TF03 Single-Point Long-Distance LiDAR

Product Manual

Specified Product

Product model: TF03
Product name: Single-Point Long-Distance LiDAR

Manufacturer

Company name: Benewake (Beijing) Co., Ltd.
Address: No. 28, Xinxi Road, Haidian District, Beijing, PRC

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Note: This product currently is a prototype for research and development, with some parameters to be determined, and any change shall never be subject to any prior notice.

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://www.benewake.com/feedback.html), and we are looking forwards to your participation.

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

Content

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℃~60℃; please do not use it beyond this temperature range, so as to avoid risks.

- The storage temperature of the product is -40℃~85℃; 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 detecting objects with high reflectivity, such as mirrors and smooth tiles, the product may have a high risk of failures.

- When there is any transparent object between the product and the target, such as glass and water, there will be a risk of failures.

- When the product transmitter and receiver lens are covered by dirt, there will be a risk of failures. Please keep the lens clean.

2 Physical Interface

2.1 Description about line sequence and connection

Wiring terminal model: GH1.25-7P.

Figure1 Line sequence
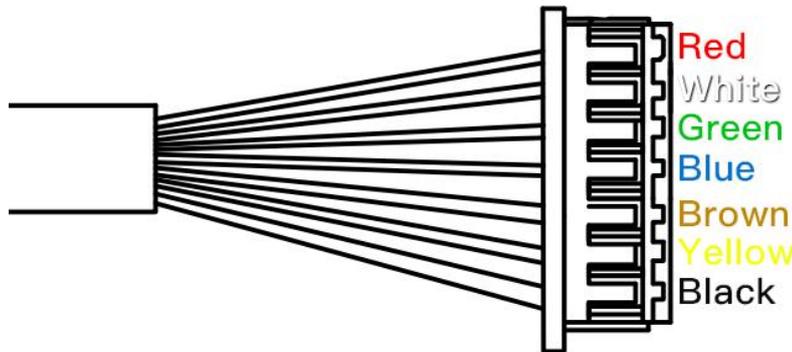
Table 1 Pin functions and connection instructions

No.	Color	Pin	Function
1	Red	VCC	Voltage input
2	White	CAN_L	CAN bus low
3	Green	CAN_H	CAN bus high
4	Blue	GPIO	IO output [1]
5	Brown	TTL_RXD	UART receiver
6	Yellow	TTL_TXD	UART 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, and the supply voltage is allowed to fluctuate by ±0.5V.

Table 2 TF03 main electrical parameters

Parameter	Typical value
Power supply voltage	5V
Average current	≤180mA
Peak current	≤180mA

[1] IO output function can be customized according to actual requirements.

