SenSym

SCX Series

Precision compensated pressure sensors

FEATURES

- 0...1 to 0...150 psi
- Precision temperature compensation
- Calibrated zero and span
- Small size
- Low noise
- High accuracy
- High impedance for low power applications

APPLICATIONS

- Medical equipment
- Barometry
- Computer peripherals
- Pneumatic control
- HVAC

GENERAL DESCRIPTION

The SCX series sensors will provide a very cost effective solution for pressure applications that require high accuracy over a wide temperature range. These internally calibrated and temperature compensated sensors were specifically designed to provide an accurate and stable output over a 0°C to 70°C temperature range. This series is intended for use with non-corrosive, non-ionic working fluids such as air, dry gases, and the like.

Devices are available to measure absolute, differential, and gage pressures from 1 psi (SCX01) up to 150 psi (SCX150). The absolute (A) devices have an internal vacuum reference and an output voltage proportional to absolute pressure. The differential (D) devices allow application of pressure to either side of the pressure sensing diaphragm and can be used for gage or differential pressure measurements.

The SCX devices feature an integrated circuit sensor element and laser trimmed thick film ceramic housed in a compact nylon case. This package provides excellent corrosion resistance and provides isolation to external package stresses. The package has convenient mounting holes and pressure ports for ease of use with standard plastic tubing for pressure connection.

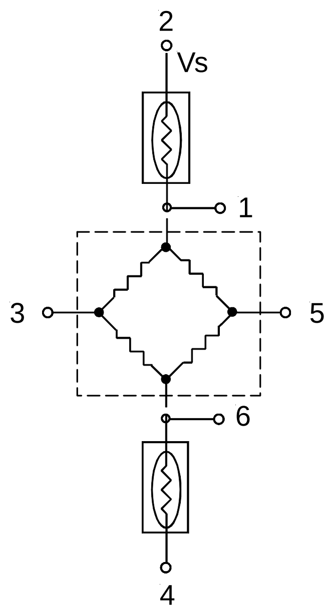
All SCX devices are calibrated for span to within ±1 % and provide a very low zero pressure output of ±300 microvolts maximum. Thus, for many applications no trimming networks are required in the signal conditioning circuitry. If the application requires extended temperature range operation, beyond 0 to 70°C, two pins which provide an output voltage proportional to temperature are available for use with external circuitry.

Scale: 1 cm
½ inch

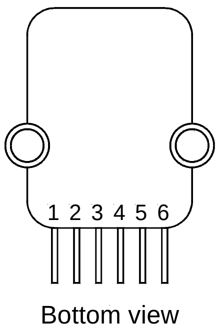
The output of the bridge is ratiometric to the supply voltage and operation from any D.C. supply voltage up to +20 V is acceptable.

Because these devices have very low noise and excellent temperature compensation, they are ideal for medical and other high performance applications. The 100 microsecond response time also makes this series an excellent choice for computer peripherals and pneumatic control applications.

EQUIVALENT CIRCUIT



ELECTRICAL CONNECTION



Pin 1) Temperature output (+)
Pin 2) V_S
Pin 3) Output (+)
Pin 4) Ground
Pin 5) Output (-)
Pin 6) Temperature output (-)

Note: The polarity indicated is for pressure applied to port B (for absolute devices pressure is applied to port A and the output polarity is reversed.)

PRESSURE SENSOR CHARACTERISTICS[1]

STANDARD PRESSURE RANGES

Part Number	Operating pressure	Proof pressure[2]	Full-scale span[1,3]		
			Min.	Typ.	Max.
SCX01DN	0 - 1 psid	20 psid	17.82 mV	18 mV	18.18 mV
SCX05DN	0 - 5 psid	20 psid	59.4 mV	60 mV	60.6 mV
SCX15AN	0 - 15 psia	30 psia	89.1 mV	90 mV	90.9 mV
SCX15DN	0 - 15 psid	30 psid	89.1 mV	90 mV	90.9 mV
SCX30AN	0 - 30 psia	60 psia	89.1 mV	90 mV	90.9 mV
SCX30DN	0 - 30 psid	60 psid	89.1 mV	90 mV	90.9 mV
SCX100AN	0 - 100 psia	150 psia	99.0 mV	100 mV	101.0 mV
SCX100DN	0 - 100 psid	150 psid	99.0 mV	100 mV	101.0 mV
SCX150DN	0 - 150 psid	150 psid	89.0 mV	90 mV	91.0 mV

Maximum ratings (for all devices)

Supply voltage V_S	+20 V_{DC}
Common-mode pressure	50 psig
Lead temperature (soldering, 4 seconds)	250°C

Environmental specifications (for all devices)

Temperature range	
Compensated	0 to 70°C
Operating	-40°C to +85°C
Storage	-55°C to +125°C
Humidity limits (no condensation)	0 to 99 %RH

COMMON PERFORMANCE CHARACTERISTICS[1]

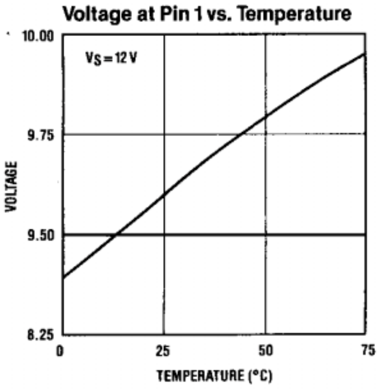
Characteristic	Min.	Typ.	Max.	Unit
Zero pressure offset[12]	-300	0	+300	µV
Combined linearity and hysteresis[4]	---	±0.1	±0.5	%FSO
Temperature effect on span (0 - 70°C)[5]	---	±0.2	±1.0	%FSO
Temperature effect on offset (0 - 70°C)[5]	---	±100	±500	µV
Repeatability[6]	---	±0.2	±0.5	%FSO
Input impedance[7]	---	4.0	---	kΩ
Output impedance[8]	---	4.0	---	kΩ
Common-mode voltage[9]	5.8	6.0	6.2	V_{DC}
Response time[10]	---	100	---	µsec
Long term stability of offset and span[11]	---	±0.1	---	mV

