

# OP-37

## Low Noise Operational Amplifier

### Features

- Very low noise  
Spectral noise density —  $3.0 \text{ nV}/\sqrt{\text{Hz}}$   
1/f noise corner frequency — 2.7 Hz
- Very low  $V_{os}$  drift  
0.2  $\mu\text{V}/\text{Month}$   
0.2  $\mu\text{V}/^\circ\text{C}$
- High gain — 1.8 Million
- High output drive capability —  $\pm 12\text{V}$  into  
600 $\Omega$  load
- High slew rate — 17  $\text{V}/\mu\text{S}$
- High gain bandwidth product — 63 MHz
- Good common mode rejection ratio —  
126 dB
- Low input offset voltage — 10  $\mu\text{V}$
- Minimum low frequency noise — 0.08  $\mu\text{V}_{p-p}$   
(0.1 Hz to 10 Hz)
- Low input bias and offset currents — 10 nA
- Compensated for ac stability with  $A_{vCL} \geq 5$

### Description

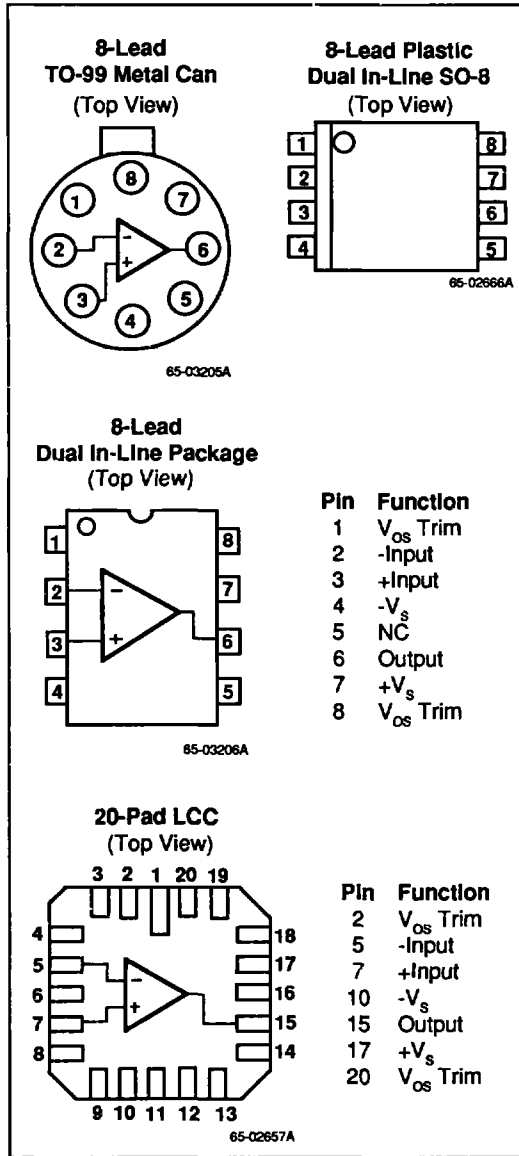
The OP-37 is designed for instrumentation grade signal conditioning where low noise (both spectral density and burst), wide bandwidth, and high slew rate are required along with low input offset voltage, low input offset temperature coefficient, and low input bias currents. The OP-37 is a decompensated version of the OP-27 and is ac stable in gain configurations equal to five and higher.

Digital nulling techniques performed at wafer sort make it feasible to guarantee temperature stable input offset voltages as low as 25  $\mu\text{V}$ . Input bias current cancellation techniques are used to obtain 10 nA input bias currents.

The OP-37 design uniquely addresses the needs of the instrumentation designer. Power supply rejection and common mode rejection are both in excess of 120 dB. Input offset voltage can be externally trimmed without affecting input offset voltage drift with temperature or time. The drift performance is, in fact, so good that the system designer must be cautioned that stray thermoelectric voltages generated by dissimilar metals at the contacts to the input terminals are enough to degrade its performance. For this reason it is also important to keep both input terminals at the same relative temperature.

The OP-37 is available in LCC, SO-8 (small-outline), TO-99 can, plastic mini-DIP and ceramic mini-DIP packages, and can be ordered with Mil-Std-883 Level B processing.

Connection Information



Ordering Information

Part Number	Package	Operating Temperature Range
OP-37EN	N	0°C to +70°C
OP-37FN	N	0°C to +70°C
OP-37GN	N	0°C to +70°C
OP-37EM	M	0°C to +70°C
OP-37FM	M	0°C to +70°C
OP-37GM	M	0°C to +70°C
OP-37ED	D	-25°C to +85°C
OP-37FD	D	-25°C to +85°C
OP-37GD	D	-25°C to +85°C
OP-37ET	T	-25°C to +85°C
OP-37FT	T	-25°C to +85°C
OP-37GT	T	-25°C to +85°C
OP-37AD	D	-55°C to +125°C
OP-37AD/883B	D	-55°C to +125°C
OP-37BD	D	-55°C to +125°C
OP-37BD/883B	D	-55°C to +125°C
OP-37CD	D	-55°C to +125°C
OP-37CD/883B	D	-55°C to +125°C
OP-37AT	T	-55°C to +125°C
OP-37AT/883B	T	-55°C to +125°C
OP-37BT	T	-55°C to +125°C
OP-37BT/883B	T	-55°C to +125°C
OP-37CT	T	-55°C to +125°C
OP-37CT/883B	T	-55°C to +125°C
OP-37AL/883B	L	-55°C to +125°C
OP-37BL/883B	L	-55°C to +125°C

