# ANALOG DEVICES

# Ultra-Low Noise and Distortion, High Speed Op-Amp

Preliminary Technical Data

# AD8099

## FEATURES

**Ultra-Low Noise**
**0.95nV/rt Hz**
**2.6pA/rt Hz**
**Ultra-Low Distortion**
- **2nd Harmonic**
  - **-100dB @ 1MHz**
  - **-92dB @ 10MHz**
- **3rd Harmonic**
  - **-100dB @ 1MHz**
  - **-92dB @ 10MHz**

**High Speed**
- **500MHz, (G = +2)**
- **500MHz (G=+10)**
- **1600 V/s (G=+10)**
- **External Compensation**

**Low Power 15mA $I_S$**
**Offset Voltage 1mV Max**
**Wide Supply Voltage Range**
- **5V to 12V**

## APPLICATIONS

**Pre-amp**
**Receiver**
**Instrumentation**
**IF and Baseband Amplifier**
**Filters**
**A-to-D Driver**
**DAC Buffer**

## CONNECTION DIAGRAMS

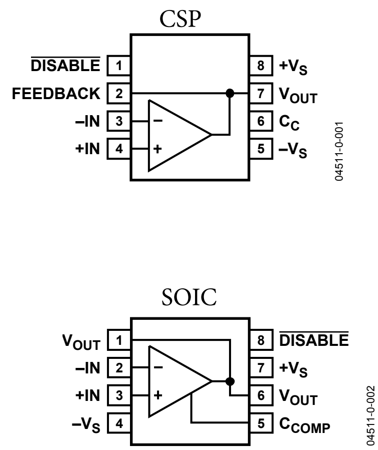


Figure 1.0 SOIC and CSP Pinouts

## GENERAL DESCRIPTION

The AD8099 is a ultra low noise (0.95nV/vHz) and distortion (92dBc@10MHz) voltage feedback op-amp. Few op amps have noise or distortion as good as the AD8099, none have the combination making it ideal for 16 and 18 bit systems. Incredibly, this highest performance high-speed op amp uses only 15mA of supply current and contains a disable pin that lowers the power and puts the amplifier output into high impedance. ADI's proprietary 2nd generation XFCB process enables such high performance amplifiers with relatively low power.

Featuring external compensation the AD8099 allows the user to chose the gain bandwidth product that best suites the application. The AD8099 is externally compensated enabling gains from +2 to +10 with minimal trade-off in bandwidth. The AD8099 also features extremely high slew rate of 1600V/us giving the designer the flexibility to use the entire dynamic range without trading off bandwidth and distortion. The AD8099 is a very well behaved amp that settles to 0.002% in 35ns and has fast overload recovery of 50ns.

The AD8099 amplifier offers low power of 15 mA, and is capable of driving 100ohm loads at break through performance levels. With the wide supply voltage range (5V to 12V), low offset voltage (1mV max), wide bandwidth (500MHz for low gains) and a GBWP up to 3GHz; the AD8099 is designed to work in a wide variety of applications.

The AD8099 amplifier is available in tiny lead frame chip-scale packaging (LFCSP) with new standard pin out that is specifically optimized for high performance high-speed amplifiers. The new package and pin out enables the breakthrough performance that previously was not achievable with amplifiers.

The AD8099 is also offered in the industry standard package (8-lead SOIC) with the industry standard pin out. The AD8099 is rated to work over the extended industrial temperature range, -40C to +125C

