



## PRECISION DUAL MICROPOWER CMOS OPERATIONAL AMPLIFIER

### GENERAL DESCRIPTION

The ALD2731A/ALD2731 is a precision dual low-cost high-slew-rate monolithic CMOS micropower operational amplifier intended for a broad range of analog applications using  $\pm 1V$  to  $\pm 5V$  dual power supply systems, as well as  $+2V$  to  $+10V$  battery operated systems. All device characteristics are specified for  $+5V$  single supply or  $\pm 2.5V$  dual supply systems. Supply current is  $250\mu A$  per amplifier maximum at  $5V$  supply voltage. It is manufactured with Advanced Linear Devices' enhanced EPAD<sup>®</sup> silicon gate CMOS process.

The ALD2731A/ALD2731 features extremely low input power requirements, practically removing any loading effects on high source impedance signal sources such as capacitive sensors. These devices do not add any significant errors, regardless of what the source impedance variations may be, thereby improving overall system precision and accuracy. The device is designed to offer the benefits of CMOS technology by providing a wide range of desired specifications. The most important of these specifications is extremely low input bias/offset currents at extremely low input offset voltages. It has been developed specifically for the  $+5V$  single supply or  $\pm 1V$  to  $\pm 5V$  dual supply user and offers the popular industry standard pin configuration of  $\mu A741$  and ICL7611 types.

Several additional important characteristics of the device make application easier to implement at those voltages. First, the operational amplifier can operate with rail to rail input and output voltages. This means the signal input voltage and output voltage can be equal to the positive and negative supply voltages. This feature allows numerous analog serial stages and flexibility in input signal bias levels. Second, the device was designed to accommodate mixed applications where digital and analog circuits may operate off the same power supply or battery. Third, the output stage can typically drive up to  $50pF$  capacitive and  $10K\Omega$  resistive loads.

These features, combined with extremely low input currents, high open loop voltage gain of  $100V/mV$ , useful bandwidth of  $700KHz$ , a slew rate of  $0.7V/\mu s$ , low power dissipation of  $0.5mW$ , low offset voltage and temperature drift, make the ALD2731A/ALD2731 a versatile, micropower operational amplifier.

The ALD2731A/ALD2731, designed and fabricated with silicon gate CMOS technology, offers  $0.01pA$  typical input bias current. On chip offset voltage trimming, using EPAD technology, allows the device to be used without nulling. Additionally, robust design and rigorous screening make this device especially suitable for operation in temperature-extreme environments and rugged conditions.

### ORDERING INFORMATION ("L" suffix denotes lead-free (RoHS))

Operating Temperature Range		
$0^{\circ}C$ to $+70^{\circ}C$	$0^{\circ}C$ to $+70^{\circ}C$	$-55^{\circ}C$ to $125^{\circ}C$
8-Pin Small Outline Package (SOIC)	8-Pin Plastic Dip Package	8-Pin CERDIP Package
ALD2731ASAL	ALD2731APAL	
ALD2731SAL	ALD2731PAL	
ALD2731ASA	ALD2731APA	ALD2731ADA
ALD2731SA	ALD2731PA	ALD2731DA

\* Contact factory for leaded (non-RoHS) or high temperature versions.

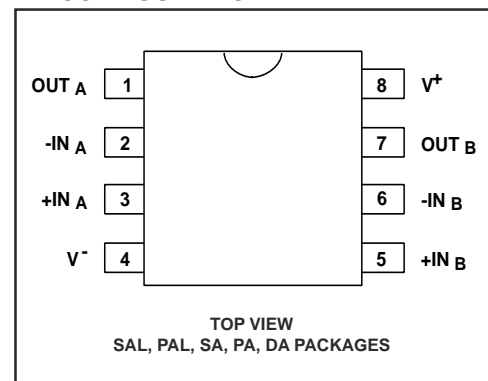
### FEATURES & BENEFITS

- Two package versions -- lead-free (RoHS compliant) and legacy leaded (tin-lead)
- Extremely low input offset voltages --  $0.6mV$  typical
- Extremely low input bias currents --  $0.01pA$  typical
- All parameters specified for  $+5V$  single supply or  $\pm 2.5V$  dual supply systems
- Rail to rail input and output voltage ranges
- No frequency compensation required -- unity gain stable
- Ideal for high source impedance applications
- Dual power supplies  $\pm 1.0V$  to  $\pm 5.0V$
- Single power supply  $+2.0V$  to  $+10.0V$
- High voltage gain -- typ.  $100V/mV$  @  $\pm 2.5V$
- Drive as low as  $10K\Omega$  load
- Output short circuit protected
- Unity gain bandwidth of  $0.7MHz$
- Slew rate of  $0.7V/\mu s$
- Micropower symmetrical complementary output drive
- Suitable for rugged, temperature-extreme environments

