

## FEATURES

Specified from  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$

0.9  $\mu\text{V}/^{\circ}\text{C}$  maximum input offset voltage drift

5 ppm/ $^{\circ}\text{C}$  maximum gain drift ( $G = 1$ )

Low power

2.3 mA maximum supply current

Low noise

3.2 nV/ $\sqrt{\text{Hz}}$  maximum input voltage noise at 1 kHz

200 fA/ $\sqrt{\text{Hz}}$  current noise at 1 kHz

Excellent ac specifications

2 MHz bandwidth ( $G = 100$ )

0.6  $\mu\text{s}$  settling time to 0.001% ( $G = 10$ )

80 dB minimum CMRR at 20 kHz ( $G = 1$ )

High precision dc performance

84 dB CMRR minimum ( $G = 1$ )

2 nA maximum input bias current

Inputs protected to 40 V from opposite supply

Gain set with a single resistor ( $G = 1$  to 10,000)

## ENHANCED PRODUCT FEATURES

Supports defense and aerospace applications (AQEC standard)

Military temperature range ( $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ )

Controlled manufacturing baseline

One assembly/test site

One fabrication site

Enhanced product change notification

Qualification data available on request

## GENERAL DESCRIPTION

The **AD8421-EP** is a low cost, low power, extremely low noise, ultralow bias current, high speed instrumentation amplifier that is ideally suited for a broad spectrum of signal conditioning and data acquisition applications. This product features extremely high CMRR, allowing it to extract low level signals in the presence of high frequency common-mode noise over a wide temperature range.

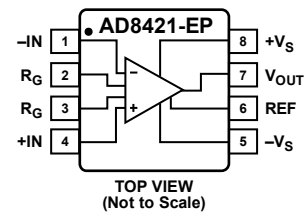
The 10 MHz bandwidth, 35 V/ $\mu\text{s}$  slew rate, and 0.6  $\mu\text{s}$  settling time to 0.001% ( $G = 10$ ) allow the **AD8421-EP** to amplify high speed signals and excel in applications that require high channel count, multiplexed systems. Even at higher gains, the current feedback architecture maintains high performance; for example, at  $G = 100$ , the bandwidth is 2 MHz and the settling time is 0.8  $\mu\text{s}$ . The **AD8421-EP** has excellent distortion performance, making it suitable for use in demanding applications such as vibration analysis.

Rev. 0

[Document Feedback](#)

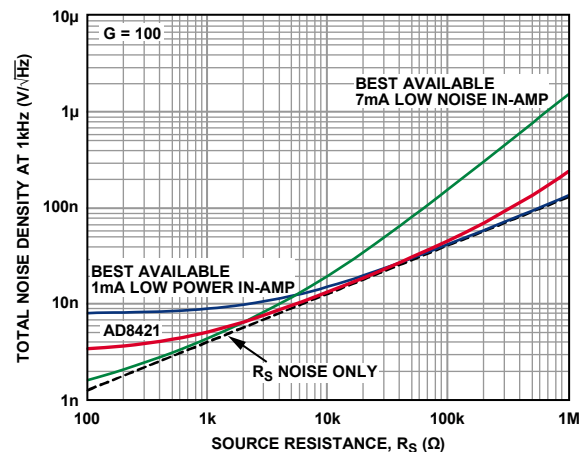
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## PIN CONNECTION DIAGRAM



11139-001

Figure 1.



11139-078

Figure 2. Noise Density vs. Source Resistance

The **AD8421-EP** delivers 3 nV/ $\sqrt{\text{Hz}}$  input voltage noise and 200 fA/ $\sqrt{\text{Hz}}$  current noise with only 2 mA quiescent current, making it an ideal choice for measuring low level signals. For applications with high source impedance, the **AD8421-EP** employs innovative process technology and design techniques to provide noise performance that is limited only by the sensor.

The **AD8421-EP** uses unique protection methods to ensure robust inputs while still maintaining very low noise. This protection allows input voltages up to 40 V from the opposite supply rail without damage to the part.

A single resistor sets the gain from 1 to 10,000. The reference pin can be used to apply a precise offset to the output voltage.

The **AD8421-EP** is specified over the military temperature range of  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ . It is available in an 8-lead MSOP package.

Additional application and technical information can be found in the [AD8421](#) data sheet.

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**REVISION HISTORY**

5/13—Revision 0: Initial Version

## SPECIFICATIONS

$V_S = \pm 15\text{ V}$ ,  $V_{REF} = 0\text{ V}$ ,  $T_A = 25^\circ\text{C}$ ,  $G = 1$ ,  $R_L = 2\text{ k}\Omega$ , unless otherwise noted.

Table 1.

Parameter	Test Conditions/ Comments	Min	Typ	Max	Unit
<b>COMMON-MODE REJECTION RATIO (CMRR)</b>					
CMRR DC to 60 Hz with 1 k $\Omega$ Source Imbalance	$V_{CM} = -10\text{ V to }+10\text{ V}$				
G = 1		84			dB
G = 10		104			dB
G = 100		124			dB
G = 1000		134			dB
Over Temperature, G = 1	$T_A = -55^\circ\text{C to }+125^\circ\text{C}$	80			dB
CMRR at 20 kHz	$V_{CM} = -10\text{ V to }+10\text{ V}$				
G = 1		80			dB
G = 10		90			dB
G = 100		100			dB
G = 1000		100			dB
<b>NOISE</b>					
Voltage Noise, 1 kHz <sup>1</sup>	$V_{IN+}, V_{IN-} = 0\text{ V}$				
Input Voltage Noise, $e_{ni}$			3	3.2	nV/ $\sqrt{\text{Hz}}$
Output Voltage Noise, $e_{no}$				60	nV/ $\sqrt{\text{Hz}}$
Peak to Peak, RTI	$f = 0.1\text{ Hz to }10\text{ Hz}$				
G = 1			2		$\mu\text{V p-p}$
G = 10			0.5		$\mu\text{V p-p}$
G = 100 to 1000			0.07		$\mu\text{V p-p}$
Current Noise					
Spectral Density	$f = 1\text{ kHz}$		200		fA/ $\sqrt{\text{Hz}}$
Peak to Peak, RTI	$f = 0.1\text{ Hz to }10\text{ Hz}$		18		pA p-p
<b>VOLTAGE OFFSET<sup>2</sup></b>					
Input Offset Voltage, $V_{OSI}$	$V_S = \pm 5\text{ V to } \pm 15\text{ V}$			70	$\mu\text{V}$
Over Temperature	$T_A = -55^\circ\text{C to }+125^\circ\text{C}$			160	$\mu\text{V}$
Average TC				0.9	$\mu\text{V}/^\circ\text{C}$
Output Offset Voltage, $V_{OSO}$				600	$\mu\text{V}$
Over Temperature	$T_A = -55^\circ\text{C to }+125^\circ\text{C}$			1.5	mV
Average TC				9	$\mu\text{V}/^\circ\text{C}$
Offset RTI vs. Supply (PSR)	$V_S = \pm 2.5\text{ V to } \pm 18\text{ V}$				
G = 1		90	120		dB
G = 10		110	120		dB
G = 100		124	130		dB
G = 1000		130	140		dB
<b>INPUT CURRENT</b>					
Input Bias Current			1	2	nA
Over Temperature	$T_A = -55^\circ\text{C to }+125^\circ\text{C}$			8	nA
Average TC			50		pA/ $^\circ\text{C}$
Input Offset Current			0.5	2	nA
Over Temperature	$T_A = -55^\circ\text{C to }+125^\circ\text{C}$			3	nA
Average TC			1		pA/ $^\circ\text{C}$

