Nooploop TOFSense-F Laser Range Sensor User Manual

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Disclaimer

Document Information

Nooploop reserves the right to change product specifications without notice. As far as possible changes to functionality and specifications will be issued in product specific errata sheets or in new versions of this document. Customers are advised to check with Nooploop for the most recent updates
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Regulatory Approvals

The TOFSense-F series sensors, as supplied from Nooploop, has not been certified for use in any particular geographic region by the appropriate regulatory body governing radio emissions in that region although it is capable of such certification depending on the region and the manner in which it is used. All products developed by the user incorporating the TOFSense-F series sensors must be approved by the relevant authority governing radio emissions in any given jurisdiction prior to the marketing or sale of such products in that jurisdiction and user bears all responsibility for obtaining
such approval as needed from the appropriate authorities.

1Introduction

This document mainly introduces how to use the TOFSense-F and TOFSense-F P, as well as the precautions to be taken during use. You may need to refer to the following information for assistance in understanding:

- TOFSense-F_Datasheet.pdf

2 UART Output

2.1 Active Output

The UART active output mode can be used in single module configurations for TOFSense-F/TOFSense-F P modules, which by default output measurement information at a frequency of 50Hz (maximum 350Hz), and the

output format follows the NLink_TOFSense_Frame0 protocol.
To connect TOFSense-F series products to the NAssistant software via a USB to TTL module (referring to the data manual for wiring and power voltage), after successful identification, click to enter the setting page . The configuration diagram for UART active output mode is shown in Figure

1. After configuring the parameters, you need to click the ‘Write Parameters’ button to save the

parameters. Once the parameters are written successfully, you can read the parameters once to confirm if they have been successfully saved. (After changing the baud rate parameter of the module, you need to unplug and replug the USB to TTL module for the module to be automatically recognized.)

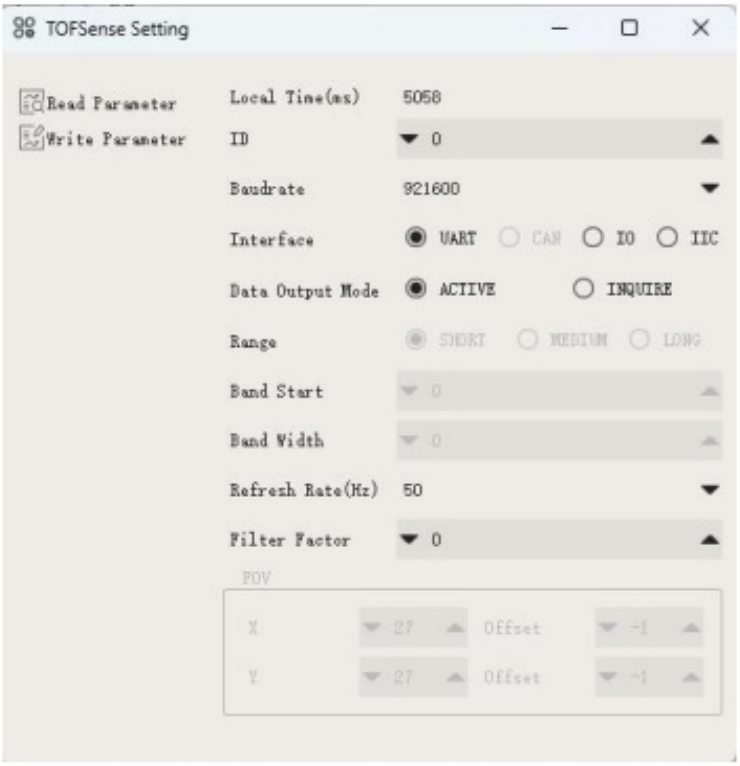


Figure 1: Configuration diagram for UART active output mode

2.2 Query Output

The UART query output mode can be used in single module configurations for TOFSense-F series products. In this mode, the controller sends a query command containing the module ID to the module to be queried, and the module outputs a frame of measurement information. The query frame format follows the NLink_TOFSense_Read_Frame0 protocol, and the output frame format follows the NLink_TOFSense_Frame0 protocol.
To connect TOFSense-F series products to the NAssistant software via a USB to TTL module (referring to the data manual for wiring and power voltage), after successful identification, click to enter the setting page . The configuration diagram for UART query output mode is shown in Figure

