HESAI

PandarQT

64-Channel Short-Range Mechanical LiDAR User Manual

Website

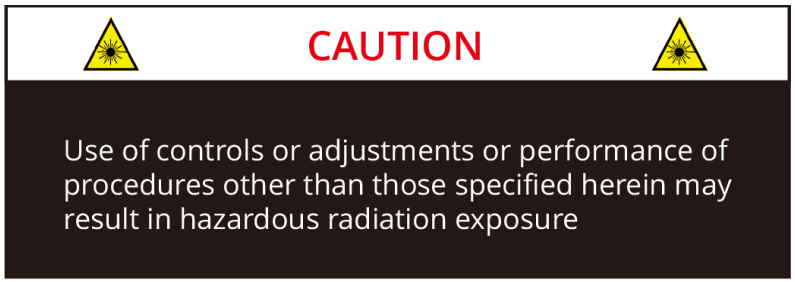
Contents

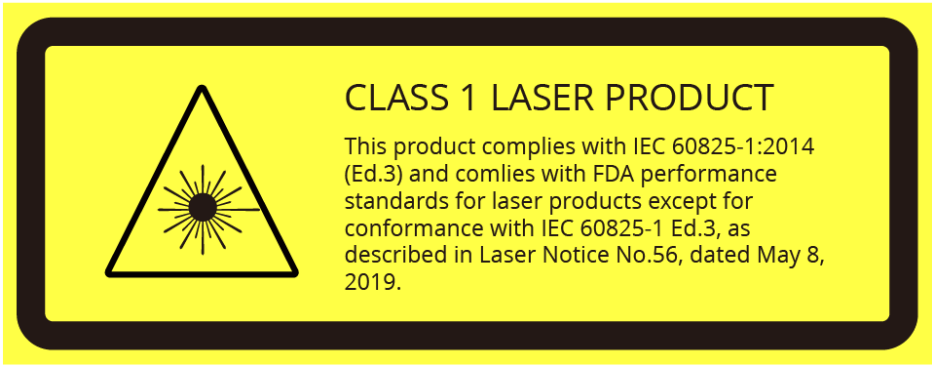
Safety Notice

PLEASE READ AND FOLLOW ALL INSTRUCTIONS CAREFULLY AND CONSULT ALL RELEVANT NATIONAL AND INTERNATIONAL SAFETY REGULATIONS FOR YOUR APPLICATION.

■ Caution

To avoid violating the warranty and to minimize the chances of getting electrically shocked, please do not disassemble the product. The product must not be tampered with and must not be changed in any way. There are no user-serviceable parts inside the product. For repairs and maintenance inquiries, please contact an authorized Hesai Technology service provider.





■ Laser Safety Notice - Laser Class 1

This device 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

NEVER LOOK INTO THE TRANSMITTING LASER THROUGH A MAGNIFYING DEVICE (MICROSCOPE, EYE LOUPE, MAGNIFYING GLASS, ETC.)

■ Safety Precautions

In all circumstances, if you suspect that the product malfunctions or is damaged, stop using it immediately to avoid potential hazards and injuries. Contact an authorized Hesai Technology service provider for more information on product disposal.

Handling

This product contains metal, glass, plastic, as well as sensitive electronic components. Improper handling such as dropping, burning, piercing, and squeezing may cause damage to the product.
In case the product is dropped, STOP using the product immediately and contact Hesai technical support.

Cover Lens

This product contains high-speed rotating parts. To avoid potential injuries, DO NOT operate the product if the cover lens is loose or damaged. To ensure optimal performance, do not touch the product's cover lens with bare hands. If the cover lens is already stained, please refer to the cleaning method in the Sensor Maintenance chapter of user manuals.

Eye Safety

Although the product meets Class 1 eye safety standards, DO NOT look into the transmitting laser through a magnifying product (microscope, eye loupe, magnifying glass, etc.). For maximum self-protection, avoid looking directly at the product when it is in operation.

Repair

DO NOT open and repair the product without direct guidance from Hesai Technology. Disassembling the product may cause degraded performance, failure in water resistance, or potential injuries to the operator.

Power Supply

Use only the cables and power adapters provided by Hesai Technology. Using off-spec or damaged cables or adapters, or supplying power in a humid environment can result in fire, electric shock, personal injuries, product damage, or property loss.

Hot Surface

During or after a period of operation, DO NOT touch the product's cover lens with your skin. Such direct contact with the hot surface can result in discomfort or even burns. If you incorporate this LiDAR product into your product(s), you should also communicate the hot surface risks to the intended users of your product(s).

Vibration

Strong vibration may cause damage to the product and should be avoided. If you need the mechanical vibration and shock limits of this product, please contact Hesai technical support.

Radio Frequency Interference

Please observe the signs and notices on the product that prohibit or restrict the use of electronic devices. Although the product is designed, tested, and manufactured to comply with the regulations on RF radiation, the radiation from the product may still influence electronic devices.

Medical Device Interference

Some components in the product can emit electromagnetic fields, which may interfere with medical devices such as cochlear implants, heart pacemakers, and defibrillators. Consult your physician and medical device manufacturers for specific information regarding your medical device(s) and whether you need to keep a safe distance from the product. If you suspect that the product is interfering with your medical device, stop using the product immediately.

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. Exposing the product to high concentrations of industrial chemicals, including liquefied gases that are easily vaporized (such as helium), can damage or weaken the product's function. Please observe all the signs and instructions on the product.

Light Interference

Some precision optical instruments may be interfered by the laser light emitted from the product.

1 Introduction

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

This manual is under constant revision. To obtain the latest version, please visit the Download page of Hesai's official website, or contact Hesai technical support.

1.1 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 diffusely 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

1.2 LiDAR Structure

Laser emitters and receivers are attached to a motor that rotates horizontally.

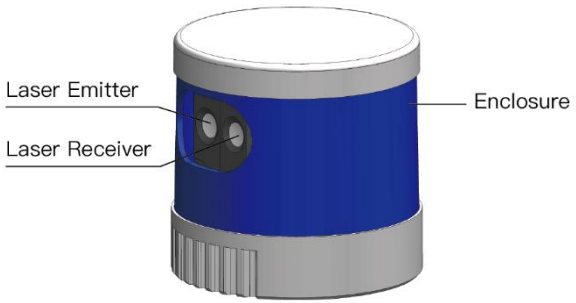


Figure 1.2 Partial Cross-Sectional Diagram

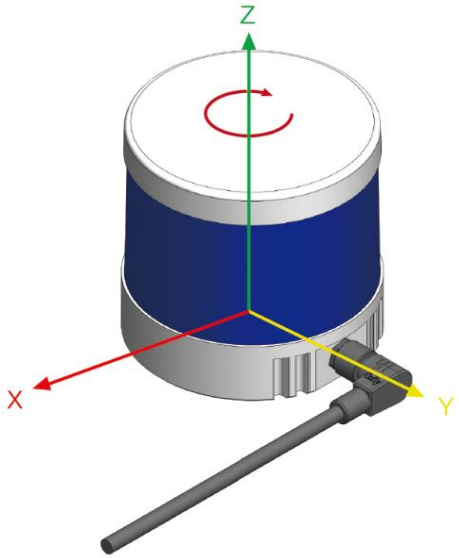


Figure 1.3 Coordinate System (Isometric View)

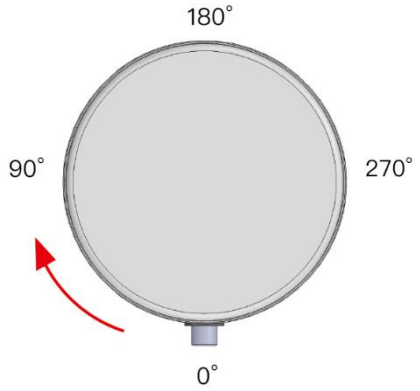


Figure 1.4 Default Rotation Direction (Top View)

The LiDAR's coordinate system is illustrated in Figure 1.3. Z-axis is the axis of rotation.
By default, the LiDAR rotates clockwise in the top view. To select counterclockwise rotation, see Section 4.2 (Web Control - Settings).

The origin is shown as a red dot in Figure 1.6 on the next page. All measurements are relative to the origin.

When the horizontal center of the emitter-receiver array passes the zero-degree position in Figure 1.4, the azimuth data in the corresponding UDP data block will be 0°.

1.3 Channel Distribution

The vertical resolution is unevenly distributed across all channels, as illustrated in Figure 1.5 and detailed in Appendix I (Channel Distribution).

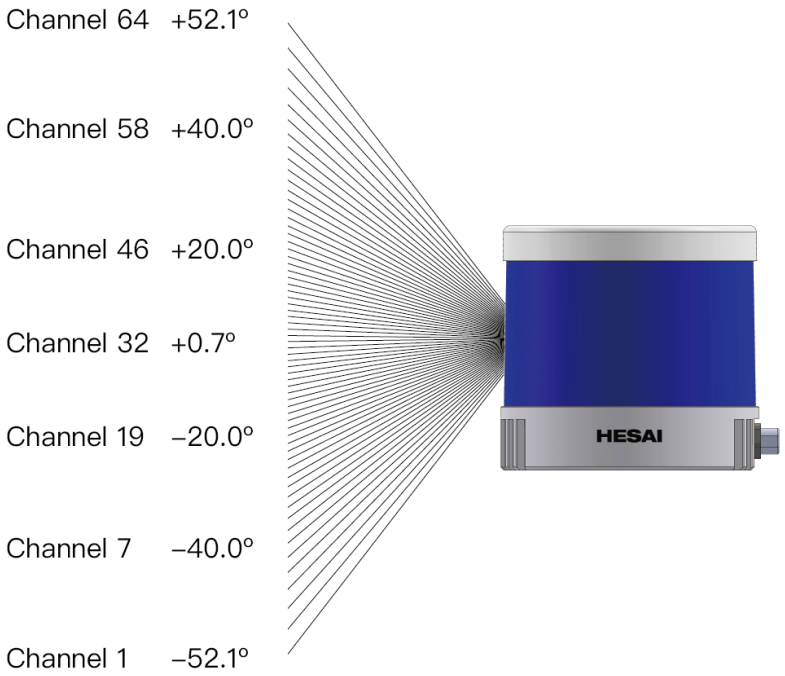


Figure 1.5 Channel Vertical Distribution

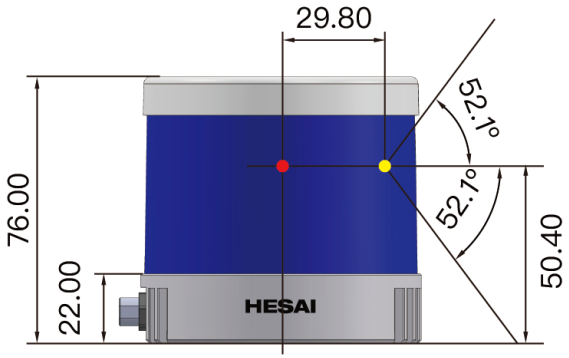


Figure 1.6 Laser Firing Position (Unit: mm)

Each channel has an intrinsic angle offset, both horizontally and vertically. The offsetted angles are recorded in this LiDAR unit's calibration file.

NOTE The calibration file provides the elevation and azimuth of each channel's incident beam, relative to the center of the entrance pupil (shown as a yellow dot in Figure 1.6).

In case you need to obtain the file again:

- Send this TCP command *PTC_COMMAND_GET_LIDAR_CALIBRATION*, as described in Hesai TCP API Protocol (Chapter 6).
- Or contact a sales representative or technical support engineer from Hesai.

1.4 Specifications

SENSOR	
Scanning Method	Mechanical Rotation
Channel	64
Instrument Range	0.1 to 60 m
Range Capability	0.1 to 20 m (at 10% reflectivity)
Range Accuracy	±3 cm (typical)
Range Precision	2 cm (typical)
FOV (Horizontal)	360°
Resolution (Horizontal)	0.6°
FOV (Vertical)	104.2° (-52.1° to +52.1°)
Resolution (Vertical)	Finest at 1.45°
Frame Rate	10 Hz
Returns	Single Return (First, Last)
	Dual Return (First & Last)
CERTIFICATIONS	
	Class 1 Laser Product
	CE, FCC, FDA, IC, KCC, RCM, UKCA

MECHANICAL/ELECTRICAL/OPERATIONAL		
Wavelength	885 nm	
Ingress Protection	IP67 & IP69K	
Dimensions	Height: 76.0 mm	Diameter: 80.2 mm
Rated Voltage Range	DC 12 to 48 V	
Power Consumption	8 W	
Operating Temperature	-20°C to 65°C	
Weight	0.47 kg	
DATA I/O		
Data Transmission	UDP/IP Ethernet (Automotive 100BASE-T1)	
	Slave Mode	
Measurements	Distance, Azimuth Angle	
Data Points Generated	Single Return: 384,000 points/sec	
	Dual Return: 768,000 points/sec	
Point Cloud Data Rate	Single Return: 13.37 Mbps	
	Dual Return: 26.74 Mbps	
Clock Source	PTP	
PTP Clock Accuracy	≤1 μs (typical)	
PTP Clock Drift	≤1 μs/s	

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

NOTE Range capability: test data of the middle 48 channels (Channels 9~56), measured under 100 klux ambient intensity, with PoD > 90%.

