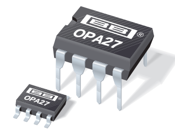


OPA27
OPA37

SBOS135B – JANUARY 1984 – REVISED FEBRUARY 2005

Ultra-Low Noise, Precision OPERATIONAL AMPLIFIERS

FEATURES

- **LOW NOISE: 4.5nV/√Hz max at 1kHz**
- **LOW OFFSET: 100μV max**
- **LOW DRIFT: 0.4μV/°C**
- **HIGH OPEN-LOOP GAIN: 117dB min**
- **HIGH COMMON-MODE REJECTION: 100dB min**
- **HIGH POWER-SUPPLY REJECTION: 94dB min**
- **FITS OP-07, OP-05, AD510, AND AD517 SOCKETS**

APPLICATIONS

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

DESCRIPTION

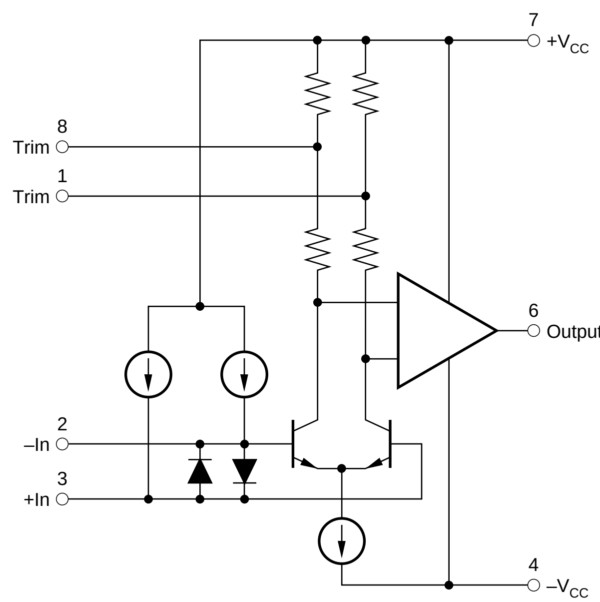
The OPA27 and OPA37 are ultra-low noise, high-precision monolithic operational amplifiers.

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 Texas Instrument OPA27 and OPA37 are improved replacements for the industry-standard OP-27 and OP-37.



ABSOLUTE MAXIMUM RATINGS[1]

Supply Voltage	±22V
Internal Power Dissipation [2]	500mW
Input Voltage	$\pm V_{CC}$
Output Short-Circuit Duration [3]	Indefinite
Differential Input Voltage [4]	±0.7V
Differential Input Current [4]	±25mA
Storage Temperature Range	–55°C to +125°C
Operating Temperature Range	–40°C to +85°C
Lead Temperature:	
P (soldering, 10s)	+300°C
U (soldering, 3s)	+260°C

NOTES: (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. (2) Maximum package power dissipation versus ambient temperature. (2) To common with $\pm V_{CC}$ = 15V. (4) 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.

PACKAGE/ORDERING INFORMATION[1]

PRODUCT	PACKAGE-LEAD	θ_{JA}	PACKAGE DRAWING	PACKAGE MARKING
OPA27	DIP-8	100°C/W	P	OPA27GP
OPA27	SO-8	160°C/W	D	OPA27U
OPA37	DIP-8	100°C/W	P	OPA37GP
OPA37	SO-8	160°C/W	D	OPA37U

NOTE: (1) For the most current package and ordering information, see the Package Option Addendum located at the end of this document, or see the TI website at www.ti.com.

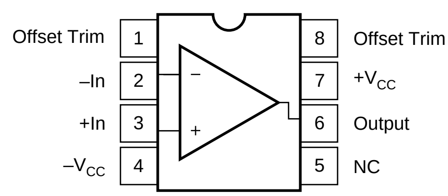
ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

PIN CONFIGURATION

Top View



NC = No Connection

ELECTRICAL CHARACTERISTICS

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

PARAMETER	CONDITIONS	OPA27 OPA37 MIN	TYP	MAX	UNITS
INPUT NOISE (6)					
Voltage, f_O = 10Hz			3.8	8.0	nV/√Hz
f_O = 30Hz			3.3	5.6	nV/√Hz
f_O = 1kHz			3.2	4.5	nV/√Hz
f_B = 0.1Hz to 10Hz			0.09	0.25	μV_{PP}
Current,(1) f_O = 10Hz			1.7		pA/√Hz
f_O = 30Hz			1.0		pA/√Hz
f_O = 1kHz			0.4	0.6	pA/√Hz
OFFSET VOLTAGE (2)					
Input Offset Voltage			±25	±100	µV
Average Drift (3)	$T_{A\ MIN}$ to $T_{A\ MAX}$		±0.4	±1.8 (6)	µV/°C
Long Term Stability (4)			0.4	2.0	µV/mo
Supply Rejection	±V_{CC} = 4 to 18V	94	120		dB
	±V_{CC} = 4 to 18V		±1	±20	µV/V
BIAS CURRENT					
Input Bias Current			±15	±80	nA
OFFSET CURRENT					
Input Offset Current			10	75	nA
IMPEDANCE					
Common-Mode			2 || 2.5		GΩ || pF
VOLTAGE RANGE					
Common-Mode Input Range		±11	±12.3		V
Common-Mode Rejection	V_{IN} = ±11VDC	100	122		dB
OPEN-LOOP VOLTAGE GAIN, DC	R_L ≥ 2kΩ	117	124		dB
	R_L ≥ 1kΩ		124		dB
FREQUENCY RESPONSE					
Gain-Bandwidth Product (5)	OPA27	5 (6)	8		MHz
	OPA37	45 (6)	63		MHz
Slew Rate (5)	V_O = ±10V,				
	R_L = 2kΩ				
	OPA27, G = +1	1.7 (6)	1.9		V/µs
	OPA37, G = +5	11 (6)	11.9		V/µs
Settling Time, 0.01%	OPA27, G = +1		25		µs
	OPA37, G = +5		25		µs
RATED OUTPUT					
Voltage Output	R_L ≥ 2kΩ	±12	±13.8		V
	R_L ≥ 600Ω	±10	±12.8		V
Output Resistance	DC, Open Loop		70		Ω
Short Circuit Current	R_L = 0Ω		25	60 (6)	mA
POWER SUPPLY					
Rated Voltage			±15		VDC
Voltage Range,					
Derated Performance		±4		±22	VDC
Current, Quiescent	I_O = 0mADC		3.3	5.7	mA
TEMPERATURE RANGE					
Specification		–40		+85	°C
Operating		–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 specification 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 specified by design.

ELECTRICAL CHARACTERISTICS

At V_{CC} = ±15V and –40°C ≤ T_A ≤ +85°C, unless otherwise noted.

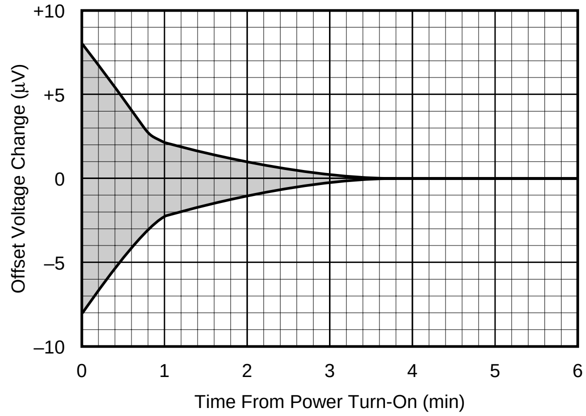
PARAMETER	CONDITIONS	OPA27 OPA37 MIN	TYP	MAX	UNITS
INPUT VOLTAGE (1)					
Input Offset Voltage			±48	±220 (3)	µV
Average Drift (2)	$T_{A\ MIN}$ to $T_{A\ MAX}$		±0.4	±1.8 (3)	µV/°C
Supply Rejection	±V_{CC} = 4.5 to 18V				
	±V_{CC} = 4.5 to 18V	90 (3)	122		dB
BIAS CURRENT					
Input Bias Current			±21	±150 (3)	nA
OFFSET CURRENT					
Input Offset Current			20	135 (3)	nA
VOLTAGE RANGE					
Common-Mode Input Range		±10.5 (3)	±11.8		V
Common-Mode Rejection	V_{IN} = ±11VDC	96 (3)	122		dB
OPEN-LOOP GAIN, DC					
Open-Loop Voltage Gain	R_L ≥ 2kΩ	113 (3)	120		dB
RATED OUTPUT					
Voltage Output	R_L = 2kΩ	±11.0 (3)	±13.4		V
Short Circuit Current	V_O = 0VDC		25		mA
TEMPERATURE RANGE					
Specification		–40		+85	°C

NOTES: (1) Offset voltage specification 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 specified by design.

