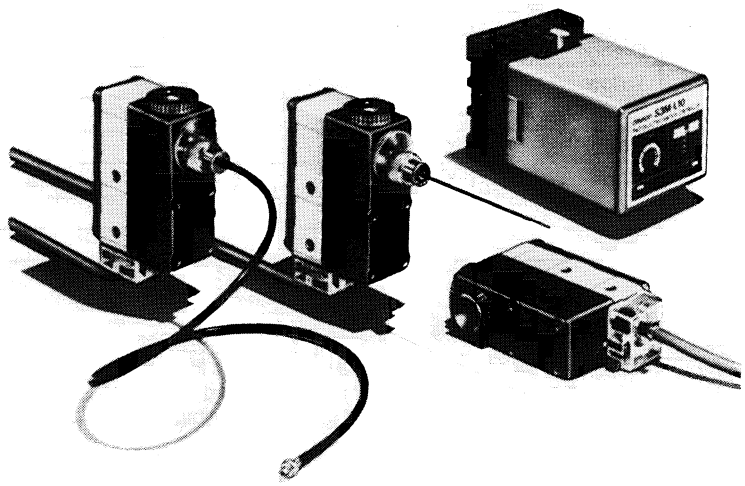
OMRON

Color Registration Mark: Incandescent — E3ML

Color Registration Mark Sensor Offers High-Speed Detection

- 20 microsecond response time ideal for printing and packaging equipment
- 99-step sensitivity adjustment and incandescent light source assure accurate detection of minute color differences
- Fiber-optic versions available for sensing in confined spaces
- Optional filters improve detection of certain colors



Ordering Information

■ SENSORS

Method of detection		Diffuse reflective		Fiber-optic
Sensing distance		8 mm; 6 to 10 mm (0.30 in; 0.24 to 0.39 in)	20 mm; 16 to 24 mm (0.79 in; 0.63 to 0.94 in)	See Fiber-Optic Cables below
Part number	NPN output	**E3ML-M8E4-G**	**E3ML-S2E4-G**	**E3ML-XE4-G**
	PNP output	**E3ML-M8F4-G**	**E3ML-S2F4-G**	**E3ML-XF4-G**

■ FIBER-OPTIC CABLES

Method of detection	Through-beam	Diffuse reflective	
Sensing distance	10 mm; 0 to 10 mm (0.39 in; 0 to 0.39 in)	0.5 mm; 0.2 to 2 mm (0.02 in; 0.008 to 0.08 in)	1.2 mm; 0.5 to 4 mm (0.05 in; 0.02 to 0.16 in)
Description	Straight cable 50 cm (1.64 ft) with M4 threaded head	Bendable probe 1.5 mm dia. x 80 mm L (0.059 x 3.15 in)	Straight cable 50 cm (1.64 ft) with M4 threaded head
Required sensor	E3ML-XE4-G or E3ML-XF4-G		
Part number	**E32-TB50**	**E32-DB8**	**E32-DB50**

■ ACCESORIES

Description		Part number
Controller	Provides power source for lamp and switch circuit; relay and NPN transistor outputs; ON-delay, OFF-delay and one-shot timing functions; ON/OFF and AND gate logic functions. Includes mounting socket.	**S3M-L10-US-AC120**
Color filters	Yellow; improves detection of green marks on blue backgrounds	**E3ML-ZF1**
	Orange; improves detection of red marks on blue backgrounds	**E3ML-ZF2**
	Red; improves detection of red marks on green backgrounds	**E3ML-ZF3**
Mounting track for controller socket	DIN rail, 50 cm (1.64 ft) length	**PFP-50N**
	DIN rail, 1 m (3.28 ft) length	**PFP-100N**
	End plate	**PFP-M**

■ REPLACEMENT PARTS

Description		Part number
Incandescent light bulb	Filament perpendicular to bulb axis (optional bulb)	**E3ML-ZLB**
	Filament parallel to bulb axis (supplied with all E3ML sensors)	**E3ML-ZLA**
Desiccator cell	Prevents moisture from collecting inside the sensor	**E3ML-ZK**
Lens	For E3ML-M8□4-G sensors, 8 mm	**E3ML-ZHM8**
	For E3ML-S2□4-G sensors, 20 mm	**E3ML-ZHS2**
Socket	For S3M-L10-US-AC120 controller (supplied with controller)	**14PFA**
Relay	For S3M-L10-US-AC120 controller (supplied with controller)	**G2R-1-S-DC12**

