

Z300 V3

**High-precision Visual Displacement
Measurement System**

**Manual 1:
SETUP MANUAL**

OMRON

Z300 V3

High-precision Visual Displacement Measurement System

Manual 1: Setup Manual

Revised May 2004

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About this Manual:

This manual describes the hardware for the Z300 (High-precision Visual Displacement Measurement System) and how to install the components, and it includes the sections described below. This is one of two manuals used to operate the Z300. Refer to the following table for the contents of each manual.

Manual	Contents	Cat. No.
1: Setup Manual	Provides information on system hardware and installation. Be sure to read this manual first.	Z161
2: Operation Manual	Describes operation of the Z300.	Z162

Please read the above manuals carefully and be sure you understand the information provided before attempting to install or operate the Z300.

Section 1 *Features* introduces the features of the Z300.

Section 2 *Wiring and Connection* describes procedures for wiring power supplies and ground wires and for connecting to external devices.

Section 3 *Installation* provides installation methods for the Controller and Sensor.

Section 4 *Non-visual Mode* explains how to make settings for Z300 operation using the DIP switch instead of the menus.

Section 5 *Maintenance* explains maintenance procedures for ensuring the Z300's performance.

Section 6 *Troubleshooting* provides information on hardware errors that may occur with the Z300. Refer to this section before requesting service from your OMRON representative.

Section 7 *Specifications and Dimensions* provides the specifications and dimensions of the Z300 and its peripheral devices.

⚠ WARNING Failure to read and understand the information provided in this manual may result in personal injury or death, damage to the product, or product failure. Please read each section in its entirety and be sure you understand the information provided in the section and related sections before attempting any of the procedures or operations given.

PRECAUTIONS

This section provides general precautions for using the Z300 V3 Sensor.

The information contained in this section is important for the safe and reliable application of the Z300 V3 Sensor. You must read this section and understand the information contained before attempting to set up or operate a Z300 V3 Sensor.

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Read and Understand this Manual

Please read and understand this manual before storing, installing, programming, operating, maintaining, or disposing of the products. Please consult your OMRON representative if you have any questions or comments.

WARRANTY

OMRON's exclusive warranty is that the products are free from defects in materials and workmanship for a period of one year (or other period if specified) from date of sale by OMRON.

OMRON MAKES NO WARRANTY OR REPRESENTATION, EXPRESS OR IMPLIED, REGARDING NON-INFRINGEMENT, MERCHANTABILITY, OR FITNESS FOR PARTICULAR PURPOSE OF THE PRODUCTS. ANY BUYER OR USER ACKNOWLEDGES THAT THE BUYER OR USER ALONE HAS DETERMINED THAT THE PRODUCTS WILL SUITABLY MEET THE REQUIREMENTS OF THEIR INTENDED USE. OMRON DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED.

LIMITATIONS OF LIABILITY

OMRON SHALL NOT BE RESPONSIBLE FOR SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES, LOSS OF PROFITS OR COMMERCIAL LOSS IN ANY WAY CONNECTED WITH THE PRODUCTS, WHETHER SUCH CLAIM IS BASED ON CONTRACT, WARRANTY, NEGLIGENCE, OR STRICT LIABILITY.

In no event shall the responsibility of OMRON for any act exceed the individual price of the product on which liability is asserted.

IN NO EVENT SHALL OMRON BE RESPONSIBLE FOR WARRANTY, REPAIR, OR OTHER CLAIMS REGARDING THE PRODUCTS UNLESS OMRON'S ANALYSIS CONFIRMS THAT THE PRODUCTS WERE PROPERLY HANDLED, STORED, INSTALLED, AND MAINTAINED AND NOT SUBJECT TO CONTAMINATION, ABUSE, MISUSE, OR INAPPROPRIATE MODIFICATION OR REPAIR.

SUITABILITY FOR USE

OMRON shall not be responsible for conformity with any standards, codes, or regulations that apply to the combination of the product in the customer's application or use of the products.

At the customer's request, OMRON will provide applicable third party certification documents identifying ratings and limitations of use that apply to the products. This information by itself is not sufficient for a complete determination of the suitability of the products in combination with the end product, machine, system, or other application or use.

The following are some examples of applications for which particular attention must be given. This is not intended to be an exhaustive list of all possible uses of the products, nor is it intended to imply that the uses listed may be suitable for the products:

- Outdoor use, uses involving potential chemical contamination or electrical interference, or conditions or uses not described in this manual.
- Nuclear energy control systems, combustion systems, railroad systems, aviation systems, medical equipment, amusement machines, vehicles, safety equipment, and installations subject to separate industry or government regulations.
- Systems, machines, and equipment that could present a risk to life or property.

Please know and observe all prohibitions of use applicable to the products.

NEVER USE THE PRODUCT FOR AN APPLICATION INVOLVING SERIOUS RISK TO LIFE OR PROPERTY WITHOUT ENSURING THAT THE SYSTEM AS A WHOLE HAS BEEN DESIGNED TO ADDRESS THE RISKS, AND THAT THE OMRON PRODUCTS ARE PROPERLY RATED AND INSTALLED FOR THE INTENDED USE WITHIN THE OVERALL EQUIPMENT OR SYSTEM.

PROGRAMMABLE PRODUCTS

OMRON shall not be responsible for the user's programming of a programmable product, or any consequence thereof.

CHANGE IN SPECIFICATIONS

Product specifications and accessories may be changed at any time based on improvements and other reasons.

It is our practice to change model numbers when published ratings or features are changed, or when significant construction changes are made. However, some specifications of the products may be changed without any notice. When in doubt, special model numbers may be assigned to fix or establish key specifications for your application on your request. Please consult with your OMRON representative at any time to confirm actual specifications of purchased products.

DIMENSIONS AND WEIGHTS

Dimensions and weights are nominal and are not to be used for manufacturing purposes, even when tolerances are shown.

ERRORS AND OMISSIONS

The information in this manual has been carefully checked and is believed to be accurate; however, no responsibility is assumed for clerical, typographical, or proofreading errors, or omissions.

Meanings of Signal Words

The following signal words are used in this manual.



Indicates a potentially hazardous situation which, if not avoided, will result in minor or moderate injury, or may result in serious injury or death. Additionally there may be significant property damage.

Meanings of Alert Symbols

The following alert symbols are used in this document.



Cautions to indicate potential laser beam hazard

Laser Safety

WARNING

Do not to expose your eyes to the laser radiation either directly or indirectly (i.e., after reflection from a mirror or shiny surface).

The laser radiation has a high power density and exposure may result in loss of sight.



Sensor Head is a Class 3B Laser Product according to EN60825-1 (IEC60825-1) and Class II Laser Product according to FDA (21 CFR1040.10) (see note). The Z510 Series is meant to be built into final system equipment. Pay special attention to the following precautions for the safe use of the product:

Note:Europe: Class 2 and Class 3B of EN60825-1: 1994 = IEC60825-1: 1993

U.S.A.: Class II and Class IIIB of FDA (21 CFR1040.10).

	Z300-S2T	Z300-S5T	Z300-S10	Z300-S60
Wave length	650 nm	670 nm	670 nm	658 nm
Maximum pulse duration	7 ms	7 ms	7 ms	17.5 ms
Cycle	0.5 to 10 ms	0.5 to 10 ms	0.5 to 10 ms	0.5 to 25 ms
Peak power	1 mW max.	1 mW max.	1 mW max.	15 mW max.
Class	2			3B

- (1)Use this product as specified in the operation manual. Otherwise, you may be exposed to hazardous laser radiation.
- (2)The Z300 series radiates laser beams in the visible light range. Do not expose your eyes directly to the laser radiation. Ensure that the laser beam path is terminated during use. If a mirror or shiny surface is positioned in the laser beam path, ensure that the reflected beam path is also terminated. If the Unit must be used without terminating the laser beam path, position the laser beam path so that it is not at eye level.
- (3)To avoid exposure to hazardous laser radiation, do not displace nor remove the protective housing during operation, maintenance, and any other servicing.
- (4)The user should return the product to OMRON for all repair and servicing.
- (5)As for countries other than those of Europe and the U.S.A., observe the regulations and standards specified by each country.

As for the Laser Product Classifications, refer to the Appendix.
Refer to page 77.

Labeling on Laser Use

The Sensor has the following WARNING label on the side.



Re-labeling

The following labels are provided, to be used selectively according to countries.

for use in the U.S.: FDA label (Aperture label, Caution logo label, Certification and Identification label)

for use in countries other than the U.S.: Warning label according to EN/IEC standards.

Be sure to turn off the sensor before replacing the label, or your hand or other body parts may be exposed to the hazardous laser beam radiating from the sensor.

Use in the U.S.

When a laser product mounted on a certain device is to be used in the U.S., it has to meet the requirements set forth by the FDA (regulations for laser products set forth by the Food and Drug Administration).

Applications have been approved by CDRH (Center for Devices and Radiological Health) for Z300-S2T, Z300-S5T, Z300-S10, Z300-S60. Three different FDA labels are enclosed in the sensor package. Attach them to the sensor body.

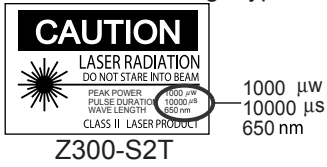
The Z300 is designed to be built into the finished system unit. Refer to the following technical standard for installation.

21CFR1040.10 and 1040.11

PRECAUTIONS

FDA Labels for Laser Products

Class II Caution logo type



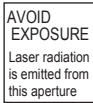
Class II Caution logo type



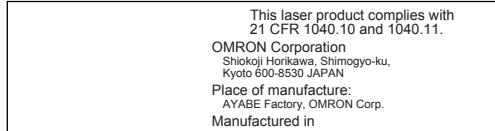
Class IIIB Danger logo type



Aperture Label



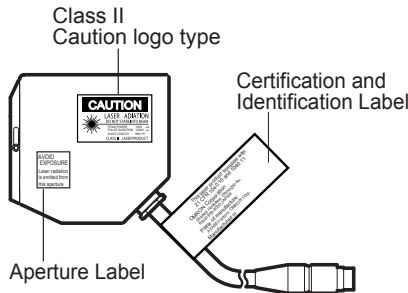
Certification and Identification Label



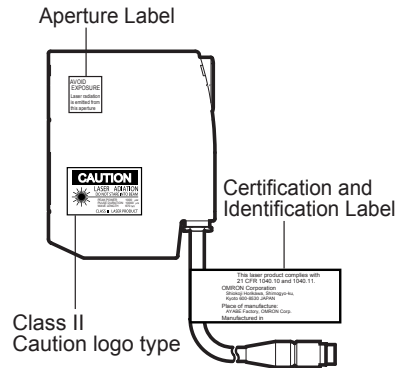
Be sure to attach FDA labels; do not attach English WARNING labels by mistake.

Areas to Attach Labels

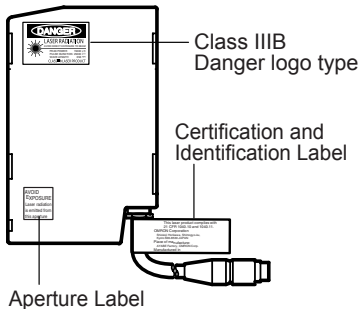
Z300-S2T



Z300-S5T/S10



Z300-S60



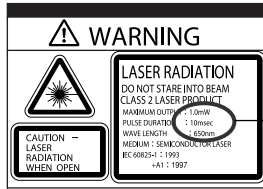
- Use in Countries Other than the U.S.

Replace the warning label in Japanese on the sensor main body with the attached EN/IEC warning label upon use in countries other than the U.S. Attach the label in the area where the original Japanese warning label was provided.

EN60825-1(IEC60825-1) standard is applied to products exported to European countries. The Z300 conforms to the standard.

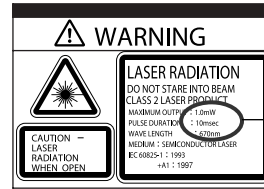
PRECAUTIONS

Warning Labels



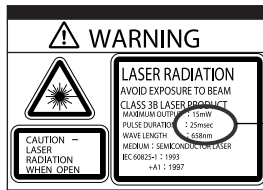
1.0mW
10msec
650 nm

Z300-S2T



1.0mW
10msec
670 nm

Z300-S5T
Z300-S10



15 mW
25msec
658 nm

Z300-S60

Be sure to attach correct warning labels; do not attach FDA labels by mistake.

Regulations and standards

The Z300 conforms to the following EC directives and EN standards.

1. EC Directives
EMC Directive: No.89//336/EEC
2. EN Standards
EN61326: 1997+A1:1998+A2:2001(EMI:Class A)

<h2>Precautions for Safe Use</h2>

Please observe the following precautions for safe use of the product.

- (1) Do not use the Z300 in environment with flammable or explosive gases.
- (2) Install the Z300 away from high-voltage devices and moving machinery to allow safe access during operation and maintenance.
- (3) Use the Z300 with the power supply voltages specified in this manual.
- (4) Use crimp terminals for wiring. Do not connect the power supply wires by just twisting stranded wire and connecting directly to the terminals.
- (5) Use the wire and crimp terminals of the proper sizes as specified in this manual.
- (6) Confirm that wiring has been performed correctly before turning ON the power supply.
- (7) Cover the terminal blocks with the Terminal Block Protection Covers. Uncovered terminal blocks can result in electric shock.
- (8) Use a DC power supply with countermeasures against high-voltage spikes (safe extra low-voltage circuits on the secondary side).
- (9) Be sure to securely tighten the screws when mounting the Z300.
- (10) Do not attempt to dismantle, repair, or modify the Z300.
- (11) Dispose of the Z300 as industrial waste.

Precautions for Correct Use

Please observe the following precautions to prevent failure to operate, malfunctions, or undesirable effects on product performance.

Components

The Sensor and Console connected to the Z300-VC10V4 Controller must be products designed specifically for the Z300.

- Sensor (Z300-S2T, Z300-S5T, Z300-S10, Z300-S60)
- Console (Z300-KP)

Installation Site

Do not install the Z300 in locations subjected to the following conditions:

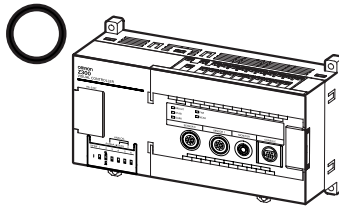
- Ambient temperature outside of 0 to +40°C for the F300-M09 Video Monitor (recommended monitor) or outside of 0 to +50°C for other Z300 components.
- Condensation due to rapid temperature fluctuations
- Relative humidities outside 35 to 85%
- Corrosive or flammable gases
- Dust, salt, or iron particles
- Direct vibration or shock
- Reflection of intense light (such as other laser beams or electric arc-welding machine)
- Strong magnetic fields
- Direct sunlight
- Water, oil, or chemical fumes or spray

Installation Orientation

Orientation of Controller

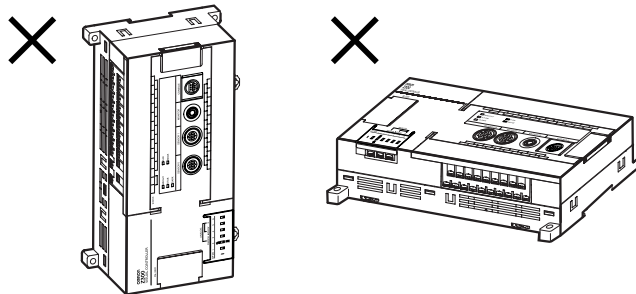
To improve heat dissipation, install the Controller in the following direction only:

CORRECT



Do not install the Controller in the orientations shown in the following diagram.

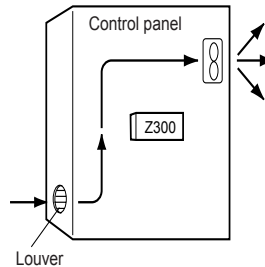
INCORRECT



PRECAUTIONS

Ambient Temperature

- Maintain a minimum clearance of 50 mm above and below the Z300 to improve air circulation.
- Do not install the Z300 immediately above significant heat sources, such as heaters, transformers, or large-capacity resistors.
- Do not let the ambient temperature exceed 50°C.
- Provide a forced-air fan cooling or air conditioning if the ambient temperature is near 50°C so that the ambient temperature never exceed 50°C.

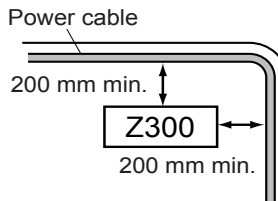


Ambient Illumination

Although the Z300 is rated for use in environments where the ambient illumination does not exceed 3000lx, if possible, do not use the Z300 near lighting equipment that turns ON and OFF continuously. If this is unavoidable, reduce the influence of the light by, for example, using a light baffle.

Noise Resistance

- Do not install the Z300 in a cabinet containing high-voltage equipment.
- Do not install the Z300 within 200 mm of power cables.



Sensor Maintenance

- Install the Sensor in a clean environment and keep the filter on the front panel of the Sensor free from oil and dust. If affected by oil or dust, clean the filter as follows:
 1. Use a blower brush (used to clean camera lenses) to blow large dust particles from the surface. Do not blow the dust away with your mouth.
 2. Use a soft cloth (for lenses) with a small amount of alcohol to remove the remaining dust. Do not use a scrubbing action when cleaning as scratches on the filter could result in the Sensor malfunctioning.

Environment

The Sensor cannot accurately detect the following types of objects:

- Objects with an extremely low reflection ratio
- Objects with a small curvature
- Largely inclined objects

Connecting Cables

Always turn OFF the Z300's power before connecting or disconnecting cable.

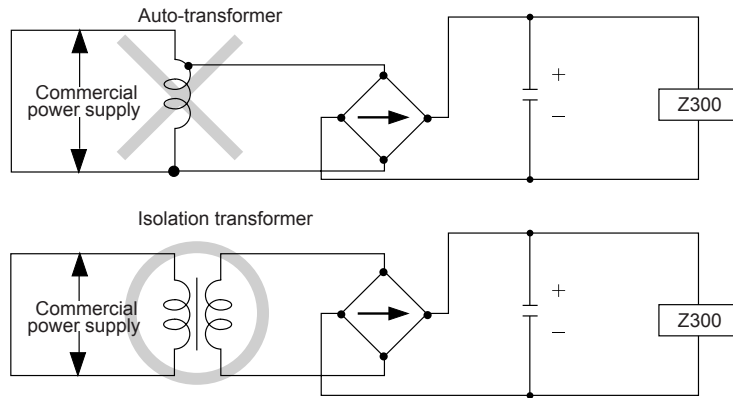
PRECAUTIONS

Touching Signal Lines in Connectors or Terminals

To prevent damage from static electricity, use a wrist strap or another device for preventing electrostatic discharges when touching terminals or signal lines in connectors.

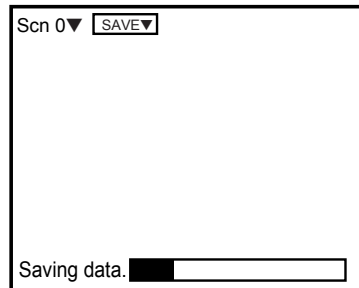
Wiring

When using a transformer for the Z300's driving power supply, use an isolation transformer in the way shown below. Do not use an auto-transformer. Doing so may result in equipment failure.



Turning OFF the Power (Visual Mode Only)

Do not turn OFF the power while a message is being displayed indicating that processing is being performed. Data in memory will be destroyed, and the Z300 may not operate correctly the next time it is started.



Using the RESET Signal

Do not use the RESET input immediately after power is turned ON. When using the RESET input to synchronize startup timing, wait at least 1 second after the Z300's power supply is turned ON before turning ON the RESET terminal.

Securing the Video Monitor (When Using the Recommended F150-M09)

Observe the following precautions to prevent noise interference, because the video monitor case is connected to the 0 V line in the internal circuits.

1. Do not ground the video monitor.
2. Do not ground the metallic part of the connector.
3. Secure the video monitor with plastic screws if it is being mounted to a metallic surface.

PRECAUTIONS

Warming Up

After turning ON the power supply, allow the Z300 to stand for at least 30 minutes before use. The circuits are unstable immediately after the power supply is turned ON and attempting measurement may result in inconsistent measurement values.

Confirming Package Contents

Check the contents of the package as soon as you receive the Z300. It is extremely rare for components to be missing, but contact the nearest OMRON representative if any of the following items are missing.

1. Z300-VC10EV3 Controller Qty: 1
2. SETUP MANUAL (This Manual) Qty: 1
3. OPERATION MANUAL Qty: 1

Product Availability

Some of the products listed may not be available in some countries. Please contact your nearest OMRON sales office by referring to the addresses provided at the back of this manual.

Visual Aids

The following headings appear in the left column of the manual to help you locate different types of information.

- | | |
|-----------------|--|
| Note | Indicates information of particular interest for efficient and convenient operation of the product. |
| Notice | Indicates information required to take full advantage of the functions and performance of the product. Incorrect application methods may result in the loss of damage or damage to the product. Read and follow all precautionary information. |
| CHECK | Indicates points that are important in using product functions or in application procedures. |
| 1,2,3... | Indicates lists of one sort or another, such as procedures, checklists, etc. |
| SeeAlso | Indicates where to find related information. |

Notation

Screen Messages In this manual, screen message are given in bold/italic.

