Basics of Photoelectric Sensing

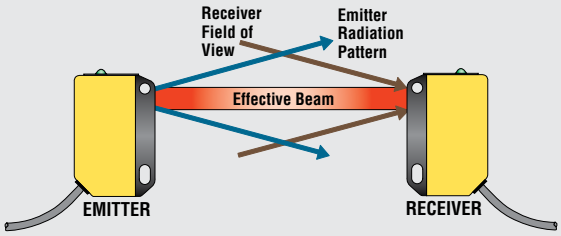
How a sensor pair works

A photoelectric sensor is an optical control used in a variety of automated processes. It works by detecting a visible or invisible beam of light, and responding to a change in the received light intensity.

Effective beam: "Working" part of a photoelectric beam.

Radiation pattern: Total area of sensing energy emission.

Field of view: Area of response.



Components of a Sensor

Emitter contains the light source, usually an LED, and an oscillator which modulates the LED at a high rate of speed. The emitter sends a modulated light beam to the receiver.

Receiver decodes the light beam and switches an output device that interfaces with the load.

Range

The range is the specified operating distance of a sensor or sensing system.

- **Opposed mode:** The distance from the emitter to the receiver.
- **Retroreflective mode:** The distance from the sensor to the retroreflector.
- **Proximity mode:** The distance from the sensor to the object being sensed.

Contrast

Contrast is the ratio of the amount of light falling on a receiver in the "light" state, compared to the "dark" state. Increasing contrast in any sensing situation will increase the reliability of the sensing system.

Beam Pattern

A beam pattern is plotted on a 2-dimensional graph to illustrate how the sensor responds to its emitter or sensing target. Use the beam pattern to estimate placement of the sensing system with respect to adjacent objects.

Excess Gain

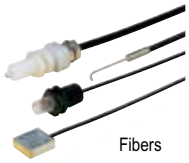
Excess gain is a measurement of the amount of light falling on a receiver, over and above the amount of light required to operate the sensor.

Types of Sensors

1. **Self-contained sensors:** One-piece photoelectric sensors that contain both the optics and the electronics. These sensors perform their own modulation, demodulation, amplification and output switching.

2. **Remote systems:** Sensing systems in which the amplification and the optical sensing are divided. The opto-elements contain only the optical components, allowing the sensing heads to be extremely small. The amplifier module contains the power input, amplification and output switching. This allows the sensitive electronics to be located away from the sensing event.

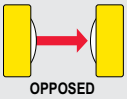
3. **Fiber optic systems:** Sensing systems in which fiber optic cables are used with either remote or self-contained sensors. Fiber optic devices have no electrical circuitry and no moving parts, and can be used to safely pipe light into and out of hostile environments.



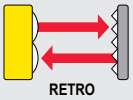
Sensing Modes

One way to tell sensors apart is by their **sensing mode**, the method in which a sensor sends and receives light. Photoelectric sensors are divided into three basic sensing modes: opposed, retroreflective and proximity.

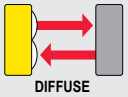
Opposed mode: The sensor's emitter and receiver are housed in two separate units. The emitter is placed opposite the receiver. An object is detected when it breaks the effective beam.

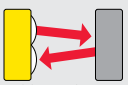


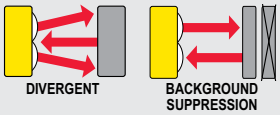
Retroreflective mode: The sensor contains both the emitter and receiver elements. The effective beam is established between the emitter, the retroreflector and the receiver. As with an opposed-mode sensor, an object is sensed when it interrupts or breaks the effective beam.



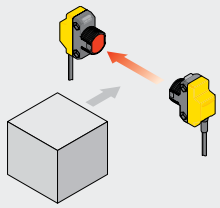
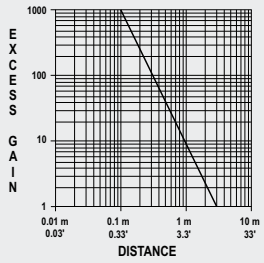
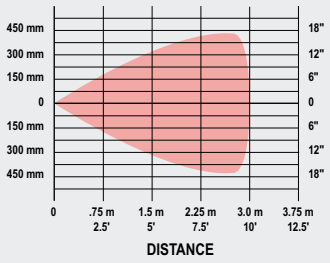
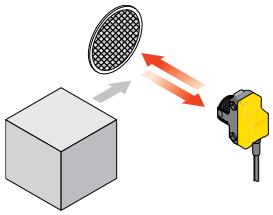
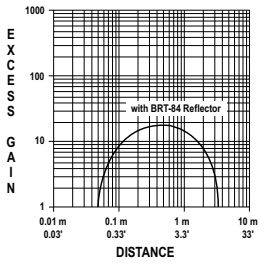
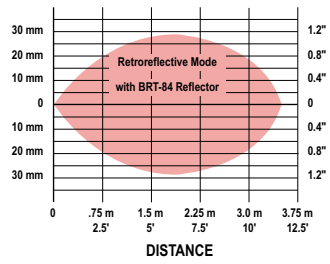
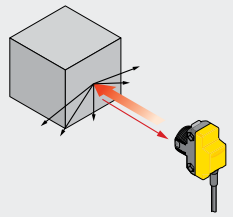
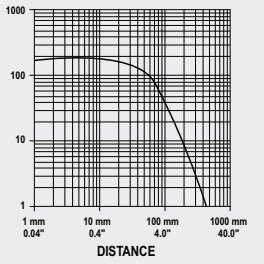
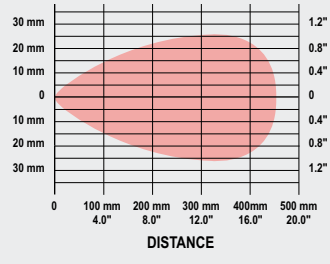
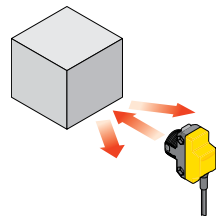
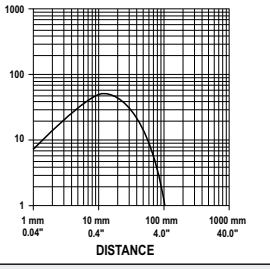
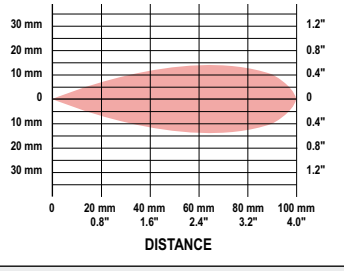
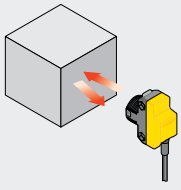
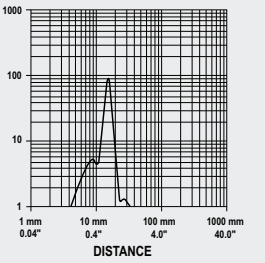
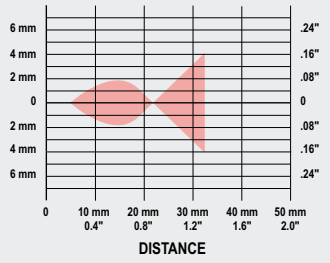
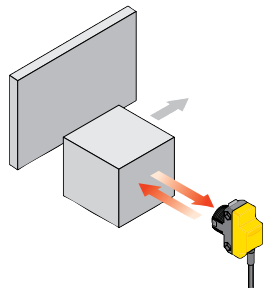
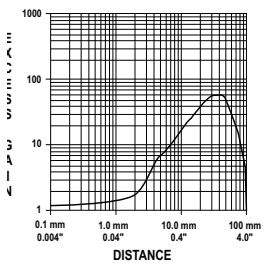
Proximity mode: These sensors contain both emitter and receiver elements. A proximity-mode sensor detects an object when emitted light is reflected off the object, back to the sensor.





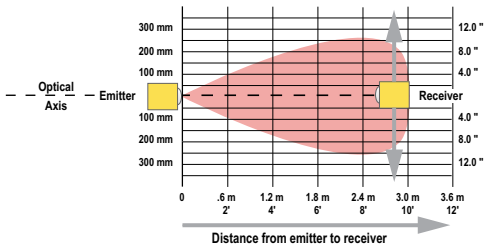


Sensing Modes

Configuration	Features	Excess Gain	Beam Pattern
OPPOSED 	• Most reliable mode for opaque targets • High excess gain results in long sensing range • Good performance in contaminated environments • High tolerance to misalignment		
RETROREFLECTIVE 	• Convenient when space is limited • High excess gain results in long sensing range		
DIFFUSE 	• Convenient when space is limited • Used in applications requiring reflectivity monitoring		
DIVERGENT 	• Convenient when space is limited • Good performance in detecting clear materials at close range • Used in applications requiring reflectivity monitoring • Reliable in detection of shiny or vibrating surfaces		
CONVERGENT 	• Used for accurate positioning • Excellent in small color mark or small object detection applications • Used for accurate counting of radiused objects • High excess gain allows detection of objects having low reflectivity		
BACKGROUND SUPPRESSION 	• Definite range limit used to ignore backgrounds • High excess gain allows detection of objects having low reflectivity • Good at detecting targets of varying reflectivity		

Beam Patterns

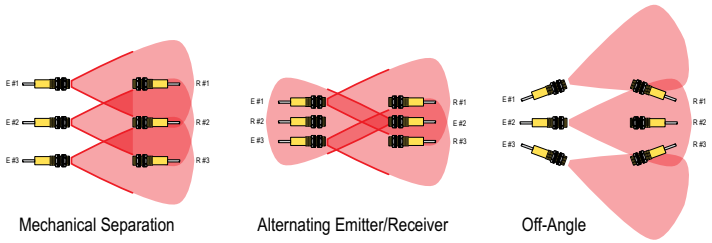
A beam pattern is plotted on a 2-dimensional graph to illustrate how the photoelectric receiver is designed to respond to its emitter. Maximum light energy occurs along the sensor's optical axis. The light energy decreases towards the beam pattern boundaries. The horizontal axis usually shows the range of the sensor.



Beam Pattern (Opposed Mode shown)

Uses for Beam Patterns

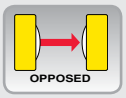
- Predict general radiation pattern given a specific target.
- Predict how multiple sensors can be mounted on a line without generating crosstalk.
- Provide accurate depiction of a light pattern a few feet from the sensor.

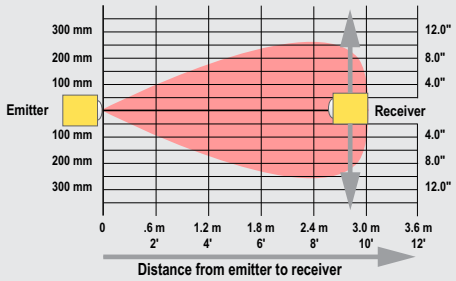


Using Beam Patterns to Avoid Optical Crosstalk

Reading a Beam Pattern

OPPOSED MODE



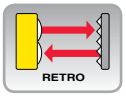


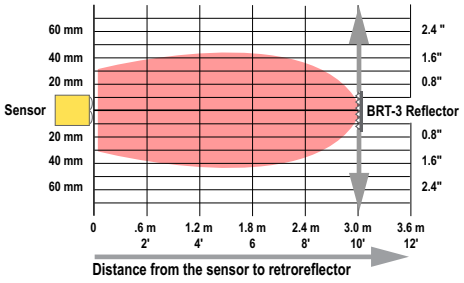
Uses: To predict how closely adjacent, parallel opposed-mode sensor pairs can be placed to each other without generating optical crosstalk.

Horizontal: Scale shows separation distance between the emitter and receiver.

Vertical: The balloon-shaped plot defines the boundary of the receiver's response to the emitter. The receiver response is measured on either side of the optical axis.

RETROREFLECTIVE MODE





Retroreflective beam patterns are plotted using a model BRT-3 (75 mm) retroreflector (except where otherwise specified).

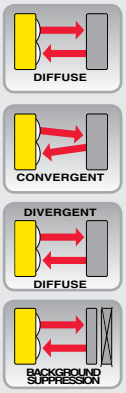
Uses: To show the area within which the sensor will respond to the retroreflector. The size of the beam pattern is proportional to the size and the reflective efficiency of the retroreflector.

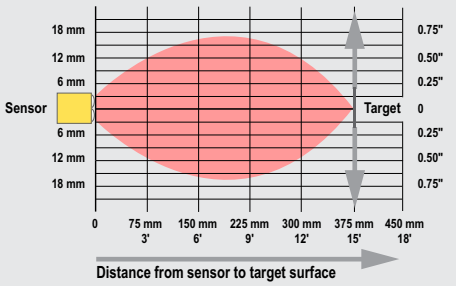
Horizontal: The scale shows the related distance between the retroreflective sensor and the retroreflector.

