ELECTROTECNIA y ELECTRÓNICA (Mecánica y Electromecánica) – 2018

TRABAJO DE APLICACIÓN Nº 12

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TEMA 12: TRANSDUCTORES e INSTRUMENTACIÓN.

HOJAS DE DATOS

1- **Termorresistores de platino Pt100**
2- **Termocuplas**
3- **Transductor de presión**

TABLAS DE RESISTENCIA VS. TEMPERATURA PARA PT100

(Extractadas del manual *Transducer Interfacing Handbook – Analog Devices*)

PLATINUM RTD RESPONSE*

TABLE 1. RESISTANCE vs. TEMPERATURE

TEMP °C	RESISTANCE (ohms – or millivolts per milliampere of excitation)	INCREMENTAL RESISTANCE TEMPCO ΔΩ/Δ°C (100Ω@0°C)	RELATIVE RESISTANCE TEMPCO ΔΩ/Ω/Δ°C [%/°C]
-200	18.53	0.421	2.27
-150	39.65	0.416	1.05
-100	60.20	0.406	0.67
-50	80.25	0.396	0.49
0	100.00	0.391	0.39
+ 50	119.40	0.385	0.322
+100	138.50	0.379	0.274
+150	157.32	0.374	0.238
+200	175.84	0.368	0.209
+250	194.08	0.362	0.187
+300	212.03	0.356	0.168
+350	229.69	0.350	0.152
+400	247.06	0.344	0.139
+450	264.14	0.338	0.128
+500	280.93	0.332	0.118
+550	297.43	0.327	0.110
+600	313.65	0.322	0.103
+650	329.57	0.316	0.096
+700	345.21	0.310	0.090
+750	360.55	0.304	0.084
+800	375.61	0.298	0.079

TABLE 2. TEMPERATURE vs. RESISTANCE ($R_O = 100.0\Omega$)

RESISTANCE (ohms – or millivolts per milliampere of excitation)	TEMPERATURE °C
20	-197.55
40	-149.17
60	-100.49
80	- 50.63
100	0.00
120	+ 51.56
140	+103.98
160	+157.19
180	+211.33
200	+266.39
220	+322.46
240	+379.57
260	+437.79
280	+497.21
300	+557.85
320	+619.84
340	+683.26
360	+748.19

*Summarized from <u>The Omega 1979 Temperature Measurement Handbook</u>, Omega Engineering, Inc., Stamford Connecticut 06907

TABLAS DE TENSIÓN VS. TEMPERATURA PARA TERMOCUPLAS DE DISTINTOS TIPOS

(Extractadas del manual *Transducer Interfacing Handbook – Analog Devices*)

THERMOCOUPLE RESPONSES

TABLE 7-1. VOLTAGE AS A FUNCTION OF TEMPERATURE

	B		E		J		K		R		S		T		
Temperature °C	Output mV	Tempco μV/°C	Output mV	Tempco μV/°C	Output mV	Tempco μV/°C	Output mV	Tempco μV/°C	Output mV	Tempco μV/°C	Output mV	Tempco μV/°C	Output mV	Tempco μV/°C	Temperature °C
- 200	–	–	- 8.824	25.1	- 7.890	21.8	- 5.891	15.2	–		–		- 5.603	15.8	- 200
- 100	–	–	- 5.237	45.1	- 4.632	41.1	- 3.553	30.5	–		–		- 3.378	28.4	- 100
0	+ 0.000	–	0.000	58.7	0.000	50.4	0.000	39.5	0.000	5.25	0.000	5.4	0.000	38.8	0
+ 25	- 0.002	0.1	1.495	60.9	1.277	51.7	1.000	40.5	0.141	6.0	0.142	6.0	0.992	40.7	+ 25
+ 100	+ 0.033	0.9	6.317	67.5	5.268	54.4	4.095	41.4	0.647	7.5	0.645	7.3	4.277	46.8	+ 100
+ 200	+ 0.178	2.0	13.419	74.0	10.777	55.5	8.137	39.9	1.468	8.85	1.440	8.45	9.286	53.2	+ 200
+ 300	0.431	3.05	21.033	77.9	16.325	55.4	12.207	41.5	2.400	9.75	2.323	9.1	14.860	58.1	+ 300
+ 400	0.786	3.95	28.943	80.0	21.846	55.2	16.395	41.9	3.407	10.35	3.260	9.6	20.869	61.8	+ 400
+ 500	1.241	5.0	36.999	80.8	27.388	55.9	20.640	42.6	4.471	10.9	4.234	9.9	–		+ 500
+ 600	1.791	5.95	45.085	80.7	33.096	58.5	24.902	42.5	5.582	11.3	5.237	10.15	–		+ 600
+ 700	2.430	6.8	53.110	79.8	39.130	62.3	29.128	41.9	6.741	11.8	6.274	10.55	–		+ 700
+ 800	3.154	7.65	61.022	78.4	45.498	64.6	33.277	41.0	7.949	12.3	7.345	10.8	–		+ 800
+ 900	3.957	8.4	68.783	76.7	51.875	62.4	37.325	39.9	9.203	12.7	8.448	11.2	–		+ 900
+1000	4.833	9.1	76.358	75.0	57.942	59.2	41.269	38.9	10.503	13.2	9.585	11.5	–		+1000
+1100	5.777	9.75	–		63.777	57.8	45.108	37.8	11.846	13.6	10.754	11.9			+1100
+1200	6.783	10.35	–		69.536	57.2	48.828	36.5	13.224	13.9	11.947	12.0			+1200
+1300	7.845	10.9	–		–		52.398	34.9	14.624	14.0	13.155	12.2			+1300
+1400	8.952	11.2	–		–		–		16.035	14.1	14.368	12.2			+1400
+1500	10.094	11.6	–		–		–		17.445	14.1	15.576	12.1			+1500
+1600	11.257	11.7							18.842	13.9	16.771	11.8			+1600
+1700	12.426	11.7							20.215	13.5	17.942	11.5			+1700
+1800	13.585	11.5							–		–				+1800