E.g.: Application

SECTION 1

Features

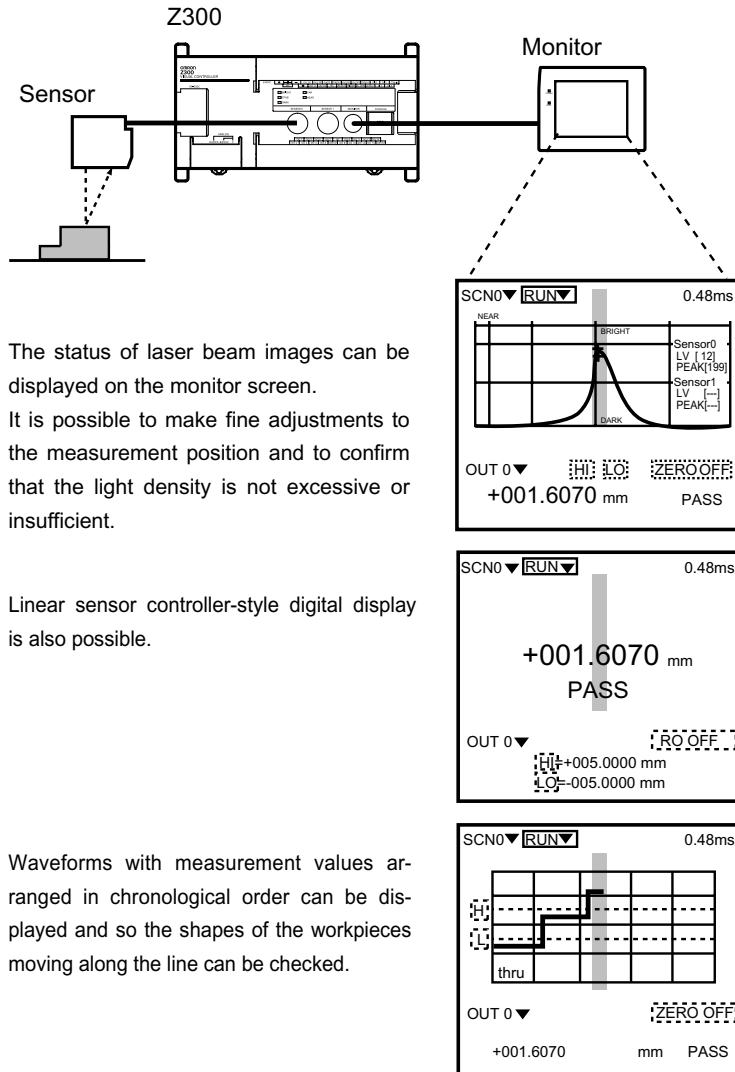
This section introduces the features of the Z300.

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1-1 Monitoring While Viewing the Measurement Status

Monitoring suited to the application is possible at every stage from installation and adjustment to operation and maintenance.

For details on the display, refer to page 12 in the Operation Manual.



The status of laser beam images can be displayed on the monitor screen. It is possible to make fine adjustments to the measurement position and to confirm that the light density is not excessive or insufficient.

Linear sensor controller-style digital display is also possible.

Waveforms with measurement values arranged in chronological order can be displayed and so the shapes of the workpieces moving along the line can be checked.

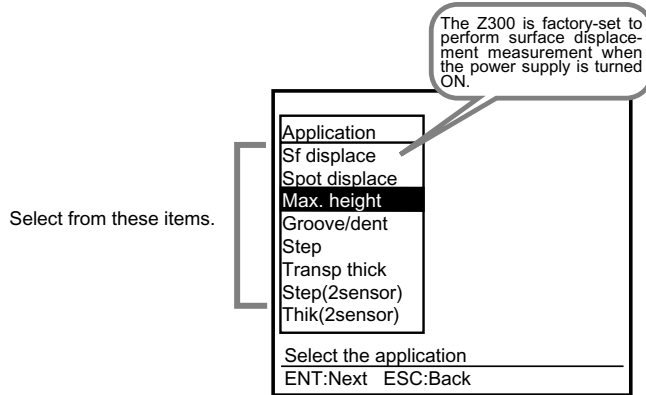
1-2 Simple Setup Using Menus!

Set the measurement conditions on the Console according to the menus displayed on the monitor screen. The Z300 has 2 types of menu.

First, try out the **Application Menu**.

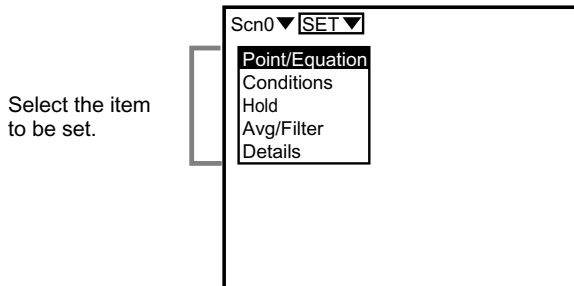
Measurement conditions for a representative application are already set and so setting can be performed simply by selecting the measurement items.

Refer to page 28 in the Operation Manual.



Use the **Expert Menu** to set different measurement conditions from the preset ones, or to add more detailed settings to the Application Menu settings.

Refer to page 43 in the Operation Manual.



1-3 A Wide Variety of Useful Functions

Useful Feature for Sensor Installation!

The Sensor's installation conditions and orientation can be adjusted while monitoring the CCD's received light density.

Refer to page 118 in the Operation Manual.

Useful for Analyzing the Causes of NG Images!

Laser beam images and waveforms for NG images can be recorded. Recorded images can be reproduced to help analyze the cause of NG images.

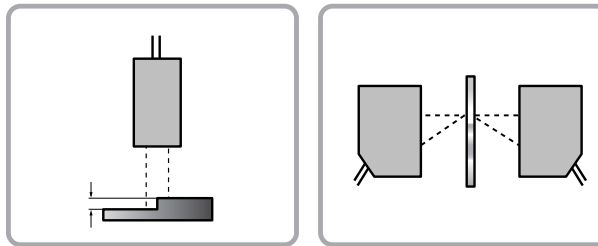
Refer to page 122 in the Operation Manual.

Easy Settings for Measuring Workpiece Thickness and Level Differences!

Two Sensors can be connected to the Controller, allowing measurement conditions to be set easily.

(Connect the same models of Sensor.)

Refer to page 29 in the Operation Manual.



A Variety of Output Formats!

Not only is analog output available, but communications with external devices can also be performed via terminal blocks or RS-232C.

For details on terminal block output, refer to page 150 in the Operation Manual.

For details on RS-232C output, refer to page 157 in the Operation Manual.

For details on analog output, refer to page 173 in the Operation Manual.

Comprehensive Hold Functions!

Hold Mode can be set freely at up to 4 points (times).

Refer to page 65 in the Operation Manual.

SECTION 2

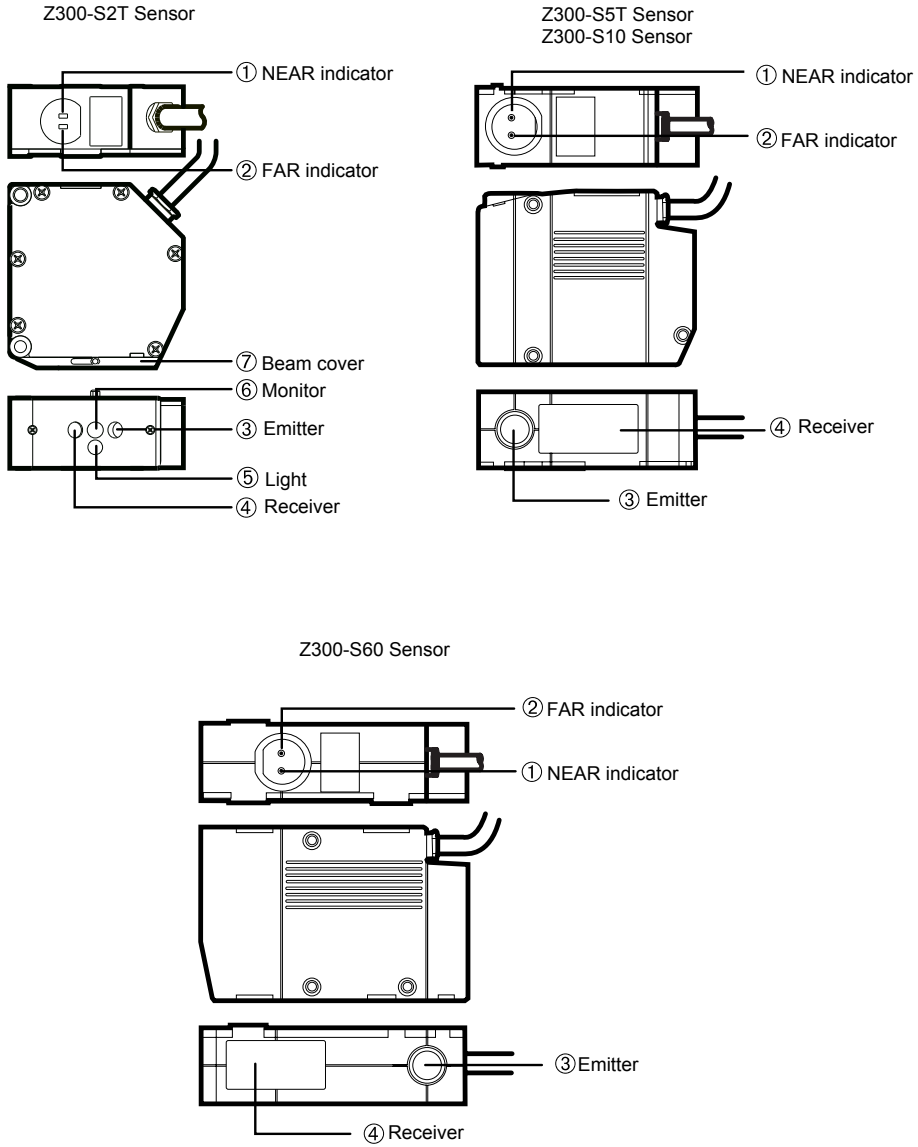
Wiring and Connection

Procedures for wiring power supplies and ground wires and for connecting to external devices are described in this section.

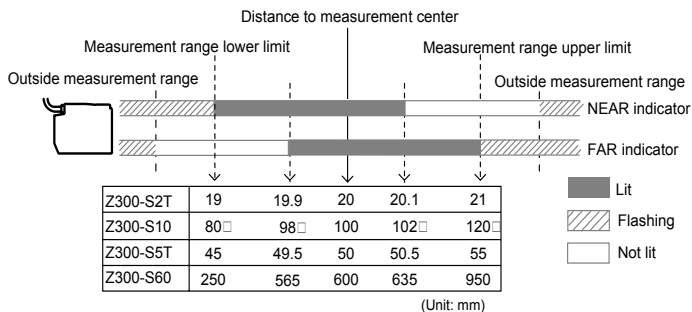
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2-1 Component Names and Functions

Sensor



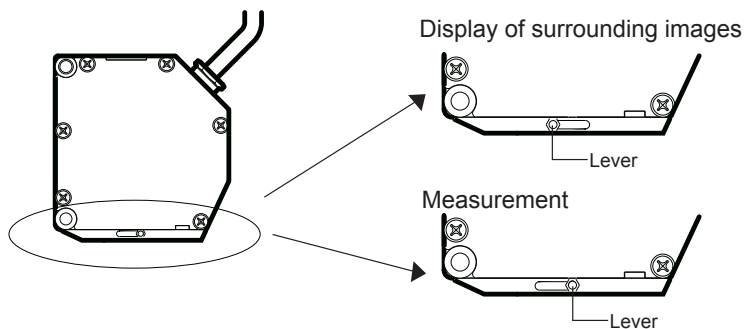
①, ② If the distance between the front of the Sensor and the workpiece is the measurement range, these indicators turn ON or OFF according to the distance. If the workpiece is outside the measurement range or if the light density is insufficient, both indicators will flash.



These indicators also act as laser beam warning indicators.

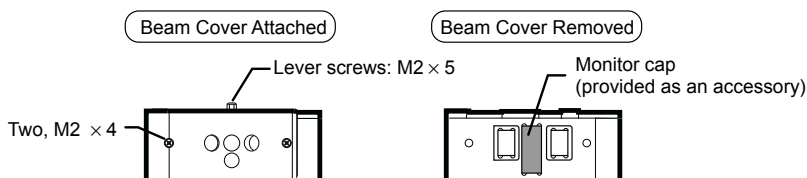
- Immediately after the power supply is turned ON, one or both of these indicators will light or flash.
- For 15 to 25 seconds after the power supply is turned ON, both indicators will be OFF indicating that the laser beam is OFF.
- When the laser beam turns ON, one of these indicators will light or flash.
- When the laser beam turns OFF, both indicators will turn OFF.

- ③ Emits laser beam.
- ④ Receives laser beam.
- ⑤ Light used when displaying surrounding images.
- ⑥ Captures surrounding images.
- ⑦ Used for switching between display of surrounding images and measurement. To display surrounding images, loosen the screws of the beam cover lever and move the lever to the left. To perform measurement, move the lever to the right. Tighten the lever screws with a flat-bladed screwdriver to a torque in the range 0.15 to 0.3 N•m (1.5 to 3 kgf•cm).

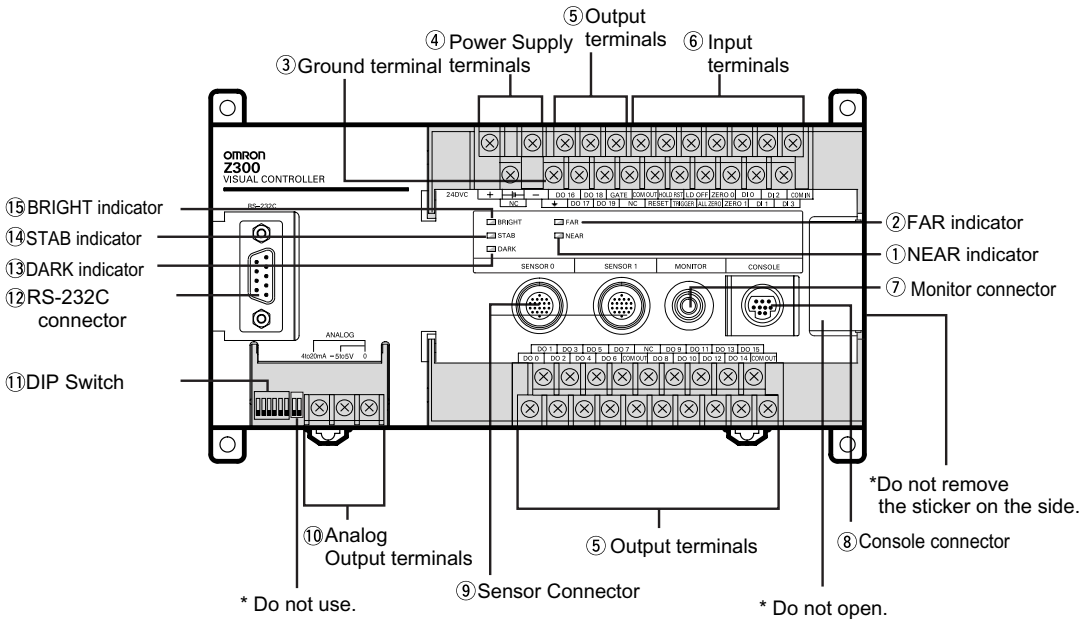


CHECK When Using the Z300-S2T

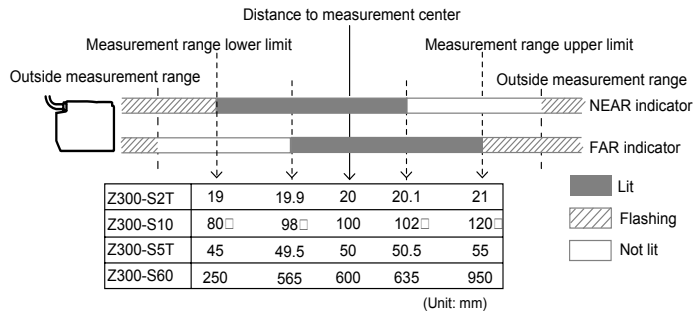
- When performing measurement with the beam cover removed, attach the monitor cap provided with the Sensor in the way shown below.
- When displaying surrounding images, be sure to attach the beam cover. Surrounding images cannot be displayed correctly without the beam cover attached.



Controller



①, ② If the distance between the front of the Sensor and the workpiece is the measurement range, these indicators turn ON or OFF according to the distance. If the workpiece is outside the measurement range or if the light density is insufficient, both indicators will flash.



These indicators also act as laser beam warning indicators.

- Immediately after the power supply is turned ON, one or both of these indicators will light or flash.
 - For 15 to 25 seconds after the power supply is turned ON, both indicators will be OFF indicating that the laser beam is OFF.
 - When the laser beam turns ON, one of these indicators will light or flash.
 - When the laser beam turns OFF, both indicators will turn OFF.
- ③ Connects to the ground wire.
 - ④ Connects to the power supply.
 - ⑤, ⑥ Connects to external devices such as a PLC.
 - ⑦ Connects to the monitor.
 - ⑧ Connects to a console.
 - ⑨ Connects to the sensor.
 - ⑩ Connected when using analog output.
 - ⑪ Set when using the Z300 in Non-visual Mode.

Refer to page 55.

- ⑫ Connects to external devices such as a personal computer or PLC.
- ⑬, ⑭, ⑮

Turn ON according to the light density at the Sensor.

If LDOFF is input via the terminal block or RS-232C, or if the Sensor is not connected, all of the indicators flash.

- BRIGHT indicator...Turns ON when the light density is too high.
- DARK indicator ...Turns ON when the light density is insufficient.
- STAB indicator ...Turns ON when the light density is suitable.

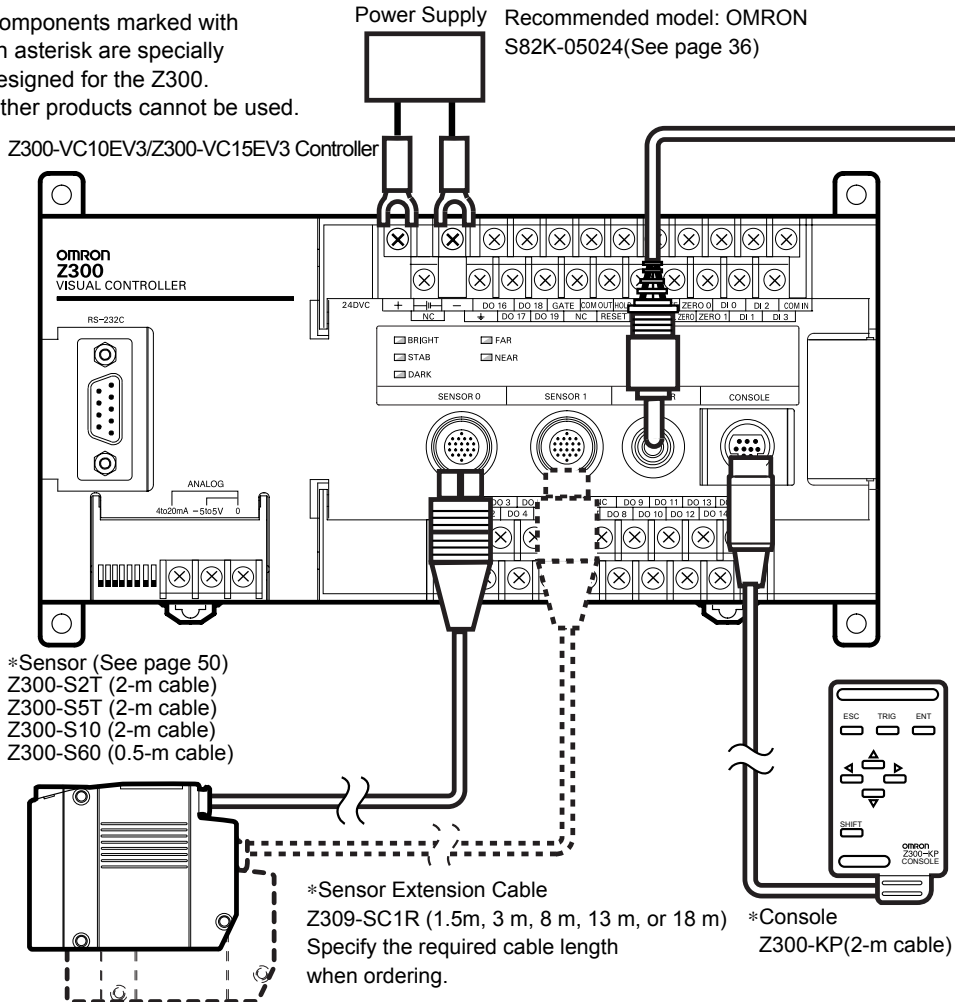
2-2 System Configuration

2-2-1 System Configuration for Visual Mode

The Z300 is provided with menus that allow easy setting of measurement conditions to suit the application. Perform settings on the Console using the menu items displayed on the monitor. Waveform measurement results can also be displayed on the monitor.

The mode used for this type of operation is called "Visual Mode." If the DIP switch on the Controller is set to VISUAL, the Z300 goes into Visual Mode when the power supply is turned ON. The DIP switch is factory-set to VISUAL.

*Components marked with an asterisk are specially designed for the Z300. Other products cannot be used.



*Sensor (See page 50)
 Z300-S2T (2-m cable)
 Z300-S5T (2-m cable)
 Z300-S10 (2-m cable)
 Z300-S60 (0.5-m cable)

*Sensor Extension Cable
 Z309-SC1R (1.5m, 3 m, 8 m, 13 m, or 18 m)
 Specify the required cable length when ordering.

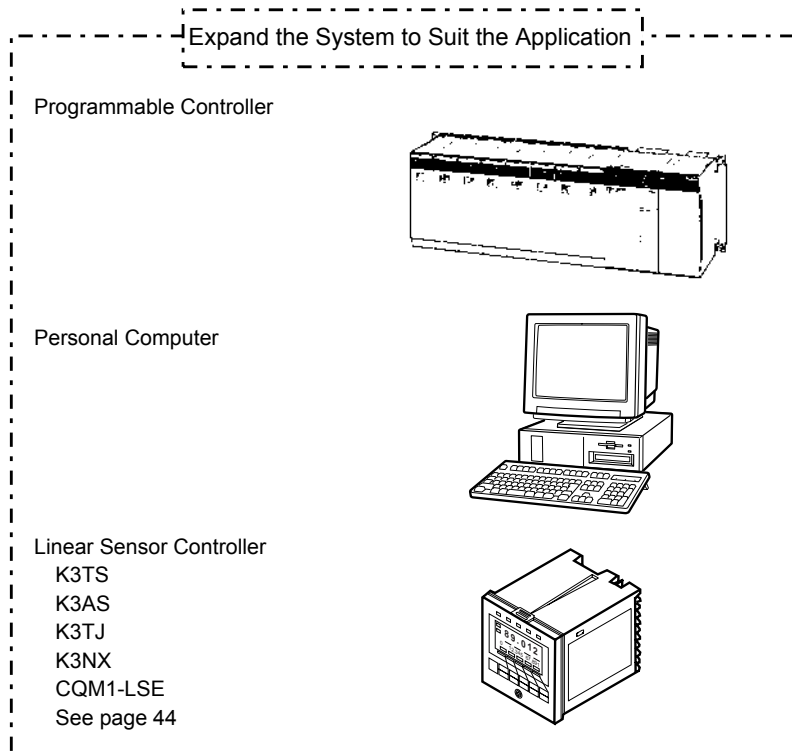
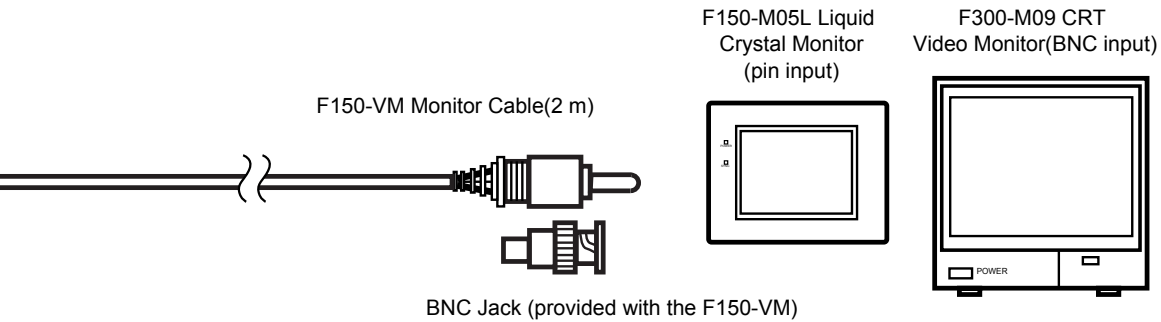
*Console
 Z300-KP(2-m cable)

CHECK

- Up to 2 Sensors can be connected.
 When performing measurement with 2 Sensors at the same time, use Sensors of the same model. It is possible to connect different Sensors but it will not be possible to perform measurement using both at the same time.
 For details on using different models, refer to page 146 in the Operation Manual.

