

DE1.1 LiDAR TF01

Release level: Public

Confidential level: Public

Product series: DELiDAR-TF01

Overview

Dear users :

Congratulations! You have chosen the device DE LiDAR-TF01 manufactured by Benewake.

Please read this manual carefully before you install this device and put it into operation. Instructions and hints included in this manual provides better use of the product. Keep the instruction for reference of later work on the equipment.

Benewake (Beijing) Co. Ltd (www.benewake.com), is a high-tech company focusing on “Robotic eyes”. IDG capital has granted Benewake A round investment. In 2016, we were awarded “Demo China EXPO” champion. We aim to turn the expensive LiDAR into core compartments for consumer use, and seek for intelligent robots to be owned by normal families.

The core R&D team members of Benewake come from Wake Forest University, Washington University, Humboldt University, Ecole Centrale Marseille, and Beijing Jiaotong University. 18% of our employee has a Doctor degree , and 42% with a Master degree.

Benewake, make the best Robotic Eyes.

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1. Product overview

Based on ToF (Time of Flight) principle, with unique characteristic of optics , electronics, and design, the product can achieve stable, accurate, high – sensitivity and high – speed distance measurement.

| | | |
|---------------------|------------------------------------|---|
| Features | Sensitivity | High |
| | Detection range | Max10m (@90% Reflection) Recommended flying height < 12m |
| | Detection frequency | 100Hz (up to 500Hz) |
| | Anti – ambient light | Work under 100k Lux ambient light |
| | Shape | Exquisite size , light weight (43 g) |
| | Accuracy | Cm level @ detection range |
| Applications | UAV(drones) floating at fix height | |
| | Terrain Following | |
| | Machine control, security sensor | |
| | Distance measurement | |

Table 1 Features & applications

2. Working principle

Time of Flight (ToF) is a distance measurement method. The modulated near-infrared light emitted from sensor is reflected by the object. By calculating the time difference or phase difference between emission and reflection, the distance from the object can be deduced and so does the depth information.



Figure 1 DE1.0 Simulated light path

3. Electrical characteristics

| Parameter | Symbol | Typ. | Unit |
|-------------------|-----------|-----------|------|
| Supply voltage | DC | 5 (±5%) | V |
| Power Consumption | P | ≤1 | W |
| LED peak current | I_{max} | 200 | mA |
| TTL | V_{TTL} | 0 ~ 3.3 | V |

TF01 Electrical characteristics

Table 2 TF01 Electrical characteristics

($T_a=20\text{ }^{\circ}\text{C}$)

4. Optical characteristics

| Parameter | Symbol | Conditions/Comments | Typ. | Unit |
|----------------------|----------|--|---------|--------|
| Operating range | L | 100Klux ambient light @90% Reflection | 30-1000 | cm |
| Emitting half-angle | α | Customizable | 1.5 | Degree |
| Receiving half-angle | β | Customizable | 1.5 | Degree |

| | | | | |
|-----------------------|-----------|-------------------------------------|--------|----|
| Detection | De | Minimum detectable object size @ 5m | 4 - 6 | cm |
| Resolution | Re | Sensitivity to distance change | 0.5 | cm |
| Operating temperature | T | | -10~60 | °C |
| Peak Wavelength | λ | | 850 | nm |

Table 3 Optical characteristics

Test conditions: stable working for 8 hours.

5. Data output and protocol

Table below is protocol for DELiDAR TF01.

| | |
|---------------------|--------|
| Protocol | UART |
| Baud rate | 115200 |
| Data bit | 8 |
| Checksum bit | 1 |

Table 4 Communication Protocol

5.1 Standard data format of the serial port

Data is output in hexadecimal format, 9 bytes per frame , including one distant info , called “Dist”. Every “Dist” has a serial number info to it , called Sequence. Frame end bit is checksum bit.

