

## 100 kPa On-Chip Temperature Compensated and Calibrated Silicon Pressure Sensors

The MPX2100 series devices silicon piezoresistive pressure sensors providing a highly accurate and linear voltage output directly proportional to the applied pressure. The sensor is a single, monolithic silicon diaphragm with the strain gauge and a thin-film resistor network integrated on-chip. The chip is laser trimmed for precise span and offset calibration and temperature compensation.

### Features

- Temperature Compensated Over 0°C to +85°C
- Available in Absolute, Differential and Gauge Configurations
- Easy to Use Chip Carrier Package Options
- Ratiometric to Supply Voltage
- $\pm 0.25\%$  Linearity (MPX2100D Series)

## MPX2100 Series

0 to 100 kPa (0 to 14.5 psi)  
 40 mV Full Scale Span  
 (Typical)

### Application Examples

- Pump/Motor Controllers
- Robotics
- Level Indicators
- Medical Diagnostics
- Pressure Switching
- Barometers

| ORDERING INFORMATION                    |                 |          |            |        |      |               |              |          |                |
|---|-----------------|----------|------------|--------|------|---------------|--------------|----------|----------------|
| Device Name                             | Package Options | Case No. | # of Ports |        |      | Pressure Type |              |          | Device Marking |
|   |                 |          | None       | Single | Dual | Gauge         | Differential | Absolute |                |
| <b>Unibody Package (MPX2100 Series)</b> |                 |          |            |        |      |               |              |          |                |
| MPX2100A                                | Tray            | 344      | •          |        |      |               |              | •        | MPX2100A       |
| MPX2100D                                | Tray            | 344      | •          |        |      |               | •            |          | MPX2100D       |
| MPX2100AP                               | Tray            | 344B     |            | •      |      |               |              | •        | MPX2100AP      |
| MPX2100GP                               | Tray            | 344B     |            | •      |      | •             |              |          | MPX2100GP      |
| MPX2100DP                               | Tray            | 344C     |            |        | •    |               | •            |          | MPX2100DP      |
| MPX2100GVP                              | Tray            | 344D     |            | •      |      | •             |              |          | MPX2100GVP     |
| MPX2100ASX                              | Tray            | 344F     |            | •      |      |               |              | •        | MPX2100A       |

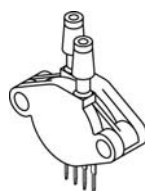
### PACKAGES



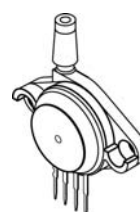
MPX2100A/D  
 CASE 344-15



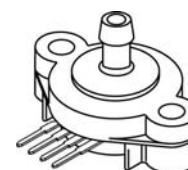
MPX2100AP/GP  
 CASE 344B-01



MPX2100DP  
 CASE 344C-01



MPX2100GVP  
 CASE 344D-01



MPX2100ASX  
 CASE 344F-01

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

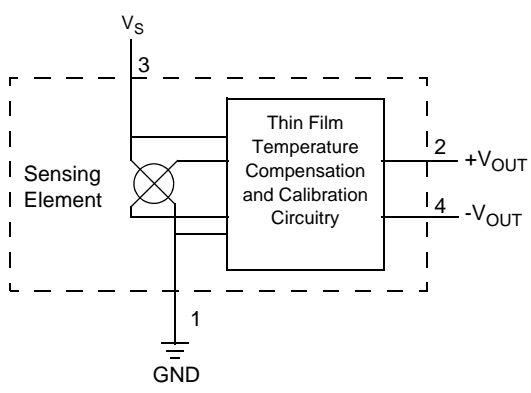


Figure 1. Temperature Compensated Pressure Sensor Schematic

### Voltage Output versus Applied Differential Pressure

The differential voltage output of the sensor is directly proportional to the differential pressure applied.

The absolute sensor has a built-in reference vacuum. The output voltage will decrease as vacuum, relative to ambient, is drawn on the pressure (P1) side.

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).

