5V RAIL-TO-RAIL PRECISION OPERATIONAL AMPLIFIER

GENERAL DESCRIPTION

The ALD1702A/ALD1702B/ALD1702/ALD1703 is a monolithic operational amplifier intended primarily for a wide range of analog applications in +5V single power supply and ±5V dual power supply systems as well as +4V to +10V battery operated systems. All device characteristics are specified for +5V single supply or ±2.5V dual supply systems. It is manufactured with Advanced Linear Devices' enhanced ACMOS silicon gate CMOS process.

The ALD1702A/ALD1702B/ALD1702/ALD1703 is designed to offer a balanced trade-off of performance parameters providing a wide range of desired specifications. It has been developed specifically with the 5V single supply or ±2.5 dual supply user in mind and offers the industry pin configuration of μA741 and ICL7611 types.

Several important characteristics of the device make many applications easy to implement for these supply voltages. First, the operational amplifier can operate with rail to rail input and output voltages. This feature allows numerous analog serial stages to be implemented without losing operating voltage margin. Second, the device was designed to accommodate mixed applications where digital and analog circuits may work off the same 5V power supply. Third, the output stage can drive up to 400pF capacitive and 5KΩ resistive loads in non-inverting unity gain connection and double the capacitance in the inverting unity gain mode.

These features, coupled with extremely low input currents, high voltage gain, useful bandwidth of 1.5MHz, slew rate of 2.1V/μs, low power dissipation, low offset voltage and temperature drift, make the ALD1702A/ALD1702B/ALD1702/ALD1703 a truly versatile, user friendly, operational amplifier.

The ALD1702A/ALD1702B/ALD1702/ALD1703 is designed and fabricated with silicon gate CMOS technology, and offers 1pA typical input bias current. On-chip offset voltage trimming allows the device to be used without nulling in most applications. The device offers typical offset drift of less than 7μV/°C which eliminates many trim or temperature compensation circuits. For precision applications, it is designed to settle to 0.01% in 8μs. Additionally, robust design and rigorous screening make this device especially suitable for operation in temperature-extreme environments and rugged conditions.

FEATURES

- Rail-to-rail input and output voltage ranges
- All parameters specified for +5V single supply or ±2.5V dual supply systems.
- High load capacitance capability -- 4000pF typical
- No frequency compensation required -- unity gain stable
- Extremely low input bias currents -- 1.0pA typical (30pA max.)
- Ideal for high source impedance applications
- Dual power supply ±2.5V to ±5.0V operation
- Single power supply +5V to +10V operation
- High voltage gain -- typically 85V/mV @ ±2.5V and 250V/mV @ ±5.0V
- Drive as low as 2KΩ load with 5mA drive current
- Output short circuit protected
- Unity gain bandwidth of 1.5MHz (1MHz min.)
- Slew rate of 2.1V/μs (1.4V/μs min.)
- Low power dissipation
- Suitable for rugged, temperature-extreme environments

APPLICATIONS

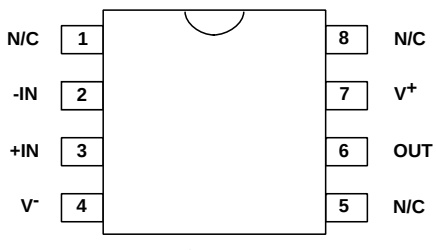
- Voltage amplifier
- Voltage follower/buffer
- Charge integrator
- Photodiode amplifier
- Data acquisition systems
- High performance portable instruments
- Signal conditioning circuits
- Sensor and transducer amplifiers
- Low leakage amplifiers
- Active filters
- Sample/Hold amplifier
- Picoammeter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

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

Operating Temperature Range		
0°C to +70°C	0°C to +70°C	-55°C to 125°C
8-Pin Small Outline Package (SOIC)	8-Pin Plastic Dip Package	8-Pin CERDIP Package
ALD1702ASAL	ALD1702APAL	ALD1702ADA
ALD1702BSAL	ALD1702BPAL	ALD1702BDA
ALD1702SAL	ALD1702PAL	ALD1702DA
ALD1703SAL	ALD1703PAL	ALD1703DA

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

PIN CONFIGURATION



TOP VIEW
SAL, PAL, DA PACKAGES

* N/C pins are internally connected. Do not connect externally.

