Dual Very Low Noise Precision Operational Amplifier

FEATURES

Very low noise density of 5 nV/√Hz at 1 kHz maximum
Excellent input offset voltage of 75 µV maximum
Low offset voltage drift of 1 µV/°C maximum
Very high gain of 1500 V/mV minimum
Outstanding CMR of 106 dB minimum
Slew rate of 2.4 V/µs typical
Gain bandwidth product of 5 MHz typical
Industry-standard 8-lead dual pinout

FUNCTIONAL BLOCK DIAGRAMS

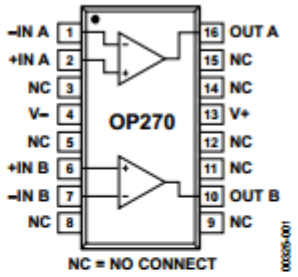

Figure 1. 16-Lead SOIC (S-Suffix)

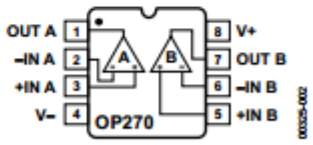

Figure 2. 8-Lead PDIP (P-Suffix) 8-Lead CERDIP (Z-Suffix)

GENERAL DESCRIPTION

The OP270 is a high performance, monolithic, dual operational amplifier with exceptionally low voltage noise density (5 nV/√Hz maximum at 1 kHz). It offers comparable performance to the industry-standard OP27 from Analog Devices, Inc.

The OP270 features an input offset voltage of less than 75 µV and an offset drift of less than 1 µV/°C, guaranteed over the full military temperature range. Open-loop gain of the OP270 is more than 1,500,000 into a 10 kΩ load, ensuring excellent gain accuracy and linearity, even in high gain applications. The input bias current is less than 20 nA, which reduces errors due to signal source resistance. With a common-mode rejection (CMR) of greater than 106 dB and a power supply rejection ratio (PSRR) of less than 3.2 µV/V, the OP270 significantly reduces errors due to ground noise and power supply fluctuations. The power consumption of the dual OP270 is one-third less than two OP27 devices, a significant advantage for power conscious applications. The OP270 is unity-gain stable with a gain bandwidth product of 5 MHz and a slew rate of 2.4 V/µs.

The OP270 offers excellent amplifier matching, which is important for applications such as multiple gain blocks, low noise instrumentation amplifiers, dual buffers, and low noise active filters.

The OP270 conforms to the industry-standard 8-lead DIP pinout. It is pin compatible with the MC1458, SE5532/A, RM4558, and HA5102 dual op amps, and can be used to upgrade systems using those devices.

For higher speed applications, the ADA4004-2 or the AD8676 are recommended. For a quad op amp, see the OP470 data sheet.

SPECIFICATIONS

V_S = ±15 V, T_A = 25°C, unless otherwise noted.

Table 1.

			OP270E			OP270F			OP270G			
Parameter	**Symbol**	**Test Conditions**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Unit**
Input Offset Voltage	V_{OS}			10	75		20	150		50	250	µV
Input Offset Current	I_{OS}	V_{CM} = 0 V		1	10		3	15		5	20	nA
Input Bias Current	I_B	V_{CM} = 0 V		5	20		10	40		15	60	nA
Input Noise Voltage[1]	e_n p-p	0.1 Hz to 10 Hz		80	200		80	200		80		nV p-p
Input Noise Voltage Density[2]	e_n	f_O = 10 Hz		3.6	6.5		3.6	6.5		3.6		nV/√Hz
	e_n	f_O = 100 Hz		3.2	5.5		3.2	5.5		3.2		nV/√Hz
	e_n	f_O = 1 kHz		3.2	5.0		3.2	5.0		3.2		nV/√Hz
Input Noise Current Density	i_n	f_O = 10 Hz		1.1			1.1			1.1		pA/√Hz
	i_n	f_O = 100 Hz		0.7			0.7			0.7		pA/√Hz
	i_n	f_O = 1 kHz		0.6			0.6			0.6		pA/√Hz

Large-Signal Voltage Gain	A_{VO}	V_O = ±10 V, R_L = 10 kΩ	1500	2300		1000	1700		750	1500		V/mV
		V_O = ±10 V, R_L = 2 kΩ	750	1200		500	900		350	700		V/mV
Input Voltage Range[3]	IVR		±12	±12.5		±12	±12.5		±12	±12.5		V
Output Voltage Swing	V_O	R_L ≥ 2 kΩ	±12	±13.5		±12	±13.5		±12	±13.5		V
Common-Mode Rejection	CMR	V_{CM} = ±11 V	106	125		100	120		90	110		dB
Power Supply Rejection Ratio	PSRR	V_S = ±4.5 V to ±18 V		0.56	3.2		1.0	5.6		1.5	5.6	µV/V
Slew Rate	SR		1.7	2.4		1.7	2.4		1.7	2.4		V/µs
Supply Current (All Amplifiers)	I_{SY}	No load		4	6.5		4	6.5		4	6.5	mA
Gain Bandwidth Product	GBP			5			5			5		MHz
Channel Separation[1]	CS	V_O = ±20 V p-p, f_O = 10 Hz	125	175		125	175			175		dB
Input Capacitance	C_{IN}			3			3			3		pF
Input Resistance												
Differential Mode	R_{IN}			0.4			0.4			0.4		MΩ
Common Mode	R_{INCM}			20			20			20		GΩ
Settling Time	t_S	A_V = +1, 10 V, step to 0.01%		5			5			5		µs

[1] Guaranteed but not 100% tested.
[2] Sample tested.
[3] Guaranteed by CMR test.