Notes:

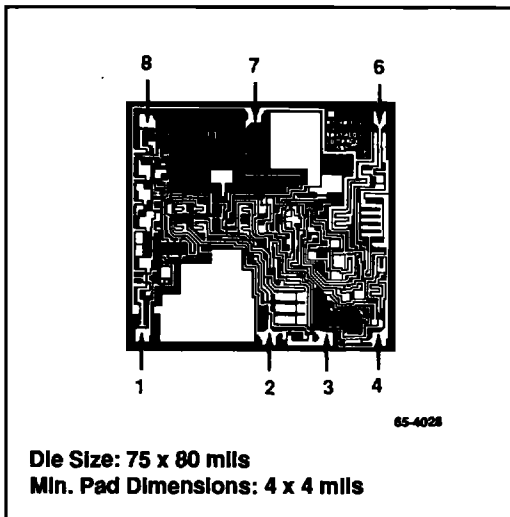
/883B suffix denotes Mil-Std-883, Level B processing  
 N = 8-lead plastic DIP  
 D = 8 lead ceramic DIP  
 T = 8-lead metal can (TO-99)  
 L = 20-pad leadless chip carrier  
 M = 8-lead plastic SCIC  
 Contact a Raytheon sales office or representative for ordering information on special package/temperature range combinations.

### Absolute Maximum Ratings

- Supply Voltage .....±22V
- Input Voltage\* .....±22V
- Differential Input Voltage .....0.7V
- Internal Power Dissipation\*\* .....658 mW
- Output Short Circuit Duration .....Indefinite
- Storage Temperature Range .....-65°C to +150°C
- Operating Temperature Range
  - OP-37A/B/C .....-55°C to +125°C
  - OP-37E/F/G (Hermetic) .....-25°C to +85°C
  - OP-37E/F/G (Plastic) .....0°C to +70°C
- Lead Soldering Temperature
  - (SO-8, 10 sec) .....+260°C
  - (DIP, LCC, TO-99; 60 sec) .....+300°C

\*For supply voltages less than ±22V, the absolute maximum input voltage is equal to the supply voltage.  
 \*\*Observe package thermal characteristics.

### Mask Pattern



### Thermal Characteristics

	8-Lead Small Outline	8-Lead Ceramic DIP	TO-99 8-Lead Metal Can	20-Pad LCC	8-Lead Plastic DIP
Max. Junction Temp.	125°C	175°C	175°C	175°C	125°C
Max. P <sub>D</sub> T <sub>A</sub> <50°C	300 mW	833 mW	658 mW	925 mW	468 mW
Therm. Res θ <sub>JC</sub>	—	45°C/W	50°C/W	37°C/W	—
Therm. Res. θ <sub>JA</sub>	240°C/W	150°C/W	190°C/W	105°C/W	160°C/W
For T <sub>A</sub> >50°C Derate at	4.17 mW/°C	8.33 mW/°C	5.26 mW/°C	7.0 mW/°C	6.25 mW/°C

**Electrical Characteristics** ( $V_s = \pm 15V$  and  $T_A = +25^\circ C$  unless otherwise noted)

Parameters	Test Conditions	OP-37A/E			OP-37B/F			OP-37C/G			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage <sup>5</sup>		10	25		20	60		30	100		$\mu V$
Long Term Input Offset Voltage Stability <sup>1 2</sup>		0.2	1.0		0.3	1.5		0.4	2.0		$\mu V/Mo$
Input Offset Current		7.0	35		9.0	50		12	75		nA
Input Bias Current		$\pm 10$	$\pm 40$		$\pm 12$	$\pm 55$		$\pm 15$	$\pm 80$		nA
Input Noise Voltage <sup>2</sup>	0.1 Hz to 10 Hz	0.08	0.18		0.08	0.18		0.09	0.25		$\mu V_{p-p}$
Input Noise Voltage Density <sup>2</sup>	$F_o = 10$ Hz	3.5	5.5		3.5	5.5		3.8	8.0		$\frac{nV}{\sqrt{Hz}}$
	$F_o = 30$ Hz	3.1	4.5		3.1	4.5		3.3	5.6		
	$F_o = 1000$ Hz	3.0	3.8		3.0	3.8		3.2	4.5		
Input Noise Current Density <sup>2</sup>	$F_o = 10$ Hz	1.7	4.0		1.7	4.0		1.7			$\frac{pA}{\sqrt{Hz}}$
	$F_o = 30$ Hz	1.0	2.3		1.0	2.3		1.0			
	$F_o = 1000$ Hz	0.4	0.6		0.4	0.6		0.4	0.6		
Input Resistance (Diff. Mode) <sup>4</sup>		1.5	6.0		1.2	5.0		0.8	4.0		M $\Omega$
Input Resistance (Com. Mode)		3.0			2.5			2.0			G $\Omega$
Input Voltage Range <sup>3</sup>		$\pm 11$	$\pm 12.3$		$\pm 11$	$\pm 12.3$		$\pm 11$	$\pm 12.3$		V
Common Mode Rejection Ratio	$V_{CM} = \pm 11V$	114	126		106	123		100	120		dB
Power Supply Rejection Ratio	$V_s \pm 4V$ to $\pm 18V$	100	120		100	120		94	118		dB
Large Signal Voltage Gain	$R_L \geq 2$ k $\Omega$ , $V_o = \pm 10V$	1000	1800		1000	1800		700	1500		V/mV
	$R_L \geq 1$ k $\Omega$ , $V_o = \pm 10V$	800	1500		800	1500		1500			
	$V_o = \pm 1V$ , $V_s = \pm 4V^4$	250	700		250	700		200	500		
Output Voltage Swing	$R_L \geq 2$ k $\Omega$	$\pm 12$	$\pm 13.8$		$\pm 12$	$\pm 13.8$		$\pm 11.5$	$\pm 13.5$		V
	$R_L \geq 600\Omega$	$\pm 11$	$\pm 12$		$\pm 11$	$\pm 12$		$\pm 11$	$\pm 12$		
Slew Rate <sup>4</sup>	$R_L \geq 2$ k $\Omega$	11	17		11	17		11	17		V/ $\mu S$
Gain Bandwidth Product <sup>4</sup>	$F_o = 10$ kHz	45	63		45	63		45	63		MHz
	$F_o = 1$ MHz		40			40			40		MHz
Open Loop Output Resistance	$V_o = 0$ , $I_o = 0$		70			70			70		$\Omega$
Power Consumption			90	140		90	140		100	170	mW
Offset Adjustment Range	$R_p = 10$ k $\Omega$		$\pm 4.0$			$\pm 4.0$			$\pm 4.0$		mV

