BME 271 Lab 5: Spirometer

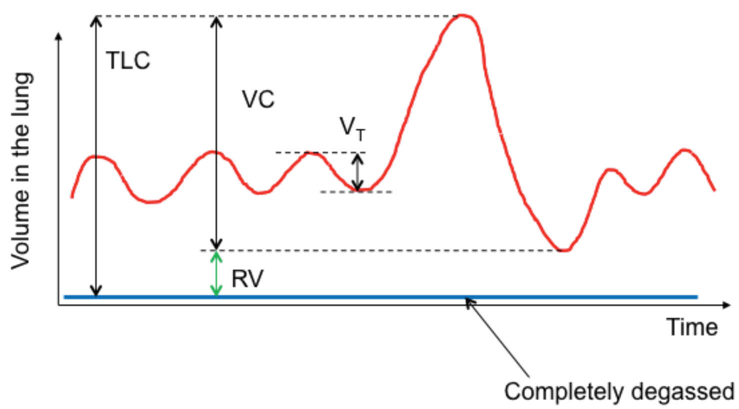
FALL 2012

Background

Spirometry

In this lab you will build a spirometer to characterize lung function by measuring volumetric airflow. A spirometer is a device that measures breath, as characterized by the volume and speed of inhaled and exhaled air. It is an important tool in assessing lung function, and diagnosing diseases such as asthma and pulmonary fibrosis. Below-average spirometry values indicate that a patient's lungs are not functioning well.

The figure below illustrates the volume of air in the lung over a period of normal breathing, and a large inhalation.



The parameters here are:

- TLC: Total lung capacity; the largest volume the lung can expand. Typical values: 6.0 L/Male, 4.7 L/Female.
- RV: Residual volume; the smallest volume the lung can deflate to.
- VC: Vital capacity = TLC – RV; the largest volume change the lung can undergo.
- VT: Tidal volume; the peak-to-peak change during a quiet breath. Typical values: 500 mL/Male, 390 mL/Female.

The most basic maneuver of a spirometry test is to forcibly exhale a full inspiration and measure the volume of exhaled air. This is called Forced Vital Capacity (FVC), and you will measure it, along with Forced Expiratory Volume (FEV) in the first second of exhalation (FEV_1). The ratio FEV_1/FVC is around 75-80% in healthy adults. In addition to this, you will measure Peak Expiratory Flow (PEF), which is the maximum flow rate achieved by forced exhalation after full inhalation.

Your Spirometer

Figure 1a shows a clinical spirometer. Figure 1b illustrates a spirometer based on a Venturi tube and a differential sensor, which is what you will build in this lab. The device is based on the Venturi effect, which dictates that when air flows from a wide section of pipe to a narrow section, the pressure of the air drops. Since air flow (Q) is the same in both sections, it can be calculated using the equation:

$$Q = (A_1 A_2) \cdot \sqrt{\frac{2(p_1 - p_2)}{\rho(A_1^2 - A_2^2)}} = (A_1 A_2) \cdot \sqrt{\frac{2\Delta p}{\rho(A_1^2 - A_2^2)}} \tag{1}$$

In this equation, Q is air flow rate in m^3/s, A_1 is the cross-sectional area of the wider pipe in m^2, A_2 is the cross-sectional area of the narrower pipe, p_1 and p_2 are the pressures in the wider and narrower sections, respectively, in Pa, and $\rho = 1.2\ \mathrm{kg/m}^3$ is air density. The device you will build will transduce the pressure difference Δp to a voltage signal that you will condition, digitize, and process in LabView.

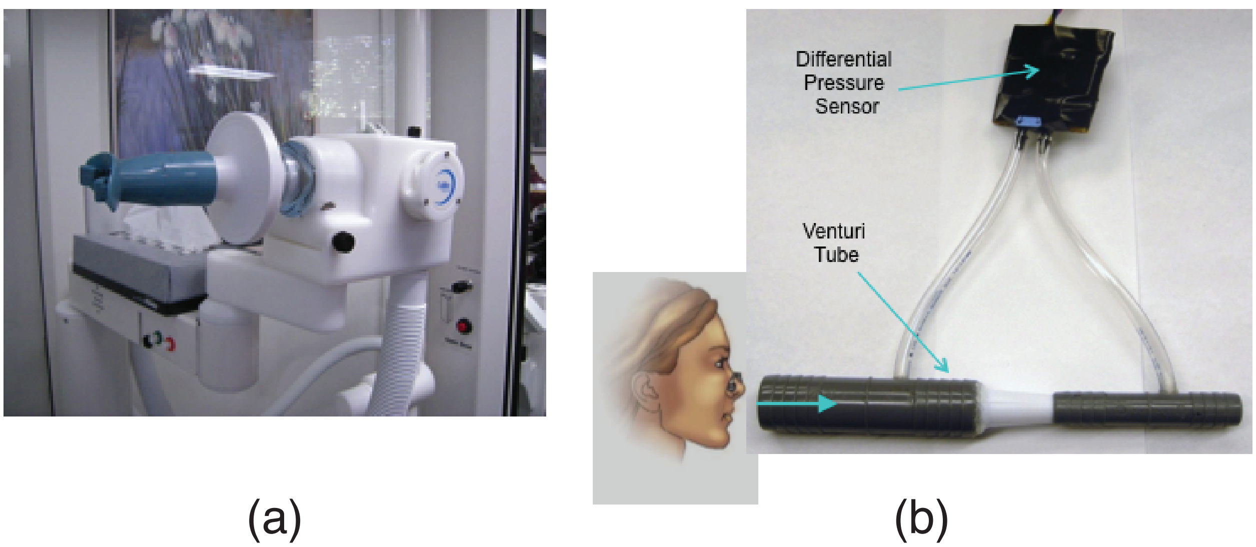


Figure 1: (a) A clinical spirometer. (b) Illustration of the spirometer you will build, which is based on measuring the pressure difference between two sections of a Venturi tube with different diameters.

The technical objectives of this lab are to:

1. Measure the pressure difference in a Venturi tube using electronic sensors.
2. Condition the signal.
3. Read the signal using your NI DAQ card, convert the signal to quantitative units and analyze the data with LabView.