Vertical: The scale depicts the farthest distance on either side of the sensor's optical axis where a retroreflector can establish a beam with the sensor.

Blind Spot: If a beam pattern shows an area of no response at close range, it is indicating that the sensor has a "blind spot" area, where a retroreflector should not be located.

PROXIMITY MODE





Proximity-mode beam patterns are plotted using an 8 x 10 90% reflective white Kodak test card.

Uses: To show the boundary within which the edge of a light-colored diffuse surface will be detected as it moves past the sensor. The sensor's optical axis is represented as "0" on the vertical scale.

Horizontal: The scale shows the distance from the sensor to the target's surface.

Vertical: The scale shows the width of the sensor response measured on either side of the optical axis.

Excess Gain (EG)

Measuring Excess Gain

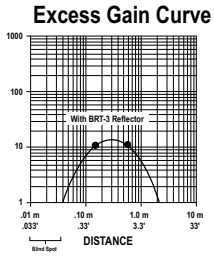
Excess gain is a measurement of the sensing light energy over and above the minimum amount required to operate the sensor's amplifier. This extra sensing energy is used to overcome signal attenuation caused by contaminants in the sensing environment.

Choose a sensor that will give you the optimal excess gain for your application. In most sensing situations, high excess gain relates directly to sensing reliability.

$$\text{Excess Gain} = \frac{\text{Light energy falling on receiver element}}{\text{Sensor's amplifier threshold}}$$

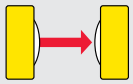
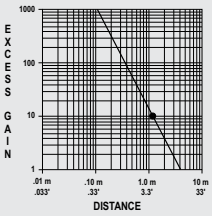
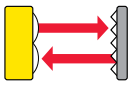
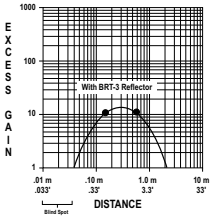
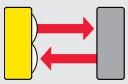
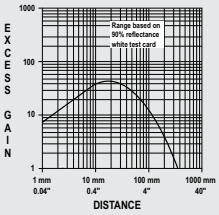
Excess Gain Curve

An excess gain curve is plotted on an X/Y axis. It shows the excess gain available for a particular sensor or sensing system as a function of distance. Excess gain curves are plotted for conditions of perfectly clean air and maximum receiver gain.



Threshold: The level of sensing energy required to cause the sensor's output to switch "ON" or "OFF." Excess gain of one (1x) is the measured voltage at the amplifier threshold level. Excess gain charts are useful when comparing sensors for an application, as direct measurement of amplifier voltage is often impractical.

Reading an Excess Gain Curve

OPPOSED MODE 	The excess gain of an opposed-mode sensor pair is directly related to sensing distance. If the sensing distance is doubled, the excess gain is reduced by a factor of one-fourth, so the curve is always a straight line, when plotted on a log-log scale.		**Reading an Opposed Mode Curve** If an environment is moderately dirty (with 10x minimum excess gain required), sensors can be mounted up to approximately 1.2 meters apart.
RETROREFLECTIVE MODE 	The shape of a retroreflective excess gain curve is significantly influenced by the size of the retroreflector. The larger the retroreflector, the larger the shape and size of the curve.		**Reading a Retro Mode Curve** If an environment is moderately dirty (with 10x minimum excess gain required), a BRT-3 retroreflector can be mounted 0.15 to 0.5 meters away from the sensor for reliable sensing.
PROXIMITY MODE 	Excess gain for proximity-mode sensors is usually lower than that of other photoelectric sensing modes, because proximity modes depend on light reflected off the surface of a target. The curves are plotted using a Kodak 90% reflectance white test card as the reference material. Other materials are ranked compared to the test card in the table below.		**Reading a Proximity Mode Curve** Use the online Relative Reflectivity Chart to estimate the excess gain required. Multiply the excess gain required to sense the material by the excess gain level required for the environment.

Excess Gain Guidelines

Excess gain of one (1x) describes the measured sensing energy at the amplifier threshold level. These guidelines show how much excess gain is required to overcome environmental conditions.

EG	General Conditions
1.5x	**Clean air:** No dirt buildup on lenses or reflectors.
5x	**Slightly dirty**: Slight buildup of dust, dirt, oil, moisture, etc. on lenses or reflectors. Lenses are cleaned on a regular schedule.
10x	**Moderately dirty:** Obvious contamination of lenses or reflectors (but not obscured). Lenses cleaned occasionally or when necessary.
50x	**Very dirty:** Heavy contamination of lenses. Heavy fog, mist, dust, smoke, or oil film. Minimal cleaning of lenses.

Relative Reflectivity

When using a proximity sensor, refer to the Relative Reflectivity chart to determine how reflectivity of different target surfaces will affect the excess gain requirements. Here are some sample targets.

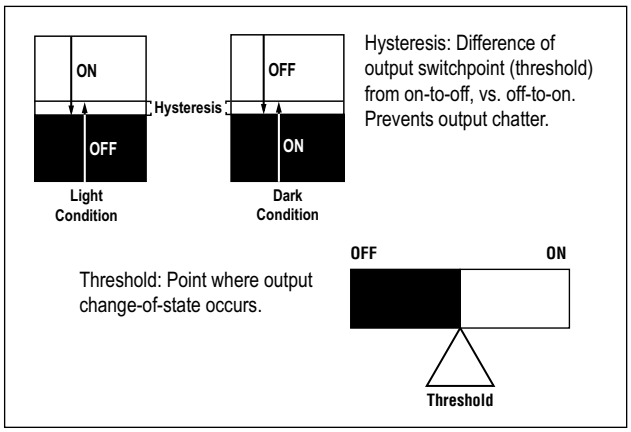
Material	General Reflectivity	Minimum Excess Gain Required
Stainless steel, microfinish	400%	0.2
Natural aluminum, unfinished	140%	0.6
Kraft paper, cardboard	70%	1.3
Clear plastic bottle	40%	2.3
Tissue paper (1 ply)	35%	2.6
Rough wood pallet (clean)	20%	4.5

Contrast

Measuring contrast

Contrast is also referred to as the light-to-dark ratio. While most sensors do not allow direct measurement of light signals, contrast can be estimated. The higher the contrast ratio, the better and more accurately your sensor will detect its target.

$$\text{Contrast} = \frac{\text{Received light in the light condition}}{\text{Received light in the dark condition}}$$

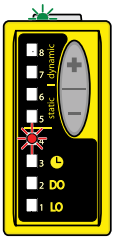


Contrast Guidelines

Follow these contrast guidelines to improve sensing reliability:

1. Choose a sensor or lensing option that will optimize contrast in any photoelectric sensing situation.
2. Adjust alignment and gain for maximum contrast during sensor installation.
3. If light and dark conditions are separated by 1/3 or more of the adjustment range of a sensor's sensitivity potentiometer, contrast is sufficient. Most Banner sensors intended for low-contrast applications are microprocessor-driven and will provide feedback of relative contrast.

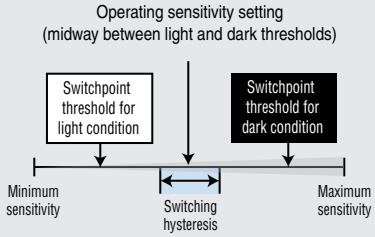
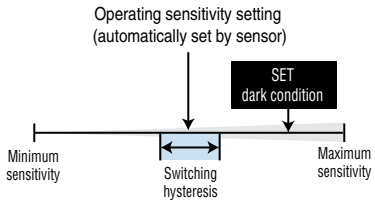
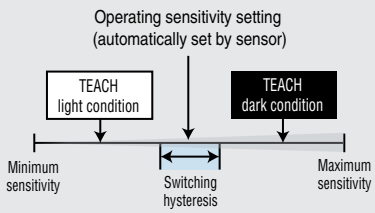
Bargraph LED Number	Relative Contrast/ Recommendation
6 to 8	Excellent: Very stable operation.
4 to 5	Good: Minor sensing variables will not affect sensing reliability
2 to 3	Low: Minor sensing variables will affect sensing reliability.
1	Marginal: Consider an alternate sensing scheme.



Bargraph sensors offer relative feedback in low-contrast applications.

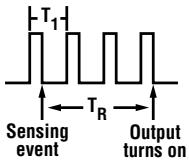
Adjusting Sensitivity

Field-adjust the sensitivity of a sensor in order to maximize the contrast in an application.

Technique	Process	Concept
Potentiometer Adjustment Manually adjust sensitivity with the potentiometer.	1. Adjust potentiometer to minimum. 2. Present the light and dark sensing conditions individually, turning the potentiometer slowly clockwise, until the alignment indicator just comes on. Note the settings. 3. Adjust the potentiometer to approximately midway between the two settings.	
SET Mode Adjustment Sensor's microprocessor auto-mates sensitivity adjustment.	Present the dark sensing condition, and press the SET button. The sensor automatically sets the operating sensitivity below the switchpoint threshold for the dark condition.	
TEACH Mode Adjustment Sensor's microprocessor optimizes sensitivity adjustment between two user-set reference points.	1. Present the light sensing condition, and single-click the TEACH button. 2. Present the dark sensing condition, and (again) single-click the TEACH button. 3. The sensor automatically sets the operating sensitivity.	

Response Time

Response time is the maximum time required for the sensor to respond to a change in the input signal. It is the time from when the sensor sees its target to when it gives an output signal to the load. Response time is the time between the leading (or trailing) edge of the sensing event and the output's change of state.



T1 = Time of one light pulse
TR = Response time

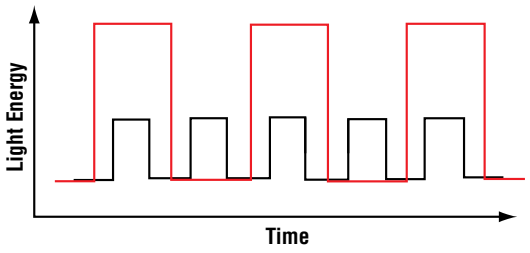
Importance

Response time can help determine how long a fast-moving object must stay in the sensor's field-of-view in order to be detected. It is especially important when your application requires detection of:

- High-speed events
- Small objects moving at high speeds
- Narrow gaps between objects
- Brief intervals between sensing events

Modulation

The speed of response of a modulated photoelectric sensor is limited by its frequency of modulation. There is a direct trade-off between sensor response time and sensing range (excess gain). High-speed sensors are modulated faster, thus yielding shorter range. If an LED is pulsed less often, it can be pulsed with a higher current, thereby producing more light energy.



Fast Response Yields Lower Excess Gain

Repeatability

The repeatability specification is used in applications where customers need to know the precise position of a moving part.

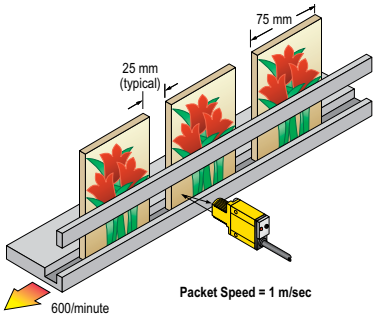
The sensor's output is allowed to switch only after a few modulated light pulses are counted. The response time before a modulated sensor turns on is equal to the time required for the sensor to count that number of pulses, and the sensor output changes state as soon as the sensor counts enough light pulses of the correct frequency.

Since the sensing event can occur at any time during a modulation cycle, the actual time between the sensing event and the sensor's output change can vary by up to one modulation cycle. This variation is the sensor's repeatability.

Calculating Response Time

You can determine a sensor's required response time when you know the size, speed and spacing of the objects to be detected.

$$\text{Response Time} = \frac{\text{Object width (or gap between objects)}}{\text{Object velocity}}$$



Calculate Response Time for Seed Packets with a Convergent Sensor

Application Example

To calculate the required sensor response time, the production line speed is first converted to the speed of, in this case, a seed packet.
When calculating the speed of the seed packet, take into account the space between the packets.

1. Determine how many packets are being processed per second:
   600 packets/minute = 10 packets per second
2. Determine the distance of linear travel: 75 mm (packet width)
   + 25 mm (space between packets) = 100 mm
3. Calculate speed of packet = 100 mm/packet x 10 packets/sec

Packet Speed = 1 m/sec

Knowing the speed of the object (1 m/sec), it is possible to calculate the time during which the sensor "sees" a packet of seeds.

