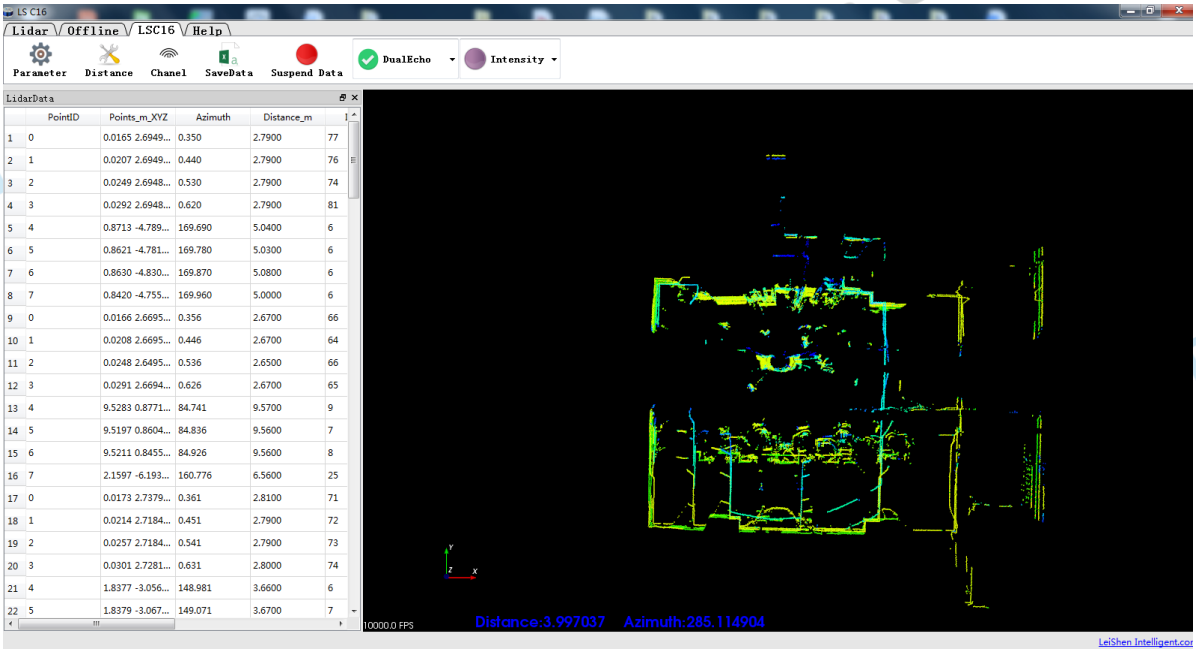


1) Introduction of Real-time LiDAR Data Receive Button

Setting data port number (default 2368) ,telemetry port(default 2369)

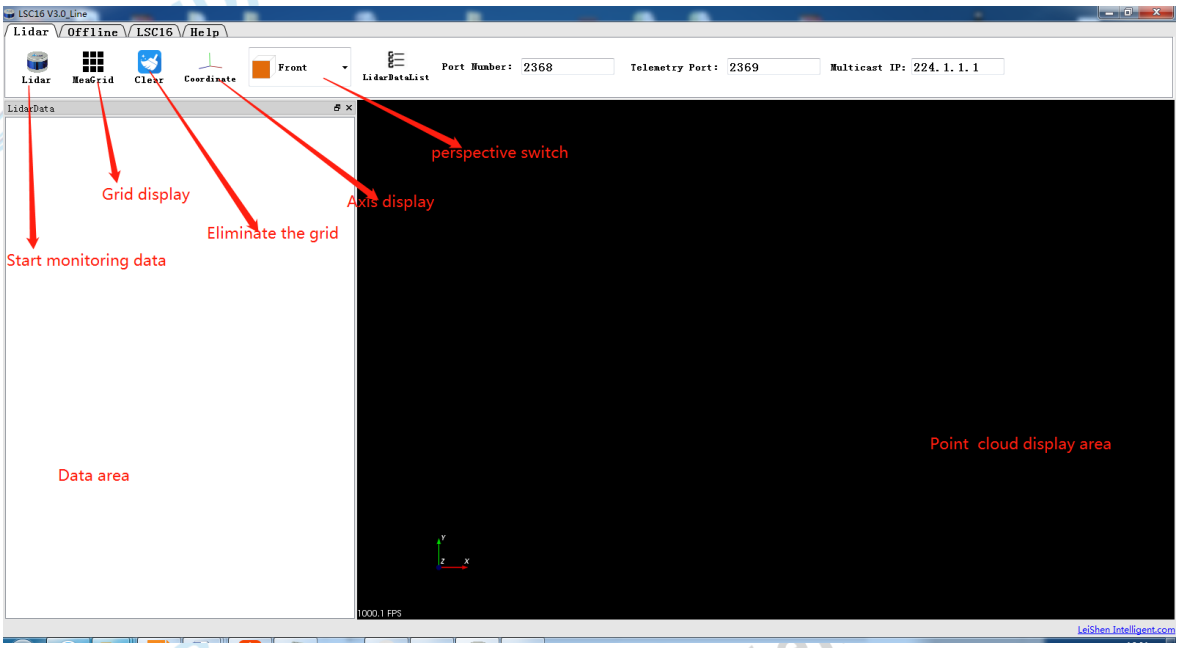
When LiDAR's power supply is connected to the network cable, click on  to get real-time receiving LiDAR data. Click on “Confirm” button on interface to check whether the software automatically detects the received data or not. It also can check real time data and display condition. If click “Cancel”, no LiDAR date shows. Select LSC16(single channel) or LSC16-2(dual channel) data to display directly.





