

# 10 kPa On-Chip Temperature Compensated & Calibrated Silicon Pressure Sensors

The MPX2010/MPXV2010G series silicon piezoresistive pressure sensors provide a very accurate and linear voltage output — directly proportional to the applied pressure. These sensors house a single monolithic silicon die with the strain gauge and thin-film resistor network integrated on each chip. The sensor is laser trimmed for precise span, offset calibration and temperature compensation.

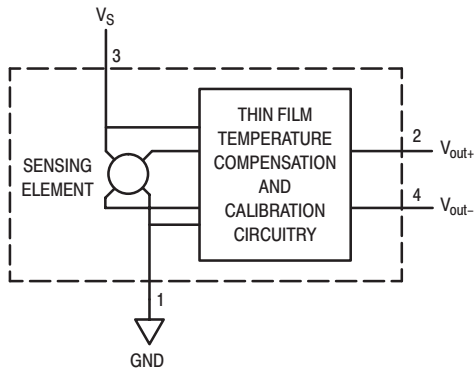
### Features

- Temperature Compensated over 0°C to +85°C
- Ratiometric to Supply Voltage
- Differential and Gauge Options

### Application Examples

- Respiratory Diagnostics
- Air Movement Control
- Controllers
- Pressure Switching

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



**Figure 1. Temperature Compensated and Calibrated Pressure Sensor Schematic**

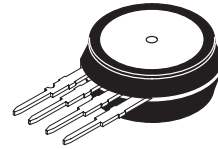
### VOLTAGE OUTPUT versus APPLIED DIFFERENTIAL PRESSURE

The output voltage of the differential or gauge sensor increases with increasing pressure applied to the pressure side (P1) relative to the vacuum side (P2). Similarly, output voltage increases as increasing vacuum is applied to the vacuum side (P2) relative to the pressure side (P1).

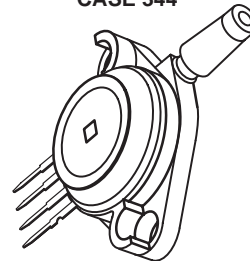
**Preferred** devices are Motorola recommended choices for future use and best overall value.

REV 9

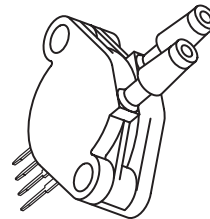
### UNIBODY PACKAGE



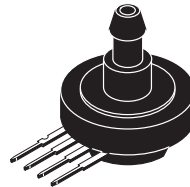
**MPX2010D  
CASE 344**



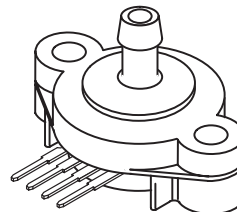
**MPX2010GP  
CASE 344B**



**MPX2010DP  
CASE 344C**



**MPX2010GS  
CASE 344E**



**MPX2010GSX  
CASE 344F**

### PIN NUMBER

|   |                   |   |                   |
|---|-------------------|---|-------------------|
| 1 | Gnd               | 3 | V <sub>S</sub>    |
| 2 | +V <sub>out</sub> | 4 | -V <sub>out</sub> |

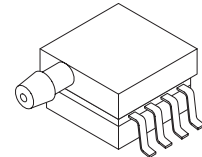
NOTE: Pin 1 is noted by the notch in the lead.

## MPX2010 MPXV2010G SERIES

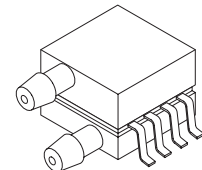
Motorola Preferred Device

**COMPENSATED  
PRESSURE SENSOR**  
 0 to 10 kPa (0 to 1.45 psi)  
**FULL SCALE SPAN: 25 mV**

### SMALL OUTLINE PACKAGE SURFACE MOUNT



**MPXV2010GP  
CASE 1369**



**MPXV2010DP  
CASE 1351**

### PIN NUMBER

|   |                   |   |     |
|---|-------------------|---|-----|
| 1 | Gnd               | 5 | N/C |
| 2 | +V <sub>out</sub> | 6 | N/C |
| 3 | V <sub>S</sub>    | 7 | N/C |
| 4 | -V <sub>out</sub> | 8 | N/C |

NOTE: Pin 1 is noted by the notch in the lead.

