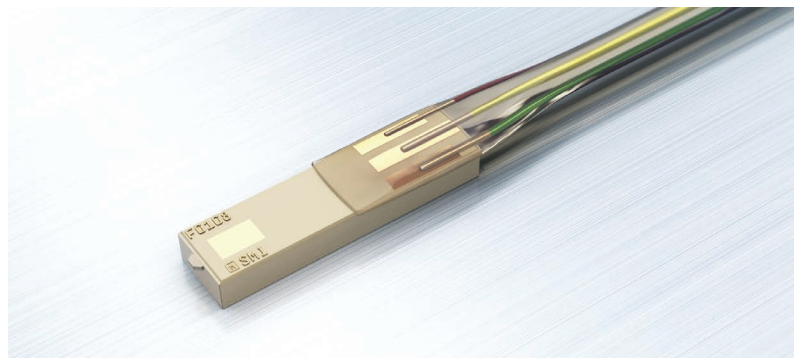
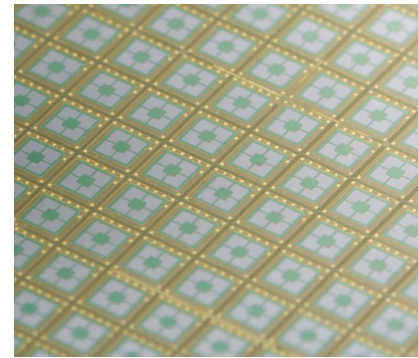
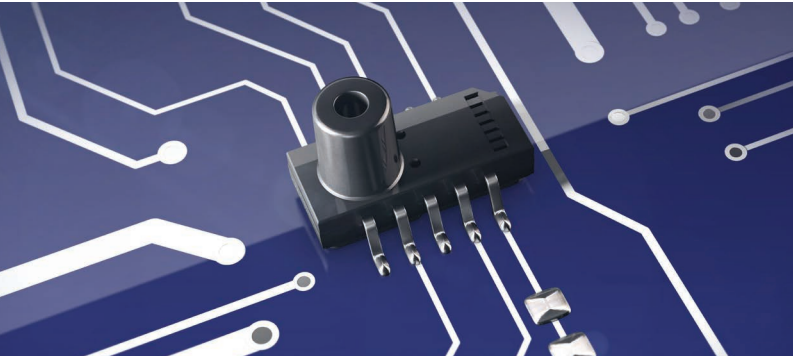


**SMi**  
PRESSURE SENSORS

is now part of



Innovate for Life



## About SMI

A pioneer in the MEMS sensor industry, with more than 25 years of experience, we design and manufacture pressure sensing solutions to serve challenging applications in the medical, invasive medical, automotive, industrial, HVAC and consumer markets. We develop unique solutions for applications requiring ultra-low pressure ranges, extraordinary robustness in harsh environments, high pressure and extremely small size. Our innovative products measure pressure from ultra-low pressure ranges (< 0.5 inH<sub>2</sub>O) all the way to high pressure ranges (> 50 Bar) all while being small-sized for their respective sensitivity.

Our IATF 16949:2016 certified fab enables us to provide turn-key solutions to our customers with the possibility of joint or custom development. This integrated business model, with in-house manufacturing in Silicon Valley, enables unique process and design capability while maintaining high quality and control and offering highest levels of service to our customers.

SMI is part of TE Connectivity (TE), a global technology leader, providing connectivity and sensor solutions essential in today's increasingly connected world. TE is one of the largest sensor companies in the world with sensors vital to the next generation

of data-driven technology. Offering an unmatched portfolio of solutions for applications across a wide range of industries, including automotive, industrial, medical, appliance, aerospace & defense, and industrial and commercial transportation.

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# Innovate for Life

## Our Mission

*Enabling our customers' success in improving health, safety and the environment by providing creative pressure sensor solutions leveraging our leading MEMS technology.*



### Health

With the help of our solutions the critical parameter pressure can be controlled in applications which increase the quality of life and even save lives. Examples are CPAP, dialysis machines and minimally invasive surgery devices.



### Safety

Pressure sensors are used in a variety of automotive applications like airbags and tire pressure monitoring systems (TPMS) that help to keep occupants safe. Another application area is fire building pressurization and smoke management.



### Environment

Pressure sensors are utilized to increase energy efficiency, reduce waste and emissions and support renewable energy. Examples are HVAC control and air distribution, exhaust gas filter systems and wind turbines.





# Medical Applications

The medical market is a demanding space requiring both high performance and reliability with cost effective solutions. Applications ranging from hospital patient monitoring devices to portable CPAP machines demand everything from high resolution and high accuracy to low-power consumption and small size. As medical devices become ubiquitous throughout hospitals and proliferate into the home, SMI's small, high performing, and cost effective solutions are ready for customers to develop and manufacture cutting edge solutions.

## Respiratory Devices

### CPAP (Continuous Positive Airway Pressure)

CPAP machines use mild air pressure to keep an airway open to enable regular breathing patterns. SMI is a world market leader in sensors utilized for CPAP machines. We offer a variety of pressure sensors that supply feedback of the applied air pressure in the mask/delivery hose to a microcontroller. This includes our ultra-low pressure sensor technology that can be used to measure flow rates of the CPAP blower.

### Respirators and Ventilators

Ventilators are life saving devices for patients who are unable to breathe unassisted. Ventilators move breathable air into and out of the lungs and are found everywhere from intensive care units to home portable units. SMI's low pressure technology allows for highly reliable and accurate measurements for this life critical application.

