# Low Power, Rail-to-Rail Output, Precision JFET Amplifiers

Data Sheet

# AD8641/AD8642/AD8643

## FEATURES

**Low supply current: 250 µA max**
**Very low input bias current: 1 pA max**
**Low offset voltage: 750 µV max**
**Single-supply operation: 5 V to 26 V**
**Dual-supply operation: ±2.5 V to ±13 V**
**Rail-to-rail output**
**Unity-gain stable**
**No phase reversal**
**SC70 package**

## APPLICATIONS

**Line-/battery-powered instruments**
**Photodiode amplifiers**
**Precision current sensing**
**Medical instrumentation**
**Industrial controls**
**Precision filters**
**Portable audio**
**ATE**

## GENERAL DESCRIPTION

The AD8641/AD8642/AD8643 are low power, precision JFET input amplifiers featuring extremely low input bias current and rail-to-rail output. The ability to swing nearly rail-to-rail at the input and rail-to-rail at the output enables designers to buffer CMOS DACs, ASICs, and other wide output swing devices in single-supply systems. The outputs remain stable with capacitive loads of more than 500 pF.

The AD8641/AD8642/AD8643 are suitable for applications utilizing multichannel boards that require low power to manage heat. Other applications include photodiodes, ATE reference level drivers, battery management, and industrial controls.

The AD8641/AD8642/AD8643 are fully specified over the extended industrial temperature range of −40°C to +125°C. The AD8641 is available in 5-lead SC70 and 8-lead SOIC lead-free packages. The AD8642 is available in 8-lead MSOP and 8-lead SOIC lead-free packages. The AD8643 is available in 14-lead SOIC and 16-lead, 3 mm × 3 mm, LFCSP lead-free packages.

## PIN CONFIGURATIONS

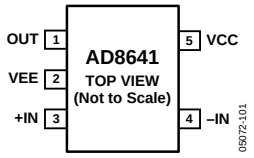



*Figure 1. 5-Lead SC70 (KS-5)*

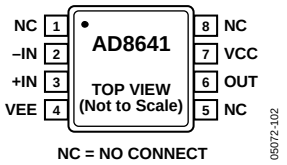



*Figure 2. 8-Lead SOIC (R-8)*

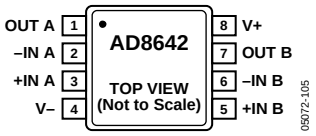



*Figure 3. 8-Lead SOIC (R-8)*

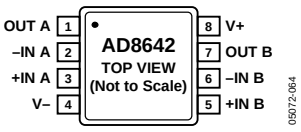



*Figure 4. 8-Lead MSOP (RM-8)*

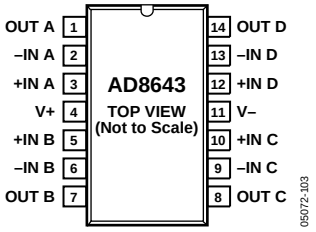
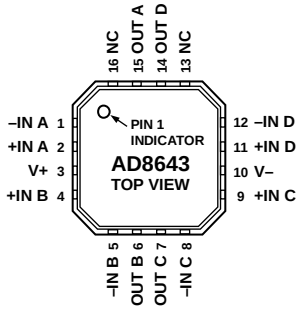



*Figure 5. 14-Lead SOIC (R-14)*




NOTES
1. NC = NO CONNECT.
2. EXPOSED PAD SHOULD BE CONNECTED TO V+.

*Figure 6. 16-Lead LFCSP (CP-16) (Not Drawn to Scale)*

**Rev. E**


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## REVISION HISTORY

**9/11—Rev. D to Rev. E**

Changes to Thermal Resistance Section ... 5

**7/11—Rev. C to Rev. D**

Changes to Figure 6 ... 1

**11/10—Rev. B to Rev. C**

Changes to Figure 6 ... 1
Added Thermal Resistance Section and Table 4 ... 5
Updated Outline Dimensions ... 13
Changes to Ordering Guide ... 15

**4/05—Rev. A to Rev. B**

Added AD8643 ... Universal
Added 14-Lead SOIC ... Universal
Added 16-Lead LFCSP ... Universal
Updated Outline Dimensions ... 13
Changes to Ordering Guide ... 14

**3/05—Rev. 0 to Rev. A**

Added AD8642 ... Universal
Changes to General Description ... 1
Added Figure 3 and Figure 4 ... 1
Changes to Specifications ... 3
Changes to Absolute Maximum Ratings ... 5
Changes to Figure 22 ... 8
Changes to Figure 23 ... 9
Changes to Figure 41 ... 12
Updated Outline Dimensions ... 13
Changes to Ordering Guide ... 14

**10/04—Initial Version: Revision 0**

# SPECIFICATIONS

## ELECTRICAL CHARACTERISTICS

$V_S$ = 5.0 V, $V_{CM}$ = 2.5 V, $T_A$ = 25°C, unless otherwise noted.

**Table 1.**

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| INPUT CHARACTERISTICS | | | | | | |
| Offset Voltage | $V_{OS}$ | | | 50 | 750 | µV |
| | | AD8643 LFCSP only | | | 1 | mV |
| | | –40°C < $T_A$ < +85°C | | | 1.5 | mV |
| | | +85°C < $T_A$ < +125°C, $V_{CM}$ = 1.5 V | | | 1.6 | mV |
| Input Bias Current | $I_B$ | | | 0.25 | 1 | pA |
| | | –40°C < $T_A$ < +125°C | | | 180 | pA |
| Input Offset Current | $I_{OS}$ | | | | 0.5 | pA |
| | | –40°C < $T_A$ < +125°C | | | 60 | pA |
| Input Voltage Range | | | 0 | | 3 | V |
| Common-Mode Rejection Ratio | CMRR | $V_{CM}$ = 0 V to 2.5 V | 74 | 93 | | dB |
| Large Signal Voltage Gain | $A_{VO}$ | $R_L$ = 10 kΩ, $V_O$ = 0.5 to 4.5 V | 80 | 140 | | V/mV |
| Offset Voltage Drift | $\Delta V_{OS}/\Delta T$ | –40°C < $T_A$ < +125°C | | 2.5 | | µV/°C |
| OUTPUT CHARACTERISTICS | | | | | | |
| Output Voltage High | $V_{OH}$ | | 4.95 | | | V |
| | | $I_L$ = 1 mA, –40°C to +125°C | 4.94 | | | V |
| Output Voltage Low | $V_{OL}$ | | | | 0.05 | V |
| | | $I_L$ = 1 mA, –40°C to +125°C | | 0.01 | 0.05 | V |
| Output Current | $I_{OUT}$ | | | ±6 | | mA |
| POWER SUPPLY | | | | | | |
| Power Supply Rejection Ratio | PSRR | $V_S$ = 5 V to 26 V | 90 | 107 | | dB |
| Supply Current/Amplifier | $I_{SY}$ | | | 195 | 250 | µA |
| | | –40°C < $T_A$ < +125°C | | | 270 | µA |
| DYNAMIC PERFORMANCE | | | | | | |
| Slew Rate | SR | | | 2 | | V/µs |
| Gain Bandwidth Product | GBP | AD8641, AD8642 | | 3 | | MHz |
| | | AD8643 | | 2.5 | | MHz |
| Phase Margin | $Ø_m$ | | | 50 | | Degrees |
| NOISE PERFORMANCE | | | | | | |
| Voltage Noise | $e_N$ p-p | f = 0.1 Hz to 10 Hz | | 4.0 | | µV p-p |
| Voltage Noise Density | $e_N$ | f = 1 kHz | | 28.5 | | nV/√Hz |
| Current Noise Density | $i_N$ | f = 1 kHz | | 0.5 | | fA/√Hz |

$V_S$= ±13 V, $V_{CM}$ = 0 V, $T_A$ =25°C, unless otherwise noted.

