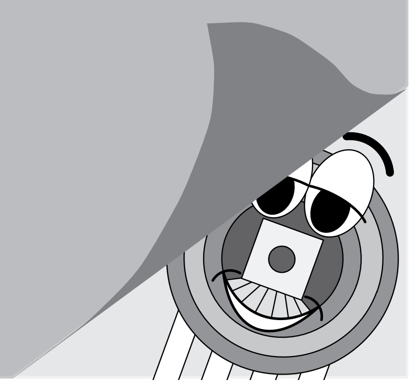
MOTOROLA

senseōn™

Sense the Possibilities

PRESSURE SENSOR DISTRIBUTOR HANDBOOK



(602) 244–4556

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INTRODUCTION

Welcome to the **wild, zany and madcap** world of Motorola's SENSEON™ Pressure Sensors!

This handbook will guide you through the basic what, where, how and whys of Motorola SENSEON Pressure Sensors and hopefully provide a few smiles along the way. It begins with some pressure sensor fundamentals so you can feel comfortable discussing the basics with your customers. In fact, once you've read this handbook, you'll probably know more about pressure sensors than many of your customers. We'll also show you where to look for potential business, preview new products, introduce you to the competition and share some market strategies with you.

The handbook requires minimal technical background in order to grasp the basic concepts (i.e., you DON'T have to be a ***rocket scientist***, but you should know enough not to stick a knife in the toaster). However, if you are technical, our guess is that you won't be bored. After all, pressure sensors are relatively easy to understand, and with our ASPs, you'll probably be more concerned with counting your money and figuring how to stay out of a higher tax bracket!

First thing, let's tell you our meaning of Senseon.

senseon™

Sense the Possibilities

WHAT IS A SEMICONDUCTOR–BASED PRESSURE SENSOR?

PRODUCT DEFINITION

A solid state pressure sensor is a silicon–based (semiconductor) device that converts pressure to an electrical signal. Located on the top surface of the die is a thin layer of silicon called the "diaphragm." When pressure is applied (such as water in a pipe or air in an air duct) to the diaphragm, a corresponding voltage signal will appear on the sensor output pins. As the pressure increases, the output signal increases. Take a look at the pressure vs signal diagram below (Figure 1) and you'll notice that the output is essentially a straight–line relationship. This is called a "linear" relationship. Pressure sensors are rated on how linear they are across a designated pressure range.

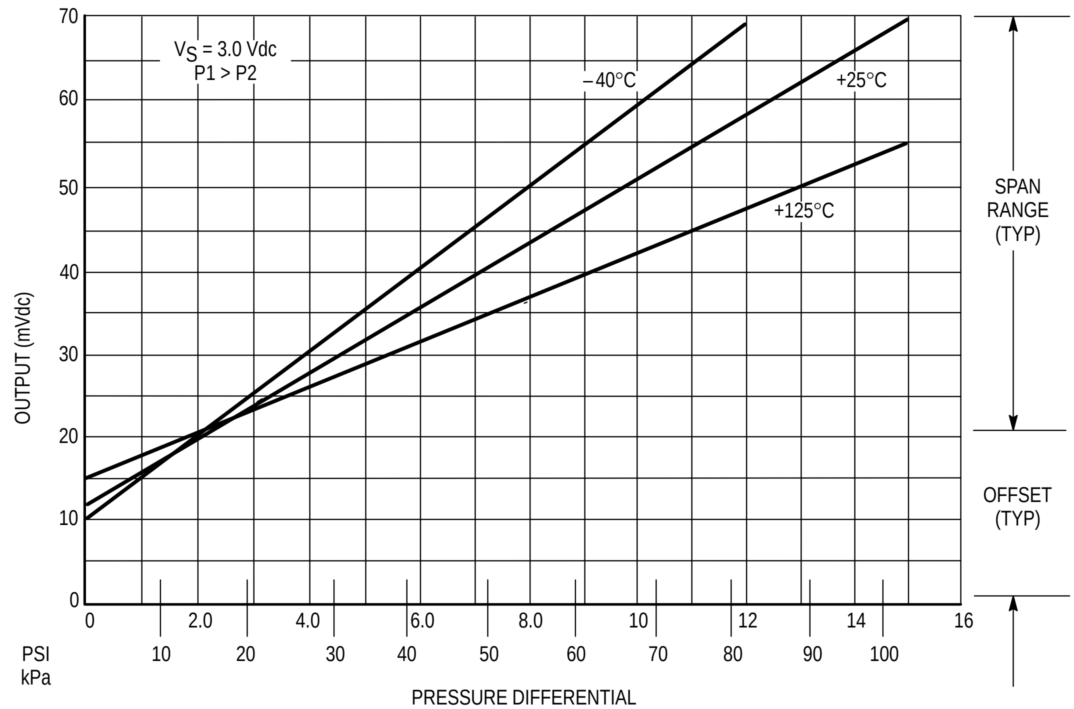
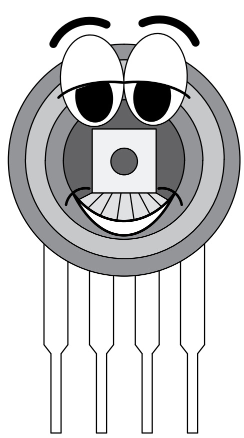


Figure 1. Typical MPX100 X–ducer™ Output versus Pressure Differential

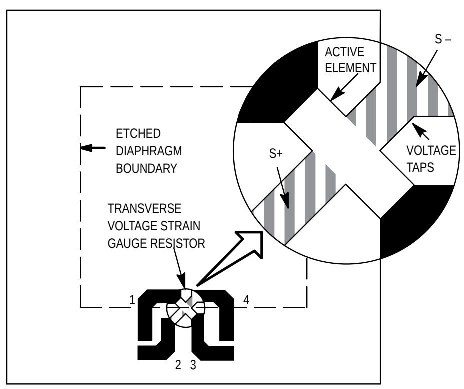


HOW IS PRESSURE MEASURED?

How is pressure on the diaphragm converted to a voltage signal at the output, you ask? OK, maybe that was the farthest question from your mind, but located on the edge of the diaphragm is a thing called a "piezoresistive element." Hmmmm . . . OK, how about a "transverse voltage strain gauge"? Any clearer? Well, this is what Motorola calls the X–ducer™. Basically, this element acts like a variable resistor. As the diaphragm flexes due to pressure, the element is also stressed and changes its resistance (see Figure 2 below). When you hook up a voltage supply across the X–ducer™ element, this will force an electric current to flow through the element. From Ohm's Law:

Output Voltage = Current x Resistance

So any change in the element resistance causes a change in the output voltage. Are you impressed? Are you asleep? Can you handle the "pressure?" Let's move on!



PIN #
1. GROUND
2. $+V_{OUT}$
3. V_S
4. $–V_{OUT}$

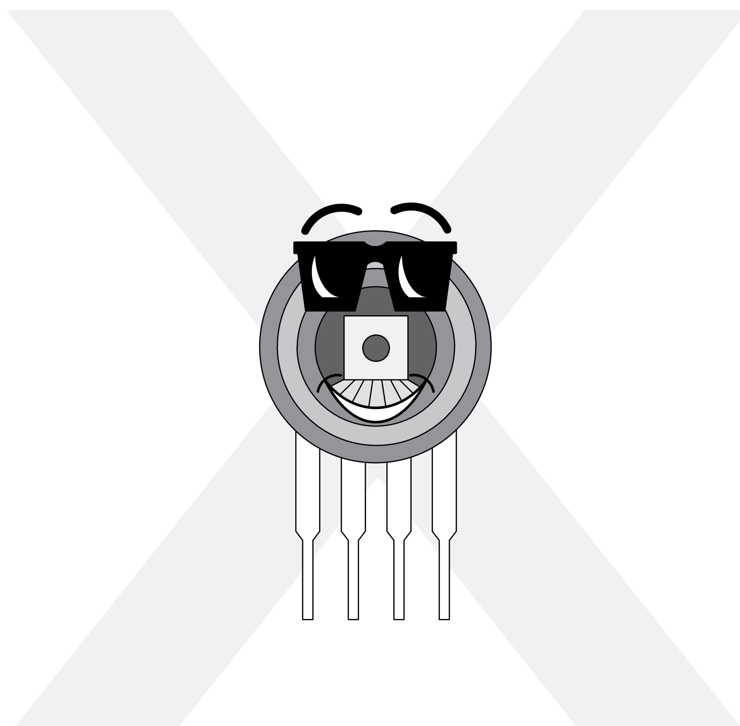
Figure 2. Basic Uncompensated Sensor Element — Top View

WHAT IS AN X–ducer™?

PRODUCT DEFINITION

The Motorola "X–ducer™," named for the shape of the sensing element, (see Figure 2 on page 5) is a monolithic silicon strain gauge that develops a voltage that is proportional to the applied stress.

