

# Freescale Semiconductor

 MPX2010  
 Rev 13, 10/2008

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

The MPX2010 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. 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
- Available in Easy-to-Use Tape & Reel

## MPX2010 Series

0 to 10 kPa (0 to 1.45 psi)  
 25 mV Full Scale  
 (Typical)

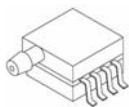
### Application Examples

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

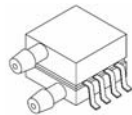
### ORDERING INFORMATION

Device Name	Package Options	Case No.	# of Ports			Pressure Type			Device Marking
			None	Single	Dual	Gauge	Differential	Absolute	
<b>Small Outline Package (MPXV2010 Series)</b>									
MPXV2010GP	Tray	1369		•		•			MPXV2010GP
MPXV2010DP	Tray	1351			•		•		MPXV2010DP
<b>Unibody Package (MPX2010 Series)</b>									
MPX2010D	Tray	344	•				•		MPX2010D
MPX2010DP	Tray	344C			•		•		MPX2010DP
MPX2010GP	Tray	344B		•		•			MPX2010GP
MPX2010GS	Tray	344E		•		•			MPX2010D
MPX2010GSX	Tray	344F		•		•			MPX2010D
<b>MPAK Package (MPXM2010 Series)</b>									
MPXM2010D	Rail	1320	•				•		MPXM2010D
MPXM2010DT1	Tape and Reel	1320	•				•		MPXM2010D
MPXM2010GS	Rail	1320A		•		•			MPXM2010GS
MPXM2010GST1	Tape and Reel	1320A		•		•			MPXM2010GS

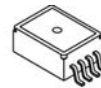
### SMALL OUTLINE PACKAGES



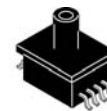
MPXV2010GP  
CASE 1369-01



MPXV2010DP  
CASE 1351-01



MPXM2010D/DT1  
CASE 1320-02



MPXM2010GS/GST1  
CASE 1320A-02

### UNIBODY PACKAGES



MPX2010D  
CASE 344-15



MPX2010GP  
CASE 344B-01



MPX2010DP  
CASE 344C-01



MPX2010GS  
CASE 344E-01



MPX2010GSX  
CASE 344F-01

## Operating Characteristics

**Table 1. Operating Characteristics** ( $V_S = 10 V_{DC}$ ,  $T_A = 25^\circ C$  unless otherwise noted,  $P1 > P2$ )

Characteristic	Symbol	Min	Typ	Max	Units
Pressure Range <sup>(1)</sup>	$P_{OP}$	0	—	10	kPa
Supply Voltage <sup>(2)</sup>	$V_S$	—	10	16	$V_{DC}$
Supply Current	$I_O$	—	6.0	—	mAdc
Full Scale Span <sup>(3)</sup>	$V_{FSS}$	24	25	26	mV
Offset <sup>(4)</sup>	$V_{OFF}$	-1.0	—	1.0	mV
Sensitivity	$\Delta V/\Delta P$	—	2.5	—	mV/kPa
Linearity	—	-1.0	—	1.0	% $V_{FSS}$
Pressure Hysteresis (0 to 10 kPa)	—	—	$\pm 0.1$	—	% $V_{FSS}$
Temperature Hysteresis ( $-40^\circ C$ to $+125^\circ C$ )	—	—	$\pm 0.5$	—	% $V_{FSS}$
Temperature Coefficient on Full Scale Span	$TCV_{FSS}$	-1.0	—	1.0	% $V_{FSS}$
Temperature Coefficient on Offset	$TCV_{OFF}$	-1.0	—	1.0	mV
Input Impedance	$Z_{IN}$	1300	—	2550	$\Omega$
Output Impedance	$Z_{OUT}$	1400	—	3000	$\Omega$
Response Time <sup>(5)</sup> (10% to 90%)	$t_R$	—	1.0	—	ms
Warm-Up Time	—	—	20	—	ms
Offset Stability <sup>(6)</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 at a different 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. 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>**

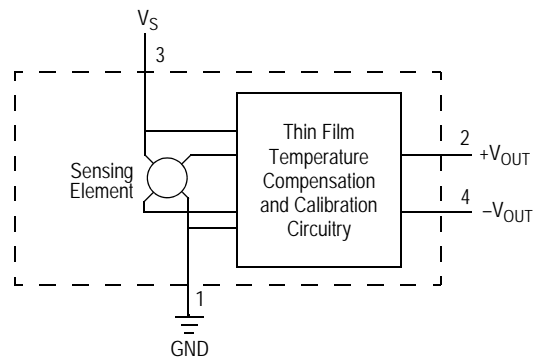
Rating	Symbol	Value	Unit
Maximum Pressure (P1 > P2)	$P_{MAX}$	75	kPa
Burst Pressure (P1 > P2)	$P_{BURST}$	100	kPa
Storage Temperature	$T_{STG}$	-40 to +125	°C
Operating Temperature	$T_A$	-40 to +125	°C

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

## 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).

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**

## On-Chip Temperature Compensation and Calibration

Figure 2. shows the output characteristics of the MPX2010 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. 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 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.