**Table 2.**

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| INPUT CHARACTERISTICS | | | | | | |
| Offset Voltage | $V_{OS}$ | | | 70 | 750 | µV |
| | | AD8643 LFCSP only | | | 1 | mV |
| | | −40° < $T_A$ < +125°C | | | 1.5 | mV |
| Input Bias Current | $I_B$ | | | 0.25 | 1 | pA |
| | | −40°C < $T_A$ < +125°C | | | 260 | pA |
| Input Offset Current | $I_{OS}$ | | | | 0.5 | pA |
| | | −40°C < $T_A$ < +125°C | | | 65 | pA |
| Input Voltage Range | | | −13 | | +10 | V |
| Common-Mode Rejection Ratio | CMRR | $V_{CM}$ = −13 V to +10 V | 90 | 107 | | dB |
| Large Signal Voltage Gain | $A_{VO}$ | $R_L$ = 10 kΩ, $V_O$ = −11 V to +11 V | 215 | 290 | | V/mV |
| Offset Voltage Drift | $\Delta V_{OS}/\Delta T$ | −40°C < $T_A$ < +125°C | | 2.5 | | µV/°C |
| OUTPUT CHARACTERISTICS | | | | | | |
| Output Voltage High | $V_{OH}$ | | +12.95 | | | V |
| | | $I_L$ = 1 mA, −40°C to +125°C | +12.94 | | | V |
| Output Voltage Low | $V_{OL}$ | | | | −12.95 | V |
| | | $I_L$ = 1 mA, −40°C to +125°C | | | −12.94 | V |
| Output Current | $I_{OUT}$ | | | ±12 | | mA |
| POWER SUPPLY | | | | | | |
| Power Supply Rejection Ratio | PSRR | $V_S$ = ±2.5 V to ±13 V | 90 | 107 | | dB |
| Supply Current/Amplifier | $I_{SY}$ | | | 200 | 290 | µA |
| | | −40°C < $T_A$ < +125°C | | | 330 | µA |
| DYNAMIC PERFORMANCE | | | | | | |
| Slew Rate | SR | | | 3 | | V/µs |
| Gain Bandwidth Product | GBP | | | 3.5 | | MHz |
| Phase Margin | $Ø_m$ | | | 60 | | Degrees |
| NOISE PERFORMANCE | | | | | | |
| Voltage Noise | $e_N$ p-p | f = 0.1 Hz to 10 Hz | | 4.2 | | µV p-p |
| Voltage Noise Density | $e_N$ | f = 1 kHz | | 27.5 | | nV/√Hz |
| Current Noise Density | $i_N$ | f = 1 kHz | | 0.5 | | fA/√Hz |

# ABSOLUTE MAXIMUM RATINGS

Absolute maximum ratings apply at 25°C, unless otherwise noted.

**Table 3.**

| Parameter | Rating |
|---|---|
| Supply Voltage | 27.3 V |
| Input Voltage | VS– to VS+ |
| Differential Input Voltage | ±Supply Voltage |
| Output Short-Circuit Duration | Indefinite |
| Storage Temperature Range | |
| KS-5, R-8, RM-8, R-14, CP-16 Packages | −65°C to +150°C |
| Operating Temperature Range | −40°C to +125°C |
| Junction Temperature Range | |
| KS-5, R-8, RM-8, R-14, CP-16 Packages | −65°C to +150°C |
| Lead Temperature (Soldering, 60 sec) | 300°C |

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 RESISTANCE

$\theta_{JA}$ is specified for the worst-case conditions, that is, a device soldered in a circuit board for surface-mount packages. This was measured using a standard 4-layer board. For the LFCSP package, solder the exposed pad to a copper plane, which should be connected to V+.

**Table 4.**

| Package Type | $\theta_{JA}$ | $\theta_{JC}$ | Unit |
|---|---|---|---|
| 5-Lead SC70 (KS) | 430 | 149 | °C/W |
| 8-Lead SOIC (R) | 121 | 43 | °C/W |
| 8-Lead MSOP (RM) | 142 | 45 | °C/W |
| 14-Lead SOIC (R) | 110 | 36 | °C/W |
| 16-Lead LFCSP (CP) | 81 | 16 | °C/W |

