Precision Instrumentation Amplifier

Enhanced Product

AD8221-EP

FEATURES

Specified from −55°C to +125°C
- **0.9 µV/°C maximum input offset average TC**
- **10 ppm/°C maximum gain vs. temperature (G = 1)**

Excellent ac specifications
- **80 dB minimum CMRR at 10 kHz (G = 1)**
- **−3 dB bandwidth: 825 kHz typical (G = 1)**
- **2 V/µs typical slew rate**

Low noise
- **8 nV/√Hz, at 1 kHz, maximum input voltage noise**
- **0.25 µV p-p RTI (G = 100 to 1000)**

High accuracy dc performance
- **80 dB minimum CMRR DC to 60 Hz (G = 1)**
- **70 µV maximum input offset voltage**
- **2 nA maximum input bias current**

Wide power supply range: ±2.3 V to ±18 V

Available in space-saving MSOP

Gain set with 1 external resistor (gain range 1 to 1000)

ENHANCED PRODUCT FEATURES

Supports defense and aerospace applications (AQEC standard)
Military temperature range (−55°C to +125°C)
Controlled manufacturing baseline
One assembly/test site
One fabrication site
Enhanced product change notification
Qualification data available on request

APPLICATIONS

Bridge amplifiers
Precision data acquisition systems
Strain gages
Transducer interfaces

TYPICAL CONNECTION DIAGRAM

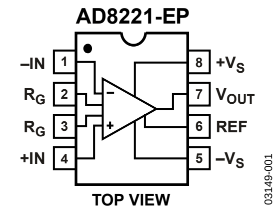

Figure 1.

GENERAL DESCRIPTION

The AD8221-EP is a gain programmable, high performance instrumentation amplifier that delivers the industry's highest CMRR over frequency in its class. The CMRR of instrumentation amplifiers on the market today falls off at 200 Hz. In contrast, the AD8221-EP maintains a minimum CMRR of 80 dB to 10 kHz at G = 1. High CMRR over frequency allows the AD8221-EP to reject wideband interference and line harmonics, greatly simplifying filter requirements.

Possible applications include precision data acquisition, biomedical analysis, and aerospace instrumentation.

Low voltage offset, low offset drift, low gain drift, high gain accuracy, and high CMRR make this device an excellent choice in applications that demand the best dc performance possible, such as bridge signal conditioning.

Programmable gain affords the user design flexibility. A single resistor sets the gain from 1 to 1000. The AD8221-EP operates on both single and dual supplies and is well suited for applications where ±10 V input voltages are encountered.

The AD8221-EP is specified over the −55°C to +125°C military temperature range. It is available in an 8-lead MSOP package.

Additional application and technical information can be found in the AD8221 data sheet.

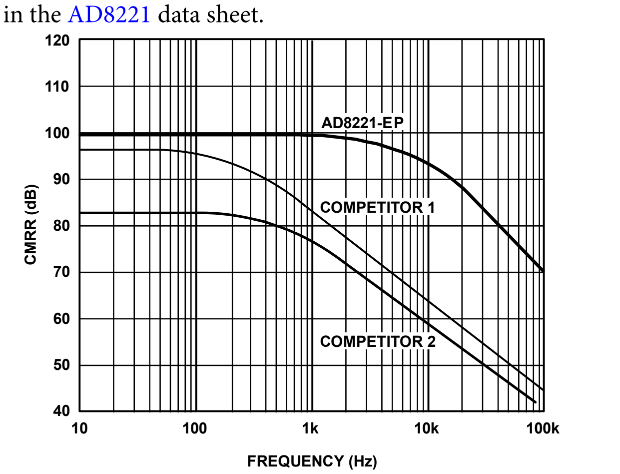

Figure 2. Typical CMRR vs. Frequency for G = 1

Rev. 0

Document Feedback

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Technical Support
www.analog.com

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REVISION HISTORY

4/16—Revision 0: Initial Version

SPECIFICATIONS

V_S = ±15 V, V_{REF} = 0 V, T_A = 25°C, G = 1, R_L = 2 kΩ, unless otherwise noted.

Table 1.

Parameter	Test Conditions/Comments	Min	Typ	Max	Unit
COMMON-MODE REJECTION RATIO (CMRR)					
CMRR DC to 60 Hz with 1 kΩ Source Imbalance	V_{CM} = −10 V to +10 V				
G = 1		80			dB
G = 10		100			dB
G = 100		120			dB
G = 1000		130			dB
CMRR at 10 kHz	V_{CM} = −10 V to +10 V				
G = 1		80			dB
G = 10		90			dB
G = 100		100			dB
G = 1000		100			dB
NOISE	RTI noise = $\sqrt{e_{NI}^2 + (e_{NO}/G)^2}$				
Voltage Noise, 1 kHz					
Input Voltage Noise, e_{NI}	V_{IN+}, V_{IN-}, V_{REF} = 0			8	nV/√Hz
Output Voltage Noise, e_{NO}				75	nV/√Hz
Referred to Input (RTI)	f = 0.1 Hz to 10 Hz				
G = 1			2		µV p-p
G = 10			0.5		µV p-p
G = 100 to 1000			0.25		µV p-p
Current Noise	f = 1 kHz		40		fA/√Hz
	f = 0.1 Hz to 10 Hz		6		pA p-p
VOLTAGE OFFSET[1]					
Input Offset, V_{OSI}	V_S = ±5 V to ±15 V			70	µV
Over Temperature	T_A = −55°C to +125°C			150	µV
Average Temperature Coefficient (TC)				0.9	µV/°C
Output Offset, V_{OSO}	V_S = ±5 V to ±15 V			600	µV
Over Temperature	T_A = −55°C to +125°C			1.2	mV
Average TC				9	µV/°C
Offset RTI vs. Supply (PSR)	V_S = ±2.3 V to ±18 V				
G = 1		90	100		dB
G = 10		100	120		dB
G = 100		120	140		dB
G = 1000		120	140		dB
INPUT CURRENT					
Input Bias Current			0.5	2	nA
Over Temperature	T_A = −55°C to +125°C			3.75	nA
Average TC			11		pA/°C
Input Offset Current			0.3	1	nA
Over Temperature	T_A = −55°C to +125°C			2.25	nA
Average TC			7		pA/°C
REFERENCE INPUT					
R_{IN}			20		kΩ
I_{IN}	V_{IN+}, V_{IN-}, V_{REF} = 0		50	60	µA
Voltage Range		$-V_S$		$+V_S$	V
Gain to Output			1 ± 0.0001		V/V

