

AD8691/AD8692/AD8694

FEATURES

- Offset voltage: 400 μV typ
- Low offset voltage drift: 6 $\mu\text{V}/^\circ\text{C}$ max (AD8692/AD8694)
- Very low input bias currents: 1 pA max
- Low noise: 8 nV/ $\sqrt{\text{Hz}}$
- Low distortion: 0.0006%
- Wide bandwidth: 10 MHz
- Unity-gain stable
- Single-supply operation: 2.7 V to 6 V

APPLICATIONS

- Photodiode amplification
- Battery-powered instrumentation
- Medical instruments
- Multipole filters
- Sensors
- Portable audio devices

GENERAL DESCRIPTION

The AD8691, AD8692, and AD8694 are low cost, single, dual, and quad rail-to-rail output, single-supply amplifiers featuring low offset and input voltages, low current noise, and wide signal bandwidth. The combination of low offset, low noise, very low input bias currents, and high speed make these amplifiers useful in a wide variety of applications. Filters, integrators, photodiode amplifiers, and high impedance sensors all benefit from this combination of performance features. Audio and other ac applications benefit from the wide bandwidth and low distortion of these devices.

Rev. B

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PIN CONFIGURATIONS

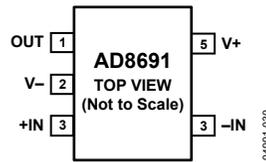


Figure 1. 5-Lead TSOT

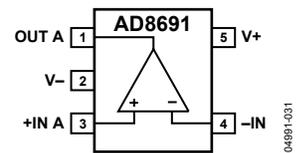


Figure 2. 5-Lead SC70



Figure 3. 8-Lead MSOP



Figure 4. 8-Lead SOIC

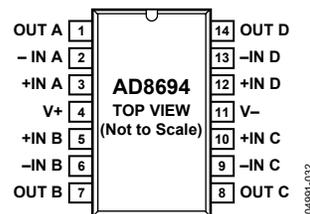


Figure 5. 14-Lead SOIC

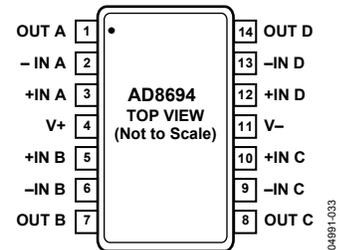


Figure 6. 14-Lead TSSOP

Applications for these amplifiers include PA controls, laser diode control loops, portable and loop-powered instrumentation, audio amplification for portable devices, and ASIC input and output amplifiers.

The small SC70 and TSOT package options for the AD8691 allow it to be placed next to sensors, thereby reducing external noise pickup.

The AD8691, AD8692, and AD8694 are specified over the extended industrial temperature range of -40°C to $+125^\circ\text{C}$. The AD8691 single is available in 5-lead SC70 and TSOT packages. The AD8692 dual is available in 8-lead MSOP and narrow SOIC surface-mount packages. The AD8694 quad is available in 14-lead TSSOP and narrow 14-lead SOIC packages.

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REVISION HISTORY

3/05—Rev. A to Rev. B

Added AD8694 Universal

1/05—Rev. 0 to Rev. A

Added AD8691 Universal
Changes to Features..... 1
Added Figure 1 and Figure 2..... 1
Changes to Electrical Characteristics 3
Changes to Figure 6 caption..... 6
Changes to Figure 9..... 6
Updated Outline Dimensions 11
Changes to Ordering Guide 11

10/04—Revision 0: Initial Version

ELECTRICAL CHARACTERISTICS

$V_S = 2.7\text{ V}$, $V_{CM} = V_S/2$, $T_A = 25^\circ\text{C}$, unless otherwise noted.

Table 1.

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|-----------------------------------|--------------------------|--|------|----------|------|------------------------------|
| INPUT CHARACTERISTICS | | | | | | |
| Offset Voltage | V_{OS} | $V_{CM} = -0.3\text{ V to } +1.6\text{ V}$ $V_{CM} = -0.1\text{ V to } +1.6\text{ V}; -40^\circ\text{C} < T_A < +125^\circ\text{C}$ | | 0.4 | 2.0 | mV |
| Input Bias Current | I_B | $-40^\circ\text{C} < T_A < +85^\circ\text{C}$ $-40^\circ\text{C} < T_A < +125^\circ\text{C}$ | | 0.2 | 1 | pA |
| Input Offset Current | I_{OS} | $-40^\circ\text{C} < T_A < +85^\circ\text{C}$ $-40^\circ\text{C} < T_A < +125^\circ\text{C}$ | | 0.1 | 0.5 | pA |
| Input Voltage Range | | | -0.3 | | +1.6 | V |
| Common-Mode Rejection Ratio | CMRR | $V_{CM} = -0.3\text{ V to } +1.6\text{ V}$ $V_{CM} = -0.1\text{ V to } +1.6\text{ V}; -40^\circ\text{C} < T_A < +125^\circ\text{C}$ | 68 | 90 | | dB |
| Large Signal Voltage Gain | A_{VO} | $R_L = 2\text{ k}\Omega$, $V_O = 0.5\text{ V to } 2.2\text{ V}$ $R_L = 2\text{ k}\Omega$, $V_O = 0.5\text{ V to } 2.2\text{ V}$ | 90 | 250 | | V/mV |
| Offset Voltage Drift | $\Delta V_{OS}/\Delta T$ | | | 2 | 12 | $\mu\text{V}/^\circ\text{C}$ |
| | | | | 1.3 | 6 | $\mu\text{V}/^\circ\text{C}$ |
| INPUT CAPACITANCE | | | | | | |
| Common-Mode Input Capacitance | C_{CM} | | | 5 | | pF |
| Differential Input Capacitance | C_{DM} | | | 2.5 | | pF |
| OUTPUT CHARACTERISTICS | | | | | | |
| Output Voltage High | V_{OH} | $I_L = 1\text{ mA}$ $-40^\circ\text{C} < T_A < +125^\circ\text{C}$ | 2.64 | 2.66 | | V |
| Output Voltage Low | V_{OL} | $I_L = 1\text{ mA}$ $-40^\circ\text{C} < T_A < +125^\circ\text{C}$ | 2.6 | | | V |
| Short-Circuit Current | I_{SC} | | | 25 | 40 | mV |
| Closed-Loop Output Impedance | Z_{OUT} | $f = 1\text{ MHz}$, $A_V = 1$ | | | 60 | mV |
| | | | | ± 20 | | mA |
| | | | | 12 | | Ω |
| POWER SUPPLY | | | | | | |
| Power Supply Rejection Ratio | PSRR | $V_S = 2.7\text{ V to } 5.5\text{ V}$ $-40^\circ\text{C} < T_A < +125^\circ\text{C}$ | 80 | 95 | | dB |
| Supply Current/Amplifier | I_{SY} | $V_O = 0\text{ V}$ $-40^\circ\text{C} < T_A < +125^\circ\text{C}$ | 75 | 95 | | dB |
| | | | | 0.85 | 0.95 | mA |
| | | | | | 1.2 | mA |
| DYNAMIC PERFORMANCE | | | | | | |
| Slew Rate | SR | $R_L = 2\text{ k}\Omega$ | | 5 | | V/ μs |
| Settling Time | t_S | To 0.01% | | 1 | | μs |
| Gain Bandwidth Product | GBP | | | 10 | | MHz |
| Phase Margin | ϕ_O | | | 60 | | Degrees |
| Total Harmonic Distortion + Noise | THD + N | $G = 1$, $R_L = 600\ \Omega$, $f = 1\text{ kHz}$, $V_O = 250\text{ mV p-p}$ | | 0.003 | | % |
| NOISE PERFORMANCE | | | | | | |
| Voltage Noise | $e_{n\text{ p-p}}$ | $f = 0.1\text{ Hz to } 10\text{ Hz}$ | | 1.6 | 3.0 | $\mu\text{V p-p}$ |
| Voltage Noise Density | e_n | $f = 1\text{ kHz}$ | | 8 | 12 | nV/ $\sqrt{\text{Hz}}$ |
| | e_n | $f = 10\text{ kHz}$ | | 6.5 | | nV/ $\sqrt{\text{Hz}}$ |
| Current Noise Density | i_n | $f = 1\text{ kHz}$ | | 0.05 | | pA/ $\sqrt{\text{Hz}}$ |

