

D12 Expert Series – TEACH-Mode Fiber Optic Sensors

One-button programmable sensors for use with glass or plastic fibers



D12 Expert Features

- Fiber optic sensors for DIN rail mounting; 10 to 30V dc operation
- Visible red (680 nm) light source; models for use with either glass or plastic fibers
- High optical sensing power when needed, also excels at low-contrast sensing
- Easy TEACH-mode programming automatically adjusts sensitivity to optimal setting*
- D12E sensors are designed for low-contrast sensing applications (switching threshold set to just above the “dark” condition)
- D12E2 sensors set their switching threshold midway between the “dark” and “light” conditions to ignore subtle changes, such as web flutter
- Output may be programmed for either light or dark operate
- Fast 200 microsecond sensing response; Programmable 40 millisecond pulse stretcher
- Secure one-button programming is easy to use; one button sets both TEACH and sensor configuration settings
- 7-segment LED bargraph indicates relative received signal strength and sensing contrast, programming status, and diagnostic trouble warnings
- Marginal sensing alarm
- Separate input allows remote programming by an external device, such as a switch or a process controller

*U.S. Patent #5808296

D12 Expert Series Glass Fiber Optic Models

Models	Switching Threshold Setting	Cable**	Supply Voltage	Output Type	Maximum Range
D12EN6FV	Just above the “dark” condition	2 m (6.5')	10-30V dc	NPN (sinking)	Range varies by sensing mode and fiber optics used; see page 11.
D12EP6FV				PNP (sourcing)	
D12E2N6FV	Midway between “dark” and “light” conditions			NPN (sinking)	
D12E2P6FV				PNP (sourcing)	

D12 Expert Series Plastic Fiber Optic Models

Models	Switching Threshold Setting	Cable**	Supply Voltage	Output Type	Maximum Range
D12EN6FP	Just above the “dark” condition	2 m (6.5')	10-30V dc	NPN (sinking)	Range varies by sensing mode and fiber optics used; see page 12.
D12EP6FP				PNP (sourcing)	
D12E2N6FP	Midway between “dark” and “light” conditions			NPN (sinking)	
D12E2P6FP				PNP (sourcing)	

**NOTE: 9 m (30') cables are available by adding suffix “W/30” to the model number of any cabled sensor (e.g., D12EN6FP W/30)

IMPORTANT: SEE SAFETY USE WARNING ON PAGE 4

D12 Expert Series

D12 Expert Series Overview

D12 Expert self-contained sensors offer one-button programming which provides security for your settings, yet is simple to set. D12 Expert sensors offer two programming modes: TEACH mode and SENSOR OUTPUT CONFIGURATION mode. The D12 Expert also features an advanced and comprehensive LED status display, plus sensor self-diagnostics and an alarm output to signal marginal sensing conditions.

Unlike competitive sensors, D12 Expert models have no exposed switches or adjustments. All programming is accomplished using a single, sealed push button, using quick commands. Your settings remain secure, and the sensor is sealed against the elements of the sensing environment. Also, a separate input is provided for remote programming (see page 9).

Models are available for either glass or plastic fiber optics (see page 1). Fiber optics are purchased separately to fit your exact sensing application. A few representative fiber optic styles are listed on pages 11 and 12. See the Banner Photoelectric Sensors Catalog for the full selection of fiber optic assemblies.

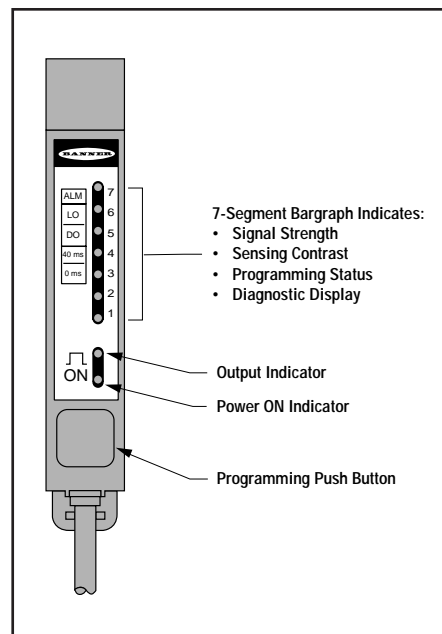


Figure 1. D12 Expert Series features

D12 Expert Series Programming Modes

TEACH Mode

All photoelectric sensing applications (excluding analog response applications) involve differentiating between two received light levels. The condition with the higher received light level is known as the *light condition*, and the condition with the lower received light level is known as the *dark condition*. The difference between the two conditions is the *sensing contrast*.

The D12 Expert TEACH mode evaluates the light and dark sensing conditions and automatically adjusts the sensitivity to the optimal level. Programming is fast, easy, and accurate.