### Recommended Products

Highly accurate pressure sensing and stability over life - SM6X31  
Flow sensing with low noise and offset - SM7X31, SM933X

## Non-invasive Blood Pressure

Blood pressure is a key vital sign of the cardiovascular system that helps doctors diagnose a variety of medical conditions including hypertension. SMI offers a variety of products to accurately measure blood pressure which is typically in the range of 0 to 300mmHg (5,8 PSI). Our high resolution calibrated sensors can even resolve heart beats to determine pulse. Blood pressure is measured by a variety of devices including portable home use machines, patient monitoring devices in the hospital and also smart phone based devices.

### Recommended Products

Pressure sensing with low noise for high resolution - SM4X31  
Pressure sensing with small footprint for safety check - SM5G

## Further Applications

- > Dialysis Machine
- > Infusion Pumps
- > Patient Monitors
- > Oxygen Concentrators
- > Spirometer
- > Hospital Bed
- > Negative Pressure Wound Therapy

## DPF / GPF

### Diesel and Gasoline Particulate Filter

Diesel particulate filters (DPF) and gasoline particulate filters (GPF) are used to remove particulate matter from the exhaust gas of a diesel engine, or respectively a gasoline direct injection engine. The filters catch a large percentage of the particulate matter, but while doing so become obstructed requiring a cleaning process. A pressure sensor can be used to determine the level of obstruction in the filter by measuring the differential pressure across the filter and determine when a cleaning process should be initiated. SMI's platinum based pressure sensors enable accurate and reliable direct measurement of the diesel exhaust gas, while surviving the harsh environment.

### Recommended Products

Differential pressure sensing in harsh environment - SM30G Platinum Series

## Transmission

As a critical component in the operation of a vehicle, the transmission performance will directly influence the performance of a vehicle. The use of pressure sensors in the transmission greatly improves the control while shifting gears enabling a smoother drive experience and higher fuel economy. SMI's latest generation of harsh environment pressure sensors are small-sized and robust to high pressure and temperature, as well as pressure spikes and cavitation.

### Recommended Products

Absolute pressure sensing in harsh environment with immunity to dynamic spikes - SM97A, SM98A

## Further Applications

- > Tire Pressure Monitoring System (TPMS)
- > Manifold Absolute Pressure (MAP/TMAP)
- > Barometric Air Pressure (BAP)
- > Fuel/Oil Pressure
- > Brake Booster
- > Fuel Vapor Pressure
- > Exhaust Gas Recirculation (EGR)
- > Air Conditioning (AC)
- > Crank Case Pressure
- > Air Brakes
- > Occupant Detection
- > Airbags



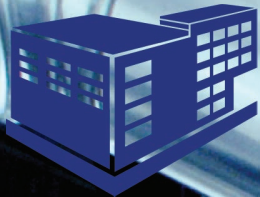


# Automotive Applications



As demands for higher efficiency, increased safety, and improved driver experience continue to push the automotive market, the need for more sensors and active monitoring of the various systems in the vehicle are needed. To meet the often times harsh environments, high temperatures, and dynamic pressure environments found in these systems of the vehicle, SMI has developed a series of cutting edge, high performing products to address these demanding applications.





# Industrial Applications

Factories around the world are being challenged to improve efficiency, increase output, and reduce waste. In order to control the processes being run and the facilities being utilized, pressure sensors play a key role in driving optimum performance. SMI's broad portfolios of pressure sensors can assist in everything from the control of a liquid dispense, to feedback in a pump and valve system, to accurately maintaining pressure in critical clean room environments. SMI provides a variety of off the shelf and tailored solutions to meet the widely varying needs of industrial customers.



## Pressure Transmitters

Pressure transmitters and switches measure the pressure of fluid and gas in a variety of industrial applications. During an industrial process pressure transmitters monitor the pressure and confirm the machinery is applying the correct level of pressure. The requirements on pressure vary widely however, quality expectations and performance are typically on the high-end. Depending on the type of transmitter SMI offers fitting die, uncompensated packaged parts and calibrated solutions.

### Recommended Products

Calibrated with best stability over life - SM5X31, SM6X31, SM7X31, SM923X, SM933X

For custom circuitry - SM9G/D

Sensor only - SM97A, SM98A, SM30D

## Liquid Level Measurement

Liquid level measurement is required in a variety of applications from water storage to manufacturing control and can often require precise accuracy. SMI's sensors provide a precise reading of the liquid level. We have also designed our packages in a way that is robust against contact to liquid.

### Recommended Products

Pressure sensing with robustness to liquid - SM1X31, SM4X31

## Safety Cabinets

Safety cabinets and ventilation hoods are critical in medical and industrial environments where dangerous chemicals or gases are being used. In order to pull these gases away from the environment, a small negative pressure must be pulled by a fan and measured by a low pressure sensor.

### Recommended Products

Stable low pressure sensing - SM6X31, SM7X31

## Further Applications

- > Oil Filled Media Isolated Sensors
- > Automation
- > Water Heaters & Boilers
- > Gas Flow
- > Wind Turbines
- > Refrigeration
- > Hydraulic & Pneumatic Pressure

## Catheter

### Therapeutic Catheter

Our line of *in vivo* pressure sensors, IntraSense, can be used to monitor and guide therapeutic procedures in-vivo. Its small size allows designers to maximize the diameter of the working channel, and linear response across a wide pressure range allows for both point-of-use diagnostics as well as process guidance. It can be calibrated across a wide pressure range for high-pressure injection applications (from -600 to 1400mmHg). For example, in embolic agent delivery, pressure will rise sharply when embolization is complete, while a drop in pressure will be seen in crossing catheters once the occlusion is breached. Pressure readouts can be used to confirm the correct placement of therapeutic catheters in the heart or major vessels, and can provide additional safety in ablative systems, where correct treatment or insufflation pressure is critical.

