

White Paper

Magnetic Cylinder Sensors

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1. Introduction

Pneumatic cylinders are working cylinders that are driven by means of compressed air, whereby a distinction is generally made between cylinders that can be charged with compressed air in one or in both directions (Fig. 1). With single-acting cylinders, a piston rod is moved by charging one cylinder end with compressed air. As soon as the cylinder is no longer charged with compressed air, the piston rod is returned to its initial position via a spring. With double-acting pneumatic cylinders, the piston rod is moved from both cylinder ends by charging with compressed air.

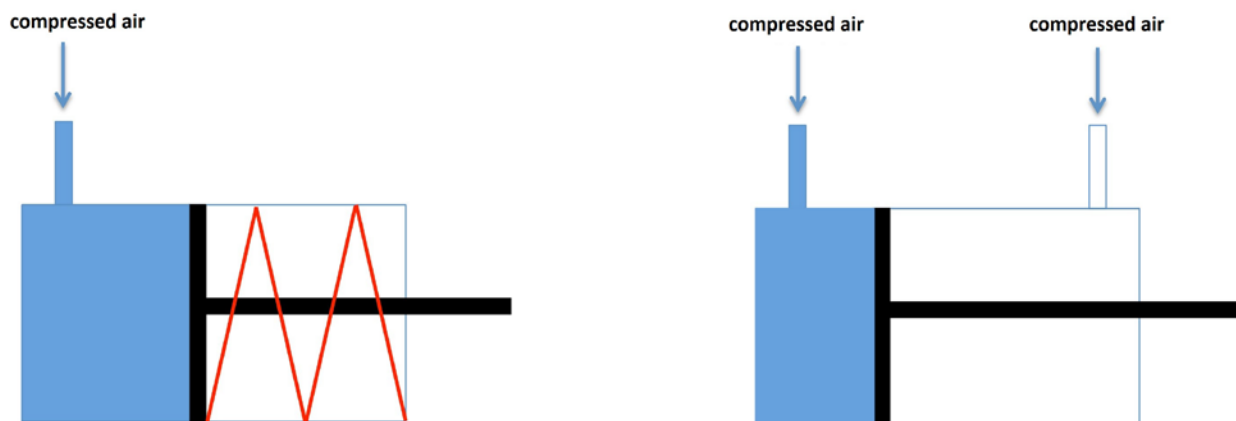


Fig. 1: Pneumatic cylinders that can be charged with compressed air in one direction

Pneumatic cylinders are used in many automated applications, e.g., in injection molding tools in the plastics industry or in drive, conveying and handling technology.

In these and many other areas of use, it is often necessary to receive a switching signal at certain piston positions of a pneumatic cylinder.

Recommended for this task are magnetic cylinder sensors, as they very reliably detect the position of piston rods in pneumatic cylinders and do so contactlessly and wear-free.

2. Classification of magnetic sensors

Cylinder sensors are classified as magnetic field sensors. The following graphic (Fig. 2) provides an overview of the classification of magnetic sensors.

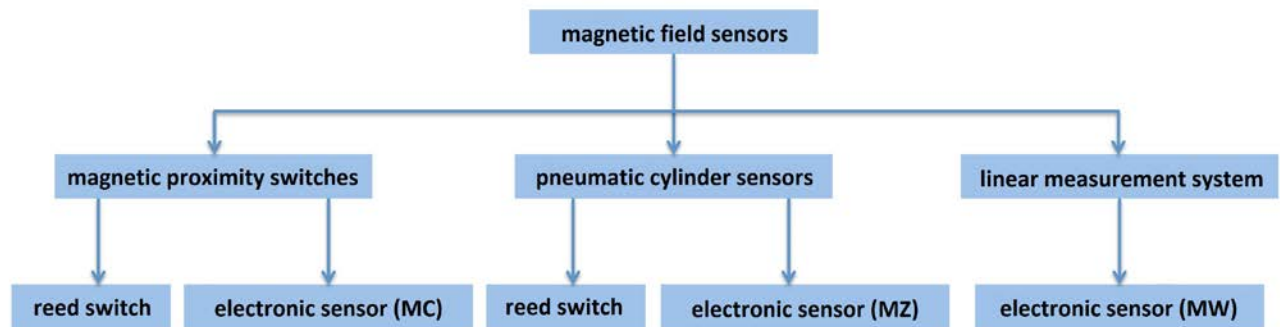


Fig. 2: Classification of magnetic field sensors

3. Operating principle of magnetic cylinder sensors

The piston of a pneumatic cylinder integrates a permanent magnet that generates a magnetic field which penetrates all non-ferromagnetic materials (e.g., the housing of the cylinder).

