Considerations Concerning the Pressure Sensors Interfacing Modeling in the Frame of the Modern Measurement Systems

Gianina CRETU
"Gh. Asachi" University of Iasi
Bd.D. Mangeron nr.53, RO-700050 Iasi
gianinag2004@yahoo.com

Abstract—**Because of the great variety of conditions, ranges, and materials for which pressure must be measured, there are many different types of pressure sensor designs. In this paper I made a classification of pressure sensors.**

Index Terms—**pressure sensors, modern measurement systems, implementation IEEE 1451 standard, virtual instruments, smart sensors.**

I. INTRODUCTION

Pressure sensors have bigger and bigger signification in various measurement environments as well in automatic conduction technology.

Modern micro system technologies offers new ways of combining sensing, signal processing and actuation on a microscopic scale and allows both traditional and new sensors to realized for a wide range of application and operational environments. The main task of measuring instruments, sensors and transducers designing has always been to reach high metrology performances. At different stages of measurement technology development, this task was solved using technological methods, consisting in technology perfection, as well structural methods.

Today's crisis in the area of high technologies has evidently shown, that is not enough to use only the technological methods. Is need now smart sensors with increased accuracy, reliability and speed. Nowadays, intelligent sensors are extremely necessary for such applications. It has been considered that there are a lot of new technologies, suitable for smart sensors creation, for example, micro or nano - cantilevers, porous silicon, think films, resonant piezoelectric, molecular architecture and nanotechnologies and other modern technologies let to produce different sensors classes: physical, chemical and biological.

Virtual instruments have because of its flexibility and inconstancy a huge potential for those that work in the field of education, science and technology. National Instruments (NI) provides a broad range of pressure measurement solutions with several advantages over traditional pressure measurement and logging systems.

The virtual instruments achieved through software extend the options of the real ones. National Instruments (NI) pressure measurement systems use the concept of virtual instrumentation to provide increased flexibility and additional analysis compatibilities at a lower cost. A new concept of sensor for pressure measurement is the sensitive pressure sensor with nitride membrane and optoelectronic read-out system. Measured pressure is transformed into thick layer nitride membrane deflection. A microelectronic sensor for low-level pressures measuring is a problematic matter. There are technological troubles with creating a pressure sensor with diaphragm for sensing pressure under 5kPa.

II. HOT POINTS OF DEVELOPMENT

Because of the great variety of conditions, ranges, and materials for which pressure must be measured, there are many different types of pressure sensor designs. Often pressure can be converted to some intermediate form, such as displacement. The sensor then converts this displacement into an electrical output such as voltage or current. The three most universal types of pressure transducers of this form are the strain gauge, variable capacitance, and piezoelectric.

Bridge sensors are used for high and low pressure applications, and can measure absolute, gauge, or differential. All bridge sensors make use of a strain gauge and a diaphragm.

When a change in pressure causes the diaphragm to deflect, a corresponding change in resistance is induced on the strain gauge, which can be measured by a Data Acquisition System (DAQ). These strain gauge pressure transducers come in several different varieties: the bonded strain gauge, the sputtered strain gauge, and the semiconductor strain gauge.

- In the bonded strain gauge pressure sensor, a metal foil strain gauge is actually glued or bonded to the surface where strain is being measured. These bonded foil strain gauges are used because of their quick 1 000 Hz response times to changes in pressure as well as their large - 452º F to -525 º F operating temperature.
- Sputtered strain gauge manufacturers sputter deposit a layer of glass into the diaphragm and the deposit a thing metal film strain gauge on to the transducer's diaphragm. Sputtered strain gauge sensors actually from a molecular bond between the strain gauge element, the insulating later, and the sensing diaphragm. These gauges are most suitable for long-term use and harsh measurement conditions.
- Integrated circuit manufacturers have developed composite pressure sensors that are particularly easy to use. These devices commonly employ a semiconductor diaphragm into which a semiconductor strains gauge and temperature – compensation sensors have been grown.