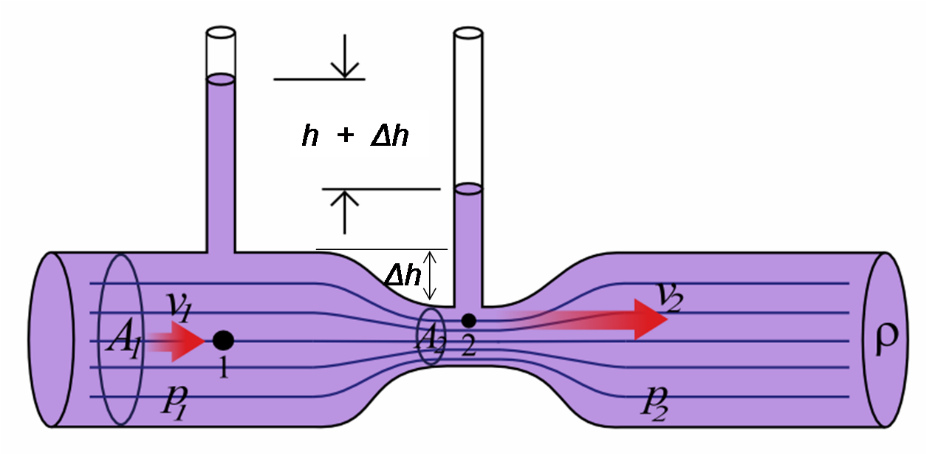


Figure 2: Venturi tube.

Steps

1. Build the circuit in Fig. 3 on a breadboard. When connecting the differential pressure sensor, check the pinout diagram of the pressure sensor on the attached datasheet.

2. Connect the output of the circuit to your DAQ board, with the ground switch set to (FS). In the DAQ Assistant Express VI, select Continuous sampling, 100 Samples, 1 kHz rate, and max/min input voltages of ±10 V. Make a waveform chart in LabView. Why is the noise so much lower in these than in the ECG?

3. The tunable DC offset (at the top of the circuit schematic) can be used to cancel out a small DC differential voltage that you will observe at the output of the transducer. Watching the measured signal in Labview, tune the DC offset to get zero output, with the pressure sensor plugged in. Note that the required offset may change a bit as as the transducer warms up, so you may want to check the offset again a few minutes after powering up the sensor. To remove this offset more robustly, you can place another DAQ Assistant outside of the first loop, set to 1 iteration, and set the DAQ to collect about 100 samples. Then you can average that output and subtract it from the signal coming out of your main DAQ assistant. This way, the average offset will be measured and subtracted each time your VI starts.

4. Connect the Venturi tube to your sensor. Note that the sensor expects the higher pressure from the wider pipe to come into Port #1, and the lower pressure from the narrower pipe to come into Port #2.

5. Filter your digitized signal in LabView. In setting the filter parameters, keep in mind that your signal of interest has frequencies components mostly between 0 and 5 Hz.

6. Convert your measured (and filtered) voltage to pressure (Pa or kPa), using the fact that the gain on your amplifier is 470, and (as is listed on the datasheet) 0.8 mV/kPa

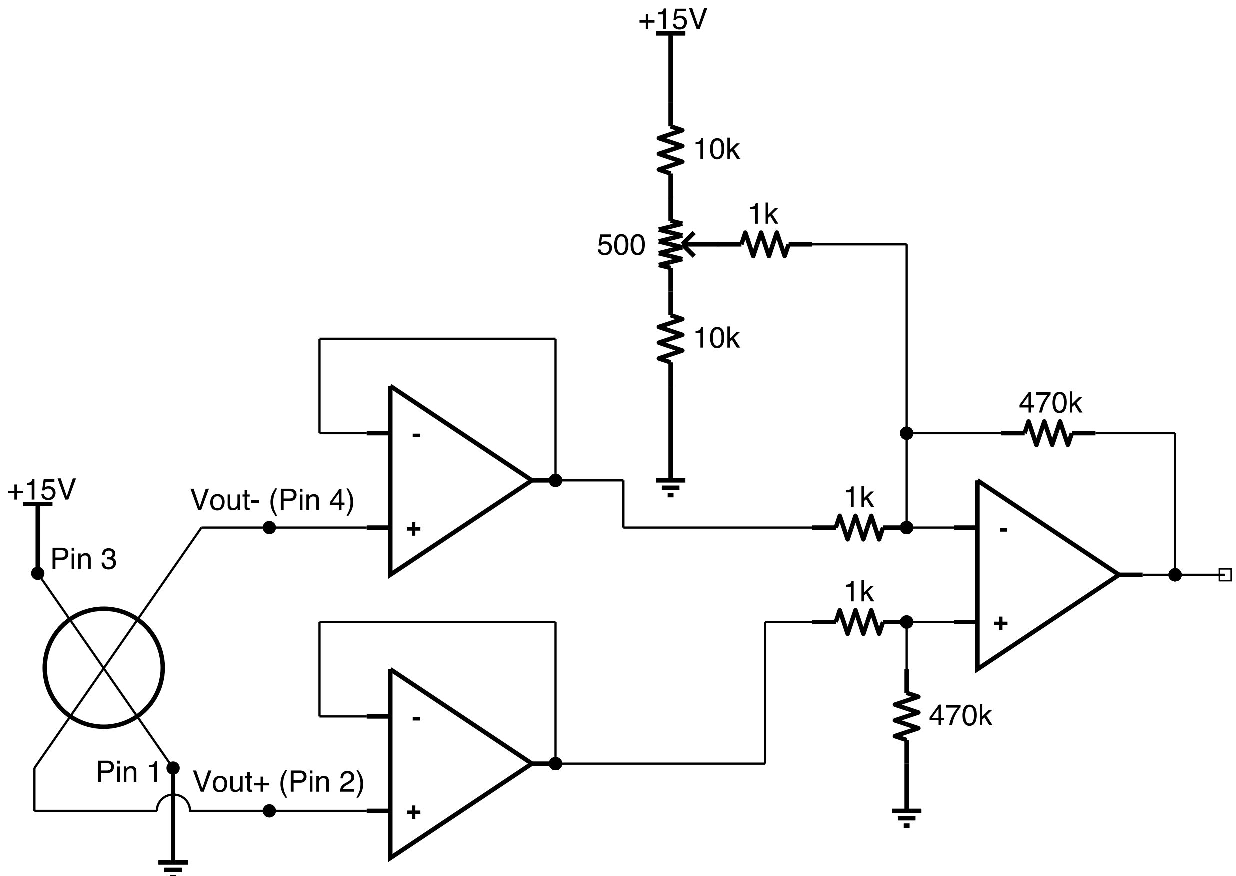


Figure 3: Pressure sensor and amplifier circuit to build.

is your sensitivity. You can implement the conversion using the Formula Express VI. Make a chart for the pressure.

