ADVANCED
LINEAR
DEVICES, INC.

ALD4704A/ALD4704B
ALD4704

QUAD RAIL-TO-RAIL CMOS OPERATIONAL AMPLIFIER

GENERAL DESCRIPTION

The ALD4704 is a quad CMOS monolithic operational amplifier with MOSFET input that has rail-to-rail input and output voltage ranges. The input voltage can be beyond positive power supply voltage V^+ or the negative power supply voltage V^- by up to 300mV. The output voltage swings to within 60mV of either positive or negative power supply voltages at rated load.

With high impedance load, the output voltage approaches to within 1mV of the power supply rails. This device is designed as an alternative to the popular J-FET input operational amplifiers in applications where lower operating voltages, such as 9V battery or ±3.25V to ±6V power supplies are being used. It offers high slew rate of 5V/µs at low operating power. The ALD4704 is designed and manufactured with Advanced Linear Devices' standard enhanced ACMOS silicon gate CMOS process for low unit cost and exceptional reliability.

The rail-to-rail input and output feature of the ALD4704 expand signal voltage range for a given operating supply voltage and allow numerous analog serial stages to be implemented without losing operating voltage margin. The output stage is designed to drive up to 10mA into 400pF capacitive and 1.5KΩ resistive loads at unity gain and up to 4000pF at a gain of 5. Short circuit protection to either ground or the power supply rails is at approximately 15mA clamp current. The output can both source and sink 10mA into a load with symmetrical drive and is ideally suited for applications where push-pull voltage drive is desired.

For each of the operational amplifier, the offset voltage is trimmed on-chip to eliminate the need for external nulling in many applications. For precision applications, the output is designed to settle to 0.1% in 2µs. For large signal buffer applications, the operational amplifier can function as an ultrahigh input impedance voltage follower/buffer that allows input and output voltage swings from positive to negative supply voltages. This feature is intended to greatly simplify systems design and eliminate higher voltage power supplies in many applications.

FEATURES

- Rail-to-rail input and output voltage ranges
- 5.0V/µs slew rate
- Symmetrical push-pull output drive
- Inputs can extend beyond supply rails by 300mV
- Outputs settle to 2mV of supply rails
- High capacitive load capability -- up to 4000pF
- No frequency compensation required – unity gain stable
- Extremely low input bias currents -- 1.0pA typical (20pA max.)
- Ideal for high source impedance applications
- High voltage gain -- typically 100V/mV
- Output short circuit protected
- Unity gain bandwidth of 2.1MHz

APPLICATIONS

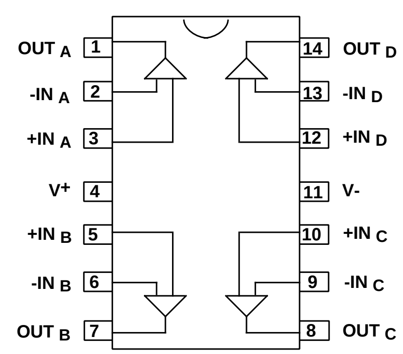
- Voltage amplifier
- Voltage follower/buffer
- Charge integrator
- Photodiode amplifier
- Data acquisition systems
- High performance portable instruments
- Signal conditioning circuits
- Low leakage amplifiers
- Active filters
- Sample/Hold amplifier
- Picoammeter
- Current to voltage converter
- Coaxial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

ORDERING INFORMATION

Operating Temperature Range*		
-55°C to +125°C	0°C to +70°C	0°C to +70°C
14-Pin CERDIP Package	14-Pin Small Outline Package (SOIC)	14-Pin Plastic Dip Package
ALD4704A DB	ALD4704A SB	ALD4704A PB
ALD4704B DB	ALD4704B SB	ALD4704B PB
ALD4704 DB	ALD4704 SB	ALD4704 PB

