TOFSense-F Datasheet V2.0

Language: English

Firmware: V1.1.9

Product Series: TOFSense-F, TOFSense-F P, TOFSense-F2 Mini, TOFSense-F2, TOFSense-F2 P, TOFSense-F2 PH

Catalogue

Disclaimer

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1 Introduction

1.1 Product Overview

TOFSense-F Datasheet

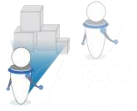
Overview

TOFSense-F/F2 series are single-point laser ranging sensors based on TOF (Time of Flight) technology. Ranging distance from 5cm to 50m, a distance resolution of 1mm, a maximum data update frequency of 350Hz, and a FOV (Field of View) of 1~3°. They support UART, IIC communication, and I/O complementary level output. In UART mode, they support both active output and query output.

Key Features

- Based on TOF (time-of-flight) laser ranging technology
- Ranging Range: 5cm~50m
- Measurement Resolution:1mm
- Typical Ranging Accuracy: ±3.0cm
- Standard Deviation: 1.7cm@1.0m
- Field of View(FOV)1~3°
- Supports UART, IIC, I/O communication
- UART, IIC, and I/O share the same interface
- Supports both active and query output in UART mode
- Power Supply: 4.3~5.2V
- 750~830nm laser meets the Class2 standard specified in IEC 60825-1:2014 Edition 3
- Ambient light immunity up to approximately 100K LUX illumination

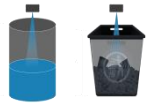
Applications



Robot Obstacle Avoidance

Personnel Detection

Detection and Measurement



Hydraulic Level Detection

UAV Altitude Hold

- High-speed measurement and safety monitoring in transportation and industrial automation fields
- Other scenarios

1.2 Product Interface

The UART interface pinout is abbreviated as "V G R T" corresponding to VCC, GND, RX, TX (Note: In UART communication, the TX and RX of both sides should be cross-connected, i.e., 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 of the IIC interface is abbreviated as "V G D C" corresponding to VCC, GND, IIC_SDA, IIC_SCL.

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 figures do not represent the actual size, please refer to Chapter 8 for the actual size.