2) Software Interface Related Introduction

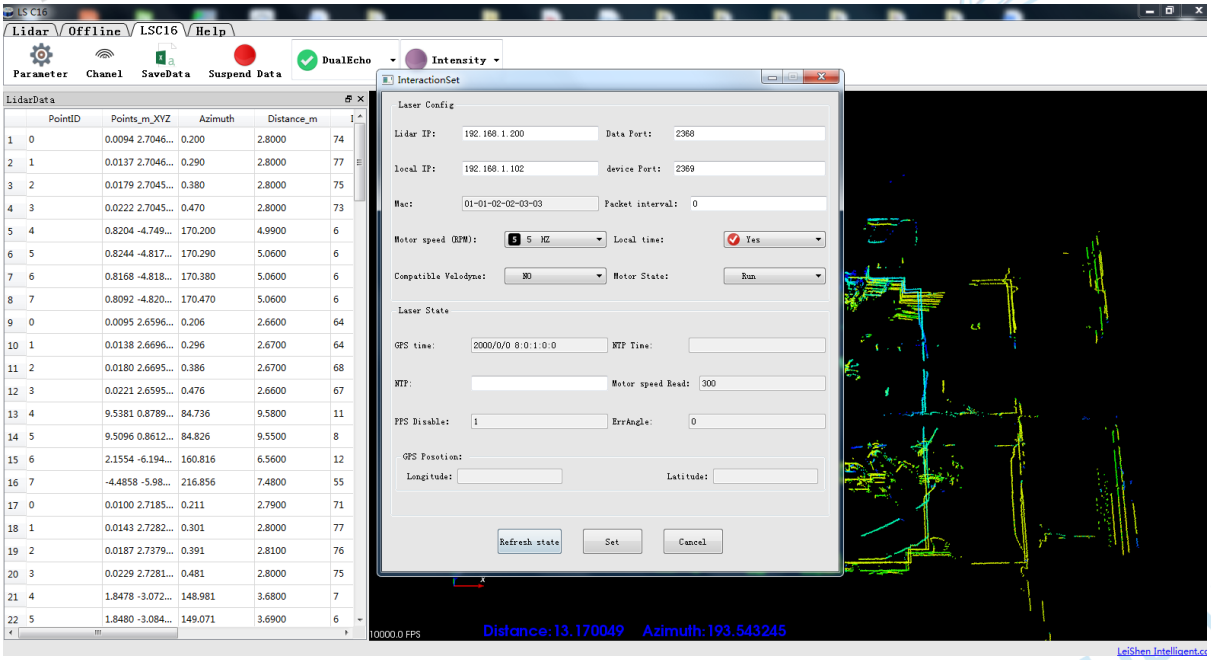
The software interface includes menu area, toolbar area, 3D window area, data table area, play frame information area, company website link and so on. The sections are shown in the following figure.



The data sheet contains (PointID, Points_m_XYZ, adjusted time, Azimuth, Distance, Intensity, Laser_id, timestamp). In particular, Point ID is the point number, Points_m_XYZ is coordinate of the space x, y and z. Azimuth is the azimuth, Distance the distance, Intensity the reflection intensity, Laser_id the LiDAR channel, adjusted time the adjusted time, and timestamp the time stamp.

3)User Configuration Write

Click the icon to pop up the LiDAR parameter setting form as shown below, where it is possible to set the relevant LiDAR.

