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TF02-i Distance Sensors

Benewake TF02-i Distance Sensors User Manual

Contents

Benewake TF02-i Distance Sensors

Specifications

Type	Parameters	Values
Operating range	90% reflectivity, 0Klux	0.1m~40m
	10% reflectivity, 0Klux	0.1m~13.5m
	90% reflectivity, 100Klux	0.1m~40m
	10% reflectivity, 100Klux	0.1m~13.5m

Product Overview
TF02-i is a single-point ranging LiDAR upgraded based on TF02-Pro. It has been optimized and upgraded in terms of communication interface, input voltage, etc., to meet the needs of various industrial scenarios. The product is based on the principle of ToF (time of flight) and has stable, accurate, and highly sensitive measurement performance.

Technical Specifications
TF02-i offers accurate distance measurement with a resolution of 1cm. It operates within a range of 0.1m to 40m for 90% reflectivity and 0Klux lighting conditions. Maintenance and Cleaning

- Before switching on, check if the exposed window mirror is clean; clean it promptly if dirty.
- After use, check the optics for contamination and clean if necessary.
- Clean the optics regularly if operating in a severe environment for an extended period.
- Disconnect power before cleaning. Gently wipe the window with a soft cloth in one direction when the device is not operating to avoid damage.

PREFACE
Dear users:
Thank you for choosing Benewake products. For the purpose of offering 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 may meet. This user manual contains the relevant information on product introduction, usage and maintenance of TF02-i, covers the product operation introduction and common problem solutions. Please read this manual carefully before using the product. Remember the precautions to avoid hazards, and please follow the described steps in the manual when using it.

If you have any problems in the process of usage, you are welcome to contact Benewake at any time for help.

Contact Details

- **Official website: en.benewake.com**
- **TEL** +86-10-57456983
- **Technical questions please contact support@benewake.com**
- Consult sale information or request brochure please contact **bw@benewake.com**
- **Headquarters Address**

  Benewake (Beijing) Co., Ltd. 3rd Floor, Haiguo Jiaye Sci-Tech Park, Haidian District, Beijing, China

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Disclaimer

As our products are constantly improving and updating, the specifications of TF02-i are subject to change. Please refer to the official website for latest version.

OVERVIEW

TF02-i is a single-point ranging LiDAR upgraded based on TF02-Pro. It has been optimized and upgraded in terms of communication interface, input voltage, etc., to meet the needs of various industrial scenarios. The product is based on the principle of ToF (time of flight) and has stable, accurate and highly sensitive measurement performance.

Technical Specification

Table 1- 1 Technical Specification of TF02-i

Type	Parameters		Values
Product performance	Operating range	90% reflectivity, 0Klux	0.1m~40m
		10% reflectivity, 0Klux	0.1m~13.5m
		90% reflectivity, 100Klux	0.1m~40m
		10% reflectivity, 100Klux	0.1m~13.5m
	Accuracy[1]		±5cm 0.1m~5m ±1% 5m~40m
	Distance resolution[1]		1cm
	Frame rate[2]		1Hz~100Hz adjustable, default100Hz
	Repeatability[1]		1σ: 2cm 0.1m~35m@90% reflectivity
	Ambient light immunity		100Klux
	Enclosure rating		IP65
Optical parameters	Photobiological safety		Class1 (IEC60825)
	Central wavelength		850nm
	Light source		VCSEL
	FoV[3]		3°
Electrical parameters	Supply voltage		DC 7V~30V
	Average current		≤70mA @12V
	Power consumption		≤0.85W @12V
	Peak current		100mA
Others	Dimension		69mm×41.5mm×31.5mm (L×H×W)
	Housing		ABS/PC/PMMA
	Operating temperature		-20℃~60℃
	Storage temperature		-30℃~80℃
	Weight		60g (with cables)
	Cable length		70cm

Note

1. The detection is measured with the standard white board (90% reflectivity).
2. The frame rate can be adjusted. The default value is 100Hz and the maximum value is 100Hz, the customized frame rate should be calculated by the formula: 200/n (n is an integer with ≥ 2).
3. The angle is a theoretical value, the actual angle value has some deviation.

Maintenance and Cleaning

• Before switching on, please check if the exposed window mirror is clean, and clean it promptly if it is dirty.

- After using the device, check the optics. If it is contaminated, please clean it promptly.

- The optics should be cleaned regularly if the device be operated in a severe environment for a long time.

- Before regular cleaning, please disconnect the power. Using a soft cloth to gently wipe the window in the same direction when the device is not operating, to avoid repeated wiping and damage to the window mirror.

