

Features

- Single-Supply Operation from +2.1V ~ +5.5V
- Rail-to-Rail Input / Output
- Gain-Bandwidth Product: 11MHz (Typ)
- Low Input Bias Current: 1pA (Typ)
- Low Offset Voltage: 3.5mV (Max)
- High Slew Rate: 9V/μs
- Settling Time to 0.1% with 2V Step: 0.3μs
- Low Noise : 8nV/√Hz @10kHz
- Quiescent Current: 1.1mA per Amplifier (Typ)
- Operating Temperature: -40°C ~ +125°C

Applications

- Sensors
- Active Filters
- Cellular and Cordless Phones
- Laptops and PDAs
- Audio
- Handheld Test Equipment
- Battery-Powered Instrumentation
- A/D Converters

Pin Configuration

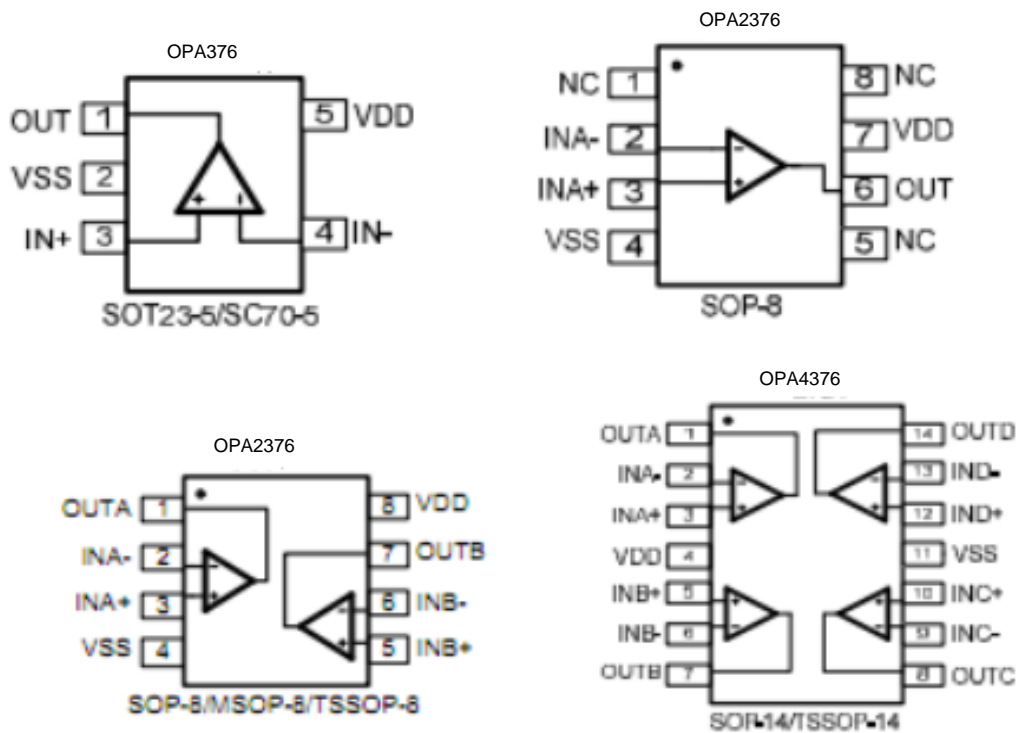


Figure 1. Pin Assignment Diagram



Absolute Maximum Ratings

Condition	Min	Max
Power Supply Voltage (V_{DD} to V_{SS})	-0.5V	+7.5V
Analog Input Voltage ($IN+$ or $IN-$)	$V_{SS}-0.5V$	$V_{DD}+0.5V$
PDB Input Voltage	$V_{SS}-0.5V$	+7V
Operating Temperature Range	-40°C	+125°C
Junction Temperature	+160°C	
Storage Temperature Range	-55°C	+150°C
Lead Temperature (soldering, 10sec)	+260°C	
Package Thermal Resistance ($T_A=+25^\circ\text{C}$)		
SOP-8, θ_{JA}	125°C/W	
MSOP-8, θ_{JA}	216°C/W	
SOT23-5, θ_{JA}	190°C/W	
SOT23-6, θ_{JA}	190°C/W	
SC70-5, θ_{JA}	333°C/W	
ESD Susceptibility		
HBM	8KV	
MM	400V	

Note: Stress greater than those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions outside those indicated in the operational sections of this specification are not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

Package/Ordering Information

MODEL	CHANNEL	ORDER NUMBER	PACKAGE DESCRIPTION	PACKAGE OPTION	MARKING INFORMATION
OPA376	Single	OPA376AIDC	SC70-5	Tape and Reel,3000	721
		OPA376AIDB	SOT23-5	Tape and Reel,3000	721
		OPA376AID	SOP-8	Tape and Reel,4000	OPA721
OPA2376	Dual	OPA2376AIDR	SOP-8	Tape and Reel,4000	OPA2376
		OPA2376AIDB	MSOP-8	Tape and Reel,3000	OPA2376
		OPA2376	TSSOP-8	Tape and Reel,3000	OPA2376
OPA4376	Quad	OPA4376AIP	TSSOP-14	Tape and Reel,3000	OPA4376
		OPA4376AI	SOP-14	Tape and Reel,2500	OPA4376



Electrical Characteristics

(At $V_S=5V$, $T_A = +25^\circ C$, $V_{CM} = V_S/2$, $R_L = 600 \Omega$, unless otherwise noted.)