Specifications

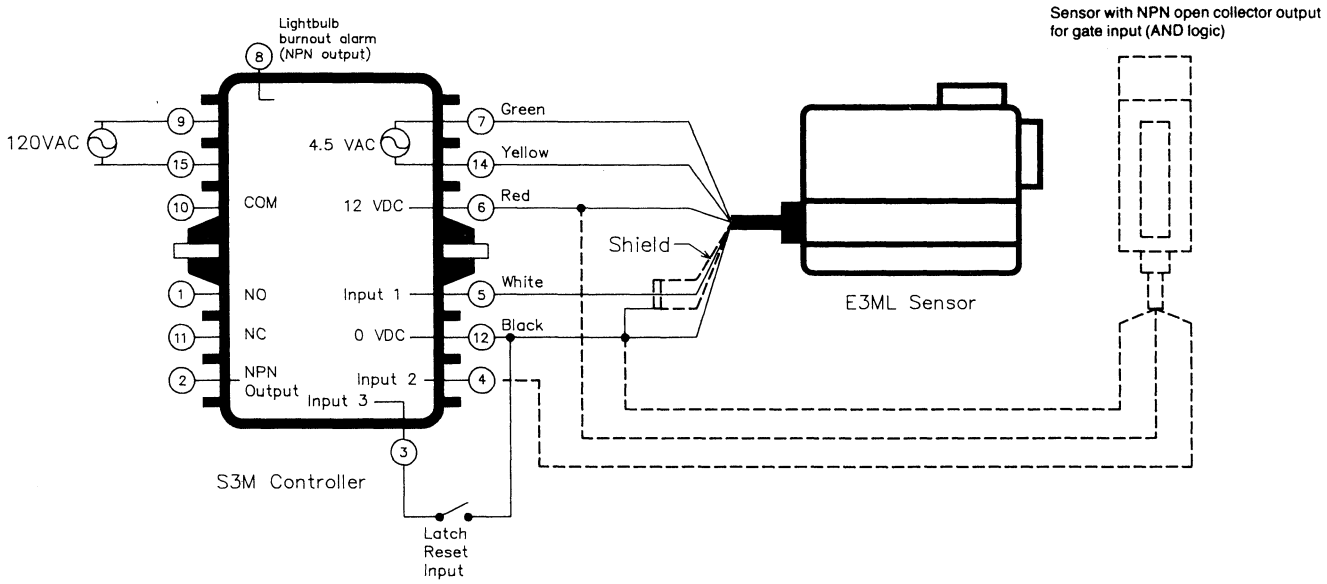
■ SENSORS

Sensor part number			E3ML-M8□4-G	E3ML-S2□4-G	E3ML-X□4-G		
Fiber-optic part number			—	—	E32-TB50	E32-DB8	E32-DB50
Method of detection			Diffuse reflective		Separate	Diffuse reflective	
Supply voltage		Circuit section	10 to 30 VDC				
		Lamp section	4.5 VAC				
Power consumption		Circuit section	40 mA max.				
		Lamp section	3.5 VA				
Sensing distance			8 mm; 6 to 10 mm (0.31 in; 0.24 to 0.39 in)	20 mm; 16 to 24 mm (0.79 in; 0.63 to 0.94 in)	10 mm; 0 to 10 mm (0.39 in; 0 to 0.39 in)	0.5 mm; 0.2 to 2 mm (0.02 in; 0.008 to 0.08 in)	1.2 mm; 0.5 to 4 mm (0.05 in; 0.02 to 0.16 in)
Light source			Incandescent bulb				
Minimum detectable mark (black mark on white paper)			1.5 x 4 mm (0.06 x 0.16 in)	0.5 x 6 mm (0.02 x 0.24 in)	1 mm (0.04 in) square	0.3 x 1.6 mm (0.01 x 0.06 in)	0.3 x 3.2 mm (0.01 x 0.13 in)
Detectable object type			Marks on different backgrounds		Opaque materials	Marks on different backgrounds	
Operation mode			Light-ON/Dark-ON, switch selectable				
Sensitivity			Adjustable				
Mutual interference protection			Not provided				
Control output	DC solid-state	Type	NPN-SPST open collector with pull-up (E3ML-□□E4-G) PNP-SPST open collector with pull-down (E3ML-□□F4-G)				
		Max. load	80 mA				
		Max. on-state voltage drop	1 VDC				
Response time		On	20 μs max.				
		Off	20 μs max.				
Repeat response frequency			10 kHz				
Circuit protection		Output short-circuit	Provided				
		DC power supply reverse polarity	Provided				
Indicators			Light Incident (red LED)				
Fiber cable style			—		Straight	—	Straight
Fiber cable length			—		50 cm (1.97 in)	—	50 cm (1.97 in)
Sensing head			—		M4 threaded head	Probe with 1.5 mm (0.06 in) dia. x 80 mm (3.15 in) stainless steel tube	M4 threaded head
Max. fiber bending radius			—		5 mm (0.2 in)	10 mm (0.4 in)	5 mm (0.2 in)
Fiber filament			—		Plastic		
Materials		Lens	Glass		—		
		Case	Metal, diecast zinc				
		Cable sheath	Plastic				
Mounting			Side surface with two M5 threaded holes; front surface with four M5 threaded holes				
Connections		Prewired	6-conductor cable, 4 m (13.12 ft) length				
Weight			600 g (1.32 lbs) with electrical cable				
Sensor enclosure ratings		UL	—				
		NEMA	1, 4, 4X, 12				
		IEC 144	IP67				
Ambient temperature	Operating	Fiber cable	—		-25° to 70°C (-13° to 158°F)	-25° to 100°C (-13° to 212°F)	-25° to 70°C (-13° to 212°F)
		Sensor	-10° to 55°C (14° to 131°F)				
	Storage	Fiber cable	—		-25° to 70°C (-13° to 158°F)	-25° to 100°C (-13° to 212°F)	-25° to 70°C (-13° to 212°F)
		Sensor	-25° to 70°C (-13° to 158°F)				

■ CONTROLLER

Part number				S3M-L10-US-AC120
Supply voltage				120 VAC, 50/60 Hz
Power consumption				13 VA max.
On-board power supply	DC	Voltage		12 VDC
		Current		100 mA max.
		Short-circuit protection		Provided
	AC	Voltage		4.5 VAC
		Current		0.78 A max.
		Short-circuit protection		Not provided
Input signal	Number of inputs			Three; input, gate and latch reset
	Require input type			NPN open collector or NPN with current output
	Signal voltage level (positive polarity)		High	4 to 12 VDC
			Low	0 to 1 VDC
	Minimum required input time			1 ms (when using 0.1 to 1 second time delay) 2 ms (when using 1 to 10 second time delay)
	Input impedance			Approx. 4.7 kΩ
Logic functions				ON/OFF, AND (gate input), Latch
Control output	Contact	Type		SPDT, with G2R-112S-V-US-DC12 (included)
		Max. load		3 A, 220 VAC (p.f. = 1)
		Min. load		10 mA, 5 VDC
	DC solid-state	Type		NPN with pull-up (4.7 kΩ output impedance)
		Max. load		80 mA
Response time	On	Contact output		15 ms max.
		DC solid-state output		20 μs max.
	Off	Contact output		15 ms max.
		DC solid-state output		20 μs max.
Timing functions		Type		Normal, ON-delay, OFF-delay, one-shot or latch; switch selectable
		Range		0.1 to 1 second or 1 to 10 seconds, switch selectable
Lamp burnout alarm		Type		NPN open collector with pull-up (4.7 KΩ output impedance)
		Max. load		50 mA
Indicators				Power On (red); Output Operation (red)
Materials		Case		Plastic
Mounting		Controller		Requires 14PFA socket (included)
		Controller socket		DIN track or bottom surface with two through holes
Connections				Plated steel terminal screws on socket
Weight				650 g (1.43 lbs) including socket
Enclosure ratings		UL		1
		NEMA		1
		IEC 144		IP22
Approvals		UL		Recognized, File Number E41515
		CSA		Certified, File Number LR46463
Ambient temperature		Operating		−10° to 55°C (14° to 131°F)
		Storage		−25° to 70°C (−13° to 158°F)

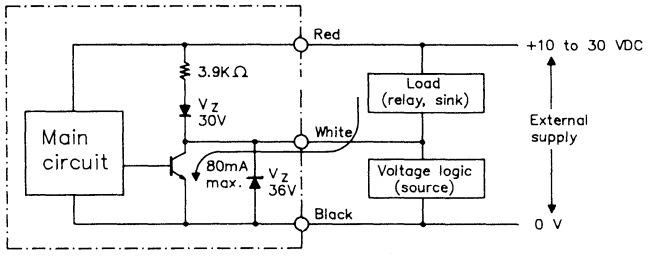
Connections



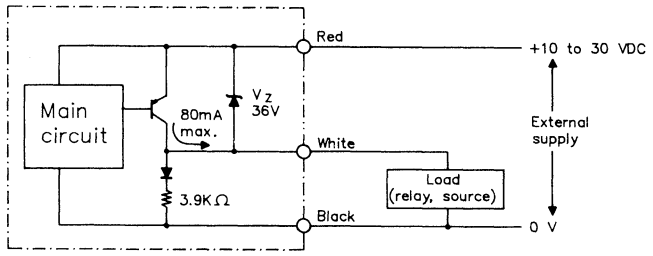
Sensor Operation

■ OUTPUT CIRCUIT DIAGRAMS

NPN output (E3ML-□□E4-G)