7. Convert the measured pressure to flow rate (L/s), using Eq. 1 and the fact that the tubing diameters are 14.5 mm and 5.5 mm. You can implement the conversion using the Formula Express VI. Note that to convert from (m^3/s) to (L/s) you must multiply by 1000. Make a chart for the flow rate.

8. Use the Time Domain Math Express VI (select 'Calculate Integral') to integrate your flow rate over time, yielding a Volume signal. Make a chart for this signal. The value of this signal at the end of a forced exhalation is the FVC. Measure and record FVC, FEV_1, and FEV_1/FVC for each member in your group. We recommend using alcohol swabs to sanitize the mouthpiece between users.

9. Create a Flow vs Volume Graph - the X-axis will be Volume, and the Y-Axis will be Flow. This will be an X-Y graph, rather than a standard chart. Then attach the flow rate and the Volume to this. The result you see during a forced exhale should look like the top part of the graph in Fig. 4. What does this chart tell you about the

relationship between Flow and Volume during a forced exhalation?

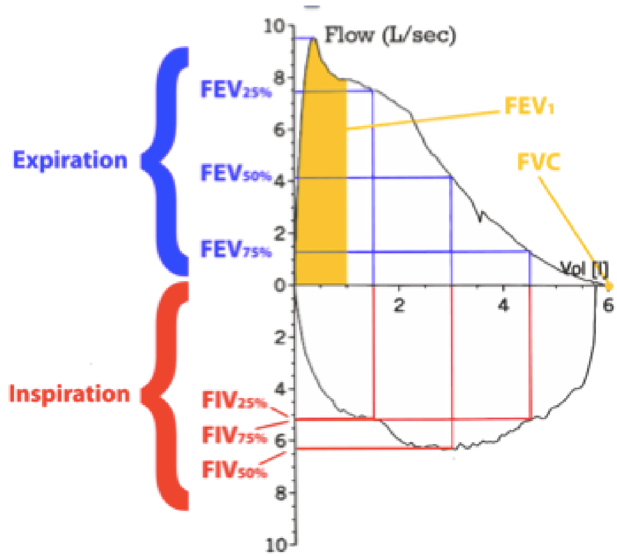


Figure 4: A typical flow vs volume curve for expiration and inhalation.

10. At some point, validate your volume measurements using the 3 L syringe. What are the potential sources of error in your measurements?
11. Since the sensor can only measure unidirectional flow, how could you go about measuring Tidal Volume? Implement your idea.

Freescale Semiconductor

MPX2053
Rev 8, 02/2009

50 kPa On-Chip Temperature Compensated and Calibrated Silicon Pressure Sensors

MPX2053 Series

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

The MPX2053 series devices are silicon piezoresistive pressure sensors that provide a highly accurate and linear voltage output directly proportional to the applied pressure. A single, monolithic silicon diaphragm with the strain gauge and an integrated thin-film resistor network. Precise span and offset calibration with temperature compensation are achieved by laser trimming.

Features

- Temperature Compensated Over 0°C to +85°C
- Easy-to-Use Chip Carrier Package Options
- Ratiometric to Supply Voltage
- Gauge Ported and Non Ported Options
- Available in Easy-to-Use Tape & Reel
- Differential and Gauge Pressure Options

Application Examples

- Pump/Motor Control
- Robotics
- Level Detectors
- Medical Diagnostics
- Pressure Switching
- Blood Pressure Measurement

ORDERING INFORMATION

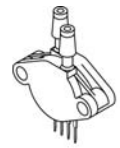
Device Name	Case No.	# of Ports			Pressure Type			Device Marking
		None	Single	Dual	Gauge	Differential	Absolute	
Small Outline Package (MPXV2053G Series)								
MPXV2053GP	1369		•		•			MPXV2053GP
MPXV2053DP	1351			•		•		MPXV2053DP
MPXV2053GVP	1368		•		•			MPXV2053GV
Unibody Package (MPX2053 Series)								
MPX2053D	344	•				•		MPX2053D
MPX2053DP	344C			•		•		MPX2053DP
MPX2053GP	344B		•		•			MPX2053GP
MPAK Package (MPXM2053 Series)								
MPXM2053D	1320	•				•		MPXM2053D
MPXM2053DT1	1320	•				•		MPXM2053D
MPXM2053GS	1320A		•		•			MPXM2053GS
MPXM2053GST1	1320A		•		•			MPXM2053GS

freescale™ semiconductor

UNIBODY PACKAGES

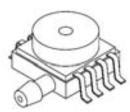
MPX2053D
CASE 344-15

MPX2053GP
CASE 344B-01

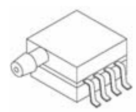


MPX2053DP
CASE 344C-01

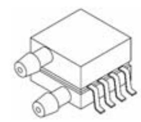
SMALL OUTLINE PACKAGES



MPXV2053GVP
CASE 1368-01

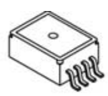


MPXV2053GP
CASE 1369-01



MPXV2053DP
CASE 1351-01

MPAK PACKAGES



MPXM2053D/DT1
CASE 1320-02

MPXM2053GS/GST1
CASE 1320A-02

Operating Characteristics

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

Characteristic	Symbol	Min	Typ	Max	Units
Pressure Range(1)	P_{OP}	0	—	50	kPa
Supply Voltage(2)	V_S	—	10	16	V_{DC}
Supply Current	I_O	—	6.0	—	mAdc
Full Scale Span(3)	V_{FS}	38.5	40	41.5	mV
Offset(4)	—	–1.0	—	1.0	mV
Sensitivity	—	ΔV/ΔP	—	0.8	—
Non-Linearity	—	–0.6	—	0.4	$\%V_{FS}$
Pressure Hysteresis (0 to 50 kPa)	—	—	±0.1	—	$\%V_{FS}$
Temperature Hysteresis (-40° to 125°C)	—	—	±0.5	—	$\%V_{FS}$
Temperature Coefficient of Full Scale	TCV_{FS}	–2.0	—	2.0	$\%V_{FS}$
Temperature Coefficient of Offset	TCV_{OFF}	–1.0	—	1.0	mV
Input Impedance	Z_{IN}	1000	—	2500	Ω
Output Impedance	Z_{OUT}	1400	—	3000	Ω
Response Time(5) (10% to 90%)	t_R	—	1.0	—	ms
Warm-Up Time	—	—	20	—	ms
Offset Stability(6)	—	—	±0.5	—	$\%V_{FS}$

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. 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(1)

Rating	Max Value	Unit
Supply Voltage	16	V
Pressure (P1 > P2)	200	kPa
Storage Temperature	–40 to +125	°C
Operating Temperature Range	–40 to +125	°C

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

Figure 1 shows a block diagram of the internal circuitry integrated on a pressure sensor chip.

