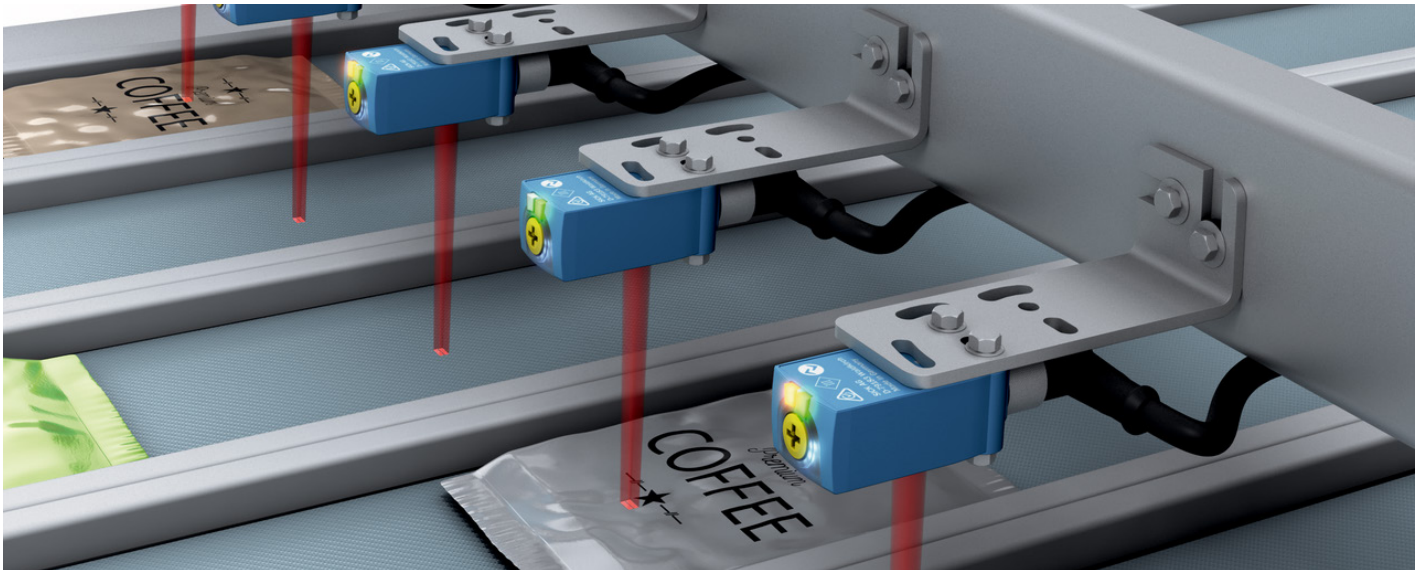
WHITE PAPER

INTELLIGENT OPTO-ELECTRONIC SENSORS AID IN DIGITAL TRANSFORMATION OF MACHINES AND PLANTS

How miniature photoelectric sensors of the next generation simplify commissioning and digital data transmission for more flexible and efficient processes

SICK
Sensor Intelligence.



Introduction

The digitalization of machines and plants require intelligent opto-electronic sensors. Such sensors must be able to master difficult and challenging applications, and also serve the requirements of digital transformation by supplying diagnostic and process data. Many applications are difficult and complex enough to need special sensor technology. Sensors must be able to provide status and process information not only for automation systems, but also for higher-level applications and digital services with the help of IO-Link communication technology.

Smart and user-friendly sensors work well in applications requiring independent execution of functions such as distance measurement, temperature monitoring, occupancy control of containers, or counting of operating hours. Tight assembly space is a decisive constraint in many machines and plants, which often only permits the use of miniature sensors. At the same time, performance parameters – high range and sensing distances, minimized black/white shift, active background suppression – are required that could previously only be met by larger sensors. The difficult and challenging applications are served with new optics concepts, newly developed sender LEDs, and the ASIC platform of the fifth generation. This has made it possible to integrate the performance of larger sensor series into new miniature photoelectric sensors of the next generation.