ELECTRICAL SPECIFICATIONS

V_S = ±15 V, −40°C ≤ T_A ≤ 85°C, unless otherwise noted.

Table 2.

			OP270E			OP270F			OP270G			
Parameter	**Symbol**	**Test Conditions**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Unit**
Input Offset Voltage	V_{OS}			25	150		45	275		100	400	µV
Average Input Offset Voltage Drift	TCV_{OS}			0.2	1		0.4	2		0.7	3	µV/°C
Input Offset Current	I_{OS}	V_{CM} = 0 V		1.5	30		5	40		15	50	nA
Input Bias Voltage	I_B	V_{CM} = 0 V		6	60		15	70		19	80	nA
Large-Signal Voltage Gain	A_{VO}	V_O = ±10 V, R_L = 10 kΩ	1000	1800		600	1400		400	1250		V/mV
	A_{VO}	V_O = ±10 V, R_L = 2 kΩ	500	900		300	700		225	670		V/mV
Input Voltage Range[1]	IVR		±12	±12.5		±12	±12.5		±12	±12.5		V
Output Voltage Swing	V_O	R_L ≥ 2 kΩ	±12	±13.5		±12	±13.5		±12	±13.5		V
Common-Mode Rejection	CMR	V_{CM} = ±11 V	100	120		94	115		90	100		dB
Power Supply Rejection Ratio	PSRR	V_S = ±4.5 V to ±18 V		0.7	5.6		1.8	10		2.0	1.5	µV/V
Supply Current (All Amplifiers)	I_{SY}	No load		4.4	7.2		4.4	7.2		4.4	7.2	mA

[1] Guaranteed by CMR test.

ABSOLUTE MAXIMUM RATINGS

Table 3.

Parameter	Rating
Supply Voltage	18 V
Differential Input Voltage[1]	1.0 V
Differential Input Current[1]	±25 mA
Input Voltage	Supply voltage
Output Short-Circuit Duration	Continuous
Storage Temperature Range	−65°C to +150°C
Lead Temperature Range (Soldering, 60 sec)	300°C
Junction Temperature (T_J)	−65°C to +150°C
Operating Temperature Range	−40°C to +85°C

[1] The OP270 inputs are protected by back-to-back diodes. To achieve low noise performance, current-limiting resistors are not used. If the differential voltage exceeds +10 V, the input current should be limited to ±25 mA.

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

For military processed devices, refer to the Standard Microcircuit Drawing (SMD) available at the Defense Logistics Agency website.