PARAMETER	CONDITIONS	OPA376/2376/4376							
		TYP	MIN/MAX OVER TEMPERATURE					UNITS	MIN / MAX
		+25°C	+25°C	0°C to 70°C	-40°C to 85°C	-40 °C to 125°C			
INPUT CHARACTERISTICS									
Input Offset Voltage (V_{OS})		0.8	3.5	3.9	4.3	4.6	mV	MAX	
Input Bias Current (I_B)		1					pA	TYP	
Input Offset Current (I_{OS})		1					pA	TYP	
Input Common Mode Voltage Range (V_{CM})	$V_S = 5.5V$	-0.1 to +5.6					V	TYP	
Common Mode Rejection Ratio (CMRR)	$V_S = 5.5V, V_{CM} = -0.1V$ to 4V	82	65	64	64	63	dB	MIN	
	$V_S = 5.5V, V_{CM} = -0.1V$ to 5.6V	75					dB	MIN	
Open-Loop Voltage Gain (A_{OL})	$R_L = 600\Omega, V_O = 0.15V$ to 4.85V	90	80	76	75	68	dB	MIN	
	$R_L = 10k\Omega, V_O = 0.05V$ to 4.95V	108					dB	MIN	
Input Offset Voltage Drift ($\Delta V_{OS}/\Delta T$)		2.4					$\mu V/^\circ C$	TYP	
OUTPUT CHARACTERISTICS									
Output Voltage Swing from Rail	$R_L = 600\Omega$	0.1					V	TYP	
	$R_L = 10k\Omega$	0.015					V	TYP	
Output Current (I_{OUT})		70	55	45	42	38	mA	MIN	
Closed-Loop Output Impedance	$f = 100kHz, G = 1$	7.5					Ω	TYP	
POWER-DOWN DISABLE									
Turn-On Time		1.1					μs	TYP	
Turn-Off Time		0.3					μs	TYP	
DISABLE Voltage-Off			0.8				V	MAX	
DISABLE Voltage-On			2				V	MIN	
POWER SUPPLY									
Operating Voltage Range			2.1	2.1	2.1	2.1	V	MIN	
			5.5	5.5	5.5	5.5	V	MAX	
Power Supply Rejection Ratio (PSRR)	$V_S = +2.5V$ to +5.5V $V_{CM} = (-V_S) + 0.5V$								
Quiescent Current/Amplifier (I_Q)	$I_{OUT} = 0$	91	74	72	72	68	dB	MIN	
		1.1	1.5	1.65	1.7	1.85	mA	MAX	



Electrical Characteristics

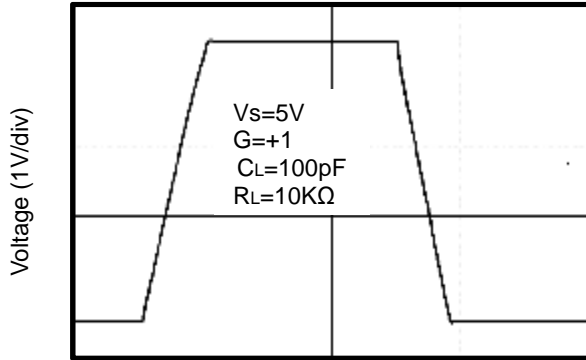
(At $V_S=5V$, $T_A = +25^\circ C$, $V_{CM} = V_S/2$, $R_L = 600\ \Omega$, unless otherwise noted.)

PARAMETER	CONDITIONS	OPA376/2376/4376							
		TYP	MIN/MAX OVER TEMPERATURE					UNITS	MIN / MAX
		+25°C	+25°C	0°C to 70°C	-40°C to 85°C	-40°C to 125°C			
DYNAMIC PERFORMANCE									
Gain-Bandwidth Product (GBP)	$R_L = 10k\Omega$, $C_L = 100pF$	11						MHz	TYP
Phase Margin (ϕ_o)	$R_L = 10k\Omega$, $C_L = 100pF$	51						Degrees	TYP
Full Power Bandwidth (BWP)	< 1% distortion, $R_L = 600\Omega$	400						kHz	TYP
Slew Rate (SR)	$G = +1$, 2V Step, $R_L = 10k\Omega$	9						V/ μs	TYP
Settling Time to 0.1% (t_s)	$G = +1$, 2V Step, $R_L = 600\Omega$	0.3						μs	TYP
Overload Recovery Time	$V_{IN} \cdot Gain = V_S$, $R_L = 600\Omega$	1.5						μs	TYP
NOISE PERFORMANCE									
Voltage Noise Density (e_n)	$f = 1kHz$	11.5						nV / \sqrt{Hz}	TYP
	$f = 10kHz$	8						nV / \sqrt{Hz}	TYP

Typical Performance characteristics

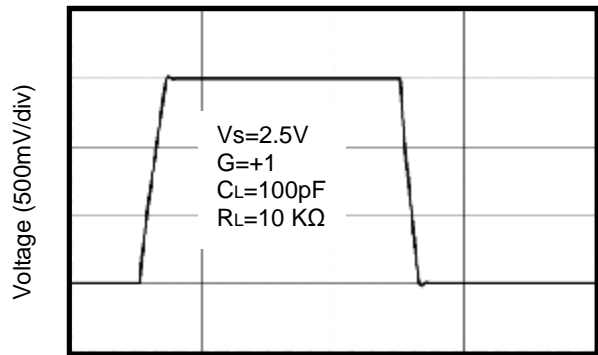
(At $V_s=5V$, $T_A = +25^\circ C$, $V_{CM} = V_s/2$, $R_L = 600\Omega$, unless otherwise noted.)

Large-Signal Step Response



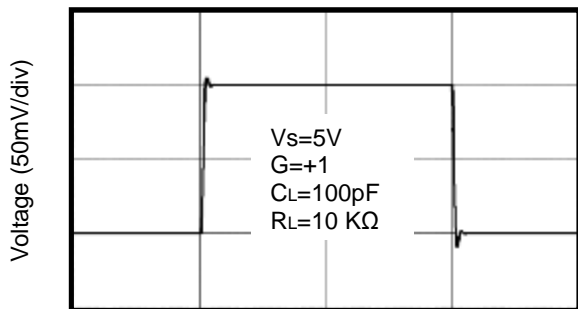
Time (1µs/div)

Large-Signal Step Response



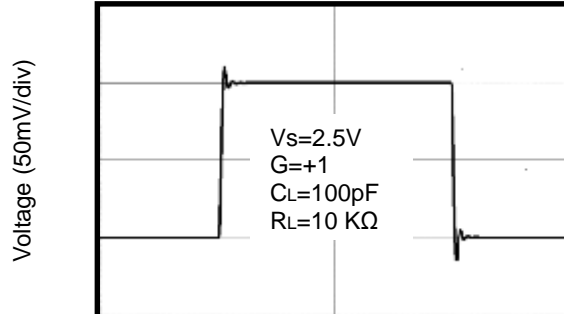
Time (1µs/div)

