Hummingbird D1-R

LiDAR User Manual

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Preface

Product Name

Hummingbird D1-R LiDAR

Manufacturer

Seyond Inc.

Legal Information

Manual Overview

- This manual introduces the Hummingbird D1-R LiDAR (hereinafter referred to as “HD1-R” or "LiDAR"), covering installation, usage, maintenance, troubleshooting, disposal, as well as software operation and LiDAR configuration instructions.
- This manual is intended for project developers (R&D personnel, designers), installers, electrical professionals, safety specialists, and maintenance personnel.

Original Documentation

This document is the original documentation from Seyond Inc.

Manual Notes

- This document covers usage instructions and troubleshooting measures for common scenarios. However, it cannot guarantee a complete resolution to all issues. If you encounter other problems during product use, please contact Seyond personnel promptly.
- This manual will be updated as product technology advances. For the latest user manual, please consult Seyond personnel.
- All features described herein are for reference only. Actual product functionality may vary. For specific feature requirements, contact Seyond technical support.

Phone: +01 (650) 963-9573 (US)

Email: info@cn.seyond.com

Precautions

As this product involves laser technology, carefully read this manual before use and strictly observe all precautions to avoid hazards. During operation, strictly follow the procedures outlined in this manual.

Safety Precautions

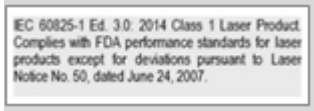
- Before using the product, carefully read this manual and strictly follow the relevant instructions.
- To reduce the risk of electric shock and avoid voiding the warranty, do not disassemble or modify the LiDAR. This product contains no user-serviceable parts. For maintenance and repairs, consult a Seyond-certified service technician.

WARNING

Using controls, adjustments, or operating procedures not specified in this manual may result in harmful radiation leakage.

WARNING

- Class 1 laser product.
- The metal housing of the laser LiDAR is an integral part of the product. Do not open or disassemble it.
- Failure to follow the instructions in this manual for using, controlling, adjusting, or operating the LiDAR may result in serious radiation hazards.
- This product incorporates a protective enclosure and fault scanning design. Personnel will not come into contact with or be exposed to radiation emitted by the laser system during use or maintenance.
- Do not use this product if the protective enclosure is removed or fault scanning measures are disabled.
- Do not install the laser LiDAR near any heat sources, such as radiators, heat registers, stoves, or other heaters.
- Repair of laser-powered components must be performed only by Seyond service personnel or personnel certified by Seyond.



WARNING

This product complies with the following standard：

- IEC 60825-1:2014
- 21 CFR 1010.2，US FDA Laser Notice 56.

Electrical Safety

- Power the product using the supplied cable and power adapter provided by Seyond.
- Using damaged cables or adapters in damp environments may cause fire, electric shock, personal injury, product damage, or other property loss.

Burn Prevention

- Prolonged contact with hot surfaces of the product may cause discomfort or injury.
- To prevent heat buildup, ensure adequate ventilation around the device.
- The device may become hot during extended operation. It is recommended to wait several minutes after powering off before touching it.

Usage& Maintenance

This product is constructed of metal, glass, and plastic, and contains sensitive electronic components inside.

- Do not drop, burn, puncture, impact, or crush this product.
- If you suspect the product is damaged under any circumstances, immediately cease use to prevent injury to users or damage to the product.
- Users (including customer engineering developers, 4S shop maintenance personnel, drivers, etc.) are strictly prohibited from disassembling or maintaining this product. Disassembly may cause product damage, compromise waterproof performance, or result in personal injury.
- Do not touch the LiDAR optical lens with your hands to prevent performance degradation. For optimal performance, regularly inspect the LiDAR optical lens for cleanliness.

Follow these steps to clean the optical lens:

① Prepare a clean, lint-free cloth. Moisten the cloth with alcohol and wring it out thoroughly.

② Moisten the LiDAR optical lens with the cloth f o r 1 minute. Avoid wiping the LiDAR optical lens.

③ Wait 1 minute, then gently wipe away any residue from the optical lens using a clean, lint-free cloth. Dry thoroughly.

④ Use high-quality paper towels or lens-cleaning paper to wipe the window clean. Avoid applying excessive force to prevent damage to the optical coating.

Emergency Cleaning Procedure

1. Use a clean, slightly damp tissue.
2. Wipe the lens gently.

Product Window Lens Cleaning Precautions

- Clean after rain, snow, or dusty conditions.
- Clean immediately when obvious dirt (mud, insects) is present.
- Clean at least once per month.
- Wash hands thoroughly or wear PVC powder-free cleanroom gloves before handling the product. Do not touch the window directly with your hands to avoid fingerprints or contamination on it.
- Dust-free clothes used to wipe the device body must not be reused to clean the LiDAR window glass.
- The outer surface of the LiDAR window is coated. When cleaning, observe the following precautions:

  Avoid direct skin contact with the optical window.
- Do not use corrosive cleaners or solvents. Do not use paper towels for cleaning to prevent scratching the material.
- Do not touch the window with hard or sharp objects to avoid scratches. If scratches have already occurred, stop using the product and contact Seyond technical support.

Operating Environment

- Do not subject the product to strong vibrations. Do not place it in an environment with strong mechanical shocks or vibrations. For impact and vibration performance parameters, please contact Seyond staff for technical support.
- Products should be packed with shockproof materials to avoid damage during transportation.
- Do not look directly at the transmitted laser through magnifying devices (such as microscopes or magnifying glasses), even though the product is designed to meet Class 1 eye safety standards. For maximum self-protection, users should avoid looking directly at the laser while it is in operation.
- Do not view the transmitted laser through other electronic devices.
- Do not place this product near flammable or explosive materials.
- Do not expose this product to areas with explosive atmospheres, such as those containing high concentrations of flammable chemicals or vapors.
- Do not expose this product to environments with high concentrations of industrial chemicals, including near volatile liquefied gases (such as helium), to prevent damage or impairment of product functionality.