Specification notes:

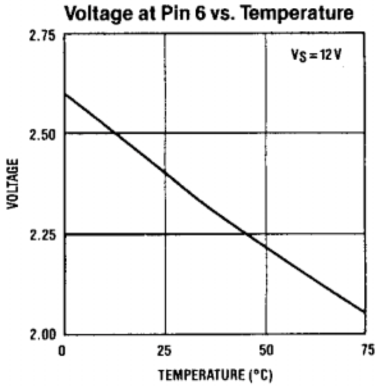
1. Reference conditions: unless otherwise noted: supply voltage, V_S = 12 V, T_A = 25°C, common-mode line pressure = 0 psig, pressure applied to Port B. For absolute devices only, pressure is applied to Port A and the output polarity is reversed.
2. Maximum pressure above which causes permanent sensor failure.
3. Span is the algebraic difference between the output voltage at full-scale pressure and the output at zero pressure. Span is ratiometric to the supply voltage.
4. See Definition of Terms. Hysteresis - the maximum output difference at any point within the operating pressure range for increasing and decreasing pressure.
5. Maximum error band of the offset voltage and the error band of the span, relative to the 25°C reading.
6. Maximum difference in output at any pressure with the operating pressure range and temperature within 0°C to +50°C after:
   a) 1,000 temperature cycles, 0°C to +70°C
   b) 1.5 million pressure cycles, 0 psi to full-scale span
7. Input impedance is the impedance between pins 2 and 4.
8. Output impedance is the impedance between pins 3 and 5.
9. This is the common-mode voltage of the output arms (pins 3 and 5) for V_S = 12 V_{DC}.
10. Response time for a 0 psi to full-scale span pressure step change, 10 % to 90 % rise time.
11. Long term stability over a one year period.
12. Maximum zero pressure offset for absolute devices is 0 ±500 µV.

TYPICAL PERFORMANCE CHARACTERISTICS

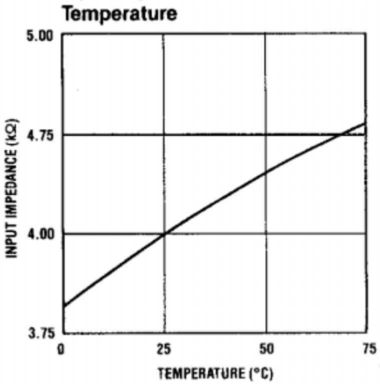
Voltage at Pin 1 vs. Temperature



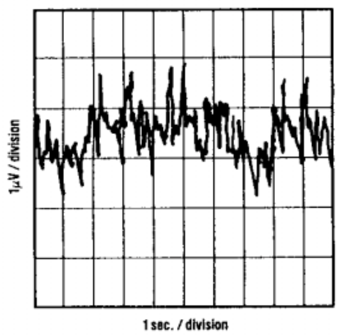
Voltage at Pin 6 vs. Temperature



Input Impedance vs. Temperature



0.1 Hz to 10 Hz Noise



GENERAL DISCUSSION

The SCX series devices give a voltage output which is directly proportional to applied pressure. The devices will give an increasing positiv going output when increasing pressure is applied to pressure port P_B of the device. If the input pressure connections are reversed, the output will increase with decreases in pressure. The devices are ratiometric to the supply voltage and changes in the supply voltage will cause proportional changes in the offset voltage and full-scale span. Since for absolute devices pressure is applied to port P_A, output polarity will be reversed.

User calibration

The SCX devices are fully calibrated for offset and span and should therefore require little if any user adjustment in most applications. For precise span and offset adjustments, refer to the applications section herein.

Vacuum reference (absolute device)

Absolute sensors have a hermetically sealed vacuum reference chamber. The offset voltage on these units is therefore measured at vacuum, 0 psia. Since all pressure is measured relative to a vacuum reference,all changes in barometric pressure or changes in altitude will cause changes in the device output.

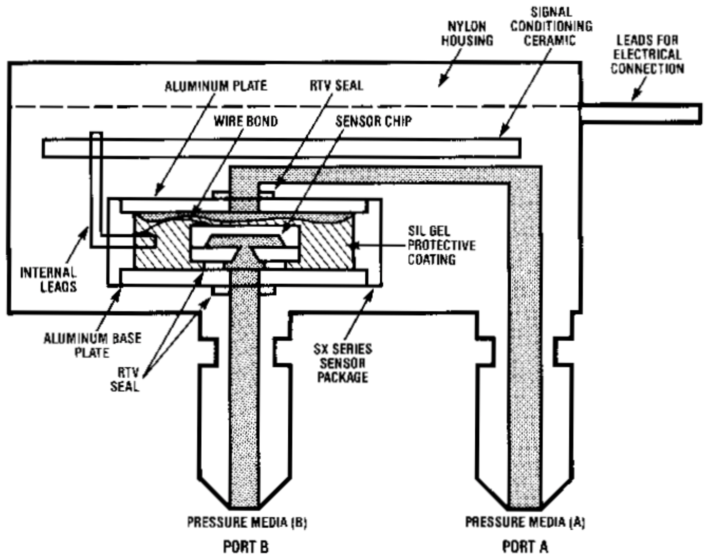
Media compatibility

SCX devices are compatible with most non-corrosive gases. Because the circuit 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, plastic, aluminium, RTV, silicon, and glass for use with Port B. For questions concerning media compatibility, contact the factory.