AD8691/AD8692/AD8694

$V_S = 5.0\text{ V}$, $V_{CM} = V_S/2$, $T_A = 5^\circ\text{C}$, unless otherwise noted.

Table 2.

| Parameter | Symbol | Conditions | A Grade | | | Unit |
|-----------------------------------|--------------------------|--|---------|----------|------|------------------------------|
| | | | Min | Typ | Max | |
| INPUT CHARACTERISTICS | | | | | | |
| Offset Voltage | V_{OS} | $V_{CM} = -0.3\text{ V to }+3.9\text{ V}$ $V_{CM} = -0.1\text{ V to }+3.9\text{ V}; -40^\circ\text{C} < T_A < +125^\circ\text{C}$ | | 0.4 | 2.0 | mV |
| Input Bias Current | I_B | $-40^\circ\text{C} < T_A < +85^\circ\text{C}$ $-40^\circ\text{C} < T_A < +125^\circ\text{C}$ | | 0.2 | 1 | pA |
| Input Offset Current | I_{OS} | $-40^\circ\text{C} < T_A < +85^\circ\text{C}$ $-40^\circ\text{C} < T_A < +125^\circ\text{C}$ | | 0.1 | 0.5 | pA |
| Input Voltage Range | | | -0.3 | | +3.9 | V |
| Common-Mode Rejection Ratio | CMRR | $V_{CM} = -0.3\text{ V to }+3.9\text{ V}$ $V_{CM} = -0.1\text{ V to }+3.9\text{ V}; -40^\circ\text{C} < T_A < +125^\circ\text{C}$ | 70 | 95 | | dB |
| Large Signal Voltage Gain | A_{VO} | $V_O = 0.5\text{ V to }4.5\text{ V}, R_L = 2\text{ k}\Omega, V_{CM} = 0\text{ V}$ $V_O = 0.5\text{ V to }4.5\text{ V}, R_L = 2\text{ k}\Omega, V_{CM} = 0\text{ V}$ | 250 | 2000 | | V/mV |
| Offset Voltage Drift | $\Delta V_{OS}/\Delta T$ | | | | | $\mu\text{V}/^\circ\text{C}$ |
| AD8691 | | | 2 | | 12 | $\mu\text{V}/^\circ\text{C}$ |
| AD8692/AD8694 | | | 1.3 | | 6 | $\mu\text{V}/^\circ\text{C}$ |
| INPUT CAPACITANCE | | | | | | |
| Common-Mode Input Capacitance | C_{CM} | | | 5 | | pF |
| Differential Input Capacitance | C_{DM} | | | 2.5 | | pF |
| OUTPUT CHARACTERISTICS | | | | | | |
| Output Voltage High | V_{OH} | $I_L = 1\text{ mA}$ $I_L = 10\text{ mA}$ $-40^\circ\text{C to }+125^\circ\text{C}$ | 4.96 | 4.98 | | V |
| | | | 4.7 | 4.78 | | V |
| | | | 4.6 | | | V |
| Voltage Low | V_{OL} | $I_L = 1\text{ mA}$ $I_L = 10\text{ mA}$ $I_L = 10\text{ mA}$ $-40^\circ\text{C to }+125^\circ\text{C}$ $-40^\circ\text{C to }+125^\circ\text{C}$ | | 20 | 40 | mV |
| AD8691/AD8692 | | | | 165 | 210 | mV |
| AD8694 | | | | 185 | 240 | mV |
| AD8691/AD8692 | | | | | 290 | mV |
| AD8694 | | | | | 370 | mV |
| Short-Circuit Current | I_{SC} | | | ± 80 | | mA |
| Closed-Loop Output Impedance | Z_{OUT} | $f = 1\text{ MHz}, A_V = 1$ | | 10 | | Ω |
| POWER SUPPLY | | | | | | |
| Power Supply Rejection Ratio | PSRR | $V_S = 2.7\text{ V to }5.5\text{ V}$ $-40^\circ\text{C} < T_A < +125^\circ\text{C}$ | 80 | 95 | | dB |
| | | | 75 | 95 | | dB |
| Supply Current/Amplifier | I_{SY} | $V_O = 0\text{ V}$ $-40^\circ\text{C} < T_A < +125^\circ\text{C}$ | | 0.95 | 1.05 | mA |
| | | | | | 1.3 | mA |
| DYNAMIC PERFORMANCE | | | | | | |
| Slew Rate | SR | $R_L = 2\text{ k}\Omega$ | | 5 | | V/ μs |
| Settling Time | t_s | To 0.01% | | 1 | | μs |
| Full Power Bandwidth | BW _P | <1% distortion | | 360 | | kHz |
| Gain Bandwidth Product | GBP | | | 10 | | MHz |
| Phase Margin | ϕ_O | | | 65 | | Degrees |
| Total Harmonic Distortion + Noise | THD + N | $G = 1, R_L = 600\ \Omega, f = 1\text{ kHz}, V_O = 1\text{ V p-p}$ | | 0.0006 | | % |
| NOISE PERFORMANCE | | | | | | |
| Voltage Noise | $e_{n\text{ p-p}}$ | $f = 0.1\text{ Hz to }10\text{ Hz}$ | | 1.6 | 3.0 | $\mu\text{V p-p}$ |
| Voltage Noise Density | e_n | $f = 1\text{ kHz}$ $f = 10\text{ kHz}$ | | 8 | 12 | nV/ $\sqrt{\text{Hz}}$ |
| | e_n | $f = 10\text{ kHz}$ | | 6.5 | | nV/ $\sqrt{\text{Hz}}$ |
| Current Noise Density | i_n | $f = 1\text{ kHz}$ | | 0.05 | | pA/ $\sqrt{\text{Hz}}$ |