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### MAXIMUM RATINGS(NOTE)

| Rating                     | Symbol           | Value       | Unit |
|----------------------------|------------------|-------------|------|
| Maximum Pressure (P1 > P2) | P <sub>max</sub> | 75          | kPa  |
| Storage Temperature        | T <sub>stg</sub> | -40 to +125 | °C   |
| Operating Temperature      | T <sub>A</sub>   | -40 to +125 | °C   |

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

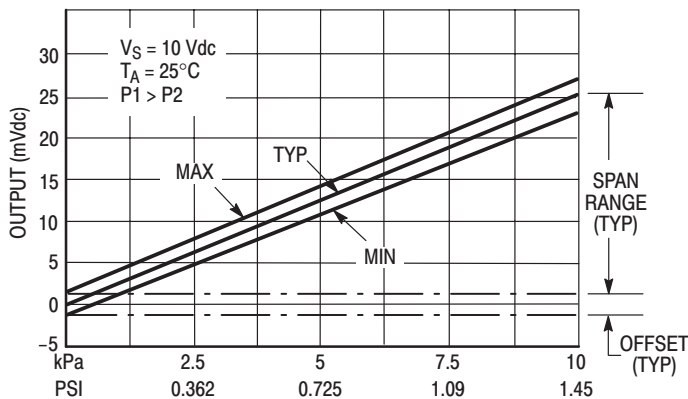
### OPERATING CHARACTERISTICS (V<sub>S</sub> = 10 Vdc, T<sub>A</sub> = 25°C unless otherwise noted, P1 > P2)

| Characteristic  | Symbol             | Min  | Typ  | Max  | Unit              |
|---|--------------------|------|------|------|-------------------|
| Pressure Range <sup>(1)</sup>                           | P <sub>OP</sub>    | 0    | —    | 10   | kPa               |
| Supply Voltage <sup>(2)</sup>                           | V <sub>S</sub>     | —    | 10   | 16   | Vdc               |
| Supply Current  | I <sub>o</sub>     | —    | 6.0  | —    | mAdc              |
| Full Scale Span <sup>(3)</sup>                          | V <sub>FSS</sub>   | 24   | 25   | 26   | mV                |
| Offset <sup>(4)</sup>                                   | V <sub>off</sub>   | -1.0 | —    | 1.0  | mV                |
| Sensitivity   | ΔV/ΔP              | —    | 2.5  | —    | mV/kPa            |
| Linearity <sup>(5)</sup>                                | —                  | -1.0 | —    | 1.0  | %V <sub>FSS</sub> |
| Pressure Hysteresis <sup>(5)</sup> (0 to 10 kPa)        | —                  | —    | ±0.1 | —    | %V <sub>FSS</sub> |
| Temperature Hysteresis <sup>(5)</sup> (-40°C to +125°C) | —                  | —    | ±0.5 | —    | %V <sub>FSS</sub> |
| Temperature Effect on Full Scale Span <sup>(5)</sup>    | TCV <sub>FSS</sub> | -1.0 | —    | 1.0  | %V <sub>FSS</sub> |
| Temperature Effect on Offset <sup>(5)</sup>             | TCV <sub>off</sub> | -1.0 | —    | 1.0  | mV                |
| Input Impedance   | Z <sub>in</sub>    | 1000 | —    | 2550 | Ω                 |
| Output Impedance  | Z <sub>out</sub>   | 1400 | —    | 3000 | Ω                 |
| Response Time <sup>(6)</sup> (10% to 90%)               | t <sub>R</sub>     | —    | 1.0  | —    | ms                |
| Warm-Up   | —                  | —    | 20   | —    | ms                |
| Offset Stability <sup>(7)</sup>                         | —                  | —    | ±0.5 | —    | %V <sub>FSS</sub> |

#### NOTES:

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<sub>FSS</sub>) 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<sub>off</sub>) is defined as the output voltage at the minimum rated pressure.
5. Accuracy (error budget) consists of the following:
  - Linearity: Output deviation from a straight line relationship with pressure, using end point method, over the specified pressure range.
  - Temperature Hysteresis: Output deviation at any temperature within the operating temperature range, after the temperature is cycled to and from the minimum or maximum operating temperature points, with zero differential pressure applied.
  - Pressure Hysteresis: Output deviation at any pressure within the specified range, when this pressure is cycled to and from the minimum or maximum rated pressure, at 25°C.
  - TcSpan: Output deviation at full rated pressure over the temperature range of 0 to 85°C, relative to 25°C.
  - TcOffset: Output deviation with minimum rated pressure applied, over the temperature range of 0 to 85°C, relative to 25°C.
6. 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.
7. Offset stability is the product's output deviation when subjected to 1000 hours of Pulsed Pressure, Temperature Cycling with Bias Test.

**ON-CHIP TEMPERATURE COMPENSATION and CALIBRATION**

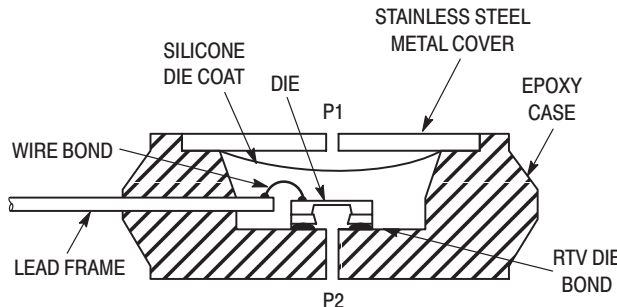


**Figure 2. Output versus Pressure Differential**

Figure 2 shows the output characteristics of the MPX2010/MPXV2010G series at 25°C. The output is directly proportional to the differential pressure and is essentially a straight line.