MECHANICAL AND MOUNTING CONSIDERATIONS

The SCX nylon housing 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 SCX sensors have two (2) tubes available for pressure connection. For absolute devices, only port P_A is active. Applying pressure through the other port will result in pressure dead ending into the backside of the silicon sensor and the device will not give an output signal with pressure.

For gage applications, pressure should be applied the port P_B. Port P_A is then the vent port which is left open to the atmosphere. For differential pressure applications, to get proper output signal polarity, port P_B should be used as the high pressure port and P_A should be used as the low pressure port.



Physical construction (cutaway diagram) (not drawn to scale)

APPLICATION INFORMATION

The following circuits show some typical designs using the SCX series sensors. For specific applications information or assistance, please contact your nearest Sensym sales office or the Sensym factory.

Low pressure applications

For sensing pressures below 1 psi, the circuit shown in Figure A uses the SCX01DN to provide a 2 to 5 V output for a 0 to 10 inch of water column input pressure. This output signal is compatible with many A/D converters and hence can be used to interface to a microprocessor system. This low-cost circuit is easily adaptable to lower full-scale pressures down to 5 inches of water column.

Circuit description

The LM10 is used to provide a voltage reference for the excitation voltage (V_E), and for the voltage node V_{REF}. With this configuration, V_E and V_{REF} are not affected by noise or voltage variations in the 12 V power supply. R_3 is used to adjust V_{REF} to set the initial offset voltage at the output, V_{OUT}.
The pressure signal, V_{IN}, is amplified by amplifiers B_1, and B_2 (see Sensym Application Note SSAN-17A for details on this amplifier) R_2 is used to adjust the signal gain of the circuit. The output equation is given below.

$$V_{OUT} = V_{IN} \; [\; 2 (1+ {}^{R}/_{R1})]+V_{REF}$$

For the best circuit performance, a careful selection of components in necessary. Use wirebound pots of insure low temperature coefficients and low longterm drift. A five-element resistor array (10kΩ) SIP should be used for the resistors in the amplifier stage in order to obtain closely matched values and temperature coefficients. All other resistors should be 1% metal film. Amplifiers B_1, and B_2 should have low offset voltage and low noise. Signal lines should be as short as possible and the power supply should be capacitively bypassed on the PC board.

Adjustment procedure

1. With zero-pressure applied, adjust the offset adjust R_3, until V_{OUT} = 2.000 V
2. Apply full-scale pressure (10 in. W.C) to port B_1 and adjust the full-scale adjust R_2, so that V_{OUT} = 5.000 V.
3. Repeat procedure if necessary.

Medical applications

For blood pressure monitoring applications, the circuit shown in Figure B provides a 0.5 V to 3.5 V output for a 0 to 300 mm Hg input pressure. The circuit is easily calibrated and is not affected by changes in the voltage supply. Because 300 mm Hg is approximately 5.8 psi, an SCX05DN is used.

Circuit description

The circuit shown here in Figure B is very similar to that shown in Figure A. The internal 200 mV reference voltage of the LM10 is amplified to provide power to the sensor and to provide a voltage reference, V_{REF}. This allows the circuit to operate at a supply voltage between 5 and 20 volts without affecting performance of the circuit. By adjusting R_3, V_{REF} is used to set the initial zero-pressure voltage at V_{OUT}. The pressure signal, V_{IN}, is amplified by amplifiers B_1 and B_2. These amplifiers should be precision op amps with low offset voltages and high common-mode rejection. The signal gain is adjusted by R_2, and the overall equation for the output voltage is given by ,

$$V_{OUT} = V_{IN} \; [\; 2 (1+ {}^{R}/_{R1})]+V_{REF}$$

Adjustment procedure

1. With zero-pressure applied, adjust the offset adjust R_3, until V_{OUT} = 0.500 V
2. Apply full-scale pressure (300 mm Hg) to port B_1 and adjust R_2, until V_{OUT} = 3.500 V.
3. Repeat procedure if necessary.

APPLICATION INFORMATION (cont.)

Parallel A/D conversion

The SCX sensor can be easily interfaced to a microprocessor bus. Using an A/D converter, for a 0 to 1 psig input, the circuit in Figure C will provide an eight-bit parallel output which is proportional to applied pressure. The circuit allows for easy calibration and uses a single 5 V supply.

Circuit description

The output signal of the sensor is amplified by A_1, and A_2. The pot, in resistor R_1, can be adjusted to calibrate the gain of the circuit as shown in the following gain equation:

$$V_{OUT} = V_{IN} \quad 2\, [1+ {}^{R}/_{R1}]$$

By adjusting R_3, V_{IN} (-) on the A/D converter is used to adjust the initial offset voltage. A zener diode (LT1004) sets the initial input voltage and provides the reference voltage for the converter. The converter will output the maximum digital code when the A/D converter´s input voltage, V_{OUT}, is twice the zener voltage, minus 1 $^{1}/_{2}$ LSB. The A/D converter, as shown, is a free-running configuration where the binary output is updated continously*. The only requirement is that the WR and INTR must be momentarily grounded after power-up to ensure proper operation.

Adjustment procedure

1. With no pressure applied, adjust the offset pot R_3 until all bits are zero except the LSB, which should be switching between one and zero.
2. Apply full-scale pressure (1 psig) to port B, and adjust the full-scale pot R_2 until all bits are ones except the LSB which should be flickering between one and zero.
3. Repeat procedure if necessary.

