

INTRODUCTION

AV Sensors offers a diverse range of pressure transducers featuring low-level output, temperature compensation, and an integrated gain programming resistor. This laser-trimmed resistor precisely adjusts the gain of an external (customer-provided) amplifier, compensating for sensor pressure sensitivity variations. As a result, the amplifier's output remains consistent and independent of the sensor, enabling seamless interchangeability and cost-effective, high-level performance. This capability is available across our CHT-2 Series, CTO-X Series, CHT-SM56xx, and MIOF-xxx CC series with isolated diaphragms. For detailed specifications, please refer to the individual product data sheets.

BASIC CIRCUIT

The effective electrical model of the transducer, together with a basic signal conditioning circuit, is shown in Figure 1.

The pressure sensor is a fully active Wheatstone bridge which has been temperature compensated and offset adjusted by means of thick film, laser trimmed resistors. The excitation to the bridge is a constant current which is supplied through the +EX and -EX pins. The low-level bridge output is at +O and -O, and the amplified span is set by the gain programming resistor (r).

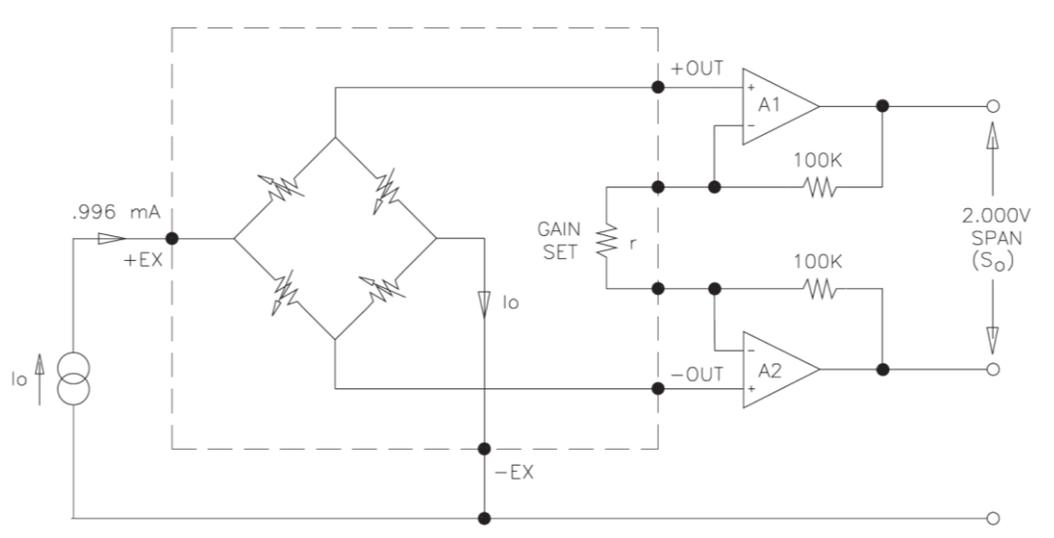


Figure 1 - Basic Configuration, Interchangeable Sensor using a Gain Resistor

Resistor r is laser trimmed for each unit using the following algorithm:

$$r = \frac{200S_i}{2-S_i} \quad [1]$$

Where: S_i - sensor span value (V) at a reference excitation current ($I_O = 0.996$ mA)

r - resistance in (k Ω)

The output span, S_o , at the differential output of amplifiers A1- A2 (see Figure 1) is then programmed as follows:

$$S_o = AS_i \left(\frac{r + 2R}{r} \right) = 2A \left[\frac{R}{100} + \frac{S_i(100-R)}{200} \right] \quad [2]$$

Where: $A = I / I_o$, ratio of excitation current I to reference current I_o (Figure 1)
 R - feedback resistors, in [k Ω]
 S_i - sensor span at the input of the amplifier

If 100k feedback resistors are used, the expression for output span is simplified to:

$$S_o = 2A \quad [3]$$

and is constant for all sensors independent of sensor span S_i . The output span is also independent of the pressure range of the sensor. For other values of the feedback resistors (R), the output span (S_o) will vary with the sensor span (S_i). Assuming $I = I_o$, we can calculate S_o variations.

Table 1. Output Span (S_o) Variation

R	$S_o(S_i=40 \text{ mV})$	$S_o(S_i=90 \text{ mV})$	S_o Variation [$\pm\%$]
50 K	1.0200	1.0450	1.23
75 K	1.5100	1.5225	0.41
99 K	1.9804	1.9809	0.01
100 K	2.0000	2.0000	0.00
101 K	2.0196	2.0191	0.01
200 K	3.9600	3.9100	0.63
500 K	9.8400	9.6400	1.02

As shown in Table 1, a large deviation from the optimum feedback resistance of 100 k can be tolerated while still maintaining transducer interchangeability. For the optimum feedback resistance (100 k), calibration accuracy is a function of the accuracy of the excitation current, feedback resistors and sensor trimming. The inaccuracy caused by the excitation current and feedback resistors can be made negligible by the use of precision components. Therefore without pressure testing, a 1% system accuracy can be achieved. The standard gain programming resistor, r , has a TCR 50 ppm/ $^{\circ}\text{C}$ and a trimming range of 2.5 to 12.5 k Ω . For volume orders, a custom trimming algorithm can be made to achieve any desired output span.

