TOFSense User Manual V2.5

Language: English

Firmware: V2.0.4

NAssistant: V4.4.0

Product Series: TOFSense,TOFSense P,TOFSense PS

Content

Disclaimer

Document Information
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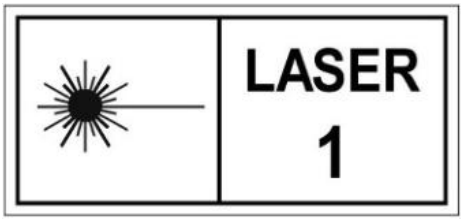
Certification Description:

- The TOFSense series products comply with the Class 1 standard specified in IEC 60825-1:2014 Edition 3.



1. Caution - Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.
2. According to IEC 60825-1:2014 Safety of laser products - Part 1:Equipment classification and requirements. The maximum output laser power of the product is 50.5uW.

- The TOFSense series products comply with the Class 1 laser product standard specified in GB 7247.1-2012.

1. Attention: Improper use of the control or adjustment device, or failure to follow each step of the operation may result in harmful radiation exposure.
2. According to GB 7247.1-2012 Safety of laser products - Part 1: Equipment classification and requirements, the maximum output laser power of the product is 50.5uW.

1 Introduction

This document mainly introduces how to use the TOFSense, TOFSense P, and TOFSense PS systems and the precautions to be taken during use. You may need to refer to the following materials to help you understand:

- TOFSense_Datasheet.pdf

2 UART Output

2.1 Active Output

UART active output mode can only be used when a single module is connected. In this mode, the TOFSense module outputs measurement information actively at a frequency of 10Hz, and the TOFSense P/TOFSense PS modules output at a frequency of 30Hz. The output format follows the NLink_TOFSense_Frame0 protocol.

To connect the TOFSense series products to the NAssistant software via a USB to TTL module (reference the data manual for the wire sequence and power supply voltage), after successful recognition, click on the settings page . The UART active output mode configuration is shown in Figure 1. After configuring the parameters, click the "Write Parameters" button to save the parameters. After successfully writing the parameters, read the parameters once to confirm whether the parameters have been written successfully.

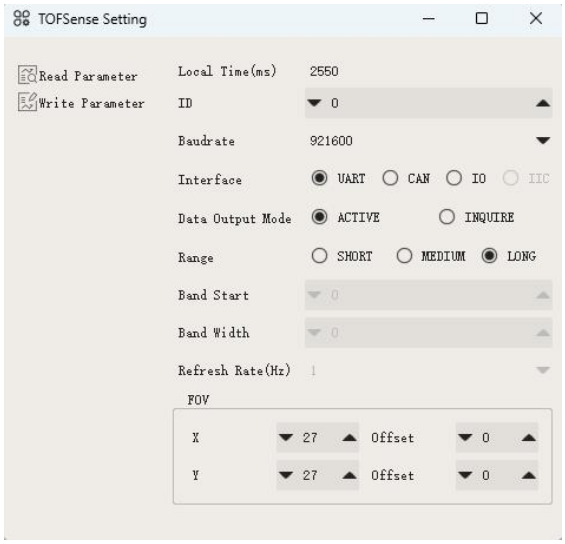


Figure 1: Configuration diagram for UART active output mode

2.2 Query Output

The UART query output mode can be used in single module and cascaded configurations. 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 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.