Radio Frequency Interference

Before use, carefully read the certification and safety information on the product's back label. Although the product is designed, tested, and manufactured in compliance with relevant regulations for radio frequency energy radiation, radiation from the product may still cause other electronic devices to malfunction.

Medical Device Interference

Certain components and radio devices within this product emit electromagnetic fields that may interfere with medical devices such as cochlear implants, pacemakers, and defibrillators. Consult your physician and medical device manufacturer for specific information regarding your medical device, including whether a safe distance from this product is required. If you suspect this product is interfering with your medical device, discontinue use immediately.

End-of-Life Disposal

This LiDAR product has no special requirements for disposal or rescue operations.

1. Product Description

1.1. Product Introduction

❖ **Product Overview**

The Hummingbird D1-R is a high-performance short-range wide-angle LiDAR built on Seyond's next-generation all-solid- state platform. It features an ultra-wide field of view of 140° (horizontal) x 100° (vertical) and high resolution of 0.55° (horizontal) x 0.52° (vertical), with a minimum blind spot of just 10 cm. The Hummingbird D1-R delivers stable, high-quality point cloud data even in harsh environments, demonstrating superior reliability and longevity. It finds extensive applications in robotics, smart infrastructure, and other fields.

❖ **Product Features**

- Modular design offers compact size, low power consumption, and lightweight advantages.
- Ultra-wide-angle and high-precision design while maintaining a standard 30m range measurement capability, meeting diverse requirements across various scenarios.
- Ultra-small ranging blind spot enables accurate detection of obstacles at extremely close distances.
- Complies with international Eye-safety Class 1 (IEC-60825) requirements.

1.2. Working Principle

This product employs Time-of-Flight (TOF) measurement for distance detection:

1) The laser transmitter emits an ultra-short laser pulse.

2) The laser strikes an object, causing diffuse reflection, and the laser receiver detects the reflected light.

3) By measuring the time the laser beam takes to travel through the air, the distance from the target object to the sensor can be accurately calculated.

Therefore, the measured distance is expressed as:

$$d = \frac{ct}{2}$$

d: Distance c: Speed of light t: Time of flight of the laser beam

1.3. Structure Description

The Hummingbird D1-R is a pure solid-state flash LiDAR with a laser source wavelength of 940 nm.

The three-dimensional coordinate system is defined as follows.

- x is perpendicular to the ground and points upward.
- y is parallel to the ground and points to the right.
- Z is parallel to the ground and points forward.

- The point cloud center is located at the exact center of the RX lens surface.
- The crosshair center is located on the RX lens axis, 17.5 mm along the Z direction from the front surface of the LiDAR.

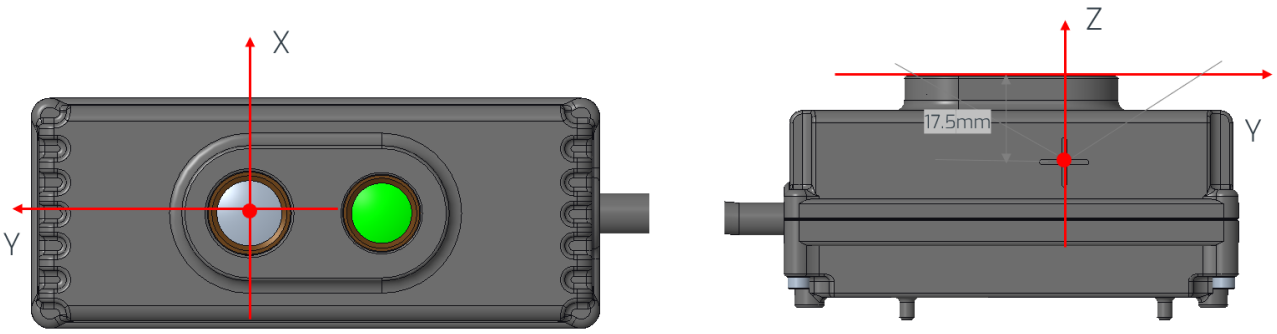


Figure 1. Schematic of LiDAR Coordinate System

1.4. Scanning Mode

The Hummingbird D1-R employs a 2D addressable VCSEL array scanning mode.

FOV: Horizontal 140°, resolution 0.55°; Vertical 100° (-50° to 50°), resolution 0.52°.

An example of the LiDAR point cloud distribution is shown in the figure.

