AMS 3011 - Differential pressure transmitters for high system pressures

In these application notes AMSYS describes the new, miniaturized AMS 3011 pressure transmitter series [1] which is based on a silicon sensing element and now available in a new, practical design. This transmitter* shall also be used to explain a term which is often ignored yet crucial to many applications: system pressure.

Figure 1: *AMS 3011 with a range of screw-on pressure connectors.*

Strictly speaking, there are just two different ways of measuring pressure: the measurement of absolute pressure and that of differential pressure. All other forms of measurement are based on these two methods.

*the present transmitters are sensors with an additional electronic controller which makes them independent. Both words transmitter and sensor will be used in this application note.

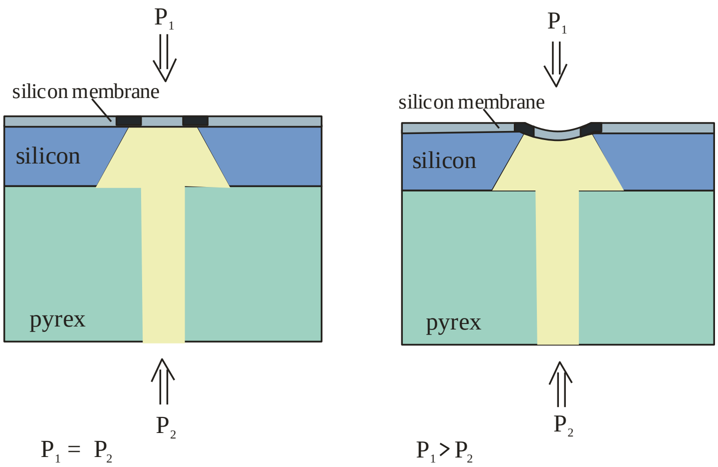
AMSYS GmbH & Co. KG
An der Fahrt 4
55124 Mainz
Germany

Phone: +49 6131 469 8750
Fax: +49 6131 469 87566
Email: info@amsys-sensor.com
Internet: www.amsys-sensor.com

AMS 3011 - Differential pressure transmitters for high system pressures

Measuring differential pressure

When measuring differential pressure two pressures P_1 and P_2 are compared which are applied externally through the relevant housing to the topside and underside of the pressure-sensitive sensing element. The following generally applies: $P_1 \leq P_2$ or vice versa $P_1 \geq P_2$. With most silicon-based sensors the requirement is that just one pressure ratio, i.e. $P_1/P_2 \geq 1$ or $P_1/P_2 \leq 1$, can be recorded and evaluated. In general, measuring pressure with this restriction is called "differential pressure sensing".



The left graphic in *Figure 2* is a diagram of $P_1 = P_2$. The membrane is not deformed and the sensor generates no output signal with the same pressure present on both sides.
If $P_1 > P_2$ (right), when pressure is applied the silicon membrane deflects towards the lower pressure; in its piezoresistive bridge resistors it produces an output signal proportional to the applies pressure of $V_{OUT} = f(P_1-P_2)$.

Figure 2: membrane of a piezoresistive sensing element at differential pressure where $P_1 \geq P_2$.

Bidirectional differential sensors

Besides the measurement of differential pressure mentioned above there are also applications which require that both conditions $P_1 \leq P_2$ and $P_1 \geq P_2$ are met. These include, for example, ventilation and air exhaust systems, overshooting and/or undershooting a given liquid level, inhalation and exhalation setups, etc. As there is no generally recognized term for this kind of differential pressure sensing, AMSYS calls sensors which can measure this type of differential pressure "bidirectional differential pressure sensors". [2] These AMSYS sensors are thus capable of measuring both positive and negative pressure. The following applies: $P_1/P_2 \geq 1$ and $P_1/P_2 \leq 1$.