## 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.

# TYPICAL PERFORMANCE CHARACTERISTICS

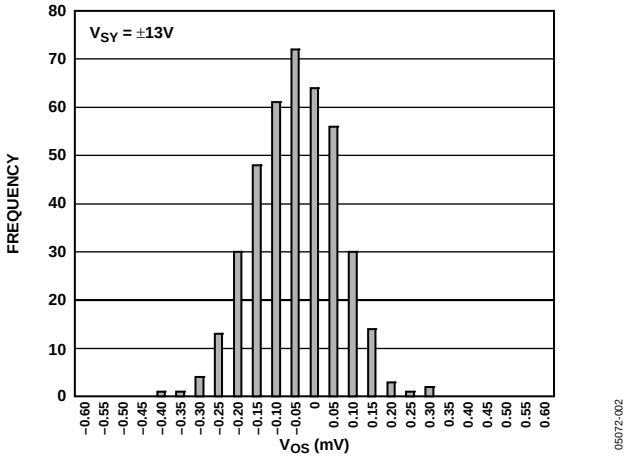



Figure 7. Input Offset Voltage

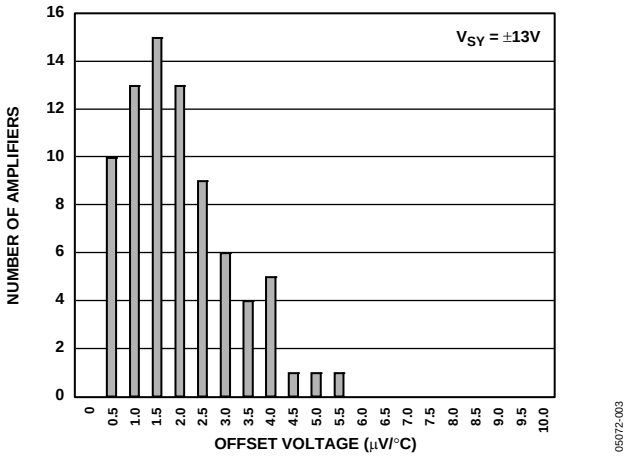



Figure 8. Offset Voltage Drift

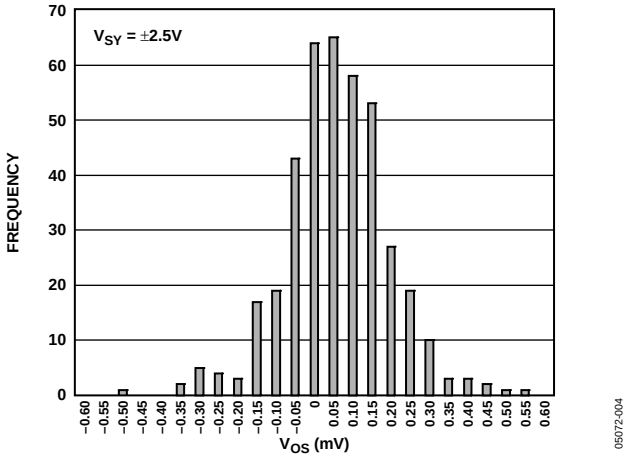



Figure 9. Input Offset Voltage

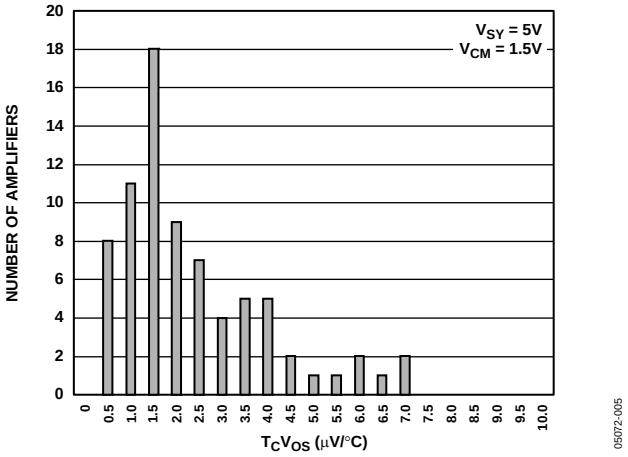



Figure 10. Offset Voltage Drift

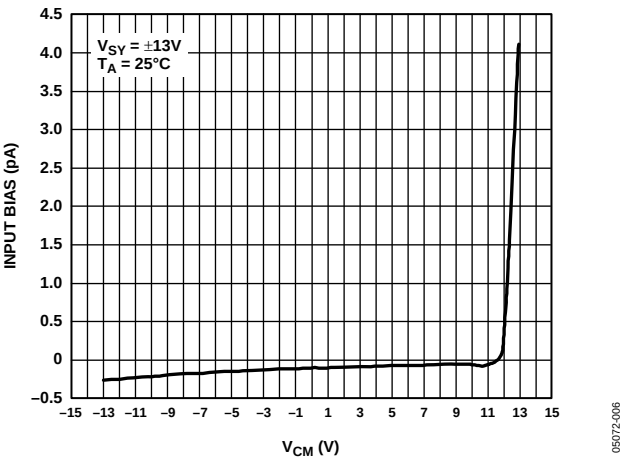



Figure 11. Input Bias Current vs. $V_{CM}$

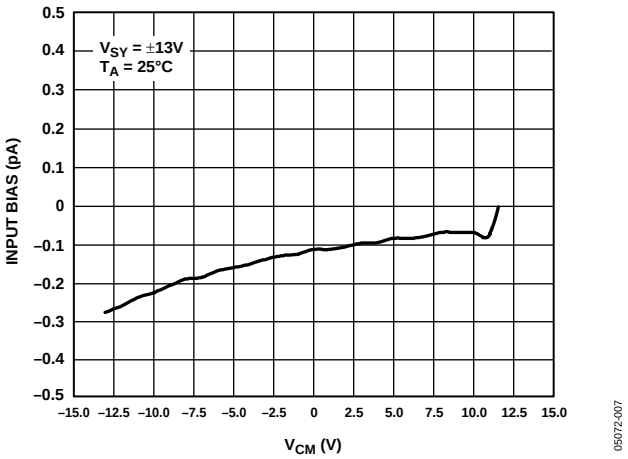



Figure 12. Input Bias Current vs. $V_{CM}$

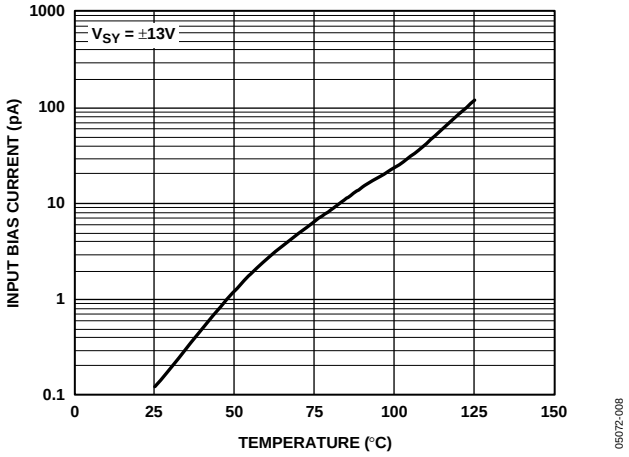



Figure 13. Input Bias Current vs. Temperature

