CE30-D Solid State Array LiDAR

Specification

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Product

Product model: CE30-D

Product name: Solid-state LiDAR

Manufacturer

Company name: Benewake(Beijing) Co., Ltd.

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Contents

1. Product Overview

Features

- Complete Solid-state LiDAR
- Large measuring range: max to 28 meters with centimeter-level accuracy
- High resolution: angular resolution reach to 0.19 degree (3 mrad)

Table 1 CE30-D Specification

Parameter	**Typical Value**
Method	Time of flight
Peak Wavelength	850nm
FoV[1]	60*4 degrees
Pixel Resolution	320*20
Angular Resolution (vertical)	0.2 degree
Frame Rate	30 fps
Response Time	≤167ms
Ranging Resolution	1cm
Detecting Range[2]	0.4~28m@90% reflectivity 0.2~10m@10% reflectivity
Unambiguity Range[3]	28m
Repeatability（1σ）[4]	≤5cm

1 The FoV is open for customization.

2 The test environment is standard room temperature and no ambient light. After LiDAR worked steadily for 20 minutes, a white board with the reflectivity of 90% was placed in the central FOV, and the 4×4 pixels in the center of the field are evaluated. The maximum detecting distance will be different corresponding to different angles, please refer to the operation manual for details.

3 If a reliable signal is received (such as an object with high reflectivity) beyond the unambiguity range of 28m, the LiDAR may output values within 28m.

4 Refer to 2

Accuracy[5]	≤20cm
Ambient Light Resistance[6]	60klux
Data Interface	UDP
Operating Temperature[7]	0~50℃
Storage Temperature	-30~70℃
Supply Voltage	DC 12V ± 0.5%（≥4A）
average current	0.667A
peak current	4A
Power Consumption	≤8W
Power Consumption	≤8W
Dimensions	83*57*54mm(length*width*height)
Enclosure Rating	IP65
Weight	356g

2. Principle of Ranging

The ranging principle of CE30 is based on Time of Flight (TOF). The modulated near-infrared light is emitted from CE30, which will be reflected by an object and received by CE30 again. CE30 calculates the phase difference and time difference between the emitted and received light to determine the distance between CE30 and detected object.

CE30-D's detection zone is shown in Figure 1. Its horizontal field of view is 60 degrees and vertical field of view is 4 degrees. Compared with single-line LiDAR, CE30 has a wider vertical FoV and therefore the object can be better recognized.

In a measuring period, each frame will detect a different distance range. The LiDAR combines all these frames to get all distance data within measuring range.

[5] Refer to 2

[6] It is recommended to use the LiDAR with light intensity below 60klux. The accuracy of LiDAR may decrease slightly outdoors. Please refer to operation manual for details.

[7] The optimum ambient temperature range is between 10℃ and 45℃.The LiDAR can still be in proper function beyond the temperature range, but its accuracy may decrease slightly. Please refer to operation manual for details.