CHECK When Using the Z300-S60

- When using the Extension Cable, set the length of the Extension Cable in **SYS/ Environment**. This reduces errors due to the extended cable length.
For details, refer to page 140 in the Operation Manual



Notice Always turn OFF the power supply before connecting or disconnecting cables. The peripheral device may be damaged if connected or disconnected with the power supply turned ON.

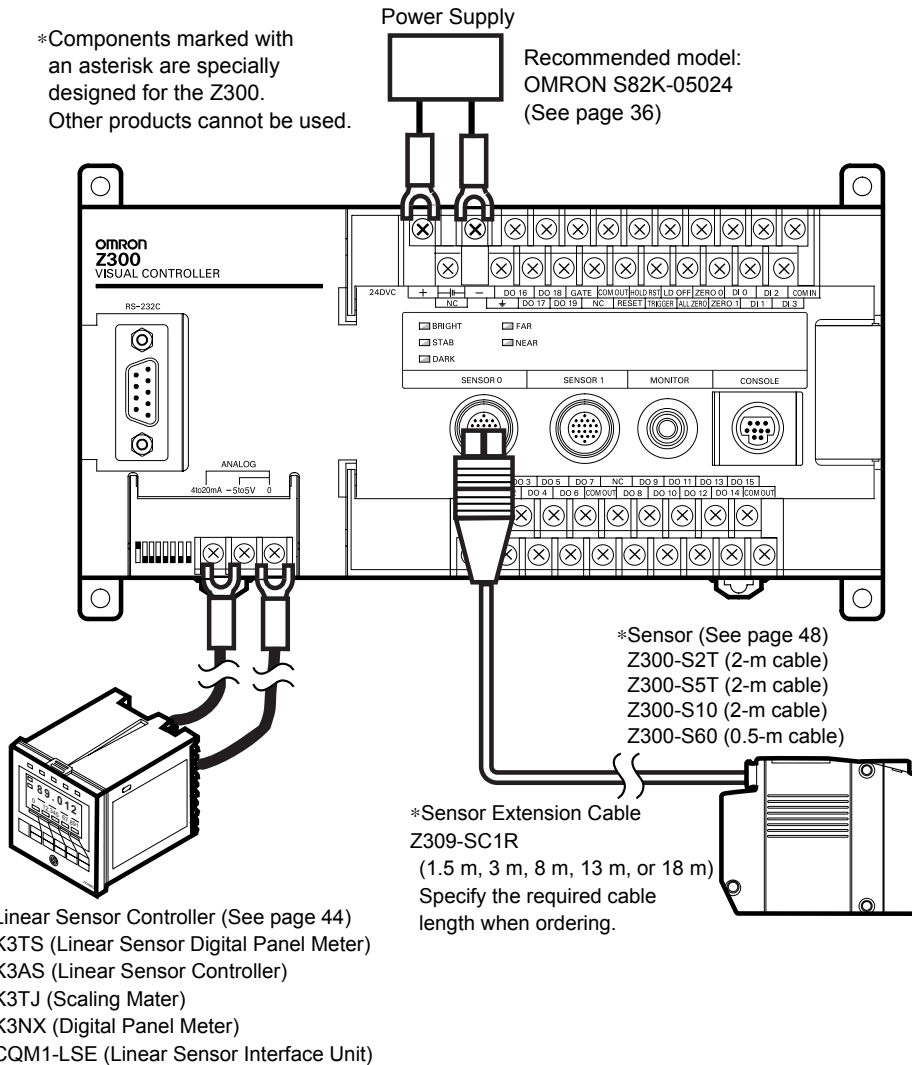
2-2-2 System Configuration for Non-visual Mode

The Z300 can be used without a monitor but with a Linear Sensor Controller connected. In this case, the Z300's menus cannot be used. The way in which the Z300's analog outputs are used is set at the Linear Sensor Controller.

The mode for this type of operation (without being able to see menus and waveforms) is called "Non-visual Mode." To perform operation in Non-visual Mode, the DIP switch on the Controller must be set to NON VISUAL.

Refer to page 55.

Notice Turn OFF the power supply before changing the DIP switch settings.



CHECK When Using the Z300-S60
Use with a cable extension length of less than 3 m in Non-visual Mode.

CHECK Only 1 Sensor can be connected. Connect it to SENSOR 0.

Notice Always turn OFF the power supply before connecting or disconnecting cables. The peripheral device may be damaged if connected or disconnected with the power supply turned ON.

2-3 Connecting Peripheral Devices

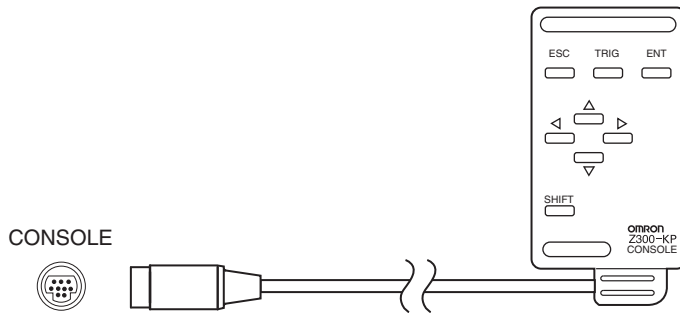
This section shows how to connect peripheral devices to the Controller.

Notice Always turn OFF the power supply before connecting or disconnecting a peripheral device's cable. The peripheral device may be damaged if it is connected while the power is ON.

Notice The various connectors on the Controller are capped when the Controller is shipped. When a connector is not being used, leave the cap in place or replace the cap to protect against dust, dirt, and static electricity.

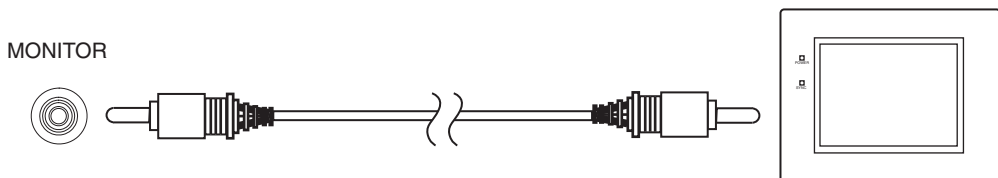
Connecting a Console

Connect the console Z300-KP to the Controller's console connector.



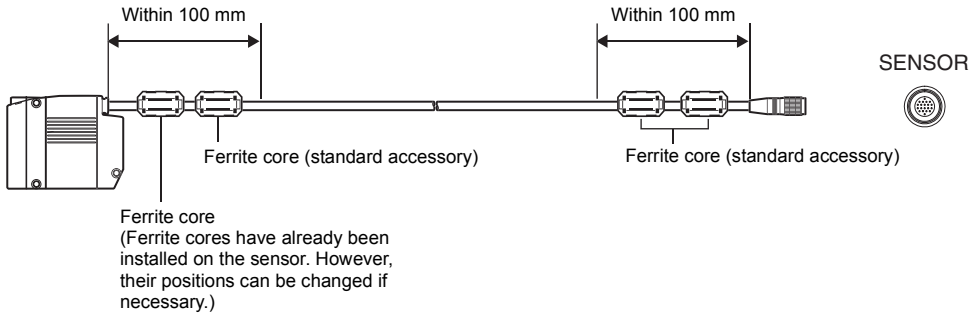
Connecting a Monitor

Connect the monitor cable F150-VM to the Controller's monitor connector.

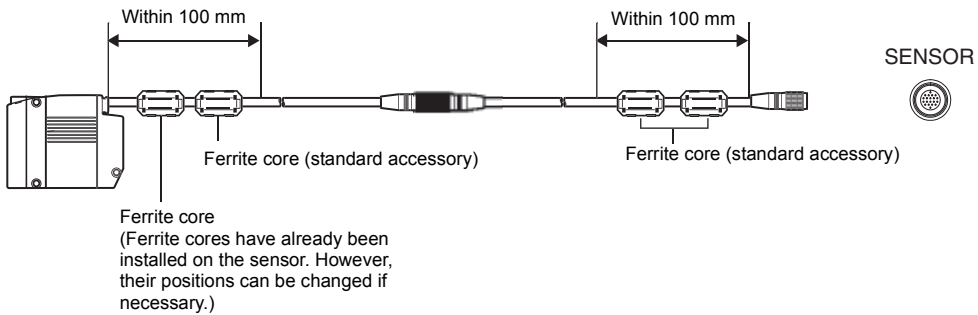


Connecting a Sensor

Connect the sensor to the Controller's sensor connector. Three ferrite cores (supplied with the sensor) must be attached to the sensor cable. Two ferrite cores can be connected within 100 mm from the sensor and within 100 mm from the controller's connector, respectively.



When using an extension cable, make sure that two ferrite cores are connected within 100 mm from the sensor and within 100 mm from the controller's connector, respectively.



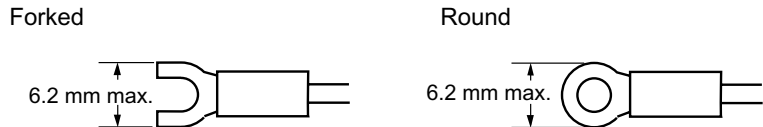
2-4 Power Supply and Ground

Wire the power supply and the ground to their respective terminals.

2-4-1 Crimp Terminals and Cables

The terminal block uses M3 terminal screws. Use appropriate crimp terminals for M3 screws as shown below. Tighten the screws to a torque of between 0.5 and 0.6 N•m. After wiring, confirm that the wiring is correct.

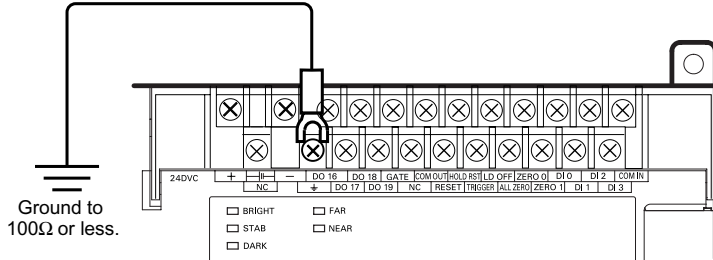
Notice Cover the terminal blocks with the Terminal Block Protection Covers. Uncovered terminal blocks can result in electric shock.



Recommended Crimp Terminals

	Manufacturer	Model	Recommended wire size
Forked	J.S.T. Mfg Co.,Ltd	V1.25-N3A	1.31 to 1.65mm ²
Round	J.S.T. Mfg Co.,Ltd	V1.25-MS3	

2-4-2 Ground Wiring



Notice

- Be sure to ground to 100Ω or less.
- Always connect a ground wire to the Z300's ground terminal. To avoid grounding problems, do not share the ground wire with any other devices or wire the ground to the building's steel framing.
- Use a grounding point that is as close as possible and keep the ground wiring as short as possible.

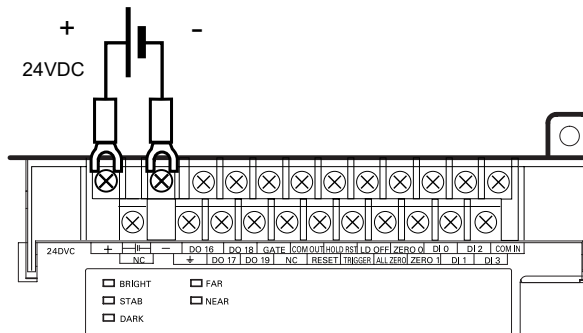
2-4-3 Wiring the Power Supply

Use a power supply that meets the following specifications.

CHECK Use a DC power supply with countermeasures against high-voltage spikes (safe extra low-voltage circuits on the secondary side). Excessively high voltages can result in electric shock.

Recommended Power Supply: OMRON S82K-05024

Output current	1.6 A min.
Power supply voltage	24 VDC (21.6 to 26.4VDC)



Notice

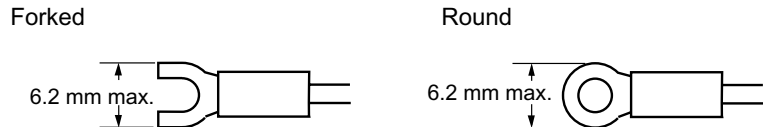
- Wire the Power Supply Unit independently of other devices. In particular, keep the power supply wired separately from inductive loads.
- Keep the power supply wiring as short as possible. (10 m max.)
- If UL recognition is required, use a UL class II power supply.

2-5 Terminal Block Connections

2-5-1 Crimp Terminals and Cables

The terminal block uses M3 terminal screws. Use appropriate crimp terminals for M3 screws as shown below. Tighten the screws to a torque of between 0.5 and 0.6 N•m.

Notice Cover the terminal blocks with the Terminal Block Protection Covers. Uncovered terminal blocks can result in electric shock.



Recommended Crimp Terminals

	Manufacturer	Model	Recommended wire size
Forked	J.S.T. Mfg Co.,Ltd	V1.25-N3A	1.31 to 1.65mm ²
Round	J.S.T. Mfg Co.,Ltd	V1.25-MS3	

2-5-2 Internal Specifications

CHECK Use a DC power supply with countermeasures against high-voltage spikes (safe extra low-voltage circuits on the secondary side). Excessively high voltages can result in electric shock.

Input Specifications

Item	Specification	
Model	Z300-VC10EV3 (NPN mode)	Z300-VC15EV3 (PNP mode)
Input voltage	12 to 24 VDC \pm 10%	
ON current *1	5 to 15 mA	
ON voltage *1	8.8 V max.	
OFF current *2	0.1 mA max.	
OFF voltage *2	4.5 V min.	
ON delay	RESET input: 10 ms max. Other inputs: 0.5 ms max	
OFF delay	RESET input: 15 ms max. Other inputs: 0.7 ms max.	
Internal circuits		

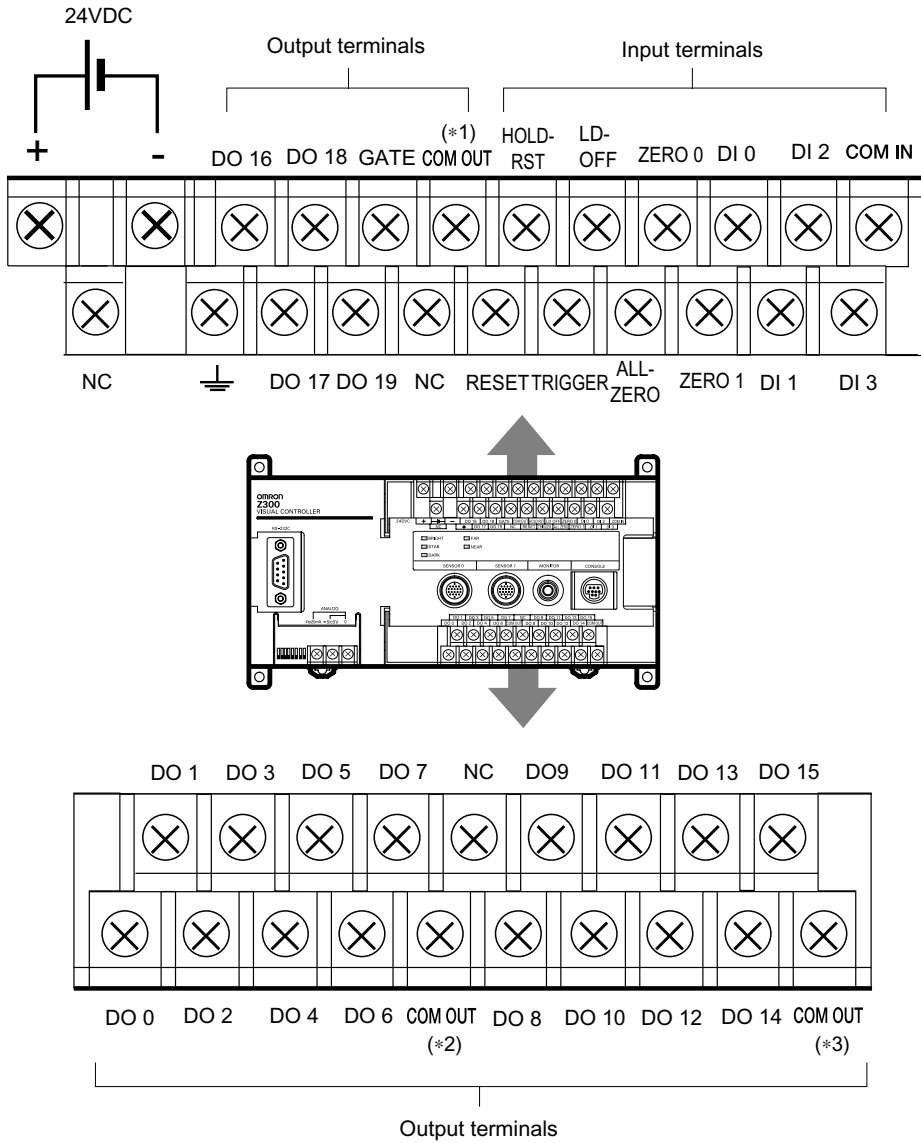
Output Specifications

Item	Specification	
Model	Z300-VC10EV3 (NPN mode)	Z300-VC15EV3 (PNP mode)
Output voltage	12 to 24 VDC $\pm 10\%$	
Load current	45 mA max.	
ON residual voltage	2 V max.	
OFF leakage current	0.1 mA max.	
Internal circuits		

Notice Do not exceed the maximum load current specified for the Controller.

- *1 ON Current/ON Voltage
This refers to the current or voltage values needed to shift from the OFF→ON state.
The ON voltage value is the potential difference between each of the input terminals and COM IN.
- *2 OFF Current/OFF Voltage
This refers to the current or voltage values needed to shift from the ON→OFF state.
The OFF voltage value is the potential difference between each of the input terminals and COM IN.

2-5-3 Terminal Names



CHECK There are 3 types of COM OUT (*1 to *3) for each output terminal. Connect with reference to the table at right.

2-5-4 Terminal Applications

Output Terminals

Name	Application	Name	Application	
DO 0	Measurement results output	DO 14	Measurement results output	
DO 1		DO 15		
DO 2		DO 16		
DO 3		DO 17		
DO 4		DO 18		
DO 5		DO 19		
DO 6		Control terminals For details, refer to page 150 in the Operation Manual.	GATE	
DO 7			COM OUT (*1)	Common for DO 16 to 19 and GATE
DO 8			COM OUT (*2)	Common for DO 0 to 7
DO 9		Common for DO 8 to 15	COM OUT (*3)	
DO 10				
DO 11				
DO 12				
DO 13				

Input Terminals

Name	Application
HOLD RST	Control terminals For details, refer to page 150 in the Operation Manual.
LD OFF	
TRIGGER	
ALL ZERO	
ZERO 0	
ZERO 1	
DI 0	Command input
DI 1	
DI 2	
DI 3	
RESET	For resetting the Z300
COMIN	Common for all input terminals

Notice

- Do not reverse the connections of the signal terminals and COM terminals.
- Do not input the RESET input immediately after turning ON the power. When using RESET input to synchronize startup timing, wait at least 1 s after turning ON the Z300's power supply before turning ON the RESET terminal.

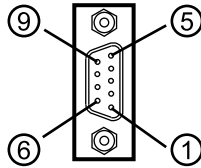
CHECK

- The initial status of the output terminals is OFF. The terminals, however, may turn ON for approximately 0.5 s when the power is turned ON. Be sure to allow for this when connecting to an external device.

2-6 RS-232C Connections

2-6-1 Connector

The Z300 uses 9-pin D-SUB female connectors. Use a compatible connector.



Recommended Plug and Hood

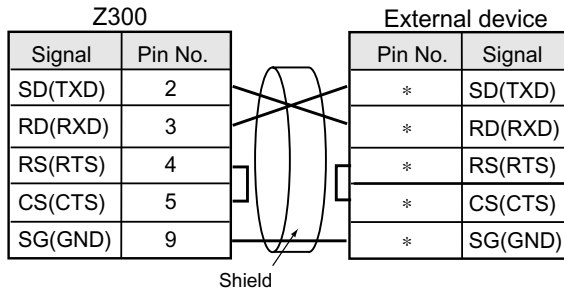
Model	Manufacturer
Plug: XM2A-0901	OMRON Corp.
Hood: XM2S-0911	

Pin No.	Signal	Name
1	FG(GND)	Protective frame ground
2	SD(TXD)	Send Data
3	RD(RXD)	Receive Data
4	RS(RTS)	Request to Send
5	CS(CTS)	Clear to Send
6	NC	Not connected
7	NC	Not connected
8	NC	Not connected
9	SG(GND)	Signal ground

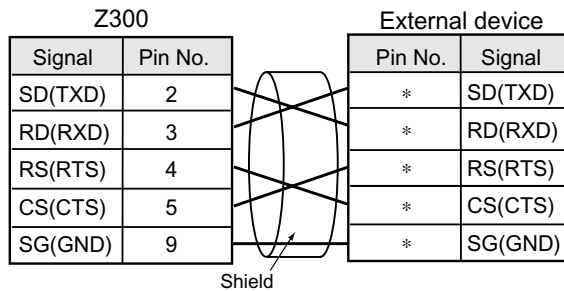
2-6-2 Wiring

Only use a shielded RS-232C cable. The maximum cable length is 15 m.