### 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 4.) 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.

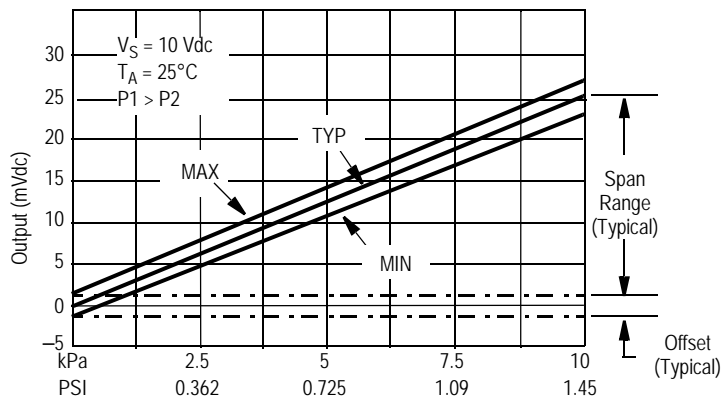


Figure 2. Output vs. Pressure Differential

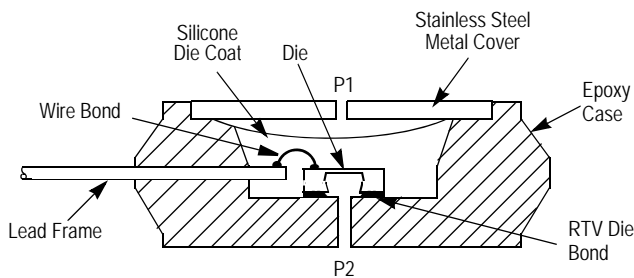


Figure 3. Unibody Package: Cross Sectional Diagram (not to scale)

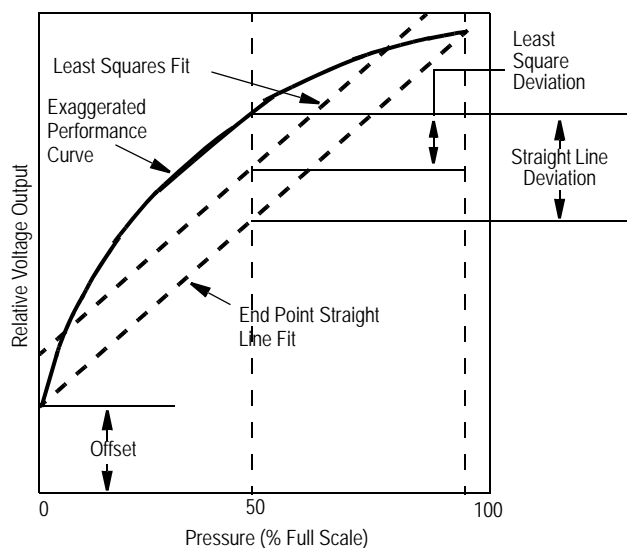


Figure 4. Linearity Specification Comparison

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

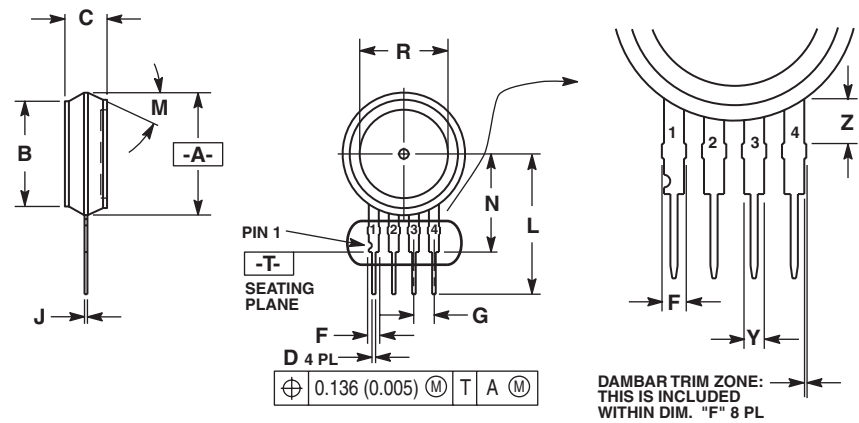
Freescale designates the two sides of the pressure sensor as the Pressure (P1) side and the Vacuum (P2) side. The Pressure (P1) side is the side containing silicone gel which isolates the die from the environment. The pressure sensor is designed to operate with positive differential pressure applied,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

