Single-Supply, Rail-to-Rail, Low Cost Instrumentation Amplifier

AD623

FEATURES

- Easy to use
- Higher performance than discrete design
- Single-supply and dual-supply operation
- Rail-to-rail output swing
- Input voltage range extends 150 mV below ground (single supply)
- Low power, 550 µA maximum supply current
- Gain set with one external resistor
  - Gain range: 1 (no resistor) to 1000
- High accuracy dc performance
  - 0.10% gain accuracy (G = 1)
  - 0.35% gain accuracy (G > 1)
  - 10 ppm maximum gain drift (G = 1)
  - 200 µV maximum input offset voltage (AD623A)
  - 2 µV/°C maximum input offset drift (AD623A)
  - 100 µV maximum input offset voltage (AD623B)
  - 1 µV/°C maximum input offset drift (AD623B)
  - 25 nA maximum input bias current
- Noise: 35 nV/√Hz RTI noise @ 1 kHz (G = 1)
- Excellent ac specifications
  - 90 dB minimum CMRR (G = 10); 70 dB minimum CMRR (G = 1) at 60 Hz, 1 kΩ source imbalance
  - 800 kHz bandwidth (G = 1)
  - 20 µs settling time to 0.01% (G = 10)

APPLICATIONS

- Low power medical instrumentation
- Transducer interfaces
- Thermocouple amplifiers
- Industrial process controls
- Difference amplifiers
- Low power data acquisition

GENERAL DESCRIPTION

The AD623 is an integrated single-supply instrumentation amplifier that delivers rail-to-rail output swing on a 3 V to 12 V supply. The AD623 offers superior user flexibility by allowing single gain set resistor programming and by conforming to the 8-lead industry standard pinout configuration. With no external resistor, the AD623 is configured for unity gain (G = 1), and with an external resistor, the AD623 can be programmed for gains up to 1000.

CONNECTION DIAGRAM

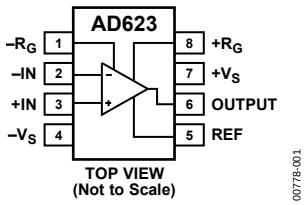


Figure 1. 8-Lead PDIP (N), SOIC (R), and MSOP (RM) Packages

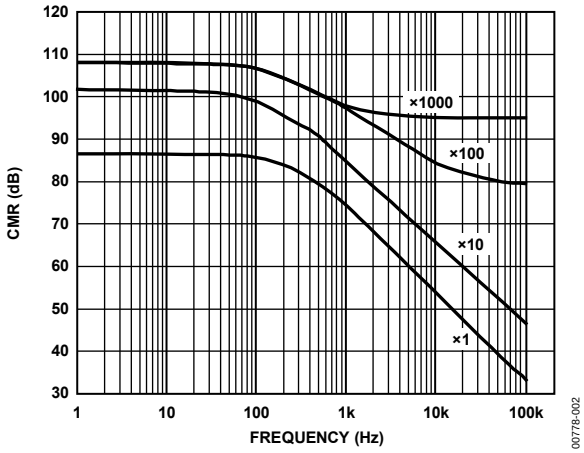


Figure 2. CMR vs. Frequency, 5 V_S, 0 V_S

The AD623 holds errors to a minimum by providing superior ac CMRR that increases with increasing gain. Line noise, as well as line harmonics, are rejected because the CMRR remains constant up to 200 Hz. The AD623 has a wide input common-mode range and can amplify signals that have a common-mode voltage 150 mV below ground. Although the design of the AD623 was optimized to operate from a single supply, the AD623 still provides superior performance when operated from a dual voltage supply (±2.5 V to ±6.0 V).

Low power consumption (1.5 mW at 3 V), wide supply voltage range, and rail-to-rail output swing make the AD623 ideal for battery-powered applications. The rail-to-rail output stage maximizes the dynamic range when operating from low supply voltages. The AD623 replaces discrete instrumentation amplifier designs and offers superior linearity, temperature stability, and reliability in a minimum of space.

Rev. D

SPECIFICATIONS

SINGLE SUPPLY

Typical @ 25°C single supply, V_S = 5 V, and R_L = 10 kΩ, unless otherwise noted.

Table 1.

