CE30-D Solid State Array LiDAR

Specification

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1. Product Overview

Features

- Complete Solid-state LiDAR
- Large measuring range: max to 30 meters with centimeter-level accuracy
- High resolution: angular resolution reach to 0.19 degree (3 mrad)

Table 1 CE30-D Specification

Parameter[1]	**Typical Value**
Method	Time of flight
Peak Wavelength	850nm
FoV[2]	60*4 degrees
Pixel Resolution	320*20
Angular Resolution (vertical)	0.2 degree
Frame Rate	30 fps
Ranging Resolution	1cm
Detecting Range[3]	0.4~30m@90% reflectivity
Repeatability（1σ）	≤5cm
Accuracy	≤15cm
Ambient Light Resistance	60klux
Data Interface	UDP
Operating Temperature	0~50℃

1 Specific parameters may slightly differ due to the test environment and the test method. The white board with the reflectivity of 90% is used below as default, and the data from the center of the field of view is used to determine the parameters. Due to the high signal intensity, the center blind zone can reach to 70cm, and the edge blind zone is 40cm.

2 The FoV is open for customization.

3 The parameter will be different when detecting object with different reflectivity.

Supply Voltage	DC 12V ± 0.5V（≥3A）
Power Consumption	≤8W
Dimensions	83*57*54mm
Enclosure Rating	IP65
Weight	334g

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.

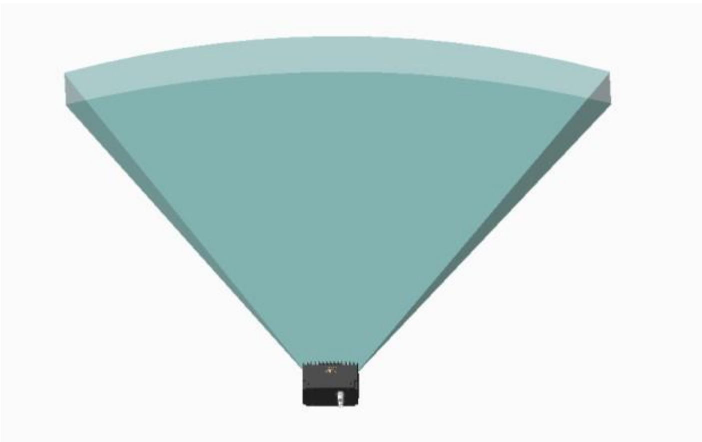


Figure 1 Illustration of CE30-D detection zone

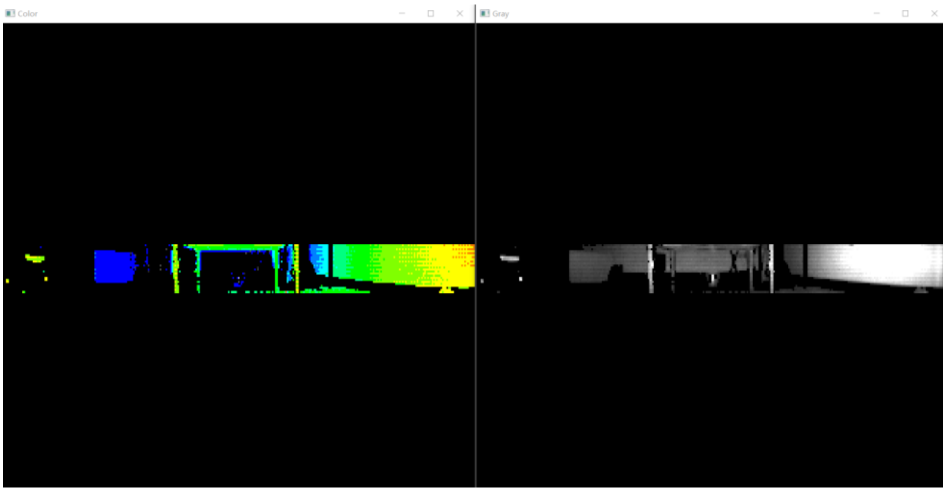


Figure 2 Real detection data display. The left image is depth image and the right is corresponding grey image. Some rods (such as table legs) are well detected in the image.