Light condition: Sensing condition characterized by higher level of received sensing energy.

Calculating Light Condition

$$\frac{\text{Object width (75 mm)}}{\text{Object velocity (1 m/sec)}} = .075 \text{ sec}$$

Time of each packet passing the sensor = 75 ms

Dark condition: Sensing condition characterized by lower level of light energy (or none).

Calculating Dark Condition

$$\frac{\text{Space width (25 mm)}}{\text{Object velocity (1 m/sec)}} = .025 \text{ sec}$$

Time of each space passing the sensor = 25 ms

In this application, the time between the packets is much less than the time during which the sensor "sees" a packet. As a result, the dark (or "OFF") time between packets is the more important consideration.

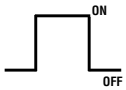
Outputs

The output circuit is the section of the sensor that interfaces to the external load. Output also refers to the useful energy delivered by the sensor.

Knowing the voltage and current requirements of the load is crucial to selecting the best sensor. Sensors with analog outputs always interface to circuits or devices which operate at low levels of dc voltage and current. Sensors with discrete outputs interface to either ac or dc loads.

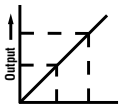
Discrete/Analog Output

The output of a sensor is either discrete or analog. A **discrete**, or switched, output has only two states: "ON" and "OFF." ON and OFF commonly refer to the status of the load that the sensor output is controlling.



Discrete

An **analog** sensor is one that varies over a range of voltage (or current) and is proportional to some sensing parameter. Analog sensors provide a metered or gradual response.

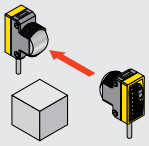


Analog

Light Operate/Dark Operate

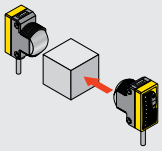
The sensor should be active when the application requires it. With discrete photoelectric sensors, the input and the output are characterized by one of two sensing terms: Light Operate and Dark Operate.

Light Operate


The sensor "sees" light.

Light Operate (LO): A condition where a photoelectric sensor output energizes its load when the sensor "sees" a sufficient amount of its own modulated light.

Dark Operate


The sensor "sees" dark.

Dark Operate (DO): The complement of LO, where the sensor output energizes its load when it no longer "sees" the modulated light.

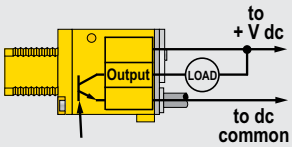
Contact Configuration Types

Solid-State Relays

Switching is accomplished by elements such as a transistor or SCR, without moving parts, heated filament or vacuum gaps.

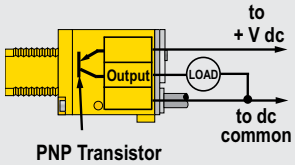
Complementary outputs: The dual-output configuration of a sensing device, where one output is Normally Open and the other is Normally Closed. In this case, both outputs have the same switchpoint, but only one output conducts at a time.

NPN output (sinking): Output switch configured with its collector open and its emitter connected to ground (dc common). The load is connected between the output (collector) and the positive of the dc supply.



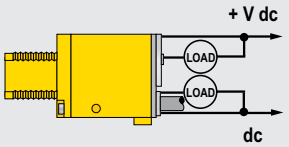
NPN Transistor

PNP output (sourcing): Output switch configured with its collector open and its emitter connected to the positive of the sensor supply voltage. The load is connected between the output (collector) and ground (dc common).



PNP Transistor

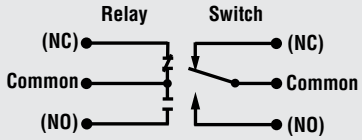
Bipolar outputs: The dual-output configuration of a dc sensing device, where one output switch is a sinking device (NPN) and the other output switch is a sourcing device (PNP). Both outputs have the same switchpoint.



Bipolar Output

E/M Relays

Used when a sensor provides direct control of a load that draws more current than can be handled by a solid-state relay. Double-throw contacts are used in interfaces that require complementary switching. E/M relays are useful when a string of sensor outputs are wired together in series for AND logic. Some E/M relay configurations include SPST, SPDT, DPST and DPDT.



Normally Open (NO): Designation for contacts of a switch or relay that are not connected when at rest. When activated, the contacts close (become connected).

Normally Closed (NC): Designation for contacts of a switch or relay that are connected when at rest. When activated, the contacts open (separate).

Response Time

The response time of sensors with discrete output depends largely on the sensor's output switching device. In general, sensors with solid-state outputs provide faster switching.

Sensors with electromechanical relays can only provide slow switching; the relay switching speed is the largest component of the specified sensor response time.

Miniature page 65

- WORLD-BEAM Q12
- M12
- T8
- S12/SB12
- VS2
- VS3

Compact page 87

- WORLD-BEAM QS18
- WORLD-BEAM Q20
- MINI-BEAM
- S18/M18
- T18
- Q25

Midsize page 145

- WORLD-BEAM QS30
- S30
- SM30/SMI30
- T30
- Q40
- PicoDot
- QM42/QMT42

Fullsize page 185

- Q45
- OMNI-BEAM
- Q60

MINIATURE SENSORS

WORLD-BEAM® Q12 page 66

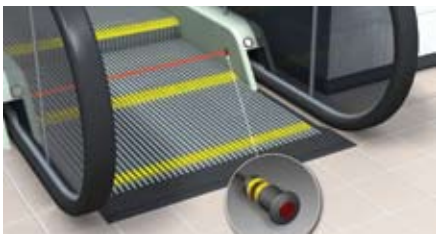
- Universal housing for consistent mounting regardless of sensing mode
- Fits extremely confined areas
- Opposed, retroreflective and fixed-field modes
- Overmolded design for enhanced durability and shielding
- Models with PFA jacket for wet or corrosive environments

M12 page 70

- 12 mm threaded metal barrel
- Ideal replacement for range limited proximity sensors
- Opposed, retroreflective, diffuse and fixed-field modes
- Excellent background suppression for fixed-field models

T8 page 74

- 8 mm thread ultra-miniature sensor
- Convenient T-shaped package
- 50 or 100 mm diffuse range
- Powerful 2 m opposed range



S12/SB12 page 77

- 12 mm plastic barrel
- Thread- or snap-barrel housing
- 1.5 or 15 m opposed-mode sensing range

VS2 page 80

- Ultra-thin opposed and convergent modes
- Flat front mounting
- Range up to 3 m

VS3 page 83

- Advanced coaxial lens design
- Range up to 1200 mm
- Accurate detection of shiny objects
- Sensing up to the face of retroreflective models

WORLD-BEAM®
Q12 Miniature Side-Mount Sensors

- Sets a new industry standard for ultra-miniature photoelectric sensors
- Features a housing as small as 22 by 8 by 12 mm for powerful sensing performance in extremely confined areas
- Rated IP67 for use in the widest range of locations and applications
- Mounts directly on or inside manufacturing equipment, with robust metal-lined mounting holes consistently located on all models
- Uses unique overmolded design for enhanced durability and shielding
- Provides bright, visible red (640 nm) sensing beam for simple alignment
- Features models with liquid-tight PFA jackets for use in wet and corrosive environments
- Provides excellent crosstalk avoidance circuitry for multi-sensor applications

ACCESSORIES page 68

OPPOSED

RETRO

POLAR RETRO

FIXED-FIELD

Q12 Opposed

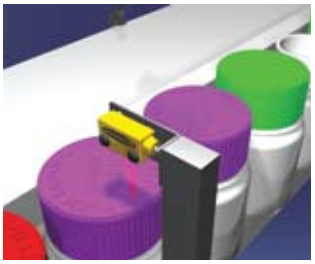
page 67

- 2 m range
- 1.3 millisecond response time
- Embedable in confined spaces

Q12 Retroreflective

page 67

- Range up to 1.5 m
- 700 microsecond response time
- Ideal for difficult to access areas and detection of shiny objects (polarized retroreflective models)



Q12 Fixed-Field

page 67

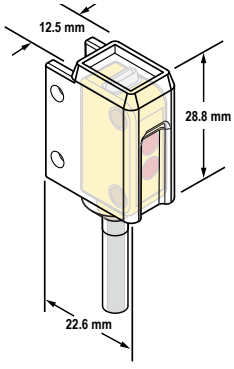
- Range of 15, 30 or 50 mm, depending on model
- Excellent background cutoff
- Small sensitivity to target color

Q12 PFA-Jacketed

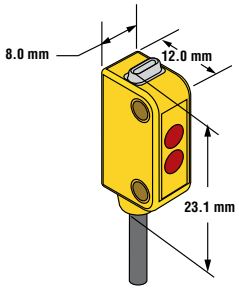
page 67

- Liquid tight to withstand wet and corrosive environments
- Chemical resistant for use in cleaning, printing, etching and other chemical processes
- Opposed and fixed-field models

Opposed, Retroreflective and Fixed-field Models
Suffix E, R, LV and FF



Chemical-resistant Models
Suffix CR

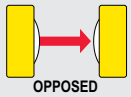
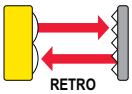
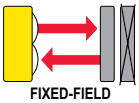


Polarized Retroreflective Models
Suffix LP

ONLINE
AUTOCAD, STEP, IGES & PDF

WORLD-BEAM® Q12, 10-30V dc

Visible Red LED

Sensing Mode/LED	Range††	Connection	Output	Models† LO	Models† DO	Excess Gain	Beam Pattern
 OPPOSED	2 m	2 m	–	Q126E Emitter		EGC-1 (p. 68)	BP-1 (p. 69)
		4-Pin Pico Pigtail QD	–	Q126EQ Emitter			
		3-Pin Pico Pigtail QD	–	Q126EQ3 Emitter			
		2 m	Bipolar NPN/PNP	**Q12AB6R**	**Q12RB6R**		
		4-Pin Pico Pigtail QD	Bipolar NPN/PNP	**Q12AB6RQ**	**Q12RB6RQ**		
		3-Pin Pico Pigtail QD	PNP	**Q12AP6RQ3**	**Q12RP6RQ3**		
		3-Pin Pico Pigtail QD	NPN	**Q12AN6RQ3**	**Q12RN6RQ3**		
 RETRO	1.5 m	2 m	Bipolar NPN/PNP	**Q12AB6LV**	**Q12RB6LV**	EGC-2 (p. 68)	BP-2 (p. 69)
		4-Pin Pico Pigtail QD	Bipolar NPN/PNP	**Q12AB6LVQ**	**Q12RB6LVQ**		
		3-Pin Pico Pigtail QD	PNP	**Q12AP6LVQ3**	**Q12RP6LVQ3**		
		3-Pin Pico Pigtail QD	NPN	**Q12AN6LVQ3**	**Q12RN6LVQ3**		
 POLAR RETRO	1 m	2 m	Bipolar NPN/PNP	**Q12AB6LP**	**Q12RB6LP**	EGC-3 (p. 68)	BP-3 (p. 69)
		4-Pin Pico Pigtail QD	Bipolar NPN/PNP	**Q12AB6LPQ**	**Q12RB6LPQ**		
		3-Pin Pico Pigtail QD	PNP	**Q12AP6LPQ3**	**Q12RP6LPQ3**		
		3-Pin Pico Pigtail QD	NPN	**Q12AN6LPQ3**	**Q12RN6LPQ3**		
 FIXED-FIELD	15 mm Cutoff	2 m	Bipolar NPN/PNP	**Q12AB6FF15**	**Q12RB6FF15**	EGC-4 (p. 69)	—
		4-Pin Pico Pigtail QD	Bipolar NPN/PNP	**Q12AB6FF15Q**	**Q12RB6FF15Q**		
		3-Pin Pico Pigtail QD	PNP	**Q12AP6FF15Q3**	**Q12RP6FF15Q3**		
		3-Pin Pico Pigtail QD	NPN	**Q12AN6FF15Q3**	**Q12RN6FF15Q3**		
	30 mm Cutoff	2 m	Bipolar NPN/PNP	**Q12AB6FF30**	**Q12RB6FF30**	EGC-5 (p. 69)	—
		4-Pin Pico Pigtail QD	Bipolar NPN/PNP	**Q12AB6FF30Q**	**Q12RB6FF30Q**		
		3-Pin Pico Pigtail QD	PNP	**Q12AP6FF30Q3**	**Q12RP6FF30Q3**		
		3-Pin Pico Pigtail QD	NPN	**Q12AN6FF30Q3**	**Q12RN6FF30Q3**		
	50 mm Cutoff	2 m	Bipolar NPN/PNP	**Q12AB6FF50**	**Q12RB6FF50**	EGC-6 (p. 69)	—
		4-Pin Pico Pigtail QD	Bipolar NPN/PNP	**Q12AB6FF50Q**	**Q12RB6FF50Q**		
		3-Pin Pico Pigtail QD	PNP	**Q12AP6FF50Q3**	**Q12RP6FF50Q3**		
		3-Pin Pico Pigtail QD	NPN	**Q12AN6FF50Q3**	**Q12RN6FF50Q3**		

Connection options:

Bipolar Models Only:
For 9 m cable, add suffix **W/30** to the 2 m model number (example, **Q126E W/30**).
QD models: A model with a QD requires a mating cordset (see page 68).
• For 4-pin 150 mm Euro-style QD, add suffix **Q5** (example, **Q126EQ5**).