		AD623A			AD623ARM			AD623B			
Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Unit**
GAIN	G = 1 + (100 k/R_G)										
Gain Range		1		1000	1		1000	1		1000	
Gain Error[1]	G1 V_{OUT} = 0.05 V to 3.5 V G > 1 V_{OUT} = 0.05 V to 4.5 V										
G = 1			0.03	0.10		0.03	0.10		0.03	0.05	%
G = 10			0.10	0.35		0.10	0.35		0.10	0.35	%
G = 100			0.10	0.35		0.10	0.35		0.10	0.35	%
G = 1000			0.10	0.35		0.10	0.35		0.10	0.35	%
Nonlinearity	G1 V_{OUT} = 0.05 V to 3.5 V G > 1 V_{OUT} = 0.05 V to 4.5 V										
G = 1 to 1000			50			50			50		ppm
Gain vs. Temperature											
G = 1			5	10		5	10		5	10	ppm/°C
G > 1[1]			50			50			50		ppm/°C
VOLTAGE OFFSET	Total RTI error = V_{OSI} + V_{OSO}/G										
Input Offset, V_{OSI}			25	200		200	500		25	100	µV
Over Temperature				350			650			160	µV
Average Tempco			0.1	2		0.1	2		0.1	1	µV/°C
Output Offset, V_{OSO}			200	1000		500	2000		200	500	µV
Over Temperature				1500			2600			1100	µV
Average Tempco			2.5	10		2.5	10		2.5	10	µV/°C
Offset Referred to the Input vs. Supply (PSR)											
G = 1		80	100		80	100		80	100		dB
G = 10		100	120		100	120		100	120		dB
G = 100		120	140		120	140		120	140		dB
G = 1000		120	140		120	140		120	140		dB
INPUT CURRENT											
Input Bias Current			17	25		17	25		17	25	nA
Over Temperature				27.5			27.5			27.5	nA
Average Tempco			25			25			25		pA/°C
Input Offset Current			0.25	2		0.25	2		0.25	2	nA
Over Temperature				2.5			2.5			2.5	nA
Average Tempco			5			5			5		pA/°C

Parameter	Conditions	AD623A Min	AD623A Typ	AD623A Max	AD623ARM Min	AD623ARM Typ	AD623ARM Max	AD623B Min	AD623B Typ	AD623B Max	Unit
INPUT											
Input Impedance											
Differential			2||2			2||2			2||2		GΩ||pF
Common-Mode			2||2			2||2			2||2		GΩ||pF
Input Voltage Range[2]	V_S = 3 V to 12 V	(–V_S) – 0.15		(+V_S) – 1.5	(–V_S) – 0.15		(+V_S) – 1.5	(–V_S) – 0.15		(+V_S) – 1.5	V
Common-Mode Rejection at 60 Hz with 1 kΩ Source Imbalance											
G = 1	V_{CM} = 0 V to 3 V	70	80		70	80		77	86		dB
G = 10	V_{CM} = 0 V to 3 V	90	100		90	100		94	100		dB
G = 100	V_{CM} = 0 V to 3 V	105	110		105	110		105	110		dB
G = 1000	V_{CM} = 0 V to 3 V	105	110		105	110		105	110		dB
OUTPUT											
Output Swing	R_L = 10 kΩ	0.01		(+V_S) – 0.5	0.01		(+V_S) – 0.5	0.01		(+V_S) – 0.5	V
	R_L = 100 kΩ	0.01		(+V_S) – 0.15	0.01		(+V_S) – 0.15	0.01		(+V_S) – 0.15	V
DYNAMIC RESPONSE											
Small Signal –3 dB Bandwidth											
G = 1			800			800			800		kHz
G = 10			100			100			100		kHz
G = 100			10			10			10		kHz
G = 1000			2			2			2		kHz
Slew Rate			0.3			0.3			0.3		V/µs
Settling Time to 0.01%	V_S = 5 V										
G = 1	Step size: 3.5 V		30			30			30		µs
G = 10	Step size: 4 V, V_{CM} = 1.8 V		20			20			20		µs

[1] Does not include effects of external resistor, R_G.
[2] One input grounded. G = 1.

DUAL SUPPLIES

Typical @ 25°C dual supply, V_S = ±5 V, and R_L = 10 kΩ, unless otherwise noted.

Table 2.

