

TF02 Single-Point Range LiDAR

Product Manual



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Benewake (Beijing) Co., Ltd.

Product as mentioned

Product Model: TF02

Product Name: Single-Point Range LiDAR (Middle Range sensor)

Manufacturer

Company: Benewake (Beijing) Co., Ltd.

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Respected users:

Hello! Thank you for choosing Benewake products! We are honored to join you for solving problems.

In order to offer you better use experience, we hereby have prepared a product operating manual to help you use the product more conveniently and thus better help you solve problems.

This operation manual covers the product operation introduction and common problem solutions, but it is really hard to covers all the problems you maybe meet. If you have other problems while using our products, please consult our technical support staff (support@benewake.com) and we'll do our best to solve your all problems. If you have any comment or suggestion while using our products, you can give us feedback to our official website (<http://www.benewake.com/feedback.html>). We're looking forward to your participation.

We are Benewake who is dedicated to making the best “Robotic Eyes” worldwide!

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1 Considerations

1.1 About the 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 Product use

- This product can only be maintained by qualified professionals and only the original spare parts can be used to ensure its performance and safety.
- There is no reversed polarity input protection and over-voltage protection. Please complete wiring and supply power correctly according to the contents of the Manual.
- The working temperature of the product is between -10°C~60°C; please do not use it beyond the range of temperature to avoid risks.
- The storage temperature of the product is between -20°C~80°C; please do not store it beyond the range of temperature to avoid risks.
- Any assembly or maintenance by opening the shell beyond this Manual is forbidden to ensure the product performance.

1.3 Product failures

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

2 Physical interface

2.1 Line sequence descriptions

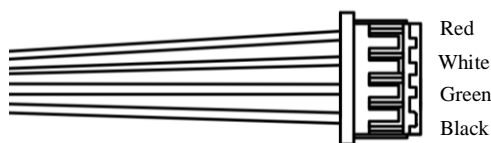


Figure 1 Line sequence of TF02 pins

TF02 external terminal type is 1.25-4p(Molex510210400).

Table 1 TF02 pin functions and connection commands

No.	Color	Line sequence of serial port	Line sequence of CAN port
1	Red	+5V	+5V
2	Black	GND	GND
3	White	TTL-RXD	CAN-L
4	Green	TTL-TXD	CAN-H

2.2 Electrical specifications

There is no reversed polarity input protection and over-voltage protection. Please ensure that the wiring and power supply are normal, and the supply voltage is allowed to fluctuate by $\pm 0.5V$.

Parameter	Numerical value
Power supply voltage	$5 \pm 0.5V$
Peak current	1A
Average power	1W

3 Product installation

M2.5 round head cross screws are recommended to the installation of LiDAR and external structure. Keep the optical lens in the front panel of LiDAR clean and not to be covered.

The zero point of LiDAR ranging is on the optical window surface of the LiDAR front panel.

