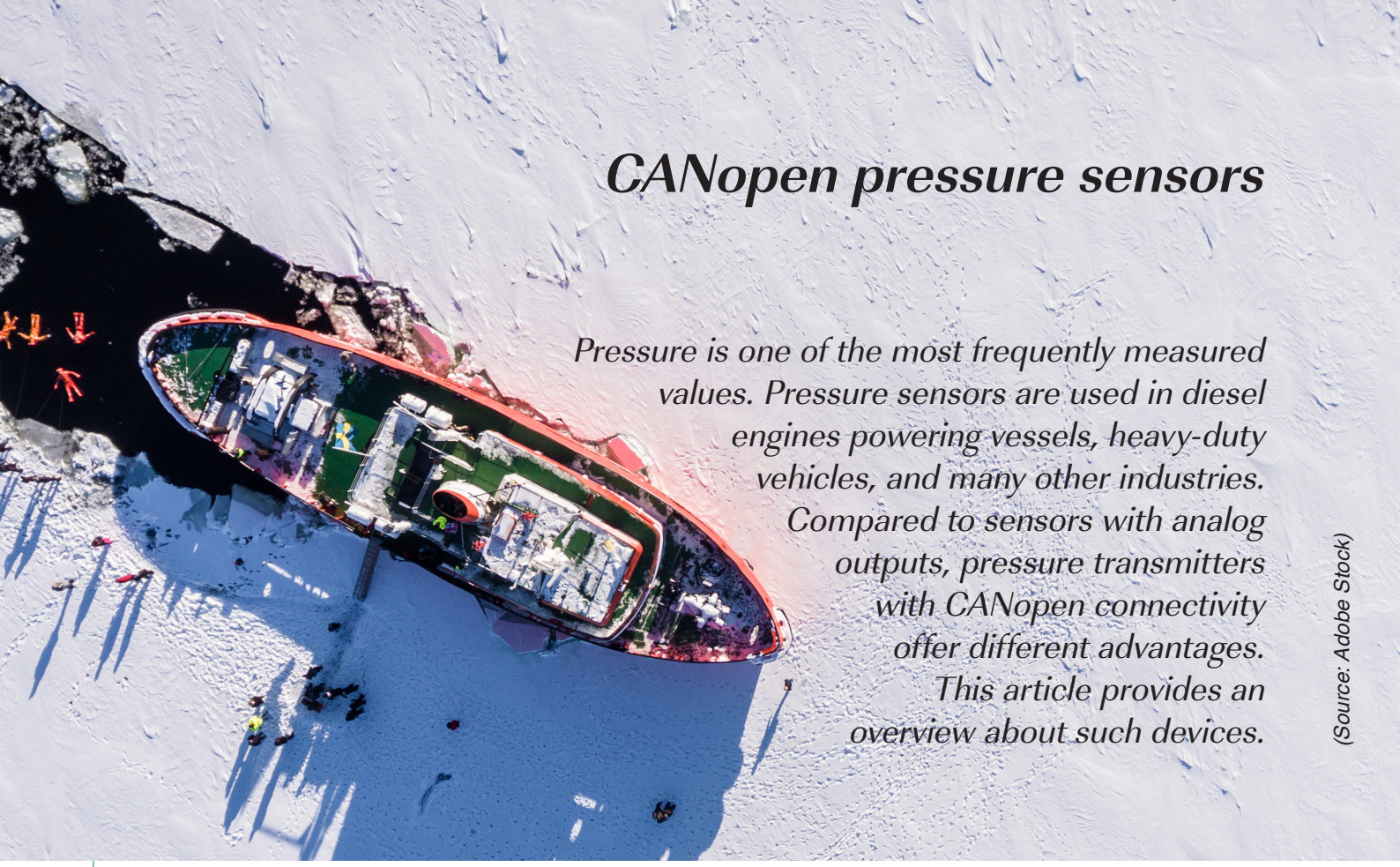

# CANopen pressure sensors

*Pressure is one of the most frequently measured values. Pressure sensors are used in diesel engines powering vessels, heavy-duty vehicles, and many other industries. Compared to sensors with analog outputs, pressure transmitters with CANopen connectivity offer different advantages. This article provides an overview about such devices.*

(Source: Adobe Stock)

According to a report from MarketsandMarkets, the global pressure sensor market is expected to have a CAGR (compound annual growth rate) of 6,5 % from 2024 to 2029. Piezoresistive pressure sensors are poised to dominate the market. Regarding connectivity, the wired pressure sensors hold the largest share. These are directly connected to PLCs (programmable logic controllers), monitoring systems, or data acquisition devices allowing uninterrupted data exchange as well as real-time monitoring and response.