2. After configuring the parameters, you need to click the ‘Write Parameters’ button to save the

parameters. Once the parameters are written successfully, you can read the parameters once to confirm if they have been successfully saved. (After changing the baud rate parameter of the module, you need to unplug and replug the USB to TTL module for the module to be automatically recognized.)
Figure 2: Configuration diagram for UART query output mode

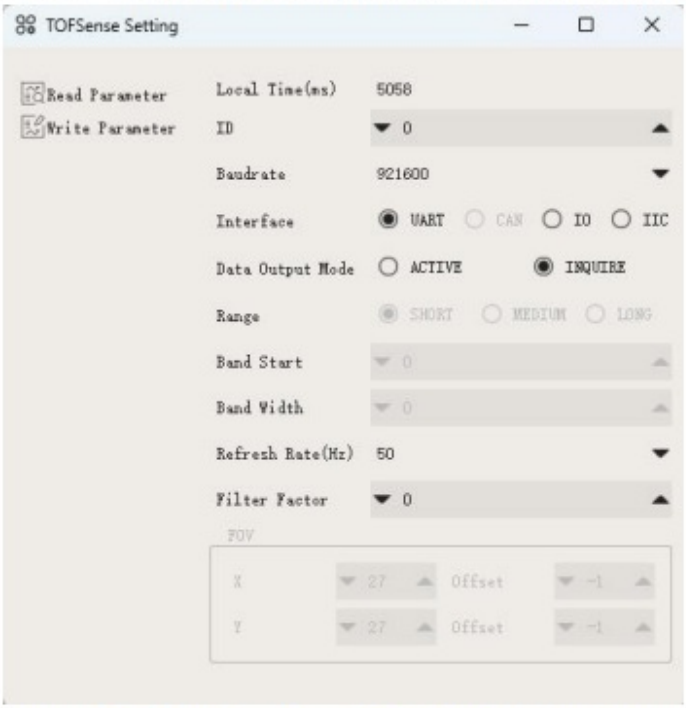


Figure 2: Configuration diagram for UART query output mode

3 IIC Output

3.1 IIC Communication

In IIC communication mode, the controller can send a read frame to the specified slave address of the module to be queried according to the IIC communication timing to obtain distance and other related information of the module. In addition, various parameters such as the output mode of the module can also be changed through IIC communication. The format of the read and write frames follows the NLink_TOFSense_IIC_Frame0 protocol. When the module is in UART mode (note that NAssistant cannot recognize modules in IIC mode), TOFSense-F series products can be connected to the NAssistant software via a USB to TTL module (referring to the data manual for wiring and power voltage). After successful identification, click to enter the setting page . The configuration diagram for IIC output mode is shown in Figure 3. The IIC slave address of the module (7-bit slave address is 0x08 + module ID, and the ID setting range is 0

to 111) can be changed by setting the module ID. After configuring the parameters, you need to click the ‘Write Parameters’ button to save the parameters.

Note: After switching to IIC mode, please refer to the FAQ section for a way to switch back to UART mode
Figure 3: Configuration diagram for IIC output mode

