AN1303

A Simple 4-20 mA Pressure Transducer Evaluation Board

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INTRODUCTION

The two wire 4–20 mA current loop is one of the most widely utilized transmission signals for use with transducers in industrial applications. A two wire transmitter allows signal and power to be supplied on a single wire–pair. Because the information is transmitted as current, the signal is relatively immune to voltage drops from long runs and noise from motors, relays, switches and industrial equipment. The use of additional power sources is not desirable because the usefulness of this system is greatest when a signal has to be transmitted over a long distance with the sensor at a remote location. Therefore, the 4 mA minimum current in the loop is the maximum usable current to power the entire control circuitry. An evaluation board designed to meet these requirements is shown in Figure 1. A description of this 4–20 mA Pressure Transducer Evaluation Board, as well as a summary of the information required to use it, are presented here.

Figure 2 is a block diagram of a typical 4–20 mA current loop system which illustrates a simple two chip solution to converting pressure to a 4–20 mA signal. This system is designed to be powered with a 24 Vdc supply. Pressure is converted to a differential voltage by the Motorola MPX7100 pressure sensor. The voltage signal proportional to the monitored pressure is then converted to the 4–20 mA current signal with the Burr–Brown XTR101 Precision Two–Wire Transmitter. The current signal can be monitored by a meter in series with the supply or by measuring the voltage drop across R_L. A key advantage to this system is that circuit performance is not affected by a long transmission line.