ABSOLUTE MAXIMUM RATINGS

Supply voltage, V^+ ____ 10.6V
Differential input voltage range ____ -0.3V to V^+ +0.3V
Power dissipation ____ 600 mW
Operating temperature range SAL, PAL 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
T_A = 25°C V_S = ±2.5V unless otherwise specified

		1702A			1702B			1702			1703				Test
Parameter	**Symbol**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Unit**	**Conditions**
Supply Voltage	V_S	±2.0		±5.0	±2.0		±5.0	±2.0		±5.0	±2.0		±5.0		Dual Supply
	V^+	4.0		10.0	4.0		10.0	4.0		10.0	4.0		10.0	V	Single Supply
Input Offset Voltage	V_{OS}			0.9			2.0			4.5			10.0	mV	$R_S \le 100K\Omega$
				1.7			2.8			5.3			11.0	mV	0°C $\le T_A \le$ +70°C
Input Offset Current	I_{OS}		1.0	25		1.0	25		1.0	25		1.0	30	pA	T_A = 25°C
				240			240			240			450	pA	0°C $\le T_A \le$ +70°C
Input Bias Current	I_B		1.0	30		1.0	30		1.0	30		1.0	50	pA	T_A = 25°C
				300			300			300			600	pA	0°C $\le T_A \le$ +70°C
Input Voltage Range	V_{IR}	-0.3		5.3	-0.3		5.3	-0.3		5.3	0.15		4.85	V	V^+ = +5V
		-2.8		2.8	-2.8		2.8	-2.8		2.8	-2.35		2.35	V	V_S = ±2.5V
Input Resistance	R_{IN}		10^{12}			10^{12}			10^{12}			10^{12}		Ω	
Input Offset Voltage Drift	TCV_{OS}		7			7			7			10		μV/°C	$R_S \le 100K\Omega$
Power Supply Rejection Ratio	PSRR	70	80		65	80		65	80		60	80		dB	$R_S \le 100K\Omega$
		70	80		65	80		65	80		60	80		dB	0°C $\le T_A \le$ +70°C
Common Mode Rejection Ratio	CMRR	70	83		65	83		65	83		60	83		dB	$R_S \le 100K\Omega$
		70	83		65	83		65	83		60	83		dB	0°C $\le T_A \le$ +70°C
Large Signal Voltage Gain	A_V	50	85		50	85		50	85		32	85		V/mV	R_L =10KΩ
			400			400			400			300		V/mV	$R_L \ge$1MΩ
		20			20			20			10			V/mV	R_L =10KΩ
															0°C $\le T_A \le$ +70°C
Output Voltage Range	V_O low		0.002	0.01		0.002	0.01		0.002	0.01		0.002	0.01	V	R_L =1MΩ V^+ = 5V
	V_O high	4.99	4.998		4.99	4.998		4.99	4.998		4.99	4.998		V	0°C $\le T_A \le$ +70°C
	V_O low		-2.44	-2.35		-2.44	-2.35		-2.44	-2.35		-2.4	-2.3	V	R_L =10KΩ
	V_O high	2.35	2.44		2.35	2.44		2.35	2.44		2.3	2.4			0°C $\le T_A \le$ +70°C
Output Short Circuit Current	I_{SC}		8			8			8			8		mA	
Supply Current	I_S		1.1	2.0		1.1	2.0		1.1	2.0		1.1	2.5	mA	V_{IN} = 0V No Load
Power Dissipation	P_D		5.5	10.0		5.5	10.0		5.5	10.0		5.5	12.5	mW	V_S = ±2.5V
Input Capacitance	C_{IN}		1			1			1			1		pF	
Bandwidth	B_W	1.0	1.5		1.0	1.5		1.0	1.5		0.7	1.5		MHz	
Slew Rate	S_R	1.4	2.1		1.4	2.1		1.4	2.1		1.1	2.1		V/μs	A_V = +1 R_L = 10KΩ
Rise time	t_r		0.2			0.2			0.2			0.2		μs	R_L = 10KΩ C_L = 100pF

OPERATING ELECTRICAL CHARACTERISTICS (cont'd)

