TOFSense-F Datasheet V1.2

Language: English

Firmware: V1.1.8

Product Series: TOFSense-F,TOFSense-F P

Content

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1 Introduction

1.1 Product Overview

TOFSense-F Datasheet

Overview

TOFSense-F/TOFSense-F P is a single-point laser ranging sensor based on TOF (time-of-flight) technology. The measuring range is 5cm~15m/5cm~25m, with a distance resolution of 1mm; the data update frequency can reach up to 350Hz; FOV field of view angle is 1~2°; it supports UART, IIC communication and I/O complementary level output; in UART mode, it supports both active and query output data.

Key Features

- Based on TOF (time-of-flight) laser ranging technology
- Measurement range

TOFSense-F	5cm~15m
TOFSense-F P	5cm~25m

- Measurement resolution 1mm
- Typical ranging accuracy

TOFSense-F	
0.05~3m	5%
3~15m	8%
TOFSense-F P	
0.05~25m	3%

- Standard deviation

TOFSense-F	5.0cm@7.0m
TOFSense-F P	1.8cm@12.5m

- Field of view (FOV), 1~2°
- Supports UART IIC, and I/O communication
- UART, IIC, and I/O share the same interface
- Supports both active and query output in UART mode
- Poweredby 3.7~5.2V with reverse protection
- Power consumption of approximately 610mW
- The 750~830nm laser meets the Class2 standard specified in IEC 60825-1:2014 Edition 3.
- Resistant to ambient light with a capability of approximately 100K LUX illuminance.

Applications

- UAV height determination and ceiling detection
- Robot obstacle avoidance
- Measurement and detection
- High-speed measurement and safety monitoring in traffic and industrial automation
- Material level measurement
- .....

1.2 Product Interface

The wire sequence for the UART interface is abbreviated as "V G R T" corresponding to VCC, GND, RX, and TX in the diagram; (Note: in UART communication, the TX and RX of both sides should be cross-connected, that is, module 1's TX is connected to module 2's RX, and module 1's RX is connected to module 2's TX).

The wire sequence for the IIC interface is abbreviated as "V G D C" corresponding to VCC, GND, IIC_SDA, and IIC_SCL in the diagram;

The I/O interface shares the same interface, and the wire sequence is "V G H L" corresponding to VCC, GND, I/O_H, and I/O_L in the order indicated in the diagram.

Where VCC is the power supply and GND is the ground.

Note: The diagram does not represent the actual size, please refer to Chapter 8 for the actual size.

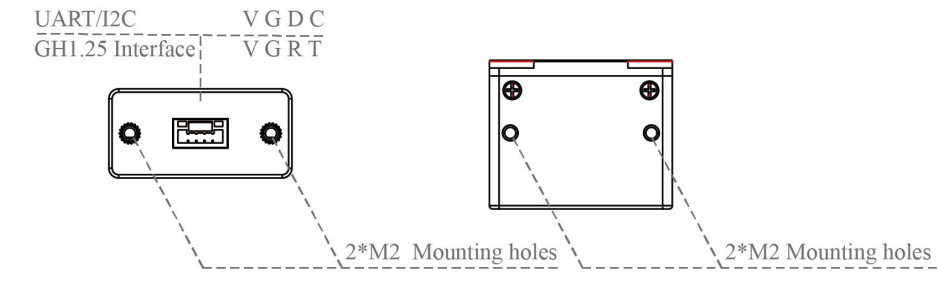


Figure 1: TOFSense-F/TOFSense-F P Interface

1.3 Technology Overview

TOF is a technology for absolute distance detection, which means the sensor emits modulated near-infrared light and detects the distance of the scene being captured by calculating the time difference or phase difference between the light emission and reflection after encountering an object. Compared to binocular schemes and 3D structured light schemes, TOF has advantages such as longer working distance, wider range of applications, and higher accuracy at longer distances. Therefore, it is often used in scenarios such as personnel proximity detection, robot obstacle avoidance, and camera auto-focus.