| | | | | | | | |
|------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Byte1 - 2 | Byte3 | Byte4 | Byte5 | Byte6 | Byte7 | Byte8 | Byte9 |
|------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|

| 0x59 59 | Dist_L | Dist_H | Strength_L | Strength_H | Sequence_L | Sequence_H | CheckSum_L |
|--------------------------------|---|--------|------------|------------|------------|------------|------------|
| Data coding information | | | | | | | |
| Byte1 | 0x59 , frame head , same in every frame | | | | | | |
| Byte2 | 0x59 , frame head , same in every frame | | | | | | |
| Byte3 | Dist_L distance value lower eight bit Distance is shown by HEX , eg.1000cm=03 E8 (HEX) | | | | | | |
| Byte4 | Dist_H distance value upper eight bit | | | | | | |
| Byte5 | Strength_L Lower eight bit Strength stands for signal quality, scale 0-2000 , indoor<3 reject, outdoor<10 reject | | | | | | |
| Byte6 | Strength_H Uppereight bit | | | | | | |
| Byte7 | Sequence _L Serial number lower eight bit Sequence scale vary from 00 00 to FF FF , stands for 0 to 65535 , to mark the continuity of the data | | | | | | |
| Byte8 | Sequence _H Serial number upper eight bit | | | | | | |
| Byte9 | Checksum check lower eight bit , Checksum = Byte1 + Byte2 + ... + Byte8 , Checksum is the sum of the former eight bit , we only send the lower eight bit. | | | | | | |

Table 5 Data coding information and details

5.2 Pix data format of the serial port

The data is outputted in character string and the unit is m. E.g. the output string 1.21 corresponds to the measuring distance of 1.21m.

6. Noise Model

| Strength | Correction Dist standard deviation/cm |
|----------|---------------------------------------|
| > 110 | < 0.7 |
| 80 – 100 | 0.7 – 1.1 |
| 50 – 80 | 1.1 – 2 |
| 20 – 50 | 2 – 5 |
| < 20 | > 5 |

Table 6 500Hz TF01 noise model

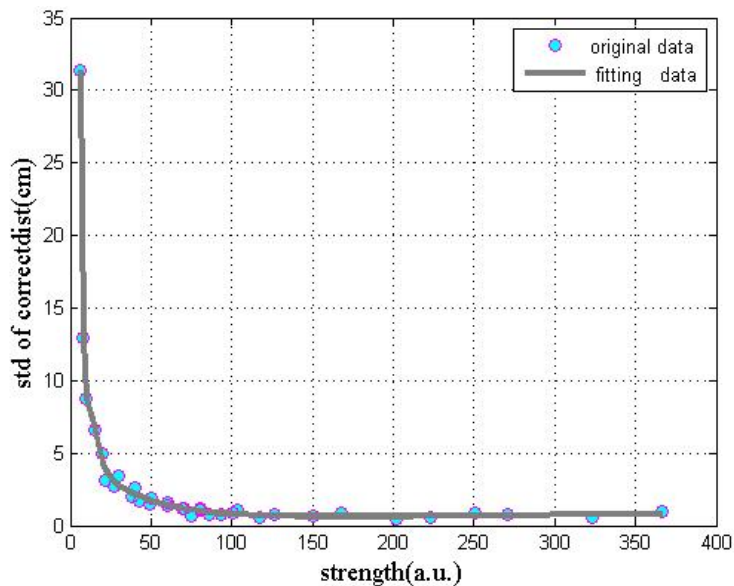


Figure 2 correction dist standard deviation-strength curve

7. Line sequence



Figure 3 TF01 line sequence

Note: line sequence of the CAN bus – Red (Vcc), Black (GND), Green (CAN-H) and White (CAN-L).

