

AD8691/AD8692/AD8694

FEATURES

- Offset voltage: 400 μ V typical**
- Low offset voltage drift: 6 μ V/ $^{\circ}$ C maximum**
(AD8692/AD8694)
- Very low input bias currents: 1 pA maximum**
- Low noise: 8 nV/ \sqrt 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 $+125^{\circ}$ 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.

Rev. E

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PIN CONFIGURATIONS

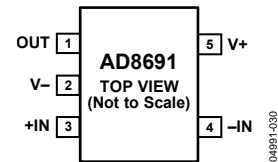


Figure 1. 5-Lead TSOT

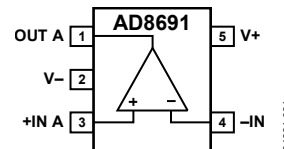


Figure 2. 5-Lead SC70



Figure 3. 8-Lead MSOP

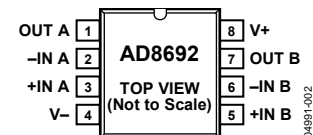


Figure 4. 8-Lead SOIC

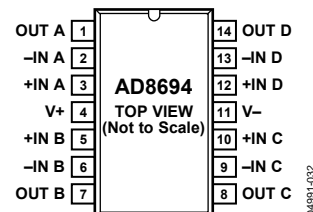


Figure 5. 14-Lead SOIC

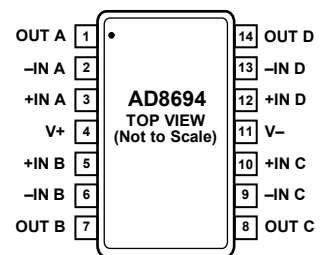


Figure 6. 14-Lead TSSOP

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11/10—Rev. C to Rev. D

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5/07—Rev. B to Rev. C

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3/05—Rev. A to Rev. B

Added AD8694	Universal
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1/05—Rev. 0 to Rev. A

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10/04—Revision 0: Initial Version

SPECIFICATIONS

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}	$I_L = 1\text{ mA}$ $-40^\circ\text{C} < T_A < +125^\circ\text{C}$		25	40	mV
Short-Circuit Current	I_{SC}			± 20		mA
Closed-Loop Output Impedance	Z_{OUT}	$f = 1\text{ MHz}, A_v = 1$		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_m			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

$V_S = 5.0\text{ V}$, $V_{CM} = V_S/2$, $T_A = 25^\circ\text{C}$, unless otherwise noted.

Table 2.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
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	$\Delta V_{OS}/\Delta T$					$\mu\text{V}/^\circ\text{C}$
				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}	$I_L = 1\text{ mA}$ $I_L = 10\text{ mA}$ $-40^\circ\text{C to }+125^\circ\text{C}$	4.96	4.98		V
			4.7	4.78		V
			4.6			V
Output 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
				165	210	mV
				185	240	mV
					290	mV
					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_m			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	$f = 1\text{ kHz}$		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.

Parameter	Rating
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°C to $+150^\circ\text{C}$
Operating Temperature Range	-40°C to $+125^\circ\text{C}$
Junction Temperature Range	-65°C to $+150^\circ\text{C}$
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