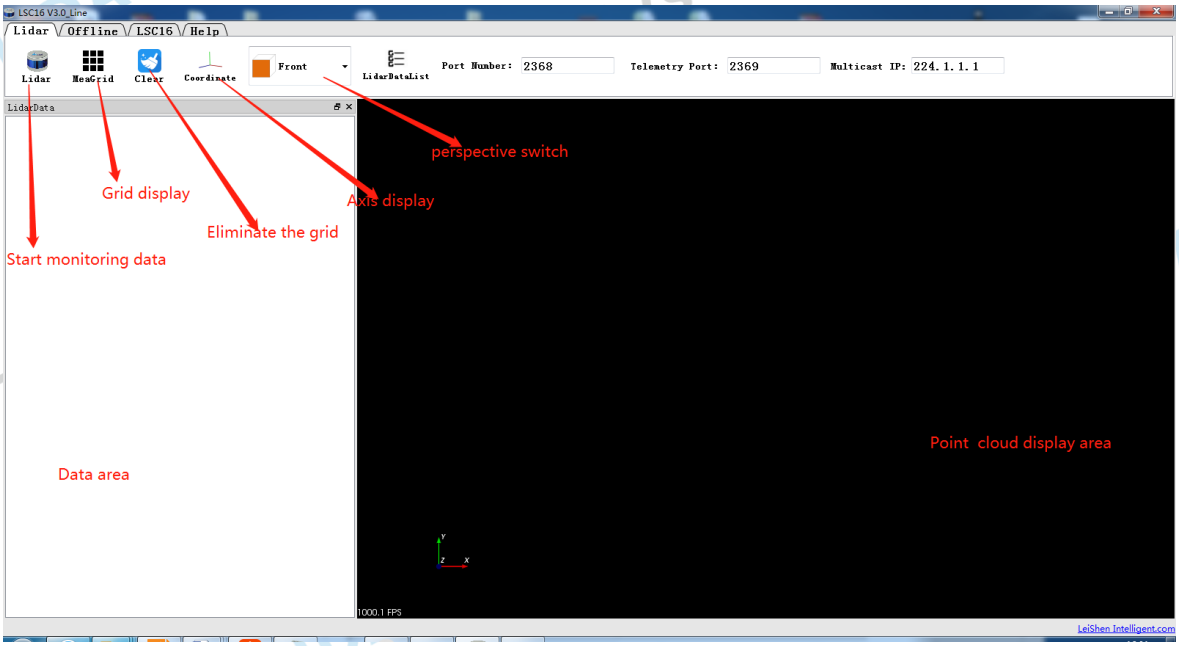


LiDAR parameter setting is in the upper section of the form, where it is possible to set such parameters as LiDAR local IP, LiDAR destination IP, LiDAR local port, LiDAR

destination port, LiDAR speed setting, get local time or not, and Mac address information. Users can also set “compatible with Velodyne or not” (the device information stream packet is not sent with the main data stream), and “stop LiDAR or not” (the third item under the combobox option offers choice whether to send the current LiDAR speed information; if it is selected, distance will no longer be shown in the distance column and is replaced by speed value). The LiDAR real-time status information is in the lower section. The DIFOP status packet sent periodically according to the LiDAR shows its current status information, including GPS location information, satellite time information, motor speed, current LiDAR IP, and the current LiDAR port number.

Clicking the Status Information Refresh allows to get the previous configuration information of the LiDAR (content of device information stream). After filling in the setting information, click the Settings button to send the UCWP packet to the LiDAR. When the LiDAR receives the UCWP packet, it is necessary to disconnect the power for the settings to take effect.

4) LiDAR Menu

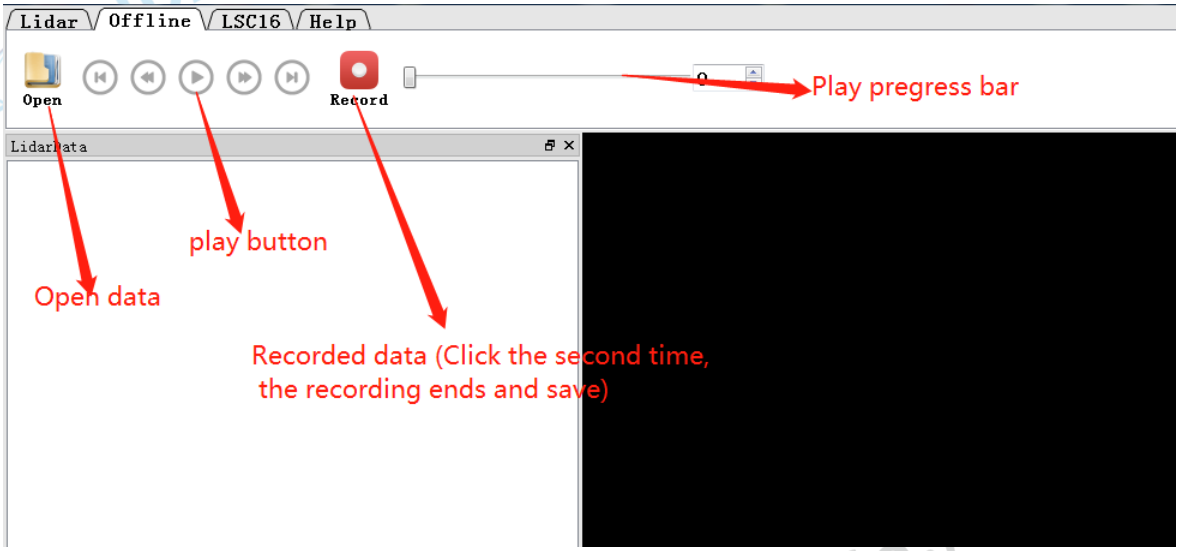


Offone menu

Click  Button, select LiDAR type.

