

# **F3S-A Series Safety Light Curtain**

# **Instruction Manual**

**OMRON**

## Introduction

Thank you for purchasing the F3S-A Series Safety Light Curtain (hereafter referred to as the F3S-A). The F3S-A was developed using advanced technologies and long-standing experience, and this manual describes the procedure that will ensure its proper use. Always heed the following points when using the F3S-A:

- Make sure that personnel operating the F3S-A are knowledgeable about the machine on which it is installed.
- Read this manual completely and be sure you understand the information provided before attempting to operate the F3S-A.
- Keep the manual in a safe, convenient location and refer to it as necessary.

### Regulations and Standards

1. The F3S-A has not received the type approval provided by Article 44-2 of the Industrial Safety and Health Law of Japan.  
Therefore it cannot be used in Japan as a safety device for the pressing or shearing machine provided by Article 42 of that law.
  2. (1) The F3S-A is electro-sensitive protective equipment (ESPE) in accordance with European Union (EU) Machinery Directive Annex IV, B. Safety Components, Item 1.  
(2) The F3S-A complies with the foreign regulations and standards below.
    - (1) EU regulations
      - Machinery Directive: No. 98/37/EC
      - EMC Directive: No. 89/336/EEC
    - (2) EN standards (European standards)
      - EN61496-1 (TYPE 4 ESPE), IEC61496-2 (TYPE 4 AOPD)  
**Note** EC Type-Examination is based on IEC61496-2 because EN61496-2 has not been published as of May 1999.
    - (3) International standards
      - IEC61496-1 (TYPE 4 ESPE), IEC61496-2 (TYPE 4 AOPD)
  - (3) The F3S-A received approvals as shown below from the EU accredited body TÜV Rheinland Product Safety GmbH.
    - Certificate of a Notified Body for EC Type-Examination provided by Machinery Directive (Type 4 ESPE)
    - Certificate of a Competent Body provided by EMC Directive
    - TÜV Rheinland Type Approval  
TYPE 4 ESPE (EN61496-1)  
TYPE 4 AOPD (IEC61496-2)  
Applications: EN954-1 Category B, 1, 2, 3, 4
  - (4) The F3S-A received approvals as shown below from the third-party testing laboratory UL.
    - UL Listed
    - UL Listed to Canadian safety standards

Both for	TYPE 4 ESPE (IEC61496-1)
	TYPE 4 AOPD (IEC61496-2)

**Note** IEC61496-1 and -2 are applied standards to UL instead of draft UL subject 491 and draft UL subject 2496.  
UL IEC-based standards are expected to be published as UL61496-1 and -2 soon.

    - Programmable system certificate (UL1998, IEC61496-1)
3. The following standards are referenced when designing the F3S-A. To comply with these standards, be sure to design and use in accordance with all regulations and standards related to them.  
Contact an expert agency such as TÜV and UL if any of the above points are unclear.

- EN415-4, prEN691, EN692, prEN693
- OSHA 29 CFR 1910. 212
- OSHA 29 CFR 1910. 217
- ANSI B11.1 to B11.19
- ANSI/RIA 15.06

### Precautions in Using the Product



The F3S-A conforms to the EU Machinery Directive and EMC Directive. However, no test has been performed to confirm whether the F3S-A conforms to other directives, rules, and standards that are required for other applications. When using the F3S-A under the following applications, be sure to refer to relevant regulations and standards and perform tests on the system incorporating the F3S-A according to the requirements specified in these regulations and standards in order to confirm compliance. If there are any questions about the relevant regulations and standards, contact TÜV Rheinland Product Safety GmbH in Germany or any other institute concerned.

- (1) When using the F3S-A under conditions or environments not described in this manual.
- (2) When using the F3S-A on machines or systems applied in life-threatening situations (nuclear power control, railroads, aircraft, automobiles, combustion facilities, medical systems, aerospace development, or large amusement machines).

### Precautions on Safety

#### ● Conventions for Safe Use

The following conventions are used for precautionary items in this manual in order to ensure safe and proper use of the F3S-A. Items listed here are critical for safety and must be heeded at all times.

 <b>WARNING</b>	Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.
	Indicates prohibited actions.

**⚠ WARNING**

Do not use the F3S-A on machines that cannot be stopped by electrical control in an emergency. For instance, the F3S-A **may not** be used on machines using full-revolution clutches.

When using the F3S-A on PSDI (Presence Sensing Device Initiation) mode, the appropriate control circuit shall be installed between the F3S-A and the machinery.

For further information on PSDI, please refer to OSHA 1910.217, IEC61496-1, and other relevant standards and regulations.

Always maintain a safety distance between the F3S-A and dangerous machine parts (see 3-1 *Installation Conditions*). Serious injury may result if the machine does not stop before someone reaches a dangerous part.

Install the F3S-A so that some part of the operator's body remains in the detection zone at all times when operating in dangerous machine parts (see 3-1 *Installation Conditions*).

Install protective structures around the machine so that you must pass through the detection zone to reach dangerous machine parts (see 3-1 *Installation Conditions*).

Do not install the F3S-A in a location affected by wall reflections (see 3-1 *Installation Conditions*).

Failure to do so may cause detection to fail and result in serious injury.

When installing multiple F3S-A sets, connect the sets or install some barriers to prevent mutual interference (see 3-2 *Configuration*).

Always use a correct combination of emitters and receivers (see 3-2 *Configuration*).

Failure to do so may create undetectable zones.

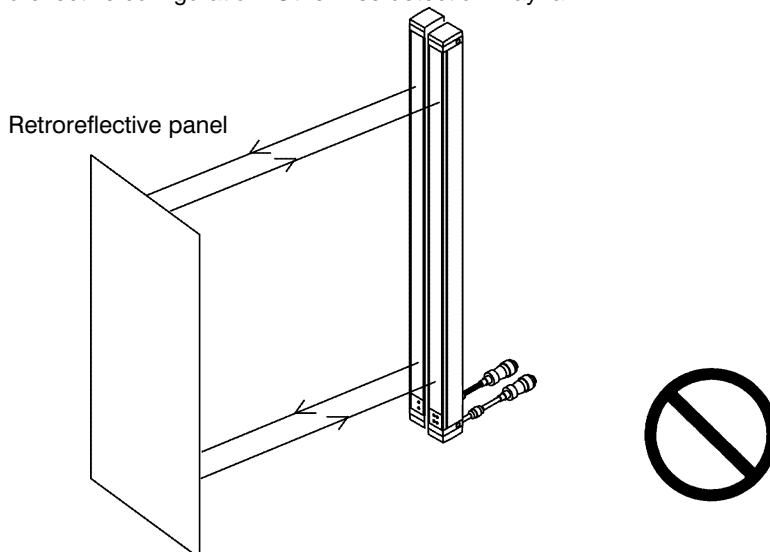
Be sure to wire correctly. Parallel connection or mixed connection may cause detection to fail or cause mutual interference (see 3-5 *Wiring*).

Do not short the output lines to the +24V line. Doing so will cause the output to be always ON, creating a dangerous situation.

Be sure to use both output lines when constructing the safety system. The safety system constructed using only one line may result in serious injury under a faulty condition of the output circuit.

Connect a load between the output and 0V line. If a load is mistakenly connected between the output and +24V line, the operating mode will switch to the mode in which output is turned ON when light is interrupted (see 3-5 *Wiring*), creating a dangerous situation.

Do not use the F3S-A in a retroreflective configuration. Otherwise detection may fail.



**Notes**

For your safety, always heed the following:

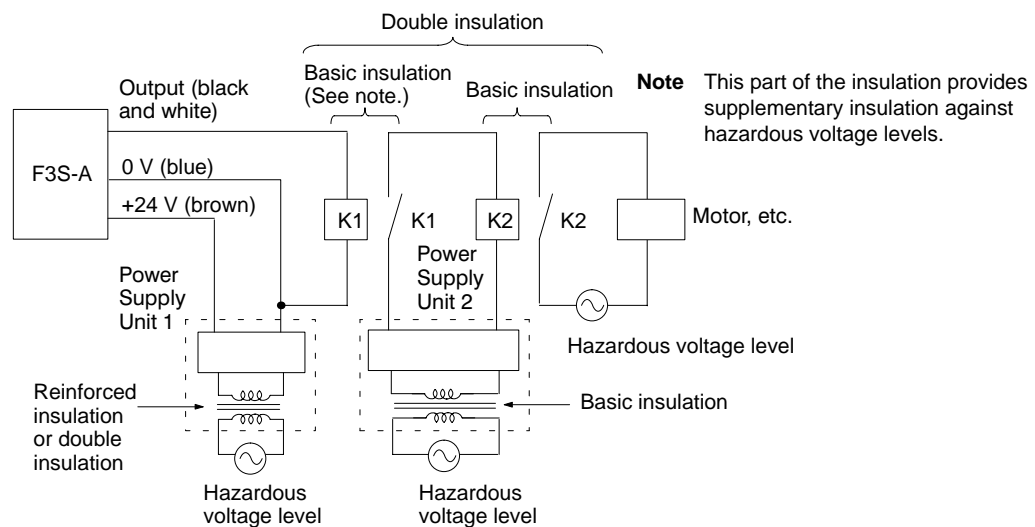
(1) DC power supply units must satisfy all the conditions below.

- The power supply is connected to the F3S-A only and not to other devices or machines.
- The power supply voltage is within the rating (24 VDC  $\pm$ 10%).

- The power supply conforms to EMC Directive (industrial environment).
- The power supply conforms to Low-voltage Directive.
- The power supply conforms to UL508 (output current is less than 8A) or UL1310.
- The power supply uses double or reinforced insulation between the primary and secondary circuits.
- The power supply automatically resets overcurrent protection characteristics (voltage drop).
- The power supply maintains an output holding time of at least 20 ms.
- When using a commercially available switching regulator, make sure FG (frame ground terminal) is connected to PE (protective earth). Faulty operation caused by switching noise may result if the terminal is not connected.
- Use one of the following wiring configurations to reduce noise terminal voltage to the primary side of the power supply.
  - Connect the 0V line to PE (protective earth).
  - Mount a capacitor with a minimum 47-nF capacity and minimum 630 V voltage rating between the 0V line and PE.
- Recommended power supplies: S82K, S82J, S82F or S82F-P made by OMRON.

(2) Loads must satisfy all the conditions below.

- Is not shorted
- Does not use current higher than the rating.
- Is double insulated as shown in the figure below to protect the load from hazardous voltage levels when the load is a relay. The basic insulation shown in the following illustration should insulate against hazardous voltage levels (230 VAC, etc.), not simply against 24 VDC.



(3) Be sure to conduct inspections regularly (see *Section 6 Maintenance*).

(4) Do not use the F3S-A in environments exposed to flammable or explosive gases.

(5) Do not disassemble, repair or modify the F3S-A.

(6) Make sure the F3S-A, cap screws and cord connectors are mounted securely.

(7) Do not connect the F3S-A to an AC power supply.

(8) Be sure to dispose of the F3S-A as industrial waste.

## Notice

Failure to observe the following items may result in F3S-A damage, deterioration or improper operation.

### ■ Installation Environment

- Do not install the F3S-A in the following environments:
  - Areas exposed to intense interference light such as direct sunlight.
  - Areas with high-humidity where condensation is likely to occur.
  - Areas exposed to corrosive gases.
  - Areas exposed to vibration or shock levels higher than specification provisions.
  - Areas exposed to contact with water.
- Do not use cellular phones or transceivers near the F3S-A.

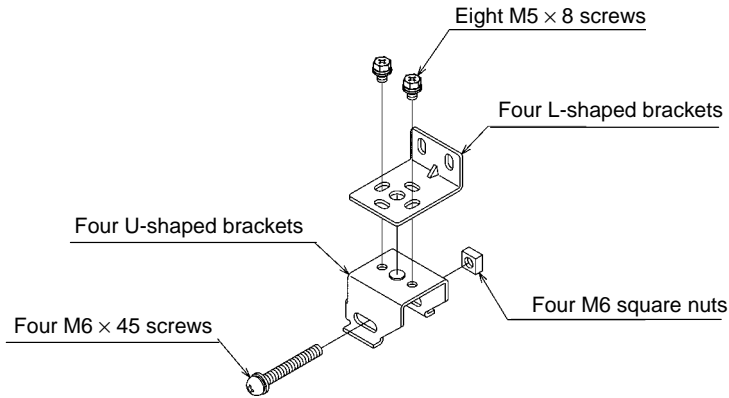
### ■ Wiring and Mounting

- Be sure to turn OFF the power prior to wiring. Otherwise the diagnostic function may prevent the sensor from operating.
  - Be sure to use shielded twisted-pair cables (cross-section at least 0.2 mm<sup>2</sup> in diameter) when extending the sync line without using an F39-JA□A extension cord.
  - When using resin or other connectors in place of the unit's metal connector, make sure the conductor path in the connector is rated IP54 or higher.
  - Check signal names for all terminals and wire terminals correctly.
  - When using two or more F3S-A sets, be sure to connect a sync line and the same power supply unit to all F3S-As. (Turn ON all power supplies at the same time (within 0.5 s) if separate power supply units are used for each F3S-A.) Never exceed specifications for the total number of sets and total number of optical axes.
  - The F3S-A will start operating in five seconds after the power is turned ON. Make sure that no faulty operation will occur in the control system.
  - Once power is turned ON, do not turn it OFF again before the F3S-A becomes operational (LED indicator lights).
  - Be sure to route F3S-A wires separated from high-potential power lines or through an exclusive conduit.
  - Make sure the emitter and receiver are facing the proper direction.
  - Use the interference light search function for no longer than 8 hours from startup, otherwise the F3S-A will switch to OFF-hold condition (stop due to temporary sensor failure).
- Do not use thinners, benzene or acetone to clean the F3S-A because they will dissolve resin and paint.
- Do not use screw locking adhesives (screw lock) to secure the cap unit or cord cap screws because the adhesive may cause the resin to deteriorate and crack.
- The detector unit cannot detect transparent or semi-transparent materials.
- After unpacking the emitter and receiver that are packed together, install them opposite each other.

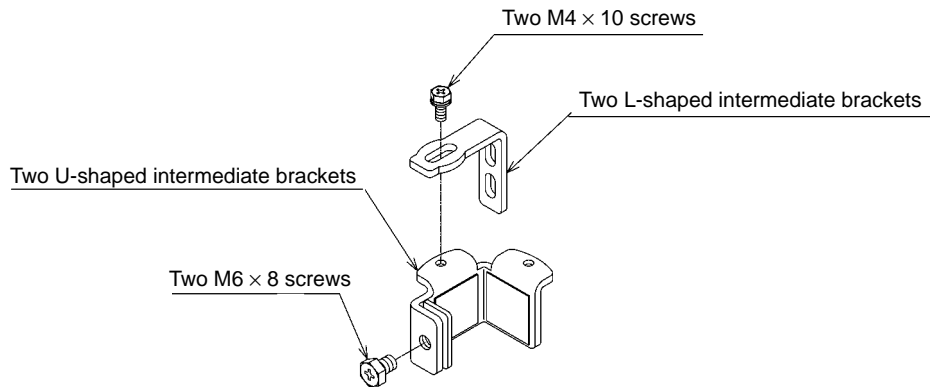
## Prior to Use

Make sure the following items were delivered, and contact your nearest OMRON representative or dealer if any item is missing.

- F3S-A Unit x 1 (emitter x 1, receiver x 1)
- Mounting brackets (top and bottom) x 4

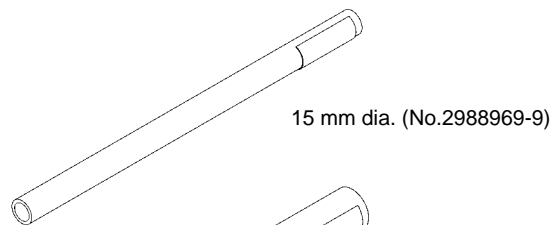


- Mounting brackets (intermediate) x 2 (only with the F3S-A322 and F3S-A482)

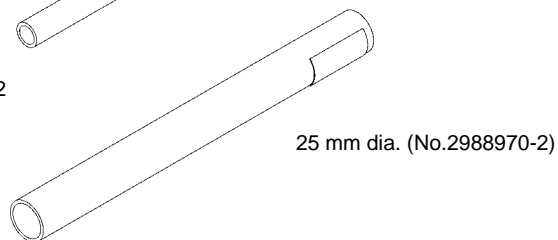


- Test rod x 1

For the F3S-A□□1



For the F3S-A□□2



- Instruction Manual (this manual) x 1

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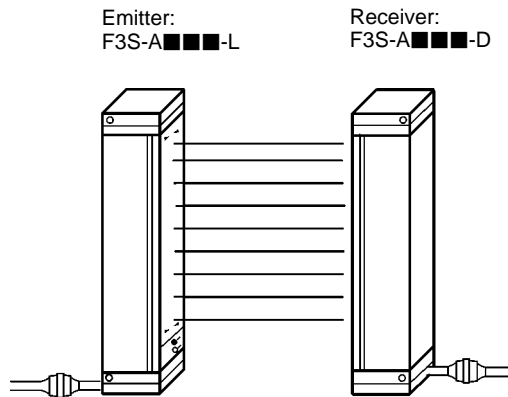
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# SECTION 1

## Description

The F3S-A Safety Light Curtain is a multi-axis transmission-type light curtain developed with microprocessor technology. It is used to stop a production machine immediately when any part of the detection zone is interrupted. The F3S-A detects non-transparent objects of at least 15 mm in diameter (F3S-A-1) or of at least 25 mm in diameter (F3S-A-2) as well as parts of an operator's body, and can be used to form a safety system for stopping a machine when any part of an operator's body is detected.

The F3S-A has two outputs, both of which consist of a PNP transistor with Light-ON operating mode.



## 1-1 Features

### EU Machinery Directive Compliance and UL Listed

The F3S-A complies with the EN standards; EN61496-1 and IEC61496-2 (Safety of Machinery: Electro-sensitive Protective Equipment), provided by the EU Machinery Directive. (EN61496-2 has not been published yet.)

Also, the F3S-A complies with the international standard IEC61496-1 and -2, and carries UL mark and C-UL (UL listed to Canadian safety standard) mark. It achieves the highest possible level of safety by providing two channel outputs and CPUs, as well as a number of self-diagnosis circuits. The F3S-A also has an optical system with excellent directionality that minimizes the effects of interference light such as room lighting and mutual interference.

### Connection Function for Sensor Sets

The F3S-A has a connection function that prevents problems due to mutual interference among multiple sets linked in series, parallel or mixed configurations. The connection configuration can be selected according to the number of outputs required in the control system and the number of directions into dangerous parts.

Mutual interference never occurs with multiple sets because the optical axes of connected sensors are all controlled separately using a sync signal. Be sure to see *1-5 Ratings and Performance* for further details however because the number of sensors that can be connected as well as the total number of optical axes are limited.

## 1-2 Basic Functions

### Emitter

The emitter emits light together with an electrical signal for synchronization to the receiver it faces. At this time, the light indicator lights indicating the emitter is emitting.

**Receiver**

The receiver turns ON control outputs when all optical axes are receiving light, and turns OFF control output if any optical axis is interrupted. The ON-state indicator will light when outputs are ON and the OFF-state indicator will light when the outputs are OFF. The instability indicator will light when the light from any optical axis is insufficient.

## 1-3 Additional Functions

**External Diagnosis Function**

This function determines whether the basic function of the receiver is operating properly. Proper operation can be checked by having the external diagnosis input of the emitter opened or connected to 9 to 24 V after turning the power ON.

**Interference Light Search Function**

This function checks for the presence or absence of interference light and can be selected by turning ON power when the external diagnosis input of the emitter is opened or connected to 9 to 24 V.

## 1-4 Safety Function

The F3S-A performs various diagnostic tests in order to ensure safety. When a failure is discovered, the F3S-A immediately turns OFF control outputs and indicates failure status on the indicators.

**Lock-out Condition**

The F3S-A stops machine operation with lock-out if it determines that a failure discovered as a result of self diagnosis is unrecoverable. Normal operation will not resume once the emitter or receiver enters lock-out status. In this case, terminate operation immediately and replace with a new one.

**OFF-hold Condition**

The F3S-A stops machine operation with OFF hold if it determines that a failure discovered as a result of self diagnosis is temporary and recoverable. Eliminate the cause of the failure and turn F3S-A power back ON to resume normal operation.

**Note** The F3S-A does not have a muting function (function that disables detection).

## 1-5 Ratings and Performance

Item	Model	F3S-A161	F3S-A321	F3S-A481	F3S-A082	F3S-A162	F3S-A242	F3S-A322	F3S-A482
No. of optical axes		16	32	48	8	16	24	32	48
Protective height		150 mm	310 mm	470 mm	140 mm	300 mm	460 mm	620 mm	940 mm
Optical-axis pitch		10 mm			20 mm				
Optical resolution		Non-transparent: 15 mm in diameter			Non-transparent: 25 mm in diameter				
Detection distance		0.2 to 5.0 m							
Response time		ON → OFF: 20 ms max., OFF → ON: 55 ms max. (with stable light)							
Supply voltage		24 VDC ±10% (ripple range (p-p): 10% max.)							
Current consumption		200 mA max.							
Light source		Infrared LED (860-nm wavelength)							
Effective aperture angle		Within ±2.5° for the emitter and receiver at a detection distance of at least 3 m as provided by IEC61496-2.							
Operating mode*1		Light ON							
Control output*1		Two PNP transistor outputs, 300 mA max. load current, and 2 V max. residual voltage (except for voltage drop due to cord extension)							
Mutual interference interrupting function		Split light emitting system using sync line connection (between emitters and between multiple receivers) No. of serial connections: Up to 3 sets No. of parallel connections: Up to 4 sets Total no. of optical axes: Up to 192 axes (with mixed serial and parallel connection)							
External diagnosis function*1		After power ON External diagnosis input line : Open or 9 to 24 V : Emitting OFF External diagnosis input line : 0 to 1.5 V : Emitting ON (3 mA max. short-circuit current)							
Interference light search function		Prior to power ON External diagnosis input line : Open or 9 to 24 V : Interference light search, 8 hrs max. (continuous) External diagnosis input line : 0 to 1.5 V : Emitting ON (3 mA max. short-circuit current)							
Muting function		Not available							
Indicator	Emitter	Light indicator (orange LED) : Lit when emitting, flashing during external diagnosis and interference light search. Failure indicator (yellow LED) : Lit with emitter lock-out, flashing during emitter OFF-hold and interference light search *2.							
	Receiver	ON-state indicator (green LED) : Lit when receiving light. OFF-state indicator (red LED) : Lit with interrupted light or failure, flashing during interference light search. Instability indicator (orange LED) : Lit with an insufficient light and interference light search. Failure indicator (yellow LED) : Lit with receiver lock-out, flashing during receiver OFF hold and interference light search *2.							
Connection method		Connector-mounted cord pullout method							
Protection circuit		Output short protection							
Ambient temperature		During operation : -10 to 55 C (with no freezing) During storage : -30 to 70 C							
Ambient humidity		During operation : 35 to 85% RH (with no condensation) During storage : 35 to 95% RH							

Item	Model	F3S-A161	F3S-A321	F3S-A481	F3S-A082	F3S-A162	F3S-A242	F3S-A322	F3S-A482
Ambient light intensity		Incandescent lamps : 3,000 lx max. (receiver surface light intensity) Sunlight : 10,000 lx max. (receiver surface light intensity)							
Insulation resistance		20 MΩ min. (at 500 VDC)							
Dielectric strength voltage		1000 VAC 50/60 Hz for 1 min							
Degree of protection		IP64(IEC60529)							
Vibration resistance		Durability : 10 to 55 Hz, double-amplitude: 1.5 mm, X, Y and Z directions: For 2 hours Normal operation : 10 to 55 Hz, double-amplitude: 0.7 mm, X, Y and Z directions: For 50 min *3							
Shock resistance		Durability : 300 m/s <sup>2</sup> [30 G], X, Y and Z directions: 3 times Normal operation : 100 m/s <sup>2</sup> [10 G], X, Y and Z directions: 1,000 times *3							
Cord *4		Emitter and receiver: 8 cores (0.3 mm <sup>2</sup> x 4 cores, 0.2 mm <sup>2</sup> x 4 cores), external dimension: 6 mm in diameter with spiral shield, allowable bend radius R36 mm							
Materials		Case : Aluminum Front cover : PMMA (acrylic resin) Cord : PVC							
Accessories		Test rod, mounting brackets (top and bottom), mounting brackets (intermediate) for the F3S-A322 and F3S-A482 only, Instruction Manual							
Applicable standard		IEC61496-1, EN61496-1 TYPE 4 ESPE IEC61496-2 TYPE 4 AOPD							

\*1 The logic (ON/OFF) may differ from that normally used because a safety circuit is used. Be sure to check this carefully.