T_A = 25°C V_S = ±2.5V unless otherwise specified

Parameter	Symbol	1702A			1702B			1702			1703			Unit	Test Conditions
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max		
Overshoot Factor			10			10			10			10		%	R_L =10KΩ C_L = 100pF
Maximum Load Capacitance	C_L		400 4000			400 4000			400 4000			400 4000		pF pF	Gain = 1 Gain = 5
Input Noise Voltage	e_n		26			26			26			26		nV/√Hz	f =1KHz
Input Current Noise	i_n		0.6			0.6			0.6			0.6		fA/√Hz	f =10Hz
Settling Time	t_s		8.0 3.0			8.0 3.0			8.0 3.0			8.0 3.0		µs µs	0.01% 0.1% A_V = -1 R_L=5KΩ C_L=50pF

T_A = 25°C V_S = ±5.0V unless otherwise specified

Parameter	Symbol	1702A			1702B			1702			1703			Unit	Test Conditions
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max		
Power Supply Rejection Ratio	PSRR		83			83			83			83		dB	R_S ≤ 100KΩ
Common Mode Rejection Ratio	CMRR		83			83			83			83		dB	R_S ≤ 100KΩ
Large Signal Voltage Gain	A_V		250			250			250			250		V/mV	R_L =10KΩ
Output Voltage Range	V_O low V_O high	4.8	-4.9 4.93	-4.8	4.8	-4.9 4.93	-4.8	4.8	-4.9 4.93	-4.8	4.8	-4.9 4.93	-4.8	V	R_L =10KΩ
Bandwidth	B_W		1.7			1.7			1.7			1.7		MHz	
Slew Rate	S_R		2.8			2.8			2.8			2.8		V/µs	A_V = +1 C_L = 50pF

V_S = ±2.50V -55°C ≤ T_A ≤ +125°C unless otherwise specified

Parameter	Symbol	1702ADA			1702BDA			1702DA			Unit	Test Conditions
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max		
Input Offset Voltage	V_{OS}			3.0			4.0			6.5	mV	R_S ≤ 100KΩ
Input Offset Current	I_{OS}			8.0			8.0			8.0	nA	
Input Bias Current	I_B			10.0			10.0			10.0	nA	
Power Supply Rejection Ratio	PSRR	60	75		60	75		60	75		dB	R_S ≤ 100KΩ
Common Mode Rejection Ratio	CMRR	60	83		60	83		60	83		dB	R_S ≤ 100KΩ
Large Signal Voltage Gain	A_V	10	25		10	25		7	25		V/ mV	R_L = 10KΩ
Output Voltage Range	V_O low V_O high	4.8	0.1 4.9	0.2	4.8	0.1 4.9	0.2	4.8	0.1 4.9	0.2	V	R_L = 10KΩ

Design & Operating Notes:

1. The ALD1702A/ALD1702B/ALD1702/ALD1703 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 ALD1702A/ALD1702B/ALD1702/ALD1703 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. A unity gain buffer using the ALD1702A/ALD1702B/ALD1702/ALD1703 will typically drive 400pF of external load capacitance without stability problems. In the inverting unity gain configuration, it can drive up to 800pF of load capacitance. Compared to other CMOS operational amplifiers, the ALD1702A/ALD1702B/ALD1702/ALD1703 has shown itself to be more resistant to parasitic oscillations.

2. The ALD1702A/ALD1702B/ALD1702/ALD1703 has complementary p-channel and n-channel input differential stages connected in parallel to accomplish rail to rail input common mode voltage range. 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 above the negative supply voltage. Since offset voltage trimming on the ALD1702A/ALD1702B/ALD1702/ALD1703 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 provision in his design to allow for input offset voltage variations.

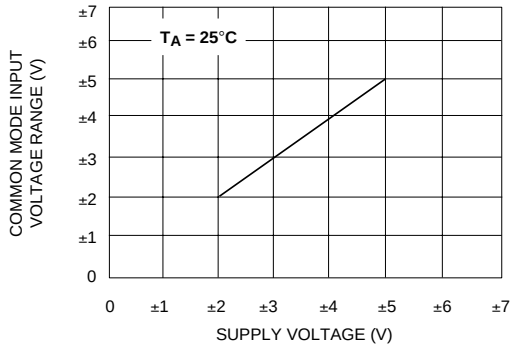
3. The input bias and offset currents are essentially input protection diode reverse bias leakage currents, and are typically less than 1pA at room temperature. This low input bias current assures that the analog signal from the source will not be distorted by input bias currents. Normally, this extremely high input impedance of greater than $10^{12}\Omega$ 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.