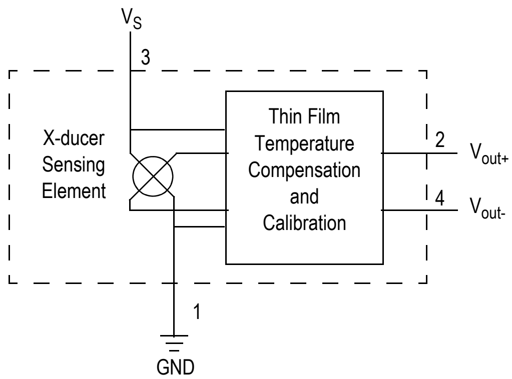


Figure 1. Temperature Compensated Pressure Sensor Schematic

Voltage Output versus Applied Differential Pressure

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

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

On-Chip Temperature Compensation and Calibration

Figure 2 shows the minimum, maximum and typical output characteristics of the MPX2053 series at 25°C. The output is directly proportional to the differential pressure and is essentially a straight line.

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.

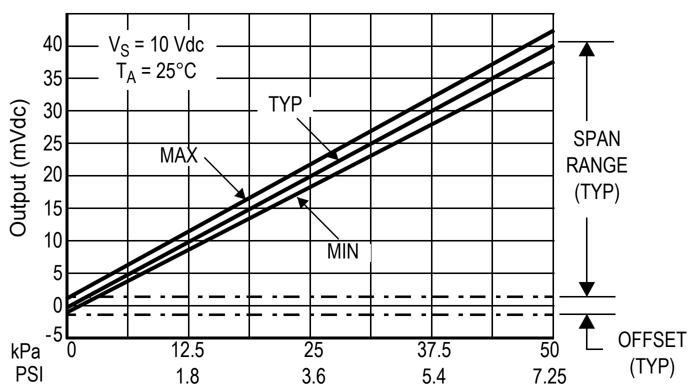


Figure 2. Output vs. Pressure Differential

LINEARITY

Linearity refers to how well a transducer's output follows the equation: $V_{out} = V_{off}$ + sensitivity x P over the operating pressure range. There are two basic methods for calculating nonlinearity: (1) end point straight line fit (see Figure 3) 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. The specified pressure sensor linearities are based on the end point straight line method measured at the midrange pressure.

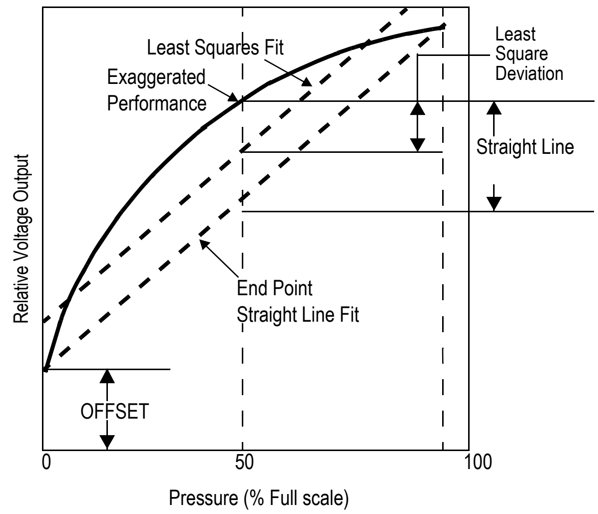


Figure 3. Linearity Specification Comparison

Figure 4 illustrates 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 MPX2053 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. Refer to application note AN3728, for more information regarding media compatibility.

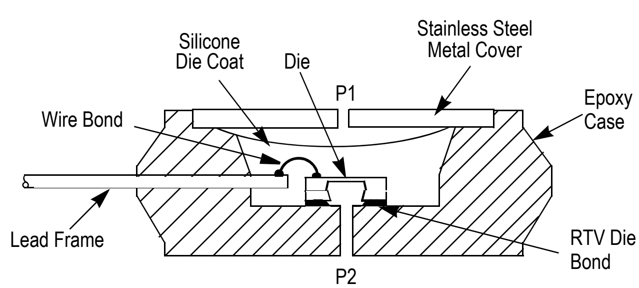
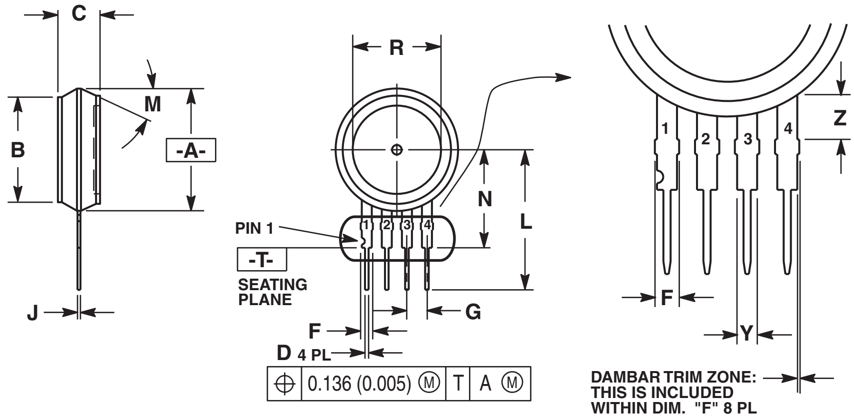


Figure 4. Unibody Package — Cross-Sectional Diagram (Not to Scale)

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).

