RS-Bpearl

User Manual

Revision History

Issue	Modifications	Release Date	Edited by
1.0	Original issue	2019-8-14	PD
2.0	Updated product appearance image Updated product mechanical dimensions Updated sensor power consumption Updated use instructions of RSView in Apendix C Updated Appendix A Added footnotes to product specifications Updated the information in the table of Laser Channels and Vertical Angles	2019-12-11	PD
2.0.1	Updated product mechanical dimensions drawing in Appendix E Corrected some minor description errors Changed product name to RS-Bpearl	2020-2-18	PD
3.0.0	Added network timing function Added function to the LiDAR WEB Interface Added description of shifting LiDAR configuration interface to the WEB Interface Updated Appendix A Updated the DIFOP protocol Updated sensor driver description Added anticlockwise rotation function to the LiDAR motor rotation direction.	2021-12-17	PD

Terminologies

MSOP	Main data Stream Output Protocol
DIFOP	Device Info Output Protocol
FOV	Field Of View
PTP	Precision Time Protocol
GPS	Global Positioning System
UTC	Universal Time Coordinated
Protocol	Protocol version number, 00 represents old version, 01 represents the latest version
Wave_mode	Echo flag
Temp	LiDAR temperature information
Resv	Reserved data flag
UCWP	User Configuration Write Protocol
Azimuth	LiDAR horizontal rotation angle
Timestamp	Time stamp which is used to record system time
Header	Frame header in protocol packet
Tail	Frame tail in protocol packet

Contents

1. Manufacturer Information

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3. Certifications

CE FC RoHS IP67

This manual is updated from time to time without prior notice, to get the latest version, please visit RoboSense company website to download or contact the RoboSense Technical Support or Sales.

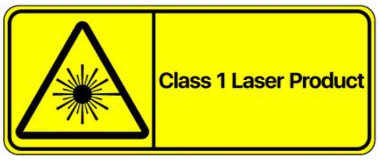
1. Safety Notices

To avoid risks of accidents, damage to sensor or violating of your product warranty, please read and follow the instructions in this manual carefully before operating the product.

- Laser Safety

This product meets the following standards for laser products:

IEC 60825-1:2014;



- Sensor Overheating Sign

Please pay attention to the overheating sign on the LiDAR surface to avoid a hot LiDAR surface that may lead to sensor failure or undesirable consequences.

- Read Instructions – Please reading all instructions on sensor operation and use
- Retain Instructions – The safety and operating instructions should be retained for future reference.
- Heed Warnings - All warnings on the product and in the operating instructions should be adhered to.
- Servicing – Except for what's described in this manual, the sensor has no field serviceable parts. For servicing, please contact RoboSense sales or the authorized distributors.

2. Product Appearance and Interface

2.1. Product Appearance

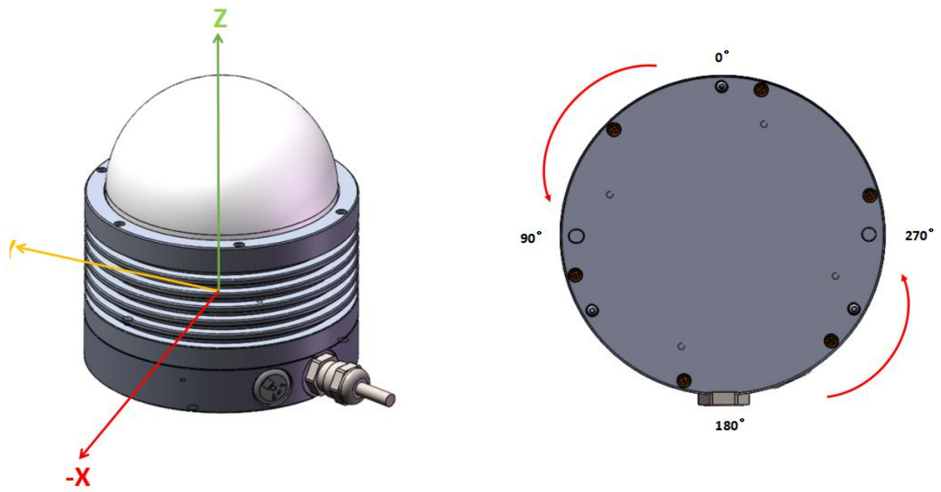


Figure 2-1 LiDAR Coordinates and Rotation Direction

2.2. Aviation Plug and Pin Definition

The data output access of the RS-Bpearl is physically protected by an aviation plug. From the LiDAR to the aviation plug the cable length is 1 meter. The pins of the aviation plug are defined as follows:

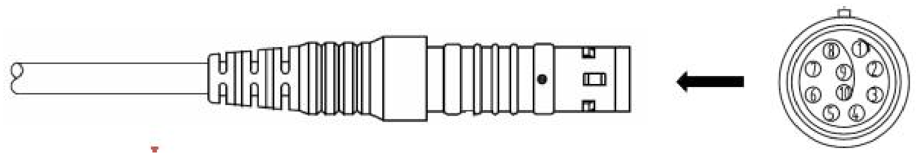


Figure 2-2 RS-Bpearl Aviation Plug

Table 2-1 Definition of Pins of Aviation Plug of RS-Bpearl

Pin	Wire Color	Function
1	Red	+12V
2	Yellow	+12V
3	White	GROUND
4	Black	GROUND

5	Green	GPS PULSE
6	Blue	GPS REC
7	Brown	LiDAR Ethernet RX+
8	Brown white	LiDAR Ethernet RX-
9	Orange	LiDAR Ethernet TX+
10	Orange white	LiDAR Ethernet TX-

2.3. Interface Box

Your RS-Bpearl comes with an Interface Box, which has 2 LED lights and provides convenient connections to power, RJ45 Ethernet, and GPS. (The length of the integrated cable attached to the Interface Box of the aviation plug version LiDAR is 3 meters, for other cable lengths, please contact RoboSense technical support).

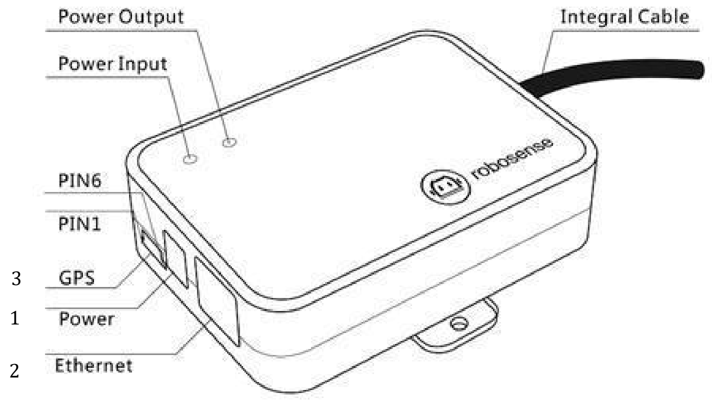


Figure 2-3 Definition of Interface Box Ports

Specifications of Interface Box ports:

Table 2-2 Interface Box Port Specification

No.	Port	Specification
1	Power Input	Standard DC 5.5-2.1 connector
2	Network	Standard RJ45 Ethernet connector
3	GPS timing	SH1.0-6P Female connector

1.1.1 Power

The power supply interface of the RS-Bpearl on the Interface Box is a standard DC 5.5-2.1

connector.

There are 2 LEDs (power indicators) on the Interface Box: when the power input is normal, the red LED is on, the green LED is always on by default. When the red LED is off, the Interface BOX enters the protection state. If either LED (when connected to GPS) is off, please check whether the power input is normal; If the power input is normal, the Interface BOX may be damaged. Please contact your technical support or account manager at RoboSense.

1.1.2 RJ45 Ethernet Port

The network interface on the Interface Box follows the EIA/TIA568 standard.

1.1.3 GPS Time Synchronization

GPS REC receives GPS UART standard input; GPS PULSE receives GPS PPS input.

The definitions of pins of the GPS port are detailed in the figure below:

Table 2-3 GPS Port Definition

Pin No.	function
1	GPS_PULSE
2	+5V
3	GND
4	GPS_REC
5	GND
6	NC

Note: When the "ground" of RS-Bpearls is connected to an external system, the negative polarity ("ground") of the external system and the "ground" of the GPS system must share a non-isolated common ground.

3. Unboxing & Installation

3.1. Standard Package

The table below lists the contents of a standard RS-Bpearl package from the factory.

Table 3-1 Standard Factory Package of the RS-Bpearl

No.	Contents	SPEC/QTY
1	LiDAR	RS-Bpearl*1
2	Interface Box	3M *1
3	Power Adapter	DC12Vx3.34A/40W *1
4	Power Cable	1.2M *1
5	Ethernet Cable	1.5M *1
6	Screw Pack	M4x15 *3； M4x20 *3

Note: There might be variants of the sensor and accessories that you are going to purchase or interested in, please contact RoboSense Sales for details.

3.2. Sensor Mounting

The RS-Bpearl can be mounted to any application with a mounting base. As shown in the figure below, the mounting base of the RS-Bpearl should be flat, uneven surfaces should be avoided. The precise locator pins on the mounting base should strictly follow the dimensions of the locator holes at the bottom of the LiDAR, and the height of the locator pin should not be higher than 4mm. We recommend using aluminum alloy for the mounting base material, which facilitates heat dissipating of the LiDAR during operating.

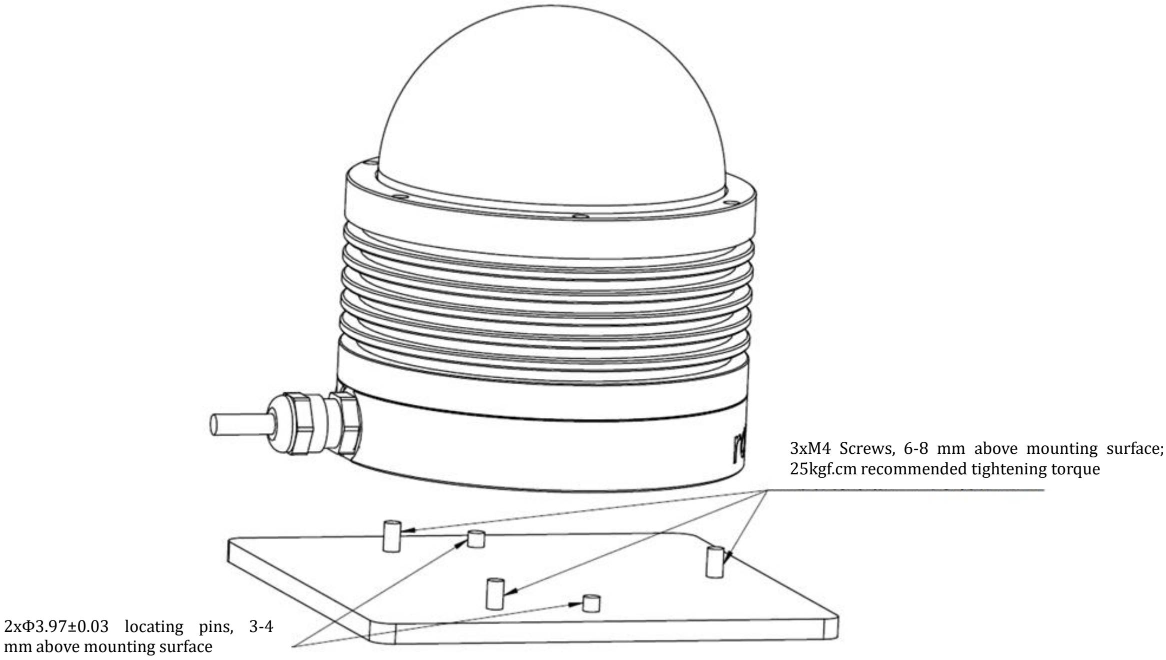


Figure 3-1 LiDAR Mounting Details

The following situations should be **avoided** when mounting the LiDAR:

1) The reserved mounting space for the LiDAR is smaller than the volume of the LiDAR itself.

2) The integrated sensor cable is too tight.

3.3. Quick Connection

Users are allowed to configure the network settings of the RS-Bpearl, which is set at the factory with default IP and port numbers, as shown in the table below:

Table 3-2 actory Default Network Configuration

	IP Address	MSOP Port No.	DIFOP Port No.
RS-Bpearl	192.168.1.200	6699	7788
Computer	192.168.1.102		

To establish communication between the LiDAR and computer, it's required to set the computer's IP address to the same network segment as the LiDAR, for example 192.168.1.x (the value of x could be from 1 to 254), and the subnet mask to 255.255.255.0. If you don't know the network configuration of the LiDAR, please connect the LiDAR to computer and use wireshark to capture the LiDAR data packets to analyze.

The wiring diagram of the Interface Box connection is as shown in the figure below:

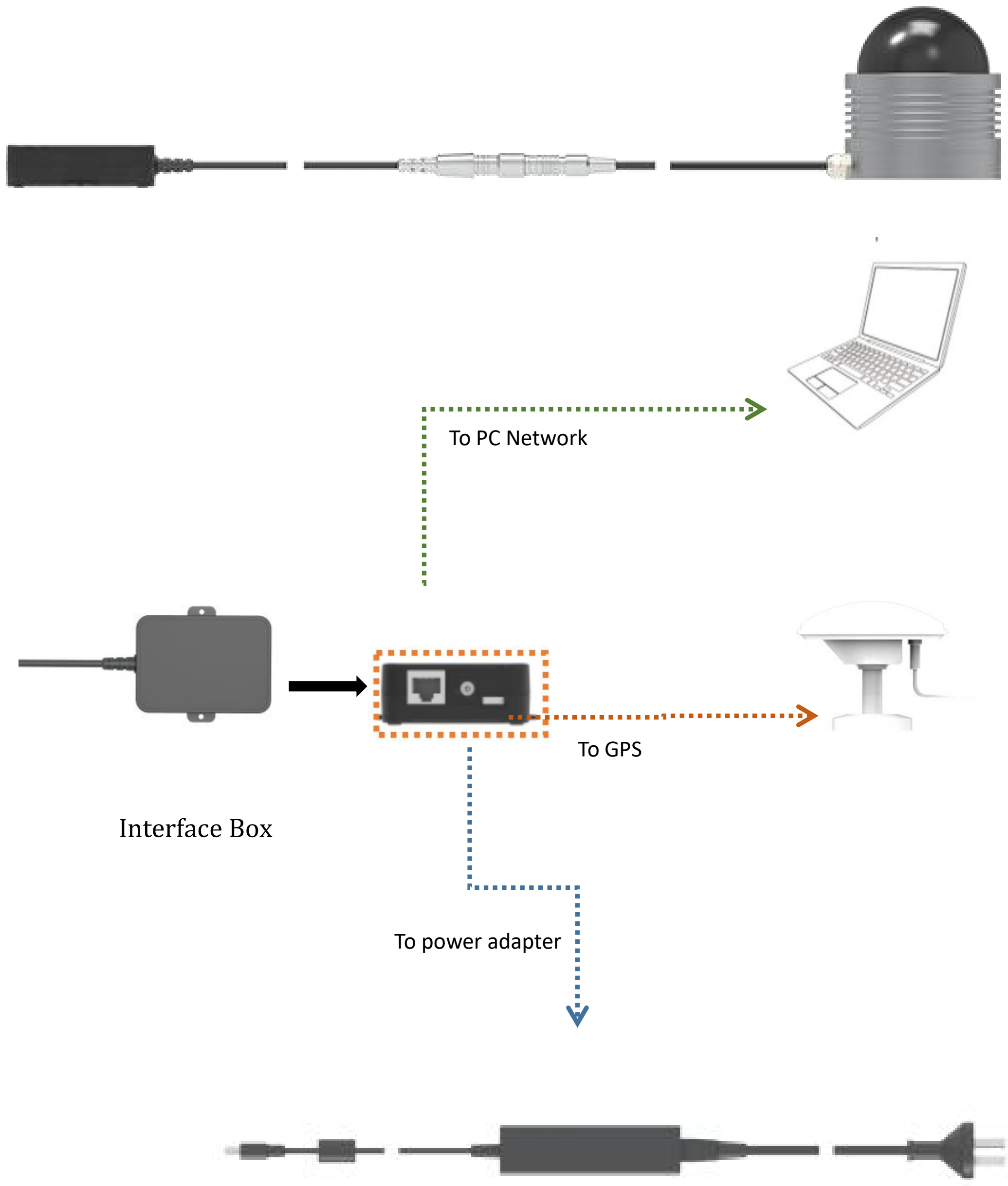


Figure 3-2 Interface Box Connection

4. Sensor Specifications and Features

4.1. Sensor Specification[1]

Table 4-1 Sensor Specifications

Sensor			
Laser Channels	32	FOV(Horizontal)	360°
Laser Wavelength	905nm	FOV(Vertical)	0° ~90°
Laser Emission Angle	Horizontal(maximum): 9 mrad,	Angular Resolution (Horizontal)	0.1° / 0.2° / 0.4°
Laser Safety	Class 1 Eye-safe	Angular Resolution (Vertical)	2.81°
Measurement Range[2]	0.1m to 30m(10%NIST targets)	Ranging Accuracy (Typical)[3]	Up to ±3cm
Blind Distance	≤0.1m	Frame Rate	5Hz/10Hz/20Hz
Rotation Speed	300/600/1200rmp(5/10/20Hz)/		
Output			
Data Rate	5576,000pts/s (Single Return Mode); 1,152,000pts/s(Dual Return Mode)		
Ethernet	100Mbps		
Data Output Protocol	UDP packets over Ethernet		
UDP Packets Content	Distance, Calibrated Reflectivity Measurements, Time Stamps		
Mechanical			
Operating Voltage	9V-32V	Dimension	ϕ100mm * H111 mm
Power Consumption[4]	13w(Typical)	Operating Temperature[5]	-20℃~+60℃[5]
Weight	0.92kg (LiDAR)	Storage Temperature	-40℃~+85℃
Time Synchronization	$GPRMC with 1 PPS & PTP	Sensor Protection	IP67

[1] The data above is only for serial production products, and may not be applicable to any samples, testing devices and other non-production versions. If you have any questions, please contact RoboSense Sales.

2. The measurement range takes a 10% NIST diffuse reflector as the target, and the test results may be affected by environment conditions, including but not limited to factors such as ambient temperature and light

[3] The ranging accuracy takes a 50% NIST diffuse reflector as the target. The test results may be affected by environment conditions, including but not limited to factors such as ambient temperature and target distance. The accuracy value is applicable to most channels, and there may exists differences between some channels.

[4] The power consumption of the device may be affected by environment conditions, including but not limited to factors such as ambient temperature, target distance, target reflectivity, etc.

5 The operating temperature of the device may be affected by environment conditions, including but not limited to factors such as ambient light and airflow changes.

4.2. Point Cloud Display

4.2.1. Coordinate Mapping

Since the data packet output by the LiDAR only provides the horizontal rotation angle and distance infomation, in order to present a 3D point cloud image, the angle and distance information in polar coordinates need to be converted into x, y, z coordinates in the Cartesian coordinate system, and the conversion formula is as follows:

$$\begin{cases} x = r\cos(\omega)\sin(\alpha + \delta); \\ y = r\cos(\omega)\cos(\alpha + \delta); \\ z = r\sin(\omega); \end{cases}$$

Where r is the measured distance, ω is the vertical angle of the laser, α is the horizontal rotation angle of the laser in the Polar Coordinate System, and x, y, z are the coordinate values in the Cartesian Coordinate System.

ω and δ can be obtained from the DIFOP data packets, please refer to B.14 and B.15 in Appendix B for details.

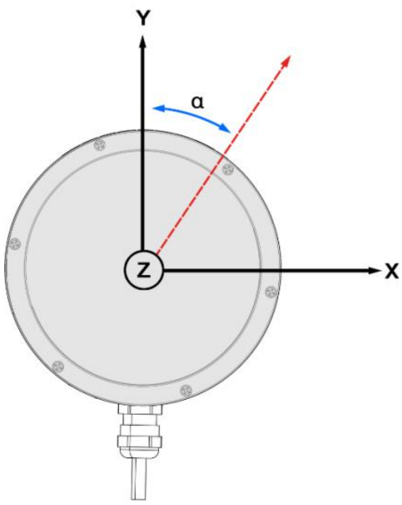


Figure 4-1 LiDAR Polar Coordinates

Note 1: ROS source code of RS-Helios has by default completed the coordinate conversion to conform to the right-handed coordinate system of ROS. The X-axis of ROS is the positive Y direction in Figure 4-1, and the Y-axis of ROS is the negative X direction in Figure 4-1.