The X–ducer uses a patented shear stress design that optimizes important device characteristics such as linearity, repeatability, reproducibility, sensitivity and signal–to–noise ratio.



W HAT KINDS OF PRESSURE SENSORS ARE THERE?

There are three basic types of pressure sensors:
Differential, Gauge and **Absolute**.

The standard Motorola **Differential** and **Gauge** pressure sensors have two sides: one designated the "pressure" side; the other, the "vacuum" side.

DIFFERENTIAL

Differential pressure sensors are used when the application calls for measuring the *difference* between two pressure points. One side of the sensor is hooked up to one pressure point, and the other side is hooked up to a different pressure point. A typical application of a **Differential** sensor would be to measure the pressure drop across an air filter in an air duct. When installed in–line with a filter, the sensor will be exposed to air pressure on both front and back of the diaphragm equal to the pressures experienced on the front and back sides of the filter. With a clean filter, the pressure difference between the two sides of the sensor should be approximately zero. As the filter gets dirty, the pressure on the front side becomes greater than the pressure on the back side. The sensor "senses" this difference, thus letting you know when a new filter is needed.

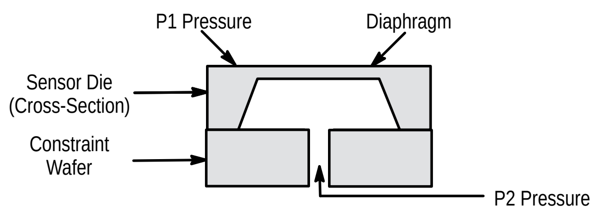


Figure 3

GAUGE

A **Gauge** sensor is a variation of the differential design sensor in that one side of the sensor is opened to the atmosphere. An example of this would be a simple blood pressure gauge.

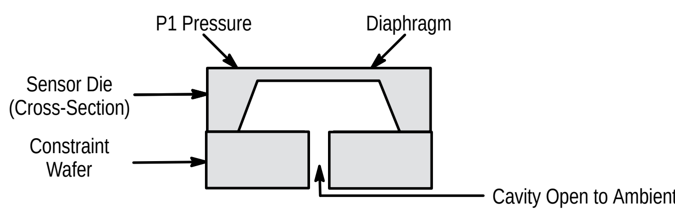


Figure 4

ABSOLUTE

An **Absolute** pressure sensor has only one side accessible. Sealed inside the die, behind the diaphragm, is a reference vacuum. **Absolute** pressure sensors are used in applications such as altimeters, manifold pressure, weather stations, weather balloons, and barometers.

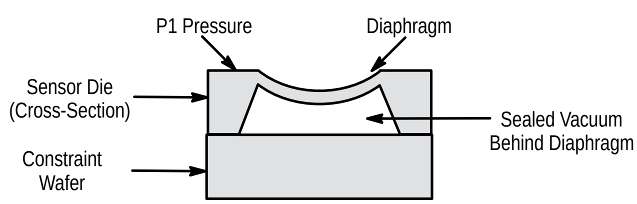


Figure 5

All three sensor types, **Differential**, **Gauge** and **Absolute**, can also be described as UNCOMPENSATED, TEMPERATURE COMPENSATED/CALIBRATED, HIGH IMPEDANCE or SIGNAL CONDITIONED. This will help you to identify the type of integration level your customer requires.

UNCOMPENSATED

The UNCOMPENSATED type is just that, no frills, bells or whistles. This low cost, basic sensor has incorporated just the X–ducer™ on–chip. The output will vary (within a specified range) depending on temperature. Other parameters such as *zero pressure offset* and *full–scale span** may vary from device to device (but still within a specified range). Typical output is in the 60 mVolt range with full rated pressure applied. Uncompensated sensors are on the low end of the price scale.

TEMPERATURE COMPENSATED & CALIBRATED

Next we have the TEMPERATURE COMPENSATED AND CALIBRATED pressure sensors. These devices include the X–ducer™ plus on–chip thin film resistors/thermistors that are laser trimmed to yield a rock–solid output signal over temperature. Zero pressure offset and full–scale span are calibrated so that negligible variance will occur from device to device. Typical output at full rated pressure for these devices is 40 mVolts. Temperature compensated and calibrated sensors are moderately priced.

HIGH IMPEDANCE TEMPERATURE COMPENSATED & CALIBRATED

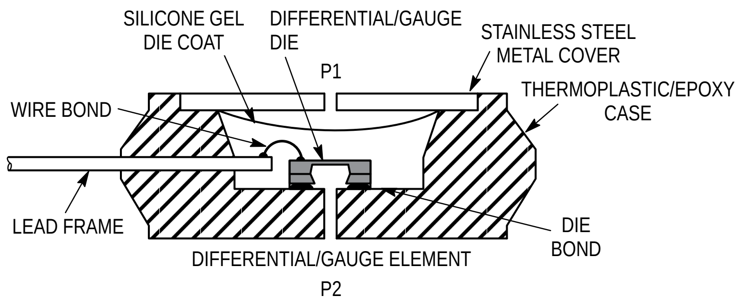
HIGH IMPEDANCE TEMPERATURE COMPENSATED AND CALIBRATED pressure sensors include the X–ducer™ plus on–chip thin film resistors/thermistors that are laser trimmed to yield a very consistent output signal over temperature and high impedance. Zero pressure offset and full–scale span are calibrated so that negligible variance will occur from device to device. Typical output at full rated pressure for these devices is 40 mVolts. High impedance temperature compensated and calibrated sensors are also moderately priced.

SIGNAL CONDITIONED

The *"State–of–the–Art"* in Motorola Senseon pressure sensors are the SIGNAL CONDITIONED sensors. These sensors contain the X–ducer™, temperature compensation and calibration circuitry on–chip, along with amplifier circuitry to increase the output signal for full rated pressure to typically 4.5 Volts. These sensors are typically more expensive than the UNCOMPENSATED sensors, but are still considerably less than our competition.

*These parameters are defined in the Glossary section.

WHAT IS A PRESSURE SENSOR MADE OF?



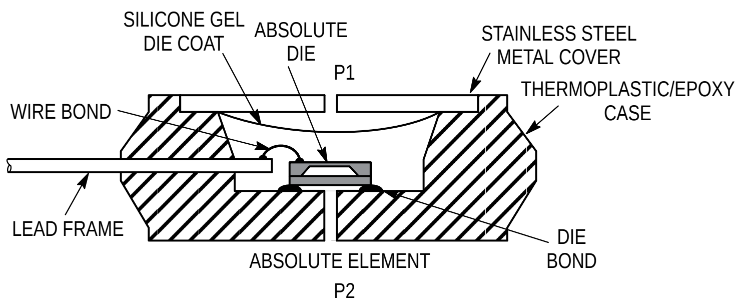


Figure 6

DEFINITIONS

Chip (Die): Silicon

Die Coating: Silicone based, clear or white gel. The purpose of the gel is to protect the metal and wire bonds on the die from particulates.

Wire Bonds: Gold

Leadframe: Copper with gold plating

Case: 4–pin standard packages are thermoplastic, 30% glass reinforced, flame retarded, polyester resin called Valox, grade 420–SEO or epoxy. The 6–pin standard packages are epoxy.

Die Bond: White, paste–like, one–part RTV silicone rubber

Cap: Stainless steel cover

W HAT SETS MOTOROLA'S SENSEON SENSORS APART FROM THE COMPETITION?

TECHNOLOGY

Technology! First and foremost, Motorola's unique and patented technology regarding the pressure sensor element is called the X–ducer™. Most (if not all) other manufacturers of solid state sensors employ a *wheatstone bridge* (see Figure 7 on the next page) resistor element to convert the pressure signal to a linear voltage output. The wheatstone bridge consists of four resistive elements that must be precisely matched and positioned around the diaphragm for optimal performance. This process can result in uncertain yields and is expensive to manufacture. To the customer, these disadvantages can be manifested in an unreliable supply, variable device–to–device performance and higher cost.

Motorola's X–ducer™ simplifies this process by using a single resistive element. This process is highly manufacturable and repeatable, resulting in higher reliability and yields that translate to higher quality and lower cost.

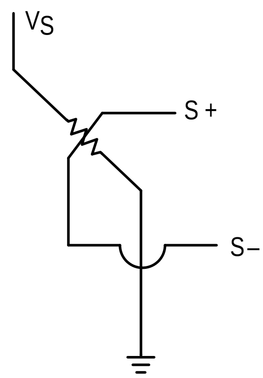
Motorola's pressure sensor integrates the calibration and temperature compensation functions on–chip, not on a separate substrate, utilizing state–of–the–art thin film processing and interactive laser trimming to provide reliability unmatched in a hybrid device.

DISTRIBUTION

Distribution! All the other major semiconductor sensor manufacturers rely on manufacturers reps. Motorola takes full advantage of our top–rate direct sales force and our quality distributor network to make fast turns.