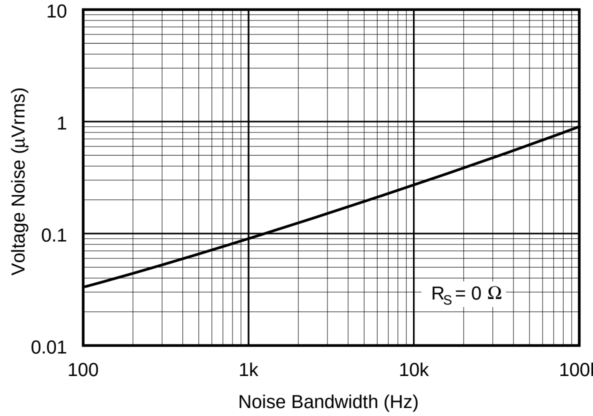
TYPICAL PERFORMANCE CURVES

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

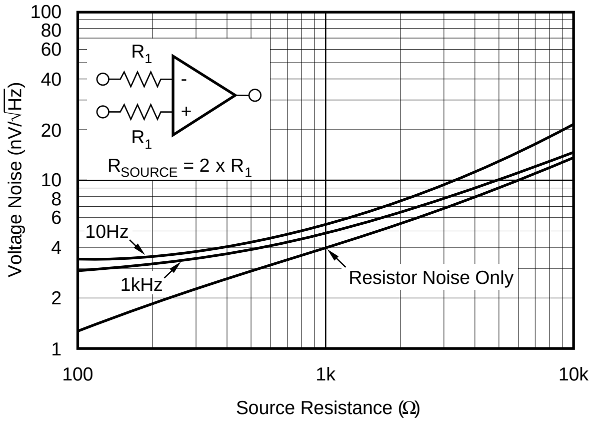
INPUT OFFSET VOLTAGE WARM-UP DRIFT



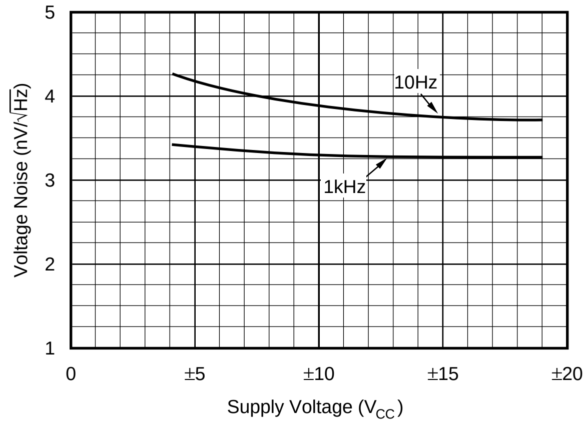
INPUT VOLTAGE NOISE vs NOISE BANDWIDTH
(0.1Hz to Indicated Frequency)



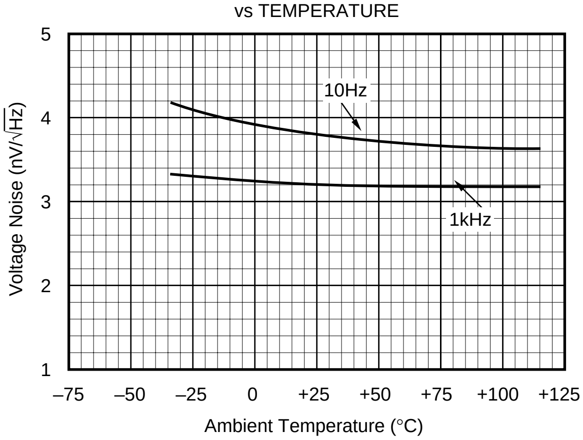
TOTAL INPUT VOLTAGE NOISE SPECTRAL DENSITY
vs SOURCE RESISTANCE



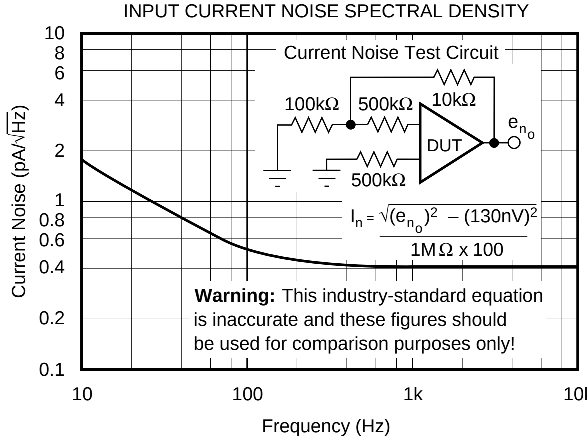
VOLTAGE NOISE SPECTRAL DENSITY
vs SUPPLY VOLTAGE



VOLTAGE NOISE SPECTRAL DENSITY
vs TEMPERATURE



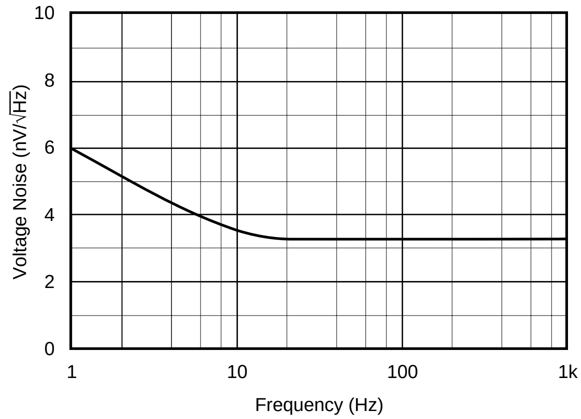
INPUT CURRENT NOISE SPECTRAL DENSITY



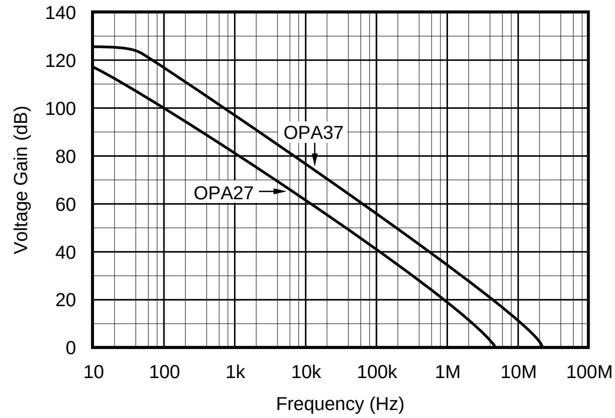
TYPICAL PERFORMANCE CURVES (Cont.)