Average power	≤0.9W

3 Installation Instructions

Figure 2 Exterior
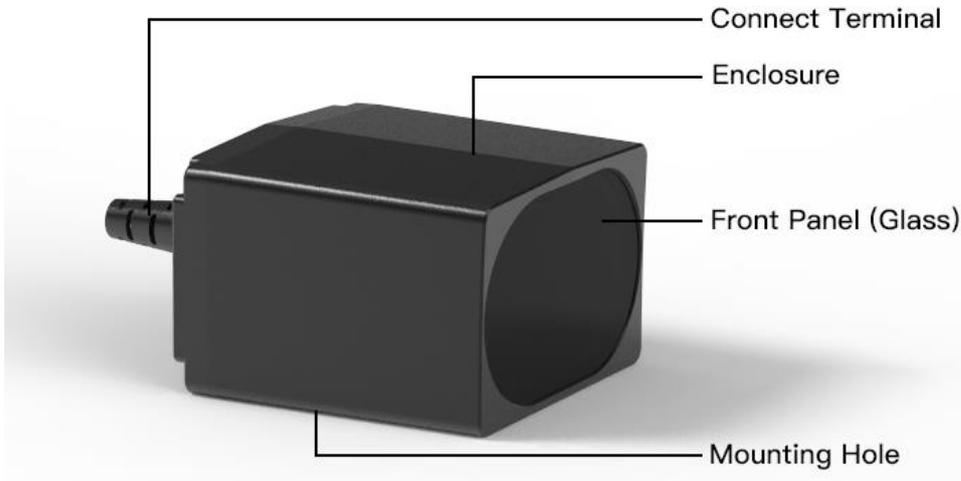
3.1 Product Overview

3.2 Production 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 3 TF03 dimensions (Left 1: top view; Left 2: vertical view; Left 3: front view)
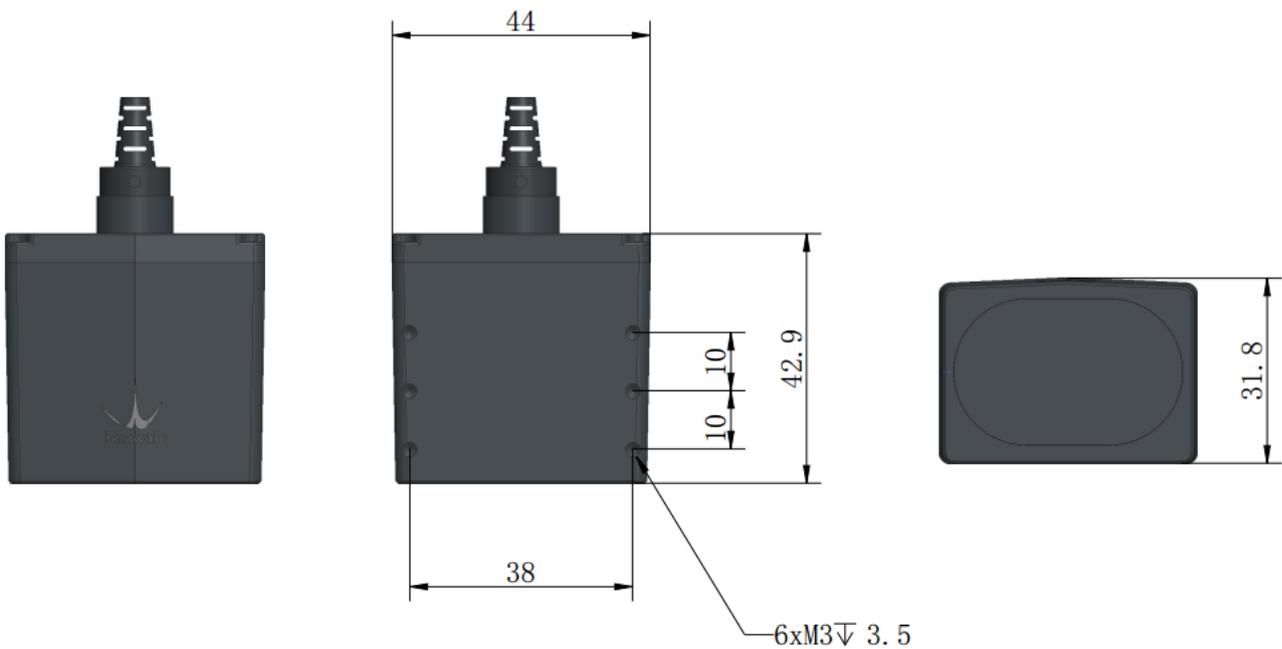
4 Communication Protocol and Data Format

TF03 supports serial port and CAN bus communication.

4.1 Serial Port Version

Here follow the TF03 serial communication protocol and data format, and the output level (LVTTL) of the serial port is 0-3.3V.

Table 3 TF03 serial communication protocol

Parameter	Description
Communication protocol	UART
Baud rate	115200
Data bit	8
Stop bit	1
Checksum bit	None

1) Serial standard data format

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

Table 4 TF03 serial data frame 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	/
Byte5	Reserved	/
Byte6	Reserved	/
Byte7	Reserved	/
Byte8	Checksum	Low 8 bits of Checksum, Checksum = Byte0 + Byte2 +... + Byte7

2) Serial Pixhawk data format

Output in the form of strings (unit: m), for example, range of 1.21m and it will output the string 1.21; each distance value ends by line feed. The products of the serial port version can support the output in the form of Pixhawk changed by instructions.

4.2 CAN version

The CAN communication protocol can be customized according to users' needs; the CAN baud rate, ID and frame format can be modified.

Table 5 TF03 CAN communication protocol

Parameter	Description
Communication protocol	CAN
Baud rate	1M
ID	0x0003
Frame format	Standard frame

The output data (hexadecimal numbers) of TF03 is shown in the table below. Each data frame contains 8 bytes and the data contains the distance information, namely, Dist; other bits are reserved.