Small-Signal Step Response



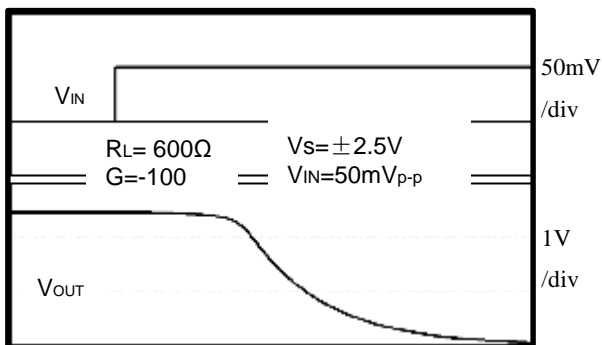
Time (1µs/div)

Small-Signal Step Response



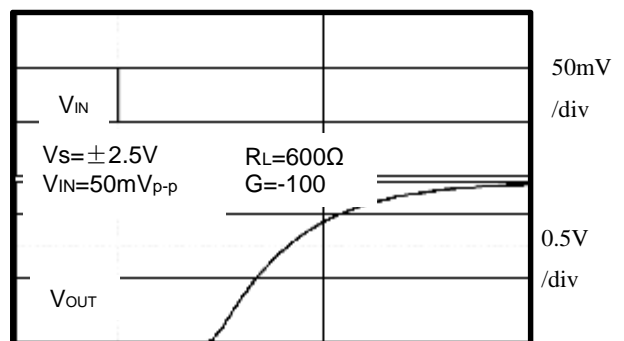
Time (1µs/div)

Positive Overload Recovery



Time (2µs/div)

Negative Overload Recovery

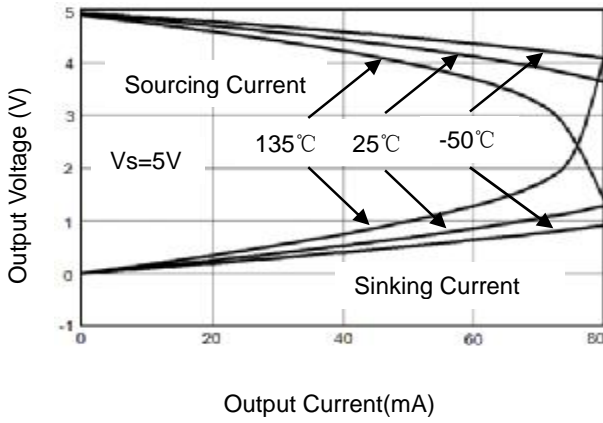


Time (2µs/div)

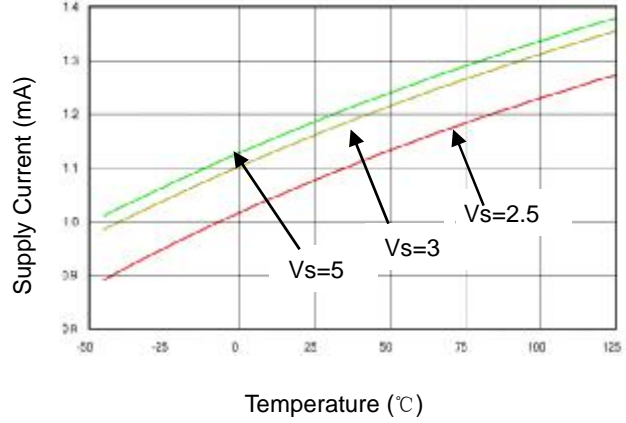
Typical Performance characteristics

(At $V_s=5V$, $T_A = +25^\circ C$, $V_{CM} = V_s/2$, $R_L = 600\Omega$, unless otherwise noted.)

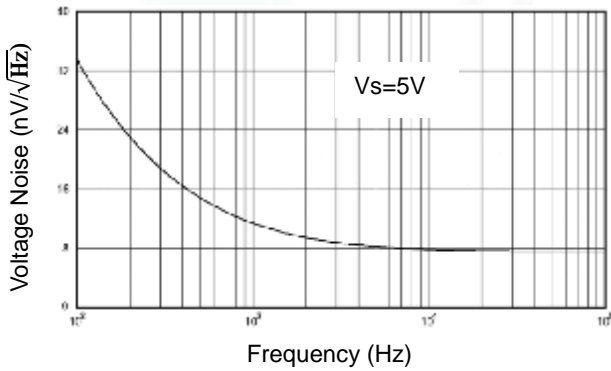
Output Voltage Swing vs. Output Current



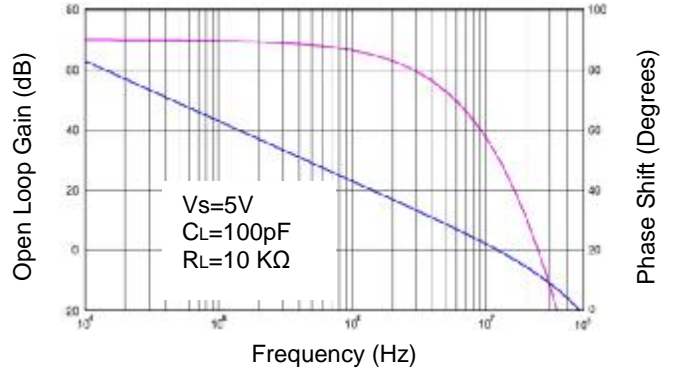
Supply Current vs. Temperature



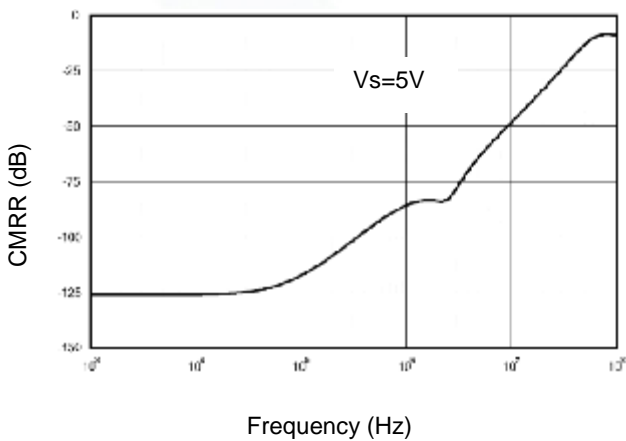
Input Voltage Noise Spectral Density vs. Frequency



