Freescale Semiconductor
Application Note

AN1304
Rev 2, 05/2005

Integrated Sensor Simplifies Bar Graph Pressure Gauge

by: Warren Schultz
Discrete Applications Engineering

INTRODUCTION

Integrated semiconductor pressure sensors such as the MPX5100 greatly simplify electronic measurement of pressure. These devices translate pressure into a 0.5 to 4.5 volt output range that is designed to be directly compatible with microcomputer A/D inputs. The 0.5 to 4.5 volt range also facilitates interface with ICs such as the LM3914, making Bar Graph Pressure Gauges relatively simple. A description of a Bar Graph Pressure Sensor Evaluation Board and its design considerations are presented here.

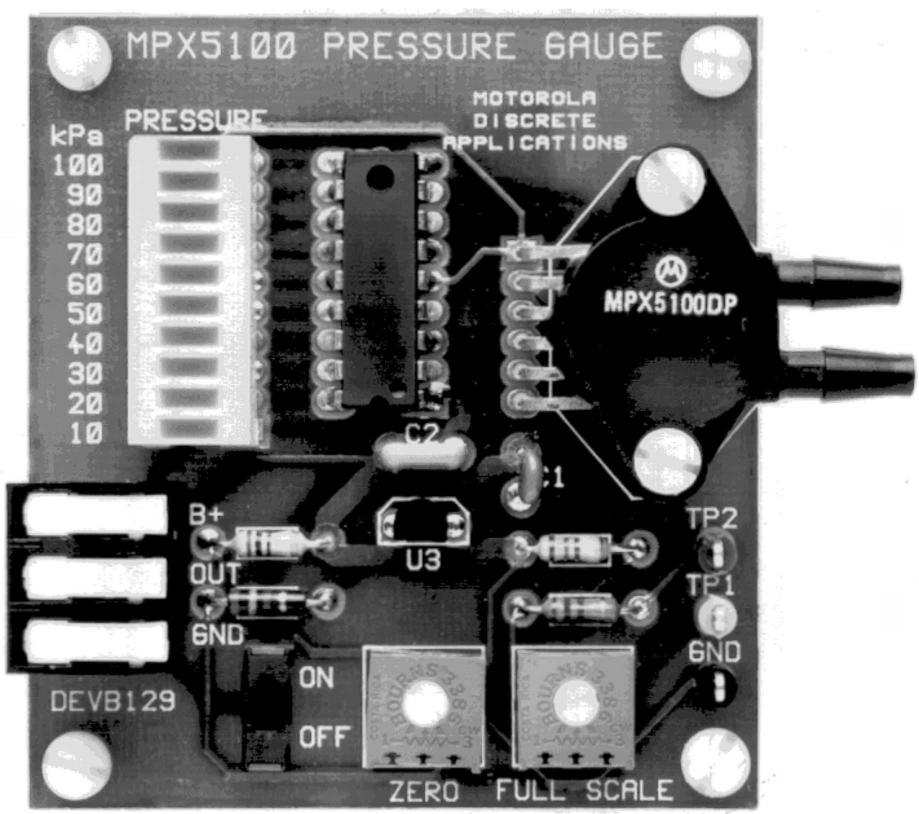

Figure 1. DEVB129 MPX5100 Bar Graph Pressure Gauge (Board No Longer Available)

EVALUATION BOARD DESCRIPTION

A summary of the information required to use evaluation board number DEVB129 is presented as follows. A discussion of the design appears under the heading Design Considerations.

Function

The evaluation board shown in Figure 1 is designed to provide a 100 kPa full scale pressure measurement. It has two input ports. P1, the pressure port is on the top side of the MPX5100 sensor, and P2, a vacuum port, is on the bottom side. These ports can be supplied up to 100 kPa (15 psi)[1] of pressure on P1 or up to 100 kPa of vacuum on P2, or a differential pressure up to 100 kPa between P1 and P2. Any of these sources will produce the same output.

The primary output is a 10 segment LED bar graph, which is labeled in increments of 10 kPa. If full scale pressure is adjusted for a value other than 100 kPa the bar graph may be read as a percent of full scale. An analog output is also provided. It nominally supplies 0.5 volts at zero pressure and 4.5 volts at 100 kPa. Zero and full scale adjustments are made with potentiometers so labeled at the bottom of the board. Both adjustments are independent of each other.

Electrical Characteristics

The following electrical characteristics are included to describe evaluation board operation. They are not specifications in the usual sense and are intended only as a guide to operation.