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## REVISION HISTORY

# SPECIFICATIONS

## SPECIFICATIONS WITH ±5 V SUPPLY

**Table 1. $V_S$ = ±5 V @ $T_A$ = 25°C, G = +2, $C_C$=6.8pF, $C_L$=5pF, $R_L$ = 100Ω to ground, unless otherwise noted**

| Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| DYNAMIC PERFORMANCE | | | | | |
| –3 dB Bandwidth | G =+2, $V_o$= 0.2Vp-p | | 500 | | MHz |
| | G =+2, $V_o$= 2Vp-p | | 70 | | MHz |
| | G =+10, $V_o$= 0.2Vp-p | | 500 | | MHz |
| | G =+10, $V_o$= 2Vp-p | | 70 | | MHz |
| Bandwidth for 0.1 dB Flatness | G = +2, $V_O$ = 0.2 V p-p | | 150 | | MHz |
| Slew Rate | G = +2, $V_O$ = 2 V Step | | 500 | | V/µs |
| Settling Time to 0.1% | G = +2, $V_O$ = 2 V Step | | 12 | | ns |
| Overload recovery Input/Output | | | 50/20 | | ns |
| NOISE/DISTORTION PERFORMANCE | | | | | |
| 2nd/3rd harmonic) | $f_C$ = 1 MHz, $V_O$ = 2 V p-p | | -100/100 | | dBc |
| 2nd/3rd harmonic | $f_C$ = 10 MHz, $V_O$ = 2 V p-p | | -85/87 | | dBc |
| 2nd/3rd harmonic) | $f_C$ = 1 MHz, $V_O$ = 2 V p-p $R_L$ = 500 Ω | | -100/100 | | dBc |
| 2nd/3rd harmonic | $f_C$ = 10 MHz, $V_O$ = 2 V p-p $R_L$ = 500 Ω | | -92/92 | | dBc |
| Input Voltage Noise | f = 100 kHz | | 1 | | nV/√Hz |
| Input Current Noise | f = 100 kHz | | 2.6 | | pA/√Hz |
| Differential Gain Error | NTSC, G = +2, $R_L$ = 150 Ω | | 0.01 | | % |
| Differential Phase Error | NTSC, G = +2, $R_L$ = 150 Ω | | 0.01 | | Degree |
| DC PERFORMANCE | | | | | |
| Input Offset Voltage | | | 0.2 | 1 | mV |
| | $T_{min}$ - $T_{max}$ | | | 1.5 | mV |
| Input Offset Voltage Drift | $T_{MIN}$ to $T_{MAX}$ | | 3 | | µV/°C |
| Input Bias Current[1] | | | 3 | | µA |
| | $T_{MIN}$ to $T_{MAX}$ | | 8 | | µA |
| Input Offset Current | | | | | µA |
| Open-Loop Gain | $V_O$ = +/-2.5 | | 86 | | dB |
| INPUT CHARACTERISTICS | | | | | |
| Common-Mode Input Impedance | | | 1/1.8 | | MΩ/pF |
| Differential Input Impedance | | | 4/2.0 | | MΩ/pF |
| Input Common-Mode Voltage Range | | | -3.6 to 3.6 | | V |
| Common-Mode Rejection Ratio | $V_{CM}$ = +/-2.5 | | 90 | | dB |
| OUTPUT CHARACTERISTICS | | | | | |
| Output Voltage Swing | $R_L$ = 500Ω | | -3.5 to 3.5 | | V |
| Short-Circuit Current | $V_o$ = +/- 3.0 V | | 100 | | mA |
| Capacitive Load Drive | 30% Overshoot | | 35 | | pF |
| POWER SUPPLY | | | | | |
| Operating Range | | 5 | | 12 | V |
| Quiescent Current/Amplifier | | 12 | 15 | 18 | mA |
| Power Supply Rejection Ratio | $V_S$ ± 1 V | | -80 | | dB |

[1] Plus (or no sign) indicates current into pin; minus indicates current out of pin.

