SenSym

SCC SERIES

0 to 5, to 0 to 300 psi

PRESSURE SENSORS

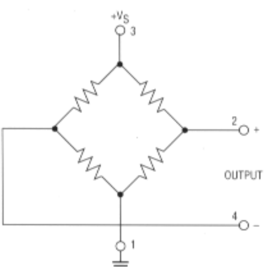
FEATURES

- **Low Cost Sensor Element**
- **Internal Temperature Compensation**
- **Differential or Gage Pressures**

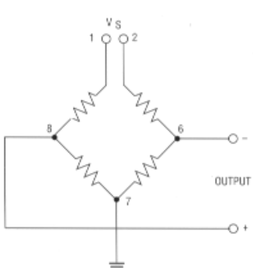
APPLICATIONS

- **Pneumatic Controls**
- **Automotive Diagnostics**
- **Medical Equipment**
- **Dental Equipment**
- **Environmental Controls**

EQUIVALENT CIRCUITS



Button Sensor or "N" Package



(Open Bridge)

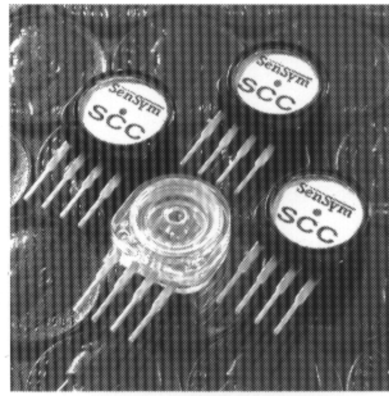
TO Can Packages

GENERAL DESCRIPTION

The SCC series offer an extremely low cost sensor element with a temperature stable output when driven with a constant current source. These integrated circuit sensors were designed for extremely cost sensitive applications where precise accuracy over a wide temperature range is not required. This series is intended for use with non-corrosive, non-ionic working fluids such as air, dry gases, and the like.

Absolute devices have an internal vacuum reference and an output voltage proportional to applied pressure. The differential devices allow application of pressure to either side of the diaphragm and devices are thereby available to measure both differential and gage pressures.

This product is packaged either in SenSym's standard low cost chip carrier "button" package or a metal TO can package. Both packages are designed for applications where the sensing element is to be integral to the OEM equipment. These



packages can be o-ring sealed, epoxied, and/or clamped onto a pressure fitting. A closed bridge four-pin SIP configuration is provided for electrical connection to the button package. The TO can offers a 5-pin open bridge configuration.

For further technical information on this series, please contact your local SenSym office or the factory.

PRESSURE SENSOR CHARACTERISTICS

Maximum Ratings (For All Devices)

Supply Current, I_S	1.5mA
Temperature Ranges	
Compensated	0°C to +50°C
Operating	−40°C to +85°C
Storage	−55°C to +125°C
Humidity	0 to 100% RH
Lead Temperature (Soldering 2-4 seconds)	250°C
Common-Mode Pressure	150 psi

PERFORMANCE CHARACTERISTICS (Individual Models) I_S=1.0mA, T_A=25°C[1]

Part #	Operating Pressure Range	Maximum Over Pressure	Accuracy[2]	Effect[3, 8] On Span (0°C–50°C)	Effect[4, 8] on Offset (0°C–50°C)	Full-Scale Span[5] (mV)
SCC05(D, G)	0-5 psid (g)	20 psi	0.50%	1.50%	30μV/°C	25-65
SCC15A	0-15 psia	30 psia	0.50%	1.50%	40μV/°C	40-95
SCC15(D, G)	0-15 psid (g)	30 psi	0.50%	1.50%	40μV/°C	40-95
SCC30(D, G)	0-30 psid (g)	60 psi	0.50%	1.50%	60μV/°C	60-150
SCC100A	0-100 psia	150 psia	0.50%	1.50%	30μV/°C	85-225
SCC100(D, G)[9]	0-100 psig	150 psig	0.50%	1.50%	90μV/°C	85-225
SCC300A	0-300 psia	450 psia	0.50%	1.50%	50μV/°C	50-120

PERFORMANCE CHARACTERISTICS (All Models) I_S = 1.0mA, T_A = 25°C

Characteristics	Min	Typ	Max	Unit
Zero Pressure Offset[10]	−30.0	−10	20.0	mV
Combined, Linearity, Hysteresis, Repeatability[2]	—	0.25	0.50	%FSO
Long Term Stability of Offset and Span[6]	—	0.10	—	mV
Response Time (10% to 90%)[7]	—	0.10	—	mSec
Input Impedance	4.00	5.00	6.50	kΩ
Output Impedance	4.00	5.00	6.50	kΩ

SPECIFICATION NOTES:

Note 1: Reference Conditions: Supply Current=1.0mA, T_A=25°C, Common-mode Line Pressure = 0 psig, Pressure Applied to P1, unless otherwise noted.