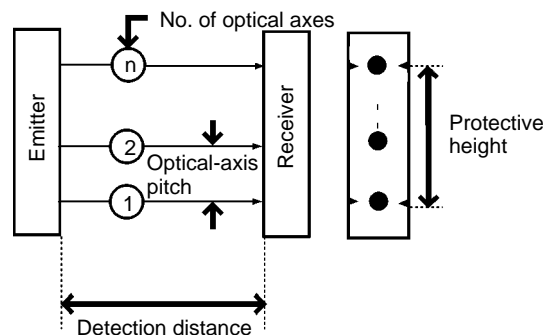
\*2 Lock-out: Output status OFF due to unrecoverable failure. OFF-hold: Output status OFF due to temporary failure.

\*3 In accordance with IEC61496-1

\*4 The optional extension cord provides the same performance.  
(Reference)

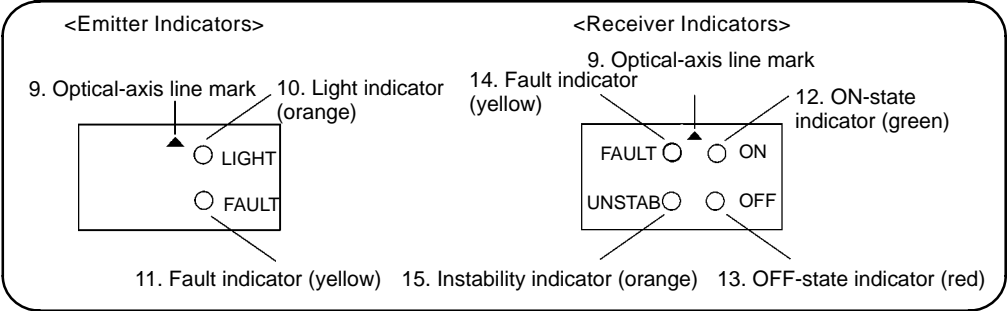
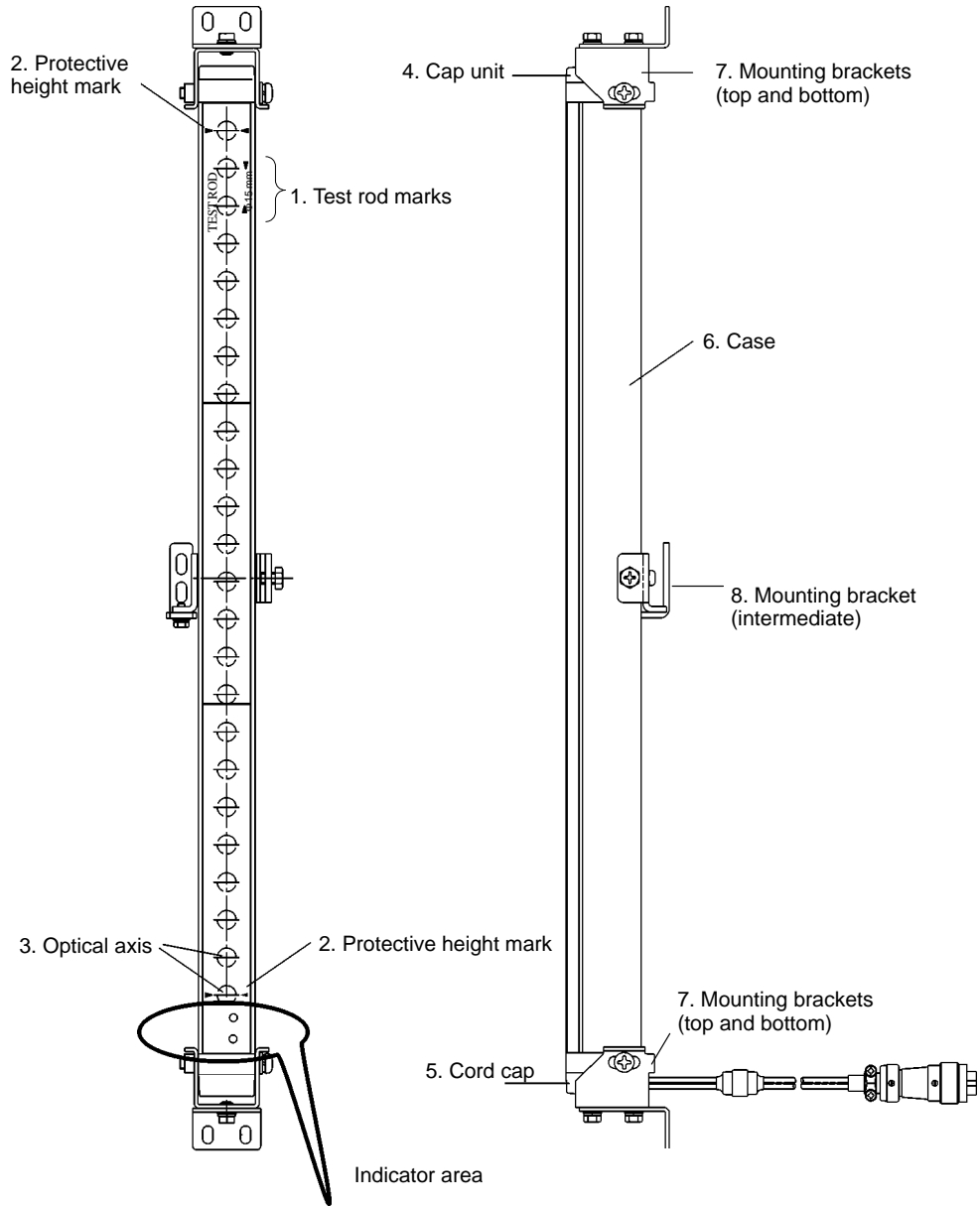
Resistance: Power line and output line: 66.3 Ω/km  
Sync line: 94.0 Ω/km

Use a cord of at least the same performance to extend the cord length. The total cord length must be 100 m or less. Be sure to route F3S-A cords separated from high-potential power lines or through an exclusive conduit.



# SECTION 2

## Part Names and Description



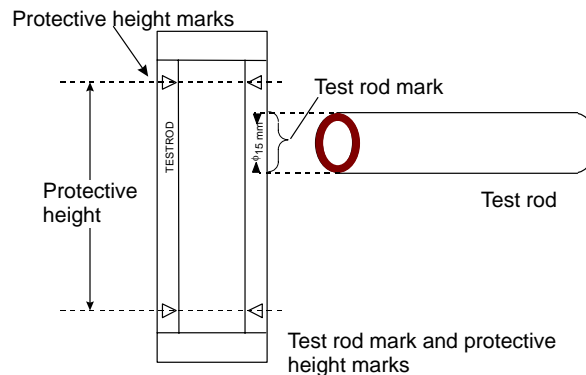
## 1. Test Rod Marks

The test rod is used in daily inspections to check whether the F3S-A has maintained the detection capability about the optical resolution. See *6-1 Daily Inspections* for more details.

Test rod marks indicate the diameter of the test rod that must be used. The diameter of the test rod is compared to the gap between the two white triangle marks in order to determine whether the test rod is correct. This is particularly important in applications where the F3S-A1 (10-mm optical-axis pitch) is connected with F3S-A□□2 (20-mm optical-axis pitch). Use the test rod marks to select the correct test rod.

## 2. Protective Height Mark

The protective height is indicated by white triangle marks.



## 3. Optical Axis

The light emitting elements of the emitter and the light receiving elements of the receiver align at intervals of 10 mm (F3S-A□□1) or 20 mm (F3S-A□□2). The elements, however, are not visible because the optical surface (light transmitting surface) of the F3S-A is comprised of an infrared pass filter. The model can be checked only via the nameplate.

## 4. Cap Unit , 5. Cord Cap

Remove these caps in order to attach the serial connection cord used to connect F3S-As in series.

## 6. Case

Case is painted yellow to clearly define it as a safety sensor.

## 7. Mounting Brackets (Top and Bottom)

Mounting bracket combinations can be varied for side or rear mounting. Torsion and tilt angles are both adjustable.

## 8. Mounting Brackets (Intermediate)

The intermediate mounting brackets are accessories for the F3S-A322 and F3S-A482 only. Here again mounting bracket combinations can be varied for side or rear mounting, and both torsion and tilt angles are adjustable. Note that on the emitter and receiver machined hole positions for the mounting surface are symmetrical on the left and right side (See *3-4 Mounting*).

## 9. Optical-axis Line Mark

The center line for optical axes is indicated by white triangle marks. This position is a reference line for measuring safety distance.

## <Emitter Indicators>

### 10. Light Indicator (Orange)

The light indicator lights when the emitter is emitting light normally, and flashes while the light is OFF during external diagnosis.

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**11. Fault Indicator (Yellow)**

The fault indicator flashes to indicate the emitter is in OFF-hold condition.  
The fault indicator remains lit to indicate the emitter is in lock-out condition.

**<Receiver Indicators>**

**12. ON-state Indicator (Green)**

The ON-state indicator remains lit if the F3S-A is operating normally and all optical axes are receiving light. It also indicates that both outputs are ON.

**13. OFF-state Indicator (Red)**

The OFF-state indicator remains lit if an object is detected in the detection zone and at least one optical axis is interrupted. It indicates that both outputs are OFF when the F3S-A is operating correctly.

**14. Fault Indicator (Yellow)**

The fault indicator flashes to indicate the receiver is in OFF-hold condition.  
The fault indicator remains lit to indicate the receiver is in lock-out condition.

**15. Instability Indicator (Orange)**

The instability indicator remains lit with an insufficient light.




# SECTION 3

## Wiring and Mounting

### 3-1 Installation Conditions

#### 3-1-1 Detection Zone and Intrusion Path

##### WARNING

 <b>WARNING</b>
Do not use the F3S-A on machines that cannot be stopped by electrical control in an emergency. For instance, the F3S-A <b>may not</b> be used on machines using full-revolution clutches.
When using the F3S-A on PSDI (Presence Sensing Device Initiation) mode, the appropriate control circuit shall be installed between the F3S-A and the machinery. For further information on PSDI, please refer to OSHA1910.217, IEC61496-1, and other relevant standards and regulations.
Install protective structures around the machine so that you must pass through the detection zone to reach dangerous machine parts. Install the F3S-A so that some part of the operator's body remains in the detection zone at all times when operating in dangerous machine parts. Failure to do so may result in serious injury.
Be sure to use both output lines when constructing the safety system. The safety system constructed using only one line may result in serious injury under a faulty condition of the output circuit.

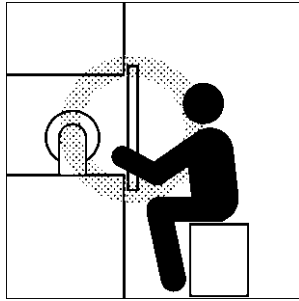
The F3S-A may be installed on a machine that can be stopped by electrical control in an emergency. Make sure the machine structure does not hinder stop and other safety functions.

The F3S-A detection zone is the entire range bound by the protective height of the emitter and receiver. Be sure to install protective structures around the machine so that you must pass through the detection zone to reach dangerous machine parts.

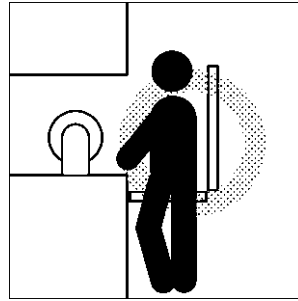
Also install the F3S-A so that operators working in dangerous machine parts are detected at all times. Connect F3S-As in series as explained in *3-2 Configuration* so that some part of the operator's body remains in the detection zone at all times whenever there is a wide gap between the F3S-A and machine where operators may not be detectable.

**Correct Installation**

Dangerous machine parts can be reached only by passing through the sensor detection zone.

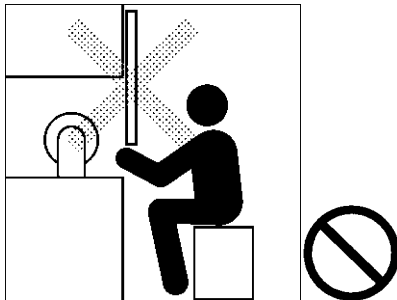


Some part of the operator's body remains in the detection zone while they are working.

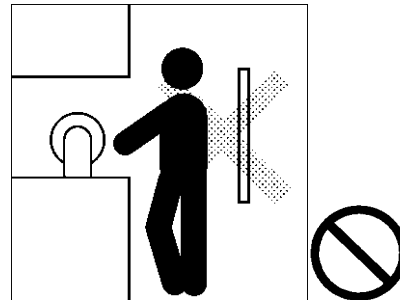


**Incorrect Installation**

Dangerous machine parts can be reached without passing through the sensor detection zone.



A worker is between the sensor detection zone and dangerous machine parts.



### 3-1-2 Safety Distance

**WARNING**

Always maintain a safety distance between the F3S-A and dangerous machine parts.  
 Serious injury may result if the machine does not stop before someone reaches a dangerous machine part.

A safety distance is the minimum distance that must be maintained between the F3S-A and a dangerous machine part in order to stop the machine before someone or something reaches it. Safety distance is calculated based on the following equation when a person moves perpendicular to the detection zone of a light curtain.

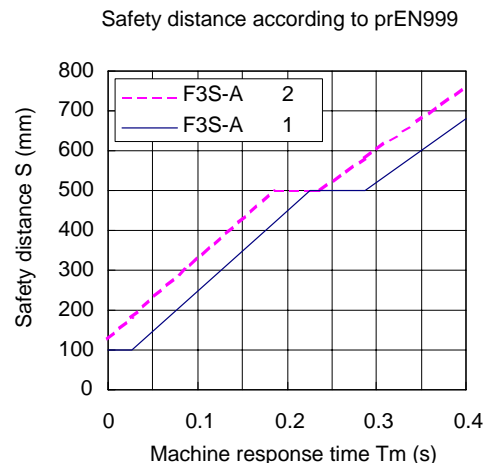
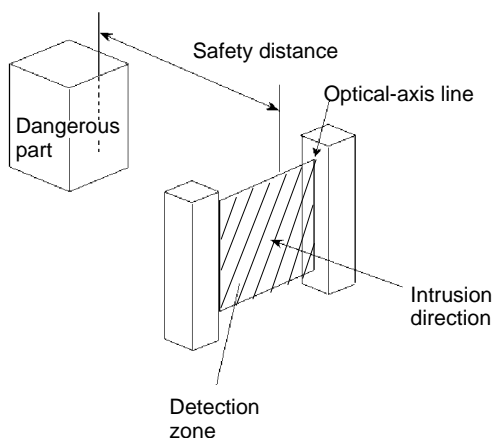
Safety distance (S)  
 = Intrusion speed into the detection zone (K)  
 × Total response time for the machine and light curtain (T)  
 + Additional distance calculated based on the optical resolution of the light curtain (C) (1)

Intrusion speed (K), response time (T), and supplemental distance (C) vary with national standards and individual machine standards. The equation will also be different if the direction of intrusion is not perpendicular to the detection zone of the light curtain. See related standards for more details.

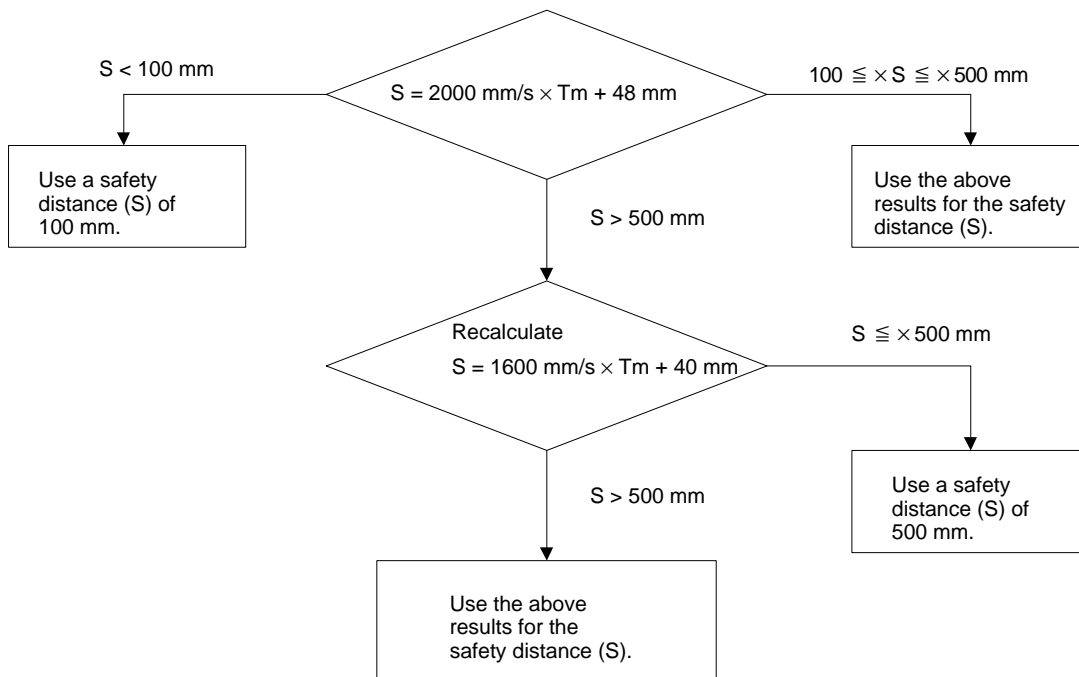
#### Using prEN999 Standards Formula

When safety distance is not provided by European standards for individual machine, the distance can be calculated using prEN999 (Safety of machinery-The positioning of protective equipment in respect of approach speeds of parts of the human body).

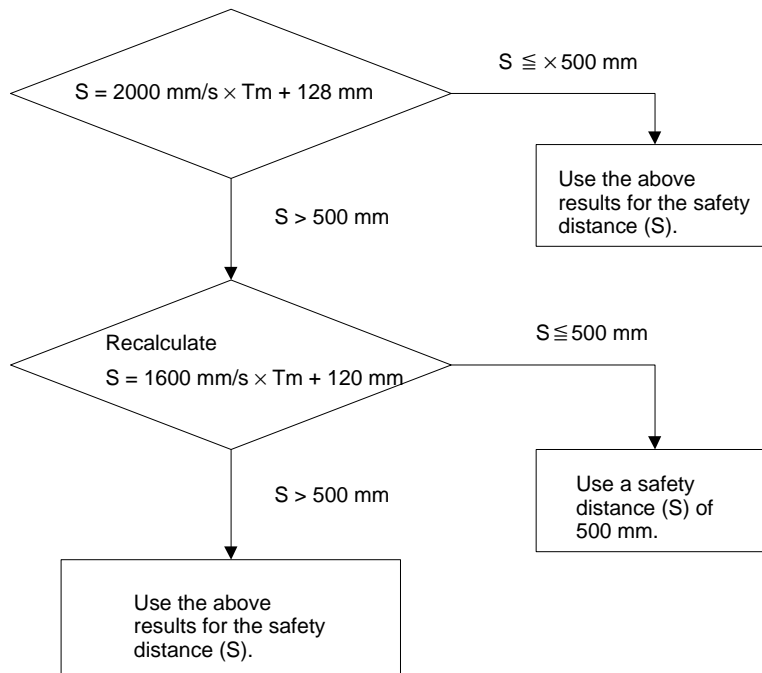
Use the following flowchart to calculate safety distance for the F3S-A in accordance with prEN999. Tm in the flowchart indicates machine response time. To make this calculation simpler, some elements that can be calculated from the light curtain response time and the optical resolution of the light curtain are calculated beforehand.



(1) F3S-A 1 (10-mm Optical-axis Pitch)



(2) F3S-A 2 (20-mm optical axis pitch)



Example of Flow Charts of the Safety Distance Calculation (According to prEN999, Vertical Approach)

(Reference)

Method for calculating safety distance as provided by prEN999 (for intrusion perpendicular to the detection zone)

Substitute  $K = 2,000 \text{ mm/s}$  and  $C = 8 (d - 14 \text{ mm})$  in equation (1) and calculate as shown below.

$$S = 2000 \text{ mm/s} \times (T_m + T_s) + 8(d - 14 \text{ mm}) \quad (2)$$

Where.....  $S = \text{safety distance (mm)}$

$T_m = \text{machine response time (s)}$  (see note 1)

$T_s = \text{light curtain response time (s)}$  (see note 2)

$d = \text{optical resolution of the light curtain (mm)}$

(2) Use  $S = 100 \text{ mm}$  if the result of equation (2) is  $100 \text{ mm}$  or less, or recalculate using the following equation with  $K = 1,600 \text{ mm/s}$  if the result is over  $500 \text{ mm}$ .

$$S = 1600 \text{ mm/s} \times (T_m + T_s) + 8(d - 14 \text{ mm}) \quad (3)$$

(3) Use  $S = 500 \text{ mm}$  if the result from equation (3) is  $500 \text{ mm}$  or less.

The F3S-A flowchart summarizes results of equations (2) and (3) substituting  $T_s = 0.02 \text{ s}$  and  $d = 15 \text{ mm}$  for an F3S-A 1, or  $d = 25 \text{ mm}$  for an F3S-A 2.

- Note**
1. The machine response time refers to the time from the moment when a machine receives a stop signal to the moment when the dangerous part of the machine stops.
  2. The light curtain response time refers to the time required for changing from ON to OFF.

**Using ANSI B11.19 Standards (U.S.A.) Formula**

$$\begin{aligned} \text{Safety Distance (S)} &= \text{Intrusion speed (K)} \\ &\quad \times \text{Response time (} T_s + T_c + T_r + T_{bm} \text{)} \\ &\quad + \text{Additional distance (Dpf)} \end{aligned} \quad (4)$$

Where...

$K = \text{Intrusion speed (OSHA recommended speed is } 1600 \text{ mm/sec)}$

The intrusion speed  $K$  has not been determined by ANSI B11.19, although various studies determined this value of  $1600 \text{ mm/sec}$  to over  $2500 \text{ mm/sec}$ .

The employer should consider all factors, including the physical ability of the operator, when determining the value of  $K$  to be used.

$T_s = \text{Stopping time of machine (sec)}$

$T_r = \text{F3S-A's maximum response time (= } 0.020 \text{ sec)}$ .

$T_c = \text{Maximum response time of machine control circuit to activate machine's brake.}$

$T_{bm} = \text{Additional time (sec)}$

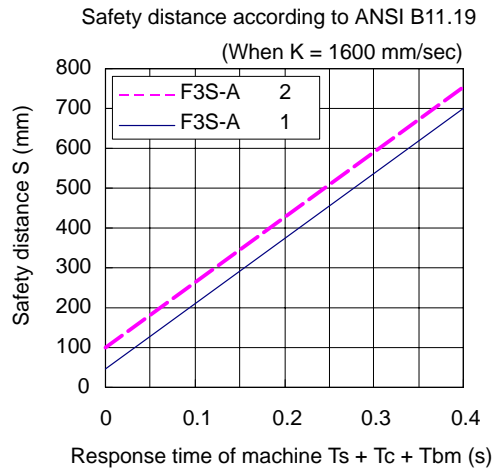
When the machine has a brake monitor, calculation of  $T_{bm}$  shall be;

$$T_{bm} = \text{Brake monitor set time} - (T_s + T_c)$$

When the machine does not have a brake monitor, we recommend the use of at least 20% of  $(T_s + T_c)$  as the additional time.

Dpf = Additional distance. According to ANSI standard, calculation of Dpf shall be;

Or  $Dpf = 3.4 \times (d - 7.0)$  (mm) : d is resolution of F3S-A



(Example of calculation of safety distance according to ANSI B11.19)

Assume that an object approaches vertically to the detection zone.

K = 1600 mm/sec, Ts + Tc = 0.06 sec, brake monitor set time = 0.1 sec:

Calculation (When using the F3S-A 1)

From formula (4)

$K = 1600$  (mm/sec),  $Dpf = 3.4 \times (15 - 7.0) = 27.2$  mm

$S = 1600 \times (0.06 + 0.02 + 0.1 - 0.06) + 27.2$   
 $= 219.2$  mm

Calculation (When using the F3S-A 2)

From formula (4)

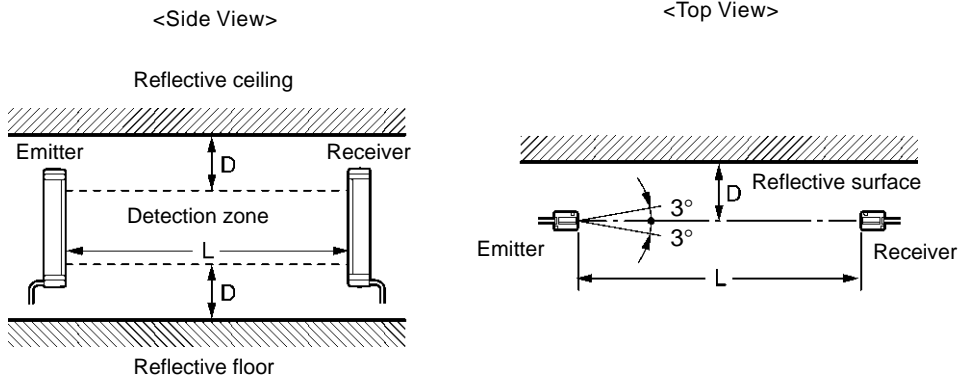
$K = 1600$  (mm/sec),  $Dpf = 3.4 \times (25 - 7.0) = 61.2$  mm

$S = 1600 \times (0.06 + 0.02 + 0.1 - 0.06) + 61.2$   
 $= 253.2$  mm

### 3-1-3 Distance from Reflective Surfaces

**WARNING**

Be sure to install the F3S-A to minimize the effects of reflections from reflective surfaces. Failure to do so will cause detection to fail and may result in serious injury. Install the F3S-A as least distance D shown below from reflective surfaces (highly reflective surfaces) like metal walls, floors, ceilings and workpieces.