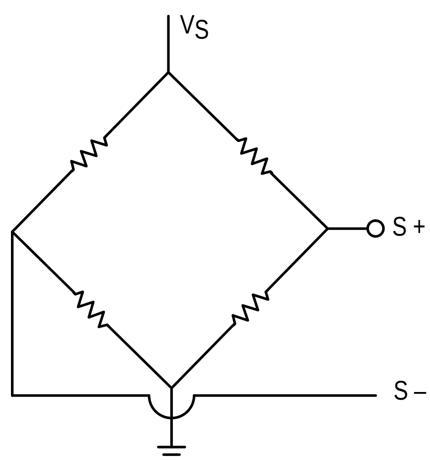
X–ducer™ versus WHEATSTONE BRIDGE

MOTOROLA X–ducer™ SENSOR



- SINGLE ELEMENT — NO MATCHING REQUIRED
- IMPROVED LINEARITY & HYSTERESIS
- EASIER TO COMPENSATE
- STATE OF THE ART
- PATENTED TECHNOLOGY

WHEATSTONE BRIDGE SENSOR



- HAS 4 MATCHED RESISTORS
- PERFORMANCE KEYED TO RESISTOR MATCHING
- COMPLEX COMPENSATION SCHEMES
- OLD TECHNOLOGY
- MANY SOURCES

Figure 7. X–ducer™ vs WHEATSTONE BRIDGE

SOME ADVANTAGES AND DISADVANTAGES OF DIFFERENT LEVELS OF INTEGRATION

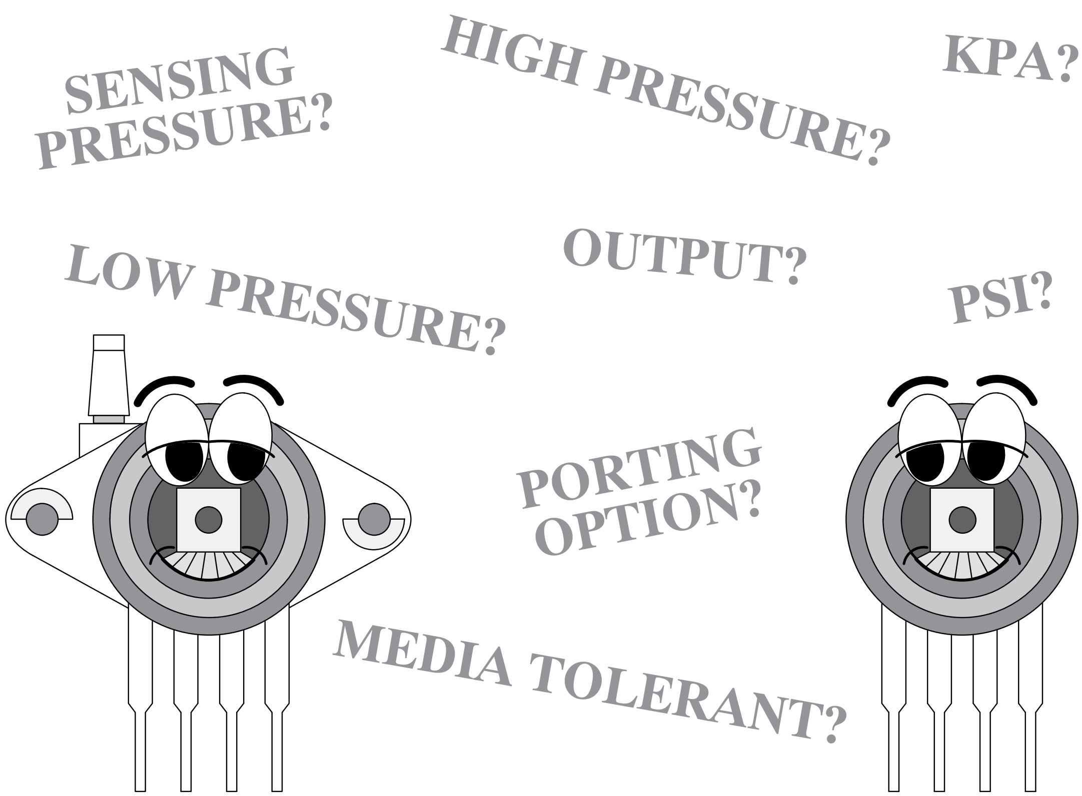
	ADVANTAGES	DISADVANTAGES
UNCOMPENSATED (BARE ELEMENT) SENSORS	Higher Sensitivity than Compensated Devices	Significant Device–to–Device Variation in Offset and Span
	Lowest Device Cost	Significant Large Temperature Drift in Offset and Span
	Low–Level Output Allows Flexibility of Signal Conditioning	Usually Requires Additional Signal Conditioning Interface
		Relatively Low Input Impedance (400 Ω Typical)
TEMPERATURE COMPENSATED & CALIBRATED (MPX2000 SERIES)	Reduced Device–to–Device Variations in Offset and Span	Lower Sensitivity Due to Span and Compensation
	Reduced Temperature Drift in Offset and Span	Higher Cost Compared with Uncompensated Device
	Reasonable Input Impedance (2K Ω Typical)	Usually Requires Signal Conditioning to Allow Interfacing
	Low Level Output Allows Flexibility in Signal Conditioning	
INTEGRATED PRESSURE SENSORS (MPX4000 and MPX5000 SERIES)	Highest Level of Functionality On–chip	Highest Cost Compared with Compensated / Uncompensated Device
	Signal Conditioning, Calibration of Span and Offset, Temperature Compensation	Integrated Signal Conditioning Interface Creates Fixed Transfer Function
COMPENSATED & CALIBRATED HIGH IMPEDANCE (MPX7000 SERIES)	High Input Impedance	Lower Sensitivity Due to Span Compensation
	Reduced Device–to–Device Variations in Offset and Span	Higher Cost Compared with Uncompensated Device
	Reduced Temperature Drift in Offset and Span	Usually Requires Signal Conditioning to Allow Interfacing
	Low Level Output Allows Flexibility in Signal Conditioning	

WHAT QUESTIONS DO I ASK?

There are just a few questions you need to ask a customer in order to specify just the right pressure sensor or sensor–based system solution to do the job. They are:

- Is pressure being sensed with your product?
- What is the pressure range?
- What are the electrical requirements: output signal, power supply, etc.
- What is the operating temperature range?
- What type of media will the sensor come in contact with? (i.e., air, water, gas, saline, etc.)
- What kind of package do they need? Any porting requirements? (see Figure 8 on page 16)

Answers received from these few questions will point you in the right direction. If you need assistance, don’t hesitate to call your friendly sensor marketers!



WHAT IS THE DEVICE NUMBERING SYSTEM FOR MOTOROLA PRESSURE SENSORS?

MPX Y # # ### ZZZZ

Motorola Pressure X–Ducer (MPX)

MEDIA TOLERANT

9

MAXIMUM RATED PRESSURE (kPa)

PACKAGE SELECTION

–	Unibody
B	Backside Piston Fit
D	Dual Piston Fit
S	Surface Mount
T	Top Piston Fit

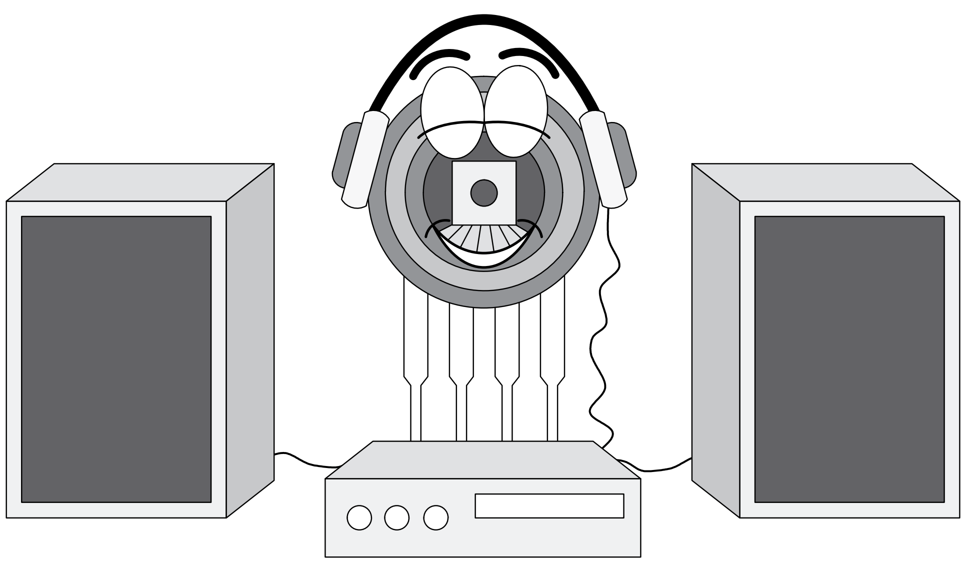
FAMILY

–	Basic Element
2	Temp Comp & Cal
4,5	Signal Conditioned
7	High Impedance

MEASUREMENT TYPE/PORTING OPTION

A	Absolute Element
AP	Absolute Ported
AS	Absolute Stovepipe Ported
D	Differential and Gauge Element
DP	Differential Dual Ported
GP	Gauge Ported
GVP	Gauge Vacuum Ported
GS	Gauge Stovepipe Ported
GVS	Gauge Vacuum Stovepipe
GSX	Gauge Vacuum Ported, Axial
GVSX	Gauge Vacuum Stove Ported, Axial
GVW	Gauge Vacuum, Water Tolerant

Note: Actual device marking may be abbreviated due to space constraints but packaging label will reflect full part number.



