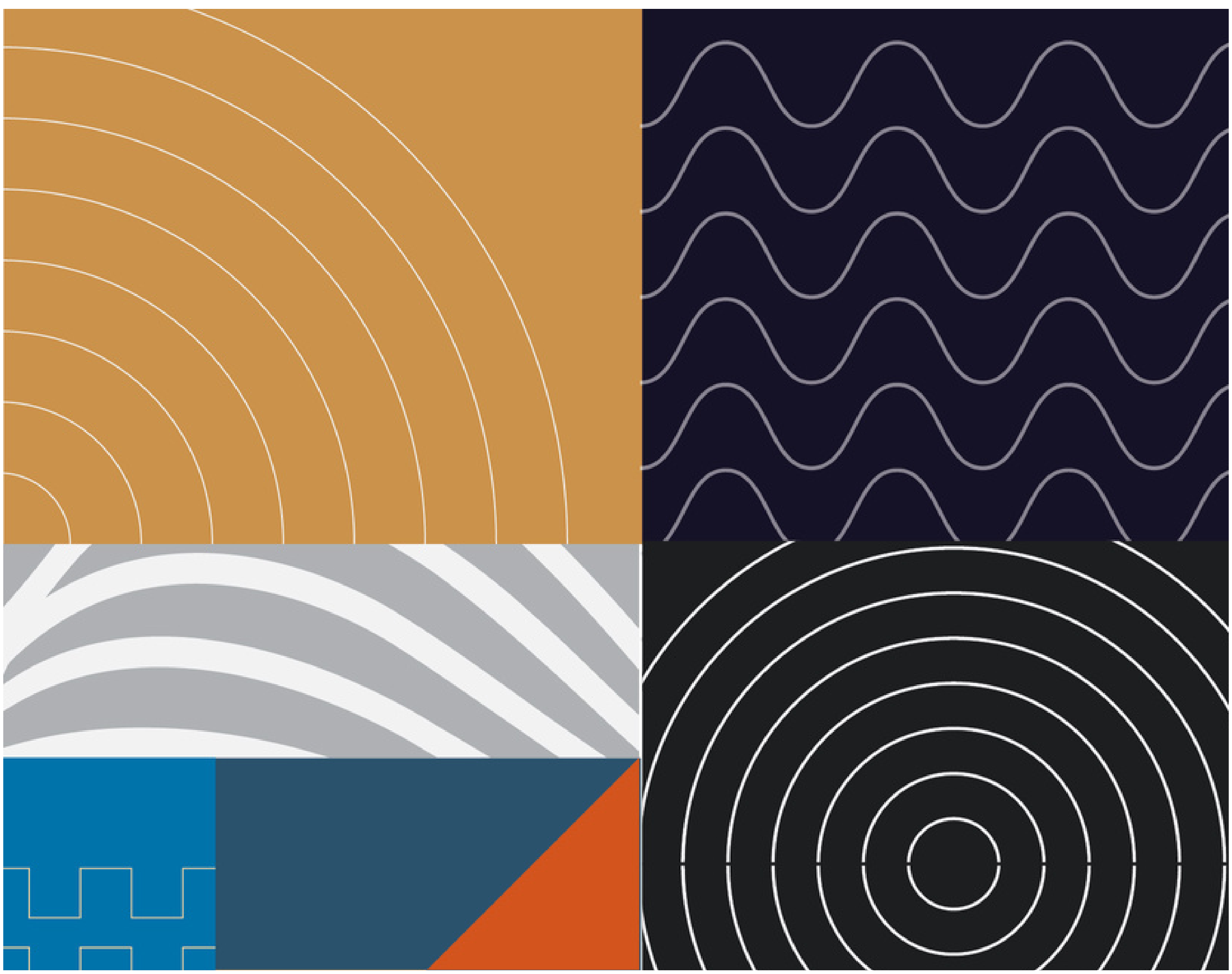
NEW PRODUCT ANNOUNCEMENT

NEW MEMS PRESSURE SENSORS



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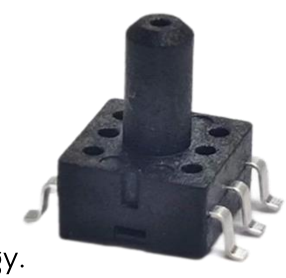
New Product Introduction

