AN1654

ASB210 — 10″ H_2O Sensor Module

Prepared by: Bill Lucas and Warren Schultz

A plug–in module that is part of a systems development tool set for pressure sensors is presented here. It provides a pulsed analog signal from an MPX2010 sensor to a Motorola Sensor Development Controller. The pulsed architecture improves the sensitivity of MPX2010 sensors, providing a 0–10″ H_2O measurement range.

PLUG–IN MODULE DESCRIPTION

A summary of information for using systems development plug–in module ASB210 includes the schematic in Figure 2, connector pinout in Figure 3, a pin by pin description of functionality, specs in Tables 1 & 2, and a parts list in Table 3. Figure 4 in the Applications section provides a quick reference for making connections. A discussion of the design appears under the heading Design Considerations.

Function

The plug–in module shown in Figure 1 is designed to supply pressure and temperature inputs to a sensor development controller. The MPX2010 sensor is pulsed with a 20 volt bias to increase its sensitivity relative to operation at 10 volts DC. Its pulsed output is amplified, level shifted, filtered, and converted to a single ended signal that fits within a zero to 5 volt window. Connections are made through a DB–9 connector, which allows this board to be plugged directly into its controller. If physical separation is desired, a standard 9 pin straight– through serial cable can be inserted between the two boards.

