DESCRIPTION

The AO1376 presents a new generation of low-noise operational amplifier, offering outstanding dc precision and ac performance. Rai-to-Rail input and output, low offset (3.5mV, maximum), low noise (8nV / $\sqrt{Hz}$), quiescent current of 1.1mA, and high gain-bandwidth of 11MHz make AO1376 very attractive for a variety of precision and portable applications. In addition, this AO1376 has reasonably wide supply range with excellent PSRR, making it attractive for applications that run directly from batteries without regulation.

The AO1376 (single) is available in SOT-25, SC70-5 and SOP8 packages.

ORDERING INFORMATION

Package Type	Part Number	
SOT-25 SPQ: 3,000pcs/Reel	E5	AO1376E5R
		AO1376E5VR
SC70-5 SPQ: 3,000pcs/Reel	C5	AO1376C5R
		AO1376C5VR
SOP8 SPQ: 4,000pcs/Reel	M8	AO1376M8R
		AO1376M8VR
Note	V: Halogen free Package R: Tape & Reel	
AiT provides all RoHS products		

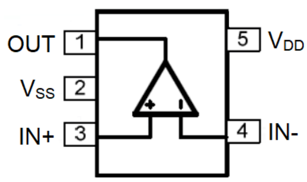
FEATURES

- Low Noise : 8nV/ $\sqrt{Hz}$ @10kHz
- Single-Supply Operation
- Supply Voltage: 2.1V to 5.5V
- Rail-to-Rail Input / Output
- Low Offset Voltage: 3.5mV (Max.)
- Gain-Bandwidth: 11MHz (Typ.)
- Low Input Bias Current: 1pA (Typ.)
- High Slew Rate: 9V/μs
- Settling Time to 0.1% with 2V Step: 0.3μs
- Quiescent Current: 1.1mA per Amplifier (Typ.)
- Operating Temperature: -40°C ~ +125°C
- Available in SOT-25, SC70-5 and SOP8 packages

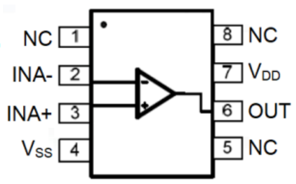
APPLICATION

- ADC Buffer
- Audio Equipment
- Medical Instrumentation
- Handheld Test Equipment
- Active Filtering
- Sensor Signal Conditioning
- Battery-Powered Instrumentation

TYPICAL APPLICATION

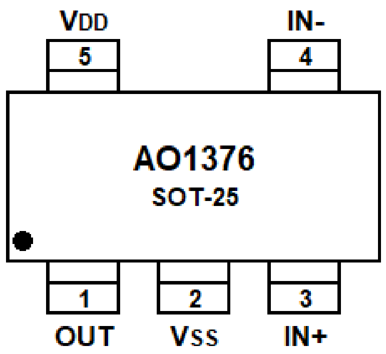


SOT-25/ SC70-5

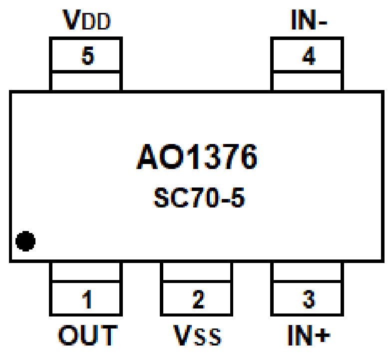


SOP8

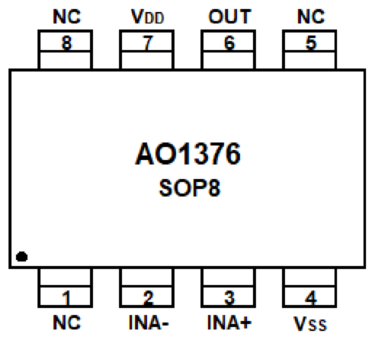
PIN DESCRIPTION



Top View



Top View



Top View

Pin #			Symbol	Function
SOT-25	SC70-5	SOP8		
1	1	6	OUT	Output
2	2	4	V_{SS}	Ground or Negative Power Supply Input
3	3	3	IN+/INA+	Analog Positive Input / Input A
4	4	2	IN-/INA-	Analog Inverting Input / Input A
5	5	7	V_{DD}	Positive Power Supply Input
-	-	1,5,8	NC	No connection

