# Low Cost, Low Noise, CMOS, RRO Operational Amplifiers

## AD8691/AD8692/AD8694

## FEATURES

**Offset voltage: 400 µV typical**
**Low offset voltage drift: 6 µV/°C maximum (AD8692/AD8694)**
**Very low input bias currents: 1 pA maximum**
**Low noise: 8 nV/√Hz**
**Low distortion: 0.0006%**
**Wide bandwidth: 10 MHz**
**Unity-gain stable**
**Single-supply operation: 2.7 V to 6 V**
**Qualified for automotive applications**

## 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.

Applications for these amplifiers include power amplifier (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°C. The AD8691 single is available in 5-lead SC70 and 5-lead 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.

See the Ordering Guide section for automotive grades.

## PIN CONFIGURATIONS

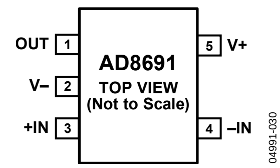

Figure 1. 5-Lead TSOT

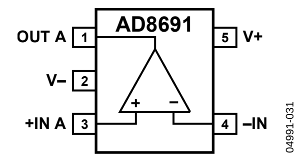

Figure 2. 5-Lead SC70

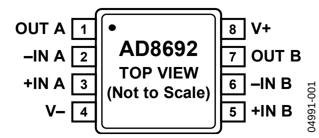

Figure 3. 8-Lead MSOP

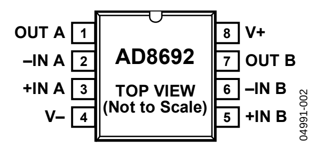

Figure 4. 8-Lead SOIC

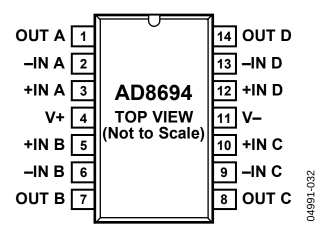

Figure 5. 14-Lead SOIC

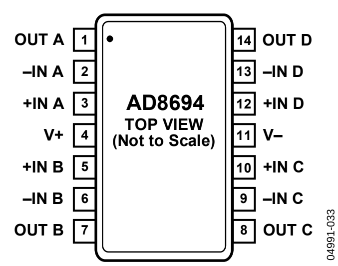

Figure 6. 14-Lead TSSOP

**Rev. E**


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**10/04—Revision 0: Initial Version**

# SPECIFICATIONS

## ELECTRICAL CHARACTERISTICS

$V_S$ = 2.7 V, $V_{CM}$ = $V_S$/2, $T_A$ = 25°C, unless otherwise noted.

**Table 1.**

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| INPUT CHARACTERISTICS | | | | | | |
| Offset Voltage | $V_{OS}$ | $V_{CM}$ = −0.3 V to +1.6 V | | 0.4 | 2.0 | mV |
| | | $V_{CM}$ = −0.1 V to +1.6 V; −40°C < $T_A$ < +125°C | | | 3.0 | mV |
| Input Bias Current | $I_B$ | | | 0.2 | 1 | pA |
| | | −40°C < $T_A$ < +85°C | | | 50 | pA |
| | | −40°C < $T_A$ < +125°C | | | 260 | pA |
| Input Offset Current | $I_{OS}$ | | | 0.1 | 0.5 | pA |
| | | −40°C < $T_A$ < +85°C | | | 20 | pA |
| | | −40°C < $T_A$ < +125°C | | | 75 | pA |
| Input Voltage Range | | | −0.3 | | +1.6 | V |
| Common-Mode Rejection Ratio | CMRR | $V_{CM}$ = −0.3 V to +1.6 V | 68 | 90 | | dB |
| | | $V_{CM}$ = −0.1 V to +1.6 V; −40°C < $T_A$ < +125°C | 60 | 85 | | dB |
| Large Signal Voltage Gain | $A_{VO}$ | | | | | |
| AD8691/AD8692 | | $R_L$ = 2 kΩ, $V_O$ = 0.5 V to 2.2 V | 90 | 250 | | V/mV |
| AD8694 | | $R_L$ = 2 kΩ, $V_O$ = 0.5 V to 2.2 V | 60 | | | V/mV |
| Offset Voltage Drift | $\Delta V_{OS}/\Delta T$ | | | | | |
| AD8691 | | | | 2 | 12 | µV/°C |
| AD8692/AD8694 | | | | 1.3 | 6 | µV/°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 mA | 2.64 | 2.66 | | V |
| | | −40°C < $T_A$ < +125°C | 2.6 | | | V |
| Output Voltage Low | $V_{OL}$ | $I_L$ = 1 mA | | 25 | 40 | mV |
| | | −40°C < $T_A$ < +125°C | | | 60 | mV |
| Short-Circuit Current | $I_{SC}$ | | | ±20 | | mA |
| Closed-Loop Output Impedance | $Z_{OUT}$ | f = 1 MHz, $A_V$ = 1 | | 12 | | Ω |
| POWER SUPPLY | | | | | | |
| Power Supply Rejection Ratio | PSRR | $V_S$ = 2.7 V to 5.5 V | 80 | 95 | | dB |
| | | −40°C < $T_A$ < +125°C | 75 | 95 | | dB |
| Supply Current/Amplifier | $I_{SY}$ | $V_O$ = 0 V | | 0.85 | 0.95 | mA |
| | | −40°C < $T_A$ < +125°C | | | 1.2 | mA |
| DYNAMIC PERFORMANCE | | | | | | |
| Slew Rate | SR | $R_L$ = 2 kΩ | | 5 | | V/µs |
| Settling Time | $t_S$ | To 0.01% | | 1 | | µs |
| Gain Bandwidth Product | GBP | | | 10 | | MHz |
| Phase Margin | $Ø_m$ | | | 60 | | Degrees |
| Total Harmonic Distortion + Noise | THD + N | G = 1, $R_L$ = 600 Ω, f = 1 kHz, $V_O$ = 250 mV p-p | | 0.003 | | % |
| NOISE PERFORMANCE | | | | | | |
| Voltage Noise | $e_{n\ p\text{-}p}$ | f = 0.1 Hz to 10 Hz | | 1.6 | 3.0 | µV p-p |
| Voltage Noise Density | $e_n$ | f = 1 kHz | | 8 | 12 | nV/√Hz |
| | $e_n$ | f = 10 kHz | | 6.5 | | nV/√Hz |
| Current Noise Density | $i_n$ | f = 1 kHz | | 0.05 | | pA/√Hz |

$V_S$ = 5.0 V, $V_{CM}$ = $V_S$/2, $T_A$ = 25°C, unless otherwise noted.