### APPLICATIONS

- Voltage amplifier
- Voltage follower/buffer
- Charge integrator
- Photodiode amplifier
- Data acquisition systems
- High performance portable instruments
- Signal conditioning circuits
- Sensor and transducer amplifiers
- Low leakage amplifiers
- Active filters
- Sample/Hold amplifier
- Picoammeter
- Current to voltage converter

### PIN CONFIGURATION



## ABSOLUTE MAXIMUM RATINGS

Supply voltage, V+ \_\_\_\_\_ 10.6V  
 Differential input voltage range \_\_\_\_\_ -0.3V to V+ +0.3V  
 Power dissipation \_\_\_\_\_ 600mW  
 Operating temperature range SAL, PAL, SA, PA packages \_\_\_\_\_ 0°C to +70°C  
 DA package \_\_\_\_\_ -55°C to +125°C  
 Storage temperature range \_\_\_\_\_ -65°C to +150°C  
 Lead temperature, 10 seconds \_\_\_\_\_ +260°C

**CAUTION: ESD Sensitive Device. Use static control procedures in ESD controlled environment.**

## OPERATING ELECTRICAL CHARACTERISTICS TA = 25°C VS = ±2.5V unless otherwise specified

Parameter	Symbol	ALD2731A			ALD2731			Unit	Test Conditions
		Min	Typ	Max	Min	Typ	Max		
Supply Voltage	VS	±1.0		±5.0	±1.0		±5.0	V	Dual Supply Single Supply
	V+	2.0		10.0	2.0		10.0	V	
Input Offset Voltage	VOS		0.6	1.0		1.0	2.0	mV	RS ≤ 100KΩ
Input Offset Current	IOS		0.01	10 200		0.01	10 200	pA pA	TA = 25°C 0°C ≤ TA ≤ +70°C
Input Bias Current	IB		0.01	10 200		0.01	10 200	pA pA	TA = 25°C 0°C ≤ TA ≤ +70°C
Input Voltage Range	VIR	-0.3		+5.3	-0.3		+5.3	V	V+ = +5V VS = ±2.5V
		-2.8		+2.8	-2.8		+2.8	V	
Input Resistance	RIN		10 <sup>14</sup>			10 <sup>14</sup>		Ω	
Input Offset Voltage Drift	TCVOS		5			5		μV/°C	RS ≤ 100KΩ
Power Supply Rejection Ratio	PSRR		85			85		dB	RS ≤ 100KΩ 0°C ≤ TA ≤ +70°C
			85			85		dB	
Common Mode Rejection Ratio	CMRR		85			85		dB	RS ≤ 100KΩ 0°C ≤ TA ≤ +70°C
			85			85		dB	
Large Signal Voltage Gain	AV		100			100		V/mV	RL = 100KΩ RL = 1MΩ
			300			300		V/mV	
Output Voltage Range	VO low		0.001	0.01		0.001	0.01	V	RL = 1MΩ, V+ = +5V 0°C ≤ TA ≤ +70°C
	VO high	4.99	4.999		4.99	4.999		V	
	VO low		-2.48	-2.40		-2.48	-2.40	V	RL = 100KΩ 0°C ≤ TA ≤ +70°C
		VO high	2.40	2.48		2.40	2.48		
Output Short Circuit Current	ISC		1			1		mA	
Supply Current	IS		240	360		240	360	μA	VIN = 0V, No Load
Power Dissipation	PD			1.8			1.8	mW	VS = ±2.5V
Input Capacitance	CIN		1			1		pF	
Bandwidth	BW		700			700		KHz	
Slew Rate	SR		0.7			0.7		V/μs	AV = +1, RL = 100KΩ