Characteristic	Symbol	MIn	Typ	Max	Units
Power Supply Voltage	B+	6.8	—	13.2	Volts
Full Scale Pressure	PFS	—	—	100	kPa
Overpressure	PMAX	—	—	700	kPa
Analog Full Scale	VFS	—	4.5	—	Volts
Analog Zero Pressure Offset	VOFF	—	0.5	—	Volts
Analog Sensitivity	SAOUT	—	40	—	mV/kPa
Quiescent Current	ICC	—	20	—	mA
Full Scale Current	IFS	—	140	—	mA

Content

Board contents are described in the following parts list, schematic, and silk screen plot. A pin-by-pin circuit description follows in the next section.

Pin-by-Pin Description

B+

Input power is supplied at the B+ terminal. Minimum input voltage is 6.8 volts and maximum is 13.2 volts. The upper limit is based upon power dissipation in the LM3914 assuming all 10 LED's are lit and ambient temperature is 25°C. The board will survive input transients up to 25 volts provided that power dissipation in the LM3914 does not exceed 1.3 watts.

OUT

An analog output is supplied at the OUT terminal. The signal it provides is nominally 0.5 volts at zero pressure and 4.5 volts at 100 kPa. This output is capable of sourcing 100 µA at full scale output.

GND

There are two ground connections. The ground terminal on the left side of the board is intended for use as the power supply return. On the right side of the board, one of the test point terminals is also connected to ground. It provides a convenient place to connect instrumentation grounds.

TP1

Test point 1 is connected to the zero pressure reference voltage and can be used for zero pressure calibration. To calibrate for zero pressure, this voltage is adjusted with R6 to match the zero pressure voltage that is measured at the analog output (OUT) terminal.

TP2

Test point 2 performs a similar function at full scale. It is connected to the LM3914's reference voltage which sets the trip point for the uppermost LED segment. This voltage is adjusted via R5 to set full scale pressure.

P1, P2

Pressure and Vacuum ports P1 & P2 protrude from the MPX5100 sensor on the right side of the board. Pressure port P1 is on the top and vacuum port P2 is on the bottom. Neither is labeled. Either one or a differential pressure applied to both can be used to obtain full scale readings up to 100 kPa (15 psi). Maximum safe pressure is 700 kPa.

DESIGN CONSIDERATIONS

In this type of an application the design challenge is how to interface a sensor with the bar graph output. MPX5100 Sensors and LM3914 Bar Graph Display drivers fit together so cleanly that having selected these two devices the rest of the design is quite straight forward.

A block diagram that appears in Figure 4 shows the LM3914's internal architecture. Since the lower resistor in the input comparator chain is pinned out at R_{LO}, it is a simple matter to tie this pin to a voltage that is approximately equal to the MPX5100's zero pressure output voltage. In Figure 2, this is accomplished by dividing down the 5 volt regulator's output voltage through R1, R4, and adjustment pot R6. The voltage

1. 100 kPa = 14.7 psi, 15 psi is used throughout the text for convenience.

generated at the wiper of R6 is then fed into R_{LO} which matches the sensor's zero pressure voltage and zeros the bar graph.

The full scale measurement is set by adjusting the upper comparator's reference voltage to match the sensor's output at full pressure. An internal regulator on the LM3914 sets this voltage with the aid of resistors R2, R3, and adjustment pot R5 that are shown in Figure 2.

The MPX5100 requires 5 volt regulated power that is supplied by an MC78L05. The LED's are powered directly from LM3914 outputs, which are set up as current sources. Output current to each LED is approximately 10 times the reference current that flows from pin 7 through R2, R5, and R3 to ground. In this design it is nominally (4.5 V/4.9K)10 = 9.2 mA.

Over a zero to 85°C temperature range accuracy for both the sensor and driver IC are ±2.5%, totaling ±5%. Given a 10 segment display total accuracy is approximately ±(10 kPa +5%).

CONCLUSION

Perhaps the most noteworthy aspect to the bar graph pressure gauge described here is how easy it is to design. The interface between an MPX5100 sensor, LM3914 display driver, and bar graph output is direct and straight forward. The result is a simple circuit that is capable of measuring pressure, vacuum, or differential pressure; and will also send an analog signal to other control circuitry.