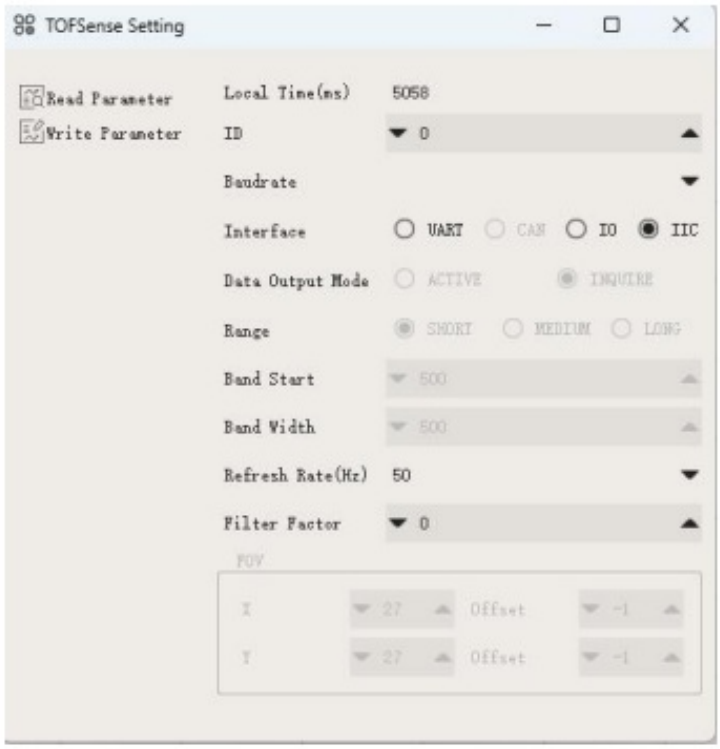


Figure 3: Configuration diagram for IIC output mode

4 I/O Output

In I/O output mode, the module cannot output distance values. The two signal lines have opposite levels, and the level of the I/O port is inverted only when the distance changes from small to large and exceeds the high threshold value, or when it changes from large to small and falls below the low threshold value.

When the module is in UART mode (note that NAssistant cannot recognize modules in I/O mode), TOFSense-F series products can be connected to the NAssistant software via a USB to TTL module (referring to the data manual for wiring and power voltage). After successful identification, click to enter the setting page . First, set the hysteresis starting point ‘Band_Start’ and the hysteresis width ‘Bandwidth’ to determine the hysteresis interval. The configuration diagram for I/O output mode is

shown in Figure 4. The distance value is converted to a high or low level output by hysteresis comparison, and the TX/SCL and RX/SDA outputs are complementary. The hysteresis comparison schematic is shown in Figure 5. After configuring the parameters, you need to click the ‘Write Parameters’ button to save the parameters.
Note: After switching to I/O mode, if you need to change parameters such as Band_Start and Bandwidth, you can refer to the FAQ section to switch back to UART mode and then configure the parameters.
For example, if Band_Start and Bandwidth are set to 500 (unit: mm), the low threshold value is 0.5 meters, and the high threshold value is 1 meter. When the ranging value is 0.3 meters, RX is high level and TX is low level. When the ranging value increases to 0.8 meters, RX is high and TX is low. When the ranging value exceeds 1 meter, the level is reversed, RX is low, and TX is high. When the ranging value drops from more than 1 meter to 0.8 meters, RX is low and TX is high, and when the ranging value drops below 0.5 meters, the level is reversed, RX is high, and TX is low.

If only one threshold value is needed, Bandwidth can be set to 0. Also note that the high level output by the module is 3.3V, and the output current is small. When driving other devices, be sure to check if it can be driven. If it cannot be directly driven, you can use a relay or other methods to drive it.
Figure 4: I/O output mode configuration diagram

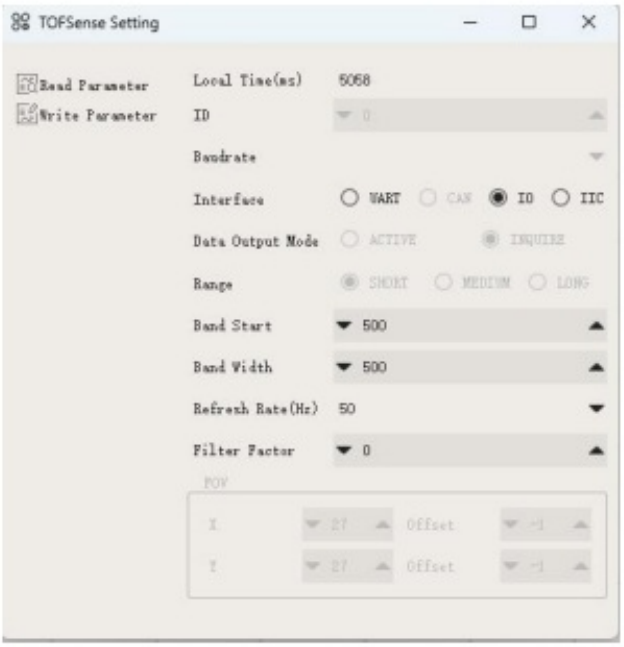


Figure 4: I/O output mode configuration diagram

For TOFSense-F/TOFSense-F P, the value range of Band_Start and Bandwidth is [0~15000] / [0~25000], with the unit of mm.

