

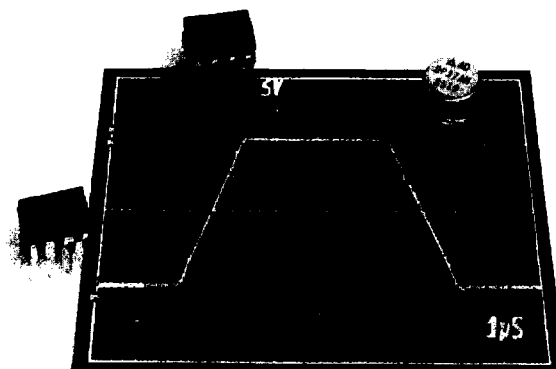


Ultra-Low Noise, High Speed Precision Op Amp ($A_{VCL} \geq 5$)

AD OP-37

FEATURES

Ultra-Low Noise: 80nV p-p (0.1Hz to 10Hz),
3nV/ $\sqrt{\text{Hz}}$ at 1kHz
High Speed: 17V/ μs
High Gain Bandwidth Product: 63MHz
Ultra-Low Offset Voltage Drift: 0.2 $\mu\text{V}/^\circ\text{C}$
High Offset Stability Over Time: 0.2 $\mu\text{V}/\text{month}$
Low Offset Voltage: 10 μV
High CMRR: 126dB Over $\pm 11\text{V}$ Input Voltage Range
Fits OP-07, OP-05, OP-06, 5534, LH0044,
5130, 3510, 725, 714 and 741 Sockets
in Gains ≥ 5
Military Grade and Plus Parts Available
8-Pin Plastic Mini-DIP, CERDIP or TO-99 Hermetic
Metal Can
Available in Wafer-Trimmed Chip Form



PRODUCT DESCRIPTION

The AD OP-37 offers the combined features of high precision, ultra-low noise and high speed in a monolithic bipolar operational amplifier. High speed accurate amplification of very low level signals, where inherent device noise can be the limiting factor, is attainable with the AD OP-37 in applications requiring gains greater than or equal to five. This instrumentation grade op amp features industry standard dc performance; typical input offset voltages of 10 μV and typical input offset voltage temperature coefficients of 0.2 $\mu\text{V}/^\circ\text{C}$. The super low input voltage noise performance of the AD OP-37 is characterized by an e_n p-p (typ) of 80nV (0.1Hz to 10Hz), an e_n (typ) of 3.0nV/ $\sqrt{\text{Hz}}$ (at 1kHz) and a 1/f noise corner frequency of 2.7Hz. High speed performance is assured by a typical 17V/ μs slew rate and a typical 63MHz gain bandwidth product. Long-term stability is guaranteed by an input offset voltage drift specification of 0.2 $\mu\text{V}/\text{month}$.

Source resistance related input errors with the AD OP-37 are minimized by a low input bias current of $\pm 10\text{nA}$ (typ) and an input offset current of 7nA (typ). An input bias current cancellation circuit restricts bias and offset currents over the extended temperature range to $\pm 20\text{nA}$ (typ) and 15nA (typ), respectively. Other factors inducing input referred errors such as power supply variations and common-mode voltages are attenuated by a PSRR and CMRR of 120dB.

The AD OP-37 is available in six performance grades. The AD OP-37E, AD OP-37F and AD OP-37G are specified for operation over the -25°C to $+85^\circ\text{C}$ temperature range, while the AD OP-37A, AD OP-37B and AD OP-37C are specified for -55°C to $+125^\circ\text{C}$ operation. All devices are available in either the TO-99 hermetically-sealed metal cans or the hermetically-sealed CERDIP packages, while the industrial grades are also available in plastic Mini-DIPs.

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PRODUCT HIGHLIGHTS

1. High speed accurate amplification (gains ≥ 5) of very low level low frequency voltage inputs is enhanced by a high gain bandwidth product and ultra-low input voltage noise.
2. The AD OP-37 maintains high dc accuracy over an extended temperature range due to ultra-low offset voltage, offset voltage drift and input bias current.
3. Internal frequency compensation, factory adjusted offset voltage and full device protection eliminate the need for additional components. Circuit size and complexity are reduced while reliability is increased.
4. Long-term stability and accuracy is assured with low offset voltage drift over time.
5. Input referred errors are greatly reduced by superior common-mode and power supply rejection characteristics.
6. Monolithic construction along with advanced circuit design and processing techniques result in low cost.