## Notes:

1. Long Term Input Offset Voltage Supply refers to the average trend line of  $V_{os}$  vs. Time over extended periods after the first 30 days of operation. Excluding the initial hour of operation, changes in  $V_{os}$  during the first 30 operating days are typically 2.5  $\mu V$ .
2. This parameter is tested on a sample basis only.
3. Caution: The Common Mode Input Range is a function of supply voltage. See Typical Performance Curves. Also, the input protection diodes do not allow the device to be removed or inserted into the circuit without first removing power.
4. Parameter is guaranteed but not tested.
5. Input Offset Voltage measurements are performed by automated test equipment approximately 0.5 seconds after application of power.

**Electrical Characteristics** ( $V_s = \pm 15V$ ,  $-55^\circ C \leq T_A \leq +125^\circ C$  unless otherwise noted)

Parameters	Test Conditions	OP-37A			OP-37B			OP-37C			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage <sup>1</sup>		30	60		50	200		70	300	$\mu V$	
Average Input Offset Voltage Drift <sup>2</sup>		0.2	0.6		0.3	1.3		0.4	1.8	$\mu V/^\circ C$	
Input Offset Current		15	50		22	85		30	135	nA	
Input Bias Current		$\pm 20$	$\pm 60$		$\pm 28$	$\pm 95$		$\pm 35$	$\pm 150$	nA	
Input Voltage Range		$\pm 10.3$	$\pm 11.5$		$\pm 10.3$	$\pm 11.5$		$\pm 10.2$	$\pm 11.5$	V	
Common Mode Rejection Ratio	$V_{CM} = \pm 10V$	108	122		100	119		94	116	dB	
Power Supply Rejection Ratio	$V_s \pm 4.5V$ to $\pm 18V$	96	116		94	114		86	110	dB	
Large Signal Voltage Gain	$R_L \geq 2 k\Omega$ , $V_o = \pm 10V$	600	1200		500	1000		300	800	V/mV	
Output Voltage Swing	$R_L \geq 2 k\Omega$	$\pm 11.5$	$\pm 13.5$		$\pm 11$	$\pm 13.2$		$\pm 10.5$	$\pm 13$	V	

**Electrical Characteristics** ( $V_s = \pm 15V$ ,  $-25^\circ C \leq T_A \leq +85^\circ C$  for hermetic package types,  $0^\circ C \leq T_A \leq +70^\circ C$  for plastic package types unless otherwise noted)

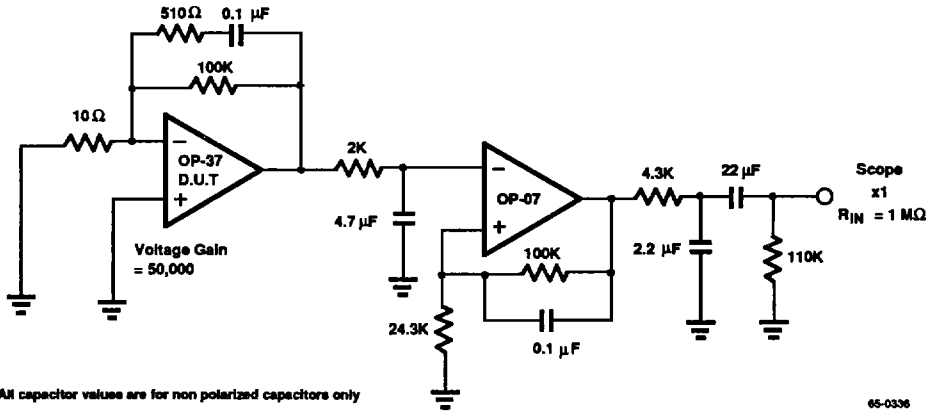
Parameters	Test Conditions	OP-37E			OP-37F			OP-37G			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage <sup>1</sup>		20	50		40	140		55	220	$\mu V$	
Average Input Offset Voltage Drift <sup>2</sup>		0.2	0.6		0.3	1.3		0.4	1.8	$\mu V/^\circ C$	
Input Offset Current		10	50		14	85		20	135	nA	
Input Bias Current		$\pm 14$	$\pm 60$		$\pm 18$	$\pm 95$		$\pm 25$	$\pm 150$	nA	
Input Voltage Range		$\pm 10.5$	$\pm 11.8$		$\pm 10.5$	$\pm 11.8$		$\pm 10.5$	$\pm 11.8$	V	
Common Mode Rejection Ratio	$V_{CM} = \pm 10V$	110	124		102	121		96	118	dB	
Power Supply Rejection Ratio	$V_s \pm 4.5V$ to $\pm 18V$	97	118		96	116		90	114	dB	
Large Signal Voltage Gain	$R_L \geq 2 k\Omega$ , $V_o = \pm 10V$	750	1500		700	1300		450	1000	V/mV	
Output Voltage Swing	$R_L \geq 2 k\Omega$	$\pm 11.7$	$\pm 13.6$		$\pm 11.4$	$\pm 13.5$		$\pm 11$	$\pm 13.3$	V	

