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WHITEPAPER

SENSORS FOR THE DETECTION OF TRANSPARENT OBJECTS

Author: Dipl.-Ing. Christian Fiebach
Chief Executive Officer ipf electronic gmbh

IPF ELECTRONIC

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1 INTRODUCTION

In industry, there is a large number of applications and process sequences in which transparent objects or materials must be detected. As in all other areas of application, the sensor solutions in question should be optimally matched to the corresponding tasks. Nevertheless, users in this context are repeatedly confronted with new challenges in practice, which can, however, be mastered in most cases with sensor technology that is optimally aligned to the respective area of application. Basically, however, this first raises the question of which sensor or which technology is generally suitable for the detection of specific transparent objects or materials and which advantages but also disadvantages can be associated with the use of different solutions in concrete applications.

ipf electronic has decades of experience in this field and can therefore contribute to the topic of this white paper not only with a wide-ranging sensor portfolio, but above all with extensive expert knowledge based primarily on concrete solutions that have been implemented for customers from very different industries. In addition, ipf electronic is continuously expanding its range of products, with the latest developments being specifically designed for the detection of transparent objects/materials.

2 ULTRASONIC SENSORS

Ultrasonic sensors detect all objects and materials that reflect sound. Therefore, they are also suitable for detecting transparent objects. Ultrasonic fork sensors, ultrasonic barriers or ultrasonic diffuse-reflection sensors are usually recommended for this purpose.

2.1 ULTRASONIC FORK SENSORS

Ultrasonic fork sensors are disposable systems consisting of a transmitter and receiver. If the sound path between the transmitter and receiver is interrupted by a transparent object, the switching output in the receiver changes its signal.

All-in-one solutions such as the **UG800170** (fork width 74mm) or **UGKB0170** (fork width 114mm) ultrasonic fork sensors with M8- connection are particularly easy to integrate into applications, because the transmitter and receiver do not have to be specifically aligned. This makes mounting the devices unproblematic in most cases. Ultrasonic fork sensors are ideal for detecting transparent strip materials such as thin foils. Due to the switching frequency of 150Hz typical for ultrasonic sensors as disposable systems as well as a response time of 1ms, such solutions are also recommended for use in relatively fast-running processes, such as in the beverage industry.

All-in-one solution such as the ultrasonic fork sensors **UG800170** (left) or **UGKB0170** are particularly suitable for the detection of transparent strip materials. (All images: ipf electronic gmbh)

2.2 ULTRASONIC BARRIERS

If an application does not allow the use of ultrasonic forks due to the available installation space or the specific query situation, alternatives such as the **UY210100** ultrasonic fork sensors from ipf electronic are available. These disposable systems also consist of a transmitter and receiver, which, however, are installed separately from each other and, with a maximum range of up to 300mm, allow much higher switching distances than ultrasonic fork sensors with predefined fork widths. The other technical features of ipf electronic's ultrasonic fork sensors are otherwise comparable to the ultrasonic forks described: a high sound intensity due to an integrated amplifier, a high switching frequency of 150Hz, and a short response time of 1ms. The ultrasonic barriers and forks in protection class IP67 are suitable for use in a temperature range from-15°C to +60°C.

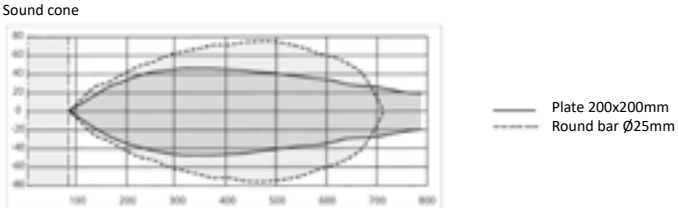
The transmitter and receiver of the **UY210100** ultrasonic barriers are installed separately and enable ranges of up to 300mm.