TABLE 7-2. TEMPERATURE AS A FUNCTION OF VOLTAGE READING

	B		E		J		K		R		S		T		
mV	°C	°C/mV	°C	°C/mV	°C	°C/mV	°C	°C/mV	°C	°C/mV	°C	°C/mV	°C	°C/mV	mV
-10.000	–		–		–		–		–		–		–		-10.000
- 5.000	–		- 94.4	21.70	- 109.1	25.10	- 153.7	43.48	–		–		-166.5	49.5	- 5.000
- 2.000	–		- 35.3	18.40	- 40.8	21.10	- 53.1	28.13	–		–		- 55.1	30.0	- 2.000
- 1.000	–		- 17.3	17.60	- 20.1	20.40	- 25.9	26.49	–		–		- 26.6	27.6	- 1.000
0.000	+ 42.0	4°/μV	0.0	17.06	0.0	19.84	0.0	25.35	0.0	190.5	0.0	185.2	0.0	25.8	0.000
+ 1.000	449.6	220	16.8	16.64	19.6	19.25	+ 25.0	24.69	+ 145.0	122.7	+ 146.4	125.8	+ 25.2	24.6	+ 1.000
+ 2.000	634.2	160	33.2	16.21	38.9	19.08	+ 49.5	24.27	258.2	106.4	264.3	111.7	49.2	23.4	+ 2.000
+ 5.000	1018.2	109	80.3	15.19	95.1	18.43	+ 122.0	24.42	548.2	90.1	576.6	99.0	115.3	20.9	+ 5.000
+10.000	1491.8	87	153.0	14.02	186.0	18.03	246.3	24.60	961.7	76.6	1035.8	86.2	213.3	18.6	+10.000
+20.000	–		286.7	12.90	366.5	18.13	485.0	23.50	1684.1	73.5	–		385.9	16.3	+20.000
+30.000	–		413.2	12.47	546.3	17.57	720.8	23.95	–		–		–		+30.000
+40.000	–		537.1	12.36	713.9	15.94	967.5	25.48	–		–		–		+40.000
+50.000	–		661.1	12.47	870.2	15.79	1232.3	27.78	–		–		–		+50.000
+60.000	–		787.0	12.71	1035.0	16.95									+60.000
+70.000	–		915.9	13.09	–										+70.000

HOJAS DE DATOS DE UN SENSOR PIEZORRESISTIVO - TRANSDUCTOR DE PRESIÓN

HAWKER SIDDELEY SenSym SOLID STATE SENSORS

INTRODUCTION

This section of the handbook provides an overview of the technology (in layman's terms) and a brief description of the different types of sensor products available from SenSym. It is meant as a brief introduction to those of you unfamiliar with SenSym's technology and/or products.

Piezoresistive pressure sensors (strain gage sensors) are fabricated using silicon processing techniques common in the semiconductor industry. For this reason they have taken on some of the semiconductor terminology.

Piezoresistive sensors are often referred to as IC sensors (integrated circuit), solid state sensors, monolithic sensors (formed from single crystal silicon) or just silicon sensors. All SenSym sensors are piezoresistive silicon sensors. They are processed in wafer form, where each 4" wafer will contain a few hundred to a few thousand sensor die depending on the size of the sensor die (a typical sensor chip measures 80 x 80 mils or 2mm x 2mm). A standard run of 24 wafers can be processed at one time, producing, on average 24,000 sensor die per run.

