HESAI Pandar40P 40 Channel Mechanical LiDAR User Manual

www.hesaitech.com
Pandar40P
40-Channel Mechanical LiDAR

User Manual

HESAI Wechat

http://weixin.qq.com/r/Fzns9IXEI9jorcGX92wF

Contents

About This Manual

Using This Manual

- Make sure to read through this user manual before your first use and follow the instructions herein when you operate the product. Failure to comply with the instructions may result in product damage, property loss, personal injuries, and/or a breach of warranty.
- This user manual does not contain information on product certifications. Please check the certification marks on the product's bottom plate and read through the corresponding certification warnings.
- If you incorporate this LiDAR product into your product(s), you are required to provide this user manual (or the means to access this user manual) to the intended users of your product(s).

Access to This Manual

To obtain the latest version:

- Visit the Download page of Hesai's official website: **https://www.hesaitech.com/en/download**
- Or contact your sales representative at Hesai
- Or contact Hesai's technical support team: **service@hesaitech.com**

Technical Support

If your question is not addressed in this user manual, please contact us at: **service@hesaitech.com**
www.hesaitech.com/zh/support
https://github.com/HesaiTechnology (Please leave your questions under the corresponding GitHub projects.)

Legends

Warnings: instructions that must be followed to ensure safe and proper use of the product.

Notes: additional information that may be helpful.

Safety Notice

Special Warnings

Laser Safety
Hot Surface

CAUTION

Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure

INVISIBLE LASER RADIATON

CLASS 1 LASER PRODUCT
This product complies with IEC/EN 60825-1: 2014 and complies with FDA performance standards for laser products except for conformance with IEC 60825-1 Ed.3., as described in Laser Notice No.56, dated May 8, 2019.

Hot Surface

During or after a period of operation, do NOT touch the product's enclosure with your skin.

Abnormalities

In any of the circumstances listed below, stop using the product immediately:

- You suspect that the product malfunctions or is damaged. For example, the product produces significant noise or is visibly vibrating.
- You or other people in the nearby environment feel discomfort.
- Any device or equipment in the nearby environment malfunctions.

Meanwhile, contact Hesai Technology or an authorized Hesai Technology service provider for more information on product disposal. Contact information can be found in the product's user manual (refer to the About this Manual section).

Prohibition of Disassembly
Unless expressly agreed to in writing by Hesai Technology, do NOT disassemble the product.

Operating Environment

Radio Frequency Interference
Before using the product, make sure to read all the signs and notices on the product enclosure (including the bottom plate). Although the product is designed, tested, and manufactured to comply with the regulations on RF radiation (such as FCC, CE-EMC, or KCC), the radiation from the product may still influence electronic devices.

Vibration

- If significant mechanical shocks and vibration may exist in the product's operating environment, please contact Hesai's technical support team to obtain the shock and vibration limits of this product model. Exposure to over-the-limit shocks or vibration may damage the product.
- Make sure to package the product in shock-proof materials to avoid damage during transport.

Explosive Atmosphere and Other Air Conditions

- Do NOT use the product in any area where potentially explosive atmospheres are present, such as high concentrations of flammable chemicals, vapors, or particulates (including particles, dust, and metal powder) in the air.
- Do NOT expose the product to high concentrations of industrial chemicals, including liquefied gases that are easily vaporized (such as helium). Such exposure can damage or weaken the product's function.

Ingress Protection
Please check the product's user manual for its IP rating (refer to the Specifications section). Make sure to avoid any ingress beyond that rating.

Operating Temperature
Please check the product's user manual for its operating temperature (refer to the Specifications section). Make sure not to exceed the operating temperature range.

Recommended Storage Conditions
Store the product in a dry, well ventilated place. The recommended ambient temperature is 23±5°C, and the humidity between 30% and 70%.

Light Interference
Certain precision optical instruments may be interfered by the laser light emitted from the product. Please check all the instructions of these instruments and take preventive measures if necessary. For example, when the product is temporarily not used for measurement, the protective leather cover (supplied with the product) can be used to block laser light emission.

Personnel
Recommended Operator Qualifications
The product should be operated by professionals with engineering backgrounds or experience in operating optical, electrical, and mechanical instruments. Please follow the instructions in this manual when operating the product and contact Hesai technical support if needed.

Medical Device Interference

- Some components in the product can emit electromagnetic fields. If the product operators or other people in the nearby environment wear medical devices (such as cochlear implants, heart pacemakers, and defibrillators), make sure to consult the physicians and medical device manufacturers for medical advice, such as determining whether it is safe to work near the product.
- If you suspect that the product is interfering with your medical device, stop using the product immediately.

Installation and Operation
Power Supply

- You are recommended to use only the cables and power adapters provided by Hesai Technology.
- If you are to design, configure, or select the power supply system (including cables) for the product, make sure to comply with the electrical specifications in the product's user manual (refer to the Specifications section and the Power Supply Requirements section); for technical support, please contact Hesai Technology. Do NOT use off-spec or damaged cables or adapters.

Electrical Interface

- Before powering on the product, make sure the electrical interfaces are dry and clean. Do NOT power on the product in a humid environment.
- Please check the Interfaces section in the product's user manual and strictly follow the instructions on plugging/unplugging the connector.
  If abnormalities already exist (such as bent pins, broken cables, and loose screws), stop using the product and contact Hesai technical support.
- To prevent breakdown, turn off the power source before connection and disconnection.

Eye Safety
The product is a Class 1 laser product. It satisfies the requirements of:

- IEC 60825-1:2014.
- 21 CFR 1040.10 and 1040.11 except for deviations (IEC 60825-1 Ed.3) pursuant to Laser Notice No.56, dated May 8, 2019.

Please follow the standard laser safety guidelines accordingly.

For maximum self-protection, it is strongly warned NOT to look into the transmitting laser through a magnifying product (microscope, eye loupe, magnifying glass, etc.).

 This product does not have a power switch. It starts operating once connected to power. During operation, the entire cover lens can be regarded as the product's laser emitting window; looking at the cover lens can be regarded as looking into transmitting laser.

Product Enclosure

- The product contains metal, glass, plastic, as well as sensitive electronic components. In case the product has been dropped and burnt, stop using it immediately and contact Hesai technical support.
- Do NOT squeeze or pierce the product. If the product enclosure is broken, stop using it immediately and contact Hesai technical support.
- The product contains high-speed rotating parts. To avoid potential injuries, do NOT operate the product if the enclosure is loose.
- Before operating the product, make sure it is properly and securely mounted. The mounting should prevent the product from leaving its mounting position in case of external forces (such as collisions, high winds, and stone impacts).
- If the product enclosure consists of fins or grooves, please wear gloves when handling the product. Applying too much pressure with your bare hands may cause cuts, bruises or other injuries.

Product Enclosure: Cover Lens

- To keep the product's cover lens from fingerprints and other stains, do NOT touch the cover lens with bare hands. If the cover lens is already stained, please refer to the cleaning method in the Sensor Maintenance section of the user manual.
- To prevent scratches, do NOT touch the product's cover lens with hard or sharp objects. If scratches already exist, stop using the product and contact Hesai technical support. Severe scratches may affect the quality of the product's point cloud data.

Hot Surface
During operation or a time period after operation, the product's enclosure can be hot.

- To prevent discomfort or even burns, do NOT touch the product's enclosure with your skin.
- To prevent fires, do NOT touch the product's enclosure with flammable materials.

Peripherals
The product may be used along with accessories and devices, such as suction cup mounts, extension cables, power supplies, network devices, GPS/PTP devices, and cleaning equipment. Please refer to all relevant specifications in the product's user manual, or contact Hesai technical support. Using off-spec or unsuitable devices may result in product damage or even personal injuries.

Firmware and Software Upgrading
Make sure to use only the upgrade files provided by Hesai Technology. Make sure to observe all the instructions provided for that upgrade file.

Custom Firmware and Software

- Before using a custom version of firmware and software, please thoroughly understand the differences in functions and performance between this custom version and the standard version.
- Make sure to strictly follow all the instructions and safety precautions provided for that custom version. If the product does not function as anticipated, stop using the product immediately and contact Hesai technical support.

Point Cloud Data Processing
The point cloud data processing features (provided on certain product models) are configurable and are intended only to assist users in extracting information from the point cloud data. Users are in full control whether to use any of these features. Moreover, users are responsible for analyzing the product's intended application scenarios and evaluating the risks of enabling one or more of these features in combination. The point cloud data processing features include but are not limited to: Noise Filtering, Interstitial Points Filtering, Retro Multi-Reflection Filtering, and Nonlinear Reflectivity Mapping.

Repair and Maintenance
For product repair or maintenance issues, please contact Hesai Technology or an authorized Hesai Technology service provider. Contact information can be found in the product's user manual (refer to the About this Manual section).

Repair
Unless expressly agreed to in writing by Hesai Technology, do NOT by yourself or entrust any third party to disassemble, repair, modify, or retrofit the product. Such a breach:

- can result in product damage (including but not limited to water resistance failure), property loss, and/or personal injuries;
- shall constitute a breach of warranty.

Introduction

This manual describes the specifications, installation, and data output format of Pandar40P.

Operating Principle

Distance Measurement: Time of Flight (ToF)

1. A laser diode emits a beam of ultrashort laser pulses onto the target object.
2. The laser pulses are reflected after hitting the target object. The returning beam is detected by an optical sensor.
3. Distance to the object can be accurately measured by calculating the time between laser emission and receipt.

$d = \frac{ct}{2}$	d: distance c: speed of light t: travel time of the laser beam

Figure 1.1 Distance Measurement Using Time of Flight

LiDAR Structure

40 pairs of laser emitters and receivers are attached to a motor that rotates horizontally.

Figure 1.2 Partial Cross-Sectional Diagram

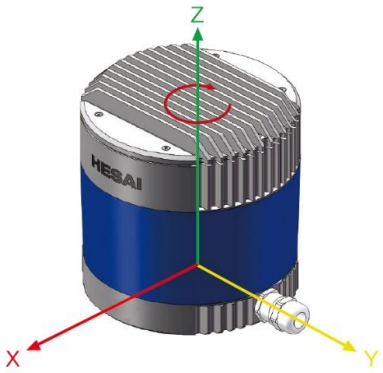


Figure 1.3 Coordinate System (Isometric View)

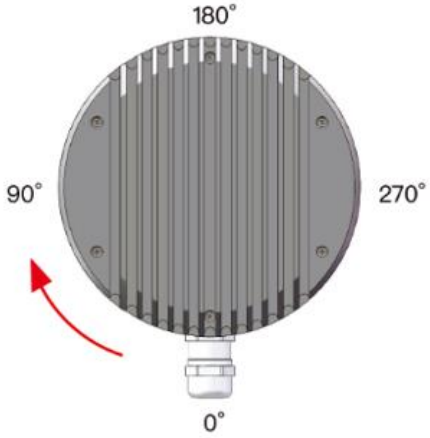


Figure 1.4 Rotation Direction (Top View)

The LiDAR's coordinate system is illustrated in Figure 1.3. Z-axis is the axis of rotation.
The origin is shown as a red dot in Figure 1.6 on the next page. All measurements are relative to the origin.
Each laser channel has an intrinsic horizontal angle offset. When Channel 12 passes the zero-degree position in Figure 1.4, the azimuth data in the corresponding UDP data block will be 0°.

Channel Distribution

The vertical resolution is

- 0.33° between Channel 6 and Channel 30
- 1° between Channel 5 and Channel 6, Channel 30 and Channel 38
- not evenly distributed in the remaining channels, as detailed in Appendix I

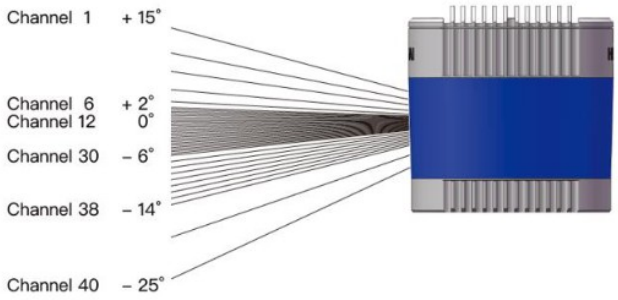


Figure 1.5 Channel Vertical Distribution

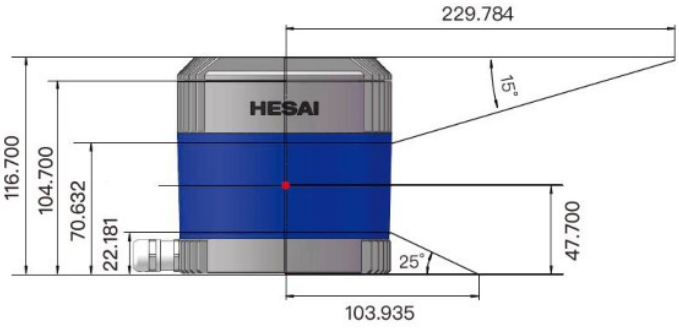


Figure 1.6 Laser Firing Position (Unit: mm)

Each channel has an intrinsic angle offset, both horizontally and vertically. The offsetted angles are recorded in this LiDAR unit's angle correction file, which is provided when shipping the unit.
In case you need to obtain the file again:

- Send this PTC command PTC_COMMAND_GET_LIDAR_CALIBRATION, as described in Hesai TCP API Protocol (Chapter 5).
- Or export the file using Pandar View, see the Pandar View user manual.
- Or contact a sales representative or technical support engineer from Hesai.

