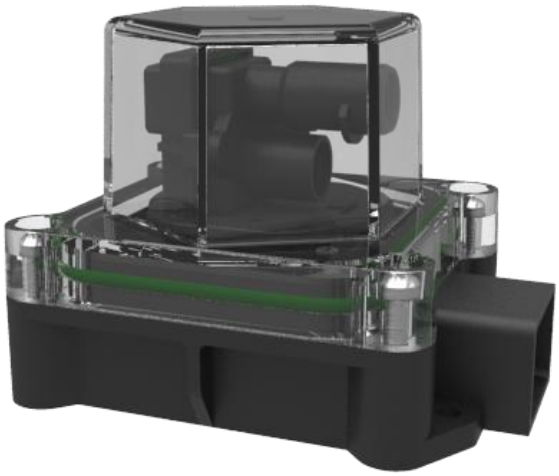
Benewake

VLS-H5 User Manual



Preface

This user manual contains the introduction, use and maintenance of VLS-H5 LiDAR. Please read this manual carefully before formal use, and strictly follow the steps described in the manual during use to avoid product damage, property loss, personal injury or/and violation of product warranty terms.

If you encounter problems that cannot be solved during use, please contact Benewake staff for assistance.

Contact Details

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Disclaimer

The VLS-H5 product is constantly being improved, and its specifications and parameters will undergo iterative changes. Please refer to the official website for latest version.

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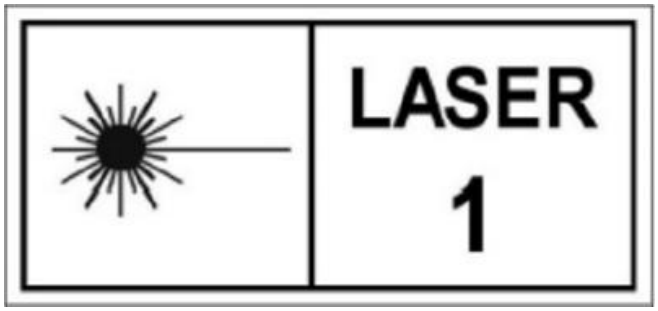
1 Laser Safety Information



This LiDAR uses visible red laser spot.
Class 1 according to IEC 60825-1:2014, EN 60825-1:2014+A11:2021.

CAUTION!
Use of controls, adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

2 Installation and Maintenance

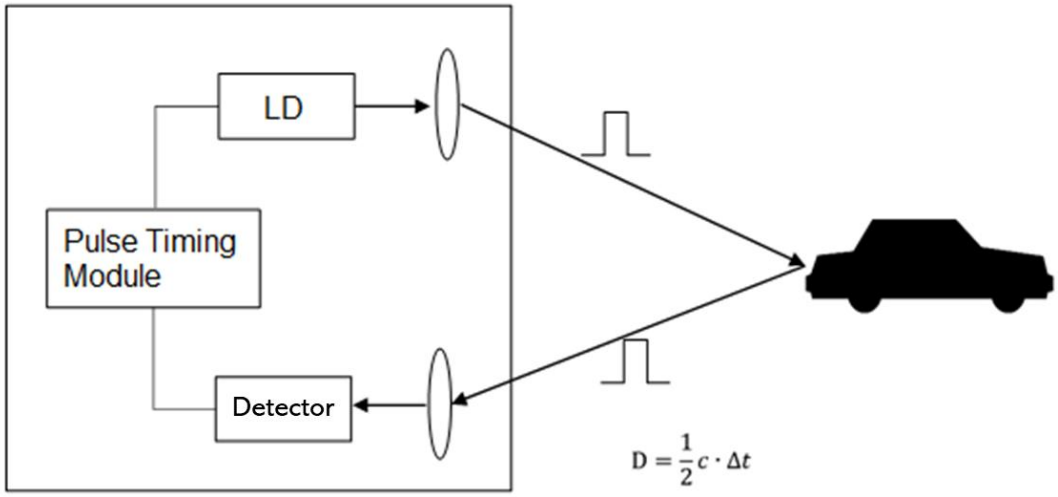
CAUTION!
This laser product is classified as Class 1 during operational procedures. When the ranging feature is activated, the laser emitter of the LiDAR module may emit laser radiation, therefore, the LiDAR should NOT be aimed at humans and animals to ensure safety.

