# GRONET

# GCH32

## User Manual

**V2.1.3 2022.07**

## Safety Instruction

Before using the product, please read and follow the instructions of this manual carefully, and refer to any relevant national and international safety regulations.

### Attention

Please do not disassemble or modify the Lidar privately. If you need special instructions, please consult the technical support staff of Gronet Intelligent for warranty and maintenance matters.

### Laser Safety Level

The laser safety level of this product meets the following standards:

● IEC 60825-1:2014

● 21 CFR 1040.10 and 1040.11 standards, except for the deviations (IEC 60825-1, third edition) stated in the Laser Notice No. 56 issued on May 8, 2019. Please do not look directly at the transmitting laser through a magnifying device (such as a microscope, a head-mounted magnifying glass, or other forms of magnifying glasses).

### Eye Safety

The product design complies with Class 1 human eye safety standards. However, it is prohibited to look directly at the transmitting laser through magnifying equipment (such as a microscope, head-mounted magnifier or other forms of magnifying glasses). To maximize self-protection, please avoid looking directly at the running product.



### Safety Warning

In any case, if the product is suspected to have malfunctioned or been damaged, please stop using it immediately to avoid injury or further damage to the product.

### Operation

This product is composed of metal and plastic, and contains precise circuit electronic components and optical devices. Improper operations such as high temperature, drop, puncture or squeeze may cause irreversible damage to the product.

### Power Supply

Use the connecting cable and matching connectors provided by Gronet Intelligent to supply power. Using cables or adapters that do not meet the power supply requirements or are damaged, or supply power in a humid environment may cause abnormal operation, fire, personal injury, product damage, or other property loss.

### Light Interference

Some precise optical equipment may be interfered by the laser emitted by this product, please pay attention when using it.

### Housing

The product contains high-speed rotating parts, please do not operate when the housing is unfastened. Do not use a product with damaged housing, so as to avoid irreparable losses. To avoid product performance degradation, please do not touch the photomask with your hands.

### Vibration

Avoid product damage caused by strong vibration. If the product's mechanical shock and vibration performance parameters are needed, please contact Gronet Intelligent for technical support.

### Radio Frequency Interference

Before use, please read the certification and safety information on the nameplate of the product base. Although the design, testing and manufacturing of the product comply with the relevant regulations on radiofrequency energy radiation, the radiation from the product may still cause other electronic equipment to malfunction.

### Deflagration and Other Air Conditions

Do not use the product in any area with potentially explosive air, such as areas where the air contains high concentrations of flammable chemicals, vapors or particles (like fine grains, dust or metal powder). Do not expose the product to the environment of high-concentration industrial chemicals, including near evaporating liquefied gas (such as helium), so as not to damage or impair the function of the product. Please follow all signs and instructions.

### Maintenance

Do not disassemble the Lidar without authorization. Disassembling the product may cause the waterproof performance to fail or personal injury.

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# 1. Product Profile

## 1.1 Overview

The GCH32 Hybrid Solid-State Lidar is an auto-grade product designed specifically for autonomous vehicles. Equipped with a hybrid solid-state structure, it reaches a detection range of 200 meters, a measurement accuracy of ±3 cm, a 120° horizontal field of view (FOV), and a point-generating rate of up to 426,000 pts/sec. With its high performance, the GCH32 Lidar provides accurate environmental perception for semi-autonomous and autonomous driving.

## 1.2 Mechanism

The GCH32 Hybrid Solid-State Lidar adopts the Time of Flight (TOF) method. The Lidar starts timing (t1) when the laser pulses are sent out. And when the laser encounters the target object and the light returns to the sensor unit, the receiving end stops timing (t2).

Distance = Speed of Light*(t2 – t1)/2



Figure 1.1 Mechanism of the GCH32 Lidar
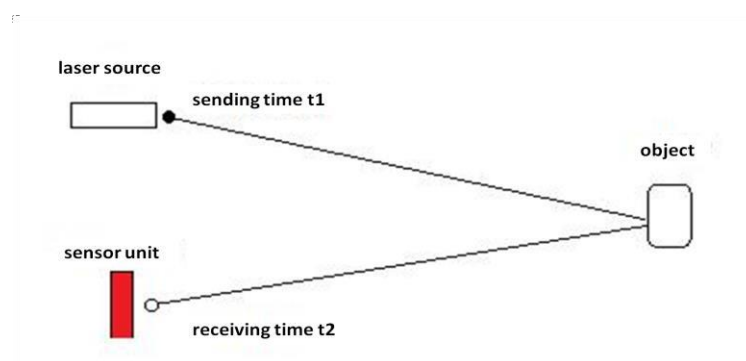
## 1.3 Specification

Table 1.1 Specifications of GCH32

| Model | GCH32 |
|---|---|
| Detection Method | Pulse |
| Wavelength | 905 nm |
| Laser Class | Class 1 (eye-safe) |

| Channels | | 32 |
|---|---|---|
| Detection Range | Typical | 100 m /150 m/ 200 m |
| | Minimum | 90 m / 135 m/ 180 m |
| Range Accuracy | | ±3 cm (0.5 m ~ 200 m) |
| Data Point Generated (Single Echo Mode) | | 426,000 pts/sec |
| Data Point Generated (Dual Echo Mode) | | 852,000 pts/sec |
| Vertical FOV | | -6.67° ~ 4.58° |
| Horizontal FOV | | 120° |
| Horizontal Angular Resolution | | 5 Hz: 0.045º / 10 Hz: 0.09º / 20 Hz: 0.18º |
| Vertical Angular Resolution | | 0.33° (nonuniform distribution) |
| Scanning Rate | | 5 Hz / 10 Hz / 20 Hz |
| Communication Interface | | Ethernet |
| Operating Voltage | | 9 V～36 VDC |
| Power Consumption | | 10 W |
| Operating Temperature | | -20℃ ～ +65℃ |
| Shock Test | | 500 m/sec², lasting for 11 ms |
| Vibration Test | | 5 Hz～2000 Hz, 3G rms |
| IP Grade | | IP67 |
| Dimensions | | 155*107.5*90 mm |
| Weight | | 1.5 kg |

## 1.4 Dimensions

There are 4 mounting holes at the back of GCH32 Lidar. Four M6*12 mechanical screws with spring washers and flat washers are needed for locking and fixing the Lidar. There are 2 kinds of GCH32 Lidar for you to choose from according to actual needs. Figure 1.2

is the dimension drawing of GCH32 Lidar whose cable interface is on its back; while figure 1.3 is the dimension drawing of GCH32 Lidar whose cable interface is on its side face.
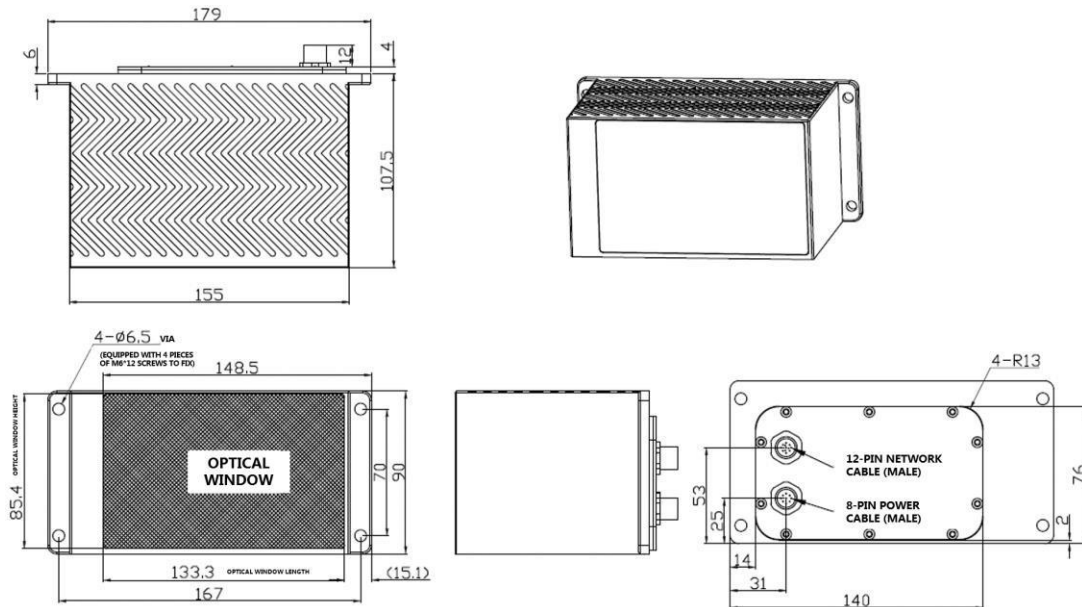


Figure 1.2 GCH32 Lidar Dimensions (Cable Interface on the Back)
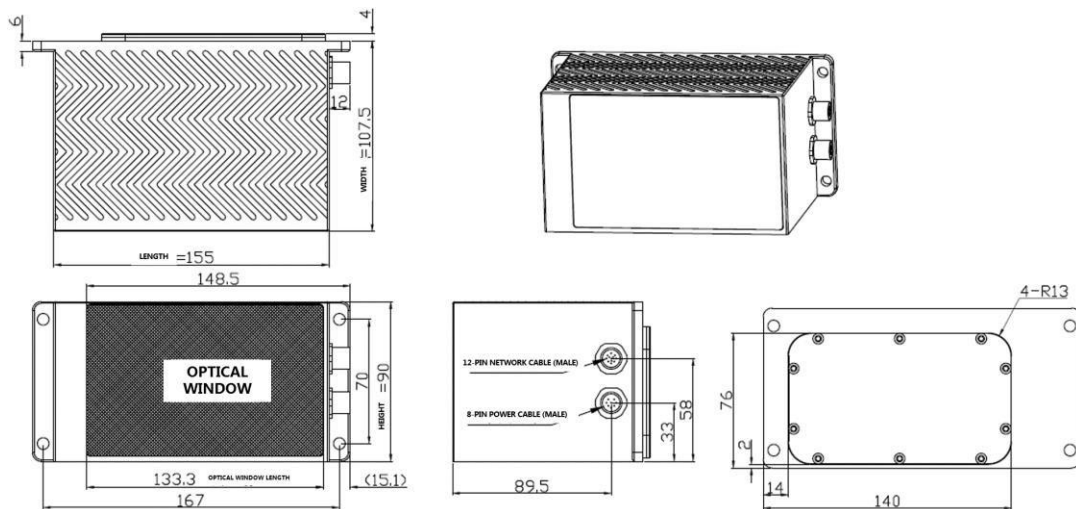


Figure 1.3 GCH32 Lidar Dimensions (Cable Interface on the Side)

The GCH32 Lidar utilizes mirror rotation to scan 120° horizontally. Through special optical design, it realizes a denser laser channel distribution in the vertical direction. Figure 1.4 shows the appearance of the GCH32 Lidar while Figure 1.5 shows the optical center position, which is also the coordinate origin of the host computer display software.