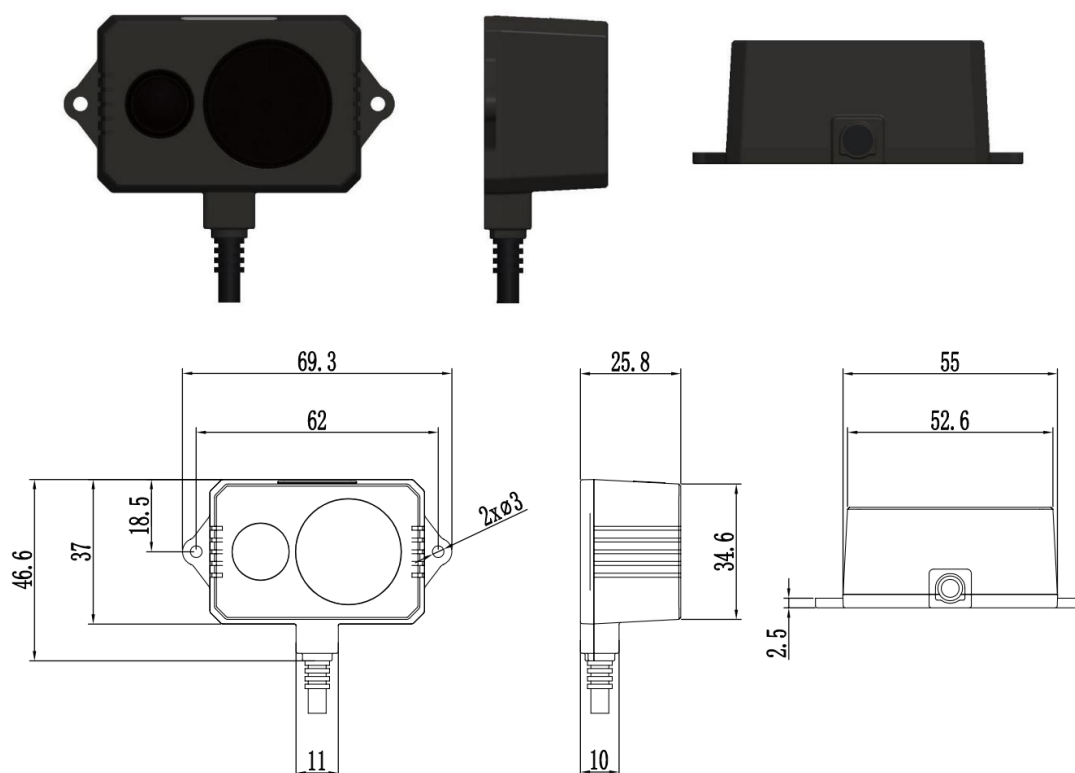


Figure 2 TF02 structural dimensions

4 Communication protocol and data format

There are two type of communication version:serial port version and CAN bus communication version.

4.1 Serial port version

The serial port version of TF02 adopts an UART-LVTTL interface; refer to the specific communication protocol in Table 2. The output level of the serial port is a LVTTL level (0-3.3V).

Table 2 TF02 serial port communication protocol

Item	Content
Communication protocol	UART
Baud rate	115200
Data bit	8
Stop bit	1
Checksum bit	None

1) Serial data format

The output data (hexadecimal numbers) of TF02 is shown in Table 3. Each data frame consists of 9

bytes and the data contains the measured distance information, namely, DIST; the signal strength information, namely, STRENGTH; the signal credibility information, namely is, SIG; the frame tail acts as a data checksum bit.

Table 3 TF02 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 high8-bits
Byte4	STRENGTH_L	STRENGTH low 8-bits
Byte5	STRENGTH_H	STRENGTH high 8-bits
Byte6	SIG	The byte means the data credibility, which is divided into 8 levels, represented by 0x01-0x08 respectively; when the credibility is 7 or 8, it indicates that the data is credible; when the credibility is any other numerical value, the data is incredible.
Byte7	Reserved bit	0x00
Byte8	Checksum	Low 8 bits of Checksum bit, Checksum = Byte0 + Byte2 + ... + Byte7, Checksum are the low 8 bits of the checksum of former 8 bytes

2) Pixhawk serial data format

The Pixhawk data format refers that the unit of the output string is M(meter). For example, if the ranging distance is 1.21meters, then it will output the string 1.21 and each distance value ends with a symbol of line break. The serial port products can support to be modified with Pixhawk format output via host computers or commands.

Note: If the TF02 output distance is 22(m), it indicates outrange or insufficient signal strength; this distance is not reliable and should be cancelled.

4.2 CAN bus version

The CAN communication protocol of TF02 can be customized according to customers' needs and the CAN

baud rate, ID and frame format can be modified. The contents of the protocol are shown in Table 4.

Table 4 CAN communication protocol of TF02

Item	Content
Communication protocol	CAN
Baud rate	1M
ID	0x00090002
Frame format	Extended frame






See Table 5 for the TF02 data format of the CAN version; all data is hexadecimal numbers, each frame of data has a total of 8 bytes and the data contains the measured distance information, that is, DIST; the signal strength information, that is, STRENGTH; the reliability information, that is, SIG.

