Pressure-Transducer Interfacing

Chapter 11

This chapter considers applications of pressure transducers. Many types of pressure transducer are interfaced electrically in a manner quite similar to temperature transducers (for example, those using bridges—similar to RTD bridges—and potentiometers—similar to linearized thermistors configured as potentiometers).

Furthermore, pressure measurements are often transmitted as 4-to-20mA currents, or read out by scanning DPM's, or isolated (for safety or to handle large common-mode voltages), using the same facilities as temperature measurements. In such cases, the treatment is abbreviated, and the reader is referred to the earlier chapters, where more-complete discussions may usually be found. In any event, the reader will find familiarity with the temperature-transducer-application chapters—and, indeed, the introductory chapters—to be helpful for this chapter and those that follow.

STRAIN-GAGE-BASED TRANSDUCERS

Figure 11-1 shows an instrumentation-amplifier approach to signal-conditioning the output of a strain-gage bridge. Excitation for the bridge and for the amplifiers is furnished by the 2B35 supply,* set for 10V at the *sense* terminals, which monitor the voltage directly across the bridge. This compensates for voltage drops in the excitation line.

The bridge output is read by an AD522 IC differential instrumentation amplifier, with a gain of 1000, to achieve a 0 to 10V

*The 2B35 has a ±15V dual output, for amplifiers and electronic peripherals, and a programmable voltage or current output for transducer excitation. Input is at mains voltage and frequency.

output for zero to 100psi at the pressure transducer. Since the pressure is not expected to change rapidly in this application, a 10-second unit-lag filter is used for noise reduction, unloaded by a follower-connected AD542J FET-input op amp.

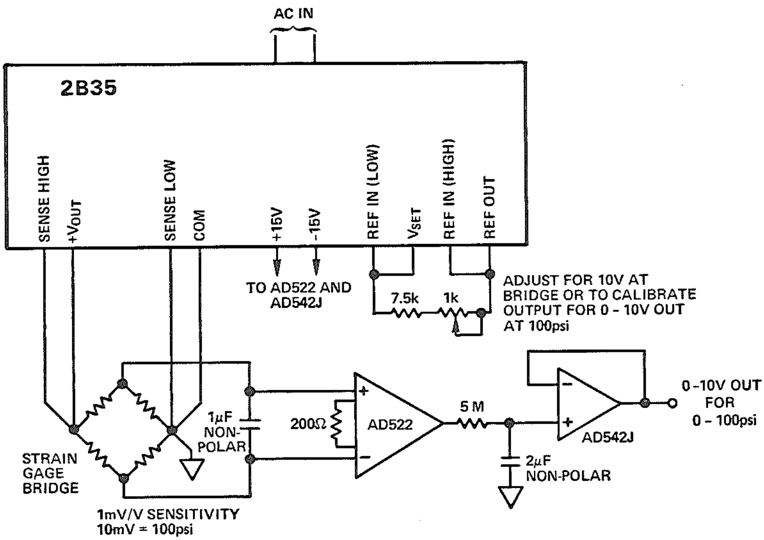


Figure 11-1. Pressure measurement interface with strain-gage bridge

The choice of AD522 grade depends on the ambient temperature range and the degree of resolution required. For example, the AD522A has a maximum offset drift of 6μV/°C, referred to the input, at a gain of 1000. If the ambient temperature in the vicinity of the AD522 can vary by ±20°C, the maximum drift would be about ±120μV, a little more than 1% of full scale. The AD522B would have a corresponding maximum drift of ±40μV, less than 0.5% of full scale. A 2B30 signal conditioner could have been used instead of the AD522 and the AD542, to provide a system solution.

Figure 11-2 shows the role of the 2B31 signal conditioner in interfacing a strain-gage pressure transducer (BLH Electronics, DHF Series). The 2B31 supplies regulated excitation (+10V) to the transducer and operates at a gain of 333.3 to achieve 0 to 10V output for 0 to 10,000psi at the pressure transducer.

The bridge-balance potentiometer is used to cancel out any offset which may be present, and the fine-span potentiometer adjustment is used to set the full-scale output accurately. A rapid check on

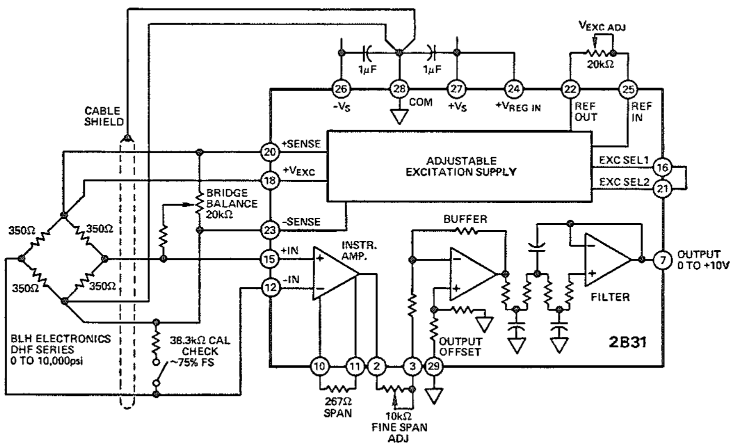


Figure 11-2. Pressure-transducer interface application using the 2B31 signal conditioner

system calibration can be obtained by depressing the *cal check* pushbutton switch, to shunt a calibration resistor across the bridge, which provides a reading of about 75% of full scale.

