EN

WHITEPAPER

MINIATURE SENSORS

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

IPF ELECTRONIC

TABLE OF CONTENTS

1 INTRODUCTION

Sensors are an investment good and should have a long service life in use. Therefore, users usually tend to place such devices at a greater distance from moving objects, if possible, in order to avoid possible collisions and thus damage to the sensor during detection. However, longer sensor ranges are usually accompanied by larger device designs. For this reason, compromises often have to be made between the installation situation given in a specific application, i.e. the space available for sensor mounting, and the maximum range of a specific device in order to obtain a truly optimal solution.

However, if the mounting space for a sensor is limited to such an extent that a device in a standard size no longer fits, the use of miniature sensors is recommended in most cases, always taking into account the ranges required for an application. Due to their dimensions, such solutions can also be much better protected against undesirable external influences, e.g. mechanical damage, by selecting a specific installation location and possibly also by special design-related measures.

This white paper provides an overview of a wide variety of sensors in miniature format, whereby ipf electronic's broad portfolio has a solution ready for almost every technology.

2 INDUCTIVE PROXIMITY SWITCHES

Inductive sensors detect all conductive metals at short distances, while other materials do not affect their switching behavior. The devices are extremely robust and are therefore suitable for extremely harsh operating conditions and environments with very high dirt loads in almost any type. With a diameter of 6.5mm and a length of 16mm, the **IB06A023** in cylindrical design is one of the compact solutions among inductive proximity switches. The device design with lateral cable entry on the stainless steel housing is striking. The sensor in protection class IP67, which belongs to the special devices, achieves a maximum switching distance of 1.5mm. As a special design, ipf electronic also developed the cuboid-shaped **IB98E314** (switching distance 2mm) with an overall height of only 9.5mm (length 24.5mm, width 23mm), which can be mounted in the aluminum housing via two lateral holes.

The **IB06A023** (right) and **IB98E314**, which belong to the special devices, are among the compact solutions for inductive sensors.

The cross-section of the cylindrical **IOR40176** is only 4mm. This means that the inductive sensor has just the diameter of a match head and, with a length of 30mm, it is shorter than a match. The inductive sensor also impresses with other special properties. Since the proximity switch works with a clocked coil behind the active surface instead of a continuously operated oscillating circuit, it can be completely made of stainless steel and

ipf electronic gmbh | Rosmarter Allee 14 • 58762 Altena • Germany | Tel +49 2351 9365-0 • info@ipf-electronic.com • **www.ipf-electronic.com**

has an extended switching distance of 3mm. Even with different metals (e.g. aluminum or steel), the **IOR40176** achieves the same maximum ranges. In this context, for the sake of completeness, a quick explanation of the functionalities of inductive sensors should be given.

The **IOR40176** is just the size of a match head with a diameter of only 4mm.

2.1 CONTINUOUSLY OPERATED OSCILLATING CIRCUIT VS. CLOCKED COIL

The operating principle of the continuously operated oscillating circuit is based on the fact that the oscillating circuit coil behind the active face of a proximity switch generates an electromagnetic alternating field, which is continuously excited and expands in the space in front of the active face. If an electrically conductive material enters this field, eddy currents are induced in it, which draw energy from the oscillating circuit. This ''damping'' of the oscillator is converted into a switching signal in the output amplifier of the devices.

In the operating principle of the clocked coil, the coil for generating the magnetic field is not a component of an oscillator. Instead, the magnetic field is generated by periodic, quick transmission current pulses flowing through the coil. This field induces a voltage in the object being sensed, creating an eddy current flow there. After the transmit current pulse is switched off, the eddy current in the object decays. As a result, a voltage is induced back in the coil. This induction voltage forms an evaluable signal that is in principle independent of energy losses in the field. As already described above, the decisive advantage of this functional principle is that the sensor, including the active area, can be completely integrated into a stainless steel housing. The result: extremely robust sensors such as the **IOR40176**, which still function reliably in applications where other solutions may fail.