## SPECIFICATIONS WITH +5 V SUPPLY

**Table 2. $V_S$ = +5 V @ $T_A$ = 25°C, G = +2, $C_C$=6.8pF, $C_L$=5pF, $R_L$ = 100Ω to ground, unless otherwise noted**

| Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| DYNAMIC PERFORMANCE | | | | | |
| –3 dB Bandwidth | G =+2, $V_o$= 0.2Vp-p | | 500 | | MHz |
| | G =+2, $V_o$= 2Vp-p | | 70 | | MHz |
| | G =+10, $V_o$= 0.2Vp-p | | 500 | | MHz |
| | G =+10, $V_o$= 2Vp-p | | 70 | | MHz |
| Bandwidth for 0.1 dB Flatness | G = +2, $V_O$ = 0.2 V p-p | | 150 | | MHz |
| Slew Rate | G = +2, $V_O$ = 2 V Step | | 500 | | V/μs |
| Settling Time to 0.1% | G = +2, $V_O$ = 2 V Step | | 12 | | ns |
| Overload recovery Input/Output | | | 50/20 | | ns |
| NOISE/DISTORTION PERFORMANCE | | | | | |
| 2nd/3rd harmonic) | $f_C$ = 1 MHz, $V_O$ = 2 V p-p | | -100/100 | | dBc |
| 2nd/3rd harmonic | $f_C$ = 10 MHz, $V_O$ = 2 V p-p | | -85/87 | | dBc |
| 2nd/3rd harmonic) | $f_C$ = 1 MHz, $V_O$ = 2 V p-p $R_L$ = 500 Ω | | -100/100 | | dBc |
| 2nd/3rd harmonic | $f_C$ = 10 MHz, $V_O$ = 2 V p-p $R_L$ = 500 Ω | | -92/92 | | dBc |
| Input Voltage Noise | f = 100 kHz | | 1 | | $nV/\sqrt{Hz}$ |
| Input Current Noise | f = 100 kHz | | 2.6 | | $pA/\sqrt{Hz}$ |
| Differential Gain Error | NTSC, G = +2, $R_L$ = 150 Ω | | 0.01 | | % |
| Differential Phase Error | NTSC, G = +2, $R_L$ = 150 Ω | | 0.01 | | Degree |
| DC PERFORMANCE | | | | | |
| Input Offset Voltage | | | 0.2 | 1 | mV |
| | $T_{min}$ - $T_{max}$ | | | 1.5 | mV |
| Input Offset Voltage Drift | $T_{MIN}$ to $T_{MAX}$ | | 3 | | μV/°C |
| Input Bias Current[1] | | | 3 | | μA |
| | $T_{MIN}$ to $T_{MAX}$ | | 8 | | μA |
| Input Offset Current | | | | | μA |
| Open-Loop Gain | $V_O$ = +/-2.5 | | 86 | | dB |
| INPUT CHARACTERISTICS | | | | | |
| Common-Mode Input Impedance | | | 1/1.8 | | MΩ/pF |
| Differential Input Impedance | | | 4/2.0 | | MΩ/pF |
| Input Common-Mode Voltage Range | | | -3.6 to 3.6 | | V |
| Common-Mode Rejection Ratio | $V_{CM}$ = +/-2.5 | | 90 | | dB |
| OUTPUT CHARACTERISTICS | | | | | |
| Output Voltage Swing | $R_L$ = 500Ω | | -3.5 to 3.5 | | V |
| Short-Circuit Current | $V_o$ = +/- 3.0 V | | 100 | | mA |
| Capacitive Load Drive | 30% Overshoot | | 35 | | pF |
| POWER SUPPLY | | | | | |
| Operating Range | | 5 | | 12 | V |
| Quiescent Current/Amplifier | | 12 | 15 | 18 | mA |
| Power Supply Rejection Ratio | $V_S$ ± 1 V | | -80 | | dB |

[1] Plus (or no sign) indicates current into pin; minus indicates current out of pin.

# TYPICAL PERFORMANCE CHARACTERISTICS

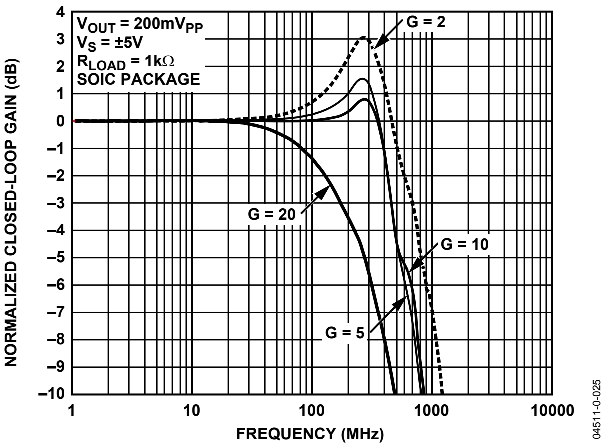


Figure 2. Small Signal Gains vs. Frequency (SOIC)

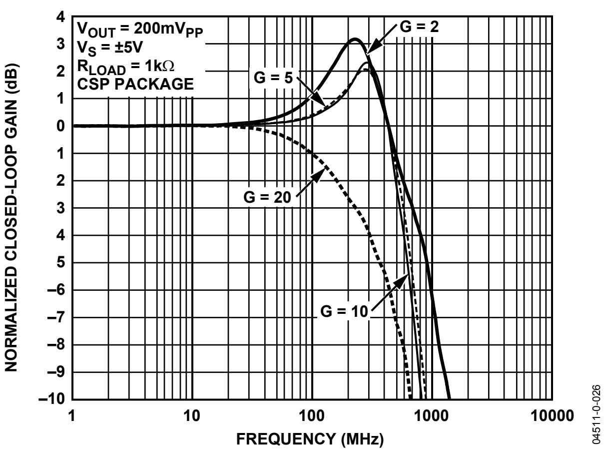


Figure 3. Small Signal Gains vs. Frequency (CSP)

