Precision Instrumentation Amplifier

AD8221

FEATURES

Easy to use
Available in space-saving MSOP
Gain set with 1 external resistor (gain range 1 to 1000)
Wide power supply range: ±2.3 V to ±18 V
Temperature range for specified performance:
  −40°C to +85°C
Operational up to 125°C[1]
Excellent AC specifications
  80 dB minimum CMRR to 10 kHz (G = 1)
  825 kHz, –3 dB bandwidth (G = 1)
  2 V/μs slew rate
Low noise
  8 nV/√Hz, @ 1 kHz, maximum input voltage noise
  0.25 μV p-p input noise (0.1 Hz to 10 Hz)
High accuracy dc performance (AD8221BR)
  90 dB minimum CMRR (G = 1)
  25 μV maximum input offset voltage
  0.3 μV/°C maximum input offset drift
  0.4 nA maximum input bias current

APPLICATIONS

Weigh scales
Industrial process controls
Bridge amplifiers
Precision data acquisition systems
Medical instrumentation
Strain gages
Transducer interfaces

CONNECTION DIAGRAM

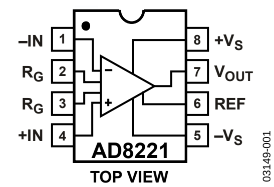


Figure 1.

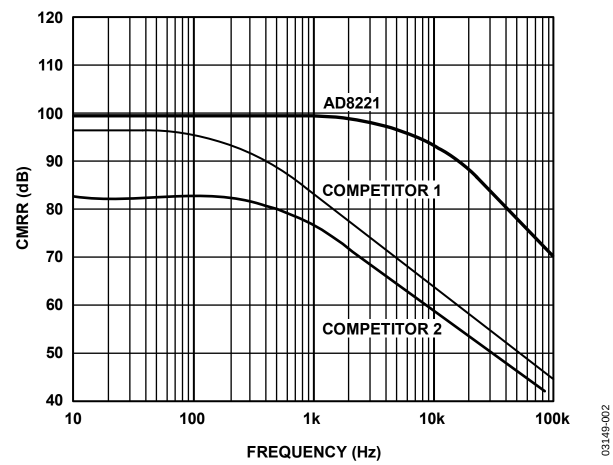


Figure 2. Typical CMRR vs. Frequency for G = 1

GENERAL DESCRIPTION

The AD8221 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 maintains a minimum CMRR of 80 dB to 10 kHz for all grades at G = 1. High CMRR over frequency allows the AD8221 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 part 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 operates on both single and dual supplies and is well suited for applications where ±10 V input voltages are encountered.

The AD8221 is available in a low cost 8-lead SOIC and 8-lead MSOP, both of which offer the industry's best performance. The MSOP requires half the board space of the SOIC, making it ideal for multichannel or space-constrained applications.

Performance is specified over the entire industrial temperature range of −40°C to +85°C for all grades. Furthermore, the AD8221 is operational from −40°C to +125°C[1].

[1] See Typical Performance Characteristics for expected operation from 85°C to 125°C.

SPECIFICATIONS

$V_S = \pm15$ V, $V_{REF} = 0$ V, $T_A = 25°C$, G = 1, $R_L = 2$ kΩ, unless otherwise noted.

Table 1.