Located within the cylinder switch (Fig. 3 shows the MZR40175 and MZR40178) is a magnetoresistive sensor that changes its resistance if a magnetic field is located in its vicinity. This change in resistance is converted to a switching signal by connected electronics.

The cylinder sensor switches accordingly as soon as it detects the field of the permanent magnet of the piston rod.

When using magnetic cylinder sensors, note that their alignment with respect to the sensor axis changes the switching distance (Fig. 4).



Fig. 3: Cylinder switches MZR40175 and MZR40178 for the C-groove of pneumatic cylinder-

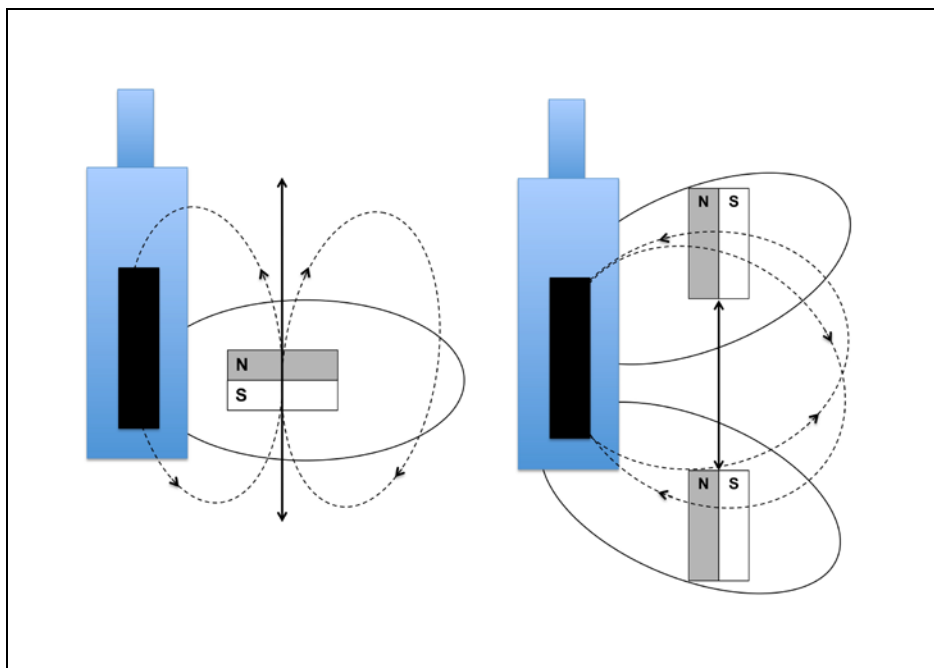


Fig. 4: Correct (left) and incorrect (right) alignment of a cylinder sensor.

4. Advantages of fully electronic systems

During use, magnetic cylinder sensors are often exposed to substantial stresses.

Here are just a few examples:

- mechanical loading caused by strong vibrations, impacts or shocks
- high or low ambient temperatures
- contact with coolants, lubricants, cleaning agents, solvents, paints, oils, etc.

Below are several figures from practical work that are intended to illustrate the extreme conditions under which cylinder sensors must function.



Fig. 5: Magnetic cylinder sensors on a special hydraulic cylinder. The sensors must withstand very high mechanical loads and temperatures of up to +100°C.



Fig. 6: Two very compact sensors on an extremely short pneumatic cylinder.



Fig. 7: The sensors even withstand paint splatters, dried-on paint residues or cleaning agents and solvents.



Fig. 8: Cylinder sensors in an extremely oily environment on a machine.

In spite of these and other significant loads, cylinder sensors always function trouble-free. As fully electronic systems, such sensors have a number of advantages over devices that use reed contacts (Fig. 9) for the position sensing of pistons.

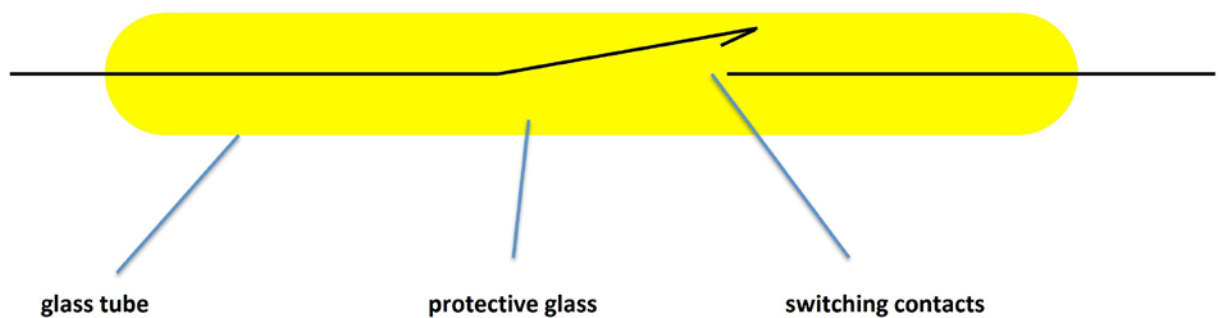


Fig. 9: Switch with mechanical reed contact that is actuated if a magnetic field is in its vicinity.