ABSOLUTE MAXIMUM RATINGS

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℃)	
θ_{JA}, SOT-25	190°C/W
θ_{JA}, SC70-5	333°C/W
θ_{JA}, SOP8	125°C/W
ESD Susceptibility	
HBM	8kV
MM	400V

Stress beyond above listed “Absolute Maximum Ratings” may lead permanent damage to the device. These are stress ratings only and operations of the device at these or any other conditions beyond those indicated in the operational sections of the specifications are not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

At V_S=5V, T_A = +25℃, V_{CM} = V_S/2, R_L = 600Ω, unless otherwise noted.

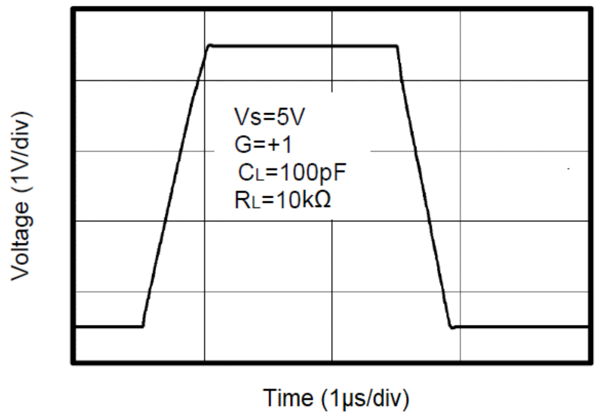
Parameter	Symbol	Conditions	Typ	Min/Max Over Temperature					
			+25℃	+25℃	0℃ to 70℃	-40℃ to 85℃	-40℃ to 125℃	Units	Min / Max
INPUT CHARACTERISTICS									
Input Offset Voltage	V_{OS}		0.8	3.5	3.9	4.3	4.6	mV	Max
Input Bias Current	I_B		1	-	-	-	-	pA	Typ
Input Offset Current	I_{OS}		1	-	-	-	-	pA	Typ
Input 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 = 600Ω, V_O = 0.15V to 4.85V	90	80	76	75	68	dB	Min
		R_L = 10kΩ, V_O = 0.05V to 4.95V	108	-	-	-	-	dB	Min
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$		2.4	-	-	-	-	μV/℃	Typ
OUTPUT CHARACTERISTICS									
Output Voltage Swing from Rail		R_L = 600Ω	0.1	-	-	-	-	V	Typ
		R_L = 10kΩ	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	91	74	72	72	68	dB	Min
Quiescent Current/Amplifier	I_Q	I_{OUT} = 0	1.1	1.5	1.65	1.7	1.85	mA	Max

Parameter	Symbol	Conditions	Typ	Min/Max Over Temperature					
			+25℃	+25℃	0℃ to 70℃	-40℃ to 85℃	-40℃ to 125℃	Units	Min / Max
DYNAMIC PERFORMANCE									
Gain-Bandwidth Product	GBP	R_L = 10kΩ, C_L = 100pF	11	-	-	-	-	MHz	Typ
Phase Margin	φ_O	R_L = 10kΩ, C_L = 100pF	51	-	-	-	-	Degrees	Typ
Full Power Bandwidth	BWP	< 1% distortion, R_L = 600Ω	400	-	-	-	-	kHz	Typ
Slew Rate	SR	G = +1, 2V Step, R_L = 10kΩ	9	-	-	-	-	V/μs	Typ
Settling Time to 0.1%	t_S	G = +1, 2V Step, R_L = 600Ω	0.3	-	-	-	-	μs	Typ
Overload Recovery Time		V_{IN} ·Gain = V_S, R_L = 600Ω	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

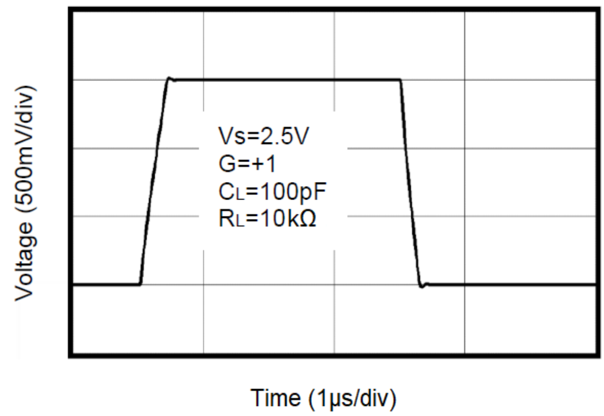
TYPICAL PERFORMANCE CHARACTERISTIC

At V_S=5V, T_A = +25℃, V_{CM} = V_S/2, R_L = 600Ω, unless otherwise noted.

