

# Freescale Semiconductor

MPX53  
Rev 5, 09/2008

## 50 kPa Uncompensated Silicon Pressure Sensors

The MPX53 series silicon piezoresistive pressure sensors provide a very accurate and linear voltage output, directly proportional to the applied pressure. These standard, low cost, uncompensated sensors permit manufacturers to design and add their own external temperature compensating and signal conditioning networks. Compensation techniques are simplified because of the predictability of Freescale's single element strain gauge design.

### Features

- Low Cost
- Patented Silicon Shear Stress Strain Gauge Design
- Ratiometric to Supply Voltage
- Easy to Use Chip Carrier Package Options
- 60 mV Span (Typical)
- Differential and Gauge Options

### MPX53 Series

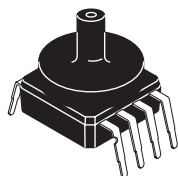
0 to 50 kPa (0 to 7.25 psi)  
60 mV Full Scale Span  
(Typical)

### Application Examples

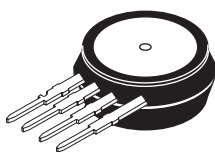
- Air Movement Control
- Environmental Control Systems
- Level Indicators
- Leak Detection
- Medical Instrumentation
- Industrial Controls
- Pneumatic Control Systems
- Robotics

| ORDERING INFORMATION |                 |          |            |        |      |               |              |          |
|----------------------|-----------------|----------|------------|--------|------|---------------|--------------|----------|
| Device Name          | Package Options | Case No. | # of Ports |        |      | Pressure Type |              |          |
|                      |                 |          | None       | Single | Dual | Gauge         | Differential | Absolute |
| MPX53D               | Tape & Reel     | 344      | •          |        |      |               | •            |          |
| MPX53DP              | Rail            | 344C     |            |        | •    |               | •            |          |
| MPX53GP              | Rail            | 344B     |            | •      |      | •             |              |          |
| MPXV53GC7U           | Rail            | 482C     |            | •      |      | •             |              |          |

### SMALL OUTLINE PACKAGE

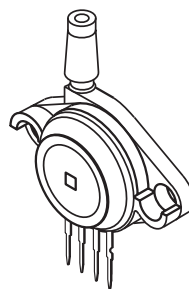


MPXV53GC7U  
CASE 482C-03

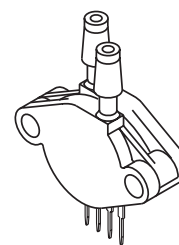


MPX53D  
CASE 344-15

### UNIBODY PACKAGES



MPX53GP  
CASE 344B-01



MPX53DP  
CASE 344C-01

## Operating Characteristics

Table 1. Operating Characteristics ( $V_S = 3.0$  Vdc,  $T_A = 25^\circ\text{C}$  unless otherwise noted,  $P_1 > P_2$ )

| Characteristic                             | Symbol              | Min   | Typ       | Max   | Units                        |
|--------------------------------------------|---------------------|-------|-----------|-------|------------------------------|
| Pressure Range <sup>(1)</sup>              | $P_{OP}$            | 0     | —         | 50    | kPa                          |
| Supply Voltage <sup>(2)</sup>              | $V_S$               | —     | 3.0       | 6.0   | $V_{DC}$                     |
| Supply Current                             | $I_O$               | —     | 6.0       | —     | mAdc                         |
| Full Scale Span <sup>(3)</sup>             | $V_{FSS}$           | 45    | 60        | 90    | mV                           |
| Offset <sup>(4)</sup>                      | $V_{OFF}$           | 0     | 20        | 35    | mV                           |
| Sensitivity                                | $\Delta V/\Delta P$ | —     | 1.2       | —     | mV/kPa                       |
| Linearity                                  | —                   | -0.6  | —         | 0.4   | % $V_{FSS}$                  |
| Pressure Hysteresis (0 to 50 kPa)          | —                   | —     | $\pm 0.1$ | —     | % $V_{FSS}$                  |
| Temperature Hysteresis                     | —                   | —     | $\pm 0.5$ | —     | % $V_{FSS}$                  |
| Temperature Coefficient of Full Scale Span | $TCV_{FSS}$         | -0.22 | —         | -0.16 | % $V_{FSS}/^\circ\text{C}$   |
| Temperature Coefficient of Offset          | $TCV_{OFF}$         | —     | $\pm 15$  | —     | $\mu\text{V}/^\circ\text{C}$ |
| Temperature Coefficient of Resistance      | $TCR$               | 0.31  | —         | 0.37  | % $Z_{IN}/^\circ\text{C}$    |
| Input Impedance                            | $Z_{IN}$            | 355   | —         | 505   | $\Omega$                     |
| Output Impedance                           | $Z_{OUT}$           | 750   | —         | 1875  | $\Omega$                     |
| Response Time <sup>(5)</sup> (10% to 90%)  | $t_R$               | —     | 1.0       | —     | ms                           |
| Warm-Up Time <sup>(6)</sup>                | —                   | —     | 20        | —     | ms                           |
| Offset Stability <sup>(7)</sup>            | —                   | —     | $\pm 0.5$ | —     | % $V_{FSS}$                  |

