Falcon Prime
LiDAR System

User Manual

Preface

Product

Falcon Prime LiDAR

Manufacturer

INNOVUSION

Legal Disclaimer

Overview

This manual provides instructions for the installation, usage, maintenance and diagnostic evaluation of Falcon Prime LiDAR (hereinafter referred to as "Falcon Prime" or "LiDAR"). The contents of the manual are based on the different phases of LiDAR life cycle, including the installation, configuration, and maintenance of the LiDAR.

The intended users of this manual include project developers (R&D personnel and designers), installers, electrical professionals, safety professionals and service personnel.

Original document

This document is the original document owned by Innovusion.

Manual description

Although this document covers instructions to handle the frequent problems, it is still not guaranteed to get all problems fully solved. If you encounter other problems not covered in the manual, please contact Innovusion staff in time. This manual will be updated when new information becomes available.

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E-mail: info@ innovusion.com

Precautions

This user manual provides descriptions about Falcon Prime introduction, installation, transferring, usage, maintenance, diagnostic evaluation, disposal, etc., and software instructions.

Considering this is a laser product (1550 nm), please fully read and comprehend all information within this manual before operation, and keep in mind the precautions to avoid danger. Please strictly follow the instructions and steps described in the manual during operation.

Safety notices

Before using the product, please read this manual carefully and strictly follow the relevant instructions.

To reduce the risk of electric shock and avoid violating the warranty, please do not disassemble or modify the LiDAR without permission. This product does not contain user's serviceable parts. Please consult Innovusion's certified service personnel for maintenance and repair.

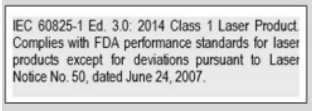
Caution

Use of controls, adjustments or performance of procedures other than those specified for this product may result in hazardous radiation leakage.

Caution

➢ Class 1 laser product.
➢ Failure to use, control, adjust or operate LiDAR as specified herein may result in serious radiation hazards.
➢ The product incorporates a Class 4 fiber laser system which, by itself, may be hazardous. This device incorporates a protective housing and a scan failure safeguard in the machine design such that there is no exposure or human access to laser radiation generated by the fiber laser during operation or maintenance.
➢ UNDER NO CIRCUMSTANCE shall attempts be made to operate the laser with protective housing removed or the scan failure safeguards overridden.
➢ Service procedures when the laser is powered up, are only intended to be operated by Innovusion service personnel or persons trained and certified by Innovusion.

Caution



This product meets the following standards:

- IEC 60825-1:2007
- IEC 60825-1:2014
- 21 CFR 1040.10 and 1040.11, except for the deviation of Laser Notice No.50 issued on June 24, 2007.

Device maintenance

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

- Do not use the product improperly, such as dropping, burning, piercing, bumping or squeezing.
- Once the product falls or hits, it should be shut off immediately. Please contact Innovusion staff for technical support.
- If there is any possibility that the product may have been damaged, please stop using it immediately to prevent the user from being hurt or the product from being damaged during operation.

- Do not touch the LiDAR window with your hands in case of any performance degradation.
- If the LiDAR window is stained, please clean the product as described in the **Cleaning** section of this manual.
- It is strictly forbidden for users to disassemble or modify the device without permission. Dismantling this product may result in product damage, loss of waterproof performance or personal injury.

Electrical safety

- Always use the connecting cable and power adapter provided by Innovusion to supply power.
- Using damaged cables or adapters in a humid environment may lead to fire, electric shock, personal injury, product damage or other property losses.

Heat dissipation

- Long time contact with the hot surface of the product may cause personal discomfort or injury.
- To avoid heat accumulation, please ensure that the device is in well-ventilated surroundings.
- LiDAR may generate high amount of heat during long operation. It is recommended to shut off the power for a few minutes before you touch it.

Operating environment

- Do not subject the product to strong vibration. To obtain specifications please contact Innovusion staff for technical support.
- Do not look directly at the transmitting laser through a magnifying device (such as a microscope and magnifying glass).
- Do not place this product near flammable and explosive materials.
- Do not expose this product to areas with explosive air, such as areas with high concentration of flammable chemicals and steam in the air.
- Do not expose this product to environment with high-density industrial chemicals, including near easily vaporized liquefied gas (e.g. helium), so as to avoid performance degradation.

Radio frequency interference

Before operation, please read through the certification and safety information on the product label. Although the design, testing and manufacturing of the product comply with the relevant provisions of RF energy radiation, the radiation from the product may still lead to the failure of other electronic equipment.

Medical device interference

Some components and radio devices contained in this product will emit electromagnetic fields that may interfere with medical devices, such as cochlear implants, pacemakers and defibrillators. Consult your doctor and medical device manufacturer for specific information about your medical device, e.g. whether you need to keep a safe distance from this product. If there's any possibility that this product is interfering with your medical device, please stop using it immediately.

1 Product description

1.1 Product introduction

❖ **Product overview**

Falcon Prime LiDAR (hereinafter referred to as "Falcon Prime" or "LiDAR" or "FP") is an ultra-long range image-grade LiDAR. The highly integrated LiDAR can achieve an ultra-wide field of view of 120° × 25°， and the angular resolution is as high as 0.05° × 0.05°. Falcon Prime is widely used in fields such as V2X, highway, railway, and other intelligent transportation systems, providing accurate data for road condition management.

❖ **Product features**

- Compact design for easy integration and low maintenance cost
- Wide field of view (FOV), high precision, a long detection range of up to 500 meters, and image-grade pointcloud enable it to meet the demands of various scenarios.
- The 1550 nm laser wavelength meets the requirements of Class 1 in the international eye safety (IEC-60825), providing better eye protection.

1.2 Label description

Table 1 Label description

Serial No.	Name	Serial No.	Name
1	Company's LOGO	2	Product name
3	Product model	4	Rated input

1.3 Time of flight

Innovusion LiDAR system uses time-of-flight (ToF) methodology.

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

2） When the laser is projected onto the object, the diffuse reflection occurs, and the laser detector receives the diffuse reflection light.

3） By measuring the flight time of the laser beam in the air, the distance between the target object and the sensor can be calculated accurately.

Therefore, the measured distance is expressed as:

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

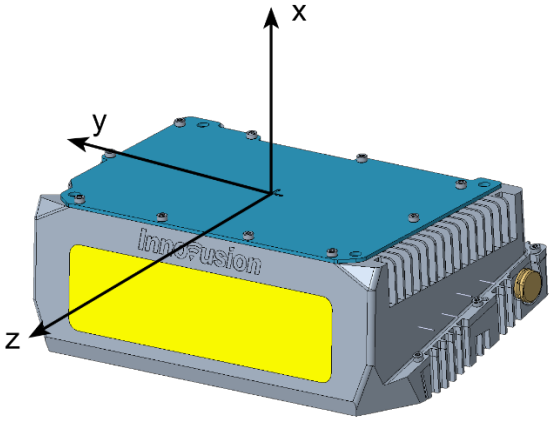
d: distance c: speed of flight t: flight time of the laser beam

1.4 Architecture

Falcon Prime is a semi-solid-state LiDAR with a laser light source wavelength of 1550nm.

The three-dimensional coordinate system is defined as follows.

- x is perpendicular to the ground, pointing up.
- y is parallel to the ground, pointing right.
- z is parallel to the ground, pointing forward.



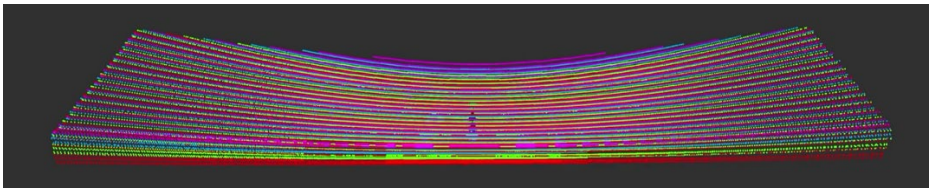
1.5 Scanning pattern

Falcon Prime is designed with dual-axes mirror scanning pattern, which can maximize the point density in specific region of interest (ROI). The pointcloud density of ROI is about six times that of the non-ROI. By sending commands from the server to the LiDAR, the ROI is adjusted in real time within the entire FOV.

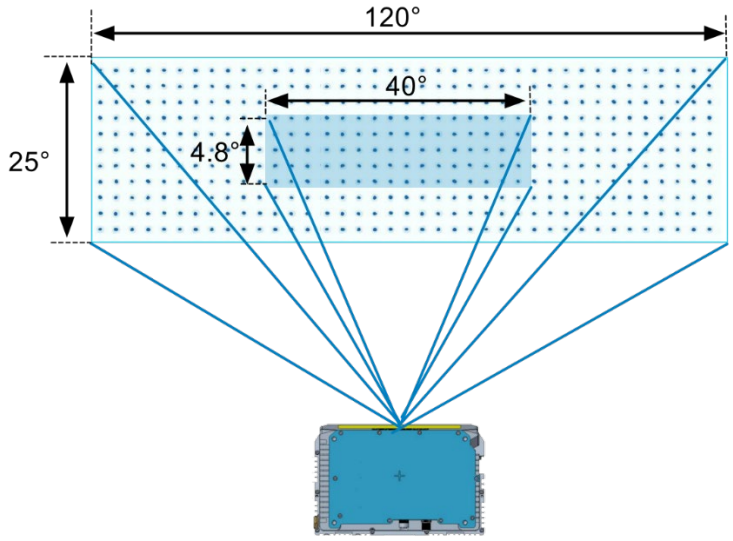
FOV (H × V): 120°×25°. Angular resolution (H × V): 0.18°×0.24°.

FOV in ROI (H × V): 40°×4.8°. Angular resolution in ROI (H × V): 0.09°×0.08°.

An example of the LiDAR scan is shown in the figure.



The diagram of the scanning area is as follows

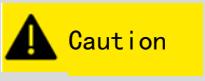


1.6 Specifications

Table 2 Specifications

Performance	
Maximum detection range	500 m
Detection range (10% reflectivity)	250 m
Detection range (blind area)	≤ 2 m
FOV (H × V)	120° × 25°
Angular resolution (H × V)	0.18° × 0.24°
FOV in ROI (H × V)	40° × 4.8°, configurable
Angular resolution in ROI (H × V)	0.09° × 0.08°
Distance accuracy	± 5 cm
Distance precision	± 2 cm@1σ
Vertical scanning lines	1500 lines/s, configurable
Frame rate	10 FPS
Reliability	
Safety protection	IP67K (body), IP69K (window)
Working temperature	-40°C ~ +75°C
Laser wavelength	1550 nm
Laser safety	Class-1 (IEC-60825)
Electrical and Data	
Rated voltage	24V DC
Power consumption	< 34W

Data transmission	1000Base-T Ethernet M12/RJ45 (UDP, TCP)
Data transmission cable length	15/25 m, configurable
Data output	Pointcloud (X,Y,Z) intensity or reflectivity
Time synchronization	NTP, PTP and gPTP
Timestamp accuracy	10 µsec resolution for each data point
Mechanical	
Dimension (W × H × D)	228 ×84 × 148 mm
Weight	2.3 kg



Specifications subject to change without notice.

2 Installation

2.1 Precautions for installation

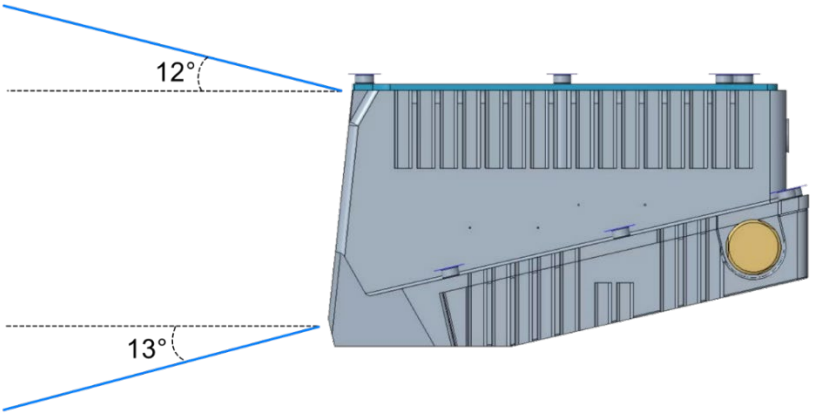
Please follow the instructions below during installation of Falcon Prime.

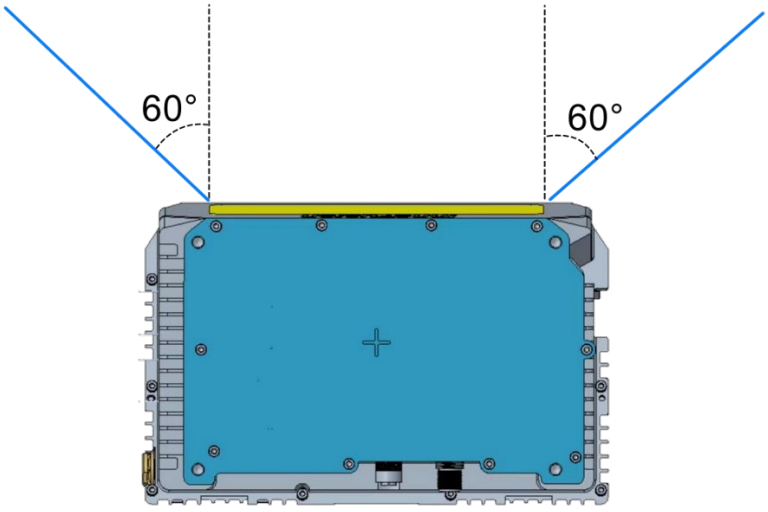
Personnel requirements

Only qualified and trained professionals can install it.

Installation

- If parts are damaged or lost during installation, please contact Innovusion staff for support.
- Make sure the LiDAR installation surface is flat.
- It is recommended that the mounting surface be made of aluminum alloy, which is helpful to the heat dissipation of the LiDAR.
- Make sure that the LiDAR cable keeps a certain degree of slackness.
- A space of 5 cm should be reserved at the outlet of the LiDAR to facilitate wiring.
- Before installing the LiDAR, please make sure that the installation position does not block the LiDAR angle of view. The vertical viewing angle of the LiDAR is -13 °~+12°, and the horizontal viewing angle of the LiDAR is -60 °~+60°. The specific viewing angle of the LiDAR is shown in the figure below.





Storage

- Please store the product in a well-ventilated and dry place.
- Without the official consent of Innovusion and under severe conditions, do not continuously immerse the product in water to avoid harmful effects. (Avoid exposing the product to an environment exceeding the Ingress protection rating)

Transportation

- The equipment should be packed in a packing box filled with cushioning materials. This can help avoid damage to the products during transportation.
- Please handle it with care. It is strictly prohibited to impact, to avoid damage or direction deviation of optical components in the LiDAR.
- Consider whether handling tools or assistants are needed, think about the space and location during transportation, and minimize the handling distance.
- Do not place the device in an unstable position or handle it in an incorrect posture in case of device damage and personal injury.

Disposal of packaging materials

➢ Packaging materials are recyclable. Please dispose of them correctly when they are discarded.
➢ Packaging bags, cartons or plastic films should be kept out of reach of infants and young children to avoid injury or suffocation.

2.2 Installation instructions

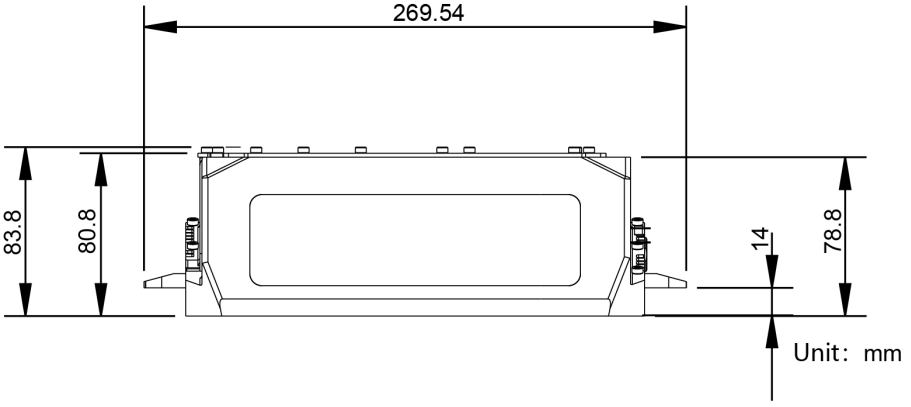
2.2.1 Power description

The power supply voltage of Falcon Prime LiDAR is 24V DC, and the power consumption is less than 34W in normal working conditions.