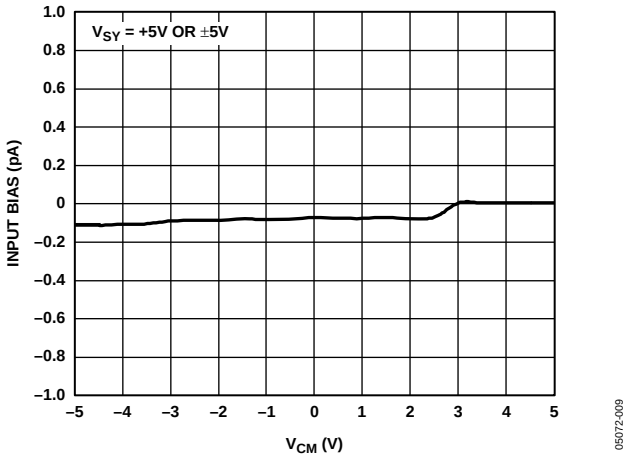



Figure 14. Input Bias Current vs. $V_{CM}$

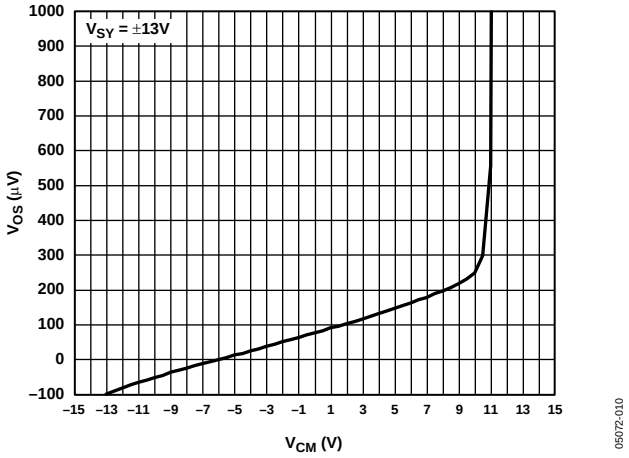



Figure 15. Input Offset Voltage vs. $V_{CM}$

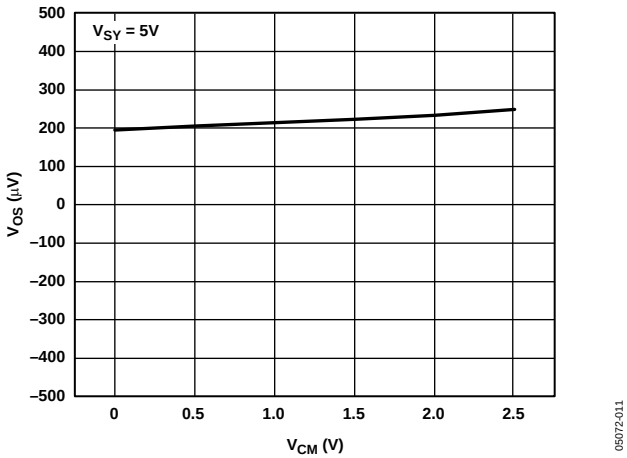



Figure 16. Input Offset Voltage vs. $V_{CM}$

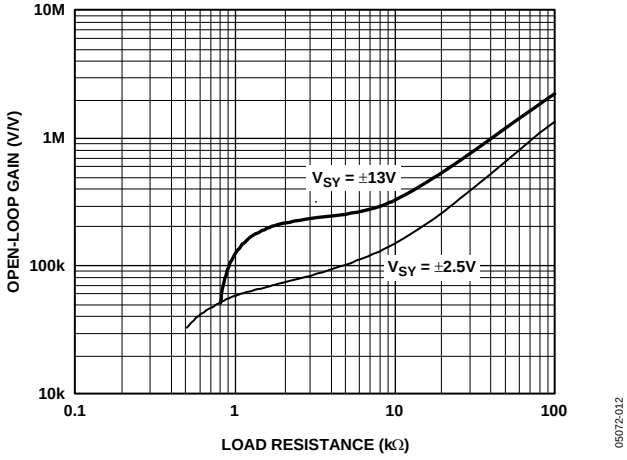



Figure 17. Open-Loop Gain vs. Load Resistance

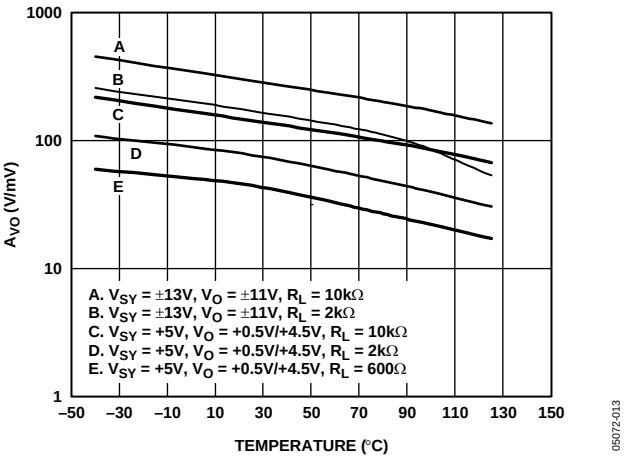



Figure 18. Open-Loop Gain vs. Temperature

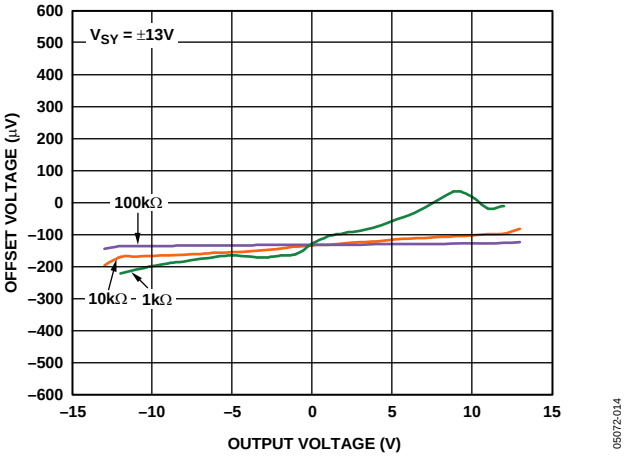



Figure 19. Input Error Voltage vs. Output Voltage for Resistive Loads

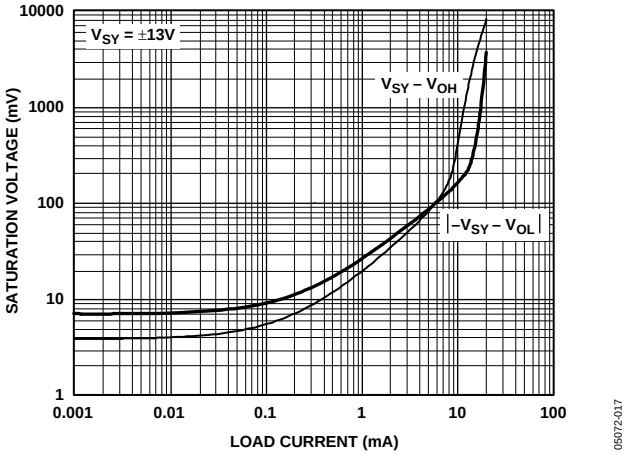



Figure 22. Output Saturation Voltage vs. Load Current

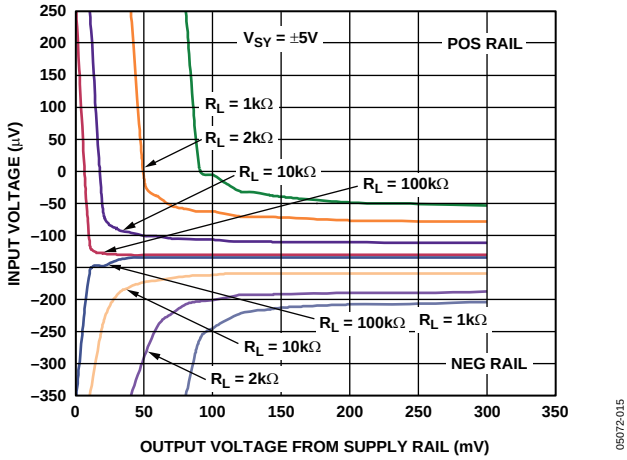