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SPECIFICATIONS ($T_A = +25^\circ\text{C}$, $V_S = \pm 15\text{V}$, unless otherwise specified)

MODEL		AD OP-37G			AD OP-37F			AD OP-37E		
PARAMETER	SYMBOL	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX
OPEN LOOP GAIN	A_{VO}	700 400 200 450	1,500 1,500 500 1,000		1,000 800 250 700	1,800 1,500 700 1,300		1,000 800 250 750	1,800 1,500 700 1,500	
OUTPUT CHARACTERISTICS										
Voltage Swing	V_O	± 11.5 ± 10.0 ± 11.0	± 13.5 ± 11.5 ± 13.3		± 12.0 ± 10.0 ± 11.4	± 13.8 ± 11.5 ± 13.5		± 12.0 ± 10.0 ± 11.7	± 13.8 ± 11.5 ± 13.6	
Open-Loop Output Resistance	R_O		70			70			70	
FREQUENCY RESPONSE										
Gain Bandwidth Product	GBW	45	63		45	63		45	63	
Slew Rate	SR	— 11	40 17		— 11	40 17		— 11	40 17	
INPUT OFFSET VOLTAGE										
Initial	V_{OS}		30 55	100 220		20 40	60 140		10 20	25 60
Average Drift	TCV_{OS}		0.4	1.8		0.3	1.3		0.2	0.6
Long Term Stability	V_{OS}/Time		0.4	2.0		0.3	1.5		0.2	1.0
Adjustment Range			± 4.0			± 4.0			± 4.0	
INPUT BIAS CURRENT										
Initial	I_B		± 15 ± 25	± 80 ± 150		± 12 ± 18	± 55 ± 95		± 10 ± 14	± 40 ± 60
INPUT OFFSET CURRENT										
Initial	I_{OS}		12 20	75 135		9 14	50 85		7 10	35 50
INPUT NOISE										
Voltage	e_n p-p		0.09	0.25		0.08	0.18		0.08	0.18
Voltage Density	e_n		3.8 3.3 3.2	8.0 5.6 4.5		3.5 3.1 3.0	5.5 4.5 3.8		3.5 3.1 3.0	5.5 4.5 3.8
Current Density	i_n		1.7 1.0 0.4	— — 0.6		1.7 1.0 0.4	4.0 2.3 0.6		1.7 1.0 0.4	4.0 2.3 0.6
INPUT VOLTAGE RANGE										
Common Mode	CMVR	± 11.0 ± 10.5	± 12.3 ± 11.8		± 11.0 ± 10.5	± 12.3 ± 11.8		± 11.0 ± 10.5	± 12.3 ± 11.8	
Common-Mode Rejection Ratio	CMRR	100 96	120 118		106 102	123 121		114 110	126 124	
INPUT RESISTANCE										
Differential	R_{IN}	0.8	4		1.2	5		1.5	6	
Common Mode	R_{INCM}		2			2.5			3	
POWER SUPPLY										
Rated Performance			± 15			± 15			± 15	
Operating			$\pm (4-18)$			$\pm (4-18)$			$\pm (4-18)$	
Current, Quiescent	I_Q		3.3	5.6		3.0	4.6		3.0	4.6
Rejection	PSR		2	20		1	10		1	10
Power Consumption	P_d		2 100	32 170		2 90	16 140		2 90	15 140
OPERATING TEMPERATURE RANGE										
	T_{min}, T_{max}	—25		+85	—25		+85	—25		+85
PACKAGE OPTIONS										
Plastic Mini-DIP (N8A)		AD OP-37GN			AD OP-37FN			AD OP-37EN		
CERDIP (Q8A)		AD OP-37GQ			AD OP-37FQ			AD OP-37EQ		
TO-99 (H08A)		AD OP-37GH			AD OP-37FH			AD OP-37EH		

NOTES

¹Input Offset Voltage measurements are performed by automated test equipment approximately 0.5 seconds after application of power. A and E grades are guaranteed fully warmed up.

²Long-Term Input Offset Voltage Stability refers to the average trend line of V_{OS} vs. time after the first 30 days.

Specifications subject to change without notice.