Parameter	Test Conditions/ Comments	Min	Typ	Max	Unit
<b>DYNAMIC RESPONSE</b>					
Small Signal Bandwidth	-3 dB		10		MHz
G = 1			10		MHz
G = 10			2		MHz
G = 1000			0.2		MHz
Settling Time 0.01%	10 V step		0.7		μs
G = 1			0.4		μs
G = 10			0.6		μs
G = 1000			5		μs
Settling Time 0.001%	10 V step		1		μs
G = 1			0.6		μs
G = 10			0.8		μs
G = 1000			6		μs
Slew Rate			35		V/μs
G = 1 to 100					
<b>GAIN<sup>3</sup></b>					
Gain Range	$G = 1 + (9.9 \text{ k}\Omega/R_G)$	1		10,000	V/V
Gain Error	$V_{OUT} = \pm 10 \text{ V}$			0.05	%
G = 1				0.3	%
G = 10 to 1000					
Gain Nonlinearity	$V_{OUT} = -10 \text{ V to } +10 \text{ V}$			1	ppm
G = 1	$R_L \geq 2 \text{ k}\Omega$		1	3	ppm
	$R_L = 600 \Omega$		30	50	ppm
G = 10 to 1000	$R_L \geq 600 \Omega$		5	10	ppm
	$V_{OUT} = -5 \text{ V to } +5 \text{ V}$				
Gain vs. Temperature <sup>3</sup>				5	ppm/°C
G = 1				-80	ppm/°C
G > 1					
<b>INPUT</b>					
Input Impedance			30  3		GΩ  pF
Differential			30  3		GΩ  pF
Common Mode					
Input Operating Voltage Range <sup>4</sup>	$V_S = \pm 2.5 \text{ V to } \pm 18 \text{ V}$	$-V_S + 2.3$		$+V_S - 1.8$	V
Over Temperature	$T_A = -55^\circ\text{C}$	$-V_S + 2.5$		$+V_S - 2.0$	V
	$T_A = +125^\circ\text{C}$	$-V_S + 2.1$		$+V_S - 1.8$	V
<b>OUTPUT</b>					
Output Swing	$R_L = 2 \text{ k}\Omega$				V
Over Temperature	$V_S = \pm 2.5 \text{ V to } \pm 18 \text{ V}$	$-V_S + 1.2$		$+V_S - 1.7$	V
Short-Circuit Current	$T_A = -55^\circ\text{C to } +125^\circ\text{C}$	$-V_S + 1.4$	65	$+V_S - 1.9$	V
<b>REFERENCE INPUT</b>					
$R_{IN}$			20		kΩ
$I_{IN}$	$V_{IN+}, V_{IN-} = 0 \text{ V}$		20	24	μA
Voltage Range		$-V_S$		$+V_S$	V
Reference Gain to Output			$1 \pm 0.0001$		V/V

Parameter	Test Conditions/ Comments	Min	Typ	Max	Unit
POWER SUPPLY					
Operating Range	Dual supply	±2.5		±18	V
	Single supply	5		36	V
Quiescent Current Over Temperature	$T_A = -55^\circ\text{C}$ to $+125^\circ\text{C}$		2	2.3	mA
				2.8	mA
TEMPERATURE RANGE					
For Specified Performance		-55		+125	$^\circ\text{C}$

<sup>1</sup> Total voltage noise =  $\sqrt{(e_{n1})^2 + (e_{no}/G)^2 + e_{RG}^2}$ . See the [AD8421](#) data sheet for more information.

<sup>2</sup> Total RTI  $V_{OS} = (V_{OS1}) + (V_{OS0}/G)$ .

<sup>3</sup> These specifications do not include the tolerance of the external gain setting resistor,  $R_G$ . For  $G > 1$ , add  $R_G$  errors to the specifications given in this table.

<sup>4</sup> Input voltage range of the [AD8421-EP](#) input stage only. The input range can depend on the common-mode voltage, differential voltage, gain, and reference voltage. See the Typical Performance Characteristics section for more information.

## ABSOLUTE MAXIMUM RATINGS

Table 2.

Parameter	Rating
Supply Voltage	±18 V
Output Short-Circuit Current Duration	Indefinite
Maximum Voltage at –IN or +IN <sup>1</sup>	–V <sub>S</sub> + 40 V
Minimum Voltage at –IN or +IN	+V <sub>S</sub> – 40 V
Maximum Voltage at REF <sup>2</sup>	+V <sub>S</sub> + 0.3 V
Minimum Voltage at REF	–V <sub>S</sub> – 0.3 V
Storage Temperature Range	–65°C to +150°C
Operating Temperature Range	–55°C to +125°C
Maximum Junction Temperature	150°C
ESD	
Human Body Model	2 kV
Charged Device Model	1.25 kV
Machine Model	0.2 kV

<sup>1</sup> For voltages beyond these limits, use input protection resistors. See the [AD8421](#) data sheet for more information.

<sup>2</sup> There are ESD protection diodes from the reference input to each supply, so REF cannot be driven beyond the supplies in the same way that +IN and –IN can. See the [AD8421](#) data sheet for more information.

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

$\theta_{JA}$  is specified for a device in free air using a 4-layer JEDEC printed circuit board (PCB).

Table 3.

Package	$\theta_{JA}$	Unit
8-Lead MSOP	138.6	°C/W

## ESD CAUTION



**ESD (electrostatic discharge) sensitive device.** Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

## PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

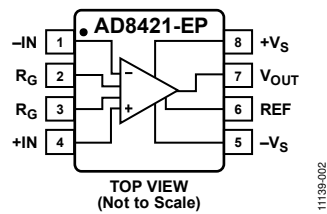


Figure 3. Pin Configuration

Table 4. Pin Function Descriptions

Pin No.	Mnemonic	Description
1	-IN	Negative Input Terminal.
2, 3	R <sub>G</sub>	Gain Setting Terminals. Place resistor across the R <sub>G</sub> pins to set the gain. $G = 1 + (9.9 \text{ k}\Omega/R_G)$ .
4	+IN	Positive Input Terminal.
5	-V <sub>S</sub>	Negative Power Supply Terminal.
6	REF	Reference Voltage Terminal. Drive this terminal with a low impedance voltage source to level shift the output.
7	V <sub>OUT</sub>	Output Terminal.
8	+V <sub>S</sub>	Positive Power Supply Terminal.

# TYPICAL PERFORMANCE CHARACTERISTICS

$T_A = 25^\circ\text{C}$ ,  $V_S = \pm 15\text{ V}$ ,  $V_{REF} = 0\text{ V}$ ,  $R_L = 2\text{ k}\Omega$ , unless otherwise noted.