Specifications

SENSOR

Scanning Method	Mechanical Rotation
Channel	40
Range Capability	0.3 to 200 m (at 10% reflectivity)
Range Accuracy ①	±5 cm (0.3 to 1 m) ±2 cm (1 to 200 m)
FOV (Horizontal)	360°
Resolution (Horizontal)	0.2° (10 Hz), 0.4° (20 Hz)
FOV (Vertical)	40° (-25° to +15°)
Resolution (Vertical)	0.33° (-6° to +2°) 1° (+2° to +3°, -14° to -6°) 2° (+3° to +5°) 3° (+5° to +11°) 4° (+11° to +15°) 5° (-19° to -14°) 6° (-25° to -19°)
Frame Rate	10 Hz, 20 Hz
Returns	Single Return (Last, Strongest) Dual Return (Last and Strongest)

MECHANICAL/ELECTRICAL/OPERATIONAL

Wavelength	905 nm
Laser Class	Class 1 Eye Safe
Ingress Protection	IP6K7
Dimensions	Height: 116.7 mm Top/Bottom: Φ118.0 / 116.0 mm
Rated Voltage Range	DC 9 to 48 V
Power Consumption ②	18 W (typical)
Operating Temperature	-20℃ to 65℃
Storage Temperature	-40℃ to 85℃
Weight	1.52 kg

DATA I/O

Data Transmission	UDP/IP Ethernet (100 Mbps)
Measurements	Distance, Azimuth Angle, Intensity
Data Points Generated	Single Return: 720,000 points/sec Dual Return: 1,440,000 points/sec
Point Cloud Data Rate	Single Return: 18.78 Mbps Dual Return: 37.56 Mbps
Clock Source	GPS / PTP
PTP Clock Accuracy	≤1 μs
PTP Clock Drift ③	≤1 μs/s

Specifications are subject to change. Please refer to the latest version.

1. Range accuracy
   • Defined as the average range error across all channels.
   • May vary with range, temperature, and target reflectivity.
2. Power consumption
   • Not including accessories such as the connection box.
3. PTP Clock Drift
   • Defined as the drift at a constant temperature after the LiDAR (slave clock) loses connection to the PTP master.

Setup

Mechanical Installation

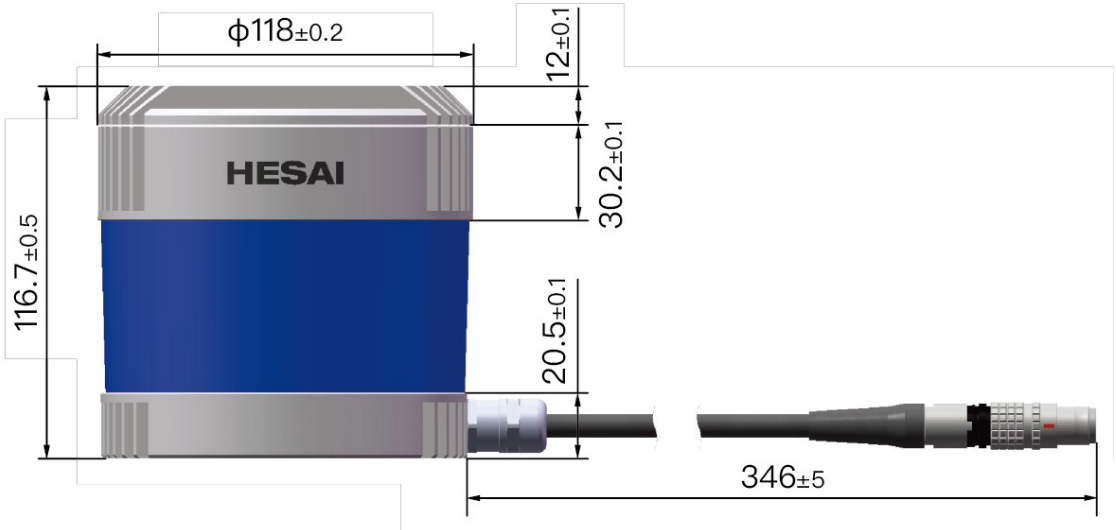


Figure 2.1 Front View (Unit: mm)

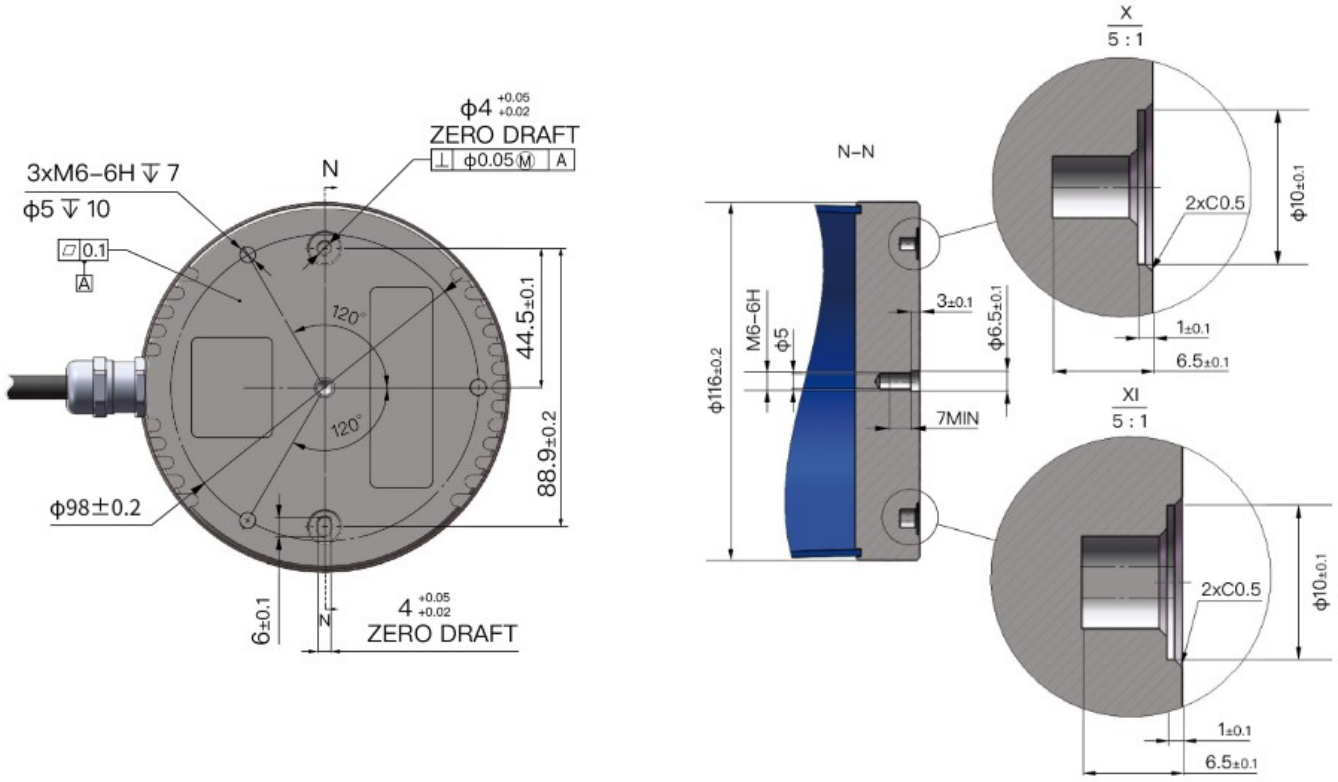


Figure 2.2 Bottom View (Unit: mm)

Quick Installation

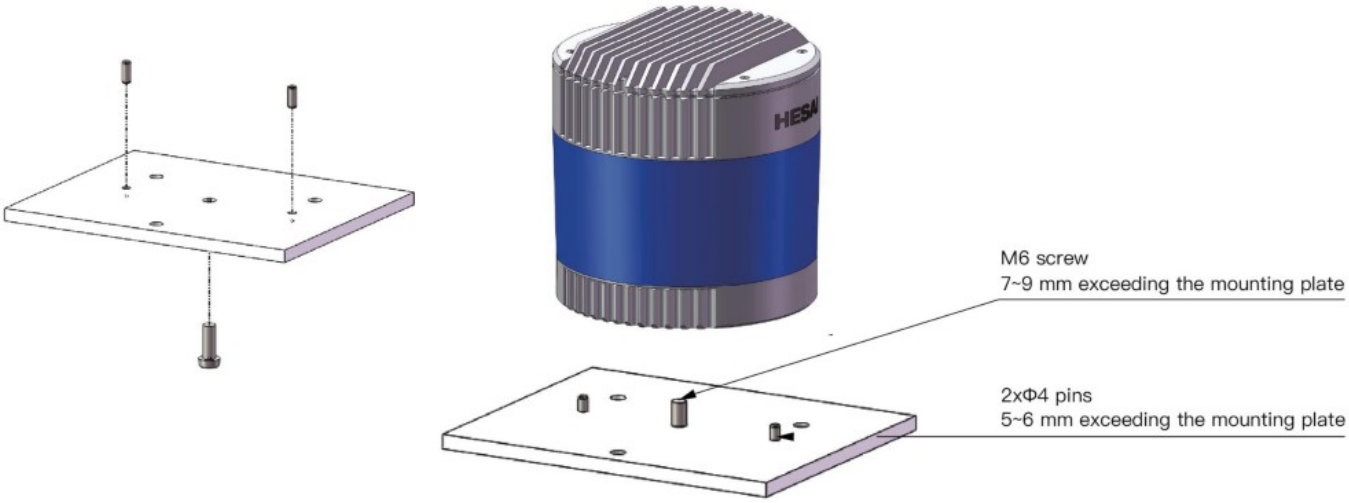


Figure 2.3 Quick Installation

Stable Installation

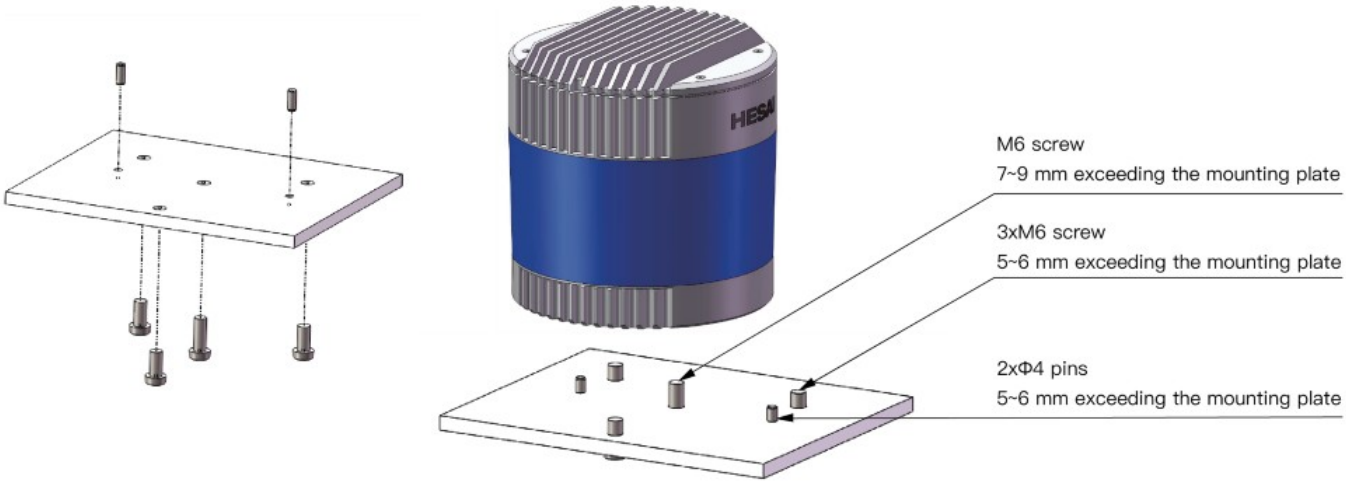


Figure 2.4 Stable Installation

Interfaces

Lemo Contact is the default communication connector. (Another option is the Phoenix Contact, detailed in the appendix)
Lemo part number: FGG.2T.316.CLAC75Z (male plug, on the LiDAR)

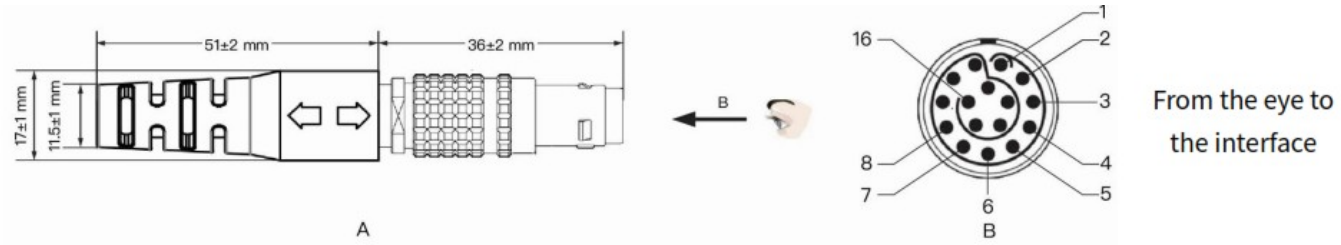


Figure 2.5 Lemo Connector (Male Plug)

Pin #	Signal	Color	Voltage
1 ~ 4	–	–	–
5	Ethernet RX-	BLUE	-1 to 1 V
6	Ethernet RX+	BLUE/WHITE	-1 to 1 V
7	Ethernet TX-	ORANGE	-1 to 1 V
8	Ethernet TX+	ORANGE/WHITE	-1 to 1 V
9	GPS Serial Data	WHITE	-13 to +13 V
10	GPS PPS	YELLOW	TTL 3.3/5 V
11	Power	RED	9 to 48 V
12	Power	GRAY	9 to 48 V
13	Ground (Return)	BLACK	0 V
14	Ground (Return)	GRAY/WHITE	0 V
15	–	PURPLE	–
16	–	PURPLE/WHITE	–

 For the GPS PPS signal, pulse width is recommended to be over 1 ms, and the cycle is 1 s (rising edge to rising edge)

 Before connecting or disconnecting an external GPS signal (either using the cable's GPS wire or via the connection box's GPS port), make sure the LiDAR is powered off. If the LiDAR has to stay powered on, make sure to:

- ground yourself in advance
- avoid touching the GPS wire or GPS port with bare hands

Connector Use

Connection	Disconnection
• Turn off the power source • Align the red dots on the connector shells • Push the plug straight into the socket	• Turn off the power source • Pull the release sleeve on the male connector to its out ermost position and hold there • Pull the plug from the socket

 **Warnings**

- DO NOT attempt to force open a connection by pulling on the cables or the shells, or by twisting the connectors in any way. Doing so can loosen the connectors' shells, or even damage the contacts.
- In case a connector's shell is accidentally pulled off, stop using the connector and contact Hesai technical support.

