TOFSense Datasheet V3.0

Language: English

Firmware: V3.0.4

Product Series: TOFSense, TOFSense-UART, TOFSense S

Catalogue

Disclaimer

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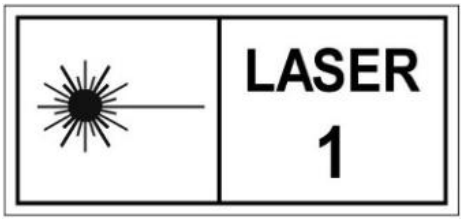
Certification instructions

- TOFSense series products comply with the Class1 standard specified in IEC 60825-1:2014 3rd edition.



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.

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

1. Attention: If control or adjustment devices are not used according to regulations, or if various steps of operation are not carried out according to regulations, it may cause 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.

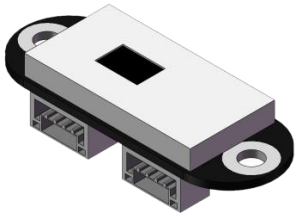
1 Introduction

1.1 Product Overview

TOFSense Datasheet

Overview

TOFSense/TOFSense-UART/TOFSense S are laser ranging sensors based on the TOF (time-of-flight) technology. The ranging distance is 3cm~8m, with a distance resolution of 1mm. The data update frequency is 30Hz. The field of view (FOV) is adjustable with a maximum viewing angle of 27°. The sensors support UART, CAN communication, and can output data actively or upon request. They also support cascading multiple sensors for ranging. TOFSense/TOFSense-UART support I/O complementary level output.



Key Features

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

TOFSense/UART/S	3cm~8m

- Measurement resolution of 1mm
- Typical ranging accuracy

TOFSense/UART/S	
0.03~1.0m	±1.5cm
1.0~8.0m	±3.0cm

- Standard deviation

TOFSense/UART/S	2.5cm@4.0m

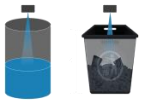
- Adjustable field of view (FOV), 15~27°
- Supports UART and CAN communication, and partially supports I/O communication
- UART, CAN and I/O share the same interface
- Supports cascading multiple modules
- Active and query output
- One-click firmware upgrade
- 3.7~5.2V@UART/(I/O), 4.2~5.2V@CAN Power supply
- Power consumption is approximately 290mW
- The 940nm laser complies with the Class1 standard specified in IEC 60825-1:2014 3rd edition and the Class 1 laser product standard specified in GB 7247.1-2012

Applications

Robot Obstacle Avoidance

Personnel Detection

Detection and Measurement



Hydraulic Level Detection

UAV Altitude Hold

- Step detection
- 1D gesture recognition
- Other scenarios

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 of the CAN interface, as shown in the diagram, is abbreviated as "V G H L" corresponding to VCC, GND, CAN_H, CAN_L.
The wire sequence of the I/O interface, as shown in the diagram, is abbreviated as "V G H L" corresponding to VCC, GND, I/O_H, I/O _L.
Among them, VCC refers to the power supply, and GND refers to the power ground.