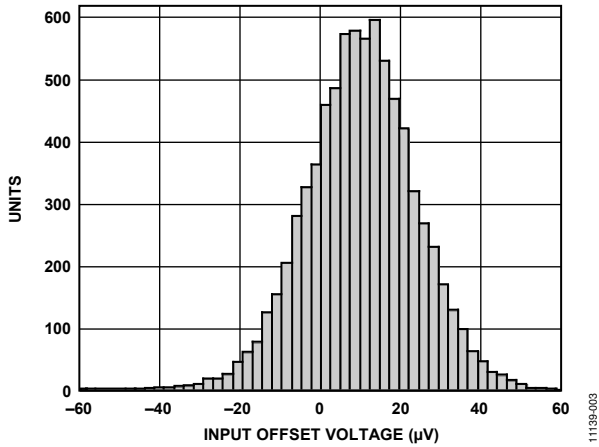


Figure 4. Typical Distribution of Input Offset Voltage

11139-003

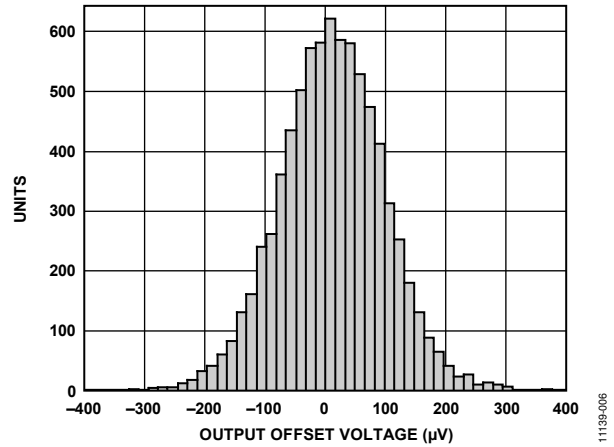


Figure 7. Typical Distribution of Output Offset Voltage

11139-006

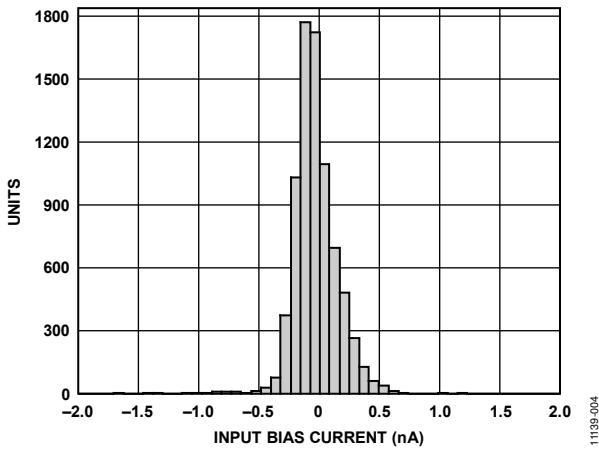


Figure 5. Typical Distribution of Input Bias Current

11139-004

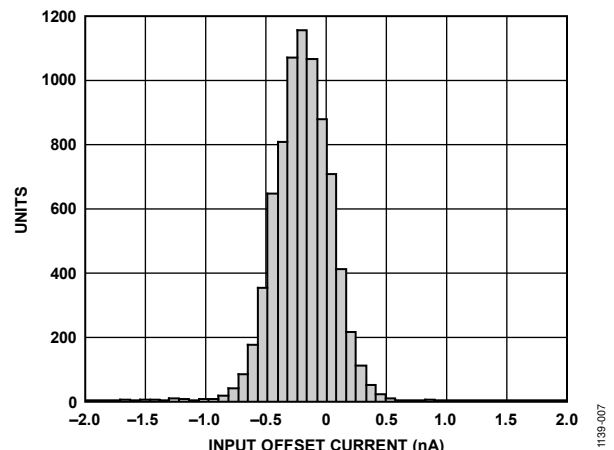


Figure 8. Typical Distribution of Input Offset Current

11139-007

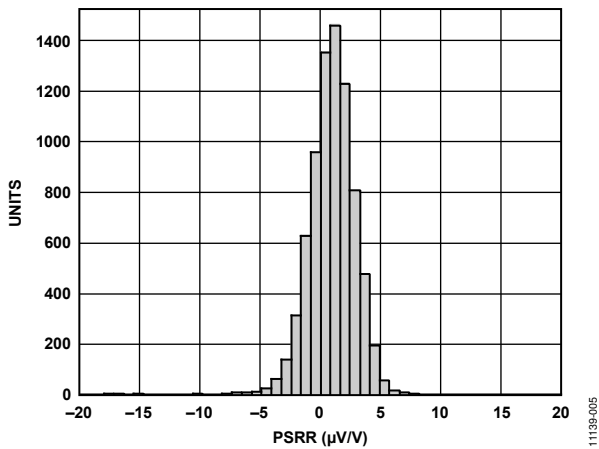


Figure 6. Typical Distribution of PSRR (G = 1)

11139-005

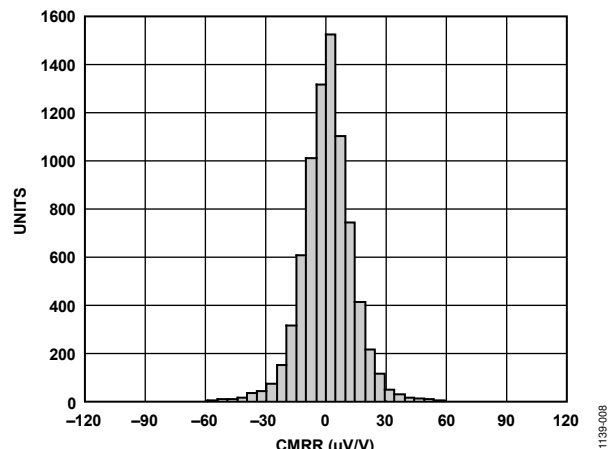


Figure 9. Typical Distribution of CMRR (G = 1)

11139-008



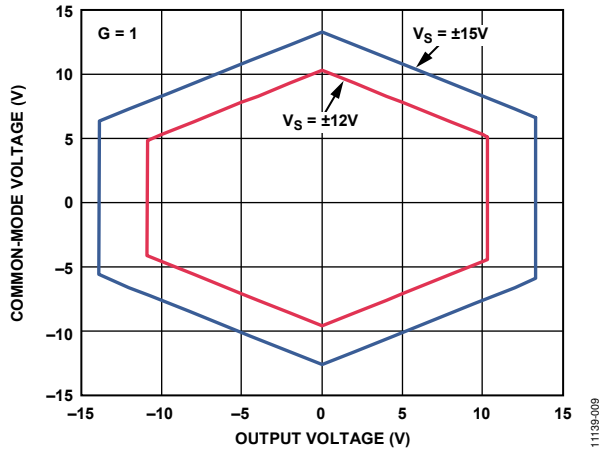


Figure 10. Input Common-Mode Voltage vs. Output Voltage;  $V_S = \pm 12\text{ V}$  and  $\pm 15\text{ V}$  ( $G = 1$ )

11139-009

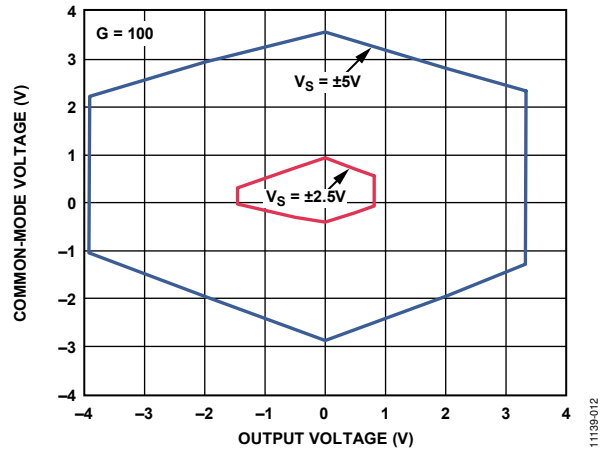


Figure 13. Input Common-Mode Voltage vs. Output Voltage;  $V_S = \pm 2.5\text{ V}$  and  $\pm 5\text{ V}$  ( $G = 100$ )

11139-012

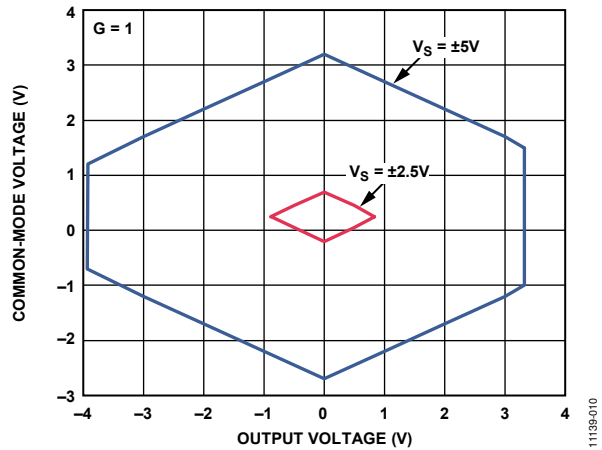


Figure 11. Input Common-Mode Voltage vs. Output Voltage;  $V_S = \pm 2.5\text{ V}$  and  $\pm 5\text{ V}$  ( $G = 1$ )

11139-010

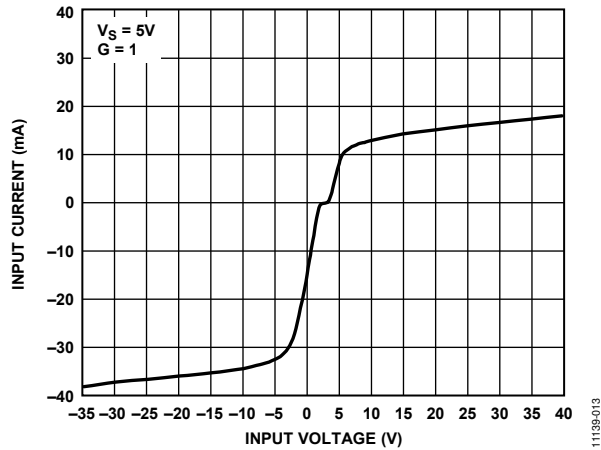


Figure 14. Input Overvoltage Performance;  $G = 1$ ,  $+V_S = 5\text{ V}$ ,  $-V_S = 0\text{ V}$

11139-013

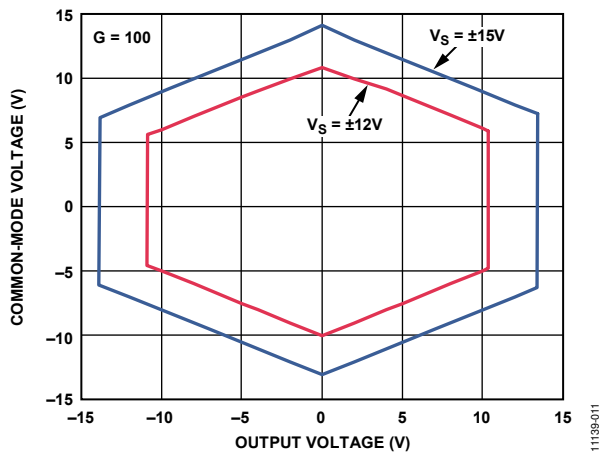


Figure 12. Input Common-Mode Voltage vs. Output Voltage;  $V_S = \pm 12\text{ V}$  and  $\pm 15\text{ V}$  ( $G = 100$ )