**Table 2.**

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| INPUT CHARACTERISTICS | | | | | | |
| Offset Voltage | $V_{OS}$ | $V_{CM}$ = −0.3 V to +3.9 V | | 0.4 | 2.0 | mV |
| | | $V_{CM}$ = −0.1 V to +3.9 V; −40°C < $T_A$ < +125°C | | | 3.0 | mV |
| Input Bias Current | $I_B$ | | | 0.2 | 1 | pA |
| | | −40°C < $T_A$ < +85°C | | | 50 | pA |
| | | −40°C < $T_A$ < +125°C | | | 260 | pA |
| Input Offset Current | $I_{OS}$ | | | 0.1 | 0.5 | pA |
| | | −40°C < $T_A$ < +85°C | | | 20 | pA |
| | | −40°C < $T_A$ < +125°C | | | 75 | pA |
| Input Voltage Range | | | −0.3 | | +3.9 | V |
| Common-Mode Rejection Ratio | CMRR | $V_{CM}$ = −0.3 V to +3.9 V | 70 | 95 | | dB |
| | | $V_{CM}$ = −0.1 V to +3.9 V; −40°C < $T_A$ < +125°C | 67 | 95 | | dB |
| Large Signal Voltage Gain | $A_{VO}$ | | | | | |
| AD8691/AD8692 | | $V_O$ = 0.5 V to 4.5 V, $R_L$ = 2 kΩ, $V_{CM}$ = 0 V | 250 | 2000 | | V/mV |
| AD8694 | | $V_O$ = 0.5 V to 4.5 V, $R_L$ = 2 kΩ, $V_{CM}$ = 0 V | 150 | | | V/mV |
| Offset Voltage Drift | $\Delta V_{OS}/\Delta T$ | | | | | |
| AD8691 | | | | 2 | 12 | µV/°C |
| AD8692/AD8694 | | | | 1.3 | 6 | µV/°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 mA | 4.96 | 4.98 | | V |
| | | $I_L$ = 10 mA | 4.7 | 4.78 | | V |
| | | −40°C to +125°C | 4.6 | | | V |
| Output Voltage Low | $V_{OL}$ | $I_L$ = 1 mA | | 20 | 40 | mV |
| AD8691/AD8692 | | $I_L$ = 10 mA | | 165 | 210 | mV |
| AD8694 | | $I_L$ = 10 mA | | 185 | 240 | mV |
| AD8691/AD8692 | | −40°C to +125°C | | | 290 | mV |
| AD8694 | | −40°C to +125°C | | | 370 | mV |
| Short-Circuit Current | $I_{SC}$ | | | ±80 | | mA |
| Closed-Loop Output Impedance | $Z_{OUT}$ | f = 1 MHz, $A_V$ = 1 | | 10 | | Ω |
| POWER SUPPLY | | | | | | |
| Power Supply Rejection Ratio | PSRR | $V_S$ = 2.7 V to 5.5 V | 80 | 95 | | dB |
| | | −40°C < $T_A$ < +125°C | 75 | 95 | | dB |
| Supply Current/Amplifier | $I_{SY}$ | $V_O$ = 0 V | | 0.95 | 1.05 | mA |
| | | −40°C < $T_A$ < +125°C | | | 1.3 | mA |
| DYNAMIC PERFORMANCE | | | | | | |
| Slew Rate | SR | $R_L$ = 2 kΩ | | 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 | $Ø_m$ | | | 65 | | Degrees |
| Total Harmonic Distortion + Noise | THD + N | G = 1, $R_L$ = 600 Ω, f = 1 kHz, $V_O$ = 1 V p-p | | 0.0006 | | % |
| NOISE PERFORMANCE | | | | | | |
| Voltage Noise | $e_{n\,p\text{-}p}$ | f = 0.1 Hz to 10 Hz | | 1.6 | 3.0 | µV p-p |
| Voltage Noise Density | $e_n$ | f = 1 kHz | | 8 | 12 | nV/√Hz |
| | $e_n$ | f = 10 kHz | | 6.5 | | nV/√Hz |
| Current Noise Density | $i_n$ | f = 1 kHz | | 0.05 | | pA/√Hz |

# ABSOLUTE MAXIMUM RATINGS

$T_A$ = 25°C, unless otherwise noted.

**Table 3.**

| Parameter | Rating |
|---|---|
| Supply Voltage | 6 V |
| Input Voltage | $V_{SS}$ − 0.3 V to $V_{DD}$ + 0.3 V |
| Differential Input Voltage | ±6 V |
| Output Short-Circuit Duration to GND | Observe derating curves |
| Storage Temperature Range | −65°C to +150°C |
| Operating Temperature Range | −40°C to +125°C |
| Junction Temperature Range | −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.

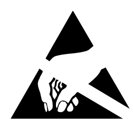
## THERMAL CHARACTERISTICS

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

**Table 4. Thermal Resistance**

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

$V_S$ = +5 V or ±2.5 V, unless otherwise noted.

