PACECAT

V1.3

LDS-50C-E User Manual

360° TOF Laser Scan Ranging LiDAR

Jinhua Lanhai Photoelectricity Technology Co., Ltd.

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Contacts

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Website: https://www.pacecat.net/

Safety Notes

- Please read the Instructions carefully before use and do not operate the device in violation of the instructions; otherwise, user shall bear the consequences of device damage;
- Unless otherwise permitted by Jinhua Lanhai, user should not dismantle the Device, or remove the optical cover while the Device is running;
- It is forbidden to scrap the optical cover with any solid object, for the surface damage may affect the ranging accuracy and increase noise data; keep the surface clean to avoid weakening the ranging performance due to dust;
- Before installing the equipment, it is necessary to ensure that the installation holes are aligned with the reserved screws on the base, and the installation surface is flat to prevent deformation of the LiDAR base due to size mismatch or surface protrusion of foreign objects, which may affect the normal operation of the LiDAR;
- Antistatic protection: Test should be carried out in antistatic area for the Device may be damaged by static electricity;
- It is forbidden to handle the Device in inflammable and explosive place, or store it in the corrosive place in order to keep safety;
- The Device should be well cooled during long-term running;
- Do not stare at the laser output surface directly for a long period to keep safety, for the Device will continuously transmit infrared laser that conforms to FDA Class I laser device safety standard;
- For any fault of the Device, please contact Jinhua Lanhai for detection. Maintenance and part replacement must be carried out by Jinhua Lanhai.

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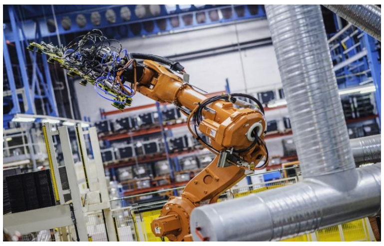
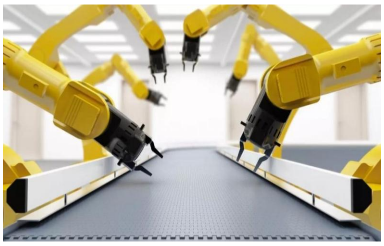
I. Introduction


AGV


Service Robot


Industrial Robot


Robot Arm


Industrial Robot

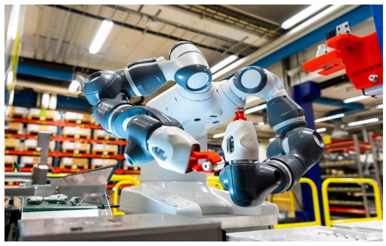

Industrial Robot

Fig.1-1 Application Scenarios of LDS-50C-E

The typical rotation frequency of the LDS-50C-E is 15Hz(900RPM),and the angular resolution at this speed is 0.18°,which can be switched to 10Hz(600RPM) according to the needs.

The LDS-50C-E LiDAR uses a near - infrared pulsed laser as the light source, and the laser pulses are emitted only within the time frame of nanoseconds (ns). Therefore, it can ensure the safety of humans and pets, and complies with the EN/IEC 60825 - 1 Class 1 laser safety standard. The application of near - infrared pulsed lasers combined with filters can effectively avoid light interference, so it can be used normally in both indoor and outdoor environments.

II. Operating Principle

The LDS-50C-E is designed based on the TOF (Time of Flight) principle, and can range up to 36,000 times per second. The ranging data is sent to the power supply processing module through high-speed optical communication, and the distance value and intensity information between the target object and the LiDAR are output from the communication interface. As shown in Fig. 2-1, in the working state, the laser emits a laser beam, which will be reflected when it illuminates the obstacle object. The receiver detects the reflective signal, and measures the time difference between the reflected light and the emitted light through the time analysis module. The flight distance of the light can be obtained by multiplying the time by the speed of light, so as to calculate the position information of the obstacle. In order to obtain target information from more angles, distance and intensity information from different angles are obtained inside the LiDAR through motor rotation, so as to obtain a complete two-dimensional point cloud image. The default design of the internal motor drive of LDS-50C-E is counterclockwise rotation.