ipf electronic gmbh | Rosmarter Allee 14 • 58762 Altena • Germany | Tel +49 2351 9365-0 • info@ipf-electronic.com • **www.ipf-electronic.com**

3 MAGNETIC FIELD SENSORS

If inductive sensors reach their limits in terms of range, magnetic field sensors are an alternative. Magnetic field sensors or magnetic proximity switches also operate without contact and detect magnetic objects or magnets, regardless of whether they are moving or not. Magnetic fields penetrate all non-magnetizable materials. Therefore, these sensors can also detect magnets used as switching elements, for example through non-ferrous metal, stainless steel, aluminum, plastic, wooden walls or heavy soiling. The achievable switching distance of the sensors depends on the strength of the acting magnetic field.

The miniature designs in ipf electronic's portfolio of magnetic field sensors include the **MC050176** and **MC0501A6**, both in the M5 design. Depending on the strength of the magnets used as switching elements (e.g. **AM000009**), maximum switching distances of up to 40mm can be achieved with these sensors. This means that the two solutions mentioned achieve the same switching distances as magnetic field sensors in sizes M8 and M12. By using even stronger magnets, even higher switching distances can be realized.

Alternative to inductive sensors: Magnetic field sensors such as the **MC050176** and MC0501A6 achieve large switching distances despite their miniature design.

The devices are completely made of stainless steel and therefore, like inductive sensors, extremely robust as well as insensitive to contamination. Magnetic field sensors are used for positioning (e.g. position control on lifting devices), speed control (e.g. on conveyor belts or on gearwheels through aluminum housings) or for position sensing (e.g. of goods carriers). In addition, these devices are more frequently found in the chemical and food industries. There they are used, for example, to detect so-called pigs for cleaning pipeline systems and thus to determine their exact position in a pipeline.

ipf electronic gmbh | Rosmarter Allee 14 • 58762 Altena • Germany | Tel +49 2351 9365-0 • info@ipf-electronic.com • **www.ipf-electronic.com**

4 CYLINDER SENSORS

From a technological point of view, cylinder sensors are similar developments to magnetic field sensors, but serve a very specific field of application: the contactless and thus wear-free position detection of a cylinder piston in hydraulic or pneumatic cylinders. For this purpose, the cylinder sensors are either inserted into the round groove of a cylinder, fastened with an adapter or inserted directly into a T-slot from the outside or from above.

The cylinder sensor **MZR40178** is designed for mounting in pneumatic cylinders and is inserted into a 3.75mm round groove (C-slot) for this purpose. The stainless steel sensor housing has a diameter of 3.6mm and a length of 20mm. A hexagon socket screw (grub screw) ensures secure mounting of the **MZR40178**.

One solution that protrudes from the round groove of a pneumatic cylinder is the **MZR40175** cylinder sensor. A striking detail is the plug connection integrated in the housing for direct connection. Such a solution can be useful whenever the sensor moves in an application and thus the connection cable is subject to a certain amount of wear. A preassembled cable can be used to bridge the moving distance and the cable can be quickly replaced in the event of a defect or breakage without having to dismantle the sensor itself. Another special feature of the **MZR40175** is also the robust housing made of die-cast zinc. This gives the sensor a certain unique selling point, since comparable devices on the market are usually only offered with a plastic housing.

However, such materials are subject to aging processes under certain environmental influences and become brittle, for example, which significantly shortens the durability of the sensor. Particularly harsh or aggressive environmental conditions can affect the plastic of the housing even more, possibly making it soft or hard or extremely brittle and fragile. In addition, such cylinder sensors made of plastic can only be fastened with a comparatively low torque, as otherwise the thread of the grub screw is destroyed during installation. There are attempts to solve this problem with metal inserts. However, these can break out, for example, as the plastic becomes increasingly brittle due to external influences. The **MZR40178** and **MZR40175** cylinder sensors in metal housings, however, are subject to virtually no wear and are designed for ambient temperatures of -25°C to +70°C, for example.