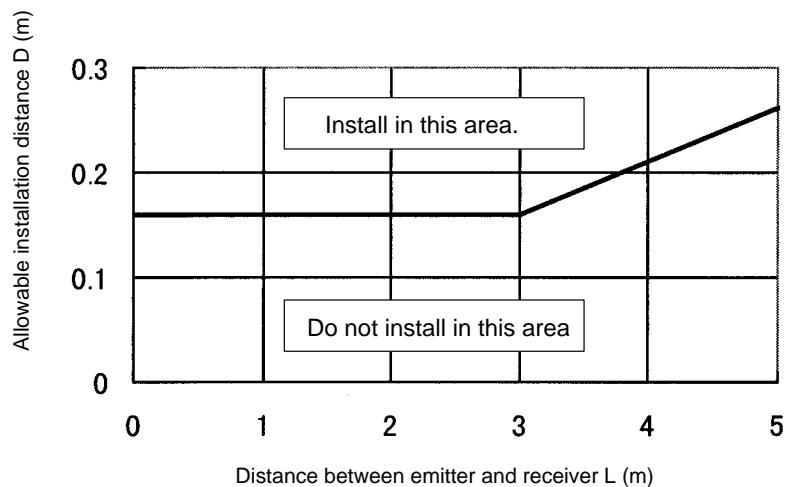


This indicates protective height marks (See Section 2.).

Distance between the emitter and receiver (detection distance L)	Allowable installation distance D
0.2 to 3 m	0.16 m
3 to 5 m	$L \times \tan 3^\circ = L \times 0.052$ (m)

Note. The effective aperture angle for the F3S-A is  $\pm 2.5^\circ$  (when  $L > 3$  m) as provided by IEC61496-2, but install the F3S-A away from reflective surfaces at an effective aperture angle of  $\pm 3^\circ$  to consider misalignment during installation.

**Allowable Distance from Sensor to Reflective Surface**



**3-1-4 Check List (1/3)**

The last person in charge will check off boxes on the check list.

Mark the following items to check installation conditions.

- 1, 2, 3...**
1. Machine structure does not hinder stop and other safety functions.
  2. Intrusion into dangerous machine parts not possible without passing through the F3S-A detection zone.
  3. Protective structure that allows the F3S-A to detect operators when they are working in dangerous parts.
  4. Safety distance calculated.  
Calculated distance:  $S = ( \quad )$  mm
  5. The actual distance is higher than the calculated distance.  
Actual distance =  $( \quad )$  mm
  6. Reflective surfaces are not installed in prohibited areas.



## 3-2 Configuration

Multiple sets of the F3S-A can be connected. Connecting to sync lines prevents mutual interference and ensures safety. Multiple sets can be connected in serial, parallel or mixed (serial and parallel) configurations depending on the detection zone and number of outputs.

**⚠ WARNING**

Always use correct combinations of emitters and receivers.  
 A non-detection zone is created, for example, when an F3S-A161-L (10-mm pitch, 16-optical axis emitter) is combined with an F3S-A162-D (20-mm pitch, 16-optical axis receiver).

Never connect multiple receivers to one emitter or multiple emitters to one receiver in series or mixed connection.  
 Doing so may cause detection to fail due to mutual interference.

Never use the F3S-A in a retroreflective configuration. Doing so may cause detection to fail.

### 3-2-1 Connection

(1) 1 Set

**Application**

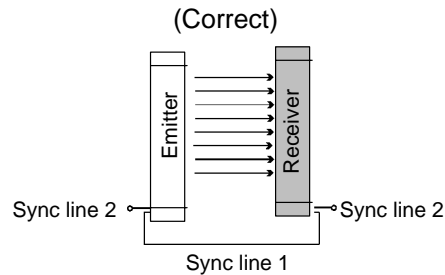
This is the most common configuration, and it is used with one dangerous machine part entered from one direction only.

**Wiring**

Connect a sync line to the emitter and receiver. Make sure the sync line 2 for the emitter and receiver is open. See Section 3-5 for more details.

**Output**

1 set



(2) Series Connection (Up to 3 Sets)

**Application**

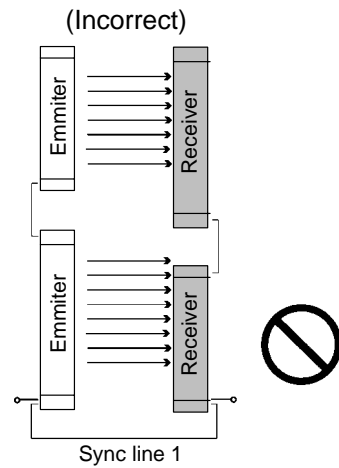
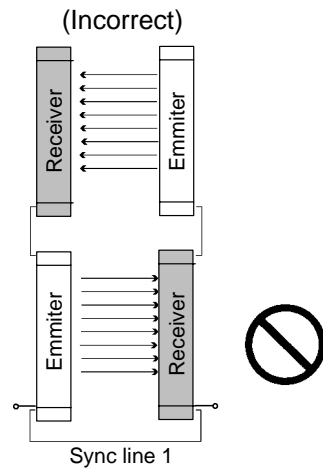
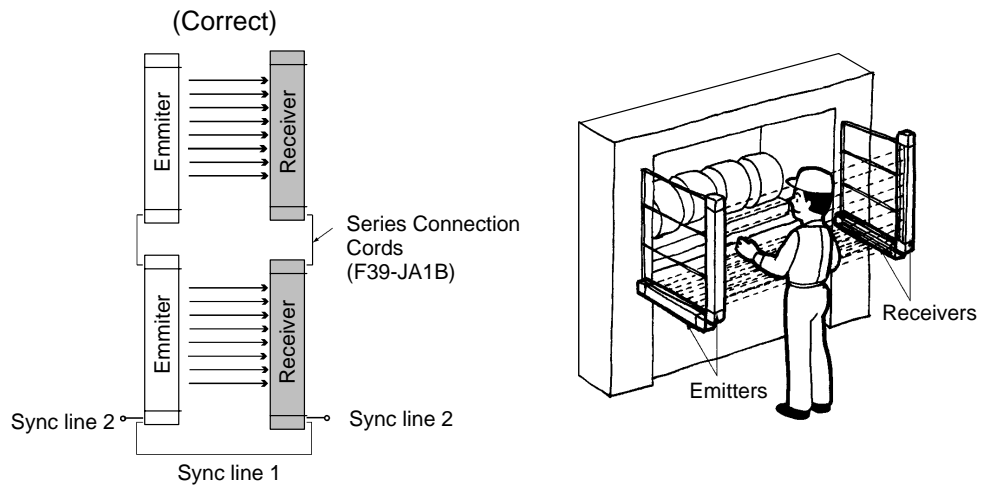
This configuration is used with one dangerous machine part that can be entered from two or more directions.

**Wiring**

Wire as described in (1) above, then route serial connection cords (F39-JA1B optional) between emitters and between receivers. See Section 3-5 for more details.

**Output**

1 set. Output turns OFF if either F3S-A is interrupted.



Do not connect the emitter and receiver in series. The F3S-A will be put in OFF-hold condition.

Do not face emitters and receivers from different set types.

Otherwise the F3S-A will be put in OFF-hold condition and detection will fail.

(3) Parallel Connection (Up to 4 Sets)

**Application**

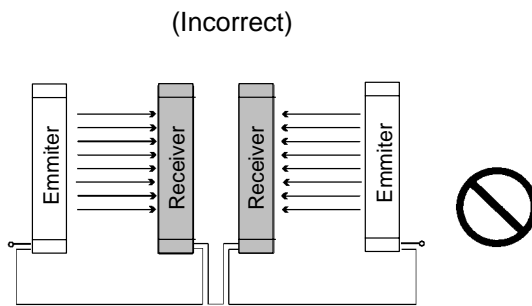
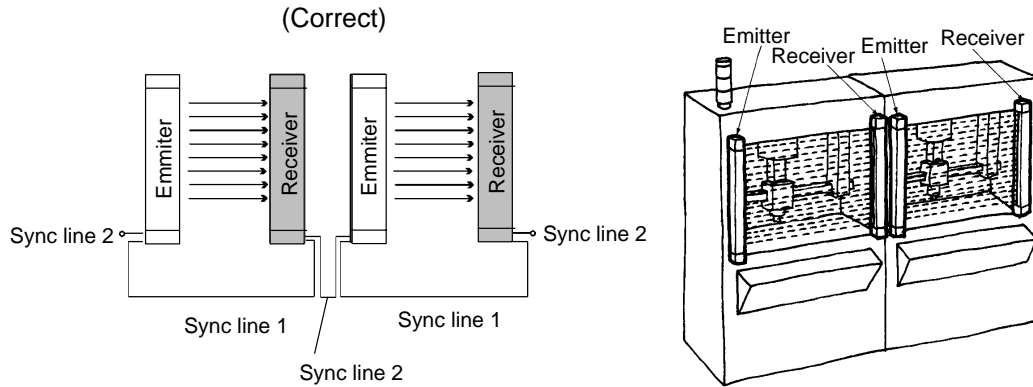
This configuration is used with two or more dangerous machine parts that can be entered from one direction.

**Wiring**

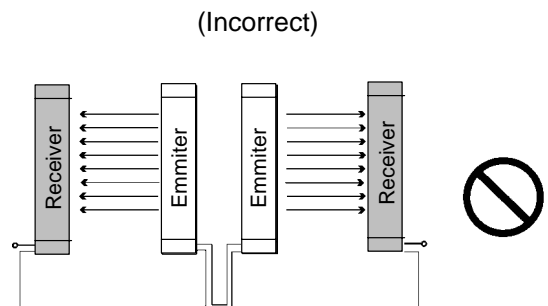
Connect a sync line (emitter → receiver → emitter → receiver) in that order. See Section 3-5 for more details.

**Output**

The number of outputs equals the number of parallel connected sets. Only the F3S-A output from which light is interrupted will turn OFF.



Do not connect receivers in parallel or the F3S-A will be put in OFF-hold condition.



Do not connect emitters in parallel or the F3S-A will be put in OFF-hold condition.

**(4) Mixed Connection (3 Sets in Series x 4 Sets in Parallel with Up to 192 Optical Axes)**

**Application**

This configuration is used with two or more dangerous machine parts that can be entered from two or more directions.

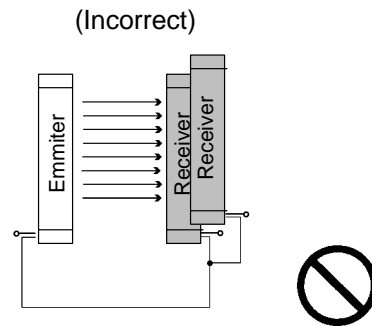
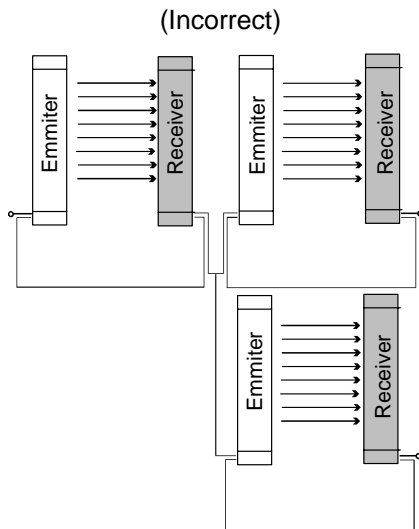
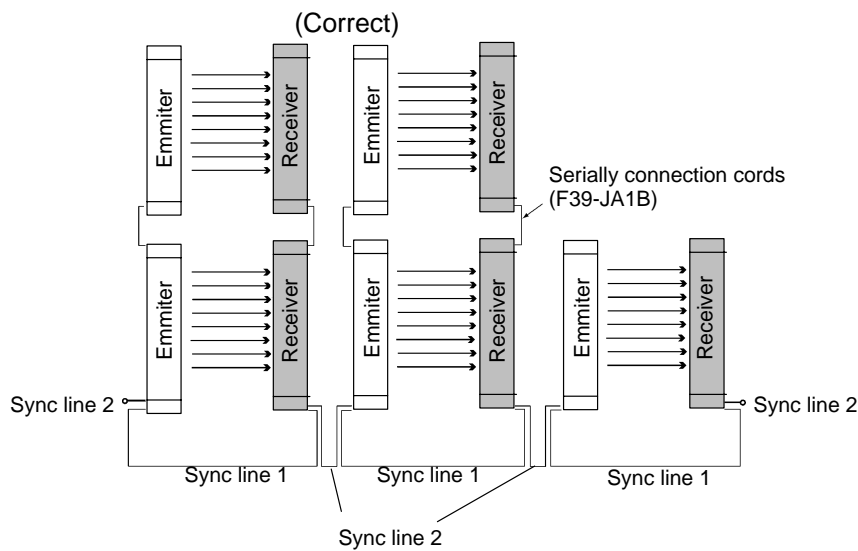
**Wiring**

Connect a sync line (emitter → receiver → emitter → receiver) in that order for sets connected in parallel.

For serially connected emitters and receivers use serial connection cord to connect emitter to emitter and receiver to receiver. See Section 3.5 for more details.

**Output**

The number of outputs equals the number of parallel connected sets. If any serially-connected F3S-A detects interrupted light, the output from that F3S-A only will turn OFF. This has no affect on other parallel-connected F3S-As.



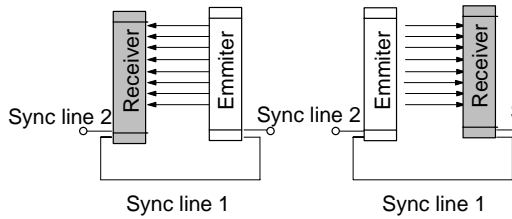
Do not connect two or more receivers to one emitter in parallel. The F3S-A may be put in OFF-hold condition.

Do not connect two or more emitters to one receiver in parallel. Mutual interference may put the F3S-A in OFF-hold condition.

(5) No Connection

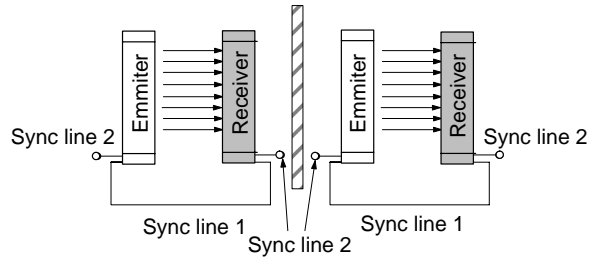
Take action to prevent mutual interference when two or more sensors are installed without connection due to wiring limitations. After installation, use the interference light search function described in Section 4.2 to make sure there is no mutual interference that will put the F3S-A in OFF-hold condition.

(Correct)



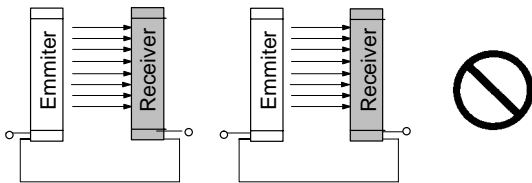
Install the emmitters and receivers so that the emmitters' backs are facing each other.

(Correct)



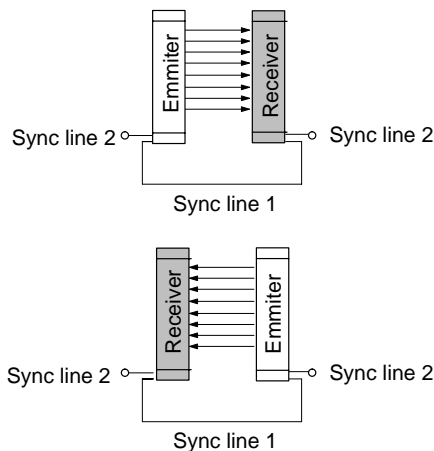
Install a barrier.

(Incorrect)



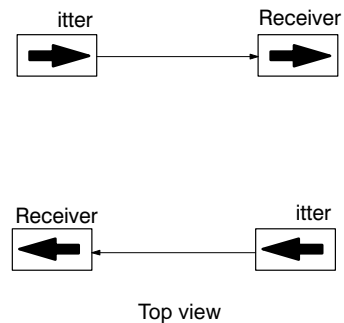
Install the emmitters and receivers so that the emitter's back is facing the receiver's back. They are not connected by a sync line and there is no barrier between them.

(Correct)

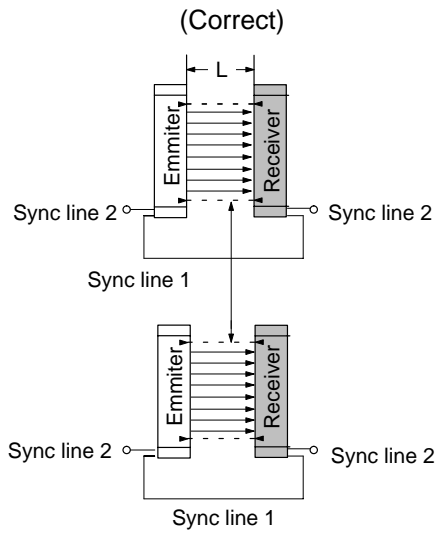


Arrange them vertically with emmitters and receivers on opposite sides. (Possible to have them in contact with each other)

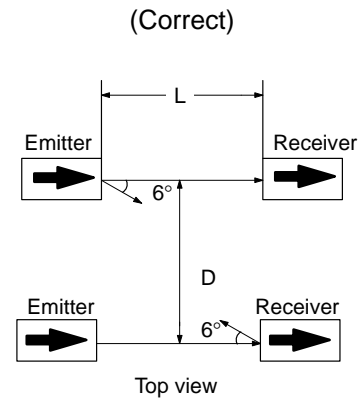
(Correct)



Arrange them horizontally with emmitters and receivers on opposite sides. (Possible to have them in contact with each other)



Arrange the emitter vertically so that the distance between their protective height mark is longer than in the following table.



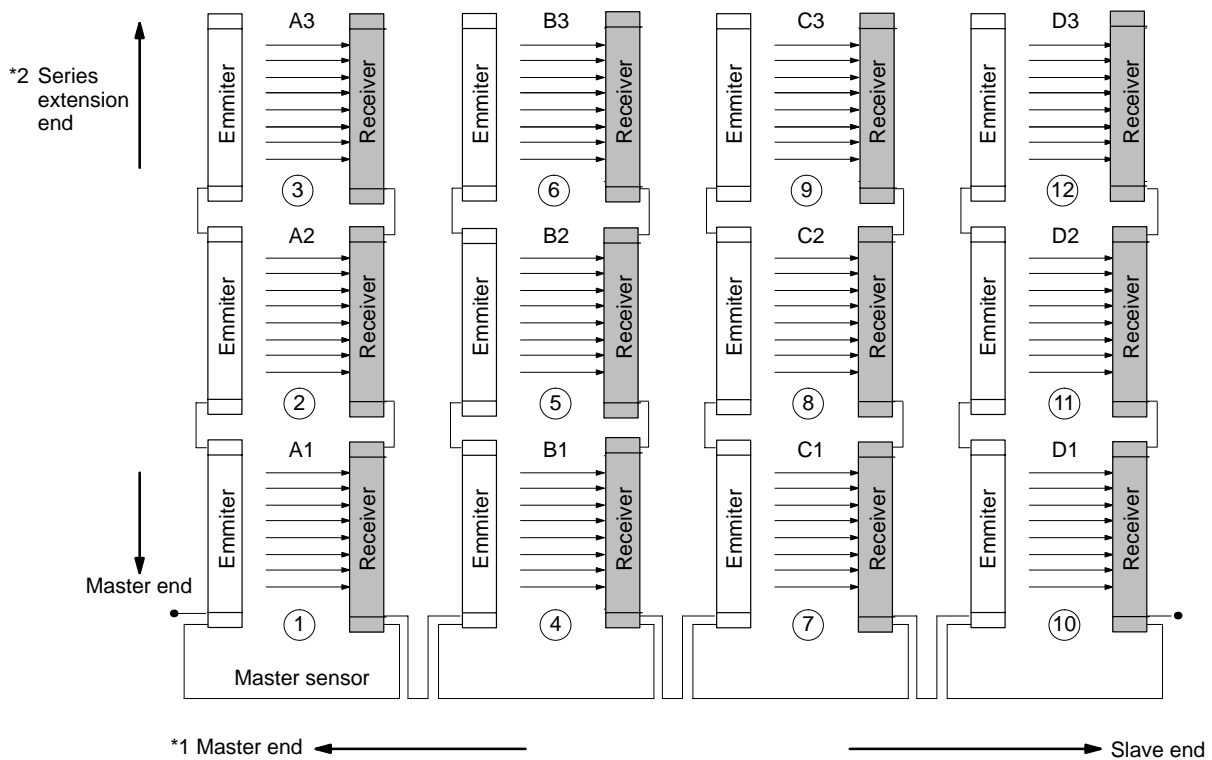
Arrange the emitter horizontally so that the distance between their optical axis is longer than in the following table.

Distance between emitter and receiver (detection distance L)	Permissible installation distance (D)
0.2 to 3 m	0.32 m
3 to 5 m	$L \times \tan 6^\circ = L \times 0.105$ (m)

### 3-2-2 Order for Executing Emitting and Receiving Functions

When connecting F3S-As together, one of them must be designated as a master sensor to prevent mutual interference.

1. The master sensor can be designated by connecting the master select input terminal of the emitter to the 0V line.
2. No sensors other than the A1 shown below can be designated as the master sensor.
3. The master sensor controls operation of the rest of the F3S-As. Mutual interference is prevented by operating all the F3S-As in sequence.
4. With the mixed connection, the serially connected group has priority in the operation sequence in the order of <sup>\*3</sup>A1 → A2 → A3 → B1 → B2...D2 → D3 as shown in the figure below (in the order of circled numbers 1 to 12).



**\*1 Master End/Slave End**

When F3S-As are connected in parallel, the master sensor end is called the master end and the other end is called the slave.

**\*2 Master End/Series Extension End**

In a series configuration, the master sensor end is called the master end and the other end is called the serial extension end.

**\*3 A1, A2, to D4**

These are sensor IDs when F3S-As are connected together. A1 is the master sensor.

Series connection is comprised of A1 and A2 (2 sets connected in series) or A1, A2 and A3 (3 sets connected in series).