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

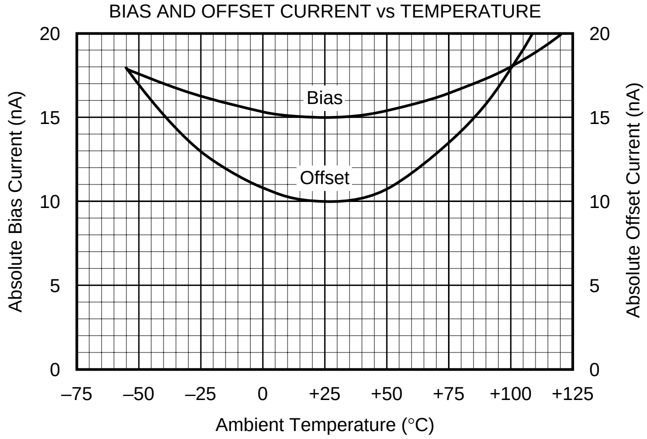
INPUT VOLTAGE NOISE SPECTRAL DENSITY



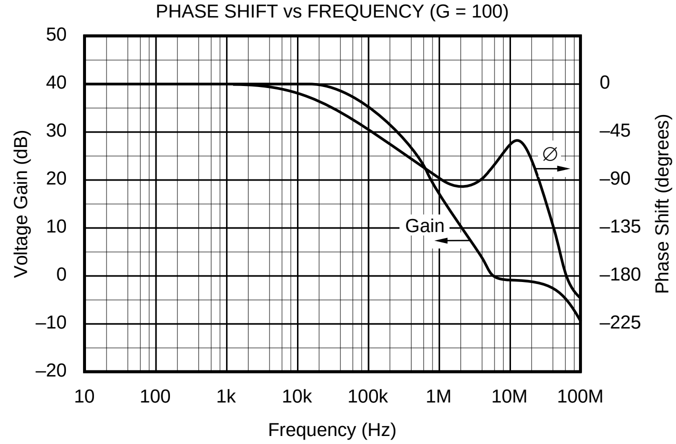
OPEN-LOOP FREQUENCY RESPONSE



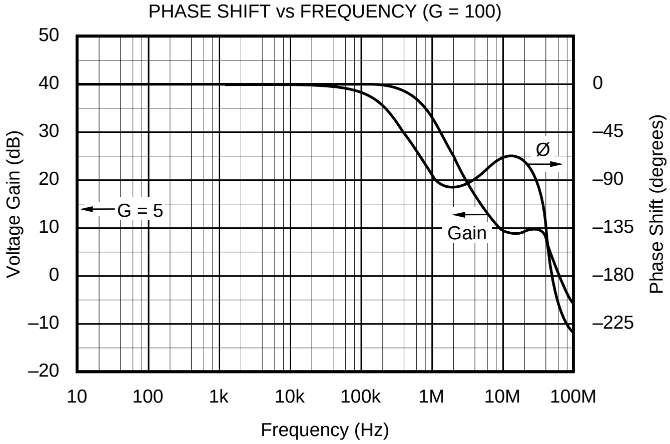
BIAS AND OFFSET CURRENT vs TEMPERATURE



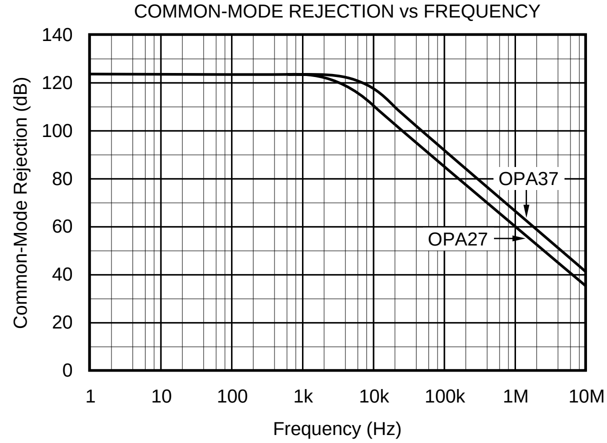
OPA27 CLOSED-LOOP VOLTAGE GAIN AND PHASE SHIFT vs FREQUENCY (G = 100)



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



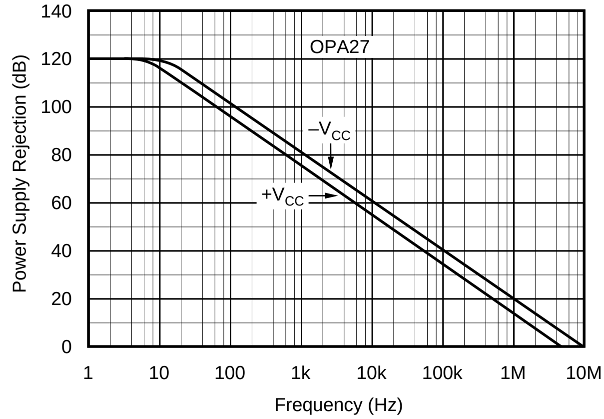
COMMON-MODE REJECTION vs FREQUENCY



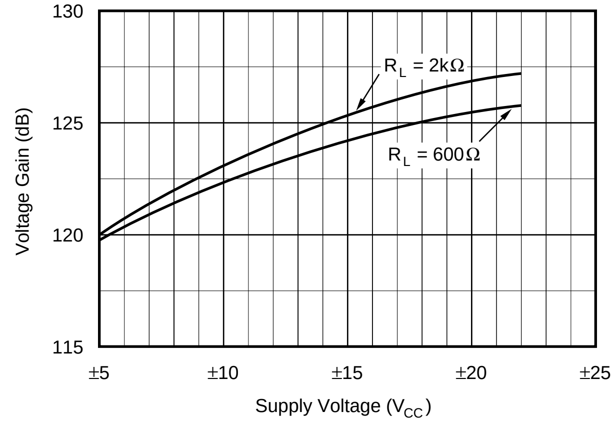
TYPICAL PERFORMANCE CURVES (Cont.)

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

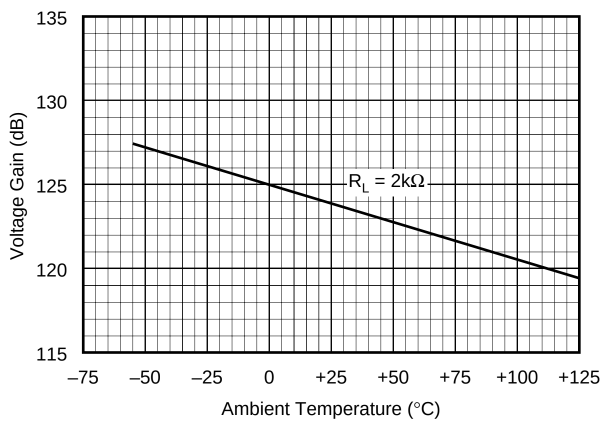
POWER SUPPLY REJECTION vs FREQUENCY



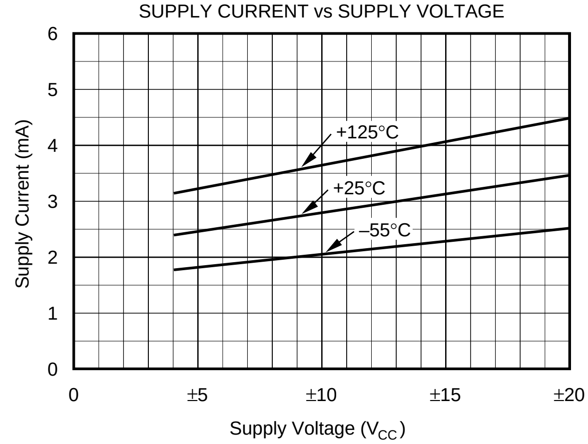
OPEN-LOOP VOLTAGE GAIN vs SUPPLY VOLTAGE



