



1.8 nV/ $\sqrt{\text{Hz}}$, 36 V Precision Quad Amplifier

ADA4004-4

FEATURES

- Very low voltage noise: 1.8 nV/ $\sqrt{\text{Hz}}$
- Low input bias current: 100 nA maximum
- Offset voltage: 100 μV maximum
- High gain: 120 dB
- Wide bandwidth: 12 MHz
- $\pm 5\text{ V}$ to $\pm 15\text{ V}$ operation

APPLICATIONS

- Precision instrumentation
- Filter blocks
- Microphone preamplifier
- Industrial control
- Thermocouples and RTDs
- Reference buffers

GENERAL DESCRIPTION

The ADA4004-4 is a 1.8 nV/ $\sqrt{\text{Hz}}$ precision quad amplifier in a 16 mm² LFCSP_VQ package featuring 40 μV offset, 0.7 $\mu\text{V}/^\circ\text{C}$ drift, 12 MHz bandwidth, and low 1.7 mA/amplifier supply current.

The ADA4004-4 is designed on the high performance *iPolar*[™] process, enabling improvements such as reduced noise and power consumption, increased speed and stability, and a smaller footprint size. Novel design techniques enable the ADA4004-4 to achieve 1.8 nV/ $\sqrt{\text{Hz}}$ voltage noise density and a low 6 Hz 1/f noise corner frequency while consuming just 1.7 mA/amplifier. The small package saves board space, reduces cost, and improves layout flexibility.

Applications for these amplifiers include high precision controls, PLL filters, high performance precision filters, medical and analytical instrumentation, precision power supply controls, ATE, and data acquisition systems.

The high performance ADA4004-4 is offered in the very small 16-lead, 4 mm \times 4 mm LFCSP_VQ and the 14-lead, narrow SOIC_N, lead-free, surface-mount packages. Operation is fully specified from $\pm 5\text{ V}$ to $\pm 15\text{ V}$ from -40°C to $+125^\circ\text{C}$.

PIN CONFIGURATIONS

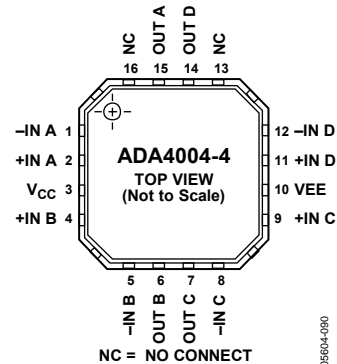


Figure 1. 16-Lead LFCSP_VQ (CP-16-4 Suffix)

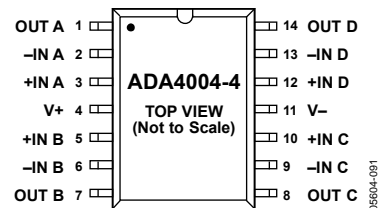


Figure 2. 14-Lead SOIC_N (R-14 Suffix)

Rev. A

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REVISION HISTORY

7/06—Rev. 0 to Rev. A

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1/06—Revision 0: Initial Version

SPECIFICATIONS

$V_S = \pm 5.0\text{ V}$, $V_{CM} = 0\text{ V}$, $T_A = +25^\circ\text{C}$, unless otherwise specified.

Table 1.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
INPUT CHARACTERISTICS						
Offset Voltage	V_{OS}	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		40	140	μV
Input Bias Current	I_B	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		40	85	nA
Input Offset Current	I_{OS}	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		40	85	nA
Input Voltage Range		$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	-3.5		100	V
Common-Mode Rejection Ratio	CMRR	$V_{CM} = -3.0\text{ V to }+3.0\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	105	111		dB
Open-Loop Gain	A_{VO}	$R_L = 2\text{ k}\Omega$, $V_O = -2.5\text{ V to }+2.5\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	95	110		dB
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		0.7	1	$\mu\text{V}/^\circ\text{C}$
OUTPUT CHARACTERISTICS						
Output Voltage High	V_{OH}	$R_L = 2\text{ k}\Omega$ to ground $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	3.7	3.9		V
Output Voltage Low	V_{OL}	$R_L = 2\text{ k}\Omega$ to ground $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	3.4	3.6		V
Short Circuit Limit	I_{SC}	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		-3.6	-3.55	V
Output Current	I_O	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$ $V_{OUT} = \pm 3.6\text{ V}$		-3.6	-3.5	V
POWER SUPPLY						
Power Supply Rejection Ratio	PSRR	$V_S = \pm 5.0\text{ V to } \pm 15.0\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	110	118		dB
Supply Current/Amplifier	I_{SY}	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	110		1.7	mA
DYNAMIC PERFORMANCE						
Slew Rate	SR	$R_L = 2\text{ k}\Omega$ to ground		2.7		$\text{V}/\mu\text{s}$
Gain Bandwidth Product	GBP			12		MHz
NOISE PERFORMANCE						
Voltage Noise	$e_{n\text{ p-p}}$	0.1 Hz to 10 Hz		0.1		$\mu\text{V p-p}$
Voltage Noise Density	e_n	$f = 1\text{ kHz}$		1.8		$\text{nV}/\sqrt{\text{Hz}}$
Current Noise Density	i_n	$f = 10\text{ Hz}$		3.5		$\text{pA}/\sqrt{\text{Hz}}$
Current Noise Density	i_n	$f = 200\text{ Hz}$		1.2		$\text{pA}/\sqrt{\text{Hz}}$

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$V_S = \pm 15\text{ V}$, $V_{CM} = 0\text{ V}$, $T_A = +25^\circ\text{C}$, unless otherwise specified.