ABSOLUTE MAXIMUM RATINGS

$T_A = 25^\circ\text{C}$, unless otherwise noted.

Table 3.

| Parameters | Ratings |
|--|---|
| Supply Voltage | 6 V |
| Input Voltage | $V_{SS} - 0.3 \text{ V to } V_{DD} + 0.3 \text{ V}$ |
| Differential Input Voltage | $\pm 6 \text{ V}$ |
| Output Short-Circuit Duration to GND | Observe derating curves |
| Storage Temperature Range | $-65^\circ\text{C to } +150^\circ\text{C}$ |
| Operating Temperature Range | $-40^\circ\text{C to } +125^\circ\text{C}$ |
| Junction Temperature Range | $-65^\circ\text{C to } +150^\circ\text{C}$ |
| Lead Temperature Range (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 CHARACTERISTICS

Table 4.

| Package Type | θ_{JA}^1 | θ_{JC} | Unit |
|--------------------|-----------------|---------------|--------------------|
| 8-Lead MSOP (RM) | 210 | 45 | $^\circ\text{C/W}$ |
| 8-Lead SOIC (R) | 158 | 43 | $^\circ\text{C/W}$ |
| 5-Lead TSOT (UJ-5) | 207 | 61 | $^\circ\text{C/W}$ |
| 5-Lead SC70 (KS) | 376 | 126 | $^\circ\text{C/W}$ |
| 14-Lead TSSOP (RU) | 180 | 35 | $^\circ\text{C/W}$ |
| 14-Lead SOIC (R) | 120 | 36 | $^\circ\text{C/W}$ |

¹ θ_{JA} is specified for the worst-case conditions, that is, the device soldered in the circuit board for surface-mount packages.

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.



TYPICAL PERFORMANCE CHARACTERISTICS

$V_S = +5\text{ V}$ or $\pm 2.5\text{ V}$, unless otherwise noted.