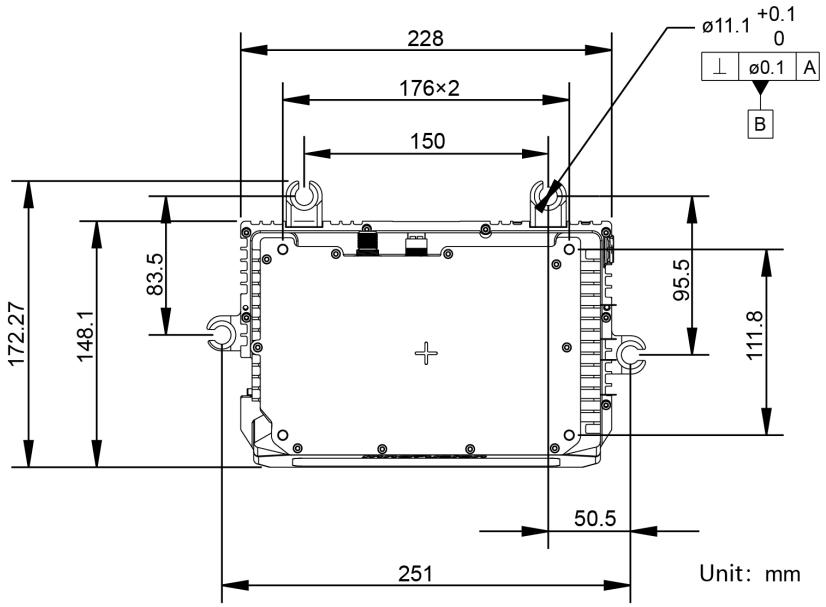
2.2.2 Dimensions

According to different application scenarios, Falcon Prime has two forms: with lugs and without lugs. This section will introduce the product dimensions in two forms.

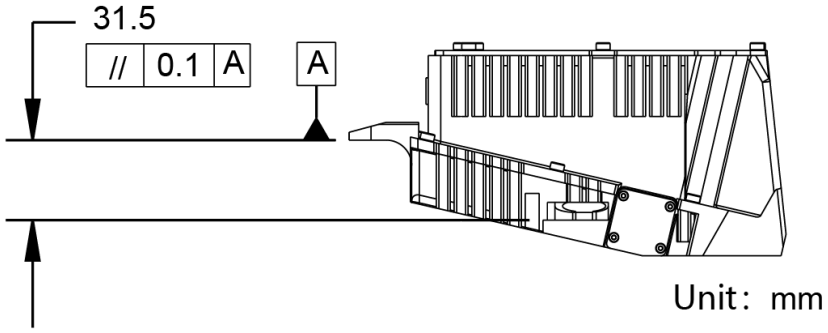
❖ **Dimensions (with lugs)**



Main view

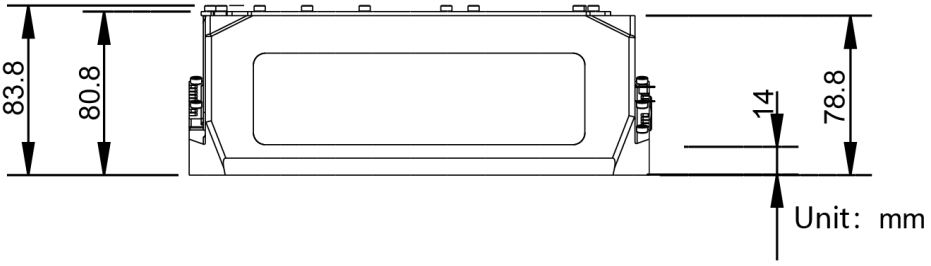


Top view

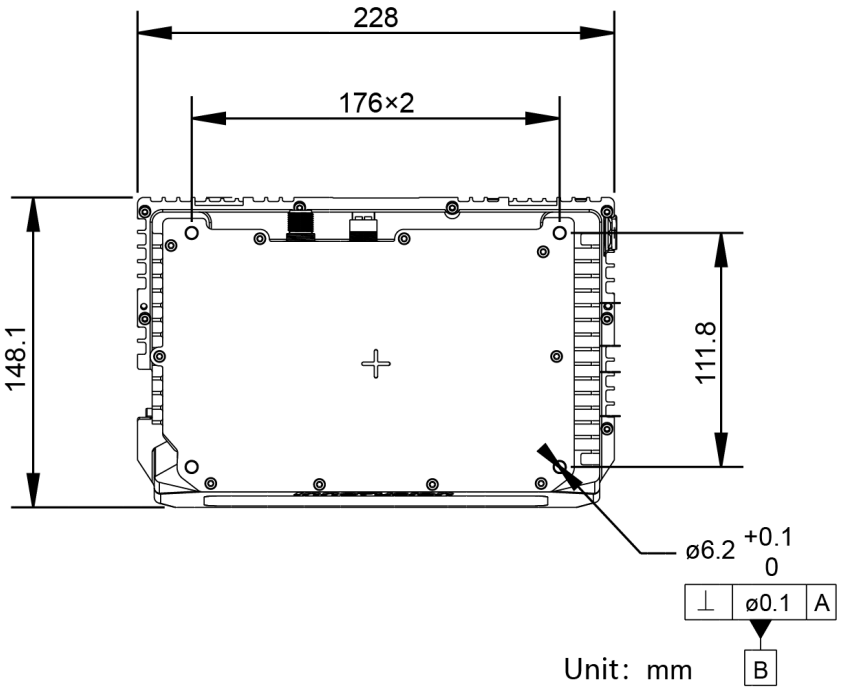


Left view

❖ **Dimensions (without lugs)**



Main view



Top view

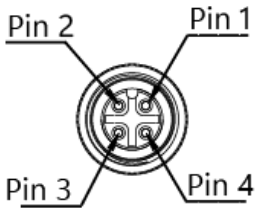
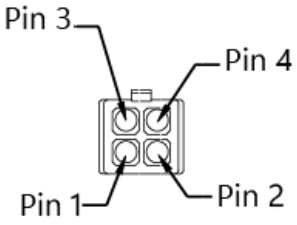
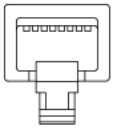
2.2.3 Cable description

Falcon Prime provides different cables according to the application scenarios. This section will introduce the cables used in two scenarios.

❖ **Highway and V2X Scenarios**

Table 3 Cable description in highway and V2X scenarios

Serial No.	Name	Description
1	Power interface	M12-4 core Female Connector Pins are defined as follows.

		 [1]: Power supply [2]: Power supply [3]: Grounding [4]: Grounding
2	Power interface	Pins are defined as follows.  [1]: Grounding [2]: Grounding [3]: Power supply [4]: Power supply
3	Network interface	M12 X-coded Male connector Pins are defined as follows.  [1]: Tranceive Data+ [2]: Tranceive Data- [3]: Receive Data+ [4]: Receive Data- [5]: Bi-directional Data+ [6]: Bi-directional Data- [7]: Bi-directional Data- [8]: Bi-directional Data+
4	Network interface	RJ45 Interface. Pins are defined as follows.  [1]: Tranceive Data+ [2]: Tranceive Data- [3]: Receive Data +

		[4]: Bi-directional Data+ [5]: Bi-directional Data- [6]: Receive Data- [7]: Bi-directional Data+ [8]: Bi-directional Data-

❖ **Railway Scenario**

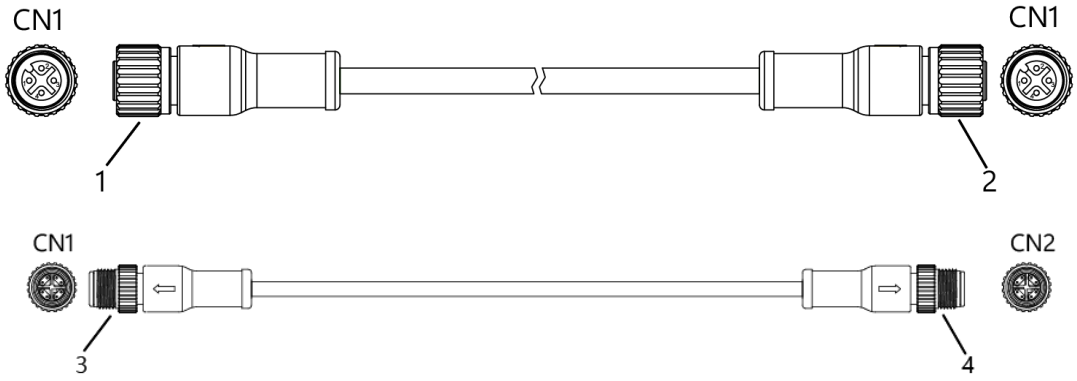


Table 4 Cable description in railway scenario

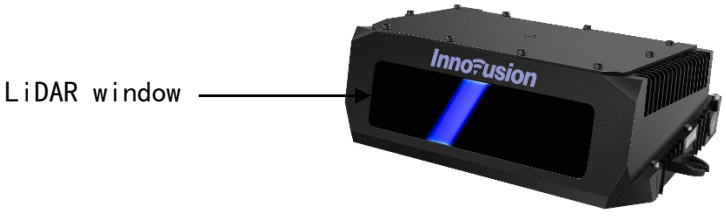
Serial No.	Name	Description
1	Power interface	M12-4 core Female Connector Pins are defined as follows.  [1]: Power supply [2]: Power supply [3]: Grounding [4]: Grounding
2	Power interface	Pins are defined as follows.  [1]: Power supply [2]: Power supply [3]: Grounding [4]: Grounding
3	Network interface	M12 X-coded Male connector Pins are defined as follows.

		 [1]: Tranceive Data+ [2]: Tranceive Data- [3]: Receive Data+ [4]: Receive Data- [5]: Bi-directional Data+ [6]: Bi-directional Data- [7]: Bi-directional Data- [8]: Bi-directional Data+
4	Network interface	M12 X-coded Male connector Pins are defined as follows.  [1]: Tranceive Data+ [2]: Tranceive Data- [3]: Receive Data+ [4]: Receive Data- [5]: Bi-directional Data+ [6]: Bi-directional Data- [7]: Bi-directional Data- [8]: Bi-directional Data+

2.3 Cleaning

For optimal performance of LiDAR, it is important to regularly check whether the LiDAR window is clean or not. The steps for cleaning the optical window are as follows.

- Prepare a clean microfiber cloth, soak it in the alcohol and wring it out.
- Loose the debris from LiDAR window with the clean dust-free wiper for 1 minute. Do not wipe dirt directly off the LiDAR window glass without loosening it sufficiently.



- Wait for 1 minute, gently wipe the window with the clean microfiber cloth and dry it.

➢ Wipe the window with a high-quality paper towel or mirror paper. Do not apply excessive force to avoid damaging the optical coating.

➢ Please wash your hands or wear PVC powder-free clean gloves before touching the product.
➢ The dust-free wiper that has wiped the sensor body should not be used to wipe the LiDAR window glass.
➢ The LiDAR window is made of glass. Please pay attention to the following items when cleaning:

- Avoid direct skin contact with the optical window.
- Do not use corrosive cleaners and solvents.
- Do not use paper towels to clean to avoid scratching the window.

3 System operation

You can operate the LiDAR in the following methods.

- Operate the LiDAR in the Robot Operating System (ROS).
- Operate the LiDAR on the Innovusion Lidar Appliance (ILA) platform.
- Operate the LiDAR in Docker.
- Operate the LiDAR by the SDK command.

This chapter only introduces the first three methods of operating LiDAR. For more information, please contact Innovusion staff.

3.1 change LiDAR IP address

- Start the system after connecting to the power supply.
- The system completes initialization and generates data after powering on for 11-18 seconds.

Caution	➢ The system does not have a power switch. It will become operational when power is applied.

- Connect the server to the LiDAR to ensure that the network is connected.
- Unzip SDK files.

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

Caution	➢ In the steps, package.tgz is the name of the LiDAR SDK file. Please obtain the latest SDK file according to the actual situation of the system.

- Enter the file directory.

```
$ cd ~/apps/pcs/ innovusion_lidar_util
```

- Change the LiDAR IP address. Users can change the IP address, netmask address and gateway address of the LiDAR according to their needs.

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

- After the LiDAR is powered off and restarted, the IP address of the LiDAR is changed.

Caution	➢ The default LiDAR IP address is 172.168.1.10.

3.2 Operate in ROS

3.2.1 Start the system

- Start the system after connecting to the power supply.
- The system completes initialization and generates data after powering on for 11-18 seconds.

Caution	➢ The system does not have a power switch. It will become operational when power is applied.

3.2.2 Obtain pointcloud data

Caution	➢ Make sure the system is turned on before starting the ROS driver. ➢ After the system is shut down, opened, or the software is restarted, the ROS driver needs to be restarted. ➢ Please turn off the pointcloud in ILA service before using ROS to obtain pointcloud data. ➢ For the installation method of ROS, please refer to http://wiki.ros.org/.

- Connect the computer/server to the LiDAR to ensure that the network is connected. For the connection method, refer to **Cable connection**.
- Modify the computer IP address so that the computer IP address and LiDAR IP address are in the same network segment.

Caution	➢ The default LiDAR IP address is 172.168.1.10. ➢ It is recommended to check the access to the LiDAR IP address by using the ping command. You should make sure that the computer is connected to the LiDAR network.

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

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

Caution	➢ package.deb is the driver name of the LiDAR. Obtain the latest driver version based on the actual system conditions.

- Execute the `roscore` command to run ROS. When the driver is installed correctly, the return value is shown in the figure.

```
roscore
```

```
demo@demo-OMEN-by-HP-Laptop-16-b0xxx:~$ roscore
... logging to /home/demo/.ros/log/a09b36de-9f71-11ec-874a-c85acfaa1d16/roslaunch-demo-OMEN-by-HP-Laptop-16-b0xxx-9812.log
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://demo-OMEN-by-HP-Laptop-16-b0xxx:42677/
ros_comm version 1.14.12


SUMMARY
========

PARAMETERS
 * /rosdistro: melodic
 * /rosversion: 1.14.12

NODES

auto-starting new master
process[master]: started with pid [9822]
ROS_MASTER_URI=http://demo-OMEN-by-HP-Laptop-16-b0xxx:11311/

setting /run_id to a09b36de-9f71-11ec-874a-c85acfaa1d16
process[rosout-1]: started with pid [9833]
started core service [/rosout]
```

- Obtain the pointcloud data of the LiDAR. When pointcloud data is obtained correctly, the return value is shown in the figure.
  - If the TCP port is used, execute the following command to obtain the pointcloud data of the LiDAR.

```
source /opt/ros/melodic/setup.bash
roslaunch innovusion_pointcloud innovusion_points.launch device_ip:= <device_ip> port:=< TCP_port >
processed:= <Processed_number>
```

  - If the UDP port is used, execute the following command to obtain the pointcloud data of the LiDAR.

```
source /opt/ros/melodic/setup.bash
roslaunch innovusion_pointcloud innovusion_points.launch device_ip:= <device_ip> udp_port:= <UDP_port>
processed:= <Processed_number>
```

Caution The default value of device_ip is 172.168.1.10. By default, the port number is 8010, and Processed_number is 1.

```
demo@demo-OMEN-by-HP-Laptop-16-b0xxx:~$ source /opt/ros/melodic/setup.bash
demo@demo-OMEN-by-HP-Laptop-16-b0xxx:~$ roslaunch innovusion_pointcloud innovusion_points.launch
... logging to /home/demo/.ros/log/fa995632-a0e0-11ec-970d-c85acfaa1d16/roslaunch-demo-OMEN-by-HP-L
aptop-16-b0xxx-5048.log
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://demo-OMEN-by-HP-Laptop-16-b0xxx:40029/

SUMMARY
========

PARAMETERS
 * /innovusion_nodelet_manager_cloud/aggregate_frames: 1
 * /innovusion_nodelet_manager_cloud/apd_data:
 * /innovusion_nodelet_manager_cloud/background_input:
 * /innovusion_nodelet_manager_cloud/background_output:
 * /innovusion_nodelet_manager_cloud/cali_data:
 * /innovusion_nodelet_manager_cloud/calibration:
 * /innovusion_nodelet_manager_cloud/continue_live: 1
 * /innovusion_nodelet_manager_cloud/coordinate_mode: 0
 * /innovusion_nodelet_manager_cloud/debug_ref_time:
 * /innovusion_nodelet_manager_cloud/delay_correction:
 * /innovusion_nodelet_manager_cloud/device_ip: 172.168.1.10
 * /innovusion_nodelet_manager_cloud/e_data:
 * /innovusion_nodelet_manager_cloud/extended_packet_format: False
 * /innovusion_nodelet_manager_cloud/fe_data:
 * /innovusion_nodelet_manager_cloud/file_rewind: 0
```