Table 2.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
INPUT CHARACTERISTICS						
Offset Voltage	V_{OS}	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		40	125	μV
Input Bias Current	I_B	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		40	90	nA
Input Offset Current	I_{OS}	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$			165	nA
Input Voltage Range		$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$			60	nA
Common-Mode Rejection Ratio	CMRR	$V_{CM} = -12.5\text{ V to } +12.5\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	-12.5	110	113	V
Open-Loop Gain	A_{VO}	$R_L = 2\text{ k}\Omega$, $V_O = -12.5\text{ V to } +12.5\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	100	500	1200	dB
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		250	500	V/mV
OUTPUT CHARACTERISTICS						
Output Voltage High	V_{OH}	$R_L = 2\text{ k}\Omega$ to ground $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	13.4	13.6		V
Output Voltage Low	V_{OL}	$R_L = 2\text{ k}\Omega$ to ground $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	13.1	13.3		V
Short Circuit Limit	I_{SC}			25		mA
Output Current	I_O	$V_{OUT} = \pm 13.6\text{ V}$		± 10		mA
POWER SUPPLY						
Power Supply Rejection Ratio	PSRR	$V_S = \pm 5.0\text{ V to } \pm 15.0\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	110	118		dB
Supply Current/Amplifier	I_{SY}	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	110		1.775	dB
					2.10	mA
DYNAMIC PERFORMANCE						
Slew Rate	SR	$R_L = 2\text{ k}\Omega$ to ground		2.7		V/ μs
Gain Bandwidth Product	GBP			12		MHz
NOISE PERFORMANCE						
Voltage Noise	$e_{n\text{ p-p}}$	0.1 Hz to 10 Hz		0.15		$\mu\text{V p-p}$
Voltage Noise Density	e_n	$f = 1\text{ kHz}$		1.8		nV/ $\sqrt{\text{Hz}}$
Current Noise Density	i_n	$f = 10\text{ Hz}$		3.5		pA/ $\sqrt{\text{Hz}}$
Current Noise Density	i_n	$f = 200\text{ Hz}$		1.2		pA/ $\sqrt{\text{Hz}}$

ABSOLUTE MAXIMUM RATINGS

Table 3.

Parameter	Rating
Supply Voltage	$\pm 18\text{ V}/+36\text{ V}$
Input Voltage	$\pm V$ supply
Differential Input Voltage	$\pm V$ supply
Output Short-Circuit Duration to GND	Indefinite
Storage Temperature Range	-65°C to $+150^{\circ}\text{C}$
Operating Temperature Range	-40°C to $+125^{\circ}\text{C}$
Junction Temperature Range	-65°C to $+150^{\circ}\text{C}$
Lead Temperature (Soldering 60 sec)	300°C

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.

THERMAL RESISTANCE

θ_{JA} is specified for the worst-case conditions, that is, a device soldered in circuit board for surface-mount packages.

Table 4.

Package Type	θ_{JA}	θ_{JC}	Unit
14-Lead SOIC_N (R-14)	120	36	$^{\circ}\text{C}/\text{W}$
16-Lead LFCSP_VQ (CP-16-4)	44	31.5	$^{\circ}\text{C}/\text{W}$

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although this product features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.