† For sensors with a PFA chemical-resistant jacket (opposed and fixed-field), add suffix **CR** to the 2 m model number (example, **Q12AB6FF15CR**).
†† Retroreflective range is specified using a BRT-60X40C retroreflector.
Actual sensing range may differ, depending on the efficiency and reflective area of the retroreflector used. See Accessories for more information.
PFA chemical-resistant models provide a range of 1.5 m in opposed mode and 12, 28 or 48 mm in fixed-field mode, depending on model.

WORLD-BEAM® Q12 Specifications

Sensing Beam	640 nm visible red
Supply Voltage and Current	10 to 30V dc (10% max. ripple) @ 20 mA max. current
Supply Protection Circuitry	Protected against reverse polarity and transient voltages
Output Configuration	**Bipolar:** 1 NPN (current sinking) and 1 PNP (current sourcing); light operate (LO) or dark operate (DO), depending on model **Single-output:** 1 NPN or 1 PNP; light operate (LO) or dark operate (DO), depending on model
Output Rating	50 mA total across both outputs with overload and short circuit protection **OFF-state leakage current:** **NPN:** 200 µA **PNP:** 10 µA **ON-state saturation voltage:** **NPN:** 1.25V @ 50 mA **PNP:** 1.45V @ 50 mA
Output Protection Circuitry	Protected against false pulse on power-up; short-circuit protected.

More on next page

WORLD-BEAM® Q12 Specifications (cont'd)

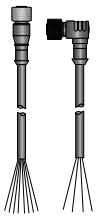
Output Response Time	**Opposed:** 1.3 milliseconds ON; 900 microseconds OFF **All others:** 700 microseconds ON/OFF
Delay at Power-up	120 milliseconds; outputs do not conduct during this time.
Repeatability	175 microseconds
Switching Frequency	**Opposed models:** 385 Hz **All other models:** 715 Hz
Indicators	**2 LED indicators** (Emitters-Green only): **Green**—power ON **Yellow**—light sensed
Construction	**Polarized Retroreflective:** Thermoplastic elastomer housing with glass lens **Standard:** Thermoplastic elastomer housing with polycarbonate lens **Chemical-resistant:** Housing encased in PFA jacket; cable encased in 3/16" O.D. PFA tubing.
Environmental Rating	**Standard:** IEC IP67 **Chemical-resistant:** IEC IP67 (NEMA 6) and PW12 1200 psi washdown per NEMA ICS 5, Annex F-2002
Connections	**Bipolar:** 2 m or 9 m attached PVC cable, or 150 mm pigtail with 4-pin Pico-style (**Q**) or 4-pin Euro-style (**Q5**) quick-disconnect fitting. QD cordsets are ordered separately. See pages 68. **Single output:** 150 mm pigtail with 3-pin Pico-style (**Q3**) quick-disconnect fitting. QD cordsets are ordered separately. See page 68. **Chemical-resistant:** 2 m attached cable encased in 3/16" O.D. PFA tubing
Operating Conditions	**Temperature:** -20° to +55° C **Storage temperature:** -30° to +75° C **Relative humidity:** 95% max. @ 50° C (non-condensing)
Certifications	CE c UL us
Hookup Diagrams	**Emitters:** DC02 (p. 716) **Bipolar:** DC04 (p. 716) **Single output:** DC01 (p. 716)

Cordsets

Euro QD

See page 658

Length	Threaded 4-Pin Straight	Threaded 4-Pin Right-Angle
2 m	MQDC-406	MQDC-406RA
5 m	MQDC-415	MQDC-415RA
9 m	MQDC-430	MQDC-430RA

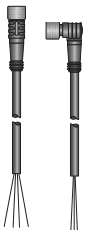


Additional cordset information available. See page 655.

Pico QD

See page 655

Length	Threaded 4-Pin Straight	Threaded 4-Pin Right-Angle	Threaded 3-Pin Straight	Threaded 3-Pin Right-Angle
2 m	PKG4M-2	PKW4M-2	PKG3M-2	PKW3M-2
5 m	PKG4M-5	PKW4M-5	PKG3M-5	PKW3M-5
7 m	–	–	PKG3M-7	–
9 m	PKG4M-9	PKW4M-9	PKG3M-9	PKW3M-9
10 m	–	–	PKG3M-10	–



Brackets

WORLD-BEAM® Q12

pg. 644 SMBQ12A

pg. 645 SMBQ12T

Additional bracket information available. See page 601.

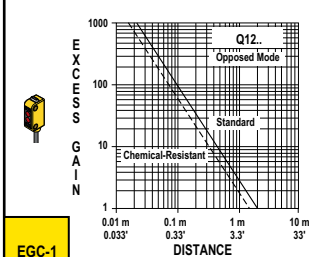
REFLECTORS PAGE 684

APERTURES PAGE 709

Excess Gain Curves

● = Visible Red LED P = Visible Red LED Polarized

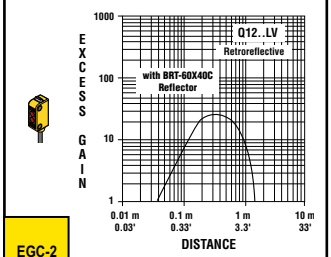
Opposed Mode WORLD-BEAM® Q12



EGC-1

Range: 2 m **LED:** ●

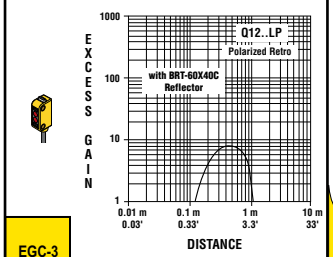
Retroreflective Mode WORLD-BEAM® Q12



EGC-2

Range: 1.5 m **LED:** ●

Polarized Retroreflective Mode WORLD-BEAM® Q12



EGC-3

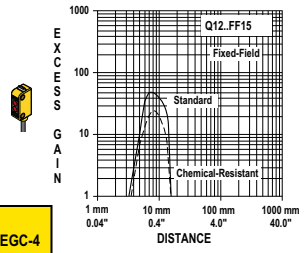
Range: 1 m **LED:** P

More on next page

Excess Gain Curves (Performance based on 90% reflectance white test card)

● = Visible Red LED

Fixed-Field Mode WORLD-BEAM® Q12



EGC-4

Cutoff: 15 mm | **LED:** ●

90% white card
Standard Models:
Ø 0.4 mm spot size @ 10 mm focus
Ø 1.5 mm spot size @ 15 mm cutoff

Chemical-Resistant Models:
Ø 0.4 mm spot size @ 8 mm focus
Ø 1.5 mm spot size @ 13 mm cutoff

Using 18% gray test card: cutoff distance will be 95% of value shown.
Using 6% black test card: cutoff distance will be 90% of value shown.

Fixed-Field Mode WORLD-BEAM® Q12

EGC-5

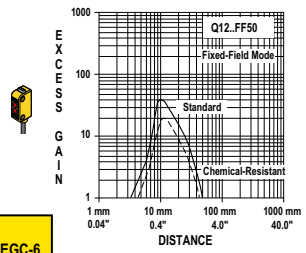
Cutoff: 30 mm | **LED:** ●

90% white card
Standard Models:
Ø 0.5 mm spot size @ 16 mm focus
Ø 3.0 mm spot size @ 30 mm cutoff

Chemical-Resistant Models
Ø 0.5 mm spot size @ 14 mm focus
Ø 3.0 mm spot size @ 28 mm cutoff

Using 18% gray test card: cutoff distance will be 90% of value shown.
Using 6% black test card: cutoff distance will be 80% of value shown.

Fixed-Field Mode WORLD-BEAM® Q12



EGC-6

Cutoff: 50 mm | **LED:** ●

90% white card
Standard Models:
Ø 0.5 mm spot size @ 16 mm focus
Ø 6.5 mm spot size @ 50 mm cutoff

Chemical-Resistant Models:
Ø 0.5 mm spot size @ 14 mm focus
Ø 6.5 mm spot size @ 48 mm cutoff

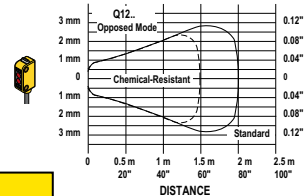
Using 18% gray test card: cutoff distance will be 80% (standard) or 70% (chemical resistant) of value shown.
Using 6% black test card: cutoff distance will be 60% (standard) or 50% (chemical resistant) of value shown.

Beam Patterns

● = Visible Red LED P = Visible Red LED Polarized

Opposed Mode WORLD-BEAM® Q12

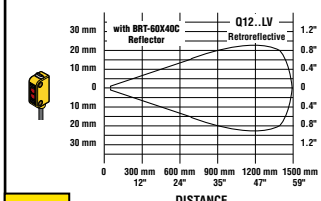
Effective Beam: 5.7 mm



BP-1

Range: 2 m | **LED:** ●

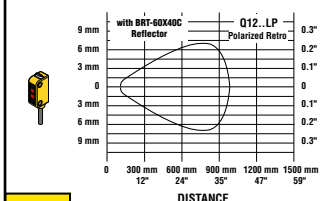
Retroreflective Mode WORLD-BEAM® Q12



BP-2

Range: 1.5 m | **LED:** ●

Retroreflective Mode WORLD-BEAM® Q12

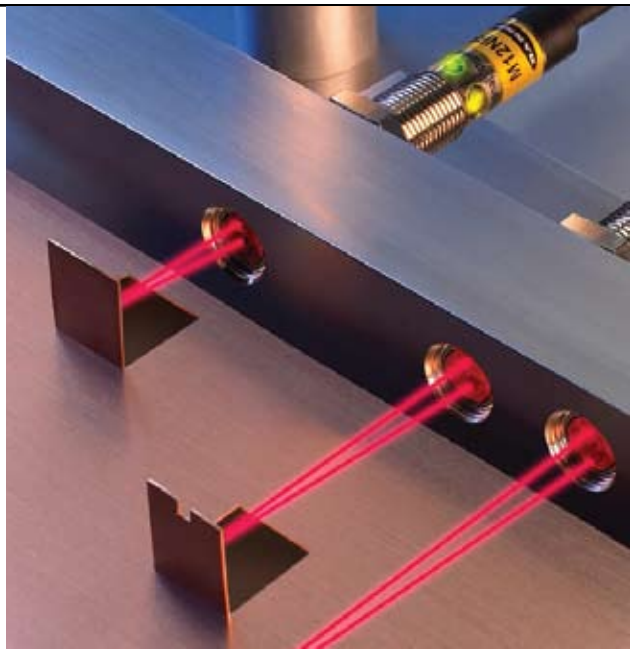


BP-3

Range: 1 m | **LED:** P

M12
Barrel-Mount Sensors

- Features compact 12 mm threaded metal barrel
- Available in opposed, polarized and non-polarized retroreflective, diffuse and fixed-field modes
- Provides single-turn sensitivity adjustment on opposed, retroreflective and diffuse models
- Features fixed-field models with excellent background suppression and recessed mounting
- Visible red sensing beam for easy alignment
- Fully encapsulated electronics–rated IP67
- Provides excellent crosstalk avoidance circuitry for diffuse, retroreflective and fixed-field models



ACCESSORIES page 72

OPPOSED

RETRO

POLAR RETRO

DIFFUSE

FIXED-FIELD

ONLINE
AUTOCAD, STEP, IGES & PDF

Opposed, Retroreflective Diffuse and Fixed-field Models Suffix E, R, LP, LV, D and FF

M12, 10-30V dc

Visible Red LED

Sensing Mode/LED	Range	Connection	Models NPN	Models PNP	Excess Gain	Beam Pattern
OPPOSED	5 m	2 m	M12E Emitter		EGC-1 (p. 72)	BP-1 (p. 73)
		4-Pin Euro QD	M12EQ8 Emitter			
		2 m	M12NR	M12PR		
		4-Pin Euro QD	M12NRQ8	M12PRQ8		
DIFFUSE	400 mm	2 m	M12ND	M12PD	EGC-4 (p. 72)	BP-4 (p. 73)
		4-Pin Euro QD	M12NDQ8	M12PDQ8		
RETRO	2.5 m†	2 m	M12NLV	M12PLV	EGC-2 (p. 72)	BP-2 (p. 73)
		4-Pin Euro QD	M12NLVQ8	M12PLVQ8		
POLAR RETRO	1.5 m†	2 m	M12NLP	M12PLP	EGC-3 (p. 72)	BP-3 (p. 73)
		4-Pin Euro QD	M12NLPQ8	M12PLPQ8		

More on next page

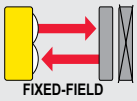
Connection options: A model with a QD requires a mating cordset (see page 72).