8. GUI

8.1 Standard interface

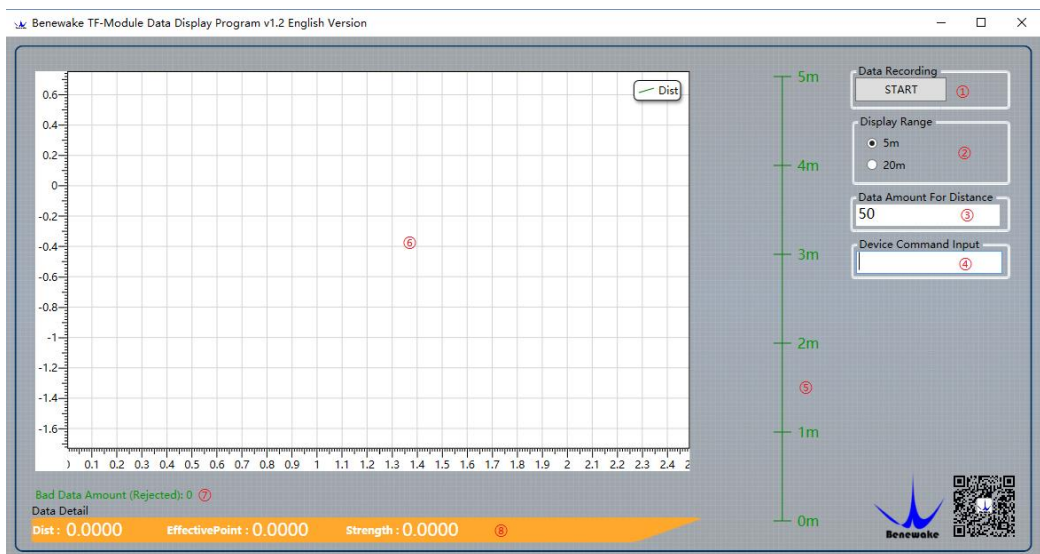


Figure 4 Windows TF-Module Data Display Program UI

- ① "Start" button, press the button to record TF-01 HEX data, the data will be saved in the same directory with the GUI;
- ② "Display Range", click 5m or 20m to switch display scale between 5m and 20m;

- ③ “Data Amount for Distance”, Data amount to get an average distance(DAGAD)
- ④ Device command input area, input HEX command in this window and press Enter to send, to change functions or setting;
- ⑤ Scale to display the real-time measurement;
- ⑥ Area to display average distance-number of measurements;
- ⑦ the amount of the data rejected.
- ⑧ Data Detail area : Dist stands for distance , unit cm. Effective Point stands for data quantity of TF-01 output. Strength stands for signal strength.

8.2 Pix interface

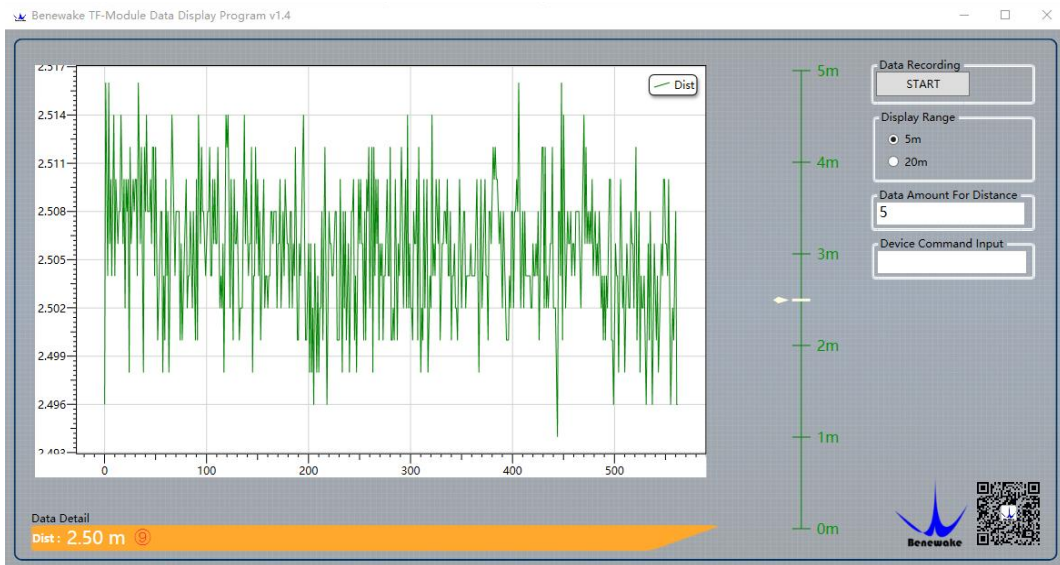


Figure 5 PIX - Windows TF-Module Data Display Program UI

- ⑨ Data display zone: Dist represents the distance measured, in unit m. The functions of other zones are identical to ① - ⑥.

