TF03 Long-Distance LiDAR

RS485-RS232

Product Manual

www.benewake.com
Benewake (Beijing) Co., Ltd.

Specified Product

Product model: TF03 RS485-RS232

Product Name: Long-Distance LiDAR

Manufacturer

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

Address: NO.28 Xinxi Road, Haidian District, Beijing, PRC

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Foreword

Dear users:

Thanks for choosing Benewake products, and it's our pleasure to help you to solve any technical question.

For the purpose of offering a better operation experience to you, we hereby write this manual for an easier and simpler operation of our product, hoping to better solve the common problems you maybe meet. Please contact us if you have any questions.(bw@benewake.com)

This operation manual covers the product operation introduction and common problem solutions, but it is really hard to cover all the problems you maybe meet. So if you have any further questions or problems, please feel free to consult our technical support service (support@benewake.com). We will do our best to solve any problem related to the product. If you have any other good advice or suggestions, welcome to visit our official website and offer us your feedback there (http://en.benewake.com/contact_us), and we are looking forwards to your participation.

We are Benewake who dedicated to making the best "Robotic Eyes" worldwide!

目录

1 Attentions

1.1 About this Document

- This Manual provides information necessary for the use of this product.
- Please read this Manual carefully before using this product and make sure that you have fully understood its contents.

1.2 Usage of Product

- This product can only be maintained by qualified professionals and only the original spare parts can be used to ensure its performance and safety.
- The product itself has no polarity and overvoltage protection. Please complete wiring and supply power correctly according to the contents of the Manual.
- The working temperature of the product is -25°C~60°C; please do not use it beyond this temperature range, so as to avoid risks.
- The storage temperature of the product is -40°C~85°C; please do not store it beyond this temperature range, so as to avoid risks.
- Do not open its enclosure for assembly or maintenance beyond this Manual; otherwise, it will affect the product performance.

1.3 Conditions with Potential Product Failure

- When the product transmitter and receiver lens are covered by dirt, there will be a risk of failures. Please keep the lens clean.
- The product will have a risk of failure when immersed completely in water. Do not use it underwater.
- When detecting objects with high reflectivity, such as mirrors and smooth tiles, the product may have a high risk of failures.

2 Physical Interface

2.1 Description about the line sequence and connection

Wiring terminal model: MH1.25-7P, core wire: AWG30, diameter:0.254mm, cross-sectional area:0.05mm^2.

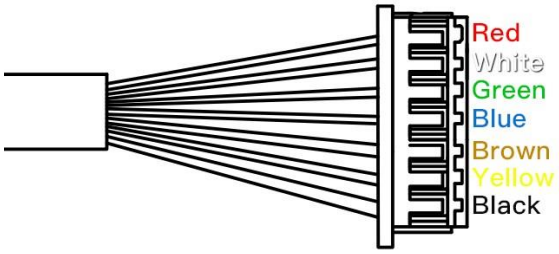


Figure 1 TF03 Line Sequence

Table 1 TF03 Pin functions and connection instructions

No	color	Pin	Function
1	Red	VCC	Voltage Input
2	White	485-B	485
3	Green	485-A	485
4	Blue	/	/
5	brown	232_RXD	receiver
6	Yellow	232_TXD	transmitter
7	Black	GND	GND

2.2 Electrical Characteristics

This product has no overvoltage or polarity protection. Please ensure that the wiring and power supply are normal.

Table 2 main electrical parameters

Parameter	Typical value
Power supply voltage	6-24V
Average current	≤200mA @ 6V ≤100mA @ 12V ≤50mA @ 24V
Peak current	≤200mA @ 6V ≤100mA @ 12V ≤50mA @ 24V
Average power	≤1.2W

3 Installation Instructions

3.1 Product Overview

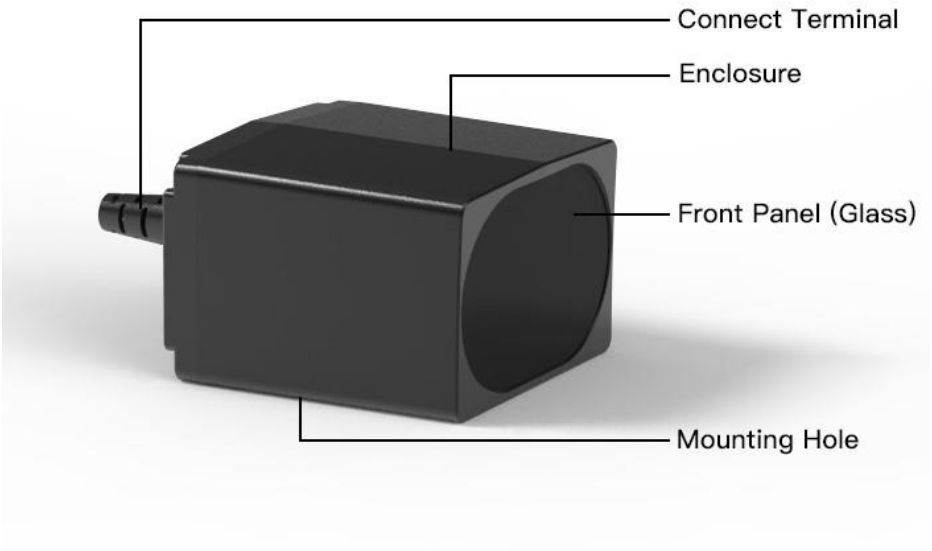


Figure 2 Exterior

3.2 Product Structure

The LiDAR mounting holes are applicable to M3 screws. Note that the length of the screw entering the enclosure shall be no more than 3.5mm.