NOTE Range accuracy (difference between the average of multiple measurements and the true value, measured under the same conditions) and range precision (standard deviation of multiple measurements, measured under the same conditions) may vary with range, temperature, and target reflectivity.

2 Setup

2.1 Mechanical Installation

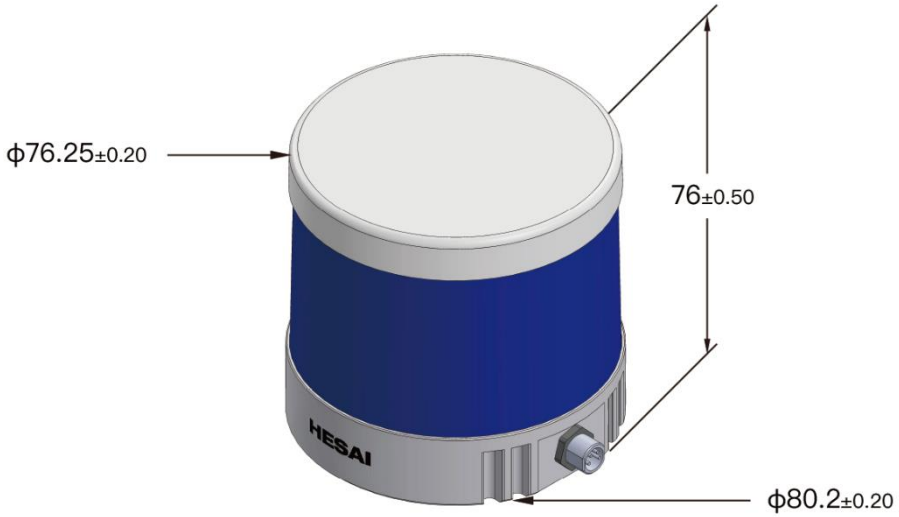


Figure 2.1 Isometric View (Unit: mm)

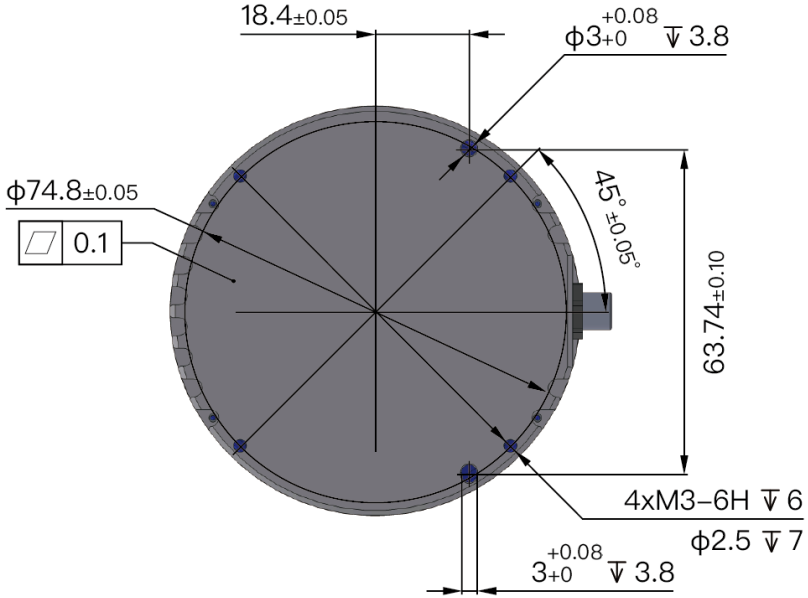


Figure 2.2 Mounting Base (Unit: mm)

■ Recommended Installation

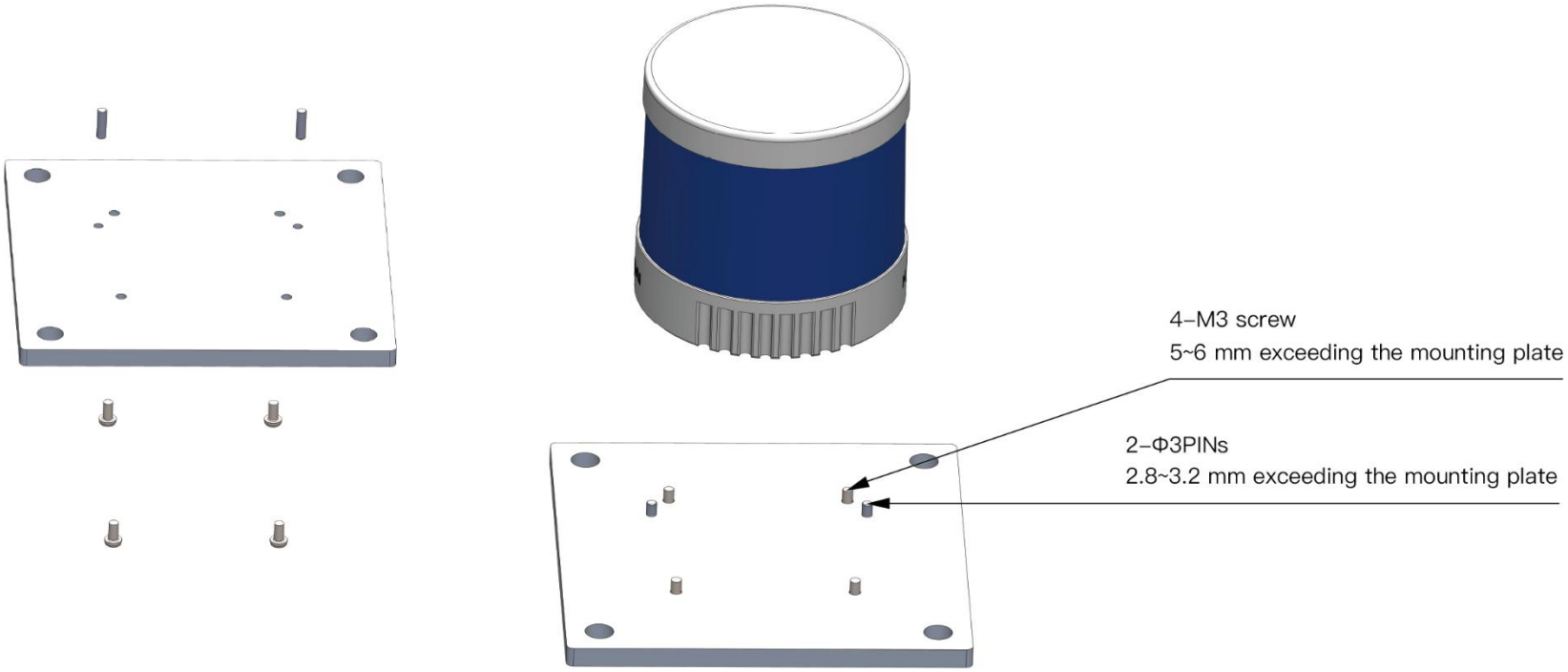


Figure 2.3 Recommended Installation

■ Side Installation

Figure 2.4 Side Installation

2.2 Interfaces

PandarQT uses a 4-pin M8 male socket (with pins inside), which includes power wires and a 100BASE-T1 twisted-pair.

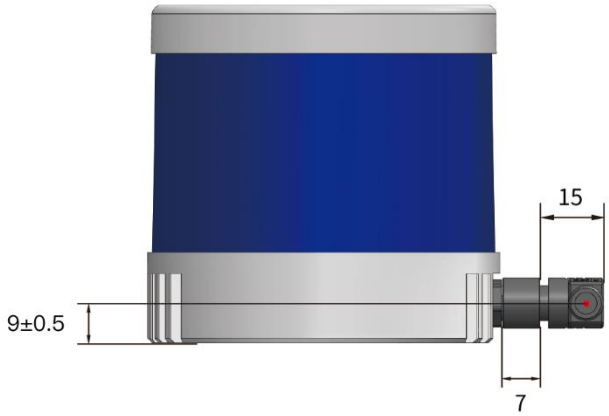


Figure 2.5 Connector Dimensions (Unit: mm)

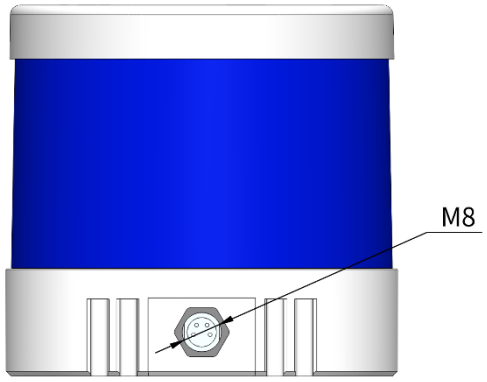


Figure 2.6 Connector

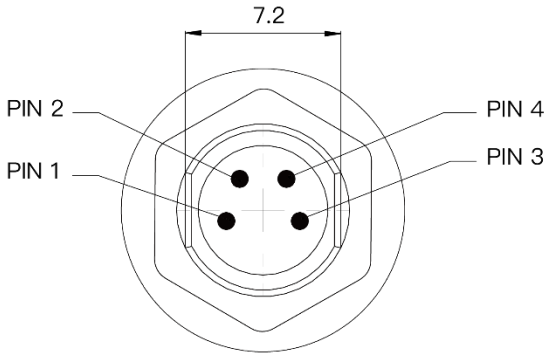


Figure 2.7 Connector Pinout (4-pin)

Pin definition is listed below:

Pin #	Signal	Voltage
1	VIN	12 to 48 V
2	GND	0 V
3	Ethernet_TRX+	-1 to 1 V
4	Ethernet_TRX-	-1 to 1 V

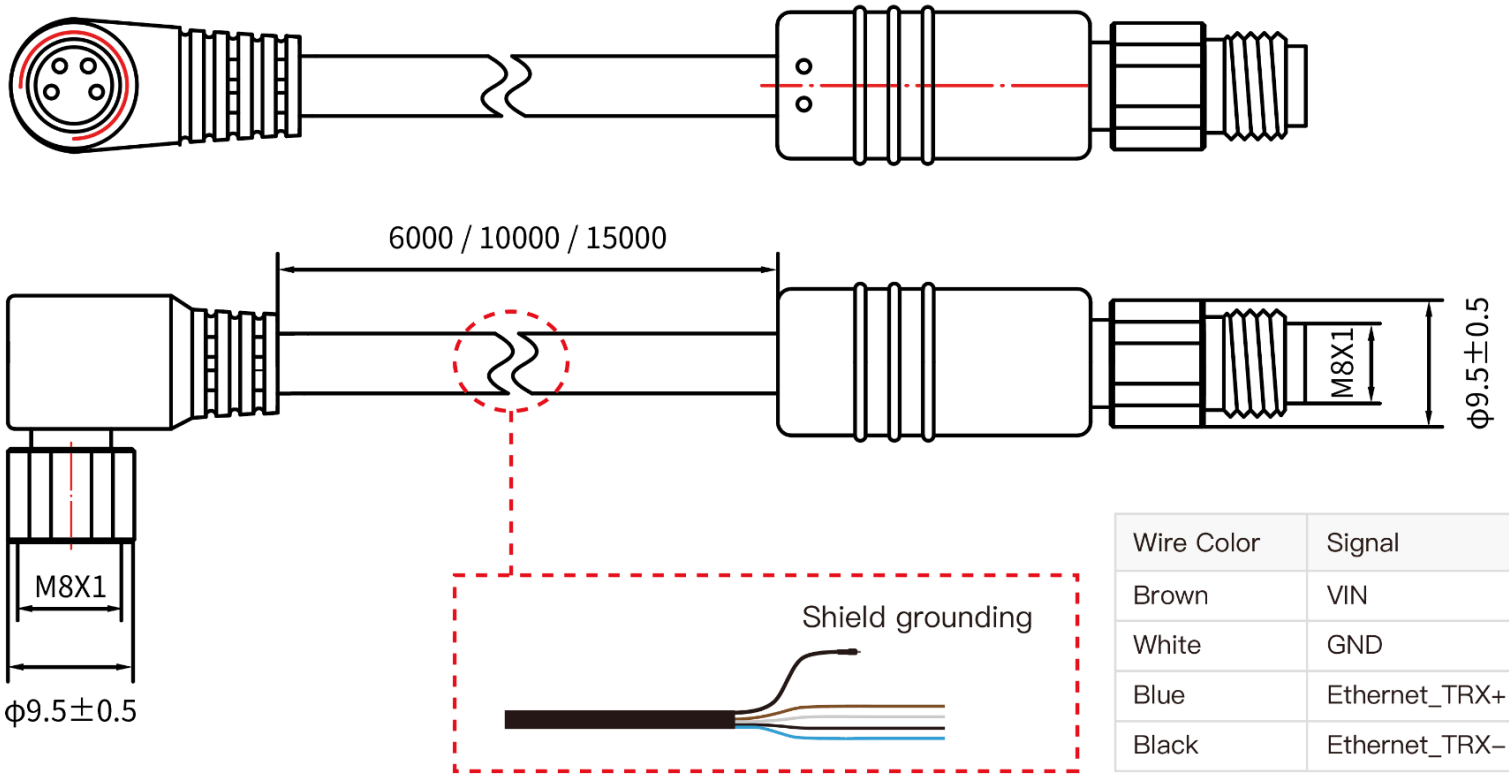
NOTE Please plug and unplug the connector with care. Do not pull, twist, or squeeze it with excessive force.