Parameter	Test Conditions/Comments	Min	Typ	Max	Unit
POWER SUPPLY					
Operating Range	V_S = ±2.3 V to ±18 V	±2.3		±18	V
Quiescent Current			0.9	1	mA
Over Temperature	T_A = −55°C to +125°C		1	1.2	mA
DYNAMIC RESPONSE					
Small Signal −3 dB Bandwidth					
G = 1			825		kHz
G = 10			562		kHz
G = 100			100		kHz
G = 1000			14.7		kHz
Settling Time 0.01%	10 V step				
G = 1 to 100			10		µs
G = 1000			80		µs
Settling Time 0.001%	10 V step				
G = 1 to 100			13		µs
G = 1000			110		µs
Slew Rate	G = 1	1.5	2		V/µs
	G = 5 to 100	2	2.5		V/µs
GAIN	G = 1 + (49.4 kΩ/R_G)				
Gain Range		1		1000	V/V
Gain Error	V_{OUT} ± 10 V				
G = 1				0.1	%
G = 10				0.3	%
G = 100				0.3	%
G = 1000				0.3	%
Gain Nonlinearity	V_{OUT} = −10 V to +10 V				
G = 1 to 10	R_L = 10 kΩ		5	15	ppm
G = 100	R_L = 10 kΩ		7	20	ppm
G = 1000	R_L = 10 kΩ		10	50	ppm
G = 1 to 100	R_L = 2 kΩ		15	100	ppm
Gain vs. Temperature					
G = 1			3	10	ppm/°C
G > 1[2]				−50	ppm/°C
INPUT					
Input Impedance					
Differential			100‖2		GΩ‖pF
Common Mode			100‖2		GΩ‖pF
Input Operating Voltage Range[3]	V_S = ±2.3 V to ±5 V	$-V_S$ + 1.9		$+V_S$ − 1.1	V
Over Temperature	T_A = −55°C to +125°C	$-V_S$ + 2.0		$+V_S$ − 1.2	V
Input Operating Voltage Range	V_S = ±5 V to ±18 V	$-V_S$ + 1.9		$+V_S$ − 1.2	V
Over Temperature	T_A = −55°C to +125°C	$-V_S$ + 2.0		$+V_S$ − 1.3	V
OUTPUT	R_L = 10 kΩ				
Output Swing	V_S = ±2.3 V to ±5 V	$-V_S$ + 1.1		$+V_S$ − 1.2	V
Over Temperature	T_A = −55°C to +125°C	$-V_S$ + 1.4		$+V_S$ − 1.3	V
Output Swing	V_S = ±5 V to ±18 V	$-V_S$ + 1.2		$+V_S$ − 1.4	V
Over Temperature	T_A = −55°C to +125°C	$-V_S$ + 1.6		$+V_S$ − 1.5	V
Short-Circuit Current			18		mA
TEMPERATURE RANGE					
Specified Performance		−55		+125	°C

[1] Total RTI V_{OS} = (V_{OSI}) + (V_{OSO}/G).
[2] Does not include the effects of external resistor R_G.
[3] One input grounded. G = 1.

ABSOLUTE MAXIMUM RATINGS

Table 2.

Parameter	Rating
Supply Voltage	±18 V
Internal Power Dissipation	200 mW
Output Short-Circuit Current	Indefinite
Input Voltage (Common-Mode)	$\pm V_S$
Differential Input Voltage	$\pm V_S$
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	−55°C to +125°C

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

THERMAL CHARACTERISTICS

Specification for a device in free air.

Table 3.

Package	θ_{JA}	Unit
8-Lead MSOP, 4-Layer JEDEC Board	135	°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

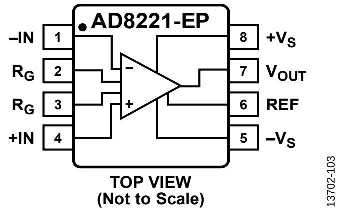

Figure 3. Pin Configuration

Table 4. Pin Function Descriptions

Pin No.	Mnemonic	Description
1	−IN	Negative Input Terminal.
2, 3	R_G	Gain Setting Terminal. Place resistor across the R_G pins to set the gain. $G = 1 + (49.4\ k\Omega/R_G)$.
4	+IN	Positive Input Terminal.
5	$-V_S$	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_{OUT}	Output Terminal.
8	$+V_S$	Positive Power Supply Terminal.

TYPICAL PERFORMANCE CHARACTERISTICS

T = 25°C, V_S = ±15 V, R_L = 10 kΩ, unless otherwise noted.

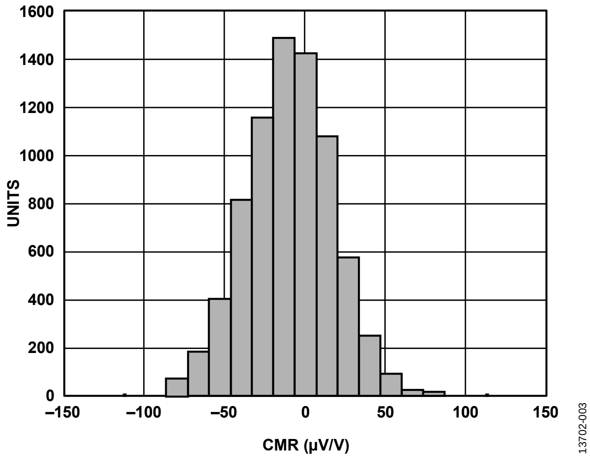

Figure 4. Typical Distribution for CMR (G = 1)