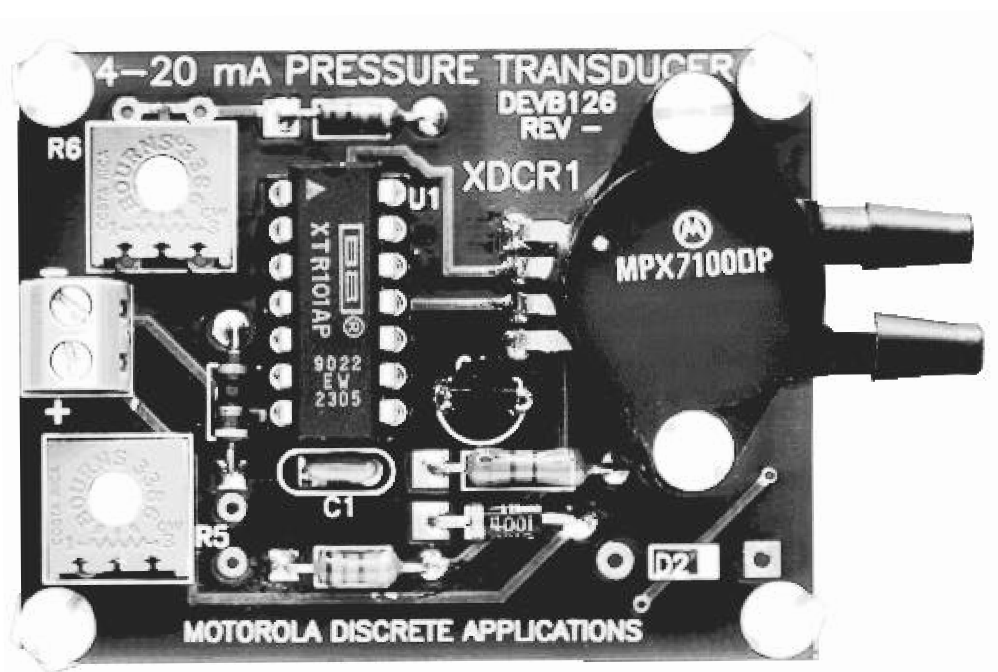

Figure 1. 4–20 mA Pressure Transducer Evaluation Board

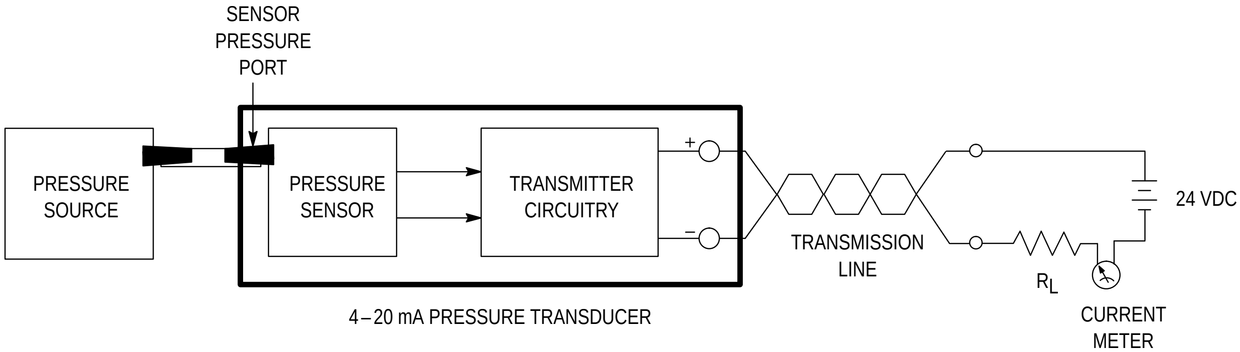

Figure 2. System Block Diagram

INPUT TERMINALS

A schematic of the 4–20 mA Pressure Transducer Evaluation Board is shown in Figure 3. Connections to this evaluation board are made at the terminals labeled (+) and (–). Because this system utilizes a current signal, the power supply, the load and any current meter must be put in series with the (+) to (–) terminals as indicated in the block diagram.

The load for this type of system is typically a few hundred ohms. As described above, a typical use of a 4–20 mA current transmission signal is the transfer of information over long distances. Therefore, a long transmission line can be connected between the (+) and (–) terminals on the evaluation board and the power supply/load.

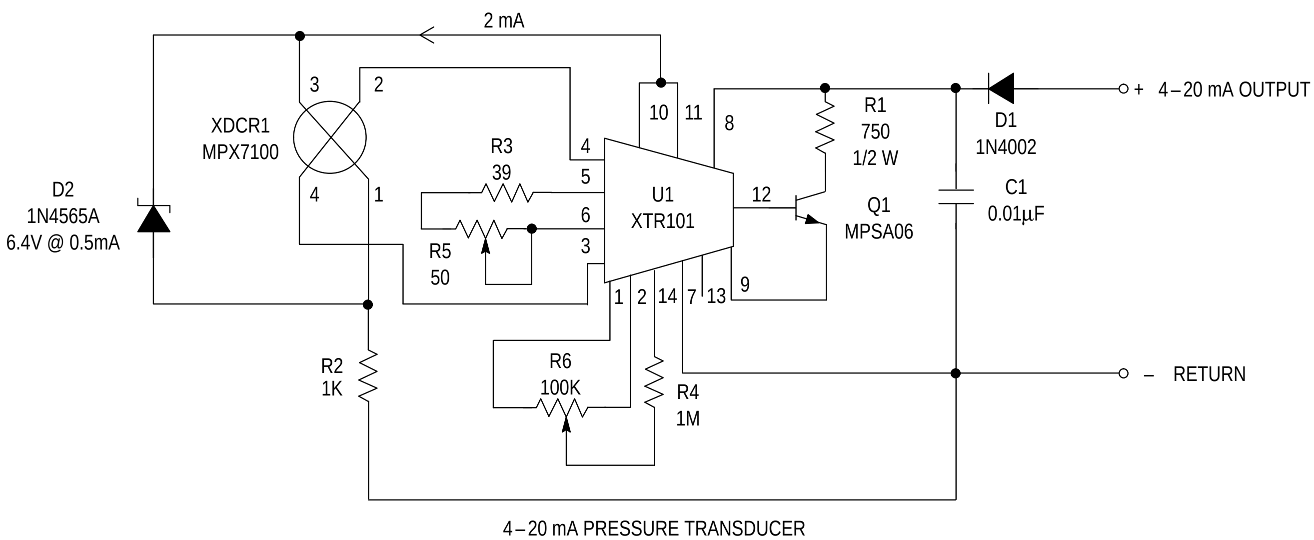

Figure 3. Schematic Diagram

PRESSURE INPUT

The device supplied on this evaluation board is an MPX7100DP, a high impedance (10 kΩ typ) 15 PSI sensor which provides two ports. P1, the positive pressure port, is on top of the sensor and P2, the vacuum port, is on the bottom of the sensor. The system can be supplied up to 15 PSI of positive pressure to P1 or up to 15 PSI of vacuum to P2 or a differential pressure up to 15 PSI between P1 and P2. Any of these pressure applications will create the same results at the sensor output.

CIRCUIT DESCRIPTION

The XTR101 current transmitter provides two one–milliamp current sources for sensor excitation when its bias voltage is between 12 V and 40 V. The MPX7100 series sensors are constant voltage devices, so a zener, D2, is placed in parallel with the sensor input terminals. Because the MPX7100 series parts have a high input impedance the zener and sensor combination can be biased with just the two milliamps available from the XTR101.

The offset adjustment is composed of R4 and R6. They are used to remove the offset voltage at the differential inputs to the XTR101. R6 is set so a zero input pressure will result in the desired output of 4 mA.