D12 Expert sensors offer high excess gain needed for demanding sensing environments, and/or for long-range sensing. However, unlike standard D12 sensors, D12 Expert sensors also excel in *low contrast* sensing applications. When a D12 Expert sensor recognizes a low-contrast application during the TEACH mode process, the sensor's on-board microprocessor expands the bottom end of the sensitivity range to establish an accurate setting which will allow the sensor to respond to the slight difference in received light levels.

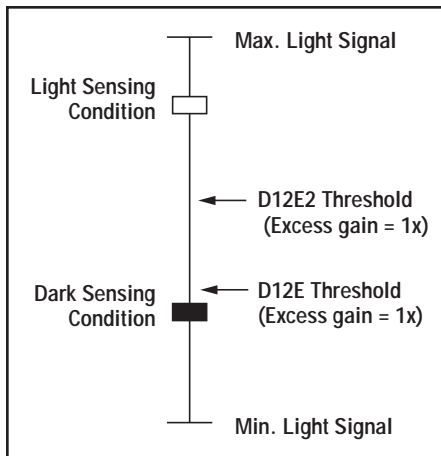


Figure 2. Comparing placement of switching thresholds for D12E and D12E2 sensors

D12E and D12E2 models set their sensing threshold points differently during the TEACH mode process. D12E sensors automatically place the switching threshold just above the dark condition that is taught to the sensor (see Figure 2). This scheme works exceptionally well for sensing a very small sensing contrast, where the light level represented by the dark condition remains constant. However, in some applications, a subtle rise in the amount of light received in the dark condition may prevent the D12E from responding to the intended sensing event.

D12E2 models automatically set the switching threshold at the mid-point between the light and dark sensing conditions taught to the sensor (Figure 2). This mid-point switching threshold allows D12E2 model sensors to ignore subtle changes in both the light and dark sensing conditions. D12E2 models were first developed to ignore a small amount of web flutter in high-speed registration color-mark-sensing applications.

At the end of the TEACH mode process, the D12 Expert bargraph indicator flashes one to seven segments to indicate the relative sensing contrast (see page 8), so you know how forgiving your application will be to changing sensing conditions.

SENSOR OUTPUT CONFIGURATION Mode


The OUTPUT CONFIGURATION PROGRAM mode allows you to set the sensor's output for either no delay or for a fixed 40 millisecond pulse stretcher (OFF-delay) for use with loads (or circuit inputs) that are too slow to react to a quick event. With no OFF delay, sensing response is a fast 200 microseconds (.0002 seconds) both ON and OFF.

The output can also be configured for either light operate (LO) or dark operate (DO). Light operate energizes the sensor's load output when the light condition is sensed, and dark operate energizes the load output for the dark condition.

The output configuration can be checked at any time by simply holding down the push button for 2 seconds. The sensor's 7-segment LED display will indicate the current setting for 10 seconds (see Figure 3), while the sensor continues normal operation. Factory settings for the output configuration are no delay (0 ms) and light operate (LO).

D12 Expert Series

D12 Expert Series Specifications

Supply Voltage and Current	10 to 30V dc at 45 mA max. (exclusive of load); 10% maximum ripple
Supply Protection Circuitry	Protected against reverse polarity and transient voltages
Output Configuration	NPN open collector (both outputs) or PNP open collector (both outputs), depending on model; Load output: N.O. and programmable light- or dark-operate; Alarm output: N.O.
Output Rating	150 mA maximum each output; the total load may not exceed 150 mA Off-state leakage current: less than 10 microamps at 30V dc On-state saturation voltage: less than 1 volt at 10 mA dc and less than 1.5 volts at 150 mA dc
Output Protection Circuitry	Protected against false pulse on power-up and overload of outputs (trips at 175 mA)
Output Response Time	200 microseconds ON and OFF (40 milliseconds OFF when OFF-delay selected) (NOTE: False pulse protection circuit causes a 0.1 second delay on power-up)
Output Operation Mode	Light operate or dark operate; selected by push button
Output Timing Functions	ON/OFF (no delay) or fixed 40 millisecond OFF-delay; selected by push button
Repeatability	66 microseconds
Adjustments	Push button TEACH mode sensitivity setting; remote teaching input is provided
Indicators	Green LED lights for DC power ON and flashes when ready for TEACH mode; 1 Hz when ready to learn first condition; 2 Hz for second condition Yellow LED lights for load output ON (conducting) 7-segment Moving Dot Red LED Display indicates relative received light signal strength, output program settings, relative contrast level and alarm
Construction	Black ABS (Cyclocac® KJB) housing with acrylic cover, stainless steel M3 x 0.5 hardware for use with VALOX® mounting bracket (supplied); the plastic fiber clamping element is Delrin®
Environmental Rating	Rated NEMA 4; IEC IP66
Connections	PVC-jacketed 2 m (6.5') or 9 m (30') cables
Operating Conditions	Temperature: -20° to +70° C (-5° to +158°F) Maximum relative humidity: 90% at 50°C (non-condensing)
Certifications	

VALOX® and Cyclocac® are registered trademarks of General Electric Co.;
Delrin® is a registered trademark of Dupont



WARNING . . . Not a Safety Device

These photoelectric sensors do NOT include the self-checking redundant circuitry necessary to allow their use in personnel safety applications. A sensor failure or malfunction can result in either an energized or a de-energized sensor output condition.