- DO NOT attempt to assemble the connector's shell and cable collet; DO NOT connect a connector without its shell. Doing so may damage the LiDAR's circuits.

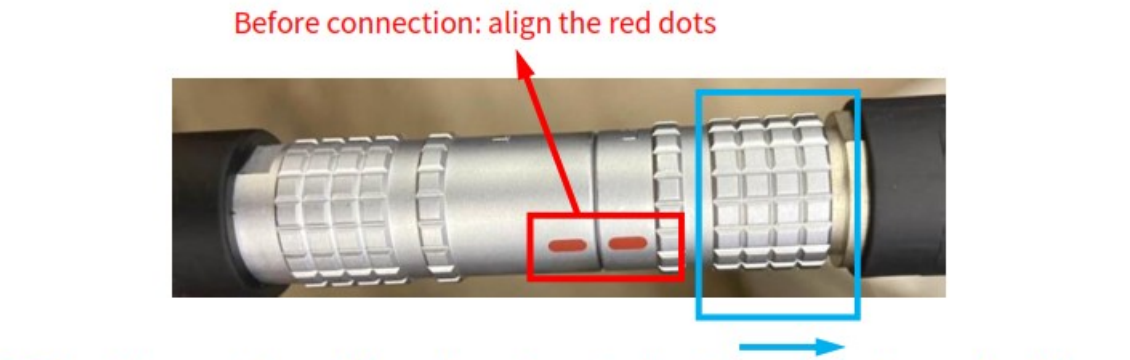


Figure 2.6 Lemo Connection/Disconnection

Cables
OD (outside diameter) = 7.50±0.30 mm
Minimum bend radius: 7.5 * OD

⚠To avoid damaging the cable, do not bend the cable at the cable gland.

Connection Box (Optional)

Users may connect the LiDAR directly or using the connection box.
Lemo part number: PHG.2T.316.CLLC75Z (female socket, on the connection box)

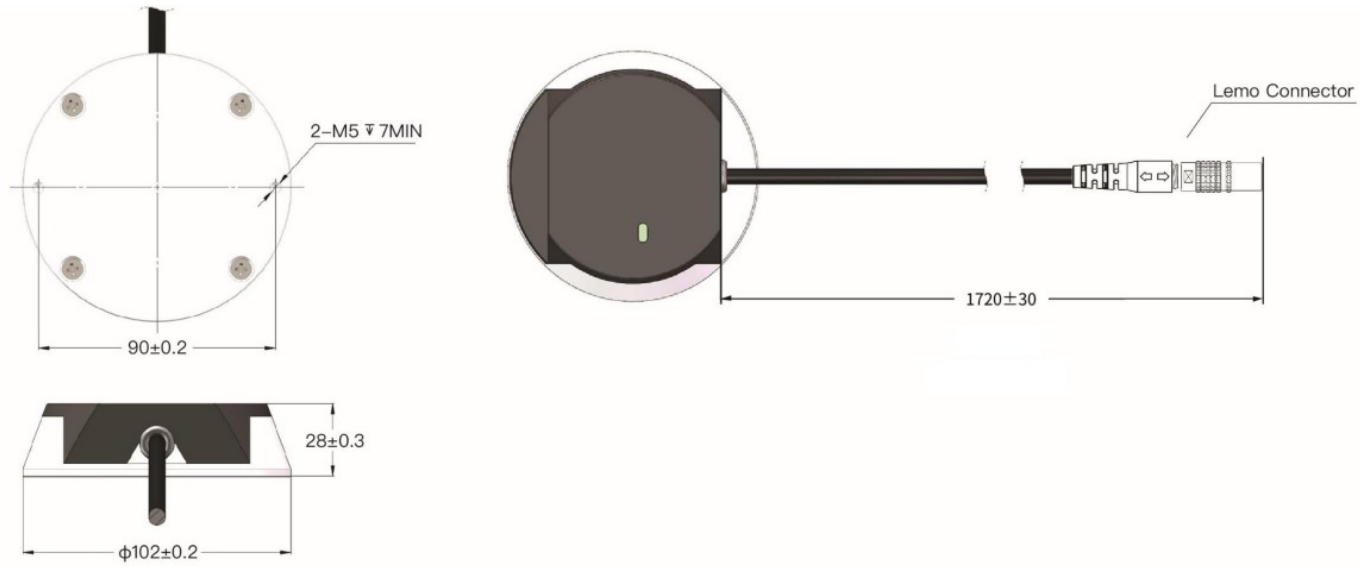


Figure 2.7 Connection Box (Unit: mm)

Connection Box Interfaces

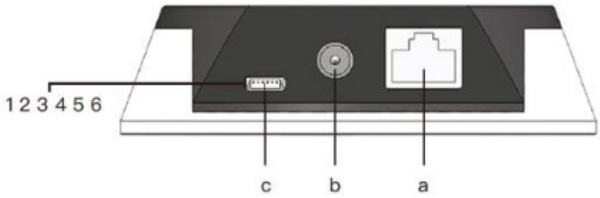


Figure 2.8 Connection Box (Front)

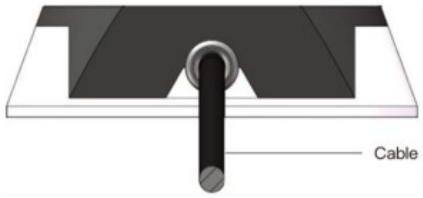


Figure 2.9 Connection Box (Back)

Port #	Port Name	Description
a	Standard Ethernet Port	RJ45, 100 Mbps Ethernet
b	Power Port	Use DC-005 DC power adapter External power supply: 9 V to 48 V, at least 18 W
c	GPS Port	Connector part number: JST SM06B-SRSS-TB Recommended connector for the external GPS module: JST SHR-06V-S-B Voltage standard: RS232 Baud rate: 9600 bps

The GPS port pin numbers are 1 to 6 from left to right, defined as follows:

Pin #	Direction	Pin Description	Requirements
1	Input	PPS (pulse-per-second) signal for synchronization	TTL level 3.3/5 V Recommended pulse width: ≥1 ms Cycle: 1 s (from rising edge to rising edge)
2	Output	Power for the external GPS module	5 V
3	Output	Ground for the external GPS module	–
4	Input	Receiving serial data from the external GPS module	RS232 level
5	Output	Ground for the external GPS module	–
6	–	Reserved	–

Connection

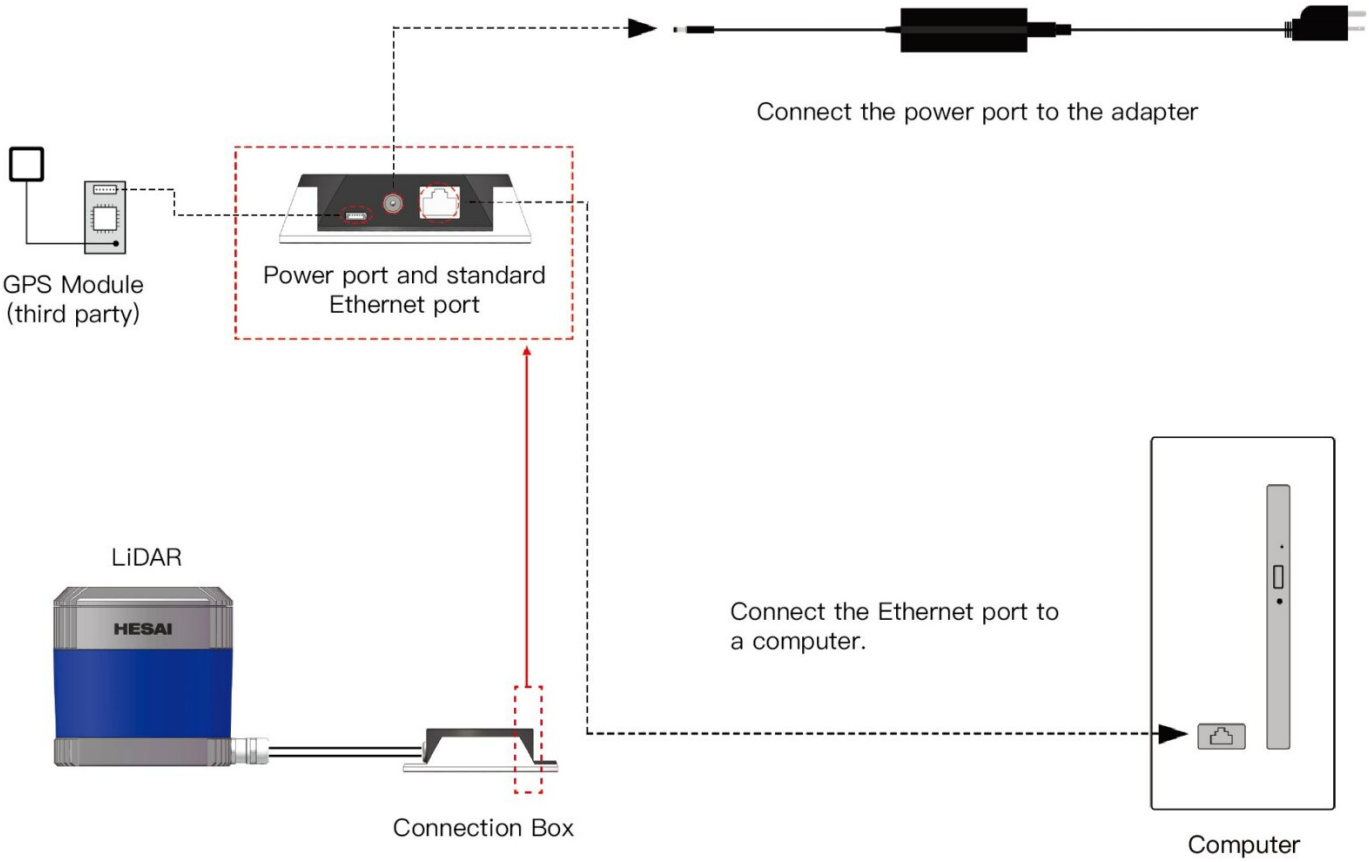


Figure 2.10 Connection Box – Connection

Refer to Appendix III (PTP Protocol) when PTP protocol is used.

Get Ready to Use

Before operating the LiDAR, strip away the protective cover outside the cover lens.
The LiDAR does not have a power switch. It starts operating once connected to power and the Ethernet.
To receive data on your PC, set the PC's IP address to 192.168.1.100 and subnet mask to 255.255.255.0

For Ubuntu:	For Windows:
Input this ifconfig command in the terminal: ~$ sudo ifconfig enp0s20f0u2 192.168.1.100 (replace enp0s20f0u2 with the local Ethernet port nam e)	Open the Network Sharing Center, click on "Ethernet" In the "Ethernet Status" box, click on "Properties" Double-click on "Internet Protocol Version 4 (TCP/IPv 4)" Configure the IP address to 192.168.1.100 and subne t mask to 255.255.255.0

To record and display point cloud data, see PandarView User Manual.
To set parameters, check device info, or upgrade firmware/software, see Chapter 4 (Web Control)
To obtain the SDKs (Software Development Kits) for your product model,

- please find the download link at: **www.hesaitech.com/en/download** (Product Documentation select product model)
- or visit Hesai's official GitHub page: **https://github.com/HesaiTechnology**

Data Structure

The LiDAR outputs Point Cloud Data Packets and GPS Data Packets using 100 Mbps Ethernet UDP/IP. Unless otherwise specified, all the multi-byte fields are unsigned values in little endian format.

