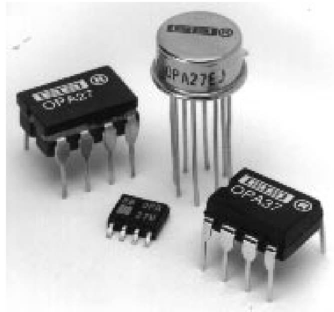
BURR - BROWN®



OPA27
OPA37

Ultra-Low Noise Precision OPERATIONAL AMPLIFIERS

FEATURES

- LOW NOISE: 3.8nV/√Hz max at 1kHz
- LOW OFFSET: 25µV max
- LOW DRIFT: 0.6µV/°C
- HIGH OPEN-LOOP GAIN: 120dB min
- HIGH COMMON-MODE REJECTION: 114dB min
- HIGH POWER SUPPLY REJECTION: 100dB min
- FITS OP-07, OP-05, AD510, AD517 SOCKETS

APPLICATIONS

- PRECISION INSTRUMENTATION
- DATA ACQUISITION
- TEST EQUIPMENT
- PROFESSIONAL AUDIO EQUIPMENT
- TRANSDUCER AMPLIFIER
- RADIATION HARD EQUIPMENT

DESCRIPTION

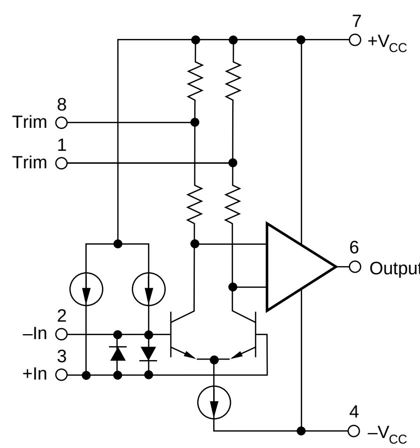
The OPA27/37 is an ultra-low noise, high precision monolithic operational amplifier.

Laser-trimmed thin-film resistors provide excellent long-term voltage offset stability and allow superior voltage offset compared to common zener-zap techniques.

A unique bias current cancellation circuit allows bias and offset current specifications to be met over the full –55°C to +125°C temperature range.

The OPA27 is internally compensated for unity-gain stability. The decompensated OPA37 requires a closed-loop gain ≥ 5.

The Burr-Brown OPA27/37 is an improved replacement for the industry-standard OP-27/OP-37.



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SPECIFICATIONS

ELECTRICAL

At V_{CC} = ±15VDC and T_A = **+25°C** unless otherwise noted.

PARAMETER	CONDITIONS	OPA27/37A, OPA27/37E			OPA27/37B, OPA27/37F			OPA27/37C, OPA27/37G			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
INPUT											
NOISE(6)											
Voltage, f_O = 10Hz			3.1	5.5		3.5	5.5		3.8	8.0	nV/√Hz
f_O = 30Hz			2.9	4.5		3.1	4.5		3.3	5.6	nV/√Hz
f_O = 1kHz			2.7	3.8		3.0	3.8		3.2	4.5	nV/√Hz
f_B = 0.1Hz to 10Hz			0.07	0.18		0.08	0.18		0.09	0.25	µVp-p
Current,(1) f_O = 10Hz			1.7	4.0		1.7	4.0		1.7		pA/√Hz
f_O = 30Hz			1.0	2.3		1.0	2.3		1.0		pA/√Hz
f_O = 1kHz			0.4	0.6		0.4	0.6		0.4	0.6	pA/√Hz
OFFSET VOLTAGE (2)											
Input Offset Voltage			±6	±25		±12	±60		±25	±100	µV
Average Drift (3)	$T_{A\ MIN}$ to $T_{A\ MAX}$		±0.2	±0.6		±0.3	±1.3		±0.4	±1.8 (6)	µV/°C
Long Term Stability (4)			0.2	1		0.3	1.5		0.4	2.0	µV/mo
Supply Rejection	±V_{CC} = 4 to 18V	100	134		100	125		94	120		dB
	±V_{CC} = 4 to 18V		±0.2	±10		±0.6	±10		±1	±20	µV/V
BIAS CURRENT											
Input Bias Current			±11	±40		±13	±55		±15	±80	nA
OFFSET CURRENT											
Input Offset Current			6	35		8	50		10	75	nA
IMPEDANCE											
Common-Mode			3 || 2.5			2.5 || 2.5			2 || 2.5		GΩ || pF
VOLTAGE RANGE											
Common-Mode Input Range		±11	±12.3		±11	±12.3		±11	±12.3		V
Common-Mode Rejection	V_{IN} = ±11VDC	114	128		106	125		100	122		dB
OPEN-LOOP GAIN, DC											
Open-Loop Voltage Gain	R_L ≥ 2kΩ	120	126		120	125		117	124		dB
	R_L ≥ 1kΩ	118	125		118	125			124		dB
FREQUENCY RESPONSE											
Gain-Bandwidth Product (5)	OPA27	5	8		5	8		5 (6)	8		MHz
	OPA37	45	63		45	63		45 (6)	63		MHz
Slew Rate (5)	V_O = ±10V, R_L = 2kΩ										
	OPA27, G = +1	1.7	1.9		1.7	1.9		1.7 (6)	1.9		V/µs
	OPA37, G = +5	11	11.9		11	11.9		11 (6)	11.9		V/µs
Settling Time, 0.01%	OPA27, G = +1		25			25			25		µs
	OPA37, G = +5		25			25			25		µs
RATED OUTPUT											
Voltage Output	R_L ≥ 2kΩ	±12	±13.8		±12	±13.8		±12	±13.8		V
	R_L ≥ 600Ω	±10	±12.8		±10	±12.8		±10	±12.8		V
Output Resistance	DC, Open Loop		70			70			70		Ω
Short Circuit Current	R_L = 0Ω		25	60		25	60		25	60 (6)	mA
POWER SUPPLY											
Rated Voltage			±15			±15			±15		VDC
Voltage Range, Derated Performance		±4		±22	±4		±22	±4		±22	VDC
Current, Quiescent	I_O = 0mADC		3	4.7		3	4.7		3.3	5.7	mA
TEMPERATURE RANGE											
Specification											
A, B, C (J, Z)		–55		+125	–55		+125	–55		+125	°C
E, F (J, Z)		–25		+85	–25		+85				°C
G (P, U, J, Z)								–40		+85	°C
Operating											
J, Z		–55		+125	–55		+125	–55		+125	°C
P, U								–40		+85	°C

NOTES: (1) Measured with industry-standard noise test circuit (Figures 1 and 2). Due to errors introduced by this method, these current noise specifications should be used for comparison purposes only. (2) Offset voltage specifications on grades A and E are also guaranteed with units fully warmed up. Grades B, C, F, and G are measured with automatic test equipment after approximately 0.5 seconds from power turn-on. (3) Unnulled or nulled with 8kΩ to 20kΩ potentiometer. (4) Long-term voltage offset vs time trend line does not include warm-up drift. (5) Typical specification only on plastic package units. Slew rate varies on all units due to differing test methods. Minimum specification applies to open-loop test. (6) This parameter guaranteed by design.

ELECTRICAL

At V_{CC} = ±15VDC and $\mathbf{T_A = T_{MIN}}$ **to** $\mathbf{T_{MAX}}$ unless otherwise noted.

