# TOFSense-M Datasheet V3.0


**Language: English**

**Firmware:** V2.0.2

**Product Series:** TOFSense-M, TOFSense-M S

# Catalogue



 

# 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 on this product. |

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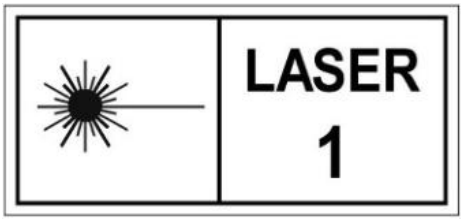
| Regulatory Approvals |
| --- |
| The TOFSense-M series sensors, as supplied from Nooploop currently have the following laser product certifications. Users need to confirm whether these certifications are applicable according to the region where such products are used or sold. All products developed by the user incorporating the TOFSense-M 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. |

# Certification instructions

- TOFSense-M 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.

- TOFSense-M 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.

# 1 Introduction

## 1.1 Product Overview

# TOFSense-M Datasheet

## Overview

TOFSense M/TOFSense M S is a multi point array laser ranging sensor based on TOF (Time of Flight) technology. Its ranging range is 1.5cm-4m, Distance resolution is 1mm. Its maximum data update frequency is 60Hz. 8*8 and 4*4 dot matrices, UART and CAN communication, active output and query output, multi-sensor cascade ranging are supported.

## Key Features

- Based on TOF (Time of Flight) laser ranging technology
- Ranging range

| TOFSense-M/M S | |
|---|---|
| Ambient Light/LUX | Ranging Range |
| 600 | 1.5cm~4m |
| 60K | 1.5cm~2m |
| 100K | 1.5cm~1.2m |

- Measurement resolution:1mm
- Typical ranging accuracy

| | |
|---|---|
| TOFSense-M/M S | ±1.5cm |

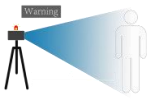
- Standard Deviation

| | |
|---|---|
| TOFSense-M/M S | 1cm@4m |

- Optional pixel points: 8*8, 4*4
- Diagonal field of view(FOV): 65°
- Update frequency: 15Hz@8*8, 60Hz@4*4
- Support UART and CAN communication
- UART and CAN share the same interface
- Supports multi-module cascading
- Active and query data output
- One-click firmware upgrade
- Power supply: 3.7~5.2V@UART, 4.2~5.2V@CAN with reverse-polarity-proof connectors
- Power consumption: approximately 670mW
- 940nm laser compliant with Class 1 standards defined in IEC 60825-1:2014 Edition 3 and GB 7247.1-2012

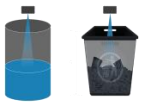
## Applications

Robot Obstacle Avoidance

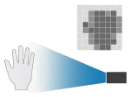



Personnel Detection

Detection and Measurement



Hydraulic Level Detection



Intelligent Gesture Control

UAV Altitude Hold

- Step detection
- 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 CAN interface is abbreviated as "V G H L" corresponding to VCC, GND, CAN_H, CAN_L.

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.