PRESSURE SENSOR PRODUCTS!

Table 1. Uncompensated

Device Series	Max Pressure Rating		Over Pressure (kPa)	Offset mV (Typ)	Full Scale Span mV (Typ)	Sensitivity (mV/kPa)	Linearity % of FSS(1) (Min) (Max)	
	psi	kPa						
MPX10D	1.45	10	75	20	35	3.5	–1.0	1.0
MPX50D	7.3	50	200	20	60	1.2	–0.25	0.25
MPX100D,A	14.5	100	200	20	60	0.6	–0.25	0.25
MPX200D,A	29	200	400	20	60	0.3	–0.25	0.25
MPX700A	100	700	2800	20	60	0.086	– 1.0	1.0
MPX700D	100	700	2800	20	60	0.086	–0.50	0.50
MPX906D	**0.87**	**6**	**100**	**20**	**20**	**3.3**	**–0.50**	**2.0**

Table 2. Compensated and Calibrated (On–Chip)

MPX2010D	1.45	10	75	±1.0	25	2.5	–1.0	1.0
MPX2050D	7.3	50	200	±1.0	40	0.8	–0.25	0.25
MPX2052D	7.3	50	200	±0.1	40	0.8	–0.55	0.25
MPX2100A	14.5	100	400	±2.0	40	0.4	–1.0	1.0
MPX2100D	14.5	100	400	±1.0	40	0.4	–0.25	0.25
MPX2200A	29	200	400	±1.0	40	0.2	–1.0	1.0
MPX2200D	29	200	400	±1.0	40	0.2	–0.25	0.25
MPX2700D	100	700	2800	±1.0	40	0.057	–0.5	0.5

Table 3. High Impedance (On–Chip)

MPX7050D	7.3	50	200	±1.0	40	0.8	–0.25	0.25
MPX7100A	14.5	100	400	±2.0	40	0.4	–1.0	1.0
MPX7100D	14.5	100	400	±1.0	40	0.4	–0.25	0.25
MPX7200A	29	200	400	±2.0	40	0.2	–1.0	1.0
MPX7200D	29	200	400	±1.0	40	0.2	–0.25	0.25

Table 4. Compensated and Calibrated (On–Chip) Medical Grade

Device Series	Max Pressure Rating		Supply Voltage (Vdc)	Offset mV (Max)	Sensitivity (µV/V/mmHg)	Output Impedance Ohms (Max)	Linearity % of FSS(1) (Min) (Max)	
	psi	kPa						
MPX2300DT1	5.8	40	6.0	0.75	5.0	330	–2.0	2.0

(1)Based on end point straight line fit method. Best fit straight line linearity error is approximately 1/2 of listed value.

Table 5. Signal Conditioned (On–Chip)

Device Series	Max Pressure Rating		Over Pressure (kPa)	Full Scale Span V (Typ)	Sensitivity (mV/kPa)	Accuracy (0–85°C) % of V_{FSS}
	psi	kPa				
MPX4100A	15.2	105	400	4.59	54	±1.8
MPX4101A	14.7	102	400	4.59	54	±1.8
MPX4115A	16.6	115	400	4.59	45.9	±1.5
MPX4250A	36.2	250	400	4.69	20	±1.5
MPX5010D	1.45	10	75	4.5	450	±5.0
MPX5050D	7.3	50	200	4.5	90	±2.5
MPX5100A	16.6	115	400	4.5	45	±2.5
MPX5100D	14.5	100	400	4.5	45	±2.5
MPX5500D	72.5	500	2000	4.5	9.0	±2.5
MPX5700D	100	700	2800	4.5	6.0	±2.5
MPX5999D	150	1000	4000	4.7	5.0	±2.5

WHAT ARE THE PRESSURE PACKAGING OPTIONS?

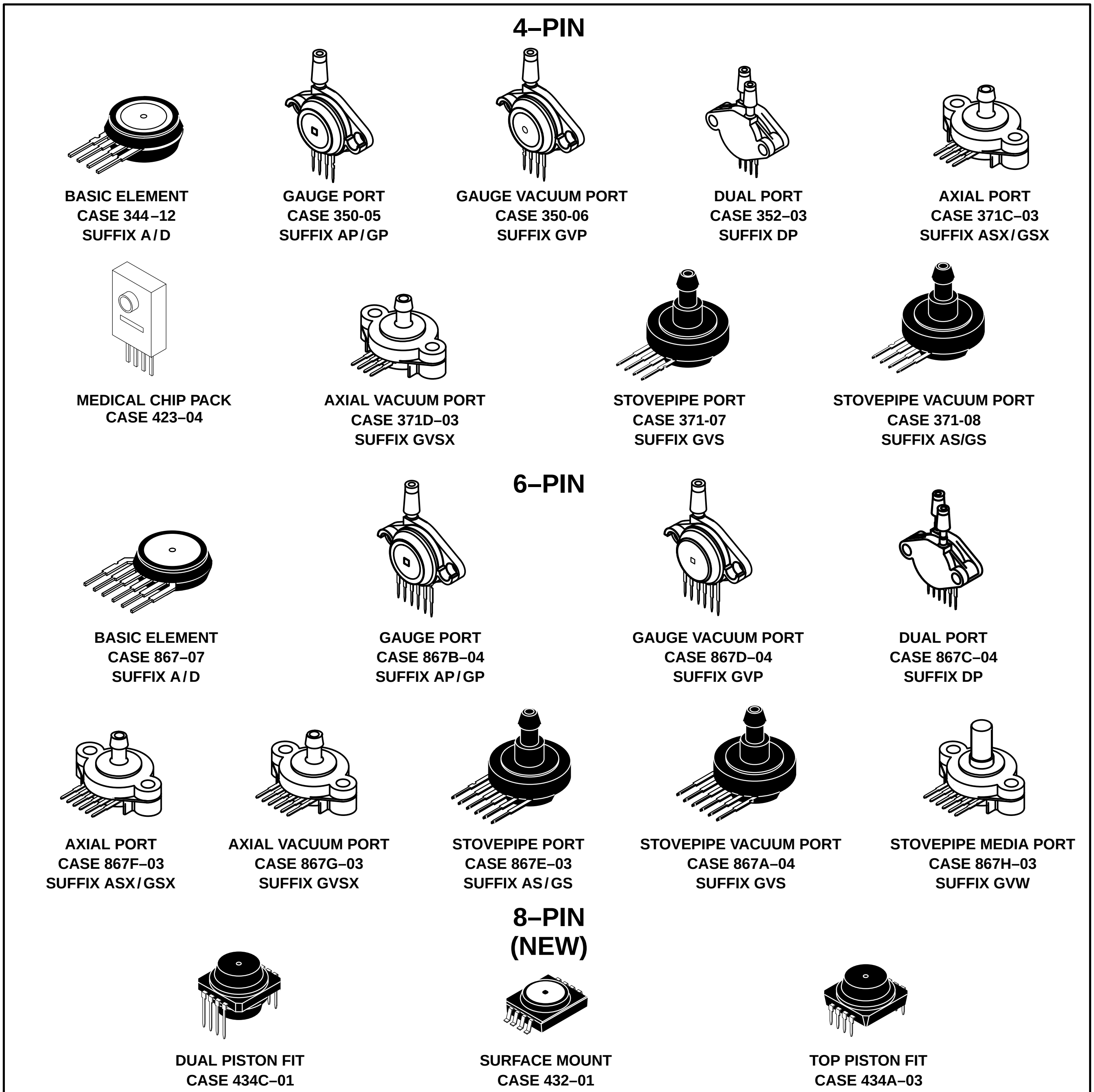


Figure 8

Measurement Configuration	Suffix	Description
Absolute	A	Case 344–03 Basic chip carrier
	AP	Case 350–01 Standard port on pressure side
	AS	Case 371–03 Axial port on pressure side
Differential	D	Case 344–03 Basic chip carrier
	DP	Case 352–02 Standard port both sides
Gauge	GP	Case 350–01 Standard port on pressure side
	GVP	Case 350–02 Standard port on vacuum side
	GS	Case 371–03 Axial port on pressure side
	GVS	Case 371–01 Axial port on vacuum side
	GVW	

* Packages not to scale.

WHO IS THE COMPETITION?