PARAMETER	CONDITIONS	OPA27/37A, OPA27/37E			OPA27/37B, OPA27/37F			OPA27/37C, OPA27/37G			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
TEMPERATURE RANGE											
Specification Range											
A, B, C (J, Z)		–55		+125	–55		+125	–55		+125	°C
E, F (J, Z)		–25		+85	–25		+85				°C
G (P, U, J, Z)								–40		+85	°C
INPUT											
OFFSET VOLTAGE (1)											
Input Offset Voltage											
A, B, C			±24	±60		±45	±200		±60	±300	µV
E, F, G			±17	±50		±33	±140		±48	±220 (3)	µV
Average Drift (2)	$T_{A\,MIN}$ to $T_{A\,MAX}$		±0.2	±0.6		±0.3	±1.3		±0.4	±1.8 (3)	µV/°C
Supply Rejection											
A, B, C	$\pm V_{CC}$ = 4.5 to 18V	96	130		94	127		86	122		dB
E, F, G	$\pm V_{CC}$ = 4.5 to 18V	97	130		96	127		90 (3)	122		dB
BIAS CURRENT											
Input Bias Current											
A, B, C			±16	±60		±22	±95		±29	±150	nA
E, F, G			±13	±60		±16	±95		±21	±150 (3)	nA
OFFSET CURRENT											
Input Offset Current											
A, B, C			23	50		25	85		35	135	nA
E, F, G			12	50		14	85		20	135 (3)	nA
VOLTAGE RANGE											
Common-Mode Input Range											
A, B, C		±10.3	±11.5		±10.3	±11.5		±10.3	±11.5		V
E, F, G		±10.5	±11.8		±10.5	±11.8		±10.5 (3)	±11.8		V
Common-Mode Rejection	V_{IN} = ±11VDC										
A, B, C		108	124		100	122		94	120		dB
E, F, G		110	126		102	124		96 (3)	122		dB
OPEN-LOOP GAIN, DC											
Open-Loop Voltage Gain	$R_L \geq 2k\Omega$										
A, B, C		116	121		114	120		110	118		dB
E, F, G		118	123		117	122		113(3)	120		dB
RATED OUTPUT											
Voltage Output	$R_L = 2k\Omega$										
A, B, C		±11.5	±13.7		±11.0	±13.5		±10.5	±13.3		V
E, F, G		±11.7	±13.8		±11.4	±13.6		±11.0 (3)	±13.4		V
Short Circuit Current	V_O = 0VDC		25			25			25		mA

NOTES: (1) Offset voltage specifications on grades A and E are also guaranteed with the units fully warmed up. Grades B, C, F, and G are measured with automatic test equipment after approximately 0.5s from power turn-on. (2) Unnulled or nulled with 8kΩ to 20kΩ potentiometer. (3) This parameter guaranteed by design in P-DIP, "P" package and SOIC "U" package.

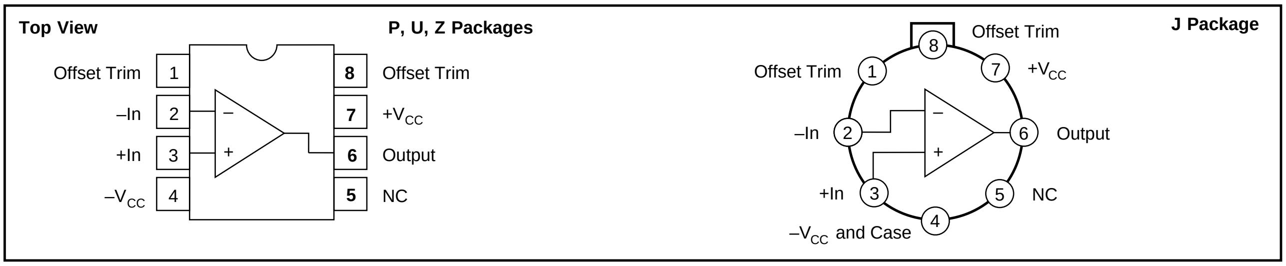
ABSOLUTE MAXIMUM RATINGS

Supply Voltage .... ±22V
Internal Power Dissipation (1) 500mW
Input Voltage .... $\pm V_{CC}$
Output Short-Circuit Duration (2) .... Indefinite
Differential Input Voltage (3) .... ±0.7V
Differential Input Current (3) .... ±25mA
Storage Temperature Range:
J, Z .... –65°C to +150°C
P, U .... –55°C to +125°C
Operating Temperature Range:
A, B, C, E, F, G (J, Z) .... –55°C to +125°C
G (P, U) .... –40°C to +85°C
Lead Temperature:
J, Z, P (soldering, 10s) .... +300°C
U (soldering, 3s) .... +260°C

PACKAGE TYPE	θ_{JA}	UNITS
TO-99 (J)	150	°C/W
8-Pin Hermetic DIP (Z)	150	°C/W
8-Pin Plastic DIP (P)	100	°C/W
8-Pin SOIC (U)	160	°C/W

NOTES: (1) Maximum package power dissipation vs ambient temperature: (2) To common with $\pm V_{CC}$ = 15V. (3) The inputs are protected by back-to-back diodes. Current limiting resistors are not used in order to achieve low noise. If differential input voltage exceeds ±0.7V, the input current should be limited to 25mA.

CONNECTION DIAGRAMS



ORDERING INFORMATION

MODEL [1]	PACKAGE	TEMPERATURE RANGE (°C)	OFFSET VOLTAGE MAX (μV), 25°C
OPA27AJ	TO-99	–55 to +125	±25
OPA27BJ	TO-99	–55 to +125	±60
OPA27CJ	TO-99	–55 to +125	±100
OPA27EJ	TO-99	–25 to +85	±25
OPA27FJ	TO-99	–25 to +85	±60
OPA27GJ	TO-99	–40 to +85	±100
OPA27AZ	Ceramic	–55 to +125	±25
OPA27BZ	Ceramic	–55 to +125	±60
OPA27CZ	Ceramic	–55 to +125	±100
OPA27EZ	Ceramic	–25 to +85	±25
OPA27FZ	Ceramic	–25 to +85	±60
OPA27GZ	Ceramic	–40 to +85	±100
OPA27GP	Plastic	–40 to +85	±100
OPA27GU[2]	SOIC	–40 to +85	±100

NOTE: (1) Packages and prices for OPA37 are same as for OPA27. (2) OPA27GU may be marked OPA27U. Likewise, OPA37GU may be marked OPA37U.

PACKAGE INFORMATION

MODEL	PACKAGE	PACKAGE DRAWING NUMBER(1)
OPA27AJ	TO-99	001
OPA27BJ	TO-99	001
OPA27CJ	TO-99	001
OPA27EJ	TO-99	001
OPA27FJ	TO-99	001
OPA27GJ	TO-99	001
OPA27AZ	Ceramic	001
OPA27BZ	Ceramic	161
OPA27CZ	Ceramic	161
OPA27DZ	Ceramic	161
OPA27EZ	Ceramic	161
OPA27FZ	Ceramic	161
OPA27GZ	Ceramic	161
OPA27GP	Plastic	006
OPA27GU	SOIC	182

NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix D of Burr-Brown IC Data Book.

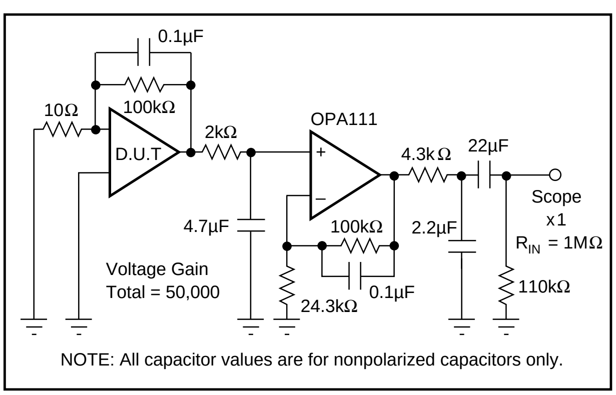


FIGURE 1. 0.1Hz to 10Hz Noise Test Circuit.