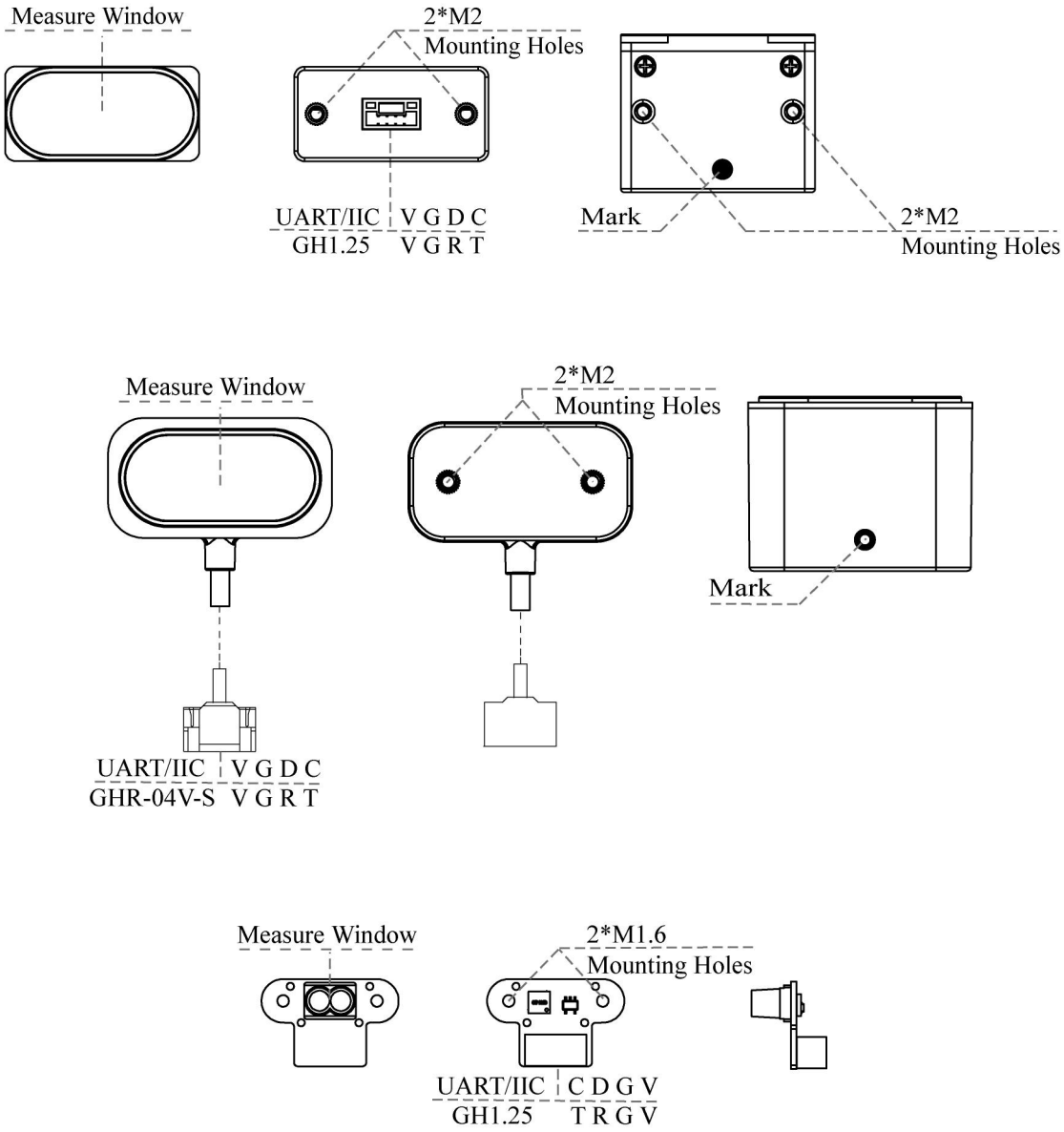


Figure 1: GH1.25 Female Connector Interface

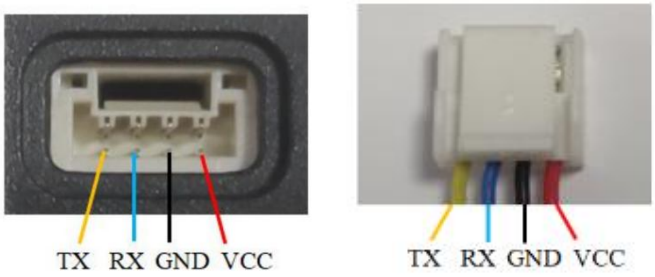


Figure 2: GH1.25 4P Actual Line Sequence of Female Connector Interface(Left), Terminal Interface(Right)

1.3 Technology Overview

TOF is an absolute distance detection technology where the sensor emits modulated near-infrared light, which reflects off an object. The sensor calculates the distance to the object by measuring the time difference or phase difference between light emission and reflection, generating depth information. Compared to binocular and 3D structured light solutions, TOF offers longer working distances, wider application scenarios, and higher accuracy at longer ranges. Therefore, it is commonly used in applications such as personnel proximity detection, robot obstacle avoidance, and camera autofocus.

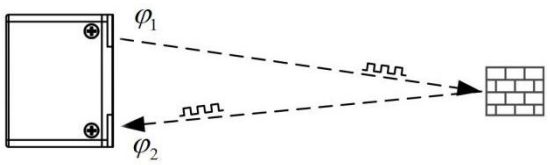


Figure 3: TOF Ranging Principle Illustration

1.4 Functional Overview

TOFSense-F/TOFSense-F2 series 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-F2 supports both active out 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-F2 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 Specifications