- When cleaning the window, do not use alcohol to clean, so as not to damage the window.

- If you require deep cleaning of internal optics, please contact **bw@benewake.com** to offer professional advice.

Appearance and Structure

The appearance and dimensions of TF02-i are shown in Figure 1- 1 and Figure 1- 2:

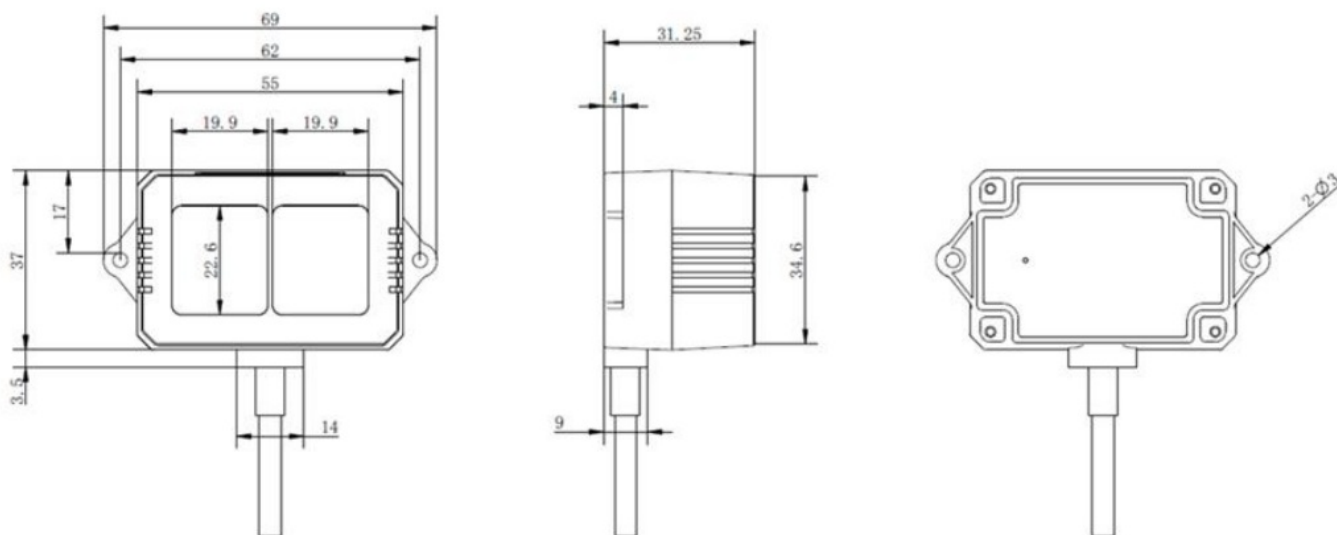Figure 1- 1 Appearance of TF02-i

Figure 1- 2 Dimension of TF02-i (Unit: mm)

TF02-i is recommended to use M2.5 round Phillips screws for installation. Please remove the protective film of the optical lens before use. The lens of front panel of LiDAR cannot be covered. Please keep it clean. The surface of optical lens is the rangingzero of LiDAR. The detection angle of TF02-i is 3°. At different distances, the size of light spot, namely the edge length of the detection range, is different. Side length of the detection range at different distances (the detection range is a square), as shown in Table 1- 2.

Table 1- 2 Spot Size at Different Distances

Distance m	1	2	3	5	7	10	20	30	40
Spot size cm	5	10	16	26	37	52	105	156	208

Note: The side length of target object generally should be larger than size of the TF02-i light spot; if the side length of the detected object is smaller than size of light spot, the output (Distance) from TF02-i will be a value between the actual distance values of the two objects.

Storage

- Device should be stored at -30°C to 80°C with a relative humidity ≤ 60% and ventilation free from corrosive gases.
- Before storage, please make sure that all connections are disconnected or dust covers are inserted or covered to ensure cleanliness.
- If storage time is over three months, please carry out a working test before using, to ensure that the device can be used in normal condition.
- For ensuring the product performance, do not open the product shell or remove the IR-pass filter.

Application
When using the product, please read the specifications, user manual and the precautions mentioned in the user manual in detail to ensure that the product is used within the rated specifications. The product is designed for use in the following scenarios:

- Robot
- Intelligent Transportation
- Intelligent Device
- UAV
- Other Industrial Products

If you use the product beyond the above application scope, please carefully evaluate whether the reliability requirements of the product to be applied match this product, or contact Benewake at any time to assist in solving it.