Figure 20. Input Error Voltage vs. Output Voltage Within 300 mV of Supply Rails

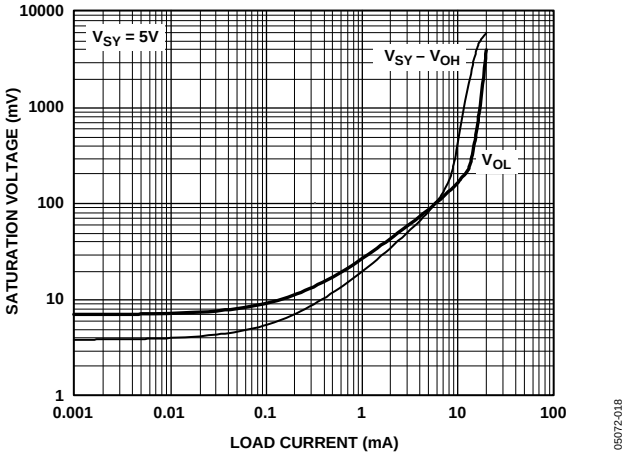



Figure 23. Output Saturation Voltage vs. Load Current

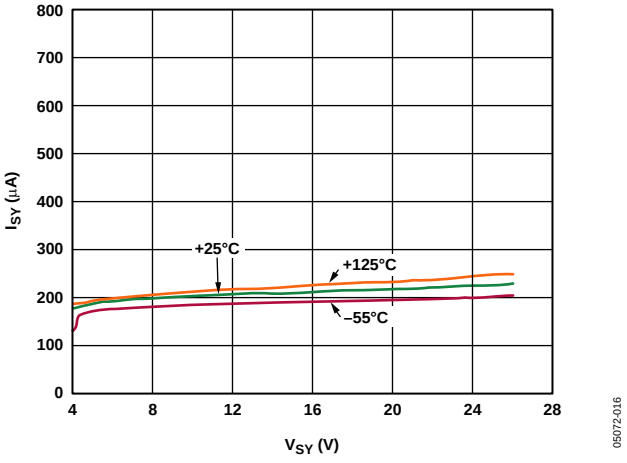



Figure 21. Quiescent Current vs. Supply Voltage at Different Temperatures

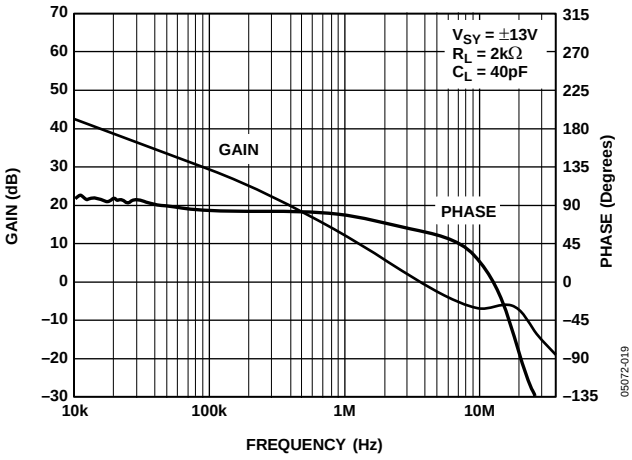



Figure 24. Open-Loop Gain and Phase Margin vs. Frequency

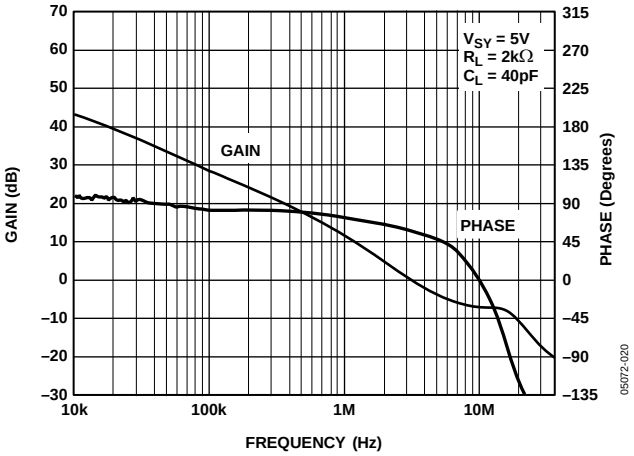



Figure 25. Open-Loop Gain and Phase Margin vs. Frequency

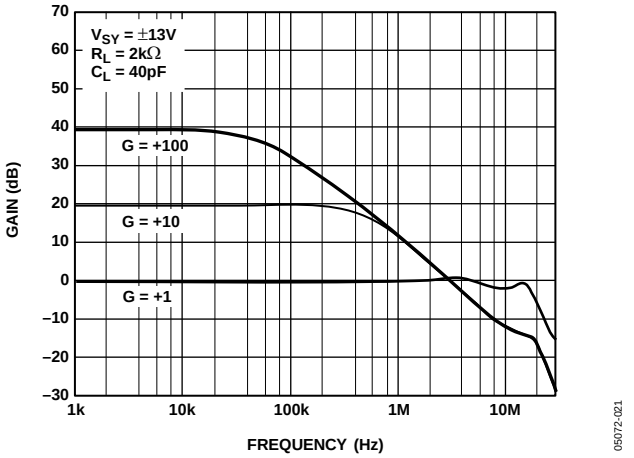



Figure 26. Closed-Loop Gain vs. Frequency

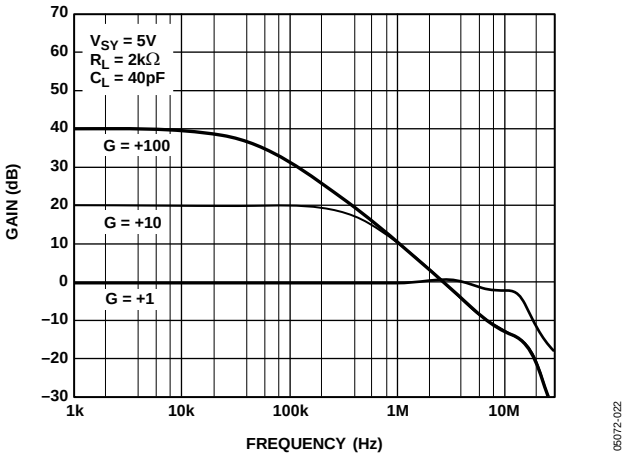



Figure 27. Closed-Loop Gain vs. Frequency