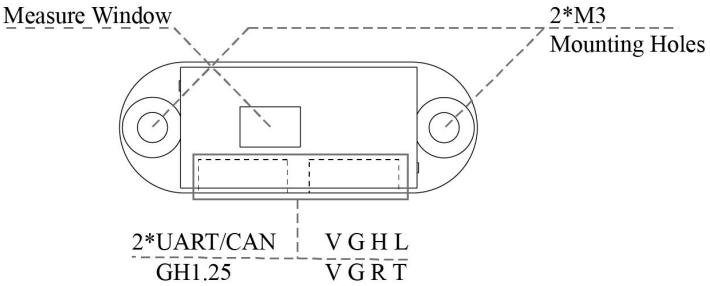



Figure 1: TOFSense-M Interface

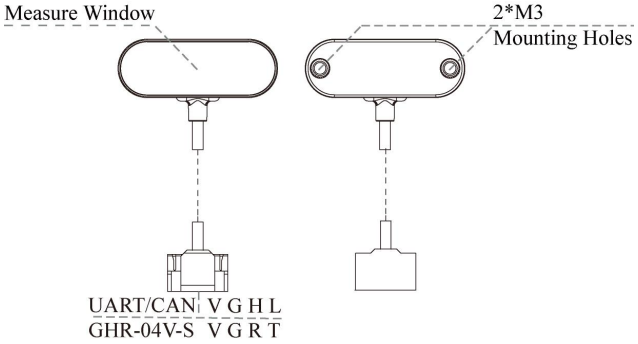



Figure 2: TOFSense-M S Interface

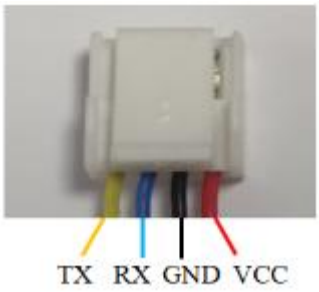



Figure 3: GH1.25 4P Actual line sequence of the interface

## 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.

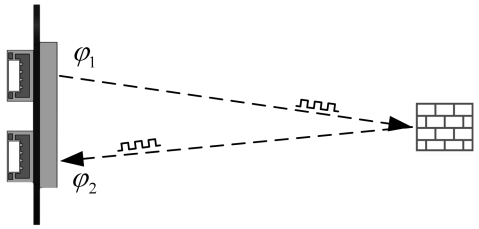



Figure 4: TOF Ranging Principle Illustration

## 1.4 Functional Overview

TOFSense-M/TOFSense-M S supports 8*8 and 4*4 multi-region point array data output with a diagonal FOV of up to 65°, meeting various scene requirements. It can output distance measurements (dis), distance status (dis status), signal strength, and other information.

**Output Modes**:

- Active output: The module autonomously and continuously sends measurement data frames at up to 60Hz.
- Query output: The module outputs measurement data frames after receiving a query frame.

**Connection Modes**:

TOFSense-M/TOFSense-M S supports UART and CAN output methods, both of which share the same physical interfaces. UART output supports active and query output for single modules query, as well as query output for multiple cascaded connections. CAN output supports active and query output for single modules, as well as active output and query output for multiple cascaded modules.

# 2 Typical Specifications

Table 1: Typical Specifications

| Parameters | Typical | | Note |
|---|---|---|---|
| Product Model | TOFSense-M | TOFSense-M S | * |
| Product Weight: g | 2.8 | 5.8 | * |
| Size: mm | 35.8*13.3*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 | | The interface can also be used as a CAN interface, and the default baud rate is 1Mbps. |
| Cascade Quantity | UART: 8 | | Maximum tested. See FAQ in the user manual for additional cascading. |
| | CAN: 7 | | |
| Typical Ranging Range: m | 0.015~4.00@600 LUX<br>0.015~2.00@60K LUX<br>0.015~1.20@100K LUX | | Data were obtained based on the experiment in Chapter 4. |
| Typical Ranging Accuracy | Accuracy:±1.5cm<br>Standard deviation<1.0cm | | 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 | 45@Horizontal&Vertical<br>65@Diagonal | | Detection target within the field of view range at the measured distance. |
| Supply Voltage: V | [3.7,5.2]@UART,<br>[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 | 670 | | For UART active output, under the long-distance measurement mode, the supply voltage is 5.0V and the current is 134mA. |
| 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-M/TOFSense-M S support UART and CAN communication modes.

### 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 Pixel

Supports outputting distance information for 64 pixels (8*8 array) or 16 pixels (4*4 array).