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

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

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

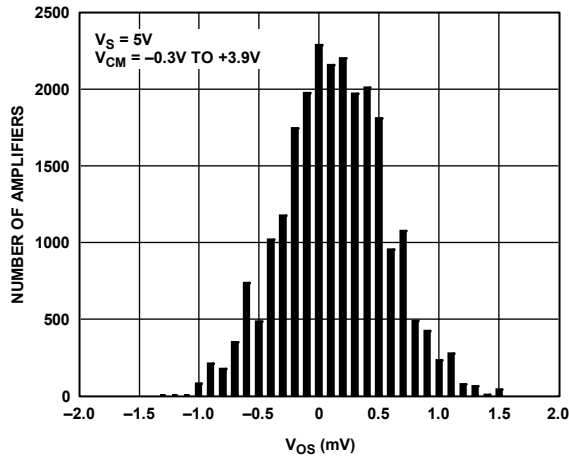


Figure 7. Input Offset Voltage Distribution

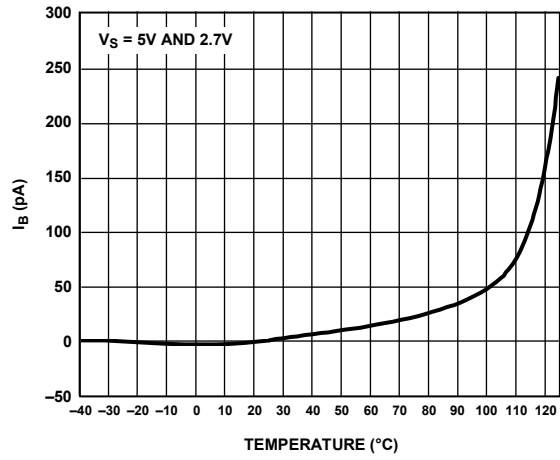


Figure 10. Input Bias Current vs. Temperature

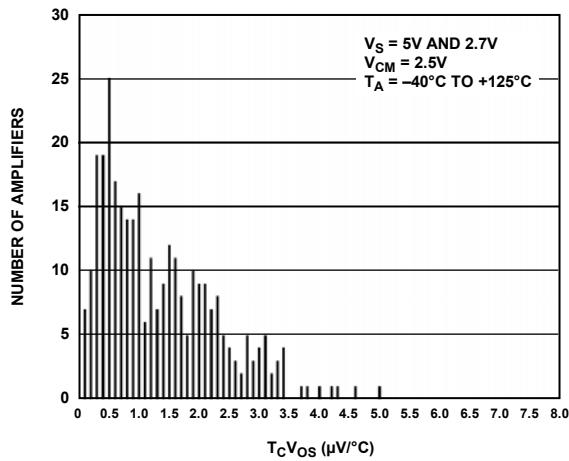


Figure 8. AD8692/AD8694 Input Offset Voltage Drift Distribution

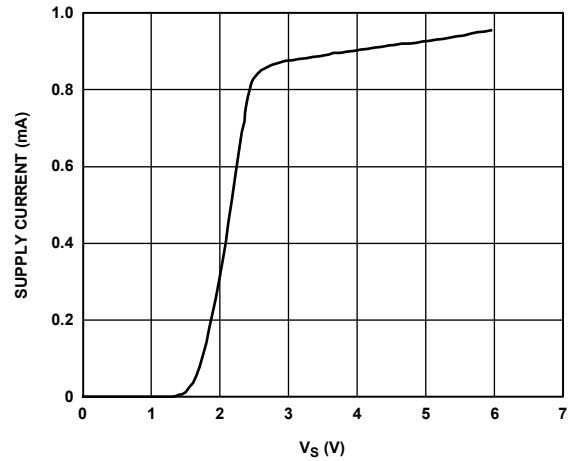


Figure 11. Supply Current vs. Supply Voltage