Note 2: Accuracy is the sum of Hysteresis and Linearity. Hysteresis is the maximum output difference at any point within the operating pressure range for increasing and decreasing pressure. Linearity refers to the best straight line fit as measured for the offset, full-scale and ½ full-scale pressure at 25°C.

Note 3: This is the maximum temperature shift for span when measured between 0°C and 50°C relative to the 25°C reading. Typical temperature coefficients for span and resistance are −2200ppm/°C and +2200ppm/°C respectively.

Note 4: This is the maximum temperature shift for offset when measured at 0°C and 50°C divided by the temperature difference.

Note 5: Span is the algebraic difference between the output voltage at full-scale pressure and the output at zero pressure.

Note 6: Maximum difference in output at any pressure with the operating pressure range and temperature within 0°C to 50°C after:

a) 100 temperature cycles, 0°C to 50°C.

b) 1.0 million pressure cycles, 0 psi to full-scale span.

Note 7: Response time for a 0 psi to full-scale span pressure step change. 10% to 90% rise time.

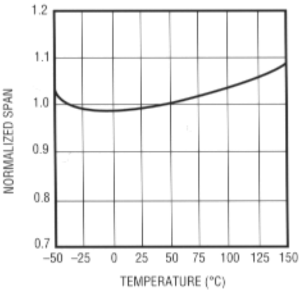
Note 8: Temp effect on span and offset are guaranteed by design. Therefore these parameters are not 100% tested.

Note 9: The SCC100D devices can only be used in a forward gauge mode. Application of more than 30 psig to the back side of any of the SCC Series devices can result in device failure. On the SCC100GD2 pressure can only be applied to the back side of the die. No pressure is accessible from the front/top side of die.

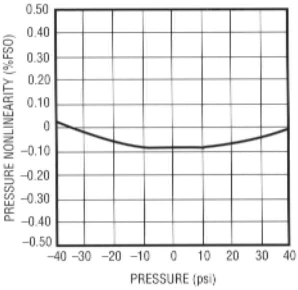
Note 10: The zero pressure offset is +30 to −20mV max for parts SCCxxxGD2 and SCCxxxDD4 devices.

TYPICAL PERFORMANCE CHARACTERISTICS

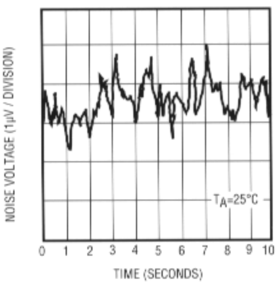
Span vs Temperature



Nonlinearity vs Pressure



0.1Hz to 10Hz Noise



APPLICATION INFORMATION

General Information

The SCC family of pressure sensors function as a wheatstone bridge. When pressure is applied to the device the resistors in the arms of the bridge change as shown in Figure I.

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

$$V_O = (S \times P + V_{OS})\, V_B$$

Where: V_O is the output voltage in mV

S is the sensitivity in mV/V/psi

P is the pressure in psi

V_{OS} is the offset error, (the differential output voltage when the applied pressure is zero)

V_B is the bridge voltage in volts.

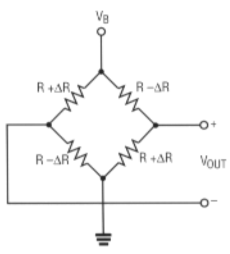


Figure I. Button Sensor Bridge Schematic

The offset and sensitivity calibrations present little problem in most applications, as they can easily be corrected for in the amplification circuitry, or corrected digitally if a microprocessor is used in the system. Generally, it is the temperature errors which cause the greatest difficulty in using the basic sensor element.

Temperature Effects

The output voltage, V_O, will be equal to the product shown in equation 1 if the temperature is constant. However, a characteristic of all piezoresistive silicon pressure sensors, is a change in sensitivity over temperature.