Table 4. Analog Devices Equivalent to SMD

SMD Part Number	Analog Devices Equivalent
5962-8872101PA	OP270AZMDA

TYPICAL PERFORMANCE CHARACTERISTICS

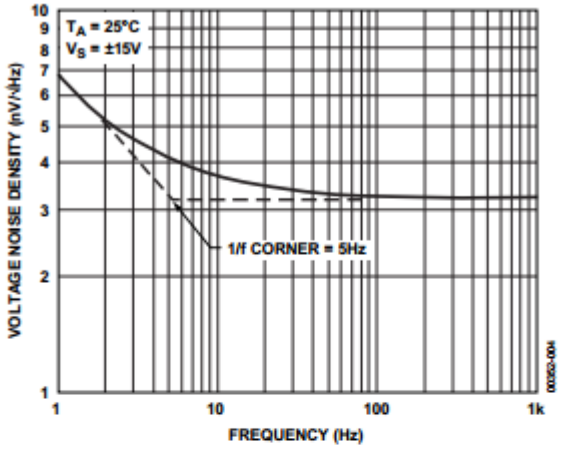

Figure 3. Voltage Noise Density vs. Frequency

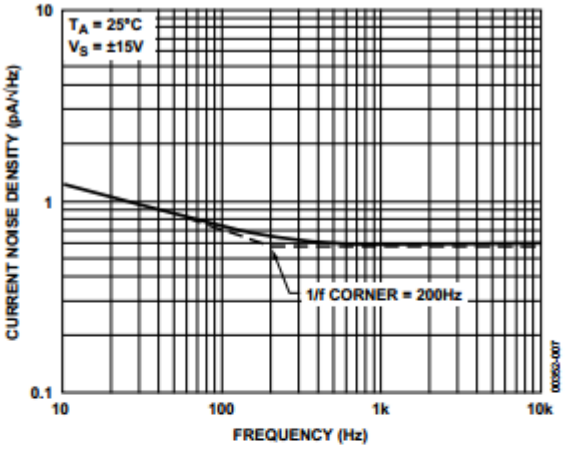

Figure 6. Current Noise Density vs. Frequency

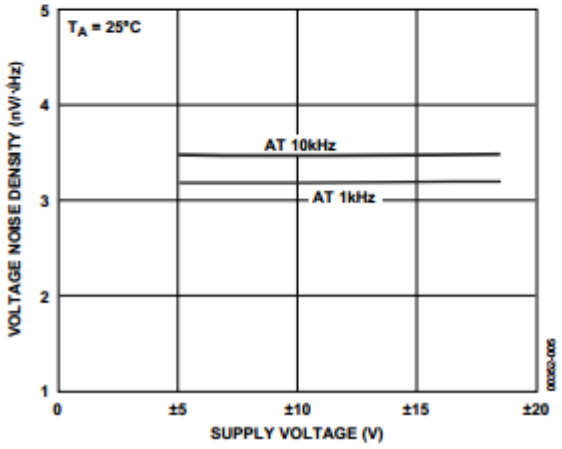

Figure 4. Voltage Noise Density vs. Supply Voltage

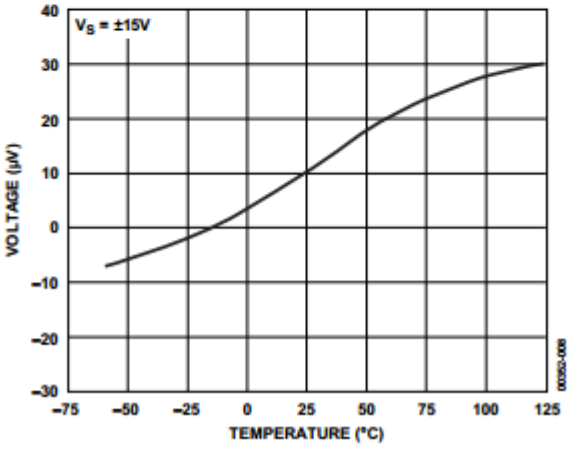

Figure 7. Input Offset Voltage vs. Temperature

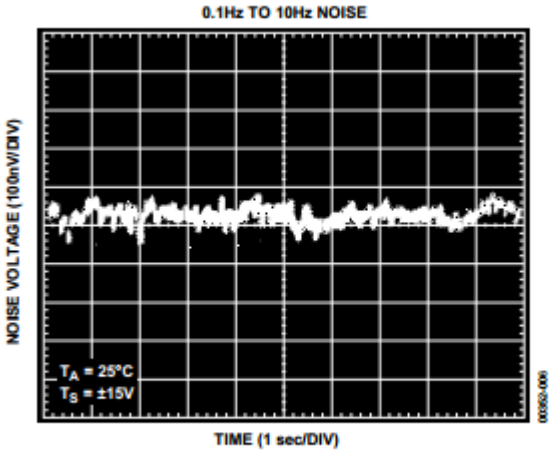

Figure 5. 0.1 Hz to 10 Hz Input Voltage Noise

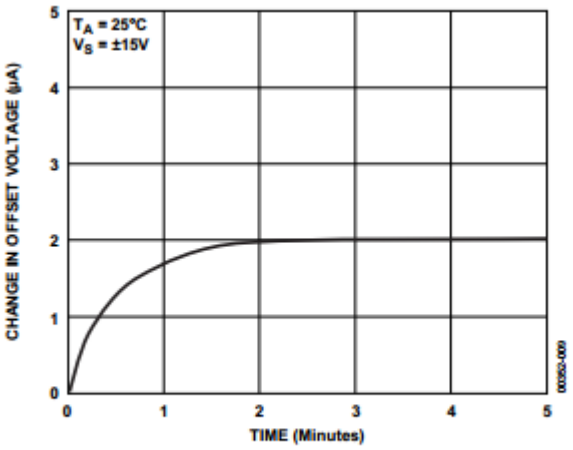

Figure 8. Warm-Up Offset Voltage Drift

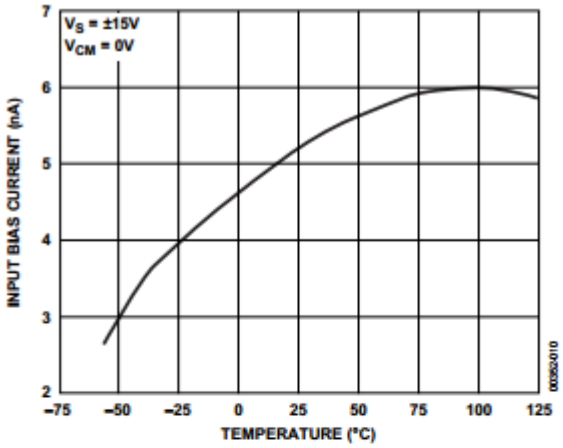

Figure 9. Input Bias Current vs. Temperature

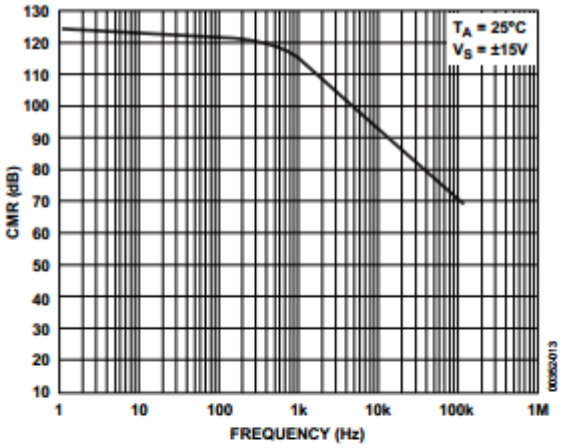

Figure 12. CMR vs. Frequency

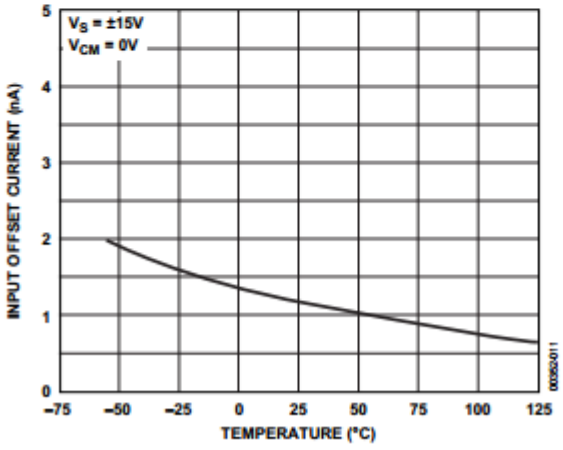

Figure 10. Input Offset Current vs. Temperature

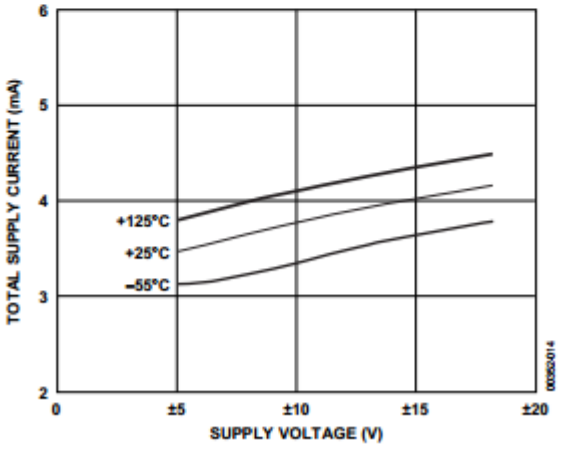

