DESCRIPTION

The AO2904 offers high-voltage (36V) operation and low input offset voltage, as well as excellent speed/power consumption ratio, providing an excellent bandwidth (1.2MHz) and slew rate of 0.5V/μs. The op-amp is unity gain stable and feature a low input bias current.

The input can operate normally within of the negative power rail to 1.5V below of the positive power rail. The AO2904 operational amplifiers is specified at the full temperature range of −40°C to +125°C under single power supplies of 3V to 36V or dual power supplies of ±1.5V to ±18V.

The AO2904 is available in SOP8, MSOP8 and TSSOP8 packages.

ORDERING INFORMATION

Package Type	Part Number	
SOP8 SPQ:4,000pcs/Reel	M8	AO2904M8R
		AO2904M8VR
MSOP8 SPQ: 4,000pcs/Reel	MS8	AO2904MS8R
		AO2904MS8VR
TSSOP8 SPQ: 4,000pcs/Reel	TMX8	AO2904TMX8R
		AO2904TMX8VR
Note	V: Halogen free Package R: Tape & Reel	
AiT provides all RoHS products		

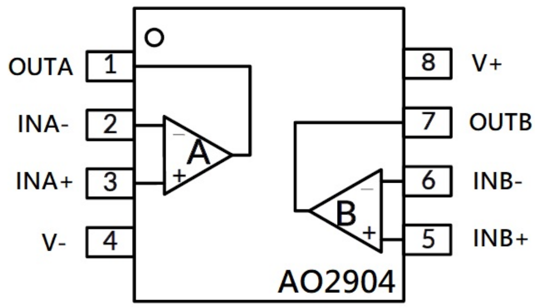
FEATURES

- Wide Supply Range: 3V to 36V
- Unity-Gain Bandwidth:1.2MHz
- Low Input Offset Voltage: ±2.5mV (Max at 25°C)
- Quiescent Current:1.3mA
- Common-Mode Input Voltage Range Include Ground
- Specified up to +125°C

APPLICATION

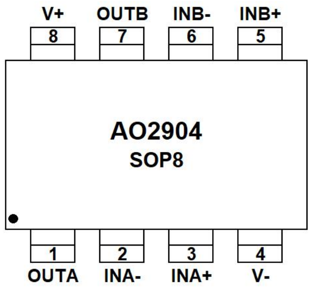
- Merchant network and server power supply units
- Multi-function printers
- Power supplies and mobile chargers
- Motor control: AC induction, brushed DC, brushless DC, high-voltage, low-voltage, permanent magnet, and stepper motor
- Desktop PC and motherboard
- Indoor and outdoor air conditioners
- Washers, dryers, and refrigerators
- AC inverters, string inverters, central inverters, and voltage frequency drives
- Uninterruptible power supplies
- Electronic point-of-sale systems
- Sensors
- Photodiode Amplification
- Active filter
- Test Equipment
- Driving A/D Converters

TYPICAL APPLICATION

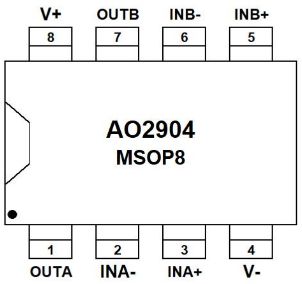


SOP8/MSOP8/TSSOP8

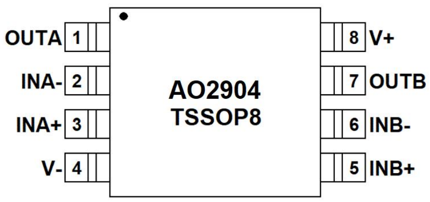
PIN DESCRIPTION



SOP8, M8
Top View



MSOP8, MS8
Top View



TSSOP8, TMX8
Top View

Pin #	Symbol	I/O	Functions
1	OUTA	O	Output, Channel A
2	INA-	I	Inverting Input, Channel A
3	INA+	I	Noninverting Input, Channel A
4	V-	-	Negative (Lowest) power supply or ground (for single supply operation)
5	INB+	I	Noninverting Input, Channel B
6	INB-	I	Inverting Input, Channel B
7	OUTB	O	Output, Channel B
8	V+	-	Positive (Highest) Power Supply

ABSOLUTE MAXIMUM RATINGS

Over operating free-air temperature range (unless otherwise noted)