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

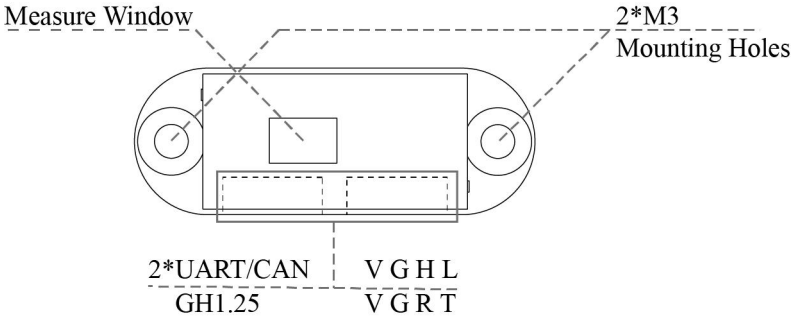


Figure 1: TOFSense/TOFSense-UART Interface

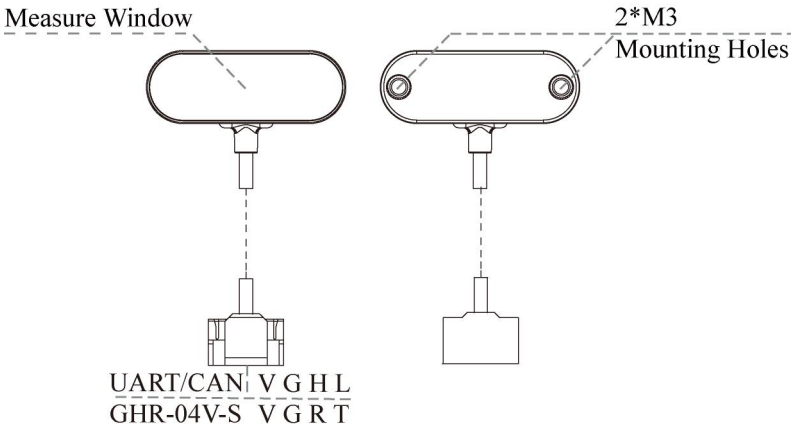


Figure 2: TOFSense S Interface

The actual terminal wire sequence of TOFSense S product is shown in Figure 3.

Figure 3: TOFSense S Actual Interface Wire Sequence

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. In outdoor environments, near-infrared light from sunlight can affect the measurement effectiveness of the module.

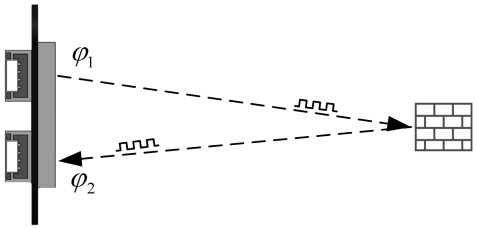


Figure 4: TOF Ranging Principle Illustration

1.4 Functional Overview

TOFSense/TOFSense-UART/TOFSense S support multiple FOV angle settings, which can meet various scene requirements. It can output distance measurement values distance, distance status, signal strength and other information.

Output method: Supports active output and query output. Active output refers to the module independently and continuously sending measurement data frames at a frequency of 30Hz; The query output refers to the module receiving the query frame and then outputting the measurement data frame.

Connection method: Supports UART and CAN output methods, both of which share the same physical interfaces. Among them, UART output supports active output, query output of a single module, and query output under multiple cascaded connections; CAN output supports active output and query output of a single module, as well as active output and query output under cascading connections of multiple modules. TOFSense/TOFSense UART supports I/O output and can output complementary levels in I/O mode.

2 Typical Specifications

Table 1: Typical Specifications

Parameters	Typical			Note
Product Model	TOFSense	TOFSense-UART	TOFSense S	*
Product Weight: g	2.7		5.8	*
Size: mm	35.8*13.0*8.3		35.6*13.0*7.0	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 921600bps.
	CAN	*	CAN	The interface can also be used as a CAN interface, and the default baud rate is 1Mbps.
	I/O		*	The interface can also be used as an I/O mode interface, and the signal line level is 3.3V.
Cascade Quantity	UART: 8			The maximum number of cascaded levels supported has been tested.
	CAN: 7			
Typical Ranging Range: m	0.03~8.00			Data were obtained based on the experiment in Chapter 4.
Typical Ranging Accuracy	Accuracy±1.5cm@[0.03,1.0]m, Standard deviation<0.3cm Accuracy±3.0cm@(1.0,8.0]m, Standard deviation<5.0cm			Data were obtained based on the experiment in Chapter 4.
Wavelength: nm	940			Complies with Class 1 standards as defined by IEC 60825-1:2014 3rd edition and Class 1 laser product standards as defined by GB 7247.1-2012.
Field Of View (FOV): degrees	15~ 27			Resolution is 1 degree and supports setting X and Y direction offsets.
Supply Voltage: V	[3.7,5.2]@UART/(I/O), [4.2,5.2]@CAN			All communication interface power supplies have electrical connections, and the power supply interface can be any one of the interfaces.
Power Consumption: mW	290			In UART active output mode, under the long-range distance measurement mode, the power supply voltage is 5.0V, and the current is 58mA.
Operating Temperature : ℃	[-20,65]			The data is obtained from rough testing in actual environment, and actual usage should be based on the working environment.
Protection Level	*		IP66	Protection level