### Recommended Products

Pressure Sensing - SMI-1A IntraSense

## Endoscope

IntraSense offers the potential for increased patient safety in many endoscopic applications. Pressure can indicate if the procedure is going according to plan. Point-of-use pressure measurement provides the best data to the physician to confirm patient safety. Silicon is inherently sensitive to bright lights, and shifts in output can accompany changes in light intensity. IntraSense is available in a special light-blocking version, which minimizes the effects of bright light on the performance of the sensor, thereby providing the best possible accuracy. IntraSense also provides point-of-use guidance in insufflation for the most pressure-sensitive applications.

### Recommended Products

Pressure Sensing - SMI-1B IntraSense lightshielded

## Further Applications

- > Diagnostic Catheter
- > Ablation Equipment



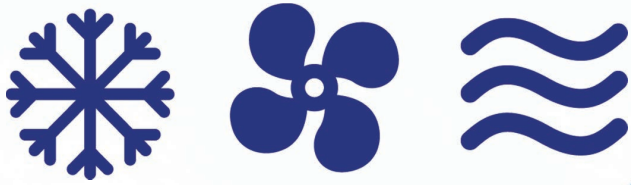


# Invasive Medical Applications



The human body has a variety of pressure regulated systems that can be monitored effectively with the use of pressure sensor. Applications include the measurement of intravascular pressure (IVP), intracranial pressure (ICP) and intraocular pressure (IOP). As well as monitoring and controlling embolization procedures, and monitoring intrarenal and intraurethral pressure during ureteroscopy. Furthermore biopsies, emergency surgery and biliary tract surgery can benefit from pressure monitoring. By utilizing SMI's ultra-small connected pressure sensor, surgeons can more accurately diagnose symptoms and measure patient's vitals leading to higher success rates and faster recovery. SMI offers small pressure sensor solutions down to 1-French in size.





# HVAC Applications

As cities become denser and pollution becomes an ongoing challenge, the need for high efficiency HVAC systems becomes more critical. Whether it is accurate measurement of air flow into a room or monitoring the cleanliness of a filter, HVAC applications require ultra-low pressure measurement with high accuracy that needs to last 10 years or more. SMI has been a pioneer in the low pressure space for over 25 years, and offers solutions for exactly these types of demanding applications.



## Variable Air Volume

In HVAC systems it is often necessary to control and vary the air volume flowing into a given room. This system is regulated by an ultra-low differential pressure sensor to control damper position and in turn the volume of air flow. SMI has industry leading technology for accurate measurement at high resolution of pressure down to 1”H<sub>2</sub>O (250Pa) that are utilized in such applications.

### Recommended Products

Stable air flow sensing - SM6X31, SM7X31, SM933X

## Filter Monitoring

HVAC systems utilize filters to confirm cooled or heated air is clean before being delivered to the desired space. Over time as filters are used they can become contaminated and increase the pressure losses in the HVAC system. SMI has a family of low pressure sensors designed to detect such pressure build ups and indicate the need to clean or replace a filter.

### Recommended Products

Air flow sensing with high resolution - SM7X31, SM933X

## Fire Protection

In case of fire in a high-rise building the emergency stairways need to be kept free of smoke to allow safe egress for the occupants. A stair pressurization system confirms the exit stairs stay free of smoke. One control unit per floor measures and controls the pressure in the staircase in reference to the main building. If the fire alarm system is turned on stair pressurization fans supply clean outside air into the staircase. The higher air pressure prevents smoke from entering the staircase when the emergency doors are opened, smoke is basically pushed back, clearing the escape route. SMI's sensors assist in smoke management by measuring the pressure in the staircase and the building.

### Recommended Products

Accurate and stable pressure sensing - SM7X31, SM923X, SM933X

## Further Applications

- > Ventilation
- > Compressor and Chiller
- > Air Handling Unit



## Consumer Applications

### Washing Machine

As a demand for more efficient washing machines increases, more and more designs are beginning to incorporate MEMS based pressure sensors to detect water level. SMI has a series of products that are small in size, extremely accurate, and robust against water to enable such measurements. These sensors are able to detect down to the millimeter level of water change for optimal efficiency of the washing machine.

#### Recommended Products

Accurate water level pressure sensing - SM6X31, SM5G



### Vacuum Cleaner

Pressure sensors are being utilized in vacuum cleaners for a variety of functions to improve efficiency and user friendliness. These types of functions include detection of floor type to optimize height and brush speed, filter cleanliness for filter replacement, and to indicate when the bag is full. SMI has a suite of products designed to address each of these challenges that are small in size and cost effective.

#### Recommended Products

Floor type detection with high resolution - SM4X31

Filter cleanliness detection with high resolution - SM5X31, SM6X31, SM7X31

Vacuum bag indicator with small footprint - SM30D, SM5420E

### Air Filter & Purifier

For people living in metropolitan areas, air quality can fluctuate drastically potentially causing respiratory issues or long term damage to the body. Air filters utilize HEPA filters to enhance air quality by removing contaminants both for personal air filter devices and for room filters. Over time however, the HEPA filter can become dirty and rendered ineffective. SMI specializes in ultra-low pressure sensors to detect cleanliness levels of the filter and inform consumers when to change or clean the filter.

#### Recommended Products

SM5X31, SM6X31, SM7X31

### Further Applications

- > Coffee & Espresso Machines
- > Water Purifier
- > Refrigerators
- > Cooking Hood
- > Rice Cooker



# AccuStable Solutions

For the most demanding applications, SMI provides AccuStable sensor solutions. Our AccuStable solutions offer extraordinary performance and reliability. Only after extensive testing our devices earn the AccuStable quality label.

