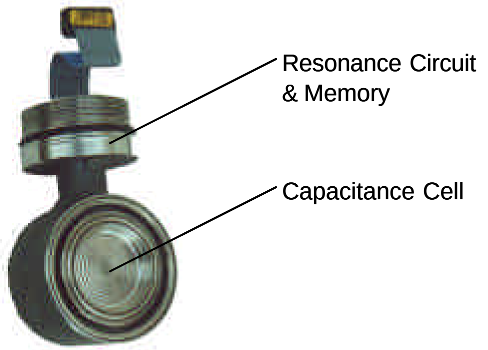
Direct Digital Capacitance Sensing

Keeping the sensor signal digital from the very beginning to the very end allows for infinitely more sophisticated and precise signal processing and it may remain totally free of the noise pickup and degradation associated with analogue methods. A digital measurement therefore reduces the Total Probable Error (TPE).

A direct digital capacitance sensing pressure measurement principle is used in the pressure transmitters in the SMAR LD30x and LD29x series of transmitters, including LD301 and LD291 for HART, LD302 and LD292 for FOUNDATION fieldbus H1, and LD303 and LD293 for PROFIBUS PA, as well as LD290 being pure 4-20 mA output.

When the original LD300 was introduced in 1988 it was the first to use direct digital capacitance sensing, and thus became the world's first completely digital pressure transmitter. The sensor module consists of a mechanical part (the capacitance cell) and an electronics part (resonance circuit).

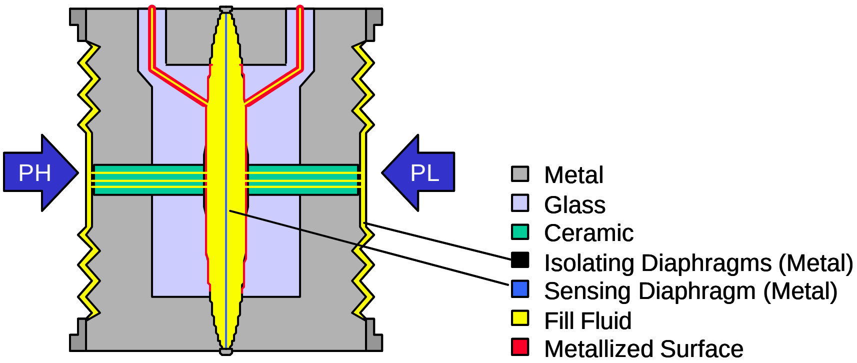


Additionally, the measurement involves software in the main circuit boards.

Capacitance Cell

The original principle of the capacitance cell is tried and tested time and again in every process, and every industry, around the world. Over the years SMAR has invested millions of dollars in the development of the sensor and the capacitance principle has been perfected by engineers at SMAR.

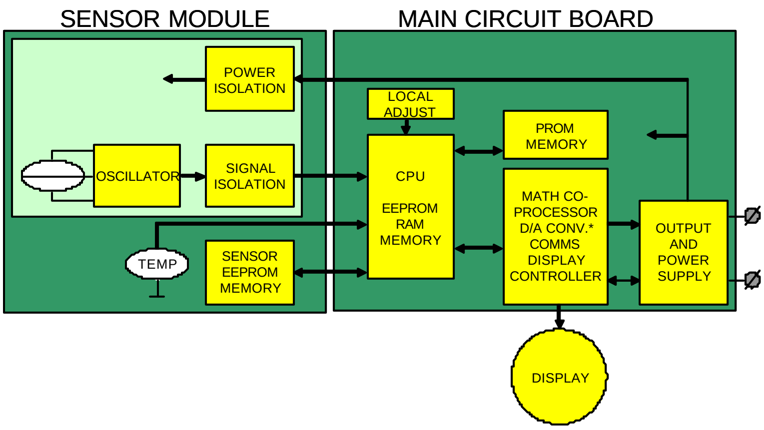
The process fluid is in contact with the isolating diaphragms which provide resistance against contamination and corrosion. A wide variety of materials is available to suit different processes. The pressure is transmitted by the fill-fluid to the sensing diaphragm located at the center of the cell. Overpressure causes the isolating diaphragms to block the transmission of the fill-fluid, thus protecting the sensing diaphragm. This ensures the sensor is not damaged. A broad selection of fill-fluids is available to fit diverse processes. The sensing diaphragm deflects slightly as a result of the difference between the pressures applied to the high and low sides of the sensor. The sensing diaphragm is a moving capacitor plate while the two metallized surfaces are fixed plates. The small sensing diaphragm deflection results in capacitance variation between the moving and fixed plates. Since the sensing diaphragm movement is minimal, hysterisis has been minimized. The design ensures linearity and repeatability from zero to the sensor limits.