## Pressure measuring devices

Pressure is defined as the exertion of force per unit area. Pressure sensing solutions measure the pressure of gases or liquids. Such devices include pressure gauges, pressure sensors, pressure transducers, as well as pressure transmitters. Pressure gauges are simple mechanical devices that are read visually. They do not require electrical power, and do not provide a feedback signal.

Pressure sensors operate by sensing pressure and converting it into an electrical quantity. Piezoresistive and capacitive are the two most commonly seen types in industrial applications with piezoresistive being the most used. A piezoresistive pressure sensor consists of a silicon diaphragm with a piezoresistive strain gauge diffused into it. The electrical resistance of piezoresistive material changes when it is strained or compressed. As pressure increases, the piezoresistive material is more resistant to the electrical current passing through it. This results in the output voltage, being directly proportional to the pressure. Capacitive pressure sensors use a thin diaphragm (e.g. from metal) that serves as a capacitor plate. The diaphragm is exposed to a reference pressure on one side and to the process pressure on the other. Pressure changes cause a deformation of the sensing plate causing changes in the electrical capacitance. The latter are directly proportional to the applied process pressure. Thus, such pressure sensors detect pressure variations by sensing changes in the resistance or capacitance.

Pressure transducers consist of a pressure sensor mounted to an industrial process connection. The transducer converts pressure into an analog electrical signal, typically measured in millivolts. These signals are relatively weak and require amplification to carry these values over a distance. The signals are also not linearized or temperature compensated.

Pressure transmitters include the elements of the transducers and have additional circuitry that linearizes, compensates, and amplifies the signal from a transducer. Thus, such devices can transmit the signal over large distances to a remote receiver and provide calibration features to improve the accuracy and measuring range of the device. Typical outputs of pressure transmitters are analog signals (e.g. 0 $V_{DC}$ to 10 $V_{DC}$ or 4 mA to 20 mA) or digital interfaces such as, for example, CANopen.

In principle, there are absolute pressure transmitters, gauge pressure transmitters, and differential pressure transmitters. The absolute pressure transmitters measure the absolute pressure referenced to a full vacuum. Fluid pressure is compared against the reference pressure of an absolute vacuum in a sealed reference chamber. Thus, the sensor measures pressures that are not influenced by ▷

atmospheric pressures. Such transmitters are often used for high-accuracy low-pressure measurements. Gauge pressure transmitters are referenced to atmospheric conditions and are widely used in the process industries to measure the pressures of liquids, gas, and steam. They can measure low and high pressures. Differential pressure transmitters measure the difference between two pressures and are used for a long time to measure the flow rate. Today, absolute and gauge pressure transmitters are replacing pressure gauges, switches, and transducers as they are more stable and reliable and can transmit the pressure values to control devices.

## CiA 404 CANopen device profile for measuring devices

The CiA 404 device profile is dedicated to analog transducers (e.g. pressure transducers) that may also provide digital I/O capability. The specified analog input function distinguishes between a field value and a process value. Field values are non-scaled readings from the analog/digital converter. This value is converted to the physical dimension or is given in percent of the measuring range, and the result is called process value. An example for a process value is a value in Pa or bar for pressure measurement. The process values are given with selectable resolutions e.g. 8-bit, 16-bit, and 32-bit integer, or Real32. Thus, the pressure values are output on the CANopen interface with the offset, resolution, and physical unit required by the respective process application. The electronics implementing the CiA 404 CANopen profile in pressure measuring devices enables them to provide pressure values in a standardized way. This allows for a simplified integration into CANopen networks and enables the use of off-the-shelf CANopen tools e.g. for device setup and diagnostics.