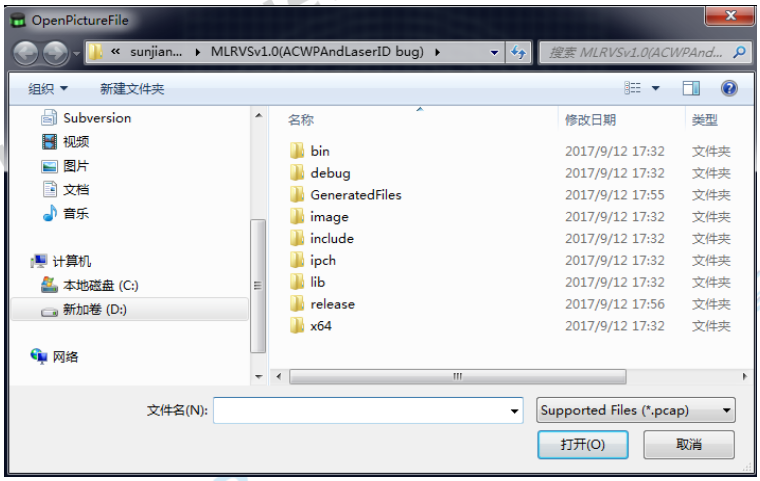
Click  button, open offline data.

Click  button, start saving offline data, valid when LiDAR receives data in real time.



Play pcap offline point cloud

Click button to pop up the dialog box:



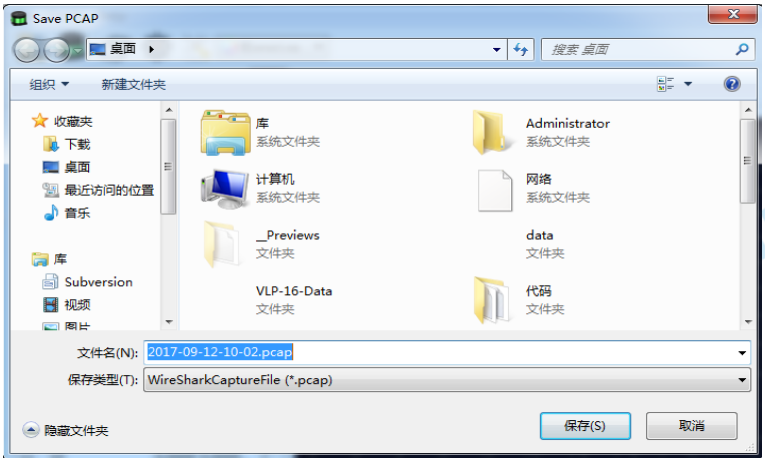
Select the pcap file you want to play and click the Open button.

Click button, chose LSC16 data to connect display, Start play offline point cloud pcap files and visualize point cloud data.

Introduction of play related buttons:

For the play/pause button, a pause is enabled by clicking when it is playing and playback resumes by clicking when it is paused.

Clicking the button stores data and records pcap point cloud file. This function can only be used when the LiDAR data is received in real time and in playback mode. After clicking, the pcap file storage dialog will pop up and storage starts after the path is selected, as shown below:



Clicking  again stops storing.

Note: When an offline pcap file is playing, the button is gray and the function is disabled.

The progress bar in the toolbar shows the progress of the playing file, with the data in the input box being the number of frames at which the file is playing.

5) Introduction of Point Cloud Display

In the point cloud data, there are 20 circles and 40 × 40 grids in the display box. There is a distance of 10m between the radius of two neighboring circles and 10m between two grids (horizontal or vertical). The radius of the outermost circle is 200m. Grids and auxiliary circles make it easy for users to see the location of point cloud.

3D Display the orientation of the interface axes with XY on the axis of the point cloud reference system xyz Axis in the same direction.

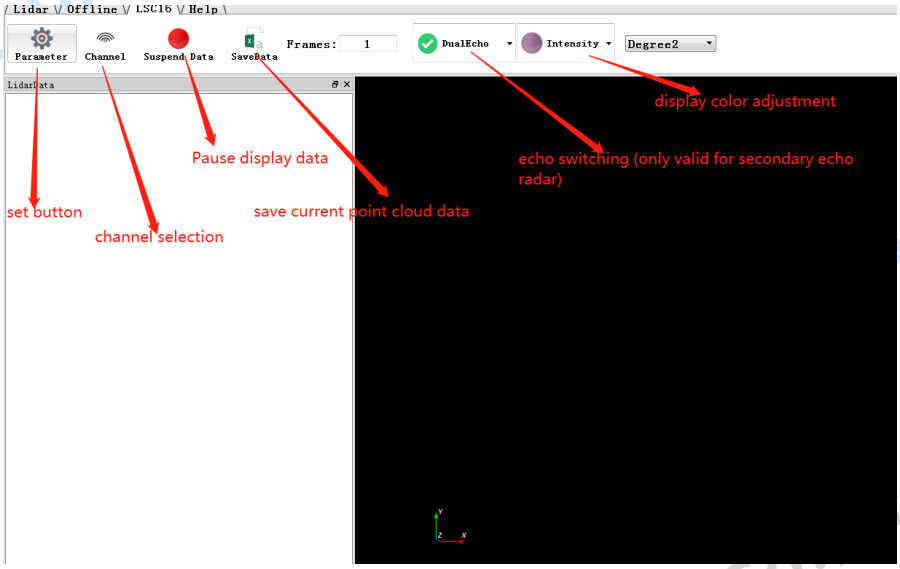
Point cloud display interface supports the following operations:

a) By moving the mouse wheel the display interface zooms in/out; holding down the right mouse button to drag up/down can also do.