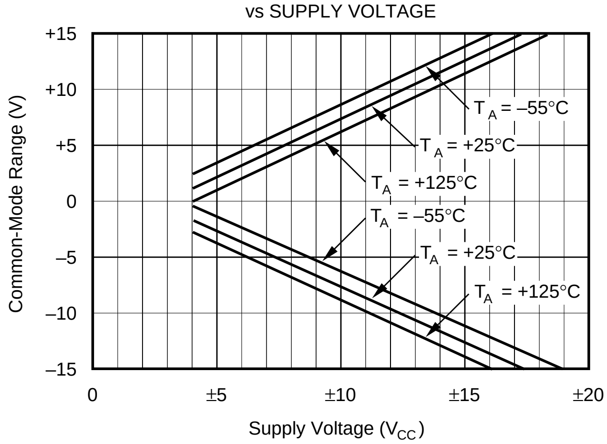
OPEN-LOOP VOLTAGE GAIN vs TEMPERATURE



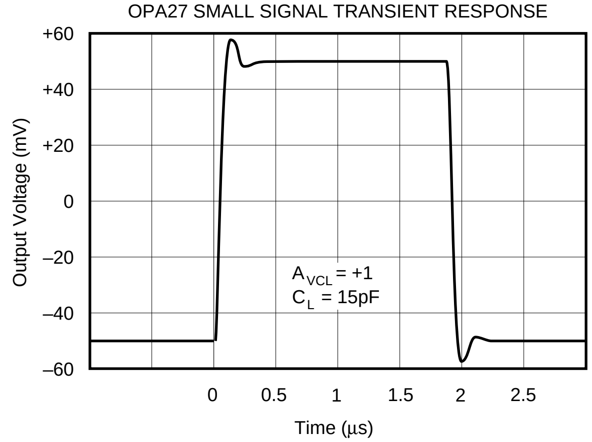
SUPPLY CURRENT vs SUPPLY VOLTAGE



COMMON-MODE INPUT VOLTAGE RANGE
vs SUPPLY VOLTAGE

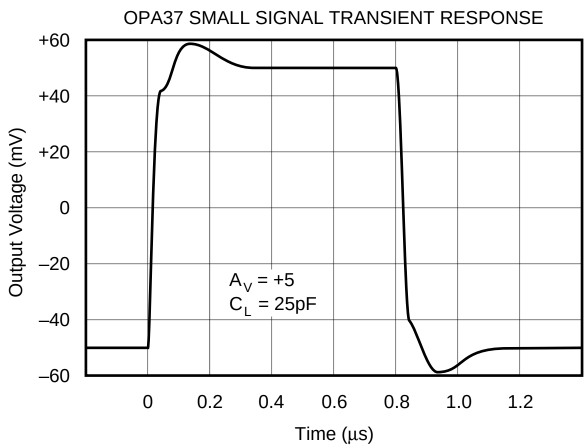


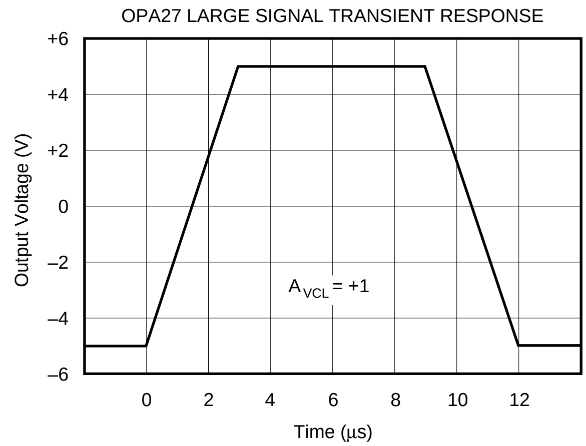
OPA27 SMALL SIGNAL TRANSIENT RESPONSE

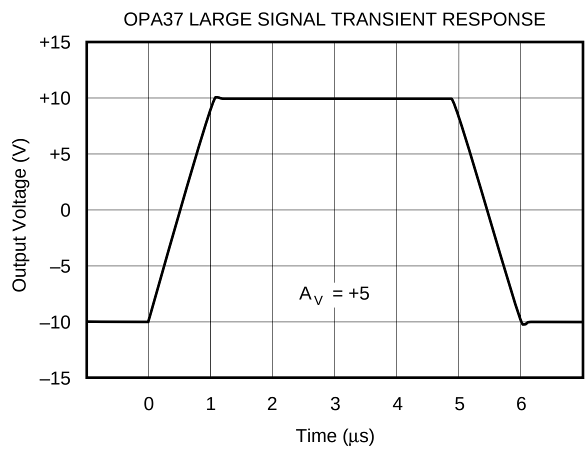


TYPICAL PERFORMANCE CURVES (Cont.)

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







APPLICATIONS INFORMATION

OFFSET VOLTAGE ADJUSTMENT

The OPA27 and OPA37 offset voltages are laser-trimmed and 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 0.1μV/°C 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.

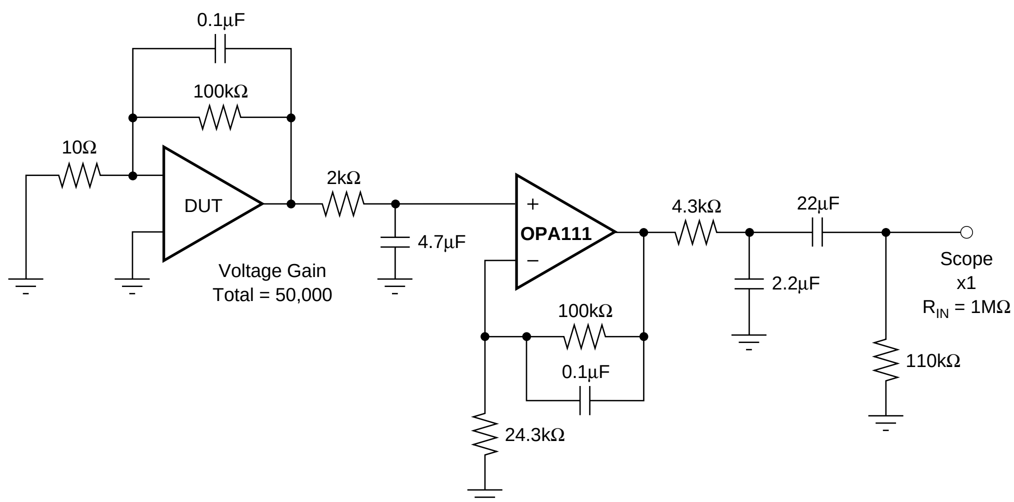
The OPA27 and OPA37 can replace 741-type operational amplifiers by removing or modifying the trim circuit.

THERMOELECTRIC POTENTIALS

The OPA27 and OPA37 are laser-trimmed to microvolt-level input offset voltages, 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 and OPA37 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.



NOTE: All capacitor values are for nonpolarized capacitors only.

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

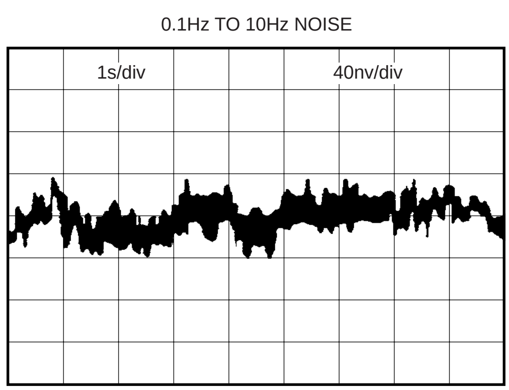


FIGURE 2. Low Frequency Noise.

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 OPA111 low-noise FET operational amplifier is recommended for lower total noise than the OPA27, as shown in Figure 5.

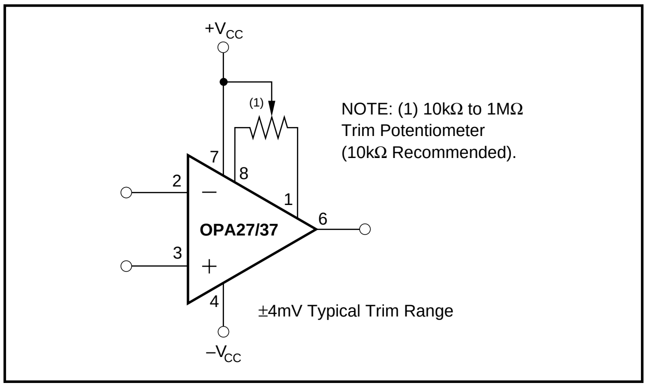


FIGURE 3. Offset Voltage Trim.

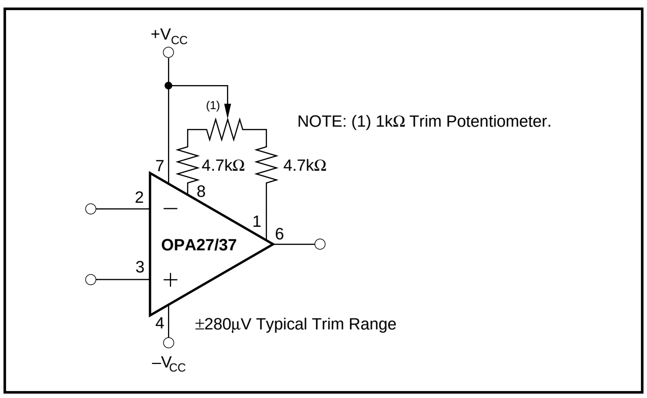


FIGURE 4. High Resolution Offset Voltage Trim.

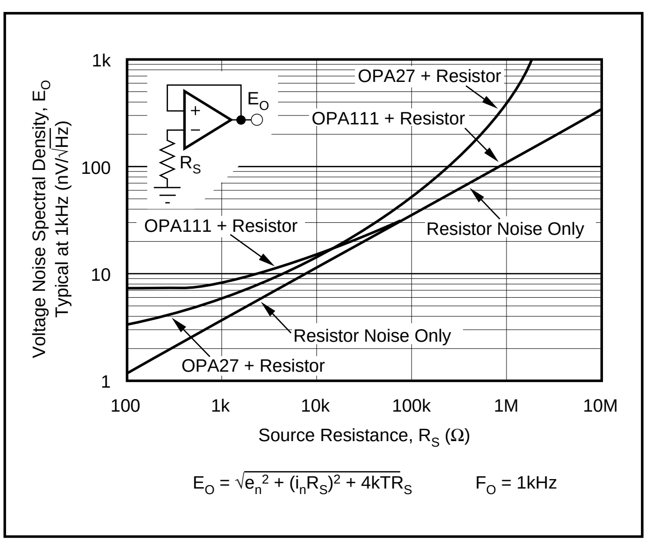


FIGURE 5. Voltage Noise Spectral Density Versus Source Resistance.

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 and OPA37. 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 OPA27 as a unity-gain buffer (follower) a feedback resistor of 1kΩ is recommended, as shown in Figure 6.

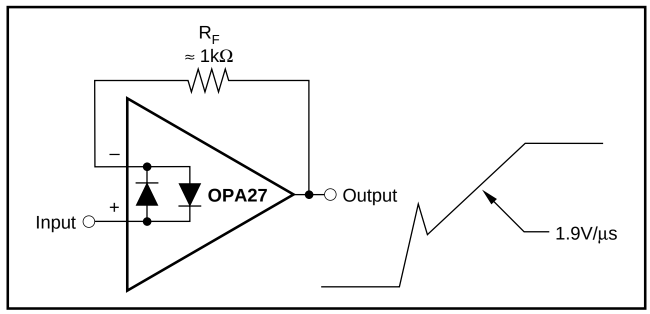


FIGURE 6. Pulsed Operation.

