# Ultralow Input Bias Current Operational Amplifier

# AD549

## FEATURES

**Ultralow input bias current**
- **60 fA maximum (AD549L)**
- **250 fA maximum (AD549J)**

**Input bias current guaranteed over the common-mode voltage range**

**Low offset voltage**
- **0.25 mV maximum (AD549K)**
- **1.00 mV maximum (AD549J)**

**Low offset drift**
- **5 µV/°C maximum (AD549K)**
- **20 µV/°C maximum (AD549J)**

**Low power**
- **700 µA maximum supply current**
- **Low input voltage noise**

**4 µV p-p over 0.1 Hz to 10 Hz**

**MIL-STD-883B parts available**

## APPLICATIONS

**Electrometer amplifier**

**Photodiode preamp**

**pH electrode buffer**

**Vacuum ion gauge measurement**

## CONNECTION DIAGRAM

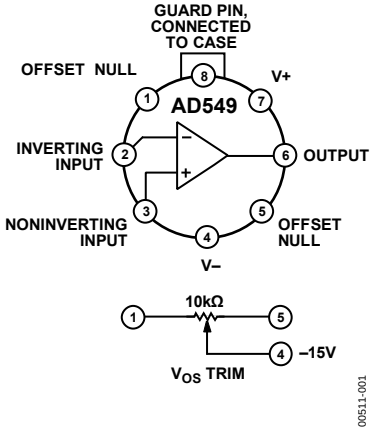



*Figure 1.*

## GENERAL DESCRIPTION

The AD549[1] is a monolithic electrometer operational amplifier with very low input bias current. Input offset voltage and input offset voltage drift are laser trimmed for precision performance. The ultralow input current of the part is achieved with Topgate™ JFET technology, a process development exclusive to Analog Devices, Inc. This technology allows fabrication of extremely low input current JFETs compatible with a standard junction isolated bipolar process. The $10^{15}$ Ω common-mode impedance, which results from the bootstrapped input stage, ensures that the input current is essentially independent of the common-mode voltage.

The AD549 is suited for applications requiring very low input current and low input offset voltage. It excels as a preamp for a wide variety of current output transducers, such as photodiodes, photomultiplier tubes, or oxygen sensors. The AD549 can also be used as a precision integrator or low droop sample-and-hold. The AD549 is pin compatible with standard FET and electrometer op amps, allowing designers to upgrade the performance of present systems at little additional cost.

The AD549 is available in a TO-99 hermetic package. The case is connected to Pin 8, thus, the metal case can be independently connected to a point at the same potential as the input terminals, minimizing stray leakage to the case. The AD549 is available in four performance grades. The J, K, and L versions are rated over the commercial temperature range of 0°C to +70°C. The S grade is specified over the military temperature range of −55°C to +125°C and is available processed to MIL-STD-883B, Rev. C. Extended reliability plus screening is also available. Plus screening includes 168 hour burn-in, as well as other environmental and physical tests derived from MIL-STD-883B, Rev. C.

## PRODUCT HIGHLIGHTS

1. The AD549 input currents are specified, 100% tested, and guaranteed after the device is warmed up. They are guaranteed over the entire common-mode input voltage range.
2. The AD549 input offset voltage and drift are laser trimmed to 0.25 mV and 5 µV/°C (AD549K), and to 1 mV and 20 µV/°C (AD549J).
3. A maximum quiescent supply current of 700 µA minimizes heating effects on input current and offset voltage.
4. AC specifications include 1 MHz unity-gain bandwidth and 3 V/µs slew rate. Settling time for a 10 V input step is 5 µs to 0.01%.

[1] Protected by U.S. Patent No. 4,639,683.

# SPECIFICATIONS

@ 25°C and $V_S$ = ±15 V dc, unless otherwise noted; all minimum and maximum specifications are guaranteed; specifications in **boldface** are tested on all production units at final electrical test, and results from those tests are used to calculate outgoing quality levels.