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

**Table 3. Pressure (P1) Side Delineation**

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
MPXM2010D/DTI	1320	Side with Part Marking
MPXM2010GS/GSTI	1320A	Side with Port Attached

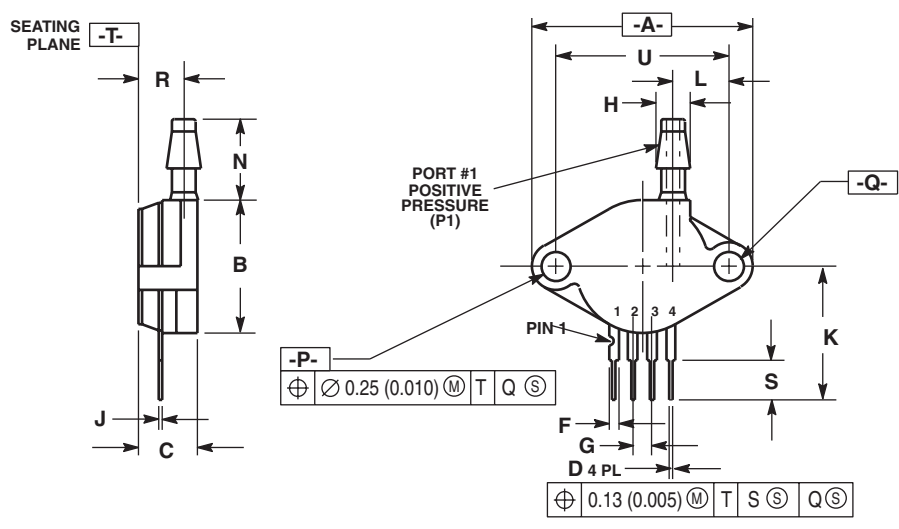
**PACKAGE DIMENSIONS**



- 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).

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.595	0.630	15.11	16.00
B	0.514	0.534	13.06	13.56
C	0.200	0.220	5.08	5.59
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	
J	0.014	0.016	0.36	0.40
L	0.695	0.725	17.65	18.42
M	30° NOM		30° NOM	
N	0.475	0.495	12.07	12.57
R	0.430	0.450	10.92	11.43
Y	0.048	0.052	1.22	1.32
Z	0.106	0.118	2.68	3.00

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

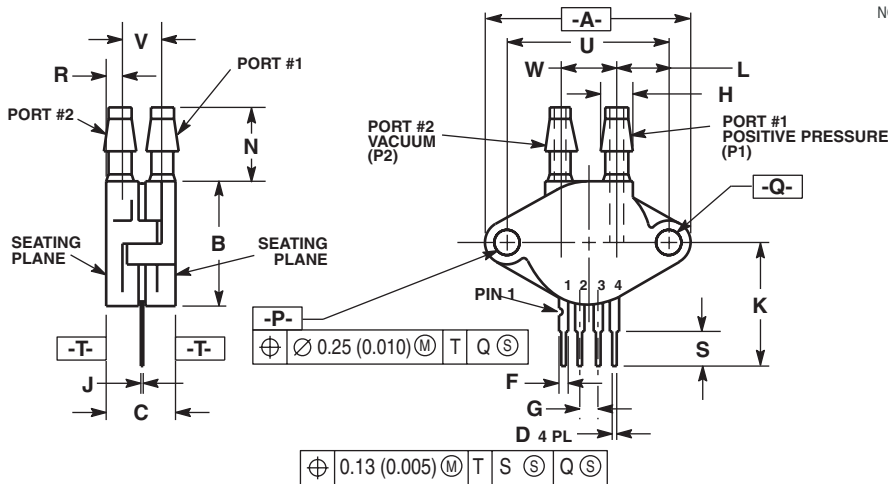


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.145	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	0.159	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	