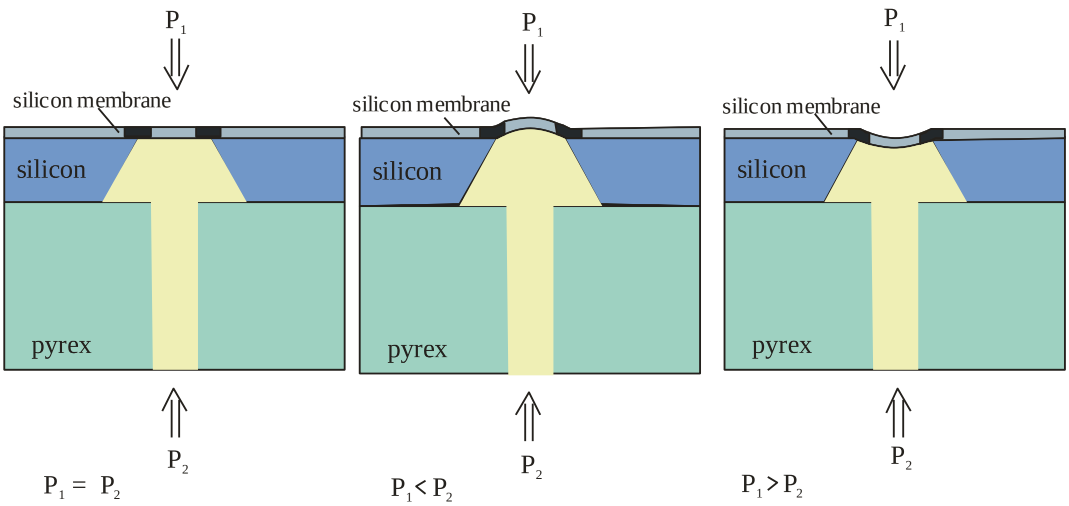


Figure 3: silicon sensing element when measuring differential pressure and $\mathbf{P_1 = P_2}$, $\mathbf{P_1 < P_2}$ and $\mathbf{P_1 > P_2}$.

Figure 3 is a schematic diagram of how the deflection of a differential pressure sensing element membrane is to be perceived under the application of positive and negative pressure. The change in the direction of the membrane deflection causes a change in polarity in the sensing element output signal.
With the sensing elements of these sensors, the differential pressure to be measured can have both a positive and negative polarity. This means that pressure P_1 at the connection node on the topside of the sensing element can be either greater or smaller than pressure P_2 at the connection node on the underside of the sensing element and vice versa.

System pressure (common mode pressure)

In an attempt to explain this term more clearly, the following practical application shall be presented (*Figure 4*). With the help of a differential pressure sensor the permeability of a filter mounted in a pipe is to be tested [3]. The sensor has one connector upstream and one downstream of the filter and is itself installed in the system's control electronics – in other words, in the ambient atmosphere.
If the filter is new and permeable, the drop in pressure or difference in pressure upstream and downstream of the filter is low and the resulting measurement signal minimal. As the filter clogs up in the course of time, the difference in pressure increases and the measurement signal can attain its maximum value.

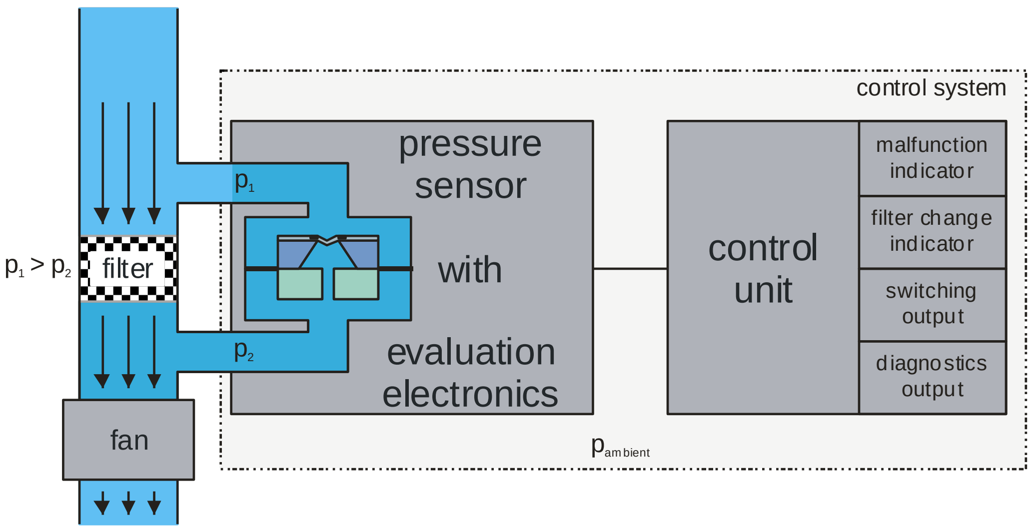


Figure 4: *filter control with a differential sensor*

P_1 is the pressure upstream of the filter and P_2 the pressure downstream of the filter. P_1 equals P_2 when no filter is present or the filter is completely permeable. As a rule, P_1 is greater than P_2, however.

As long as P_1 and P_2 do not greatly differ from $P_{ambient}$, the issue of system pressure is irrelevant. If, however, it applies that the static internal pressure of the pipe is (P1, P2) > $P_{ambient}$, all pressurized parts of the pressure sensor must be able to withstand this difference in pressure to the external pressure.