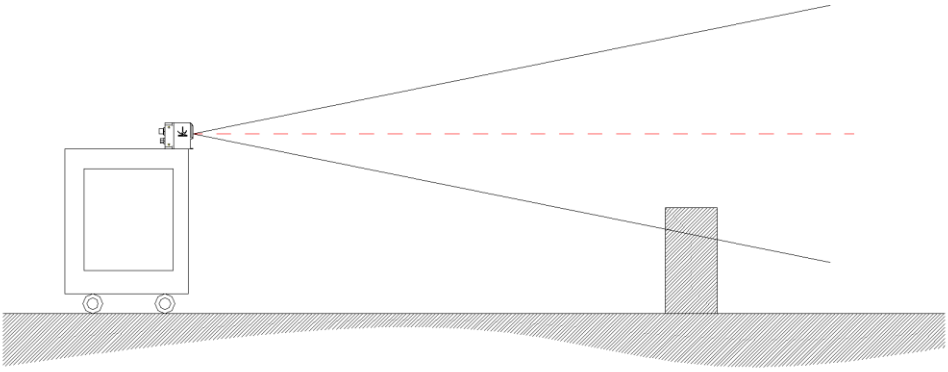


Figure 3 Single-line LiDAR (red line) only detect in a horizontal plane, while CE30-D can detect lower obstacles

3. Detection Range Description

3.1.Blind Zone

When detecting objects with high reflectivity, a blind zone as shown in Figure 4 would appear. This is caused by the overexposure when objects' reflected light is excessive. LiDAR will filter the data from this overexposure zone. When the detected object's reflectivity is lower, the blind zone can become smaller. The blind zone is 30 cm long when detect objects with 10% reflectivity.

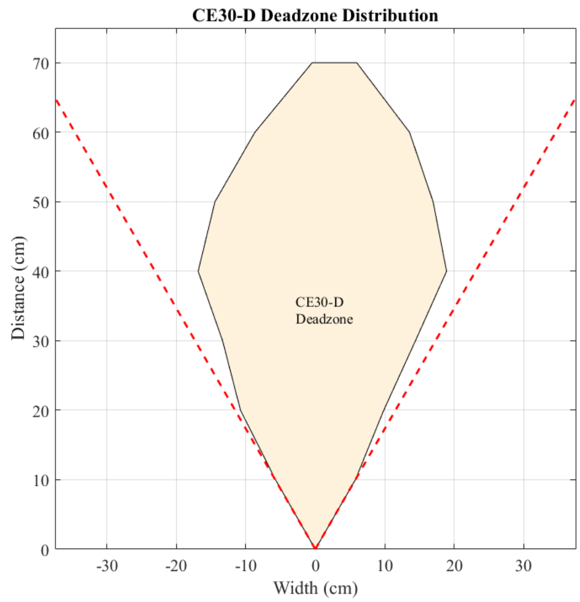


Figure 4 Blind zone distribution (test with 90% reflectivity objects)

3.2.Detection Range

The maximum detectable range is different in different area of field of view. The detectable area of a 90% reflectivity object is shown in Figure 5.

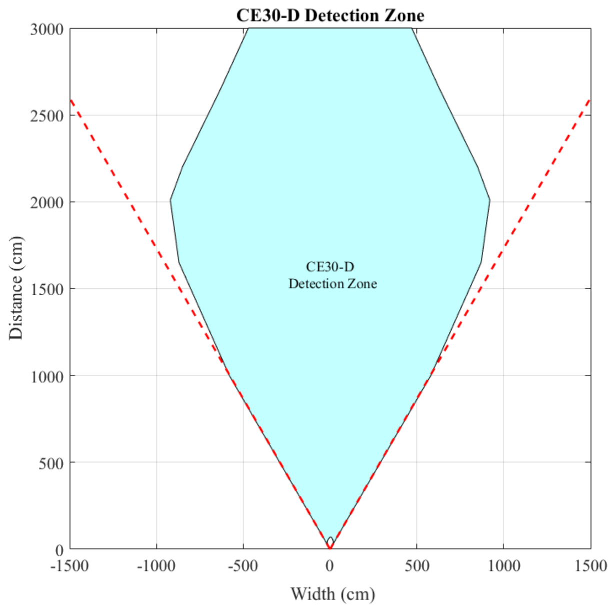


Figure 5 CE30-D's detectable area

4. Vertical Angle Resolution

CE30-D has 20 lines in vertical direction, and the vertical angle resolution is 0.2 degree, so that CE30-D has more precise resolution capacity. The detection angle in vertical direction is presented in *Table 2*.