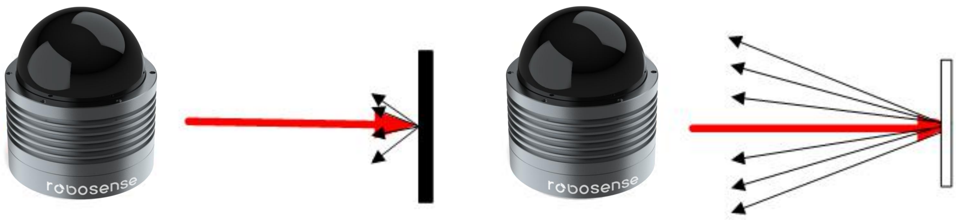
Note 2: The origin of the LiDAR sensor coordinate is at the center of the LiDAR base.

4.3. Reflectivity

RS-Bpearl measures the reflectivity of objects. The reflectivity is an index that measures the ability of an object to reflect light and is greatly related to the material of the object itself.

RS-Bpearl reports calibrated reflectivity values from 0 to 255, among which diffuse reflectors report values from 0 to 100, and retroreflectors report values from 101 to 255. Black objects are with low reflectivity values, white objects are with high reflectivity values, the most ideal reflection reports the reflectivity value of 255.

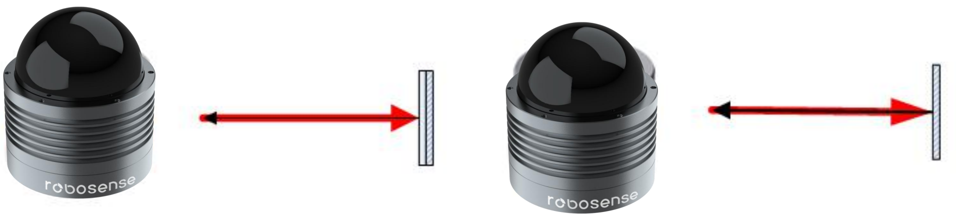
Diffuse Reflectors



Black, absorbent diffuse reflector
Reflectivity ≈0

White, reflective diffuse reflector
Reflectivity <100

Retro-Reflectors



Retro-reflector covered with semi-transparent white surface
Reflectivity>100

Retro-reflector without any coverage
Reflectibity≈255

Figure 4-2 Definition of Reflectivity

4.4. Laser Return Modes

4.4.1. Principle of Laser Return Modes

RS-Bpearl supports multiple laser return modes, namely: Strongest Return, Last Return and Dual Return. When set to Dual Return mode, the details of the target will increase, and the volume of data is twice that in the Single Return mode.

Due to beam divergence, multiple laser returns are possible from any single laser shot. A pulse may diverge and becomes larger as it travels in the air, when a pulse is large enough to hit multiple objects, it will produce multiple reflections. Usually, the farther away the object is, the weaker the energy of the pulse arrived at the receiver. For bright or retroreflective surfaces, the situation may be the opposite.

RS-Bpearl analyzes the received multiple returns, and reports the strongest return, last return or dual returns at the same time, depending on the laser return mode settings. If the LiDAR is set to the strongest return mode, only the value of strongest return will be reported. Similarly, if the LiDAR is set to the last return mode, only the value of the last return will be reported. If the LiDAR is set the dual return mode, both the strongest and last return value will be reported.

Note:

1. The sensor records both returns only when the distance between two objects is 1 meter or more.

2. When a laser pulse hits only one object, there is only the strongest return.

3. When a laser pulse hits two solid walls or other objects at two different distances, two returns will be produced. In this case, there are two situations:

(1) When the strongest return is not the last return, the strongest and last return will be reported;

(2) When the strongest return is the last return, the strongest return and the second strongest return will be reported.

4.4.2. Return Mode Flag

The RS-Bpearl is set in the Strongest Return mode at factory by default. If you need to change this settings, please refer to Figure C14 in Appendix C RSView of this user manual for instructions. The 300th byte in a DIFOP packet is the flag of return mode, which corresponds to the following:

Table 4-2 Return Mode and the Corresponding Flag

Flag	**Return Mode**
00	Dual Return
01	Strongest Return
02	Last Return

4.5. Phase Locking

To minimize interference between multiple LiDARs, RS-Bpearl provides a phase-locking feature that enables users to control where the lase firings overlap.

The phase locking feature, when a PPS pulse signal is triggered, askes the RS-Helios to rotate to a specific angle to fire laser pulses. When multiple RS-Helios sensors are used at the same time, the relative rotation angle between them is kept unchanged. The normal phase locking requires the normal and stable PPS pulse triggering signal.

Figure 4-3 shows the RS-Bpearl set with different phases. The red arrows indicate the firing angle of the sensor’s laser at the moment it receives the rising edge of the PPS signal. In the cases below: 0 degrees, 135 degrees, and 270 degrees respectively.

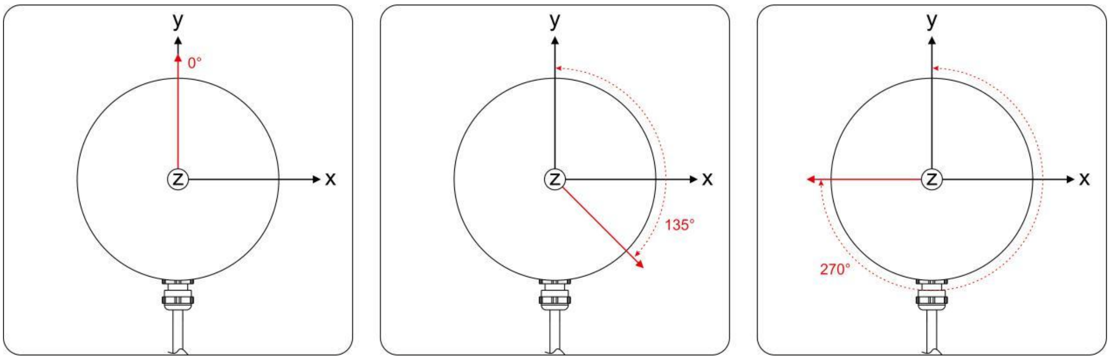


Figure 4-3 RS-Bpearl Different Phase Settings

For the RS-Bpearl_2.0, users can use the RS-Bpearl RSView to check and modify the Phase Locking settings: click **Tools > RS-LiDAR Information** for the "Phase Lock" parameter setting. The phase locking value can be set from 0 to 359.

For the RS-Bpearl_3.0, users can use the RS-Bpearl Web Interface to check and modify the Phase Locking settings: click **Setting > Phase Lock Setting,** for the "Phase Lock" parameter setting. The phase locking value can be set from 0 to 359.

The Phase Lock feature will only be available when the rotation speed of the RS-Bpearl is set as 600RPM or 1200RPM.

4.6. Time Synchronization

The RS-Bpearl_2.0 only supports GPS+PPS time synchronization, while the RS-Bpearl_3.0 supports both GPS+PPS and PTP/gPTP time synchronization methods. Users can use the RS-Bpearl Web Interface to set the time synchronization methods (Please refer to Appendix A.2 for instructions of setting at Web Interface.). Both the RS-Bpearl_2.0 and the RS-Bpearl_3.0 can be connected to an external GPS module, and can synchronize the sensor system time with the time provided by the GPS.

4.6.1. GPS Time Synchronization

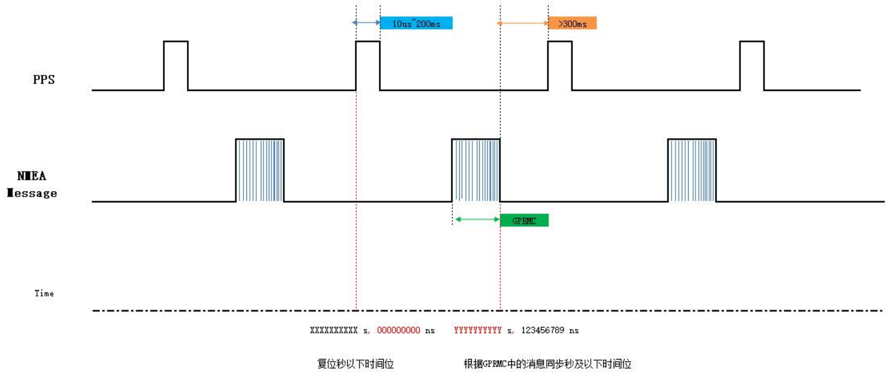


Figure 4-4 GPS Time Synchronizatio Timing Diagram

The GPS module continuously sends GPRMC message and PPS synchronization pulse signals to the sensor. The PPS synchronization pulse width is from 20ms to 200ms, and the GPRMC message must be sent within 500ms after the rising edge of the PPS synchronization pulse.

4.6.2. The Use of GPS for Time Synchronization

The GPS_REC interface in the Interface Box of the RS-Bperl follows the RS232 level standard, as shown in the table below:

Table 4-3 GPS Receive Pin Definition

Level	Receive Pin Definition	
	GPS REC	GPS PULSE
RS232	Receive the RS232 serial data output by the GPS module	Receive the positive synchronization pulse signal output by the GPS module, the level is required to be 3.0V~15.0V

Note 1: The GPS_REC interface in the RS-Bpearl Interface Box is the SH1.0-6P female connector, and the pin definition is as shown in Figure 2-3.

The external GPS module needs to set the serial output baud rate to 9600bps, 8 bits, no parity, 1 stop bit. RS-Bpearl only accepts the GPRMC sentence sent by the GPS module. The standard structure of the GPRMC sentence is as follows:

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

<1> UTC Time

<2> Receiver status, A=active, V=void

<3> Latitude

<4> Latitudinal hemisphere N (northern hemisphere) or S (southern hemisphere)

<5> Longitude

<6> Longitudinal hemisphere E (east longitude) or W (west longitude)

<7> Speed over the ground(knots)

<8> Track made good (degrees True)

<9> UTC date

<10> Magnetic declination

<11> Magnetic declination direction, E (east) or W (west)

<12> Mode indicator (A=autonomous, D=differential, E=estimated, N=not valid)

*The last hh is the XOR sum of all characters from $ to *

Please note that：

1. The sending time interval of 1 PPS pulse needs to be controlled within 1s±100us;

2. The status bit in the GPRMC message must be A valid before time synchronization is allowed;

3. The length of GPRMC messages sent by existing GPS modules on the market is not consistent. The length of GPRMC messages reserved in the DIFOP packet of RS-Bpearl is up to 86 bytes, which is compatible with the GPRMC message format sent by most GPS modules on the market. If an incompatibility occurs, please contact RoboSense technical support.

4.6.3. PTP Time Synchronization

PTP (Precision Time Protocol) is a time synchronization protocol, which itself is only used for high-precision time synchronization between devices, but it can also be borrowed for frequency synchronization between devices. Compared with various existing time synchronization mechanisms, PTP has the following advantages:

1) Compared with NTP (Network Time Protocol, Network Time Protocol), PTP can meet higher-precision time synchronization requirements. NTP can only achieve sub-second time synchronization precision, while PTP can reach sub-microsecond time synchronization precision.

2) Compared with GPS (Global Positioning System), PTP requires lower construction and maintenance costs.

4.6.4. PTP Wiring Diagram (Valid for RS-Bpearl 3.0)

To use the PTP synchronization method, the user need to make the following preparations, connect devicesaccording to the connection method shown in the figure below:

1) Select PTP mode in the web interface (please refer to Appendix A.2 for Web Interface configuration);

2) Prepare a PTP Master timing host (plug and play, no additional configuration required);

3) Ethernet switch;

4) Devices supporting PTP protocol

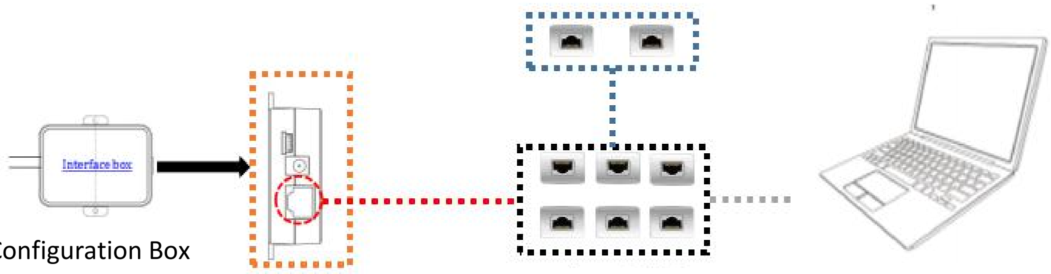


Figure 4-5 PTP Connecting Diagram

Note:

1. The PTP Master timing equipment is a third-party equipment that needs to be purchased by the user independently, which is not included in the RoboSense standard product shipping package.

2. As a PTP Slave device, our LiDAR only obtains the time sent by the PTP Master, and does not make accuracy judgments. If the time of the LiDAR deviates from the real time, please check whether the time provided by the PTP Master is accurate;

3. After the LiDAR is synchronized, the PTP Master is disconnected, and the time in the point cloud data packet will be superimposed according to the LiDAR's internal clock, and it will be reset after the LiDAR is powered off and restarted.

4.6.5. Time Calculation

The MSOP data packet contains time data. When external time synchronization signal is not available, a default system time will be used for the timing. The sensor time will be updated when external time synchronization signals are available.

The time stamp in the MSOP data packet could be parsed as below:

1) The time stamp data in the MSOP data packet contains year, month, day, hour, minute, second, millisecond, and microsecond parts. As shown in Figure 4-6, the year, month, day, hour, minute, and second are represented by: 0X15, 0X0C, 0X07, 0X03, 0X06, and 0X23; converted to decimal is: year 2021, month 12, day 7, hour 3, minute 6, second 35.

2) The millisecond and microsecond data are generated from the internal timing of the LiDAR, the maximum value is 0X03E7 (999); as shown in Figure 4-6, the millisecond and microsecond parts are represented by: 0Xe1 0X72, 0Xe1 0Xc5; converted to decimal is 370 milliseconds, 453 microseconds.

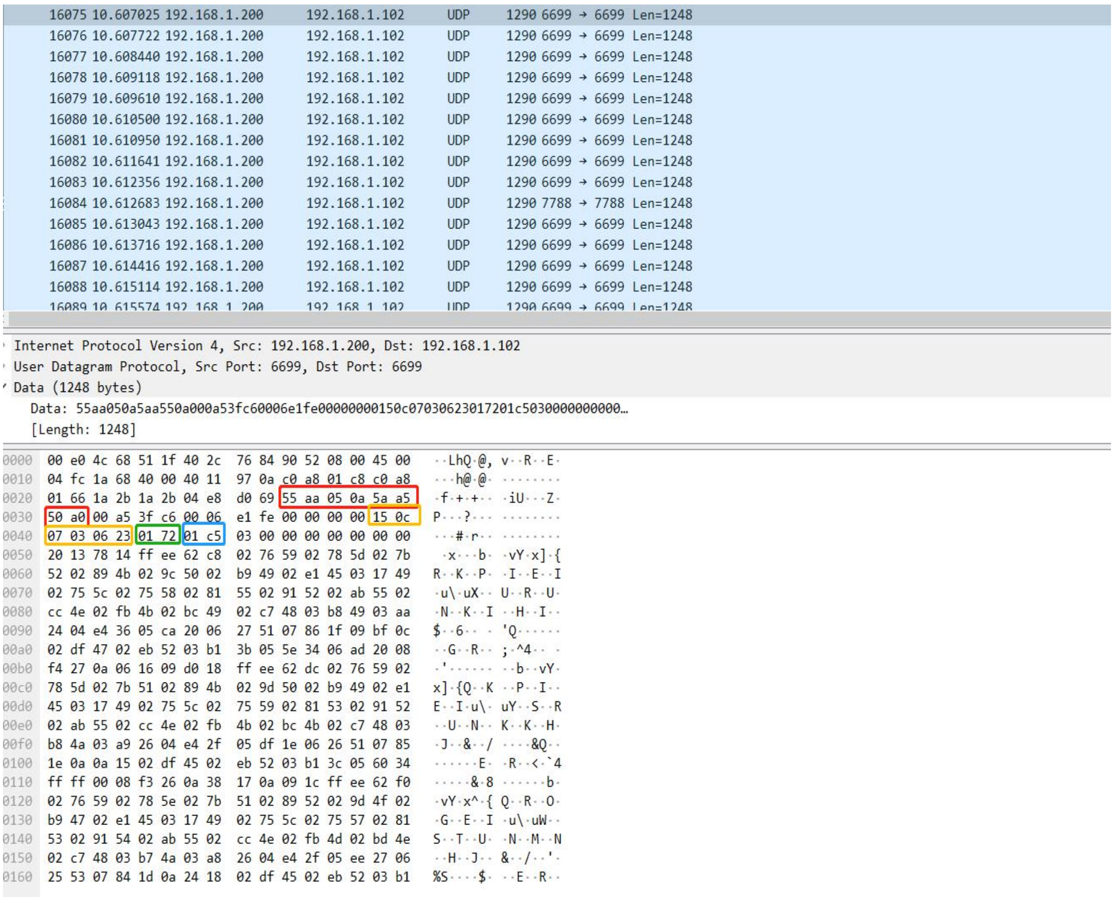


Figure 4-6 Time Stamp

Note:

Red box: Header ID;

Yellow box: Year, month, day, hour, minute, second respectively;

Green box: Millisecond;

Blue box: Microsecond.

5. Communication Protocols

The communication between RS-Bperl and computer is through Ethernet and by sending UDP packets. There are mainly three types of communication protocols, as shown in the table below:

Table 5-1 Communication Protocols

Protocol	Abbreviation	Function	Type	Packet Size	Time Interval between packets
Main data Stream Output Protocol	MSOP	Output measured data	UDP	1248 bytes	~0.66ms
Device Information Output Protocol	DIFOP	Output sensor information	UDP	1248 bytes	~1s
User Configuration Write Protocol	UCWP	Input sensor configuration parameters	UDP	1248 bytes	INF

Note: The following sections describe and define the valid payload (1248byte) of the protocols.

1) The main data stream output protocol MSOP, encapsulates the distance, angle, reflectivity and other information measured by the LiDAR into an UDP packet and outputs to the computer;

2) Device information output protocol DIFOP, outputs various configuration information of the current state LiDAR to the computer;

3）UCWP is only valid for the RS-Bpearl_2.0

4）The time interval between DIFOP packets of the RS-Bpearl_2.0 is about 100ms.