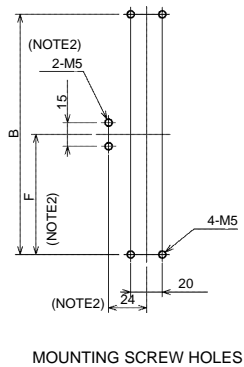
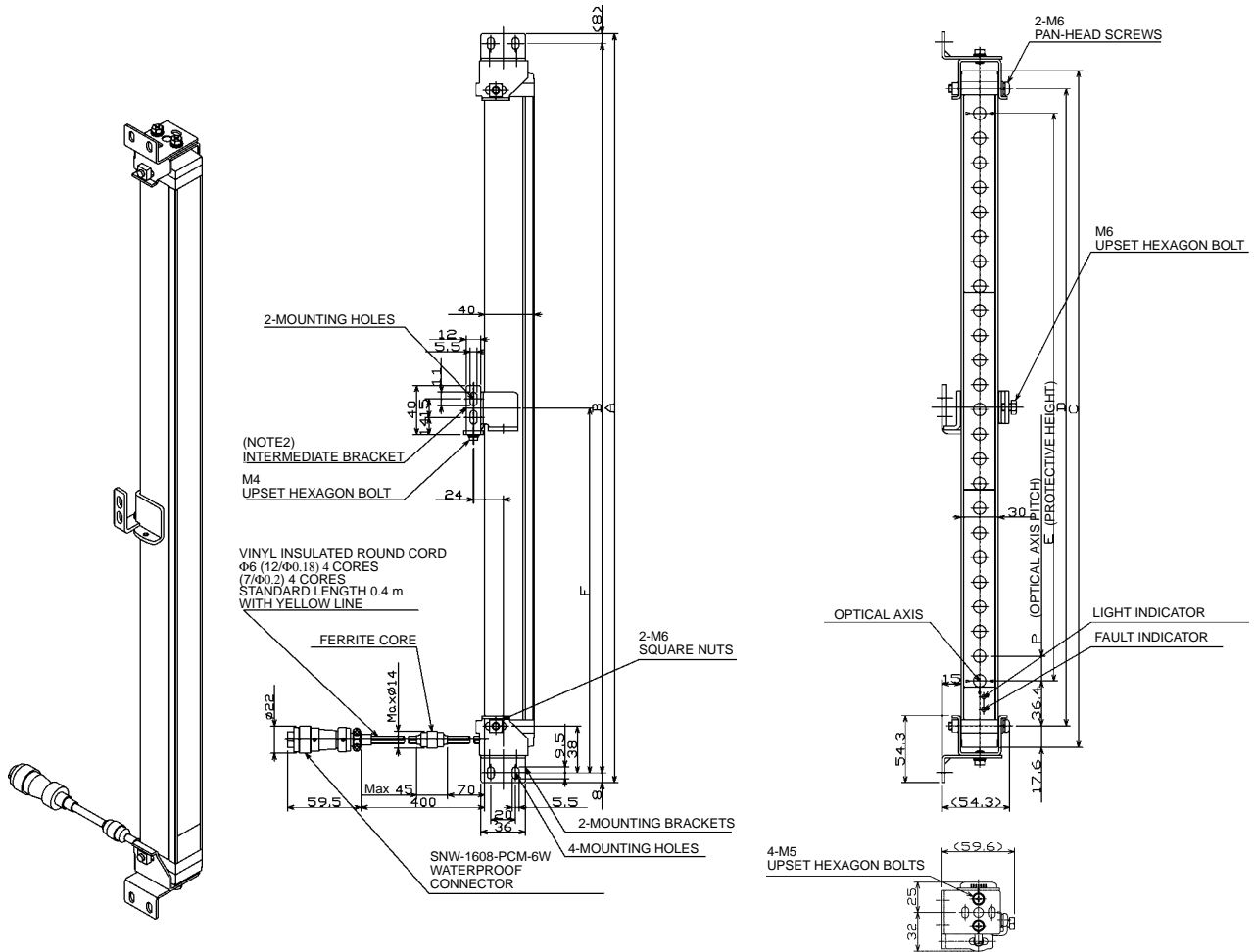
Parallel connection is comprised of A1 and B1 (2 sets connected in parallel) A1, B1 and C1 (3 sets connected in parallel) or A1, B1, C1, and D1 (4 sets connected in parallel).

### 3-3 Dimensional Drawings

#### 3-3-1 Side Mounting

##### Emitter

F3S-A -L



NOTE1 SIZES AND NUMBER OF OPTICAL AXES ARE AS BELOW

UNIT : mm

P	A	B	C	D	E	F	P	UM OP S	RO
F3S-A161-L	288.4	272.4	228.5	196.4	150	—	10	16	
F3S-A321-L	448.4	432.4	388.5	356.4	310	—	10	32	
F3S-A481-L	608.4	592.4	548.5	516.4	470	—	10	48	
F3S-A082-L	288.4	272.4	228.5	196.4	140	—	20	8	
F3S-A162-L	448.4	432.4	388.5	356.4	300	—	20	16	
F3S-A242-L	608.4	592.4	548.5	516.4	460	—	20	24	
F3S-A322-L	768.4	752.4	708.5	676.4	620	376.2	20	32	
F3S-A482-L	1088.4	1072.4	1028.5	996.4	940	536.2	20	48	

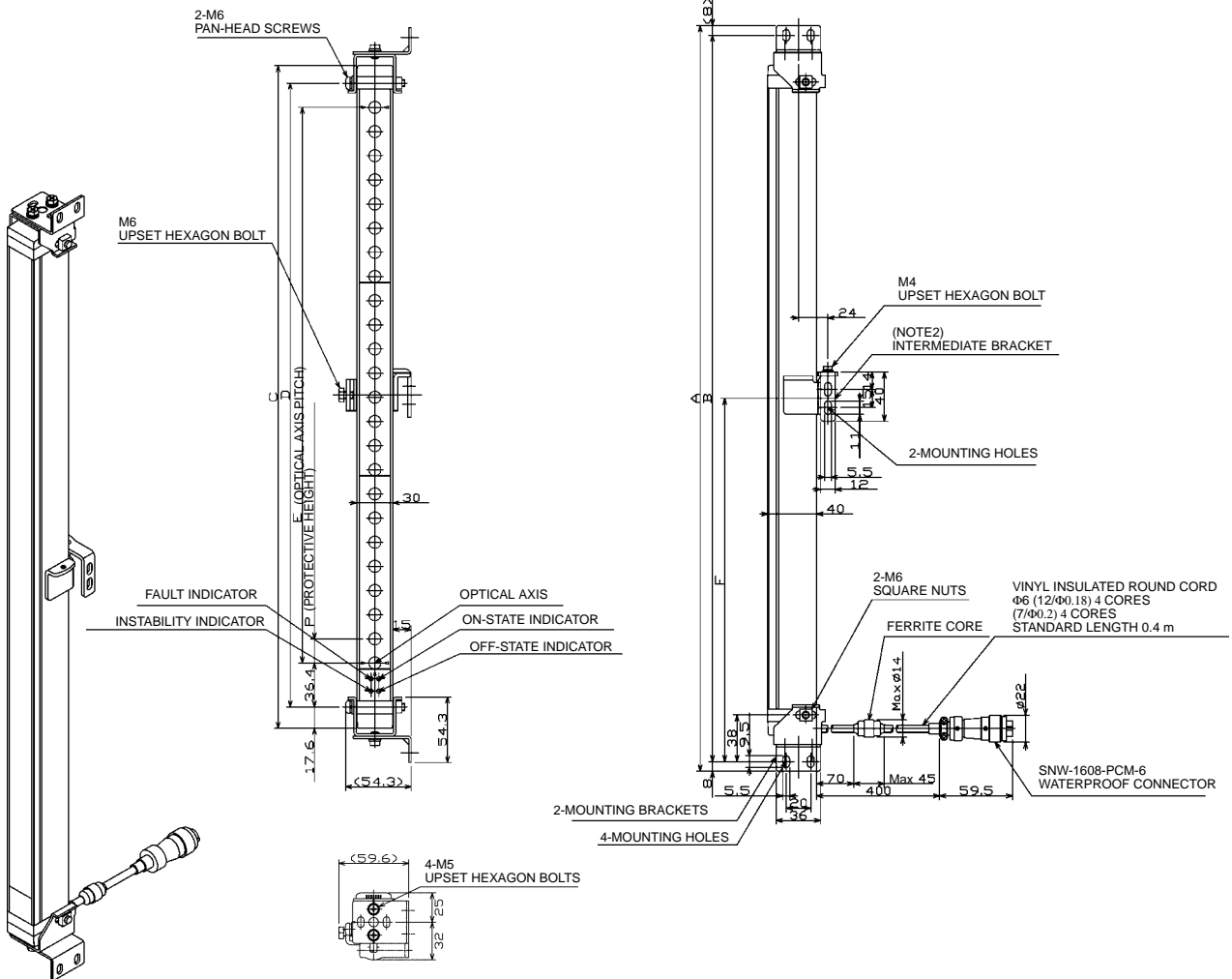
NOTE 2 THIS INTERMEDIATE BRACKET AND MOUNTING SCREW HOLES FOR IT ARE APPLIED TO TYPE F3S-A322-L AND F3S-A482-L

- A Full length when mounting bracket
- B Bracket mounting hole center width
- C Full length of main sensor
- D Sensor mounting hole center width
- E Protective height
- F Mounting bracket (intermediate) mounting position
- P: Optical axis pitch



Receiver

F3S-A -D



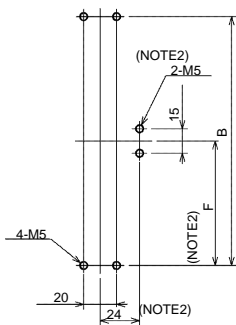
NOTE1 SIZES AND NUMBER OF OPTICAL AXES ARE AS BELOW

UNIT : mm

P	A	B	C	D	E	F	P	UM OP	RO S
F3S-A161-D	288.4	272.4	228.5	196.4	150				16
F3S-A321-D	448.4	432.4	388.5	356.4	310		10		32
F3S-A481-D	608.4	592.4	548.5	516.4	470				48
F3S-A082-D	288.4	272.4	228.5	196.4	140				8
F3S-A162-D	448.4	432.4	388.5	356.4	300				16
F3S-A242-D	608.4	592.4	548.5	516.4	460				24
F3S-A322-D	768.4	752.4	708.5	676.4	620	376.2			32
F3S-A482-D	1088.4	1072.4	1028.5	996.4	940	536.2			48

NOTE 2 THIS INTERMEDIATE BRACKET AND MOUNTING SCREW HOLES FOR IT ARE APPLIED TO TYPE F3S-A322-L AND F3S-A482-L

- A Full length when mounting bracket
- B Bracket mounting hole center width
- C Full length of main sensor
- D Sensor mounting hole center width
- E Protective height
- F Mounting bracket (intermediate) mounting position
- P: Optical axis pitch

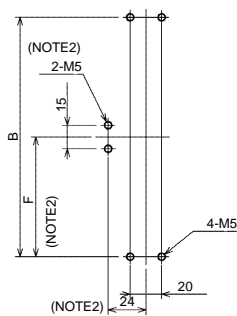
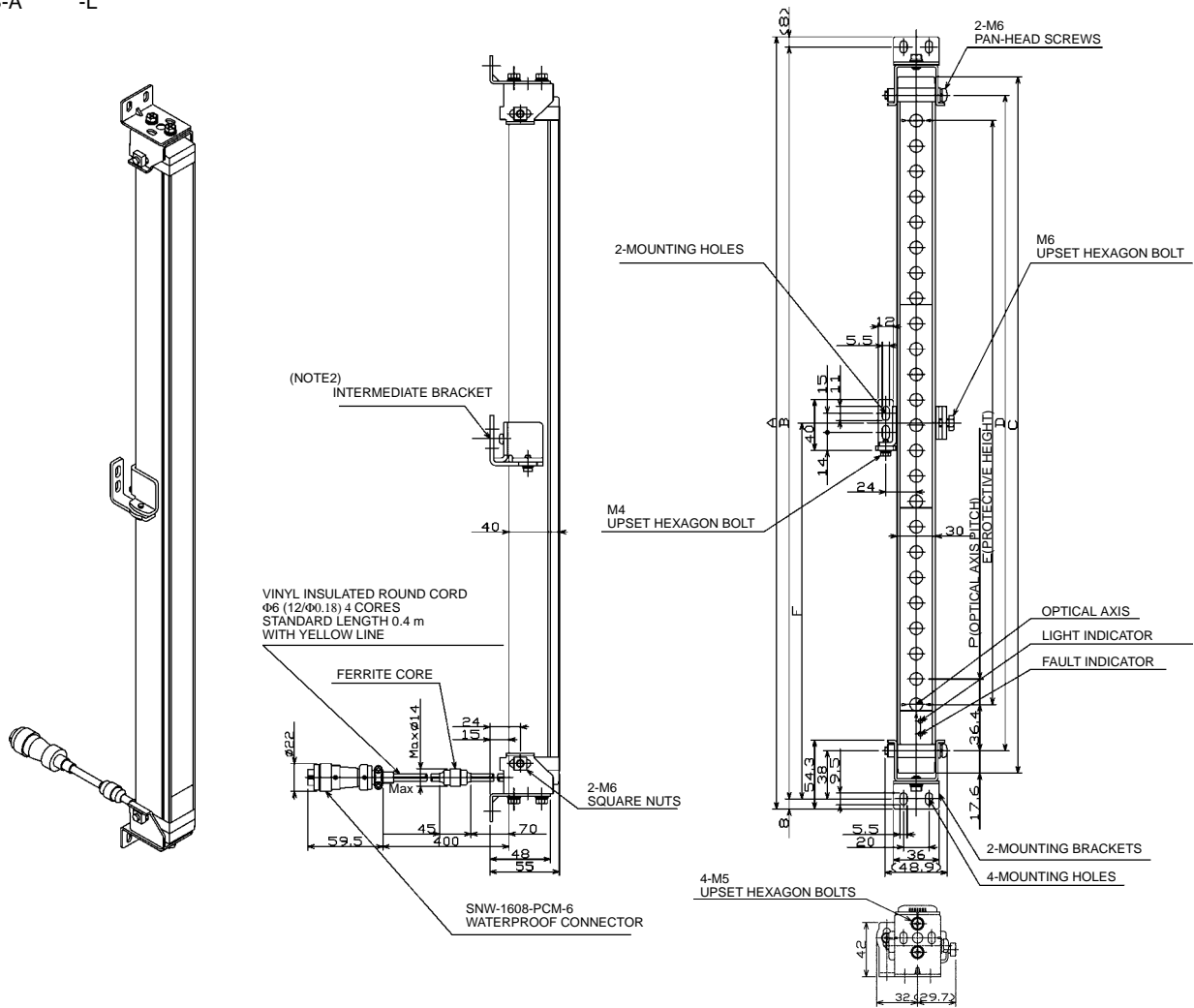


MOUNTING SCREW HOLES

### 3-3-2 Rear Mounting

#### Emitter

F3S-A -L



MOUNTING SCREW HOLES

NOTE1 SIZES AND NUMBER OF OPTICAL AXES ARE AS BELOW

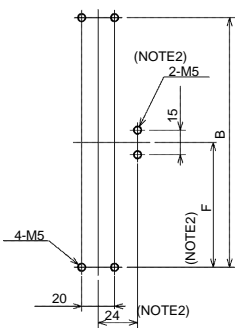
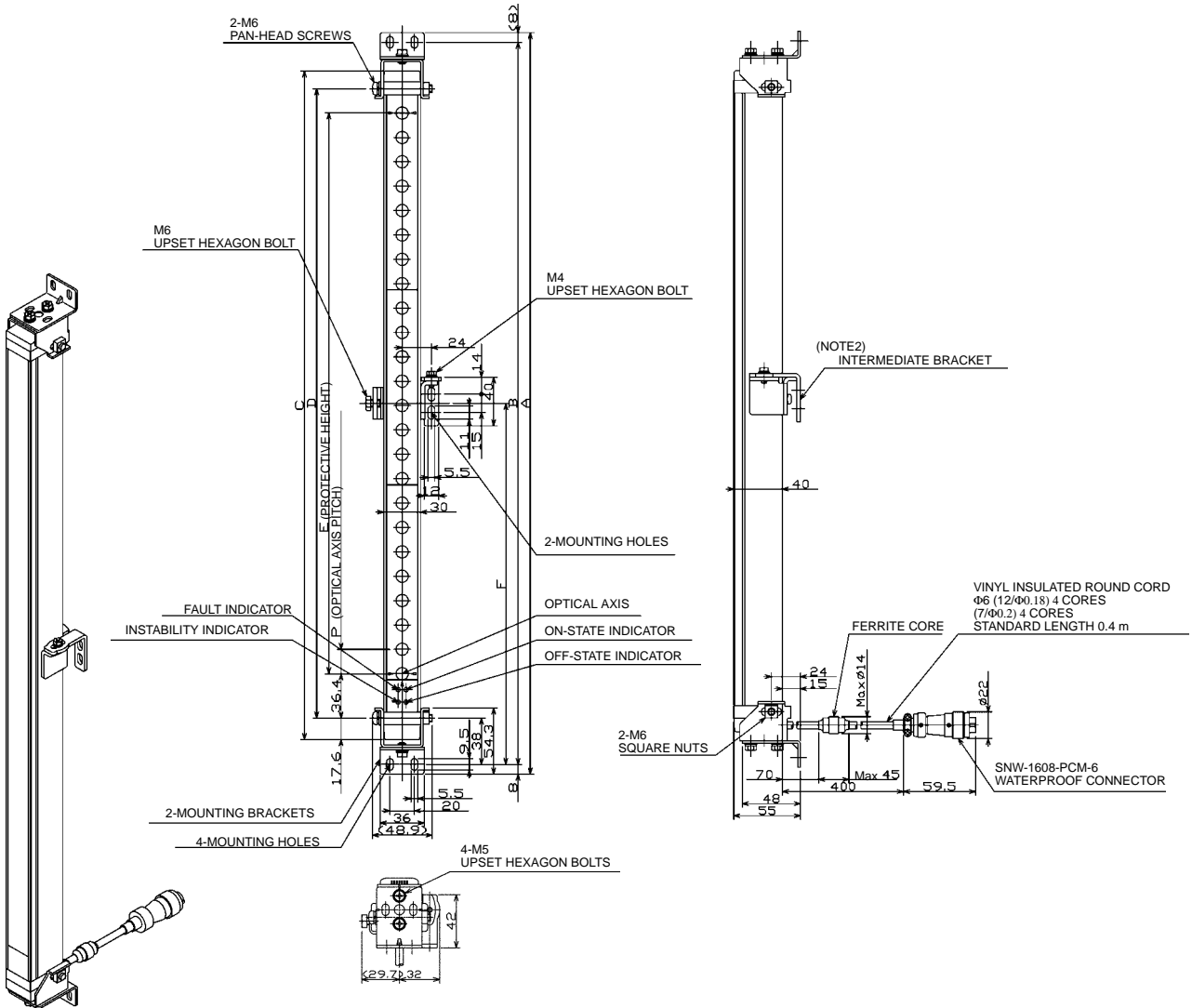
TYPE	A	B	C	D	E	F	P	UNIT : mm	
								UM	RO
F3S-A161-L	288.4	272.4	228.5	196.4	150			16	
F3S-A321-L	448.4	432.4	388.5	356.4	310		10	32	
F3S-A481-L	608.4	592.4	548.5	516.4	470			48	
F3S-A082-L	288.4	272.4	228.5	196.4	140			8	
F3S-A162-L	448.4	432.4	388.5	356.4	300			16	
F3S-A242-L	608.4	592.4	548.5	516.4	460		20	24	
F3S-A322-L	768.4	752.4	708.5	676.4	620	376.2		32	
F3S-A482-L	1088.4	1072.4	1028.5	996.4	940	536.2		48	

NOTE 2 THIS INTERMEDIATE BRACKET AND MOUNTING SCREW HOLES FOR IT ARE APPLIED TO TYPE F3S-A322-L AND F3S-A482-L

- A Full length when mounting bracket
- B Bracket mounting hole center width
- C Full length of main sensor
- D Sensor mounting hole center width
- E Protective height
- F Mounting bracket (intermediate) mounting position
- P: Optical axis pitch

Receiver

F3S-A -D



MOUNTING SCREW HOLES

NOTE 1 SIZES AND NUMBER OF OPTICAL AXES ARE AS BELOW

P	A	B	C	D	E	F	P	UNIT : mm	
								UM	RO
F3S-A161-D	288.4	272.4	228.5	196.4	150			16	
F3S-A321-D	448.4	432.4	388.5	356.4	310		10	32	
F3S-A481-D	608.4	592.4	548.5	516.4	470			48	
F3S-A082-D	288.4	272.4	228.5	196.4	140			8	
F3S-A162-D	448.4	432.4	388.5	356.4	300			16	
F3S-A242-D	608.4	592.4	548.5	516.4	460			24	
F3S-A322-D	768.4	752.4	708.5	676.4	620	376.2		32	
F3S-A482-D	1088.4	1072.4	1028.5	996.4	940	536.2		48	

NOTE 2 THIS INTERMEDIATE BRACKET AND MOUNTING SCREW HOLES FOR IT ARE APPLIED TO TYPE F3S-A322-L AND F3S-A482-L

- A Full length when mounting bracket
- B Bracket mounting hole center width
- C Full length of main sensor
- D Sensor mounting hole center width
- E Protective height
- F Mounting bracket (intermediate) mounting position
- P: Optical axis pitch

### 3-4 Mounting

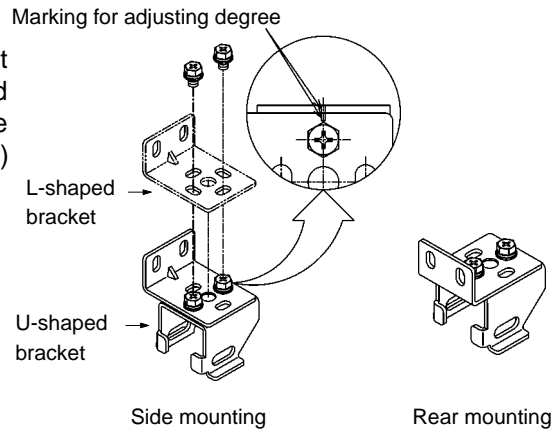
#### 3-4-1 Mounting Procedure

- Mount the F3S-A to ensure a bend radius of at least R36 (mm) on the F3S-A cord so as to minimize the possibility of functional failure due to age deterioration. Be careful not to allow the bend radius of the cord to become smaller than R36 even if the cord comes in contact with the mounting surface.
- The emitter and receiver must be mounted level. Design a mounting configuration based on the effective aperture angle of the F3S-A (about  $\pm 1.5^\circ$  with a detection distance of 5 m) and the adjustment range for the mounting brackets (See section 3-4-3 for more details.).

**[Procedure] With the F3S-A161, 321, 481, 082, 162, 242**

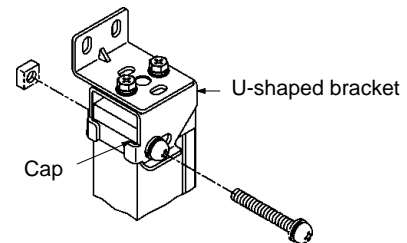
**1. Mounting Bracket (Top and Bottom) Assembly**

Choose the mounting direction for the L- and U-shaped bracket combination based on the mounting direction (side or rear) and temporarily secure the brackets with two M5 x 8 screws. Be sure to align the markings for adjusting degree (scribed lines) on the L- and U-shaped brackets at this time.



**2. Mounting Bracket (Top and Bottom) Installation**

Clasp the cap with the U-shaped bracket and insert the M6 x 45 screw through the mounting holes of the U-shaped bracket and the F3S-A. Press the U-shaped bracket flush against the rear of the F3S-A and secure it temporarily with square nuts.



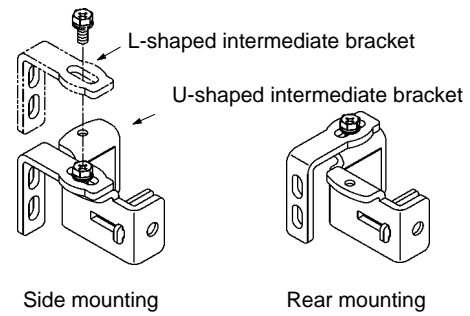
**3. Sensor Mounting**

Secure the L-shaped bracket to the mounting surface making sure that the emitter and receiver are mounted at the same height.

**F3S-A322 and 482**

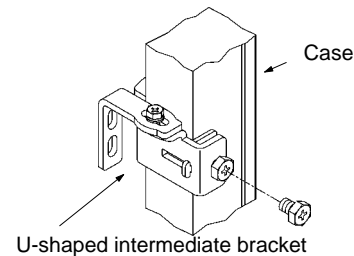
**1. Mounting Bracket (Intermediate) Assembly**

Choose the mounting direction for the L- and U-shaped intermediate bracket combination based on the mounting direction (side or rear) and temporarily secure the brackets with the M4 x 10 screw.



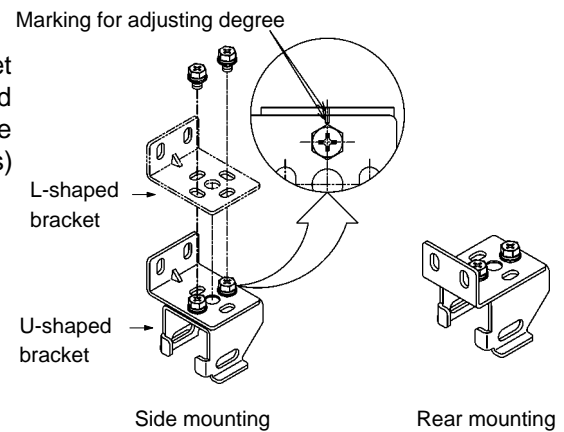
**2. Mounting Bracket (Intermediate) Installation**

Clasp the center of the case with the U-shaped bracket and temporarily secure the bracket to the F3S-A with the M6 x 8 screw. The mounting bracket (intermediate) for the emitter is oriented upside down when compared to the bracket of the receiver. Refer to Section 3-3 for details.



