# Micropower, Single- and Dual-Supply, Rail-to-Rail Instrumentation Amplifier

# AD627

## FEATURES

**Micropower, 85 μA maximum supply current**
**Wide power supply range (+2.2 V to ±18 V)**
**Easy to use**
- **Gain set with one external resistor**
- **Gain range 5 (no resistor) to 1000**

**Higher performance than discrete designs**
**Rail-to-rail output swing**
**High accuracy dc performance**
- **0.03% typical gain accuracy (G = +5) (AD627A)**
- **10 ppm/°C typical gain drift (G = +5)**
- **125 μV maximum input offset voltage (AD627B dual supply)**
- **200 μV maximum input offset voltage (AD627A dual supply)**
- **1 μV/°C maximum input offset voltage drift (AD627B)**
- **3 μV/°C maximum input offset voltage drift (AD627A)**
- **10 nA maximum input bias current**

**Noise: 38 nV/√Hz RTI noise @ 1 kHz (G = +100)**
**Excellent ac specifications**
- **AD627A: 77 dB minimum CMRR (G = +5)**
- **AD627B: 83 dB minimum CMRR (G = +5)**
- **80 kHz bandwidth (G = +5)**
- **135 μs settling time to 0.01% (G = +5, 5 V step)**

## APPLICATIONS

**4 to 20 mA loop-powered applications**
**Low power medical instrumentation—ECG, EEG**
**Transducer interfacing**
**Thermocouple amplifiers**
**Industrial process controls**
**Low power data acquisition**
**Portable battery-powered instruments**

## FUNCTIONAL BLOCK DIAGRAM

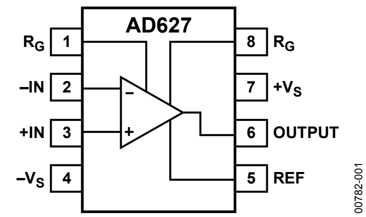



*Figure 1. 8-Lead PDIP (N) and SOIC_N (R)*

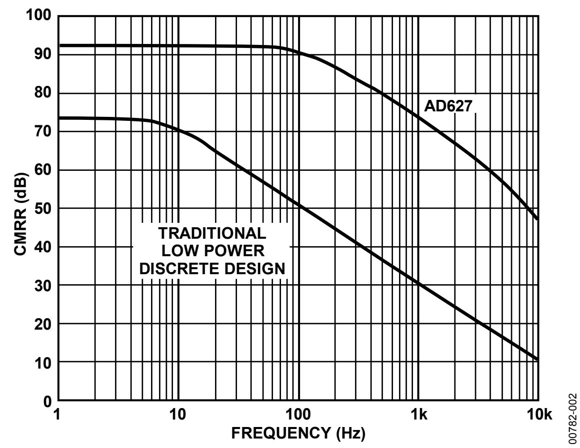



*Figure 2. CMRR vs. Frequency, ±5 $V_S$, Gain = +5*

## GENERAL DESCRIPTION

The AD627 is an integrated, micropower instrumentation amplifier that delivers rail-to-rail output swing on single and dual (+2.2 V to ±18 V) supplies. The AD627 provides excellent ac and dc specifications while operating at only 85 μA maximum.

The AD627 offers superior flexibility by allowing the user to set the gain of the device with a single external resistor while conforming to the 8-lead industry-standard pinout configuration. With no external resistor, the AD627 is configured for a gain of 5. With an external resistor, it can be set to a gain of up to 1000.

A wide supply voltage range (+2.2 V to ±18 V) and micropower current consumption make the AD627 a perfect fit for a wide range of applications. Single-supply operation, low power consumption, and rail-to-rail output swing make the AD627 ideal for battery-powered applications. Its rail-to-rail output stage maximizes dynamic range when operating from low supply voltages. Dual-supply operation (±15 V) and low power consumption make the AD627 ideal for industrial applications, including 4 to 20 mA loop-powered systems.