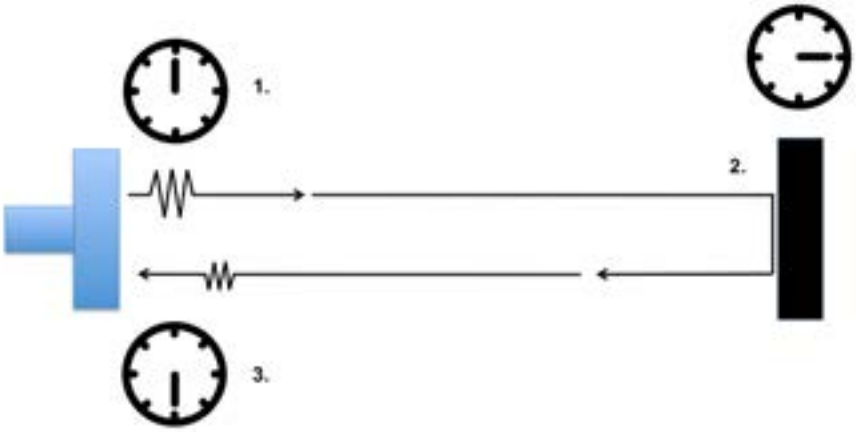
Small, compact and technologically sophisticated: the **MZR40178** (center) and **MZR40175** cylinder sensors.

ipf electronic gmbh | Rosmarter Allee 14 • 58762 Altena • Germany | Tel +49 2351 9365-0 • info@ipf-electronic.com • **www.ipf-electronic.com**

5 ULTRASONIC SENSORS

Ultrasonic sensors operate on the principle of time-of-flight measurement and can therefore detect different objects and media from great distances without contact, completely independent of the material or object properties (solid, liquid, granular, powdery, transparent, etc.). For example, an ultrasonic scanner cyclically emits a quick, high-frequency sound pulse that propagates through the air at the speed of sound. When this sound pulse hits an object, it is reflected by its surface and returns to the receiver of the ultrasonic scanner as an echo. The transducer integrated in the device acts as both transmitter and receiver. The distance of an object or medium to the probe can be determined from the time required by the sound pulse from transmission to reception of the echo.

Due to their special operating principle, ultrasonic sensors are also predestined for use in harsh environments. The classic fields of application for ultrasonic sensors include, for example, filling level monitoring, the detection of foils or other thin materials, diameter detection, loop control (coils) or presence monitoring.



The distance of an object to the sensor can be determined via the time-of-flight measurement of the sound pulse: 1. Sound pulse is transmitted. 2. Sound pulse is reflected by the object. 3. The echo of the sound pulse is received.

One of the miniature designs in ipf electronic's ultrasonic sensor portfolio is the **UT089570**. The ultrasonic sensor in M8 has a length of 70mm, is suitable for ambient temperatures from 0°C to +50°C and enables switching distances from 20mm to 100mm. Thanks to the IO-Link interface, the sensor with switching output can be switched from a pushbutton to a reflex barrier, which means that the device can also be set in a variety of ways to a background (e.g. machine part, sheet metal, etc.) instead of an object to be detected. Comparable to an optical system, in this operating mode the switching output is activated when an object is located between the sensor and the background. After installation, all settings and adjustments can be made via the IO-Link interface, which can be particularly advantageous in applications where the sensor is very difficult to access.

The UT089570 in M8, here compared in size to a 2 euro coin, has a length of 70mm. The achievable switching distances are between 20mm and 100mm.

ipf electronic gmbh | Rosmarter Allee 14 • 58762 Altena • Germany | Tel +49 2351 9365-0 • info@ipf-electronic.com • **www.ipf-electronic.com**

6 OPTICAL SENSORS

Optical sensors enable very high ranges and detect a variety of different objects regardless of their nature (geometry, shape, color, material, etc.). For the respective application-specific tasks, ipf electronic offers through-beam sensors, retro-reflective sensors and diffuse reflection sensors.

6.1 THROUGH-BEAM SENSORS

Due to the extremely slim design, especially the **OS050075** (transmitter) in combination with the **OE050175** (receiver) stand out among the disposable systems. Transmitter and receiver in the V2A housing have a diameter of only 5mm with a length of 36mm each. The maximum possible distance between the two components of the light barrier operating with red light is 0.5m.