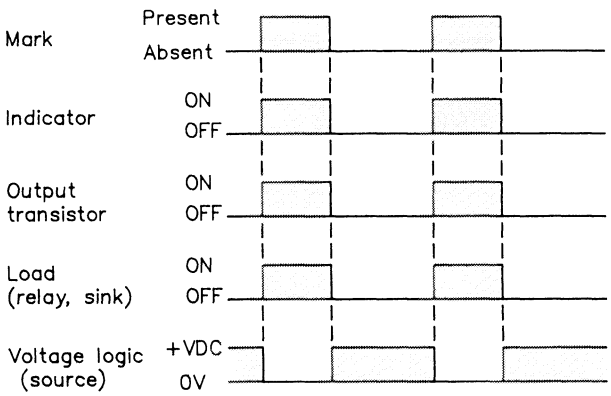


PNP output (E3ML-□□F4-G)

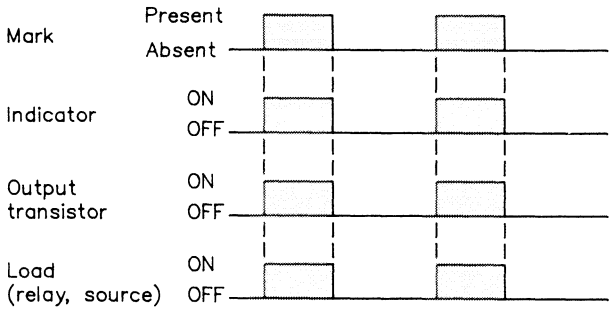


■ TIMING CHARTS

NPN output (E3ML-□□E4-G)



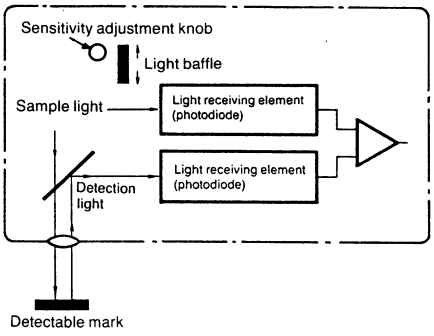
PNP output (E3ML-□□F4-G)



■ THEORY OF SENSOR OPERATION

All models of the E3ML color mark sensor utilize a replaceable incandescent light bulb to provide a detection light beam and a sample light beam. This specially designed light bulb requires a highly stable 4.5 VAC power supply for proper operation. A S3M-L10-US-AC120 sensor controller is recommended because it has a built-in 4.5 VAC power supply especially designed for the E3ML sensor.

The detection light beam is focused on the detectable object through the sensor lens. The light reflected from the detectable object passes through the same lens and is then focused onto one of the two internal light-receiving photodiodes. The sample light beam is internally directed to the second of the light receiving photodiodes.



The difference between the light incident on the two light receiving photodiodes is then amplified to allow detection of slight increases or decreases in the amount of detection light reflected back through the sensor lens. The sensed change in detection light levels will result in an output signal from the solid-state transistor.

A built-in desiccator cell prevents moisture from collecting in the lens area of the sensor. For flexibility in installing E3ML models without fiber-optics, the lens and the desiccator cell positions may be interchanged. This allows the lens to be on the opposite side from the controls or on the top of the unit.

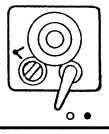
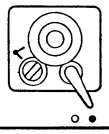
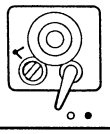
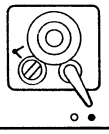
■ ADJUSTMENTS

Mode Selector Switch

The position of the Light-ON/Dark-ON mode selector switch is chosen based on the light reflective/transmission properties of the mark being detected, the light reflective/transmission properties of the background, and the desired operation of the solid-state output signal.

The switch position is changed by removing the plastic snap-fit cover located at the bottom of the E3ML sensor and then moving the switch to either the Light-ON position (white mark on housing) or Dark-ON position (black mark on housing).

To turn on the E3ML output transistor and to energize a relay-type load when the mark is present, the mode selector switch should be positioned according to the following table.

Method of detection	Diffuse reflective		Separate	
Mark and background reflection/transmission conditions	Mark reflects more light than the background	Mark reflects less light than the background	Mark transmits more light than the background	Mark transmits less light than the background
Mode selector switch	Light-ON 	Dark-ON 	Light-ON 	Dark-ON 

Sensitivity Adjustment Knob

The sensitivity adjustment knob located on the bottom of the E3ML sensor is used to optimize the sensor's ability to detect the mark and the background.

One complete revolution of the knob will cause the rotary dial, which is numbered 0 through 9, to increment one number. The sensor's internal adjustment mechanism may be damaged if the knob is turned beyond the 0 or 9 position on the dial.

When the knob is turned clockwise, the sensitivity of the sensor will increase and the number on the rotary dial will increase.

When the knob is turned counterclockwise, the sensitivity of the sensor will decrease and the number on the rotary dial will decrease.

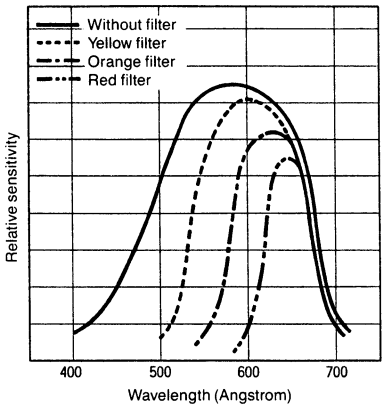
Use of Filters

Three different filters, available as accessories, may be used with the lens type sensors. Filters enhance a sensor's ability for stable operation in detecting small differences in the amount of light reflected from the mark and from the background. The filters are provided with a ring that allows them to be secured over the outer lens surface.

The graph displays the effect on the sensor's relative sensitivity to colors when using the different filters.