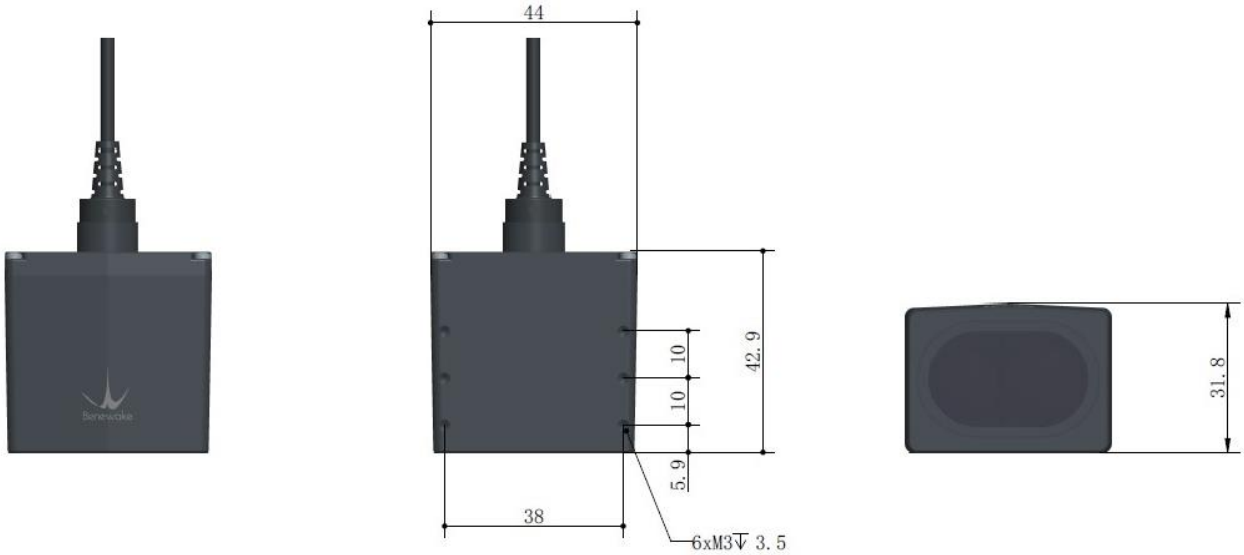


Figure 2 TF03 dimensions (Left 1: top view; Left 2: vertical view; Left 3: front view)

3.3 Detection angle descriptions

TF03 has a 0.5-degree detection angle and rectangular light spots; see Table 3 for simulated diagrams of the light spots. Therefore, at different distances, the spot size, namely detecting range, is different as shown in Figure 4.

Note: The side length of common objects detected should be greater than that of the detection range of TF03; When the side length of the detected object is less than that of the detection range, the LiDAR effective range will be reduced