PUI Audio is introducing a new product line of pressure sensors based on microelectromechanical (MEMS) technology to complement our sensor offerings. These new MEMS pressure sensors provide solutions to applications that need pressure sensing or seek to combine the excellence of a high-fidelity MEMS microphone with a MEMS Pressure Sensor. These new sensors use an innovative MEMS architecture to deliver good linearity, high sensitivity, and high stability in small, surface-mount packages. Application examples include medical, wearables, industrial, security applications, robotics, or factory automation. These pressure sensors can be applied to accurately capture precise measurements and are used to generate real-time alerts.

New MEMS Pressure Sensor Part Numbers

PSA071040 Analog Pressure Sensor



The PSA071040 is a piezoresistive gauge pressure sensor suitable for biomedicine, automotive electronics, and other applications. At its core is a silicon piezoresistive pressure-sensitive network constructed using MEMS fabrication and structure creation technology.

The pressure sensitive network consists of an elastic film and four resistors integrated on the film. The four resistors form a Wheatstone bridge structure. Pressure applied to the elastic film deforms the bridge's resistors, generating a voltage output signal that is linearly proportional to the applied pressure.

This sensor's typical applications include blood pressure monitors, oxygen generators, massage chairs, and coffee machines.

Key Features

- Measuring Range 0kPa~40kPa
- Wheatstone Resistor Bridge Built with MEMS Technology
- Gauge Pressure Type
- Small Outline Integrated Circuit (SOIC)Package
- Suitable For Non-Corrosive Gas Pressure Sensing
- Operating Temperature (T_O) Range: -20℃ ≤ T_O ≤ 85℃

PSD0603130 Digital Pressure Sensor

The PSD0603130 is a high-resolution absolute pressure sensor that is based on MEMS piezoresistive technology. It is housed in a compact 8-pin LGA package that features an anti-magnetic stainless-steel cap. It has a serial digital interface that allows connection to either SPI or I²C buses. This sensor includes a high linearity and an ultra-low power 24-bit delta-sigma analog-to-digital converter (ΔΣADC) with internally stored factory-calibrated linearization coefficients that along with amplifying the pressure sensitive element's output signal, applying temperature and linearity compensation, generates an accurate 24-bit digital pressure value. The PSD0603130 also includes a 16-bit temperature sensor with a nominal resolution of 0.003°C.

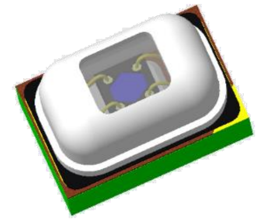
The SPI and I2C interface maximize compatibility with the communication interfaces on a wide range of popular micro-controllers.

This product can be used in barometers, mobile altimeters, indoor navigation and map AIDS, industrial pressure and temperature sensing systems, pressure and temperature data loggers, security surveillance, adventure and sports watches, gas meters, weather station equipment, oil contact applications.

Key Features

- Measuring Range: 30kPa~130kPa
- Temperature Accuracy: ±0.5℃
- 24-Bit Pressure Effective Measurement Bits(Pa)
- 16-Bit Temperature Effective Measurement Bits（℃)
- Programmable Interrupt Control
- Standby Current: < 0.2μA
- Waterproof and Anti-corrosion Design
- Operating Temperature (T_O)Range: -40℃ ≤ T_O ≤ 85℃
- Digital Output: I²C/SPI

PSA0201700 Analog Pressure Sensor



An absolute pressure sensor that offers extremely high sensitivity and excellent stability in a very small size. The chip's integrated force resistor forms a Wheatstone bridge, without additional external resistance, The sensor's sensitivity is 0.12mV/Pa. The power supply volage range is 1.8V to 5V with a suggested nominal value of 3.3V.
It has the characteristics of high precision, good stability, low noise and low power consumption.
This sensor can be used in tire pressure monitoring, wind tunnel, air pump, water pump.