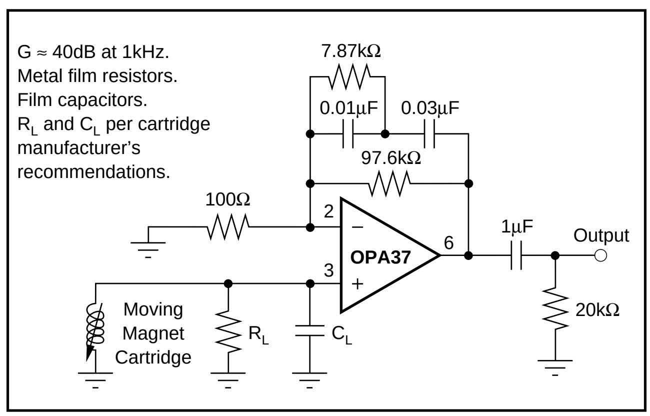


FIGURE 7. Low-Noise RIAA Preamplifier.

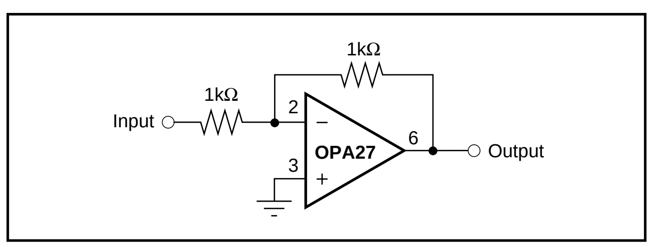


FIGURE 8. Unity-Gain Inverting Amplifier.

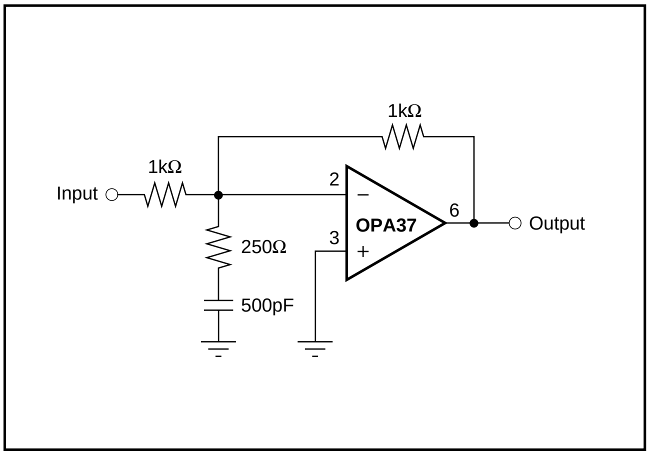


FIGURE 9. High Slew Rate Unity-Gain Inverting Amplifier.

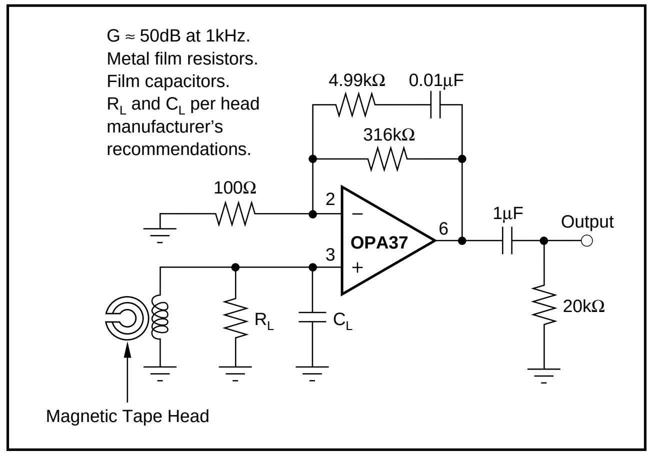


FIGURE 10. NAB Tape Head Preamplifier.

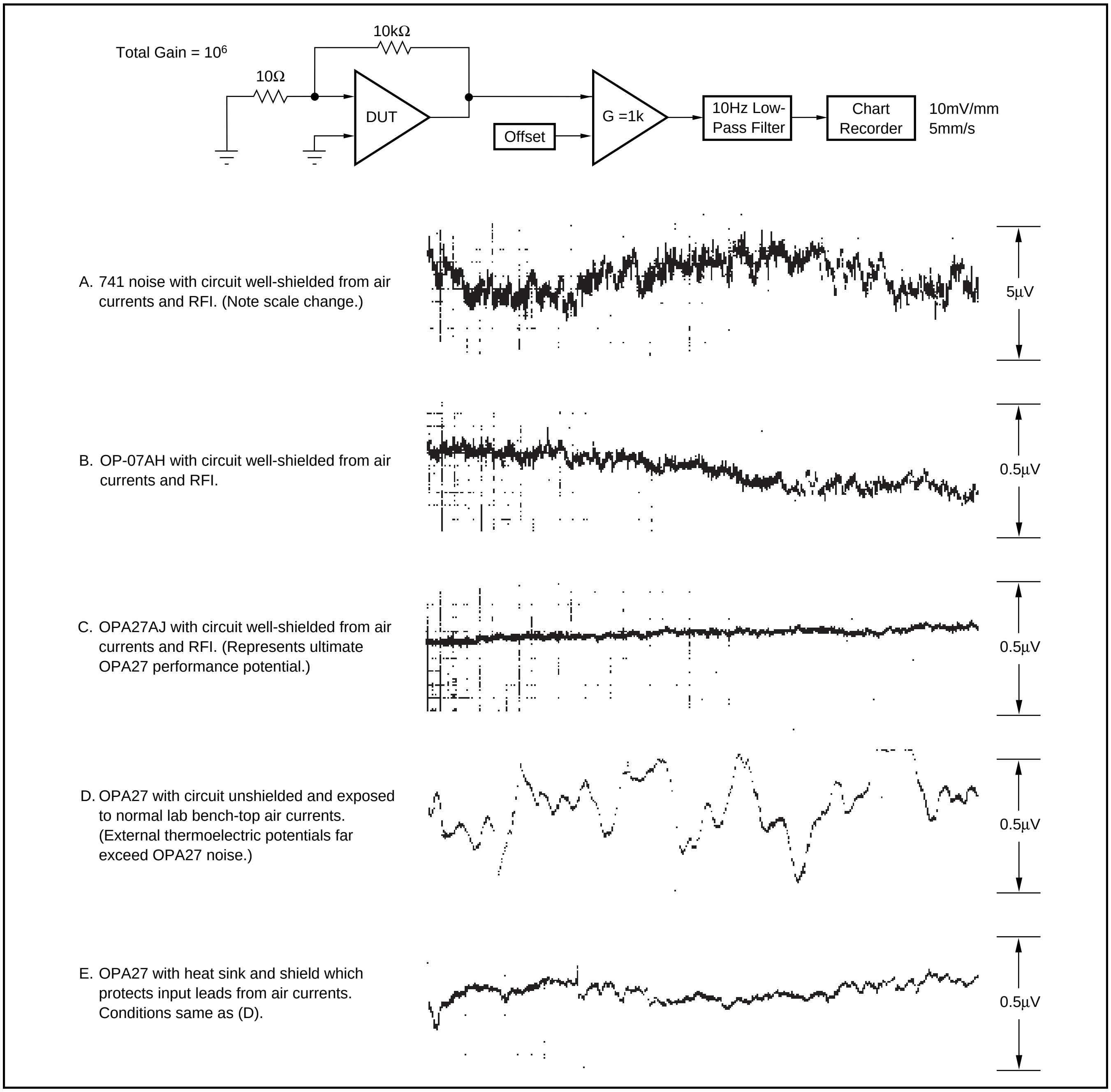


FIGURE 11. Low Frequency Noise Comparison.