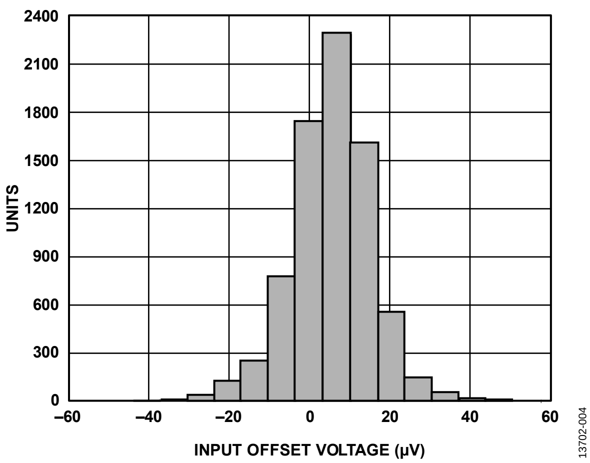

Figure 5. Typical Distribution of Input Offset Voltage

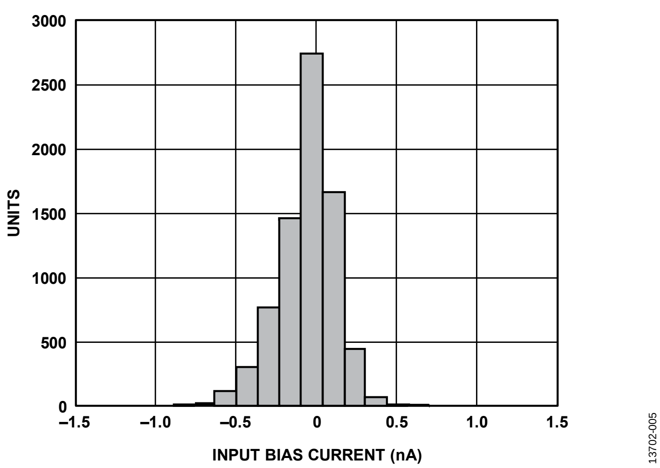

Figure 6. Typical Distribution of Input Bias Current

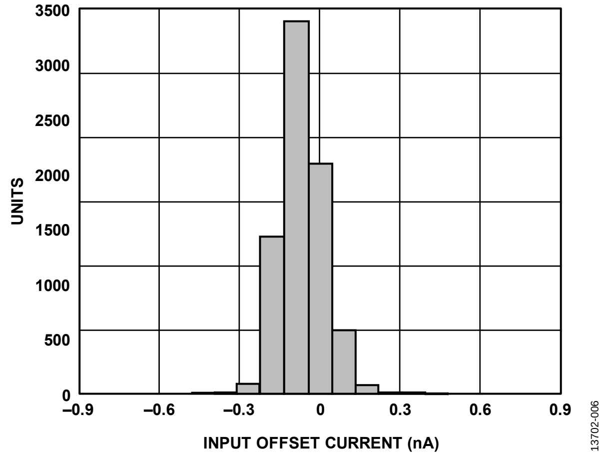

Figure 7. Typical Distribution of Input Offset Current

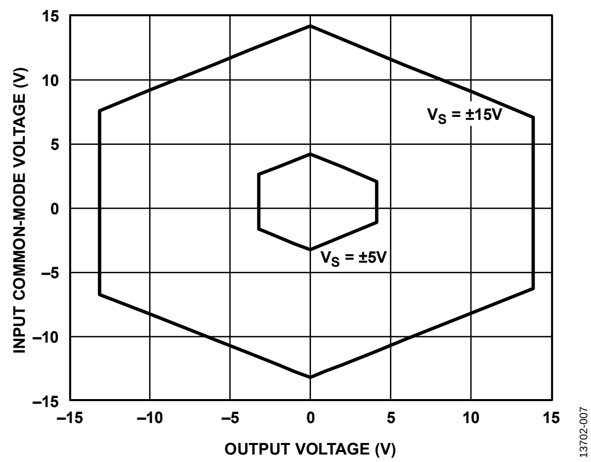

Figure 8. Input Common-Mode Voltage vs. Output Voltage, G = 1

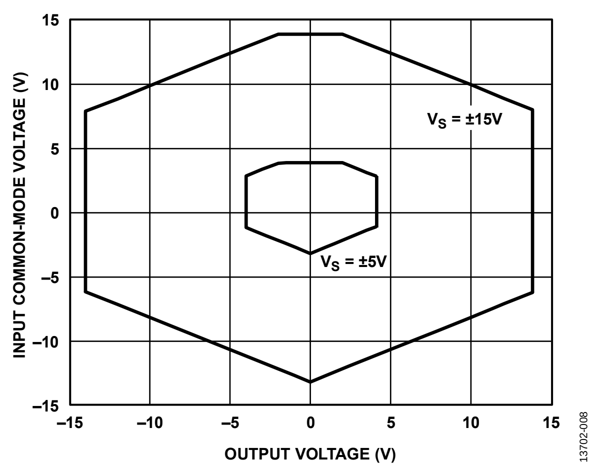

Figure 9. Input Common-Mode Voltage vs. Output Voltage, G = 100

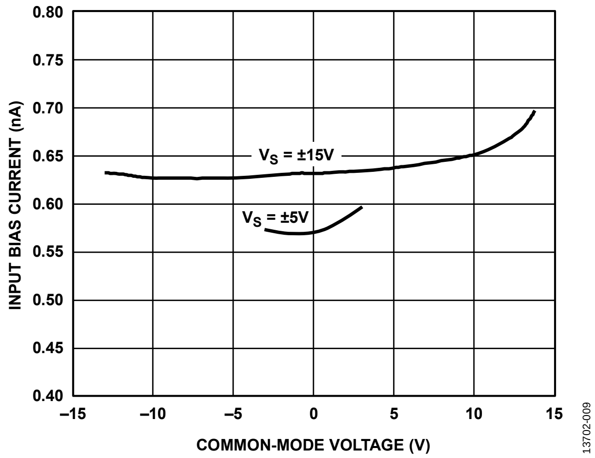

Figure 10. Input Bias Current (I_{BIAS}) vs. Common-Mode Voltage (CMV)