Sensor Fabrication and Basic Characteristics

For most SenSym sensors, four strain sensitive resistors are ion implanted into silicon wafers using standard semiconductor photolithography techniques. These resistors are connected in a wheatstone bridge configuration whereby two resistors increase with positive pressure while the other two decrease in resistance (see Figure 1).

In simple mathematical terms the sensor can be modeled as follows:

When pressure is applied to the device (see Figure 1) the resistors in the arms of the bridge change by an amount, Δ. The alignment of the resistor on the silicon determines if the resistor will increase or decrease with applied pressure.

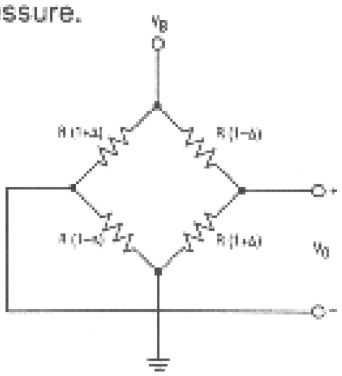


Figure 1.

The resulting differential output voltage Vo, is easily shown to be $Vo=V_B \times \Delta$. Since the change in resistance, is directly proportional to pressure, Vo can be written as:

$$Vo = (S \times P \times V_B) \pm V_{OS}$$

Where: Vo is the output voltage in mV.
S is the sensitivity in mV/V per psi
P is the pressure in psi
V_B is the bridge voltage in volts.
V_{os} if the offset error (the differential output voltage when the applied pressure is zero).

After processing of the top surface of the silicon wafer is completed to form the resistors and interconnections, a diaphragm is created by chemically etching the silicon from the back side. The diaphragm thickness determines the pressure range (sensitivity) of the sensor. This relationship is not a linear function; for example, doubling the thickness of the diaphragm decreases the sensitivity by a factor of four. Typical diaphragm thicknesses are 5 to 200 microns, depending on the pressure range (pretty thin stuff). As pressure is applied to the sensor the resistors are strained, causing an imbalance in the wheatstone bridge proportional to the applied pressure. The differential output of the raw sensor is, however, not precise in terms of calibration and temperature effects. For example, on a single wafer the range of sensitivity from die-to-die can be as high as 2:1. It is partially because of this that SenSym offers a variety of levels of signal conditioned sensors from the basic "raw" state up through fully calibrated and compensated transmitters.

Types of Pressure Measurements

ABSOLUTE - A SenSym absolute sensor refers to a chip that has a vacuum reference sealed in the cavity under the diaphragm. Any measurement that is referenced to a fixed reference pressure (generally a hard vacuum) is referred to as an absolute measurement. The more common absolute applications include:

* Altimeters
* Barometers
* Vacuum measurements

In some applications an absolute sensor may be used for convenience. Since the sensor has the reference pressure sealed inside the chip it only requires one pressure input. In applications such as depth measurements the sensor can be submerged in liquid without the need of a vent (reference pressure) tube to the surface.

GAGE - A SenSym gage sensor refers to a chip that has the reference cavity vented to atmosphere. Any measurement that is referenced to barometric pressure is called a gage measurement. The sensor will measure positive and negative pressures (pressures greater than and less than barometric pressure). Gage sensors are useful in equipment that may be taken from one altitude to another. The sensor automatically compensates for any change in barometric pressure (barometric pressure is the reference pressure). Hence, airplanes and automobiles can measure air speed and engine vacuum at sea level and at 10,000 feet with the same accuracy.

Typical gage pressure applications are:

* Blood pressure
* Engine vacuum
* Tire pressure

DIFFERENTIAL - A measurement where one pressure is measured relative to a second pressure will use a differential sensor. Since gage measurements are actually a special type of differential measurement the same basic sensor is used for both sensors. A second pressure port is added for the differential sensor.

Typical differential pressure applications are:

* Air flow
* Filter status

SENSOR SELECTION

This handbook is arranged in sections which specify basic sensors, compensated sensors and fully signal conditioned devices. The basic differences in the levels of signal conditioning are explained herein.

Basic Sensor Element

The basic sensor element is the simplest form of sensor available from SenSym. These products feature:

* Packaged sensor (plastic, ceramic or T0-5 can)
* Pressure tested
* No external temperature compensation
* No calibration
* Lowest cost

Basic sensor product families from SenSym include the SCC, SPX, SX series. The basic differences between these families are:

SCC Series – Offers limited span temperature compensation when excited with a constant current source. Small sensor chip offers lowest cost.