* For timing specifications and bus interface, see the ADC0804 Datasheet from National Semiconductor.

Serial A/D conversion

The circuit shown in Figure D is similar to that shown in Figure C, except the output is bit serial. Also shown (under the dashed line) is a complimentary circuit for converting the serial output to a parallel output for simplified testing.

Circuit description

The three op amp configuration allows V_{OUT} to be at the same common-mode voltage as V_{IN}, and takes advantage of the excellent CMRR of the ADC0831. R_2 is used to adjust the gain of the amplifier such that

$$V_{OUT} = V_{IN} \quad 2\, [{}^{3}/_{2}+ {}^{2R}/_{R1}]$$

The A/D converter will output the maximum digital code when V_{OUT} is equal to the zener voltage minus 1 $^{1}/_{2}$ LSB. the initial offset of the circuit can be nulled out by adjusting pot R_3. The converter circuit requires only a clock and a chip select (CS) line in order to operate. As shown in Figure E, when CS goes low, the A/D converter will start a new conversion on the next rising edge of the clock. On the next falling edge of the clock, D_O will have a zero start bit. Then, starting with the MSB, the data out line (D_O) will provide the converted digital output during the next eight consecutive falling edges of the clock. The serial output can be read by using an oscilloscope, a microprocessor, or a simple serial-to-parallel converter as shown in Figure D.

Adjustment procedure

1. With zero-pressure, adjust R_3, until the output of the A/D converter is alternating between 00 and 01 (HEX).
2. Apply full-scale pressure (1 psig) to port B, and adjust R_4 unti l the digital output alternates between the FE to FF transition.
3. Repeat procedure if necessary.

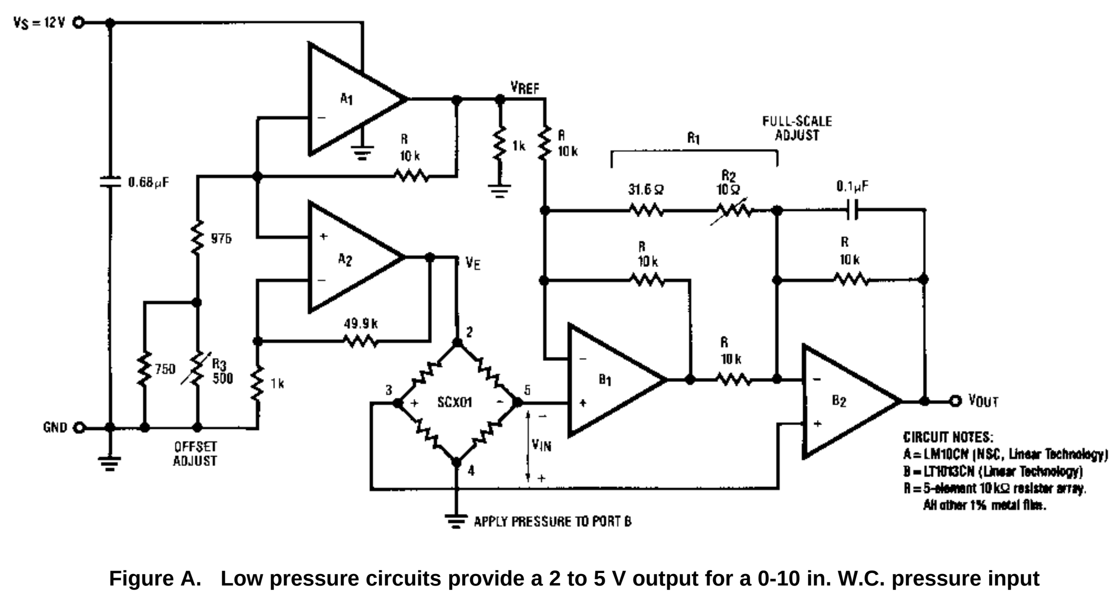


Figure A. Low pressure circuits provide a 2 to 5 V output for a 0-10 in. W.C. pressure input