## OPERATING ELECTRICAL CHARACTERISTICS (cont'd)

$T_A = 25^\circ\text{C}$   $V_S = \pm 2.5\text{V}$  unless otherwise specified (cont'd)

Parameter	Symbol	ALD2731A			ALD2731			Unit	Test Conditions
		Min	Typ	Max	Min	Typ	Max		
Rise time	$t_r$		0.2			0.2		$\mu\text{s}$	$R_L = 100\text{K}\Omega$
Overshoot Factor			20			20		%	$R_L = 100\text{K}\Omega$ , $C_L = 50\text{pF}$
Settling Time	$t_s$		10			10		$\mu\text{s}$	0.1%, $A_V = 100$ , $R_L = 100\text{K}\Omega$ , $C_L = 50\text{pF}$
Channel Separation	$c_s$		140			140		dB	$A_V = 100$

$T_A = 25^\circ\text{C}$   $V_S = \pm 5.0\text{V}$  unless otherwise specified

Parameter	Symbol	ALD2731A			ALD2731			Unit	Test Conditions
		Min	Typ	Max	Min	Typ	Max		
Power Supply Rejection Ratio	PSRR		90			90		dB	$R_S \leq 100\text{K}\Omega$
Common Mode Rejection Ratio	CMRR		90			90		dB	$R_S \leq 100\text{K}\Omega$
Large Signal Voltage Gain	$A_V$		250			250		V/mV	$R_L = 100\text{K}\Omega$
Output Voltage Range	$V_{O\text{ low}}$ $V_{O\text{ high}}$	4.90	-4.98 4.98	-4.90	4.90	-4.98 4.98	-4.90	V	$R_L = 100\text{K}\Omega$
Bandwidth	$B_W$		1.0			1.0		MHz	
Slew Rate	$S_R$		1.0			1.0		V/ $\mu\text{s}$	$A_V = +1$ , $C_L = 50\text{pF}$

$V_S = \pm 2.5\text{V}$   $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$  unless otherwise specified

Parameter	Symbol	ALD2731A			ALD2731			Unit	Test Conditions
		Min	Typ	Max	Min	Typ	Max		
Input Offset Voltage	$V_{OS}$			2.0			3.0	mV	$R_S \leq 100\text{K}\Omega$
Input Offset Current	$I_{OS}$			2.0			2.0	nA	
Input Bias Current	$I_B$			2.0			2.0	nA	
Power Supply Rejection Ratio	PSRR		75			75		dB	$R_S \leq 100\text{K}\Omega$
Common Mode Rejection Ratio	CMRR		83			83		dB	$R_S \leq 100\text{K}\Omega$
Large Signal Voltage Gain	$A_V$		50			50		V/mV	$R_L = 100\text{K}\Omega$
Output Voltage Range	$V_{O\text{ low}}$ $V_{O\text{ high}}$	2.35	-2.47 2.45	-2.40	2.35	-2.47 2.45	-2.40	V V	$R_L = 100\text{K}\Omega$