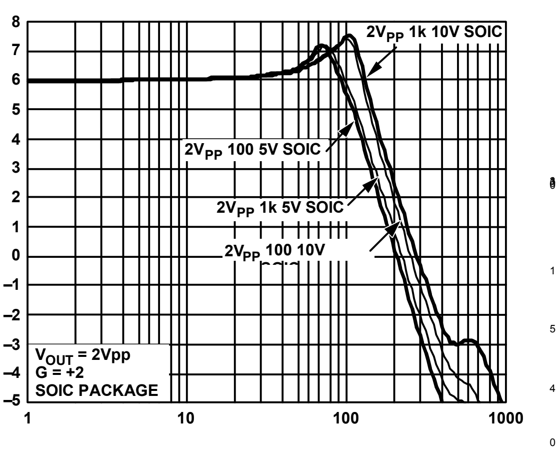


Figure 4 . Large Signal Gain vs. Various Loads and Supplies SOIC

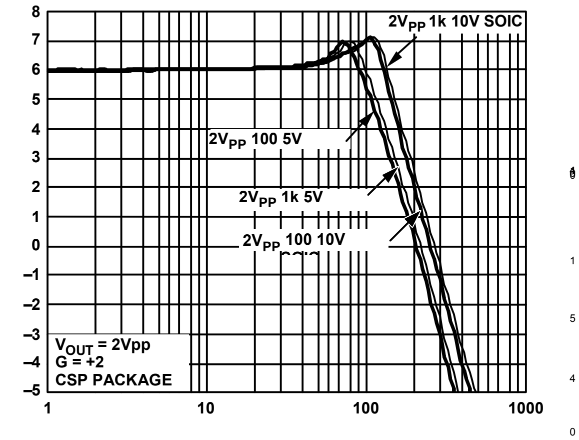


Figure 5. Large Signal Gain vs. Various Loads and Supplies CSP

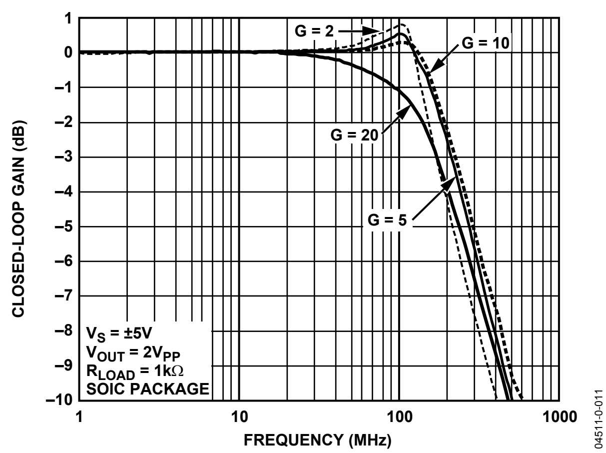


Figure 6. Various Large Signal Gains vs. Frequency SOIC

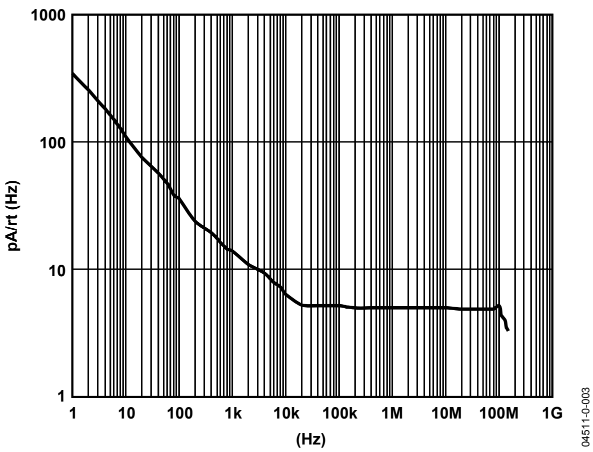


