

AN1082

Simple Design for a 4-20 mA Transmitter Interface Using a Motorola Pressure Sensor

Prepared by: Jean Claude Hamelain
Motorola Toulouse Application Lab Manager

INTRODUCTION

Pressure is a very important parameter in most industrial applications such as air conditioning, liquid level sensing and flow control.

In most cases, the sensor is located close to the measured source in a very noisy environment, far away from the receiver (recorder, computer, automatic controller, etc.)

The transmission line can be as long as a few hundred meters and is subject to electromagnetic noise when the signal is transmitted as voltage. If the signal is transmitted as a current it is easier to recover at the receiving end and is less affected by the length of the transmission line.

The purpose of this note is to describe a simple circuit which can achieve high performance, using standard Motorola pressure sensors, operational amplifiers and discrete devices.

PERFORMANCES

The following performances have been achieved using an MPX2100DP Motorola pressure sensor and an MC33079 quad operational amplifier. The MPX2100DP is a 100 kPa temperature compensated differential pressure sensor. The load is a 150 ohm resistor at the end of a 50 meter telephone line. The 15 volt power supply is connected at the receiver end.

Power Supply	+15 Vdc, 30 mA
Connecting Line	3 wire telephone cable
Load Resistance	150 to 400 Ohms
Temperature Range	-40 to +85°C (up to +125°C with special hardware)
Pressure Range	0 to 100 kPa
Total Maximum Error	Better than 2% full scale

Basic Circuit

The Motorola MPX2100DP pressure sensor is a very high performance piezoresistive pressure sensor. Manufacturing technologies include standard bipolar processing techniques with state of the art metallization and on-chip laser trim for offset and temperature compensation.

This unique design, coupled with computer laser trimming, gives this device excellent performance at competitive cost for demanding applications such as automotive, industrial or medical.

MC33078, 79 operational amplifiers are specially designed for very low input voltage, a high output voltage swing and very good stability versus temperature changes.

First Stage

The Motorola MPX2100 and the operational amplifier are directly powered by the 15 Vdc source. The first stage is a simple true differential amplifier made with both of the operational amplifiers in the MC33078. The potentiometer, R_G , provides adjustment for the output.

This first stage is available as a pressure sensor kit, SEK-1 (refer to EB130/D). If using the kit, the resistors must be changed according to the schematic below to provide a full 4-20 mA output.

Current Generator

The voltage to current conversion is made with a unity gain differential amplifier, one of the four operational amplifiers in an MC33079. The two output connections from the first stage are connected to the input of this amplifier through R3 and R5. Good linearity is achieved by the matching between R3, R4, R5 and R6, providing a good common mode rejection. For the same reason, a good match between resistors R8 and R9 is needed.

The MC33078 or MC33079 has a limited current output; therefore, a 2N2222 general purpose transistor is connected as the actual output current source to provide a 20 mA output.

To achieve good performance with a very long transmission line it may be necessary to place some capacitors (C1, C2) between the power supply and output to prevent oscillations.