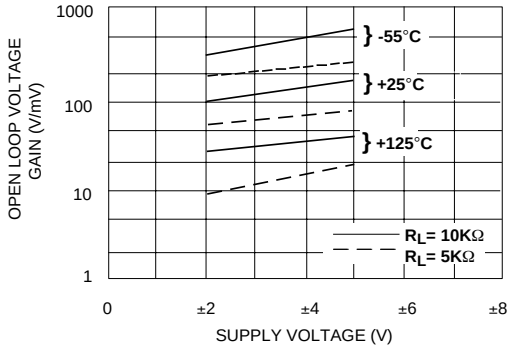
5. The ALD1702A/ALD1702B/ALD1702/ALD1703 operational amplifier has been designed to provide full static discharge protection. Internally, the design has been carefully implemented to minimize latch up. However, care must be exercised when handling the device to avoid strong static fields that may degrade 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 to not exceed 0.3V of the power supply voltage levels.

TYPICAL PERFORMANCE CHARACTERISTICS

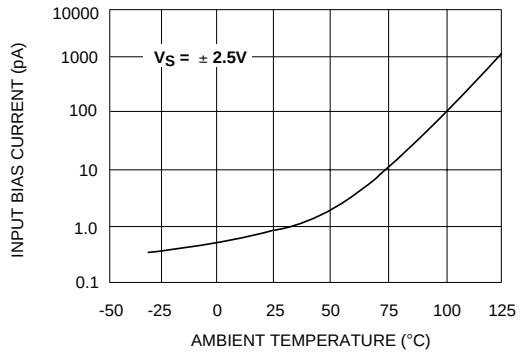
COMMON MODE INPUT VOLTAGE RANGE AS A FUNCTION OF SUPPLY VOLTAGE



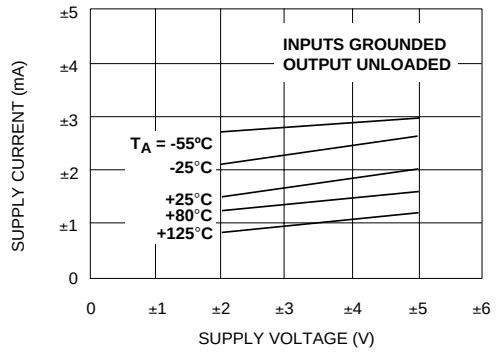
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF SUPPLY VOLTAGE AND TEMPERATURE



INPUT BIAS CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE

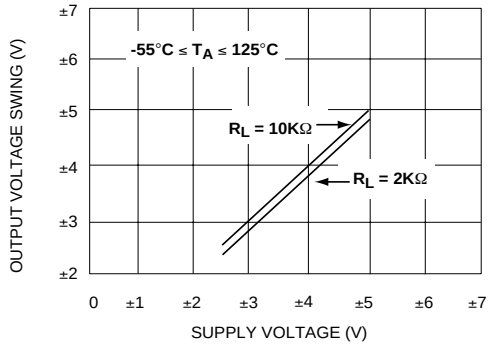


SUPPLY CURRENT AS A FUNCTION OF SUPPLY VOLTAGE

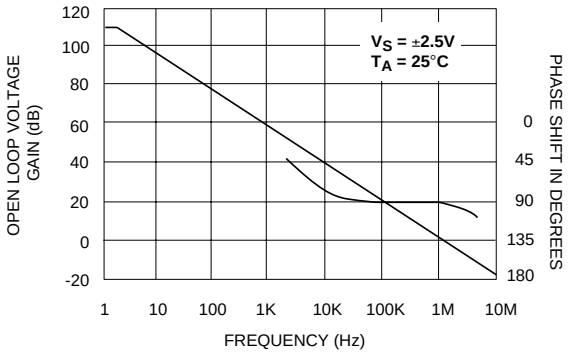


TYPICAL PERFORMANCE CHARACTERISTICS (cont'd)