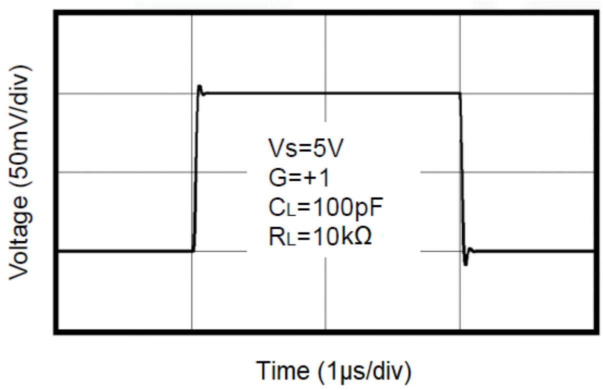
1. Large-Signal Step Response



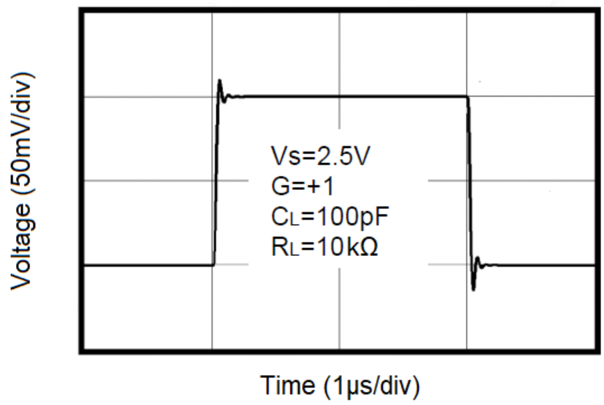
2. Large-Signal Step Response



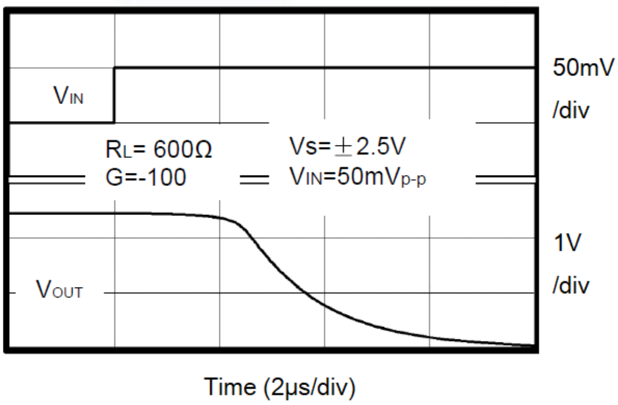
3. Small-Signal Step Response



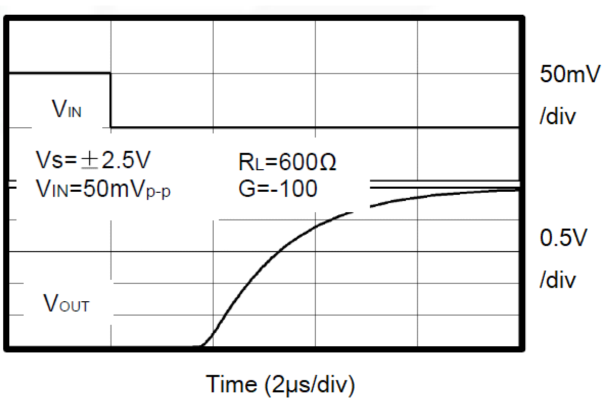
4. Small-Signal Step Response



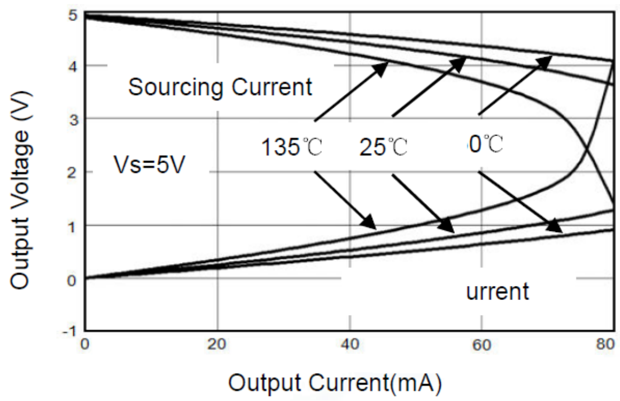