**Table 1.**

| | AD549J | | | AD549K | | | AD549L | | | AD549S | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Min** | **Typ** | **Max** | **Min** | **Typ** | **Max** | **Min** | **Typ** | **Max** | **Min** | **Typ** | **Max** | **Unit** |
| INPUT BIAS CURRENT[1] | | | | | | | | | | | | | |
| Either Input, $V_{CM}$ = 0 V | | 150 | **250** | | 75 | **100** | | 40 | **60** | | 75 | **100** | fA |
| Either Input, $V_{CM}$ = ±10 V | | 150 | 250 | | 75 | 100 | | 40 | 60 | | 75 | 100 | fA |
| Either Input at $T_{MAX}$, $V_{CM}$ = 0 V | | 11 | | | 4.2 | | | 2.8 | | | 420 | | pA |
| Offset Current | | 50 | | | 30 | | | 20 | | | 30 | | fA |
| Offset Current at $T_{MAX}$ | | 2.2 | | | 1.3 | | | 0.85 | | | 125 | | pA |
| INPUT OFFSET VOLTAGE[2] | | | | | | | | | | | | | |
| Initial Offset | | 0.5 | **1.0** | | 0.15 | **0.25** | | 0.3 | **0.5** | | 0.3 | **0.5** | mV |
| Offset at $T_{MAX}$ | | | **1.9** | | | **0.4** | | | **0.9** | | | **2.0** | mV |
| vs. Temperature | | 10 | **20** | | 2 | **5** | | 5 | **10** | | 10 | **15** | µV/°C |
| vs. Supply | | 32 | **100** | | 10 | **32** | | 10 | **32** | | 10 | **32** | µV/V |
| vs. Supply, $T_{MIN}$ to $T_{MAX}$ | | 32 | **100** | | 10 | **32** | | 10 | **32** | | 32 | **50** | µV/V |
| Long-Term Offset Stability | | 15 | | | 15 | | | 15 | | | 15 | | µV/month |
| INPUT VOLTAGE NOISE | | | | | | | | | | | | | |
| f = 0.1 Hz to 10 Hz | | 4 | | | 4 | **6** | | 4 | | | 4 | | µV p-p |
| f = 10 Hz | | 90 | | | 90 | | | 90 | | | 90 | | nV/√Hz |
| f = 100 Hz | | 60 | | | 60 | | | 60 | | | 60 | | nV/√Hz |
| f = 1 kHz | | 35 | | | 35 | | | 35 | | | 35 | | nV/√Hz |
| f = 10 kHz | | 35 | | | 35 | | | 35 | | | 35 | | nV/√Hz |
| INPUT CURRENT NOISE | | | | | | | | | | | | | |
| f = 0.1 Hz to 10 Hz | | 0.7 | | | 0.5 | | | 0.36 | | | 0.5 | | fA rms |
| f = 1 kHz | | 0.22 | | | 0.16 | | | 0.11 | | | 0.16 | | fA/√Hz |
| INPUT IMPEDANCE | | | | | | | | | | | | | |
| Differential | | | | | | | | | | | | | |
| $V_{DIFF}$ = ±1 | | $10^{13}$\|\|1 | | | $10^{13}$\|\|1 | | | $10^{13}$\|\|1 | | | $10^{13}$\|\|1 | | Ω\|\|pF |
| Common Mode | | | | | | | | | | | | | |
| $V_{CM}$ = ±10 V | | $10^{15}$\|\|0.8 | | | $10^{15}$\|\|0.8 | | | $10^{15}$\|\|0.8 | | | $10^{15}$\|\|0.8 | | Ω\|\|pF |
| OPEN-LOOP GAIN | | | | | | | | | | | | | |
| $V_{OUT}$ @ ±10 V, $R_L$ = 10 kΩ | **300** | 1000 | | **300** | 1000 | | **300** | 1000 | | **300** | 1000 | | V/mV |
| $V_{OUT}$ @ ±10 V, $R_L$ = 10 kΩ, $T_{MIN}$ to $T_{MAX}$ | **300** | 800 | | **300** | 800 | | **300** | 800 | | **300** | 800 | | V/mV |
| $V_{OUT}$ = ±10 V, $R_L$ = 2 kΩ | **100** | 250 | | **100** | 250 | | **100** | 250 | | **100** | 250 | | V/mV |
| $V_{OUT}$ = ±10 V, $R_L$ = 2 kΩ, $T_{MIN}$ to $T_{MAX}$ | **80** | 200 | | **80** | 200 | | **80** | 200 | | **25** | 150 | | V/mV |
| INPUT VOLTAGE RANGE | | | | | | | | | | | | | |
| Differential[3] | | | ±20 | | | ±20 | | | ±20 | | | ±20 | V |
| Common-Mode Voltage | **−10** | | **+10** | **−10** | | **+10** | **−10** | | **+10** | **−10** | | **+10** | V |
| Common-Mode Rejection Ratio | | | | | | | | | | | | | |
| −10 V ≤ $V_{CM}$ ≤ +10 V | **80** | 90 | | **90** | 100 | | **90** | 100 | | **90** | 100 | | dB |
| $T_{MIN}$ to $T_{MAX}$ | **76** | 80 | | **80** | 90 | | **80** | 90 | | **80** | 90 | | dB |