Figure 1.4 External View of GCH32



Figure 1.5 Optical Center of the GCH32 Lidar

## 2. Electrical Interface

## 2.1 Power Supply

The power input range of the GCH32 Lidar is 9 V～36 VDC. If other DC power supply

is adopted, the recommended output voltage of the power supply is 12 V, 19 V or 24 V. Please note that 9 V and 36 V are short-term power supplies in extreme environments, which cannot be used as working voltage. When the voltage output fluctuates, the Lidar may not be able to work normally.
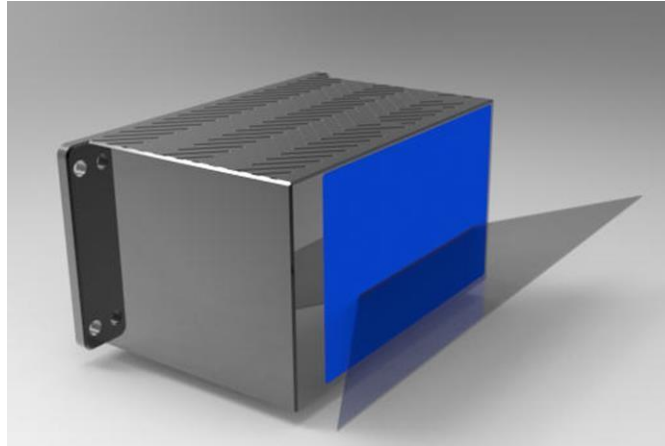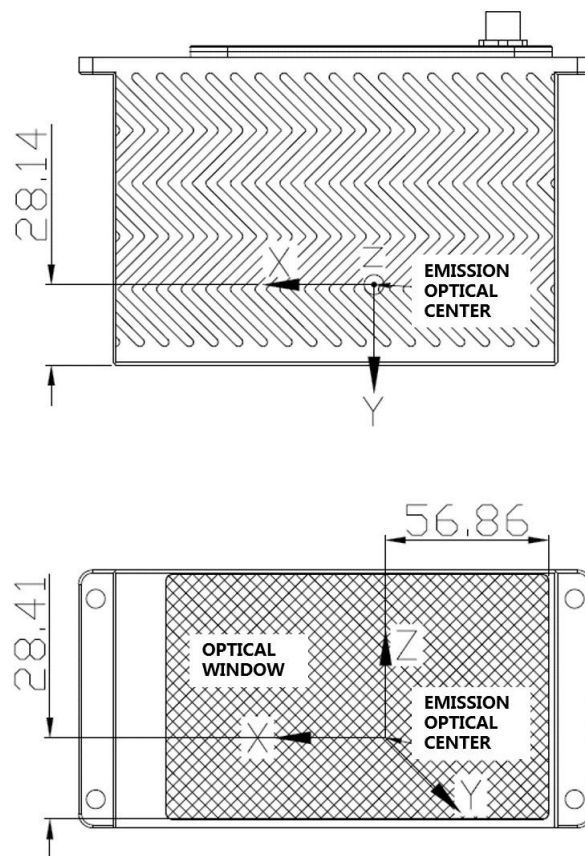
The maximum output current should be ≥2 A (the Lidar requires a large instantaneous current to start, therefore a small starting current may cause its failure to start normally). The output ripple noise should be <120 mVp-p and output voltage accuracy <5%.

The higher the power supply voltage and the stronger the discharge capacity, the more severe the impact on the Lidar (such as powered by direct vehicle power supply without adapters or interface boxes). Therefore, it is necessary to use high-power TVS transient suppression diodes to avoid Lidar damage.

The length of the Lidar power supply cable is 5~10 m, and the power supply voltage needs to be over 19 V. If the power cable is more than 10 m long, then it is recommended to use a 220 VAC adapter for power supply (DC long-distance power supply is not recommended).

## 2.2 Wiring Definition

The cables connecting to the interfaces on the side of the GCH32 Lidar base are a 12-pin cable and an 8-pin shielded cable, whose wiring definitions are as shown in the figures below.
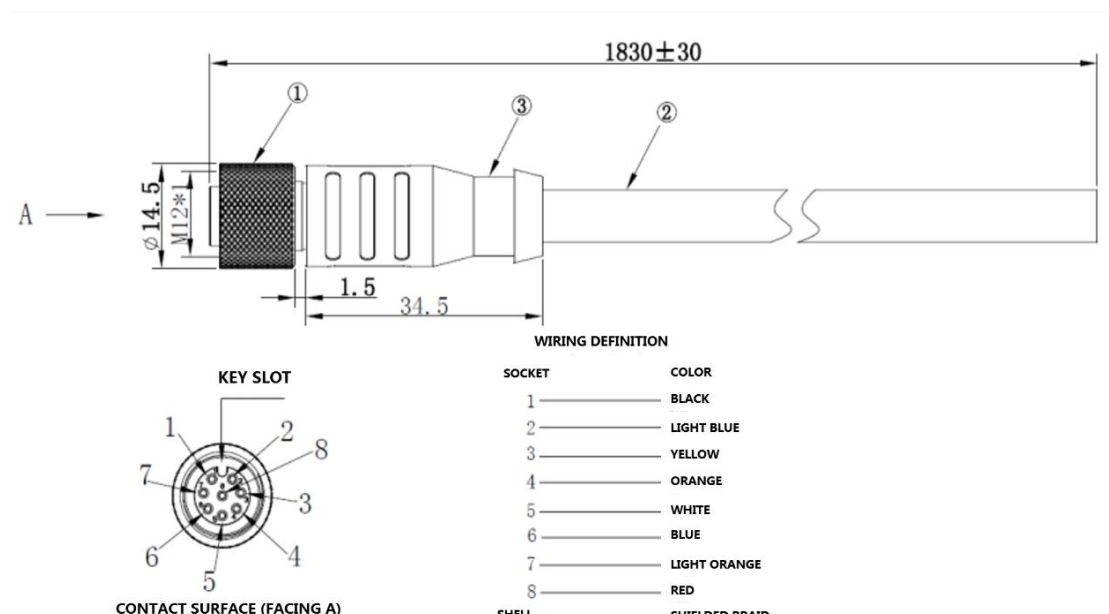


WIRING DEFINITION

| SOCKET | COLOR |
| --- | --- |
| 1 | BLACK |
| 2 | LIGHT BLUE |
| 3 | YELLOW |
| 4 | ORANGE |
| 5 | WHITE |
| 6 | BLUE |
| 7 | LIGHT ORANGE |
| 8 | RED |
| SHELL | SHIELDED BRAID |

Figure 2.1 The 8-Pin Cable
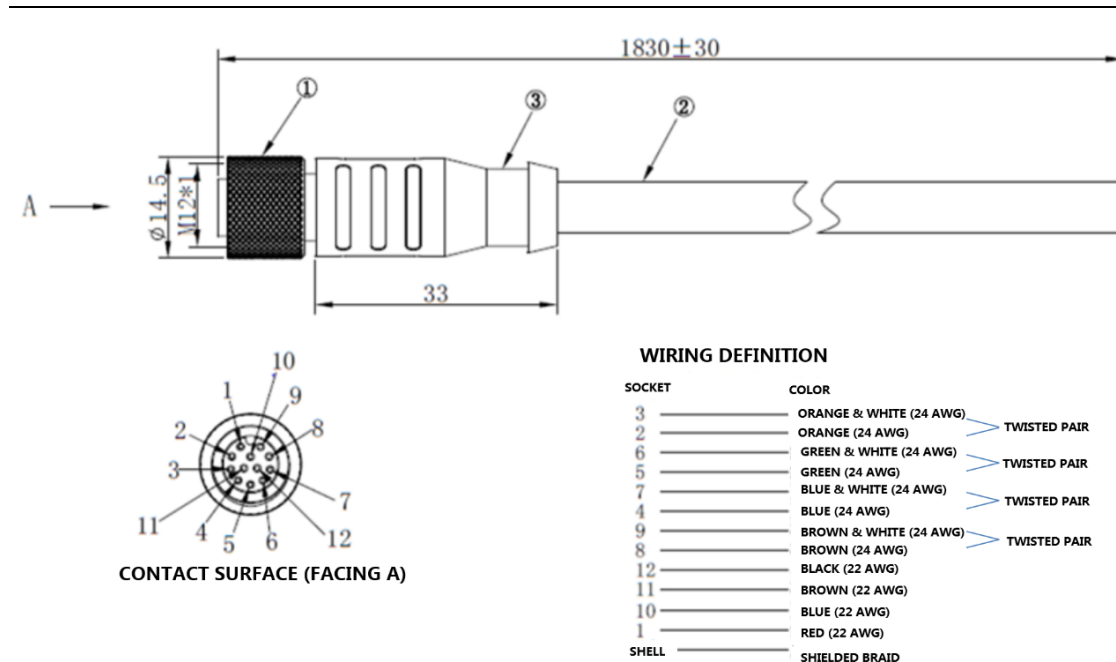
Figure 2.2 The 12-Pin Cable

Table 2.1 The 8-Pin Cable Wiring Definition

| S/N | Color | Definition | Description |
|---|---|---|---|
| 1 | Black | GND | Power GND |
| 2 | Light Blue | GND | Power GND |
| 3 | Yellow | N.C | |
| 4 | Orange | GPS_GND | Signal GND |
| 5 | White | GPS_PPS | GPS inputting PPS signal |
| 6 | Blue | GPS_GPRMC | GPS inputting GPRMC signal |
| 7 | Light Orange | VCC | Power+ |
| 8 | Red | VCC | Power+ |

Table 2.2 The 12-Pin Automotive Ethernet Cable Wiring Definition

| S/N | Cable Color and Specification | Definition | Description |
|---|---|---|---|
| 1 | Red (22) | N.C | |
| 2 | Orange (24) | Ethernet TX1+ | Ethernet TX+ |
| 3 | White and Orange (24) | Ethernet TX1- | Ethernet TX- |
| 4 | Blue (24) | Ethernet TX3+ | Ethernet TX+ |
| 5 | Green (24) | Ethernet RX2+ | Ethernet RX+ |
| 6 | White and Green (24) | Ethernet RX2- | Ethernet RX- |
| 7 | White and Blue (24) | Ethernet TX3- | Ethernet TX- |
| 8 | Brown (24) | Ethernet RX4+ | Ethernet RX+ |
| 9 | White and Brown (24) | Ethernet RX4- | Ethernet RX- |
| 10 | Blue (22) | N.C | |
| 11 | Brown (22) | N.C | |

| 12 | Black (22) | N.C | |
| Shell | Shield | PE | GND |

## 2.3 Interface Box

An interface box is sent to you along with the Lidar, whose function is to facilitate the direct connection to the power adapter, Ethernet cable, and the 4-pin GPS module. Please note that the interface box is not a necessary accessory for Lidar operation.