Parameter	Conditions	AR Grade Min	AR Grade Typ	AR Grade Max	BR Grade Min	BR Grade Typ	BR Grade Max	Unit
COMMON-MODE REJECTION RATIO								
CMRR DC to 60 Hz with 1 kΩ Source Imbalance	$V_{CM} = -10$ V to +10 V							
G = 1		80			90			dB
G = 10		100			110			dB
G = 100		120			130			dB
G = 1000		130			140			dB
CMRR at 10 kHz	$V_{CM} = -10$ V to +10 V							
G = 1		80			80			dB
G = 10		90			100			dB
G = 100		100			110			dB
G = 1000		100			110			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			8	nV/√Hz
Output Voltage Noise, e_{NO}				75			75	nV/√Hz
RTI	f = 0.1 Hz to 10 Hz							
G = 1			2			2		µV p-p
G = 10			0.5			0.5		µV p-p
G = 100 to 1000			0.25			0.25		µV p-p
Current Noise	f = 1 kHz		40			40		fA/√Hz
	f = 0.1 Hz to 10 Hz		6			6		pA p-p
VOLTAGE OFFSET[1]								
Input Offset, V_{OSI}	$V_S = \pm5$ V to ±15 V			60			25	µV
Over Temperature	T = −40°C to +85°C			86			45	µV
Average TC				0.4			0.3	µV/°C
Output Offset, V_{OSO}	$V_S = \pm5$ V to ±15 V			300			200	µV
Over Temperature	T = −40°C to +85°C			0.66			0.45	mV
Average TC				6			5	µV/°C
Offset RTI vs. Supply (PSR)	$V_S = \pm2.3$ V to ±18 V							
G = 1		90	110		94	110		dB
G = 10		110	120		114	130		dB
G = 100		124	130		130	140		dB
G = 1000		130	140		140	150		dB
INPUT CURRENT								
Input Bias Current			0.5	1.5		0.2	0.4	nA
Over Temperature	T = −40°C to +85°C			2.0			1	nA
Average TC			1			1		pA/°C
Input Offset Current			0.2	0.6		0.1	0.4	nA
Over Temperature	T = −40°C to +85°C			0.8			0.6	nA
Average TC			1			1		pA/°C
REFERENCE INPUT								
R_{IN}			20			20		kΩ
I_{IN}	V_{IN+}, V_{IN-}, $V_{REF} = 0$		50	60		50	60	µA
Voltage Range		$-V_S$		$+V_S$	$-V_S$		$+V_S$	V
Gain to Output			1 ± 0.0001			1 ± 0.0001		V/V

Parameter	Conditions	AR Grade Min	AR Grade Typ	AR Grade Max	BR Grade Min	BR Grade Typ	BR Grade Max	Unit
POWER SUPPLY								
Operating Range	V_S = ±2.3 V to ±18 V	±2.3		±18	±2.3		±18	V
Quiescent Current			0.9	1		0.9	1	mA
Over Temperature	T = –40°C to +85°C		1	1.2		1	1.2	mA
DYNAMIC RESPONSE								
Small Signal –3 dB Bandwidth								
G = 1			825			825		kHz
G = 10			562			562		kHz
G = 100			100			100		kHz
G = 1000			14.7			14.7		kHz
Settling Time 0.01%	10 V step							
G = 1 to 100			10			10		µs
G = 1000			80			80		µs
Settling Time 0.001%	10 V step							
G = 1 to 100			13			13		µs
G = 1000			110			110		µs
Slew Rate	G = 1	1.5	2		1.5	2		V/µs
	G = 5 to 100	2	2.5		2	2.5		V/µs
GAIN	G = 1 + (49.4 kΩ/R_G)							
Gain Range		1		1000	1		1000	V/V
Gain Error	V_{OUT} ± 10 V							
G = 1				0.03			0.02	%
G = 10				0.3			0.15	%
G = 100				0.3			0.15	%
G = 1000				0.3			0.15	%
Gain Nonlinearity	V_{OUT} = –10 V to +10 V							
G = 1 to 10	R_L = 10 kΩ		3	10		3	10	ppm
G = 100	R_L = 10 kΩ		5	15		5	15	ppm
G = 1000	R_L = 10 kΩ		10	40		10	40	ppm
G = 1 to 100	R_L = 2 kΩ		10	95		10	95	ppm
Gain vs. Temperature								
G = 1			3	10		2	5	ppm/°C
G > 1[2]				–50			–50	ppm/°C
INPUT								
Input Impedance								
Differential			100||2			100||2		GΩ||pF
Common Mode			100||2			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	$–V_S$ + 1.9		$+V_S$ – 1.1	V
Over Temperature	T = –40°C to +85°C	$–V_S$ + 2.0		$+V_S$ – 1.2	$–V_S$ + 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	$–V_S$ + 1.9		$+V_S$ – 1.2	V
Over Temperature	T =–40°C to +85°C	$–V_S$ + 2.0		$+V_S$ – 1.2	$–V_S$ + 2.0		$+V_S$ – 1.2	V
OUTPUT	R_L = 10 kΩ							
Output Swing	V_S = ±2.3 V to ±5 V	$–V_S$ + 1.1		$+V_S$ – 1.2	$–V_S$ + 1.1		$+V_S$ – 1.2	V
Over Temperature	T = –40°C to +85°C	$–V_S$ + 1.4		$+V_S$ – 1.3	$–V_S$ + 1.4		$+V_S$ – 1.3	V
Output Swing	V_S = ±5 V to ±18 V	$–V_S$ + 1.2		$+V_S$ – 1.4	$–V_S$ + 1.2		$+V_S$ – 1.4	V
Over Temperature	T = –40°C to +85°C	$–V_S$ + 1.6		$+V_S$ – 1.5	$–V_S$ + 1.6		$+V_S$ – 1.5	V
Short-Circuit Current			18			18		mA