Key Features

- Typical Pressure Range：0~700 kPa
- Minuscule Size: 1.35mm^3 (1.5mm ×1.0mm ×0.9mm)
- Wheatstone Resistor Bridge Sensor
- No External Resistance Required
- High Precision, Good Stability
- Low Noise, Low Power Consumption
- Overload Pressure: 2100kPa (3X)
- Operating Temperature (T_O) Range: -40℃ ≤ T_O ≤ 125℃

New MEMS Pressure Sensor Operation

MEMS pressure sensors combine mechanical and electronic components on a silicon die. This enables cost effective and miniaturized pressure sensor solutions.

These new PUI Audio **piezoresistive sensor** devices (PSA0201700, PSA071040 and PSD0603130) consist of conductive sensing elements that are fabricated directly on to a diaphragm. The resistors in these new sensors are connected in a **Wheatstone bridge network** that enables accurate measurement of change in resistance. An applied pressure alters the resistance values. This results in the generation of a voltage that is proportional to the applied pressure. This voltage is measured and directly proportional to the change in resistance of the bridge network components.

The piezoresistive elements are arranged so that they experience differential s that maximizes the output signal for a given pressure. A change in pressure will cause a change in resistances in the bridge resulting in a corresponding output voltage or current. More details are provided in below section.

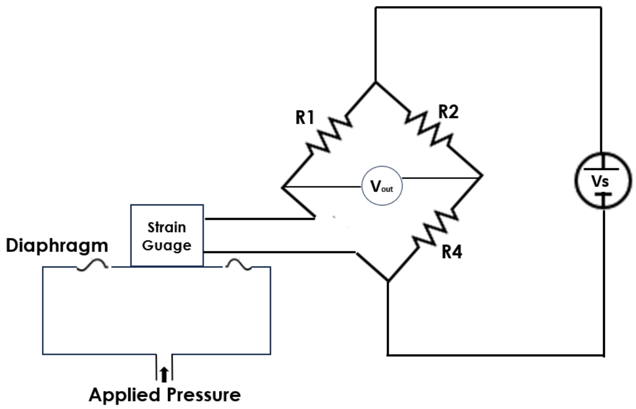


Figure 1. A generalized diagram of the bridge pressure sensor.

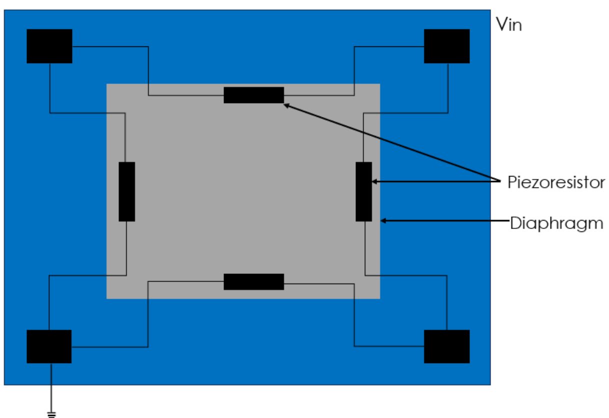


Figure 2. The physical layout of a MEMS pressure sensor.

What are different type of Pressure Sensors?

Piezoresistive Sensors

MEMS (Micro-Electro-Mechanical Systems) piezoelectric pressure sensors are miniature devices used to measure pressure. They work based on the piezoelectric effect, which is the ability of certain materials to generate an electric charge when mechanical stress or pressure is applied to them. Sensors based on this material technology work as follows.

Piezoelectric Material: The core component of a MEMS piezoelectric pressure sensor is a thin piezoelectric material, typically made from materials like quartz or lead zirconate titanate (PZT). This material is chosen because of its ability to generate electrical charge in response to mechanical deformation.

Sensor Structure: The piezoelectric material is typically configured in a diaphragm or membrane structure. This diaphragm is placed in such a way that when exposed to changing, it causes the diaphragm to deform slightly.

Deformation and Piezoelectric Effect: When the pressure changes, the diaphragm deforms, causing mechanical stress on the piezoelectric material. This stress causes the atoms within the material to shift positions slightly, creating a charge imbalance within the material. This charge imbalance results in the generation of a small electrical voltage across the piezoelectric material. The magnitude of this voltage is directly proportional to the applied pressure.

Electrical Circuit: The electrical voltage generated by the piezoelectric material is very small, typically in the millivolt range. To measure this voltage accurately, it is typically connected to an electrical circuit that includes an amplifier and possibly other signal conditioning components. The amplifier increases the small voltage signal to a level that can be easily measured and processed by external electronics.