* Contact factory for industrial temperature range

PIN CONFIGURATION



DB, PB, SB Package

ABSOLUTE MAXIMUM RATINGS

Supply voltage, V^+ referenced to V^-		$-0.3V$ to $V^+ +13.2V$
Supply voltage, V_S referenced to V^-		$\pm 6.6V$
Differential input voltage range		$-0.3V$ to $V^+ +0.3V$
Power dissipation		600 mW
Operating temperature range	PB, SB package	0°C to +70°C
	DB package	-55°C to +125°C
Storage temperature range		-65°C to +150°C
Lead temperature, 10 seconds		+260°C

OPERATING ELECTRICAL CHARACTERISTICS

$T_A = 25°C$ $V_S = \pm 5.0V$ unless otherwise specified

Parameter	Symbol	4704A Min	4704A Typ	4704A Max	4704B Min	4704B Typ	4704B Max	4704 Min	4704 Typ	4704 Max	Unit	Test Conditions
Supply Voltage	V_S V^+	±3.25 6.5		±6.0 12.0	±3.25 6.5		±6.0 12.0	±3.25 6.5		±6.0 12.0	V V	Dual Supply Single Supply
Input Offset Voltage	V_{OS}			1.0 1.5			2.0 3.0			5.0 6.0	mV mV	$R_S \le 100K\Omega$ $0°C \le T_A \le +70°C$
Input Offset Current	I_{OS}		1.0	15 240		1.0	15 240		1.0	15 240	pA pA	$T_A = 25°C$ $0°C \le T_A \le +70°C$
Input Bias Current	I_B		1.0	20 300		1.0	20 300		1.0	20 300	pA pA	$T_A = 25°C$ $0°C \le T_A \le +70°C$
Input Voltage Range	V_{IR}	-5.3		5.3	-5.3		5.3	-5.3		5.3	V	
Input Resistance	R_{IN}		10^{12}			10^{12}			10^{12}		Ω	
Input Offset Voltage Drift	TCV_{OS}		5			5			5		µV/°C	$R_S \le 100K\Omega$
Power Supply Rejection Ratio	PSRR	65	80		65	80		60	80		dB	$R_S \le 100K\Omega$ $0°C \le T_A \le +70°C$
Common Mode Rejection Ratio	CMRR	65	83		65	83		60	83		dB	$R_S \le 100K\Omega$ $0°C \le T_A \le +70°C$
Large Signal Voltage Gain	A_V	15	28 100		15	28 100		10	28 100		V/mV V/mV V/mV	$R_L = 100K\Omega$ $R_L \ge 1M\Omega$ $R_L = 10K\Omega$
Output Voltage Range	V_O low V_O high V_O low V_O high	 4.90 4.99	-4.96 4.95 -4.998 4.998	-4.90 -4.99 	 4.90 4.99	-4.96 4.95 -4.998 4.998	-4.90 -4.99 	 4.90 4.99	-4.96 4.95 -4.998 4.998	-4.90 -4.99 	V V V V	$R_L = 10K\Omega$ $0°C \le T_A \le +70°C$ $R_L \ge 1M\Omega$ $0°C \le T_A \le +70°C$
Output Short Circuit Current	I_{SC}		15			15			15		mA	
Supply Current	I_S		10	13		10	13		10	13	mA	$V_{IN} = -5.0V$ No Load
Power Dissipation	P_D			130			130			130	mW	All amplifiers, No Load $V_S = \pm 5.0V$
Input Capacitance	C_{IN}		1			1			1		pF	
Bandwidth	B_W		2.1			2.1			2.1		MHz	
Slew Rate	S_R		5.0			5.0			5.0		V/µs	$A_V = +1$ $R_L = 2.0K\Omega$
Rise time	t_r		0.1			0.1			0.1		µs	$R_L = 10K\Omega$
Overshoot Factor			15			15			15		%	$R_L = 10K\Omega$ $C_L = 100pF$