3 Functional Description

3.1 ID

ID is a variable set to distinguish between different sensors. Used to identify each sensor when cascading multiple sensors together.

3.2 Interface

TOFSense series supports configuration for UART, CAN, and I/O communication methods (some models may not support one or both communication methods, the actual supported communication method shall prevail).

3.2.1 UART

Under the serial communication, the range of baud rate settings is as shown in Table 2.

Table 2: UART Baudrate Parameter List, Unit:bps

UART_Baudrate	Note
115200,230400,460800,921600,1000000,1200000, 1500000,2000000,3000000	Default baud rate: 921600

3.2.2 CAN

Under the CAN output mode, the range of baud rate settings is as shown in Table 3.

Table 3: CAN Baudrate Parameter List, Unit:bps

CAN_Baudrate	Note
100K, 250K, 500K, 1M	Default baud rate: 1M

3.3 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.

3.4 Signal Strength

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

3.5 FOV

The size of the FOV field of view angle determines the field of view of the module. The module can change the X direction field of view angle fov.x, Y direction field of view angle fov.y, X direction offset fov.x_offset, and Y direction offset fov.y_offset. X. Y direction field of view angle setting range: 15 °~27 °, offset setting range: -6 °~6 °.

3.6 Function Key

It is used to switch back to UART mode when using CAN or other communication modes. First, hold down the button while the module is powered off, and then power on the module. Release the button when the indicator light changes from fast blinking to slow blinking. At this time, the module will enter temporary

UART mode. You can use the NAssistant to identify and enter the setting page to change the module's communication mode to UART and then click "Write Parameters" to switch back to UART mode. TOFSense S does not have a button.

3.7 Indicator Light

There are two types of indicator light blinking states: fast blinking and slow blinking (1Hz). TOFSense S does not have an indicator light. The LED states and meanings are shown in Table 4.

Table 4: Meaning of Indicator Light

Status	Note
Fast blinking (0.1s interval)	Module startup phase
	Module firmware update
Slow blinking (1s interval)	Module normal operation

3.8 Distance Status

The module can output the current distance status, and users can use the distance status for data processing. The meaning of the distance status is shown in Table 5.

Table 5: Meaning of Distance Status

Value	TOFSense/TOFSense-UART/TOFSense S
0	Ranging measurement is valid
1	Standard deviation greater than 15mm
2	Signal strength lower than 1Mcps
3	Distance measurement below threshold.
4	Phase exceeding limit.
7	Phase mismatch.
9	Signal lower than crosstalk threshold.
11	Distances of multiple targets.
12	Weak signal strength.
14	Invalid measurement distance.
255	No target detected.