1. 1.0 kPa (kiloPascal) equals 0.145 psi.

2. Device is ratiometric within this specified excitation range. Operating the device above the specified excitation range may induce additional error due to device self-heating.

3. Full Scale Span ( $V_{FSS}$ ) is defined as the algebraic difference between the output voltage at full rated pressure and the output voltage at the minimum rated pressure.

4. Offset ( $V_{OFF}$ ) is defined as the output voltage at the minimum rated pressure.

5. Response Time is defined as the time for the incremental change in the output to go from 10% to 90% of its final value when subjected to a specified step change in pressure.

6. Warm-up Time is defined as the time required for the product to meet the specified output voltage after the pressure is stabilized.

7. Offset stability is the product's output deviation when subjected to 1000 hours of Pulsed Pressure, Temperature Cycling with Bias Test.

## Maximum Ratings

**Table 2. Maximum Ratings<sup>(1)</sup>**

| Rating                           | Symbol      | Value       | Unit |
|----------------------------------|-------------|-------------|------|
| Maximum Pressure ( $P_1 > P_2$ ) | $P_{MAX}$   | 175         | kPa  |
| Burst Pressure ( $P_1 > P_2$ )   | $P_{Burst}$ | 200         | kPa  |
| Storage Temperature              | $T_{STG}$   | -40 to +125 | °C   |
| Operating Temperature            | $T_A$       | -40 to +125 | °C   |

1. Exposure beyond the specified limits may cause permanent damage or degradation to the device.

Figure 1 shows a schematic of the internal circuitry on the stand-alone pressure sensor chip.

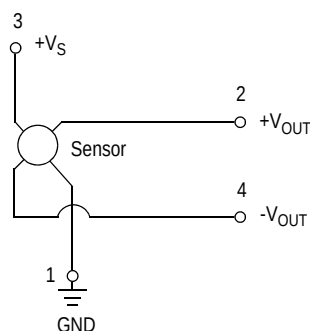


**Figure 1. Uncompensated Pressure Sensor Schematic**

## Voltage Output versus Applied Differential Pressure

The differential voltage output of the sensor is directly proportional to the differential pressure ( $P_1$ ) relative to the vacuum side ( $P_2$ ). Similarly, output voltage increases as

increasing vacuum is applied to the vacuum side ( $P_2$ ) relative to the pressure side ( $P_1$ ).

## Temperature Compensation

Figure 2 shows the typical output characteristics of the MPX53 series over temperature.

The piezoresistive pressure sensor element is a semiconductor device which gives an electrical output signal proportional to the pressure applied to the device. This device uses a unique transverse voltage diffused semiconductor strain gauge which is sensitive to stresses produced in a thin silicon diaphragm by the applied pressure.

Because this strain gauge is an integral part of the silicon diaphragm, there are no temperature effects due to differences in the thermal expansion of the strain gauge and the diaphragm, as are often encountered in bonded strain gauge pressure sensors. However, the properties of the strain gauge itself are temperature dependent, requiring that the device be temperature compensated if it is to be used over an extensive temperature range.

Temperature compensation and offset calibration can be achieved rather simply with additional resistive components, or by designing your system using the MPX2053 series sensors.

Several approaches to external temperature compensation over  $-40$  to  $+125^{\circ}\text{C}$  and  $0$  to  $+80^{\circ}\text{C}$  are presented in Freescale Application Note, AN840.

## LINEARITY

Linearity refers to how well a transducer's output follows the equation:  $V_{\text{out}} = V_{\text{off}} + (\text{sensitivity} \times P)$  over the operating pressure range (see Figure 3). There are two basic methods for calculating nonlinearity: (1) end point straight line fit or (2) a least squares best line fit. While a least squares fit gives the "best case" linearity error (lower numerical value), the calculations required are burdensome.