5.1. MSOP and DIFOP

The UDP packet sent by RS-Bpearl has a payload of 1248 bytes, the data structure of the MSOP packets and the DIFOP packet is as shown in the figure below:

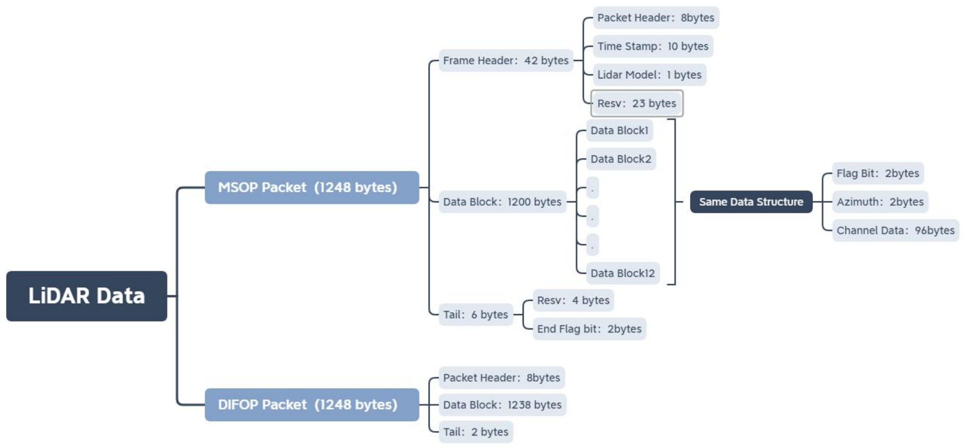


Figure 5-1 RS-Bpearl_2.0 UDP Packet Structure

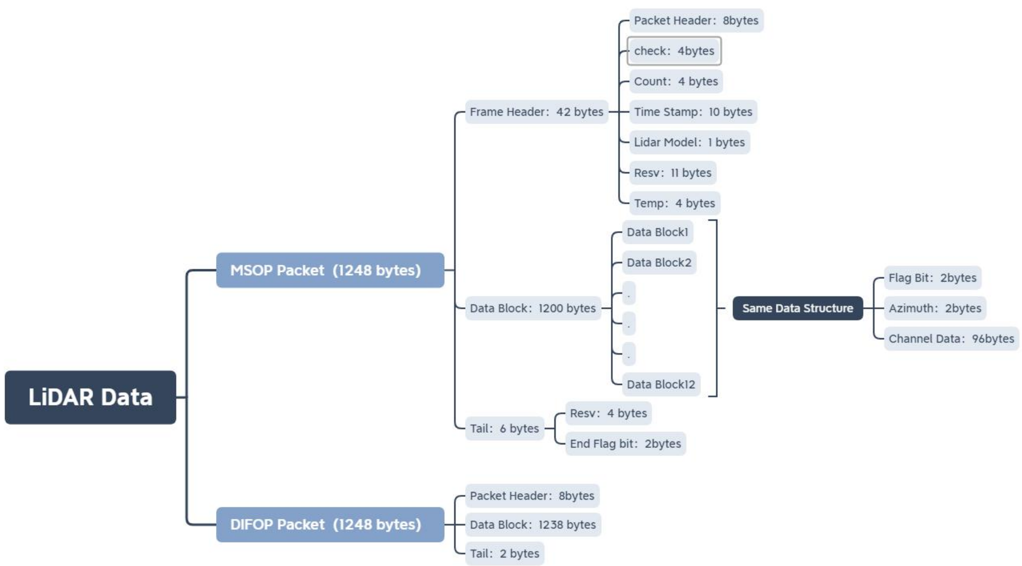


Figure 5-2 RS-Bpearl_3.0 UDP Packet Structure

5.2. Main Data Stream Output Protocol（MSOP）

Main data Stream Output Protocol is abbreviated as MSOP

I/O type: device output, computer analysis

Default port number: 6699

5.2.1. Header

The header has 42 bytes and is used to identify the beginning of the UDP data packet. The structure of the Header is as shown in the table below:

Among the 42 bytes of the UDP header of the RS-BPearl_2.0, the beginning 8 byts are for the header identification. For the rest 34 bytes, byte 21 to byte 30 are time stamps, byte 31 identifies the LiDAR model, the rest bytes are reserved bytes.

The header of the RS-BPearl_3.0 is defined as shown in the table below:

Table 5-2 RS-Bpearl_3.0 MSOP Header Definition

Header（42bytes）			
Field	Offset	Length（byte）	Definition
Header ID	0	8	Header ID, 8 bytes in length, used for packet header identification, defined as 0x55,0xAA,0x05,0x0A,0X5A,0XA5,0X50,0XA0
Checksum	8	4	For internal packet check use
Packet Count	12	4	Packet count
Resv	16	4	Reserved for future updates
Time Stamp	20	10	Store timestamps, Appendix B.10 provides specific definition
LiDAR Model	30	1	Identify LiDAR model 0x01:RS-LiDAR-16 0x02:RS-LiDAR-32 0x03:RS-Bpearl 0x04:RS-Ruby 0x05:RS-Ruby Lite

			0x06:RS-Helios
Resv	31	7	Reserved for future updates
Temp	38	2	Device temperature
Top Temp	40	2	Top board temperature

Note: The defined time stamp is used for recording the system time, the resolution is 1us.

5.2.2. Data Blocks

As shown in the table below, the Data Blocks in the MSOP packet store the data measured by the sensor, and has a total of 1200 bytes. There are a total of 12 data blocks in one MSOP Packet. Each data block has 100 bytes and represents a complete measurement.

Table 5-3 Data Block Definition

Data Block（1200bytes）			
Data Block 1	Data Block 2	Data Block n	Data Block 12
0XFFEE	0XFFEE	0XFFEE	0XFFEE
Azimuth 1	Azimuth 2	Azimuth n	Azimuth 12
Channel data 1	Channel data 1	Channel data 1	Channel data 1
Channel data 2	Channel data 2	Channel data 2	Channel data 2
... ...	... ...	... ...	... ...
Channel data 31	Channel data 31	Channel data 31	Channel data 31
Channel data 32	Channel data 32	Channel data 32	Channel data 32

Note: In the dual return mode, for each data block, the odd-numbered data blocks reports the last return data, and the even-numbered data blocks reports the strongest return data.

5.2.2.1. Channel Data

Each channel data has 3 bytes, the upper two bytes store distance information, and the lower one byte stores reflectivity information, as shown in the figure below.

Table 5-4 Channel Data

Channel data n （3 bytes）		
2 bytes Distance		1 byte Reflectivity
Distance1 [15:8]	Distance2 [7:0]	Reflectivity

Distance information contains 2 bytes, the unit is m, the resolution is 0.5cm.

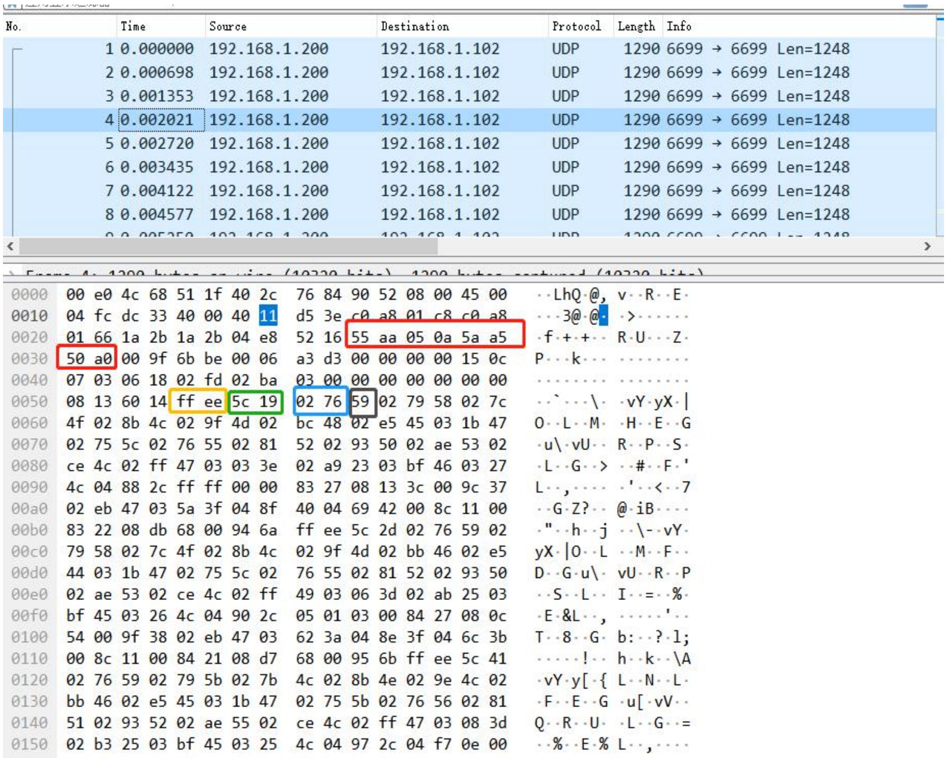


Figure 5-3 MSOP Packet

Note:

Red box: Header ID

Orange box: Data Block flag

Green box: Azimuth value of Channel data 1

Blue box: Distance value of Channel data 1

Black box: Reflectivity value of Channel data 1

1. Calculate distance based on distance data in the data packet:

1）Find the distance value in the data packet and convert to a hexadecimal number: 0x02, 0x76

2）Convert to a 16-bit unsigned integer: 0x0276

3）Convert to a decimal number: 630

Divide by 100 to obtain the actual value: 6.30

4）Calculate according to the distances resolution

5）Result: 6.30*0.5 = 3.125m.

2. Calculate azimuth based on azimuth data in the data packet:

1）Find the azimuth value in the data packet and convert to a hexadecimal number: 0x5c, 0x19

2）Convert to a 16-bit unsigned integer: 0x5c19

3）Convert to a decimal number: 23577

Divided by 100。

4）Result：235.77 degrees

5.2.2.2. Azimuth Value

The azimuth value of each data block is the azimuth value reported by the first laser of the firing sequence of this data block. Azimuth value is recorded by angle encoder with the zero position of the angle encoder corresponding the zero degree of the azimuth value. The azimuth resolution is 0.01 degrees.

5.2.3. Tail

The Tail is 6 bytes in length, among which 4 bytes are reserved, and the other 2 bytes are 0x00 and 0xFF.

5.3. Device Info Output Protocol（DIFOP）

Device Info Output Protocol is abbreviated as DIFOP

I/O type: device output, computer read.

Default port number: 7788.

DIFOP is an "output-only" protocol to periodically send the LiDAR serial number (S/N), firmware version information, host computer driver compatibility information, network configuration information, calibration information, motor operating configuration, operating status, and fault diagnosis information to users. By reading DIFOP, users can learn specific information of various parameters of the LiDAR currently in use.

The basic structure of the DIFOP packet is as shown in the table below.

Table 5-5 RS-Bpearl_2.0 DIFOP Packet Structure

Segments	No.	Information Registers	Offset	Length（byte）
Header	0	DIFOP header	0	8
Data	1	Motor speed	8	2
	2	Ethernet	10	22
	3	FOV setting	32	4
	4	Reserved	36	2
	5	Motor phase lock	38	2
	6	Top board firmware version	40	5
	7	Bottom board firmware version	45	5
	8	Reserved	50	242
	9	Serial number	292	6
	10	Zero angle offset	298	2
	11	Return mode	300	1
	12	Upper computer compatibility	301	2
	13	UTC time	303	10
	14	Operating status	313	18
	15	Reserved	331	11
	16	Fault diagnosis	342	40
	17	GPRMC	382	86
	18	Corrected vertical angle	468	96
	19	Corrected horizontal angle	564	96

	20	Reserved	660	586
Tail	21	Tail	1246	2

Table 5-6 RS-Bpearl_3.0 DIFOP Packet Structure

Segments	No.	Information Registers	Offset	Length（byte）
Header	0	DIFOP header	0	8
Data	1	Motor speed	8	2
	2	Ethernet source IP	10	4
		Ethernet destination IP	14	4
		LiDAR MAC address	18	6
		MSOP port number	24	2
		Reserved	26	2
		DIFOP port mumber	28	2
		Reserved	30	2
	3	FOV start angle	32	2
		FOV end angle	34	2
	4	TCP MSOP port number	36	2
	5	Motor phase lock	38	2
	6	Top board firmware version	40	5
		Bottom board firmware version	45	5
		Bottom board software version	50	5
		Motor firmware version	55	5

		Reserved	60	3
	7	Reserved	63	227
	8	Reverse Zero angle offset	290	2
	9	Serial number	292	6
	10	Zero angle offset	298	2
	11	Return mode	300	1
	12	Time synchronization mode	301	1
		Synchronization status	302	1
		UTC Time	303	10
	13	Operating status	313	18
	14	Reserved	331	11
		Rotation direction flag	337	1
		Elapsed time flag	338	4
		Fault diagnosis	342	40
	15	GPRMC	382	86
	16	Corrected vertical angle	468	96
	17	Corrected horizontal angle	564	96
	18	Reserved	660	586
Tail	19	Tail	1246	2

Note: The Header (the DIFOP identifier) in the table above is 0xA5,0xFF,0x00,0x5A,0x11,0x11,0x55,0x55, it can be used to identify the packet. The tail is 0x0F,0xF0.

For detailed description of information registers as well as their usage, please refer to Appendix B of this user manual.

5.4. User Configuration Write Protocol (UCWP）

User Configuration Write Protocol is abbreviated as UCWP.

I/O type: Computer writes into the device.

Function: User can reconfigure Ethernet connection, time, motor and some other parameters of the LiDAR.

Note: The UCWP is only available for the RS-Bpearl_2.0 sensors. The RS-Bpearl_3.0 uses the Web Interface to configure the sensor. Please refer to Appendix A for detailed instructions of using Web Interface for sensor configuration.

Each UCWP Packet is 48 bytes long, and is comprised of a 8-byte long Header and a 40-byte long data block.

The UCWP packet structure is as shown in the table below:

Table 5-7 UCWP Packet Structure

Segments	No.	Information Registers	Offset	Length（byte）
Header	0	UCWP header	0	8
Data	1	Motor speed	8	2
	2	Ethernet	10	22
	3	FOV setting	32	4
	4	Time	36	10
	5	Motor phase lock	46	2

Note: The Header (UCWP identifier) in the table above is 0xAA,0x00,0xFF,0x11,0x22,0x22,0xAA,0xAA, among which, the first 4 bytes 0xAA, 0x00, 0xFF, 0x11 forms the sequence to identify the packet.

Reminder: RS-Bpearl doesn’t have a battery system to support the continuous operation of the RTC while the sensor power is off. In the case of no GPS or no GPS signal, it is imperative to write time into the sensor through a computer, otherwise a default system time will be used for the sensor timing.

Please refer to Appendix B for the detailed definition of the Ethernet, Time, Motor Speed and Motor Phase Lock.

If the user wants to reconfigure the LiDAR IP to 192.168.1.105, the destination PC IP to 192.168.1.225, the MAC_ADDR to 001C23174ACC, the MSOP port to 6688, the DIFOP port to 8899, the FOV start angle to 0 degrees, and the FOV end angle to 120 degrees, time 9:45:30:100:200 on March 10, 2017, motor speed to 600rpm, and the motor phase lock angle to

90 degrees, according to the definition of the UCWP Packet and each registers, you can send UDP packets to LiDAR according to the following table.

Table 5-8 Example Configuration of LiDAR through UCWP

Information Registers	Setting	Configuration	Length (byte）
Header		0xAA,0x00,0xFF,0x11,0x22,0x22,0xAA,0xAA	8
Motor Speed	600rpm	0x02 0x58	2
LiDAR IP （LIDAR_IP）	192.168.1.105	0xC0 0xA8 0x01 0x69	4
Destination PC IP （DEST_PC_IP）	192.168.1.225	0xC0 0xA8 0x01 0xE1	4
LiDAR MAC Address （MAC_ADDR）	001C23174ACC	0x00,0x1C,0x23, 0x17,0x4A,0xCC	6
MSOP Port（port1）	6688	0x1A20	2
MSOP Port（port2）	6688	0x1A20	2
DIFOP Port（port3）	8899	0x22C3	2
DIFOP Port（port4）	8899	0x22C3	2
FOV start angle	0	0x0000	2
FOV end angle	12000	0x2EE0	2
UTC_Time	Year:2017 Month:3 Day:10 Hour:9	0x11	10

	Minute:45 Second:30 Millisecond: 100 Microsecond: 200	0x03 0x0A 0x09 0x2D 0x1E 0x00,0x64 0x00,0xC8	
Motor Phase Lock	90	0x005A	2

While configuring LiDAR according to this protocol, it is imperative to configure all the information registers in the table above. Configuring only part of it will lead to invalid configuration. Configuration will take effect once the parameters are changed, except that the network parameters will take effect during the initialization process when the LiDAR is restarted.

Note: RSVIEW provides the LiDAR configuration user interface. Except for the UCWP, user can also use the RSVIEW to configure the RS-Bpearl. When performing the parameter configuration, please make sure there is stable power supply for the LiDAR. After the parameter configuration is done, please make sure to power off the LiDAR, otherwise there is a risk of parameter configuring error.

6. Vertical Angles and Exact Point Time Calculation

6.1. Channel Number and Vertical Angles

The RS-Bpearl LiDAR comes with a total of 32 laser heads vertically allocated along the vertical field of view of 90 degrees with non-uniform angular resolution. Each laser head, also called a laser channel, is installed with a designated vertical angle; Due to errors in actual assembly processes, users can check the DIFOP data packets for the calibrated vertical angule value of each laser channels.

6.2. Exact Point Time Calculation

6.2.1. Exact Point Time Calculation in Single Return Mode

In single return mode, each MSOP Packet has 12 data blocks and each data block stores measurements of 1 firing sequences of 32 lasers, therefore, each MSOP Packet records 12 firing sequences of 32 lasers. It takes 55.52us to complete one sequence of firing and recharging of the 32 lasers: The time to complete 32 laser shooting 1.28us * 32=40.96us (time interval between 2 laser shooting is 1.28us), plus the time cost for two laser charge, the wait time after each charge and the reference signal time 2 * 4.00us + 2 * 1.20us + 4.16us=14.56us.

After the first laser charge, the RS-BPearl will complete the shooting from channel 1 to channel 8 and channel 17 to channel 24. Then a second laser charge and complets the shooting from channel 9 to channel 16 and channel 25 to channel 32.

The laser number(data_index) is defined as laser 1 to 32, and the laser firing sequence number(sequence_index) is defined as sequence 1 to 12. The time stamp of each MSOP packet is the time stamp of the first laser shooting (laser point), to calculate the exact time of each laser shooting(laser point), a time offset(time_offset) needs to be added to the time stamp.

The time offset of channel 1 to channel 8 and channel 17 to channel 24 is calculated as:

Time_offset = 55.52 * (sequence_index - 1) + 2.56 * mod((data_index – 1) , 16) + 1.28 * floor((data_index-1) / 16)

The time offset of channel 9 to channel 16 and channel 25 to channel 32 is calculated as:

Time_offset = 55.52 * (sequence_index - 1) + 2.56 * mod((data_index – 1) , 16) + 1.28 * floor((data_index-1) / 16) + 5.2

The exact time of each laser point is calculated as:

Exact_point _time = Timestamp + Time_offset

Table 6-1 Time Offset of each Laser Point in the MSOP Packet in the Single Return Mode

channel ID	Ideal Vertical Angle of Channel	MSOP Packet											
		Data Block 1	Data Block 2	Data Block 3	Data Block 4	Data Block 5	Data Block 6	Data Block 7	Data Block 8	Data Block 9	Data Block 10	Data Block 11	Data Block 12
1	89.5	0.00	55.52	111.04	166.56	222.08	277.60	333.12	388.64	444.16	499.68	555.20	610.72
2	81.0625	2.56	58.08	113.60	169.12	224.64	280.16	335.68	391.20	446.72	502.24	557.76	613.28
3	78.25	5.12	60.64	116.16	171.68	227.20	282.72	338.24	393.76	449.28	504.80	560.32	615.84
4	72.625	7.68	63.20	118.72	174.24	229.76	285.28	340.80	396.32	451.84	507.36	562.88	618.40
5	67	10.24	65.76	121.28	176.80	232.32	287.84	343.36	398.88	454.40	509.92	565.44	620.96
6	61.375	12.80	68.32	123.84	179.36	234.88	290.40	345.92	401.44	456.96	512.48	568.00	623.52
7	55.75	15.36	70.88	126.40	181.92	237.44	292.96	348.48	404.00	459.52	515.04	570.56	626.08
8	50.125	17.92	73.44	128.96	184.48	240.00	295.52	351.04	406.56	462.08	517.60	573.12	628.64
9	86.6875	25.68	81.20	136.72	192.24	247.76	303.28	358.80	414.32	469.84	525.36	580.88	636.40
10	83.875	28.24	83.76	139.28	194.80	250.32	305.84	361.36	416.88	472.40	527.92	583.44	638.96
11	75.4375	30.80	86.32	141.84	197.36	252.88	308.40	363.92	419.44	474.96	530.48	586.00	641.52
12	69.8125	33.36	88.88	144.40	199.92	255.44	310.96	366.48	422.00	477.52	533.04	588.56	644.08
13	64.1875	35.92	91.44	146.96	202.48	258.00	313.52	369.04	424.56	480.08	535.60	591.12	646.64
14	58.5625	38.48	94.00	149.52	205.04	260.56	316.08	371.60	427.12	482.64	538.16	593.68	649.20
15	52.9375	41.04	96.56	152.08	207.60	263.12	318.64	374.16	429.68	485.20	540.72	596.24	651.76
16	47.3125	43.60	99.12	154.64	210.16	265.68	321.20	376.72	432.24	487.76	543.28	598.80	654.32
17	44.5	1.28	56.80	112.32	167.84	223.36	278.88	334.40	389.92	445.44	500.96	556.48	612.00
18	38.875	3.84	59.36	114.88	170.40	225.92	281.44	336.96	392.48	448.00	503.52	559.04	614.56
19	33.25	6.40	61.92	117.44	172.96	228.48	284.00	339.52	395.04	450.56	506.08	561.60	617.12
20	27.625	8.96	64.48	120.00	175.52	231.04	286.56	342.08	397.60	453.12	508.64	564.16	619.68
21	22	11.52	67.04	122.56	178.08	233.60	289.12	344.64	400.16	455.68	511.20	566.72	622.24
22	16.375	14.08	69.60	125.12	180.64	236.16	291.68	347.20	402.72	458.24	513.76	569.28	624.80
23	10.75	16.64	72.16	127.68	183.20	238.72	294.24	349.76	405.28	460.80	516.32	571.84	627.36
24	5.125	19.20	74.72	130.24	185.76	241.28	296.80	352.32	407.84	463.36	518.88	574.40	629.92
25	41.6875	26.96	82.48	138.00	193.52	249.04	304.56	360.08	415.60	471.12	526.64	582.16	637.68
26	36.0625	29.52	85.04	140.56	196.08	251.60	307.12	362.64	418.16	473.68	529.20	584.72	640.24
27	30.4375	32.08	87.60	143.12	198.64	254.16	309.68	365.20	420.72	476.24	531.76	587.28	642.80
28	24.8125	34.64	90.16	145.68	201.20	256.72	312.24	367.76	423.28	478.80	534.32	589.84	645.36
29	19.1875	37.20	92.72	148.24	203.76	259.28	314.80	370.32	425.84	481.36	536.88	592.40	647.92
30	13.5625	39.76	95.28	150.80	206.32	261.84	317.36	372.88	428.40	483.92	539.44	594.96	650.48
31	7.9375	42.32	97.84	153.36	208.88	264.40	319.92	375.44	430.96	486.48	542.00	597.52	653.04
32	2.3125	44.88	100.40	155.92	211.44	266.96	322.48	378.00	433.52	489.04	544.56	600.08	655.60

6.2.2 Exact Point Time Calculation in Dual Return Mode

In dual return mode, each MSOP Packet has 12 data blocks and each 2 data blocks store the dual return measurements of 1 firing sequences of 32 lasers, for example, Block 1 and Block 2 store the dual return measurements of 1 firing sequences of 32 lasers, where Block 1 stores the strongest return measurements, Block 2 stores the last return measurements.