Accuracy and stability are critical parameters for a vast number of applications influencing effectiveness and efficiency. An everyday life example is tire pressure measurement, where accurate measurement results influence fuel efficiency. According to a NHTSA (National Highway Traffic Safety Administration) study a 1% decrease in tire pressure correlates to a 0.3% reduction

in fuel economy. The correct applied tire pressure starts with the accurate measurement of the same. The illustrated principle is applicable for many applications, e.g. energy-efficient building pressurization in HVAC.

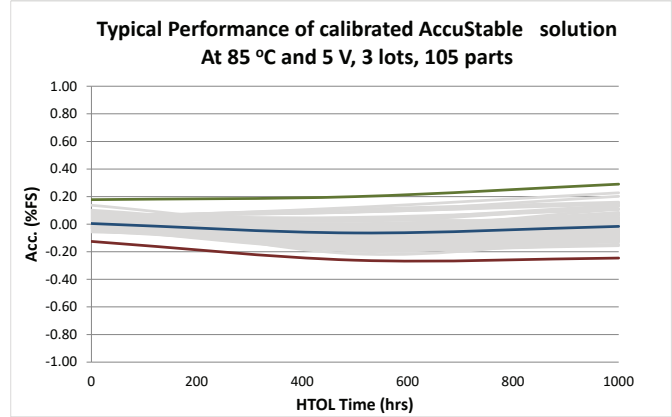


Committed to efficiency, parts with the AccuStable quality label provide accuracy and stability better than 1% over 10 year lifetime. Parts qualify based on 1000 hours of HTOL (high temperature operating life) under product specific operating conditions.

## AccuStable Products - Qualifying Operating Conditions

Product Series	Temperature in °C	Supply Voltage in V	Product Series	Temperature in °C	Supply Voltage in V
SM30D	150	10	SM1X31	125	5
SM30G Platinum	150	10	SM4X31	125	5
SM5108E	125	5	SM5X31	85	5
SM95G	85	5	SM6X31	85	5
SM97A	150	6	SM7X31	85	5
SM98A	150	5			

For bare MEMS die, this means that tested parts have span and offset shift of less than 1% over 1000 hours of HTOL. Our fully calibrated and pressure and temperature compensation solutions



marked as AccuStable provide < 1% total accuracy error initially and < 1% shift during operation over 10 year lifetime. Accuracy error combines linearity and hysteresis over the full range

of product specific operating conditions (pressure range and compensated temperature range). Only solutions combining an extraordinary accuracy with a long-time stability are allowed to have this high quality label.

All of SMI's MEMS die families qualify for this designation. Starting with the low pressure die SM95G (pressure ranges from 0.15 to 1.5 PSI), to the medium pressure dies SM30D (5 to 500 PSI) and the small-sized SM5108E (30 to 100 PSI), all the way to the high pressure harsh environment solutions SM30G Platinum, SM97A and SM98A (up to 20 bar). A wide array of SMI's calibrated sensor with digital output also qualifies as AccuStable. This includes the SMXX31 family providing a 16-bit digital output. Our calibrated AccuStable sensor solutions ensure accurate measurements across the entire pressure range from 0.07 to 30 PSI.



# Harsh Environment Solutions

Harsh environment conditions like extreme temperatures and harsh media exist in automotive and industrial applications. The capability to provide sensor reliability while operating under extreme conditions is important. For example in automotive applications sensors should deliver accurate results over the time of 10 to 15 years (or 150,000–250,000 miles). Additionally, the sensors must potentially endure high shocks. With these requirements in mind we designed our harsh environment MEMS die solutions.


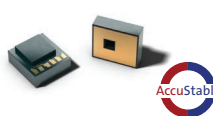

SMI’s sensors are robust to extreme temperatures with an operating temperature range from -40°C to +150°C and resistant to harsh media, such as exhaust gas and coolant liquid. Media resistance is achieved through backside pressurization (SM97A and SM98A) or platinum metallization (SM30G). In contrast to traditional pressure sensors SMI’s absolute backside pressure die only expose silicon materials to the media, and therefore the electronic structures on the front side of the die are not affected by the harsh media, resulting in a more robust solution. Noble metal bond-pads, deployed in the SM30G Platinum Series, also helps to shield the sensitive die components from aggressive media like acid gases.

The highest operating pressure range of the SM97A/SM98A sensor family is 20 Bar with 50 Bar versions currently in development. Within this range the sensors demonstrate a proof pressure (overpressure) of up to 6XFS and burst pressure of up to 10XFS suitable for the most demanding applications. In addition, automotive and industrial applications pressure can suddenly

rise or drop rapidly, which adds stress to the sensor. The backside pressure dies continue to perform reliably despite of pressure spikes. For a stable and accurate performance over time our sensors have been extensively tested and all harsh environment dies have earned the AccuStable quality label. For more information about AccuStable solutions please see page 15.

Typical automotive harsh environment applications are DPF/GPF, EGR, Transmission, SCR, AC and Fuel Vapor. Harsh environment conditions can also be found in industrial and HVAC applications, e.g. compressors and pumps, controls and switches and oil filled modules.