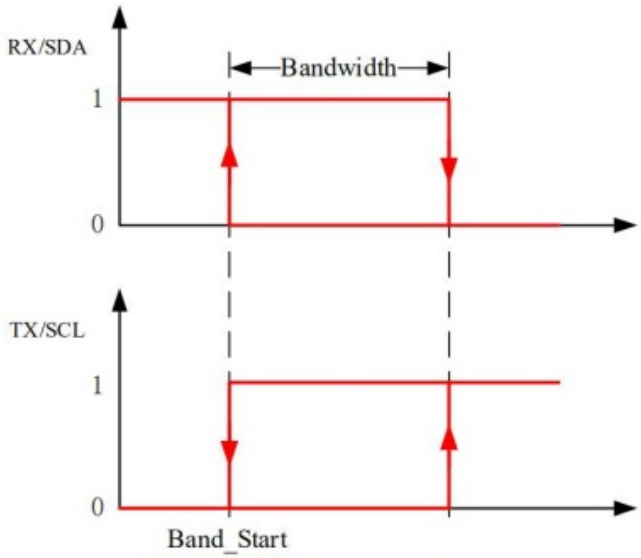


Figure 5: Hysteresis comparison diagram

Figure 5: Hysteresis comparison diagram

5NAssistant Operations

5.1 Firmware Update

At present, TOFSense-F/TOFSense-FP does not support firmware online upgrading.

5.2 Record, Replay and Export

NAssistant provides a convenient data recording, playback, and export function. Users can click the button on the main page menu bar to start real-time raw data recording, and click the button again to stop recording and output the *.dat file. The recorded *.dat file can be extracted by clicking the button to open the default storage path and sent to the after-sales engineer for troubleshooting. The software is equipped with a playback control bar, which can adjust the playback rate, progress, etc. (the recorded data is the data received by the NAssistant software during the time between the two clicks of the recording button).

Both real-time and playback modes can export text data to a local .xlsx file by clicking the button
Click the button again to stop exporting and automatically open the folder where the file is located. The exported data is the data received or played back by the NAssistant software during the time between the two clicks of the export button.
Note: If the folder is not automatically opened, find the corresponding folder according to the log prompt in the lower left corner of the software's main page, or click the menu button, click "Open Data Folder", and look for it in the "export_data" folder.

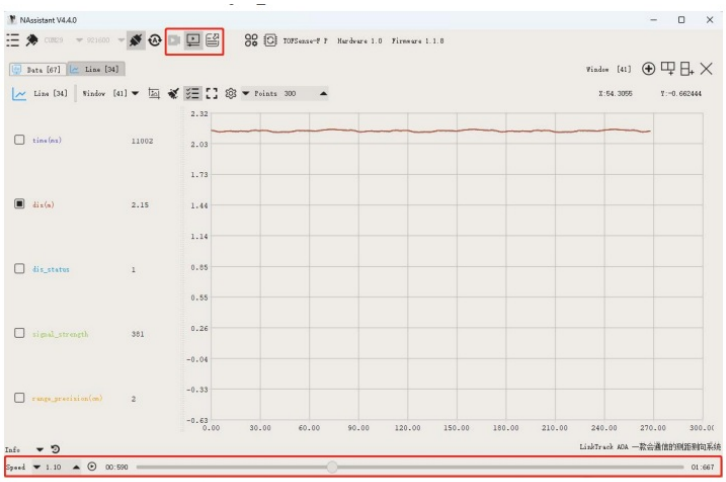


Figure 6: Data recording playback and export

Figure 6: Data recording playback and export

6 FOV

The field of view parameter represents the angle covered by the module's emitted ranging light. The initial field of view parameter for the module is 1~2 degrees.