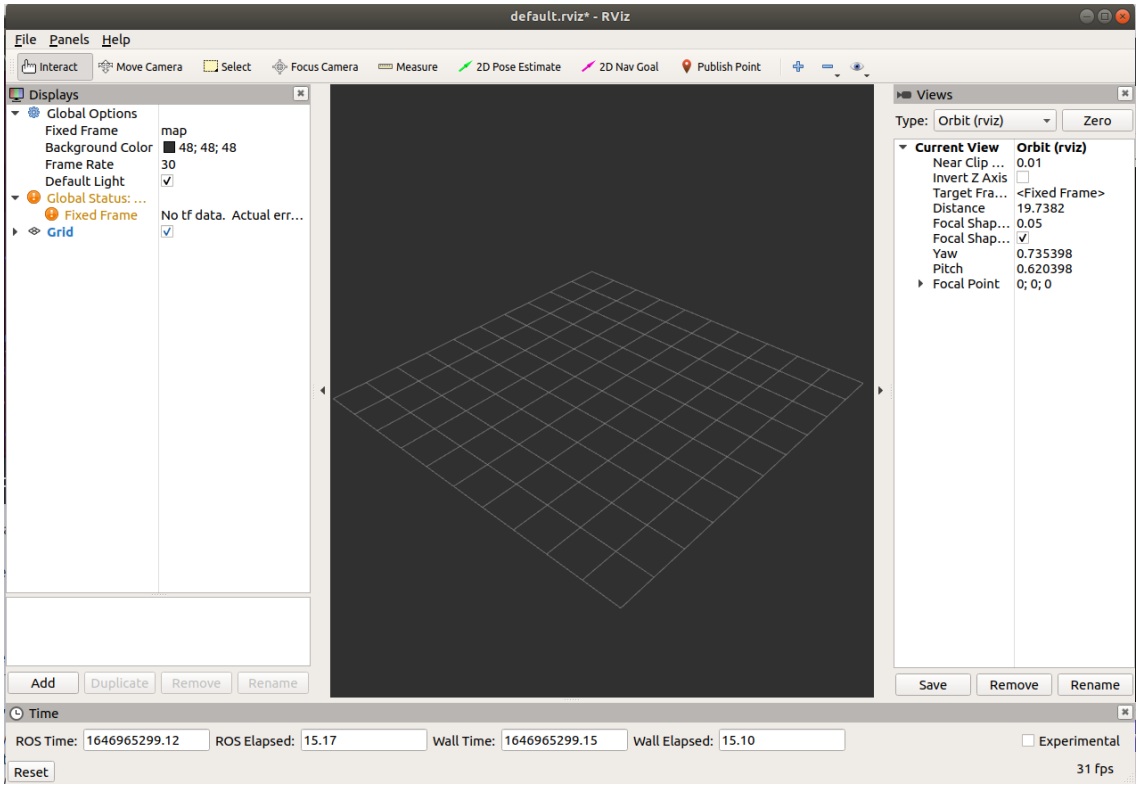
3.2.3 View LiDAR pointcloud data

> **Caution** Before viewing the pointcloud data, please confirm that the pointcloud data has been correctly obtained.

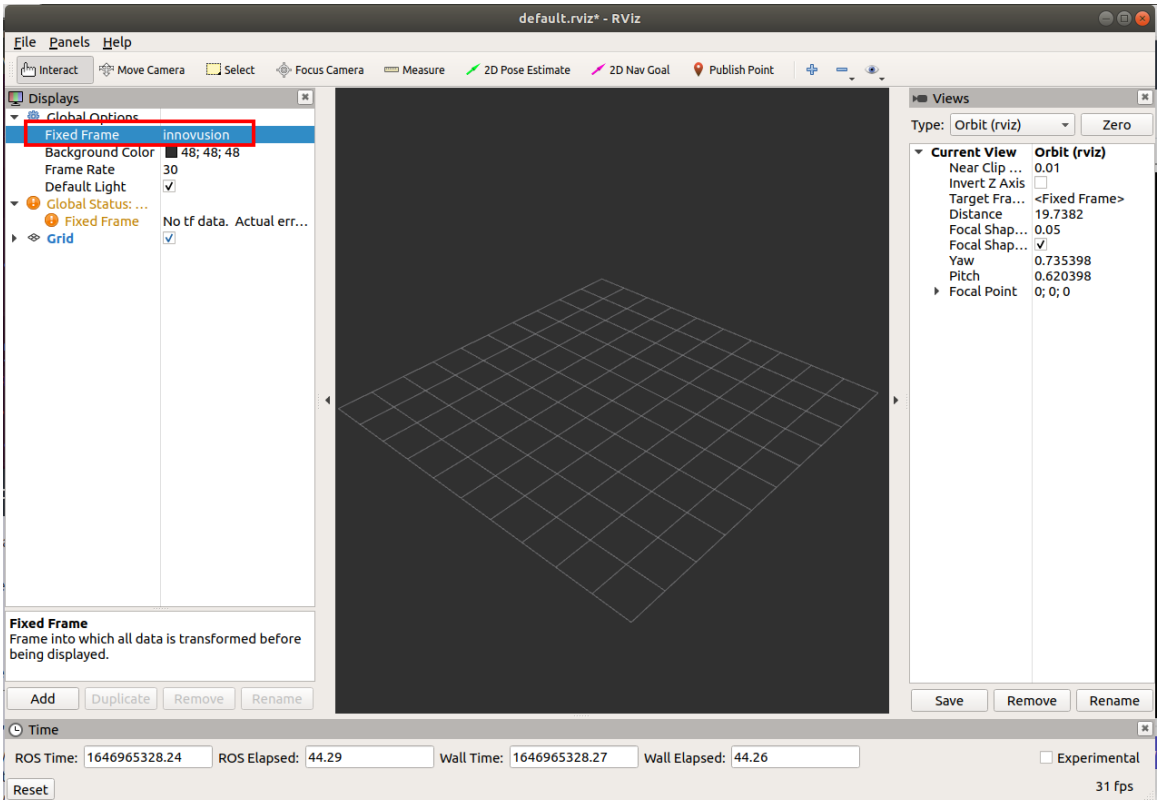
➢ Execute the rviz command to start the graphical tool rviz of ROS. The return value is shown below, and the rviz client is started.

```
rviz
```

```
demo@demo-OMEN-by-HP-Laptop-16-b0xxx:~$ rviz rviz
[ INFO] [1646808931.535449917]: rviz version 1.13.21
[ INFO] [1646808931.535492615]: compiled against Qt version 5.9.5
[ INFO] [1646808931.535502544]: compiled against OGRE version 1.9.0 (Ghadamon)
[ INFO] [1646808931.539157206]: Forcing OpenGl version 0.
[ INFO] [1646808932.122437501]: Stereo is NOT SUPPORTED
[ INFO] [1646808932.122552411]: OpenGL device: NVIDIA GeForce RTX 3060 Laptop GP
U/PCIe/SSE2
[ INFO] [1646808932.122633840]: OpenGl version: 4.6 (GLSL 4.6).
QObject::connect: Cannot queue arguments of type 'QVector<int>'
(Make sure 'QVector<int>' is registered using qRegisterMetaType().)
QObject::connect: Cannot queue arguments of type 'QVector<int>'
(Make sure 'QVector<int>' is registered using qRegisterMetaType().)
```

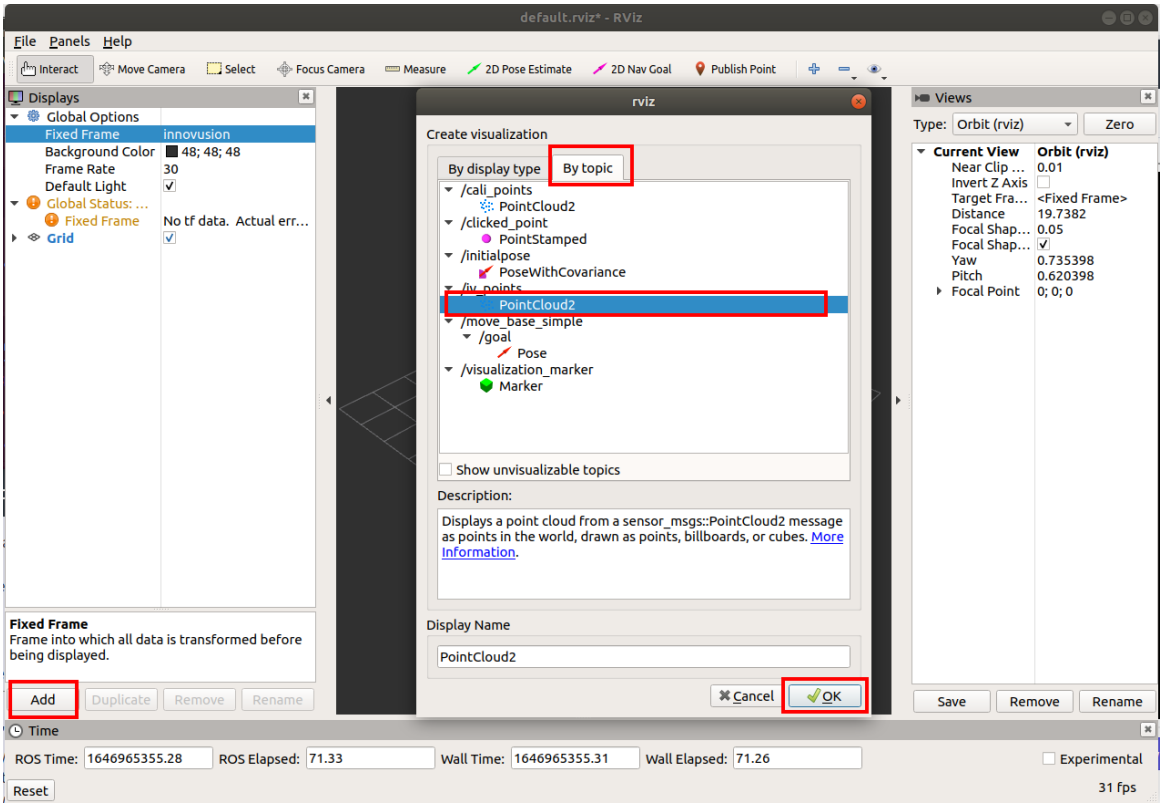


➢ Select [Global Options] > [Fixed Frames], and modify the value to **innovusion**.

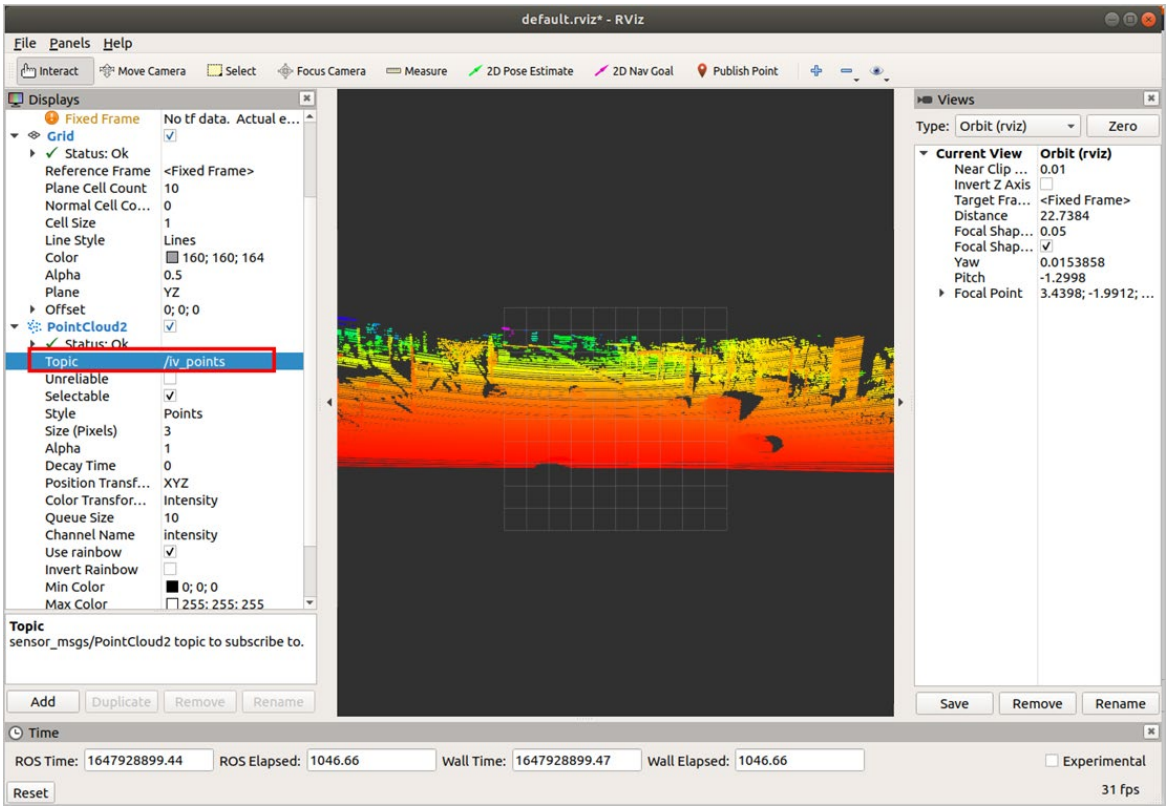


➢ Add and adjust **PointCloud2**.

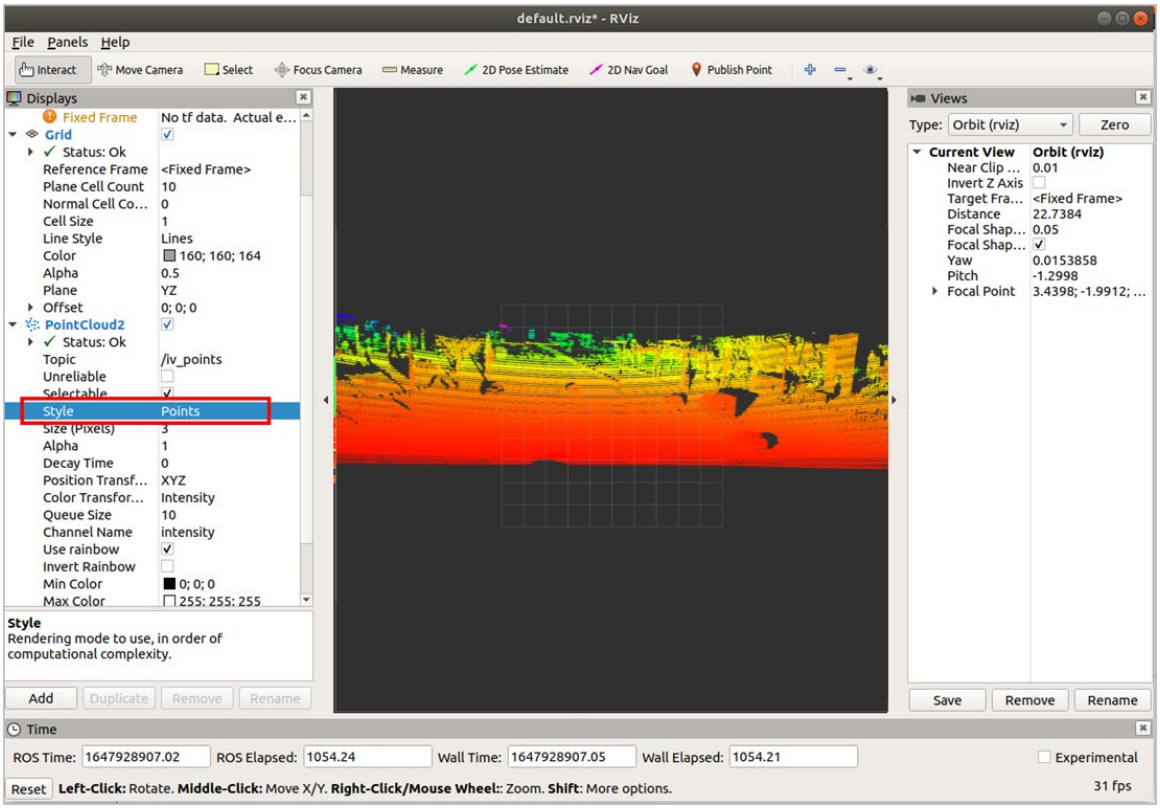
- Add **PointCloud2** to the [**Displays**] column.
  - Click **Add.**
  - Select [By topic] > [iv_points] > [PointCloud2].
  - Click **OK**.