Filter selection should be based on the following combinations of mark and background colors:

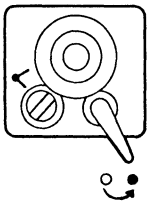
Mark color	Green tones	Red tones	Red tones
Background color	Blue tones	Blue tones	Green tones
Recommended filter color	Yellow	Orange	Red
Filter part number	E3ML-ZF1	E3ML-ZF2	E3ML-ZF3



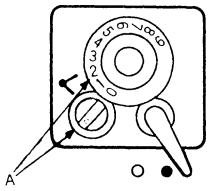
Method of Adjustment

Before adjusting the E3ML sensor, allow three to five minutes of warm-up after the sensor has been energized. In applications that require the sensor to detect small color differences, allow at least 30 minutes of warm-up after the sensor has been energized before making adjustments. Follow this adjustment procedure after allowing the sensor the proper warm-up time:

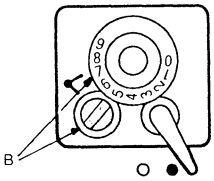
1. Position then fasten the E3ML sensor above the object to be detected, at the rated sensing distance.
2. Select the appropriate position for the Light-ON/Dark-ON mode selector switch.



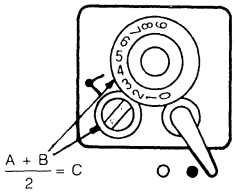
3. Turn the sensitivity adjustment knob to number 9 position on the rotary dial to obtain maximum sensitivity.
4. When using a diffuse reflective type sensor, place the color with the higher reflectance under the light spot emitting from the sensor. When using the separate type sensor, place the color that transmits the most light between the fiber-optic sensing heads.
5. Turn the sensitivity adjustment knob counterclockwise to reduce the sensitivity of the sensor. Continue reducing the sensitivity until the red indicator light located on the bottom of the sensor is no longer illuminated. Note the number on the rotary dial and the position of the adjustment knob. In the following example, this is shown as position "A" and has a value of 2.2 turns.



6. When using a diffuse reflective type sensor, position the color with the lower reflectance under the light spot. When using the separate type sensor, place the color that transmits the least light between the sensing heads.
7. Increase the sensitivity of the sensor by turning the sensitivity adjustment knob clockwise. Continue increasing the sensitivity until the red indicator light on the bottom of the sensor is illuminated. Note the number on the rotary dial and the position of the adjustment knob. In the example, this is position "B" and has a value of 7.2 turns.



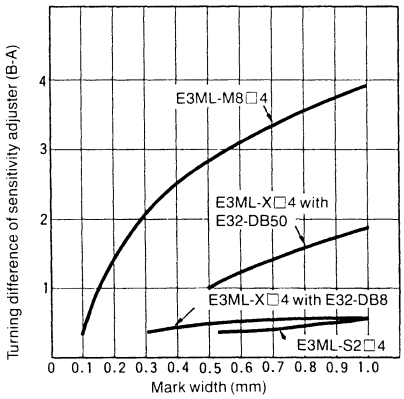
8. Turn the adjustment knob to the position midway between the positions "A" and "B". In the example, this is shown as position "C" and has a value of 4.7 turns.



■ ENGINEERING DATA

Detection Stability by Mark Size

The graph below shows the detection stability of a black mark on a white background. Using the reference points A and B from the Sensitivity Adjustment section, subtract A from B to determine the "turning difference" of the adjustment knob. The greater the turning difference between points A and B, the more reliably the mark can be detected.

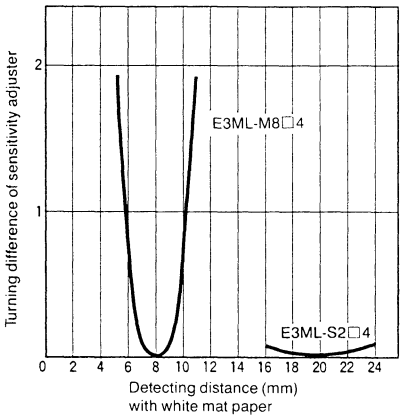


Detection Stability by Sensing Distance

The following graphs show how the detection stability varies with changes in the sensing distance. The values were derived by using the position of the sensitivity adjusting knob when the operation indicator illuminates at the rated detecting distance.

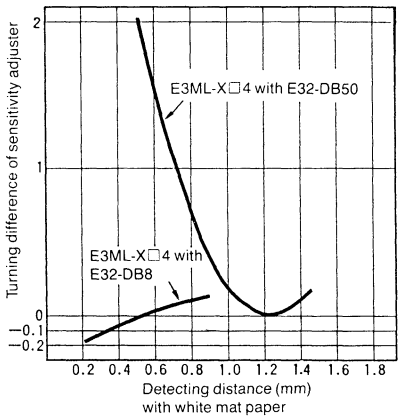
The subsequent data show how much the adjusting knob should be turned clockwise in order to cause the operation indicator to illuminate at each of the other detecting distances.

E3ML-M8□4-G, E3ML-S2□4-G



E3ML-M8□4-G sensors are extremely sensitive to changes in sensing distance. For example, a change of ±2 mm in the sensing distance corresponds to a turning difference of "1" in the Detection Stability by Mark Size graph, so marks measuring more than 0.2 mm in width can be detected.

E3ML-X□4-G with fiber-optics



However, 0.2mm wide marks cannot be detected at a change of ±3 mm in sensing distance.

E3ML-S2□4 sensors are not as susceptible to changes in detecting distance, as reflected in the shallow detection curve.

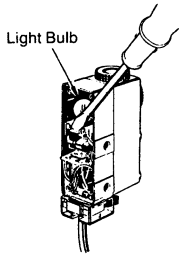
■ SENSOR MAINTENANCE

To ensure proper sensor performance, the incandescent light bulb should be replaced after approximately 3,000 hours of use.

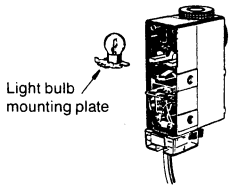
Light Bulb Replacement

Follow these steps to replace the light bulb and its integral mounting plate:

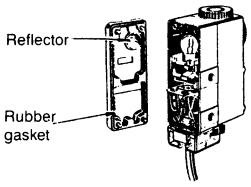
1. De-energize the sensor, loosen the four screws at the back of the sensor and remove the back cover.
2. Insert the tip of a small flat-blade screwdriver into the slot in the light bulb mounting plate and gently slide the plate out.



3. Clean the new light bulb with an alcohol-dampened cloth. Make sure that there are no fingerprints or grease spots on the surface of the bulb.
4. Install the new light bulb and mounting plate by sliding the assembly between the two spring metal contact points.



5. Replace the back cover and tighten the four securing screws with a torque of 3 kgf-cm (2.6 in-lbs). Ensure that the rubber gasket has been properly positioned.