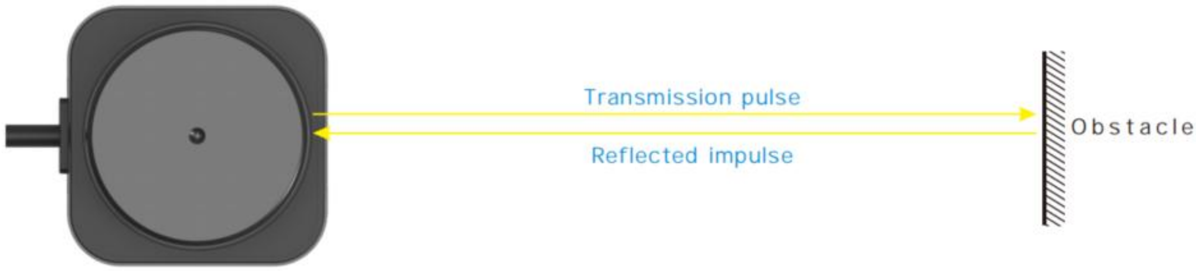


Fig 2-1 Operating Principle

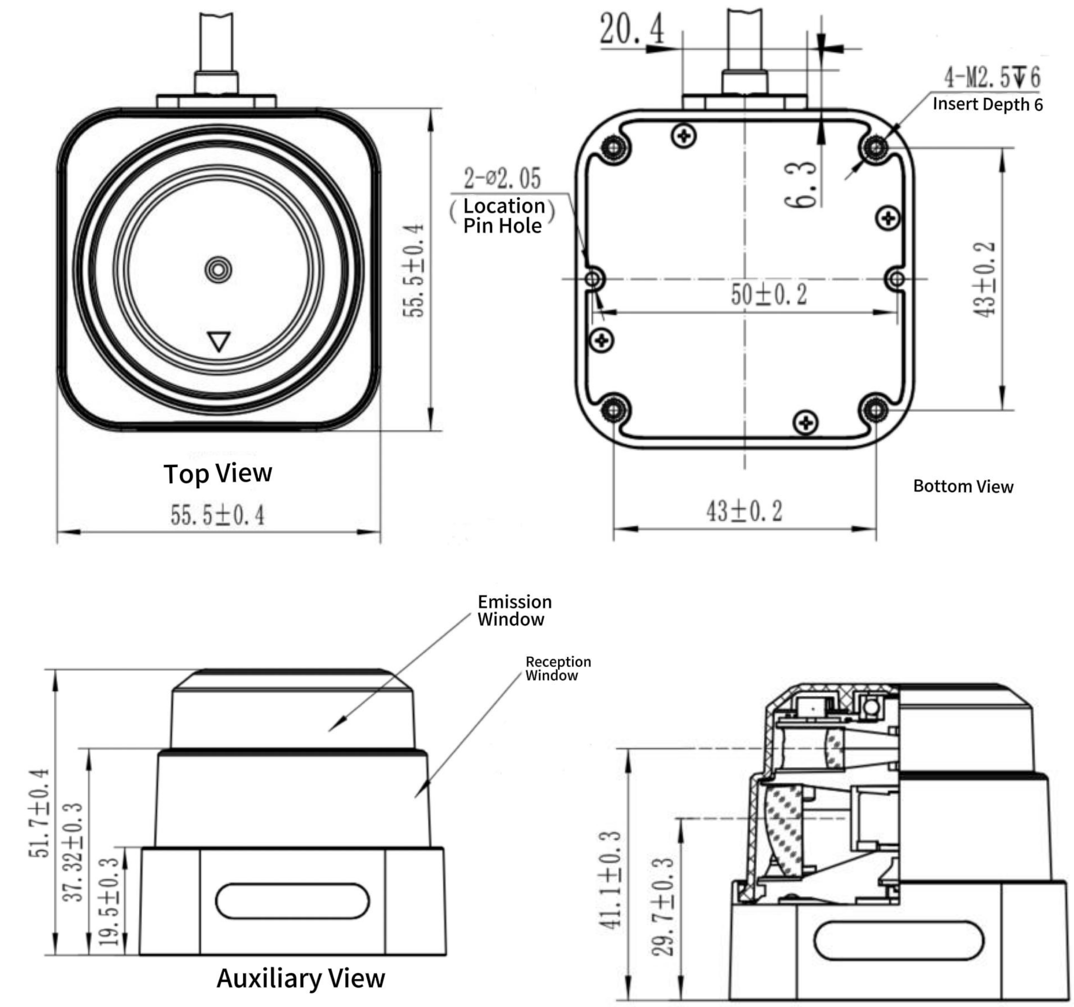
III. Product Advantage

- It has hardware filtering and drag point removal functions, which can effectively avoid interference caused by some noise points;
- It can output the reflection intensity of target synchronously, which can be used for algorithm judgment;
- The range accuracy can be ±2.5cm, and the linear consistency of targets with different reflectance is good;
- Photoelectric wireless data transmission, brushless motor design, long service life;
- Multi - LiDARs operate simultaneously without interference from each other.;
- Special optical design, effectively improve the anti-fouling ability

IV． Mechanical Dimensions & Optical Window

4.1 Mechanical Dimensions

Unit：mm



Note: Dimensions without tolerance indication are ±0.2mm

Fig. 4-1 Schematic diagram of appearance and internal structure dimensions

4.2 Optical Windows

The obstruction of the optical window by the outer cover can affect the ranging performance and accuracy. Therefore, when designing LDS-50C-E, PACECAT reasonably arranged the laser emission and reception window. If there are special needs or transparent covers need to be used to protect this sensor, please refer to this document for information on the size of the optical ranging window and contact PACECAT to understand the feasibility of the solution design.

Fig.4-2 Schematic Diagram of Laser Vertical Angle

As shown in Fig. 4-2, the vertical Angle of the laser emitted by each device will have a slight deviation. Taking the horizontal plane as a reference, the vertical Angle deviation of the LDS-50C-E is within ±0.3°.

As shown in Fig.4-3, LiDAR installation angle, spot pitch angle and spot length need to be considered when designing the device window. The center of the default device window coincides with the optical axis of the LiDAR transmitting and receiving system. Assuming that the assembly Angle error is 1° and the LiDAR pitch Angle is 0.3°, the distance from window to center of LiDAR is L=0.5m.The length of spot d=(6.5+5.2*L)/1000. The length of spot at 0.5m is 9.1mm. The gap between the window and the top of the LiDAR a=L*Tan(1+0.3) +0.5d-10.6, the calculated gap distance is 5.30mm; Window size W=32.2+a.According to the calculation, the window size is at least 37.5mm.

Regardless of whether the LiDAR pitch Angle and the machine assembly Angle are positive or negative, the overall window size needs to ensure that the emission and reception window are not blocked.

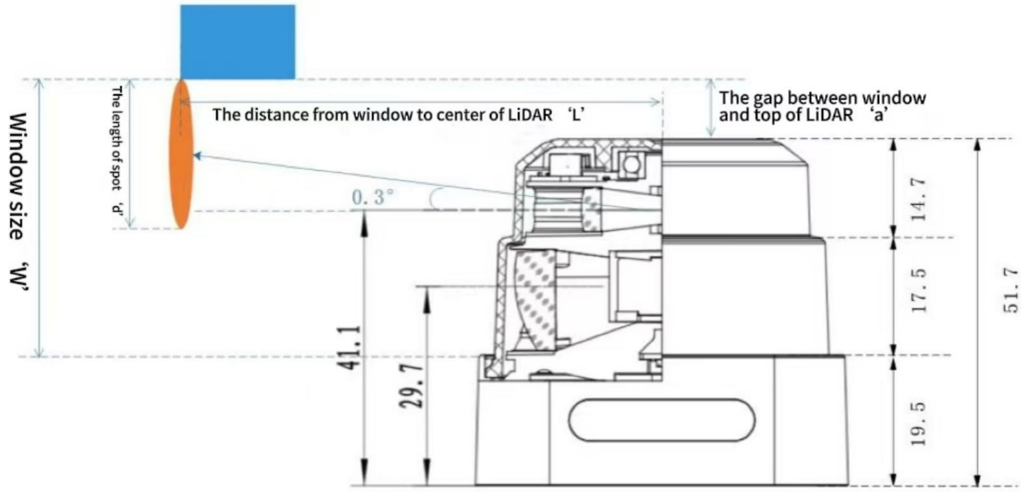


Fig. 4-3 LiDAR installation window opening diagram

4.3 Assembly Recommendation

In order to avoid any impact on the LiDAR caused by the interference between LiDARs, it is recommended to install the LiDAR as follows:

As shown in Figure 4-4, when two or more LiDARs are installed in the same height plane, it is recommended to tilt the LiDARs down to avoid shooting.

As shown in Figure 4-5, 4-6, 4-7 and 4-8, when two or more LiDARs are installed on different planes, it is recommended to adjust the LiDAR optical Windows to different heights to avoid shooting.