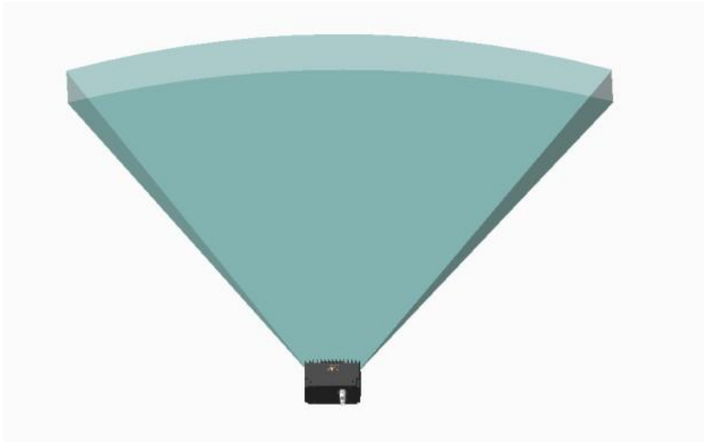


Figure 1 Illustration of CE30-D detection zone

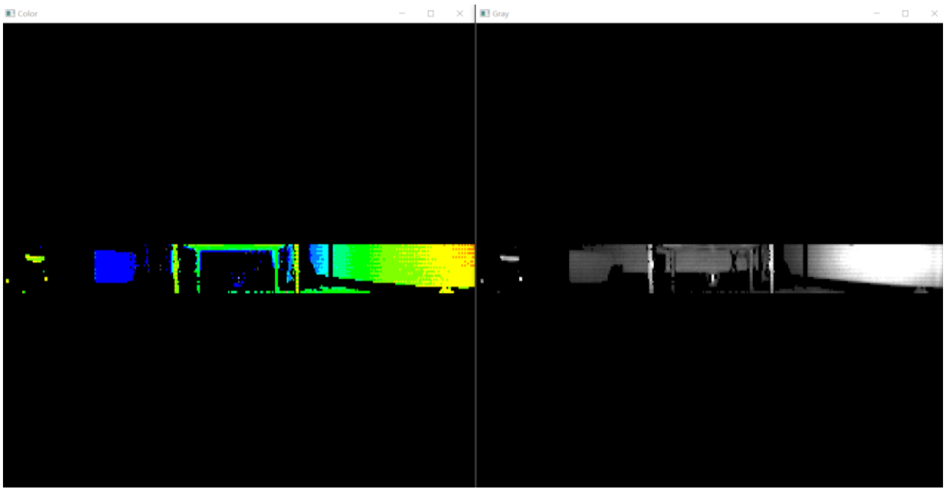


Figure 2 Real detection data display. The left image is depth image and the right is corresponding grey image. Some rods (such as table legs) are well detected in the image.

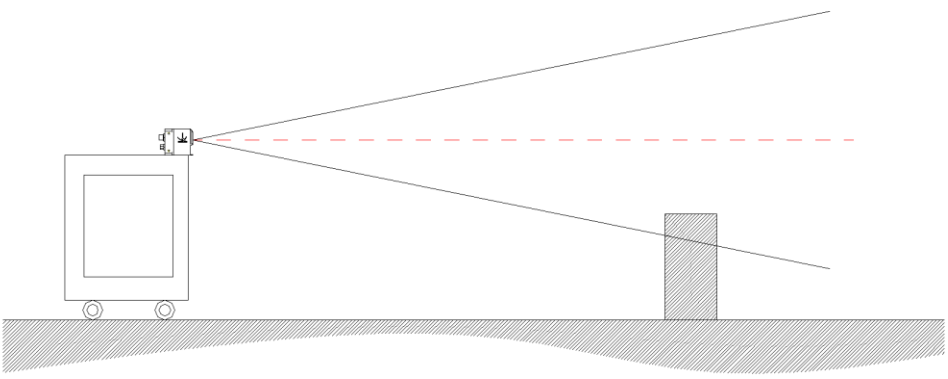


Figure 3 Single-line LiDAR (red line) only detect in a horizontal plane, while CE30-D can detect lower obstacles

3. Communication Protocol

CE30-D LiDAR communicate with other devices through UDP protocol. The LiDAR's IP address is fixed to 192.168.1.80 and the port is 2368.

The communication command stream consists of command data and optional parameter data. The communication form is defined as follows:

1 Command data (string) needs to be filled at the beginning of the command stream.

2 Commands are separated from parameters, parameters, and parameters by a space (0x20).

3 The length of each command is fixed to 50 bytes. If the actual length of the command is less than 50 bytes, it is padded with 0x00.

4 After the Lidar is started, you need to command to turn on the ranging mode. The data stream communication protocol refers to 3.2.

Note: The code example is as follows:

```
c++ code    //C++    Code example
string cmd("getDistanceAndAmplitudeSorted");
cmd.append(50 - cmd.size(), 0x00);
c code      // C    Code example

char cmd[50];
char *getDistance = "getDistanceAndAmplitudeSorted";
memset(cmd, 0x00, 50 * sizeof(char));
memcpy(cmd, getDistance, strlen(getDistance));
```

3.1. Instruction format

3.1.1. Get version information

cmd:"version"
return:Returns a 6-byte version number, char type, such as "v4.3.2"

3.1.2. Start measurement

cmd:"getDistanceAndAmplitudeSorted"
return:See section 3.2

3.1.3. Stop measurement

cmd:"join"
return:none

3.1.4. Change IP

cmd:"ifconfig xxx xxx xxx xxx"
return:4 byte return value
0-success
-1-fail
note:After the IP is configured and returned, the system will automatically reset.

3.1.5. Time synchronization

cmd:"updateTimeStamp [offset0] [offset1] [offset2] [offset3]"
return:4 byte return value
0-sucess
-1-fail

Set the time synchronization point, the timestamp in the data packet is relative to the time synchronization point at this time. If the time synchronization point is not set, the start ranging instruction will be received as the time synchronization point, and the subsequent timestamp is relative to the receiving. The relative time to the instruction.