AD OP-37C			AD OP-37B			AD OP-37A			CONDITIONS	UNITS
MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX		
700	1,500		1,000	1,800		1,000	1,800		$R_L \geq 2k\Omega$, $V_{OUT} = \pm 10V$	V/mV
400	1,500		800	1,500		800	1,500		$R_L \geq 1k\Omega$, $V_{OUT} = \pm 10V$	V/mV
200	500		250	700		250	700		$R_L = 600\Omega$, $V_{OUT} = \pm 1V$, $V_S = \pm 4V$	V/mV
300	800		500	1,000		600	1,200		$R_L \geq 2k\Omega$, $V_{OUT} = \pm 10V$, $T_a = \text{min to max}$	V/mV
± 11.5	± 13.5		± 12.0	± 13.8		± 12.0	± 13.8		$R_L \geq 2k\Omega$	V
± 10.0	± 11.5		± 10.0	± 11.5		± 10.0	± 11.5		$R_L \geq 600\Omega$	V
± 10.5	± 13.0		± 11.0	± 13.2		± 11.5	± 13.5		$R_L \geq 2k\Omega$, $T_a = \text{min to max}$	V
	70			70			70		$I_{OUT} = 0A$, $V_{OUT} = 0V$	Ω
45	63		45	63		45	63		$f_o = 10kHz$	MHz
—	63		—	40		—	40		$f_o = 1MHz$	MHz
11	17		11	17		11	17		$R_L \geq 2k\Omega$	V/ μs
	30	100		20	60		10	25	(Note 1)	μV
	70	300		50	200		30	60	$T_a = \text{min to max}$	μV
	0.4	1.8		0.3	1.3		0.2	0.6	$T_a = \text{min to max}$	$\mu V/^{\circ}C$
	0.4	2.0		0.3	1.5		0.2	1.0	(Note 2)	$\mu V/\text{month}$
	± 4.0			± 4.0			± 4.0		$R_p = 10k\Omega$	mV
	± 15	± 80		± 12	± 55		± 10	± 40	$T_a = \text{min to max}$	nA
	± 35	± 150		± 28	± 95		± 20	± 60		nA
	12	75		9	50		7	35		nA
	30	135		22	85		15	50	$T_a = \text{min to max}$	nA
	0.09	0.25		0.08	0.18		0.08	0.18	0.1Hz to 10Hz	$\mu V p-p$
	3.8	8.0		3.5	5.5		3.5	5.5	$f_o = 10Hz$	$nV/\sqrt{Hz}$
	3.3	5.6		3.1	4.5		3.1	4.5	$f_o = 30Hz$	$nV/\sqrt{Hz}$
	3.2	4.5		3.0	3.8		3.0	3.8	$f_o = 1000Hz$	$nV/\sqrt{Hz}$
	1.7	—		1.7	4.0		1.7	4.0	$f_o = 10Hz$	$pA/\sqrt{Hz}$
	1.0	—		1.0	2.3		1.0	2.3	$f_o = 30Hz$	$pA/\sqrt{Hz}$
	0.4	0.6		0.4	0.6		0.4	0.6	$f_o = 1000Hz$	$pA/\sqrt{Hz}$
± 11.0	± 12.3		± 11.0	± 12.3		± 11.0	± 12.3		$T_a = \text{min to max}$	V
± 10.2	± 11.5		± 10.3	± 11.5		± 10.3	± 11.5			V
100	120		106	123		114	126		$V_{CM} = \pm 11V$	dB
94	116		100	119		108	122		$V_{CM} = \pm 10V$, $T_a = \text{min to max}$	dB
0.8	4		1.2	5		1.5	6			M Ω
	2			2.5			3			G Ω
	± 15			± 15			± 15			V
	$\pm (4-18)$			$\pm (4-18)$			$\pm (4-18)$			V
	3.3	5.6		3.0	4.6		3.0	4.6	$V_S = \pm 15V$	mA
	2	20		1	10		1	10	$V_S = \pm 4V$ to $\pm 18V$	$\mu V/V$
	4	51		2	20		2	16	$V_S = \pm 4.5V$ to $\pm 18V$, $T_a = \text{min to max}$	$\mu V/V$
	100	170		90	140		90	140	$V_{OUT} = 0V$	mW
—55		+125	—55		+125	—55		+125		$^{\circ}C$
AD OP-37CQ AD OP-37CH			AD OP-37BQ AD OP-37BH			AD OP-37AQ AD OP-37AH				

Specifications shown in boldface are tested on all production units at final electrical test. Results from those tests are used to calculate outgoing quality levels. All min and max specifications are guaranteed, although only those shown in boldface are tested on all production units.

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	±18V
Internal Power Dissipation (Note 1)	500mW
Input Voltage (Note 2)	±18V
Output Short Circuit Duration	Indefinite
Differential Input Voltage (Note 3)	±0.7V

NOTES:

Note 1: Maximum package power dissipation vs. ambient temperature.

Package Type	Maximum Ambient Temperature for Rating	Derate Above Maximum Ambient Temperature
TO-99 (H)	80°C	7.1mW/°C
MINI-DIP (N)	36°C	5.6mW/°C
CERDIP (Q)	75°C	6.7mW/°C

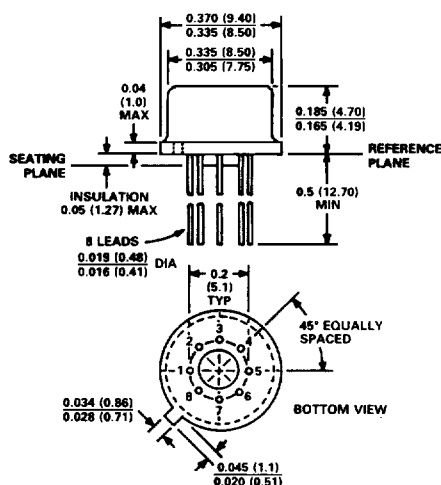
Note 2: For supply voltages less than ±18V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: The AD OP-37's inputs are protected by back-to-back diodes. To achieve low noise current limiting resistors could not be used. If the differential input voltage exceeds ±0.7V, the input current should be limited to 25mA.

