DESCRIPTION

The AO1378 amplifier is a new generation of zero-drift, micro-power, CMOS operational amplifiers, the AO1378 offer bandwidth of 1.8MHz, rail-to-rail inputs and outputs, and single-supply operation from 1.8V to 5.5V. The Combination of low input voltage noise, high gain bandwidth (1.8MHz) and low power (180µA) enable AO1378 to achieve optimum performance for low-power precision applications.

The AO1378 uses chopper stabilized technique to provide very low offset voltage (less than 5µV maximum) and near zero drift over temperature. Low quiescent supply current of 180µA per amplifier and very low input bias current of 20pA make the devices an ideal choice for low offset, low power consumption and high impedance applications. The AO1378 offers excellent CMRR without the crossover associated with traditional complementary input stages. This design results in superior performance for driving analog-to-digital converters (ADCs) without degradation of differential linearity.

The AO1378 is available in SOT-25 and SOP8 packages.

ORDERING INFORMATION

Package Type	Part Number	
SOT-25 SPQ: 3,000pcs/Reel	E5	AO1378E5R
		AO1378E5VR
SOP8 SPQ: 4,000pcs/Reel	M8	AO1378M8R
		AO1378M8VR
Note	V: Halogen free Package R: Tape & Reel	
AiT provides all RoHS products		

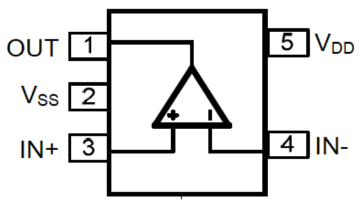
FEATURES

- Single-Supply Operation from +1.8V ~ +5.5V
- Rail-to-Rail Input / Output
- Gain-Bandwidth Product: 1.8MHz (Typ. @25°C)
- Low Input Bias Current: 20pA (Typ. @25°C)
- Low Offset Voltage: 30µV (Max. @25°C)
- Quiescent Current: 180µA per Amplifier (Typ)
- Operating Temperature: -45°C ~ +125°C
- Zero Drift: 0.03µV/°C (Typ)
- Embedded RF Anti-EMI Filter
- Available in SOT-25 and SOP8 packages

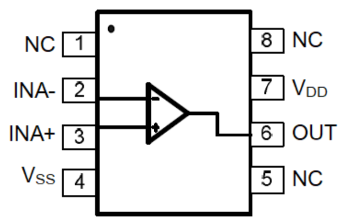
APPLICATION

- Portable Medical Devices
  -Glucose Meters
  -Oxygen Metering
  -Heat Rate Monitors
- Weight Scales
- Battery-Powered Instruments
- Thermopile Modules
- Handheld Test Equipment
- Sensor Signal Conditioning
- Transducer Application
- Temperature Measurements

TYPICAL APPLICATION

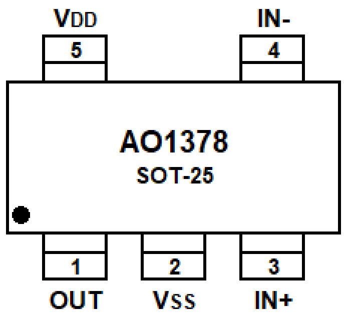


SOT-25

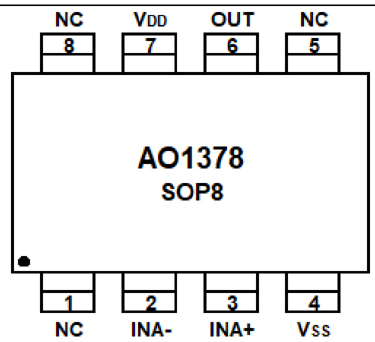


SOP8

PIN DESCRIPTION



Top View



Top View

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

ABSOLUTE MAXIMUM RATINGS

Power Supply Voltage (V_{DD} to V_{SS})	-0.5V ~ +7.5V
Analog Input Voltage (IN+ or IN-)	Vss-0.5V ~ V_{DD}+0.5V
PDB Input Voltage	Vss-0.5V ~ +7V
Operating Temperature Range	-45°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
$θ_{JA}$, SOP8	125°C/W
ESD Susceptibility	
HBM	6kV
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.