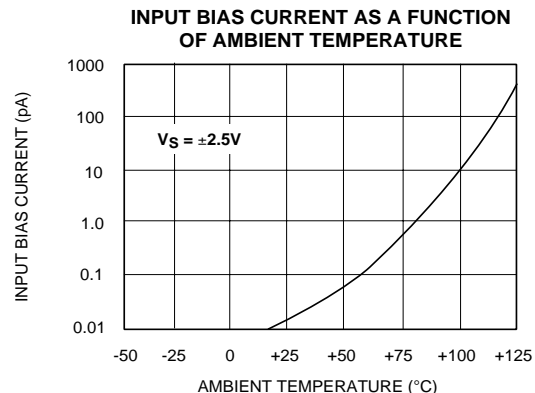
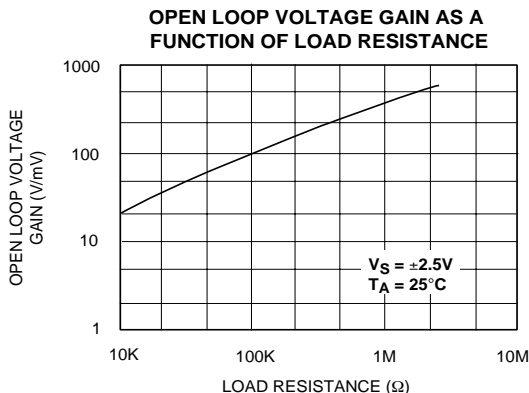
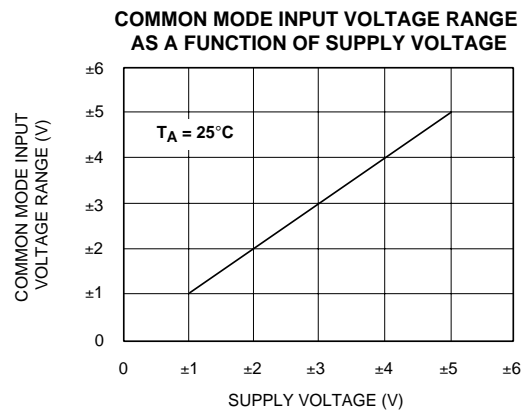
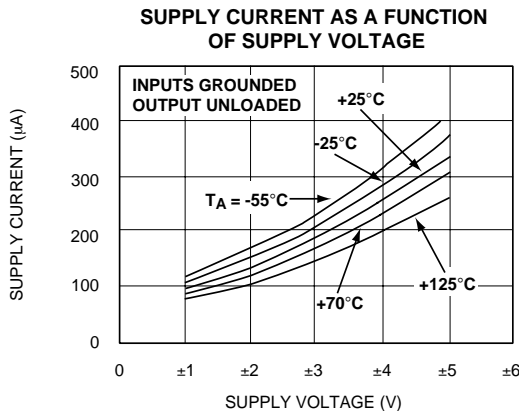
## Design & Operating Notes:

1. The ALD2731A/ALD2731 CMOS operational amplifier uses a 3 gain stage architecture and an improved frequency compensation scheme to achieve large voltage gain, high output driving capability, and better frequency stability. In a conventional CMOS operational amplifier design, compensation is achieved with a pole splitting capacitor together with a nulling resistor. This method is, however, very bias dependent and thus cannot accommodate the large range of supply voltage operation as is required from a stand alone CMOS operational amplifier. The ALD2731A/ALD2731 is internally compensated for unity gain stability using a novel scheme that does not use a nulling resistor. This scheme produces a clean single pole roll off in the gain characteristics while providing for more than 70 degrees of phase margin at the unity gain frequency.
2. The ALD2731A/ALD2731 has complementary p-channel and n-channel input differential stages connected in parallel to accomplish rail to rail common mode input voltage ranges. This means that with the ranges of common mode input voltage close to the power supplies, one of the two differential stages is switched off internally. To maintain compatibility with other operational amplifiers, this switching point has been selected to be about 1.5V below the positive supply voltage. Since offset voltage trimming on the ALD2731A/ALD2731 is made when the input voltage is symmetrical to the supply voltages, this internal switching does not affect a large variety of applications such as an inverting amplifier or non-inverting amplifier with a gain larger than 2.5 (5V operation), where the common mode voltage does not make excursions below this switching point. The user should, however, be aware that this switching does take place if the operational amplifier is connected as a unity gain buffer and should make provisions in the design to allow for input offset voltage variations.
3. The input bias and offset currents are essentially input protection diode reverse bias leakage currents, and are typically 0.01 pA at room temperature. This low input bias current assures that the analog signal from the source will not be distorted by input bias currents.

Normally, this extremely high input impedance of greater than  $10^{14}\Omega$  would not be a problem as the source impedance would limit the node impedance. However, for applications where source impedance is very high, it may be necessary to limit noise and hum pickup through proper shielding.