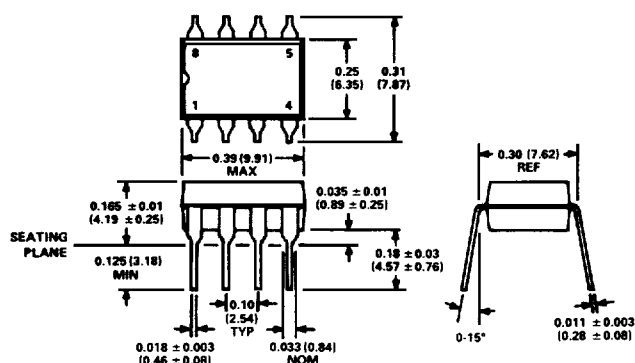
OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).

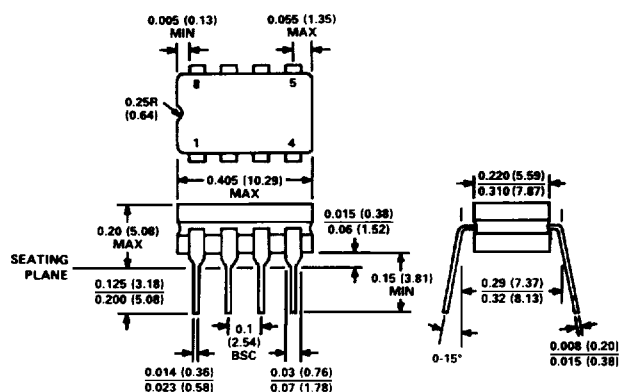
TO-99 (H) Package



MINI-DIP (N) Package



CERDIP (Q) PACKAGE

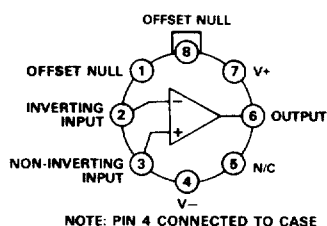


Differential Input Current (Note 3)	±25mA
Storage Temperature Range	-65°C to +150°C
Operating Temperature Range	
AD OP-37A, AD OP-37B, AD OP-37C	-55°C to +125°C
AD OP-37E, AD OP-37F, AD OP-37G	-25°C to +85°C
Lead Temperature Range (Soldering 60sec)	300°C

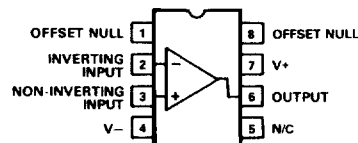
CONNECTION DIAGRAMS

(Top View)

TO-99 (H) Package

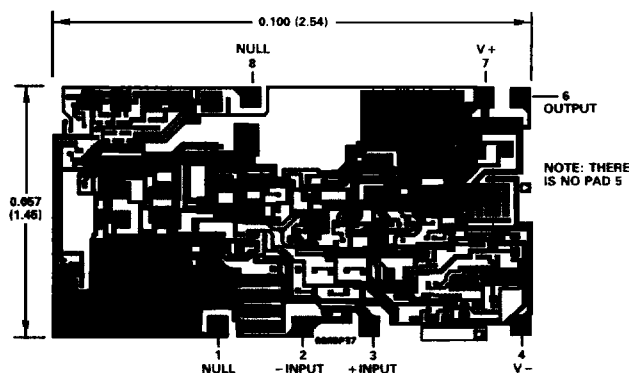


Plastic Mini-DIP (N) Package and CERDIP (Q) Package



CHIP DIMENSIONS AND BONDING DIAGRAM

Dimensions shown in inches and (mm).



THE AD OP-37 IS AVAILABLE IN WAFER-TRIMMED CHIP FORM. CONSULT THE FACTORY FOR DETAILS.

AD OP-37 ORDERING GUIDE

Model	Package	Temperature Range (°C)	Max Initial Offset (μV)	Max Offset Drift (μV/°C)
AD OP-37GH	TO-99	-25 to +85	100	1.8
AD OP-37GN	MINI-DIP	-25 to +85	100	1.8
AD OP-37GQ	CERDIP	-25 to +85	100	1.8
AD OP-37FH	TO-99	-25 to +85	60	1.3
AD OP-37FN	MINI-DIP	-25 to +85	60	1.3
AD OP-37FQ	CERDIP	-25 to +85	60	1.3
AD OP-37EH	TO-99	-25 to +85	25	0.6
AD OP-37EN	MINI-DIP	-25 to +85	25	0.6
AD OP-37EQ	CERDIP	-25 to +85	25	0.6
AD OP-37CH	TO-99	-55 to +125	100	1.8
AD OP-37CQ	CERDIP	-55 to +125	100	1.8
AD OP-37BH	TO-99	-55 to +125	60	1.3
AD OP-37BQ	CERDIP	-55 to +125	60	1.3
AD OP-37AH	TO-99	-55 to +125	25	0.6
AD OP-37AQ	CERDIP	-55 to +125	25	0.6

APPLICATION NOTES FOR THE AD OP-37

The AD OP-37 can be used in the sockets of many of the popular precision bipolar input operational amplifiers on the market. Elimination of external frequency compensation or nulling circuitry may be possible in many cases. In 741 replacement situations, if nulling has been implemented, it should be modified or removed for correct AD OP-37 performance.