■ Extension Cable (Optional)

The default length is 6, 10, or 15 m.

Contact Hesai if you need customized cables for connecting the LiDARs to your control units directly.

Refer to Appendix IV (Power Supply Requirements) for wire gauge and cable length selection.



Wire Color	Signal
Brown	VIN
White	GND
Blue	Ethernet_TRX+
Black	Ethernet_TRX–

Figure 2.8 Extension Cable and Connector Size

2.3 Connection Box (Optional)

Users may connect the LiDAR directly or using the connection box.

The connection box converts automotive 100BASE-T1 to 100BASE-TX typical Ethernet, as well as providing a power port.

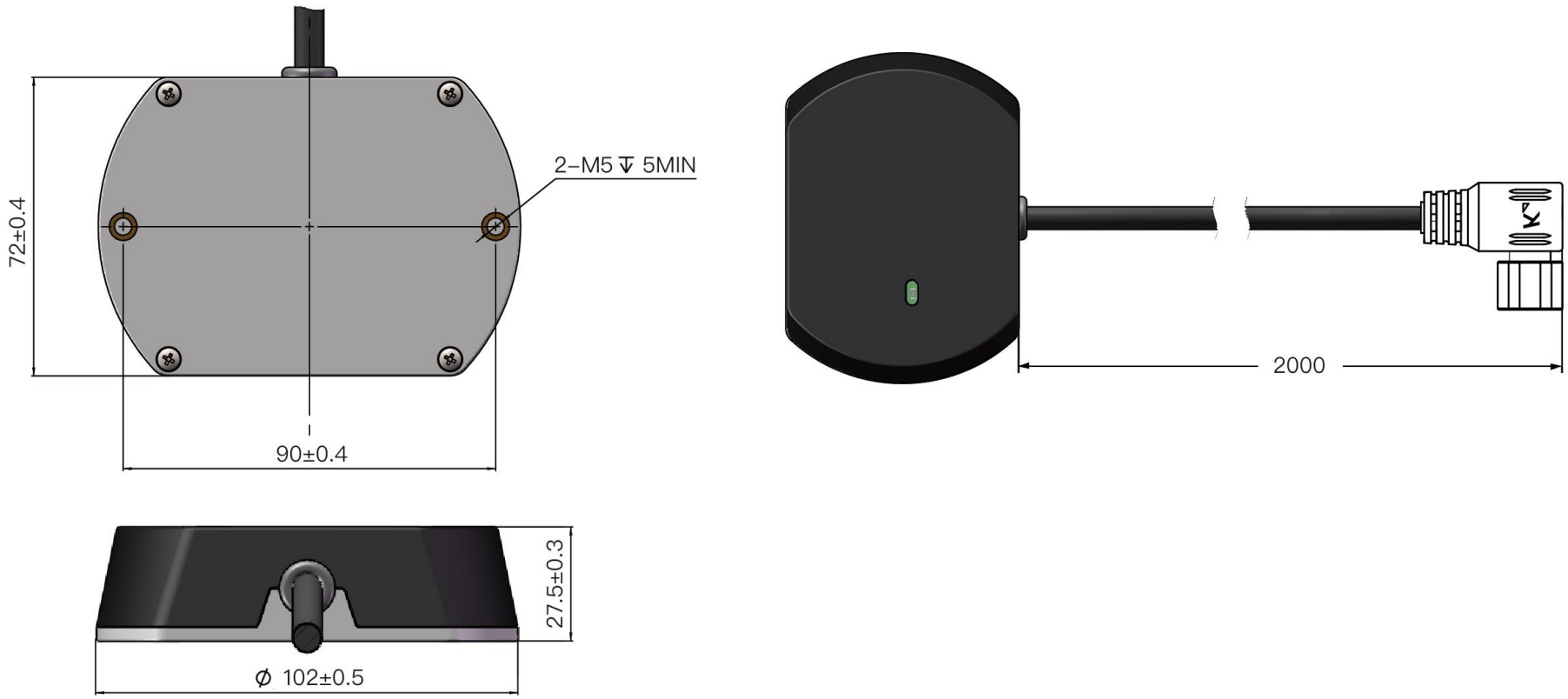


Figure 2.9 Connection Box - Connection (Unit: mm)

2.3.1 Connection Box Interfaces

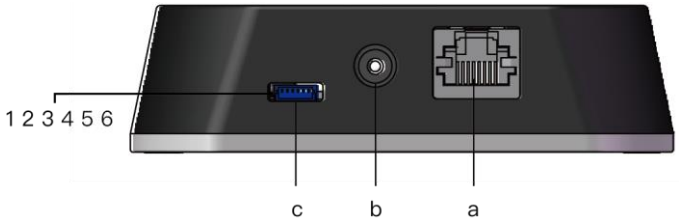


Figure 2.10 Connection Box (Front)

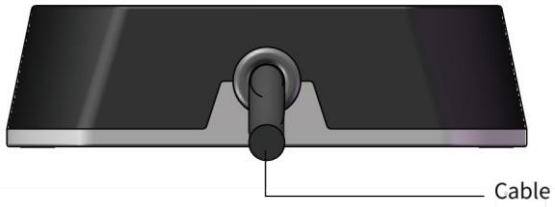


Figure 2.11 Connection Box (Back)

Port #	Port Name	Description
a	Standard Ethernet Port	RJ45, 100BASE-TX Ethernet
b	Power Port	Connects to a DC power adapter Connector part number: PJ-057AH External power supply: • 24 W at least • Rated input voltage: 12 to 48 V • Allowable input voltage: 9 to 55 V
c	Reserved	-

2.3.2 Connection

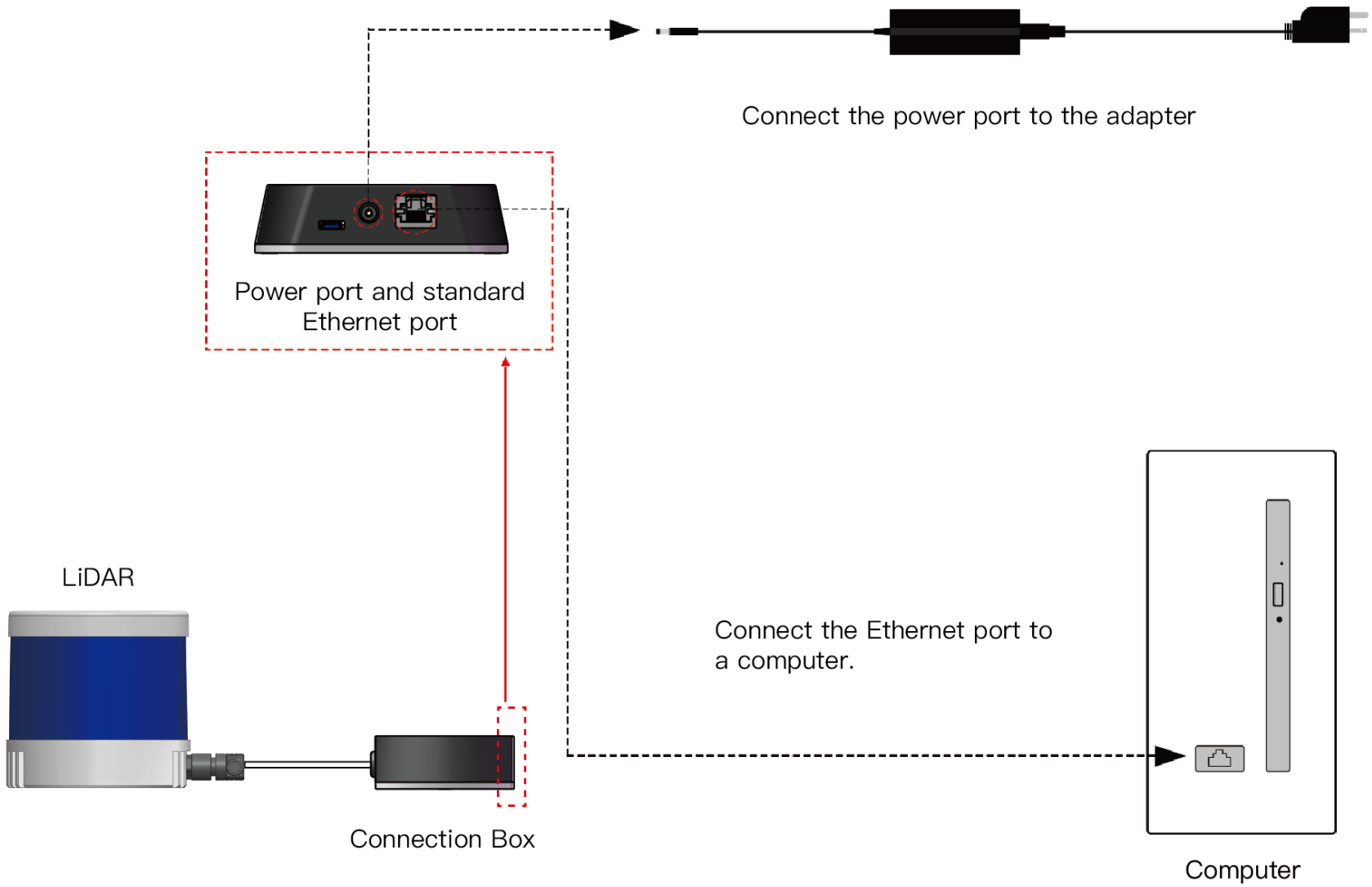


Figure 2.12 Connection Box - Connection

NOTE Refer to Appendix III when PTP protocol is used.

2.4 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 name)	Open the Network Sharing Center, click on "Ethernet" In the "Ethernet Status" box, click on "Properties" Double-click on "Internet Protocol Version 4 (TCP/IPv4)" Configure the IP address to 192.168.1.100 and subnet mask to 255.255.255.0

To record and display point cloud data, see Chapter 5 (PandarView)

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

3 Data Structure

The LiDAR outputs Point Cloud Data Packets using 100BASE-T1 Automotive Ethernet UDP/IP.

All the multi-byte values are unsigned and in little endian format.