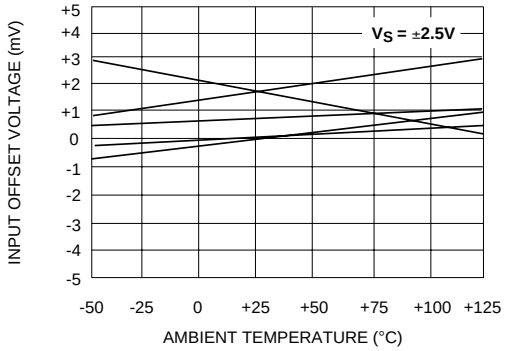
OUTPUT VOLTAGE SWING AS A FUNCTION OF SUPPLY VOLTAGE



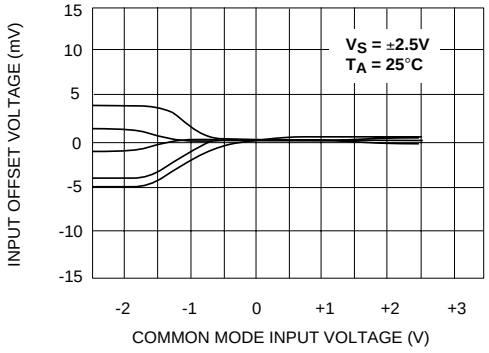
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF FREQUENCY



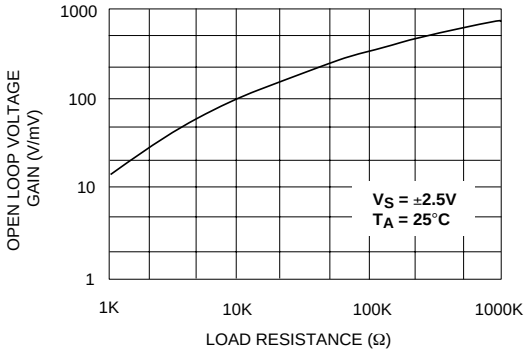
INPUT OFFSET VOLTAGE AS A FUNCTION OF AMBIENT TEMPERATURE REPRESENTATIVE UNITS



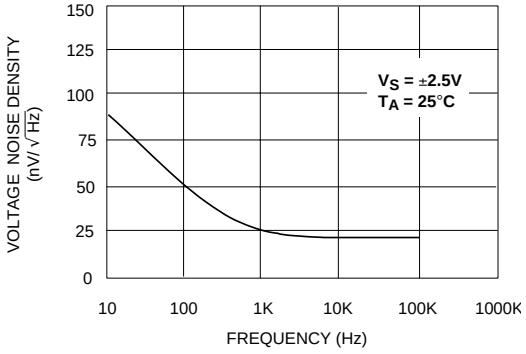
INPUT OFFSET VOLTAGE AS A FUNCTION OF COMMON MODE INPUT VOLTAGE



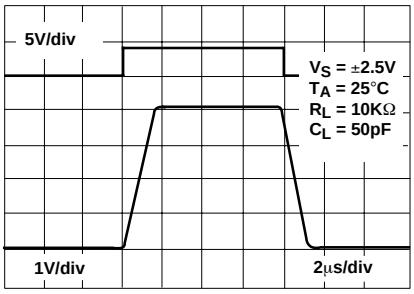
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF LOAD RESISTANCE