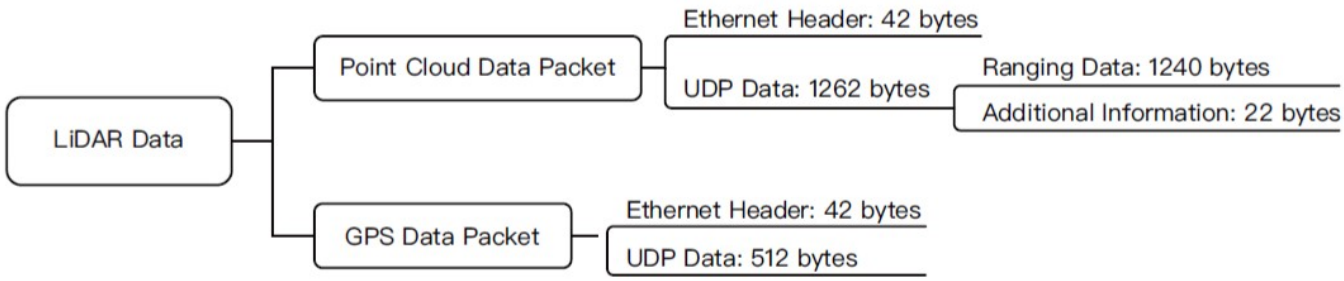


Figure 3.1 Data Structure with UDP Sequence OFF

UDP sequence is OFF by default . When UDP sequence is ON, the Additional Information in the UDP data changes from 22 bytes to 26 bytes.

Point Cloud Data Packet

Ethernet Header

Each LiDAR has a unique MAC address. The source IP is 192.168.1.201 by default, and the destination IP is 255.255.255.255 (broadcast).

Point Cloud Ethernet Header: 42 bytes

Field	Bytes	Description
Ethernet II MAC	12	Destination: broadcast (OxFF: OxFF: OxFF: OxFF: OxFF: OxFF) Source: (xx:xx:xx:xx:xx:xx)
Ethernet Data Packet Type	2	0x08, Ox00
Internet Protocol	20	Shown in the figure below
UDP Port Number	4	UDP source port (0x2710, representing 10000) Destination port (0x0940, representing 2368)
UDP Length	2	0x04F6 when UDP sequence is OFF, representing 1270 bytes (8 bytes more than the size of the Point Cloud UDP Data, shown in Figure 3.1) Ox04FA when UDP sequence is ON, representing 1274 bytes
UDP Checksum	2	Shown in the figure below

```
⊟ Internet Protocol, Src: 192.168.1.201 (192.168.1.201), Dst: 255.255.255.255 (255.255.255.255)
    Version: 4
    Header length: 20 bytes
  ⊞ Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)
    Total Length: 1290
    Identification: 0x8e3d (36413)
  ⊞ Flags: 0x02 (Don't Fragment)
    Fragment offset: 0
    Time to live: 64
    Protocol: UDP (17)
  ⊞ Header checksum: 0xe534 [correct]
    Source: 192.168.1.201 (192.168.1.201)
    Destination: 255.255.255.255 (255.255.255.255)
```

Figure 3.2 Point Cloud Ethernet Header – Internet Protocol

UDP Data

Ranging Data: 1240 bytes (10 blocks)

Block 1	**Block 2**	**Block 3**	**…**	**Block 10**
0xFFEE	0xFFEE	0xFFEE	…	0xFFEE
Azimuth 1	Azimuth 2	Azimuth 3	…	Azimuth 10
Channel 1	Channel 1	Channel 1	…	Channel 1
Channel 2	Channel 2	Channel 2	…	Channel 2
…	…	…	…	…
Channel 40	Channel 40	Channel 40	…	Channel 40

Block size = 2 + size of Azimuth + 40* size of Channel X

Each block in the Ranging Data: 124 bytes			
Field	Bytes	Description	
OxFFEE	2	Header, meaningless, OxFF first	
Azimuth	2	Current reference angle of the rotor Unit: 0.01°	
Channel X	3	2-byte Distance	Distance Value = Distance ‘ 4 mm
		1-byte Reflectivity	Range: 0 to 255 The mapping from this field to target reflectivity can be selected in Section 4.2 (Web Control -Settings)

In Dual Return mode, the measurements from each round of firing are stored in two adjacent blocks:

- The odd number block is the last return, and the even number block is the strongest return
- If the last and strongest returns coincide, the second strongest return will be placed in the even number block
- The Azimuth changes every two blocks

Additional Information: 22/26 bytes when UDP sequence is OFF/ON

Field	Bytes	Description	
Reserved	5	–	
High Temperature Shutdown Flag	1	Ox01 for high temperature; Ox00 for normal operation •When high temperature is detected, the shutdown flag will be set to Ox01, and the system will shut down after 60 s. The flag remains Ox01 during the 60 s and the shutdown period •When the system is no longer in high temperature status, the shutdown flag will be reset to Ox00 and the system will automatically return to normal operation	
Reserved	2	–	
Motor Speed	2	Unit: RPM	
Timestamp	4	The “vs time” part of the absolute time of this data packet (defined in Appendix II), in units of 1 is Range: 0 to 1000000 vs (1 s)	
Return Mode	1	0x37 for Strongest Return mode 0x38 for Last Return mode 0x39 for Dual Return mode	
Factory Information	1	0x42 (or Ox43)	
Date & Time	6	The absolute UTC time of this data packet, accurate to the second.	
		Each Byte	Range (Decimal)
		Year (current year minus 2000)	Positive integers
		Month	1 to 12
		Day	1 to 31
		Hour	0 to 23
		Minute	0 to 59
		Second	0 to 59
UDP Sequence	4	Added only when UDP sequence is ON Label the sequence number of Point Cloud UDP packets 0 to 0xFF FF FF FF	

Point Cloud Data Analysis
The analysis of point cloud UDP data consists of three steps.

Analyze the vertical angle, horizontal angle, and distance of a data point

Take Channel 5 in Block 3 as an example:

1. Vertical angle of Channel 5 is 3.00°, according to Appendix I (Channel Distribution)

   The accurate vertical angle is recorded in this LiDAR’s unit’s angle correction file, see Section 1.3 (Channel Distribution).

- 0° represents the horizontal direction
- Define upward as positive
- The Channel # counts from 1 from the uppermost

2. Horizontal angle = current reference angle of the rotor + horizontal angle offset + firing time angular offset
   - Current reference angle of the rotor is the Azimuth field of Block 2
   - Horizontal angle offset: -1.042° for Channel 5, according to Appendix I (Channel Distribution)

   The accurate horizontal angle offset is recorded in this LiDAR's unit's angle correction file, see Section 1.3 (Channel Distribution).

   Firing time angular offset = Firing Time Offset of Channel 5 (see Appendix II) * Spin Rate of the Motor (see Section 4.1 Web Control – Home)
   - Define clockwise in the top view as positive
3. Actual distance in real world millimeters = distance measurement * Distance Unit (4 mm)

   Distance measurement is the Distance field of Channel 5 in Block 3

(Continued on the next page)

Draw the data point in a spherical or rectangular coordinate system
Obtain the real-time point cloud data by analyzing and drawing every data point in a frame

GPS Data Packet

GPS Data Packets are triggered every second.

Before NMEA messages are available from the external GPS module
Each rising edge of the LiDAR's internal 1 Hz signal triggers a GPS Data Packet. The time and date in the GPS Data Packets are unreal, starting from the UTC time 00 01 01 00 00 00 (year, month, day, hour, minute, second) and increasing with the internal 1 Hz signal.

Once the LiDAR receives the PPS (pulse-per-second) signal and NMEA messages
The internal 1 Hz signal will be locked to the PPS. Each rising edge still triggers a GPS Data Packet. Meanwhile, the LiDAR will extract the actual date and time from NMEA messages ($GPRMC or $GPGGA), and stamp them into both Point Cloud Data Packets and GPS Data Packets.

- Point Cloud Data Packets: 6-byte Date & Time (year, month, day, hour, minute, second)
- GPS Data Packets: 6-byte Date (year, month, day) and 6-byte Time (second, minute, hour)

The GPS module sends first the PPS signal and then the NMEA message. At the rising edge of the PPS pulse, the corresponding NMEA message is not yet available. Therefore, the LiDAR extracts date and time from the previous NMEA message and automatically adds 1 full second.

When GPS signal is lost
The LiDAR will still trigger GPS Data Packets by the rising edge of the internal 1 Hz signal. However, the GPS time in the packets will be counted by the internal 1 Hz signal and will drift from the actual GPS time.

Ethernet Header
The source IP is 192.168.1.201 by default. The destination IP address is 255.255.255.255 and in broadcast form.

GPS Ethernet Header:42 bytes		
Field	**Bytes**	**Description**
Ethernet II MAC	12	Destination: broadcast (OxFF: OxFF: OxFF: OxFF: OxFF: OxFF) Source: (xx: xx:xx:xx:xx:xx)
Ethernet Data Packet Type	2	Ox08, Ox00
Internet Protocol	20	Shown in the figure below
UDP Port Number	4	UDP source port (0x2710, represents 10000) Destination port (0x277E, represents 10110)
UDP Length	2	0x208, representing 520 bytes (8 bytes more than the size of the GPS UDP D ata, shown in Figure 3.1)
UDP Checksum	2	–

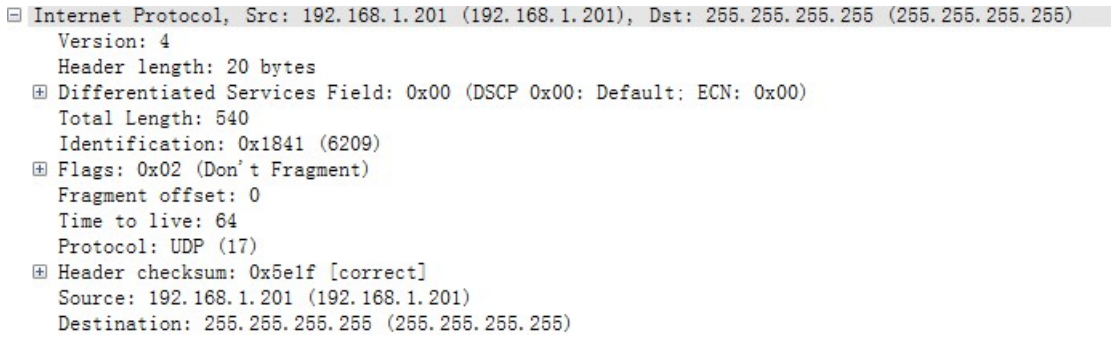


Figure 3.3 GPS Ethernet Header – Internet Protocol

UDP Data

GPS UDP data: 512 bytes				
Field	Bytes	Description		
GPS Time Data	18	Header	2 bytes	OxFFEE (OxFF first)
		Date	6 bytes	Year, month, and day (2 bytes each, lower byte first) in ASC II
		Time	6 bytes	Second, minute, and hour (2 bytes each, lower byte first) in ASCII
		Reserved	4 bytes	–
GPRMC/GPGGA Data	g	NMEA sentence that contains date and time ASCII code, valid till 2 bytes after the asterisk (•) The LiDAR can receive either GPRMC or GPGGA, see Chapter 4 (Web Control – Settings)		
Reserved	404	404 bytes of OxDF		
GPS Positioning Status	1	ASCII code, obtained from $GPRMC or $GPGGA When $GPRMC is selected: When $GPGGA is selected: A (hex = 41) for Active 0 = invalid V (hex = 56) for Void 1= GPS fix (SPS) NUL (hex = 0) for GPS being unlocked 2 = DGPS fix 3 = PPS fix 6 = estimated (dead reckoning)		
PPS Lock Flag	1	1- locked 0 – unlocked		
Reserved	4	–		

GPRMC Data Format
$GPRMC, <01>, <02>, <03>, <04>, <05>, <06>, <07>, <08>, <09>, <10>, <11>, <12>*hh

Field #	**Field**	**Description**
<01>	UTC Time	Hour, minute, and second Typically in hhmmss (hour, minute, second) format
<02>	Location Status	A (hex = 41) for Valid Position V (hex = 56) for Invalid Position NUL (hex = 0) for GPS being unlocked
<09>	UTC Date	Date information Typically in ddmmyy (day, month, year) format
…		

The LiDAR's GPS data interface is compatible with a variety of GPRMC formats, as long as:
<01> is the hour, minute, and second information
<09> is the date information.