Conversely, an end point fit will give the "worst case" error (often more desirable in error budget calculations) and the calculations are more straightforward for the user.

Freescale's specified pressure sensor linearities are based on the end point straight line method measured at the midrange pressure.

Figure 4 illustrates the differential or gauge configuration in the unibody chip carrier (Case 344). A silicone gel isolates the die surface and wire bonds from the environment, while allowing the pressure signal to be transmitted to the silicon diaphragm.

The MPX53 series pressure sensor operating characteristics and internal reliability and qualification tests are based on use of dry air as the pressure media. Media other than dry air may have adverse effects on sensor performance and long term reliability. Refer to application note AN3728, for more information regarding media compatibility.

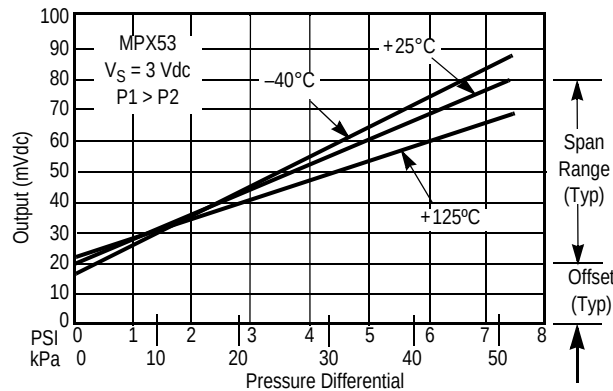


Figure 2. Output vs. Pressure Differential

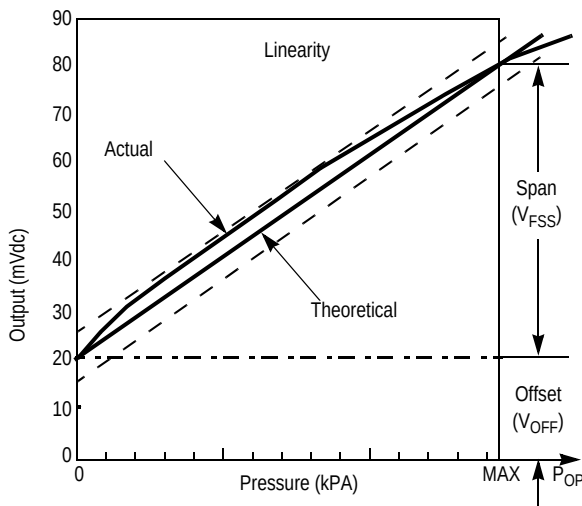


Figure 3. Linearity Specification Comparison

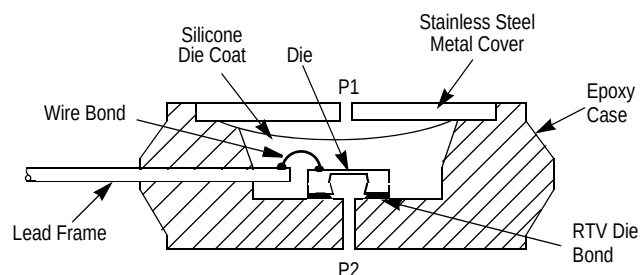


Figure 4. Unibody Package — Cross-Sectional Diagram (Not to Scale)

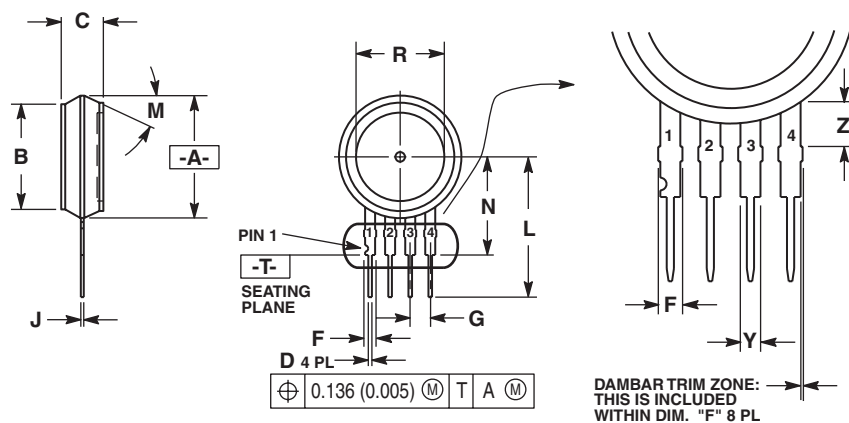
**PRESSURE (P1)/VACUUM (P2) SIDE IDENTIFICATION TABLE**

Freescall designates the two sides of the pressure sensor as the Pressure (P1) side and the Vacuum (P2) side. The Pressure (P1) side is the side containing silicone gel which isolates the die from the environment. The Freescall MPX pressure sensor is designed to operate with positive differential pressure applied,  $P1 > P2$ .