Never use these products as sensing devices for personnel protection. Their use as a safety device may create an unsafe condition which could lead to serious injury or death.

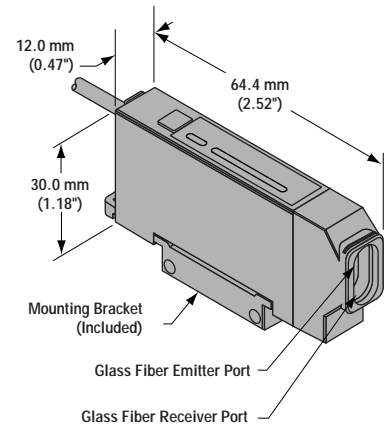
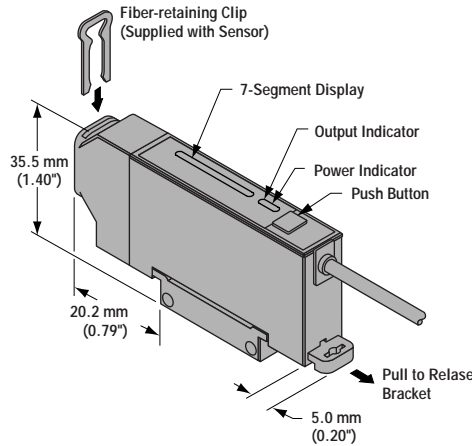
Only MICRO-SCREEN™, MINI-SCREEN®, MULTI-SCREEN®, MACHINE-GUARD™ and PERIMETER-GUARD™ Systems, and other systems so designated, are designed to meet OSHA and ANSI machine safety standards for point-of-operation guarding devices. No other Banner sensors or controls are designed to meet these standards, and they must NOT be used as sensing devices for personnel protection.

D12 Expert Dimensions

D12 Expert Series – Glass Fiber Optic Models

Glass Fiber Installation:

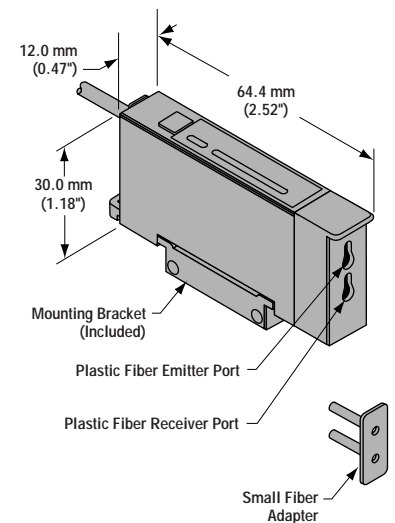
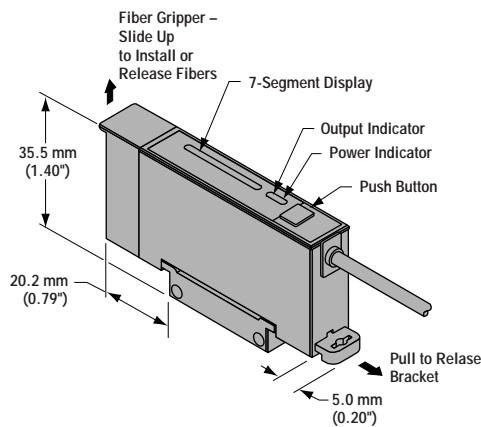
- Slide the sensor ends of the fiber(s) into the D12 Expert fiber ports as far as they will go.
- Push firmly on the fiber ends to compress the o-rings (supplied with the fibers) and to align the grooves in the fiber ends with the slot above the emitter port. Slide the retaining clip into the slot and press the clip until it snaps into the grooves.



D12 Expert Series – Plastic Fiber Optic Models

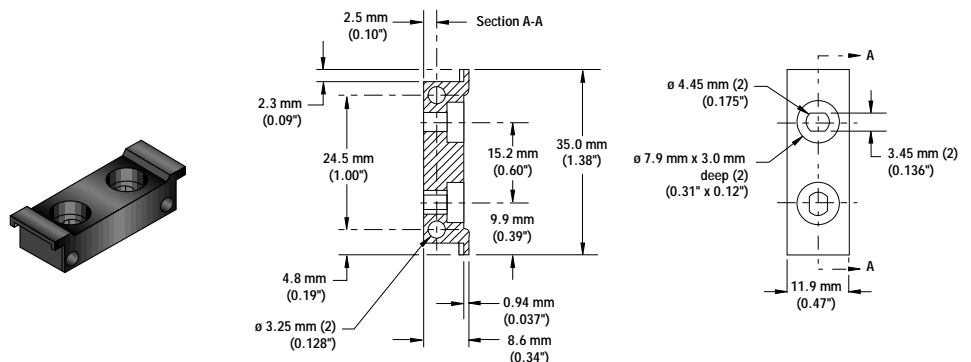
Plastic Fiber Installation:

- Cut fiber ends per instructions included with the fibers. Slide the fiber gripper up (open). (For .010" or .020" dia. fibers, insert the small fiber adaptor into the ports as far as it will go.)
- Insert the prepared plastic fiber sensor ends gently into the ports as far as they will go.
- Slide the fiber gripper back down to lock.



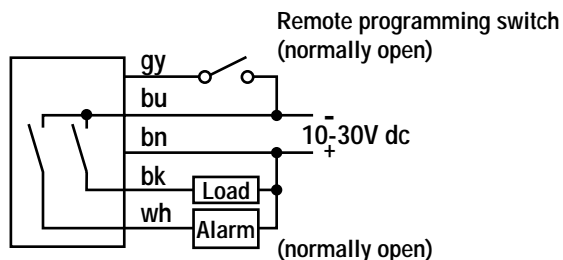
Mounting Bracket

D12E Sensors mount directly to a standard 35mm DIN rail, or may be through-hole mounted using the supplied mounting bracket and M3 x 0.5 hardware.

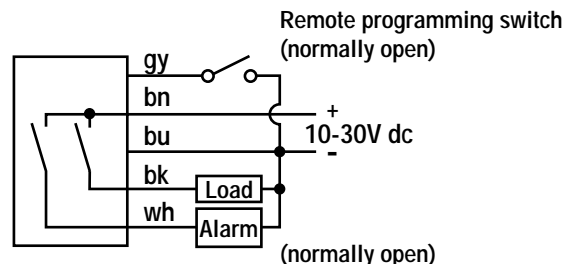


D12 Expert Hookups

NPN (Sinking) Outputs



PNP (Sourcing) Outputs



Running and Programming the D12 Expert

RUN Mode

Normal operation of the D12 Expert is called RUN mode. During RUN mode, the 7-segment LED display becomes a moving dot signal strength indicator (see Figure 1). When the light and dark sensing conditions are analyzed by the sensor during TEACH mode, the sensor's microprocessor automatically distributes the range of signal strength seen in the light condition evenly between the 7 LEDs. This display gives a true reading of the relative signal strength for the current application, and is a useful indicator of changing sensing conditions.

Maximum Sensitivity

D12 Expert sensors are factory set for maximum sensitivity. Use the following TEACH mode procedure at any time to return the sensitivity to its maximum setting.

Following the TEACH mode procedure on page 8, teach the following two conditions:

1. **No light reaching the receiver.** One easy way to do this is to disconnect the emitter and/or receiver fiber at the sensor.
2. **Maximum light reaching the receiver.** The best way to do this is to pipe the light from the sensor's emitter port directly into the receiver port, using a short individual fiber. If this is not convenient, then return the greatest amount of light possible to the receiver by using a reflective target at close range (diffuse mode sensing) or by bringing the sensing end tips together (opposed mode sensing).

Factory Default Settings

D12E and D12E2 sensors are factory set at the following defaults: maximum sensitivity, light operate output and pulse stretcher OFF.

Perform the procedures on the following pages to program your own settings. Unlike competitive sensors, the D12E has no exposed switches or adjustments.

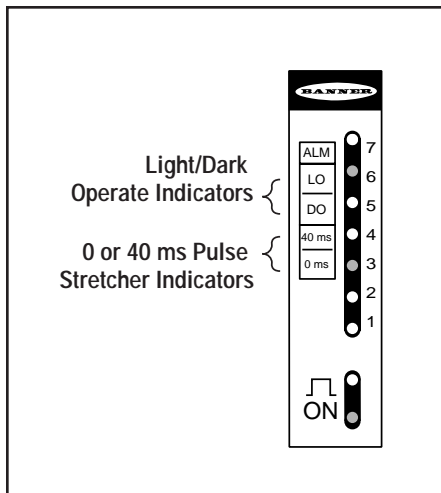


Figure 3. D12 Expert setting indicators, shown set to factory defaults

Output Configuration Programming

Programming is performed using the push button and a combination of single-, double-, and triple-clicks. (For a description of these clicks, see Remote Programming on page 9). Two output functions may be programmed by the push button:

1. Either no delay or a fixed 40 millisecond pulse stretcher (OFF-delay) for loads (or circuit inputs) that are too slow to react to a quick event. With no OFF-delay, sensing response is a fast 200 microseconds (.0002 seconds), both ON and OFF.
2. The output may be programmed for either light operate (LO) or dark operate (DO). In light operate, the sensor load output is energized during the light condition; in dark operate the load output is energized during the dark condition.