In applications where the initial factory adjusted input offset voltage provides insufficient accuracy, further offset trimming can be accomplished with the resistor network shown in Figure 1. The adjustment range attainable using a 10k Ω potentiometer will be $\pm 4\text{mV}$. If a smaller adjustment range is required, the sensitivity of the nulling can be increased by using a smaller potentiometer in series with fixed resistor(s). For example, a 1k Ω pot in series with two 4.7k Ω resistors will yield a $\pm 280\mu\text{V}$ range.

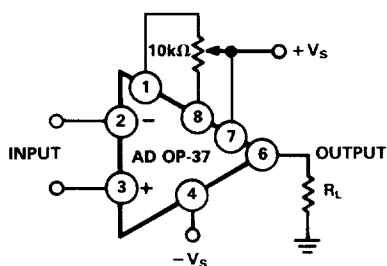


Figure 1. Optional Offset Nulling Circuit

Zeroing the initial offset with potentiometers other than 10k Ω , but between 1k Ω and 1M Ω , will introduce an additional input offset voltage temperature drift error of from 0.1 to 0.2 $\mu\text{V}/^\circ\text{C}$. Additionally, by intentionally trimming in a dc level shift a voltage dependent offset drift will be created. It will be approximately the input offset voltage at 25 $^\circ\text{C}$ divided by 300 (in $\mu\text{V}/^\circ\text{C}$).

Parasitic thermocouple EMF's can be generated where dissimilar metals meet the contacts to the input terminals of the AD OP-37. These temperature dependent voltages can manifest themselves as drift type errors. Optimized temperature performance will be obtained when both contacts are maintained at the same temperature.

Output stability with the AD OP-37 is possible with capacitive loads of up to 1000pF and $\pm 10\text{V}$ output swings. Larger capacitances should be decoupled with a 50 Ω resistor inside the feedback loop.

High closed loop gain and excellent linearity can be achieved by operating the AD OP-37 within an output current range of $\pm 10\text{mA}$. Minimizing output current will provide the highest linearity.

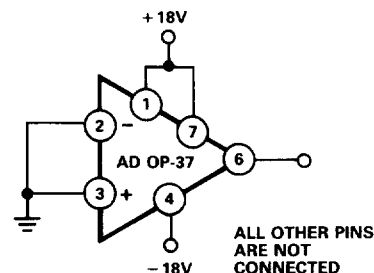


Figure 2. Burn-In Circuit

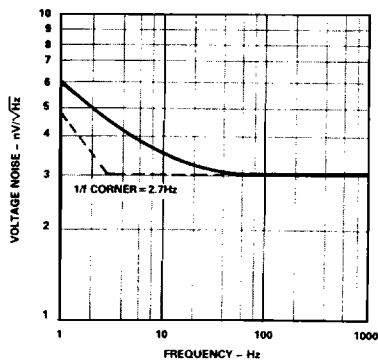
CAUTION: NOISE MEASUREMENTS

Precise measurement of the extremely low input noise associated with the AD OP-37 is a difficult task. In order to observe the rated noise in the 0.1Hz to 10Hz frequency range the following cautions should be exercised.

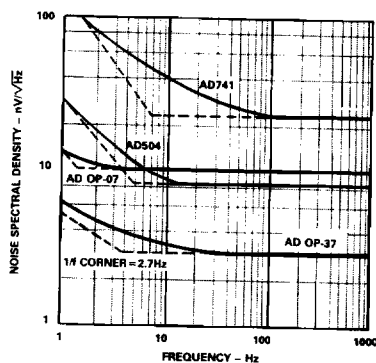
- (1) The test time to measure 0.1Hz to 10Hz noise should not exceed 10 seconds. As shown in the noise test frequency response plot in this data sheet the 0.1Hz corner is only defined by a single zero. A test time of 10 seconds acts as an additional zero to eliminate noise contributions from frequencies lower than 0.1Hz.
- (2) Warm-up for a least five minutes will eliminate temperature induced effects. During the first few minutes the offset voltage typically increases 4 μV . In a 10 second measurement interval prior to temperature stabilization the reading could include several nanovolts of warm-up offset error in addition to the noise.
- (3) For reasons similar to (2) the device under test should be well shielded from air currents or other heat sinks to eliminate the possibility of temperature changes over time invalidating the measurements. Sudden motion in the vicinity or physical contact with the package can also increase the observed noise.

An input voltage noise spectral density test is recommended when measuring noise on a large number of units. Because the 1/f noise corner frequency is around 3Hz, a 1kHz noise voltage density measurement combined with a 0.1Hz to 10Hz peak-to-peak noise reading will guarantee 1/f and white noise performance over the rated frequency spectrum.