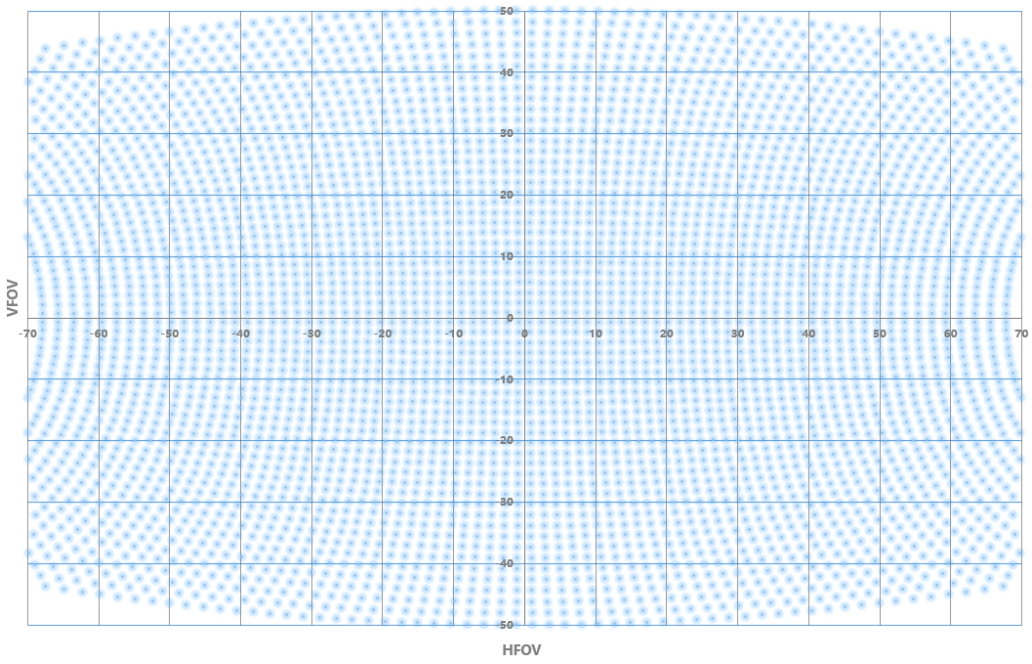


Figure 2. HD1-R Point Cloud Distribution Example

1.5. Product Dimensions

Hummingbird D1-R dimensions（H×W×D）: 37.4mm × 92.4mm × 45mm

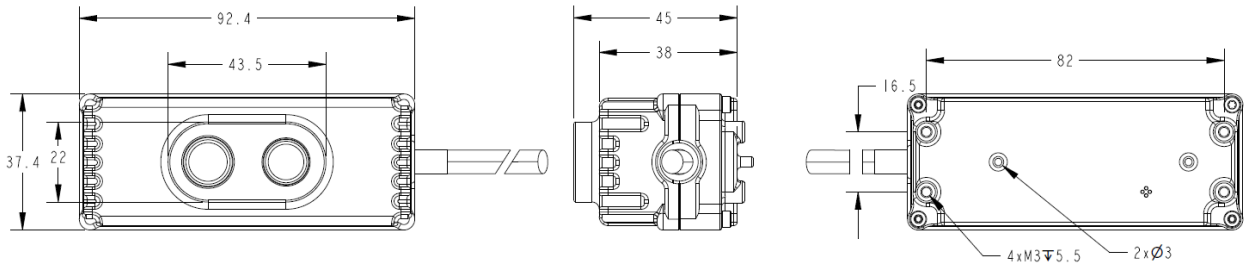


Figure 3. HD1-R External Dimensions Diagram

1.6. Technical Specifications

Detection Capability	
Laser Wavelength	940 nm
Detection Range	0.1–50 m
Detection Distance	30m@10% standard reflector
Distance Measurement Precision	< 3cm @ 1σ
Distance Measurement Accuracy	±3cm
Field of View (H × V)	140° × 100°
Angular Resolution (H × V)	0.55° × 0.52°
Frame Rate	10 FPS
Operating Conditions	
Operating Voltage	9-32V DC
Operating Current	0.45A@12V
Power Consumption	6W
Operating Temperature	-40°C to 75°C
Safety Protection Rating	IP67
Compliance Certifications	IEC 60825-1:2014 Class 1 Eye Safety
Mechanical Structure	
Dimensions (H × W × D)	37.4mm * 92.4mm * 45mm
Weight	220g
Connector	M12 aviation connector
Transmission Control	
Data Transmission Interface	TCP/UDP
Data Output	100BASE-TX
Points per Second	490,000 pts/s
Point Cloud Data Transfer Rate	Single Echo 19.68Mbps
Time synchronization	PTP, GPTP, NTP, PPS
Echo Mode	Single Echo

IMU	Built-in IMU：ICM-45686

Table 1. Technical Specifications

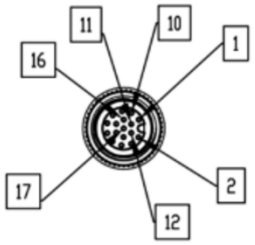
Note:

Here, the temperature for typical operating conditions is defined as 20℃.

For any changes to the parameter table, please refer to the latest product manual or consult the after-sales service team.

1.7. Electrical Interface

The pin assignment of HD1-R is as shown below:

Name	Description
LiDAR Interface Cable	 Pin definitions are as follows. [1] : Power Interface (Ground) [2] : Power Interface (Ground) [3] : Power Interface (Ground) [4] : Unused pin [5] : D0_3V3（reserved） [6] : GPMC_3V3 [7] : PPS_3V3 [8] : M12 shielding layer [9] : Power Supply Interface (Positive): [10] : Power Supply Interface (Positive) [11] : Power Supply Interface (Positive) [12] : Unused pin [13] : Ethernet signals transmit port [14] : Ethernet signals transmit port [15] : Ethernet signals receive port

	[16] : Ethernet signals receive port [17] : Unused pin

Table 2. Cable Connection Interface Specifications

1.8. System Connection Method Description

Refer to the diagram below for connection instructions between LiDAR, MetAdaptor 1.0, and other auxiliary devices.