6. Perform the previously explained sensitivity adjustment procedure.

Lens Cleaning

Dirt and foreign matter on the lens surface should be regularly removed with a soft, lint-free cloth.

Desiccator Cell Replacement

Each E3ML sensor is equipped with a screw-in desiccator cell which absorbs moisture inside the sensor. It is located on top of the sensor. A viewing window located at the center of the cell allows the cell to be monitored for proper operation.

A properly functioning desiccator cell will be white. A blue colored cell is fully spent and should be replaced with a new cell. A reddish colored cell can be rejuvenated: Remove the cell and bake it at 100°C (212°F) for 12 hours then reinstall the cell.

Controller Operation

■ THEORY OF CONTROLLER OPERATION

The S3M controller is designed to provide control functions especially for the E3ML sensor:

4.5 VAC power source for the light bulb

12 VDC power source for the switching circuit

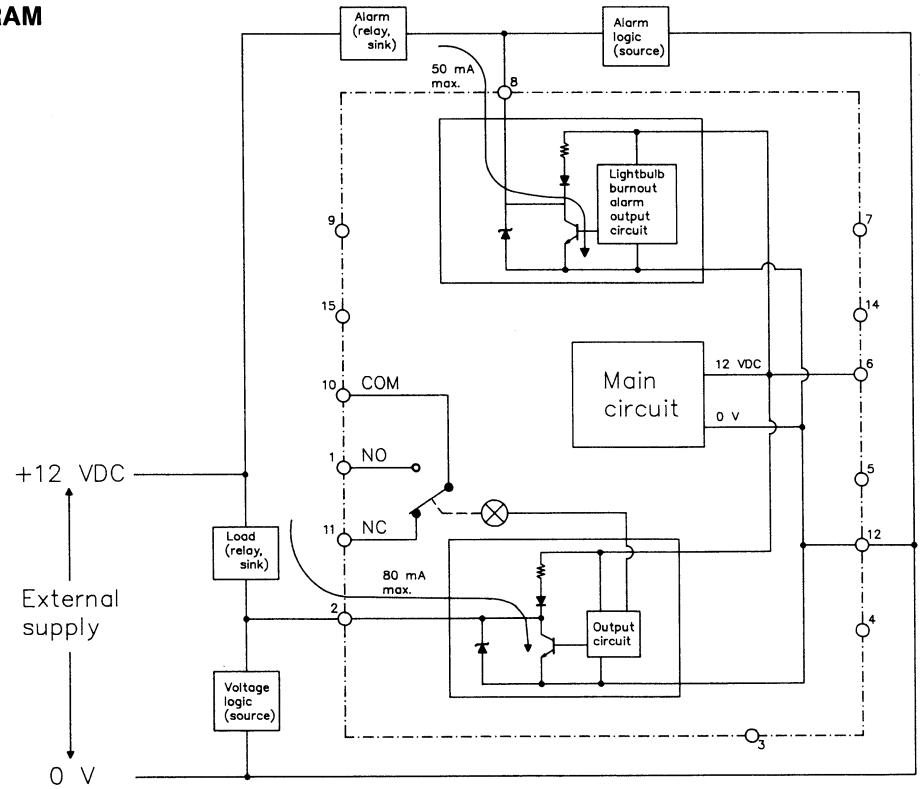
ON/OFF, AND, Latch and output timing logic

NPN open collector solid-state and SPDT relay outputs

E3ML light bulb burnout alarm output

■ OUTPUT CIRCUIT DIAGRAM

S3M-L10-US-AC120



■ TIMING CHARTS

Normal ON/OFF Operation

The relay and solid-state outputs of the S3M controller provide ON/OFF operation when the top two mode selector switches, located on the face of the controller, are set in the H-ON and NORM positions, respectively. The output from the E3ML sensor must be connected, as shown in the connections diagram, to Input 1 (terminal 3). Input 2 (terminal 4) must be left open.

Model selector switch position	Timing chart
Normal ON/OFF operation GATE H ON — L ON FUNC. — NORM. ON. D — LATCH O.S.D OFF. D 1 SEC. — 10 SEC.	E3ML sensor output: ON / OFF Controller operation indicator: ON / OFF Controller output: Relay (NO contact): ON / OFF Solid-state: High (+V) / Low (0V)

AND Operation

The S3M controller provides an AND (gate) logic function when the top two mode selector switches are set in the L-ON and NORM positions, respectively. The output from the E3ML sensor must be connected to Input 1 (terminal 5). The second sensor must provide a solid-state NPN open collector output and have its output connected to Input 2 (terminal 4). The controller output will operate when the outputs from both sensors are turned on.

Model selector switch position	Timing chart
AND operation GATE H ON — L ON FUNC. — NORM. ON. D — LATCH O.S.D OFF. D 1 SEC. — 10 SEC.	E3ML sensor output: ON / OFF Second sensor gate output: ON / OFF Controller operation indicator: ON / OFF Controller output: Relay (NO contact): ON / OFF Solid-state: High (+V) / Low (0V)

Latch Operation

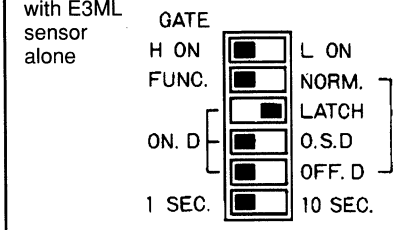
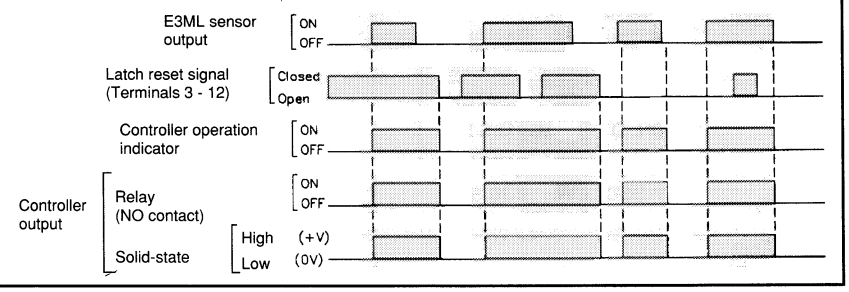
The S3M controller is equipped with a latch function that maintains the relay and solid-state outputs in the ON position until an independent reset signal is received. The latch function can be used with the E3ML sensor alone or when using the AND logic function with E3ML and another sensor.

The sensor(s) must be connected to the controller socket as shown in the connections diagram. An external switch suitable for switching 12 VDC must also be placed between the Reset Input (terminal 3) and 0 VDC (terminal 12).