Figure 7 . Input Current Noise vs. Frequency Disable Pin=+Vs

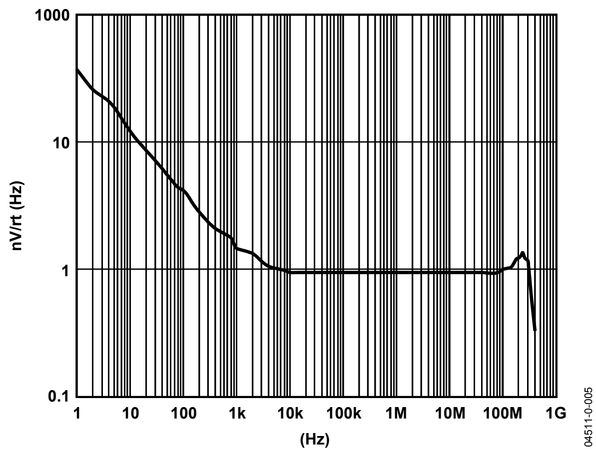


Figure 10. Voltage Noise vs. Frequency

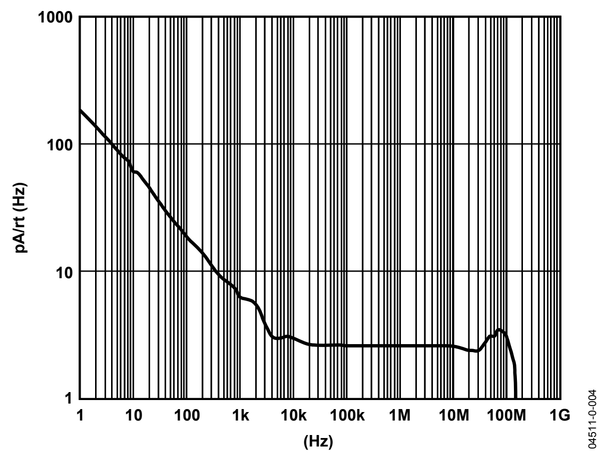


Figure 8. Input Current Noise vs. Frequency, Disable Pin =Open

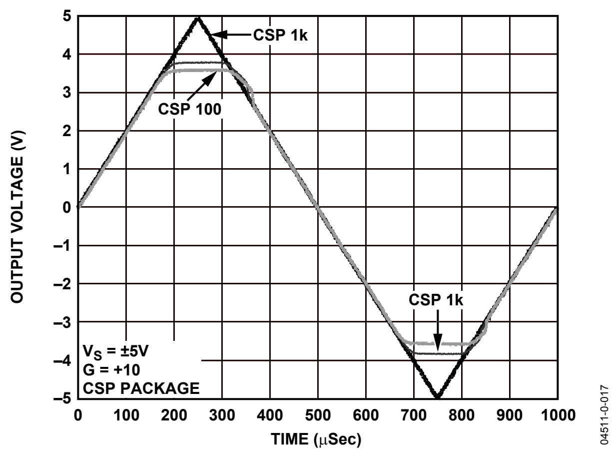


Figure 11. Output Overdrive (CSP)

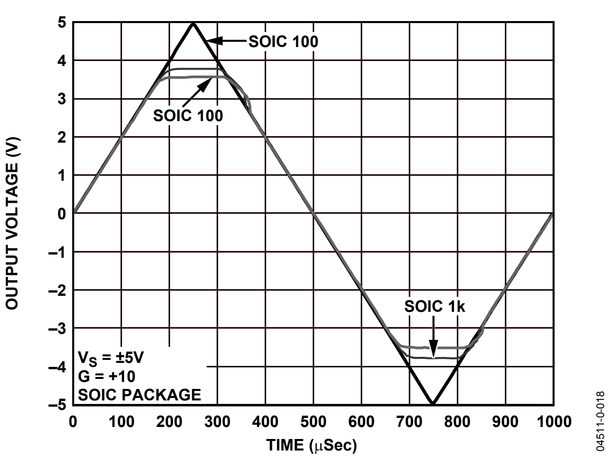


Figure 9. Output Overdrive (SOIC)

