High Common-Mode Voltage, Programmable Gain Difference Amplifier

AD628

FEATURES

High common-mode input voltage range
±120 V at V_S = ±15 V
Gain range 0.1 to 100
Operating temperature range: −40°C to +85°C
Supply voltage range
Dual supply: ±2.25 V to ±18 V
Single supply: 4.5 V to 36 V
Excellent ac and dc performance
Offset temperature stability RTI: 10 µV/°C maximum
Offset: ±1.5 V mV maximum
CMRR RTI: 75 dB minimum, dc to 500 Hz, G = +1

APPLICATIONS

High voltage current shunt sensing
Programmable logic controllers
Analog input front end signal conditioning
+5 V, +10 V, ±5 V, ±10 V, and 4 to 20 mA
Isolation
Sensor signal conditioning
Power supply monitoring
Electrohydraulic controls
Motor controls

GENERAL DESCRIPTION

The AD628 is a precision difference amplifier that combines excellent dc performance with high common-mode rejection over a wide range of frequencies. When used to scale high voltages, it allows simple conversion of standard control voltages or currents for use with single-supply ADCs. A wideband feedback loop minimizes distortion effects due to capacitor charging of Σ-Δ ADCs.

A reference pin (V_{REF}) provides a dc offset for converting bipolar to single-sided signals. The AD628 converts +5 V, +10 V, ±5 V, ±10 V, and 4 to 20 mA input signals to a single-ended output within the input range of single-supply ADCs.

The AD628 has an input common mode and differential mode operating range of ±120 V. The high common mode, input impedance makes the device well suited for high voltage measurements across a shunt resistor. The inverting input of the buffer amplifier is available for making a remote Kelvin connection.

FUNCTIONAL BLOCK DIAGRAM

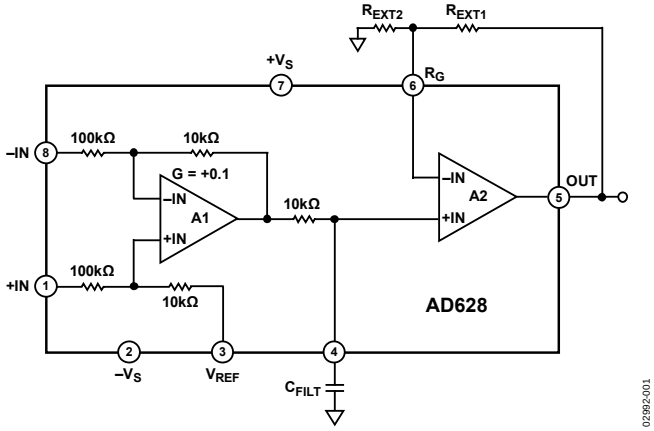

Figure 1.

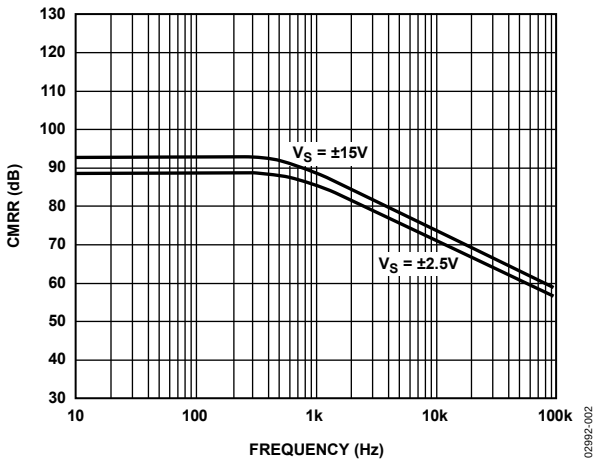

Figure 2. CMRR vs. Frequency of the AD628

A precision 10 kΩ resistor connected to an external pin is provided for either a low-pass filter or to attenuate large differential input signals. A single capacitor implements a low-pass filter. The AD628 operates from single and dual supplies and is available in an 8-lead SOIC_N or an 8-lead MSOP. It operates over the standard industrial temperature range of −40°C to +85°C.

Rev. G

SPECIFICATIONS

T_A = 25°C, V_S = ±15 V, R_L = 2 kΩ, R_{EXT1} = 10 kΩ, R_{EXT2} = ∞, V_{REF} = 0 V, unless otherwise noted.

Table 1.