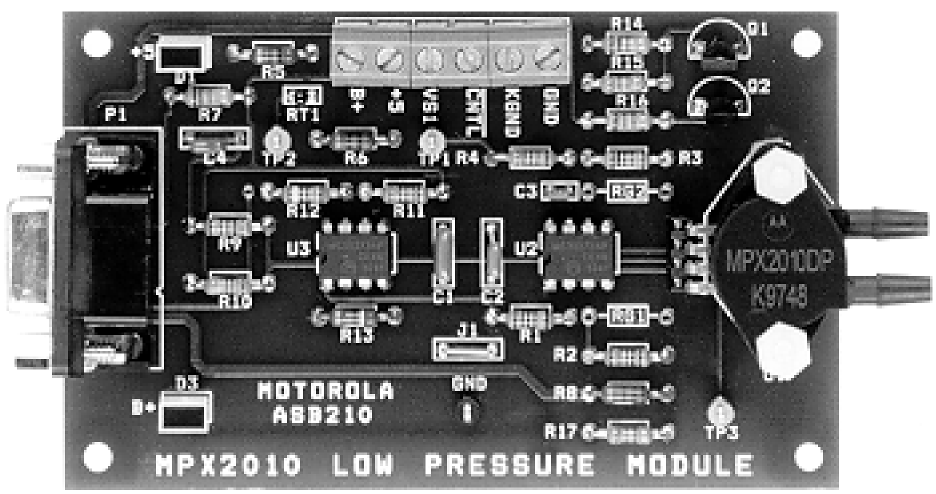

Figure 1. ASB210 — 10″ H_2O Sensor Module

REV 1

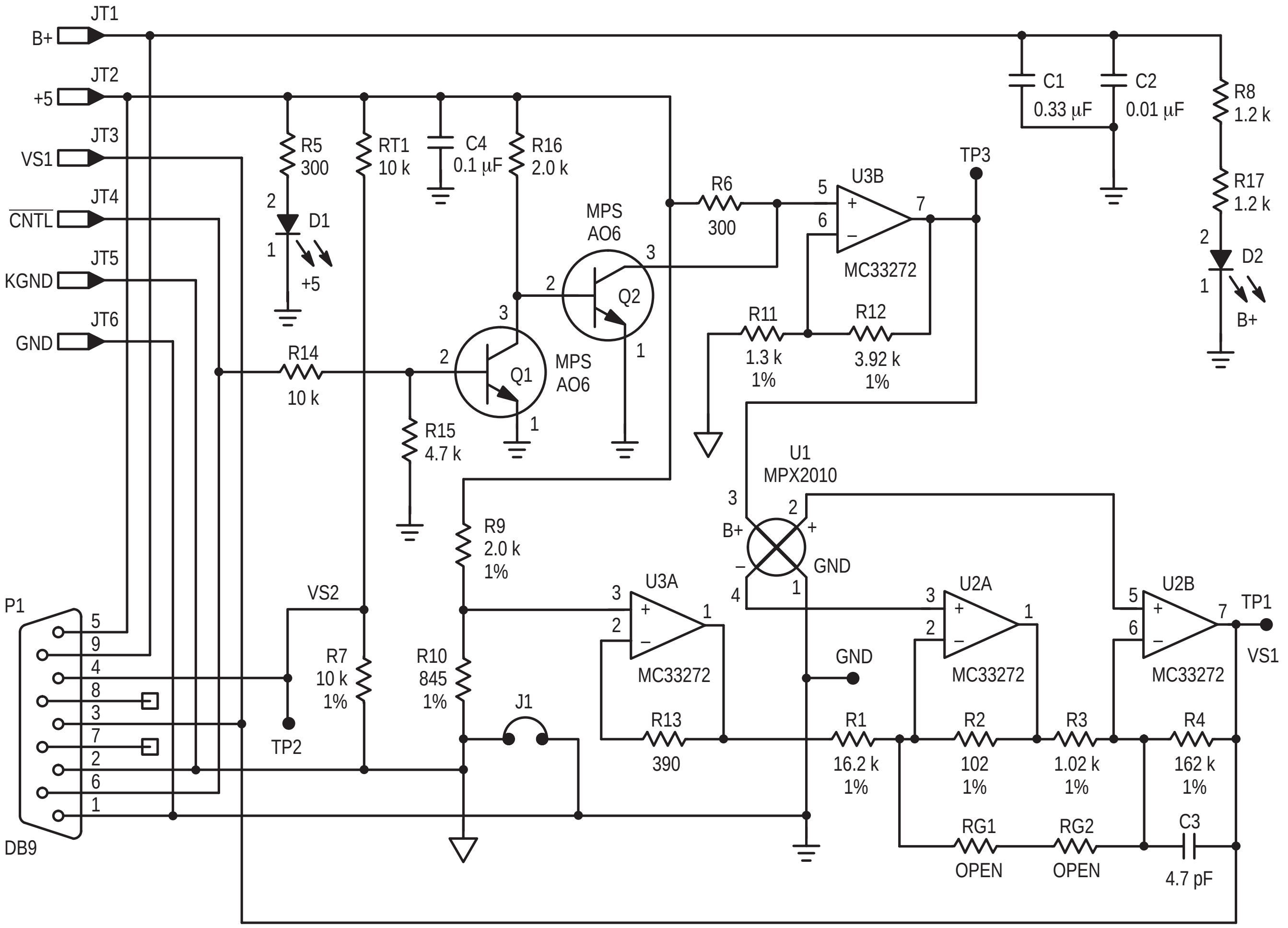

Figure 2. Schematic

Electrical Characteristics

Unless otherwise specified, the electrical characteristics in Tables 1, 2, & 3, apply to operation at 25 degrees Celsius, B^+ = 24.0 volts, and a +5 volt input of 5.00 volts. The values in Tables 2 and 3 are nominal values.

Table 1. Electrical Characteristics

Characteristic	Symbol	Min	Typ	Max	Units
DC Supply Voltage +5 B^+	 +5 B^+	 4.75 22	 5.0 24	 5.25 26	 Volts Volts
Pressure Sensor Output Voltage — Zero Pressure — Full Scale	VS1 — —	 — —	 1.5 3.5	 — —	 Volt Volts
Temp Sensor Output Voltage	VS2	—	2.5	—	Volts
Quiescent Current	I_{CC}	—	25	—	mA

Table 2. VS2 Versus Temperature

Temperature °C	R_T Ohms	VS2 Volts	Temperature °C	R_T Ohms	VS2 Volts
0	32773	1.17	40	5323	3.26
5	25456	1.41	45	4365	3.48
10	19932	1.67	50	3599	3.68
15	15725	1.94	55	2983	3.85
20	12497	2.22	60	2486	4.00
25	10000	2.50	65	2082	4.14
30	8055	2.77	70	1753	4.25
35	6528	3.03	75	1482	4.35

Content

Board contents are described by the following parts list and the schematic in Figure 2. A pin by pin circuit description follows in the next section.