The effects of temperature on full scale span and offset are very small and are shown under Operating Characteristics.

This performance over temperature is achieved by having both the shear stress strain gauge and the thin-film resistor circuitry on the same silicon diaphragm. Each chip is dynamically laser trimmed for precise span and offset calibration and temperature compensation.



**Figure 3. Unibody Package — Cross-Sectional Diagram (not to scale)**

Figure 3 illustrates the differential/gauge die in the basic 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.

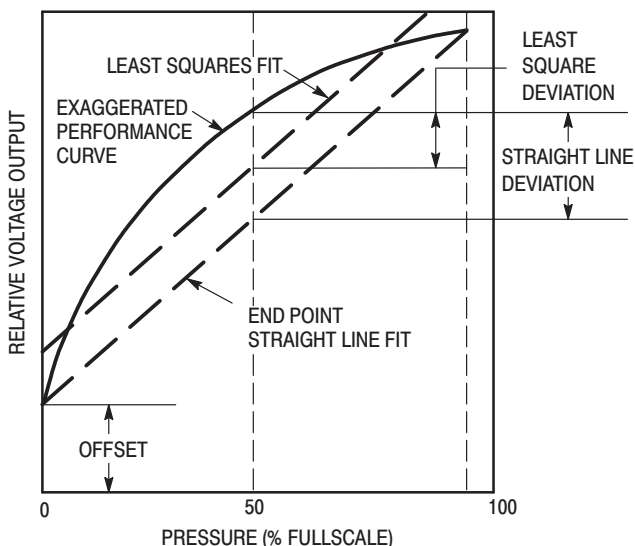
The MPX2010/MPXV2010G series pressure sensor oper-

ating 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. Contact the factory for information regarding media compatibility in your application.

**LINEARITY**

Linearity refers to how well a transducer's output follows the equation:  $V_{out} = V_{off} + \text{sensitivity} \times P$  over the operating pressure range. There are two basic methods for calculating nonlinearity: (1) end point straight line fit (see Figure 5) 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. Motorola's specified pressure sensor linearities are based on the end point straight line method measured at the midrange pressure.



**Figure 4. Linearity Specification Comparison**

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

Motorola 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 Motorola MPX

pressure sensor is designed to operate with positive differential pressure applied,  $P1 > P2$ .

The Pressure (P1) side may be identified by using the table below:

| Part Number | Case Type | Pressure (P1) Side Identifier |
|-------------|-----------|-------------------------------|
| MPX2010D    | 344       | Stainless Steel Cap           |
| MPX2010DP   | 344C      | Side with Part Marking        |
| MPX2010GP   | 344B      | Side with Port Attached       |
| MPX2010GS   | 344E      | Side with Port Attached       |
| MPX2010GSX  | 344F      | Side with Port Attached       |
| MPXV2010GP  | 1369      | Side with Port Attached       |
| MPXV2010DP  | 1351      | Side with Part Marking        |