TYPICAL PERFORMANCE CHARACTERISTICS

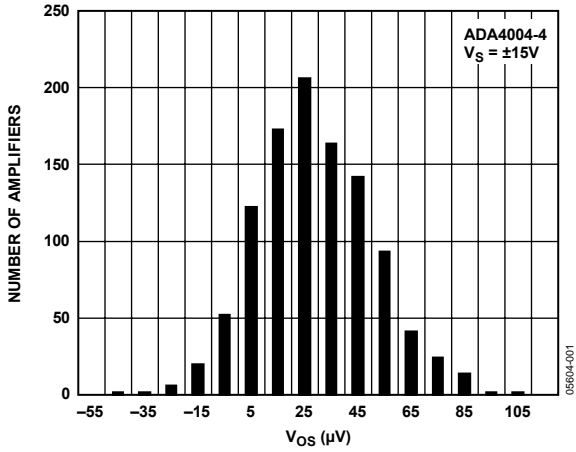


Figure 3. Number of Amplifiers vs. Input Offset Voltage

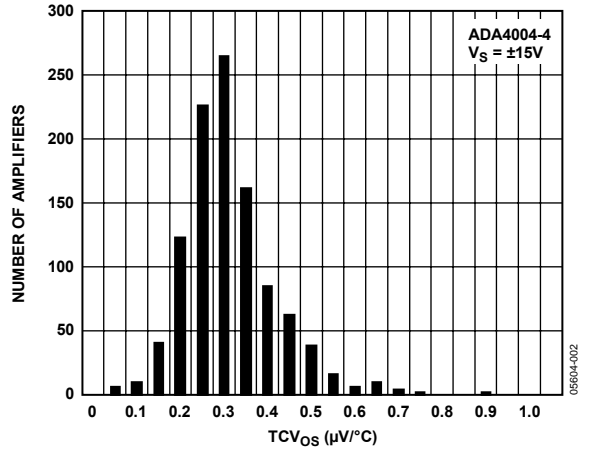


Figure 6. Number of Amplifiers vs. TCV_{os}

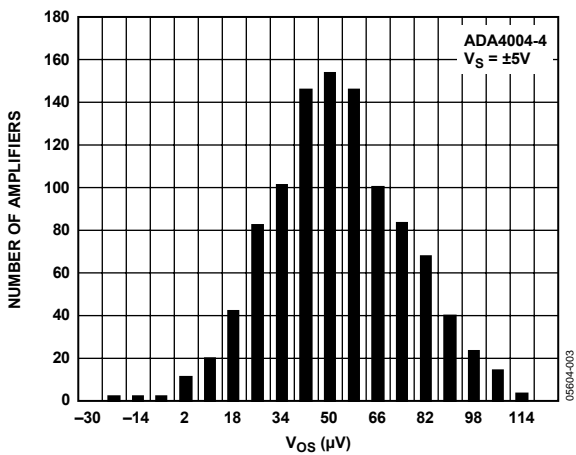


Figure 4. Number of Amplifiers vs. Input Offset Voltage

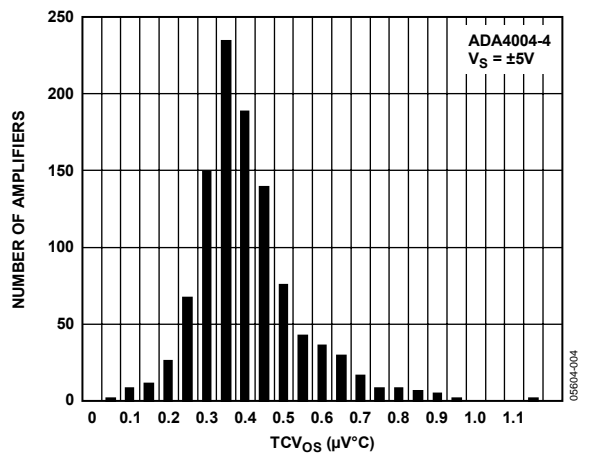


Figure 7. Number of Amplifiers vs. TCV_{os}

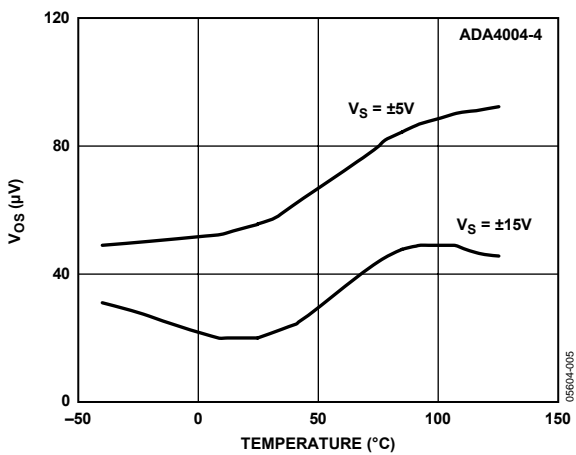


Figure 5. Input Offset Voltage vs. Temperature

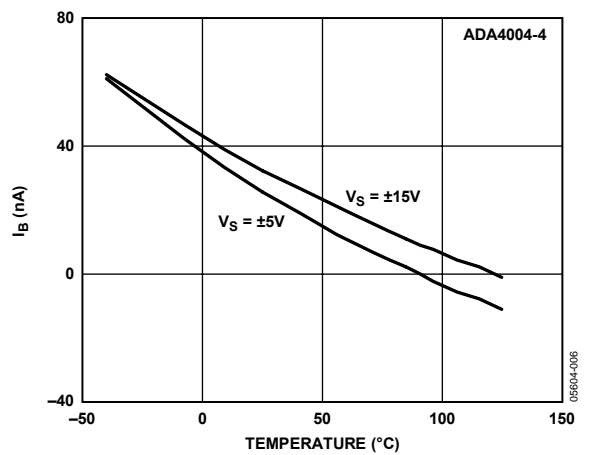


Figure 8. Input Bias Current vs. Temperature