SIMPLE SIGNAL CONDITONING CIRCUIT

The signal conditioning circuit shown in Figure 2 provides a precision constant current source for sensor excitation and an instrumentation amplifier with the gain programmed by sensor feedback resistor r. To correct for pressure non-linearity or to generate output options other than 0-5V please refer to Technical Note AN-001, "Signal Conditioning Circuit, Popular Outputs using On Board Gain Adjust Circuitry"

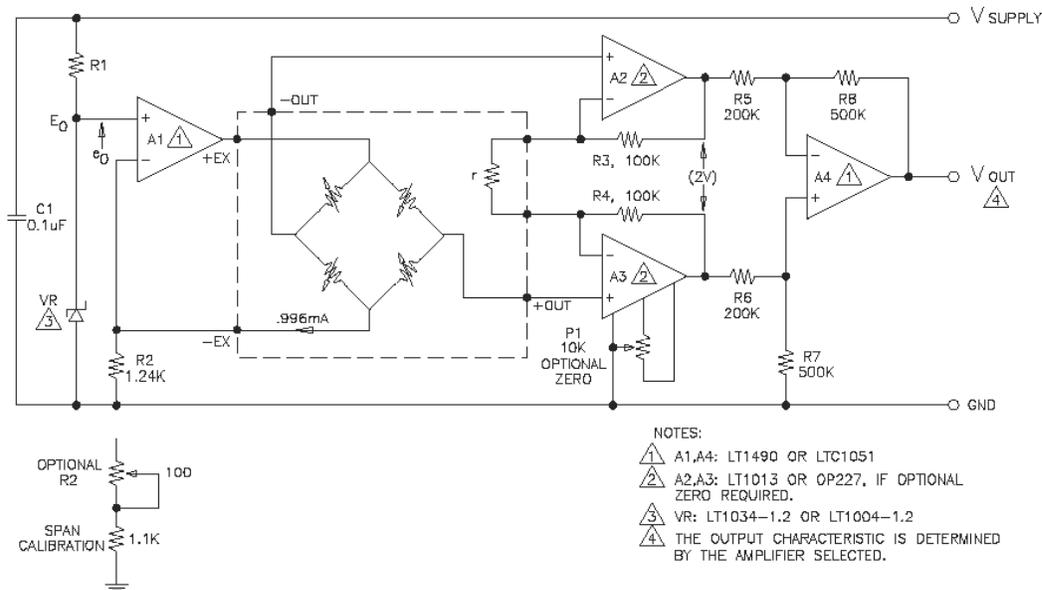


Figure 2 – Simple Signal Conditioning Circuit

The current source is controlled by the 1% band-gap reference diode, VR. The reference current I_O is defined by:

$$I_O = (E_O - e_o) / R_2 \quad [4]$$

Where: E_O - diode reference voltage: 1.235V \pm 1% (LT1034-1.2 or LT1004-1.2)

e_o - offset of amplifier A1 (\sim 0)

R2 - current set resistor

Selecting amplifier A1 with an offset voltage below 1 mV and a \pm 1% tolerance of resistor R delivers current $I_O = 0.996$ mA with a typical accuracy of 1.08%.

The first differential stage of the instrumentation amplifier A2-A3 may have a zeroing potentiometer (P).

For OP227 amplifiers, the zero range is typically 4 mV in reference to the input with a differential offset below 0.5 mV.

This leaves about 3.5 mV zeroing range for the compensation of the sensor offset which typically is below 1 mV.

The second stage of the amplifier provides additional amplification $R8/R5$ and translates the differential floating voltage from the first stage into a single ended output voltage. Modifying equation [3] the expression for overall span (S) can be found as follows:

$$S = 2 A \bullet R8/R5 = 5.000V @ A=1 \quad [5]$$

The overall accuracy of the span is effected by the accuracy of feedback resistors R3 through R8.

ACCURACY & CALIBRATION

Using 0.1% resistors such as Mepco/Electra 5063Z, a typical gain error will be about 0.24%. The accuracy error may be decreased when matched thin film resistors are used such as Beckman 694-3-A. The combined span error of the entire signal conditioning circuit at a reference temperature will then typically be about 1.1% without any adjustment or pressure testing. This will be superimposed on the sensor's accuracy of 1%.

OPTIONAL SPAN CALIBRATION

If additional calibration and normalization are desired, resistor R2 can be replaced with a series combination of a potentiometer and a resistor (Figure 2). The potentiometer can be adjusted to set the bridge excitation current (I) to achieve the exact span voltage (S) with full scale pressure applied to the sensor.

GAIN ERROR

If no pressure source is available, the gain error of the amplifier can be reduced by using the procedure outlined below. This method may be used instead of using the precision resistors discussed above for R2 through R8. The sensor span error of 1% will remain however.

Calibration procedure:

- Replace resistor r with an external resistor 7.50k Ω 0.1%
- Check gain K of the instrumentation amplifier and calculate the gain ratio X (in reference to the ideal gain KO = 69.028V/V) where $X = K/KO$
- Set current IO = 0.996/X(mA) by adjusting the potentiometer, thus completing calibration.