**ORDERING INFORMATION — UNIBODY PACKAGE (MPX2010 SERIES)**

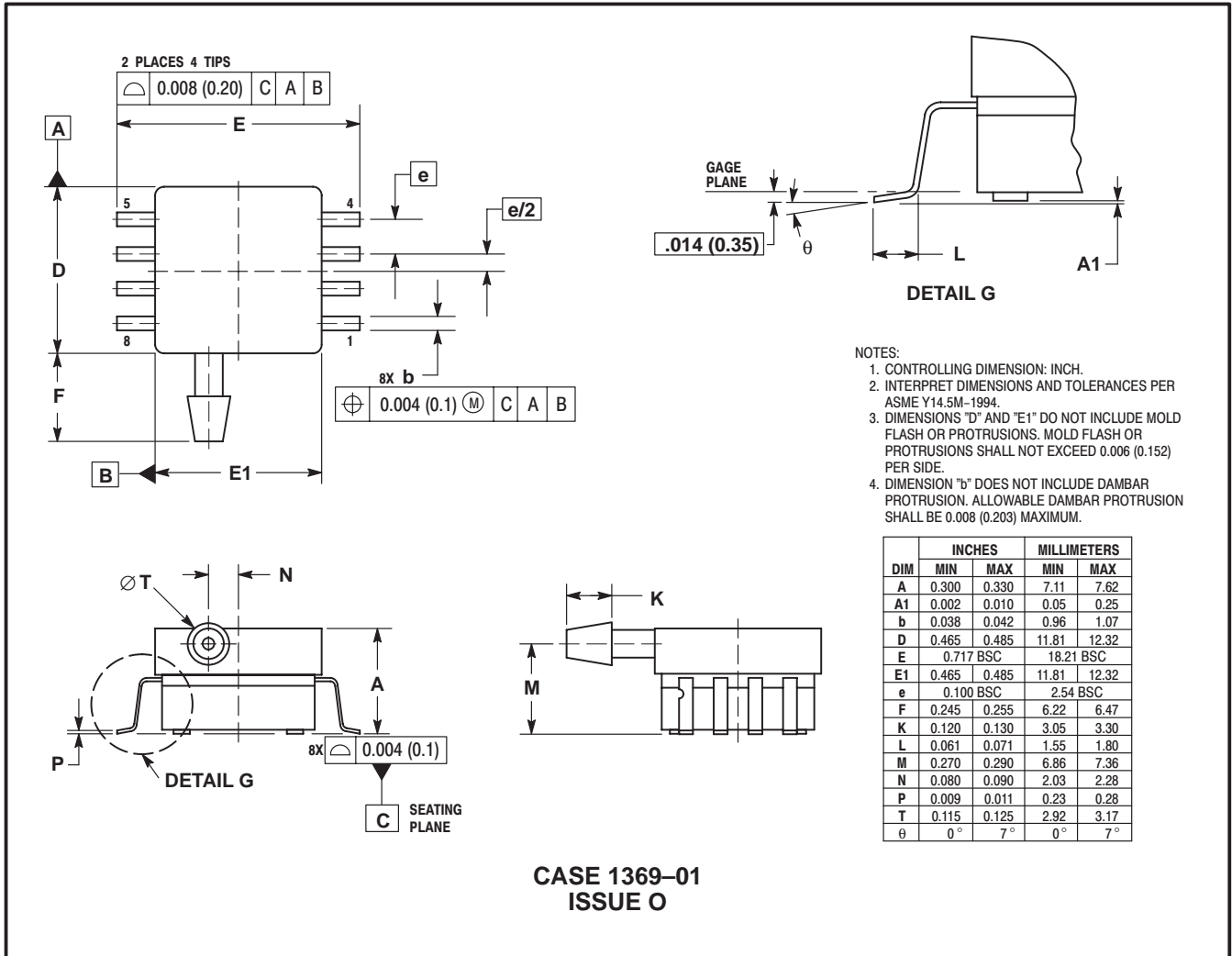
| Device Type     | Options                 | Case Type | MPX Series   |                |
|-----------------|-------------------------|-----------|--------------|----------------|
|                 |                         |           | Order Number | Device Marking |
| Basic Element   | Differential            | 344       | MPX2010D     | MPX2010D       |
| Ported Elements | Differential, Dual Port | 344C      | MPX2010DP    | MPX2010DP      |
|                 | Gauge                   | 344B      | MPX2010GP    | MPX2010GP      |
|                 | Gauge, Axial            | 344E      | MPX2010GS    | MPX2010D       |
|                 | Gauge, Axial PC Mount   | 344F      | MPX2010GSX   | MPX2010D       |

**ORDERING INFORMATION — SMALL OUTLINE PACKAGE (MPXV2010G SERIES)**

| Device Type     | Options                      | Case No. | MPX Series Order No. | Packing Options | Marking   |
|-----------------|------------------------------|----------|----------------------|-----------------|-----------|
| Ported Elements | Gauge, Side Port, SMT        | 1369     | MPXV2010GP           | Trays           | MPXV2010G |
|                 | Differential, Dual Port, SMT | 1351     | MPXV2010DP           | Trays           | MPXV2010G |

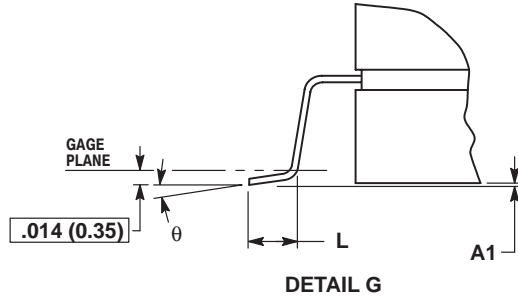
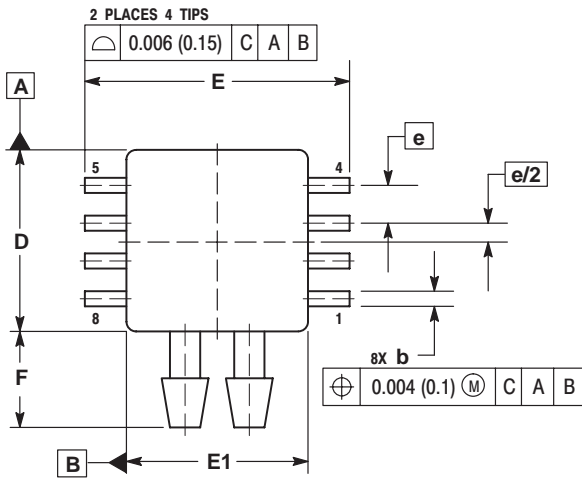
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SMALL OUTLINE PACKAGE DIMENSIONS