5. Positive Overload Recovery



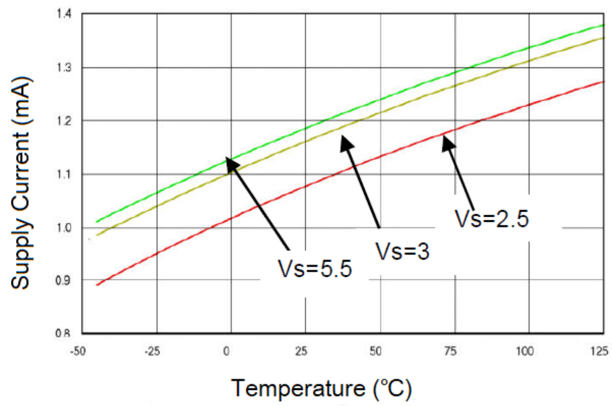
6. Negative Overload Recovery



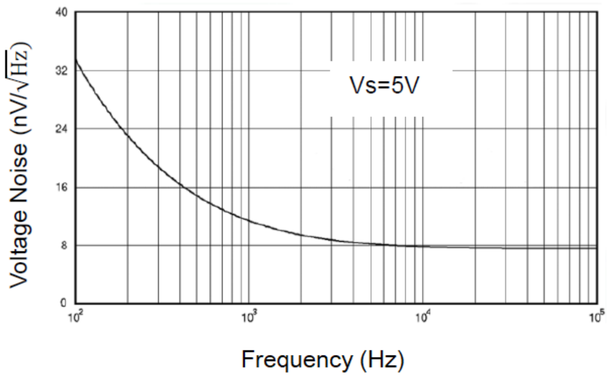
7. Output Voltage Swing vs. Output Current



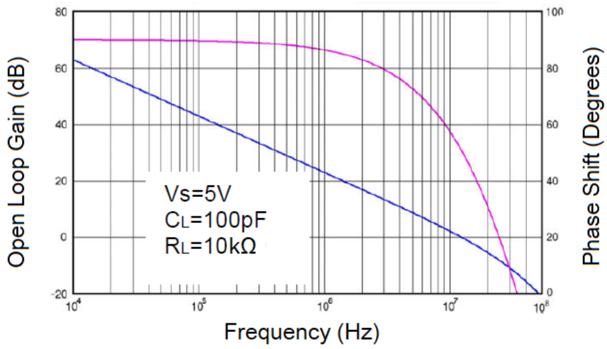
8. Supply Current vs. Temperature



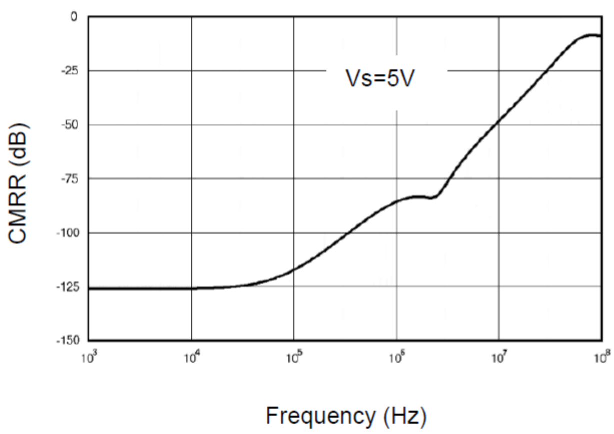
9. Input Voltage Noise Spectral Density vs. Frequency