Standard Wiring



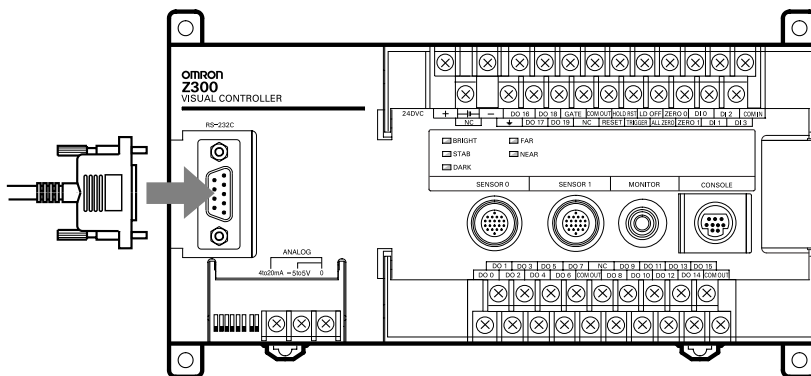
Wiring for RS/CS Control



Note Pin numbers on the external device will depend on the device being connected. Refer to the manual for the personal computer or PLC being connected.

2-6-3 Connection

Align the connector with the socket and press the connector straight into place. Tighten the two screws on the edges of the connector.



Notice

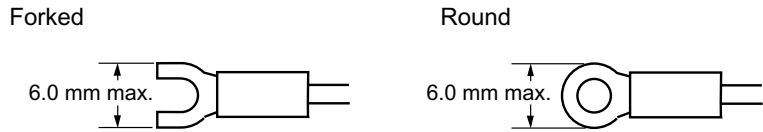
- Always turn OFF the power supply before connecting or disconnecting cables. The peripheral device may be damaged if connected or disconnected with the power supply turned ON.
- Always tighten the connector screws.

2-7 Linear Sensor Controller Connections

2-7-1 Crimp Terminals and Cables

The terminal block uses M3 terminal screws. Use appropriate crimp terminals for M3 screws as shown below. Tighten the screws to a torque of between 0.5 and 0.6 N•m.

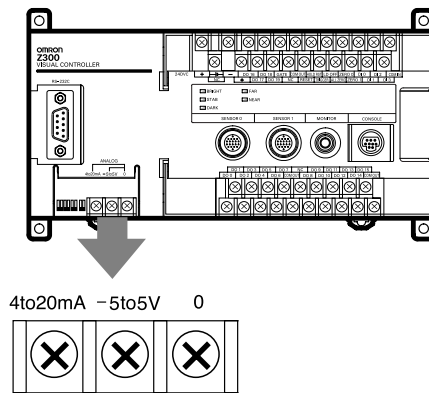
Caution Cover the terminal blocks with the Terminal Block Protection Covers. Uncovered terminal blocks can result in electric shock.



Recommended Crimp Terminals

	Manufacturer	Model	Recommended wire size
Forked	J.S.T. Mfg Co.,Ltd	V1.25-B3A	1.31 to 1.65mm ²
Round	J.S.T. Mfg Co.,Ltd	V1.25-MS3	

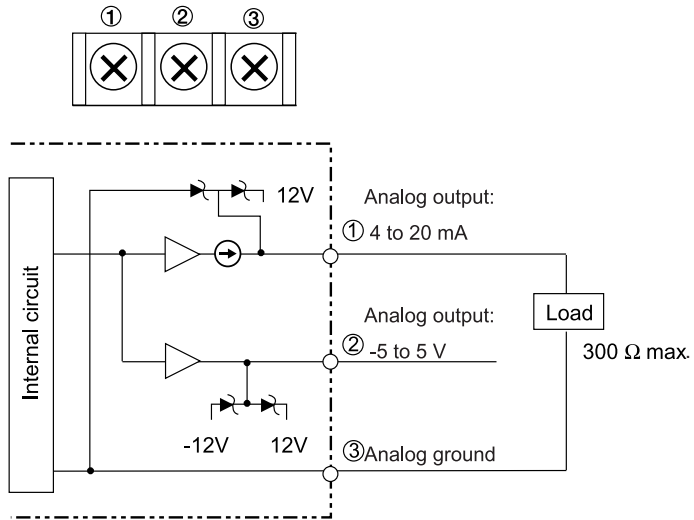
2-7-2 Terminal Names



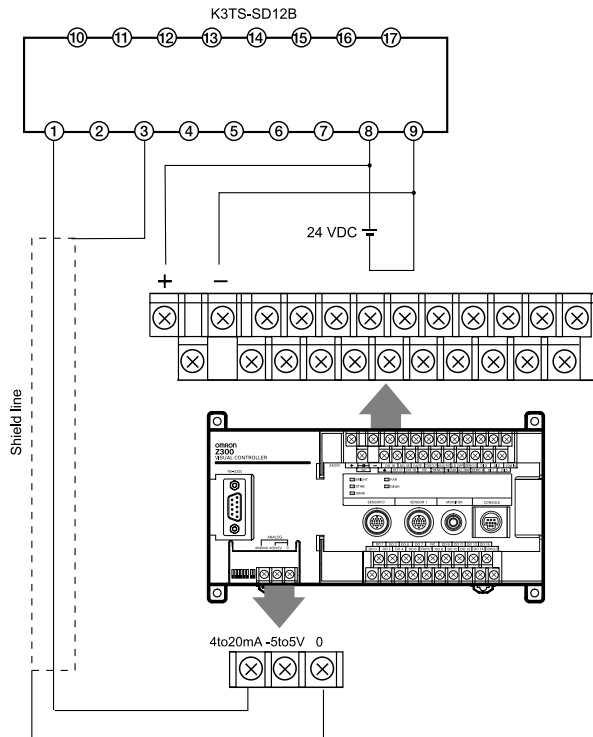
Name	Application
4 to 20mA	Analog output terminal for current output in the range 4 to 20 mA.
-5 to 5V	Analog output terminal for voltage output in the range -5 to 5 V.
0	Connected to input devices as a ground for analog output.

CHECK Terminal 0 and the 4 to 20-mA terminal can be used for 1 to 5-V voltage output by connecting the 250-Ω resistor provided.

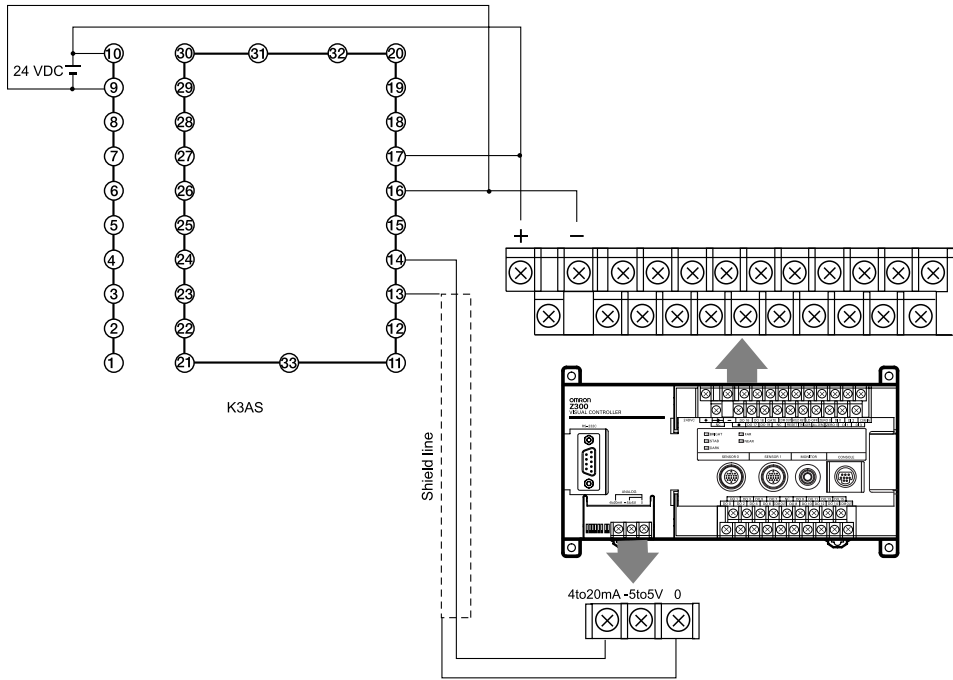
2-7-3 Internal Specifications



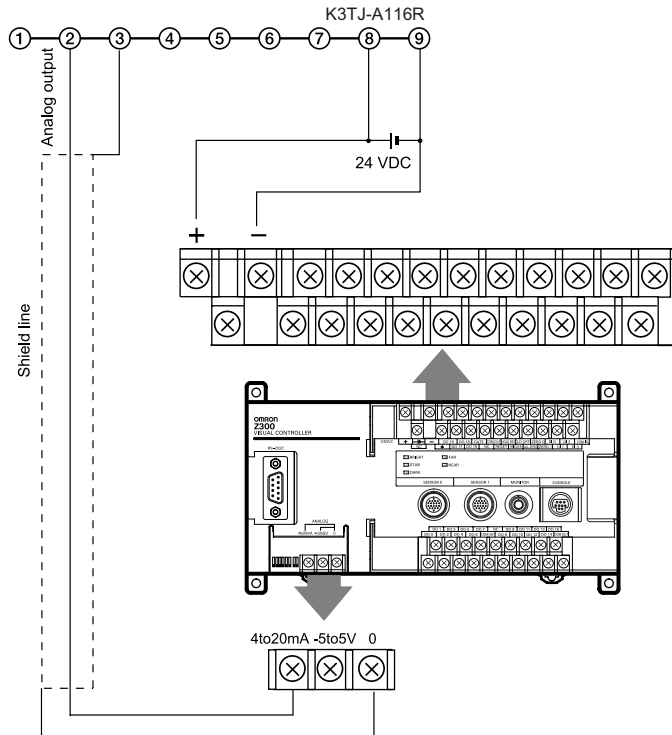
2-7-4 Connection Examples for the Linear Sensor Controller Connecting to the Linear Sensor Digital Panel Meter (K3TS)



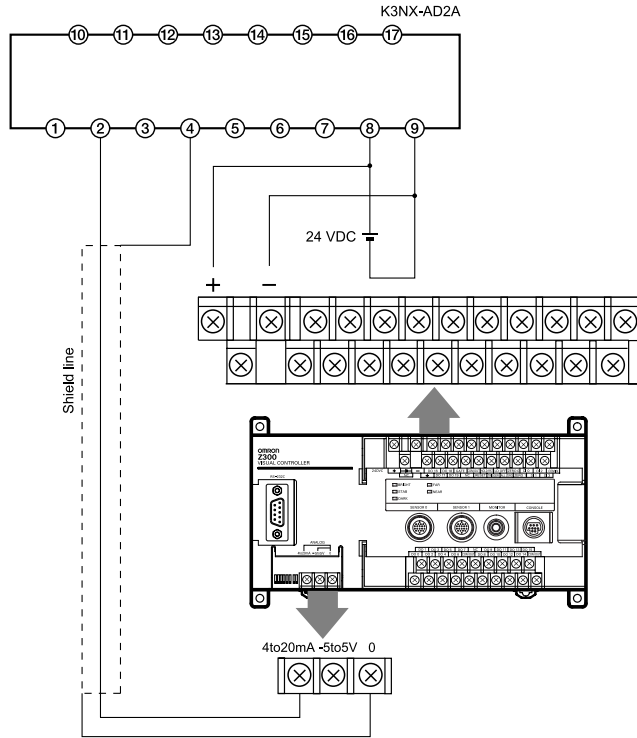
Connecting to the Linear Sensor Controller (K3AS)



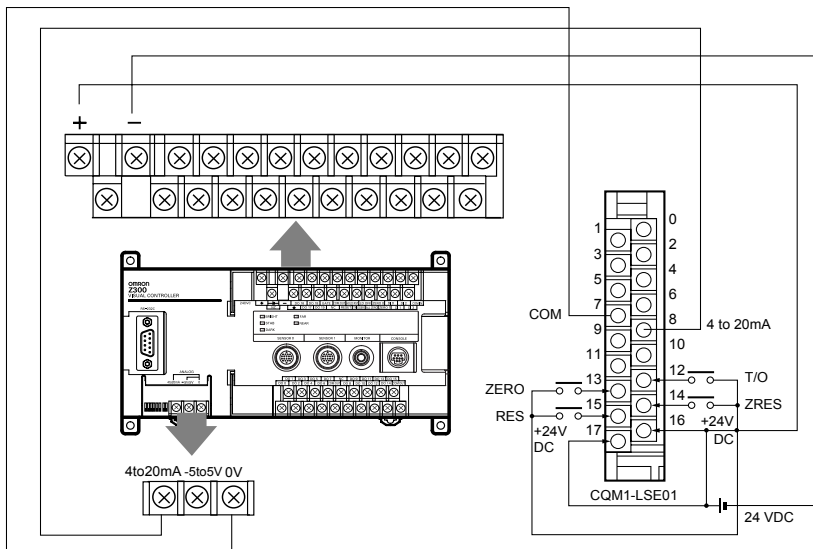
Connecting to the Scaling Meter (K3TJ)



Connecting to the Digital Panel Meter (K3NX)



Connecting to the Linear Sensor Interface Unit (CQM1-LSE)



SECTION 3

Installation

This section provides installation methods for the Controller and Sensor.

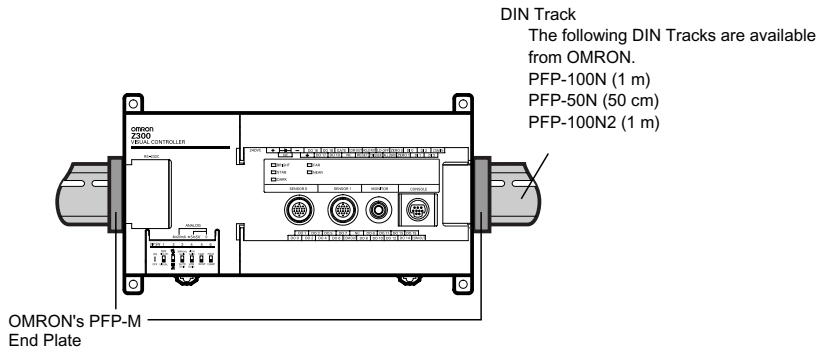
3-1	Mounting the Controller	48
3-2	Mounting the Sensor	50

3-1 Mounting the Controller

There are two ways to mount the Controller: DIN Track mounting or surface-mounting.

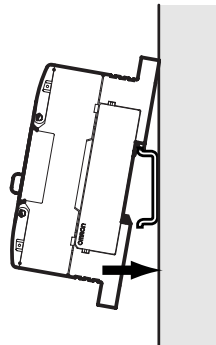
3-1-1 DIN Track Mounting

The Controller can be easily mounted to or removed from 35-mm DIN Track.



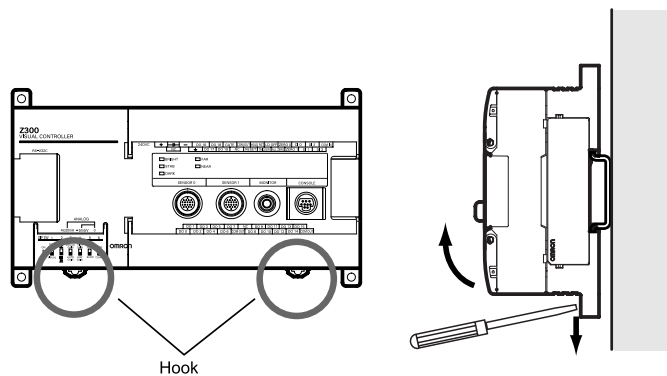
Mounting the Controller

Hook the Controller into the DIN Track as shown in the diagram and then press in at the bottom until the Controller locks into place.



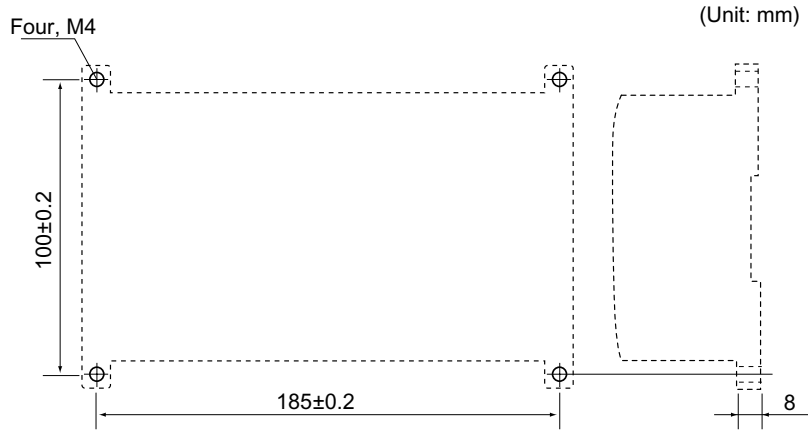
Removing the Controller

Use a flat-bladed screwdriver to pull the hook down and then pull out the Controller from the bottom.




3-1-2 Surface Mounting

Use the holes and dimensions shown in the following diagram.



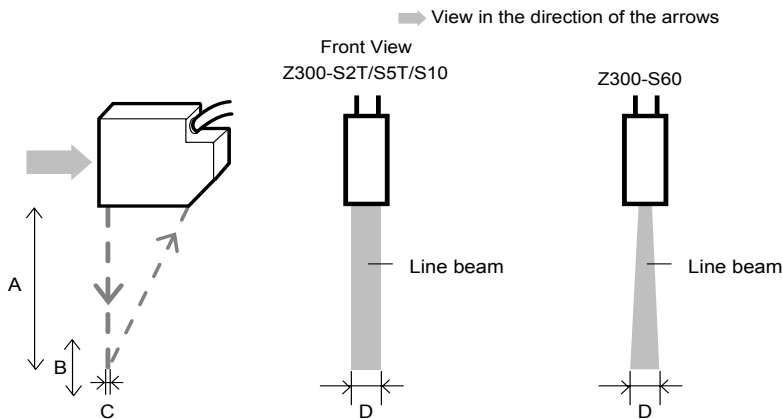
3-2 Mounting the Sensor

Up to 2 Sensors can be connected per Controller. When using the Z300 in Non-visual Mode, however, only 1 Sensor can be connected.

⚠ WARNING Do not to expose your eyes to the laser radiation either directly or indirectly (i.e., after reflection from a mirror or shiny surface). The laser radiation has a high power density and exposure may result in loss of sight. 

Notice Only sensors specifically for the Z300 can be used. Using another type of sensor may result in damage to the sensor or controller.

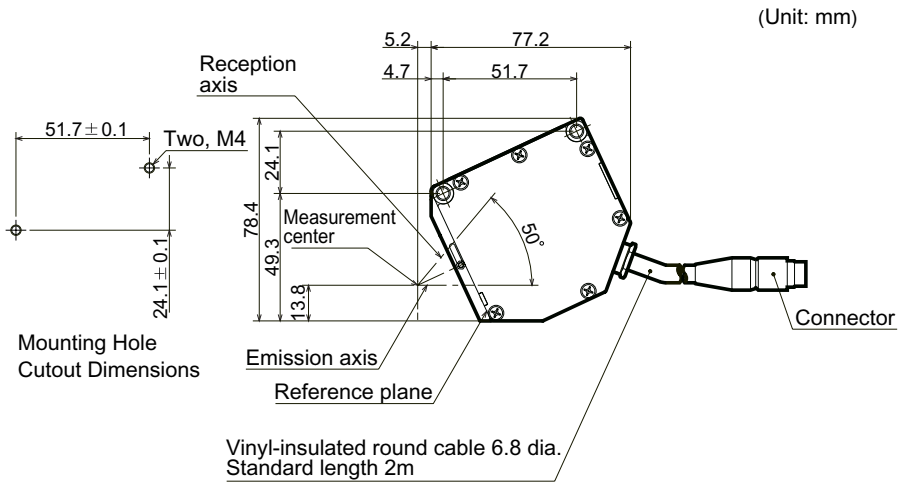
3-2-1 Sensor Types



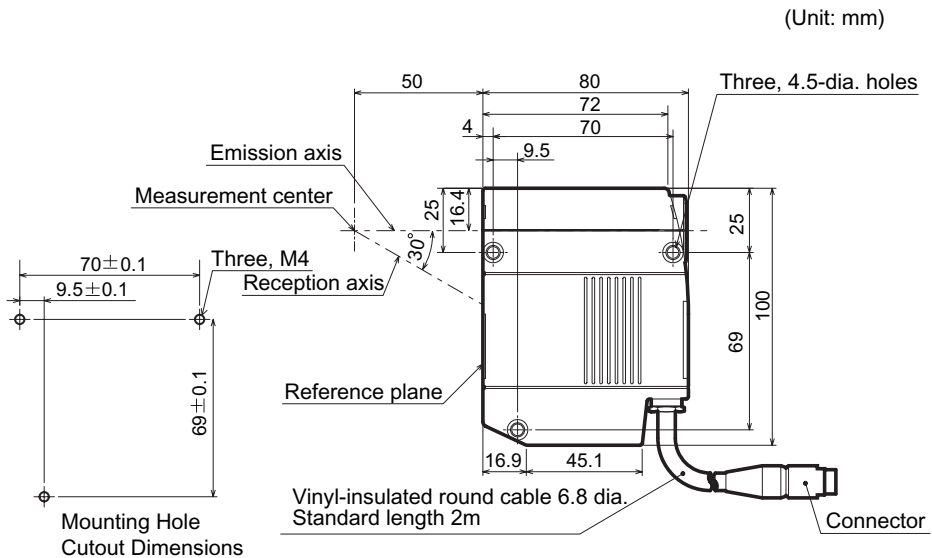
	Reference distance (A)	Measurement range (B)	Spot diameter (C)	Line beam width (D)
Super-precision Model: Z300-S2T	20mm	±1mm	B=-1mm : 50µm B=0mm : 20µm B=+1mm : 50µm	0.3mm (The width of the measurement region is 0.2 mm)
High-precision Model: Z300-S5T	50mm	±5mm	B=-5mm : 140µm B=0mm : 30µm B=+5mm : 140µm	0.4mm
Long-range Model: Z300-S10	100mm	±20mm	B=-20mm : 280µm B=0mm : 60µm B=+20mm : 280µm	1.0mm
Super Long-range Model: Z300-S60	600mm	±350mm	B=-350mm : 0.8mm B=0mm : 0.4mm B=+350mm : 1.3mm	B=-350mm : 10mm (The width of the measurement region is 5.0mm) B=0mm : 18mm (The width of the measurement region is 12.4mm) B=+350mm : 26mm (The width of the measurement region is 20mm)