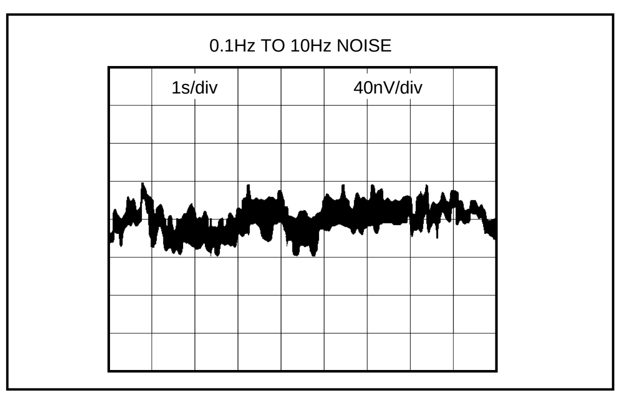
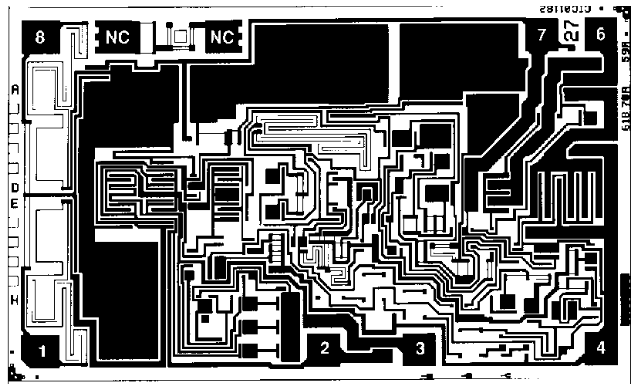
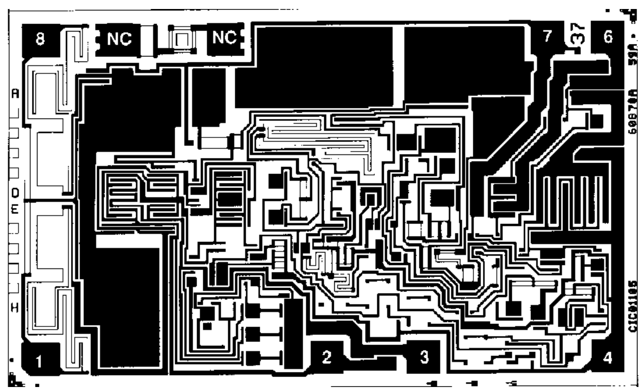


FIGURE 2. Low Frequency Noise.

DICE INFORMATION



OPA27 DIE TOPOGRAPHY



OPA37 DIE TOPOGRAPHY

PAD	FUNCTION	PAD	FUNCTION
1	Offset Trim	5	No Pad
2	–In	6	Output
3	+In	7	$+V_{CC}$
4	$-V_{CC}$	8	Offset Trim
		NC	No Connection

Substrate Bias: $-V_{CC}$

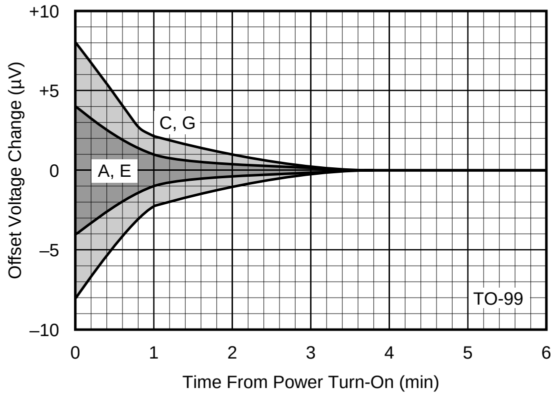
MECHANICAL INFORMATION

	MILS (0.001")	MILLIMETERS
Die Size	99 x 61 ±5	2.51 x 1.55 ±0.13
Die Thickness	20 ±3	0.51 ±0.08
Min. Pad Size	4 x 4	0.10 x 0.10
OPA27 Transistor Count		47
OPA37 Transistor Count		42
Backing		Gold

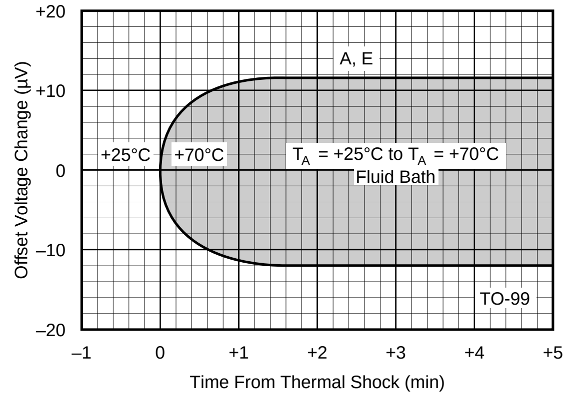
TYPICAL PERFORMANCE CURVES

$T_A = +25°C$, $\pm V_{CC} = \pm 15VDC$ unless otherwise noted.

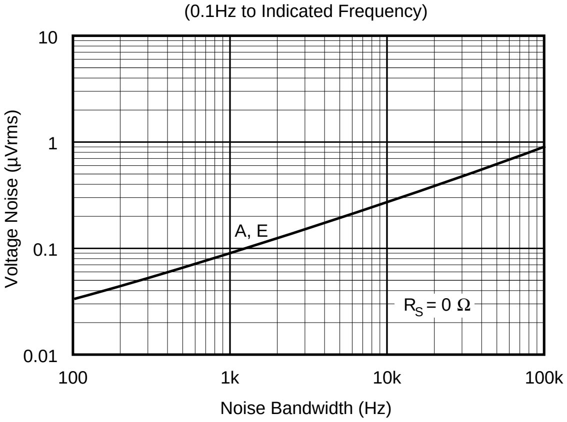
INPUT OFFSET VOLTAGE WARM-UP DRIFT



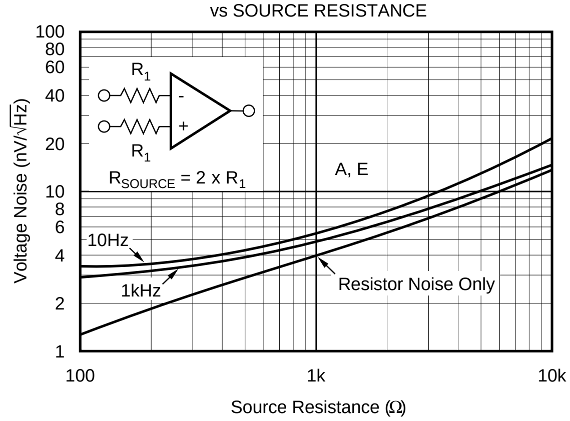
INPUT OFFSET VOLTAGE CHANGE
DUE TO THERMAL SHOCK



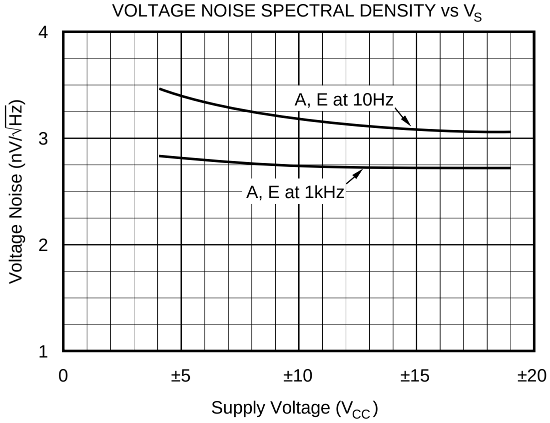
INPUT VOLTAGE NOISE vs NOISE BANDWIDTH
(0.1Hz to Indicated Frequency)



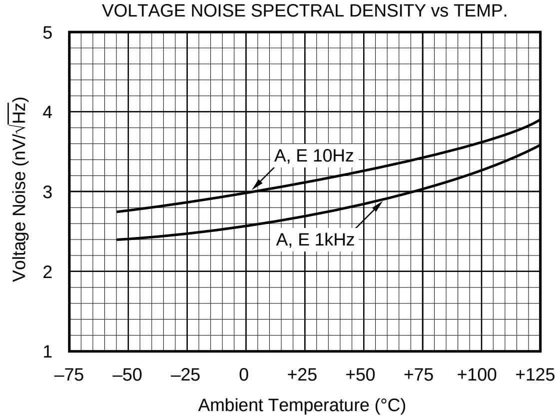
TOTAL INPUT VOLTAGE NOISE SPECTRAL DENSITY
vs SOURCE RESISTANCE



VOLTAGE NOISE SPECTRAL DENSITY vs V_S



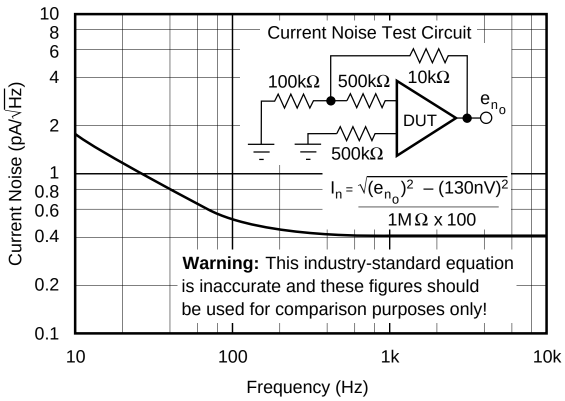
VOLTAGE NOISE SPECTRAL DENSITY vs TEMP.