Recommended Products			
			
<b>Product Family</b>	<b>SM30G Platinum</b> Medium Pressure Harsh Media Die	<b>SM97A</b> Ultra-High Pressure Harsh Media Die	<b>SM98A</b> Ultra-High Pressure Harsh Media Die
<b>Pressure Type</b>	Differential/Gauge	Backside Absolute	Backside Absolute
<b>Pressure Range</b>	5 / 15 / 30 PSI	10 / 20 Bar	10 / 20 Bar
<b>Proof Pressure</b>	1 / 3 / 3 XFS	6 XFS	2 / 2 XFS
<b>Burst Pressure</b>	8 / 5 / 5 XFS	15 / 10 XFS	15 / 10 XFS
<b>Temperature Range</b>	-40°C to +150°C	-40°C to +150°C	-40°C to +150°C



# Customized Solutions



## TailorSense Innovation tailored to you

With the help of SMI's TailorSense Product Configurator the customer can build the perfect calibrated sensor system meeting all target requirements.

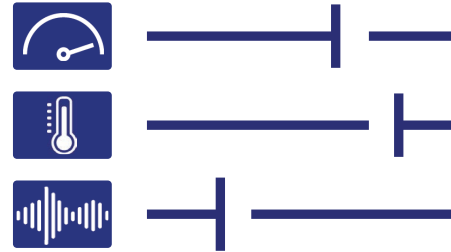
The Product Configurator lets the customer define a sensor system tailored to the needs of a specific application. Pressure range and pressure type can be configured as well as package type and package porting. In addition different options for the output type, output accuracy and compensated temperature range and supply voltage are available.

By choosing these parameters based on the application, the customer is able to optimize the sensor system for its specific target application. For example, the full resolution and output range of the sensor system are available if the pressure range has been optimized for the specific application. And the configurable sensor output type, including amplified analog and digital I<sup>2</sup>C or SPI, allow integration with a variety of interfaces.

With TailorSense our customers do not have to compromise when choosing a sensor system solution. In addition TailorSense solutions are available in a timely manner: Samples ship within 2 weeks and production quantity is available within 8 weeks. The tailored solution can easily be integrated into the target application.

Please visit [www.si-micro.com/product-configurator](http://www.si-micro.com/product-configurator) to design your tailored sensor system or contact [sales@si-micro.com](mailto:sales@si-micro.com)

### 1. You choose the sensor configuration



### 2. We manufacture your solution



### 3. We ship samples within 2 weeks, order quantity within 8 weeks



### 4. You receive the calibrated sensor solution for your application



#### Custom Die Solutions

Many applications require the use of a pressure sensor die instead of a packaged standard product. In those cases significant engineering effort is spent on the selection and development of suitable processes for handling, die-attach bonding, electrical contact, and media protection of the

purchased die. The Design for Manufacturability is crucial in applications where commercial success and product quality are critical factors. SMI offers custom die design to enable our customers to develop truly innovative and unique products.

# Solutions Overview

## Bare MEMS Die

For OEM and custom solutions, SMI provides a broad selection of bare pressure sensor die. With offerings from low pressure to media resistant high pressure, SMI can provide high performance solutions for your application while meeting the robust and high quality demands of the automotive, medical, and industrial markets. The pressure sensor die are available in gauge and absolute pressure configurations. For more robust applications, backside absolute pressure dies are available. Pressure ranges vary from 0.3 PSI (~20 mbar) to 290 PSI (~20 bar). All bare MEMS die solutions are described further on page 22.

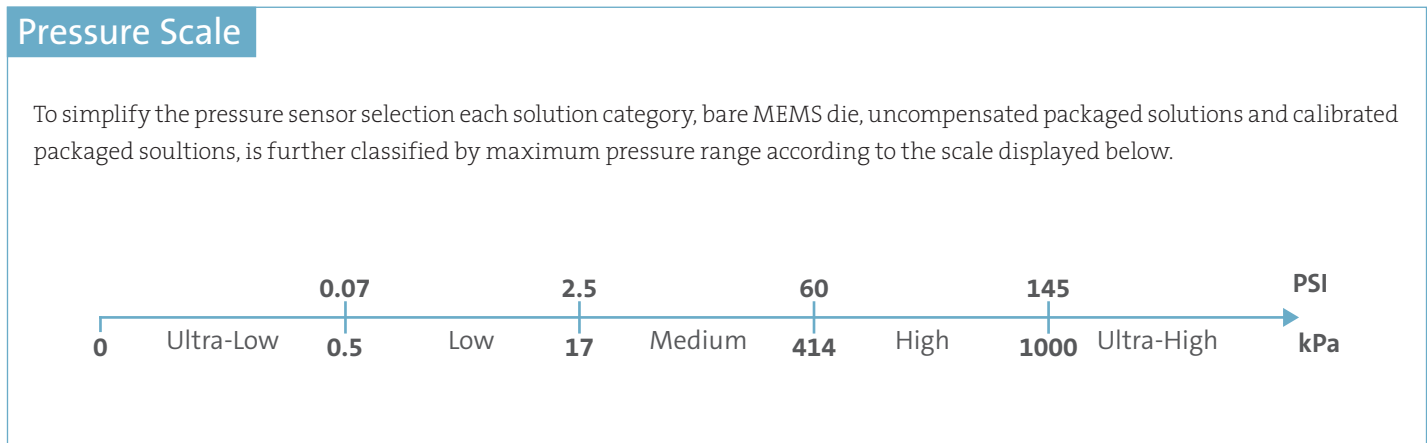
## Uncompensated Packaged Solutions

SMI carries a full selection of uncompensated standard packaged solutions. Customer can configure the sensors according to their requirements. Packages range from the very small JEDEC SOIC-8 plastic housing with hole or long port porting option

to the versatile JEDEC SOIC-16 plastic package with various porting options for design flexibility. The entire uncompensated packaged solutions offering can be found on page 22.