Parameter	Conditions	AD623A Min	AD623A Typ	AD623A Max	AD623ARM Min	AD623ARM Typ	AD623ARM Max	AD623B Min	AD623B Typ	AD623B Max	Unit
GAIN	G = 1 + (100 k/R_G)										
Gain Range		1		1000	1		1000	1		1000	
Gain Error[1]	G1 V_{OUT} = –4.8 V to +3.5 V G > 1 V_{OUT} = 0.05 V to 4.5 V										
G = 1			0.03	0.10		0.03	0.10		0.03	0.05	%
G = 10			0.10	0.35		0.10	0.35		0.10	0.35	%
G = 100			0.10	0.35		0.10	0.35		0.10	0.35	%
G = 1000			0.10	0.35		0.10	0.35		0.10	0.35	%

Parameter	Conditions	AD623A Min	AD623A Typ	AD623A Max	AD623ARM Min	AD623ARM Typ	AD623ARM Max	AD623B Min	AD623B Typ	AD623B Max	Unit
Nonlinearity	G1 V_{OUT} = −4.8 V to +3.5 V G > 1 V_{OUT} = −4.8 V to +4.5 V										
G = 1 to 1000			50			50			50		ppm
Gain vs. Temperature											
G = 1			5	10		5	10		5	10	ppm/°C
G > 1[1]			50			50			50		ppm/°C
VOLTAGE OFFSET	Total RTI error = V_{OSI} + V_{OSO}/G										
Input Offset, V_{OSI}			25	200		200	500		25	100	µV
Over Temperature				350			650			160	µV
Average Tempco			0.1	2		0.1	2		0.1	1	µV/°C
Output Offset, V_{OSO}			200	1000		500	2000		200	500	µV
Over Temperature				1500			2600			1100	µV
Average Tempco			2.5	10		2.5	10		2.5	10	µV/°C
Offset Referred to the Input vs. Supply (PSR)											
G = 1		80	100		80	100		80	100		dB
G = 10		100	120		100	120		100	120		dB
G = 100		120	140		120	140		120	140		dB
G = 1000		120	140		120	140		120	140		dB
INPUT CURRENT											
Input Bias Current			17	25		17	25		17	25	nA
Over Temperature				27.5			27.5			27.5	nA
Average Tempco			25			25			25		pA/°C
Input Offset Current			0.25	2		0.25	2		0.25	2	nA
Over Temperature				2.5			2.5			2.5	nA
Average Tempco			5			5			5		pA/°C
INPUT											
Input Impedance											
Differential			2||2			2||2			2||2		GΩ||pF
Common-Mode			2||2			2||2			2||2		GΩ||pF
Input Voltage Range[2]	V_S = +2.5 V to ±6 V	(−V_S) − 0.15		(+V_S) − 1.5	(−V_S) − 0.15		(+V_S) − 1.5	(−V_S) − 0.15		(+V_S) − 1.5	V
Common-Mode Rejection at 60 Hz with 1 kΩ Source Imbalance											
G = 1	V_{CM} = +3.5 V to −5.15 V	70	80		70	80		77	86		dB
G = 10	V_{CM} = +3.5 V to −5.15 V	90	100		90	100		94	100		dB
G = 100	V_{CM} = +3.5 V to −5.15 V	105	110		105	110		105	110		dB
G = 1000	V_{CM} = +3.5 V to −5.15 V	105	110		105	110		105	110		dB
OUTPUT											
Output Swing	R_L = 10 kΩ, V_S = ±5 V	(−V_S) + 0.2		(+V_S) − 0.5	(−V_S) + 0.2		(+V_S) − 0.5	(−V_S) + 0.2		(+V_S) − 0.5	V
	R_L = 100 kΩ	(−V_S) + 0.05		(+V_S) − 0.15	(−V_S) + 0.05		(+V_S) − 0.15	(−V_S) + 0.05		(+V_S) − 0.15	V

Parameter	Conditions	AD623A Min	AD623A Typ	AD623A Max	AD623ARM Min	AD623ARM Typ	AD623ARM Max	AD623B Min	AD623B Typ	AD623B Max	Unit
DYNAMIC RESPONSE											
Small Signal −3 dB Bandwidth											
G = 1				800			800		800		kHz
G = 10				100			100		100		kHz
G = 100				10			10		10		kHz
G = 1000				2			2		2		kHz
Slew Rate				0.3			0.3		0.3		V/µs
Settling Time to 0.01%	V_S = ±5 V, 5 V step										
G = 1				30			30		30		µs
G = 10				20			20		20		µs

[1] Does not include effects of external resistor, R_G.
[2] One input grounded. G = 1.

BOTH DUAL AND SINGLE SUPPLIES

Table 3.