For example, the following two formats are both acceptable:
$GPRMC,072242,A,3027.3680,N,11423.6975,E,000.0,316.7,160617,004.1,W*67
$GPRMC,065829.00,A,3121.86377,N,12114.68322,E,0.027,,160617,,,A*74

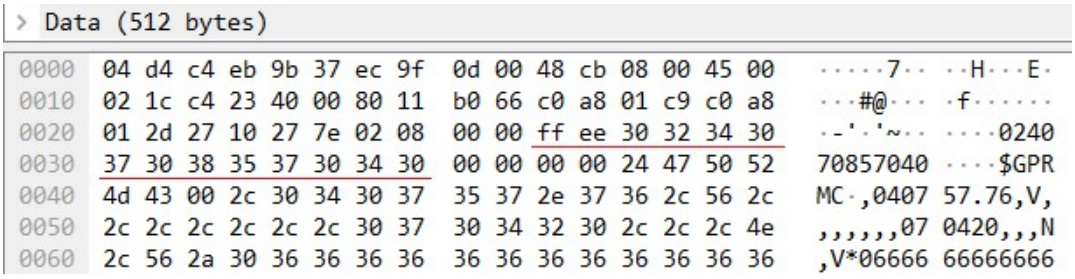
GPGGA Data Format
$GPGGA, <01>, <02>, <03>, <04>, <05>, <06>, <07>, <08>, <09>, <10>, <11>, <12>*hh

Field #	Field	Description
<01>	UTC Time	Hour, minute, and second Typically in hhmmss (hour, minute, second) format
…		
<06>	GPS Fix Quality	0 = invalid 1= GPS fix (SPS) 2 = DGPS fix 3 = PPS fix 6 = estimated (dead reckoning)
…		

The LiDAR's GPS data interface is compatible with a variety of GPGGA formats, as long as:
<01> is the hour, minute, and second information

For example, the following two formats are both acceptable:
$GPGGA,123519,4807.038,N,01131.000,E,1,08,0.9,545.4,M,46.9,M,,*47
$GPGGA,134658.00,5106.9792,N,11402.3003,W,2,09,1.0,1048.47,M,-6.27,M,08,AAAA*60

GPS Data Analysis



Date

Field	Data (ASCII Code)	Characters	Meaning
Year	0x30 0x32		20
Month	0x34 0x30		4
Day	0x37 0x30	'7', '0'	7

Data

Field	Data (ASCII Code)	Characters	Meaning
Second	0x38 0x35		58
Minute	0x37 0x30	‘7’, ‘0’	7
Hour	Ox34 0x30		4

μsTime
4 bytes, in units of s, using the same clock source as the GPS Timestamp in Point Cloud Data Packets Reset to 0 at the rising edge of each PPS signal

Web Control

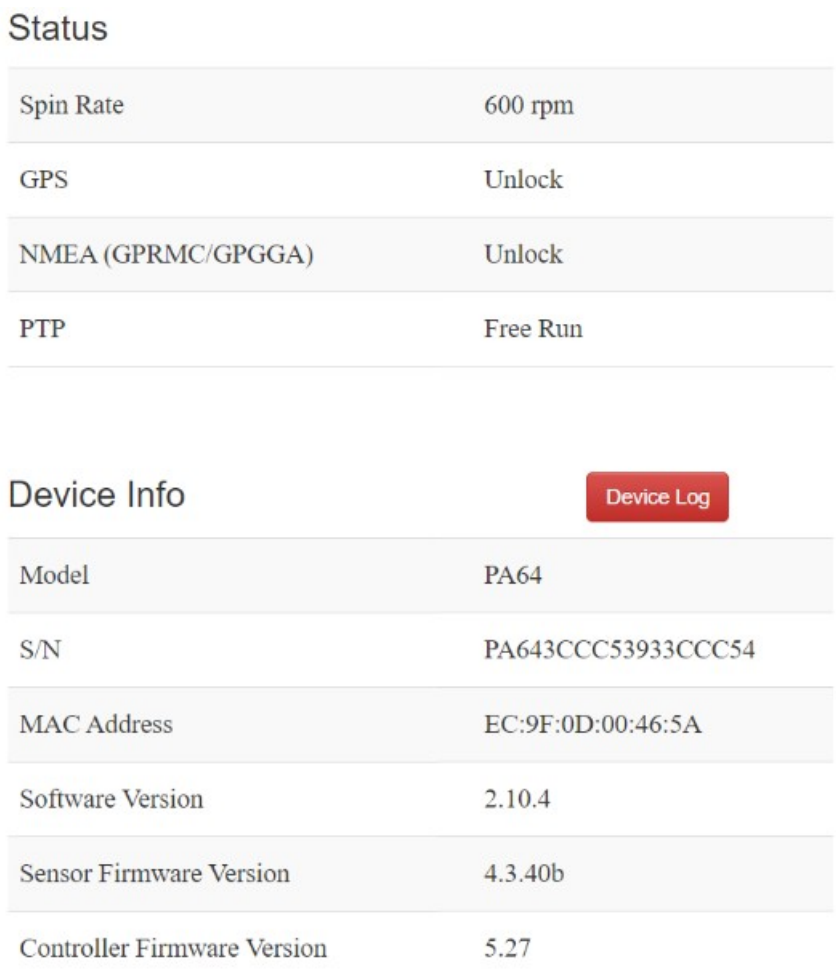
Web control is used for setting parameters, checking device info, and upgrading.

To access web control

1. Connect the LiDAR to your PC using an Ethernet cable
2. Set the IP address according to Section 2.4 (Get Ready to Use)
3. Enter this URL into your web browser: 192.168.1.201

Google Chrome and Mozilla Firefox are recommended.

Home



This screenshot may not display the most current version numbers. See Section 4.5 (Upgrade).

Spin Rate of the motor (revs per minute) = frame rate (Hz) * 60

GPS (PPS) Status

Lock	LiDAR's internal clock is in sync with the GPS
Unlock	Not in sync

NMEA (GPRMC/GPGGA) Status

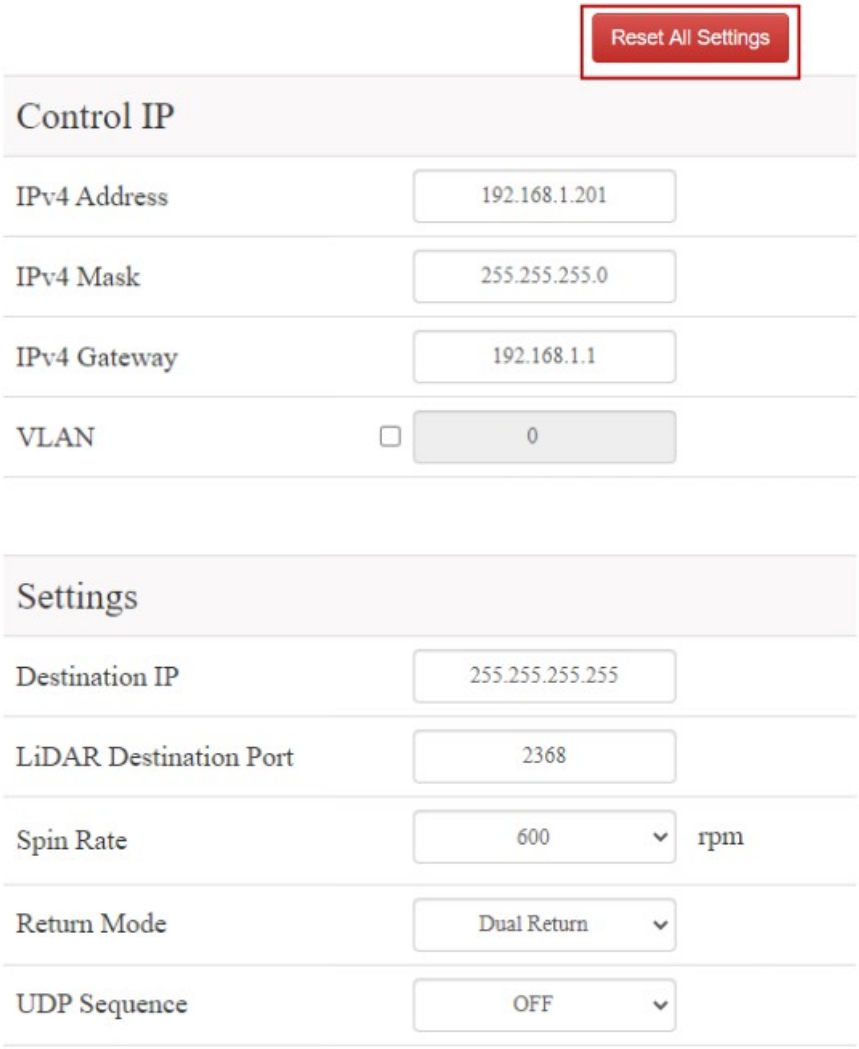
Lock	After receiving a valid NMEA message
Unlock	Not receiving a valid NMEA message in 2 seconds

PTP Status

Free Run	No PTP master is selected
Tracking	Slave is trying to sync with the selected PTP Master, but the absolute offset is over 1 µs
Locked	Absolute offset between Slave and Master is < 1 µs
Frozen (Holdover)	LiDAR has lost connection to the PTP master and is attempting to recover it. Meanwhile, LiDAR starts drifting from the previous clock; when drifting out of specifications, it goes back to the Free Run mode.

Device Log
Click to download a .JSON file containing the LiDAR's status, device info, all configurable parameters, and upgrade log.

Settings

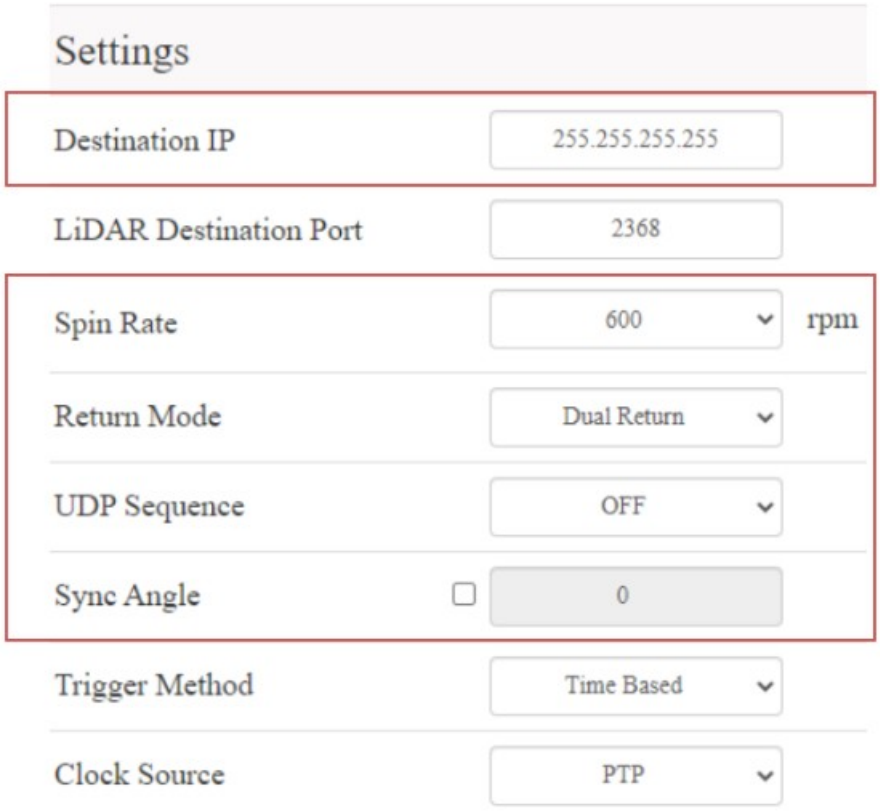


In the Settings page

- Standby Mode: effective immediately
- All other settings: effective after clicking the “Save” button at the bottom

1. Reset All Settings By clicking the “Reset All Settings” button on the top-right corner, all configurable parameters on web control will be reset to factory defaults.
   The default values are shown in the screenshots in
   • Section 4.2 (Settings)
   • Section 4.3.1 (Azimuth FOV – for All Channels)
2. **Control IP**

VLAN Tagging	(VLAN ID) 1 to 4094
	To enable VLAN tagging: • Make sure the receiving host also supports VLAN. • Check the checkbox and input the LiDAR's VLAN ID (same as the receiving host's VLAN ID). Notes • Once configured, the VLAN ID does not change during firmware upgrades. Warnings If the LiDAR's VLAN ID differs from the receiving host's, users will lose access to web con trol. To minimize such risks, the VLAN ID is zero (invalid value) by default. • When checking the checkbox, users will be alerted to input a valid VLAN ID. • When unchecking the checkbox, the VLAN ID will default to zero.