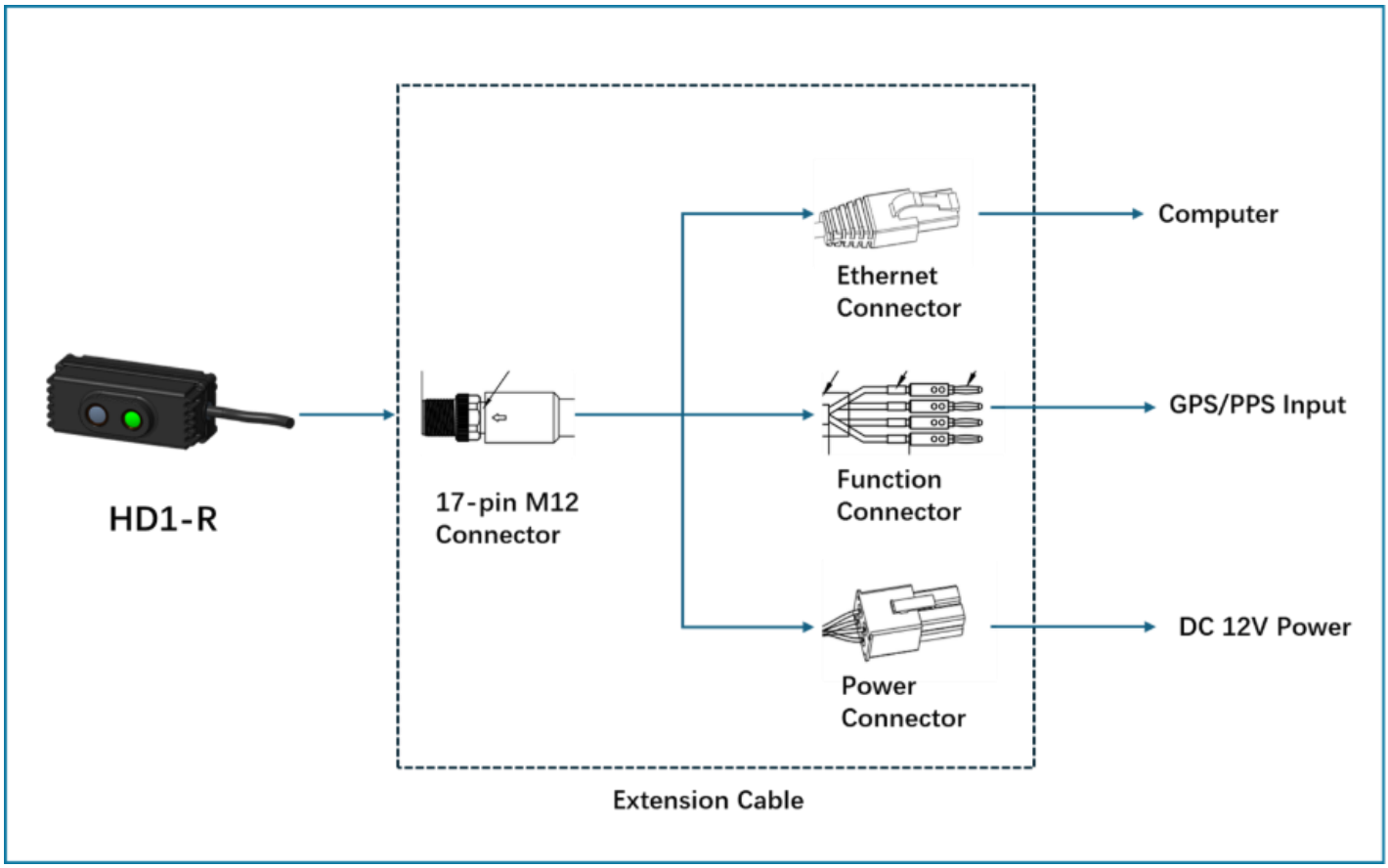


Figure 4. HD1-R Auxiliary Device Connection Example

1.9. Point Cloud Coordinate System

The point cloud coordinate system for Hummingbird D1-R is defined as follows:

X is perpendicular to the ground and points upward.

Y is parallel to the ground and points to the right.

Z is parallel to the ground and points forward.

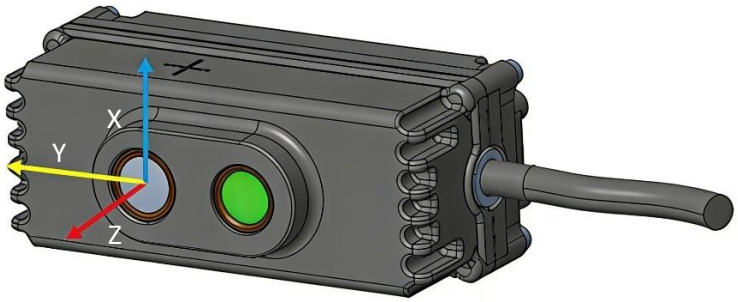


Figure 5. Diagram of LiDAR Point Cloud Coordinate System

2. Installation Method

Notes:

Before installing the Hummingbird D1-R LiDAR, please carefully read the following notes:

1. Dust or contamination on the optical window will affect LiDAR performance. It is recommended to clean the window according to the maintenance instructions in this manual before installation.
2. The LiDAR's field of view (FOV) must not be blocked. Even transparent glass placed in front of the lens can affect performance.
3. The LiDAR mounting structure only ensures the LiDAR's own mechanical reliability; the LiDAR body must not bear any additional external loads.
4. It is recommended to use thermal interface material (TIM) between the LiDAR and the mounting bracket to increase heat dissipation area. The heat dissipation structure should align with airflow direction for more effective cooling.

The mechanical installation drawing of the LiDAR is shown as follows.

Figure 6. Installation of LiDAR

2.1. Bracket Design and Installation Recommendations

a) The LiDAR can be directly mounted and fixed through an adapter bracket (recommended manufacturing processes: die-casting or stamping/bending). Positioning and fixation are achieved via the threaded holes and locating pins shown below.

b) The rear cover of the LiDAR is equipped with four M3 threaded holes and two locating pins (diameter = Ø3 mm).

c) The flatness of the LiDAR mounting surface should be less than 0.3 mm.

d) The effective thread depth of the LiDAR screw holes is 5.5 mm. It is recommended to use M3 × 0.5, grade 8.8 screws, with a tightening torque of 1–1.2 N·m.

e) The mounting structure or adapter bracket must consider static strength, random vibration, and mechanical

shock conditions. It should have sufficient rigidity to avoid degrading point cloud quality.