The instruction sets the calculation of the time synchronization point:
offset = (offset3 << 24) | (offset2 << 16) | (offset1 << 8) | offset0;
t_sync = now;
Calculation of timestamps in packets
t_cur = now
timestamp = (t_cur - tsync + offset) % us_per_hour;

Therefore timestamp is a value between 0 and 3600000000, where offset can usually be set to an all-zero value. If time synchronization is not set, the time at which the start of ranging is received is taken as the time synchronization point and the offset is 0.

3.1.6. Reset Command

cmd:"reset"
return:return 4 bytes 0x00
After receiving the reset command, CE30D sends a response byte and then performs a reset operation.

3.1.7. Shutdown Command

cmd:"shutdown"
return:return 4 bytes 0x00
After receiving the shutdown command, the CE30D sends a response byte and then performs a shutdown operation.

3.2. CE30-D Data Package Form

CE30-D is a 320*24 solid state array LiDAR. It has 6400 photoreceptors.

CE30-D output data row by row. Data of 320 rows is divided to 27 data packages, and each data package will contain 12 rows' data. The first 26 packages have 12 rows' measuring data. The last package will contain 8 rows' measuring data and 4 rows' padding data.

Each column data corresponds to a certain horizontal deflection angle, and each row data corresponds to a certain vertical deflection angle. Please refer to the product manual for details.

Each data package contains header, data block, time stamp and factory information. The size of each package is fixed to 816 bytes.

CE30-D's communication protocol:

Header	Data Block 1	Data Block 2	Data Block 3	...	Data Block 11	Data Block 12	Time Stamp	Factory Info.
42 bytes	Heading Code 0xFFEE	Heading Code 0xFFEE	Heading Code 0xFFEE		Heading Code 0xFFEE	Heading Code 0xFFEE	4 bytes	2 bytes
	Horizontal Deflection Angle 1	Horizontal Deflection Angle 2	Horizontal Deflection Angle 3		Horizontal Deflection Angle 11	Horizontal Deflection Angle 12		
	Photoreceptor Cell 0 Data	Photoreceptor Cell 0 Data	Photoreceptor Cell 0 Data		Photoreceptor Cell 0 Data	Photoreceptor Cell 0 Data		
	Photoreceptor Cell 1 Data	Photoreceptor Cell 1 Data	Photoreceptor Cell 1 Data		Photoreceptor Cell 1 Data	Photoreceptor Cell 1 Data		
	Photoreceptor Cell 2-18 Data	Photoreceptor Cell 2-18 Data	Photoreceptor Cell 2-18 Data		Photoreceptor Cell 2-18 Data	Photoreceptor Cell 2-18 Data		
	Photoreceptor Cell 19 Data	Photoreceptor Cell 19 Data	Photoreceptor Cell 19 Data		Photoreceptor Cell 19 Data	Photoreceptor Cell 19 Data		

Notes: each horizontal deflection angle corresponds to a column of photoreceptors. In the table, the photoreceptor cells N of different data blocks are different photoreceptor cells.

Each data package contains:

- A 42 bytes data header
- 12 data blocks, each is 64 bytes long
- A 4 bytes time stamp
- A 2 bytes factory information

Every data block contain photoreceptor array's one column (from top to bottom) data. It consists of following data:

- A 2 bytes heading code, which's value is 0xFFEE
- A 2 bytes horizontal deflection angle
- 20 photoreceptor cells' data

Every photoreceptor cell's data consists of following data:

- A 2 bytes distance information
- A 1 byte intensity information

Thus, every data package's size is 42+64*12+4+2=816 bytes.

3.3. Calculation of Deflection Angle

Every CE30 contains 320*20 photoreceptor cells. Every photoreceptor cell has a measurement direction, and this direction describe the attitude angle based on CE30's local coordinate system. For convenience, we define:

- Vertical deflection angle: the angle between the measurement direction and CE30's horizontal reference surface
- Horizontal deflection angle: the angle between the measurement direction and CE30's vertical reference surface

The photoreceptor cells that located in the same column have the same horizontal deflection angle. The vertical deflection angle can be obtained through formula or table. Vertical deflection angle, horizontal deflection angle and the distance measured by photoreceptor cell together describe a space point based on CE30's local coordinate system.