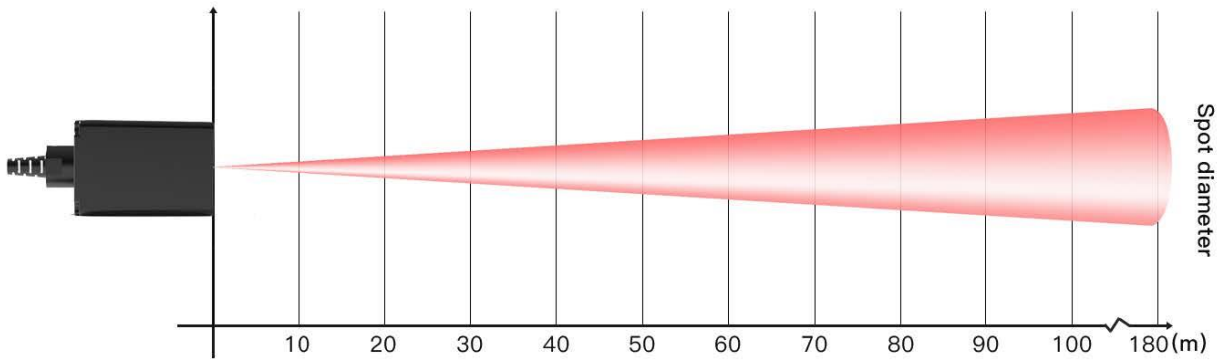
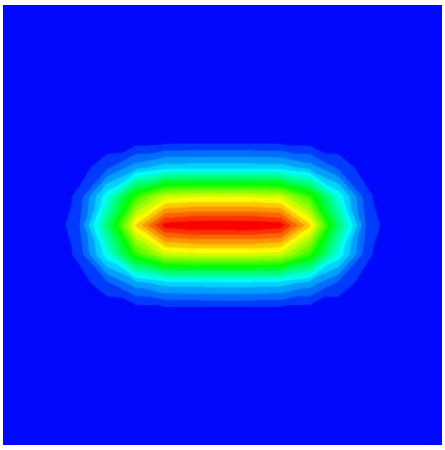
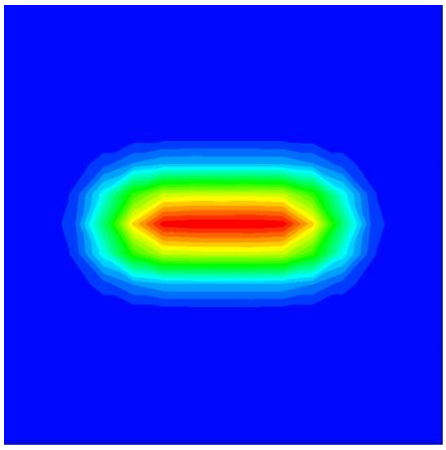
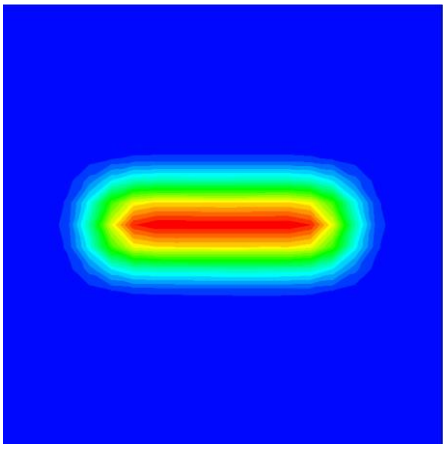
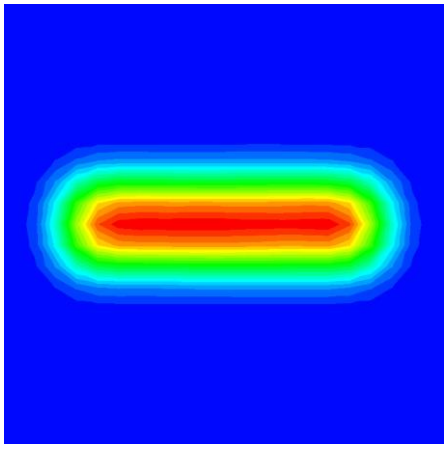


Figure 3 Detection angle schematic of TF03

Table 3 Spot simulated diagrams and sizes at different distances

			
Spot 20m away	Size：20cm*6cm	Spot 50m away	Size：50cm*14cm

			
Spot 100m away	Size：100cm*28cm	Spot 150m away	Size：150cm*42cm

Note: In it, the red is the strongest, the green is weak, and the dark blue is the background, and the spot size is the length and width of the green in the figure.

4 Communication protocol and Data format

The TF03 RS485/RS232 version supports RS485 and RS232 communication modes. By default, both interfaces can communicate, so long as the corresponding interface lines are connected, they can be used.

4.1 Communication protocol

The communication protocol of TF03 RS485/RS232 is the same as that of UART. TF03 RS232-RS485 communication protocol is shown in Table 4.

Table 4 TF03 Serial port communication protocol

Item	Content
Communication protocol	RS232-RS485
Baud rate	115200
Data bit	8
Stop bit	1
Checksum bit	None

1）Standard data output format of Serial port（RS485、RS232）

The output data (hexadecimal numbers) of TF03 is shown in table 5. Each data frame consists of 9 bytes and the data contains the measured distance information; namely, DIST; the frame tail acts as a data checksum bit; other bytes are reserved.

Table 5 TF03 serial data format

Data bit	Definition	Description
Byte0	Frame header	0x59
Byte1	Frame header	0x59
Byte2	DIST_L	DIST low 8-bits
Byte3	DIST_H	DIST high 8-bits
Byte4	Reserved bit	/
Byte5	Reserved bit	/
Byte6	Reserved bit	/
Byte7	Reserved bit	/
Byte8	Checksum	Low 8 bits of Checksum bit. Checksum = Byte0 + Byte2+…+Byte7

4.2 Customer parameter configurations

4.2.1 The General Format Description of Commands

Custom parameters configurations are open in order that problems could be solved conveniently. Parameters, such as output data format, output frame rate could be changed by sending command. Parameter will be stored in flash and needn't to be configured again if restart after configured successfully.

Please change the configuration according to the real demands and never try uncorrelated command frequently thus unnecessary loss from wrong command; please configure the product according to the demands of the manual and never send unstated command.

The Format of Command is:

Byte	byte0	byte1	byte2	byte3~ byteN-2	byteN-1
Descriptions	Head	Len	ID	Payload	Check sum

Head：fixed to 0x5A

Len：the length of the entire instruction frame (unit: Byte)

ID：identifies the function of each instruction

Payload：have different meanings and lengths in different ID instruction frames

Check sum: the lower 8 bits of the Len-1 byte data.