Parameters	Typical					
Product Model	TOFSense-F	TOFSense-F P	TOFSense-F2 Mini	TOFSense-F2	TOFSense -F2 P	TOFSense-F2 PH
Product Weight: g	7.5		1	7.5		*
Dimensions: mm[1]	22.7*28.0*13.6		19.0*12.0*10.3	22.7*28.0*13.6		31.0*24.1*16.6
Communication Interface[2]	UART					
	IIC					
	I/O					
IIC Default Slave Address	0x08					
Refresh Rate: Hz	350		50	100		
Typical Ranging Distance: m	0.05~15.0	0.05~25.0	0.02~7.8	0.05~25.0	0.05~50.0	
Typical Ranging Accuracy[3]	Accuracy ±6cm@[0.05,3)m ±5%@[3,15]m	Accuracy 3%@[0.05,25]m	Accuracy ±4cm@[0.02,7.8]m	Accuracy ±3.0cm@[0.05,25]m	Accuracy ±3.0cm@[0.05,50]m	
	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	Standard Deviation <2.0cm@[0.02,1]m <8.7cm@(1,7.8]m	Standard Deviation <1.0cm@[0.05,10]m <6.0cm@(10,25]m	Standard Deviation <1.0cm@[0.05,10]m <6.0cm@(10,50]m	
Wavelength: nm[4]	750~830		940	905		
Ambient Light Immunity	About 100K LUX					
Field of View (FOV): Degrees	1~2°		2~3°	1~2°		
Supply Voltage:V[5]	[4.3,5.2]					
Power Consumption: mW	610		100	250		
Operating Temperature: °C[6]	[-10,60]					*
IP Rating	*					IP68

[1] Length * Width * Height, please refer to Chapter 8 for detailed dimensions.
[2] The interface can serve as UART, IIC, and IO interfaces simultaneously, with a TTL signal line level of 3.3V. The default UART baud rate is 921600.
[3] The data was obtained based on the experiment in Chapter 4.
[4] 750-830nm laser complies with the Class2 standard specified in IEC 60825-1:2014 3rd edition, and is currently under review for the 940 and 905 bands
[5] UART active output, power supply voltage 5.0V.
[6] The data was obtained through actual environmental testing, and actual use should be based on the working environment.

3 Functional Description

3.1 ID

ID is a variable set to distinguish between different sensors.

3.2 Interface

TOFSense-F/F2 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 (Unit: bps)

UART_Baudrate	Note
4800,9600,14400,19200,38400,43000,57600,7680 0,115200,230400,460800,921600,1000000,120000 0,1500000,2000000,3000000	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). 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 that vary according to the distance hysteresis interval.

3.5 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/F2 Series
0	Measurement distance is invalid.
1	Measurement distance is valid.

3.6 Signal Strength

Indicates the strength of the current return signal, with larger values indicating a stronger return signal. At the same distance from the object being measured, the different reflectivity of the surface of the object being measured can lead to changes in signal intensity. The higher the reflectivity, the greater the signal intensity, and vice versa.

3.7 Range Precision

At the same distance from the object being measured, the different reflectivity of the surface of the object being measured can lead to changes in signal intensity. The higher the reflectivity, the greater the signal intensity, and vice versa.

3.8 FOV

The size of the FOV field of view determines the field of view of the TOFSense-F/TOFSense-F P/TOFSense-F2 P/TOFSense-F2 PH, The module's field of view is 1~2°. The field of view of the TOFSense F2 Mini module is 2-3 °.

3.9 Mode Switch

If the module is in UART mode, you can connect to NAssistant 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, 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]		*
Location	Nooploop 3rd Experiment Base (Shenzhen)		*
Time	202208		*
Environment	Indoor open space		*
Working Mode	UART active output		*
FOV：°	1~2		*
Power Supply Voltage: V	5		*
Refresh Rate: Hz.	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:

$$Error = Measure\_Value - Real\_Value$$

Measure_Value --- Measuring distance

Real_Value --- Actual distance

Defined standard deviation std:

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

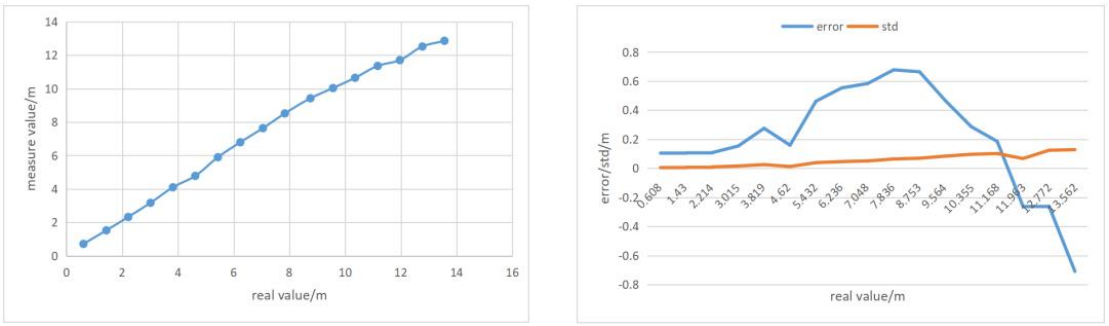
N --- Number of sampling points

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 4, based on the above conditions for processing the measurement data.