11139-011

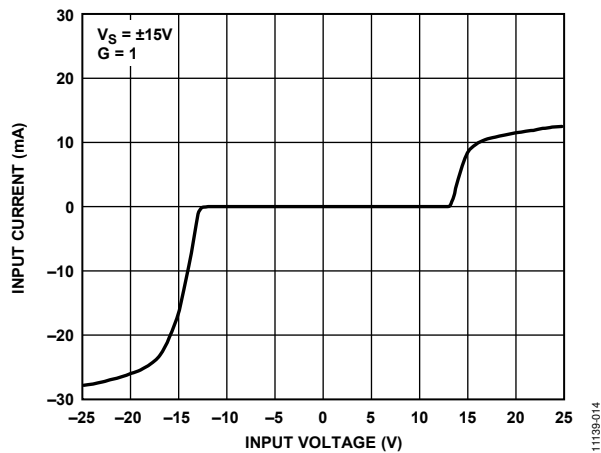


Figure 15. Input Overvoltage Performance;  $G = 1$ ,  $V_S = \pm 15\text{ V}$

11139-014

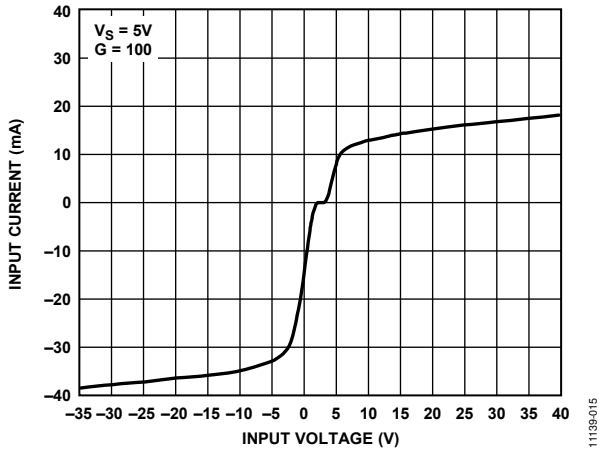


Figure 16. Input Overvoltage Performance;  $+V_S = 5V$ ,  $-V_S = 0V$ ,  $G = 100$