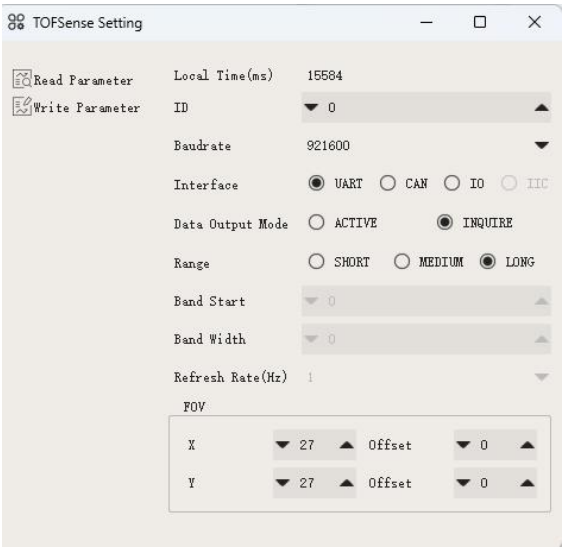


Figure 2: Configuration diagram for UART query output mode

3 CAN Output

3.1 Active Output

The CAN active output mode can be used in single module and cascaded configurations. In this mode, the TOFSense module outputs measurement information at a frequency of 10Hz, while TOFSense P/TOFSense PS modules output at a frequency of 30Hz, and the output format follows the NLink_TOFSense_CAN_Frame0 protocol.

To connect TOFSense 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 CAN active output mode is shown in Figure 3. After configuring the parameters, you need to click the 'Write Parameters' button to save the parameters. (If the device has previously been switched to CAN or IO mode and cannot be recognized directly, follow the FAQ to hold down the button and power on to configure it to UART mode before changing the parameters).

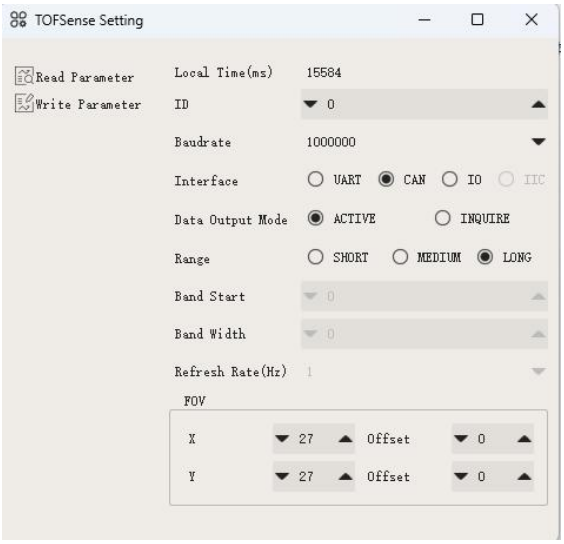


Figure 3: Configuration diagram for CAN active output mode

3. 2 Query Output

The CAN query output mode can be used in single module and cascaded configurations. 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_CAN_Read_Frame0 protocol, and the output frame format follows the NLink_TOFSense_CAN_Frame0 protocol.

To connect TOFSense 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 CAN query output mode is shown in Figure 4. After configuring the parameters, you need to click the 'Write Parameters' button to save the parameters. (If the device has previously been switched to CAN or IO mode and cannot be recognized directly, follow the FAQ to hold down the button and power on to configure it to UART mode before changing the parameters).

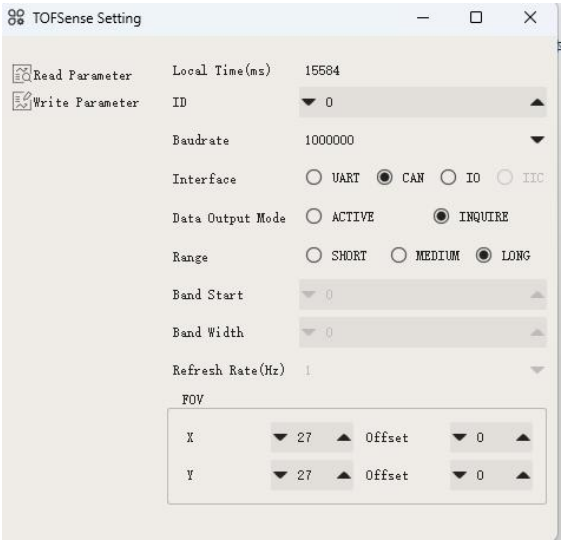


Figure 4: Configuration diagram for CAN query output mode

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 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 5. The distance value is converted to a high or low level output by hysteresis comparison, and the TX/CAN_L and RX/CAN_H outputs are complementary. The hysteresis comparison schematic is shown in Figure 6. In this mode, the module cannot be cascaded. 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.