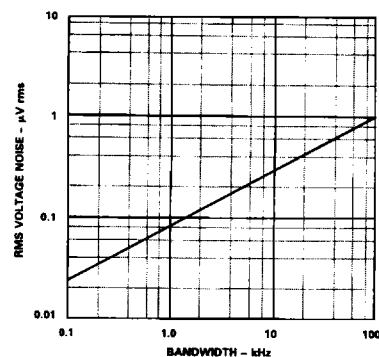
Typical Performance Curves (@ $T_A = +25^\circ\text{C}$, $V_S = \pm 15\text{V}$)



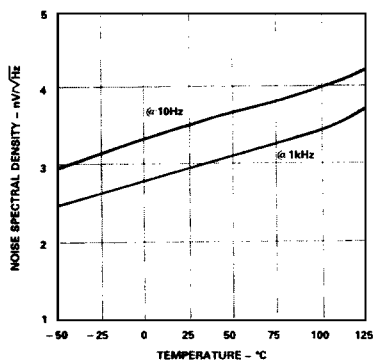
Input Voltage Noise Spectral Density



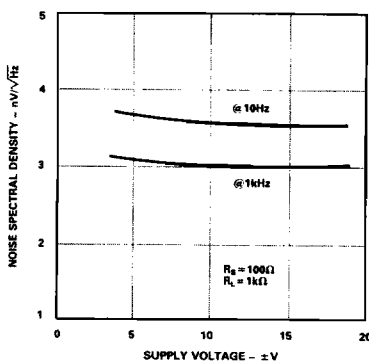
Comparison of Op Amp Input Voltage Noise Spectra



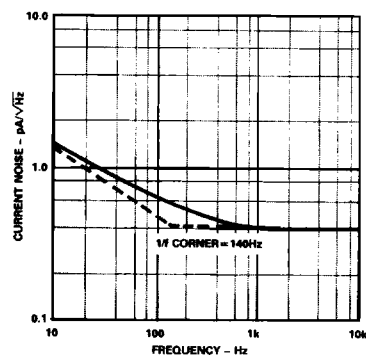
Input Wideband Noise vs. Bandwidth (0.1Hz to Frequency Indicated)