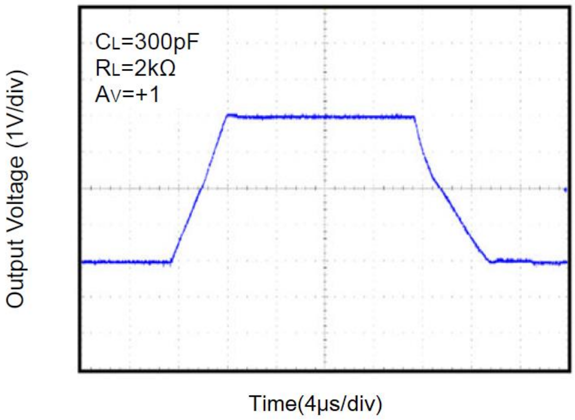
ELECTRICAL CHARACTERISTICS

V_S = +5V, V_{CM} = +2.5V, V_O = +2.5V, T_A = +25℃ , unless otherwise noted.

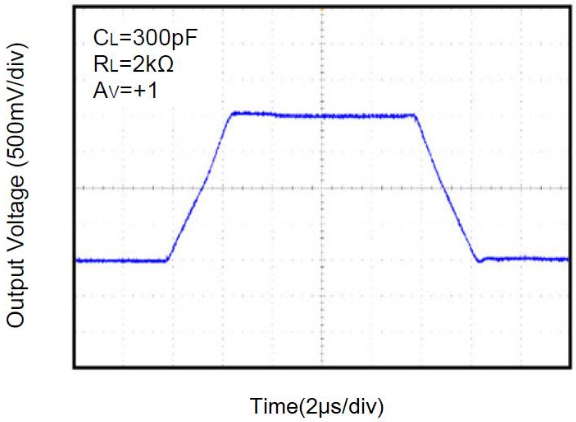
Parameter	Symbol	Conditions	Min	Typ	Max	Unit
INPUT CHARACTERISTICS						
Input Offset Voltage	V_{OS}		-	1	30	μV
Input Bias Current	I_B		-	20	-	pA
Input Offset Current	I_{OS}		-	10	-	pA
Common-Mode Rejection Ratio	CMRR	V_{CM} = 0V to 5V	-	110	-	dB
Large Signal Voltage Gain	A_{VO}	R_L = 10kΩ, V_O = 0.3V to 4.7V	-	145	-	dB
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta_T$		-	30	-	nV/°C
OUTPUT CHARACTERISTICS						
Output Voltage High	V_{OH}	R_L = 100kΩ to - V_S	-	4.998	-	V
		R_L = 10kΩ to - V_S	-	4.994	-	
Output Voltage Low	V_{OL}	R_L = 100kΩ to + V_S	-	2	-	mV
		R_L = 10kΩ to + V_S	-	5	-	
Short Circuit Limit	I_{SC}	R_L =10Ω to - V_S	-	60	-	mA
Output Current	I_O		-	65	-	mA
POWER SUPPLY						
Power Supply Rejection Ratio	PSRR	V_S = 2.5V to 5.5V	-	115	-	dB
Quiescent Current	I_Q	V_O = 0V, R_L = 0Ω	-	180	-	μA
DYNAMIC PERFORMANCE						
Gain-Bandwidth Product	GBP	G = +100	-	1.8	-	MHz
Slew Rate	SR	R_L = 10kΩ	-	0.95	-	V/μs
Overload Recovery Time			-	0.10	-	ms
NOISE PERFORMANCE						
Voltage Noise	e_n p-p	0Hz to 10Hz	-	0.3	-	μV_{P-P}
Voltage Noise Density	e_n	f = 1kHz	-	38	-	$nV/\sqrt{Hz}$

