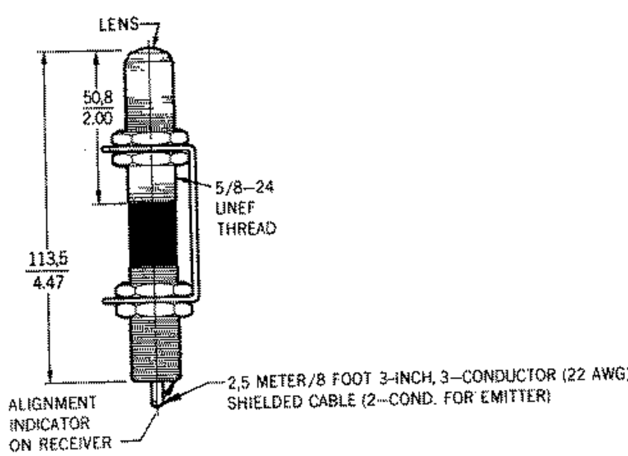
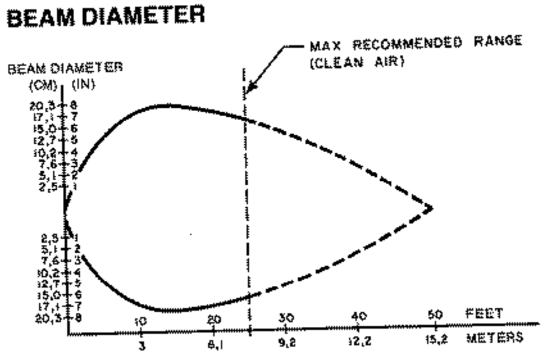
## SPECIFICATIONS

| | | |
|---|---|---|
| **Maximum Scanning Distance (in clean air)** | | 25 feet (7,6 m) |
| **Supply Voltage** | | 12 to 16 VDC or 22 to 26 VDC; 10% max. power supply ripple |
| **Power Dissipation** | | 12 VDC Emitter — 1.0 watts max. Receiver — 0.4 watts max. (excluding load) |
| | | 24 VDC Emitter — 1.6 watts max. Receiver — 0.6 watts max. (excluding load) |
| **Current Consumption** | | Emitter — 60 mA max.; Receiver — 20 mA max. (excluding load) |
| **Output** | Load Current | 100 mA max. (light operated) current sinking |
| | Voltage Drop | 1.4 VDC max. at 100 mA load |
| | Leakage Current (Off state) | < 10µA |
| **Maximum Rate of Operation** | | 6000 operations/minute |
| **Typical Response Time** | On | 5 msec. |
| | Off | 5 msec. |
| **Circuit Protection** | | False pulsing, Industrial electrical noise, Line transients, Momentary short circuit, Reverse polarity |
| **Temperature Range** | | -40°F to 158°F (-40°C to 70°C) |
| **Sealing** | | NEMA 1, 3, 4, 12 and 13 (Explosion-proof versions: NEMA 7 and 9) |
| **Housing** | | Anodized aluminum |
| **Mounting** | | Threaded bushings, slotted bracket |
| **Weight** | | 1.2 lbs. (544 g) |
| **Logic** | Standard | Built-in ON/OFF (immediate response) control; light operated or dark operated will operate a relay directly |
| | Optional | Printed circuit logic cards used with MICRO SWITCH control bases permit optional logic |

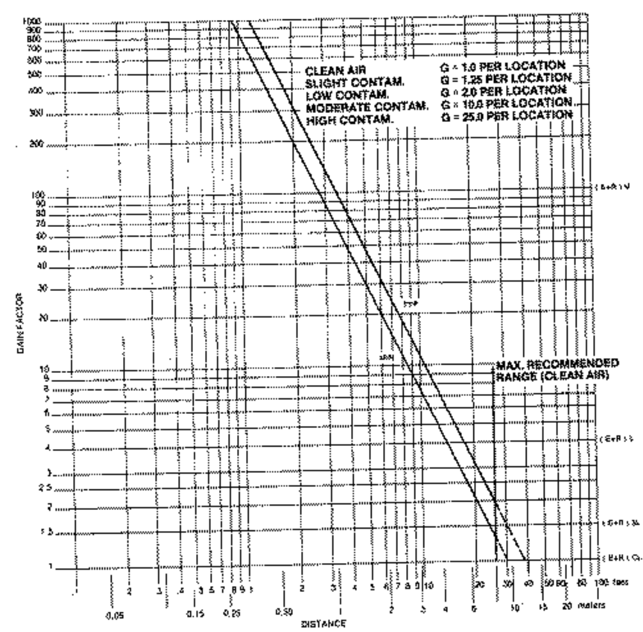
### MOUNTING DIMENSIONS



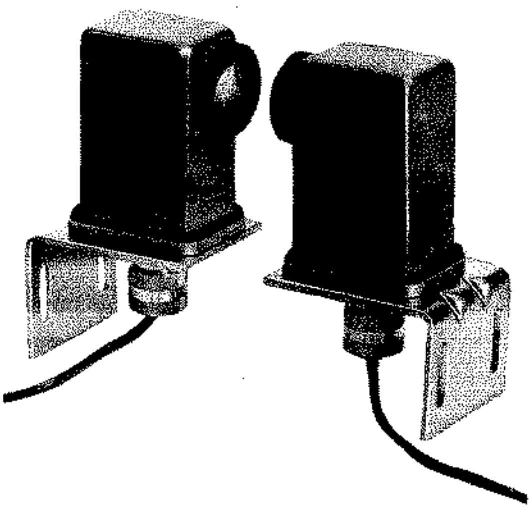

### BEAM DIAMETER




### EXCESS GAIN



# MLS5B DC thru scan controls



### FEATURES
- *250-foot thru scan range*
- *12 to 18 VDC or 22 to 30 VDC operation*
- *Sealing: NEMA 1, 3, 12 & 13 — 4 optional*
- *UL-CSA recognized*
- *High intensity LED pulsing for penetrability*
- *Alignment indicator*
- *Reverse polarity and short circuit protection*
- *Noise protected circuitry*
- *Direct compatibility with logic level circuitry*
- *Compact prewired emitter and receiver*
- *Dusttight steel housing*

### GENERAL INFORMATION
At very close ranges the MLS5B can be utilized for its penetrating power. It can detect objects inside or behind such porous materials as paper, denim or light weight canvas. The 12 VDC models are powered from a G4B, LCR or FEC control base. G4B and LCR control bases can accept optional plug-in logic cards and also provide optional dark operation. A 10-kilohm, 1/2-watt pull-up resistor is required for interface with LOG Series logic cards. If flooded with intense ambient light, the control output locks off, rather than triggers.

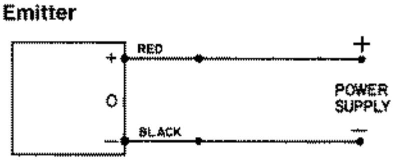
### FOR A COMPLETE CONTROL
**Required**
- Thru scan emitter — **FE-MLS5EB**
- Thru scan receiver — **FE-MLS5RB**
- Appropriately rated DC power supply

**Optional**
- Output devices
- Logic cards
- Control base

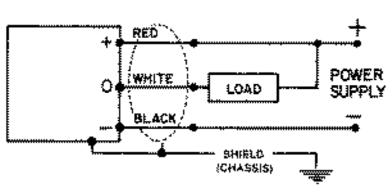
### INSTALLATION/WIRING
Instruction Sheet PK 9030 is included with each control, and is also available upon request.

Both emitter/receiver are prewired with 8-foot, 3 conductor shielded cable. Emitter cable contains two #22 AWG conductors. Receiver has three conductors (#22 AWG), and a shielded wire.

**Emitter**




**Receiver**




### ORDER GUIDE

| Description | Listing |
|---|---|
| Emitter — 12 VDC | **FE-MLS5EB** |
| Receiver — 12 VDC, light operated (L.O.) | **FE-MLS5RB** |
| NEMA 4 Emitter — 12 VDC | FE-MLS5EB-4 |
| NEMA 4 Receiver — 12 VDC | FE-MLS5RB-4 |
| Emitter — 24 VDC | FE-MLS5EB-00300 |
| Receiver — 24 VDC, light operated (L.O.) | FE-MLS5RB-00300 |
| Receiver — 24 VDC, dark operated (D.O.) | FE-MLS5RB-DO-300 |
| NEMA 4 Receiver — 24 VDC | FE-MLS5RB-40300 |

### OPTIONAL LENS ASSEMBLIES

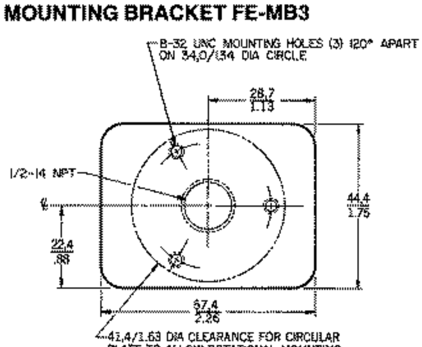
| | |
|---|---|
| Lensholder with 1.5-inch focus lens (for emitter)* | FE-LH27-108 |
| Lensholder with 6-inch focus lens (for receiver)*, glass lens | FE-LH27-127-1 |

*Lens offers only a limited operating range either side of the focal point due to concentration of light.

### REPLACEMENT PARTS

| Description | Listing |
|---|---|
| Lensholder, receiver/emitter — plastic | FE-LH27-127 |
| Mounting bracket (1) without mounting hardware | FE-MB3 |

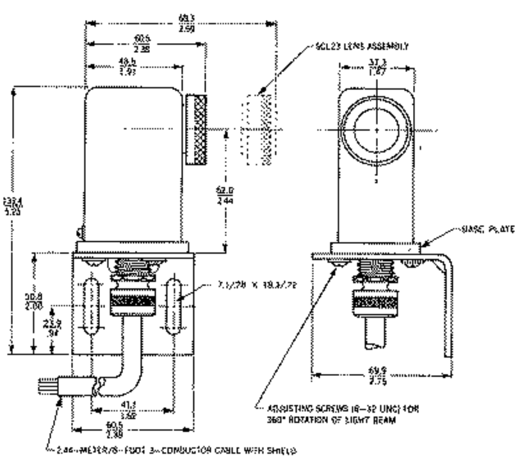
### MOUNTING BRACKET FE-MB3



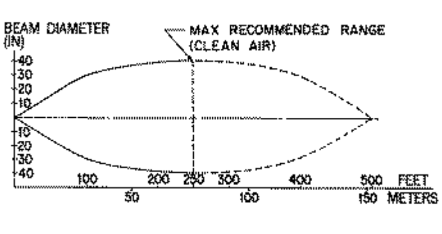
## SPECIFICATIONS

| | | |
|---|---|---|
| **Maximum Scanning Distance (In clean air)** | | 250 feet (76,2 m) |
| **Supply Voltage** | | 12 to 18 VDC; 20% max. power supply ripple 22 to 30 VDC; 10% max. power supply ripple |
| **Power Dissipation** | | 12 VDC Emitter — 1.5 watts max.; 12 VDC Receiver — 1.0 watts max. (excluding load) |
| | | 24 VDC Emitter — 3.0 watts max.; 24 VDC Receiver — 1.5 watts max. (excluding load) |
| **Current Consumption** | | 12 VDC Emitter — 60 mA max.; 12 VDC Receiver — 40 mA max. (excluding load) |
| | | 24 VDC Emitter — 90 mA max.; 24 VDC Receiver — 50 mA max. (excluding load) |
| **Output** | Load Current | 120 mA max. (light operated) current sinking |
| | Voltage Drop | 1.5 VDC max. at 120 mA load |
| | Leakage Current (Off state) | $< 10\mu A$ |
| **Maximum Rate of Operation** | | 1200 operations/minute |
| **Typical Response Time** | On | 30 msec. |
| | Off | 20 msec. |
| **Circuit Protection** | | Industrial electrical noise, Line transients, Momentary short circuit, Reverse polarity |
| **Temperature Range** | | –40°F to 158°F (–40°C to 70°C) |
| **Sealing** | | NEMA 1, 3, 12 and 13 — 4 optional |
| **Housing** | | Steel shell with epoxy finish |
| **Mounting** | | Right-angle brackets |
| **Weight** | | 3 lbs. (1,4K g) |
| **Logic** | Standard | Built-in ON/OFF (immediate response) control; light operated or dark operated will operate a relay directly |
| | Optional | Printed circuit logic cards permit dark operation as well as optional logic. Transition responsive cards cannot be used. Cards plug into a control base used to power the MLS5B |

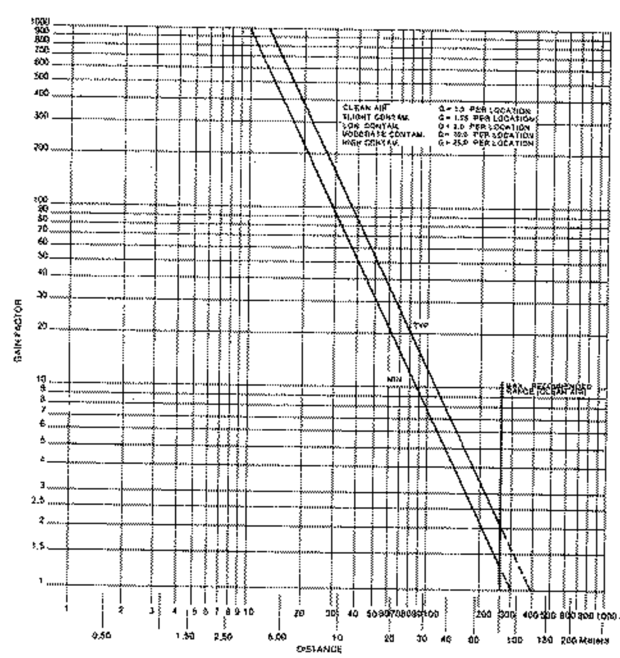
## MOUNTING DIMENSIONS



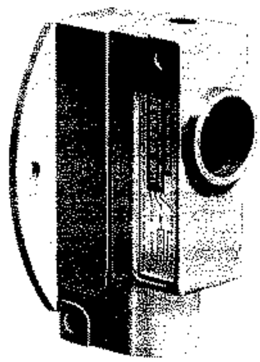
## BEAM DIAMETER



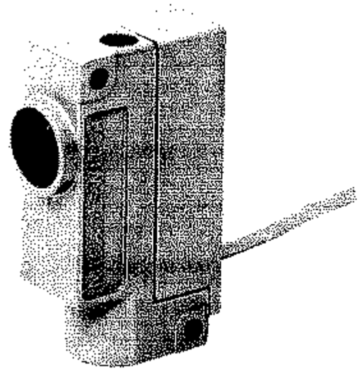

## EXCESS GAIN



# MLS7A DC photoelectric controls



Flange Mount



Side Mount

## GENERAL INFORMATION

MLS7A includes a noise-sheltered integrated receiver circuit, flexible printed wire circuitry; and a unique solid acrylic optical system that eliminates dead spots, condensation on inside surfaces, maintenance and adjustment.

Output is disabled for 10 milliseconds after power is applied, preventing false pulses when operating loads with a response time longer than 0.5 millisecond.

The MLS7A is the most indestructable photoelectric built by MICRO SWITCH and can hold up where many others fail. The solid opto block, potted construction and epoxy finished die cast housing all contribute to its reputation as "the hammer".

The MLS7A-3000/4000 Series is designed to meet requirements for "hazardous locations". Approved by Factory Mutual, this series meets requirements for Class II, Groups E and G, NEMA 9. All features of the MLS7A are retained.

## FEATURES

- *10-foot retroreflective scan range with FE-RR1 reflector*
- *12 to 16 VDC operation*
- *Sealing: NEMA 1, 3, 4, 12 & 13**
- *FM Class II, Divisions 1 and 2, Groups E and G (NEMA 9)*
- *UL and CSA recognized*
- *Alignment indicator*
- *Reverse polarity and short circuit protection*
- *Direct drive a 100 milliamp relay*
- *Direct compatibility with logic level circuitry*
- *Cast aluminum housing epoxy finish*
- *Prewired with 39 inches shielded 20 ga. cable*
- *Optional mounting bracket*

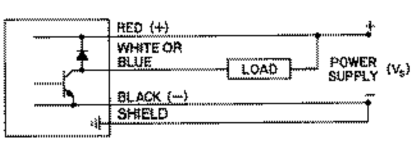
## FOR A COMPLETE CONTROL

**Required**
- Retroreflective control – **FE-MLS7A-1011**
- Appropriately rated DC power supply
- Reflector – **FE-RR1**

**Optional**
- Control base

## INSTALLATION/WIRING

Instruction Sheet PK 9033 is included with each control, and is also available upon request. PK 9045 covers hazardous location listings.




## ORDER GUIDE

| Description | Listing |
|---|---|
| 12 VDC normally open (N.O.) light operated; side mount | **FE-MLS7A-1011** |
| 12 VDC normally closed (N.C.) dark operated; side mount | FE-MLS7A-1012 |
| 12 VDC N.O. light operated; flange mount | FE-MLS7A-2011 |
| 12 VDC N.C. dark operated; flange mount | FE-MLS7A-2012 |
| 24 VDC N.O. light operated; side mount | FE-MLS7A-1021 |
| 24 VDC N.C. dark operated; side mount | FE-MLS7A-1022 |
| 24 VDC N.O. light operated; flange mount | FE-MLS7A-2021 |

## HAZARDOUS LOCATIONS

| Description | Listing |
|---|---|
| 24 VDC N.O. light operated; side mount | FE-MLS7A-3021 |

## ACCESSORIES

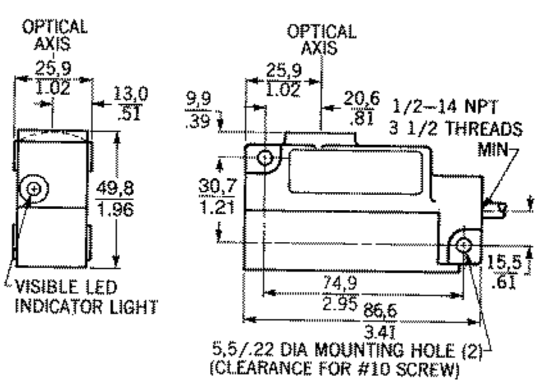
| Description | Listing |
|---|---|
| Auxiliary two-piece mounting bracket with hardware | FE-MB6 |

## SPECIFICATIONS

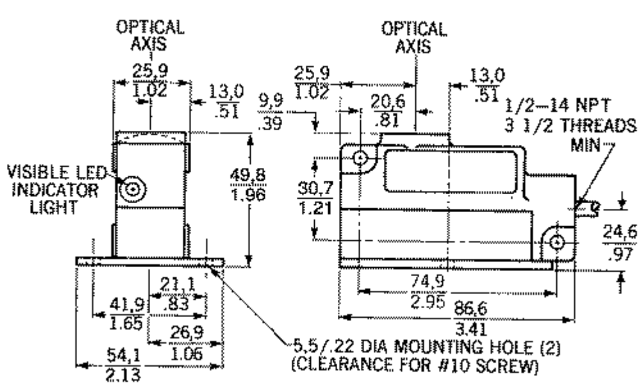
| | | |
|---|---|---|
| **Maximum Scanning Distance (in clean air)** | | 10 feet (3, 0m) with 3 in. reflector (FE-RR1) |
| **Supply Voltage** | | 12 to 16 VDC or 22 to 26 VDC; 10% max. power supply ripple |
| **Power Dissipation** | | 12 VDC — 2 watts max. (excluding load) 24 VDC — 4 watts max. (excluding load) |
| **Current Consumption** | | 100 mA max. (excluding load) |
| **Output** | Load Current | 120 mA max. (light or dark operated) current sinking |
| | Voltage Drop | 1.4 VDC max. sinking 120 mA max. |
| | Leakage Current (Off state) | < 10μA |
| **Maximum Rate of Operation** | | 7500 operations/minute |
| **Typical Response Time** | On | 4 msec. |
| | Off | 4 msec. |
| **Circuit Protection** | | False pulsing, Industrial electrical noise, Line transients, Momentary short circuit, Reverse polarity |
| **Temperature Range** | | –40°F to 158°F (–40°C to 70°C) Hazardous location listings limited to 60°C (140°F). |
| **Sealing** | | NEMA 1, 3, 4, 12 and 13: 9 optional |
| **Housing** | | Diecast aluminum with epoxy finish |
| **Mounting** | | Side or flange mount |
| **Weight** | | 10.5 ozs. (298 g) |
| **Logic** | Standard | Built-in ON-OFF (immediate response) control; light or dark operated models will operate a relay directly |
| | Optional | Printed circuit logic cards used with MICRO SWITCH control bases permit optional logic. Transition responsive cards cannot be used |

### MOUNTING DIMENSIONS

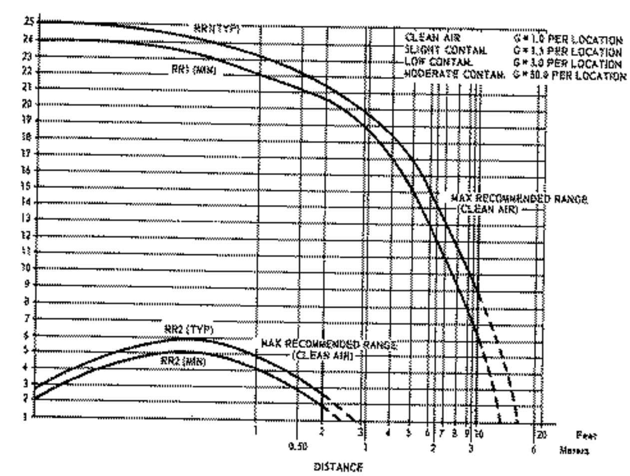
**Side Mount**



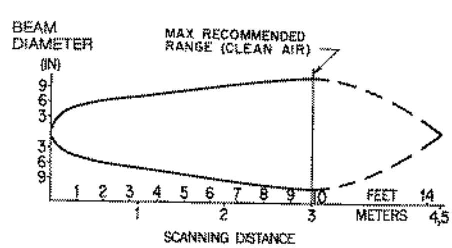

**Flange Mount**



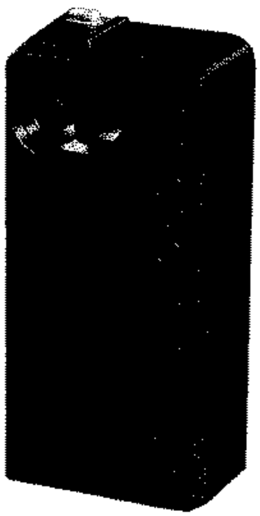

### EXCESS GAIN




### BEAM DIAMETER



# MLS8C/9C Long range AC photoelectric controls



## FOR A COMPLETE CONTROL

**Required**
- Retroreflective control—**FE-MLS8C**
- Reflector—**FE-RR1**

**Optional**
- Logic cards

## INSTALLATION/WIRING

Instruction sheet PK 9069 is included with each control, and is also available upon request.

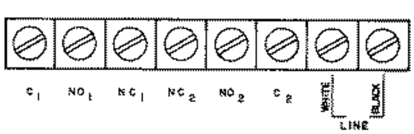
## FOR A COMPLETE CONTROL

**Required**
- Diffuse scan control—**FE-MLS9C**

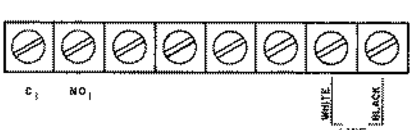
## INSTALLATION/WIRING

Instruction sheet PK 9070 is included with each control, and is also available upon request.

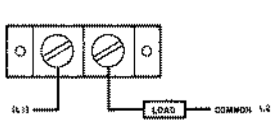
### Standard Relay or Solenoid




### Solid State Circuit




### Two Wire AC




## FEATURES

- *40-foot retroreflective scan range with FE-RR1 reflector*
- *5 or 9-foot diffuse scan range*
- *Self-contained AC operation*
- *Sealing: NEMA 1, 3, 4, 12 & 13*
- *UL listed*
- *Excellent immunity to ambient light and electrical noise*
- *Gunsight for easy mechanical alignment*
- *Enhanced sensitivity control*
- *Synchronous detection*
- *False pulse protection in all power conditions*
- *Optional plug-in logic capability*
- *Polycarbonate housing for strength and durability*

## GENERAL INFORMATION

The controls provides On-Off response without a plug-in card or jumper. Optional logic function cards plug in for time delay, pulse, or other modified output. With or without logic card, the FE-MLS8C can be set to respond either to a dark signal (beam blocked) or a light signal (beam not blocked). FE-MLS8C cannot be disabled (for selective response to input signals).

A 2-wire AC control, FE-MLS8C-2W is available with L.O./D.O. convertible output. Timing cards cannot be used with these 2-wire controls. Leakage current on 2-wire AC devices is under 2 mA making them ideal for interfacing with programmable controllers, etc.

## ORDER GUIDE RETROREFLECTIVE SCAN

| Description | Listing |
|---|---|
| Immediate response (ON-OFF) with standard DPDT relay 115 AC input | **FE-MLS8C** |
| Same as FE-MLS8C except with CSA approved conduit opening | FE-MLS8C-C |
| Two-wire AC, 102 to 132 VAC, 50/60 Hz input | FE-MLS8C-2W |
| Immediate response (ON-OFF) with standard DPDT relay 198 to 264 VAC, 50/60 Hz input | FE-MLS8C-T230 |
| Immediate response (ON-OFF) with 22-26 VAC or 20-30 VDC input DPDT relay | FE-MLS8C-T24 |

## ORDER GUIDE DIFFUSE SCAN

| Description | Listing |
|---|---|
| 115 VAC input, immediate response (ON-OFF) with standard DPDT relay; 9-foot scan range | **FE-MLS9C** |
| Same as FE-MLS9C except 230 VAC input | FE-MLS9C-T230 |
| Same as FE-MLS9C except 22 to 26 VAC or 20 to 30 VDC input | FE-MLS9C-T24 |
| 115 VAC input, immediate response (ON-OFF) with standard DPDT relay; 5-foot scan range | FE-MLS9C-SR |

## ACCESSORIES

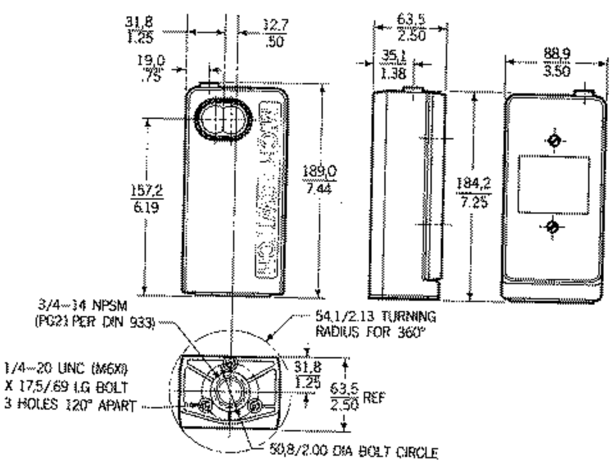
| Description | Listing |
|---|---|
| 10 amp 115 VAC DPDT relay (standard) | **FE-21051RY** |
| 10 amp DPDT relay (for T24) | FE-21054RY |
| 10 amp DPDT relay (for T230) | FE-21052RY |
| SPST N.O. completely isolated solid state triac (zero crossing) | FE-SW24A |
| SPST N.O. using dual VMOS field effect transistors | FE-SW25A |
| On-delay logic card | FE-LC1-C |
| Off-delay logic card | FE-LC2-C |
| On-off delay logic card | **FE-LC3-CC** |
| One-shot pulse output logic card | FE-LC4-C |
| Delayed one-shot pulse output logic card | FE-LC5-CC |
| Pulsed output response to a preset count | FE-LC10-A |
| Mounting bracket (std. hardware) 350° rotation, 90° tilt | **FE-MB8** |
| Same as MB8 except epoxy finish | FE-MB8-1 |
| Universal mounting bracket | FE-MB9-BRKT |
| Back cover | FE-8C-C-COV |
| Housing MSL8C/9C | FE-6RB-HSG |

# Long range AC photoelectric controls **MLS8C/9C**

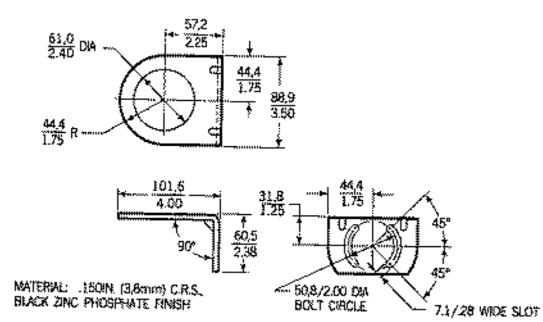
## SPECIFICATIONS

| | | | |
|---|---|---|---|
| **Maximum Scanning Distance (in clean air)** | | 40 feet (12 m) with 3 in. reflector (FE-RR1) | |
| **Supply Voltage** | | 102 to 132 VAC or 198 to 264 VAC, 50/60 Hz | |
| **Power Dissipation** | Standard Relay | 6.6 VA max. including relay (excluding load) or 13.2 VA (240 VAC version) | |
| | Optional | FE-MLS8C-2W; 0.3 VA max. (excluding load) | |
| **Current Consumption** | | 50 mA max. (excluding load) | |
| **Output** | Standard | DPDT relay, UL recognized, 10 amps 1/6 HP @ 115 VAC (coil 110 VDC) or 10 amps 1/3 HP @ 240 VAC (T-230 version) | |
| | Optional | — FE-SW24A (solid state) | FE-MLS8C-2W |
| | Load Current | — 3 amps @ −40°F to 104°F | 0.5 amps max., full temperature range |
| | Voltage Drop | — 1.5 VAC @ 3 amps | 7 volts max. @ 0.5 amp load |
| | Leakage Current (Off state) | — 0.5 mA (excluding load) | 2mA max. |
| **Maximum Rate of Operation** | | 1500 operations/minute | 1000 operations/minute |
| **Typical Response Time** | | FE-MLS8C | FE-MLS9C |
| | On | 20 msec. | 30 msec. |
| | Off | 20 msec. | 30 msec. |
| **Circuit Protection** | | False pulsing, Industrial electrical noise, Line transients | |
| **Temperature Range** | | −40°F to 158°F (−40°C to 70°C) | |
| **Sealing** | | NEMA 1, 3, 4, 12 and 13 | |
| **Housing** | | Glass reinforced polycarbonate | |
| **Mounting** | | Three 1/4-20 bolts into threaded metal inserts | |
| **Weight** | | 1.0 lb. (454 g) | |
| **Logic** | Standard | Built in ON-OFF (immediate response) control; L.O. or D.O. by slide switch | |
| | Optional | Multi-function logic cards (cannot be used with FE-MLS8C2W) | |