This product is designed and calibrated for installation with exposed lenses. If a protective window needs to be added in front of the lens, it is necessary to ensure the use of materials with high transmission and anti-reflective coating.
Avoid the presence of smoke and fog in the detection field.
Avoid condensation.
Avoid direct exposure to moisture and water.
Do not use rough fabric or dirty towels or aggressive products to clean the laser lenses.
Do not use a supply voltage higher than the maximum required in the specifications to power the product.
Clean the laser lenses with compressed air. When needed, wipe the laser lenses only with a soft, clean microfiber cloth.
Make sure the sensor is securely mounted to prevent false readings or damage.
Only trained and qualified personnel may install, setup and repair the LiDAR.

3 Product Overview

3.1 Measuring principle

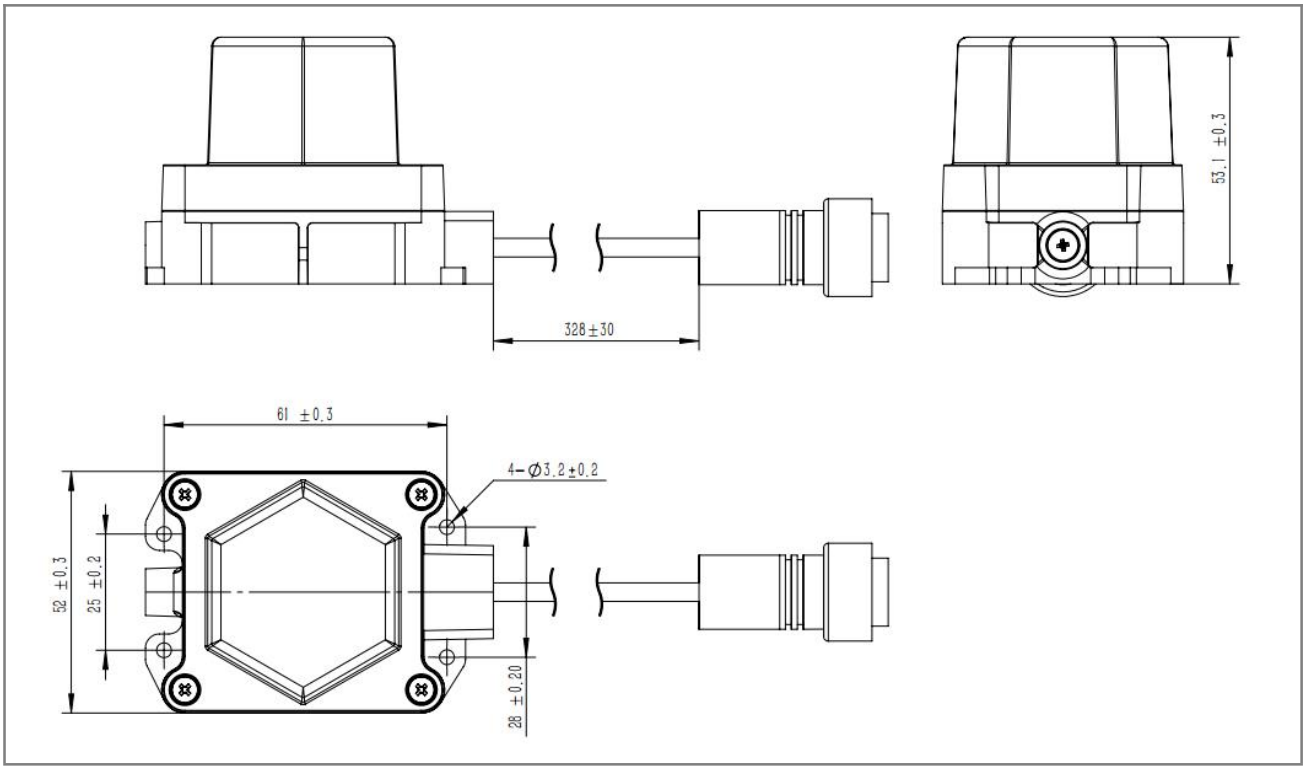
VLS-H5 is a typical Pulse Time of Flight (PToF) sensor. VLS-H5 emits a narrow pulse laser, which is collimated by the transmitting lens, which enters the receiving system after being reflected by the measured target and is focused on the detector by the receiving lens. The time between the transmitted signal and the received signal is calculated through the circuit amplification and filtering, and the distance between VLS-H5 and the measured target can be calculated through the speed of light.