The AD627 does not compromise performance, unlike other micropower instrumentation amplifiers. Low voltage offset, offset drift, gain error, and gain drift minimize errors in the system. The AD627 also minimizes errors over frequency by providing excellent CMRR over frequency. Because the CMRR remains high up to 200 Hz, line noise and line harmonics are rejected.

The AD627 provides superior performance, uses less circuit board area, and costs less than micropower discrete designs.


**Rev. D**

# SPECIFICATIONS

## SINGLE SUPPLY

Typical @ 25°C single supply, $V_S$ = 3 V and 5 V, and $R_L$ = 20 kΩ, unless otherwise noted.

**Table 1.**

| Parameter | Conditions | AD627A Min | AD627A Typ | AD627A Max | AD627B Min | AD627B Typ | AD627B Max | Unit |
|---|---|---|---|---|---|---|---|---|
| GAIN | G = +5 + (200 kΩ/$R_G$) | | | | | | | |
| Gain Range | | 5 | | 1000 | 5 | | 1000 | V/V |
| Gain Error[1] | $V_{OUT}$ = (−$V_S$) + 0.1 to (+$V_S$) − 0.15 | | | | | | | |
| G = +5 | | | 0.03 | 0.10 | | 0.01 | 0.06 | % |
| G = +10 | | | 0.15 | 0.35 | | 0.10 | 0.25 | % |
| G = +100 | | | 0.15 | 0.35 | | 0.10 | 0.25 | % |
| G = +1000 | | | 0.50 | 0.70 | | 0.25 | 0.35 | % |
| Nonlinearity | | | | | | | | |
| G = +5 | | | 10 | 100 | | 10 | 100 | ppm |
| G = +100 | | | 20 | 100 | | 20 | 100 | ppm |
| Gain vs. Temperature[1] | | | | | | | | |
| G = +5 | | | 10 | 20 | | 10 | 20 | ppm/°C |
| G > +5 | | | −75 | | | −75 | | ppm/°C |
| VOLTAGE OFFSET | | | | | | | | |
| Input Offset, $V_{OSI}$[2] | | | 50 | 250 | | 25 | 150 | μV |
| Over Temperature | $V_{CM}$ = $V_{REF}$ = +$V_S$/2 | | | 445 | | | 215 | μV |
| Average TC | | | 0.1 | 3 | | 0.1 | 1 | μV/°C |
| Output Offset, $V_{OSO}$ | | | | 1000 | | | 500 | μV |
| Over Temperature | | | | 1650 | | | 1150 | μV |
| Average TC | | | 2.5 | 10 | | 2.5 | 10 | μV/°C |
| Offset Referred to the Input vs. Supply (PSRR) | | | | | | | | |
| G = +5 | | 86 | 100 | | 86 | 100 | | dB |
| G = +10 | | 100 | 120 | | 100 | 120 | | dB |
| G = +100 | | 110 | 125 | | 110 | 125 | | dB |
| G = +1000 | | 110 | 125 | | 110 | 125 | | dB |
| INPUT CURRENT | | | | | | | | |
| Input Bias Current | | | 3 | 10 | | 3 | 10 | nA |
| Over Temperature | | | | 15 | | | 15 | nA |
| Average TC | | | 20 | | | 20 | | pA/°C |
| Input Offset Current | | | 0.3 | 1 | | 0.3 | 1 | nA |
| Over Temperature | | | | 2 | | | 2 | nA |
| Average TC | | | 1 | | | 1 | | pA/°C |
| INPUT | | | | | | | | |
| Input Impedance | | | | | | | | |
| Differential | | | 20‖2 | | | 20‖2 | | GΩ‖pF |
| Common-Mode | | | 20‖2 | | | 20‖2 | | GΩ‖pF |
| Input Voltage Range[3] | $V_S$ = 2.2 V to 36 V | (−$V_S$) − 0.1 | | (+$V_S$) − 1 | (−$V_S$) − 0.1 | | (+$V_S$) − 1 | V |
| Common-Mode Rejection Ratio[3] DC to 60 Hz with 1 kΩ Source Imbalance | $V_{REF}$ = $V_S$/2 | | | | | | | |
| G = +5 | $V_S$ = 3 V, $V_{CM}$ = 0 V to 1.9 V | 77 | 90 | | 83 | 96 | | dB |
| G = +5 | $V_S$ = 5 V, $V_{CM}$ = 0 V to 3.7 V | 77 | 90 | | 83 | 96 | | dB |
| OUTPUT | | | | | | | | |
| Output Swing | $R_L$ = 20 kΩ | (−$V_S$) + 25 | | (+$V_S$) − 70 | (−$V_S$) + 25 | | (+$V_S$) − 70 | mV |
| | $R_L$ = 100 kΩ | (−$V_S$) + 7 | | (+$V_S$) − 25 | (−$V_S$) + 7 | | (+$V_S$) − 25 | mV |
| Short-Circuit Current | Short circuit to ground | | ±25 | | | ±25 | | mA |