## MOUNTING DIMENSIONS

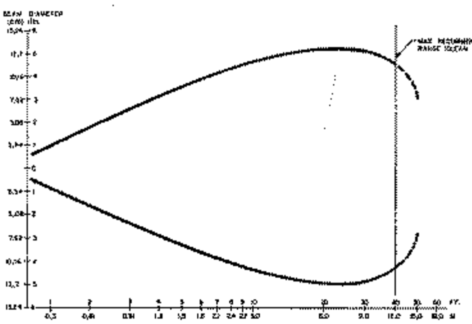



## MOUNTING BRACKET FE-MB8

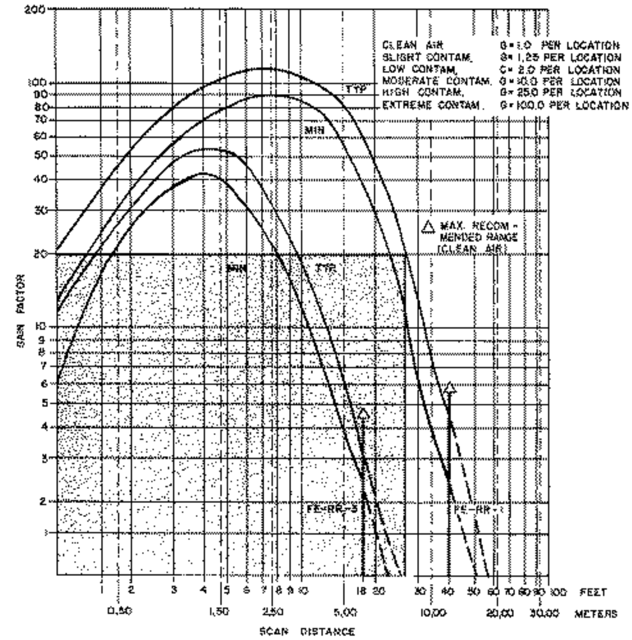


# MLS8C/9C Long range AC photoelectric controls

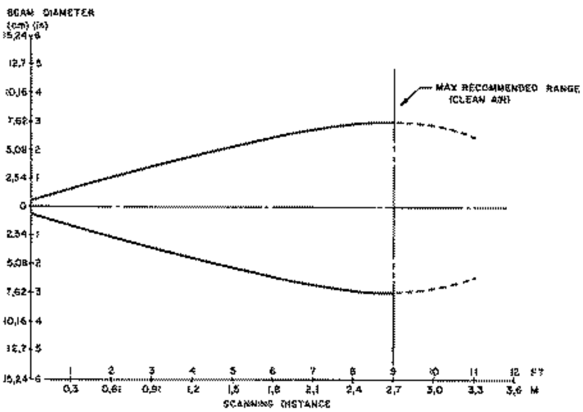
## BEAM DIAMETER RETROREFLECTIVE SCAN



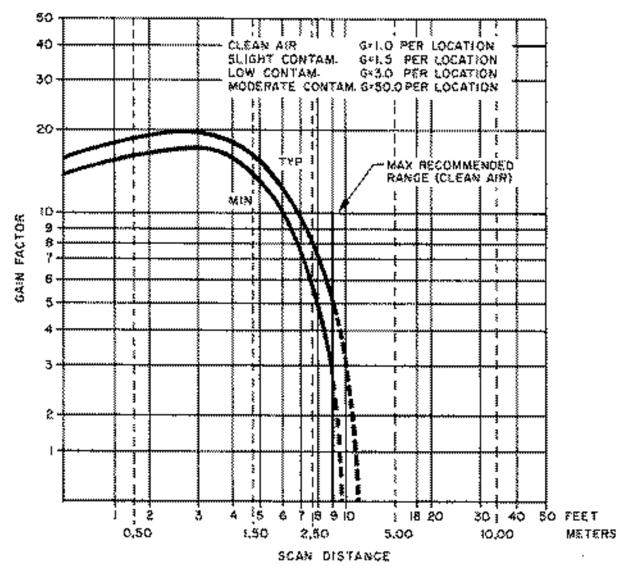
## EXCESS GAIN RETROREFLECTIVE SCAN



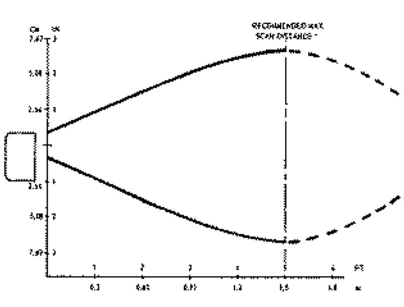

## BEAM DIAMETER DIFFUSE SCAN



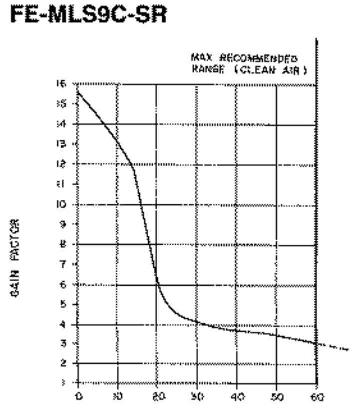

## EXCESS GAIN DIFFUSE SCAN FE-MLS9C



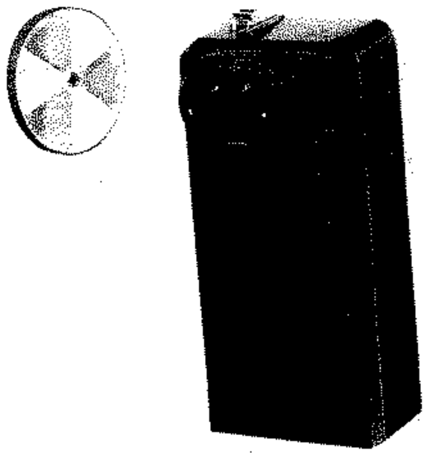

## FE-MLS9C-SR BEAM SIZE



## FE-MLS9C-SR



# Polarized scan controls FE-MLS8C-P



### FEATURES

- *15-foot retroreflective scan range with FE-RR1 reflector*
- *Self-contained AC operation*
- *Sealing: NEMA 1, 3, 4, 12 & 13*
- *UL listed*
- *Polarized visible LED for ambient light rejection*
- *Gunsight for easy mechanical alignment*
- *Sensitivity control*
- *Excellent immunity to ambient light and electrical noise*
- *False pulse protection*
- *Synchronous detection*
- *Optional plug-in logic capability*
- *Easy wiring*

### GENERAL INFORMATION

The polarized FE-MLS8C-P photoelectric control emits a visible LED beam and uses a special lens which filters the beam of light so that it is projected in one plane only. The control responds only to the de-polarized reflected light from corner-cube type reflectors (FE-RR1). It is designed to ignore the random light reflected from most varieties of shrink wrap materials, shiny luggage, aluminum cans or common reflective material. The control is self-contained and operates on AC line voltage. It consists of a modulated light emitting diode, photoreceiver, and amplifier circuitry with 10 amp DPDT relay (standard version).

### FOR A COMPLETE CONTROL

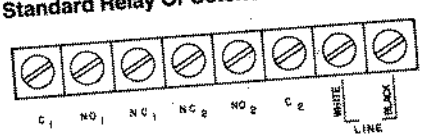
**Required**
- Polarized scan control—**FE-MLS8C-P**
- Reflector—**FE-RR1**

**Optional**
- Logic cards

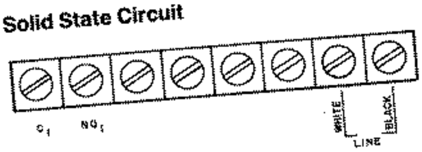
### INSTALLATION/WIRING

Instruction Sheet PK 9072 is included with each control, and is also available upon request.

**Standard Relay Or Solenoid**




**Solid State Circuit**



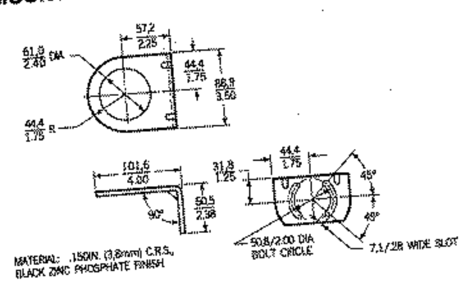

### ORDER GUIDE

| Description | Listing |
|---|---|
| Immediate response (ON-OFF with standard DPDT relay 115 VAC input) | **FE-MLS8C-P** |

### ACCESSORIES

| Description | Listing |
|---|---|
| 10 amp DPDT relay (standard) | FE-21051RY |
| SPST N.O. completely isolated solid state triac (zero crossing) | FE-SW24A |
| SPST N.O. using dual VMOS field effect transistors | FE-SW25A |
| On-delay logic card | FE-LC1-C |
| Off-delay logic card | FE-LC2-C |
| On-Off delay logic card | FE-LC3-CC |
| One-shot pulse output logic card | FE-LC4-C |
| Delayed one-shot pulse output logic card | FE-LC5-CC |
| Pulsed output response to a preset count | FE-LC10-A |
| Mounting bracket (std. hardware) 350° rotation, 90° tilt | FE-MB8 |
| Same as MB8 except epoxy finish | FE-MB8-1 |
| Universal mounting bracket | FE-MB9-BRKT |

### MOUNTING BRACKET FE-MB8

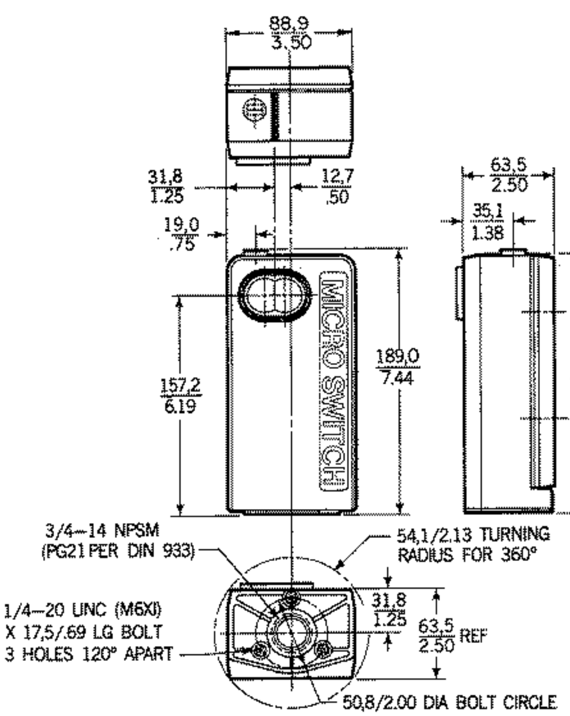


# FE-MLS8C-P Polarized scan controls

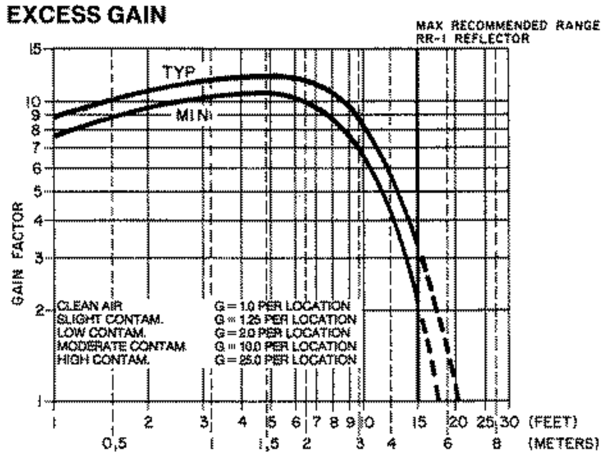
## SPECIFICATIONS

| | | | |
|---|---|---|---|
| **Maximum Scanning Distance (in clean air)** | | 15 feet (4,5 m) with 3 in. reflector (FE-RR1) | |
| **Supply Voltage** | | 102 to 132 VAC, 50/60 Hz. | |
| **Power Dissipation** | | 6.6 VA including relay (excluding load) | |
| **Current Consumption** | | 50 mA max. (excluding load) | |
| **Output** | | DPDT relay, UL recognized 10 amps, 1/6 HP @ 115 VAC (Coil 110 VDC) | FE-SW25A-SPST-NO |
| | Load Current | 3 amps @ –40°F to 104°F; inrush current 30 amps max. | 30 amps max. @ –40°F to 158°F; inrush current 100 mA max. |
| | Voltage Drop | 1.5 VAC max. @ 3 amps load | 2.1 VAC max. @ 100 mA |
| | Leakage Current (Off state) | — | 10 μA max. |
| **Maximum Rate of Operation** | | 1000 operations/minute | 1500 operations/minute |
| **Typical Response Time** | On | 30 msec. | 20 msec. |
| | Off | 30 msec. | 10 msec. |
| **Circuit Protection** | | False pulsing, Industrial electrical noise, Line transients | |
| **Temperature Range** | | –40°F to 131°F (–40°C to 55°C) | |
| **Sealing** | | NEMA 1, 3, 4, 12 and 13 | |
| **Housing** | | Glass reinforced polycarbonate | |
| **Mounting** | | Three 1/4-20 bolts into threaded metal inserts | |
| **Weight** | | 1.0 lb. (454 g) | |
| **Logic** | Standard | Built-in ON-OFF (immediate response) control; L.O. or D.O. by slide switch | |
| | Optional | 7 logic cards | |

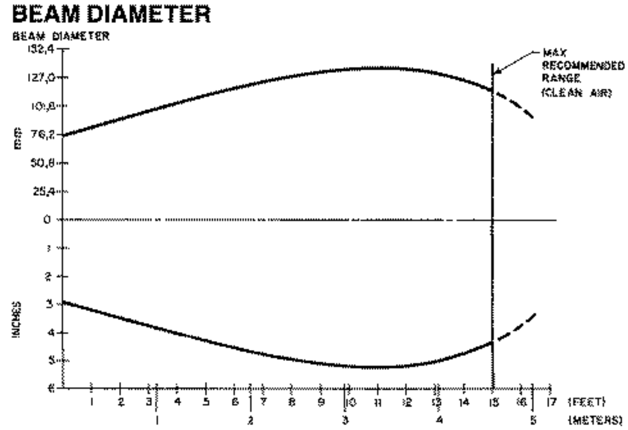
## MOUNTING DIMENSIONS



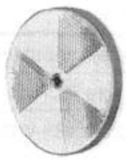

## EXCESS GAIN




## BEAM DIAMETER



# AC or DC controls MLS10



**FEATURES**

- *12-foot retroreflective scan range (relay output) with FE-RR1 reflector*
- *6.5-foot retroreflective scan range (2-wire AC/DC) with FE-RR1 reflector*
- *Up to 20-inch diffuse scan range*
- *Up to 25-foot thru scan range*
- *Self-contained either AC or DC operation*
- *Sealing: NEMA 12 and IP65*
- *UL listed*
- *Gunsight for easy mechanical alignment*
- *LED output indicator for easy set-up and alignment*
- *Reverse polarity and short circuit protection*
- *False pulse protection*
- *Sensitivity adjustment (optional)*
- *Metric design versions for worldwide use*
- *Terminal strip termination*

**GENERAL INFORMATION**

MLS10 controls require no separate amplifier for signal conditioning. FE-MLS10-G20A, -F20A and FE-MLS10S-F20A models have an open collector, current sinking transistor capable of handling 120 mA of steady state current.

The polycarbonate housing has a choice of one or two conduit openings with metric or US threads. They can be surface mounted using two #10 screws or an optional mounting bracket provides tilt and rotary adjustment.

Logic is available on some versions by adding a -T1 (On-delay), -T2 (Off-delay) or a -T3 (On-Off delay) to the end of the listing. When either pot or both, are turned clockwise, an extended delay results. Time ranges are independently adjustable up to 12 sec. nominal for On, Off, or On-Off delay. An additional 300 msec. delay exists over standard On-Off units even with the pots turned fully counterclockwise (Off).

**FOR A COMPLETE CONTROL**

**Required**

- Retroreflective control – **FE-MLS10-A10A**
- Reflector – **FE-RR1**
- Appropriately rated power supply for DC devices

**INSTALLATION/WIRING**

Instruction sheet PK 9051 is included with each control, and is also available upon request.

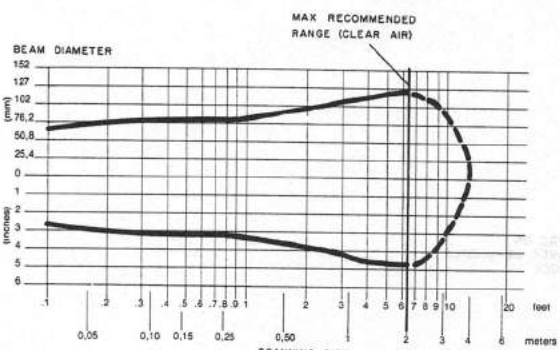
**ORDER GUIDE RETROREFLECTIVE SCAN**

| Description | Listing |
|---|---|
| 115 VAC input, light operated, SPDT relay output (12 ft. scan) | **FE-MLS10-A10A** |
| 115 VAC input, normally open, light operated, 2-wire device with SCR output (2 mA leakage current), with sensitivity adjustment | FE-MLS10S-A16A |
| 24 VDC input, N.O., light operated, current sinking 120 mA output | FE-MLS10-G20A |
| 12 VDC input N.O., light operated, current sinking 120 mA output | FE-MLS10-F20A |
| 12 VDC input, N.O., light operated, current sinking 120 mA output, with sensitivity adjustment | FE-MLS10S-F20A |

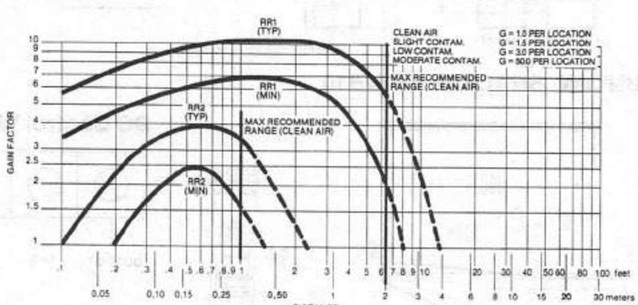
**ACCESSORIES**

| Description | Listing |
|---|---|
| Mounting bracket | FE-MB10 |

**BEAM DIAMETER RETROREFLECTIVE SCAN**




**EXCESS GAIN RETROREFLECTIVE SCAN**

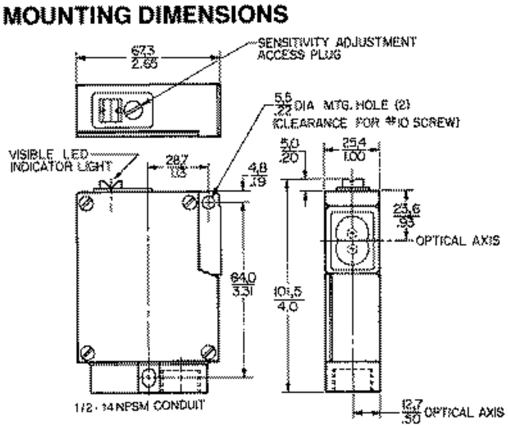


# MLS10 AC or DC controls

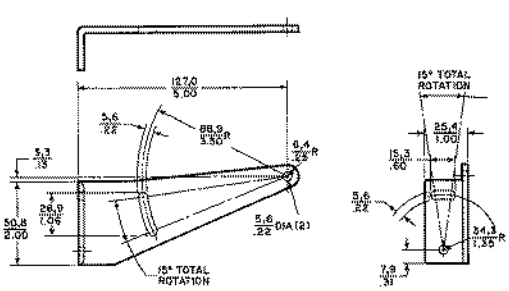
## SPECIFICATIONS

| | | | | |
|---|---|---|---|---|
| **Maximum Scanning Distance (in clean air)** | | 12 feet (3,66 m) with 3 in. reflector (FE-RR1) relay output retro | | |
| | | 6.5 feet (2,0 m) with 3 in. reflector (FE-RR1) 2 wire AC/DC | | |
| **Supply Voltage** | | AC version: 105 to 132 VAC, 50/60 Hz | 2-wire AC: 102 to 132 VAC, 50/60 Hz | DC versions: 12 to 16 VDC or 22 to 26 VDC |
| **Power Dissipation** | | 4.6 VA max. (excluding load) | 0.3 VA max. (excluding load) | Various 0.6 to 2.6 watts depending on unit. |
| **Current Consumption** | | 35 mA max. (excluding load) | 2 mA max. (excluding load) | |
| **Output** | Load Current | 6 amps @ 120 VAC | 0.5 amps @ 50°C (light operated) | 120 mA max. (light operated) current sinking |
| | Voltage Drop | — | $<$ 10 VAC | 1.7 VDC max. at 120 mA |
| | Leakage Current (Off State) | — | 2 mA max. | $< 10\mu A$ |
| **Maximum Rate of Operation** | | 665 operations/minute | 750 operations/minute | 7500 operations/minute |
| **Typical Response Time** | On | 40 msec. | 30 msec. | 3 msec. |
| | Off | 50 msec. | 50 msec. | 5 msec. |
| **Circuit Protection** | | False pulsing, Line transients, Short circuit (DC), Reverse polarity (DC) | | |
| **Temperature Range** | | –4°F to 122°F (–20°C to 50°C) | –4°F to 122°F (–20°C to 50°C) | –4°F to 140°F (–20°C to 60°C) |
| **Sealing** | | NEMA 12 and IP65 | | |
| **Housing** | | Polycarbonate/Glassfill | | |
| **Mounting** | | Surface mounted using two #10 screws or an optional mounting bracket | | |
| **Weight** | | 4 ozs. (113, 4g) | | |
| **Logic** | Standard | Built-in ON-OFF (immediate response) control; light operated will operate a relay directly | | |
| | Optional | DC versions with MICRO SWITCH control bases offer a variety of logic options. ON delay or OFF delay by individual catalog listing | | |

## MOUNTING DIMENSIONS

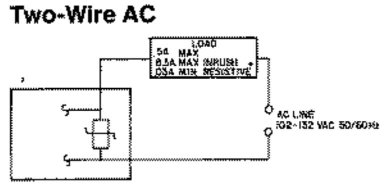



## MOUNTING BRACKET FE-MB10

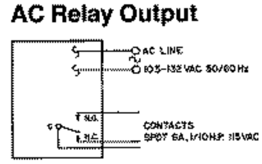



## WIRING

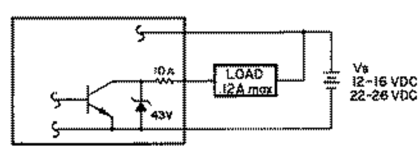
### Two-Wire AC



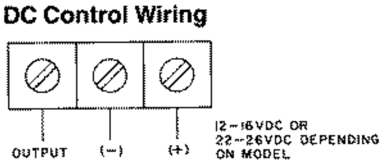

### AC Relay Output

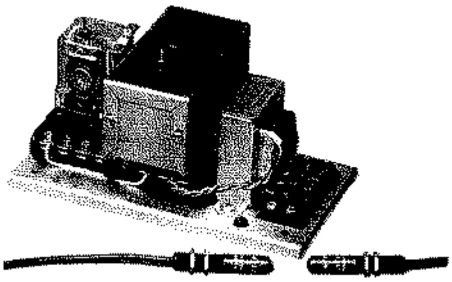



### DC Current Sinking




### DC Control Wiring





## FEATURES

### LED Emitters and Photoreceivers

- *Up to 30-foot thru scan range (see Specifications for maximum scan distances)*
- *Sealing: NEMA 1, 3, 4, 12 and 13*
- *Discrete emitters and receivers*
- *Remote sensing*
- *Small package size*
- *Tubular and 90° housings*
- *Explosion-proof controls available*

### Amplifier Modules

- *Dual indicator LEDs (FE-MLS-TR3)*
- *Alignment and output LEDs (FE-MLS-TR5-14/FE-MLS-TR8B)*
- *Adjustable sensitivity*
- *Selectable light or dark operated*
- *Short circuit and false pulse protection*
- *Synchronous detection*
- *Time delay and pulsed logic modules*
- *Interchangeability with existing TRB control bases*
- *Color coded logic identification*

## FOR A COMPLETE CONTROL

### Required

MLS-TR uses a modular approach to provide a flexible, easily customized control system. A complete control consists of:

- A choice of discrete LED emitters and photoreceivers in tubular or 90° housings.
- One of three different TR amplifier modules which house the modulating and demodulating circuitry.
- A FE-TRB modular control base.

Note: Only one set of emitters/receivers can be wired to each amplifier module.

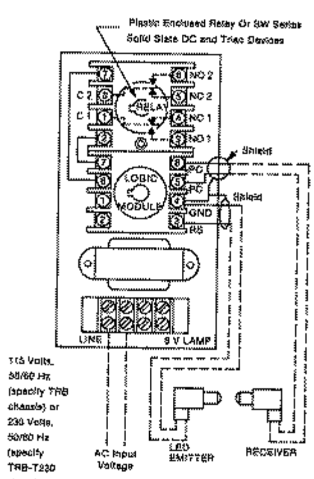
## INSTALLATION/WIRING

Instruction Sheets are included with each control, and are available upon request. Only one set of emitters/receivers can be wired to each amplifier module.

| | |
|---|---|
| TRB Control bases | PK 9038 |
| Amplifier modules | PK 9057 |
| Emitters/Photoreceivers | PK 9061 |

### Typical TRB Chassis

Solid connections shown are factory wired. Dotted connections are customer wired.




## ORDER GUIDE

### LED EMITTERS AND PHOTORECEIVERS

| Description | Listing |
|---|---|
| 0.25 inch diameter tubular delrin housing LED emitter. Recommended thru scan range 3.5 feet. | **FE-MTE1** |
| 0.25 inch diameter tubular delrin housing photoreceiver (receiver). Use with FE-MTE1. | **FE-MTR1** |
| 0.38 inch diameter tubular delrin housing LED emitter. Recommended thru scan range 8.0 feet. | FE-MTE2 |
| 0.38 inch diameter tubular delrin housing photoreceiver (receiver). Use with FE-MTE2. | FE-MTR2 |
| 90° housing LED emitter. Recommended thru scan range 10.0 feet | **FE-MCE1** |
| 90° housing photoreceiver (receiver). Use with FE-MCE2. | **FE-MCR1** |
| 90° housing LED emitter. Recommended thru scan range 30.0 feet. | FE-MCE2 |
| 90° housing photoreceiver (receiver). Use with FE-MCE2. | FE-MCR2 |
| Explosion-proof version of MCE2.* | FE-MCE2X |
| Explosion-proof version of MCR2.* | FE-MCR2X |

* Factory Mutual approved for Class I, Div. 1, Group B, C, D; Class II, Div. 1, Groups E and G. 24 Ft. lead lengths available. Add -24 to listing.

### AMPLIFIER MODULES

| | |
|---|---|
| A simple ON-OFF amplifier circuit that responds immediately to a sufficient change in light at the phototransistor. The output is ON for the duration of the input signal. | **FE-MLS-TR3** |
| A combination ON and OFF delay circuit output which turns ON only if the input signal exceeds the preset ON delay. After the input signal ends the output remains ON for the duration of the preset OFF delay. 0.15 to 15.0 seconds typical range. | FE-MLS-TR5-14 |
| A non-repeat delayed one-shot pulsed output. An adjustable ON delay is started by a momentary input signal. An adjustable output pulse turns ON immediately at the end of the delay. When the output pulse ends, the circuit is ready for another input signal. Recycling does not occur if the original input signal is sustained. 0.15 to 15.0 seconds typical range. | FE-MLS-TR8B |

### CONTROL BASES

| | |
|---|---|
| Standard 2-socket, 115 VAC input model with plug-in DPDT relay. | **FE-TRB** |
| Standard 2-socket, 115 VAC input model without relay. | FE-TRB-LRY |
| Same as FE-TRB except UL recognized. | FE-TRBU |
| Standard 2-socket, 230 VAC input model with plug-in DPDT relay. | FE-TRB-T230 |

# MLS-TR Modular controls

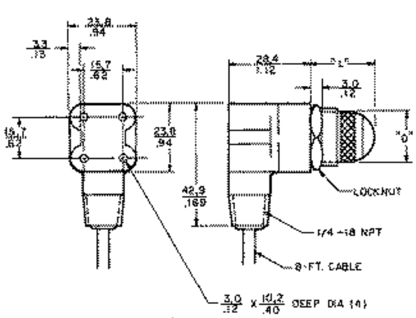
## SPECIFICATIONS

| Maximum Scanning Distance (in clean air) | Housing Style | Emitter | Receiver | Max. Range |
|---|---|---|---|---|
| | 0.25" dia. tubular | FE-MTE1 | FE-MTR1 | 3.5 feet (1m) |
| | 0.38" dia. tubular | FE-MTE2 | FE-MTR2 | 8.0 feet (2,4m) |
| | 90° | FE-MCE1 | FE-MCR1 | 10.0 feet (3m) |
| | 90° | FE-MCE2 | FE-MCR2 | 30.0 feet (9,1m) |

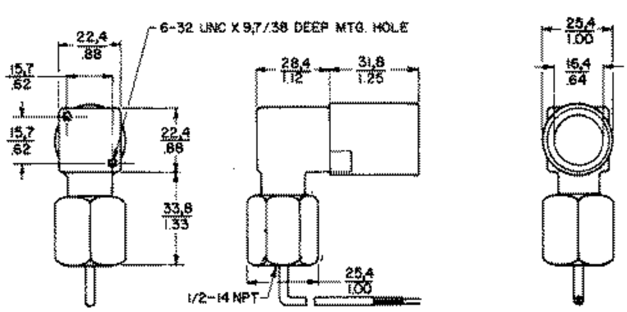
| | | | |
|---|---|---|---|
| **Supply Voltage** | Control base | 102 to 132 VAC or 204 to 264 VAC, 50/60 Hz. | |
| | Module | 11 to 17 VAC 50/60 Hz; 13 to 22 VDC regulated or 15 VDC ± 10% power supply ripple | |
| **Power Dissipation** | Module | 4.5 watts max. (excluding load) | |
| | Control base | 16 VA max. | |
| **Current Consumption** | Amplifier | 80 mA (excluding load) | |
| **Output** | Standard | DPDT relay, UL recognized 10 amps 1/6 HP at 115 VAC | |
| | Optional | SW solid state DC and triac device or FE-26-300 reed relays. See Output Specifications. | |
| | Module<br>(Voltage Drop) | FE-MLS-TR3 (L.O./D.O. selectable)<br>0.125 amp max. at 30 VDC<br>Light operated; 3 VDC max. at 0.125 amp | FE-MLS-TR5-14 or FE-MLS-TR8B (L.O./D.O. selectable) 0.25 amp max. at 30 VDC<br>Light operated; 3 VDC max. at 0.25 amps |
| | | Dark operated; 1.5 VDC max. at 0.125 amps | Dark operated; 1.5 VDC max. at 0.25 amps |
| | | Dark operated; 0.4 VDC max. at 0.02 amps | Dark operated; 0.4 VDC max. at 0.02 amps |
| **Maximum Rate of Operation** | | 1700 operations/minute | |
| **Typical Response Time** | On | 17 msec. | |
| | Off | 18 msec. | |
| **Circuit Protection** | | False pulsing, Industrial electrical noise, Short circuit | |
| **Temperature Range** | Emitters/Receivers | −40°F to 140°F (−40°C to 60°C) | |
| | Modules | −14°F to 140°F (−10°C to 60°C) | |
| **Sealing** | | Emitters/Receivers NEMA 1, 3, 4, 12 and 13 | |
| **Housing** | | Emitters/Receivers — Plastic or tubular aluminum | |
| **Mounting** | | Varies with product | |
| **Weight** | | Varies with product | |
| **Logic** | | Selectable by amplifier module (FE-MLS-TR3, FE-MLS-TR5-14, FE-MLS-TR8B) | |

## MOUNTING DIMENSIONS

**FE-MCE1/FE-MCR1, FE-MCE2/FE-MCR2**




**FE-MCE2-X/FE-MCR2-X**

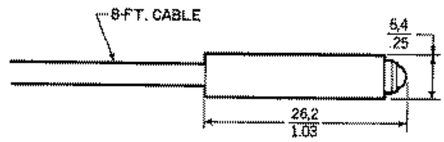



| | FE-MCE1<br>FE-MCR1 | FE-MCE2<br>FE-MCR2 |
|---|---|---|
| Dimension D | 15,9<br>.62 | 22,2<br>.88 |
| Dimension L | 20,6<br>.81 | 34,9<br>1.38 |

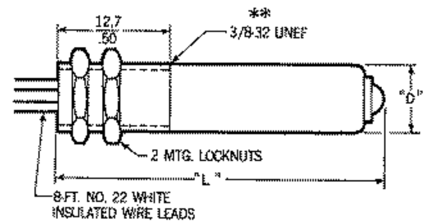
All emitters and receivers have 8 ft. of 22 gage wire unless designated as special length.