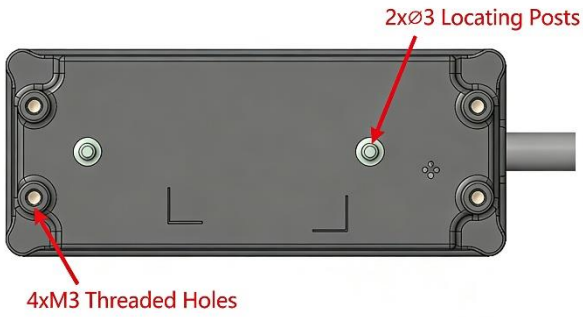


Figure 7. Installation of LiDAR

2.2. Thermal Environment Requirements

a) The front housing and rear housing of the LiDAR are the primary heat dissipation surfaces.

b) The installation must ensure clearance around all sides of the LiDAR. A minimum distance > 6.5 mm is recommended to prevent interference under extreme conditions and to ensure proper airflow for heat dissipation.

c) It is recommended to use thermal interface material between the LiDAR and the mounting bracket to increase the heat dissipation area. The heat dissipation design should align with the direction of natural airflow.

d) The bracket material should have thermal conductivity greater than 50 W/m·K, such as ADC12 aluminum alloy.

e) A typical mounting bracket design is shown below (refer to original image in the source document).

f) Ensure that the LiDAR's base or top cover is not covered by non-metallic material, and avoid any thermal insulation materials around the LiDAR to prevent overheating.

g) For harsher installation environments, it is recommended to provide the installation CAD model to Seyond for thermal simulation verification.

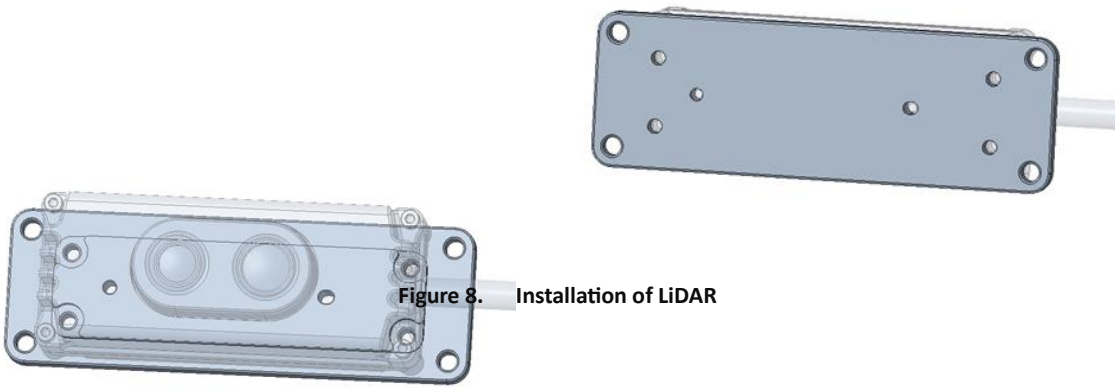


Figure 8. Installation of LiDAR

3. Modifying LiDAR Configuration Parameters

3.1. Modify LiDAR IP

Note:

- The system has no power switch; it is ready for use immediately after powering on.
- In the steps, `package.tgz` refers to the LiDAR SDK file name. Obtain the latest SDK file based on your system's actual configuration.
- The LiDAR's default IP address is: 172.168.1.10; Default subnet mask is: 255.255.255.0; Default gateway is:172.168.1.1.

1) Connect the power supply when starting the system to power it on.
2) After 7–13 seconds of power-on, the system completes initialization and begins generating data.
3) Connect the host computer to the LiDAR and ensure the network connection is active.
4) Extract the SDK files.

```
tar -xzvf ..<package.tgz>
```

5) Enter the file directory.

```
cd ~/SDK_file_path/apps/tools/lidar_util
```

6) Modify the LIDAR IP address. Users may adjust the LIDAR's IP address, subnet mask, and gateway as needed.

```
./ innovusion_lidar_util <ip of LIDAR> set_network <new_ip_address> <new_netmask_address>
[new_gateway_address]
```

7) After performing a soft reboot on the LiDAR, the IP address modification was successful.

```
./innovusion_lidar_util <ip of LIDAR> soft_reboot //<ip of LIDAR> isthe IP address beforemodification
```

3.2. Modify the LiDAR port

Note：

- Ensure the LiDAR is powered on. The system lacks a physical power switch; it becomes operational upon powering up.
- In the steps, `package.tgz` is the SDK file name for the LiDAR. Obtain the latest SDK file based on your system's actual configuration.

1) Connect the host computer to the LiDAR and ensure the network connection is active.
2) Extract the SDK file.

```
tar -xzvf ..<package.tgz>
```

3) Switch to administrator privileges and navigate to the file directory.

```
sudo su // Enter administrator password

cd ~/<SDK file path>/apps/tools/lidar_util
```

4) Download the PCS_ENV configuration file.

./innovusion_lidar_util <ip of LIDAR> download_internal_file PCS_ENV <filename> //<filename> is the name of the file to download

```
root@sza0287:/home/demo/Robin util# ./innovusion_lidar_util 172.168.1.10 download_internal_file
PCS_ENV pcs.env
root@sza0287:/home/demo/Robin util#
```

5) Install VIM.

```
sudo apt install vim
```

6) Enter the PCS_ENV file.

```
sudo vim <filename>
```

7) Press the "i" key on your keyboard to enter insert mode and modify the port.

```
TCP_SERVICE_PORT=8010
UDP_IP=0.0.0.0
UDP_PORT_DATA=8010
UDP_PORT_MESSAGE=8010
UDP_PORT_STATUS=8010
STATUS_INTERVAL_MS=50
LOG_OPTION="--log-filename /tmp/inno_pc_server.txt --log-file-rotate-number 3 --log-file-max-size-k 2000"
MIN_RUN_TIME=5
```

8) Exit edit mode by typing `:wq` to save and exit the PCS_ENV file.