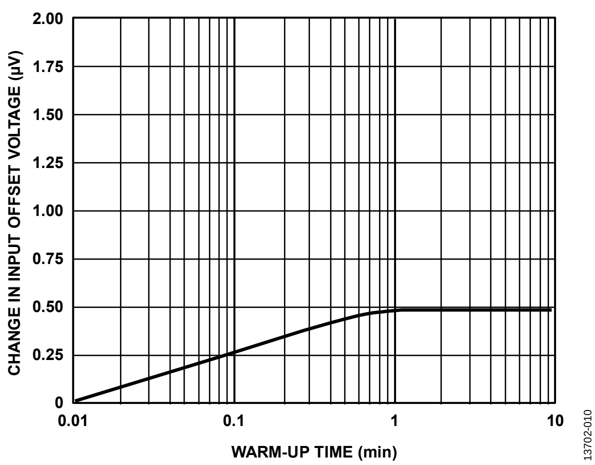

Figure 11. Change in Input Offset Voltage vs. Warm-Up Time

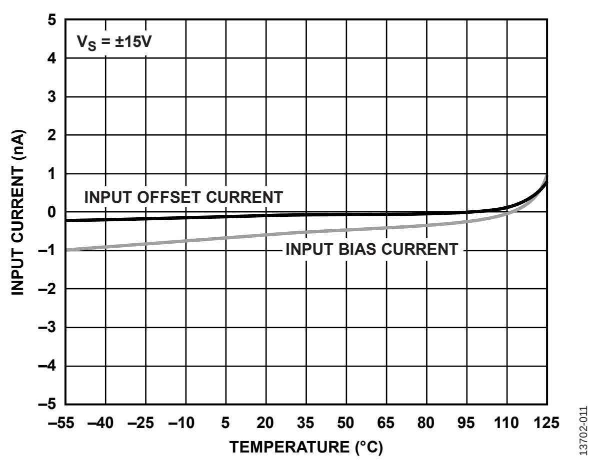

Figure 12. Input Offset Current and Input Bias Current vs. Temperature

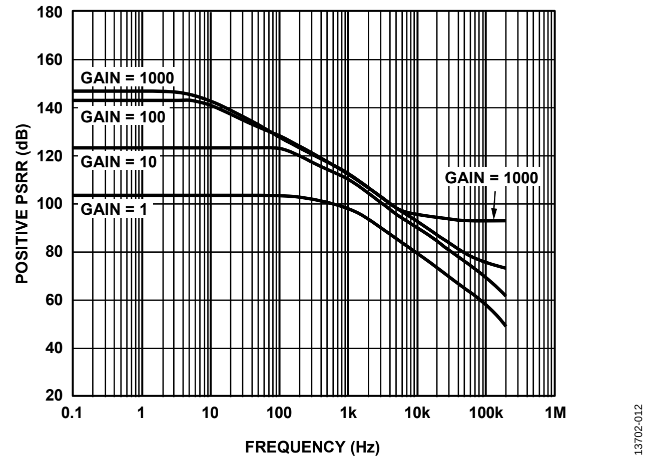

Figure 13. Positive PSRR vs. Frequency, RTI (G = 1 to 1000)

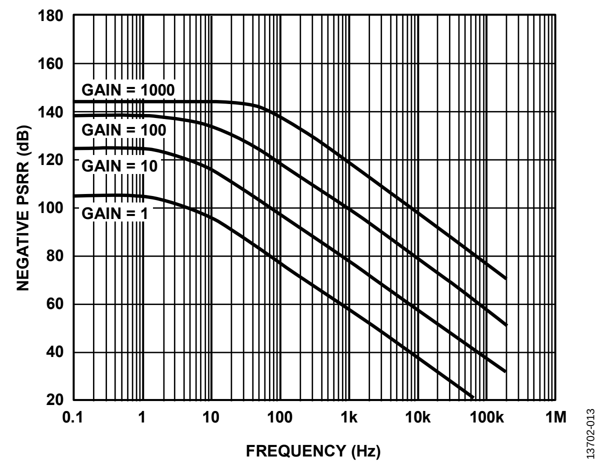

Figure 14. Negative PSRR vs. Frequency, RTI (G = 1 to 1000)