TYPICAL PERFORMANCE CHARACTERISTICS

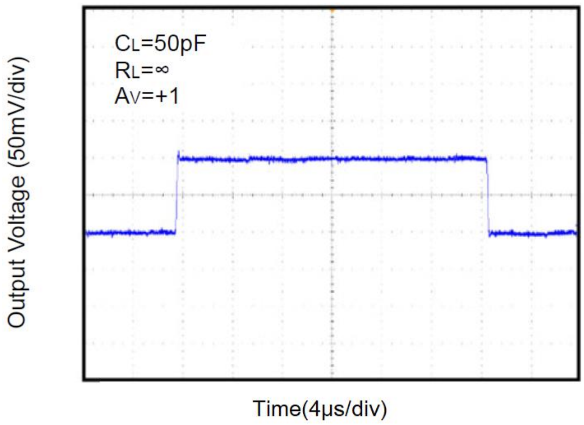
1. Large Signal Transient Response at +5V



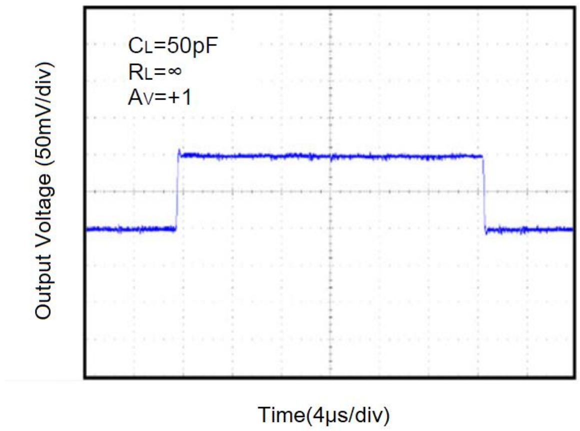
2. Large Signal Transient Response at +2.5V



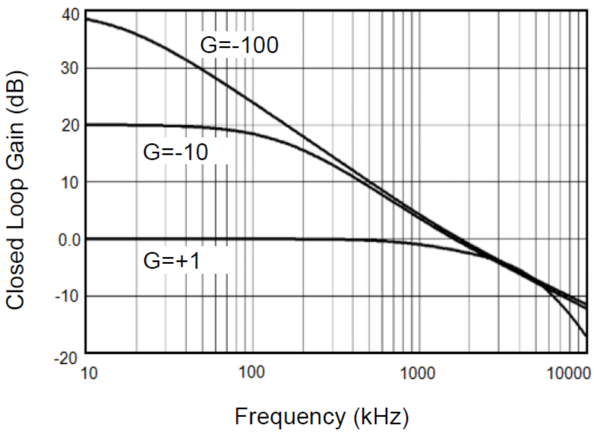
3. Small Signal Transient Response at +5V



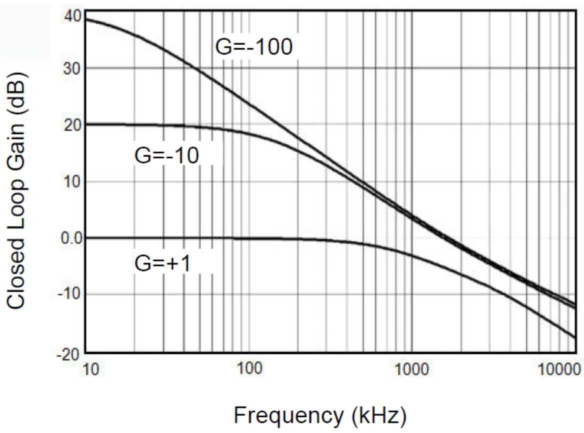
4. Small Signal Transient Response at +2.5V



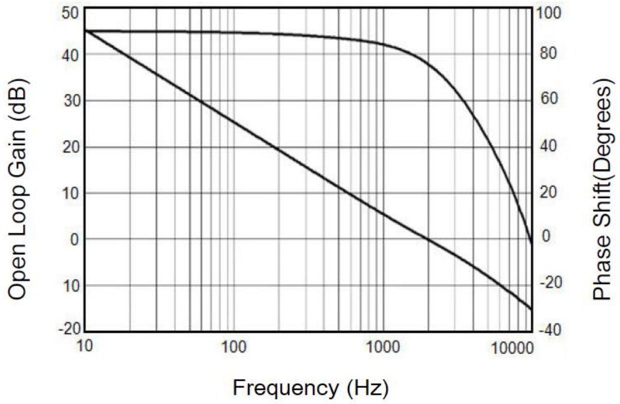
5. Closed Loop Gain vs. Frequency at +5V