Parameter	Conditions	AR Grade Min	AR Grade Typ	AR Grade Max	BR Grade Min	BR Grade Typ	BR Grade Max	Unit
TEMPERATURE RANGE								
Specified Performance		–40		+85	–40		+85	°C
Operating Range[4]		–40		+125	–40		+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.
[4] See Typical Performance Characteristics for expected operation between 85°C to 125°C.

Table 2.

Parameter	Conditions	ARM Grade Min	ARM Grade Typ	ARM Grade 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
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 = –40°C to +85°C			135	μV
Average TC				0.9	μV/°C
Output Offset, V_{OSO}	V_S = ±5 V to ±15 V			600	μV
Over Temperature	T = –40°C to +85°C			1.00	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 = –40°C to +85°C			3	nA
Average TC			3		pA/°C
Input Offset Current			0.3	1	nA
Over Temperature	T = –40°C to +85°C			1.5	nA
Average TC			3		pA/°C

Parameter	Conditions	ARM Grade Min	Typ	Max	Unit
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
POWER SUPPLY					
Operating Range	$V_S = \pm 2.3$ V to ± 18 V	±2.3		±18	V
Quiescent Current			0.9	1	mA
Over Temperature	T = −40°C to +85°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]	$V_S = \pm 2.3$ V to ± 5 V	$-V_S + 1.9$		$+V_S - 1.1$	V
Over Temperature	T = −40°C to +85°C	$-V_S + 2.0$		$+V_S - 1.2$	V
Input Operating Voltage Range	$V_S = \pm 5$ V to ± 18 V	$-V_S + 1.9$		$+V_S - 1.2$	V
Over Temperature	T = −40°C to +85°C	$-V_S + 2.0$		$+V_S - 1.2$	V
OUTPUT	R_L = 10 kΩ				
Output Swing	$V_S = \pm 2.3$ V to ± 5 V	$-V_S + 1.1$		$+V_S - 1.2$	V
Over Temperature	T = −40°C to +85°C	$-V_S + 1.4$		$+V_S - 1.3$	V
Output Swing	$V_S = \pm 5$ V to ± 18 V	$-V_S + 1.2$		$+V_S - 1.4$	V
Over Temperature	T = −40°C to +85°C	$-V_S + 1.6$		$+V_S - 1.5$	V
Short-Circuit Current			18		mA

Parameter	Conditions	ARM Grade Min	Typ	Max	Unit
TEMPERATURE RANGE					
Specified Performance		−40		+85	°C
Operating Range[4]		−40		+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.
[4] See Typical Performance Characteristics for expected operation between 85°C to 125°C.

ABSOLUTE MAXIMUM RATINGS

Table 3.

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[1]	−40°C to +125°C

[1] Temperature range for specified performance is –40°C to +85°C. See Typical Performance Characteristics for expected operation from 85°C to 125°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.

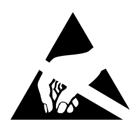
THERMAL CHARACTERISTICS

Specification for a device in free air.

Table 4.