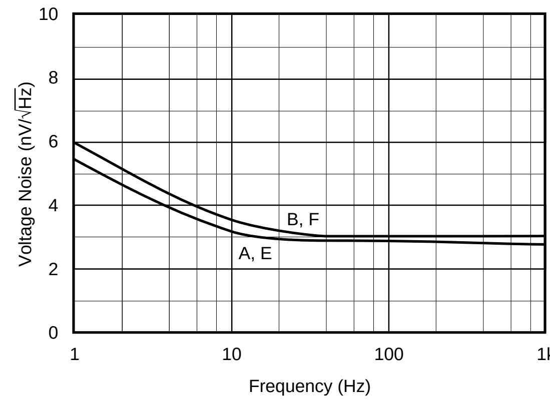
TYPICAL PERFORMANCE CURVES (CONT)

T_A = +25°C, $\pm V_{CC}$ = ±15VDC unless otherwise noted.

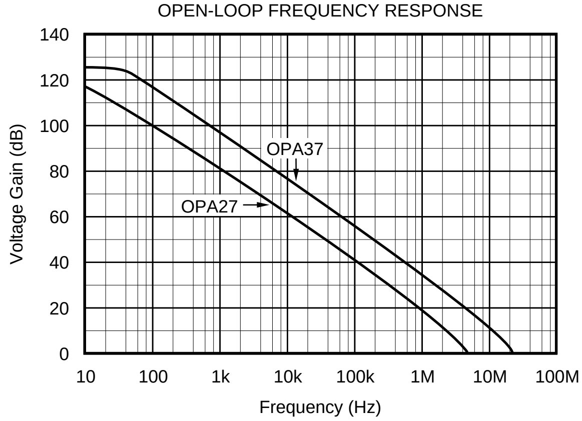
INPUT CURRENT NOISE SPECTRAL DENSITY



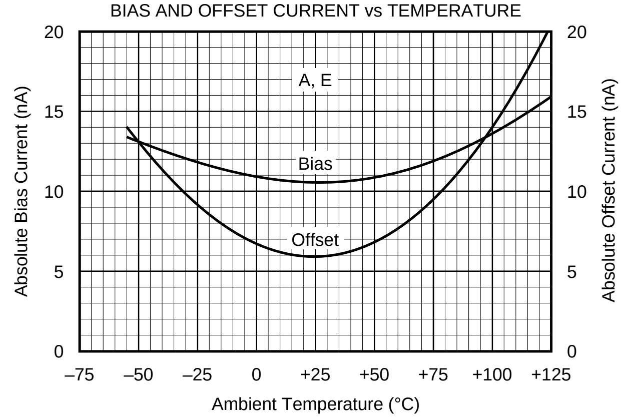
INPUT VOLTAGE NOISE SPECTRAL DENSITY



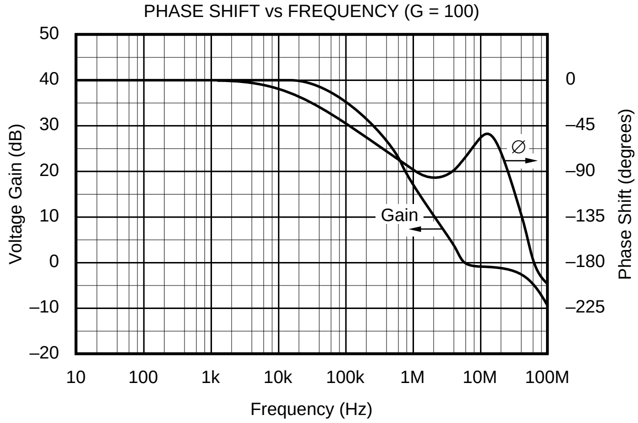
OPEN-LOOP FREQUENCY RESPONSE



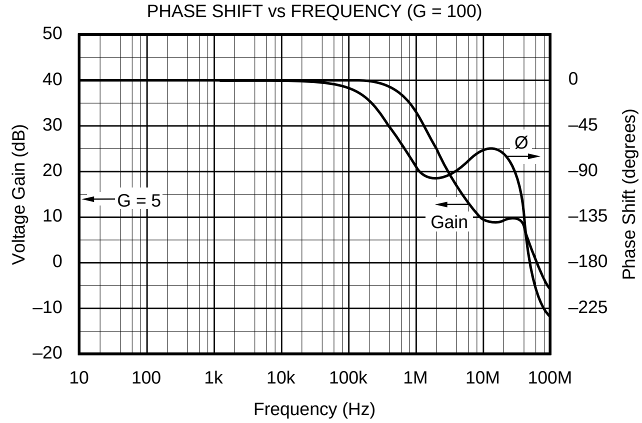
BIAS AND OFFSET CURRENT vs TEMPERATURE



OPA27 CLOSED-LOOP VOLTAGE GAIN AND PHASE SHIFT vs FREQUENCY (G = 100)

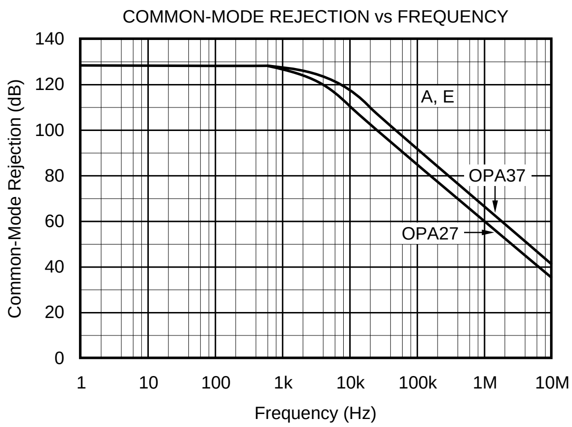


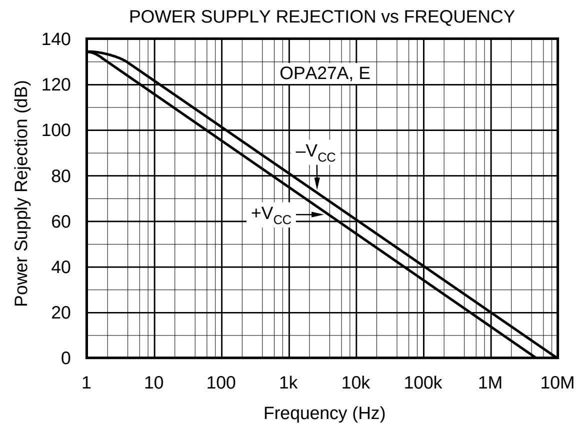
OPA37 CLOSED-LOOP VOLTAGE GAIN AND PHASE SHIFT vs FREQUENCY (G = 100)