The laser number(data_index) is defined as laser 1 to 32, and the laser firing sequence number(sequence_index) is defined as sequence 1 to 12. The time stamp of each MSOP packet is the time stamp of the first laser shooting(laser point), to calculate the exact time of each laser shooting(laser point), a time offset(time_offset) needs to be added to the time stamp.

The time offset of channel 1 to channel 8 and channel 17 to channel 24 is calculated as:

Time_offset = 55.52 * (floor ((sequence_index - 1) /2)) + 2.56 * mod((data_index – 1) , 16) + 1.28 * floor((data_index-1) / 16)

Time_offset = 55.52 * (floor ((sequence_index - 1) /2)) + 2.56 * mod((data_index – 1) , 16) + 1.28 * floor((data_index-1) / 16) + 5.2

The exact time of each laser point is calculated as:

Exact_point _time = Timestamp + Time_offset

Table 6-2 Time Offset of each Laser Point in the MSOP Packet in the Dual Return Mode

channel ID	Ideal Vertical Angle of Channel	MSOP Packet											
		Data Block 1	**Data Block 2**	**Data Block 3**	**Data Block 4**	**Data Block 5**	**Data Block 6**	**Data Block 7**	**Data Block 8**	**Data Block 9**	**Data Block 10**	**Data Block 11**	**Data Block 12**
1	89.5	0.00	0.00	55.52	55.52	111.04	111.04	166.56	166.56	222.08	222.08	277.60	277.60
2	81.0625	2.56	2.56	58.08	58.08	113.60	113.60	169.12	169.12	224.64	224.64	280.16	280.16
3	78.25	5.12	5.12	60.64	60.64	116.16	116.16	171.68	171.68	227.20	227.20	282.72	282.72
4	72.625	7.68	7.68	63.20	63.20	118.72	118.72	174.24	174.24	229.76	229.76	285.28	285.28
5	67	10.24	10.24	65.76	65.76	121.28	121.28	176.80	176.80	232.32	232.32	287.84	287.84
6	61.375	12.80	12.80	68.32	68.32	123.84	123.84	179.36	179.36	234.88	234.88	290.40	290.40
7	55.75	15.36	15.36	70.88	70.88	126.40	126.40	181.92	181.92	237.44	237.44	292.96	292.96
8	50.125	17.92	17.92	73.44	73.44	128.96	128.96	184.48	184.48	240.00	240.00	295.52	295.52
9	86.6875	25.68	25.68	81.20	81.20	136.72	136.72	192.24	192.24	247.76	247.76	303.28	303.28
10	83.875	28.24	28.24	83.76	83.76	139.28	139.28	194.80	194.80	250.32	250.32	305.84	305.84
11	75.4375	30.80	30.80	86.32	86.32	141.84	141.84	197.36	197.36	252.88	252.88	308.40	308.40
12	69.8125	33.36	33.36	88.88	88.88	144.40	144.40	199.92	199.92	255.44	255.44	310.96	310.96
13	64.1875	35.92	35.92	91.44	91.44	146.96	146.96	202.48	202.48	258.00	258.00	313.52	313.52
14	58.5625	38.48	38.48	94.00	94.00	149.52	149.52	205.04	205.04	260.56	260.56	316.08	316.08
15	52.9375	41.04	41.04	96.56	96.56	152.08	152.08	207.60	207.60	263.12	263.12	318.64	318.64
16	47.3125	43.60	43.60	99.12	99.12	154.64	154.64	210.16	210.16	265.68	265.68	321.20	321.20
17	44.5	1.28	1.28	56.80	56.80	112.32	112.32	167.84	167.84	223.36	223.36	278.88	278.88
18	38.875	3.84	3.84	59.36	59.36	114.88	114.88	170.40	170.40	225.92	225.92	281.44	281.44
19	33.25	6.40	6.40	61.92	61.92	117.44	117.44	172.96	172.96	228.48	228.48	284.00	284.00
20	27.625	8.96	8.96	64.48	64.48	120.00	120.00	175.52	175.52	231.04	231.04	286.56	286.56
21	22	11.52	11.52	67.04	67.04	122.56	122.56	178.08	178.08	233.60	233.60	289.12	289.12
22	16.375	14.08	14.08	69.60	69.60	125.12	125.12	180.64	180.64	236.16	236.16	291.68	291.68
23	10.75	16.64	16.64	72.16	72.16	127.68	127.68	183.20	183.20	238.72	238.72	294.24	294.24
24	5.125	19.20	19.20	74.72	74.72	130.24	130.24	185.76	185.76	241.28	241.28	296.80	296.80
25	41.6875	26.96	26.96	82.48	82.48	138.00	138.00	193.52	193.52	249.04	249.04	304.56	304.56
26	36.0625	29.52	29.52	85.04	85.04	140.56	140.56	196.08	196.08	251.60	251.60	307.12	307.12
27	30.4375	32.08	32.08	87.60	87.60	143.12	143.12	198.64	198.64	254.16	254.16	309.68	309.68
28	24.8125	34.64	34.64	90.16	90.16	145.68	145.68	201.20	201.20	256.72	256.72	312.24	312.24
29	19.1875	37.20	37.20	92.72	92.72	148.24	148.24	203.76	203.76	259.28	259.28	314.80	314.80
30	13.5625	39.76	39.76	95.28	95.28	150.80	150.80	206.32	206.32	261.84	261.84	317.36	317.36
31	7.9375	42.32	42.32	97.84	97.84	153.36	153.36	208.88	208.88	264.40	264.40	319.92	319.92
32	2.3125	44.88	44.88	100.40	100.40	155.92	155.92	211.44	211.44	266.96	266.96	322.48	322.48

7. Trouble Shooting

When using the RS-Bpearl, users may encounter some common problems, this chapter lists some common problems and the corresponding solutions.

Problem	Solution
The red LED indicator in the Interface Box is off or blinking	● Check whether the input power connection and polarity are normal. ● Check whether the voltage and current of the input power supply meet the requirements (voltage input⩽12V, input current⩾3A).
The red LED indicator in the Interface Box is on but the green LED is off or blinking	● Check if the connection cable between the Interface Box and the LiDAR gets loose.
LiDAR motor does not rotate	● Check whether the LED indicators on the Interface Box are normal, and check whether the power input is normal. ● Check if the connection cable between the Interface Box and the LiDAR gets loose.
LiDAR keeps restarting at startup	● Check whether the input power connection and polarity are normal. ● Check whether the voltage and current of the input power supply meet the requirements (voltage input⩽12V, input current⩾3A). ● Check whether the mounting base of the device is level or whether the fixing screws at the bottom of the LiDAR are too tight.
LiDAR rotates but no data output	● Check whether the network connection is normal. ● Check whether the computer network configuration is correct. ● Use another software (such as wireshark) to check whether the packet output is normal. ● Turn off firewalls and other security software that may block the network. ● Check whether the power supply is normal.
Can see data in Wireshark but not in RSVIEW	● Turn off the computer firewall, and allow the RSVIEW to bypass the firewall. ● Make sure that the IP of the computer is consistent with the IP of the

	LiDAR. ● Make sure that the Data Port setting on RSVIEW is correct. ● Make sure that the RSVIEW installation directory or configuration file storage directory only contain English characters. ● Make sure that the data packets received by wireshark are MSOP packets.
Frequent data dropouts	● Check whether there is excessive traffic and/or collisions on network. ● Check whether there are other network devices in the network sending excessive broadcast packets, which slows the sensor down. ● Check whether the computer or the interfaces are fast enough to meet the packet flow requirements. ● Remove all other network devices and directly connect sensor to the computer to test whether there is packet loss.
GPS/PTP not synchronizing	● Make sure that the GPS baud rate is 9600bps and serial port set to 8N 1(8 bits, no parity, 1 stop bit). ● Check whether the GPS signal level RS232. ● Make sure that the 1PPS pulse is continuous and the connection is correct. ● Make sure that the GPRMC message of NMEA is correct. ● Make sure that the GPS and Interface Box share the same ground. ● Make sure that the GPS has received valid message.
No data output when sensor connected to a router	● Turn off the DHCP function of the router or set the IP of the sensor to the correct IP inside the router.
Abnormal shape of point cloud	● Make sure that the configuration file of the LiDAR is correct.
In the point cloud, there is a fixed blank area that continuously rotates	● This phenomenon is normal, because the ROS driver performs frame display according to a fixed number of packets, and the blank part of the data will be displayed in the next frame.
RSVIEW software outputs point cloud into a ray	● If you are using a windows 10 system, please set RSVIEW to run in the mode compatible with windows 7.

Appendix A Web Interface

The parameter setting of the RS-Bpearl_2.0 can only be done through RSVIEW, please refer to Appendix C for detailed instructions. While the parameter setting, operation status-check and firmware upgrade of the RS-Bpearl_3.0 can only be done through the Web Interface.

The address of the Web Interface of the RS-Bpearl changes with the LiDAR IP. The factory default LiDAR IP is 192.168.1.200. If the user has changed the LiDAR IP, the address of the Web Interface will be changed to the newly set LiDAR IP address.

After the LiDAR is correctly connected and configured according to the requirements, user can use the computer connected to the LiDAR to access the LiDAR IP address (default Device IP "192.168.1.200") to enter the homepage of the LiDAR web interface, the homepage defaults to the "Device" page.

A.1 Device Information Screen

After accessing the LiDAR Web Interface, you will be at the “Device” screen directly, which shows information of the LiDAR currently in use:

Figure A-1 Homepage of the Web Interface

1. Top Board: the top board firmware version;

2. Bottom Board: the bottom board firmware version;

3. Software Version: the software version;

4. S/N: the sensor serial number;

5. Model: the product model number;

6. Web App Version: the version of the current Web Interface.

A.2 Device Parameter Setting Screen

Click the **Setting** button on the Web Interface, you will open the “Setting” screen, where you will find settings for Device IP, port number, return mode, rotation speed, etc. Definition of the functionality and features are as shown in the figure below:

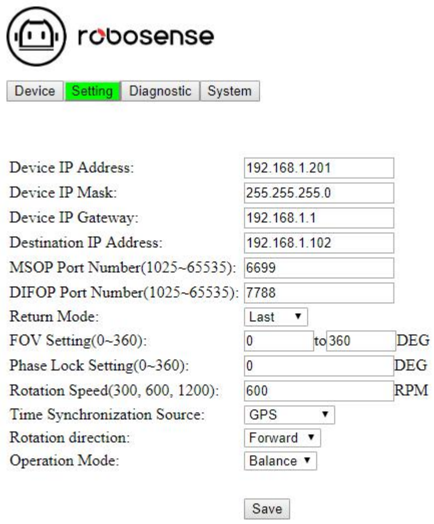


Figure A-2 -1 Setting LiDAR Parameters at the Web Interface

1. Communication of LiDAR supports both unicast (default) and broadcast modes. Destination IP address 255.255.255.255 indicates broadcast mode. The default factory setting of the Destination IP is 192.168.1.102;
2. The MSOP and DIFOP port numbers can be configured in a range from 1025 to 65535;
3. The Return Mode has three options: Last(default), Strongest and Dual;
4. The FOV can be set from 0° to 360°, when set, only the point cloud of the set FOV will be output.
5. The sensor rotation speed can be set, which only 300rpm, 600rpm(default), and 1200rpm are supported at the moment;
6. The Time Synchronization Source has options: GPS(default), PTP-E2E, PTP-P2P, PTP-GPTP;
7. The Rotation direction has 2 options: forward(default), reversal;
8. Click the dropdown menu of "Operation Mode", users can select the working mode between Standby and Balance(default). When the Standby mode is selected, the LiDAR motor and transmitter will stop working.

Note：

1. Please make sure that the Device IP and Destination IP are at the same network segment, otherwise, LiDAR connection error may occur;

2. The MSOP and DIFOP port number can be set within a range from 1025 to 65535;

3. Please click “Save” after each modification. A system reminder of modification success will appear if the

modification takes effect.

A.3 Device Diagnostics/Operation Status Screen

Click the **Diagnostic** button on the front page of the Web Interface, you will see the **Diagnostic Screen**, where you can learn the operating status of the LiDAR in real time, including the input voltage, current, rotating speed, operating time, and temperature, etc. The figure below shows the Diagnostic screen and the features:

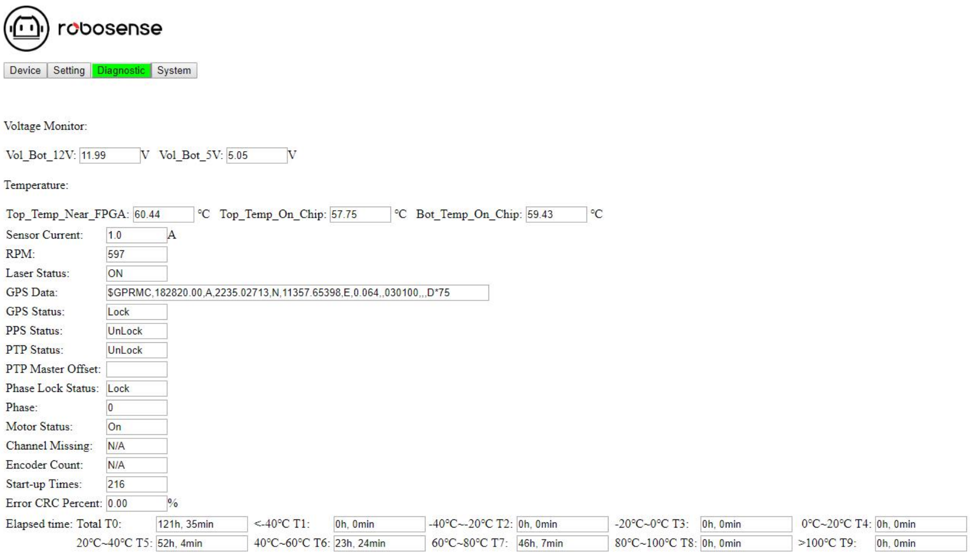


Figure A-3 Device Diagnostic/Operation Status Screen at the Web Interface

Description:

1. **Voltage Monitor:** Users can view the real time voltage of the power supply of the LiDAR;
2. **Temperature:** Users can view the real time operating temperature of the LiDAR;
3. **RPM:** Users can view the real time motor rotating speed, when the LiDAR operation mode is set as Standby, the motor rotating speed will be 0;
4. **Laser Status:** The laser status has two options of "On" and "Off".

   (1) When laser status is "ON", the LiDAR is operating normally;

   (2) When laser status is "Off", the LiDAR operation encounters problems;

   when the LiDAR operation mode is set as Standby, the laser status is "Off";
5. **GPS Status/PTP Status:** Users can view the time synchronization status;
6. **Start-up Times**: Users can view the total number of Star-ups of the LiDAR, which will be accumulated every time the LiDAR is restarted;
7. **Elapsed time Total T0:** Users can view the total operation time of the LiDAR and the accumulated operation time of the LiDAR at each temperature range.

Note:

1. The diagnostic screen is refreshed every second.

2. If the voltage/current box turns red, please check whether the LiDAR is currently in Standby mode, if not, check whether the LiDAR is working normally;

3. After the LiDAR is circle powered again, within 10 minutes of operation, the number of start-up times is refreshed every 1 minute; after 10 minutes of operation, the number of start-up times is refreshed every 30 minutes.

A.4 Device/System Update Screen

Click the **System** button on the front page of the Web Interface, you will see the **System Screen**, where you can update the top board firmware, bottom board firmware, software, web app, motor firmware, and config file. The procedure of device update, taking the Top Board Firmware Update as an example, are as shown below:

1. Prepare the Top Board firmware that is going to be used for the update. Click the **Choose File** button to navigate to the folder where the new TOP Board firmware is located.

Figure A-4 Click Choose File to Find the New Firmware

2. Select the right firmware that is going to be used for the update, and click **Open** to upload the file. (The saving path of the firmware should only contain English characters)

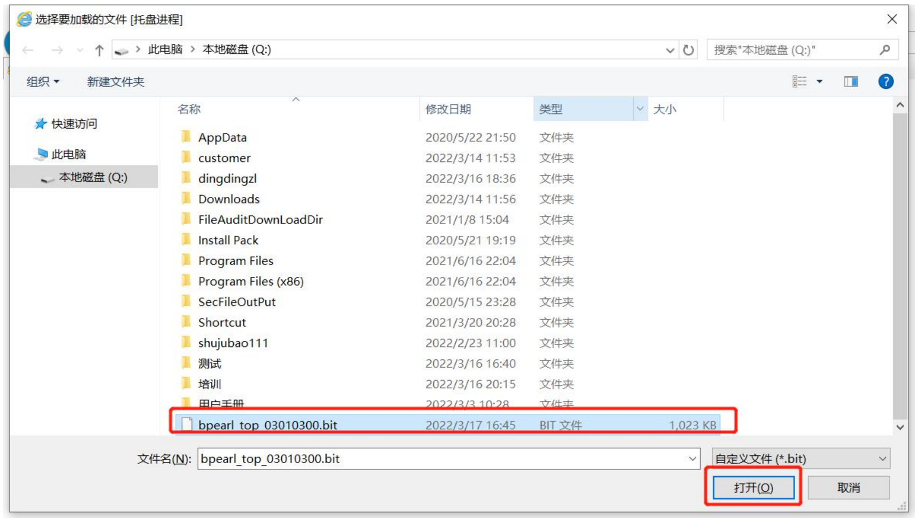


Figure A-5 Select the Right Firmware

3. When the new firmware is successfully uploaded, the file name of the firmware will appear in the box behind the Top Board Firmware Update, click **Update** to initiate the update process.