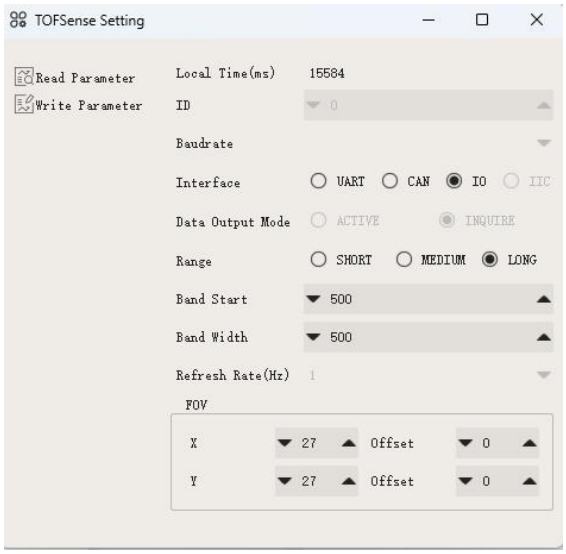


Figure 5: I/O output mode configuration diagram

The values of Band_Start and Bandwidth are in the range of [0~5000], with unit:mm.

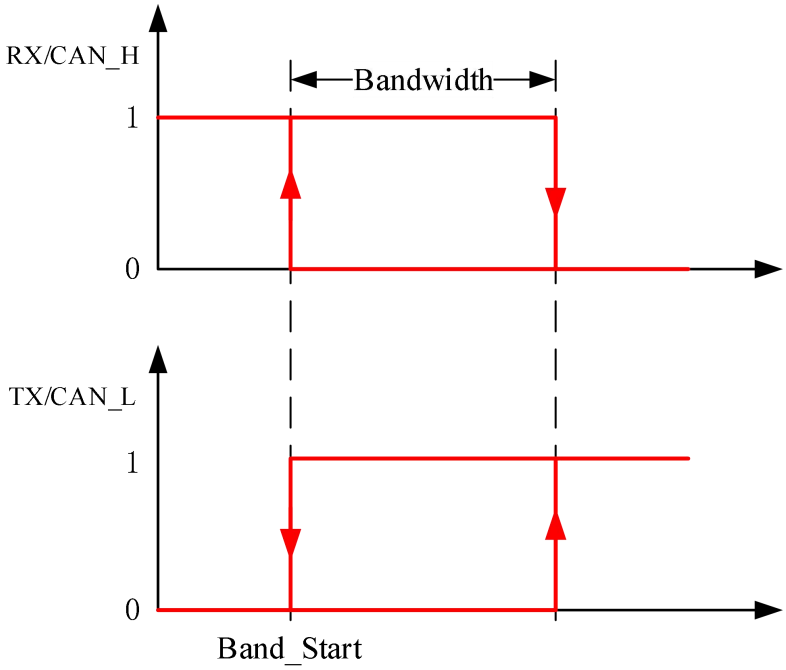


Figure 6: Hysteresis comparison diagram

5 NAssistant Operations

5.1 Firmware Update

Firmware upgrade requires a computer with internet access to install the NAssistant software. The firmware is mainly divided into two types: public version firmware and test version firmware.

The steps for firmware update, reflash, and downgrade are as follows:

1. Click the firmware update button on the software's main page to enter the firmware update page. It will automatically load the latest public version firmware (you can also click "Public Version Firmware" to load the latest public version firmware after switching to other firmware). Click "Test Version Firmware" and enter the firmware test code obtained from Nooploop's official website in the pop-up window. Click "OK" to load the corresponding test version firmware.

2. Click the "Firmware Update" button to update the firmware (if the firmware version of the module currently connected by NAssistant is lower than or equal to the loaded firmware version, then the "Firmware Update" button will be grayed out and cannot be clicked. In this case, you need to click the "**Ignore Version**" button first to downgrade or reflash with the same version).