2.3 ULTRASONIC DIFFUSE-REFLECTION SENSORS

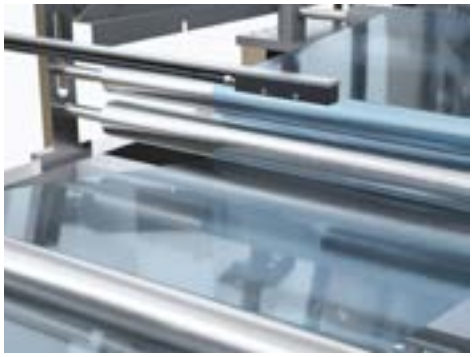
If even longer ranges and additional challenges in the detection of transparent objects have to be overcome, then an ultrasonic diffuse-reflection sensors such as the **UT189520** in M18 design with M12-connector plug may be a solution. The diffuse-reflection sensors with an operating range of 80 to 800mm are among the more recent developments in the field of ultrasonic sensors and are particularly impressive due to their high degree of application flexibility. For example, the sensors alone allow three different operating modes that can be set via teach-in.

Another advantage is the integrated IO-Link interface, with which the ultrasonic diffuse-reflection sensors can be very easily switched to a reflex barrier. With conventional ultrasonic sensors that only allow the operating mode as diffuse-reflection sensors, irregular, round or slanted surfaces of the objects to be detected can deflect the signal echo in such a way that it does not hit the receiver. Reliable detection is therefore not guaranteed in every case. In reflective mode, however, a **UT189520** can be adjusted in a variety of ways to a background instead of an object to be detected. Transparent objects in the detection range are therefore reliably detected as deviations from the background, regardless of their surface or geometry, and are thus unambiguously detected.

Ultrasonic diffuse-reflection sensors such as the **UT189520** can be easily switched to a retro-reflective sensor via IO-Link and can therefore be set to a background instead of an object in order to reliably detect transparent objects with irregular, round or angled surfaces, for example.



Sound cone of a **UT189520**.The range of the ultrasonic diffuse-reflection sensors depends largely on the shape of the object to be detected.



Ultrasonic diffuse-reflection sensors in use: detection of transparent PET bottles (left) and during the tear-off inspection of a film.

2.4 DETECTION OF VERY THIN, TRANSPARENT MATERIALS

When using ultrasonic barriers, very thin, transparent materials that have a certain natural vibration can sometimes pose a very special problem. A good example of this is the detection of transparent foils. In this case, it is essential to ensure that the material has sufficient voltage between the transmitter and receiver. Otherwise, the sound pulse from the transmitter can also cause the foil to be detected to vibrate via the air molecules. Similar to a loudspeaker membrane, the vibrating foil generates a sound signal that reaches the receiver. Since this does not interrupt the signal path between transmitter and receiver, the receiver does not switch. The result: the foil is not detected.

2.5 USE UNDER DEMANDING ENVIRONMENTAL CONDITIONS

Ultrasonic sensors offer a clear advantage over conventional optical systems, for example, as described in chapter 3.1, in applications with demanding environmental conditions. Ultrasonic sensors are generally insensitive to contamination and can therefore also be used where a certain amount of dirt or dust is present. Even humid environments usually do not affect the functionality of the devices. When mounting ultrasonic sensors, however, care should be taken to ensure that the installation positions do not encourage deposits on the sensor surface or the transducer.

3 OPTICAL SENSORS

Optical systems, or more precisely optical sensors operating with red or infrared light, offer another possibility for detecting transparent objects in the form of retro-reflective light barriers. However, such devices also have their pitfalls in practice.

3.1 CONVENTIONAL OPTOSENSORS AND TRANSMITTANCE

Conventional optosensors are taught using the 2-point method. This means that teaching is first carried out without an object between the reflector and the sensor and then with an object to be detected in the light barrier, so that the sensor can automatically determine a switching threshold from the resulting limit values.
However, the use of such solutions is made difficult in practice by the so-called transmittance of transparent objects for visible radiation. Completely transparent glass, for example, has a high transmittance and thus a high optical transmittance for light in the visible range.