Calibration

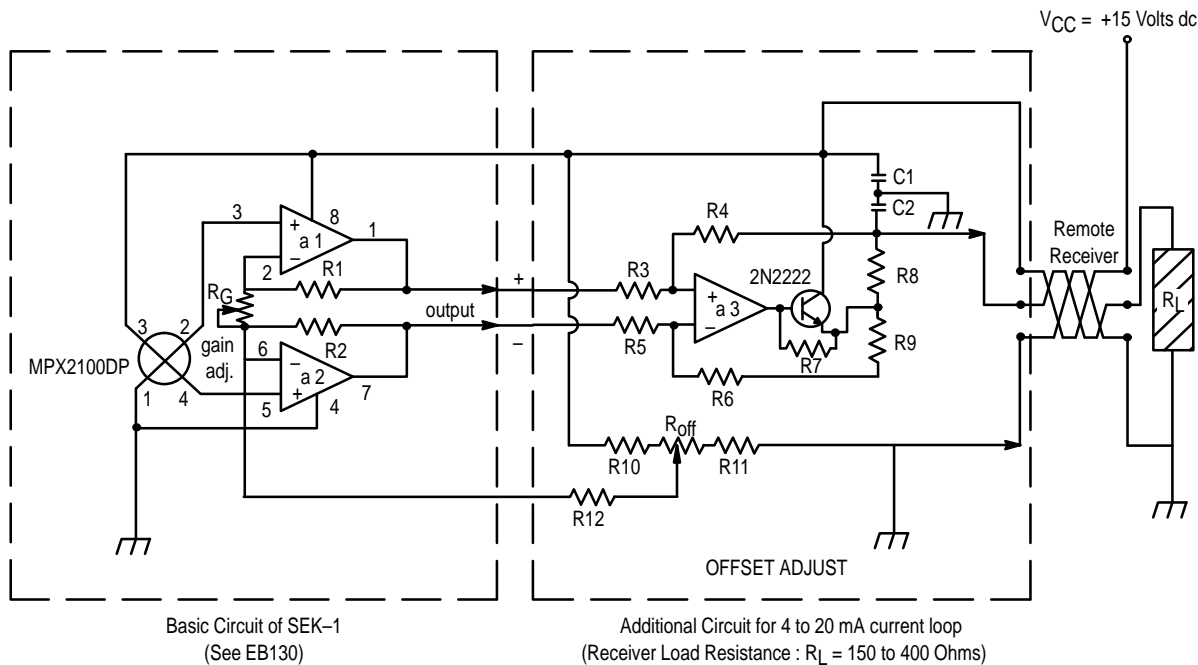
The circuit is electrically connected to the 15 Vdc power supply and to the load resistor (receiver).

The high pressure is connected to the pressure port and the low pressure (if using a differential pressure sensor), is connected to the vacuum port.

It is important to perform the calibration with the actual transmission line connected.

The circuit needs only two adjustments to achieve the 4-20 mA output current.

1. With no pressure (zero differential pressure), adjust R_{Off} to read exactly 4 mA on the receiver.
2. Under the full scale pressure, adjust R_G to exactly read 20 mA on the receiver. The calibration is now complete.



$R_G = 47$ K Pot. $R_7 = 1$ K
 $R_{off} = 1$ M Pot. $R_{10} = 110$ K
 * $R_1 = R_2 = 330$ K $R_{11} = 1$ M
 * $R_3 = R_4 = 27$ K $R_{12} = 330$ K
 * $R_5 = R_6 = 27$ K $C_1 = C_2 = 0.1$ μ F
 * $R_8 = R_9 = 150$ $a_1, a_2, a_3 = 1/4$ MC33079
 * All resistor pairs must be matched at better than 0.5%

Note A: If using SEK-1 $a_1, a_2, a_3 = 1/2$ MC33078
 R_G from 20 K to 47 K
 R_1 and R_2 from 1M to 330 K

NOTICE: THE PRESSURE SENSOR OUTPUT IS RATIO-METRIC TO THE POWER SUPPLY VOLTAGE. THE OUTPUT WILL CHANGE WITH THE SAME RATIO AS VOLTAGE CHANGE.

Figure 1. Demo Kit with 4–20 mA Current Loop

The output is ratiometric to the power supply voltage. For example, if the receiver reads 18 mA at 80 kPa and 15 V power supply, the receiver should read 16.8 mA under the same pressure with 14 V power supply.

For best results it is mandatory to use a regulated power supply. If that is not possible, the circuit must be modified by inserting a 12 V regulator to provide a constant supply to the pressure sensor.

When using a Motorola MC78L12AC voltage regulator, the circuit can be used with power voltage variation from 14 to 30 volts.

The following results have been achieved using an

MPX2100DP and two MC33078s. The resistors were regular carbon resistors, but pairs were matched at $\pm 0.3\%$ and capacitors were 0.1 μ F. The load was 150 ohms and the transmission line was a two pair telephone line with the +15 Vdc power supply connected on the remote receiver side.