Table 6 TF03 CAN data frame format

Data bit	Definition	Description
Byte0	DIST_L	DIST low 8 bits
Byte1	DIST_H	DIST high 8 bits
Byte2	Reserved	/
Byte3	Reserved	/
Byte4	Reserved	/
Byte5	Reserved	/

4.3 Custom parameter configurations

In order to solve your problem more flexibly, TF03 has specially enabled the function for customizing the product configuration parameters via its serial port. Users can modify the product original parameters by sending relevant instructions, such as output data format and output frame rate. After parameter configuration is successful, input/write in configuration instructions, and the configuration

parameters will be saved in Flash and no reconfiguration is needed in case of power-off reboot.

Please modify the product configurations as needed. Never attempt unrelated instructions frequently so as to avoid unnecessary loss caused by wrong instructions; ensure that the product is configured according to the instructions listed in this Manual. Do not send any undeclared instruction.

The instruction frame includes Head, Len, ID, parameters (optional) and Check sum, where Head is fixed to 0x5A; Len is the length of the entire instruction frame (unit: Byte); ID identifies the function of each instruction; parameters have different meanings and lengths in different ID instruction frames; and Check sum is the lower 8 bits of the Len-1 byte data.

4.3.1 Obtaining version number

Send to TF03：

Byte	0	1	2	Len-1
Descriptions	Head(0x5A)	Len	0x01	Check_sum

TF03 returns:

Byte	0	1	2	3~5	Len-1
Descriptions	Head(0x5A)	Len	0x01	Version	Check_sum

Version: For example, the third, fourth and fifth bytes are 112, 50 and 9 respectively, indicating the version number 9.50.112.

4.3.2 System software reset

Send to TF03：

Byte	0	1	2	Len-1
Descriptions	Head(0x5A)	Len	0x02	Check_sum

TF03 returns:

Byte	0	1	2	3	Len-1
Descriptions	Head(0x5A)	Len	0x02	Status	Check_sum

Status: 0 (Successful); -1 (Failed).

4.3.3 Setting operating frequency

Send to TF03：

Byte	0	1	2	3	4	Len-1
Descriptions	Head(0x5A)	Len	0x03	Freq_low	Freq_high	Check_sum

Freq: Operating frequency, >0 (operating frequency set)

TF03 returns：

Byte	0	1	2	3	4	Len-1
Descriptions	Head(0x5A)	Len	0x03	Freq_low	Freq_high	Check_sum

Freq: Operating frequency actually achieved in the TF03

This instruction takes effect immediately and the configurations are not saved by default.

The serial port baud rate supports 1Hz and Hz x 10/100/1000, such as 10Hz, 20Hz…100Hz, 200Hz…1000Hz, 2000Hz…10000Hz.

Up to 1000Hz is supported when the baud rate is 115200; while up to 10000 Hz is supported when the baud rate is 1M.

4.3.4 Single trigger instruction

Send to TF03：

Byte	0	1	2	Len-1
Descriptions	Head(0x5A)	Len	0x04	Check_sum

TF03 returns：

Data frame. See in Figure 4.

4.3.5 Setting output format

Send to TF03：

Byte	0	1	2	3	Len-1
Descriptions	Head(0x5A)	Len	0x05	Format	Check_sum

Format: 0x01 (standard data format output), 0x02（Pixhawk data format output）

TF03 returns：

Byte	0	1	2	3	Len-1
Descriptions	Head(0x5A)	Len	0x05	Format	Check_sum

Format: Output format configured in the TF03. 0x01 (standard data format output), 0x02 （Pixhawk data format output）. This instruction takes effect immediately and configurations are not saved by default.

4.3.6 Setting serial port baud rate

Send to TF03：

Byte	0	1	2	3	4	5	6	Len-1
Descriptions	Head(0x5A)	Len	0x06	baudrate_low_0	baudrate_low_8	baudrate_high_16	baudrate_high_24	Check_sum

E.g:115200，byte3：0x00，byte4：0xC2，byte5：0x01，byte6：0x00

TF03 returns:

Byte	0	1	2	3	4	5	6	Len-1
Descriptions	Head(0x5A)	Len	0x06	baudrate_low_0	baudrate_low_8	baudrate_high_16	baudrate_high_24	Check_sum

Baudrate: serial port baud rate actually configured in the TF03

This instruction cannot take effect until it is executed and restarted with saved configurations.