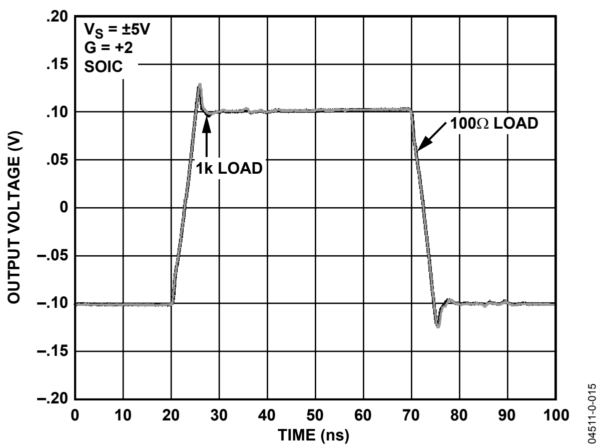


Figure 12 Small Signal Pulse Response vs. Rload

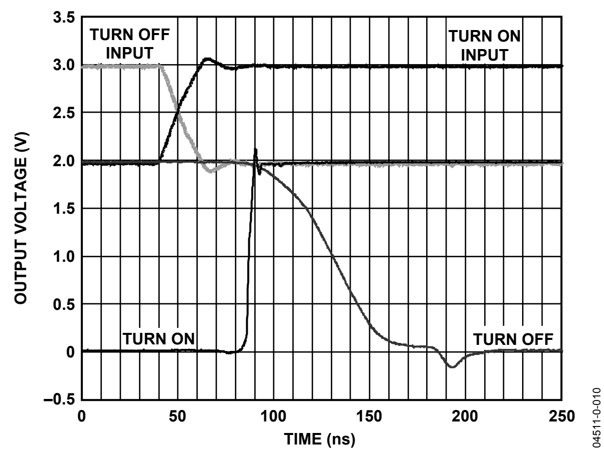


Figure 15. Switching Speed

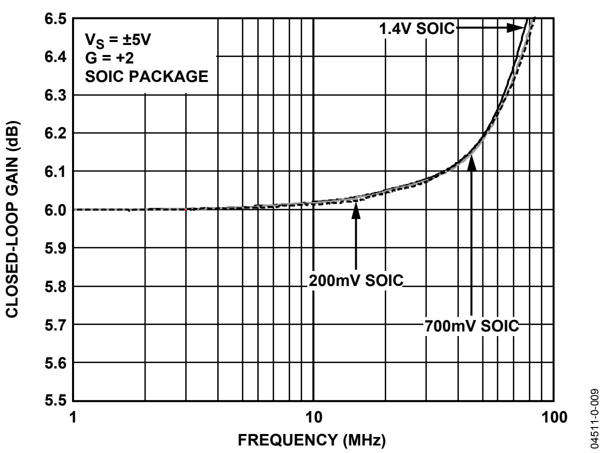


Figure 23. . 0.1dB Flatness (SOIC)

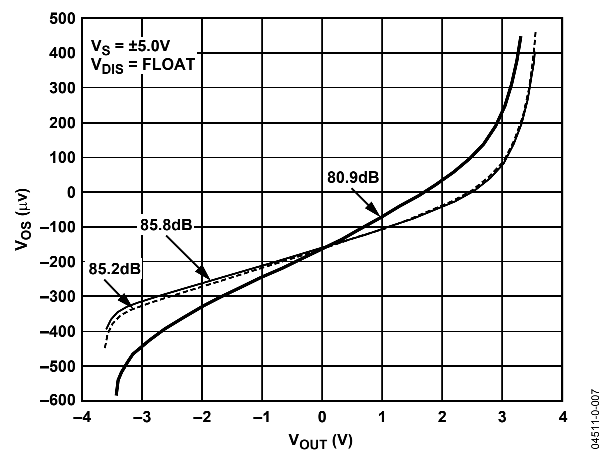


Figure 16. Input Offset Voltage vs. Output Voltage vs. Open Loop Gain

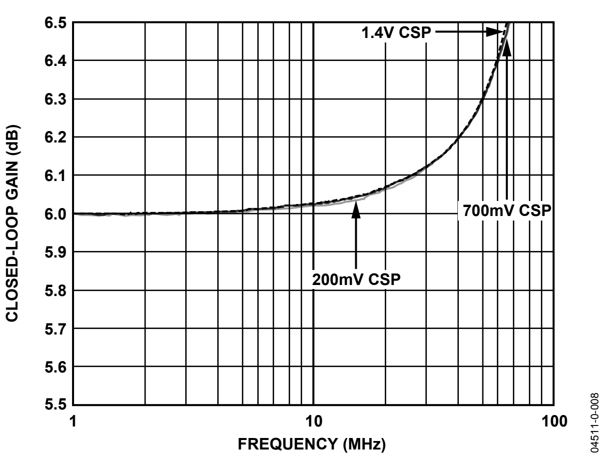


Figure 14. 0.1dB Flatness (CSP)