- Select [PointCloud2] > [Topic] and modify the **Topic** value to **/iv_points**.

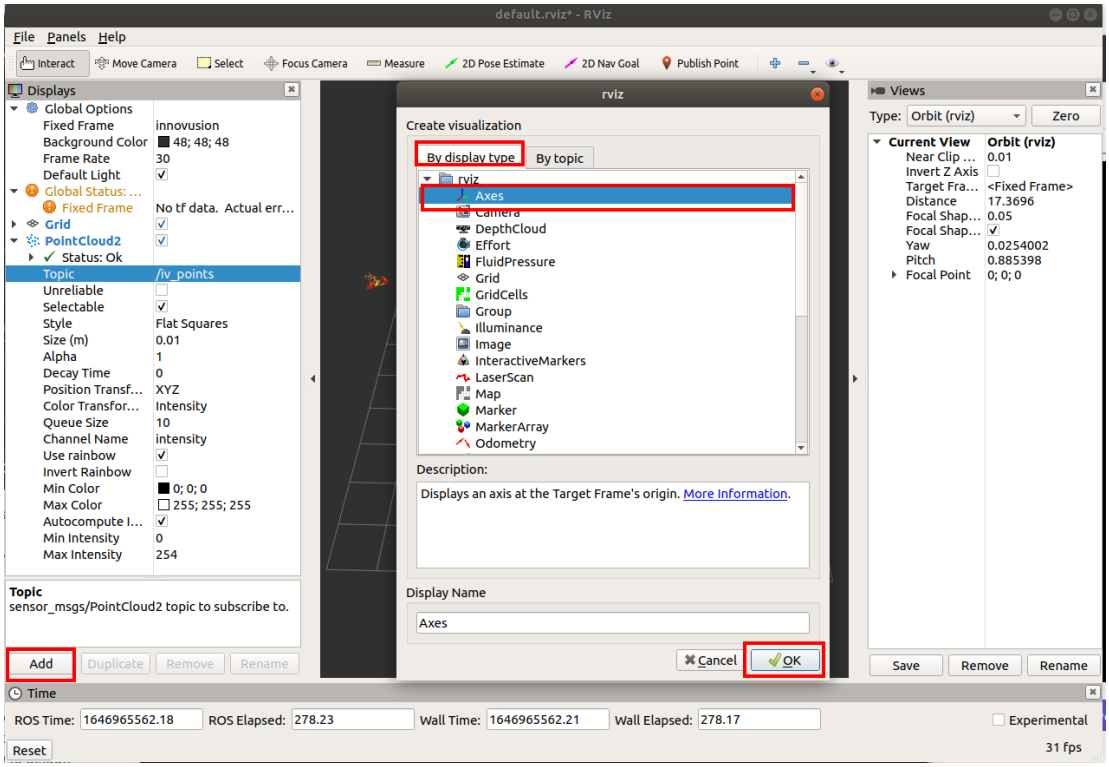


- Select [PointCloud2] > [Style], and modify the **Style** value to **Points**.

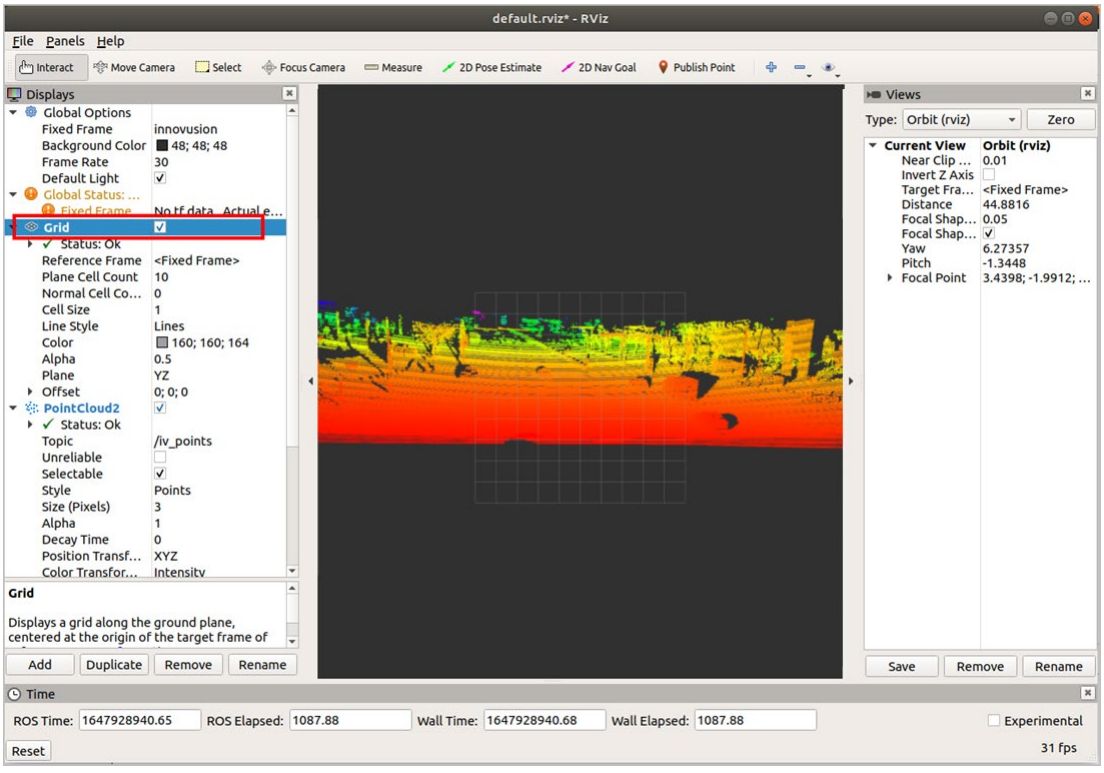


➢ (Optional) The users can switch the angle and distance with the mouse to view the real-time pointcloud status of the LiDAR, and view more information as needed.

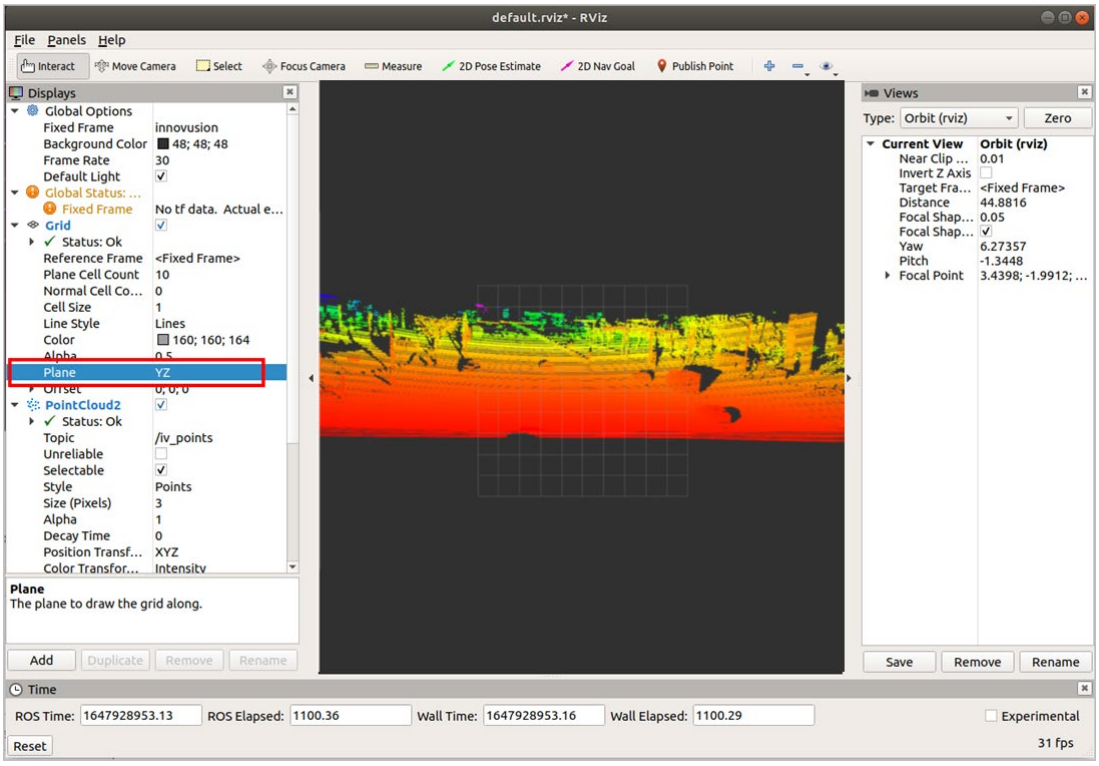
- You can add **Axes** to display the coordinate system on the pointcloud state diagram as a reference.
  - Select [Add] > [By display type] > [Axes].
  - Click **OK** to add **Axes**.
  - Select **Axes** to display the coordinate system on the pointcloud state diagram as a reference.



- Select **Grid** to display the grid on the pointcloud state diagram as a reference. Grid is enabled by default when rviz is enabled.



- Modify the **plane** value to get the pointcloud state diagram under different reference coordinates. There are three optional **plane** values: **XY**, **XZ** and **YZ**.



3.2.4 Record LiDAR pointcloud data

Users can record the pointcloud data of the LiDAR in bag format in ROS.

Caution

➢ Before recording the pointcloud data of the LiDAR, please confirm that the pointcloud data has been correctly obtained. For information on how to get pointcloud data, see **Getting pointcloud data**.

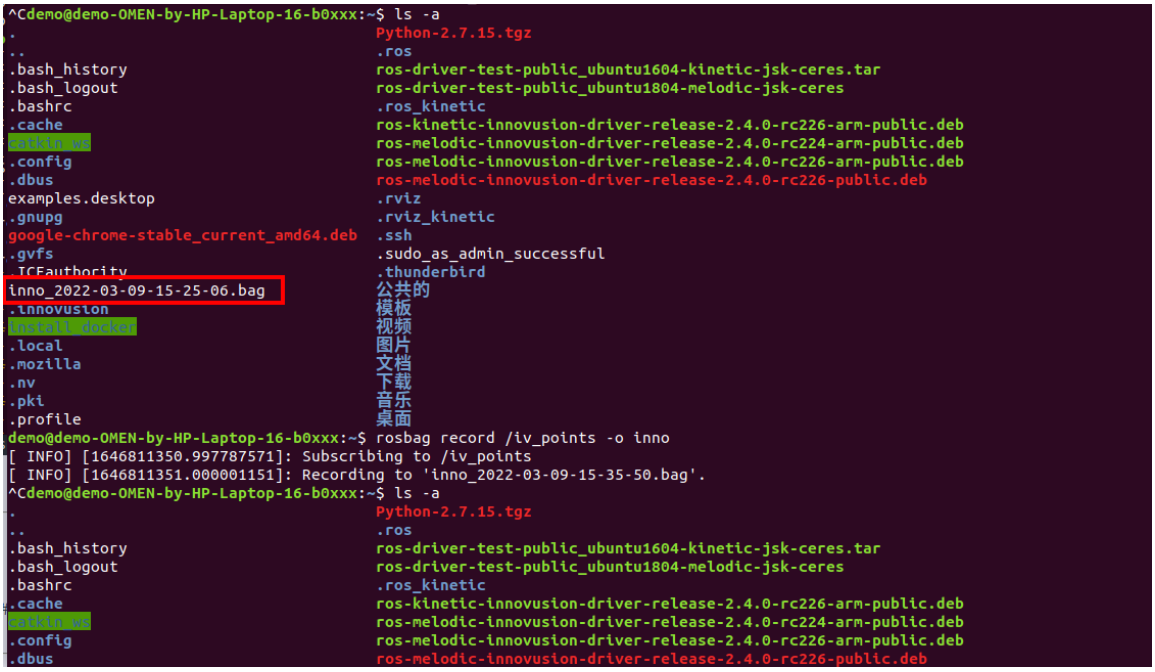
➢ Execute the following command to record pointcloud data in bag format. Recording starts at the command execution time.

```
rosbag record /iv_points -o inno
```

```
demo@demo-OMEN-by-HP-Laptop-16-b0xxx:~$ rosbag record /iv_points -o inno
[ INFO] [1646810706.460522054]: Subscribing to /iv_points
[ INFO] [1646810706.463553818]: Recording to 'inno_2022-03-09-15-25-06.bag'.
```

➢ Press **Ctrl+C** to stop recording pointcloud data.

➢ (Optional) Execute `ls - a` command to view the recorded pointcloud data file of the LiDAR.



3.2.5 Replay LiDAR pointcloud data

Users can replay the pointcloud data file of the LiDAR in rviz in bag format.

Caution	➢ Before replaying LiDAR pointcloud data, please confirm that the recorded pointcloud data file has been obtained.

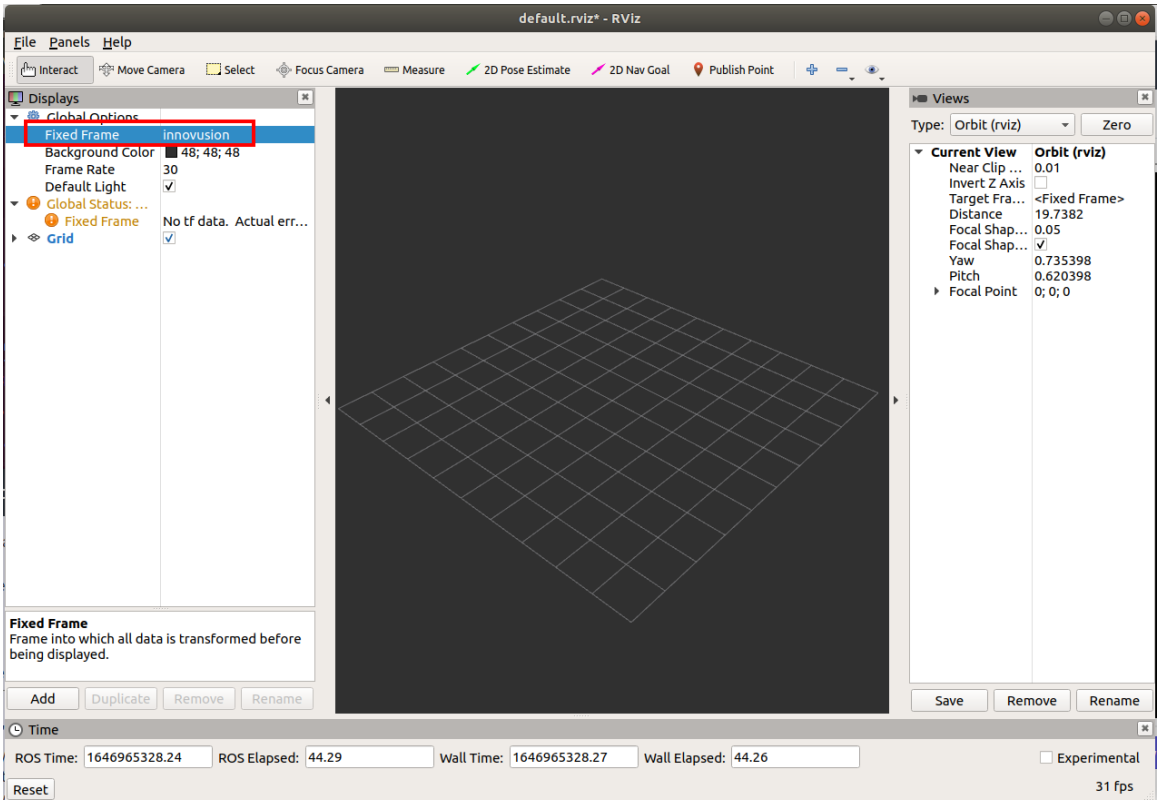
➢ Execute the roscore command to run ROS. When the driver is installed correctly, the return value is shown in the figure.

```
roscore
```

➢ Execute rviz command to start the graphical tool rviz of ROS. After start, the return value is shown below, and the rviz client is started.