9. Serial port and CAN port instructions

Serial port instruction:

| Serial port instruction | Measuring frequency/Hz |
|--------------------------------|-------------------------------|
| 42 57 02 00 00 00 00 E6 | 100 |
| 42 57 02 00 00 00 01 E6 | 200 |
| 42 57 02 00 00 00 02 E6 | 300 |
| 42 57 02 00 00 00 03 E6 | 400 |
| 42 57 02 00 00 00 04 E6 | 500 |

CAN port conversion cycle instruction:

| CAN port instruction | Conversion cycle/ms |
|-----------------------------|----------------------------|
| 42 57 02 00 01 00 00 23 | 2 |
| 42 57 02 00 02 00 00 23 | 4 |
| 42 57 02 00 03 00 00 23 | 6 |
| 42 57 02 00 04 00 00 23 | 8 |
| 42 57 02 00 05 00 00 23 | 10 |

CAN port output cycle instruction:

| CAN port instruction | Output cycle/ms |
|-------------------------|-----------------|
| 42 57 02 00 01 00 00 24 | 2 |
| 42 57 02 00 02 00 00 24 | 4 |
| 42 57 02 00 03 00 00 24 | 6 |
| 42 57 02 00 04 00 00 24 | 8 |
| 42 57 02 00 05 00 00 24 | 10 |

10. Corrosion resistance

Mix the pesticide with water with the ratio of 1:30. Place the product inside the solution for 48 hours, and then take it out to observe the property of the product for corrosion resistance.

| No. | Type of pesticide | Result | Comment |
|-----|-------------------------------|--------|--------------------------------|
| 1 | Hymexazol | NG | Corrosion; material turns soft |
| 2 | Phenoxyacetate acid compounds | NG | Corrosion; material turns soft |
| 3 | Trifluralin | NG | Corrosion; material turns soft |
| 4 | Cypermethrin | NG | Corrosion; material turns soft |
| 5 | Decamethrin | OK | No change on product surface |
| 6 | Copper sulfate basic | OK | No change on product surface |
| 7 | Glyphosate | OK | No change on product surface |

| | | | |
|---|----------------------|----|------------------------------|
| 8 | Glufosinate-ammonium | OK | No change on product surface |
| 9 | Azoles | OK | No change on product surface |

Table 7 Corrosion resistance test

11. Dimension and specification

Picture below is reference design , the shape and size can be highly customized.

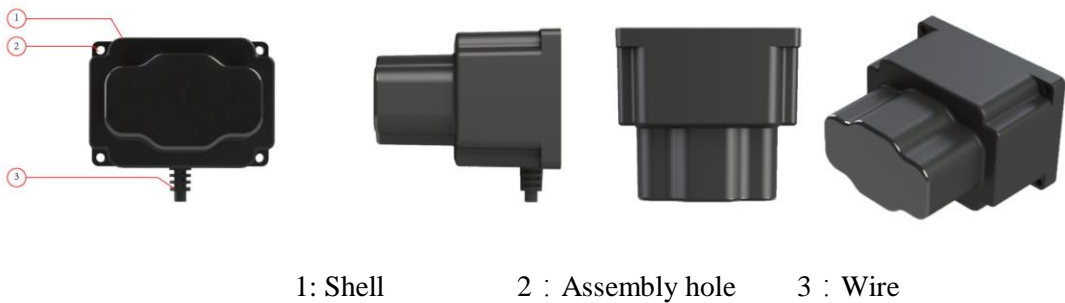


Figure 6 DELiDAR TF01 Mechanical Dimensions (reference design)

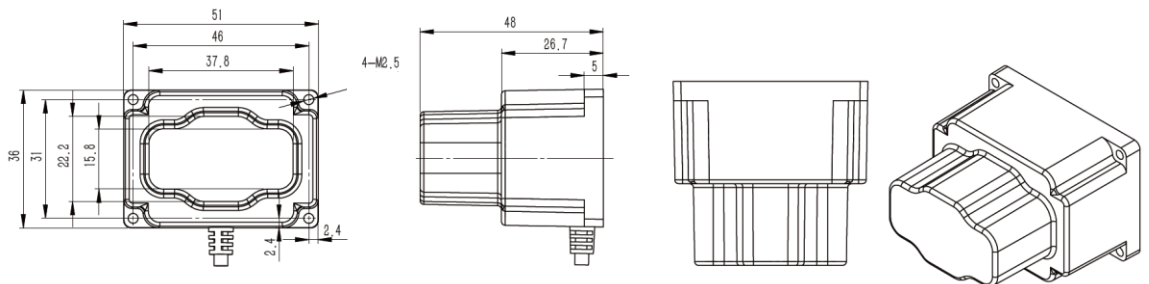


Figure 7 DELiDAR TF01 contour dimension (unit : mm)

12. Installation and fixation

Please use the M2.5 pan head screw to install the product. Insert an elastic washer between the screw and the shell to avoid the shell to be damaged from over-screwing.