Figure 13. Total Supply Current vs. Supply Voltage

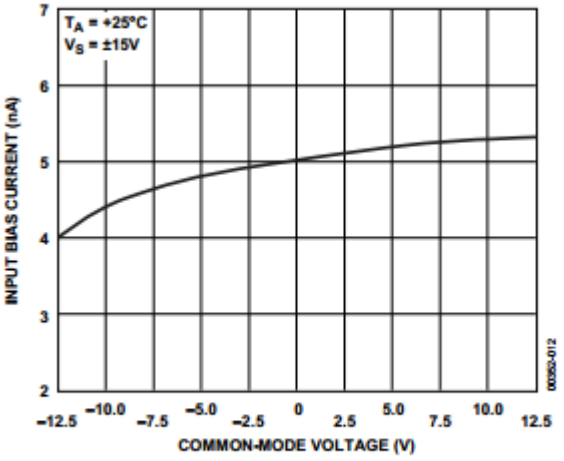

Figure 11. Input Bias Current vs. Common-Mode Voltage

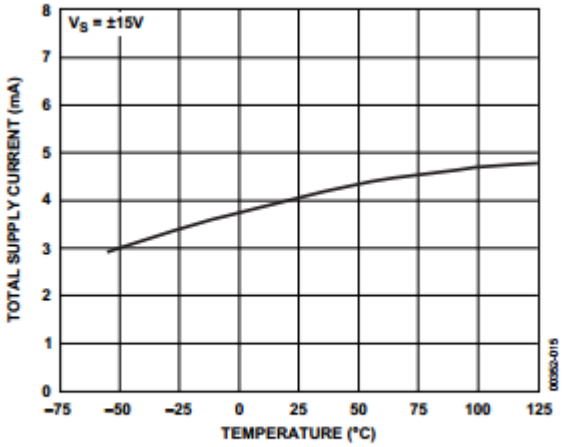

Figure 14. Total Supply Current vs. Temperature

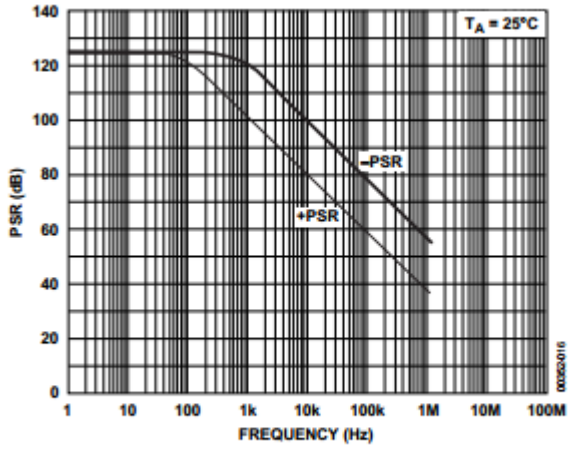

Figure 15. PSR vs. Frequency

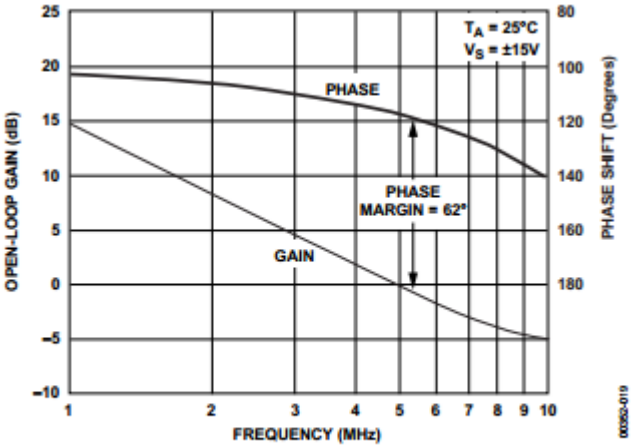

Figure 18. Open-Loop Gain and Phase Shift vs. Frequency

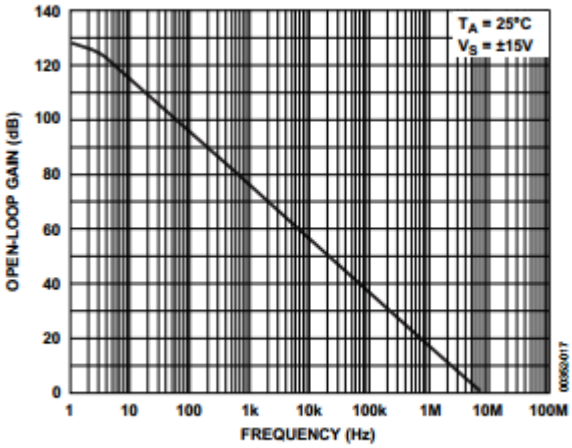

Figure 16. Open-Loop Gain vs. Frequency

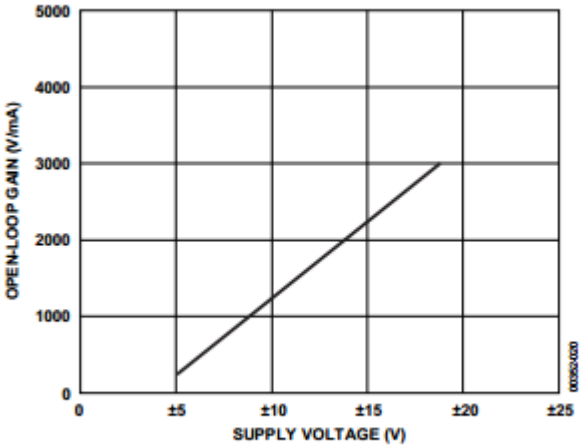

Figure 19. Open-Loop Gain vs. Supply Voltage

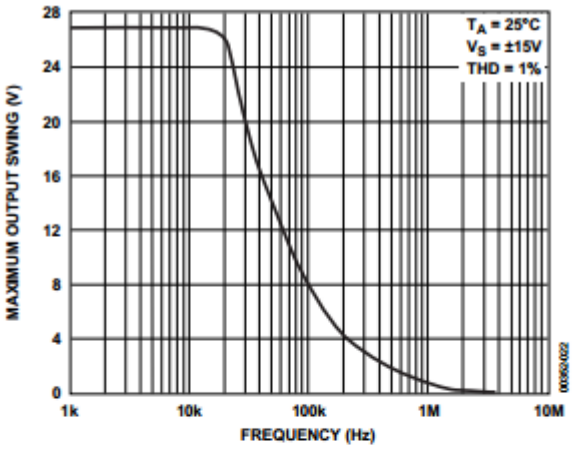

Figure 21. Maximum Output Swing vs. Frequency

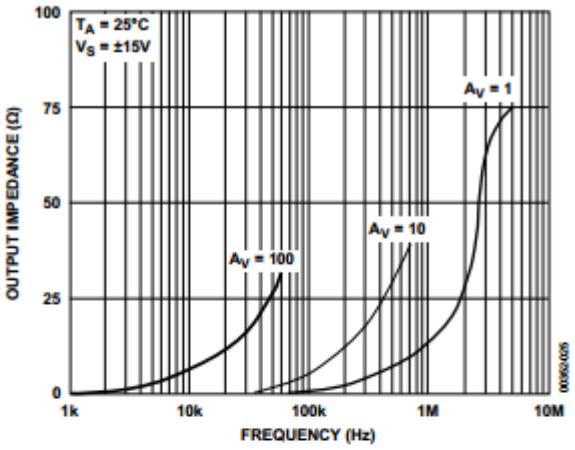

Figure 24. Output Impedance vs. Frequency

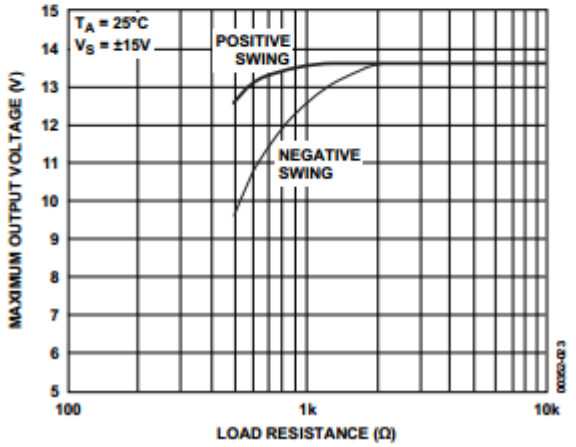

Figure 22. Maximum Output Voltage vs. Load Resistance

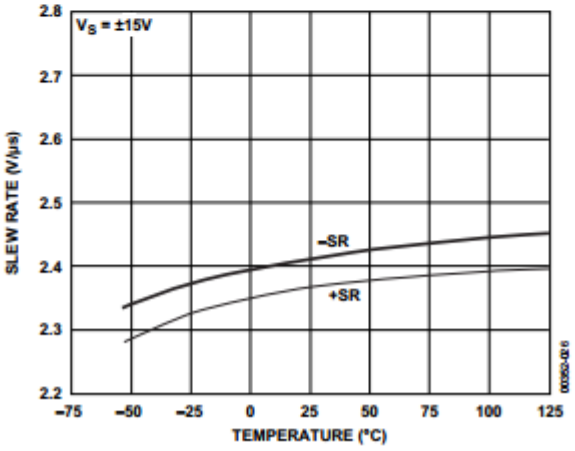

Figure 25. Slew Rate vs. Temperature

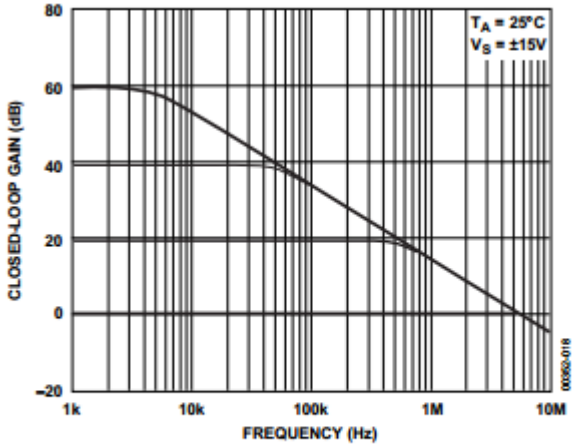