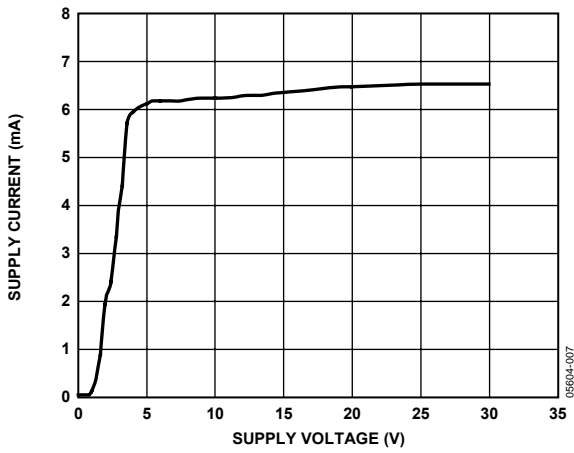


Figure 9. Supply Current vs. Total Supply Voltage

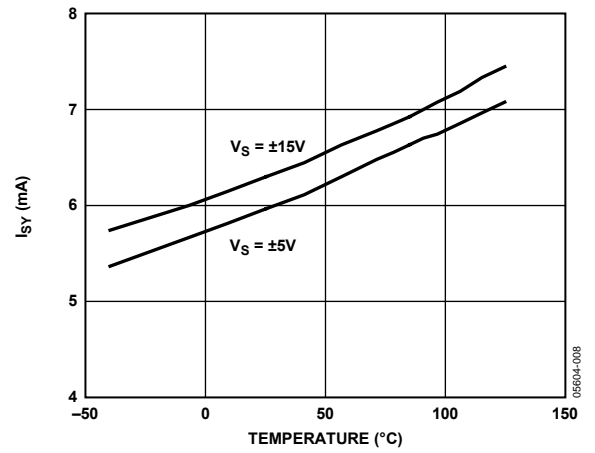


Figure 12. Supply Current vs. Temperature

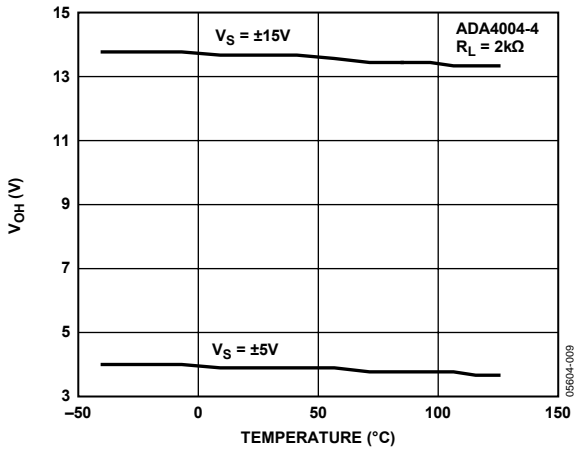


Figure 10. V_{OH} vs. Temperature

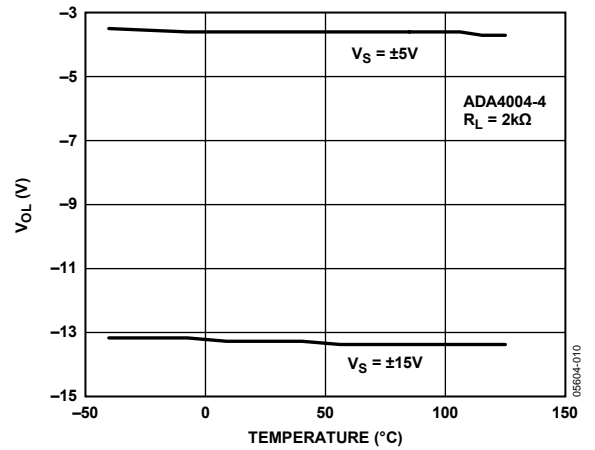


Figure 13. V_{OL} vs. Temperature

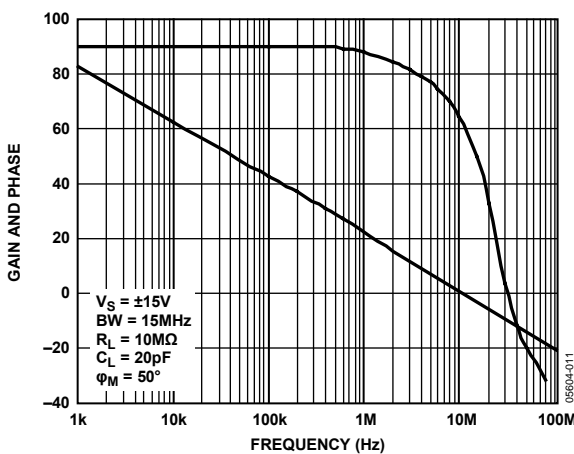


Figure 11. Gain and Phase vs. Frequency

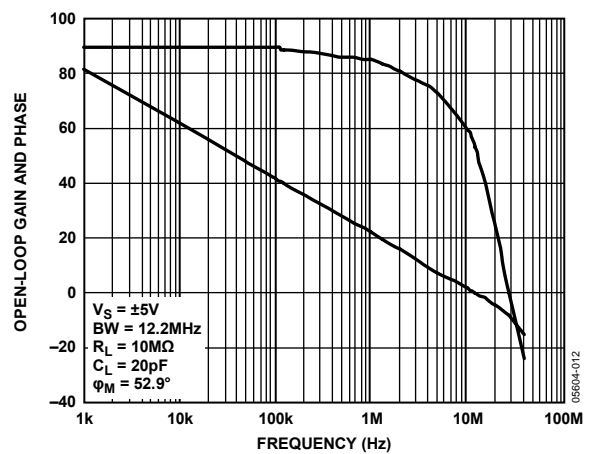


Figure 14. Open-Loop Gain and Phase vs. Frequency

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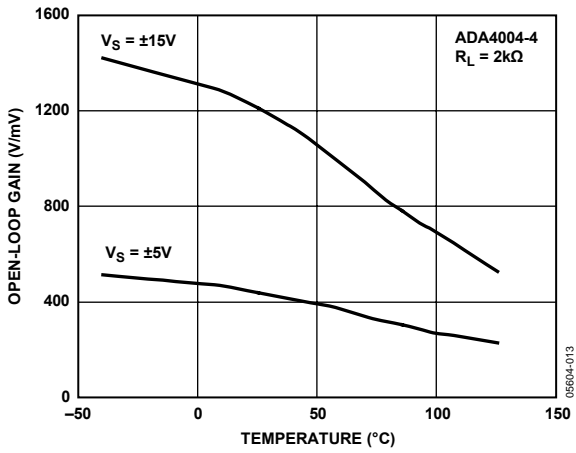