## 3.4 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 4.

Table 4: Meaning Of Distance Status

| Value | Note |
|---|---|
| 0 | Measurement data is valid. |
| 1 | Signal strength is too low. |
| 2 | Phase Target |
| 3 | Target Noise Overestimation |
| 4 | Target consistency check failed. |
| 5 | Measurement data is not updated. |
| 6 | Wrap-around operation is not performed (usually on the first measurement) |
| 7 | Inconsistent Rate |
| 8 | Current target signal strength low. |
| 9 | Large pulse effective range (possibly due to merged targets) |
| 10 | Measurement data is valid, but target is not detected in previous check. |
| 11 | Inconsistent measurement results |
| 12 | Target Blurred |
| 13 | Target is detected but data is inconsistent, usually occurs when secondary targets are present. |
| 255 | Target is not detected. |

## 3.5 Signal Strength

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

## 3.6 FOV

The size of the FOV determines the field of view range of the TOFSense-M series. The module's FOV is fixed and cannot be altered, with 45° horizontally and vertically, and 65° diagonally.

## 3.7 Indicator Light

There are two types of indicator light blinking states: fast blinking and slow blinking (1 flash per second). TOFSense-M S does not have an indicator light. The LED states and meanings are shown in Table 5.

Table 5: 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 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-M S does not have a button.You can refer to the user manual FAQ for methods to switch back to UART mode.

# 4 Typical Performance

## 4.1 Test Condition

Table 6: Test Parameter Configuration

| Name | Content | | Note |
|---|---|---|---|
| Hardware | TOFSense-M | TOFSense-M | * |
| Temperature: ℃ | [10,40] | [10,40] | * |
| Location | Nooploop 2rd Experiment Base (Shenzhen) | Nooploop No.2 Experimental Base Rooftop (Shenzhen) | * |
| Time | 202308 | 202308 | * |
| Environment | Indoor Open Area | Outdoor Open Area | * |
| Working mode | UART Active Output | UART Active Output | * |
| Mode | 8*8 | 8*8 | * |
| FOV: ° | 65 | 65 | * |
| Power supply voltage: v | 5 | 5 | * |
| Refresh rate: Hz | 15 | 15 | * |

Note: Under this configuration, the node periodically outputs measurement data, with a certain distance sampling measurement. Each measurement takes 1ms. It is recommended to use NAssistant for data recording and export.

Definition error：

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

Measure_Value: Measuring distance

Real_Value: Actual distance

Defined standard deviation std:

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

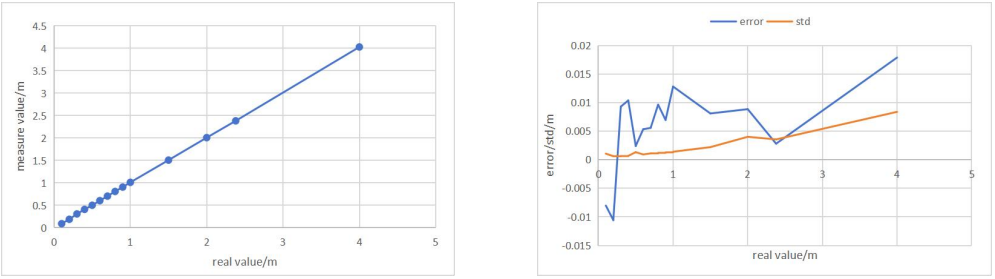
N: Number of sampling points

A: A random variable consisting of N sampled values

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

## 4.2 Result

The measurement results for 64 points tested on the same plane were found to be largely consistent. Among these 64 points, only the central four points were used as data sampling points for further processing. Based on these conditions, the final results of the TOFSense-M data are presented in Figure 5.




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

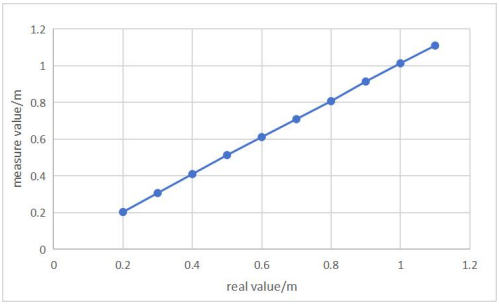
Figure 5: TOFSense-M Test results

Calculated based on experimental results, as shown in Table 7.