Table 5 Data frame format of CAN versions

Data bit	Definition	Description
Byte0	DIST_H	DIST hight eight-digit
Byte1	DIST_L	DIST low eight-digit
Byte2	STRENGTH_H	STRENGTH high eight-digit
Byte3	STRENGTH_L	STRENGTH low eight-digit
Byte4	TIME	A larger numerical value indicates longer exposure time.
Byte5	SIG	This bite means the credibility of the data , and the credibility is represented by 0x01-0x08 respectively; when the credibility is 7 or 8, it indicates that the data is credible; when the credibility is any other numerical value, it is not recommended to use the data of this frame.
Byte6	Reserved bit	Reserved bit
Byte7	Reserved bit	Reserved bit

5 Steps for quick testing

5.1 Tools for product testing

				
TF02 (serial port)	TTL - USB board	USB cable	Computer	Host computer software

5.2 Test steps

1) Download the host computer software

Please download 『TF02_GUI. zip』 to get the test host computer software from <http://www.benewake.com/en/down.html>.

Note: Please close the anti-virus software before decompressing 『TF host computer. zip』 ; otherwise, the files in the host computer software will be deleted as viruses; the host computer currently only supports running on the Windows system.

2) Equipment connection

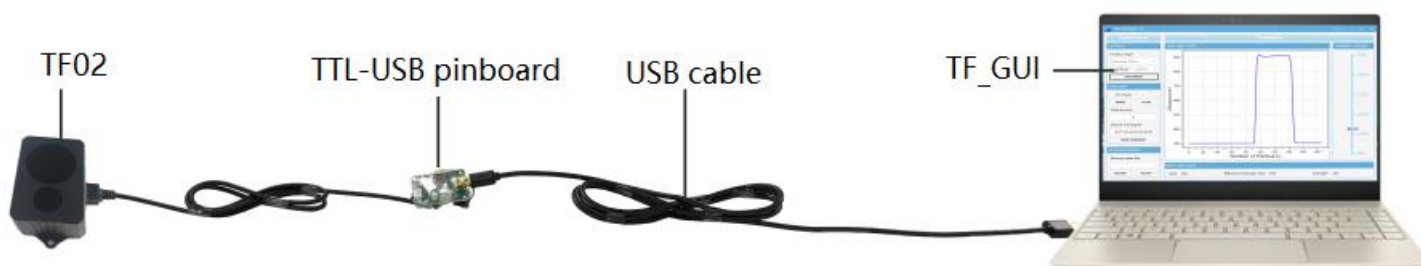


Figure 3 TF02 connected with a computer

As shown in Figure3, connect 『TF02』 , 『TTL-USB pinboard』 and 『USB cable』 in turn, ensure no looseness, and then connect the 『USB cable』 with the 『computer』 .