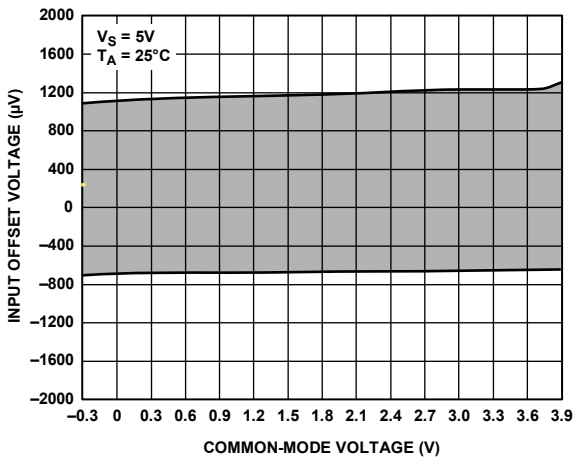


Figure 9. Input Offset Voltage vs. Common-Mode Voltage

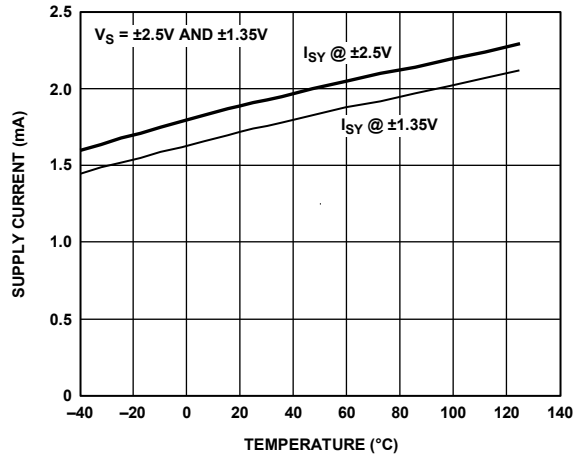


Figure 12. Supply Current vs. Temperature

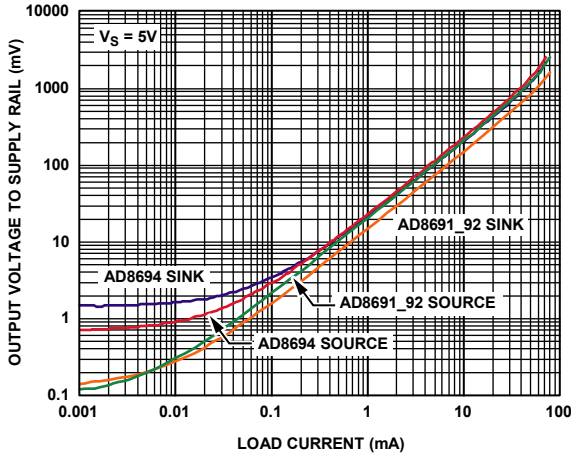


Figure 13. Output Voltage to Supply Rail vs. Load Current

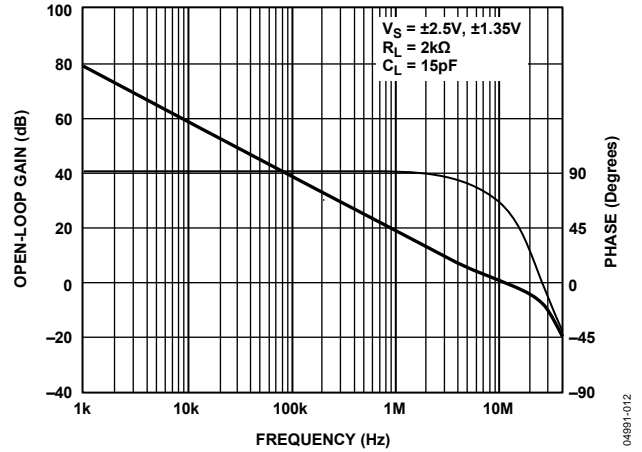


Figure 16. Open-Loop Gain and Phase vs. Frequency

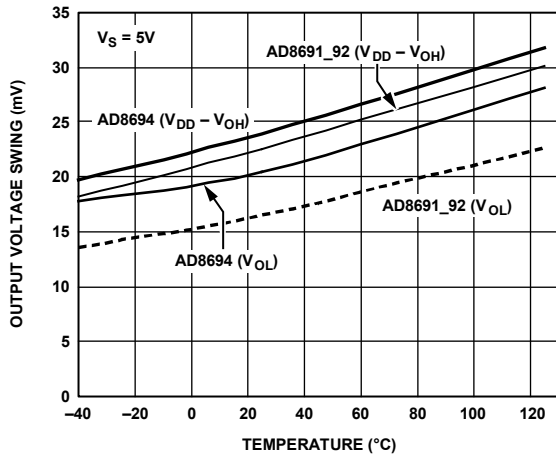


Figure 14. Output Voltage Swing vs. Temperature ($I_L = 1 \text{ mA}$)