		AD628AR			AD628ARM			
Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Unit**
DIFFERENTIAL AND OUTPUT AMPLIFIER								
Gain Equation	G = +0.1 (1 + R_{EXT1}/R_{EXT2})							V/V
Gain Range	See Figure 29	0.1[1]		100	0.1[1]		100	V/V
Offset Voltage	V_{CM} = 0 V; RTI of input pins[2]; output amplifier G = +1	−1.5		+1.5	−1.5		+1.5	mV
vs. Temperature			4	8		4	8	µV/°C
CMRR[3]	RTI of input pins; G = +0.1 to +100	75			75			dB
	500 Hz	75			75			dB
Minimum CMRR Over Temperature	−40°C to +85°C	70			70			dB
vs. Temperature			1	4		1	4	(µV/V)/°C
PSRR (RTI)	V_S = ±10 V to ±18 V	77	94		77	94		dB
Input Voltage Range								
Common Mode		−120		+120	−120		+120	V
Differential		−120		+120	−120		+120	V
Dynamic Response								
Small Signal Bandwidth −3 dB	G = +0.1		600			600		kHz
Full Power Bandwidth			5			5		kHz
Settling Time	G = +0.1, to 0.01%, 100 V step			40			40	µs
Slew Rate			0.3			0.3		V/µs
Noise (RTI)								
Spectral Density	1 kHz		300			300		nV/√Hz
	0.1 Hz to 10 Hz		15			15		µV p-p
DIFFERENTIAL AMPLIFIER								
Gain			0.1			0.1		V/V
Error		−0.1	+0.01	+0.1	−0.1	+0.01	+0.1	%
vs. Temperature				5			5	ppm/°C
Nonlinearity				5			5	ppm
vs. Temperature			3	10		3	10	ppm
Offset Voltage	RTI of input pins	−1.5		+1.5	−1.5		+1.5	mV
vs. Temperature				8			8	µV/°C
Input Impedance								
Differential			220			220		kΩ
Common Mode			55			55		kΩ
CMRR[4]	RTI of input pins; G = +0.1 to +100	75			75			dB
	500 Hz	75			75			dB
Minimum CMRR Over Temperature	−40°C to +85°C	70			70			dB
vs. Temperature			1	4		1	4	(µV/V)/°C
Output Resistance			10			10		kΩ
Error		−0.1		+0.1	−0.1		+0.1	%

Parameter	Conditions	AD628AR			AD628ARM			Unit
		Min	Typ	Max	Min	Typ	Max	
OUTPUT AMPLIFIER								
Gain Equation	G = (1 + R_{EXT1}/R_{EXT2})							V/V
Nonlinearity	G = +1, V_{OUT} = ±10 V			0.5			0.5	ppm
Offset Voltage	RTI of output amp	−0.15		+0.15	−0.15		+0.15	mV
vs. Temperature				0.6			0.6	µV/°C
Output Voltage Swing	R_L = 10 kΩ	−14.2		+14.1	−14.2		+14.1	V
	R_L = 2 kΩ	−13.8		+13.6	−13.8		+13.6	V
Bias Current			1.5	3		1.5	3	nA
Offset Current			0.2	0.5		0.2	0.5	nA
CMRR	V_{CM} = ±13 V	130			130			dB
Open-Loop Gain	V_{OUT} = ±13 V	130			130			dB
POWER SUPPLY								
Operating Range		±2.25		±18	±2.25		±18	V
Quiescent Current				1.6			1.6	mA
TEMPERATURE RANGE		−40		+85	−40		+85	°C

[1] To use a lower gain, see the Gain Adjustment section.
[2] The addition of the difference amplifier and output amplifier offset voltage does not exceed this specification.
[3] Error due to common mode as seen at the output: $V_{OUT} = \left[\frac{(0.1)(V_{CM})}{10^{\frac{75}{20}}}\right] \times [Output\ Amplifier\ Gain]$.
[4] Error due to common mode as seen at the output of A1: $V_{OUT\ A1} = \left[\frac{(0.1)(V_{CM})}{10^{\frac{75}{20}}}\right]$.

T_A = 25°C, V_S = 5 V, R_L = 2 kΩ, R_{EXT1} = 10 kΩ, R_{EXT2} = ∞, V_{REF} = 2.5 V, unless otherwise noted.

Table 2.