Note: Best performances in temperature can be achieved using metal film resistors. The two potentiometers must be chosen for high temperatures up to 125°C.

The complete circuit with pressure sensor is available under reference TZA120 and can be ordered as a regular Motorola product for evaluation.

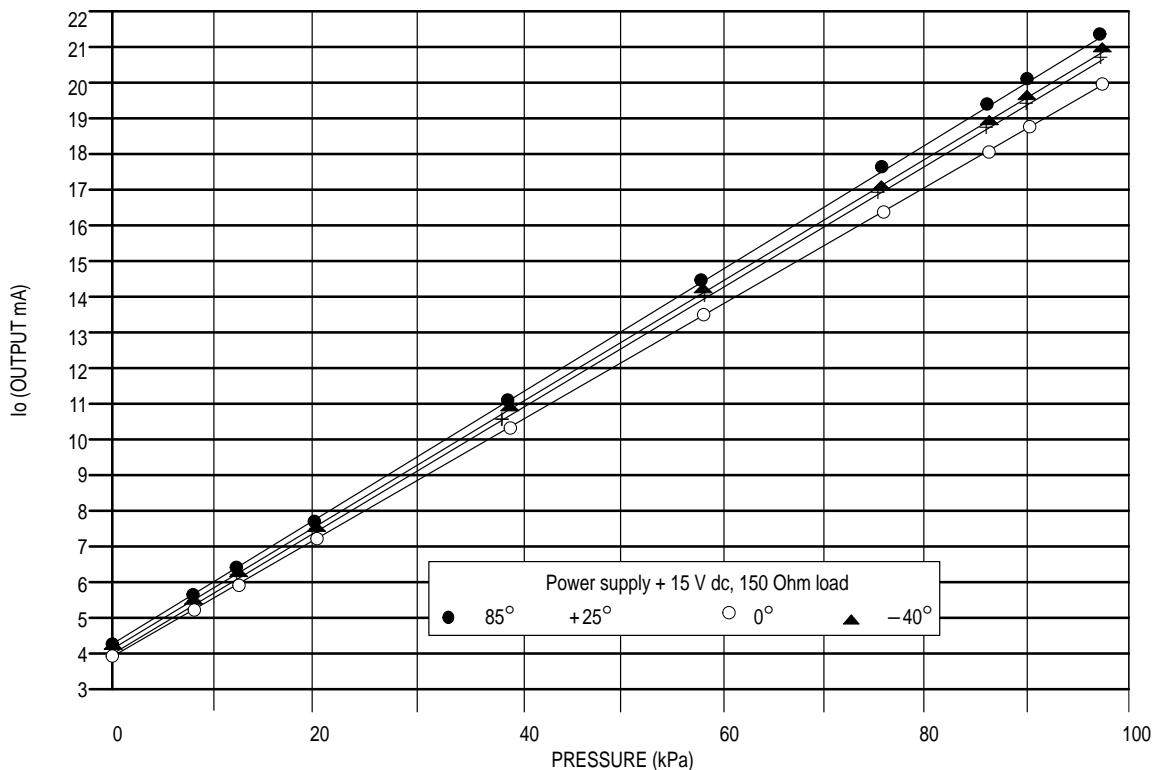
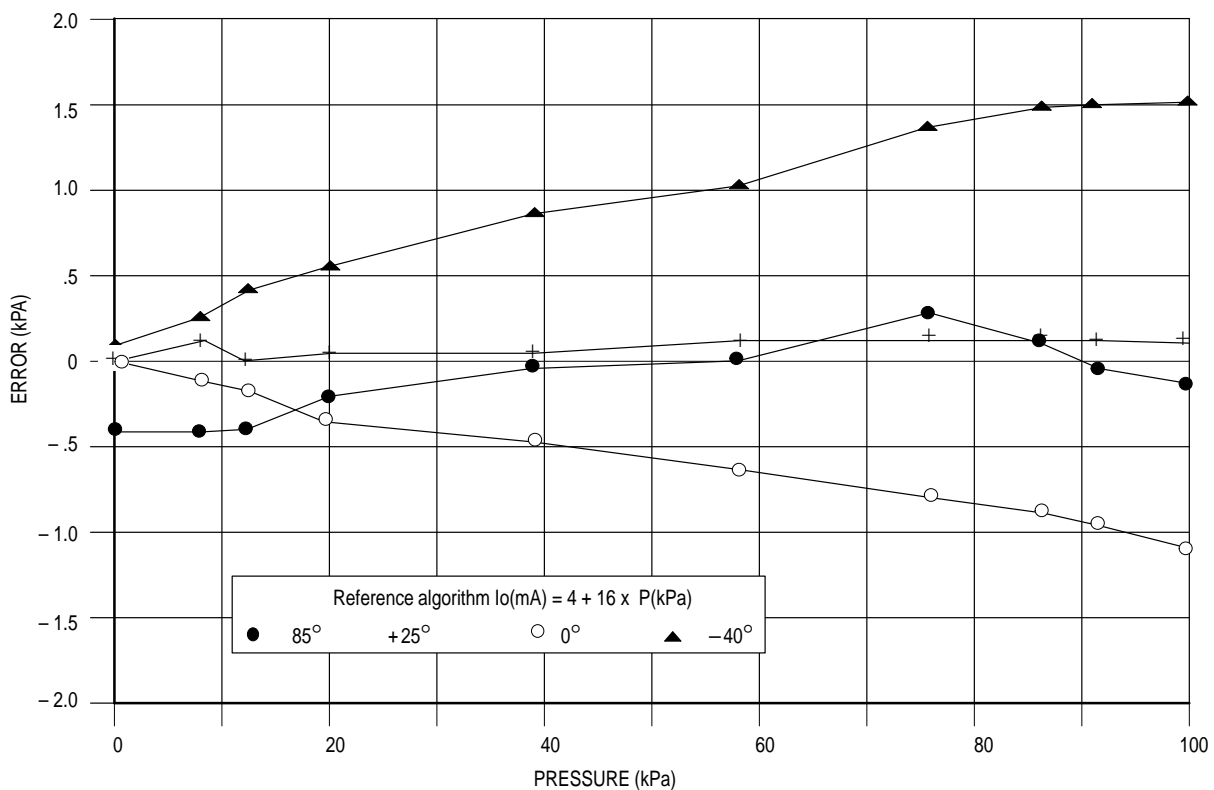