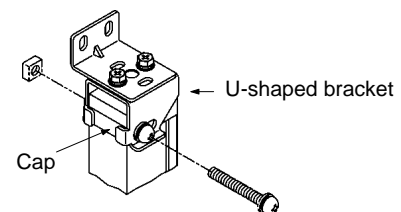
**3. Mounting Bracket (Top and Bottom) Assembly**

Choose the mounting direction for the L- and U-shaped bracket combination based on the mounting direction (side or rear) and temporarily secure the brackets with two M5 x 8 screws. Be sure to align the markings for adjusting degree (scribed lines) on the L- and U-shaped brackets at this time.



**4. Mounting Bracket (Top and Bottom) Installation**

Clasp the cap with the U-shaped bracket and insert the M6 x 45 screw through the mounting holes of the U-shaped bracket and the F3S-A. Press the U-shaped bracket flush against the rear of the F3S-A and secure it temporarily with square nuts.

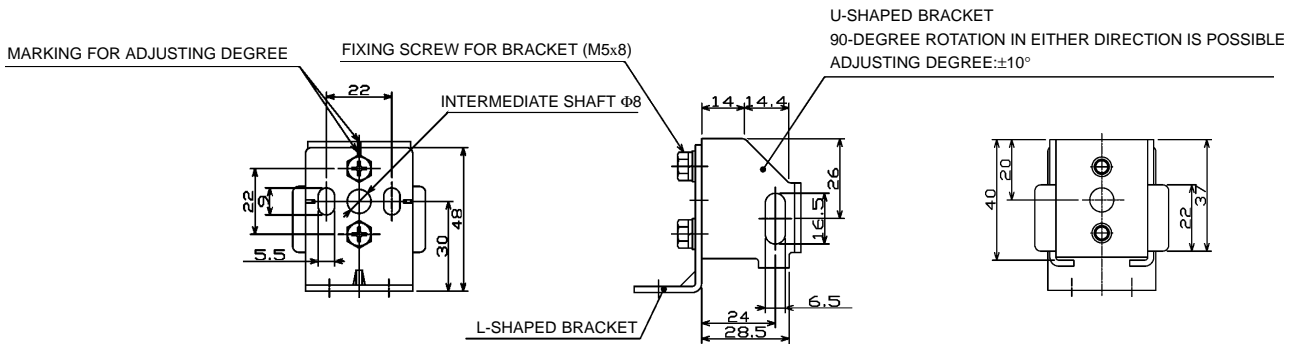
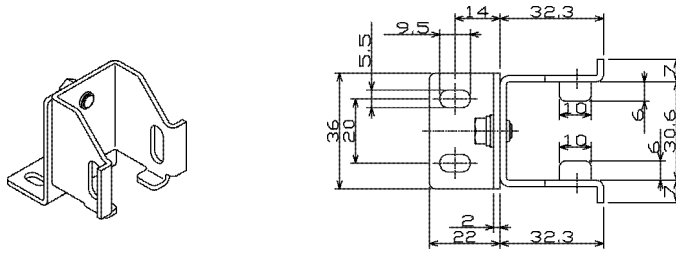


**5. Sensor Mounting**

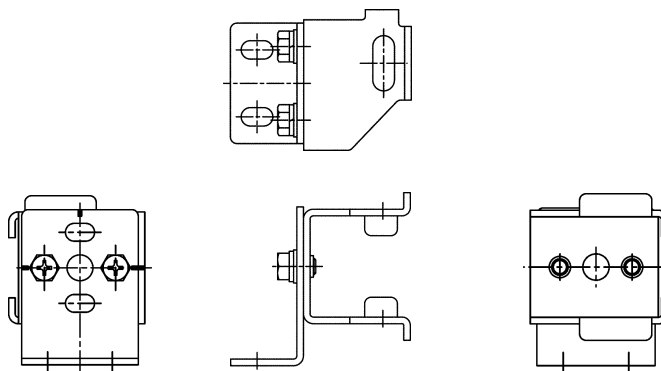
Secure the L-shaped bracket to the mounting surface making sure that the emitter and receiver are mounted at the same height. Then secure the L-shaped intermediate bracket to the mounting surface.

### 3-4-2 Dimensional Drawing of the Mounting Bracket Assembly (Rear Mounting)

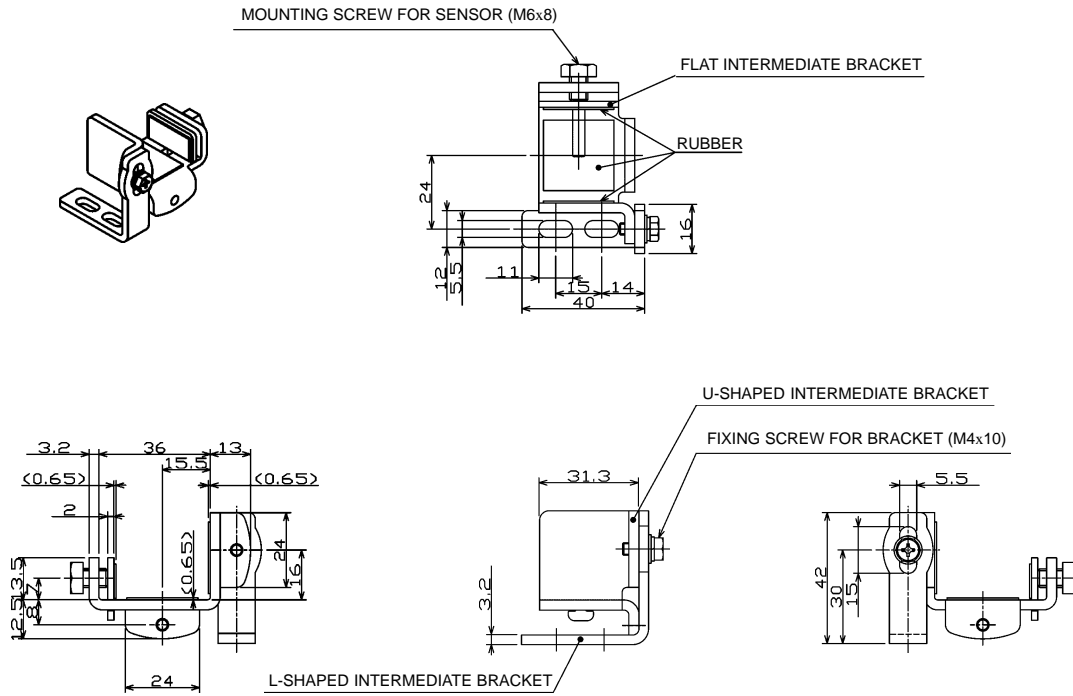
#### Mounting Brackets (Top and Bottom)



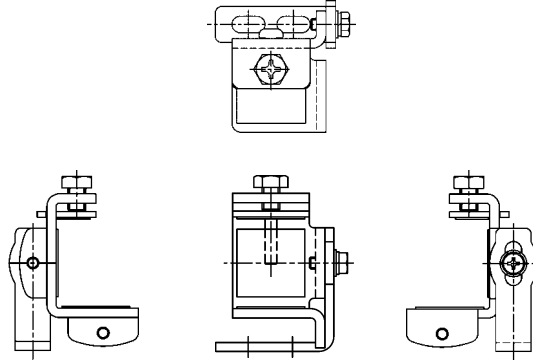
#### Configuration of U-shaped Intermediate Bracket Mounted at 90 Degree Angle



Mounting Brackets (Intermediate): Use with the F3S-A322 and F3S-A482.

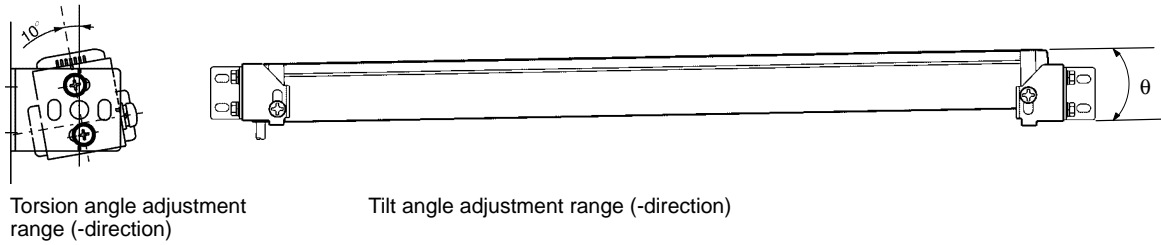
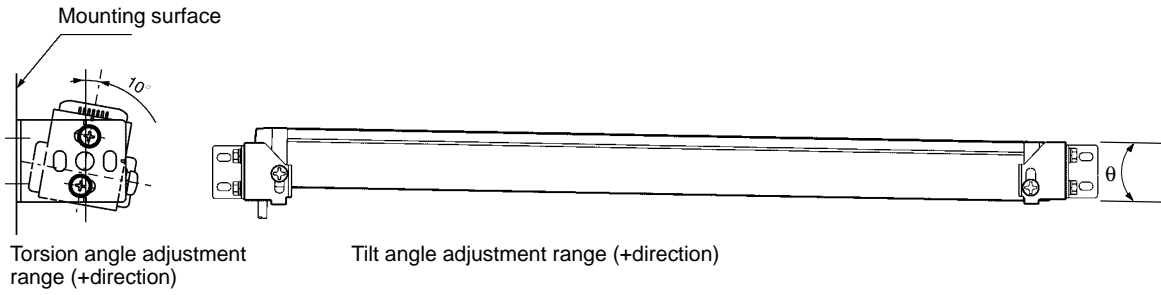


Configuration of U-shaped Intermediate Bracket Mounted at 90 Degree Angle

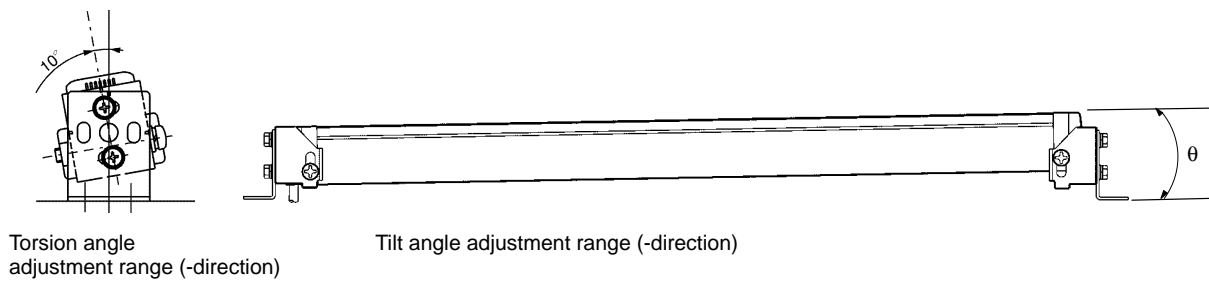
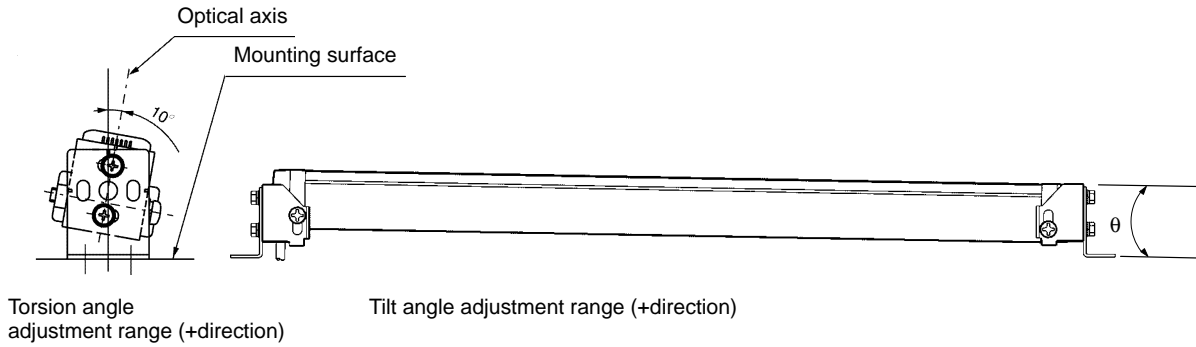


### 3-4-3 Mounting Angle Adjustment Range

#### Side Mounting



#### Rear Mounting




Tilt Angle Adjustment Range ( $\theta$ )

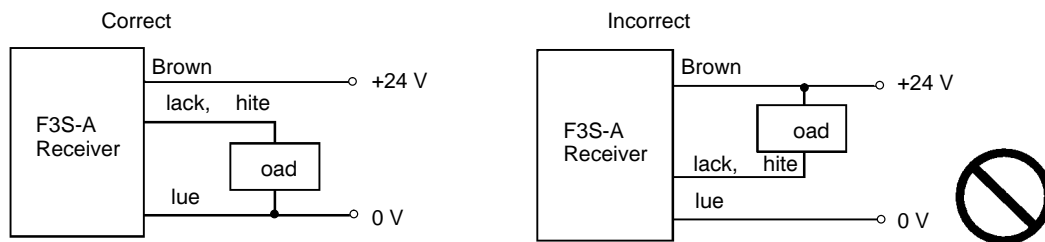
Model	$\theta$
F3S-A161	2.9°
F3S-A321	1.6°
F3S-A481	1.1°
F3S-A082	2.9°
F3S-A162	1.6°
F3S-A242	1.1°
F3S-A322	0.8°
F3S-A482	0.6°



## 3-5 Wiring

### WARNING

 <b>WARNING</b>
Do not short output lines to the +24V line.
Connect a load between the output and 0 V line. If a load is mistakenly connected between the output and +24 V line, the operating mode will switch to the mode in which output is turned ON when light is interrupted, creating a dangerous situation.
Be sure to use both output lines when constructing the safety system. The safety system constructed using only one line may result in serious injury under a faulty condition of the output circuit.

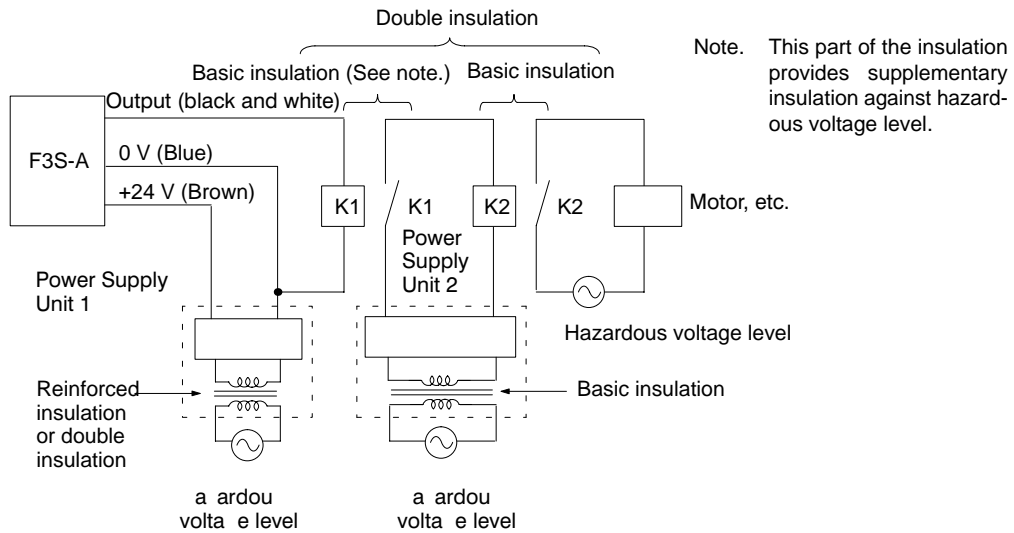


### 3-5-1 Power Supply Units and Loads

DC power supply units must satisfy all the conditions below.

- The power supply is connected to the F3S-A only and not to other devices or machines.
- The power supply conforms to EMC Directive (industrial environment).
- The power supply conforms to Low-voltage Directive.
- The power supply conforms to UL508 (output current is less than 8A) or UL1310.
- The power supply uses double or reinforced insulation between the primary and secondary circuits.
- The power supply automatically resets overcurrent protection characteristics (voltage drop).
- The power supply maintains an output holding time of at least 20 ms.
- FG (frame ground terminal) should be connected to PE when using a commercially available switching regulator.
- Recommended power supplies: S82K, S82J, S82F or S82F-P made by OMRON.

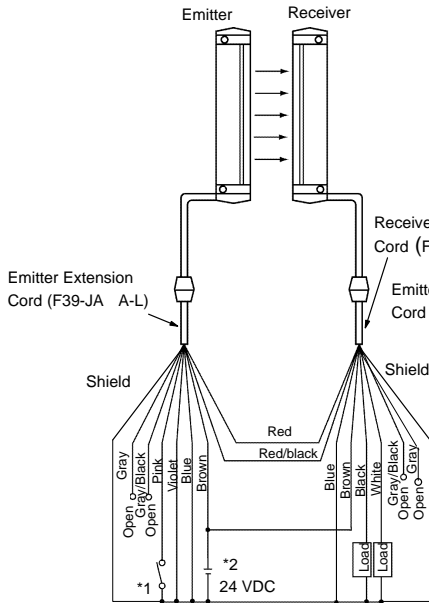
Use double insulation as shown in the figure below to protect the load from hazardous voltage levels when the load is a relay. The basic insulation shown in the following illustration should insulate against hazardous voltage levels (230 VAC, etc.), not simply against 24 VDC.



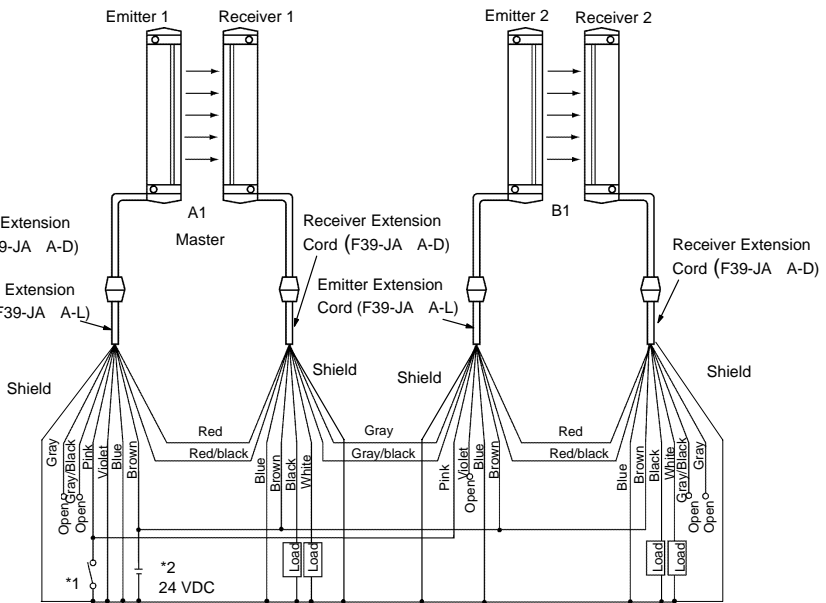
### 3-5-2 Wiring Diagram

See Section 3-2 for more details on sensor IDs (A1, A2, B1)

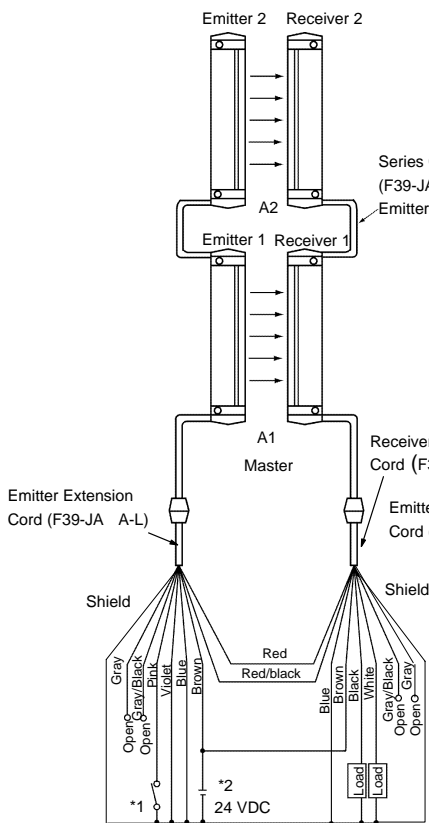
■ 1 Set



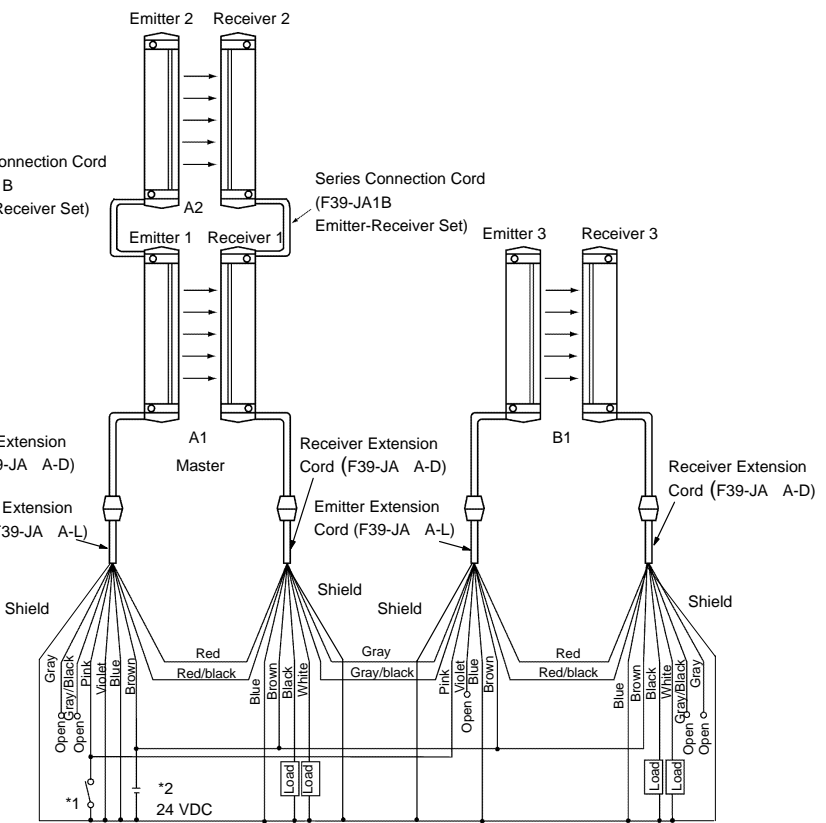
■ Parallel Connection



■ Series Connection



■ Mixed Connection



\*1 External diagnosis switch that is shorted for normal operation and is open for external diagnosis.

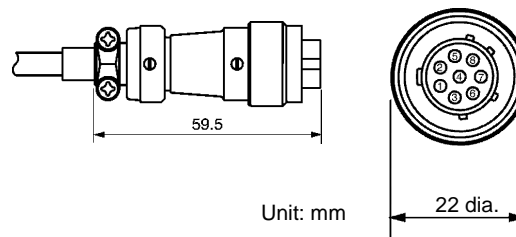
\*2 Use the same power supply unit.

### 3-5-3 Wiring Procedure

1. Connect the emitter extension cord (F39-JA A-L optional) to the emitter.  
The cord with the **yellow line** on the outer jacket is the emitter extension cord.
2. Connect the receiver extension cord (F39-JA A-D optional) to the receiver.
3. Connect the shielded wire of the cord to the 0V line of the power supply.  
Connect the 0V line of the power supply directly to protective earth (PE) or mount a capacitor (metallized polyester capacitor, etc.) with a minimum 47-nF capacity and minimum 630 V voltage rating between the 0V line and PE.

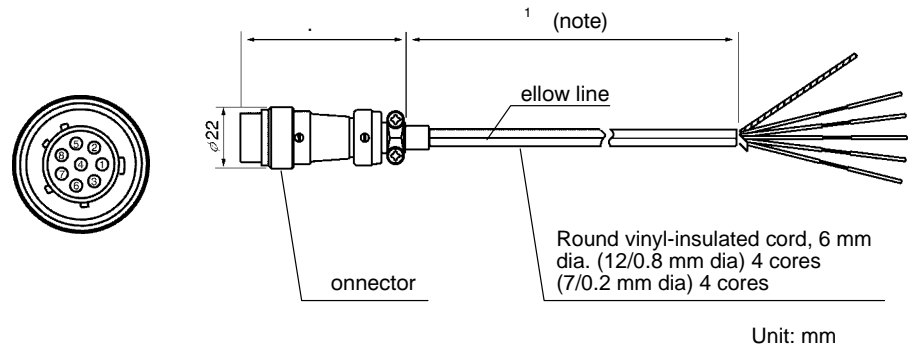
Note. Be sure to wire correctly. Failure to do so may damage the F3S-A.  
Be sure to use shielded twisted pair cable (cross-section at least 0.2 mm<sup>2</sup> in diameter) when extending the sync line (red, red/black, gray, gray/black) without using an extension cord. Be sure to connect the shield to the 0V line of the power supply.