## Notes:

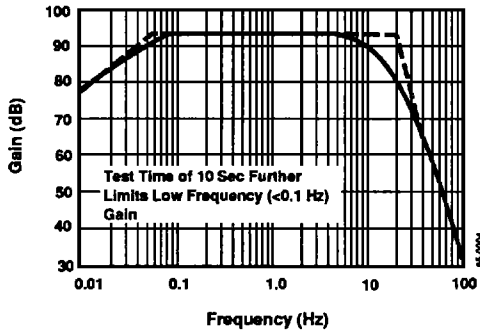
1. Input Offset Voltage measurements are performed by automated test equipment approximately 0.5 seconds after application of power.
2.  $T_C V_{OS}$  performance is guaranteed unnullled or when nullled with  $R_p = 8.0 k\Omega$  to  $20 k\Omega$ .

# Typical Performance Characteristics

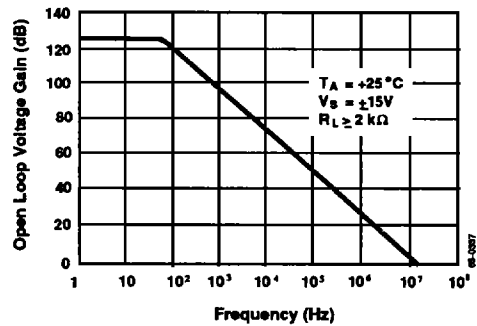
## 0.1 Hz to 10 Hz Noise Test Circuit



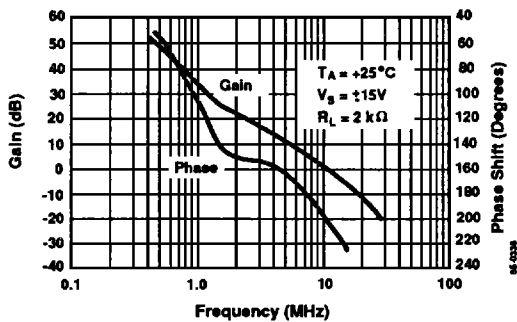
## 0.1 Hz to 10 Hz Peak-to-Peak Noise Tester Frequency Response



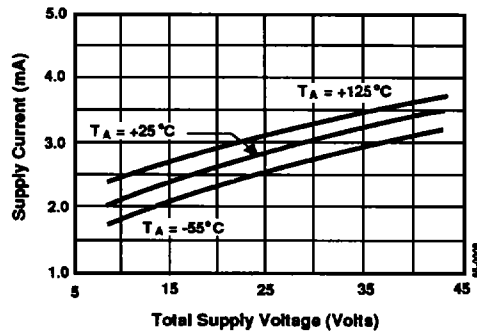
## Open Loop Gain vs. Frequency



## Gain, Phase Shift vs. Frequency

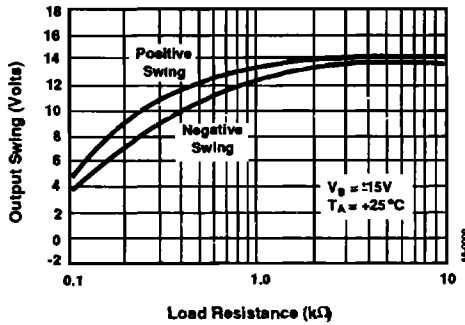


## Supply Current vs. Supply Voltage

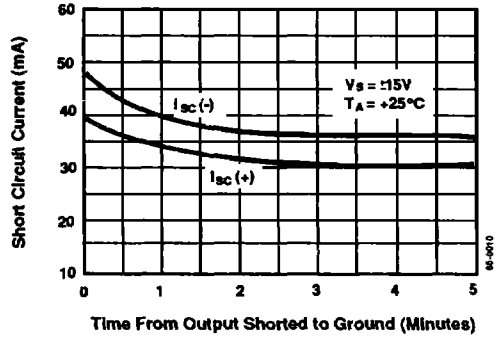


Typical Performance Characteristics (Continued)