INTERFACE

Description Of Wiring Sequence
Terminal model: MH1.25-7P-W/B, size of single wire is AWG26, diameter of single wire is 0.404mm, cross-sectional area is 0.129mm2, which show in Table 2- 1.
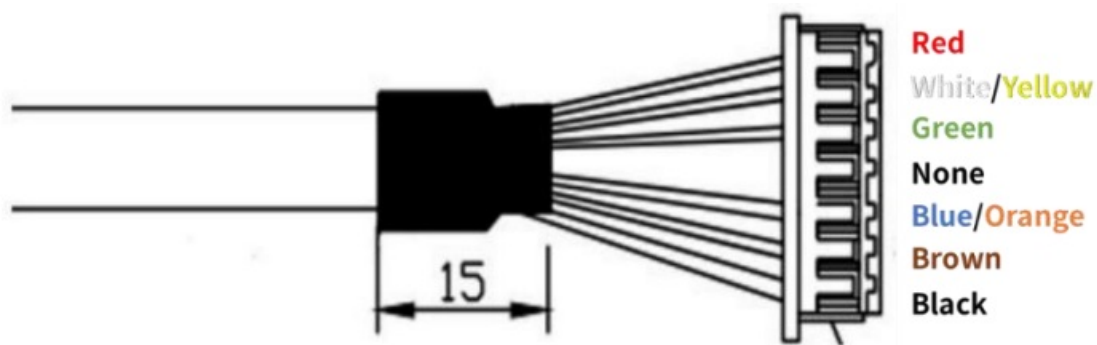
Figure 2- 1 TF02-i external wiring connector and wiring sequence

Table 2- 1 The Function Description of Each Wire

Pin	Wiring color	Function	Comment
1	Red	VCC	Power supply
2	White/Yellow	RS485-B/CAN_L	RS485-B/CAN bus
3	Green	RS485-A/CAN_H	RS485-A/CAN bus
4	N/A	N/A	N/A
5	Blue/Orange	UART_RXD	UART receive (Debug)
6	Brown	UART_TXD	UART transmit (Debug)
7	Black	GND	Ground

Warning

1. The hardware of RS-485 and CAN is different; Do not mix UART cable with RS485 or CAN bus, otherwise it will cause damage of MCU.
2. TF02-i with RS-485 interface does not support UART debugging pins.

Electrical Characteristics
Table 2- 2 Main Electrical Parameters of TF02-i

Parameter	Values
Supply voltage	DC 7V~30V
Average current	≤70mA@12V
Peak current	100mA
Average power consumption	≤0.85W@12V

COMMUNICATION PROTOCOL

There are two communication interfaces available. The hardware of RS485 and CAN is different. The interface can not be switched by command.

RS-485 Communication Protocol

Communication protocol
Modbus protocol is the default setting for RS-485 interface. The parameter is shown in Table 3- 1. The default value of baud rate and slave ID is 115200 and 0x01.

Table 3- 1 RS-485 Communication protocol of TF02-i

Characteristics	Values
Communication interface	RS-485
Baud rate	115200
Data bit	8
Stop bit	1
Parity	None

Note
The following baud rates are supported: 9600 14400 19200 38400 43000 57600 768000 115200(default) 128000 230400 256000. It is not recommended to use a baud rate above 115200 for communication because of communication stability.

Parameter configuration description of Modbus protocol
Description of data frame
When Modbus protocol of TF02-i is enabled, the Modbus command format of reading distance is shown in Table 3- 2.

Table 3- 2 The command format of reading distance

Addr.	Function code	Register Addr.		Register Value		CRC_Low	CRC_High
01(Default)	03	00	00	00	01	xx	xx

The response data frame format is shown in Table 3- 3.

Table 3- 3 The response date frame format

Addr.	Function code	Length	Dist_High	Dist_Low	CRC_Low	CRC_High
01(Default)	03	02	XX	XX	xx	xx

Function code
The function code of TF02-I is shown in Table 3- 4.

Table 3- 4 The function code

Function Code	Description
03	Read register
06	Write register

Register address list

- All register addresses are hexadecimal and register values are 16 bits;
- After setting parameter, save and restart to take effect.