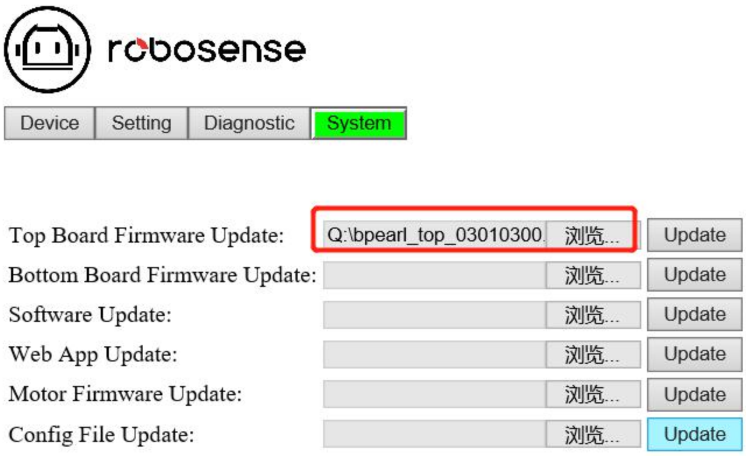


Figure A-6 Click **Update**

4. After the Update process completes, the Web Interface will prompt Update Successful, and the LiDAR will automatically restart, after the sensor is restarted, load the Web Interface again to check if the firmware update is successful.

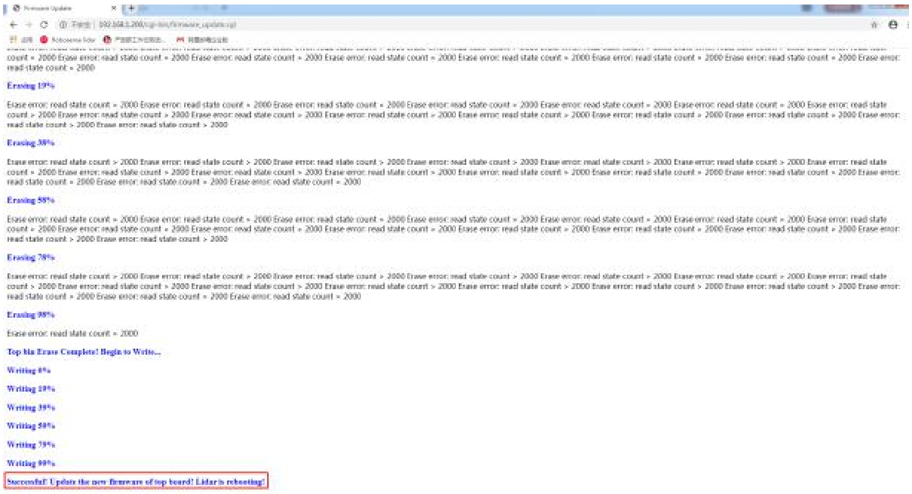


Figure A-7 Update Successful

Appendix B Information Registers

Here are definitions and more details on the information registers as mentioned in Section 5.

B.1 Motor Speed (MOT_SPD)

MOT_SPD (2 bytes in total)						
Byte No.	byte1	byte2				
Function	MOT_SPD					

Register description:

(1) This register is used to configure the motor rotation direction and motor speed;

(2) The data storage adopts the big-endian format.

(3) Supported rotation speed:

(byte1==0x04) && (byte2==0xB0): speed 1200rpm, clockwise rotation;

(byte1==0x02) && (byte2==0x58): speed 600rpm, clockwise rotation;

(byte1==0x02) && (byte2==0x58): speed 300rpm, clockwise rotation;

If set with data other than the above described, the rotation speed of the motor is 0.

B.2 Ethernet(ETH)

ETH (22 bytes in total）								
Byte No.	byte1	byte2	byte3	byte4	byte5	byte6	byte7	byte8
Function	LIDAR_IP				DEST_PC_IP			
Byte No.	byte9	byte10	byte11	byte12	byte13	byte14	byte15	byte16
Function	MAC_ADDR						port1	
Byte No.	byte17	byte18	byte19	byte20	byte21	byte22		
Function	port2		port3		port4			

Register description:

(1) LIDAR_IP is the source IP address of the LiDAR. It takes 4 bytes

(2) DEST_PC_IP is the IP address of the destination PC. It takes 4 bytes

(3) MAC_ADDR is the LiDAR MAC address.

(4) port1 to port4 are port number information.

port1 is the port for LiDAR to output MSOP packets and port2 is the port for destination PC to receive MSOP packets. port3 is the port for LiDAR to output DIFOP packets and port4 is the port for destination PC to receive DIFOP packets. By default, we suggest port1 and port2 to be set the same, port3 and port4 to be set the same.

B.3 FOV Setting(FOV_SET)

FOV_SET (4 bytes in total)						
Byte No.	byte1	byte2	byte3	byte4		
Function	FOV_START		FOV_END			

Register Description:

Set the azimuth range that the sensor can output valid data, the values of FOV_START and FOV_END could be any integer between 0 to 36000, corresponding 0~360°, the data storage adopts the big endian ordering. For example: byte1 = 0x5d， byte2 = 0xc0， byte3 = 0x1f， byte4 = 0x40, therefore:

FOV_START = 93*256+192=24000

FOV_END = 31*256+64=8000

Which indicates that the azimuth range for valid data output is from 240.00° to 80.00° in clockwise direction.

Note: *In all above calculations, bytes have been converted from hexadecimal to decimal.*

B.4 TCP MSOP Port Number

TCP MSOP(2bytes in total)						
Byte No.	byte1	byte2				
Function	Port					

Register Description:

MSOP port number setting in the TCP communication mode.

B.5 Motor Phase Offset(MOT_PHASE)

MOT_PHASE(2 bytes in total)

Byte No.	byte1	byte2				
Function	MOT_PHASE					

Register description:

This register can be used together with the PPS pulse of GPS to adjust the phase offset of the motor at the top of seconds. The value can be set from 0 to 360 corresponding 0 to 360°. The data storage adopts the big endian ordering. For example: the byte1=0x01、 byte2=0x0e, so the motor phase should be 1*256+14 = 270.

Note: *In all above calculations, bytes have been converted from hexadecimal to decimal.*

B.5 Top Board Firmware Version(TOP_FRM)

TOP_FRM(5 bytes in total)						
Byte No.	byte1	byte2	byte3	byte4	byte5	
Function	TOP_FRM					

Register description：

This register corresponds to the top board firmware version:

For RS-Bpearl_2.0:

Top board firmware file version: T6R23V6_T6_A

Top board firmware version displayed in DIFOP packets: 06 23 06 06 A0

The mark "_A" in the version number means that the firmware is for Application purpose, and "_F" means that it is the factory version.

For RS-Bpearl_3.0:

Top board firmware file version: 03010303

Top board firmware version displayed in DIFOP packets:00 03 01 03 03

B.6 Bottom Board Firmware Version(BOT_FRM)

BOT_FRM(5bytes in total)						
Byte No.	byte1	byte2	byte3	byte4	byte5	
Function	BOT_FRM					

Register description：

For RS-Bpearl_2.0:

Bottom board firmware file version: B7R14V4_T1_F

Top board firmware version displayed in DIFOP packets: 07 14 04 01 F0

The mark "_A" in the version number means that the firmware is for Application purpose, and "_F" means that it is the factory version.

For RS-Bpearl_3.0:

Bottom board firmware file version: 03011300

Top board firmware version displayed in DIFOP packets: 00 03 01 13 00

B.7 Software Version(SOF_FRM)

SOF_FRM (5 bytes in total)					
Byte No.	byte1	byte2	byte3	byte4	byte5
Function	SOF_FRM				

Register description:

This register corresponds to the Software Firmware version:

Software firmware file version: 21101904

Software firmware version displayed in DIFOP packets: 00 21 10 19 04

B.8 Motor Firmware Version(MOT_FRM)

MOT_FRM (5 bytes in total)					
序号	byte1	byte2	byte3	byte4	byte5
功能	SOF_FRM				

Register description:

This register corresponds to the Motor Firmware version:

Motor firmware file version: 21061600

Motor firmware version displayed in DIFOP packets: 00 21 06 16 00

B.9 Time Synchronization(TIMESTAMP_VER）

TIMESTAMP_VER (2 bytes in total)

Byte No.	byte1	byte2				
Function	Timestamp_setting	Timestamp_State				

Register description:

（1）byte1: Time synchronization mode

00：GPS

01：E2E

02：P2P

03：gptp

byte2: Time synchronization status

00：Time synchronization invalid

01：GPS Time synchronization successful

02：PTP Time synchronization successful

B.10 UTC Time(UTC_TIME)

UTC_TIME (10 bytes in total)								
Byte No.	byte1	byte2	byte3	byte4	byte5	byte6	byte7	byte8
Function	year	month	day	hour	min	sec	ms	
Byte No.	byte9	byte10						
Function	us							

Register description:

1) year

reg name：set_year								
Byte No.	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Function	set_year[7:0]: 0~255 corresponds 2000~2255 year							

2) month

reg name：set_month								
Byte No.	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Function	Reserved	Reserved	Reserved	Reserved	set_month[3:0]：1~12 month			

3) day

reg name：set_day								
Byte No.	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Function	Reserved	Reserved	Reserved	set_day[4:0]：1~31 day				

4) hour

reg name：set_hour								
Byte No.	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Function	Reserved	Reserved	Reserved	set_hour[4:0]：0~23 hour				

5) min

reg name：set_min								
Byte No.	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Function	Reserved	Reserved	set_min[5:0]：0~59 min					

6) sec

reg name：set_sec								
Byte No.	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0

Function	Reserved	Reserved	set_sec[5:0]：0~59 sec

7) ms

reg name：set_ms								
Byte No.	bit15	bit14	bit13	bit12	bit11	bit10	bit9	bit8
Function	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	ms[9:8]	
Byte No.	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Function	set_ms[7:0]							

Note: set_ms[9:0], value range: 0~999

8) us

reg name：set_us								
Byte No.	bit15	bit14	bit13	bit12	bit11	bit10	bit9	bit8
Function	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	us[9:8]	
Byte No.	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Function	set_us[7:0]							

Note: set_us[9:0], value range: 0~999

B.11 Operation Status(STATUS)

B.11.1 Operation Status (valid for RS-Bpearl 2.0)

STATUS (18 bytes in total)								
Byte No.	byte1	byte2	byte3	byte4	byte5	byte6	byte7	byte8
Function	Idat1_reg			Idat2_reg			Vdat_12V_reg	
Byte No.	byte9	byte10	byte11	byte12	byte13	byte14	byte15	byte16

Function	Vdat_12V_M_reg		Vdat_5V_reg		Vdat_3V3_reg		Vdat_2V5_reg	
Byte No.	17byte	18byte						
Function	Vdat_1V2_reg							

Register description:

(1) Idat, including 2 current values, where Idat1 is the sensor power supply current, and Idat2 is the top board power supply current. Idat_reg contains 3 bytes to be Idat_reg[23:0]. The highest bit Idat_reg[23] is the sign flag bit, Idat_reg[23] = 1 means a negative value, and Idat_reg[23] = 0 means a positive value. Idat_reg[22:0] corresponds to the current value, the LSB is 1uA, and the current calculation formula is:

$$Idat=\begin{cases} Idat\_reg[22:0]\cdots\cdots\cdots(Idat\_reg[23]=0) \\ -Idat\_reg[22:0]\cdots\cdots(Idat\_reg[23]=1) \end{cases}$$

For example, if byte1 = 0x8C, byte2 = 0xD5, byte3 =0x 00, the actual current value is:

Idat = -Idat_reg[22:0] = -0x0CD500 uA = -840960uA≈-841mA

(2) Vdat, including 6 voltage values, each Vdat_reg contains 2 bytes to be Vdat_reg[15:0]. The upper 4 bits of Vdat_reg[15:12] data are invalid. Vdat_reg[11:0] corresponds to the voltage value, and the calculation formula of each voltage is as follows:

$$Vdat\_12V = Vdat\_12V\_reg[11:0]/4096 * 2.5 * 12$$

$$Vdat\_12V\_M = Vdat\_12V\_M\_reg[11:0]/4096 * 2.5 * 12$$

$$Vdat\_5V = Vdat\_5V\_reg[11:0]/4096 * 2.5 * 4$$

$$Vdat\_3V3 = Vdat\_3V3\_reg[11:0]/4096 * 2.5 * 2$$

$$Vdat\_2V5 = Vdat\_2V5\_reg[11:0]/4096 * 2.5 * 2$$

$$Vdat\_1V2 = Vdat\_1V2\_reg[11:0]/4096 * 2.5 * 2$$

The unit used in the above calculations is volt (V).

B.11.2 Operation Status (valid for RS-Bpearl 3.0)

STATUS (18 bytes in total)								
Byte No.	byte1	byte2	byte3	byte4	byte5	byte6	byte7	byte8
Function	Reserved						Vdat_0V5_reg	
Byte No.	byte9	byte10	byte11	byte12	byte13	byte14	byte15	byte16

Function	Vdat_12V__reg		Vdat_5V_reg		Vdat_1V25_reg		Vdat_0V_reg	
Byte No.	17byte	18byte						
Function	Vdat_1V_reg							

Note: [Value] is the decimal value obtained by converting the corresponding offset byte, using big-endian mode, with the high order first and the low order last.

Register description:

Vdat, including 6 voltage values, each Vdat_reg contains 2 bytes. The calculation formula of each voltage is as follows:

Vdat_0V5_reg = value/4096 V

Vdat_12V_reg = value/4096x24.5 V

Vdat_5V_reg = value/4096x11 V

Vdat_1V25_reg = value/4096x3 V

Vdat_0V_reg = value/4096x3 V

Vdat_1V_reg = value/4096x3 V

The unit used in the above calculations is volt (V).

B.12 Fault Diagnosis (FALT_DIGS)

B.12.1 Fault Diagnosis(valid for RS-Bpearl 2.0)

Fault Diagnosis (40bytes in total)								
Byte No.	byte1	byte2	byte3	byte4	byte5	byte6	byte7	byte8
Function	internal debug							
Byte No.	byte9	byte10	byte11	byte12	byte13	byte14	byte15	byte16
Function	internal debug		cksum_st	manc_err1		manc_err2		gps_st
Byte No.	byte17	byte18	byte19	byte20	byte21	byte22	byte23	byte24
Function	temperature1		temperature2		temperature3		temperature4	
Byte No.	byte25	byte26	byte27	byte28	byte29	byte30	byte31	byte32

Function	temperature 5		internal debug					r_rpm1
Byte No.	byte33	byte34	byte35	byte36	byte37	byte38	byte39	byte40
Function	r_rpm2	internal debug						

Register description:

(1) The cksum_st of byte11 in the table shows the error status in reading the checksum of the temperature drift compensation value of the EEPROM. cksum=0x00 means that the temperature drift compensation value is normal and available, cksum=0x01 means that the temperature drift compensation value is abnormal, and the FPGA internal temperature drift correction has error.

(2) manc_err1 and manc_err2 are used to calculate the count of the bit error of data communication transmission, manc_err1 is used to calculate the count of 1bit errors, and manc_err2 is used to calculate the count of 2bit errors. The formula for calculating the bit error rate is as follows:

$$manc\_err1\_per = manc\_err1/65536 * 100\%$$

$$manc\_err2\_per = manc\_err2/65536 * 100\%$$

When manc_err1_per or manc_err2_per is 0, the communication transmission value is normal.

(3) temperature1, temperature2 are the bottom board temperature, temperature3, temperature4 are the top board temperature. The temperature value consists of 2 bytes, and the lower 3 bits of temperature[2:0] are meaningless. The high 13-bit temperature[15:3] is the effective temperature value, of which the highest bit temperature[15] is the sign flag bit, temperature[15] = 0 means a positive value, and temperature[15] = 1 means a negative value. The temperature calculation formula is as follows:

$$temperature1\_4 = \begin{cases} temperature[15:3] \quad /16 & (temperature[15] = 0) \\ -((8192 - temperature[15:3])/16) & (temperature[15] = 1) \end{cases}$$

Temperature5 is the bottom board temperature, which consists of 2 bytes, and the high 4 bits temperature[15:12] data are meaningless. The lower 12 bits temperature[11:0] are the effective temperature values, the highest bit temperature[11] is the sign flag bit, temperature[11] = 1 means a negative value, and temperature[11] = 0 means a positive value. The temperature calculation formula is as follows:

$$temperature5 = \begin{cases} temperature[11:0]/4 & (temperature[11] = 0) \\ -(4096 - temperature[11:0])/4 & (temperature[11] = 1) \end{cases}$$

(4) byte16 is the GPS signal input status register gps_st, which uses 3 bits to indicate whether the currently connected PPS signal and GPRMC signal are valid, and at the same time indicate whether the current system time is the local time of the device or the synchronized UTC time. The bits are defined as follows:

GPS input status register GPS_ST			
BIT	Function	Value	Status
bit0	PPS_LOCK	0	PPS is invalid
		1	PPS is valid
bit1	GPRMC_LOCK	0	GPRMC is invalid
		1	GPRMC is valid
bit2	UTC_LOCK	0	LiDAR internal timestamp is not synchronizing the UTC.
		1	LiDAR internal timestamp is synchronizing the UTC.
bit3~bit7	Reserved	x	N/A

(1) The real-time rotation speed of the motor is composed of two bytes, byte32 and byte33. The calculation formula is as: Motor real-time rotation speed = (256 * r_rpm1 + r_rpm2)÷6
(2) The reset is used for internal debug,

B.12.2 Fault Diagnosis(valid for RS-Bpearl 3.0)

Fault Diagnosis (40bytes in total)								
Byte No.	byte1	byte2	byte3	byte4	byte5	byte6	byte7	byte8
Function	Reserved							
Byte No.	byte9	byte10	byte11	byte12	byte13	byte14	byte15	byte16
Function	Reserved			manc_err1		manc_err2		gps_st
Byte No.	byte17	byte18	byte19	byte20	byte21	byte22	byte23	byte24
Function	Temp1	Temp2	Reserved		Temp3	Temp4	Temp5	Temp6
Byte No.	byte25	byte26	byte27	byte28	byte29	byte30	byte31	byte32
Function	Reserved							r_rpm1
Byte No.	byte33	byte34	byte35	byte36	byte37	byte38	byte39	byte40

Function	r_rpm2	Reserved

Note: [Value] is the decimal value obtained by converting the corresponding offset byte, using big-endian mode, with the high order first and the low order last.

Register description:

(1) manc_err1 and manc_err2 are used to calculate the error of data communication transmission, manc_err1 is used to calculate the count of 1bit errors, and manc_err2 is used to calculate the count of more than 1bit errors.

When manc_err1_per or manc_err2_per is 0, the communication transmission value is normal.

(2) temp1, temp2 is the temperature of the bottom board, the temperature value is composed of 2bytes, and the temperature calculation formula is:

Temp=（Value（tamp1）*256+Value（tamp2）&0Xffff）*503.975/4096.0-273.15

(3) temp3 and temp4 are APD temperatures, the temperature value is composed of 2 bytes, and the temperature calculation formula is:

When Value≤32768, the temperature value is positive; the calculation formula is as follows:

temp= ((value(362)*256 + value(363)) & 0x7FF8) /128.0

When Value>32768, the temperature value is negative; the calculation formula is as follows:

temp= ((value(362)*256 + value(363)) & 0x7FF8) /128.0

(4) temp5 and temp6 are the temperature of the top board. The temperature value is composed of 2 bytes. The temperature calculation formula is as follows:

When Value≤32768, the temperature value is positive; the calculation formula is as follows:

temp= ((value(362)*256 + value(363)) & 0x7FF8) /128.0

When Value>32768, the temperature value is negative; the calculation formula is as follows:

temp= ((value(362)*256 + value(363)) & 0x7FF8) /128.0

(5) byte16 is the GPS signal input status register gps_st, which uses 3 bits to indicate whether the currently connected PPS signal and GPRMC signal are valid, and at the same time indicate whether the current system time is the local time of the device or synchronized UTC time. The bits are defined as follows:

GPS input status register GPS_ST			
BIT	Function	Value	Status
bit0	PPS_LOCK	0	PPS lock invalid

		1	PPS lock valid
bit1	GPRMC_LOCK	0	GPRMC lock invalid
		1	GPRMC lock valid
bit2	UTC_LOCK	0	LiDAR internal timestamp is not synchronizing the UTC.
		1	LiDAR internal timestamp is synchronizing the UTC.
bit3	GPRMC input status	0	No GPRMC input
		1	with GPRMC input
bit4	PPS input status	0	No PPS input
		1	with PPS input
bit5~bit7	Reserved	x	N/A

(1) The real-time rotation speed of the motor is composed of two bytes, byte32 and byte33. The calculation formula is as follows:

Motor real-time rotation speed = (256 * r_rpm1 + r_rpm2)÷6

B.13 ASCII Code in GPRMC Packet

GPRMC register reserve 86 bytes, it stores the whole GPRMC message from GPS module to the register in ASCII code.