| Parameter | Conditions | AD627A Min | AD627A Typ | AD627A Max | AD627B Min | AD627B Typ | AD627B Max | Unit |
|---|---|---|---|---|---|---|---|---|
| DYNAMIC RESPONSE | | | | | | | | |
| Small Signal −3 dB Bandwidth | | | | | | | | |
| G = +5 | | | 80 | | | 80 | | kHz |
| G = +100 | | | 3 | | | 3 | | kHz |
| G = +1000 | | | 0.4 | | | 0.4 | | kHz |
| Slew Rate | | | +0.05/−0.07 | | +0.05/−0.07 | | | V/μs |
| Settling Time to 0.01% | $V_S$ = 3 V, 1.5 V output step | | | | | | | |
| G = +5 | | | 65 | | | 65 | | μs |
| G = +100 | | | 290 | | | 290 | | μs |
| Settling Time to 0.01% | $V_S$ = 5 V, 2.5 V output step | | | | | | | |
| G = +5 | | | 85 | | | 85 | | μs |
| G = +100 | | | 330 | | | 330 | | μs |
| Overload Recovery | 50% input overload | | 3 | | | 3 | | μs |

[1] Does not include effects of External Resistor $R_G$.
[2] See Table 8 for total RTI errors.
[3] See the Using the AD627 section for more information on the input range, gain range, and common-mode range.

## DUAL SUPPLY

Typical @ 25°C dual supply, $V_S$ = ±5 V and ±15 V, and $R_L$ = 20 kΩ, unless otherwise noted.