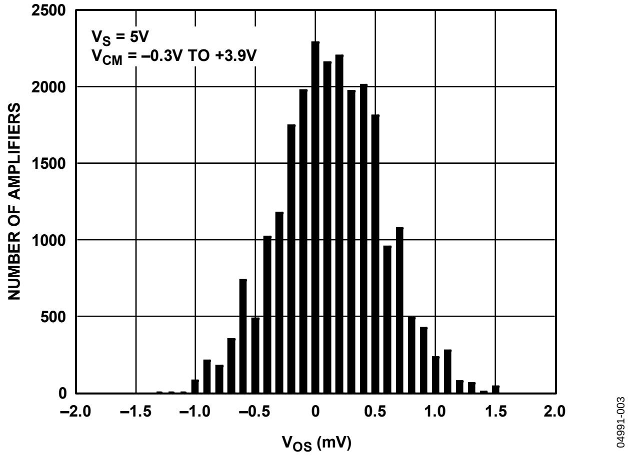



*Figure 7. Input Offset Voltage Distribution*

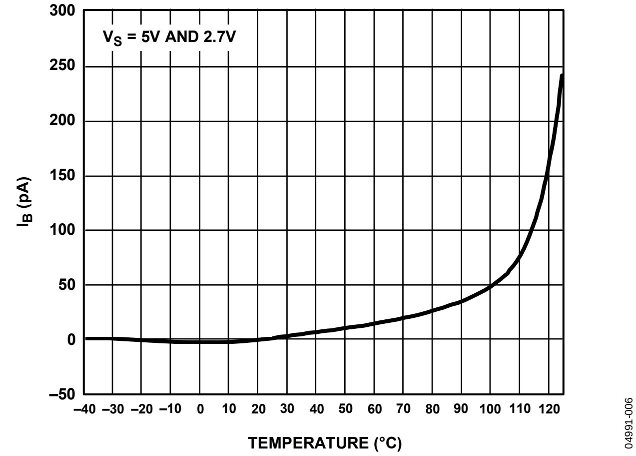



*Figure 10. Input Bias Current vs. Temperature*

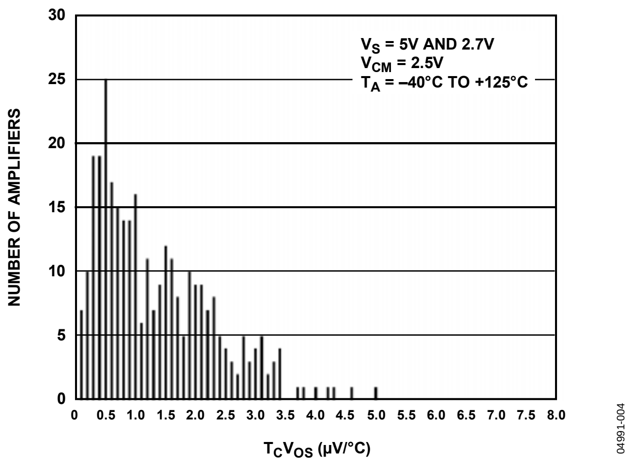



*Figure 8. AD8692/AD8694 Input Offset Voltage Drift Distribution*

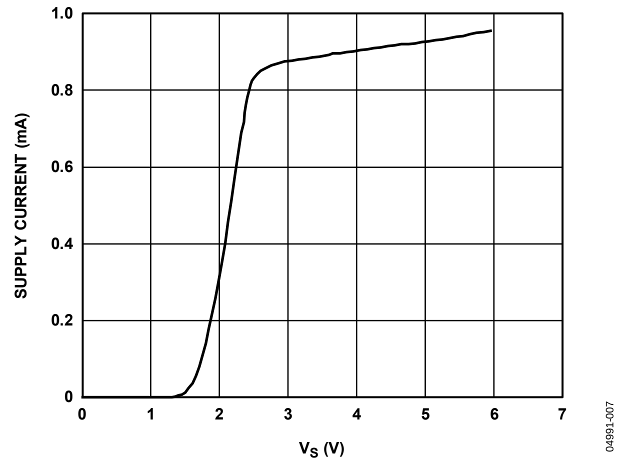



*Figure 11. Supply Current vs. Supply Voltage*

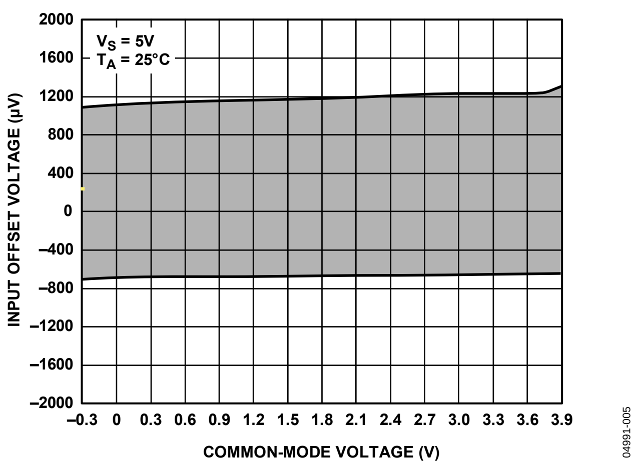



*Figure 9. Input Offset Voltage vs. Common-Mode Voltage*

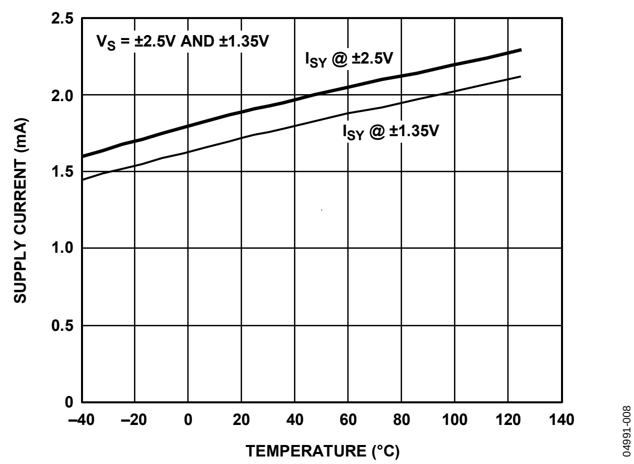



*Figure 12. Supply Current vs. Temperature*

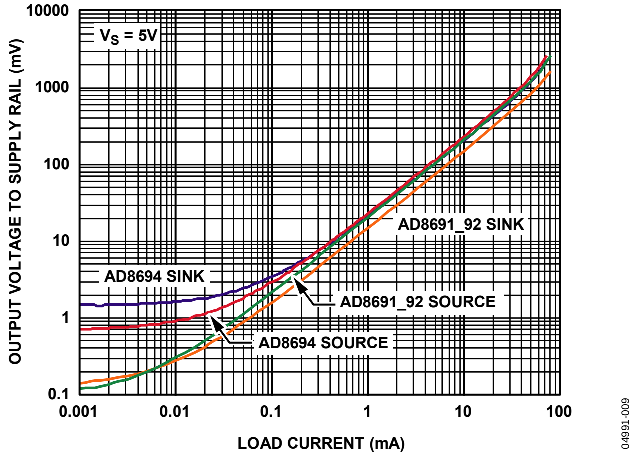



Figure 13. Output Voltage to Supply Rail vs. Load Current

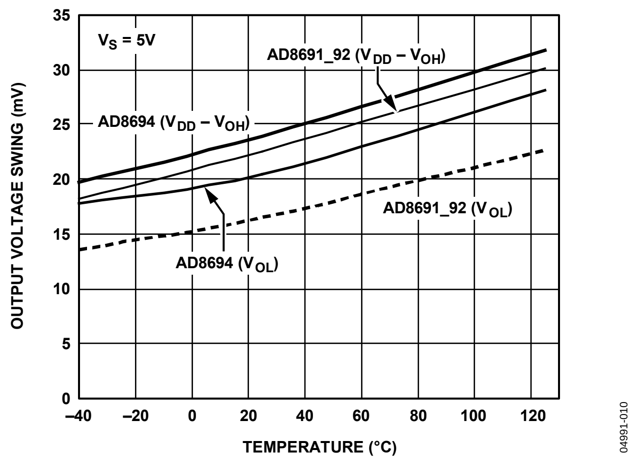



Figure 14. Output Voltage Swing vs. Temperature ($I_L$ = 1 mA)