B.14 Corrected Vertical Angle(COR_VERT_ANG)

COR_VERT_ANG (48bytes in total)									
Byte No.	byte1	byte2	byte3	byte4	byte5	byte6	byte7	byte8	byte9
Function	Channel 1_COR_VERT_ANG			Channel 2_COR_VERT_ANG			Channel 3_COR_VERT_ANG		
Byte No.	byte10	byte11	byte12	byte13	byte14	byte15	byte16	byte17	byte18
Function	Channel 4_COR_VERT_ANG			Channel 5_COR_VERT_ANG			Channel 6_COR_VERT_ANG		
Byte No.	byte19	byte20	byte21	byte22	byte23	byte24	byte25	byte26	byte27
Function	Channel 7_COR_VERT_ANG			Channel 8_COR_VERT_ANG			Channel 9_COR_VERT_ANG		

Byte No.	byte28	byte29	byte30	byte31	byte32	byte33	byte34	byte35	byte36
Function	Channel 10_COR_VERT_ANG			Channel 11_COR_VERT_ANG			Channel 12_COR_VERT_ANG		
Byte No.	byte37	byte38	byte39	byte40	byte41	byte42	byte43	byte44	byte45
Function	Channel 13_COR_VERT_ANG			Channel 14_COR_VERT_ANG			Channel 15_COR_VERT_ANG		
Byte No.	byte46	byte47	byte48	byte49	byte50	byte51	byte52	byte53	byte54
Function	Channel 16_COR_VERT_ANG			Channel 17_COR_VERT_ANG			Channel 18_COR_VERT_ANG		
Byte No.	byte55	byte56	byte57	byte58	byte59	byte60	byte61	byte62	byte63
Function	Channel 19_COR_VERT_ANG			Channel 20_COR_VERT_ANG			Channel 21_COR_VERT_ANG		
Byte No.	byte64	byte65	byte66	byte67	byte68	byte69	byte70	byte71	byte72
Function	Channel 22_COR_VERT_ANG			Channel 23_COR_VERT_ANG			Channel 24_COR_VERT_ANG		
Byte No.	byte73	byte74	byte75	byte76	byte77	byte78	byte79	byte80	byte81
Function	Channel 25_COR_VERT_ANG			Channel 26_COR_VERT_ANG			Channel 27_COR_VERT_ANG		
Byte No.	byte82	byte83	byte84	byte85	byte86	byte87	byte88	byte89	byte90
Function	Channel 28_COR_VERT_ANG			Channel 29_COR_VERT_ANG			Channel 30_COR_VERT_ANG		
Byte No.	byte91	byte92	byte93	byte94	byte95	byte96			
Function	Channel 31_COR_VERT_ANG			Channel 32_COR_VERT_ANG					

Register description:

(1) The angle value is divided into positive and negative values. The vertical angle of each channel consists of 3 bytes, of which the first byte represents positive or negative of the value, and the second and third bytes represents the value of the angle, which is stored in big-endian mode.

(2) The first byte 0x00 represents positive while 0x01 represents negative.

(3) LSB=0.01º.

(4) For example, the register for vertical angle of Channel 1 is as below: byte1=0x00, byte2=0x22 convert to decimal is 34, byte3=0XF6 convert to decimal is 246, so the vertical angle of Channel 1 is：

$$(34*256+ 246) *0.01º = 89.50º$$

B.15 Corrected Horizontal Angle(COR_HOR_ANG)

COR_HOR_ANG (48 bytes in total)									
Byte No.	byte1	byte2	byte3	byte4	byte5	byte6	byte7	byte8	byte9
Function	Channel 1_COR_HOR_ANG			Channel 2_COR_HOR_ANG			Channel 3_COR_HOR_ANG		
Byte No.	byte10	byte11	byte12	byte13	byte14	byte15	byte16	byte17	byte18
Function	Channel 4_COR_HOR_ANG			Channel 5_COR_HOR_ANG			Channel 6_COR_HOR_ANG		
Byte No.	byte19	byte20	byte21	byte22	byte23	byte24	byte25	byte26	byte27
Function	Channel 7_COR_HOR_ANG			Channel 8_COR_HOR_ANG			Channel 9_COR_HOR_ANG		
Byte No.	byte28	byte29	byte30	byte31	byte32	byte33	byte34	byte35	byte36
Function	Channel 10_COR_HOR_ANG			Channel 11_COR_HOR_ANG			Channel 12_COR_HOR_ANG		
Byte No.	byte37	byte38	byte39	byte40	byte41	byte42	byte43	byte44	byte45
Function	Channel 13_COR_HOR_ANG			Channel 14_COR_HOR_ANG			Channel 15_COR_HOR_ANG		
Byte No.	byte46	byte47	byte48	byte49	byte50	byte51	byte52	byte53	byte54
Function	Channel 16_COR_HOR_ANG			Channel 17_COR_HOR_ANG			Channel 18_COR_HOR_ANG		
Byte No.	byte55	byte56	byte57	byte58	byte59	byte60	byte61	byte62	byte63
Function	Channel 19_COR_HOR_ANG			Channel 20_COR_HOR_ANG			Channel 21_COR_HOR_ANG		
Byte No.	byte64	byte65	byte66	byte67	byte68	byte69	byte70	byte71	byte72
Function	Channel 22_COR_HOR_ANG			Channel 23_COR_HOR_ANG			Channel 24_COR_HOR_ANG		
Byte No.	byte73	byte74	byte75	byte76	byte77	byte78	byte79	byte80	byte81
Function	Channel 25_COR_HOR_ANG			Channel 26_COR_HOR_ANG			Channel 27_COR_HOR_ANG		
Byte No.	byte82	byte83	byte84	byte85	byte86	byte87	byte88	byte89	byte90
Function	Channel 28_COR_HOR_ANG			Channel 29_COR_HOR_ANG			Channel 30_COR_HOR_ANG		

Byte No.	byte91	byte92	byte93	byte94	byte95	byte96			
Function	Channel 31_COR_HOR_ANG			Channel 32_COR_HOR_ANG					

Register description:

(1) The angle value is divided into positive and negative values. The horizontal angle of each channel consists of 3 bytes, of which the first byte represents positive or negative of the value, and the second and third bytes represents the value of the angle, which is stored in big-endian mode.

(2) The first byte 0x00 represents positive, while 0x01 represents negative.

(3) LSB=0.01º.

(4) For example, the register for horizontal angle of Channel 10 is as below: byte1=0x01，byte2=0x00 convert to decimal is 0, byte3=0x0A convert to decimal is 10, so the horizontal angle of Channel 10 is：

-（0*256+10）*0.01=-0.1

Appendix C RSView

This appendix gets you started with RSView. It shows you how to use the application to acquire, visualize, save, and replay sensor data. You can also use other free tools, such as Wireshark or tcp-dump. But RSView is free and relatively easy to use. The version used here is RSView3.1.12.

C.1 Software Features

RSView provides real-time visualization of 3D point cloud data from the RS-Bpearl LiDAR sensors. RSView can also review pre-recorded data stored in .pcap (Packet Capture) files, but RSView still does not support playing .pcapng files.

RSView displays distance measurements from the RS-Bpearl LiDAR sensor as point data. It supports custom-colored display of variables such as intensity-of-return, time, distance, azimuth, and laser ID. The data can be exported in CSV format.

Functionality and features of RSView include:

- Visualize live streaming sensor data over Ethernet
- Record live sensor data to pcap files
- Visualize sensor data from a recorded pcap file
- Different types of visualization modes, such as distance, time, azimuth, etc.
- Display point data in a spreadsheet
- Export point cloud data in CSV format
- Distance measurement tool
- Display multiple frames of data simultaneously (Trailing Frames)
- Display or hide subsets of lasers
- Crop views

C.2 Install RSView

Installer for RSView is provided for Windows 64-bit system and there is no need for other dependencies. You can download the latest installer from RoboSense website (https://www.robosense.ai/resources). The downloaded compressed file is an installation-free version, and you can start using it directly by decompressing it. Make sure the decompressing path only contains English characters.

C.3 Set Up Network

As mentioned in Section 3, the LiDAR has a factory default IP address to be sent to computer. Therefore, by default, the static IP address of the computer needs to be set to 192.168.1.102, and the subnet mask needs to be set to 255.255.255.0. In addition, you need to make sure that the RSView is not blocked by firewalls or third-party security software.

C.4 Visualize Streaming Sensor Data

1. Connect RS-Helios to power and connect to computer by network cable.
2. Right Click to start the RSView application with **Run As Administrator.**
3. Click on **File > Open** and select **Sensor Stream** (Figure C-1).

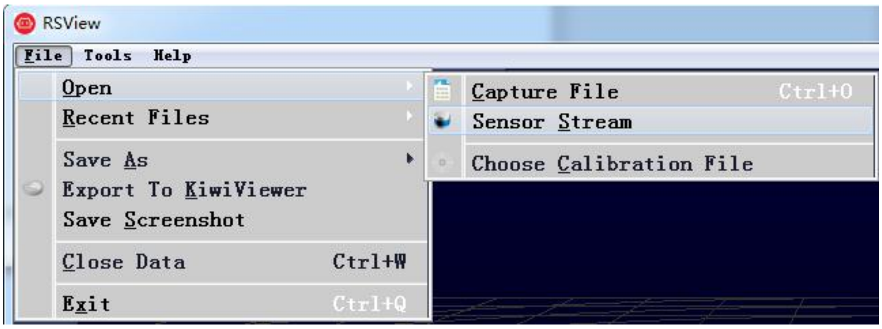


Figure C-1 RSView Open Sensor Stream

4. The Sensor Configuration dialog will appear. In “Type of Lidar”, chose RSBpearl. In “Intensity”, chose Mode3. Then click **OK**, as shown in Figure C-2:

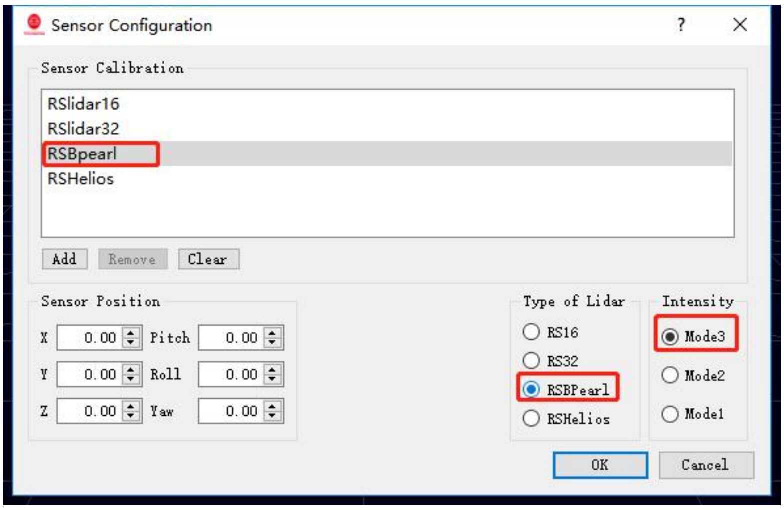


Figure C-2 Select RS-Bpearl Parameter Configuration File

5. Click the **Tool** to select **Sensor Network Configuration** to set the MSOP port number and DIFOP port number corresponding to the RS-Bpearl.

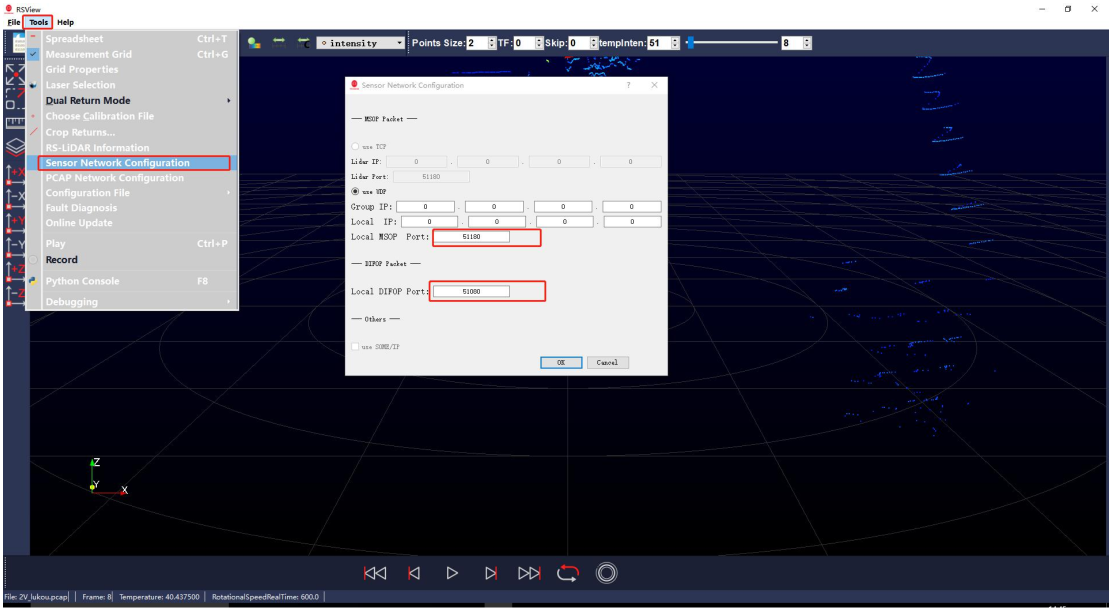


Figure C-3 MSOP and DIFOP Port Number Setting

6. RSView begins displaying the sensor data stream (Figure C-4). The stream can be paused by pressing the **Play** button, pressing again, the stream resumes.

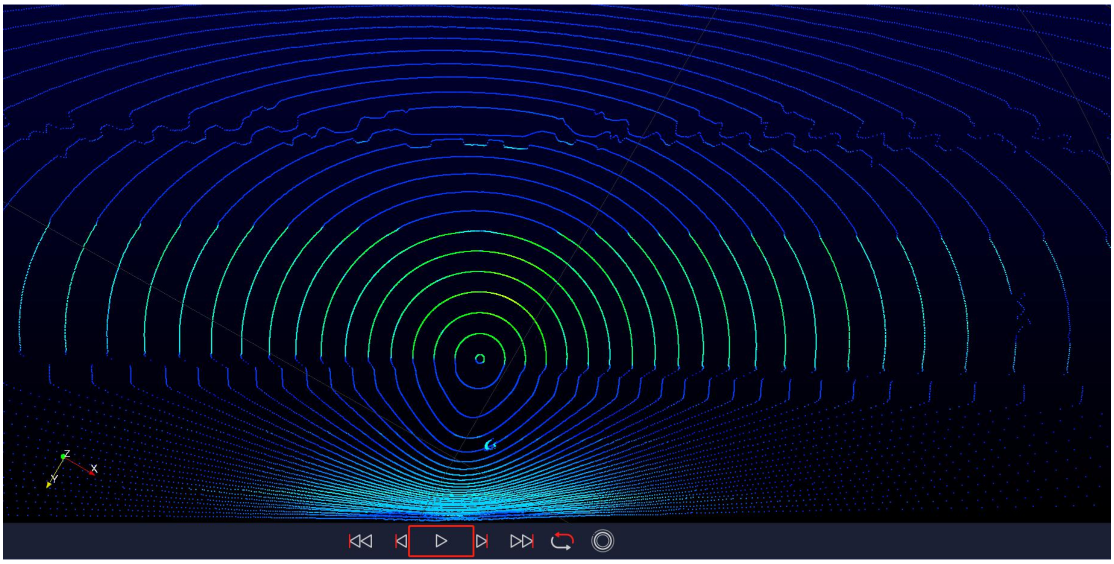


Figure C-4 Sensor Stream Data Display in RSView

C.5 Capture Streaming Sensor Data to PCAP File

1. Click the **Record** button when streaming (Figure C-5).

Figure C-5 RSView Record Button

2. In the "Choose Output File" dialog that pops up, set the save path and file name, and then click the **Save (S)** button (Figure C-6). RSView will start to write the packet file into the target pcap file. (Note: RS-Bpearl will generate huge volume of data. As the recording time becomes longer, the target pcap file will become larger. Therefore, it is better to save the recorded file to the HDD or SSD instead of a slow subsystem such as a USB drive or network drive.)

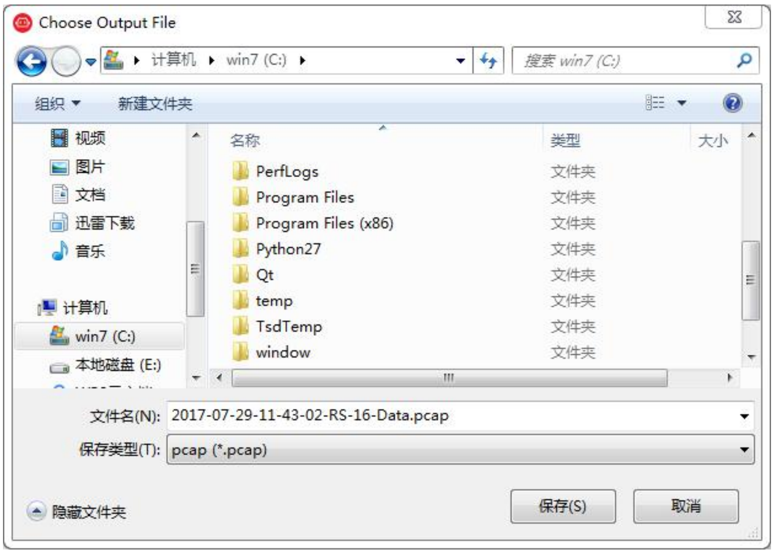


Figure C-6 RSView Record Saving Dialog

3. Click the **Record** button again to stop saving pcap data.

C.6 Replay Captured Sensor Data from PCAP File

You can use RSView to replay or check the pcap file saved by RS-Bpearl. You can press the **Play** button to play or select frames in the data that you are interested in. You can also use the mouse to select a portion of 3D point cloud which the details will then be tabulated in a spreadsheet for analysis. The saving path of the pcap file should only contain English characters.