State-of-the-Art Miniature Photoelectric Sensors

The miniature photoelectric sensor market is populated by about a dozen manufacturers and product series. As a rule, all suppliers offer the basic principles of operation of through-beam photoelectric sensors, photoelectric retro-reflective sensors, and photoelectric proximity sensors. From a technical point of view, most devices offer standard functionalities, including:

- Various switching distances (180 millimeters for photoelectric proximity sensors, four meters for photoelectric retro-reflective sensors, eight meters for through-beam photoelectric sensors)
- Background blanking
- Switching output
- Teach-in buttons and potentiometers for setting the sensors
- Cable or plug-in connection technology

IO-Link as a connection to the digitalized world of machines and applications is now standard for new sensors coming onto the market. A few miniature photoelectric sensors have integrated distance measurement with two switching outputs. Miniature photoelectric sensors of the next generation also offer smart automation functions for applications like counting objects, measuring the length of objects or gaps, or monitoring temperature.

Demands on detection behavior

With new industries, applications, products, parts, materials, and processes, there are increasing demands on detection capability, reliability, and availability of opto-electronic sensors. This also applies to miniature photoelectric sensors. From reflective displays for cell phones or tablets, mirror-printed transparent foils, deep-dark and low-remission solar wafers, to very flat objects like packages for herbs on a conveyor belt – all these applications place equally high demands on the performance of the sensors as do objects with uneven and perforated surfaces (e.g., containers or printed circuit boards with holes, grooves, and cutouts).

The new miniature series of SICK's W4F offers solutions for reliably detecting such detection-critical objects. At the same time, standard requirements are also placing increasingly higher demands on optical performance, in the form of greater working distances, improved sensitivity, and more reliable suppression of ambient and background influences, such as those caused by sunlight, reflections, or reflectors on work clothing.

Demands on communicability and connectivity

All common miniature photoelectric sensors on the market are available as sensors of the standard I/O signal level with switching outputs and can transmit their signals to automation systems of the control level via the fieldbus level. Occasionally, sensors with distance measurement functionality also offer an analog output with or without additional switching outputs.

With advancing digitalization in mechanical and plant engineering and the possibility of creating new markets and business models through smart digital automation, the IO-Link communication system is becoming increasingly important for data exchange. Especially for the connection of intelligent sensors and actuators for edge computing. The resulting range of functions offers new benefits for users in terms of diagnostics, pre-failure notifications and process data.

Added value through integrated sensor intelligence

Increasingly, automation and communication functions are being shifted to the field level. For such remote signal processing, sensors and actuators are equipped with corresponding intelligence in addition to IO-Link technology. This enables smart tasks to be executed directly in the sensor.

Counting objects and operating hours, measuring temperatures, vibrations, lengths, and distances, evaluating environmental information, or detecting occupancy in workpiece carriers (load mapping) are intelligent sensor functions that relieve the fieldbus and control level. And in some cases, are not even needed there, but can be used directly in the process. At the same time, it is possible to make them available in MES/ERP systems or cloud applications via IO-Link and Ethernet (Rest API), for predictive maintenance as part of condition monitoring of machines and plants.

Reducing Complexity, Standardizing Operation with Miniature Photoelectric Sensors

The diversity of manufacturers and products in sensor technology aligns with different operating concepts – this applies both across manufacturers and within the product ranges of the suppliers. Newer platforms and product architectures are moving toward providing users with a consistent look and feel along different sensor series from a single manufacturer – an identical user experience that makes it much easier to operate and commission sensors from different product families.

The miniature photoelectric sensors of the next generation tie in with the successful intuitive BluePilot operating concept already on the market, whose simplicity has also proven itself in larger sensors in the small and compact classes. The sensors can be set quickly, accurately, and reliably via a Teach-Turn control element or a teach-in button. The blue LED display gives the user direct feedback for optimal alignment. In addition, BluePilot activates a visual indication if the detection quality should drop due to contamination or vibration. This allows faults to be corrected and prevented early on, avoiding unplanned system downtime.