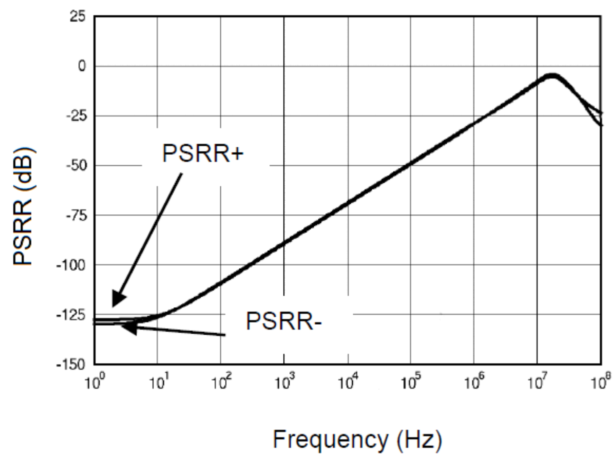
10. Open Loop Gain, Phase Shift vs. Frequency



11. CMRR vs. Frequency



12. PSRR vs. Frequency



DETAILED INFORMATION

Size

AO1376 op amps are unity-gain stable and suitable for a wide range of general-purpose applications. The small footprints of the AO1376 packages save space on printed circuit boards and enable the design of smaller electronic products.

Power Supply Bypassing and Board Layout

AO1376 operates from a single 2.1V to 5.5V supply or dual ±1.05V to ±2.75V supplies. For best performance, a 0.1μF ceramic capacitor should be placed close to the V_{DD} pin in single supply operation. For dual supply operation, both V_{DD} and V_{SS} supplies should be bypassed to ground with separate 0.1μF ceramic capacitors.

Low Supply Current

The low supply current (typical 1.1mA per channel) of AO1376 will help to maximize battery life. They are ideal for battery powered systems

Operating Voltage

AO1376 operate under wide input supply voltage (2.1V to 5.5V). In addition, all temperature specifications apply from -40℃ to +125℃. Most behavior remains unchanged throughout the full operating voltage range. These guarantees ensure operation throughout the single Li-Ion battery lifetime

Rail-to-Rail Input

The input common-mode range of AO1376 extends 100mV beyond the supply rails (V_{SS}-0.1V to V_{DD}+0.1V). This is achieved by using complementary input stage. For normal operation, inputs should be limited to this range.

Rail-to-Rail Output

Rail-to-Rail output swing provides maximum possible dynamic range at the output. This is particularly important when operating in low supply voltages. The output voltage of AO1376 can typically swing to less than 2mV from supply rail in light resistive loads (>100kΩ), and 15mV of supply rail in moderate resistive loads (10kΩ).

Capacitive Load Tolerance

The AO1376 is optimized for bandwidth and speed, not for driving capacitive loads. Output capacitance will create a pole in the amplifier's feedback path, leading to excessive peaking and potential oscillation. If dealing with load capacitance is a requirement of the application, the two strategies to consider are (1) using a small resistor in series with the amplifier's output and the load capacitance and (2) reducing the bandwidth of the amplifier's feedback loop by increasing the overall noise gain. Figure 1. shows a unity gain follower using the series resistor strategy. The resistor isolates the output from the capacitance and, more importantly, creates a zero in the feedback path that compensates for the pole created by the output capacitance.

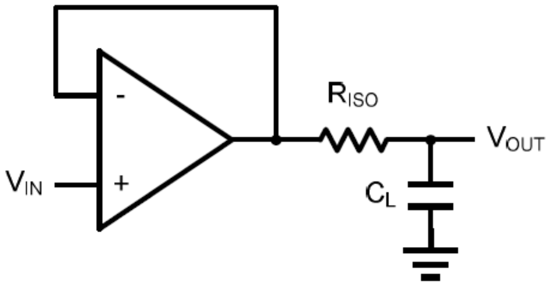


Figure 1. Indirectly Driving a Capacitive Load Using Isolation Resistor

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 2 is an improvement to the one in Figure1. 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.