9) Upload the PCS_ENV file.

. /innovusion_lidar_util <ip of LIDAR> upload_internal_file PCS_ENV <filename> //<filename> is the name of the file to upload

```
root@sza0287:/home/demo/Robin util# ./innovusion_lidar_util 172.168.1.10 upload_internal_file PC
S_ENV pcs.env
before upload_internal_file PCS_ENV, need to verify parameters
2023-07-27 17:24:19.405 [ INFO] 28804 utils.cpp:440 open pcs.env
upload_internal_file PCS_ENV pcs.env succeed.
root@sza0287:/home/demo/Robin util#
```

10) After powering off and restarting the LiDAR, the port modification takes effect.

4. Software Operation

4.1. ROS1 Environment Operations

This section is based on Ubuntu 20.04 with ROS version noetic.

4.1.1. Acquire Point Cloud Data

Note:

- Ensure the system is powered on before launching the ROS driver.
- After system shutdown, power-on, or software restart, the ROS driver must be restarted.
- For ROS environment installation instructions, refer to http://wiki.ros.org/.

1) Connect the computer/host machine to the LiDAR and ensure the network connection is active.

2) Modify the computer's IP address so that it is in the same subnet as the LiDAR's IP address.

Note:

1. The LiDAR's default IP address is: 172.168.1.10.
2. It is recommended to use the ping command to verify the connection between the host computer and the LiDAR.

3) Check the computer/host system version to obtain the corresponding driver. Copy the driver to the system root directory and execute the `dpkg -i` command to install the driver.

```
dpkg -i < package.deb>
```

Note:

`package.deb` refers to the LiDAR driver name. Please obtain the latest driver version based on your actual system configuration. Currently supported system versions are listed in Table 3.

System Version	CPU Category	Support Status
Ubuntu 18.04	ARM	Support
	X86	Support
Ubuntu 20.04	ARM	Support
	X86	Support

Table 3 System Version Support

4) Execute the `roscore` command to run the ROS environment.

```
roscore
```

5) Execute the following command to retrieve LiDAR point cloud data.

```
roslaunch seyond start.launch lidar_ip:=172.168.1.10 udp_port:=8010
```

Note:

Default LiDAR IP 172.168.1.10, UDP destination port 8010,

4.1.2. View LiDAR Point Cloud Status

Note:

Before viewing LiDAR point cloud status, ensure point cloud data has been correctly acquired.

1) Execute the `rviz` command to launch ROS's graphical visualization tool, rviz. Upon successful execution, the return value will appear as shown below, indicating the rviz client has been opened.

```
rviz -f seyond
```

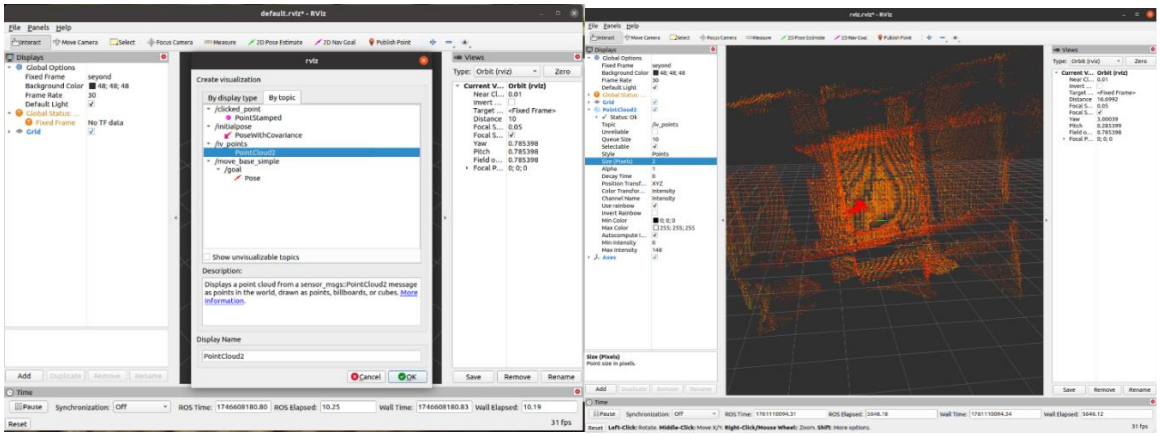
2) Add and configure PointCloud2.

- Add PointCloud2 to the [Displays] section.

  ① Select [Add] > [By topic] > [/iv_points] > [PointCloud2].

  ② Click OK.

- Select 【PointCloud2】 > 【Style】 and modify the Style value to Points.



4.1.3. Record LiDAR Point Cloud Data

Users can record LiDAR point cloud data in .bag format within the ROS environment.

Note:

- Before recording LiDAR point cloud data, ensure point cloud data is correctly acquired via ROS.
- For details on acquiring point cloud data, refer to Acquire Point Cloud Data.

1) Execute the following command to record point cloud data in .b a g format. Recording begins at the time the command is executed.

```
rosbag record /iv_points -o inno // Begins recording point cloud data in the current directory. The name of the file will be "inno-year-month-day-hour-minute-seconds.bag".
```

2) Press Ctrl+C to stop point cloud data recording.

3) (Optional) Run the ls -a command to view the recorded LiDAR point cloud data files.

4.1.4. Playback LiDAR Point Cloud Data

Users can playback LiDAR point cloud data files in .bag format using ROS.

Note:

- Before replaying LiDAR point cloud data, please ensure you have obtained the recorded point cloud data file.

1) Execute the `roscore` command to run the ROS environment.

```
roscore
```

2) Open a new terminal window and execute the rviz command to launch ROS's graphical visualization tool, rviz.

```
rviz -f seyond
```

3) Open a new terminal window and execute the following command to playback LiDAR point cloud data in rviz.

```
rosbag play <bag-file> -l
```

4) Then select the corresponding point cloud in rviz. For instructions, see View LiDAR point cloud status.