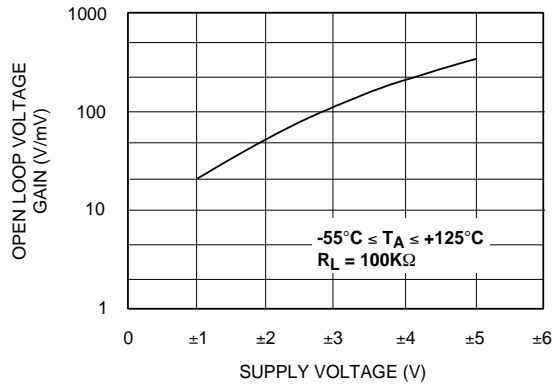
4. The output stage consists of class AB complementary output drivers, capable of driving a low resistance load. The output voltage swing is limited by the drain to source on-resistance of the output transistors as determined by the bias circuitry, and the value of the load resistor. When connected in the voltage follower configuration, the oscillation resistant feature, combined with the rail to rail input and output feature, makes an effective analog signal buffer for medium to high source impedance sensors, transducers, and other circuit networks.
5. The ALD2731A/ALD2731 operational amplifier has been designed to provide full static discharge protection. Internally, the design has been carefully implemented to minimize latch up. However, care must be exercised when handling the device to avoid strong static fields that may degrade a diode junction, causing increased input leakage currents. In using the operational amplifier, the user is advised to power up the circuit before, or simultaneously with, any input voltages applied and to limit input voltages not to exceed 0.3V of the power supply and voltage levels.
6. The ALD2731A/ALD2731, with its micropower operation, offers numerous benefits in reduced power supply requirements, less noise coupling and current spikes, less thermally induced drift, better overall reliability due to lower self heating, and lower input bias current. It requires practically no warm up time as the chip junction heats up to only 0.1°C above ambient temperature under most operating conditions.
7. The ALD2731A/ALD2731 has an internal design architecture that provides robust high temperature operation. Contact factory for custom screening versions.

## TYPICAL PERFORMANCE CHARACTERISTICS

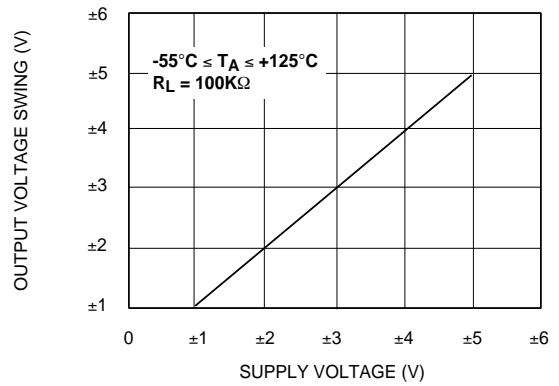


## TYPICAL PERFORMANCE CHARACTERISTICS (cont'd)

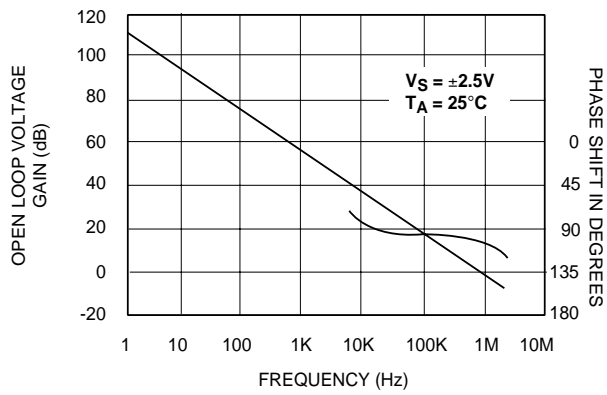
**OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF SUPPLY VOLTAGE AND TEMPERATURE**



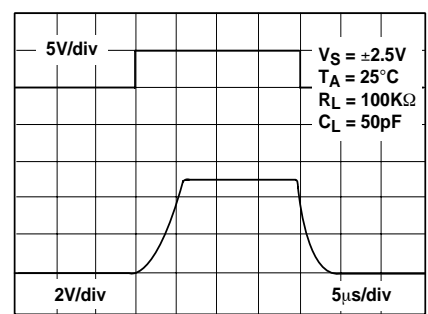
**OUTPUT VOLTAGE SWING AS A FUNCTION OF SUPPLY VOLTAGE**



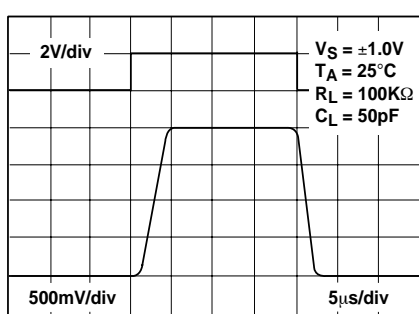
**OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF FREQUENCY**