Register address list using function code: 0x03(read only)

Table 3- 5 Register address of function code (0x03)

Register Addr.	Definition	Description
00 00	Dist	Distance value, unit: cm
00 01	Strength	Signal strength
00 03	High 16 bits of timestamp	High 2 bytes of time stamp, unit: ms
00 04	Low 16 bits of timestamp	Low 2 bytes of time stamp, unit: ms
00 06	High 16 bits of firmware version	0x00 and main version number
00 07	Low 16 bits of firmware version	Sub-version and revised version number

Register address list using function code: 0x06(write only): Table 3- 6 Register address of function code (0x06)

Register Addr.	Definition	Description
00 80	Save setting	Write any value to save settings
00 81	Power off/Reboot	Register value: 0x00: power off (Not currently supported) 0x01: reboot
00 82	Disable Modbus	Register Value: 0x01: Disable Modbus

00 83	High rate	16	bits	of	baud	Set baud rate, save and reboot to take effect
00 84	Low 16 bits of baud rate					Set baud rate, save and reboot to take effect
00 85	Slave ID					Set slave ID, save and reboot to take effect (default 0x01)
00 86	Frame rate					Set frame rate, save and reboot to take effect (default 100Hz)
00 87	Working mode					Set working mode, save and reboot to take effect. Register value: 0x00: continuous detection mode (default) 0x01: triggering mode
00 88	Low power consumption mode					Set low power consumption mode, save and reboot to take effect. Register value: 0x00: Disable (default) 0x0N: Enable, N is a positive integer with ≤10,which is sampling frequent of TF02-i
00 89	Restore default					Write any value, save and reboot to take effect

Parameter configuration

Table 3- 7 General command of RS-485 serial communication mode

Function	Command	Respnse	Description
Enable Modbus	5A 05 15 01 75	5A 05 15 01 75	Save and reboot to take effect
Strength threshold and distance under threshold	5A 07 22 XX LL HH SU	5A 07 22 XX LL HH SU	The default setting is: When strength is below 60, make distance output 4500cm: XX=60/10=6(DEC)=06(HEX) 4500(DEC)=1194(HEX) LL=94 HH=11
Save setting	5A 04 11 6F	5A 05 11 00 70	

Table 3- 8 General command of Modbus protocol

Function		Command			Response	Description
						DH: High 8 bits of distance
Read		01 03 00	00	00	01 03 02 DH	DL: Low 8 bits of distance
distance		01 84 0A			DL CL CH	CH: High 8 bits of CRC
						CL: Low 8 bits of CRC
Read distance and signal strength		01 03 00 00 00 02 C4 0B			01 03 04 DH DL SH SL CL CH	SH: High 8 bits of signal strength SL: Low 8 bits of signal strength
Read firmware version		01 03 00 02 24 0A	06	00	01 03 04 00 VM VS VC CL CH	VM: Main version number VS: Sub-version number VC: Revised version number
						BH1: High 8 bits of baud rate
						BH2: Secondary high 8 bits of
Set baud rate		01 06 00 83 BH1 BH2 CL CH 01 06 00 84 BL1 BL2 CL CH			01 06 00 83 BH1 BH2 CL CH 01 06 00 84 BL1 BL2 CL CH	baud rate BL1: Secondary low 8 bits of baud rate BL2: Low 8 bits of baud rate For example: Set baud rate to 9600 (0x00002580):
						BH1=00 BH2=00 CL=78 CH=22,
						BL1=25 BL2=80 CL=D2 CH=D3
Modify ID	slave	01 06 00 85 IH IL CL CH			01 06 00 85 IH IL CL CH	IH: High 8 bits of slave ID IL: Low 8 bits of slave ID For example: Modify slave ID to 0x0002: IH=00 IL=02 CL=19 CH=E2
Modify frame rate		01 06 00 86 FH FL CL CH			01 06 00 86 FH FL CL CH	FH: High 8 bits of frame rate FL: Low 8 bits of frame rate For example: Modify frame rate to (0x0064): FH=00 FL=64 CL=69 CH=C8 — 100

Low power consumption mode	01 06 00 88 LH LL CL CH		01 06 00 88 LH LL CL CH	LH: High 8 bits of sampling frequent in low power consumption mode LL: Low 8 bits of sampling frequent in low power consumption mode For example: Set it to 5Hz low power consumption mode,
				LH=00 LL=05 CL=C9 CH=E3
Save setting	01 06 00	80	00	01 06 00 80 00	Save and reboot to take effect

	00 88 22	00 88 22	
Disable Modbus	01 06 00 82 00 01 E8 22	01 06 00 82 00 01 E8 22	Save and reboot to take effect
Restore default	01 06 00 89 00 00 58 20	01 06 00 89 00 00 58 20	

Warning
RTU mode is only supported for communication in serial communication.