Pulsed time of flight

3.2 Technical Specifications

Performance Parameters	
Model	VLS-H5
Detection range①	5 m @ (30% reflectivity, 0 KLux,< 0.5NTU)
Blind zone	≤ 0.1 m
Accuracy①	< 3 cm @ (0.1 ~ 2m, 10% reflectivity, 0 KLux,< 0.5NTU)
Repeatability accuracy①	< 2 cm @ (1 σ , 0.1 ~ 2m, 10% reflectivity, 0 KLux,< 0.5NTU)
Range resolution	1 mm
Scan angle	360° (including intentionally removed angles at edges)
Angular resolution	≤ 1°
Scanning frame rate	6 Hz
Ambient light resistance	100 KLux
Optical Parameters	
Light source	Red Laser
Eye safety	Class1 (IEC 60825-1:2014; EN 60825-1:2014+A11:2021)
Mechanical and Electrical Parameters	
Average power consumption②	< 450 mA @ 5.4 V
Peak current②	< 750 mA
Power supply	DC 5.4 V ± 5%
Operating temperature	0 ℃ ~ + 50 ℃
Storage temperature	- 20 ℃ ~ + 70 ℃
Protection level	IPX8， underwater 4m
Cable length③	350± 20 mm
Connector	Aviation plug socket M14-4P female head punch pin gold plated 1.0 PA66 black
Typ. Dimensions③	52.0 mm × 75.0 mm × 53.1 mm (cable excluded)
Communication Protocol	
Communication Interface	UART
Serial port output	3.3 V TTL
Baud rate	230400
Dimensions (Unit: mm)	

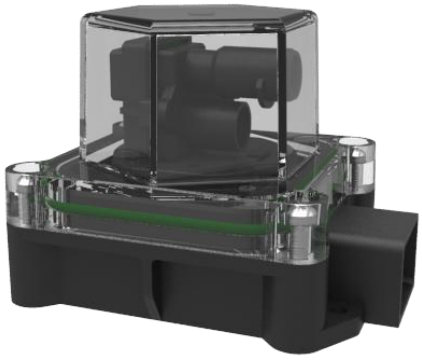


Notes:

1. Measured when all the light spots fall on the target object;
2. Measured at 0 KLux and 25 ℃ indoors, for reference only. Parameters may change when the environment changes;
3. The size is typical values for reference only.

3.3 Structural Appearance

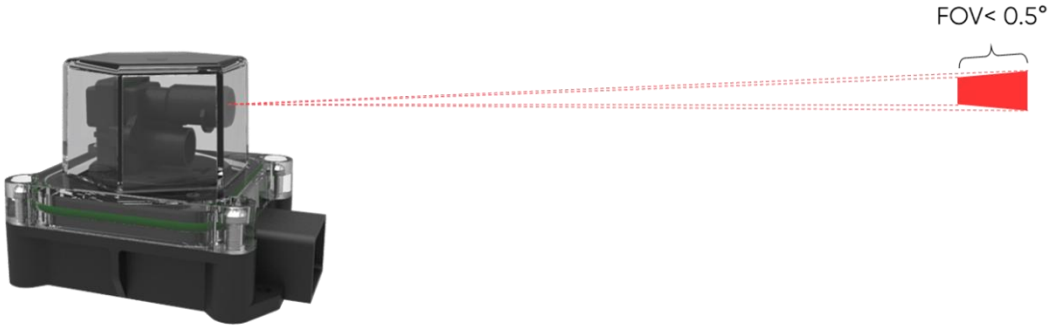
The overall appearance of the LiDAR is as shown in the figure below:



VLS-H5 Appearance

3.4 FoV

The field of view of VLS-H5 is shown in the following figure, with a rectangular spot shape and a divergence angle of less than 0.5 ° in any direction.