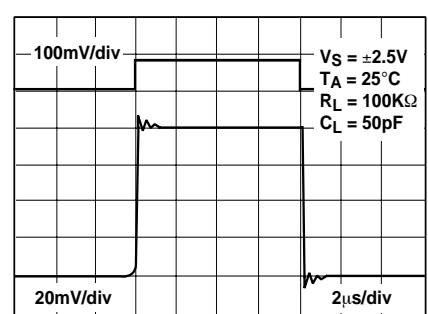
**LARGE-SIGNAL TRANSIENT RESPONSE**



**LARGE-SIGNAL TRANSIENT RESPONSE**

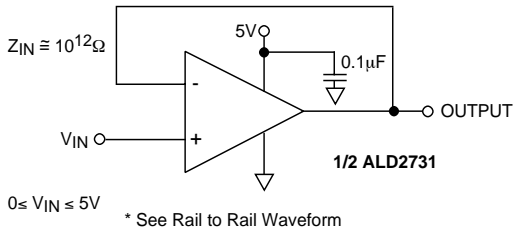


**SMALL-SIGNAL TRANSIENT RESPONSE**

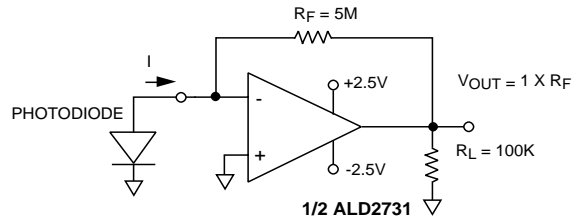


# TYPICAL APPLICATIONS

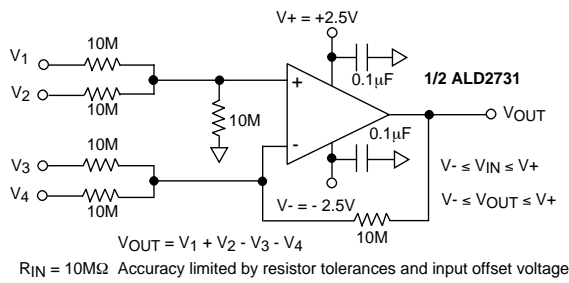
## RAIL-TO-RAIL VOLTAGE FOLLOWER/BUFFER



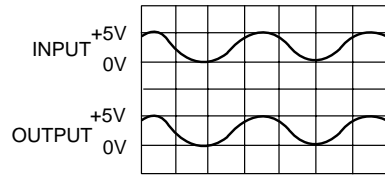
## PHOTO DETECTOR CURRENT TO VOLTAGE CONVERTER



## HIGH INPUT IMPEDANCE RAIL-TO-RAIL PRECISION DC SUMMING AMPLIFIER

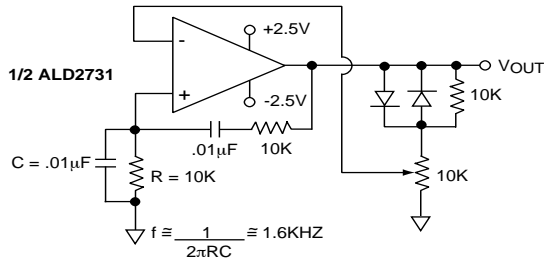


## RAIL-TO-RAIL WAVEFORM



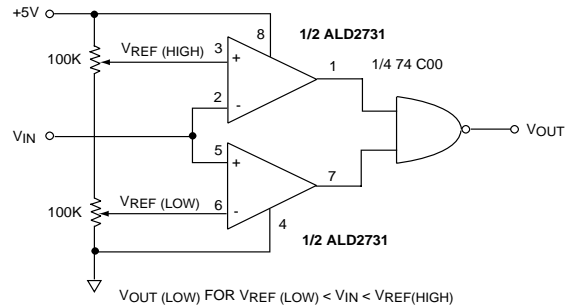
**Performance waveforms.**  
Upper trace is the output of a Wien Bridge Oscillator. Lower trace is the output of Rail-to-rail voltage follower.