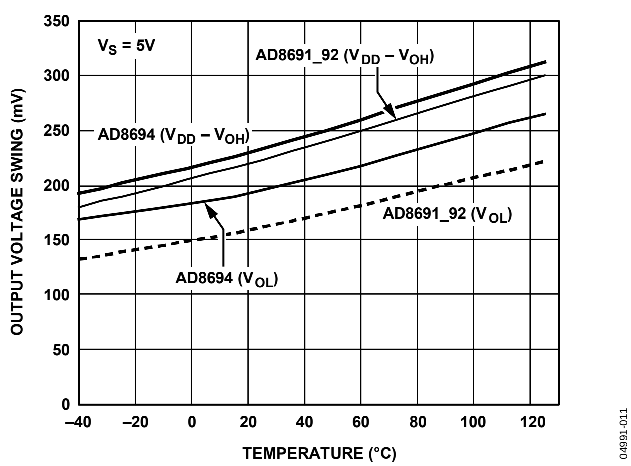



Figure 15. Output Voltage Swing vs. Temperature ($I_L$ = 10 mA)

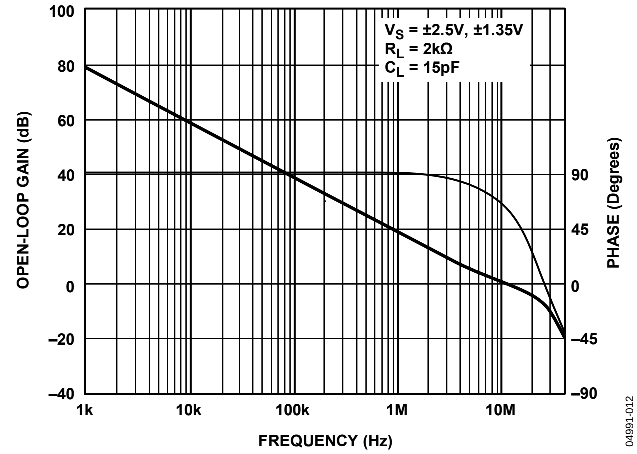



Figure 16. Open-Loop Gain and Phase vs. Frequency

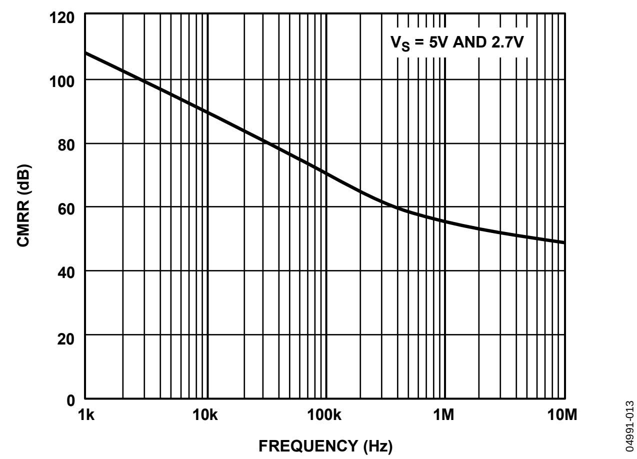



Figure 17. CMRR vs. Frequency

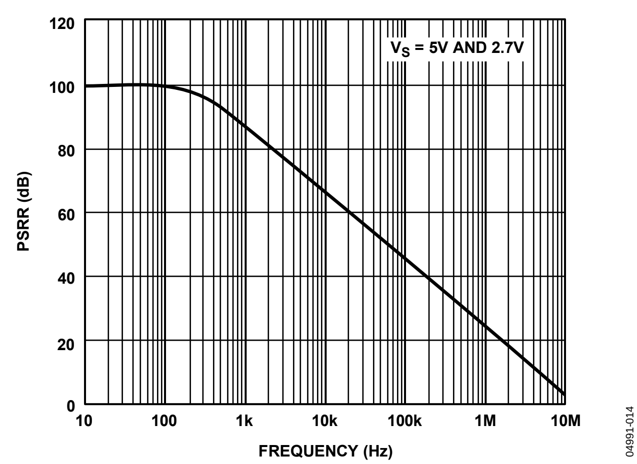



Figure 18. PSRR vs. Frequency

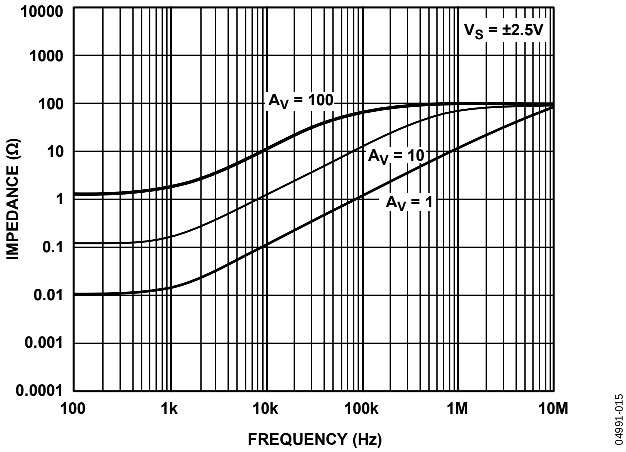



Figure 19. Closed-Loop Output Impedance vs. Frequency

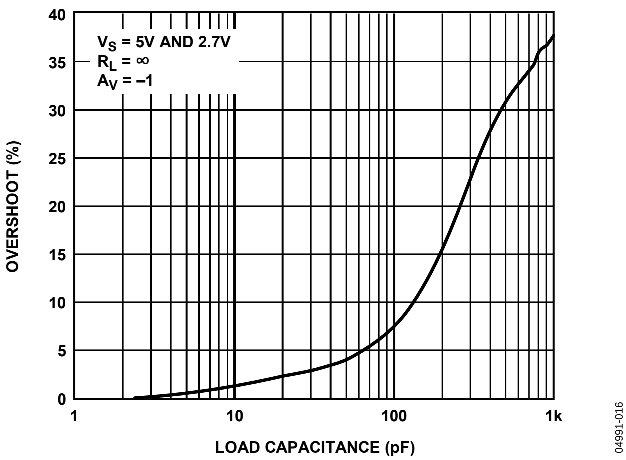



Figure 20. Small Signal Overshoot vs. Load Capacitance