## MOUNTING DIMENSIONS

### FE-MTE1/FE-MTR1




### FE-MTE2/FE-MTR2

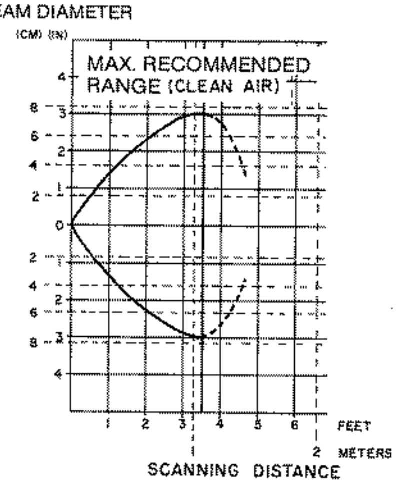



** 1/4 - 32 UNEF (TLS4)

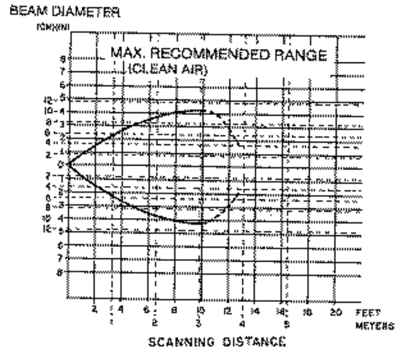
| | FE-MTE2<br>FE-MTR2 |
|---|---|
| Dimension D | 9,5<br>.38 |
| Dimension L (max.) | 45,2<br>1.78 |

## BEAM DIAMETERS

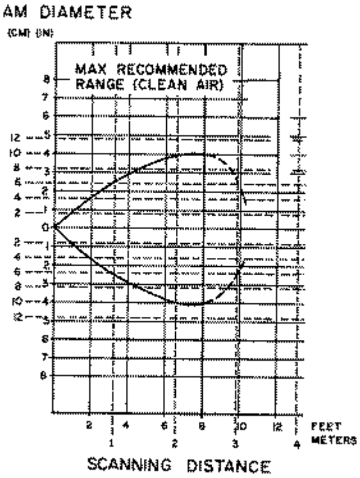
### FE-MTE1



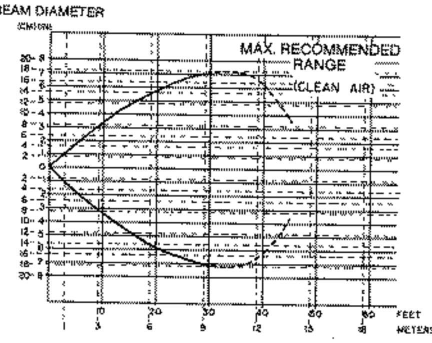

### FE-MCE1




### FE-MTE2

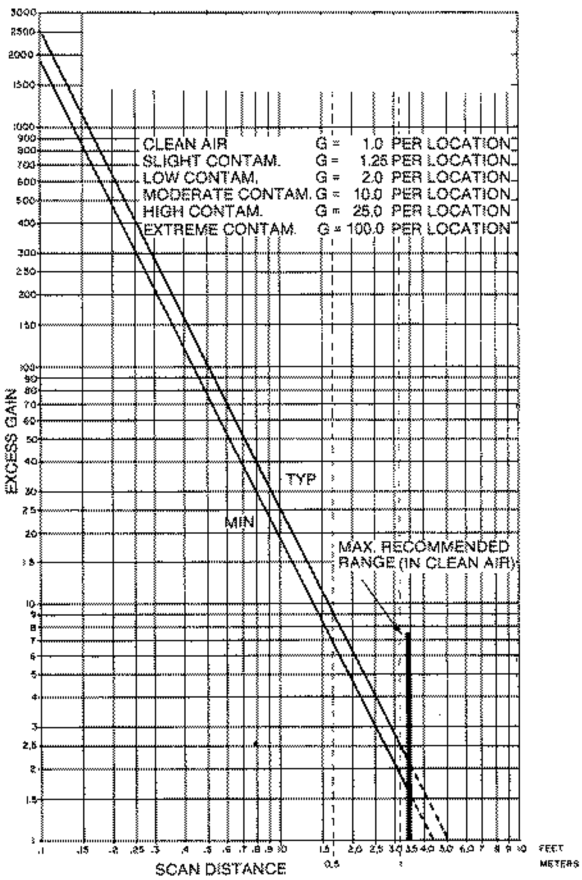



### FE-MCE2/E2X

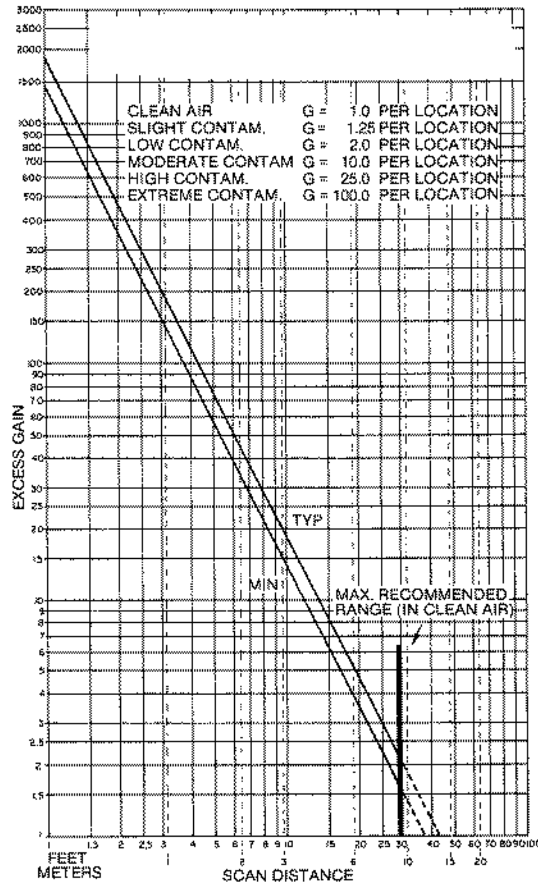


## EXCESS GAIN

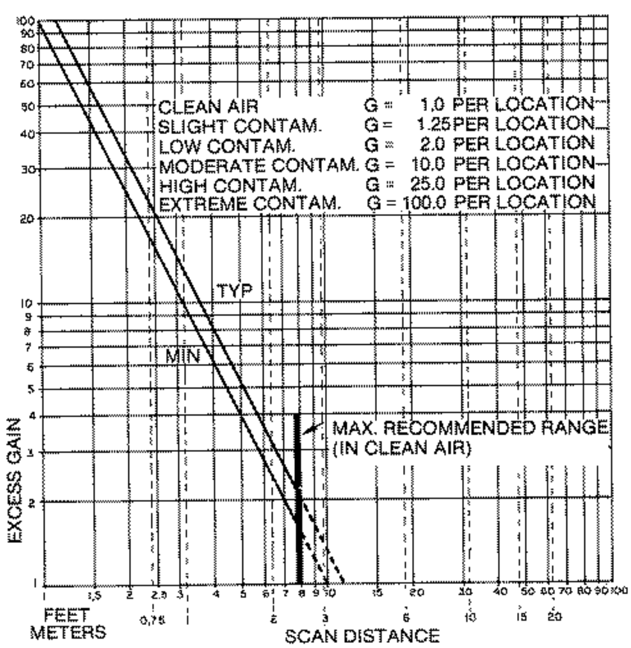
### MTE1/MTR1



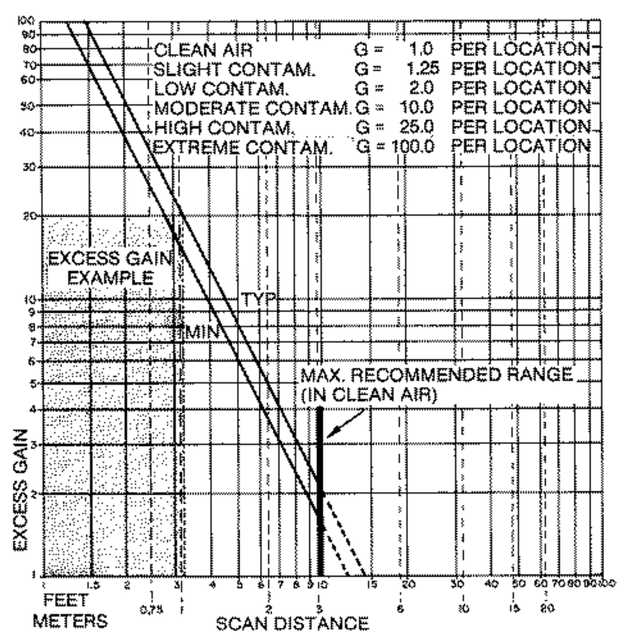

### MCE2X/MCR2X
### MCE2/MCR2

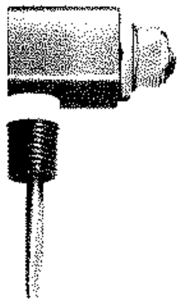



### MTE2/MTR2

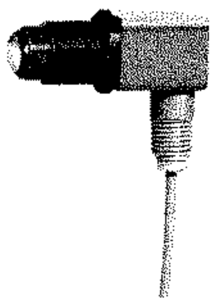



### MCE1/MCR1





Light Source



Photoreceiver

## GENERAL INFORMATION

Discrete (separate) light sources and photoreceivers, like incandescent scanners, must be wired to a control base.

Most of the light sources contain an incandescent lamp, though a few contain a non-modulated, visible beam light-emitting diode (VLED). The photoreceiver contains either a low-impedance cadmium selenide photocell, or a high-speed, temperature-stable silicon phototransistor that responds to the incandescent lamp or VLED beam. The photosensor output signal is conditioned and amplified to operate the control base output device. See the guidelines for selecting amplifiers and output devices to determine the speed of response of the complete control.

## TEMPERATURE RANGE

The temperature range for light sources and photoreceivers is –40°F to 140°F (–40° to 60°C), unless noted otherwise in the individual descriptions. (Ambient temperature for VLED light sources may extend lower, depending on the operating current's effect on diode internal temperature.)

## SCAN DISTANCE AND IMAGE SIZE

The scan distance of a light source-photoreceiver pair depends on light source intensity, photoreceiver sensitivity (type of photosensor), amplifier used, and sometimes operating mode (light or dark). Any light source can be paired with any photoreceiver, though some combinations are not recommended. Refer to the scan distance chart for recommended combinations. A light source image size chart is also included.

## LEADWIRES

Light sources and photoreceivers are prewired with an 8-foot cable, unless noted otherwise. Optional lead lengths are available in large quantity orders for an additional charge. See information about extending leadwires.

## ACCESSORIES

Mounting brackets, photoreceiver apertures (masks), and armor-grip cable are described in the Accessories section.

## MOUNTING

Heavy-duty cast aluminum units can be mounted:

1. using the mounting holes at the back of the housing;
2. using the integral pipe thread extension for connection to conduit;
3. using the lensholder hex nut to secure the unit to a panel.

Aluminum tubular units (some threaded) fit where space is limited. They are permanently sealed with epoxy. They can be mounted in standard fuse clips or held in place with a set screw. Threaded units can be panel-mounted using the hex nut(s). See auxiliary mounting brackets, Accessories section.

## GENERAL RESPONSE TIME GUIDELINES

- Phototransistor – 20 to 30 μs
- Photocell – 1 ms max.
- Transition amplifier – 100 μs
- Threshold amplifier – 1 ms
- Threshold amplifier used with photocell – 1.5 to 2 ms

# Order guide for light sources

(Listed within subgroups in a generally increasing order of light intensity or brightness.)

**90° HOUSING**

| Description | Dwg. | Lamp | Listing |
|---|---|---|---|
| Standard general purpose light source with adjustable focus. Typical max. scan: 3-5 feet. | A | #12 plug-in lamp rated at 5,000-hour life at 150mA, 6.3 VAC (or VDC) | **FE-LS1C** |
| Typical max. scan: 5-10 feet; adjustable focus. | A | #15 plug-in lamp rated for 10,000-hour life at 340 mA, 5.5 VAC (or VDC) | **FE-LS1LC** |
| Typical max. scan: 10-20 feet; adjustable focus. See (1) Apertures, (2) Mounting Brackets in Accessories. | B | #210 plug-in lamp rated for 10,000-hour life at 1.5 amps, 4.5 VAC (or VDC) | **FE-LS2C** |
| Typical max. scan: 25-50 feet; adjustable focus. | B | | FE-LS2BZ |

**TUBULAR ALUMINUM HOUSING**

| Description | Dwg. | Lamp | Listing |
|---|---|---|---|
| Smallest size light source, 0.25 inch diameter. Typical max. scan: 3-4 inches; fixed focus | C | Potted lamp rated for 100,000-hour life at 60 mA, 5 VAC (or VDC) | **FE-TLS1**++ |
| Same as TLS1, but approx. twice as bright (double scan distance) with shorter life. Fixed focus. | C | Potted lamp rated for 25,000-hour life at 115mA, 5 VAC (or VDC) | FE-TLS1M++ |
| Only low-voltage (5 VAC) tubular light source with replaceable lamp, 0.25 inch diameter Typical max. scan: 2-3 feet. | D | #7715 plug-in lamp rated for 40,000-hour life at 115 mA, 5 VAC (or VDC) | FE-TLS4++ |
| Typical max. scan: 3-4 inches; fixed focus. 0.38 inch diameter | D | Potted lamp rated for 100,000-hour life at 60 mA, 5 VAC (or VDC) | FE-TLS2++ |
| Typical max. scan: 2-3 feet; adjustable focus. 0.38 inch diameter. | E | #7349 plug-in lamp rated for 5,000-hour life at 200 mA, 6.3 VAC (or VDC) | **FE-TLS3** |
| 0.38 inch diameter | E | Fine focus version of TLS3: for detection of very small parts (thin wires, etc.); not recommended for registration control because of low light intensity. | FE-TLS3FF |

++ Low-voltage (5 VAC) light source to be used only with G4B2, LCRP2, TRB1, or PE2-2 control base. These bases are standard control bases with a 10-ohm, 5-watt resistor wired in series with the LAMP terminals. A standard base can easily be adapted for low-voltage lamp use by wiring in the resistor.

**VISIBLE LED (VLED) LIGHT SOURCES (Not modulated, emits red visible light)**

| Description | Dwg. | LED | Listing |
|---|---|---|---|
| Typical max. scan: 3 inches. Potted LED.* Tubular. | C | Rated for 100,000-hour life at 50 mA, 3-20 VDC | FE-TLD1 |
| Typical max. scan: 4 inches. Adjustable focus.** Plug-in LED. Tubular. | E | | FE-TLD3 |
| Typical max. scan: 2 feet. Adjustable focus.** Plug-in LED. 90° housing. | A | | FE-LSD1 |

* A 270-ohm, 3-watt current-limiting resistor is included with each FE-TLD1 light source. Refer to Instruction Sheet PK 9017 for wiring information.
** A 470-ohm, 1-watt current-limiting resistor is included with each FE-TLD3/LSD1 light source. Refer to Instruction Sheet PK 9017 for wiring information.

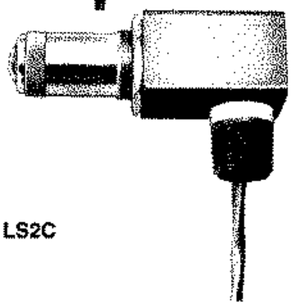
LS1C listing is available with die cast housing by adding a "**-DC**" suffix.

# Order guide for light sources

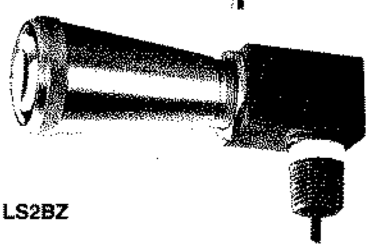
## 90° HOUSING

LS1C

LS1LC



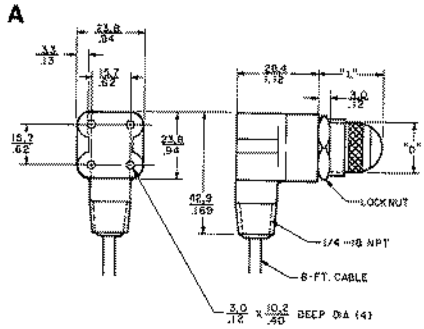
LS2C



LS2BZ

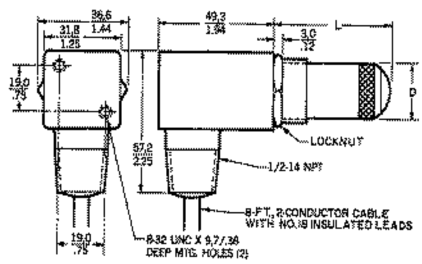
## MOUNTING DIMENSIONS

A




| | LS1C LSD1 | LS1LC |
|---|---|---|
| Dimension D | 15,9<br>.62 | 22,2<br>.88 |
| Dimension L (max. — adjustable lensholder fully extended) | 20,6<br>.81 | 34,9<br>1.38 |

B




| | LS2C | LS2BZ |
|---|---|---|
| Dimension D | 23,8<br>.94 | 42,1<br>1.66 |
| Dimension L (max. — adjustable lensholder fully extended) | 50,8<br>2.00 | 85,7<br>3.38 |

## TUBULAR ALUMINUM HOUSING

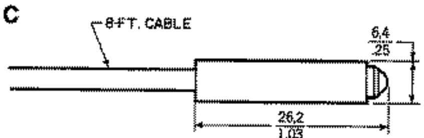
TLS1

TLS2

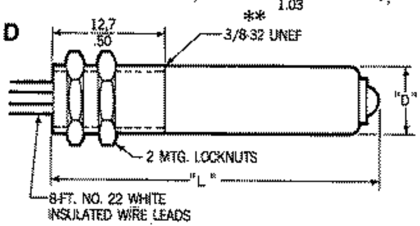
TLS3

## TLS1, TLS1M, TLD1

C



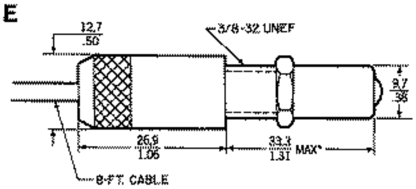

D




** 1/4 - 32 UNEF (TLS4)

| | TLS2 | TLS4 |
|---|---|---|
| Dimension D | 9,5<br>.38 | 6,4<br>.25 |
| Dimension L (max) | 45,2<br>1.78 | 30,2<br>1.19 |

E




| | TLS3 TLD3 | TLS3FF |
|---|---|---|
| Dimension L (max.) | 33,3<br>1.31 | 69,9<br>2.75 |

## VISIBLE LED LIGHT SOURCES

TLD3

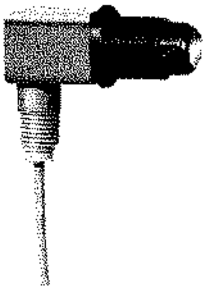
TLD1

LSD1

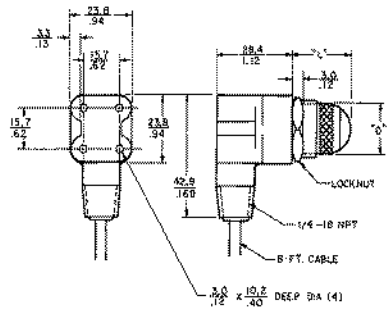
Selected products in this catalog are subject to a low volume charge.

# Order guide for photoreceivers

## 90° HOUSING



## MOUNTING DIMENSIONS




| | PC1L<br>PC1LBG<br>PC4LF |
|---|---|
| Dimension D | 15,9<br>.62 |
| Dimension L (max. — with adjustable lensholder fully extended) | 28,6<br>1.12 |

| Description | Sensor | Listing |
|---|---|---|
| Standard general purpose photoreceiver with adjustable focus | Plug-in photocell | **FE-PC1L** |
| PC1L with a blue-green filter in the lensholder for registration control of red/orange/brown registration marks against a lighter background. | Plug-in photocell | **FE-PC1LBG** |
| Similar to PC1L, but with phototransistor high-speed response and 180°F (82°C) upper temperature limit. | Plug-in phototransistor | **FE-PC4LF** |

PC1L and PC4LF are available with die cast housings by adding a "**-DC**" suffix.

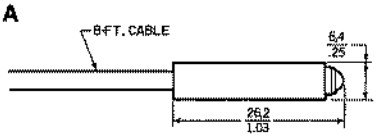
## TUBULAR ALUMINUM HOUSING

**TPCOL**

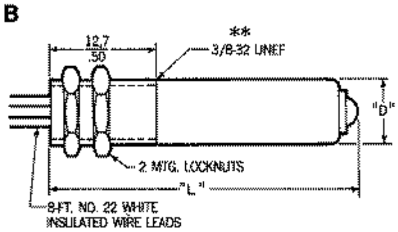
**TPC2L**

## MOUNTING DIMENSIONS

**A**




**B**



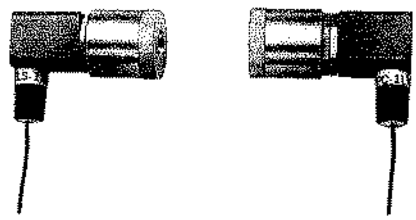

** 1/4 - 32 UNEF (TLS4)

| | TPC2L<br>TPC2LBG<br>TPC4LF<br>TPC4LTA | TPC3L |
|---|---|---|
| Dimension D | 9,5<br>.38 | 9,5<br>.38 |
| Dimension L | 51,6<br>2.03 | 82,6<br>3.25 |

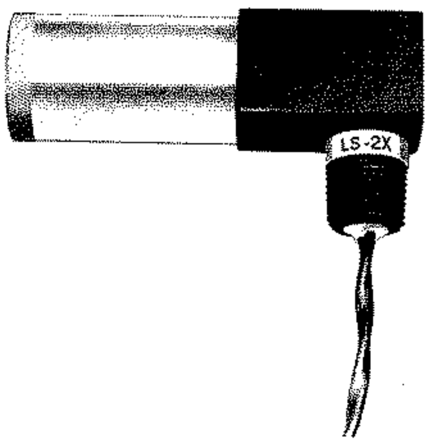
| Description | Sensor | Listing | |
|---|---|---|---|
| Smallest photoreceiver | Potted photocell | **FE-TPCOL** | 0.25 inch dia. Dwg. A |
| Similar to TPCOL, but with photo transistor high-speed response and 180°F (82°C) upper temperature limit | Potted phototransistor | **FE-TPCO4F** | |
| Threaded housing; 10° field of vision | Potted photocell | **FE-TPC2L** | 0.38 inch dia. Dwg. B |
| TPC2L with a blue-green filter for registration control of red/orange/brown registration marks against a lighter background. | Potted photocell | **FE-TPC2LBG** | |
| Narrow 4° field of view for use in bright ambient light, or to detect smaller objects. | Potted photocell | FE-TPC3L | |
| Similar to TPC2L, but with photo transistor high-speed response and 180°F (82°C) upper temperature limit. | Potted phototransistor | **FE-TPC4LF** | |
| Same as above, except with 257°F (125°C) upper temperature limit and 8-ft. Teflon leads. | Potted high-temperature phototransistor | **FE-TPC4LTA** | |

# Explosion-proof light sources and photoreceivers

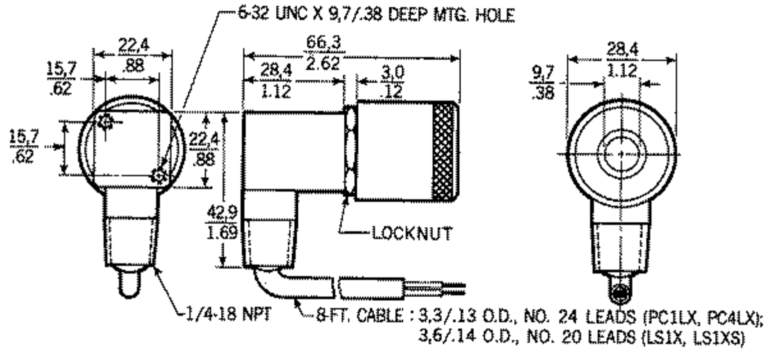
**LS1X and LS1XS Light Sources**
**PC1LX and PC4LX Photoreceivers**

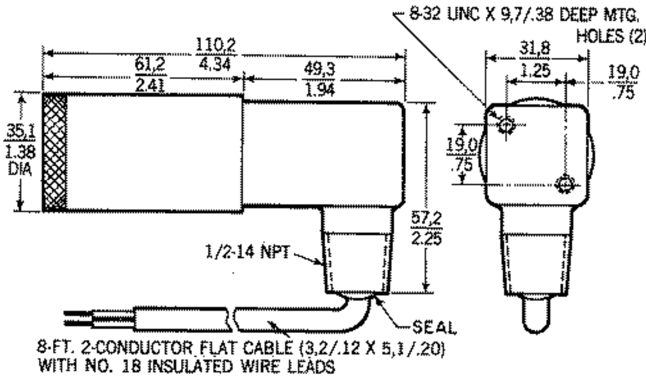


**LS2X Light Source**




## MOUNTING DIMENSIONS




## GENERAL INFORMATION

Explosion-proof units can be used in National Electrical Code Class 1, Division 1, Groups A, B, C, and D hazardous locations. Also Class 1, Division 2, Groups A, B, C and D; Class 2, Divisions 1 and 2, Groups E and G. Factory Mutual Laboratory Report #OCOH8.AE is available from MICRO SWITCH.

A cast aluminum cylinder of threaded inner body/outer body construction provides flame paths to cool exploding gases below the kindling temperature before they reach the combustible atmosphere outside. The protective cylinder includes a Pyrex glass window. Threads on internal lensholders are staked for fixed focus.

Standard 8-foot leads can be extended only through explosion-proof connection boxes in accord with NEC Article 501. (See next page.)

## SCAN DISTANCE

Refer to the Maximum Scan Distance Chart. Substitute the LS1X or LS1XS light source for LS1C; substitute the PC1LX photoreceiver for PC1L (PC4LX for PC4LF). Then reduce the scan distance given by 30%.

## ORDER GUIDE
## LIGHT SOURCES

| Description | Lamp | Listing |
|---|---|---|
| General purpose unit; fixed infinity focus. | #12 plug-in lamp rated for 5000-hour life at 150 mA, 6.3 VAC (or VDC) | FE-LS1X |
| Fixed short range focus (6") for detecting small objects. | #12 plug-in lamp rated for 5000-hour life at 150 mA, 6.3 VAC (or VDC) | FE-LS1XS |
| Long range: fixed infinity focus. | #210 plug-in lamp rated for 10,000-hour life at 1.5 amps, 4.5 VAC (or VDC) | FE-LS2X |

## PHOTORECEIVERS

| Description | Sensor | Listing |
|---|---|---|
| General purpose unit. | Plug-in photocell | FE-PC1LX |
| Phototransistor high-speed response and 180°F (82°C upper temperature limit.) | Plug-in phototransistor | FE-PC4LX |

## REPLACEMENT PARTS

| Light Source | Lamp | Complete Lensholder Assembly (Includes explosion-proof cylinder) |
|---|---|---|
| FE-LS1X | FE-BULB-12 | FE-LH-LS1X |
| FE-LS1XS | FE-BULB-12 | FE-LH-LS1XS |
| FE-LS2X | FE-BULB-210 | FE-SCL986 |
| **Photoreceiver** | **Sensor** | — |
| FE-PC1LX | FE-1320A-1* | FE-LH-PC1LX |
| FE-PC4LX | FE-PT1F | FE-LH-PC1LX |

* This listing refers to various sensors, any one of which may be supplied by MICRO SWITCH. Supersedes the 603AL, 1320 and 1320A listings.

# Maximum number of light sources powered from control bases

| | Control Bases | | | |
|---|---|---|---|---|
| Light Sources | G4B Series LCRP TRB TRBL | PE2-2* G4B2* TRB1* | PE2 PE2-1 | LCRP1 TRBXL 30-134 |
| LS1C, LS1X | 6 | — | 4 | Additional light sources can be powered by the heavy-duty control bases above. The number depends on the particular application. Contact MICRO SWITCH. |
| LS1LC, R3 Series | 4 | — | 2 | |
| LS2BZ, LS2C, LS2X, R5 Series | 1 | — | 1 | |
| TLS1, TLS2 | 15 | 1 | — | |
| TLS1M, TLS4 | 7 | 1 | — | |
| TLS3, TLS3FF | 4 | — | 5 | |
| +LSD1, TLD1, TLD3 | 1 | — | — | |

*These control bases include a 10-ohm, 5-watt dropping resistor in series with the LAMP terminals. To operate more than one low-voltage tubular light source, substitute the correct dropping resistor for the 10-ohm, 5-watt resistor by:
Dividing the total number of light sources into 10 (ohms) and multiplying the number by 5 (watts) for the lower-resistance, higher-watt resistor needed.
For example:
2 light sources — use a 5-ohm, 10-watt resistor.
5 light sources — use a 2-ohm, 25-watt resistor.
+Operate from DC voltage (15 VDC and GND terminals), not from AC voltage (lamp terminals).

## EXTENDING LEADWIRES ON LIGHT SOURCES, PHOTORECEIVERS, AND SCANNERS

### GENERAL INFORMATION

Most light sources, photoreceivers, and scanners have 8-foot leadwires (shielded cable for photoreceivers and and retro scanners). These leadwires may be extended.

### LIGHT SOURCES

When extending the length of light source leadwire, it is important to assure that the wire resistance does not exceed 10% of the working (hot) lamp filament resistance. The chart shows the minimum wire size which should be used with extended leadwires. Maximum scan distance must be reduced by 1/3.

### PHOTORECEIVERS

Leadwires may be extended to any length (using shield wire of the same gauge), if the shield is continuous. Running photoreceiver leads in a separate conduit (never in conduit with power lines or lines switching inductive loads) reduces noise and false signals.

| | Leadwire Extension | | |
|---|---|---|---|
| Product | Up To 50 Ft. | 50 To 100 Ft. | 100 To 200 Ft. |
| TLS1, 1M, 2, 3, 3FF, 4; LS1C, 1X*, 1SX* | 18 AWG. | 18 AWG. | 18 AWG. |
| R3 Series; LS1LC | 18 AWG. | 18 AWG. | 18 AWG. |
| R5 Series; LS2BZ, 2C, 2SC, 2X* | 14 AWG. | 12 AWG. | 10 AWG. |
| TLD1, TLD3, LSD1 | 22 AWG. | 22 AWG. | 22 AWG. |

*Extensions to explosion-proof scanners may only be made through explosion-proof connection boxes in accordance with NEC Article 501.

# Maximum number of photoreceivers in series and in parallel

## PHOTOTRANSISTOR TYPE

### In Series or in Parallel

Only two phototransistors can be wired in series or in parallel. This is due to an inherent voltage drop across the light-sensitive diode in the phototransistor.

| | Maximum Number of Photoreceivers | |
|---|---|---|
| | In Series | In Parallel |
| Phototransistor Type | 2 | 2 |
| Photocell Type | Depends on application: As many cells that have a combined resistance when illuminated of no more than 15 kilohms. | As many cells that have a combined dark resistance of no less than 30 kilohms. |

## PHOTOCONDUCTIVE CELL TYPE

### In Series

When you connect photocells in series, the critical factor is the maximum light resistance of illuminated cells.

To determine how many cells can be wired in series —

1. When using a threshold responsive amplifier: the total resistance of all illuminated cells in the circuit cannot exceed 30 kilohms (30,000 ohms) for logic cards (LOG Series*), 8 kilohms for logic modules (TR Series*). However, to assure operational stability despite temperature changes and voltage variation, the suggested maximum light resistance (with amplifier sensitivity adjustment fully clockwise) is half the absolute maximum: 15 kilohms for cards, 4 kilohms for modules.

   To achieve the recommended ten-to-one (10:1) signal ratio, the dark resistance of each cell should be at least ten times the sum of the resistances of all illuminated cells.

2. When using a transition responsive amplifier: the dark resistance of each cell should be at least twice the sum of the resistances of the illuminated cells (2:1 signal ratio); and the maximum combined light resistance of all cells no more than 250 kilohms.

### Operation

Set for light operated (L.O.) — the amplifier will operate only if all cells are illuminated.

Set for dark operated (D.O.) — the amplifier will operate even if only one cell is dark (one light beam blocked).

### In Parallel

When you connect photocells in parallel, the critical factor is the minimum dark resistance of non-illuminated (dark) cells.

Dark cell resistance should be measured at the maximum ambient light level (the most unfavorable operating condition).

To determine how many cells can be wired in parallel —

1. When using a threshold responsive amplifier: the total dark resistance of cells in the circuit should be more than 30 kilohms for logic cards (LOG Series* *), more than 8 kilohms for logic modules (TR Series * *).