The interface box of the GCH32 Lidar includes: an automotive Ethernet port, an automotive power port, a Φ2.1 mm DC socket, an indicator light, a RJ45 network port and a 4-Pin GPS port, as shown in Figure 2.3.



| PIN | DEFINITION |
| --- | --- |
| 1 | NC |
| 2 | GND |
| 3 | GPS_REC |
| 4 | GND |
| 5 | +5V |
| 6 | GPS_PPS |
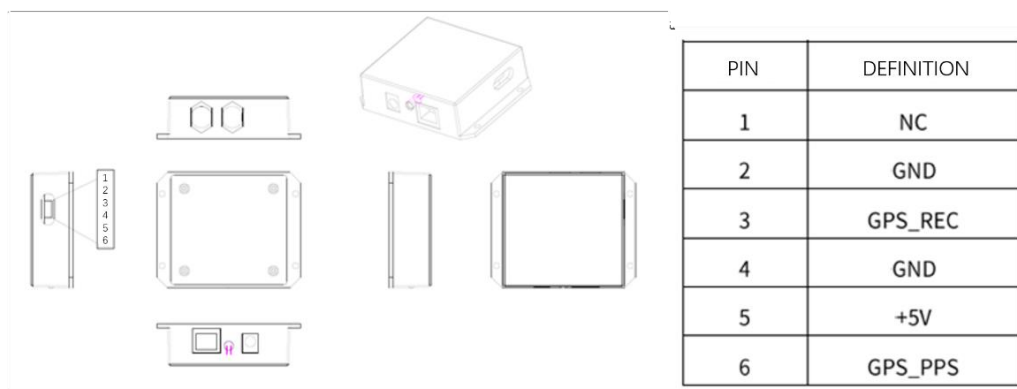
Figure 2.3 Interface Box and GPS Pin Definition

Table 2.3 The Interface Definition of the 4-Pin GPS

| PIN | Definition |
| --- | --- |
| 1 | +5V Input |
| 2 | GPS_TX |
| 3 | GPS_PPS (TTL 5V) |
| 4 | GND |

If the interface box is not needed, please move the 8-pin or 12-pin terminal wires out of the box and connect them to the power supply, Ethernet interface and GPS device interface separately. To realize this, you only need to disassemble the interface box housing, disconnect the solder joints of the wires, and take out the wires from the interface box.

# 3. Get ready

## 3.1 Lidar Connection

To get ready for the Lidar operation, please connect the Lidar, host computer, GPS module and power supply though the interface box as shown in Figure 3.1.



Figure 3.1 Connecting the Lidar

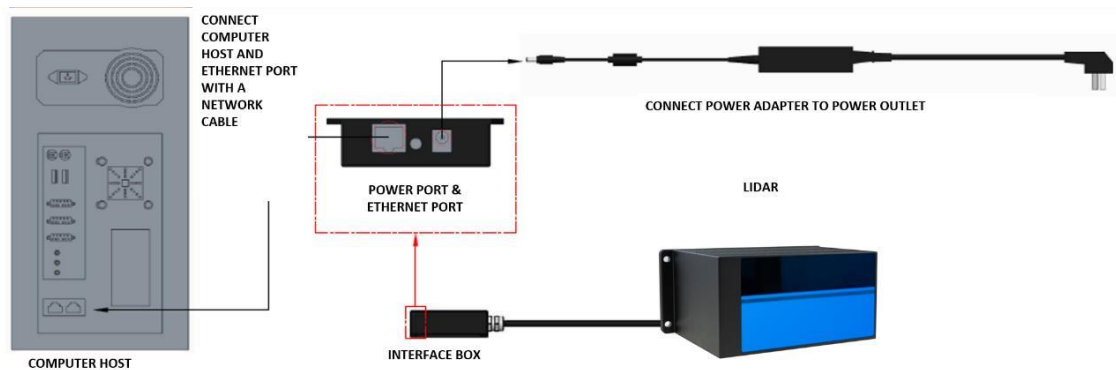## 3.2 Software Preparation

The Gronet GCH32 Lidar can be operated under both Windows operating system and Linux operating system. Software needed is as follows:

**Wireshark**: to capture the ARP (Address Resolution Protocol) packets.

Note: Wireshark is a third-party software, and you may need to download it by yourself. Gronet Intelligent bears no responsibility for any copyright and commercial disputes caused by users' use of the software.

To view the point cloud data generated by the Lidar, you can either use the GCH32 **Windows Client** or the **ROS Drive Program.**

**GCH32 Windows Client (optional)**: a host computer software to view point cloud image under Windows operating system, which is also referred to as "point cloud display software". Simple functions like parameter configuration, Lidar test and fault detection can be realized through the client, too.

☐ Software Acquisition

This GCH32 Windows Client has been pre-stored in the USB flash drive provided along with the Lidar. It can also be obtained from the sales or technical support personnel. No installation is required to the client.

☐ Operating Environment

This software can only run under the Windows x64 operating system at present. The computer configuration requirements for installing the software are: CPU: Intel(R) Core (TM) i5 or higher; Graphics Card: NVIDIA GeForce GTX750 or higher achieves the best effect, otherwise the display of the point cloud may be affected. And the computer graphics card must support OpenGL 2 or higher graphics acceleration to display the point cloud normally.

☐ Supplemental Software

To use the GCH32 Windows Client, the installation of the **WinPcap** third-party library is necessary. This software has also been pre-stored in the USB flash drive provided with the Lidar.

To install the WinPcap software, please follow the following steps:

**Step 1.** Insert the USB driver into computer port and open it.

**Step 2.** Find the WinPcap installation file and double-click it to initiate the installation.

**Step 3.** Click "next" to enter the installation path selection interface.

**Step 4.** Click "next" to enter the installation interface.

**Step 5.** Click the "install" button, and wait for the installation to be completed.

**ROS Drive Program (optional)**: to view the point cloud data under Linux operating system. This program has been pre-stored in the USB flash drive provided with the Lidar. It can also be obtained from the sales or technical support personnel. No installation is required.

# 4. Usage Guide

This part states operation instructions of the GCH32 Windows Client and ROS drive presented by the Gronet Intelligent System Co. Ltd.

## 4.1 Operation Under Windows OS

### 4.1.1 Lidar Configuration

The default IP address and port number of the Lidar network are as follows:

Table 4.1 Default Lidar Network Configuration

|  | **IP Address** | **UDP Device Package Port** | **UDP Data Package Port** |
|---|---|---|---|
| Lidar | 192.168.1.200 | 2368 (Fixed) | 2369 (Fixed) |

| Computer | 192.168.1.102 | 2369 | 2368 |
|---|---|---|---|

**Note:**

1) The Lidar IP (local IP) and the computer IP (destination IP) cannot be set to the same, otherwise the Lidar will not work normally.

2) In the multicast mode, no two destination ports should be set to the same port number.

When connecting to the Lidar, if the computer IP and the Lidar IP are in different network segments, the gateway is needed to be set; if they are in the same network segment, different IPs are needed to be set, for example: 192.168.1.x, and the subnet mask is 255.255.255.0. If you need to find the Ethernet configuration information of the Lidar, please connect the Lidar to the computer and use "Wireshark" to capture the ARP packet of the device for analysis. For the feature identification of the ARP packet, see the figure below.
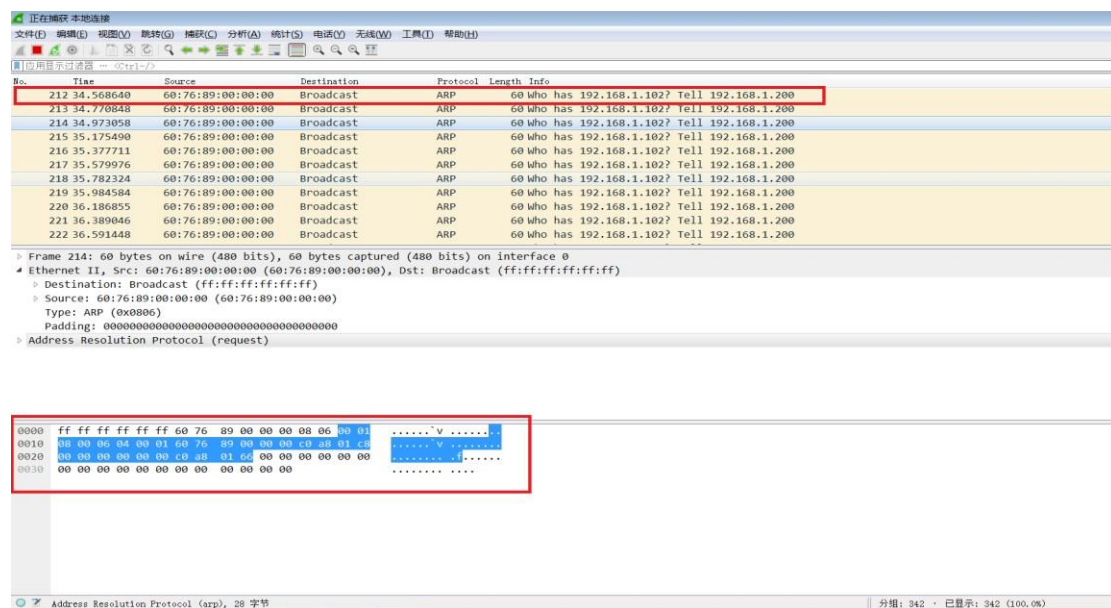