New Technologies and Concepts for Miniature Photoelectric Sensors

At the heart of the miniature photoelectric sensor is an ASIC developed by the manufacturer‘s in-house design group. It makes it possible to integrate sensor functions and performance parameters previously only known from the manufacturer’s larger product families into a miniature package, thus providing a significant increase in performance in the miniature opto-electronic sensor market.

The ability to operate multiple sender LEDs simultaneously without significant heating inside the housing, as well as digitalization of the remitted light directly at each pixel of the multi-pixel receiver, give these miniature photoelectric sensors an optical and functional performance that is clearly superior to the performance of other miniature photoelectric sensors on the market – as well as the manufacturer’s own predecessor product family – as determined in comparative tests.

Higher performance due to larger working distances and operating reserves

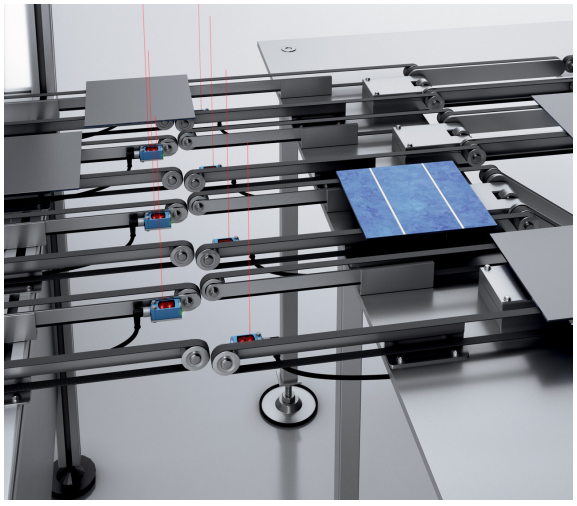
The comparison of working distances includes a total of eight product families also on the market, the miniature photoelectric product families of the next generation and the predecessor series. In an internal manufacturer comparison, all scanning and sensing distances are significantly improved with the new product family – by up to 47 percent for the photoelectric proximity sensors. The sensing distance of the various sensors variants extends from the immediate close range up to 220 millimeters – the market average of around 180 millimeters is about 20 percent less.

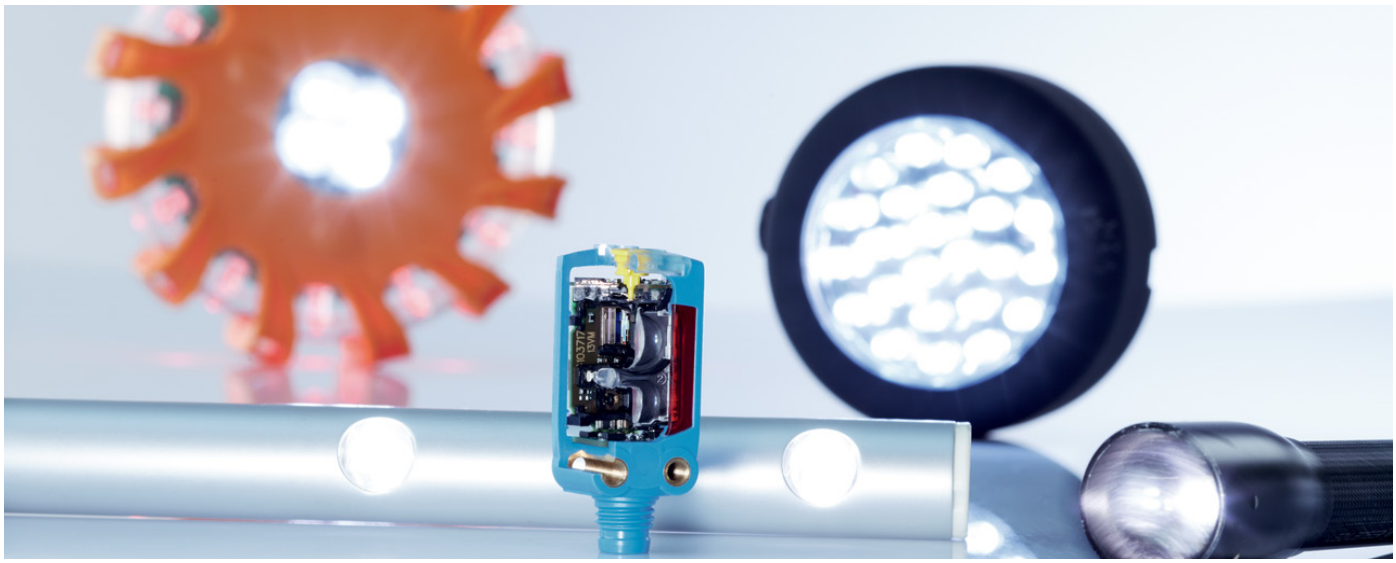
The miniature photoelectric retro-reflective sensors offer sensing ranges of up to five meters - the miniature through-beam photoelectric sensor of the next generation even up to ten meters. Here, too, the respective values of the tested market competitors are significantly lower. For the user, the added performance means that the new miniature photoelectric sensors can also be used at greater working distances, additional operating reserves can be utilized and, under certain circumstances, the variety of different sensor series and makes can be reduced.