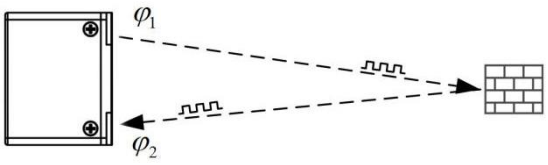


Figure 2: TOF ranging principle illustration

1.4 Functional Overview

TOFSense-F/TOFSense-F P can meet the needs of various scenarios and can output information such as distance measurement value "dis", distance status "dis status", signal strength "signal strength", and ranging accuracy "range_precision".

Output method: In UART mode, TOFSense-F/TOFSense-F P supports both active and query output. In IIC mode, the host sends a read parameter frame to read the slave data. Active output means the module continuously sends measurement data frames on its own, with a default frequency of 50Hz and a maximum of 350Hz. Query output means that each time the module receives a query frame, it will output a measurement data frame.

Connection method: TOFSense-F/TOFSense-F P supports UART, IIC, and I/O output methods, all of which use the same physical interface. In UART output, it supports active and query output for a single module. In IIC mode, it supports reading and writing parameters for a single module. In I/O mode, it can output complementary levels.

2 Typical Specifications

Table 1:Typical Specification

Parameters	Typical		Note
Product model	TOFSense-F	TOFSense-F P	*
Product weight: g	7.5		*
Size: mm	22.7*28.0*13.6		Length * width * height. Refer to Chapter 8 for detailed dimensions.
Communication interface	UART		The interface can be used as a UART interface at the same time. TTL signal line level is 3.3V. The default baud rate is 921600.
	IIC		Interface can be used as IIC interface at the same time, signal line level 3.3V; The baud rate tops out at 400Kbps.
	I/O		The interface can also be used as an I/O mode interface, and the signal line level is 3.3V.
IIC default slave address	0x08		7 bit address, slave address is 0x08+ module ID.
Typical ranging range: m	0.05~15.0	0.05~25.0	Data were obtained based on the experiment in Chapter 4.
Typical ranging accuracy	Accuracy 5% @[0.05,3]m 8% @(3,15]m	Accuracy 3% @[0.05,25]m	Data were obtained based on the experiment in Chapter 4.
	Standard deviation <2.0cm @[0.05,3]m <5.0cm @(3,7]m <15.0cm @(7,15]m	Standard deviation <5.0cm @[0.05,10]m <10.0cm @(10,20]m <15.0cm @(20,25]m	
Wavelength: nm	750~830		Conform to the Class2 standard specified by IEC 60825-1:2014, 3rd Edition.
Ambient light resistance	About 100K LUX		*
Field of view (FOV): degrees	1~2°		*
Supply voltage: V	[3.7,5.2]		*
Power consumption: mW	610		UART active output, supply voltage 5.0V, current 122mA.
Working temperature: ℃	[-10,60]		The data is obtained by rough test in the actual environment. The actual use depends on the working environment.

3 Functional Description

3.1 ID

ID is a variable set to distinguish between different sensors.

3.2 Interface & Baudrate

The TOFSense-F series supports configuration for UART, IIC, and I/O communication modes.

3.2.1 UART

In serial communication, the baud rate setting range is as shown in Table 2.

Table 2: UART Baudrate Parameter List

UART Baudrate	Note
4800,9600,14400,19200,38400,43000,57600,76800,115200,230400,460800,921600,1000000,1200000,1500000,2000000,3000000	Default baud rate: 921600

3.2.2 IIC

In IIC output mode, the baud rate setting range is as shown in Table 3.

Table 3: IIC Baudrate Parameter List

IIC Baudrate	Note
The maximum is 400K.	The highest baud rate is 400Kbps, determined by the host.

3.3 IIC Address

The IIC slave address of the current module. The setting range is as shown in Table 4.