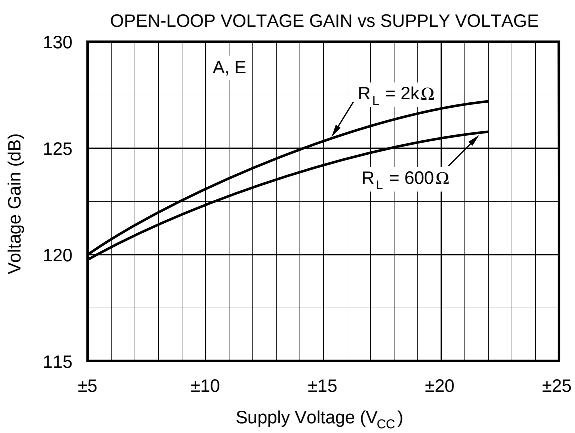


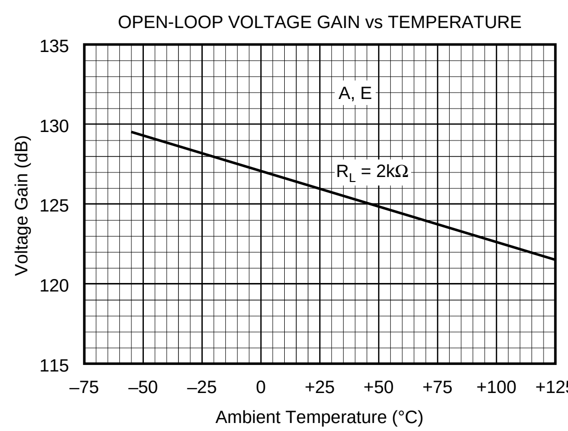
TYPICAL PERFORMANCE CURVES (CONT)

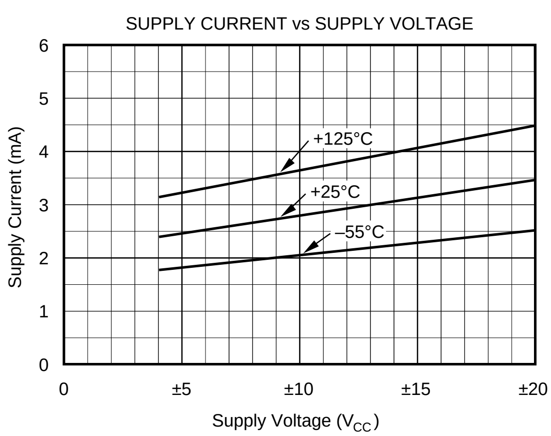
T_A = +25°C, $\pm V_{CC}$ = ±15VDC unless otherwise noted.

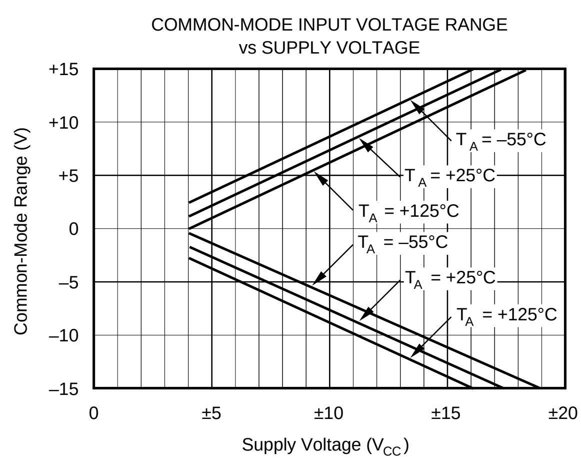








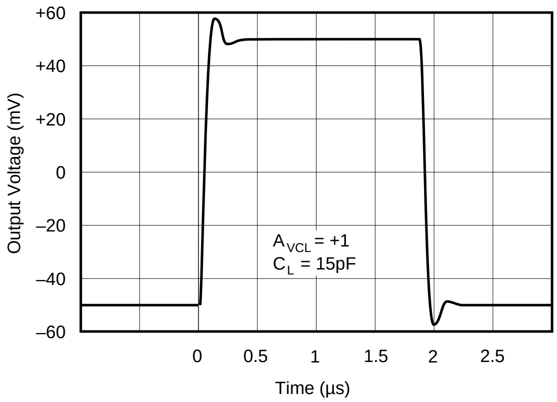




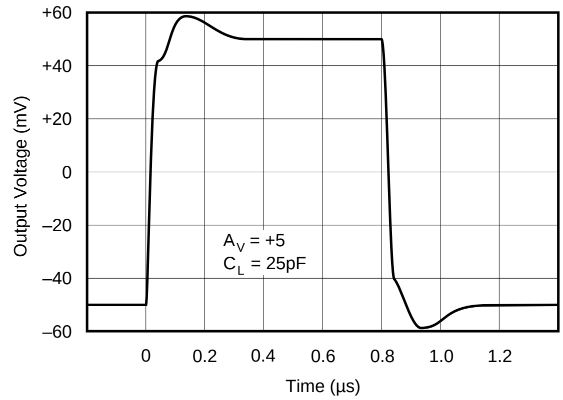
TYPICAL PERFORMANCE CURVES (CONT)

T_A = +25°C, $\pm V_{CC}$ = ±15VDC unless otherwise noted.

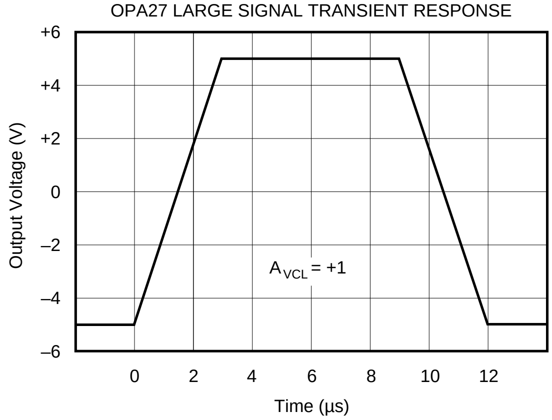
OPA27 SMALL SIGNAL TRANSIENT RESPONSE



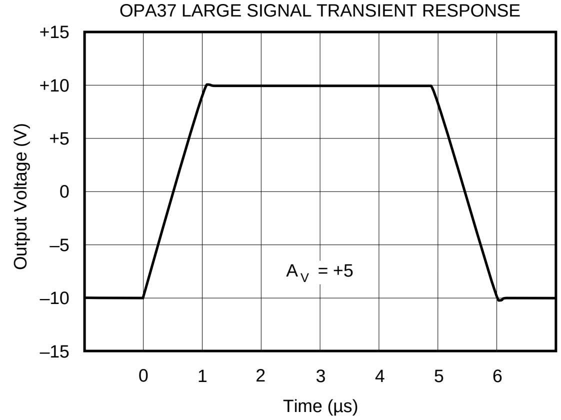
OPA37 SMALL SIGNAL TRANSIENT RESPONSE



OPA27 LARGE SIGNAL TRANSIENT RESPONSE



OPA37 LARGE SIGNAL TRANSIENT RESPONSE



APPLICATIONS INFORMATION

OFFSET VOLTAGE ADJUSTMENT

The OPA27/37 offset voltage is laser-trimmed and will require no further trim for most applications. Offset voltage drift will not be degraded when the input offset is nulled with a 10kΩ trim potentiometer. Other potentiometer values from 1kΩ to 1MΩ can be used but V_{OS} drift will be degraded by an additional 0.1 to 0.2µV/°C. Nulling large system offsets by use of the offset trim adjust will degrade drift performance by approximately 3.3µV/°C per millivolt of offset. Large system offsets can be nulled without drift degradation by input summing.

The conventional offset voltage trim circuit is shown in Figure 3. For trimming very small offsets, the higher resolution circuit shown in Figure 4 is recommended.

The OPA27/37 can replace 741-type operational amplifiers by removing or modifying the trim circuit.

THERMOELECTRIC POTENTIALS

The OPA27/37 is laser-trimmed to microvolt-level input offset voltage and for very low input offset voltage drift.

Careful layout and circuit design techniques are necessary to prevent offset and drift errors from external thermoelectric potentials. Dissimilar metal junctions can generate small EMFs if care is not taken to eliminate either their sources (lead-to-PC, wiring, etc.) or their temperature difference. See Figure 11.

Short, direct mounting of the OPA27/37 with close spacing of the input pins is highly recommended. Poor layout can result in circuit drifts and offsets which are an order of magnitude greater than the operational amplifier alone.