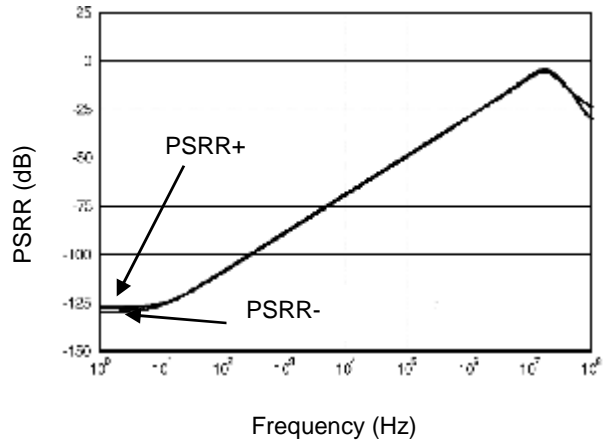
Open Loop Gain, Phase Shift vs. Frequency



CMRR vs. Frequency



PSRR vs. Frequency



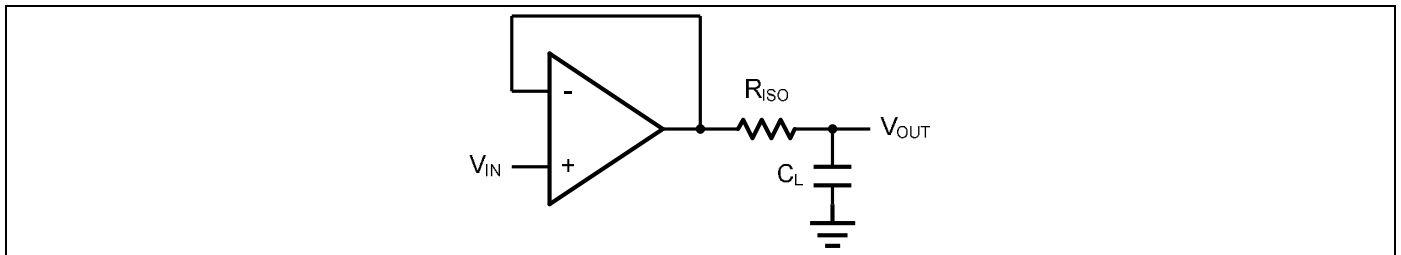


Figure 2. Indirectly Driving a Capacitive Load Using Isolation Resistor

The bigger the R_{ISO} resistor value, the more stable V_{OUT} will be. However, if there is a resistive load R_L in parallel with the capacitive load, a voltage divider (proportional to R_{ISO}/R_L) is formed, this will result in a gain error.

The circuit in Figure 3 is an improvement to the one in Figure 2. R_F provides the DC accuracy by feed-forward the V_{IN} to R_L . C_F and R_{ISO} serve to counteract the loss of phase margin by feeding the high frequency component of the output signal back to the amplifier's inverting input, thereby preserving the phase margin in the overall feedback loop. Capacitive drive can be increased by increasing the value of C_F . This in turn will slow down the pulse response.

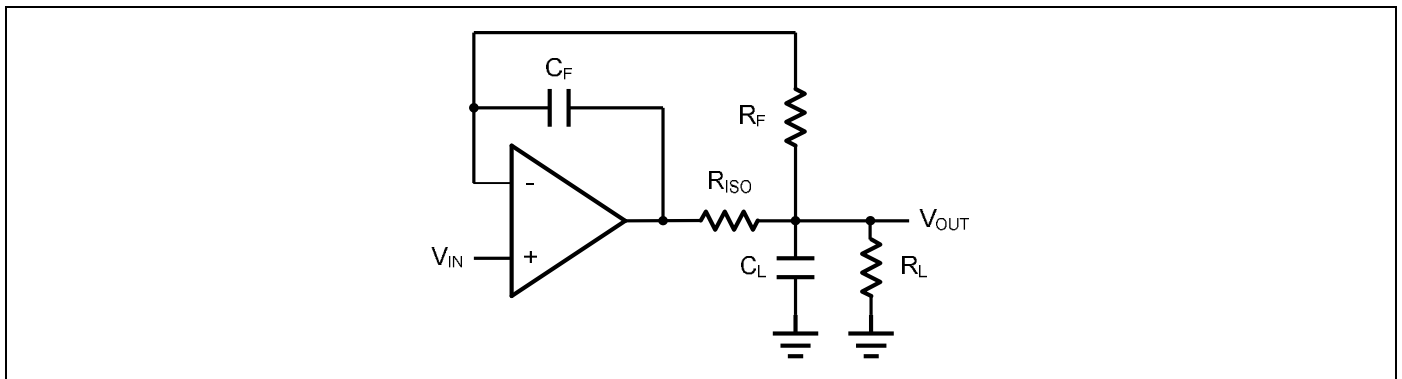


Figure 3. Indirectly Driving a Capacitive Load with DC Accuracy

Typical Application Circuits

Differential amplifier

The differential amplifier allows the subtraction of two input voltages or cancellation of a signal common the two inputs. It is useful as a computational amplifier in making a differential to single-end conversion or in rejecting a common mode signal. Figure 4. shown the differential amplifier using OPA376/2376/4376.