Reliable detection of low-remission objects

Objects with remission values of less than one percent, such as deep blue wafers in electronics and solar cell production, require photoelectric proximity sensors with a very high sensitivity. All miniature photoelectric proximity sensors of the next generation feature a high-intensity PinPoint LED and a multi-pixel receiver with 127 photo diodes. These are the prerequisites for detecting even extremely faint remissions.

A special sensor variant with V-optics also optimizes the detection performance and achieves the best values in the performance comparison. At the same time, the miniature sensor can continuously measure the distance to an object and output it via IO-Link. This opens additional inspection possibilities, for example for the absence of a part or for double layers.





Reliable object detection in front of close, dark backgrounds

The black/white shift allows a statement to be made about the extent to which an opto-electronic photoelectric proximity sensor is capable of reliably detecting white objects against a black background. In all tested miniature photoelectric proximity sensors from other manufacturers, a significant shift in the sensing distance of up to 50 millimeters can be observed from a set sensing distance of about 150 millimeters – if this is reached by the sensor at all.

This significant change means that these photoelectric proximity sensors can only detect objects reasonably reliably in a range of up to about 80 to 100 millimeters – not to mention reliable distance measurement. Only the photoelectric proximity sensor of the next generation and another sensor on the market – though this one is almost twice as large – achieve the best mark in the test of around eight millimeters of shift with a set sensing distance of 200 millimeters. If mounting space is tight, only the smaller of the two sensors offers the required combination of compactness and performance.

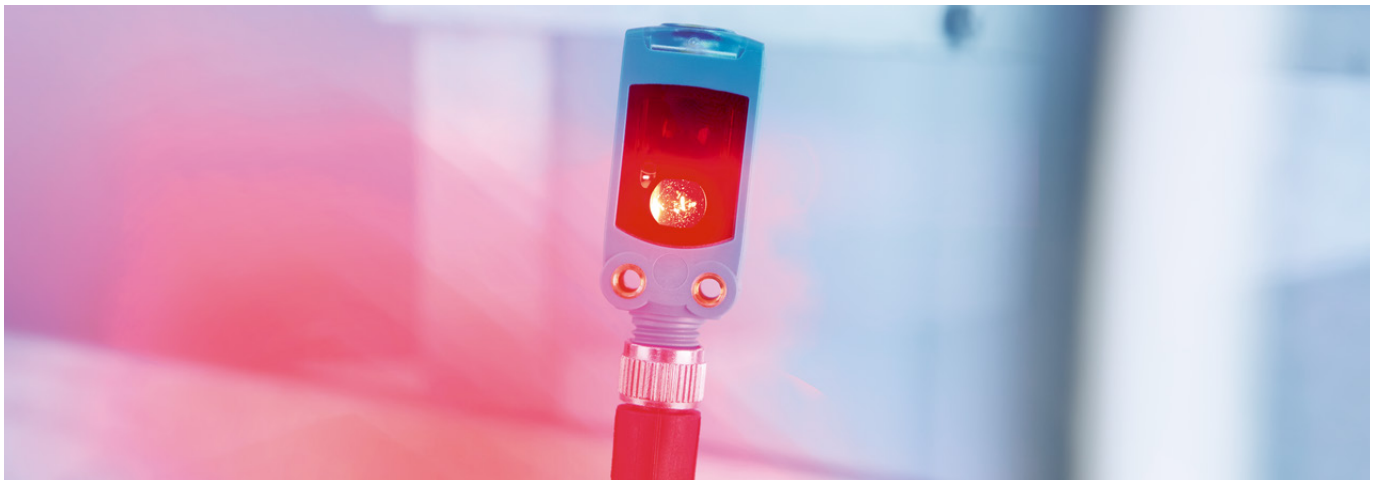
High insensitivity to optical interference due to diffuse LED