For example:

1. **Enable Modbus protocol in RS-485 serial communication mode:**
   - 5A 05 15 01 75 //Enable Modbus protocol
   - 5A 04 11 6F //Save settings

   Enter Modbus protocol mode after rebooting.
2. **Disable Modbus protocol:**
   - 01 06 00 82 00 01 E8 22 //Default address is 0x01, disable Modbus protocol
   - 01 06 00 80 00 00 88 22 //Default address is 0x01, save setting

   Exit Modbus protocol after rebooting.

Warning

1. 0 is the broadcast ID, the transmitting and receiving ID cannot be set to 0.
2. The following baud rates are supported: 1000kbps 900 kbps 800 kbps 666 kbps 500 kbps 400 kbps 250 kbps 200 kbps 160 kbps 125 kbps

CAN Communication Protocol
Communication Protocol
The CAN communication protocol of TF02-i supports customer-defined protocol parameters or customized services, and the CAN protocol baud rate and ID can be modified. The CAN protocol is shown in Table 3- 9.

Table 3- 9 CAN communication protocol of TF02-

Communication interface	CAN
Baud rate	250kbps
Transmitting ID	0x00000003
Receiving ID	0x00000003
Frame format	Standard frame

Warning

1. 0 is the broadcast ID, the transmitting and receiving ID cannot be set to 0.
2. The following baud rates are supported: 1000kbps 900 kbps 800 kbps 666 kbps 500 kbps 400 kbps 250 kbps 200 kbps 160 kbps 125 kbps 100 kbps.

CAN Communication Data Frame
The data protocol of CAN is shown in Table 3- 10. Each data frame consists of 8 bytes and the data contains the distance (unit: cm), signal strength and timestamp (unit: ms).

Table 3- 10 The date frame format of CAN communication

Data byte	Definition	Description
Byte0	Dist_L	Low 8 bits of distance
Byte1	Dist_H	High 8 bits of distance
Byte2	Strength_L	Low 8 bits of signal strength
Byte3	Strength_H	High 8 bits of signal strength
Byte4	Timestamp	Low 8 bits of timestamp
Byte5	Timestamp	Secondary low 8 bits of timestamp
Byte6	Timestamp	Secondary high 8 bits of timestamp
Byte7	Timestamp	High 8 bits of timestamp

CAN Bus Network
The CAN bus network is mainly hung in CAN_H and CAN_L, and each node performs serial differential transmission of signals through two lines. In order to avoid signal reflection and interference, it is recommended to connect 120Ω end point resistors at both ends of the bus, as shown in Figure 3- 1.
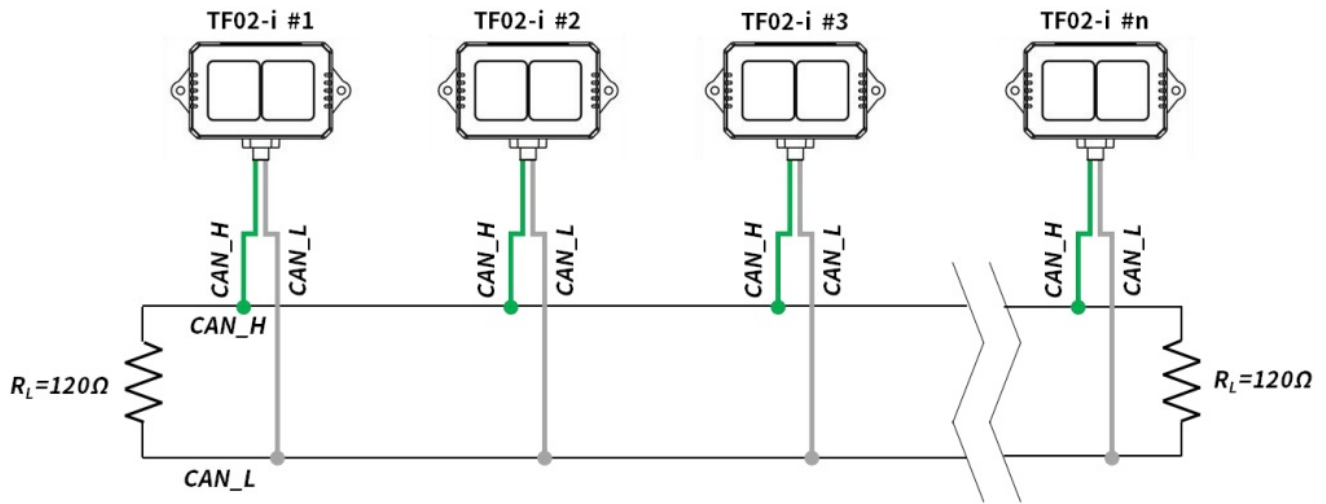
Figure 3- 1 CAN bus network of TF02-i

Note

It is recommended to contact Benewake to communicate the details of use to complete networking requirements.