3) Host computer connection and reading

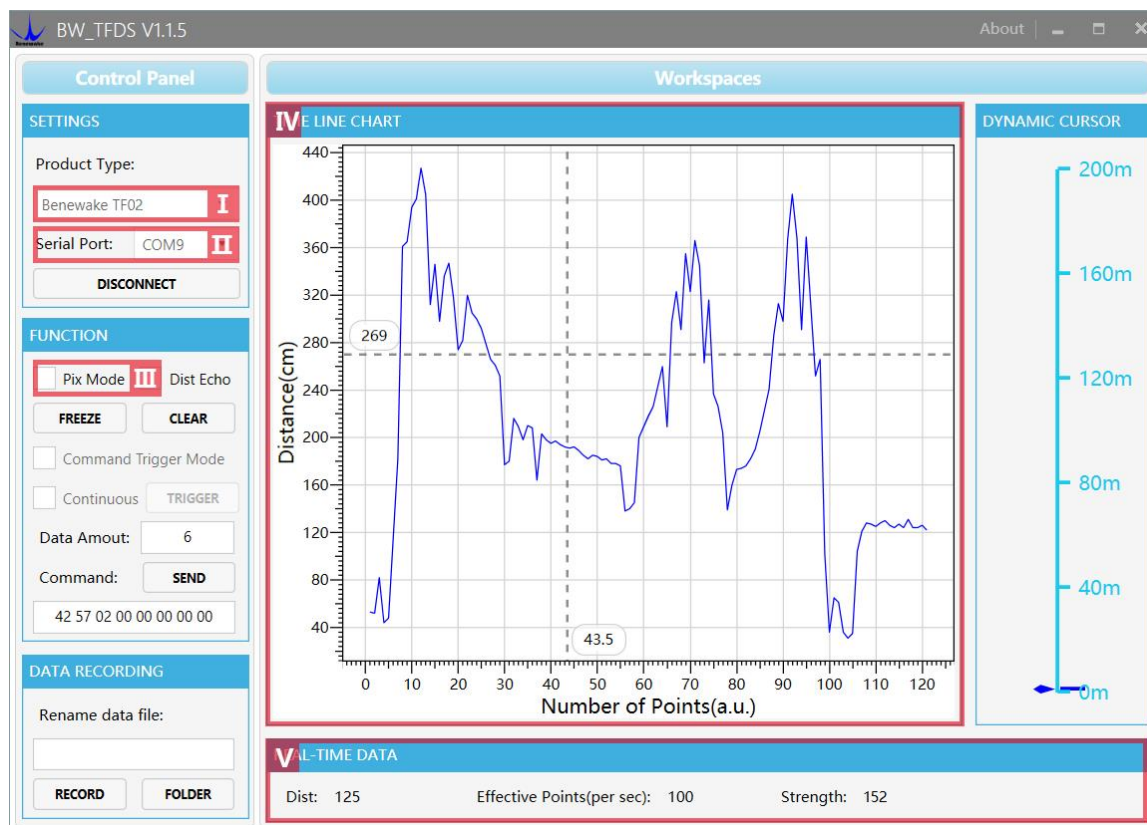


Figure 4 TF host computer interface

As shown in Figure4, open the TF host computer, select I 『Benewake TF02』 and select the serial port for automatic identification (here is II 『COM9』) .

Then, click 『CONNECT』 to connect to the host computer.

After connected successfully, continuous output data images will occur in the right IV 『TIME LINE CHART』 area (with the horizontal and longitudinal coordinates indicating the data size and the real-time ranging value respectively) and the V 『REAL TIME DATA』 area below will display the current real-time test distance (Dist: 125cm), the effective data size per second (Effective Points: 100).

4) Other commands

If TF02 needs to output Pixhawk format strings, check III 『Pix Mode』 first and then the data images can be normally output in the IV 『TIME LINE CHART』 area. After the Pix Mode is checked, the distance unit will change to m.

6 Custom parameter configurations

6.1 Function description

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. Parameters 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.

6.2 Configuration command coded format

Table 6 command coded format description

Data bit	Definition	Description
Byte0	0xAA	Frame header
Byte1	0x55	Frame header
Byte2	0xF0	default
Byte3	0x00	default
Byte4	EE	Parameter 1,see detail function description in table 7
Byte5	FF	Parameter 2,see detail function description in table 7
Byte6	GG	Parameter 3,see detail function description in table 7
Byte7	HH	Command code, see detail function description in table 7

6.3 Parameters configuration and its description

Please connect TF02 with PC by the method of chapter 5.2. Configuration command should be sent to product by TF host computer or other serial port testing software; configuration command could also be sent by customer's host computer.

a) Enter into configuration mode, send: AA 55 F0 00 01 00 00 02,feedback:AA 55 F0 00 01 00 00 02 means

sent successfully;

b) Configure product parameter, send: AA 55 F0 00 EE FF GG HH(Table 7),feedback: AA 55 F0 00 EE FF GG HH means sent successfully;

c) Exit configuration mode, send: AA 55 F0 00 00 00 00 02,feedback:AA 55 F0 00 00 00 00 02 means sent successfully.

Table 7 Parameters configuration command list

No.	Configurable item	Command List	Description
①	Trigger Mode	AA 55 F0 00 03 00 00 F1	Timing trigger (default)
		AA 55 F0 00 01 00 00 F1	Command trigger
②	Fix output frame rate	AA 55 F0 00 EE 00 00 F2	EE: output frequency, range[1,100], valid only in timing trigger mode
③	Working trigger command	AA 55 F0 00 EE 00 00 42	EE: amount of returned data, range [1,64]. When the system is in command-triggered mode, the command can be used to trigger TF02 one time or several times continuously without entering configuration mode.
④	Serial port baud rate	AA 55 F0 00 EE 00 00 60	EE: 0-9600,1-14400,2-19200,3-38400,4-56000,5-57600, 6-115200,7-128000,8-256000 Supports 9 kinds of baud rate, you need to enter the command at the correct baud rate.
⑤	Minimum threshold of signal strength	AA 55 F0 00 EE FF 00 90	EE: low byte FF: high byte In the case of configuration mode, minimum threshold of signal strength can be set and power-down can be saved in flash.