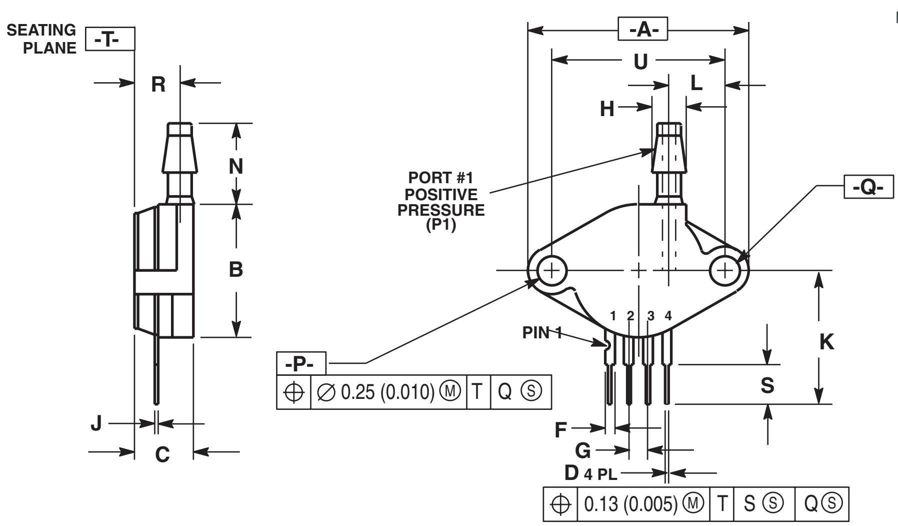
	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.595	0.630	15.11	16.00
B	0.514	0.534	13.06	13.56
C	0.200	0.220	5.08	5.59
D	0.016	0.020	0.41	0.51
F	0.048	0.064	1.22	1.63
G	0.100 BSC		2.54 BSC	
J	0.014	0.016	0.36	0.40
L	0.695	0.725	17.65	18.42
M	30˚ NOM		30˚ NOM	
N	0.475	0.495	12.07	12.57
R	0.430	0.450	10.92	11.43
Y	0.048	0.052	1.22	1.32
Z	0.106	0.118	2.68	3.00

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



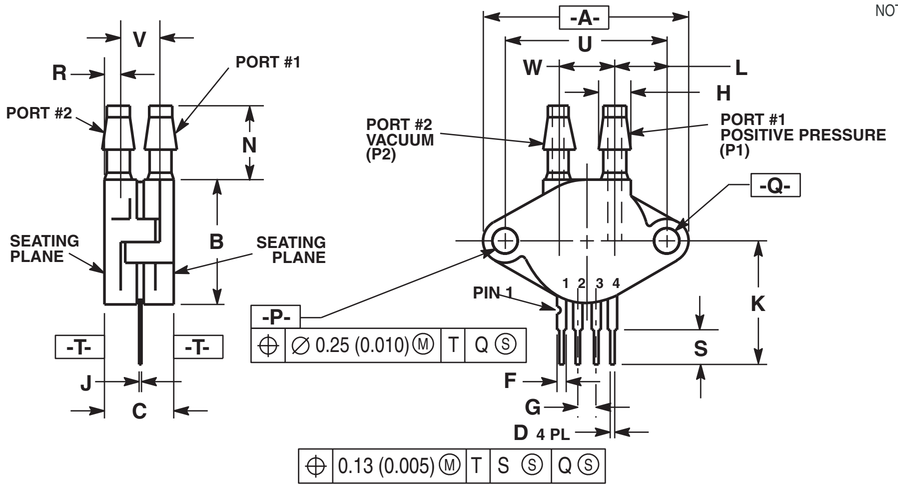
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	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	

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

CASE 344B-01
ISSUE B
UNIBODY PACKAGE

PACKAGE DIMENSIONS



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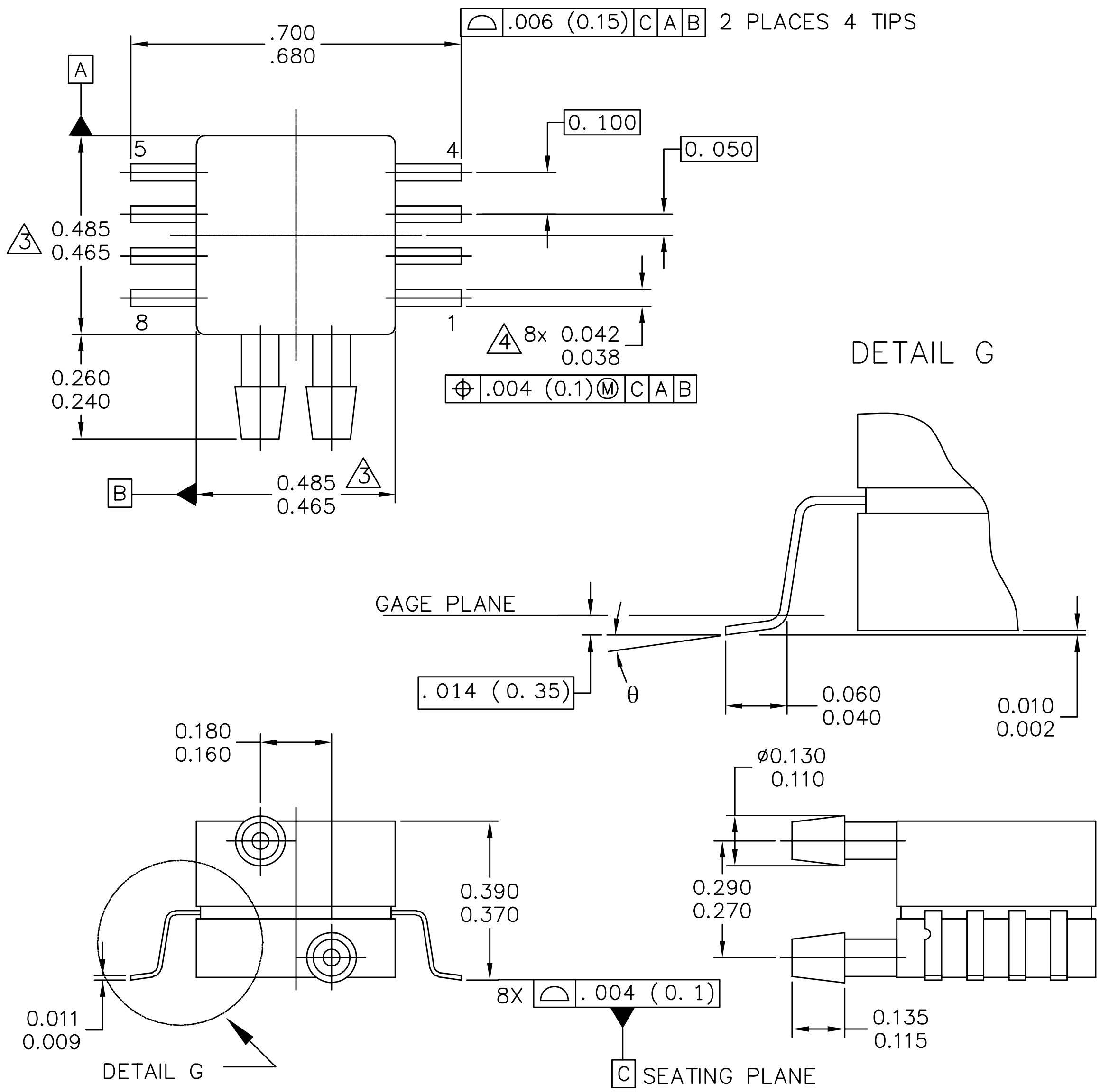
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS 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