Because electronic cylinder sensors have no moving parts or switching elements, they function wear-free, unlike switches with reed contact which, e.g., tend to bounce in the event of vibrations or impacts. Due to their protection class IP67, all cylinder sensors from ipf electronic are extremely well protected and are also very robust due to, among other things, the fully casted electronics and housing versions made of metal. Another advantage is that the devices can also be used at very low and very high temperatures (operating temperature range from -40 °C to +130 °C).

Compared to switches with reed contacts, fully electronic cylinder sensors feature higher accuracy with very good repeat accuracy and a high switching frequency (up to 1kHz). In addition, these are extremely precise due to very short travel paths and are very flexible, as they can be calibrated for various magnetic field strengths or different pneumatic cylinder types. Switches with reed contacts do, in fact, operate voltage-free and function without supply voltage. They are, however, not protected against short circuits and cannot be constructed arbitrarily small since the reed contact requires a certain installation space.

Summary: The advantages of electronic cylinder sensors make them the clear winner. And, even if one includes the lower procurement costs of switches with reed contact compared to those for cylinder sensors, the investment in cylinder sensors will likely prove worthwhile over the long term due to the trouble-free and extremely reliable operation.

5. Various solutions for different cylinder types

Various application areas require different cylinder types. ipf electronic therefore offers a very wide selection of different magnetic cylinder sensors (Fig. 10) with various fastening concepts and adapters for easy mounting to all common cylinder types.

The predominant cylinder types are equipped with C-groove (rounded groove), T-groove, or dovetail groove. There are also tie rod cylinders, profile cylinders as well as round cylinders.

In addition to directly mountable sensor solutions for C-groove, T-groove, dovetail and tie rod cylinders from all common manufacturers, ipf electronic has developed a wide range of adapters for the flexible and extremely reliable fastening of its cylinder sensors to other cylinder types as shown in Fig. 11.



Fig. 10: Versatile sensors for all common pneumatic cylinders from leading manufacturers

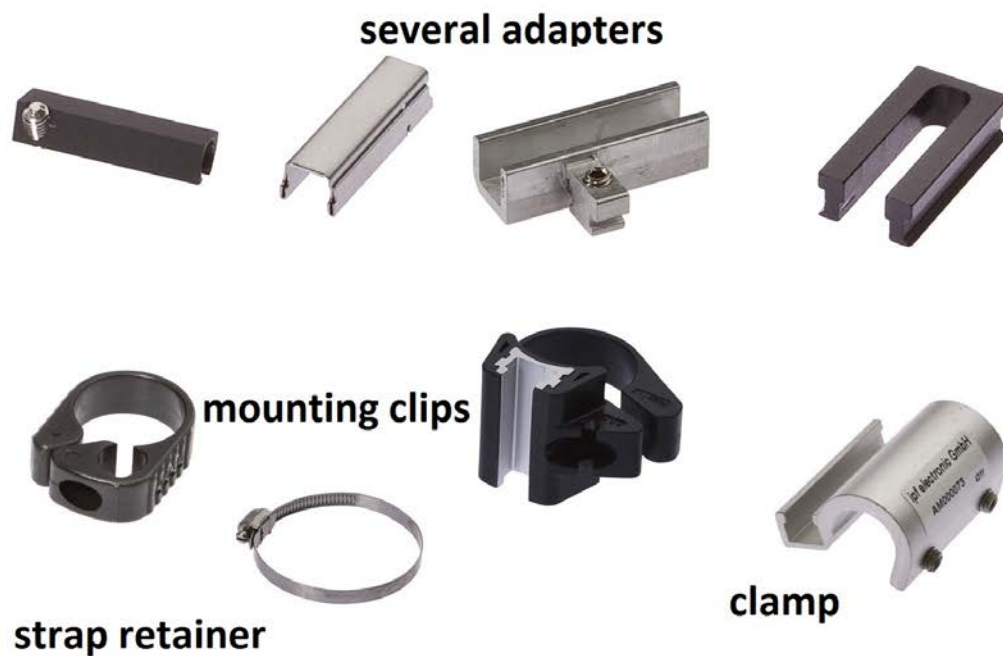


Fig. 11: A wide range of fastening solutions increase the functional flexibility of the sen-