4 Typical Performance

4.1 Test Condition

Table 6: Test Parameter Configuration

Name	Content	Note
Hardware	TOFSense	*
Temperature: ℃	[10,40]	*
Location	Nooploop 2rd Experiment Base (Shenzhen)	*
Time	202107	*
Environment	Indoor open space	*
Working Mode	UART active output	*
FOV:°	27	*
Power Supply Voltage: V	5	*
Refresh Rate: Hz	30	*

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:

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

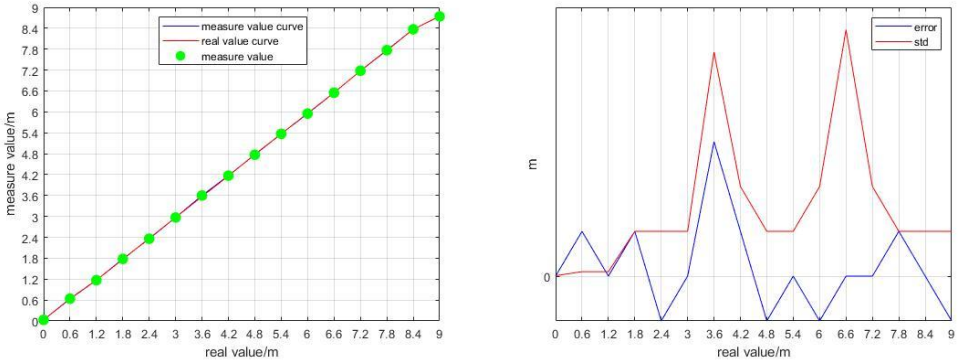
Among them: N ---Number of sampling points

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

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

4.2 Result

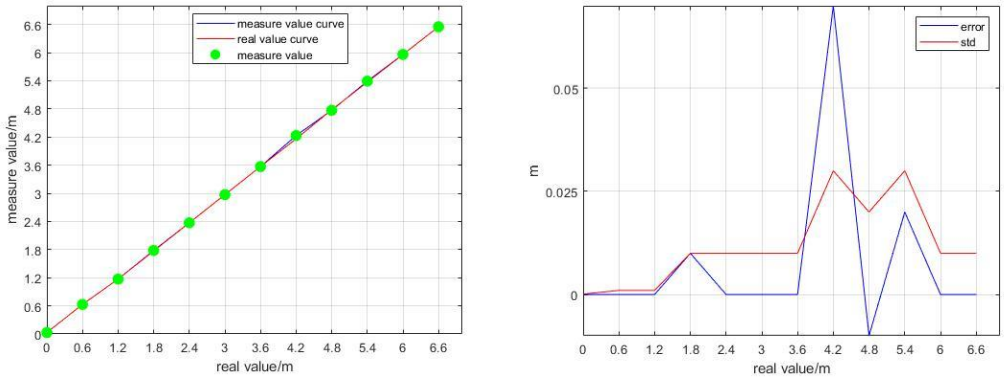
The final result of the TOFSense data are shown in Figure 5, Figure 6 and Figure 7.



a. Measurement Value and True Value Curve

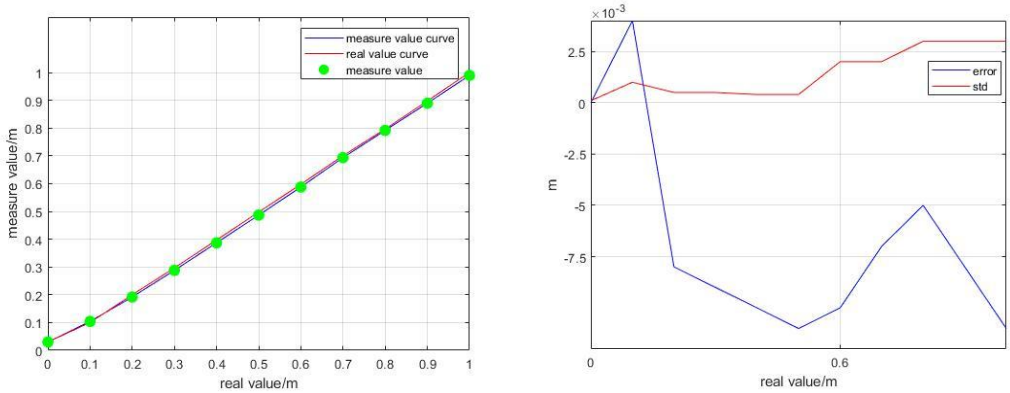
b. Error and Standard Deviation Curve

Figure 5: Long Distance Mode Test Results



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

Figure 6: Medium Distance Mode Test Results



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

Figure 7: Short Distance Mode Test Results

Calculated based on experimental results, as shown in Table 8.