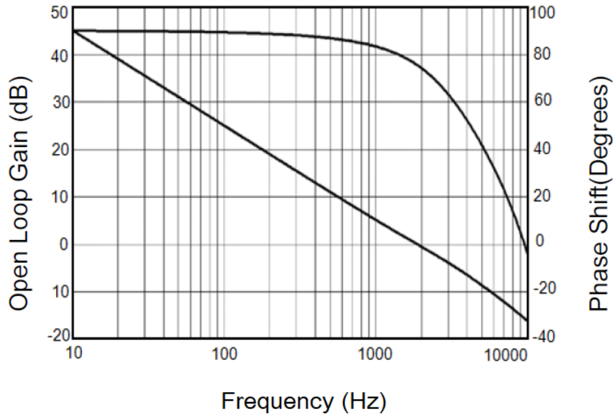
6. Closed Loop Gain vs. Frequency at +2.5V



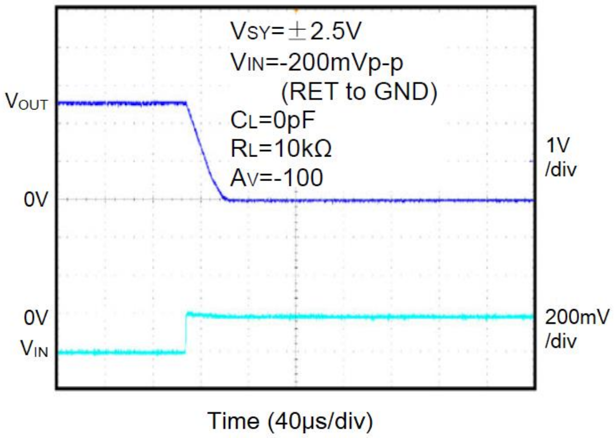
7. Open Loop Gain, Phase Shift vs. Frequency at +5V



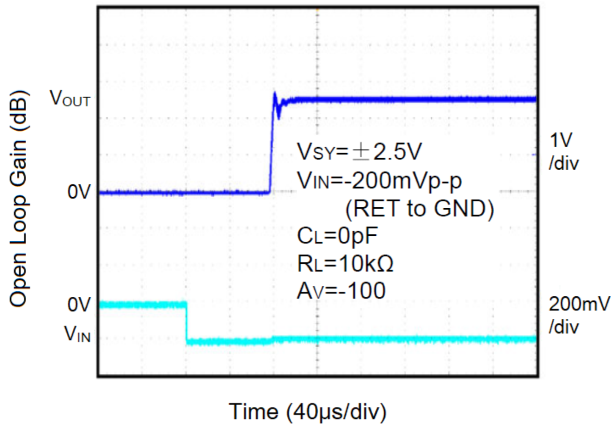
8. Open Loop Gain, Phase Shift vs. Frequency at +2.5V