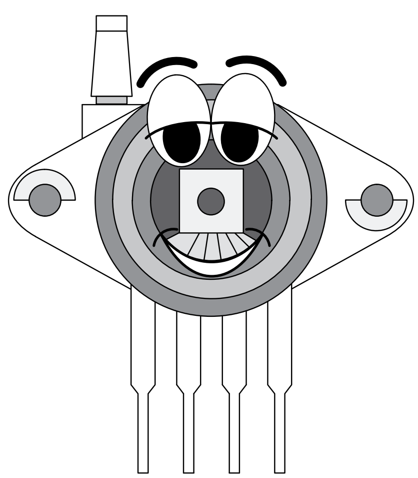
The competition for pressure sensors is ***not*** the normal competition for products like TO–92s, SOTs or even microprocessors. They are companies like Microswitch, which is a division of Honeywell, I.C. Sensors, Sensym, Lucas Novasensor, and a new kid on the block, Data Instruments which just bought out Next Sensors. Listed below are their basic strengths and weaknesses.

These are just some of the companies with a concentration in the United States. There are others such as Fujikura.

	STRENGTHS	**WEAKNESSES**
HONEYWELL– MICROSWITCH	Reliable Good Product Range Applications Support	Poor Delivery Noisy
I.C. SENSORS*	Quick Turn–around (Custom)	Low Volume Narrow Product Range*
SENSYM	Compensated Product Price Aggressive	Old Technology Drift & Delivery Problems Poor Quality Image
NOVASENSOR	Strong Technology Base Custom Product Ability	Narrow Product Range Poor Manufacturing Capability
DATA INSTRUMENTS**	Price Aggressive	

*Recent alliance with FUJIKURA could improve product portfolio.

**Recently bought Next Sensors.



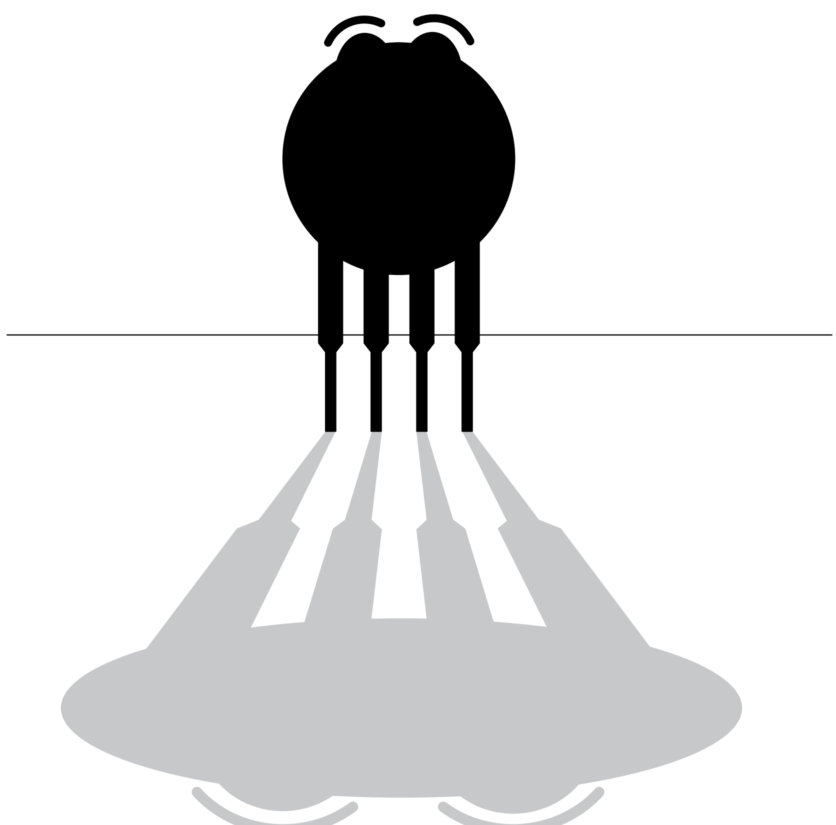
WHAT'S IN IT FOR ME?

How about fewer customer–related headaches because leadtimes for most standard products are 4 weeks or less and on–time deliveries are approaching 100%!

And what about the fact that you can get literature requests fulfilled typically on the same day!

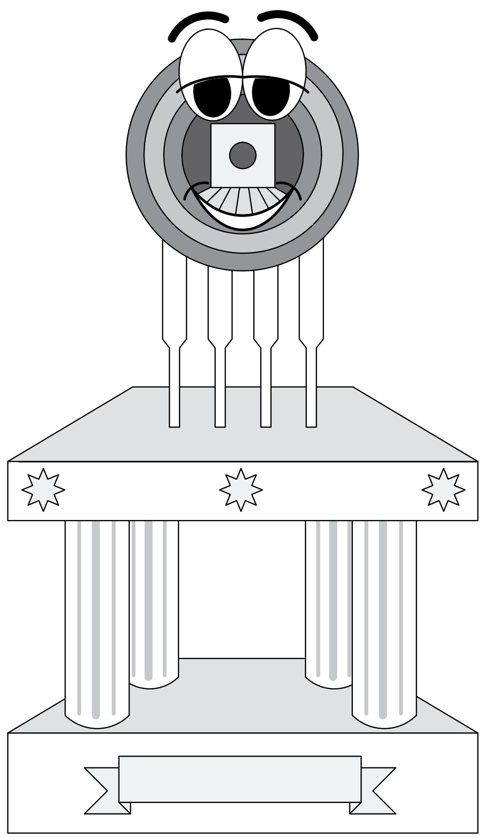
A friendly and expert engineering and applications staff is just a phone call away! Call the Marketing Group direct at (602) 244–4556.

Also, catch us on the external Web: http://design–net.com/senseon/senseon.html for detailed product information, application support and a few surprises!



SO… WHERE ARE SENSORS USED AND WHO USES THEM?

The next few pages review just a few of the applications in which SENSEON pressure sensors are used. Existing and new applications evolve every day as our customers realize that they can convert their expensive mechanical pressure sensors over to Motorola’s lower–cost semiconductor–based sensors. Remember, many of your *microprocessor* customers may be measuring some external phenomena such as pressure or flow or force. We may not be able to satisfy all their sensing needs immediately, but future products on the Motorola sensor calendar may meet their needs.



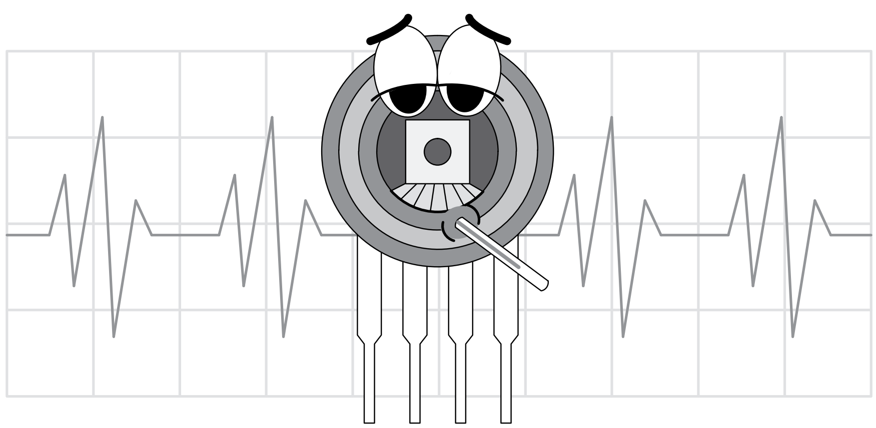
NEW APPLICATIONS AND NEW OPPORTUNITIES WORK TOGETHER TO SENSE THE POSSIBILITIES!

MEDICAL / BIOMEDICAL APPLICATIONS

WHERE DO I LOOK FOR PRESSURE SENSOR BUSINESS?