The transmitter **OS050075** (left) and the receiver **OE050175** (receiver) of the through-beam sensor have a length of 36mm each and a diameter of only 5mm. Transmitter and receiver can be aligned at a distance of up to 0.5m from each other.

ipf electronic gmbh | Rosmarter Allee 14 • 58762 Altena • Germany | Tel +49 2351 9365-0 • info@ipf-electronic.com • **www.ipf-electronic.com**

6.2 OPTICAL DIFFUSE-REFLECTION SENSORS WITH BACKGROUND SUPPRESSION

The optical diffuse-reflection sensors of the **OTQ4** series are equally slim. The functional principle of the devices is based on the triangulation method, which not only enables reliable background suppression, but also ensures object detection almost independently of the surface color. The rod-shaped sensors are only 4mm wide and 6.2mm long with a height of 44.8mm and detect even the smallest objects. Due to fixed scanning distances of 30mm or 50mm, the devices, which also operate with red light, are easy to install and also tamper-proof. Automatic interference suppression prevents mutual optical interference when several **OTQ4**s are in operation directly next to each other.

Convincing features in the smallest of spaces: The rod-shaped optical sensors of the OTQ4 series feature, among other things, background suppression and automatic interference suppression.

The optical diffuse-reflection sensor of the **OTQ9** series are also extremely compact in design. As with the **OTQ4**, their operating principle is based on the triangulation method. The diffuse-reflection sensor are approximately the size of a 10 eurocent coin and are thus among the smallest optical sensors with integrated amplifier and adjustable background suppression.

The scanning range, which can be adjusted on both stationary (static) and moving (dynamic) objects, extends from 2mm to 60mm. The devices, which operate with visible red light, are particularly suitable for detecting the smallest objects and for reliable position detection in fast-running processes due to a high switching frequency and a quick response and drop-out time.

ipf electronic gmbh | Rosmarter Allee 14 • 58762 Altena • Germany | Tel +49 2351 9365-0 • info@ipf-electronic.com • **www.ipf-electronic.com**

6.3 ENERGETIC DIFFUSE-REFLECTION SENSORS

Energetic diffuse-reflection sensors occupy a special position among optical sensors, since they operate according to the principle of intensity distinction. The diffuse-reflection sensor have a fixed switching threshold in relation to the specific amount of light detected (sensitivity). If the amount of light (intensity) reflected by an object reaches or exceeds this threshold, the signal output switches. If these conditions are not met, the sensor does not generate a switching signal. Energetic diffuse-reflection sensor thus reliably detect all objects that reflect sufficient light or enough light to exceed the internal switching threshold. With a length of 36mm and a diameter of 5mm, the **OT059170** is the smallest energetic diffuse-reflection sensor in ipf electronic's portfolio.

Only 5mm is the diameter of the **OT059170** energetic diffuse-reflection sensor, which also has an IO-Link interface.

ipf electronic gmbh | Rosmarter Allee 14 • 58762 Altena • Germany | Tel +49 2351 9365-0 • info@ipf-electronic.com • **www.ipf-electronic.com**

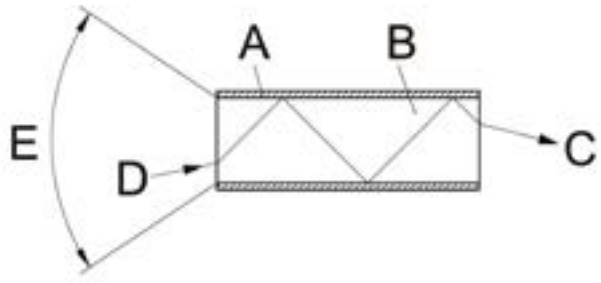
7 FIBER OPTIC SENSORS

Fiber optic sensors have been developed, among other things, to find solutions for applications where there is very little space available for the installation of optical sensors or where the installation location is very difficult to access. The fiber optics make it possible to relocate the evaluation electronics or the actual sensor technology to an area where there is sufficient installation space and also an easily accessible mounting location.