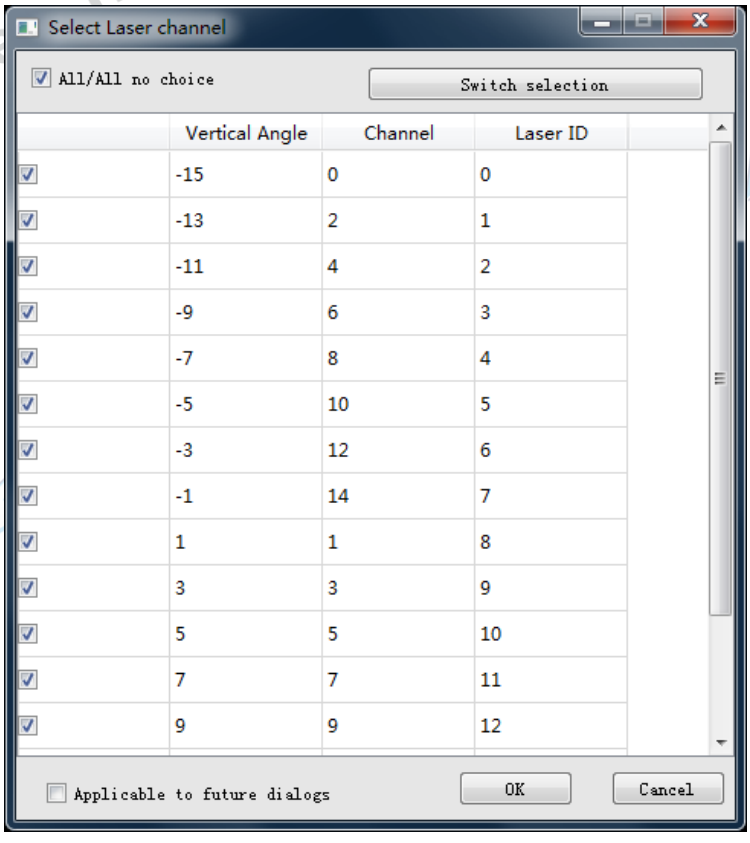
b) Dragging while holding down the right mouse button helps to adjust the perspective of the display interface.

c) Dragging while holding down the mouse wheel helps to pan the display interface; pressing the shift key on the keyboard while clicking the left mouse button can also do.

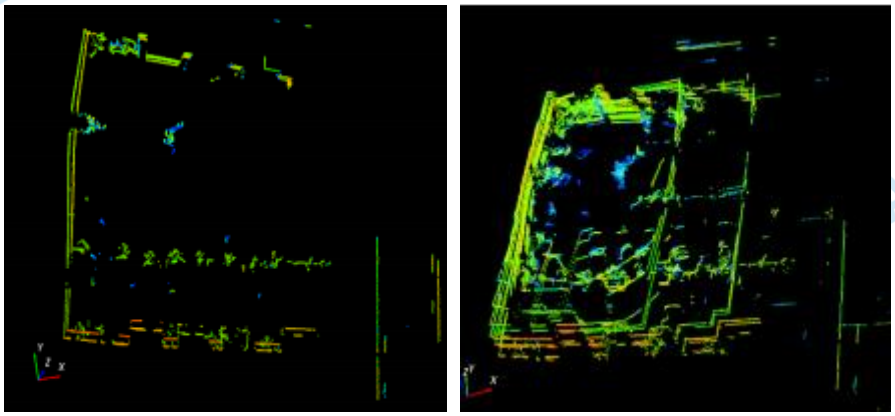
LSC16 Menu



Click button to control the LiDAR channels signals. click on the left check box to close (open) a channel data, click on the upper left corner of the selection all / all can open (close) all channel data. Click on the lower left corner of the applicable dialog box, you can record the current state of LiDAR harness selection for the next application. The vertical angle in the form table indicates the perpendicular angle of the corresponding channel data, and the channel denotes the data arrangement sequence number of the channel corresponding to the channel, laser id indicates the LiDAR channel number.