Figure 4.1 Wireshark captures APR packets

## 4.1.2 GCH32 Windows Client Interface

The software interface includes menu area, tool bar area, 3D window area, data table area, etc.
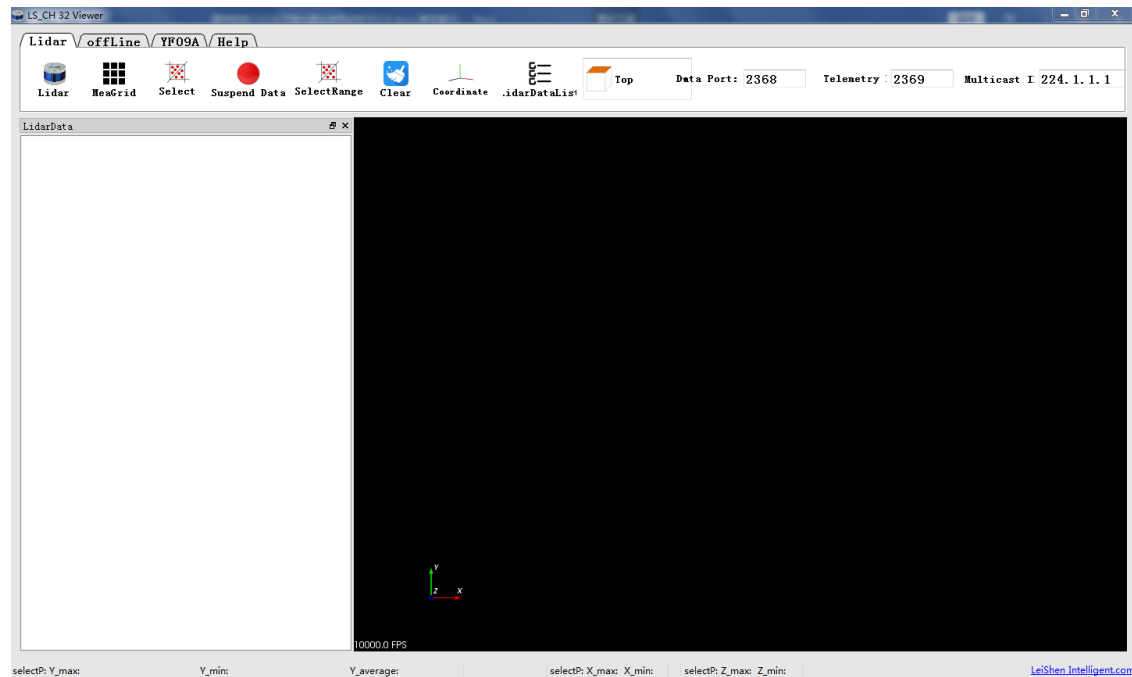
Figure 4.2 Initial Interface

**Note:** To view the software version, click "Help->About" in the toolbar.

**Point cloud display interface supports the following operations:**

1) Zoom in/out the display interface with the mouse wheel; hold the right mouse button and drag it up/down to zoom in/out.

2) Hold the left mouse button and drag it to adjust the angle of view;

3) Hold the mouse wheel and drag it to pan the display interface; or hold the shift key on the keyboard and the left mouse button to pan the interface.

**Menu button function introduction**

☐ Lidar Menu

| Button | Description |
|---|---|
| Lidar | Click to start receiving display data |
| MeaGrid | Show/hide measurement grid |
| Select | Mark the selected points in the point cloud image |

| Button | Description | |
|---|---|---|
| **Suspend Data** | Pause point cloud image and data generating | |
| **SelectRange** | Select point clouds from different angles | |
| **Clear** | Clear screen | |
| **Coordinate** | Show/hide coordinate | |
| **LidarDataList** | Show/hide the column on the left | |
| Top / Front / Top / Left | Three-view option: set the observation angle from top, front, and left. | |

**Note:** In the point cloud display area, with 20 circles and 40*40 grids, the radius of every two adjacent circles differs by 10 m. The difference between each two grids (horizontal or longitudinal) is 10 m. And the radius of the outermost circle is 200 m.

The grids and circles make it easy to view the position of the point cloud. The direction of the coordinate axis in the 3D display interface is consistent with the direction of the X-Y axis in the point cloud reference system.

☐ Offline Menu

| Button | Description | |
|---|---|---|
| **Open** | Open offline data | |
| **Record** | Record and save data, valid only when Lidar receives data in real time | |
| ⏮ | Skip to the beginning | |
| ⏪ | When paused, view the previous frame; When playing, rewind (click multiple times to select 2x, 3x, 1/2x, 1/4x and 1x speed) | 2x 3x 1/2x 1/4x |
| ▶ | Click to start playing after the point cloud file is loaded. When playing, click to pause | |
| ⏩ | When paused, view the next frame; When playing, fast forward (click multiple times to select 2x, 3x, 1/2x, 1/4x and 1x speed) | 2x 3x 1/2x 1/4x |

| Button | | Description |
|---|---|---|
| ⏭ | Skip to the end | |
| ⎯⎯⎯ 198 ⬍ | Drag the progress bar or enter the frame number to skip to the specified position | |

☐ Setup Menu

| Button | Description | |
|---|---|---|
| ⚙ **Parameter** | Open Lidar parameter form | The upper part of the form shows the Lidar configuration. The parameters include local IP, destination IP, subnet mask, gateway, data port, device port, and motor speed setting (5Hz/10Hz/20Hz can be selected under combobox), whether to obtain the local time, Mac address information, and device packet sending interval. The lower part shows the real-time status information. According to the DIFOP status packet sent out regularly by the Lidar, the current status information is displayed, including GPS position information, satellite time information, motor speed, current Lidar IP, and current Lidar port number. |
| 📶 **Channel** | Select laser channel | Vertical Angle column represents the vertical angle of the corresponding channel data and Channel column represents the data sequence number corresponding to the channel. |
| 📄 **SaveData** | Save the data in .csv format | The data includes Points_X, Points_Y, Points_Z, Laser_id, Azimuth, Distance, Intensity. |
| ● Intensity ▾ | Set the display mode of the point cloud | Intensity, laser ID, azimuth angle, etc. |

**Note**: The computer graphics card must support OpenGL 2 or higher graphics acceleration to display the point cloud normally.

### 4.1.3 Operation Procedure

**Step 1.** Set the data port number (default 2368), device port (or telemetry port in the picture below) number (default 2369).

Data Port: 2368    Telemetry Port: 2369

**Step 2.** When the power supply of the Lidar is connected to the network cable, click

to receive the Lidar data in real time.

**Step 3.** The data table contains ID, Points_m_XYZ, Distance, Azimuth, Intensity, in which ID is the Lidar channel number; Points_m_XYZ are the coordinates; Distance is the distance value; Azimuth is the azimuth angle; and Intensity is the reflection intensity.
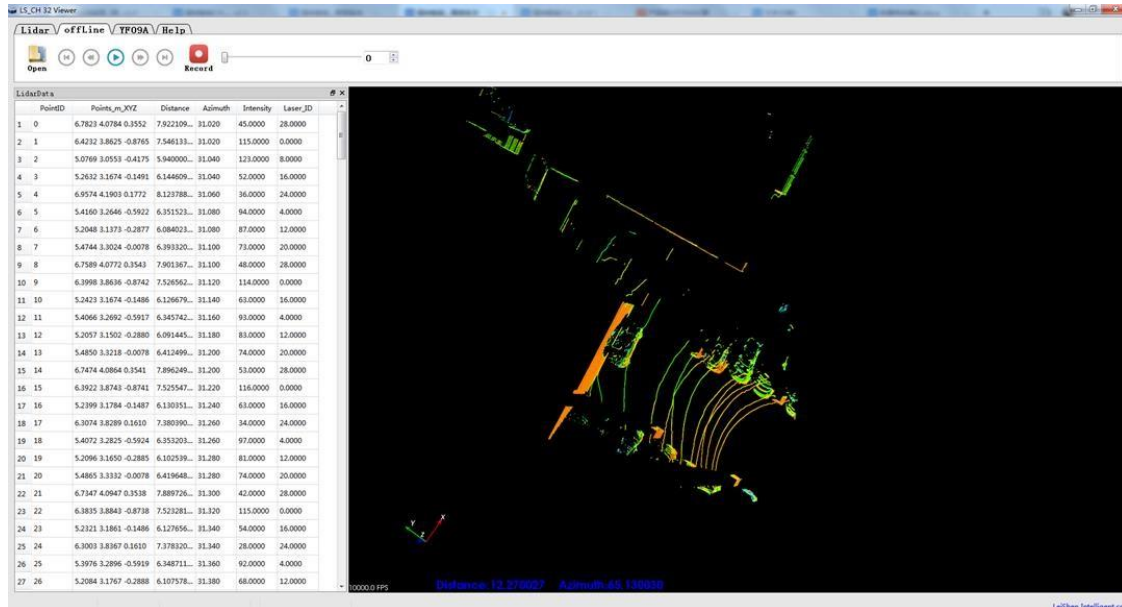


Figure 4.3 Real-Time Lidar Point Cloud Display

## 4.1.4 Point Cloud Data Parsing

If you need to parse Lidar data, please follow the steps below:

**Step 1**. Parse the data package to obtain the relative horizontal angle, ranging information, intensity data and microsecond timestamp information of each laser;

**Step 2**. Read the device package to obtain information such as the horizontal correction angle value, UTC (GPS or NTP time service) and the current configuration of the device;

**Step 3**. Obtain the vertical angle of each line according to the laser beam distribution;

**Step 4**. According to the distance measurement value, vertical angle and the calculated horizontal angle of the point cloud data, the XYZ coordinate values are obtained;

**Step 5**. If necessary, calculate the precise time of the point cloud data through UTC, microsecond timestamp, light-emitting time of each laser, as well as single and dual echo modes;

**Step 6**. Reconfigure information such as Ethernet, PPS synchronization horizontal angle, motor speed and other information as needed, and pack the configuration package protocol.

## 4.1.5 Note

**Notice about the Lidar setting and usage:**

1) It is not possible to use GCH32 Windows Client to receive data in two processes (open twice at the same time) on the same computer. The port occupancy of the PC is generally exclusive, so the other software that uses the same process or the same port number cannot work normally after a process is bound to a specified port number. When GCH32 Windows Client detects that the port is occupied, it will prompt that the communication network port configuration has failed, and automatically close the software. You need to close the software process that occupied the port, and reopen the Client to use it normally.