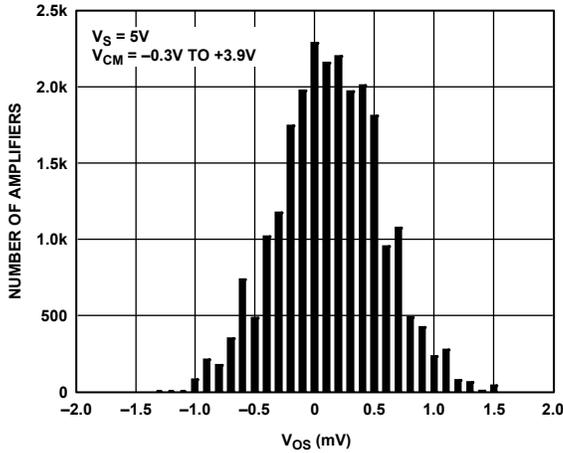


Figure 7. Input Offset Voltage Distribution

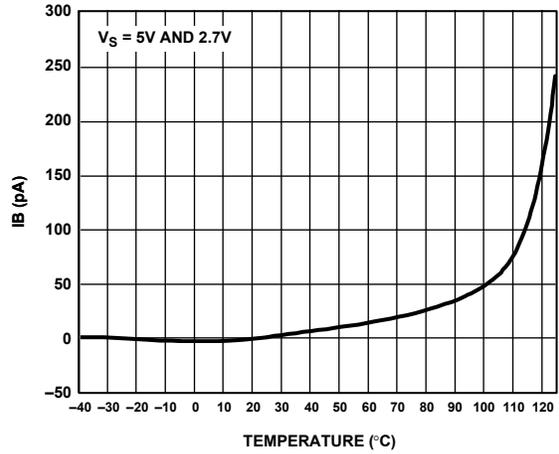


Figure 10. Input Bias Current vs. Temperature

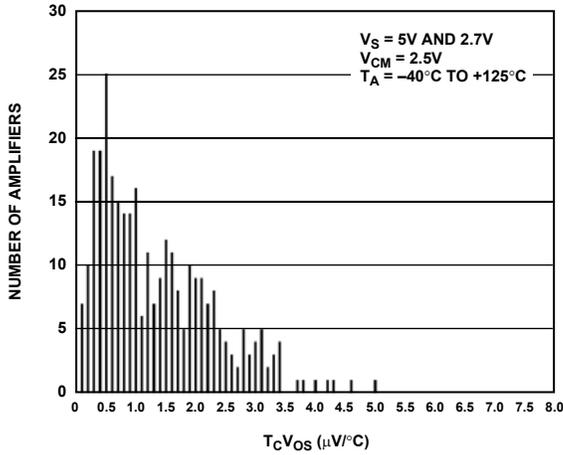


Figure 8. AD8692/AD8694 Input Offset Voltage Drift Distribution

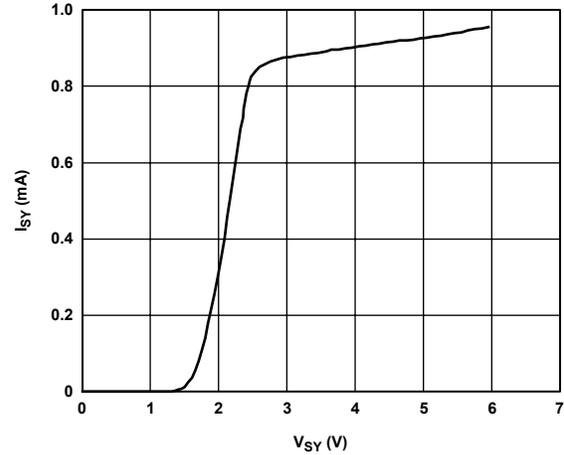


Figure 11. Supply Current vs. Supply Voltage

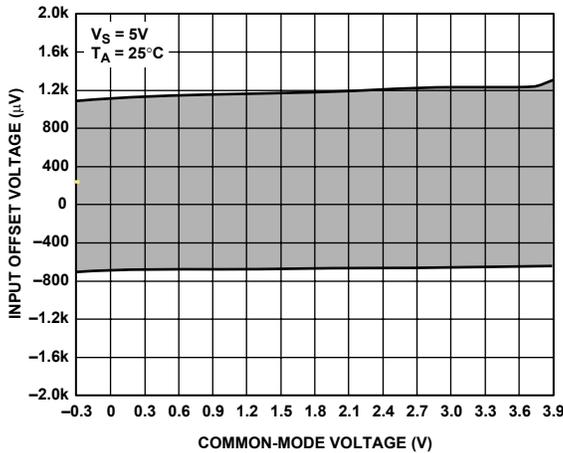


Figure 9. Input Offset Voltage vs. Common-Mode Voltage

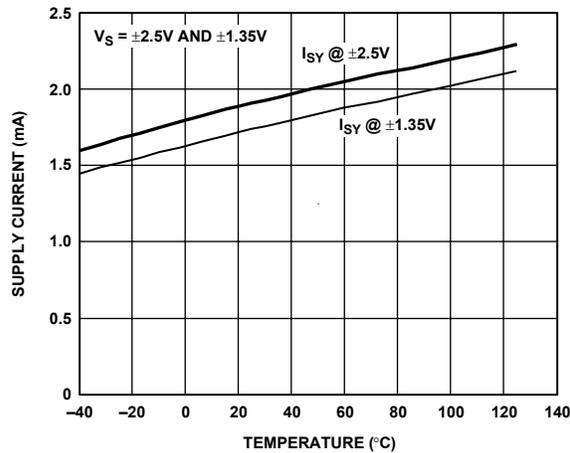


Figure 12. Supply Current vs. Temperature

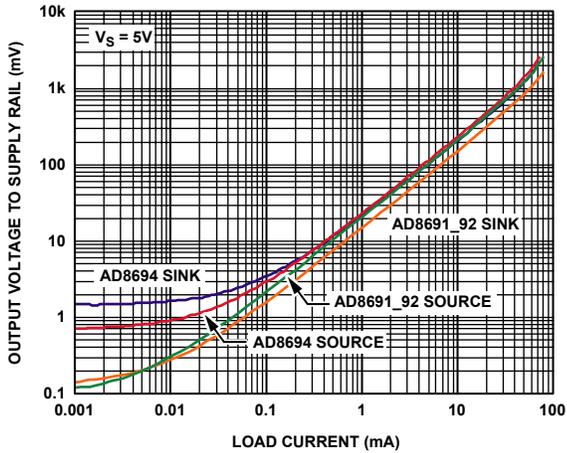


Figure 13. Output Voltage to Supply Rail vs. Load Current

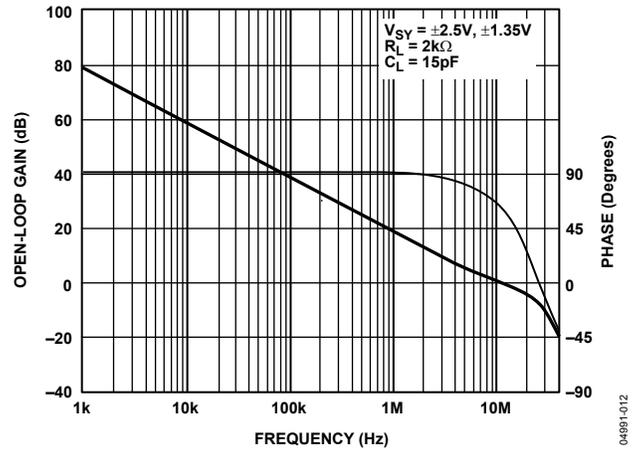


Figure 16. Open-Loop Gain and Phase vs. Frequency

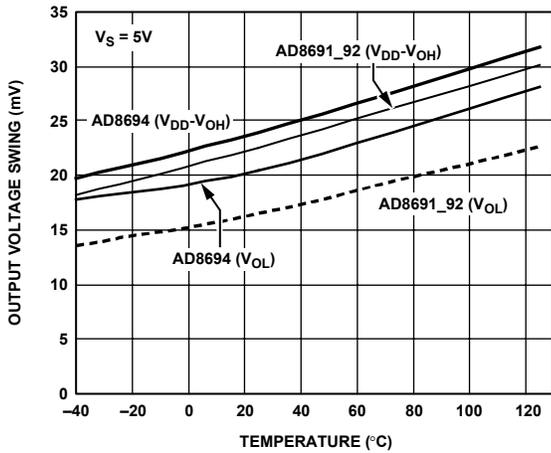


Figure 14. Output Voltage Swing vs. Temperature ($I_L = 1 \text{ mA}$)