4.2.2 Commands

Function	Command	Response	Remark	Default setting
Obtaining version number	5A 04 01 5F	5A 07 01 V1 V2 V3 SU	the version number V3.V2.V1 SU is check sum, the same below	/
System reset	5A 04 02 60	success: 5A 05 02 00 61 fail: there isn't any reaction over 1s	/	/
Frame rate	5A 06 03 LL HH SU	success: is same as command fail: there isn't any reaction over 1s	/	100fps
Output enabling switch	enable: 5A 05 07 01 67 disable: 5A 05 07 00 66	success: is same as command fail: there isn't any reaction over 1s	/	enabled
Single trigger instruction	5A 04 04 62	Data frame	/	/
Setting output format	5A 05 05 LL SU	success: is same as command fail: there isn't any reaction over 1s	LL: format, 06: RS485 output	RS485 output
Baud rate	5A 08 06 H1 H2 H3 H4 SU	success: is same as command fail: there isn't any reaction over 1s	Frame rate = (H4 << 24)+(H3 << 16)+(H2 << 8)+H1	115200
Enabling checksum switch	enable: 5A 05 08 01 68 disable: 5A 05 08 00 67	success: is same as command fail: there isn't any reaction over 1s	/	enable
Restoring factory settings	5A 04 10 6E	success: 5A 05 10 00 6F fail: 5A 05 10 ER SU	Fail(when ER is not 0)	/
Save settings	5A 04 11 6F	success: 5A 05 11 00 70 fail: 5A 05 11 ER SU	same as above	/
Configuring over range threshold value	5A 06 4F LL HH SU	success: 5A 05 4F 00 AE fail: there isn't any reaction over 1s	over range threshold value =(HH << 8) + LL, unit cm	18000
Enabling rain-fog algorithm	enable: 5A 05 64 00 C3 disable: 5A 05 64 01 C4	success: 5A 05 64 00 C3 fail: there isn't any reaction over 1s	/	enable

Configuring offset	5A 06 69 LL HH SU	success：5A 05 69 00 C8 fail：there isn't any reaction over 1s	Offset = (HH << 8) + LL，unit cm	0

Interpretation:

1) The supported output frame rate is as follows:

1、2、…9、

10、20、…90、

100、200…900、

1000、2000…9000、10000；

2) When using the trigger mode, you need to disable data output, and then use the trigger command;

3) "Configuring offset" can be used for customer secondary calibration radar distance, supported from firmware version v1.11.3.

5 Quick Test Procedures

5.1 Required Tools of Product Test

Note: the product package contains only TF03 products and factory certificate, and other accessories are collected by yourself.

The version of TF03-RS485 connected to the computer needs to use 485-USB board, the version of TF03-RS232 connected to the computer need to use 232-USB board, please pay attention to different versions of the line sequence when connecting. the following example represents the serial port version TF03 connected to the computer tools and methods.

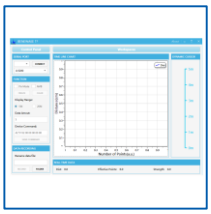
				
TF03 (232/485)	232/485 - USB Board	USB Cable	PC	TF display program

Figure 4 Tools example

5.2 Test procedures

1) Download the TF display program

Please download the TF display program from http://benewake.com/en/down.html

Note: Please close the anti-virus software before unpacking the TF display program; otherwise, the files in the TF display program will be deleted as viruses; The TF display program currently only supports running on the Windows system. See Attachment 1: Instruction of TF Series PC Display Software.

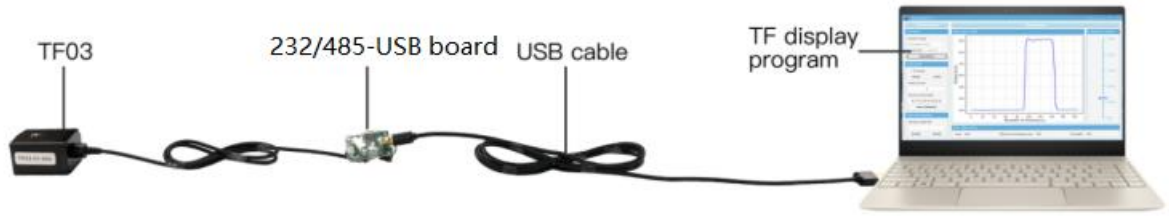


Figure 5 How to connect TF03 to PC for test

As figure 6 shown, connect 『TF03』-> 『232/485 - USB board』-> 『USB cable』, ensure no looseness, and then connect the 『USB cable』with the 『computer』.