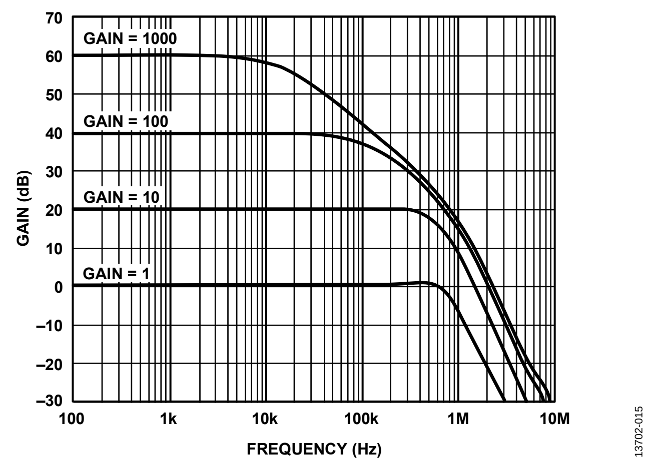

Figure 15. Gain vs. Frequency

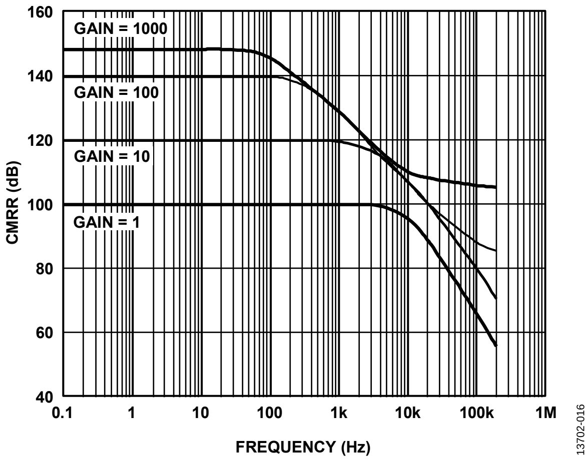

Figure 16. CMRR vs. Frequency, RTI

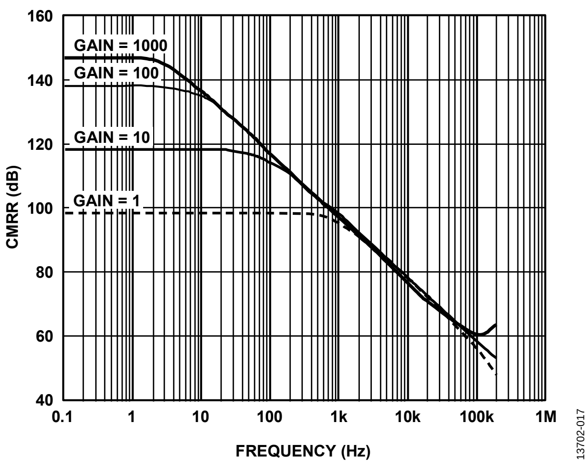

Figure 17. CMRR vs. Frequency, RTI, 1 kΩ Source Imbalance

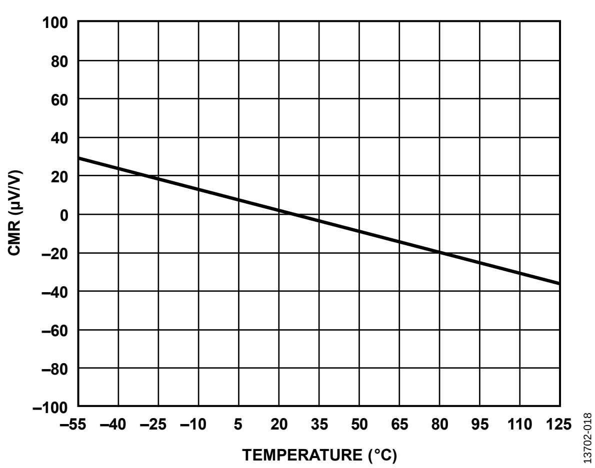

Figure 18. CMR vs. Temperature

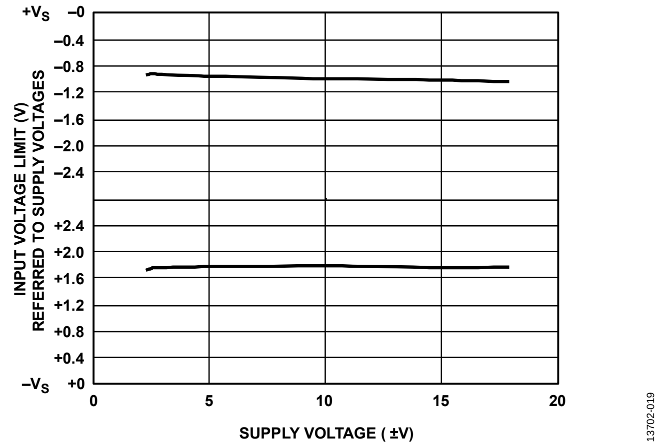

Figure 19. Input Voltage Limit vs. Supply Voltage, G = 1

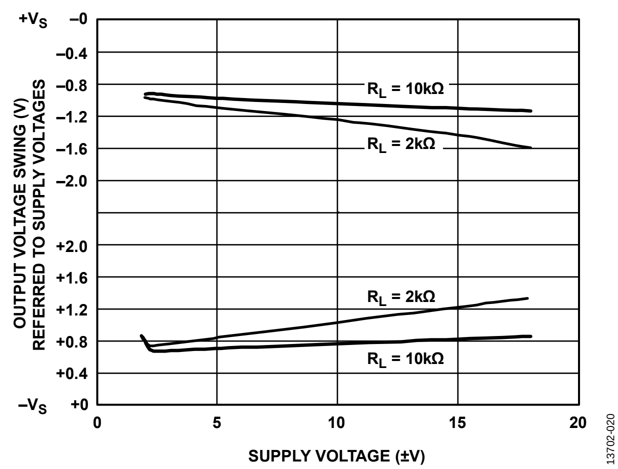

Figure 20. Output Voltage Swing vs. Supply Voltage, G = 1

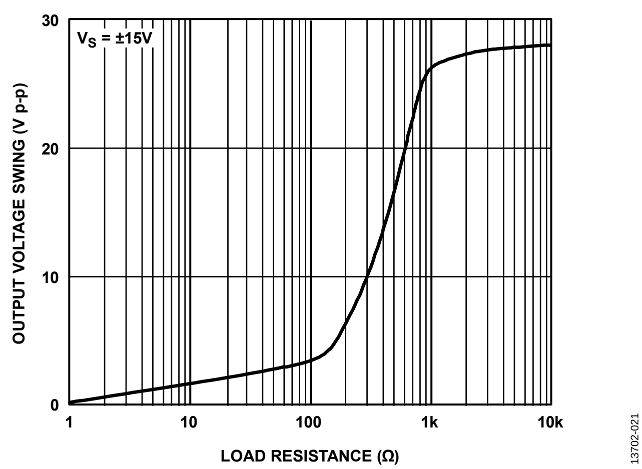

Figure 21. Output Voltage Swing vs. Load Resistance

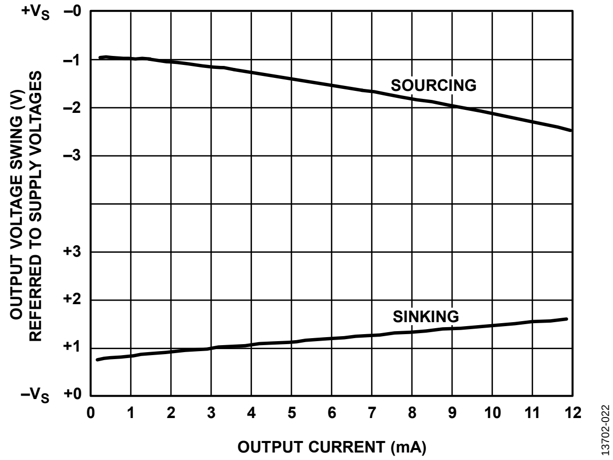