**Table 2.**

| Parameter | Conditions | AD627A | | | AD627B | | | Unit |
|---|---|---|---|---|---|---|---|---|
| | | Min | Typ | Max | Min | Typ | Max | |
| GAIN | G = +5 + (200 kΩ/$R_G$) | | | | | | | |
| Gain Range | | 5 | | 1000 | 5 | | 1000 | V/V |
| Gain Error[1] | $V_{OUT}$ = (−$V_S$) + 0.1 to (+$V_S$) − 0.15 | | | | | | | |
| G = +5 | | | 0.03 | 0.10 | | 0.01 | 0.06 | % |
| G = +10 | | | 0.15 | 0.35 | | 0.10 | 0.25 | % |
| G = +100 | | | 0.15 | 0.35 | | 0.10 | 0.25 | % |
| G = +1000 | | | 0.50 | 0.70 | | 0.25 | 0.35 | % |
| Nonlinearity | | | | | | | | |
| G = +5 | $V_S$ = ±5 V/±15 V | | 10/25 | 100 | | 10/25 | 100 | ppm |
| G = +100 | $V_S$ = ±5 V/±15 V | | 10/15 | 100 | | 10/15 | 100 | ppm |
| Gain vs. Temperature[1] | | | | | | | | |
| G = +5 | | | 10 | 20 | | 10 | 20 | ppm/°C |
| G > +5 | | | −75 | | | −75 | | ppm/°C |
| VOLTAGE OFFSET | Total RTI error = $V_{OSI}$ + $V_{OSO}$/G | | | | | | | |
| Input Offset, $V_{OSI}$[2] | | | 25 | 200 | | 25 | 125 | µV |
| Over Temperature | $V_{CM}$ = $V_{REF}$ = 0 V | | | 395 | | | 190 | µV |
| Average TC | | | 0.1 | 3 | | 0.1 | 1 | µV/°C |
| Output Offset, $V_{OSO}$ | | | | 1000 | | | 500 | µV |
| Over Temperature | | | | 1700 | | | 1100 | µV |
| Average TC | | | 2.5 | 10 | | 2.5 | 10 | µV/°C |
| Offset Referred to the Input vs. Supply (PSRR) | | | | | | | | |
| G = +5 | | 86 | 100 | | 86 | 100 | | dB |
| G = +10 | | 100 | 120 | | 100 | 120 | | dB |
| G = +100 | | 110 | 125 | | 110 | 125 | | dB |
| G = +1000 | | 110 | 125 | | 110 | 125 | | dB |
| INPUT CURRENT | | | | | | | | |
| Input Bias Current | | | 2 | 10 | | 2 | 10 | nA |
| Over Temperature | | | | 15 | | | 15 | nA |
| Average TC | | | 20 | | | 20 | | pA/°C |
| Input Offset Current | | | 0.3 | 1 | | 0.3 | 1 | nA |
| Over Temperature | | | | 5 | | | 5 | nA |
| Average TC | | | 5 | | | 5 | | pA/°C |
| INPUT | | | | | | | | |
| Input Impedance | | | | | | | | |
| Differential | | | 20‖2 | | | 20‖2 | | GΩ‖pF |
| Common Mode | | | 20‖2 | | | 20‖2 | | GΩ‖pF |
| Input Voltage Range[3] | $V_S$ = ±1.1 V to ±18 V | (−$V_S$) − 0.1 | | (+$V_S$) − 1 | (−$V_S$) − 0.1 | | (+$V_S$) − 1 | V |
| Common-Mode Rejection Ratio[3] DC to 60 Hz with 1 kΩ Source Imbalance | | | | | | | | |
| G = +5 to +1000 | $V_S$ = ±5 V, $V_{CM}$ = −4 V to +3.0 V | 77 | 90 | | 83 | 96 | | dB |
| G = +5 to +1000 | $V_S$ = ±15 V, $V_{CM}$ = −12 V to +10.9 V | 77 | 90 | | 83 | 96 | | dB |
| OUTPUT | | | | | | | | |
| Output Swing | $R_L$ = 20 kΩ | (−$V_S$) + 25 | | (+$V_S$) − 70 | (−$V_S$) + 25 | | (+$V_S$) − 70 | mV |
| | $R_L$ = 100 kΩ | (−$V_S$) + 7 | | (+$V_S$) − 25 | (−$V_S$) + 7 | | (+$V_S$) − 25 | mV |
| Short-Circuit Current | Short circuit to ground | | ±25 | | | ±25 | | mA |

| Parameter | Conditions | AD627A Min | AD627A Typ | AD627A Max | AD627B Min | AD627B Typ | AD627B Max | Unit |
|---|---|---|---|---|---|---|---|---|
| DYNAMIC RESPONSE | | | | | | | | |
| Small Signal −3 dB Bandwidth | | | | | | | | |
| G = +5 | | | 80 | | | 80 | | kHz |
| G = +100 | | | 3 | | | 3 | | kHz |
| G = +1000 | | | 0.4 | | | 0.4 | | kHz |
| Slew Rate | | | +0.05/−0.06 | | | +0.05/−0.06 | | V/µs |
| Settling Time to 0.01% | $V_S$ = ±5 V, +5 V output step | | | | | | | |
| G = +5 | | | 135 | | | 135 | | µs |
| G = +100 | | | 350 | | | 350 | | µs |
| Settling Time to 0.01% | $V_S$ = ±15 V, +15 V output step | | | | | | | |
| G = +5 | | | 330 | | 330 | | | µs |
| G = +100 | | | 560 | | 560 | | | µs |
| Overload Recovery | 50% input overload | | 3 | | 3 | | | µs |