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

$$\dot{V}_O = \dot{S}PV_B(1) + SP\dot{V}_B$$

As shown in the datasheet, the temperature coefficient of the span, TCS, is –2200ppm/°C. Thus, in order for the output voltage to be independent of temperature, the voltage across the bridge, V_B, must change with temperature in equal magnitude but in the "opposite direction" from the sensitivity change with temperature. Or in mathematical terms

$$\frac{\dot{V}_B}{V_B} = -\frac{\dot{S}}{S}$$

Although diode strings and transistor techniques can be used to temperature compensate the bridge (and in fact will be required for extended temperature operation) such techniques are difficult to use in volume production. For the SCC series a much simpler solution does exist as SenSym's SCC family of pressure sensors are manufactured such that the bridges input resistance[2], changes linearly at the rate of:

$$\frac{\dot{R}_B}{R_B} = 2200 \pm 200 \text{ ppm/°C}$$

Therefore, if these devices are excited with a constant current source, the voltage across the bridge will increase with temperature as R_B increases, and thereby offset the decrease in sensitivity as shown below.

$$V_B = R_B I \qquad \dot{V}_B = \dot{R}_B I$$

$$\frac{\dot{V}_B = \dot{R}_B}{V_B = R_B} \qquad \frac{\dot{V}_B = \dot{R}_B}{V_B = R_B}$$

APPLICATION INFORMATION

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

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

(2) The input resistance is the resistance "seen" by the bridge voltage, V_B, with no pressure applied.

Constant Current Sources

In order to optimize the SCC series performance over temperature, a constant current source must be constructed. The construction of such a device can be complex or straight forward depending on the temperature range and degree of accuracy required. The following are two of the recommended constant current sources for the SCC family.

Lowest Cost Constant Current Source

A very low cost current source solution is possible, if the temperature range is limited and the power supply voltage (V_S) is constant over temperature, by using a single resistor, R_S, in series with the bridge(R_B), as shown in Figure II.

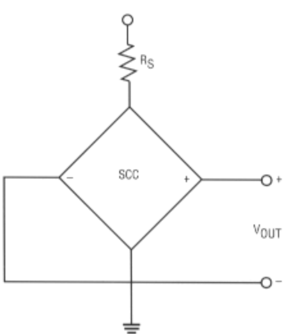


Figure II: Single Resistor Current Source

The quality of the constant current source created by R_S is determined by the temperature coefficient of the two resistors in series ($R_S + R_B$).

If the resistor value $R_S >> R_B$ then the TCR is very good, but the signal from the sensor is proportionally very small. If the resistor value $R_B >> R_S$, then the signal is good but the span TC is very poor (~ –2200 ppm/°C). The following equations or Graph I, can be used to determine the value of R_S which will provide the largest signal from the sensor, while still providing adequate span TC compensation. The key equations associated with the circuit shown in Figure II are:

$$\text{(a) } V_B = V_S \bullet \frac{R_B}{R_S + R_B}$$

$$\text{(b) } \frac{\dot{V}_B}{V_B} = \frac{\dot{R}_B}{R_B} - \frac{\dot{R}_S}{R_S} \times \left(1 - \frac{R_B}{R_S + R_B}\right)$$

$$\text{(c) } \dot{SC} = \dot{S} + \dot{V}_B$$

where SC is the compensated span

Solving for (b) we find that the ratio of R_B to R_S for the SCC family of pressure sensors is:

$$\frac{R_B}{R_S} = \frac{\frac{\dot{R}_B}{R_B} - \frac{\dot{R}_S}{R_S}}{\frac{\dot{S}_C}{S_C} - \frac{\dot{S}_U}{S_U}}$$

where SC is the compensated span

SU is the uncompensated span

For example, assume that the span must be within 1% of the calibrated value (25°C), and that the temperature is limited to 25°C ±10°C. Also, assume the worst case die parameters of TCR = 2200 ppm/°C, TCS = 2300 ppm/°C and that the series resistor has a worst case temperature coefficient $\dot{R}_S/R_S$ = +100 ppm/°C. The allowable TC error will be:

$$\frac{\dot{S}_C}{S_C} = \frac{1\%\text{ error}}{10°C} = -1000 \text{ ppm/°C}$$

By knowing the compensated span TC desired, we can now solve for the ratio of R_B to R_S.

$$\frac{R_B}{R_S} = \frac{2200 - 100}{-1000 - (-2300)} - 1 = 0.5$$

Therefore, if we assume that R_B = 6.0k then R_S = 12k, the span TC error is less than 1% for all variations of die parameters. This simple configuration, shown in Figure III is only recommended when low cost is required and peformance over temperature is not critical.