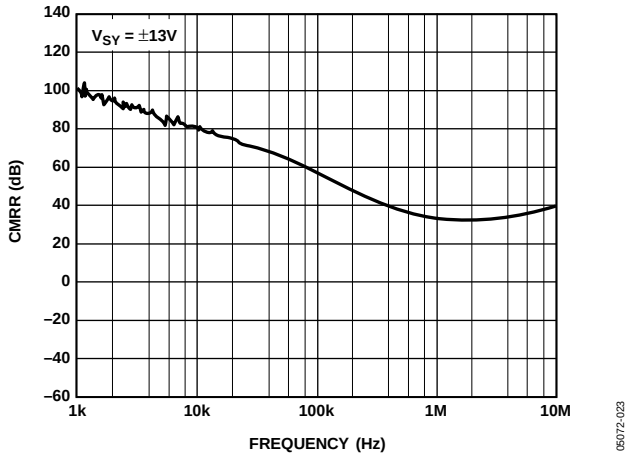



Figure 28. CMRR vs. Frequency

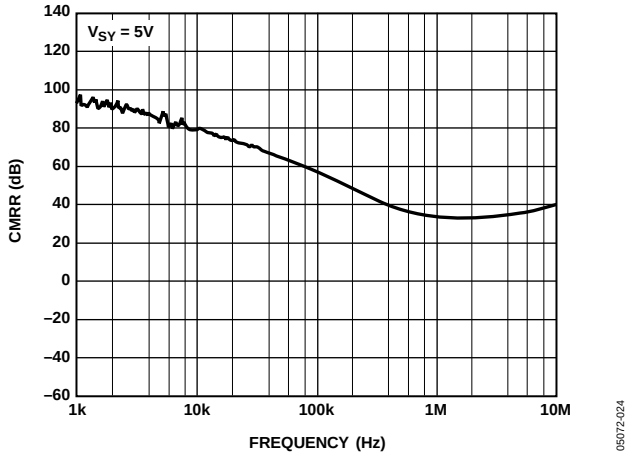



Figure 29. CMRR vs. Frequency

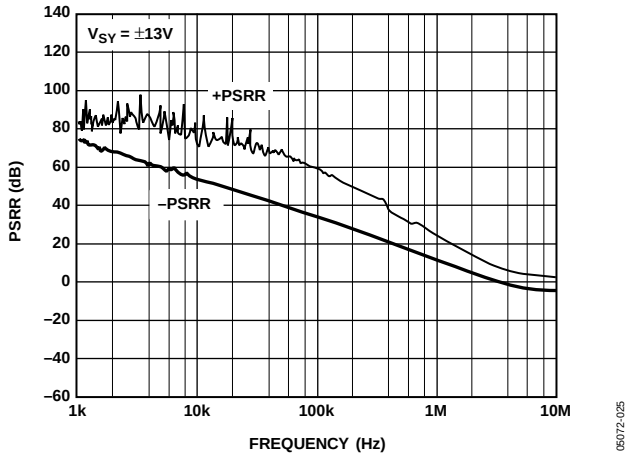



Figure 30. PSRR vs. Frequency

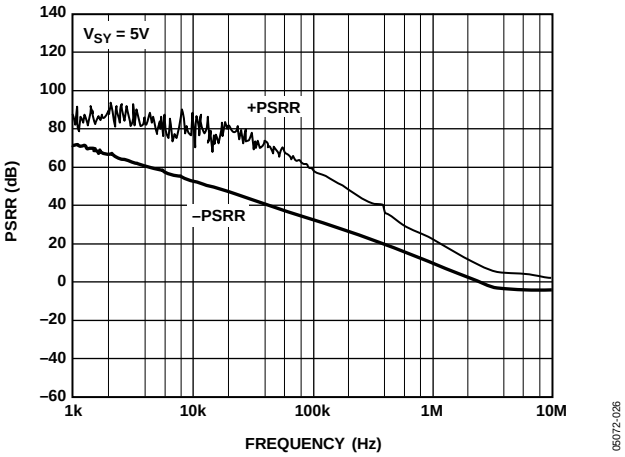



Figure 31. PSRR vs. Frequency

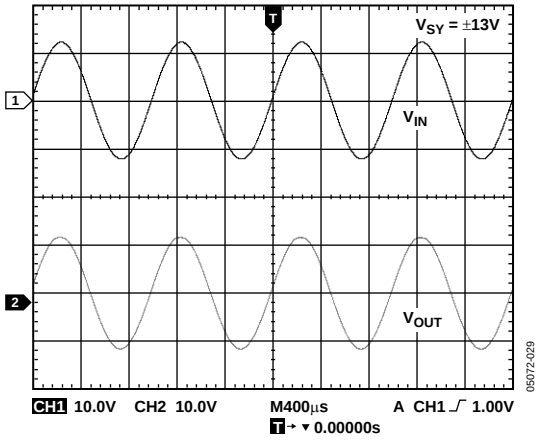



Figure 34. No Phase Reversal

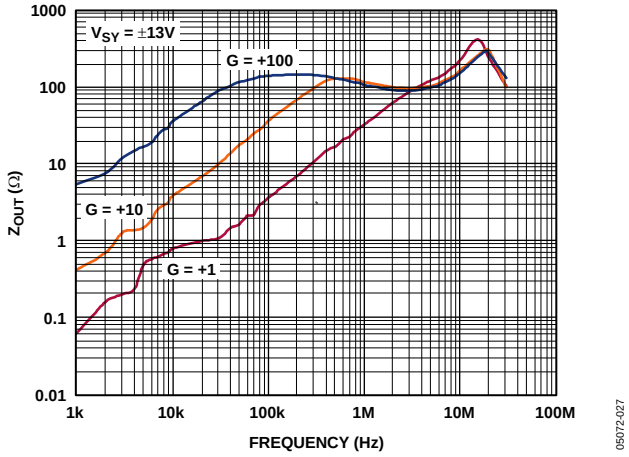



Figure 32. Output Impedance vs. Frequency

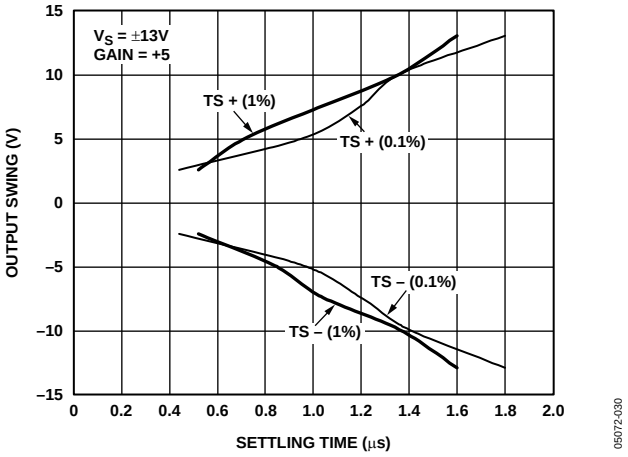



Figure 35. Output Swing and Error vs. Settling Time

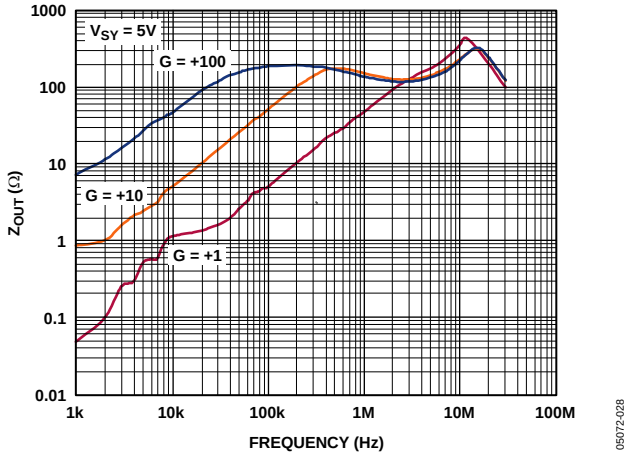



Figure 33. Output Impedance vs. Frequency