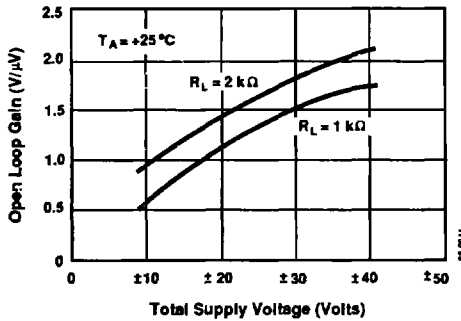
Maximum Output Swing vs. Resistive Load



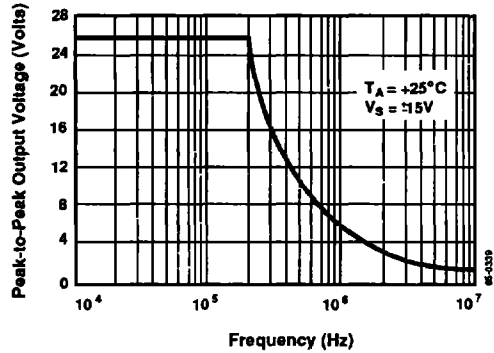
Short Circuit Current vs. Time



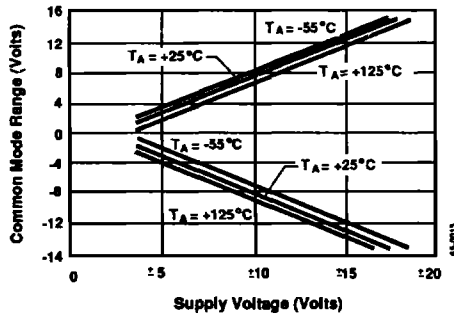
Open Loop Voltage Gain vs. Supply Voltage



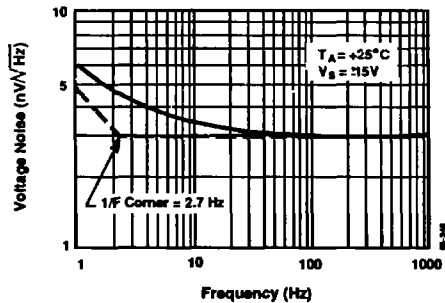
Maximum Undistorted Output vs. Frequency



Common Mode Input Range vs. Supply Voltage

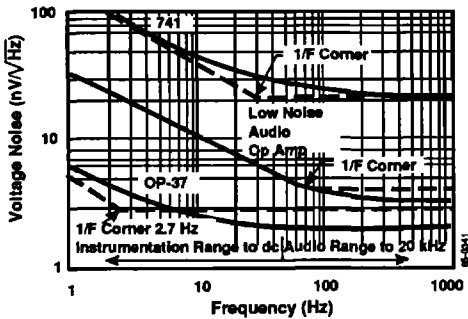


OP-37 Voltage Noise vs. Frequency

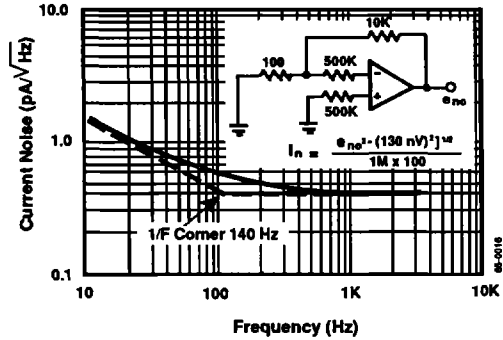


Typical Performance Characteristics (Continued)

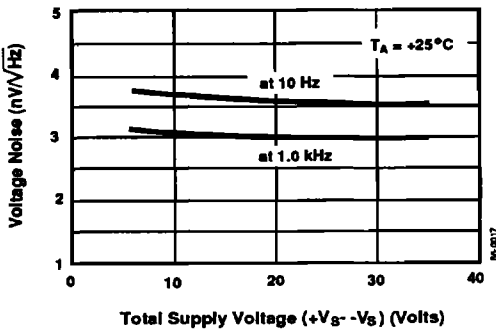
A Comparison of Op Amp Voltage Noise Spectrums