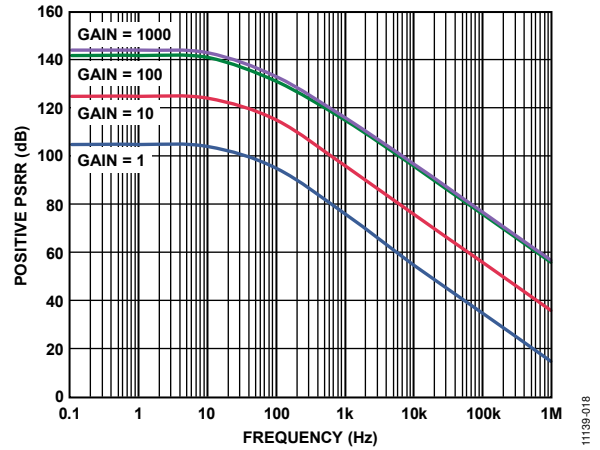


Figure 19. Positive PSRR vs. Frequency

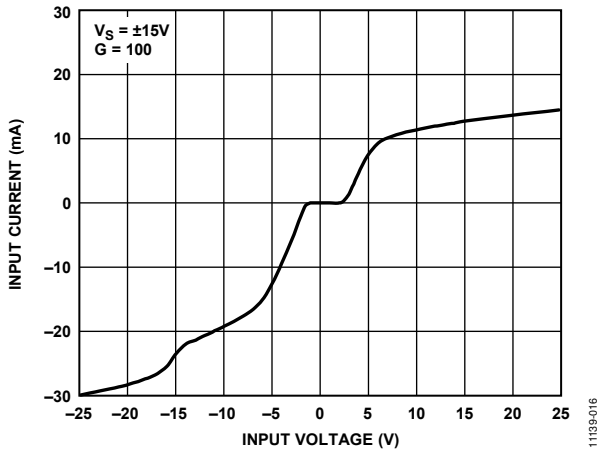


Figure 17. Input Overvoltage Performance;  $V_S = \pm 15V$ ,  $G = 100$

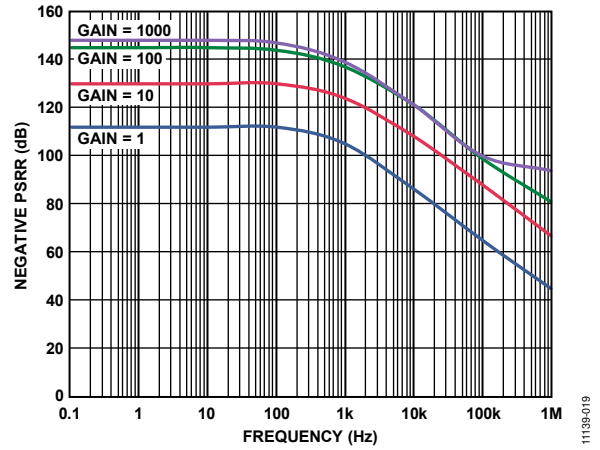


Figure 20. Negative PSRR vs. Frequency

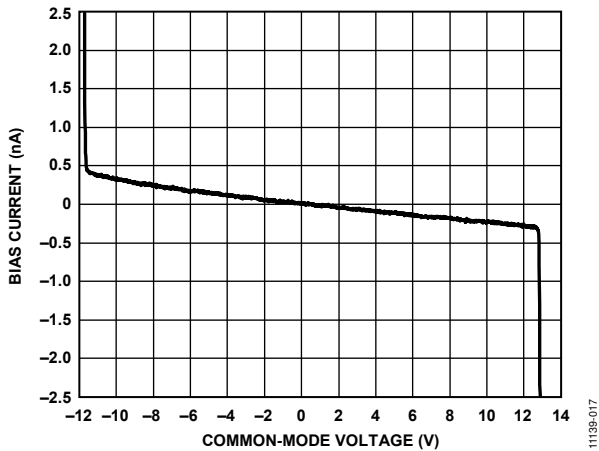


Figure 18. Input Bias Current vs. Common-Mode Voltage

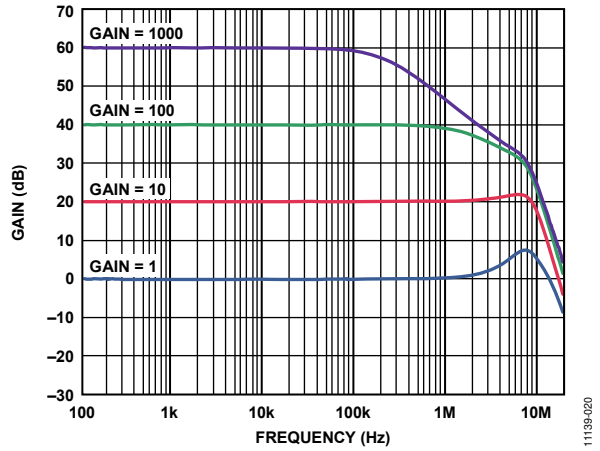


Figure 21. Gain vs. Frequency

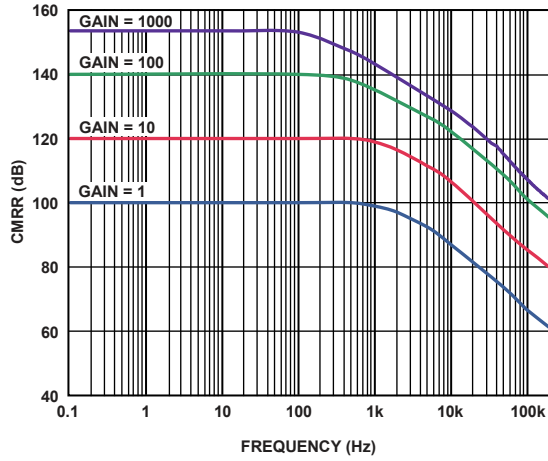


Figure 22. CMRR vs. Frequency

11139-021

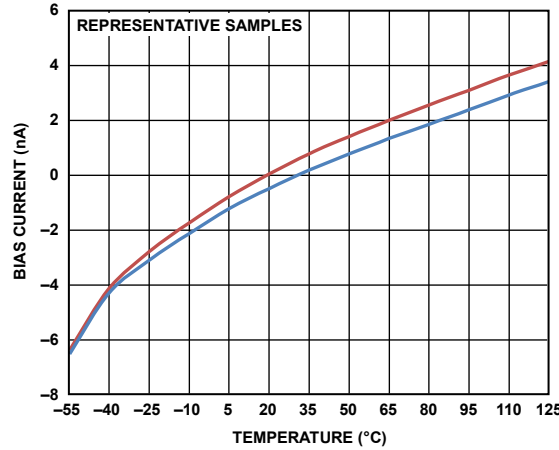


Figure 25. Input Bias Current vs. Temperature

11139-125

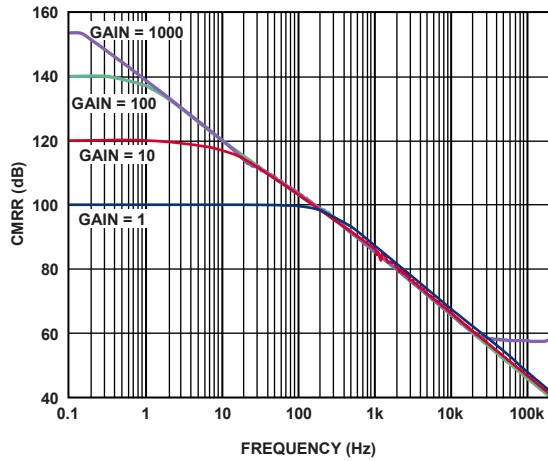


Figure 23. CMRR vs. Frequency, 1 kΩ Source Imbalance

11139-022

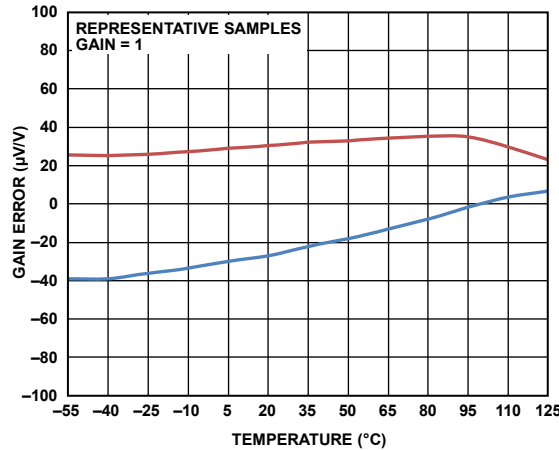


Figure 26. Gain vs. Temperature (G = 1)

11139-126

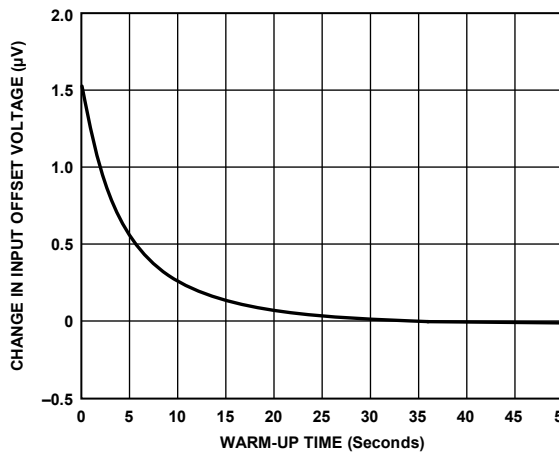


Figure 24. Change in Input Offset Voltage ( $V_{os}$ ) vs. Warm-Up Time

11139-023

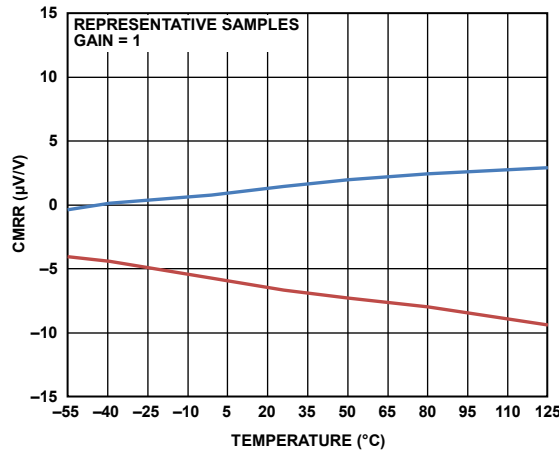


Figure 27. CMRR vs. Temperature (G = 1)

11139-127

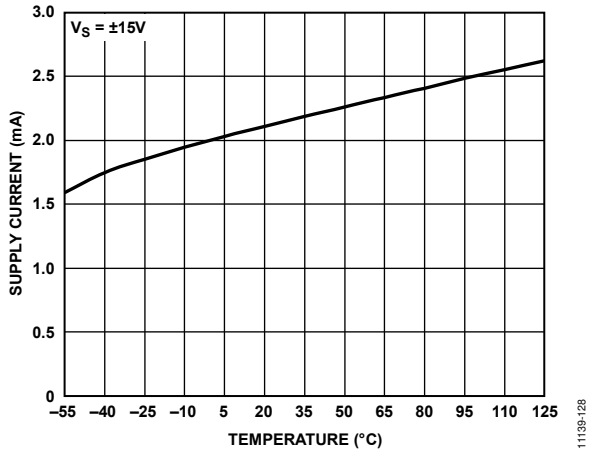


Figure 28. Supply Current vs. Temperature (G = 1)

11139-128

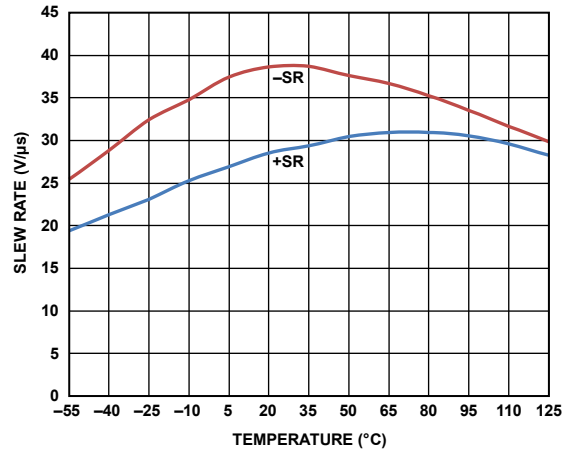


Figure 31. Slew Rate vs. Temperature,  $V_S = \pm 5\text{ V}$  (G = 1)

11139-131

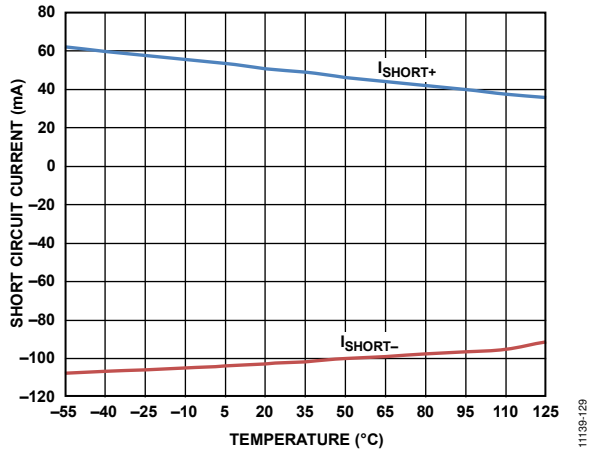


Figure 29. Short-Circuit Current vs. Temperature (G = 1)

11139-129

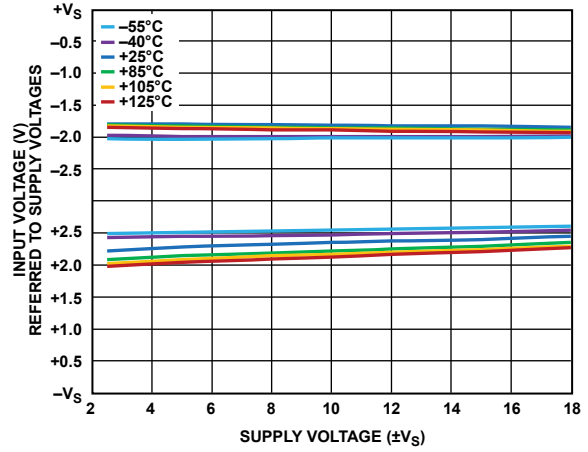


Figure 32. Input Voltage Limit vs. Supply Voltage

11139-132

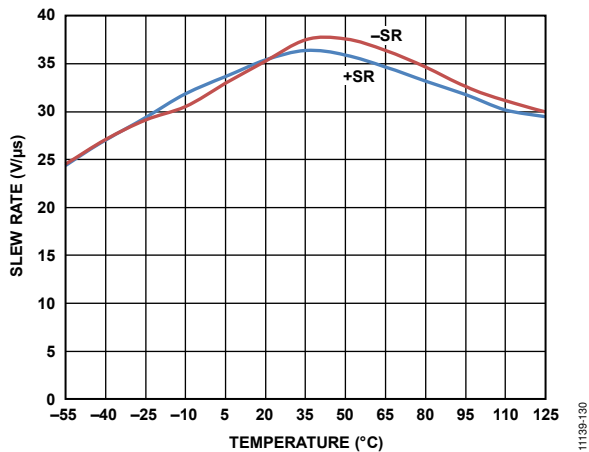


Figure 30. Slew Rate vs. Temperature,  $V_S = \pm 15\text{ V}$  (G = 1)