For 9 m cable, add suffix **W/30** to the 2 m model number (example, **M12PD W/30**).
QD models: For a 4-pin 150 mm Euro-style pigtail QD, add suffix **Q5** (example, **M12PDQ5**).

† Retroreflective range is specified using a BRT-84 retroreflector.
Actual sensing range may differ, depending on the efficiency and reflective area of the retroreflector used. See Accessories for more information.

M12, 10-30V dc (cont'd)

Visible Red LED

Sensing Mode/LED	Range	Connection	Models NPN	Models PNP	Excess Gain	Beam Pattern
 FIXED-FIELD	25 mm Cutoff	2 m	**M12NFF25**	**M12PFF25**	EGC-5 (p. 72)	–
		4-Pin Euro QD	**M12NFF25Q8**	**M12PFF25Q8**		
	50 mm Cutoff	2 m	**M12NFF50**	**M12PFF50**	EGC-6 (p. 72)	–
		4-Pin Euro QD	**M12NFF50Q8**	**M12PFF50Q8**		
	75 mm Cutoff	2 m	**M12NFF75**	**M12PFF75**	EGC-7 (p. 72)	–
		4-Pin Euro QD	**M12NFF75Q8**	**M12PFF75Q8**		

Connection options: A model with a QD requires a mating cordset (see page 72).

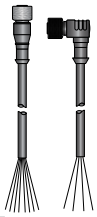
For 9 m cable, add suffix **W/30** to the 2 m model number (example, **M12PD W/30**).
QD models: For a 4-pin 150 mm Euro-style pigtail QD, add suffix **Q5** (example, **M12PDQ5**).

M12 Specifications

Sensing Beam	**Fixed-field:** 680 nm visible red **All others:** 660 nm visible red
Supply Voltage and Current	10 to 30V dc (10% max. ripple) @ 20 mA max current (exclusive of load)
Supply Protection Circuitry	Protected against reverse polarity and transient voltages
Output Configuration	Complementary (1 normally open and 1 normally closed) solid-state, NPN or PNP, depending on model
Output Ratings	100 mA total across both outputs with overload and short circuit protection **OFF-state leakage current:** **ON-state saturation voltage:** **NPN:** < 200 µA @ 30V dc (see Application Note 1) **NPN:** <1.6V @ 100 mA **PNP:** < 10 µA @ 30V dc **PNP:** < 3.0V @ 100 mA
Output Protection Circuitry	Protected against false pulse on power-up, short-circuit protected
Output Response Time	**Opposed:** 625 microsecond ON/375 microseconds OFF **All others:** 500 microseconds ON/OFF
Delay at Power-up	100 milliseconds; outputs do not conduct during this time.
Repeatability	**Opposed:** 85 microseconds **All others:** 95 microseconds
Indicators	**2 LED indicators**: **Green**–power ON **Yellow**–light sensed
Adjustments	**Fixed-field:** none **All others:** single-turn Gain (sensitivity) potentiometer
Construction	**Housing:** Nickel-plated brass **Lenses:** PMMA **Cable endcap and Gain potentiometer adjuster:** PBT
Environmental Rating	IEC IP67; NEMA 6, IEC IP68 and 1200 PSI washdown, NEMA 1CS 5 Annex F-2002
Connections	2 m or 9 m 4-wire PVC-jacketed cable, 4-pin integral Euro-style QD (**Q8**), or 150 mm pigtail with threaded 4-pin Euro-style quick-disconnect fitting (**Q5**), depending on model. QD cordsets ordered separately. See page 72.
Operating Conditions	**Operating temperature:** –20° to +60° C **Relative humidity:** 90% max @ +50° C
Application Notes	**1.** NPN off-state leakage current is < 200 µA for load resistances > 3 kΩ or optically isolated loads. For load current of 100 mA, leakage is < 1% of load current
Certifications	CE
Hookup Diagrams	**Emitters:** DC02 (p. 716) **All others:** DC03 (p. 716)

Cordsets

Euro QD		
See page 658		
Length	Threaded 4-Pin Straight	Threaded 4-Pin Right-Angle
2 m	MQDC-406	MQDC-406RA
5 m	MQDC-415	MQDC-415RA
9 m	MQDC-430	MQDC-430RA



Additional cordset information available. See page 655.

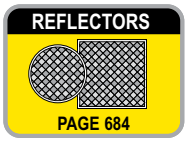
Brackets

M12

pg. 647

SMBQS12PD

Additional bracket information available. See page 601.

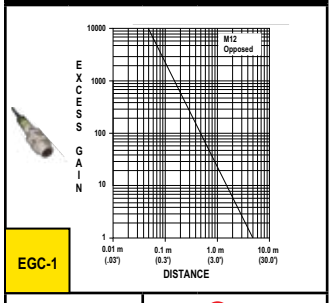


Excess Gain Curves

(Diffuse and Fixed-field mode performance based on 90% reflectance white test card)

● = Visible Red LED P = Visible Red LED Polarized

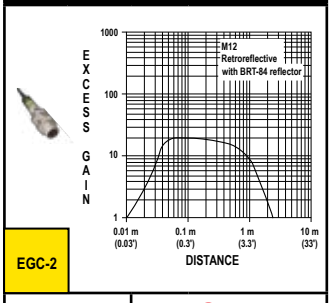
Opposed Mode M12



EGC-1

Range: 5 m **LED:** ●

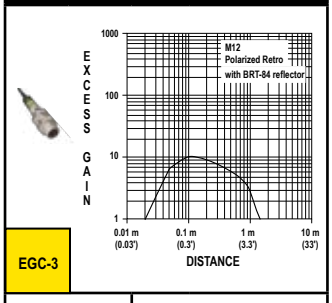
Retroreflective Mode M12



EGC-2

Range: 2.5 m **LED:** ●

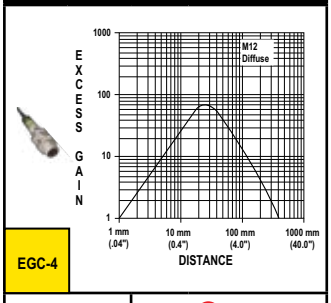
Polarized Retroreflective Mode M12



EGC-3

Range: 1.5 m **LED:** P

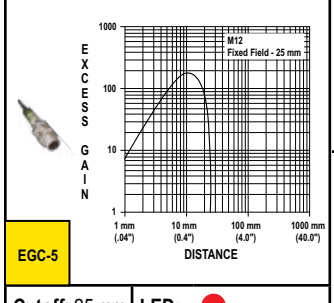
Diffuse Mode M12



EGC-4

Range: 400 mm **LED:** ●

Fixed-Field Mode M12



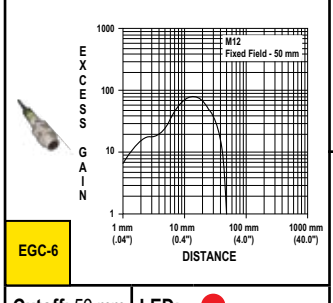
EGC-5

90% white test card:
Ø 2 mm spot size @ 25 mm focus
Ø 2 mm spot size @ 25 mm cutoff

Using 18% gray test card: cutoff distance will be 96% of value shown.
Using 6% black test card: cutoff distance will be 94% of value shown.

Cutoff: 25 mm **LED:** ●

Fixed-Field Mode M12



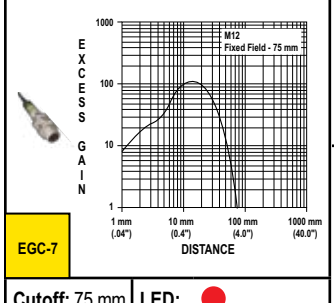
EGC-6

90% white test card:
Ø 2 mm spot size @ 25 mm focus
Ø 7 mm spot size @ 50 mm cutoff

Using 18% gray test card: cutoff distance will be 90% of value shown.
Using 6% black test card: cutoff distance will be 85% of value shown.

Cutoff: 50 mm **LED:** ●

Fixed-Field Mode M12



EGC-7

90% white test card:
Ø 2 mm spot size @ 25 mm focus
Ø 13 mm spot size @ 75 mm cutoff

Using 18% gray test card: cutoff distance will be 80% of value shown.
Using 6% black test card: cutoff distance will be 70% of value shown.

Cutoff: 75 mm **LED:** ●

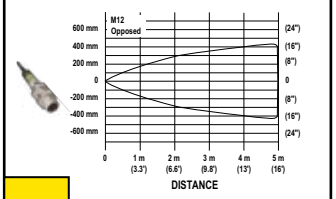
Beam Patterns

(Diffuse mode performance based on 90% reflectance white test card)

● = Visible Red LED P = Visible Red LED Polarized

Opposed Mode M12

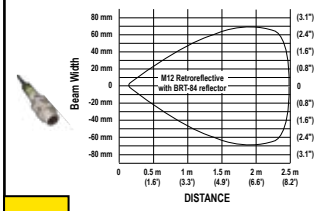
Effective Beam: 10 mm



BP-1

Range: 5 m | **LED:** ●

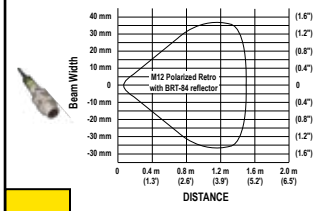
Retroreflective Mode M12



BP-2

Range: 2.5 m | **LED:** ●

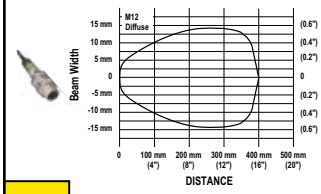
Retroreflective Mode M12



BP-3

Range: 1.5 m | **LED:** P

Diffuse Mode M12



BP-4

Range: 400 mm | **LED:** ●

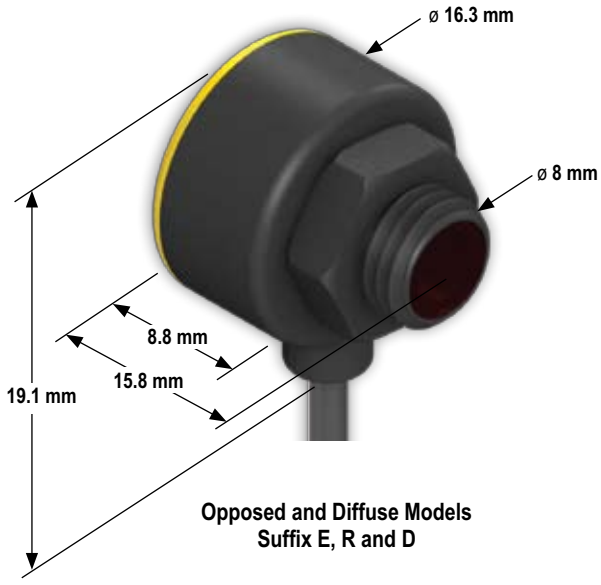
T8
Right-Angle Barrel-Mount Sensors

- Features EZ-BEAM® technology, with specially designed optics and electronics for reliable sensing without adjustments
- Ideal for presence sensing in small areas previously accessible only to remote sensors and fiber optic cable
- Can replace range-limited 8 mm inductive proximity sensors
- Offers visible sensing beam for easy alignment
- Available in dark- or light-operate models
- Offered in opposed mode with 2 m range or diffuse mode with 50 and 100 mm ranges

ACCESSORIES page 76

OPPOSED

DIFFUSE

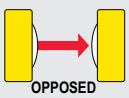


Opposed and Diffuse Models
Suffix E, R and D

ONLINE
AUTOCAD, STEP, IGES & PDF

T8, 10-30V dc

Visible Red LED

Sensing Mode/LED	Range	Connection	Output Type	Models NPN	Models PNP	Excess Gain	Beam Pattern
 OPPOSED	2 m	2 m	—	T86EV Emitter		EGC-1 (p. 76)	BP-1 (p. 76)
		3-Pin Pico Pigtail QD		T86EVQ Emitter			
		2 m	LO	T8AN6R	T8AP6R		
		3-Pin Pico Pigtail QD		T8AN6RQ	T8AP6RQ		
		2 m	DO	T8RN6R	T8RP6R		
		3-Pin Pico Pigtail QD		T8RN6RQ	T8RP6RQ		

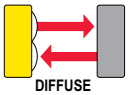
More on next page

Connection options: A model with a QD requires a mating cordset (see pages 76).