2) At the same time, since Qt is adopted in the low-level software development, please create English paths when naming files and path folders.

3) Since the port number of the GCH32 Lidar can be modified through user configuration, and the Lidar sends data to the host computer through the preset destination IP and port. Therefore, when the local laptop or desktop computer and other devices are receiving data, their IP address should be the same as the destination IP, and the port bound to the local host computer program needs to be the same as the destination port number, as shown in the figure below (these are the data packet parameters captured and analyzed by Wireshark software). The data in the red boxes indicate the destination IP and port number of the Lidar.



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

Figure 4.4 Data Packet Parameters Captured by Wireshark Software

Please set the host computer IP according to the following steps:

**Step 1.** In the Control Panel -> Network and Internet -> Network Sharing Center, click the "local connection" button.

**Step 2.** Click "Properties" in the pop-up status box, and click "TCP/IPv4 protocol" in the pop-up properties box, as shown in the figure below.
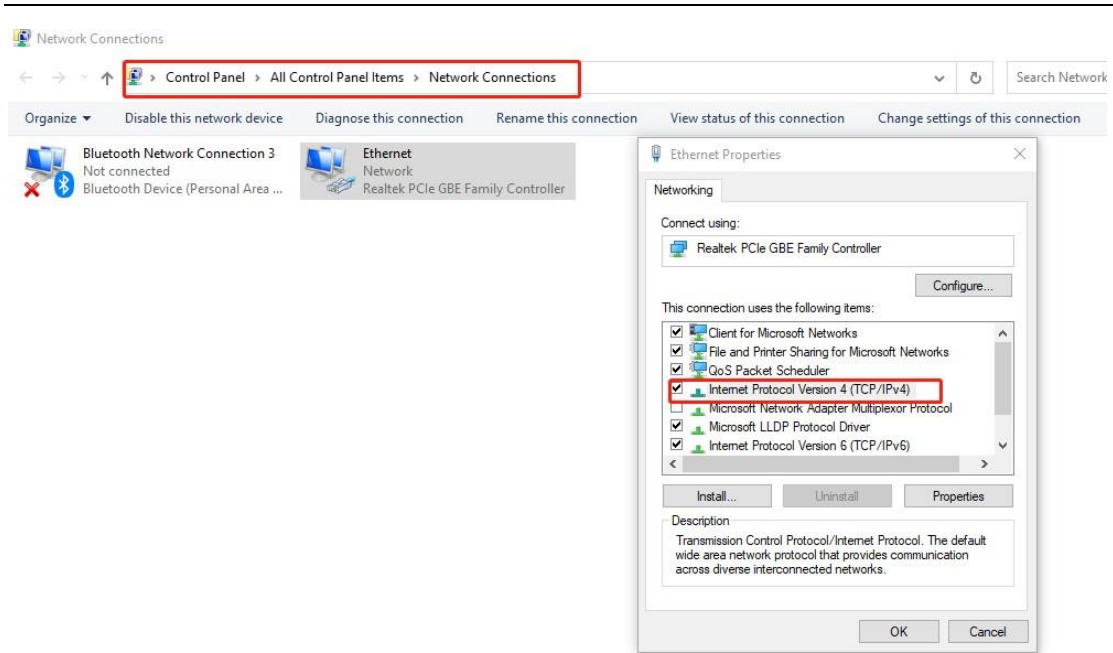
Figure 4.5 Network Connections

**Step 3.** In the TCP/IPv4 property settings, set the IP address to the Lidar's destination IP (The default destination IP of the Lidar is 192.168.1.102), and the subnet mask is set to 255.255.255.0.
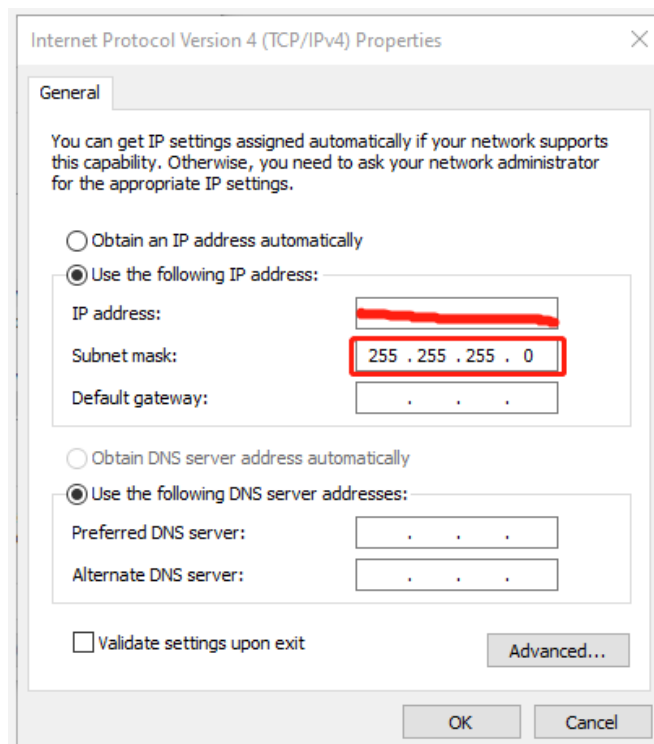


Figure 4.6 IP Address and Subnet Mask Setting

4) Since the GCH32 Windows Client needs to obtain a large number of data packets through the network in a short time, it may be considered as a malicious program by

the network firewall and be prohibited. Therefore, there may be situations in which the data packet has been sent to the computer by the Wireshark software, but the client cannot display it.

To address this problem, in Control Panel -> System and Security -> Windows Firewall Settings, click to allow this program to pass through Windows Firewall, setting steps are as shown in the figures below:

**Step 1.** In Control Panel -> System and Security -> Windows Defender Firewall, click "Allow an app or feature through the Windows Defender Firewall".

**Step 2.** Browse to find the software installation path, select it and click OK.

**Step 3.** Tick the part marked in the red box according to the nature of your network, and click OK to see the data.
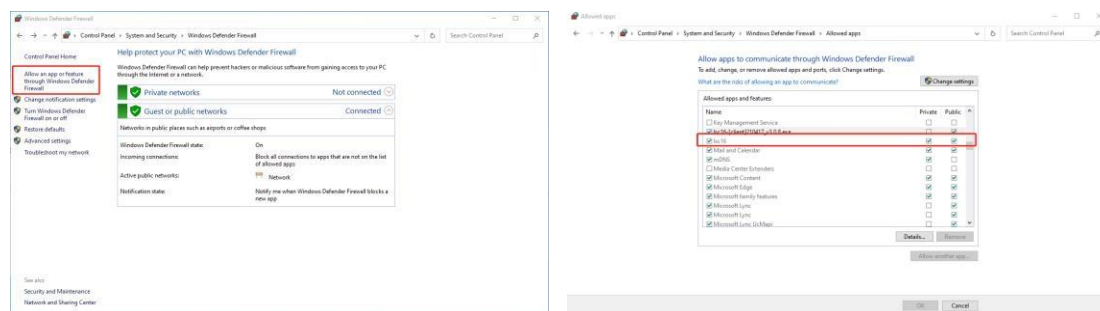


Figure 4.7 Windows Defender Firewall Setting

**Computer graphics settings**

When installing the GCH32 Windows Client on a desktop or laptop with dual graphics cards, the default global settings of the computer operating system is to use the global settings (automatic selection: integrated graphics), which affects the display efficiency of the software. In order to ensure the use and display efficiency of the software, you need to manually set the computer graphics.

The condition of dual graphics cards can be checked in the computer configuration, and the condition of the display adapter can be seen in My Computer->Properties->Device Manager.

Take a laptop with Intel(R)HD Graphics 530 integrated graphics and NVIDIA GeForce GTX 960 discrete graphics as an example. The setting steps to manually switch the applicable graphics card of the software to high-performance discrete graphics card are as follows:

**Step 1.** Right-click on a blank space on the desktop to pop up a right-click menu and select "NVIDIA Control Panel".

**Step 2**. Select the "Manage 3D Settings" in the NVIDIA Control Panel interface.

**Step 3**. Click the "Program Settings" button in the Manage 3D Settings interface.

**Step 4**. Click the "Add" button on the Manage 3D Settings interface.

**Step 5**. Click the "Browse" button in the pop-up interface.

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

**Step 7**. Click "OK" to automatically return to the NVIDIA control panel, select the high-performance NVIDIA processor in the combo box of the preferred graphics processor for this program in Option -2., and click "Apply" in the lower right corner.
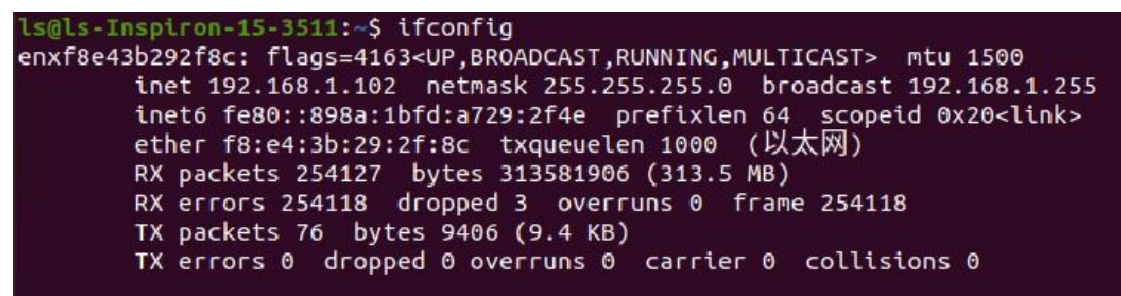
After the computer application is set, close the NVIDIA Control Panel to complete the setting.

## 4.2 ROS Driver Operation Under Linux OS

### 4.2.1 Hardware Connection and Test

**Step 1.** Connect the Lidar to the internet and power supply

**Step 2.** Set the computer wired IP according to the destination IP of the Lidar, (whether the computer wired IP is set successfully can be checked by the ifconfig command, as shown in the figure, the destination IP is 192.168.1.102)



Figure 4.8 ifconfig Command Feedback

**Note**: The default destination IP of the Lidar is 192.168.1.102, and the computer must be configured according to the actual Lidar destination IP. After setting the IP for the first time, please restart the Lidar.