[1] Does not include effects of External Resistor $R_G$.
[2] See Table 8 for total RTI errors.
[3] See the Using the AD627 section for more information on the input range, gain range, and common-mode range.

## DUAL AND SINGLE SUPPLIES

**Table 3.**

| Parameter | Conditions | AD627A Min | AD627A Typ | AD627A Max | AD627B Min | AD627B Typ | AD627B Max | Unit |
|---|---|---|---|---|---|---|---|---|
| NOISE | | | | | | | | |
| Voltage Noise, 1 kHz | $Total\ RTI\ Noise = \sqrt{(e_{ni})^2 + (e_{no}/R_G)^2}$ | | | | | | | |
| Input, Voltage Noise, $e_{ni}$ | | | 38 | | | 38 | | nV/√Hz |
| Output, Voltage Noise, $e_{no}$ | | | 177 | | | 177 | | nV/√Hz |
| RTI, 0.1 Hz to 10 Hz | | | | | | | | |
| G = +5 | | | 1.2 | | | 1.2 | | µV p-p |
| G = +1000 | | | 0.56 | | | 0.56 | | µV p-p |
| Current Noise | f = 1 kHz | | 50 | | | 50 | | fA/√Hz |
| 0.1 Hz to 10 Hz | | | 1.0 | | | 1.0 | | pA p-p |
| REFERENCE INPUT | | | | | | | | |
| $R_{IN}$ | $R_G$ = ∞ | | 125 | | | 125 | | kΩ |
| Gain to Output | | | 1 | | | 1 | | |
| Voltage Range[1] | | | | | | | | |
| POWER SUPPLY | | | | | | | | |
| Operating Range | Dual supply | ±1.1 | | ±18 | ±1.1 | | ±18 | V |
| | Single supply | 2.2 | | 36 | 2.2 | | 36 | V |
| Quiescent Current | | | 60 | 85 | | 60 | 85 | µA |
| Over Temperature | | | 200 | | | 200 | | nA/°C |
| TEMPERATURE RANGE | | | | | | | | |
| For Specified Performance | | −40 | | +85 | −40 | | +85 | °C |

[1] See Using the AD627 section for more information on the reference terminal, input range, gain range, and common-mode range.

# ABSOLUTE MAXIMUM RATINGS

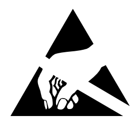
**Table 4.**

| Parameter | Rating |
|---|---|
| Supply Voltage | ±18 V |
| Internal Power Dissipation[1] | |
| PDIP (N-8) | 1.3 W |
| SOIC_N (R-8) | 0.8 W |
| −IN, +IN | $-V_S$ − 20 V to $+V_S$ + 20 V |
| Common-Mode Input Voltage | $-V_S$ − 20 V to $+V_S$ + 20 V |
| Differential Input Voltage (+IN − (−IN)) | $+V_S - (-V_S)$ |
| Output Short-Circuit Duration | Indefinite |
| Storage Temperature Range (N, R) | −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: $\theta_{JA}$ = 90°C/W.
8-lead SOIC_N package: $\theta_{JA}$ = 155°C/W.