Table 3. Parts List

Item	Quantity	Reference	Part
1	1	C1	.33 µF
2	1	C2	.01 µF
3	1	C3	.001 µF
4	1	C4	4.7 pF
5	2	D1,D2	LED (RED)
6	1	P1	DB9
7	1	RT1	10K Thermistor
8	1	R1	16.2K 1%
9	1	R2	102 1%
10	1	R3	1.02K 1%
11	1	R4	162K 1%
12	2	R5,R6	300
13	1	R7	10K 1%
14	2	R8,R17	1.2K
15	1	R9	2.00K 1%
16	1	R10	845 1%
17	1	R11	1.3K 1%
18	1	R12	3.92K 1%
19	1	R13	390
20	1	R14	10K
21	1	R15	4.7K
22	1	R16	2.0K
26	1	U1	MPX2010
27	2	U2,U3	MC33272

Pin by Pin Description

Inputs and outputs are grouped into two connectors. A DB–9 connector provides a plug–in feature. If this connector is used, no other connections are necessary. Alternately, power, ground, control signal, and output connections can be made through screw terminals at the top of the board. The screw terminals and the DB–9 are wired in parallel. DB–9 connector pinouts are shown in Figure 3.

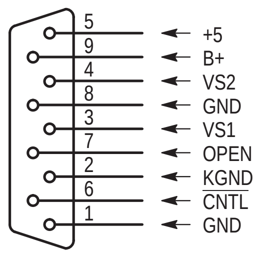

Figure 3. DB–9 Pinout

DB–9 Connector

B^+:
Power for the sensor and op amps is supplied through pin 9 on the DB–9 connector. This voltage is labeled B^+. It is specified from 22 VDC min to 26 VDC max.

+5:
5 volt power is supplied through pin 5. It is specified from 4.75 VDC min to 5.25 VDC max.

GND:
The ground connection is on pin one. It connects the sensor's analog ground to the controller's digital ground.

KGND:
An additional ground connection, labeled KGND, is made on pin 2. As shipped, KGND is tied to GND via jumper J1. If J1 is opened, KGND provides a separate signal ground return that does not carry the op amp and pressures sensor bias currents. This feature can be helpful if a cable is used between the sensor module and its controller.

VS1:
The pressure sensor output signal, VS1, is connected to pin 3. It is the output of a two op amp discrete instrumentation amplifier that has pressure sensor U1 as its input. Nominal output voltage is 1.5 volts at zero pressure and 3.5 volts at full scale, when the sensor is pulsed on.

VS2:
A temperature dependent output signal is connected to pin 4. It is derived from a thermistor and has a nominal output voltage of 2.5 volts at 25 degrees C. The thermistor's output is a function of both ambient air temperature, and temperature rise on the board that is conducted through the leads. It will typically read several degrees higher than the temperature of still ambient air.

$\overline{\text{CNTL}}$:
A control signal is supplied on pin 6. It switches high to apply a 20 volt bias to the sensor, with a duty cycle that is less than 10%. For the purposes of writing controller code, it is important to note that an inadvertent high on this pin will likely damage the sensor.

Board Code:
A board code that lets the controller know that this is an ASB210 module is supplied with an open on pin 7 and an open on pin 8.

Screw Terminals

Connections for B^+, +5, VS1, CNTL, KGND, & GND are wired in parallel with the DB–9 connector. As shipped, KGND and GND are tied together with Jumper J1.

Test Points TP1–TP3, & GND

Test points TP1, TP2, & TP3 provide access to output and bias signals. TP1 is connected to the pressure output signal. TP2 is connected to the thermistor output signal. The sensor's pulsed 20 volt bias voltage, supplied from op amp U3B, appears on TP3. A test point for ground is also provided.

Indicator Lights

B^+:
The B^+ light is provided to indicate the presence of the B^+ power supply.

+5:
The +5 light is provided to indicate the presence of 5 volt power.

APPLICATION EXAMPLE

An application example shown in Figure 4 illustrates system connections to an ASB200 sensor development controller and a pressure source. This arrangement can be run stand alone, or the ASB200 can be connected to an MMDS or MMEVS system for code development. The two boards are designed such that the DB–9 connectors plug into each other. Once they are plugged in, it is only a matter of connecting a power supply and a pressure source to get a system up and running. If physical separation between the sensor location and the controller is desired, a standard 9 wire straight–through serial cable can be used between the two boards.