These two output functions are programmed in sequence – first the output timing, followed by the light/dark operate selection – as explained in the chart. The factory settings are 0 millisecond OFF-delay (no delay) and light operate (LO). To check the output configuration at any time, hold down the push button for 2 seconds. The sensor's 7-segment LED display will indicate the setting for 10 seconds, while the sensor continues normal operation.

NOTE: To escape from PROGRAM mode and return to RUN mode at any point, push and hold the push button for 2 seconds.

Push button		Mode	Indicator Status
<p>Push and hold 2 seconds or longer</p> <p>Output settings are displayed</p>	<p>Push and Hold ≥ 2 Seconds</p>	<p>Change from RUN mode to OUTPUT CONFIGURATION (DISPLAY) mode</p>	<p>Two steady red LEDs indicate the output settings: light or dark operate and output timing (0 or 40ms).</p> <p>NOTE: The sensor continues to operate normally during the display period. The display will automatically return to RUN mode if the push button is not clicked within 10 seconds.</p>
<p>Triple-click</p> <p>Output timing selection is displayed</p>	<p>Triple-Click</p>	<p>Change to OUTPUT CONFIGURATION (PROGRAM) mode</p>	<p>Red LED flashes at 1Hz opposite either 0 ms or 40 ms output timing</p> <p>NOTE: The sensor will return to RUN mode if the push button is not clicked within 90 seconds.</p>
<p>Single-click to toggle between 0 ms and 40 ms</p>		<p>Output timing selection</p>	<p>Flashing red LED toggles between 0 ms (no delay) and 40 ms (off-delay)</p>
<p>Double-click</p> <p>Output timing is stored and the LO or DO selection is displayed</p>	<p>Double-Click</p>	<p>Continue in OUTPUT CONFIGURATION (PROGRAM) mode</p>	<p>Red LED flashes at 1 Hz opposite either LO or DO output mode</p> <p>NOTE: The sensor will return to RUN mode if the push button is not clicked within 90 seconds.</p>
<p>Single-click to toggle between LO and DO</p>		<p>Light/dark operate selection</p>	<p>Flashing red LED toggles between LO and DO</p>
<p>Double-click</p> <p>LO/DO choice is stored and the sensor returns to RUN mode.</p>	<p>Double-Click</p>	<p>Return to RUN mode</p>	<p>The 7-segment LED bar graph indicates relative received signal strength.</p>

TEACH-Mode Programming

Sensitivity is automatically set (and optimized) by “teaching” the sensor the light and dark conditions, in TEACH mode. TEACH mode is accomplished by presenting each of the two sensing conditions to the fiber optics. They may be presented in either order (the light condition first, then the dark, or vice versa). When the button is clicked, the sensor samples the sensing condition and registers it into memory. After the second sensing condition is registered, the sensor automatically sets its sensitivity to the optimum value for the application, and the sensor returns to RUN mode.

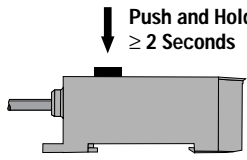
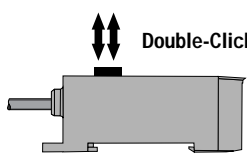
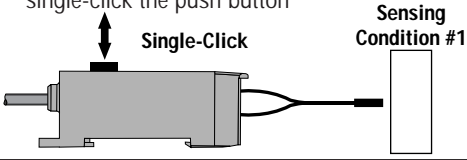
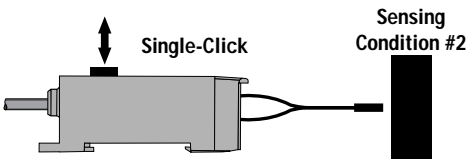
NOTE: There is a period of a few seconds at the end of TEACH mode when the display is blank, before RUN mode begins.

Contrast Indication

When the push button is clicked to teach the second condition (see above), the 7-segment display flashes 1 to 7 LEDs three times to indicate relative contrast level (see Figure 4). Contrast is the difference in light level between the two sensing conditions. Higher contrast allows a higher sensitivity level, and, therefore, a higher excess gain. In short, a high contrast level is directly related to sensing reliability, and to the sensor’s ability to “forgive” subtle changes in sensing conditions.