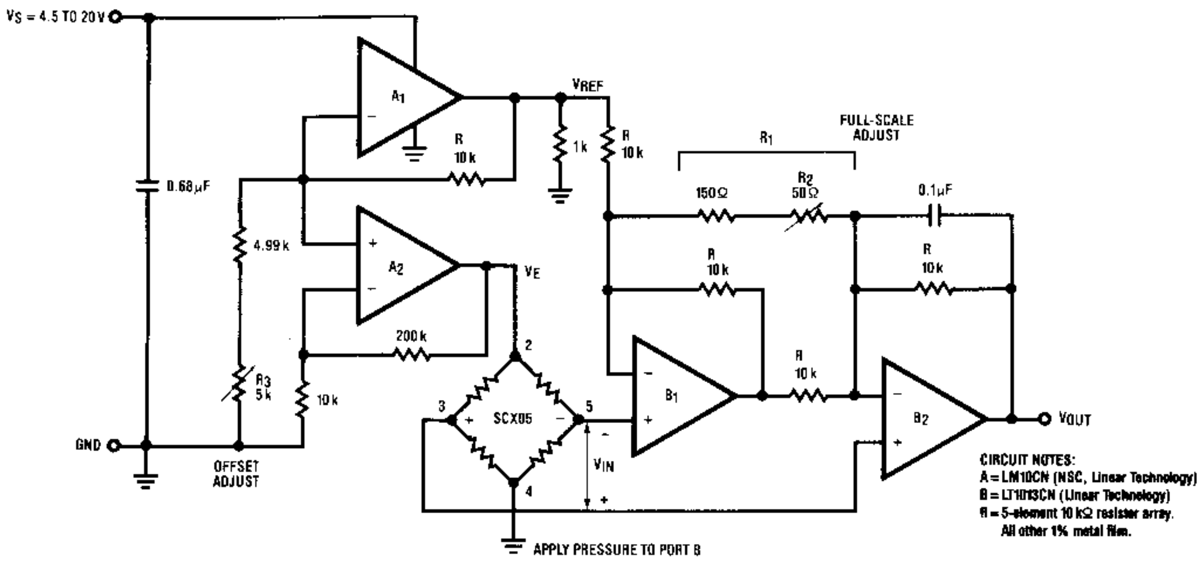


Figure B. Medical application circuit provide a 0.5 to 3.5 V output for a 0-300 mmHg pressure input