## Operating Characteristics

**Table 1. Operating Characteristics**

 ( $V_S = 10$  Vdc,  $T_A = 25^\circ\text{C}$  unless otherwise noted,  $P_1 > P_2$ )

| Characteristics   | Symbol              | Min   | Typ       | Max  | Unit        |
|---|---------------------|-------|-----------|------|-------------|
| Pressure Range <sup>(1)</sup>                           | $P_{OP}$            | 0     | —         | 100  | kPa         |
| Supply Voltage <sup>(2)</sup>                           | $V_S$               | —     | 10        | 16   | Vdc         |
| Supply Current  | $I_o$               | —     | 6.0       | —    | mAdc        |
| Full Scale Span <sup>(3)</sup>                          | $V_{FSS}$           | 38.5  | 40        | 41.5 | mV          |
| Offset <sup>(4)</sup>                                   | $V_{off}$           | -1.0  | —         | 1.0  | mV          |
| MPX2100D Series<br>MPX2100A Series                      |                     | -2.0  | —         | 2.0  |             |
| Sensitivity   | $\Delta V/\Delta P$ | —     | 0.4       | —    | mV/kPa      |
| Linearity <sup>(5)</sup>                                | —                   | -0.25 | —         | 0.25 | % $V_{FSS}$ |
| MPX2100D Series<br>MPX2100A Series                      |                     | -1.0  | —         | 1.0  |             |
| Pressure Hysteresis <sup>(5)</sup> (0 to 100 kPa)       | —                   | —     | $\pm 0.1$ | —    | % $V_{FSS}$ |
| Temperature Hysteresis <sup>(5)</sup> (-40°C to +125°C) | —                   | —     | $\pm 0.5$ | —    | % $V_{FSS}$ |
| Temperature Effect on Full Scale Span <sup>(5)</sup>    | $TCV_{FSS}$         | -1.0  | —         | 1.0  | % $V_{FSS}$ |
| Temperature Effect on Offset <sup>(5)</sup>             | $TCV_{off}$         | -1.0  | —         | 1.0  | mV          |
| Input Impedance   | $Z_{in}$            | 1000  | —         | 2500 | $\Omega$    |
| Output Impedance  | $Z_{out}$           | 1400  | —         | 3000 | $\Omega$    |
| Response Time <sup>(6)</sup> (10% to 90%)               | $t_R$               | —     | 1.0       | —    | ms          |
| Warm-Up   | —                   | —     | 20        | —    | ms          |
| Offset Stability <sup>(7)</sup>                         | —                   | —     | $\pm 0.5$ | —    | % $V_{FSS}$ |

- 1.0 kPa (kiloPascal) equals 0.145 psi.
- 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.
- 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.
- Offset ( $V_{off}$ ) is defined as the output voltage at the minimum rated pressure.
- 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.
- 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.
- 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>**

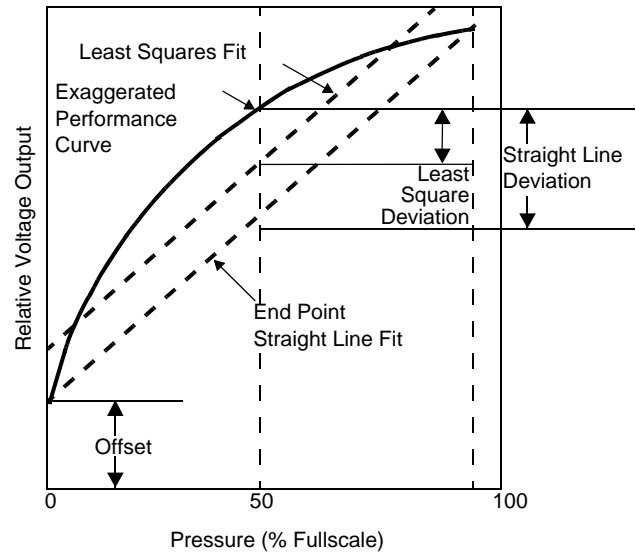
| Rating                     | Symbol           | Value       | Unit |
|----------------------------|------------------|-------------|------|
| Maximum Pressure (P1 > P2) | P <sub>max</sub> | 400         | kPa  |
| Storage Temperature        | T <sub>stg</sub> | -40 to +125 | °C   |
| Operating Temperature      | T <sub>A</sub>   | -40 to +125 | °C   |

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

### 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 2) 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 2. Linearity Specification Comparison**

## On-Chip Temperature Compensation and Calibration

Figure 3 shows the output characteristics of the MPX2100 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.