Table 2 Detection angle in vertical direction

Vertical Line	Vertical Angle（°）
1	1.9
2	1.7
3	1.5
4	1.3
5	1.1
6	0.9
7	0.7
8	0.5
9	0.3
10	0.1
11	-0.1
12	-0.3
13	-0.5
14	-0.7
15	-0.9
16	-1.1
17	-1.3
18	-1.5
19	-1.7
20	-1.9

5. 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 protocol stipulate that the length of all commands is fixed to 50 bytes. If the actual length of the command string is shorter than 50 bytes, the last should be filled with 0x00 after the end of command string to reach the length of 50 bytes. After the LiDAR is powered up, command is needed to start measurement. Communication protocol will be introduced in section 4.1.

LiDAR Command:

a. Get version information

CMD: “version”

Return: 6 bytes version information

b. Start measurement

CMD: “getDistanceAndAmplitudeSorted”

Return: measurement data package

5.1. 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. Vertical deflection angle is defined in Table 2.

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.

5.2. 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.

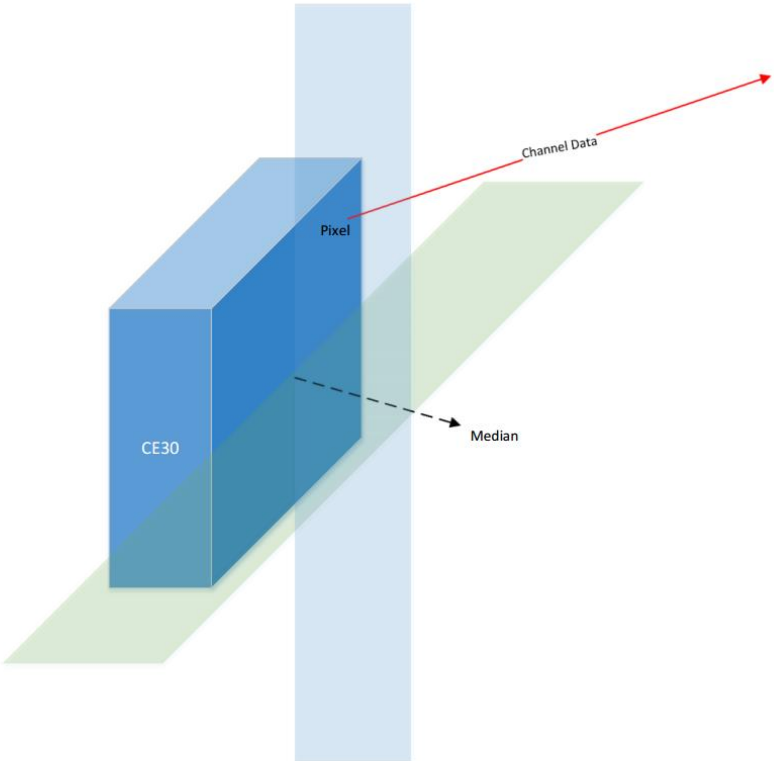


Figure 6 Illustration of LiDAR's deflection angle

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°

5.3. 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

5.4. 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

6. 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.

SDK: https://github.com/codincodee/ce30_viz

Driver: https://github.com/codincodee/ce30_driver

7. 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.