Supply Voltage, V_S= (V+) - (V-)		+40V
Signal Input Pin Voltage [(1)]		(V-)-0.3 ~ (V+) +0.3 V
Signal Output Pin Voltage [(2)]		(V-)-0.3 ~ (V+) +0.3 V
Differential Input Voltage		(V-)-(V+) ~ (V+) -(V-) V
Output Short-Circuits [(3)]		Continuous
$θ_{JA}$, Package Thermal Impedance[(4)]	SOP8	110°C/W
	MSOP8	170°C/W
	TSSOP8	240°C/W
T_A, Operating Temperature		-40℃ ~ +125℃
T_J, Junction Temperature [(5)]		-40℃ ~ +150℃
T_{STG}, Storage Temperature		-65℃ ~ +150℃
$V_{(ESD)}$, Electrostatic Discharge	Human-body model (HBM), ANSI/ESDA/JEDEC JS001-2017	±500V
	Charge Device Model (CDM), ANSI/ESDA/JEDEC JS-002-2018	±1000V
	Machine Model (MM), JESD22-A115C (2010)	±100V

Stresses above may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the Electrical Characteristics is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

(1) Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.3V beyond the supply rails should be current-limited to 10mA or less.

(2) Output terminals are diode-clamped to the power-supply rails. Output signals that can swing more than 0.3V beyond the supply rails should be current-limited to ±10mA or less.

(3) Short-circuit to ground, one amplifier per package.

(4) The package thermal impedance is calculated in accordance with JESD-51.

(5) The maximum power dissipation is a function of $T_{J(MAX)}$, $R_{θJA}$, and T_A. The maximum allowable power dissipation at any ambient temperature is PD = ($T_{J(MAX)}$ - T_A) / $R_{θJA}$. All numbers apply for packages soldered directly onto a PCB.

RECOMMENDED OPERATING CONDITIONS

Over operating free-air temperature range (unless otherwise noted)

		Min.	Non.	Max.	Units
V_S=(V+)-(V-), Supply Voltage	Single-Supply	3.0	-	36	V
	Dual-Supply	±1.50	-	±18	

ELECTRICAL CHARACTERISTICS

At T_A = +25°C, V_S=3V to 36V, R_L = 10kΩ connected to V_S/2, and V_{OUT} = V_S/2, V_{CM}= V_S/2,

Full [9] = -40°C to +125°C, unless otherwise noted.[1]

Parameter	Symbol	Conditions	Temp	Min.[2]	Typ.[3]	Max.[2]	Units
POWER SUPPLY							
Operating Voltage Range	V_S	-	25℃	3	-	36	V
Quiescent Current	I_Q	V_S=±2.5V, I_O=0mA	25℃	-	1.30	1.50	mA
			Full	-	-	1.80	
		V_S=±18V, I_O=0mA	25℃	-	1.75	2.00	
			Full	-	-	2.40	
Power-Supply Rejection Ratio	PSRR	V_S=±2.5V to ±18V	25℃	90	100	-	dB
			Full	80	-	-	
INPUT							
Input Offset Voltage	V_{OS}	V_{CM}=V_S/2	25℃	-2.5	±1.0	2.5	mV
			Full	-6.0	-	6.0	
I Input Offset Voltage Average Drift	V_{OS}, T_C	V_{CM}=V_S/2	Full	-	±8.0	-	μV/℃
Input Bias Current [4][5]	I_B	V_{CM}=V_S/2	25℃	-	±15	±35	nA
			Full	-	-	±50	
Input Offset Current [5]	I_{OS}	V_{CM}=V_S/2	25℃	-	±0.5	±4.0	nA
			Full	-	-	±5.0	
Common-Mode Voltage Range	V_{CM}	V_S= 3V to 36V	25℃	(V-)	-	(V+)-1.5	V
		V_S= 5V to 36V	Full	(V-)	-	(V+)-2	
Common-Mode Rejection Ratio	CMRR	V_S= ±18V, V_{CM}=(V-) to (V+)-1.5V	25℃	80	100	-	dB
		V_S= ±18V, V_{CM}=(V-) to (V+)-2.0V	Full	70	-	-	
OUTPUT							
Open-Loop Voltage Gain	A_{OL}	R_L=10KΩ, V_S = ±18V, Vo=-16.5V to 16.5V	25℃	102	110	-	dB
			Full	70	-	-	
Output Swing	V_{OH}	I_{OUT}=50uA	25℃	-	1.27	1.40	V
		I_{OUT}=1mA	25℃	-	1.32	1.45	
		I_{OUT}=5mA	25℃	-	1.41	1.60	
	V_{OL}	I_{OUT}=50uA	25℃	-	55	120	mV
		I_{OUT}=1mA	25℃	-	0.77	1	V
Short-Circuit Current [6] [7]	I_{SC}	V_S=±10V, Vo=0V, I_{SOURCE}	25℃	50	60	-	mA
		V_S=±10V, Vo=0V, I_{SINK}	25℃	12	20	-	