Output and Measurement: The amplified electrical signal is then sent to external measurement equipment, such as a microcontroller or data acquisition system, where it can be converted into a pressure reading in appropriate units (e.g., psi, kPa). Calibration is often necessary to ensure the accuracy and reliability of pressure measurements.

Response Time: MEMS piezoelectric pressure sensors can respond very quickly to pressure changes due to their small size and low mass. This makes them suitable for applications where rapid pressure measurements are required.

Summarizing, MEMS *piezoelectric pressure sensors* work by converting applied pressure into mechanical deformation of a piezoelectric material, which in turn generates an electrical voltage. The voltage is then amplified and processed to provide an accurate measurement of the pressure being applied to the sensor. *Piezoelectric* sensors are commonly used in various application areas such as automotive, industrial, medical devices, and consumer electronics, where small size, high accuracy, and fast response times are important.

Digital Vs Analog Pressure Sensors

Digital

Digital MEMS (Micro-Electro-Mechanical Systems) piezoelectric pressure sensors are advanced devices used to measure pressure, and they work by converting mechanical pressure into a digital output signal. These sensors are known for their accuracy, stability, and versatility. The following explains the characteristics and benefits of sensors that feature a digital interface and generate digital output values.

Charge-to-Digital Conversion: Unlike traditional analog piezoelectric sensors, digital MEMS piezoelectric sensors incorporate charge-to-digital conversion circuitry directly on the sensor chip. This circuitry converts the generated electrical charge into a digital output signal.

Digital Output: The digital output is typically in the form of a digital word or binary values, which represents the magnitude of the generated charge and thus the applied pressure. The digital output is highly accurate, is immune to electrical or radiated noise, and directly read by a microcontroller or other digital processing equipment.

Signal Processing and Calibration: The digital output can be further processed by external electronics, if necessary, to provide calibrated and compensated pressure readings. Calibration is essential to account for any sensor-specific characteristics or variations such as inherent sensor non-linearity or temperature coefficients.

Communication Interface: Many digital MEMS piezoelectric sensors have built-in communication interfaces, such as I^2C or SPI, which allow them to communicate directly with microcontrollers or other digital devices. This simplifies the integration of the sensor into a wider system.

Temperature Compensation: Pressure sensors may include temperature compensation circuitry to correct for temperature-related variations in the piezoelectric material's properties, ensuring accurate pressure measurements over a range of temperatures.

Analog

As with digital MEMS pressure sensors, analog MEMS piezoelectric pressure sensors are devices used to measure pressure by utilizing the piezoelectric effect. They work by converting mechanical pressure into an analog electrical signal. The following explains the characteristics and benefits of sensors that feature an analog output interface.

Charge Amplification: The electrical charge generated by the piezoelectric material is very small, typically in the picocoulomb (pC) range. To make this signal measurable, an amplifier or charge-sensitive amplifier is used to amplify the charge signal. This amplification process increases the signal's amplitude and makes it more suitable for measurement.

Voltage Conversion: The amplified charge signal is then converted into a voltage signal. This is typically achieved by passing the charge through a high-impedance circuit. The voltage output is proportional to the original charge generated by the piezoelectric material.

Output Signal: The final output is an analog voltage signal that represents the applied pressure. This signal can be measured using analog voltage measurement equipment, such as an oscilloscope, data acquisition system, or analog-to-digital converter (ADC).

Calibration and Compensation: Analog MEMS piezoelectric pressure sensors often require calibration to ensure accurate pressure measurements. Additionally, temperature variations can affect the sensor's performance, so some sensors incorporate temperature compensation circuits to provide accurate readings over a range of temperatures.

Summarizing, whether a sensor has an analog or digital output, the sensor structure and internal signal processing circuity is common to both. The differences exist in the interface that connects to systems that process the sensor’s output. For external systems that require digital values, the sensor outputs digital values through a serial interface such as I^2C or SPI. Analog outputs have the advantage of simple external processing circuitry, whereas sensors with a digital interface offer advantages such as digital outputs that support microcontrollers and microprocessors, ease of integration, and noise immunity. Both analog and digital sensors are suitable for various applications, including industrial, automotive, and medical devices.