R3 and R5 are used to provide the full scale current span of 16 mA. R5 is set such that a 15 PSI input pressure results in the desired output of 20 mA. Thus the current signal will span 16 mA from the zero pressure output of 4 mA to the full scale output of 20 mA. To calculate the resistor required to set the full scale output span, the input voltage span must be defined. The full scale output span of the sensor is 24.8 mV and is ΔV_{IN} to the XTR101. Burr–Brown specifies the following equation for R_{span}. The 40 and 16 mΩ values are parameters of the XTR101.

$$R_{span} = 40 / \left[(16\ \text{mA} / \Delta\text{Vin}) - 0.016\ \text{mhos} \right]$$
$$= 64\ \Omega$$

The XTR101 requires that the differential input voltage at pins 3 and 4, V2 – V1 be less than 1V and that V2 (pin 4) always be greater than V1 (pin 3). Furthermore, this differential voltage is required to have a common mode of 4–6 volts above the reference (pin 7). The sensor produces the differential output with a common mode of approximately 3.1 volts above its reference pin 1. Because the current of both 1 mA sources will go through R2, a total common mode voltage of about 5.1 volts (1 kΩ x 2 mA + 3.1 volts = 5.1 volts) is provided.

The printed circuit layout and the component layout for the evaluation board are shown in Figures 4a–4c. Table 1 is the parts list for the evaluation board. Some extra pads and the labels R7 and R8 were provided on the board to allow replacement of the variable resistors with fixed resistors R5 and R6 and select–in–test resistors R7 and R8 for particular applications.

OTHER CONSIDERATIONS

The 4–20 mA Pressure Transducer Evaluation Board has been designed to demonstrate the performance of the Motorola MPX7100 pressure sensor in conjunction with a 4–20 mA current transmitter. Several design considerations should be considered when actually optimizing for an application.

1. The optional external transistor, Q1, is recommended by Burr–Brown to increase accuracy by reducing temperature change inside the XTR101 package as the output current spans from 4 mA to 20 mA. Also for power supply voltages above 24 V, the 750 Ω 1/2W resistor, R1, is recommended to limit the power dissipation in the MPSA06 to below its 625 mW rating.
2. Keeping lead lengths short in the portion of the circuit where the span adjust and zero adjust resistors connect to the XTR101 is recommended to reduce noise pick–up and parasitic resistance.
3. C1 is a bypass capacitor and, therefore, should be connected across pins 7 and 8 of the XTR101 as close to the device as possible.

CALIBRATION

1. Connect the evaluation board as shown in the block diagram of Figure 2.
2. With no pressure connections to the sensor, adjust R6 so that I_{out} is 4 mA.
3. Supply 15 PSI to the sensor, (either positive pressure to the pressure port or vacuum to the vacuum port) and adjust R5 so that I_{out} is 20 mA.
4. You may need to repeat steps 2 and 3 to ensure proper calibration.

CONCLUSION

This circuit is an example of how the higher impedance MPX7000 series sensors can be utilized in an industrial application. It provides a simple design alternative where remote pressure sensing is required.

Table 1. Parts List for 4–20 mA Pressure Transducer Evaluation Board

Designator	Quantity	Description	Rating	Manufacturer	Part Number
	1	PC Board (see Figure 3)		Motorola	DEVB126
	1	Input/Output Terminals		PHX CONT	#1727010
	4	1/2″ standoffs, Nylon threaded			
	4	1/2″ screws, Nylon			
	2	5/8″ screws, Nylon			
	2	4–40 nuts, Nylon			
		Capacitor			
C1	1	0.01 µF	50 V		
		Diodes			
D1	1	100 V Diode	1 A		1N4002
D2	1	6.4 V Zener			1N4565A
		Transistor			
Q1	1	NPN Bipolar		Motorola	MPSA06
		Resistors, Fixed			
R1	1	750 Ω	1/2 W		
R2	1	1 kΩ			
R3	1	39 Ω			
R4	1	1 MΩ			
		Resistors, Variable			
R5	1	50 Ω, one turn		Bourns	#3386P–1–500
R6	1	100 KΩ, one turn		Bourns	#3386P–1–104
		Integrated Circuit			
U1	1	Two wire current transmitter		Burr–Brown	XTR101
		Sensor			
XDCR1	1	High Impedance	15 PSI	Motorola	MPX7100DP

NOTE: All resistors are 1/4 W with a tolerance of 5% unless otherwise noted. All capacitors are 100 volt, ceramic capacitors with a tolerance of 10% unless otherwise noted.