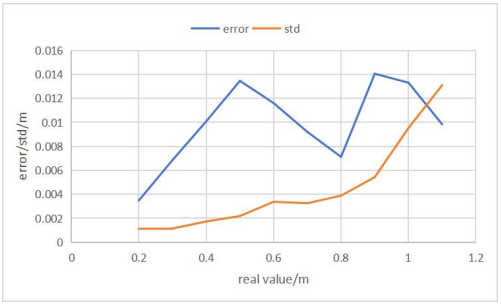
Table 7: TOFSense-M Accuracy Parameters

| Blind Zone (cm) | Maximum Distance (m) | Accuracy(cm) | Standard Deviation (cm) | Ambient Light(lux) |
|---|---|---|---|---|
| 1.5 | 4.0 | ±1.5@1.5~350<br>±1%@350~400 | <1.0 | 600 |

Based on the above conditions, when processing measurement data in an outdoor environment with 100K LUX of intense light, the final results of TOFSense-M are shown in Figure 6.




a.Measurement Value and True Value Curve




b.Error and Standard Deviation Curve

Figure 6: TOFSense-M Outdoor 100K LUX Test Results

Based on the experimental findings, the precision parameters under 100K LUX of ambient light are tabulated in Table 8.

Table 8: TOFSense-M Outdoor 100K LUX Accuracy Parameters

| Blind Zone (cm) | Maximum Distance (m) | Accuracy(cm) | Standard Deviation (cm) | Ambient Light(lux) |
|---|---|---|---|---|
| 1.5 | 1.2 | ±1.5 | <1.5 | 100K |

# 5 Protocol

The data communication format for the TOFSense-M series follows the NLink protocol, please refer to the user manual for more 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 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, where the low byte precedes the high byte.

## 5.3 Type

**Fixed-length Protocol:** Protocols with a fixed length.
**Variable-length Protocol:** Protocols with a varying length.
NLink protocol consists of both fixed-length and variable-length protocol , meeting the needs of different scenarios.

## 5.4 Description

Table 10: NLink Protocol Content Overview

| Protocol | Type | Description |
|---|---|---|
| NLINK_TOFSENSE_M_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_CAN_FRAME0 | Fixed-length | CAN output protocol, which includes distance, distance status, and signal strength. |
| NLINK_TOFSENSE_CAN_READ_FRAME0 | Fixed-length | CAN reading protocol, which includes node ID. |

# 6 Firmware

The officially released firmware version format is VA.B.C, while the beta version format for the testing release is VA.B.C.BetaD. Both can be checked for updates and upgraded via NAssistant, supporting wired firmware upgrade.

# 7 Software

NAssistant is a debugging software of TOFSense-M series. 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