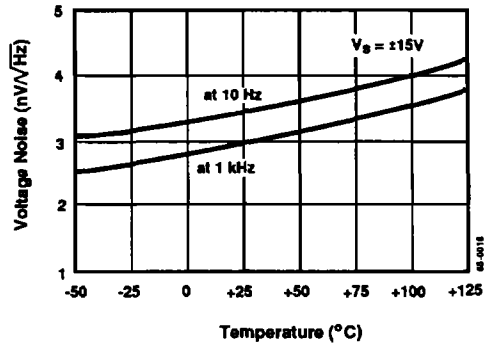
Current Noise vs. Frequency



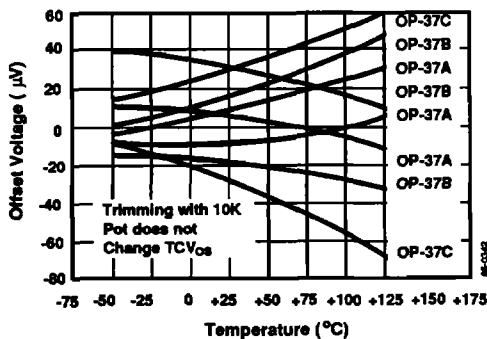
Voltage Noise vs. Supply Voltage



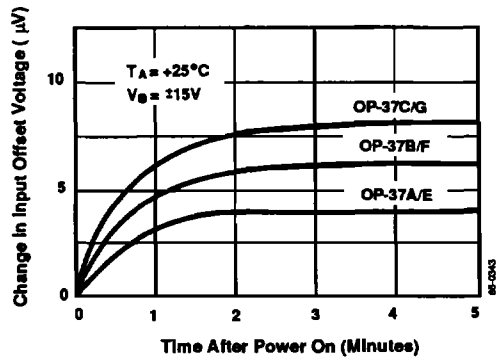
Voltage Noise vs. Temperature



Offset Voltage Drift of Representative Units



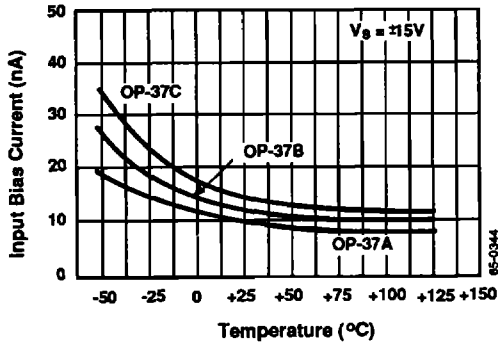
Warm-Up Drift



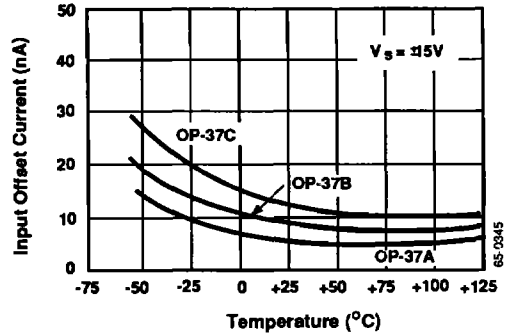


Typical Performance Characteristics (Continued)

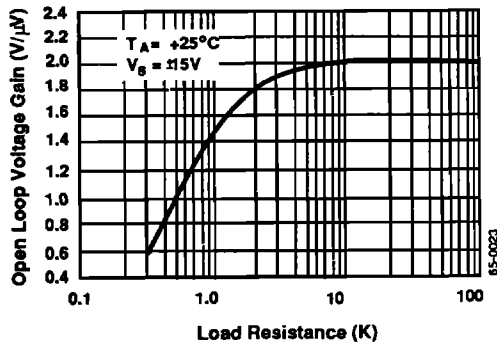
Input Bias Current vs. Temperature



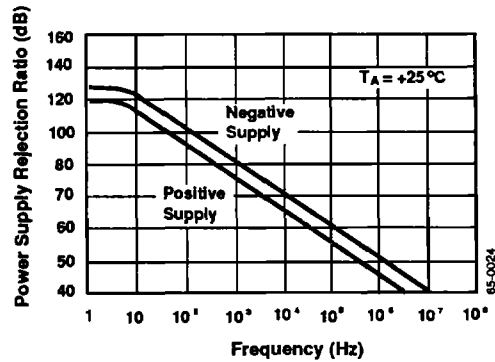
Input Offset Current vs. Temperature



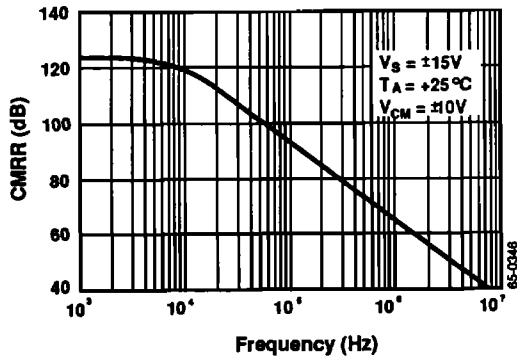
Open Loop Voltage Gain vs. Load Resistance



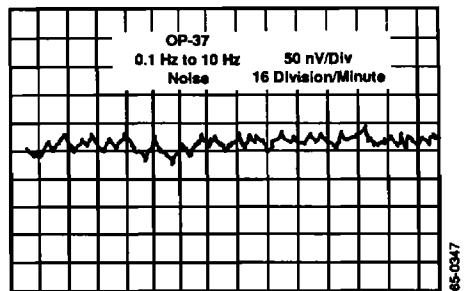
PSRR vs. Frequency



CMRR vs. Frequency

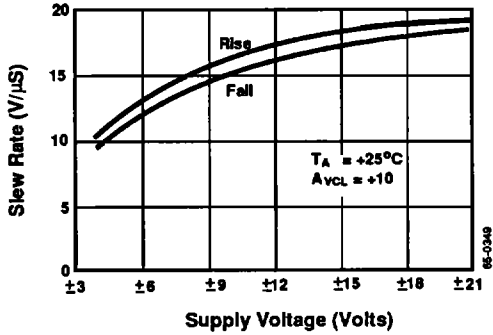


OP-37 0.1 Hz to 10 Hz Peak-to-Peak Noise  
Vertical Scale 50 nV/Division  
Recorder Speed 8 Divisions/Minute