2. When using a transition responsive amplifier: the total dark resistance of cells in the circuit should be at least twice the light resistance (with maximum light resistance 250 kilohms).

### Operation

Set for light operated (L.O.) — the amplifier will operate even if only one cell is illuminated.

Set for dark operated (D.O.) — the amplifier will operate only when none of the cells are illuminated (when all light beams are blocked).

*One megohm for models 3-4 and 3-4L.
* *More than 1 megohm for models 3-4 and 3-4L.

# Maximum scan distance for light sources and photoreceivers

The chart below gives the typical maximum thru scan distances (in clear air) for common light source-photoreceiver combinations. If no distance is given for a light source-photoreceiver combination, that combination is not recommended. Distance is affected by the amplifier used, and the operating mode (along the bottom).

| Photoreceivers | AMPLIFIERS | | LIGHT SOURCES: TLS1, TLS2 | | TLS1M | | TLS3 | | TLS4 | |
|---|---|---|---|---|---|---|---|---|---|---|
| TPCOL<br>TPCO4F | Cards: | LOG (except 3-4, 3-4L, 4, 4L) | 4 in. (10,2 cm) | | 8 in. (20,3 cm) | | 3 ft. (0,9 m) | | 18 in. (46 cm) | |
| | | LOG3-4, 3-4L, 4, 4L | 9 in. (22,9 cm) | | 2 ft. (0,61 m) | | 5 ft. (1,5 m) | | 4 ft. (1,2 m) | |
| | Modules: | TR3, 3-1, 5R, 8, 8A, 8B, TR1500 | 3 in. | 4 in. | 6 in. | 8 in. | 2 ft. | 3 ft. | 12 in. | 18 in. |
| | | TR4-2, 4-2L, 5, 5-14 STR10, TRIC | 4 in. | 3 in. | 8 in. | 6 in. | 3 ft. | 2 ft. | 18 in. | 12 in. |
| | | TR6 | 4 inches | | 8 inches | | 3 feet | | 18 inches | |
| | | TR3-4, 3-4L, 4, 4L, 1500A | 9 inches | | 2 feet | | 5 feet | | 4 feet | |
| TPC2L<br>TPC4LF<br>TPC4LT(A) | Cards: | LOG (except 3-4, 3-4L, 4, 4L) | 4 in. (10,2 cm) | | | | 4 ft. (1,2 m) | | | |
| | | LOG3-4, 3-4L, 4, 4L | 9 in. (22,9 cm) | | | | 6 ft. (1,8 m) | | | |
| | Modules: | TR3, 3-1, 5R, 8, 8A, 8B, TR1500 | 3 in. | 4 in. | | | 3 ft. | 4 ft. | | |
| | | TR1500B, TR4-2, 4-2L, 5, 5-14; STR10, TRIC | 4 in. | 3 in. | | | 4 ft. | 3 ft. | | |
| | | TR6 | 4 inches | | | | 4 feet | | | |
| | | TR3-4, 3-4L, 4, 4L | 9 inches | | | | 6 feet | | | |
| PC1L<br>PC4LF | Card: | LOG (except 3-4, 3-4L, 4, 4L) | | | | | | | | |
| | | LOG3-4, 3-4L, 4, 4L | | | | | | | | |
| | Modules: | TR3, 3-1, 5R, 8, 8A, 8B, TR1500 | | | | | | | | |
| | | TR4-2, 4-2L, 5, 5-14; STR10, TRIC | | | | | | | | |
| | | TR6 | | | | | | | | |
| | | TR3-4, 3-4L, 4, 4L | | | | | | | | |
| OPERATING MODE | | | D.O. | L.O. | D.O. | L.O. | D.O. | L.O. | D.O. | L.O. |

**LIGHT BEAM IMAGE SIZES**

SCAN DISTANCE

| LIGHT SOURCE | 1" | 1-1/4" | 1-1/2" | 1-3/4" | 2" | 2-1/4" | 2-1/2" | 3" | 4" | 5" | 6" | 7" | 8" | 9" |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LS1C* | | | | | 1/2 × 1/4 | | 5/8 × 9/32 | | 15/16 × 3/8 | | 1 1/4 × 13/32 | | 1 5/8 × 7/16 | |
| LS1LC* | | | | | | | | | | | 1 1/8 × 1/2 | | 1 3/8 × 9/16 | |
| LS2BZ* | | | | | | | | | | | | | | |
| LS2C* | | | | | | | | | 1 1/4 × 7/8 | | | | 2 × 1 1/8 | |
| LSD1* | | | | | | | | | | | 3/4 Dia. | | | |
| TLD1 | 3/16 × 1/32 | | 5/16 × 1/16 | | 1/2 × 1/16 | | 9/16 × 5/64 | 19/32 × 3/32 | 1 × 5/32 | | 1 1/4 × 3/8 | | | |
| TLD3* | 5/8 Dia. | | | | 3/4 Dia. | | | 1 Dia. | 1 1/8 Dia. | | | | | |
| TLS1 | 3/16 × 1/32 | | 5/16 × 1/16 | | 1/2 × 1/16 | | 9/16 × 5/64 | 19/32 × 3/32 | 1 × 5/32 | | 1 1/4 × 3/8 | | | |
| TLS1M | 11/32 × 1/64 | | 15/32 × 1/32 | | 17/32 × 3/64 | | 5/8 × 1/16 | | 1 × 1/8 | | 1 5/8 × 1/4 | | 2 × 1/2 | |
| TLS2 | 7/32 × 1/32 | | 15/32 × 1/16 | | 1/2 × 3/32 | 21/32 × 3/32 | 23/32 × 3/32 | 15/16 × 3/32 | 1 × 1/8 | | 1 1/4 × 1/4 | | | |
| TLS3* | 19/32 × 11/32 | | 23/32 × 3/8 | | 15/16 × 13/32 | | 1 3/32 × 13/32 | | 1 5/8 × 1/2 | | 2 1/4 × 9/16 | | 2 7/16 × 5/8 | |
| TLS3FF* | 3/8 Dia. | | | | 5/8 Dia. | | | 3/4 Dia. | 1 Dia. | | | | | |
| TLS4* | | | | | | | | | | | 1 1/4 × 1/4 | | | |

* Lensholder adjusted for sharpest image (i.e., retracted as far as possible).

# Maximum scan distance for light sources and photoreceivers

NOTES:

1. Measurements were made using a standard TRB control base (module amplifiers) and a G4B control base (card amplifiers). Line voltage was 105 VAC; higher line voltage gives longer scan distance (but shorter lamp life).
2. Measurements were made at 77°F (25°C). Derate distance 2% per 1.8°F (1°C) up to 140°F (60°C) when using a photoreceiver with a photocell-type sensor. (Derating is not necessary for phototransistor-type sensors.)
3. All image sizes are approximate. Dimensions are in inches, unless specified otherwise.

LIGHT SOURCES

| TLD1 | | TLD3 | | LSD1 | | LS1C | | LS1LC | | LS2C | | LS2BZ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 in. (7,6 cm) | | | | | | | | | | | | | |
| 6 in. (15 cm) | | | | | | | | | | | | | |
| 3 inches | | | | | | | | | | | | | |
| 3 inches | | | | | | | | | | | | | |
| 3 inches | | | | | | | | | | | | | |
| 6 inches | | | | | | | | | | | | | |
| | | 4 in. (10,2 cm) | | | | | | | | | | | |
| | | 8 in. (20,3 cm) | | | | | | | | | | | |
| | | 4 inches | | | | | | | | | | | |
| | | 4 inches | | | | | | | | | | | |
| | | 4 inches | | | | | | | | | | | |
| | | 8 inches | | | | | | | | | | | |
| | | | | 2 ft. (0,6 m) | | 5 ft. (1,5 m) | | 10 ft. (3 m) | | 20 ft. (6,1 m) | | 50 ft. (15,2 m) | |
| | | | | 4 ft. (1,2 m) | | 10 ft. (3 m) | | 25 ft. (7,6 m) | | 45 ft. (13,7 m) | | 70 ft. (21,3 m) | |
| | | | | 2 feet | | 3 ft. | 5 ft. | 5 ft. | 10 ft. | 10 ft. | 20 ft. | 25 ft. | 50 ft. |
| | | | | 2 feet | | 5 ft. | 3 ft. | 10 ft. | 5 ft. | 20 ft. | 10 ft. | 50 ft. | 25 ft. |
| | | | | 2 feet | | 5 feet | | 10 feet | | 20 feet | | 50 feet | |
| | | | | 4 feet | | 10 feet | | 25 feet | | 45 feet | | 70 feet | |
| D.O. | L.O. | D.O. | L.O. | D.O. | L.O. | D.O. | L.O. | D.O. | L.O. | D.O. | L.O. | D.O. | L.O. |

**LIGHT BEAM IMAGE SIZES**

SCAN DISTANCE

| LIGHT SOURCE | 10″ | 11″ | 1′ | 2′ | 3′ | 4′ | 5′ | 6′ | 10′ | 15′ | 20′ | 25′ | 50′ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LS1C*** | | | 2×15/32 | 4×15/32 | 5½×½ | 8×5/8 | | | | | | | | |
| LS1LC* | | | 1½×7/8 | 3×1 3/8 | 4×1 7/8 | 5 5/8×2¼ | 6×2½ | 10×3 | | | | | | |
| LS2BZ* | | | | | | | 4½×1½ | 5×1½ | 8½×2½ | 12×2¾ | 14×3 | 16×3½ | 30×5½ | |
| LS2C* | | | 2½×1 1/8 | 3×1 1/8 | 5½×1 1/8 | 6½×1 1/8 | 8×1½ | 13×2¾ | 17×4 | 25×4½ | 31×5 | | | |
| LSD1* | | | 1 1/8 Dia. | 1 5/8 Dia. | | | | | | | | | | |
| TLD1 | | | | | | | | | | | | | | |
| TLD3* | | | | | | | | | | | | | | |
| TLS1 | | | | | | | | | | | | | | |
| TLS1M | | | 3×1 | | | | | | | | | | | |
| TLS2 | | | | | | | | | | | | | | |
| TLS3* | | | 2½×¾ | 4×7/8 | 6×1 | | | | | | | | | |
| TLS3FF* | | | | | | | | | | | | | | |
| TLS4* | | | 2×3/8 | 4×3/4 | | | | | | | | | | |

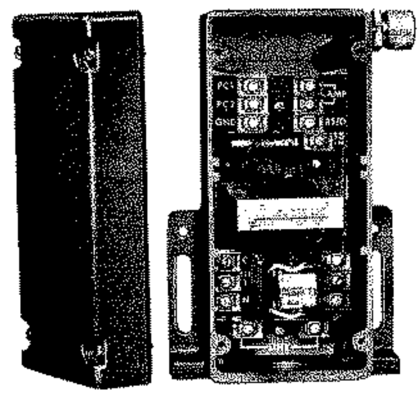
* Lensholder adjusted for sharpest image (i.e., retracted as far as possible).

# Control bases product comparison guide

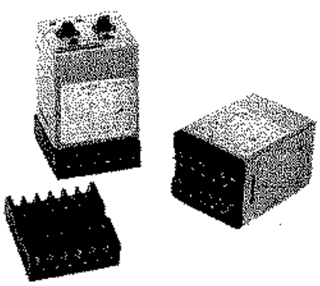
## GENERAL INFORMATION

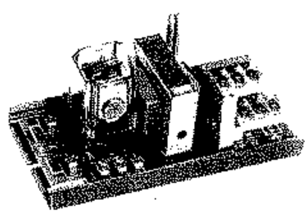
A control base is used to power discrete light sources and photoreceivers, scanners, and DC-powered modulated LED controls. It can be remotely positioned from the scanning setup. A control base is not used with a control — modulated or incandescent — that includes a self-contained power supply.

The control base includes a step-down transformer power supply that converts 115 VAC or 230 VAC to useable levels of AC current and voltage. In addition, some control bases include a socket for a plug-in amplifier/logic card (module for the TRB Series) and a plug-in output device (or socket for one). Current sinking digital logic level output is available directly from the plug-in amplifier.

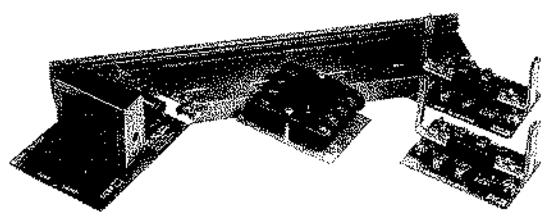


G4B





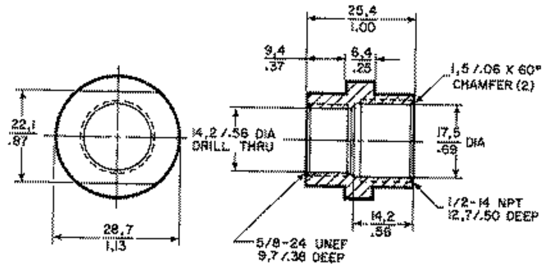
G4B-OPN



<table>
<tr><th></th><th>FEC (Pg. 134)</th><th>G4B (Pg. 136)</th><th>LCR (Pg. 138)</th></tr>
<tr><td>Style</td><td>Self-contained.</td><td>Single-piece.</td><td>Modular component sections.</td></tr>
<tr><td>Use with</td><td>All MICRO SWITCH 12 VDC 3-wire current sinking and 2-wire photoelectric controls.</td><td colspan="2">Any discrete light source or scanner; or 12 VDC powered modulated LED control. FE-G4B-REG is recommended for use with the MLS4B-1000, MLS7A and MLS10/11/12 series 12 VDC controls.</td></tr>
<tr><td>Electrical Input</td><td>100 to 110 or 200 to 220 VAC, 50/60 Hz.</td><td colspan="2">105 to 130 or 210 to 260 VAC for -T230 models.</td></tr>
<tr><td>Electrical Output</td><td>3 amp SPDT 250 VAC plug-in relay included.</td><td>10-amp DPDT plug-in relay included. Optional solid state DC, triac, and reed relays.</td><td>Relay ordered separately. Digital logic output available directly from card connector component.</td></tr>
<tr><td>Response Time</td><td>20 msec. standard relay.</td><td colspan="2">Depends on photoreceiver and output device used.</td></tr>
<tr><td>Logic</td><td>ON/OFF, ON/OFF delay and one shot pulse.</td><td colspan="2">Varies with LOG Series amplifier/logic cards that plug into a card connector. Note: LOG card is necessary.</td></tr>
<tr><td>Temperature Range</td><td>14°F to 122°F (−10°C to 50°C)</td><td colspan="2">−40°F to 158°F (−40°C to 70°C)</td></tr>
<tr><td>Enclosure*</td><td>NEMA 12</td><td>Enclosed models — UL and CSA listed; NEMA 1, 3, 4, 12, 13. Unenclosed models — UL recognized.</td><td>None</td></tr>
<tr><td>General Information</td><td>Plug-in module includes a transformer that converts 110 or 220 VAC 50/60 Hz to 12 VDC ±10%, a SPDT, 3 amp 250 VAC relay and LED indicator for Power, Input and Output. All external wiring is made to the terminal base.</td><td>Includes a line voltage stepdown transformer, an AC to DC rectifier, a socket for a LOG series amplifier/logic card and an octal socket for a plug-in output device.</td><td>Custom, modular approach to building a control base. Complete base usually includes power supply, amplifier/logic card, output device and a section of PVC mounting track. Individual components ordered separately.</td></tr>
</table>

***Application note:** Enclosures are based, in general, on the broad definitions outlined in NEMA Standards. Therefore, it will be necessary to ascertain that a particular enclosure will be adequate when exposed to the specific conditions that might exist in intended applications. Except as might otherwise be noted, all references to products relative to NEMA enclosure types are based on MICRO SWITCH evaluation only.

## CONDUIT ADAPTER

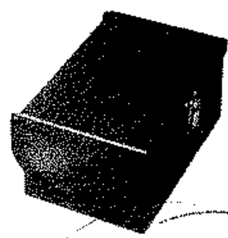


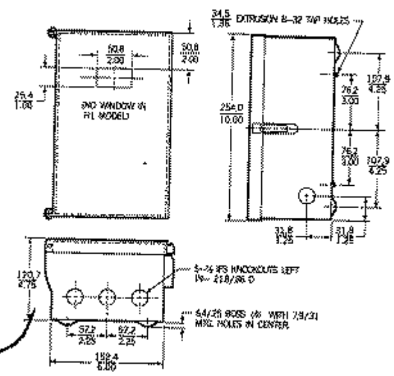

### ORDER GUIDE

| Description | Listing |
| --- | --- |
| For MLS4B only. 5/8"-24 UNEF conduit adapter — 1/2"-14 NPT. | FE-CA4 |

## ENCLOSURES

Control base enclosures (1) prevent accidental contact of personnel with the control base; (2) shield the base from electrical noise. All enclosures are steel with a gray hammered finish, and have knockouts for wiring access.





Counter Window for counter or Red Lyons

### ORDER GUIDE

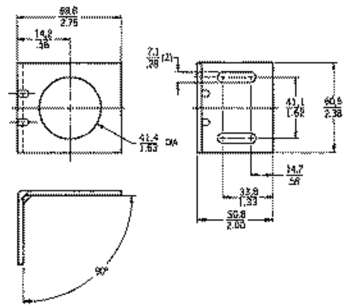
| Description | Listing |
| --- | --- |
| For any two- or three-socket TRB Series control base (except TRB2). Has a hinged cover and locking hasp. Dusttight and driptight; meets NEMA 1. | FE-H1 |

# Accessories

### MOUNTING BRACKETS

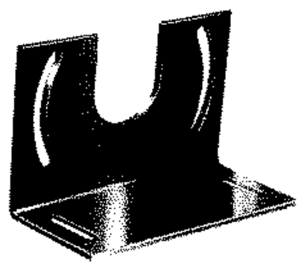
The mounting brackets here are optional for light sources, photoreceivers, and self-contained controls.

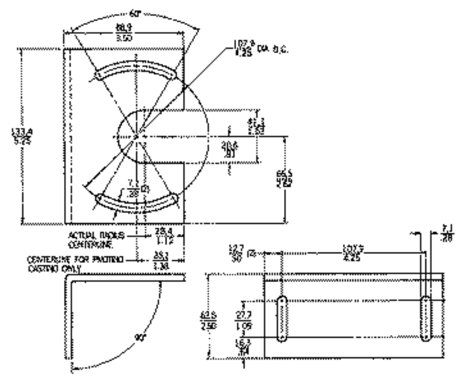
There are two types of auxiliary bracket: (1) those for a single unit, and (2) those that fix the relative position of a light source and a photoreceiver (two units) for reflective scanning.



**ORDER GUIDE**

| Description | Listing |
|---|---|
| An integral part of MLS3B, MLS5B, TR1R, R3, and R5 controls. Permits 1-inch vertical and 360° horizontal positioning adjustment. Cadmium-plated steel; mounting hardware not included. | FE-MB3 |





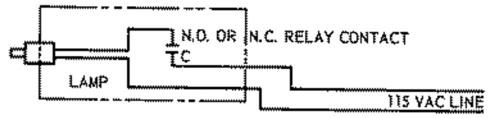
**ORDER GUIDE**

| Description | Listing |
|---|---|
| For MLS1A, MLS2A, and R4A Series controls. Permits 1-inch vertical and 60° horizontal. positioning adjustment. Zinc-plated steel; includes only the hardware for fastening bracket to control. | FE-MB4 |

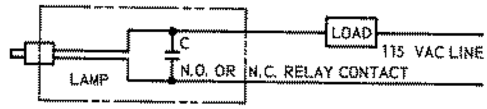
### NEON INDICATOR

A high-visibility red neon indicator threads into the side of some self-contained controls, and functions as a power indicator (connected to the line terminals), or as an output indicator (connected to relay terminals).

#1




#2




### ORDER GUIDE

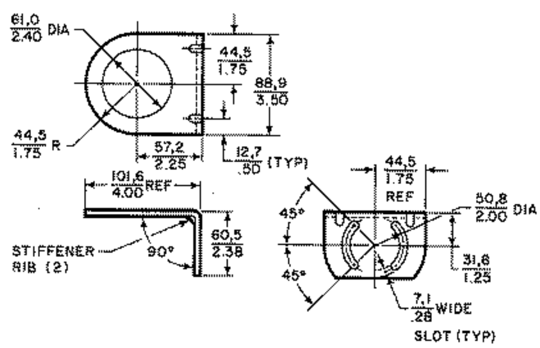
| Description | Listing |
|---|---|
| For MLS1A and R4A Series controls. 115 VAC (only) lamp in watertight Pyle National fitting; threads into housing. | FE-NEON-DR37-093 |

### MOUNTING BRACKETS

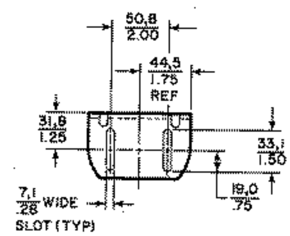
FE-MB8

FE-MB8-2

FE-MB8

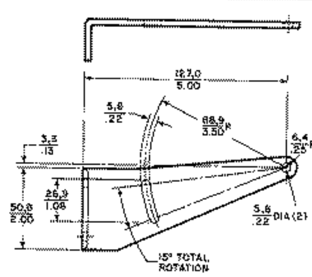


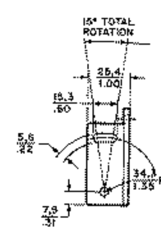

FE-MB8-2




### ORDER GUIDE

| Description | Listing |
|---|---|
| For MLS8/9 Series controls only. Permits 360° horizontal positioning; 90° tilt. Standard hardware inlcuded. | FE-MB8 |
| Same as FE-MB8 except epoxy finish. | FE-MB8-1 |
| For MLS8/9 Series controls only. Universal interface mounting bracket. | FE-MB9-BRKT |





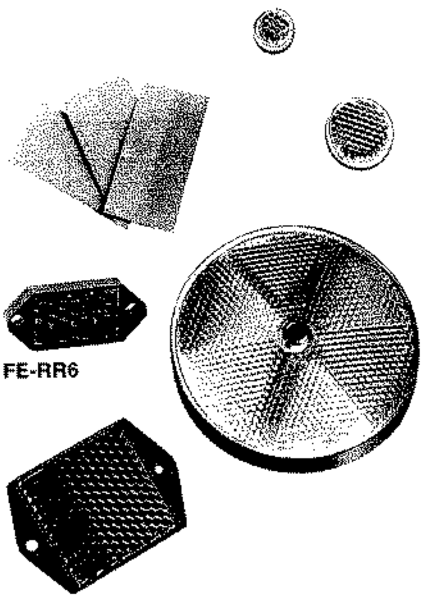

### ORDER GUIDE

| Description | Listing |
|---|---|
| For MLS10/11/12 Series controls only. Mounting bracket. | FE-MB10 |

# Accessories

## RETROREFLECTIVE TARGETS

A larger reflector returns more light to the photosensor, and increases scan distance. The efficiency column will help in determining approximate scan distance capabilities of various reflectors. Since our retro-reflective products scan range ratings are based on using the 3″ diameter FE-RR1, it is referenced as the base standard or 100%.



FE-RR6

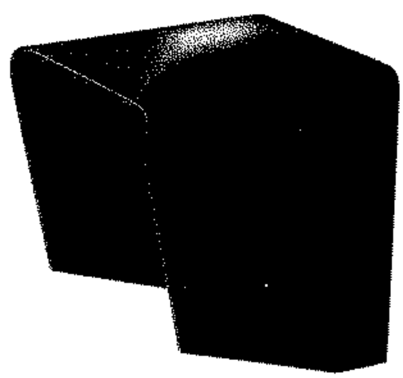
FE-RR8

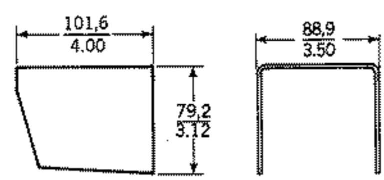
### ORDER GUIDE

| Description | Efficiency | Listing |
|---|---|---|
| 3-inch diameter molded acrylic disc with plastic backing and rim, and .18 dia. mounting hole. Max. 150°F (66°C) ambient temperature. | 100% | FE-RR1 |
| 1 x 2-inch reflective tape. Max. 200°F (93°C) ambient temperature. | 20% | FE-RR2 |
| 1-inch diameter acrylic disc (no mounting hole). Max. 150°F (66°C) ambient temperature. | 45% | FE-RR3 |
| 5/8-inch diameter acrylic disc (no mounting hole). Max. 150°F (66°C) ambient temperature. | 30% | FE-RR4 |
| 1 x 2-inch high contrast reflective tape with pressure sensitive adhesive and liner. Max. 150°F (66°C) ambient temperature. | 30% | FE-RR5 |
| 2.2″ x 1″ x .37″ Rectangular molded acrylic reflector-mounting holes on each end. Max. 150°F (66°C) ambient temperature. | 65% | FE-RR6 |
| 1 x 2-inch corner-cubed micro prismatic retroflective material (20 mils thick) with pressure sensitive adhesive and liner. Can not be cut. Max. 200°F (93°C) ambient temperature. Will work with polarized light. | 40% | FE-RR7 |
| 2.8″ x 2″ x .30″ Rectangular molded acrylic reflector – mounting holes on each end. | 108% | FE-RR8 |
| Same as FE-RR7 except 2.75 inch x 8.25 inch. | | FE-RR9 |

## WEATHER SHIELD AND EYESHADE

The weather shield extends over the lens of some self-contained controls to help keep dust, moisture, etc. off the lens.

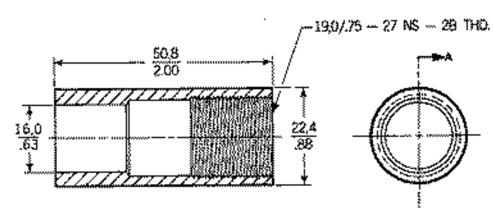





### ORDER GUIDE

| Description | Listing |
|---|---|
| For MLS1A, MLS2A and R4A Series controls. Black, anodized aluminum with double-faced tape for affixing to the control. | FE-ES-1 |

The eyeshade threads onto the lensholder of some photoreceivers to help prevent bright indoor ambient light from triggering the photosensor.




### ORDER GUIDE

| Description | Listing |
|---|---|
| For PC1L and PC4LF photoreceivers. Black anodized aluminum. | FE-26-320 |

# Additional accessories and replacement parts

## ACCESSORIES

### Bulbs

| Description | Listing |
|---|---|
| For SA1RML | FE-BULB-4 |
| For LS1C, LS1X | FE-BULB-12 |
| For LS1LC, Retro 3T Series, TR1R, R3T | FE-BULB-15 |
| For LS2C, LS2BZ, LS2SC, LS2X, R5T | FE-BULB-210 |
| For R4A (1434) | FE-BULB-1424 |
| For TLS3, TLS3-FF (industry #7349, previously #2307) | FE-BULB-7349 |
| Replacement LED for TLD3, LSD1 | FE-LD-1B |
| Replacement LED for MCEI, MCE2 | FE-LD-45022 |
| For TLS4, FE-R6 | FE-BULB-349S |

### Lensholders (Lens, lens housing and mounting nut)

| Description | Listing |
|---|---|
| For LS1C (SCL8, 17-007) | FE-LH-LS1C |
| For LS1C-G (glass) | FE-LH-LS1C-G |
| For LS1C-SP (SCL31) | FE-LH-LS1C-SP |
| For LS1LC (SCL20, 26-065) | FE-LH-LS1LC |
| For LS1X (SCL987) | FE-LH-LS1X |
| For LS1XS (SCL985) | FE-LH-LS1XS |
| For LS2C (SCL10, 26-231) | FE-LH-LS2C |
| For MCE1 | FE-LH-MCE1 |
| For MCR1 | FE-LH-MCR1 |
| For MLS2E (A or B series) | FE-LH-MLS2E |
| For MLS2R (A or B series) | FE-LH-MLS2R |
| For PC1L, PC4LF, PC4LTA (SCL18, 26-115) | FE-LH-PC1L |
| For PC1LBG (SCL36, 26-245) | FE-LH-PC1LBG |
| For PC1LX (SCL988) + PC4LX | FE-LH-PC1LX |
| For PC1L-G (Glass) | FE-LH-PC1L-G |
| For PC1L-SP (SCL30) | FE-LH-PC1L-SP |
| For TLS3 (SCL3, 17-210) | FE-LH-TLS3 |
| For TPC2, TLS3FF (SCL6) | FE-LH-TPC2 |
| For R3AT, R3ABG, MLS3B-02000 Series (SCL24) | FE-LH-27-108 |
| For R3T, TR1R Series (SCL23), MLS5, MLS3, Plastic | FE-LH-27-127 |
| For R3T1, MLS3B-01000 Series, MLS5 (SCL27) Glass | FE-LH-27-127-1 |
| For R4A, R5T (SCL26) | FE-LH-37-101 |
| For MLS1A Series | FE-SCL45 |
| For LS2X | FE-SCL986 |
| For LS2BZ | FE-89037 |

# Additional accessories and replacement parts

## ACCESSORIES

### Mounting Tracks

| Description | Listing |
| --- | --- |
| 3 in. wide, 12 in. long PVC mounting track (LCR Series) | FE-LCR12 |
| Same as FE-LCR12, except 18 inches long. | FE-LCR18 |

### Solid State Relays

| Description | Listing |
| --- | --- |
| SPST-NO, .5 amp, 30 VDC (G4B, G4B-OPN, TRB Series) | FE-SW1A |
| SPDT, .5 amp, 30 VDC (G4B, G4B-OPN, TRB Series) | FE-SW1C |
| SPST-NO, 2 amp, 30 VDC | FE-SW2A |
| SPDT, 2 amp, 30 VDC | FE-SW2C |
| SPST-NO, 3 amp, 130 VAC | FE-SW8A |
| SPST-NO, 3 amp, 260 VAC | FE-SW8A1 |
| SPST-NO, 6 amp, 130 VAC | FE-SW8A2 |
| SPDT, 3 amp, 130 VAC | FE-SW8C |
| SPDT, 6 amp, 130 VAC | FE-SW8C2 |
| SPDT, 6 amp, 260 VAC | FE-SW8C3 |
| SPST-NO, .5 amp, 200 VDC | FE-SW14A |
| SPDT, .5 amp, 200 VDC | FE-SW14C |
| SPST-NO, 4 amp, 100-240 VAC (LCRP3A) | FE-SW23A |
| SPST-NO, 3 amp (–40 to +40°C),102-132 VAC (MLS8C and 9C)<br>2 amp (55°C)<br>1 amp (70°C) | FE-SW24A |
| SPST-NO, 30 mA, 5-140 VAC; 5-140 VDC (MLS8C and 9C) | FE-SW25A |

## REPLACEMENT PARTS

### Miscellaneous Components And Hardware

| Description | Listing |
| --- | --- |
| Audio alignment aid (MLS2B) | FE-EARPHONE |
| Bus bar supplied with LCR1 & LCRP | FE-LCR-JUMPER |
| Neon output indicator w/Pyle Nat'l Fitting (R4A, MLS1A, MLS2B) | FE-NEON-DR37-093 |

### Photocells

| Description | Listing |
| --- | --- |
| Replacement photocell (CL1915-1) with spacer, Standard PC1L family | FE-1320A-1 |
| Assembly for FE-PC1LBG | FE-26-308 |

## REPLACEMENT PARTS

### Phototransistors

| Description | Listing |
|---|---|
| Hi-temp (for PC3LTA) | FE-PT1 |
| For PC4LF | FE-PT1F |
| Plug-in for MCR1, MCR2, R3T, R4A, R5T, TR1R Series — Previously FPT-130 & 41-015 | FE-41-030 |

### Relays (Specifications, see pages 142-143.)

| Description | Listing |
|---|---|
| For PE3, 4, 5, 6, 7 (FE-21000) | FE-S1006A |
| DPDT plug-in relay for TRB series, R4A, G4B, MLS1A, MLS2B, LCR0, 120T — Previously 21-010 | FE-S2443 |
| For PE2, PE2-T230 (FE-21012) | FE-S2730 |
| SPDT plug-in reed relay | FE-26-300 |
| DPDT plug-in reed relay | FE-26-300-2C |
| For LCRP3 | FE-21008RY |
| For TR1R, TR1R-DP | FE-21019RY |
| For TR1RA, TR1RA-DP | FE-21025RY |
| For MLS8B/9B (115 VAC) | FE-21036RY |
| Standard relay for LCRP3A | FE-21039RY |
| Standard relay for MLS8C, MLS9C (115 VAC) | FE-21051RY |
| For MLS8C, MLS9C (230 VAC) | FE-21052RY |
| For MLS8C, MLS9C (24 VAC/DC) | FE-21054RY |

The FE-21030 (21030) is now sold under the part number FMBZ01.