Table 8: TOFSense Accuracy Parameters

Mode	Blind Zone (cm)	Maximum Distance (m)	Accuracy (cm)	Standard Deviation (cm)
Short	3.0	1.00	±1.5	<0.3
Medium	3.0	6.50	±3.0	<3.0
Long	3.0	8.00	±3.0	<5.0

5 Protocol

TOFSense/TOFSense-UART/TOFSense S data communication format follows the NLink protocol. For details, please refer to the user manual.

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 values. Data is the transmitted data content, and Sum Check is the lowest byte obtained by adding Frame Header, Function Mark, and Data (i.e., adding 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, content includes node timestamp, distance, distance status, and signal strength.
NLINK_TOFSENSE_READ _FRAME0	Fixed-length	UART read protocol, content includes node ID.
NLINK_TOFSENSE_CAN_FRAME0	Fixed-length	CAN output protocol, content includes distance, distance status, and signal strength.
NLINK_TOFSENSE_CAN_READ_FRAME0	Fixed-length	CAN reading protocol, which includes node ID.

6 Firmware

The format of the firmware version number for the official release is VA.B.C, and the format of the firmware version number for testing release is VA.B.C.BetaD. Both can be checked for the latest firmware and upgraded via NAssistant, and support wired firmware upgrade.

7 Software

NAssistant is a debugging software that is compatible with TOFSense/TOFSense-UART/TOFSense S. Its main functions include configuration and debugging, status display, function application, and firmware

upgrade.

Configuration and debugging: Used to configure node-related parameters, such as ID, operating mode, baud rate, etc.

Function application: Used for application development, such as data import/export, distance waveform storage, historical data playback, etc.

Firmware upgrade: Used for wired firmware upgrade of the product.