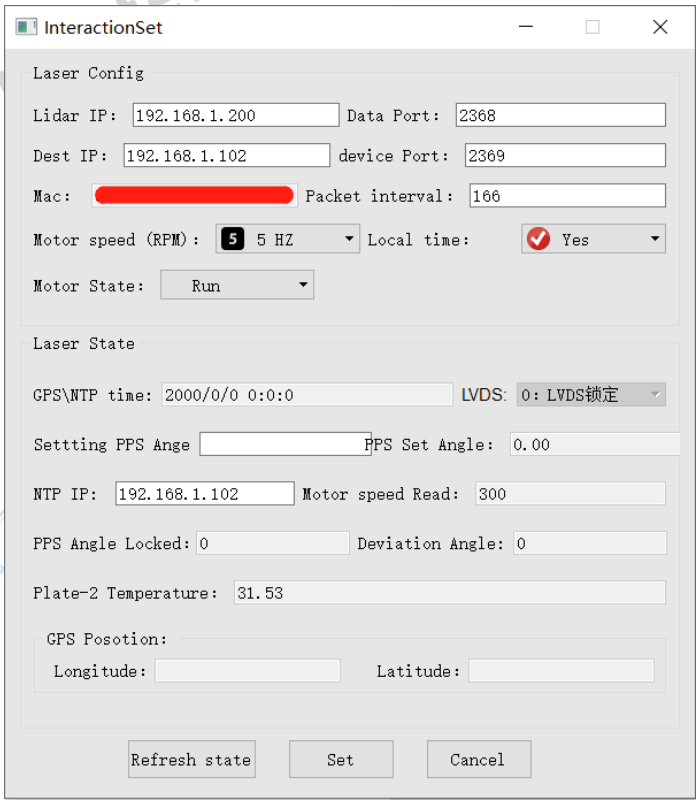
As shown in the following figure, the left image shows some of the channel data hidden in the 16 lines, and the right image is the complete data:



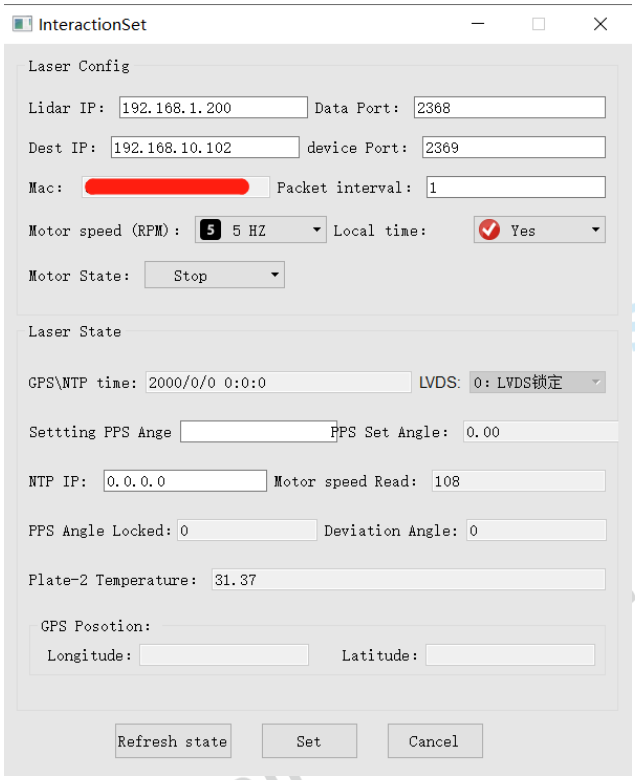
10.5 Parameter configuration example of lidar network communication mode

Unicast

The lidar's source IP address and destination IP address are in the same network segment.

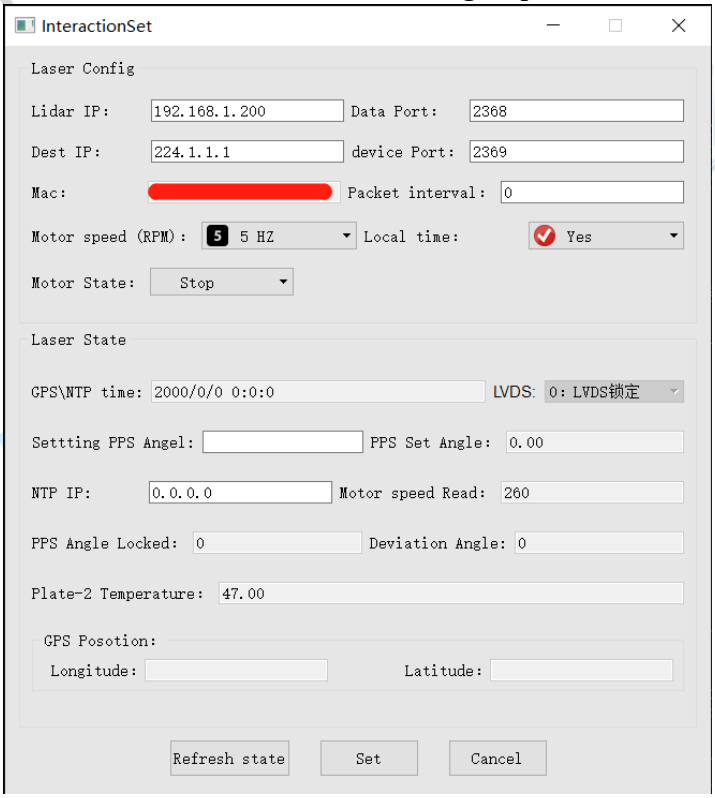


When the lidar's source IP address and destination IP address are in different network segments, for example, the lidar's destination IP address is 192.168.10.102, and the lidar's source IP is 192.168.1.200, they need to be connected through a switch.