Parameter	Conditions	AD623A Min	AD623A Typ	AD623A Max	AD623ARM Min	AD623ARM Typ	AD623ARM Max	AD623B Min	AD623B Typ	AD623B Max	Unit
NOISE											
Voltage Noise, 1 kHz	Total RTI noise = $\sqrt{(e_{ni})^2 + (e_{no}/G)^2}$										
Input, Voltage Noise, e_{ni}			35			35			35		nV/√Hz
Output, Voltage Noise, e_{no}			50			50			50		nV/√Hz
RTI, 0.1 Hz to 10 Hz											
G = 1			3.0			3.0			3.0		µV p-p
G = 1000			1.5			1.5			1.5		µV p-p
Current Noise	f = 1 kHz		100			100			100		fA/√Hz
0.1 Hz to 10 Hz			1.5			1.5			1.5		pA p-p
REFERENCE INPUT											
R_{IN}			100 ± 20%			100 ± 20%			100 ± 20%		kΩ
I_{IN}	V_{IN}+, V_{REF} = 0 V		50	60		50	60		50	60	µA
Voltage Range		$-V_S$		$+V_S$	$-V_S$		$+V_S$	$-V_S$		$+V_S$	V
Gain to Output			1 ± 0.0002			1 ± 0.0002			1 ± 0.0002		V
POWER SUPPLY											
Operating Range	Dual supply	±2.5		±6	±2.5		±6	±2.5		±6	V
	Single supply	2.7		12	2.7		12	2.7		12	V
Quiescent Current	Dual supply		375	550		375	550		375	550	µA
	Single supply		305	480		305	480		305	480	µA
Over Temperature				625			625			625	µA
TEMPERATURE RANGE											
For Specified Performance		−40		+85	−40		+85	−40		+85	°C

ABSOLUTE MAXIMUM RATINGS

Table 4.

Parameter	Rating
Supply Voltage	±6 V
Internal Power Dissipation[1]	650 mW
Differential Input Voltage	±6 V
Output Short-Circuit Duration	Indefinite
Storage Temperature Range	−65°C to +125°C
Operating Temperature Range	−40°C to +85°C
Lead Temperature (Soldering, 10 sec)	300°C

[1] Specification is for device in free air:

8-Lead PDIP Package: θ_{JA} = 95°C/W

8-Lead SOIC Package: θ_{JA} = 155°C/W

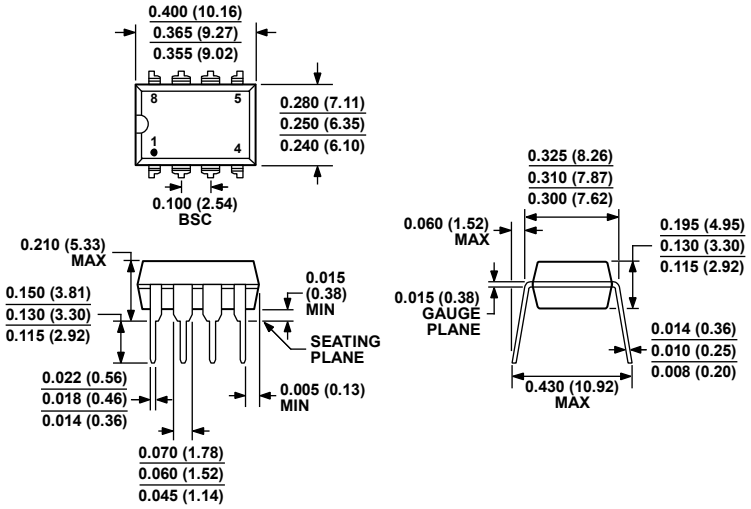
8-Lead MSOP Package: θ_{JA} = 200°C/W.

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.

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

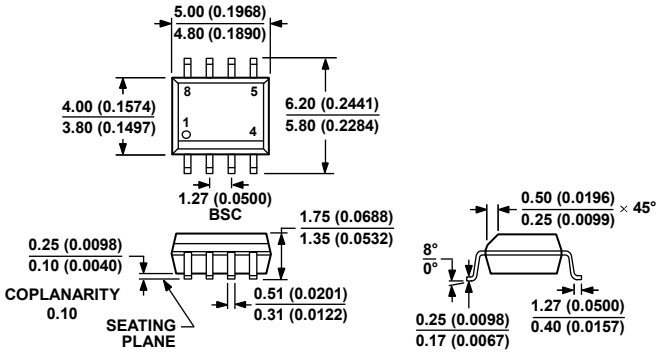


COMPLIANT TO JEDEC STANDARDS MS-001

CONTROLLING DIMENSIONS ARE IN INCHES; MILLIMETER DIMENSIONS (IN PARENTHESES) ARE ROUNDED-OFF INCH EQUIVALENTS FOR REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN. CORNER LEADS MAY BE CONFIGURED AS WHOLE OR HALF LEADS.