Parameter	Symbol	Conditions	Temp	Min.(2)	Typ. (3)	Max.(2)	Units
FREQUENCY RESPONSE							
Slew Rate (8)	S_R	V_S=±2.5V, G=+1, C_L=100pF	25℃	-	0.5	-	V/µs
Gain-Bandwidth Product	G_{BW}	V_S=±2.5V, G=+11, V_{pp}=50mV	25℃	-	1.2	-	MHz
		V_S=±18V, G=+11, V_{pp}=50mV	25℃	-	1.4	-	
Settling Time,0.01%	t_S	V_S=±2.5V, G=+1, C_L=100pF, Step=2V	25℃	-	4.0	-	µs
Overload Recovery Time	t_{OR}	V_{IN}x Gain≥ V_S, V_S=±2.5V, V_{pp}=1V, G=11	25℃	-	4.0	-	µs
Phase Margin (5)	Φm	V_S=±2.5V, G=+1, C_L=50pF	25℃		52		°
Capacitive Load Drive	C_{LOAD}	-	25℃		100		pF
NOISE							
Input Voltage Noise	E_N	f = 0.1Hz to 10Hz, V_S=±2.5V	25℃	-	0.91	-	µV_{pp}
Input Voltage Noise Density (5)	e_n	f=1KHz	25℃	-	38	-	nV/ $\sqrt{Hz}$

(1) Electrical table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device.
(2) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlations using statistical quality control (SQC) method.
(3) Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration.
(4) Positive current corresponds to current flowing into the device.
(5) This parameter is ensured by design and/or characterization and is not tested in production.
(6) The maximum power dissipation is a function of $T_{J(MAX)}$, $R_{θJA}$, and TA. The maximum allowable power dissipation at any ambient temperature is PD = ($T_{J(MAX)}$ - T_A) / $R_{θJA}$. All numbers apply for packages soldered directly onto a PCB.
(7) Short circuit test is a momentary test.
(8) Number specified is the slower of positive and negative slew rates.
(9) Specified by characterization only.

TYPICAL PERFORMANCE CHARACTERISTICS

T_A = +25℃, V_S=±18V, R_L = 10kΩ connected to $V_S/2$, V_{CM}= $V_S/2$, unless otherwise noted.