When using the E3ML sensor alone, the top three mode selector switches on the controller should be set in the L-ON, FUNC, and LATCH positions, respectively. Then, when the connection between the Reset Input and 0 VDC is closed and the E3ML sensor output is turned on, the controller output will latch on. The outputs will turn off when the connection between the Reset Input and 0 VDC is opened.

When using the E3ML sensor and a second sensor in the AND operation mode, the top three mode selector switches on the controller should be set in the H-ON, FUNC, and LATCH positions, respectively. Then, when the connection between the Reset Input and 0 VDC is closed and the E3ML and other sensor outputs are turned on, the controller outputs will latch on. The outputs will turn off when the connection between the Reset Input and 0 VDC is opened.

Model selector switch position	Timing chart
Latch operation with AND operation (E3ML and another sensor) GATE H ON — L ON FUNC. — NORM. ON. D — LATCH O.S.D OFF. D 1 SEC. — 10 SEC.	E3ML sensor output: ON / OFF Second sensor gate output: ON / OFF Latch reset signal (Terminals 3-12): Closed / Open Controller operation indicator: ON / OFF Controller output: Relay (NO contact): ON / OFF Solid-state: High (+V) / Low (0V)

Model selector switch position	Timing chart
Latch operation with E3ML sensor alone  	

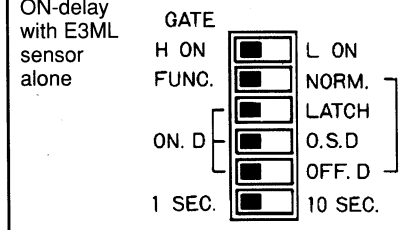
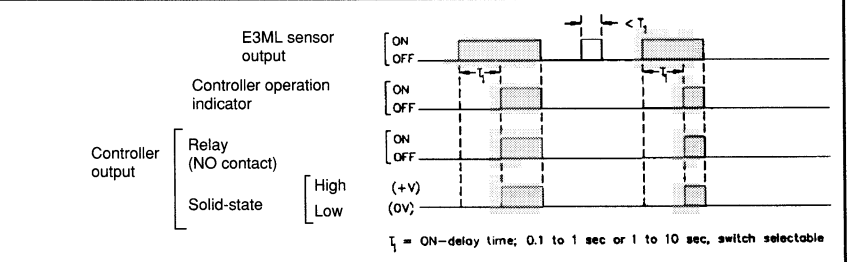
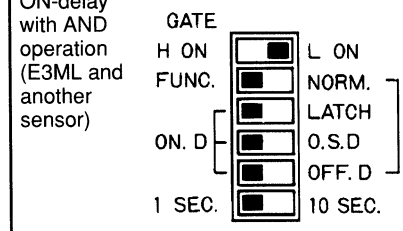
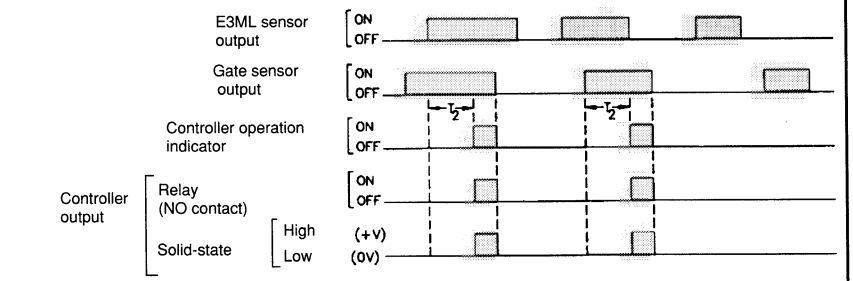
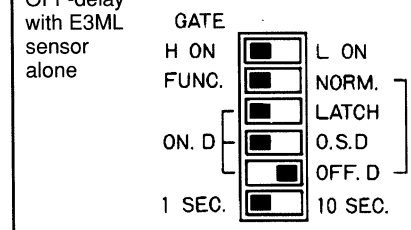
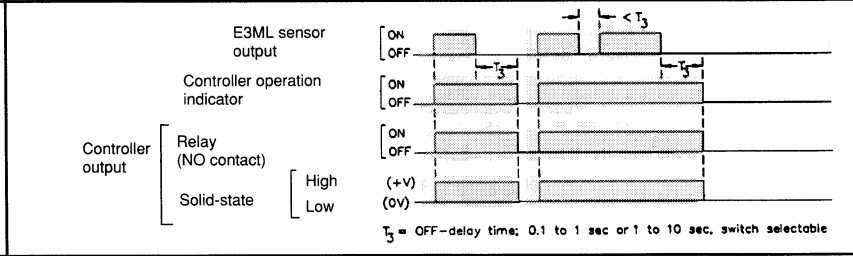
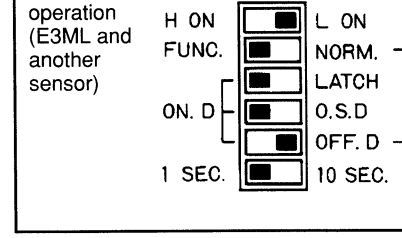
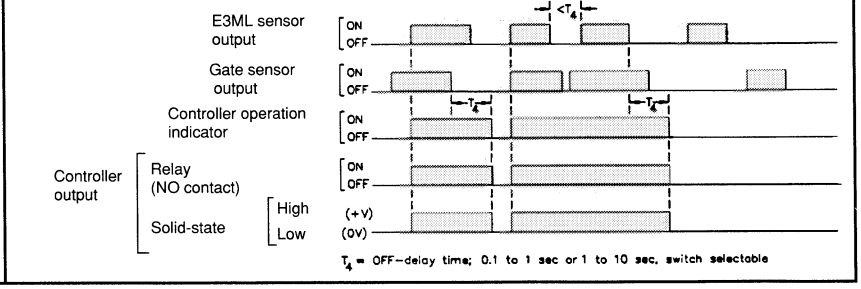
ON-Delay, OFF-Delay and One-Shot Timer Operation

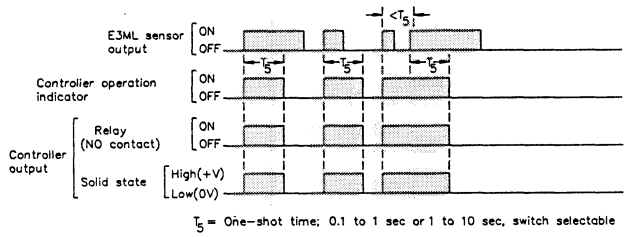
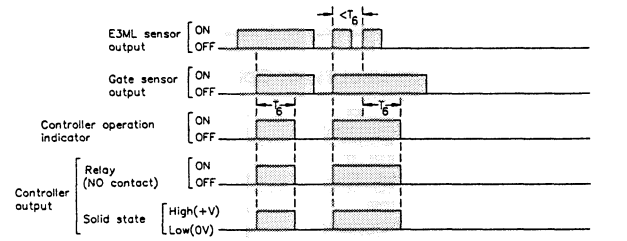
The S3M controller provides selectable ON-delay, OFF-delay or one-shot output timers when using the E3ML sensor alone or when using the AND logic function. The sensor(s) must be connected to the controller socket as shown in the connections diagram.