1. Click **File** > **Open** and select **Capture File**

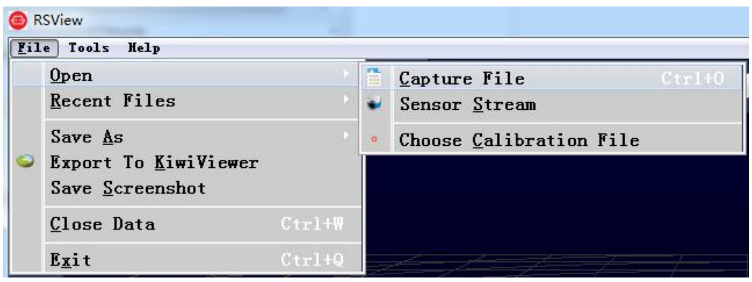


Figure C-7 Open the pcap record file

2. In the pop-up "Open File" dialog, select a recorded pcap file and click **Open (O)**.

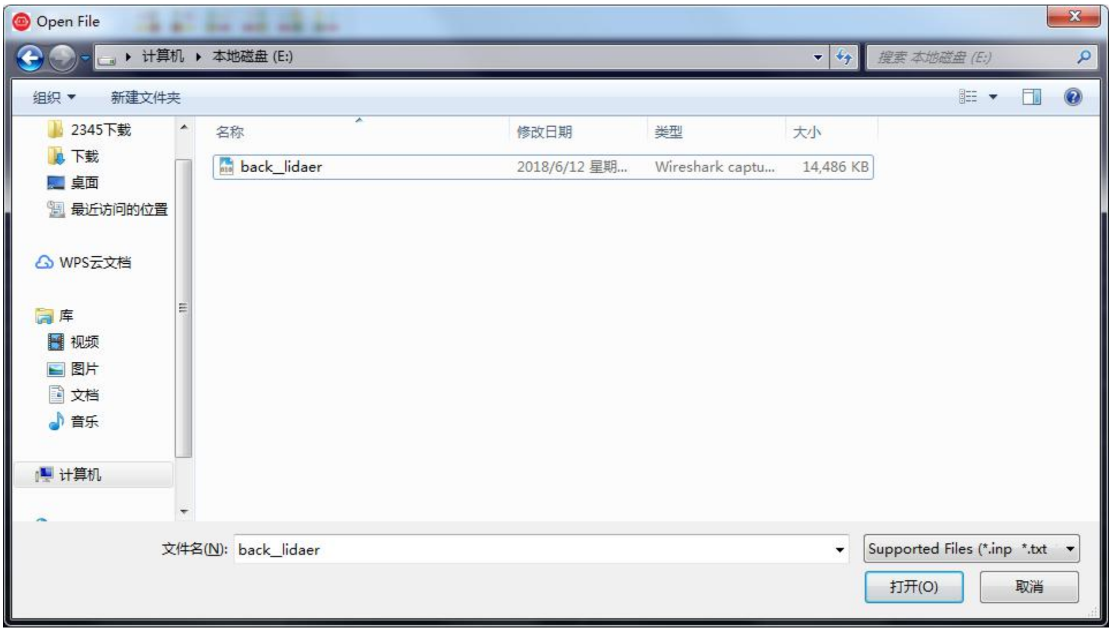


Figure C-8 Open Recorded pacp File

3. In the pop-up "Sensor Configuration" dialog, add and select the correct RS-Bpear configuration file and click the **OK** button.

4. Click the **Play** button to play or pause the data. Use the Scrub sliding tool to slide back and forth to select frames at different positions in the data. This tool and the **Record** button are in the same toolbar (Figure C-9)

Figure C-9 RSView Play Button and Scrub Tool

5. In order to get a more detailed analysis, select a frame of data that you are interested in and click the **Spreadsheet** button (Figure C-10). A sidebar data table will be displayed on the right side of the screen, which contains details of all the data of this frame

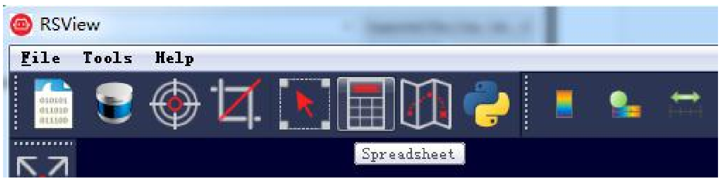


Figure C-10 RSView Spreadsheet Tool

6. You can adjust the width of each column of the table, or sort to get a better view.

	Point ID	Points	adjustedtime	azimuth	distance_m	intensity	laser_id	timestamp
0	739	1.776…	998301570.000	993	10.380	5	11	998301570
1	752	1.814…	998301620.000	1011	10.415	6	11	998301620
2	753	1.820…	998301623.000	1012	10.390	25	12	998301623
3	754	1.829…	998301626.000	1013	10.390	13	13	998301626
4	766	1.846…	998301670.000	1029	10.415	6	11	998301670
5	767	1.861…	998301673.000	1030	10.440	25	12	998301673
6	768	1.861…	998301676.000	1031	10.390	13	13	998301676
7	769	1.871…	998301679.000	1032	10.410	33	14	998301679
8	780	1.877…	998301720.000	1047	10.410	6	11	998301720
9	781	1.893…	998301723.000	1048	10.440	25	12	998301723
10	782	1.896…	998301726.000	1049	10.405	13	13	998301726
11	783	1.906…	998301729.000	1050	10.425	40	14	998301729

Figure C-11 RSView Spreadsheet Display

7. Click **Show only selected elements** in Spreadsheet to get the data corresponding to the selected points (Figure C-12). If you didn't select any elements, there will be no contents in the Spresdsheet.

	Point ID	Points	adjustedtime	azimuth	distance_m	intensi	Show only selected elements.	stamp
0	739	1.776…	998301570.000	993	10.380	5	11	998301570
1	752	1.814…	998301620.000	1011	10.415	6	11	998301620

Figure C-12 RSView show only elements Tool

8. Click the **Select All Points** tool, which turns your mouse into a data point selection tool (Figure C-13).

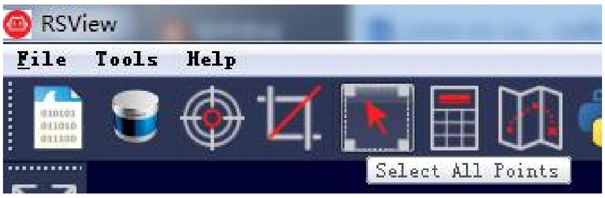


Figure C-13 RSView Select All Points Tool

9. In the 3D rendered data pane, use your mouse to draw a rectangle to frame some data points. The data of these points will immediately populate the Spreadsheet and the selected data points will turn pink in the data pane (Figure C-14).

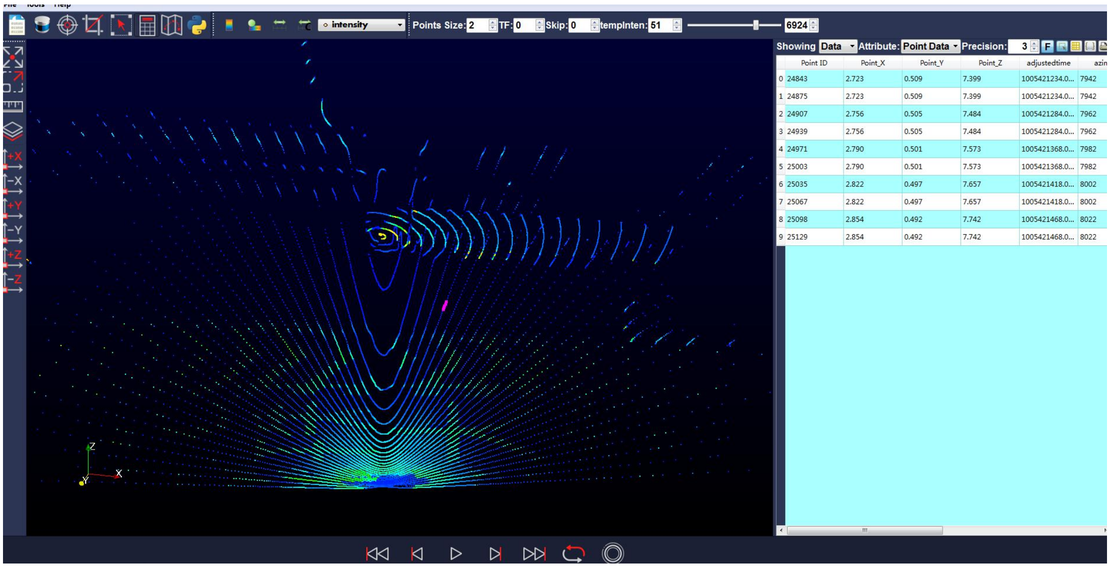


Figure C-14 RSView List Selected Points

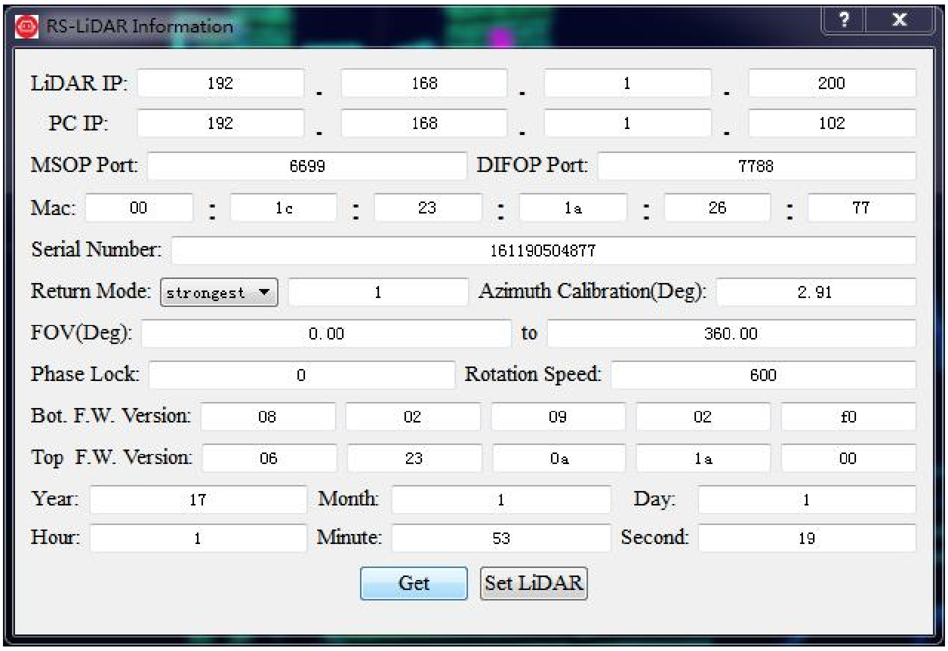
10. Any selected points can be saved via **Spreadsheet>Show only selected elements>Output CSV data.**

C.7 Configure LiDAR Parameters with RSView

Only the RS-Bpearl_2.0 LiDAR sensors can be configured by RSView, for the RS-Beparl_3.0, the sensor configuration is done through the Web Interface (Please refer to Appendix A for details).

RSView provides a tool integrated with the UCWP protocol that can be used to configure the motor speed, Ethernet, time synchronization, output angles and echo mode set by the factory firmware.

When configuring the parameters of the RS-Bpearl factory firmware, it is necessary to first ensure that the RS-Bpearl device has been normally connected and can display data in real time. Click **Tools > RS-LiDAR Information**, and the configuration window will pop up. Click the **Get** button in the window to display the parameters set by the current firmware of the RS-Bpearl.



FigureC-15 RS-LiDAR Information

We can modify the parameters we want to set in the window (the red boxes are just examples), and then click **Set LiDAR**. After a prompt indicating "modification successful" appears, check the RS-LiDAR Information by clicking the **Get** button again to verify whether the parameters have been modified successfully.

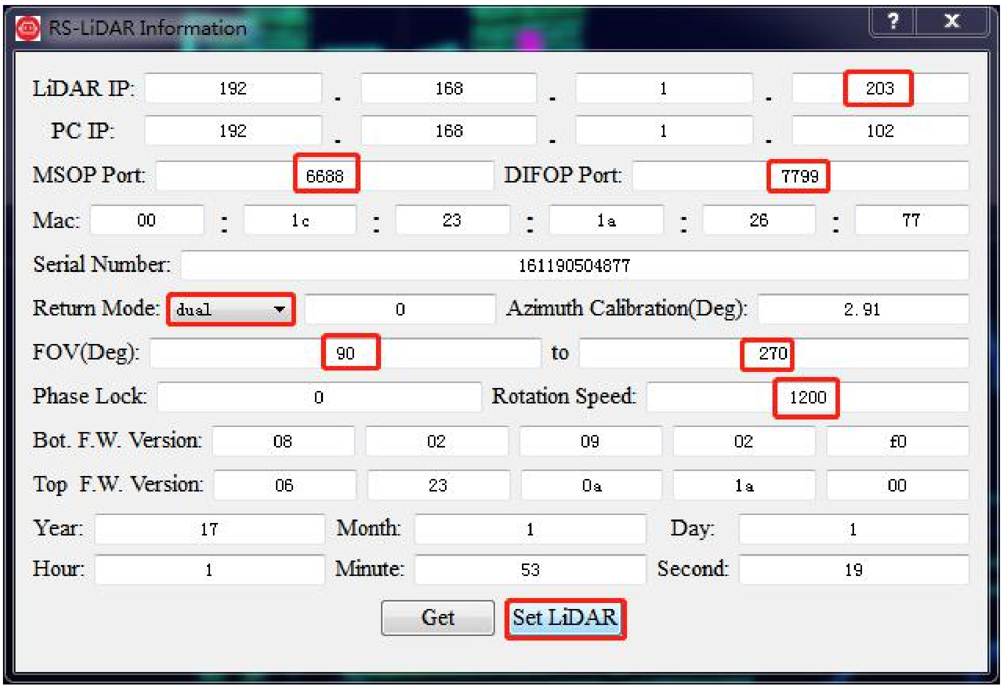


Figure C-16 Set LiDAR information

Note:

1. Before configuring the LiDAR paramenters at the RS-LiDAR Information screen, you must first

click the **Get** button.

2. During the parameter setting process, make sure not to power off the LiDAR, otherwise the modified parameters may not be saved successfully.

3. If the MSOP Port or DIFOP Port parameters set by the RS-Bpearl factory firmware are modified, you need to configure the RSView Data Port according to Section C4.5 when reconnecting the LiDAR.

C.8 Online Firmware Update with RSView

Firmware Update through RSView is only available for the RS-Bpearl_2.0 LiDAR sensors, the RS-Bpearl_3.0 LiDAR sensors depends on the Web Interface for the update of sensor firmware.

To update LiDAR firmware through RSView, it is necessary to first ensure that the RS-Bpearl LiDAR sensor has been normally connected, and can display the point cloud and obtain the factory firmware information as shown in figure C.17.

Click **Tools > Online Update**, as shown in Figure C-17, you can select the top board update and the bottom board Update.

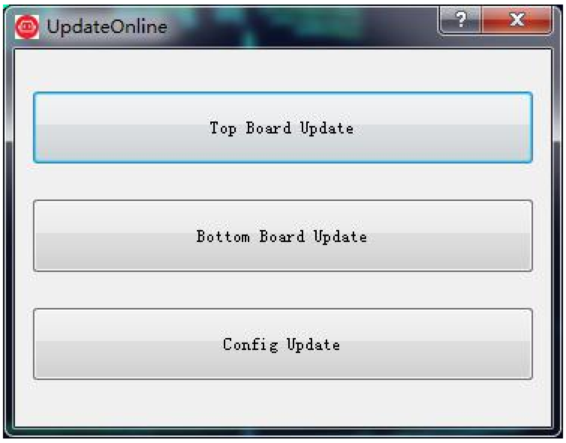


Figure C-17 Online Firmware Update with RSView

For example, after clicking Bottom Board Update, select the .rpd firmware file required for the update in the pop-up window, and then click **Open** to start the update process, which will last for some time. After the update is completed, a reminder of "Online Update Successful" will be displayed.

Note: Config Updata is not available for the moment.

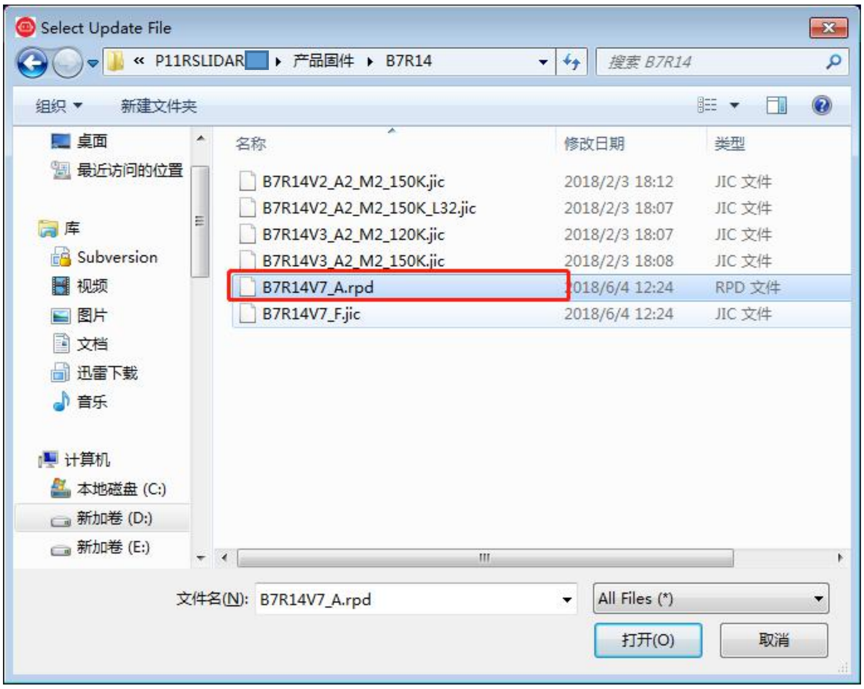


Figure C-18 Select the Firmware File for the Update

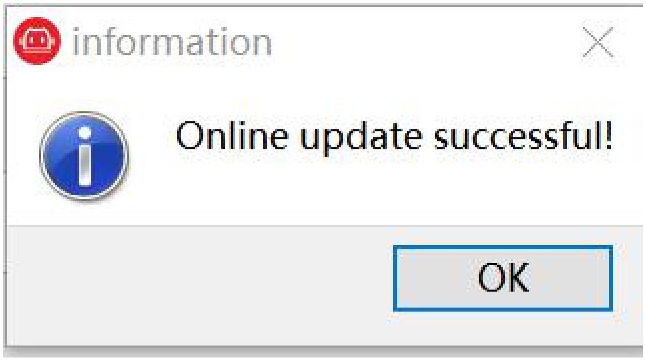


Figure C-19 Online update successful reminder

C.10 Fault Diagnosis with RSView

Fault Diagnosis with RSView is only available for the RS-Bpearl_2.0 LiDAR sensors. Fault Diagnosis for the RS-Bpearl_3.0 LiDAR sensors can only be done with the Web Interface. (Please refer to Appendix A for details.)

To perform fault diagnosis with RSView, it is necessary to first make sure that the RS-Bpearl sensor is normally connected and can display point cloud data and obtain factory firmware information as shown in C.8.

Click **Tools > Fault Diagnosis** to pop up the Fault Diagnosis window. Click the **Start** button to start monitoring the real-time status of the RS-Bpearl, including current, voltage, temperature, data error rate and other information.

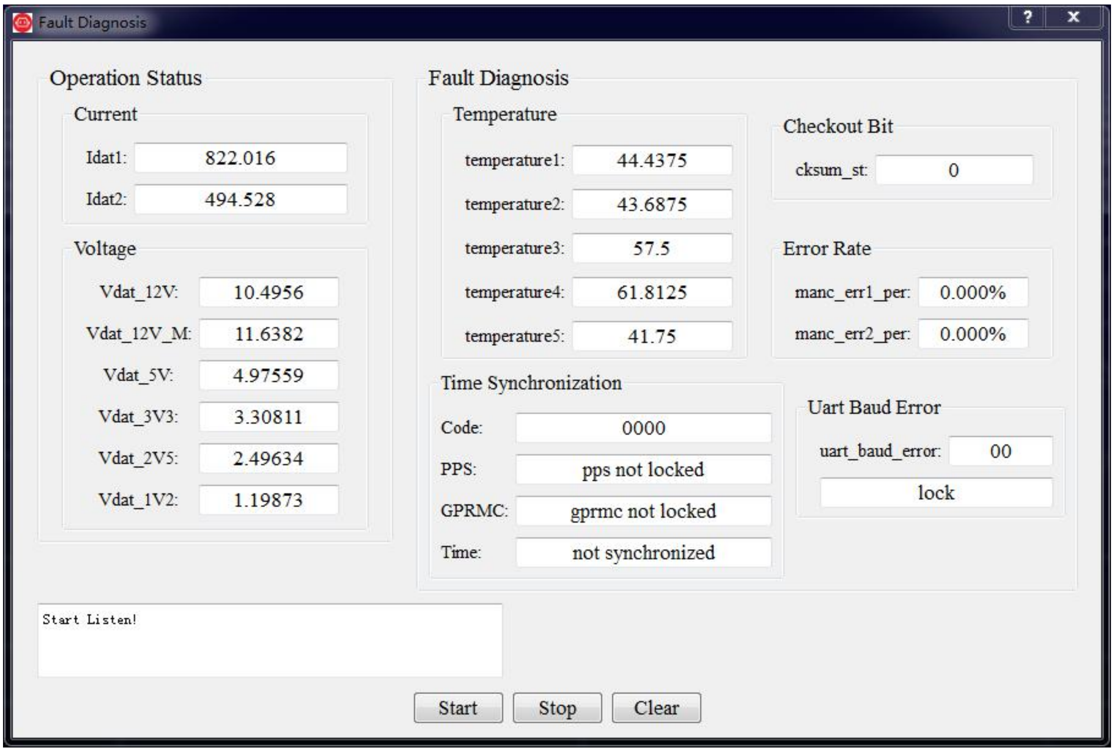


Figure C-20 Fault Diagnosis

Appendix D RS-Bpearl ROS&ROS2 Package

This appendix explains how to use Ubuntu+ROS or Ubuntu+ROS2 to acquire and visualize RS-Bpearl data.

