

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.

Figure 1 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 MPX5100 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.

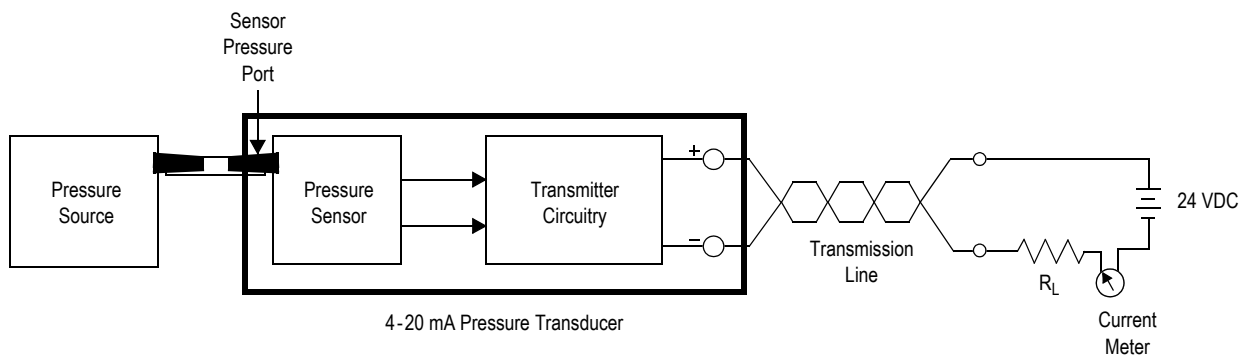


Figure 1. System Block Diagram

INPUT TERMINALS

A schematic of the 4-20 mA Pressure Transducer topology is shown in Figure 2. Connections to this topology 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.

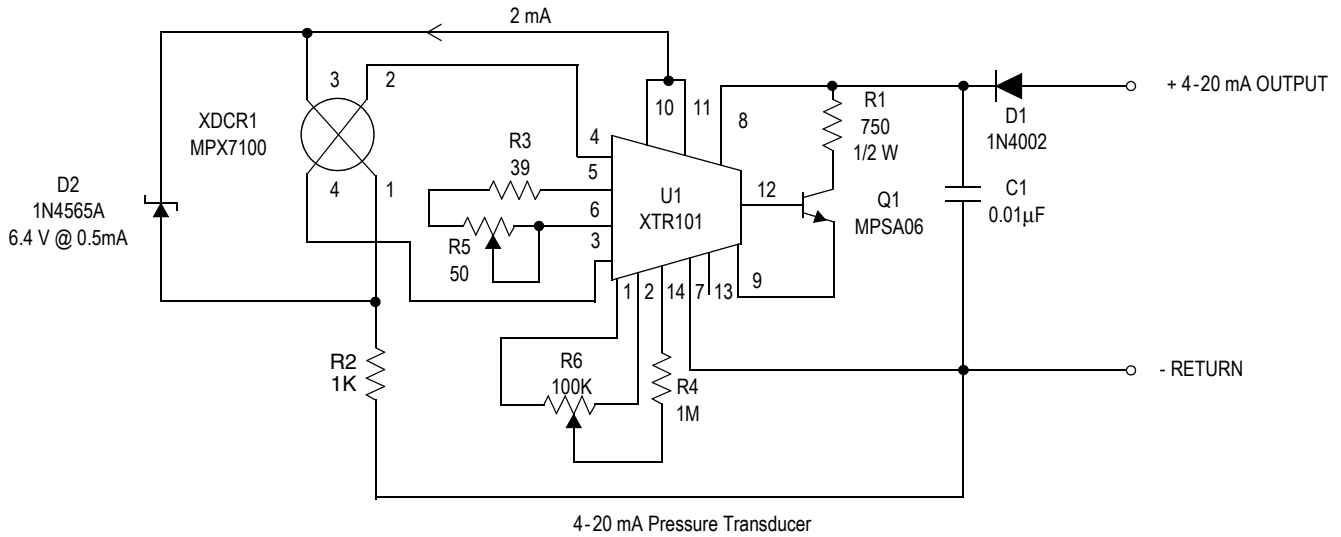


Figure 2. Schematic Diagram

PRESSURE INPUT

The device supplied on this topology is an MPX5100DP, 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 MPX5100 series sensors are constant voltage devices, so a zener, D2, is placed in parallel with the sensor input terminals. Because the MPX5100 series parts have a high 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 m Ω values are parameters of the XTR101.

$$\begin{aligned} R_{span} &= 40 / [(16 \text{ mA} / \Delta V_{in}) - 0.016 \text{ mhos}] \\ &= 64 \Omega \end{aligned}$$

The XTR101 requires that the differential input voltage at pins 3 and 4, $V_2 - V_1$ be less than 1V and that V_2 (pin 4) always be greater than V_1 (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 ($1 \text{ k}\Omega \times 2 \text{ mA} + 3.1 \text{ volts} = 5.1 \text{ volts}$) is provided.

CONCLUSION

This circuit is an example of how the MPX5000 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 | | Freescale | 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 | | | |
| C1 | 1 | Capacitor 0.01 μ F | 50 V | | |
| D1 | 1 | Diodes 100 V Diode | 1 A | | 1N4002 |
| D2 | 1 | 6.4 V Zener | | | 1N4565A |
| Q1 | 1 | Transistor NPN Bipolar | | Freescale | MPSA06 |
| R1 | 1 | Resistors, Fixed 750 Ω | 1/2 W | | |
| R2 | 1 | 1 k Ω | | | |
| R3 | 1 | 39 Ω | | | |
| R4 | 1 | 1 M Ω | | | |
| R5 | 1 | Resistors, Variable 50 Ω , one turn | | Bourns | #3386P-1-500 |
| R6 | 1 | 100 K Ω , one turn | | Bourns | #3386P-1-104 |
| U1 | 1 | Integrated Circuit Two wire current transmitter | | Burr-Brown | XTR101 |
| XDCR1 | 1 | Sensor High Impedance | 15 PSI | Freescale | MPX5100DP |

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.

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