## CANopen-capable pressure transmitters

Following, an (incomplete) overview on pressure transmitters with CANopen connectivity is given. Most of them support the CiA 404 CANopen profile or/and the CAN-based J1939 higher-layer protocol. The transmitters with CANopen/J1939 interfaces reduce installation costs due to the simplified wiring compared with analog sensors. Via the CAN interface users can get access to additional device data e.g. for diagnostics and maintenance purposes. The digitally available data can be made available worldwide using IoT (Internet of Things) applications. Calibration and control of the sensors is also possible via CAN.

The KD41 gauge pressure transmitter from Ashcroft (U.S.A.) offers CANopen and J1939 interfaces. The stainless-steel device with stem mounting and ingress protections of IP65, IP67, or IP69K is dedicated for pressure measurements from 1 bar to 1400 bar. Markets and applications include machine automation, hydraulics, pneumatics, off-road equipment, pumps and compressors, etc. Bit rates up to 1 Mbit/s (with 125 kbit/s as default) are supported. The user can choose between variants with different start-up behavior (automatic and non-automatic), bus termination, galvanic isolation, and EMC requirements. The pressure transmitter enables conversion of field values (calibrated electrical value at input terminal of the transducer) to process values (with a real physical dimension) according to the principles as specified in the CiA 404. This process is also called linear transformation or linearization. The device is working within the temperature limits from -40 °C to +105 °C.

On request, the long-term CiA member Baumer (Germany) provides the PBM4 gauge pressure transmitter with a CANopen interface. It enables relative pressure measurements from 0 bar to 2000 bar in industrial and mobile hydraulic applications. The IP67-rated device with stainless-steel housing is fully welded and provides the E1 approval for mobile hydraulics. The possible operation temperature ranges from -40 °C to +125 °C. The CANopen interface works at bit rates of up to 1 Mbit/s (125 kbit/s as default) and supports the CANopen specifications CiA 301 and CiA 404. To set the bit rate and the node-ID via CAN, the layer setting services according to CiA 305 are implemented. The device deploys the 5-pin M12 connector with pin assignment according to the CiA 106 document.

Buerkert (Germany), also a member from CiA, offers the 8312 pressure transmitter with CANopen. It is used for measuring either relative or absolute pressures (on request) in liquids or gases and is available with ceramic thick film or metallic thin film strain gauge measuring principles. Different linearized and temperature-compensated measuring ranges from -1 bar to 5 bar, 0 bar to 0,25 bar up to 0 bar to 16 bar are selectable. The possible media temperature range is from -20 °C to +85 °C (ceramic) and -40 °C to +125 °C (metallic). The IP67-protected transmitter uses the M12 socket connector with CiA-106 pin assignment. The device digitizes the pressure value and makes it available for use through the CANopen interface. Therefore, it supports the CiA 404 CANopen profile for measuring devices and closed-loop controllers. A driver used for data exchange and settings of the 8312 is integrated in the Buerkert PC tool Communicator and is available on company's website. LSS (see CiA 305) services are implemented as well.

The DST 10B OEM (original equipment manufacturer) gauge pressure transmitter is produced from Danfoss (Denmark). The manufacturer is CiA member with different subsidiaries. The device implementing the CiA 404 profile is dedicated for water distribution (e.g. water pumps) and air handling (e.g. industrial air compressors) applications. It is available in pressure ranges from 0 bar to 4 bar up to 0 bar to 40 bar. The device is able to work with media temperatures from -40 °C to +100 °C. The CAN interface is accessible at the 5-pin M12 connector integrated in the IP67-rated stainless-steel housing. The connector pin assignment accords to the CiA 106. Beginning of 2024, the DST 10B has passed the CANopen conformance test ▷


*Figure 1: The DST-P10B pressure transmitter (Source: Danfoss)*

by CiA, which ensures the device compliance with the CANopen application layer and communication profile (CiA 301).

All industrial pressure sensor models from Dynisco (U.S.A.) are available in CANopen versions, states the manufacturer. For instance, the strain gauge pressure transmitter IDA3XCAN series for pressure ranges from 0 bar to 20 bar up to 0 bar to 2000 bar. The device's functions and communication software are implemented according to the CiA 404 CANopen profile. The digital pressure output value has a resolution of 12 bit. The bidirectional communication combined with internal functions such as transducer setup and calibration, pressure operating alarms, sensor watchdog control, etc. enable more versatile operating conditions and security functions than analog transmitters. The device's node-ID can be adjusted by hardware jumpers for simplified field replacement. The stainless-steel device is protected according to IP65 or IP67 and can be deployed at medium temperatures from -35 °C to +120 °C. It uses the 7-pin round socket connector.