3. Wait for the progress bar to reach 100 and the page to return to normal from grayed out. Confirm whether the firmware version displayed on the main page is consistent with the loaded firmware version. If it is consistent, it means the update was successful.

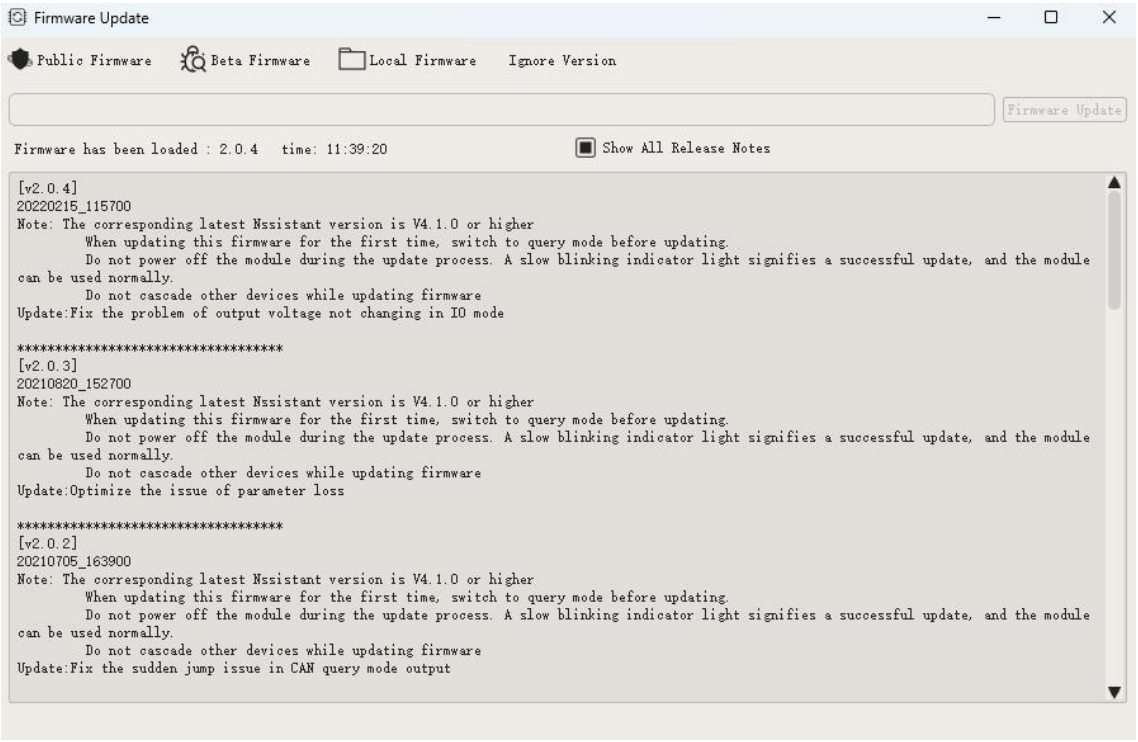


Figure 7: Firmware update page schematic diagram

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.