11139-130

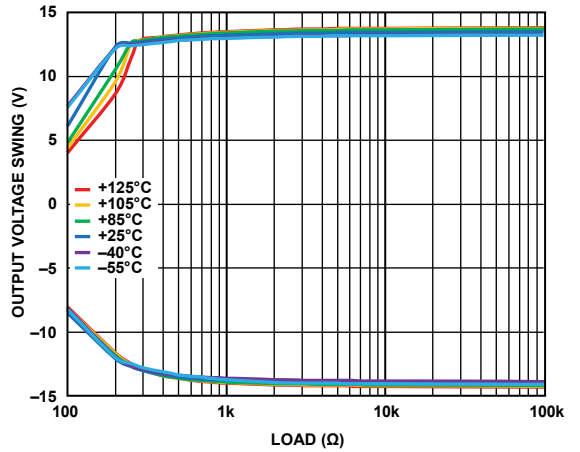


Figure 33. Output Voltage Swing vs. Load Resistance

11139-135

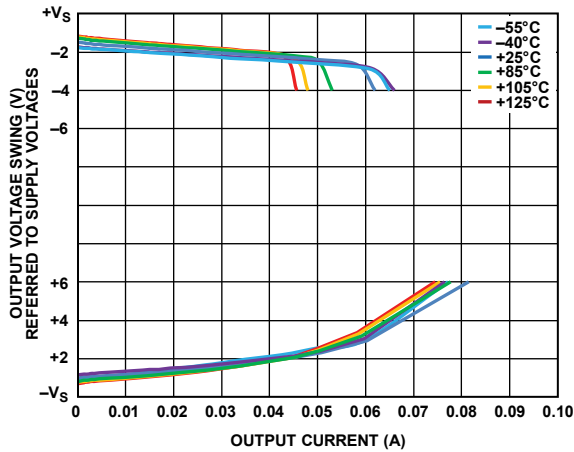


Figure 34. Output Voltage Swing vs. Output Current

11139-136

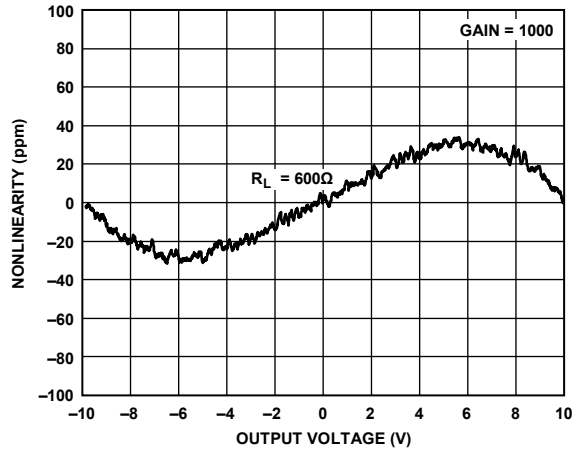


Figure 37. Gain Nonlinearity ( $G = 1000$ ),  $R_L = 600 \Omega$ ,  $V_{OUT} = \pm 10 V$

11139-072

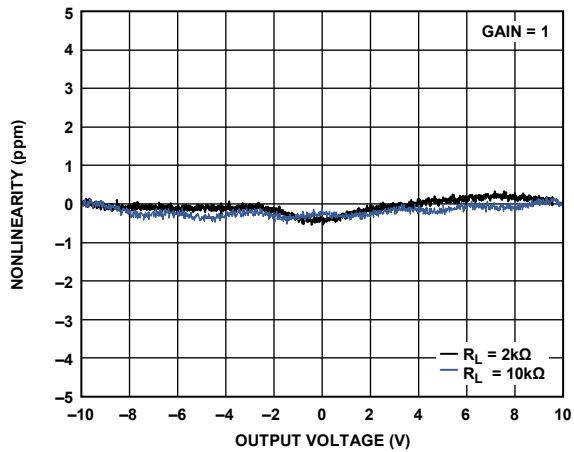


Figure 35. Gain Nonlinearity ( $G = 1$ ),  $R_L = 10 k\Omega$ ,  $2 k\Omega$

11139-035

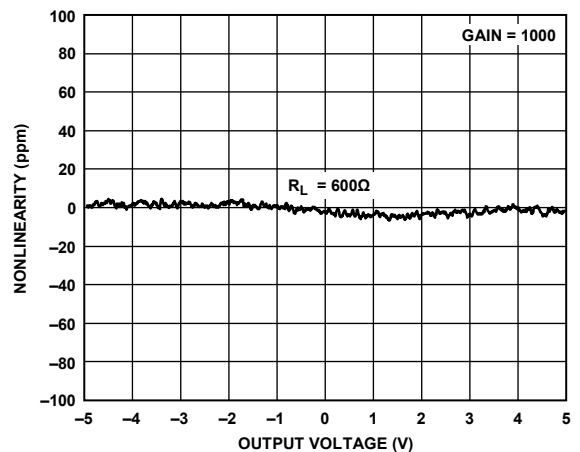


Figure 38. Gain Nonlinearity ( $G = 1000$ ),  $R_L = 600 \Omega$ ,  $V_{OUT} = \pm 5 V$

11139-073

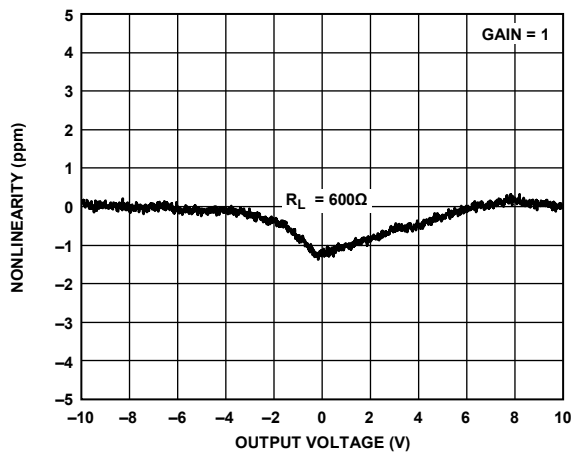


Figure 36. Gain Nonlinearity ( $G = 1$ ),  $R_L = 600 \Omega$

11139-036

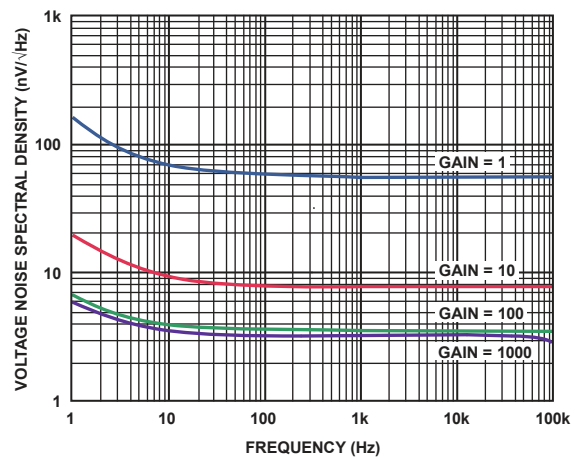


Figure 39. RTI Voltage Noise Spectral Density vs. Frequency

11139-037

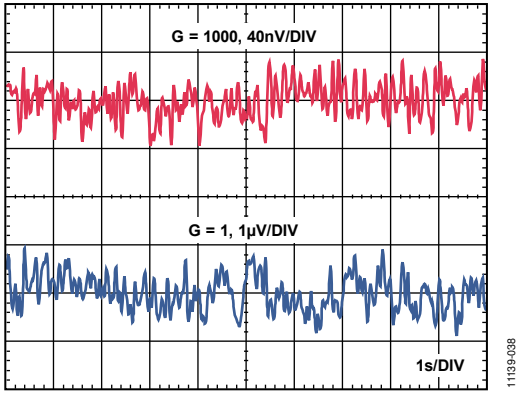


Figure 40. 0.1 Hz to 10 Hz RTI Voltage Noise ( $G = 1$ ,  $G = 1000$ )