4.3.7 Output enabling switch

Send to TF03：

Byte	0	1	2	3	Len-1
Descriptions	Head(0x5A)	Len	0x07	Enable	Check_sum

Enable: 0 (Output disabled), 1 (Output enabled)

TF03 returns:

Byte	0	1	2	3	Len-1
Descriptions	Head(0x5A)	Len	0x07	Enable	Check_sum

Enable: 0 (Output disabled), 1 (Output enabled)

This instruction takes effect immediately and configurations are not saved by

default.

4.3.8 Enabling checksum switch

Send to TF03：

Byte	0	1	2	3	Len-1
Descriptions	Head(0x5A)	Len	0x08	Enable	Check_sum

Enable: 0 (Checksum disabled, Check_sum may be any value.), 1 (Checksum enabled)

TF03 returns:

Byte	0	1	2	3	Len-1
Descriptions	Head(0x5A)	Len	0x08	Enable	Check_sum

Enable: 0 (Checksum disabled), 1 (Checksum enabled)

This instruction takes effect immediately and configurations are not saved by default.

4.3.9 Restoring factory settings

Send to TF03：

Byte	0	1	2	Len-1
Descriptions	Head(0x5A)	Len	0x10	Check_sum

TF03 returns:

Byte	0	1	2	3	Len-1
Descriptions	Head(0x5A)	Len	0x10	Status	Check_sum

Status: 0 (Successful); non-0 (Failed). This instruction takes effect immediately.

4.3.10 Saving current settings to FLASH

Send to TF03：

Byte	0	1	2	Len-1
Descriptions	Head(0x5A)	Len	0x11	Check_sum

TF03 returns:

Byte	0	1	2	3	Len-1
Descriptions	Head(0x5A)	Len	0x11	Status	Check_sum

Status: 0 (Successful); non-0 (Failed)

After this instruction has been executed, all configuration information is still effective upon reboot.

4.3.11 Configuring over range threshold value

Send to TF03：

Byte	0	1	2	3	4	Len-1
Descriptions	Head(0x5A)	Len	0x4F	Value_low	Value_high	Check_sum

Value:over range threshold value, unsigned short type; 0 indicates no range limit; in addition, it cannot be configured as 0xFFFF.

TF03 returns:

Byte	0	1	2	3	Len-1
Descriptions	Head(0x5A)	Len	0x4F	Status	Check_sum

Status: 0 (Successful), non-0 (Failed)。

This instruction takes effect immediately and configurations are not saved by default.

4.3.12 Configuring CAN Send ID

Send to TF03：

Byte	0	1	2	3	4	5	6	Len-1
Descriptions	Head(0x5A)	Len	0x50	ID_low_0	ID_low_8	ID_high_16	ID_high_24	Check_sum

ID: CAN Send ID

TF03 returns:

Byte	0	1	2	3	Len-1
Descriptions	Head(0x5A)	Len	0x50	Status	Check_sum

Status: 0 (Successful); non-0 (Failed)

This instruction can not take effect until it is executed and restarted with saved

configurations.

4.3.13 Configuring CAN Receive ID

Send to TF03：

Byte	0	1	2	3	4	5	6	Len-1
Descriptions	Head(0x5A)	Len	0x51	ID_low_0	ID_low_8	ID_high_16	ID_high_24	Check_sum

ID: CAN Receive ID

TF03 returns:

Byte	0	1	2	3	Len-1
Descriptions	Head(0x5A)	Len	0x51	Status	Check_sum

Status: 0 (Successful), non-0 (Failed).

This instruction can not take effect until it is executed and restarted with saved configurations.

4.3.14　Configuring CAN baud rate

Send to TF03：

Byte	0	1	2	3	4	5	6	Len-1
Descriptions	Head(0x5A)	Len	0x52	baudrate_low_0	baudrate_low_8	baudrate_high_16	baudrate_high_24	Check_sum

baudrate: CAN communication baudrate, currently able to support 1M, 500K, 250K and 125K only.

TF03 returns:

Byte	0	1	2	3	Len-1
Descriptions	Head(0x5A)	Len	0x52	Status	Check_sum

Status: 0 (Successful); non-0 (Failed).

This instruction can not take effect until it is executed and restarted with saved configurations.

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. For TTL-USB boards, please contact sales or technical support.