⑥	Read version number	AA 55 F0 00 00 00 00 A0	<p>Feedback version number</p> <p>AA 55 F0 00 mode major minor patch</p> <p>Version number is divided into three levels, such as version number v1.3.5,</p> <p>Major is 1;</p> <p>Minor is 3;</p> <p>Patch is 5;</p>
⑦	Kalman Filter ON /OFF	AA 55 F0 00 EE 00 00 35	<p>EE: 01 Kalman Filter OFF</p> <p>09 Kalman Filter ON</p>
⑧	Set CAN baud rate	AA 55 F0 00 EE 00 00 63	<p>EE: 0-125,1-250,3-500,4-666,5-10000 (Unit: K) Supports 5 kinds of baud rate, you need to enter the command at the correct baud rate.</p>
⑨	Set threshold of measuring range	AA 55 F0 00 EE FF DD 91	<p>EE: low byte</p> <p>FF: high byte</p> <p>DD: Switching level variation</p> <p>In the case of configuration mode, the threshold of measurement range (Unit: cm) can be set by using this command. When DD is 0:the IO level signal is HIGH if the dist is greater than the threshold value,the IO level signal is LOW if dist is lower than threshold. When DD is 1:the IO level signal is LOW if the dist is greater than the threshold value, the IO level signal is HIGH if dist is lower than the threshold.</p>

①Trigger mode:timing trigger mode and command trigger mode are included.Default value is timing trigger mode,output frequency is 100Hz,[1,100] could be set by “fix output frame rate”command;product will not work except by “working trigger command” (it’s unnecessary to enter into configuration mode to this command and could be sent directly,it will be called “working command” for short below)in command trigger mode.Number of distance measurement times(range[1,64]) could be set in ”working command”.For

example,set EE=08,TF02 will measure distance 8 times and then stopped when sending “working command”,TF02 will work again if sending “working command” again.Note:command trigger function is only supported in the version V2.1.4 or higher.

⑤Minimum threshold of signal strength:the default is 20,sig=3 and could not be trusted if signal strength lower than 20. Untrusted data could be filtered by signal strength and sig value.Threshold could also be changed if you have any other demands.For example,if you don’t want to use the data when signal lower than 50,you can change it by this command,sig=3 when signal strength lower than 50,dist could be filtered by sig.Note:real measurement distance maybe far less than the value in datasheet if minimum threshold of signal strength increased.

⑦Kalman filter:default is ON,there will be 5 frame(50ms) delay in order to filter abnormal jump.It could be OFF by this command if real time data is needed.

⑧Set CAN baud rate:this function is supported in the version V2.1.6 or higher(CAN ID setting method could be got by contacting with FAE).

⑨ Set threshold of measuring range:it’s only suitable to the judgement application of distance threshold,HIGH LOW level threshold and inversion could be set by this command.Note:this function is supported in the version V2.1.4 or higher(this function is only supported in serial port,it need to be custom made in CAN port).

7 BootLoader upgrade

Use the BTools Sub software to upgrade BootLoader; the software interface is shown in Figure 5.

This host computer software is mainly used for remote firmware upgrading and suitable for remote upgrading of all TF02 products. The Serial port version TF02 upgrade needs to connect with the computer via the USB-TTL board while the CAN port version TF02 upgrade needs to connect to the computer through the CAN to the USB board (connection mode refer to chapter 5.2), thus to enter the host computer interface and complete the upgrade.