Fig1. Supply Voltage vs. Quiescent Current

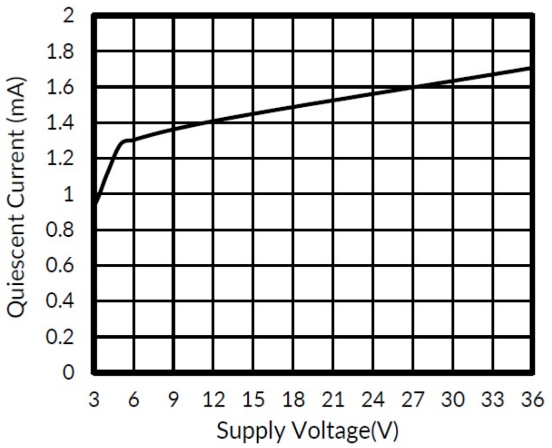


Fig2. Quiescent Current vs. Temperature

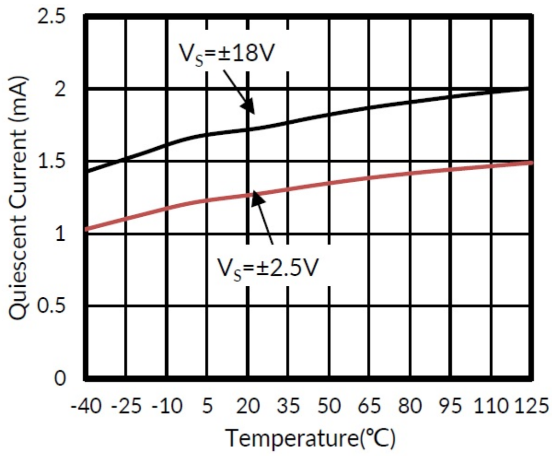


Fig3. Offset Voltage vs. Common Mode Voltage

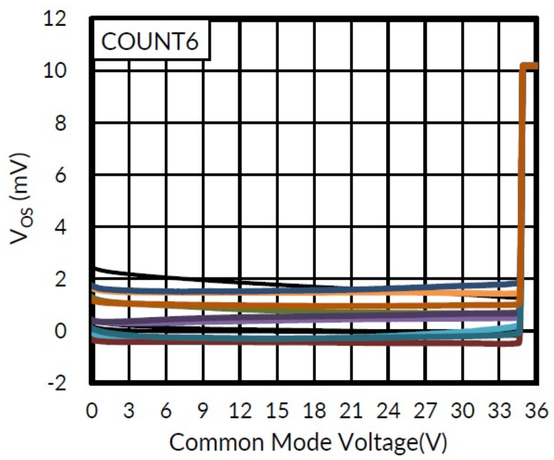


Fig4. Offset Voltage vs. Temperature

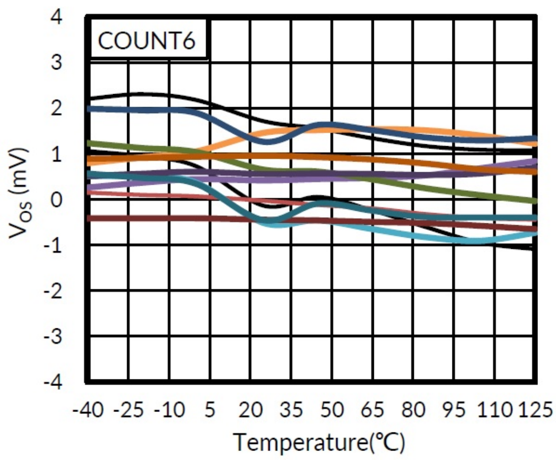


Fig5. Input Bias Current vs. Common Mode Voltage

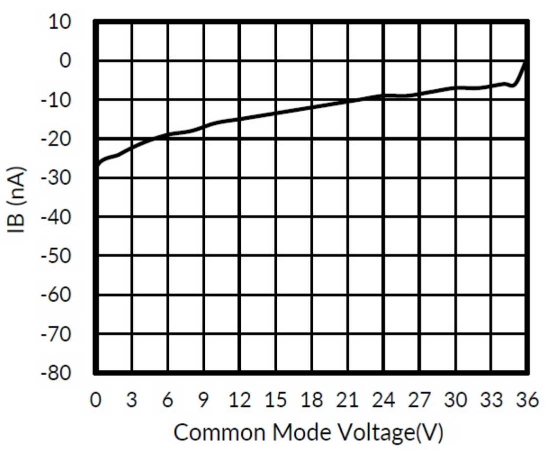


Fig6. 0.1Hz to 10Hz Input Voltage Noise