3) TF display software connection and reading

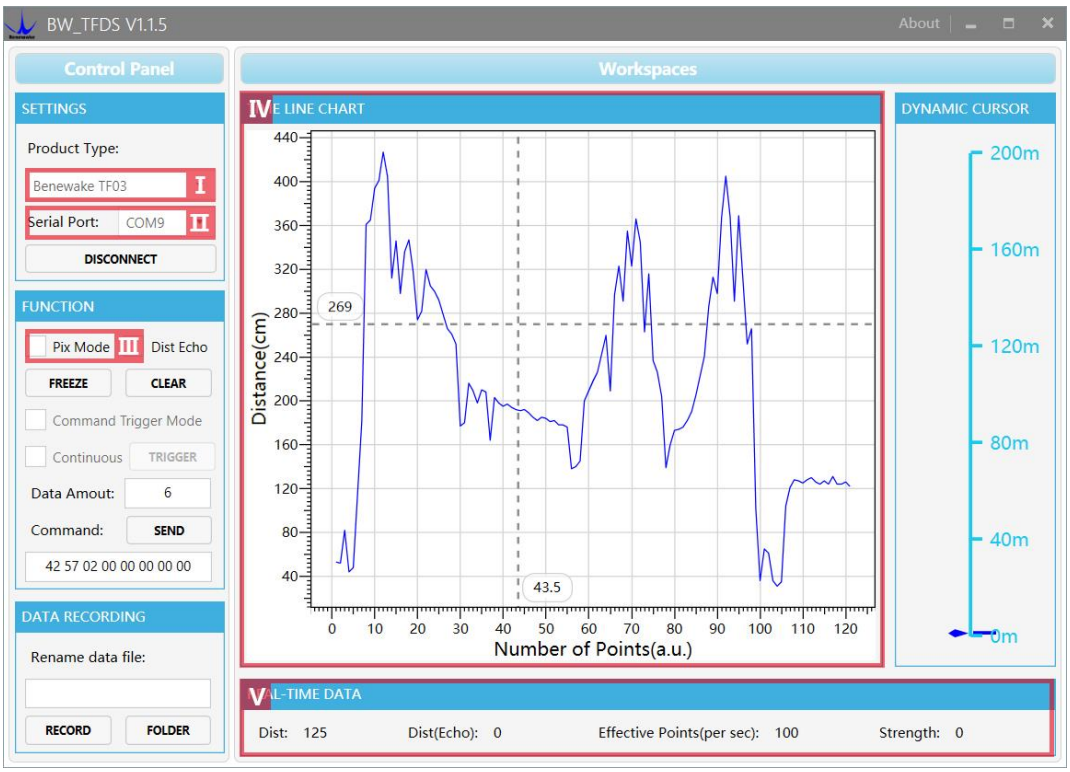


Figure 6 The interface of TF display software

As shown in Figure 7, open the TF display program, select Ⅰ『Benewake TF03』 and select the serial port for automatic identification (here is Ⅱ『COM9』).

Then, click『CONNECT』to connect to the TF display program.

After connected successfully, continuous output data images will occur in the right Ⅳ『TIME LINE CHART』area and the Ⅴ『REAL TIME DATA』area below will display the current test distance (Dist: 125cm), the output frame rate (Effective Points: 100Hz).

Note: the Dist(Echo) and Strength are unmeaning in here.

4）Another note

If TF03 is required to output in Pixhawk mode, check Ⅲ『Pix Mode』 first and then the data images will be normally output in the Ⅳ『TIME LINE CHART』area. After the Pix Mode is checked, the distance unit will change to m.

5.3 Test Example

5.3.1 Test Range with Different Reflectivity

As shown in Figure 8, the 180m version of TF03, red and blue curves represent the relationship between the reflectance and range of the target under different ambient light intensities indoors and outdoors, respectively.

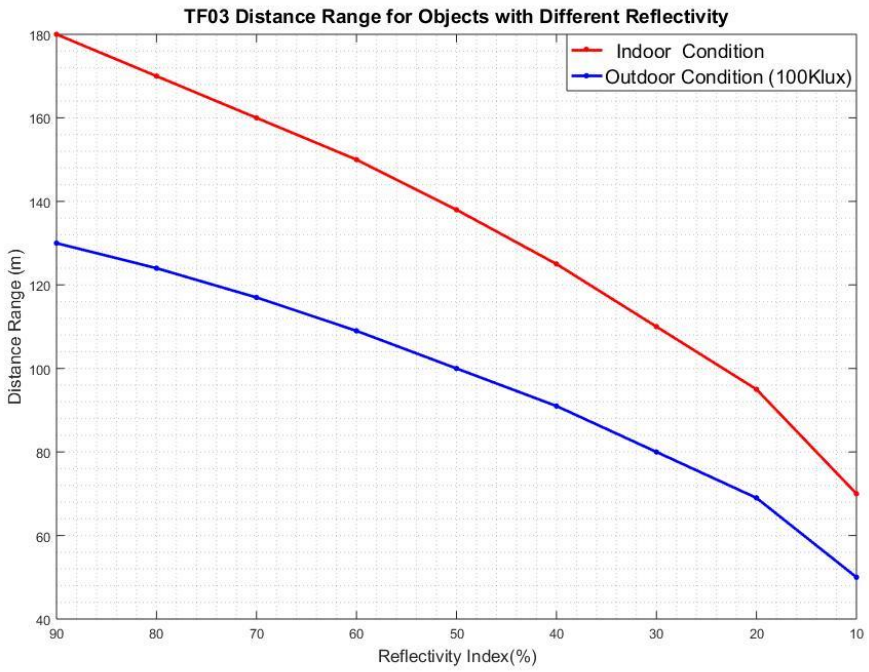


Figure 8 The relationship between TF03 range and reflectance (version 180m)

5.3.2 Testing Accuracy of Different Materials

The test accuracy of TF03 at different distances and reflectivity is shown in Figure 9. Two

typical background boards(blackboard and whiteboard), are selected. The reflectivity of whiteboard is 90% and that of blackboard is 10%.