Figure 4 Tools example

TF03	TTL - USB board	USB cable	Computer	TF display program

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
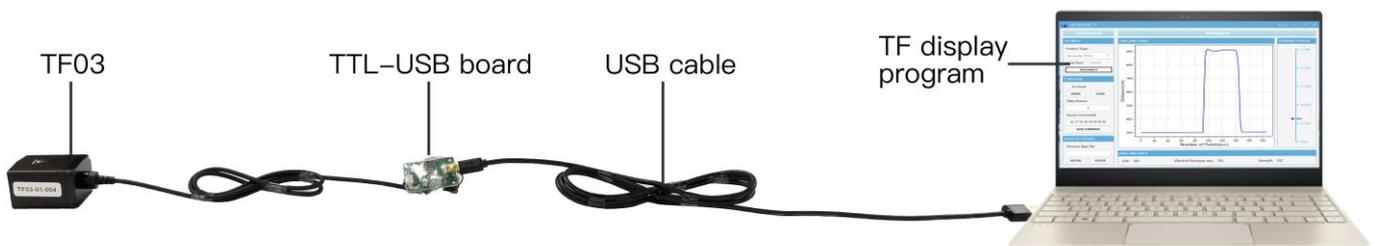
2) Equipment connection

As figure 5 shown, connect 『TF03』 -> 『TTL - 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
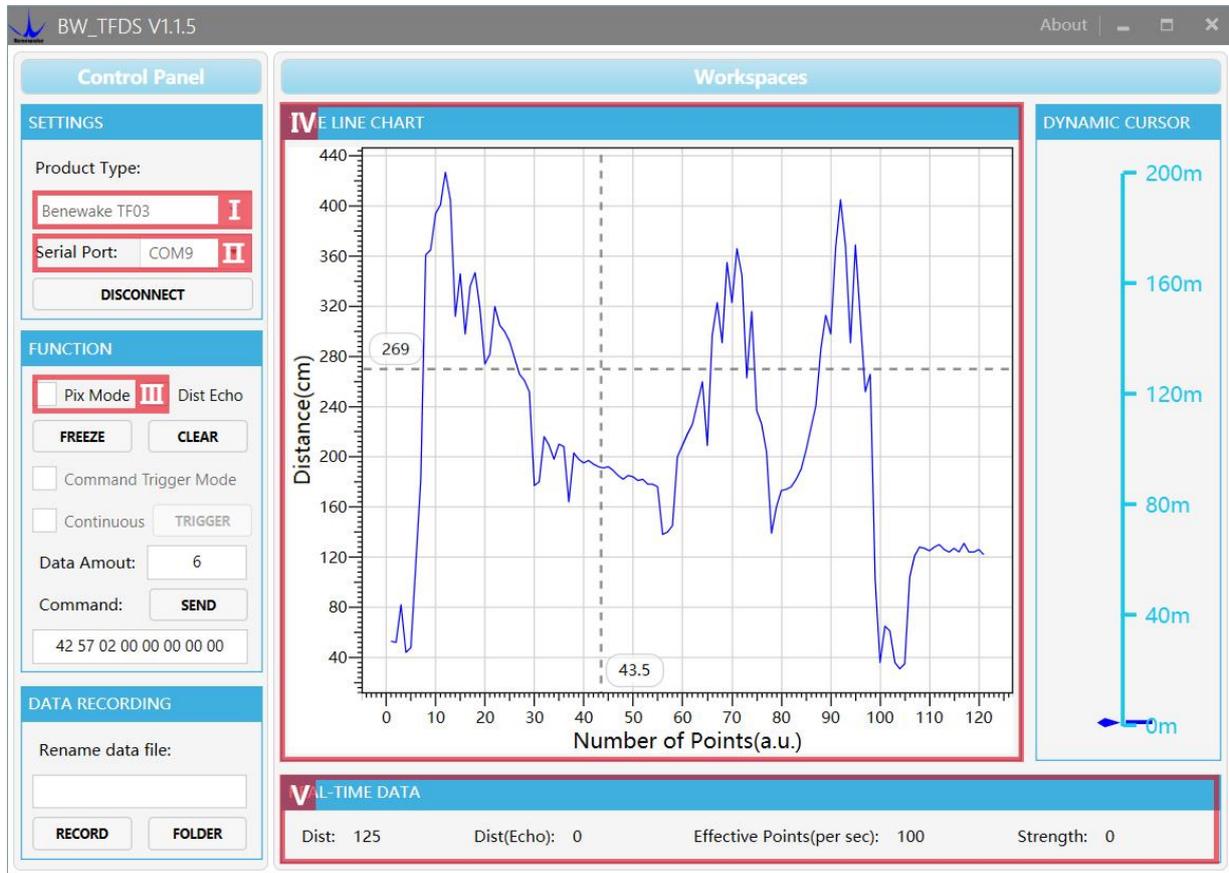
As shown in Figure 6, open the TF display program, select Ⅰ 『Benewake TF03』 and select the serial port for automatic identification (here is Ⅱ 『COM9』).