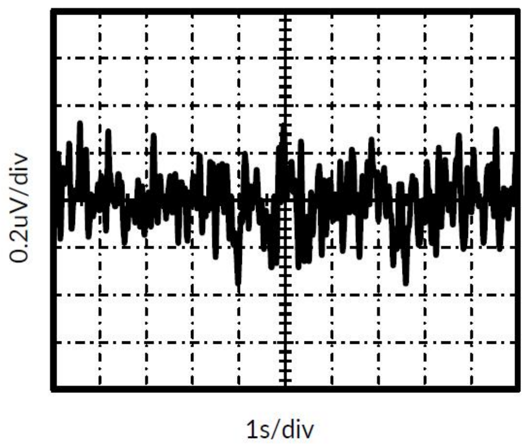


Fig7. 50mV Small-Signal Step Response

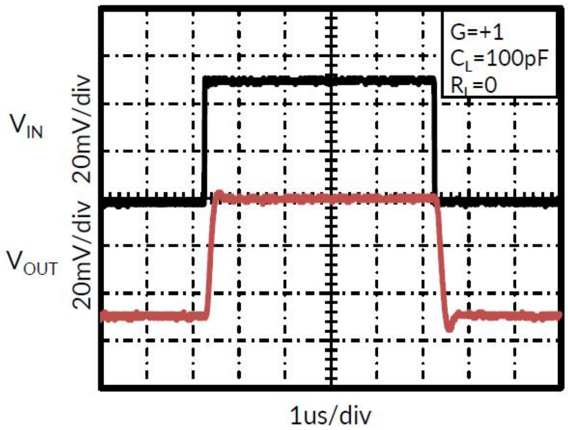


Fig8. 10V Large-Signal Step Response

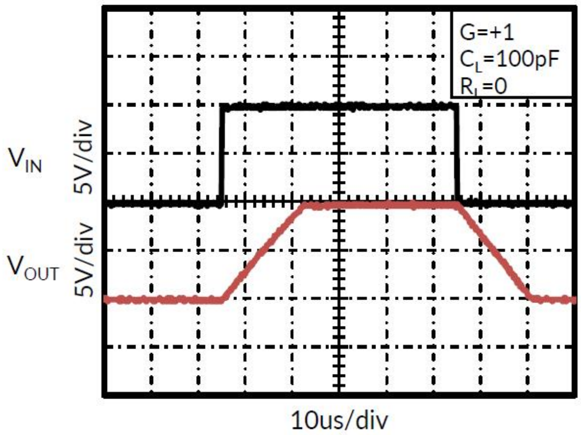


Fig9. Positive Overload Recovery

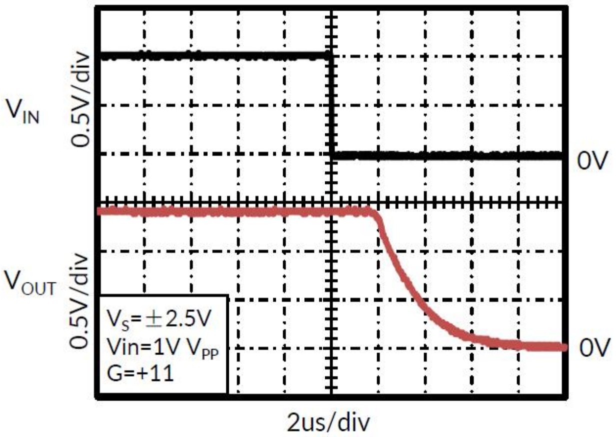


Fig10. Negative Overload Recovery

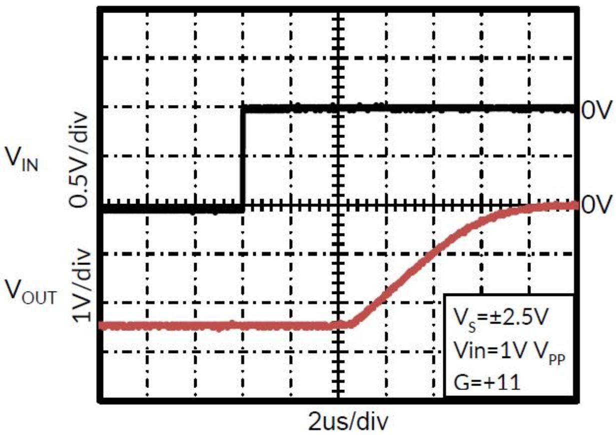
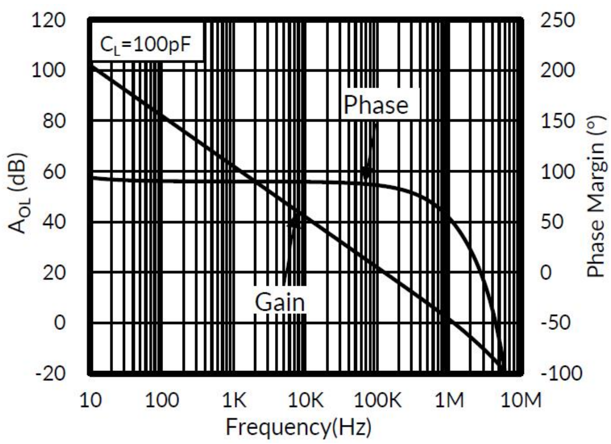
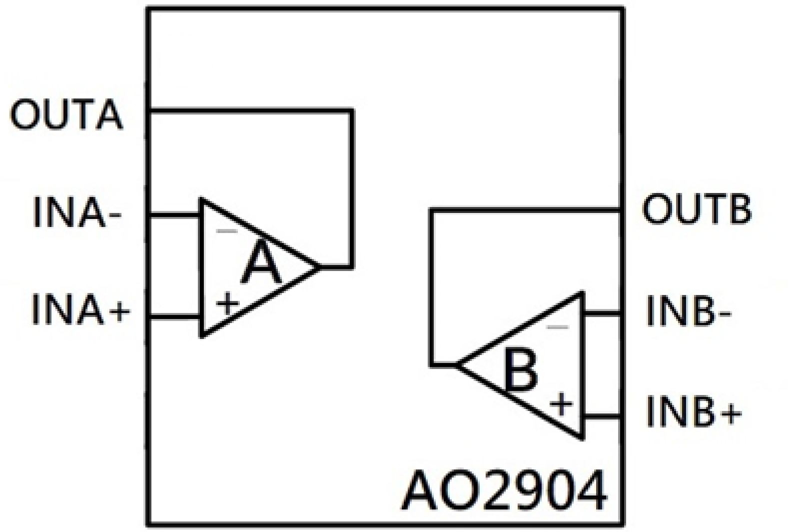