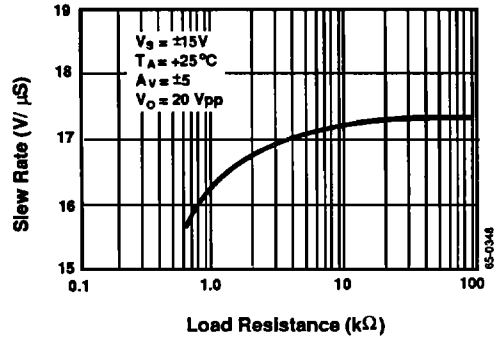


Typical Performance Characteristics (Continued)

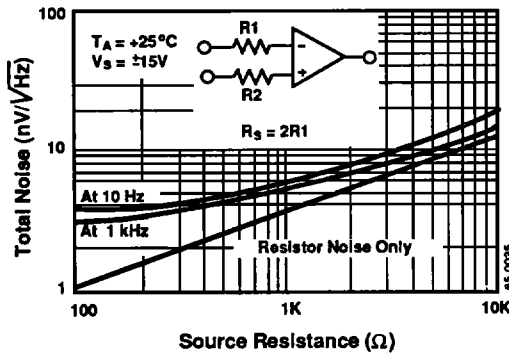
Slew Rate vs. Supply Voltage



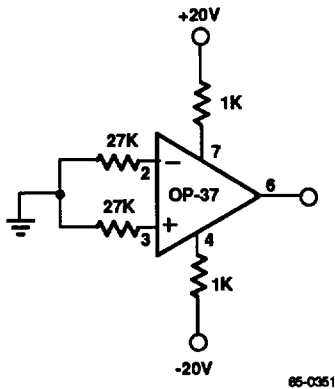
Slew Rate vs. Load



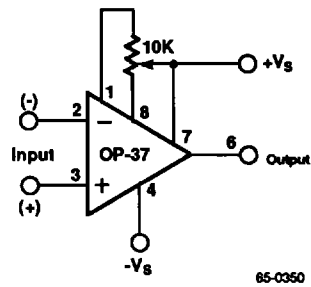
Total Noise vs. Source Resistance



Burn-In Circuit



Offset Nulling Circuit



## Typical Applications

### Low Impedance Microphone Preamp (Figure 1)

In this preamp the transformer converts the low microphone impedance up to a value that is close to the optimum source impedance required by the OP-37 for best noise performance. The optimum source impedance can be calculated as the ratio of  $e_n/i_n$  which for the OP-37 is approximately  $7000\Omega$ . Fortunately the noise performance does not degrade appreciably until the source impedance is four or five times this optimum value. The source impedance at the output of this transformer of  $15\text{ k}\Omega$  still provides near optimum noise performance. (A high quality audio transformer with a step-up ratio of 6.7 to one is not available.) C1 rolls off the high frequency response at 90 kHz giving a noise power bandwidth of 140 kHz.

### Instrumentation

The OP-37 is particularly adaptable to instrumentation applications. When wired into a single op amp difference amplifier configuration, the OP-37 exhibits outstanding common mode rejection ratio. The spot voltage noise is so low that it is dominated almost entirely by the resistor Johnson noise.

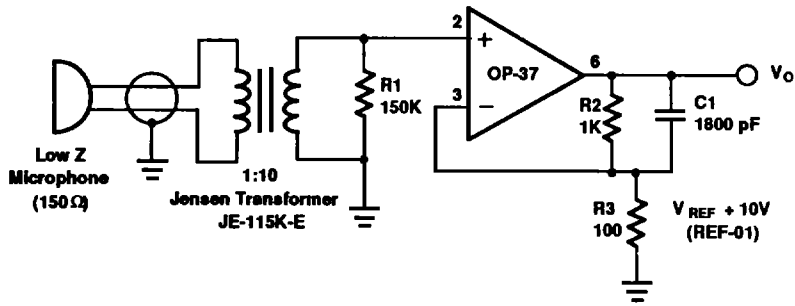
The three op amp instrumentation amplifier of Figure 4 avoids the low input impedance characteristics of difference amplifiers at the expense of two more operational amplifiers and a slight degradation in noise performance. The

noise increases because two amplifiers are contributing to the input voltage spectral noise instead of one. Thus, the noise contribution, exclusive of resistor Johnson noise, increases by slightly more than the  $\sqrt{2}$ . The spectral noise voltage increases from approximately  $3\text{ nV}/\sqrt{\text{Hz}}$  to approximately  $4.9\text{ nV}/\sqrt{\text{Hz}}$ , with the third amplifier contributing about 10% of the noise. The gain of the input amplifier is set at 25 and the second stage at 40 for an overall gain of 1000. R7 is trimmed to optimize the common mode rejection ratio (CMRR) with frequency. With balanced source resistors a CMRR of 100 dB is achieved. With a  $1\text{ k}\Omega$  source impedance imbalance CMRR is degraded to 80 dB at 5 kHz due to the finite ( $3\text{ G}\Omega$ ) input impedance.

### DAC Current to Voltage Converter

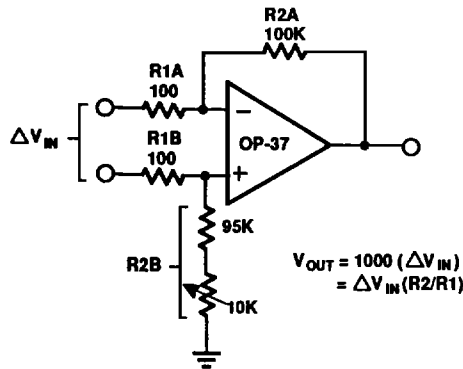
Many high speed voltage output D/A conversion applications require a high speed op amp to convert a standard current output DAC (such as a DAC-08 or DAC-10) to voltage output. The OP-37 is ideal for this because it has the speed and settling time for fast data conversion, but still has excellent dc specifications to ensure high accuracy.