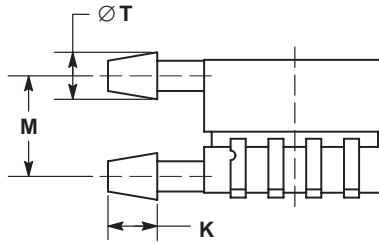
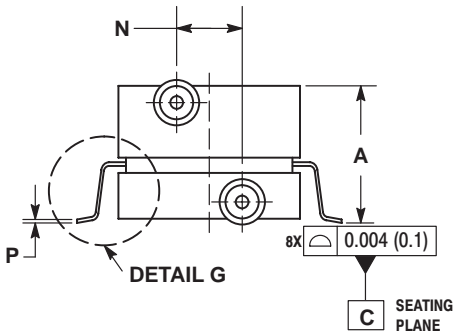


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SMALL OUTLINE PACKAGE DIMENSIONS—CONTINUED



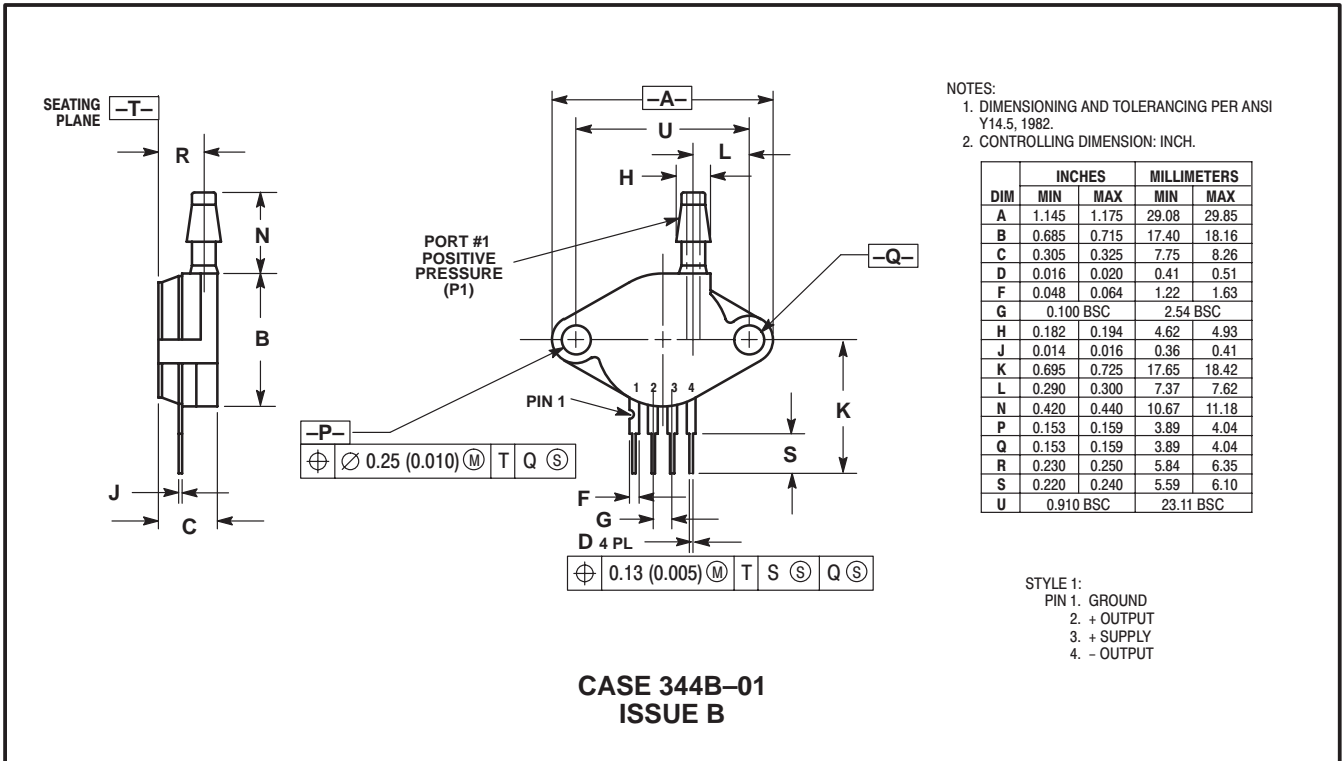
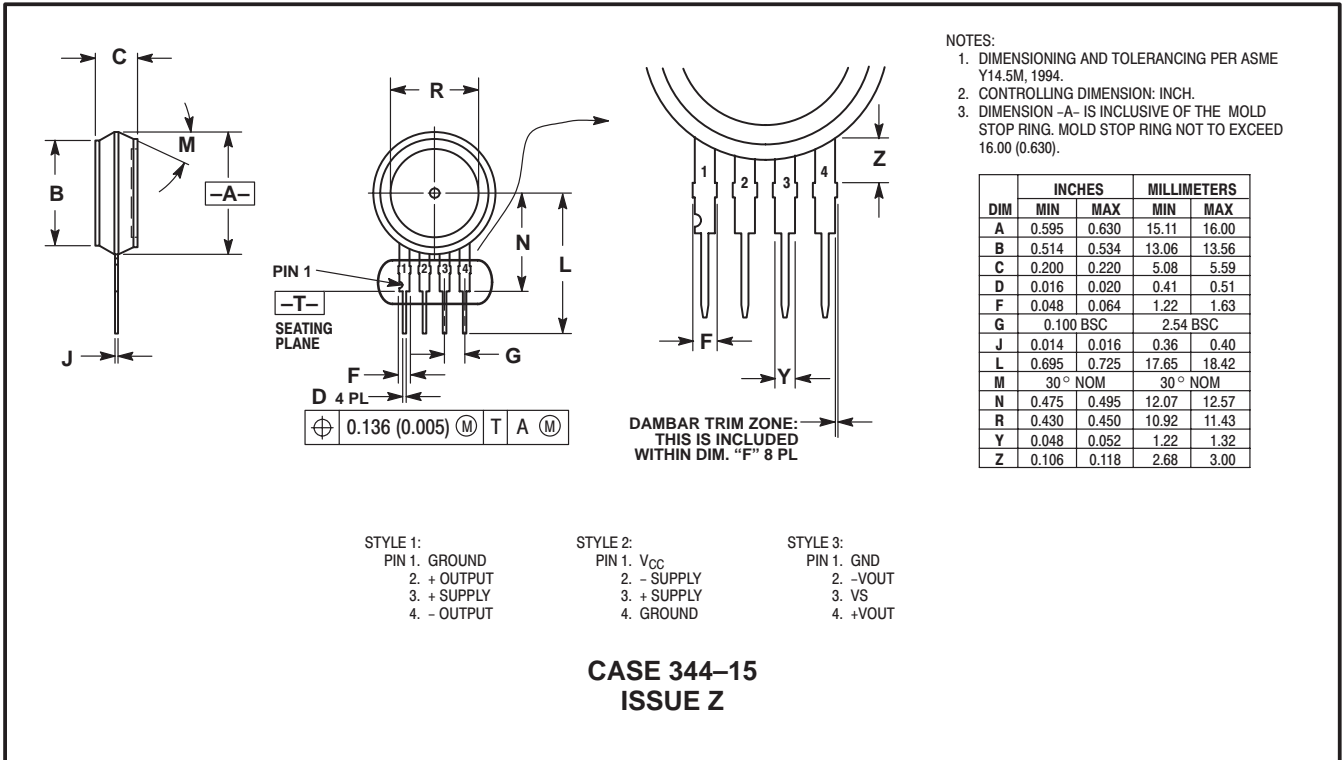
- NOTES:  
1. CONTROLLING DIMENSION: INCH.  
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.  
3. DIMENSIONS "D" AND "E1" DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.006 (0.152) PER SIDE.  
4. DIMENSION "b" DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.008 (0.203) MAXIMUM.
- |            |            |
|------------|------------|
| STYLE 1:   | STYLE 2:   |
| PIN 1. GND | PIN 1. N/C |
| 2. +Vout   | 2. Vs      |
| 3. Vs      | 3. GND     |
| 4. -Vout   | 4. Vout    |
| 5. N/C     | 5. N/C     |
| 6. N/C     | 6. N/C     |
| 7. N/C     | 7. N/C     |
| 8. N/C     | 8. N/C     |