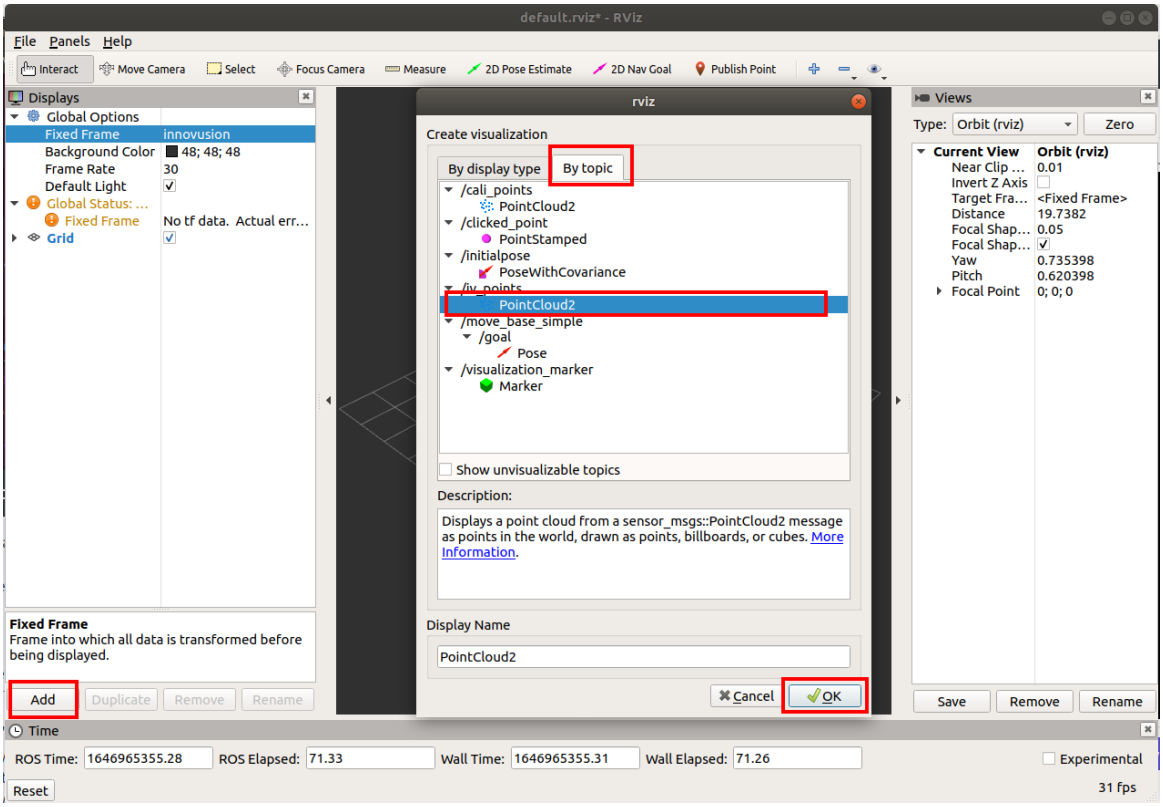
```
rviz
```

➢ Select [Global Options] > [Fixed Frames] and modify the value to innovusion.

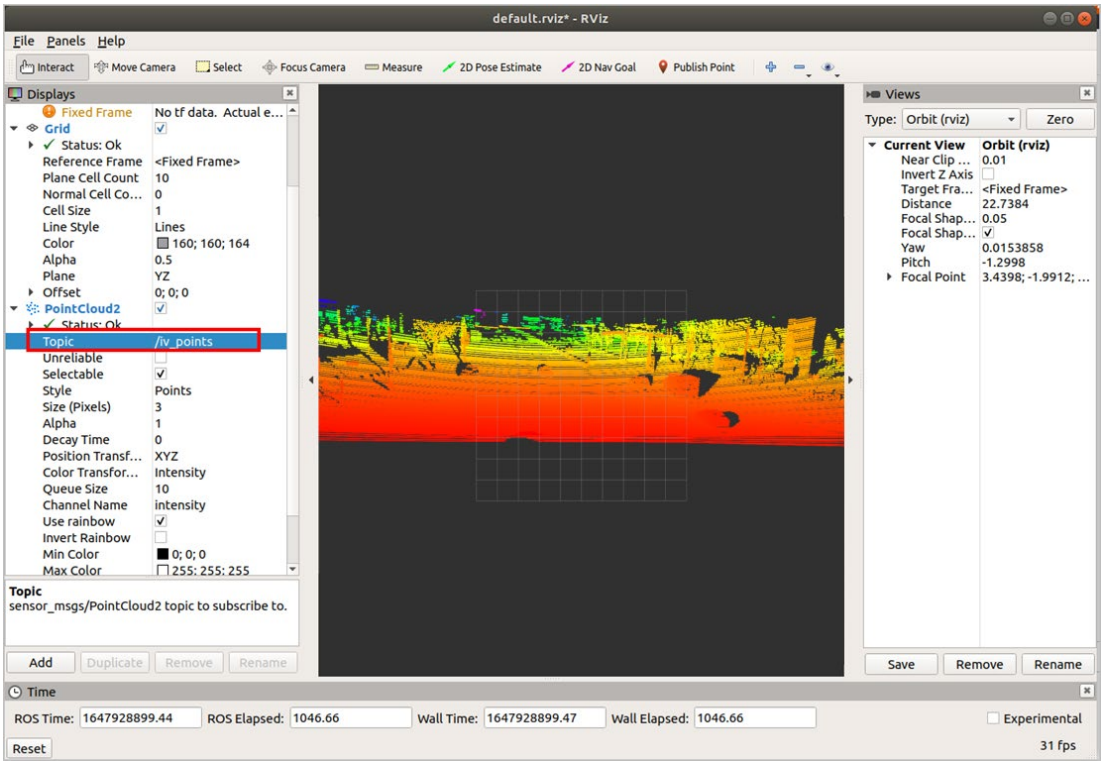


➢ Adjust the parameters in PointCloud2.

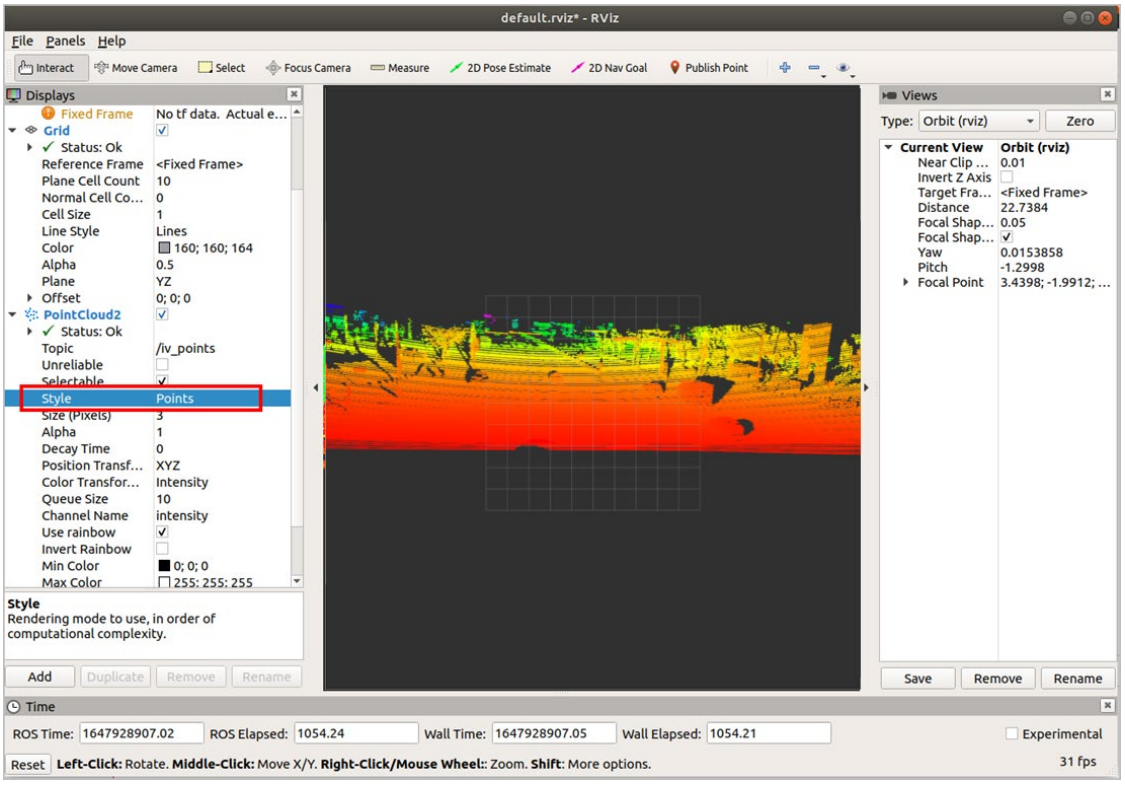
- Add PointCloud2 to Display column.
  - Select [Add] > [By topic] > [iv_points] > [PointCloud2].
  - Click **OK**.



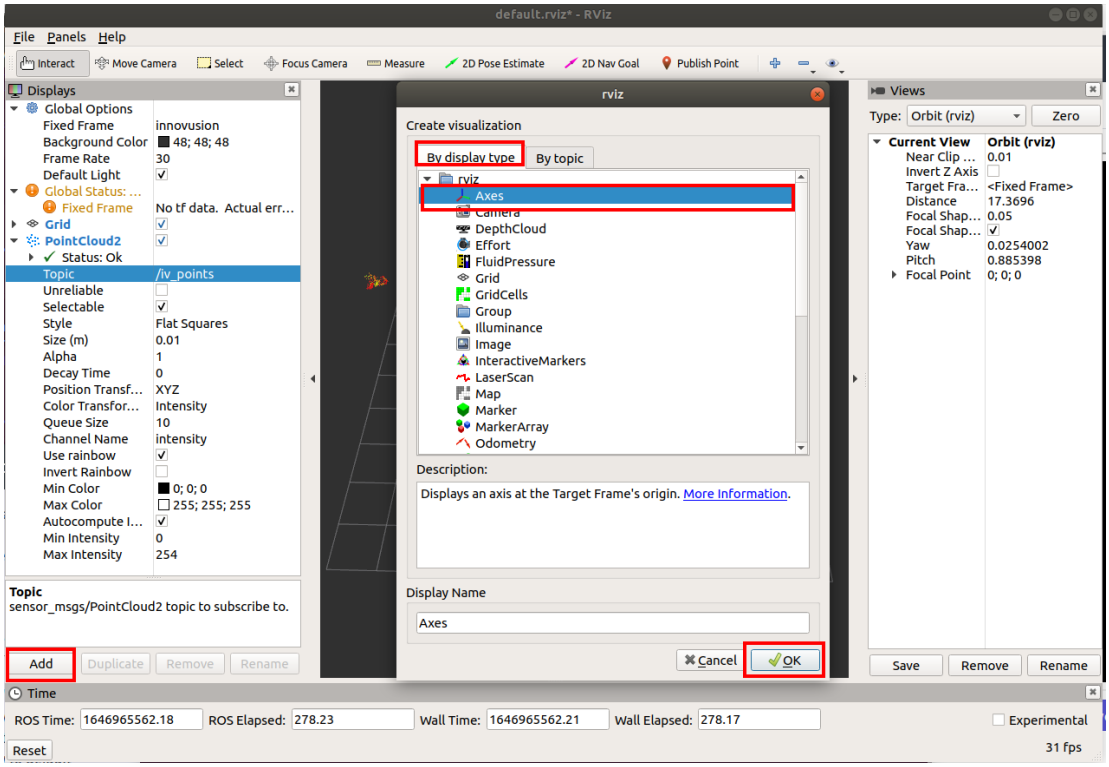
- Select [PointCloud2] > [Topic] and modify **Topic** value to**/iv_points.**



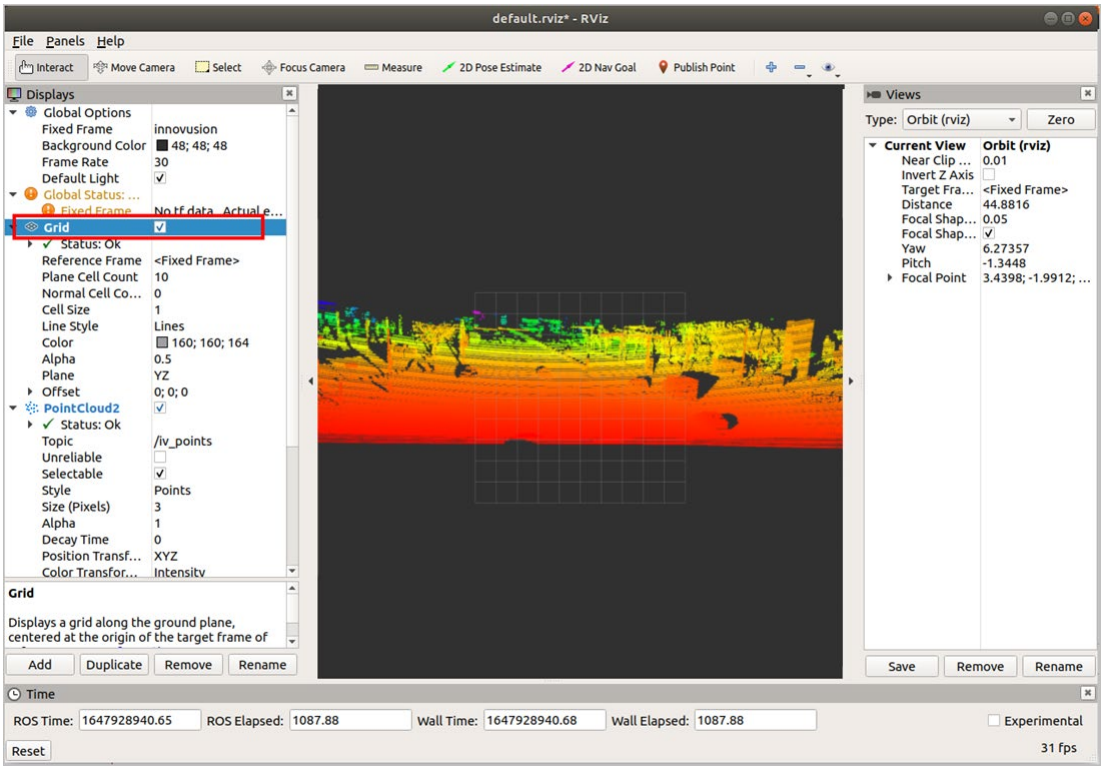
- Select [PointCloud2] > [Style] and modify **Style** value to **Points**.