#### Connector (Main Unit End)



Pin No.	Receiver	Emitter
1	0 V	0 V
2	+24 V	+24 V
3	Sync line 2 (+)	Sync line 2 (+)
4	Sync line 1 (+)	Sync line 1 (+)
5	Sync line 1 (-)	Sync line 1 (-)
6	Sync line 2 (-)	Sync line 2 (-)
7	Control output 2	Master selection input
8	Control output 1	External diagnosis input

Emitter Extension Cord (F39-JA A-L Optional)



Pin No.	Wire Color (Label Marking)	Signal Name (Label Marking)
1	Blue (Blue)	0 V (0 V)
	Shield (Shield)	
2	Brown (Brown)	+24 V (24 VDC)
3	Gray (Gray)	Sync line 2 (+) (SYNC.2 (+))
4	Red (Red)	Sync line 1 (+) (SYNC.1 (+))
5	Red/Black* (Red/Black)	Sync line 1 (-) (SYNC.1 (-))
6	Gray/Black* (Gray/Black)	Sync line 2 (-) (SYNC.2 (-))
7	Violet (Violet)	Master selection input (MASTER)
8	Pink (Pink)	External diagnosis input (EXT.)

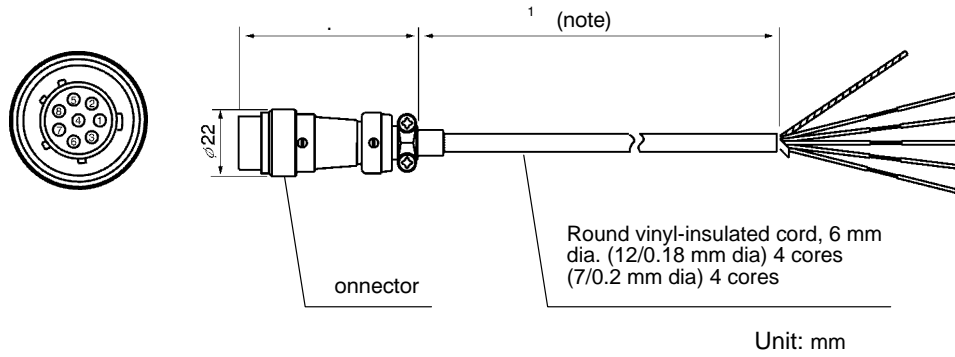
\*The red/black wire and the gray/black wire are red and gray wires, respectively, with a black line.

Note. Dimensions differ according to the model as shown in the following table.

Unit: mm

Model	L
F39-JA1A-L	3000
F39-JA2A-L	7000
F39-JA3A-L	10000

Receiver Extension Cord (F39-JA A-D Optional)



Pin No.	Wire Color (Label Marking)	Signal Name (Label Marking)
1	Blue (Blue)	0 V (0 V)
	Shield (Shield)	
2	Brown (Brown)	+24 V (24 VDC)
3	Gray (Gray)	Sync line 2 (+) (SYNC.2(+))
4	Red (Red)	Sync line 1 (+) (SYNC.1(+))
5	Red/Black* (Red/Black)	Sync line 1 (-) (SYNC.1(-))
6	Gray/Black* (Gray/Black)	Sync line 2 (-) (SYNC.2(-))
7	White (White)	Control output 2 (OUTPUT2)
8	Black (Black)	Control output 1 (OUTPUT1)

\*The red/black wire and the gray/black wire are red and gray wires, respectively, with a black line.

Note. The dimensions differ according to the model as shown in the following table.

Units: mm

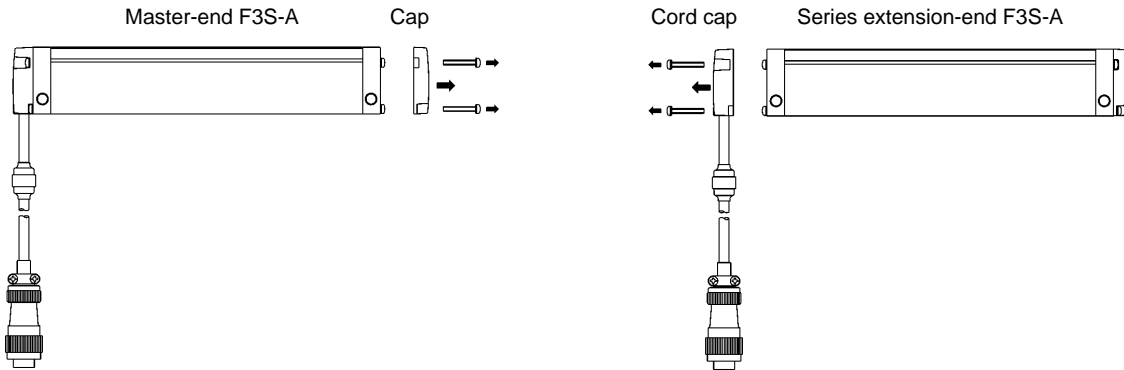
Model	L
F39-JA1A-D	3000
F39-JA2A-D	7000
F39-JA3A-D	10000

### 3-5-4 Series Connection Procedure

Note. The series connection cord is the same for both the emitter and the receiver.

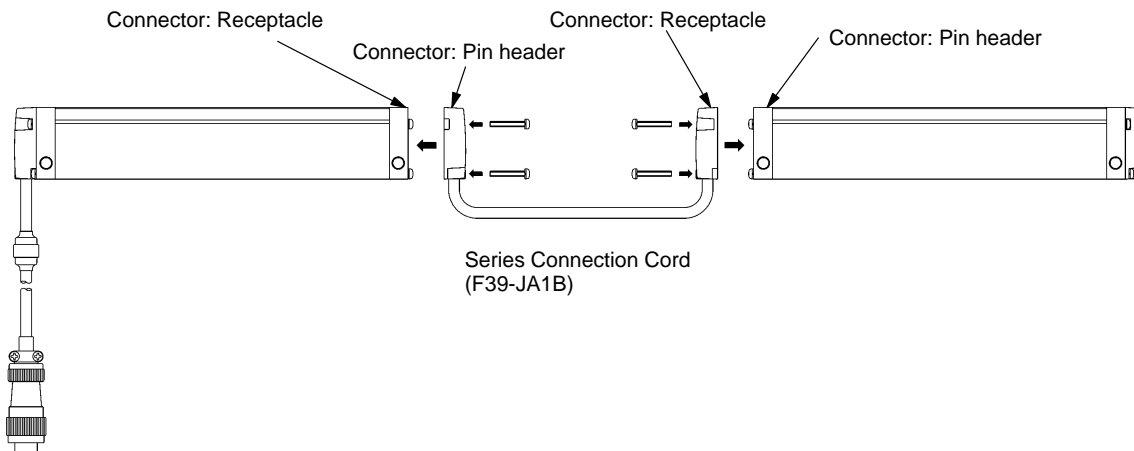
[Procedure]

1. Remove the cap from the master-end F3S-A (e.g., master sensor) as well as the cord cap on the series extension-end F3S-A. Save the four M3 x L20 screws used to secure the caps and reuse them to secure the series connection cord.

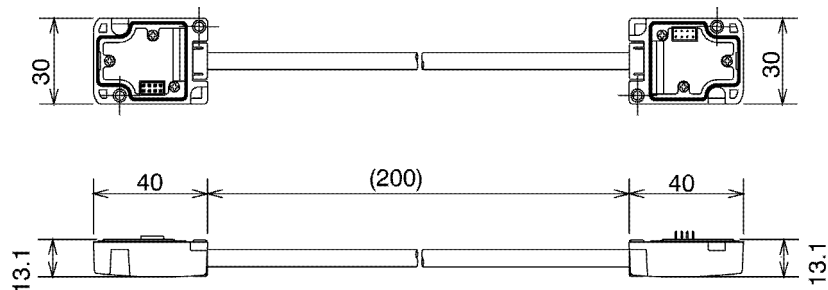


2. Make sure the connectors are properly connected and secure the series connection cord to both F3S-As with screws. Use a torque force of 0.54 N·m (5.5 kg·cm) to tighten the screws.

Reverse the above procedure to remove the series connection cord and replace the cap or cord cap. Use a torque force of 0.54 N·m (5.5 kg·cm) to secure the caps.



#### Series Connection Cord (F39-JA1B Optional)



### 3-5-5 Check List (2/3)

The last person in charge will check the items shown in the following check list.

**Check the following items to make sure wiring is correct before turning ON power.**

1. The power supply unit is only connected to the F3S-A.
2. The power supply unit is a 24-VDC unit that conforms to the EMC Directive, Low-voltage Directive and output holding specifications.
3. The polarity of the power supply connection is not reversed.
4. The emitter extension cord is properly connected to the emitter and the receiver extension cord is properly connected to the receiver.
5. Double insulation is used between the output and the hazard potential (commercial power supplies, etc.).
6. Outputs are not shorted to the +24V line.
7. Loads are not connected to the +24V line.
8. Sync lines are not connected to the +24V line or 0V line.
9. No lines are connected to a commercial power supply.
10. When two or more F3S-A's are used, they are connected properly or countermeasures are taken to prevent mutual interference.
11. With parallel connection, the master select input terminal of the master emitter is connected to the 0V line and the master select input terminal of the slave emitter is open.
12. With parallel connection, the external diagnosis input terminals of all emitters are connected together.

**Turn ON power and make sure the F3S-A is operating properly as described below.**

See *Section 4. Operation* for more details on operation and functions. If the F3S-A is not operating properly, take action as described in *Section 7. Troubleshooting*.

1. The F3S-A will begin operating normally within 5 seconds after power is turned ON if the external diagnosis input terminal is connected to the 0V line.
2. The external diagnosis function will activate if the external diagnosis input terminal is opened after power is turned ON.



## 3-6 Adjustment

### 3-6-1 Adjustment Procedure

When using a series connection, adjust the optical axes from the series extension end in sensor ID order (A3 → A2 → A1). Any attempt to adjust the optical axes in order starting from the master end will not be accepted because the OFF-state indicator (red) will remain lit if the series extension end is not receiving light.

[Procedure]

1. Check the following points.

The optical surfaces of the emitter and receiver should not be dirty.

There should be no light-interrupting objects in the F3S-A detection zone.

2. Adjust the torsion angle of the emitter while monitoring the indicator for the receiver and locate the point where the ON-state indicator (ON: green) is lit and the instability indicator (UNSTAB: orange) goes OFF.

If the instability indicator does not go OFF, temporarily set the torsion angle at the most stable state and adjust the tilt angle.

If the ON-state indicator is OFF, adjust the tilt angle.

3. Adjust the torsion angle and tilt angle so that light-receiving condition becomes as stable as possible. The level of stability becomes higher as the offset angle that ensures stable light-receiving condition becomes larger. When the above adjustments have been completed, tighten all brackets and mounting screws while being careful not to change the optical axis adjustment for the F3S-A. The tightening torque for these screws is shown in the following table.

Mounting bracket types	Screw designation and length (mm)	Tightening torque
Mounting brackets (top and bottom)	M5 × 8	2.3 N·m (23.5 kg·cm)
	M6 × 45	4.3 N·m (43.9 kg·cm)
Mounting brackets (intermediate)	M4 × 10	1.2 N·m (12.2 kg·cm)
	M6 × 8	4.3 N·m (43.9 kg·cm)

4. If stable light receiving condition is not obtained through the angle adjustment of the emitter, perform the following adjustments.

If the instability indicator does not go OFF, temporarily fix the emitter at the most stable state and conduct angle adjustment for the receiver according to the procedure described in the above step 2.

If the ON-state indicator is not lit, reset the emitter to its initial temporary mounting state (refer to *Section 3-4*) and conduct angle adjustment for the receiver according to the procedure described in the above step 2.

5. If stable light receiving condition is not obtained through the above angle adjustment of the receiver, check for parallelism between the emitter mounting surface and the receiver mounting surface and also check if the emitter and receiver are mounted to the same height.

### 3-6-2 Check List (3/3)

The last person in charge will check the items in the following check list.

After mounting the F3S-A, make sure it is operating properly as shown below. Also make sure that interference light is not received by the F3S-A.

See *Section 4. Operation* for more details on operation and functions.

If the F3S-A is not operating properly take action as described in *Section 7. Troubleshooting*.

1. Make sure the test rod is not deformed.  
Make sure the F3S-A is operating as shown below with the machine stopped.
2. Make sure there is nothing in the detection zone. The light indicator (orange) for the emitter and the ON-state indicator (green) for the receiver will light within 5 seconds after F3S-A power is turned ON.
3. A test rod with the same diameter as that printed on an optical surface can be detected at any position in the detection zone. In other words, the OFF-state indicator (red) on the receiver will remain lit when the test rod enters the detection zone.

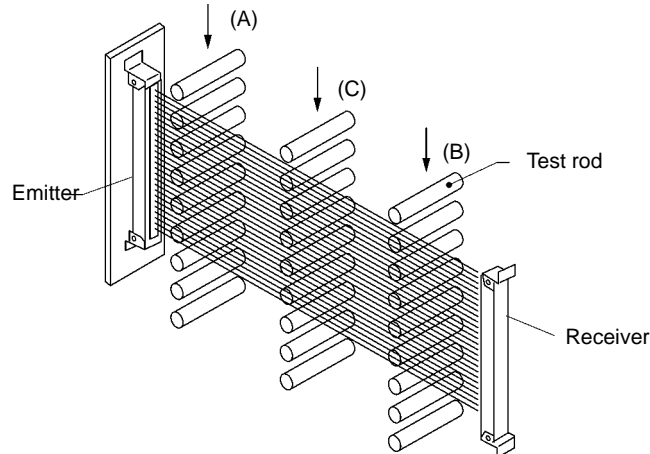
Detection check points are:

- (A) Protective height directly in front of the emitter
- (B) Protective height directly in front of the receiver
- (C) Protective height midway between the emitter and receiver

\*When using an F3S-A 1 and F3S-A 2 together, use the correct test rod for each type of sensor because the diameters of the test rods are different.

F3S-A 1: 15-mm diameter test rod ID No. 2988969-9

F3S-A 2: 25-mm diameter test rod ID No. 2988970-2



4. If the external diagnosis input terminal is opened after F3S-A power is turned ON, output turns OFF because light emission is stopped. If the external diagnosis input terminal is shorted to the 0V line, output turns ON because light is emitted.
5. The interference light search function activates if the F3S-A power is turned ON with the external diagnosis input terminal left open. (The OFF-state indicator (red) and the fault indicator (yellow) for the receiver flash simultaneously.)

The receiver indicators indicate that there is no interference light. (The instability indicator (orange) for the receiver is not lit. If it was lit, this would indicate the presence of interference light.)

Operate the machine and check to see if the dangerous part stops under the conditions below.

6. The dangerous part moves when there is nothing in the detection zone.
7. The dangerous part stops immediately when the test rod is inserted into the detection zone directly in front of the emitter, directly in front of the receiver and midway between the emitter and receiver. (Be sure to use the correct test rod as explained in 3.)
8. The dangerous part remains stopped as long as the test rod is present in the detection zone.
9. The dangerous part stops when the F3S-A power supply is turned OFF.
10. The overall machine response time actually measured is less than the calculated response time.

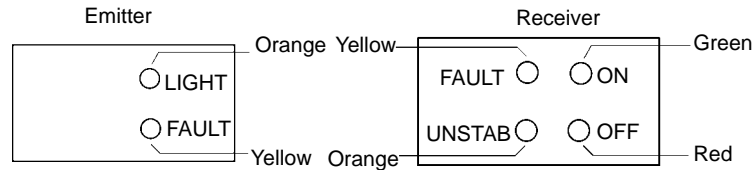
# SECTION 4 Operation

## Symbols

Indicator Status

- Not lit
- Lit (continuously lit)
- Flashing (flashing in about 0.5-s intervals)
- Flicker (irregularly lit and not lit)

Indicator Layout and Colors



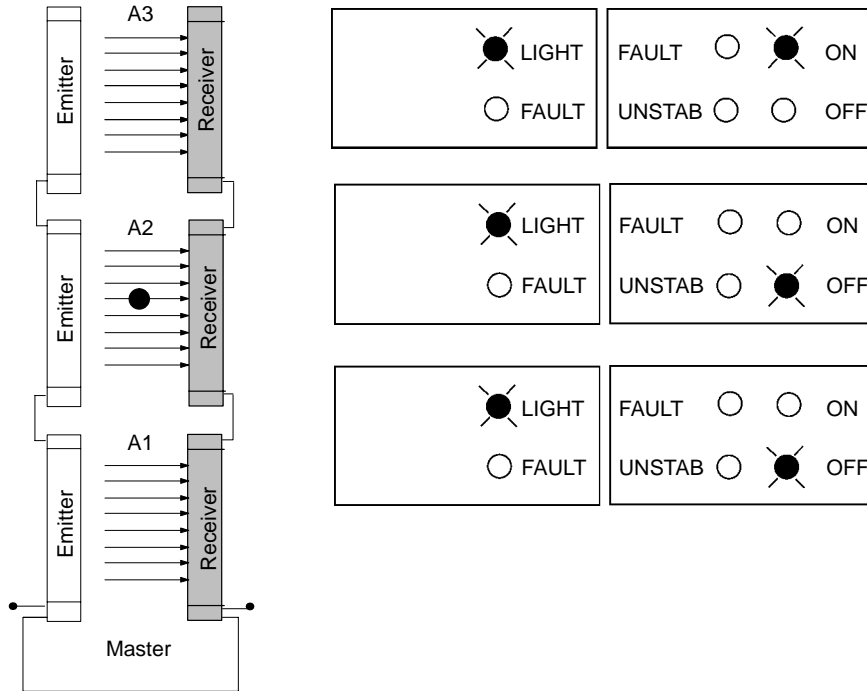
## 4-1 Normal Operation

Status	Indication		Output 1	Output 2
Stable light reception Adequate light for all optical axes	<input checked="" type="radio"/> LIGHT <input type="radio"/> FAULT	FAULT <input type="radio"/> ON UNSTAB <input type="radio"/> OFF	ON	ON
Interrupted light An interrupted optical axis	<input checked="" type="radio"/> LIGHT <input type="radio"/> FAULT	FAULT <input type="radio"/> ON UNSTAB <input type="radio"/> OFF	OFF	OFF
Unstable light reception Insufficient light for at least one optical axis The instability indicator (UNSTAB) will flicker if the amount of light received approaches stable light received status.	<input checked="" type="radio"/> LIGHT <input type="radio"/> FAULT	FAULT <input type="radio"/> ON UNSTAB <input checked="" type="radio"/> OFF	ON	ON
	<input checked="" type="radio"/> LIGHT <input type="radio"/> FAULT	FAULT <input type="radio"/> ON UNSTAB <input checked="" type="radio"/> OFF	ON	ON
Timing Chart				
Power supply	ON	5 s max.		
Light emission	ON			
Light receiving status	Light reception	55 ms (Stable light reception)	20 ms	
Output (both 1 and 2)	ON	(See Note)	(See Note)	

**Note** Includes maximum OFF time of 210  $\mu$ s for self diagnosis. See *Output Waveform with Output ON* in 4-4 I/O Circuits.

Series Connection

- Both outputs will turn OFF if any set enters interrupted status.
- The OFF-state indicator for the interrupted receiver as well as subsequent receivers connected on the master end will light. If A2 is interrupted for example, then the OFF-status indicators of A1 and A2 will light.



## 4-2 Selecting Additional Functions

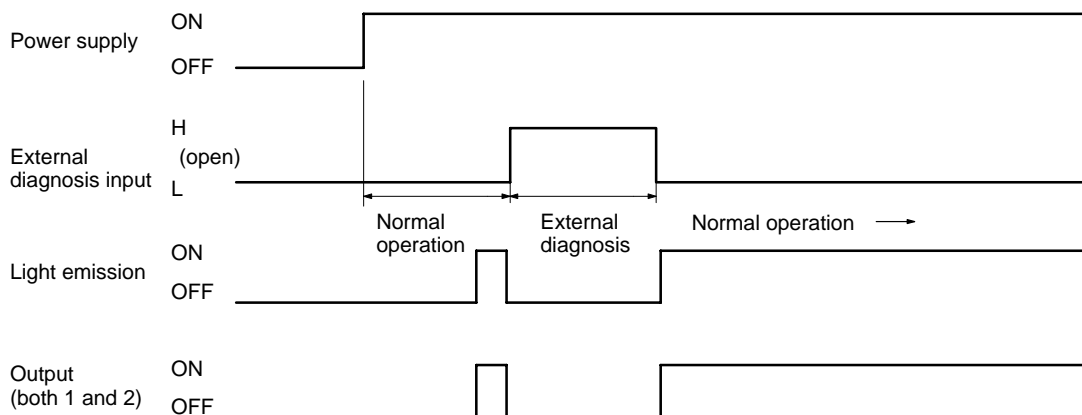
The F3S-A is also equipped with the functions below. Check to see if the F3S-A operates properly and interference light is not received by carrying out these function.

### External Diagnosis Function

This function determines whether the basic function of the receiver is operating properly. The receiver is operating correctly if both receiver outputs are OFF when the external diagnosis input terminal is opened after power is turned ON. The external diagnosis cannot be performed if the light is interrupted.

Procedure	Indication	Output 1	Output 2
1. Check to see if the external diagnosis input terminal is connected to the 0V line before turning F3S-A power ON.	<div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; padding: 5px;"> <input type="radio"/> LIGHT <input type="radio"/> FAULT                 </div> <div style="border: 1px solid black; padding: 5px;">                     FAULT <input type="radio"/> <input type="radio"/> ON UNSTAB <input type="radio"/> <input type="radio"/> OFF                 </div> </div>	OFF	OFF
2. Check to see if F3S-A output turns ON when power is turned ON.	<div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; padding: 5px;"> <input checked="" type="radio"/> LIGHT <input type="radio"/> FAULT                 </div> <div style="border: 1px solid black; padding: 5px;">                     FAULT <input type="radio"/> <input checked="" type="radio"/> ON UNSTAB <input type="radio"/> <input type="radio"/> OFF                 </div> </div>	ON	ON
3. External diagnosis will begin (light emission stops) when the external diagnosis input terminal is opened.	<div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; padding: 5px;"> <input checked="" type="radio"/> LIGHT <input type="radio"/> FAULT                 </div> <div style="border: 1px solid black; padding: 5px;">                     FAULT <input type="radio"/> <input type="radio"/> ON UNSTAB <input type="radio"/> <input checked="" type="radio"/> OFF                 </div> </div>	OFF	OFF
4. Connect the external diagnosis input terminal to the 0V line to terminate the external diagnosis function. This may be done with F3S-A power ON or OFF.	(After returning to normal operation) <div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; padding: 5px;"> <input checked="" type="radio"/> LIGHT <input type="radio"/> FAULT                 </div> <div style="border: 1px solid black; padding: 5px;">                     FAULT <input type="radio"/> <input checked="" type="radio"/> ON UNSTAB <input type="radio"/> <input type="radio"/> OFF                 </div> </div>	ON	ON

Timing Chart

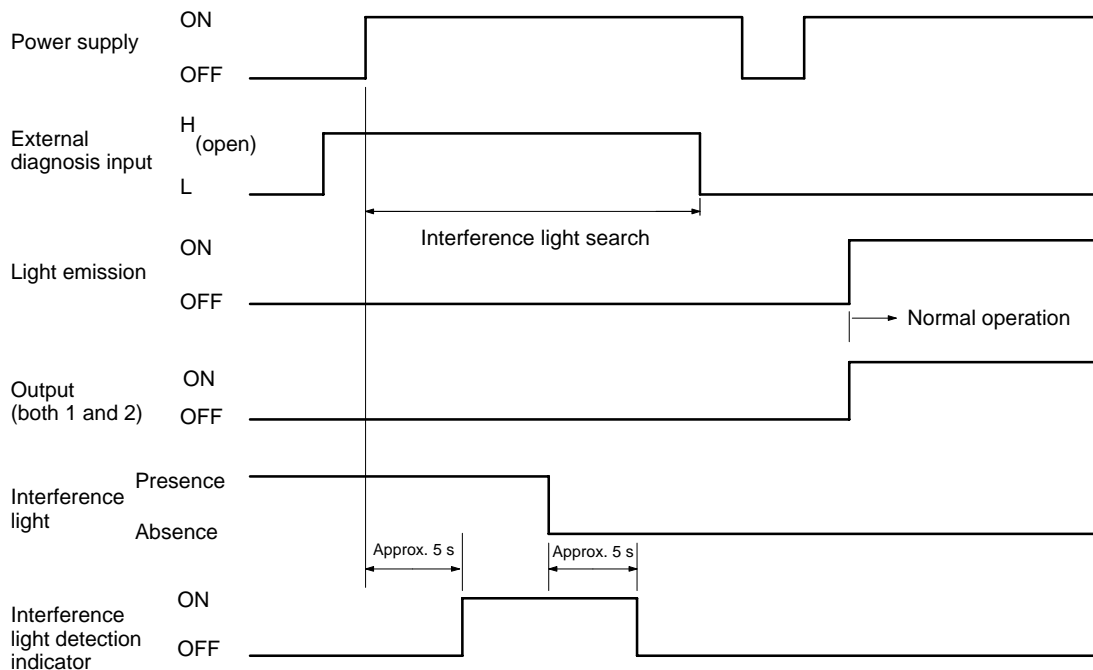


**Interference Light Search Function**

This function checks for the presence or absence of harmful interference light. The receiver searches for interference light when F3S-A power is turned ON with the external diagnosis input terminal open. It takes about 5 seconds to detect interference light, and the indicator will continue indicating the presence of interference light for 5 seconds even after the light is eliminated.