When using a timing function with only the E3ML sensor as an input device, the top two mode selector switches must be set in the H-ON and FUNC positions, respectively.

When using the timing function with the AND operation mode (E3ML and another sensor), the top two mode selector switches must be set in the L-ON and FUNC positions, respectively.

Timing ranges of 0.1 to 1 second or 1 to 10 seconds are selected by moving the lower selector switch to the appropriate position. Use the time adjustment knob to set the final time value. The desired timing function is activated by positioning the remaining selector switches as shown below:

Model selector switch position	Timing chart
ON-delay with E3ML sensor alone  	 T_1 = ON-delay time; 0.1 to 1 sec or 1 to 10 sec, switch selectable
ON-delay with AND operation (E3ML and another sensor)  	 T_2 = ON-delay time; 0.1 to 1 sec or 1 to 10 sec, switch selectable
OFF-delay with E3ML sensor alone  	 T_3 = OFF-delay time; 0.1 to 1 sec or 1 to 10 sec, switch selectable
OFF-delay with AND operation (E3ML and another sensor)  	 T_4 = OFF-delay time; 0.1 to 1 sec or 1 to 10 sec, switch selectable

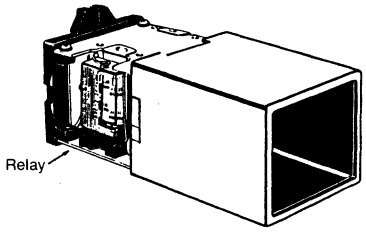
Model selector switch position	Timing chart
One-Shot with E3ML sensor alone GATE H ON — L ON FUNC. — NORM. LATCH ON. D — O.S.D OFF. D 1 SEC. — 10 SEC.	 T_5 = One-shot time; 0.1 to 1 sec or 1 to 10 sec, switch selectable
One-Shot with AND operation (E3ML and another sensor) GATE H ON — L ON FUNC. — NORM. LATCH ON. D — O.S.D OFF. D 1 SEC. — 10 SEC.	 T_6 = One-shot time; 0.1 to 1 sec or 1 to 10 sec, switch selectable

■ CONTROLLER MAINTENANCE

Relay Replacement

The S3M controller uses a replaceable SPDT relay. Follow this procedure to replace the relay:

1. Remove the controller from its socket.
2. Remove the light gray controller cover by first inserting from the bottom a small flat-blade screwdriver into the two slots between the black base and the cover. Then, while holding the cover in one hand, push on the face of the controller with the other hand, sliding the controller out of the cover.
3. The output relay is located on the same side as the time adjustment knob. Remove the relay by moving the top of the single hold-down clip to the side and then removing the old relay.
4. Install the new relay, slide the cover over the controller until the detents catch, and re-install the controller into the socket.

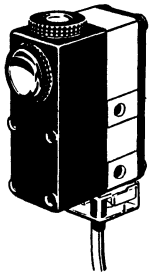


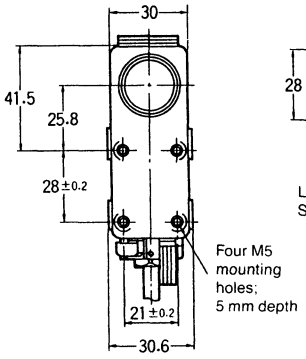
Dimensions

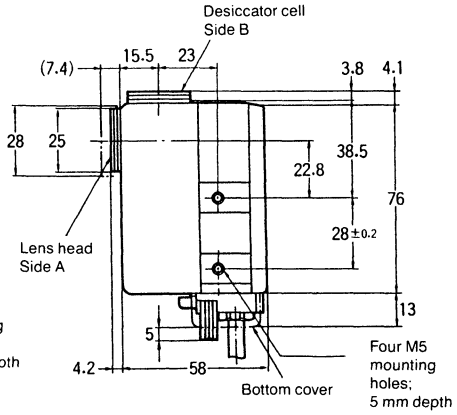
Unit: mm

■ SENSORS

E3ML-M8□4-G

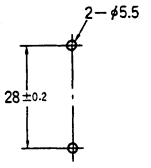




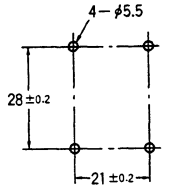


NOTE: Lens head and desiccator cell can be installed at either Side A or Side B location.

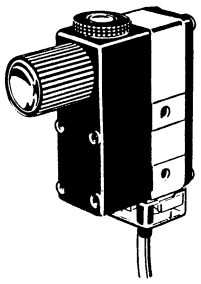
Mounting holes
Side mounting

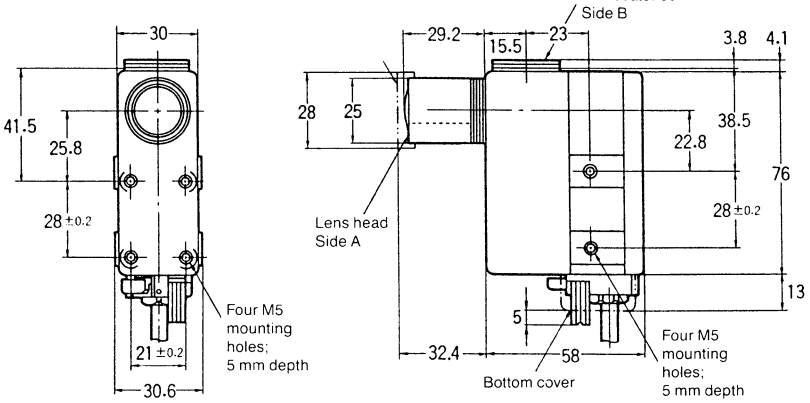


Front mounting



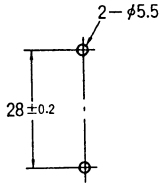
E3ML-S2□4-G



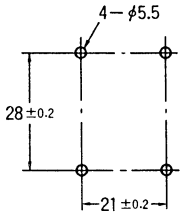


NOTE: Lens head and desiccator cell can be installed at either Side A or Side B location.