Fiber optic sensors are basically differentiated by the fiber optics. Glass fiber optics consist of a bundle of ultra-thin glass fibers, while plastic fiber optics consist of extremely thin plastic fibers. The ends of the light guides, known as front ends, facilitate installation and have diffuse-reflection sensors for additional optics. The diffuse-reflection sensor are available in various designs, including e.g. angled diffuse-reflection sensor.

Optical fibers with different diffuse-reflection sensor.

Fiber optic cables from ipf electronic consist of a bundle of individual fibers approximately 50µm thick. In combination with the appropriate fiber optic amplifier, fiber optic cables are non-contact and thus wear-free position switches that can also be used under harsh environmental conditions. The fiber optic amplifiers emit modulated infrared light, which is transmitted by the light-conducting glass fibers according to the principle of total reflection. The single optical fiber consists of core and cladding glass. The light beam entering the core glass is guided through the optical fiber due to the reflection at the core/sheath contact surfaces.



Reflection in an glass fiber: cladding (A), core (B), IR light (C, D), opening angle 67° (E).

ipf electronic gmbh | Rosmarter Allee 14 • 58762 Altena • Germany | Tel +49 2351 9365-0 • info@ipf-electronic.com • **www.ipf-electronic.com**

Fiber optics detect objects regardless of their properties (e.g. shape, color, surface structure, material). Since the fiber optic ends or fiber optic heads have very small dimensions and the fiber optics themselves are flexible, object interrogation can be solved very elegantly, especially in places that are difficult to access. Due to the excellent optical and mechanical properties of ipf electronic's fiber optics, this technology is particularly suitable for use in automation and manufacturing processes as well as in the field of small parts detection.

Fiber optics can also be used in potentially explosive atmospheres or in zones with electric and/or magnetic fields (e.g. high-voltage installations, electric welding equipment) without any special precautions, especially since such conditions do not impair their function. Glass fiber optics find versatile applications in all industrial sectors, including mechanical engineering, chemicals, pharmaceuticals, and ceramics and plastics processing. The solutions are available as through-beam sensors or diffuse-reflection sensor, depending on the application requirements.

An impression of the size of a glass fiber optic is given by the fiber optic barrier **LS030101**. The diameters of the diffuse-reflection sensor are 1.5mm (front) and 6mm. The fiber bundle itself has a diameter of only 1mm. The fiber optic barrier has a maximum range of 180mm and is suitable for use at elevated ambient temperatures up to +180°C.

The **LS030101** fiber optic barrier achieves switching distances of up to 180mm and is designed for ambient temperatures from -40°C to +180°C.

ipf electronic gmbh | Rosmarter Allee 14 • 58762 Altena • Germany | Tel +49 2351 9365-0 • info@ipf-electronic.com • **www.ipf-electronic.com**

8 CAPACITIVE SENSORS

Capacitive sensors open up a wide range of applications because they detect metallic and non-metallic objects as well as liquid media without contact. The ranges of the devices depend on the material, the object dimensions and the set response sensitivity. Capacitive sensors achieve the greatest switching distances with ferromagnetic materials (steel, iron) and water. The potential tasks of these sensors include presence monitoring, positioning, counting, level sensing and distance measurement. The portfolio of capacitive sensors from ipf electronic includes very compact solutions such as the **KB060170** (diameter 6.5mm, length 54mm) and the **KB080100** (diameter 8mm, length 42mm). Both sensors in stainless steel housing (IP65) are designed for ambient temperatures from-10°C to +70°C and have standard switching distances of up to 1.5mm.

The **KB060170** (above) and **KB080100** capacitive sensors in stainless steel housings have diameters of 6.5mm and 8mm respectively.

The **KB050180** is certainly out of the ordinary, not only because of its dimensions (diameter 5mm, length 20mm). Since the solution consists of a two-part system with an external amplifier, the sensor (maximum switching distance up to 1mm) can withstand very low as well as high ambient temperatures from-55°C to +125°C.