PACKAGE DIMENSIONS



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	CASE NUMBER: 1351-01	27 JUL 2005
	STANDARD: NON-JEDEC	

PAGE 1 OF 2

CASE 1351-01
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 PPROTRUSIONS. 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:		STYLE 2:	
PIN 1:	GND	PIN 1:	N/C
PIN 2:	+Vout	PIN 2:	Vs
PIN 3:	Vs	PIN 3:	GND
PIN 4:	−Vout	PIN 4:	Vout
PIN 5:	N/C	PIN 5:	N/C
PIN 6:	N/C	PIN 6:	N/C
PIN 7:	N/C	PIN 7:	N/C
PIN 8:	N/C	PIN 8:	N/C

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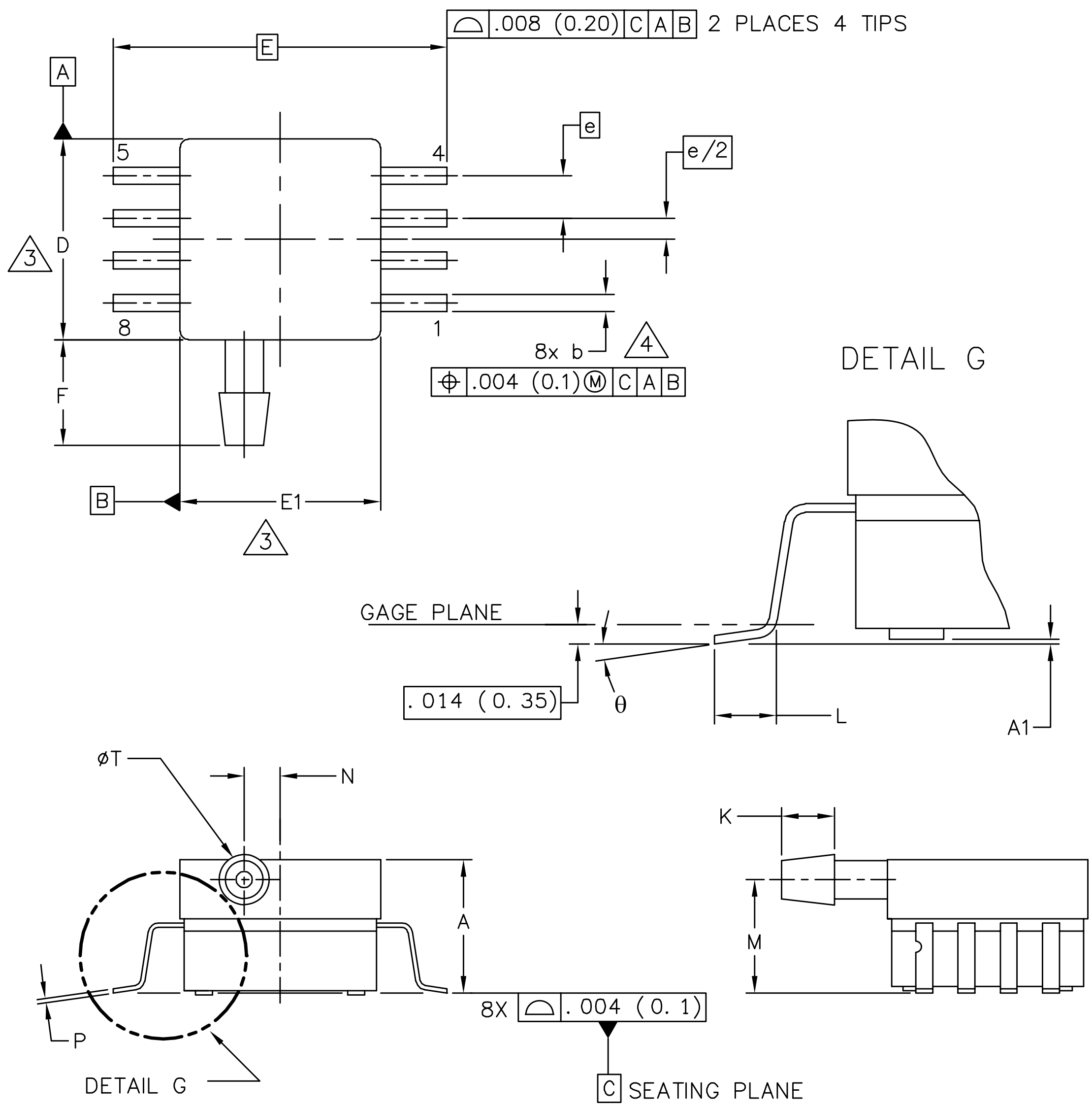
	CASE NUMBER: 1351−01	27 JUL 2005
	STANDARD: NON−JEDEC	

PAGE 2 OF 2

CASE 1351-01
ISSUE A
SMALL OUTLINE PACKAGE

PACKAGE DIMENSIONS



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	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.

3. DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PPROTRUSIONS. MOLD FLASH AND PROTRUSIONS SHALL NOT EXCEED .006 (0.152) PER SIDE.