Red or infrared light can also pass through a transparent object, depending on the material's transmittance up to nearly 100 percent. Since this results in virtually no optical attenuation of a conventional retro-reflective light barrier, an extremely low switching threshold must be selected for detection that is close to the range without an object within the light barrier. Because this sometimes leads to malfunctions in practice, highly sensitive retro-reflective light barriers are usually used that react to the slightest

attenuation of the optical system.

What is desirable on the one hand can be a disadvantage on the other, because such devices are also very sensitive to contamination. Depending on the switching threshold determined, an optical sensor can therefore be attenuated even by the slightest soiling, e.g. by a film of dust on the transmitter or reflector that is barely visible to the naked eye, and thus switch even though there is no object in the detection range of the light barrier. The operation of high-sensitivity optical sensors for the detection of transparent objects under the described environmental conditions is therefore possibly associated with effort, because either the transmitter optics or the reflector must be checked regularly for soiling, or the corresponding components must be cleaned if there is obviously a malfunction of the device due to dirt deposits.

3.2 POWERFUL SOLUTION ESPECIALLY FOR TRANSPARENCY

Developments such as the **ON450522** optical sensor from ipf electronic, meanwhile, can overcome the challenges that arise with conventional retro-reflective light barriers when detecting transparent objects, because the device with IO-Link interface was developed specifically for this task.

The sensor functions like a retro-reflective light barriers, but still does not require a reflector. Instead, the clocked, point-shaped red light of the emitting element (wavelength 630nm) is set to any reference surface, which must be able to reflect the red light to a sufficient degree.

The **ON450522** does not require a reflector, since the clocked, point-shaped red light of the emitting element can be adjusted to any reference surface, such as a transport crate in this case.

The sensitivity of the **ON450522** can be easily adjusted via teach-in depending on the transparency and nature of the object or material to be detected, with a total of three sensitivity levels available for selection:

- Damping approx. 10%- detection of clear foils, PET bottles or clear glass
- Damping approx. 20%- detection of clear glass bottles, multilayer foils, etc.
- Damping approx. 30%- detection of colored glass, less transparent bottles or opaque (light-impermeable) objects

The outstanding features of the device include a high switching frequency 2kHz in combination with a very short response time ≤0.25ms and a high range up to 1,000mm (distance between sensor and reference surface).

ON450522 auto-reflective sensors with outstanding features: switching frequency 2kHz, response time ≤0.25ms and range up to 1,000mm.

The auto-reflective sensor is therefore ideal for use in extremely fast-running processes as well as in a wide range of other applications that place very different demands on the extremely reliable detection of transparent objects.
Another advantage is the IO-Link interface, e.g. with regard to flexible parameterization. For example, the sensor makes it possible to use a conveyor belt as a reference surface and to hide it as a background via the parameter settings so that transparent objects transported on the belt can be reliably detected. Due to the internal signal processing, the **ON450522** can also compensate for a certain degree of contamination of the optics. The sensor in IP67 is also designed for an operating temperature range of-25°C to +60°C.

4 SUMMARY AND CONCLUSION

The selection of a suitable sensor for the detection of transparent objects is not always easy, since the requirements and also the operating conditions for the potential solutions are different in each application. In a first step, however, some basic questions can provide orientation and thus assistance:

- What is to be detected?
- What environmental conditions are encountered in an application?
- How big are the objects to be detected?
- At what distance from the potential sensor solution are these objects located?
- What is the position of the objects to be detected relative to the sensor?
- Are there other decisive factors, such as special installation situations, that must be taken into account when selecting a sensor??

Whatever the task, with the right technology in the right place, even difficult situations can be mastered in most cases and thus the problems that may be associated with them can be solved. ipf electronic not only offers very different solutions for this, but also valuable application experience from a wide range of industries.

ipf electronic gmbh
info@ipf-electronic.com • **www.ipf-electronic.com**

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