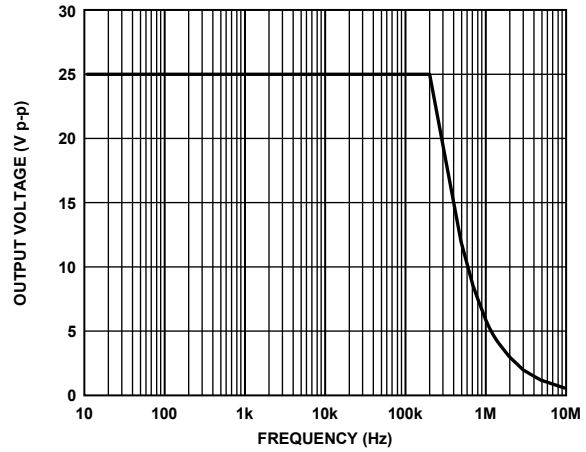


Figure 43. Large Signal Frequency Response

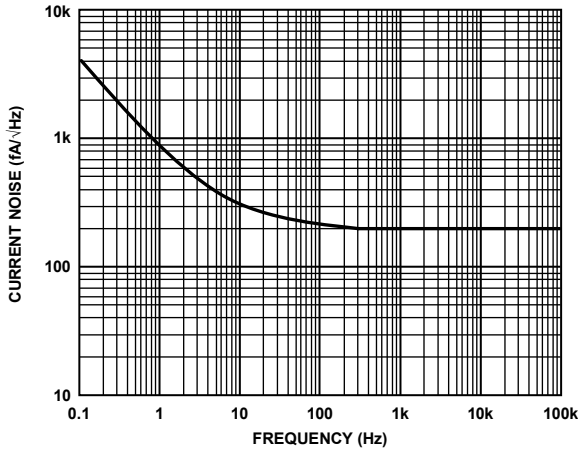


Figure 41. Current Noise Spectral Density vs. Frequency

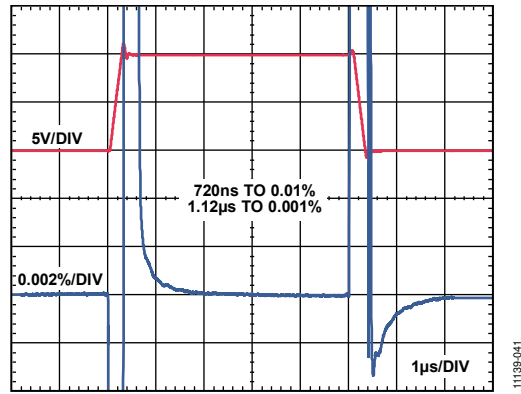


Figure 44. Large Signal Pulse Response and Settling Time ( $G = 1$ ), 10 V Step,  $V_s = \pm 15$  V,  $R_L = 2$  k $\Omega$ ,  $C_L = 100$  pF

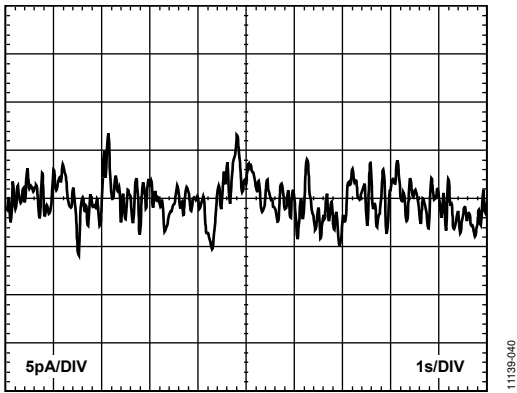


Figure 42. 0.1 Hz to 10 Hz Current Noise

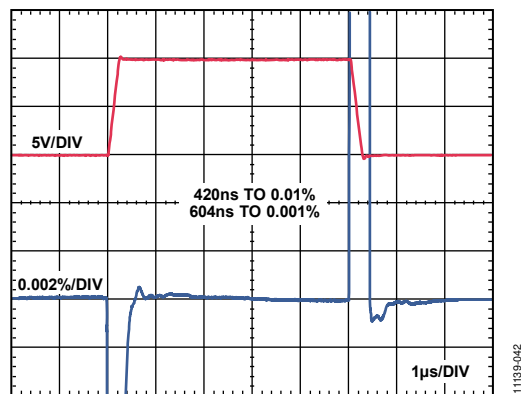


Figure 45. Large Signal Pulse Response and Settling Time ( $G = 10$ ), 10 V Step,  $V_s = \pm 15$  V,  $R_L = 2$  k $\Omega$ ,  $C_L = 100$  pF

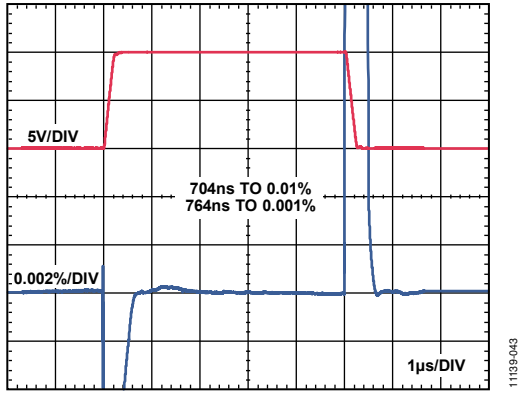


Figure 46. Large Signal Pulse Response and Settling Time ( $G = 100$ ), 10 V Step,  $V_S = \pm 15$  V,  $R_L = 2$  k $\Omega$ ,  $C_L = 100$  pF

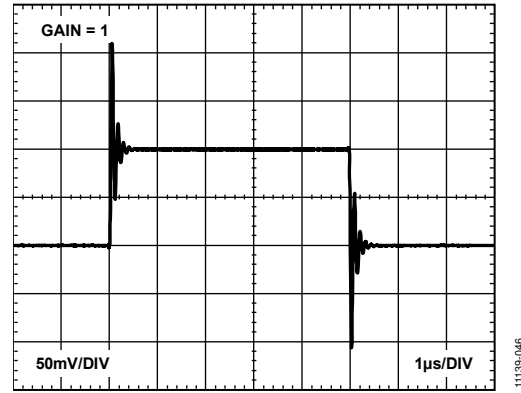


Figure 49. Small Signal Pulse Response ( $G = 1$ ),  $R_L = 600$   $\Omega$ ,  $C_L = 100$  pF

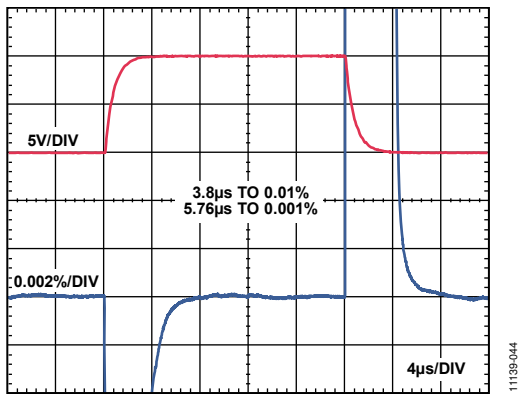


Figure 47. Large Signal Pulse Response and Settling Time ( $G = 1000$ ), 10 V Step,  $V_S = \pm 15$  V,  $R_L = 2$  k $\Omega$ ,  $C_L = 100$  pF

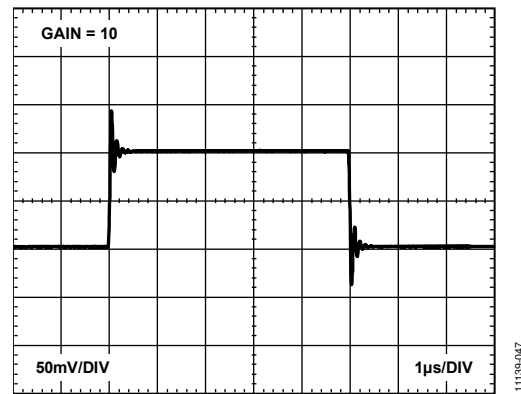


Figure 50. Small Signal Pulse Response ( $G = 10$ ),  $R_L = 600$   $\Omega$ ,  $C_L = 100$  pF

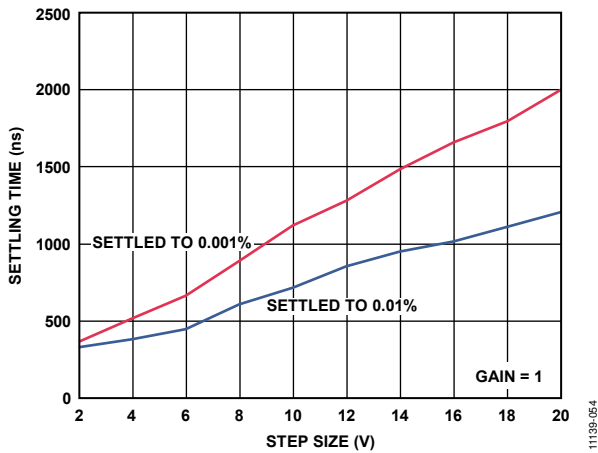


Figure 48. Settling Time vs. Step Size ( $G = 1$ ),  $R_L = 2$  k $\Omega$ ,  $C_L = 100$  pF