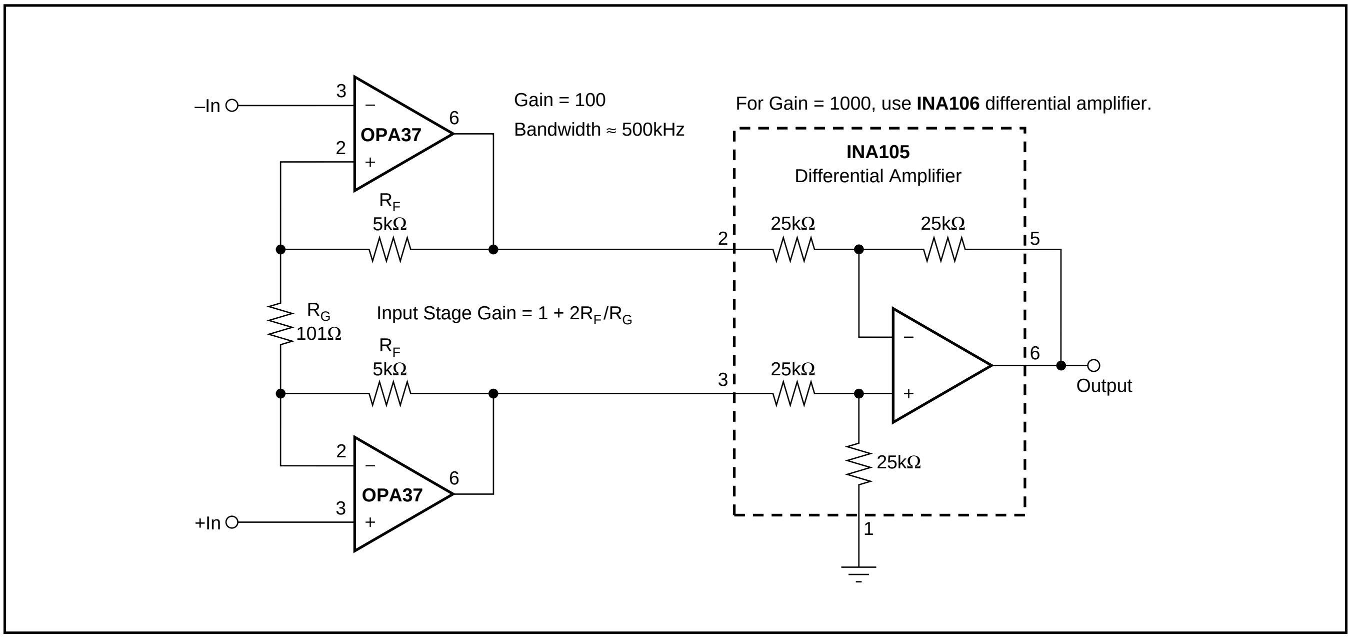


FIGURE 12. Low Noise Instrumentation Amplifier.

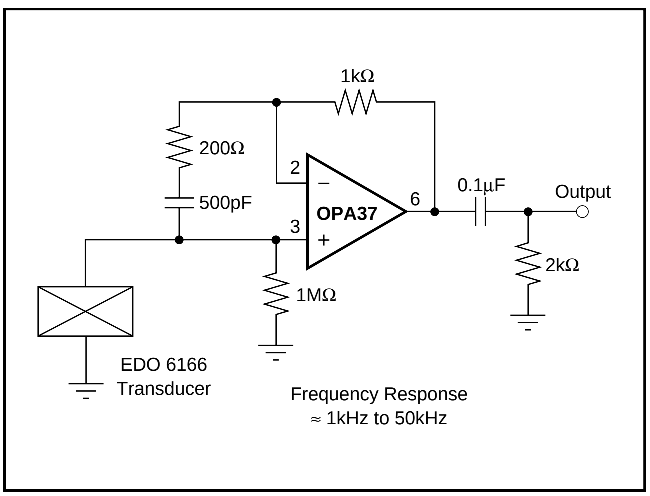


FIGURE 13. Hydrophone Preamplifier.

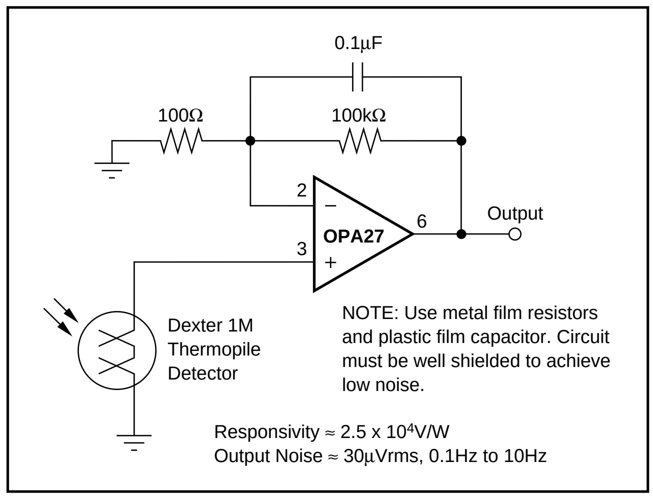
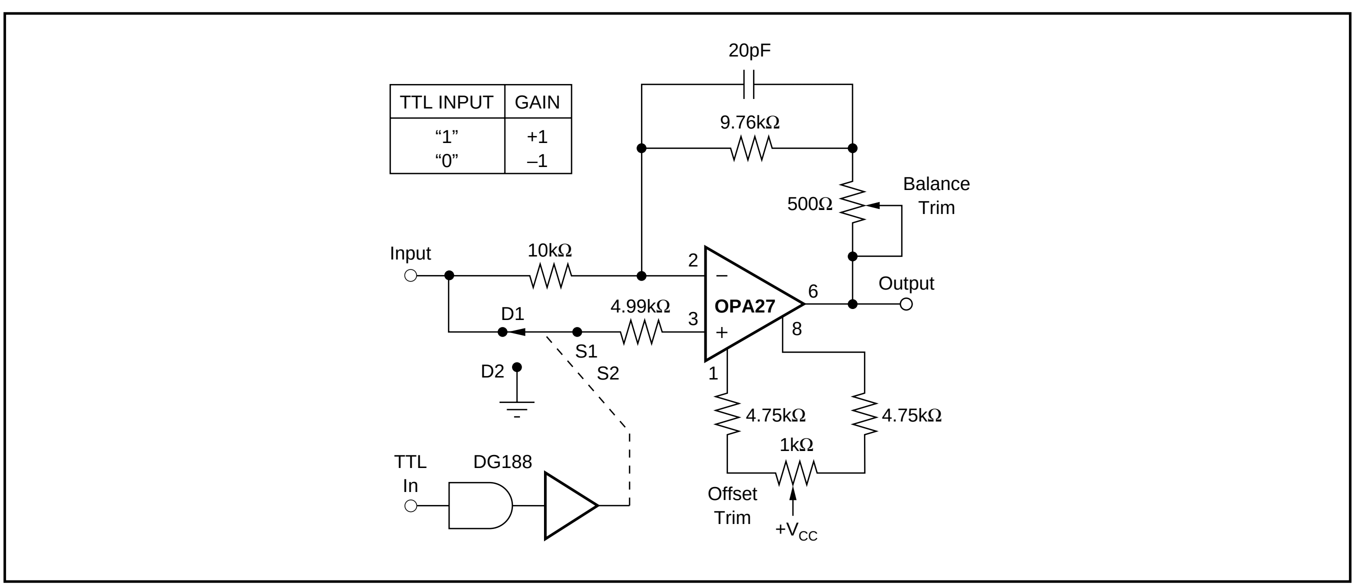


FIGURE 14. Long-Wavelength Infrared Detector Amplifier.



TTL INPUT	GAIN
"1"	+1
"0"	–1

FIGURE 15. High Performance Synchronous Demodulator.