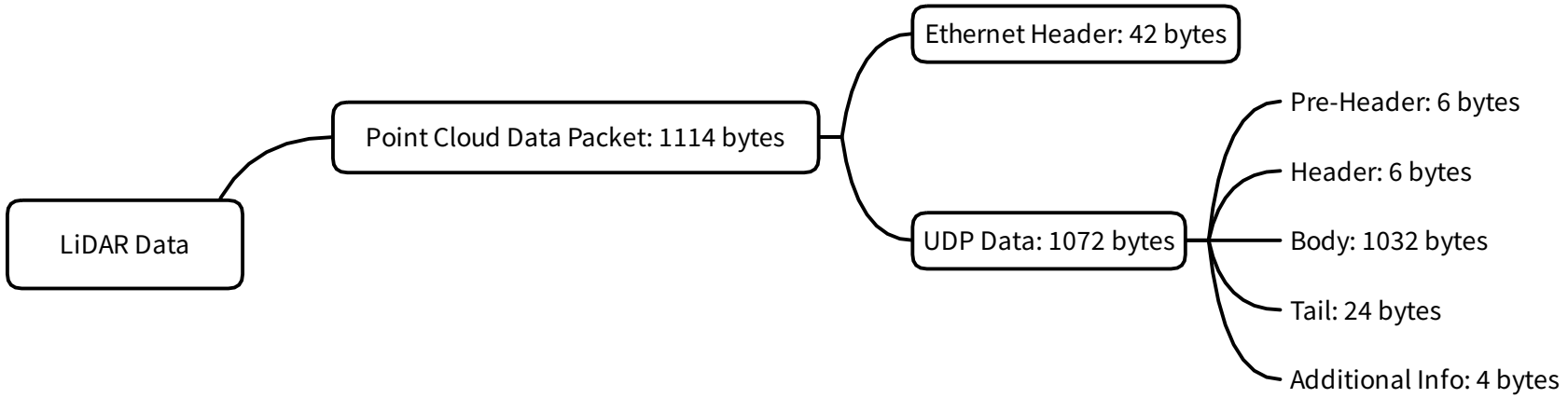


Figure 3.1 Data Structure

3.1 Point Cloud Data Packet

3.1.1 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 (0xFF: 0xFF: 0xFF: 0xFF: 0xFF: 0xFF) Source: (xx:xx:xx:xx:xx:xx)
Ethernet Data Packet Type	2	0x08, 0x00
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	0x0438, representing 1080 bytes (8 bytes more than the size of the Point Cloud UDP Data, shown in Figure 3.1)
UDP Checksum	2	-

```
▼ Internet Protocol Version 4, Src: 192.168.1.201 (192.168.1.201), Dst: 255.255.255.255 (255.255.255.255)
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  ▸ Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 1100
    Identification: 0x9dec (40428)
  ▸ Flags: 0x4000, Don't fragment
    Time to live: 64
    Protocol: UDP (17)
    Header checksum: 0xd643 [validation disabled]
    [Header checksum status: Unverified]
    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

3.1.2 UDP Data

■ **Pre-Header**

Pre-Header: 6 bytes		
Field	Bytes	Description
0xEE	1	SOP (start of packet)
0xFF	1	SOP (start of packet)
Protocol Version Major	1	To distinguish between product models 0x03 for PandarQT
Protocol Version Minor	1	For each product model, to indicate the current protocol version Currently 0x01 for PandarQT
Reserved	2	-

■ **Header**

Header: 6 bytes		
Field	Bytes	Description
Laser Num	1	0x40 (64 channels)
Block Num	1	0x04 (4 blocks per packet)
First Block Return	1	Reserved
Dis Unit	1	0x04 (4 mm)
Return Number	1	Number of returns that each channel generates 0x01 - one return 0x02 - two returns
UDP Seq	1	[7:1] is reserved Least significant bit [0] shows whether this packet includes a UDP sequence number field 1 - UDP sequence ON

■ Body

Body: 1032 bytes		
Field	Bytes	Description
Azimuth 1	2	For Block 1: current reference angle of the rotor, in little endian format (lower byte first) azimuth angle = Azimuth / 100°
Block 1	256	For Block 1: measurements made by Channels 1 to 64, see table below
Azimuth 2	2	For Block 2
Block 2	256	For Block 2
Azimuth 3	2	For Block 3
Block 3	256	For Block 3
Azimuth 4	2	For Block 4
Block 4	256	For Block 4

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

- The odd number block is the first return, and the even number block is the last return.
- The azimuth changes every two blocks.

Each Block in the Body: 4 * 64 = 256 bytes			
Field	Bytes	Description	
Channel X	4	2-byte Distance	Distance Value = Distance * 4 mm In little endian format (lower byte first)
		1-byte Reflectivity	Reflectivity Value = Reflectivity * 1% Range: 0 to 255 **NOTE** This field is not yet supported.
		1-byte Reserved	-

■ **Tail**

<table>
<tr><th colspan="3">Tail: 24 bytes</th></tr>
<tr><th>Field</th><th>Bytes</th><th>Description</th></tr>
<tr><td>Reserved</td><td>10</td><td>-</td></tr>
<tr><td>Motor Speed</td><td>2</td><td>speed_2_bytes [15:0] = speed (RPM)</td></tr>
<tr><td>Timestamp</td><td>4</td><td>The "µs time" part of the absolute time of this data packet (defined in Appendix II)
Unit: µs
Range: 0 to 1000000 µs (1 s)</td></tr>
<tr><td>Return Mode</td><td>1</td><td>0x33 for the First Return mode
0x38 for the Last Return mode
0x3B for the Dual Return mode (first & last)</td></tr>
<tr><td>Factory Information</td><td>1</td><td>0x42</td></tr>
<tr><td>Date & Time</td><td>6</td><td>The absolute time of this data packet, accurate to the second.

<table><tr><th>Each Byte</th><th>Range</th></tr><tr><td>Year (current year minus 1900)</td><td>Positive integers</td></tr><tr><td>Month</td><td>1 to 12</td></tr><tr><td>Day</td><td>1 to 31</td></tr><tr><td>Hour</td><td>0 to 23</td></tr><tr><td>Minute</td><td>0 to 59</td></tr><tr><td>Second</td><td>0 to 59</td></tr></table></td></tr>
</table>

■ Additional Info

Additional Info: 4 bytes		
Field	Bytes	Description
UDP Sequence	4	Sequence number of this UDP packet 0 to 0xFF FF FF FF in little endian format

3.1.3 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 2 as an example:

1) Vertical angle of Channel 5 is -43.848°, according to Appendix I (Channel Distribution)

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

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

2) Horizontal angle = current reference angle of the rotor + horizontal angle offset + firing time angular offset

- Current reference angle of the rotor: Azimuth field of Block 2
- Horizontal angle offset: 7.388° for Channel 5, according to Appendix I (Channel Distribution)

NOTE The accurate horizontal angle offset is recorded in this LiDAR's unit's calibration 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 the horizontal angles' positive direction

3) Actual distance in real world millimeters = distance measurement * Distance Unit (4 mm)

Distance measurement is the Distance field of Channel 5 in Block 2

(Continued on the next page)

(Continued)

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

4 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

NOTE Google Chrome and Mozilla Firefox are recommended.

4.1 Home

NOTE 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

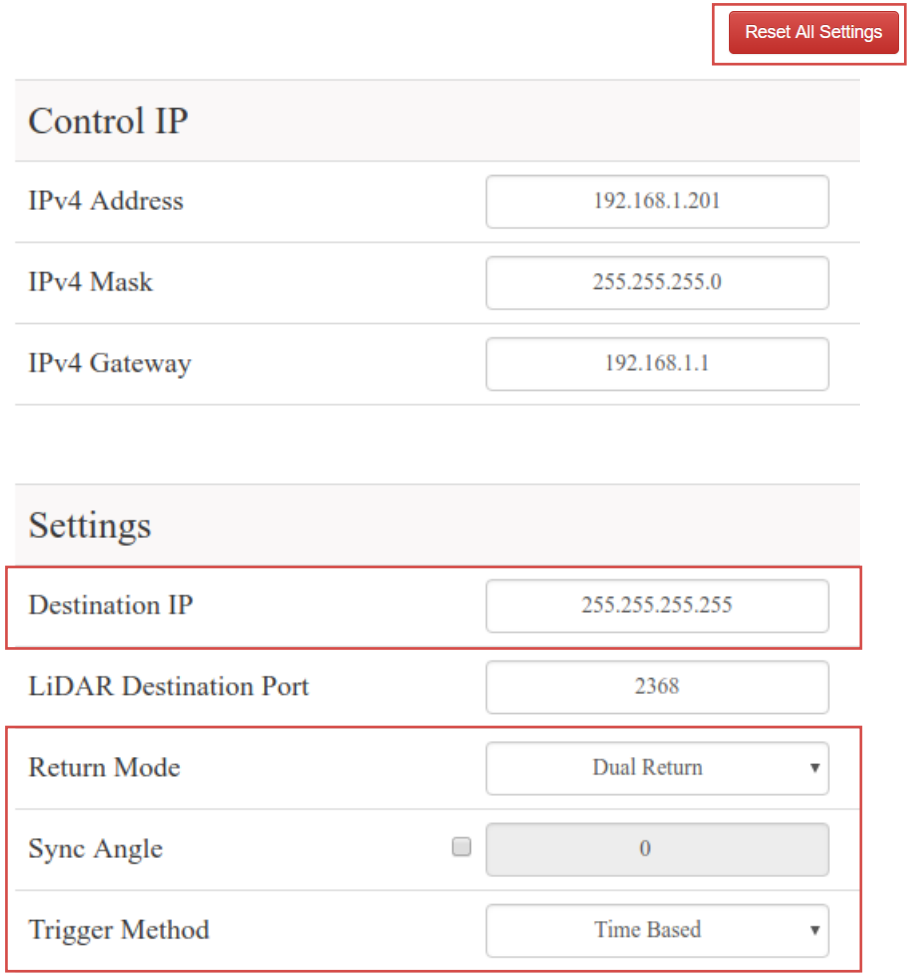
PTP Status

Free Run	No PTP master is selected
Tracking	Slave is trying to sync with the selected PTP Master, but the absolute offset exceeds the user-specified limit in Section 4.2 (Settings)