### Transformers

| Description | Listing |
|---|---|
| For TRB, TRB1, 2, 3, 12, TRBL (FE-40003) | FE-XFRM-F9-133 |
| For LCRP1, TRBXL (FE-40005) | FE-XFRM-F9-136 |
| For 115 VAC; TR1R Series, PE2 (FE-40-011) | FE-XFRM-F9-151 |
| For 120T and CT Timers | FE-XFRM-F9-155 |
| For R4A (FE-40025) | FE-XFRM-F9-173 |
| For LCRP, LCRP2 | FE-XFRM-40023 |
| For G4B, G4B-OPN | FE-XFRM-40026 |
| For MLS1A, MLS2B, LCRP3A, G4B-REG, 115 VAC | FE-XFRM-40048 |
| For MLS1A-T230, MLS2B-T230, G4B-REG, 230 VAC, LCRP3A-T230 | FE-XFRM-40049 |
| For MLS8B (FE-40050) | FE-XFRM-40053 |
| For MLS6EB/6RB | FE-XFRM-40054 |
| For MLS8B-T230, MLS9B-T230 | FE-XFRM-40055 |

# Repair policy for MICRO SWITCH products

## GENERAL

1. a. Products returned for repair must be accompanied by a purchase order authorizing repair.

   Return to: MICRO SWITCH
   11 W. Spring St.
   Freeport, IL 61032
   Attention:
   Repair Department #57

   b. Products should be returned freight prepaid.
2. a. Products returned for repair will automatically be repaired, **without**prior approval of repair charges by the customer. If estimates are required, they must be requested in writing and accompany the return(s).

   b. If a formal written analysis is required by the customer, the Marketing Department must be notified in advance of the product return.
3. Repaired products will be returned to the customer FOB, Freeport.
4. a. Products returned in a condition practical to repair, and prior to an obsolete product cut-off date, will be accepted for repair.

   b. Some products returned are beyond economical repair. In such cases, the customer will be notified, and MICRO SWITCH will return the product at the customer's expense. MICRO SWITCH reserves the right to make the final determination of repairability.

## WARRANTY REPAIRS

5. a. Products under warranty defective during normal use and service will be repaired at MICRO SWITCH expense.

   b. Products under warranty damaged due to customer misuse will be repaired at customer expense.
6. Products repaired/reconditioned under warranty continue to be covered for the balance of the original 18 month warranty period.

## NON-WARRANTY REPAIRS

7. Products no longer under warranty returned for repair will be repaired at customer expense.
8. Repair charges on non-warranty returns include inspection, testing and handling costs, as well as cost of repair and apply whether or not units required service.

# Table of Contents

# Modulated Light Source (MLS) Controls

## GENERAL INFORMATION

As a general rule the first choice in photoelectric controls is a Modulated Light Source control. The Modulated Light Source (MLS) controls can be applied in bright or variable ambient light conditions, low visibility scanning conditions, high vibration areas and other locations where environmental conditions are severe. A MLS control is the only type of photoelectric control that should be used outdoors where it is subject to bright sunlight and adverse weather conditions.

MLS controls use a frequency modulated Light Emitting Diode (LED) as its light source. The LED has no filament to break, thus it is inherently vibration resistant and offers long life. A phototransistor is used as the receiving device. The transistor is the fastest, most light and temperature stable device available. It also has the best spectral match for the LED.

In a frequency modulated light source the LED is pulsed at a high current level for a short time period. This provides high energy light pulses capable of traversing long distances and or penetrating severe environments. The receiver circuit is designed to respond only to a narrow frequency band near the pulsing frequency of the LED. The control responds to the frequency rather than the intensity of the received light. This is the reason the MLS controls ignore ambient light conditions and perform well in areas where environmental conditions are severe.

MICRO SWITCH offers a full line of Modulated Light Source products with a variety of scanning options, input/output options and package options. Scanning options include Thru, Reflective and Fiber Optic scan. Input/Output options include AC or DC input and output capability which are available as solid state devices or relay contacts. The MLS output can be used to interface with a Programmable Logic Controller, solid state device or electromechanical relay. Several package styles are available to meet space and mounting restrictions as well as provide the performance required for specific applications.

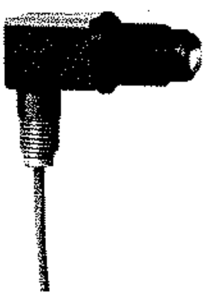
| Advantages | Application Considerations |
|---|---|
| 1. Ambient light immunity<br>2. High excess gain<br>a. For penetration power thru dust, dirt, mist, steam, etc.<br>b. For long distance scanning (Up to 2500 feet)<br>3. For applications with high vibration<br>4. For diffuse scanning of objects with low reflectivity | 1. Not as fast as non-modulated controls |

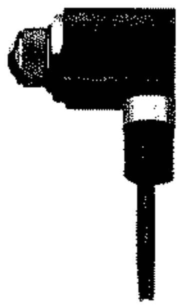
# Non-Modulated Controls

## GENERAL INFORMATION

A typical non-modulated control consists of a steady state light source and a photoreceiver as shown below.

**Photoreceiver** **Light Source**





| Advantages | Application Considerations |
|---|---|
| 1. Best for registration control when an incandescent light source and photocell are used. | 1. Not recommended when stray ambient light is present. |
| 2. Fastest operating speed (less than 1 msec. response) | 2. Not recommended where high excess gain is needed. |

## PHOTORECEIVERS:

Photoreceivers are made up of a photosensor and lensing. The photosensor converts received light to an electronic signal. The lens focuses as much light as possible to the photosensor.

MICRO SWITCH uses two types of photosensors:

- Phototransistor
- Photocell

Each has certain advantages that make it suitable for specific applications. Generally speaking, the phototransistor is used where quick response is required and ambient temperature varies over a wide range. A photocell is the first choice when two or more sensors are to be wired in series or parallel, and when detecting red against white color contrast.

## LIGHT SOURCES:

Light sources are made up of a lamp or LED and lensing to best control the light image. Both the lamp and LED have certain advantages, depending on the application. The LED offers long life, vibration and shock resistance, plus ease of alignment (visible LED). The incandescent lamp offers longer sensing range than the LED and is useful when performing color detection.

Some of the non-modulated controls are supplied with adjustable focus. Adjustable focus allows for pinpointing the brightest light at the photosensor, despite fixed mounting. Optimized focus is usually desired except in applications subject to vibration. A broad de-focused spot will remain aligned except in the case of severe vibration. Focus adjustments should only be made at the light source. Photoreceiver lens holders should always be retracted into the housing.

## AMBIENT LIGHT

No matter what type of non-modulated control is used, ambient light is an environmental factor that must be prepared for in advance. It can affect control reliability by degrading the dark (beam interrupted) resistance, thus lowering the signal ratio. In high ambient light applications, an MLS control will provide the best performance. However, when an MLS control cannot be used (registration control for example), there are ways to protect against ambient light.

- Place a shield behind the light source to block background light from shining directly into the receiver lens.
- Remove highly reflective objects from the viewing angle — normally 10°.
- Use a narrow vision (4° view) receiver, or an accessory aperture to reduce the viewing angle.
- A makeshift eyeshade or hood extending in front of the lens can prevent reflections within the lens.

These measures decrease ambient light, but they also decrease light from the source, reducing scanning distance and making alignment critical.

# Non-Modulated Controls

**COLOR DIFFERENTIATION (Registration Control)**

Contrast is the key to distinguishing color. High contrast (dark on light or vice versa) provides the best signal ratio and control reliability.

When the background is clear (transparent) the best method of detecting any color mark is thru scan. When the background is a second color, contrasts such as black-on-white usually assure sufficient signal ratio (difference between light and dark) to be handled with diffuse scan. Red (or a color which contains much red pigment, such as yellow, orange or brown) on a white or light background is a special case.

Because white light contains red, photosensors that are more sensitive to the red-infrared region of the spectrum do not register enough of a signal ratio between white and red. CdSe (cadmium selenide) photocells and all phototransistors fall in this range. CdS (Cadmium sulphide) cells, however, peak in the green-yellow portion of the spectrum, and are not sensitive to red light. Also, photoreceivers with a CdS cell include a blue-green filter (transmits only blue and green) to block red wave lengths. A photoreceiver with a CdS cell makes red appear dark on a light background.

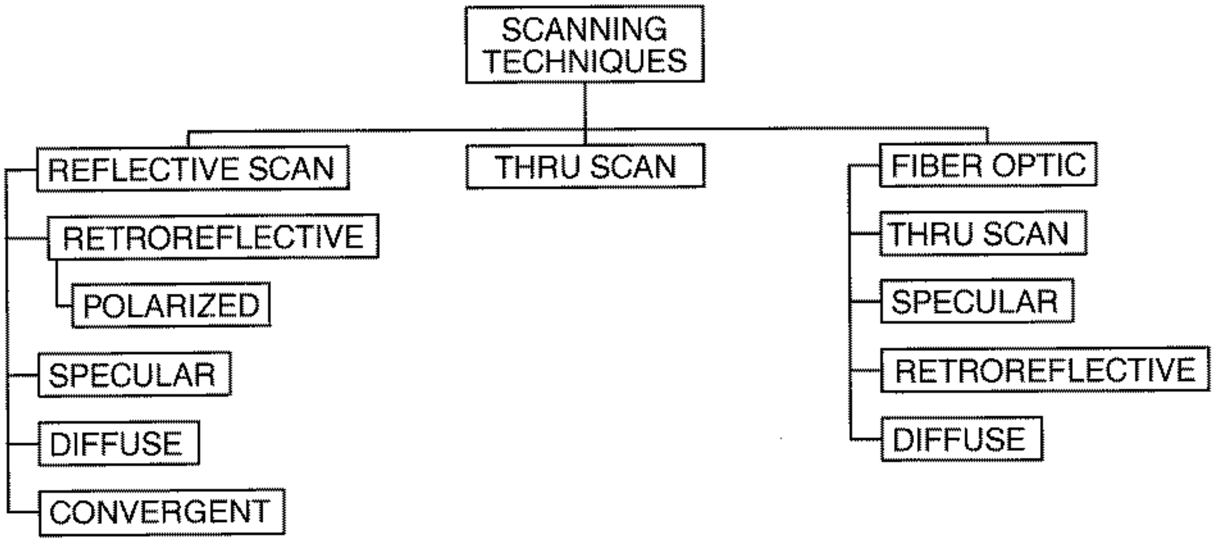
| Background | Mark | Photosensor | Scan Technique |
|---|---|---|---|
| Clear film | Black<br>Blue<br>Red | Any | Thru scan |
| White, kraft or metal foil | Black<br>Blue | Phototransistor<br>or<br>CdSe photocell | Thru scan |
| | Red | CdS photocell<br>with<br>Blue-green filter | Thru scan |
| Black, blue, or other dark colors | Red | | Diffuse scan |
| Red | Black<br>Blue | Any | Diffuse scan |

A retroreflective control with a short focal length lens (but without a retro target) can be used to detect registration marks. It is placed near the mark, and is actually used in the diffuse scan technique. If a retro scanner is used to detect marks on a shiny surface, it should be cocked somewhat off the perpendicular to make certain only diffuse reflections are picked up. Otherwise, the shiny surface of the mark could mirror-reflect so brightly it could overcome the dark signal a CdS cell normally gets from red. This would mean a light signal from both background and mark. In detecting colors, you should use diffuse (weakened) rather than specular (mirror) reflection.

Either a cadmium selenide photocell or a phototransistor can be used to detect colored marks — black, blue, green — which contain little or no red pigment. (Red as a background presents no difficulty, since a black or blue mark against a red background would appear dark on light.) The phototransistor — because of its longer life, faster response, and temperature stability — is usually preferable.

# Scanning Techniques

**OVERVIEW**




**Retroreflective**
- Light beam is directed at a reflective target (reflector, tape or other reflective object) – one which returns light along the same path it was sent.
- The object to be detected passes between photoelectric control and reflective target.

**Polarized**
- Will work only with cornercube reflector or special polarized reflective tape.
- Will not false trigger when sensing shiny object.

**Specular**
- Light beam is directed at a shiny surface which will always occupy the same position in relationship to the photoelectric control.
- Light will be reflected at the same angle at which it was received.
- When object is not present light will be reflected at a different angle.

**Diffuse**
- Light beam is directed at the object to be detected.
- Light will be reflected off the object in many directions.
- Some of the light reflected from the object will be sensed by the receiver.

**Convergent**
- Light beam is directed at object to be detected (ignore's background surfaces).
- Object must be at a given distance in relationship to photoelectric control before light will be reflected to receiver.

**Thru**
- Light source (emitter) and receiver are placed opposite each other.
- The object to be detected passes between the two.

**Fiber Optic**
- Not a scanning technique but rather another way of transmitting light beam.
- Must use bifurcated cables when using retroreflective and diffuse scans.

# Scanning Techniques

## ADVANTAGES/APPLICATION CONSIDERATIONS

| Scan Types | Advantages | Application Considerations |
|---|---|---|
| Retroreflective/Polarized | 1. One sided scanning<br>2. Ease of alignment<br>3. Immune to vibration | 1. Avoid detecting small parts or precise positioning<br>2. Avoid clear material detecting<br>3. Avoid sensing shiny objects (use polarized controls) |
| Polarized | 1. One sided sensing<br>2. Does not false trigger off highly reflective objects<br>3. Senses clear materials<br>4. Ease of alignment<br>5. Immune to vibration | 1. Reduced scan range compared to retrotreflective<br>2. Avoid detecting small parts or precise positioning |
| Specular | 1. Best for shiny versus dull surfaces<br>2. Detecting height differential from background, i.e., cloth on a shiny table | 1. Alignment angle between emitter and receiver critical<br>2. Distance from control to target must be constant |
| Diffuse | 1. No reflector required<br>2. Convenient for installation<br>3. One sided scanning<br>4. Senses clear materials when distance is not fixed<br>5. Color sensing (incandescent controls)<br>6. Ease of alignment | 1. Sensing range is always specified to white test paper<br>2. Shiny material requires close control of scanning angle<br>3. Background object's reflectivity cannot be more than target reflectivity<br>4. Large effective beam, avoid small parts detection<br>5. Contaminated area a problem<br>6. Avoid counting applications |
| Convergent | 1. First choice for detecting clear materials<br>2. Ignores unwanted background surface reflection<br>3. Detects objects with low reflectivity<br>4. Detects height differential | 1. Distance must be constant<br>2. Surface reflectivity a factor |
| Thru | 1. Most reliable when target is opaque<br>2. Long range scanning, most excess gain<br>3. Use in high contamination areas, dirt, mist, condensation, oil film, etc.<br>4. Precise positioning or edge-guiding of opaque material<br>5. Parts counting | 1. Avoid clear material detecting<br>2. For small parts must use aperture<br>3. Alignment critical<br>4. Additional wiring (2 units)<br>5. Vibration a factor |
| Fiber Optics | 1. High temperature applications<br>2. Where space is limited<br>3. Size and flexibility of fiber leads<br>4. Corrosive areas<br>5. Noise immunity | 1. Cost<br>2. Breakage<br>3. Short range scanning |

# Scanning Techniques

There are several scanning techniques — ways to set up an emitter (light source) and receiver (photosensor) to detect objects. The best technique to use is the one that yields the highest signal ratio for the particular object to be detected, subject to scanning distance and mounting restrictions.

Characteristics of the objects to be detected that have a bearing on which scan technique to use include:

- degree of opacity
- degree of reflectiveness
- position of objects as they pass the control
- color as a special consideration

## REFLECTIVE SCAN

With a reflective scan control, the light source and photosensor (usually in the same housing) are placed on the same side of the object to be detected. The light beam is reflected either from a permanent reflective target or directly from the object to be detected back to the photosensor. There are five types of reflective scan:

- Retroreflective
- Polarized Retroreflective
- Diffuse
- Convergent
- Specular

### Retroreflective Scan

With retroreflective scan, emitter (light source) and receiver (photosensor) are in the same housing. The light beam is directed at a retroreflective target — one which returns the light along the same path it was sent. Retroreflective targets are available as acrylic disks, tape or chalk. Perhaps the most commonly used retro target is the familiar bicycle-type reflector. A larger reflector returns more light to the receiver, and thus allows greater distance scanning. With retro targets, alignment is not critical. The control (emitter and receiver) can be as much as 15° to either side of the perpendicular to the target. Also, since alignment need not be exact, retroreflective scan is an excellent way to counteract vibration.

Retroreflection from a stationary target normally provides a high signal ratio as long as the object passing between the control and target is not highly reflective. Retroreflective scan is a preferred technique to detect translucent objects, and assures a higher signal ratio than is obtainable with thru scan. With thru scan, the "dark" signal may not register very dark at the photosensor in the receiver, because some light will pass through the object. With retroreflective scan, however, any light that passes through the translucent object on the reflector is diminished again as it returns from the reflector.

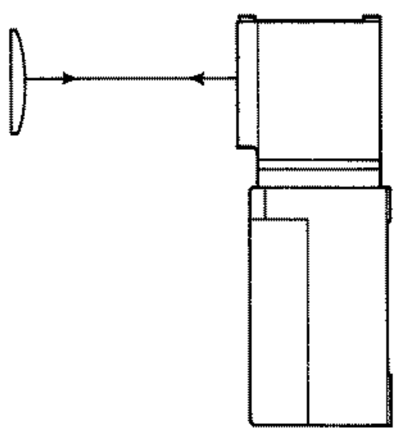
Another way to use retroreflective scan is to apply retroreflective tape or chalk coding to cartons or other items that must be sorted.

Retroreflective scanning is useful in conveyor applications and general beam break applications. It is not as reliable as thru scanning if the environment is dirty, if scanning distance is great, or if product breaking the beam is reflective (e.g. glass, polished stainless, etc.).

Some retroreflective controls can be used at distances up to 40 feet in clean air conditions. As the distance to target increases a larger retro target should be used to intercept and return as much light as possible.

Single-unit wiring and maintenance are additional advantages of retroreflective scanning.

Retroreflector scan advantages include single-unit wiring and non-critical alignment with reflector.



### Polarized Scan

Polarized scan is a modified retroreflective scan. As with other retroreflective controls, polarized controls usually contain both an emitter and receiver in one unit. Polarized controls use a special lens which filters the emitter's beam of light so that it is projected in one plane only. The receiver responds only to the de-polarized reflected light from corner-cube type reflectors or polarized sensitive reflective tape. It is designed to ignore the light reflected from highly reflective targets such as shrink wrap materials, shiny luggage or aluminum cans.

The visible beam can be seen on the reflector for easier and more accurate alignment.

Must be corner cubed reflector or polarized sensitive reflective tape.

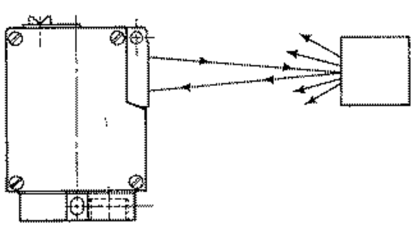
# Scanning Techniques

### Diffuse Scan

Usually diffuse scan controls contain both the emitter and the receiver. In the diffuse scanning mode the emitted light strikes the product surface at some arbitrary angle and the light is then diffused from the surface at all angles. The product or target is the reflector. The target actually makes the beam instead of breaking the beam.

Non-shiny (matte) surfaces such as kraft paper, rubber, and cork absorb most incident light and reflect only a small amount. Light is reflected or scattered nearly equally in all directions. In diffuse scan, the control is positioned perpendicular to a dull surface. Emitted light is reflected back from the target to operate the receiver. Because the light is scattered, only a small percentage returns. Therefore, scanning distance is somewhat limited. A portion of the diffused light is returned to the receiver. Alignment is not critical in picking up diffuse reflection. Diffuse scan is the mode to use for web break and ejected part detection, conveyor jam detection, etc.

Target makes the beam instead of breaking the beam



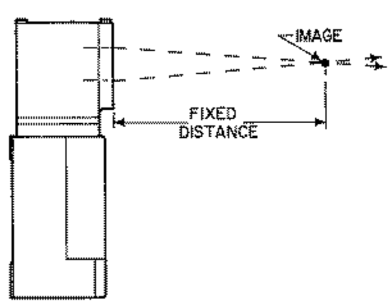
### Convergent Beam

Convergent beam scanning is a special variation of the diffuse mode. The control's optical system is the key to its operation. It simultaneously focuses and converges the light beams to a fixed-focal point in front of the control. The control is essentially blind a short distance before and beyond this focal point. Operation is even possible when highly reflective backgrounds are present. Like diffuse scanning, convergent beam scanning senses light reflected back directly from an object.

Convergent beam scanning is used to detect products which are only inches away from another reflective surface. It is the first choice for edge-guiding or positioning clear or translucent materials. Because the beam is well defined, it is also a good second choice for position sensing of opaque materials.

Parts can be sensed on a conveyor from above while ignoring the conveyor belt. Or they can be sensed from the side without detecting guides or rails directly in back of the object. Convergent beam scanning can detect the presence of fine wire, resistor leads, needles, bottle caps, pencils, the stack height of material, fill level of clear liquids and discriminate the product against its background. It is also capable of sensing black code marks against a contrasting background.

Fixed focus light beams




### Specular Scan

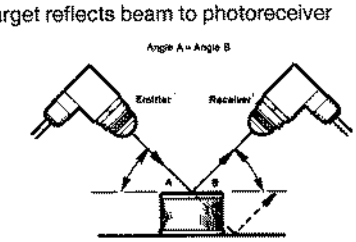
In the specular scanning mode, the emitter and receiver are in separate housings. An emitter and receiver are mounted at equal angles from the perpendicular to a reflective surface (see below). The distance from the surface of an object to the control(s) must remain constant.

The specular mode is useful in some applications where differentiating between a shiny and a dull surface is necessary. An example of this would be checking for the presence or absence of foil or poly wrap on cartons.

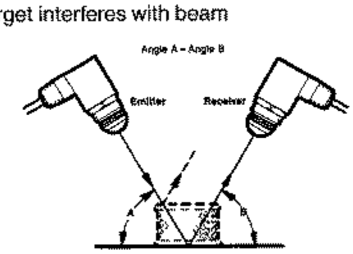
The angle at which light strikes the reflecting surface equals the angle at which it reflects from the surface. Positioning of the emitter (light source) and receiver must be precise (mounting brackets which fix the emitter-receiver relationship are available), and the distance of the reflecting surface from the emitter and receiver must be consistently controlled. The size of the angle determines the depth of scanning field. With a narrower angle, there is more depth of field. With a wider angle, there is less depth of field. In a fill level detection application, for example, this means that a wider angle between emitter and receiver allows detection of fill level more precisely.

Specular scan provides a good signal ratio when required to distinguish between shiny and non-shiny (matte) surfaces. When monitoring a non-flat shiny surface with high and/or low points that fall outside the depth of field these points will appear as dark signals to the receiver.

Target reflects beam to photoreceiver




Target interferes with beam



# Scanning Techniques

## THRU SCAN

In thru (sometimes referred to as direct) scan, the emitter (light source) and receiver (photosensor) are positioned opposite each other, so light from the emitter shines directly on the receiver. The object to be detected passes between the two. If the object is opaque, thru scan will usually yield the highest signal ratio and is a logical first choice.

As long as the target blocks enough light as it interrupts the light beam, it may be skewed or tipped in any manner. As a rule of thumb, object size should be at least the diameter of the receiver lens. When detecting small objects, place an aperture over the receiver lens in order to reduce its diameter. Detecting small objects typically requires thru scan.

Because thru scan does not rely on the reflectiveness of the object to be detected or a permanent reflector for light to reach the receiver, no light is lost at the reflecting surface.

While thru scan provides the longest scanning distance, it has certain limitations. Alignment is critical, and difficult to maintain where vibration is a factor. Also, with separate emitter and receiver, there is additional wiring which may be inconvenient if the application is difficult to reach. This factor also adds to installation time and cost.

## FIBER OPTICS

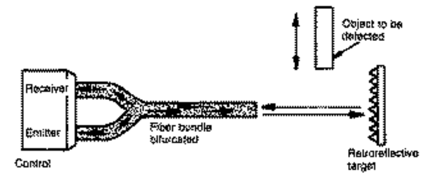
Fiber optics is not a scanning technique, but a method of controlling or transmitting the signal (light beam) from or to the control. Fiber optics use transparent fibers of glass or plastic to conduct and guide light energy. They are used in photoelectric controls as light-pipes.

The control's beam is transmitted through a cable. It returns through a separate cable either combined in the same cable assembly (bifurcated) or within a separate cable assembly (thru scan) to the receiver.

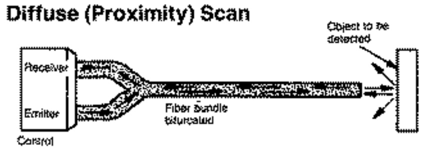
Scanning options depend on the type of cable selected. Retroreflective and diffuse scan use a bifurcated cable and thru scan uses two separate cables (emitter and receiver). Scan distances vary depending on type of scan from 0.4 to 54 inches. An optical lens accessory that attaches to some cable ends significantly increases scan distances.

Combining the optic cables with photoelectric controls has many advantages. Small parts detection and usage in limited mounting space is obvious. High temperature, high vibration or high electrical noise levels at any control can cause false triggering. With fiber optics, the light emitting and receiving components are located remotely at the control's housing and only passive light-transmission fibers need be exposed to the severe environment.

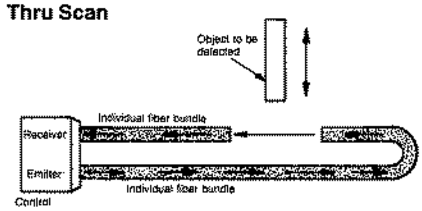
**Retroreflective Scan**



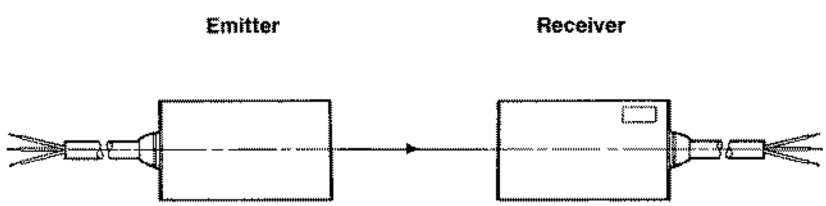

**Diffuse (Proximity) Scan**




**Thru Scan**




In thru scan the emitter is aimed directly at the receiver.



# Excess Gain

## GENERAL INFORMATION

Excess gain is defined as the ratio of optical power available at a given emitter-to-receiver range to the minimum optical power required to trigger the receiver.

In modulated light source controls excess gain is measured as a voltage (typically at millivolt levels) usually at the first stage of receiver amplification. The measured voltage is compared to the minimum voltage required to just turn-on the receiver's amplifier and then calculated or displayed as that ratio. An excess gain of 1 represents the minimum amount of light required for operation. An excess gain of 50 indicates that there is 50 times more light energy than required falling on the receiver.

Once a light signal or the optical power is established between an emitter and receiver in any scanning situation, there may be attenuation (or reduction) of that signal by elements such as dirt, dust, smoke, moisture, or other contaminants in the scanning environment. Excess gain is the extra light energy which is available to overcome attenuation.

## DEFINITIONS

Attenuation — Loss or reduction of beam intensity as a result of environmental factors (dust, humidity, steam, etc.)

Optical power — Power or intensity of the projected light available from a particular emitter . . . beam intensity

Clean air — Ideal conditions. Climate controlled or sterile areas

Slight contamination — Indoor locations, non-industrial areas, office buildings

Low contamination — Warehouse locations, light industry applications, material handling operations

Moderate contamination — Milling operations, areas of high humidity, steam

High contamination — Heavy particle laden air, extreme washdown environments, grain elevators

Extreme contamination — Coal bins, residue on lens

# Excess Gain

## THRU SCAN

In thru scan the light from the emitter goes directly to the receiver. Therefore, the excess gain available from thru scan controls is much greater than for any other scanning technique.

Excess gain of a thru scan pair is directly related to scanning distance by the inverse square law. As a result, the excess gain is always a straight line if plotted on a log-log scale. This is a useful fact, because if the excess gain is known at any one distance, then the excess gain for any other distance may be calculated. For example, cutting the scanning distance in half will increase the penetration power by a factor of four.

Thru scan controls are best suited for dirty conditions, as the light only traverses the distance once. This means that typically higher excess gain (G) values are possible with this scanning mode. Also, the closer the emitter and receiver are to each other the higher the penetration power.

To determine excess gain (G) for any thru scan control:

Determine emitter gain factor $G_E$ (from chart)

Determine receiver gain factor $G_R$ (from chart)

$G = G_E \times G_R$

Contamination for both emitter and receiver must be considered (see Definition) using the following guidelines:

### GAIN FACTOR:

Clean air
$G = 1.0$ per location
Slight contamination
$G = 1.25$ per location
Low contamination
$G = 2.0$ per location
Moderate contamination
$G = 10.0$ per location
High contamination
$G = 25$ per location
Severe contamination
$G = 100$ per location

The environment in which emitter and receiver are to be placed are estimated, and the two numbers multiplied together for the required G. Using the excess gain chart, the maximum range for that product under the estimated conditions can be determined.

The excess gain available from any scanning system can be plotted as a function of distance. For customer convenience MICRO SWITCH includes an excess gain curve with all product ordering specifications. These curves can be used to determine general product performance under different degrees of contamination.

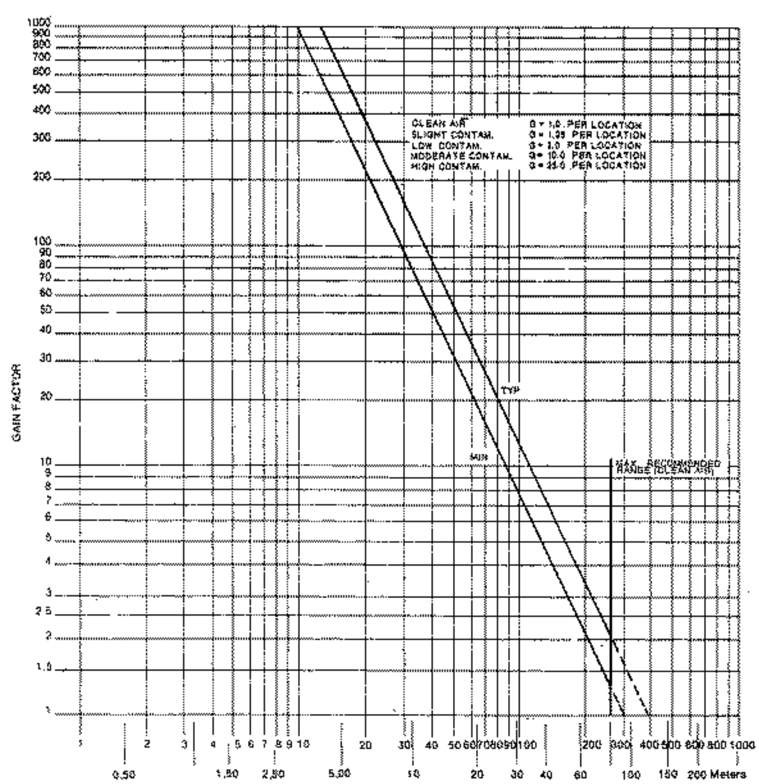
Excess gain curves are plotted for conditions of clean air and maximum receiver gain. Since actual operating conditions rarely fall into the clean air category, excess gain curves provide a useful guide for determining the scanning range of a particular photoelectric control; given specific application parameters.

---

The following is a step-by-step procedure for using a typical thru scan excess gain chart.