Figure 15. Open-Loop Gain vs. Temperature

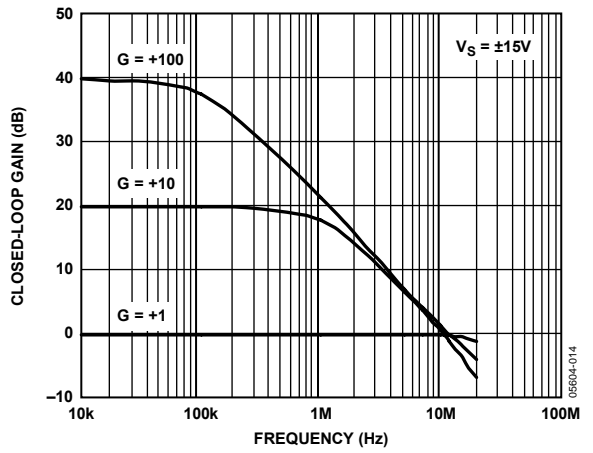


Figure 18. Closed-Loop Gain vs. Frequency

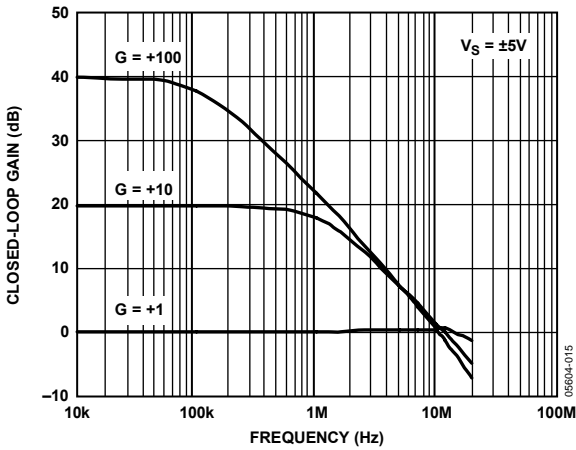


Figure 16. Closed-Loop Gain vs. Frequency

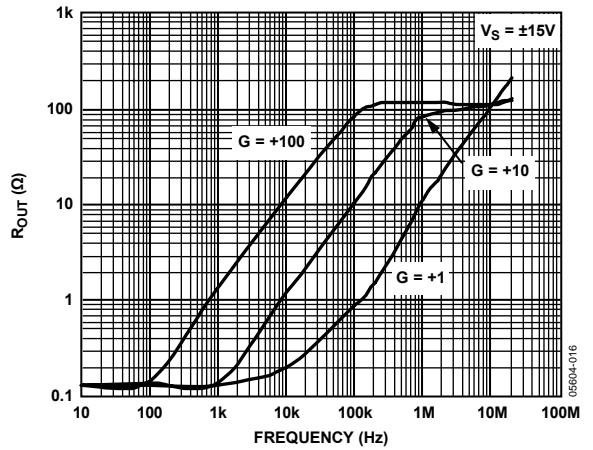


Figure 19. Output Impedance vs. Frequency

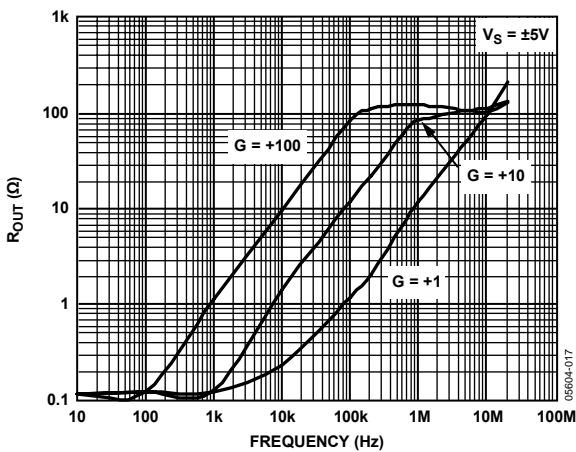


Figure 17. Output Impedance vs. Frequency

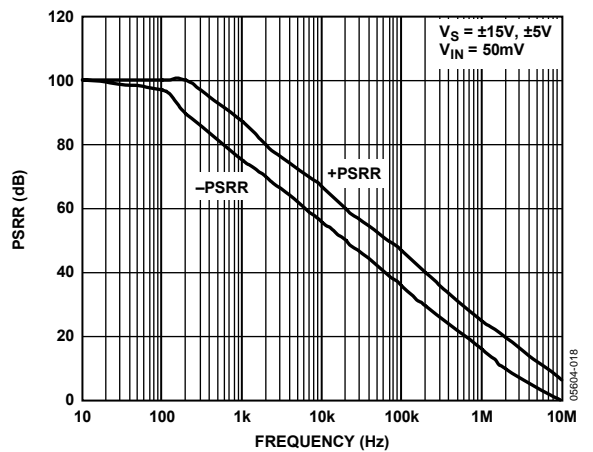


Figure 20. PSRR vs. Frequency

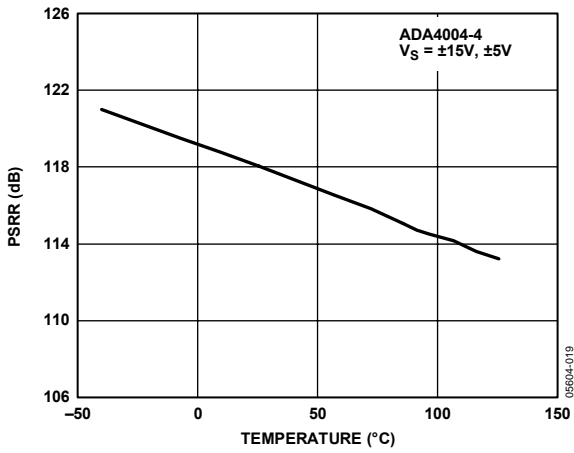


Figure 21. PSRR vs. Temperature