		AD628AR			AD628ARM			
Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Unit**
DIFFERENTIAL AND OUTPUT AMPLIFIER								
Gain Equation	G = +0.1(1+ R_{EXT1}/R_{EXT2})							V/V
Gain Range	See Figure 29	0.1[1]		100	0.1[1]		100	V/V
Offset Voltage	V_{CM} = 2.25 V; RTI of input pins[2]; output amplifier G = +1	−3.0		+3.0	−3.0		+3.0	mV
vs. Temperature			6	15		6	15	µV/°C
CMRR[3]	RTI of input pins; G = +0.1 to +100	75			75			dB
	500 Hz	75			75			dB
Minimum CMRR Over Temperature	−40°C to +85°C	70			70			dB
vs. Temperature			1	4		1	4	(µV/V)/°C
PSRR (RTI)	V_S = 4.5 V to 10 V	77	94		77	94		dB
Input Voltage Range								
Common Mode[4]		−12		+17	−12		+17	V
Differential		−15		+15	−15		+15	V
Dynamic Response								
Small Signal Bandwidth – 3 dB	G = +0.1		440			440		kHz
Full Power Bandwidth			30			30		kHz
Settling Time	G = +0.1; to 0.01%, 30 V step		15			15		µs
Slew Rate			0.3			0.3		V/µs
Noise (RTI)								
Spectral Density	1 kHz		350			350		nV/√Hz
	0.1 Hz to 10 Hz		15			15		µV p-p
DIFFERENTIAL AMPLIFIER								
Gain			0.1			0.1		V/V
Error		−0.1	+0.01	+0.1	−0.1	+0.01	+0.1	%
Nonlinearity				3			3	ppm
vs. Temperature			3	10		3	10	ppm
Offset Voltage	RTI of input pins	−2.5		+2.5	−2.5		+2.5	mV
vs. Temperature				10			10	µV/°C
Input Impedance								
Differential			220			220		kΩ
Common Mode			55			55		kΩ
CMRR[5]	RTI of input pins; G = +0.1 to +100	75			75			dB
	500 Hz	75			75			dB
Minimum CMRR Over Temperature	−40°C to +85°C	70			70			dB
vs. Temperature			1	4		1	4	(µV/V)/°C
Output Resistance			10			10		kΩ
Error		−0.1		+0.1	−0.1		+0.1	%
OUTPUT AMPLIFIER								
Gain Equation	G = (1 + R_{EXT1}/R_{EXT2})							V/V
Nonlinearity	G = +1, V_{OUT} = 1 V to 4 V			0.5			0.5	ppm
Output Offset Voltage	RTI of output amplifier	−0.15		+0.15	−0.15		+0.15	mV
vs. Temperature				0.6			0.6	µV/°C
Output Voltage Swing	R_L = 10 kΩ	0.9		4.1	0.9		4.1	V
	R_L = 2 kΩ	1		4	1		4	V
Bias Current			1.5	3		1.5	3	nA
Offset Current			0.2	0.5		0.2	0.5	nA
CMRR	V_{CM} = 1 V to 4 V	130			130			dB
Open-Loop Gain	V_{OUT} = 1 V to 4 V	130			130			dB

Parameter	Conditions	AD628AR Min	AD628AR Typ	AD628AR Max	AD628ARM Min	AD628ARM Typ	AD628ARM Max	Unit
POWER SUPPLY								
Operating Range		±2.25		+36	±2.25		+36	V
Quiescent Current				1.6			1.6	mA
TEMPERATURE RANGE		−40		+85	−40		+85	°C

[1] To use a lower gain, see the Gain Adjustment section.
[2] The addition of the difference amplifier and output amplifier offset voltage does not exceed this specification.
[3] Error due to common mode as seen at the output: $V_{OUT} = \left[\frac{(0.1)(V_{CM})}{10^{\frac{75}{20}}}\right] \times [Output\ Amplifier\ Gain]$.
[4] Greater values of voltage are possible with greater or lesser values of V_{REF}.
[5] Error due to common mode as seen at the output of A1: $V_{OUT}\ A1 = \left[\frac{(0.1)(V_{CM})}{10^{\frac{75}{20}}}\right]$.

ABSOLUTE MAXIMUM RATINGS

Table 3.

Parameter	Rating
Supply Voltage	±18 V
Internal Power Dissipation	See Figure 3
Input Voltage (Common Mode)	±120 V[1]
Differential Input Voltage	±120 V[1]
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] When using ±12 V supplies or higher, see the Input Voltage Range section.