Multicast

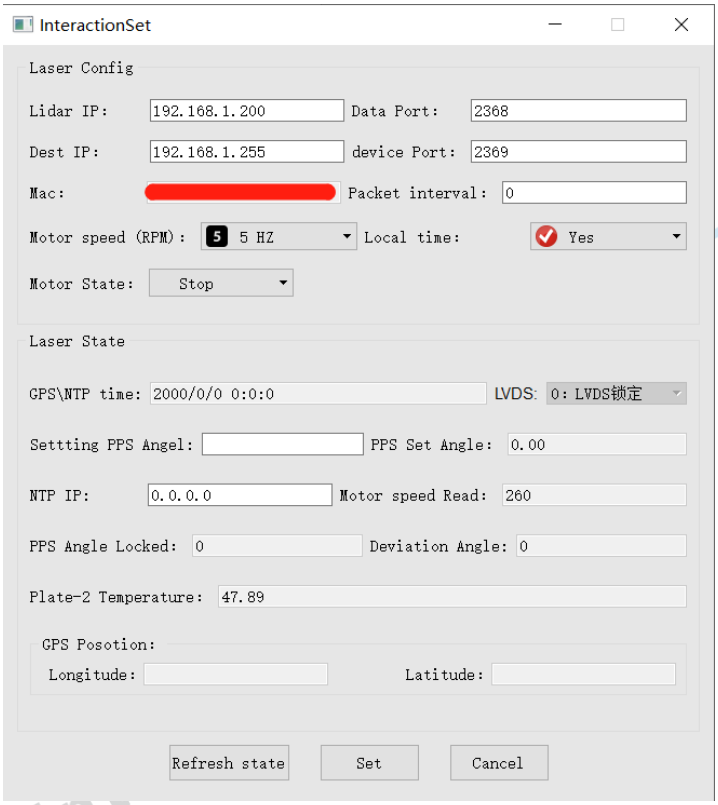
The target IP of lidar is the address of the multicast group.



Broadcast

Set the lidar to work in the broadcast mode, the lidar's destination IP address is the

broadcast address, and the lidar's source IP address and the lidar's destination IP address are in the same network segment.



The target IP address of lidar is the broadcast address, and when the source IP address of lidar and the target IP address of lidar are not in the same network segment, they need to be connected through a switch.

10.6 Attention

1. LiDAR Setup and Use Issues

(1) LeiShen 16-line LiDAR display software cannot be used in two processes (opened twice when it is already running) in the same PC to receive data because the use of PC port is generally exclusive. When one process is bound to a specified port number , other same processes or software using the same port number cannot work normally. For example, if software Veloview uses the same port number, it is impossible to use either of the software in the same PC to receive LiDAR data synchronously, in which case one of the software crashes. Moreover, as the underlying software development using Qt is unable to identify a Chinese path, no Chinese path is recommended in naming a file or a path folder.

When LeiShen 16-line LiDAR display software detects the port is temporarily used, it will prompt for communication network port configuration failure and automatically close the software. Users need to close the process of software that occupies the port, and re-open LeiShen 16-line LiDAR display software for normal operation.

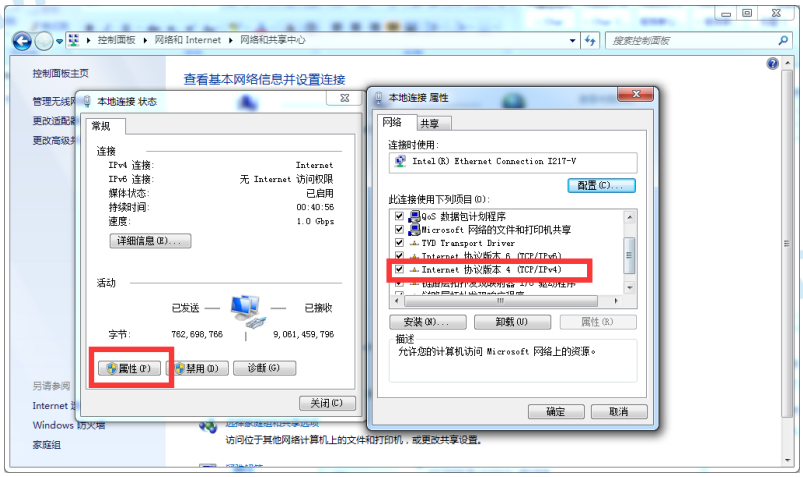
(2) As LeiShen 16-line LiDAR is able to modify the port number through the user configuration so that the LiDAR sends data to the upper computer through the preset destination IP and port, it is necessary to set the IP as the destination IP of the LiDAR when the local notebook or desktop and other device are receiving data. The port bound to program in the local upper computer shall have the set destination port number, as shown below. The packet parameters captured and analyzed by Wireshark are as follows:

	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.3.208	192.168.3.144	UDP	1248	2368 → 2368 Len=1206
2	0.000704	192.168.3.208	192.168.3.144	UDP	1248	2368 → 2368 Len=1206
3	0.001318	192.168.3.208	192.168.3.144	UDP	1248	2368 → 2368 Len=1206