A decisive performance feature of photoelectric proximity sensors is their insensitivity to optical interference from the application environment. These can be caused, for example, by reflective machine parts, by sunlight, RF and LED light, or by reflectors on work clothing. This is also accompanied by detection reliability in cases where there is a glossy background immediately behind the set sensing distance. The more precise the detection transition of an opto-electronic sensor from foreground to background, the less a shiny, reflective object can interfere with the sensor. In the comparative test, the miniature photoelectric proximity sensor of the next generation also performed best here.

The false switching zone of most devices starts at a set sensing distance of 25 millimeters and reaches a required switching safety distance of up to 1.5 meters at a set sensing distance of 75 millimeters. This means that these sensors can no longer reliably detect objects in front of shiny backgrounds, even at short sensing distances. At the same time, faulty switching can occur due to optical interference from the surroundings.

The miniature photoelectric proximity sensor of the next generation, on the other hand, outperforms others throughout the entire working distance – even with a maximum sensing distance of 220 millimeters. This absolute maximum error-free background blanking is achieved by the option of supplying a second sender LED with energy by means of the innovative ASIC technology without heating up the inside of the sensor housing. This emitted light source, known as a diffuse LED, illuminates the receiver field of view. The ASIC thus receives two signals: that of the actual sender LED and that of the diffuse LED.

The ASIC calculates the signals, enabling minimization of the switching safety distance directly behind the object. At the same time, it supports the reliable blanking of optical interference from the wider application environment. The sensor can actively detect reflective objects and selectively blank up to six sources of ambient light in the field of view using digital filters.



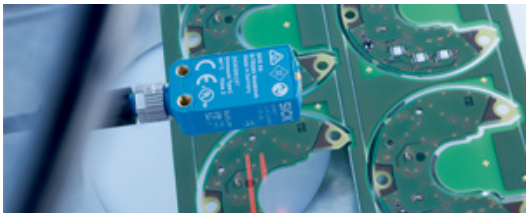
Pixel-by-pixel digitalization of photo streams improves detection reliability
In addition to the concept of the diffuse LED, applied for the first time in this form, another innovation is implemented in the miniature photoelectric proximity sensors of the next generation. The digitalization of the photo streams of the remitted light directly at each pixel of the multi-pixel receiver. This enables the sensor to achieve not only a very high sensitivity, but also a long sensing range and reliable detection behavior, even for poorly reflecting object surfaces. This adds the possibility to set up digital filters for ambient light suppression on the ASIC, which currently ensure the best ambient light suppression of all miniature photoelectric proximity sensors on the market.

Digitalization of the photo streams also makes it possible to collect additional process data such as distance information and remission values and diagnostic data.

High-precision foreground suppression for flat objects
Reliable detection of flat objects on conveyor systems from above is a major challenge for opto-electronic sensors in industries like packaging and electronics, among others. With a Dual PinPoint LED specially developed for this application, it is possible to detect objects with a thickness of less than one millimeter, even if they are glossy or jet black or have glossy-black contrasts.