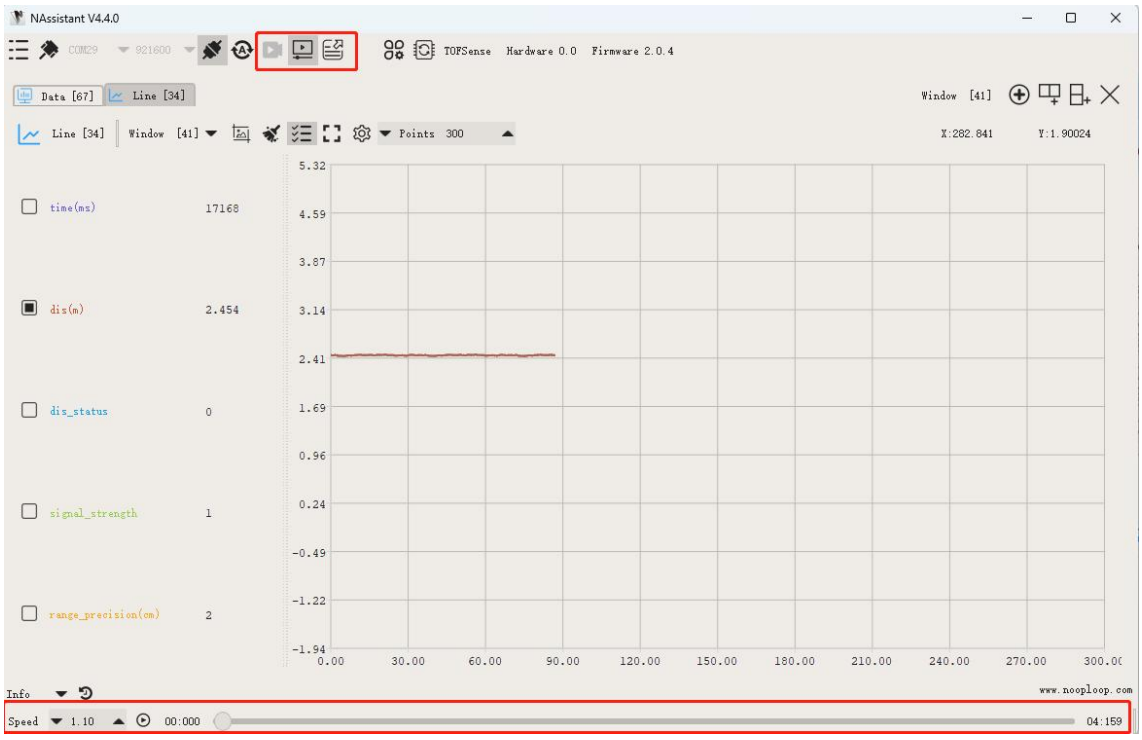


Figure 8: Data recording, playback, and export

6 FOV

The field of view (FOV) parameter represents the angle that the module's emitted ranging light can cover. The initial FOV parameter for the module is fov.x=27° , fov.y=27° , fov.x_offset=0° , fov.y_offset=0° . By setting the X-direction FOV to 25° , Y-direction FOV to 15° , X-direction offset to 1° , and Y-direction offset to -1° , the module's region of interest can be changed to the one shown on the right side of Figure 9.