Fig11. Open−Loop Gain and Phase Margin vs. Frequency



BLOCK DIAGRAM



DETAILED INFORMATION

Overview

These AO2904 consist of two independent, high-gain frequency-compensated operational amplifier designed to operate from a single supply over a wide range of voltages. Operation from split supplies also is possible if the difference between the two supplies is within the supply voltage range specified in Recommended Operating Conditions and VS is at least 1.5V more positive than the input common-mode voltage. The low supply-current drain is independent of the magnitude of the supply voltage. Applications include transducer amplifiers, dc amplification blocks, and all the conventional operational amplifier circuits that now can be implemented more easily in single-supply-voltage systems. For example, these devices can be operated directly from the standard 5V supply used in digital systems and easily can provide the required interface electronics without additional ±5V supplies.

Unity-Gain Bandwidth

The unity-gain bandwidth is the frequency up to which an amplifier with a unity gain may be operated without greatly distorting the signal. These devices have a 1.2MHz unity-gain bandwidth.

Slew Rate

The slew rate is the rate at which an operational amplifier can change its output when there is a change on the input. These devices have a 0.5V/μs slew rate.

Input Common Mode Range

The valid common mode range is from device ground to V_S - 1.5V (V_S - 2V across temperature). Inputs may exceed V_S up to the maximum V_S without device damage. At least one input must be in the valid input common-mode range for the output to be the correct phase. If both inputs exceed the valid range, then the output phase is undefined. If either input more than 0.3V below V- then input current should be limited to 1mA and the output phase is undefined.

Device Functional Modes

These devices are powered on when the supply is connected. This device can be operated as a single-supply operational amplifier or dual-supply amplifier, depending on the application.

Application Information

The AO2904 operational amplifiers are useful in a wide range of signal conditioning applications. Inputs can be powered before VS for flexibility in multiple supply circuits.

Application Schematic

A typical application for an operational amplifier is an inverting amplifier. This amplifier takes a positive voltage on the input, and makes it a negative voltage of the same magnitude. In the same manner, it also makes negative voltages positive.

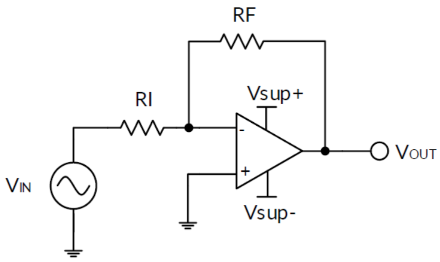


Figure 1. Application Schematic

Design Requirements

The supply voltage must be chosen such that it is larger than the input voltage range and output range. For instance, this application scales a signal of ±0.5V to ±1.8V. Setting the supply at ±12V is sufficient to accommodate this application.

Detailed Design Procedure

Determine the gain required by the inverting amplifier using Equation 1 and Equation 2:

(1) $A_V = \frac{V_{OUT}}{V_{IN}}$

(2) $A_V = \frac{1.8}{-0.5} = -3.6$

Once the desired gain is determined, choose a value for RI or RF. [Subscripts should be fixed in the accompanying figures and equations also.] Choosing a value in the kiloohm range is desirable because the amplifier circuit uses currents in the milliampere range. This ensures the part does not draw too much current. This example uses 10kΩ for RI which means 36kΩ is used for RF. This was determined by Equation 3.

(3) $A_V = -\frac{RF}{RI}$

Power Supply Recommendations

CAUTION
Supply voltages larger than specified in the recommended operating region can permanently damage the device. Place 0.1μF bypass capacitors close to the power-supply pins to reduce errors coupling in from noisy or high-impedance power supplies. For more detailed information on bypass capacitor placement, see Layout Guidelines.

Layout Guidelines

For best operational performance of the device, use good PCB layout practices, including:

(1) Noise can propagate into analog circuitry through the power pins of the circuit as a whole, and operational amplifier itself. Bypass capacitors are used to reduce the coupled noise by providing low-impedance power sources local to the analog circuitry. – Connect low-ESR, 0.1μF ceramic bypass capacitors between each supply pin and ground, placed as close to the device as possible. A single bypass capacitor from V+ to ground is applicable for single supply applications.