The **KB050180** is a two-part system with external amplifier. Therefore, the actual sensor can withstand very high and low ambient temperatures.

ipf electronic gmbh | Rosmarter Allee 14 • 58762 Altena • Germany | Tel +49 2351 9365-0 • info@ipf-electronic.com • **www.ipf-electronic.com**

9 APPLICATION EXAMPLE

Sensors in ''miniature format'' can be used in many ways in practice and, not only because of their compact design, prove their worth especially in applications where conventional devices reach their limits. Some application examples of selected solutions.

9.1 LONG-LASTING IN DIFFICULT ENVIRONMENTS

OTQ9 series sensors have become a bestseller in Federal-Mogul Sealing Systems' manufacturing operations for several valid reasons. Federal-Mogul Sealing Systems is a company of Federal-Mogul Corporation, a leading global manufacturer of products and solutions primarily for the automotive industry and producers of light and heavy commercial vehicles. At its site in Herdorf, Germany, Federal-Mogul Sealing Systems manufactures cylinder-head gaskets for internal combustion engines and heat shields. Production covers almost all vehicle makes and also all engine variants. The number of different tools required, for example for the punching machines used to manufacture the cylinder-head gaskets, is correspondingly high.

Production takes place from the running steel coil, with the multilayer steel gaskets (MLS gaskets) being manufactured using progressive dies that combine several work steps. In the MLS stamping plant, forked light barriers were initially used to control the feed rate of the steel strips. However, the sensitive and also expensive devices had high failure rates due to their use, with some devices were already destroyed during the retooling of the punching machine. Attempts with a laser diffuse-reflection sensor did not bring the desired success due to the external device dimensions and the too low switching frequency. In the search for a real alternative to forked light barriers, the company finally became aware of the **OTQ9** series of optical sensors, more specifically the **OTQ90170** sensor (see Chapter 6.2).

With regard to the application as described, the diffuse-reflection sensor was able to convince in several respects as an economical solution to the costly forked light barriers: through its extremely compact design, its background suppression, its dynamically adjustable scanning range and the high switching frequency and low response time. All together these features gave a lot of potential for flexible applications in the MSL stamping plant. Due to its dimensions of just 9.2x10.8x21.2mm, the **OTQ90170** can be installed directly in the progressive dies. The devices are already preset for the respective applications in the stamping plant of Federal-Mogul Sealing Systems. It is also possible to teach the sensor externally via a teach box.

Due to its dimensions, the **OTQ90170** can be installed directly in the progressive dies of the MLS stamping plant for feed rate control.

For feed control, a hole is made in the steel strip at a defined point during the first cut. This hole must be detected by the so-called feed sensor to ensure the correct position of the material in the die for each individual stroke. The further transport of the strip takes place so quickly that only milliseconds are available for the reliable detection of the position

hole in order to provide a switching signal for the PLC of the punching machine. If this does not happen, the system is stopped immediately via the PLC. At the time of the query, background suppression is also necessary, since the sensor also ''sees'' the shiny upper tool through the position hole and this must not be detected under any circumstances.

Another decisive plus point for the applications at Federal-Mogul Sealing Systems is the comparatively large and, if required, dynamically adjustable scanning range of the optical sensor (maximum range 60mm), which means that the solution can be used very flexibly for a wide variety of queries. In this specific application, a switching distance of around 30mm is mostly used. Depending on how fast the respective feed rate is set for processing or at which cycle rate the punching machine runs, smaller waves sometimes occur in the strip during further transport, which increases its distance to the sensor. The sensor can compensate for this due to the large adjustment range with exact adjustability of the end reach, whereby the scanning range or reach of the **OTQ90170** is ideally set so that it ends a quick distance before the upper tool.

High process reliability: Optical sensors integrated in various stations of the progressive tool ensure that the respective plates are available for processing.