Procedure	Indication	Output 1	Output 2
1. Check to see if the external diagnosis input terminal is open before turning ON the power supply.	<div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; padding: 5px;"> <p style="text-align: center;">○ LIGHT</p> <p style="text-align: center;">○ FAULT</p> </div> <div style="border: 1px solid black; padding: 5px;"> <p>FAULT ○ ○ ON</p> <p>UNSTAB ○ ○ OFF</p> </div> </div>	OFF	OFF
2. Execute the interference light search function by turning power ON.	<p style="text-align: center;">No interference light detected</p> <div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; padding: 5px;"> <p style="text-align: center;">⊗ LIGHT</p> <p style="text-align: center;">⊗ FAULT</p> </div> <div style="border: 1px solid black; padding: 5px;"> <p>FAULT ⊗ ○ ON</p> <p>UNSTAB ○ ⊗ OFF</p> </div> </div> <p style="text-align: center;">Interference light detected</p> <div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; padding: 5px;"> <p style="text-align: center;">● LIGHT</p> <p style="text-align: center;">● FAULT</p> </div> <div style="border: 1px solid black; padding: 5px;"> <p>FAULT ● ○ ON</p> <p>UNSTAB ● ● OFF</p> </div> </div>	OFF	OFF
3. Connect the external diagnosis input terminal to the 0V line to terminate the external diagnosis function and then turn the power back ON.	<p style="text-align: center;">(After returning to normal operation)</p> <div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; padding: 5px;"> <p style="text-align: center;">● LIGHT</p> <p style="text-align: center;">○ FAULT</p> </div> <div style="border: 1px solid black; padding: 5px;"> <p>FAULT ○ ● ON</p> <p>UNSTAB ○ ○ OFF</p> </div> </div>	ON	ON







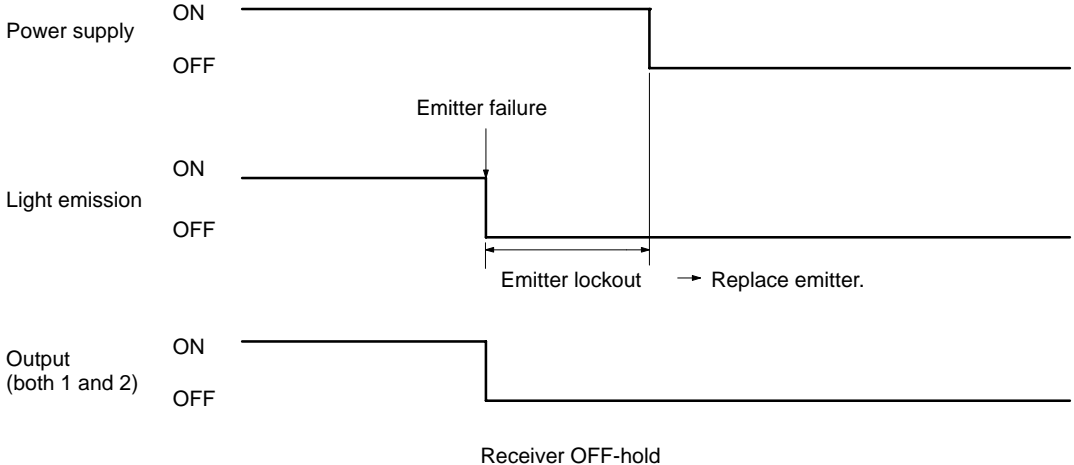






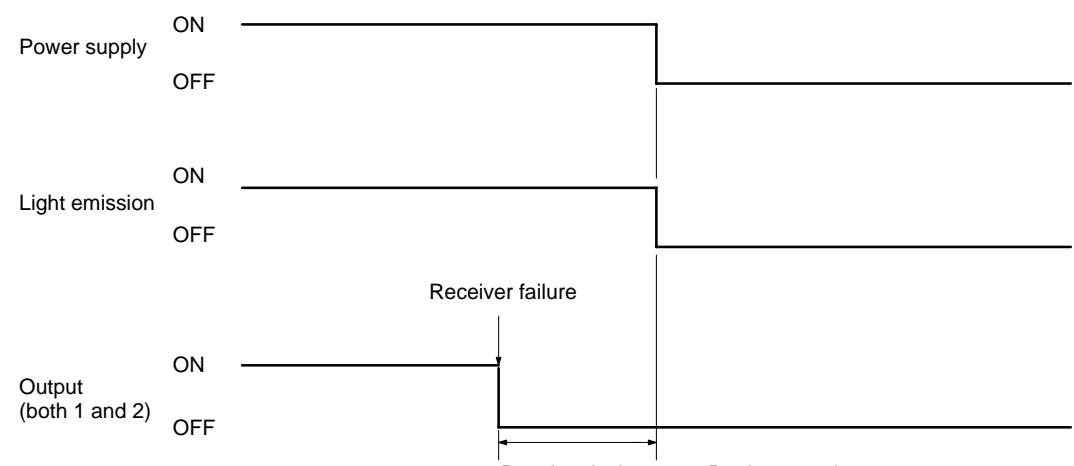
Timing Chart



### 4-3 When a Failure Occurs

#### Lock-out Condition



















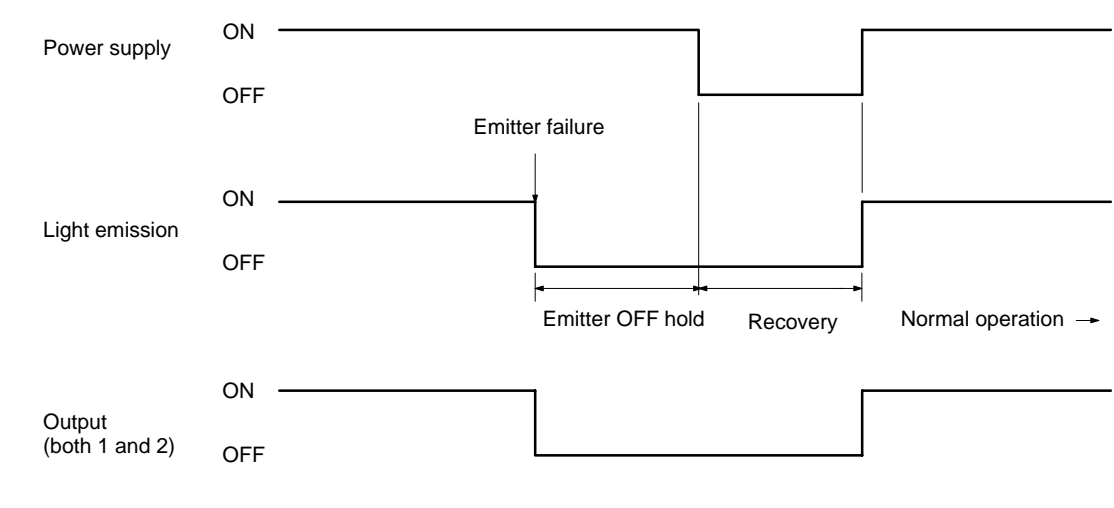


















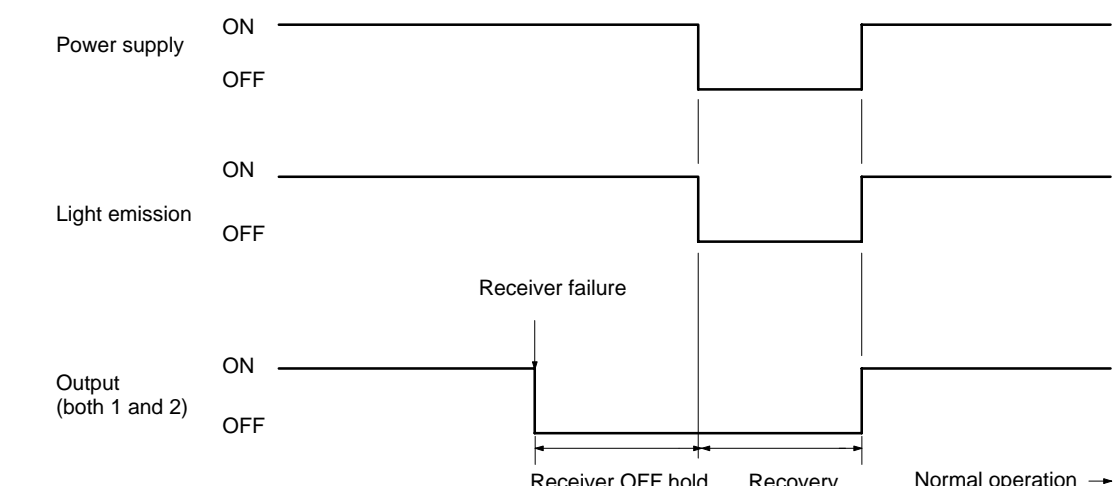
The F3S-A stops machine operation with lock-out condition when it determines that an unrecoverable failure has occurred. Terminate operation immediately and replace the locked out emitter or receiver with a new one.

Status	Indication		Output 1	Output 2
<b>Emitter lock-out</b> The sync signal to the emitter and receiver is stopped.	 LIGHT  FAULT	FAULT   ON UNSTAB   OFF	OFF	OFF
Timing Chart 				
<b>Receiver lock-out</b> Receiver output is OFF and the sync signal to the emitter on the slave end is stopped.	 LIGHT  FAULT	FAULT   ON UNSTAB   OFF	OFF	OFF
Timing Chart 				



**OFF-hold Condition**

The F3S-A stops machine operation with OFF-hold condition when it determines that a temporary, recoverable failure, such as an incorrect cord connection, short, broken wire, noise, power ON timing mismatch or shorted output load, has occurred.

Status	Indication	Output 1	Output 2						
<p><b>Emitter OFF-hold</b> The sync signal to the emitter and receiver is stopped.</p>	<table border="1" style="width: 100%; text-align: center;"> <tr> <td style="width: 50%; vertical-align: top;">  LIGHT    FAULT                 </td> <td style="width: 50%; vertical-align: top;"> <table border="1" style="width: 100%;"> <tr> <td style="width: 50%;">FAULT</td> <td style="width: 50%; text-align: right;"> ON</td> </tr> <tr> <td style="width: 50%;">UNSTAB</td> <td style="width: 50%; text-align: right;"> OFF</td> </tr> </table> </td> </tr> </table>	 LIGHT   FAULT	<table border="1" style="width: 100%;"> <tr> <td style="width: 50%;">FAULT</td> <td style="width: 50%; text-align: right;"> ON</td> </tr> <tr> <td style="width: 50%;">UNSTAB</td> <td style="width: 50%; text-align: right;"> OFF</td> </tr> </table>	FAULT	 ON	UNSTAB	 OFF	OFF	OFF
 LIGHT   FAULT	<table border="1" style="width: 100%;"> <tr> <td style="width: 50%;">FAULT</td> <td style="width: 50%; text-align: right;"> ON</td> </tr> <tr> <td style="width: 50%;">UNSTAB</td> <td style="width: 50%; text-align: right;"> OFF</td> </tr> </table>	FAULT	 ON	UNSTAB	 OFF				
FAULT	 ON								
UNSTAB	 OFF								
<p>Timing Chart</p> 									
Status	Indication	Output 1	Output 2						
<p><b>Receiver OFF-hold</b> Receiver outputs are OFF and the sync signal to the emitter on the slave end is stopped.</p>	<table border="1" style="width: 100%; text-align: center;"> <tr> <td style="width: 50%; vertical-align: top;">  LIGHT    FAULT                 </td> <td style="width: 50%; vertical-align: top;"> <table border="1" style="width: 100%;"> <tr> <td style="width: 50%;">FAULT</td> <td style="width: 50%; text-align: right;"> ON</td> </tr> <tr> <td style="width: 50%;">UNSTAB</td> <td style="width: 50%; text-align: right;"> OFF</td> </tr> </table> </td> </tr> </table>	 LIGHT   FAULT	<table border="1" style="width: 100%;"> <tr> <td style="width: 50%;">FAULT</td> <td style="width: 50%; text-align: right;"> ON</td> </tr> <tr> <td style="width: 50%;">UNSTAB</td> <td style="width: 50%; text-align: right;"> OFF</td> </tr> </table>	FAULT	 ON	UNSTAB	 OFF	OFF	OFF
 LIGHT   FAULT	<table border="1" style="width: 100%;"> <tr> <td style="width: 50%;">FAULT</td> <td style="width: 50%; text-align: right;"> ON</td> </tr> <tr> <td style="width: 50%;">UNSTAB</td> <td style="width: 50%; text-align: right;"> OFF</td> </tr> </table>	FAULT	 ON	UNSTAB	 OFF				
FAULT	 ON								
UNSTAB	 OFF								
<p>Timing Chart</p> 									

**When a Failure Occurs with Connection**

**Series Connection**

When an emitter goes to OFF-hold or lock-out condition, all remaining emitters and receivers will go to OFF-hold condition.

When a receiver goes to OFF-hold or lock-out condition, all remaining receivers will go to OFF-hold condition.

**Parallel Connection**

When an emitter goes to OFF-hold or lock-out condition, all emitters and receivers on the slave end of that emitter will go to OFF-hold condition. All emitters and receivers on the master end of the emitter will continue to operate normally.

When a receiver goes to OFF-hold or lock-out condition, all emitters and receivers on the slave end of that receiver will go to OFF-hold condition. All emitters and receivers on the master end of the receiver will continue to operate normally.

**Mixed Connection**

The following table summarizes the OFF-hold condition of emitters and receivers affected by an emitter or receiver that goes to OFF-hold or lock-out condition.

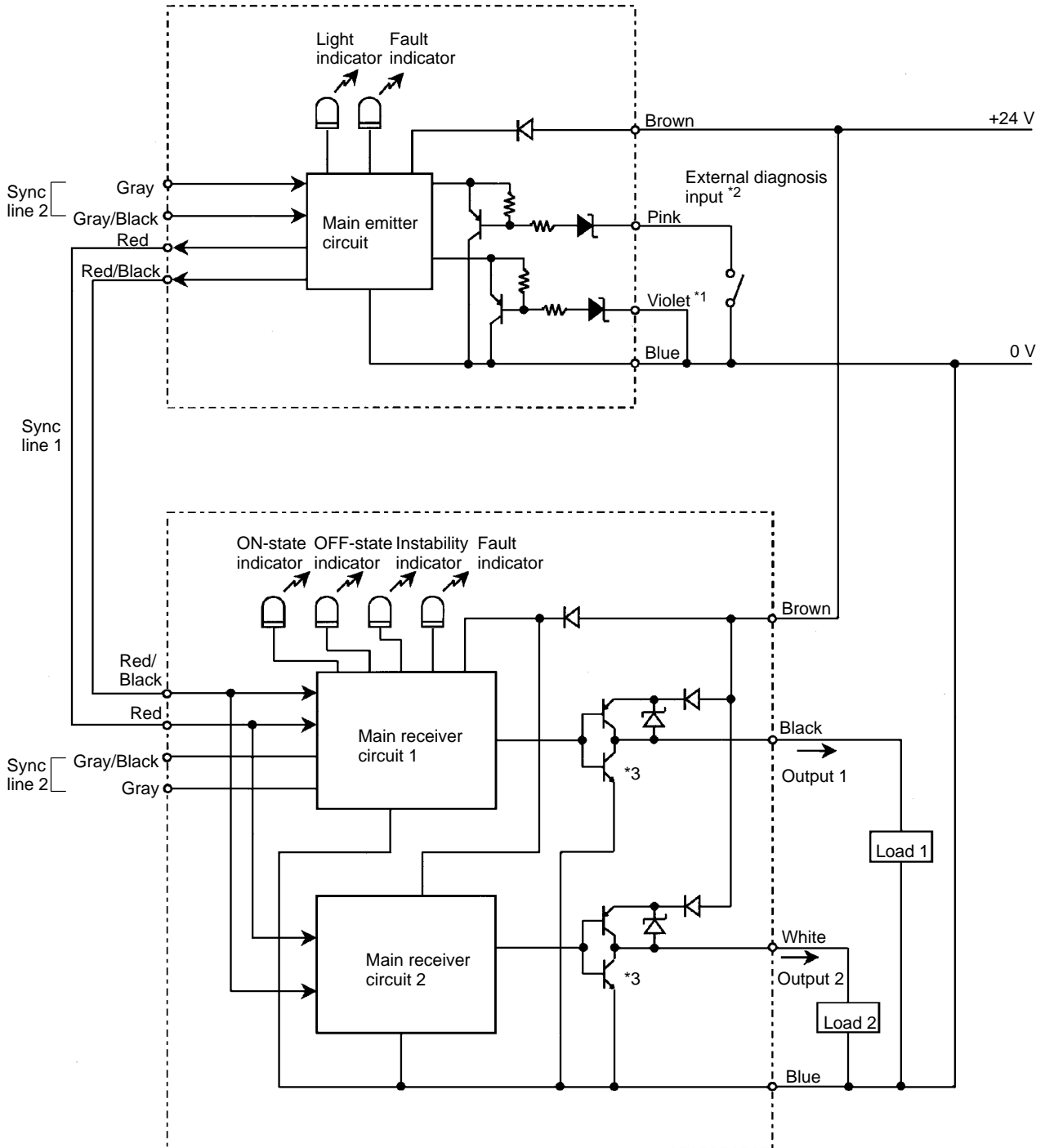
See *Executing Order for the Light Emitting and Light Receiving Function* under 3-2 Configuration for more details on sensor IDs A1, A2 to D4.

			OFF-hold Condition of Emitters and Receivers affected by a Sensor that goes to OFF-hold or Lock-out Condition																								
			A 1	A 2	A 3	A 1	A 2	A 3	B 1	B 2	B 3	B 1	B 2	B 3	C 1	C 2	C 3	C 1	C 2	C 3	D 1	D 2	D 3	D 1	D 2	D 3	
			E	E	E	R	R	R	E	E	E	R	R	R	E	E	E	R	R	R	E	E	E	R	R	R	
Sensor (Emitter or Receiver) that goes to OFF-hold or Lock-out Condition	A1	E	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
	A2	E	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	A3	E	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	A1	R	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	A2	R	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	A3	R	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	B1	E	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	B2	E	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	B3	E	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	B1	R	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	B2	R	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	B3	R	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	C1	E	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	C2	E	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	C3	E	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
C1	R	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
C2	R	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
C3	R	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
D1	E	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
D2	E	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
D3	E	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
D1	R	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
D2	R	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
D3	R	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	

E: Emitter FS-A□□□-L      R: Receiver F-A□□□-D  
 ■ : Sensor goes to OFF-hold condition      □ : Sensor continues to operate normally

# 4-4 I/O Circuits

## Circuit Diagram



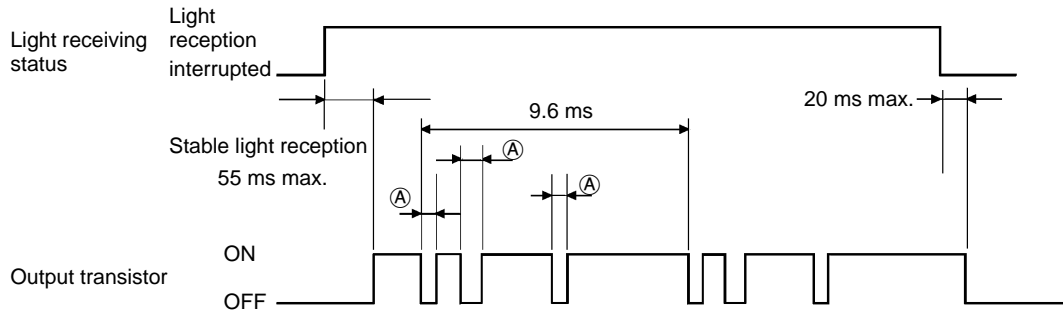
- \*1 Master: Connect to 0V  
Slave: Open
- \*2 Short: Normal light emission  
Open: External diagnosis function or interference light search function
- \*3 Cannot be used for NPN output.

**Output Waveform with Output ON**

The output transistor will be OFF for a maximum of 210 μs as shown in the following table in order to perform output circuit self diagnosis when the sensor is receiving light. The output circuit is diagnosed as proper when this OFF signal is fed back. If the output signal does not contain an OFF signal, the receiver determines that there is an output circuit or wiring failure and goes to OFF-hold condition.

The width and number of OFF signals are determined by the number of sensors connected in series. (See the table below.)

Check the input response time of a machine connected to the F3S-A carefully to ensure the machine will not malfunction due to the OFF signal.



Number of sensors connected in series	1	2	3
Number of pulses per 9.6 ms (number of A)	3 to 4	6 to 8	9 to 12
Pulse width at A(μs)	35 to 70	35 to 140	35 to 210
Total time of pulse widths per 9.6 ms (sum of A: μs )	200 max.	400 max.	600 max.

# SECTION 5 Applications

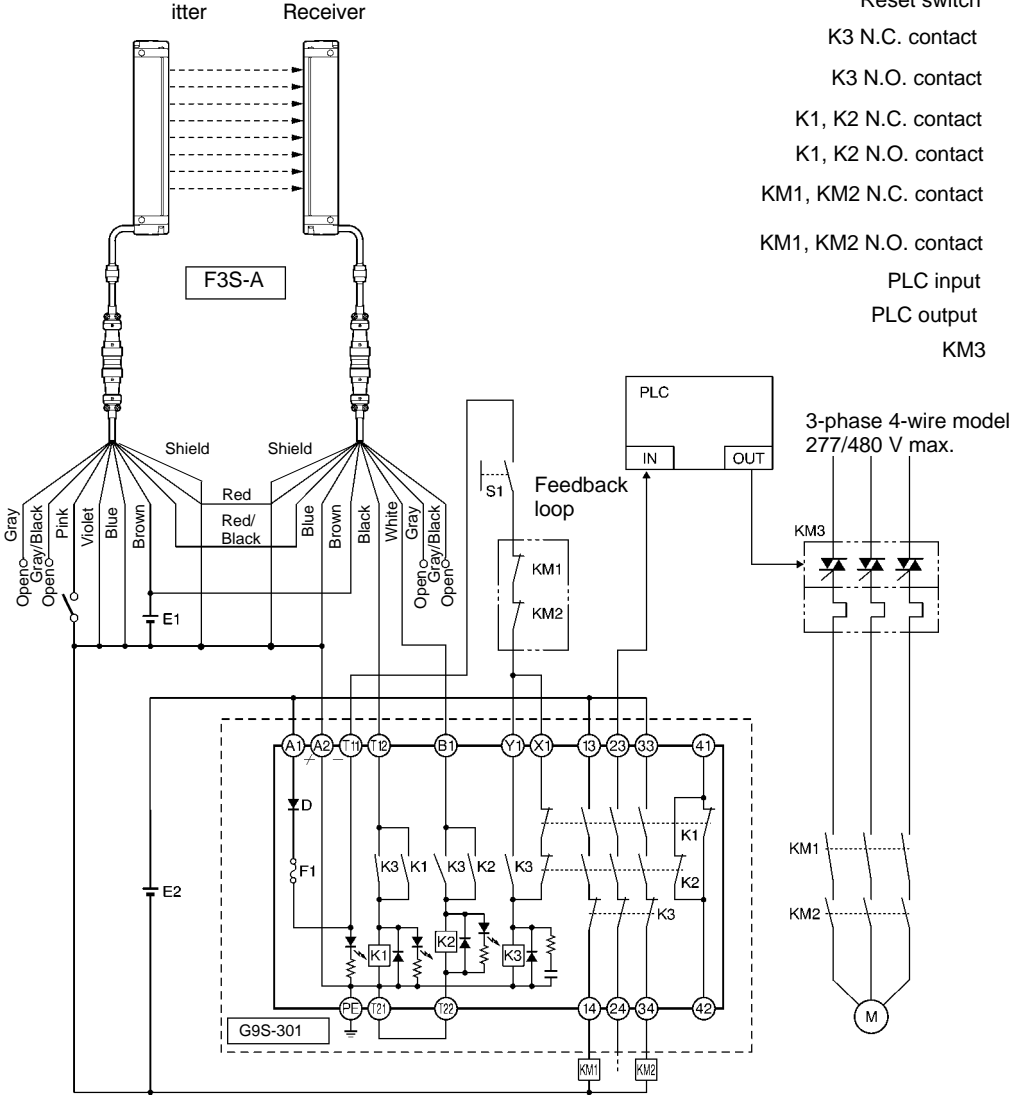
This section shows examples of a motor control system that combines an F3S-A and a G9S-301 safety relay unit.