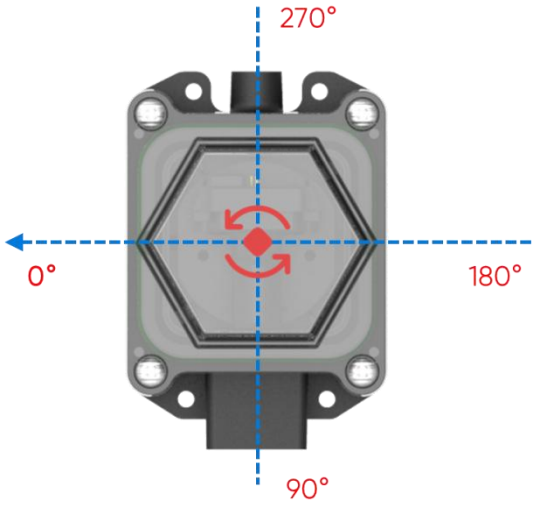
FoV of VLS-H5

NOTICE

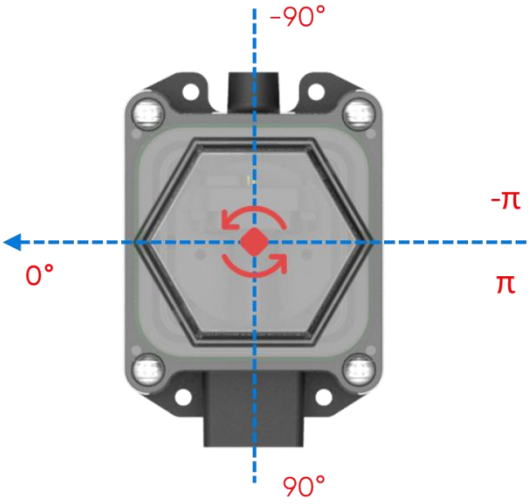
0.5° is theoretic values. Because the manufacturing error and the installing error exist, there is divergence between actual and theoretic values.

3.5 Coordinate system definition

The X-axis (i.e. 0 angle position) of the coordinate system is defined in left front of the sensor, and the origin of the coordinate system is the rotation center of the distance measuring unit. The rotation angle increases counterclockwise, as shown in the following figure:



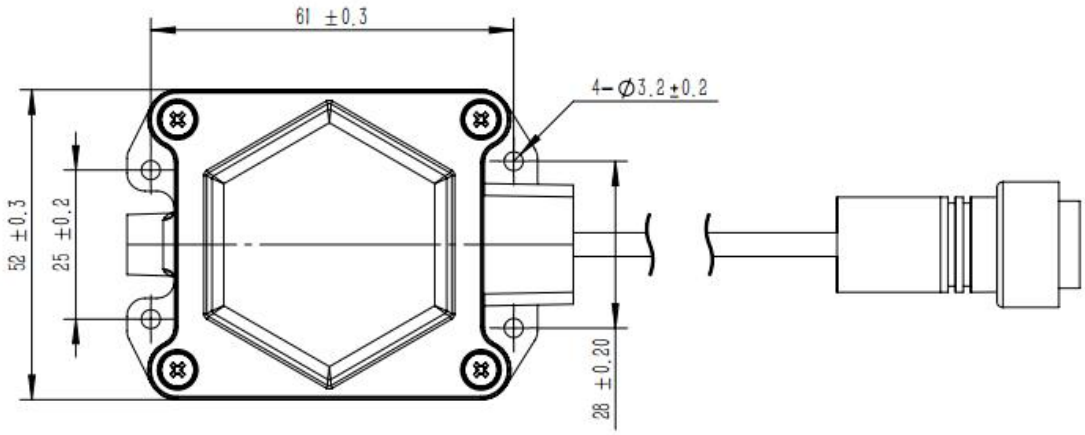
Following the right-hand rule within ROS, the angle range is (- π , π), with "angle_min" being the starting angle and "angle_max" being the ending angle.