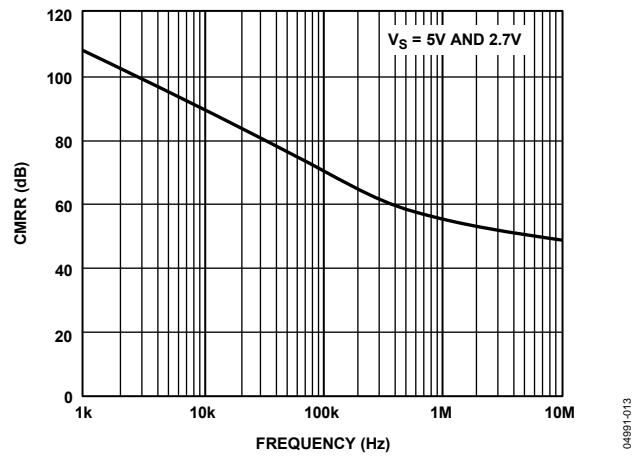


Figure 17. CMRR vs. Frequency

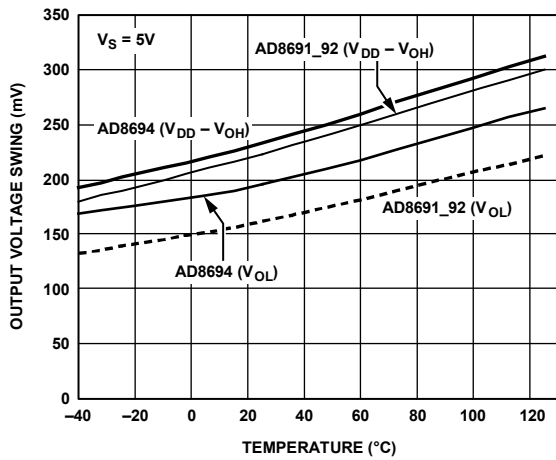


Figure 15. Output Voltage Swing vs. Temperature ($I_L = 10 \text{ mA}$)

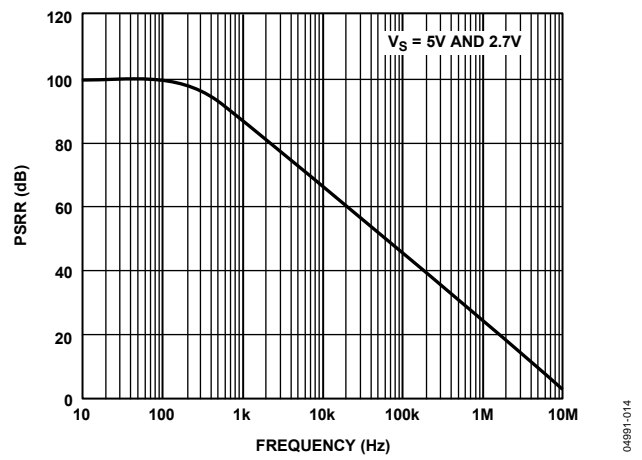


Figure 18. PSRR vs. Frequency

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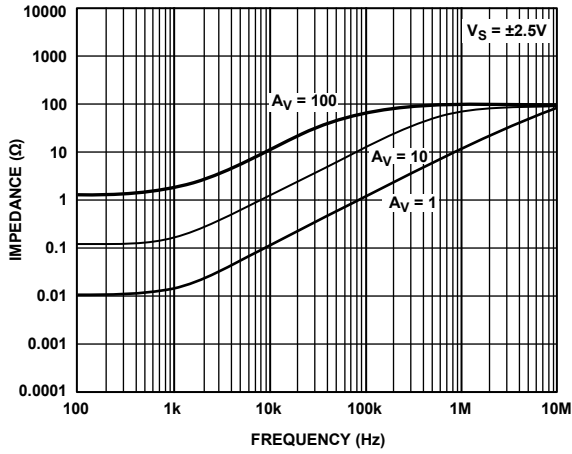