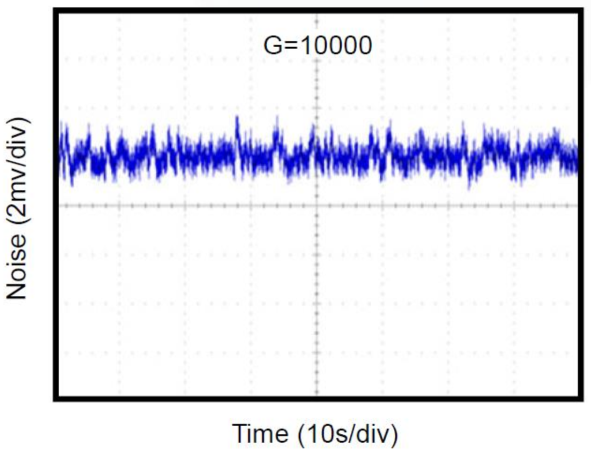
9. Positive Overvoltage Recovery



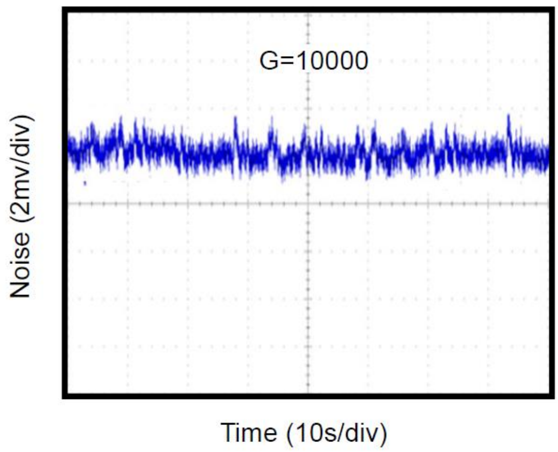
10. Negative Overvoltage Recovery



11. 0.1Hz to 10Hz Noise at +5V



12. 0.1Hz to 10Hz Noise at +2.5V



DETAILED INFORMATION

Size

AO1378 op amps are unity-gain stable and suitable for a wide range of general-purpose applications. The small footprints of the AO1378 packages save space on printed circuit boards and enable the design of smaller electronic products.

Power Supply Bypassing and Board Layout

AO1378 operates from a single 1.8V to 5.5V supply or dual ±0.9V 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 180uA per channel) of AO1378 will help to maximize battery life. They are ideal for battery powered systems

Operating Voltage

AO1378 operate under wide input supply voltage (1.8V 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 AO1378 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 AO1378 can typically swing to less than 5mV from supply rail in light resistive loads (>100kΩ), and 60mV of supply rail in moderate resistive loads (10kΩ).

Capacitive Load Tolerance

The AO1378 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.

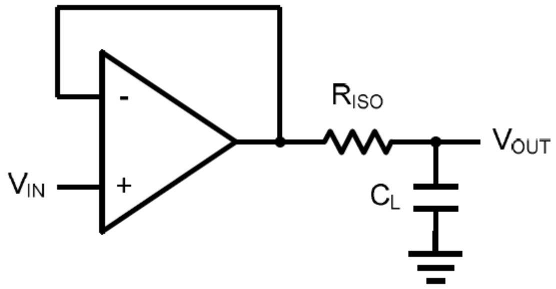


Figure 1. Indirectly Driving a Capacitive Load Using Isolation Resistor

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 Figure 1. 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.

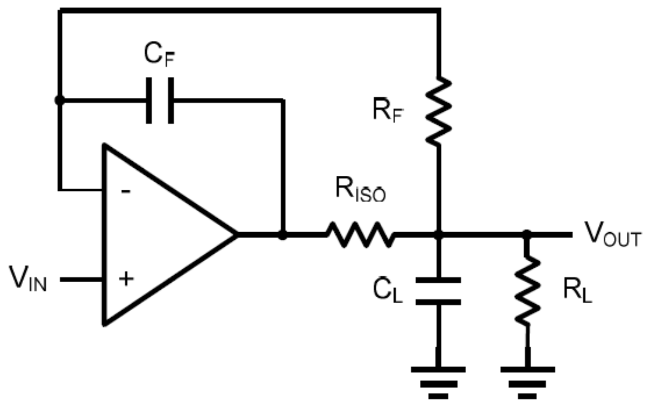


Figure 2. Indirectly Driving a Capacitive Load with DC Accuracy

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 AO1378.