SPX Series – Offers a low impedance shear sensor element.

SX Series – General purpose, ultra stable, high impedance sensor. Larger chip allows higher signals at low pressure.

Temperature Compensated and Calibrated Sensor

These sensors are the most user friendly and require a minimum value-added by the user. The output in millivolts is extremely flexible and easily adapted to microprocessor based systems. The basic features are as follows:

* Basic sensor + laser trimmed compensation
* Temperature compensated
* Calibrated (offset and span adjusted)
* Moderate Cost

Sensors in this family include the SCX and SSX series. Features of each are:

SCX Series – Plastic housing. High performance/low cost.

SSX Series – Stainless steel isolated package for rugged applications.

High Level Output Devices

The high level output sensors take the basic approach of the TC sensors described previously and then add an amplifier to achieve a voltage output typically in the range of 1-6 V_{DC}. Features are:

* Temperature compensated
* Calibrated (offset and span adjusted)
* Amplified Voltage (1-6 V_{DC}) or Current (4-20 mA) Outputs

Sensors in this class of devices include the 142SC, ST2000, and the new SMRT digital output products. Features of each family are:

14SC – 1-6 V_{DC} high level output in a plastic package.

ST2000 – 1-6 V_{DC} and 4-20 mA outputs in a media isolated stainless steel package.

SMRT – High precision digital output in a standard plastic package.

As a general rule, the basic sensors and temperature compensated sensors can be used to measure positive as well as negative gage pressures and will measure pressures higher than the calibration pressure (until the diaphragm ruptures). The signal conditioned devices are limited to the specific pressure range and voltage swing for which they are calibrated.

CONCLUSION

This introduction was designed to give a brief overview of the products and technology available from SenSym. The individual product datasheets and application notes will give specific details about each of the products. Please call us if you have any questions or concerns. We have on-line application engineers waiting to serve you. We wish you luck with your sensor application and hope you find our Handbook useful.

SenSym

SX01, SX05
0 to 1psi and 0 to 5psi Pressure Sensors

FEATURES

- Accurate Low Pressure Readings
- Low Cost
- High Impedance Bridge
- Low Noise
- Low Power Consumption for Battery Operation

APPLICATIONS

- Medical Instrumentation
- Portable and Battery Powered Equipment
- Air Flow Monitoring
- HVAC
- Industrial Controls

GENERAL DESCRIPTION

The SX Series of pressure sensors provide the lowest cost components for measuring low pressures. These low pressure range devices were specifically designed to accurately measure differential, and gage, pressures of 0 to 1psi (SX01) and 0 to 5psi (SX05). They are meant for use with non-corrosive and non-ionic media, such as air, dry gases and the like.

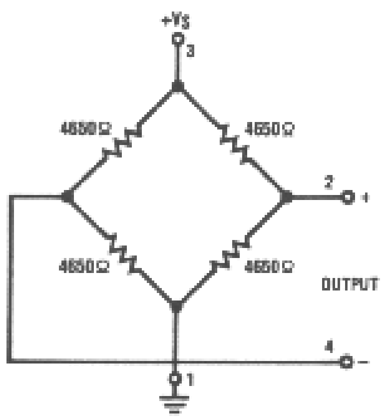
These differential devices allow application of pressure to either side of the diaphragm and can be used for gage or differential pressure measurements.

The SX devices are available in two package styles. For applications where the sensing element is to be integral to the equipment or repackaged, the basic sensor package can be O-ring sealed and epoxied and/or clamped onto a pressure fitting. Devices are also available in the "N" (glass-filled nylon) package which provides for convenient mounting as well as easy pressure connection using appropriate tubing.

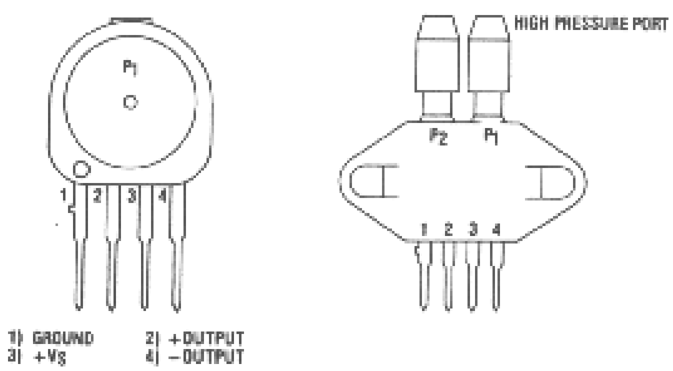
Because of its high-impedance bridge, the SX Series is ideal for portable and low power or battery operated systems. Due to its low noise, the SX will also be found to be an excellent choice for medical and other low pressure measurements.