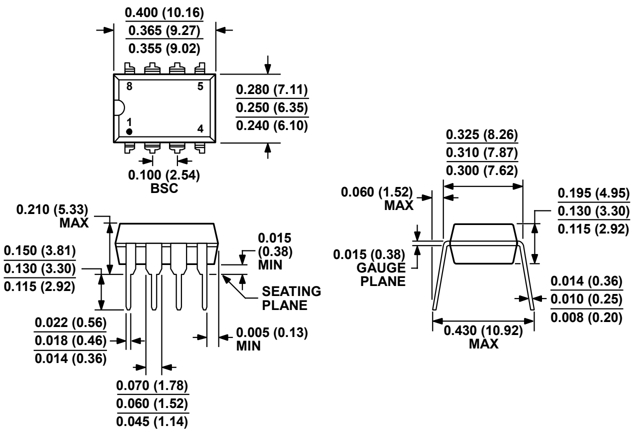
Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute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

## ESD CAUTION



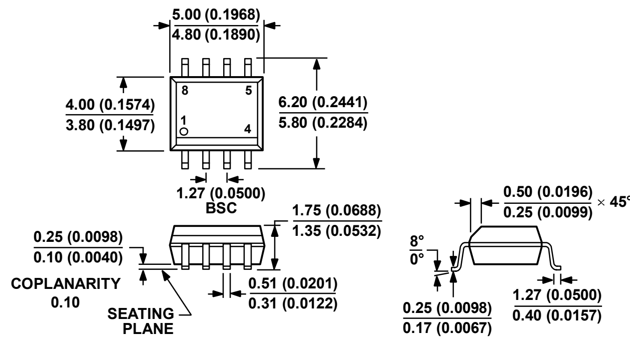
**ESD (electrostatic discharge) sensitive device.** Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken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

*Figure 53. 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 54. 8-Lead Small Standard Outline Package [SOIC_N]*
*Narrow Body (R-8)*
*Dimensions shown in millimeters (and inches)*

## ORDERING GUIDE

| Model | Temperature Range | Package Description | Package Option |
|---|---|---|---|
| AD627AN | –40°C to +85°C | 8-Lead Plastic Dual In-Line Package [PDIP] | N-8 |
| AD627ANZ[1] | –40°C to +85°C | 8-Lead Plastic Dual In-Line Package [PDIP] | N-8 |
| AD627AR | –40°C to +85°C | 8-Lead Small Standard Outline [SOIC_N] | R-8 |
| AD627AR-REEL | –40°C to +85°C | 8-Lead Small Standard Outline [SOIC_N] | R-8 |
| AD627AR-REEL7 | –40°C to +85°C | 8-Lead Small Standard Outline [SOIC_N] | R-8 |
| AD627ARZ[1] | –40°C to +85°C | 8-Lead Small Standard Outline [SOIC_N] | R-8 |
| AD627ARZ-R7[1] | –40°C to +85°C | 8-Lead Small Standard Outline [SOIC_N] | R-8 |
| AD627ARZ-RL[1] | –40°C to +85°C | 8-Lead Small Standard Outline [SOIC_N] | R-8 |
| AD627BN | –40°C to +85°C | 8-Lead Plastic Dual In-Line Package [PDIP] | N-8 |
| AD627BNZ[1] | –40°C to +85°C | 8-Lead Plastic Dual In-Line Package [PDIP] | N-8 |
| AD627BR | –40°C to +85°C | 8-Lead Small Standard Outline [SOIC_N] | R-8 |
| AD627BR-REEL | –40°C to +85°C | 8-Lead Small Standard Outline [SOIC_N] | R-8 |
| AD627BR-REEL7 | –40°C to +85°C | 8-Lead Small Standard Outline [SOIC_N] | R-8 |
| AD627BRZ[1] | –40°C to +85°C | 8-Lead Small Standard Outline [SOIC_N] | R-8 |
| AD627BRZ-RL[1] | –40°C to +85°C | 8-Lead Small Standard Outline [SOIC_N] | R-8 |
| AD627BRZ-R7[1] | –40°C to +85°C | 8-Lead Small Standard Outline [SOIC_N] | R-8 |

[1] Z = RoHS Compliant part.