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

PACKAGE DIMENSIONS

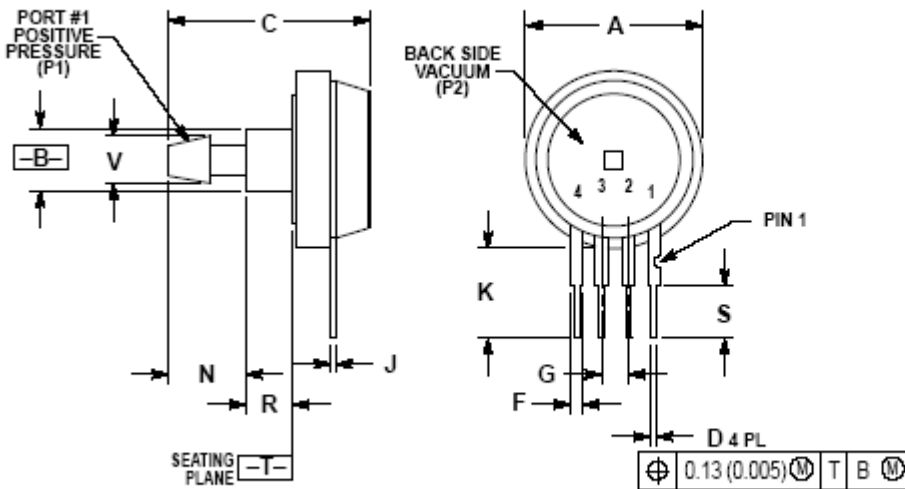


- NOTES:  
 1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
 2. CONTROLLING DIMENSION: INCH.

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



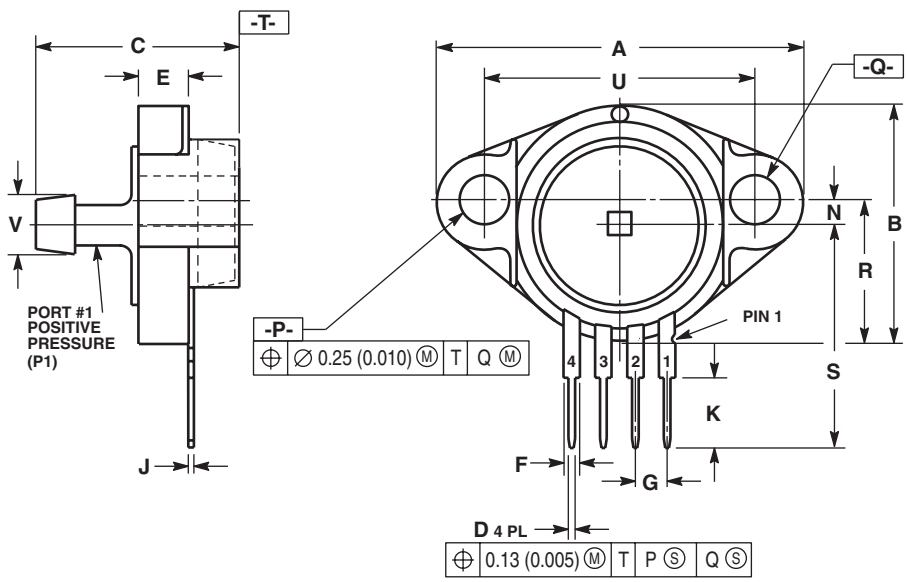
- NOTES:  
 1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
 2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.890	0.720	17.53	18.28
B	0.245	0.255	6.22	6.48
C	0.790	0.820	19.81	20.82
D	0.018	0.020	0.41	0.51
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	0.345	0.375	8.78	9.53
N	0.300	0.310	7.62	7.87
R	0.178	0.186	4.52	4.72
S	0.220	0.240	5.59	6.10
V	0.182	0.194	4.62	4.93