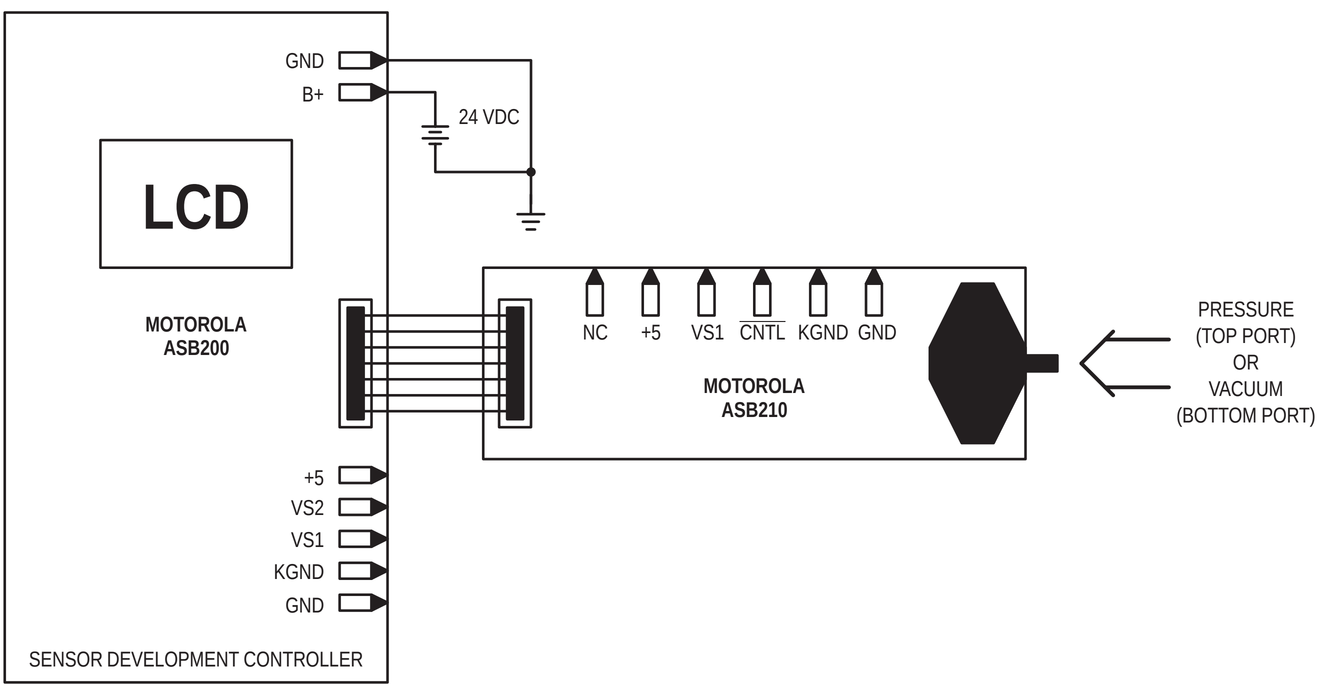

Figure 4. Application Example

DESIGN CONSIDERATIONS

MPX2010 sensors are designed with transducers that schematically look like Wheatstone bridges. Therefore, an increase in bias voltage produces a corresponding increase in sensitivity. The MPX2010's 10 volt DC bias spec is a compromise between the higher sensitivity that can be obtained with larger bias voltage, and better thermal stability with lower bias voltage. To measure 10″ of water full scale, it is necessary to use a higher bias voltage without incurring the thermal errors that a DC bias would produce. The reference design in Figure 2 does this by pulsing the bias voltage to the sensor.

With the exception of Q1 and Q2, this circuit has the same architecture as it would for DC operation. Q1 takes the control signal on pin 6 of DB–9 connector P1, and switches the base of Q2. With a logic high at the input, Q1 shuts off Q2, and U3B multiplies the 5 volt reference to 20 volts for biasing the sensor. When the input is low, Q2 is biased on. This condition switches the 5 volt reference at pin 5 of op amp U3B to ground, thereby removing bias to the sensor. Both op amps U2 and U3 are continuously powered from power supply B^+, so that they are biased and ready to respond when the sensor is switched on. For proper thermal management in the sensor, the input pulse should be less than 10% duty cycle, and last a maximum of 100 µsec.