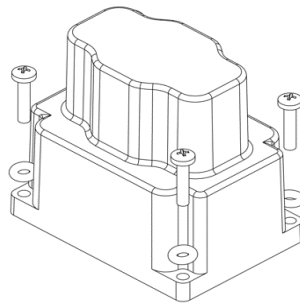


Figure 8 Installation and fixation instruction

13. Frequently Asked Questions

(1) What is the spread of the laser beam?

At very close distance (<0.5m), the beam diameter is about the size of the aperture of the lens. For distance larger than 0.5m, the beam diameter can be estimated using the following equation:

distance / 20 = beam diameter at the this distance

The actual spread is ~52 milli-radians or ~3 degree.

(2) How do distance, target size, aspect, and reflectivity affect returned signal strength?

The device transmits a focused IR beam that reflects off a target, among which a portion of which returns to the receiver. The distance between the device and the target is determined by the difference between the moment of signal transmission to the moment of signal reception. The effective reception of a reflected signal is influenced by, but not limited to, the following factors:

- Target distance

Returned signal strength ~ $1/D^2$

D: distance

- Target size

Returned signal strength ~ $1/C^4$

C: cross section of a target

- Aspect

The orientation of the target to the sensor influences the observable cross section.

- Reflectivity

The reflective characteristics of the surface of the target influence the amount of returned signal.

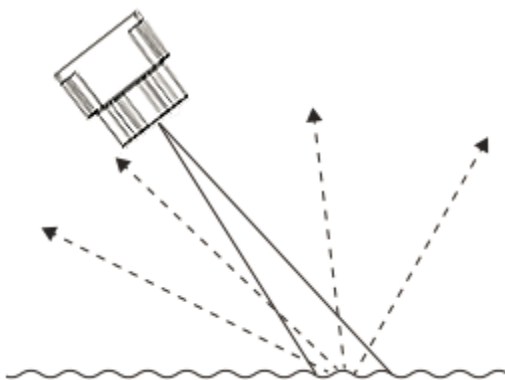
Generally, it is difficult to detect a small target, especially when it is distant, poorly reflective, and its aspect is away from the normal. Nevertheless, the returned signal strength can be improved by attaching an IR reflector to the target, enlarging the size of the target, modifying its orientation, or reducing its distance from the sensor.

(3) How does the device work with different reflective surfaces?

Generally speaking, the reflective characteristics of the surface of an object can be deduced into three categories: diffuse reflective, specular and retro-reflective.

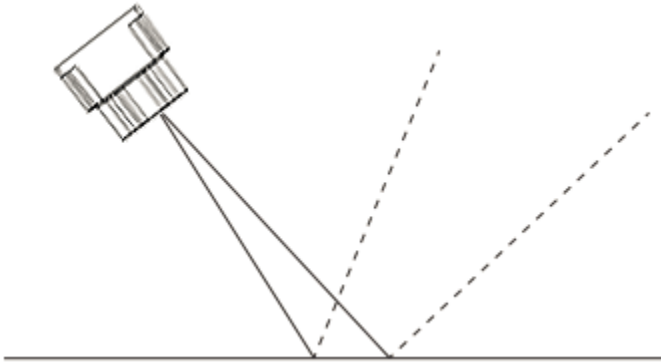
- Diffuse reflective surface

For surfaces of materials like paper, matte walls and granite, their textured quality results in the uniform dispersion of reflected energy. Therefore the reflected energy of the dispersed laser is relatively predictable in percentage. As a result, these materials can be read very well.



- Specular surface

For specular surfaces, only a small amount or even none of the reflected light reaches the receiver, depending on the smoothness of the surface and the observation angle. The suggestion is to view the object from the normal.



Cautions :

- The product must be maintained by our engineers since it is customized optical instrument with high precision.
- Operating temperature : -10-60°C , storage temperature : 0-70°C
- The operating environment must be kept clean. Prevent dust or other stuff from getting into the lens.
- Keep away from high temperature and high humidity environment for storage, transportation or operation.
- Keep away from acid or strong sulfur environment.

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