Table 4: IIC Address Parameter List

IIC Address	Note
0x08~0x77	The default address is 0x08 (7-bit address), and the slave address is 0x08 + module ID, which can be changed by changing the module ID parameter. Pay attention to shift and add read-write bits when communicating, that is, when the address is 0x08, the byte with the read-write bit to be sent is 0x10 (write) and 0x11 (read).

3.4 I/O Output Mode

In this mode, the module can output two complementary high and low levels based on the changes in the distance hysteresis interval.

3.5 Signal Strength

Indicates the strength of the current return signal, with larger values indicating a stronger return signal.

3.6 Range Precision

Indicates the repeat accuracy of the current ranging, with smaller values indicating better ranging accuracy.

3.7 Distance Status

The module can output the current distance status, and the user can process the data based on the distance status. The meaning of the distance status is as shown in Table 5.

Table 5: Distance status meaning

Value	TOFSense-F/TOFSense-F P
0	Measurement distance is invalid
1	Measurement distance is valid

3.8 FOV

The size of the FOV field of view determines the field of view of the TOFSense-F/TOFSense-F P, and the module's field of view is 1~2°.

3.9 Mode Switch

If the module is in UART mode, you can connect to the NAssistant software to switch to IIC or I/O mode. If the module is in IIC mode, you need to send a command to the module through IIC communication to switch back to UART mode. In addition, if there is no IIC test environment or if it is switched to I/O mode, you can refer to the FAQ section in the user manual to switch back to UART mode by sending a serial command immediately after power-on of the module.

4 Typical Performance

4.1 Test Condition

Table 6: Test parameter configuration

Name	Content		Note
Hardware	TOFSense-F	TOFSense-F P	*
Temperature: ℃	[10,40]	[10,40]	*
Location	Nooploop 3rd Experiment Base (Shenzhen)	Nooploop 3rd Experiment Base (Shenzhen)	*
Time	202208	202208	*
Environment	Indoor open space	Indoor open space	*
Working mode	UART actively outputs	UART actively outputs	*
FOV:°	1~2	1~2	*
Power supply voltage: V	5	5	*
The refresh rate: Hz.	50	50	*

In this configuration, the node periodically outputs measurement data, samples measurement at a certain distance interval, and each measurement time is 1 minute. Data recording and export can be done through NAssistant.

Definition error:

$$error = measure\_value - real\_value$$

Among them: measure_value ---Measuring distance

real_value ---Actual distance

Defined standard deviation std:

$$std = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}|A_i - \mu|^2}$$

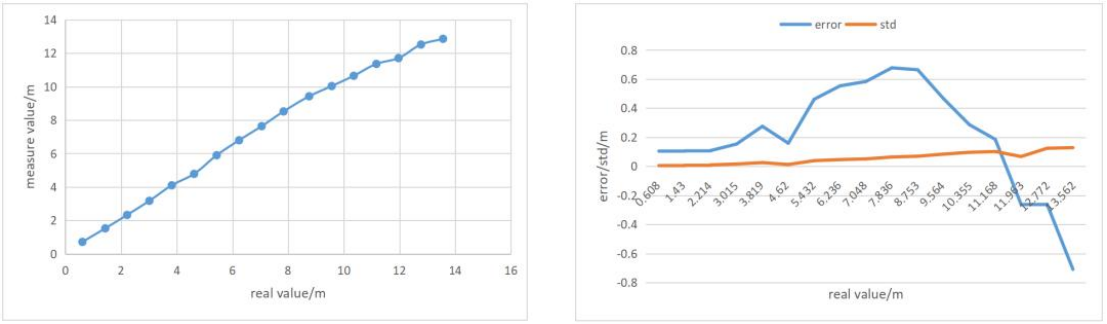
Among them: N ---Number of sampling points

A ---A random variable consisting of N sampled values

$$\mu = \frac{1}{N}\sum_{i=1}^{N} A_i$$

4. 2 Result

The final result of the TOFSense-F data is shown in Figure 3, based on the above conditions for processing the measurement data.