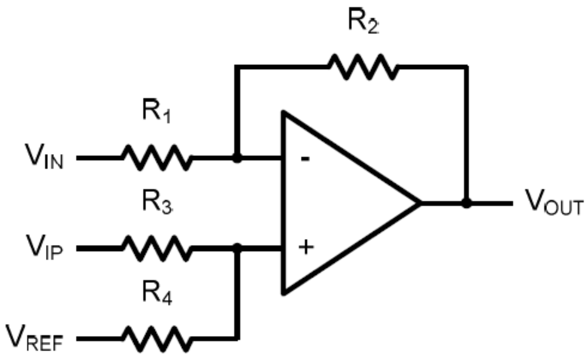


Figure 3. Differential Amplifier

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

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

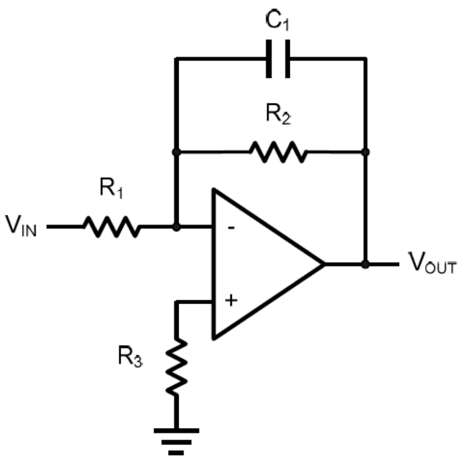


Figure 4. Low Pass Active Filter

Instrumentation Amplifier

The triple AO1378 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.

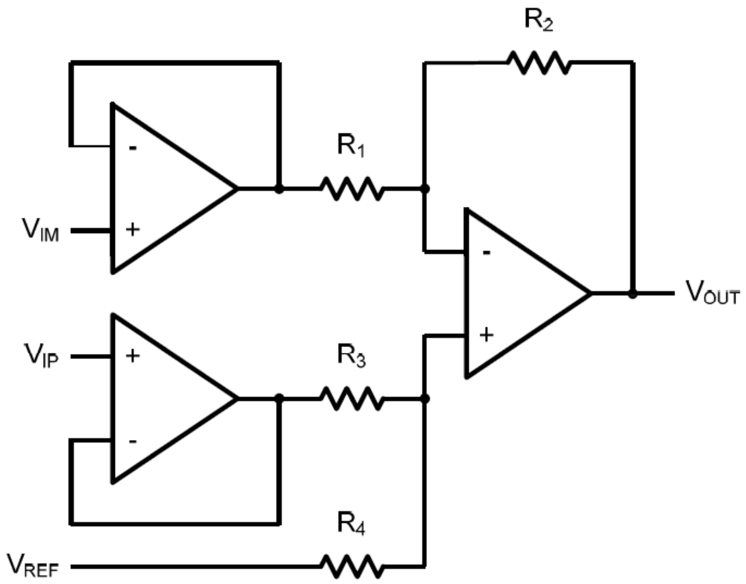
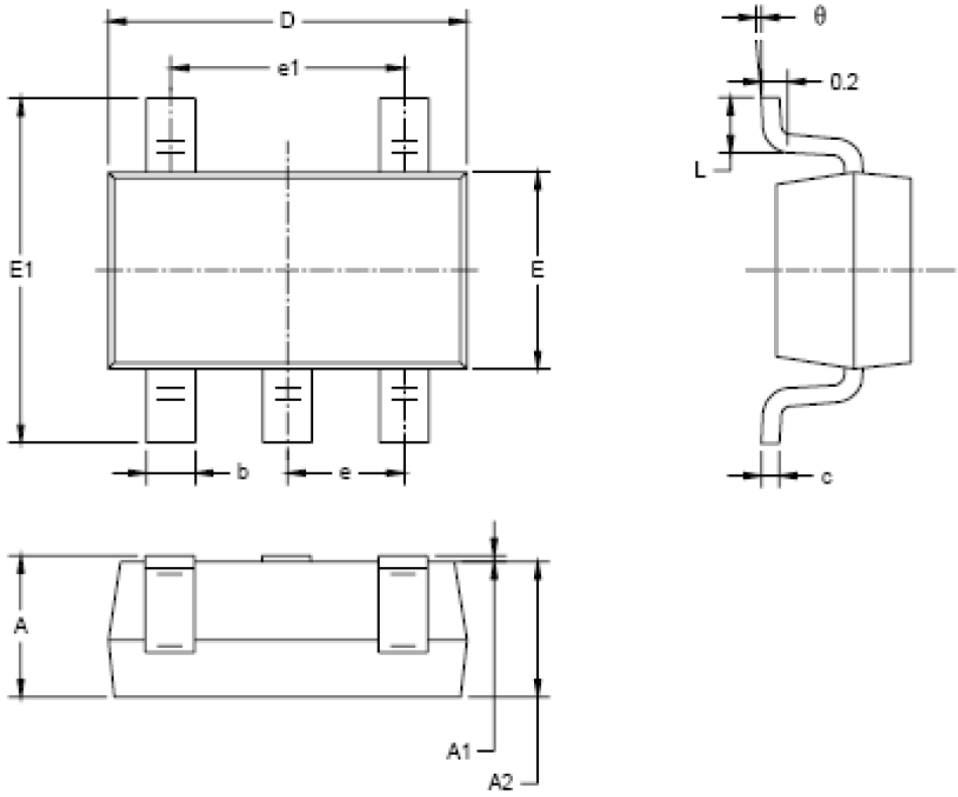