Figure 22. Output Voltage Swing vs. Output Current, G = 1

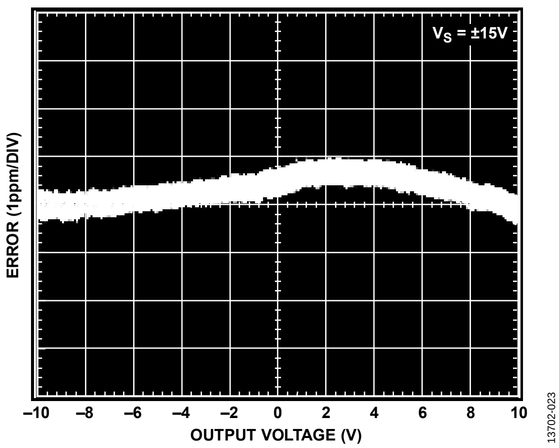

Figure 23. Gain Nonlinearity, G = 1, R_L = 10 kΩ

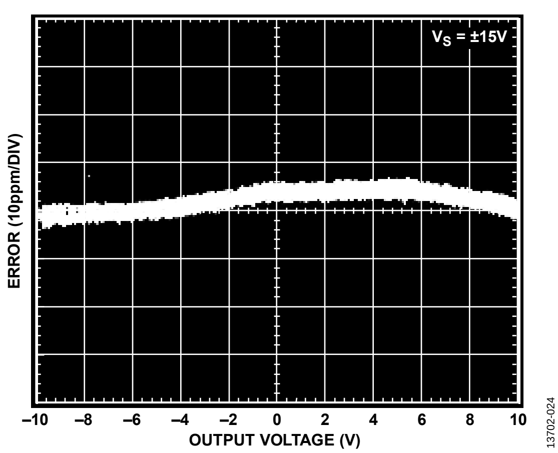

Figure 24. Gain Nonlinearity, G = 100, R_L = 10 kΩ

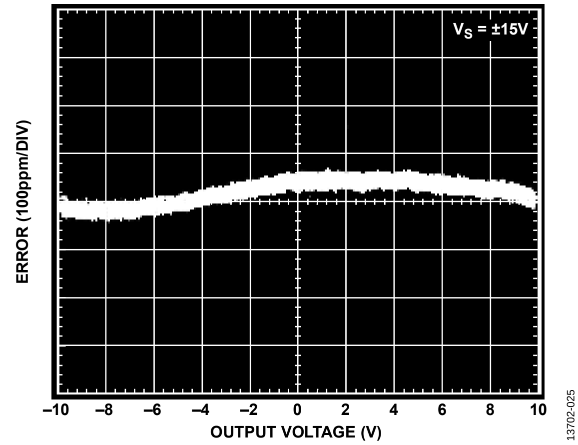

Figure 25. Gain Nonlinearity, G = 1000, R_L = 10 kΩ

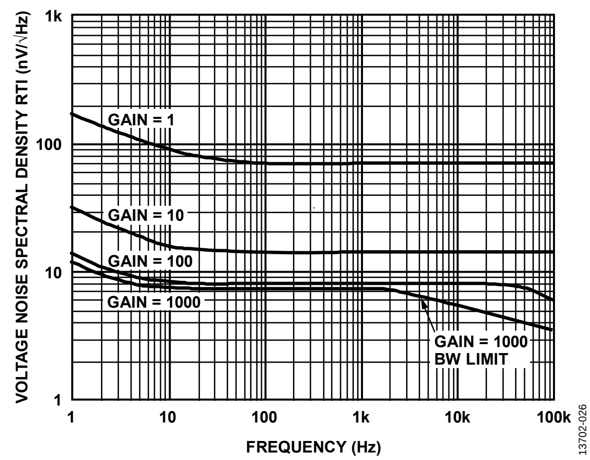

Figure 26. Voltage Noise Spectral Density vs. Frequency (G = 1 to 1000)

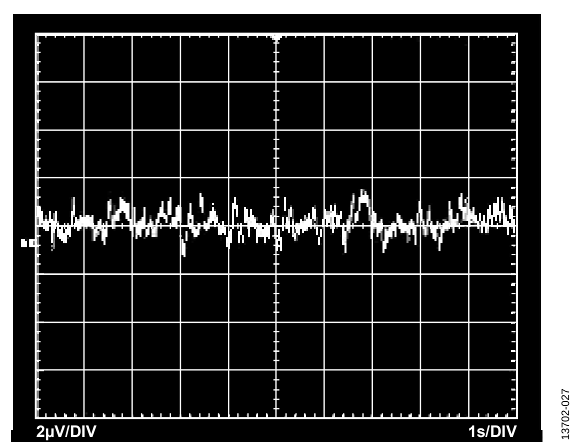

Figure 27. 0.1 Hz to 10 Hz RTI Voltage Noise (G = 1)

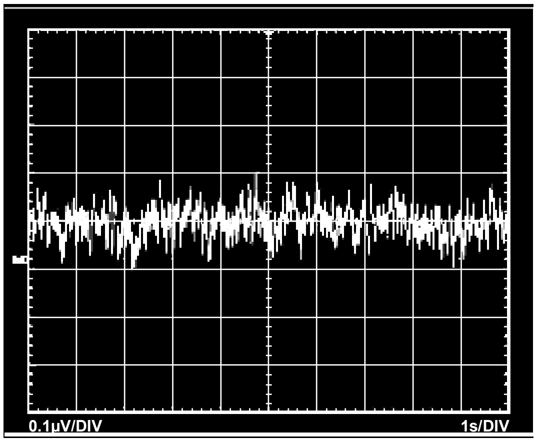

Figure 28. 0.1 Hz to 10 Hz RTI Voltage Noise (G = 1000)