## WIEN BRIDGE OSCILLATOR (RAIL-TO-RAIL) SINE WAVE GENERATOR

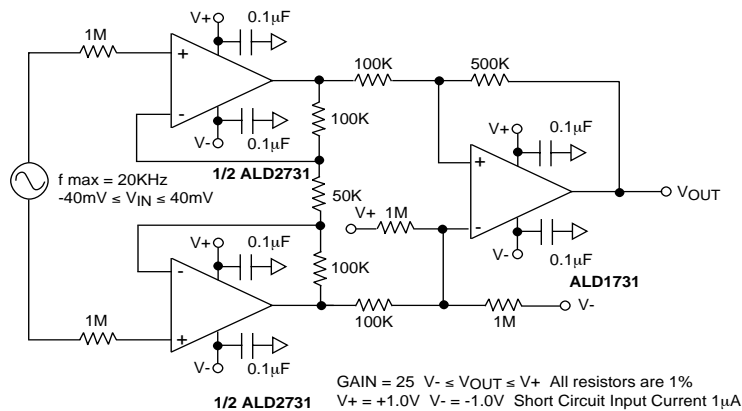


\* See Rail to Rail Waveform

## RAIL-TO-RAIL WINDOW COMPARATOR

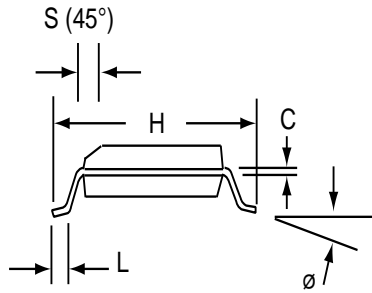
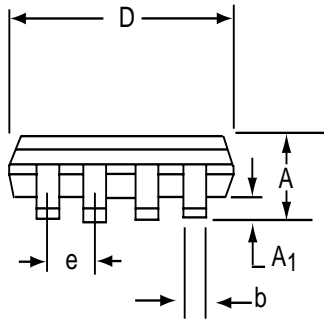
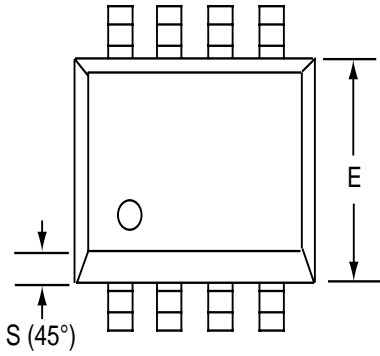


## LOW VOLTAGE INSTRUMENTATION AMPLIFIER



# SOIC-8 PACKAGE DRAWING

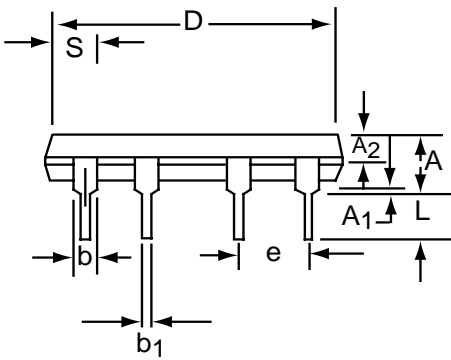
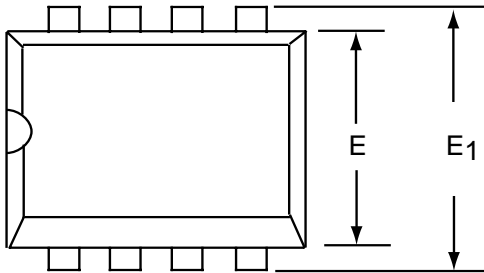
## 8 Pin Plastic SOIC Package