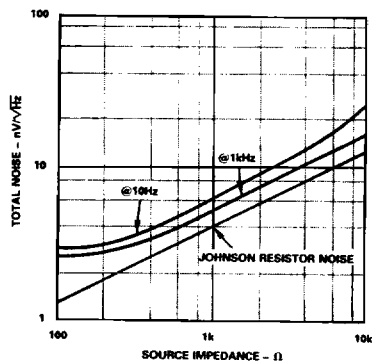
Input Voltage Noise vs. Temperature



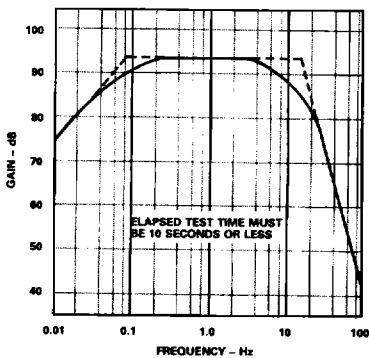
Input Voltage Noise vs. Supply Voltage



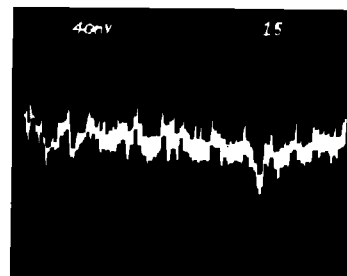
Input Current Noise Spectral Density



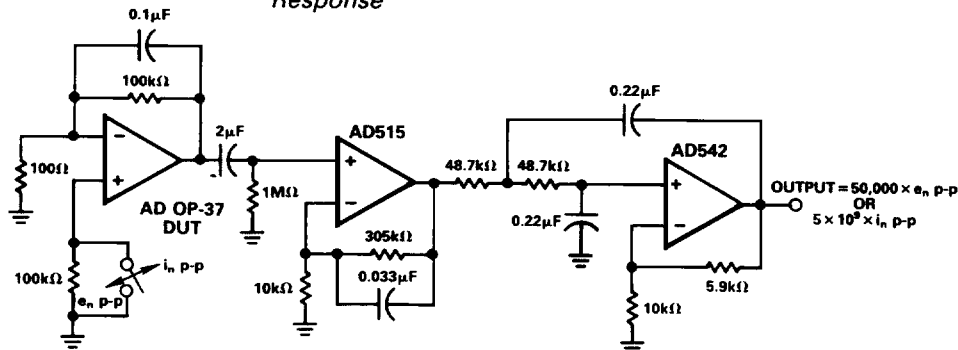
Total Noise vs. Source Impedance



0.1Hz to 10Hz Noise Test Frequency Response

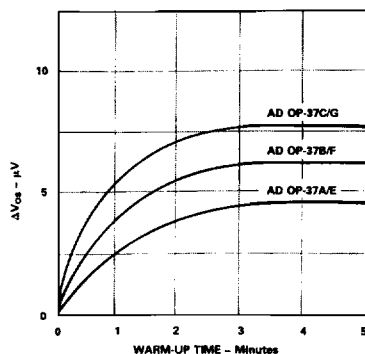


0.1Hz to 10Hz p-p Voltage Noise Response

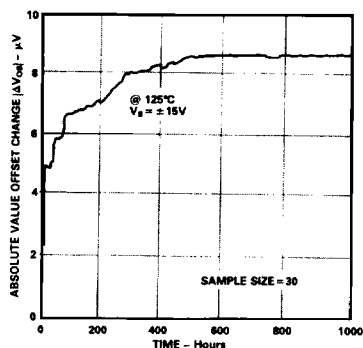


NOTE: ALL CAPACITORS MUST BE NONPOLARIZED

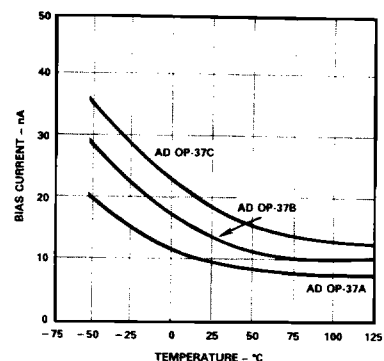
0.1Hz to 10Hz Noise Test Bandpass Filter (Voltage Gain = 50,000)



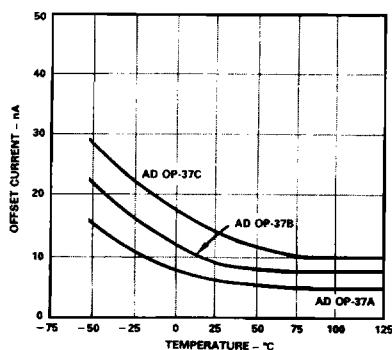
Input Offset Voltage Turn-On Drift vs. Time



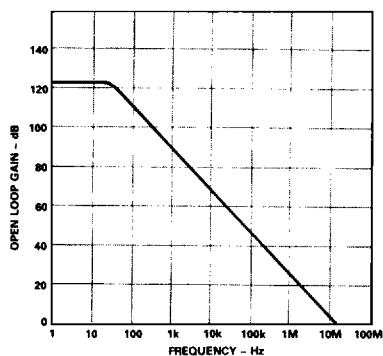
Long Term Offset Stability @ Temperature



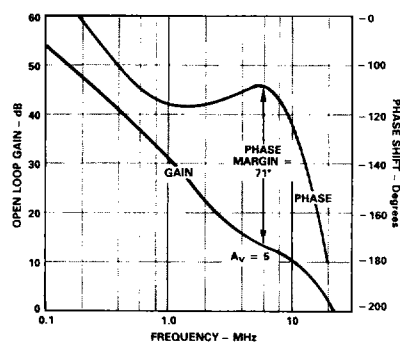
Input Bias Current vs. Temperature



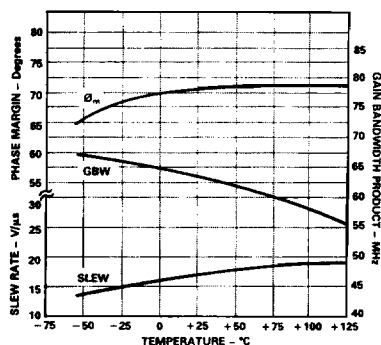
Input Offset Current vs. Temperature



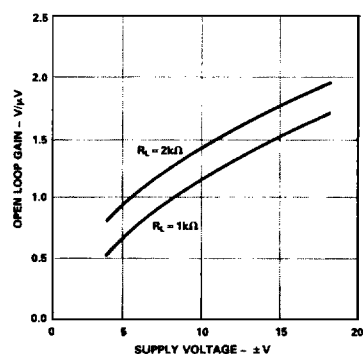
Open Loop Frequency Response



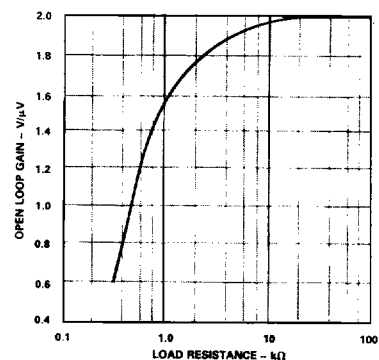
Open Loop Gain and Phase Shift vs. Frequency



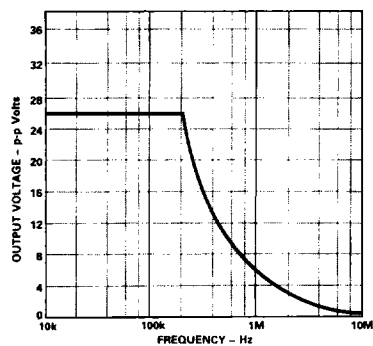
Slew Rate, Gain Bandwidth Product and Phase Margin vs. Temperature