OPERATING ELECTRICAL CHARACTERISTICS (cont'd)
T_A = 25°C V_S = ±5.0V unless otherwise specified

Parameter	Symbol	4704A			4704B			4704			Unit	Test Conditions
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max		
Maximum Load Capacitance	C_L		400 4000			400 4000			400 4000		pF pF	Gain = 1 Gain = 5
Input Noise Voltage	e_n		26			26			26		nV/√Hz	f =1KHz
Input Current Noise	i_n		0.6			0.6			0.6		fA/√Hz	f =10Hz
Settling Time	t_s		5.0 2.0			5.0 2.0			5.0 2.0		µs µs	0.01% 0.1% Av = -1 R_L = 5KΩ C_L= 50pF

V_S = ±5.0V -55°C ≤ T_A ≤ +125°C unless otherwise specified

Parameter	Symbol	4704A DB			4704B DB			4704DB			Unit	Test Conditions
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max		
Input Offset Voltage	V_{OS}			2.0			4.0			7.0	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		10	25		V/mV	R_L =10KΩ
Output Voltage Range	V_O low V_O high	 4.8	-4.9 4.9	-4.8	 4.8	-4.9 4.9	-4.8	 4.8	-4.9 4.9	-4.8	V V	R_L =10KΩ R_L =10KΩ

Design & Operating Notes:

1. The ALD4704 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. The ALD4704 is internally compensated for unity gain stability using a novel scheme. This design 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 ALD4704 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 ALD4704 is much more resistant to parasitic oscillations.

2. The ALD4704 has complementary p-channel and n-channel input differential stages connected in parallel to accomplish rail to rail input common mode voltage range. With the 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. As offset voltage trimming on the ALD4704 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 greater than 2.5 (5V operation), where the common mode voltage does not make excursions below this switching point.

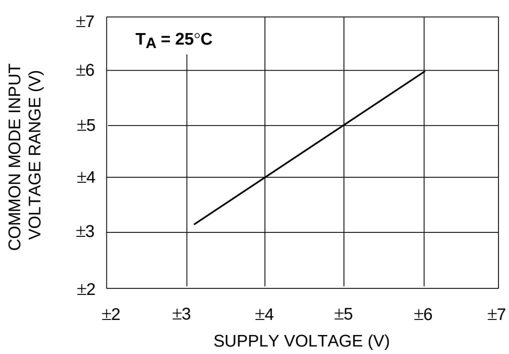
3. The input bias and offset currents are essentially input protection diode reverse bias leakage currents, and are typically less than 1pA at room temperature. This low input bias current assures that the analog signal from the source will not be distorted by input bias currents. For applications where 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 the ALD4704 an effective analog signal buffer for medium to high source impedance sensors, transducers, and other circuit networks.

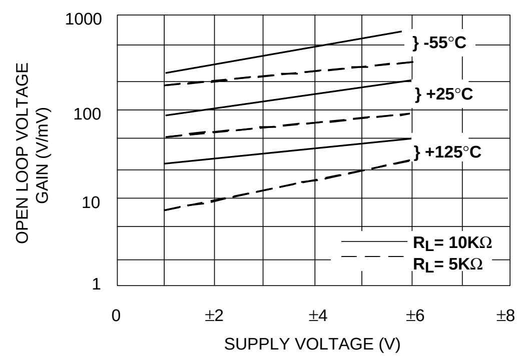
5. The ALD4704 operational amplifier has been designed with static discharge protection and to minimize latch up. However, care must be exercised when handling the device to avoid strong static fields. In using the operational amplifier, the user is advised to power up the circuit before, or simultaneously with, any input voltages applied and to limit input voltages to not exceed 0.3V of the power supply voltage levels. Alternatively, a 100KΩ or higher value resistor at the input terminals will limit input currents to acceptable levels while causing very small or negligible accuracy effects.