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 want 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.

6 TF03 Setup software

Figure 7 TF03 Setup software display
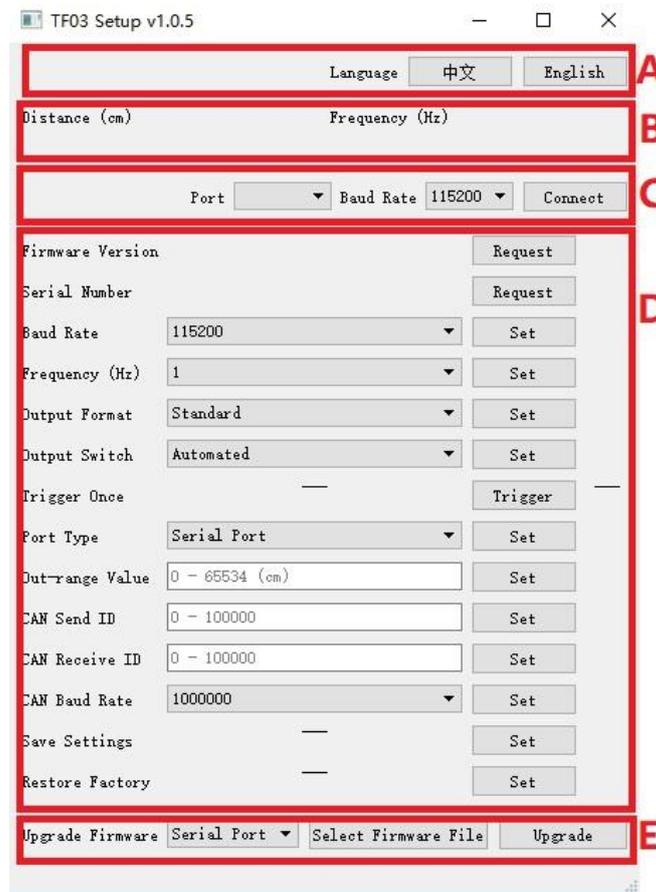
Interface of the custom TF display software is shown in the figure above.

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 0 values.

Reasons: In order to better identify the data validity of TF03, the 0 values are specifically used as abnormal state values. TF03 will output a distance value of 0, generally in two cases: first, the actual distance measured is within the blind zone of TF03; and second, the actual distance measured is beyond the range of TF03. For example, when measuring the distance to a wall, TF03 is 5cm away from the wall but its blind zone is 10cm. As TF03 is unable to measure any valid data, it may output the value 0.

Troubleshooting: Use the value 0 as a value representing abnormal data. In other words, after the value 0 is received, the TF03 output data is not used, but when a non-zero value is received, the TF03 output data will be used.

2) No data output after TF03 is connected.

Reasons: Any product before delivery will undergo strict inspection, so as to ensure that it can be used normally. Therefore, product defects may have arisen during transportation or use.

Troubleshooting: Check whether the power supply is working properly, and whether the voltage level is kept within the range of the rated input voltage. If the power supply is normal, the TF03 lens will display a faint red light.

Check whether data parsing is correct. Parse the data in accordance with the data frame format as described above.

If the problem remains unsolved, contact the technical support team (support@benewake.com). We will try our best to solve your problems.

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

Reason 1: The computer uses an operating system other than Windows.

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

Reason 2: 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.

4) 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 TF03 support other voltage input?

A1: At present, other voltage input are not supported. The standard voltage input for TF03 is 5V. If you have other needs, you can contact our sales staff for further inquiries about customization.

Q2: Can the divergence angle (spot) of TF03 be increased or decreased?

A2: 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.