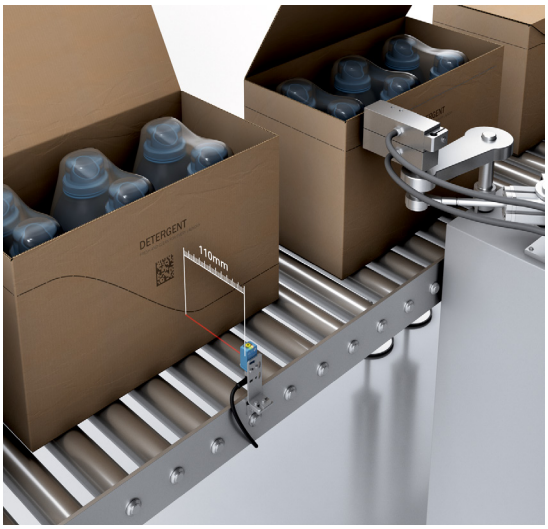
With this principle of operation, the light spot is divided into two halves – the sensor thus evaluates the data of two distance and remission signals. This allows the foreground to be blanked electronically. Only objects between the sensing range set to the background and the sensor are detected, even if they are extremely flat.

Double optics for uneven, glossy, and perforated surfaces
When detecting objects with grooves, holes, interrupted structures, different colors, difficult gloss properties, or irregular surfaces, a single light spot is not error-proof and can lead to false signals (e.g., responses of the photoelectric sensor for only one object). To meet these challenges, the photoelectric proximity sensors of the next generation offer a version with two detection cores in one housing.



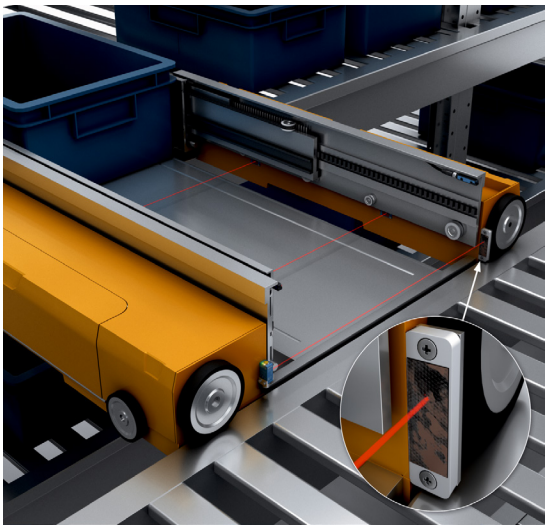
The sensor thus generates two light lines, which are evaluated so that the photoelectric sensor outputs a presence signal when one or both light lines generate remission. If neither of the two light lines hits a surface, no switching signal is output. Close backgrounds, such as a chain conveyor transporting the object, do not affect switching reliability. Reliable detection enables an increase in conveyor speed and thus machine throughput. The user also only needs one miniature photoelectric proximity sensor for the tasks, which can be mounted to save space. A logical evaluation of both signals in an automation system is not required and does not need to be programmed.

More functionality through integrated distance measurement
Various miniature photoelectric proximity sensors of the next generation are not only capable of detecting objects, but also of measuring distances within their set sensing distance or outputting two switching signals for this purpose. For a few examples, this makes it possible to use a single sensor to distinguish between upright and horizontal beverage containers, to optimize the braking ramps of robot arms for faster cycle times, or to detect roll diameters.



Future-proofing functions for digitalization
The miniature photoelectric sensors of the next generation are consistently designed as Smart Sensors for networked production and control processes. They not only provide safe and reliable detection and measurement results, but also detect incipient or emerging faults during operation and actively counteract them. Their data as well as the data exchange via IO-Link is the basis for intelligent process control and quality monitoring.