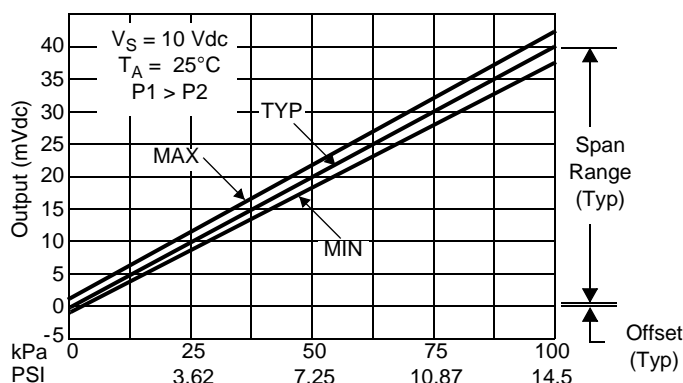


Figure 3. Output versus Pressure Differential

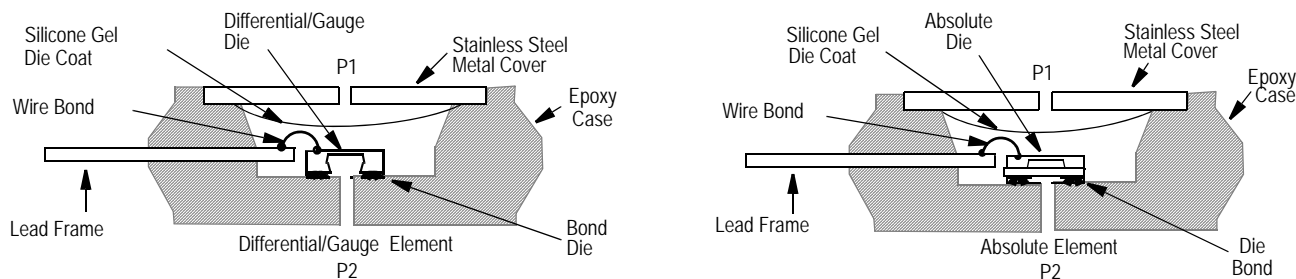


Figure 4. Cross-Sectional Diagram (not to scale)

Figure 4 illustrates the absolute sensing configuration (right) and the differential or gauge configuration 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 MPX2100 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. Contact the factory for information regarding media compatibility in your application.

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

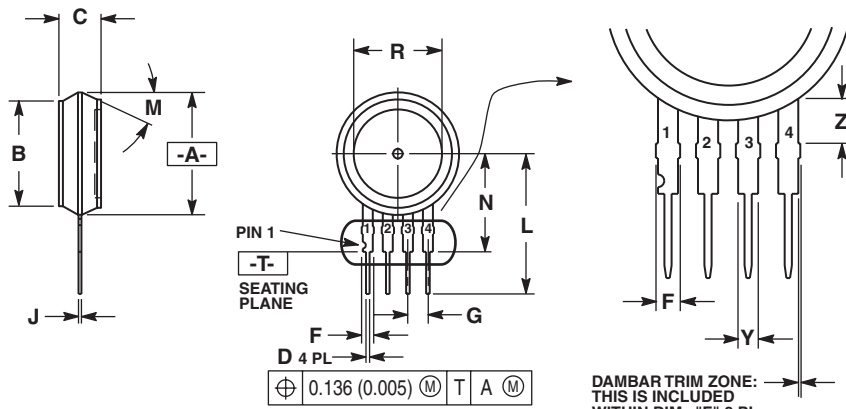
Freescale designates the two sides of the pressure sensor as the Pressure (P1) side and the Vacuum (P2) side. The Pressure (P1) side is the side containing the silicone gel which isolates the die. The differential or gauge sensor is designed to operate with positive differential pressure

applied,  $P1 > P2$ . The absolute sensor is designed for vacuum applied to P1 side.

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

| Part Number          | Case Type | Pressure (P1) Side Identifier |
|----------------------|-----------|-------------------------------|
| MPX2100A, MPX2100D   | 344       | Stainless Steel Cap           |
| MPX2100DP            | 344C      | Side with Part Marking        |
| MPX2100AP, MPX2100GP | 344B      | Side with Port Attached       |
| MPX2100ASX           | 344F      | Side with Port Attached       |
| MPX2100GVP           | 344D      | Stainless Steel Cap           |