(LEDs flash 3 times at end of TEACH mode)	Relative Contrast
#1 (only)	Unacceptable
#1 and #2	Low
#1,2, and 3	Moderate
#1,2,3, and 4	Good
#1,2,3,4, and 5	Very Good
#1,2,3,4,5, and 6	High
#1,2,3,4,5,6, and 7	Very High

Figure 4. Contrast, as indicated by the 7-segment display

Push button	Mode	Indicator Status
<p>Push and hold 2 seconds or longer</p> <p>Current output settings are displayed</p> 	<p>Change from RUN mode to OUTPUT CONFIGURATION (DISPLAY) mode</p>	<p>Two steady red LEDs indicate the output settings: light or dark operate and output timing (0 or 40ms).</p> <p>NOTE: The sensor continues to operate normally during the display period. The display will automatically return to RUN mode if the push button is not clicked within 10 seconds.</p>
<p>Double-click</p> <p>ON indicator (green LED) single-flashes at 1 Hz</p> 	<p>Change to TEACH mode</p>	<p>Green ON LED single-flashes at 1Hz and the 7-segment display indicates relative received signal strength.</p> <p>NOTE: There is no timeout for the TEACH mode sequence. To escape from TEACH mode and return to RUN mode with the previous setting, press and hold the push button for 2 seconds or longer.</p>
<p>TEACH Condition #1</p> <p>Present the first condition to the sensor and single-click the push button</p> 		<p>When the push button is single-clicked, the 7-segment display will turn each of its LEDs ON in sequence from #7 to #1, as the sensor samples and registers the first condition. The green ON LED will double-flash at 1 Hz to indicate that the sensor is ready to learn the second condition.</p> <p>NOTE: There is no timeout for the TEACH mode sequence. To escape from TEACH mode and return to RUN mode with the previous setting, press and hold the push button for 2 seconds or longer.</p>
<p>TEACH Condition #2</p> <p>Present the second condition to the sensor and single-click the push button</p> 		<p>When the push button is clicked, the 7-segment display will turn each of its LEDs ON in sequence from #7 to #1, as the sensor samples and registers the second condition. The 7-segment display will then flash 1 to 7 of its LEDs three times to indicate relative sensing contrast. (See Figure 4, above right.)</p> <p>If the contrast is acceptable, the sensor returns (after a few seconds) to RUN mode with the new, optimized sensitivity setting. If the contrast is unacceptable (indicated by only #1 LED of the 7-segment display flashing three times), the sensor returns to TEACH mode condition 1.</p> <p>NOTE: If the contrast is unacceptable, the ALARM output also pulses three times.</p>

Remote Programming

To remotely program the TEACH and OUTPUT CONFIGURATION modes, connect the sensor's gray wire to a remote programming switch. (This input parallels the push button on the sensor, so the push button sequences explained on the previous two pages also apply for a remote switch.)

Connect a remote programming switch between the gray wire and dc common (see hookup diagrams on page 6). The switch may be either a normally open contact, or an open-collector NPN transistor.

The timing diagrams (Figure 5, below) define single-, double-, and triple-click, simulating the D12 Expert's programming push button. The ON time of each click must be at least 40 milliseconds. The minimum space between clicks must be at least 40 milliseconds. The total time of two adjacent clicks of a double- or triple-click must be less than 800 milliseconds. Conversely, there must be at least 800 milliseconds between the start of a single- or double-click and the next input.

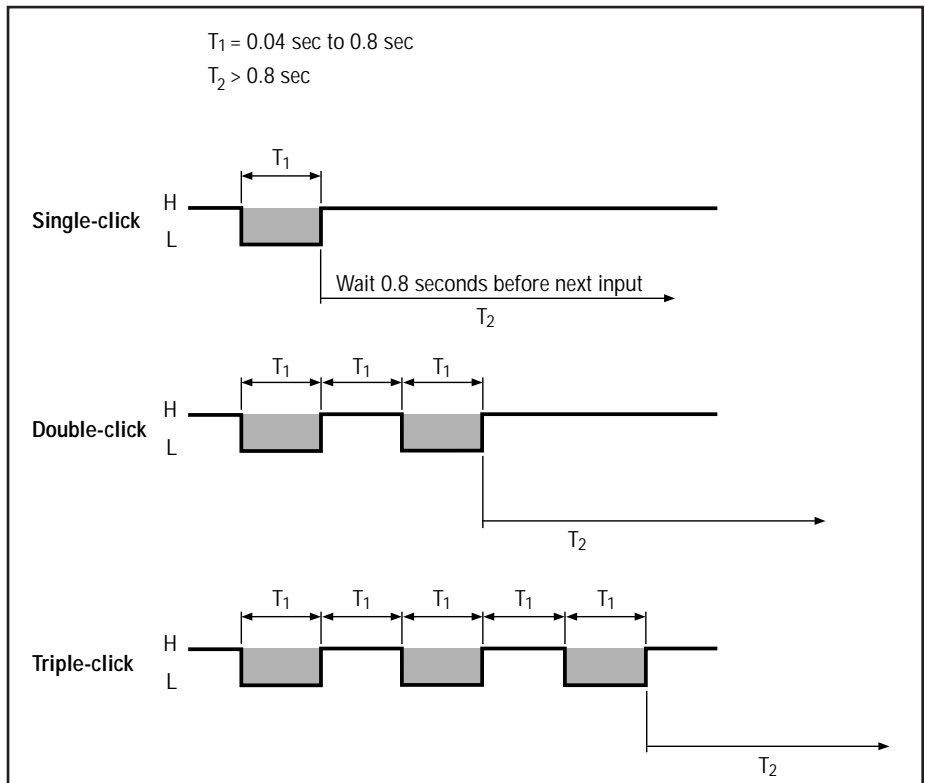


Figure 5. D12 Expert timing diagrams for remote programming

D12 Expert Series

Self-diagnostics

D12 Expert sensors provide several self-diagnostic functions. One or more flashing LEDs on the 7-segment display indicates a trouble condition. In addition, an alarm output warns of marginal sensing conditions.