Locked	Absolute offset between Slave and Master is within the user-specified limit
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.

4.2 Settings



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1. Reset All Settings

By clicking the "Reset All Settings" button on the top-right corner, all configurable parameters in the Settings page and the Azimuth FOV page will be reset to factory defaults.
The default values are shown in Section 4.2 and Section 4.3.1.

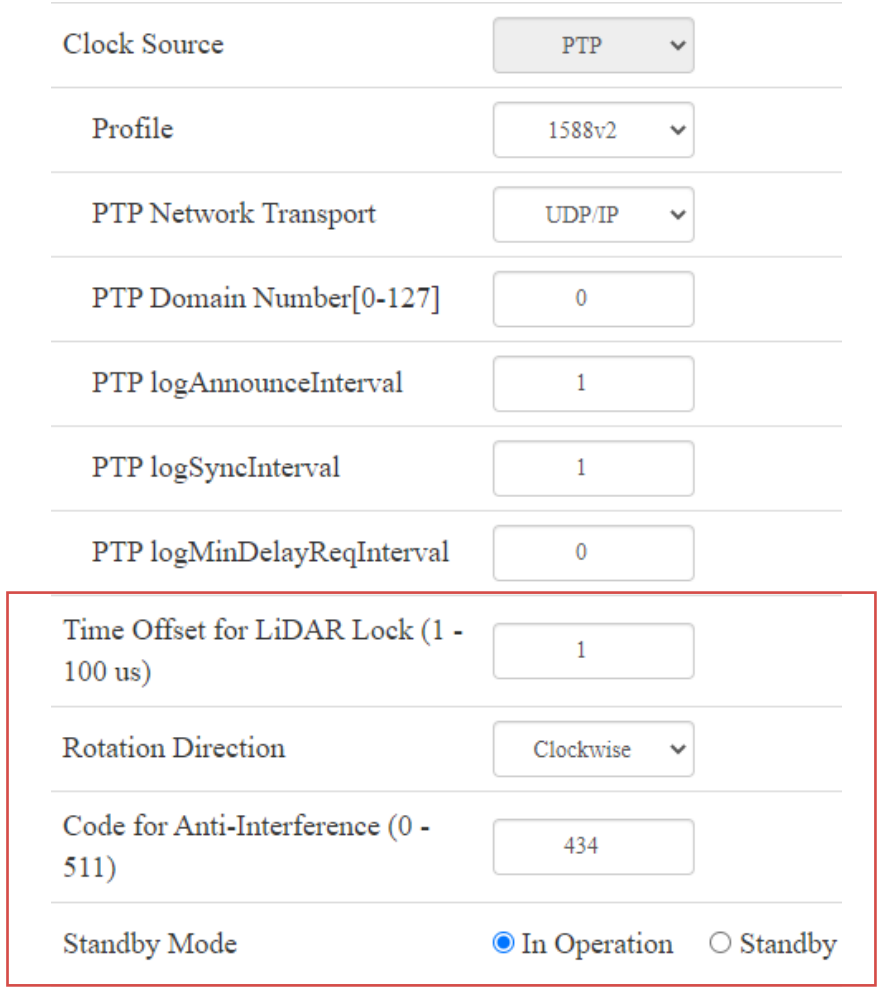
2. IP Settings

Mode	Destination IP
Broadcast (default)	255.255.255.255
Multicast	239.0.0.0~239.255.255.255
Unicast	Same as the PC's IP address

3. LiDAR Functions

Return Mode	Dual (default) / First / Last Return
Sync Angle	0~360 degrees
	By default, the LiDAR's 0° position (see Section 1.2) is not in sync with the whole second of the PTP clock. If syncing is needed, check the check box and input a sync angle. (**NOTE** Only available under clockwise rotation.)
Trigger Method	Angle-Based / Time-Based
	Angle-based: lasers fire every 0.6° at 10 Hz Time-based: lasers fire every 166.66 us

(continued)

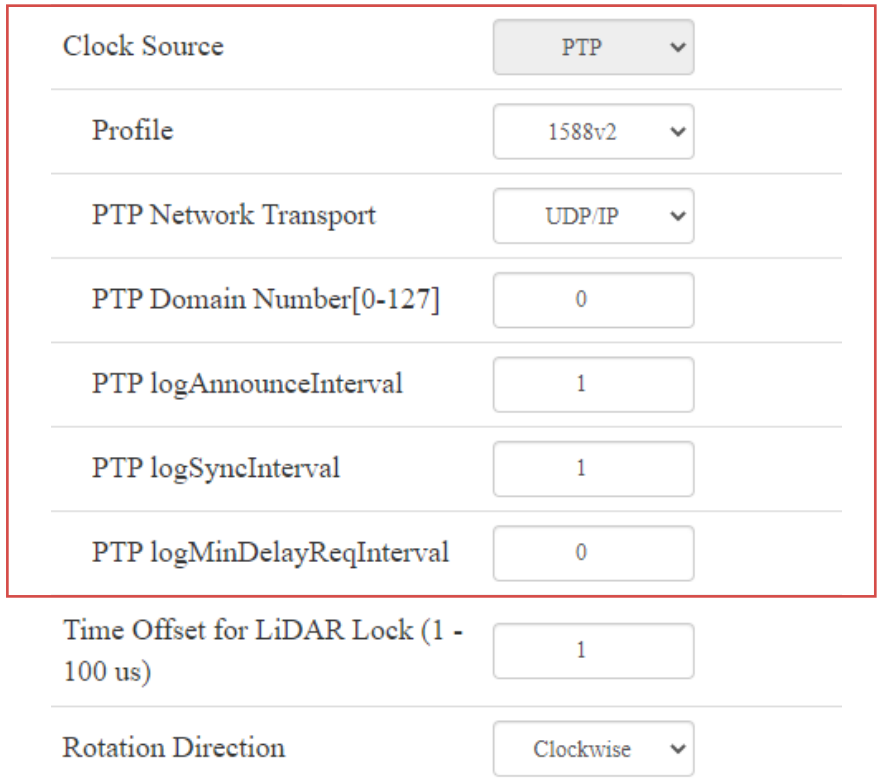


(continued)

Time Offset for LiDAR Lock	1~100 μs (integer) Specify the upper limit of the absolute offset between Slave and Master when the LiDAR is in PTP Locked status. See Section 4.1 (Home)
Rotation Direction	Clockwise / Counterclockwise **NOTE** After selecting Counterclockwise, refresh the webpage to check that the settings have taken effect. If the page after refreshing still shows Clockwise, refresh the page again and check. **NOTE** Under counterclockwise rotation, Sync Angle in the previous page is not supported.
Anti-Interference Code	0-511 To minimize interference, use different codes for nearby LiDARs
Standby Mode	Whether to stop the motor from running and lasers from firing

4. Clock Source and PTP Parameters

Clock Source	PTP
	Detailed in Appendix III (PTP Protocol)



- When PTP is selected as the clock source:

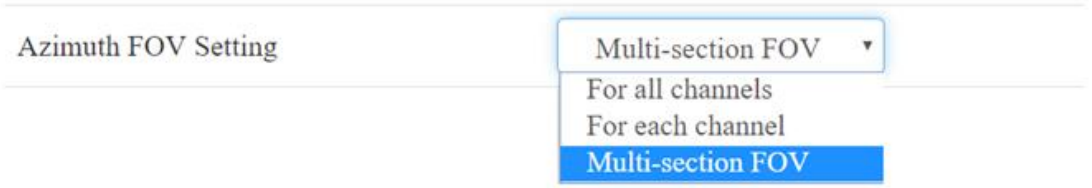
Profile	1588v2 (default) / 802.1AS
	IEEE timing and synchronization standard
PTP Network Transport	UDP/IP (default) or L2
	1588v2: users can select UDP/IP or L2 **802.1AS and 802.1AS Automotive**: only supports L2 network
PTP Domain Number	Integer from 0 to 127
	Domain attribute of the local clock

- When using the 1588v2 profile:

PTP logAnnounceInterval	-2 to 3 log seconds
	Time interval between Announce messages (default: 1)
PTP logSyncInterval	-7 to 3 log seconds
	Time interval between Sync messages (default: 1)
PTP logMinDelayReqInterval	-7 to 3 log seconds
	Minimum permitted mean time between Delay_Req messages (default: 0)

4.3 Azimuth FOV

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



4.3.1 For all channels

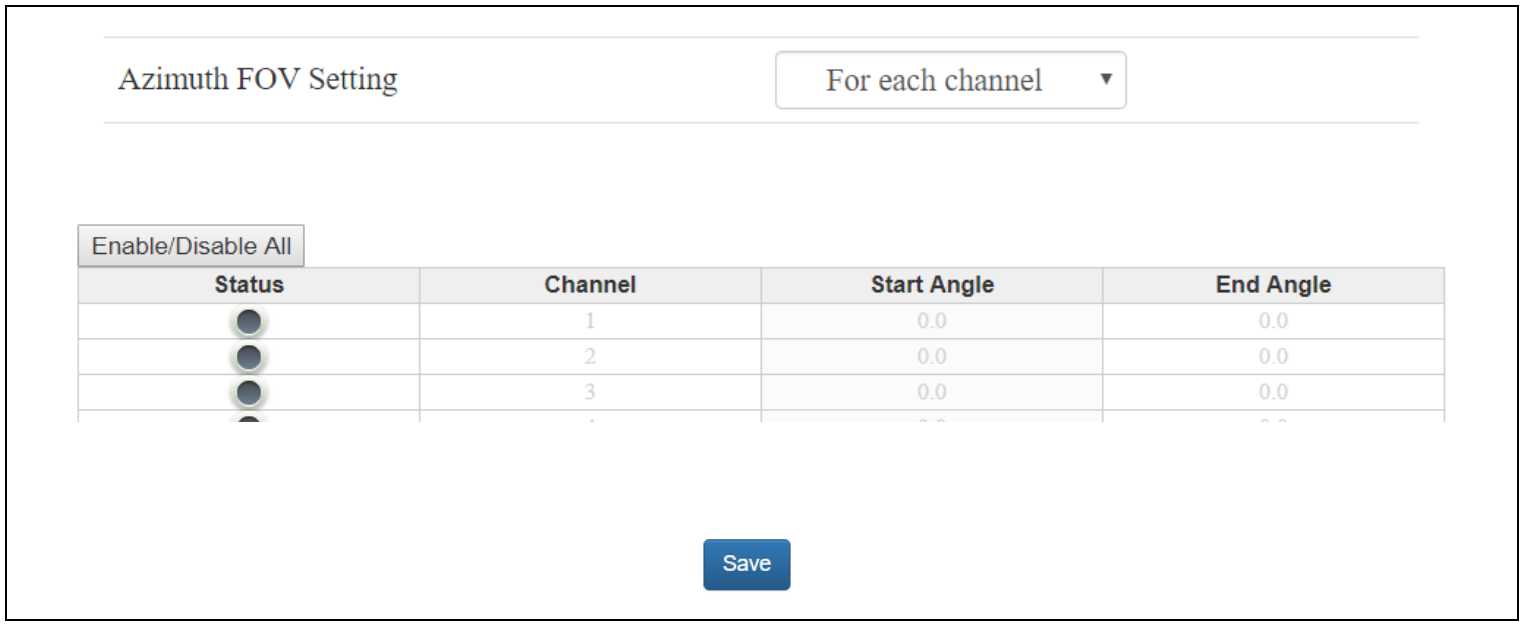
A continuous angle range, specified by a Start Angle and an End Angle, will be applied to all channels.
The LiDAR outputs valid data only within the specified range.

4.3.2 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.

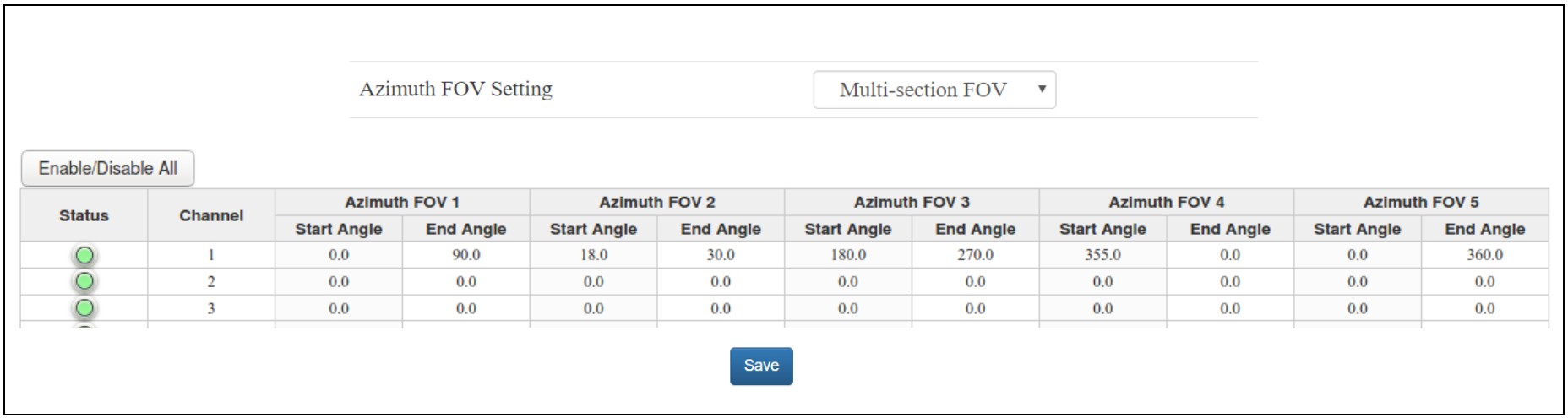


4.3.3 Multi-section FOV

Users can configure up to five 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.



Status	Channel	Azimuth FOV 1		Azimuth FOV 2		Azimuth FOV 3		Azimuth FOV 4		Azimuth FOV 5	
		Start Angle	End Angle	Start Angle	End Angle	Start Angle	End Angle	Start Angle	End Angle	Start Angle	End Angle
	1	0.0	90.0	18.0	30.0	180.0	270.0	355.0	0.0	0.0	360.0
	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

4.3.4 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°].

4.4 Operation Statistics

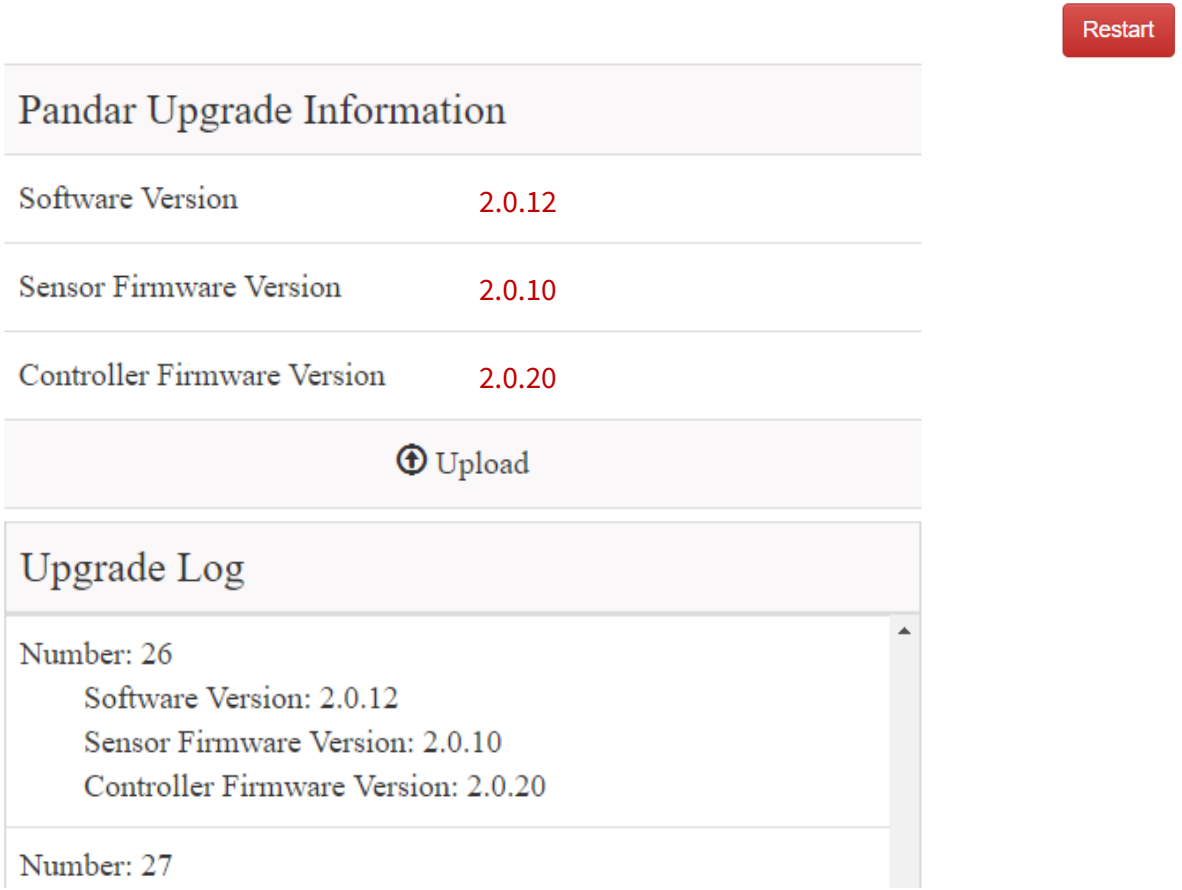
The LiDAR's operation time in aggregate and in different temperature ranges are listed, as well as the internal temperature.

Start-up Counts	1
Internal Temperature	32.65°C
System Uptime	0 h 3 min
Total Operation Time	0 h 5 min

Internal Temperature	Operation Time
< -40 °C	0 h 0 min
-40 ~ -20 °C	0 h 0 min
-20 ~ 0 °C	0 h 0 min
0 ~ 20 °C	0 h 0 min
20 ~ 40 °C	0 h 4 min
40 ~ 60 °C	0 h 1 min
60 ~ 80 °C	0 h 0 min
80 ~ 100 °C	0 h 0 min
100 ~ 120 °C	0 h 0 min
>120 °C	0 h 0 min

4.5 Upgrade

The software and firmware versions described in this manual are shown in red below.
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.

5 PandarView

PandarView is a software that records and displays point cloud data from Hesai LiDARs, available in 64-bit Windows 10 and Ubuntu-16.04/18.04.

5.1 Installation

Copy the installation files from the USB disk in the LiDAR's protective case, or download these files from Hesai's official website: www.hesaitech.com/en/download

System	Installation Files	Installation Steps
Windows	PandarViewX64_Release_V1.7.37.msi	Before upgrading PandarView to a newer version, please uninstall the current version
		Double click and install PandarView_Windows using the default settings
Ubuntu-16.04	PandarViewX64_Release_V1.7. 37.tar.gz	Unzip the file and run PandarView_Installer.bin
Ubuntu-18.04	PandarViewX64_18.04_Release_V1.7. 37.tar.gz	

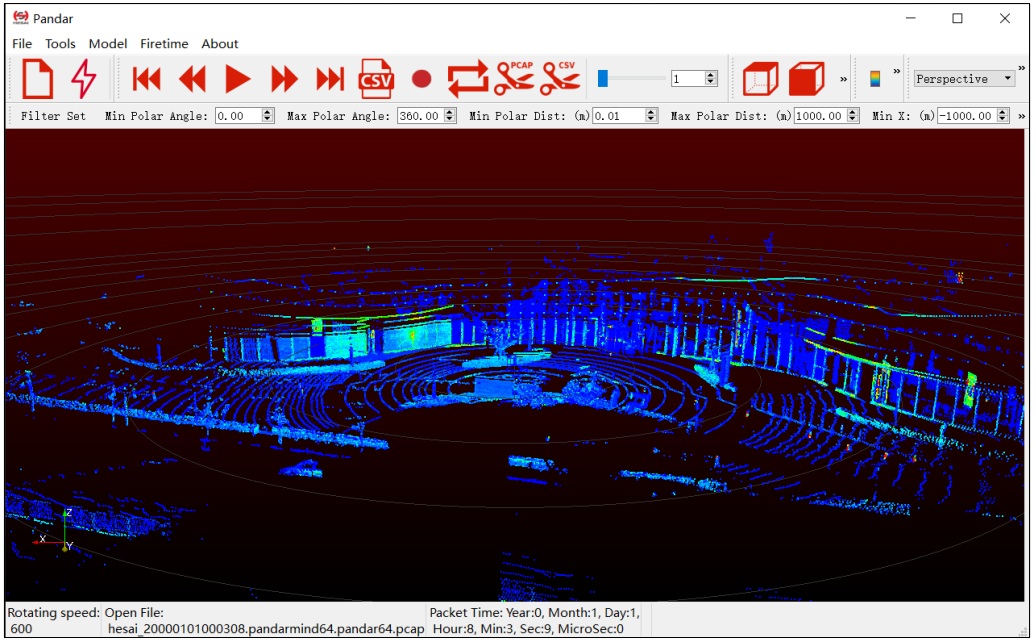
This manual describes PandarView 1.7.37. The menu bar and buttons are shown below.

NOTE Users may check the software version from "About" in the menu bar.

5.2 Check Live Data

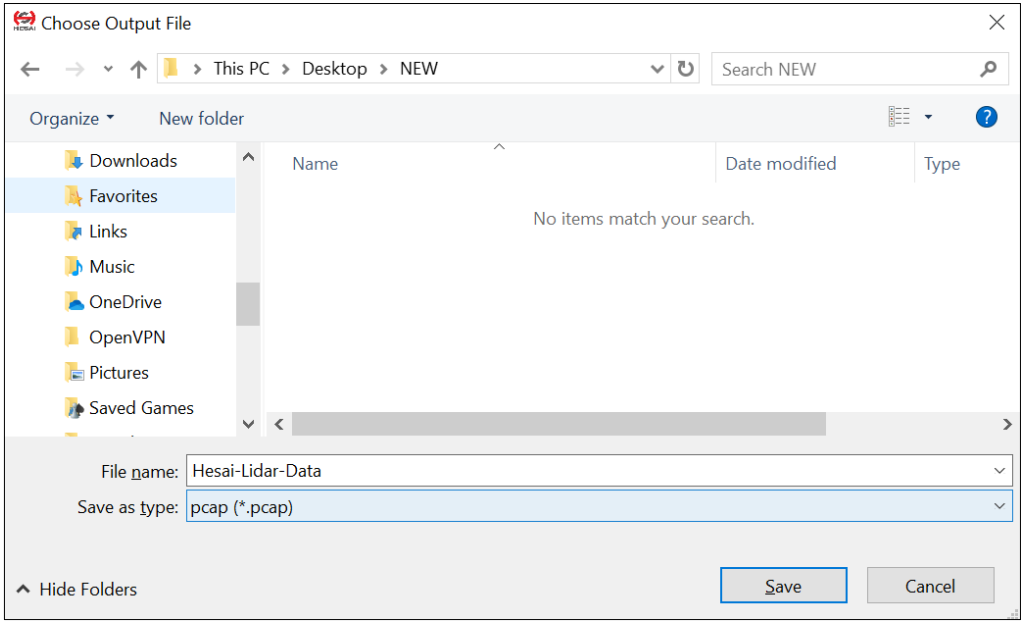
Set the PC's IP address according to Section 2.4 (Get Ready to Use)