MEDICAL / BIOMEDICAL APPLICATIONS

BLOOD PRESSURE
ESOPHAGUS PRESSURE
HEART MONITOR
INTEROCCULAR PRESSURE
SALINE PUMPS
KIDNEY DIALYSIS
BLOOD GAS ANALYSIS
BLOOD SERUM ANALYSIS
SEATING PRESSURE (PARAPLEGIC)
RESPIRATORY CONTROL
INTRAVENOUS INFUSION PUMP CONTROL
HOSPITAL BEDS

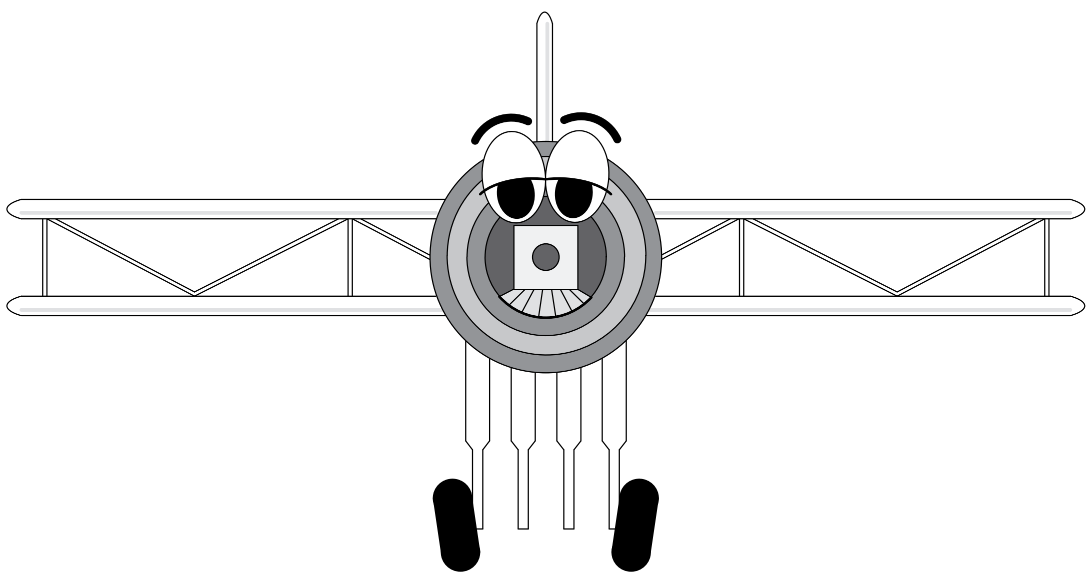


SENSOR APPLICATIONS

AUTOMOTIVE / AVIATION APPLICATIONS

AUTOMOTIVE / AVIATION APPLICATIONS

FUEL LEVEL INDICATOR
ALTIMETERS (for backpackers also)
AIR SPEED INDICATOR
EJECTION SEAT CONTROL
TURBO BOOST CONTROL
MANIFOLD VACUUM CONTROL
FUEL FLOW METERING
OIL FILTER FLOW INDICATOR
OIL PRESSURE SENSOR
AIR FLOW INDICATORS
ANTI–START
BREATHALIZER SYSTEMS
SMART SUSPENSION SYSTEMS
VARIOMETER–HANGGLIDER & SAILPLANES
AUTOMOTIVE SPEED CONTROL

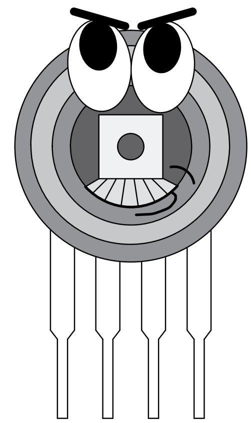


INDUSTRIAL / COMMERCIAL APPLICATIONS

SENSOR APPLICATIONS

INDUSTRIAL / COMMERCIAL APPLICATIONS

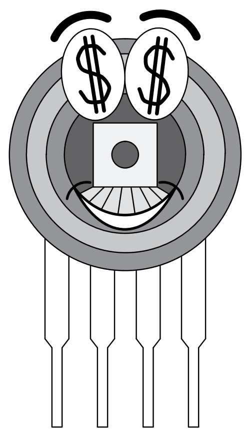
ELECTRONIC FIRE FIGHTING CONTROL
FLOW CONTROL
BAROMETER
WEATHER STATIONS (WIND SPEED, BAROMETRIC PRESSURE)
COW MILKER
SHIFT POINT INDICATORS
HVAC SYSTEMS
BUILDING AIR FLOW CONTROL
ELECTRONIC TIRE PRESSURE GAUGE
WATER FILTERED SYSTEMS (FLOW RATE INDICATOR)
AIR FILTERED SYSTEMS (FLOW RATE INDICATOR)
TACTILE SENSING FOR ROBOTIC SYSTEMS
BOILER PRESSURE INDICATORS
END OF TAPE READERS
AUTOMATIC PARTS COUNTER
DISC DRIVE CONTROL/PROTECTION SYSTEMS
OCEAN WAVE MEASUREMENT
DIVING REGULATORS
OIL WELL LOGGING
BUILDING AUTOMATION (BALANCING, LOAD CONTROL, WINDOWS)
FLUID DISPENSERS
EXPLOSION SENSING — SHOCK WAVE MONITORS
LOAD CELLS
AUTOCLAVE RELEASE CONTROL
SOIL COMPACTION MONITOR — CONSTRUCTION
WIND TUNNEL PRESSURE MEASUREMENT
WATER DEPTH FINDERS (INDUSTRIAL, SPORT FISHING/DIVING)
PNEUMATIC CONTROLS — ROBOTICS
PINCH ROLLER PRESSURE — PAPER FEED
BLOWER FAILURE SAFETY SWITCH — COMPUTER
VACUUM CLEANER CONTROL
ELECTRONIC DRUM
PRESSURE CONTROL SYSTEMS — BUILDING, DOMES
ENGINE DYNAMOMETER



BOTTOM LINE…

HOW ABOUT ASP's THAT RANGE ANYWHERE FROM $3 TO $30 FOR MODERATE QUANTITIES?

Motorola's Sensor Products Division provides diverse semiconductor–based sensor portfolio. Combined with outstanding factory support, price aggressiveness and superb quality, you have a powerful advantage in the fight to gain those lucrative existing and new design–in opportunities!



CLASSIFYING A POTENTIAL SENSOR CUSTOMER

Pressure Range

Temperature Range

Media

Electrical Requirements

— Power Supply

— Output Requirements

Package/Port Requirements

SENSOR STRATEGIES

Introduce New Products that build on our distinctive competencies and maintain our technological leadership position in the industry.

Identify and pursue "Value Added" opportunities. Provide Sensing Solutions, not just a component for a socket.

Identify and pursue opportunities for Customer Specific element and package development.

Increase market share, broaden and diversify our customer base.

SENSORS SUPPORTS SALES

RESPONSIVENESS

Additional marketing resources — Have Sensors Experts, Will Travel

Same day shipment of Literature & Samples

TRAINING AND TECHNICAL AIDS

Demo Kits & Evaluation Boards

New Applications Literature/Design Manual–Data Book

Sensor Specific TSE Training Sessions

Sensor Dedicated Factory Applications Engineering Support

SALES AIDS

Sensor Device Cross–Reference

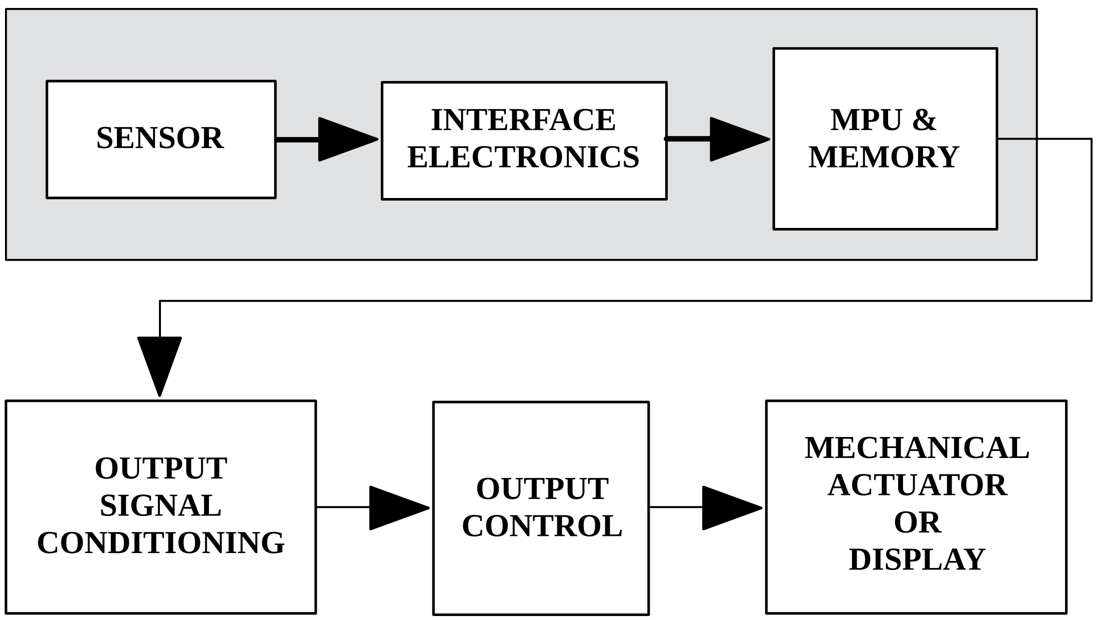
Sample Kits for all new products includes: Sample, Rel Data, Data Sheet Applications Information and a Customer Reply Card

Sample Cases

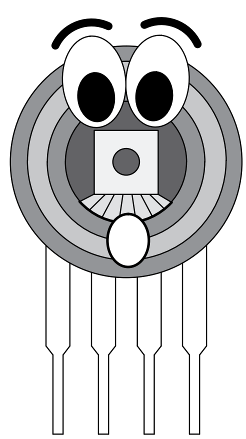
WHAT IS A SENSOR SYSTEM?