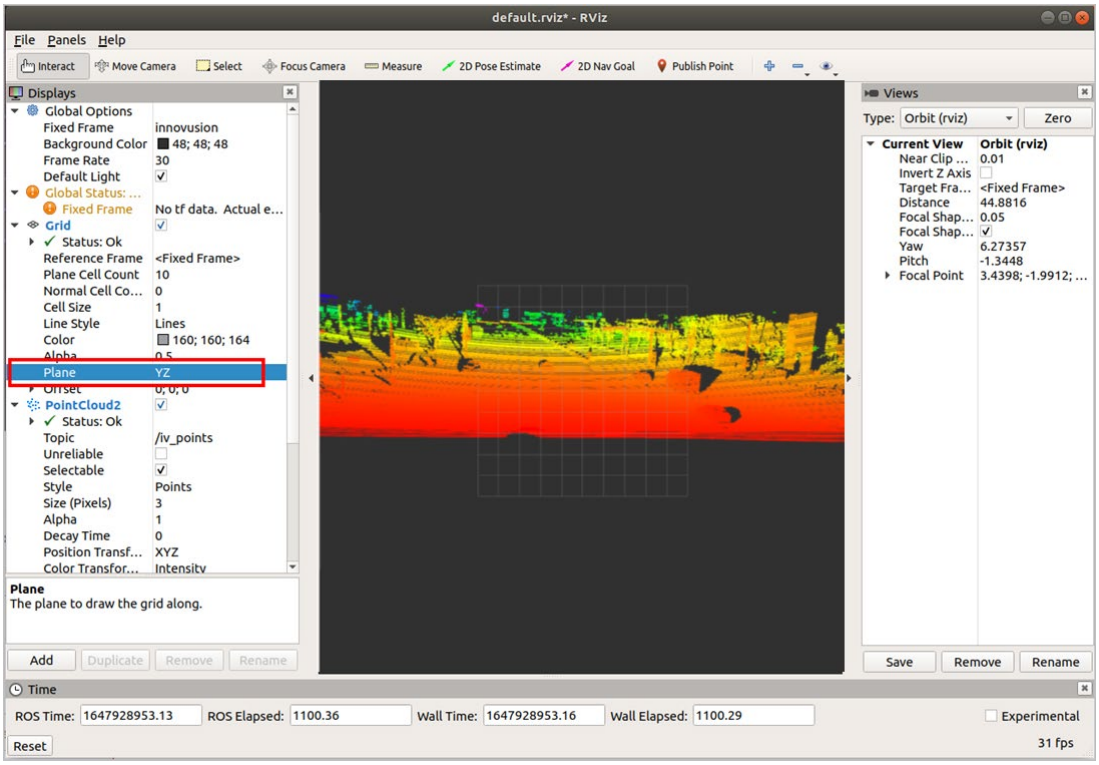
- (Optional) The user can switch the angle and distance by with mouse to view the real-time pointcloud status of the LiDAR, and view more information as needed.
  - You can add **Axes** to display the coordinate system on the pointcloud state diagram as a reference.
    - Select [Add] > [By display type] > [Axes].
    - Click **OK** to add **Axes**.



- Select **Grid** to display the grid on the pointcloud state diagram as a reference. **Grid** is enabled by default when rviz is enabled.



- Modify the **plane** value to get the pointcloud state diagram under different reference coordinates. There are three optional **plane** values: **XY**, **XZ** and **YZ**.



➢ Execute the following command to replay LiDAR pointcloud data in rviz.

```
rosbag play <filename.bag>
```

➢ Press **Space** on the terminal to pause playback of the pointcloud data file.

3.2.6 (Optional) Convert rosbag format files to pcd format files

➢ Execute roscore command to run ROS. When the driver is installed correctly, the return value is shown in the figure.

```
roscore
```

```
demo@demo-OMEN-by-HP-Laptop-16-b0xxx:~$ roscore
... logging to /home/demo/.ros/log/a09b36de-9f71-11ec-874a-c85acfaa1d16/roslaunch-demo-OMEN-by-HP-Laptop-16-b0xxx-9812.log
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://demo-OMEN-by-HP-Laptop-16-b0xxx:42677/
ros_comm version 1.14.12


SUMMARY
========

PARAMETERS
 * /rosdistro: melodic
 * /rosversion: 1.14.12

NODES

auto-starting new master
process[master]: started with pid [9822]
ROS_MASTER_URI=http://demo-OMEN-by-HP-Laptop-16-b0xxx:11311/

setting /run_id to a09b36de-9f71-11ec-874a-c85acfaa1d16
process[rosout-1]: started with pid [9833]
started core service [/rosout]
```

- Play files in bag format.

```
rosbag play <filename.bag>
```

- Convert files in bag format to pcd format files

```
rosrun pcl_ros pointcloud_to_pcd input:=/iv_points
```

3.2.7 Shut down the system

- When shutting down the system, disconnect the power supply to power off the system.

3.3 Operate on ILA

3.3.1 Start the system

- Start the system after connecting to the power supply.
- The system completes initialization and generates data after powering on for 11-18 seconds.

Caution	➢ The system does not have a power switch. It will become operational when power is applied.

3.3.2 Login

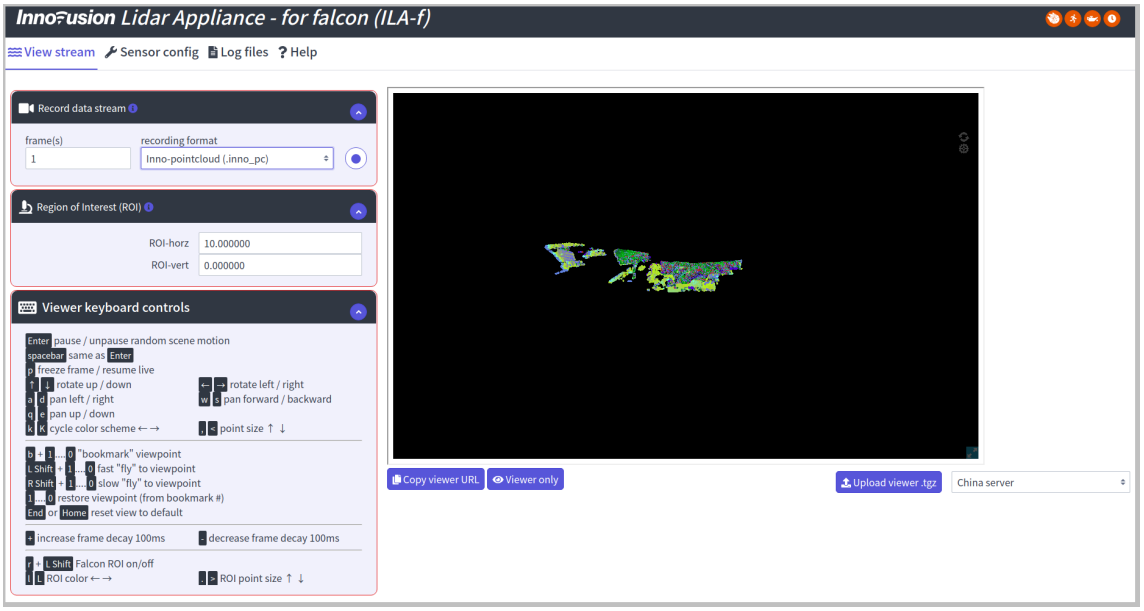
Caution	➢ It is recommended to use the Google Chrome browser to log in to the ILA page.

- Change the IP address so that the computer IP address and LiDAR IP address are in the same network segment.
- Connect the computer/server to the LiDAR to ensure that the network is connected. For the connection method, refer to **Cable connection**.
- Open the Chrome browser, and enter the LiDAR IP address and port number in the address bar `<IP Address>: <PORT>` to enter the ILA page.

Caution	➢ The default LiDAR IP address is 172.168.1.10. By default, the ILA port number is 8675. The default ILA login address is 172.168.1.10:8675. ➢ It is recommended to check the access to the LiDAR IP address by using the ping command. You should make sure that the computer is connected to the LiDAR network.

3.3.3 View the pointcloud status of the LiDAR

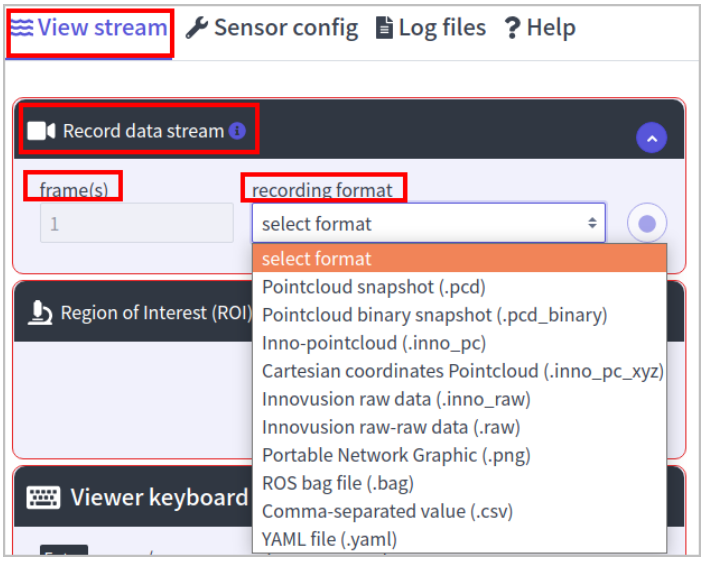
After logging in the ILA page, users can directly view the status of the LiDAR pointcloud in real time on the [View Stream] page. Users can view the LiDAR pointcloud from different perspectives using the keyboard and mouse.
Click **Viewer Only** to open the LiDAR pointcloud in a new tab.



3.3.4 Record LiDAR pointcloud data

Users can record LiDAR pointcloud data in different formats.

➢ Go to [View stream] > [Record data stream].



➢ Select the file format and size of the data to be recorded.

- Record files in inno_pc format: Select Inno-pointcloud (.inno_pc) in [recording format], and enter the number of frames of the file in [frame (s)].

  inno_pc is the private pointcloud file of Innovusion, and inno_pc outputs spherical coordinates. It is recommended to record files in inno_pc format .

- Record files in inno_pc_xyz format: Select Cartesian coordinates Ponitcloud (.inno_pc_xyz) in [recording format], and enter the number of frames for the file in [frame(s)].

  inno_pc_xyz is the private pointcloud file of Innovusion, and inno_pc_xyz outputs Cartesian coordinates. It is recommended to record files in inno_pc_xyz format.

- Record files in inno_raw format: Select **Innovusion raw data (.inno_raw)** in [recording format], and enter the file size in [MiB].

  The inno_raw format is the format specifically designed by Innovusion.
- Record files in yaml format: Select **YAML file (.yaml)** in [recording format].

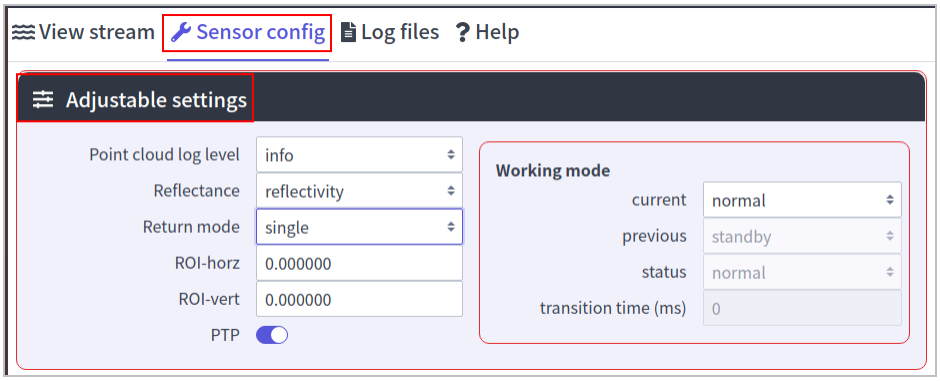
➢ Click  to record the file.

Caution

➢Pointcloud data recording starts now by default.
➢The download path of the pointcloud data is determined by the browser.
➢ Record different types of data files, and the limit of file size is different.
- The maximum frame number of recorded pcd format files, pcd_binary files, inno_pc format files, inno_pc_xyz format files, bag format files and csv format files should not exceed 100,000.
- The maximum recorded file in inno_raw format should not exceed 100,000 MiB.

3.3.5 Configure ROI

➢ Go to [Sensor config] > [Adjustable config].



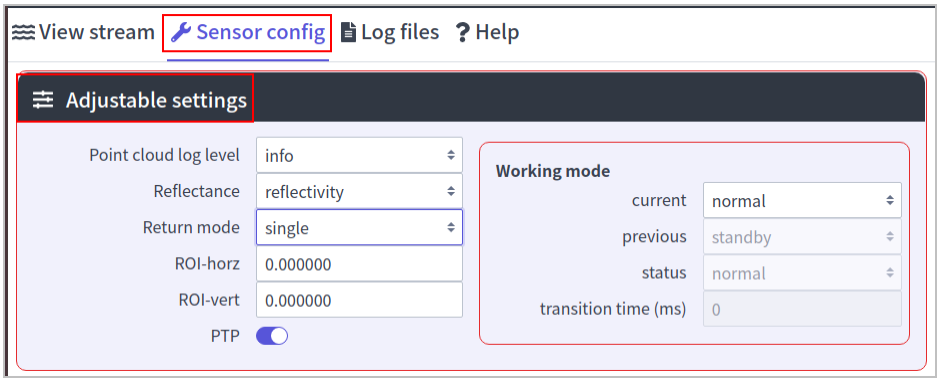
➢ Enter the coordinate of the ROI. **ROI-horz** is the horizontal coordinate of the center of ROI, and **ROI-vert** is the vertical coordinate of the center of ROI. The units of **ROI-horz** and **ROI-vert** are degrees (°).

Caution

Users can also set the position of the ROI in [View stream] > [Region of Interest].
The adjustable range of ROI in the horizontal direction is [-20, 20],
The adjustable range of ROI in the vertical direction is [-6, 6].

3.3.6 Adjust reflectance

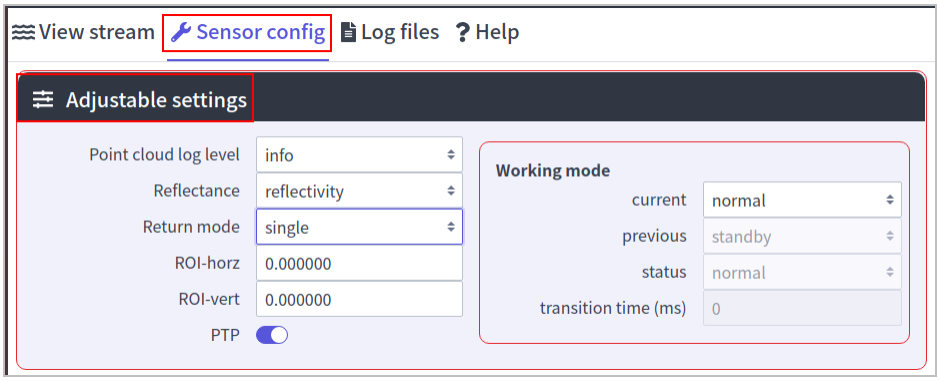
➢ Go to [Sensor config] > [Adjustable config].



- Modify the reflectance of the LiDAR (Reflectance). The reflectance can be either intensity or reflectivity.

3.3.7 Select return mode

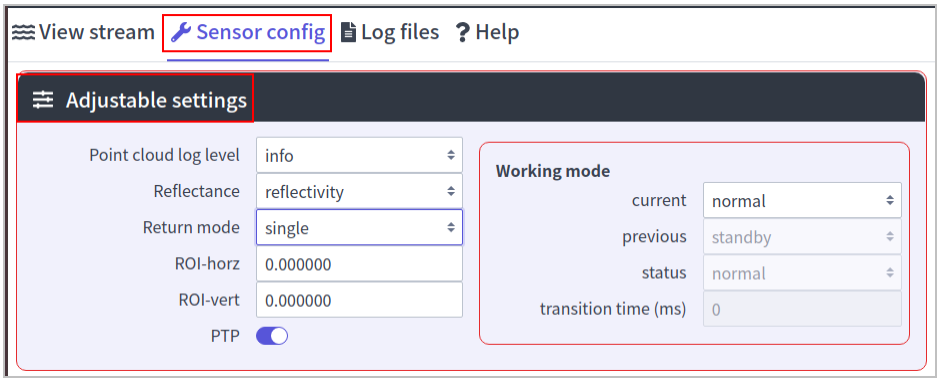
- Go to [Sensor config] > [Adjustable config].



- Configure the return mode received by the LiDAR when a laser is emitted once. Either single return mode or dual return mode can be selected, and the dual return mode has two options: "strongest + 2 strongest" and " strongest & furthest". The system defaults to choose single return mode.

3.3.8 Select working mode

- Go to [Sensor config] > [Adjustable config] > [Working mode].