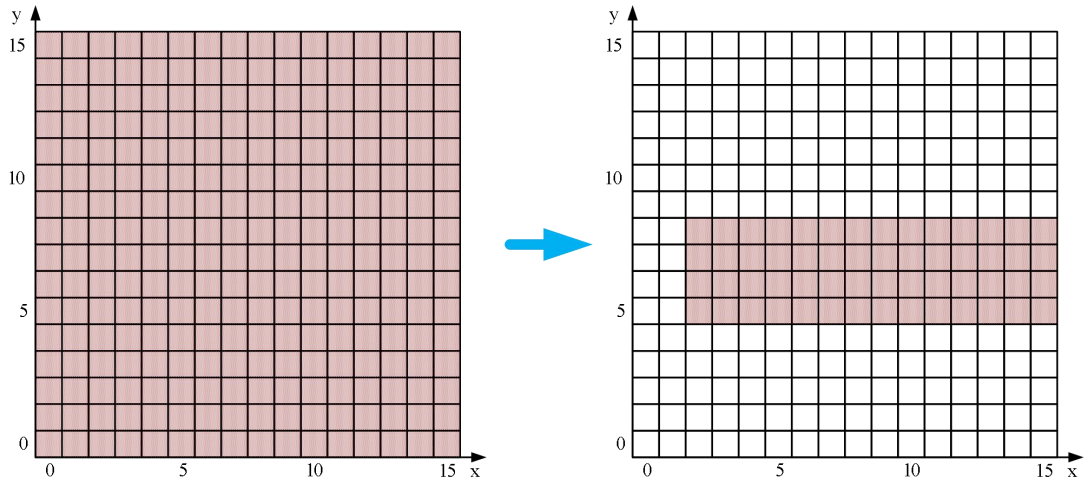


Figure 9: FOV configuration schematic diagram

A smaller FOV can improve the module's detection performance in narrow spaces and for small objects. However, changes in the FOV angle can also affect the module's maximum ranging distance. The smaller the FOV angle, the smaller the maximum ranging distance. The relationship between the maximum ranging distance and the FOV angle for TOFSense in a certain scene (indoor, white wall background) is shown in Figure 10. The measurements for TOFSense P and TOFSense PS are not yet

available. Users should choose the appropriate FOV angle based on their actual scene.

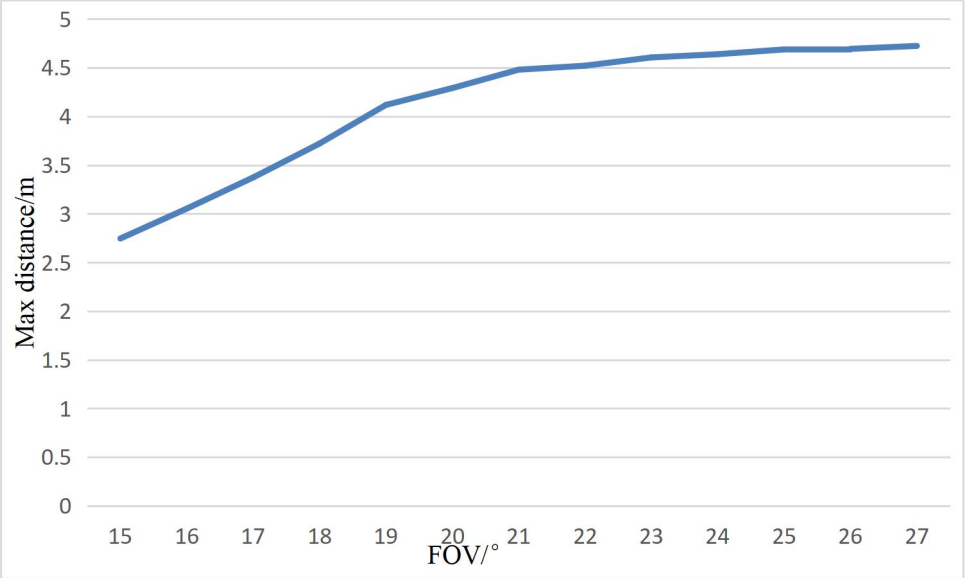


Figure 10 : The maximum ranging distance of TOFSense is related to the field of view (FOV)

7 Cascade Ranging

Multiple sensors can be configured with different IDs and connected in series, and the ranging information of all sensors can be read through a single communication interface. The connection schematic is shown in Figure 11. TOFSense PS only has one communication interface, so a converter is required for cascading.

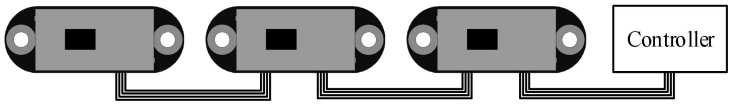


Figure 11: Cascade ranging diagram

Under cascade ranging, three methods are suitable: UART query, CAN query, and CAN active output.