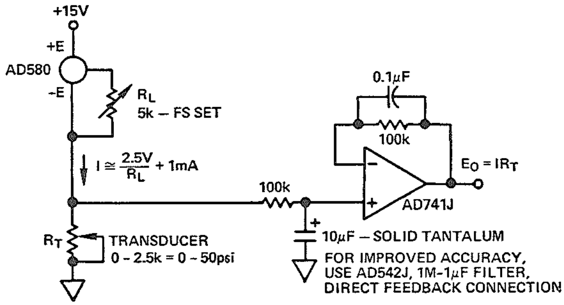
RHEOSTAT-OUTPUT PRESSURE TRANSDUCER

In transducers of this type, resistance is varied in proportion to pressure. If a constant current is caused to flow through the resistor, the voltage developed across it is proportional to pressure. The system-solution that can be implemented is to use the 2B31 to provide current excitation, amplification, and filtering, in the manner shown for RTD's in Figure 8-2.

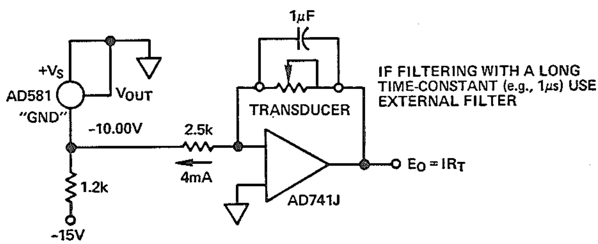
Some simple circuitry, employing IC's to perform similar functions, is shown in Figure 11-3. In a, the 2.5kΩ resistance element is furnished with current by an AD580 2.5V bandgap voltage reference connected as a current source ($I \cong \frac{2.5V}{R_L} + 1mA$).

Since V = I•R, the voltage across the resistor measures its resistance, hence the pressure. The voltage is filtered and unloaded by an output follower. For the values shown, if I = 2mA, E_O will be 5.0V full scale, corresponding to 10psi/V.

In b, an AD581 10V reference, connected as a –10V two-terminal "zener diode", furnishes a precise –10V at the input of an inverting op amp. The 2.5kΩ input resistor produces a feedback current of –4mA. The resistance element is connected in the feedback



a. Voltage reference as current source



b. Op amp as current source

Figure 11-3. Simple circuits for instrumenting rheostat-output pressure transducers

path, so that the output voltage is proportional to its resistance. In this case, for 2.5KΩ full-scale resistance, full-scale output voltage will be 10V, corresponding to 5psi/V.

The resistance element discussed here reads zero ohms for zero psi. If there were an offset, offsetting could be used as discussed in Chapter Five. Some filtering of noise is provided by the capacitor across the transducer. If additional filtering were desired, a single lag (or a more-complex filter) could be used, as discussed in Chapter Three.

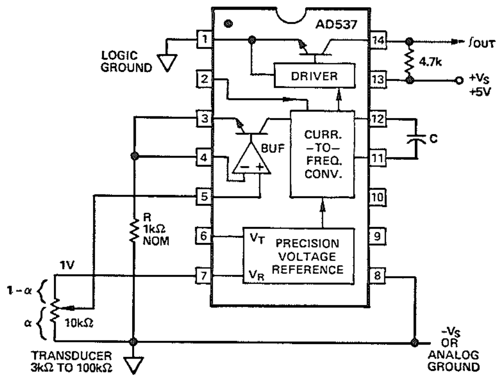
POTENTIOMETER-TO-FREQUENCY TRANSDUCER

A potentiometer-output pressure transducer can be read directly with a follower-connected op amp; it can be offset in a bridge configuration, as noted in earlier chapters. When used with the AD537 V/f converter, it will produce a pot-position-to-frequency conversion, in the form of a one-chip interface which can be powered by a single +5V supply.