4 Device Installation

4.1 Mechanical installation

As shown in the following figure. VLS-H5 has 2 installation positioning holes available for use.



4.2 Connector

Socket: M14-4P Female, Stamped Gold Plated Pins, PA66 Black

LiDAR connector appearance

Interface connector pin definitions

28AWG White	PIN 1	TX
28AWG Green	PIN 2	RX
26AWG Black	PIN 3	GND
26AWG Red	PIN 4	VCC

5 Communication Protocol and data format

5.1 Serial Communication

To connect two devices for TTL communication, the TXD of the transmitter should be connected to the RXD of the receiver, and the TXD of the receiver should be connected to the RXD of the transmitter.

The LiDAR include a power switch. When power is supplied to the LiDAR, data will begin to be transmitted after sending command "*A5 5A 01 00 00*".

Characteristics of UART Interface

Character	Value	Configurability
Baud rate	230400	Non-configurable
Data bit	8	Non-configurable
Stop bit	1	Non-configurable
Parity	None	Non-configurable

5.2 Serial port output format

The data protocols of the VLS-H5 are transmitted in hexadecimal little-endian mode. Byte data is composed of the least significant bit (LSB) first and the most significant bit (MSB) later. All data types are unsigned integers. The specific data protocol is described below.

When the LiDAR is scanning and rotating, it will continuously output measured point cloud data without interacting with the upper computer. The data includes distance, angle, target reflection intensity, rotation speed information, timestamp, etc. The format of each frame of point cloud data is as follows:

Start Char	Data Length	Motor speed		Start Angle		Data	End Angle		Timestamp		CRC check
54H	1 Byte	LSB	MSB	LSB	MSB	.....	LSB	MSB	LSB	MSB	1 Byte

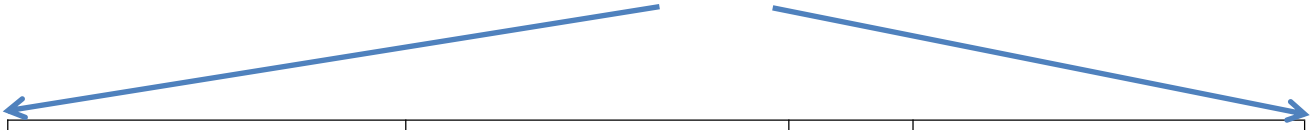
Offset (Byte)	Length (Byte)	Field	Description
0	1	Start Char	Fixed value is 0x54, indicating the start position of the data frame identifier.
1	1	Data Length	Length 1 Byte. High 3 bits reserved. Low 5 bits indicate the number of measurement points L in one frame of point cloud data. Currently fixed at 12, which is 0x2C.
2	2	LiDAR Speed	Current rotation speed, unit is degrees per second.
4	2	Start Angle	Point cloud starting angle, unit is 0.01 degrees.
6	3*L	Data	Point cloud data. The measurement data length for each point cloud is 3 bytes.
6+3*L	2	End Angle	Point cloud ending angle, unit is 0.01 degrees.
8+3*L	2	Timestamp	0～29999 ms, resets to 0 after reaching 29999. The timestamp corresponds to the first point of each frame of data.
10+3*L	1	Checksum	CRC check of all previous data to verify data accuracy.

```
Function Name  : CRC Calculation Method
uint8_t CalCRC8(uint8_t *p, uint8_t len)
{
 uint8_t crc = 0;
 uint16_t i;
 for (i = 0; i < len; i++)
 {
 crc = CrcTable[(crc ^ *p++) & 0xff];
 }
 return crc;
}
```

Point Cloud Data Parsing

The point cloud data information already contains the distance and intensity information for the 1st to the L-th points measured from the start angle. Currently, L is fixed at 12. Each point's information is represented by 3 bytes, consisting of a 2-byte distance value and a 1-byte confidence value. The data format and detailed parsing of point information are as follows:

Start Char	Data Length	Motor Speed		Start Angle		Data	End Angle		Timestamp		CRC Check
54H	2CH	LSB	MSB	LSB	MSB	.....	LSB	MSB	LSB	MSB	1 Byte



Measurement Point 1			Measurement Point 2			...	Measurement Point L		
Distance Value		Signal Strength	Distance Value		Signal Strength	...	Distance Value		Signal Strength
LSB	MSB	1 Byte	LSB	MSB	1 Byte	...	LSB	MSB	1 Byte

To calculate the data information for the L-th point, the point data format is as shown in the following table:

Offset(Byte)	Length(Byte)	Field	Description
6+3*(L-1)	2	Distance	Unit is mm
8+3*(L-1)	1	Intensity	Range is 0~255

Intensity represents the laser pulse echo strength. A larger value indicates higher ranging confidence, and a smaller value indicates lower confidence.

The angle value for each point in the point cloud information can be obtained by linear interpolation between the start angle and the end angle. For example, the calculation method for the angle value of each point for all L point cloud data points is as follows:

L is the number of measurement points per data packet; i ranges from (0, L);

L=12;

Angle difference = (End angle value - Start angle value) / (L-1) ;

for(int i=0; i<L; i++){

*Angle value for each point = Start angle value + Angle difference * i;*

}

Data Reference Example

If a frame of data is received as shown below:

54 2C 19 0E E9 35 0E 01 39 12 01 45 13 01 46 14 01 56 11 01 51 0E 01 55 0A 01 5A 0E 01 58 15 01 46 1C 01 3E 20 01 4F 24 01 53 CE 38 A6 61 C4

The data parsing is as follows:

Start Char	Data Length	Motor Speed		Start Angle		Data	End Angle		Timestamp		CRC Check
54H	2CH	19H	0EH	E9H	35H	.....	CEH	38H	A6H	61H	C4H

Measurement Point 1			Measurement Point 2			...	Measurement Point 12		
Distance Value		Signal Strength	Distance Value		Signal Strength	...	Distance Value		Signal Strength
0EH	01H	39H	12H	01H	45H	...	24H	01H	53H

Field Description	Parsing Explanation
LiDAR Speed	0E19H = 3609 degrees/s
Start Angle	35E9H = 13801, because it has been multiplied by 100, so it is 138.01 degrees
End Angle	38CEH = 14542, because it has been multiplied by 100, so it is 145.42 degrees
Measurement Point 1 Distance	010EH = 270 mm
Measurement Point 1 Signal Strength	39H = 57
Measurement Point 2 Distance	0112H = 274 mm
Measurement Point 2 Signal Strength	45H = 69
.....	.....
Measurement Point 12 Distance	0124H = 292 mm
Measurement Point 12 Signal Strength	53H = 83

5.3 Serial communication commands

All parameters will not be saved after successful configuration, and must be reconfigured when powering on again.：

1. Turn on laser, turn on the motor rotation

Request: A5 5A 01 00 00

Reply: 4F 4B

2. Reset the Lidar, turn off the laser, and stop the motor rotation

Request: A5 5A 03 00 02

Reply: 4F 4B

5.4 ROS Driver

```
# benewake_lds_ros

## Description
Get data from benewake LDS module and pubilsh laserscan
## Rquirements
#### 1. ROS Melodic or higher
## Installation
#### 1.  Compile
```
catkin_make
```
#### 2.  In file *launch/benewake_lds.launch*, set parameters:
  Parameters | Description
  -- | --
  serial_port_name | name of LDS module serial port, default is
"/dev/ttyUSB0"
  baudrate | baudrate to communicate with LDS module
  enable_angle_calib | enable or disable calibration of azimuth errors
caused by module's shell
  water_noise_filter | enable or disable noise filter, which is caused
by water.
  angle_edge_filter | enable or disable angle edge filter. This is used
to filter wrong angle data caused by the edges of lidar's shell.

#### 3. Run
```
roslaunch benewake_lds_ros benewake_lds.launch
```
```