1. Refer to the thru scan excess gain chart below.
2. Estimate the environmental conditions of the application. Product suitability may vary in accordance with the subjective definitions of clean air, slight contamination, etc. Refer to Definitions.
3. Determine the G (gain factor) value for the estimated environmental conditions at the emitter and receiver locations, for example:
   Receiver (high contamination)
   $G = 25.0$
   Emitter (moderate contamination)
   $G = 10.0$
4. Determine overall gain requirement as a product of emitter/receiver value.
   $G = 25.0 \times 10.0 = 250.0$
5. Locate this value (250) on the left (vertical) side of the excess gain chart and read across to intersect the curve.
6. Read distance values below (horizontal line) to find maximum scan range at your environmental conditions. Both minimum and typical curves are given. For the environmental conditions given this thru scan control can typically scan 24 feet.

**Typical Thru Scan Excess Gain Chart**



# Excess Gain

## RETROREFLECTIVE SCAN

Retroreflective controls exhibit excess gain curves distinct from those of thru scan controls. There is no straightforward relationship between excess gain (G) and distance for retroreflective controls. Gain, however, serves the same function in determining suitability in particular applications and differs only in respect that the emitter and receiver are together and in the same environmental conditions while the reflector location must be considered.

The shape of the excess gain curve for a retroreflective control is determined by the type of optical system used. The size of the excess gain curve depends upon the type and the size of the retroreflective target. MICRO SWITCH retroreflective excess gain curves use a 3-inch diameter corner-cube disc as a reflector. Retroreflective tape is roughly one-third as reflective as compared to a corner-cube disc of the same size. So the excess gain curves have to be derated when retroreflective tape is used as a target.

The excess gain charts of retroreflective controls provide some insight into the product performance. There is a point at which maximum G (excess gain) occurs to a given target. If the control is going to operate in a particular application, this is where it will work best. Using a retroreflective control and target at maximum G will give maximum reliability and flexibility in the application. For instance, if the device is set up for maximum G, any problems with false detection of the object which is to block the beam can be minimized by reducing sensitivity (which essentially moves the whole curve downward on the graph). Unless the blocking object is a more efficient light reflector than the retro target, the beam will be blocked by the object at the reduced sensitivity, since it blocks the beam at a point somewhere between the control and the point of maximum G.

In retroreflective scanning, the emitter and receiver are in the same environment, but the reflector's environment must also be considered. The guidelines are:

**GAIN FACTOR:**

Clean air
  G = 1.0 per location
Slight contamination
  G = 1.5 per location
Low contamination
  G = 3.0 per location
Moderate contamination
  G = 50 per location

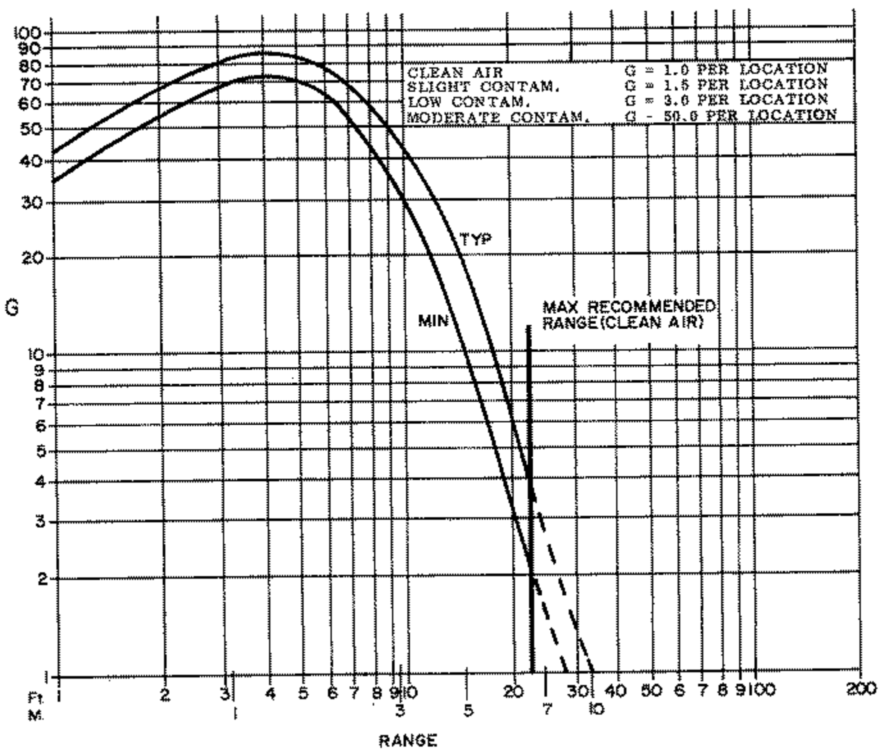
To determine excess gain (G) for any retroreflective scan control:

Determine photo gain factor $G_{PH}$ (from chart)
Determine reflector gain factor $G_{REFL}$ (from chart)

$G = G_{PH} \times G_{REFL}$

As in the thru scan, the two determined values are multiplied for the required G. Use the excess gain chart below to see the corresponding range. Note the minimum as well as the typical range. The procedure for using a retroreflective excess gain chart is the same as thru scan, described on the previous page.

**Typical Retroreflective Scan Excess Gain Chart**



# Excess Gain

## DIFFUSE SCAN

Excess gain in diffuse scanning is dramatically influenced by the variable for the reflectivity of the surface being sensed. Excess gain curves for diffuse controls are plotted using a white test card, rated at 90% reflectance, as a standard reference.

To determine excess gain (G) for any diffuse scan control:

Determine photo gain factor $G_{PH}$
(from chart)
Determine object gain factor $G_{OBJ}$
(from chart)
Determine object reflectance $R_{OBJ}$
(from chart)

$$G = (90\% / R_{OBJ}) \times G_{PH} \times G_{OBJ}$$

The object may or may not have a gain factor depending on whether or not contamination builds up on the object.

In diffuse scan, the emitter and receiver are together, although the material must also be considered. Guidelines are:

**GAIN FACTOR:**

Clean air
G = 1.0
Slight contamination
G = 1.5
Low contamination
G = 3.0
Moderate contamination
G = 50.0

The maximum diffuse detection ranges are figured using a standard 90% reflectance card. Since diffuse reflectance is rarely to these cards, the reflectance to infrared light of some common detection materials is listed to show effects on detection range.

**OBJECT REFLECTANCE:**

| | |
|---|---|
| White bond paper | 80% |
| Brown kraft paper | 65% |
| Black felt | 25% |
| Tree bark | 20% |
| Dark cotton cloth | 20% |
| Dark wool cloth | 16% |
| Medium shade stone | 10% |
| Lampblack | 2% |

The excess gain chart for diffuse scan controls gives insight as to the optimum detection range. The graphs are plotted using a 90% reflectance card. At less than this range, objects with reflectivities lower than 90% may not be detected especially if sensitivity must be reduced for background. This is sometimes called blind range. Blind range is minimized in MLS products by notching the lens in reflective controls close to the intersection of the two halves. This causes a dispersion of reflected light, reducing the blind range, as the curve of available energy at a given distance shifts inward and upward.

Diffuse scan controls require cleaner operating environments than other controls since they are designed to detect diffuse light from the surface of target materials themselves. Excess gain curves are typically lower.

The excess gain of a diffuse scan control is also affected by the size and profile of the object to be detected. The excess gain curves assume that the white test card fills the entire area of the diffuse control's effective beam. If the object to be detected is small and only fills a portion of the control's beam, there will be proportionally less light energy returned to the receiver.

Materials which have shiny or glossy surfaces require special consideration if they are to be detected with a diffuse control. These materials include glass, poly and metal films, polished metal, and many molded or extruded plastics. Because these surfaces are mirror like to some degree, the reflection is largely specular rather than diffuse.

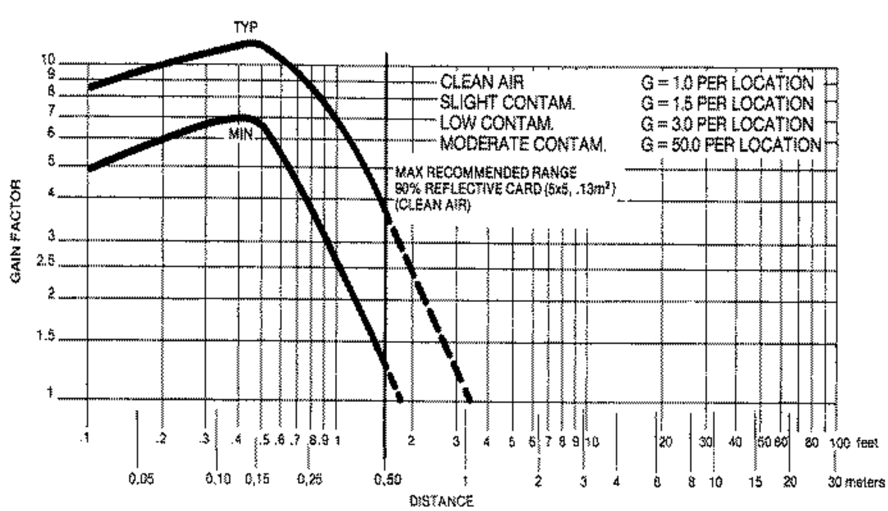
To avoid any problem of signal loss from shiny objects, polarized retroreflective control should be used.

---

Establish gain values for the target's operating environment (control and object). Calculate excess gain (G) required for the environment. Read across the graph and down to range scale to determine maximum operating distance.

It is important to note that target variations including degradation of the target resulting from a marginal environment will further alter these determinations. The best scan range for optimum performance is always the distance directly below the peak of the excess gain curve.

**Typical Diffuse Scan Excess Gain Chart**



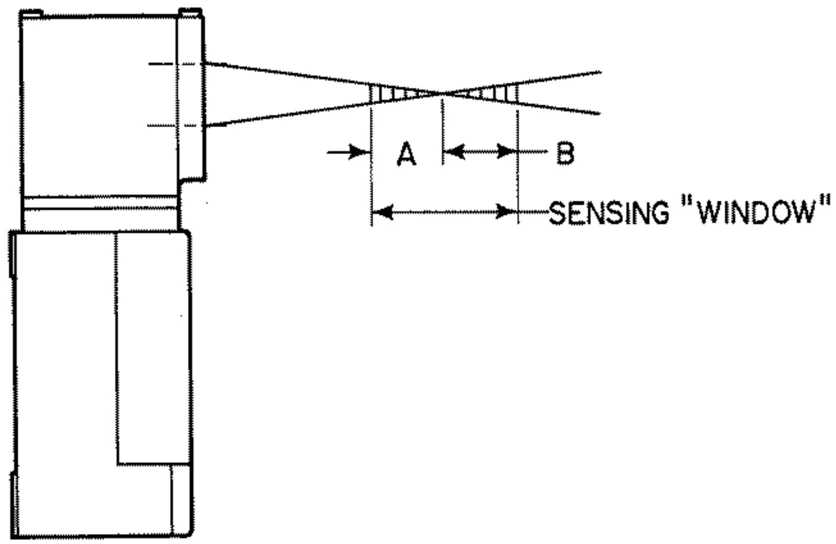
# Excess Gain

### CONVERGENT BEAM EFFECTIVE OPERATING RANGE

A convergent beam MLS control is a special variety of diffuse scan. The optical system is the key to its operation. It simultaneously focuses and converges the infrared LED beams to a fixed-focal point in front of the control. Since most of the energy of a convergent beam control is concentrated at its focus, excess gain charts are substituted with an effective operating range. Like diffuse scan, convergent beam operating ranges are developed using a 90% reflectance white test card.

Refer to the example at the right. Dimensions A and B are approximately 1/2-inch with a 90% reflective target in clean air. Changes in environmental conditions, object reflectively or decreasing sensitivity will decrease both A and B dimensions, thus decreasing the sensing window.

**Typical Convergent Beam Effective Operating Range**



# Beam Diameters and Effective Beam

## GENERAL INFORMATION

The beam diameter of a MLS Photoelectric Control is defined as the geometric pattern of radiant energy (projected light beam from emitter) capable of causing the receiver to operate. The effective beam is that region of the beam diameter where optical detection of a target occurs. The target can be inside the beam diameter and not be detected. This occurs in two instances.

1. When the target is not blocking the light (effective beam) to the receiver or reflector (thru scan and retroreflective scan).
2. When the target to be sensed is not reflecting/returning enough light back to the receiver. (diffuse scan).

## THRU SCAN CONTROLS

Figure 1 illustrates the effective beam and beam diameter for a typical thru scan pair with maximum alignment. In the example shown the effective beam has the same diameter as the emitter and receiver lens and is traced from lens to lens. The target must pass thru the effective beam to be detected. Targets outside this beam will not be detected even though they may fall within the beam diameter or radiant energy pattern.

Figure 2 illustrates a misaligned thru scan pair. Note, the definition of the effective beam is unchanged, the same size as the emitter and receiver lens.

If the lens diameter of a thru scan pair is different, the effective beam becomes a tapered path as illustrated in Figure 3. If the target is smaller than the effective beam, an aperture cap or mask can be used to reduce the size of the effective beam. The level of power available is reduced by the ratio of the hole size to the original effective beam. Refer to application information on FE7 Series thru-scan aperture masks.

**Figure 1**
**Thru Scan Pair With Maximum Alignment**

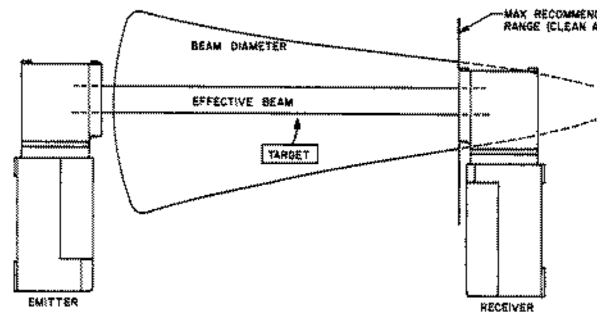



**Figure 2**
**Thru Scan Pair With Minimum Alignment**

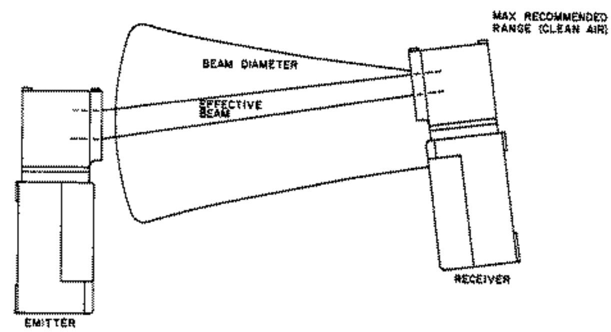
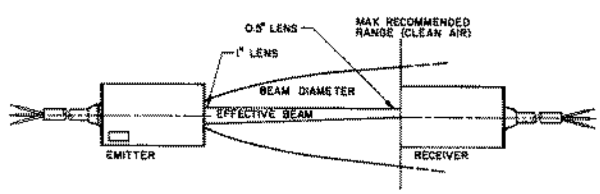



**Figure 3**
**Thru Scan Pair With Different Lens Diameters**



# Beam Diameters and Effective Beam

### RETROREFLECTIVE SCAN CONTROLS

The effective beam of a retroreflective scan control is a tapered radiant energy path from the edges of the control's lens to the edges of the reflector, refer to Figure 4. Energy outside this region is not returned and thus does not contribute to target detection. For reliable operation, the target must be equal to or greater than the diameter of the reflector. If smaller, a smaller diameter or masked reflector should be used.

### DIFFUSE SCAN CONTROLS

Figure 5 illustrates the beam diameter with no target present and the effective beam when a target is present for a diffuse scan or specular scan control. Note, in diffuse scan the effective beam exists only when the light beam is reflected from the emitter to the receiver by a target entering the beam diameter. The shape of the effective beam is dependent upon the target's shape and size and only targets within this region will be detected.

### BEAM DIAMETER CHARTS

The following beam diameter charts for each listing show the area in which the receiver will operate at various ranges. For optimum performance the receiver should be centered in the beam.

Values given in the graph are typical for clean air scanning. Fog, dust, etc. will shorten distance. If your application is in clean air, the effective beam area chart will supply information you need to set up the application.

Size and placement of the object to be detected, as well as scanning distance versus beam diameter and recommended maximum distance, is given with each control.

**Figure 4**
**Retroreflective Scan**

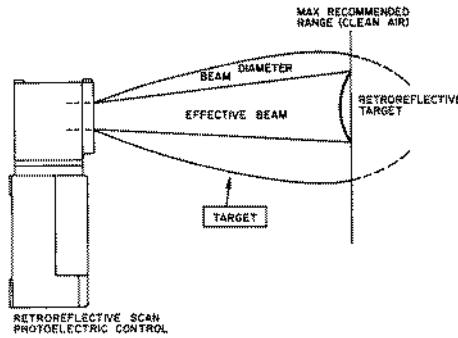
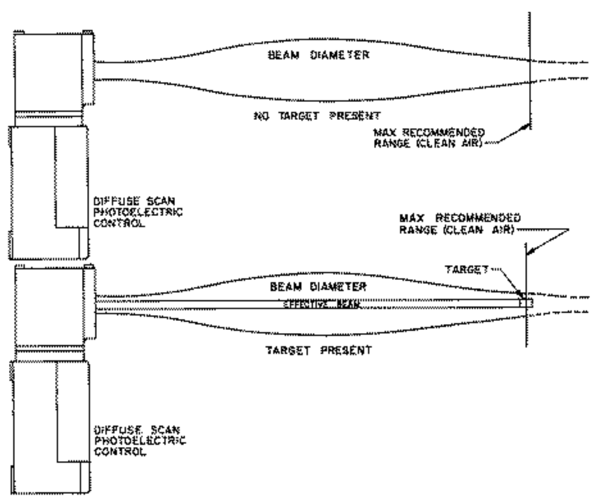



**Figure 5**
**Diffuse Scan**



# FE7 Thru Scan Aperture Masks

## GENERAL INFORMATION

MICRO SWITCH FE7 Series thru-scan photoelectrics have the ability to detect objects as small as .31 inches (8 mm). However, applications exist where smaller objects need to be detected, or highly accurate object positioning is required.

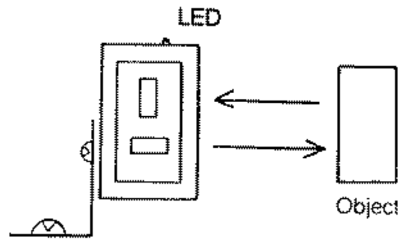
To meet these needs, various sized circular and rectangular aperture masks were developed to reduce the effective beam size down to .039 inches (1 mm).

The narrower the aperture the more accurate the photoelectric pair will be. However, the maximum scan distance will be reduced.

For accurate object positioning, rectangular aperture masks can be used. Care should be taken to insure the aperture mask is properly oriented for either horizontal or vertical movements. The FE7 Series thru-scan emitters and receivers use the top half of the lens
area only.

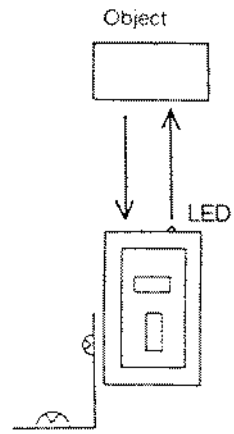
For accurate horizontal positioning, place the rectangular aperture masks as shown in Figure 1.

**Figure 1**
**Horizontal Positioning**




For accurate vertical positioning, place the rectangular aperture masks as shown in Figure 2.

**Figure 2.**
**Vertical Positioning**




## SMALL OBJECT DETECTION

The minimum detectable object sizes, using standard FE7 series thru-scan photoelectrics are:

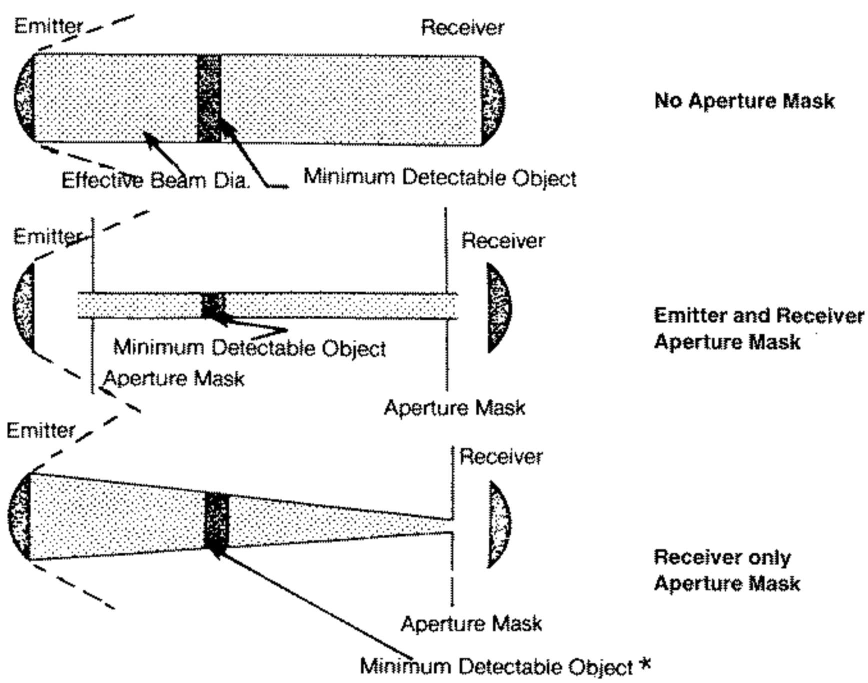
| | |
|---|---|
| FE7A-T Series | .31 inches (8 mm) |
| FE7B-T Series | .35 inches (9 mm) |
| FE7C-T Series | .47 inches (12 mm) |

The minimum detectable object is defined to be the smallest object that will block the effective beam from emitter to receiver.

To detect objects smaller than listed above, round aperture masks are attached to both emitter and receiver, or just the receiver. Adding aperture masks will reduce the effective beam size, so smaller objects can be detected. Refer to Figure 3. However, the maximum scan distance will also be reduced.

* Note that the minimum detectable object size varies due to the changing effective beam size from emitter to receiver.

**Figure 3**
**Small Object Detection**



# FE7 Thru Scan Aperture Masks

### SCAN DISTANCES

Figure 4 outlines typical scan distances when various aperture masks are placed onto the FE7 Series thru-scan photoelectric sensors (for reference only).

**Figure 4**
**Thru-Scan**

**Sensing Range with Apertures**

| Aperture Size | Location | FE7A Series | FE7B Series | FE7C Series |
|---|---|---|---|---|
| 1mm Circ. Masks | Both E and R | 7% | 2% | 2% |
| | R only | 25% | 10% | 10% |
| 2 mm Circ. Masks | Both E and R | 25% | 5% | 5% |
| | R only | 50% | 25% | 20% |
| 4 mm Circ. Masks | Both E and R | N/A | 25% | N/A |
| | R only | N/A | 50% | N/A |
| 5 mm Circ. Masks | Both E and R | N/A | N/A | 20% |
| | R only | N/A | N/A | 50% |
| 0.5 mm Rect. Masks | Both E and R | 10% | 5% | 4% |
| | R only | 35% | 20% | 25% |
| 1 mm Rect. Masks | Both E and R | 25% | 10% | 10% |
| | R only | 50% | 25% | 40% |
| 2 mm Rect. Masks | Both E and R | 50% | N/A | N/A |
| | R only | 75% | N/A | N/A |
| 2.5 mm Rect. Masks | Both E and R | N/A | 20% | N/A |
| | R only | N/A | 40% | N/A |
| 3 mm Rect. Masks | Both E and R | N/A | N/A | 25% |
| | R only | N/A | N/A | 60% |
| 4 mm Rect. Masks | Both E and R | N/A | 40% | N/A |
| | R only | N/A | 70% | N/A |
| 5 mm Rect. Masks | Both E and R | N/A | N/A | 40% |
| | R only | N/A | N/A | 70% |
| Without Aperture Masks | | 100% | 100% | 100% |

# Logic

## LIGHT OPERATED/DARK OPERATED

**LIGHT OPERATED**

Control operating mode in which the output (load) is energized when the the photosensor is illuminated.

**DARK OPERATED**

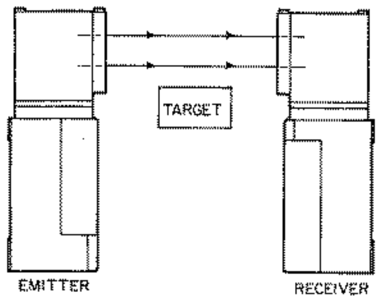
Control operating mode in which the output (load) is energized when the photosensor is dark.

## THRU SCAN

In a thru scan system, dark operated means that the output (load) is energized when a target is present, breaking the beam. Light operated means the output (load) is energized when the target is missing, making the beam.

### THRU SCAN LIGHT OPERATED VERSUS DARK OPERATED

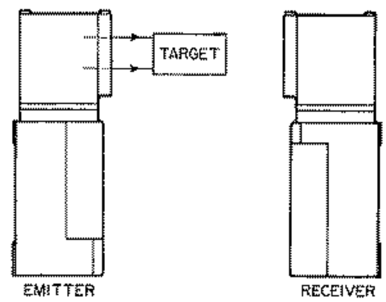
**LIGHT OPERATED**




Output On

The receiver sees light from the emitter when the target is not blocking the beam.

**DARK OPERATED**




Output On

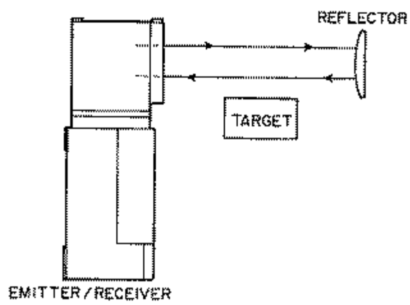
The receiver sees no light when the target is blocking the beam.

## RETROREFLECTIVE SCAN

In a retroreflective scan system the conditions are the same as for thru scan. Dark operated means the output (load) is energized when the target is present, breaking the beam. Light operated means the output (load) is energized when the target is missing, making the beam. See drawings at right.

### RETROREFLECTIVE SCAN LIGHT OPERATED VERSUS DARK OPERATED

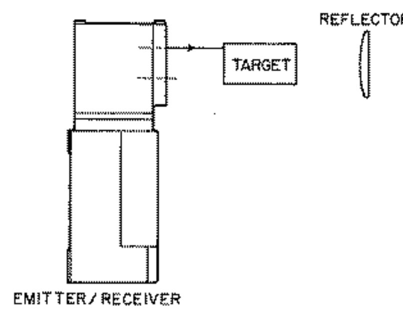
**LIGHT OPERATED**




Output On

The receiver sees light from the reflector when the target is not blocking the beam.

**DARK OPERATED**




Output On

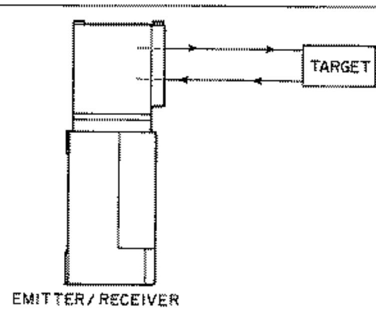
The receiver sees no light from the reflector when the target is blocking the beam.

## DIFFUSE SCAN

In diffuse, specular, or convergent beam scanning the conditions reverse from thru scan. Dark operated means the output (load) is energized when the target is missing, no light returned. Light operate means the output (load) is energized when the target is present, returning light to the photosensor. See drawings at right.

### DIFFUSE (SPECULAR/CONVERGENT) SCAN LIGHT OPERATED VERSUS DARK OPERATED

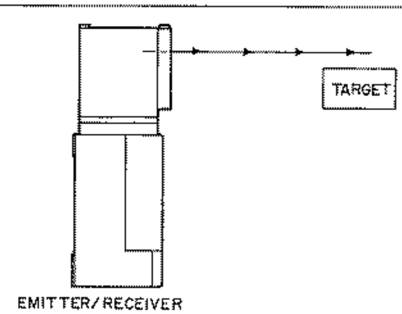
**LIGHT OPERATED**




Output On

The receiver sees light reflected directly from the target when it is in view of the control.

**DARK OPERATED**




Output On

The receiver sees no reflected light from the target when it is out of view of the control.

# Logic

Combining a control's receiver condition; light or dark operated with logic terms AND/OR can result in logic gate interfacing with multiple control hookups.

- Light-operated OR or Light-OR means that the output will energize when any one (or more) of the receivers sees light.
- Dark-operated OR or Dark-OR means that the output will energize when any one (or more) of the receivers sees dark.
- Dark-operated AND or Dark-AND means that no output will occur until all receivers are seeing dark.
- Light-operated AND or Light-AND mean that no output will occur until all receivers are seeing light.

All four logic functions, as shown, are possible whenever self-contained controls are used. Refer to the Interfacing section for directions on wiring photoelectrics in series and parallel.

Multiple non-modulated remote receivers may be wired in series or parallel to a control base.

Multiple modulated remote receivers in a component system may be wired only in parallel. As a result, only Light-OR and Dark-AND logic functions are possible. Modulated remote emitters are always wired in parallel.

| **Light-OR Logic** | **Receiver A** | **Receiver B** | **Load** |
|---|---|---|---|
| | Light | Light | Energized |
| | Light | Dark | Energized |
| | Dark | Light | Energized |
| | Dark | Dark | De-energized |
| **Dark-OR Logic** | **Receiver A** | **Receiver B** | **Load** |
| | Light | Light | De-energized |
| | Light | Dark | Energized |
| | Dark | Light | Energized |
| | Dark | Dark | Energized |
| **Dark-AND Logic** | **Receiver A** | **Receiver B** | **Load** |
| | Light | Light | De-energized |
| | Light | Dark | De-energized |
| | Dark | Light | De-energized |
| | Dark | Dark | Energized |
| **Light-AND Logic** | **Receiver A** | **Receiver B** | **Load** |
| | Light | Light | Energized |
| | Light | Dark | De-energized |
| | Dark | Light | De-energized |
| | Dark | Dark | De-energized |

The four logic conditions of Light-OR, Dark-OR, Light-AND, and Dark-AND cover most multiple control hookup situations. However, many other control logic combinations are frequently encountered. Contact MICRO SWITCH, Freeport, IL (815/235-6600) for help with any multiple photoelectric control hookup applications.

## CONTROL LOGIC

Timing logic is offered in several MICRO SWITCH product lines.

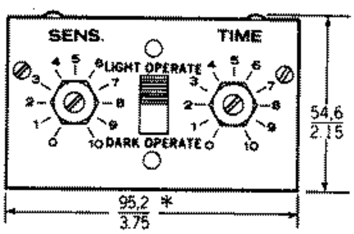
- TR Modules
- LOG Cards
- FEC Control Base
- FM Proximity Controls
- SID 2000 Sensor Interface Device

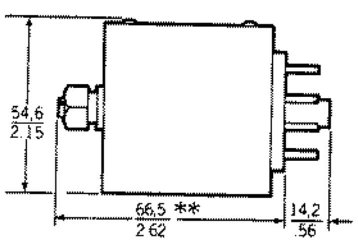
### TR Modules

TR logic modules plug into TRB control bases and are designed to be used with incandescent controls. Threshold or transition responsive modules operate exactly as do the threshold or transition responsive log cards (see Log Cards). TR modules are generally not recommended for use with modulated LED devices.

Besides operating output devices the output signal can be used as input to another module for custom logic.

**Typical mounting dimensions**




* 120,7 / 4.75 FOR STR10 MODULE

** 74,6 / 2.94 FOR MODULES WITH A DUAL KNOB (STR10, TR5-14, TR8, 8A, 8B)

### LOG Cards

Logic Cards can be used with modulated LED controls as well as incandescent controls. They plug directly into MLS1A, MLS2B (modulated LED) and R4A (incandescent) controls, and into G4B and LCR control bases.

When used with incandescent controls LOG Cards serve as amplifiers as well as logic circuits. They receive the photosensor signal, amplify it, and modify the output to respond in a particular way (as determined by time delay, pulse, or other logic).