a.Measurement value and true value curve b.Error and standard deviation curve

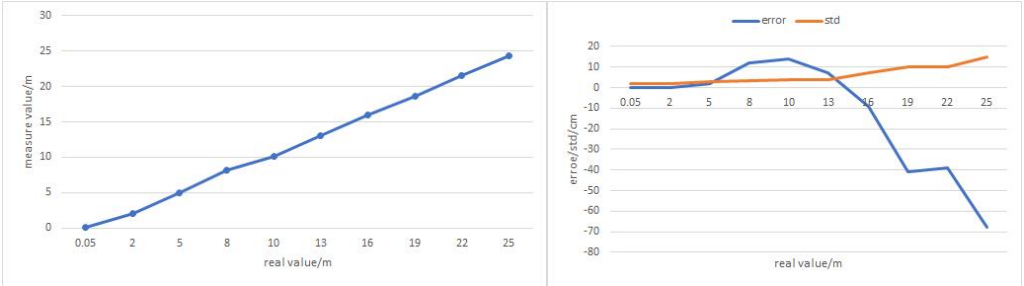
Figure 3: TOFSense-F Test Results

According to the experimental results, the calculation is shown in Table 7.

Table 7: TOFSense-F Accuracy parameters

Blind spot(cm)	Farthest distance (m)	Accuracy	Standard Deviation (cm)
5.0	15.0	5% @[0.05,3]m	<2.0 @[0.05,3]m
		8% @(3,15]m	<5.0 @(3,7]m
		*	<15.0 @(7,15]m

The final result of the TOFSense-F P data is shown in Figure 4.



a.Measurement value and true value curve b.Error and standard deviation curve

Figure 4: TOFSense-F P Test Results

According to the experimental results, as shown in Table 8.

Table 8: TOFSense-F P Accuracy parameters

Blind spot(cm)	Farthest distance (m)	Accuracy	Standard Deviation (cm)
5.0	25.0	3% @[0.05,25]m	<5.0 @[0.05,10]m
		*	<10.0 @(10,20]m
		*	<15.0 @(20,25]m

5 Protocol

The communication format of the TOFSense-F/TOFSense-F P data follows the NLink protocol, please refer to the user manual for more details.

5.1 Composition

The protocol of TOFSense-F/TOFSense-F P data communication follows the NLink protocol, please refer to the user manual for details. As shown in Table 9, the protocol consists of Frame Header, Function Mark, Data, and Sum Check. The Frame Header and Function Mark are fixed and unchanged values, Data is the data content being transmitted, and Sum Check is the lowest byte obtained by summing up the Frame Header, Function Mark, and Data (i.e., the sum of all the previous bytes).

Table 9 : Composition of Protocol

Frame Header	+	Function Mark	+	Data	+	Sum Check

5.2 Endian

NLink follows the Little-endian principle, meaning that the low byte comes first and the high byte comes later.

5.3 Type

Fixed length protocol: A protocol with fixed length.

Variable-length protocol: A protocol with varying length.

The NLink protocol consists of both fixed-length and variable-length protocols, meeting the needs of different scenarios.

5.4 Description

Table 10: NLink protocol content overview

Protocol	Type	Description
NLINK_TOFSENSE_FRAME0	Fixed-length	UART output protocol, which includes node timestamp, distance, distance status, and signal strength.
NLINK_TOFSENSE_READ _FRAME0	Fixed-length	UART read protocol, content includes node ID.
NLINK_TOFSENSE_IIC_FRAME0	Variable length	I2C communication protocol, which includes distance, distance status, signal strength, and other information.

6 Firmware

The format of the officially released firmware version number is VA.B.C, and the format of the test-released firmware version number is VA.B.C.BetaD. Currently, **firmware online upgrades are**

not supported.

7 Software

NAssistant is the debugging software that comes with the TOFSense-F/TOFSense-F P. Its main functions are: configuration debugging, status display, and functional application.

Configuration debugging: used to configure node-related parameters such as ID, working mode, baud rate, etc.

Functional application: used for application development, such as data import and export, distance waveform storage, historical data playback, etc.