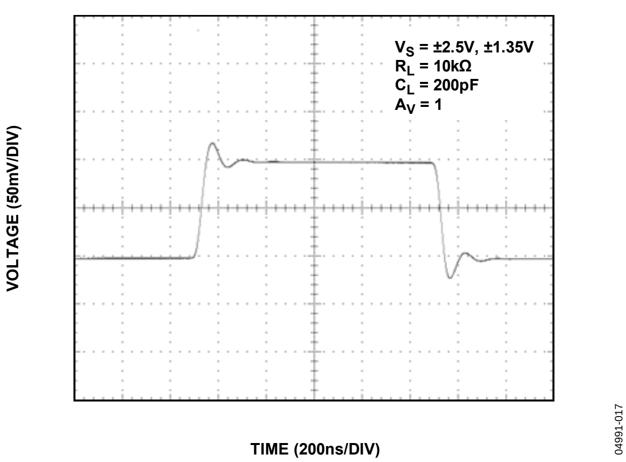



Figure 21. Small Signal Transient Response

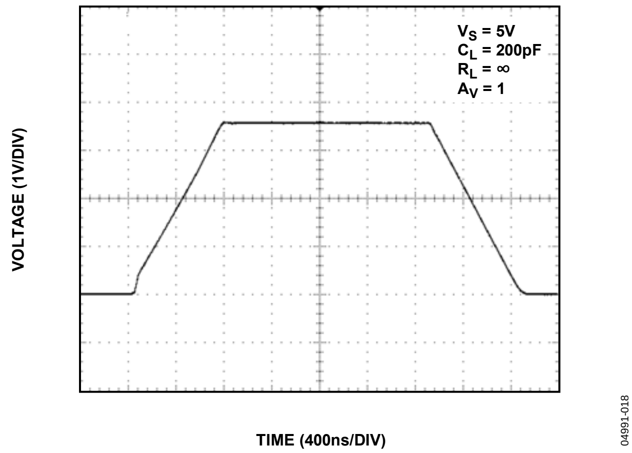



Figure 22. Large Signal Transient Response

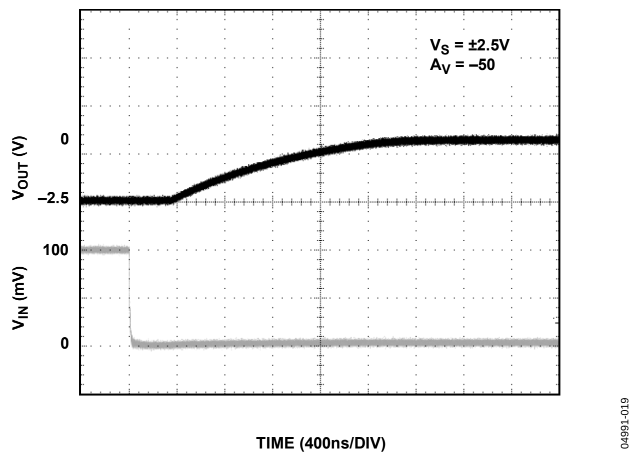



Figure 23. Positive Overload Recovery

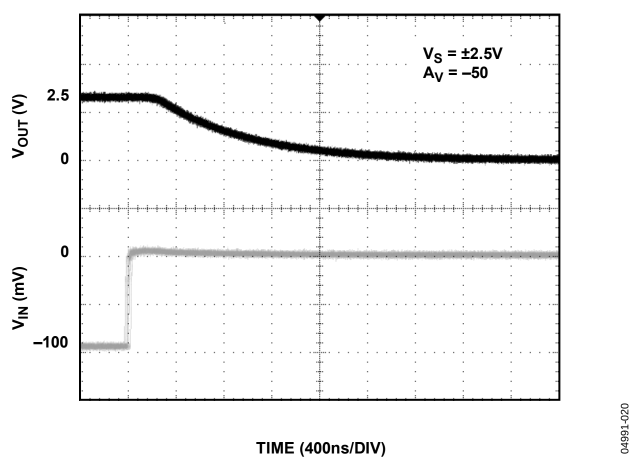



Figure 24. Negative Overload Recovery

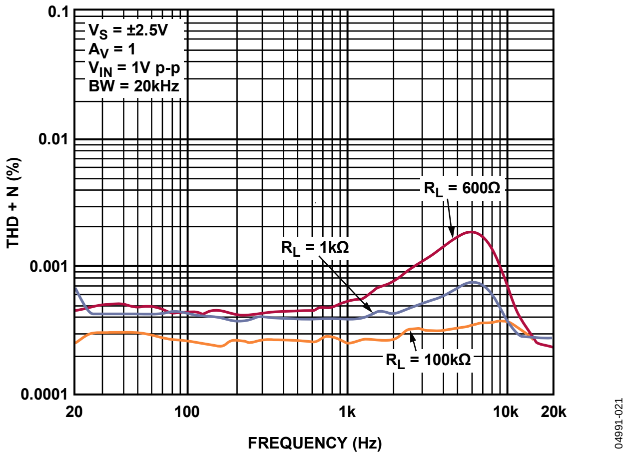



Figure 25. THD + N vs. Frequency

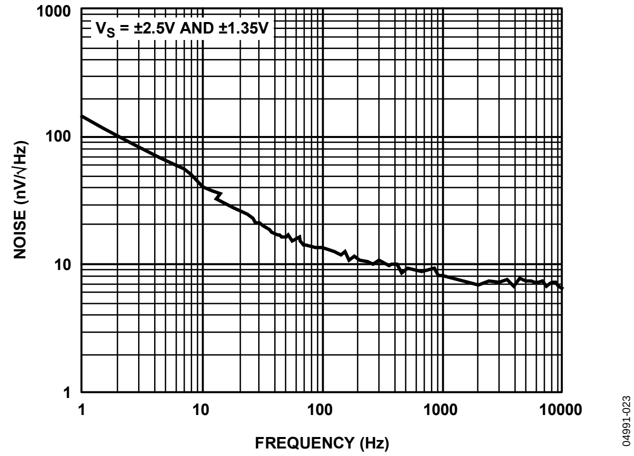



Figure 27. Voltage Noise Density

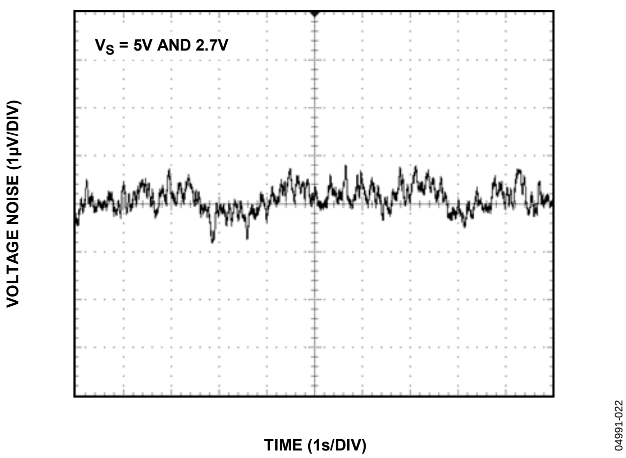



Figure 26. 0.1 Hz to 10 Hz Input Voltage Noise