**Step 3.** After the Lidar is powered on and restarted, check the wired connection icon of the computer to see whether it is connected properly.

**Step 4.** Open the terminal: ping the Lidar IP, and test whether the hardware is connected normally. If the ping is successful, then the data is received, otherwise check the hardware connection.

**Step 5.** Use "sudo tcpdump -n -i eth0" (here eth0 is the name of the wired network

device, see the device name of ifconfig wired connection display for details) to view the data packets sent by the Lidar (as shown in the figure, there are 1206-byte data packets sent by the Lidar to the destination, which means that the Lidar data is sent normally).



```
leishen@robot:~$ sudo tcpdump -n -i eth0
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on eth0, link-type EN10MB (Ethernet), capture size 262144 bytes
19:49:08.973111 IP 192.168.1.200.2368 > 192.168.1.102.2368: UDP, length 1206
19:49:08.973717 IP 192.168.1.200.2368 > 192.168.1.102.2368: UDP, length 1206
19:49:08.974308 IP 192.168.1.200.2368 > 192.168.1.102.2368: UDP, length 1206
19:49:08.974913 IP 192.168.1.200.2368 > 192.168.1.102.2368: UDP, length 1206
19:49:08.975517 IP 192.168.1.200.2368 > 192.168.1.102.2368: UDP, length 1206
19:49:08.976107 IP 192.168.1.200.2368 > 192.168.1.102.2368: UDP, length 1206
19:49:08.976714 IP 192.168.1.200.2368 > 192.168.1.102.2368: UDP, length 1206
```

Figure 4.9 sudo tcpdump -n -i eth0 Command Feedback

## 4.2.2 Software Operation Example

**Step 1.** Establish a workspace and build a compilation environment

mkdir -p ~/Gronet_ws/src

cd ~/Gronet_ws

**Note**: The workspace can be named arbitrarily. For example, "Gronet_ws" can be changed to any name.

**Step 2.** Download the Lidar ROS driver

The ROS driver can also be obtained directly from our website or customer service. Copy the obtained driver file to the newly created workspace "src", and decompress it.

**Step 3.** Compile and package

cd ~/Gronet_ws

catkin_make

**Step 4.** Run the program

source ~/Gronet_ws /devel/setup.bash

roslaunch lslidar_GCH32_decoder lslidar_ch.launch

Reopen a terminal again and execute the following command:

rviz

**Note 1**): If the Lidar destination port and motor speed are modified, please open "lslidar_ch.launch" to modify the configuration accordingly. The default data packet port is 2368, device packet port is 2369, IP address is 192.168.1.200.

**Note 2):** If timeout appears, it means that the driver has no data reception. Please check the hardware connection.

**Note 3)**: If steps 1, 2, and 3 have been completed, next time after the "Displays Window" is reopened, start directly from step 4.

**Step 5.** Display the data detected by the Lidar

In the "Displays Window" that pops up, modify the value of "Fixed Frame" to "laser_link". Click the "Add" button at the same time, and click "PointCloud2" under "By topic" to add a multi-line point cloud node.

**Note**: If the lidar destination port and IP are changed, please open "lslidar_ch.launch" to modify the configuration accordingly. The default data packet port is 2368, the device packet port is 2369, and the IP address is 192.168.1.200.

# 5. Communication Protocol

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

The communication protocols of the Lidar are:

**Main data Stream Output Protocol (MSOP):** outputting the distance, angle, intensity and other information measured by the Lidar;

**Device Information Output Protocol (DIFOP):** outputting the current status of Lidar and accessory equipment and various configuration information;

**User Configuration Write Protocol (UCWP):** setting the configuration parameters of the Lidar.

Table 5.1 UDP Packet Protocol

| Protocol Name | Abbreviation | Function | Length | Transmission Interval |
|---|---|---|---|---|
| Main data Stream Output Protocol | MSOP | Outputting measured data and timestamp | 1248 bytes | 0.28 ms |
| Device Information Output Protocol | DIFOP | Outputting parameter configuration and status information | | 1s (for 1 packet) |
| User Configuration Write Protocol | UCWP | Inputting user configured device parameters | | Not Fixed |

## 5.1 MSOP Protocol

The data package outputs measured data such as the angle value, distance value, intensity value, and timestamp of the point cloud. The data of the package adopts Little-Endian mode.

The data package includes a 42-byte Ethernet header and a 1206-byte payload, with a total length of 1248 bytes. The payload consists of 1197 bytes of point cloud data and 9 bytes of additional information (including 3 reserved bytes, 4 bytes of Timestamp and 2 bytes of Factory).

### 5.1.1 Format

The GCH32 Lidar supports single echo mode which measures the most recent echo value.

Each MSOP data packet contains 1206 bytes of data. Each packet of data contains 171 points, that is, 171*7=1197 bytes, and the frame tail is 9 bytes (including 3 reserved bytes, 4 bytes of Timestamp and 2 bytes of Factory). See the figure below:
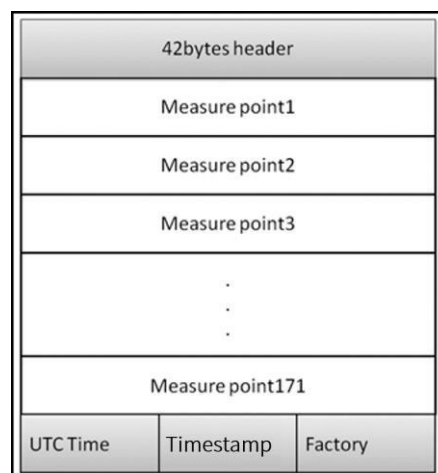


**Note**: The Lidar displays the point cloud image by frame. In the MSOP data package, if the data of the first point is FF AA BB 00 CC DD EE XX, then it is the start mark of the point cloud frame (the Lidar scans to the far right at this time). The start mark can be anywhere in a packet of data, not necessarily the packet header. This point is not displayed as point cloud data, but is only a judgment mark for the beginning of an image frame.

### 5.1.2 Data Package Parameter Description

**Ethernet Header**

The Ethernet header has a total of 42 bytes, as shown in the table below.

| Ethernet Header: 42 Bytes |
| --- |

| Name | S/N | Information | Offset | Length (byte) |
|---|---|---|---|---|
| Ethernet II MAC | 0 | Destination | 0 | 6 |
| | 1 | Source | 6 | 6 |
| Ethernet Packet Type | 2 | Type | 12 | 2 |
| Internet Protocol | 3 | Version, Header Length, Differentiated Services, Field, Total Length, Identification, Flags, Fragment Offset, Time to Live, Protocol, Header, Checksum, Source IP Address, Destination IP Address | 14 | 20 |
| UDP Port Number | 4 | Lidar Port (0x0941, represent 2369) | 34 | 2 |
| | 5 | Computer Port (0x0940, represent 2368) | 36 | 2 |
| UDP Length & Sum Check | 6 | Length (0x04BE, represent 1214 bytes) | 38 | 2 |
| | 7 | Sum Check | 40 | 2 |

**Subframe**

The subframe is the effective data area of the data packet, which contains a total of 1197 bytes, including 171 points, that is, 171*7=1197 bytes. Take the first measure point as an example:

| Byte 1 | Byte 2 | Byte 3 | Byte 4 | Byte 5 | Byte 6 | Byte 7 |
|---|---|---|---|---|---|---|
| Line_num | Horizontal angle[15:8] | Horizontal angle[7:0] | Distance[23:16] | Distance[15:8] | Distance[7:0] | strength |

**Byte 1** represents the line number, whose value range from 0 to 31, a total of 32 lines. Each line corresponds to a different vertical angle, for example, line 0 represents a vertical angle of -6.67°, line 1 represents a vertical angle of -6.33°. The angle difference between two adjacent lines is 0.333°, that is to say, the vertical angel of channel X = -6.67°+0.333*X.

**Byte 2** and **Byte 3** represent the horizontal angle, whose data are stored in Big-Endian mode. The unit is 0.01°. For example, 0x11AD=4525, that is 45.25°.

**Byte 4**, **Byte 5**, and **Byte 6** represent the distance value. Their data are stored in Big-Endian mode. The two high bytes are the integer part, whose unit is "cm"; and the last byte is the decimal part, whose unit is 1/256 cm.

To analyze the distance value, for example: the distance value in the obtained data packet is represented by the hexadecimal number 0x02, 0x18, 0x32, and the first two bytes are composed of 16-bit unsigned data, that is: 0x0218, which is converted to decimal distance value: 536 cm. The last byte is the decimal part, 0x32 equals 50 in

decimal, that is, 50*1/256 cm = 0.1953125 cm. Then the two parts add up to 536.1953125 cm.

**Byte 7** represents echo strength, and the value range is 0-255. (Echo strength can reflect the energy reflection characteristics of the measured object in the actual measurement environment. Therefore, the echo strength can be used to distinguish objects with different reflection characteristics.)

**Azimuth**

The resolution of the horizontal angle value (0.045°、0.09°、0.18°) is determined according to the motor speed (5 Hz, 10 Hz, 20 Hz). The horizontal angle defines the right side of the Lidar as 0°, the left side as 180°, and the vertical direction as 90°. The range of the Lidar's horizontal direction is 30° to 150°, as shown in the figure below.
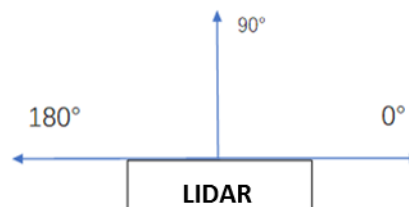


Figure 5.1 The Azimuth of the Lidar

**Additional Information**

The additional information is 6 bytes in length, including 4 bytes of microsecond Timestamp and 2 bytes of Factory.

| Additional Information: 6 bytes | | | |
|---|---|---|---|
| **Name** | | **Length (byte)** | **Function** |
| Timestamp | | 4 | Timestamp (μs) |
| Factory | Echo Information | 1 | 0x1 represents single echo Lidar<br>0x2 represents dual echo Lidar |
| | Vendor Information | 1 | 0x20 represents the GCH32 Lidar |

1) When there is a GPS device inputting PPS signal to the Lidar, the timestamp is generated according to the PPS time as the cycle time, and the range of the timestamp is 0-999999 (μs);

2) When there is an external synchronization device inputting PPS signal, the timestamp is generated according to the external synchronization PPS time as the cycle time, and the range of the timestamp is 0-999999 (μs);

3) When there is no synchronization device inputting PPS signal, the Lidar generates

timestamp with a period of 1 hour. The range of the timestamp is 0-3599_999_999 (μs).