NOISE: BIPOLAR VERSUS FET

Low-noise circuit design requires careful analysis of all noise sources. External noise sources can dominate in many cases, so consider the effect of source resistance on overall operational amplifier noise performance. At low source impedances, the lower voltage noise of a bipolar operational amplifier is superior, but at higher impedances the high current noise of a bipolar amplifier becomes a serious liability. Above about 15kΩ the Burr-Brown OPA111 low-noise FET operational amplifier is recommended for lower total noise than the OPA27 (see Figure 5).

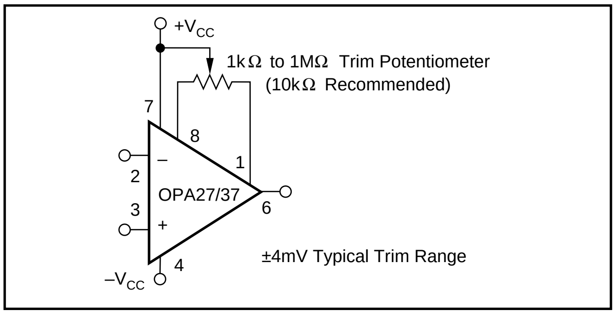


FIGURE 3. Offset Voltage Trim.

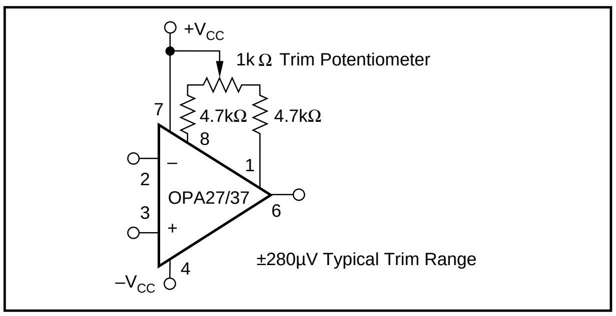


FIGURE 4. High Resolution Offset Voltage Trim.

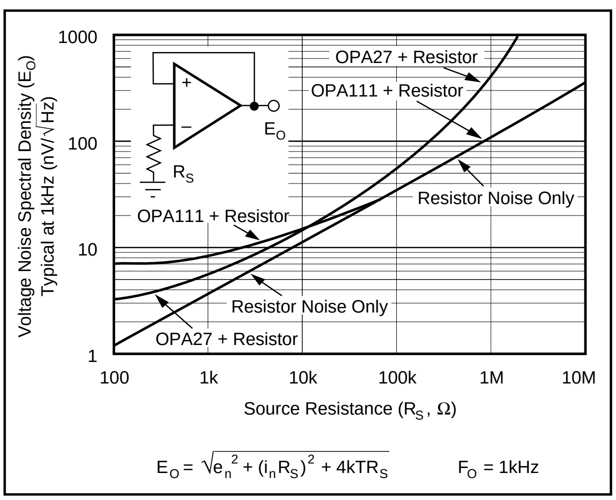


FIGURE 5. Voltage Noise Spectral Density Versus Source Resistance.

COMPENSATION

Although internally compensated for unity-gain stability, the OPA27 may require a small capacitor in parallel with a feedback resistor (R_f) which is greater than 2kΩ. This capacitor will compensate the pole generated by R_f and C_{IN} and eliminate peaking or oscillation.

INPUT PROTECTION

Back-to-back diodes are used for input protection on the OPA27/37. Exceeding a few hundred millivolts differential input signal will cause current to flow and without external current limiting resistors the input will be destroyed.

Accidental static discharge as well as high current can damage the amplifier's input circuit. Although the unit may still be functional, important parameters such as input offset voltage, drift, and noise may be permanently damaged as will any precision operational amplifier subjected to this abuse.

Transient conditions can cause feedthrough due to the amplifier's finite slew rate. When using the OP-27 as a unity-gain buffer (follower) a feedback resistor of 1kΩ is recommended (see Figure 6).

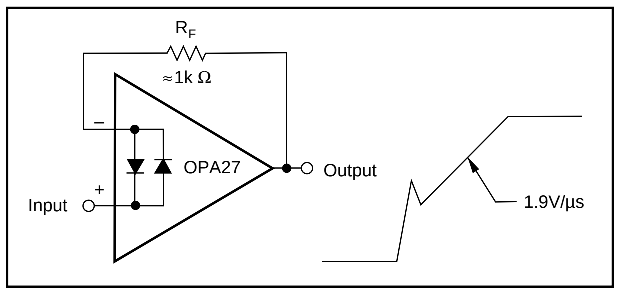


FIGURE 6. Pulsed Operation.

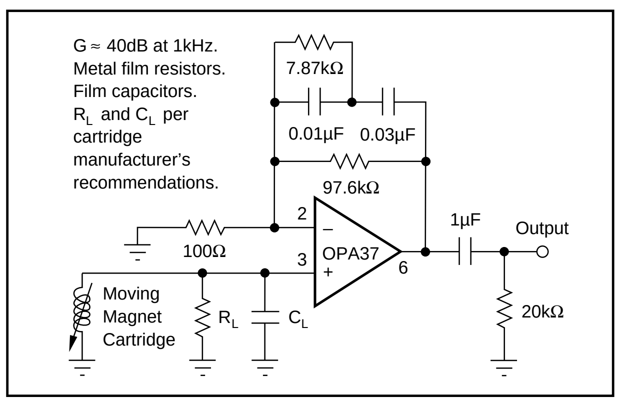


FIGURE 7. Low-Noise RIAA Preamplifier.

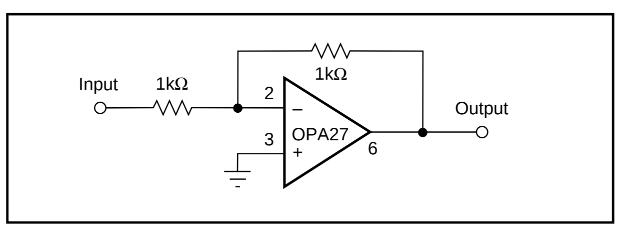


FIGURE 8. Unity-Gain Inverting Amplifier.

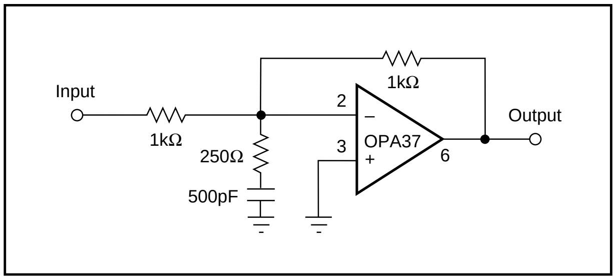


FIGURE 9. High Slew Rate Unity-Gain Inverting Amplifier.

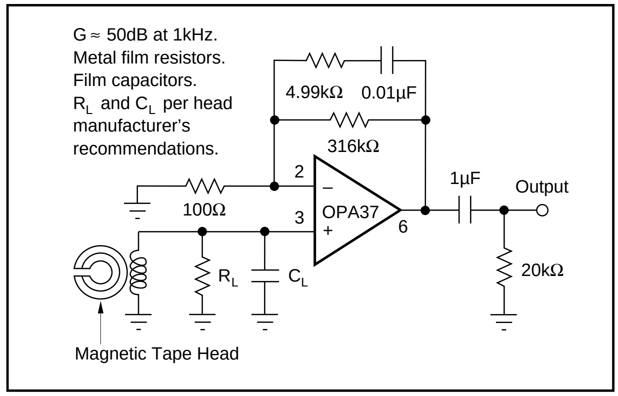


FIGURE 10. NAB Tape Head Preamplifier.