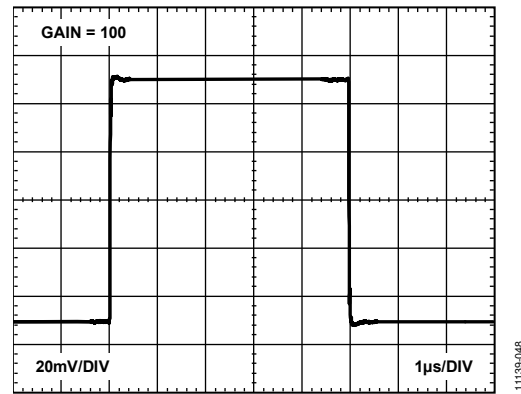


Figure 51. Small Signal Pulse Response ( $G = 100$ ),  $R_L = 600$   $\Omega$ ,  $C_L = 100$  pF

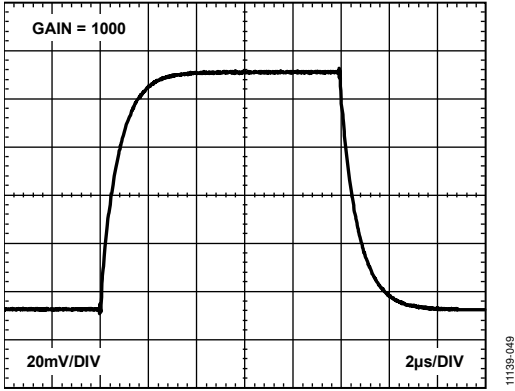


Figure 52. Small Signal Pulse Response ( $G = 1000$ ),  $R_L = 600\Omega$ ,  $C_L = 100\text{ pF}$

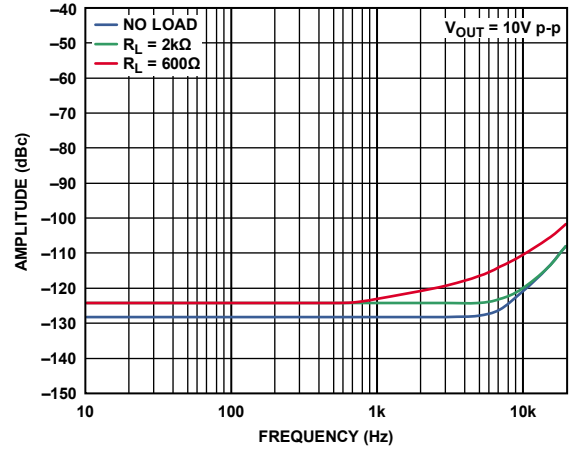


Figure 55. Third Harmonic Distortion vs. Frequency ( $G = 1$ )

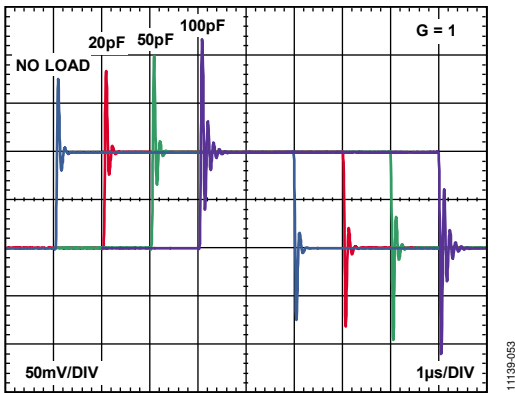


Figure 53. Small Signal Response with Various Capacitive Loads ( $G = 1$ ),  $R_L = \text{Infinity}$

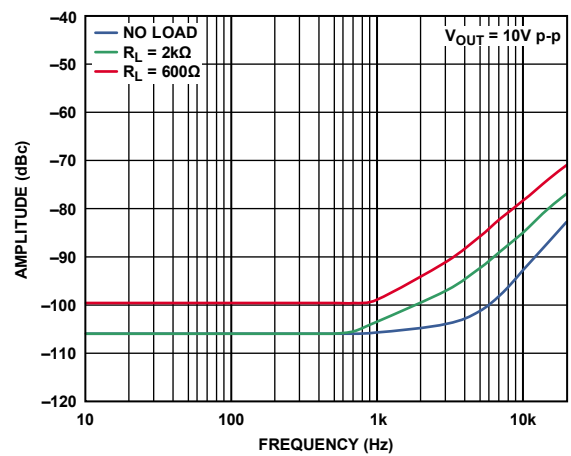


Figure 56. Second Harmonic Distortion vs. Frequency ( $G = 1000$ )

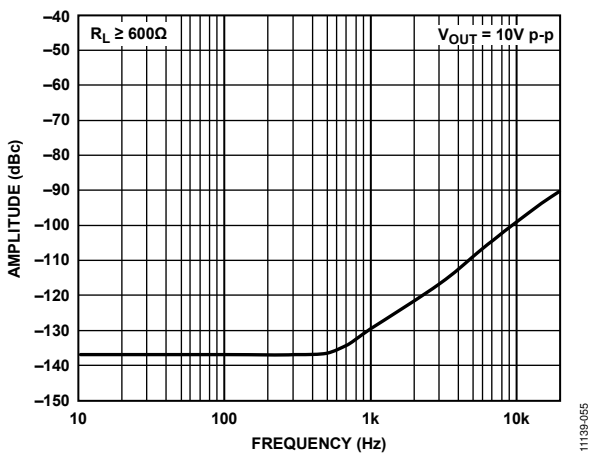


Figure 54. Second Harmonic Distortion vs. Frequency ( $G = 1$ )

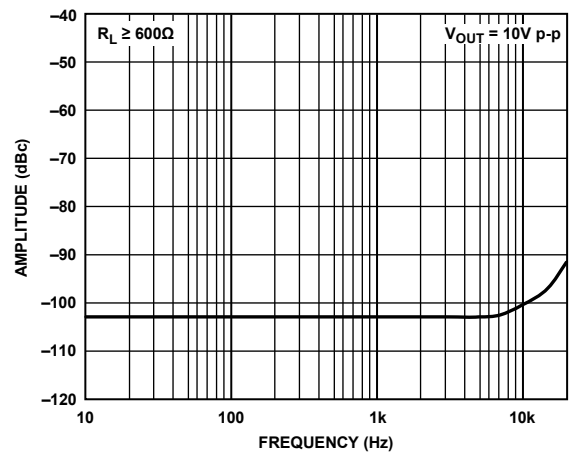


Figure 57. Third Harmonic Distortion vs. Frequency ( $G = 1000$ )



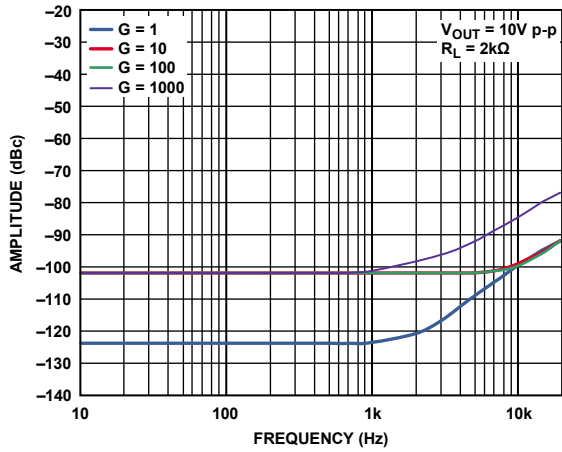
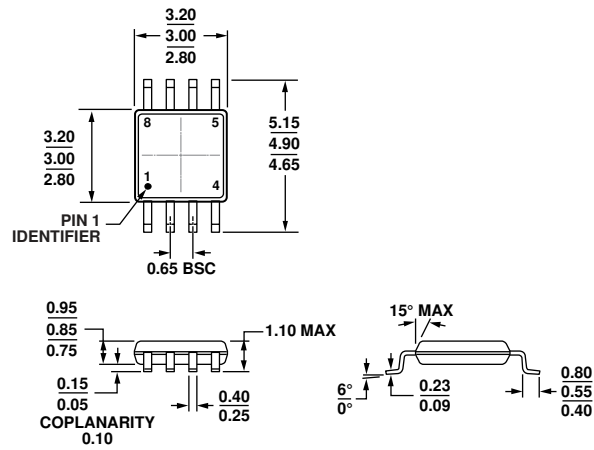


Figure 58. THD vs. Frequency

11039-077

OUTLINE DIMENSIONS



COMPLIANT TO JEDEC STANDARDS MO-187-AA  
 Figure 59. 8-Lead Mini Small Outline Package [MSOP]  
 (RM-8)  
 Dimensions shown in millimeters

10-07-2009-B

ORDERING GUIDE

Model <sup>1</sup>	Temperature Range	Package Description	Package Option	Branding
AD8421TRMZ-EP	-55°C to +125°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	Y4T
AD8421TRMZ-EP-R7	-55°C to +125°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	Y4T

<sup>1</sup> Z = RoHS Compliant Part.

**NOTES**

**NOTES**