## Calibrated Packaged Solutions

To complement the package offering, SMI provides solutions for pressure ranges from 0.02 PSI (~125 Pa) to 60 PSI (~4 bar) with either an analog output or a digital interface or both. The available pressure configurations are differential, gauge and absolute. All calibrated packaged solutions are temperature and pressure compensated and fully signal-conditioned. For the latter combining the pressure sensor cell with a signal-conditioning ASIC in a single package simplifies the use of advanced silicon micro-machined pressure sensors. For more information about our calibrated packaged solutions see pages 19-21.



## In Vivo Sensors

In addition to the solutions above SMI also offers *in vivo* pressure sensing solutions. Especially designed to enable accurate pressure measurements for invasive medical devices, e.g. catheters and scopes, throughout the human anatomy while withstanding the harsh conditions. The small sensor size of 220 μm x 750 μm x 75 μm allows for easy system integration, into devices as small as 1-French. Learn more about SMI's *in vivo* sensors on page 23.



# Calibrated Solutions

## Ultra-Low Pressure

The ultra-low pressure solutions are fully temperature compensated and pressure calibrated with pressure ranges as low as 125 Pa (0.50 inH<sub>2</sub>O). The differential/gauge sensor systems

are available in JEDEC standard SOIC-16 packages with dual vertical porting and provide a digital I<sup>2</sup>C output with 16 bit and 14 bit, respectively.

### Ultra-Low Pressure | Differential and Gauge



Product Series	SM933X Ultra-Low Pressure Differential	SM923X Ultra-Low Pressure Gauge	SM9543 Ultra-Low Pressure
Pressure Range	+/- 125 / 250 Pa	0 - 250 / 0 - 300 / 0 - 600 Pa	+/- 5 mbar
Pressure Type	Differential	Gauge	Differential
Compensated Temperature Range	-20°C to +85°C	-20°C to +85°C	-5°C to +65°C
Package Type	SOIC-16	SOIC-16	SOIC-16
Port Type	Dual Vertical	Dual Vertical	Dual Vertical
Digital Interface	I <sup>2</sup> C, 16 bit	I <sup>2</sup> C, 16 bit	I <sup>2</sup> C, 14 bit
Supply Voltage	3.3 V / 5 V	3.3 V / 5 V	3.3 V
Accuracy	1.25 %FS / 1 %FS (after AutoZero)	1.25 %FS / 1 %FS / 1 %FS (after AutoZero)	1.5% FS

## Flow Sensing

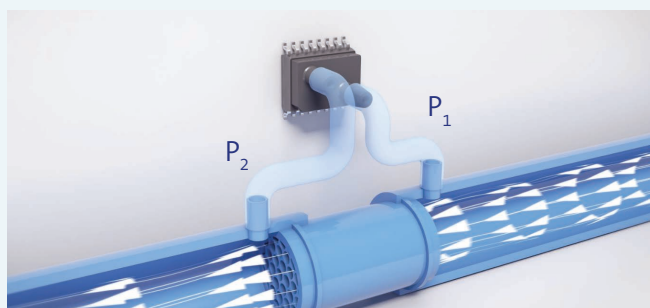
### Flow Measurement over Flow Element

With the help of the SM933X sensor the flow rate of air and gases can be determined. For this purpose a flow element, e.g. an orifice plate or a bundle of tubes, is placed in the flow channel. This flow element causes a drop in pressure. The differential pressure sensor measures the pressure difference between P<sub>1</sub> (before the flow element) and P<sub>2</sub> (after the flow element). Based on the difference in pressure the flow rate is calculated.

### SM933X - Ultra-Low Differential Pressure Sensor

The 16 bit resolution provides the ability to resolve signals as small as 0.0038 Pa. The excellent warm-up behavior and long term stability further confirm its expected performance over the life of the part. The system supply ranges from 3.0 to 5.5V and it is well suited for low power applications with its low current consumption and available sleep mode. The ASIC

architecture and higher order noise filtering provides low noise and extremely low EMI susceptibility. Measurement results are not influenced by the tubing length or affected by particles in the airflow. The small SO16 package with dual vertical port allows for easy system integration and pressure connection, while the MEMS sensor itself is robust with high burst pressure and virtually no mounting or vibration sensitivity.



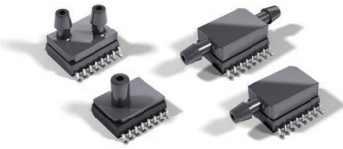
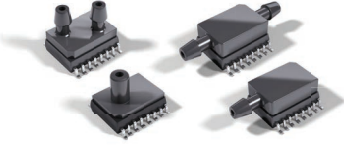
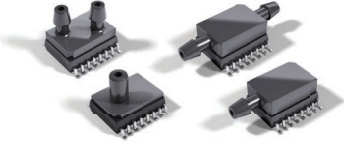



# Calibrated Solutions

## Low Pressure

All calibrated low pressure solutions are available in differential, gauge and asymmetric differential configuration with a maximum pressure range between 0.07 and 2.49 PSI. Packaged in a standard SOIC-16 JEDEC package with various porting options (dual vertical, dual horizontal and single vertical) for flexibility in the application.

The calibrated solutions offer two output signal choices, either

16 bit digital (XX31 Series), or 16 bit digital and amplified analog (XX91 Series), which can be used as an analog only as well, allowing for flexibility. Both Series offer 1 %FS digital accuracy, respectively 1.5 %FS analog accuracy for the XX91 Series. The XX31 Series earned the AccuStable quality label with a total accuracy error of less than 1% (for more information about AccuStable solutions see page 15).