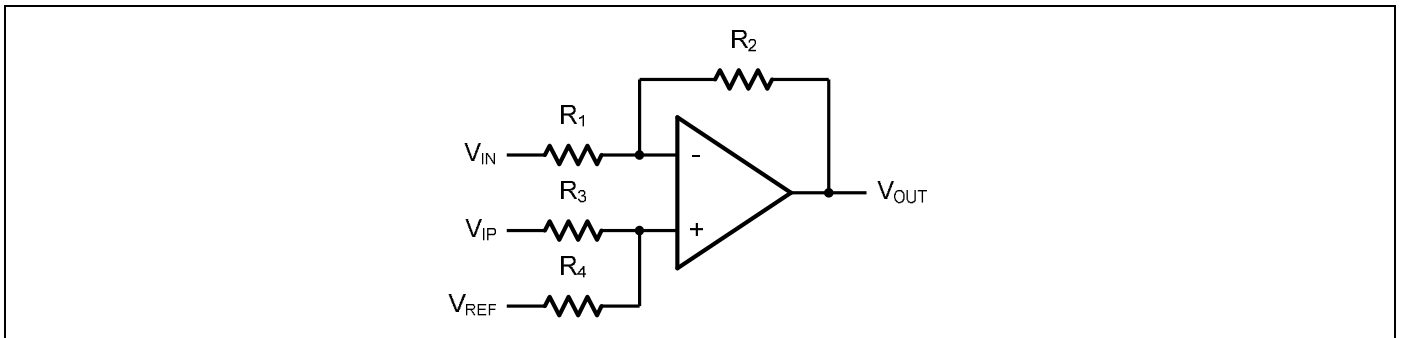


Figure 4. Differential Amplifier

$$V_{OUT} = \left(\frac{R_1 + R_2}{R_3 + R_4} \right) \frac{R_4}{R_1} V_{IN} - \frac{R_2}{R_1} V_{IP} + \left(\frac{R_1 + R_2}{R_3 + R_4} \right) \frac{R_3}{R_1} V_{REF}$$

If the resistor ratios are equal (i.e. $R_1 = R_3$ and $R_2 = R_4$), then

$$V_{OUT} = \frac{R_2}{R_1} (V_{IP} - V_{IN}) + V_{REF}$$

Low Pass Active Filter

The low pass active filter is shown in Figure 5. The DC gain is defined by $-R_2/R_1$. The filter has a -20dB/decade roll-off after its corner frequency $f_c = 1/(2\pi R_3 C_1)$.

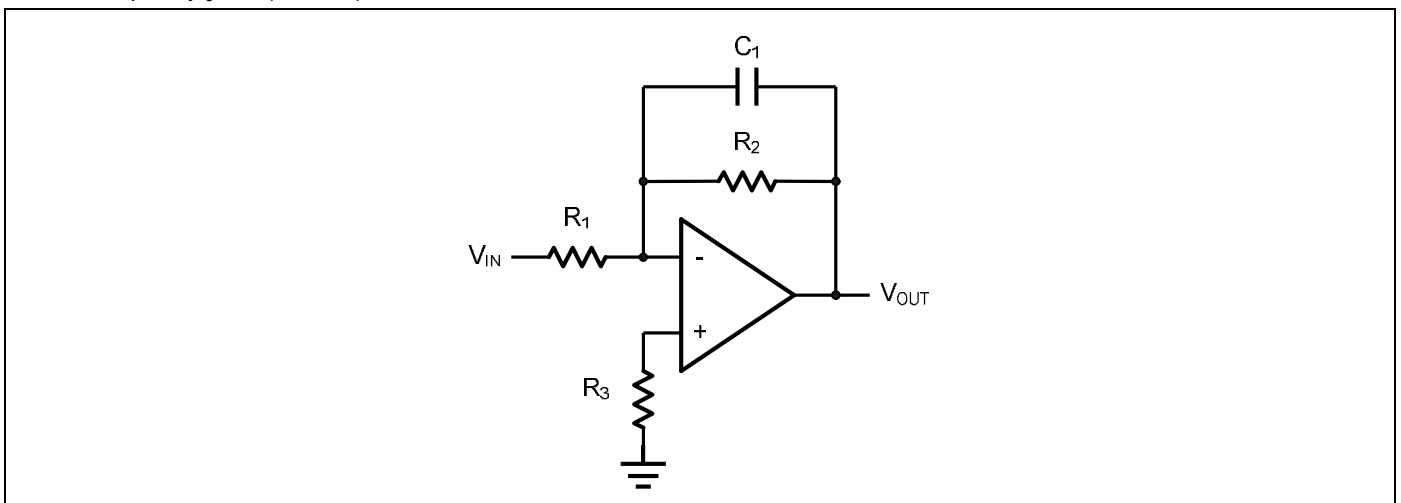


Figure 5. Low Pass Active Filter

Instrumentation Amplifier

The triple OPA376/2376/4376, can be used to build a three-op-amp instrumentation amplifier as shown in Figure 6.

The amplifier in Figure 6 is a high input impedance differential amplifier with gain of R_2/R_1 .

The two differential voltage followers assure the high input impedance of the amplifier.