a. Measurement Value and True Value Curve

b. Error and Standard Deviation Curve

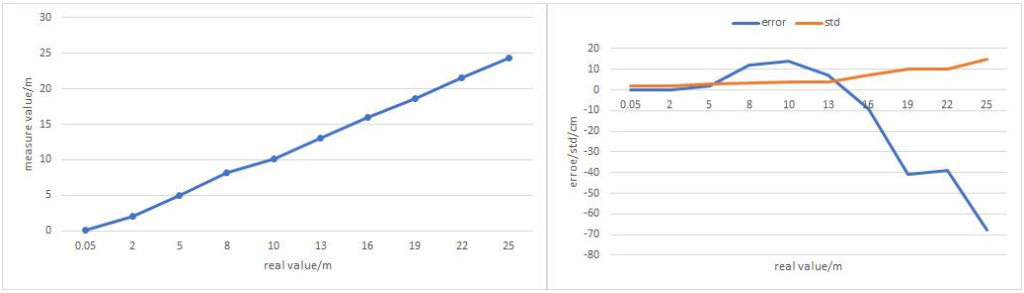
Figure 4: TOFSense-F Test Results

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

Table 7: TOFSense-F Accuracy Parameters

Blind Area(cm)	Farthest Distance (m)	Accuracy	Standard Deviation (cm)
5.0	15.0	±6cm@[0.05,3)m	<2.0@[0.05,3)m
		±5%@[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 5.



a.Measurement Value and True Value Curve b.Error and Standard Deviation Curve

Figure 5: TOFSense-F P Test Results

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

Table 8: TOFSense-F P Accuracy Parameters

Blind Area(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 data communication format of TOFSense F/F2 series modules follows the NLink protocol. Please refer to the user manual for details.

5.1 Composition

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 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	IIC 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/F2. 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