Figure 2. Output versus Pressure



Reference algorithm is the straight from output at 255 0 pressure and output at full pressure

Figure 3. Absolute Error Reference to Algorithm

Motorola reserves the right to make changes without further notice to any products herein. Motorola makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Motorola assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters which may be provided in Motorola data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. Motorola does not convey any license under its patent rights nor the rights of others. Motorola products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Motorola product could create a situation where personal injury or death may occur. Should Buyer purchase or use Motorola products for any such unintended or unauthorized application, Buyer shall indemnify and hold Motorola and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Motorola was negligent regarding the design or manufacture of the part. Motorola and  are registered trademarks of Motorola, Inc. Motorola, Inc. is an Equal Opportunity/Affirmative Action Employer.

Mfax is a trademark of Motorola, Inc.

How to reach us:

USA/EUROPE/Locations Not Listed: Motorola Literature Distribution;
P.O. Box 5405, Denver, Colorado 80217. 303-675-2140 or 1-800-441-2447

JAPAN: Nippon Motorola Ltd.; Tatsumi-SPD-JLDC, 6F Seibu-Butsuryu-Center,
3-14-2 Tatsumi Koto-Ku, Tokyo 135, Japan. 81-3-3521-8315

Mfax™: RMFAX0@email.sps.mot.com – TOUCHTONE 602-244-6609
– US & Canada ONLY 1-800-774-1848

ASIA/PACIFIC: Motorola Semiconductors H.K. Ltd.; 8B Tai Ping Industrial Park,
51 Ting Kok Road, Tai Po, N.T., Hong Kong. 852-26629298

INTERNET: <http://motorola.com/sps>