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

CASE 344E-01  
 ISSUE B  
 UNIBODY PACKAGE

### PACKAGE DIMENSIONS



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

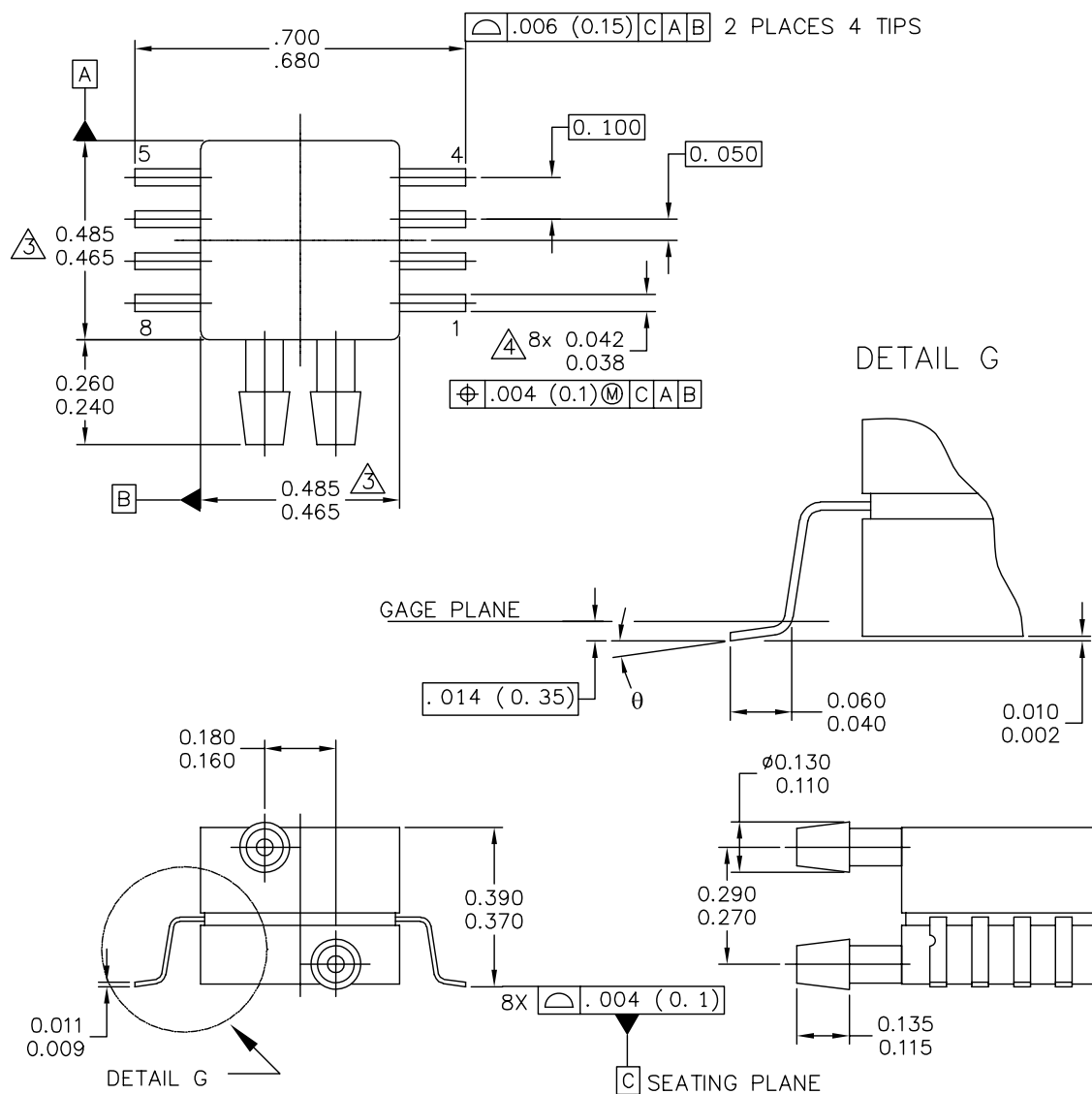
DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.080	1.120	27.43	28.45
B	0.740	0.760	18.80	19.30
C	0.630	0.650	16.00	16.51
D	0.016	0.020	0.41	0.51
E	0.160	0.180	4.06	4.57
F	0.048	0.064	1.22	1.63
G	0.100 BSC		2.54 BSC	
J	0.014	0.016	0.36	0.41
K	0.220	0.240	5.59	6.10
N	0.070	0.080	1.78	2.03
P	0.150	0.160	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



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TITLE:  8 LD SNSR, DUAL PORT	DOCUMENT NO: 98ASA99255D	REV: A
	CASE NUMBER: 1351-01	27 JUL 2005
	STANDARD: NON-JEDEC	

**CASE1351-01  
ISSUE A  
SMALL OUTLINE PACKAGE**

### PACKAGE DIMENSIONS

NOTES:

- 1. CONTROLLING DIMENSION: INCH
- 2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
- 3. DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH AND PROTRUSIONS SHALL NOT EXCEED .006 PER SIDE.
- 4. DIMENSION DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .008 MAXIMUM.

STYLE 1:

PIN 1: GND  
 PIN 2: +Vout  
 PIN 3: Vs  
 PIN 4: -Vout  
 PIN 5: N/C  
 PIN 6: N/C  
 PIN 7: N/C  
 PIN 8: N/C

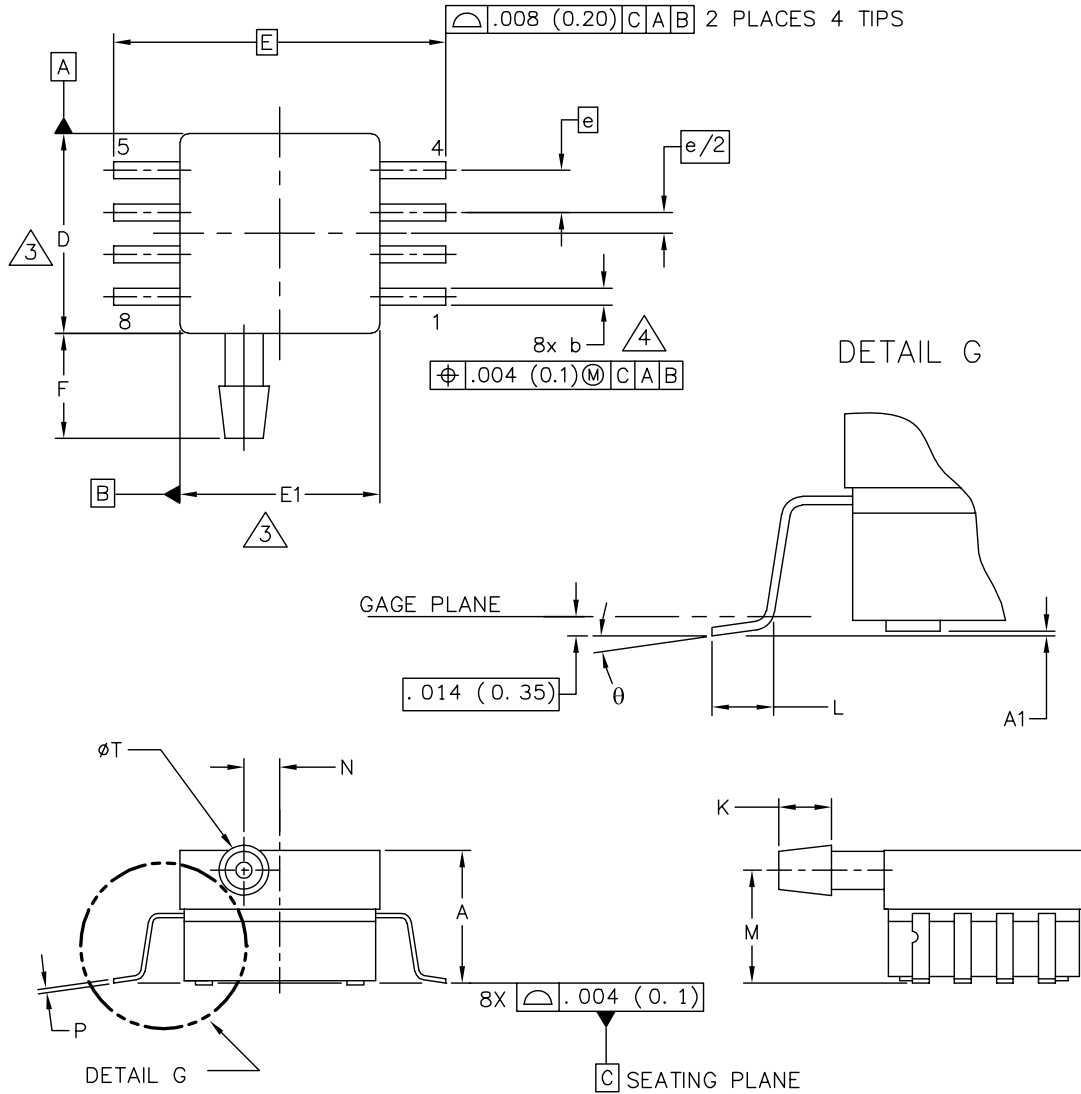
STYLE 2:

PIN 1: N/C  
 PIN 2: Vs  
 PIN 3: GND  
 PIN 4: Vout  
 PIN 5: N/C  
 PIN 6: N/C  
 PIN 7: N/C  
 PIN 8: N/C

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TITLE:  8 LD SNSR, DUAL PORT	DOCUMENT NO: 98ASA99255D	REV: A	
	CASE NUMBER: 1351-01	27 JUL 2005	
	STANDARD: NON-JEDEC		

**CASE1351-01  
 ISSUE A  
 SMALL OUTLINE PACKAGE**

PACKAGE DIMENSIONS



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TITLE:  8 LD SOP, SIDE PORT	DOCUMENT NO: 98ASA99303D	REV: B	
	CASE NUMBER: 1369-01	24 MAY 2005	
	STANDARD: NON-JEDEC		