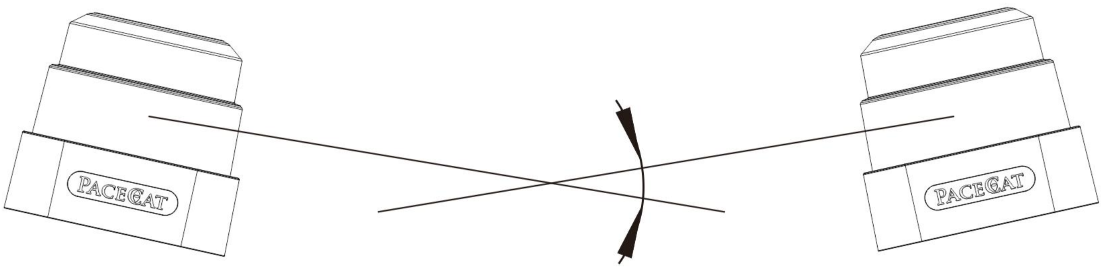


Fig. 4-4 The LiDAR is placed horizontally at the same height

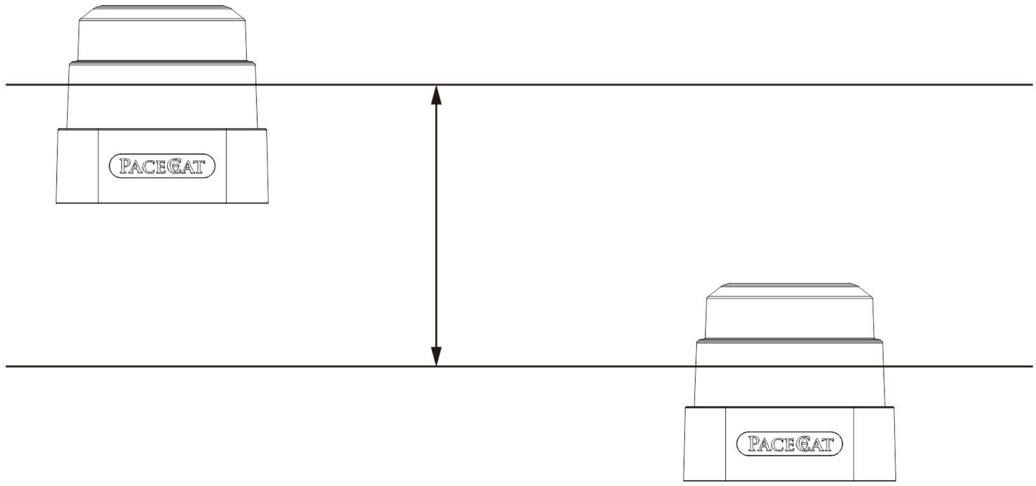


Fig. 4-5 Formal installation of LiDAR at different heights

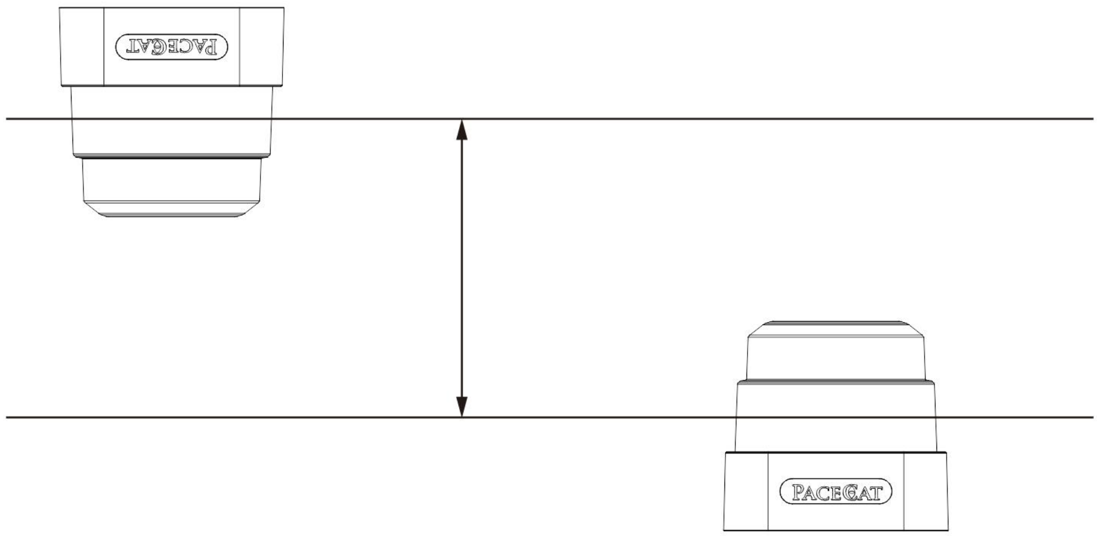


Fig. 4-6 LiDAR placed at different heights, one of which is inverted

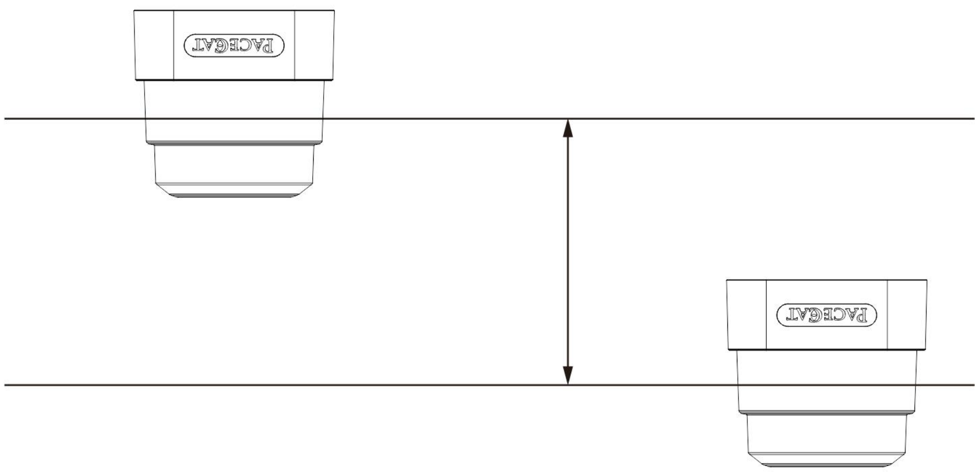


Fig. 4-7 Reverse installation of LiDAR at different heights

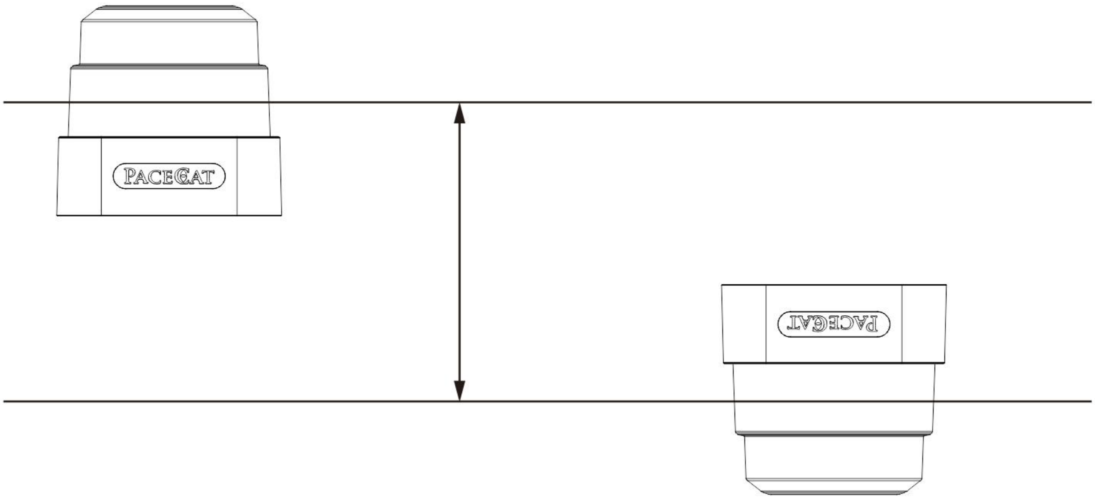


Fig. 4-7 LiDAR placed at different heights, one of which is inverted

V. Parameter Performance

5.1 Physical Parameter

Model	LDS-50C-E
Laser Wavelength	905nm±15nm
Ranging Distance	0.1-40m@90% reflection
	0.1-15m@10% reflection
Laser divergence angle	<5.2 mrad
Laser horizontal parallelism	±0.3°
Rotation direction	anticlockwise
Scanning area	360°
Scanning frequency	10Hz,15Hz（600RPM,900RPM,with a fluctuation range of ±5%）
Angle resolution	0.1°,0.15°
Ranging speed	36000Measurement value/s
Ranging accuracy	±25mm（The ranging accuracy is ±25mm under the reflection condition of 10%~ 90% within 7m, and the reliability is 90%）
Distance resolution	10mm
Light spot	Vertical length:6.5mm+4.3×distance(mm) Horizontal length:13mm+0.9×distance(mm)
Port	Ethernet UDP 100M full duplex
Power	<2.5W
Output	Original data（Distance, Angle, Energy）
Ambient light	＞80000lux
Power supply	10~26VDC
Working temperature	-10°C~50°C
Storage dimensions	-25°C~65°C