The D12 Expert's 7-segment display indicates four problems:

Display: LED #7 flashes and green ON indicator is ON steadily. (Figure 6.)

Problem: The sensor flashes the #7 LED continuously and energizes the alarm output when a marginal sensing condition develops during RUN mode. The sensing area should be checked for any change which might affect the received light level in either or both sensing conditions (for example, dirt buildup on the sensing end of a fiber, misalignment of a fiber, or a change in the target's physical properties). If no changes can be identified, try re-teaching the sensor.

Display: LED #7 flashes and green ON indicator is OFF. (Figure 7.)

Problem: Load output is overloaded. Remove power, correct the problem, and re-apply power. Sensor will come up in RUN mode with the most recent settings.

Display: LEDs #1 and 7 flash together, 6 times. (Figure 8.)

Problem: This occurs at the end of TEACH mode, when the sensor has received faulty data. Faulty data may result from an unstable target or from high electrical noise occurring while TEACH mode is in process. The sensor will return to RUN mode, with the previous setting. Try re-teaching the sensor.

Display: LEDs #2 and 7 flash together. (Figure 9.)

Problem: These LEDs flash continuously to indicate a sensor component failure. Return the sensor to the factory for replacement.

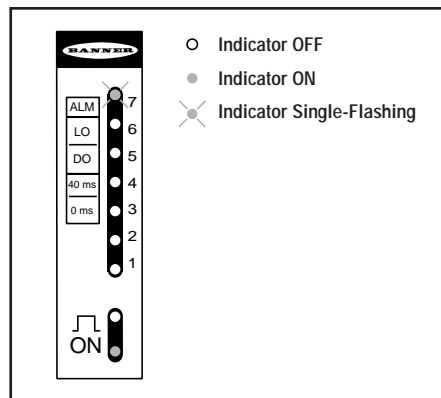


Figure 6. LED #7 flashes when a marginal sensing condition develops.

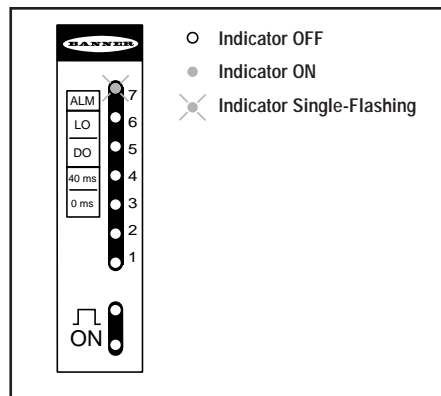


Figure 7. LED #7 flashes with the power indicator OFF; load output is overloaded.

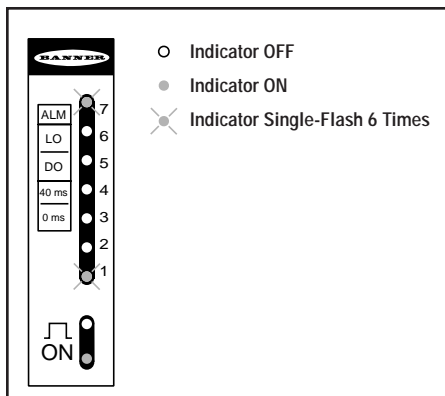


Figure 8. LEDs #1 and 7 flash together, signaling faulty data.

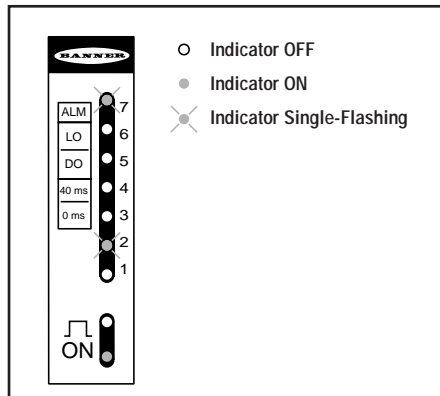
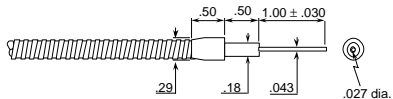
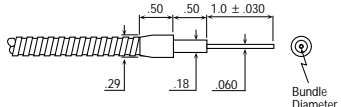
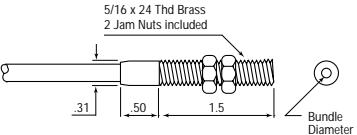
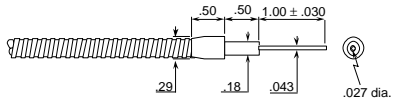
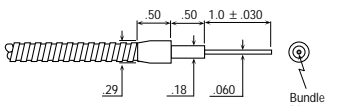
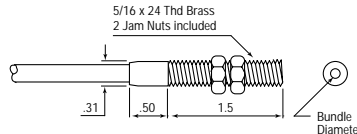