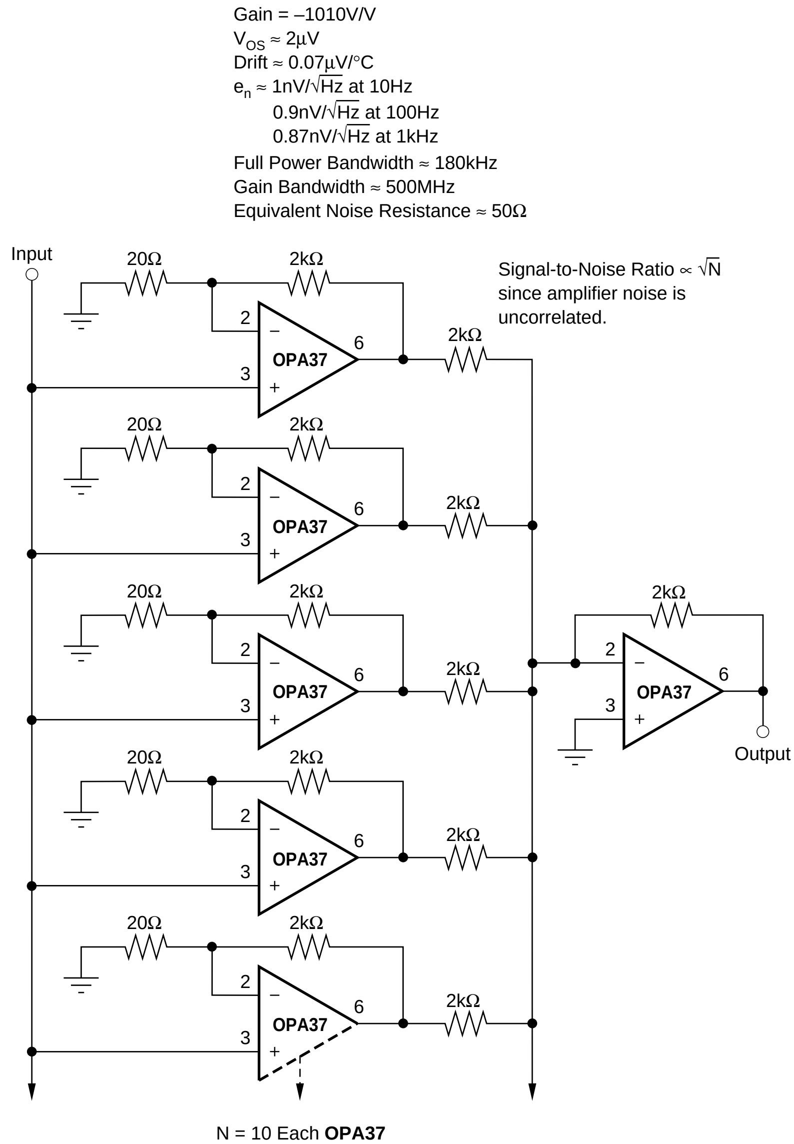


FIGURE 16. Ultra-Low Noise "N"-Stage Parallel Amplifier.

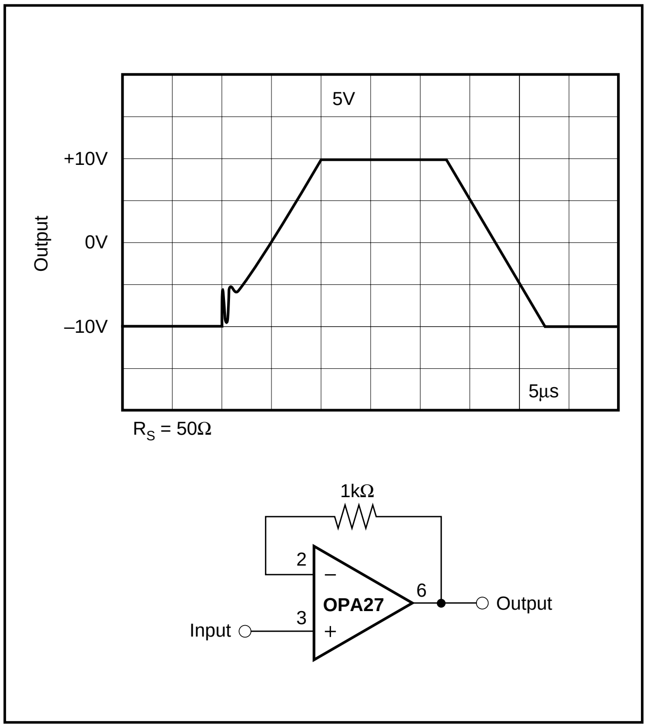


FIGURE 17. Unity-Gain Buffer.

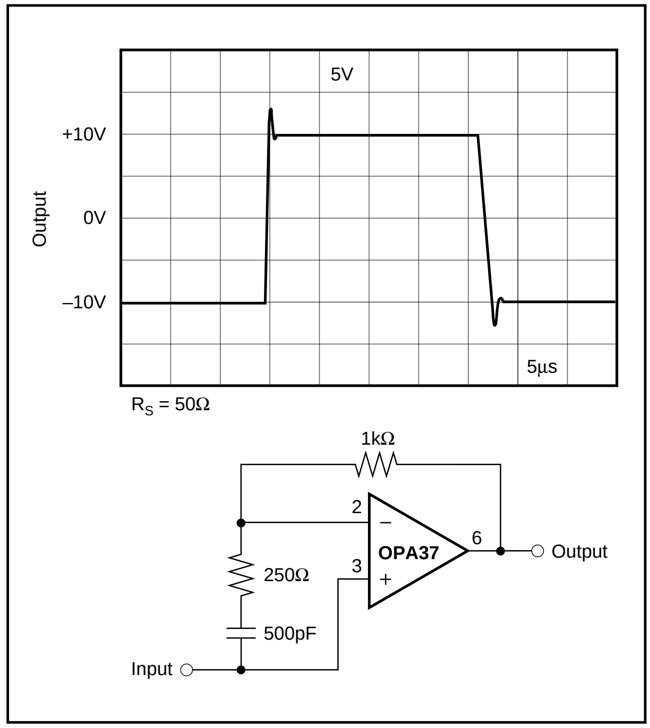


FIGURE 18. High Slew Rate Unity-Gain Buffer.

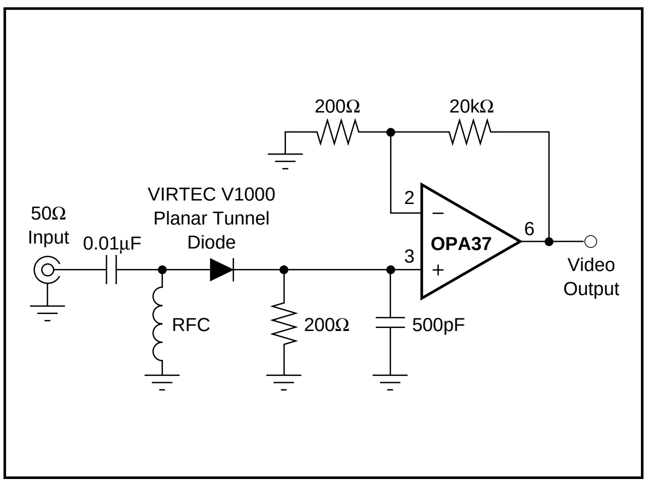


FIGURE 19. RF Detector and Video Amplifier.

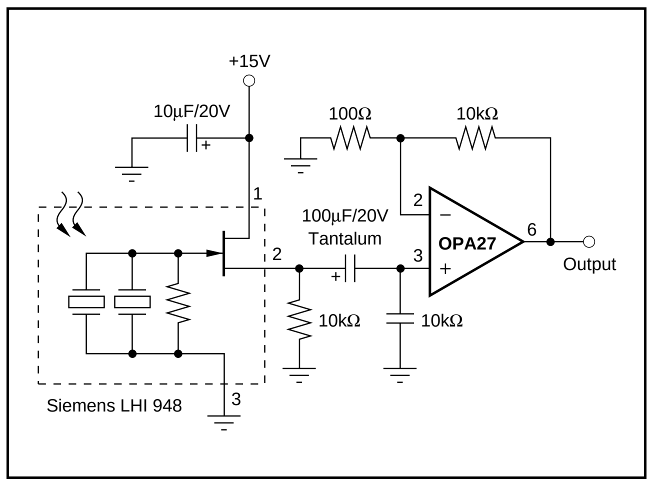


FIGURE 20. Balanced Pyroelectric Infrared Detector.

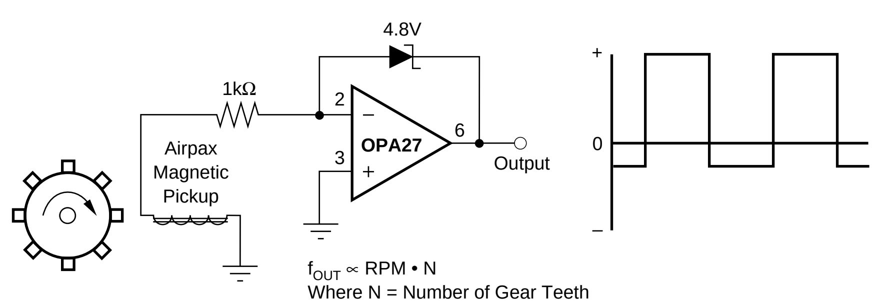


FIGURE 21. Magnetic Tachometer.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
OPA27GP	ACTIVE	PDIP	P	8	50	None	Call TI	Level-NA-NA-NA
OPA27GU	ACTIVE	SOIC	D	8	100	None	CU NIPDAU	Level-2-220C-1 YEAR
OPA27GU/2K5	ACTIVE	SOIC	D	8	2500	None	CU NIPDAU	Level-2-220C-1 YEAR
OPA37GP	ACTIVE	PDIP	P	8	50	None	Call TI	Level-NA-NA-NA
OPA37GU	ACTIVE	SOIC	D	8	100	None	CU SNPB	Level-2-220C-1 YEAR
OPA37GU/2K5	ACTIVE	SOIC	D	8	2500	None	CU SNPB	Level-2-220C-1 YEAR

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - May not be currently available - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
None: Not yet available Lead (Pb-Free).
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Green (RoHS & no Sb/Br): TI defines "Green" to mean "Pb-Free" and in addition, uses package materials that do not contain halogens, including bromine (Br) or antimony (Sb) above 0.1% of total product weight.