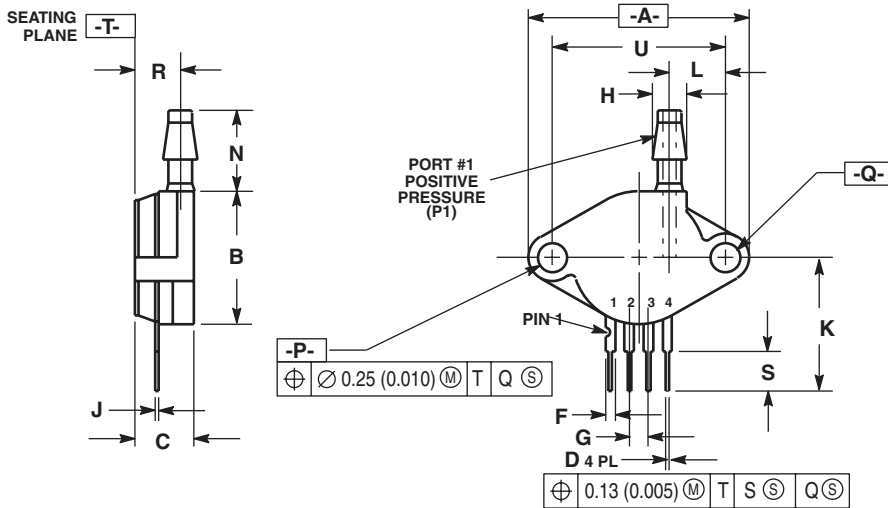
PACKAGE DIMENSIONS



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
  2. CONTROLLING DIMENSION: INCH.
  3. DIMENSION -A- IS INCLUSIVE OF THE MOLD STOP RING. MOLD STOP RING NOT TO EXCEED 16.00 (0.630).

- STYLE 1:  
 PIN 1. GROUND  
 2. + OUTPUT  
 3. + SUPPLY  
 4. - OUTPUT
- STYLE 2:  
 PIN 1.  $V_{CC}$   
 2. - SUPPLY  
 3. + SUPPLY  
 4. GROUND
- STYLE 3:  
 PIN 1. GND  
 2. -VOUT  
 3. VS  
 4. +VOUT

CASE 344-15  
 ISSUE AA  
 UNIBODY PACKAGE

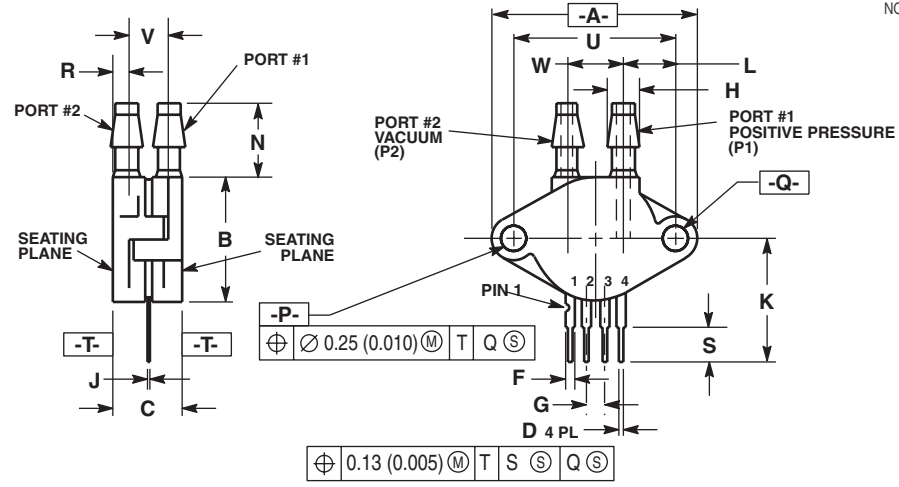


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: INCH.

- STYLE 1:  
 PIN 1. GROUND  
 2. + OUTPUT  
 3. + SUPPLY  
 4. - OUTPUT

CASE 344B-01  
 ISSUE B  
 UNIBODY PACKAGE

**PACKAGE DIMENSIONS**

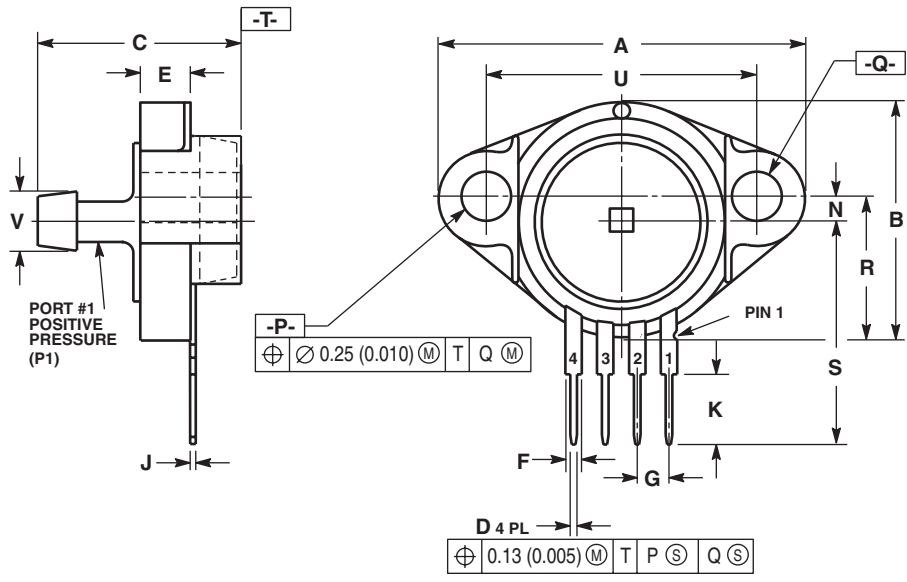


- NOTES:  
 1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
 2. CONTROLLING DIMENSION: INCH.