Figure 17. Closed-Loop Gain vs. Frequency

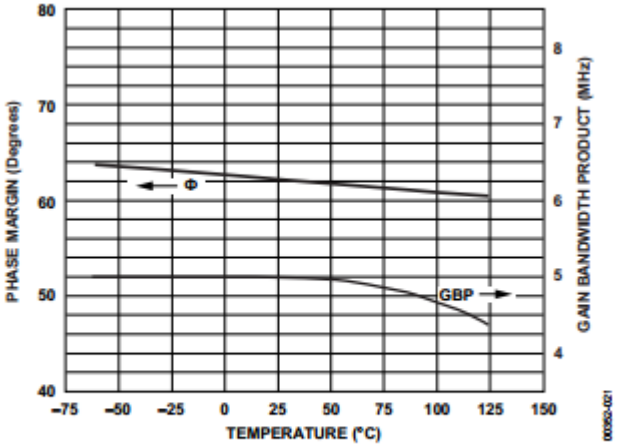

Figure 20. Phase Margin and Gain Bandwidth Product vs. Temperature

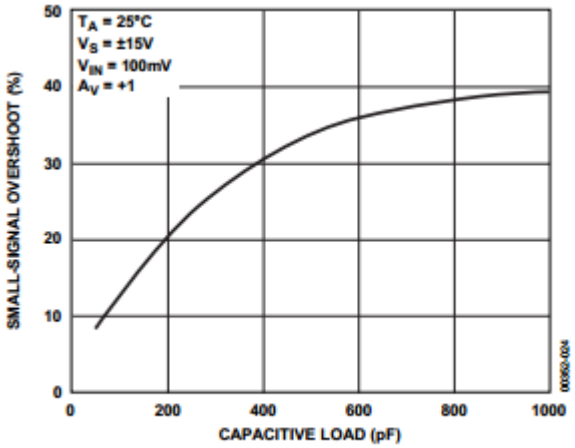

Figure 23. Small-Signal Overshoot vs. Capacitive Load

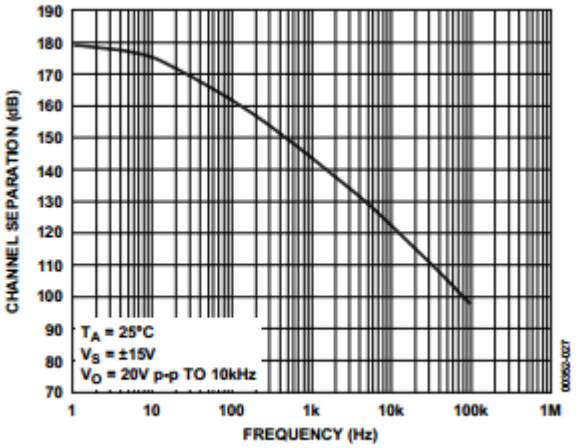

Figure 26. Channel Separation vs. Frequency

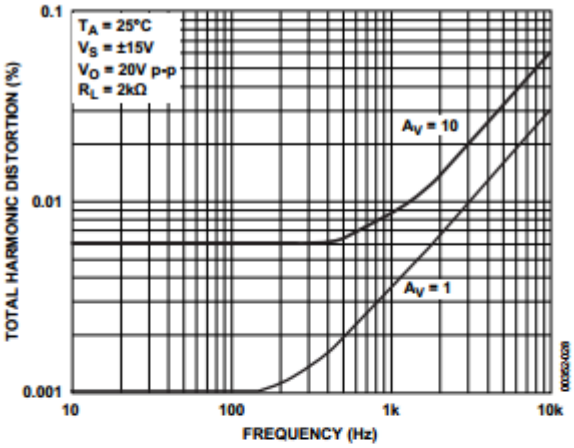

Figure 27. Total Harmonic Distortion vs. Frequency

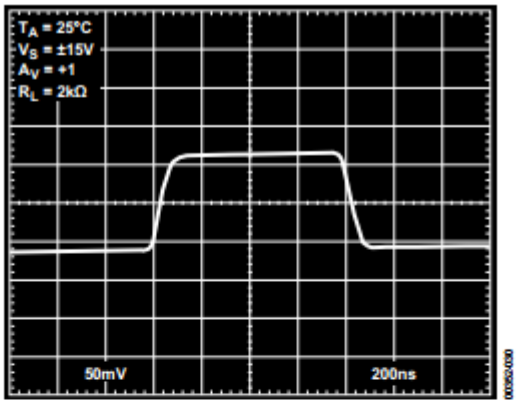

Figure 29. Small-Signal Transient Response

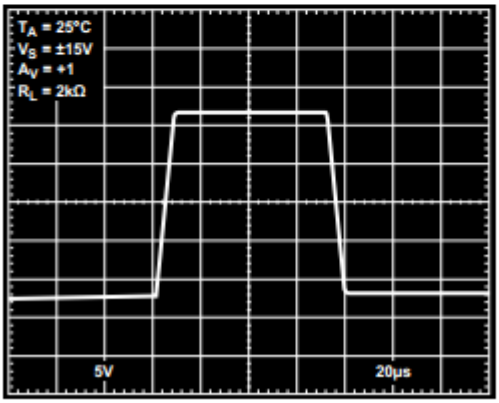

Figure 28. Large-Signal Transient Response

TEST CIRCUITS

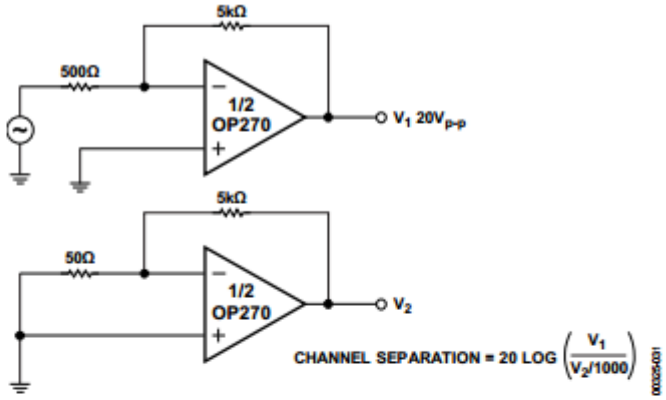

Figure 30. Channel Separation Test Circuit

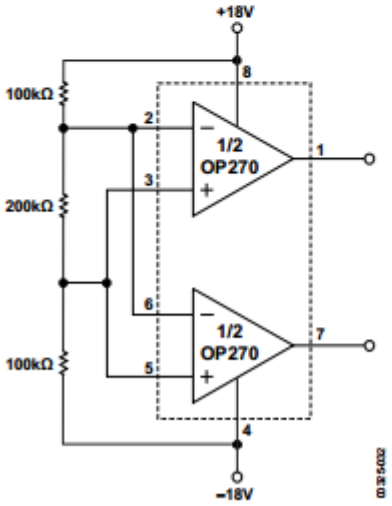

Figure 31. Burn-In Circuit

VOLTAGE AND CURRENT NOISE

The OP270 is a very low noise dual op amp, exhibiting a typical voltage noise density of only 3.2 nV/√Hz at 1 kHz. Because the voltage noise is inversely