070606-A

Figure 56. 8-Lead Plastic Dual In-Line Package [PDIP]
Narrow Body (N-8)
Dimensions shown in inches and (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 57. 8-Lead Standard Small Outline Package [SOIC_N]
Narrow Body (R-8)
Dimensions shown in millimeters and (inches)

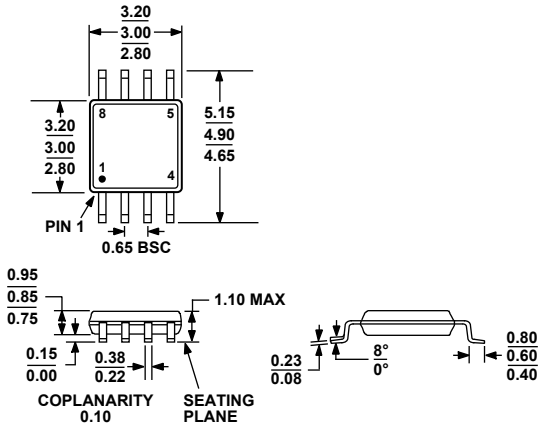


Figure 58. 8-Lead Mini Small Outline Package [MSOP]
(RM-8)
Dimensions shown in millimeters

ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option	Branding
AD623AN	−40°C to +85°C	8-Lead Plastic Dual In-Line Package [PDIP]	N-8	
AD623ANZ[1]	−40°C to +85°C	8-Lead Plastic Dual In-Line Package [PDIP]	N-8	
AD623AR	−40°C to +85°C	8-Lead Standard Small Outline Package [SOIC_N]	R-8	
AD623AR-REEL	−40°C to +85°C	8-Lead Standard Small Outline Package [SOIC_N], 13" Tape and Reel	R-8	
AD623AR-REEL7	−40°C to +85°C	8-Lead Standard Small Outline Package [SOIC_N], 7" Tape and Reel	R-8	
AD623ARZ[1]	−40°C to +85°C	8-Lead Standard Small Outline Package [SOIC_N]	R-8	
AD623ARZ-R7[1]	−40°C to +85°C	8-Lead Standard Small Outline Package [SOIC_N], 7" Tape and Reel	R-8	
AD623ARZ-RL[1]	−40°C to +85°C	8-Lead SOIC, 13" Tape and Reel	R-8	
AD623ARM	−40°C to +85°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	J0A
AD623ARM-REEL	−40°C to +85°C	8-Lead Mini Small Outline Package [MSOP], 13" Tape and Reel	RM-8	J0A
AD623ARM-REEL7	−40°C to +85°C	8-Lead Mini Small Outline Package [MSOP], 7" Tape and Reel	RM-8	J0A
AD623ARMZ[1]	−40°C to +85°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	J0A
AD623ARMZ-REEL[1]	−40°C to +85°C	8-Lead Mini Small Outline Package [MSOP], 13" Tape and Reel	RM-8	J0A
AD623ARMZ-REEL7[1]	−40°C to +85°C	8-Lead Mini Small Outline Package [MSOP], 7" Tape and Reel	RM-8	J0A
AD623BN	−40°C to +85°C	8-Lead Plastic Dual In-Line Package [PDIP]	N-8	
AD623BNZ[1]	−40°C to +85°C	8-Lead Plastic Dual In-Line Package [PDIP]	N-8	
AD623BR	−40°C to +85°C	8-Lead Standard Small Outline Package [SOIC_N]	R-8	
AD623BR-REEL	−40°C to +85°C	8-Lead Standard Small Outline Package [SOIC_N], 13" Tape and Reel	R-8	
AD623BR-REEL7	−40°C to +85°C	8-Lead Standard Small Outline Package [SOIC_N], 7" Tape and Reel	R-8	
AD623BRZ[1]	−40°C to +85°C	8-Lead Standard Small Outline Package [SOIC_N]	R-8	
AD623BRZ-R7[1]	−40°C to +85°C	8-Lead Standard Small Outline Package [SOIC_N], 7" Tape and Reel	R-8	
AD623BRZ-RL[1]	−40°C to +85°C	8-Lead Standard Small Outline Package [SOIC_N], 13" Tape and Reel	R-8	
EVAL-INAMP-62RZ[1]		Evaluation Board		

[1] Z = RoHS Compliant Part.