Parameter Configuration of CAN Communication

The configuration command format of CAN communication is shown as below.

Table 3- 11 The configuration command format

Byte	0	1	2	3	4	5-8	9-12	13
Description	Header	Length	ID	Type	Baudrate	Recv_id	Trans_id	Check_sum
Default	0x5A	0x0E	0x51	0	0x08	0x00000003	0x00000003	SU

- **Type**: 0(Standard Frame), 1(Extended Frame);
- **Recv_id:** TF02-i receiving ID, Little Endian;
- **Send_id:** TF02-i transmitting ID, Little Endian.
- **Baudrate:** The code of baud rate, default 250kbps, corresponding to 0x08. The relation between baud rate(unit: kbps) and Byte4 is shown as below:

Table 3- 12 The byte4 value corresponds to the baud rate

Byte4 value	0	1	2	3	5
Baud rate (unit: kbps)	1000	900	800	666	500
Byte4 value	**8**	**10**	**11**	**14**	**16**
Baud rate (unit: kbps)	250	200	160	125	100

Example of configuration:

- **Example1**: Standard frame, Baud rate 500kbps, receiving ID=0x00000010, transmitting ID=0x00000020
- **Command**: 5A 0E 51 00 05 10 00 00 00 20 00 00 00 EE
- **Example2**: Extended Frame, Baud rate 250kbps, receiving ID=0x0000AABB, transmitting ID=0x0000CCDD

- **Command**: 5A 0E 51 01 08 BB AA 00 00 DD CC 00 00 D0

Other Parameter Configuration

Table 3- 13 General parameter configuration of TF02-i

Function	Command	Response	Description
Read firmware version	5A 04 01 5F	5A 07 01 V1 V2 V3 SU	Version V3.V2.V1
Frame rate[1]	5A 06 03 LL HH SU[1]	5A 06 03 LL HH SU	1-100Hz, default 100Hz LL: Low 8 bits of frame rate HH: High 8 bits of frame rate
Trigger detection	5A 04 04 62	Data frame	Set frame rate to 0, detection can be triggered with this command
System reset[3]	5A 04 02 60	5A 05 02 00 61	Succeeded
		5A 05 02 01 62	Failed

Disable/Enable output	5A 05 07 00 66	5A 05 07 00 66	Disable data output
	5A 05 07 01 67	5A 05 07 01 67	Enable data output
Strength threshold and distance under threshold	5A 07 22 XX LL HH SU	5A 07 22 XX LL HH SU	The default setting is: When strength is below 60, make distance output 4500cm: XX=60/10=6(DEC)=06(HEX) 4500(DEC)=1194(HEX) LL=94 HH=11
Restore to factory settings	5A 04 10 6E	5A 05 10 00 6F	Succeeded
		5A 05 10 01 70	Failed
Save setting[4]	5A 04 11 6F	5A 05 11 00 70	Succeeded
		5A 05 11 01 71	Failed
Enable/Disable 120Ω terminal resistor[5]	5A 05 60 01 C0	5A 05 60 01 C0	Enable 120Ω terminal resistor
	5A 05 60 00 BF	5A 05 60 00 BF	Disable 120Ω terminal resistor

Warning

1. The customized frame rate should be calculated by the formula: 200/n (n is an integer with ≥ 2).

2. SU is checksum, checksum is disable by default.
3. Please keep power on and wait 1s after sending system reset command, otherwise the settings will not take effect.
4. After parameters configuration, send saving settings command to save the configuration, otherwise the settings will not take effect.
5. 120Ω terminal resistor is disable in default.

FAQ

Q: Can the frame rate be adjusted on TF02-i?
A: Yes, the frame rate can be adjusted within a range of 1Hz to 100Hz, with the default value set at 100Hz.

Q: What is the power supply voltage range for TF02-i?
A: TF02-i operates within a supply voltage range of DC 7V to 30V.

Documents / Resources

TF02-i User Manual	**Benewake TF02-i Distance Sensors** [pdf] User Manual TF02-i, TF02-i Distance Sensors, Distance Sensors, Sensors

References

- **User Manual**