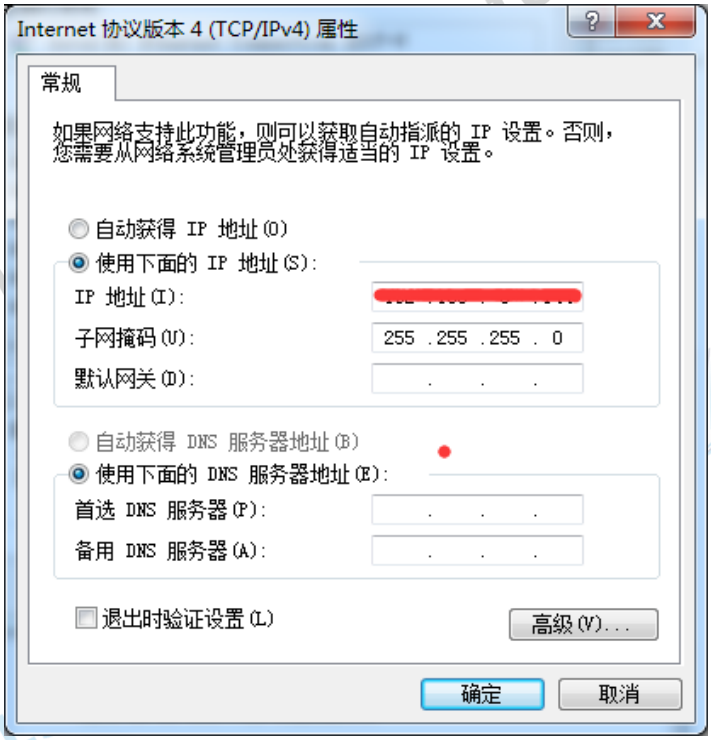
The red boxes indicate the destination IP and port of the LiDAR, respectively.

In Control Panel -> Network and Internet -> Network Share Center, click the Local Area Connection button.

Click Properties in the pop-up status box and click TCP/IP4 Protocol Version in the pop-up Properties box, as shown below.



In TCP/IP4 Properties Settings set the IP address to the destination IP of the LiDAR (the default factory IP and port of the LiDAR are shown in the LiDAR communication protocol) and the subnet mask to 255.255.255.0.



(3) Since LeiShen multi-line LiDAR display system program needs to acquire massive packets via the Internet in a short period of time, it may be prohibited by the network firewall as a malicious program. It is possible that packets are seen to have been sent to the computer using software wireshark to capture packets but are not displayed on the upper computer.

In Control Panel -> System and Security -> Windows Firewall Settings, click Allow a Program or Feature to Pass Through Windows Firewall, as shown below.

Browse to find the software installation path (by default, C:\Program Files (x86)\LeiShenIntelligentSystem\LSVIEW\LSView.exe), and click OK after it is selected to apply the program's network settings. See the following figure for details:

According to the nature of the user's network, check the boxes marked in the red box and click OK to view the data.

2. When LeiShen Intelligent multi-line LiDAR display software is installed in a desktop or laptop with dual GPUs, the default global settings for the computer operating system as use global settings (automatic selection: integrated GPU) have an effect on the display efficiency of the software. To ensure the use and display efficiency of the software, it is necessary to menually set the computer GPU settings.

Dual GPUs can be viewed in the computer configuration. As shown below, the computer's display adapter can be seen in My Computer -> Right Button -> Properties ->

Device Manager:

So it is necessary to menually adjust the settings by switching the applicable GPU of the software menually to HP discrete GPU. The setting steps are as follows:

(1)In case of a notebook with integrated GPU Intel(R)HD Graphics 530 and discrete GPU NVDIA GeForce GTX 960, right-click on the desktop space to pop up the right-click menu and select NVDIA Control Panel.

(2)Select Manage 3D Settings button in the pop-up program interface of NVDIA Control Panel.

(3)Select Program Settings button in Manage 3D Settings interface.

(4)Click Add button in Manage 3D Settings interface.

(5)Click Browse button in the pop-up Add interface.

(6)Find the application file of the software (.exe file) in the pop-up Browse interface according to its installation path:

名称	修改日期	类型	大小
bin	2017/8/26 17:37	文件夹	
doc	2017/9/13 11:01	文件夹	
iconengines	2017/9/9 15:45	文件夹	
image	2017/9/13 11:48	文件夹	
imageformats	2017/9/9 15:45	文件夹	
include	2017/9/9 15:45	文件夹	
lib	2017/9/9 15:45	文件夹	
platforms	2017/9/13 10:58	文件夹	
system32	2017/9/9 17:05	文件夹	
SysWOW64	2017/9/9 17:05	文件夹	
icudt53.dll	2014/9/3 16:42	应用程序扩展	21,025 KB
icuin53.dll	2014/9/3 16:42	应用程序扩展	2,412 KB
icuuc53.dll	2014/9/3 16:42	应用程序扩展	1,675 KB
LSLidar.exe	2017/9/29 10:37	应用程序	817 KB

(7)Click OK to automatically return to NVDIA Control Panel. Select HP NVDIA Processor from the dropdown box under option 2. Select Preferred GPU for This Program and click on the application in the lower right corner. After the computer application is set, close NVDIA Control Panel to complete settings, as shown below.