Appropriate signal conditioning is included in integrated circuit form, providing a dc voltage or current linearly proportional to pressure over a specified range.

Variable capacitance pressure transducers are generally very stable and linear, but are sensitive to high temperatures and are more complicated to setup than most pressure sensors.

Piezoelectric pressure sensors take advantage of the electrical properties of naturally occurring crystals such as quartz. They do not require an external excitation source but they do require change amplification circuitry and very susceptible to shock and vibration.

Ultrasonic silicon surface micro tubes sensors, apart from piezoelectric sensors, have a dynamic range in the air with 50 dB better. The micro tube consists of a fine nitride membrane, whereon is laid an aluminum electrode, suspended on a vacuous space. The nitride membrane is sustained by nitride brace, above the layer of silicon that make together with the aluminum electrode, a condenser. The micro tube can emit or receive ultrasounds, [1, 2]. These sensors can create more efficiently pressure ultrasonic than a solid piezoelectric crystal. Due to their small dimensions they can function at high frequencies.

Pressure, force and weight are closely linked variables and some of devices can be adapted to measure any of the variables.

Vibrating wire – many devices have been developed to make use of the change in the frequency of a stretched wire with its tension. A stretched wire is caused to vibrate at its natural frequency by can exciting actuator. The frequency of the wire is picked up by a sensor and measured. Pressures from zero to 180 kPa at ± 2% accuracy, can be measured, [3].

Micro processing is a new concept of making sensors with processing of μm order. In this way were made pressure sensors with the diameter below 0.2μm. production costs have dropped. Sensors performances have increased.

Another example is the concept of smart dust transducers that incorporate the measurement, micro processing and communication in one capsule with dimension below 5 mm.

Smart material is the focusing point of the future of material sciences, the foundation of technology and engineering of the next century.

The smart transducers are the most developed transducers. These rule out the necessity of their circuits or devices in the system. They can be introduced in the transducers networks without self changes or changes of the network – working in plug-and-play system becomes practical. With such transducers we achieve measurement systems that offer flexibility and versatility.

The pressure sensor series PS 400/ PS 500 combine high accuracy and excellent performance with simple and safe mounting and operation. By using stainless steel for the sensor body, the pressure and electrical connection, the sensors offer a high degree of operational safety and are suited for the use in harsh industrial environments. They cover all pressure ranges important in the machine engineering sector from -1 ÷ 0 up to 0 ÷ 400 bar, [4].

The MS 5534A (R0HS*) / MS 5534B (R0HS*) type is a SMD – hybrid device including a piezoresistive pressure sensor and an Analog Digital Converter (ADC) – Inter Integrated Circuit (IC), [5]. It provides a 16 bit data word from a pressure and temperature dependent voltage. Additionally the module contains six readable coefficients for a highly accurate software calibration of the sensor. As the output voltage of a pressure sensor is strongly dependent on temperature and process tolerances, it is necessary to compensate for these effects. This compensation procedure must be performed by software using an external microcontroller. A 3-Wire interface is used for all communications with a microcontroller. For both pressure and temperature measurement , the same ADC is used. The MS 5534A (R0HS*) are uses in: mobile altimeter/barometer systems; weather control systems; GPS receivers. It can withstand a pressure of 11 bars in salt water or 100 m water respectively. The advantage of combining of pressure sensor with a directly adapted integrated circuit is to save other external components and to achieve very low power consumption. The main application field for this system includes portable devices with battery supply, but its high accuracy and resolution make it also suited for industrial and automotive applications. The possibility to compensate the sensor with software allows the user to adapt it to his particular application.