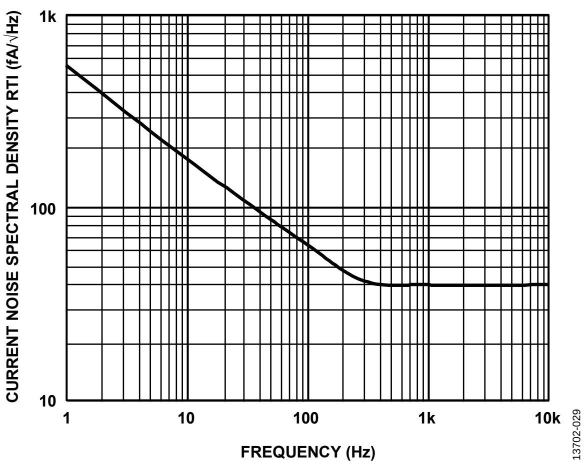

Figure 29. Current Noise Spectral Density vs. Frequency

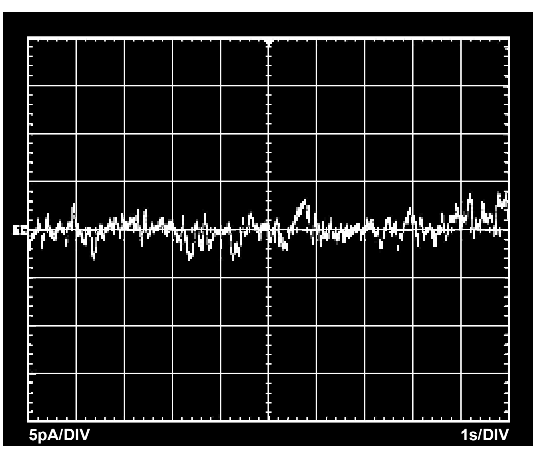

Figure 30. 0.1 Hz to 10 Hz Current Noise

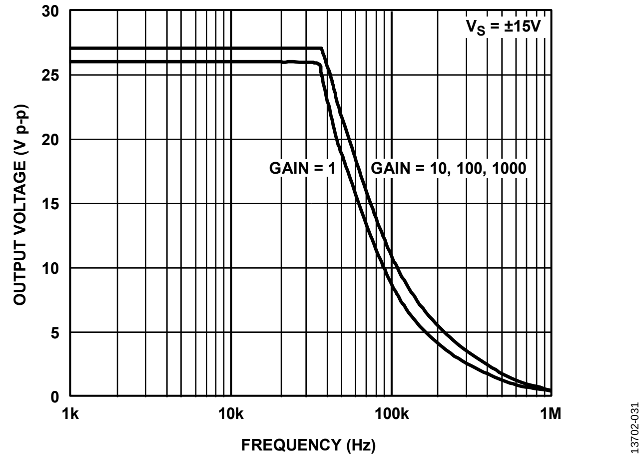

Figure 31. Large Signal Frequency Response

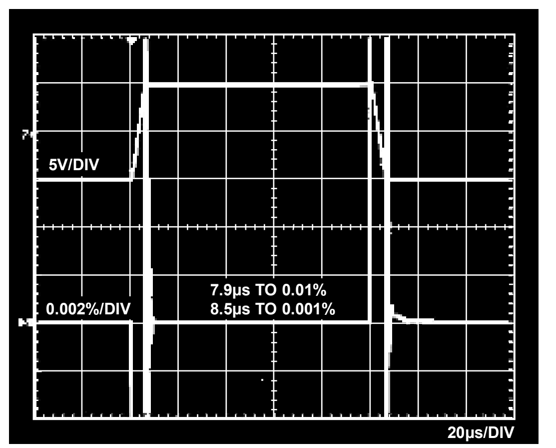

Figure 32. Large Signal Pulse Response and Settling Time (G = 1), 0.002%/DIV

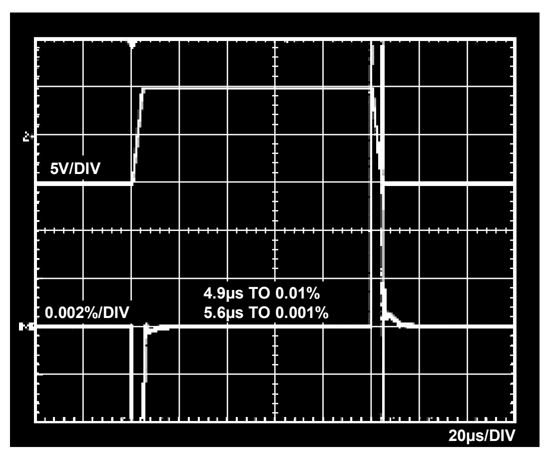

Figure 33. Large Signal Pulse Response and Settling Time (G = 10), 0.002%/DIV

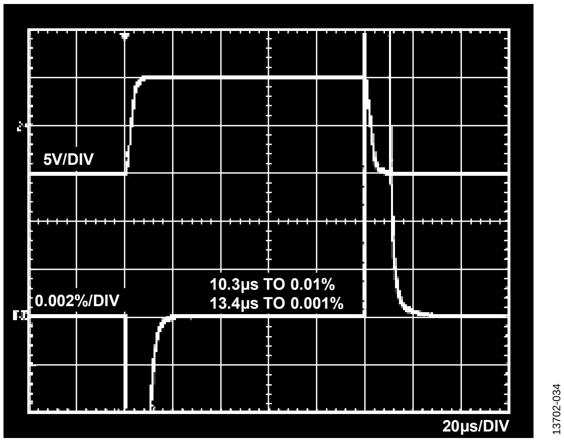

Figure 34. Large Signal Pulse Response and Settling Time (G = 100), 0.002%/DIV

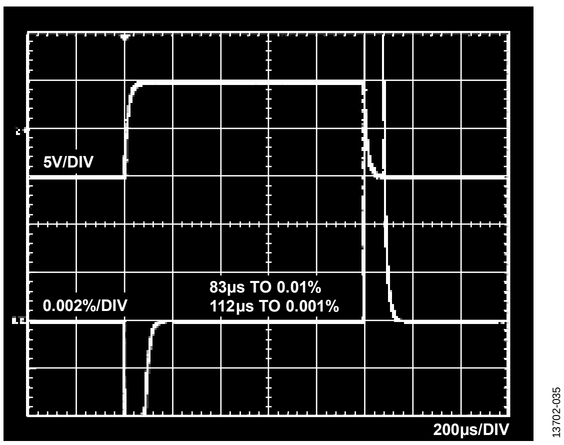

Figure 35. Large Signal Pulse Response and Settling Time (G = 1000), 0.002%/DIV

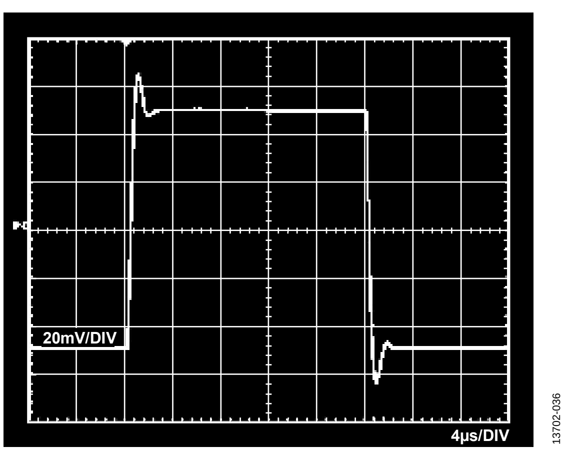

Figure 36. Small Signal Response, G = 1, R_L = 2 kΩ, C_L = 100 pF

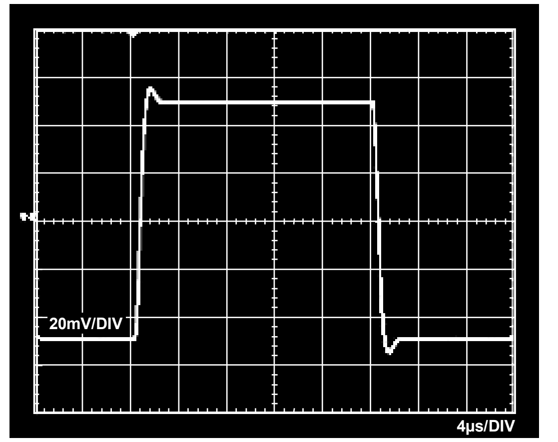