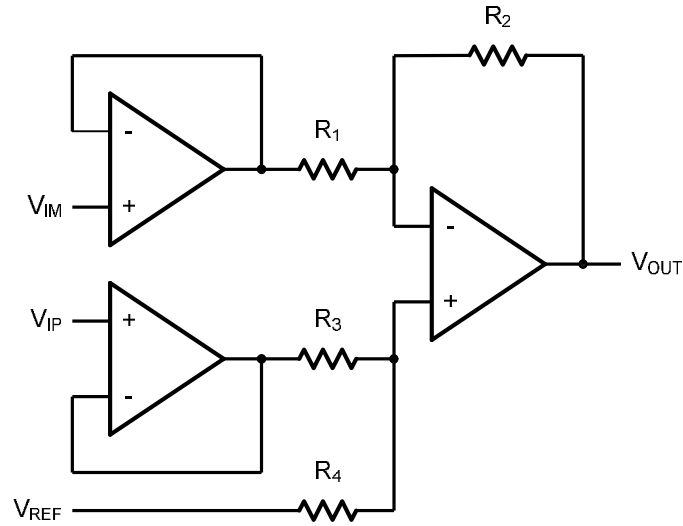
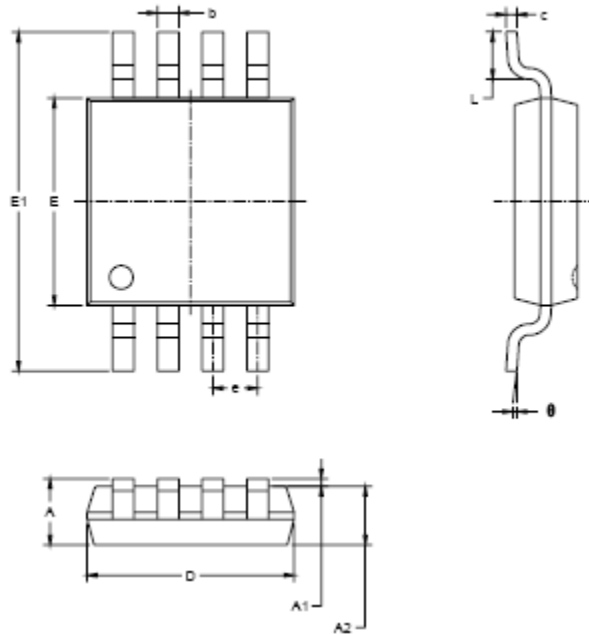


Figure 6. Instrument Amplifier

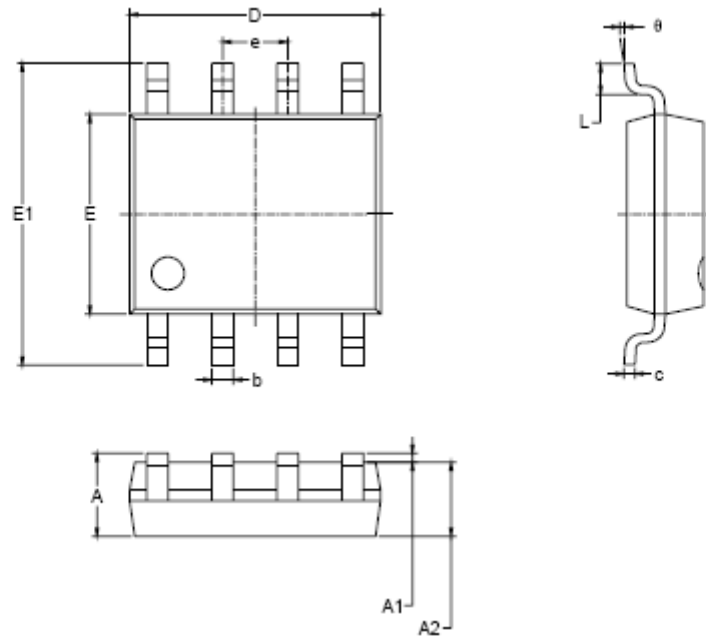
Package Information

MSOP-8



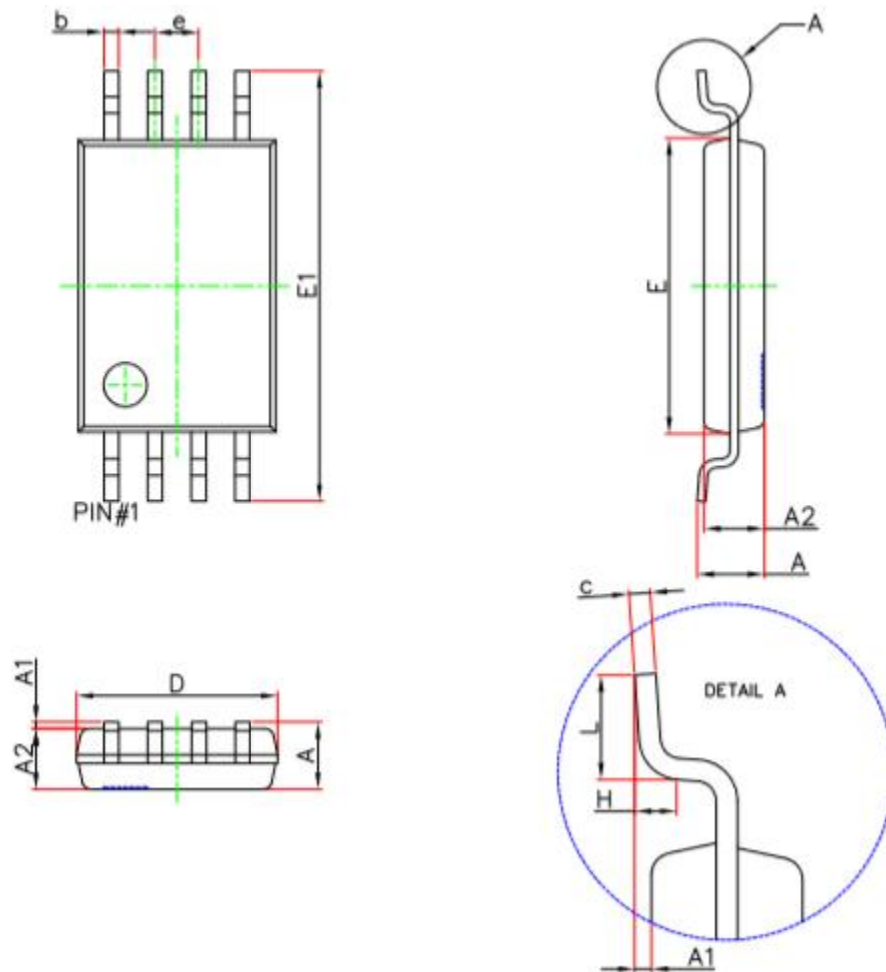
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.620	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026 BSC	
L	0.400	0.800	0.016	0.031
θ	0°	6°	0°	6°

