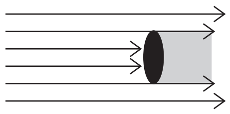
Operating Principles

(1) Properties of Light

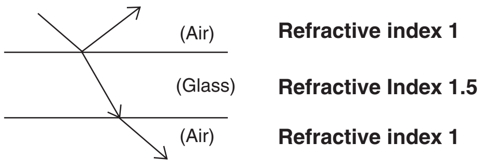
Rectilinear Propagation

When light travels through air or water, it always travels in a straight line. The slit on the outside of a Through-beam Sensor that is used to detect small objects is an example of how this principle is applied to practical use.



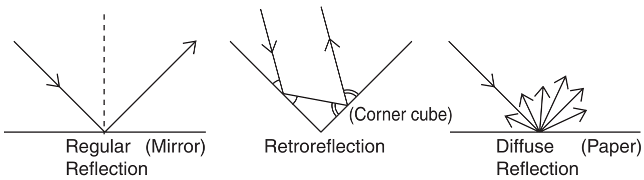
Refraction

Refraction is the phenomenon of light being deflected as it passes obliquely through the boundary between two media with different refractive indices.



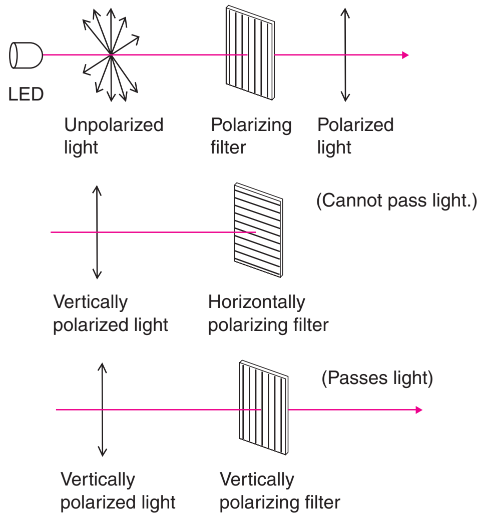
Reflection (Regular Reflection, Retroreflection, Diffuse Reflection)

A flat surface, such as glass or a mirror, reflects light at an angle equal to the incident angle of the light. This kind of reflection is called regular reflection. A corner cube takes advantage of this principle by arranging three flat surfaces perpendicular to each other. Light emitted toward a corner cube repeatedly propagates regular reflections and the reflected light ultimately moves straight back toward the emitted light. This is referred to as retroreflection.
Most retroreflectors are comprised of corner cubes that measure several square millimeters and are arranged in a precise configuration.
Matte surfaces, such as white paper, reflect light in all directions. This scattering of light is called diffuse reflection. This principle is the sensing method used by Diffuse-reflective Sensors.



Polarization of Light

Light can be represented as a wave that oscillates horizontally and vertically. Photoelectric Sensors almost always use LEDs as the light source. The light emitted from LEDs oscillates in the vertical and horizontal directions and is referred to as unpolarized light. There are optical filters that constrain the oscillations of unpolarized light to just one direction. These are known as polarizing filters. Light from an LED that passes through a polarizing filter oscillates in only one direction and is referred to as polarized light (or more precisely, linear polarized light). Polarized light oscillating in one direction (say the vertical direction) cannot pass through a polarizing filter that constrains oscillations to a perpendicular direction (e.g., the horizontal direction). The MSR function on Retro-reflective Sensors (see page 15) and the Mutual Interference Protection Filter accessory for Through-beam Sensors operate on this principle.

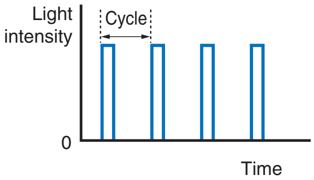


(2) Light Sources

Light Generation

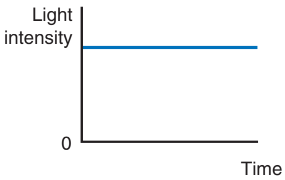
<Pulse Modulated light>

The majority of Photoelectric Sensors use pulse modulated light that basically emits light repeatedly at fixed intervals. They can sense objects located some distance away because the effects of external light interference are easily removed with this system. In models equipped with mutual interference protection, the emission cycle is varied within a specified range to handle coherent light and external light interference.

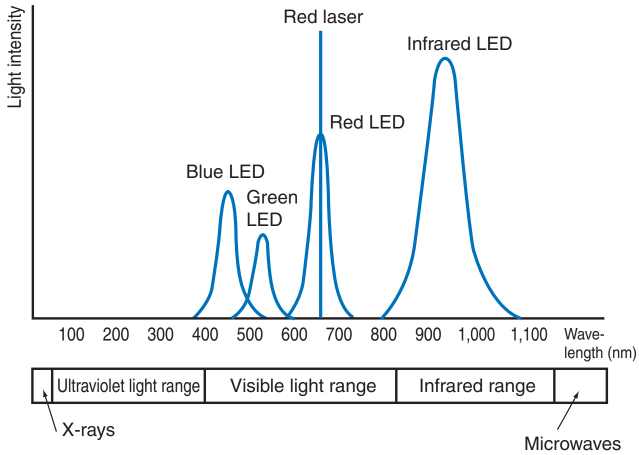


<Non-modulated Light>

Non-modulated light refers to an uninterrupted beam of light at a specific intensity that is used with certain types of Sensors, such as Mark Sensors. Although these Sensors have fast response times, their drawbacks include short sensing distances and susceptibility to external light interference.