Low Pressure   Differential, Gauge and Asymmetric							
Product Series							
	SM7X91	SM7X31 	SM6X91	SM6X31 	SM5X91	SM5X31 	
Pressure Range	0.07 - 0.29 PSI		0.3 - 0.79 PSI		0.8 - 2.49 PSI		
Pressure Type	Differential, Gauge, Asymmetric		Differential, Gauge, Asymmetric		Differential, Gauge, Asymmetric		
Compensated Temp. Range	-20°C to +85°C		-20°C to +85°C		-20°C to +85°C		
Package Type	SOIC-16		SOIC-16		SOIC-16		
Port Type	Dual Vertical or Horizontal, Single Vertical or Horizontal (Gauge)		Dual Vertical or Horizontal, Single Vertical or Horizontal (Gauge)		Dual Vertical or Horizontal, Single Vertical or Horizontal (Gauge)		
Digital Interface	I <sup>2</sup> C, 16 bit	I <sup>2</sup> C, 16 bit	I <sup>2</sup> C, 16 bit	I <sup>2</sup> C, 16 bit	I <sup>2</sup> C, 16 bit	I <sup>2</sup> C, 16 bit	
Analog Output	10% to 90% V <sub>DD</sub>	N/A	10% to 90% V <sub>DD</sub>	N/A	10% to 90% V <sub>DD</sub>	N/A	
Supply Voltage	3.3 V/5 V	3.3 V/5 V	3.3 V/5 V	3.3 V/5 V	3.3 V/5 V	3.3 V/5 V	
Digital Accuracy	1% FS	1% FS	1% FS	1% FS	1% FS	1% FS	
Analog Accuracy	1.5% FS	N/A	1.5% FS	N/A	1.5% FS	N/A	

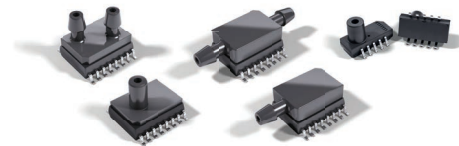
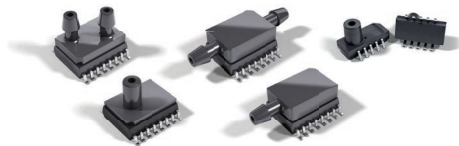
## Medium Pressure

Calibrated medium pressure solutions are available in differential, gauge and asymmetric differential configuration with a maximum pressure range between 2.5 and 60 PSI. Packaged in a standard SOIC-16 JEDEC package with various porting options (dual vertical, dual horizontal and single vertical) for flexibility in the application. Additionally, the gauge sensor systems are available with an even smaller footprint, in the JEDEC SOIC-10 package.

The calibrated solutions offer two output signal choices, either 16 bit digital (XX31 Series), or 16 bit digital and amplified analog (XX91 Series), which can be used as an analog only as well. Both Series offer 1 %FS digital accuracy, respectively 1.5 %FS analog accuracy for the XX91 Series. The XX31 Series earned the AccuStable quality label with a total accuracy error of less than 1% (for more information about AccuStable solutions see page 15).



## Medium Pressure | Differential, Gauge and Asymmetric



Product Series	SM4X91	SM4X31	AccuStable	SM1X91	SM1X31	AccuStable
	Pressure Range	2.5 - 14.9 PSI		15 - 30 PSI		
Pressure Type	Differential, Gauge, Asymmetric		Differential, Gauge, Asymmetric			
Compensated Temp. Range	-20°C to +85°C		-20°C to +85°C			
Package Type	SOIC-16 or SOIC-10 (Gauge)		SOIC-16 SOIC-16 or SOIC-10 (Gauge)			
Port Type	Dual Vertical or Horizontal, Single Vertical or Horizontal (Gauge)		Dual Vertical or Horizontal, Single Vertical or Horizontal (Gauge)			
Digital Interface	I <sup>2</sup> C, 16 bit	I <sup>2</sup> C, 16 bit	I <sup>2</sup> C, 16 bit	I <sup>2</sup> C, 16 bit		
Analog Output	10% to 90% V <sub>DD</sub>	N/A	10% to 90% V <sub>DD</sub>	N/A		
Supply Voltage	3.3 V/5 V	3.3 V/5 V	3.3 V/5 V	3.3 V/5 V		
Digital Accuracy	1% FS	1% FS	1% FS	1% FS		
Analog Accuracy	1.5% FS	N/A	1.5% FS	N/A		

The medium pressure offering is complemented with absolute pressure sensors, which measure pressure relativ to a vacuum (zero pressure). The SM1131 and SM1111 provide barometric air measurements for a pressure range of 60 to 165 kPa (~ 9 to 24 PSI). The SM1131 has an I<sup>2</sup>C interface with 16 bit digital output and can easily be connected to a microcontroller. The SM1111 provides an amplified analog output signal.

## Medium Pressure | Absolute




Product Series	SM1111	SM1131
Pressure Range	60 to 165 kPa	60 to 165 kPa
Pressure Type	Absolute	Absolute
Comp. Temp. Range	-40°C to +125°C	-40°C to +125°C
Package Type	SOIC-8	SOIC-8
Port Type	Dual Hole	Dual Hole
Digital Interface	N/A	I <sup>2</sup> C, 16 bit
Analog Output	Amplified Analog	N/A
Supply Voltage	3.3 V / 5V	3.3 V / 5V
Accuracy	1 kPa (0 to +85°C)	1 kPa

# Uncompensated Solutions

The same die used in our compensated systems are available as packaged MEMS die with uncompensated output. The customer can implement their own temperature compensation scheme

with easy-to-use standard JEDEC SO-8 and SO-16 packages. A variety of porting options are available. The operating temperature ranges from -40°C to +125°C.