The amplifier is a discrete two op amp instrumentation amplifier that has its gain described by equation 1.

(1) DIFFERENTIAL GAIN = R4/R3 +1 = 162K/1.02K +1 = 159 + 1 = 160.

Zero pressure offset voltage is established by divider R9/R10 which is buffered by U3A. The buffer is used to facilitate maintaining an impedance ratio R1/R2 = R4/R3, which maximizes the amplifier's common mode rejection characteristics. Both the zero pressure offset voltage and the bias voltage are referenced to the same 5 volt supply as the controller's A/D to minimize the effects of power supply tolerance. An expression for output voltage (V_{OUT}) that takes into account the differential input (VS+ – VS –), the common mode voltage (V_{CM}), and the zero pressure reference voltage (V_{REF}) appears in equation 2.

$$(2)\quad V_{OUT} = ((R4/R3)+1)) \cdot (VS+ - VS-) + (R2 \cdot R4/R1 \cdot R3) \cdot V_{REF} - V_{CM} \cdot ((R2 \cdot R4/R1 \cdot R3) - 1)$$

Note that when R1/R2 = R4/R3, R2 · R4/R1 · R3 = 1 and the last term is zero. A 1% mismatch in this ratio, however, adds an error term that equals –1% of the common mode voltage.

The dynamic characteristics of the circuit shown in Figure 2 produce a pulsed output waveform with a rather large spike on the leading edge. A representation of this waveform is shown in Figure 5. Time, on the horizontal axis is measured at 5 µsec per division, and voltage is measured vertically at 2 volts per division. From this figure, it is evident that in order to get an accurate reading, A/D conversions should be timed to start a minimum of 10 µsec after the sensor is turned on, and should be complete before the end of the pulse. When this timing relationship is observed, accuracy is superior to DC bias, even at lower bias voltages such as 5 or 10 volts.

The resulting 1.5 V to 3.5 V pulsed output from pin 7 of U2B is compatible with microcomputer A/D inputs. The 20 volt bias produces a 2 volt span at 10″ of water input pressure, using a gain of 160.

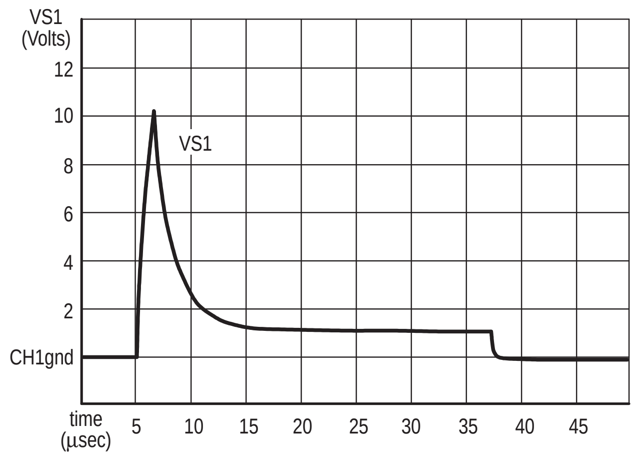

Figure 5. Pulsed Output Waveform

CONCLUSION

The ASB210 plug–in module is part of a systems development tool set for pressure sensors. Its pulsed architecture improves the sensitivity of MPX2010 sensors, providing a 0–10″ H_2O measurement range. It can be used as a reference design, and allows code to be developed without hardware fabrication.

NOTES

NOTES

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

JAPAN: Nippon Motorola Ltd.; SPD, Strategic Planning Office, 141,
4–32–1 Nishi–Gotanda, Shinagawa–ku, Tokyo, Japan. 81–3–5487–8488

Customer Focus Center: 1–800–521–6274

Mfax™: RMFAX0@email.sps.mot.com – TOUCHTONE 1–602–244–6609
Motorola Fax Back System – US & Canada ONLY 1–800–774–1848
– http://sps.motorola.com/mfax/

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

HOME PAGE: http://motorola.com/sps/

MOTOROLA