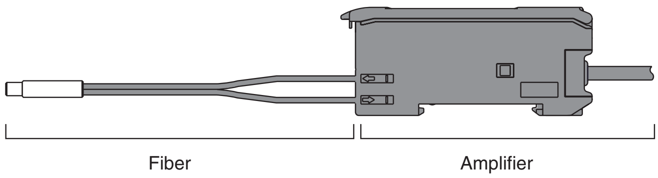
Light Source Color and Type



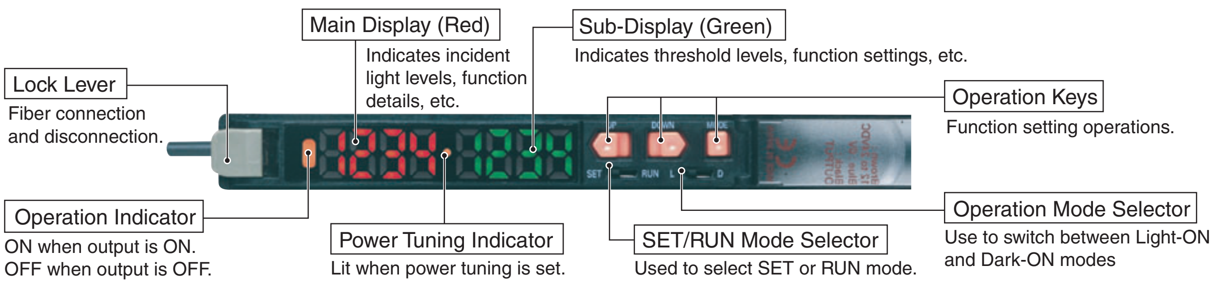
(3) Optical Fiber Sensors

Structure

With no electrical components in the sensing section (fiber), the Optical Fiber Sensor is highly resistant to noise and other environmental influences.

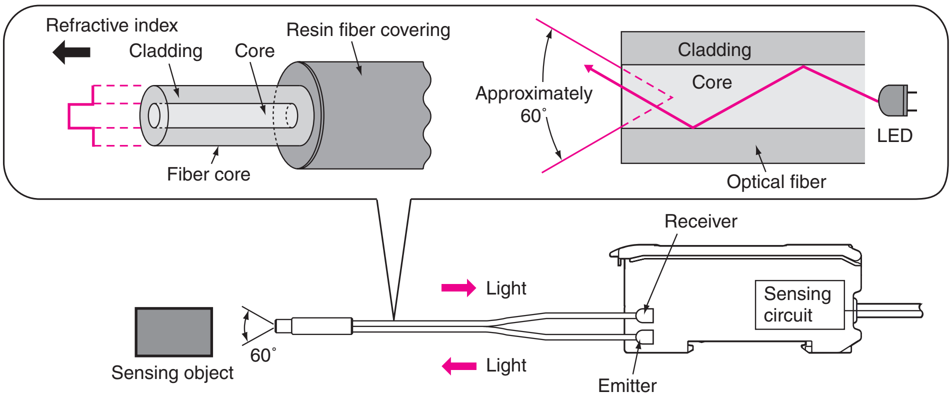


E3X-DA-S Digital Amplifier

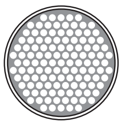
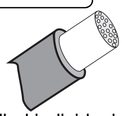
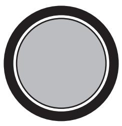
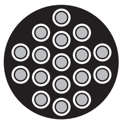
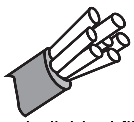


Detection Principles

Optical fiber is comprised of a central core with a high refractive index surrounded by cladding with a low refractive index. When light enters the core, repetitive total internal reflection at the boundary of the less refractive cladding guides the light down the optical fiber. The angle of the light traveling through the optical fiber increases to about 60° by the time the light exits the fiber and strikes a sensing object.



Optical Fiber Types and Characteristics

Cross section	Structure	Characteristics	Effective applications	Typical models
Flexible type (Multi-core) 	**New standard**  (Bundled individual fibers)	• Bending does not almost affect light intensity. • Allowable bend radius:1 mm	Compared to conventional Fibers: • As easy to install as soft electrical wiring. • Never have to worry about the bending radius. • Touching fibers does not affect light intensity.	E32-T11R E32-D11R
Standard type (single core) 		• Efficient light transmission at relatively long sensing distances • Allowable bend radius: 10 or 25 mm		E32-TC200 E32-DC200
Robot type (bundled) 	 (Loose individual fibers)	• Excellent bending-resistance characteristics Repeated bending: 1,000,000 times min. (typical example) • Allowable bending radius: 4 mm	• Resists damage when attached to moving parts, such as robot hands.	E32-T11 E32-D11

(4) Triangulation

Distance-settable Sensors generally operate on the principle of triangulation. This principle is illustrated in the following diagram.
Light from the Emitter strikes the sensing object and reflects diffused light. The Receiver lens concentrates the reflected light on the position detector (a semiconductor that outputs a signal according to where the light strikes it). When the sensing object is located at A near the optical system, then the light is concentrated at point a on the position detector. When the sensing object is located at B away from the optical system, then the light is concentrated at point b on the position detector.