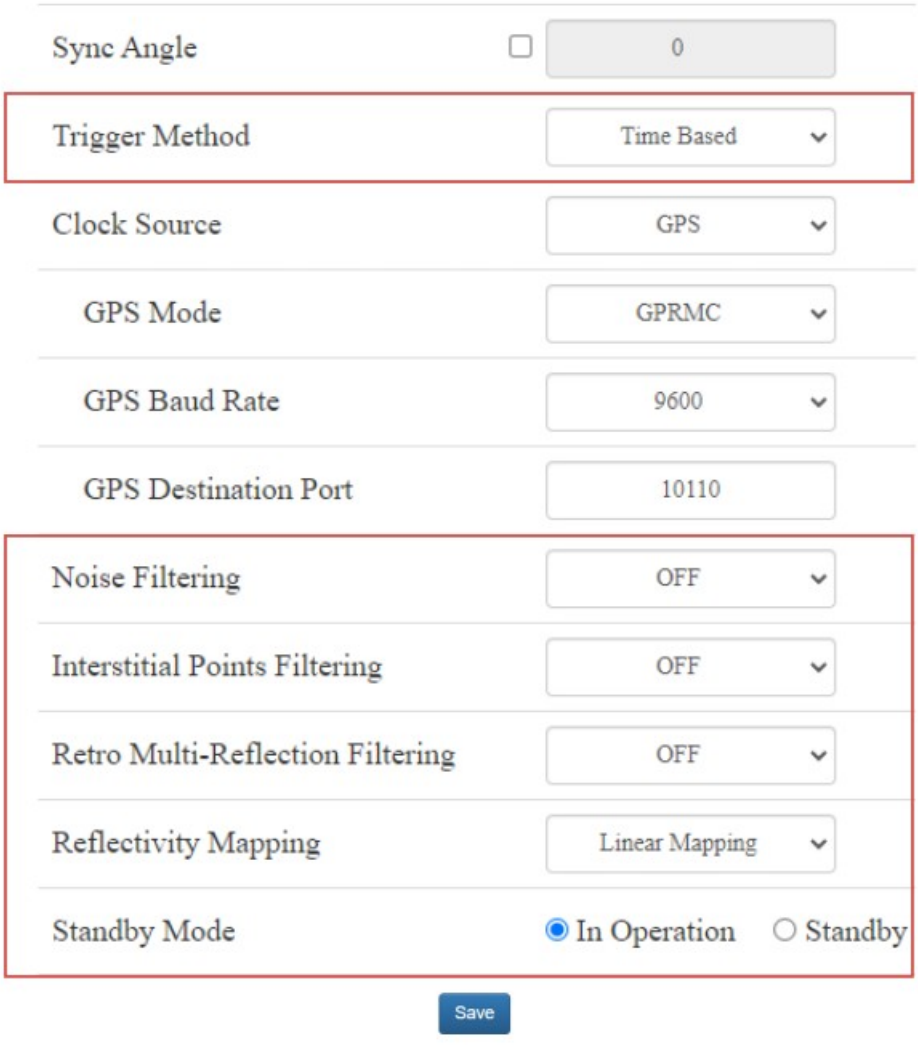
3. **Destination IP**

   Range: except for 0.0.0.0, 127.0.0.1, and the LiDAR's IP

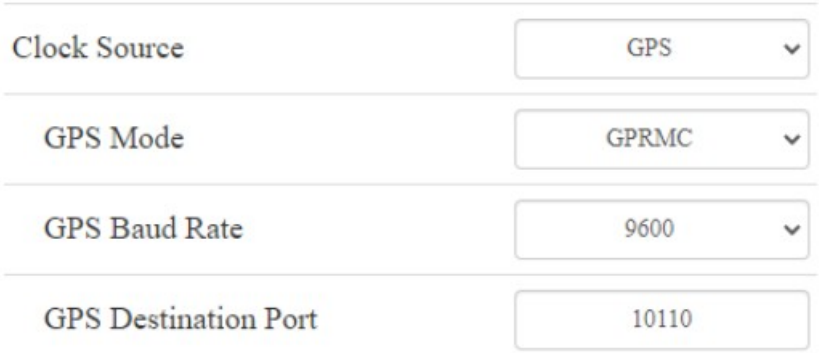
Mode	Destination IP
Broadcast (default)	255.255.255.255
Multicast	User-defined
Unicast	Same as the PC's IP address

4. **LiDAR Functions**

Spin Rate	600 rpm / 1200 rpm
Return Mode	Last / Strongest / Dual Return
UDP Sequence.	OFF / ON #1 / ON #2
	Point Cloud UDP packets can be labeled with a sequence number, see Section 3.1. ON #1: UDP sequence increments only within the user-specified azimuth FOV in Section 4.3. ON #2: Increments at all times.
Sync Angle	0-360 degrees
	By default, the LiDAR's 0° position (see Section 1.2) is not in sync with GPS PPS or the whole second of the PTP clock. If syncing is needed, check the checkbox and input a sync angle.



Trigger Method	Angle-Based / Time-Based
	Angle-based: lasers fire every 0.2° at 10 Hz or 0.4° at 20 Hz. Time-based: lasers fire every 55.56 us.
Noise Filtering	Mitigation of noise points
Interstitial Points Filtering	Interstitial point: when a beam partially hits on a front target's edge and further hits on a rear target, the return signal can result in a false point located betwe en both targets. Such points can be mitigated.
Retro Multi- Reflection Filteri ng	To mitigate the false positive points at twice the distance of a retroflector.
Reflectivity Mapping	Linear/ Nonlinear Mapping
	Linear the 1-byte reflectivity in Point Cloud Data Packets linearly represents t arget reflectivity (0 to 255%). Nonlinear increases the contrast in low-reflectivity region, see the appendix.
Standby Mode	In Operation / Standby
	In Standby mode, the motor stops running and lasers stop firing.

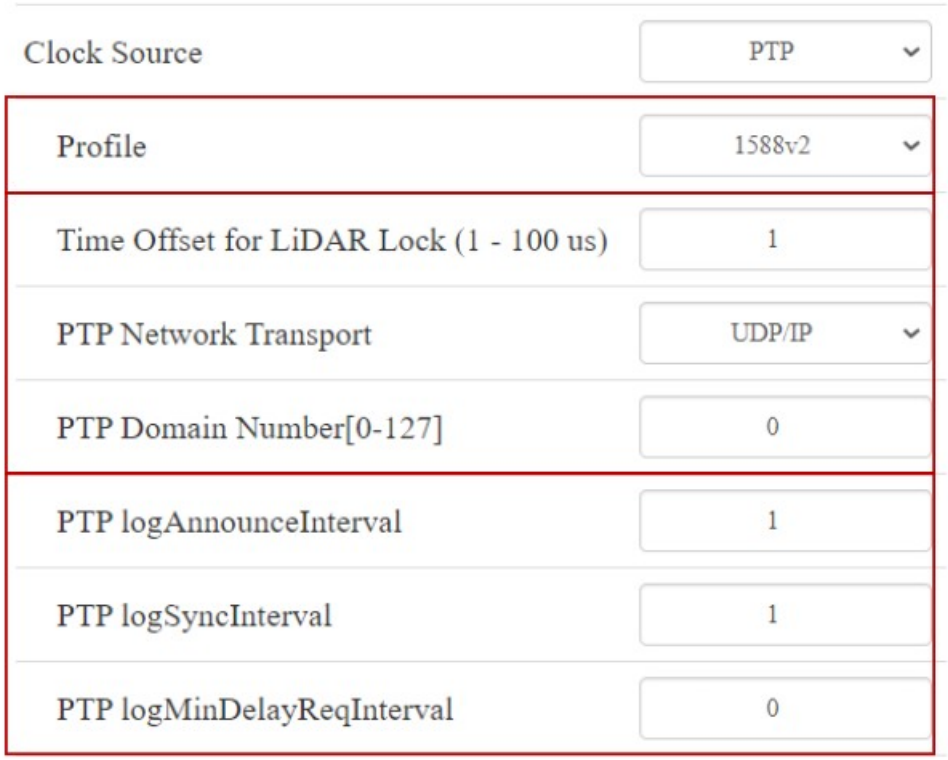


5. **Clock Source and PTP Parameters**

Clock Source	GPS / PTP
	In PTP mode, LiDARs do not output GPS Data Packets (see Appendix III PTP Protocol).

• When GPS is selected as the clock source:

GPS Mode	GPRMC / GPGGA
	Format of the NMEA data received from the external GPS module, see Section 3.2.2 (GPS UDP Data).
GPS Baud Rate	9600/19200/38400/115200
GPS Destination Port	10110 (default)
	Port used for sending GPS Data packets

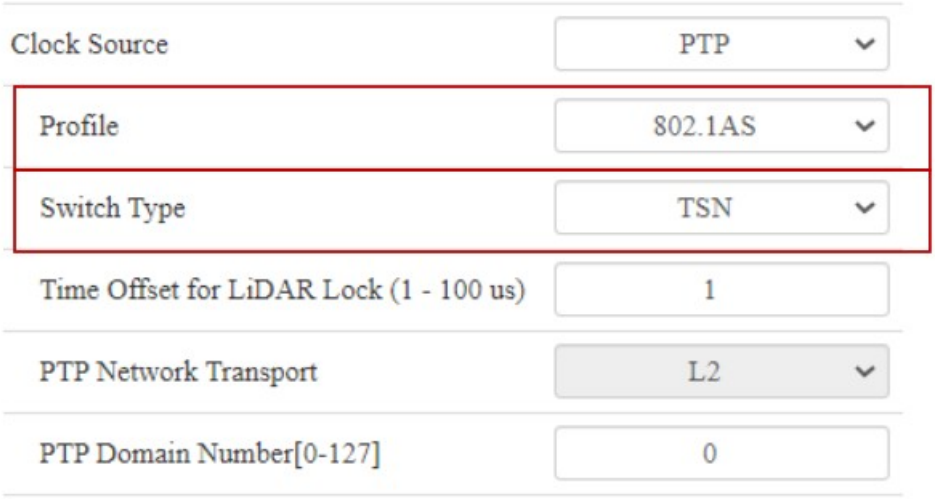


• When PTP is selected as the clock source:

Profile	1588v2 / 802.1AS / 802.1AS Automotive
	IEEE timing and synchronization standard
Time Offset for LiDAR Lock	1 to 100 vs (integer)
	Specify the upper limit of the absolute offset between Slave and Master wh en the LiDAR is in PTP Locked status. See Section 4.1 (Home)
PTP Network Transport	UDP/IP or L2
	UDP/IP: available only for 1588v2 profile L2: available for all profiles
PTP Domain Number	Integer from 0 to 127
	Domain attribute of the local clock

• When using the 1588v2 profile:

PTP logAnnounceIn- terval	-2 to 3 log seconds
	Time interval between Announce messages Default: 1 log second (2 seconds)
PTP logSyncInterva l	-7 to 3 log seconds
	Time interval between Sync messages Default: 1 log second (2 seconds)
PTP logMinDelayReq- Interval	-7 to 3 log seconds
	Minimum permitted mean time between Delay_Req messages Default: 0 log second (1 second)



• When using the 802.1AS or 802.1AS Automotive profile:

Switch Type	TSN / Non-TSN
	TSN (Time Sensitive Network): Peer-toPeer delay mechanism **Non-TSN:** End-to-End delay mechanism

Azimuth FOV

For Azimuth FOV Setting, users can select one of the three modes.

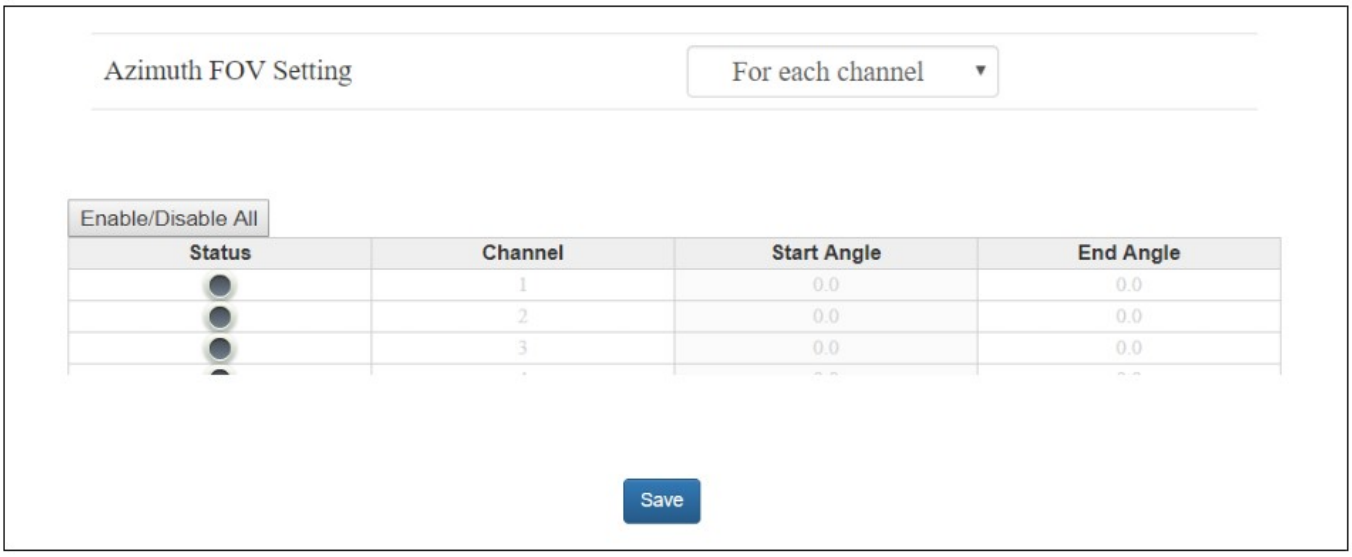
For all channels
A continuous angle range, specified by a Start Angle and an End Angle, will be applied to all channels. The LiDAR outputs valid data only within the specified range.

For each channel

Users can configure one continuous angle range for each channel.
Each channel outputs valid data only within its specified range.

The “Status” button for each channel is gray by default, indicating that the angle range is [0°, 360°].
To activate the angle range configuration for each channel, click the corresponding button to make it green.

Click the “Enable/Disable All” button to activate/deactivate the angle range configuration for all channels.