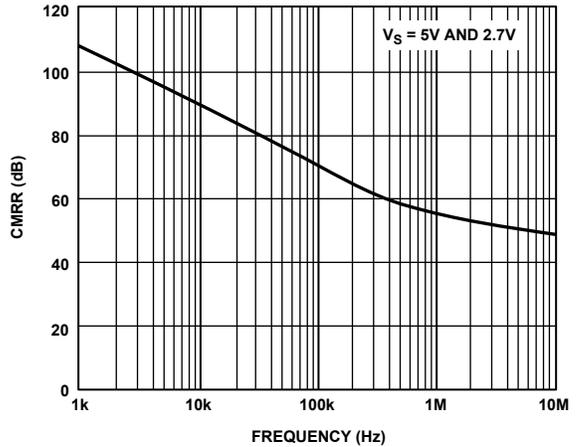


Figure 17. CMRR vs. Frequency

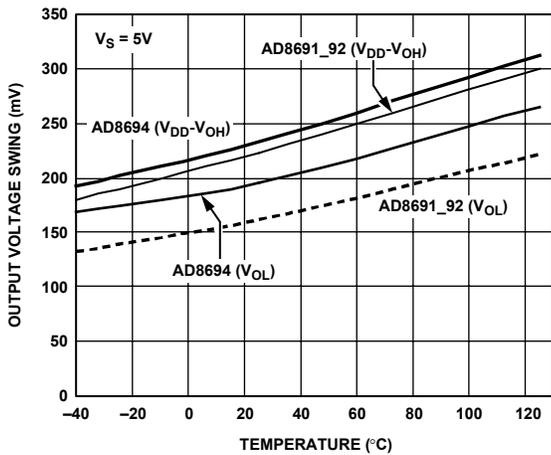


Figure 15. Output Voltage Swing vs. Temperature ($I_L = 10 \text{ mA}$)