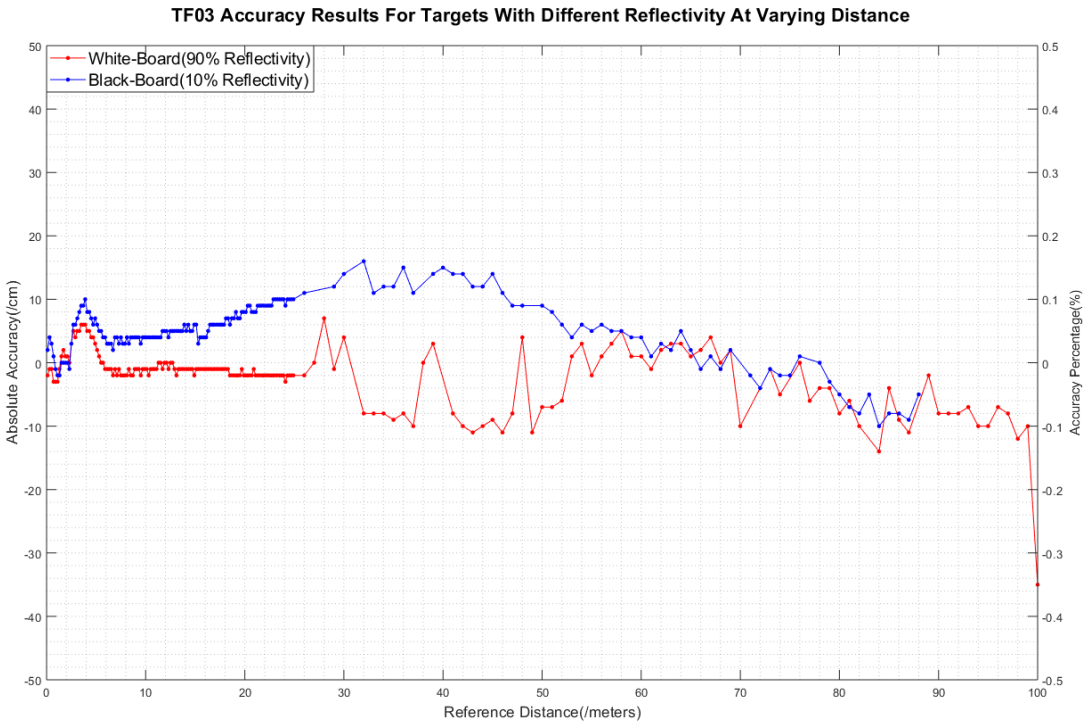


Figure 9 Error curves of TF03 at different distances and reflectivity

5.3.3 Reflectivity of Common Materials

The reflectivity of common materials is listed below, ranging from low to high. According to the test target and the corresponding reflectivity, we can measure whether the range of TF03 and other parameters meet the requirements.

No.	Materials	Reflectivity
1	black foam rubber	2.4%
2	black cloth	3%
3	black rubber	4%
4	Coal (varies from coal to coal)	4~8%
5	Black car paint	5%
6	Black paper	10%
7	opaque black plastic	14%
8	Clean rough board	20%

9	newspapers	55%
10	translucent plastic bottles	62%
11	packing case cardboard	68%
12	Clean pine	70%
13	opaque white plastic	87%
14	white card	90%
15	Kodak standard whiteboard	100%
16	Unpolished white metal surface	130%
17	Shiny light metal surface	150%
18	stainless steel	200%
19	Reflective board, reflective adhesive tape	>300%