| Parameter | AD549J Min | AD549J Typ | AD549J Max | AD549K Min | AD549K Typ | AD549K Max | AD549L Min | AD549L Typ | AD549L Max | AD549S Min | AD549S Typ | AD549S Max | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OUTPUT CHARACTERISTICS | | | | | | | | | | | | | |
| $V_{OUT}$ @ $R_L$ = 10 kΩ, $T_{MIN}$ to $T_{MAX}$ | **−12** | | **+12** | **−12** | | **+12** | **−12** | | **+12** | **−12** | | **+12** | V |
| $V_{OUT}$ @ $R_L$ = 2 kΩ, $T_{MIN}$ to $T_{MAX}$ | **−10** | | **+10** | **−10** | | **+10** | **−10** | | **+10** | **−10** | | **+10** | V |
| Short-Circuit Current | **15** | 20 | **35** | **15** | 20 | **35** | **15** | 20 | **35** | **15** | 20 | **35** | mA |
| $T_{MIN}$ to $T_{MAX}$ | **9** | | | **9** | | | **9** | | | **6** | | | mA |
| Load Capacitance Stability, G = +1 | | 4000 | | | 4000 | | | 4000 | | | 4000 | | pF |
| FREQUENCY RESPONSE | | | | | | | | | | | | | |
| Unity Gain, Small Signal | 0.7 | 1.0 | | 0.7 | 1.0 | | 0.7 | 1.0 | | 0.7 | 1.0 | | MHz |
| Full Power Response | | 50 | | | 50 | | | 50 | | | 50 | | kHz |
| Slew Rate | 2 | 3 | | 2 | 3 | | 2 | 3 | | 2 | 3 | | V/µs |
| Settling Time, 0.1% | | 4.5 | | | 4.5 | | | 4.5 | | | 4.5 | | µs |
| Settling Time, 0.01% | | 5 | | | 5 | | | 5 | | | 5 | | µs |
| Overload Recovery, 50% Overdrive, G = −1 | | 2 | | | 2 | | | 2 | | | 2 | | µs |
| POWER SUPPLY | | | | | | | | | | | | | |
| Rated Performance | | ±15 | | | ±15 | | | ±15 | | | ±15 | | V |
| Operating | **±5** | | **±18** | **±5** | | **±18** | **±5** | | **±18** | **±5** | | **±18** | V |
| Quiescent Current | | 0.60 | **0.70** | | 0.60 | **0.70** | | 0.60 | **0.70** | | 0.60 | **0.70** | mA |
| TEMPERATURE RANGE | | | | | | | | | | | | | |
| Operating, Rated Performance | 0 | | 70 | 0 | | 70 | 0 | | 70 | −55 | | +125 | °C |
| Storage | −65 | | +150 | −65 | | +150 | −65 | | +150 | −65 | | +150 | °C |

[1] Bias current specifications are guaranteed after five minutes of operation at $T_A$ = 25°C. Bias current increases by a factor of 2.3 for every 10°C rise in temperature.
[2] Input offset voltage specifications are guaranteed after five minutes of operation at $T_A$ = 25°C.
[3] Defined as maximum continuous voltage between the inputs, such that neither input exceeds ±10 V from ground.

# ABSOLUTE MAXIMUM RATINGS

**Table 2.**

| Parameter | Rating |
|---|---|
| Supply Voltage | ±18 V |
| Internal Power Dissipation | 500 mW |
| Input Voltage[1] | ±18 V |
| Output Short-Circuit Duration | Indefinite |
| Differential Input Voltage | $+V_S$ and $-V_S$ |
| Storage Temperature Range | −65°C to +125°C |
| Operating Temperature Range | |
| AD549J, AD549K, AD549L | 0°C to +70°C |
| AD549S | −55°C to +125°C |
| Lead Temperature (Soldering, 60 sec) | 300°C |

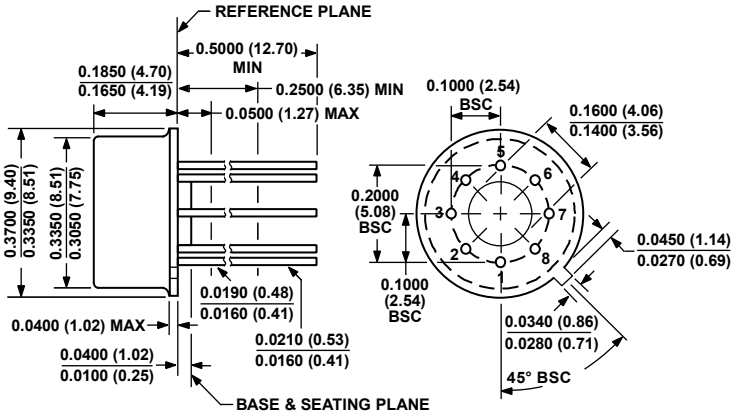
[1] For supply voltages less than ±18 V, the absolute maximum input voltage is equal to the supply voltage.

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 MO-002-AK
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.

022306-A

*Figure 47. 8-Lead Metal Can [TO-99]*
*(H-08)*
*Dimensions shown in inches and (millimeters)*

## ORDERING GUIDE

| Model | Temperature Range | Package Description | Package Option |
|---|---|---|---|
| AD549JH | 0°C to +70°C | 8-Lead Metal Can (TO-99) | H-08 |
| AD549JHZ[1] | 0°C to +70°C | 8-Lead Metal Can (TO-99) | H-08 |
| AD549KH | 0°C to +70°C | 8-Lead Metal Can (TO-99) | H-08 |
| AD549KHZ[1] | 0°C to +70°C | 8-Lead Metal Can (TO-99) | H-08 |
| AD549LH | 0°C to +70°C | 8-Lead Metal Can (TO-99) | H-08 |
| AD549LHZ[1] | 0°C to +70°C | 8-Lead Metal Can (TO-99) | H-08 |
| AD549SH/883B | −55°C to +125°C | 8-Lead Metal Can (TO-99) | H-08 |

[1] Z = RoHS Compliant Part.