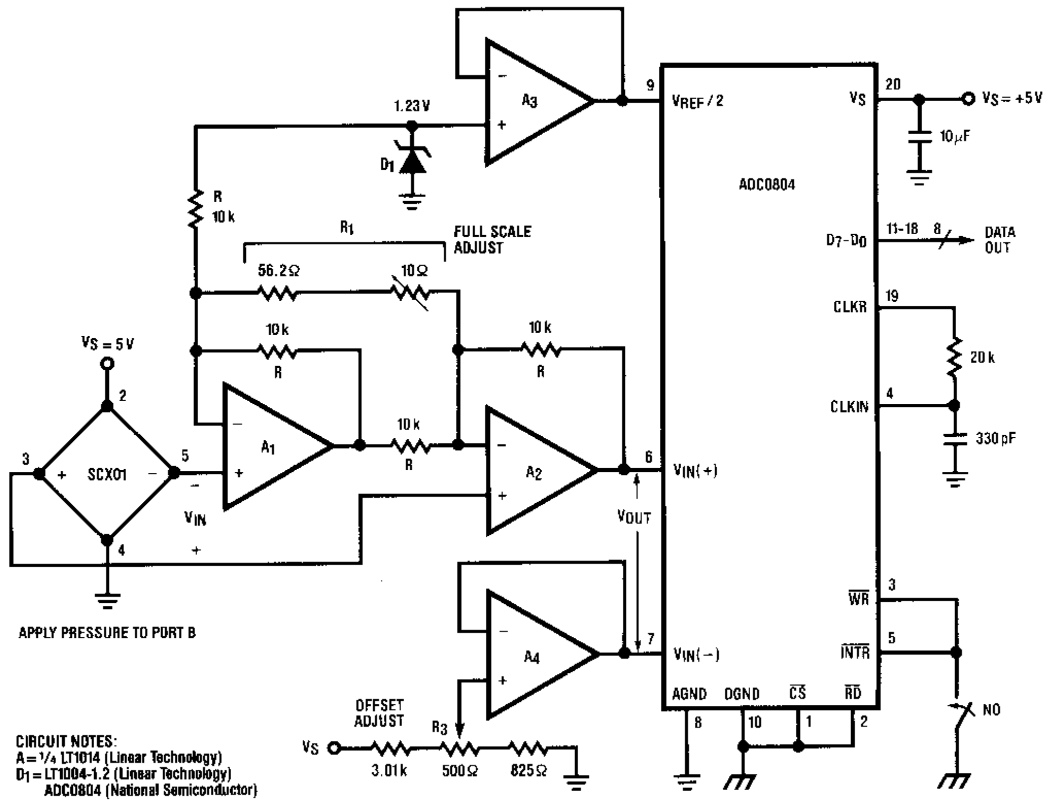


Figure C. A parallel A/D conversion circuit for 0-1 psig applications

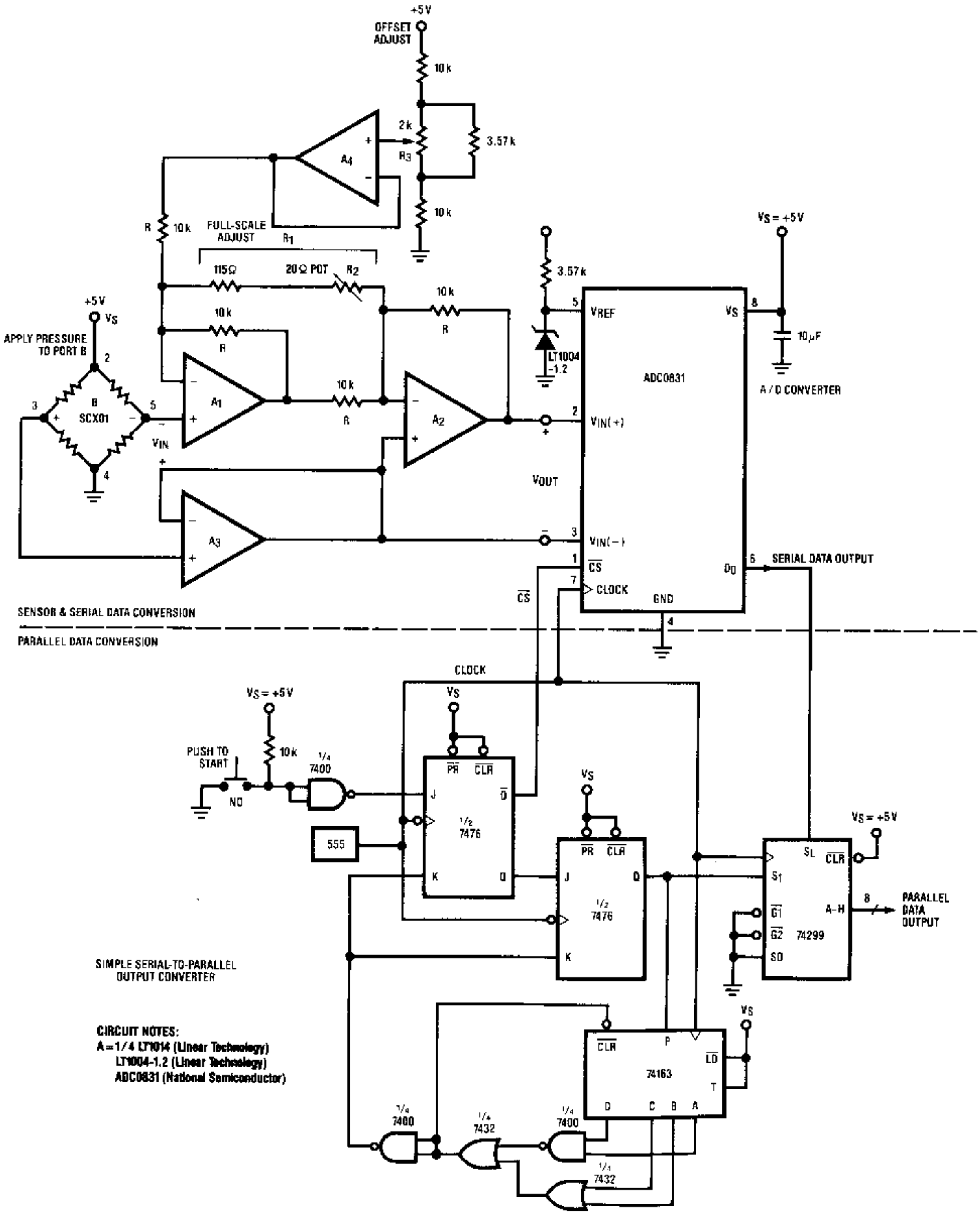


Figure D. Serial A/D conversion for 0-1 psig applications and simple test circuit

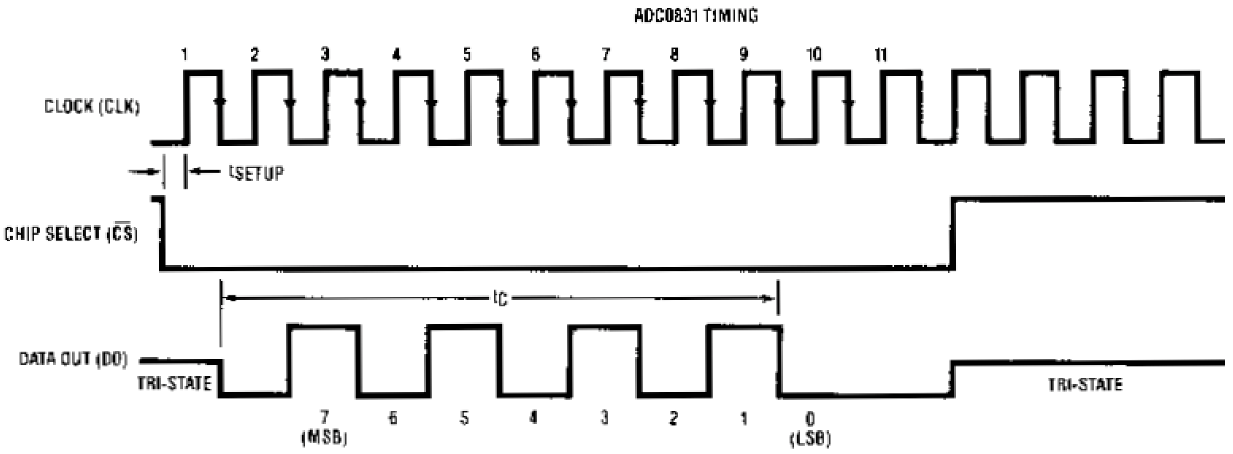


Figure E. Timing diagram

PRESSURE SWITCH

The circuit shown in Figure F is an example of using the SCX01D to make an accurate 0.5 psi switch. This design can be easily adapted to other pressure ranges by using higher pressure range SCX sensors.

Circuit description

Operating the SCX01D from 5V the sensor will have $^{5}/_{12}$ the sensitivity given on the SCX data sheet. The output at 0.5 psi will be 3.75 mV. Resistor R_4 sets the amplifier gain to 269 V/V. Zener D_1 biases the amplifier output voltage to 1.2 V with zero input pressure and amplifier A_2 swings from 1.2 V to 3.2 V for an input pressure from 0 to 1 psi. Resistors R_7 and R_8 provide 5 mV of hysteresis to comparator A_3 to ensure clean transitions for slow movins input signals. R_{11} sets the switch point for the comparator. Care must be taken when laying out the comparator circuit; lead lengths should be as short as possible.

Adjustment procedure

Apply 0.5 psi and adjust R_{11} until the output just switches from a high state (4.3 V) to a low state (0.0 V).

PORTABLE PRESSURE METER

The circuit shown in Figure G is a 0 to 200 millibar portable pressure meter. The 3 $^{1}/_{2}$ digit display will read 199.9 millibar full-scale. This circuit operates from a single 9 V battery and draws approximately 4.5 mA supply current. This will provide a typical battery life in excess of 100 hours. The minimum battery voltage is approximately 6.5 V. This meter provides resolution to 0.1 millibars. The same circuit can also be used for other pressure ranges simply by changing the sensor and gain.