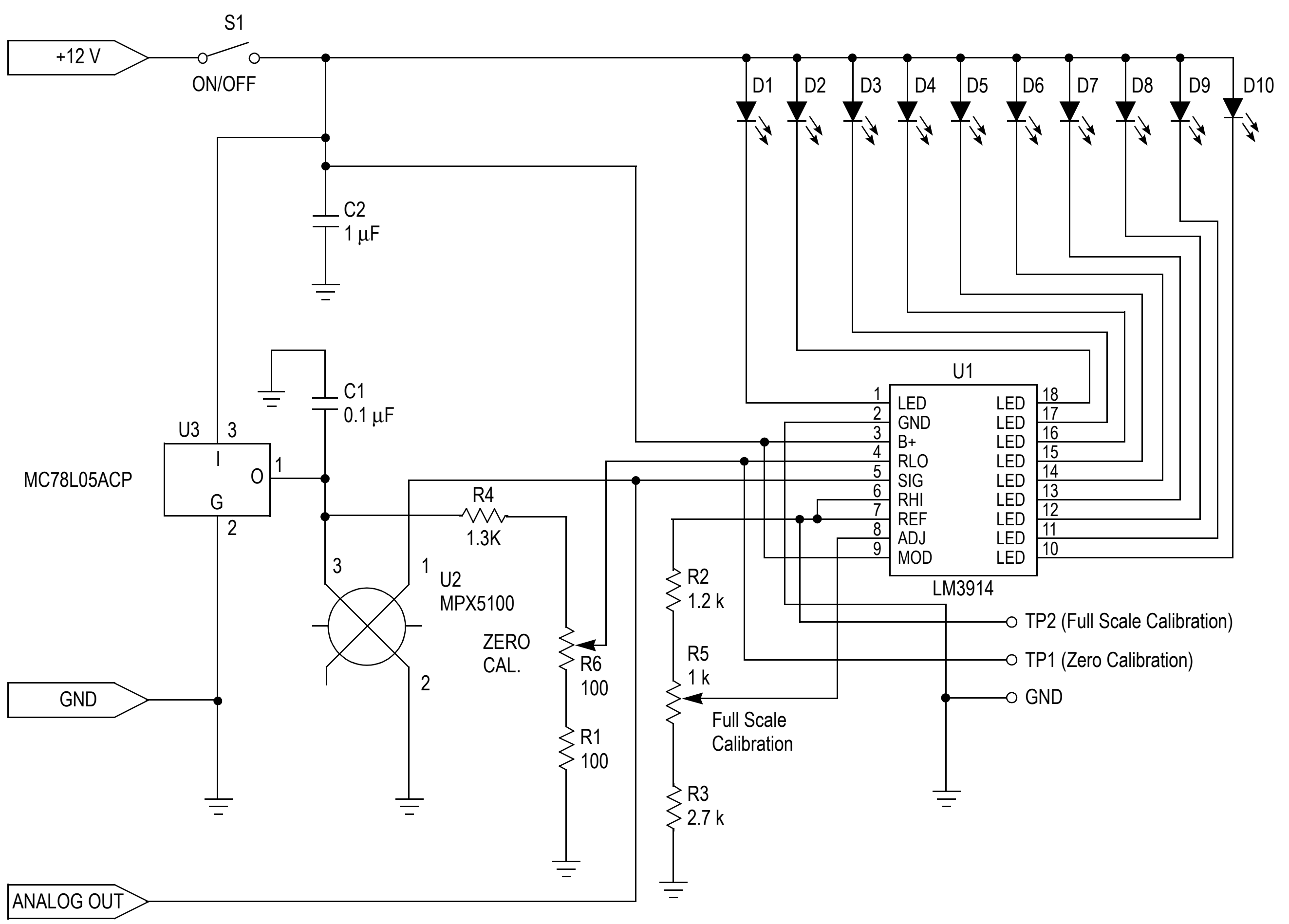

Figure 2. MPX5100 Pressure Gauge

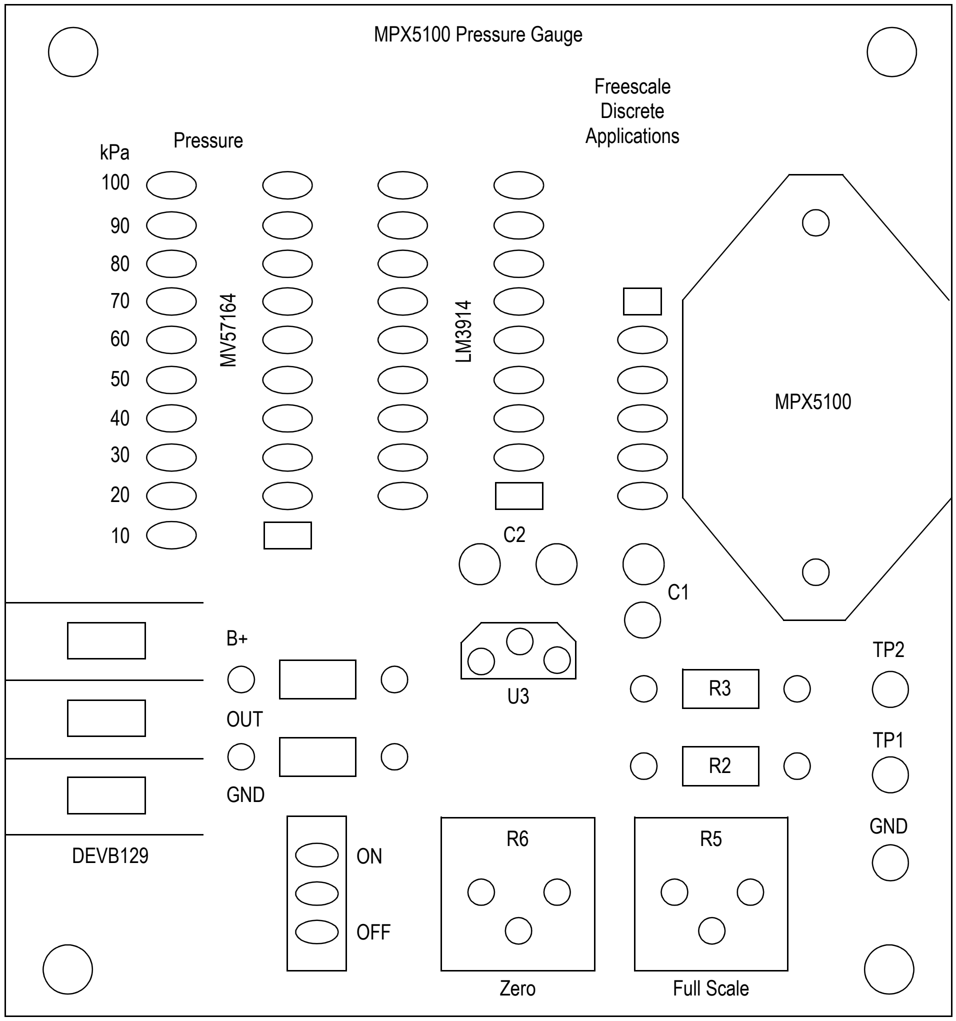

Figure 3. Silk Screen 2X

Table 1. Parts List

Designators	Quant.	Description	Rating	Manufacturer	Part Number
C1 C2	1 1	Ceramic Cap Ceramic Cap	0.1 µF 1 µF		
D1-D10	1	Bar Graph LED		GI	MV57164
R1 R2 R3 R4 R5 R6	1 1 1 1 1 1	1/4 W Film Resistor 1/4 W Film Resistor 1/4 W Film Resistor 1/4 W Film Resistor Trimpot Trimpot	100 1.2K 2.7K 1.3K 1K 100	 Bourns Bourns	
S1	1	On/Off Switch		NKK	12SDP2
U1 U2 U3	1 1 1	Bar Graph IC Pressure Sensor Voltage Regulator		National Freescale Freescale	LM3914 MPX5100 MC78L05ACP
— — — —	1 3 4 4	Terminal Block Test Point Terminal Nylon Spacer 4-40 Nylon Screw	 3/8″ 1/4″	Augat Components Corp.	25V03 TP1040104

Notes: All resistors have a tolerance of 5% unless otherwise noted.
All capacitors are 50 volt ceramic capacitors with a tolerance of 10% unless otherwise noted.