5.1 Direct mounting

Developed for direct mounting on pneumatic cylinders with C-groove from all leading manufacturers were the compact cylinder sensors of the MZR4 series, which feature a high locking power. With the MZR40787 from this series, a single sensor can be used to teach-in two piston rod positions with just a single sensor using a device-side teach button and a 24V DC signal output for both signals via two separate PNP outputs. Thus, just a single sensor is needed to detect the piston rod positions. This promises considerable advantages, particularly for applications with very limited space conditions. The sensors of the MZ07 and MZA7 series are slid in or inserted from above in the T-groove of pneumatic cylinders. Like the MZR4 series, the MZ07 series also features a cylinder sensor (MZ070787) with which two piston rod positions can be detected.

The magnetic cylinder sensors of the MZ15 series are mounted from above in the dovetail groove of pneumatic cylinders (independent of manufacturer); the MZ31 sensor series, on the other hand, was specially developed for mounting on tie rod cylinders.

5.2 Mounting with flexible adapters

The cylinder sensors of the MZR9 series can be mounted on profile or tie rod cylinders using special brackets made of aluminum. Mounting on round cylinders is performed with mounting clips or a strap retainer. The devices of the MZR9 sensor series with metal housing have a built-in amplifier and are also suitable for very short pneumatic cylinders. The sensors of the MZ13 series with integrated LED indicator are designed for round, tie rod or profile cylinders and can be used, for example, on round cylinders with strap retainers independent of the diameter of the pneumatic cylinder. Thanks to the sophisticated adapter concept from ipf electronic, it is possible to mount a specific cylinder sensor on various cylinder types. Among others, the MZR4 cylinder sensors for the C-groove described in 5.1 can, thus, also be fastened to round cylinders, T-groove cylinders, dovetail cylinders, profile cylinders and tie rod cylinders when used in combination with a wide range of fastening solutions.

The following table shows an overview of the solutions mentioned in 5.1 and 5.2.

sensor series	cylinder types					
	C-groove	T-groove	dovetail	pull rod	profile	round
MZR4	X	X	X	X	X	X
MZR9				X	X	X
MZ13				X	X	X
MZ07/A7		X	X	X	X	X
MZ15			X			
MZ31				X		

Fig. 12: Magnetic cylinder sensors for various cylinder types

6. Special solutions

As wide and diverse as the selection of magnetic cylinder sensors and adapters for flexible mounting are, there will always be applications for which very specific solutions need to be developed. Here are a few examples from practice:

The MZA7C879 (Fig. 13) with a special fastening concept for a 6.4mm rounded groove was developed specifically for use in the coupling system of rail vehicles. The cylinder sensor with an operating temperature range from -40°C to +80°C is extremely robust and withstands even very strong impacts and high levels of vibration.



Fig. 13

The MZ150182 (Fig. 14), with zinc diecast housing and an integrated position magnet, is used as a customer-specific solution on special hydraulic cylinders. The sensor must withstand harsh conditions, e.g., on clamping tools for dies or interchangeable tools. A specially developed fastening solution ensures that the sensor is securely held, even in the event of extreme impacts and vibrations.

This special solution can be used in temperatures from -15°C to +100°C.

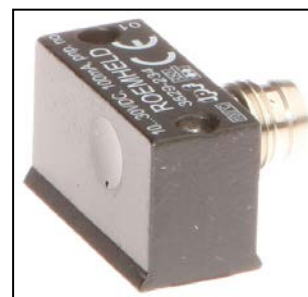


Fig. 14

There are even cylinder sensors for pneumatic cylinders integrated in robot grippers, such as the MZ07C431 (Fig. 15). The mounting concept is specially designed for the cylinder type already present in the robot gripper. The electronics of this solution were also adapted to a non-interference free (unclean) supply voltage. The MZ07C431 was also equipped with a special line that is suitable for trailing chains and a cable outlet developed at the customer's request.



Fig. 15

The MZ07A108 (Fig. 16) was developed for mounting on pneumatic cylinders of large systems for handling bulk of mass-produced parts, such as the cleaning and drying of workpieces made of metal. During operation, the device must withstand extreme vibrations. The fastening concept was designed correspondingly robust with a 2.5mm Allen bolt. Furthermore, the sensor is equipped with an M12 connection at the customer's request.



Fig. 16

The MZ07C731 (Fig. 17), on the other hand, is used in the direct vicinity of a welding plant. The robust sensor in metal housing with M12 plug connector has a connection cable with Teflon sheathing and is, thus, insensitive to damages caused by weld splatter.



Fig. 17

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