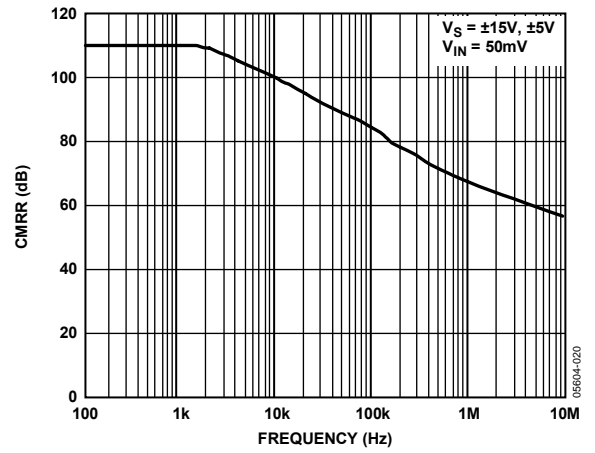


Figure 24. CMRR vs. Frequency

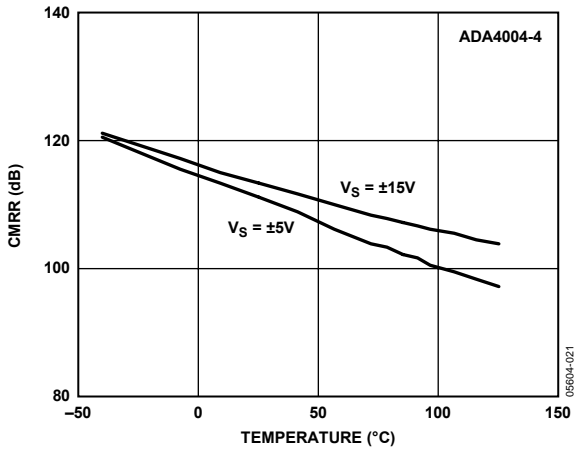


Figure 22. CMRR vs. Temperature

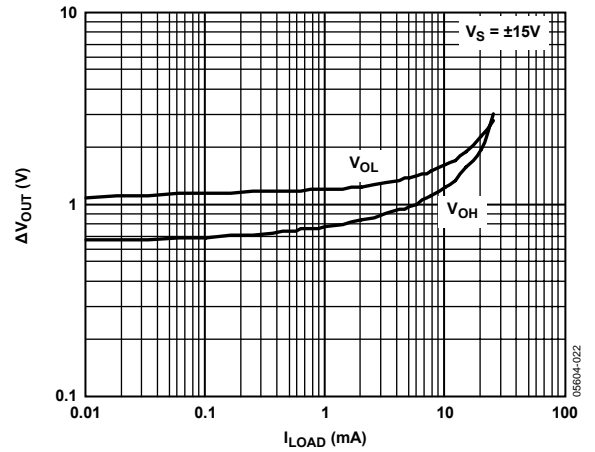


Figure 25. Output Voltage vs. Current Load

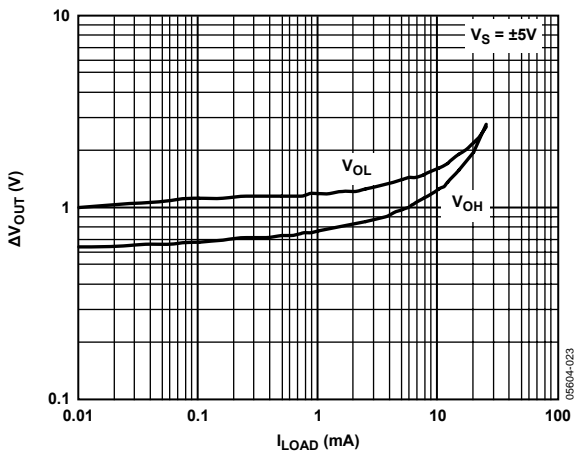


Figure 23. Output Voltage vs. Current Load

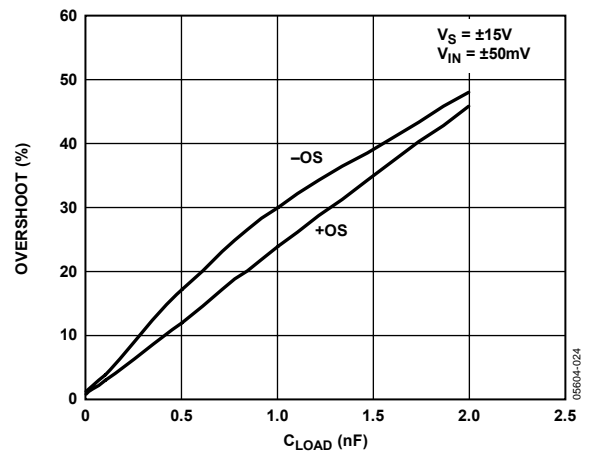


Figure 26. Small Signal Overshoot vs. Capacitive Load

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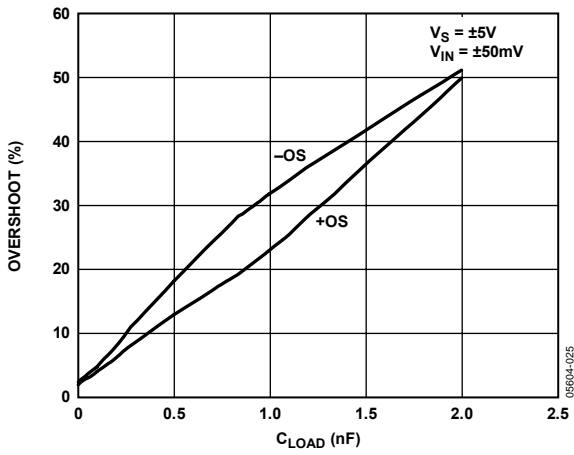