Figure 5. Instrument Amplifier

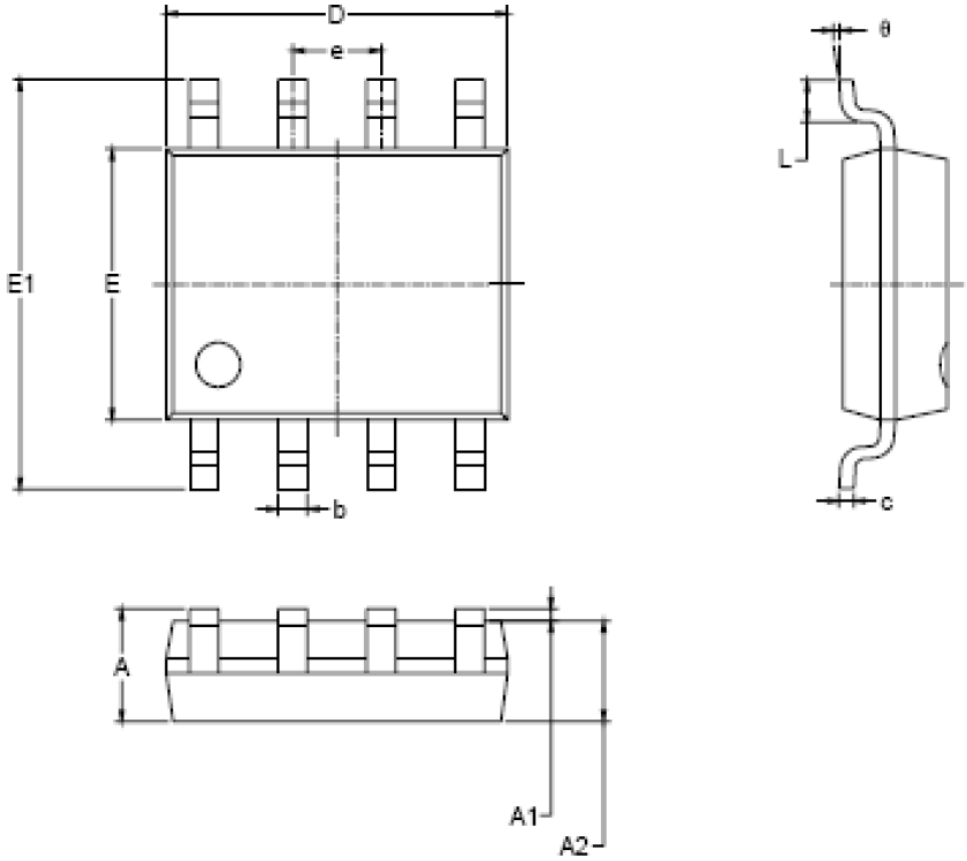
PACKAGE INFORMATION

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 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	1.270 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

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