Click on  and select your LiDAR model to begin receiving data over Ethernet.



5.3 Record Point Cloud Data

1) Click on ● to pop up the "Choose Output File" window.
2) Specify the file directory and click on "Save" to begin recording a .PCAP file.
3) Click on ● again to stop recording.



5.4 Play Point Cloud Data

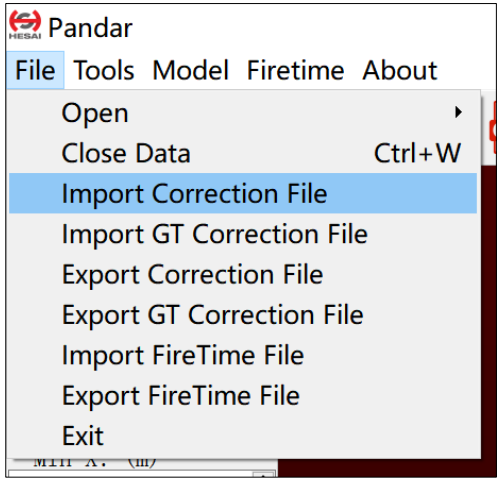
1) Open a .PCAP File

Click on  to pop up the "Choose Open File" window. Select a .PCAP file to open.

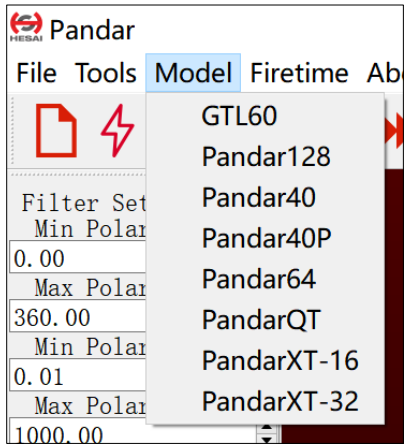
2) Import a Correction File

Each LiDAR unit has a corresponding calibration file (.CSV), see Section 1.3 (Channel Distribution).

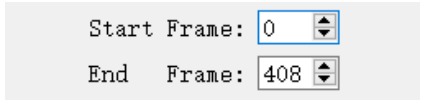
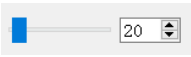
We recommend importing the calibration file of this LiDAR unit into PandarView (File -- Import Correction File), in order to display the point cloud most accurately.



If the calibration file of this LiDAR unit is temporarily not at hand, select the LiDAR model in the "Model" menu. Thus a general calibration file for this model will be loaded to improve point cloud display.



3) Play the .PCAP File

Button	Description
	Jump to the beginning of the file
	While paused, jump to the previous frame While playing, rewind. May click again to adjust the rewind speed (2x, 3x, 1/2x, 1/4x, and 1x) 
	After loading a point cloud file, click to play the file While playing, click to pause
	While paused, jump to the next frame. While playing, forward. May click again to adjust the forward speed (2x, 3x, 1/2x, 1/4x, and 1x) 
	Jump to the end of the file
	Save a single frame to .CSV
	While playing, this Record button will be gray and unclickable
	While playing, click to loop playback. Otherwise the player will stop at the end of the file
	Save multiple frames to .PCAP  Specify the start and end frames
	Save multiple frames to .CSV
	Drag this progress bar or enter a frame number to jump to a specific frame

5.5 Features

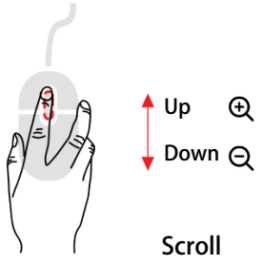
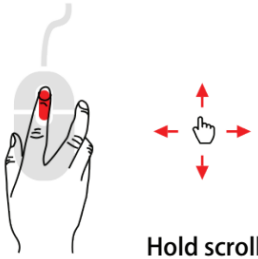
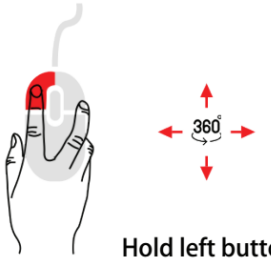
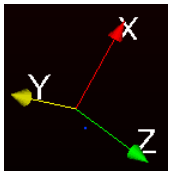
■ Standard Viewpoints

Right

Front

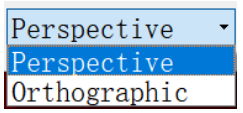
Top

■ Mouse Shortcuts

			
Scroll the mouse wheel up/down to zoom in/out	Press the mouse wheel and drag to pan the view	Hold the left button and drag to adjust the point of view	The bottom-left coordinate axes show the current point of view

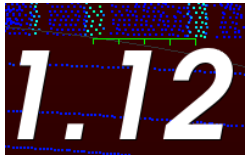
■ 3D Projection and Distance Measurement

PandarView supports perspective projection (default) and orthographic projection.



The distance ruler is available only under orthographic projection:

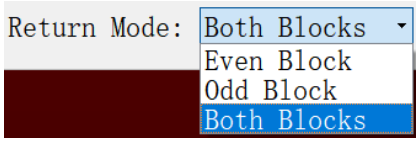
- Click on  to enter measurement mode. Hold the Ctrl key and drag the mouse to make a measurement in units of meters
- Click on  again to quit



■ Return Mode

- Both blocks (default): to show the point cloud data from all blocks
- Even/Odd Block: to show the point cloud data from even/odd-number blocks

NOTE See the definition of blocks in Section 3.1.2 (Point Cloud UDP Data)



■ UDP Port

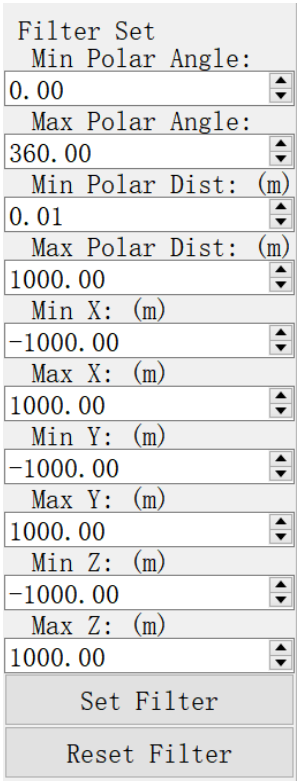
Enter the UDP port number and click "Set".

■ View Filter

To set the polar/rectangular coordinate range for viewing live point cloud data or a .PCAP file.

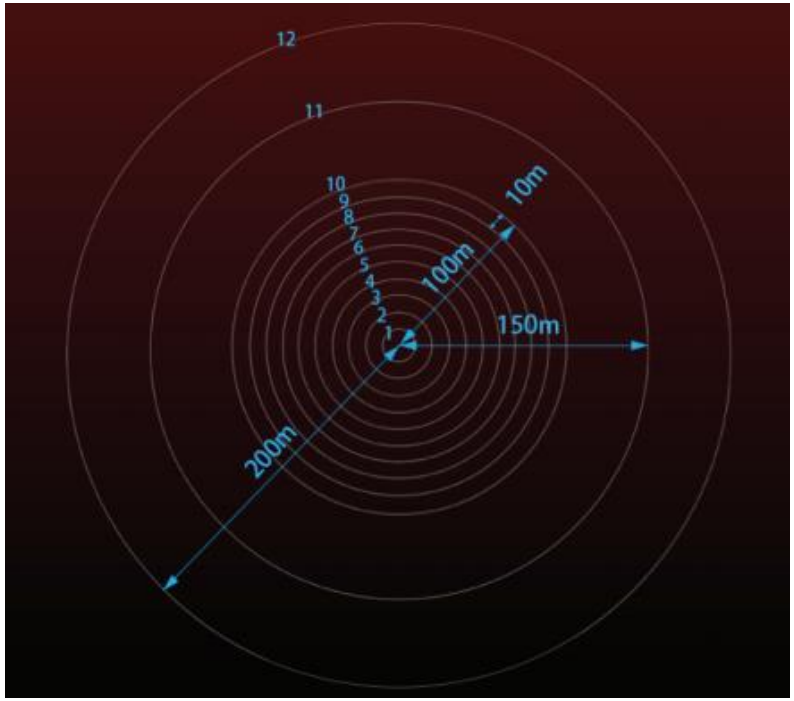
- Click "Set Filter" to apply the settings.
- Click "Reset Filter" to return to default settings (shown in the screenshot).

NOTE The filter does not apply to recording and saving .PCAP files.



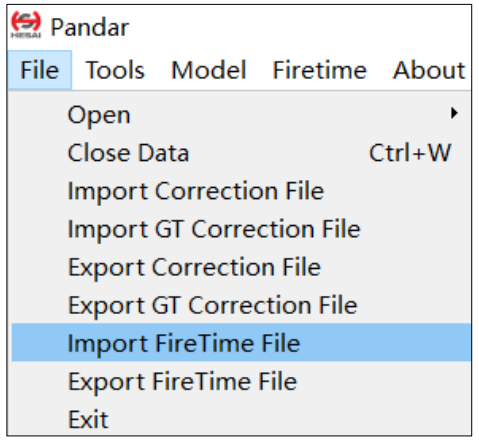
■ Distance Reference Circles

Click on  to show/hide the 12 distance reference circles. The actual distances are marked below.
To change the color and line width of these circles, click on "Tools" in the menu bar and open "Grid Properties".



■ Fire Time Correction

After opening a .PCAP file, import the fire time correction file of this LiDAR model into PandarView (File -- Import FireTime File).

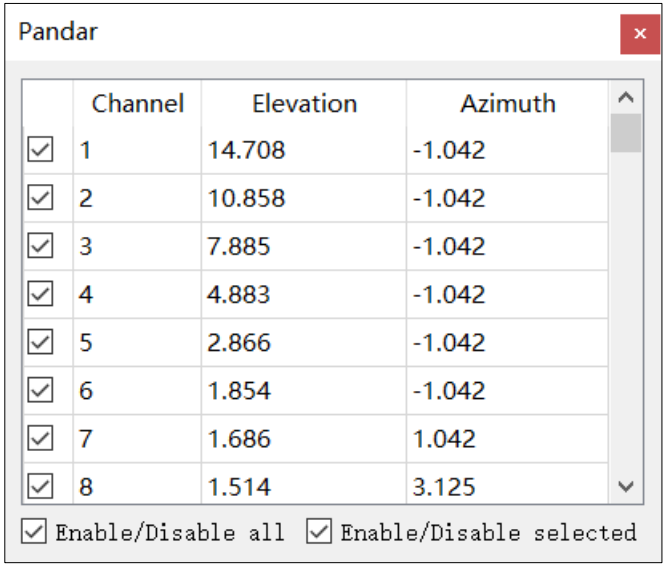


Afterwards, click on  to finetune point cloud display using the fire time correction file.

Click on  again to cancel the finetuning effects.

■ Channel Selection

Click on  to open the Channel Selection box.

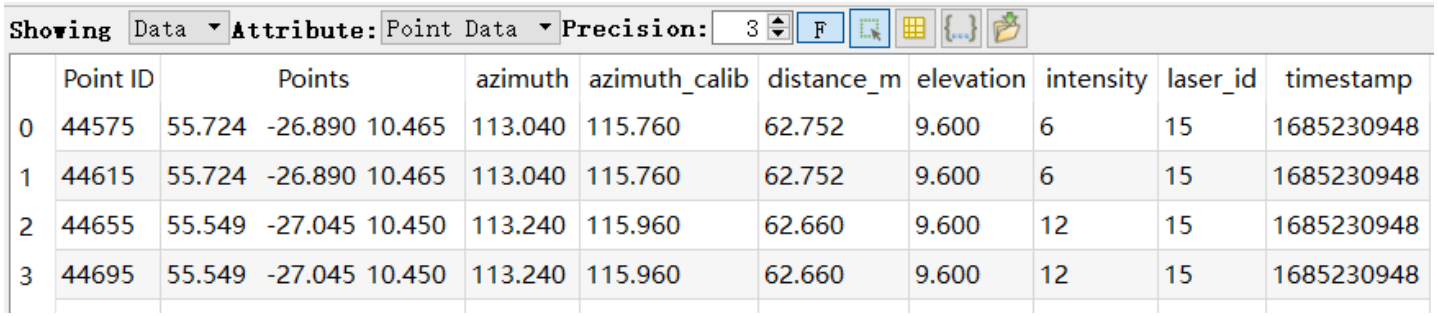


- Check/Uncheck the boxes on the left to show/hide each channel. By default, the point cloud data from all channels are shown.
- Check/Uncheck the "Enable/Disable all" option at the bottom of the table to show/hide all channels.
- When multiple channels are selected by holding the Shift or Ctrl key, check/uncheck the "Enable/Disable selected" option to show/hide multiple channels.

Click on  again to close the Channel Selection box.

■ Point Selection and Data Table

Click on  and drag the mouse over the point cloud to highlight an area of points.
Click on  to view the data of the highlighted points, as shown below.


Showing Data Attribute: Point Data Precision: 3 F

	Point ID	Points	azimuth	azimuth_calib	distance_m	elevation	intensity	laser_id	timestamp
0	44575	55.724 -26.890 10.465	113.040	115.760	62.752	9.600	6	15	1685230948
1	44615	55.724 -26.890 10.465	113.040	115.760	62.752	9.600	6	15	1685230948
2	44655	55.549 -27.045 10.450	113.240	115.960	62.660	9.600	12	15	1685230948
3	44695	55.549 -27.045 10.450	113.240	115.960	62.660	9.600	12	15	1685230948