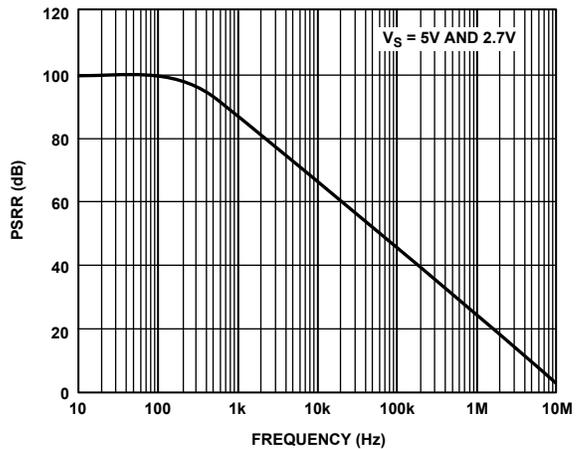


Figure 18. PSRR vs. Frequency

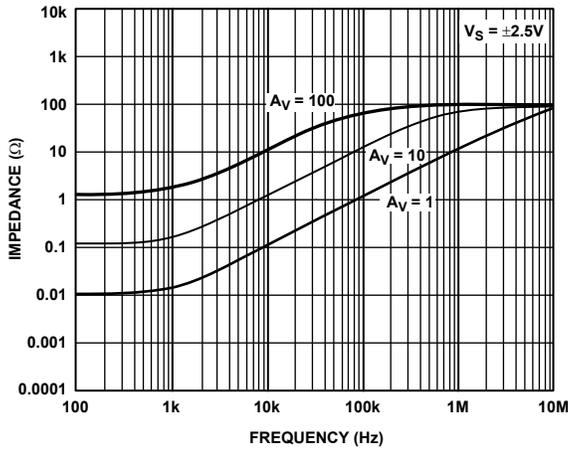


Figure 19. Closed-Loop Output Impedance vs. Frequency

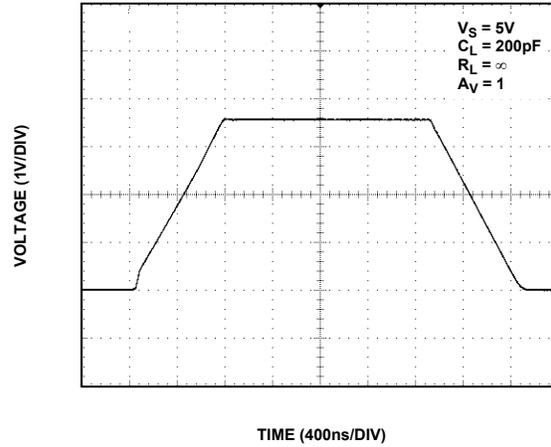


Figure 22. Large Signal Transient Response

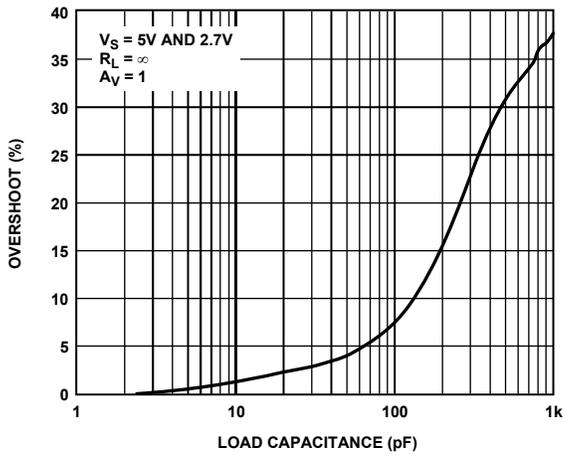


Figure 20. Small Signal Overshoot vs. Load Capacitance

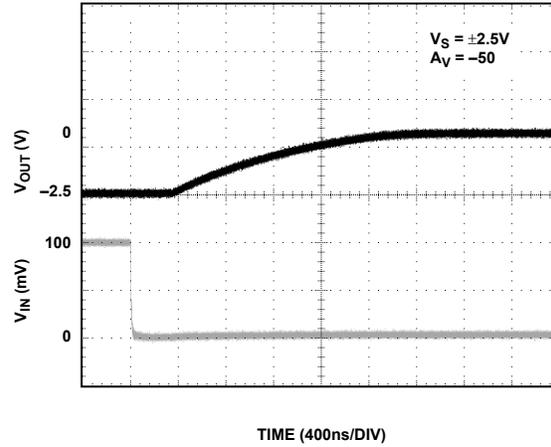


Figure 23. Positive Overload Recovery

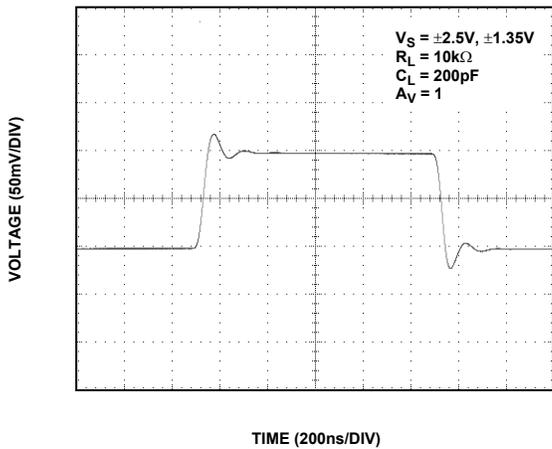


Figure 21. Small Signal Transient Response

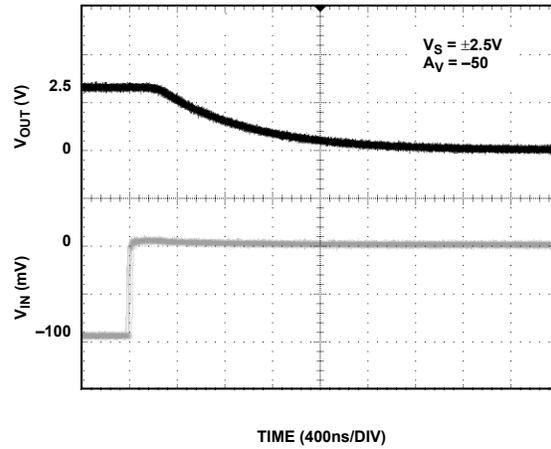


Figure 24. Negative Overload Recovery

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04891-018

04891-016

04891-019

04891-017

04891-020

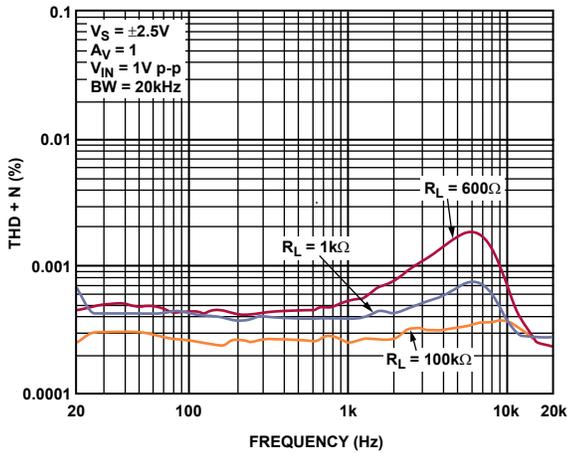


Figure 25. THD + N vs. Frequency

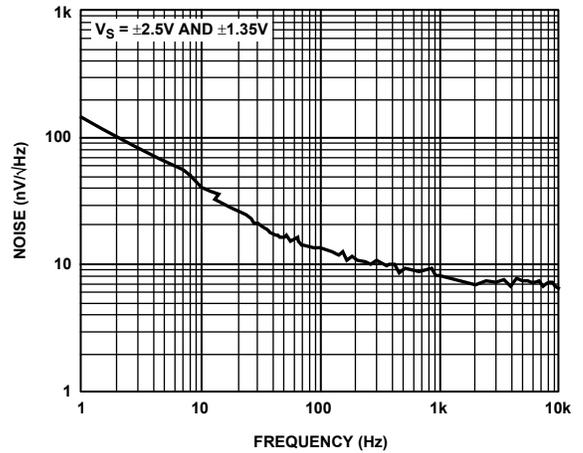


Figure 27. Voltage Noise Density

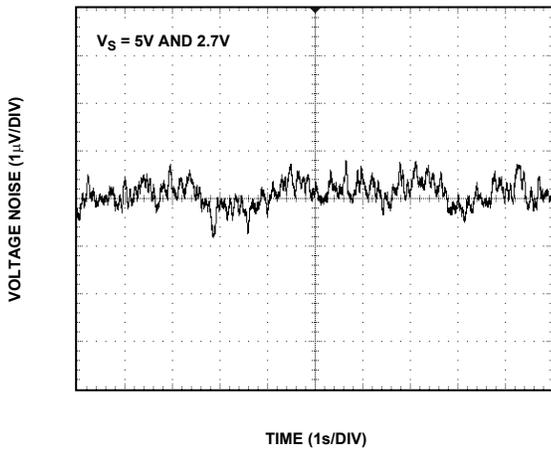


Figure 26. 0.1 Hz to 10 Hz Input Voltage Noise

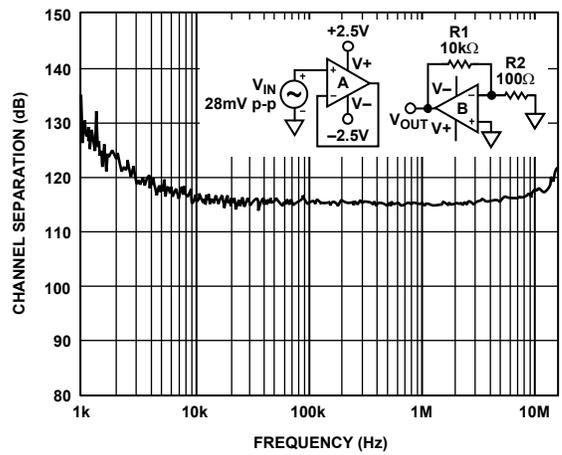


Figure 28. AD8692/AD8694 Channel Separation

AD8691/AD8692/AD8694

$V_S = +2.7\text{ V}$ or $\pm 1.35\text{ V}$, unless otherwise noted.