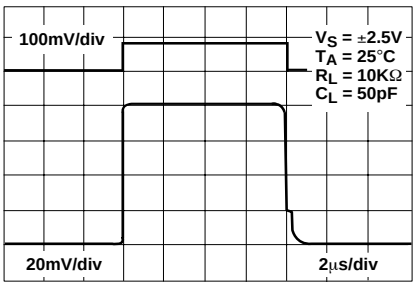
VOLTAGE NOISE DENSITY AS A FUNCTION OF FREQUENCY



LARGE - SIGNAL TRANSIENT RESPONSE

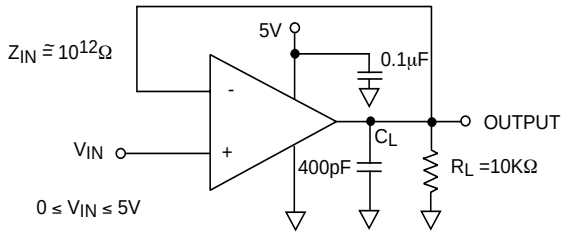


SMALL - SIGNAL TRANSIENT RESPONSE



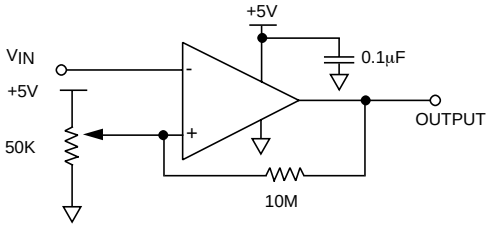
TYPICAL APPLICATIONS

RAIL-TO-RAIL VOLTAGE FOLLOWER/BUFFER

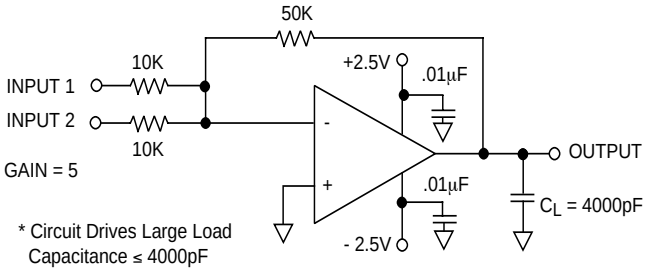


* See rail to rail waveform

RAIL-TO-RAIL VOLTAGE COMPARATOR

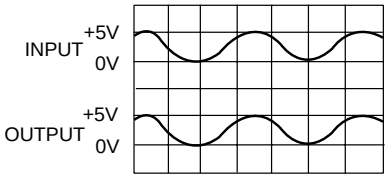


LOW OFFSET SUMMING AMPLIFIER



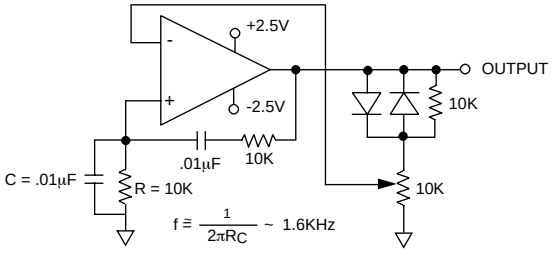
* Circuit Drives Large Load Capacitance ≤ 4000pF

RAIL-TO-RAIL WAVEFORM



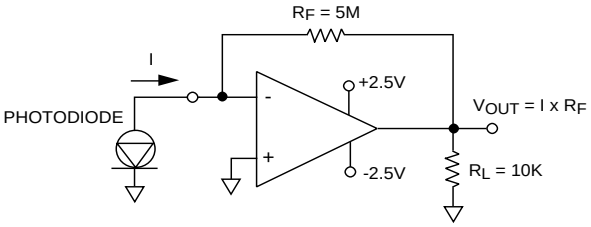
Performance waveforms.
Upper trace is the output of a Wien Bridge Oscillator. Lower trace is the output of Rail-to-rail voltage follower.