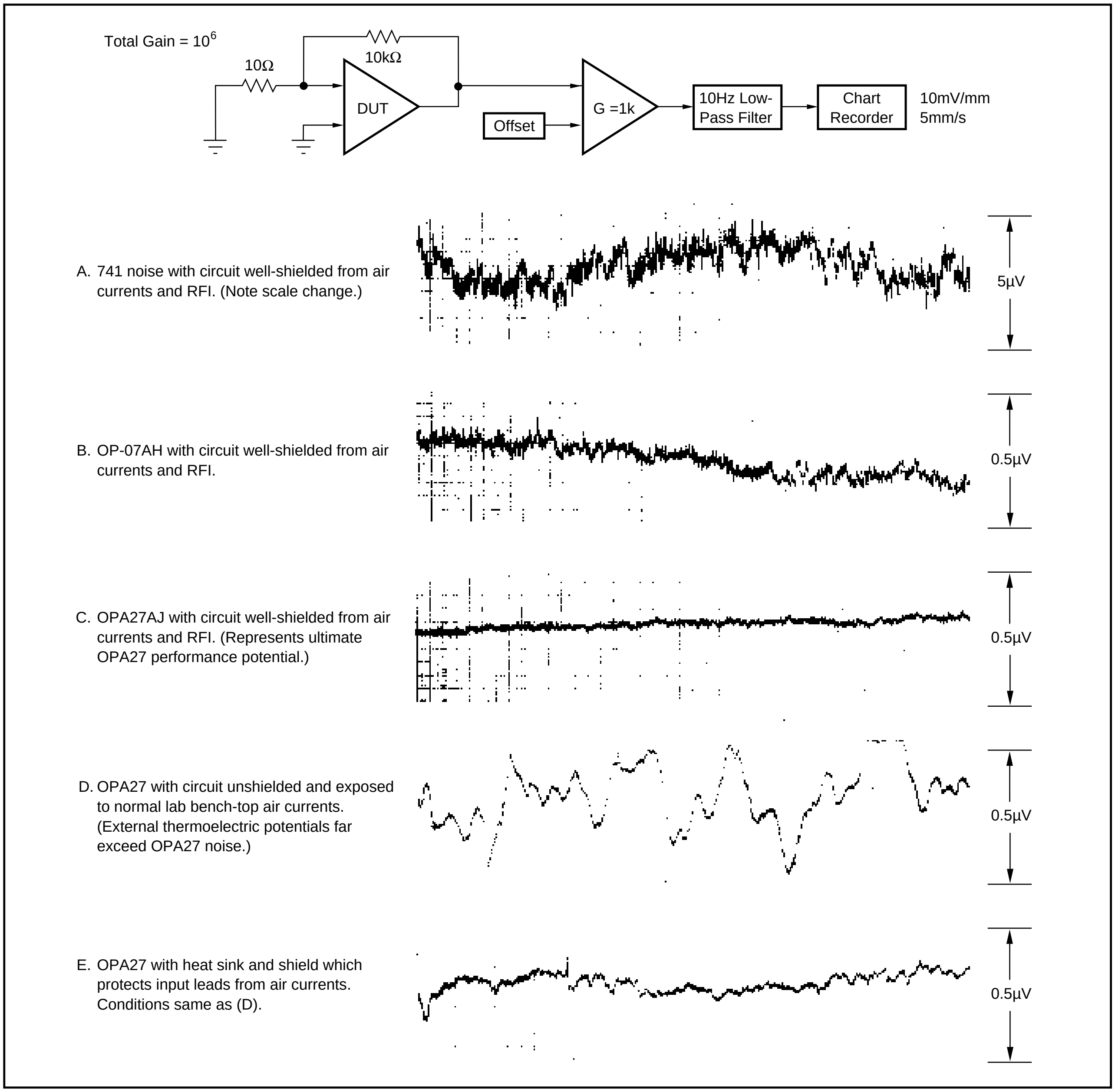


FIGURE 11. Low Frequency Noise Comparison.

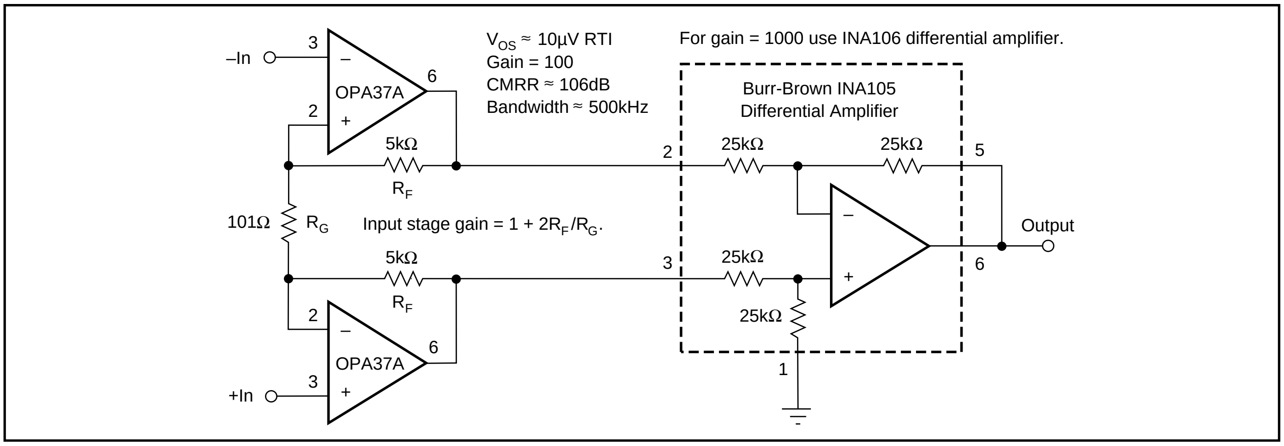


FIGURE 12. Low Noise Instrumentation Amplifier.

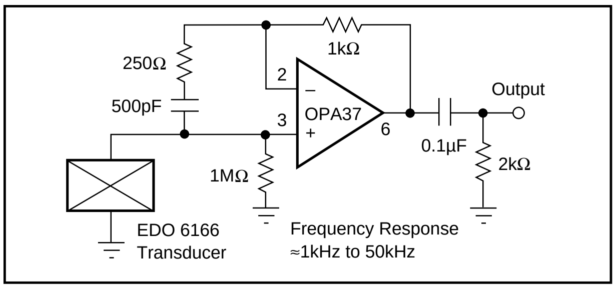


FIGURE 13. Hydrophone Preamplifier.

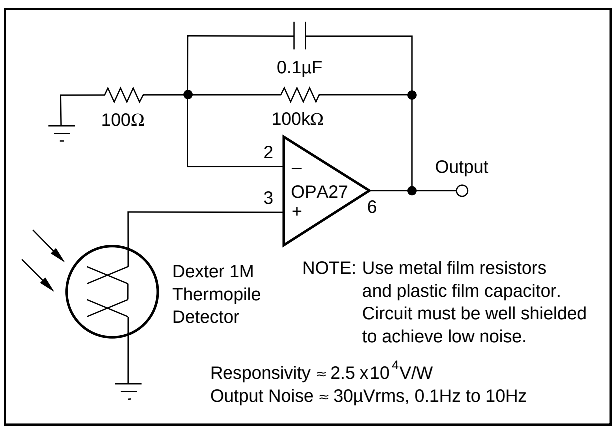


FIGURE 14. Long-Wavelength Infrared Detector Amplifier.

TTL Input	Gain
"1"	+1
"0"	–1

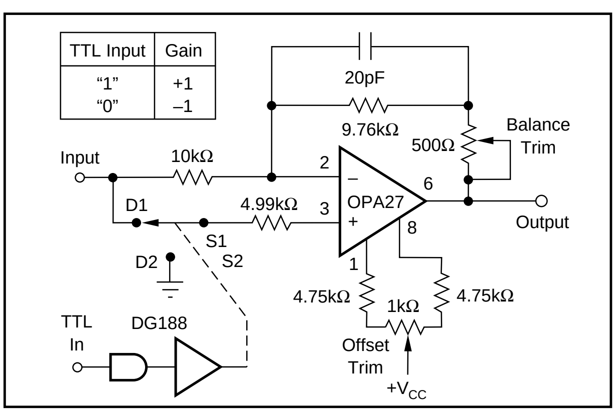


FIGURE 15. High Performance Synchronous Demodulator.