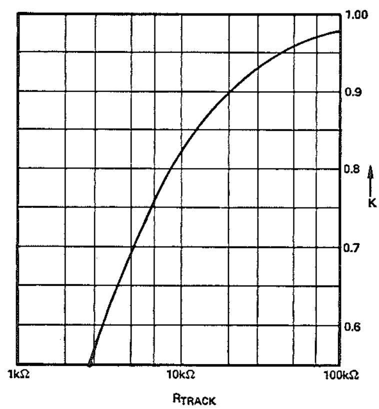
The circuit of such an interface is shown in Figure 11-4a. The pot receives its excitation from the AD537's one-volt reference, and the fractional output, α, is applied to the + input. Full-scale frequency, as noted earlier, depends on R and C, and a constant, K, which is a function of the loading on V_{REF}. For example, a 10kΩ pot will require a K-factor of 0.825, as the graph in b shows. The frequency equation is

$$f = \frac{K \circ \alpha}{10RC} \qquad (11.1)$$

where α is the fractional displacement of a potentiometer having a total resistance greater than 3kΩ.



a. Resistive-transducer-to-frequency interfacing



b. K-Factor versus load on V_R

Figure 11-4. Potentiometer-to-frequency transducer

As the equation indicates, with K = 0.825, R = 1kΩ, and C = 0.01μF, the nominal full-scale frequency (α = 1) is 8.25kHz. Polystyrene capacitors are preferred for tempco and dielectric absorption; polypropylene and Teflon are very good; polycarbonate or mica are acceptable; other types will degrade linearity. The capacitor should be wired as closely as possible to the AD537.

SCANNING PRESSURE METER

The AD2037 scanning digital voltmeter has already been discussed as a digital thermometer with RTDs and thermistors (Figures 8-6 and 9-7). Figure 11-5 shows how it is applied as a pressure meter. In this example, it furnishes excitation and 3 1/2-digit readout for a number of Data Instruments 0 to 100psi bridge-type pressure transducers. The meter's programmable gain and offset can be adjusted for a readout in any desired engineering units. The meter can scan automatically, manually or in an externally controlled random sequence.

The signal voltage appearing across the output leads of the transducer is a function of the applied pressure and the excitation voltage. The small residual offset voltage that is present at zero load can be nulled out using the zero-balance potentiometer. Transducer-span inaccuracies are calibrated via the span-adjust potentiometer. Since the front end of the AD2037 is differential,

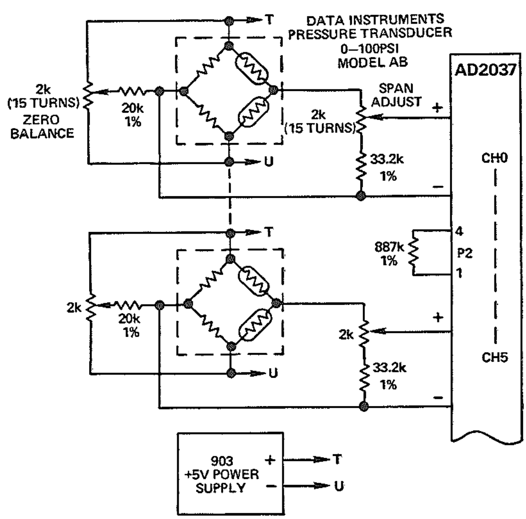


Figure 11-5. Multi-channel pressure meter

the difference measurement across the bridge will reject the 2.5V common-mode level, so long as analog ground is kept isolated from all parts of the pressure-transducer circuitry.

INTERFACING HIGH-LEVEL SEMICONDUCTOR TRANSDUCERS

The outputs of semiconductor transducers are high-level electrical signals that require little interfacing, except for offsetting and scaling. For example, the LX line of pressure transducers have a standardized output range of 2.5V to 12.5V corresponding to an input range from minimum pressure to maximum pressure.

Thus, any transducer in this family can be given a 0 to 10V range by subtracting 2.5V from the output. An AD580 and an analog subtractor is a low-cost approach (Figure 11-6a), requiring only four equal resistors. A summing inverter permits easy non-interacting offset and span adjustment, but inverts the input signal (b). Scale factors other than unity may be desirable if, for example, the 2.5V to 12.5V input is to be scaled to a 0 to 3V output to correspond to engineering units of 0 to 300psi (100psi/V).