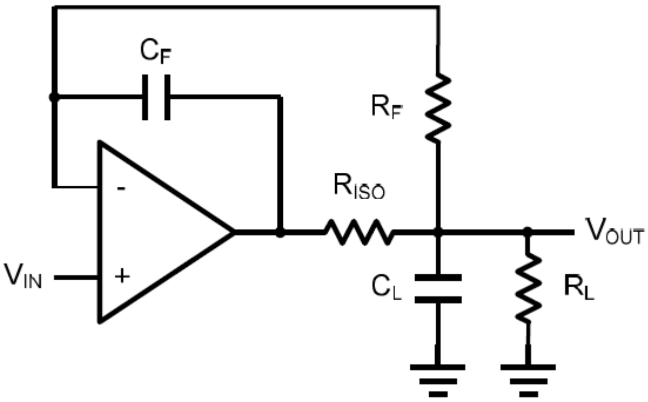


Figure 2. Indirectly Driving a Capacitive Load with DC Accuracy

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 3. shown the differential amplifier using AO1376.

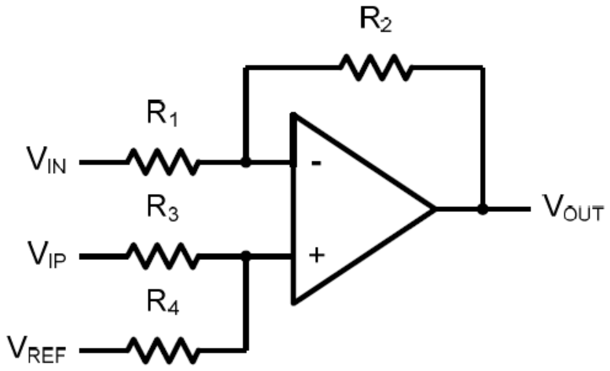


Figure 3. Differential Amplifier

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

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

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

Low Pass Active Filter

The low pass active filter is shown in Figure 4. The DC gain is defined by $-R_2/R_1$. The filter has a -20dB/decade roll-off after its corner frequency $f_C=1/(2\pi R_3C_1)$.

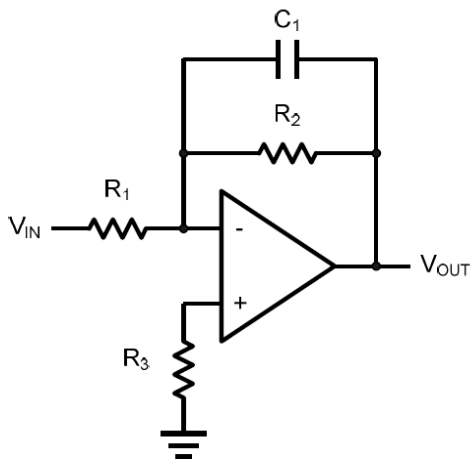


Figure 4. Low Pass Active Filter

Instrumentation Amplifier

The triple AO1376 can be used to build a three-op-amp instrumentation amplifier as shown in Figure 5. The amplifier in Figure 5 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.