AMS 3011 - Differential pressure transmitters for high system pressures

If then, for example, in a piece of pneumatic equipment static pressure P_1 in the pipe is 12 bar and the difference in pressure (ΔP) above the filter may have a maximum value of 100 mbar, for instance, a differential pressure sensor must be selected which can measure 100 mbar (low pressure) on the one hand and is specified for a system pressure of 12 bar - $P_{ambient}$ = 11 bar on the other. The system pressure is therefore the maximum pressure which can be simultaneously applied at both pressure inputs of a pressure sensor versus the external pressure without the sensor being damaged.

In applications with system pressure, it must be borne in mind that as a general rule differential sensors are only specified for a system pressure which is equal to $P_{ambient}$. Owing to the given pressure sensing element engineering, an additional offset can ensue with higher system pressures. This depends on the magnitude of the system pressure and amounts to the specified offset.

Example applications

Figure 5: *level sensing in a closed pressure tank.*

Its metal construction and underside pressurization make AMS 3011 especially suitable for critical level sensing in open or closed tanks (*Figure 5*). If, for example, a gas which must not enter the atmosphere forms above the tank liquid, requiring the gas pressure to be monitored, the use of the aforementioned differential pressure transmitter is prudent. In cases such as these the pressure in the liquid (hydrostatic pressure) is applied to the underside of the sensor and the gas pressure is measured at the topside. The sensor measures the difference between the pressure in the gas area and the pressure at the base of the tank which can then be easily converted into the fill level with the known density of the liquid by applying Pascal's law:

$$P_{hydrost}(h) = \rho \cdot g \cdot h \quad \text{(Pa)}$$

Even if the liquid in the tank has to be stored under pressure (to avoid a chemical reaction, for example), the fill level can be determined with a differential pressure sensor such as the above. In this case the maximum prevalent pressure or system pressure is the sum of the gas and hydrostatic pressure which is specified as being 16 bar for the AMS 3011.

Description of AMS 3011

AMS 3011 transmitters are supplied for various types of pressure, such as absolute, relative and differential pressure, within a pressure range of 50 mbar to 10 bar or 700 to 1,200 mbar for barometric applications.
Bidirectional differential versions allow measurements from ±25 mbar to ±1 bar.

The sensor's metal housing means that a system pressure of 16 bar is permissible. Low differential changes in pressure can thus be measured at a high internal line pressure in a pneumatic system, for instance.

AMS 3011 - Differential pressure transmitters for high system pressures

The transmitters in their metal housing can be fitted with various industrial screw-on M5 pressure connectors (e.g. hose nipples, push-in fittings, quick connector plugs, etc.). Electrical connection is through the M5 sensor plug on the side of the device. The sensors are one-side water and dust resistant according to IP67.

Thanks to underside pressurization **[4]** AMS 3011 transmitters can also be used in applications where the liquid pressure has to be measured versus the atmosphere (level indication), for example. As opposed to transmitters with oil seals AMS 3011 devices can also be used to measure low fill levels (≥ 50 cm).

AMS 3011 transmitters have an analog 0–5 V output and can be operated within a wide supply range of 8 to 36 V at -25 to 85°C. Further versions of the sensor in this series include the AMS 3010 with a 0–10 V output and AMS 3012 with a current output of 4–20 mA.

Summary

Taking the filter control unit by way of example, the term "system pressure" (common mode pressure), which to date has also been neglected in datasheets, is described in further detail. This system pressure is one of the specific properties of AMS 3011. With its metal housing the sensor can even be used to measure low differential pressures (from 50 mbar) in applications which make a system pressure of up to 16 bar necessary.

Further information

[1] AMS 3011 product details and datasheet: https://www.amsys-sensor.com/products/pressure-sensor/ams3011-pressure-transducer-5v-in-metal-housing/

[2] Application note on bidirectional differential pressure sensing: https://www.amsys-sensor.com/downloads/notes/ams4712-what-to-know-about-bidirectional-differential-pressure-sensing-amsys-505e.pdf

[3] Application note on filter monitoring with the help of AMS 5105: https://www.amsys-sensor.com/downloads/notes/ams5105-control-of-filters-and-ventilation-systems-using-the-dual-function-sensor-amsys-520e.pdf

[4] Application note on underside pressurization: https://www.amsys-sensor.com/downloads/notes/ams4711-media-compatible-pressure-transmitter-for-industrial-applications-in-matchbox-format-amsys-515e.pdf

Contact

AMSYS GmbH & Co. KG
An der Fahrt 4
55124 Mainz
GERMANY

phone: +49 (0) 6131/469 875 0
fax: +49 (0) 6131/469 875 66
email: info@amsys-sensor.com
internet: www.amsys-sensor.com