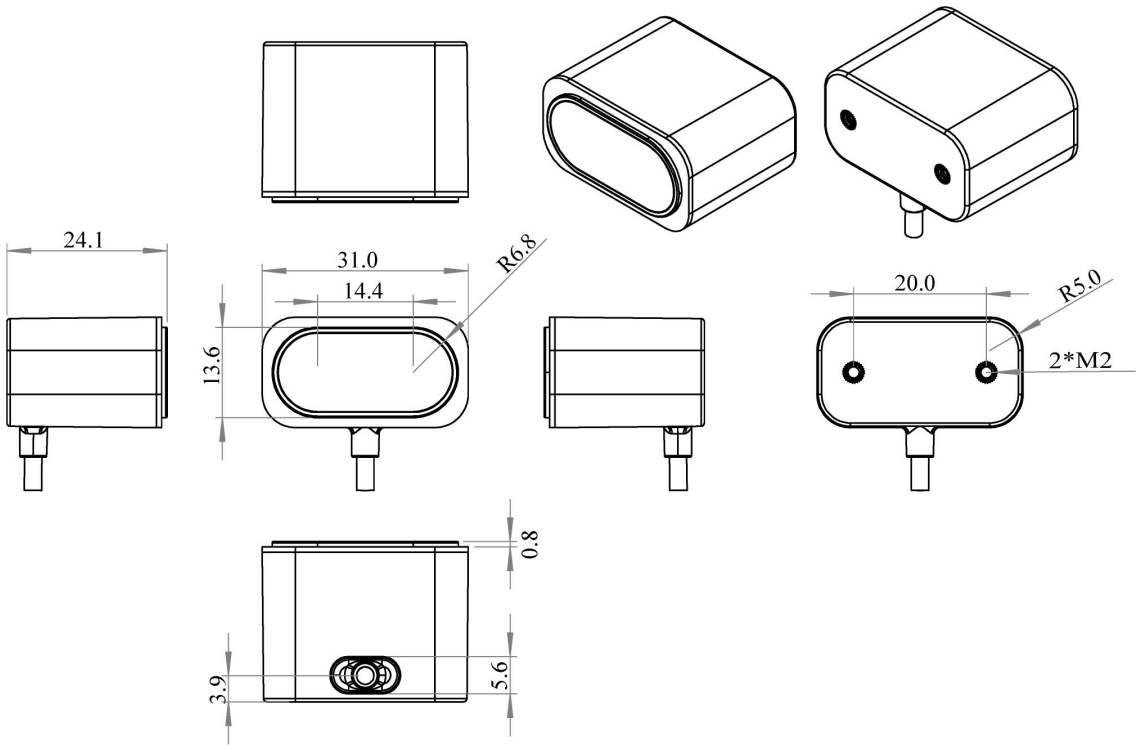


Figure 6: TOFSense-F2 PH Dimensions, Unit: mm

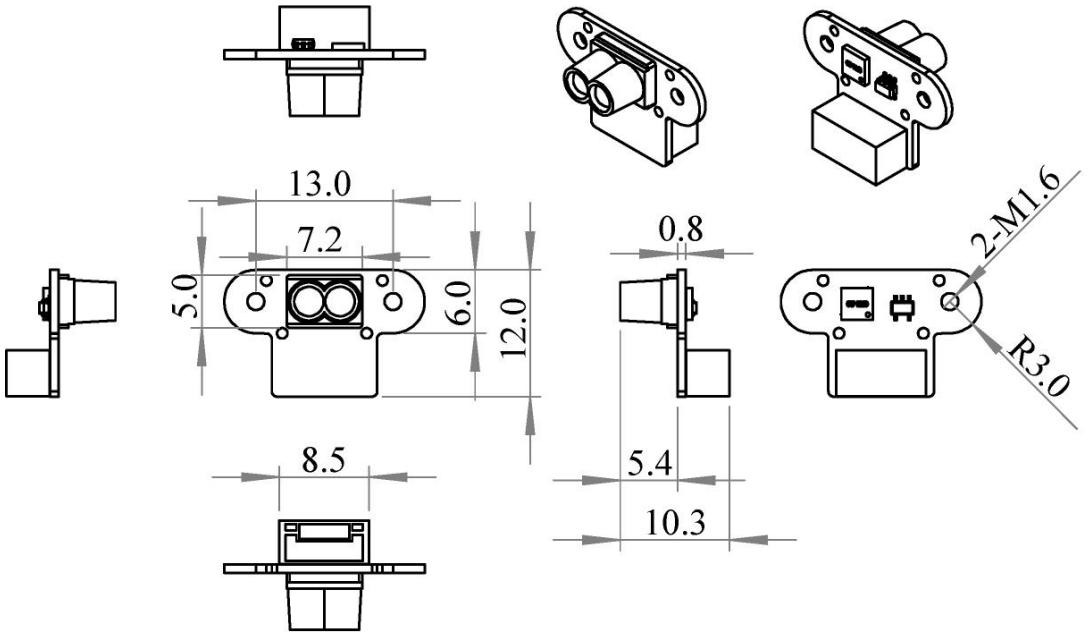


Figure 7: TOFSense-F2 Mini Dimensions, Unit: mm

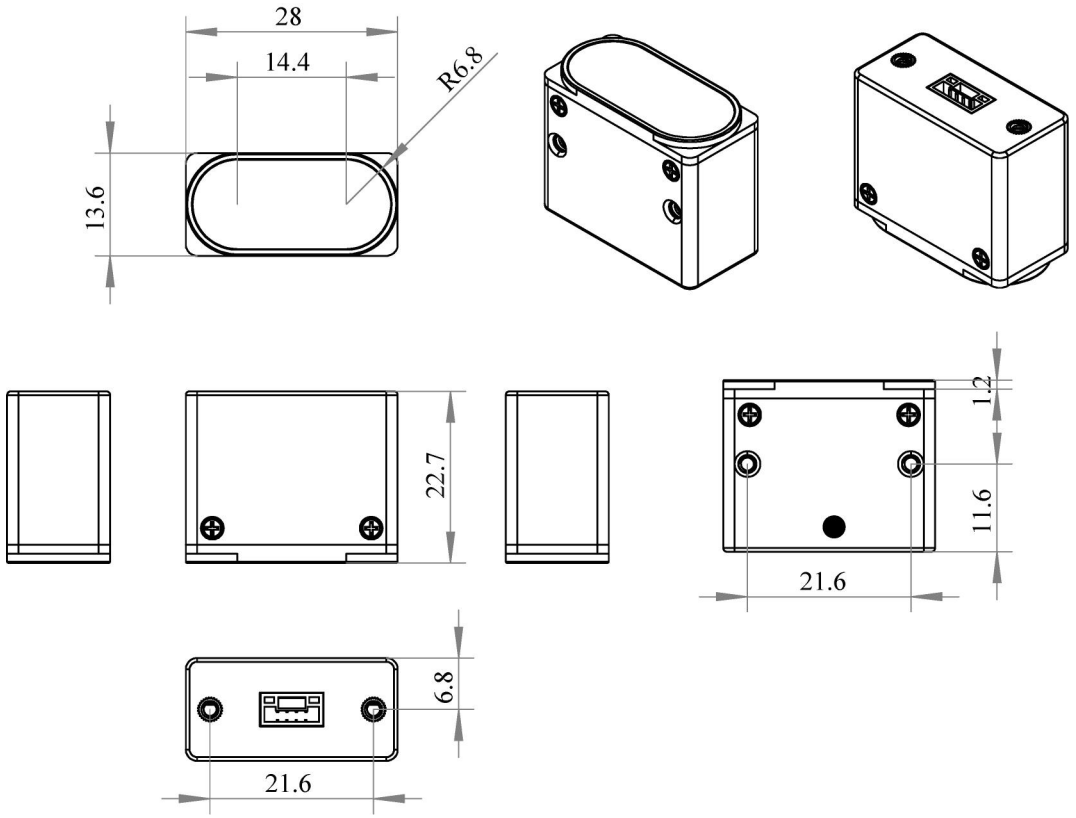


Figure 8: TOFSense-F/TOFSense-F P/TOFSense-F2/TOFSense-F2 P Dimensions, Unit: mm

Note: The actual size may vary according to the manufacturing process and measurement method. Please refer to the actual product.

8.2 Figure

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

Figure 9: TOFSense-F(Silver Dot)/TOFSense-F P(Gold Dot)/TOFSense-F2(Sliver Circle)/TOFSense-F2 P(Gold Circle)

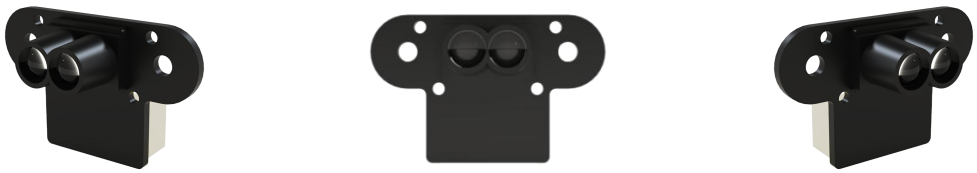


Figure 10: TOFSense-F2 Mini

9 Abbreviation and Acronyms

Table 11: Abbreviation and Acronyms

Abbreviation	Full Title
TOF	Time of Flight
FOV	Field of View
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. Released the initial version of the manual
1.1	1.1.7	20220926	1. Added accuracy and other test data 2. Optimized some description 3. Corrected dimensional drawing errors
1.2	1.1.8	20230404	1. Optimized some description
1.3	1.1.9	20240224	1. Added TOFSense F Mini/TOFSense F Pro model and dimension diagram 2. Optimized layout 3. Optimized some description
1.4	1.1.9	20240326	1. Revised some description 2. Modified some product names
1.5	1.1.9	20240402	1. Added TOFSense F2 series 2. Added refresh rates for each model
1.6	1.1.9	20240529	1. Optimized some description
2.0	1.1.9	20240703	1. Added TOFSense F2 Mini physical image, updated TOFsense F2 Mini size diagram

11 Further Information

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