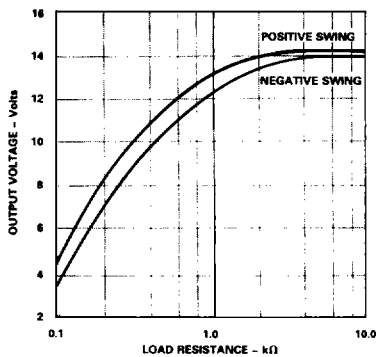
Open Loop Gain vs. Supply Voltage



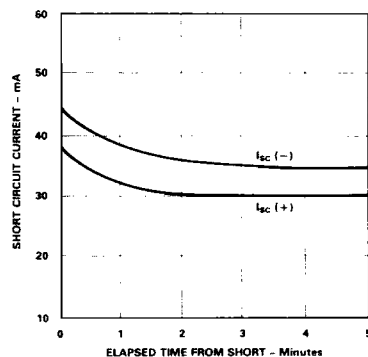
Open Loop Gain vs. Resistive Load



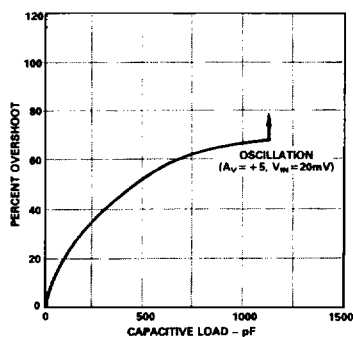
Undistorted Output Swing vs. Frequency



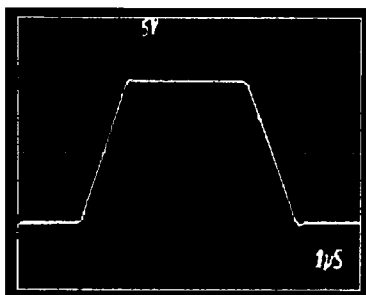
Output Swing vs. Resistive Load



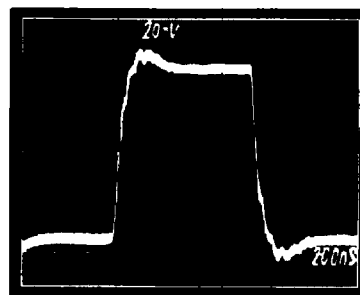
Output Short Circuit Current vs. Time



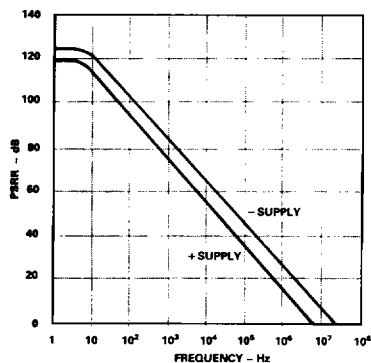
Small Signal Overshoot vs. Capacitive Load



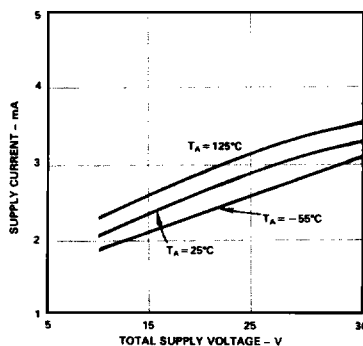
Unity Gain Follower Pulse Response (Large Signal)



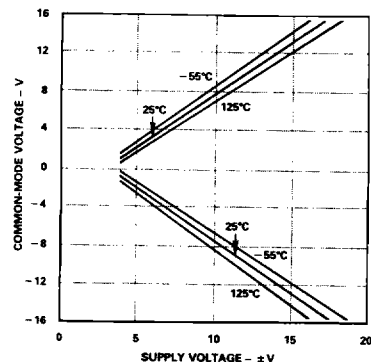
Unity Gain Follower Pulse Response (Small Signal)



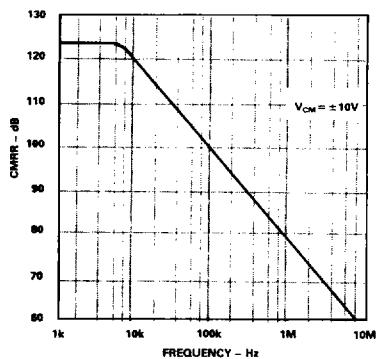
Power Supply Rejection Ratio vs. Frequency



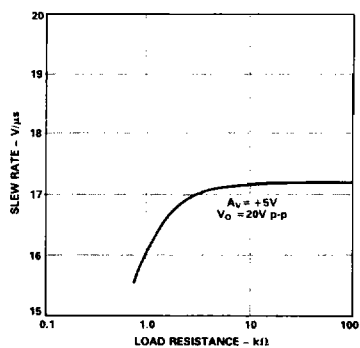
Supply Current vs. Supply Voltage



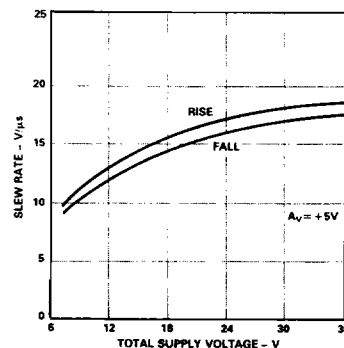
Common-Mode Input Range vs. Supply Voltage



CMRR vs. Frequency



Slew Rate vs. Resistive Load



Slew Rate vs. Supply Voltage