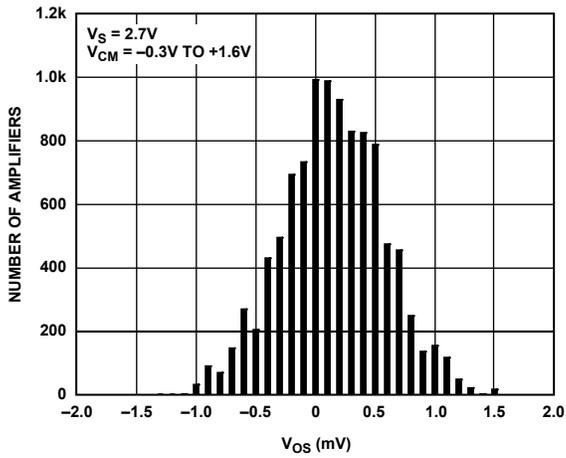


Figure 29. Input Offset Voltage Distribution

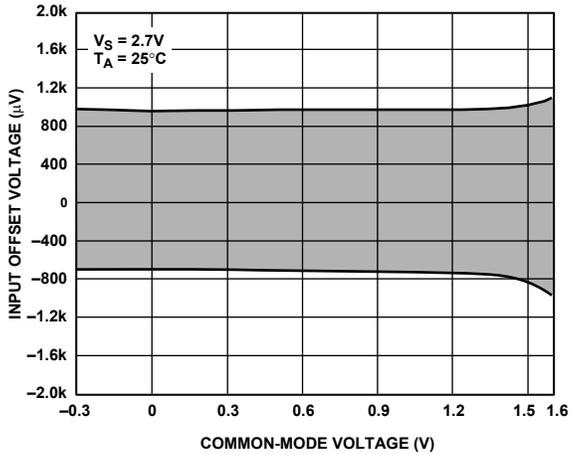


Figure 30. Input Offset Voltage vs. Common-Mode Voltage

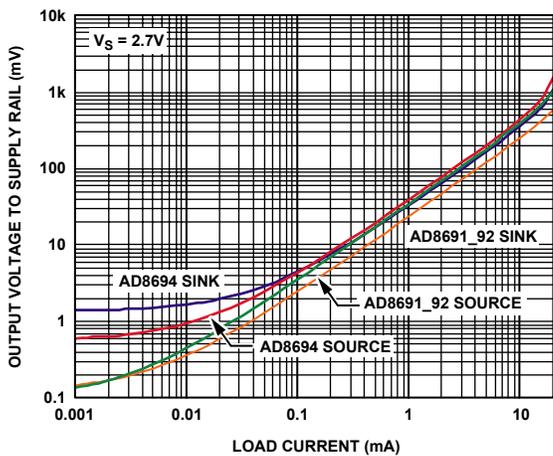


Figure 31. Output Voltage to Supply Rail vs. Load Current

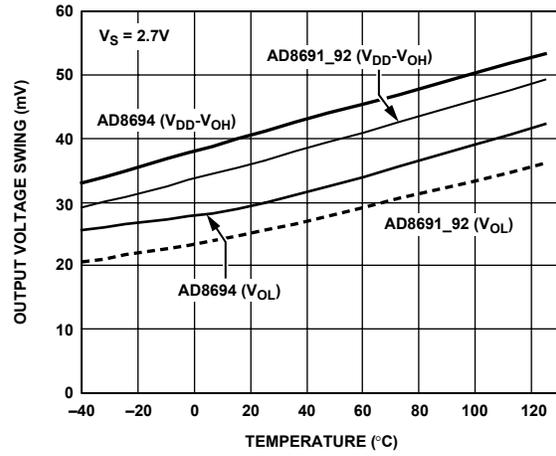


Figure 32. Output Voltage Swing vs. Temperature ($I_L = 1\text{ mA}$)

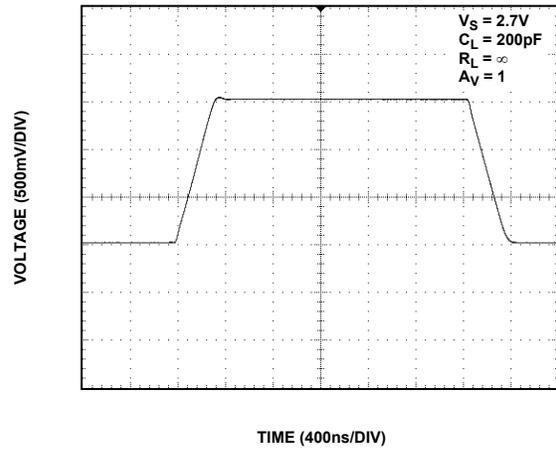


Figure 33. Large Signal Transient Response

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04891-028

04891-026

04891-029

04891-027

OUTLINE DIMENSIONS

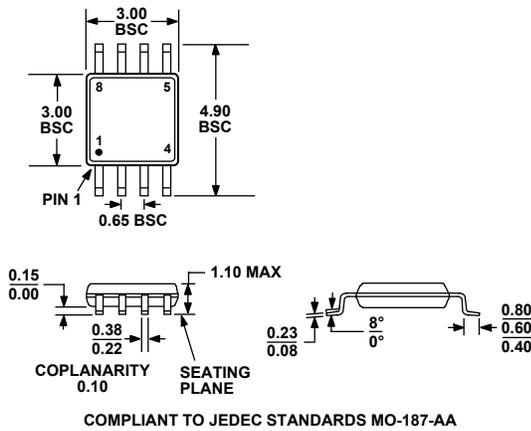


Figure 34. 8-Lead Mini Small Outline Package [MSOP] (RM-8)
Dimensions shown in millimeters

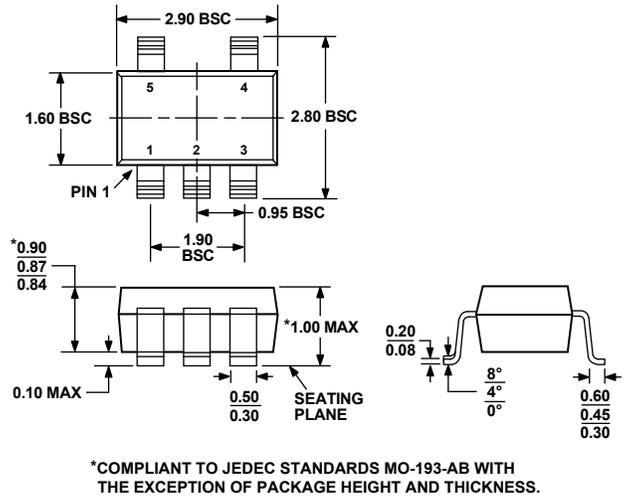


Figure 37. 5-Lead Thin Small Outline Transistor Package [TSOT] (UJ-5)
Dimensions shown in millimeters