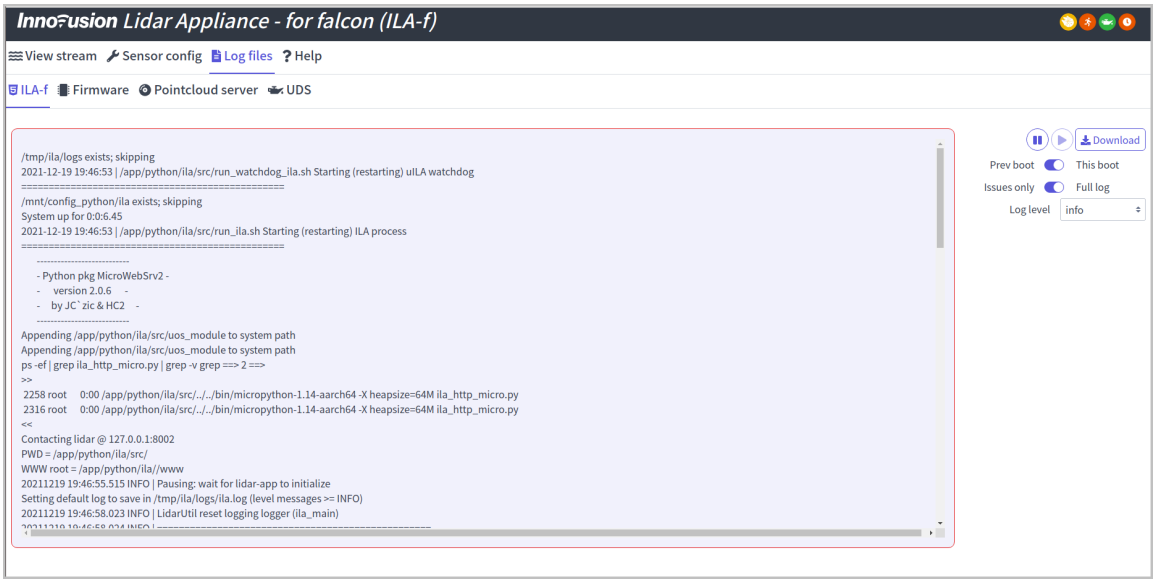
➢ Select the working mode of the LiDAR in [current]. There are two working modes for users to choose: normal and calibration.

3.3.9 View/download logs

Users can view and download different types of logs and confirm operation records and alarm information.

➢ Go to [Log files].

➢ Select the log type. Users can select four types of logs: **ILA-f**, **Firmware**, **Pointcloud server** and **UDS**.



➢ (Optional) Filter log information.

- Time range: Select Prev boot or This boot to display the last 100 logs generated before this boot, or those generated after this boot.
- Type of log: Select Issues only or Full log to display only problem logs or all logs.
- Log level: Click [log level] and select the displayed log level.

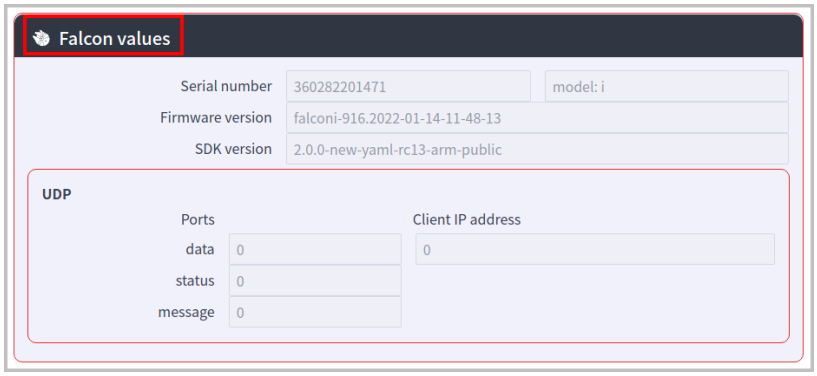
➢ Users can view logs on the left. You can also click **Download** to download the corresponding log.

Related operations

- Click ⏸ to suspend logging.
- Click ▶ to restart logging.

3.3.10 View version information

Users can check the device serial number, hardware version and SDK version information of the device in the [Sensor Config] > [Falcon Values] module.



3.3.11 Shut down the system

- When shutting down the system, disconnect the power supply to power off the system.

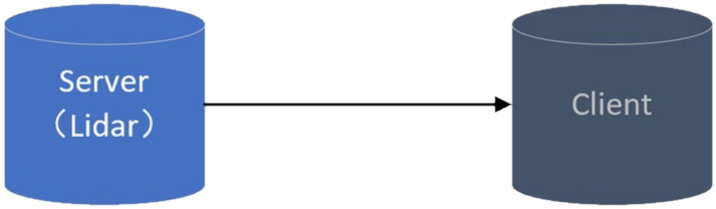
4 Communication Protocol

The device supports TCP or UDP protocol to obtain the pointcloud data of the LiDAR. This chapter describes how to transmit data between the server and the client, and obtain LiDAR information under the two protocols.

4.1 Data transmission under TCP

4.1.1 Data transmission

TCP(Transmission Control Protocol) is a communication standard for connection-oriented unicast transmission protocol. Under TCP protocol, the LiDAR serves as the server side and the client serves as the client side. The client side can initiate a connection request and request data from the server side. After establishing a reliable connection, the server side will actively send data to the client side.



4.1.2 Obtain pointcloud data

Users can use inno_pc_client to obtain the pointcloud data of the LiDAR.

inno_pc_client is an executable file in the LiDAR SDK, which can be used to obtain LiDAR pointcloud data. Please note that the executable file obtains pointcloud data under TCP protocol by default.

- Unzip SDK files.

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

Caution

➢Please obtain the latest SDK file according to the actual situation of the system.

- Enter the file directory.

```
$ cd ~/apps/pcs/
```

- Read pointcloud data.

```
./inno_pc_client --lidar-ip <INPUT_LIDAR_IP> --lidar-port <INPUT_LIDAR_TCP_PORT>
```

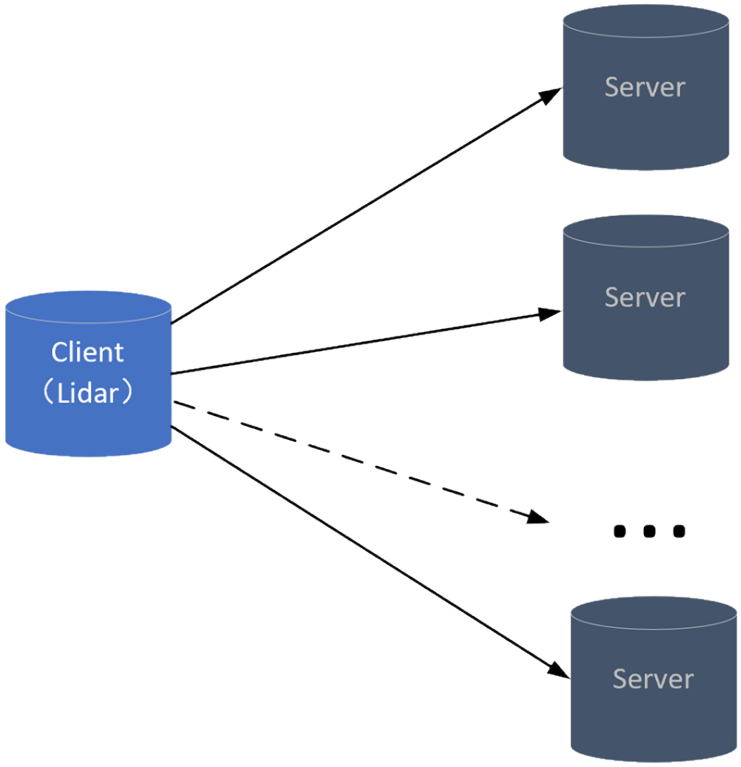
Caution

➢The default IP address of the LiDAR is 172.168.1.10, and the default port of the LiDAR is 8010.

4.2 Data transmission under UDP

4.2.1 Data transmission

Under UDP(User Datagram Protocol), the LiDAR serves as the client side and the client serves as the server side. The client side actively sends data to one or more server sides. Since UDP may lead to packet loss when transmitting large data, it is recommended to transmit only data information with small amount of data when using UDP transmission. Its connection diagram is shown in the figure below.



4.2.2 Change transmission mode

Under UDP protocol, users can modify the data transmission mode according to the actual situation.

- Unzip SDK files.

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

Caution	➤Please obtain the latest SDK file according to the actual situation of the system.

- Enter the file directory.

```
$ cd ~/apps/pcs/ innovusion_lidar_util
```

➢ Execute the following command to download the PCS_ENV file.

```
./innovusion_lidar_util lidar_ip download_internal_file PCS_ENV ./PCS_ENV
```

➢ Open the PCS_ENV file and modify UDP_IP field information as required.

- **Broadcast mode**: UDP_IP= eth0. eth0 is the default value of UDP IP. In this case, the device can obtain the pointcloud data of the LiDAR through SDK.
- **Multicast mode**: UDP_IP=239.0.0.1. At this time, the LiDAR sends data to all devices in the same subnet, and all devices in the subnet can obtain the pointcloud data of the LiDAR through SDK.
- **UDP unicast mode**: UDP_IP=<Device_IP>. The value of Device IP is the IP of the server that shares the same Intranet as the LiDAR. In unicast mode, only the server can obtain the pointcloud information of the LiDAR through UDP transmission mode.
- **UDP data transmission channel is closed**: After the UDP_IP information is commented out, the LiDAR does not actively send data through UDP.

➢ Execute the following command to upload the PCS_ENV file.

```
./innovusion_lidar_util lidar_ip upload_internal_file PCS_ENV ./PCS_ENV
```

4.2.3 Obtain pointcloud data

Users can use inno_pc_client to obtain the pointcloud data of the LiDAR.

inno_pc_client is an executable file in the LiDAR SDK, which can be used to obtain LiDAR pointcloud data.

➢ Unzip SDK files.

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

⚠ Caution	➢Please obtain the latest SDK file according to the actual situation of the system.

- Enter the file directory.

```
$ cd ~/apps/pcs/
```

- Read pointcloud data.

```
./inno_pc_client --lidar-ip <INPUT_LIDAR_IP> --lidar-udp-port <INPUT_LIDAR_UDP_PORT>
```

5 Time synchronization

LiDAR supports the PTP time synchronization mode, and the PTP time synchronization accuracy can reach the sub-microsecond level. The method for setting PTP time synchronization is as follows.

5.1 Confirm the server environment

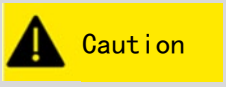
Before PTP time synchronization, check whether the server supports PTP time synchronization.

- Execute the command to install ethtool.

```
$ sudo apt-get install ethtool
```

- Check whether the network card at the server supports PTP time synchronization:

```
$ sudo ethtool -T eth0
```



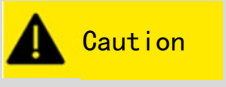
➢Use the actual network card to replace eth0, and can use the ifconfig or ip a | grep MULTICAST to query the name of its actual network card.

- For hardware timestamp support, the following output should be included.

```
l SOF_TIMESTAMPING_RAW_HARDWARE
l SOF_TIMESTAMPING_TX_HARDWARE
l SOF_TIMESTAMPING_RX_HARDWARE
```

- For software timestamp support, the following output should be included.

```
l SOF_TIMESTAMPING_SOFTWARE
l SOF_TIMESTAMPING_TX_SOFTWARE
l SOF_TIMESTAMPING_RX_SOFTWARE
```



➢If there is an unsupported hardware timestamp on the network port, please replace the server.

5.2 Install Linuxptp

Install linuxptp on the server. The linuxptp includes two services: ptp41 and phc2sys.

```
$ sudo apt-get install linuxptp
```

5.3 (Optional) Set software timestamp

- Modify the ptp41 configuration.

```
$ sudo gedit /lib/system/system/ptp4l.service
```

- Configure ExecStart=/usr/sbin/ptp41information.

```
ExecStart=/usr/sbin/ptp4l -f /etc/linuxptp/ptp4l.conf [ -A | -E | -P ] [ -2 | -4 | -6 ] [ -H | -S | -L ] [ -f config ] [ -p phc-device ] [ -s ] [ -l print-level ] [ -q ] [ -v ] [ -i interface ] ...
```

```
[Unit]
Description=Precision Time Protocol (PTP) service
Documentation=man:ptp4l

[Service]
Type=simple
ExecStart=/usr/sbin/ptp4l -f /etc/linuxptp/ptp4l.conf -i eno2 -S -A

[Install]
WantedBy=multi-user.target
~
~
```

Caution

- -S: Uses software timestamps, and hardware timestamps are used by default.
- -A: Automatically selects the E2E (End-to-End) delay measurement mechanism. At the time of start, ptp41 is run in E2E mode. It will automatically switch to P2P mode when receiving a peer delay request message.
- -E: E2E delay measurement mechanism. This item is default. The E2E mechanism is also called the “request-response” delay mechanism.
- -P: P2P delay measurement mechanism.
- -M: Prints information.

- Reload and start the ptp41 service.

```
$ sudo systemctl daemon-reload
$ sudo systemctl enable ptp4l.service
$ sudo systemctl start ptp4l.service
```

- View the ptp41 service status. Confirm that the service is running and display assuming the grand master role.

```
$ sudo systemctl status ptp4l.service
```

```
hikai@hikai-Default-string:~$ systemctl status ptp4l.service
● ptp4l.service - Precision Time Protocol (PTP) service
   Loaded: loaded (/lib/systemd/system/ptp4l.service; enabled; vendor preset: enabled)
   Active: active (running) since Thu 2021-11-11 15:47:11 CST; 1 months 11 days ago
     Docs: man:ptp4l
 Main PID: 1073 (ptp4l)
    Tasks: 1 (limit: 4915)
   CGroup: /system.slice/ptp4l.service
           └─1073 /usr/sbin/ptp4l -E -i enp2s0f0 -m

12月 23 11:14:07 hikai-Default-string ptp4l[1073]: [3612156.706] driver changed our HWTSTAMP options
12月 23 11:14:07 hikai-Default-string ptp4l[1073]: [3612156.706] tx_type   1 not 1
12月 23 11:14:07 hikai-Default-string ptp4l[1073]: [3612156.706] rx_filter 1 not 12
12月 23 11:14:07 hikai-Default-string ptp4l[1073]: [3612156.706] port 1: FAULTY to LISTENING on FAULT_CLEARED
12月 23 11:14:13 hikai-Default-string ptp4l[1073]: ptp4l[3612162.774]: port 1: LISTENING to MASTER on ANNOUNCE_RECEIPT_TIMEOUT_EXPIRES
12月 23 11:14:13 hikai-Default-string ptp4l[1073]: ptp4l[3612162.774]: selected best master clock 6cb311.fffe.347004
12月 23 11:14:13 hikai-Default-string ptp4l[1073]: ptp4l[3612162.774]: assuming the grand master role
12月 23 11:14:13 hikai-Default-string ptp4l[1073]: [3612162.774] port 1: LISTENING to MASTER on ANNOUNCE_RECEIPT_TIMEOUT_EXPIRES
12月 23 11:14:13 hikai-Default-string ptp4l[1073]: [3612162.774] selected best master clock 6cb311.fffe.347004
12月 23 11:14:13 hikai-Default-string ptp4l[1073]: [3612162.774] assuming the grand master role
hikai@hikai-Default-string:~$
```

5.4 Set the hardware timestamp

- Modify the ptp41 configuration.

```
$ sudo gedit /lib/system/system/ptp4l.service
```

➢ Configure ExecStart=/usr/sbin/ptp41information.

```
ExecStart=/usr/sbin/ptp4l -f /etc/linuxptp/ptp4l.conf [ -A | -E | -P ] [ -2 | -4 | -6 ] [ -H | -S | -L ] [ -f config ] [ -p phc-device ] [ -s ] [ -l print-level ] [ -q ] [ -v ] [ -i interface ] ...
```

```
[Unit]
Description=Precision Time Protocol (PTP) service
Documentation=man:ptp4l

[Service]
Type=simple
ExecStart=/usr/sbin/ptp4l -f /etc/linuxptp/ptp4l.conf -i eno2 -S -A

[Install]
WantedBy=multi-user.target
~
~
```

Caution

➢ -S: Uses software timestamps, and hardware timestamps are used by default.