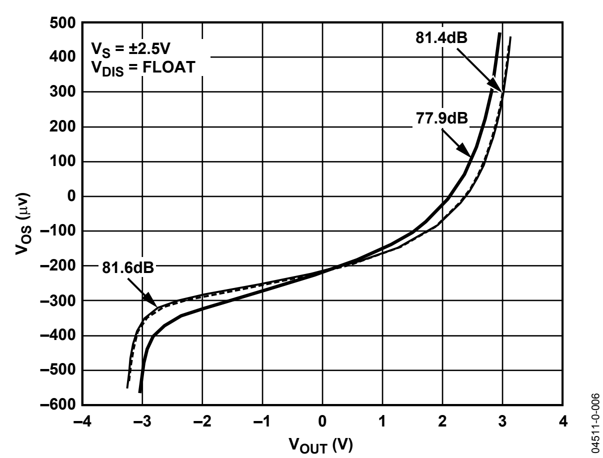


Figure 17 Input Offset Voltage vs. Output Voltage vs. Open Loop Gain

## DESIGN TOOLS AND TECHNICAL SUPPORT

Analog Devices is committed to its customers by providing technical support and online design tools. ADI offers technical support through free evaluation boards, sample ICs, spice models, interactive evaluation tools, application notes, and phone and email support—all available at www.analog.com

## OUTLINE DIMENSIONS

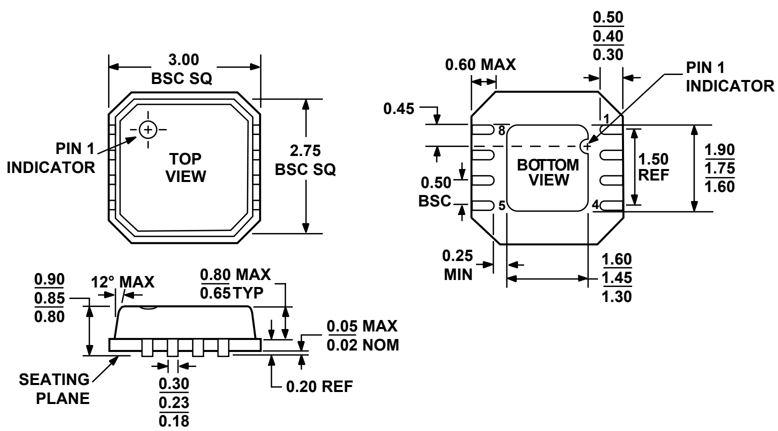


*Figure 3.*

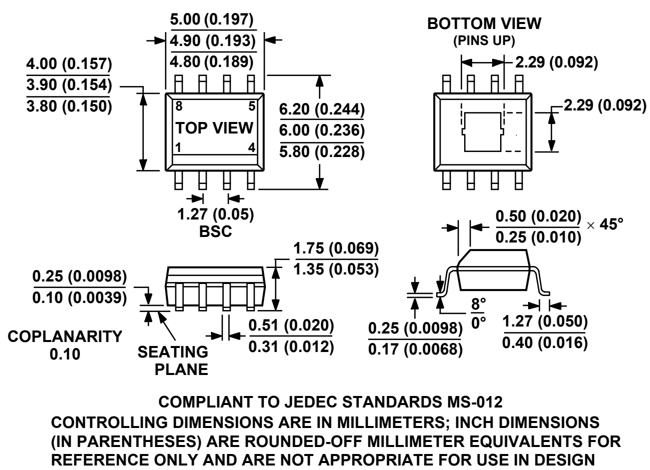


*Figure 4.*

# ORDERING GUIDE

| Model | Minimum Ordering Quantity | Temperature Range | Package Description | Package Option |
|---|---|---|---|---|
| AD8099AR* | 1 | –40°C to +125°C | 8-Lead SOIC | R-8 |
| AD8099AR-REEL* | 2,500 | –40°C to +125°C | 8-Lead SOIC | R-8 |
| AD8099AR-REEL7* | 1,000 | –40°C to +125°C | 8-Lead SOIC | R-8 |
| AD8099CP-R2 | 250 | –40°C to +125°C | 8-Lead CSP | CP-8 |
| AD8099CP-REEL | 5,000 | –40°C to +125°C | 8-Lead CSP | CP-8 |
| AD8099CP-REEL7 | 1,500 | –40°C to +125°C | 8-Lead CSP | CP-8 |

## ESD CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although this product features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.