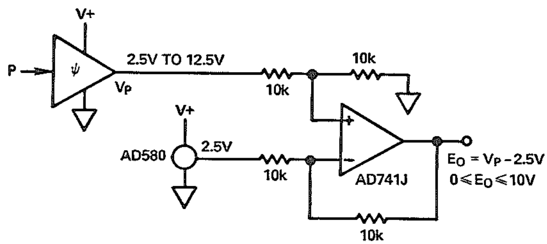
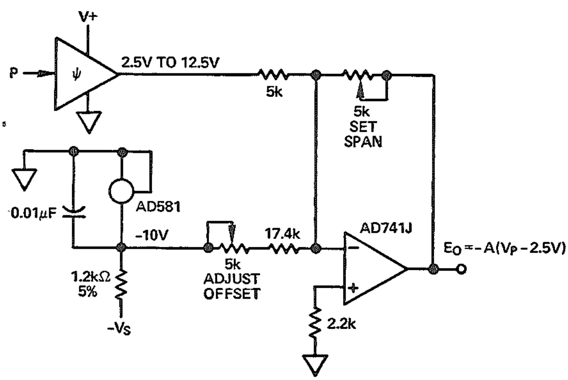
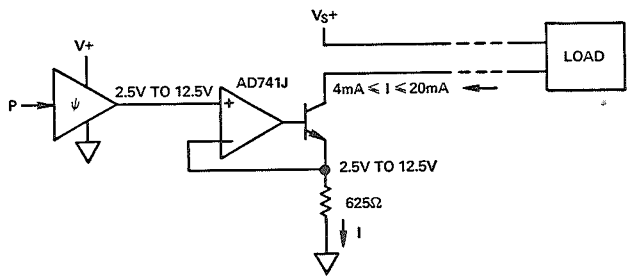


Figure 11-6a. Subtractor



b. Inverting amplifier

The 12.5/2.5 ratio of max to min nicely coincides with the 20/4 max-to-min ratio of current transmitters. Therefore, a simple voltage-to-current transducer without offset will provide the appropriate current range. One scheme is shown in essence in c.



c. Rudimentary 4-20mA current transmitter

Figure 11-6. Interfacing semiconductor pressure transducers

ISOLATED PRESSURE TRANSMITTERS

The output of a pressure transducer can be amplified to a standard voltage level and then transduced to current for transmission in standard 4-to-20mA (or other such) current loops. The 2B20 provides a useful facility for non-isolated loops, and the 2B22 provides as much as 1500V of dc isolation, as Figure 11-7 shows.

Here, the Model 2B22 is used to provide complete input-output isolation and avoid signal errors due to ground-loop currents. The process pressure is monitored by a strain-gage pressure transducer interfaced by a 2B30 signal conditioner; and excitation for the bridge, the signal conditioner, and the V/I converter is

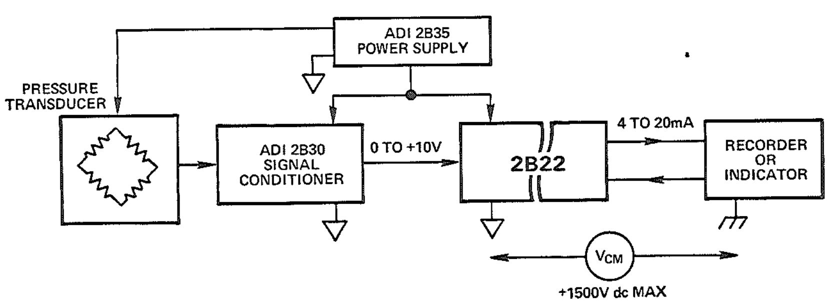


Figure 11-7. Isolated pressure transmitter

furnished by the 2B35 transducer power supply. The high-level voltage output of the 2B30 is converted to isolated 4-to-20mA current for transmission to a remote recorder or indicator.

PRESSURE-CONTROL SYSTEM

Figure 11-8 is a block diagram of a pressure-control system, showing how system-solution building blocks fit into a larger scheme. Here, the 3 to 15psi pressure in a tank is monitored by a strain-gage pressure transducer, interfaced with a 2B31 signal conditioner. The high-level voltage output of the 2B31 is converted to a 4-to-20mA current to provide a signal to the limit alarm and proportional control circuitry. A current-to-position converter controlling a motorized valve completes the pressure-control loop.

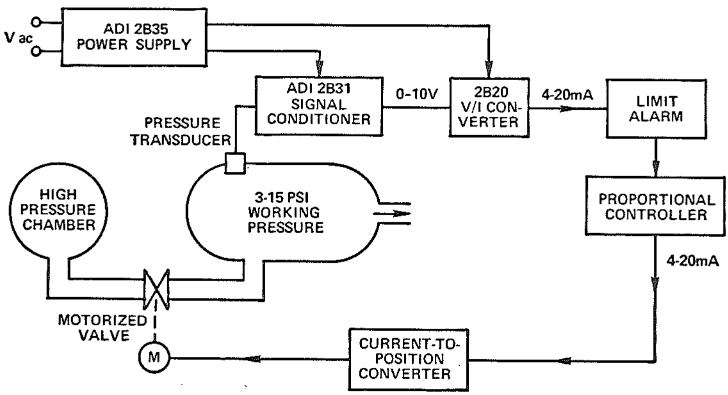


Figure 11-8. Proportional pressure control system