➢ -A: Automatically selects the E2E (End-to-End) delay measurement mechanism. At the time of start, ptp41 is run in E2E mode. It will automatically switch to P2P mode when receiving a peer delay request message.

➢ -E: E2E delay measurement mechanism. This item is default. The E2E mechanism is also called the “request-response” delay mechanism.

➢ -P: P2P delay measurement mechanism.

➢ -M: Prints information.

➢ View the ptp41 service status. Confirm that the service is running and display assuming the grand master role.

```
$ sudo systemctl status ptp4l.service
```

```
hikai@hikai-Default-string:~$ systemctl status ptp4l.service
● ptp4l.service - Precision Time Protocol (PTP) service
   Loaded: loaded (/lib/systemd/system/ptp4l.service; enabled; vendor preset: enabled)
   Active: active (running) since Thu 2021-11-11 15:47:11 CST; 1 months 11 days ago
     Docs: man:ptp4l
 Main PID: 1073 (ptp4l)
    Tasks: 1 (limit: 4915)
   CGroup: /system.slice/ptp4l.service
           └─1073 /usr/sbin/ptp4l -E -i enp2s0f0 -m

12月 23 11:14:07 hikai-Default-string ptp4l[1073]: [3612156.706] driver changed our HWTSTAMP options
12月 23 11:14:07 hikai-Default-string ptp4l[1073]: [3612156.706] tx_type   1 not 1
12月 23 11:14:07 hikai-Default-string ptp4l[1073]: [3612156.706] rx_filter 1 not 12
12月 23 11:14:07 hikai-Default-string ptp4l[1073]: [3612156.706] port 1: FAULTY to LISTENING on FAULT_CLEARED
12月 23 11:14:13 hikai-Default-string ptp4l[1073]: ptp4l[3612162.774]: port 1: LISTENING to MASTER on ANNOUNCE_RECEIPT_TIMEOUT_EXPIRES
12月 23 11:14:13 hikai-Default-string ptp4l[1073]: ptp4l[3612162.774]: selected best master clock 6cb311.fffe.347004
12月 23 11:14:13 hikai-Default-string ptp4l[1073]: ptp4l[3612162.774]: assuming the grand master role
12月 23 11:14:13 hikai-Default-string ptp4l[1073]: [3612162.774] port 1: LISTENING to MASTER on ANNOUNCE_RECEIPT_TIMEOUT_EXPIRES
12月 23 11:14:13 hikai-Default-string ptp4l[1073]: [3612162.774] selected best master clock 6cb311.fffe.347004
12月 23 11:14:13 hikai-Default-string ptp4l[1073]: [3612162.774] assuming the grand master role
hikai@hikai-Default-string:~$
```

➢ Modify the phc2sys configuration.

```
$ sudo gedit /lib/system/system/phc2sys.service
```

➢ Configure ExecStart=/usr/sbin/ phc2sysinformation.

ExecStart=/usr/sbin/ phc2sys **-d** pps-device [**-s** phc-device | **-i** interface] | **-s** phc-device | **-i** interface } [**-c** phc-device] [**-P** kp] [**-I** ki] [**-R** update-rate] [**-N** clock-readings] [**-O** offset]

```
[Unit]
Description=Synchronize system clock or PTP hardware clock (PHC)
Documentation=man:phc2sys
After=ntpdate.service
Requires=ptp4l.service
After=ptp4l.service

[Service]
Type=simple
ExecStart=/usr/sbin/phc2sys -s CLOCK_REALTIME -c enp2s0f0 -w -E linreg
[Install]
WantedBy=multi-user.target
~
```

Caution

- -s : phc-device, specify master by device (e.g. /dev/ptp0) or name (e.g. CLOCK_REALTIME, system clock). When used with the -d option, master starts in read-only mode to fix offsets that exceed 0.5 seconds.
- -c: phc-device specify slave by device (e.g. /dev/ptp1) or name. The default value is CLOCK_REALTIME (system clock).
- -W: Waits for ptp41.
- -E: Specify the synchronization algorithm between the master and slave. linreg is recommended.

- Reload the service.

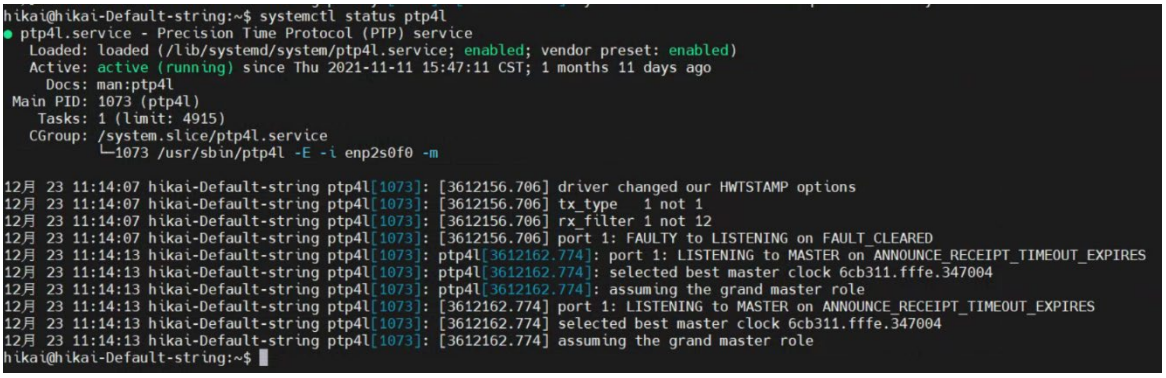
```
$ sudo systemctl daemon-reload
```

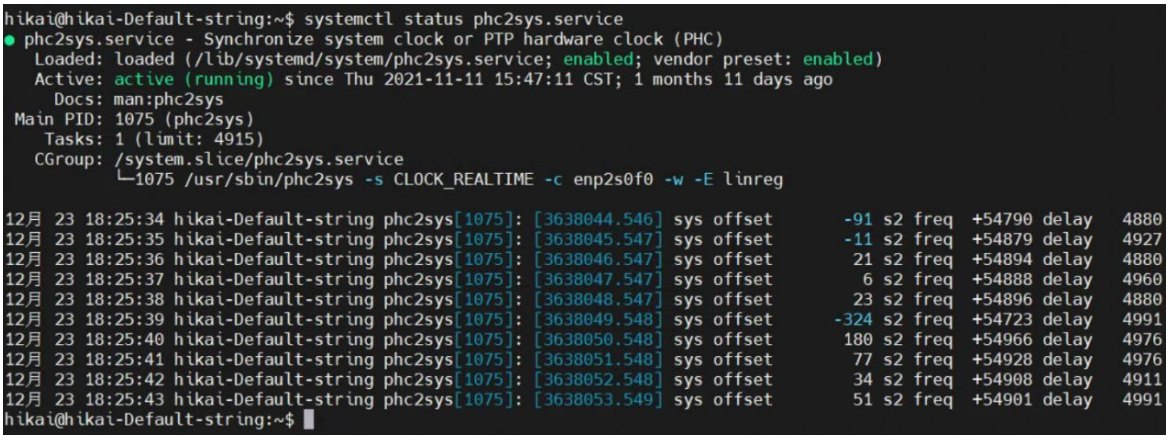
- Restart the ptp41 andphc2sys services.

```
$ systemctl enable ptp4l.service
$ systemctl restart ptp4l.service
$ systemctl enable phc2sys.service
$ systemctl restart phc2sys.service
```

- View ptp41 and phc2sys service status. Confirm that the service is running and display assuming the grand master role. s2 status exists in phc2sys.

```
$ systemctl status ptp4l.service
$ systemctl status phc2sys.service
```





5.5 Turn on PTP time synchronization

Turn on the PTP function. The setting value of ptp_en parameter is equal to 1.

```
$ ./innovusion_lidar_util <lidar ip> set_config time ptp_en 1
```

5.6 Confirm time synchronization results

Users can go to /var/log/messages to check whether the time in the log file is the same as that on the PC.

6 Troubleshooting Guide

6.1 Troubleshooting

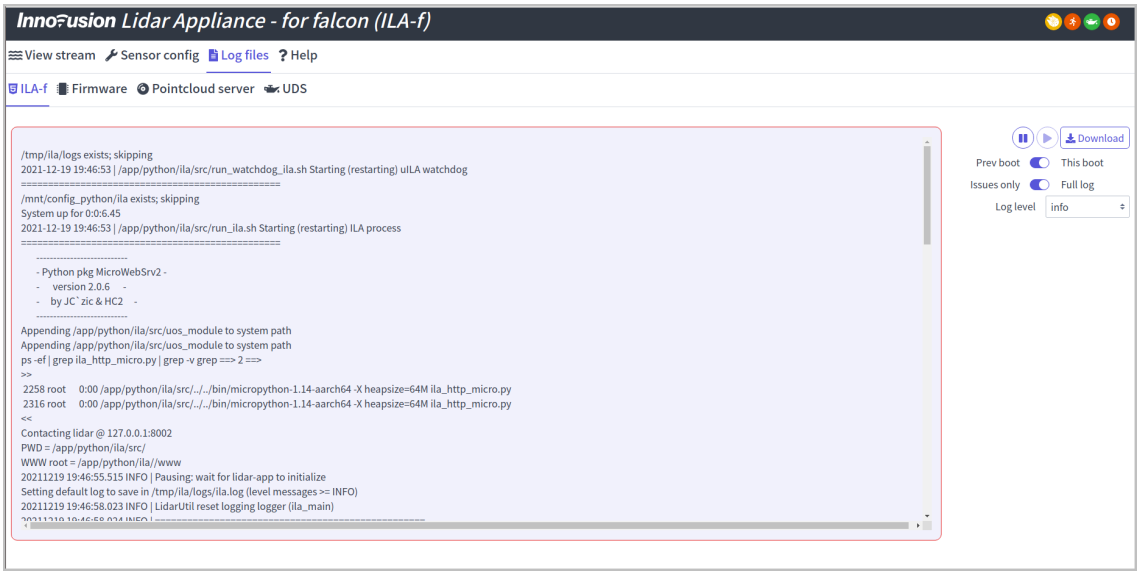
Table 5 FAQ

Serial No.	Problem	Resolution
1	Device startup failure	1. Check whether the power supply voltage is normal.
		2. Check whether the power cable is tightly plugged.
		3. Check whether the power supply current is normal, and the power consumption should be about 34W.
		4. Check whether the software configuration is correct.
		5. Power off for at least one minute, and power on again for testing.
2	Network connection failure.	1. Check whether the network cable is plugged in.
		2. Check whether the network light flashes.
		3. Check whether the network card for the server is normal, or r change to another computer and retest.
		4. Check whether the network card for the server is a Gigabit network card.
		5. Check the IP address of the server and confirm that the IP address of the server is in the same LAN as that of the device.
		6. Power off for at least one minute, and power on again for testing.

3	Pointcloud display failure/inappropriate	1. Check whether the firewall of the server is disabled.
		2. Use the Wireshark packet capture tool to check whether the data packet is complete.
		3. Check whether windows are blocked.
		4. Power off for at least one minute, and power on again for testing.
4	Noise points appear in the pointcloud	1. Check whether windows are contaminated.
		2. Check whether the object is strongly reflective.
		3. Power off for at least one minute, and power on again for testing.
5	Incorrect pointcloud FOV	1. Check whether windows are contaminated.
		2. Check whether windows are blocked.
		3. Check whether the software is configured correctly.
		4. Power off for at least one minute, and power on again for testing.
6	The ranging ability does not meet the standard.	1. Check whether windows are contaminated.
		2. Pay attention to the visibility of the weather.
		3. Check whether windows are blocked.
		4. Check whether the parameters of the mechanical hardware of the LiDAR are set correctly.
		5. Power off for at least one minute, and power on again for testing.
7	Time synchronization failure	1. Check whether the time synchronization interface is properly connected.
		2. Check the time synchronization service for normal operation.

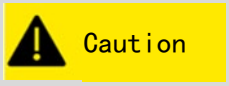
6.2 Log collection

After system failure occurs, please log in to the ILA platform to collect logs and feedback the logs to Innovusion staff. For details of the log collection mode, see **View/download logs**.



Appendix A Computer configuration reference

The following table provides the reference for configuring the computer. Users can select suitable computers according to the table.



➢The computer configuration recommended in this table only enables you to view pointcloud data. If you have other requirements, please consult Innovusion staff.

➢This table is only for reference of the minimum configuration requirements of the server. Users can upgrade the configuration of the computer based on the requirements of this table.

Table 6 Configuration reference for the computer

Attribute	Configuration
CPU	Dual-core CPU Intel I7-7th generation or other types of processors with equivalent performance or above
RAM	1 GB
Free disk space	≥ 1000 MB
Network connection	1 G/s

Appendix B Upgrade the LiDAR

- Obtain the upgrade package in img format, and connect the computer with the upgrade package to the LiDAR to ensure that the network is connected.

Caution	If necessary, please contact Innovusion staff to obtain the upgrade package in img format. The upgrade package includes firmware and software upgrades.

- Change the IP address so that the computer IP address and LiDAR IP address are in the same network segment.
- Open the Chrome browser and enter the LiDAR IP address in the address bar.

Caution	➢ The default LiDAR IP address is 172.168.1.10. ➢ It is recommended to check the access to the LiDAR IP address by using the ping command. You should make sure that the computer is connected to the LiDAR network.

- Click **Recovery/Update File**.

- Click Choose File, the [Open] window pops up, and select the required upgrade package.

- Click Start Recovery/Update to start the upgrade.
- Power off and restart the system after the upgrade.
- (Optional) View the version information on the [System info] page.

Appendix C Abbreviations and terms

Table 7 Abbreviations

Abbreviations	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
ILA	Innovusion LiDAR Appliance
IP	Internet Protocol
LiDAR	Light Detection and Ranging
MAC	Media Access Control
MEC	Multi-Access Edge Computing
NTP	Network Time Protocol
PPS	Pulse Per Second
PTP	Precision Time Protocol
PWR	Power
ROI	Region of Interest
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

Table 8 Technical Terms

Terms	Definition
Class 1 laser products	Within the corresponding wavelength and emission duration, the exposure of personnel to laser radiation is not allowed to exceed Class 1 laser products that can reach the emission limit.
NTP	Network Time Protocol (NTP) is a protocol used to synchronize computer time. It is widely used to synchronize computers to Internet time servers, such as radio or satellite receivers or telephone modem services.
PTP	Precision Time Protocol (PTP) is a high-precision time synchronization protocol. It is used for high-precision time synchronization between devices, but can also be used for frequency synchronization between devices.
Installer	Installers refer to those who have received professional training and

	have rich experience in the relevant field, fully understand the application of protective devices on the machine and can assess its working safety state.
Commissioning personnel	Commissioning personnel are those who have received professional training and have rich experience in the relevant field, fully understand the application of protective devices on the machine and can assess its working safety state.
Time of flight (TOF)	The time-of-flight (TOF) realizes distance measurement by determining the time-of-flight interval between transmitting and receiving signals. For the formula, see the **Principles of operation** section.
Laser product	Combination of any products or components used to construct or prepare for use to construct a laser or a laser system. An electronic component sold as a component to another manufacturer is not a laser product.
Laser	An electromagnetic radiation device that mainly generates or amplifies the wavelength in the range of 180nm ~ 1mm through a controlled laser emission process.
Laser equipment	A combination of laser products or laser products containing lasers.
Server	A computer that can directly issue operation and control commands. The server sends commands first to the salve computer, and then the slave computer controls the device according to this command. The slave computer reads the device status data from time to time, converts it into a digital signal and feeds it back to the server.
Configuration personnel	The configuration personnel should have expertise and experience in the relevant field and have sufficient experience to evaluate whether the machine is in a safe operation status after using protective equipment.
Eye safety	Although the product design meets the Class 1 eye safety standard, in order to protect your safety to the greatest extent, do not use amplification equipment (such as a microscope and magnifying glass) to directly look at the laser light in transmission.
Service personnel	Qualified service personnel refer to those who have received professional training and have rich experience in the relevant field, fully understand the application of protective devices on machines, and have received the guidance of the machine operation supervisor.

Revision history

Version number	Revised content	Revision time
V1.0	The first draft	2022/06/17
V1.0.1	Cable description	2022/09/07
V1.0.2	Working temperature	2022/12/14