III. SCIENTIFIC AND TECHNICAL DESCRIPTION OF THE SYSTEM

Among the applications of scientific nature that play a major part in the measurement field I have mention the measuring systems with virtual instrumentation. The virtual instruments achieved through software extend the options of the real ones. National Instruments (NI) provides a broad range of pressure measurement solutions with several advantages over traditional pressure measurement and logging systems. NI pressure measurement systems use the concept of virtual instrumentation to provide increased flexibility and additional analysis compatibilities at a lower cost. The architecture of pressure measurement is shown in figure 1:

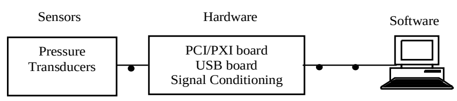

Figure 1. Pressure measurements architecture.

A virtual instruments consists of an industry – standard computer or workstation equipped with application software, hardware such as plug-in boards, and driver software, which work together to perform the functions of traditional measurement devices and instruments.

- Software is an important component of any pressure measurement system.
- Measurement hardware determines system's capabilities – channel count, signal and sensor types, sampling rate, accuracy, portability, etc. The main hardware components for a pressure measurement system are signal connectivity, signal conditioning, and the digitizer. Depending on the application requirements, some of these components may be combined into a single unit

• Pressure sensors should be selected based upon operating environments, desired measurement range, size, accuracy and cost. The output and connectivity will vary among the pressure sensor types but any of them can be easily integrated into a NI pressure measurement due to the flexibility of virtual instrumentation.

A new concept of sensor for pressure measurement is the sensitive pressure sensor with nitride membrane and optoelectronic read-out system. Measured pressure is transformed into thick layer nitride membrane deflection.

Using suitable diaphragm and measuring the distortion caused by the external pressure usually do acquisition of the pressure. Optical methods exploit changing intensity of modulated light caused by the external pressure. An optical read-out has several advantages over other technologies: A simple encapsulation; Small temperature coefficients; High resolution and accuracy.

Especially promising are the optoelectronic sensors operating with the light interference phenomena.

Many diaphragm-based optical sensors have been reported which measure pressure induced deflection using Mach-Zehnder interferometers and Fabry-Perot interferometers, [6].Drawback of this solution is a relative difficult design.

I use LPCVD silicon nitride (Si3N4) diaphragm created on the Si (100) wafer for sensing pressure element. The clean (100) wafer is coated with 160nm of silicon nitride prepared by low-pressure chemical vapor deposition (LPCVD).

Source of the laser beam is microelectronic laser FLEXPOINT 67/1AF-AV type with glass lens for laser beam focusing. Laser wavelength is 620 nm and power 0.4mW.

The position sensing device (PSD) measures position of the laser beam mark. I use a one-dimensional sensor 1L5SP type. This is a product of the SiTek Electro Optics. PSD is a lateral photodiode in that incident light generates photoelectrical current. Sensor output current signal is conditioned digitally using Analog Devices ADuC812 microcomputer.

The ADuC812 microprocessor is a basic building block of our pressure smart sensor. This product includes on-chip high performance multiplexers, analog digital converter (ADC), digital analog converter (DAC), FLASH program and data storage memory, an industrial standard 8052 microcontroller core and support several standard serial ports.

The microcontroller may also access to nonvolatile memory that contains a Transducer Electronic Data Sheets (TEDS) and to ten wires Transducer Independent Interface (TII). The one chip microcomputer provides an IEEE 1451.2 interface. The dimension of our pressure sensor is compromise between sensitivity and overall size. Double current signal is amplified and conditioned digitally by ADuC812 microcomputer.

Standard IEEE1451 family is made up of advanced transducers that can be coupled in networks, starting from interfacing the transducer up to a superior level, representation of conduct with an object pattern, attributed and data communications, [7]. The standards are written for transducers. The measuring system of pressure is shown in figure 2:

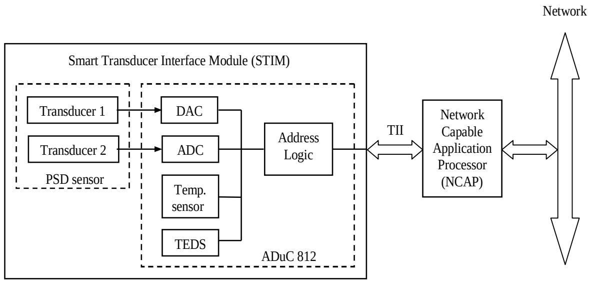

Figure 2. IEEE 1451.2 standard, implementation on the pressure sensor.