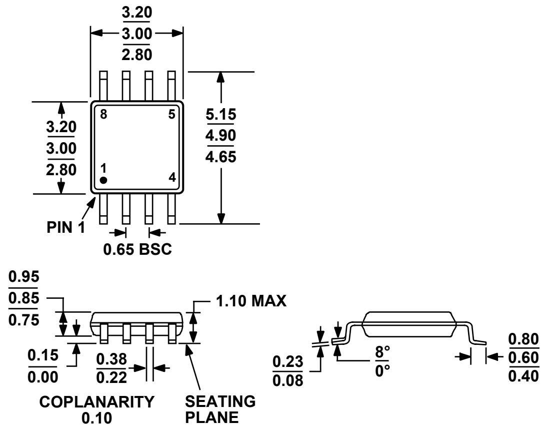
Package	θ_{JA}	Unit
8-Lead SOIC, 4-Layer JEDEC Board	121	°C/W
8-Lead MSOP, 4-Layer JEDEC Board	135	°C/W

ESD CAUTION



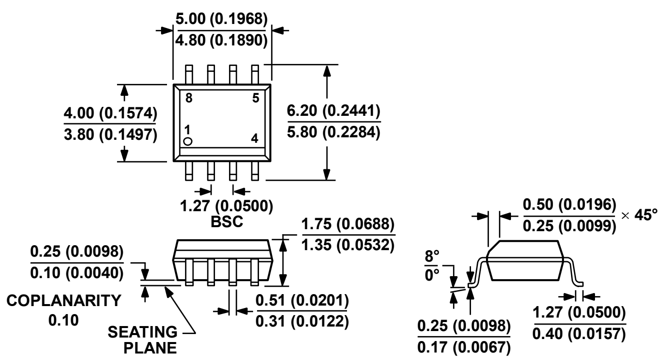
ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken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

OUTLINE DIMENSIONS



COMPLIANT TO JEDEC STANDARDS MO-187-AA

Figure 52. 8-Lead Mini Small Outline Package [MSOP]
(RM-8)
Dimensions shown in millimeters



COMPLIANT TO JEDEC STANDARDS MS-012-AA
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.

012407-A

Figure 53. 8-Lead Standard Small Outline Package [SOIC_N]
Narrow Body
(R-8)
Dimensions shown in millimeters and (inches)

ORDERING GUIDE

Model	Temperature Range for Specified Performance	Operating[1] Temperature Range	Package Description	Package Option	Branding
AD8221AR	–40°C to +85°C	–40°C to +125°C	8-Lead SOIC_N	R-8	
AD8221AR-REEL	–40°C to +85°C	–40°C to +125°C	8-Lead SOIC_N, 13" Tape and Reel	R-8	
AD8221AR-REEL7	–40°C to +85°C	–40°C to +125°C	8-Lead SOIC_N, 7" Tape and Reel	R-8	
AD8221ARZ[2]	–40°C to +85°C	–40°C to +125°C	8-Lead SOIC_N	R-8	
AD8221ARZ-R7[2]	–40°C to +85°C	–40°C to +125°C	8-Lead SOIC_N, 7" Tape and Reel	R-8	
AD8221ARZ-RL[2]	–40°C to +85°C	–40°C to +125°C	8-Lead SOIC_N, 13" Tape and Reel	R-8	
AD8221ARM	–40°C to +85°C	–40°C to +125°C	8-Lead MSOP	RM-8	JLA
AD8221ARM-REEL	–40°C to +85°C	–40°C to +125°C	8-Lead MSOP, 13" Tape and Reel	RM-8	JLA
AD8221ARM REEL7	–40°C to +85°C	–40°C to +125°C	8-Lead MSOP, 7" Tape and Reel	RM-8	JLA
AD8221ARMZ[2]	–40°C to +85°C	–40°C to +125°C	8-Lead MSOP	RM-8	JLA#
AD8221ARMZ-R7[2]	–40°C to +85°C	–40°C to +125°C	8-Lead MSOP, 7" Tape and Reel	RM-8	JLA#
AD8221ARMZ-RL[2]	–40°C to +85°C	–40°C to +125°C	8-Lead MSOP, 13" Tape and Reel	RM-8	JLA#
AD8221BR	–40°C to +85°C	–40°C to +125°C	8-Lead SOIC_N	R-8	
AD8221BR-REEL	–40°C to +85°C	–40°C to +125°C	8-Lead SOIC_N, 13" Tape and Reel	R-8	
AD8221BR-REEL7	–40°C to +85°C	–40°C to +125°C	8-Lead SOIC_N, 7" Tape and Reel	R-8	
AD8221-EVAL			Evaluation Board		

[1] See Typical Performance Characteristics for expected operation from 85°C to 125°C.
[2] Z = RoHS Compliant Part, # denotes RoHS compliant product may be top or bottom marked.