4.1.5. Shutdown the system

Disconnect the power supply to complete the shutdown.

4.2. ROS2 Environment Operations

The procedures in this section apply only to Ubuntu 20.04 with ROS version foxy.

4.2.1. Acquire Point Cloud Data

Note:

- Ensure the system is running before starting the ROS driver.
- After system shutdown, startup, or software restart, the ROS driver must be restarted. For ROS 2 environment installation instructions, refer to https://docs.ros.org.

1) Connect the computer/host machine to the LiDAR and ensure the network connection is active. Refer to the cable connection guide for connection methods.

2) Modify the computer's IP address to ensure it is in the same subnet as the LiDAR's IP address.

Note:

- The LiDAR's default IP address is: 172.168.1.10.
- It is recommended to use the ping command to verify the connection between the host computer and the LiDAR.

3) View system details to obtain the corresponding driver. Copy the driver to the system root directory and execute the `dpkg -i` command to install the driver.

```
sudo dpkg -i <package.deb>
```

Note:

- In the steps, `package.deb` is the LiDAR driver name. Obtain the latest driver version based on your system's actual configuration. Refer to Table 4 for currently supported system versions.

System Version	CPU Category	Support Status
Ubuntu 18.04	ARM	Support
	X86	Support
Ubuntu 20.04	ARM	Support
	X86	Support

Table 4. Supported System Versions

4) Acquire LiDAR point cloud data.

```
source /opt/ros/foxy/setup.bash
ros2 launch seyond start.py lidar_ip:=<LIDAR_IP>
```

Notes:

- Default LiDAR IP: 172.168.1.10, UDP destination port: 8010,

4.2.2. View LiDAR Point Cloud Status

Note:

- Before checking the LiDAR point cloud status, ensure point cloud data has been correctly acquired.

1) Execute the `rviz2` command to launch ROS's graphical visualization tool, rviz. Upon opening, the return value will appear as shown below, indicating the rviz client has been launched.

```
rviz2 -f seyond
```

2) Add and configure PointCloud2.

- Add PointCloud2 to the [Displays] section.

  ① Select 【Add】 > 【By topic】 > 【/iv_points】 > 【PointCloud2】.

  ② Click OK.

- Select 【PointCloud2】 > 【Style】 and change the Style value to Points.

4.2.3. Record LiDAR Point Cloud Data

Users can record LiDAR point cloud data in .bag format within the ROS environment.

Note:

- Before recording LiDAR point cloud data, ensure point cloud data is correctly acquired via ROS.
- For details on acquiring point cloud data, refer to Acquire Point Cloud Data.

1) Execute the following command to record point cloud data in .b a g format. Recording begins at the time the command is executed.

```
ros2 bag record /iv_points // Begins recording point cloud data in the current directory.
```

2) Press Ctrl+C to stop recording point cloud data.

4.2.4. Playback LiDAR Point Cloud Data

Users can playback LiDAR point cloud data files in .bag format via ROS.

Note:

- Ensure you have obtained the recorded point cloud data file before playing back LiDAR point cloud data.

1) Open a new terminal window and execute the `rviz` command to launch ROS's graphical visualization tool, rviz.

```
rviz2 -f seyond
```

2) Open a new terminal window and execute the following command to replay LiDAR point cloud data in rviz.

```
ros2 bag play <bag-file> -l
```

3) Then select the corresponding point cloud in rviz. For instructions, refer to View LiDAR Point Cloud Status

4.2.5. Shutdown the system

Disconnect the power supply to power off the system.

5. Data Transmission Method

The device supports acquiring the LiDAR's point cloud data via the UDP protocol. This section describes the data transmission process between the server and client over UDP, and how to obtain LiDAR information.

Under the UDP protocol, the LiDAR acts as the client, while the customer equipment/servers act as the server(s). The client (LiDAR) actively sends data to one or more servers.

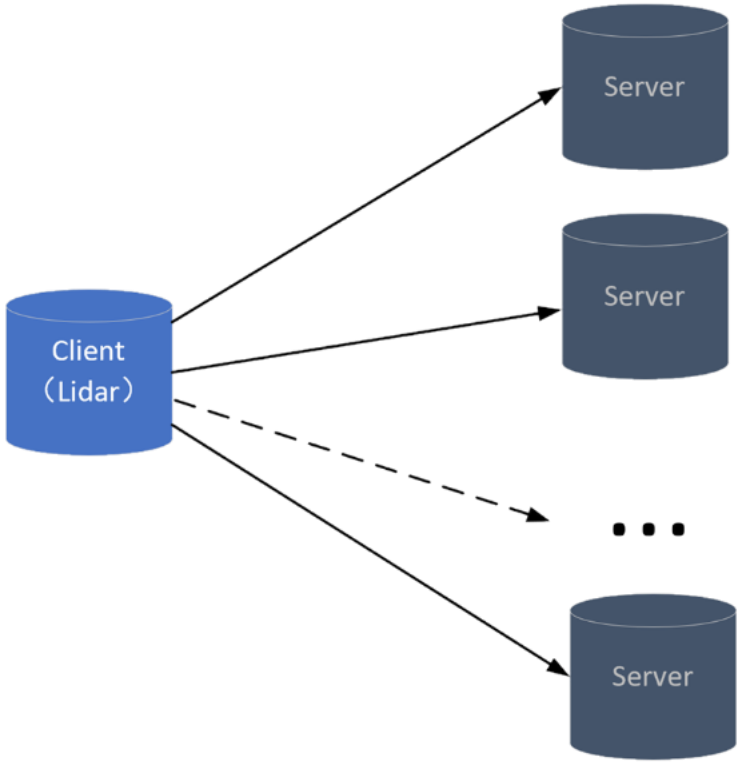


Figure 9. Data Transmission Method Diagram

5.1. Modifying Transmission Mode

Under the UDP protocol, users can modify the data transmission mode based on actual conditions.