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



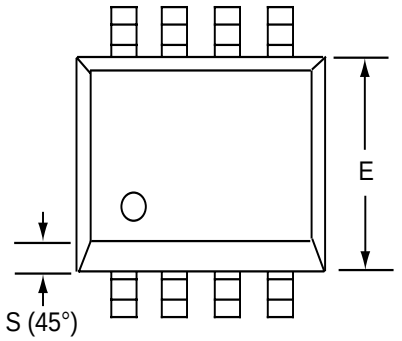
* See Rail to Rail Waveform

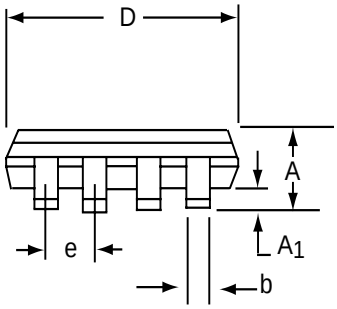
PHOTO DETECTOR CURRENT TO VOLTAGE CONVERTER

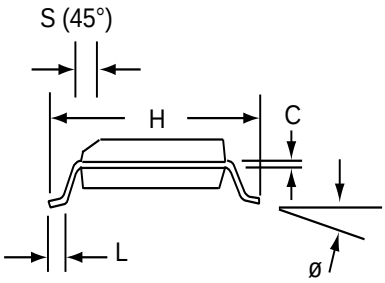


SOIC-8 PACKAGE DRAWING

8 Pin Plastic SOIC Package



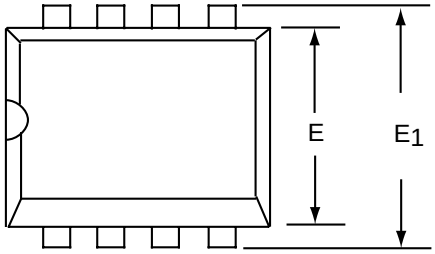


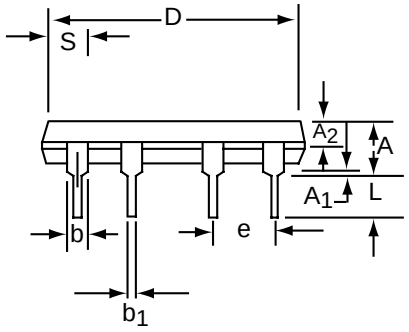


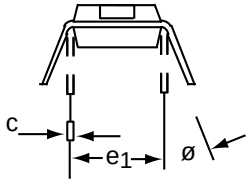
Dim	Millimeters		Inches	
	Min	Max	Min	Max
A	1.35	1.75	0.053	0.069
A_1	0.10	0.25	0.004	0.010
b	0.35	0.45	0.014	0.018
C	0.18	0.25	0.007	0.010
D-8	4.69	5.00	0.185	0.196
E	3.50	4.05	0.140	0.160
e	1.27 BSC		0.050 BSC	
H	5.70	6.30	0.224	0.248
L	0.60	0.937	0.024	0.037
Ø	0°	8°	0°	8°
S	0.25	0.50	0.010	0.020

PDIP-8 PACKAGE DRAWING

8 Pin Plastic DIP Package



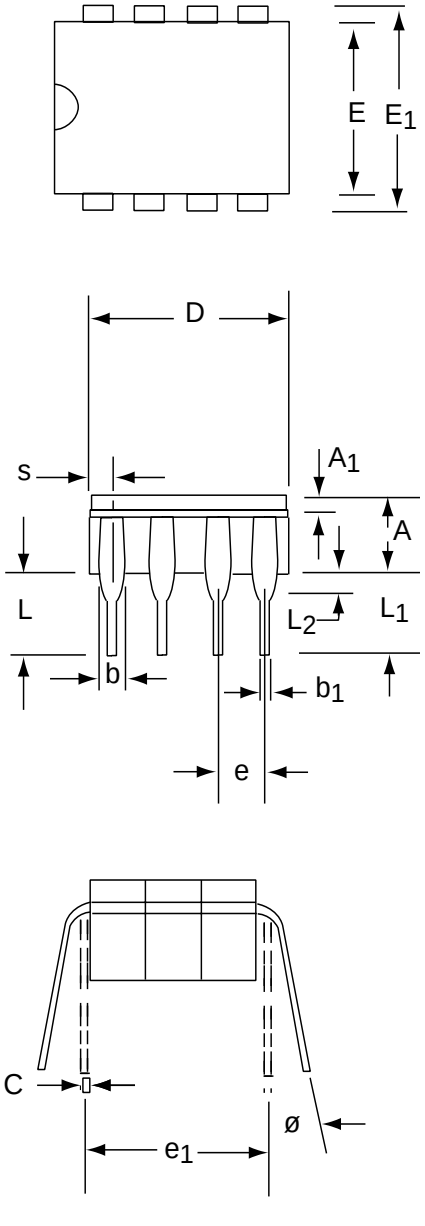




Dim	Millimeters		Inches	
	Min	Max	Min	Max
A	3.81	5.08	0.105	0.200
A_1	0.38	1.27	0.015	0.050
A_2	1.27	2.03	0.050	0.080
b	0.89	1.65	0.035	0.065
b_1	0.38	0.51	0.015	0.020
c	0.20	0.30	0.008	0.012
D-8	9.40	11.68	0.370	0.460
E	5.59	7.11	0.220	0.280
E_1	7.62	8.26	0.300	0.325
e	2.29	2.79	0.090	0.110
e_1	7.37	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
ø	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_1	1.27	2.16	0.050	0.085
b	0.97	1.65	0.038	0.065
b_1	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_1	7.73	8.26	0.290	0.325
e	2.54 BSC		0.100 BSC	
e_1	7.62 BSC		0.300 BSC	
L	3.81	5.08	0.150	0.200
L_1	3.18	--	0.125	--
L_2	0.38	1.78	0.015	0.070
S	--	2.49	--	0.098
Ø	0°	15°	0°	15°