TYPICAL PERFORMANCE CHARACTERISTICS

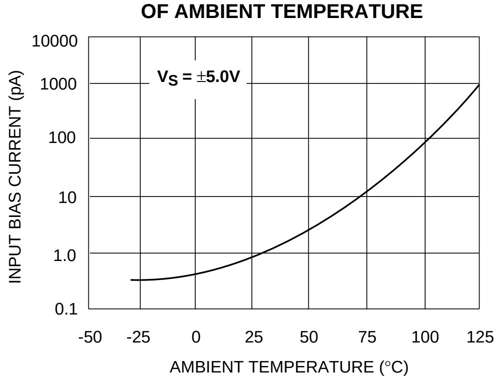
COMMON MODE INPUT VOLTAGE RANGE AS A FUNCTION OF SUPPLY VOLTAGE



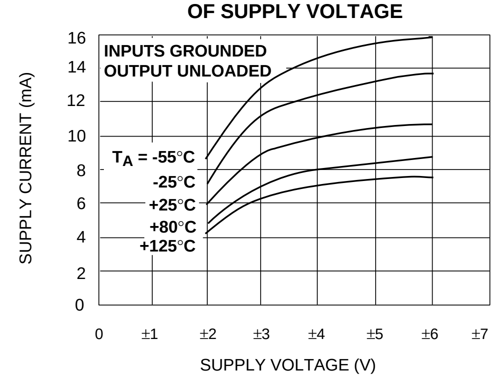
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF SUPPLY VOLTAGE AND TEMPERATURE