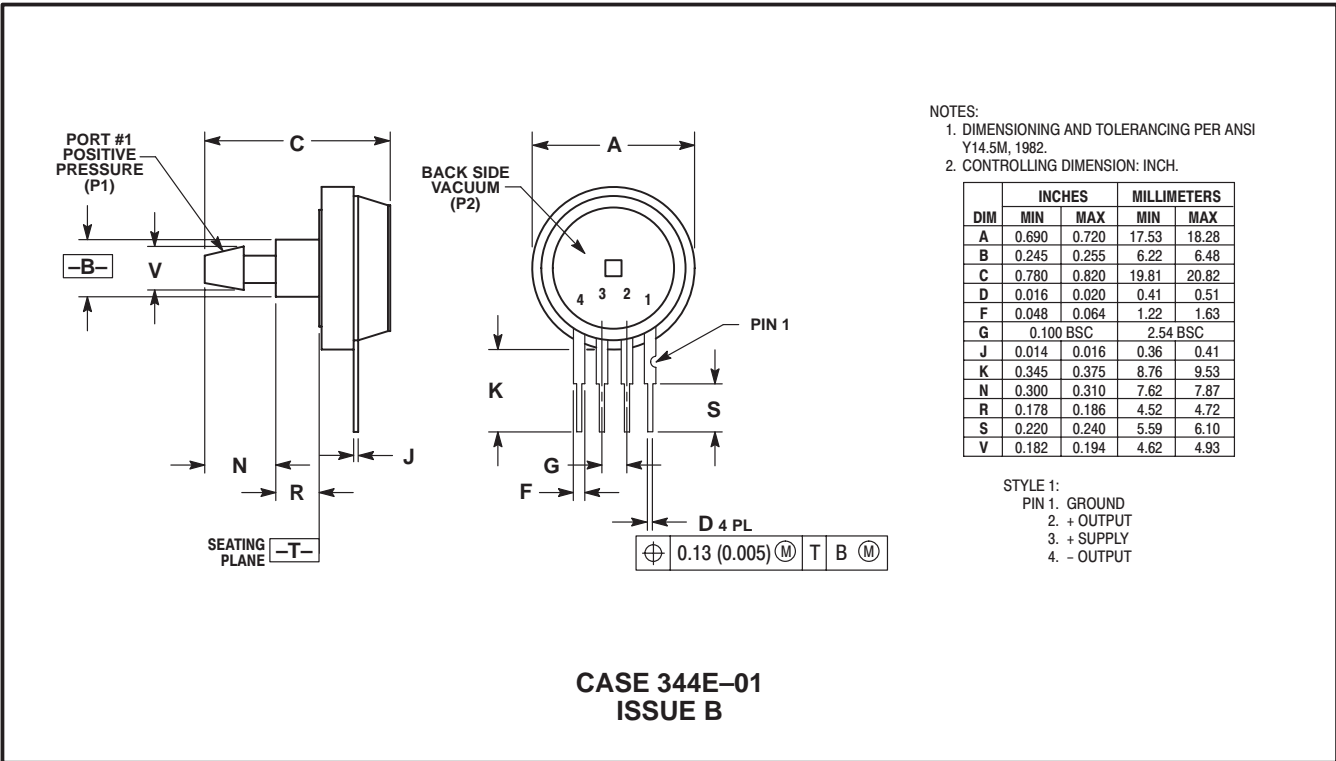
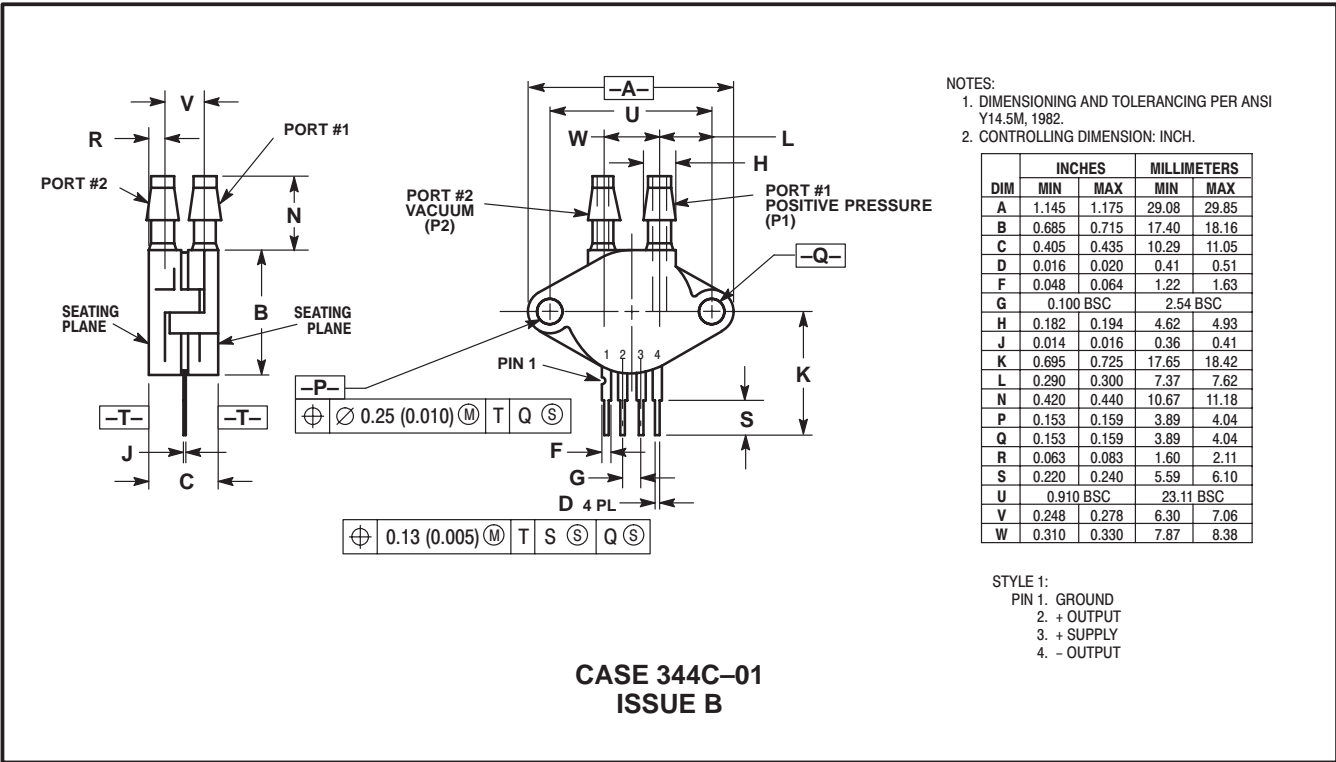
CASE 1351-01  
ISSUE O