For further technical information on the SX Series or SCX Series, please contact your local Sensym office or the factory.

EQUIVALENT CIRCUIT



ELECTRICAL CONNECTION



Note: Polarity applies for positive pressure applied to the high pressure port, P_1.

PRESSURE SENSOR CHARACTERISTICS

SX01, SX05

Maximum Ratings (For All Devices)

Supply Voltage, V_S	$+12\ V_{DC}$
Temperature Range	
Operating	-40°C to +85°C
Storage	-55°C to +125°C
Common-mode Pressure	150 psig
Lead Temperature	
(Soldering, 10 seconds)	300°C
Maximum Pressure (Note 10)	
SX01	20 psi
SX05	20 psi

SX01D PERFORMANCE CHARACTERISTICS (Note 1)

Characteristic	Min.	Typ.	Max.	Unit
Operating Pressure Range		—	1	psi
Sensitivity $T_A = 25°C$	3.0	4.0	5.0	mV/V/psi
Full-scale Span (Note 2) $T_A = 25°C$	15	20	25	mV
Temperature Coefficient of Span (Notes 6 & 9)	−2550	−2300	−2050	ppm/°C
Zero Pressure Offset $T_A = 25°C$	−35	−20	25	mV
Temperature Coefficient of Offset (Note 5)	—	+4	—	μV/V/°C
Combined Linearity and Hysteresis (Note 3)	—	0.2	0.5%	%FS
Long Term Stability of Offset and Sensitivity (Note 8)	—	0.1	—	%FS
Response Time (10% to 90%) (Note 7)	—	0.1	—	ms
Input Resistance $T_A = 25°C$	—	4.65	—	kΩ
Temperature Coefficient of Resistance (Notes 6 & 9)	+590	+630	+670	ppm/°C
Output Impedance	—	4.65	—	kΩ
Repeatability (Note 4)	—	0.5	—	%FS

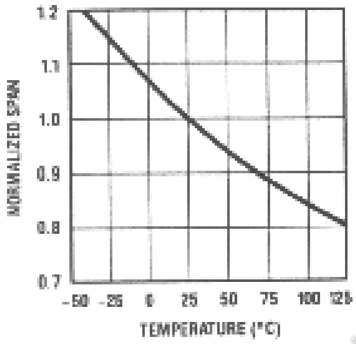
SX05D PERFORMANCE CHARACTERISTICS (Note 1)

Characteristic	Min.	Typ.	Max.	Unit
Operating Pressure Range		—	5	psi
Sensitivity $T_A = 25°C$	2.0	3.0	4.0	mV/V/psi
Full-scale Span (Note 2) $T_A = 25°C$	50	75	100	mV
Temperature Coefficient of Span (Notes 6 & 9)	−2550	−2300	−2050	ppm/°C
Zero Pressure Offset $T_A = 25°C$	−35	−20	0	mV
Temperature Coefficient of Offset (Note 5)	—	+4	—	μV/V/°C
Combined Linearity and Hysteresis (Note 3)	—	0.2	0.5%	%FS
Long Term Stability of Offset and Sensitivity (Note 8)	—	0.1	—	%FS
Response Time (10% to 90%) (Note 7)	—	0.1	—	ms
Input Resistance $T_A = 25°C$	—	4.65	—	kΩ
Temperature Coefficient of Resistance (Notes 6 & 9)	+590	+630	+670	ppm/°C
Output Impedance	—	4.65	—	kΩ
Repeatability (Note 4)	—	0.5	—	%FS

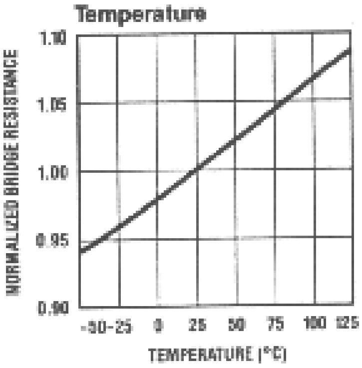
TYPICAL PERFORMANCE CHARACTERISTICS

SX01, SX05

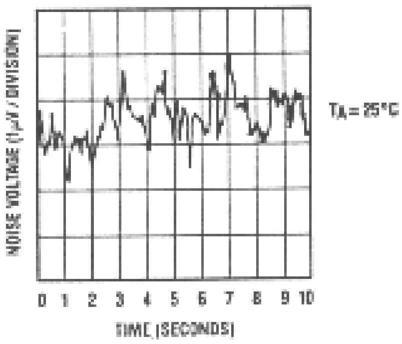
Span vs Temperature



Bridge Resistance vs Temperature



0.1 Hz to 10 Hz Noise



Specification Notes: (For All Devices)

Note 1: Reference Conditions: Supply Voltage, $V_S = 5\,V_{DC}$, T_A = 0°C to 70°C, Common-mode Line Pressure = 0 psig, Pressure Applied to P_1, unless otherwise noted.