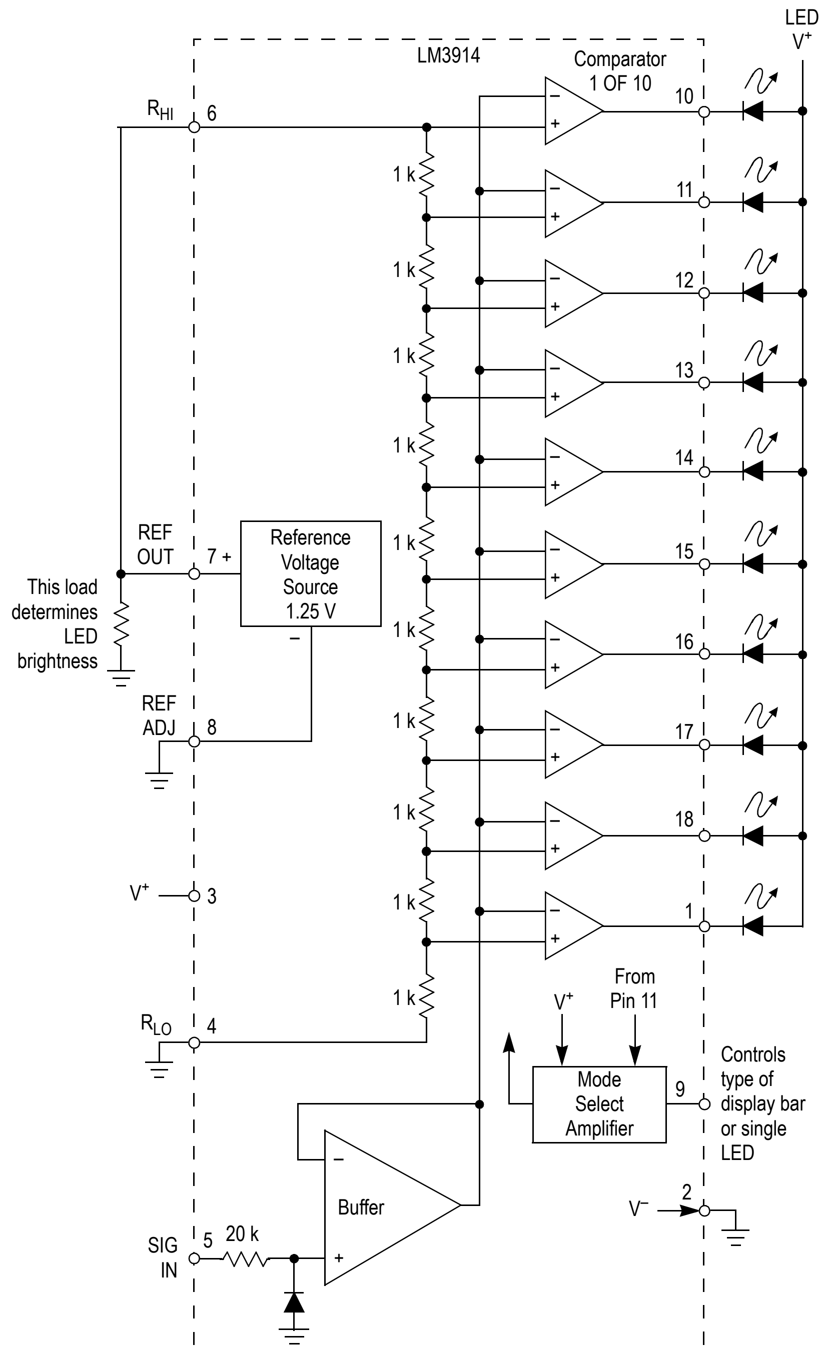

Figure 4. LM3914 Block Diagram

NOTES

NOTES

How to Reach Us:

Home Page:
www.freescale.com

E-mail:
support@freescale.com

USA/Europe or Locations Not Listed:
Freescale Semiconductor
Technical Information Center, CH370
1300 N. Alma School Road
Chandler, Arizona 85224
+1-800-521-6274 or +1-480-768-2130
support@freescale.com

Europe, Middle East, and Africa:
Freescale Halbleiter Deutschland GmbH
Technical Information Center
Schatzbogen 7
81829 Muenchen, Germany
+44 1296 380 456 (English)
+46 8 52200080 (English)
+49 89 92103 559 (German)
+33 1 69 35 48 48 (French)
support@freescale.com

Japan:
Freescale Semiconductor Japan Ltd.
Headquarters
ARCO Tower 15F
1-8-1, Shimo-Meguro, Meguro-ku,
Tokyo 153-0064
Japan
0120 191014 or +81 3 5437 9125
support.japan@freescale.com

Asia/Pacific:
Freescale Semiconductor Hong Kong Ltd.
Technical Information Center
2 Dai King Street
Tai Po Industrial Estate
Tai Po, N.T., Hong Kong
+800 2666 8080
support.asia@freescale.com

For Literature Requests Only:
Freescale Semiconductor Literature Distribution Center
P.O. Box 5405
Denver, Colorado 80217
1-800-441-2447 or 303-675-2140
Fax: 303-675-2150
LDCForFreescaleSemiconductor@hibbertgroup.com

freescale™
semiconductor

AN1304
Rev. 2
05/2005