(2) Separate grounding for analog and digital portions of circuitry is one of the simplest and most-effective methods of noise suppression. One or more layers on multilayer PCBs are usually devoted to ground planes. A ground plane helps distribute heat and reduces EMI noise pickup. Make sure to physically separate digital and analog grounds paying attention to the flow of the ground current.

(3) To reduce parasitic coupling, run the input traces as far away from the supply or output traces as possible. If these traces cannot be kept separate, crossing the sensitive trace perpendicular is much better as opposed to in parallel with the noisy trace.

(4) Place the external components as close to the device as possible. As shown in Figure 3., keeping RF and RG close to the inverting input minimizes parasitic capacitance.

(5) Keep the length of input traces as short as possible. Always remember that the input traces are the most sensitive part of the circuit.

(6) Consider a driven, low-impedance guard ring around the critical traces. A guard ring can significantly reduce leakage currents from nearby traces that are at different potentials.

Layout Example

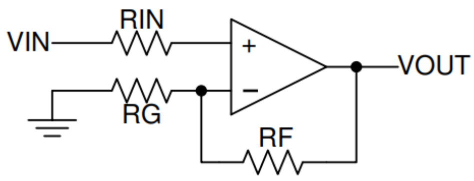


Figure 2. Operational Amplifier Schematic for Noninverting Configuration

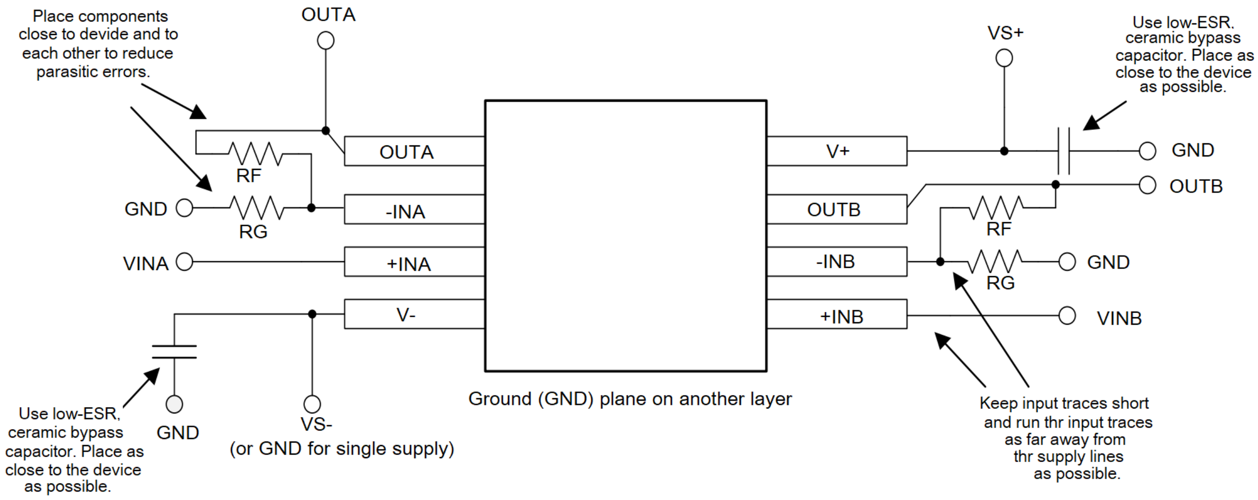
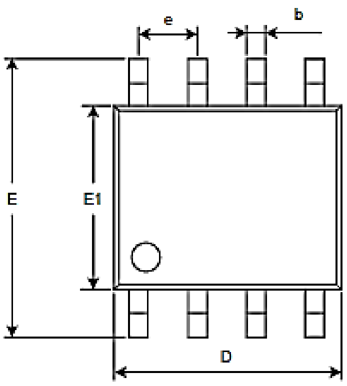
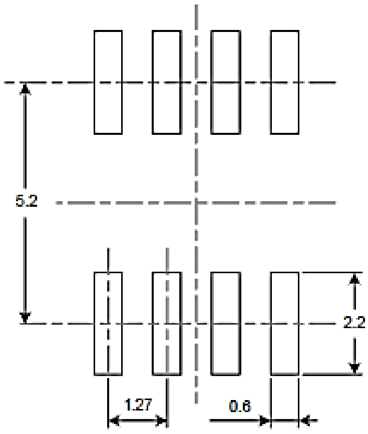