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDECindustry standard classifications, and peak solder temperature.

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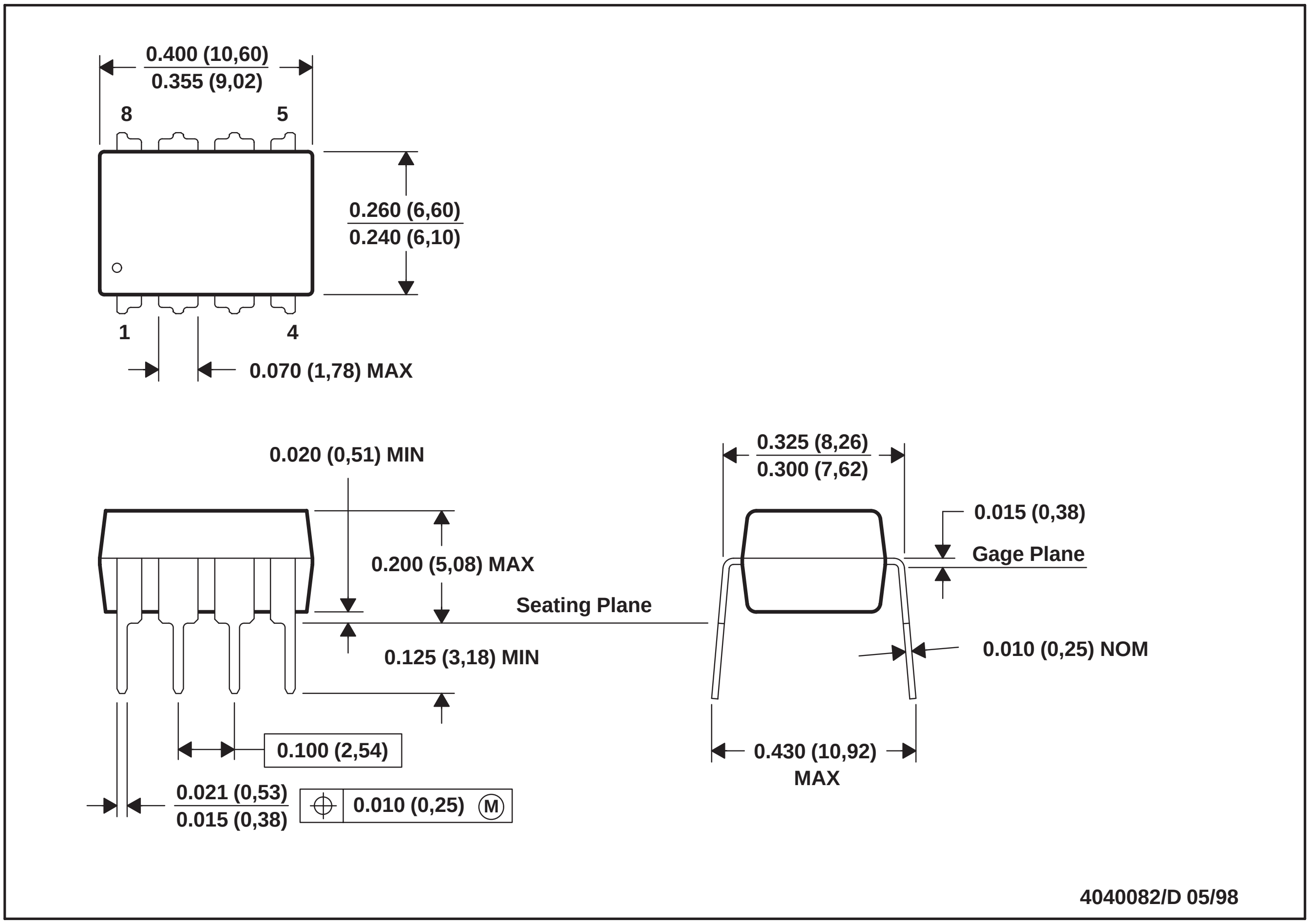
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

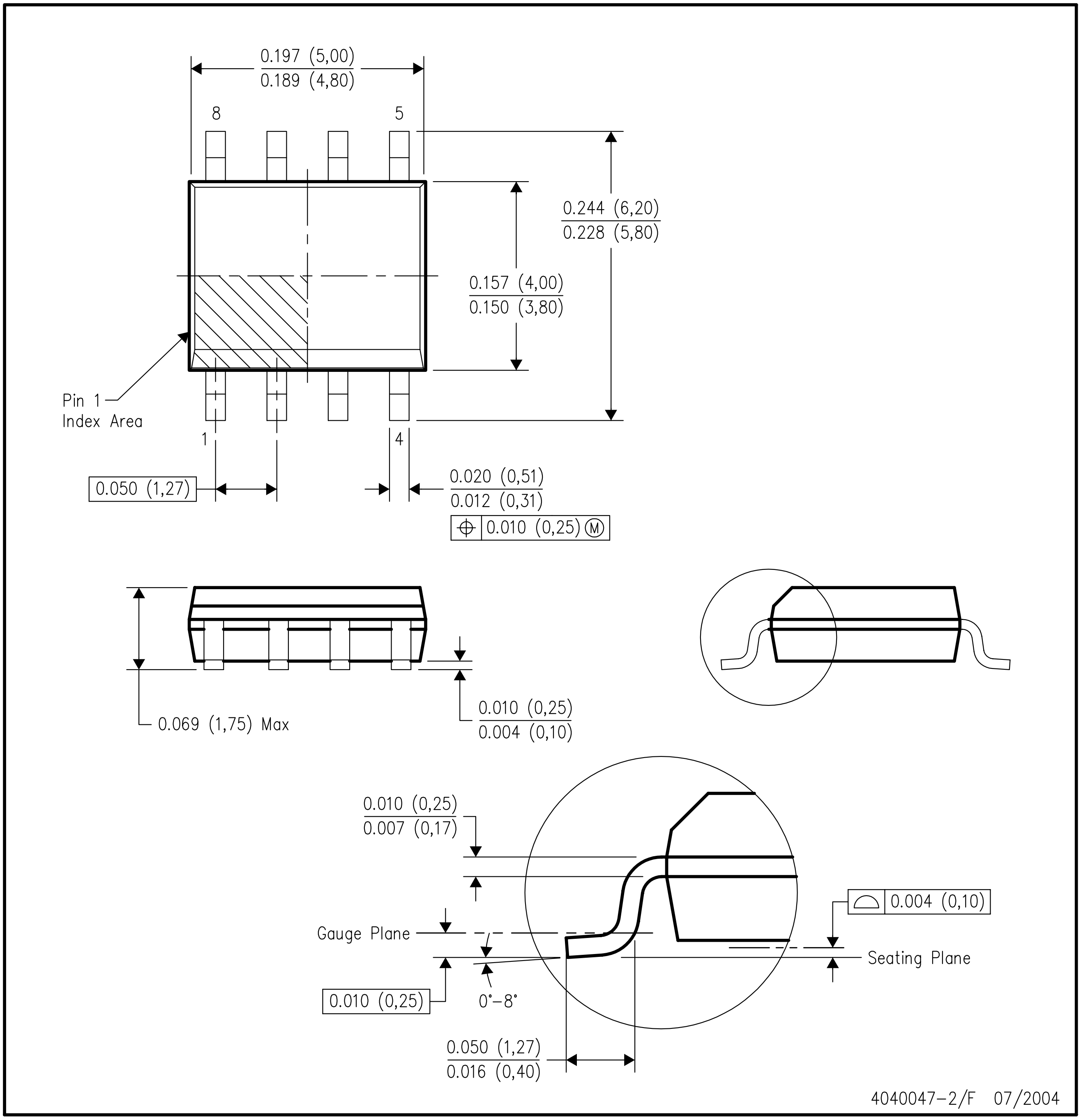
P (R-PDIP-T8) **PLASTIC DUAL-IN-LINE**



NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-001

For the latest package information, go to http://www.ti.com/sc/docs/package/pkg_info.htm

D (R–PDSO–G8) PLASTIC SMALL–OUTLINE PACKAGE



NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
D. Falls within JEDEC MS–012 variation AA.

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Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
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