7 Protocol Unpack

7.1 Introduction

This chapter's protocol analysis examples are based on the NLink protocol, and you can also download the NlinkUnpack sample analysis code developed in C language from the official website, which can effectively reduce the user's development cycle.
Based on the data situation of TOFSense-F series products, in order to represent more data with fewer bytes, we use integers to represent floating-point numbers and transmit them through protocol frames. Therefore, when unpacking, the actual data with the multiplier is actually a floating-point number and needs to be divided by the multiplier indicated in the protocol.
In particular, for int24 type, we need to first convert it to int32 type. To maintain the sign, we use the method of left shift and then divide by 256. For example, for position data, we use int24 to represent it, and the multiplier is 1000. The parsing code is as follows:
uint8_t byte[] = {0xe6,0x0e,0x00};//Decimal value: 3.814

//uint8_t byte[] = {0xec,0xfb,0xff};//Decimal value: -1.044
nt32_t temp = (int32_t)(byte[0] << 8 | byte[1] << 16 | byte[2] << 24) / 256; float result = temp/1000.0f;
Currently, the protocol verification is mainly based on the single-byte checksum at the end of the protocol frame. Example code:
uint8_t verifyCheckSum(uint8_t *data, int32_t length){ uint8_t sum = 0;
for(int32_t i=0;i<length-1;++i){ sum += data[i]; return sum == data[length-1];

7.2 Example

The document assumes a single module continuous ranging scenario.

7.2.1 NLink_TOFSense_Frame0

Data source: Connect the module to the host computer, configure UART as active output mode, using NLink_TOFSense_Frame0 protocol. For parsing distance data, please refer to the FAQ.
Raw data: 57 00 ff 00 9e 8f 00 00 ad 08 00 00 03 00 06 41
Table 1: NLink_TOFSense_Frame0 Parsing table

Data	Type	Length (Bytes)	Hex	Result
Frame Header	uint8	1	57	0x57
Function Mark	uint8	1	00	0x00
reserved	uint8	1	…	*
id	uint8	1	00	0
System_time	uint32	4	9e 8f 00 00	36766ms
dis*1000	uint24	3	ad 08 00	2.221m
dis_status	uint8	1	00	0
signal_strength	uint16	2	03 00	3
range_precision	uint8	1	06	6cm
Sum Check	uint8	1	41	0x41

7.2.2 NLink_TOFSense_Read_Frame0

Data source: Connect the module to the host computer, configure it as UART query output mode with ID set to 0. To query data, send the following bytes from the host computer. If you need to query modules with different IDs, simply change the **ID and checksum** bytes accordingly.
Raw data: 57 10 FF FF 00 FF FF 63

Table 2: NLink_TOFSense_Read_Frame0 Parsing table

Data	Type	Length (Bytes)	Hex	Result
Frame Header	uint8	1	57	0x57
Function Mark	uint8	1	10	0x10
reserved	uint16	2	…	*
id	uint8	1	00	0
reserved	uint16	2	…	*
Sum Check	uint8	1	63	0x63

7.2.3 NLink_TOFSense_F_Setting_Frame0

This protocol is a module parameter setting protocol, which can modify the parameters of the module through serial instructions. This function is an advanced feature and if the parameters are modified incorrectly, it may cause the module to not work properly. It is recommended to use this function after having a certain understanding of the entire system parameters.