INPUT BIAS CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE

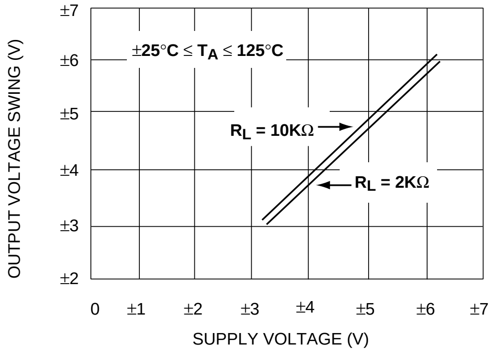


SUPPLY CURRENT AS A FUNCTION OF SUPPLY VOLTAGE

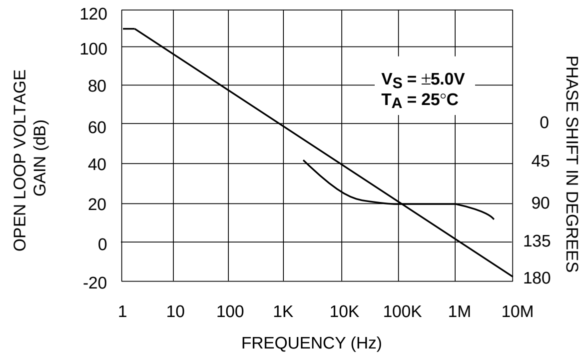


TYPICAL PERFORMANCE CHARACTERISTICS

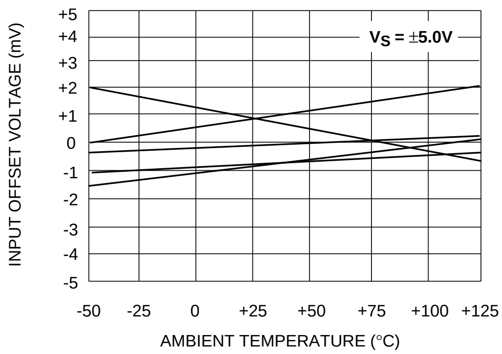
OUTPUT VOLTAGE SWING AS A FUNCTION OF SUPPLY VOLTAGE



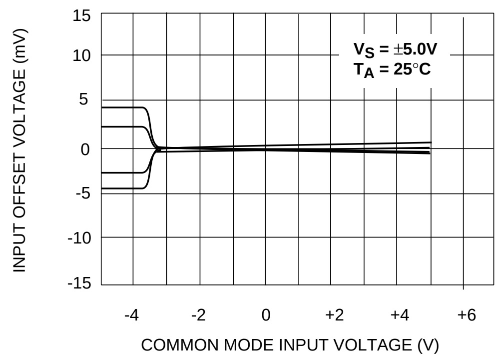
OPEN LOOP VOLTAGE AS A FUNCTION OF FREQUENCY



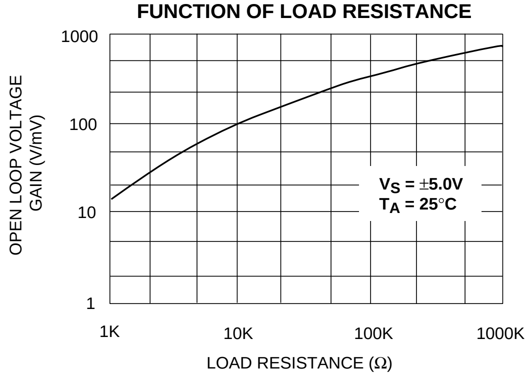
INPUT OFFSET VOLTAGE AS A FUNCTION OF AMBIENT TEMPERATURE REPRESENTATIVE UNITS



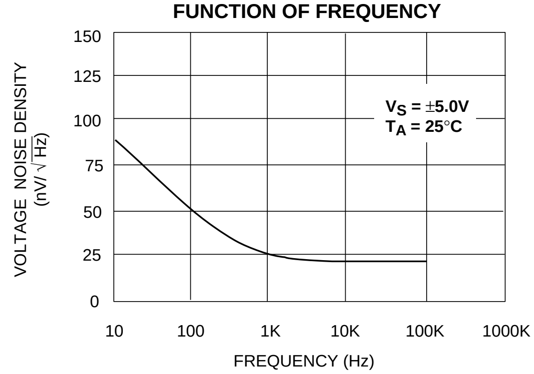
INPUT OFFSET VOLTAGE AS A FUNCTION OF COMMON MODE INPUT VOLTAGE



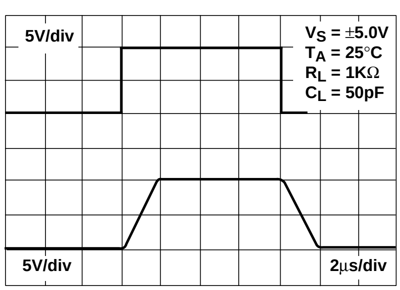
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF LOAD RESISTANCE