For 9 m cable, add suffix **W/30** to the 2 m model number (example, **T8AN6D50 W/30**).

T8, 10-30V dc (cont'd)

Visible Red LED

Sensing Mode/LED	Range	Connection	Output Type	Models NPN	Models PNP	Excess Gain	Beam Pattern
 DIFFUSE	50 mm	2 m	LO	**T8AN6D50**	**T8AP6D50**	EGC-2 (p. 76)	BP-2 (p. 76)
		3-Pin Pico Pigtail QD		**T8AN6D50Q**	**T8AP6D50Q**		
		2 m	DO	**T8RN6D50**	**T8RP6D50**		
		3-Pin Pico Pigtail QD		**T8RN6D50Q**	**T8RP6D50Q**		
	100 mm	2 m	LO	**T8AN6D100**	**T8AP6D100**	EGC-3 (p. 76)	BP-3 (p. 76)
		3-Pin Pico Pigtail QD		**T8AN6D100Q**	**T8AP6D100Q**		
		2 m	DO	**T8RN6D100**	**T8RP6D100**		
		3-Pin Pico Pigtail QD		**T8RN6D100Q**	**T8RP6D100Q**		

Connection options: A model with a QD requires a mating cordset (see pages 76).

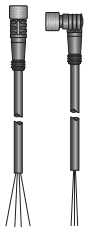
For 9 m cable, add suffix **W/30** to the 2 m model number (example, **T8AN6D50 W/30**).

T8 Specifications

Supply Voltage and Current	10 to 30V dc (10% max. ripple) at less than 25 mA (exclusive of load)
Supply Protection Circuitry	Protected against reverse polarity and transient voltages
Output Configuration	Solid-state switch NPN (current sinking) or PNP (current sourcing), depending on model. Light Operate (LO) or Dark Operate (DO), depending on model.
Output Rating	50 mA max. **OFF-state leakage current:** less than 1 µA at 24V dc **ON-state saturation voltage:** less than 0.25V at 10 mA dc; less than 0.5V at 50 mA dc
Output Protection Circuitry	Protected against false pulse on power-up and continuous overload or short circuit of outputs Overload trip point ≥ 100 mA
Output Response Time	1 millisecond ON; 0.5 milliseconds OFF
Delay at Power-up	Maximum 100 milliseconds (150 milliseconds for Diffuse); output does not conduct during this time.
Repeatability	**Opposed:** 100 microseconds **Diffuse:** 160 microseconds
Indicators	**Opposed:** Receiver has Green and Red LED Emitter has one Green LED **Green:** power ON **Red:** light sensed **Diffuse:** **Red:** light is sensed
Construction	Reinforced polycarbonate/ABS alloy housing, acrylic window with 8 mm ABS nut
Environmental Rating	IEC IP67; NEMA 6
Connections	2 m or 9 m attached cable, 3-wire with PVC outer cable jacket; or 150 mm pigtail with 3-pin Pico-style quick-disconnect fitting. QD cordsets are ordered separately. See page 76.
Operating Conditions	**Temperature:** -20° to +55° C **Relative humidity:** 80% at 50° C (non-condensing)
Vibration and Mechanical Shock	**Vibration:** All models meet IEC 60068-2-6, IEC 60947-5-2, UL491 Section 40, MIL-STD-202F Method 201A; 10 to 60 Hz, 0.5 mm peak to peak **Shock:** All models meet IEC 60068-2-27, IEC 60947-5-2; 30g peak acceleration, 11 millisecond pulse duration, half-sine wave pulse shape
Certifications	CE
Hookup Diagrams	**Emitters:** DC02 (p. 716) **All others:** DC01 (p. 716)

Cordsets

Pico QD		
See page 655		
	Threaded 3-Pin	
Length	Straight	Right-Angle
2 m	PKG3M-2	PKW3M-2
5 m	PKG3M-5	—
7 m	PKG3M-7	—
9 m	PKG3M-9	PKW3M-9
10 m	PKG3M-10	—



Additional cordset information available. See page 655.

Brackets

T8

pg. 625

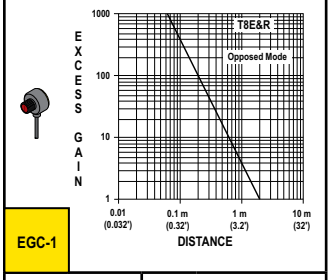
SMB8MM

Additional bracket information available. See page 601.

Excess Gain Curves (Diffuse mode performance based on 90% reflectance white test card)

● = Visible Red LED

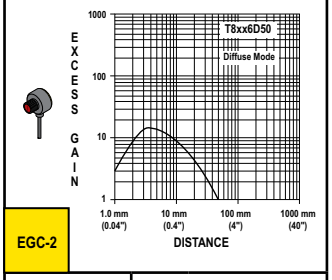
Opposed Mode T8



EGC-1

Range: 2 m **LED:** ●

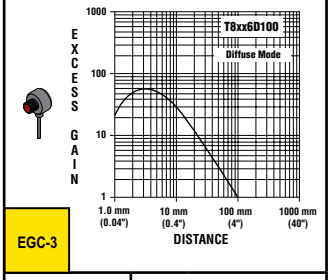
Diffuse Mode T8



EGC-2

Range: 50 m **LED:** ●

Diffuse Mode T8



EGC-3

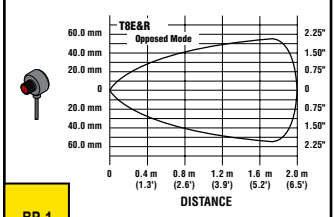
Range: 100 mm **LED:** ●

Beam Patterns (Diffuse mode performance based on 90% reflectance white test card)

● = Visible Red LED

Opposed Mode T8

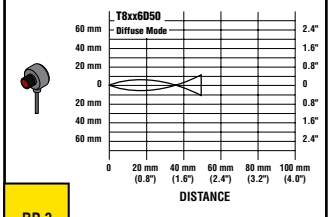
Effective Beam: 4.3 mm



BP-1

Range: 2 m **LED:** ●

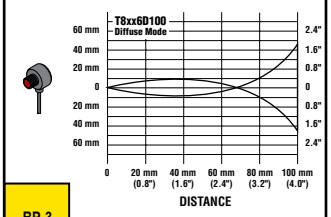
Diffuse Mode T8



BP-2

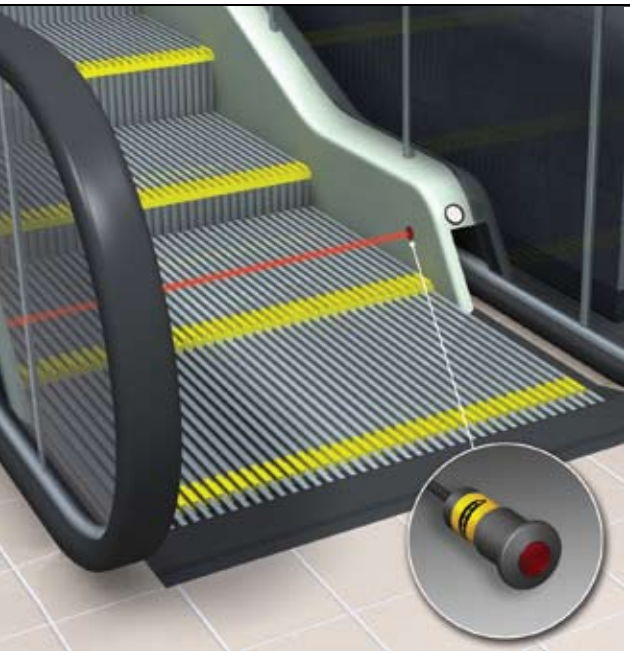
Range: 50 mm **LED:** ●

Diffuse Mode T8



BP-3

Range: 100 mm **LED:** ●

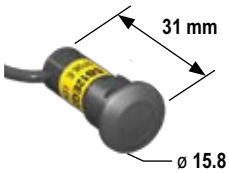


S12 & SB12

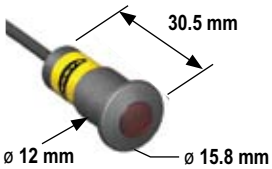
Opposed-Mode Barrel-Mount Sensors

- S12 threaded housing for heavy-duty industrial sensing
  - Rugged IP67-rated housinig
  - Reliable sensing up to 15 m
- Economical, SB12/SB12T sensors for people detection applications in escalators, turnstiles and ticket booths
  - SB12 snap-barrel housing for applications where mounting holes are precisely located and formed, and sensor can be hidden behind a protective window
  - SB12T threaded housing for robust mounting in applications with vibration, rough handling or vandalism
  - Narrow beam for reliable operation of multiple sensors in close proximity
  - Reliable short-range detection up to 1.5 m

S12
Opposed Models



SB12
Opposed Models



SB12T
Opposed Models

ONLINE
AUTOCAD, STEP, IGES & PDF

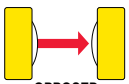
Photoelectrics Sensors
Fiber Optic Sensors
Special Purpose Sensors
Measurement & Inspection Sensors
Vision
Wireless
Indicators
Safety Light Screens
Safety Laser Scanners
Fiber Optic Safety Systems
Safety Controllers & Modules
Safety Two-Hand Control Modules
Safety Interlock Switches
Emergency Stop Devices

ACCESSORIES page 79

MINIATURE
WORLD-BEAM Q12
M12
T8
S12/SB12
VS2
VS3
COMPACT
MIDSIZE
FULLSIZE

S12, 10-30V dc

Visible Red LED

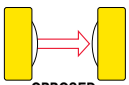
Sensing Mode/LED	Range	Connection	Models NPN	Models PNP	Excess Gain	Beam Pattern
 OPPOSED	15 m	2 m	S126E		EGC-1 (p. 79)	BP-1 (p. 79)
		2 m	S12SN6R	S12SP6R		

Connection options: A model with a QD requires a mating cordset (see page 79).

QD models: For a 4-pin 150 mm Pico-style pigtail QD, add suffix **QP** (example, **S12SN6RQP**).

SB12, 10-30V dc

Infrared Red LED

Sensing Mode/LED	Range	Connection	Output	Models NPN	Models PNP	Excess Gain	Beam Pattern
 OPPOSED	1.5 m	2 m	–	SB12E1		—	BP-2 (p. 79)
			LO	SB12ANR	SB12APR		
			DO	SB12RNR	SB12RPR		

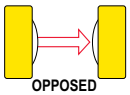
Connection options: A model with a QD requires a mating cordset (see page 79).

QD models: For a 3-pin 150 mm Pico-style pigtail QD, add suffix **Q3** (example, **SB12E1Q3**).

ACCESSORIES page 79

SB12T, 10-30V dc

Infrared Red LED

Sensing Mode/LED	Range	Connection	Output	Models NPN	Models PNP	Excess Gain	Beam Pattern
 OPPOSED	1.5 m	2 m	–	SB12TE1		—	BP-2 (p. 79)
			LO	SB12TANR	SB12TAPR		
			DO	SB12TRNR	SB12TRPR		

Connection options: A model with a QD requires a mating cordset (see page 79).

QD models: For a 3-pin 150 mm Pico-style pigtail QD, add suffix **Q3** (example, **SB12TE1Q3**).