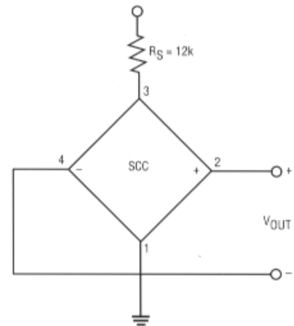
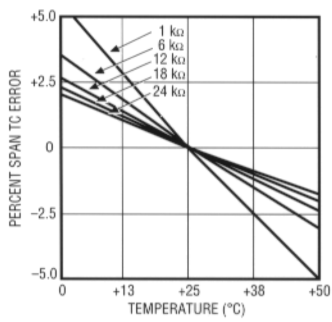


Figure III: Single Resistor Current Source

As shown in Graph I, different values of RS result in varying degree's of span TC accuracy over the temperature ranges of 0°C–50°C. The values in Graph I were calculated using the worst case die parameters as given in the above example. The values in the table also take into account the errors in span TC over temperature which will occur even if a perfect current source could be constructed.



Graph I

APPLICATION INFORMATION

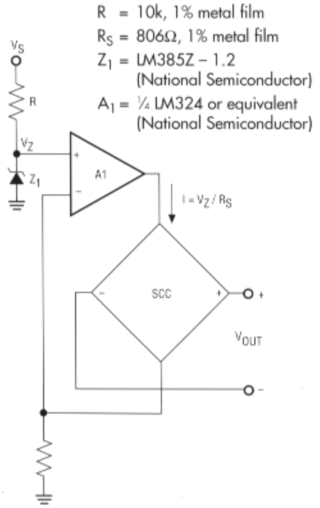


Figure IV: Single Op-Amp Current Source

One Op-Amp Constant Current Source

Typically, the most common way of generating a low cost constant current source is the single op-amp design as shown in Figure IV.

Here, the current thru the sensor is equal to the voltage at the non-inverting terminal divided by the resistor, R. The accuracy of this current source will vary given the accuracy of the op-amp, and grade of resistor values used around the sensor. However, current variations over the temperature range of 0°C – 50°C for this current source should be less than 0.5% of the full-scale current.

This scheme is probably the most commonly used as it provides reasonable accuracy with low cost and it is simple to manufacture. In using this technique with the SCC devices, we recommend a 1.2V zener such as the LM358Z – 1.2 along with an 806 1% metal film resistor.

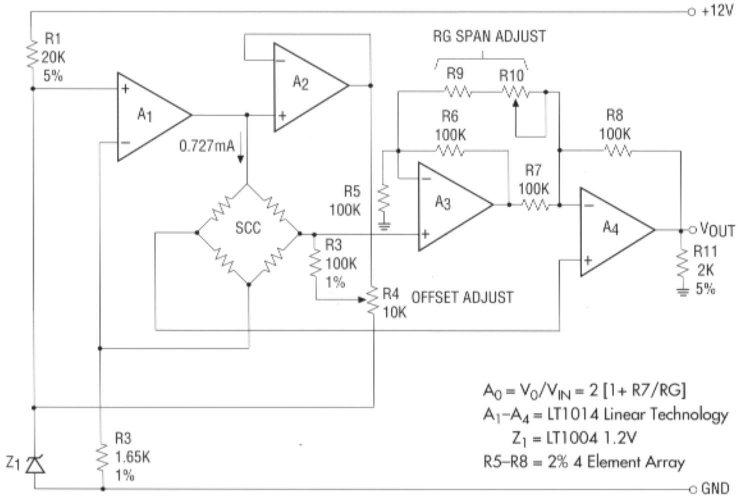
Amplifier Design

There are hundreds of instrumentation amplifier designs, and the intent here will be to briefly describe one circuit which:

- does not load the bridge
- involves minimal components
- provides maximum performance at the lowest cost

The choice of the operational amplifiers to use is based on individual cost/performance trade-offs. The accuracy will be primarily limited by offset voltage drift with temperature and noise performance.

A popular amplifier configuration which provides a 1 to 6 volt output is shown in Figure V below.