SOP-8



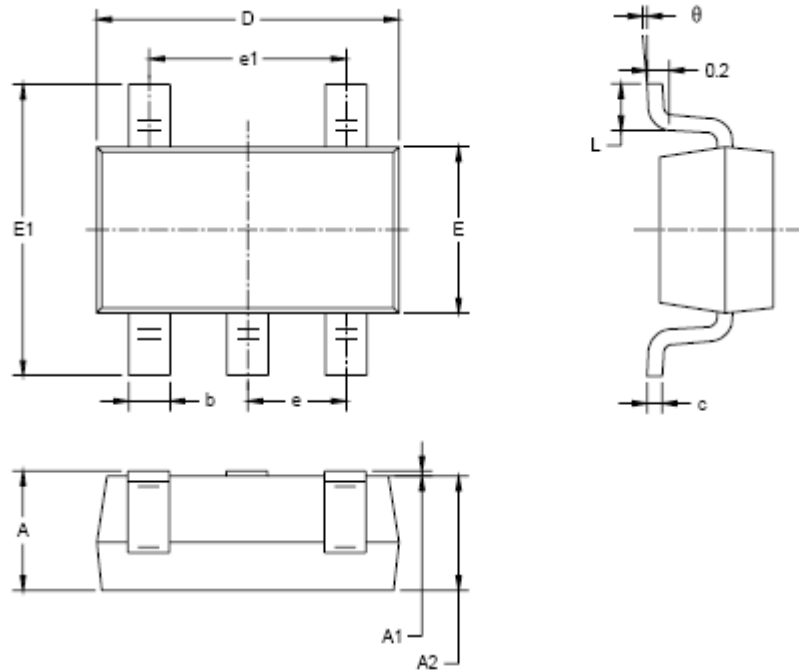
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
theta	0°	8°	0°	8°

TSSOP-8



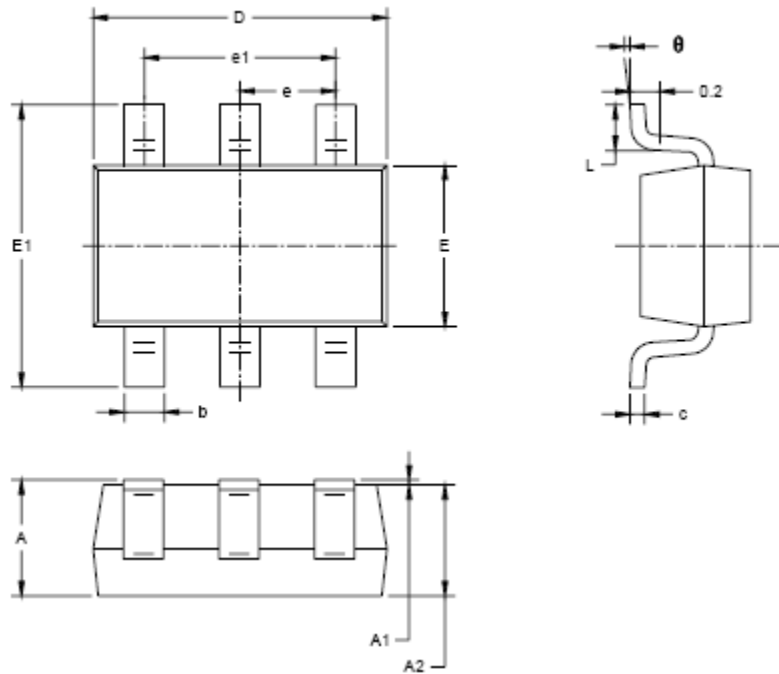
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
D	4.900	5.100	0.193	0.201
E	4.300	4.500	0.169	0.177
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
E1	6.250	6.550	0.246	0.258
A	—	1.200	—	0.047
A2	0.800	1.000	0.031	0.039
A1	0.050	0.150	0.002	0.006
e	0.65 (BSC)		0.026 (BSC)	
L	0.500	0.700	0.020	0.028
H	0.25(TYP)		0.01(TYP)	
θ	1°	7°	1°	7°

SOT23-5



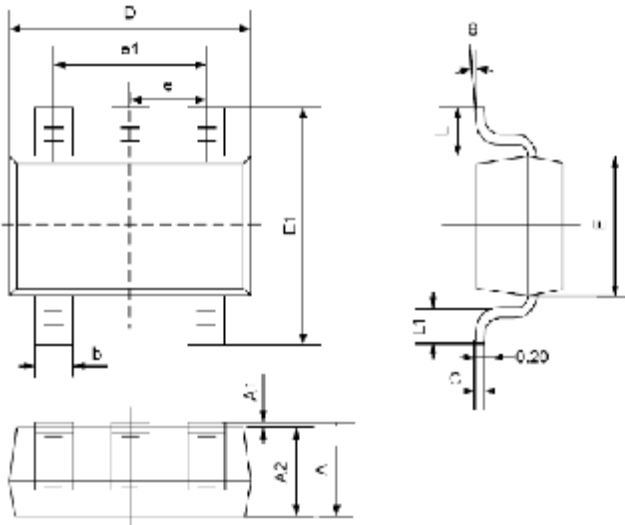
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037 BSC	
e1	1.900 BSC		0.075 BSC	
L	0.300	0.600	0.012	0.024
theta	0°	8°	0°	8°