Note 2: Span is the algebraic difference between the output voltage at full-scale pressure and the output at zero pressure.

Note 3: See Definition of Terms.
Hysteresis — the maximum output difference at any point within the operating pressure range for increasing and decreasing pressure.

Note 4: Maximum difference in output at any pressure with the operating pressure range and temperature within 0°C to +70°C after:
a) 1,000 temperature cycles, 0°C to +70°C
b) 1.5 million pressure cycles, 0psi to full-scale span.

Note 5: Slope of the best straight line from 0°C to +70°C.

Note 6: This is the best straight line fit for operation between 0°C and 70°C. For operation outside this temperature, contact factory for more specific applications information.

Note 7: Response time for a 0 psi to full-scale span pressure step change.

Note 8: Long term stability over a one year period.

Note 9: This parameter is not 100% tested. It is guaranteed by process design and tested on a sample basis only.

Note 10: If the maximum pressure is exceeded, even momentarily, the package may leak or burst, or the pressure sensing die may fracture.

DEFINITION OF TERMS

Absolute Pressure: Pressure measured relative to a vacuum. Usually expressed in pounds per square inch absolute (psia). Typically equated with barometric pressure.

Differential Pressure: The pressure difference measured between two pressure sources. Usually expressed in pounds per square inch differential (psid). When one source is the local ambient, the pressure is called *gage pressure*.

Gage Pressure: Pressure measured relative to ambient pressure (psig). Obtained by leaving one port of SXxxxD type devices open to the atmosphere.

Transducer Parameters

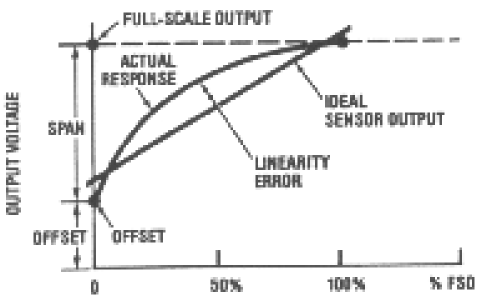
Maximum Pressure: The maximum pressure that can be applied to a transducer without rupture of either the sensing element or transducer case.

Common-Mode Pressure: The pressure that is applied to both ports simultaneously of a differential transducer.

Full-Scale Output: The actual voltage reading obtained at the endpoint of the pressure range.

Linearity: The maximum deviation of measured output at constant temperature (25 °C) from "best straight line" determined by three points (offset pressure, full-scale pressure, and one-half full-scale pressure).

Offset Voltage: The transducer output signal at zero pressure, (0 psig for gages and differential, 0 psia for absolute devices).



Operating Pressure Range: The specified range over which a transducer is intended for use.

Over-Pressure — Maximum: The maximum *normal mode* (measured) pressure that can be applied without changing the transducer's performance or accuracy beyond the specified limits. This would be applied to either port of a differential transducer. This is also called proof pressure.

Reference Pressure: The pressure used as a reference in measuring transducer errors.

Reference Temperature: The temperature used as reference in measuring transducer errors.

Sensitivity: The ratio of output signal voltage change to the corresponding input pressure change. Sensitivity is determined by computing the ratio of span to the specified input pressure range.

Span: The arithmetic difference in transducer output signal measured at the specified minimum and maximum operating pressures.

Temperature Coefficient of Offset Voltage: This defines how the offset voltage will change with temperature when a fixed voltage is applied to the bridge. For the SX series, the offset TC is typically $+4\mu V/V/°C$.

A best straight line definition, is used although the offset TC is slightly non-linear.

Temperature Coefficient of Resistance: This defines the manner in which the bridge input resistance changes with temperature. For the SX series, the resistance TC is always positive at approximately +630 ppm/°C. This means that for every 1°C rise in temperature, the resistance "seen" by the bridge voltage will typically rise by 0.063% of its nominal value.

Temperature Coefficient of Span: The span TC defines the manner in which the span/sensitivity changes with temperature. For the SX01 and SX05 devices, the span TC is always negative at approximately −2300 ppm/°C. This means that for a fixed voltage applied to the bridge, the sensitivity will decrease 0.230% for every 1°C rise in temperature.