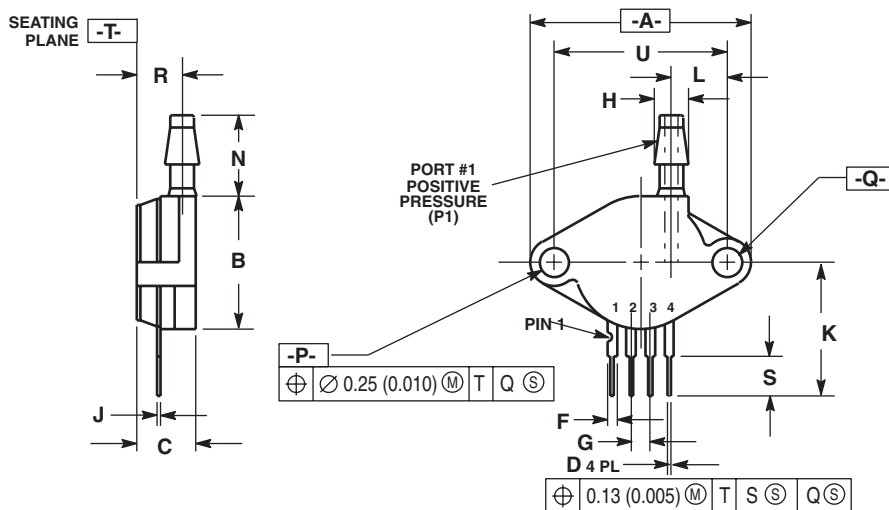
The Pressure (P1) side may be identified by using the following table.

| Part Number   | Case Type | Pressure (P1) Side Identifier |
|---------------|-----------|-------------------------------|
| MPX53D        | 344       | Stainless Steep Cap           |
| MPX53DP       | 344C      | Side with Port Marking        |
| MPX53GP       | 344B      | Side with Port Attached       |
| MPXV53 Series | 482C      | Side with Port Attached       |