One of the fastest growing applications for sensors is integrating SENSEON pressure sensors into dynamic system environments. A simplified example of a sensor system looks like this:

SIMPLIFIED ELECTRONIC CONTROL SYSTEM



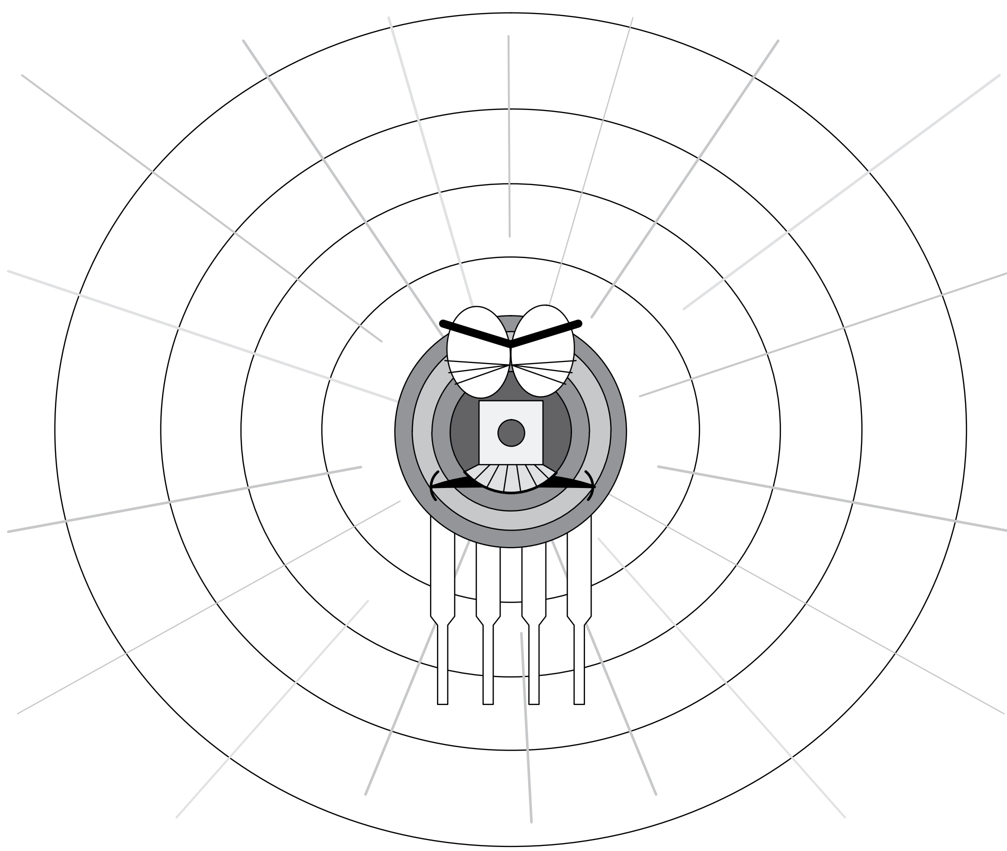
LET MOTOROLA TEAM WITH YOU
TO MEET YOUR CUSTOMER'S SENSING NEEDS!



W HAT SENSORS NEED FROM SALES!

BRING US THE OPPORTUNITY!!!

- Capability to support high–volume opportunities
- Currently ship millions into biomedical, automotive and automotive aftermarket programs
- Willing to support "NICHE" opportunities
- Successful in implementing Value Added Sensing Solutions for mid–range volume users



WHAT'S NEW?

HERE ARE SOME OF THE NEW PRESSURE ACCELER–ATION AND CHEMICAL SENSOR PRODUCTS FROM MOTOROLA

THE MPXS4100A SERIES: Surface Mount, Manifold Absolute Pressure (MAP) and Barometric Absolute Pressure (BAP) Sensor Series. These are fully signal conditioned with an output of typically 4.0 Volts and they have a pressure range of 20 to 105 kPa.

MPXS4115A: 15 to 115 kPa Signal Conditioned

ACCELERATION SENSORS

MMAS40G10D: Our 40 G accelerometers are available today and are being designed into front and side air bag systems in Europe, North America, Asia and Japan. Advantages of our semiconductor–based accelerometers include:

Calibrated Output
No Resistor Networks Are Required to Establish Output Levels
Output Is Ratiometric for Improved Accuracy
Factory Calibrated Self–Test
G–Cell Is Capped at the Factory Level
Integral Low Bypass Filter with No External Components Required
Low Cost, 16–pin DIP Plastic Package
Easy Board Implementation
Other Package Options Are Available

WHAT'S COMING?

PRESSURE SENSORS

MPX5006: Media Tolerant, Low Pressure Sensor Ideal for White Goods Applications.

MPX92200 (0 to 200 kPa) and MPX92700 (0 to 700 kPa): High Pressure On–Chip Temperature Compensated and Calibrated Pressure Sensors.

CHEMICAL SENSORS

MGS1000: Will be officially introduced late 1996. This Carbon Monoxide sensor replaces mechanical technology with state–of–the–art semiconductor–based technology. Applications include:

Combustible Gas Detection
Fire Detection
Environmental Monitoring in the Home, at the Office or at the Factory

GLOSSARY OF TERMS

ABSOLUTE PRESSURE SENSOR	A sensor that measures input pressure in relation to a zero pressure (a total vacuum on one side of the diaphragm) reference.
ANALOG OUTPUT	An electrical output from a sensor that changes proportionately with any change in input pressure.
ACCURACY — also see PRESSURE ERROR	A comparison of the actual output signal of a device to the true value of the input pressure. The various errors (such as linearity, hysteresis, repeatability and temperature shift) attributing to the accuracy of a device are usually expressed as a percent of full–scale output (FSO).
ALTIMETRIC PRESSURE TRANSDUCER	A barometric pressure transducer used to determine altitude from the pressure-altitude profile.
BAROMETRIC PRESSURE TRANSDUCER	An absolute pressure sensor that measures the local ambient atmospheric pressure.
BURST PRESSURE	The maximum pressure that can be applied to a transducer without rupture of either the sensing element or transducer case.
CALIBRATION	A process of modifying sensor output to improve output accuracy.
CHIP	A die (unpackaged semiconductor device) cut from a silicon wafer, incorporating semiconductor circuit elements such as resistors, diodes, transistors, and/or capacitors.
COMPENSATION	Added circuitry or materials designed to counteract known sources of error.
DIAPHRAGM	The membrane of material that remains after etching a cavity into the silicon sensing chip. Changes in input pressure cause the diaphragm to deflect.
DIFFERENTIAL PRESSURE SENSOR	A sensor that is designed to accept simultaneously two independent pressure sources. The output is proportional to the pressure difference between the two sources.
DIFFUSION	A thermochemical process whereby controlled impurities are introduced into the silicon to define the piezoresistor. Compared to ion implantation, it has two major disadvantages: 1) the maximum impurity concentration occurs at the surface of the silicon rendering it subject to surface contamination and making it nearly impossible to produce buried piezoresistors; 2) control over impurity concentrations and levels is about one thousand times poorer than obtained with ion implantation.
DRIFT	An undesired change in output over a period of time, with constant input pressure applied.
END POINT STRAIGHT LINE FIT	Motorola's method of defining linearity. The maximum deviation of any data point on a sensor output curve from a straight line drawn between the end data points on that output curve.
ERROR	The algebraic difference between the indicated value and the true value of the input pressure. Usually expressed in percent of full–scale span, sometimes expressed in percent of the sensor output reading.
ERROR BAND	The band of maximum deviations of the output values from a specified reference line or curve due to those causes attributable to the sensor. Usually expressed as "± % of full–scale output." The error band should be specified as applicable over at least two calibration cycles, so as to include repeatability, and verified accordingly.
EXCITATION VOLTAGE (Current) — also see SUPPLY VOLTAGE (Current)	The external electrical voltage and/or current applied to a sensor for its proper operation (often referred to as the supply circuit or voltage). Motorola specifies constant voltage operation only.
FULL–SCALE OUTPUT	The output at full–scale pressure at a specified supply voltage. This signal is the sum of the offset signal plus the full–scale span.
FULL–SCALE SPAN	The change in output over the operating pressure range at a specified supply voltage. The SPAN of a device is the output voltage variation given between zero differential pressure and any given pressure. FULL–SCALE SPAN is the output variation between zero differential pressure and when the maximum recommended operating pressure is applied.

GLOSSARY OF TERMS (continued)

HYSTERESIS — also see PRESSURE HYSTERESIS and TEMPERATURE HYSTERESIS
HYSTERESIS refers to a transducer's ability to reproduce the same output for the same input, regardless of whether the input is increasing or decreasing. PRESSURE HYSTERESIS is measured at a constant temperature while TEMPERATURE HYSTERESIS is measured at a constant pressure in the operating pressure range.