Size	55.5mm*55.5mm*51.7mm (Length * width * height）

5.2 Communication setting

The LDS-50C-E connects to the computer using a standard Ethernet interface. In order to ensure that the LiDAR can communicate with the computer properly, it is necessary to ensure that the two are in the same network segment.

LiDAR factory setting as shown in below:

LiDAR IP:192.168.158.98
LiDAR sub network mask:255.255.255.0
LiDAR Gateway:192.168.158.1
LiDAR default upload address:192.168.158.15

Computer network setting as shown in below:

Computer IP:192.168.158.15
Computer sub network mask:255.255.255.0
Computer Gateway:192.168.158.1
Setting the IP of computer steps as below:

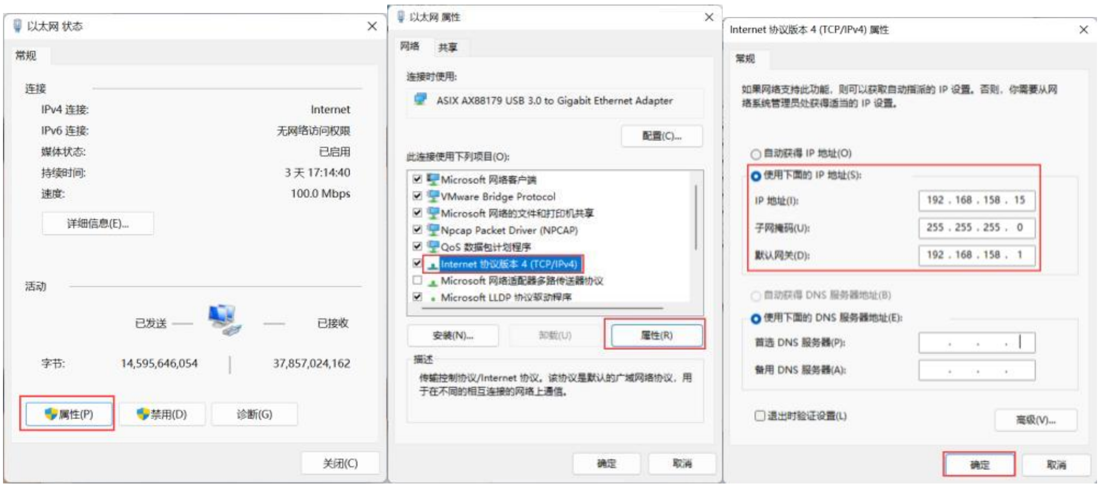
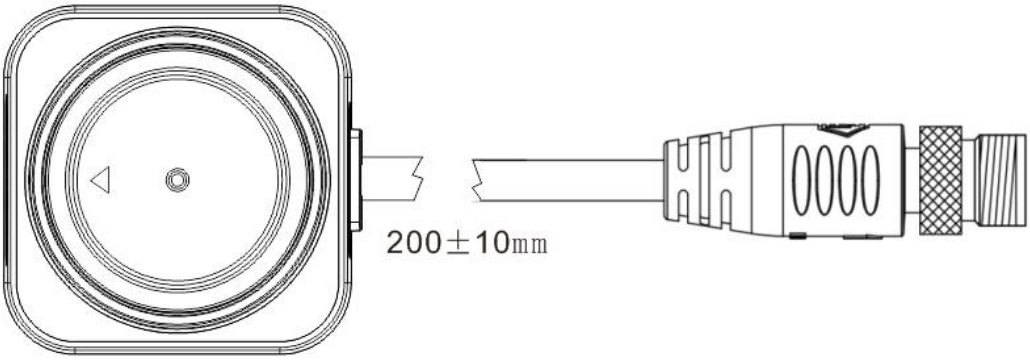
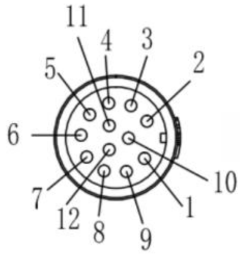


Fig. 5-1 Setting the IP of computer

5.3 Interface Definition

LDS-50C-E uses M12 interface cable, line length 200±10mm, the interface definition is shown figure 5-2



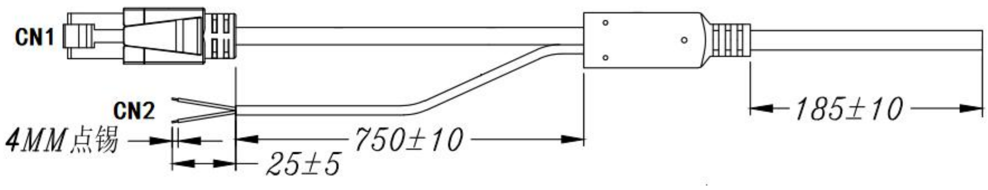


Male Connector

Wiring Method		
CN1	Color	Signal Definition
1	Red	24V
2	Black	GND
7	Green	RX+
8	Green-White	RX-
9	Orange	TX+
10	Orange-White	TX-

Figure 5-2 LiDAR Interface Definition

Replace the LiDAR cable on the basis of the LDS-50C-E model, as shown in Figure 5-3. Add the new model using a bare power cord+RJ45 crystal head interface method.You can choose based on interface requirements.