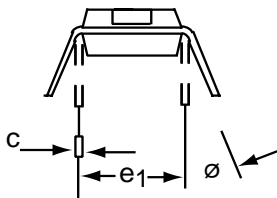
Dim	Millimeters		Inches	
	Min	Max	Min	Max
A	1.35	1.75	0.053	0.069
A <sub>1</sub>	0.10	0.25	0.004	0.010
b	0.35	0.45	0.014	0.018
C	0.18	0.25	0.007	0.010
D-8	4.69	5.00	0.185	0.196
E	3.50	4.05	0.140	0.160
e	1.27 BSC		0.050 BSC	
H	5.70	6.30	0.224	0.248
L	0.60	0.937	0.024	0.037
∅	0°	8°	0°	8°
S	0.25	0.50	0.010	0.020

# PDIP-8 PACKAGE DRAWING

## 8 Pin Plastic DIP Package



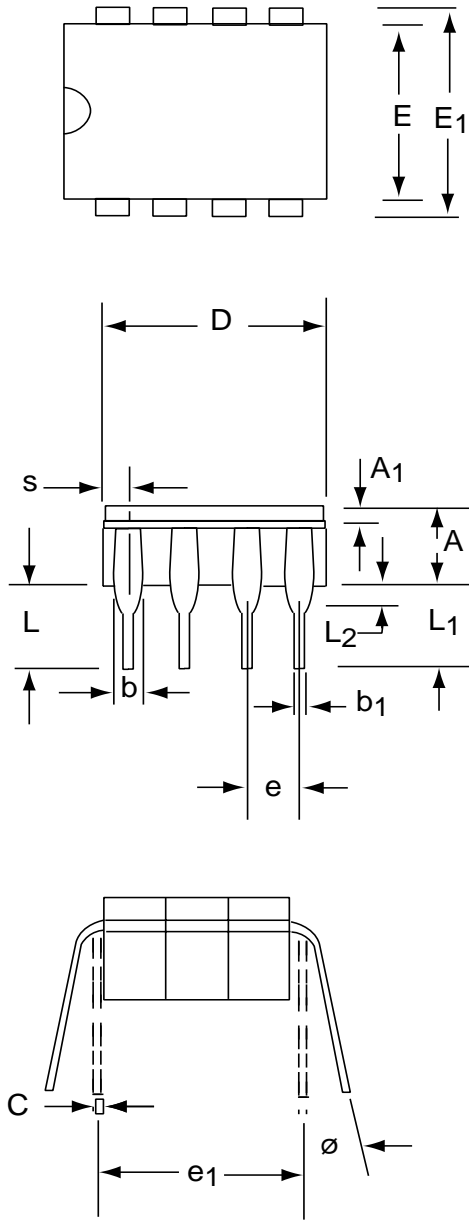
Dim	Millimeters		Inches	
	Min	Max	Min	Max
A	3.81	5.08	0.105	0.200
A <sub>1</sub>	0.38	1.27	0.015	0.050
A <sub>2</sub>	1.27	2.03	0.050	0.080
b	0.89	1.65	0.035	0.065
b <sub>1</sub>	0.38	0.51	0.015	0.020
c	0.20	0.30	0.008	0.012
D-8	9.40	11.68	0.370	0.460
E	5.59	7.11	0.220	0.280
E <sub>1</sub>	7.62	8.26	0.300	0.325
e	2.29	2.79	0.090	0.110
e <sub>1</sub>	7.37	7.87	0.290	0.310
L	2.79	3.81	0.110	0.150
S-8	1.02	2.03	0.040	0.080
∅	0°	15°	0°	15°





# CERDIP-8 PACKAGE DRAWING

## 8 Pin CERDIP Package



Dim	Millimeters		Inches	
	Min	Max	Min	Max
A	3.55	5.08	0.140	0.200
A <sub>1</sub>	1.27	2.16	0.050	0.085
b	0.97	1.65	0.038	0.065
b <sub>1</sub>	0.36	0.58	0.014	0.023
C	0.20	0.38	0.008	0.015
D-8	--	10.29	--	0.405
E	5.59	7.87	0.220	0.310
E <sub>1</sub>	7.73	8.26	0.290	0.325
e	2.54 BSC		0.100 BSC	
e <sub>1</sub>	7.62 BSC		0.300 BSC	
L	3.81	5.08	0.150	0.200
L <sub>1</sub>	3.18	--	0.125	--
L <sub>2</sub>	0.38	1.78	0.015	0.070
S	--	2.49	--	0.098
∅	0°	15°	0°	15°