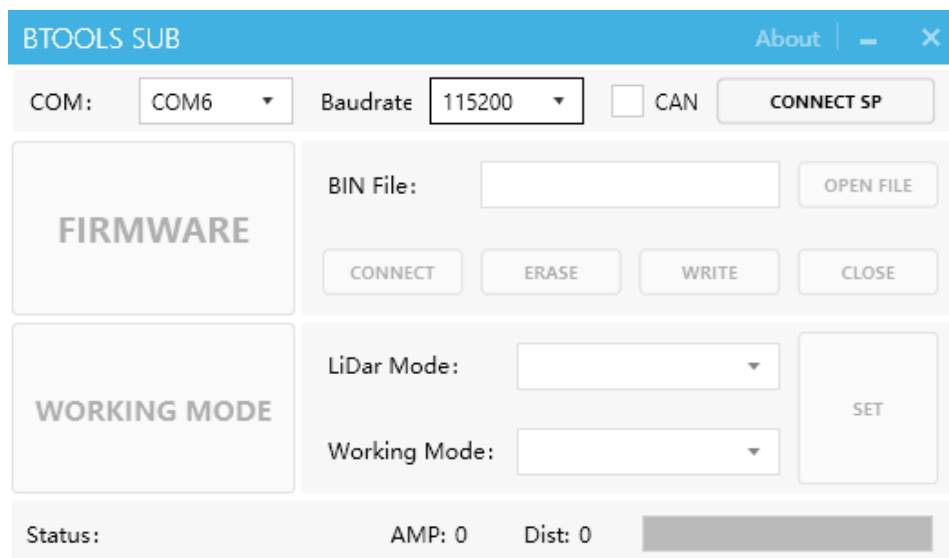


Figure 5 BTools Sub software interface

The product upgrading steps are as followings:

- 1) Double click “BTools.exe” to open the host computer interface and establish connection;
- 2) Select the port number;
- 3) When connecting a serial port version, select the baud rate “115200” and never select “CAN”;
- 4) Select “FIRMWARE” and click “OPEN FILE” to open the bin file;
- 5) Click “CONNECT” and it will pop up the “succeed” window if successfully;
- 6) Click “OK” to continue;
- 7) Click “ERASE” and it will pop up the “succeed” window in 2~3 seconds if successfully;
- 8) Click “OK” to continue;
- 9) Click "WRITE" to start writing the program; the progress bar at the bottom of the host computer interface shows the progress and it will pop up the “succeed” window if successfully;
- 10) After the program has been written, click “CLOSE” to disable the firmware write-in mode and the LiDAR will return to normal work.

Note:

- 1) The working mode configuration “WORKING MODE” is generally applicable to serial port products, and the CAN version products do not need to be configured;
- 2) According to customers’ personal need, the data package requires different formats, the AMP (signal strength) and DIST (distance value) displayed below are not always accurate, so please verify the data correctness through other host computers.

8 FAQ&A

Q1: May I ask whether TF02 can support other voltage power supply?

A1: 5V is the standard power supply of TF02. Moreover, 4.5-8.5V power supply versions are also available.
If necessary, please contact the sales staff for customization.

Q2: Can TF02 have its divergence angle (light spot) become larger or smaller?

A2: Hello, this is a custom made requirement. Please contact the sales staff for details. The divergence angle is determined on the basis of the product performance at the beginning of the product design and moreover, it also requires close coordination between the optical system and the product structure, so it can not be easily changed, but needs to be customized.

Q3: How long can the serial port line of TF02 be extended at max? Can I directly extend the serial port line to increase the transmission distance?

A3: Hello, the effective transmission distance is about 2m for data transmission of serial port TF02. If you need a longer distance of data transmission, it is recommended that you convert the serial port communication to others, for example, RS485 communications, and then extend the data cable for farther transmission.

Q4: How long is the continuous working life of TF02 under normal conditions?

A4:TF02 enjoys a one-year-long warranty period, but under normal circumstances, it can be used for more than three years.

Q5: Can TF02 support RS485 communication interface, analog output and MODBUS protocol?

A5: The standard version TF02 temporarily does not support any interfaces other than TTL serial port or CAN. It adopts a Benewake standard protocol and does not support MODBUS protocol for the time being. If there are relevant requirements, mass customization can be discussed.

Q6: Does TF02 have a command trigger function or external trigger function?

A6: “command trigger” has been added,product could measure the distance by trigger command in command trigger mode, see command in table 7.

Q7: Can TF02 change its measuring frequency?

A7: It could be changed during 1~100Hz, see command in table 7.