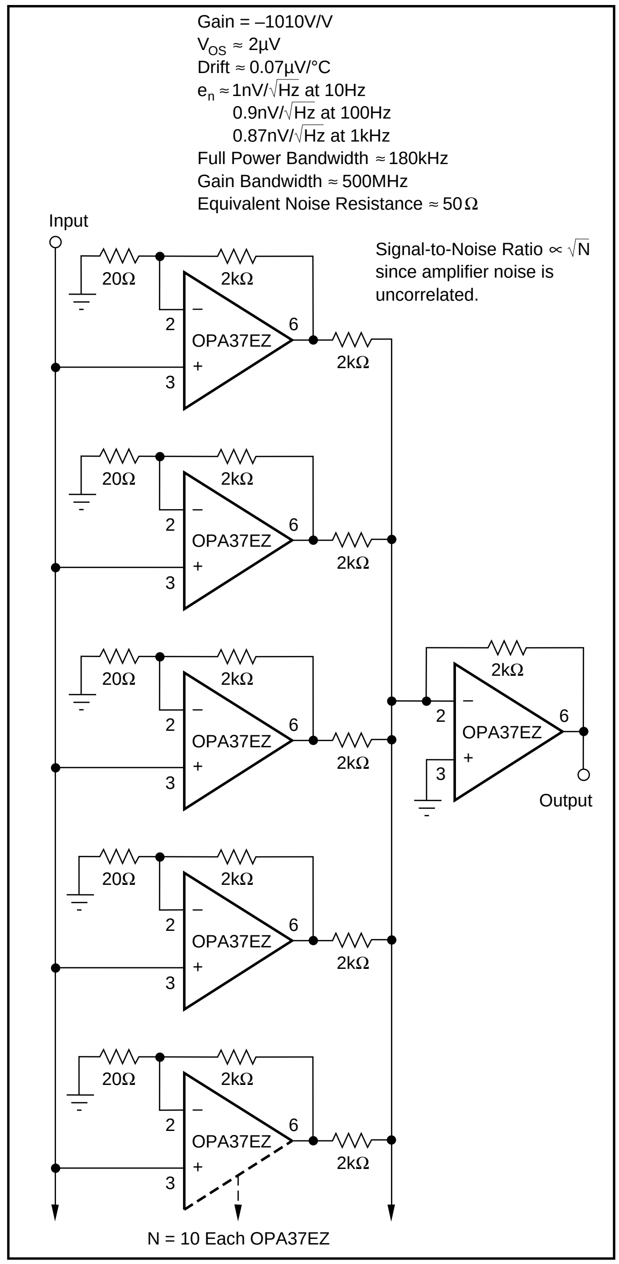


FIGURE 16. Ultra-Low Noise "N" Stage Parallel Amplifier.

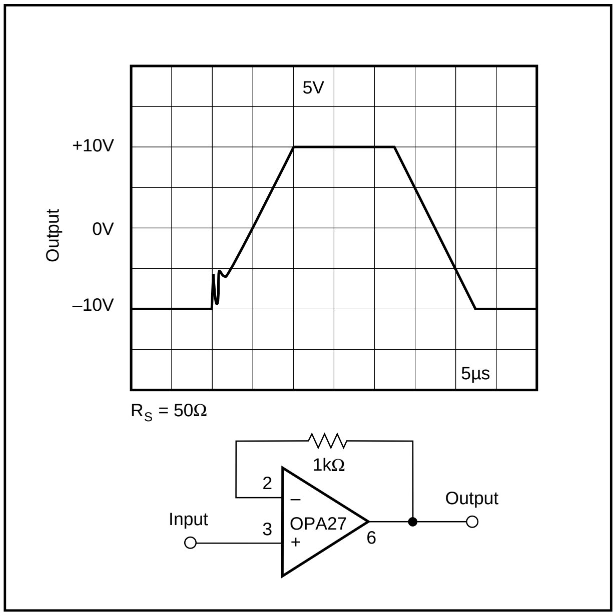


FIGURE 17. Unity-Gain Buffer.

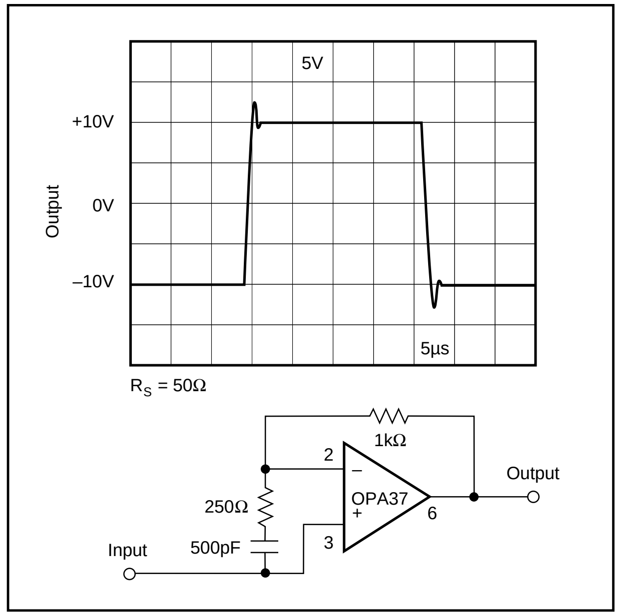


FIGURE 18. High Slew Rate Unity-Gain Buffer.

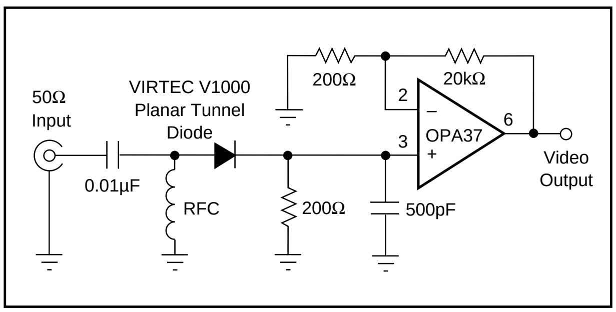


FIGURE 19. RF Detector and Video Amplifier.

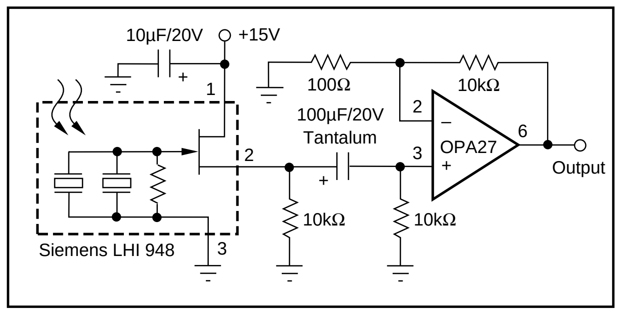


FIGURE 20. Balanced Pyroelectric Infrared Detector.

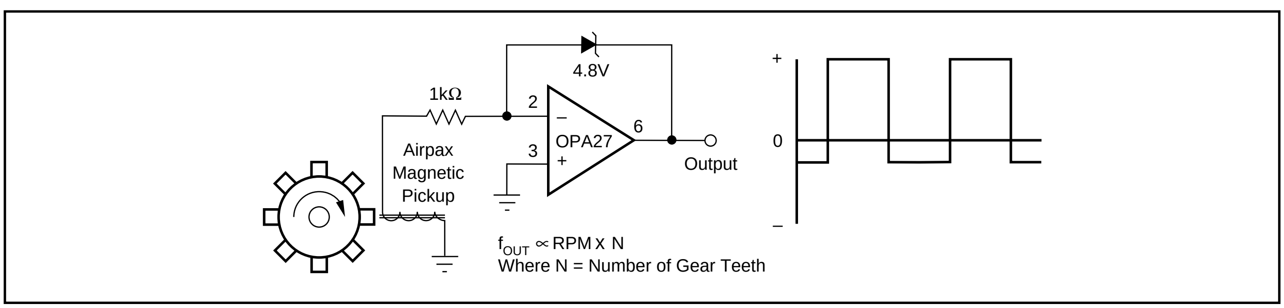


FIGURE 21. Magnetic Tachometer.