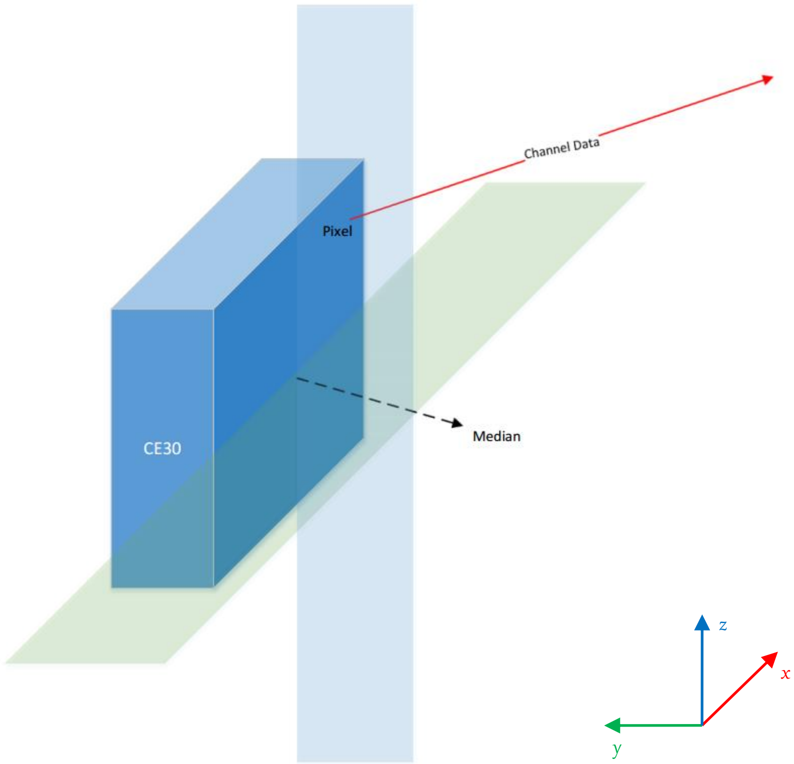


Figure 4 Illustration of LiDAR's deflection angle

Horizontal deflection angle is 2 bytes long. For example, horizontal deflection angle data 0x18 0x06 is received, the angle can be calculated through the following steps:

a. Exchange the 2 bytes' order: 0x06 0x18
b. Get 2 bytes integer: 0x618
c. Transform to decimal system: 1560
d. Multiply 0.01 to get angle: 15.60°

3.4. Calculation of Photoreceptor Cell Data

Photoreceptor cell data consists of 3 bytes, contains distance and intensity information. Distance data is 2 bytes long and intensity is 1 byte long. For example, photoreceptor cell data 0x85 0x26 0x00 is received, the information can be calculated through the following steps:

- Calculate distance:
  a. Exchange the order of first 2 bytes: 0x26 0x85
  b. Get 2 bytes integer: 0x2685
  c. Transform to decimal system: 9861
  d. Multiply 2.0 millimeters: 19722 mm
  e. Multiply 0.001 to get distance in meter: 19.722 m

3.5. Calculation of Time Stamp

Time stamp corresponds to the time to get a data block. It is 4 bytes long. When time stamp data 0x61 0x67 0xB9 0x5A is received, the time stamp can be calculated through following steps:

a. Exchange the order of the 4 bytes: 0x5A 0xB9 0x67 0x61
b. Get 4 bytes integer: 0x5AB96761
c. Transform to decimal system: 1522100065
d. Multiply 0.000001 to get seconds: 1522.100065

4. SDK

CE30-D has Linux based and Windows based SDK to let clients quickly develop and use the LiDAR. Please visit our GitHub open source community to get SDK source codes and reference documents.

5. Product Dimensions

The following images of the modules and the outline dimensional drawings are the reference design. The customization based on customer demands and different application scenarios is available.