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

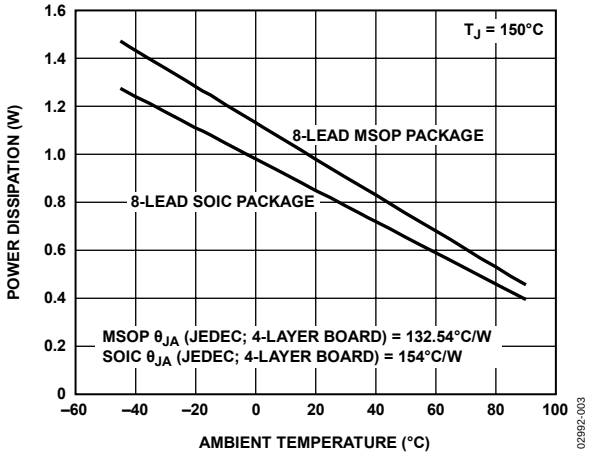

Figure 3. Maximum Power Dissipation vs. Temperature

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

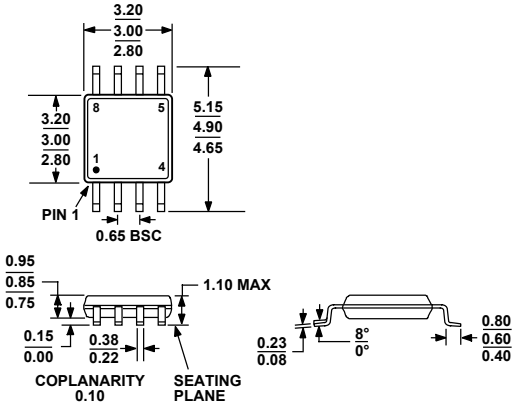

Figure 36. 8-Lead Mini Small Outline Package [MSOP]
(RM-8)
Dimensions shown in millimeters

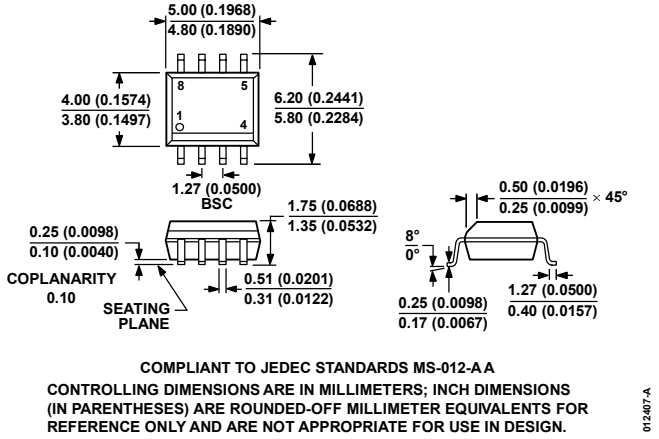

Figure 37. 8-Lead Standard Small Outline Package [SOIC_N]
Narrow Body (R-8)
Dimensions shown in millimeters and (inches)

ORDERING GUIDE

Model	Temperature Range	Description	Package Option	Branding
AD628AR	−40°C to +85°C	8-Lead SOIC_N	R-8	
AD628AR-REEL	−40°C to +85°C	8-Lead SOIC_N 13" Reel	R-8	
AD628AR-REEL7	−40°C to +85°C	8-Lead SOIC_N 7" Reel	R-8	
AD628ARZ[1]	−40°C to +85°C	8-Lead SOIC_N	R-8	
AD628ARZ-RL[1]	−40°C to +85°C	8-Lead SOIC_N 13" Reel	R-8	
AD628ARZ-R7[1]	−40°C to +85°C	8-Lead SOIC_N 7" Reel	R-8	
AD628ARM	−40°C to +85°C	8-Lead MSOP	RM-8	JGA
AD628ARM-REEL	−40°C to +85°C	8-Lead MSOP 13" Reel	RM-8	JGA
AD628ARM-REEL7	−40°C to +85°C	8-Lead MSOP 7" Reel	RM-8	JGA
AD628ARMZ[1]	−40°C to +85°C	8-Lead MSOP	RM-8	JGZ
AD628ARMZ-RL[1]	−40°C to +85°C	8-Lead MSOP 13" Reel	RM-8	JGZ
AD628ARMZ-R7[1]	−40°C to +85°C	8-Lead MSOP 7" Reel	RM-8	JGZ
AD628-EVAL		Evaluation Board		

[1] Z = RoHS Compliant Part.

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