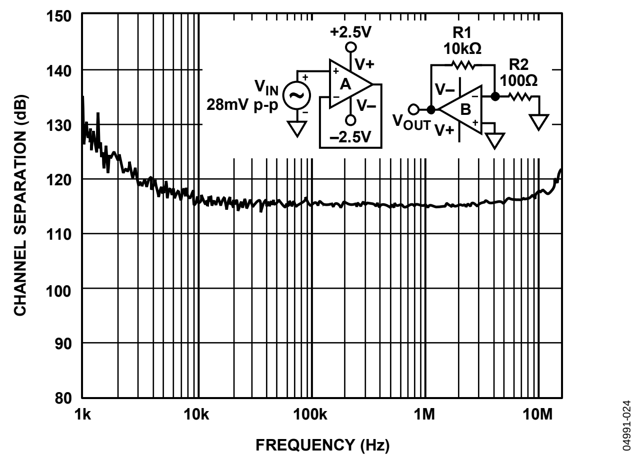



Figure 28. AD8692/AD8694 Channel Separation

$V_S$ = +2.7 V or ±1.35 V, unless otherwise noted.

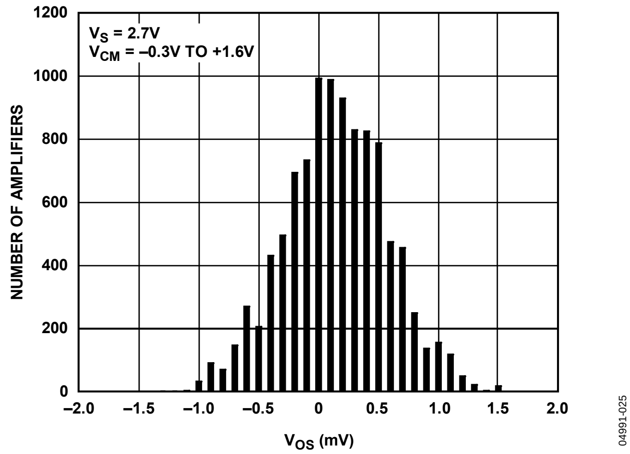



Figure 29. Input Offset Voltage Distribution

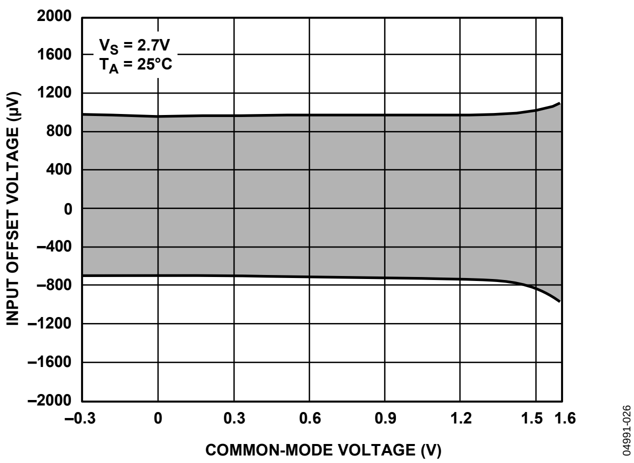



Figure 30. Input Offset Voltage vs. Common-Mode Voltage

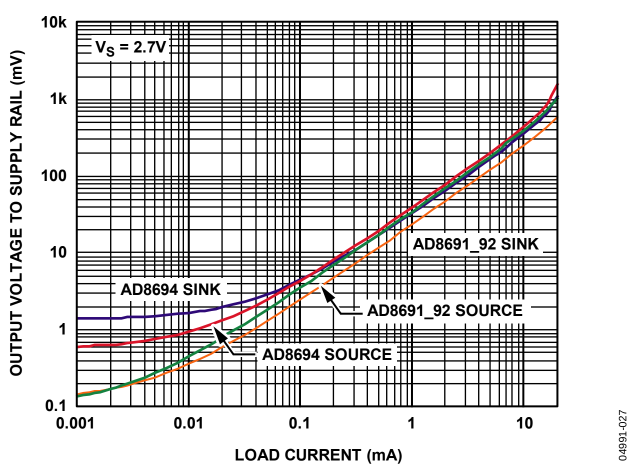



Figure 31. Output Voltage to Supply Rail vs. Load Current

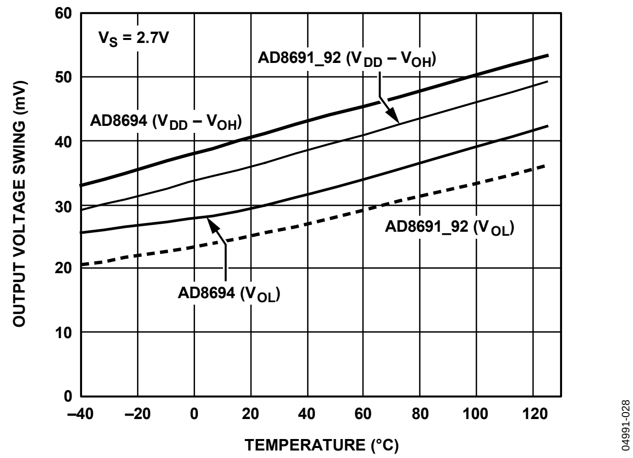



Figure 32. Output Voltage Swing vs. Temperature ($I_L$ = 1 mA)