PRESSURE UNIT CONVERSION CONSTANTS

(Most Commonly Used — Per International Conventions)

	PSI(1)	In. H_2O(2)	In. Hg(3)	kPa	millibar	cm H_2O(4)	mm Hg(5)
PSI(1)	1.000	27.680	2.036	6.8947	68.947	70.308	51.715
In. H_2O(2)	3.6127×10^{-2}	1.000	7.3554×10^{-2}	0.2491	2.491	2.5400	1.8683
In. Hg(3)	0.4912	13.596	1.000	3.3864	33.864	34.532	25.400
kPa	0.14504	4.0147	0.2953	1.000	20.000	20.2973	7.5006
millibar	0.01450	0.40147	0.02953	0.100	1.000	1.01973	0.75006
cm H_2O(4)	1.4223×10^{-2}	0.3937	2.8958×10^{-2}	0.09806	0.9806	1.000	0.7355
mm Hg(5)	1.9337×10^{-2}	0.53525	3.9370×10^{-2}	0.13332	1.3332	1.3595	1.000

Notes: 1. PSI — pounds per square inch 2. at 39°F 3. at 32°F 4. at 4°C 5. at 0°C

MECHANICAL AND MOUNTING CONSIDERATIONS

Basic Sensor Element

The basic sensor element was designed to allow easy interface with additional cases and housings which then allow pressure connection. The device can be mounted with an O-ring, gasket, or RTV seals on one or both sides of the device. The device can then be glued or clamped into a variety of fixtures and the leads can be bent as necessary to allow for ease of electrical connection. However, caution is advised as repeated bending of the leads will cause eventual breakage.

For most gage applications, pressure should be applied to the top side of the device. (See Physical Construction Drawing.) For differential applications, the top side of the device (P_1) should be used as the high pressure port and the bottom (P_2) as the low pressure port.

The basic SX package has a very small internal volume of 0.06 cubic centimeters for P_1 and 0.001 cubic centimeters for P_2.

Packaged Sensor

The packaged sensor is designed for convenient pressure connection and easy PC board mounting. To mount the device horizontally to a PC board, the leads can be bent downward and the package attached to the board using either tie wraps or mounting screws. For pressure attachment, tygon or silicon tubing is recommended.

All versions of the packaged sensor have two (2) tubes available for pressure connection.

For gage devices, pressure should be applied to port P_1. For differential pressure applications, port P_1 should be used as the high pressure port and P_2 should be used as the low pressure port.

GENERAL DISCUSSION

Output Characteristics

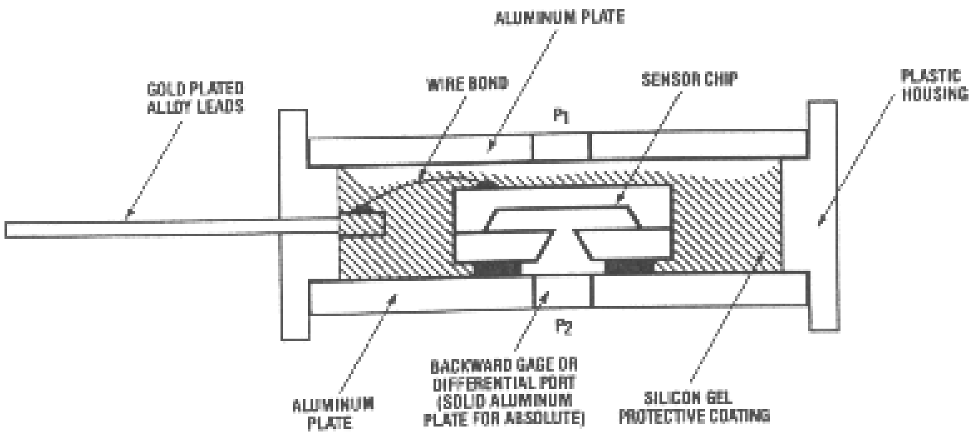
The SX series devices give a voltage output which is directly proportional to applied pressure. The devices will give an increasing positive going output when increasing pressure is applied to pressure port P_1 of the device. If the devices are operated in the backward gage mode, the output will increase with decreases in pressure. The devices are ratiometric to the supply voltage. Changes in supply voltage will cause proportional changes in the offset voltage and full-scale span.

User Calibration

SX series devices feature the basic IC pressure sensor element. This will keep overall system costs down by allowing the user to select calibration and temperature compensation circuits which specifically match individual application needs. In most cases, the primary signal conditioning elements to be added to the SX by the user are: offset and span calibration and temperature compensation. Some typical circuits are shown in the application section.