### Uncompensated | Low to High Pressure



Product Family	SM9G/D Low Pressure	SM5G Medium and High Pressure	SM5420E Medium and High Pressure
Pressure Range	0.3 to 1.5 PSI	5 to 80 PSI	15 to 100 PSI
Pressure Type	Gauge, Differential	Gauge	Absolute
Temperature Range	-40°C to +125°C	-40°C to +125°C	-40°C to +125°C
Package Type	SOIC16	SOIC8 Long Port	SOIC8
Port Type	Single Horizontal, Dual Horizontal, Single Vertical, Dual Vertical	Single Vertical	Hole, Single Vertical


# Bare MEMS Die

For customers who want complete control over packaging and signal conditioning, SMI offers sensor die. All of SMI's MEMS die families obtained the AccuStable quality label which guarantees a span and offset shift < 1% over 10 year lifetime (for more information about AccuStable solutions see page 2). These parts are typically delivered as sawn wafers on tape, but other options include picked die in waffle packs or Gel-Pak boxes. Sensor die are fully inspected and electrically probed before delivery.

### Customized die options include:

- > Backside Gold for eutectic bonding
- > Top-side Gold or Platinum for harsh media
- > Wafer Thinning for die stacking
- > Solder bumping
- > Open or closed bridge designs

### MEMS Die | Low to Ultra-High Pressure



Product Family	SM95G Low Pressure	SM30D Medium and High Pressure	SM30G Platinum Medium and High Pressure	SM5108E Medium and High Pressure	SM97A Ultra-High Pressure Harsh Media	SM98A Ultra-High Pressure Harsh Media
Pressure Range	0.3 to 1.5 PSI	5 to 500 PSI	5 to 150 PSI	30 to 100 PSI	10 and 20 Bar	10 and 20 Bar
Pressure Type	Differential/Gauge	Differential/Gauge	Differential/Gauge	Absolute	Absolute	Absolute
Temp.Range	-40°C to +125°C	-40°C to +150°C	-40°C to +150°C	-40°C to +125°C	-40°C to +150°C	-40°C to +125°C



# In Vivo Sensors

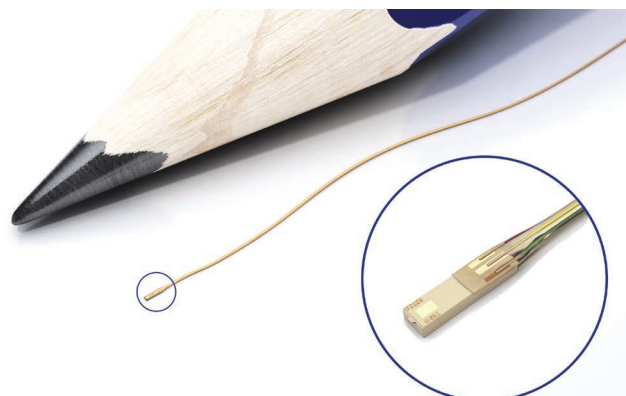
## In Vivo Pressure Sensing

In the human body, pressure is an essential parameter in almost all organs. Pressure is measured throughout the organ systems (e.g. the cardiovascular or nervous system) and therefore in different fluids (e.g. blood or cerebrospinal fluid). Determining the pressure accurately helps physicians make critical decisions related to diagnosis or treatment.

Ideally, pressure would be measured from outside the body in a non-invasive way. But indirect pressure measurement has limits, and depending on the method it can deliver inaccurate values. Erroneous measurements can result in a misguided clinical decision. This is why invasive pressure measurements are still considered the gold standard in critical patient care.

Direct pressure measurement is performed by sensors in minimally invasive medical devices. The pressure sensor is mounted to the tip of a catheter tube. In the sensor the deformation of a diaphragm indicates the amount of external pressure. Due to their small size and low energy consumption Micro Electro Mechanical Systems (MEMS) sensors are particularly suitable.

SMI's IntraSense line of products represents an advanced



piezoresistive MEMS sensor with wire connection suitable for easy integration into invasive medical equipment.

## IntraSense

### IntraSense

IntraSense is a miniature MEMS piezoresistive pressure sensor with pre-attached wires for signal transmission. At 220  $\mu\text{m}$  x 750  $\mu\text{m}$  x 75  $\mu\text{m}$ , the sensor fits into a 1-French hypo tube (O.D. of 0.33 mm) and can be mounted inside a tube or on the side or top of a catheter tip. The three encapsulated copper wires ease integration into many medical applications with a customizable

IntraSense				
Product Series	SMI-1A IntraSense	SMI-1B IntraSense Lightshielded	SMI-1A IntraSense Calibrated	SMI-1B IntraSense Calibrated Lightshielded
Pressure Range	0 to +1300 mmHg	0 to +1300 mmHg	-300 to +500 mmHg	-300 to +500 mmHg
Pressure Type	Absolute	Absolute	Absolute	Absolute
Temperature Range	0°C to 105°C	0°C to 105°C	0°C to 105°C	0°C to 105°C

wire length. The biocompatible sensors are designed for *in vivo* sensing in the human body and no further encapsulation is required. Devices are pre-tested in water or saline to provide stable performance across the clinically useful pressure range. IntraSense is also available in a light-shielded version to protect the sensor from the effects of light.

IntraSense is available as standard uncalibrated or as IntraSense Calibrated.

### IntraSense Calibrated

The calibrated version incorporates additional functionalities and simplifies setup and readout with a calibration board, in form of a 5-pin connector, on the proximal end. This product line offers amplified analog and I<sup>2</sup>C digital output options with output accuracy of +/- 1.5% FS. After calibration the device is insensitive to temperature changes; Calibration is performed in water or saline for optimum results.

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