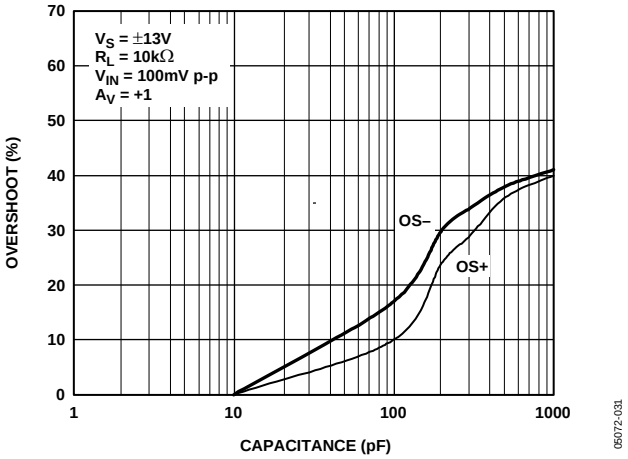



Figure 36. Small Signal Overshoot vs. Load Capacitance

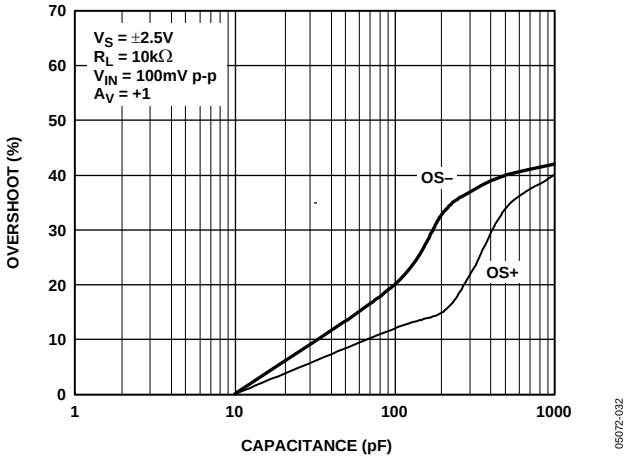



Figure 37. Small Signal Overshoot vs. Load Capacitance

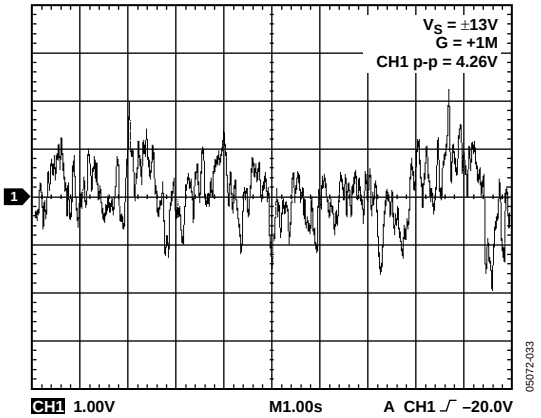



Figure 38. 0.1 Hz to 10 Hz Noise

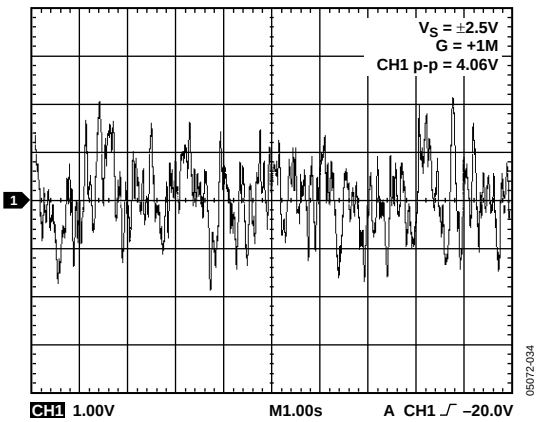



Figure 39. 0.1 Hz to 10 Hz Noise

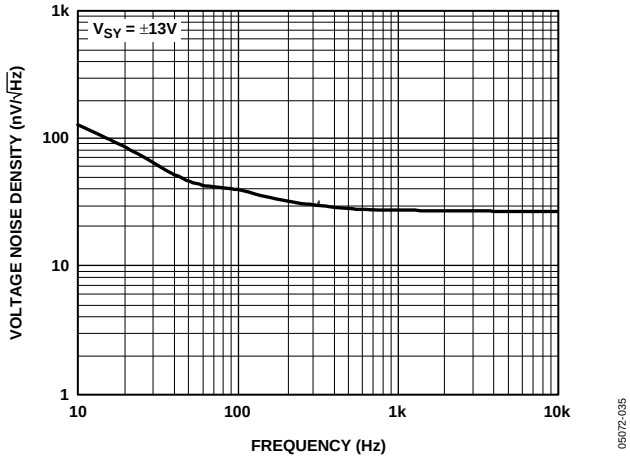



Figure 40. Voltage Noise Density

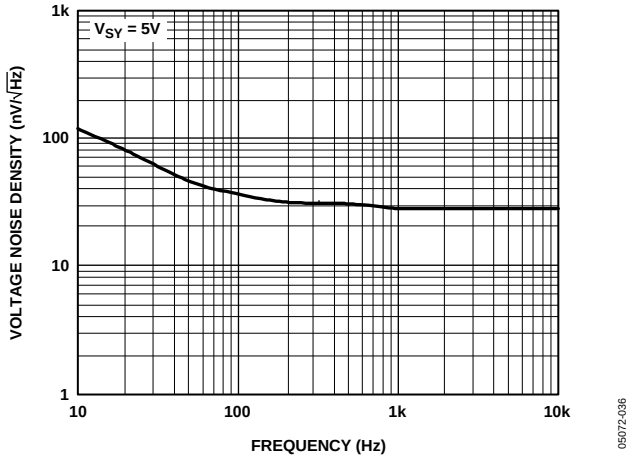



Figure 41. Voltage Noise Density

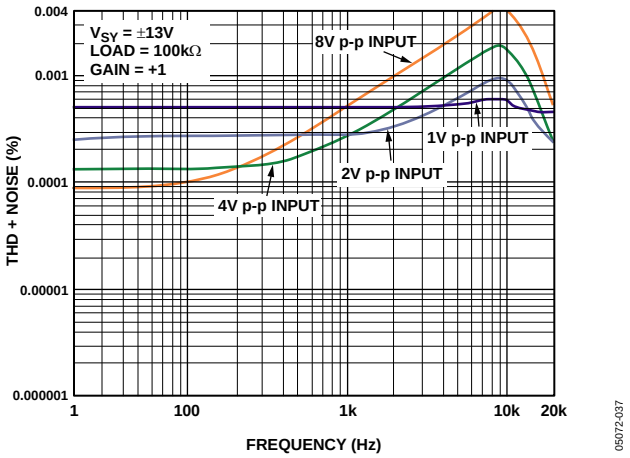



Figure 42. Total Harmonic Distortion + Noise vs. Frequency

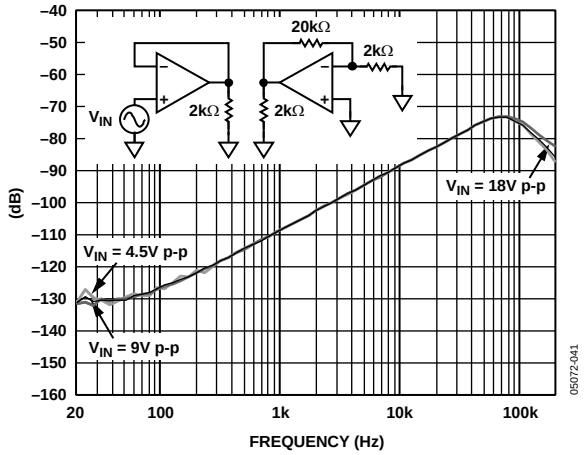
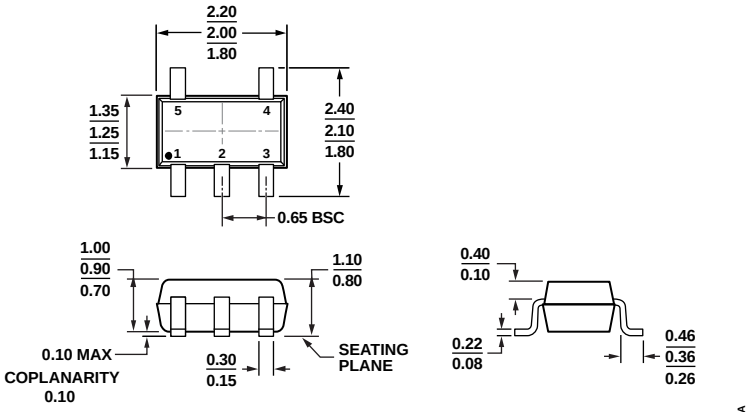