These are category 4 systems (EN954-1 provision).

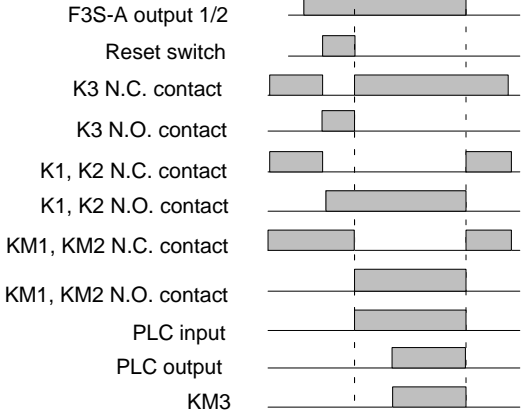
**Notes**

- Be sure to use DC-voltage power supplies for the safety relay unit and contactors KM1, KM2, KM4, and KM5.
- Always use separate power supplies for the F3S-A and other equipment.

**(1) 1 Set**



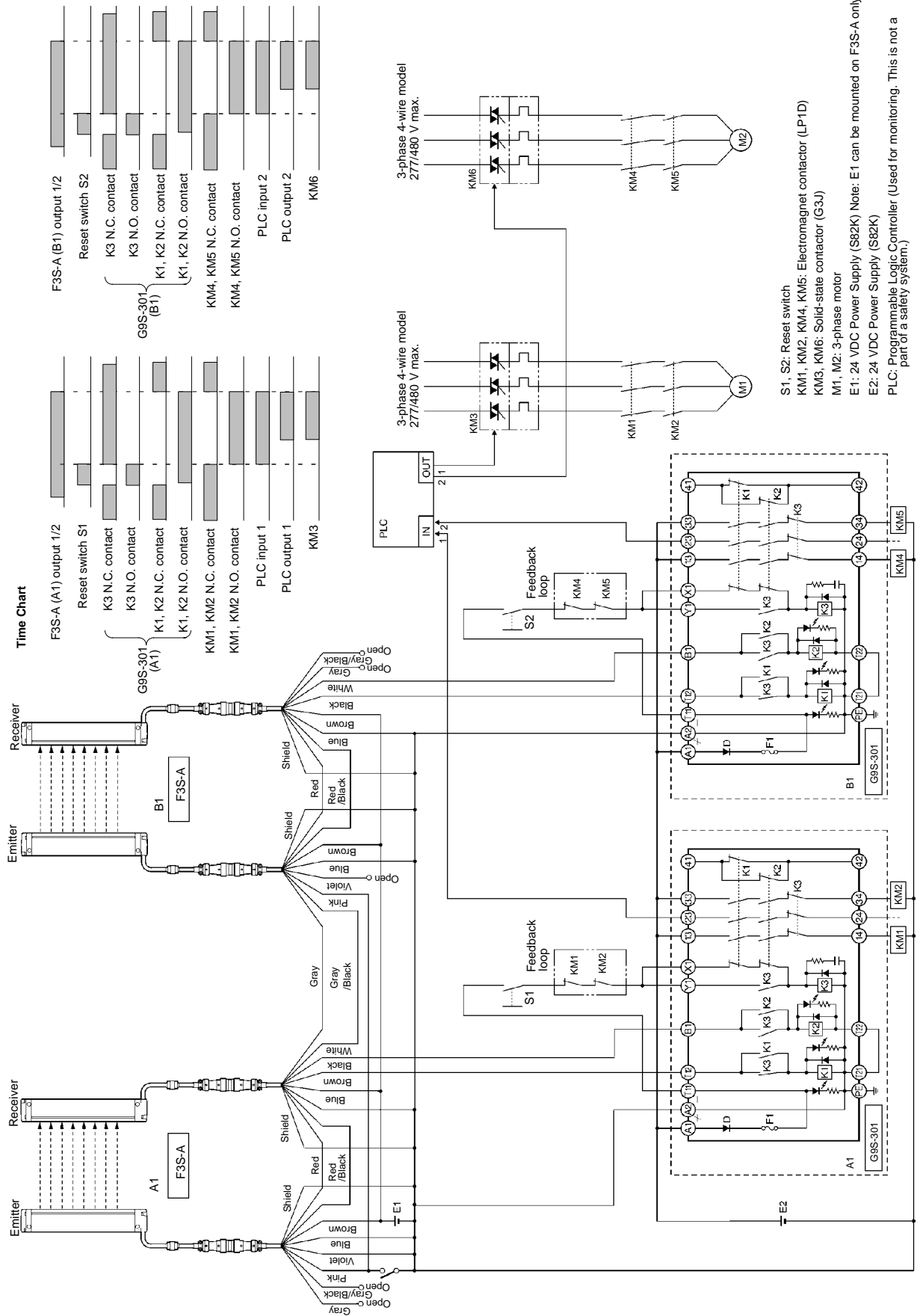
**Time Chart**



- S1: Reset switch
- KM1, KM2: Electromagnet contactor (LP1D)
- KM3: Solid-state contactor (G3J)
- M: 3-phase motor

- E1: 24 VDC Power Supply (S82K)  
Note: E1 can be mounted on the F3S-A only
- E2: 24 VDC Power Supply (S82K)
- PLC: Programmable Logic Controller (Used for monitoring. This is not a part of a safety system.)

## (2) Parallel Connection



# SECTION 6

## Maintenance

### ⚠ WARNING

Do not use the F3S-A until the following inspections are completed. Failure to do so may result in loss of life or serious injury.

- Note**
1. For safety, be sure to record and store inspection results.
  2. Make sure you are thoroughly familiar with the F3S-A and the machine prior to conducting an inspection.
  3. If the installer, design technician and user are different individuals, make sure the user has adequate guidelines for performing maintenance.

## 6-1 Daily Inspections

Be sure to inspect the following items at the start of work or after a shift change.

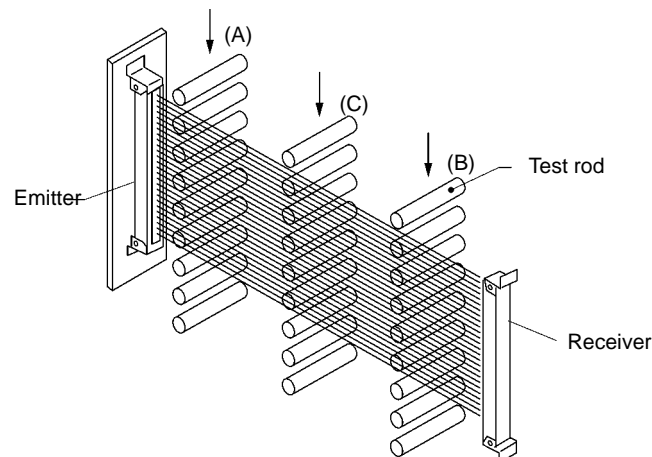
1.  No intrusion paths into dangerous machine parts except through the F3S-A detection zone.
2.  Some part of the operator's body remains in the F3S-A detection zone at all times while working in dangerous machine parts.
3.  The actual safety distance is greater than the calculated distance.
4.  No dirt or scratches on the optical surface or protective cover (F39-HA optional) of the F3S-A.
5.  The test rod is not deformed.
6.  Make sure there is nothing in the detection zone. The light indicator (orange) for the emitter and the ON-state indicator (green) for the receiver will light within 5 seconds after F3S-A power is turned ON.
7.  The test rod can be detected directly in front of the emitter (A), directly in front of the receiver (B) and midway between the emitter and receiver (C).

In other words, the OFF-state indicator (red) for the receiver will light when the test rod is inserted into the detection zone.

\*When using an F3S-A□□1 and F3S-A□□2 together, use the correct test rod for each type of sensor because the diameters of the test rods are different.

F3S-A□□1: 15-mm diameter test rod ID No. 2988969-9

F3S-A□□2: 25-mm diameter test rod ID No. 2988970-2



Operate the machine and check to see if the dangerous part stops under the conditions below.

8.  The dangerous part moves when there is nothing in the detection zone.
9.  The dangerous part stops immediately when the test rod is inserted into the detection zone directly in front of the emitter, directly in front of the receiver and midway between the emitter and receiver. (Use the correct test rod as explained in 7.)
10.  The dangerous part remains stopped as long as the test rod is present in the detection zone.
11.  The dangerous part will stop when the power supply is turned off with nothing in the detection zone.

## 6-2 Inspection Every Six Months

Inspect the following items every six months or when a machine setting is changed.

1.  Machine structure does not hinder stop and other safety functions.
2.  There is no machine modification or connection change that will adversely affect the control system.
3.  F3S-A outputs are correctly wired to the machine.
4.  The actual overall response time of the machine is less than the calculated response time.
5.  The control relay and contactor are good condition.
6.  The brackets, cap unit and cord cap are secured tightly.
7.  There is no interference light. (Carry out the interference light search function.)

## 6-3 Replacement

If the protective cover (F39-HA  optional) of the F3S-A is extremely dirty or scratched, F3SA will stop activating outputs. In this case, replace it with a new cover. The protective cover can be snapped onto the light curtain.



## SECTION 7

### Accessories (Optional)

#### Extension Cord (Emitter and Receiver Set)

Type	Length	Specification
F39-JA1A	3 m	Relaying connector type
F39-JA2A	7 m	
F39-JA3A	10 m	

#### Series Connection Cord (Emitter and Receiver Cords, 1 Each Forms a Set)

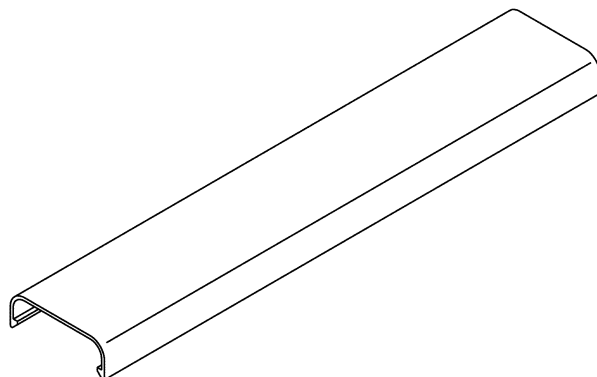
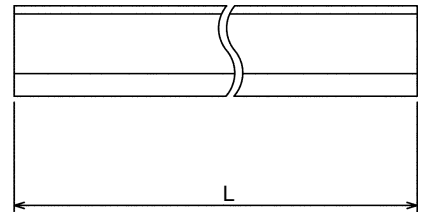
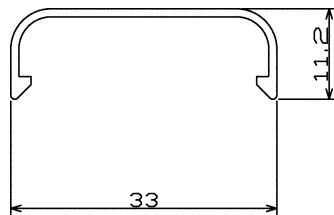
Type	Length
F39-JA1B	200 mm

#### Protective Cover

**(Emitter and Receiver Covers, 1 Each Forms a Set, Material: Acrylic)**

Unit: mm

Type	Applicable Models	L
F39-HA1	F3S-A161, F3S-A082	185
F39-HA2	F3S-A321, F3S-A162	345
F39-HA3	F3S-A481, F3S-A242	505
F39-HA4	F3S-A322	664
F39-HA5	F3S-A482	984



# SECTION 8

## Troubleshooting

### Symptoms

#### Emitter Problems

Symptoms	Cause and Remedy (See item number)
No indicator lights.	1
The light indicator (orange) flashes even though the external diagnosis function and interference light search function are not selected.	2
The external diagnosis function and interference light search function cannot be selected. (The light indicator (orange) lights without ever flashing.)	3
OFF-hold condition. (The fault indicator (yellow) flashes and the light indicator (orange) flickers.)	1, 2, 4, 5, 6, 7, 12
Lock-out condition. (The fault indicator (yellow) lights and the light indicator (orange) flickers.)	8

#### Receiver Problems

Symptoms	Cause and Remedy (See item number)
No indicator lights.	1
No light emission. (The ON-state indicator (green) does not light, only the OFF-state indicator (red) lights.)	2, 9, 10, 11, 3
Unstable light emission. (The ON-state indicator (green) lights, and the instability indicator (orange) lights or flashes.)	9, 10, 13
The fault indicator (yellow) and OFF-state indicator (red) flash even though the interference light search function is not selected.	2
The interference light search function cannot be selected. (The OFF-state indicator (red) lights without ever flashing.)	3
OFF-hold condition. (The fault indicator (yellow) flashes, the OFF-state indicator (red) lights and the instability indicator (orange) flickers.)	1, 4, 5, 6, 7, 12, 14, 15, 21
Lock-out condition. (The fault indicator (yellow) flashes, the OFF-state indicator (red) lights and the instability indicator (orange) flickers.)	8
Output load condition and indicator status are mismatched. (The OFF-state indicator (red) lights when load current flows and the ON-state indicator (green) lights when load current is not flowing.)	16
Indicators are operating normally according to light emission status, but current is not flowing to the load.	17
Indicators are operating normally according to light emission status, but current continues flowing to the load.	18
Output is OFF with series connection even with light emitting (ON-state indicator (green) lights).	19
The interference light search function continues operating and normal operation cannot be returned with parallel connection even though power is turned back ON with the external diagnosis input terminal connecting to 0V after the function is terminated.	20

## Cause and Remedy

No.	Cause and Remedy
1.Power Supply Failure	<p><b>Cause:</b>            The F3S-A and power supply are not wired correctly. (Wiring reversed, etc.)            The +24V line is shorted to the 0V line or protective earth (PE). Voltage on the primary side of the power supply failed. The power supply is damaged.            The connector between the main unit and the extension cord is loose.            The power supply has an insufficient capacity.            The PE and FG terminals of the power supply are not properly connected to PE.</p> <p><b>Remedy:</b>            Securely connect an appropriate power supply.</p>
2.Open External Diagnosis Input	<p><b>Cause:</b>            The external diagnosis input terminal of the emitter is open or shorted to the +24V line. If a switching element is used for external diagnosis input, then the switching element is damaged.            More than 8 hours elapsed since the interference light search function was selected.</p> <p><b>Remedy:</b>            Make sure the external diagnosis input terminal is securely connected to the 0V line.</p>
3.Shorted External Diagnosis Input	<p><b>Cause:</b>            The external diagnosis input terminal of the emitter is shorted to the 0V line or protective earth (PE).            If a switching element is used for external diagnosis input, then the switching element is damaged.</p> <p><b>Remedy:</b>            Make sure the external diagnosis input terminal is clearly open or apply at least 9 to 24 V.</p>
4.Master Selection Input Wiring Error	<p><b>Cause:</b>            The master selection input terminal is open if it is a master emitter.            The master selection input terminal is connected to the 0V line if it is a slave emitter.</p> <p><b>Remedy:</b>            Wire the master selection input terminal correctly.</p>
5.Sync Line Wiring Error	<p><b>Cause:</b>            The sync line between the emitter and receiver is broken.            The sync line between the emitter and receiver is shorted to the +24V line, 0V line or protective earth (PE).            The sync line for parallel connection is broken.            The sync line for parallel connection is shorted to the +24V line, 0V line or protective earth (PE). The sync line is wired incorrectly.            The cap screws for the series connection cord are loose.</p> <p><b>Remedy:</b>            Reconnect correctly.            (The F3S-A may be damaged if the sync line is shorted to the +24V line, 0V line or protective earth (PE).)</p>
6.Connection Sensor Failure	<p><b>Cause:</b>            Other F3S-A which is connected is in OFF-hold or lock-out condition.</p> <p><b>Remedy:</b>            Depending on the error condition, take steps 4, 5, 7, 8, 14, and 15 in order starting from the master emitter end.</p>
7.Power ON Sequence	<p><b>Cause:</b>            The power supply is not shared by emitters and receivers.            The power supply is not shared by all connected F3S-As.</p> <p><b>Remedy:</b>            Connect all F3S-As to the same power supply.</p>





























































No.	Cause and Remedy
8.Lock-out	Cause: Damaged F3S-A. Remedy: Terminate F3S-A operation immediately and turn the power OFF.
9.Dirt	Cause: Dirty optical surface. Light interrupting object in the detection zone. Remedy: Clean the optical surface.
10.Intense Interference Light	Cause: Extremely intense interference light such as sunlight is striking the optical surface of the receiver. Remedy: Interrupt the interference light.
11.Series Connection Sensor Failure	(With series connection) Cause: The F3S-A at the series extension end is interrupted. Remedy: None. Normal operation.
12.Noise	Cause: Significant noise. Remedy: If high-tension and power lines are run in the same duct, use other wiring or individual wiring ducts. Make sure no transceivers or cellular phones are being used near the F3S-As.
13.Improper Optical Axis Adjustment	Cause: The optical axis adjustment is incorrect. Remedy: Readjust the optical axis.
14.Shorted Output	Cause: At least one output is shorted to the +24V line, 0V line or protective earth (PE). Outputs are shorted together. Remedy: Rewire the output correctly. (The F3S-A may be damaged if an output line is shorted to the +24V line.)
15.Interference Light	Cause: Interference light is received. (Result of checking using the interference light search function.) Remedy: Interrupt the interference light. If another F3S-A is the cause of the interference light, connect sync lines.
16.Load Wiring Error	Cause: The load is connected between the output line and +24V line. Remedy: Connect the load between the output line and the 0V line.
17.Load Wiring Error	Cause: The output line is not connected to the load. The output line is broken. Remedy: Rewire the line correctly.
18.Load Wiring Error	Cause: The load is connected to a +24V line without being connected to an output line. Remedy: Rewire the line correctly.

No.	Cause and Remedy
19. Master-end Sensor Interrupted	(With series connection) Cause: The F3S-A on the master end is interrupted. Remedy: None. Normal operation.
20. External Diagnosis Input Wiring Error (With parallel connection)	Cause: The external diagnosis input terminals on the emitters are not connected together. Remedy: Connect the external diagnosis input terminals together.
21. Extension Cord Connection Error	Cause: The receiver extension cord is connected to the emitter and the emitter extension cord is connected to the receiver. Remedy: Connect the extension cords properly.

# SECTION 9

## Indicator and Output Table

 Not lit  
  Flashing  
  Lit  
  Flickering

Functions and conditions	Indicators		Output 1	Output 2
	Emitter	Receiver		
Stable light reception	 LIGHT  FAULT	FAULT   UNSTAB  	ON	ON
Unstable light reception	 LIGHT  FAULT	FAULT   UNSTAB   <i>Flickers as the light status approaches stability</i>	ON	ON
Light interrupted	 LIGHT  FAULT	FAULT   UNSTAB  	OFF	OFF
External diagnosis	 LIGHT  FAULT	FAULT   UNSTAB  	OFF	OFF
Interference (light search function): No interference light	 LIGHT  FAULT	FAULT   UNSTAB  	OFF	OFF
Interference (light search function): With interference light	 LIGHT  FAULT	FAULT   UNSTAB  	OFF	OFF
OFF-hold condition: Emitter fault	 LIGHT  FAULT	FAULT   UNSTAB  	OFF	OFF
OFF-hold condition: Receiver fault	 LIGHT  FAULT	FAULT   UNSTAB  	OFF	OFF
Lockout condition: Emitter fault	 LIGHT  FAULT	FAULT   UNSTAB  	OFF	OFF
Lockout condition: Receiver fault	 LIGHT  FAULT	FAULT   UNSTAB  	OFF	OFF

# SECTION 10

## Glossary

<b>Safety distance</b>	The minimum distance that must be maintained between the detection zone of the F3S-A and a dangerous machine part in order to stop a machine before someone or something reaches it.
<b>Lock-out</b>	A safety feature of the F3S-A. The F3S-A stops machine operation with lock-out if it determines from self diagnosis that an irrecoverable failure has occurred. If an emitter is on lock-out condition, it will stop emitting light. If a receiver is on lock-out condition, output from the receiver will be turned OFF. Normal operation will not resume after lock out. In this case, terminate operation immediately and replace the locked out end with a new part.
<b>OFF-hold</b>	A safety feature of the F3S-A. The F3S-A stops machine operation with OFF-hold if it determines that a failure discovered as a result of self diagnosis is temporary and recoverable. If an emitter is on OFF-hold condition, it will stop emitting light. If a receiver is on OFF-hold condition, output from the receiver will be turned OFF. Eliminate the cause of the failure and turn F3S-A power back ON to resume normal operation.
<b>Master sensor</b>	When multiple F3S-As are connected together, one sensor called the master sensor will control timing for all emission and receive processing in the system.
<b>Master end/slave end</b>	With parallel connection, the master sensor end is called the master end and the other end is called the slave end.
<b>Master end/series extension end</b>	With series connection, the end closest to the master sensor is called the master end the other end is called the series extension end.
<b>Protective height</b>	The length of the F3S-A from the first optical axis to the last optical axis. The height is marked on the F3S-A.
<b>Detection distance</b>	The distance between facing emitters and receivers.
<b>Detection zone</b>	The area where one pair of F3S-As can detect intrusion by people or objects. Full coverage is the product of protective height and detection distance.
<b>Test rod</b>	The rod is used to check the detection capability of the F3S-A and corresponds to the optical resolution of the F3S-A. Rods are available in 15-mm and 25-mm diameters provided as accessories for the F3S-A□□1 (10-mm pitch) and the F3S-A□□2 (20-mm pitch), respectively.
<b>EN954-1</b>	The European standard that provides machine safety, especially categories and risk assessment methods for safety-related areas of control systems.
<b>prEN999</b>	The European standard that provides machine safety, especially protective machines as it relates to machine approach procedures and speed.
<b>IEC61496-1, -2</b>	The international standard that provides machine safety, especially to electro-sensitive protective machines. IEC61496-1 provides requirements for failure mode and effect analysis, environmental requirements, as well as EMC requirements. IEC61496-2 provides effective aperture angles for optical-type protective equipment as well as requirements related to interference light protection. EN61496-1 is an EN standard that has about the same contents as IEC61496-1.
<b>ANSI B11.19</b>	The ANSI standard that provides machine safety, especially the general requirements when referenced by other B11 standards.

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**External Diagnosis  
Function**

The function used to check receiver operation by turning OFF light emission.

**Interference Light Search  
Function**

The function used to check the presence or absence of interference light that may cause faulty operation.

**ESPE**

Abbreviation for electro-sensitive protective equipment.

**AOPD**

Abbreviation for active opto-electronic protective devices.



# SECTION 11

## Referenced Standards

### International Standards

- IEC61496-1 Safety of Machinery: Electro-sensitive Protective Equipment – Part 1: General Requirements and Tests
- IEC61496-2 Safety of Machinery: Electro-sensitive Protective Equipment – Part 2: Particular Requirements for Equipment Using Active Opto-electronic Protective Devices

### European Standards

- EN61496-1 Safety of Machinery: Electro-sensitive Protective Equipment – Part 1: General Requirements and Tests
- EN415-4 Palletizers and Depalletizers
- prEN691 Woodworking Machines
- EN692 Mechanical Presses
- prEN693 Hydraulic Presses

### U.S. Federal Regulations

- OSHA 29 CFR 1910.212 General Requirements of All Machines
- OSHA 29 CFR 1910.217 Mechanical Power Presses

### U.S. National Standards

- ANSI B11.1 Mechanical Power Presses
- ANSI B11.2 Hydraulic Power Presses
- ANSI B11.3 Power Press Brakes
- ANSI B11.4 Shears
- ANSI B11.5 Iron Workers
- ANSI B11.6 Lathes
- ANSI B11.7 Cold Headers and Cold Formers
- ANSI B11.8 Drilling, Milling, and Boring Machines
- ANSI B11.9 Grinding Machines
- ANSI B11.10 Metal Sawing Machines
- ANSI B11.11 Gear Cutting Machines
- ANSI B11.12 Roll Forming and Roll Bending Machines
- ANSI B11.13 Single- and Multiple-Spindle Automatic Bar and Chucking Machines
- ANSI B11.14 Coil Slitting Machines/Systems
- ANSI B11.15 Pipe, Tube, and Shape Bending Machines
- ANSI B11.16 Metal Powder Compacting Presses
- ANSI B11.17 Horizontal Extrusion Presses
- ANSI B11.18 Machinery and Machine Systems for the Processing of Coiled Strip, Sheet, and Standards
- ANSI B11.19 Performance Criteria for the Design, Construction, Care, and Operation of Safeguarding when Referenced by the Other B11 Machine Tool Safety Standards
- ANSI/RIA 15.06 Safety Requirements for Industrial Robots and Robot Systems
- UL1998 Safety-related Software