**CASE 1369-01  
ISSUE B  
SMALL OUTLINE PACKAGE**

**PACKAGE DIMENSIONS**

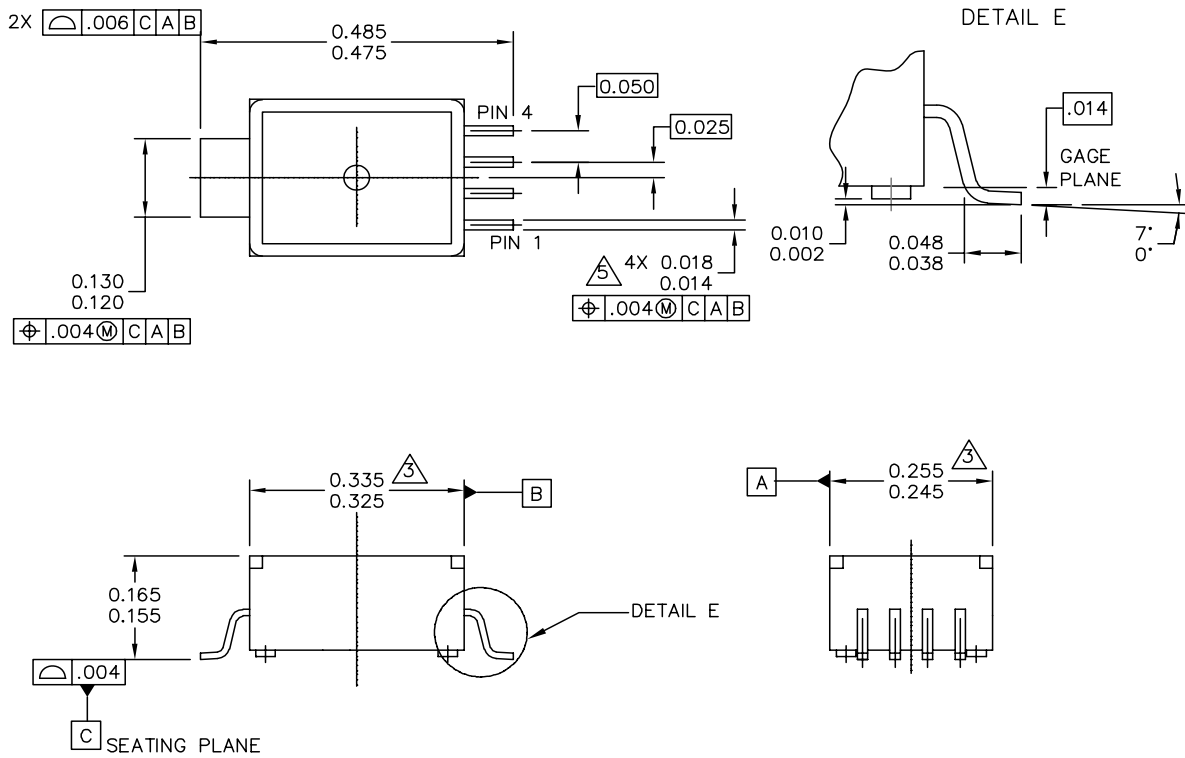
NOTES:

1. CONTROLLING DIMENSION: INCH
  2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
- ⚠ DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH AND PROTRUSIONS SHALL NOT EXCEED .006 (0.152) PER SIDE.
- ⚠ DIMENSION DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .008 (0.203) MAXIMUM.

DIM	INCHES		MILLIMETERS		DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	.300	.330	7.11	7.62	θ	0°	7°	0°	7°
A1	.002	.010	0.05	0.25	-	---	---	---	---
b	.038	.042	0.96	1.07	-	---	---	---	---
D	.465	.485	11.81	12.32	-	---	---	---	---
E	.717 BSC		18.21 BSC		-	---	---	---	---
E1	.465	.485	11.81	12.32	-	---	---	---	---
e	.100 BSC		2.54 BSC		-	---	---	---	---
F	.245	.255	6.22	6.47	-	---	---	---	---
K	.120	.130	3.05	3.30	-	---	---	---	---
L	.061	.071	1.55	1.80	-	---	---	---	---
M	.270	.290	6.86	7.36	-	---	---	---	---
N	.080	.090	2.03	2.28	-	---	---	---	---
P	.009	.011	0.23	0.28	-	---	---	---	---
T	.115	.125	2.92	3.17	-	---	---	---	---
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TITLE:  8 LD SOP, SIDE PORT					DOCUMENT NO: 98ASA99303D			REV: B	
					CASE NUMBER: 1369-01			24 MAY 2005	
					STANDARD: NON-JEDEC				

**CASE 1369-01  
ISSUE B  
SMALL OUTLINE PACKAGE**

PACKAGE DIMENSIONS



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TITLE:  5 LD M-PAC	DOCUMENT NO: 98ARH99088A	REV: B	
	CASE NUMBER: 1320-02	22 JUL 2005	
	STANDARD: NON-JEDEC		

**CASE 1320-02  
ISSUE B  
MPAK**

### PACKAGE DIMENSIONS

NOTES:

- 1. DIMENSIONS ARE IN INCHES.
- 2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.