3-2-2 Mounting Dimensions
Dimensions for Diffuse Reflection

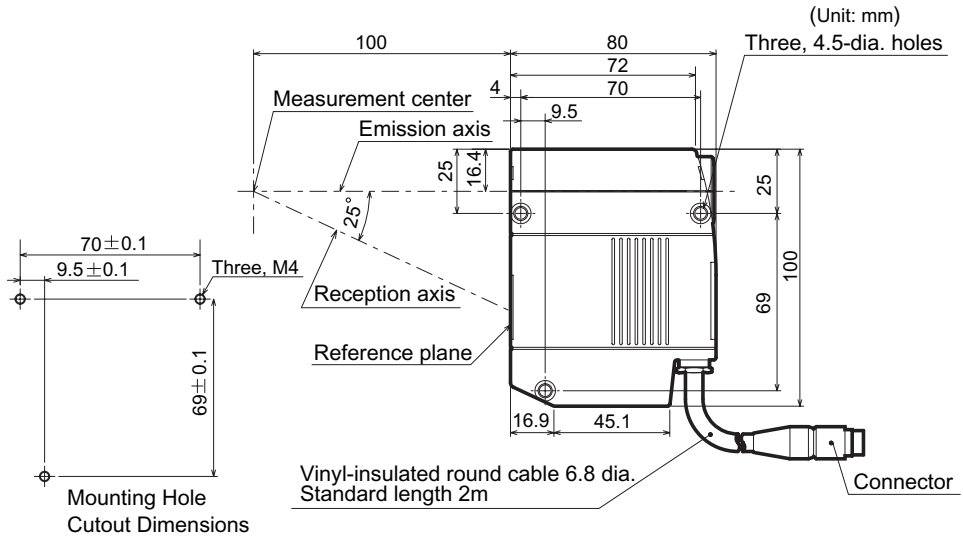
Super-precision Model: Z300-S2T



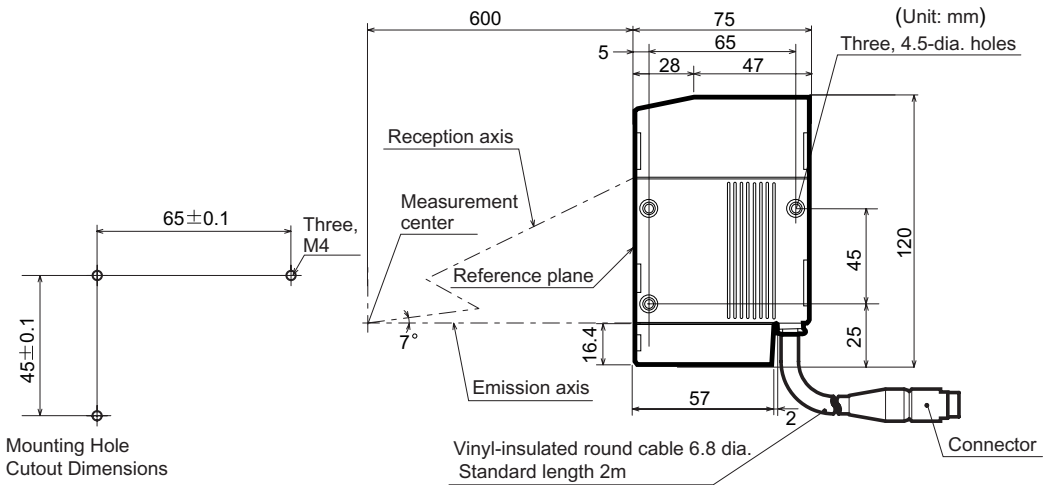
High-precision Model: Z300-S5T



Long-range Model: Z300-S10



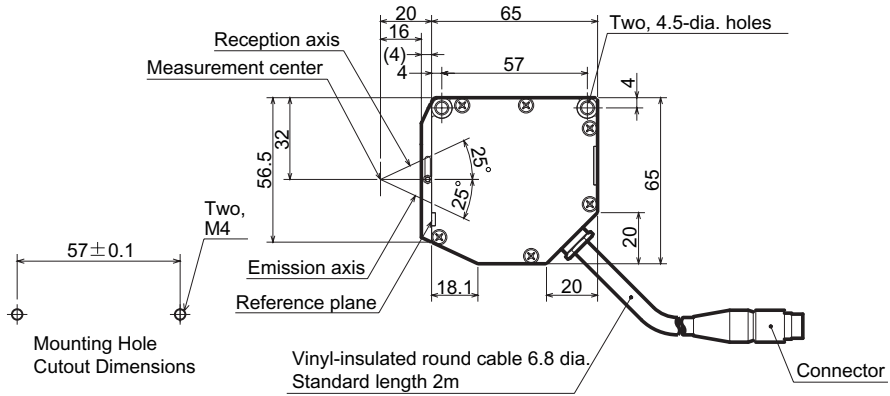
Super Long-range Model: Z300-S60



Dimensions for Mirror Reflection

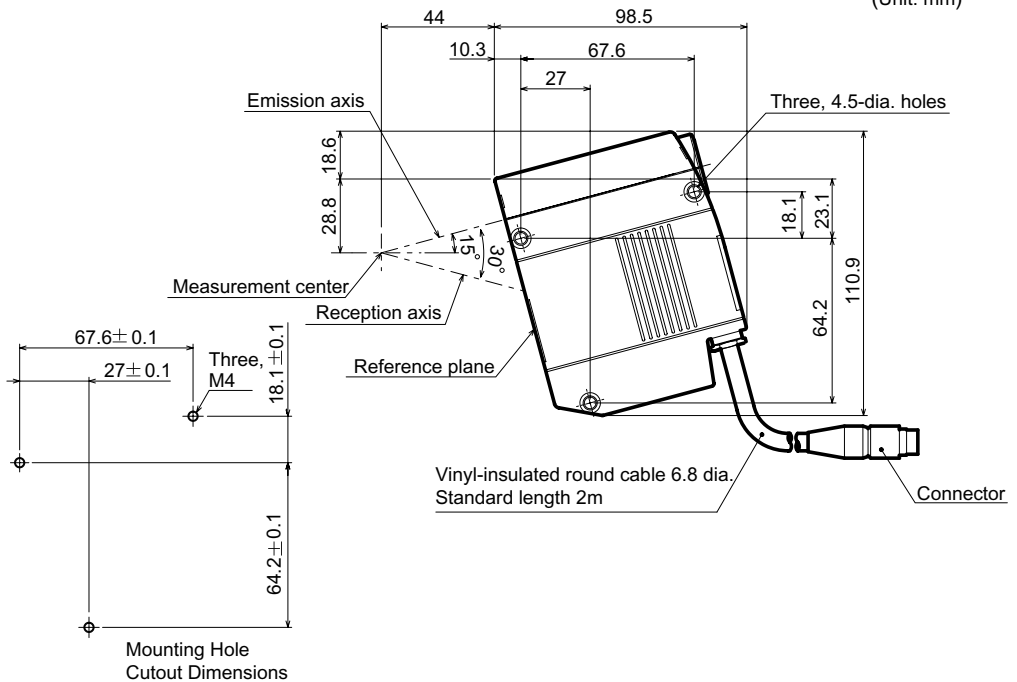
Super-precision Model: Z300-S2T

(Unit: mm)

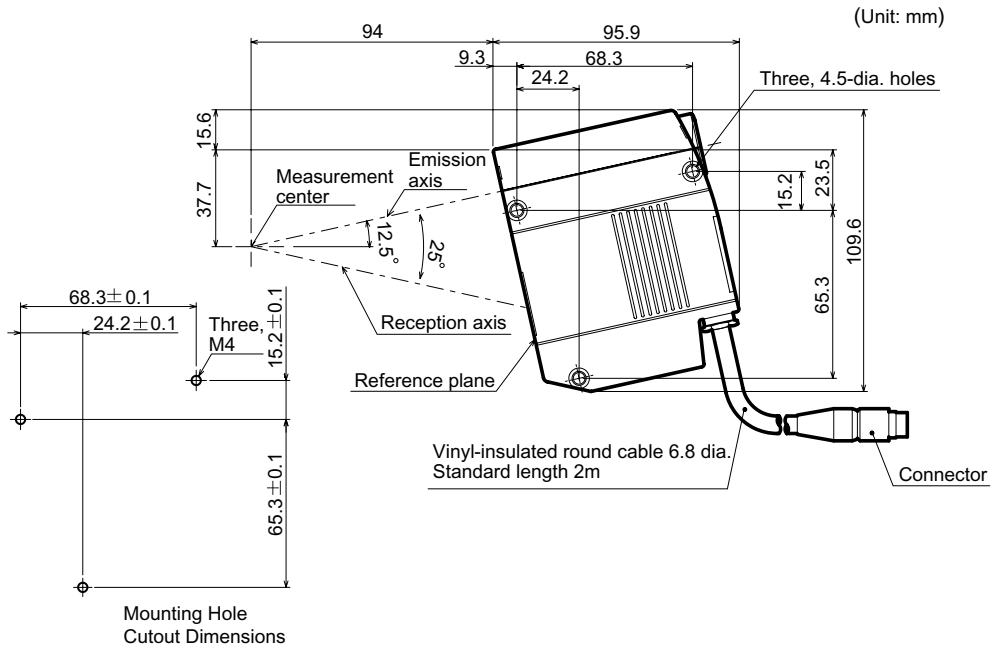


High-precision Model: Z300-S5T

(Unit: mm)



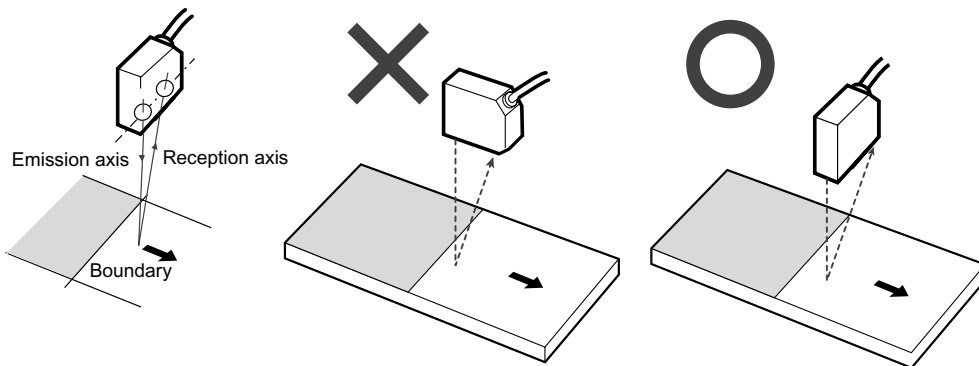
Long-range Model: Z300-S10



3-2-3 Mounting Orientation

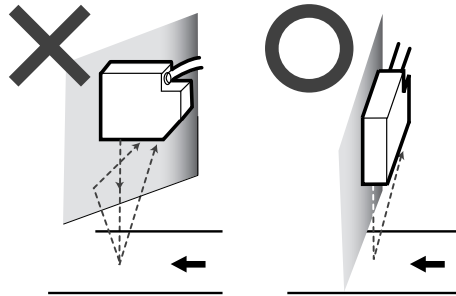
Boundaries between Different Colors and Textures

If there are parts of the workpiece where the color or texture are significantly different, measurement errors can be reduced by mounting the Sensor in the way shown below, i.e., so that the plane containing the emission axis and the reception axis is parallel to the boundary between the contrasting sections of the workpiece.



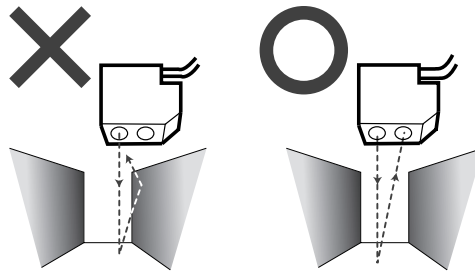
Mounting Near Walls

Errors will occur if light reflected off a wall surface is received by the Sensor. If it is not possible to mount the Sensor away from the wall, mount in the way shown below, i.e., so that the plane containing the emission axis and the reception axis is parallel to the wall surface. Also, applying matt black coating to the wall surface will help to reduce the amount of light reflected.



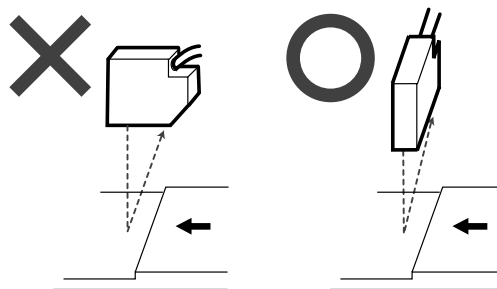
Narrow Grooves or Indentations

If measurement is performed in an indentation between two walls, or in a groove, mount the Sensor in the way shown below, i.e., so that the path along the emission and reception axes is not interrupted by a wall.



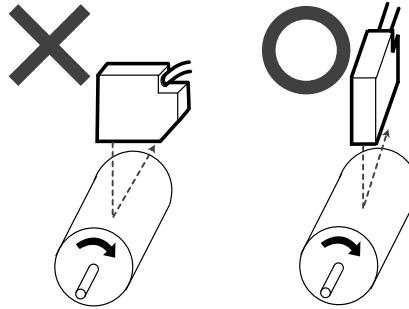
Level Differences

When measuring workpieces with level differences, the influence of the level difference can be minimized by mounting the Sensor so that the plane containing the emission axis and the reception axis is parallel to the boundary between the different levels.



Rotating Workpieces

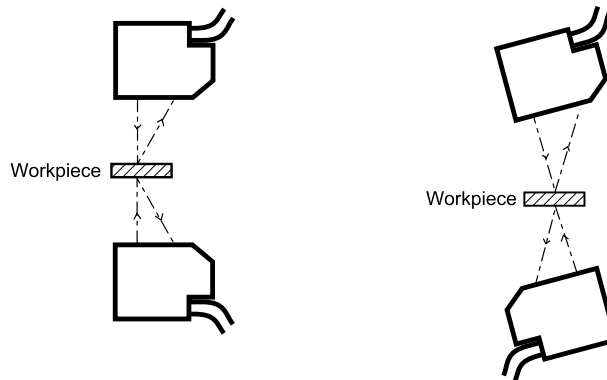
When measuring rotating workpieces, the influence of position displacement and blurring of the rotating workpiece can be minimized by mounting the Sensor so that the plane containing the emission axis and the reception axis is parallel to the axis of rotation.



Thickness Measurement

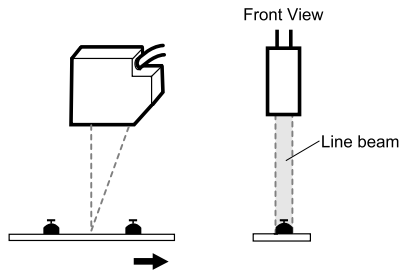
When measuring the thickness of boards, select the Sensor mounting method according to the board material.

Workpiece	Opaque		Transparent Example: Glass
	Diffuse reflection Example: Ceramic	Specular reflection Example: Stainless steel	
Sensor mounting status	Diffuse reflection mounting status	Mirror reflection mounting status	
Controller settings			



Projections

When measuring the tops of projections on the workpieces, mount the Sensor so that the entire projection passes through the line beam.

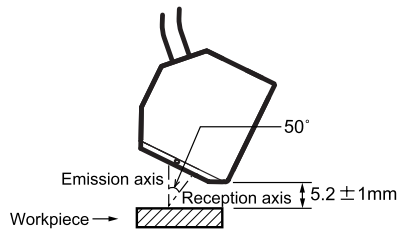


3-2-4 Mounting Distance

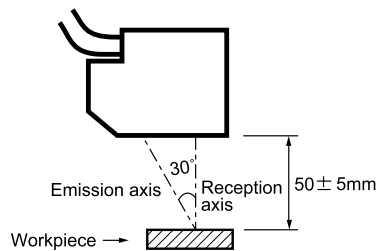
After selecting the Sensor mounting status in the menu item **Environment**, mount the Sensor in a location where the status can be measured correctly. For more details, refer to page 140 in the Operation Manual. When using Non-visual Mode, refer to page 55.

Diffuse Reflection

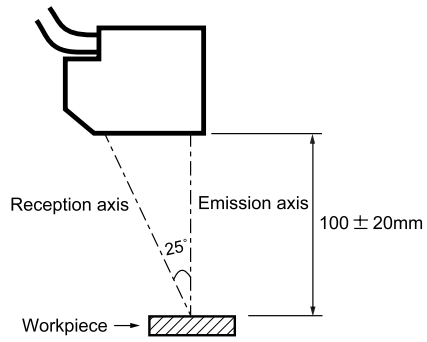
Super-precision Model: Z300-S2T



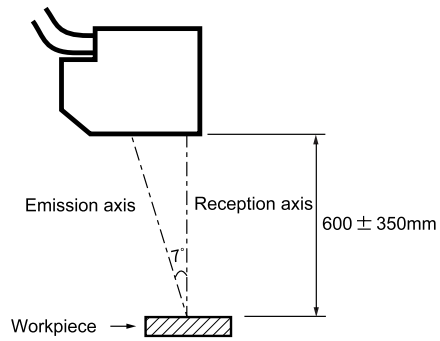
High-precision Model: Z300-S5T



Long-range Model: Z300-S10

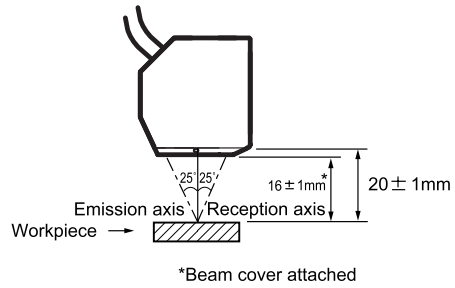


Super Long-range Model: Z300-S60

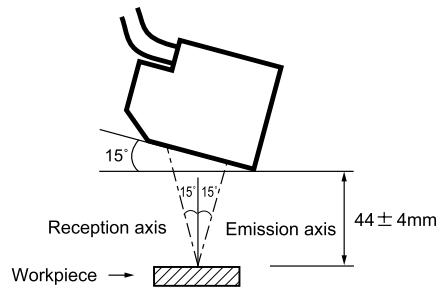


Mirror Reflection

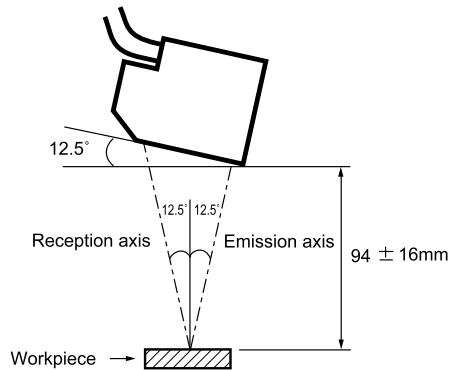
Super-precision Model: Z300-S2T



High-precision Model: Z300-S5T



Long-range Model: Z300-S10

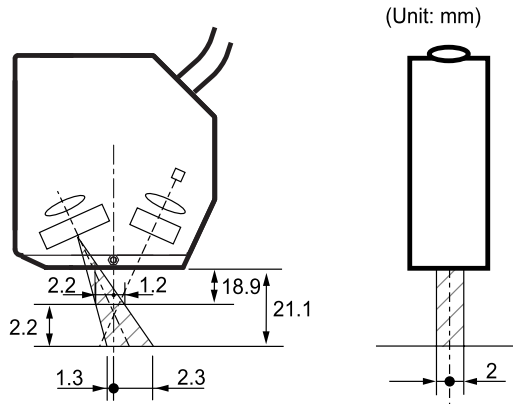


CHECK It is recommended that Sensor mounting is performed while monitoring the amount of received light in the menu item **Check position**. For details, refer to page 118 in the Operation Manual.

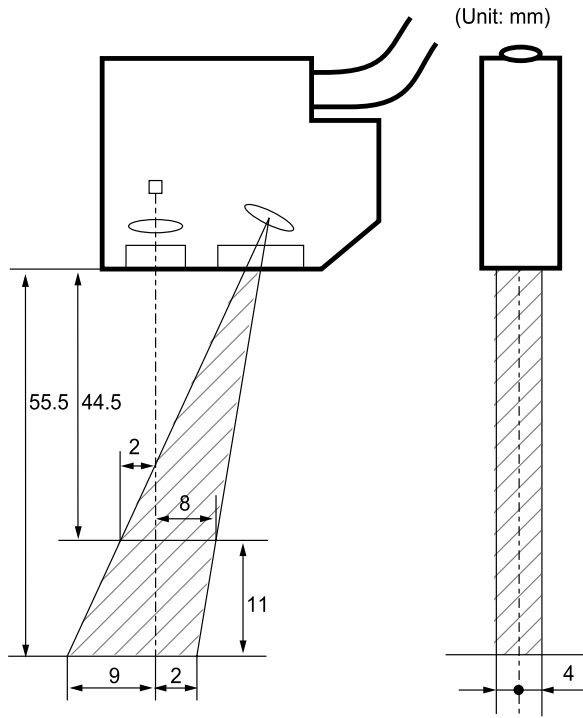
3-2-5 Mutual Interference

When using 2 or more Sensors mounted adjacently, mutual interference will not occur as long as the spots (shown below) for other Sensors are outside the shaded areas.