8 Mechanical Specifications

8.1 Size

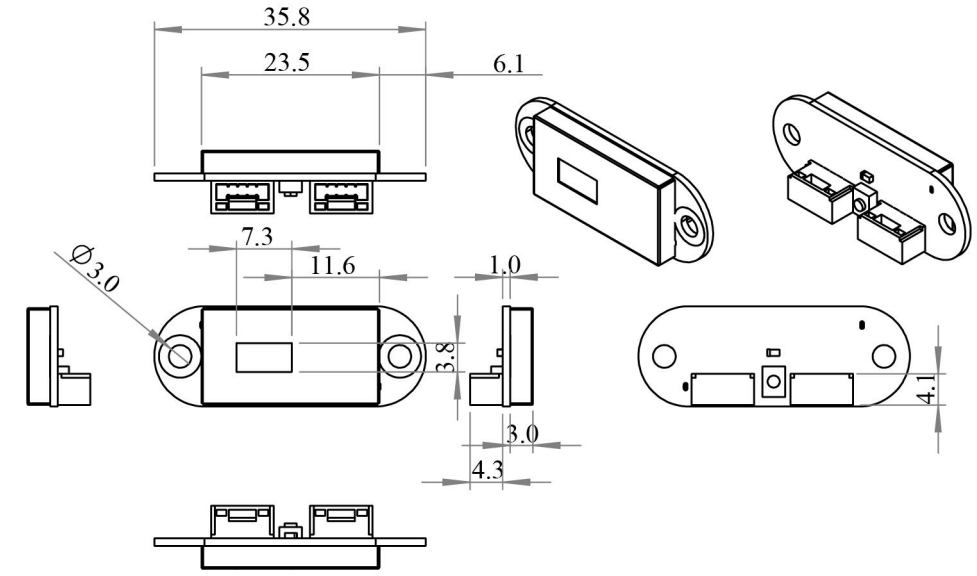


Figure 8: TOFSense/TOFSense-UART Dimensions, Unit: mm

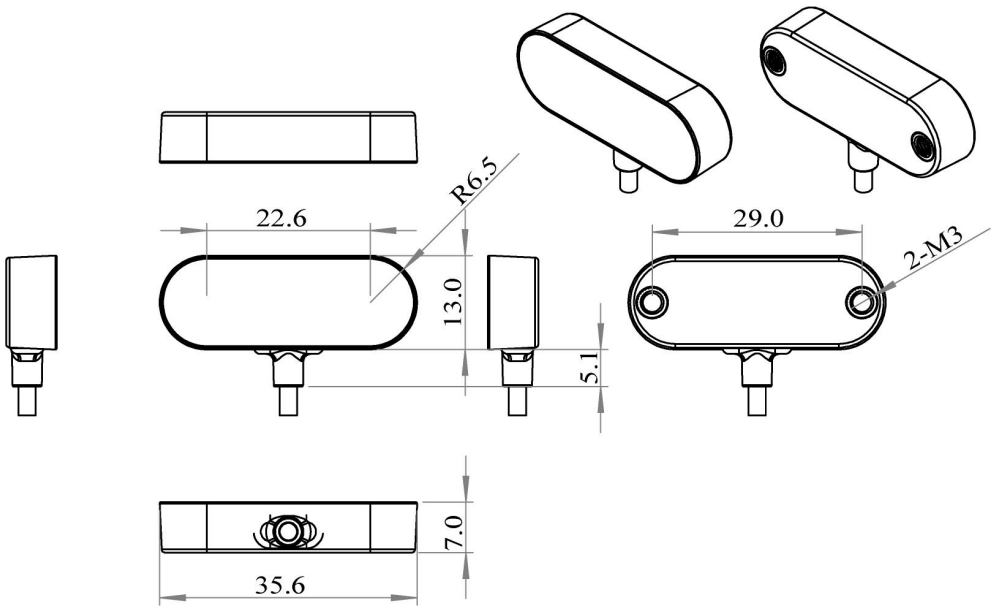


Figure 9: TOFSense S Dimensions, Unit: mm

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

9 Abbreviation and Acronyms

The meanings corresponding to the abbreviations and acronyms of some nouns.

Table 11: Abbreviation And Acronyms

Abbreviation	Full Title
TOF	Time of Flight
FOV	Field of View

10 Update Log

Table 12: Update Log

Version	Firmware Version	Data	Description
1.0	1.0.0	20190817	1. Released initial version of the manual.
1.1	1.0.4	20190923	1. Updated FOV parameter description. 2. Adapted to the latest firmware version.
1.2	1.0.6	20191213	1. Corrected errors in the manual. 2. Adapted to the latest firmware version.
2.0	2.0.0	20200730	1. Added description of I/O output mode. 2. Adapted to the latest firmware version.
2.1	2.0.0	20210623	1. Added description of TOFSense P and TOFSense PS. 2. Corrected relevant descriptions.
2.2	2.0.3	20220211	1. Added experimental data on accuracy and standard deviation for TOFSense P and TOFSense PS. 2. Optimized partial description
2.3	2.0.4	20220924	1. Added description of certifications. 2. Optimized partial description
2.4	2.0.4	20221205	1. Added description of power supply voltage for CAN mode. 2. Updated dimensional drawing, added more dimensions.
2.5	2.0.4	20230404	1. Optimized partial description
2.6	2.0.4	20240110	1. Optimized partial description 2. Corrected the description of TOFSense P 3. Added actual terminal wire sequence diagram of TOFSense PS
2.7	2.0.4	20240401	1. Removed P series 2. Optimized partial description
2.8	3.0.4	20240703	1. Optimize distance status indication 2. Optimized partial description

11 Further Information

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