As part of their diagnostic functions, the miniature photoelectric sensors send extensive data for monitoring the condition of machines and processes. The sensors detect when process parameters and specified tolerances are no longer met. In this way, device and plant maintenance can be scheduled predictively and as required, which minimizes unexpected system downtime. In the event of an emergency, the extensive diagnostic data ensures rapid identification of the cause.



With the help of their integrated intelligence, the smart miniature sensors can process measurement data remotely in the device, to independently take over automation functions – Smart Tasks – based on this data. At the same time, they feed the data into higher levels in the automation network. Here, IO-Link ensures smooth real-time communication between intelligent sensors and higher-level systems. Consistent digital data transmission simplifies commissioning and makes process control much more flexible, efficient, and economical.

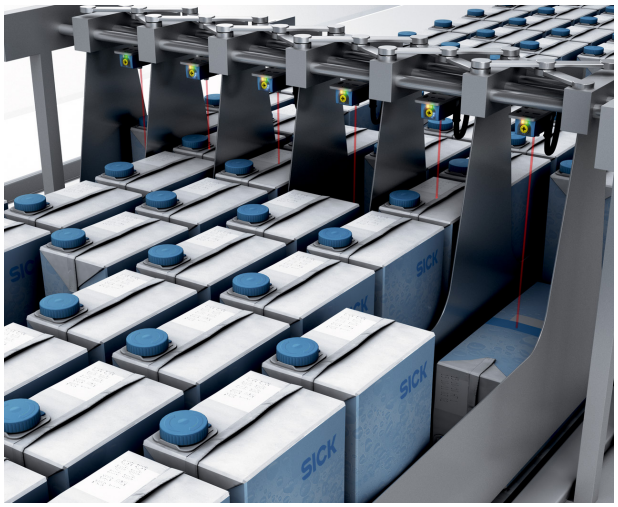
Rugged plastic housing made of Vistal® for long sensor service life
Miniature photoelectric sensors, especially the photoelectric proximity sensors, are often mounted relatively close to the detection object in manufacturing and processing operations due to their space-saving size and working distances. This allows them to be used in working environments that place special demands on the ruggedness of the sensors.

Al miniature photoelectric sensors of the next generation are characterized by their VISTAL® housing. This is a special, glass fiber-reinforced plastic that is highly resistant to extreme stresses caused by thermal, chemical, or mechanical influences, increasing the service life of the sensors. The laser marking on the housing surface of the sensors ensure clear identification of the device type, even after years of operation.

Implementation of Device and Application Technology

Sensor variants for standard and special applications
The miniature photoelectric sensors of the next generation form a synergy of the latest sensor technology and the application knowledge gained from over 100 customer-specific developments. They consider both the practical requirements of common applications and those of detection-critical tasks that push conventional sensors to the limits of their performance.

In line with their specialization, they are differentiated into two application-related product segments, namely the Optical Standard and Optical Experts. All sensors feature Digitalization-compliant connectivity with IO-Link. When set, they display two function-relevant parameters: the quality of the alignment as "Quality of Teach" and the current receiver level, which can also be output via IO-Link.



The Optical Standard
The sensors of the Optical Standard segment have proven themselves as space-saving and powerful comprehensive solution for object detection.

For large working distances: through-beam and photoelectric retro-reflective sensors
The miniature photoelectric sensor of the next generation with its dot-shaped light spot is a comprehensive solution for standard applications with sensing ranges of up to ten meters. BluePilot with an optical alignment aid facilitates commissioning. The miniature photoelectric retro-reflective sensor with dual lens and dot-shaped light spot offers a maximum working distance of five meters. As an alternative to BluePilot, it can also be put into operation via a teach pushbutton. An optical alignment aid is also on board with this sensor.

Switching and detection by measuring with photoelectric proximity switches – even through holes
Another versatile solution for a wide range of applications is the miniature photoelectric proximity sensor with standard optics and background suppression. The maximum sensing range is 220 millimeters, and adjustment is safe and user-friendly thanks to Teach-Turn adjustment. The set sensing range is displayed on the sensor. This sensor is also available as a measuring MultiSwitch variant with two switching points. The setting is made via a teach-in button. The mode display assists the operator in quickly and easily defining the switching points.