4. DIMENSION DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .008 (0.203) MAXIMUM.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX	DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS 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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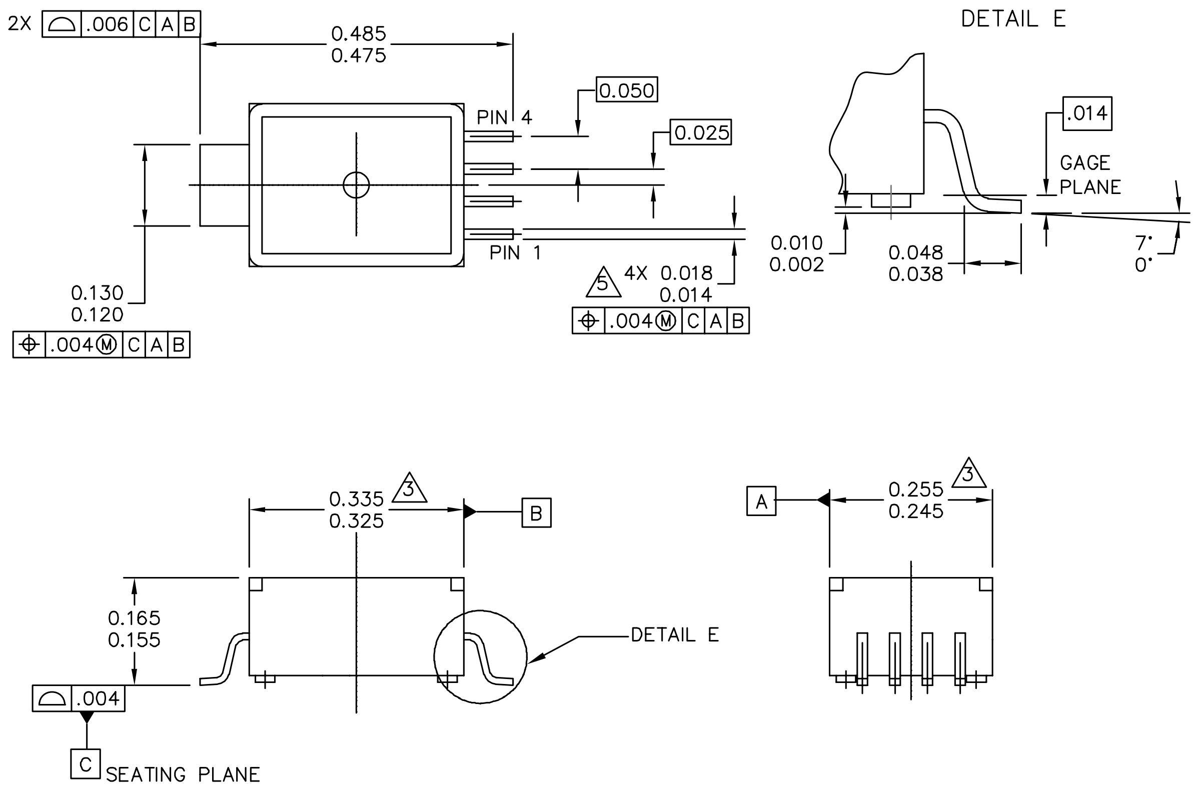
TITLE: 8 LD SOP, SIDE PORT	DOCUMENT NO: 98ASA99303D	REV: B
	CASE NUMBER: 1369–01	24 MAY 2005
	STANDARD: NON–JEDEC	

PAGE 2 OF 2

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	

PAGE 1 OF 2

CASE 1320-02
ISSUE B

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.

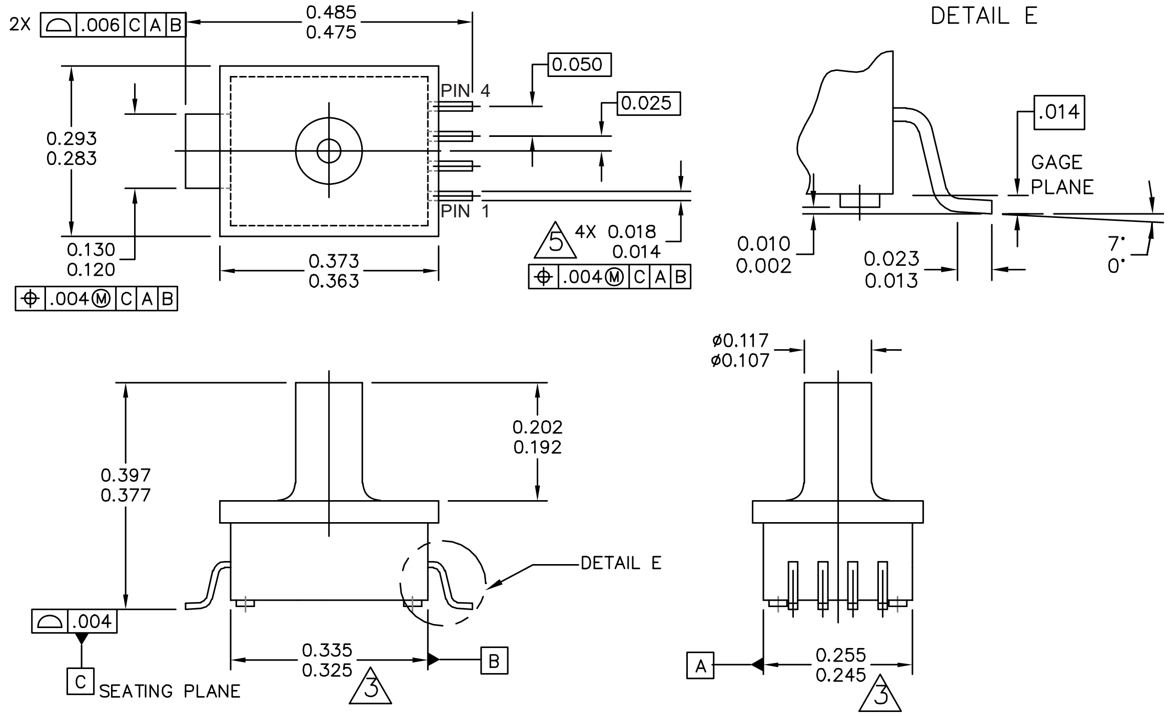
PIN 1: GND
PIN 2: +Vout
PIN 3: Vs
PIN 4: –Vout

	MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE
TITLE: 5 LD M–PAC	DOCUMENT NO: 98ARH99088A	REV: B
	CASE NUMBER: 1320–02	22 JUL 2005
	STANDARD: NON–JEDEC	

PAGE 2 OF 2

CASE 1320-02
ISSUE B

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	

PAGE 1 OF 2

CASE 1320A-02
ISSUE A

PACKAGE DIMENSIONS

NOTES:

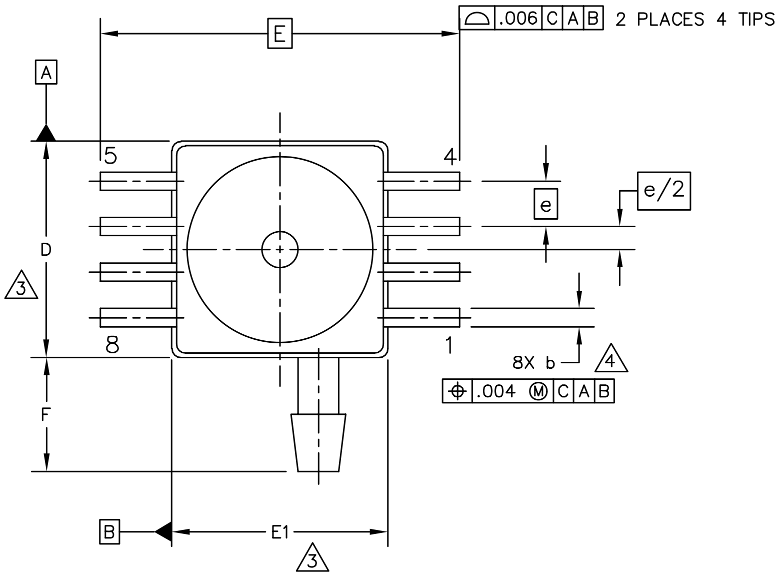
1. DIMENSIONS ARE IN INCHES.
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M–1994.
3. DIMENSIONS DOES NOT INCLUDE MOLD FLASH OR PROTRUSION. MOLD FLASH OR PROTRUSION SHALL NOT EXCEED .006" PER SIDE.
4. ALL VERTICAL SURFACES TO BE 5" MAXIMUM.
5. DIMENSION DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE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

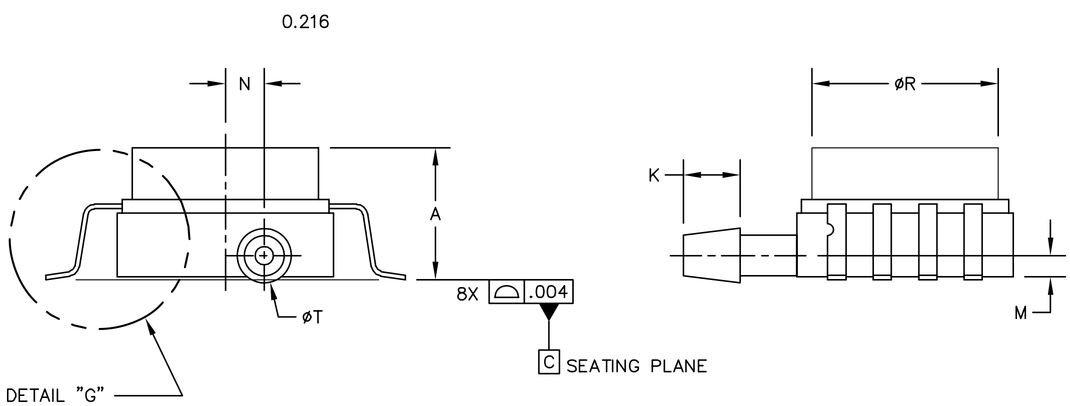
	MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE
TITLE: 5 LD M–PAC, PORTED	DOCUMENT NO: 98ARH99087A	REV: A
	CASE NUMBER: 1320A–02	22 JUL 2005
	STANDARD: NON–JEDEC	

PAGE 2 OF 2

CASE 1320A-02
ISSUE A

PACKAGE DIMENSIONS





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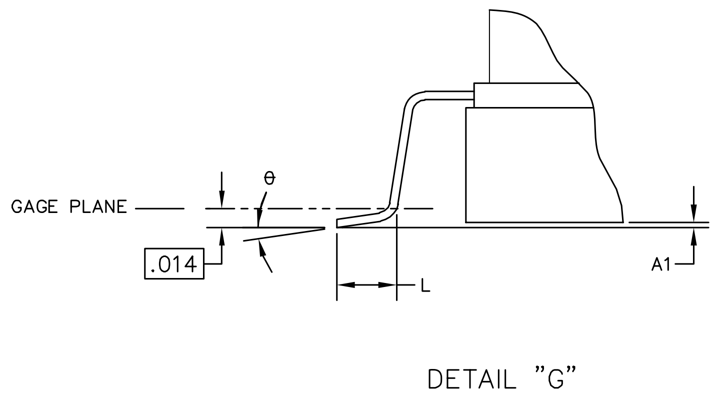
TITLE: 8 LD SOP, GVP	DOCUMENT NO: 98ASA99302D	REV: B
	CASE NUMBER: 1368–01	23 MAY 2005
	STANDARD: NON–JEDEC	

CASE 1368-01
ISSUE B
SMALL OUTLINE PACKAGE
SURFACE MOUNT



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TITLE: 8 LD SOP, GVP	DOCUMENT NO: 98ASA99302D	REV: B
	CASE NUMBER: 1368–01	23 MAY 2005
	STANDARD: NON–JEDEC	

CASE 1368-01
ISSUE B
SMALL OUTLINE PACKAGE
SURFACE MOUNT

PACKAGE DIMENSIONS

NOTES:

1. CONTROLLING DIMENSION: INCH
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M–1994.
3. THIS DIMENSIONS DOES NOT INCLUDE MOLD FLASH OR PPROTRUSIONS. MOLD FLASH AND PROTRUSIONS SHALL NOT EXCEED .006 PER SIDE.
4. THIS 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

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX	DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	.280	.300	7.11	7.62	R	.405	.415	10.28	10.54
A1	.002	.010	0.05	0.25	θ	0°	7°	0°	7°
b	.038	.042	0.96	1.07	–	---	---	---	---
D	.465	.485	11.81	12.32	–	---	---	---	---
E	.690 BSC		17.52 BSC		–	---	---	---	---
E1	.465	.485	11.85	12.32	–	---	---	---	---
e	.100 BSC		2.54 BSC		–	---	---	---	---
F	.240	.260	6.10	6.60	–	---	---	---	---
K	.115	.135	2.92	3.43	–	---	---	---	---
L	.040	.060	1.02	1.52	–	---	---	---	---
M	.035	.055	1.90	2.41	–	---	---	---	---
N	.075	.095	0.89	1.39	–	---	---	---	---
P	.009	.011	0.23	0.28	–	---	---	---	---
T	.110	.130	2.79	3.30	–	---	---	---	---

	MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE
TITLE: 8 LD SOP, GVP	DOCUMENT NO: 98ASA99302D	REV: B
	CASE NUMBER: 1368–01	23 MAY 2005
	STANDARD: NON–JEDEC	

CASE 1368-01
ISSUE B
SMALL OUTLINE PACKAGE
SURFACE MOUNT

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