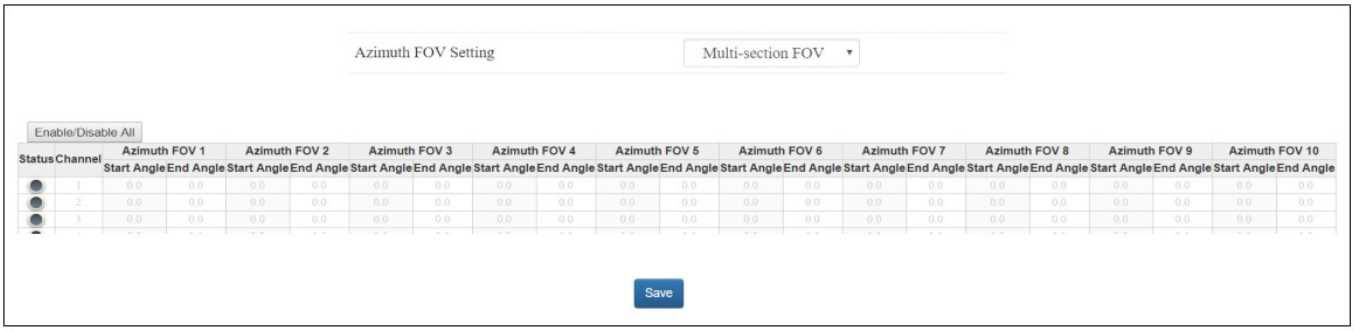


Multi-section FOV

Users can configure up to ten continuous angle ranges (i.e. sections) for each channel.
Each channel outputs valid data only within its specified ranges.

The “Status” button for each channel is gray by default, indicating that the angle range is [0°, 360°].
To activate the angle range configuration for each channel, click the corresponding button to make it green.

Click the “Enable/Disable All” button to activate/deactivate the angle range configuration for all channels.



Note

- Click “Save” to apply your settings.
- The angles in degrees are accurate to the first decimal place.
- If the Start Angle is larger than the End Angle, then the actual azimuth FOV is the union of [Start Angle, 360°] and [0°, End Angle].

For instance, when the angle range is set to be [270°, 90°], the actual azimuth FOV is [270°, 360°][0°, 90°].

Operation Statistics

The LiDAR’s operation time in aggregate and in different temperature ranges are listed, as well as the internal temperature.

Start-Up Counts	663
Internal Temperature	55.02°C
System Uptime	0 h 2 min
Total Operation Time	78 h 7 min

Internal Temperature	Operation Time
< -40 °C	0 h 0 min
-40 to -20 °C	0 h 0 min
-20 to 0 °C	0 h 44 min
0 to 20 °C	3 h 17 min
20 to 40 °C	10 h 18 min
40 to 60 °C	58 h 27 min
60 to 80 °C	4 h 29 min
80 to 100 °C	0 h 52 min
100 to 120 °C	0 h 0 min
>120 °C	0 h 0 min

Upgrade

The software and firmware versions described in this manual are shown in the picture below. During the upgrade, it is recommended to place a protective leather cover (supplied with the LiDAR) or other opaque material over the LiDAR’s cover lens. Click the “Upload” button, select an upgrade file (provided by Hesai), and confirm your choice in the pop-up window.
When the upgrade is complete, the LiDAR will automatically reboot, and the past versions will be logged

in the Upgrade Log.

A software reboot is triggered by clicking the “Restart” button on the top right corner.
Afterwards, the start-up counts in the Operation Statistics page increments by 1.

Software and Controller Firmware
When upgrading, power supply must remain on.

Sensor Firmware
When upgrading, an interruption in the power supply can result in upgrade failure. That is, the Sensor Firmware Version on the Upgrade page becomes “XXXXX” after reboot.
Solution: upgrade Sensor Firmware again, until the Upgrade page displays the correct version number after reboot.

Software upgrade
If the current version is earlier than 2.9.1, please first upgrade to 2.9.1, and then upgrade to higher versions.

Software downgrade
If the current version is between 2.9.6 and 2.10.4, and the system needs to downgrade to a version earlier than 2.7.x, please reset all settings (click the “Reset All Settings” button on the top-right corner of the Settings page) before performing the downgrade.

Communication Protocol

To receive Hesai LiDAR’s PTC (Pandar TCP Commands) and HTTP API Protocols, please contact Hesai technical support.

Sensor Maintenance

Cleaning
Stains on the product’s cover lens, such as dirt, fingerprints, and oil, can negatively affect point cloud data quality. Please perform the following steps to remove the stains.

Warnings

- Turn OFF the power source before cleaning.
- To avoid damaging the optical coating, do NOT apply pressure when wiping the cover lens.

Notes

- Only clean the stained area of the cover lens.
- Check before using a lint-free wipe. If the wipe is stained, use another.

1. Thoroughly wash your hands or wear a pair of powder-free PVC gloves.
2. To remove dust, blow dry air onto the cover lens, or use a piece of lint-free wipe to lightly brush across the dusty area. To remove persistent stains, move on to the next step.
3. Spray the cover lens with warm, neutral solvent using a spray bottle.

Solvent type	99% isopropyl alcohol (IPA) or 99% ethanol (absolute alcohol) or distilled water When using IPA or alcohol, please ensure adequate ventilation and keep away from fire.
Solvent temperature	20 to 25℃

4. When the stains have loosened, dip a piece of lint-free wipe into the solvent made in Step 3, and gently wipe the cover lens back and forth along its curved surface.
5. Should another cleaning agent be applied to remove certain stains, repeat Steps 3 and 4.
6. Spray the cover lens with clean water, and gently wipe off the remaining liquid with another piece of lint-free wipe.

Troubleshooting

In case the following procedures cannot solve the problem, please contact Hesai technical support.

Symptoms	**Points to Check**

Indicator light is off on the connection box	Verify that • power adapter is properly connected and in good condition • connection box is intact • input voltage and current satisfy the requirements in Section 2.3 (Connection Box) Po wer on again to check if the symptom persists.
Motor is not running	Verify that • power adapter is properly connected and in good condition • if a connection box is used, the connection box is intact • input voltage and current satisfy the requirements in Section 1.4 (Specifications) and 2.3 (Connection Box) • web control can be accessed (see “cannot open web control” on the next page) Powe r on again to check if the symptom persists.
Motor is running but n o output data is receiv ed, neither on Wiresh ark nor on Pa ndarVie w	Verify that • Ethernet cable is properly connected (by unplugging and plugging again) • LiDAR’s Destination IP is correctly set on the Settings page of web control • horizontal FOV is properly set on the Azimuth FOV page of web control • firmware version of the sensor is correctly shown on the Upgrade page of web control • LiDAR is emitting laser light. This can be checked by using an infrared camera, an infr ared sensor card, or a phone camera without infrared filter Power on again to check if t he symptom persists.
Can receive data on Wireshark but not on PandarView	Verify that • LiDAR Destination Port is correctly set on the Settings page of web control • PC’s firewall is disabled, or that PandarView is added to the firewall exceptions • the latest PandarView version (see the Download page of Hesai’s official website) is i nstalled on the PC Power on again to check if the symptom persists.
Cannot open web con trol	Verify that • Ethernet cable is properly connected (by unplugging and plugging again) • LiDAR’s IP is in the same subnet with the PC’s. Users may use WireShark to check t he LiDAR’s IP that broadcasts data packets Afterwards, • restart PC, or connect the LiDAR to another PC • power on again to check if the symptom persists

Abnormal packet size (missing packets)	Verify that • horizontal FOV is properly set on the Azimuth FOV page of web control • motor's spin rate is steady on the Home page of web control • LiDAR's internal temperature is between -20°C and 95°C on the Operation Statistics page of web control • Ethernet is not overloaded • no switch is connected into the network. The data transmitted from other devices may cause network congestion and packet loss Afterwards, • connect the PC only to the LiDAR and check for packet loss • power on again to check if the symptom persists
Abnormal point cloud (obviously misaligned points, flashing points, or incomplete FOV)	Verify that • LiDAR's cover lens is clean. If not, refer to Chapter 6 (Sensor Maintenance) for the cl eaning method • LiDAR's calibration file is imported, see PandarView User Manual (Use) • horizontal FOV is properly set on the Azimuth FOV page of web control • motor's spin rate is steady on the Home page of web control • LiDAR's internal temperature is between -20°C and 95°C on the Operation Statistics page of web control Afterwards, check for packet loss • If no packet is missing while the point cloud flashes, please update PandarView to the latest version (see the Download page of Hesai's official website) and restart the PC If the point cloud is still abnormal • Try connecting the LiDAR to another PC • Power on again to check if the symptom persists
GPS cannot be locked	Verify that • GPS receiver is properly connected • PPS signal is connected to the LiDAR • Destination GPS Port is correct on the Settings page of web control • input GPS signals satisfy the electrical requirements in Section 2.2 (Interface) and Se ction 2.3.1 (Connection Box) Power on again to check if the symptom persists

Appendix I Channel Distribution

The Horizontal Angle (Azimuth) Offsets and Vertical Angles (Elevation) in the table next page are design values. The accurate values are in this LiDAR's unit's angle correction file, see Section 1.3 (Channel Distribution) and Section 3.1.3 (Point Cloud Data Analysis).

Channel Distribution (To Be Continued)

Channel # in UDP Data	Horizontal Angle Offset (Azimuth)	Vertical Angle (Elevation)	Instrument Range (in meters)	Range (in meters) with Reflectivity
01 (Top Beam)	-1.042°	15.00°	130	200@20%
2	-1.042°	11.00′	130	200@20%
3	-1.042°	8.00°	130	200@20%
4	-1.042°	5.00°	130	200@20%
5	-1.042°	3.00°	230	200@20%
6	-1.042°	2.00°	230	200@20%
7	3.125°	1.67°	230	200@20%
8	-5.208°	1.33°	230	200@20%
9	-1.042°	1.00°	230	200@10%
10	3.125°	0.67°	230	200@10%
11	-5.208°	0.33°	230	200@10%
12 (Horizontal Beam)	-1.042°	0.00°	230	200@10%
13	3.125°	-0.33°	230	200@10%
14	-5.208°	-0.6T	230	200@10%
15	-1.042°	-1.00°	230	200@10%
16	3.125°	-1.33°	230	200@10%
17	-5.208°	-1.67°	230	200@10%
18	-1.042°	-2.00°	230	200@10%
19	3.125°	-2.33°	230	200@20%
20	-5.208°	-2.67°	230	200@20%
21	-1.042°	-3.00°	230	200@20%
22	3.125°	-3.33°	230	200@20%
23	-5.208°	-3.67°	230	200@20%
24	-1.042°	-4.00°	230	200@20%
25	3.125°	-4.33°	230	200@20%
26	-5.208°	-4.67°	230	200@20%
27	-1.042°	-5.00°	130	200@20%
28	3.125°	-5.33°	130	200@20%
29	-5.208°	-5.67°	130	200@20%
30	-1.042°	-6.00°	130	200@20%

31	-1.042°	-7.00°	130	200@20%
32	-1.042°	-8.00°	130	200@20%
33	-1.042°	-9.00°	130	200@20%
34	-1.042°	-10.00°	130	200@20%
35	-1.042°	-11.00°	130	200@20%
36	-1.042°	-12.00°	130	200@20%
37	-1.042°	-13.00°	130	200@20%
38	-1.042°	-14.00°	130	200@20%
39	-1.042°	-19.00°	130	200@20%
40 (Bottom Beam)	-1.042°	-25.00°	130	200@20%

Appendix II Absolute Time and Laser Firing Time

Absolute Time of Point Cloud Data Packets
The absolute time of a Point Cloud Data Packet is the sum of date, time (accurate to the second) and s time.

- Date and Time can be retrieved either from the current Point Cloud Data Packet (6 bytes of Date & Time), or from the previous GPS Data Packet (6 bytes of Date and 6 bytes of Time).
- μs time can be retrieved from the current Point Cloud Data Packet (4 bytes of Timestamp)

 When using a PTP clock source, the LiDAR does not output GPS Data Packets.

End Time of Each
Block The Body of each Point Cloud Data Packet contains 10 data blocks, as detailed in Section 3.1.2 (Point Cloud UDP Data).

Every time the LiDAR sends a command to trigger a round of firing, the measurements are:

- stored in one block in Single Return mode
- stored in two adjacent blocks in Dual Return mode

If the absolute time of a Point Cloud Data Packet is t0, the end time of each block (the time when all the lasers finish firing) can be calculated.

