BALLUFF

ANALOG DISTANCE MEASUREMENT PHOTOELECTRIC SENSORS

White Paper

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This white paper discusses two powerful distance measurement photoelectric sensor technologies: triangulation and time-of-flight.

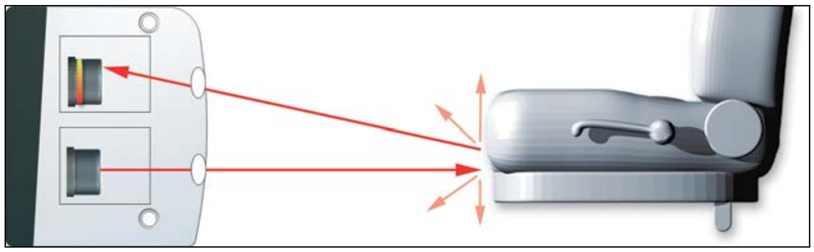
The Rise of Photoelectric Measurement Sensing

Now that high performance sensors are more affordable than ever, many manufacturers today are looking for ways to improve their industrial process control without investing a lot of time and money. Measurement sensing technology has stabilized in price due to manufacturing improvements and increases in production volume. This means that continuous position feedback can be implemented at a reasonable cost, thus allowing process owners a new level of flexibility and control to create highly profitable solutions.

Modern photoelectric sensors offer more useful industrial solutions handling a wider range of functions than ever before. The longer range characteristics of contemporary photoelectric sensors have enabled new designs to operate in environments that would have destroyed conventional photoelectric designs just a few years ago. Advancements in emitters, receivers, lenses, and processing circuits have led to products with not only longer ranges, but better resolution and higher switching frequencies too.

Measurement Using Triangulation

Distance measurement photoelectric sensors utilizing triangulation technology use the laws of geometry to assess how far a target is from the sensor. In the diagram below, the emitter is sending light towards the target through its outgoing lens. The target reflects light back to the receiver, and as its position changes, so does the angle at which the light comes back through the receiving lens. This returned light will strike the receiving element at a different position based on how far away the target is from the sensor. Processing electronics convert this position into a highly accurate analog output.

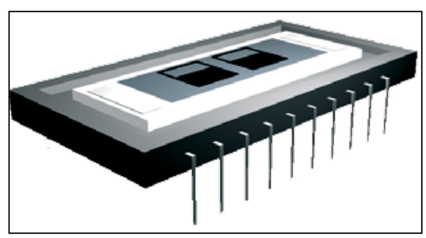


Distance sensing using triangulation

Sensors with this technology are capable of long sensing ranges, limited only by the size of the lenses and the separation between the emitter and receiver in the sensor housing. The emitters for these types of sensors are typically standard visible red or highly focused laser LEDs. Resolution is directly related to the receiving element's ability to discriminate the angles of incoming light. The two most common types of receiver elements found in these sensors are the PSD (Position Sensitive Device) and the CCD (Charged-Coupled Device).

Position Sensitive Devices (PSDs)

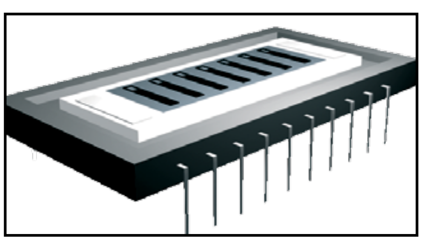
In general terms, position sensitive devices are diodes with extended light-sensitive surfaces. When light strikes the diode, it converts this energy into electrical current which is divided into two parts, based on the point on the diode where the light strikes. A processing circuit then converts these partial currents into the analog output of the sensor.



Typical PSD element: Light-sensitive edges are oriented to maximize light capture

Charged-Coupled Devices (CCDs)

Unlike PSDs, which are a single sensing element, charged-coupled devices are an array of detectors with capacitors connected to each element. The presence of light on the detector causes the capacitor to charge. Independent of this light detection, a processing circuit is continuously cycling through the detectors looking for a change in intensity at each element. This distribution of the light intensity on the array is then converted to the analog output signal.