Threshold responsive amplifiers respond to a change in light intensity above or below a certain value or threshold. Transition responsive amplifiers respond to a rate of light change. Consequently, objects must be moving at least two inches per second in order to trigger an output signal when a transition responsive amplifier is being used. Note: Transition responsive cards cannot be used with modulated LED devices.

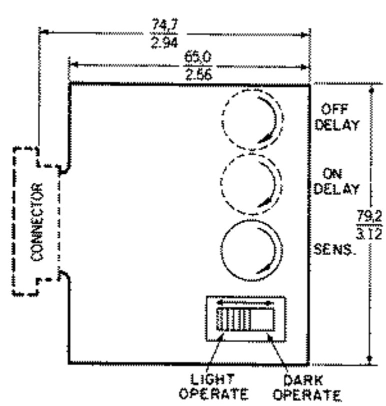
When used with modulated controls, cards are logic circuits only, not amplifiers. Amplifier circuitry is integral to modulated LED controls.

Each card (except LOG6) includes a light operated/dark operated mode selector switch, and a sensitivity adjustment that must be set fully clockwise when used with modulated LED controls.

Besides operating output devices the logic card output signal can be used as input to another card for custom logic. This is done most often with a modular LCR Series control base.

Latching logic cards cannot be used in MLS1 or MLS2 controls, which have no terminal for resetting the latch or for disabling the control.

**Typical mounting dimensions**




An overview of some of the commonly used logic functions follow.

One-Shot (Pulsed) Logic – gives a single fixed pulse in response to a change at the sensor. Example: often used as a leading edge detector for moving parts, where the first indication of presence requires a single operation to take place, but where the continued presence will not cause recycling to occur.

Maintained (Latching) Logic – with part presence, the output is continuous until the operator resets. After reset, the output will not trigger if the original target is still in front of the sensor. Example: used to detect parts for manual reject.

ON Delay – does not trigger immediately with a change at the sensor, but will trigger only if the input signal exceeds a preset time delay. Example: jam-up detection on a conveyor for parts feeding at specific intervals. A slow down or stoppage downstream will cause a slower rate of passage, recognized as overloading or jam-up, and will cause an output to give warning or shut down the equipment until the cause is eliminated. A similar type provides an output which stays ON even when the cause is corrected, until manually reset by the operator.

ON/OFF Delay – used especially for jam-up detection on vibration feeders and conveyors. The ON delay detects a jam-up and the OFF delay allows the needed time for the jam to clear the sensing area.

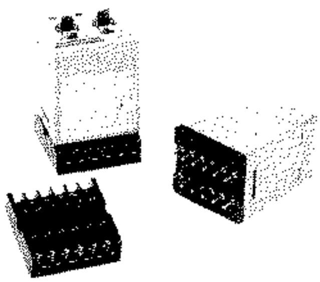
Zero-Speed Detection – provides shutdown for universal jam-up detection where the product may end up blocking the beam for too long an interval, depending on whether the jam is upstream or downstream. If the change from either light to dark or dark to light exceeds a preset time the output turns OFF or shuts down the equipment.

Divisor – the output turns ON at first input signal and OFF at the second input signal. Two input signals equal one count.

# Logic

## CONTROL BASES

### FEC

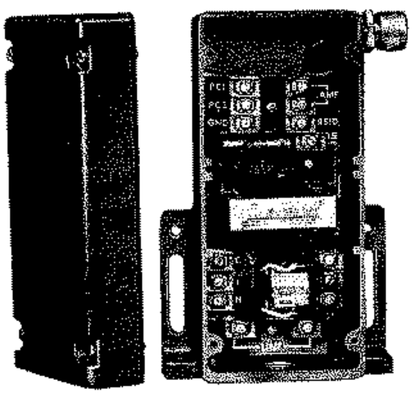


The FEC control base is designed for use with all MICRO SWITCH 12 VDC 3-wire current sinking photoelectric controls. The control base is self contained and provides up to 100 mA supply current to the sensors. It is offered in two versions; a standard control base with ON or OFF operating mode switch and a 0.1 to 5 seconds ON/OFF-delay or one shot pulse control base with ON or OFF operating mode switch. Standard items on both bases include a transformer that converts 110 or 220 VAC 50/60 Hz input to 12 VDC ±10%, a SPDT, 3 amp 250 VAC relay and LED indicators for Power, Input and Output.

All external wiring is made to the terminal base. A plug-in module contains the relay, transformer and all electronics. Both control bases provide external inhibit. Inhibit prevents the relay from being energized, regardless of input operation or ON/OFF selector switch position. External inhibit permits selective scanning for application processes such as interrogate and inspect.

It may be possible to wire several MICRO SWITCH photoelectric controls to the FEC control base in different series and parallel combinations if the 100 mA maximum rating is not exceeded. If you have such an application, contact MICRO SWITCH, Freeport for further assistance.

### FE-G4B



The FE-G4B is a single piece control base designed for use where flexibility in logic and a sealed unit are required. There are many logic cards available for use with it, varying from standard ON/OFF delay; to latched outputs, delayed one shot, or zero speed detection. The control base can be used with incandescent light sources and photoreceivers or self-contained controls to provide a complete photoelectric control system.

Optional 115 VAC or 220 VAC input units are available with standard or regulated 12 VDC output. The FE-G4B is offered in two styles, an enclosed model which is NEMA 4 sealed and an open style which has no enclosure.

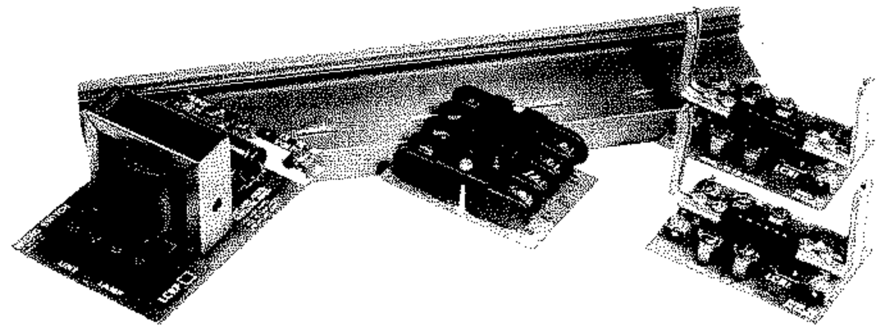
# Logic

The FE-LCRP control base can be used with a remote light source/photoreceiver combination or self-contained control to provide a complete photoelectric control system.

The LCRP Series control base is modular — made up of component sections. Power supplies, logic card connectors, and output sockets on separate printed circuit cards may be combined to give custom multiple function controls. A complete LCRP control base includes at least one LCRP power supply, one LCRI or LCRIV logic card connector (plus separately ordered logic card), an LCRO output socket (plus separate output device), and a section of LCR-12 mounting track. More than one of each of these components may be required, depending on the desired function.

Optional 115 VAC or 230 VAC heavy duty power supplies are available which provide unregulated 12 VDC power supply to the controls.

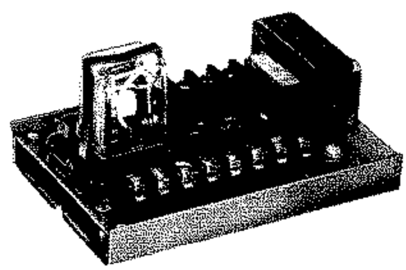
**FE-LCRP**



The FE-LCRP3A is a small, single-piece control base designed to power modulated LED DC controls or any 12 VDC model MLS control. It includes a regulated power supply and a plug-in DPDT relay, but no logic card connector. Use an LCR1 card connector and a LOG card for logic versatility.

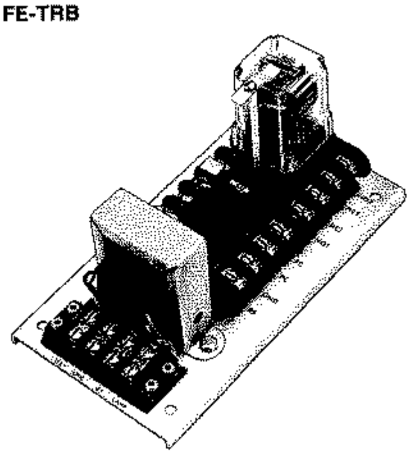
If a solid state SPST-NO relay is required order FE-SW23A.

**FE-LCRP3A**



The FE-TRB control base is designed to be primarily used with incandescent photoelectric controls. A plug-in amplifier provides ON/OFF or time delay logic. The FE-TRB is available with 115 VAC input and a 10 amp DPDT plug-in relay. Optional enclosures are available to protect the control base and inhibit electrical noise.

**FE-TRB**



# Interfacing

When interfacing a photoelectric control to a DC load, the designer has a choice of open collector current sinking or current sourcing outputs.

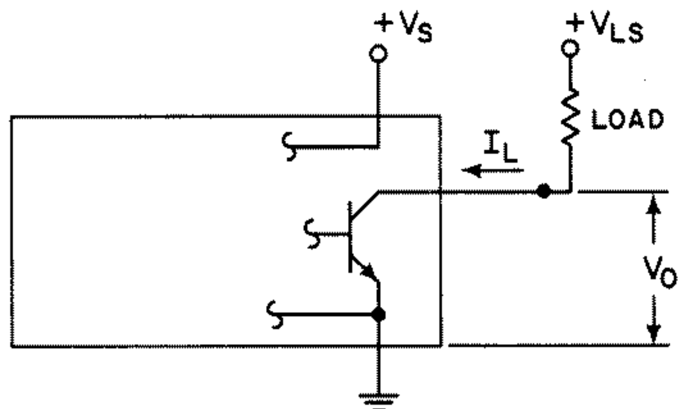
## CURRENT SINKING OUTPUT

Figure 1 represents the output stage of a typical current sinking photoelectric control. In this circuit configuration, the load is generally connected between the supply voltage and output terminal (collector) of the control. When the control is actuated (turned ON), current flows thru the load, into the output transistor to ground. The supply voltage of the control ($V_S$) need not be the same value as the load supply ($V_{LS}$)*; however, it is usually convenient to use a single supply. The control output voltage is measured between the output terminal (collector) and ground (-). When the control is not actuated, current will not flow thru the output transistor (except for a small leakage current). The output voltage, in this condition, will be equal to $V_{LS}$ (neglecting the leakage current). When the control is actuated, the output voltage will drop to ground potential (except for the saturation voltage of the output transistor).

*FE3 Series must have the same voltage supply for the load and control ($V_S = V_{LS}$)

Current sinking derives its name from the fact that it "sinks current from a load." The current flows from the load into the control. Like a mechanical switch, the control allows current to flow when turned-ON and blocks current flow when turned-OFF. Unlike an ideal switch, the control has a voltage drop when turned-ON and a small current (leakage) when turned-OFF.

**Figure 1**
**Typical Current Sinking Output Circuit**




Most MICRO SWITCH controls with current sinking outputs can drive loads which draw 100-250mA maximum. When a system's designer encounters a DC load which demands more than the rated current of the control, such as a brake or a clutch, he can interface by adding a FE-SW type output device. An output device may also be used to interface a DC load which operates at a higher voltage than the control.

Solid state relays offer the benefits of fast response (2 milliseconds ON/OFF) and infinite life.

Electromechanical relays may be used to switch loads with VA ratings exceeding the limits of the solid state devices. MICRO SWITCH DC powered photoelectric control output is more than enough to switch these relays.

## DC SINKING SERIES WIRING

Most current sinking output photoelectric controls can be wired in series. For 3-wire DC controls, the output current rating and voltage drop are the most important parameters.

Figure 2 illustrates how 3-wire DC current sinking output controls can be connected in series to provide AND logic control. In this example all controls must be ON (conducting) in order for the load to operate.

The maximum number of DC photoelectric controls that can be wired in series is limited by:

- Supply voltage
- Control's current consumption
- Control's output current
- Minimum operating voltage of the control
- Minimum voltage of the load
- Load current

Figure 3 illustrates an example of three current sinking output controls wired in series under the following limitations:

- 24 VDC supply voltage
- 20 mA current consumption (control)
- 100 mA output current (control)
- 1 VDC voltage drop (control)
- 10 VDC minimum operating voltage (control)
- 19 VDC minimum load voltage
- 30 mA load current

In the example shown in Figure 3, Control #3 must have an output circuit capable of handling both the load and current consumption of the previous two controls. Thus, Control #3 must have an output current rating of 30 mA (+) 20 mA (+) 20 mA or 70 mA. The available voltage to power the load is 21 VDC. The control's output current is 100 mA and supply voltage is 24 VDC. These controls will operate properly under the limitations previously stated.

**Figure 2**
**3-Wire DC Series Wiring For AND Logic Control**

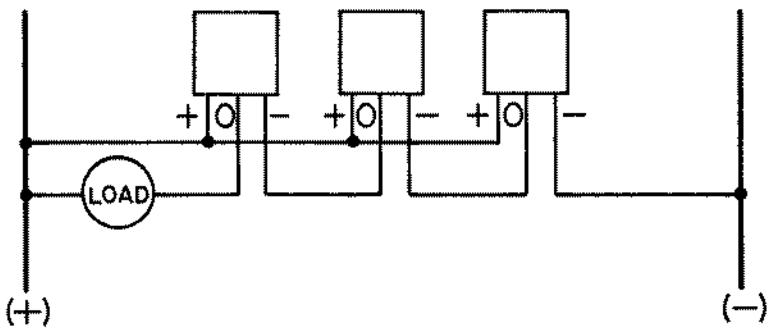
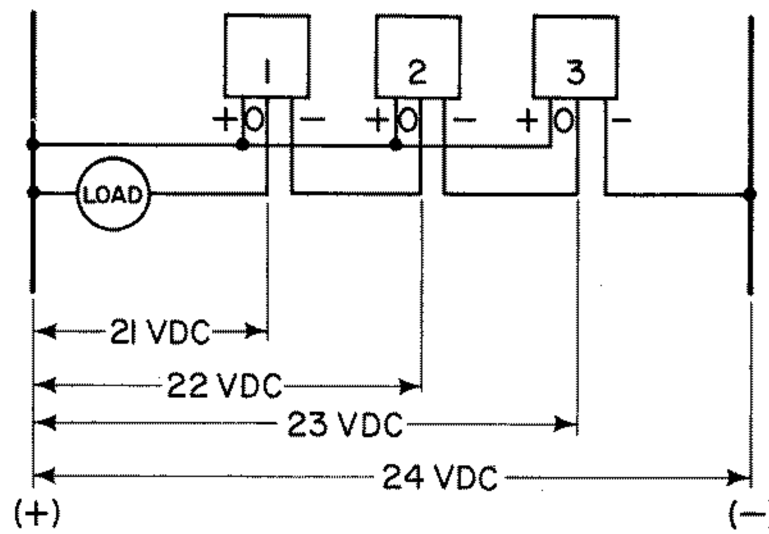



**Figure 3**
**Practical Example Of DC Series Wiring**



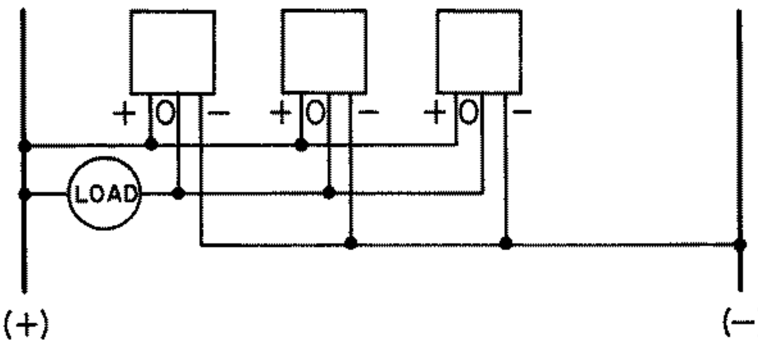
# Interfacing

## DC SINKING PARALLEL WIRING

Figure 4 illustrates how 3-wire DC current sinking output controls can be connected in parallel to provide OR logic control. In this example any DC photoelectric control can be ON (conducting) to operate the load.

When 3-wire DC current sinking output controls are wired in parallel, leakage currents are important. The leakage currents of all sensors are added together for the total leakage current of the system. In most caes, the leakage currents are small enough that adding small numbers of them together will not cause a problem.

**Figure 4**
**Wiring For OR Logic Control**



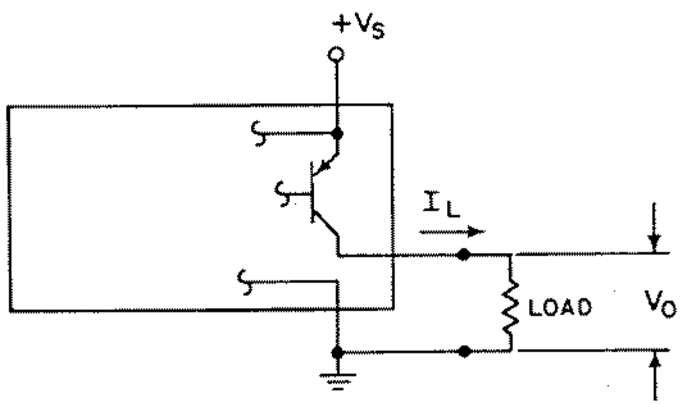

## CURRENT SOURCING OUTPUT

Figure 5 represents the output stage of a typical current sourcing output photoelectric control. In this circuit configuration, the load is generally connected between the output terminal (collector) of the control and ground. When the control is actuated, current flows from the output transistor into the load to ground. The control output voltage is measured between the output terminal and ground (-), and is equal to the voltage across the load. When the control is not actuated, current will not flow thru the output transistor (except for the leakage current). The output voltage will equal zero (neglecting the leakage current). When the control is actuated, the output voltage will rise to $V_S$ less the collector-to-emitter voltage drop of the output transistor.

Current sourcing gets its name from the fact that it "sources current to a load." The current flows from the control into the load.

When interfacing to solid state DC inputs it is best to check input requirements of the system before selecting the control.

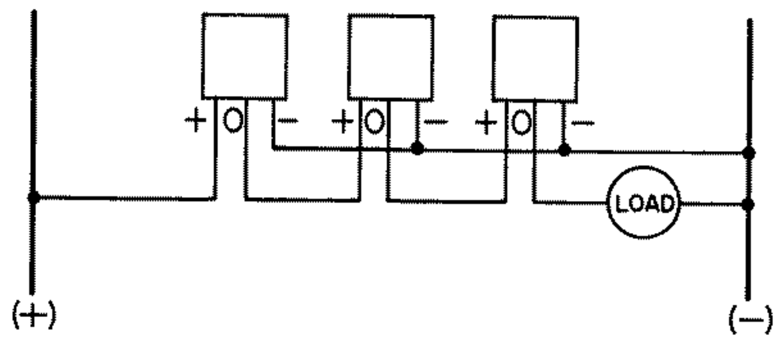
**Figure 5**
**Typical Current Sourcing Output Circuit**



## DC SOURCING SERIES WIRING

Figure 6 illustrates how 3-wire DC current sourcing output controls can be connected in series to provide AND logic control. In this example all controls must be ON (conducting) in order to operate the load.

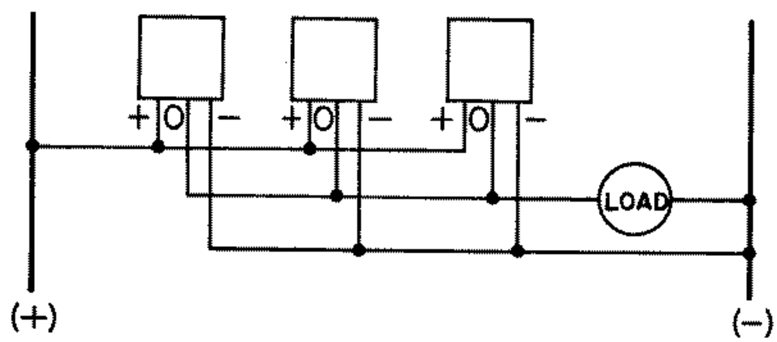
**Figure 6**
**3-Wire DC Series Wiring For AND Logic Control**




## DC SOURCING PARALLEL WIRING

Figure 7 illustrates how 3-wire DC current sourcing output controls can be connected in parallel to provide OR logic control. In this example any photoelectric control can be ON (conducting) to operate the load.

**Figure 7**
**3-Wire DC Parallel Wiring For OR Logic Control**




## INTERFACING DC CONTROLS TO AC LOADS

Interfacing DC controls to AC loads always calls for a relay. Selection of the best relay for the interface to an AC load results from answers to the following questions:

- What is the power demand of the load (VA rating)?
- What is the required switching speed?
- What is the frequency of switching?

When the answers to these three questions are known, the best relay can be selected from referring to Output Devices.

## INTERFACING AC CONTROLS TO AC LOADS

Many AC photoelectric controls have their own power source separate from the signal lines. To interface these sensors connect the control to a separate AC power supply. The 2-wire relay output can be wired directly to the output the same as any two connection mechanical switch with no wiring changes.

2-wire AC controls are wired in series with the load and draw their load current from the signal lines. That means that current must flow in the wires (and the load) even while the control is OFF. Although this OFF control current (leakage) is small, some output devices may not recognize this as an OFF condition. When interfacing these controls care must be taken to ensure the maximum load current limit of the output device is not exceeded. Leakage current for MICRO SWITCH 2-wire photoelectric controls is specified as 2 mA maximum and will normally not be a problem.

# Interfacing

### AC SERIES WIRING

Figure 8 illustrates how a 2-wire AC photoelectric control can be connected in series to provide AND logic control. In this example, all photoelectric outputs must be ON (conducting) to operate the load.

The maximum number of AC photoelectric controls that can be wired in series is limited by:

- Supply voltage
- Control's voltage drop
- Minimum operating voltage of the control
- Minimum operating voltage of the load

Figure 9 illustrates an example of five 2-wire AC photoelectric controls wired in series under the following limitations:

- 115 VAC supply voltage
- 7 VAC (max.) voltage drop (control)
- 90 VAC minimum operating voltage of control
- 75 VAC minimum operating voltage of the load

As a practical example, five 2-wire AC controls connected in series is not recommended. The reason being, the last control before the load will only have an input voltage of 87 VAC. This is below the minimum operating voltage of 90 VAC for the control. The circuit is satisfactory for four controls wired in series.

Any number of AC photoelectric controls with relay outputs can be wired in series. This is because there is no control voltage drop to be considered. Leakage current and voltage drop is zero when using electromechanical relays. Any combination of normally opened (N.O.) or normally closed (N.C.) contacts can be wired in series.

**Figure 8**
**2-Wire AC Series Wiring For AND Logic Control**

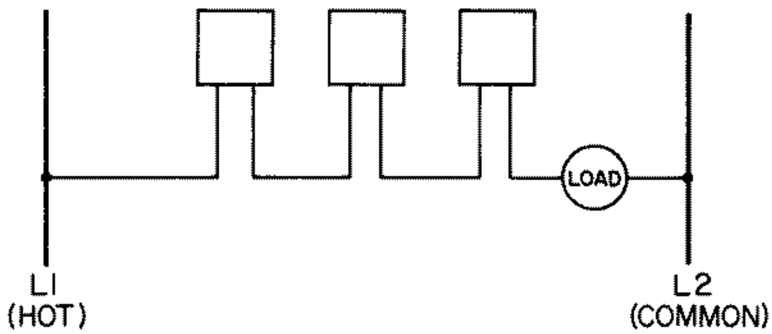
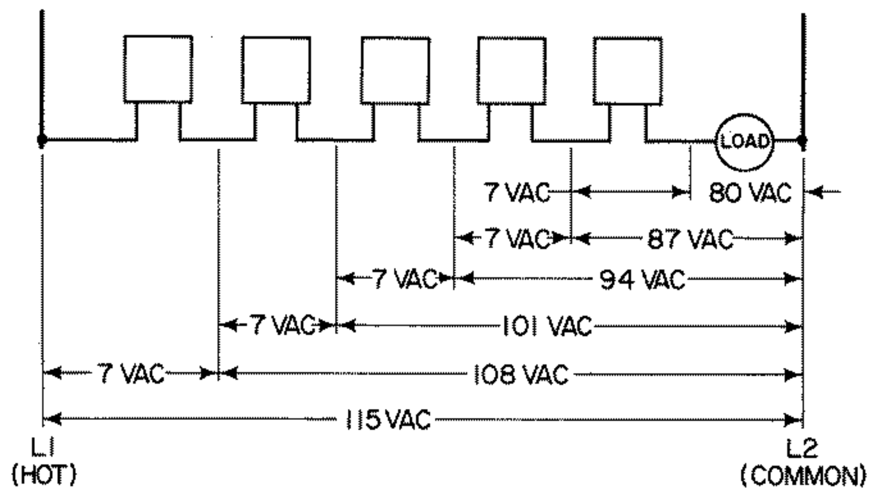



**Figure 9**
**Example of 2-Wire AC Series Wiring**



## AC PARALLEL WIRING

Figure 10 illustrates how 2-wire AC photoelectric controls can be connected in parallel to provide OR logic control. In this example any photoelectric control output can be ON (conducting) to operate the load.

The maximum number of AC photoelectric controls that can be wired in parallel is limited by:

- Control's leakage current
- Maximum OFF state load current

When connecting AC photoelectric controls in parallel care must be taken to ensure that the sum of the leakage current for each control is less than the maximum OFF state load current. Also, because of false pulse protection, if one photoelectric control is operated then released, all others in the parallel circuit will not be able to respond to a target for up to 100 milliseconds. Parallel operation for 2-wire photoelectric controls should only be used when there is no danger that any two controls will be operated within 100 milliseconds of each other.

Figure 11 illustrates an example of two AC photoelectric controls wired in parallel under the following limitations:

- 2 mA leakage current (control)
- 5 mA maximum OFF state load current

In the example shown in Figure 11 the total leakage current is 2 mA (+) 2 mA for a total of 4 mA. This is less than the maximum 5 mA OFF state load current. In operation, when Control #1 detects a target it will operate the load. If Control #2 then detects a target, it will not operate due to the voltage drop across Control #1 not being high enough to power Control #2. The load will remain ON because of Control #1. If Control #1 turns OFF, the load will drop out for 100 milliseconds, or until Control #2 can be powered.

Any number of AC controls with relay outputs can be wired in parallel. Leakage current and voltage drop is zero when using electromechanical relays. Any combination of normally open (N.O.) or normally closed (N.C.) contacts can be wired in parallel. Any contact that closes will operate the load.

**Figure 10**
**2-Wire AC Parallel Wiring For OR Logic Control**

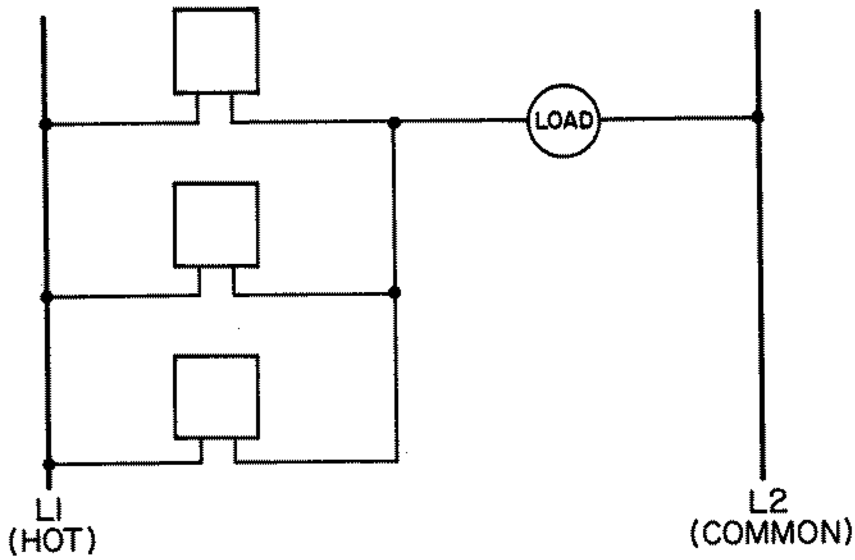
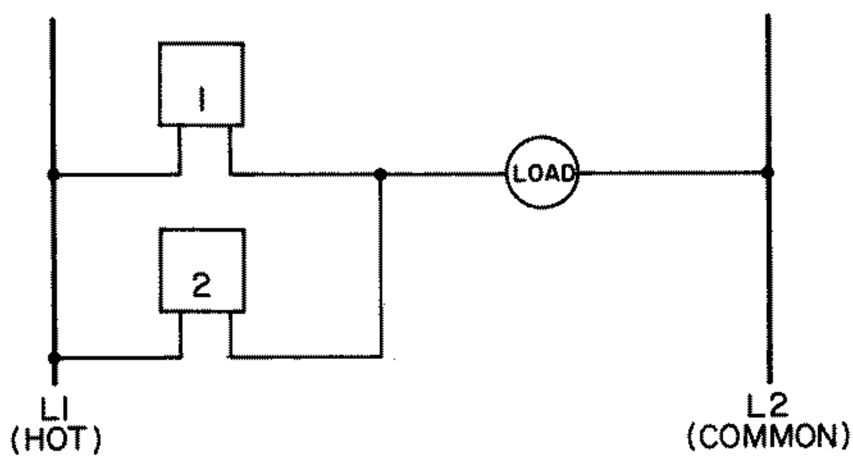



**Figure 11**
**2-Wire AC Parallel Wiring**



# Glossary of Terms

## -A-

**ALIGNMENT** — placing the emitter (light source) and receiver (photoreceiver or reflector) so as to direct the maximum amount of light on the photosensor. At long distances, when the light beam has widened, the receiver should be centered in the beam to lessen the chance of the emitter and receiver drifting out of alignment due to vibration or shock.
**ALTERNATING CURRENT (AC)** — one that reverses at regularly recurring intervals of time and has alternately positive and negative values.
**AMBIENT** — in the area. 1) Light — light in the area of the photosensor, but not originating with the control light source. Ambient light can adversely affect non-modulated control operation, and should be screened, if possible, from the sensor; 2) Temperature — average temperature of surrounding medium such as water, air, or earth, into which the heat of the equipment is dissipated.
**APERTURE** — most often an external cap (with a small opening) placed over the receiver lens to help detect small objects. It lets even a small object block enough light to be detected. Also, an internal aperture in most receivers reduces the effect of off-axis ambient light.
**ATTENUATION** — loss or reduction of beam intensity as a result of environmental factors — dust, humidity, steam etc.
**ANALOG OUTPUT** — having the property of being continuously variable, as opposed to having discrete states.

## -C-

**CASCADE** — to combine logic circuitry to get more complex logic or timing control. (Inputs and outputs are wired in series.)
**CLEAN AIR** — ideal conditions. Climate controlled or sterile area.
**COMPLEMENTARY OUTPUT** — a circuit that provides sink or source capability with a single input. Output that can be both light operated and dark operated. (Also known as 4-wire DC controls).
**CONTROL BASE** — unit remote from light source/photoreceiver in which amplification and conditioning of the input signal takes place. Usually contains a power supply and an output device.
**CONVERGENT BEAM** — A variation of the diffuse scanning mode. A photoelectric control whose optical system is the key to its operation. It simultaneously focuses and converges a very small, intense beam to a fixed-focal point in front of the control. The control is essentially blind a short distance before and beyond this focal point. Convergent beam scanning is used to detect the presence or absence of small objects while ignoring nearby background surfaces.
**CONVERTIBLE OUTPUT** — output that can be wired either as light operated or dark operated, but not at the same time.
**CURRENT** — time value of movement of free electrons. One ampere equals one coulomb per second. Conventional reference is opposite to direction of actual electron movement.
**CURRENT CONSUMPTION** — the amount of current required to power a sensor or control (excluding load). See SUPPLY CURRENT.
**CURRENT SINKING** — A DC output type such that when it is ON, current flow is from the load into the device's output, then to ground. Output is Normally High.
**CURRENT SOURCING** — A DC output type such that when it is ON, current flow is from the device into the load. Output is Normally Low.