8 Mechanical Specifications

8.1 Size

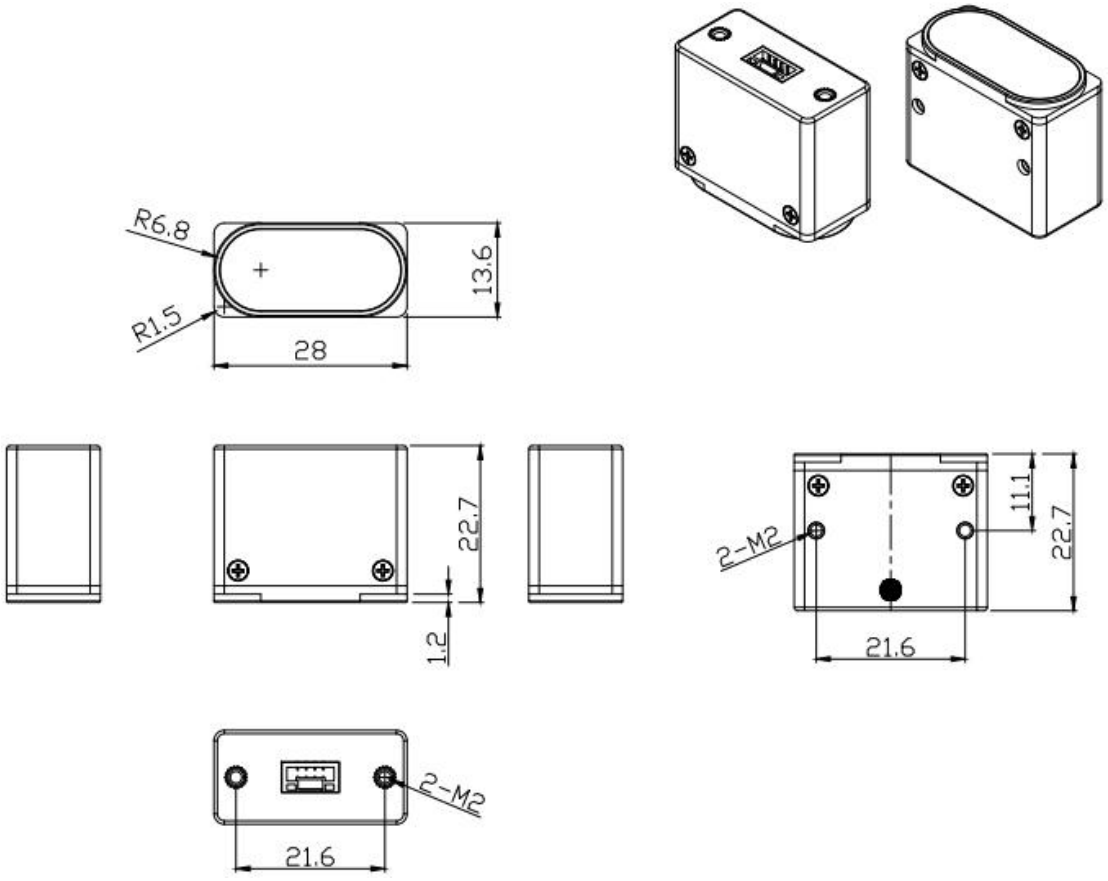


Figure 5: TOFSense-F/TOFSense-F P Dimensions, unit: mm

8.2 Figure

Note: The product images do not represent the actual size, the actual size can be found in section 8.1.

Figure 6: TOFSense-F (Silver mark) /TOFSense-F P (Gloden mark) picture

9 Abbreviation and Acronyms

Table 11: 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

10 Update Log

Table 12: Update log

Version	Firmware Version	Data	Description
1.0	1.0.5	20210918	1. Release the initial manual
1.1	1.1.7	20220926	1. Increase test data such as accuracy 2. Optimized partial description 3. Fixed dimensional drawing errors
1.2	1.1.8	20230404	1. Optimized partial description

11 Further Information

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