Figure 37. Small Signal Response, G = 10, R_L = 2 kΩ, C_L = 100 pF

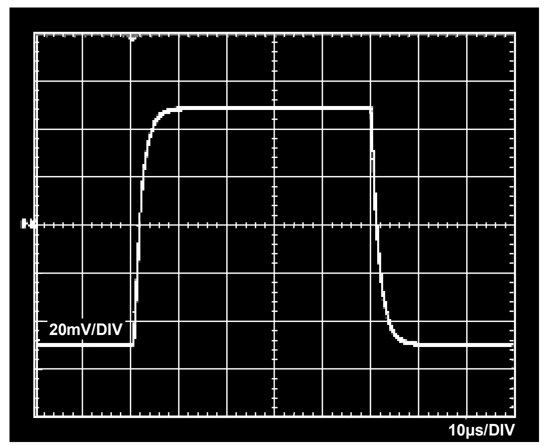

Figure 38. Small Signal Response, G = 100, R_L = 2 kΩ, C_L = 100 pF

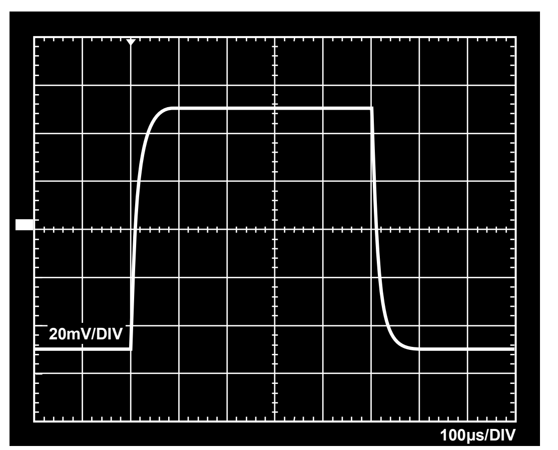

Figure 39. Small Signal Response, G = 1000, R_L = 2 kΩ, C_L = 100 pF

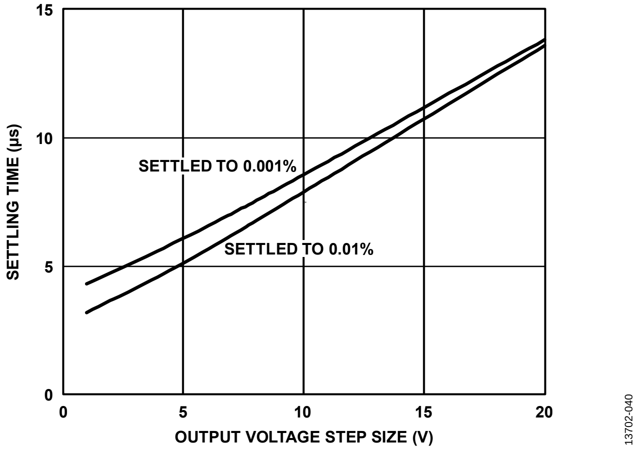

Figure 40. Settling Time vs. Output Voltage Step Size (G = 1)

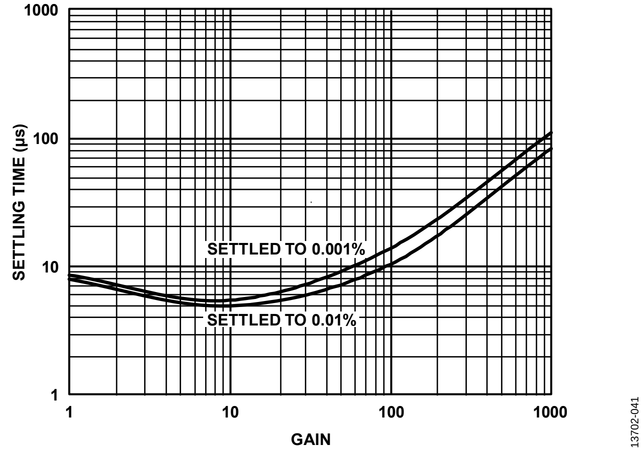

Figure 41. Settling Time vs. Gain for a 10 V Step

OUTLINE DIMENSIONS

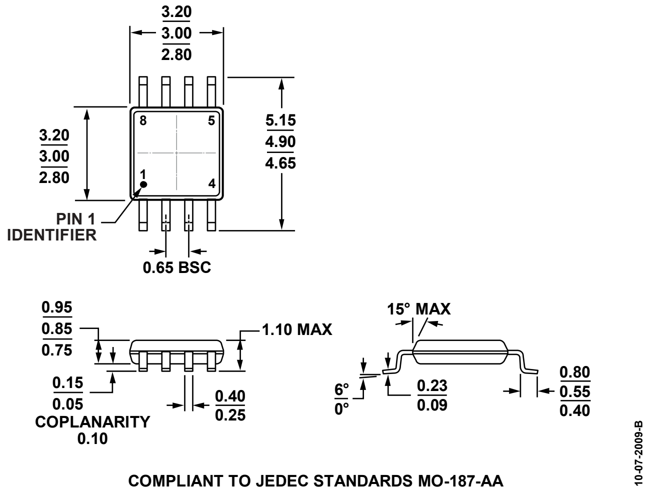

Figure 42. 8-Lead Mini Small Outline Package [MSOP]
(RM-8)
Dimensions shown in millimeters

ORDERING GUIDE

Model[1]	Temperature Range	Package Description	Package Option	Branding
AD8221TRMZ-EP	−55°C to +125°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	Y67
AD8221TRMZ-EP-R7	−55°C to +125°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	Y67

[1] Z = RoHS Compliant Part.