All the materials used in the capacitance cell exhibit exceptional strength and temperature stability. The capacitance cell is large enough to handle high static and over pressures. Every capacitance cell is manufactured in a clean room environment using specialized tools and then rigorously tested. All raw materials and every part are tracked in a comprehensive database system.

Resonance Circuit

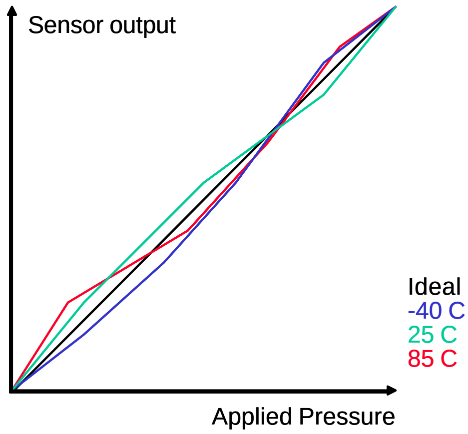
The first generation of capacitance sensors (LD200 and LD250) used analog electronics for signal conditioning. Nowadays the capacitance cell forms a part of an oscillator in an electronic resonance circuit inside the sensor module. The special circuit is completely digital and also provides high galvanic isolation between the process and sensor output. Thus the pressure is converted to a resonant frequency without going through the analog domain. The frequency is picked up by the microprocessor clock based on a precise crystal. No A/D converter is involved resulting in a much higher effective resolution.



The high resolution (small quantization error) makes high rangeability (turndown) possible. The transmitter can be ranged with a small span and yet provide exceptional accuracy in percent of range. The high rangeability means great flexibility, a single differential pressure transmitter range can handle almost all flow and level applications. A single gauge pressure transmitter can handle most pressure measurements.

Software Compensation

All types of sensors exhibit some amount of nonlinearity and slight effect due to ambient temperature change. This can be corrected. The sensor module also picks up the temperature of the capacitance cell. In the SMAR factory, each individual sensor is subjected to a large number of combinations of temperatures and pressures using high precision testers. All the capacitance cell readings and temperatures are collected providing the "finger print" of the sensor then analyzed and evaluated using proprietary algorithms. The result is a set of sensor characteristics data which gets stored in the sensor module memory along with other pertinent information such as sensor material, fill-fluid, and serial number.

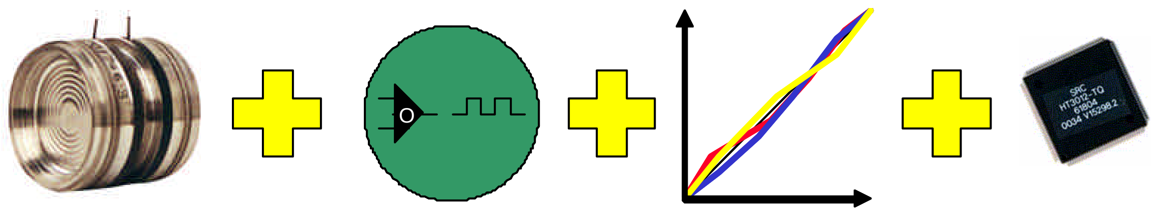


In operation, the transmitter microprocessor takes the reading from the capacitance cell plus the temperature. By applying the sensor characteristics data and a proprietary algorithm the capacitance cell reading is linearized and temperature compensated obtaining a very precise pressure reading.

SMAR has constantly pushed the digital frontiers. SMAR engineers did not take any short cuts and spared no effort developing the pressure transmitters. They even went as far as developing a custom integrated circuit, an IC with floating point arithmetic coprocessor superior to existing chips, to process the measurement faster than other pressure transmitters. Many applications require fast response time, particularly control of flow and pressure. This "super chip" is the reason why SMAR's pressure transmitters are the fastest. This enables in tighter and more responsive control which ultimately results in higher quality, yield, and reduced cost etc.

Conclusion

The pressure transmitter is designed primarily to be rugged and highly reliable. It delivers great application flexibility is ensured by a large turndown. This would normally lead to an increase in error. However, using the direct digital capacitance sensing pioneered by SMAR, the signal is kept digital all the way from the sensor to the output thus resulting in high accuracy also for smaller spans. High performance and fast response is ensured by the math-coprocessor.



For all models except LD290 the measurement value may be accessed through digital communication but is in LD291 and LD301 also converted to an analogue 4-20 mA to remain compatible with conventional systems.