## 5.2 DIFOP Protocol

The device package outputs read-only parameters and status information such as version number, Ethernet configuration, motor speed and operating status, and fault diagnosis. The data of the device package adopts Big-Endian mode.

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

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

Figure 5.2 Data Format of the Device Package

| Ethernet Header: 42 bytes | | | | |
|---|---|---|---|---|
| **Name** | **S/N** | **Information** | **Offset** | **Length (byte)** |
| Ethernet II MAC | 0 | Destination | 0 | 6 |
| | 1 | Source | 6 | 6 |
| Ethernet Packet Type | 2 | Type | 12 | 2 |
| Internet Protocol | 3 | Version, Header Length, Differentiated Services, Field, Total Length, Identification, Flags, Fragment Offset, Time to Live, Protocol, Header, Checksum, Source IP Address, Destination IP Address | 14 | 20 |
| UDP Port Number | 4 | Lidar Port (0x0940, represents 2368) | 34 | 2 |
| | 5 | Computer Port (0x0941, represents 2369) | 36 | 2 |
| UDP Length & Sum Check | 6 | Length (0x04BE, represents 1214 bytes) | 38 | 2 |
| | 7 | Sum Check | 40 | 2 |
| **Payload: 1206 bytes** | | | | |
| **Name** | **S/N** | **Information** | **Offset** | **Length (byte)** |
| Header | 0 | Device Package Identification Header | 0 | 8 |
| Data | 1 | Motor Speed | 8 | 2 |
| | 2 | Ethernet Configuration | 10 | 22 |
| | 3 | GPS Time | 36 | 6 |
| | 4 | Lidar Rotation / Stationary | 46 | 2 |
| | 5 | High Temperature Pause Sign | 48 | 1 |

| | 6 | Device Flow Packet Interval | 50 | 2 |
|---|---|---|---|---|
| | 7 | Latitude and Longitude | 212 | 22 |
| Tail | 8 | Frame Tail | 1204 | 2 |

## 5.3 UCWP Protocol

The UCWP configures the Lidar's Ethernet, motor speed and other parameters, and the data of the configuration package adopts the Big-Endian mode.

The configuration packet includes a 42-byte Ethernet header and a 1206-byte payload, with a length of 1248 bytes. The payload is composed of an 8-byte Header, 1196-byte Data, and a 2-byte Tail.

Header is the configuration packet identification header, which is fixed as 0xAA, 0x00, 0xFF, 0x11, 0x22, 0x22, 0xAA, 0xAA, and the first 4 bytes can be used as the packet inspection sequence. The tail is fixed as 0x0F, 0xF0.

**Note**: It is recommended to configure the Lidar through the GCH32 Windows Client, and you are forbidden to package and configure the Lidar parameters by yourself.

Figure 5.3 Data Format of the Configuration Package

| Ethernet Header: 42 bytes | | | | |
|---|---|---|---|---|
| **Name** | **S/N** | **Information** | **Offset** | **Length byte** |
| Ethernet II MAC | 0 | Destination | 0 | 6 |
| | 1 | Source | 6 | 6 |
| Ethernet Packet Type | 2 | Type | 12 | 2 |
| Internet Protocol | 3 | Version, Header Length, Differentiated Services, Field, Total Length, Identification, Flags, Fragment Offset, Time to Live, Protocol, Header, Checksum, Source IP Address, Destination IP Address | 14 | 20 |
| UDP Port Number | 4 | Lidar Port (0x0941, represent 2369) | 34 | 2 |
| | 5 | Computer Port (0x0940, represent 2368) | 36 | 2 |
| UDP Length & Sum Check | 6 | Length (0x04BE, represent 1214 bytes) | 38 | 2 |
| | 7 | Sum Check | 40 | 2 |
| Payload: 1206 bytes | | | | |
| **Name** | **S/N** | **Information** | **Offset** | **Length byte** |
| Header | 0 | Configuration Package Identification Header | 0 | 8 |
| Data | 1 | Motor Speed | 8 | 2 |
| | 2 | Ethernet Configuration | 10 | 22 |

| | 3 | Lidar Rotation / Stationary | 46 | 2 |
|---|---|---|---|---|
| | 4 | Configuration Flow Packet Interval | 50 | 2 |
| Tail | 5 | Frame Tail | 1204 | 2 |

## 5.3.1 Configuration Parameters and Status Description

Here below are the configuration parameters and status description of specific Lidar information.

**Motor Speed**

| Motor Speed（2 bytes） | | |
|---|---|---|
| S/N | Byte1 | Byte2 |
| Function | Speed: 5 Hz/10 Hz/20 Hz | |

The motor rotates clockwise. Three speeds can be set: when it is set to 0x04B0, the speed is 1200 rpm; when it is set to 0x0258, the speed is 600 rpm; when it is set to 0x012C, the speed is 300 rpm. Other setting data is not supported.

**Ethernet Configuration**

The length of the source IP address "IP_SRC" is 4 bytes and the length of the destination IP address "IP_DEST" is also 4 bytes. Each Lidar has a fixed MAC address "MAC_ADDR" (6 bytes in length), which cannot be configured by users. Port1 is the UDP data port number and port2 is the UDP device port number.

| Ethernet Configuration （22 bytes） | | | | | | | |
|---|---|---|---|---|---|---|---|
| S/N | Byte1 | Byte2 | Byte3 | Byte4 | Byte5 | Byte6 | Byte7 | Byte8 |
| Function | IP_SRC | | | | IP_DEST | | | |
| S/N | Byte9 | Byte10 | Byte11 | Byte12 | Byte13 | Byte14 | Byte15 | Byte16 |
| Function | MAC_ADDR (Read Only) | | | | | | Data Port: Port1 | |
| S/N | Byte17 | Byte18 | Byte19 | Byte20 | Byte21 | Byte22 | | |
| Function | Device Port: Port2 | | Reserved | | | | | |

**UTC**

The Lidar receives GPS signals and parses the $GPRMC information. The UTC synchronizes with GPS. If there is no GPS timing, UTC is all 0s. The GPS baud rate supported by the Lidar is 9600. There are 8 data bits, 1 stop bit and no parity bit.

| UTC (6 bytes Read Only) | | | | | | |
|---|---|---|---|---|---|---|
| S/N | Byte1 | Byte2 | Byte3 | Byte4 | Byte5 | Byte6 |
| Function | Year | Month | Day | Hour | Minute | Second |
| | 0~255 corresponding to the year 2000~2255 | 1~12 month | 1~31 day | 0~23 hour | 0~59 min | 0~59 sec |

**Lidar Rotation & Stationary**

| Lidar Rotation & Stationary（2 bytes） | | |
|---|---|---|
| S/N | Byte1 | Byte2 |
| Function | 0: Rotation；1: Stationary | |

0x0000 indicates that the Lidar is rotating, and 0x0001 indicates that the Lidar is stationary, and the default value of the Lidar is rotating scan.

**Device Flow Packet Interval**

| Device Flow Packet Interval（2 bytes） | | |
|---|---|---|
| S/N | Byte0 | Byte1 |
| Function | 0: send 1 device packet every time 4 data packets are sent; other values: 1 packet per second； | |

The configuration 0x0000 means to send 1 device packet every time 4 packets are sent, and other values mean 1 packet per second. The default value is 1 (1 packet per second).

**Latitude and Longitude**

| Latitude and Longitude（22 bytes Read Only） | | | | | | | |
|---|---|---|---|---|---|---|---|
| S/N | Byte1 | Byte2 | Byte3 | Byte4 | Byte5 | Byte6 | Byte7 | Byte8 |
| Function | Reserved | Latitude | | | | | | |
| S/N | Byte9 | Byte10 | Byte11 | Byte12 | Byte13 | Byte14 | Byte15 | Byte16 |
| Function | Longitude | | | | | | | |
| S/N | Byte17 | Byte18 | Byte19 | Byte20 | Byte21 | Byte22 | | |
| Function | | | | | N/S | W/E | | |

The latitude and longitude are output in the form of ASCII code.

## 5.3.2 Configuration Package Example

If you want to reset the Lidar IP as 192.168.1.105, computer IP as 192.168.1.225, data port number as 6688, device port number as 8899, motor speed as 1200 rmp, according to the definition of the UCWP Packet and each register, it can be reconfigured as follows:

Table 5.4 Configuration Package Example

| Info | Content | Config | Length byte |
|---|---|---|---|
| Header | | 0xAA, 0x00, 0xFF, 0x11, 0x22, 0x22, 0xAA, 0xAA | 8 |
| Motor Speed | 1200 rpm | 0x04, 0xB0 | 2 |
| Lidar IP (IP_SRC) | 192.168.1.105 | 0xC0, 0xA8, 0x01, 0x69 | 4 |
| Computer IP (IP_DEST) | 192.168.1.225 | 0xC0, 0xA8, 0x01, 0xE1 | 4 |

| | | | |
|---|---|---|---|
| Data Port (port1) | 6688 | 0x1A20 | 2 |
| Device Port (port2) | 8899 | 0x22C3 | 2 |
| Lidar Rotation / Stationary | Rotation | 0x0000 | 2 |
| Reserved | Reserved | 0x00 | 1180 |
| Tail | | 0x0F, 0xF0 | 2 |

When using this protocol to configure the device, byte-level or section-level addressing and writing are not allowed, and the entire list must be written completely. After the list is written, the corresponding function will be updated and take effect immediately.

# 6. Time Synchronization

There are two ways to synchronize the Lidar and external equipment: GPS synchronization and external PPS synchronization. If there is no external synchronization input, the Lidar internally generates timing information. The absolute accurate time of the point cloud data is obtained by adding the 4-byte timestamp (accurate to microsecond) of the data packet and the 6-byte UTC (accurate to second) of the device packet.

## 6.1 GPS Synchronization

When GPS synchronization is employed, the Lidar will start timing in microseconds after receiving the PPS second pulse, and the time value will be output as the timestamp of the data packet. The Lidar extracts UTC information from the $GPRMC of the GPS as the UTC (accurate to the second) output.