Figure 27. Small Signal Overshoot vs. Capacitive Load

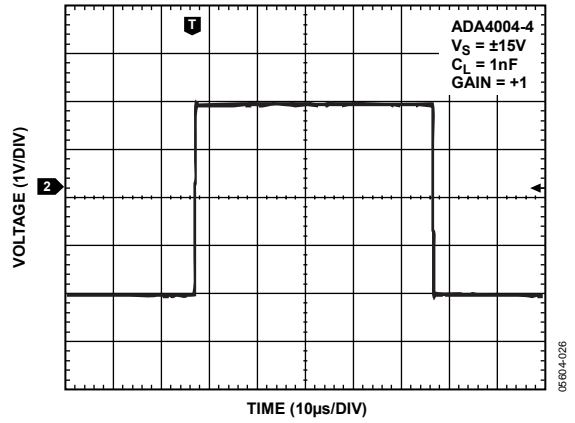


Figure 30. Large Signal Transient Response

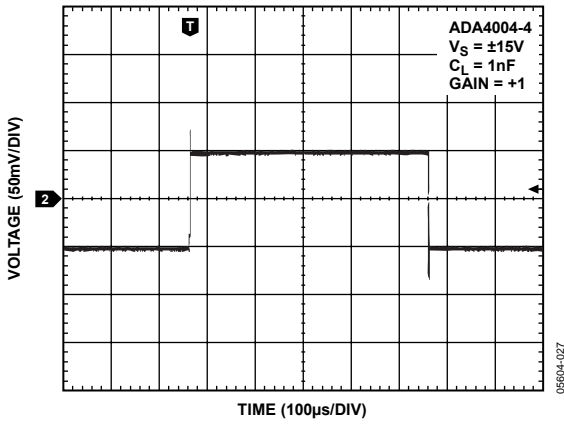


Figure 28. Small Signal Transient Response

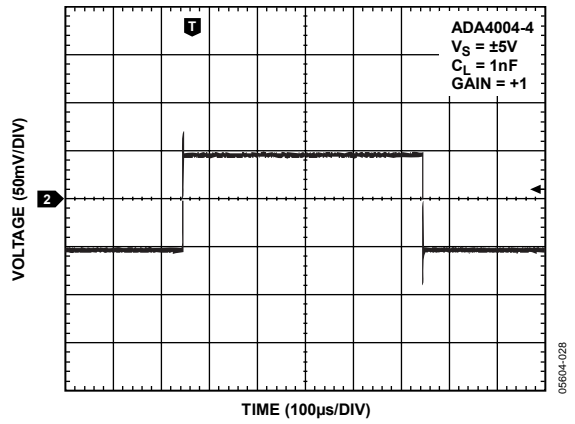


Figure 31. Small Signal Transient Response

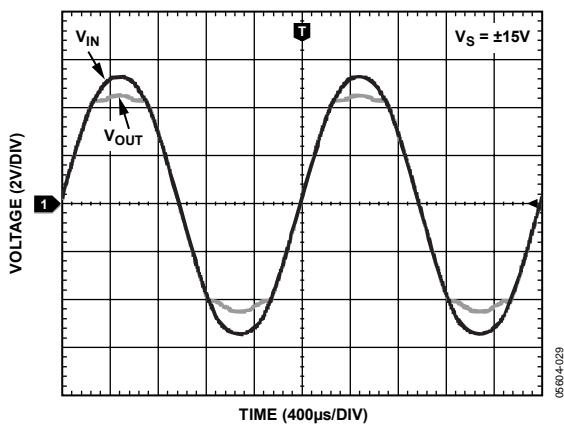


Figure 29. No Phase Reversal

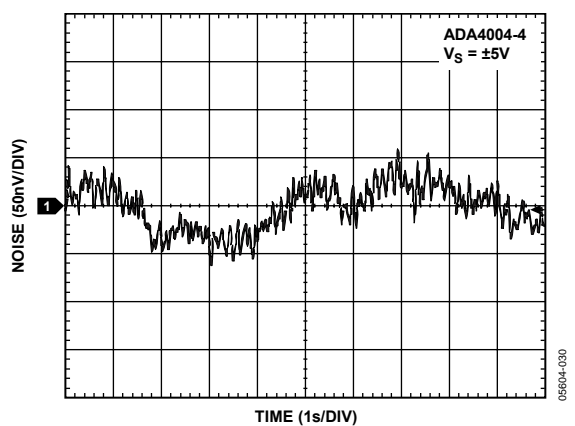


Figure 32. Voltage Noise (0.1 Hz to 10 Hz)

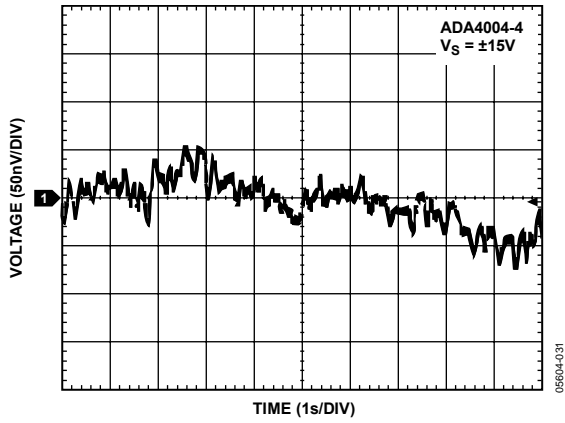


Figure 33. Voltage Noise (0.1 Hz to 10 Hz)