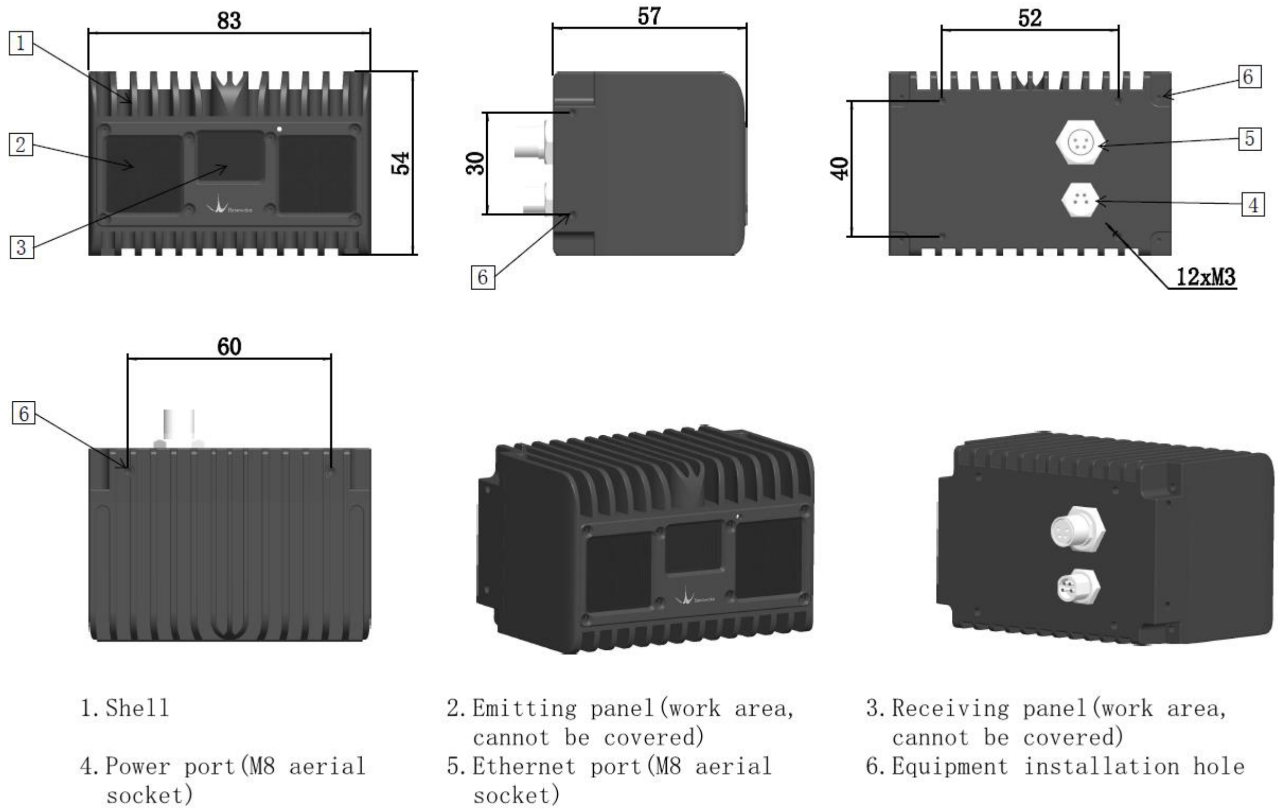


Figure 5 CE30-D outline drawing

Installation instruction:

1. CE30-D should be fixed through indexing holes. The size of indexing holes is M3.
2. Avoiding any blocking in the field of view when installing the LiDAR.
3. Any part of the robot or AGV should not stick out the LiDAR's front surface.

6. Aerial Socket Interface Description

Female: Ethernet connector, aerial socket with 8 mm diameter.

Male: Power supply connector, aerial socket with 8 mm diameter.

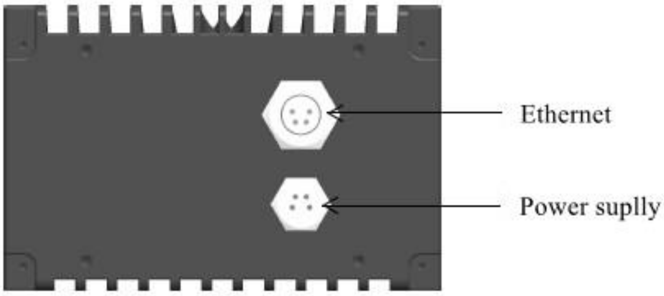
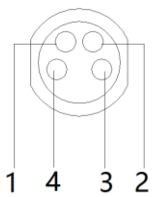


Figure 6 CE30-D aerial connection description

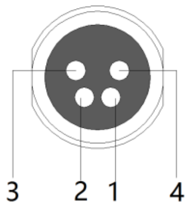
Supply



Pin Number	Description
1	/
2	/
3	GND
4	12V +

Figure 7 Power supply socket pin definition

Ethernet



Pin Number	Description
1	ETH_RX_P
2	ETH_RX_N
3	ETH_TX_P
4	ETH_TX_N

Figure 8 Ethernet socket pin definition

7. Packaging and Accessories

The CE30-D packing contain 1 CE30-D LiDAR, 1 power supply wire with aviation plug (1 meter) and 1 Ethernet wire with aviation plug (1 meter).

DC head of power supply wire with aviation plug 5.5mm*2.5mm.