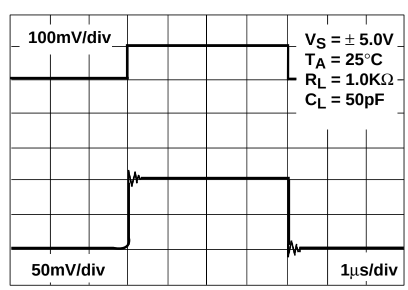
VOLTAGE NOISE DENSITY AS A FUNCTION OF FREQUENCY



LARGE - SIGNAL TRANSIENT RESPONSE

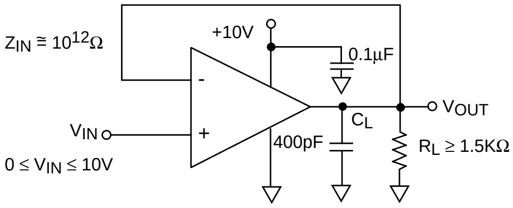


SMALL - SIGNAL TRANSIENT RESPONSE

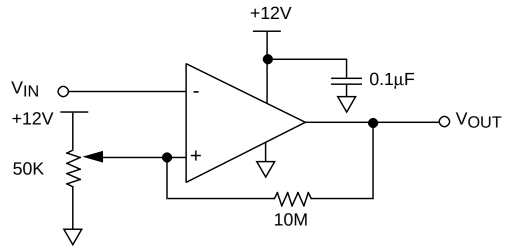


TYPICAL APPLICATIONS

RAIL-TO-RAIL VOLTAGE FOLLOWER/BUFFER



RAIL-TO-RAIL VOLTAGE COMPARATOR



LOW OFFSET SUMMING AMPLIFIER

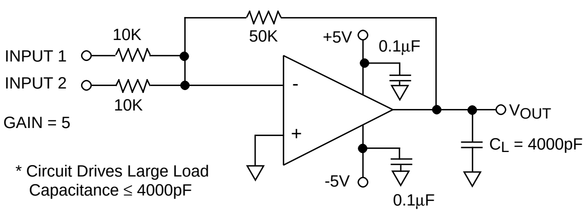
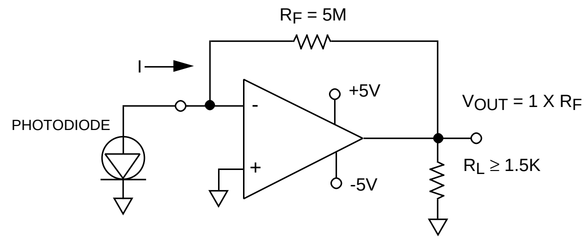
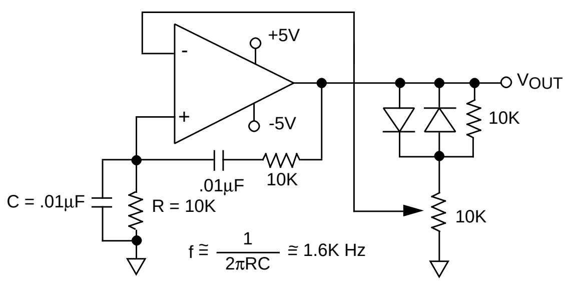


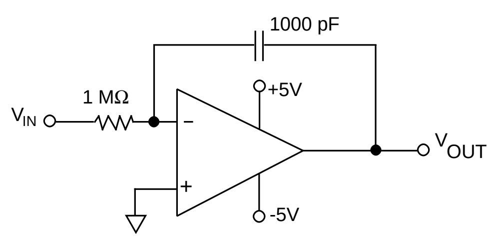
PHOTO DETECTOR CURRENT TO VOLTAGE CONVERTER



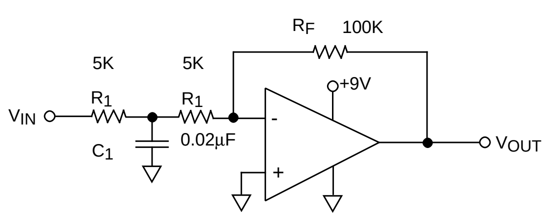
WIEN BRIDGE OSCILLATOR (RAIL-TO -RAIL) SINE WAVE GENERATOR



PRECISION CHARGE INTEGRATOR



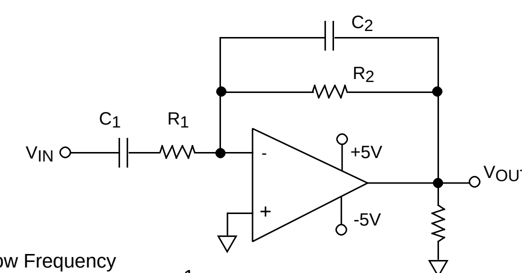
LOW PASS FILTER (RFI FILTER)



Cutoff frequency $= \frac{1}{\pi R1C1} = 3.2kHz$

Gain = 10 Frequency roll-off 20dB/decade

BANDPASS NETWORK



Low Frequency
Breakpoint $f_L = \frac{1}{2\pi R1C1} = 160Hz$

High Frequency
Cutoff $f_H = \frac{1}{2\pi R2C2} = 32KHz$

R_1 = 10K
C_1 = 100nF
R_2 = 10K
C_2 = 500pF