Media Compatibility

SX devices are compatible with most non-corrosive gases. Because the circuitry is coated with a protective silicon gel, many otherwise corrosive environments can be compatible with the sensors. As shown in the physical construction diagram below, fluids must generally be compatible with silicon gel, RTV, plastic, and aluminum for forward gage use and RTV, silicon, glass and aluminum for backward gage or differential applications. For questions concerning media compatibility, contact the factory.



Physical Construction

APPLICATION INFORMATION

SX01, SX05

General

The SX family of pressure sensors functions as a Wheatstone bridge. When pressure is applied to the device (see Figure 1) the resistors in the arms of the bridge change by an amount, Δ.

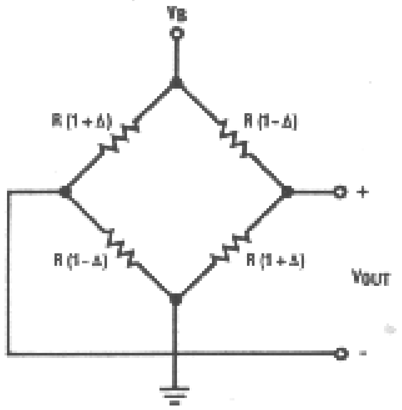


Figure 1.

The resulting differential output voltage V_O, is easily shown to be $V_O = V_B \times \Delta$. Since the change in resistance is directly proportional to pressure, V_O can be written as:

$$V_O = S \times P \times V_B \pm V_{OS} \qquad (1)$$

Where: V_O is the output voltage in mV
S is the sensitivity in mV/V per psi
P is the pressure in psi
V_B is the bridge voltage in volts.

V_{OS} is the offset error (the differential output voltage when the applied pressure is zero). The offset voltage presents little problem in most applications, since it can easily be corrected for in the amplifier circuitry, or corrected digitally if a microprocessor is used in the system.

Temperature Effects

In this discussion, for simplicity of notation, the change of a variable with temperature will be designated with a dot (·) over the variable. For example,

$$\dot{S} = \frac{\text{change in sensitivity}}{\text{change in temperature}} = \frac{\partial S}{\partial T}$$

From equation (1), and ignoring the V_{OS} term, it is seen that for a given constant pressure, the output voltage change, as a function of temperature*, is:

$$\dot{V}_O = \dot{S} P V_B \qquad (2)$$

*It should be noted that temperature in this discussion is the temperature of the silicon die. The die temperature will be dependent upon internal power dissipation, ambient temperature and, in some cases, the working fluid temperature.

Thus, in order for output voltage to be independent of temperature, the voltage across the bridge, V_B, must change with temperature in the "opposite direction" from the sensitivity change with temperature. From the typical curves for the temperature dependence of span (span = $S \times P \times V_B$), it can be seen that the sensitivity change with temperature is slightly non-linear and can be correlated very well with an equation of the form:

$$S = S_O \left[(1 - \beta T_D) + \varrho T_D^2 \right] \qquad (3)$$

where T_D is the temperature difference between 25 °C and the temperature of interest, S_O is the sensitivity at 25 °C, and beta (β) and rho (ϱ) are correlation constants.

Fortunately, between 0 °C and 70 °C the change in sensitivity with temperature is quite linear, and excellent results can be obtained over this temperature range by ignoring the second-order temperature dependent term.

Operating outside the 0°C to 70°C temperature range will require a more rigorous mathematical approach and the use of non-linear compensating circuitry, if accuracy of better than ±1% is required. Because the majority of SX applications fall within the 0°C to 70°C operating temperature range, the discussion and circuit designs given here will ignore the non-linear effects.

Thus:

$$S = S_O (1 - \beta T_D) \qquad (4)$$

Substituting equation (4) into equation (1), and ignoring V_{OS}, it can be shown that the necessary bridge voltage, V_B, will be of the form:

$$V_B = \frac{V_{BO}}{(1 - \beta T_D)} = V_{BO} \left[(1 + \beta T_D + (\beta T_D)^2 + \ldots) \right]$$

where V_{BO} is the bridge voltage at 25 °C.

This equation is again non-linear. However, for the temperature range of interest, and since β is small (0.230 % / °C from the electrical tables), the above expression can be approximated by:

$$V_B = V_{BO} \left[1 + \beta T_D \right]$$

with less than 1% error. Thus to compensate for a negative 2300 ppm / °C sensitivity change with temperature, the bridge voltage should increase with temperature at a rate of +2300 ppm / °C.

The above value of bridge voltage change will be used in the circuit discussions that follow. That is to say, the required change in terms of ppm / °C is:

$$\left(\frac{\dot{V}_B}{V_B} \right) = +2300 \text{ ppm/°C}.$$