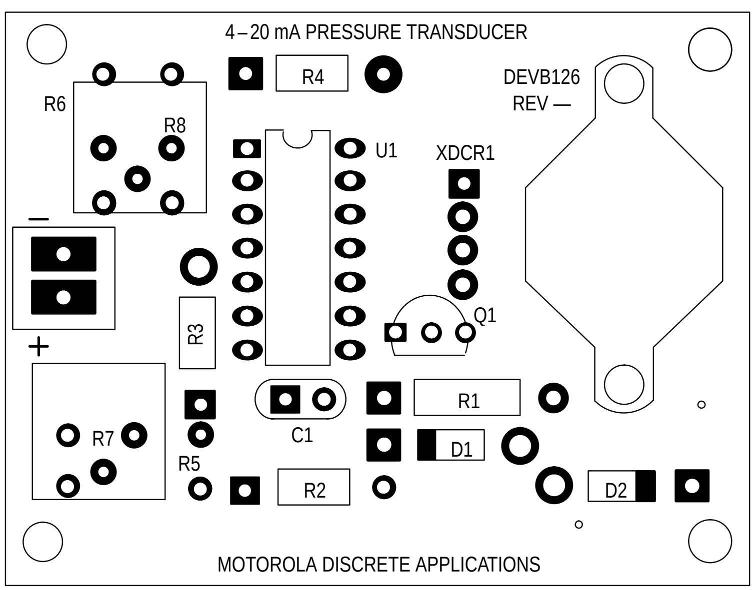

Figure 4a. Component Layout

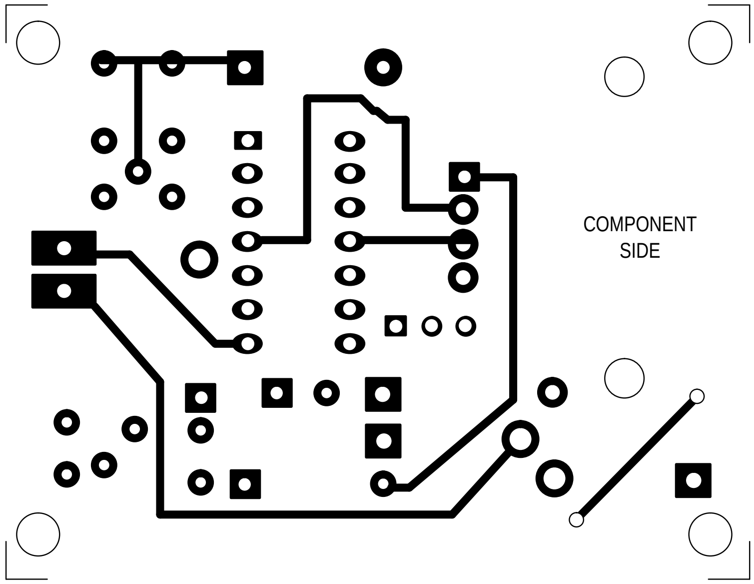

Figure 4b. Board Layout Component Side

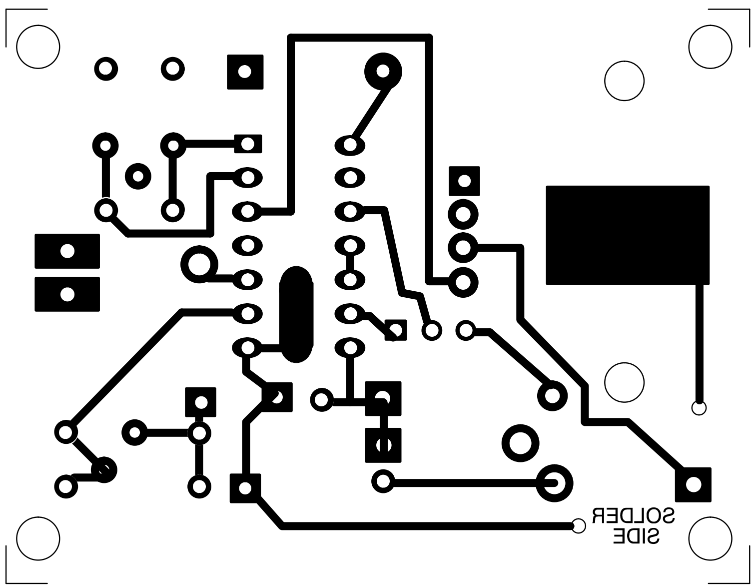

Figure 4c. Board Layout Solder Side

(With traces reversed for easy comparison to front side)

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