Wiring Method		
CN1	Color	Signal Definition
1	Orange - white	TX+
2	Orange	TX-
3	Blue - white	RX+
6	Blue	RX-
CN2	Color	Signal Definition
1	Red	24V
2	Black	GND

Figure 5-3 LDS-50C-E-1 LiDAR Line Interface Definition

5.4 Coordinate system Definition

The center in front of the LDS-50C-E LiDAR is defined as the x-axis of the coordinate system (i.e. the 0 angle position), and the origin of the coordinate system is the rotation center of the ranging unit. The rotation angle increases counterclockwise. As shown in the following figure:

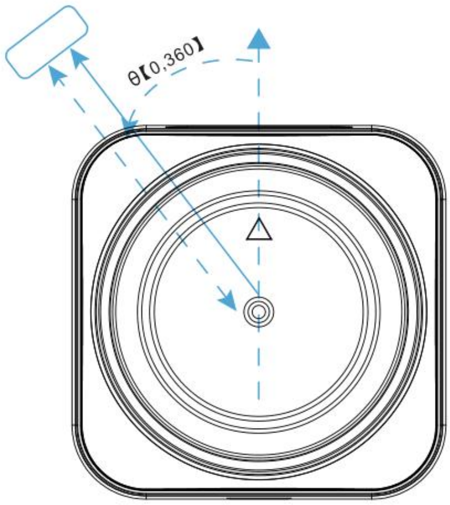


Fig. 5-3 Schematic diagram of LiDAR zero position and rotation direction

VI. Software Tutorial

Double-click the PACECATView.exe installation package, install the host computer, and open the PACECATView.exe host computer; Select 'Device'

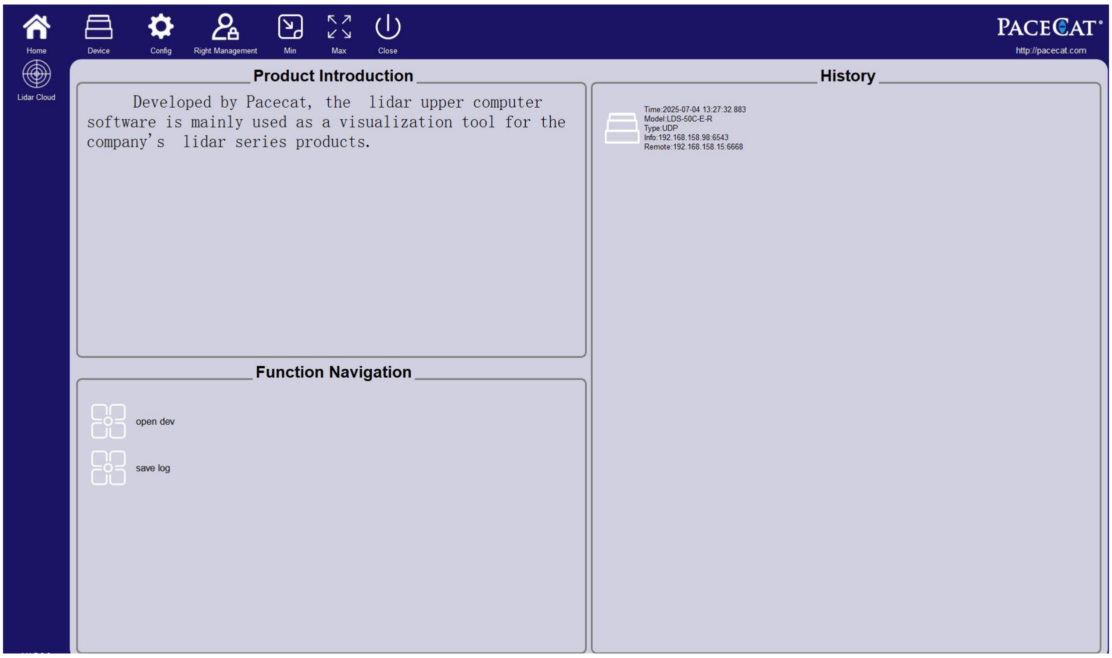


Fig.6-1 PACECATView main page

Select the LiDAR to be connected and double click.

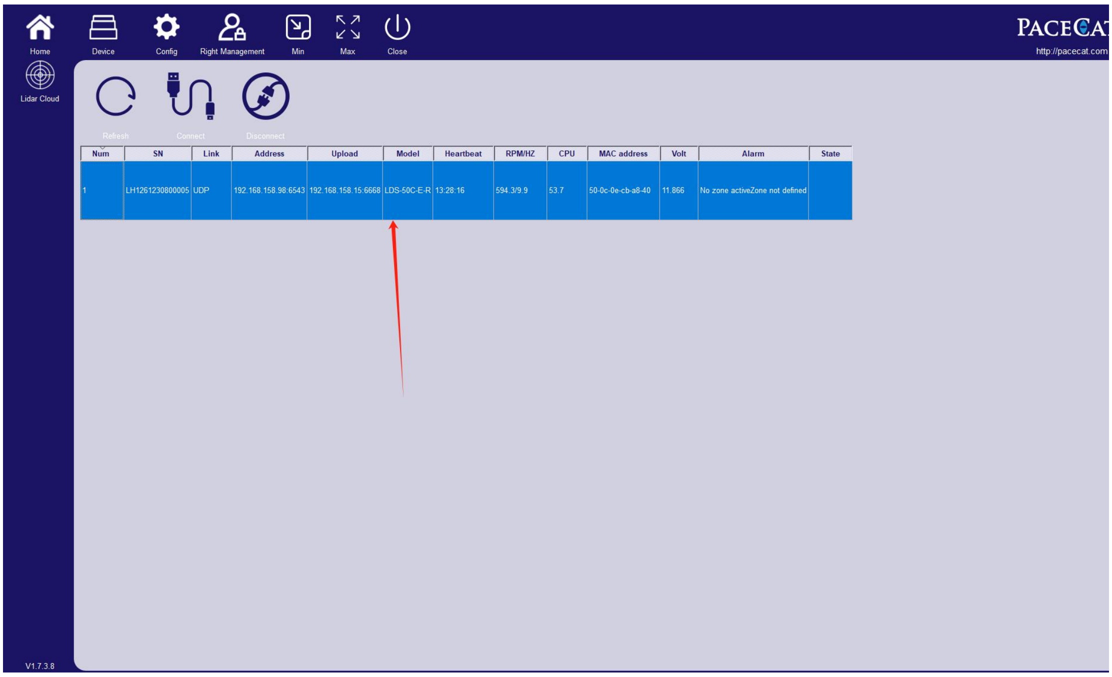


Fig.6-2 PACECATView device connection

After the upper computer successfully connects to the LiDAR, it automatically switches to 'LiDAR Cloud';

Click “Info”, Users can switch the speed, and after setting it, they can confirm whether the LiDAR has been successfully set by refreshing. If the setting fails, the LiDAR will return to its original state after refreshing.