Single Return Mode	Block	End Time (μs)		Dual Return Mode	Block	End Time (μs)
	Block 10	t0 – 28.58			Block 10 & Block 9	t0 – 28.58
	Block N	t0 – 28.58 – 55.56 * (10 – N)			Block 8 & Block 7	t0 – 28.58 – 55.56 * 1
	Block 3	t0 – 28.58 – 55.56 * 7			Block 6 & Block 5	t0 – 28.58 – 55.56 * 2
	Block 2	t0 – 28.58 – 55.56 * 8			Block 4 & Block 3	t0 – 28.58 – 55.56 * 3
	Block 1	t0 – 28.58 – 55.56 * 9			Block 2 & Block 1	t0 – 28.58 – 55.56 * 4

Firing Time Offset of Each Channel

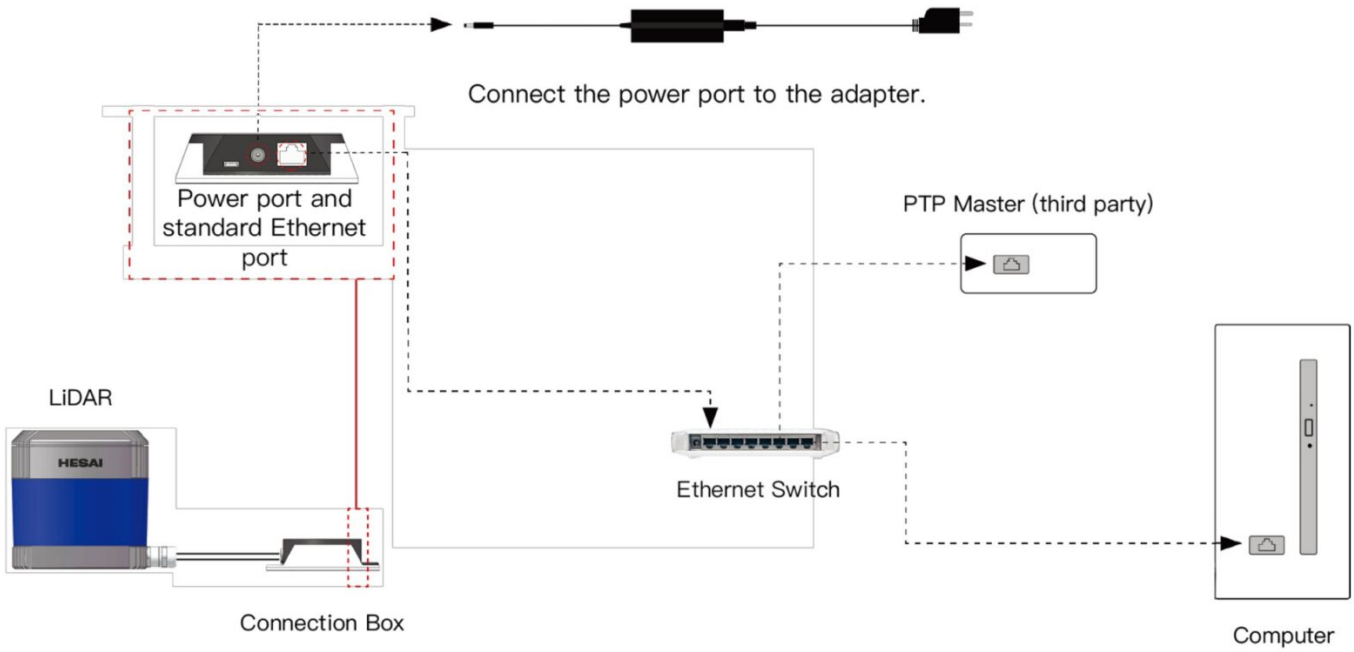
Assume that the start time of Block m is T(m), m {1, 2, …, 10}, then the laser firing time of Channel n in Block m is t(m, n) = T(m) + t(n), n {1, 2, …, 40}. The lookup table of the firing time offsets t(n) is shown below.

Firing Sequence	Channel #	At(n) (us)	Firing Sequence	Channel #	At(n) (ps)
1	8	-54.67	17	14	-27.16
2	20	-52.7	18	26	-25.19
3	15	-50.73	19	21	-23.89
4	27	-48.76	20	31	-21.92
5	7	-47.46	21	13	-20.62
6	19	-45.49	21	9	-20.62
6	5	-45.49	22	25	-18.65
7	33	-43.52	23	35	-17.35
8	37	-42.22	24	39	-16.04
8	1	-42.22	24	3	-16.04
9	11	-40.91	25	17	-14.74
10	23	-38.95	26	29	-12.77
11	18	-36.98	27	24	-11.47
12	30	-35.01	28	32	-9.5
13	10	-33.71	29	16	-8.19
14	22	-31.74	29	12	-8.19
14	6	-31.74	30	28	-6.23
15	34	-29.77	31	36	-4.92
16	38	-28.47	32	40	-3.62
16	2	-28.47	32	4	-3.62

Appendix III PTP Protocol

The Precision Time Protocol (PTP) is used to synchronize clocks across a computer network. It can achieve sub-microsecond clock accuracy.

LiDAR Connection When Using PTP



Absolute Packing Time When Using PTP

To use PTP as the clock source, connect a third-party PTP master device to get the absolute time.

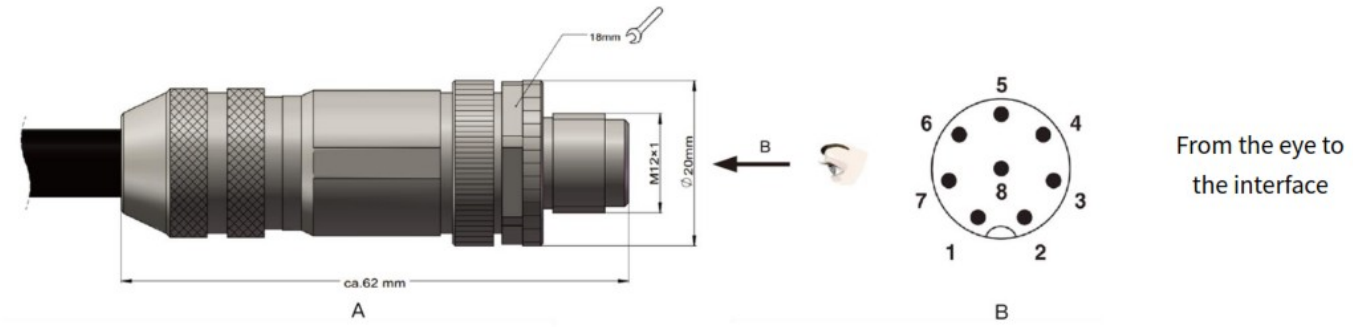
Notes

- PTP master is a third-party device and is not included with the LiDAR.
- The LiDAR works as a PTP slave device and the PTP protocol is Plug&Play.
- When using a PTP clock source, the LiDAR does not output GPS Data Packets.
- The timestamps and Date & Time fields in Point Cloud Data Packets strictly follow the PTP master device. Certain PTP master devices may have a specified offset from the Date & Time output by the LiDAR. Please verify the configuration and calibration of your PTP master device.
- If a PTP clock source is selected but no PTP master device is available, the LiDAR will count the time from an invalid past time. If a PTP clock source is supplied and later stopped, the LiDAR will continue to count the time with an internal clock.

Appendix IV Phoenix Contact

Phoenix Contact can be used as the LiDAR's communication connector, in place of the default Lemo Contact in Section 2.2 (Interfaces).
Phoenix part number:

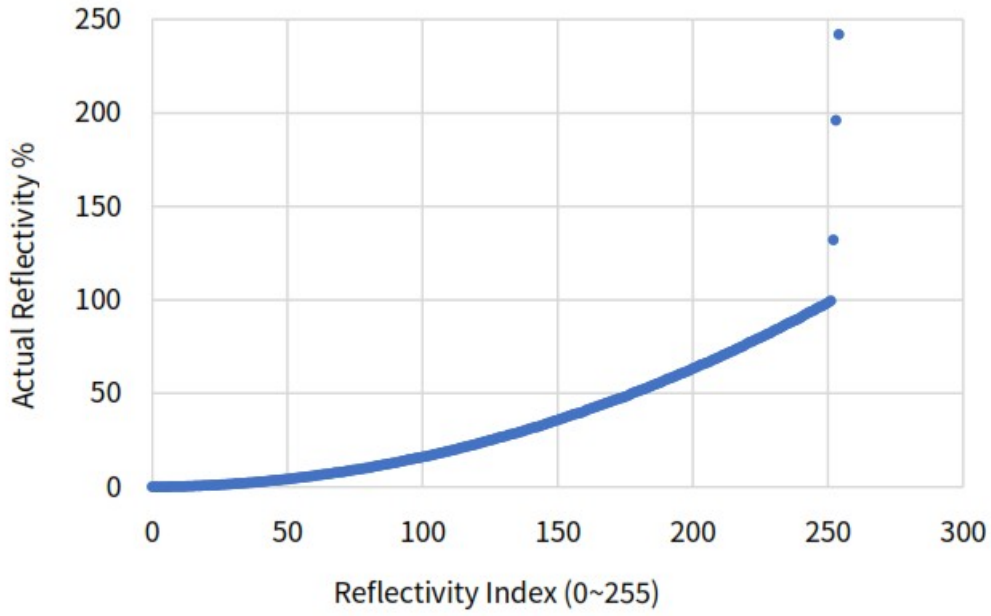
SACC-M12MS-8CON-PG 9-SH – 1511857 (male, on the LiDAR) SACC-M12FS-8CON-PG 9-SH – 1511860 (female, on the connecting box)



Pin #	Signal	Color	Voltage
1	Ethernet RX-	Blue	-1 V to 1 V
2	Ethernet RX+	Light Blue (Blue/White)	-1 V to 1 V
3	Ethernet TX-	Orange	-1 V to 1 V
4	Ethernet TX+	Light Orange (Orange/White)	-1 V to 1 V
5	GPS Serial Data	White	-13 V to +13 V
6	GPS PPS	Yellow	3.3 V/5 V
7	+12 V	Red	12 V
8	Ground (Return)	Black	–

Appendix V Nonlinear Reflectivity Mapping

By default, the 1-byte reflectivity data in Point Cloud Data Packets linearly represents target reflectivity from 0 to 255%.
Alternatively, users may choose the Nonlinear Mapping mode, see Chapter 4 (Web Control – Settings).
The nonlinear relationship is detailed below.



Nonlinear Reflectivity Mapping (Continued on the Next Page)

Reflectivity Index (0-255)	Reflectivity (%)	Reflectivity Index (0-255)	Reflectivity (0/0)	Reflectivity Index (0-255)	Reflectivity (%)	Reflectivity Index (0-255)	Reflectivity (%)
0	0	20	0.67	40	2.69	60	5.9
1	0.01	21	0.75	41	2.81	61	6.1
2	0.02	22	0.81	42	2.94	62	6.3
3	0.03	23	0.87	43	3.07	63	6.5
4	0.04	24	0.95	44	3.21	64	6.7
5	0.05	25	1.05	45	3.36	65	6.9
6	0.08	26	1.15	46	3.5	66	7.1
7	0.11	27	1.25	47	3.64	67	7.3
8	0.13	28	1.35	48	3.79	68	7.5
9	0.15	29	1.45	49	3.93	69	7.7
10	0.19	30	1.55	50	4.08	70	7.9
11	0.23	31	1.65	51	4.25	71	8.12
12	0.26	32	1.75	52	4.42	72	8.37
13	0.29	33	1.85	53	4.58	73	8.62
14	0.34	34	1.95	54	4.75	74	8.87
15	0.39	35	2.06	55	4.92	75	9.1
16	0.44	36	2.19	56	5.1	76	9.3
17	0.5	37	2.31	57	5.3	77	9.5
18	0.56	38	2.44	58	5.5	78	9.7
19	0.61	39	2.56	59	5.7	79	9.9
80	10.17	100	15.87	120	22.83	140	31.17
81	10.5	101	16.17	121	23.25	141	31.5
82	10.83	102	16.5	122	23.75	142	31.83
83	11.12	103	16.83	123	24.17	143	32.25
84	11.37	104	17.17	124	24.5	144	32.75
85	11.62	105	17.5	125	24.83	145	33.25
86	11.87	106	17.83	126	25.25	146	33.75
87	12.12	107	18.17	127	25.75	147	34.25

88	12.37	108	18.5	128	26.17	148	34.75
89	12.62	109	18.83	129	26.5	149	35.25
90	12.87	110	19.17	130	26.83	150	35.75
91	13.17	111	19.5	131	27.25	151	36.25
92	13.5	112	19.83	132	27.75	152	36.75
93	13.83	113	20.25	133	28.17	153	37.25
94	14.17	114	20.75	134	28.5	154	37.75
95	14.5	115	21.17	135	28.83	155	38.25
96	14.83	116	21.5	136	29.25	156	38.75
97	15.12	117	21.83	137	29.75	157	39.17
98	15.37	118	22.17	138	30.25	158	39.5
99	15.62	119	22.5	139	30.75	159	39.83
160	40.5	180	51.25	200	63.25	220	76.5
161	41.25	181	51.75	201	63.75	221	77.25
162	41.75	182	52.25	202	64.5	222	77.75
163	42.25	183	52.75	203	65.25	223	78.5
164	42.75	184	53.5	204	65.75	224	79.25
165	43.25	185	54.25	205	66.25	225	79.75
166	43.75	186	54.75	206	66.75	226	80.5
167	44.25	187	55.25	207	67.5	227	81.25
168	44.75	188	55.75	208	68.25	228	81.75
169	45.25	189	56.5	209	68.75	229	82.5
170	45.75	190	57.25	210	69.5	230	83.5
171	46.25	191	57.75	211	70.25	231	84.25
172	46.75	192	58.25	212	70.75	232	84.75
173	47.25	193	58.75	213	71.5	233	85.5
174	47.75	194	59.5	214	72.25	234	86.5
175	48.25	195	60.25	215	72.75	235	87.25
176	48.75	196	60.75	216	73.5	236	87.75

177	49.5	197	61.25	217	74.25	237	88.5
178	50.25	198	61.75	218	74.75	238	89.25
179	50.75	199	62.5	219	75.5	239	89.75

240	90.5
241	91.5
242	92.5
243	93.25
244	93.75
245	94.5
246	95.5
247	96.25
248	96.75
249	97.5
250	98.5
251	99.5
252	132
253	196
254	242

Appendix VI Legal Notice

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http://weixin.qq.com/r/Fzns9IXEl9jorcGX92wF

Documents / Resources

	HESAI Pandar40P 40 Channel Mechanical LiDAR [pdf] User Manual Pandar40P 40 Channel Mechanical LiDAR, Pandar40P, Pandar40P Mechanical LiDAR, 40 Channel Mechanical LiDAR, Mechanical LiDAR, 40 Channel LiDAR, Pandar40P LiDAR, LiDAR

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