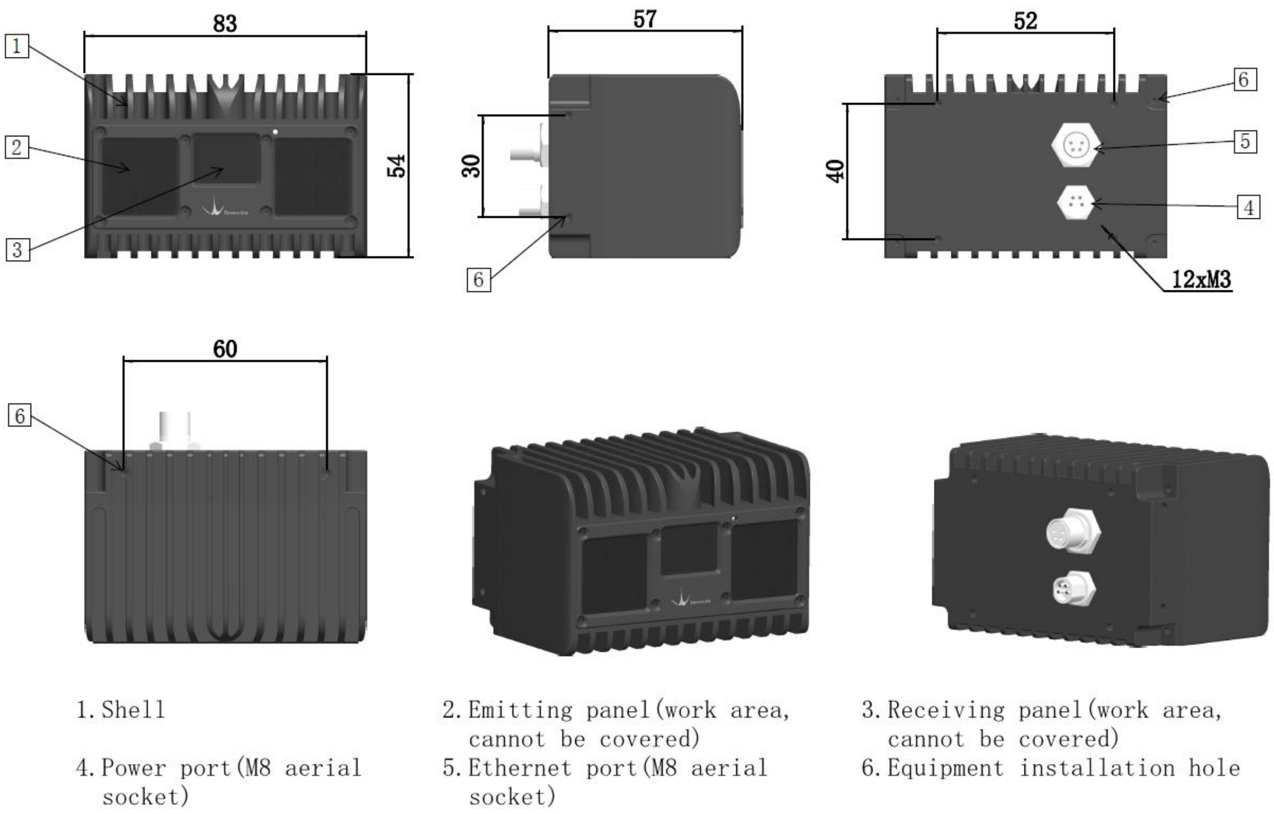


Figure 7 CE30-D outline drawing

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.

8. Aerial Socket Interface Description

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

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

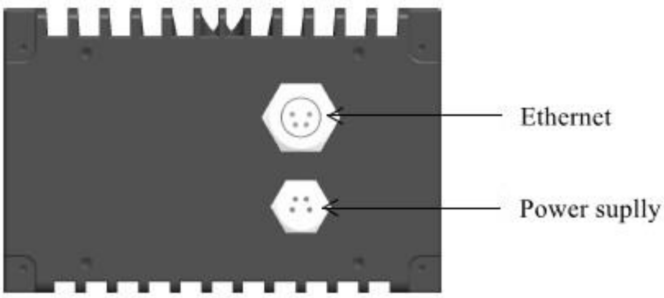
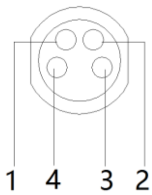
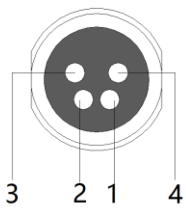


Figure 8 CE30-D aerial connection description



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

Figure 9 Power supply socket pin definition



Pin Number	Description
1	ETH_RX_P
2	ETH_RX_N
3	ETH_TX_P
4	ETH_TX_N

Figure 10 Ethernet socket pin definition

9. 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).