1) Unzip the SDK files.

```
mkdir inno-lidar-sdk
tar -zxvf <SDK file> -C inno-lidar-sdk
```

Note:

Please obtain the latest SDK file based on your system's actual configuration.

2) Navigate to the file directory.

```
cd inno-lidar-sdk/apps/tools/lidar_util
```

3) Execute the following command to download the PCS_ENV file.

```
./innovusion_lidar_util 172.168.1.10 download_internal_file PCS_ENV <file name>
```

4) Open the PCS_ENV file and modify the UDP_IP field information as needed.

- **Broadcast Mode:** UDP_IP=eth0. eth0 is the default name of the network card in LiDAR.
- **Multicast Mode:** UDP_IP=<Multicast_Address>. The LiDAR sends data to all devices within the same subnet. All devices within this subnet can obtain the LiDAR point cloud data via the SDK.
- **UDP Unicast Mode:** UDP_IP=<Device_IP>. The Device IP value corresponds to the host computer's IP address within the same internal network as the LiDAR. In unicast mode, only this host computer can obtain LiDAR point cloud information via UDP transmission.

5) Execute the following command to upload the PCS_ENV file.

```
./innovusion_lidar_util 172.168.1.10 upload_internal_file PCS_ENV <file name>
```

Appendix A LiDAR Upgrade

If users require an upgrade, please contact Seyond staff to obtain the .img format package. The upgrade package includes both firmware and software updates.

1) Obtain the .img format upgrade package and connect the computer/host machine containing the package to the LiDAR, ensuring the network connection is active.
2) Modify the IP address so that the computer's IP address is in the same subnet as the LiDAR's IP address.
3) Open the Chrome browser and enter the LiDAR's IP address in the address bar.
4) Click Recovery/Update File.
5) Click [Select File], choose the required upgrade package, and click [Open].
6) Click Start Recovery/Update to begin the upgrade.
7) After the upgrade is completed, power off and restart the system.
8) (Optional) Version information can be viewed on the System info page.

Appendix B Abbreviations and Terminology

Abbreviation	Full Name
AC	Alternating Current
DC	Direct Current
ETH	Ethernet
FAQ	Frequently Asked Questions
FOV	Field of View
GEN	Generation
GND	Ground
GPS	Global Positioning System
H × W × D	Height × Width × Depth
HFOV	Horizontal field of view
IP	Internet Protocol
LiDAR	Light Detection and Ranging
MAC	Media Access Control
MEC	Multi-Access Edge Computing
NTP	Network Time Protocol
PD	Point of detection
PPS	Pulse Per Second
PTP	Precision Time Protocol
PWR	Power
ROI	Region of Interest

Abbreviation	Full Name
ROS	Robot Operating System
SDK	Software Development Kit
SN	Serial Number
SW	Software
TCP	Transmission Control Protocol
TOF	Time of Flight
UDP	User Datagram Protocol
VFOV	Vertical field of view

Table 5. Abbreviations

Term	Definition
Class 1 laser products	Laser products for which human exposure to laser radiation at the specified wavelength and emission duration are not permitted to exceed the limits for Class 1 accessible emitters. limit.
NTP	NTP is a protocol used to synchronize computer time, widely used to synchronize computers to Internet time servers, such as radio or satellite receivers or telephone modem services.
PTP	PTP is a high-precision time synchronization protocol used for high-precision time synchronization between devices, but can also be adapted for frequency synchronization between devices.
Installation Personnel	Installation personnel are individuals who have received professional training and possess extensive experience in the relevant field, and who fully understand the application of protective devices on machinery the application of protective devices on the machine and capable of assessing their operational safety status.

Commissioning Personnel	Commissioning personnel are individuals who have received specialized training in the relevant field, possess extensive experience, and fully understand the application of protective devices on machinery and are able to assess their operational safety status.
Time-of-flight measurement method	Time-of-flight measurement achieves distance measurement by determining the time interval between the transmission and reception of signals. The formula can be found in the Working Principle section.
Laser Products	Any product or component assembly used to constitute or prepare for the constitution of a laser or laser system. Electronic components sold as parts to other manufacturers are not considered laser products.
Laser	Primarily generates or amplifies electromagnetic radiation with wavelengths ranging from 180 nanometers to 1 millimeter through a controlled laser emission process.
Laser equipment	A combination of laser products or a laser product that incorporates a laser.
Host Computer	A computer capable of directly issuing control commands. Commands from the host computer are first sent to the slave computer, which then control the equipment based on these commands. The lower-level computer periodically reads the equipment status data, converts it into digital signals, and feeds it back to the
Configuration Personnel	Configuration personnel shall possess relevant professional knowledge and experience in the field, with sufficient expertise to evaluate whether the machine is in a safe operating state after operate safely when protective equipment is in use.
Eye Safety	Although the product design complies with Class 1 eye safety standards, to maximize personal safety, do not directly observe the transmitted laser beam through magnifying devices (e.g., microscopes, magnifying glasses).
Qualified Maintenance Personnel	Qualified maintenance personnel are those who have received professional training in the relevant field, possess extensive experience, fully understand the application of protective devices on the machine and have received instruction from the machine operation supervisor regarding machine operation.

Vehicle Ethernet	Vehicle Ethernet is a new local area network technology for connecting electronic units within a vehicle.

Table 6 Technical Terms

Revision History

Version Number	Revision Details	Revision Date
V1.0	Initial Release	2025/11/14
V2.0	Added descriptions of the built-in IMU module, new mounting methods, and the heat-dissipation bracket.	2025/12/11