proportional to the square root of the collector current, the exceptionally low noise characteristic of the OP270 is achieved in part by operating the input transistors at high collector currents. Current noise, however, is directly proportional to the square root of the collector current. As a result, the outstanding voltage noise density performance of the OP270 is gained at the expense of current noise performance, which is normal for low noise amplifiers.

To obtain the best noise performance in a circuit, it is vital to understand the relationships among voltage noise (e_n), current noise (i_n), and resistor noise (e_t).

TOTAL NOISE AND SOURCE RESISTANCE

The total noise of an op amp can be calculated by

$$E_n = \sqrt{(e_n)^2 + (i_n R_s)^2 + (e_t)^2}$$

where:
E_n is the total input-referred noise.
e_n is the op amp voltage noise.
i_n is the op amp current noise.
e_t is the source resistance thermal noise.
R_S is the source resistance.

The total noise is referred to the input and at the output is amplified by the circuit gain.

Figure 32 shows the relationship between total noise at 1 kHz and source resistance. When R_S is less than 1 kΩ, the total noise is dominated by the voltage noise of the OP270. As R_S rises above 1 kΩ, total noise increases and is dominated by resistor noise rather than by the voltage or current noise of the OP270. When R_S exceeds 20 kΩ, the current noise of the OP270 becomes the major contributor to total noise.

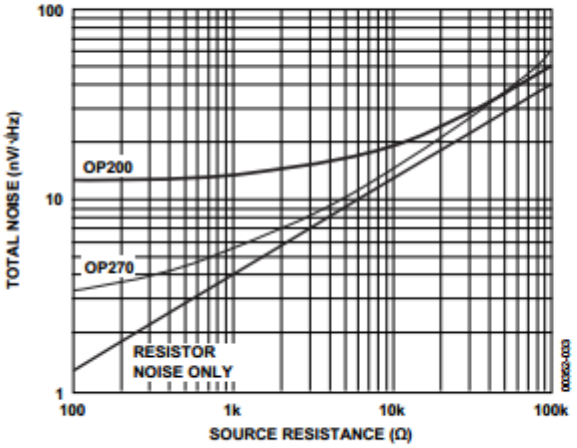

Figure 32. Total Noise vs. Source Resistance (Including Resistor Noise) at 1 kHz

Figure 33 also shows the relationship between total noise and source resistance, but at 10 Hz. Total noise increases more quickly than shown in Figure 32 because current noise is inversely proportional to the square root of frequency. In Figure 33, the current noise of the OP270 dominates the total noise when R_S is greater than 5 kΩ.