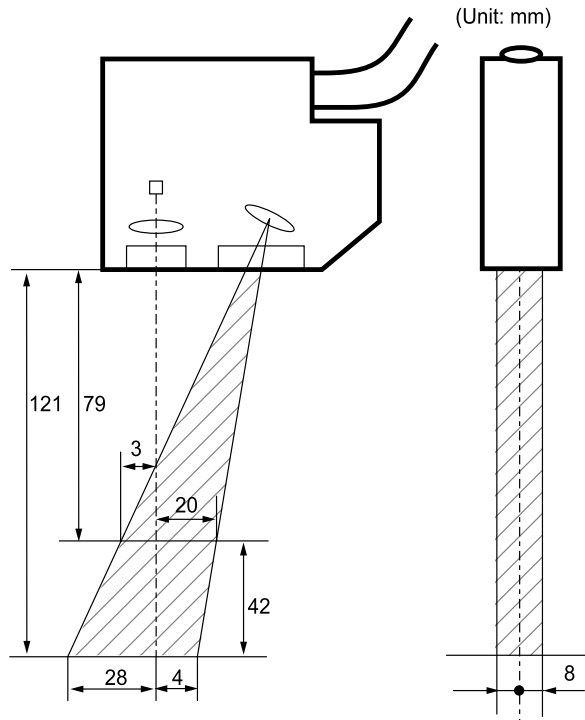
Z300-S2T



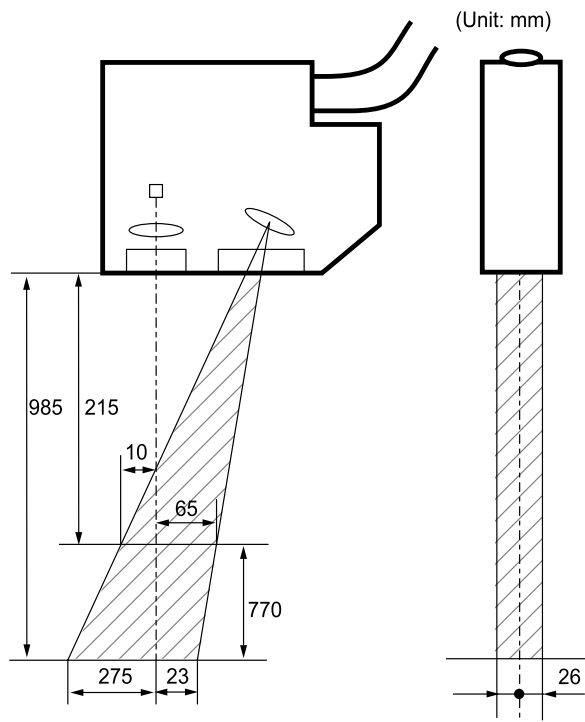
Z300-S5T



Z300-S10



Z300-S60



SECTION 4

Non-visual Mode

In Non-visual Mode, Z300 operation is performed according to the DIP switch settings without using the menus. Because the menus are not used, the monitor and console are not required. Make settings for the Sensor mounting status, sensitivity, and response time using the DIP switch on the Controller. The way that the Z300's analog outputs are used is set at the Linear Sensor Controller. For details, refer to the operation manual for the Linear Sensor Controller connected.

4-1	Restrictions	64
4-2	DIP Switch Settings	65
4-2-1	Switching to Non-visual Mode	65
4-2-2	Selecting the Sensor Setting Status	66
4-2-3	Setting the Sensor Sensitivity	69
4-2-4	Selecting the Analog Output Response Time	69
4-2-5	Selecting the Output Method for Measurement Failure	70

4-1 Restrictions

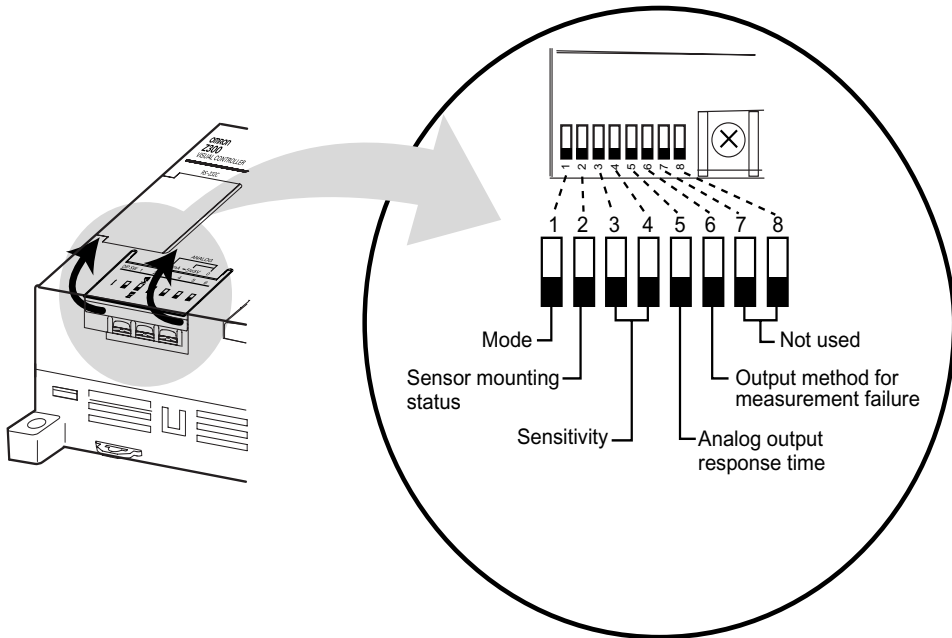
If the DIP switch setting is changed to NON VISUAL, the Controller's settings can be changed using the DIP switch without having to connect a monitor or a console.

Notice Turn OFF the power supply before changing the DIP switch settings.

The restrictions that apply when using the Z300 in Non-visual Mode are provided below.

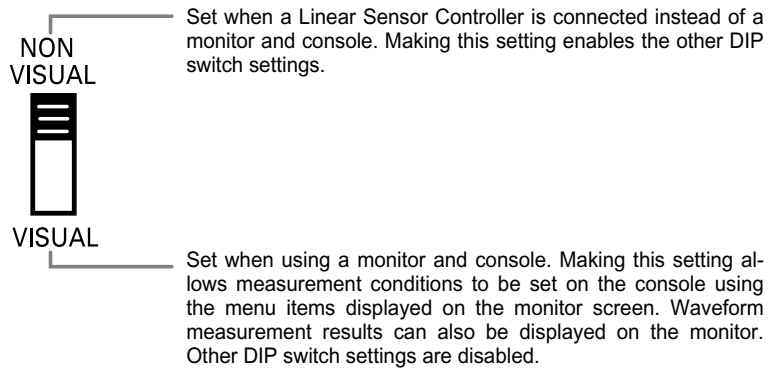
- Measurement conditions set using the monitor and console are disabled.
 - Even if a monitor and console are connected, console operations will have no effect.
 - Only 1 Sensor can be connected. It must be connected to SENSOR 0.
 - Measurement is based on the following conditions.
 - Sampling time: 0.96 ms
 - Smoothing: None
 - Noise removal: None
 - Output: Analog output only
 - Input: $\overline{\text{LD}}$ -OFF input only
 - The settings that can be changed are as follows.
 - The Sensor mounting status can be selected.
 - The Sensor's sensitivity can be set.
 - The response time for analog outputs can be selected.
 - The output method for measurement failure can be selected.
- Refer to page 55 for details of setting methods.

4-2 DIP Switch Settings



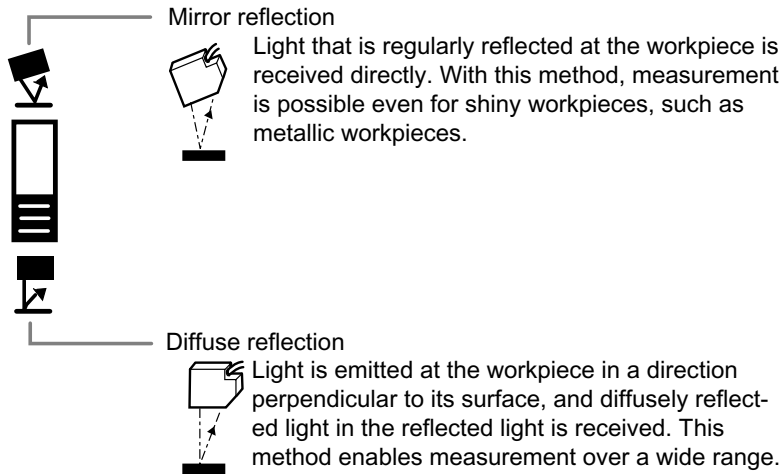
Notice Turn OFF the power supply before changing the DIP switch settings.

4-2-1 Switching to Non-visual Mode



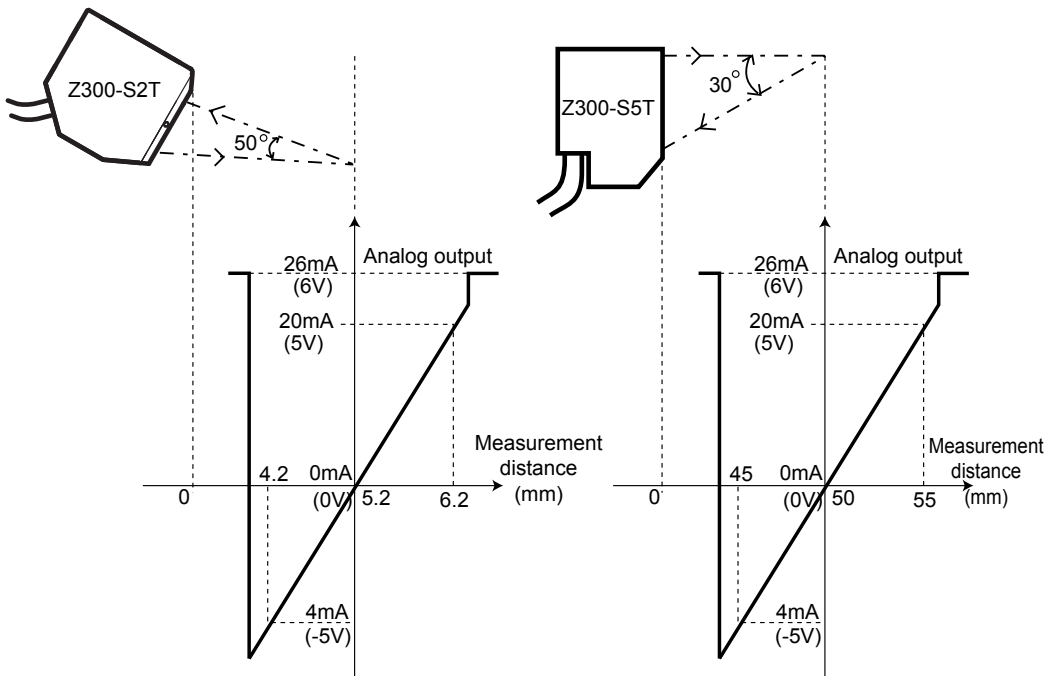
4-2-2 Selecting the Sensor Setting Status

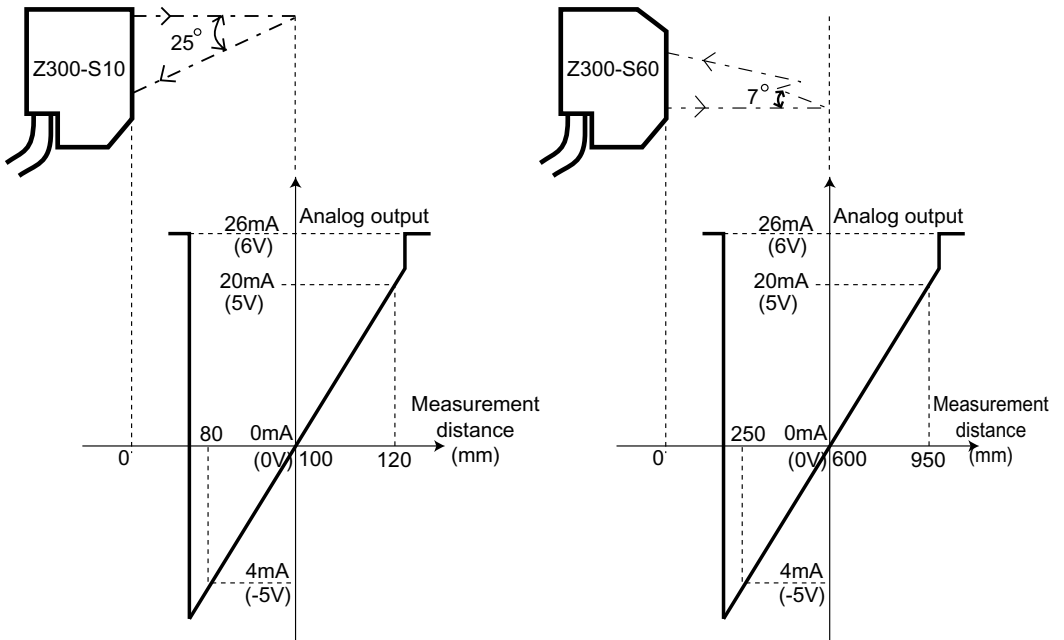
The analog output appropriate for the mounting status is set. Measurement at close to the actual dimensions is possible immediately after mounting. Adjust the mounting position while monitoring the values of the Linear Sensor Controller connected.



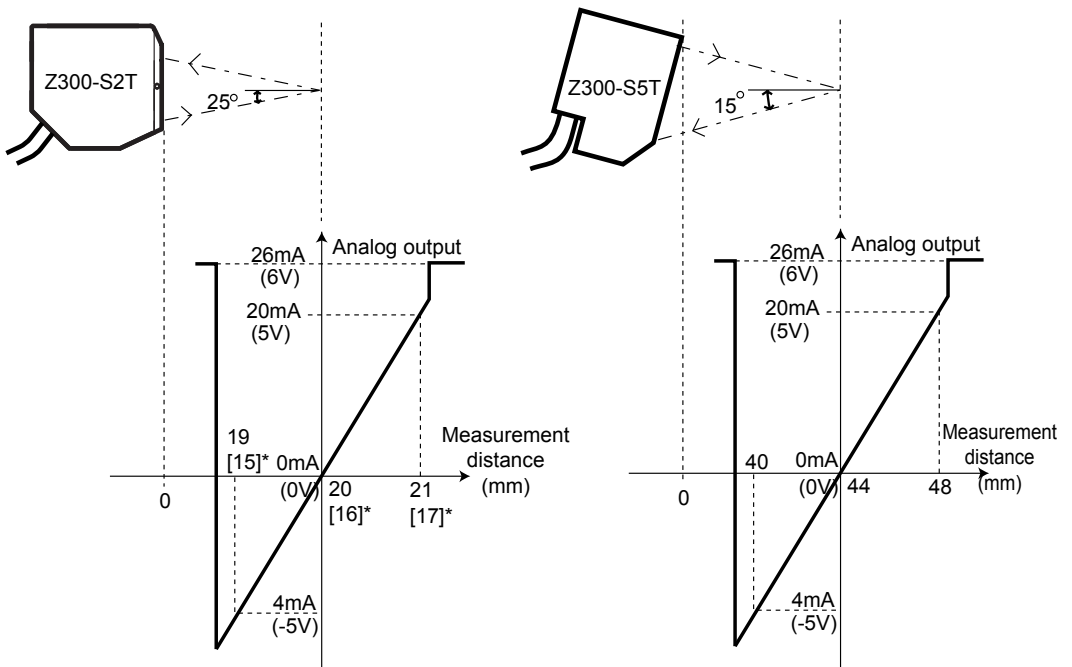
Output Characteristics

Diffuse Reflection

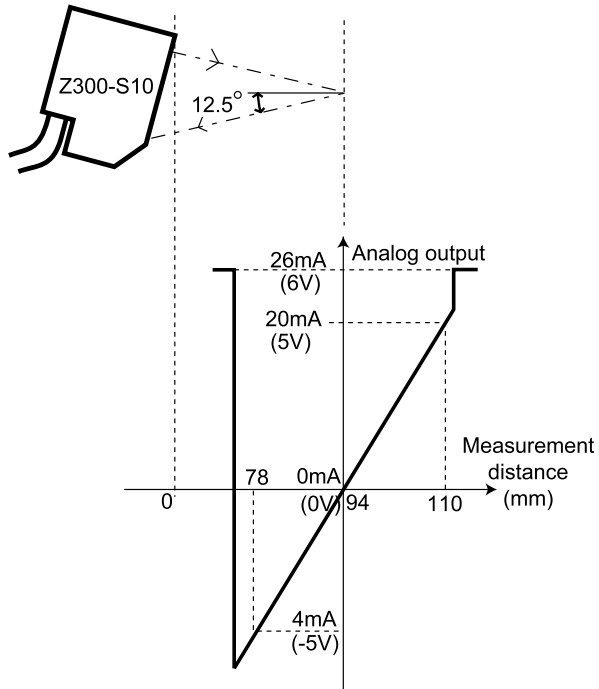




Mirror Reflection

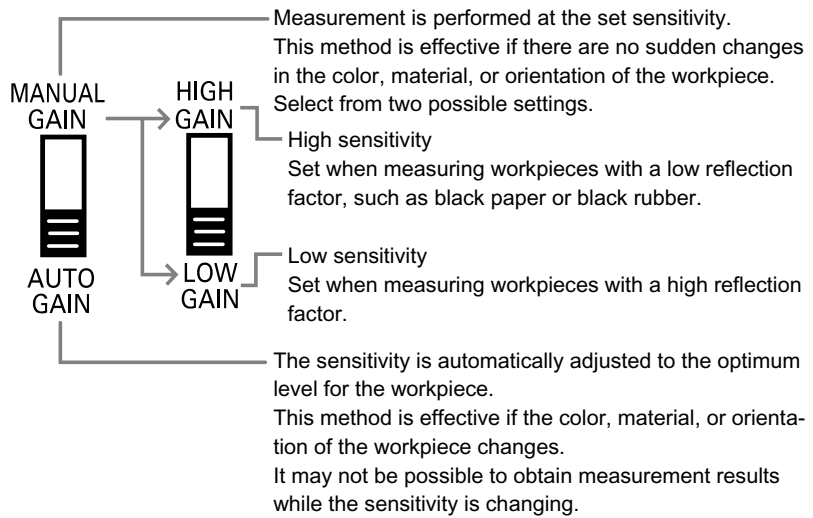


*Figures in [] are for measurement with the beam cover attached.



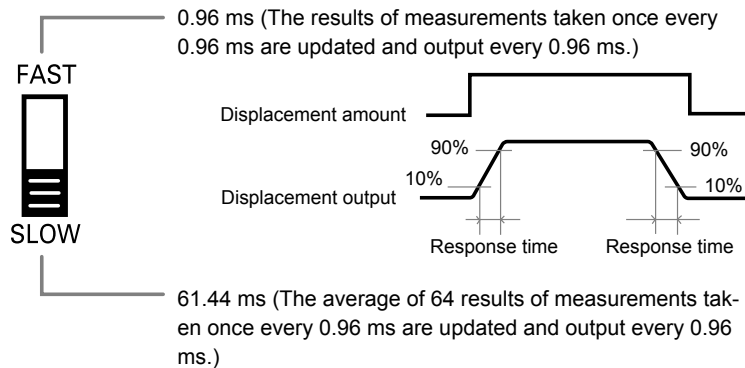
4-2-3 Setting the Sensor's Sensitivity

Set the sensitivity while monitoring the values on the Linear Sensor Controller connected.



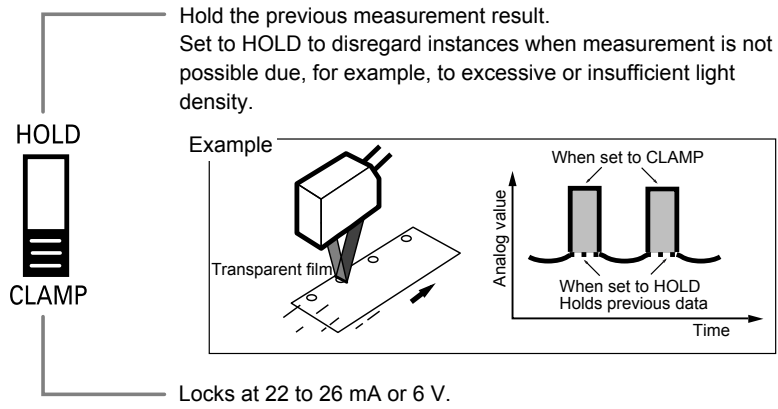
4-2-4 Selecting the Analog Output Response Time

The response time is a measure of the speed with which analog displacement output responds to a discrete change in the displacement amount. It is the time taken for the output level to change from 10% to 90% of the total change in level when rising or falling.



4-2-5 Selecting the Output Method for Measurement Failure

Select the way outputs operate when measurement is not possible due, for example, to excessive or insufficient light density. Select the output method while monitoring the values of the Linear Sensor Controller connected.



SECTION 5

Maintenance

This section explains maintenance procedures for ensuring the Z300's performance.

5 Maintenance

In order to ensure performance, carry out the maintenance procedures given below.

- Notice**
- Turn OFF the power and take safety precautions before conducting inspections. Electric shock can result from attempting safety inspections with the power turned ON.
 - Do not use thinners or benzene to clean the Z300.

5-1 Cleaning

- Remove dirt on equipment by gently wiping with a soft cloth.

Optical Filter on Front Panel of Sensor

- Use a blower brush (used to clean camera lenses) to blow large dust particles from the surface. Do not blow the dust away with your mouth.
- Use a soft cloth (for lenses) with a small amount of alcohol to remove the remaining dust.

- Notice** Do not use a scrubbing action when cleaning as scratches on the filter could result in the Sensor malfunctioning.

5-2 Regular Inspections

Inspection point	Details	Tools required
Power supply	The voltage measured at the power supply terminals must be 24 VDC +10%/-10%.	Circuit tester
Ambient temperature	The operating ambient temperature inside the cabinet must be between 0 and 50°C.	Thermometer
Ambient humidity	The operating ambient humidity inside the cabinet must be between 35% and 85%.	Hygrometer
Installation	Each component must be firmly secured. Each cable connector must be correctly inserted and locked.	Phillips screwdriver

SECTION 6

Troubleshooting

This section provides information on hardware errors that may occur with the Z300. Refer to this section before requesting service from your OMRON representative.

6 Troubleshooting

This section provides information on hardware errors and remedies to be taken. Refer to this section before requesting service from your OMRON representative.

6-1 Connection Errors

6-1-1 The Power Indicator is Not Lit.

The Power Supply is not connected properly.
The 24-VDC (21.6 to 26.4-VDC) supply voltage has dropped.

6-1-2 The Video Monitor is Blank.

The power to the Video Monitor is not ON.
The Monitor Cable is not connected properly.
The Video Monitor is malfunctioning.
When using an Liquid Crystal Monitor, the power supply capacity is insufficient.

6-1-3 Cannot Make Key Inputs from the Console.

The Console Cable is not correctly connected.
The DIP switch is set to NON VISUAL.

6-1-4 No Images are Displayed.

The Sensor cable is not connected to the Controller correctly.
There is no workpiece inside the measurement range.
The Sensor is not mounted in the correct position.