Sensor	Gain	R9	R10(POT)
SCC05D	106-275	500Ω	2K
SCC15D	72-172	1K	2K
SCC30D	46-115	1.5K	5K
SCC100D	30-81	2.26K	5K
SCC300D	57-137	1K	5K

Figure V

AMPLIFIER ADJUSTMENT PROCEDURE:

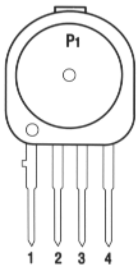
1. At reference pressure (0 psi for diff, and gage adjust R4 until the output reads 0.050 volts.
2. With full pressure applied adjust R10 (span adjust) until V_{OUT} reads 5.0V.
3. Repeat steps 1 and 2 i

ORDERING INFORMATION

To order, use the following part numbers:

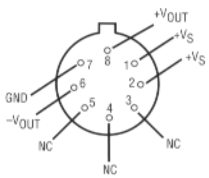
Pressure Range	Order Part Number				
	Sensor in Button Package	Sensor in "N" Package	Sensor in TO Package (Open Bridge)	Sensor in Nipple Package	Sensor in DIP Package
0 to 5 psid or psig	SCC05D	SCC05DN	SCC05GSO	SCC05DP1	SCC05GD2, SCC05DD4
0 to 15 psid or psig	SCC15D	SCC15DN	SCC15GSO	SCC15DP1	SCC15GD2, SCC15DD4
0 to 30 psid or psig	SCC30D	SCC30DN	SCC30GSO	SCC30DP1	SCC30GD2, SCC30DD4
0 to 100 psig	SCC100D	SCC100DN	SCC100GSO	—	SCC100GD2, SCC100DD4
0 to 15 psia	SCC15A	SCC15AN	SCC15AHO	SCC15AP1	SCC15AD2
0 to 30 psia	SCC30A	SCC30AN	SCC30AHO	SCC30AP1	SCC30AD2
0 to 100 psia	SCC100A	SCC100AN	SCC100AHO	—	SCC100AD2
0 to 300 psia	—	—	SCC300AHO	—	—

ELECTRICAL CONNECTIONS



1) GROUND 2) +OUTPUT
3) $+V_S$ 4) –OUTPUT

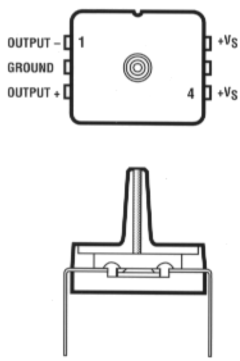
Button/"N"/Nipple Package Pinout



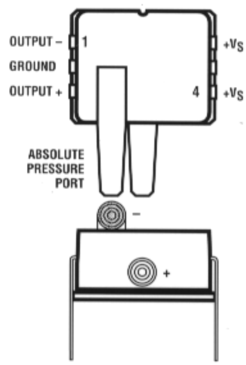
Bottom View
(Open Bridge)

TO can Pinout

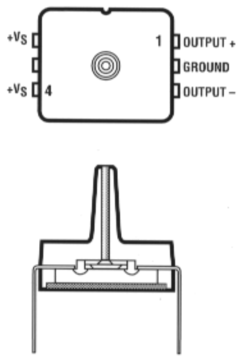
NOTE: Polarity applies for positive pressure applied to the high pressure port, P_1. TO Package only available in an Open Bridge configuration.