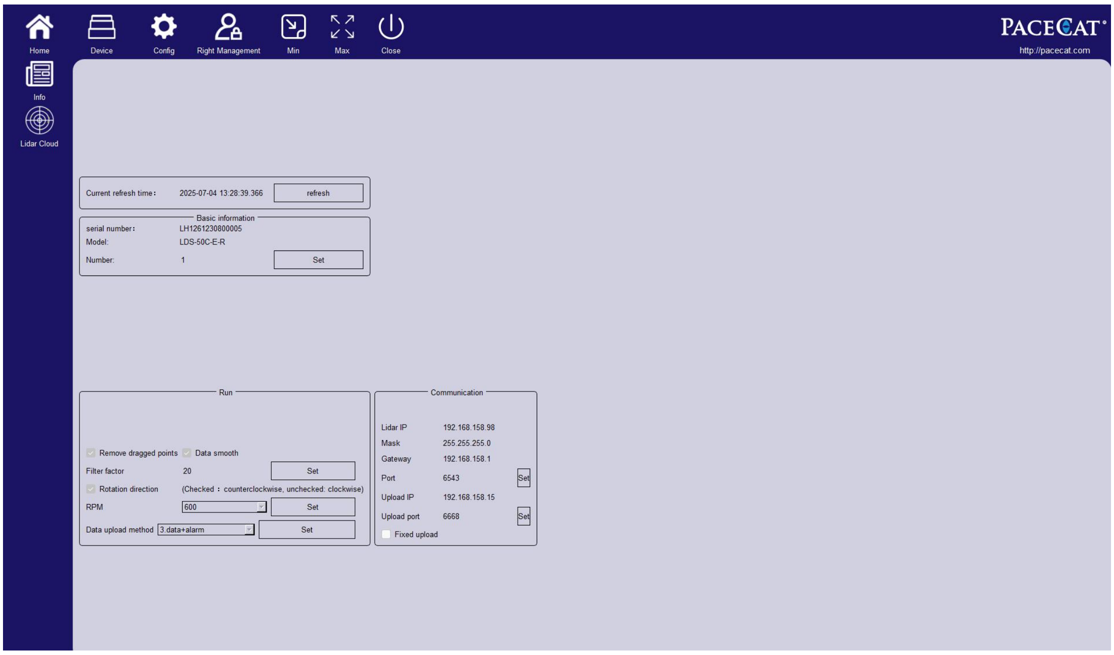


Fig. 6-3 PaceCat View basic information page

Select "LiDAR cloud" to view LiDAR cloud interface

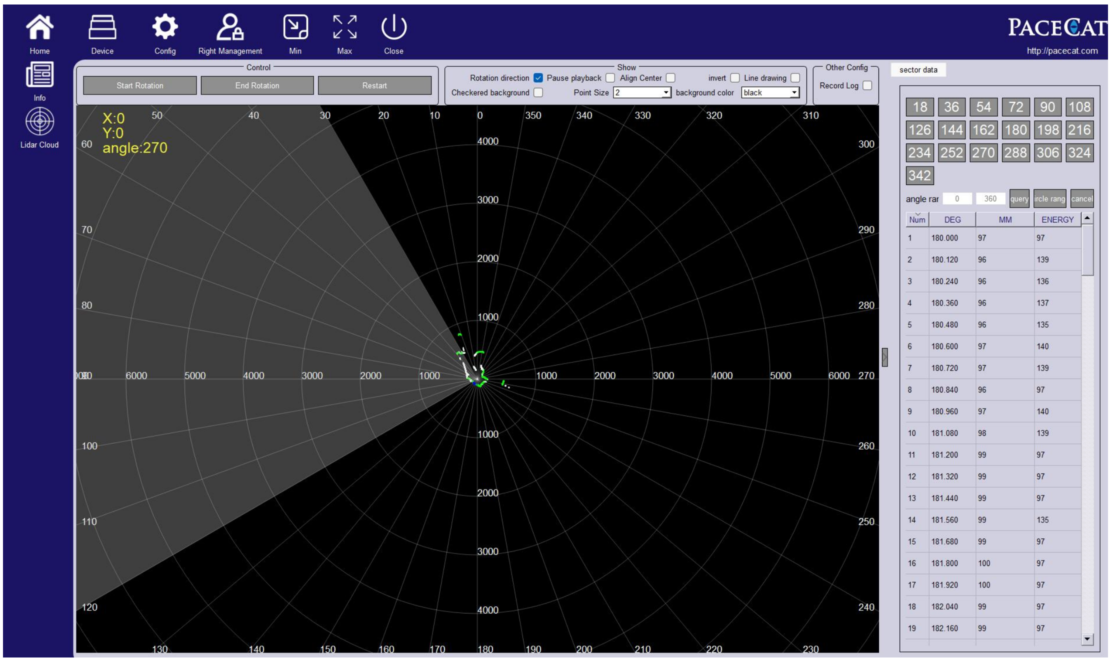
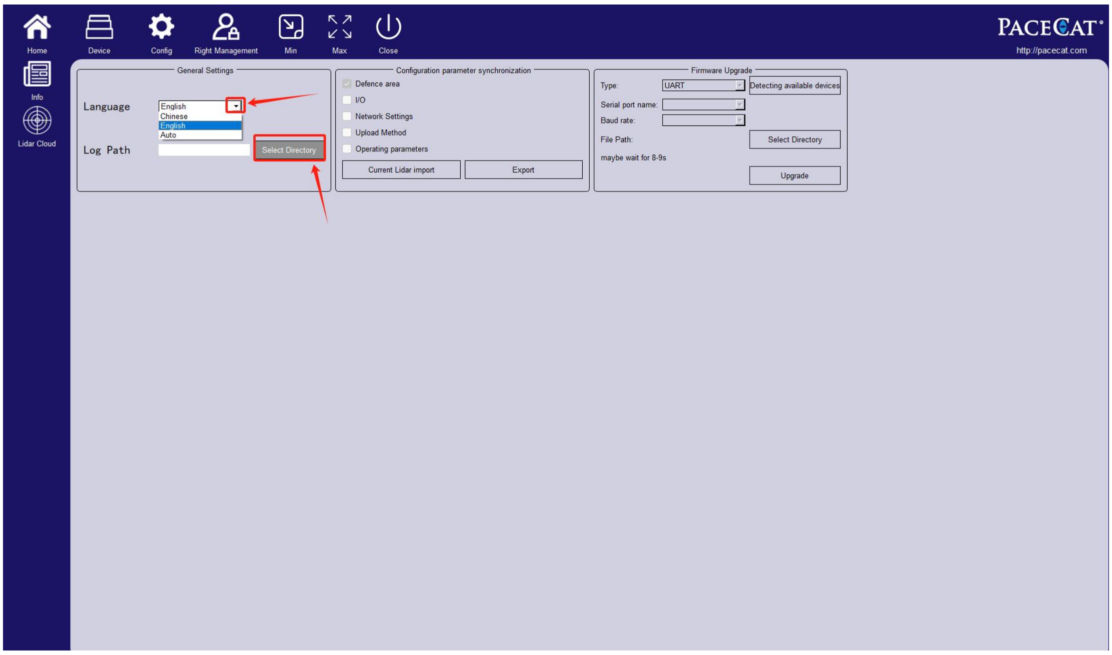


Fig. 6-4 PaceCatView LiDAR cloud interface

Users can switch languages and choose whether to save data in the Config screen.



To reconnect another LiDAR, select the Device screen and double-click the LiDAR.