How do Pressure Sensors work?

Full-Bridge

MEMS full-bridge pressure sensors are precision devices used to measure pressure changes. They operate on the principle of resistive strain gauges and can provide accurate and sensitive pressure measurements. The following is an explanation of how these sensors work.

Sensor Structure: MEMS full-bridge pressure sensors typically consist of a diaphragm, a reference diaphragm, and four strain gauges typically arranged as a Wheatstone bridge. The diaphragm is exposed to the pressure to be measured, and the reference diaphragm is usually located nearby but isolated from the pressure. The strain gauges are bonded to these diaphragms.

Strain Gauge Principle: Strain gauges are resistive elements that change their electrical resistance in response to mechanical strain or deformation. When pressure is applied to the diaphragm, it causes it to deform. This deformation results in a change in the dimensions of the strain gauges, which, in turn, causes a change in their electrical resistance.

Wheatstone Bridge Configuration: The four strain gauges in a MEMS full-bridge pressure sensor are arranged in a Wheatstone bridge configuration. This configuration uses four resistive arms arranged in a diamond shape. Two of these arms are the active strain gauges bonded to the diaphragm exposed to pressure, and the other two are fixed resistors or strain gauges bonded to the reference diaphragm.

Differential Measurement: The Wheatstone bridge configuration allows for differential measurements. When pressure is applied to the diaphragm, the resistance of the active strain gauges changes, causing an imbalance in the bridge. This imbalance results in an electrical output signal that is proportional to the applied pressure. The signal's magnitude and direction depend on the type of pressure sensor (absolute, gauge, or differential) and the applied pressure.

Signal Conditioning: The output signal from the Wheatstone bridge is typically a very small millivolt-level voltage. To measure this voltage accurately, it is often connected to an amplifier and other signal conditioning components. The amplifier increases the small bridge output voltage to a level that is easily processed by additional external electronics.

Output and Measurement: The amplified electrical signal is then sent to external measurement equipment, such as a microcontroller or data acquisition system. This equipment processes the signal and provides an accurate pressure reading in appropriate units (e.g., psi, kPa). Calibration is often necessary to ensure the accuracy and reliability of pressure measurement.

Temperature Compensation: MEMS full-bridge pressure sensors may incorporate temperature compensation circuitry to account for changes in electrical resistance due to temperature variations, ensuring accurate measurements over a device's operating temperature range.

Half-Bridge

As with full-bridge sensors, MEMS half-bridge pressure sensors measure pressure changes using strain gauge principles. They are often used in applications that require precise pressure measurements. The following explains how half-bridge sensors work.

Sensor Structure: MEMS half-bridge pressure sensors typically use a diaphragm exposed to the pressure to be measured and two strain gauges. Unlike full-bridge configurations, which use four strain gauges, half-bridge configurations use only two resistive strain gauges.

Half-Bridge Configuration: In a MEMS half-bridge pressure sensor, the two strain gauges are arranged in a half-bridge configuration. One strain gauge is bonded to the diaphragm exposed to pressure (the active gauge), while the other strain gauge (the reference gauge) is typically bonded to a fixed or unstrained part of the sensor.

Differential Measurement: The half-bridge configuration allows differential measurements. When pressure is applied to the diaphragm, the resistance of the active strain gauge changes, while the reference gauge's resistance remains relatively stable. This difference in resistance creates an electrical output signal that is proportional to the applied pressure. The signal's magnitude and direction depend on the type of pressure sensor (gauge or differential) and the applied pressure.

Signal Conditioning: The output signal from the half-bridge is typically a small electrical voltage. To measure this voltage accurately, it is often connected to an amplifier and other signal conditioning components. The amplifier amplifies the small voltage signal to a level that can be easily measured and processed by external electronics.

Output and Measurement: Typically, the amplified electrical signal is processed by external microcontrollers or data acquisition systems. This equipment generates an accurate pressure reading in appropriate units (e.g., psi, kPa). Calibration may be necessary to ensure the accuracy and reliability of the pressure measurement.