3. DIMENSION DOES NOT INCLUDE MOLD FLASH OR PROTRUSION. MOLD FLASH OR PROTRUSION SHALL NOT EXCEED .006" PER SIDE.

- 4. ALL VERTICAL SURFACES TO BE 5° MAXIMUM.

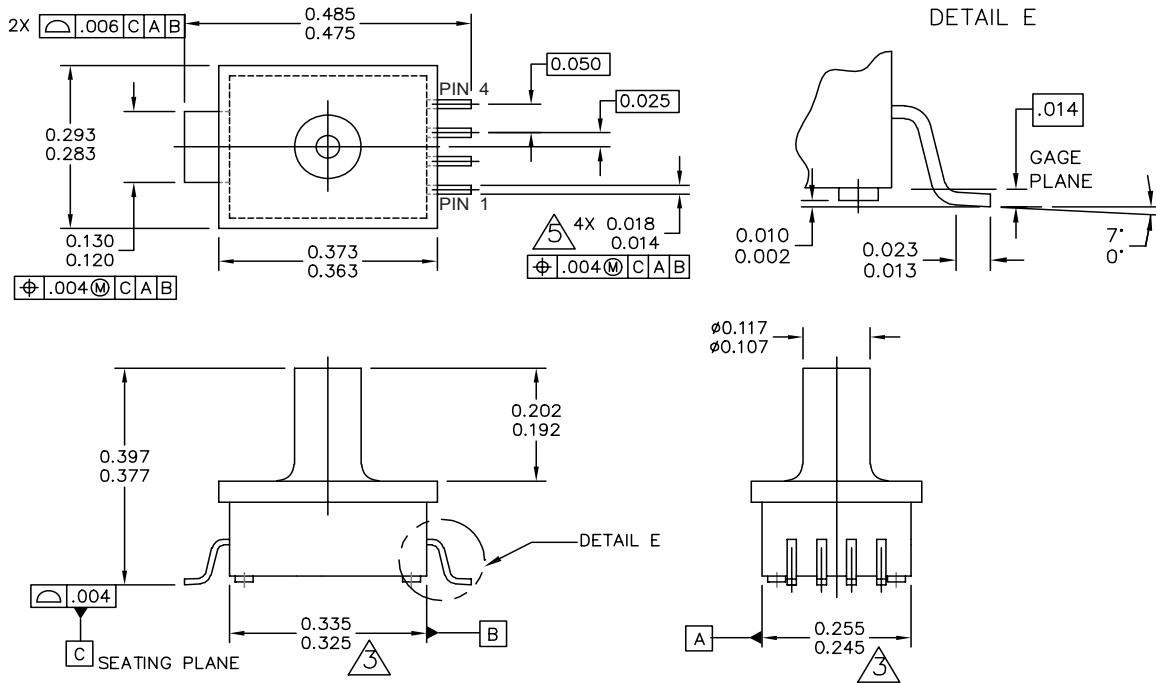
5. DIMENSION DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .008 MAXIMUM.

PIN 1: GND  
 PIN 2: +Vout  
 PIN 3: Vs  
 PIN 4: -Vout

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TITLE:  5 LD M-PAC		DOCUMENT NO: 98ARH99088A		REV: B	
		CASE NUMBER: 1320-02		22 JUL 2005	
		STANDARD: NON-JEDEC			

**CASE 1320-02  
 ISSUE A  
 MPAK**

PACKAGE DIMENSIONS



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TITLE:  5 LD M-PAC, PORTED	DOCUMENT NO: 98ARH99087A	REV: A	
	CASE NUMBER: 1320A-02	22 JUL 2005	
	STANDARD: NON-JEDEC		

**CASE 1320A-02  
 ISSUE A  
 MPAK**

**PACKAGE DIMENSIONS**

NOTES:

1. DIMENSIONS ARE IN INCHES.
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
3. DIMENSIONS DOES NOT INCLUDE MOLD FLASH OR PROTRUSION. MOLD FLASH OR PROTRUSION SHALL NOT EXCEED .006" PER SIDE.
4. ALL VERTICAL SURFACES TO BE 5" MAXIMUM.
5. DIMENSION DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .008 MAXIMUM.

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TITLE:  5 LD M-PAC, PORTED	DOCUMENT NO: 98ARH99087A	REV: A	
	CASE NUMBER: 1320A-02	22 JUL 2005	
	STANDARD: NON-JEDEC		

**CASE 1320-02  
ISSUE A  
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