6-1-5 The Video Monitor Image is Not Clear.

There is electric noise entering from the power supply or cables.
The Monitor Cable is not connected properly.

6-2 Terminal Block Errors

6-2-1 Trigger Signals (Input Signals) are Not Received.

The cables are not correctly wired.
The signal line is disconnected.
The Z300 is not in RUN mode.

6-2-2 Signals cannot be Output Externally.

The trigger signal has not been input.
The cables are not correctly wired.
The signal line is disconnected.
The Z300 is not in RUN mode.

6-3 RS-232C Communication Errors

6-3-1 No Communications are Possible.

The cables are not correctly wired.
The Z300's communications specifications do not match those of the external device.
The Z300 is not in RUN mode.

6-3-2 The Unit Operates Well Initially, But After a While There is No Response from the Z300.

The reception buffer on the external device (e.g., personal computer) is full.
Check that settings allow the data to be properly received.

SECTION 7

Appendix

This section provides the specifications and dimensions of the Z300 and its peripheral devices.

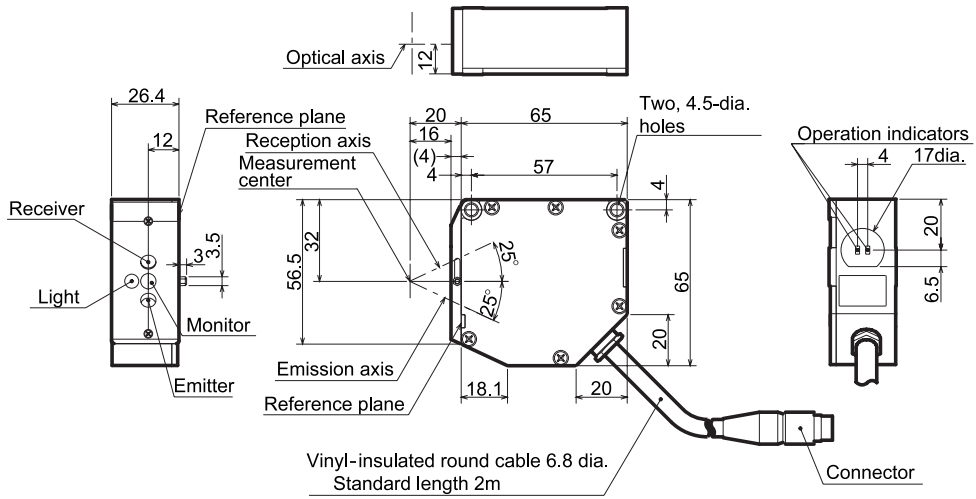
7-1	Specifications and Dimensions	78
7-2	Laser Product Classifications	88

7-1 Specifications and Dimensions

7-1-1 Sensor

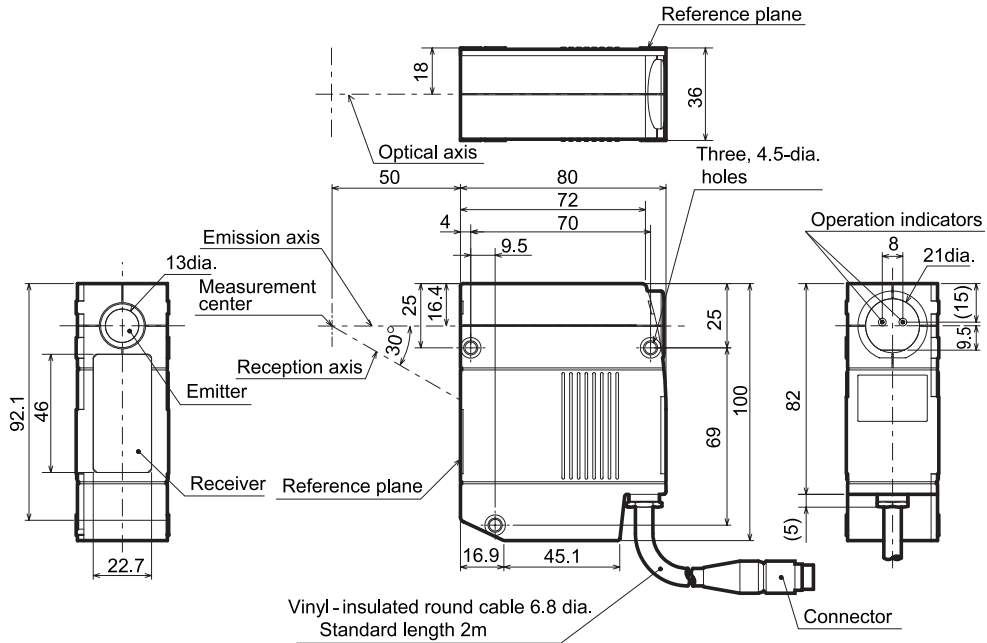
Z300-S2T

(Unit: mm)

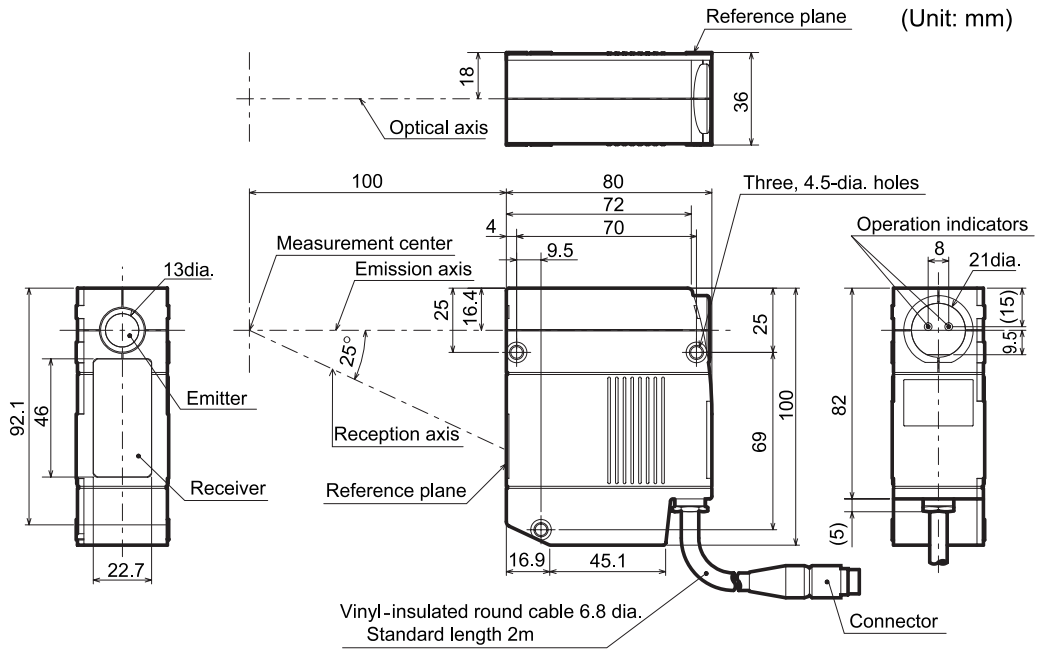


Z300-S5T

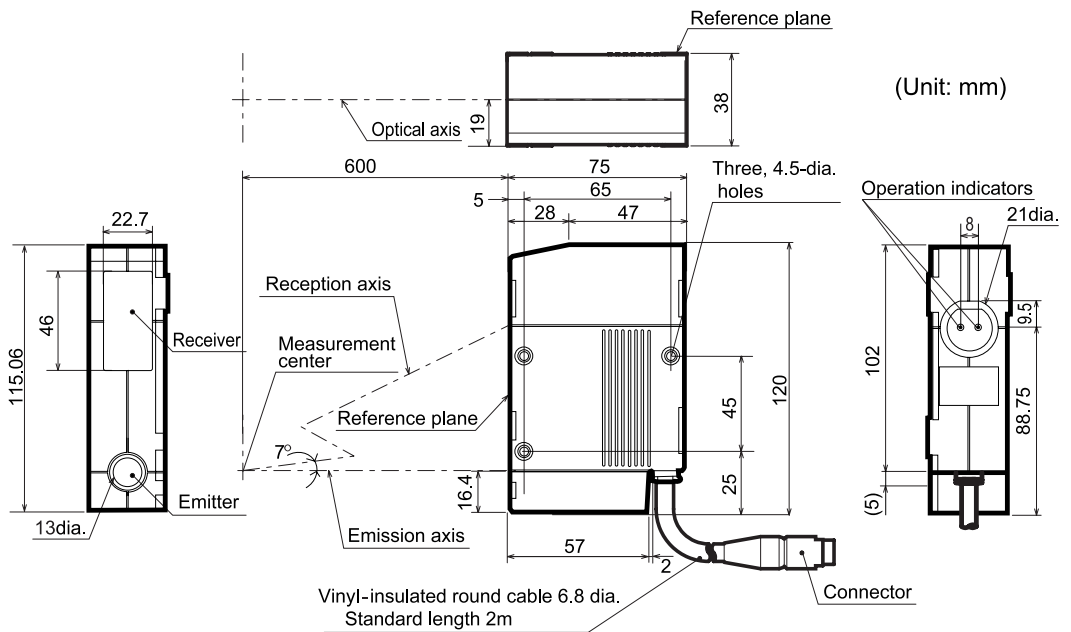
(Unit: mm)

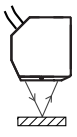





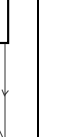


Z300-S10



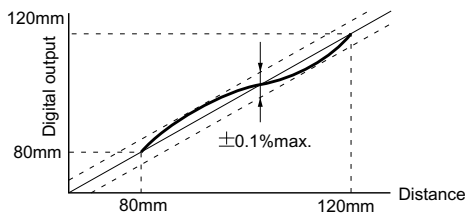
Z300-S60



Model		Z300-S2T (Super-precision Model)		Z300-S5T (High-precision Model)		Z300-S10 (Long-range Model)		Z300-S60 (Super Long-range Model)
RUN Mode		Mirror reflection	Diffuse reflection	Mirror reflection	Diffuse reflection	Mirror reflection	Diffuse reflection	Diffuse reflection only
								
Distance to measurement center		20mm (with beam cover attached: 16 mm)	±5.2mm	±44mm	±50mm	±94mm	±100mm	±600mm
Measurement range		±1mm		±4mm	±5mm	±16mm	±20mm	±350 (F.S.700mm)
Light source		Visible-light semiconductor laser (Wavelength: 650 nm, 1 mW max., Class 2)		Visible-light semiconductor laser (Wavelength: 670 nm, 1 mW max., Class 2)				Visible-light semiconductor laser (Wavelength: 658nm, 15mWmax., Class 3B)
Beam dimensions(See note1.)		20μm × 300μm (200μm*) TYP.(distance to measurement center) *Measurement region.		30μm × 400μm TYP.(distance to measurement center)		60μm × 1000μm TYP.(distance to measurement center)		0.3 mm × 16 (10.3*)mm (at 500 mm) * Measurement region
Linearity		±0.05% F.S.(See note 3.)	±0.05% F.S.(See note 2.)	±0.1% F.S.(See note 4.)				±0.07% F.S.(250 to 750 mm) ±0.1% F.S.(750 to 950 mm) (See note 4.)
Resolution		0.4μm (See notes 5 and 6.)	0.4μm (See notes 5 and 6.)	0.4μm (See notes 7 and 9.)		1μm (See notes 7 and 8.)		8μm (at 350 mm) 40μm (at 600mm) (See notes 7 and 8.)
Sampling period (See note 10.)		540μs						
LED indicators	NEAR indicator	Lights if the workpiece is close to the measurement center or is on the near side of the measurement center and inside the measurement region. Flashes if the workpiece is outside the measurement region or if the density is excessive or insufficient.						
	FAR indicator	Lights if the workpiece is close to the measurement center or is on the far side of the measurement center and inside the measurement region. Flashes if the workpiece is outside the measurement region or if the density is excessive or insufficient.						
Temperature characteristic (See note 11.)		±0.01%F.S./ °C						
Environment resistance	Degree of protection	IP64		IP67			IP66 (See note12.)	
	Ambient operating illumination	Illumination at light-receiving surface: 3,000l × max., incandescent light						
	Ambient temperature	Operating: 0 to +50°C (with no icing or condensation) Storage: -15 to +60°C (with no icing or condensation)						
	Ambient humidity	Operating and storage: 35% to 85% (with no condensation)						
	Vibration resistance	10 to 150Hz (double amplitude: 0.35 mm) for 8min each in X, Y, and Z directions						
Materials		Controller: Die-cast aluminum/Cable sheathing: Heat-resistant chlorinated vinyl Connector: zinc alloy and brass						
Cable length		2m						50cm
Minimum bending radius		68mm						
Weight		Approx. 350g		Approx. 600g			Approx. 550g	

- Note 1:** Defined at $1/e^2$ (13.5%) of the density at the light center. Light may, however, be present outside this range and if the reflection factor of the light around the workpiece is high compared to the workpiece, measurement may be affected.
- Note 2:** Error with respect to the theoretical line representing the displacement output for measurement of OMRON standard SUS blocks. The linearity varies with the type of workpiece.
- Note 3:** Error with respect to the theoretical line representing the displacement output for measurement of OMRON standard quartz glass. The linearity varies with the type of workpiece.
- Note 4:** Error with respect to the theoretical line representing the displacement output for measurement of OMRON standard white alumina ceramics. The linearity varies with the type of workpiece.

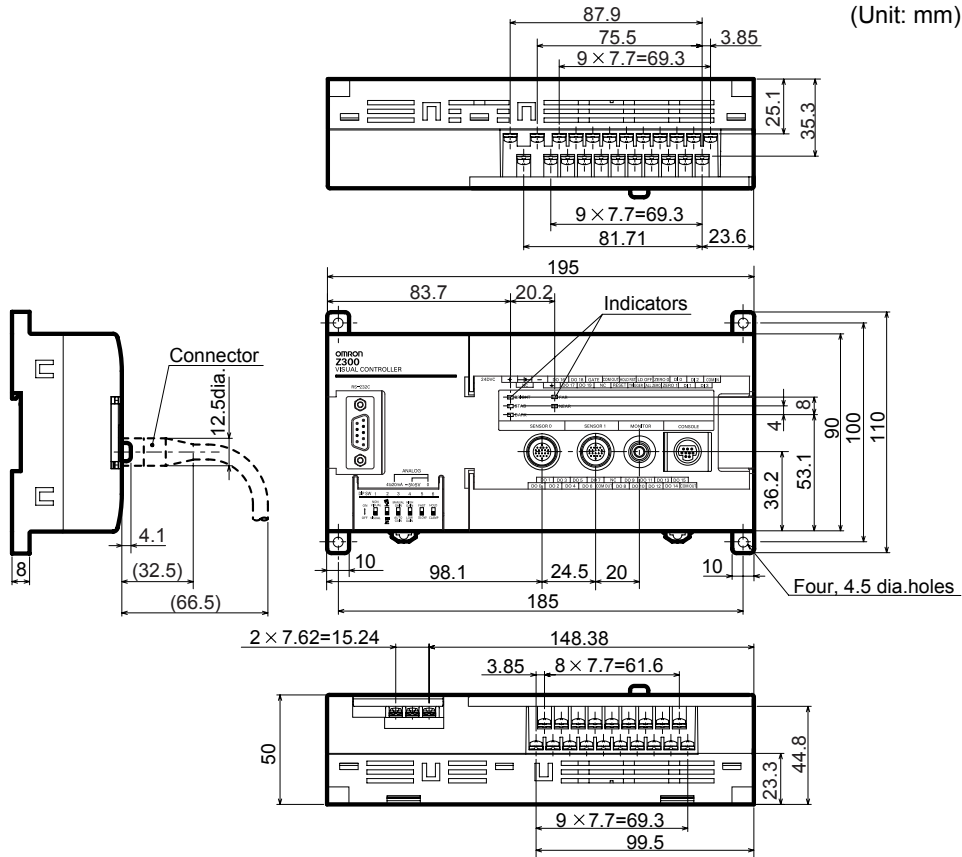
Z300-S10



- Note 5:** Displacement conversion value for peak-to-peak of displacement output. These figures are for measurement of OMRON standard quartz glass (mirror reflection) or OMRON standard SUS blocks (diffuse reflection) at the measurement center. In magnetic fields, it may not be possible to maintain resolution performance characteristics.
- Note 6:** These figures are for when the Sensor is connected to the Z300-VC10EV3, the average number of measurements is 256, and M command RS-232C output is used.
- Note 7:** Displacement conversion value for peak-to-peak of displacement output (for measurement of OMRON standard white alumina ceramic at the measurement center). In strong magnetic fields, it may not be possible to maintain resolution performance characteristics.
- Note 8:** With the Z300-VC10EV3, at an average number of measurements of 64, and M command RS-232C output is used.
- Note 9:** With the Z300-VC10EV3, at an average number of measurements of 512, and M command RS-232C output is used.
- Note 10:** Value for measurement with 1 line (high speed) set in CCD Mode.
- Note 11:** Value for measurement with the space between the Sensor and the workpiece (Z300-S5/S10/S60: white alumina ceramic; Z300-S2: quartz glass) secured with an aluminum jig.
- Note 12:** Enquire separately about products conforming to IP67.

7-1-2 Controller



Z300-VC10EV3/Z300-VC15EV3



General Specifications

Model	Z300-VC10EV3	Z300-VC15EV3
Input/output type	NPN	PNP
Supply voltage	21.6 to 26.4 VDC (including ripple)	
Current consumption	1A max. (with 2 Sensors connected) (See note 1.)	
Insulation resistance	20 MΩ min. between all DC external terminals and GR terminal (100 VDC Megger, with internal surge absorber removed)	
Dielectric strength	1,000 VAC, 50/60 Hz between all DC external terminals and GR terminal (with internal surge absorber removed)	
Leakage current	10mA max.	
Noise resistance	1,500 Vp-p; Pulse width: 0.1μs/1μs;Rising edge: 1-ns pulse	
Vibration resistance	10 to 150 Hz (double amplitude: 0.1 mm) for 8 min each in X, Y, and Z directions	
Shock resistance	200m/s ² , 3 times each in 6 directions	
Ambient temperature	Operating: 0 to +50°C(with no icing or condensation) Storage: -15 to +60°C (with no icing or condensation)	
Ambient humidity	Operating and storage: 35% to 85% (with no condensation)	
Ambient environment	No corrosive gases	
Ground	Ground the Z300's ground terminal to less than 100Ω	
Degree of protection	IEC60529 IP20 (in-panel)	
Case material	Controller: ABS	

Performance specifications

Item	Visual Mode	Non-visual Mode
Number of Sensors that can be mounted	2	1
Number of scenes	16	1
Image memory function	NG images: 20 scenes max.; Surrounding images: 4 scenes max.; Workpiece display images: 4 scenes max.	—
Processing method	Gray center of gravity, edge centering	Edge centering
Pre-image processing	Noise removal, smoothing	None
Averaging/filtering	Average number of times (12 stages, 1 to 4,096 times), HPF (high pass filter), Median	Average number of times (SLOW: 64 times; FAST: 1 time)
Light intensity tracking function	Automatic (The light intensity tracking range can be specified.) Fixed (Select from 32 stages.)	Automatic (The light intensity tracking range can not be specified.) Fixed (Select either HIGH or LOW.)
Applications	Select from the following 8 types: Surface displacement, spot displacement, maximum height, groove/indentation, level difference, transparent workpiece thickness, level difference (2 Sensors), or thickness (2 Sensors).	—
Region specification	Region specification of line beam and displacement direction is possible.	—
Two region measurement modes	Absolute coordinate mode and relative coordinate mode	—
Hold functions	Sampling, peak, bottom, peak-to-peak, average, and length	—
Two Sensor measurement modes	Simultaneous measurement and alternate measurement	—
Measurement data	4 outputs per scene	1 output
Equations	The following operations are possible for outputs 0 to 3: K+A, K-A, K+(A+B), K+(A-B), and K-(A+B) A and B: Specified measurement points K: Freed constant	—
Results output	Judgement output (HIGH, PASS, LOW, ERROR)  Measurement value output (measurement value) 	Analog output
Terminal block	11 input points: $\overline{\text{TRIGGER}}$, $\overline{\text{HOLD-RESET}}$, $\overline{\text{LD-OFF}}$, $\overline{\text{ALL-ZERO}}$, $\overline{\text{ZERO0}}$, $\overline{\text{ZERO1}}$, $\overline{\text{RESET}}$, and DI 0 to DI 3 21 output points: $\overline{\text{DO0}}$ to $\overline{\text{DO20}}$	$\overline{\text{LD-OFF}}$
Monitor interface	1 channel (for pin jack or overscan monitor)	—
Analog output resolution	The full scale for output can be divided into a maximum of 40,000 gradations. Resolution (See note 2.) *0.25 mV ($\pm 5\text{V}$) 0.4 μA (4 to 20 μA)	
Weight	Approx. 700 g (Controller only)	

Note 1:

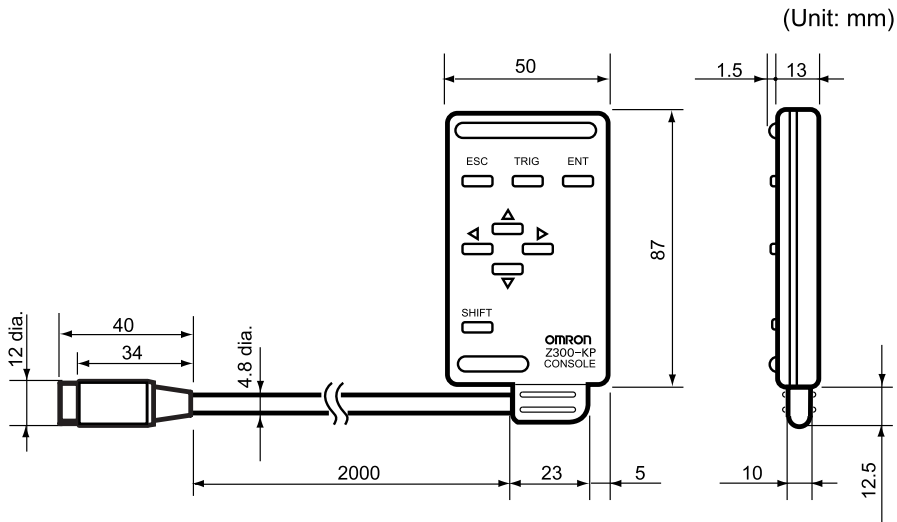
Average current at normal operation after power is turned ON.