Temperature Compensation: Like full-bridge pressure sensors, MEMS half-bridge pressure sensors may incorporate temperature compensation circuitry to account for changes in electrical resistance due to temperature variations, ensuring accurate measurements across a range of operating temperatures.

Summarizing, MEMS Wheatstone full-bridge and half-bridge pressure sensors work by utilizing strain gauges in either configuration to measure the change in resistance caused by the deformation of a diaphragm exposed to pressure. This change in resistance is converted into an electrical signal, which is then processed to provide an accurate measurement of the applied pressure. These sensors are commonly used in various applications, including automotive, industrial, and aerospace, where precision pressure measurements are required.

Application Circuit

The circuit shown in Figure 3 is a PSA071040 bridge pressure sensor circuit whose output voltage is conditioned and amplified. To facilitate remote sensing, a current mode bridge drive is used. A four-wire shielded cable is used to connect to the remotely located bridge to the conditioning circuit. The OP177 precision operat amplifier servos the bridge current to 1.67mA, driven by a 1.235V AD589 refer voltage. A PNP transistor buffers the drive current supplied by the OP177 oper amplifier. This further ensures the lowest operational amplifier self-heating, ar highest gain linearity.

The PSA071040 produces a typical output of 135mV when exposed to a 40kPa pressure. The signal is amplified by the AD620 in-amp, which is configured for a gain of 75 using an effective RG of 619Ω and the potentiometer set to 46Ω. Full-scale voltage calibration is set by adjusting the 100Ω gain potentiometer such that, for a pressure of -40kPa, the output reads -10.125V; and for 40kPa pressure, the output registers 10.125 V. For applications that require digitization, use an ADC that has a 10 V full-scale input range.

Other design considerations include the 0.1mF capacitor connected across the AD620's inputs. This capacitor, working with the typical bridge component resistance, filters EMI and RFI. The filter's corner frequency is nominally 265Hz.

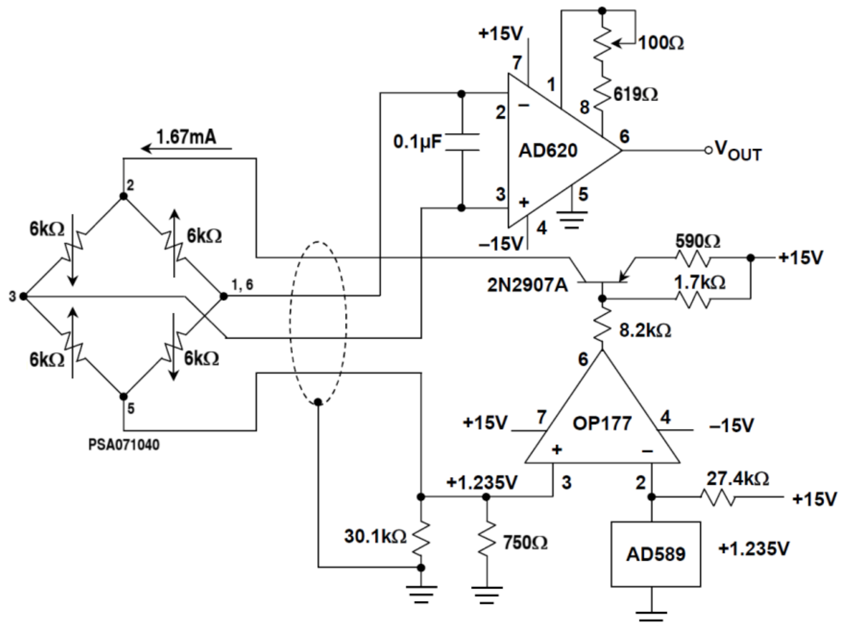


Figure 3. A precision pressure sensor amplifier. It uses a remote current-driven PSA0701040 pressure sensor, a buffered OP177 precision operational amplifier, and an AD620 precision instrument amplifier set to a gain of 75.

Conclusion

Our newly developed MEMS pressure sensors enable new application areas within the Automotive, Medical, Industrial and ioT sectors where high linearity and stability are important. With miniaturized package, low power consumption, and high accuracy, these new pressure sensors provide economical and efficient solutions for a wide range of uses.

View our offerings at:

MEMS Pressure Sensors

PUIaudio
WHEN IT NEEDS TO BE HEARD