Q3: Can TF03 change the frequency of data output? Can TF03 output switching values?

A3: 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.

# Attachment 1: Instruction of TF Series PC Display Software

Figure 8 Interface for TF series PC display software
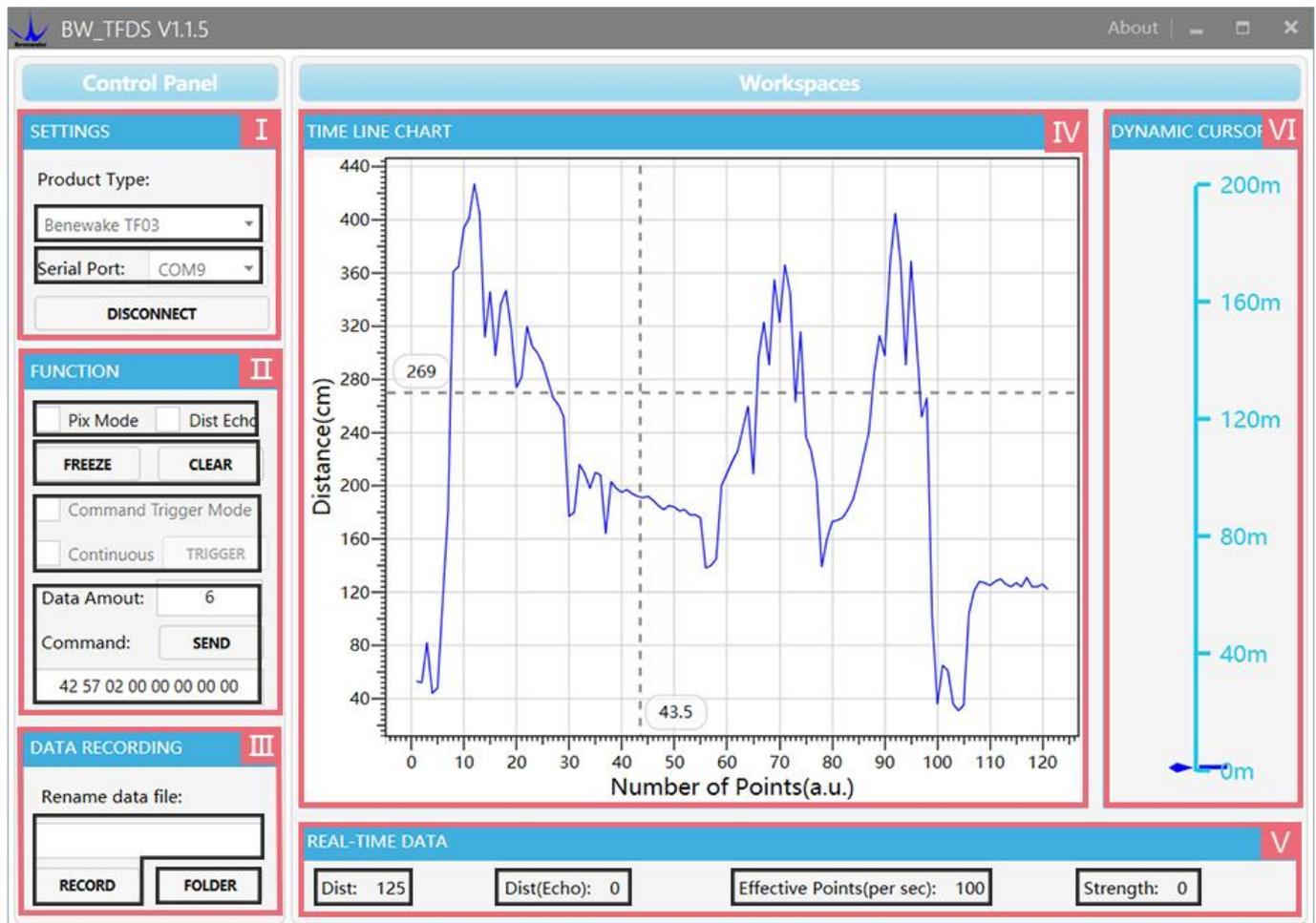
Ⅰ Product model/serial port control area 『SETTINGS』

『Product Type』: Use the TTL-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 Functional area 『FUNCTION』.

『Pix Mode options』: 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.

『Effective Point （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.

Contact information

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Technical support:

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