| 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  |

- STYLE 1:  
 PIN 1. GROUND  
 2. + OUTPUT  
 3. + SUPPLY  
 4. - OUTPUT

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



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

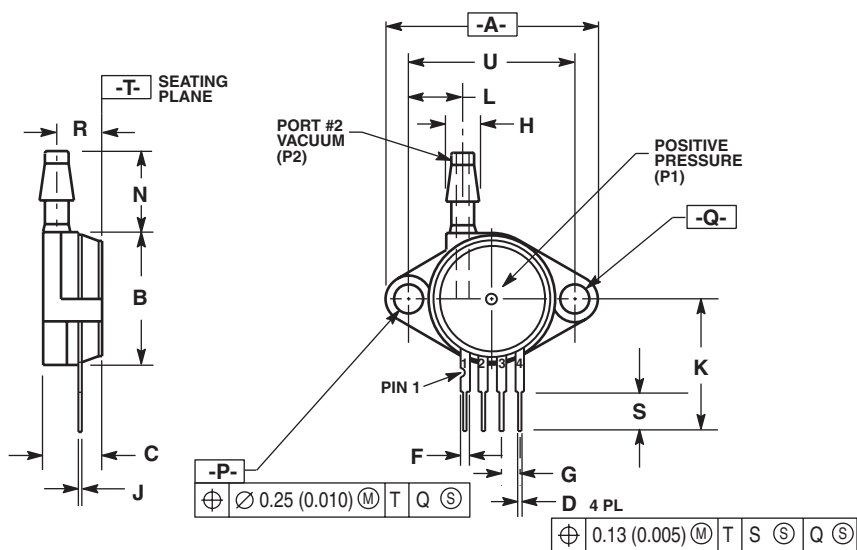
| DIM | INCHES    |       | MILLIMETERS |       |
|-----|-----------|-------|-------------|-------|
|     | MIN       | MAX   | MIN         | MAX   |
| A   | 1.080     | 1.120 | 27.43       | 28.45 |
| B   | 0.740     | 0.760 | 18.80       | 19.30 |
| C   | 0.630     | 0.650 | 16.00       | 16.51 |
| D   | 0.016     | 0.020 | 0.41        | 0.51  |
| E   | 0.160     | 0.180 | 4.06        | 4.57  |
| F   | 0.048     | 0.064 | 1.22        | 1.63  |
| G   | 0.100 BSC |       | 2.54 BSC    |       |
| J   | 0.014     | 0.016 | 0.36        | 0.41  |
| K   | 0.220     | 0.240 | 5.59        | 6.10  |
| N   | 0.070     | 0.080 | 1.78        | 2.03  |
| P   | 0.150     | 0.160 | 3.81        | 4.06  |
| Q   | 0.150     | 0.160 | 3.81        | 4.06  |
| R   | 0.440     | 0.460 | 11.18       | 11.68 |
| S   | 0.695     | 0.725 | 17.65       | 18.42 |
| U   | 0.840     | 0.860 | 21.34       | 21.84 |
| V   | 0.182     | 0.194 | 4.62        | 4.92  |

- STYLE 1:  
 PIN 1. GROUND  
 2. V (+) OUT  
 3. V SUPPLY  
 4. V (-) OUT

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



PACKAGE DIMENSIONS



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
  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   | 0.305     | 0.325 | 7.75        | 8.26  |
| 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     | 0.158 | 3.89        | 4.04  |
| R   | 0.230     | 0.250 | 5.84        | 6.35  |
| S   | 0.220     | 0.240 | 5.59        | 6.10  |
| U   | 0.910 BSC |       | 23.11 BSC   |       |

- STYLE 1:  
 PIN 1. GROUND  
 2. + OUTPUT  
 3. + SUPPLY  
 4. - OUTPUT

CASE 344D-01  
 ISSUE B  
 UNIBODY PACKAGE

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