| DIM      | INCHES    |       | MILLIMETERS |       |
|----------|-----------|-------|-------------|-------|
|          | MIN       | MAX   | MIN         | MAX   |
| A        | 0.370     | 0.390 | 9.39        | 9.91  |
| A1       | 0.002     | 0.010 | 0.05        | 0.25  |
| b        | 0.038     | 0.042 | 0.96        | 1.07  |
| D        | 0.465     | 0.485 | 11.81       | 12.32 |
| E        | 0.680     | 0.700 | 17.27       | 17.78 |
| E1       | 0.465     | 0.485 | 11.81       | 12.32 |
| e        | 0.100 BSC |       | 2.54 BSC    |       |
| F        | 0.240     | 0.260 | 6.10        | 6.60  |
| K        | 0.115     | 0.135 | 2.92        | 3.43  |
| L        | 0.040     | 0.060 | 1.02        | 1.52  |
| M        | 0.270     | 0.290 | 6.86        | 7.37  |
| N        | 0.160     | 0.180 | 4.06        | 4.57  |
| P        | 0.009     | 0.011 | 0.23        | 0.28  |
| T        | 0.110     | 0.130 | 2.79        | 3.30  |
| $\theta$ | 0°        | 7°    | 0°          | 7°    |

**UNIBODY PACKAGE DIMENSIONS**



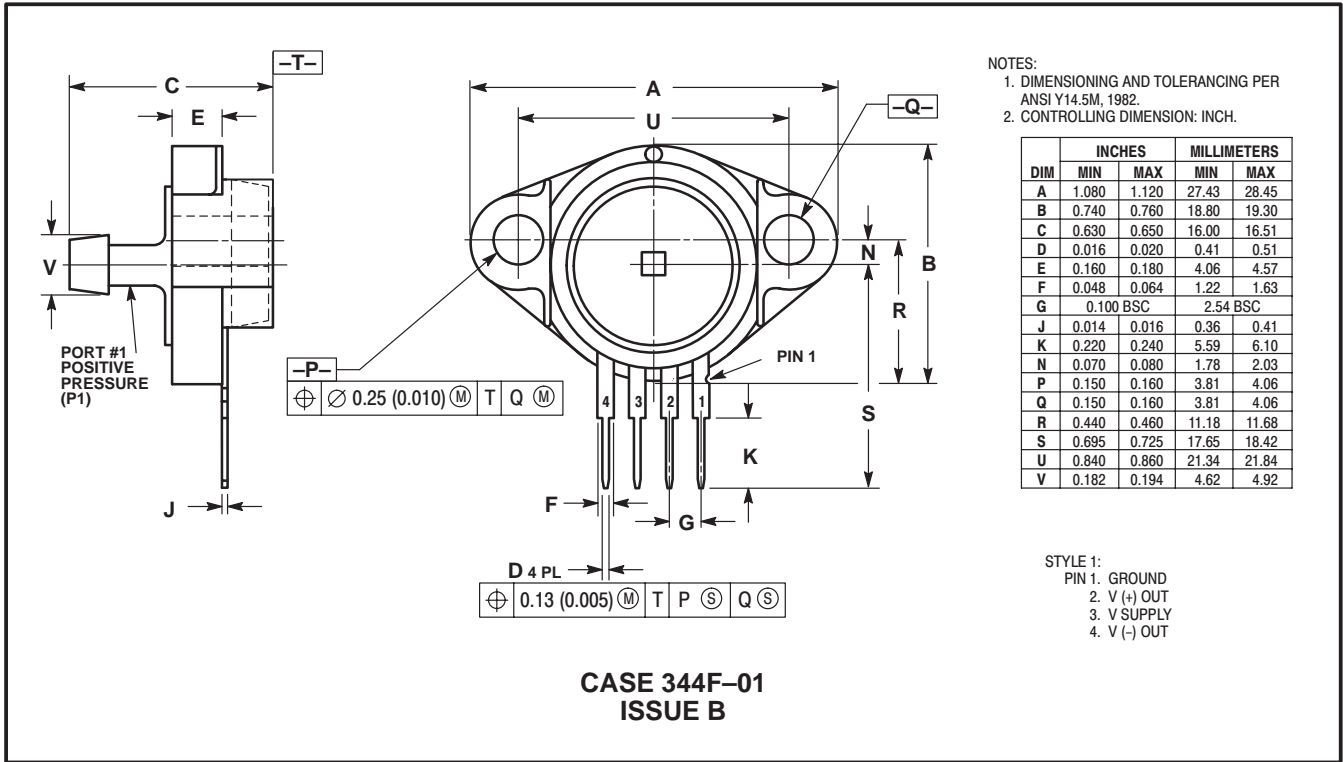
UNIBODY PACKAGE DIMENSIONS — CONTINUED



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UNIBODY PACKAGE DIMENSIONS — CONTINUED



# NOTES

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**ASIA/PACIFIC:** Motorola Semiconductors H.K. Ltd.; Silicon Harbour Centre, 2 Dai King Street, Tai Po Industrial Estate, Tai Po, N.T., Hong Kong. 852-26668334

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MPX2010/D