The  $360\Omega$  resistor is required to increase the effective gain of the OP-37 to meet the minimum gain requirement for stability. The high speed of the OP-37 allows a conversion time of  $1\text{ }\mu\text{s}$  to 1/2 LSB in this circuit. In addition, the low  $V_{os}$  and  $V_{os}$  drift of the OP-37 complements the high accuracy of the DAC-10, and the high output drive capability allows connection to demanding loads.



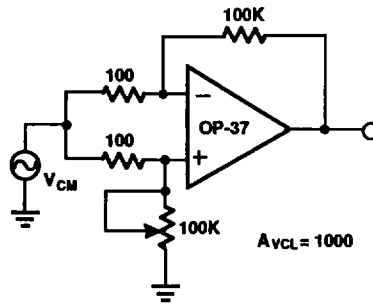
65-0321

Figure 1. Low Impedance Microphone Preamplifier



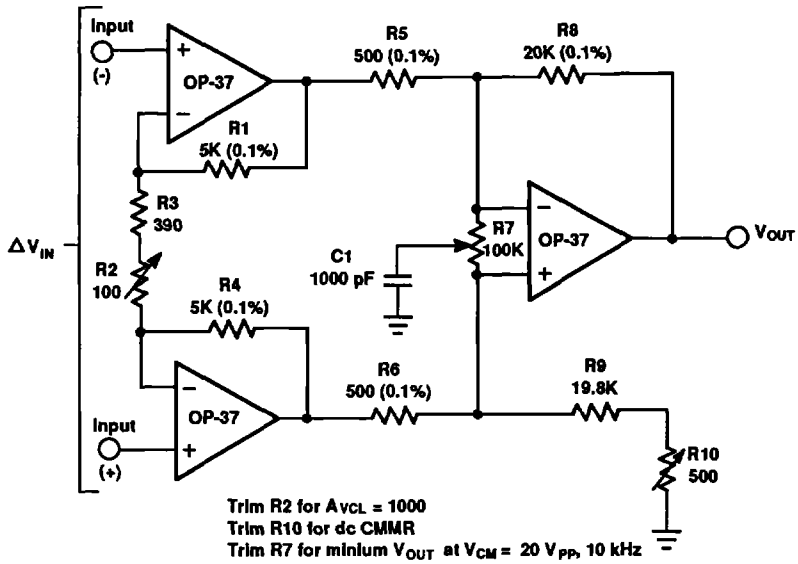
65-0353

Figure 2. A Single Op Amp IC Difference Amplifier Using an OP-37. The Difference Amplifier is Connected for a Gain of 1000.



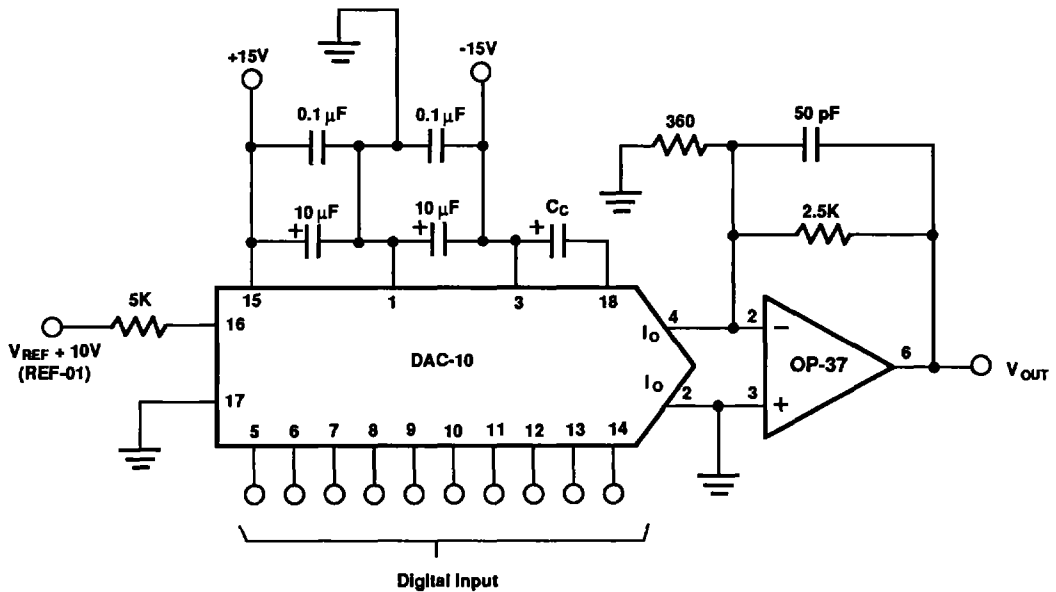
65-0354

Figure 3. Common Mode Rejection Ratio Test Circuit



65-0355

Figure 4. Three Op Amp IC Instrumentation Amplifier



65-0356

Figure 5. D/A Converter Application

Schematic Diagram