The GCH32 Lidar has two types of GPS_REC interface level protocols, namely TTL level standard and RS232 level standard; the GPS_REC interface specification on the power box is SH1.0-4P female socket. The two protocols differ in two aspects, respectively:

**TTL level pin definition:**

Pin GPS_TX receives the standard serial port data of the TTL level output from GPS module;

Pin GPS_PPS receives the positive TTL synchronous pulse signal output by the GPS module;

**RS232 pin definition:**

Pin GPS_TX receives the standard serial data of the R232 level output from the GPS module;

Pin GPS_PPS receives the positive synchronization pulse signal output by the GPS module, and the level is required to be 3.0 V~15.0 V.

If the GPS used outputs according to the RS232 serial port protocol, and the Lidar receives data according to the TTL protocol, then an RS232 to TTL conversion module is needed.

The GPS equipment is time-synchronized to mark and calculate the precise emission and data measurement time of each laser. The precise time of the Lidar point cloud can be matched with the pitch, roll, yaw, latitude, longitude and height of the GPS/inertial measurement system.

The default serial configuration baud rate of the GPS data output received by the Lidar is 9600, 8N1. The PPS high pulse width is required to be more than 1ms.

The standard format of GPRMC information is as follows:

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

Table 6.1 The Standard Format of GPRMC Information

| S/N | Name | Description/Format |
|-----|------|--------------------|
| 1 | UTC | hhmmss (hour/minute/second) |
| 2 | Positioning State | A=Effective Positioning, V=Invalid Positioning |
| 3 | Latitude | ddmm.mmmm (degree/minute) |
| 4 | Latitude Hemisphere | N (Northern Hemisphere) or S (Southern Hemisphere) |
| 5 | Longitude | dddmm.mmmm (degree/minute) |
| 6 | Longitude Hemisphere | E (East Longitude) or W (West Longitude) |
| 7 | Ground Speed | 000.0~999.9 knot |
| 8 | Ground Direction | 000.0~359.9 degree, take true north as the reference datum |
| 9 | UTC Date | ddmmyy (day/month/year) |
| 10 | Magnetic Declination | 000.0~180.0 degree |
| 11 | Direction of Magnetic Declination | E (East) or W (West) |
| 12 | Mode Indication | Only NMEA0183 version 3.00 outputs, A= autonomic positioning, D= difference, E=estimation, N=invalid data |

## 6.2 External Synchronization

In external synchronization, the Lidar receives the PPS signal input by other external devices and times it in microseconds, and the timing value is output as the timestamp of the data packet. At this time, there is no UTC reference. If UTC is required, it must be written in the configuration package, otherwise the UTC output information of the device package is invalid.

The PPS level of the external synchronization signal is 3.3 V ~5 V, and the Lidar receives the rising edge trigger, and the PPS high pulse width is required to be more than 1 ms.

## 6.3 Lidar Internal Timing

When there is no GPS and other equipment to synchronize, the Lidar uses 1 hour ($360*10^6$ μs) as the cycle. With the microsecond as the timing unit, the timing value is output as the timestamp of the data packet. At this time, there is no UTC reference. If UTC is required, it must be written in the configuration package, otherwise the UTC output information of the device package is invalid.

## 7. Angle and Coordinate Calculation

The point cloud data can be obtained from the data packet, whose effective data area contains a total of 1197 bytes, including 171 points, that is, 171*7=1197 bytes. Take the first measure point as an example:

| Byte 1 | Byte 2 | Byte 3 | Byte 4 | Byte 5 | Byte 6 | Byte 7 |
|--------|--------|--------|--------|--------|--------|--------|
| Line_num | Horizontal angle[15:8] | Horizontal angle[7:0] | Distance[23:16] | Distance[15:8] | Distance[7:0] | strength |

## 7.1 Vertical Angle

**Byte 1** represents the line number, whose value ranges from 0 to 31, a total of 32 lines. The line number respectively represents the laser beam arranged in the vertical FOV from the bottom one to the top one. Each laser beam corresponds to a different vertical angle.

Due to the special optical design of GCH32, its vertical angle is not uniformly distributed, and its specific value can be obtained through calculation. The following figure shows the vertical angle distribution of the actual emitted light. As can be seen from the figure, there are 32 lines in total, with vertical angles ranging from -6.67° to 4.58°. When the angle between the light and the horizontal direction is 150°, the vertical angular distance

between the line 0-3, line 4-7,..., line 28-31 is 0.16°, the vertical angular distance between the line 3-4, line 7-8,..., line 27-28 is 0.81°, and the vertical angle is from -6.67° to 3.17°; when the angle between the light and the horizontal direction is 90°, the vertical angular distance between the line 0-3, line 4-7,..., line 28-31 is 0.47°, the vertical angular distance between the line 3-4, line 7-8,..., line 27-28 is -0.09° ("-" indicates that the position between the two lines is exchanged), and the vertical angle is from -6.67° to 4.07°; when the angle between the light and the horizontal direction is 30°, the vertical angular distance between line 0-3, line 4-7,…, line 28-31 is 0.47°, the vertical angular distance between line 2 and 4, line 3 and 5, line 6 and 8, line 7 and 9, line 10 and 12, line 11 and 13,…, line 26 and 28, line 27 and 29 is 0.03°, and the vertical angle is from -6.67° to 4.58°
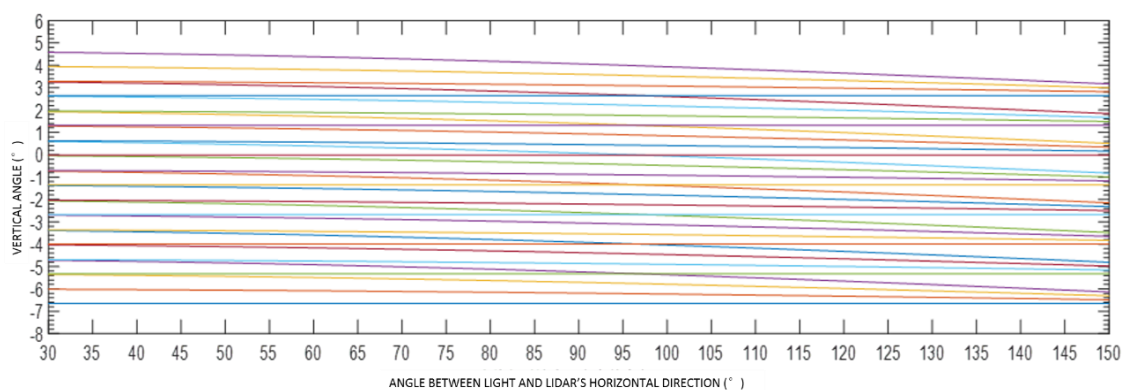


Figure 7.1 Angle Between Light and Lidar's Horizontal Direction

## 7.2 Horizontal Angle

**Byte 2** and **Byte 3** represent the horizontal angle, whose data are stored in Big-Endian mode. The unit is 0.01 degrees. For example, 0x11AD=4525, that is 45.25°.

## 7.3 Distance Value

**Byte 4**, **Byte 5**, and **Byte 6** represent the distance value. Their data are stored in Big-Endian mode. The two high bytes are the integer part, whose unit is "cm"; and the last byte is the decimal part, whose unit is 1/256 cm. To analyze the distance value, for example: the distance value in the obtained data packet is represented by the hexadecimal number 0x02, 0x18, 0x32, and the first two bytes are composed of 16-bit unsigned data, that is: 0x0218, which is converted to decimal distance value: 536 cm. The last byte is the decimal part, 0x32 equals 50 in decimal, that is, 50*1/256 cm=0.1953125 cm. Then the two parts add up to 536. 1953125 cm.

## 7.4 Cartesian Coordinate Representation

In order to obtain the vertical angle, horizontal angle and distance parameters of the

Lidar, the angle and distance information in polar coordinates can be converted to the x, y, z coordinates in the right-hand Cartesian coordinate system. The conversion relationship is shown in the following formula:

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

In the above formula, r is the distance, α is the vertical angle, θ is the horizontal rotation angle (the horizontal correction angle needs to be considered when calculating). And x, y, and z are the coordinates of the polar coordinates projected onto the x, y, and z axes.
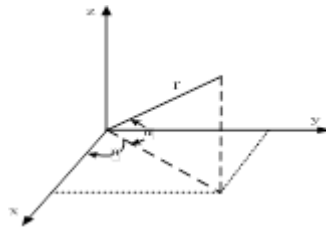


Figure 7.2 Coordinate Mapping

# 8. Accurate Time Calculation

To accurately calculate the time of the point cloud data, it is necessary to obtain the timestamp of the data packet and the UTC of the device package output by the Lidar. The timestamp and UTC come from the same synchronization source, such as a GPS.

The laser emission interval of the GCH32 Lidar is about 1.65 μs, and the measurement interval of adjacent points is 1.65 μs.

A data packet has a total of 171 measurement data. The packet packing time is about **1.65μs\*171 ~= 0.28 ms,** and the data rate is about **1s/0.28 ms = 3571 data packets/sec.**

## 8.1 Calculation of Data Packet End Time

The timestamp in the data packet is a relative time in microseconds, which is defined as the packing time of the laser measurement data of the last channel in the data packet (packet end time), and its duration is less than 1 second. Therefore, to calculate the absolute end time of the data packet, it is necessary to obtain the 4-byte microsecond timestamp in the data packet first, and then obtain the UTC (more than 1 second) from the device package. The addition of the two will be the exact time when the data packet ends.

## 8.2 Accurate Time Calculation of Channel Data

The precise measurement time of each data can be calculated with the exact time of the end of the data packet and the light-emitting time interval of the 171 points.

Each data packet block of the GCH32 Lidar contains 171 measurement data. Therefore, the end time interval of each data packet (single echo mode) is 280 μs. Assuming that the absolute time of the data packet end is $T_{Packet\_end}$, the steps for calculating the end time of the data block $\mathbf{T_{Block\_end}(N)}$ are as follows:

$$\mathbf{T_{Block\_end}(N) = (T_{Packet\_end} - 1.65~\mu s*(171\text{-}N)).~(N = 1, 2, ..., 171).}$$

## Revision History

| Version Number | Release Date | Revised Content | Issued/Revised By |
|---|---|---|---|
| V2.0.0 | 2021-12-24 | Initial Version | 1286 |
| V2.0.1 | 2022-01-07 | Wiring Definition | 1286 |
| V2.0.2 | 2022-03-03 | ROS Driver Operation | 1286 |
| V2.0.3 | 2022-06-09 | Wiring Definition; Interface Box | 1286 |
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