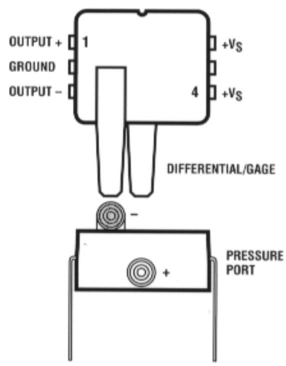
SCCxxxAD2



SCCxxxAD4



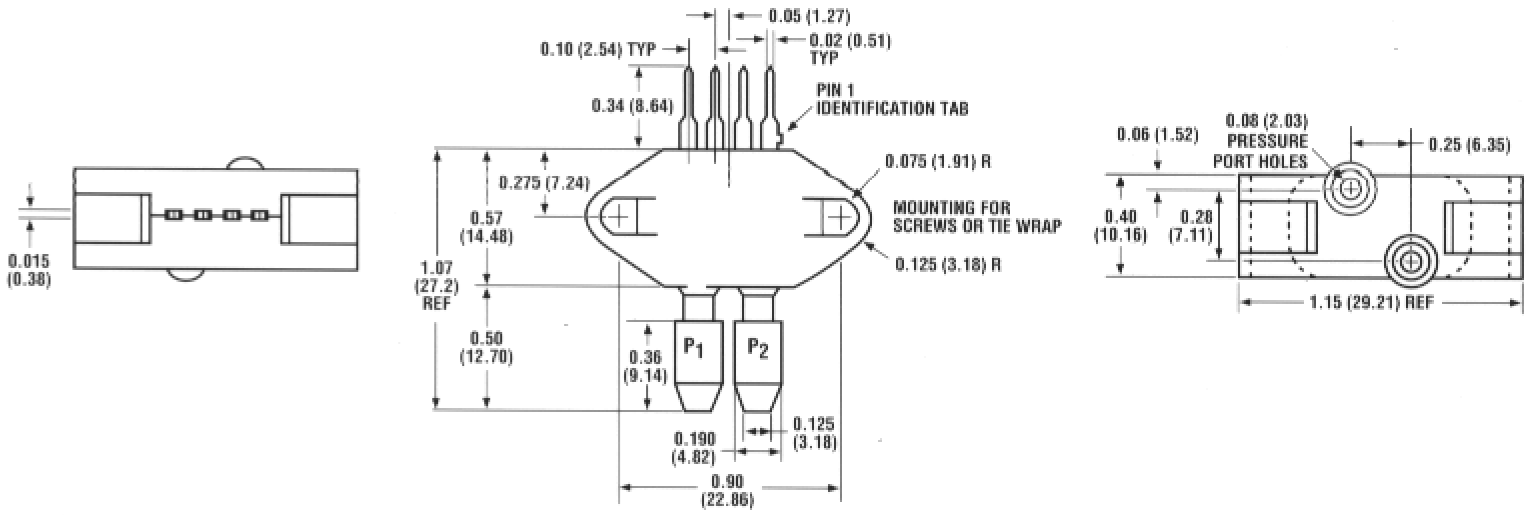
SCCxxxGD2



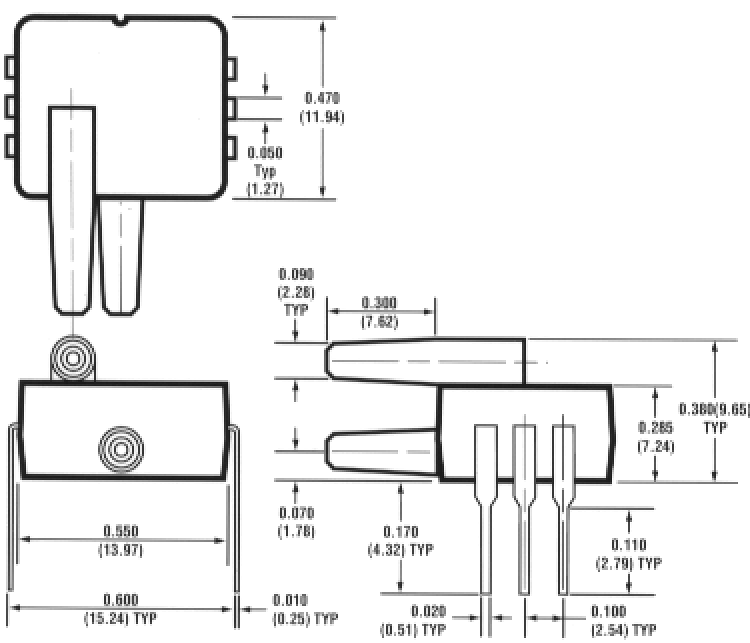
SCCxxxDD4

PACKAGE OUTLINES

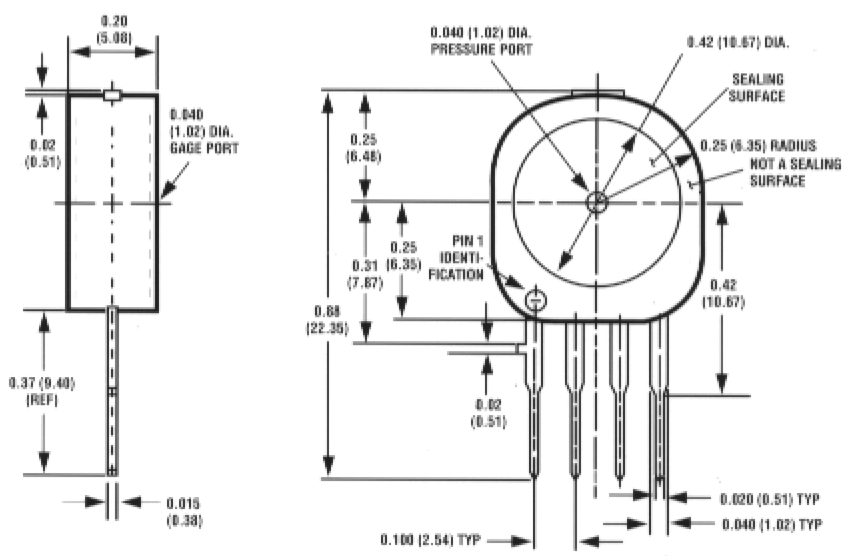
N Package



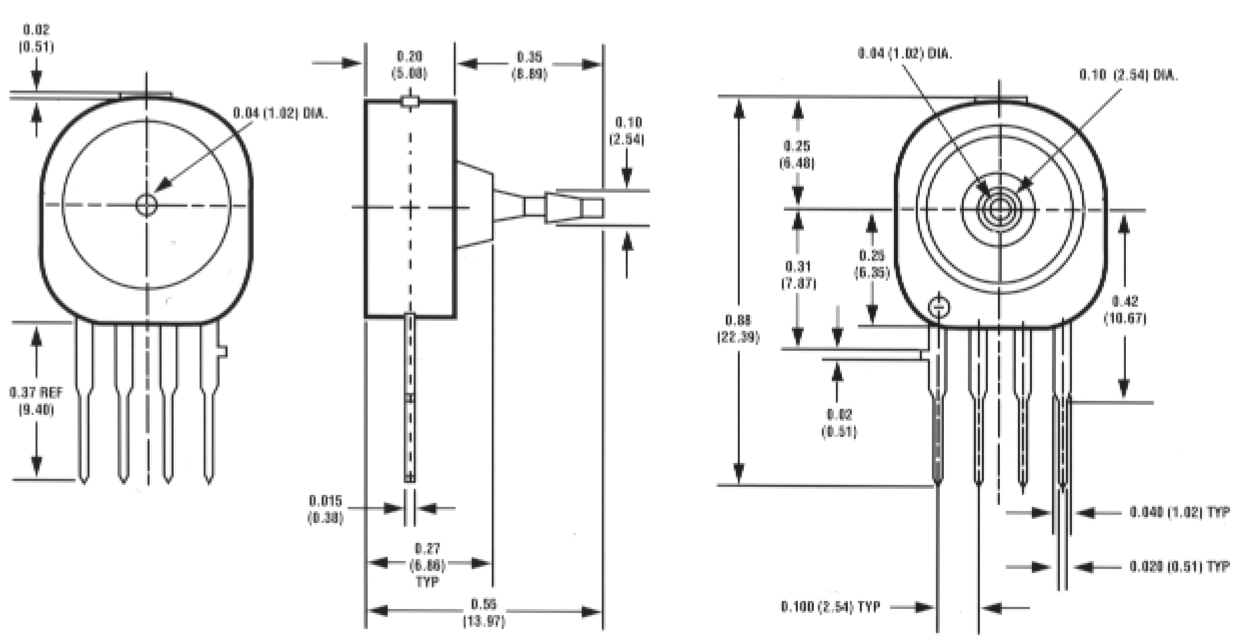
Basic Sensor Sideport 'D4' DIP Package



Button Sensor

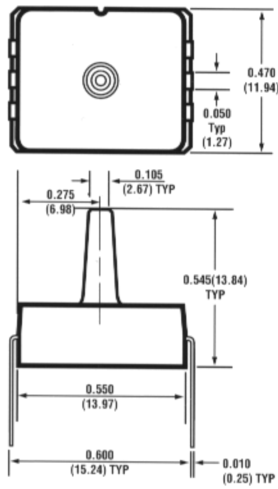


P1 Button Package

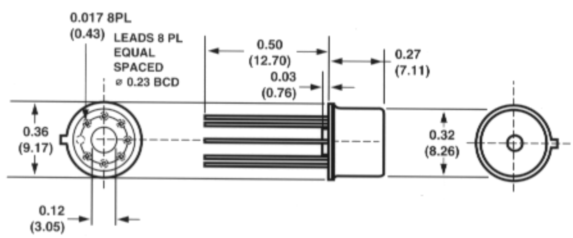


PACKAGE OUTLINES

Basic Sensor 'D2' DIP Package



AH (TO-5) Package



GSO (TO-39) Package