The IEEE 1451 standard specifies a collection of standard TEDS formats, defined as templates, for different sensor types. The templates provide the means for the measurement system to convert the binary data stored on a smart TEDS sensor EEPROM into meaningful specifications for that sensor. The collection of IEEE standard templates include IEPE accelerometers and microphone, IEPE pressure sensors, RTDs, thermistors, LVDT/RVDT, resistive sensors, and amplified sensors with voltage or current outputs, [7].

Virtual Transducer Electronic Data Sheets (TEDS) sensors are rapidly being deployed into a variety of test and measurement applications. TEDS enable data acquisition (DAQ) system to detect and automatically configure sensors. This technology provides:

- Reduced configuration time by eliminating manual data entry;
- Better reliability by storing data sheets electronically;
- Improved accuracy with detailed calibration information;
- Simplified of sensor companies offer compatible sensors.

Dozens of sensor companies offer compatible sensors.

Figure 2 shows basic components of an IEEE1451.2 compatible system. The pressure sensor is referred to as a Smart Transducer Interface Module (STIM).

The STIM contains:

- o The TEDS which stores sensor specifications;
- o Transducers (transducer1 and transducer2) - temperature and the position sensing device (PSD) sensor;
- o Necessary signal conditioning and as analogue-to-digital conversion;
- o Simple discrete digital input/output (DI/O);
- o Logic circuitry to facilitate digital communicates between the STIM and NCAP.

Trough a 10-Wire digital communication interface TII, the NCAP or networked host can initiate sensor readings, as well as request TEDS data.

IV. CONCLUSION

Pressure sensors have bigger and bigger signification in various measurement environments as well in automatic conduction technology. Modern micro system technologies offers new ways of combining sensing, signal processing and actuation on a microscopic scale and allows both traditional and new sensors to realized for a wide range of application and operational environments. Today’s crisis in the area of high technologies has evidently shown, that is not enough to use only the technological methods. Is need now smart sensors with increased accuracy, reliability and speed. Nowadays, intelligent sensors are extremely necessary for such applications. New type of optical read-out technique for pressure sensors with thin nitride diaphragm has been developed and tested. Main advantages of the sensor are wide dynamic range of measured pressure with excellent resolution. IEEE1451.2 capabilities were implemented in the pressure sensor.

REFERENCES

[1] C. Cosma , Tudose, "Ultrasunetele",Editura Științifică București, 1997

[2] Gianina Crețu, Mihai Crețu, Marius V. Păuleț, " Overview on present trends in digital transd in digital transducers development", SIELMEN 2005, The 5th International Conference on Electromecanical and Power Systems, Proceedings volume 1, October 6th- 8th, 2005, CHIȘINĂU, Republic of Moldova, pp. 327-330, ISBN 973-716-208-0

[3] George C. Barney, " Intelligent Instrumentation Microprocessor Applications in Measurement and Control" , Second Edition, Control Systems Centre, Umist, Manchester

[4] "Intelligent pressure sensors", http://www.turck.com

[5] MS 5534A (R0HS*) / MS 5534B (R0HS*), Barometer Module, Data Sheet: http://www.intersema.ch

[6] I. Pavalescu, R. Muller, V. Moagar-Poladian, "Analysis and modeling of a silicon micromachined Mach-Zehnder interferometer for pressure sensing", J. Microenerg. 7, pp. 214-217, 1997

[7] "Sensor Plug & Play: A New Standard for Automated Sensor Measurement", http://www.ni.com