Table 3: NLink_TOFSense_F_Setting_Frame0 Parsing table

Data	Type	Length (Bytes)	Description
Frame Header	uint8	1	value = 0x54
Function Mark	uint8	1	value = 0x20
mix	uint8	1	bit0: [0:write],[1:read]—WO
reserved	*	1	Reserved.The default value is 0xFF
id	uint8	1	Node ID—RW
system_time	uint32	4	terminal system time,unit:ms—WO
			node system time,unit:ms—RO
mode	uint8	1	bit1:output mode-[0:active],[1:inquire]—WR
			bit2-3:range mode-[00:short],[01:medium],[10:long]—WR
			bit4:0:interface mode-[00:uart],[01:can],[10:io],[11:iic]—WR
reserved	*	2	Reserved.The default value is 0xFF
uart_baudrate	uint24	3	UART:4800,9600,14400,19200,38400,43000,57600,76800,115200,230400,46 0800,921600,1000000,1200000,1500000,2000000,3000000
			CAN:100000,250000,500000,1000000,2000000,3000000
FOV.x	uint8	1	Reserved.The default value is 0xFF
FOV.y	uint8	1	Reserved.The default value is 0xFF
FOV.x_offect	int8	1	Reserved.The default value is 0xFF
FOV.y_offect	int8	1	Reserved.The default value is 0xFF
band_start	uint16	2	[0,25000],unit:mm
band width	uint16	2	[0,25000],unit:mm
reserved	uint8	1	Reserved.The default value is 0xFF
refresh rate	uint16	2	Data refresh rata:1,2,5,10,25,50,100,200,350Hz
filter factor	uint8	1	Filter factor: 0~255.Default:5
reserved	uint8	4	Reserved.The default value is 0xFF

Sum Check	uint8	1	the sum check is equal to all previous bytes addded

7.2.4 NLink_TOFSense_IIC_Frame0

Slave address: The module acts as a slave on the I2C bus and its default address is 0x08 (7-bit address). The slave address is 0x08 + the module ID, so changing the module's ID parameter will change the slave address. When communicating, it is important to pay attention to address shifting and adding the read/write bit, i.e., when the address is 0x08, the byte with the read/write bit is 0x10 (write) or 0x11 (read).

Register address: If there is no corresponding parameter in the register, the default output is 0xff.

Table 4: NLink_TOFSense_IIC_Frame0 Register parsing and communication flow chart

Starting address	bit																														
0x00	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Reserved																**product version**														
	[15-0] product version																														
	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	bootloader version																**hardware version**														

0x04	**[15-0] hardware version**																															
	[31-16] bootloader version																															
0x08	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	firmware version																															
	[0-31] firmware version																															
0x0C	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Reserved																**ID**								**Reserved**		**Ragne mode**		**Output mode**	**Interface mode**		
	[0-2] Interface mode: 0-UART , 1-CAN , 2-I/O , 3-IIC (RW)																															
	[3] Output mode: 0-Active output,1-Query output (RO)																															
	[4-5] Ragne mode: 0- Short,1-Median,2-Long (RO)																															
	[8-15] ID: Device ID (RW), the slave address will take effect only after a power cycle after changing the ID.																															
0x1	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	UART Baudrate																															

0	**[0-31] uart baudrate**																														
0x14	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	CAN Baudrate																														
	[0-31] can baudrate																														
0x18	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	FOV.y_offest								**FOV.x_offest**								**FOV.y**								**FOV.x**							
	[0-7] FOV.x : X direction FOV, unit: °																														
	[8-15] FOV.y : Y direction FOV, unit: °																														
	[16-23] FOV.x_offest : FOV offset in the X direction, unit: °																														
	[24-31] FOV.y_offest : FOV offset in the Y direction, unit: °																														

0x1C	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	bandwidth																**bandstart**															
	[0-15] bandstart : I/O mode latency start, unit: mm																															
	[16-31] bandwidth : I/O mode loop bandwidth, unit: mm																															

0x20	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Systime																															
	[0-31] Systime : system time, unit: ms																															
0x24	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Distance																															
	[0-31] Distance : The distance,unit: mm																															
0x28	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Signal_strength																**Dis_status**															
	[0-15] Dis_status : The distance status																															
	[16-31] Signal_strength																															
0x	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Filter factor								**Refresh rate**														**Range_precision**									

2C	**[0-7] Range_precision : Measurement accuracy, unit: cm, 0xFF represents greater than or equal to 255cm, 0x00 represents less than 1cm.** **[8-23] Refresh rate , unit:Hz** **[24-31] Filter factor: 0 ~ 255. Default :5**	(

I2C communication process:

Single data write

Start	Slave Addr|W	ACK	Reg Addr	ACK	Data[7:0]	ACK	Stop

Sinal data read

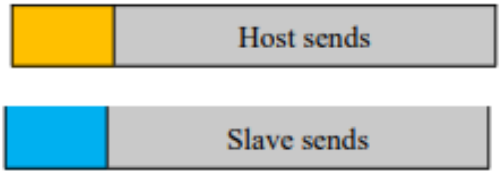
Start	Slave Addr|W	ACK	Reg Addr	ACK	Stop
Start	Slave Addr|R	ACK	Data[7:0]	NACK	Stop

Multiple data write

Start	Slave Addr|W	ACK	Reg Addr	ACK	Data[7:0]	ACK	Data[7:0]	ACK	Data[7:0]	ACK	Stop

Multiple data read

Start	Slave Addr|W	ACK	Reg Addr	ACK	Stop					
Start	Slave Addr|R	ACK	Data[7:0]	ACK	Data[7:0]		ACK	Data[7:0]	NACK	Stop



Start: Start signal W: Read flag 1 R: Write flag 0
ACK: Acknowledge NACK: Non-acknowledge Stop: Stop signal

8 FAQ

Q1. Can it be used in outdoor conditions?

The module can resist some natural light influence and can be used outdoors.

Q2. Is there interference between multiple modules?

When multiple modules are working at the same time, even if the infrared light emitted from one module crosses or hits the same position as another module, it will not affect the actual measurement. However, if two modules are at the same horizontal height and facing each other, the measurement may be affected for both of them.

Q3. Why does the module have no data output?

Each module has undergone strict testing before shipping. If there is no data, please first check if the mode, wiring (power supply voltage, wire sequence correctness, and whether the pins on both sides of the communication are conducting as recommended by using a multimeter to test), baud rate, and other configurations are correct. For IIC output mode, the host needs to read data from the set slave address through IIC communication according to the communication timing in the manual. For I/O output mode, please refer to the relevant section on I/O mode introduction.

Q4. What should be noted during installation?

If you don’t want to detect the ground or other reflective surfaces, you need to avoid obstruction within the FOV angle during installation. In addition, attention should be paid to the height of the ground, and similar reflective surfaces such as ground obstruction should be avoided within the FOV. If the installation height is close to the ground, you can consider installing the module slightly tilted upward.

Q5. Is the UART, IIC, and I/O of the module the same interface?

The module's UART, IIC, and I/O interfaces share the same physical interface, and the corresponding pin sequence can be converted for different communication modes.

Q6. After switching to IIC or I/O mode, why does NAssistant software not recognize the module? How to switch between different communication modes?

Currently, the NAssistant software only supports the recognition of modules in UART mode. In UART mode, the host computer can enter the setting page to configure the module as an IIC or I/O communication mode after successful recognition through the software. In IIC communication mode, the module can be switched back to UART or I/O mode by sending instructions to the module according to the IIC communication protocol. Additionally, if there is no IIC test environment or if it is switched to I/O mode, it can be switched back to UART mode as follows:

1. The user needs to prepare a USB to TTL module that supports 921600 baud rate (CP2102 is recommended) and install the corresponding driver, connect the USB to TTL module's TX, RX, and GND to the corresponding pins of the TOF module, and temporarily not connect the VCC pin. Then plug the USB to TTL module into the
2. Open the NAssistant software, click on the icon to enter the serial port debugging assistant, change the baud rate to 921600, select the COM port corresponding to the USB to TTL module, and then click the connect button to connect to the COM port (most situations will automatically connect). In the one-way send text box, enter **54 20 00 ff 00 ff ff ff ff 00 ff ff 00 10 0e ff ff ff ff ff ff ff ff ff ff 00 ff ff ff ff 7c** , change the send interval in the timer send column to 20ms, and then check the timer
3. At this point, connect the USB to TTL module's 5V to the TOF module's VCC pin. The module will switch to UART mode and start outputting data. Then uncheck the timer send button, disconnect the USB to TTL module, and then power on the module. Finally, click the recognition button on the main page to recognize the

If the switch fails, pull out the USB to TTL module and repeat the entire step. Do not plug and unplug the VCC pin repeatedly while sending commands. If the module can be recognized normally but the serial port output data is abnormal, you can manually change to UART mode in the setting page.