Note 2:

For measurement at an average number of times of 64 with an OMRON K3AS Linear Sensor Controller connected.

7-1-3 Console

Z300-KP



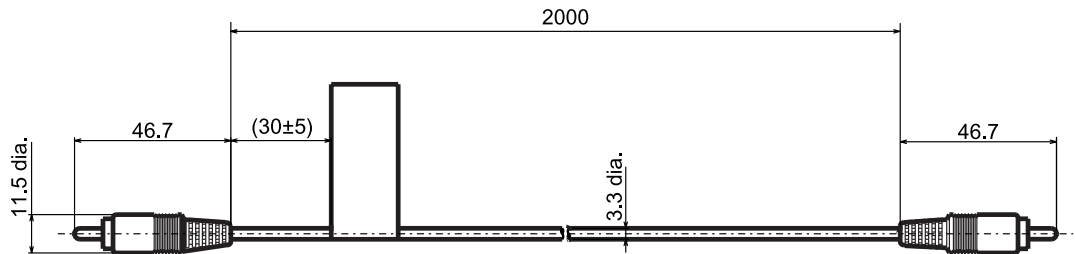
General Specifications

Vibration resistance	10 to 150 Hz; single-amplitude: 0.15 mm, 4 times for 8 minutes each in 3 directions
Shock resistance	196m/s ² ; 3 times each in 6 directions
Ambient temperature	Operating: 0 to 50°C (with no icing or condensation) Storage: -25 to 65°C (with no icing or condensation)
Ambient humidity	Operating and storage: 35% to 85% (with no condensation)
Ambient environment	No corrosive gases
Degree of protection	IEC60529 IP20 (in-panel)
Minimum bending radius	75mm
Materials	Console: ABS Cable sheathing: Heat-resistant chlorinated vinyl Connector: PC and PBT
Weight	Approx.135g

7-1-4 Cable

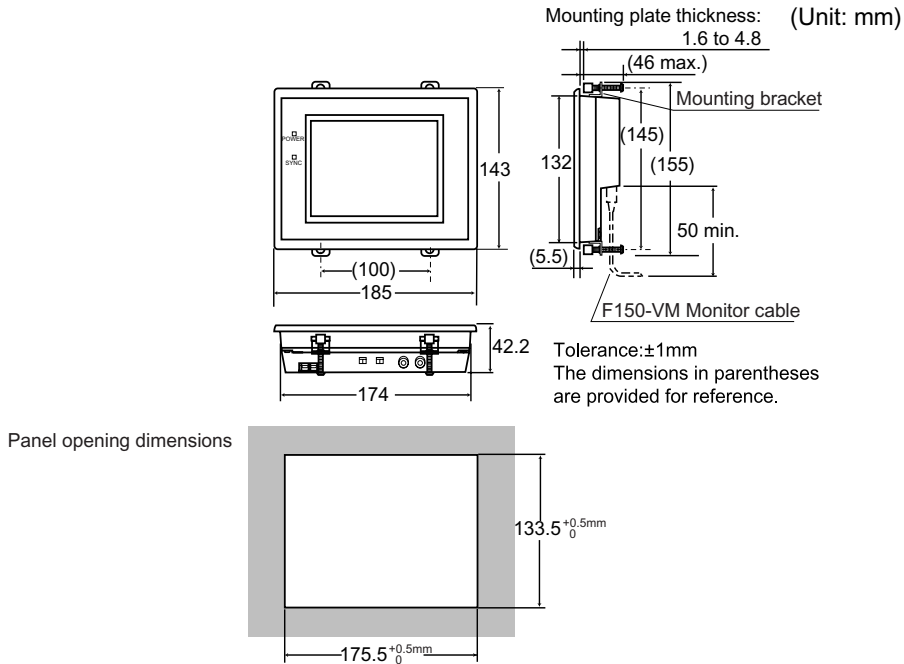
F150-VM

(Unit: mm)

**General Specifications**

Vibration resistance	10 to 150 Hz; single-amplitude: 0.15 mm, 4 times for 8 minutes each in 3 directions
Shock resistance	196m/s ² ; 3 times each in 6 directions
Ambient temperature	Operating: 0 to 50°C (with no icing or condensation) Storage: -25 to 65°C (with no icing or condensation)
Ambient humidity	Operating and storage: 35% to 85% (with no condensation)
Ambient environment	No corrosive gases
Materials	Cable sheathing: Super heat-resistant chlorinated vinyl Connector: PVC
Minimum bending radius	50 mm

7-1-5 Color Liquid Crystal Monitor

F150-M05L**General Specifications**

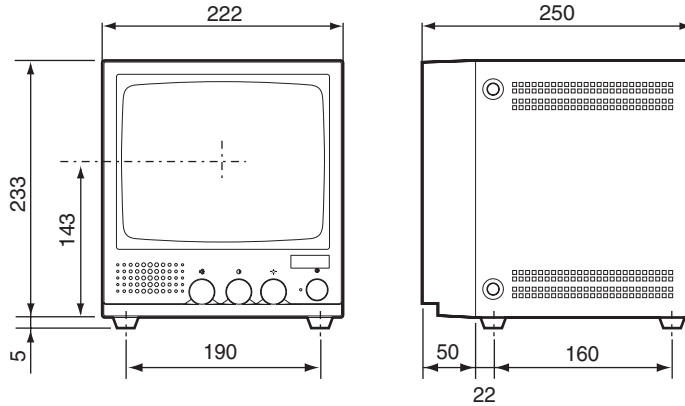
Supply voltage	20.4 to 26.4 VDC (including ripple)
Current consumption	700 mA max.
Vibration resistance	10 to 150 Hz; single-amplitude: 0.1 mm; maximum acceleration: 15 m/s ² , 10 times for 8 minutes each in 3 directions
Shock resistance	150 m/s ² , 3 times each in 6 directions
Ambient temperature	Operating: 0 to 50°C (with no icing or condensation) Storage: -25 to 65°C (with no icing or condensation)
Ambient humidity	Operating and storage: 35% to 85% (with no condensation)
Ambient environment	No corrosive gases
Materials	Case: ABS/PC Display surface: PMMA (Acrylic)
Weight	Approx. 1 kg

Performance specifications

Panel size	5.5 inches (111.36 × 83.52 mm (H × V))
Panel type	TFT color liquid crystal
Resolution	320 × 240 dots
Image pitch	0.348 × 0.348 mm (H × V)
Contrast	85:1 (typical)
Viewable angle	25° up/down and 50° left/right (with a contrast ratio > 10)
Luminance	250cd/m ² (typical)
Backlight	Cold cathode fluorescent light
Response speed	60 ms max.
Input signal	NTSC composite video (1.0 V/75 Ω termination)
Weight	Approx. 610 g

7-1-6 Video Monitor (Monochrome)

Recommended model: OMRON F150-M09 B/W Video Monitor
(Unit: mm)



General Specifications

Power supply voltage	85 to 264 V AC, 50/60 Hz
Power consumption	20 W max.
Vibration resistance	5 to 100 Hz in 3 directions, 10 minutes x 6 for each sweep At a double-amplitude of 0.16 mm or an acceleration of 7.35 m/s ² (whichever is smaller)
Ambient temperature	-10 to +50°C at operation, -20 to +65°C at storage (no freezing and condensation)
Ambient humidity	Operating and storage: 10 % to 90 % (no condensation)
Ambient environment	No corrosive gases
Materials	Front: ABS plastic Metal part: SECC (galvanized steel sheet)
Weight	Approx. 4.5 kg

Performance specifications

CRT size	9 inches (164 (H) x 123 (V) mm)
CRT type	CRT monochrome (medium persistence)
Resolution	800 TV lines min. (at center)
System	Number of scanning lines: 600 Horizontal frequency: 15.75 kHz Field frequency: 60 Hz
I/O impedance	75 Ω, high impedance (selectable)
I/O level and polarity	Composite image signal: 1 V (peak to peak) Image: 0.7 V (peak to peak), positive Synchronization: 0.3 V (peak to peak), negative
Input signal	NTSC composite video (1.0 V/75 Ω termination)

7-2 Laser Product Classifications

EN/JIS

Class	Description
Class 1	Safe inherently by engineering design.
Class 2	Low power in the visible spectrum (wavelength: 400 to 710 nm); eye protection normally afforded by aversion responses.
Class 3A	Direct intrabeam viewing with optical aids may be hazardous. Power of less than 5 mW max. for visible spectrum. Less than five times the output of the Class 1 for wavelengths other than the visible spectrum.
Class 3B	Direct intrabeam viewing may be hazardous. It is not hazardous to view the pulse laser radiation that does not focus due to scattered reflection and the power that allows safe viewing under certain conditions is less than 0.5 W.
Class 4	High power; diffused reflection may be hazardous and may lead to skin hazards or fire.

FDA/ANSI

Class	FDA definition	ANSI description
Class I/1	Limits applicable to devices that have emissions in the ultraviolet, visible, and infrared spectra, and limits below which biological hazards have not been established.	A Class 1 laser is considered to be incapable of producing damaging radiation levels during operation and maintenance and is, therefore, exempt from any control measures or other forms of surveillance.
Class IIa/2a	Limits applicable to products whose visible emission does not exceed Class I limits for emission durations of 1,000 seconds or less and are not intended for viewing.	Class 2 lasers are divided into two subclasses, 2 and 2a. A Class 2 laser emits in the visible portion of the spectrum (0.4 to 0.7 μm) and eye protection is normally afforded by the aversion response including the blink reflex.
Class II/2	Limits applicable to products that have emissions in the visible spectrum (400 to 710 nm) for emission durations in excess of 0.25 second, providing that emissions for other durations and/or wavelengths do not exceed the Class I limits. Class II products are considered hazardous for direct long-term ocular exposure.	
Class IIIa/3a	Limits to products that have emissions in the visible spectrum and that have beams where the total collectable radiant power does not exceed 5 milliwatts.	Class 3 lasers are divided into two subclasses, 3a and 3b. A Class 3 laser may be hazardous under direct and specular reflection viewing conditions, but the diffuse reflection is usually not a hazard.
Class IIIb/3b	Limits applicable to devices that emit in the ultraviolet, visible, and infrared spectra. Class IIIb products include laser systems ranging from 5 to 500 milliwatts in the visible spectrum. Class IIIb emission levels are ocular hazards for direct exposure throughout the range of the Class, and skin hazards at the higher levels of the Class.	
Class IV/4	Exceeding the limits of Class IIIb and are a hazard for scattered reflection as well as for direct exposure.	A Class 4 laser is a hazard to the eye or skin from the direct beam and sometimes from a diffuse reflection and also can be fire hazard. Class 4 lasers may also produce laser-generated air contaminants and hazardous plasma radiation.

Requirements from Regulations and Standards

Manufacturer's Requirements

EN60825 (IEC60825) "Radiation Safety of Laser Products, Equipment Classification, Requirements and User's Guide"

Requirements; Sub-clause	Classification				
	Class 1	Class 2	Class 3A	Class 3B	Class 4
Description of hazard class	Safe inherently by engineering design	Low power; eye protection normally afforded by aversion responses	Same as Class 2. Direct intra-beam viewing with optical aids may be hazardous	Direct intra-beam viewing may be hazardous	High power; diffused reflection may be hazardous
Protective housing	Required for each laser product; limits access necessary for performance of functions of the products				
Safety interlock in protective housing	Designed to prevent removal of the panel until accessible emission values are below the AEL for the class assigned				
Remote control	Not required			Permits easy addition of external interlock in laser installation	
Key control	Not required			Laser inoperative when key is removed	
Emission warning device	Not required			Give audible or visible warning when laser is switched on or if capacitor bank of pulsed laser is being charged	
Attenuator	Not required			Give means beside ON/OFF switch to temporarily block beam	
Location controls	Not required		Controls located so adjustment does not require exposure to AEL above class 1 or 2		
Viewing optics	Emission from all viewing systems must be below Class 1 AEL's as applicable				
Scanning	Scan failure shall not cause product to exceed its classification				
Class label	Required wording	Warning and explanatory labels and specified wording (Refer to page 12)			
Aperture label	Not required			Specified wording required	
Service entry label	Required as appropriate to the class of accessible radiation				
Override interlock label	Required under certain conditions as appropriate to the class of laser used				
User information	Operation manuals must contain instructions for safe use				
Purchasing and service information	Promotion brochures must reproduce classification labels; service manuals must contain safety information				
Medical products	Special calibration instructions required			Special calibration instructions, means for measurement and target-indicator required	
Fibre optic	Cable service connections require tool to disconnect if disconnection breaks protective housing and permits access above Class 1				

With respect to the requirements of remote interlock connector, key control, emission warning and attenuator, Class 3B laser products not exceeding five times the AEL of Class 2 in the wavelength range of 400 to 700 nm are to be treated as Class 3A laser products.

Note: This table is intended to provide a convenient summary of requirements. See text of standard for complete requirements.

JIS C6802 "Radiation Safety Standards for Laser Products"

Requirements; Sub-clause	Classification				
	Class 1	Class 2	Class 3A	Class 3B	Class 4
Description of hazard class	Safe inherently by engineering design	Low power; eye protection normally afforded by aversion responses	Same as Class 2. Direct intra-beam viewing with optical aids may be hazardous	Direct intra-beam viewing may be hazardous	High power; diffused reflection may be hazardous
Protective housing	Required for each laser product; limits access necessary for performance of functions of the products				
Safety interlock in protective housing	Designed to prevent removal of the panel until accessible emission values are below the AEL for the class assigned				
Remote control	Not required			Permits easy addition of external interlock in laser installation	
Key control	Not required			Laser inoperative when key is removed	
Emission warning device	Not required			Give audible or visible warning when laser is switched on or if capacitor bank of pulsed laser is being charged	
Attenuator	Not required			Give means beside On/Off switch to temporarily block beam	
Location controls	Not required		Controls located so adjustment does not require exposure to AEL above class 1 or 2		
Viewing optics	Emission from all viewing systems must be below Class 1 AEL's as applicable				
Scanning	Scan failure shall not cause product to exceed its classification				
Class label	Required wording	Warning and explanatory labels and specified wording (Refer to page 12)			
Aperture label	Not required			Specified wording required	
Service entry label	Required as appropriate to the class of accessible radiation				
Override interlock label	Required under certain conditions as appropriate to the class of laser used				
User information	Operation manuals must contain instructions for safe use				
Purchasing and service information	Promotion brochures must reproduce classification labels; service manuals must contain safety information				
Additional requirements for laser optical fibre transmission system	Cable service connections require tool to disconnect if disconnection breaks protective housing and permits access above Class 1				

With respect to the requirements of remote interlock connector, key control, emission warning and attenuator, Class 3B laser products not exceeding five times the AEL of Class 2 in the wavelength range of 400 to 700 nm are to be treated as Class 3A laser products.

Note: This table is intended to provide a convenient summary of requirements. See text of standard for complete requirements.

FDA (21 CFR1040.10 "Laser Products")

Requirements	Class (see note 1)					
	I	IIa	II	IIIa	IIIb	IV
Performance (all laser products)						
Protective housing	R (see note 2)	R (see note 2)	R (see note 2)	R (see note 2)	R (see note 2)	R (see note 2)
Safety interlock	R (see notes 3,4)	R (see notes 3,4)	R (see notes 3,4)	R (see notes 3,4)	R (see notes 3,4)	R (see notes 3,4)
Location of controls	N/A	R	R		R	R
Viewing optics	R	R	R	R	R	R
Scanning safeguard	R	R	R	R	R	R
Performance (laser systems)						
Remote control connector	N/A	N/A	N/A	N/A	R	R
Key control	N/A	N/A	N/A	N/A	R	R
Emission indicator	N/A	N/A	R	R	R (see note 10)	R (see note 10)
Beam attenuator	N/A	N/A	R	R	R	R
Reset	N/A	N/A	N/A	N/A	N/A	R (see note 13)
Performance (specific purpose products)						
Medical	S	S	S	S (see note 8)	S (see note 8)	S (see note 8)
Surveying, leveling, alignment	S	S	S	S	NP	NP
Demonstration	S	S	S	S	S (see note 11)	(see note 11)
Labeling (all laser products)						
Certification & identification	R	R	R	R	R	R
Protective housing	D (see note 5)	D (see note 5)	D (see note 5)	D (see note 5)	D (see note 5)	D (see note 5)
Aperture	N/A	N/A	R	R	R	R
Class warning	N/A	R (see note 6)	R (see note 7)	R (see note 9)	R (see note 12)	R (see note 12)
Information (all laser products)						
User information	R	R	R	R	R	R
Product literature	N/A	R	R	R	R	R
Service information	R	R	R	R	R	R

Abbreviations:

R: Required.

N/A: Not applicable.

S: Requirements: Same as for other products of that Class. Also see footnotes.

NP: Not permitted.

D: Depends on level of interior radiation.

Footnotes:

- Note 1:** Based on highest level accessible during operation.
- Note 2:** Required wherever & whenever human access to laser radiation above Class I limits is not needed for product to perform its function.
- Note 3:** Required for protective housings opened during operation or maintenance, if human access thus gained is not always necessary when housing is open.
- Note 4:** Interlock requirements vary according to Class of internal radiation.
- Note 5:** Wording depends on level & wavelength of laser radiation within protective housing.
- Note 6:** Warning statement label.
- Note 7:** CAUTION logotype.
- Note 8:** Requires means to measure level of laser radiation intended to irradiate the body.
- Note 9:** CAUTION if 2.5 mW cm^2 or less, DANGER if greater than 2.5 mW cm^2 .
- Note 10:** Delay required between indication & emission.
- Note 11:** Variance required for Class IIb or IV demonstration laser products and light shows.
- Note 12:** DANGER logotype.
- Note 13:** Required after August 20, 1986.

User's Requirements

EN60825 (IEC60825)

Requirements; Sub-clause	Classification				
	Class 1	Class 2	Class 3A	Class 3B	Class 4
Remote interlock	Not required			Connect to room or door circuits	
Key control	Not required			Remove key when not in use	
Beam attenuator	Not required			When in use prevents inadvertent exposure	
Emission indicator device	Not required			Indicates laser in energized	
Warning signs	Not required			Follow precautions on warning signs	
Beam path	Not required	Terminate beam at end of useful length			
Specular reflection	No requirements			Prevent unintentional reflections	
Eye protection	No requirements		Required if engineering and administrative procedures not practicable and MPE exceeded		
Protective clothing	No requirements			Sometimes required	Specific requirements
Training	No requirements		Required for all operator and maintenance personnel		

With respect to the requirements of remote interlock connector, key control, beam attenuator, and emission indicator, Class 3B laser products not exceeding five times the AEL of Class 2 in the wavelength range of 400 to 700 nm are to be treated as Class 3A laser products.

Note: This table is intended to provide a convenient summary of requirements. See text of standard for complete precautions.

JIS C6802

Item	Class 1	Class 2	Class 3A	Class 3B		Class 4
				3B*	3B	
Remote interlock	Not required			Connect the remote interlock of the laser beam to the emergency main interlock, the interlock of the room, or the interlock of the door.		
Key control	Not required			Do not keep the key in the lock when the laser beam is not used.		
Beam breaker or attenuator	Not required			Used to protect people from accidental radiation by the laser beam.		
Warning sign	Not required			Post a proper warning sign on the door to the room where laser beam equipment is installed.		
Beam path	Not required	The laser beam must be terminated and, as a rule, must be enclosed. If the laser beam is exposed, the vertical height of the beam must not be the same as that of the eyes.				
Mirror reflection	Not required			Appropriate optical elements must be securely attached and you must be able to control the optical elements during laser radiation.		
Eye protection	Not required			Use eye protectors except in special, specified locations.		
Protection clothes	Not required		Wear protection clothes if exposure of the skin to the laser beam may exceed the MPE of the skin.			
Training	Not required		The laser system must be operated by only properly trained people.			

Note: *Class 3B applies to any laser beam with a power of 5 mW maximum in the visible range of the laser beam.

ANSI Z136.1:1993 "American National Standard for the Safety Use of Lasers"

Control measures	Classification					
	1	2a	2	3a	3b	4
Engineering Controls	X	X	X	X	X	X
Protective Housing	X	X	X	X	X	X
Without Protective Housing	LSO shall establish Alternate Controls					
Interlocks on Protective Housing	☆	☆	☆	☆	X	X
Service Access Panel	☆	☆	☆	☆	X	X
Key Control	---	---	---	---	•	X
Viewing Portals	---	---	MPE	MPE	MPE	MPE
Collecting Optics	MPE	MPE	MPE	MPE	MPE	MPE
Totally Open Beam Path	---	---	---	---	X NHZ	X NHZ
Limited Open Beam Path	---	---	---	---	X NHZ	X NHZ
Enclosed Beam Path	None is required if 4.3.1 and 4.3.2 fulfilled					
Remote Interlock Connector	---	---	---	---	•	X
Beam Stop or Attenuator	---	---	---	---	•	X
Activation Warning Systems	---	---	---	---	•	X
Emission Delay	---	---	---	---	---	X
Indoor Laser Controlled Area	---	---	---	---	X NHZ	X NHZ
Class 3b Laser Controlled Area	---	---	---	---	X	---
Class 4 Laser Controlled Area	---	---	---	---	---	X
Laser Outdoor Controls	---	---	---	---	X NHZ	X NHZ
Laser in Navigable Airspace	---	---	---	•	•	•
Temporary Laser Controlled Area	☆ MPE	☆ MPE	☆ MPE	☆ MPE	---	---
Remote Firing & Monitoring	---	---	---	---	---	•
Labels	X	X	X	X	X	X
Area Posting	---	---	---	•	X NHZ	X NHZ

Note: LEGEND

X: Shall

• : Should

---: No requirement

☆ : Shall if enclosed Class 3b or Class 4

MPE: Shall if MPE is exceeded

NHZ: Nominal Hazard Zone analysis required

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Revision History

A manual revision code appears as a suffix to the catalog number on the front cover of the manual.

Cat. No. Z161-E1-03



Revision code

The following table outlines the changes made to the manual during each revision. Page numbers refer to the previous version.

Revision code	Date	Revised content
01	October 2001	Original production
01A	April 2002	Some terms were changed.
02	March 2003	Information on safety precautions are added. Other minor changes have been made.
03	May 2004	Page 5: Catalog numbers abbreviated. Page 82: Reference to note 1 added. Page 83: Reference to note changed and note 1 added. Page 87: Page replaced

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