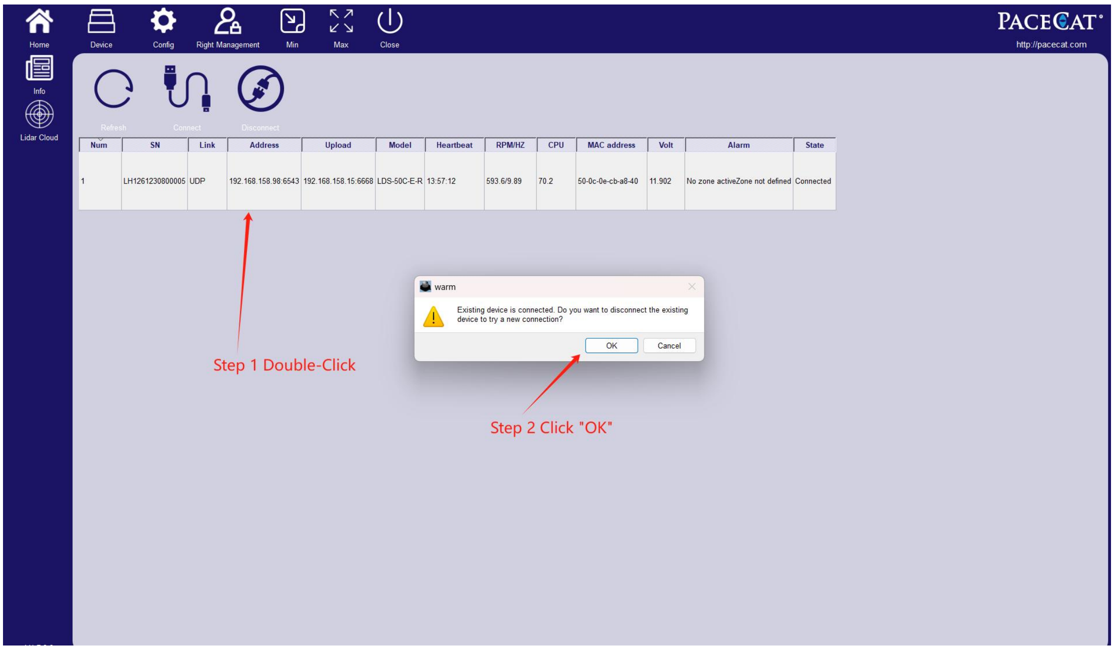


Fig. 6-6 PaceCatView reconnects to the new LiDAR View

VII. Data Communication Protocol

7.1 Data Analysis

Measurement data packet format: Point cloud data is transmitted based on the Ethernet UDP protocol packet, with a default port number of 6668 (software configurable).

format description：Low byte before high byte after.

struct

{

uint16_t code; 2byte，frame header，fixed as 0xc7fa

uint16_t count; 2byte，Number of subcontracting ranging points within a sector

uint16_t whole_fan; 2byte，Total number of ranging points within the sector

uint16_t offset; 2byte，sector offset

uint32_t begin_ang; 4byte，Sector start angle

uint32_t end_ang; 4byte，Sector termination angle

uint32_t flags; 4byte，Status package

uint32_t timestamp; 4byte，time stamp (3.6*10^6, Take the timestamp of the hour after the current time (mm),Indicates the time when the first point cloud data of the UDP packet was transmitted.)

uint32_t dev_no; 4byte，device number

uint16_t distance; 2byte* count, Subcontracting all distance data within the area

uint16_t angle; 2byte* count, Subcontracting all angle data within the area

uint8_t strength; 1byte*count, Subcontracting all strength data within the area (Automatically fill in two bytes when calculating the checksum)

uint16_t verify; 2byte,check

};

7.2 Examples with Data

A sector in LDS-50C-E packet is 18°, and the first and last sectors in a circle are 36°. The following figure analyzes the packet with a sector of 18°.

```
25 26 26 24 23 3E 04 C7 FA 5C 00 B7 00 00 00 50
46 00 00 A0 8C 00 00 03 01 00 00 FB C0 21 00 01
00 00 00 06 03 0A 03 0D 03 12 03 1A 03 1D 03 18
03 1F 03 1B 03 23 03 1F 03 2B 03 00 00 00 00 25
1B 28 1B 2C 1B 33 1B 33 1B 3C 1B 3D 1B 46 1B 4C
1B 50 1B 55 1B 5C 1B 5D 1B 62 1B 65 1B 67 1B 6E
1B 71 1B 76 1B 7C 1B 7F 1B 82 1B 87 1B 8C 1B 90
1B 94 1B 9C 1B 9D 1B 9F 1B A8 1B A8 1B B2 1B B8
1B BE 1B C0 1B C7 1B CC 1B D1 1B D3 1B D7 1B DA
1B DB 1B E2 1B E3 1B E7 1B EC 1B F4 1B FD 1B 01
1C 09 1C 14 1C 19 1C 1F 1C 22 1C 25 1C 39 1C 2D
1C 0F 1C 0E 1C 15 1C 1F 1C 22 1C 2E 1C 4C 1C 6A
1C 71 1C 7B 1C 7B 1C 81 1C 87 1C 89 1C 8E 1C 93
1C 98 1C A0 1C A8 1C B0 1C B9 1C 00 00 62 00 C4
00 26 01 88 01 EB 01 4D 02 AF 02 11 03 75 03 D7
03 39 04 97 04 F9 04 61 05 C3 05 26 06 88 06 EA
06 4C 07 AF 07 11 08 73 08 D5 08 38 09 9B 09 FD
09 60 0A C2 0A 24 0B 86 0B E9 0B 4B 0C AD 0C 0F
0D 71 0D D5 0D 37 0E 99 0E FA 0E 5E 0F C0 0F 22
10 85 10 E7 10 49 11 AB 11 0E 12 71 12 D2 12 34
13 97 13 FA 13 5C 14 BF 14 21 15 83 15 E5 15 47
16 AA 16 0C 17 6E 17 D2 17 34 18 96 18 F8 18 5B
19 BD 19 1F 1A 81 1A E4 1A 47 1B A9 1B 0A 1C 6E
1C D0 1C 32 1D 95 1D F7 1D 5A 1E BC 1E 1F 1F 80
1F E3 1F 45 20 A8 20 25 21 6C 21 CE 21 31 22 93
22 F5 22 21 1E 1E 1D 19 11 0B 0A 09 08 07 05 0D
0D 5A 58 59 58 57 56 55 54 55 56 64 66 66 65 64
64 63 64 66 65 64 65 65 63 63 62 63 62 61 5F 60
60 61 61 60 62 62 63 64 66 65 64 65 64 61 5F 5C
5B 5B 5B 5F 60 63 66 62 47 2C 2C 36 42 42 43 44
4C 5C 60 62 63 63 63 62 61 60 5D 5A 5A 5A 5A E9
9C C7 FA 5B 00 B7 00 5C 00 50 46 00 00 A0 8C 00
```