INPUT IMPEDANCE (RESISTANCE)
The impedance (resistance) measured between the positive and negative (ground) input terminals at a specified frequency with the output terminals open. For Motorola X-ducer™, this is a resistance measurement only.

ION IMPLANTATION
A process whereby impurity ions are accelerated to a specific energy level and impinged upon the silicon wafer. The energy level determines the depth to which the impurity ions penetrate the silicon. Impingement time determines the impurity concentration. Thus, it is possible to independently control these parameters, and buried piezoresistors are easily produced. Ion implantation is increasingly used throughout the semiconductor industry to provide a variety of products with improved performance over those produced by diffusion.

LASER TRIMMING (AUTOMATED)
A method for adjusting the value of thin film resistors using a computer-controlled laser system.

LEAKAGE RATE
The rate at which a fluid is permitted or determined to leak through a seal. The type of fluid, the differential pressure across the seal, the direction of leakage, and the location of the seal must be specified.

LINEARITY ERROR
The maximum deviation of the output from a straight–line relationship with pressure over the operating pressure range, the type of straight–line relationship (end point, least square approximation, etc.) should be specified.

LOAD IMPEDANCE
The impedance presented to the output terminals of a sensor by the associated external circuitry.

NULL
The condition when the pressure on each side of the sensing diaphragm is equal.

NULL OFFSET
The electrical output present, when the pressure sensor is at null.

NULL TEMPERATURE SHIFT
The change in null output value due to a change in temperature.

NULL OUTPUT
See ZERO PRESSURE OFFSET

OFFSET
See ZERO PRESSURE OFFSET

OPERATING PRESSURE RANGE
The range of pressures between minimum and maximum pressures at which the output will meet the specified operating characteristics.

OPERATING TEMPERATURE RANGE
The range of temperature between minimum and maximum temperature at which the output will meet the specified operating characteristics.

OUTPUT IMPEDANCE
The impedance measured between the positive and negative (ground) output terminals at a specified frequency with the input open.

OVERPRESSURE
The maximum specified pressure which may be applied to the sensing element of a sensor without causing a permanent change in the output characteristics.

PIEZORESISTANCE
A resistive element that changes resistance relative to the applied stress it experiences (e.g., strain gauge).

PRESSURE ERROR
The maximum difference between the true pressure and the pressure inferred from the output for any pressure in the operating pressure range.

PRESSURE HYSTERESIS
The difference in the output at any given pressure in the operating pressure range when this pressure is approached from the minimum operating pressure and when approached from the maximum operating pressure at room temperature.

GLOSSARY OF TERMS (continued)

PRESSURE RANGE — also see OPERATING PRESSURE RANGE The pressure limits over which the pressure sensor is calibrated or specified.

PRESSURE SENSOR A device that converts an input pressure into an electrical output.

PROOF PRESSURE See OVERPRESSURE

RATIOMETRIC Ratiometricity refers to the ability of the transducer to maintain a constant sensitivity, at a constant pressure, over a range of supply voltage values.

RATIOMETRIC (RATIOMETRICITY ERROR) At a given supply voltage, sensor output is a proportion of that supply voltage. Ratiometricity error is the change in this proportion resulting from any change to the supply voltage. Usually expressed as a percent of full–scale output.

RANGE See OPERATING PRESSURE RANGE

REPEATABILITY The maximum change in output under fixed operating conditions over a specified period of time.

RESOLUTION The maximum change in pressure required to give a specified change in the output.

RESPONSE TIME The time required for the incremental change in the output to go from 10% to 90% of its final value when subjected to a specified step change in pressure.

ROOM CONDITIONS Ambient environmental conditions under which sensors most commonly operate.

SENSING ELEMENT That part of a sensor which responds directly to changes in input pressure.

SENSITIVITY The change in output per unit change in pressure for a specified supply voltage or current.

SENSITIVITY SHIFT A change in sensitivity resulting from an environmental change such as temperature.

STABILITY The maximum difference in the output at any pressure in the operating pressure range when this pressure is applied consecutively under the same conditions and from the same direction.

STORAGE TEMPERATURE RANGE The range of temperature between minimum and maximum that can be applied without causing the sensor to fail to meet the specified operating characteristics.

STRAIN GAUGE A sensing device providing a change in electrical resistance proportional to the level of applied stress.

SUPPLY VOLTAGE (CURRENT) The voltage (current) applied to the positive and negative (ground) input terminals.

TEMPERATURE COEFFICIENT of FULL–SCALE SPAN The percent change in full–scale span per unit change in temperature relative to the full–scale span at a specified temperature.

TEMPERATURE COEFFICIENT of RESISTANCE The percent change in the DC input impedance per unit change in temperature relative to the DC input impedance at a specified temperature.

TEMPERATURE ERROR The maximum change in output at any pressure in the operating pressure range when the temperature is changed over a specified temperature range.

TEMPERATURE HYSTERESIS The difference in output at any temperature in the operating temperature range when the temperature is approached from the minimum operating temperature and when approached from the maximum operating temperature with zero pressure applied.

THERMAL OFFSET SHIFT See TEMPERATURE COEFFICIENT OF OFFSET

THERMAL SPAN SHIFT See TEMPERATURE COEFFICIENT OF FULL–SCALE SPAN

THERMAL ZERO SHIFT See TEMPERATURE COEFFICIENT OF OFFSET

THIN FILM A technology using vacuum deposition of conductors and dielectric materials onto a substrate (frequently silicon) to form an electrical circuit.

VACUUM A perfect vacuum is the absence of gaseous fluid.

ZERO PRESSURE OFFSET The output at zero pressure (absolute or differential, depending on the device type) for a specified supply voltage or current.

SYMBOLS, TERMS AND DEFINITIONS

The following are the most commonly used letter symbols, terms and definitions associated with solid state silicon pressure sensors.

P_{burst}	**Burst Pressure**	The maximum pressure that can be applied to a transducer without rupture of either the sensing element or transducer case.
I_{o}	**supply current**	The current drawn by the sensor from the voltage source.
I_{o+}	**output source current**	The current sourcing capability of the pressure sensor.
kPa	**kilopascals**	Unit of pressure. 1 kPa = 0.145038 PSI.
—	**Linearity**	The maximum deviation of the output from a straight–line relationship with pressure over the operating pressure range, the type of straight–line relationship (end point, least square approximation, etc.) should be specified.
mm Hg	**millimeters of mercury**	Unit of pressure. 1 mmHg = 0.0193368 PSI.
P_{max}	**overpressure**	The maximum specified pressure that may be applied to the sensing element without causing a permanent change in the output characteristics.
P_{OP}	**operating pressure range**	The range of pressures between minimum and maximum temperature at which the output will meet the specified operating characteristics.
—	**Pressure Hysteresis**	The difference in the output at any given pressure in the operating pressure range when this pressure is approached from the minimum operating pressure and when approached from the maximum operating pressure at room temperature.
PSI	**pounds per square inch**	Unit of pressure. 1 PSI = 6.89473 kPa.
—	**Repeatability**	The maximum change in output under fixed operating conditions over a specified period of time.
R_{O}	**input resistance**	The resistance measured between the positive and negative input terminals at a specified frequency with the output terminals open.
T_{A}	**operating temperature**	The temperature range over which the device may safely operate.
TCR	**temperature coefficient of resistance**	The percent change in the DC input impedance per unit change in temperature relative to the DC input impedance at a specified temperature (typically +25°C).
TCV_{FSS}	**temperature coefficient of full–scale span**	The percent change in full–scale span per unit change in temperature relative to the full–scale span at a specified temperature (typically +25°C).
TCV_{off}	**temperature coefficient of offset**	The percent change in offset per unit change in temperature relative to the offset at a specified temperature (typically +25°C).
T_{stg}	**storage temperature**	The temperature range at which the device, without any power applied, may be stored.
t_{R}	**response time**	The time required for the incremental change in the output to go from 10% to 90% of its final value when subjected to a specified step change in pressure.
—	**Temperature Hysteresis**	The difference in output at any temperature in the operating temperature range when the temperature is approached from the minimum operating temperature and when approached from the maximum operating temperature with zero pressure applied.
V_{FSS}	**full–scale span voltage**	The change in output over the operating pressure range at a specified supply voltage.
V_{off}	**offset voltage**	The output with zero differential pressure applied for a specified supply voltage or current.
V_{S}	**supply voltage dc**	The dc excitation voltage applied to the sensor. For precise circuit operation, a regulated supply should be used.
$V_{S\ max}$	**maximum supply voltage**	The maximum supply voltage that may be applied to a circuit or connected to the sensor.
Z_{in}	**input impedance**	The resistance measured between the positive and negative input terminals at a specified frequency with the output terminals open. For Motorola X-ducer™, this is a resistance measurement only.
Z_{out}	**output impedance**	The resistance measured between the positive and negative output terminals at a specified frequency with the input terminals open.
$\Delta V/\Delta P$	**sensitivity**	The change in output per unit change in pressure for a specified supply voltage.

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