Circuit description

The LM10CN (A_1) is used to generate a regulated 5 V supply to power the SCX05DN, amplifier A_2, and the ICL7106 Amplifier A_2 is a high input impedance diff-in,
diff-out amplifier. The sensor output is amplified to 200 mV full-scale for the A/D input. R_5 sets the gain to 14V/V for the values shown. The gain equation is:

$$A_V = 2\,(1 + {}^{R1}/_{R5})$$

R_4 is the zero adjust pot and R_8 provides the full-scale span adjustment. The voltage from pin 35 to pin 36 is approximately 100 mV when the display reads 199.9 millibar.

Component selection

The value of the components R_6-R_{10} and C_1-C_5 have been optimized for 200 mV full-scale (see the Intersil ICL7106 datasheet). R_4 and R_8 should be 15 turn cermet pots, R_6-R_{10} are metal film 1% resistors. C_3 the integrating capacitor should be polypropylene, the reference and auto zero capacitors can be polystrene or mylar, the clock capacitor, C_4, is mica.

Adjustment procedure

Apply 195 millibar to the meter and adjust R_8 until the display reads 195.0. Apply 0 psig and adjust R_4 until the display reads 000.0. Repeat if required.

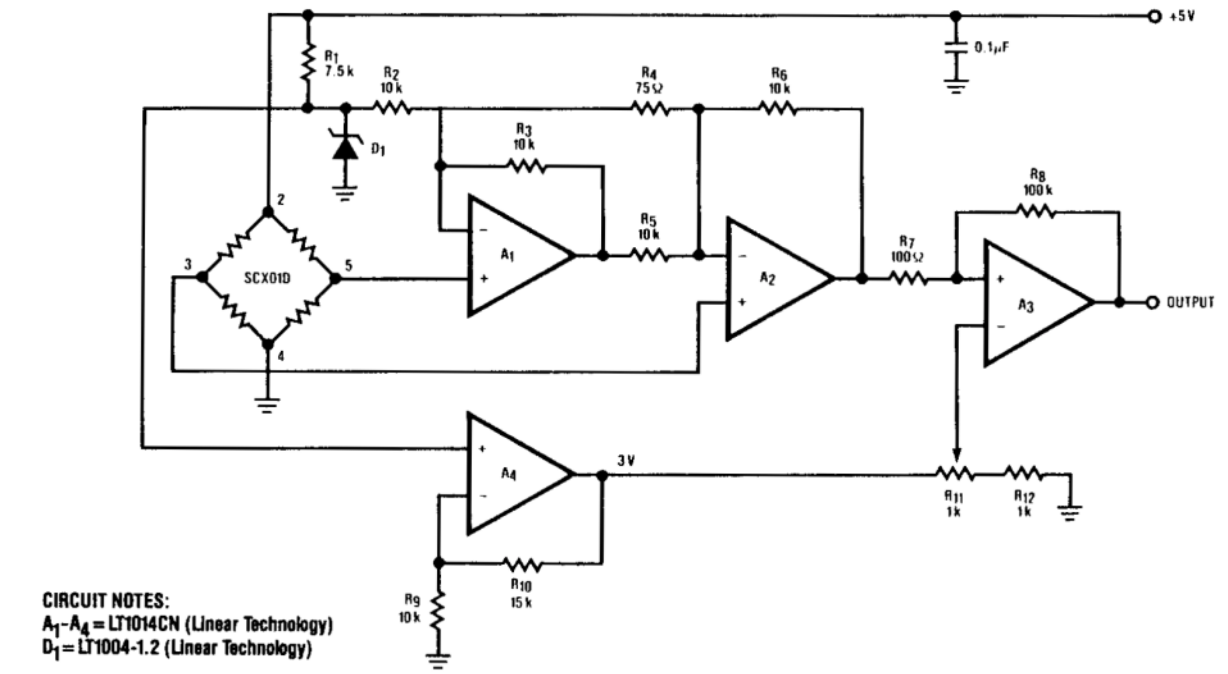


Figure F. 0.5 psi switch

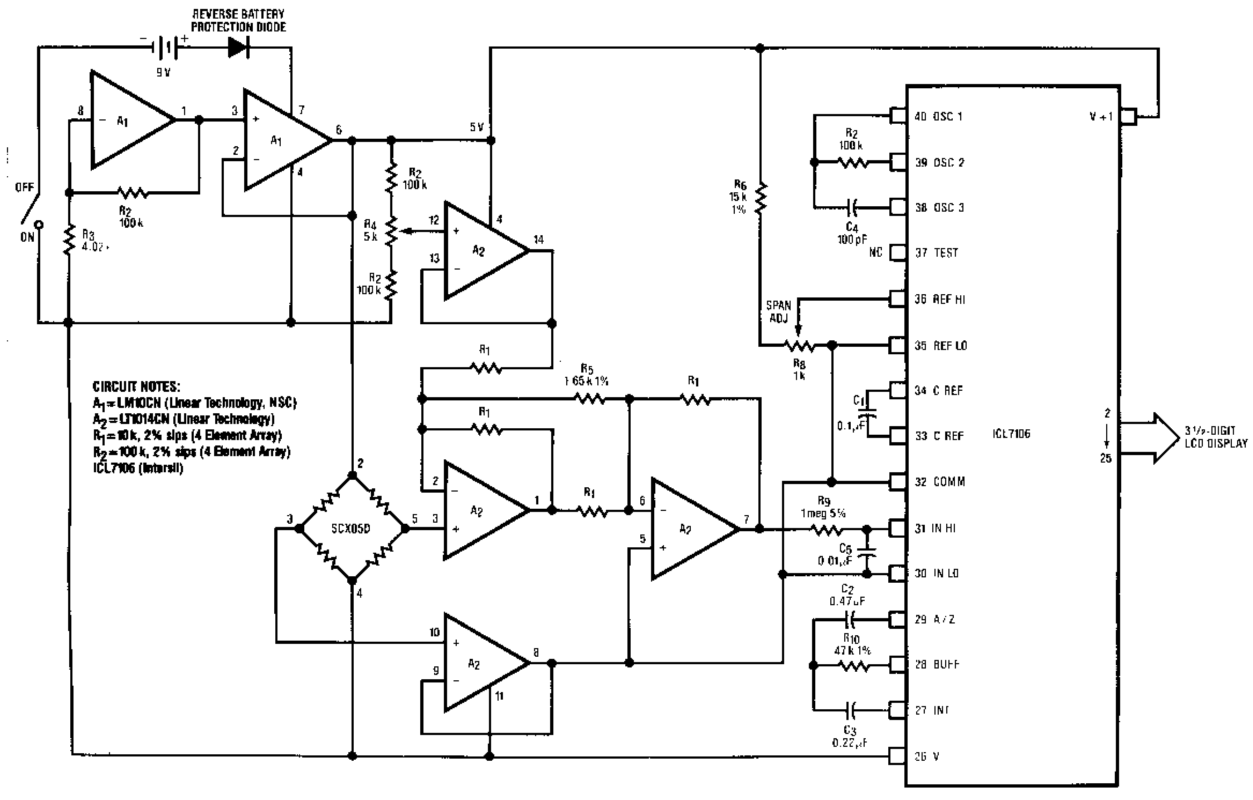
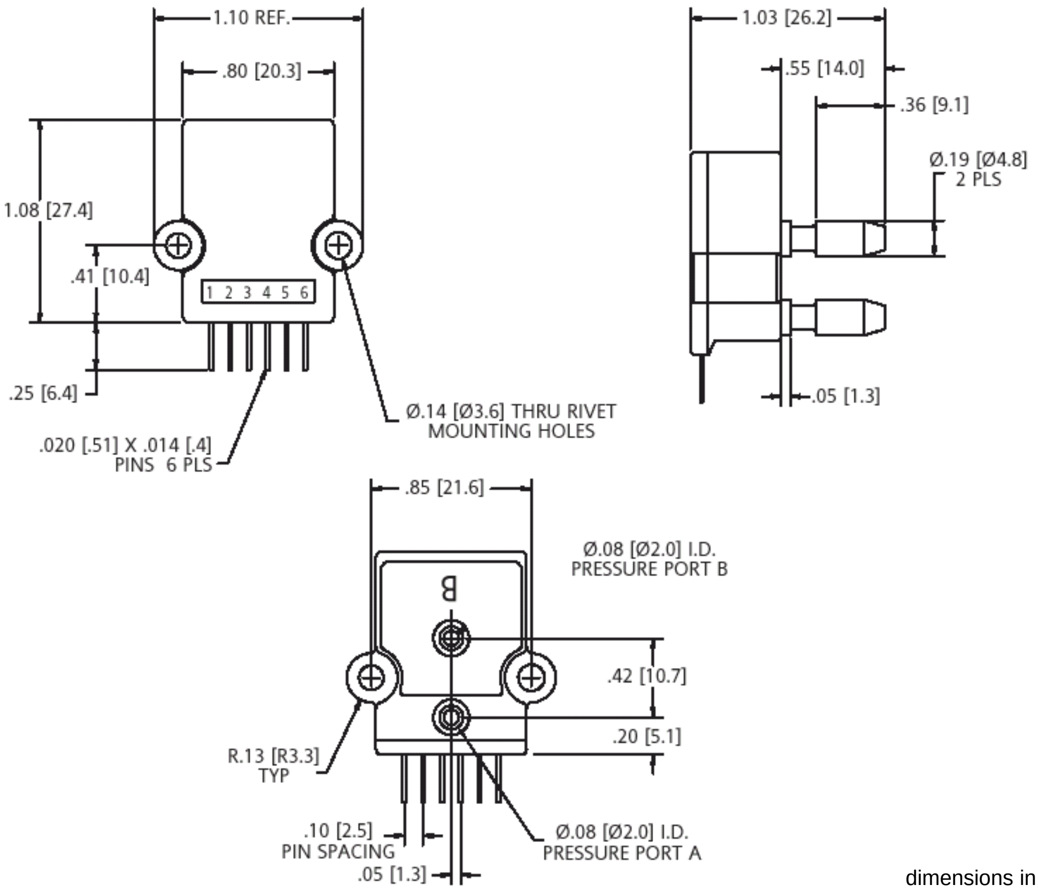


Figure G. 0 - 200 millibar meter.

PHYSICAL DIMENSIONS



mass: 10 g

dimensions in inches (mm)

ORDERING INFORMATION To order, use the following part number(s)

Description	Part number
0 to 1 psi differential/gage	SCX01DN
0 to 5 psi differential/gage	SCX05DN
0 to 15 psi absolute	SCX15AN
0 to 15 psi differential/gage	SCX15DN
0 to 30 psi absolute	SCX30AN
0 to 30 psi differential/gage	SCX30DN
0 to 100 psi absolute	SCX100AN
0 to 100 psi differential/gage	SCX100DN
0 to 150 psi differential/gage	SCX150DN

Mounting accessories	
Description	**Part number**
Xmas tree clip	SCXCLIP
6-pin right angle socket	SCXCNCT
Pressure tubing clamp	SCXSNP1