6 TF03 Software Setup

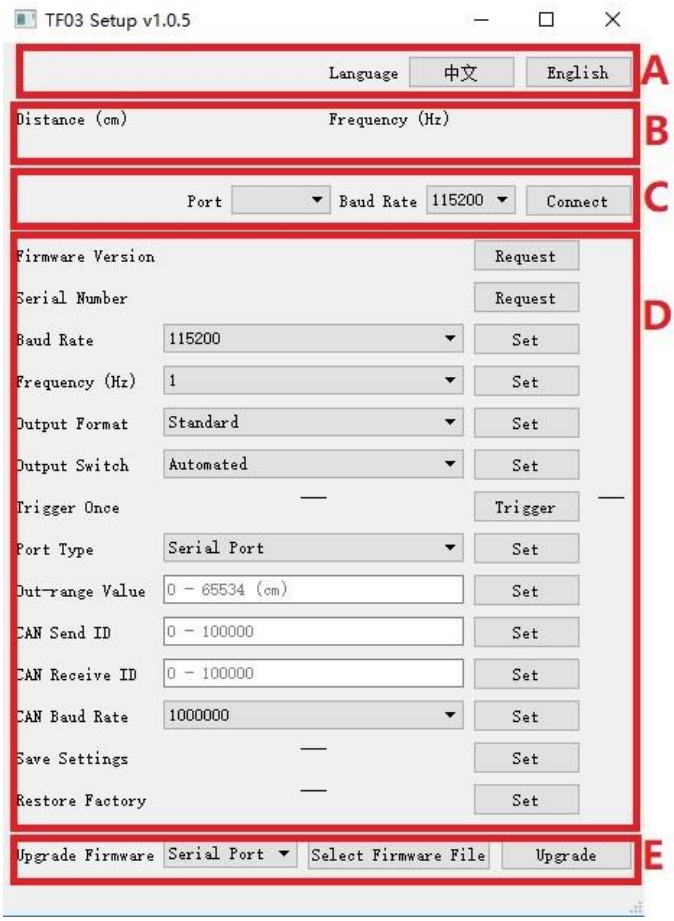


Figure 7 TF03 Setup software display

Interface of custom TF display software is shown in the figure above.

1) After TF03 is connected to the computer, select the correct port number and baud rate in Zone C manually and click the 『Connect』 button to realize communication between the TF display software and TF03.

2) After connection is successfully established, zone B will display the ranging distance and the frequency of data obtained by the TF display software. When no data is received after two seconds, the data and frequency display will disappear.

3) Zone D is dedicated to function configuration and its third column lists the buttons for sending instructions. After clicking such buttons, the setup software will send instructions and wait for reply from TF03. When no reply is received for a long time, 『No Response』 will be displayed on the right side of the instruction-sending buttons. Please note that in order to ensure that TF03 reply instructions can be obtained normally, lower the 『frame

rate』or set the『output mode』as『instruction trigger』before configuration. If the changed parameters need to be saved, click the settings button corresponding to 『Save Configuration』before power down TF03.

4) Region E is dedicated to firmware upgrade, which enables the BootLoader function to be used for upgrading the product firmware.

7 Failure reasons and troubleshooting

1) Under normal operation, TF03 sometimes will output 18000(cm).

Reasons: The actual distance measured is beyond the range of TF03, TF03 will output 18000.

Troubleshooting: Use the value 18000 as a value representing abnormal data. In other words, after value 18000 is received, the TF03 output data is not used.

2) No data output after TF03 is connected to the TF display software.

Reason Ⅰ: The computer uses and operating system other than Windows.

Troubleshooting: Currently, the TF display software can only support the Windows operating system. Use a computer with the Window operating system installed.

Reason Ⅱ: Poor connection between TF03 and computer.

Troubleshooting: Please confirm that TF03 is correctly and reliably connected to the computer, and ensure that the cables and adapter board work properly.

3) TF03 does not cover the nominal range in some cases.

Reason: TF03 bases on the time-of-flight (TOF) principle, to achieve ranging by calculating the round-trip time of flight of laser pulses. The intensity of ambient light or the reflectivity of objects under testing is different, and thus will increase the intensity of ambient noise or return light intensity. Therefore, the ranging performance of TF03 varies with different ambient light intensities and reflectivities.

Troubleshooting: Under different ambient light intensity and reflectivity of objects under testing, having different ranges is a normal phenomenon and does not affect the accuracy or repeatability. Therefore, it can be used normally.

8 Frequently asked questions

Q1：Can the divergence angle (spot) of TF03 be increased or decreased?

A1： Generally, this is a custom requirement. You need to contact the sales staff for further details. Divergence angle is determined at the beginning of product design. Determination of divergence angle is also closely linked to the optical system and the product structure. Therefore, it cannot be easily changed, and needs to be customized.

Q2： Can TF03 change the frequency of data output? Can TF03 output switching values?

A2： So far, customization of parameter configurations and adjustment of output modes have been enabled for TF03. However, switching values have to be customized according to requirements. You may consult our sales staff or technical support for further details.

Q3: Can TF03 work normally in rain, snow and fog?

A3: TF03 has a firmware version of the algorithm that penetrates the rain and fog. Contact the sales or technical support personnel for firmware upgrade. The algorithm is turned on by default in V1.11.15.