D.1 Install Software

1. Download and install Ubunutu 16.04 or Ubuntu18.04 operating system. (ROS2 users are imperative to use the Ubuntu 18.04 system)

2. ROS users: Install and test the basic functions of ROS Kinetic according to the link (http://wiki.ros.org/kinetic/Installation). (For Ubuntu 18.04 users, please install ROS-melodic)

ROS2 users: Install and test the basic functions of ROS2 Eloquent according to the link (https://index.ros.org/doc/ros2/Installation/Eloquent/).

3. Download and install libpcap-dev.

D.2 Download & Compile RoboSense LiDAR Driver Package

You can get the latest LiDAR driver package from https://github.com/RoboSense-LiDAR/rslidar_sdk , or contact our technical support to get it. After downloading, please read the **README** file in the driver package carefully, which describes in detail how to compile and use the LiDAR driver package.

rslidar_sdk is our latest LiDAR driver package, which has included drivers for all RoboSense LiDAR sensors. Three compilation modes are supported:

1. Direct Compilation

The user enters the main directory of the rslidar_sdk driver package and creates a build folder to compile and run.

```
mkdir build

cd build

cmake .. && make

./rslidar_sdk_node
```

2. Compilation in ROS

Create ros working directory:

```
cd ~

mkdir -p catkin_ws/src
```

Copy the *rslidar_sdk* driver package to the ROS working directory *~/catkin_ws/src*. Open the *CMakeLists.txt* file in the *rslidar_sdk* driver package, and change the *set (COMPILE_METHOD ORIGINAL)* at the top of the file to *set (COMPILE_METHOD CATKIN)*. At the same time, rename the *package_ros1.xml* file in the driver package to *package.xml*.

Run the following command in the terminal to compile:

```
cd ~/catkin_ws
catkin_make
```

3. Compilation in ROS2

Create ros2 working directory:

```
cd ~
mkdir -p catkin_ws/src
```

Copy the *rslidar_sdk* driver package to the ROS2 working directory *~/catkin_ws/src*. Open the *CMakeLists.txt* file in the *rslidar_sdk* driver package, and change *set(COMPILE_METHOD ORIGINAL)* at the top of the file to *set(COMPILE_METHOD COLCON)*. At the same time, rename the *package_ros2.xml* file in the driver package to *package.xml*.

Run the following command in the terminal to compile:

```
cd ~/catkin_ws
colcon build
```

D.3 Configure PC IP

In the default RS-Helios firmware, configure the static IP address of the computer to "192.168.1.102", the subnet mask to "255.255.255.0". The gateway does not need to be configured.

After the configuration is completed, you can use the *ifconfig* command to check whether the static IP takes effect.

D.4 Real Time Display

There are detailed documents in the rslidar_sdk project to guide how to display the point cloud in real time in the ROS or ROS2. Here is a brief introduction, taking the ROS as an example.

1. Connect the RS-Bpearl to the computer with a network cable, power on, run, and wait for the computer to recognize the LiDAR.

2. Run the launch file provided in the rslidar_sdk driver package to start the node program that displays data in real time. The launch file is located in rslidar_sdk/launch/start.launch. Open a terminal and run:

```
cd ~/catkin_ws
source devel/setup.bash
roslaunch rslidar_sdk start.launch
```

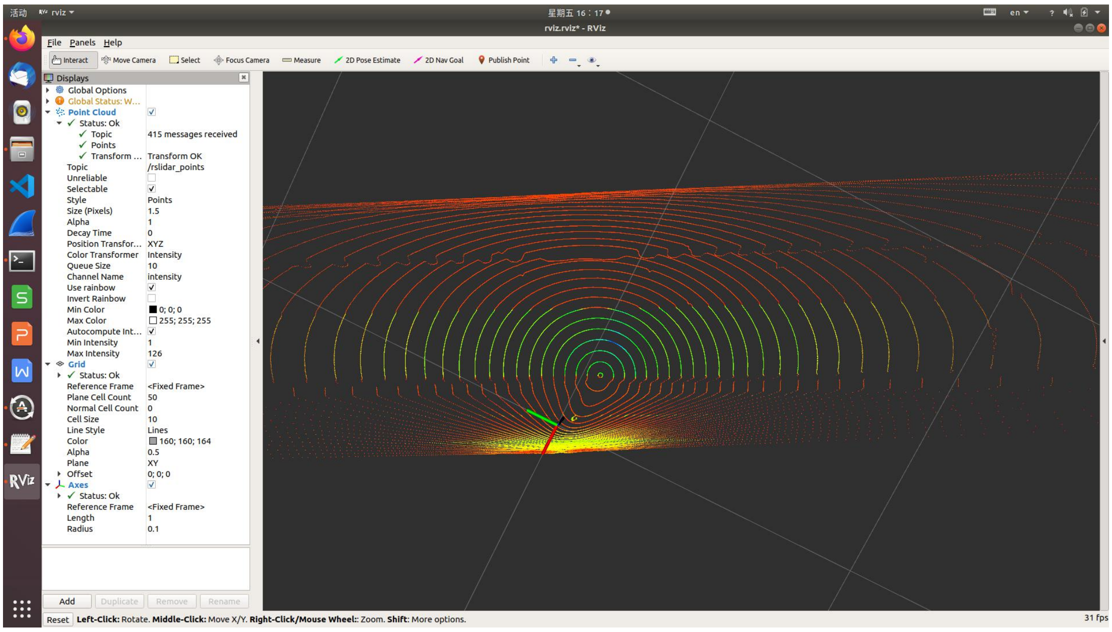


Figure D-1 rviz rviz displays RS-Bpearl point cloud data

D.5 View Offline Data

About how to parse data offline (rosbag or pcap), there is also a detailed introduction in the documentation in the rslidar_sdk driver package. Here is just a brief introduction, taking pcap as an example. You can use rslidar_sdk to parse the saved offline pcap file into point cloud data for display.

```
common:
  msg_source: 1                                    #0: not use Lidar
                                                   #1: packet message comes from online Lidar
                                                   #2: packet message comes from ROS or ROS2
                                                   #3: packet message comes from Pcap file
                                                   #4: packet message comes from Protobuf-UDP
                                                   #5: point cloud comes from Protobuf-UDP
  send_packet_ros: false                           #true: Send packets through ROS or ROS2(Used to record packet)
  send_point_cloud_ros: true                       #true: Send point cloud through ROS or ROS2
  send_packet_proto: false                         #true: Send packets through Protobuf-UDP
  send_point_cloud_proto: false                    #true: Send point cloud through Protobuf-UDP
  pcap_path: /home/robosense/lidar.pcap            #The path of pcap file

lidar:
  - driver:
      lidar_type: RS128          #LiDAR type - RS16, RS32, RSBP, RS128, RS80, RSM1, RSHELIOS
      frame_id: /rslidar         #Frame id of message
      msop_port: 6699            #Msop port of lidar
      difop_port: 7788           #Difop port of lidar
      start_angle: 0             #Start angle of point cloud
      end_angle: 360             #End angle of point cloud
      min_distance: 0.2          #Minimum distance of point cloud
      max_distance: 200          #Maximum distance of point cloud
      use_lidar_clock: false     #True--Use the lidar clock as the message timestamp
                                 #False-- Use the system clock as the timestamp
    ros:
      ros_recv_packet_topic: /rslidar_packets          #Topic used to receive lidar packets from ROS
      ros_send_packet_topic: /rslidar_packets          #Topic used to send lidar packets through ROS
      ros_send_point_cloud_topic: /rslidar_points      #Topic used to send point cloud through ROS
    proto:
      point_cloud_recv_port: 60021                     #Port number used for receiving point cloud
      point_cloud_send_port: 60021                     #Port number which the point cloud will be send to
      msop_recv_port: 60022                            #Port number used for receiving lidar msop packets
      msop_send_port: 60022                            #Port number which the msop packets will be send to
      difop_recv_port: 60023                           #Port number used for receiving lidar difop packets
      difop_send_port: 60023                           #Port number which the difop packets will be send to
      point_cloud_send_ip: 127.0.0.1                   #Ip address which the point cloud will be send to
      packet_send_ip: 127.0.0.1                        #Ip address which the lidar packets will be send to
```

Figure 15 D-2 config modifies RS-Bpearl LiDAR Information

1. Modify the parameters in rslidar_sdk/config/config.yaml

msg_source: modified to 3

pcap_path: configure to the absolute path of the pcap file: (e.g. /home/robosense/RS_Bpearl.pcap)

Make sure there is a one-to-one correspondence between MSOP and DIFOP port numbers and offline packets

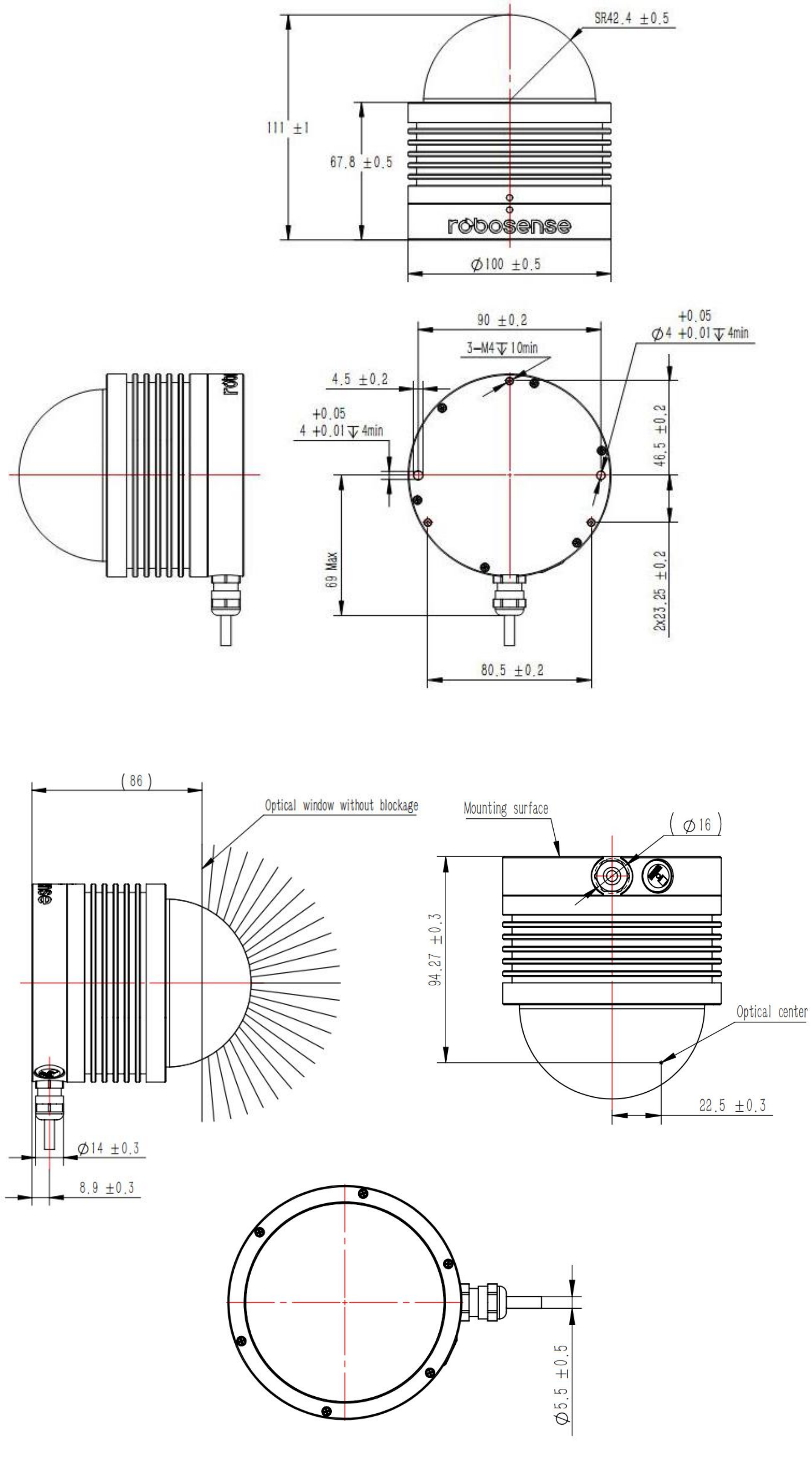
2. Open the terminal and run the node program:

```
cd ~/catkin_ws

source devel/setup.bash

roslaunch rslidar_sdk start.launch
```

Appendix E Mechanical Drawings



Appendix F Sensor Mounting

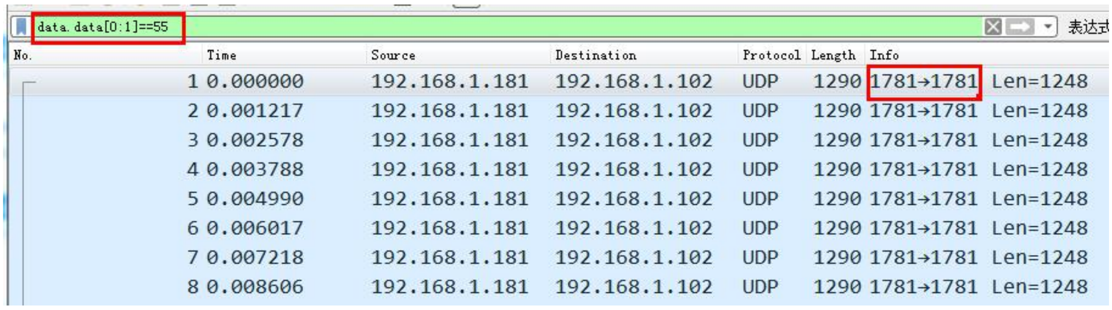
Make sure the following requirements are met when mounting the LiDAR:

1) The mounting surface of the LiDAR should be flat and uneven surfaces should be avoided.
2) The precise locator pins on the mounting base should strictly follow the dimensions of the locator holes at the bottom of the LiDAR, and the height of the locator pin should not be higher than 4mm. We recommend using aluminum alloy for the mounting base material, which facilitates heat dissipating of the LiDAR during operating.
3) If there are contact mounting surfaces on the top and bottom of the LiDAR, please ensure that the distance between the mounting surfaces is greater than the height of the LiDAR to avoid squeezing the LiDAR.
4) When connecting cables of the LiDAR, make sure not to pull the cable too tightly, and keep the cables in a slack state.

Appendix G Obtain MSOP and DIFOP Port Number from Data Packets

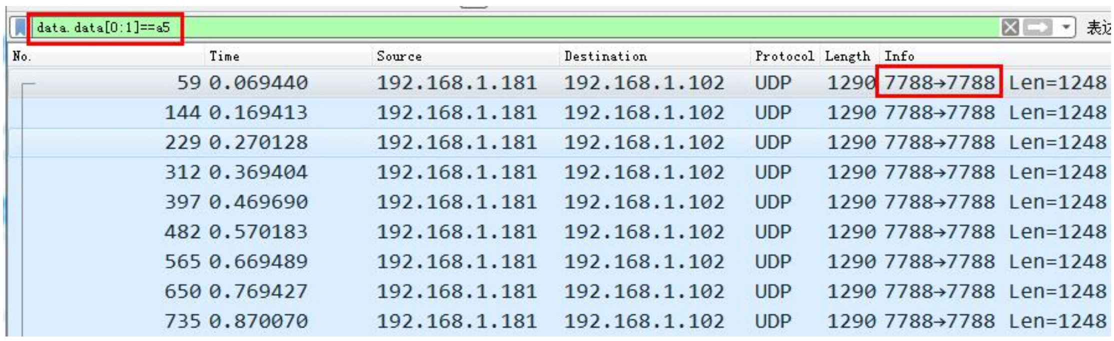
According to the description in Chapter 5, RS-Bpearl will output two types of packets, MSOP and DIFOP packets. Users can use the wireshark tool to filter the packet content to distinguish the output ports of MSOP and DIFOP packets, which can be used when setting the Data Port in RSView.

Connect the LiDAR to computer, power on LiDAR, start wireshark, select the correct network port, and start the packet capture process. Input the *data.data[0:1]==55* expression in the application display filter to filter out the MSOP packets, the MSOP port number is shown in the Info column, as shown in Figure G-1; Input the *data.data[0:1]==a5* expression, you will obtain the MSOP port number, as shown in Figure G-2.


data.data[0:1]==55

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.1.181	192.168.1.102	UDP	1290	1781→1781 Len=1248
2	0.001217	192.168.1.181	192.168.1.102	UDP	1290	1781→1781 Len=1248
3	0.002578	192.168.1.181	192.168.1.102	UDP	1290	1781→1781 Len=1248
4	0.003788	192.168.1.181	192.168.1.102	UDP	1290	1781→1781 Len=1248
5	0.004990	192.168.1.181	192.168.1.102	UDP	1290	1781→1781 Len=1248
6	0.006017	192.168.1.181	192.168.1.102	UDP	1290	1781→1781 Len=1248
7	0.007218	192.168.1.181	192.168.1.102	UDP	1290	1781→1781 Len=1248
8	0.008606	192.168.1.181	192.168.1.102	UDP	1290	1781→1781 Len=1248

Figure G-1 use wireshark to filter out the MSOP port number


data.data[0:1]==a5

No.	Time	Source	Destination	Protocol	Length	Info
59	0.069440	192.168.1.181	192.168.1.102	UDP	1290	7788→7788 Len=1248
144	0.169413	192.168.1.181	192.168.1.102	UDP	1290	7788→7788 Len=1248
229	0.270128	192.168.1.181	192.168.1.102	UDP	1290	7788→7788 Len=1248
312	0.369404	192.168.1.181	192.168.1.102	UDP	1290	7788→7788 Len=1248
397	0.469690	192.168.1.181	192.168.1.102	UDP	1290	7788→7788 Len=1248
482	0.570183	192.168.1.181	192.168.1.102	UDP	1290	7788→7788 Len=1248
565	0.669489	192.168.1.181	192.168.1.102	UDP	1290	7788→7788 Len=1248
650	0.769427	192.168.1.181	192.168.1.102	UDP	1290	7788→7788 Len=1248
735	0.870070	192.168.1.181	192.168.1.102	UDP	1290	7788→7788 Len=1248

Figure G-2 Use wireshark to filter out DIFOP port number

Appemdix H Sensor Cleaning

H.1 Attention

Please read the contents of this appendix H carefully and completely before cleaning your RS-Bpearl LiDAR, otherwise improper operation may damage the LiDAR. When the LiDAR is used in a harsh environment, it is necessary to clean up the dirt on the surface in time to keep the LiDAR clean, otherwise it will affect the normal use of the LiDAR

H.2 Required Materials

1. Clean fiber cloth
2. Spray with neutral warm soap
3. Spray with clean water
4. Isopropanol solvent
5. Clean gloves

H.3 Cleaning Method

If there is only some dust adhered to the surface of the sensor, you can directly dip a small amount of isopropanol solution with a clean fiber cloth, and then gently wipe the LiDAR surface to clean, and then wipe it dry with a clean fiber cloth.

If the surface of the LiDAR is caked with mud or dirt, first spray clean water on the surface of the dirty part to remove the mud or the dirt (Note: Do not try to wipe off the mud directly with a fiber cloth, as this may scratch the surface, especially the optical ring lens.). Secondly, spray warm soapy water on the dirty parts (The lubricating effect of soapy water can accelerate the detachment of the dirt). Gently wipe the surface of the sensor with the fiber cloth again, be careful not to scratch the surface. Finally, clean the soap residue on the surface with clean water (If there are still residues on the surface, use an isopropyl alcohol solution to clean it again), and wipe it dry with a clean microfiber cloth.

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