Fig. 7-1 Packet Analysis

Date	illustrate
c7 fa	FH (frame header)
5c 00	00 5c，Number of subcontracting ranging points within a sector is 92
b7 00	00 5f，Total number of ranging points within the sector is 183
00 00	00 00，sector offset is 0
50 46 00 00	00 00 46 50，unit is 0.001, Sector start angle is 18°
a0 8c 00 00	00 00 8c a0，unit is 0.001, Sector termination angle is 36°
03 01 00 00	00 00 01 03，converted to binary to 0001 0000 0011； Starting from the right is the 0th position 0th place:1 means mm, default mm 1st place:1 means belt strength, default belt strength 2nd place:1shows that the drag point removal function is open; 0 shows close. 3rd place:1shows filtering function is open;0 shows close. 4th place:1 means to turn on 18° as a sector;0 shows close. 5th place:1 means to turn on 9° as a sector; 0 shows close. 6th place:1 means to turn on other degrees as a sector;0 shows close. 7th place:1 means to fix resolution;0 shows close. 8th place:1 means to turn on counterclockwise,0 means clockwise rotation. 9th place: reserved 10th place: reserved 11th place: reserved
fb c0 21 00	time stamp
01 00 00 00	Device number
06 03…	distance
00 00…	angle
21…	strength
e9 9c	checksum=9ce9 =0x005c+0x00b7+0x0000+0x0000+0x4650+0x0000+0x8ca0+0x0000+0x0103+0x0021+ 0xc0fb+0x0000+0x0001+0x0306+…+0x1cb9+0x0000+…+0x22f5+0x0021+…+0x005a

7.3 Alarm Information Output Protocol

```
struct LiDARMsgHdr
{
    char sign[4];    // must be "LMSG"
    uint32_t proto_version;    // protocol version, right now is0x101
    char dev_sn[20];    // device number
    uint32_t dev_id;    //Device serial number
    uint32_t timestamp;    //Time stamp
    uint32_t flags;    // message type
    uint32_t events;    // Message Content Bit Combination
    uint16_t id;    // message number
    uint16_t extra;    //length 80
    uint32_t zone_actived;    // Current active defense zone
    uint8_t all_states[32];    // Equipment functional status
    uint32_t reserved[11];    //reserved
};
```

```
ff ff ff ff ff ff 50 0c  20 77 1c a3 08 00 45 00
00 9c 62 cd 00 00 ff 11  97 6c c0 a8 00 6f 00 00
00 00 19 90 00 00 00 88  00 ca 4c 4d 53 47 01 01
00 00 4c 48 36 34 30 31  32 31 30 34 30 30 30 30
31 00 00 00 00 00 01 00  00 00 b9 61 00 00 01 00
00 00 03 00 00 00 cd 00  50 00 00 00 00 00 00 00
00 00 00 00 00 01 01 00  00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00  00 00
```

Figure 7-2 Alarm packet parsing

4c 4d 53 47 Frame Header LMSG
01 01 00 00 version 0x00000101
4c 48 36 34 30 31 32 32 30 34 30 30 30 30 31 00 00 00 00 00 number LH6401220400001
01 00 00 00 Serial Number 0x00000001
b9 61 00 00 Time stamp 0x000061b9 unit ms
01 00 00 00 message type 0x00000001
03 00 00 00 message information 0x00000003 (Insufficient power supply + Motor stall)
cd 00 message number
50 00 extra （Current activation area+ Equipment functional status +reserved）length（4+32+4*11）
00 00 00 00 Current activation area is 0
00 00 00 00 00 00 01 01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 function status
00 00 00 00 00 00 00 00 00 00 00 reserved

7.4 Networl Heartbeat Protocol

```
Struct
{
    char sign[4];    //must be "LiDA"
    uint32_t proto_version;    // protocol version
    uint32_t timestamp[2];    // time stamp
    char dev_sn[20];    // Equipment serial number
    char dev_type[16];    // Device Type
    uint32_t version;    // Program version number
    uint32_t dev_id;    //Device id
    uint8_t ip[4];    //Device Id address
    uint8_t mask[4];    // Subnet Mask
    uint8_t gateway[4];    // gateway
    uint8_t remote_ip[4];    //update IP address
    uint16_t remote_udp;    // Upload Port
    uint16_t port;    // Service port
    uint16_t status;    // Device status
    uint16_t rpm;    //LiDAR speed，unit is 0.1, example: Obtained values 6000, it means LiDAR speed is 600
    uint16_t freq;    // Frequency, unit is 0.01,example: Obtained values 1000, frequency is 10Hz
    uint8_t ranger_version[2];    // Ranging head version number
    uint16_t CpuTemp;    //CPU's voltage, unit is 0.1,example: Obtained values 270,it means temperature 27°C
    uint16_t InputVolt;    // INPUT VOLTAGE, unit is 0.001,example: Obtained values 12000, voltage is 12V
    uint8_t alarm[16];    //alarm information
    uint32_t crc;    //check code
};
```

```
ff ff ff ff ff ff 50 0c  20 cc 1c a3 08 00 45 00
00 8c 03 11 00 00 ff 11  f7 26 c0 a8 00 81 ff ff
ff ff 19 91 1a 85 00 78  30 17 4c 69 44 41 01 01
00 00 b2 14 0b 8d 00 00  00 00 4c 48 36 34 30 31
32 31 30 34 30 30 30 31  31 00 00 00 00 00 4c 45
53 2d 34 30 44 2d 43 32  30 45 00 00 00 00 b9 38
d3 12 01 00 00 00 c0 a8  00 81 ff ff ff 00 c0 a8
00 01 c0 a8 00 14 0c 1a  8f 19 01 00 59 17 b5 03
ba 00 5e 01 40 2e 00 00  00 00 00 00 00 01 01 00
00 00 00 00 00 00 8d fe  f8 42
```

Fig. 7-3 Network Heartbeat Packet Analysis

4c 69 44 41 frame header LiDA
01 01 00 00 version 0x00000101
b2 14 0b 8d 00 00 00 00 time stamp 0x000000008d0b14b2 Unit ms
4c 48 36 34 30 31 32 32 30 34 30 30 30 30 31 00 00 00 00 00 Number LH6401220400001
4c 45 53 2d 34 30 44 2d 43 32 30 45 00 00 00 00 Device Type LES-40D-C20E
b9 38 d3 12 version 0x12d338b9
01 00 00 00 number 0x00000001
c0 a8 00 81 Device Address 192.168.0.129
ff ff ff 00 mark 255.255.255.0
c0 a8 00 01 gateway 192.168.0.1
c0 a8 00 14 server address 192.168.0.20
0c 1a Upload Port 0x1a0c/6668
8f 19 server port 0x198f/6543
01 00 Device Status 0x0001
59 17 speed 0x1759/597.7rpm
b5 03 frequency 0x03b5/94.9Hz
ba 00 Ranging version 0x00ba
5e 01 temperature 0x015e/35 ℃
40 2e voltage 0x2e40/11.840V
00 00 00 00 00 00 00 01 01 00 00 00 00 00 00 00 alarm information
8d fe f8 42 Check Code

VIII. Development Tools and Supports

In order to facilitate users to quickly use the LDS-50C-E LiDAR model for product development, Pacecat provides the following development tools:

Download SDK development packages and sample programs for platforms such as Windows and Linux, please visit:

https://github.com/BlueSeaLiDAR/sdk2

To download the Ros driver, please visit:

https://github.com/BlueSeaLiDAR/bluesea2

To download the Ros2 driver, please visit:

https://github.com/BlueSeaLiDAR/bluesea-ros2

Please Contact Pacecat if you have any questions.