8 Protocol Unpack

8.1 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
int32_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];
}
```

8.2 Example

The document assumes a single module continuous ranging scenario.

8.2.1 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 ff 3a

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
reserved	uint8	1	…	*
Sum Check	uint8	1	3a	0x3a

8.2.2 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

8. 2. 3 NLink_TOFSense_CAN_Frame0

Data source: Configure the module as CAN active output mode with ID set to 1, and connect it to the CAN receiving device.

Raw data: StdID:0x201 + **Data:** AD 08 00 00 03 00 FF FF

Table 3: NLink_TOFSense_CAN_Frame0 Parsing table

Field name	Part	Level	Type	Length(bits)	Hex	Result
Start Of Frame	SOF		*	1	*	*
Arbitration Field	ID		*	11	0x200+id	0x201
	RTR		*	1	*	*
Control Field	IDE		*	1	*	*
	r0		*	1	*	*
	DLC		*	4	*	*
Data Field	dis*1000		uint24	24	ad 08 00	2.221m
	dis_status		uint8	8	00	0
	signal_strength		uint16	16	03 00	3
	reserved		uint16	16	…	*
CRC Field	CRC		*	15	*	*
	CRC_delimiter		*	1	*	*
ACK Field	ACK Slot		*	1	*	*
	ACK_delimiter		*	1	*	*
End Of Frame	EOF		*	7	*	*

	Dominant level
	Dominant or recessive level
	Recessive level

8. 2. 4 NLink_TOFSense_CAN_Read_Frame0

Data source: The module is configured for CAN query output mode with an ID of 1. Connect the CAN query device, and the query device's ID (id_s) is 2.

Raw data: StdID:0x402 + **Data:** FF FF FF 01 FF FF FF FF

Table 4: NLink_TOFSense_CAN_Read_Frame0 Parsing table

Field name	Part	Level	Type	Length(bits)	Hex	Result
Start Of Frame	SOF		*	1	*	*
Arbitration Field	ID		*	11	0x400+id_s	0x402
	RTR		*	1	*	*
Control Field	IDE		*	1	*	*
	r0		*	1	*	*

	DLC		*	4	*	*
Data Field	reserved		uint24	24	…	*
	id		uint8	8	01	id = 1
	reserved		uint32	32	…	*
CRC Field	CRC		*	15	*	*
	CRC_delimiter		*	1	*	*
ACK Field	ACK Slot		*	1	*	*
	ACK_delimiter		*	1	*	*
End Of Frame	EOF		*	7	*	*

	Dominant level
	Dominant or recessive level
	Recessive level

9 FAQ

Q1. Can it be used outdoors (in bright light) conditions?

The module is affected by natural light. Generally speaking, the stronger the natural light, the more it will be affected, resulting in shorter ranging distance, poorer accuracy, and larger fluctuations. In strong light conditions (such as sunlight), it is generally recommended to use the module for short-range detection scenarios.

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 is there no data output from TOFSense?

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 CAN output mode, please check if the bus has termination resistors (usually 120 Ω). 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 do not want to detect the ground or other reflective surfaces, it is necessary to avoid obstructions within the FOV angle during installation. Additionally, the ground height should be taken into consideration, and it is necessary to avoid obstructions such as ground reflections within the FOV. If the installation height is close to the ground, the module can be slightly tilted upwards for installation.

Q5. Are the module's UART, CAN, and I/O the same interface?

The UART interface and the CAN interface of the module share the same physical interface. To switch between different communication modes, simply convert the corresponding wire sequence. Please note that some models only support one communication mode.

Q6. After switching to CAN or IO mode, why can't the NAssistant software 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, after successful recognition by the host computer, the module can be configured as CAN or IO communication mode on the settings page. In CAN or IO communication mode, hold down the button and power on the module. When the indicator light changes from rapid flashing to slow flashing, release the button. At this time, the module will forcibly enter temporary UART mode. Then, select the UART mode on the settings page and write the parameters into the module through the host computer.

For TOFSense-PS, in CAN mode, you can use a USB-to-TTL module to connect to the host computer. Change the baud rate to 921600 and connect it to the corresponding port of the USB-to-TTL module. Click the recognition button  several times to recognize the module normally.

Q7. What should be noted during firmware updates?

During the update process, do not power off or unplug the USB-to-TTL module. After clicking on the firmware update, wait for the indicator light to change from fast flashing to slow flashing before the module can be used normally.

Q8. Does the module output the shortest distance, the longest distance, or the average distance?