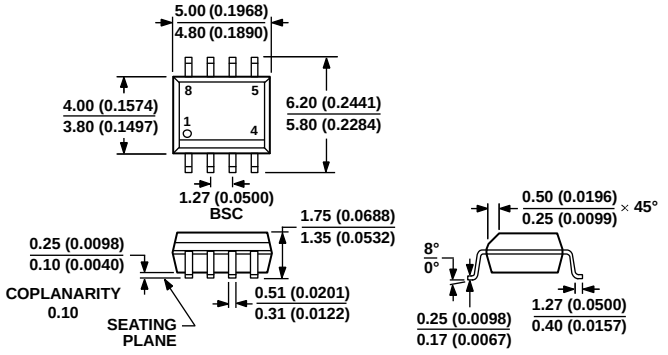

*Figure 43. Channel Separation*

# OUTLINE DIMENSIONS



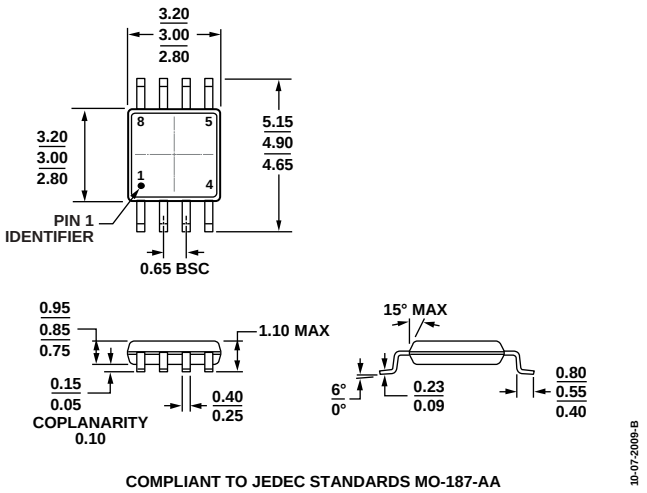

**COMPLIANT TO JEDEC STANDARDS MO-203-AA**

*Figure 44. 5-Lead Thin Shrink Small Outline Transistor Package [SC70]*
*(KS-5)*
*Dimensions shown in millimeters*



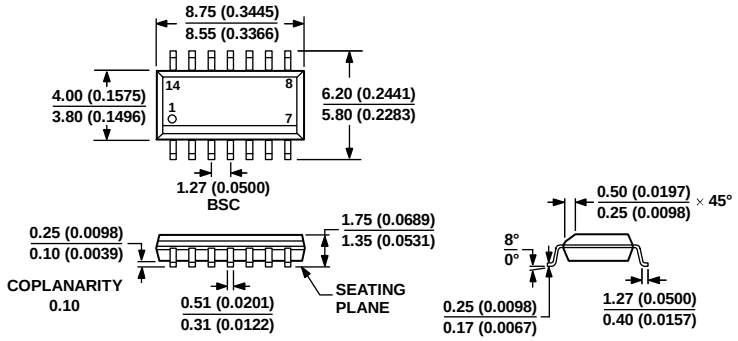

**COMPLIANT TO JEDEC STANDARDS MS-012-AA**
**CONTROLLING DIMENSIONS ARE IN MILLIMETERS; INCH DIMENSIONS (IN PARENTHESES) ARE ROUNDED-OFF MILLIMETER EQUIVALENTS FOR REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN.**

*Figure 45. 8-Lead Standard Small Outline Package [SOIC_N]*
*(R-8)*
*Dimensions shown in millimeters and (inches)*



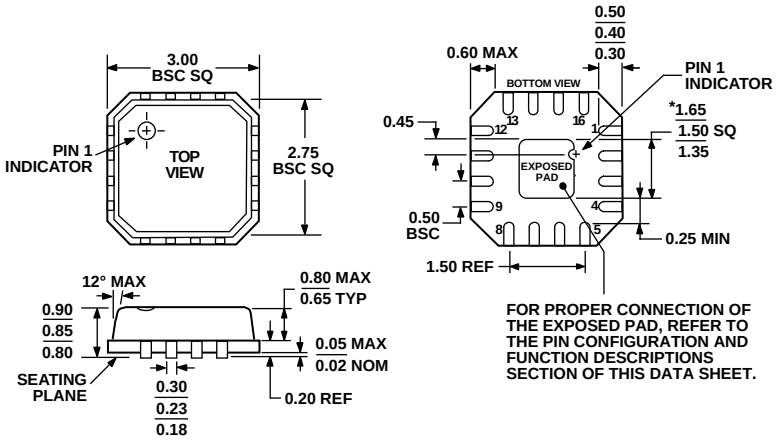

COMPLIANT TO JEDEC STANDARDS MO-187-AA

*Figure 46. 8-Lead Mini Small Outline Package [MSOP]*
*(RM-8)*
*Dimensions shown in millimeters*




COMPLIANT TO JEDEC STANDARDS MS-012-AB
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.

*Figure 47. 14-Lead Standard Small Outline Package [SOIC_N]*
*(R-14)*
*Dimensions shown in millimeters and (inches)*




*COMPLIANT TO JEDEC STANDARDS MO-220-VEED-2 EXCEPT FOR EXPOSED PAD DIMENSION.

*Figure 48. 16-Lead Lead Frame Chip Scale Package [LFCSP_VQ]*
*3 mm × 3 mm Body, Very Thin Quad (CP-16-3)*
*Dimensions shown in millimeters*

## ORDERING GUIDE

| Model[1] | Temperature Range | Package Description | Package Option | Branding |
|---|---|---|---|---|
| AD8641AKSZ-R2 | −40°C to +125°C | 5-Lead SC70 | KS-5 | A07 |
| AD8641AKSZ-REEL7 | −40°C to +125°C | 5-Lead SC70 | KS-5 | A07 |
| AD8641AKSZ-REEL | −40°C to +125°C | 5-Lead SC70 | KS-5 | A07 |
| AD8641ARZ | −40°C to +125°C | 8-lead SOIC_N | R-8 | |
| AD8641ARZ-REEL7 | −40°C to +125°C | 8-lead SOIC_N | R-8 | |
| AD8641ARZ-REEL | −40°C to +125°C | 8-lead SOIC_N | R-8 | |
| AD8642ARMZ | −40°C to +125°C | 8-lead MSOP | RM-8 | A0A |
| AD8642ARMZ-REEL | −40°C to +125°C | 8-lead MSOP | RM-8 | A0A |
| AD8642ARZ | −40°C to +125°C | 8-lead SOIC_N | R-8 | |
| AD8642ARZ-REEL7 | −40°C to +125°C | 8-lead SOIC_N | R-8 | |
| AD8642ARZ-REEL | −40°C to +125°C | 8-lead SOIC_N | R-8 | |
| AD8643ARZ | −40°C to +125°C | 14-lead SOIC_N | R-14 | |
| AD8643ARZ-REEL7 | −40°C to +125°C | 14-lead SOIC_N | R-14 | |
| AD8643ARZ-REEL | −40°C to +125°C | 14-lead SOIC_N | R-14 | |
| AD8643ACPZ-R2 | −40°C to +125°C | 16-Lead LFCSP_VQ | CP-16-3 | AUA |
| AD8643ACPZ-REEL7 | −40°C to +125°C | 16-Lead LFCSP_VQ | CP-16-3 | AUA |
| AD8643ACPZ-REEL | −40°C to +125°C | 16-Lead LFCSP_VQ | CP-16-3 | AUA |

[1] Z = RoHS Compliant Part.

## NOTES

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