The **OTQ9** series sensors have been in use for several years and have now become a bestseller, as the low-cost devices only have a limited service life due to the harsh environmental conditions. Nevertheless, the company is extremely satisfied with this economical solution, as all devices tested so far failed to meet expectations.

ipf electronic gmbh | Rosmarter Allee 14 • 58762 Altena • Germany | Tel +49 2351 9365-0 • info@ipf-electronic.com • **www.ipf-electronic.com**

9.2 EXTREME CONDITIONS ON THE RAIL

In chapter 4, very compact cylinder sensors were presented as special solutions in the field of magnetic field sensors. The following application shows the high stresses that such sensors can withstand due to their robust housings (stainless steel, die-cast zinc) and encapsulated electronics, among other things.

The coupling system of the railcars of high-speed trains is aerodynamically clad by GRP half-shells which can be opened via pneumatic cylinders for access to the coupling. The position of the cylinders (extended or retracted) must be monitored, because when the half-shells are open, the maximum permissible speed of the railcar is limited for safety reasons. Because the GRP half shells do not hermetically seal the coupling system, the pneumatic cylinders are subject to extremely harsh operating conditions under all conceivable environmental influences. The challenges: an operating temperature range of -40°C to +80°C, extreme mechanical vibrations, strong weather fluctuations (change of high and low temperatures, icing), dirt, dust, humidity, etc.. In addition, the mounting grooves of the pneumatic cylinders are only accessible from above.

Coupling system of a railcar aerodynamically clad by GRP half shells, which can be opened via pneumatic cylinders. The task: To ensure that the cylinder position is always reliably sensed under extremely harsh operating conditions.

ipf electronic developed the **MZA7C970** based on an existing magnetic cylinder sensor. The sensor is extremely compact at 16x20x9.2mm and was adapted to the 6.4mm round groove of the pneumatic cylinder with a special mounting element so that it can be mounted from above. The M8-connector integrated in the sensor housing allows the cables connected to it to be replaced separately in the event of a defect (e.g. cable breakage due to the constant vibrations in use). The housing of the cylinder sensor in protection class IP67 is made of robust zinc die casting and therefore withstands the extreme operating conditions already described. The electronics are also completely encapsulated and are thus protected against shocks and strong vibrations.

ipf electronic gmbh | Rosmarter Allee 14 • 58762 Altena • Germany | Tel +49 2351 9365-0 • info@ipf-electronic.com • **www.ipf-electronic.com**

The very robust MZA7C970 cylinder sensor in a zinc pressure housing is very compact, has a special mounting system and integrates a connector plug for quick replacement of cables that are subject to high demands in use.

The example demonstrates how, among other things, the use of certain housing materials and the adaptation of mounting systems as well as connections can be used to realize customized sensors with small dimensions for special areas of application with very high requirements.

10 SUMMARY AND CONCLUSION

If the intended installation location for a standard device is not sufficient in an application, miniature sensors can often help, especially since such solutions often have comparable properties. Another advantage of miniature sensors is that they can be better protected against mechanical damage or other undesirable environmental influences by selecting a specific installation location. When selecting a potential solution, care must of course be taken to ensure that the sensor meets the technical requirements necessary for a particular application and, in this context, also has the necessary range.

ipf electronic has a large selection of miniature sensors that operate according to different methods or are based on a wide variety of functional principles, be they inductive, capacitive or optical sensors, ultrasonic, magnetic field, cylindrical or fiber optic sensors. Since these include devices that are particularly robust due to the used housing materials and the special processing, the solutions are even suitable for use under extremely harsh environmental conditions. A suitable device in compact dimensions is therefore available for almost every possible application.

If no suitable device can be found for an application despite the wide range of miniature sensors, ipf electronic will develop application-specific special solutions on request, either based on an existing sensor or as a completely new development. Specific solutions for this can be found in this white paper, e.g. the **IB06A023** and **IB98E314** inductive sensors (see chapter 2), which belong to the special devices, and the **MZA7C970** cylinder sensor presented in an application example (see chapter 9.2).

ipf electronic gmbh | Rosmarter Allee 14 • 58762 Altena • Germany | Tel +49 2351 9365-0 • info@ipf-electronic.com • **www.ipf-electronic.com**

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

Subject to alteration! Version: March 2022