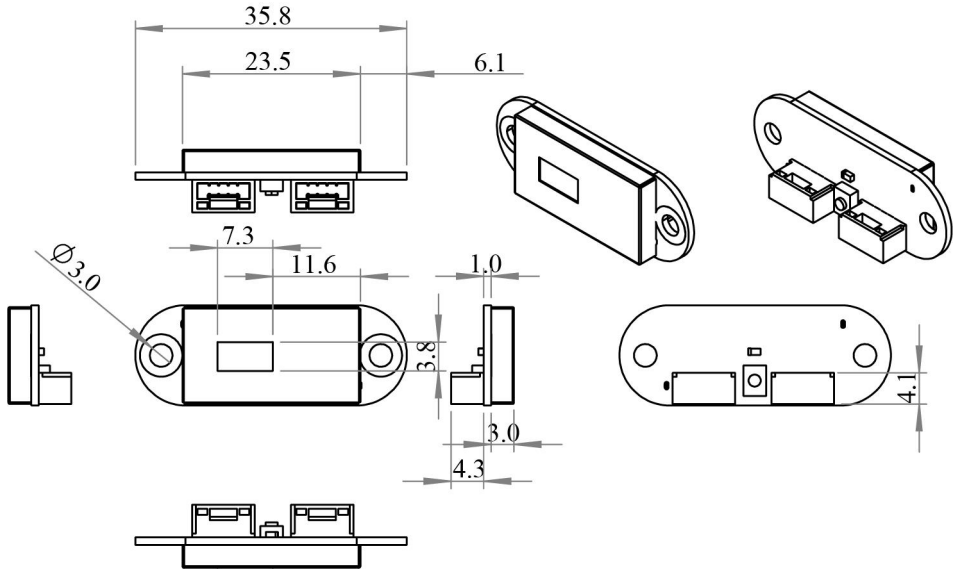



Figure 7: TOFSense-M Dimensions, Unit: mm

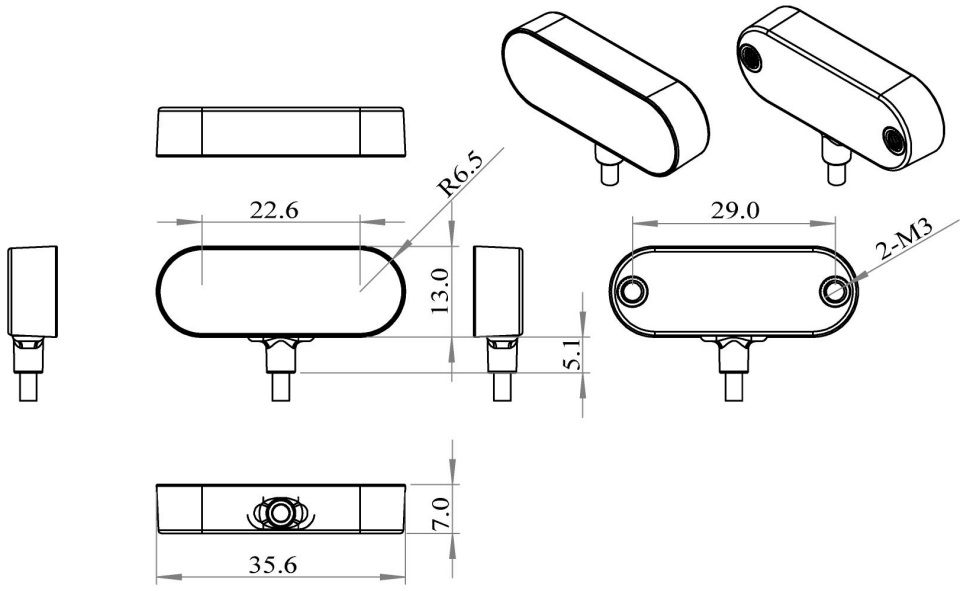



Figure 8: TOFSense-M S Dimensions, Unit: mm

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

# 9 Abbreviation and Acronyms

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 | 1.0.1 | 20211112 | 1. Released the initial version of the manual |
| 1.1 | 1.0.1 | 20220211 | 1. Added TOFSense-M experimental data<br>2. Optimized some descriptions |
| 1.2 | 1.0.4 | 20220924 | 1. Added certification-related instructions<br>2. Optimized some descriptions |
| 1.3 | 1.0.4 | 20221205 | 1. Added CAN mode power supply voltage explanation<br>2. Updated dimension diagram, adding more dimensions |
| 1.4 | 1.0.6 | 20230404 | 1. Optimized some descriptions |
| 2.0 | 2.0.0 | 20230808 | 1. Optimized some parameters<br>2. Updated some pages<br>3. Added the outdoor test data |
| 2.1 | 2.0.2 | 20240223 | 1. Added an explanation of the actual terminal wire sequence for GH1.25 |
| 3.0 | 2.0.2 | 20240629 | 1. Corrected accuracy description |

# 11 Further Information

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