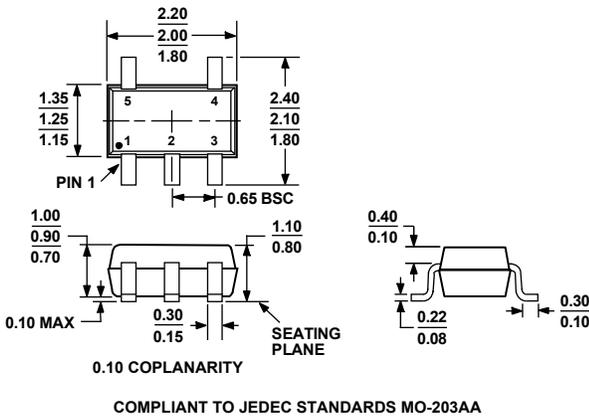


Figure 35. 5-Lead Thin Shrink Small Outline Package [SC70] (KS-5)
Dimensions shown in millimeters

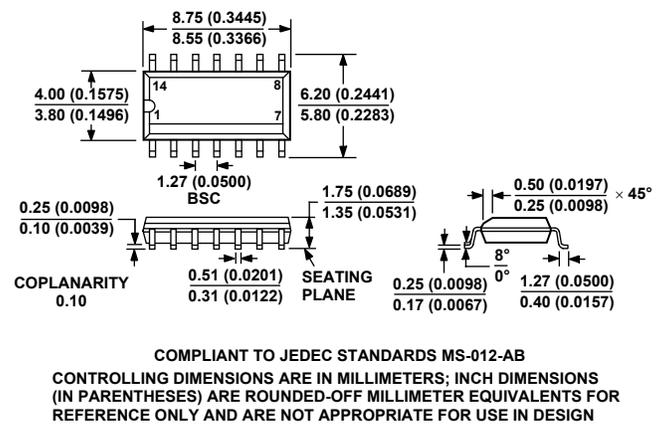


Figure 38. 14-Lead Standard Small Outline Package [SOIC] Narrow Body (R-14)
Dimensions shown in millimeters

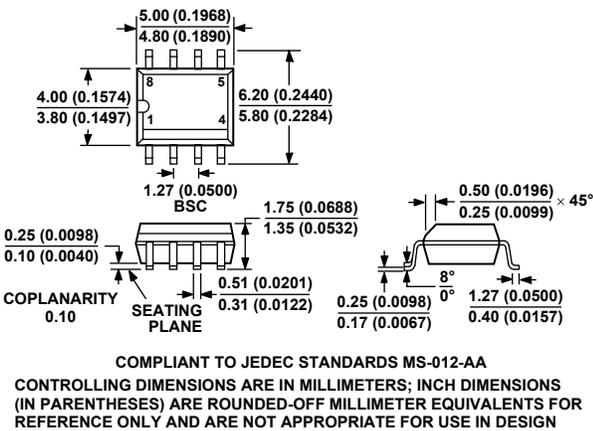


Figure 36. 8-Lead Standard Small Outline Package [SOIC] Narrow Body (R-8)
Dimensions shown in millimeters and (inches)

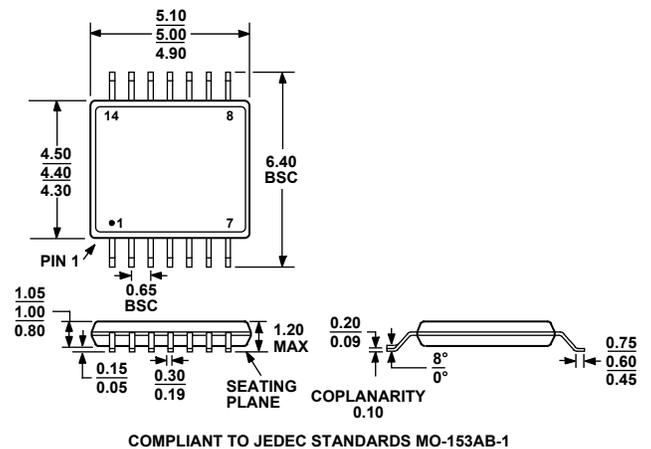


Figure 39. 14-Lead Thin Shrink Small Outline Package [TSSOP] (RU-14)
Dimensions shown in millimeters

AD8691/AD8692/AD8694

ORDERING GUIDE

| Model | Temperature Range | Package Description | Package Option | Branding |
|----------------------------|-------------------|---------------------|----------------|----------|
| AD8691AUJZ-R2 | -40°C to +125°C | 5-Lead TSOT | UJ-5 | ACA |
| AD8691AUJZ-REEL | -40°C to +125°C | 5-Lead TSOT | UJ-5 | ACA |
| AD8691AUJZ-REEL7 | -40°C to +125°C | 5-Lead TSOT | UJ-5 | ACA |
| AD8691AKSZ-R2 | -40°C to +125°C | 5-Lead SC70 | KS-5 | ACA |
| AD8691AKSZ-REEL | -40°C to +125°C | 5-Lead SC70 | KS-5 | ACA |
| AD8691AKSZ-REEL7 | -40°C to +125°C | 5-Lead SC70 | KS-5 | ACA |
| AD8692ARMZ-R2 ¹ | -40°C to +125°C | 8-Lead MSOP | RM-8 | APA |
| AD8692ARMZ-REEL | -40°C to +125°C | 8-Lead MSOP | RM-8 | APA |
| AD8692ARZ | -40°C to +125°C | 8-Lead SOIC | R-8 | |
| AD8692ARZ-REEL | -40°C to +125°C | 8-Lead SOIC | R-8 | |
| AD8692ARZ-REEL7 | -40°C to +125°C | 8-Lead SOIC | R-8 | |
| AD8694ARUZ | -40°C to +125°C | 14-Lead TSSOP | RU-14 | |
| AD8694ARUZ-REEL | -40°C to +125°C | 14-Lead TSSOP | RU-14 | |
| AD8694ARZ | -40°C to +125°C | 14-Lead SOIC | R-14 | |
| AD8694ARZ-REEL | -40°C to +125°C | 14-Lead SOIC | R-14 | |
| AD8694ARZ-REEL7 | -40°C to +125°C | 14-Lead SOIC | R-14 | |

¹ Z = Pb-free part.