Figure 9. LEDs #2 and 7 flash together, signaling a sensor component failure.

Accessories

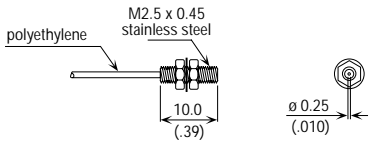
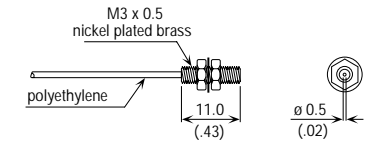
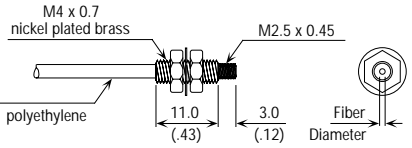
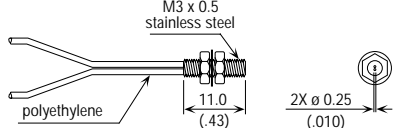
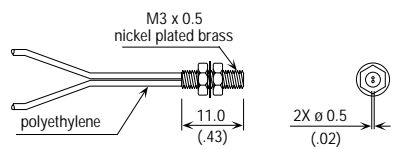
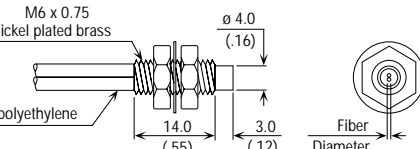
The following charts list all the fiber sizes that can be used with these sensors. Typical fiber models (one for each size and type) are indicated, along with the maximum range for each (expect less range for fiber assemblies with angled sensing ends). For a complete selection of fibers in these sizes and for more information see your current Banner Photoelectric Sensors Catalog.

Glass Fiber Assembly Fiber Diameter	Typical Fiber Model	Qty. Required for Each Unit	Maximum Range*	Sensing Tip (Dimensions in Inches)
OPPOSED MODE				
0.7 mm (.027") individual pair**	IMM.443S	2	107 mm (4.2")	
1.2 mm (.046") individual pair**	IM.753S	2	295 mm (11.6")	
1.6 mm (.062") individual pair**	IT13S	2	442 mm (17.4")	
3.2 mm (.125") individual pair**	IT23S	2	930 mm (36.6")	
DIFFUSE MODE (Based on a 90% reflectance white test card)				
0.7 mm (.027") bifurcated	BMM.443P	1	15 mm (0.6")	
1.2 mm (.046") bifurcated	BM.753S	1	46 mm (1.8")	
1.6 mm (.062") bifurcated	BT13S	1	68 mm (2.7")	
3.2 mm (.125") bifurcated	BT23S	1	178 mm (7.0")	

* Range data is for 0.9 m (3') glass fiber assemblies

** Glass fibers are used in pairs, sold individually – two are required

D12 Expert Series

Plastic Fiber Assembly Fiber Diameter	Typical Fiber Model	Qty. Required for Each Unit	Maximum Range*	Sensing Tip (Dimensions in Inches)
OPPOSED MODE				
0.25 mm (.01") individual pair	PIT16U	1	18 mm (0.7")	
0.5 mm (.02") individual pair	PIT26U	1	84 mm (3.3")	
1.0 mm (.04") individual pair	PIT46U	1	315 mm (12.4")	
1.5 mm (.06") individual pair	PIT66U	1	660 mm (26.0")	
DIFFUSE MODE (Based on a 90% reflectance white test card)				
0.25 mm (.01") bifurcated	PBT16U	1	3.8 mm (0.15")	
0.5 mm (.02") bifurcated	PBT26U	1	25 mm (1.0")	
1.0 mm (.04") bifurcated	PBT46U	1	95 mm (3.7")	
1.5 mm (.06") bifurcated	PBT66U	1	190 mm (7.5")	

* Range data is for 2 m (6') plastic fiber assemblies

WARRANTY: Banner Engineering Corporation warrants its products to be free from defects for one year. Banner Engineering Corporation will repair or replace, free of charge, any product of its manufacture found to be defective at the time it is returned to the factory during the warranty period. This warranty does not cover damage or liability for the improper application of Banner products. This warranty is in lieu of any other warranty either expressed or implied.

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