KMC pressure transmitters from CiA-member Gefran (Italy) are based on a film sensing element deposited on a stainless-steel diaphragm. Due to the stainless-steel construction, resistance to harsh environmental conditions, as well as support of CANopen and J1939, these products are especially suited for mobile hydraulic applications. In addition to pressure measurement, measured data contains the temperature of the device. The devices measure fluid pressures from 4 bar to 1000 bar and are dedicated for operating temperatures from -40 °C to +125 °C. Ingress protection is IP67/IP69K with the socket homologated connector mounted. The device supports bit rates up to 1 Mbit/s with a default bit rate of 250 kbit/s. The CANopen variants implement the CiA 404 profile and CiA 305 specification for layer setting services (LSS).

HDA 4700 by Hydac (U.S.A.) with a CAN interface is a gauge pressure transmitter used to measure relative pressures in hydraulics and pneumatics. Depending on the version, measuring ranges from 0 bar to 40 bar up to 0 bar to 2000 bar are possible. The measured pressure value is digitized and made available via the CANopen or J1939 interface supporting bit rates up to 1 Mbit/s. The device's parameters can be viewed and configured using off-the-shelf CANopen software. The IP67-protected device works at temperatures from -25 °C to +85 °C with wider ranges on request. In addition to the CiA 404 profile for sensors, the layer setting services (CiA 305) and automatic bit-rate detection (CiA 801) are implemented in the CANopen variant. The company is also member of CAN in Automation.

Jumo (Germany) provides the CANtrans p transmitter, which acquires either the relative (-1 bar to 600 bar) or absolute pressures (0 bar to 25 bar) of liquids and gases. It digitizes the pressure value and makes it available for further use via CANopen. Due to the implemented CiA 404 profile, the pressure value can be scaled to any dimensional unit or in percent of the measuring range. Fine calibration features, an auto-zeroing function, and an adjustable shift of the characteristic are possible. Undesirable signal fluctuations can be suppressed through the (adjustable) filter constant. An emergency telegram is triggered in the event of a sensor fault. The bit rate and node-ID can be set via CAN using the LSS services. The used M12 plug connector provides pinning according to CiA 106. The stainless-steel unit withstands media temperatures from -40 °C to +125 °C and is typically used in such environments as wind power plants.

*Figure 2: 23SXc pressure transmitter (Source: Keller)*

Keller Druckmesstechnik (Switzerland) produces the 23SXc absolute and relative pressure transmitters for measuring ranges from 0 bar to 0,16 bar respectively from 0 bar to 1000 bar. The devices capturing pressures and temperatures support the CiA 404 profile. In the transmitters, temperature dependencies and non-linearity are compensated by means of a mathematical model in the micro-controller. Insulated and encapsulated piezoresistive pressure sensor is housed in a fully welded stainless-steel construction without internal seals. The transmitter deploys the 5-pin M12 connector with the CiA-106 pin assignment. The IP67/IP68-rated devices can work at media temperatures from -40 °C to +125 °C. The CANopen connectivity offers a simplified integration into a wide range of automation solutions, informs the CiA member. Typical applications include engine test benches, industrial applications, automation technology, and mobile hydraulics.

The CiA-member company Sensata Technologies (U.S.A.) provides the PTE7500 series of CANopen gauge pressure transmitters for measuring ranges from 0 bar to 16 bar up to 0 bar to 600 bar. The manufacturer uses a modified version of the CANopen stack created by Embedded Office. Beside the basic CiA 301 CANopen profile, the devices support the CiA 404 and CiA 305 (LSS) specifications. Bit rates up to 1 Mbit/s are possible. The IP69K-rated, stainless-steel design with a hermetic port is built to last in high vibration and shock environments. Operating media temperatures can vary from -40 °C to +125 °C. Applications include machine tools, injection molding equipment, industrial hydraulics and pneumatics, mobile hydraulics, off-highway vehicles, pumps, compressors, etc.