PS: If the TOF module's VCC pin is connected to the USB to TTL module's 5V and the module continuously sends protocol data such as 80 00 80 00…, first click the connect button to temporarily disconnect the COM port, change the baud rate to 115200, and then click the connect button to reconnect to the COM port. If the data in the serial port debugging assistant starts with b3 b1 at this point, enter de ed 00 00 05 04 3b 01 00 00 10 in the one-way send text box and click send. Then disconnect the USB to TTL module, power on the module, and click the recognition button on the main page to recognize the module. If the data still starts with b3 b1 after re-plugging, repeat the PS steps.

Q7. Whether the module can output point cloud information ?

The module can only output one distance at a time and does not currently support the output of point cloud information.

Q8. What data will the module output when it exceeds the range?

TOFSense-F:

When the range exceeds 15 meters, the error is large in the range of 15 to approximately 20 meters. Beyond the maximum range of 20 meters, the distance output is fixed at 0 meters. At this time, you can refer to the distance

status indicator in the data manual to determine the validity of the data.

TOFSense-F P:

When the range exceeds 25 meters, the distance output is fixed at 0 meters. At this time, you can refer to the distance status indicator in the data manual to determine the validity of the data.

Q9. What is the serial port communication terminal model used by the module? Flight control, MCU without this terminal interface how to do?

The module uses a GH1.25 terminal. You can purchase GH1.25 to other terminal adapters or cut off the GH1.25-GH1.25 connection that comes with the product and weld other terminals yourself. Please refer to the data manual for wiring sequence, power supply voltage, signal line level, etc.

Q10.How to calculate the received ad 08 00 as distance value?

The data in the protocol frame is stored in little-endian mode, and it is multiplied by a certain multiple during encoding. For example, “ad 08 00” is first restored to hexadecimal data 0x0008ad,which translates to 2,221 in decimal, and divided by 1000 to become 2.221 meters.

Q11.How is the checksum calculated?

The checksum is the sum of all the bytes in the previous data, and the lowest byte is taken as the data. For example, the checksum for the data “55 01 00 ef 03” is 0x55 + 0x01 + 0x00 + 0xef + 0x03 = 0x0148, so the checksum is 48. Therefore, the complete data of this frame is 55 01 00 ef 03 48.

Q12.Why cannot I communicate in IIC mode?

In IIC mode, the SDA and SCL pins of the device are recommended to output in open drain mode, and a pull-up resistor is required on the bus. When communicating, it is necessary to write the start, stop, read, write, acknowledge, etc. functions according to the standard IIC communication timing, and when communicating with the TOF module, refer to the NLink_TOFSense_IIC_Frame0 protocol in the user manual to read and write the registers. It is particularly important to note the shifting of the 7-bit slave address and the addition of the read-write bit transmission.

Q13.What if there is an error or no data when compiling the ROS driver package

Before using the ROS driver package, the user needs to read the README.MD document in the driver package and follow the steps and precautions in the document. The user can also refer to the “ROS Driver Application Graphic Tutorial” on the official website for use.

9 Reference

[1] TOFSense-F_Datasheet.pdf

10 Abbreviation and Acronyms

Table 5: Abbreviation and Acronyms

Abbreviation	Full Title
TOF	Time of Flight
FOV	Field of View
HW	Half Wave
VCSEL	Vertical Cavity Surface Emitting Laser
UART	Universal Asynchronous Receiver/Transmitter
IIC	Inter-Integrated Circuit

11Update Log

Table 6: Update Log

Version	Firmware Version	Data	Description
1.0	1.0.5	20210918	1. Release first edition manual
1.1	1.1.7	20220926	1. Added explanation of serial setting frame protocol 2. Optimized some descriptions
1.2	1.1.8	20230404	1. Optimized the description in the FAQ section

12 Further Information

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Documents / Resources

	Nooploop TOFSense-F Laser Range Sensor [pdf] User Manual TOFSense-F, TOFSense-F P, TOFSense-F Laser Range Sensor, Laser Range Sensor

References

- Nooploop – Precise Positioning, Enabling Industry