During a single measurement, the module will obtain multiple distance values within the FOV and process them internally to output the distance with the highest proportion.

Q9. Does the module support outputting point cloud information?

The module can only output a single distance value at a time and does not currently support point cloud information output.

Q10. How is distance output in different ranging modes, as well as when exceeding the range?

TOFSense:

In short-range mode, when the range is exceeded, the distance output is a fixed value of -0.01 (0xFFFFF6 in hexadecimal).

In medium-range mode, when the range is exceeded, the distance output jumps randomly between 1-2 meters. At this time, you can refer to the signal strength and distance status for judgment.

In long-range mode, when the range is exceeded, the data output jumps randomly between 1-2 meters. At this time, you can refer to the signal strength and distance status for judgment.

TOFSense P/TOFSense PS:

In all modes, when the ranging exceeds the measurement range, the data will jump. It is recommended to judge the data availability directly through the distance status, and generally only a distance status of 0 indicates that the data is available.

Q11. What is the reason for not being able to query data in CAN query mode?

First, make sure that the wire sequence between the CAN devices is correct. Secondly, the

TOFSense series port does not contain a 120R matching resistor, so make sure that the resistance of the query device matches. Finally, check whether the format of the sent query frame meets the NLink_TOFSense_CAN_Read_Frame0 protocol, and pay special attention to the correct standard frame ID.

Q12. What is the reason for not being able to enter UART configuration mode when holding down the button?

The function button has been tested before shipment, if you cannot enter UART mode, please try again several times. Please note that the button needs to be pressed before power on, and released after the light flashes slowly.

Q13. What is the model of the serial communication terminal used by the module? What to do if there is no such terminal interface on the flight controller or microcontroller?

The module uses GH1.25 terminals. You can purchase GH1.25 to other terminal adapter cables, or cut the GH1.25-GH1.25 cable provided with the product and solder other terminals by yourself. For wire sequence, power supply voltage, signal line voltage level, please refer to the data manual.

Q14. How to calculate the distance value from the received data "ad 08 00"?

The data in the protocol frame is stored in little-endian mode and is encoded by multiplying a certain multiple. For example, if the hexadecimal data "ad 08 00" is restored, it becomes the decimal value of 2221 after conversion to hexadecimal as 0x0008ad, and divided by 1000 to obtain the value of 2.221 meters.

Q15. How is the checksum calculated?

The checksum is calculated by adding up all the previous bytes and taking the lowest byte of the result. For example, the checksum of "55 01 00 ef 03" is calculated as follows: 0x55+0x01+0x00+0xef+0x03=0x0148. The checksum is 0x48, so the complete data frame is "55 01 00 ef 03 48".

Q16. What should I do if there is an error during compilation or no data is obtained when using the ROS driver package?

Before using the ROS driver package, users need to read the README.MD document in the driver package, and follow the steps and precautions in the document to use it. Users can also refer to the "ROS Driver Application Tutorial" on the official website for instructions on how to use it.

10 Reference

[1] TOFSense_Datasheet.pdf

11 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

12 Update Log

Table 6: Update Log

Version	Firmware Version	Data	Description
1.0	1.0.0	20190817	1. Publish the initial version of the manual.
1.1	1.0.4	20190923	1. Add examples for FOV settings through UART 2. Add FOV setting instructions 3. Add FAQ 4. Fix errors in the manual
1.2	1.0.6	20191213	1. Add instructions for FOV settings 2. Fix errors in the manual
2.0	2.0.0	20200730	1. Add I/O mode instructions 2. Expand FAQ 3. Fix errors in the manual
2.1	2.0.0	20210623	1. Add descriptions for TOFSense P and TOFSense PS 2. Expand FAQ 3. Optimize manual descriptions
2.2	2.0.3	20220211	1. Optimize manual descriptions
2.3	2.0.4	20220924	1. Add certification-related instructions
2.4	2.0.4	20221205	1. Optimize manual descriptions
2.5	2.0.4	20230404	1. Add firmware update descriptions 2. Expand FAQ and optimize some descriptions

13 Further Information

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