Typical CCD element: Sensing elements are laid side-by-side to form an array

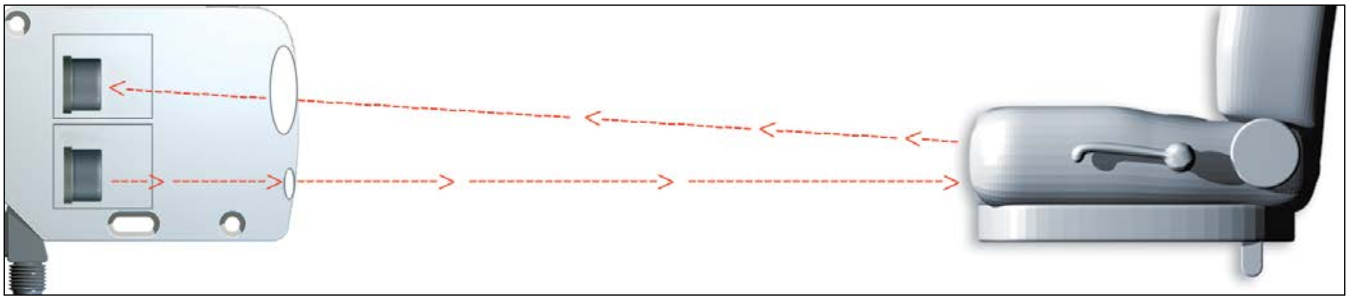
The question of performance between PSDs and CCDs has been the source of debate for many manufacturers and customers alike. Both technologies have been continuously improved for many years and are very effective at providing an accurate measurement of the distance to a target. The key differences between the two technologies are:

- PSDs are best for applications that require a faster response time.
- CCDs are best for applications that require a better resolution.

There is also a trade-off for resolution versus sensing range, independent of the receiving element used. Generally speaking, the longer the range, the less resolution that is achievable.

Time-of-Flight Measurement Sensing

A newer technology available in the market today is called time-of-flight sensing. Working similarly to RADAR, these laser sensors emit a light waveform with specific characteristics that can be marked. This light travels from the sensor, reflects off the target, and returns. The amount of time it takes for the light to make this trip is recorded from the marked waveform, and the processing electronics convert this to an analog output.



Distance sensing using time-of-flight

Time-of-flight sensing offers the best balance of long range sensing and high resolution. Laser emitters are used in time-of-flight sensing because of the required high switching frequency and the need for a tightly defined beam to maximize distance. The difficult task of receiving these light waves are left to a special type of detector called an avalanche photodiode (APD), which features a high degree of internal amplification. Leading sensor companies offer a number of photoelectric sensing families that utilize the latest versions of triangulation and time-of-flight sensors.

A summary of typical performance characteristics is below:

Sensing Type	PSD, CCD, or APD	Max. Sensing Range	Max. Resolution	Switching Frequency
Triangulation	PSD	85 mm	20 µm	400 Hz
Triangulation	PSD	300 mm	1 mm	1 kHz
Triangulation	CCD	2 m	0.5 mm	100 Hz
Time-of-Flight	APD	6 m	1 mm	250 Hz

The Bottom Line

Common applications for these technologies include part contouring, roll diameter measurement, positioning of assemblies, thickness detection, and bin level measurement. Today's industrial measurement photoelectric sensors are finding new applications in manufacturing environments across the country.

Balluff Inc., the U.S. subsidiary of Balluff GmbH & Co., Neuhausen, Germany, is a leading manufacturer of a wide range of inductive, optical, capacitive, and magnetic sensors as well as linear position transducers and ID systems. Balluff products for OEM and factory floor solutions are used to control, regulate, automate, assemble, position, and monitor manufacturing, assembly, and packing sequences for industries including metalworking, automotive, packaging, material handling, wood processing, aerospace, electrical, and electronics. For more information, go to www.balluff.com

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