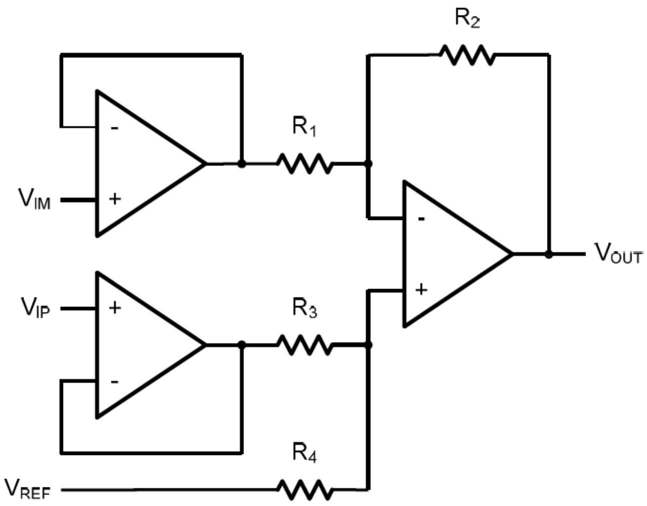
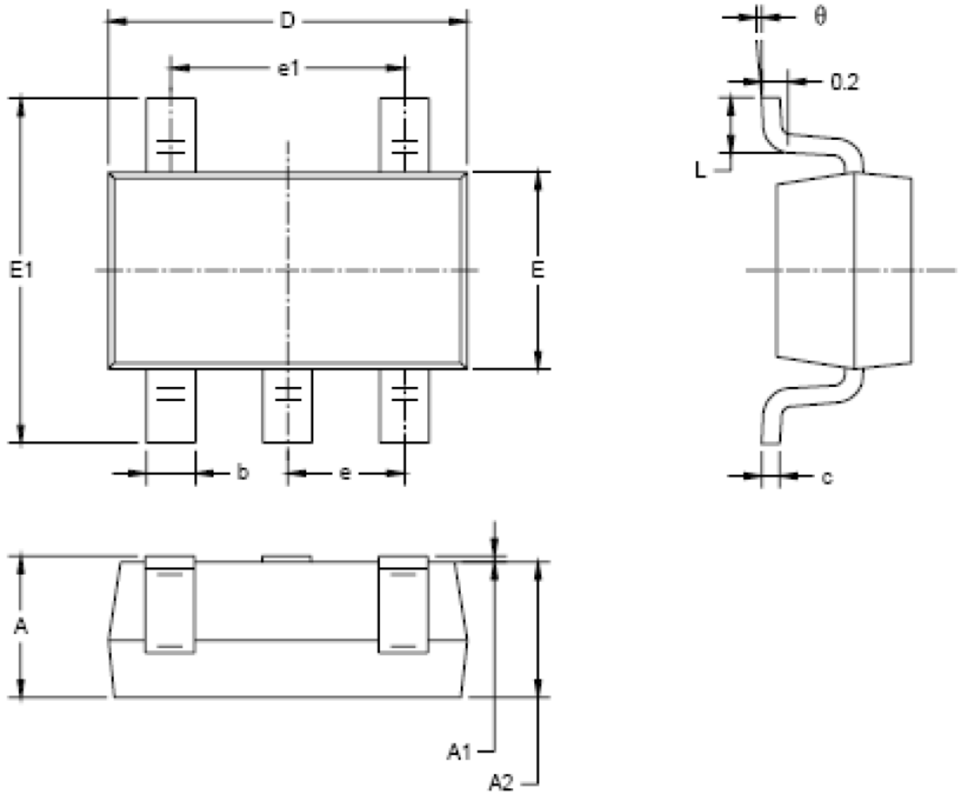