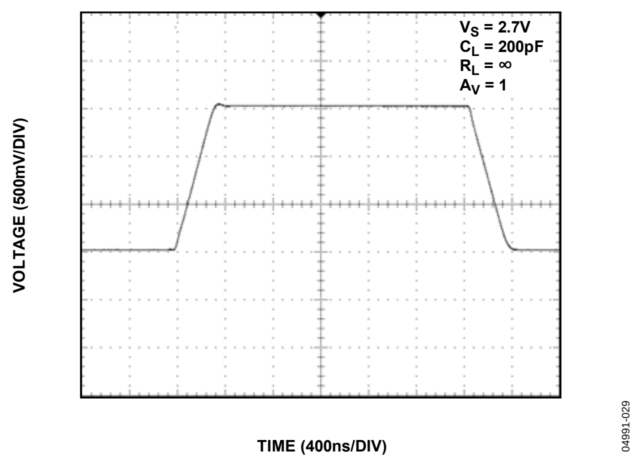



Figure 33. Large Signal Transient Response

# OUTLINE DIMENSIONS

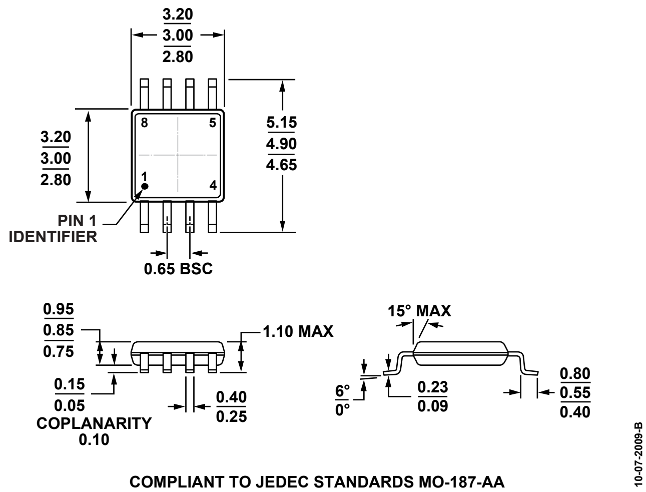



*Figure 34. 8-Lead Mini Small Outline Package [MSOP]*
*(RM-8)*
*Dimensions shown in millimeters*

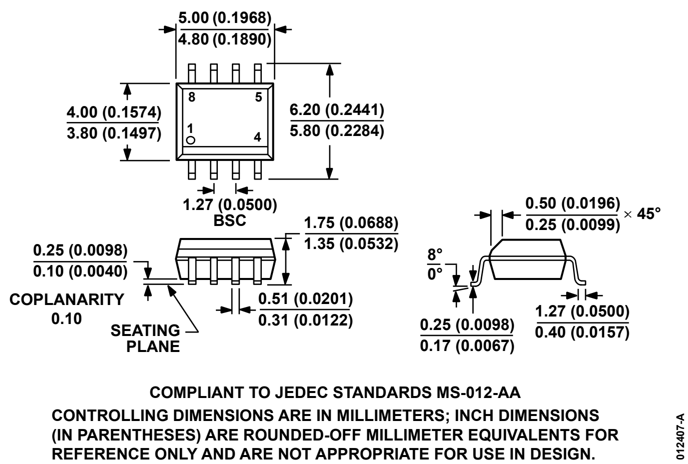



*Figure 35. 8-Lead Standard Small Outline Package [SOIC_N]*
*Narrow Body (R-8)*
*Dimensions shown in millimeters and (inches)*

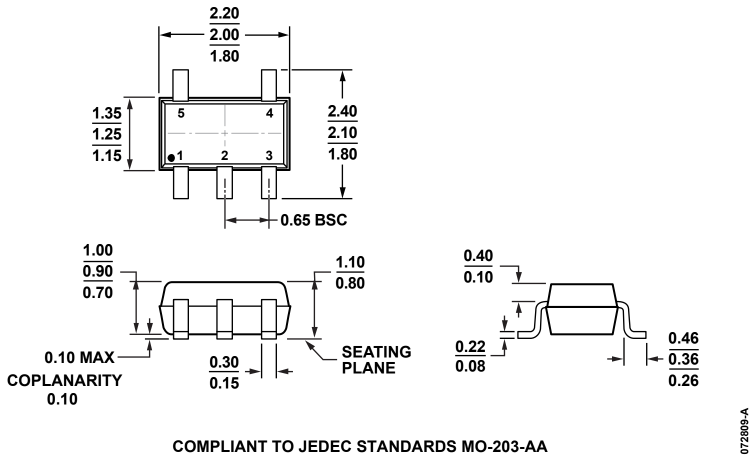



*Figure 36. 5-Lead Thin Shrink Small Outline Package [SC70]*
*(KS-5)*
*Dimensions shown in millimeters*

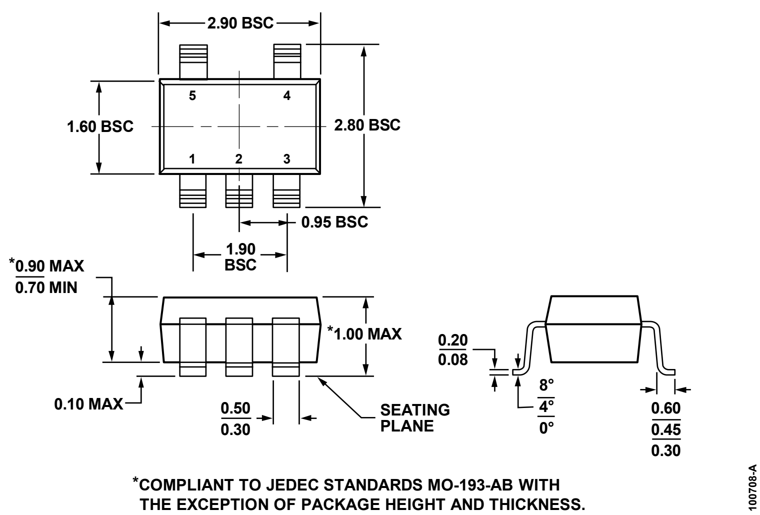



*Figure 37. 5-Lead Thin Small Outline Transistor Package [TSOT]*
*(UJ-5)*
*Dimensions shown in millimeters*