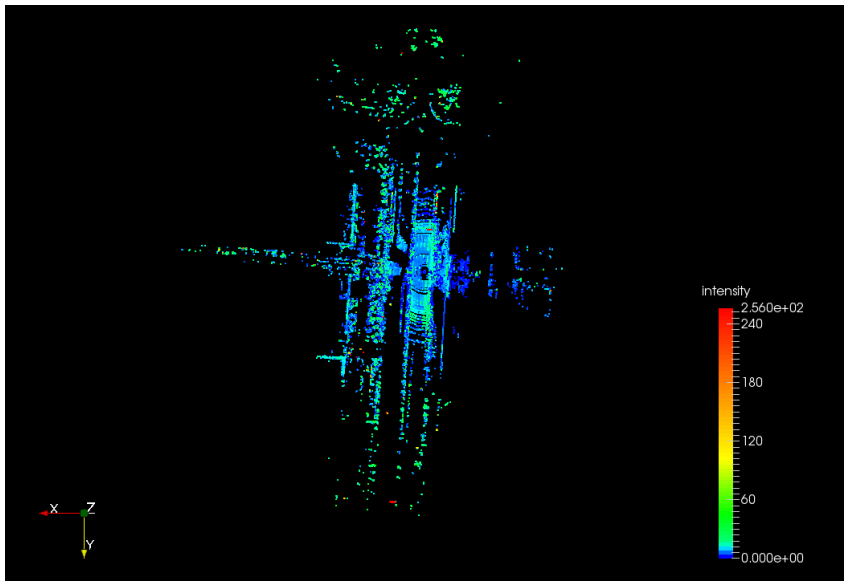
Some of the data fields are defined below:

Field	Description
points	The XYZ coordinates of each point
azimuth	Rotor's current reference angle
azimuth_calib	Azimuth + horizontal angle offset

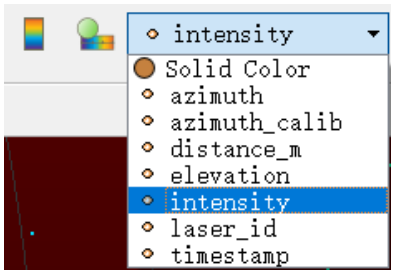
To cancel the selection, click on  again and click on any place outside the selected point cloud area.

■ Color Schemes

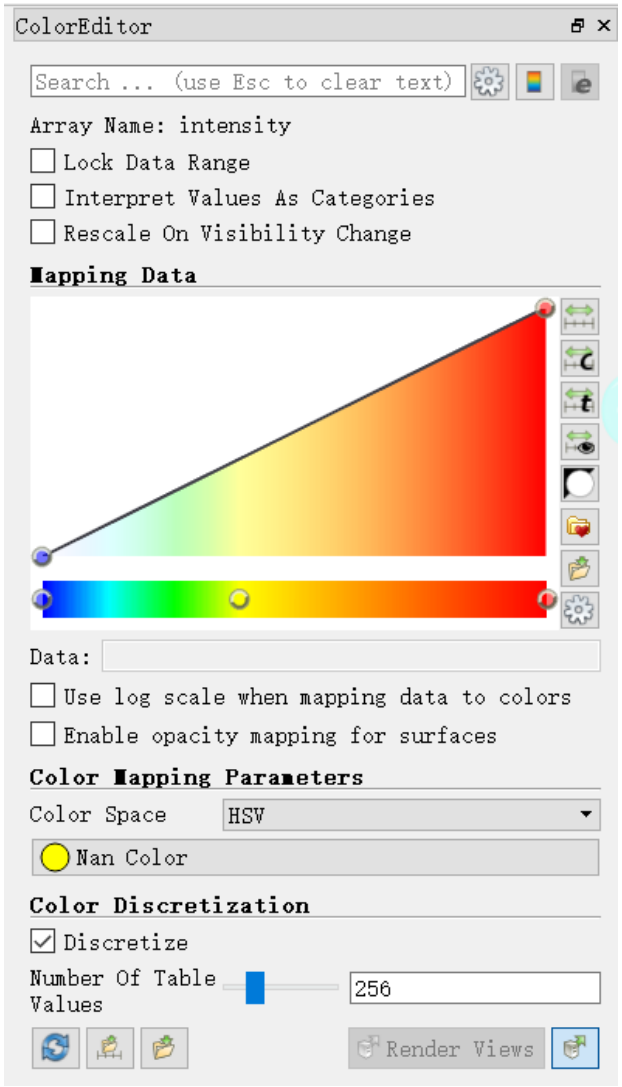
Click on to show the color legend at the lower right corner.



The default color scheme is intensity based. Users can choose from other colors schemes based on azimuth, azimuth_calib, distance, elevation, laser_id, or timestamp.



Click on  to open or close the Color Editor.



6 Communication Protocol

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

7 Sensor Maintenance

■ Storage

Store the product in a dry, well ventilated place. The ambient temperature shall be between -20°C and +65°C, and the humidity below 50%.
If the product is to be stored for a long time, we recommend powering on the product at least every two weeks.
Please check Section 1.4 (Specifications) for product IP rating, and avoid any ingress beyond that rating.

■ Transport

Package the product in shock-proof materials to avoid damage during transport.

■ 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.

NOTE

- To avoid damaging the optical coating, DO NOT apply pressure when wiping the cover lens
- 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

(Continued on the next page)

(Continued)

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 **NOTE** When using IPA or alcohol, please ensure adequate ventilation and keep away from fire.
Solvent temperature	20 to 25°C

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

8 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) Power 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) Power on again to check if the symptom persists.
Motor is running but no output data is received, neither on Wireshark nor on PandarView	Verify that ・ Ethernet cable is properly connected (by unplugging and plugging again) ・ LiDAR's IP is in the same subnet with the PC's ・ 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 infrared sensor card, or a phone camera without infrared filter Power on again to check if the symptom persists.

(Continued on the next page)

(Continued)

Symptoms	Points to Check
Can receive data on Wireshark but not on PandarView	Verify that ・ Destination IP and the Destination LiDAR Port are 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 installed on the PC Power on again to check if the symptom persists.
Cannot open web control	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 the 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

(Continued on the next page)

(Continued)

Symptoms	Points to Check
Abnormal point cloud (obviously misaligned points, flashing points, or incomplete FOV)	Verify that ・ LiDAR's cover lens is clean. If not, refer to Chapter 7 (Sensor Maintenance) for the cleaning method ・ LiDAR's calibration file is imported, see Section 5.2 (PandarView - 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 Section 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 calibration file, see Section 1.3 (Channel Distribution) and Section 3.1.3 (Point Cloud Data Analysis).

PandarQT Channel Distribution (To Be Continued)

Channel # in UDP Data	Horizontal Angle (Azimuth) Offset	Vertical Angle (Elevation)
01 (Bottom)	8.736°	-52.121°
02	8.314°	-49.785°
03	7.964°	-47.577°
04	7.669°	-45.477°
05	7.417°	-43.465°
06	7.198°	-41.528°
07	7.007°	-39.653°
08	6.838°	-37.831°
09	6.688°	-36.055°
10	6.554°	-34.32°
11	6.434°	-32.619°
12	6.326°	-30.95°
13	6.228°	-29.308°
14	6.14°	-27.69°
15	6.059°	-26.094°
16	5.987°	-24.517°
17	-5.27°	-22.964°
18	-5.216°	-21.42°
19	-5.167°	-19.889°
20	-5.123°	-18.372°

Channel # in UDP Data	Horizontal Angle (Azimuth) Offset	Vertical Angle (Elevation)
21	-5.083°	-16.865°
22	-5.047°	-15.368°
23	-5.016°	-13.88°
24	-4.988°	-12.399°
25	-4.963°	-10.925°
26	-4.942°	-9.457°
27	-4.924°	-7.994°
28	-4.91°	-6.535°
29	-4.898°	-5.079°
30	-4.889°	-3.626°
31	-4.884°	-2.175°
32	-4.881°	-0.725°
33	5.493°	0.725°
34	5.496°	2.175°
35	5.502°	3.626°
36	5.512°	5.079°
37	5.525°	6.534°
38	5.541°	7.993°
39	5.561°	9.456°
40	5.584°	10.923°

PandarQT Channel Distribution (Continued)

Channel # in UDP Data	Horizontal Angle (Azimuth) Offset	Vertical Angle (Elevation)
41	5.611°	12.397°
42	5.642°	13.877°
43	5.676°	15.365°
44	5.716°	16.861°
45	5.759°	18.368°
46	5.808°	19.885°
47	5.862°	21.415°
48	5.921°	22.959°
49	-5.33°	24.524°
50	-5.396°	26.101°
51	-5.469°	27.697°
52	-5.55°	29.315°
53	-5.64°	30.957°
54	-5.74°	32.627°
55	-5.85°	34.328°
56	-5.974°	36.064°
57	-6.113°	37.84°
58	-6.269°	39.662°
59	-6.447°	41.537°
60	-6.651°	43.475°

Channel # in UDP Data	Horizontal Angle (Azimuth) Offset	Vertical Angle (Elevation)
61	-6.887°	45.487°
62	-7.163°	47.587°
63	-7.493°	49.795°
64 (Top)	-7.892°	52.133°

Appendix II Absolute Time and Laser Firing Time

■ Absolute Time of Point Cloud Data Packets

The Body of each Point Cloud Data Packet contains 4 data blocks, detailed in Section 3.1.2 (Point Cloud UDP Data).

Single Return Mode

The measurements from one round of firing are stored in one block.