## PACKAGE DIMENSIONS

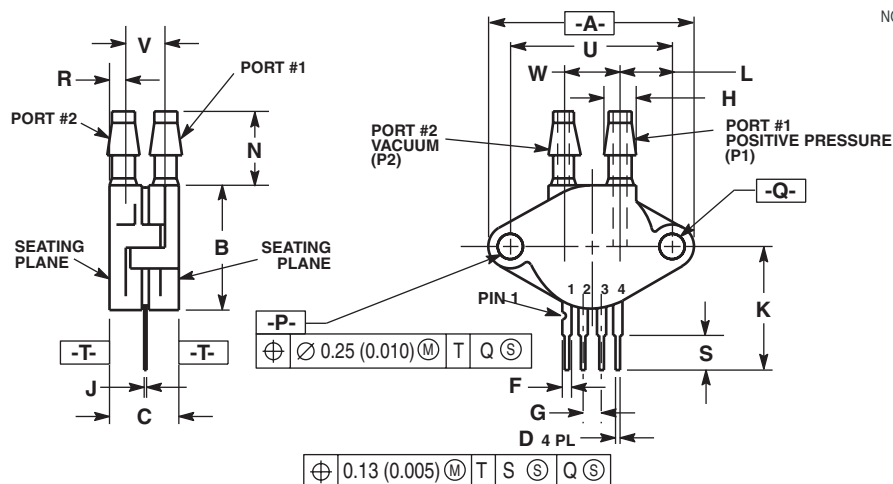


**CASE 344-15  
ISSUE AA  
UNIBODY PACKAGE**



**CASE 344B-01  
ISSUE B  
UNIBODY PACKAGE**

## PACKAGE DIMENSIONS

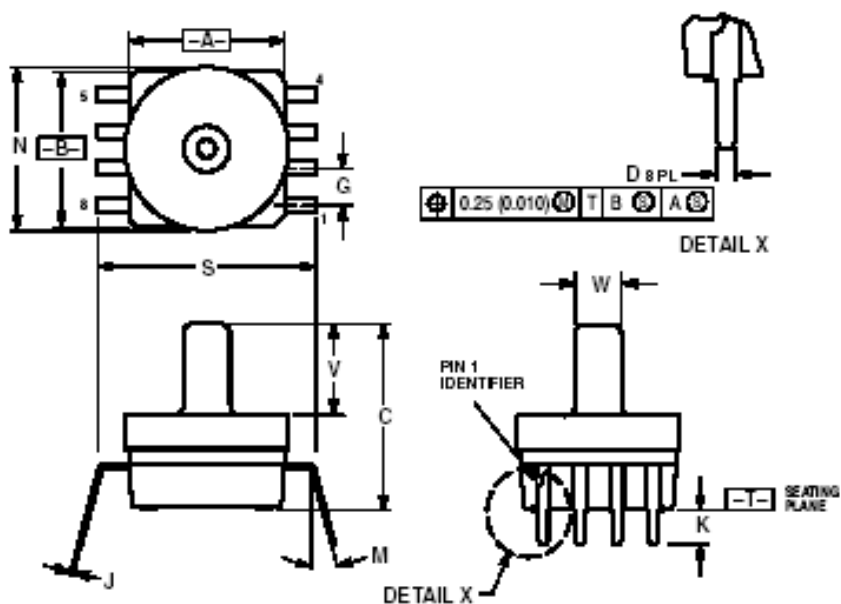


## NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

| DIM | INCHES    |       | MILLIMETERS |       |
|-----|-----------|-------|-------------|-------|
|     | MIN       | MAX   | MIN         | MAX   |
| A   | 1.145     | 1.175 | 29.08       | 29.85 |
| B   | 0.685     | 0.715 | 17.40       | 18.16 |
| C   | 0.405     | 0.435 | 10.29       | 11.05 |
| D   | 0.016     | 0.020 | 0.41        | 0.51  |
| F   | 0.048     | 0.064 | 1.22        | 1.63  |
| G   | 0.100 BSC |       | 2.54 BSC    |       |
| H   | 0.182     | 0.194 | 4.62        | 4.93  |
| J   | 0.014     | 0.016 | 0.36        | 0.41  |
| K   | 0.695     | 0.725 | 17.65       | 18.42 |
| L   | 0.290     | 0.300 | 7.37        | 7.62  |
| N   | 0.420     | 0.440 | 10.67       | 11.18 |
| P   | 0.153     | 0.159 | 3.89        | 4.04  |
| Q   | 0.153     | 0.159 | 3.89        | 4.04  |
| R   | 0.063     | 0.083 | 1.60        | 2.11  |
| S   | 0.220     | 0.240 | 5.59        | 6.10  |
| U   | 0.910 BSC |       | 23.11 BSC   |       |
| V   | 0.248     | 0.278 | 6.30        | 7.06  |
| W   | 0.310     | 0.330 | 7.87        | 8.38  |

**CASE 344C-01  
ISSUE B  
UNIBODY PACKAGE**



## NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION: 0.15 (0.006).
5. ALL VERTICAL SURFACES 5° TYPICAL DRAFT.
6. DIMENSIONS TO CENTER OF LEAD WHEN FORMED PARALLEL.

| DIM | INCHES    |       | MILLIMETERS |       |
|-----|-----------|-------|-------------|-------|
|     | MIN       | MAX   | MIN         | MAX   |
| A   | 0.415     | 0.425 | 10.54       | 10.79 |
| B   | 0.415     | 0.425 | 10.54       | 10.79 |
| C   | 0.500     | 0.520 | 12.70       | 13.21 |
| D   | 0.026     | 0.034 | 0.66        | 0.864 |
| G   | 0.100 BSC |       | 2.54 BSC    |       |
| J   | 0.009     | 0.011 | 0.23        | 0.28  |
| K   | 0.100     | 0.120 | 2.54        | 3.05  |
| N   | 0.415     | 0.425 | 10.54       | 10.79 |
| S   | 0.540     | 0.560 | 13.72       | 14.22 |
| V   | 0.245     | 0.255 | 6.22        | 6.48  |
| W   | 0.115     | 0.125 | 2.92        | 3.17  |

**CASE 482C-03  
ISSUE B  
SMALL OUTLINE PACKAGE**

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