The M01-CAN pressure sensor series from Sensor-Technik Wiedemann (STW), a long-years CiA member, has been developed for use in commercial vehicles and mobile machines. Variants for absolute (0,1 bar to 7 bar) and relative pressure measurements (5 bar to 2000 bar) are provided. The respective media temperatures can lie at -40 °C to +85 °C and -40 °C to +150 °C. The sensors are available with CANopen, J1939, or STW-proprietary connectivity. The modular principle of the series permits a large number of combinations of pressure connection, pressure range, electrical output signal, and electrical connection. The M01 series supports PL b (performance level) according to ISO 13849 and is therefore suitable for machine safety applications. For electrical connection, the M12 connector (plastic or stainless steel) is used. The protection class of IP67 and IPX9K depends on the ▷

electrical connection. A software package for CAN setting parameters is available. The variant M01-CAN2 provides a state-of-the-art CAN protocol stack and support of the STW open-source software platform Opensyde. M01-CAN is no longer recommended for new designs.

The 0630 digital pressure transmitter series from Suco (Germany) is supporting the CiA 404 CANopen profile as well as J1939 (version 0631). Variants are available for pressures from 0 bar to 1 bar up to 0 bar to 600 bar. The robust completely welded stainless-steel sensor housing enables deployment of the device in harsh operating environments. Bit rates up to 1 Mbit/s (with 250kbit/s as default) are supported. The transmitter also supports the layer setting services (LSS) according to CiA 305. The possible media temperature may range between -40 °C to +125 °C. For CANopen and J1939 connection, the IP67-protected transmitter is using the M12 connector with CiA-106-compatible pinning.


*Figure 3: CMP 8271 pressure transmitter (Source: Trafag)*

Trafag (Switzerland) offers the CMP 8270 and CMP 8271 pressure transmitters. Both devices from the CiA-member company have passed the CANopen conformance test performed by CiA. Sensor variants are available for relative and absolute pressure measurements from 0,25 bar up to 700 bar (600 bar for CMP 8270). The transmitters are dedicated for heavy-duty applications as they are completely-welded, provide high shock and vibration resistance, and are designed for operating temperatures from -40 °C to +125 °C. The devices support bit rates up to 1 Mbit/s, the self-starting function, the CANopen device profile for measuring devices (CiA 404), as well as the layer setting services (LSS, CiA 305). The manufacturer also offers a CANopen configuration tool for the transmitter, which allows configuration of all CANopen parameters as well as the access to the complete CANopen object dictionary.


*Figure 4: MH-4-CAN OEM pressure transmitter (Source: Wika)*

The MH-4-CAN OEM pressure transmitter from Wika (Germany) supports CANopen and J1939 interfaces and is dedicated for use in mobile working machines. It enables working and control pressure measurement up to 600 bar in construction equipment, agricultural and forestry machines, mobile cranes and mobile elevating work platforms as well as material handling equipment and municipal vehicles. The IP67-rated transmitter implements the CiA 404, CiA 305, and CiA 801 (automatic bit-rate detection) specifications. It works at bit rates up to 1 Mbit/s (250 kbit/s as default) and temperatures between -40 °C and +125 °C. The deployed 5-pin M12 connector provides pin-assignment according to CiA 106. In 2023, the MH-4-CAN has passed the CANopen conformance test by CiA. In 2017, the CiA-member Wika has acquired the German measuring technology specialist Tecsis, which has formerly produced the CANopen-/J1939-capable gauge pressure transmitters 3327 and 3328 still available on the market.

Zila (Germany) offers the piezoresistive CANopen pressure transmitter DS-CAN-01 for relative measurements up to 4000 bar in hydraulic and pneumatic applications. The device with operating temperatures spanning from -10 °C to +80 °C supports the CiA 404 profile. For bit-rate and node-ID setting via CAN, it implements the layer setting services (LSS, CiA 305). For CANopen connection, the 5-pin M12 plug connector with CiA-106-compatibe pinning is used. The company also provides the CANopen-connectable DTS-CAN-01 pressure-temperature transmitter allowing additional temperature measurements from -10 °C to +80 °C. The device with pressure ranges from 2 bar to 4000 bar is medium-compatible with hydraulic oil, brake fluid, gasoline, diesel, compressed air, etc. ◀

**Autor**

Olga Fischer
CAN in Automation (CiA)
pr@can-cia.org
www.can-cia.org