Attachment 1: Instruction of TF Series PC Display Software

Ⅰ Product model/serial port control area 『SETTINGS』

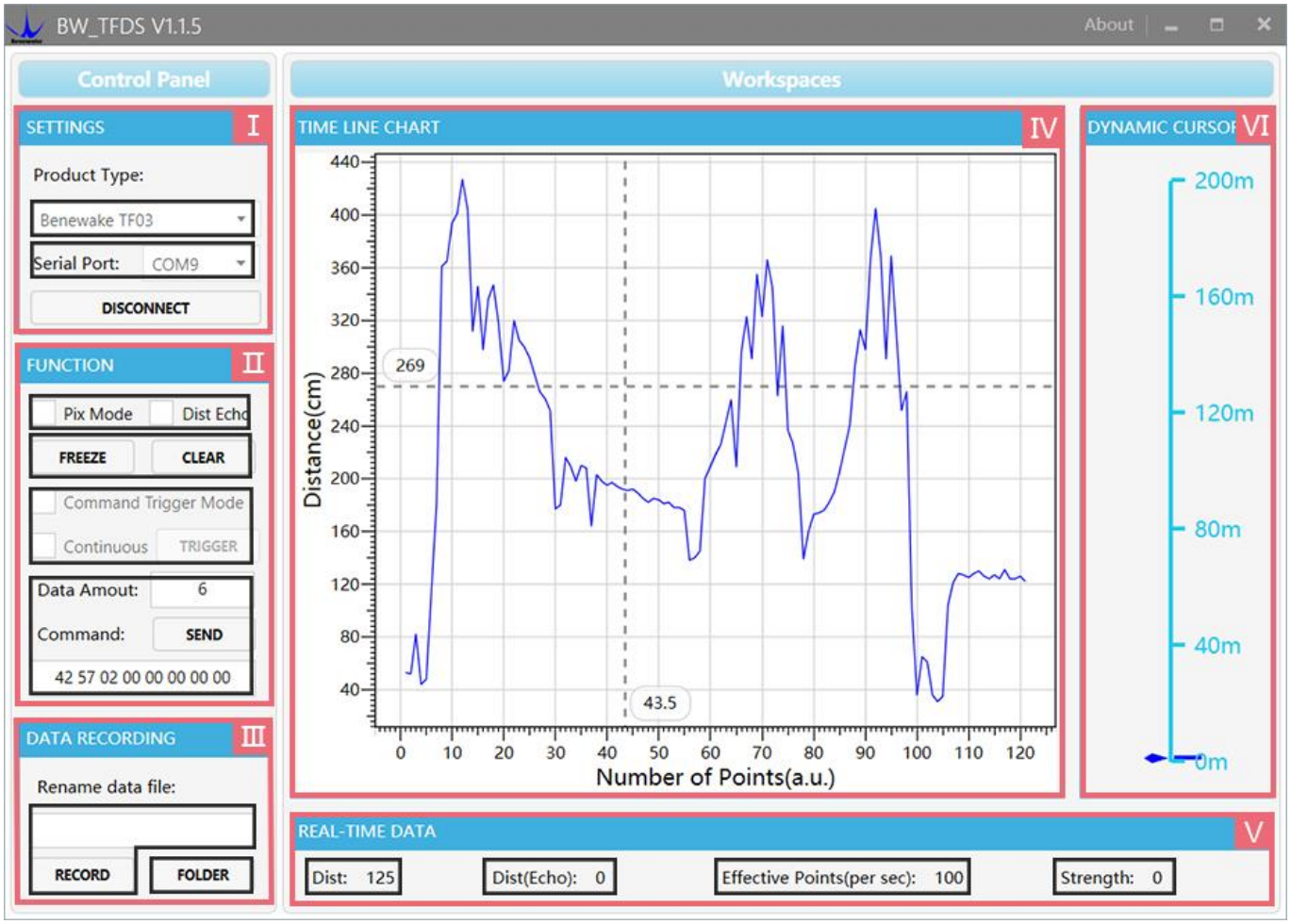


Figure 8 Interface for TF series PC display software

『Product Type』: Use the 232/485-USB pin board to connect the corresponding LiDAR model at the computer terminal; if you use the product TF03 of our company, just select Benewake TF03.

『Serial Port』: Select to identify the corresponding LiDAR port number at the computer terminal.

『CONNECT/DISCONNECT』: Click the『CONNECT』button to establish a connection with LiDAR; click the 『DISCONNECT』 button to cancel the connection.

Ⅱ Function area 『FUNCTION』

『Pix Mode』: For the Pixhawk data format, check and enable the PIX mode; uncheck and restore the standard output format.

『Dist Echo』: Unmeaning.

『FREEZE/CLEAR』: Click 『FREEZE』to pause the PC for analysis of the images in『IV』; click『CLEAR』to clear the drawing curve in『IV』and restart drawing.

『Date Amount』: 5 by default, namely, once receiving 5 points, the PC will average the numerical values of the 5 frames and then output a frame. Modification is allowable as needed (You'd better set the numerical value larger or equal to 5 for preventing stagnation of the PC). After entering the value, press the keyboard enter key to forward commands.

『Device Command』: Hexadecimal commands can be sent from this window to TF, but it should be noted that you should first enter commands, then click the enter key and then click 『SEND COMMAND』below.

Ⅲ Data recording area『DATA RECORDING』

『RECORD』: Name the data to be saved in the text window, enter the file name, press the enter key, use the『RECORD』button to record the TF data and the data will be stored in the named text file; click the button『FINISHED』to stop data recording.

『FOLDER』: Use 『FOLDER』to open the folder with data saved.

Ⅳ Data image display area『TIME LINE CHART』

The PC will draw continuous ranging images according to the data received. The vertical and horizontal coordinates represent the current distance and the number of effective points respectively

Ⅴ Real-time data display area『REAL-TIME DATA』

『Dist』: Unit: cm by default.

『EffectivePoint (per sec)』: It represents the effective data refreshed by TF per second.

『Strength』: In the pix mode, there is no strength input, so the "Strength" value is 0 by default.

Ⅵ Range scale『DYNAMIC CURSOR』

Display the real-time distance detected according to the current product model.