## -D-

**DARK OPERATED (D.O.)** — control operating mode in which the output (load) is energized when the light is blocked (retro/thru scan) or object not present (diffuse), the photosensor is dark.
**DIFFUSE SCAN** — a reflective scanning technique in which reflection from a near-by non-shiny surface illuminates the photosensor in the receiver. Sometimes called proximity scan because of the required nearness of the light source and photosensor to reflecting surface. Also used to detect color contrast, as in registration control.
**DIGITAL CIRCUIT** — a circuit that has only two stable states, operating in the manner of a switch; that is, it is either ON or OFF.
**DIRECT CURRENT (DC)** — a unidirectional current in which changes in value are so small that they may be neglected. As ordinarily used, the term designates a practically non-pulsating current.
**DIRECT SCAN** — see THRU SCAN.
**DISABLE** — to prevent output despite an input signal. A wiring terminal for this purpose is provided on most MICRO SWITCH control bases. The disabling circuit may receive its signal from the current sinking output of a photoelectric logic card, or modulated LED control, or from an electromechanical limit switch, etc. Disabling is used to prevent false or unwanted signals from triggering the control.

## -E-

**ENABLE** — the opposite of disable. To allow output in response to an input signal. We often speak of one light source-photoreceiver pair (the "gating" pair) enabling a second pair (the "inspect" pair).
**EXCESS GAIN** — the ratio of optical power available at a given emitter-to-receiver range to the minimum optical power required to trigger the receiver.
**EXTERNAL INHIBIT** — see DISABLE
**EXTREME CONTAMINATION** — coal bins, residue on lens.

## -F-

**FALL TIME** — a measure of the time required for the output voltage of a circuit to change from a high voltage level to a low voltage level, once a level change has started (90% to 10%).
**FALSE PULSE** — an improper change of state of the output, usually associated with power Turn-On or Turn-Off.
**FALSE PULSE PROTECTION** — circuitry designed to clamp output Off until the power supply has time to reach proper voltage level. Typically 200-500 msec.
**FIBER OPTICS** — transparent fibers of glass or plastic used for conducting and guiding light energy. Fiber optics are used in photoelectrics as light pipes consisting of a bundle of small optical fibers (glass) or single strand (plastic) housed inside a flexible sheathing.

# Glossary of Terms

## -G-

**GROUND** — a conducting path, intentional or accidental, between an electric circuit or equipment and the earth, or some large conducting body serving in place of the earth (a voltage reference).

## -H-

**HARDWIRED** — physically interconnected and intended for specific purpose. Hardwired logic is essentially unalterable.

**HIGH CONTAMINATION** — heavy particle laden air, extreme washdown environments, grain elevators.

**HYSTERESIS, SWITCHING** — the principle associated with sensors, such that the operate point is not at the same level as the release point. In solid state sensors, it is accomplished electrically. In mechanical switches, it results from the storing of potential energy before the transition occurs.

## -I-

**IMMEDIATE RESPONSE** — control transfers ON/OFF state immediately when target enters the detection range, and reverses state immediately when target leaves detection range.

**INFRARED (IR)** — the invisible radiation (as opposed to visible light) that certain LEDs emit. Standard MICRO SWITCH modulated LED controls have infrared emitting LEDs.

**INHIBIT** — see DISABLE.

**INPUT** — 1) The device or collective set of devices used for bringing data into another device; 2) The signal or stimulus put into a circuit to make the output do something.

**INPUT SIGNAL DURATION** — a length of time the light beam is blocked (in dark operated mode), or uninterrupted (in light operated mode). Or, the length of time a target is within the operating range.

**INSULATOR** — a non-conducting support for an electric conductor. A material that does not conduct electricity.

**INTEGRATED CIRCUIT (IC)** — an interconnected array of active and passive elements integrated within a single semiconductor substrate or other compatible material, and capable of performing one complete electronic function.

**INTERFACE** — a common boundary between electronic systems, or parts of a single system.

**INTERFACE CIRCUIT** — a circuit that links one type of device with another. Its function is to produce the required current and voltage levels for the next stage of circuitry from the previous stage.

**INTERROGATE (GATE)** — a function usually performed by a gating light source-photoreceiver pair; asking (interrogating) whether a certain condition has been met (for example, proper fill level in boxes moving along a conveyor), and thereby enabling or disabling an inspect light source-photoreceiver pair (which will count only full boxes.)

**IP** — European environmental ratings similar to USA NEMA ratings.

## -L-

**LATCHING LOGIC** — signal modification that causes the output to be energized and remain energized (maintained output). Latched output may be immediate or delayed. Usually, the latch is released by closing a circuit between the reset (RS/D) terminal and ground.

**LEAKAGE CURRENT** — small current flowing through or leaking from the output device in the OFF state due to semiconductor characteristics.

**LED (LIGHT EMITTING DIODE)** — a solid state light source that emits variable light, or (in MICRO SWITCH modulated LED controls) invisible, infrared radiation.

**LIGHT OPERATED (L.O.)** — control operating mode in which the output is energized when the light beam is not blocked (retro/thru scan), or object is present (diffuse) the photosensor is illuminated.

**LOAD CURRENT** — units = Amps/milliamps (DC) or Amps RMS/milliamps RMS (AC). The maximum amount of current that a photoelectric control will switch thru its output.

**LOGIC** — the modification of an input signal that produces delayed, pulsed, latched, or other output response. Logic circuitry is sometimes an integral part of the control, but more often, a separate plug-in card or module.

**LOW CONTAMINATION** — warehouse locations, light industry applications, material handling operations.

## -M-

**MODERATE CONTAMINATION** — milling operations, areas of high humidity, steam.

**MODULATED LIGHT SOURCE (MLS) CONTROL** — a photoelectric control that operates on modulated (pulsed) infrared radiation, and responds only to that frequency rather than steady light intensity. Modulated LED controls offer a high rejection of troublesome ambient light.

**MOMENTARY SHORT CIRCUIT PROTECTION** — output circuit protection designed to protect the control from damage due to a temporary (1–3 sec.) short circuit or until an external fuse can interrupt current.

## -N-

**NEMA RATINGS** — National Electrical Manufacturers Association ratings of an enclosure's ability to provide a degree of protection against contact with equipment and against specified environmental conditions.

**NOISE, ELECTRICAL** — noise is usually thought of as being the presence of undesirable electrical voltages or current. It causes devices to operate erratically (if the noise is on the supply line to a device), or produces false information or erratic operation if present on wires carrying the signals from the output of a device to the load. Noise can be present in the supply or picked up on lines in many ways. Pick-up from noisy adjacent wires or metal parts is possible. Good wiring practice and/or additional parts can be used to diminish the effects of noise.

**NON-MODULATED CONTROLS** — controls designed for indoor applications subject to neither bright ambient light nor extreme vibration. Usually incandescent lamp controls, scanners and light source-photoreceiver pairs.

# Glossary of Terms

## -N-

**NORMALLY HIGH** — the state of a control in which the output is high (logic 1) in voltage in the rest (OFF) condition.
**NORMALLY LOW** — the state of a control in which the output is low (logic 0) in voltage in the rest (OFF) condition.

## -O-

**OFF DELAY LOGIC** — adjustable delay (after input signal stops) before output is de-energized.
**OFF STATE CURRENT** — the supply or bias current flowing into a solid state device when it is in the unactuated state (see Leakage Current).
**OHM** — the unit of electrical resistance. Resistance through which a current of one ampere will flow when a voltage of one volt is applied.
**ON DELAY LOGIC** — adjustable delay (after onset of input signal) before output is energized.
**ONE-SHOT LOGIC** — see Pulsed Logic.
**OPACITY** — the characteristic of an object that prevents light from passing through. The opposite of translucent. Opaque objects are easy to detect since they block light almost entirely.
**OPERATING MODE** — refers to the condition of the photosensor (dark or light illuminated) that energizes output. A mode selector switch on plug-in amplifiers determines the operating mode.
**OPTICAL POWER** — power or intensity of the projected light available from a particular emitter; beam intensity.
**OR LOGIC** — an output is produced when any one or more inputs are present.
**OUTPUT** — the useful energy delivered by a circuit or device. Can mean energy produced at the output terminals of an amplifer -a source of energy.

## -P-

**PARALLEL CIRCUIT** — a circuit in which current has two or more paths to follow. Two electrical elements are in parallel if both terminals of both elements are electrically connected.
**PHOTOCELL** — a resistive, bulk effect type of photosensor, the type used when it is desirable to wire several photoreceivers in series or in parallel. The resistance decreases with increasing light intensity.
**PHOTORECEIVER** — a unit consisting of photosensor, focusing lens, and protective enclosure.
**PHOTOSENSOR** — a light sensitive portion of a photoelectric control that converts a light signal into an electrical signal. MICRO SWITCH uses photocells and phototransistors.
**PHOTOTRANSISTOR** — a type of photosensor. Typically used where speed of response is important or ambient temperature variations are great.
**POLARIZED PHOTOELECTRIC CONTROLS** — controls that emit a visible LED beam and use a special lens which filters the beam of light so that it is projected in one plane only. The control responds only to the de-polarized reflected light from corner-cube type reflectors (FE-RR1) or special polarized reflective type.
**POWER DISSIPATION** — units = Watts/milliwatts (DC) or Volt-Amps (AC). The amount of power that is consumed and converted to heat in normal operation. Supply Voltage (max) × Supply Current (max) = Power Dissipation. Volts × Amps = Watts (DC) or Volt/Amps (AC)
**PROXIMITY SCAN** — see DIFFUSE SCAN.
**PULL-DOWN RESISTOR** — a resistor connected across the output of a device or circuit to hold the output equal to or less than the zero input level. Also used to lower output impedance of digital or analog devices. Usually connected to a negative voltage or ground.
**PULL-UP RESISTOR** — a resistor connected across the output of a device or circuit to hold the output voltage equal to or greater than the input transition level of a digital device. Usually connected to a positive voltage or plus supply.
**PULSE** — a momentary sharp change in current, voltage, or other quantity that is normally constant. A pulse is characterized by a rise and fall and has a finite duration.
**PULSED LOGIC** — a signal modification that produces output independently of input signal duration. Pulse duration (dwell) is usually adjustable. Also referred to as one-shot logic. Pulsed logic may be immediate or delayed.

## -R-

**RECTIFIER** — a device that converts alternating current into direct current.
**REFLECTIVE SCAN** — a scanning technique in which the light source is aimed at a reflective surface to illuminate the photosensor. Retroreflective, specular, diffuse scan and convergent beam are all reflective scan techniques.
**REGULATION %** — the ratio of voltage extremes due to loading or line fluctuations. The process of holding constant a quantity such as voltage by means of a system that automatically corrects errors. For example, as more current is drawn from a battery or power supply, the output voltage tends to decrease (load regulation). With a power supply derived from AC, the DC output voltage can vary with the variation in AC voltage (line regulation).
**REPEATABILITY** — the ability of a sensor to reproduce output readings when the same value is applied to it consecutively in the same direction, for a specified number of cycles, or specified time duration.
**RESPONSE TIME** — the time it takes for a device to respond to an input signal. The sum of the sensor, amplifier, and output response is the total response time.
**RETROREFLECTIVE SCAN** — the reflective scan technique that uses a special reflector (retroreflector) to return light along the same path it was sent.
**REVERSE POLARITY PROTECTION** — circuitry, usually a diode, which prevents current from flowing into the control in case of accidental mis-wiring of the plus (+) and minus (–) terminals, preventing damage to the unit.
**RIPPLE** — the alternating component of voltage from a rectifier or generator. A slight fluctuation in the intensity of a steady current.
**RISE TIME** — a measure (10% to 90%) of the time required for an output voltage to rise from a state of low voltage to a

high voltage level, once a level change has started.

## -S-

**SATURATION VOLTAGE** — the voltage drop appearing across a control device that is fully turned On.
**SCAN TECHNIQUE** — a method of scanning objects. The two general categories are thru and reflective scan.
**SELF-CONTAINED CONTROL** — a photoelectric control in which all three phases of control — sensing, signal conditioning, and output — occur in a single device.
**SENSOR** — a sensing element. The basic element that usually changes some physical parameter to an electrical signal.
**SERIES CIRCUIT** — a circuit in which current has only one path to follow.
**SIGNAL CONDITIONING** — to process the form or mode of a signal so as to make it intelligible to or compatible with, a given device, including such manipulation as pulse shaping, pulse clipping, digitizing, and linearizing.
**SIGNAL RATIO** — 1) Broadly, the comparison of light seen by a photosensor when the beam is blocked to the light seen when the beam is not blocked; 2) More specifically, the comparison of photocell resistance when sensor is dark to when it is illuminated. Proper control application involves establishing a large dark-to-light ratio.
**SLIGHT CONTAMINATION** — indoor locations, non-industrial areas, office buildings.
**SPECULAR SCAN** — a reflective scan technique in which reflection from a shiny surface illuminates the photosensor, which must be precisely positioned to receive the reflected light. The angle of incidence equals the angle of reflection.
**SUPPLY CURRENT** — units = Amps or milliamps. The amount of current necessary to maintain operation of a photoelectric control, control base or sensor. Sometimes referred to as Current Consumption.
**SUPPLY VOLTAGE** — units = Volts. The range of power required to maintain proper operation of a photoelectric control, control base or sensor. The difference in potential (or range of difference in potential) necessary to operate the unit.

## -T-

**THRESHOLD RESPONSE** — a control type that responds to the change in input signal level. Plug-in amplifiers are either threshold or transition responsive.
**THRU SCAN** — a scanning technique in which the emitter (light source) is aimed directly at the receiver. Also called direct scan and transmitted scan, since light is transmitted directly, not reflected to the sensor. Presently, it is the only scanning technique commonly used to scan distances greater than 40 feet.
**TRANSIENT PROTECTION** — circuitry to guard against spikes induced on the supply lines by inductive sources such as heavy motors or solenoids turning On and Off.
**TRANSIENTS** — in electronic usage, usually refers to an unwanted, temporary, large increase or decrease in a current or supply voltage that only occurs occasionally. Almost always due to reactive components during rapid changes in voltage or current.
**TRANSITION RESPONSIVE** — a control type that responds to the rate of change in light intensity rather than the level change. Used to detect fast moving objects that cause little change in light intensity level.
**TRANSLUCENT** — allows light to pass through. Detecting translucent objects is often best done with retroreflective scan, during which the light must pass through the object twice, thereby causing more of a signal change (larger signal ratio).

## -U-

**UL** — Underwriter's Laboratories, Inc., a non-profit organization that establishes, maintains and operates laboratories for the examination and testing of devices, systems and materials primarily for safety.

## -V-

**VOLTAGE** — units = Volts (DC) or Volts RMS (AC). The term used to designate the electrical energy differential that exists between two points and is capable of producing the flow of current when a closed path is connected between the two points.
**VOLTAGE DROP** — units = Volts (DC) or Volts RMS (AC). Sometimes referred to as Saturation Voltage. In any solid state control that switches a load, there will be some voltage dropped across the output. This voltage drop or saturation voltage will often vary with the amount of current going through the output section and the load. It should be specified with current conditions.
The MLS 7A in the On state will have a Saturation Voltage of 0.4 VDC @ 20 mA and the Saturation Voltage will be 1.4 VDC max. @ 120 mA.
Note: the Saturation Voltage across a basic switch or relay contact is zero.

# UL/CSA/NEMA/IP standards

The UL and CSA references in this catalog do not imply specific approval of our products but rather that our products are designed to meet performance standards recommended by such agencies. Evaluation of our products by these agencies is limited to procedures established to examine switch performance within areas of their interest. Actual application requirements may exceed performance levels investigated by these agencies. We recommend that switches be tested to your exact application requirements.

**UL (Underwriter's Laboratories, Inc.)** is chartered as a non-profit organization to establish, maintain, and operate laboratories for the examination and testing of devices, systems and materials.

**CSA (Canadian Standards Association)** is a non-profit, non-governmental association established as a national standardization body for Canada. Included in its scope of activities is the responsibility of investigating and approving products and materials in the interest of safety.

**NEMA (National Electrical Manufacturer's Association)** prepares standards which define a product, process or procedure with reference to one or more of the following: nomenclature, composition, construction, dimensions, tolerances, safety, operating characteristics, performance, quality, electrical rating, testing and the service for which designed. The reference standards herein reflect the latest data in the NEMA Standards Publication #250 - 1985 Revision 2 on Enclosures for Industrial Controls and Systems.

**Application note:** Enclosures are based, in general, on the broad definitions outlined in NEMA Standards. Therefore, it will be necessary to ascertain that a particular enclosure will be adequate when exposed to the specific conditions that might exist in intended applications. Except as might otherwise be noted, all references to products relative to NEMA enclosure types are based on MICRO SWITCH evaluation only.

MEMBER

| NEMA REFERENCE NON-HAZARDOUS LOCATIONS | APPLICABLE TESTS |
|---|---|
| **TYPE 1** enclosures are intended for indoor use primarily to provide a degree of protection against contact with the enclosed equipment in locations where unusual service conditions do not exist. | ***Rod entry***<br>***Rust resistance*** |
| **TYPE 2** enclosures are intended for indoor use primarily to provide a degree of protection against limited amounts of falling water and dirt. They are not intended to provide protection against conditions such as dust or internal condensation. | ***Rod entry***<br>***Drip***<br>***Rust resistance*** |
| **TYPE 3** enclosures are intended for outdoor use primarily to provide a degree of protection against windblown dust, rain, and sleet; and to be undamaged by the formation of ice on the enclosure. They are not intended to provide protection against conditions such as internal condensation or internal icing. | ***Rain***<br>***Dust***<br>***External icing***<br>***Rust resistance*** |
| **TYPE 3R** enclosures are intended for outdoor use primarily to provide a degree of protection against falling rain; and to be undamaged by the formation of ice on the enclosure. They are not intended to provide protection against conditions such as dust, internal condensation, or internal icing. | ***Rod entry***<br>***Rain***<br>***External icing***<br>***Rust resistance*** |
| **TYPE 3S** enclosures are intended for outdoor use primarily to provide a degree of protection against windblown dust, rain, and sleet, and to provide for operation of external mechanisms when ice laden. The are not intended to provide protection against conditions such as internal condensation or internal icing. | ***Rain***<br>***Dust***<br>***External icing***<br>***Rust resistance*** |
| **TYPE 4** enclosures are intended for indoor or outdoor use primarily to provide a degree of protection against windblown dust and rain, splashing water, and hose directed water; and to be undamaged by the formation of ice on the enclosure. They are not intended to provide protection against conditions such as internal condensation or internal icing. | ***Hosedown***<br>***External icing***<br>***Rust resistance*** |
| **TYPE 4X** enclosures are intended for indoor or outdoor use primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water, and hose-directed water; and to be undamaged by the formation of ice on the enclosure. They are not intended to provide protection against conditions such as internal condensation or internal icing. | ***Hosedown***<br>***External icing***<br>***Corrosion resistance*** |
| **TYPE 6** enclosures are intended for indoor or outdoor use primarily to provide a degree of protection against the entry of water during temporary submersion at a limited depth; and to be undamaged by the formation of ice on the enclosure. They are not intended to provide protection against conditions such as internal condensation, internal icing, or corrosive environments. | ***Submersion***<br>***External icing***<br>***Rust resistance*** |

**NEMA REFERENCE**

| NON-HAZARDOUS LOCATIONS | APPLICABLE TESTS |
|---|---|
| **TYPE 6P** enclosures are intended for indoor or outdoor use primarily to provide a degree of protection against the entry of water during prolonged submersion at a limited depth; and to be undamaged by the formation of ice on the enclosure. They are not intended to provide protection against conditions such as internal condensation or internal icing. | ***Air pressure***<br>***External icing***<br>***Corrosion resistance*** |
| **Type 12** enclosures are intended for indoor use primarily to provide a degree of protection against dust, falling dirt, and dripping noncorrosive liquids. They are not intended to provide protection against conditions such as internal condensation. | ***Drip***<br>***Dust***<br>***Rust resistance*** |
| **Type 13** enclosures are intended for indoor use primarily to provide a degree of protection against dust, spraying water, oil, and noncorrosive coolant. They are not intended to provide protection against conditions such as internal condensation. | ***Oil exclusion***<br>***Rust resistance*** |

**HAZARDOUS LOCATIONS**

| | |
|---|---|
| **Type 7** enclosures are intended for indoor use in locations classified as Class I, Groups A, B, C, or D, as defined in the *National Electrical Code*.<br>Type 7 enclosures shall be capable of withstanding the pressures resulting from an internal explosion of specified gases, and contain such an explosion sufficiently that an explosive gas-air mixture existing in the atmosphere surrounding the enclosure will not be ignited. Enclosed heat generating devices shall not cause external surfaces to reach temperatures capable of igniting explosive gas-air mixtures in the surrounding atmosphere.<br>**Group A – Acetyline.**<br>**Group B – Atmospheres containing hydrogen manufactured gas.**<br>**Group C – Atmospheres containing diethyl ether, ethylene, or cyclopropane.**<br>**Group D – Atmospheres containing gasoline, hexane, butane, naptha, propane, acetone, toluene, or isoprene.** | ***Explosion***<br>***Hydrostatic***<br>***Temperature*** |
| **Type 9** enclosures are intended for indoor use in locations classified as Class II, Groups E, F or G, as defined in the *National Electrical Code*.<br>Type 9 enclosures shall be capable of preventing the entrance of dust. Enclosed heat generating devices shall not cause external surfaces to reach temperatures capable of igniting or discoloring dust on the enclosure or igniting dust-air mixtures in the surrounding atmosphere.<br>**Group E – Atmosphere containing metal dust.**<br>**Group F – Atmospheres containing carbon black, coal dust or coke dust.**<br>**Group G – Atmospheres containing flour, starch, or grain dust.** | ***Dust penetration***<br>***Temperature*** |

***IEC (International Electrotechnical Commission)*** is a significant worldwide organization with specifications for electrical and electronic components.

***IEC 529*** are classifications providing for degrees of protection by enclosures similar to NEMA ratings. Markings consist of the letters IP followed by two numerals signifying conformity to the codes. The first numeral indicates the degree of protection against contact with live or moving parts inside the enclosure and of equipment against ingress of solid foreign bodies. The second numeral designates the degree of protection against ingress of liquid.

***First numeral***

**6:** Complete protection, protection against ingress of dust (talcum powder).

***Second numeral***

**5:** Protection against water jets: water projected from a nozzle from any direction should have no harmful effect.

**6:** Protection against conditions on ships' deck: water from heavy seas shall not enter the enclosures under prescribed conditions.

**7:** Protection against immersion in water.

**IP TEST REQUIREMENTS**

**IP 64 SPLASHING LIQUID –** Subject the enclosure to water falling as rain from a spray nozzle. The water that enters the enclosure cannot interfere with satisfactory operation. No water in or near the cable.

**IP 65 PROTECTION AGAINST WATER JETS –** Subject the enclosure to a stream of water from a 12.5 mm (½ inch) nozzle at a pressure corresponding to a 10 meter head of water (14 PSI) from a distance of 3 meters for 15 minutes. The water that enters the enclosure cannot interfere with satisfactory operation. No water near or in the cable.

**IP 66 WATER FROM HEAVY SEAS –** Subject the enclosure to a stream of water from a 12.5mm (½ inch) nozzle at a pressure corresponding to a 10 meter head of water (14 PSI) from a distance of 1.5 meters for 15 minutes. No water may enter the enclosure.

**IP 67 IMMERSION –** Immerse the enclosure under 1 meter of water for 30 minutes. No water may enter the enclosure or the cable.

# NEMA Standards

## MICRO SWITCH EVALUATION LABORATORY INTERPRETATION OF TESTS AS PERTAINING TO OUR PRODUCTS

**NEMA TEST REQUIREMENTS**
Until recently, the Evaluation laboratory has been doing all NEMA sealing tests in accordance with NEMA Standards Publication/No. 250-1979. On December 7, 1988, Revision 2 of Publication 250 was issued. We are now upgrading our procedures to be in accordance with NEMA Standards Publication/No. 250-1985, Rev. 2 Enclosures for Electrical Equipment (1000 Volts Maximum).

The following ia s summary of the most commonly used NEMA tests according to the latest revision of NEMA Publication 250. Some of the wording is directly from NEMA 250 and some of the wording is the Evaluation Lab's interpretation of the specification as it pertains to MICRO SWITCH products.

**ROD ENTRY TEST –** A rod having a diameter of 0.125 - (3,175mm) inch cannot enter the enclosure.

**RUST RESISTANCE TEST –** This test shall apply to all enclosures with external ferrous parts. Nonferrous enclosures with no external ferrous parts need not be tested. Subject the sample to 5% salt spray test for 24 hours. There shall be no rust except at sliding surfaces.

**RAIN TEST –** A continuous water spray for 1 hour at 18 inches per hour at 5 PSI. No water may enter the enclosure.

**DUST TEST –** Dust blast the enclosure with Portland cement at 100 PSI or use alternate hose method. The hose method is 45 gallons of water per minute from a 1 inch nozzle for 5 minutes. No dust or water may enter the enclosure. (NOTE: The Evaluation Lab assumes that any enclosure that can pass the NEMA 4 hosedown test can pass the dust test).

**EXTERNAL ICING TEST –** Build up a ¾ inch coating of ice on the enclosure and hold for 3 hours. The enclosure shall be considered to have met the requirements of this test if it is found to be undamaged after the ice has melted. Enclosures which have no external cavities to trap water when mounted in the normal position shall be considered to be acceptable and need not be tested. (NOTE: The Lab assumes that most MICRO SWITCH products need not be tested because of this exclusion).

**HOSEDOWN TEST –** Subject the enclosure to a 65 gallon per minute stream of water from a 1 inch nozzle for 5 minutes.

**CORROSION - RESISTANCE –** Sheet metal enclosures shall be protected with zinc or cadmium coatings or a suitable paint. A nonmetallic enclosure is to be judged on the basis of the effect of exposure to water and ultraviolet light. Enclosures of other materials shall meet the corrosion-protection requirements of UL 508. According to UL 508, sheet extruded or cast aluminum, die-cast zinc, or another metal shall be of a grade or alloy known to be nonsusceptible to corrosion, or shall be subjected to appropriate tests, additionally protected against corrosion, or both. If testing is considered to be appropriate, the corrosion resistance test is a 200 hour, 5% salt spray test.

**SUBMERSION TEST —** Immerse the enclosure under 6 feet of water for 30 minutes. No water may enter the enclosure.

**AIR PRESSURE TEST –** For an unpotted enclosure with a conduit fitting, pressurize the enclosure to 6 PSIG, seal off, and hold 24 hours. The enclosure is considered to have passed this test if the pressure drop after 24 hours does not exceed 2 PSIG.

If the enclosure does not have connections for pressurizing the interior, the external pressurization test may be used as an alternate to the internal pressurization test above. The external pressurization test requires that the enclosure be held under 6 feet of water for 24 hours. No water may enter the enclosure.

**DRIP TEST –** Subject the enclosure to dripping water at a drip rate of 20 drops of water per minute for 30 minutes.

**DUST TEST –** (6.51.2 Indoor Dust Test) Circulating Dust Test. Subject the enclosure to Portland cement dust circulating in a chamber at a velocity of 1000 ft./min. for 5 minutes. As an alternate to the dust test, an atomized-water method of testing may be used. No dust or water may enter the enclosure.

**OIL EXCLUSION TEST –** Subject the enclosure to a 2 gallon per minute stream of test liquid through a ⅜ inch nozzle from a distance of 12 inches for 30 minutes. The test liquid is water with a wetting agent added.

**EXPLOSION TEST –** Provide a degree of protection to a hazardous gas environment from an internal explosion or from operation of internal equipment.

Withstand a series of internal explosion design tests which determine:
(1) The maximum pressure effects of the gas mixture
(b) Propagation effects of the gas mixtures.

**HYDROSTATIC TEST –** Withstand, without rupture or permanent distortion, an internal hydro-static design test based on the maximum internal pressure obtained during explosion tests and on a specified safety factor.

**TEMPERATURE TEST –** Do not develop surface temperatures which exceed prescribed limits for the specific gas corresponding to the atmospheres for which the enclosure is intended, when internal equipment is operated at rated load.

**DUST PENETRATION TEST –** Withstand a series of operation design tests while exposed to a circulating dust-air mixture, to determine that dust does not enter the enclosure and that operation of devices does not cause ignition of the surrounding atmosphere.

# MICRO SWITCH Controls in this Catalog

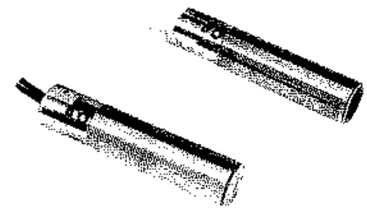
| NEMA TYPES* | 1 | 3 | 4 | 4X | 6 | 6P | 12 | 13 | | 7A | 7B | 7C | 7D | 9E | 9G |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FE3 | • | • | • | | | | • | • | | | | | | | |
| FE7A | | | | | | | • | | IP64 | | | | | | |
| FE7B | | | | | | | • | | IP64 | | | | | | |
| FE7C | | | | | | | • | | IP64 | | | | | | |
| FE7D | • | • | • | | | | • | • | IP66 | | | | | | |
| CP18 Series | • | • | • | | | • | • | • | IP67 | | | | | | |
| MP Series | • | • | • | | | | • | • | | | | | | | |
| HDMP Series | • | • | • | • | • | • | | • | | | | | | | |
| FE5F | | | | | | | | | IP60 | | | | | | |
| PJ7 | | | | | | | | | IP65 | | | | | | |
| FE8B | | | • | | | | | | IP67 | | | | | | |
| FE-MC2X/R2X | • | • | • | | | | • | • | | | • | • | • | • | • |
| FE-MLS2 | • | • | • | | | | • | • | | | | | | | |
| FE-MLS4 | • | • | • | | | | • | • | | • | • | • | • | • | • |
| FE-MLS5 | • | • | •** | | | | • | • | | | | | | | |
| FE-MLS7 | • | • | • | | | | • | • | | | | | | • | • |
| FE-MLS8 | • | • | • | | | | • | • | | | | | | | |
| FE-MLS9 | • | • | • | | | | • | • | | | | | | | |
| FE-MLS10 | | | | | | | • | | | | | | | | |
| Incandescent Explosion Proof | | | | | | | | | | • | • | • | • | • | • |

* **Application note:** Enclosures are based, in general, on the broad definitions outlined in NEMA standards. Therefore, it will be necessary to ascertain that a particular enclosure will be adequate when exposed to the specific conditions that might exist in intended applications. Except as might otherwise be noted, all references to products relative to NEMA enclosure types are based on MICRO SWITCH evaluation only.
** Optional.

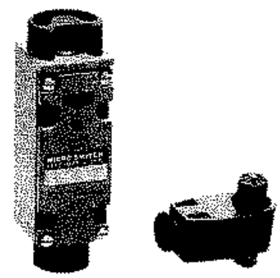
# Other MICRO SWITCH products

MICRO SWITCH All-Materials Proximity Sensors incorporate the latest developments in ultrasonic technology to detect whether or not an object is present at a predetermined setpoint distance, without touching the target. These sensors have an acoustic transducer which vibrates at ultrasonic frequencies. Pulses are emitted in a cone-shaped beam and aimed at a target object. Pulses reflected by the target to the sensor are detected as echoes. The time delay between each emitted and echoed pulse is measured to accurately determine sensor-to-target distance, thus supplying background suppression.

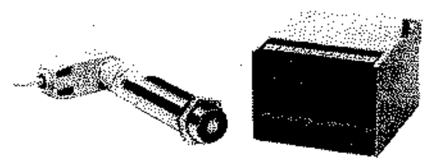
**30mm Diameter Ultrasonic Precision Distance** sensors are self-contained, providing NPN or PNP outputs. **940 Series Ultrasonic Digital Setpoint Sensor Literature.**



**941 Series Ultrasonic** sensors provide Analog or Switched digital outputs. **941 Series Ultrasonic Position Sensor Literature.**



**942 Series Ultrasonic** sensors are available with a choice of three different amplifiers to provide Switching, Analog or Digital (BCD or Hex) outputs. **942 Series Ultrasonic Position Sensor Literature.**



**945 Series Ultrasonic Position Sensors** are only 18mm in diameter. Plastic housed sensors have fixed internal setpoint and external set-point adjustment. Stainless steel housed sensors feature analog output covering 100 to 600 mm sensing range.