The absolute time of a Point Cloud Data Packet is the time when the LiDAR sends a command to trigger a round of firing that will be stored in Block 1.

Dual Return Mode

The measurements from one round of firing are stored in two adjacent blocks (Blocks 1 and 2, or Blocks 3 and 4).
The absolute time of a Point Cloud Data Packet is the time when the LiDAR sends a command to trigger a round of firing that will be stored in Blocks 1 and 2.

Calculation

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

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

■ Start Time of Each Block

Assuming that the absolute time of a Point Cloud Data Packet is t0, the start time of each block (the time when the first firing starts) can be calculated.

Single Return Mode

Block	Start Time (μs)
Block 1	t0 + 25.71
Block 2	t0 + 25.71 + 166.67
Block 3	t0 + 25.71 + 333.33
Block 4	t0 + 25.71 + 500.00

Dual Return Mode

Block	Start Time (μs)
Block 1 & Block 2	t0 + 25.71
Block 3 & Block 4	t0 + 25.71 + 166.67

■ Firing Time Offset of Each Channel

Assume that the start time of Block m is T(m), $m \in \{1, 2, 3, 4\}$, then the laser firing time of Channel n in Block m is

$$t(m, n) = T(m) + \Delta t + \Delta t(n), n \in \{1, 2, \cdots, 64\}.$$

The timing uncertainty $\Delta t \leqslant 10$ μs.

The lookup table of the firing time offsets $\Delta t(n)$ is on the next page.

Δt(n)—Firing Time Offset of Each Channel (Unit: μs)

(Continued on the Next Page)

Firing Sequence	Channel #	Δt(n)
1	1	2.31
2	2	4.37
3	3	6.43
4	4	8.49
5	5	10.54
6	6	12.60
7	7	14.66
8	8	16.71
9	9	19.16
10	10	21.22
11	11	23.28
12	12	25.34
13	13	27.39
14	14	29.45
15	15	31.50
16	16	33.56
17	17	36.61
18	18	38.67
19	19	40.73
20	20	42.78

Firing Sequence	Channel #	Δt(n)
21	21	44.84
22	22	46.90
23	23	48.95
24	24	51.01
25	25	53.45
26	26	55.52
27	27	57.58
28	28	59.63
29	29	61.69
30	30	63.74
31	31	65.80
32	32	67.86
33	33	70.90
34	34	72.97
35	35	75.02
36	36	77.08
37	37	79.14
38	38	81.19
39	39	83.25
40	40	85.30

Δt(n)—Firing Time Offset of Each Channel (Unit: μs)

(Continued)

Firing Sequence	Channel #	Δt(n)
41	41	87.75
42	42	89.82
43	43	91.87
44	44	93.93
45	45	95.98
46	46	98.04
47	47	100.10
48	48	102.15
49	49	105.20
50	50	107.26
51	51	109.32
52	52	111.38
53	53	113.43
54	54	115.49
55	55	117.54
56	56	119.60
57	57	122.05
58	58	124.11
59	59	126.17
60	60	128.22

Firing Sequence	Channel #	Δt(n)
61	61	130.28
62	62	132.34
63	63	134.39
64	64	136.45

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**

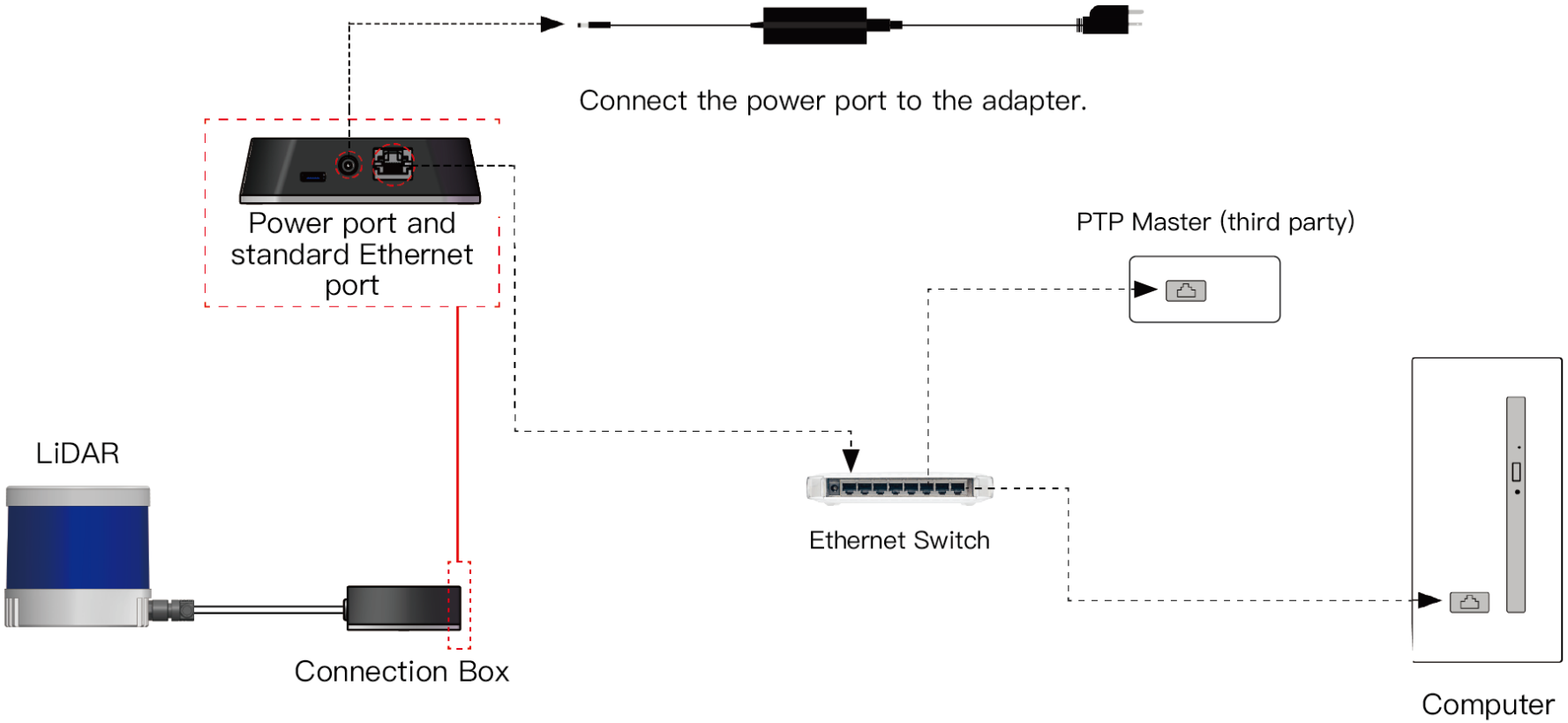


Figure III.1 Connection When Using PTP

■ 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.

NOTE

- 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. No additional setup is required.
- 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 Power Supply Requirements

To ensure that the input voltage at the LiDAR's connector is within 12 to 48 V DC, please check the specifications of the power source and the voltage drop over cables.

The LiDAR uses 22 AWG power cables. We recommend using 22 AWG cables or cables of thicker wire gauges.

- Define the cable length from the power source to the LiDAR's connector as L (unit: m)
- When using 22 AWG (59.4 Ω/km) cables, the estimated cable resistance is r = 0.12L (unit: Ω)
- The LiDAR's peak power consumption is below 24 W in all operating conditions
- Define the source voltage as $U_{in}(V)$, and the cable voltage drop during peak power consumption can be calculated as:

$$U_{drop}(V) = U_{in} - \sqrt{U_{in}^2 - 96r}\,/2$$

Users may also estimate the cable voltage drop using the following lookup table.
When cable length exceeds 10 m, source voltage should be at least 24 V.

Estimation of Cable Voltage Drop

Cable Total Length L	Source Voltage $U_{in} = 12\ V$	Source Voltage $U_{in} = 24\ V$	Source Voltage $U_{in} = 36\ V$
2 m	0.50 V	0.24 V	0.12 V
6 m	1.67 V	0.74 V	0.36 V
10 m	3.30 V (LiDAR's input voltage < 9 V)	1.30 V	0.61 V
15 m	(LiDAR's input voltage < 9 V)	2.00 V	0.92 V

NOTE When the LiDAR's input voltage approaches 55 V, make sure there is no additional overshoot in the external power system. Even a short period of overvoltage can cause irreversible damage to the LiDAR.

Appendix V Certification Info

■ FCC Declaration

FCC ID: 2ASO2PANDARQTV2

FCC Warning

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

FCC Statement

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

NOTE Any changes or modifications not expressly approved by the grantee of this device could void the user's authority to operate the equipment.

■ IC Statement

This device complies with Industry Canada licence-exempt RSS standard(s).

Operation is subject to the following two conditions:
(1) this device may not cause interference, and
(2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence.

L'exploitation est autorisée aux deux conditions suivantes:
(1) l'appareil ne doit pas produire de brouillage, et
(2) l'utilisateur de l'appareil doit accepter tout brouillage radio électrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Appendix VI Support and Contact

■ Technical Support

If your question is not addressed in this manual, please contact us at:

service@hesaitech.com
www.hesaitech.com
https://github.com/HesaiTechnology

NOTE Please leave your questions under the corresponding GitHub projects.

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