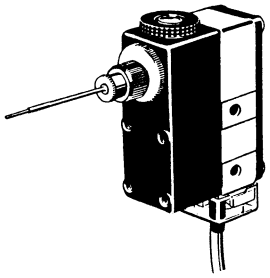
Mounting holes
Side mounting

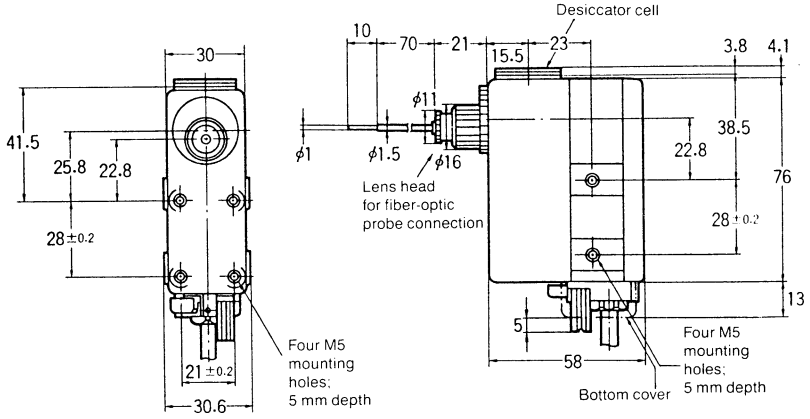


Front mounting

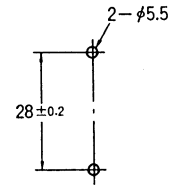


E3ML-X□4-G with E32-DB8 fiber-optic probe

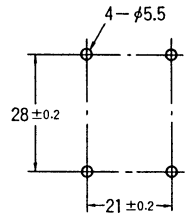




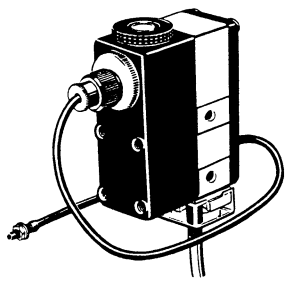
Mounting holes
Side mounting

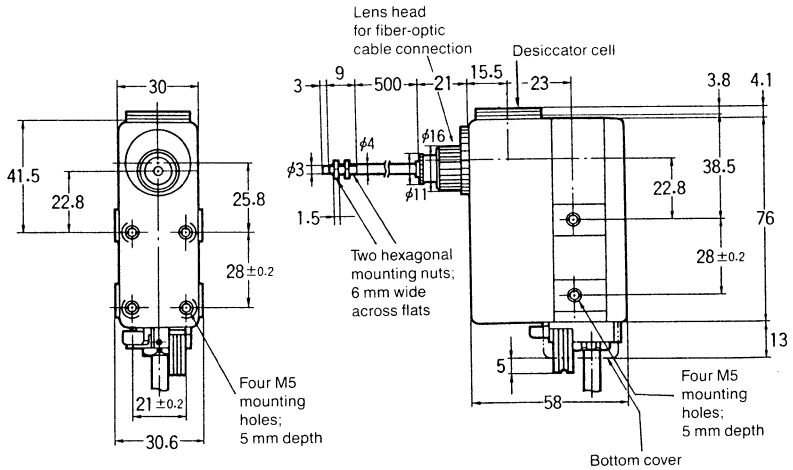


Front mounting

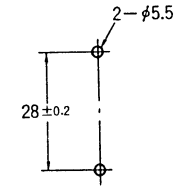


E3ML-X□4-G with E32-DB50 diffuse reflective type fiber-optic cable

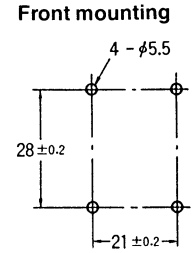




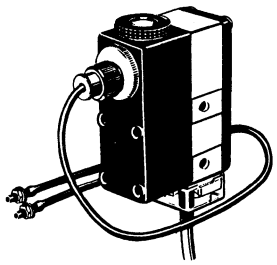
Mounting holes
Side mounting

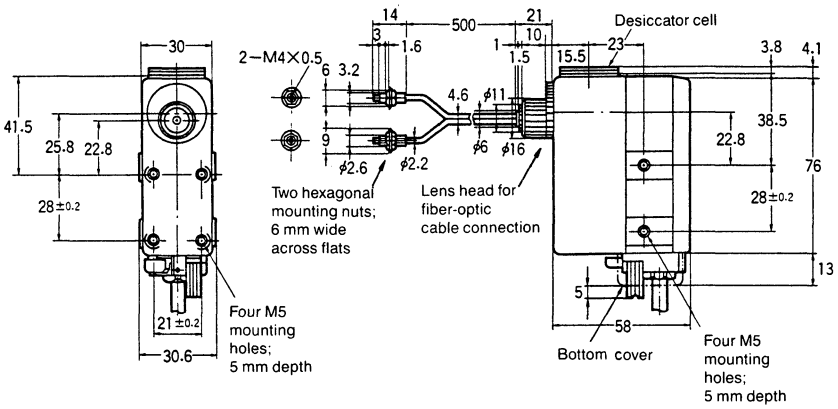


Front mounting

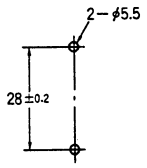


E3ML-X□4-G with E32-TB50 separate type fiber-optic cable

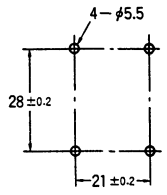




Mounting holes
Side mounting

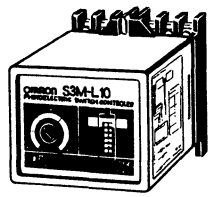


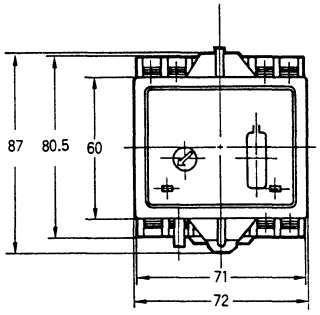
Front mounting

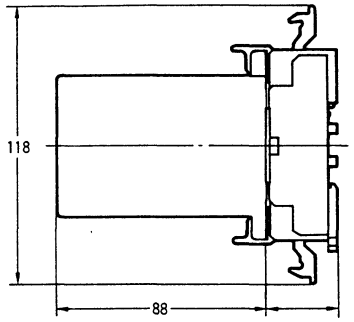


■ CONTROLLER

S3M-L10-US-AC120

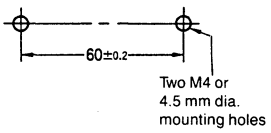






NOTE: Socket 14PFA is supplied with the controller.

Mounting holes



NOTE: DIMENSIONS SHOWN ARE IN MILLIMETERS. To convert millimeters to inches divide by 25.4.

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