Both sensor variants are also available as versions with a focused, laser-like emitted light beam. As a result, these NarrowBeam sensors can detect through holes and recesses without interfering reflections.

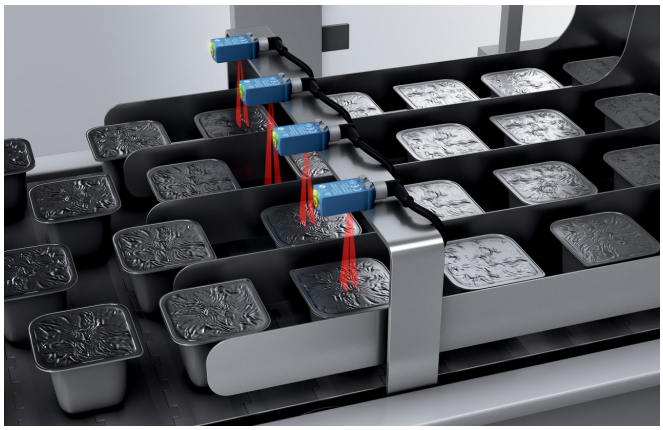
The Optical Experts
For special challenges, users can rely on the Optical Experts, which have been developed specifically for certain applications.

For remission-critical objects: photoelectric proximity sensors with V-optics
The miniature photoelectric proximity sensor of the next generation with V-optics and a focused rectangular light spot is capable of reliably detecting even highly specular or transparent objects as well as those with low remission. BluePilot, Teach-Turn adjustment, and the sensing range indicator on the device facilitate commissioning. The maximum sensing distance is specified at 50 millimeters.

At the same time, only a very small light spot is generated on the object to be detected, which means that objects smaller than 0.1 millimeters can also be detected, for example fine wires. The maximum sensing distance of these sensors is 100 millimeters – at about 50 millimeters, the light spot is smallest at two millimeters.

Perforated or uneven objects: photoelectric proximity sensors with double transmission optics

The miniature photoelectric proximity sensor of the next generation with double transmission optics has been specially designed for the safe detection of perforated materials as well as objects with recesses or uneven surfaces. The sensor has two detection cores, each of which generates a line-shaped light beam. The two linear light spots of the photoelectric proximity sensors ensure a consistently reliable switching signal, even if the objects have holes or bores. No additional controller capacity is required thanks to the integrated signal processing. BluePilot, Teach-Turn adjustment, and the sensing range indicator on the device facilitate commissioning. The maximum sensing distance is 120 millimeters.



For flat or reflective objects: photoelectric proximity sensors with foreground suppression

The miniature photoelectric proximity sensor of the next generation with foreground suppression enables reliable detection of very flat or highly reflective objects on conveyor belts, such as soup bags or thin displays. The performance is achieved using a sender LED specially developed for this application, which divides the light spot into 2 halves and thus enables a more differentiated evaluation in the light spot, and a new optics concept in which the emitted light spot is sharply imaged on the receiver by an angled lens. This achieves high precision and a reliable resolution of less than one millimeter. BluePilot, Teach-Turn adjustment, and the sensing range indicator on the device facilitate commissioning. The maximum sensing distance is specified at 100 millimeters – the sensor achieves the best performance between 30 millimeters and 70 millimeters.

Conclusion

Miniature photoelectric sensors of the next generation are sensor solutions for standard and special applications where mounting space is limited. With two of the manufacturer's larger product families, they offer an operating concept with an identical look and feel, which standardizes the operation and commissioning of the sensors for users.

Built on a specially developed ASIC platform, the miniature photoelectric sensor of the next generation ensures detection reliability and ambient light immunity. As Smart Sensors powered by IO-Link, they are ready for edge computing concepts in digitally networked machines and plants thanks to their remote signal processing, and, at the same time, they are data suppliers for digital transformation applications.

Contact Us

For more information about miniature photoelectric sensors, contact SICK at info@sick.com or visit our website at www.sick.com.