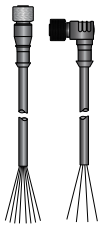
S12/SB12 Specifications

Supply Voltage and Current	**S12:** 10 to 30V dc (10% max. ripple); 25 mA (emitters) or 20 mA (receivers) exclusive of load **SB12/SB12T:** 10 to 30V dc; less than 15 mA max exclusive of load
Supply Protection Circuitry	Protected against reverse polarity and transient voltages
Output Configuration	**SB12/SB12T:** One solid state output, NPN (sinking) or PNP (sourcing), depending on model **S12:** Complementary solid-state dc switch; choose NPN (current sinking) or PNP (current sourcing) models **Light operate:** N.O. output conducts when the sensor sees the emitter's modulated light **Dark operate:** N.C. output conducts when the sensor sees dark; The N.C. (normally closed) output may be wired as a normally open marginal signal alarm output, depending upon hookup to the power supply
Output Ratings	**S12:** 100 mA maximum (each) in standard hookup; when wired for alarm output, the total load may not exceed 100 mA **OFF-state leakage current:** less than 1 µA @ 30V dc **ON-state saturation voltage:** less than 1V @ 10 mA; less than 1.5V @ 150 mA **SB12/SB12T:** 100 mA **OFF-state leakage current:** < 10 µA **ON-state saturation voltage:** < 0.2V @ 10 mA; < 0.6V @ 100 mA
Output Protection Circuitry	Protected against false pulse on power-up and continuous overload or short circuit of outputs
Output Response Time	**S12:** 3 milliseconds ON, 1.5 milliseconds OFF **SB12/SB12T:** 2.5 milliseconds ON, 1.75 milliseconds OFF
Delay at Power-up	**S12**: 100 millisecond; outputs are non-conducting during this time. **SB12/SB12T**: Less than 1 second delay on power-up.
Repeatability	**S12:** 375 microseconds **SB12/SB12T:** 350 microseconds
Switching Frequency	**SB12/SB12T:** 235 Hz
Indicators	**Green LED (emitter and receiver):** power ON **Amber LED (receiver only):** light sensed
Construction	**S12:** Housings are reinforced thermoplastic polyester; lenses are Lexan®; Polyurethane end cap **SB12/SB12T: Housing:** ABS **Lens:** Polycarbonate; epoxy encapsulant **Cable:** PVC-jacketed
Environmental Rating	**S12:** Leakproof design rated NEMA 6P (IEC IP67) **SB12:** IP65 **SB12T:** IP67
Connections	**S12:** 2 m or 9 m cable, or a 150 mm pigtail with 4-pin Pico-style QD **SB12/SB12T:** 2 m cable or 150 mm pigtail with 3-pin Pico-style QD QD cordset ordered separately. See page 79.
Operating Conditions	**S12: Temperature:** -40° to +70° C **Maximum relative humidity:** 90% at 50°C (non-condensing) **SB12/SB12T: Temperature:** -20° to +50° C
Vibration and Mechanical Shock	**S12:** Meets Mil. Std. 202F requirements. Method 201A (Vibration: frequency 10 to 60 Hz, max., double amplitude 0.06-inch acceleration 10G). Method 213B conditions H&I (Shock: 75G with unit operating; 100G for non-operation).
Certifications	CE
Hookup Diagrams	**Emitters:** DC02 (p. 716) **S12 Receivers NPN:** DC05 (p. 717) **S12 Receivers PNP:** DC06 (p. 717) **SB12/SB12T Receivers:** DC01 (p. 716)

Lexan® is a registered trademark of General Electric Co.

Cordsets

Pico QD		
See page 655		
Length	Threaded 3-Pin	
	Straight	Right-Angle
2 m	PKG3M-2	PKW3M-2
5 m	PKG3M-5	PKW3M-5
7 m	PKG3M-7	—
9 m	PKG3M-9	PKW3M-9
10 m	PKG3M-10	—



Pico QD		
See page 657		
Length	Snap-on 4-Pin	
	Straight	Right-Angle
2 m	PKG4-2	PKW4Z-2

Additional cordset information available. See page 655.

Brackets

S12

pg. 616

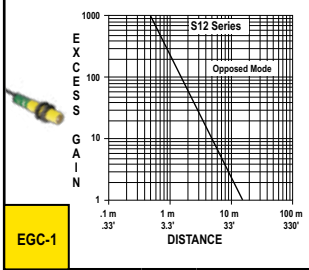
SMB12MM

Additional bracket information available. See page 601.

Excess Gain Curves

● = Visible Red LED

Opposed Mode S12



EGC-1

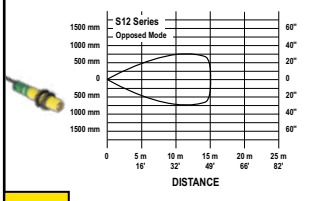
Range: 15 m | **LED:** ●

Beam Patterns

● = Visible Red LED ○ = Infrared LED

Opposed Mode S12

Effective Beam: 8.1 mm

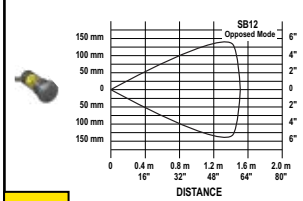


BP-1

Range: 15 m | **LED:** ●

Opposed Mode SB12/SB12T

Effective Beam: 8.3 mm

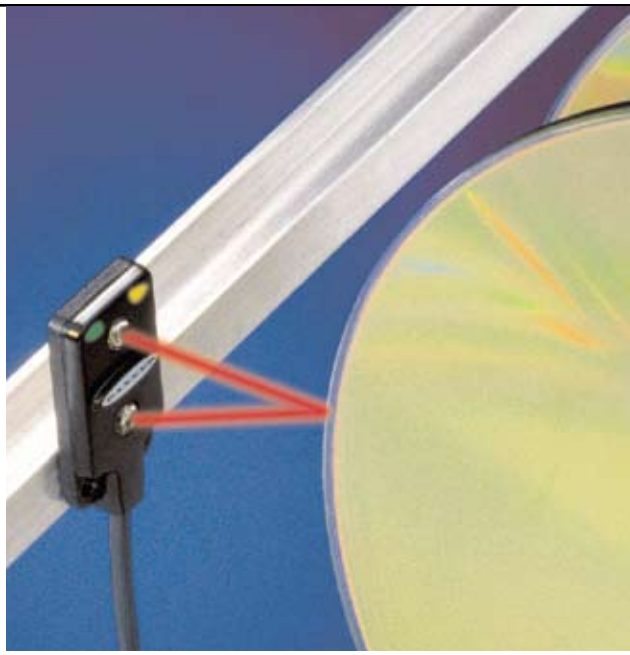


BP-2

Range: 1.5 m | **LED:** ○

VS2
Ultra-Thin Miniature Sensors

- Features EZ-BEAM® technology, with specially designed optics and electronics for reliable sensing without adjustments
- Available in opposed and convergent modes
- Ideal as a low-cost, high-quality miniaturized solution for confined areas
- Available in dark- or light-operate models
- Offers flat front mounting or optional bracket

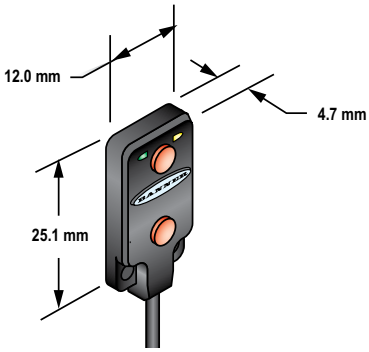


ACCESSORIES page 82

OPPOSED

CONVERGENT

Opposed Models
Suffix E and R



Convergent Models
Suffix C

ONLINE
AUTOCAD, STEP, IGES & PDF

VS2, 10-30V dc

Visible Red LED Infrared LED

Sensing Mode/LED	Range	Connection	Output Type	Models† NPN	Models† PNP	Excess Gain	Beam Pattern
OPPOSED	Optimum up to 600 mm, 1.2 m max.	2 m	—	VS25EV Emitter		EGC-1 (p. 82)	BP-1 (p. 82)
		3-Pin Pico Pigtail QD		VS25EVQ Emitter			
		2 m	LO	VS2AN5R	VS2AP5R		
		3-Pin Pico Pigtail QD		VS2AN5RQ	VS2AP5RQ		
		2 m	DO	VS2RN5R	VS2RP5R		
		3-Pin Pico Pigtail QD		VS2RN5RQ	VS2RP5RQ		
OPPOSED	3.0 m	2 m	—	VS25E Emitter		EGC-2 (p. 82)	BP-2 (p. 82)
		3-Pin Pico Pigtail QD		VS25EQ Emitter			
		2 m	LO	VS2AN5R	VS2AP5R		
		3-Pin Pico Pigtail QD		VS2AN5RQ	VS2AP5RQ		
		2 m	DO	VS2RN5R	VS2RP5R		
		3-Pin Pico Pigtail QD		VS2RN5RQ	VS2RP5RQ		

More on next page

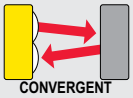
Connection options: A model with a QD requires a mating cordset (see page 82).

For 9 m cable, add suffix **W/30** to the 2 m model number (example, **VS2RP5R W/30**).

† Opposed-mode models also sold as pairs. Contact factory for more information 1-888-373-6767.

VS2, 10-30V dc (cont'd)

Visible Red LED

Sensing Mode/LED	Range	Connection	Output Type	Models† NPN	Models† PNP	Excess Gain	Beam Pattern
 CONVERGENT	15 mm ±5 mm	2 m	LO	**VS2AN5CV15**	**VS2AP5CV15**	EGC-3 (p. 82)	BP-3 (p. 82)
		3-Pin Pico Pigtail QD		**VS2AN5CV15Q**	**VS2AP5CV15Q**		
		2 m	DO	**VS2RN5CV15**	**VS2RP5CV15**		
		3-Pin Pico Pigtail QD		**VS2RN5CV15Q**	**VS2RP5CV15Q**		
	30 mm ±10 mm	2 m	LO	**VS2AN5CV30**	**VS2AP5CV30**	EGC-4 (p. 82)	BP-4 (p. 82)
		3-Pin Pico Pigtail QD		**VS2AN5CV30Q**	**VS2AP5CV30Q**		
		2 m	DO	**VS2RN5CV30**	**VS2RP5CV30**		
		3-Pin Pico Pigtail QD		**VS2RN5CV30Q**	**VS2RP5CV30Q**		

Connection options: A model with a QD requires a mating cordset (see page 82).

For 9 m cable, add suffix **W/30** to the 2 m model number (example, **VS2RP5R W/30**).

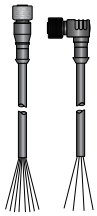
† Opposed-mode models also sold as pairs. Contact factory for more information 1-888-373-6767.

VS2 Specifications

Supply Voltage and Current	10 to 30V dc (10% max. ripple) at less than 25 mA (exclusive of load)
Supply Protection Circuitry	Protected against reverse polarity and transient voltages
Output Configuration	Solid-state switch NPN (current sinking) or PNP (current sourcing), depending on model Light Operate (LO) or Dark Operate (DO), depending on model
Output Rating	50 mA max. **OFF-state leakage current:** less than 1 µA at 24V dc **ON-state saturation voltage:** less than 0.25V at 10 mA dc; less than 0.5V at 50 mA dc
Output Protection Circuitry	Protected against false pulse on power-up and continuous overload or short circuit of outputs Overload trip point ≥ 100 mA
Output Response Time	**Opposed:** 1 millisecond ON; 0.5 millisecond OFF **Convergent:** 1 millisecond ON; OFF
Delay at Power-up	Maximum 100 millisecond (opposed) and 150 millisecond (convergent); output does not conduct during this time.
Repeatability	**Opposed:** 100 microseconds **Convergent:** 160 microseconds
Indicators	**Two LEDs:** **Green:** power ON **Yellow:** light sensed
Construction	**Opposed:** Black ABS housing with clear MABS lens **Convergent:** Black ABS housing with acrylic lens
Environmental Rating	IEC IP67; NEMA 6
Connections	2 m or 9 m attached cable, 3-wire with PVC outer cable jacket; or 150 mm pigtail with 3-pin Pico-style quick-disconnect fitting. QD cordsets are ordered separately. See page 82.
Operating Conditions	**Temperature:** -20° to +55° C **Relative humidity:** 80% at 50° C (non-condensing)
Vibration and Mechanical Shock	**Vibration:** All models meet IEC 60068-2-6, IEC 60947-5-2, UL491 Section 40, MIL-STD-202F Method 201A; 10 to 60 Hz, 0.5 mm peak to peak **Shock:** All models meet IEC 60068-2-27, IEC 60947-5-2; 30g peak acceleration, 11 millisecond pulse duration, half-sine wave pulse shape
Application Notes	M2 stainless steel mounting hardware is included. Optional mounting brackets are available. See page 82.
Certifications	CE
Hookup Diagrams	**Emitters:** DC02 (p. 716) **All others**: DC01 (p. 716)

Cordsets

Pico QD		
See page 655		
	Threaded 3-Pin	
Length	Straight	Right-Angle
2 m	PKG3M-2	PKW3M-2
5 m	PKG3M-5	PKW3M-5
7 m	PKG3M-7	—
9 m	PKG3M-9	PKW3M-9
10 m	PKG3M-10	—



Additional cordset information available. See page 655.