Figure 3. Layout Recommendation

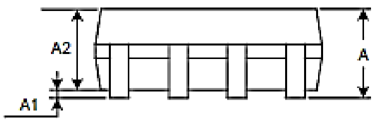
PACKAGE INFORMATION

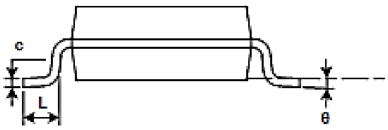
Dimension in SOP8 (Unit: mm)





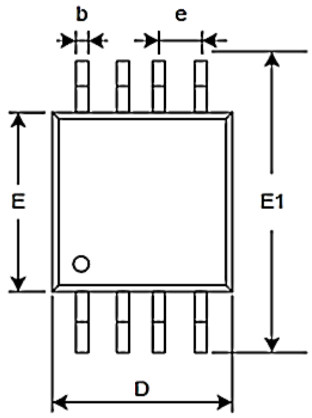
RECOMMENDED LAND PATTERN

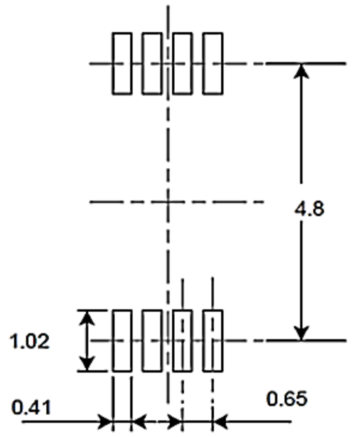




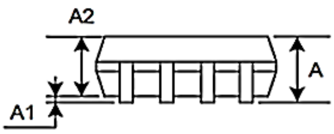
Symbol	Millimeters	
	Min	Max
A	1.350	1.750
A1	0.100	0.250
A2	1.350	1.550
b	0.330	0.510
c	0.170	0.250
D	4.800	5.000
e	1.270 BSC	
E	5.800	6.200
E1	3.800	4.000
L	0.400	1.270
θ	0°	8°

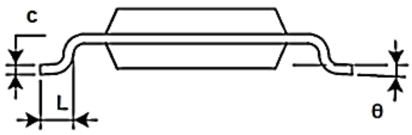
Dimension in MSOP8 (Unit: mm)





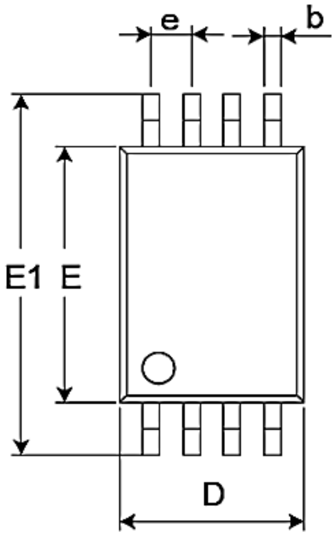
RECOMMENDED LAND PATTERN

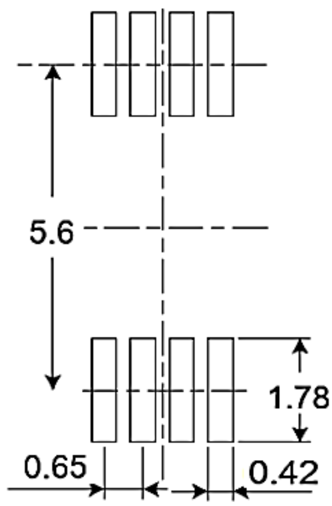




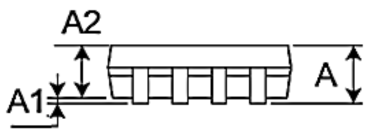
Symbol	Millimeters	
	Min	Max
A	0.820	1.100
A1	0.020	0.150
A2	0.750	0.950
b	0.250	0.380
c	0.090	0.230
D	2.900	3.100
e	0.650 BSC	
E	2.900	3.100
E1	4.750	5.050
L	0.400	0.800
θ	0°	6°

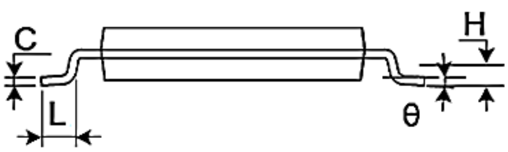
Dimension in TSSOP8 (Unit: mm)





RECOMMENDED LAND PATTERN





Symbol	Millimeters	
	Min	Max
A	-	1.200
A1	0.050	0.150
A2	0.800	1.050
b	0.190	0.300
c	0.090	0.200
D	2.900	3.100
E	4.300	4.500
E1	6.250	6.550
e	0.650 BSC	
L	0.500	0.700
H	0.250 TYP	
θ	1°	7°

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