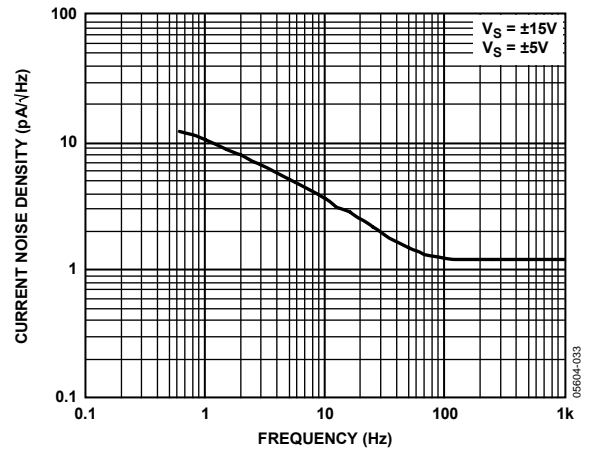


Figure 35. Current Noise Density vs. Frequency

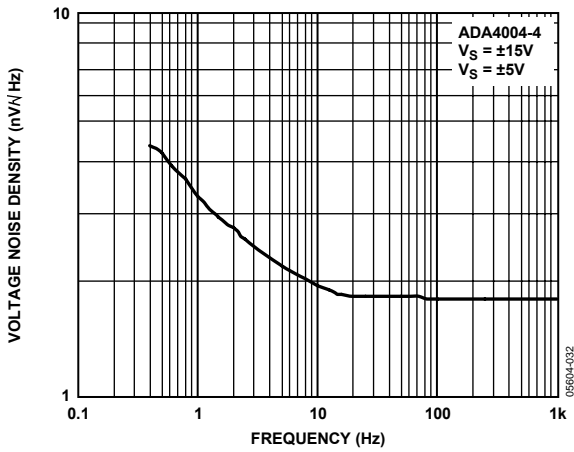


Figure 34. Voltage Noise Density vs. Frequency

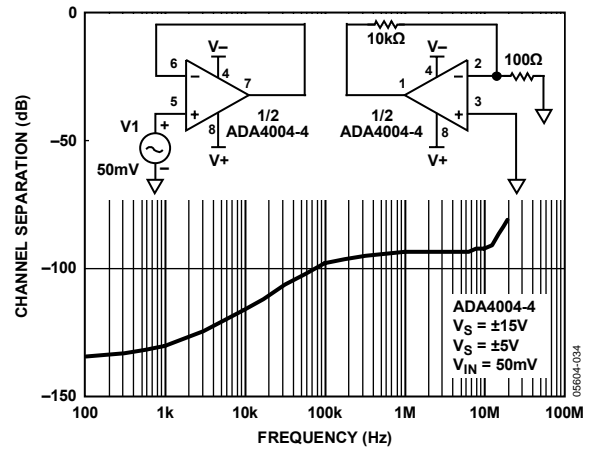
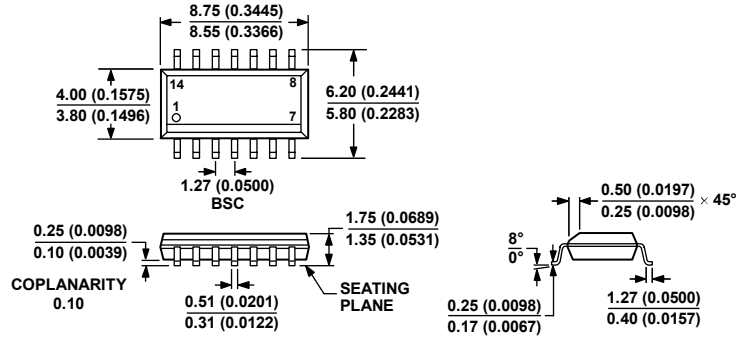


Figure 36. Channel Separation vs. Frequency

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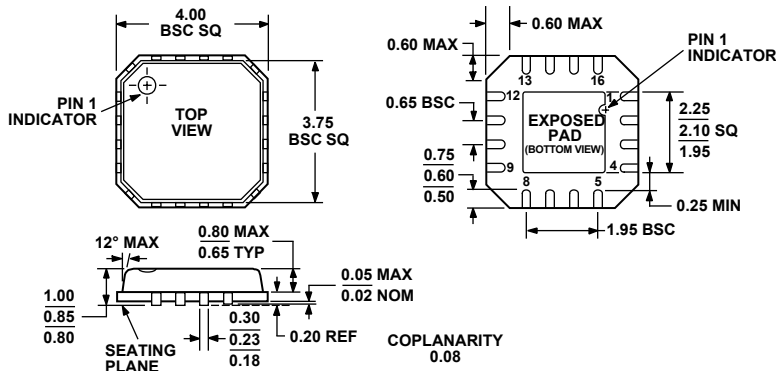
OUTLINE DIMENSIONS



COMPLIANT TO JEDEC STANDARDS MS-012-AB
CONTROLLING DIMENSIONS ARE IN MILLIMETERS; INCH DIMENSIONS
(IN PARENTHESES) ARE ROUNDED-OFF MILLIMETER EQUIVALENTS FOR
REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN.

Figure 37. 14-Lead Standard Small Outline Package [SOIC_N]
Narrow Body
(R-14)

Dimensions shown in millimeters and (inches)



COMPLIANT TO JEDEC STANDARDS MO-220-VGGC

Figure 38. 16-Lead Lead Frame Chip Scale Package [LFCSP_VQ]
4 mm x 4 mm Body, Very Thin Quad
(CP-16-4)

Dimensions shown in millimeters

ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option
ADA4004-4ACPZ-R2 ¹	-40°C to +125°C	16-Lead Lead Frame Chip Scale Package [LFCSP_VQ]	CP-16-4
ADA4004-4ACPZ-R7 ¹	-40°C to +125°C	16-Lead Lead Frame Chip Scale Package [LFCSP_VQ]	CP-16-4
ADA4004-4ACPZ-RL ¹	-40°C to +125°C	16-Lead Lead Frame Chip Scale Package [LFCSP_VQ]	CP-16-4
ADA4004-4ARZ ¹	-40°C to +125°C	14-Lead Standard Small Outline Package [SOIC_N]	R-14
ADA4004-4ARZ-R7 ¹	-40°C to +125°C	14-Lead Standard Small Outline Package [SOIC_N]	R-14
ADA4004-4ARZ-RL ¹	-40°C to +125°C	14-Lead Standard Small Outline Package [SOIC_N]	R-14

¹ Z = Pb-free part.