Figure 5. Instrument Amplifier

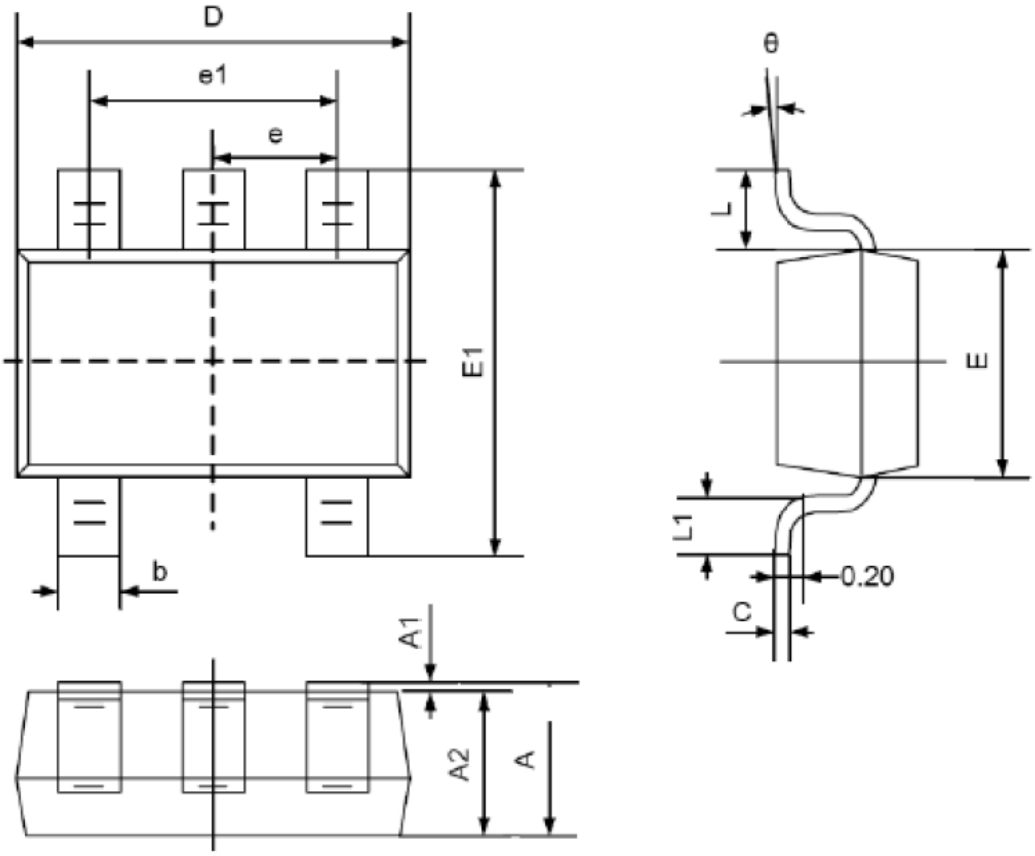
PACKAGE INFORMATION

Dimension in SOT-25 (Unit: mm)



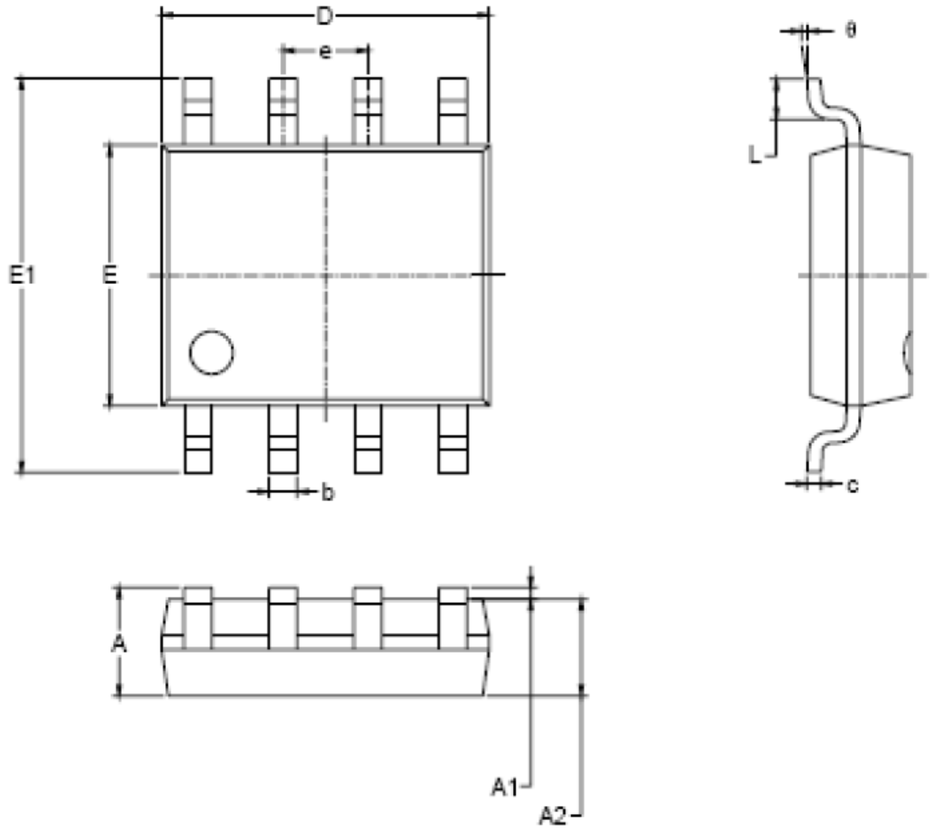
Symbol	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037 BSC	
e1	1.900 BSC		0.075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

Dimension in SC70-5 (Unit: mm)



Symbol	Millimeters		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	0.650 TYP		0.026 TYP	
e1	1.200	1.400	0.047	0.055
L	0.525 REF		0.021 REF	
L1	0.260	0.460	0.010	0.018
θ	0°	8°	0°	8°

Dimension in SOP8 (Unit: mm)



Symbol	Millimeters		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
θ	0°	8°	0°	8°

IMPORTANT NOTICE

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