Figure 32 and Figure 33 show that to reduce total noise, source resistance must be kept to a minimum. In applications with a high source resistance, the OP200, with lower current noise than the OP270, can provide lower total noise.

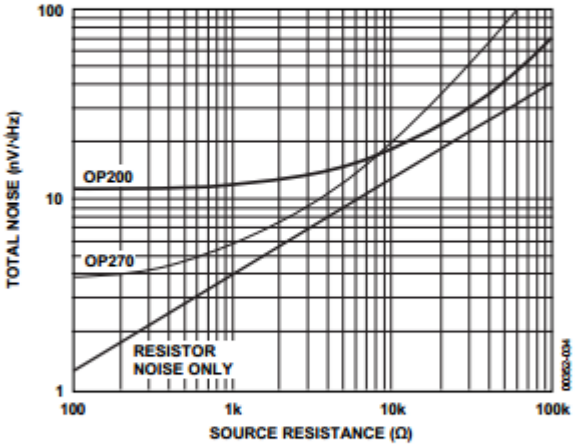

Figure 33. Total Noise vs. Source Resistance (Including Resistor Noise) at 10 Hz

Figure 34 shows peak-to-peak noise vs. source resistance over the 0.1 Hz to 10 Hz range. At low values of R_S, the voltage noise of the OP270 is the major contributor to peak-to-peak noise, with current noise becoming the major contributor as R_S increases. The crossover point between the OP270 and the OP200 for peak-to-peak noise is at a source resistance of 17 kΩ.

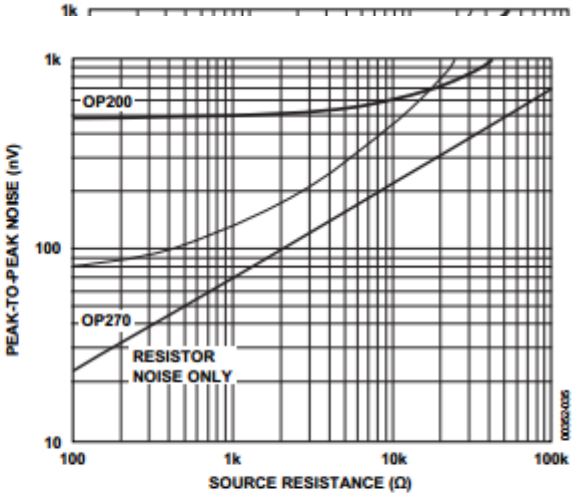

Figure 34. Peak-to-Peak Noise (0.1 Hz to 10 Hz) vs. Source Resistance (Including Resistor Noise)

Table 5. Typical Source Resistances

Device	Source Impedance	Comments
Strain Gage	<500 Ω	Typically used in low frequency applications.
Magnetic Tapehead, Microphone	<1500 Ω	Low I_B is very important to reduce self-magnetization problems when direct coupling is used. OP270 I_B can be disregarded.
Magnetic Phonograph Cartridge	<1500 Ω	Low I_B is important to reduce self-magnetization problems in direct-coupled applications. OP270 does not introduce any self-magnetization problems.
Linear Variable Differential Transformer	<1500 Ω	Used in rugged servo-feedback applications. The bandwidth of interest is 400 Hz to 5 kHz.

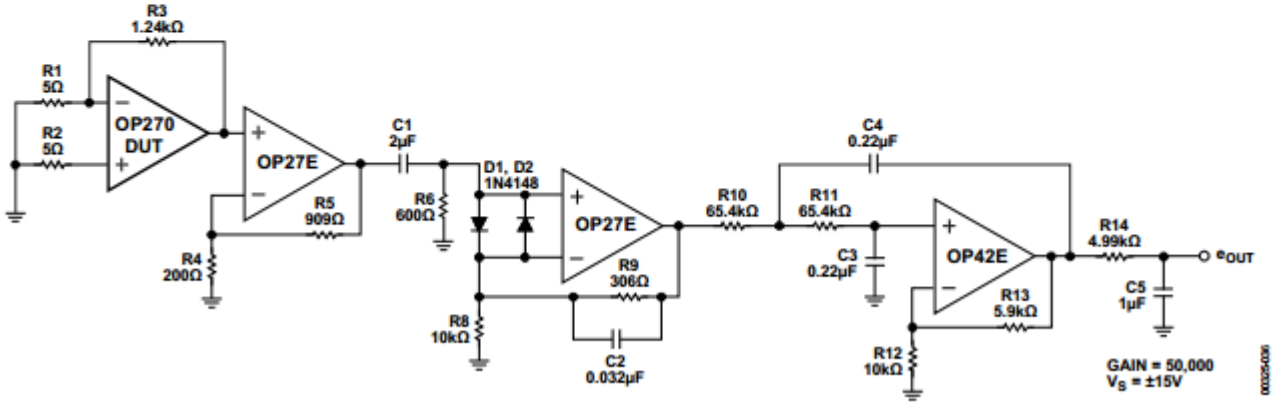

Figure 35. Peak-to-Peak Voltage Noise Test Circuit (0.1 Hz to 10 Hz)