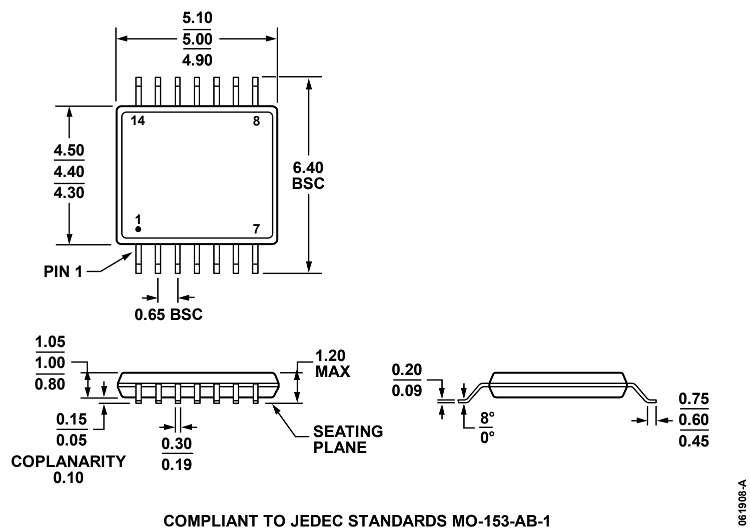



*Figure 38. 14-Lead Thin Shrink Small Outline Package [TSSOP]*
*(RU-14)*
*Dimensions shown in millimeters*

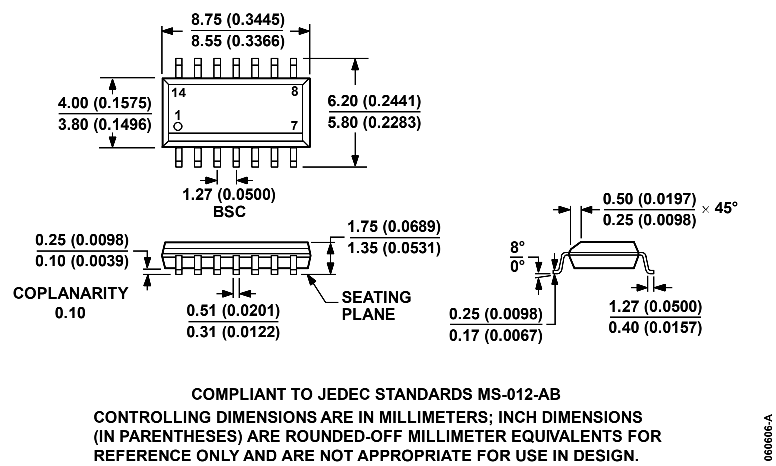



*Figure 39. 14-Lead Standard Small Outline Package [SOIC_N]*
*Narrow Body (R-14)*
*Dimensions shown in millimeters and (inches)*

## ORDERING GUIDE

| Model[1, 2] | 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 |
| AD8691WAUJZ-R7 | −40°C to +125°C | 5-Lead TSOT | UJ-5 | ACA |
| AD8691WAUJZ-RL | −40°C to +125°C | 5-Lead TSOT | UJ-5 | ACA |
| AD8692ARMZ-R7 | −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_N | R-8 | |
| AD8692ARZ-REEL | −40°C to +125°C | 8-Lead SOIC_N | R-8 | |
| AD8692ARZ-REEL7 | −40°C to +125°C | 8-Lead SOIC_N | R-8 | |
| AD8692WARMZ-REEL | −40°C to +125°C | 8-Lead MSOP | RM-8 | APA |
| AD8694ARUZ | −40°C to +125°C | 14-Lead TSSOP | RU-14 | |
| AD8694ARUZ-REEL | −40°C to +125°C | 14-Lead TSSOP | RU-14 | |
| AD8694WARUZ | −40°C to +125°C | 14-Lead TSSOP | RU-14 | |
| AD8694WARUZ-REEL | −40°C to +125°C | 14-Lead TSSOP | RU-14 | |
| AD8694ARZ | −40°C to +125°C | 14-Lead SOIC_N | R-14 | |
| AD8694ARZ-REEL | −40°C to +125°C | 14-Lead SOIC_N | R-14 | |
| AD8694ARZ-REEL7 | −40°C to +125°C | 14-Lead SOIC_N | R-14 | |

[1] Z = RoHS Compliant Part.
[2] W = Qualified for Automotive Applications.

## AUTOMOTIVE PRODUCTS

The AD8691W/AD8692W/AD8694W models are available with controlled manufacturing to support the quality and reliability requirements of automotive applications. Note that these automotive models may have specifications that differ from the commercial models; therefore, designers should review the Specifications section of this data sheet carefully. Only the automotive grade products shown are available for use in automotive applications. Contact your local Analog Devices account representative for specific product ordering information and to obtain the specific Automotive Reliability reports for these models.

## NOTES

# NOTES


D04991-0-8/11(E)

**Данный компонент на территории Российской Федерации**

**Вы можете приобрести в компании MosChip.**

Для оперативного оформления запроса Вам необходимо перейти по данной ссылке:

http://moschip.ru/get-element

Вы можете разместить у нас заказ для любого Вашего проекта, будь то серийное производство или разработка единичного прибора.

В нашем ассортименте представлены ведущие мировые производители активных и пассивных электронных компонентов.

Нашей специализацией является поставка электронной компонентной базы двойного назначения, продукции таких производителей как XILINX, Intel (ex.ALTERA), Vicor, Microchip, Texas Instruments, Analog Devices, Mini-Circuits, Amphenol, Glenair.

Сотрудничество с глобальными дистрибьюторами электронных компонентов, предоставляет возможность заказывать и получать с международных складов практически любой перечень компонентов в оптимальные для Вас сроки.

На всех этапах разработки и производства наши партнеры могут получить квалифицированную поддержку опытных инженеров.

Система менеджмента качества компании отвечает требованиям в соответствии с ГОСТ Р ИСО 9001, ГОСТ РВ 0015-002 и ЭС РД 009

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