Brackets

VS2

pg. 651

SMBVS2RA

Additional bracket information available. See page 601.

APERTURES

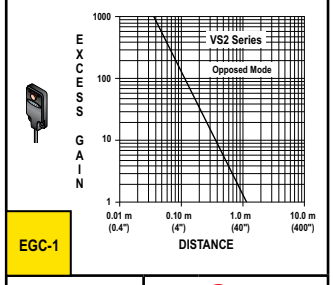
PAGE 709

Excess Gain Curves

(Convergent mode performance based on 90% reflectance white test card)

● = Visible Red LED ○ = Infrared LED

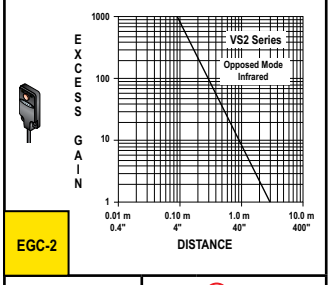
Opposed Mode VS2



EGC-1

Range: 1.2 m **LED:** ●

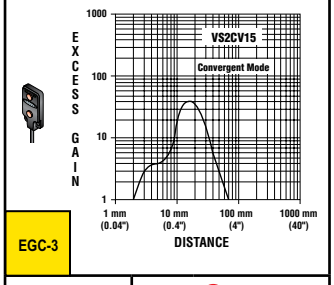
Opposed Mode VS2



EGC-2

Range: 3 m **LED:** ○

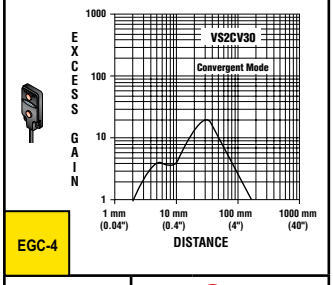
Convergent Mode VS2



EGC-3

Range: 15 mm **LED:** ●

Convergent Mode VS2



EGC-4

Range: 30 mm **LED:** ●

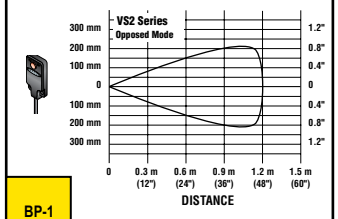
Beam Patterns

(Convergent mode performance based on 90% reflectance white test card)

● = Visible Red LED ○ = Infrared LED

Opposed Mode VS2

Effective Beam: 3 mm

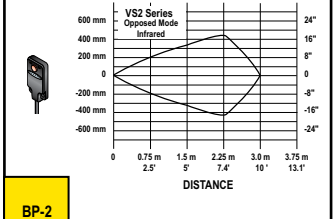


BP-1

Range: 1.2 m **LED:** ●

Opposed Mode VS2

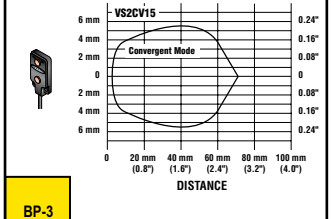
Effective Beam: 3 mm



BP-2

Range: 3 m **LED:** ○

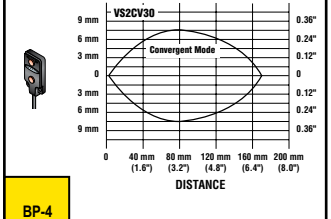
Convergent Mode VS2



BP-3

Range: 15 mm **LED:** ●

Convergent Mode VS2



BP-4

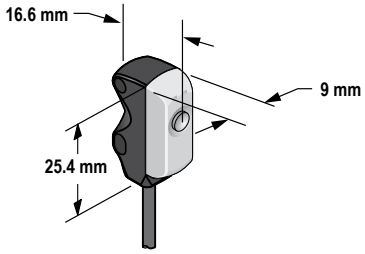
Range: 30 mm **LED:** ●

VS3
Miniature Sensors with Advanced Optics

- Features EZ-BEAM® technology, with specially designed optics and electronics for reliable sensing without adjustments
- Offers extremely compact self-contained miniature design
- Available in opposed and retroreflective sensing modes
- Uses coaxial optics on retroreflective models to eliminate blind areas at close range
- Accurately detects shiny objects
- Features visible sensing beam for easy alignment
- Available in dark- or light-operate models

ACCESSORIES page 85

Opposed, Non-Polarized Retroreflective Models
Suffix R, EV and LV



Polarized Retroreflective Models
Suffix LP

ONLINE
AUTOCAD, STEP, IGES & PDF

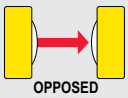
OPPOSED

COAXIAL RETRO

P COAXIAL POLAR RETRO

VS3, 10-30V dc

Visible Red LED

Sensing Mode/LED	Range	Connection	Output Type	Models† NPN	Models† PNP	Excess Gain	Beam Pattern
 OPPOSED	1.2 m	2 m	—	VS35EV Emitter		EGC-1 (p. 85)	BP-1 (p. 85)
		3-Pin Pico QD		VS35EVQ Emitter			
		2 m	LO	VS3AN5R	VS3AP5R		
		3-Pin Pico QD		VS3AN5RQ	VS3AP5RQ		
		2 m	DO	VS3RN5R	VS3RP5R		
		3-Pin Pico QD		VS3RN5RQ	VS3RP5RQ		

More on next page

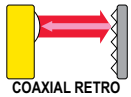
Connection options: A model with a QD requires a mating cordset (see page 85).

For 9 m cable, add suffix **W/30** to the 2 m model number (example, **VS3AN5XLV W/30**).

† Opposed-mode models also sold as pairs. Contact factory for more information 1-888-373-6767.

VS3, 10-30V dc (cont'd)

Visible Red LED

Sensing Mode/LED	Range	Connection	Output Type	Models NPN	Models PNP	Excess Gain	Beam Pattern
 COAXIAL RETRO	250 mm†	2 m	LO	**VS3AN5XLV**	**VS3AP5XLV**	EGC-2 (p. 85)	BP-2 (p. 85)
		3-Pin Pico QD		**VS3AN5XLVQ**	**VS3AP5XLVQ**		
		2 m	DO	**VS3RN5XLV**	**VS3RP5XLV**		
		3-Pin Pico QD		**VS3RN5XLVQ**	**VS3RP5XLVQ**		
 COAXIAL POLAR RETRO	250 mm†	2 m	LO	**VS3AN5XLP**	**VS3AP5XLP**	EGC-2 (p. 85)	BP-2 (p. 85)
		3-Pin Pico QD		**VS3AN5XLPQ**	**VS3AP5XLPQ**		
		2 m	DO	**VS3RN5XLP**	**VS3RP5XLP**		
		3-Pin Pico QD		**VS3RN5XLPQ**	**VS3RP5XLPQ**		

Connection options: A model with a QD requires a mating cordset (see page 85).

For 9 m cable, add suffix **W/30** to the 2 m model number (example, **VS3AN5XLV W/30**).

† Retroflective range is specified using one model BRT-32X20AM retroreflector. Actual sensing range may differ, depending on efficiency and reflective area of the retroreflector in use. See accessories for more information.

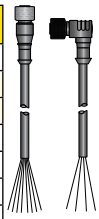
ACCESSORIES page 85

VS3 Specifications

Supply Voltage and Current	10 to 30V dc (10% max. ripple) at less than 25 mA (exclusive of load)
Supply Protection Circuitry	Protected against reverse polarity and transient voltages
Output Configuration	Solid-state switch NPN (current sinking) or PNP (current sourcing), depending on model Light Operate (LO) or Dark Operate (DO), depending on model
Output Protection Circuitry	Protected against false pulse on power-up and continuous overload or short circuit of outputs. Overload trip point ≥ 100 mA
Output Rating	50 mA max. **OFF-state leakage current:** less than 1 µA at 24V dc **ON-state saturation voltage:** less than 0.25V at 10 mA dc; less than 0.5V at 50 mA dc
Output Response Time	**Opposed:** 1 millisecond ON; 0.5 millisecond OFF **Retroreflective:** 1 millisecond ON/OFF
Delay at Power-up	Maximum 100 millisecond (opposed mode) and 150 millisecond (retroreflective); output does not conduct during this time.
Repeatability	**Opposed:** 100 microseconds **Retroreflective:** 160 microseconds
Indicators	**Two LEDs:** **Green:** power ON **Yellow:** light sensed
Construction	**Opposed and Non-polarized Retroreflective:** Black ABS housing with acrylic lens **Polarized Retroreflective:** Black ABS housing with glass lens and acrylic cover
Environmental Rating	IEC IP67; NEMA 6
Connections	2 m or 9 m attached cable, 3-wire with PVC outer cable jacket; or 3-pin Pico-style quick-disconnect fitting. QD cordsets are ordered separately. See page 85.
Operating Conditions	**Temperature:** -20° to +55° C **Relative humidity:** 80% at 50° C (non-condensing)
Vibration and Mechanical Shock	**Vibration:** All models meet IEC 60068-2-6, IEC 60947-5-2, UL491 Section 40, MIL-STD-202F Method 201A; 10 to 60 Hz, 0.5 mm peak to peak **Shock:** All models meet IEC 60068-2-27, IEC 60947-5-2; 30g peak acceleration, 11 millisecond pulse duration, half-sine wave pulse shape
Application Notes	M3 stainless steel mounting hardware is included. Optional mounting brackets are available. See page 85.
Certifications	CE
Hookup Diagrams	**Emitters:** DC02 (p. 716) **All others:** DC01 (p. 716)

Cordsets

Pico QD		
See page 655		
Length	Threaded 3-Pin	
	Straight	Right-Angle
2 m	PKG3M-2	PKW3M-2
5 m	PKG3M-5	PKW3M-5
7 m	PKG3M-7	—
9 m	PKG3M-9	PKW3M-9
10 m	PKG3M-10	—



Additional cordset information available. See page 655.

Brackets

VS3	
	
pg. 652	pg. 652
SMBVS3S	SMBVS3T

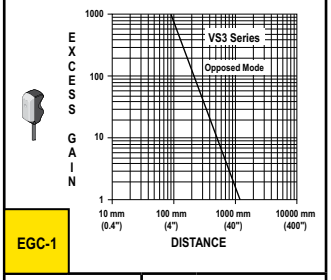
Additional bracket information available. See page 601.

REFLECTORS
PAGE 684

Excess Gain Curves

● = Visible Red LED P = Visible Red LED Polarized

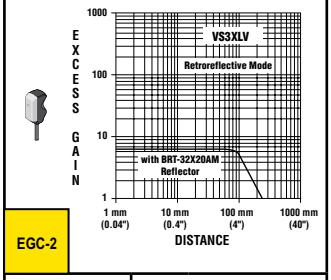
Opposed Mode VS3



EGC-1

Range: 1.2 m **LED:** ●

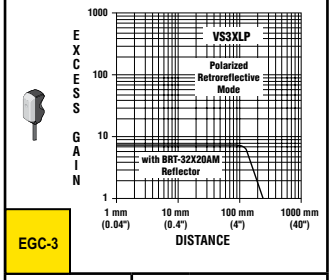
Retroreflective Mode VS3



EGC-2

Range: 250 mm **LED:** ●

Polarized Retroreflective Mode VS3



EGC-3

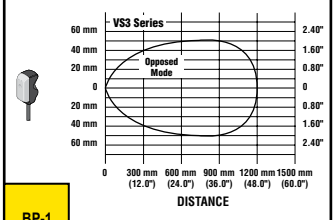
Range: 250 mm **LED:** P

Beam Patterns

● = Visible Red LED P = Visible Red LED Polarized

Opposed Mode VS3

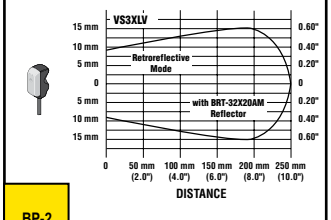
Effective Beam: 3 mm



BP-1

Range: 1.2 m **LED:** ●

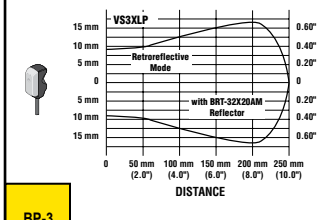
Retroreflective Mode VS3



BP-2

Range: 250 mm **LED:** ●

Polarized Retroreflective Mode VS3



BP-3

Range: 250 mm **LED:** P