SOT23-6



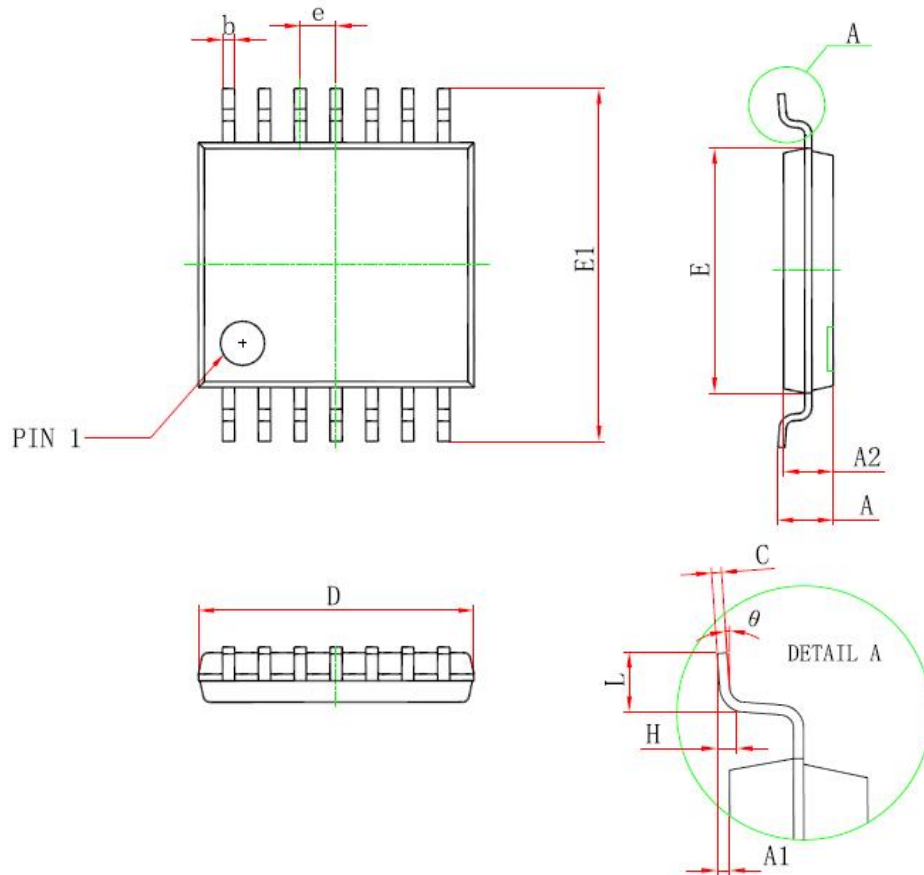
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037 BSC	
e1	1.900 BSC		0.075 BSC	
L	0.300	0.600	0.012	0.024
theta	0°	8°	0°	8°

SC70-5



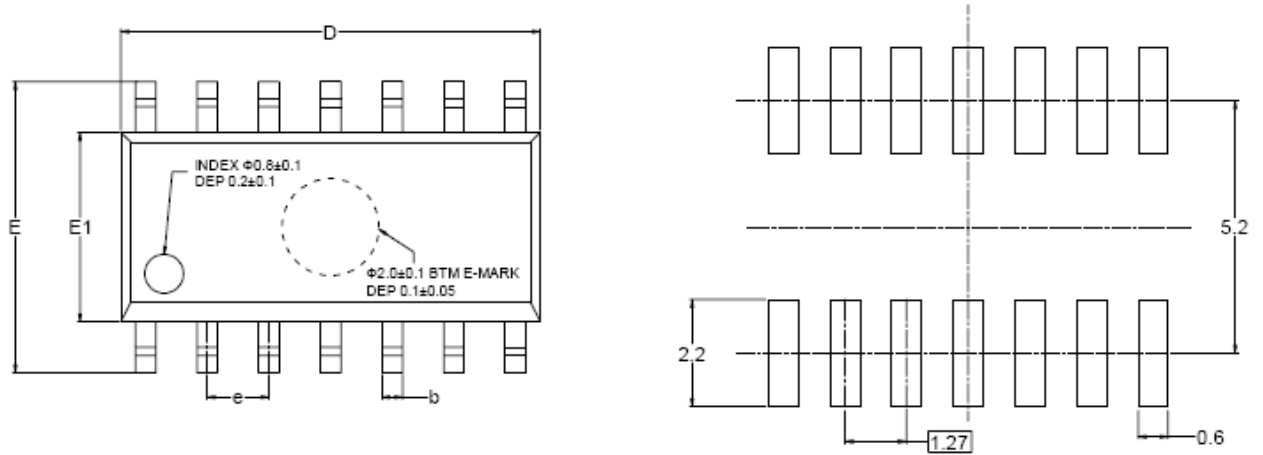
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.900	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.900	1.000	0.035	0.039
b	0.150	0.350	0.006	0.014
C	0.080	0.150	0.003	0.006
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.650TYP		0.026TYP	
e1	1.200	1.400	0.047	0.055
L	0.525REF		0.021REF	
L1	0.250	0.460	0.010	0.018
θ	0°	8°	0°	8°

TSSOP-14

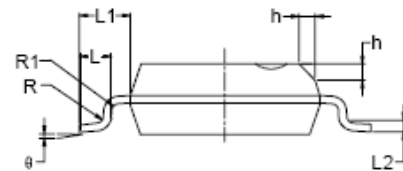
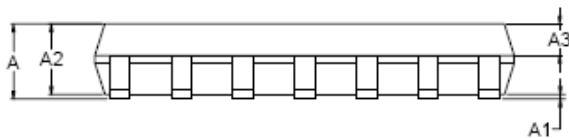


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
D	4.900	5.100	0.193	0.201
E	4.300	4.500	0.169	0.177
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
E1	6.250	6.550	0.246	0.258
A		1.200		0.047
A2	0.800	1.000	0.031	0.039
A1	0.050	0.150	0.002	0.006
e	0.65 (BSC)		0.026 (BSC)	
L	0.500	0.700	0.020	0.028
H	0.25(TYP)		0.01(TYP)	
θ	1°	7°	1°	7°

SOP-14



RECOMMENDED LAND PATTERN (Unit: mm)



Symbol	Dimensions In Millimeters			Dimensions In Inches		
	MIN	MOD	MAX	MIN	MOD	MAX
A	1.35		1.75	0.053		0.069
A1	0.10		0.25	0.004		0.010
A2	1.25		1.65	0.049		0.065
A3	0.55		0.75	0.022		0.030
b	0.36		0.49	0.014		0.019
D	8.53		8.73	0.336		0.344
E	5.80		6.20	0.228		0.244
E1	3.80		4.00	0.150		0.157
e	1.27 BSC			0.050 BSC		
L	0.45		0.80	0.018		0.032
L1	1.04 REF			0.040 REF		
L2	0.25 BSC			0.01 BSC		
R	0.07			0.003		
R1	0.07			0.003		
h	0.30		0.50	0.012		0.020
θ	0°		8°	0°		8°