Figure 19. Closed-Loop Output Impedance vs. Frequency

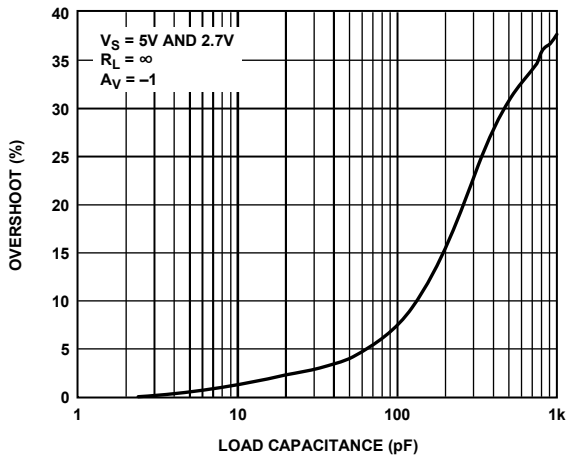


Figure 20. Small Signal Overshoot vs. Load Capacitance

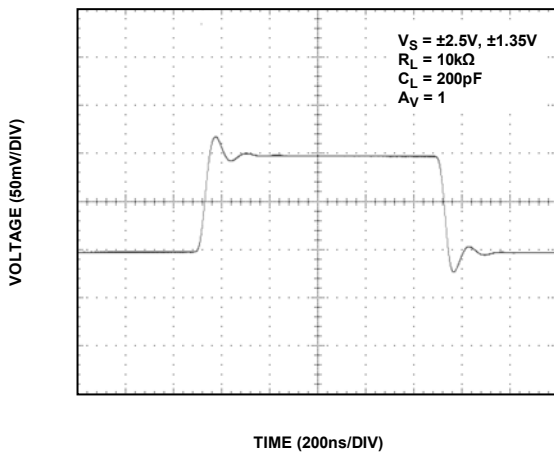


Figure 21. Small Signal Transient Response

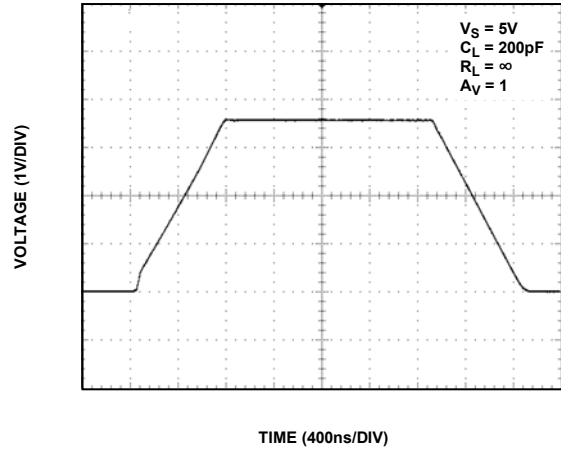


Figure 22. Large Signal Transient Response

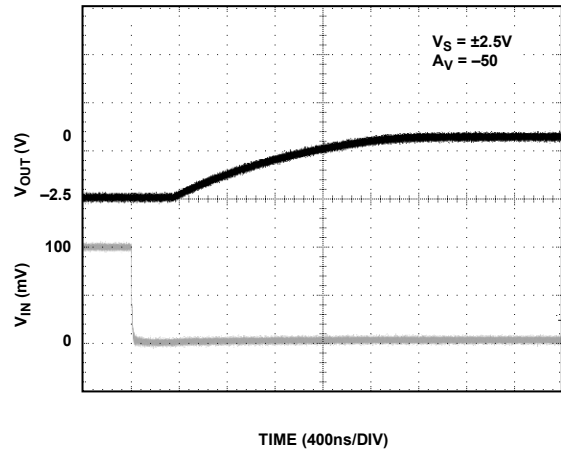


Figure 23. Positive Overload Recovery

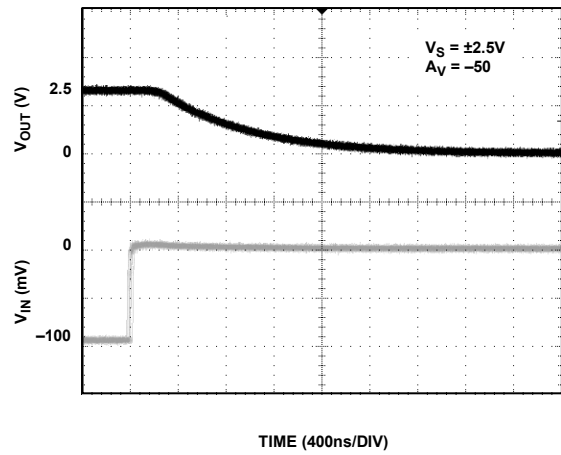


Figure 24. Negative Overload Recovery

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04991-016

04991-017

04991-018

04991-019

04991-020

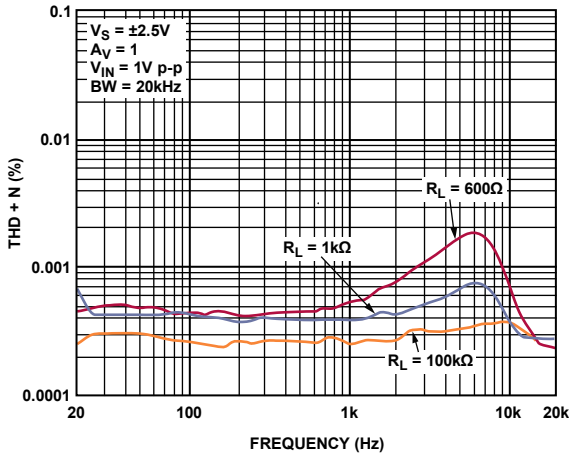


Figure 25. THD + N vs. Frequency

04891-021

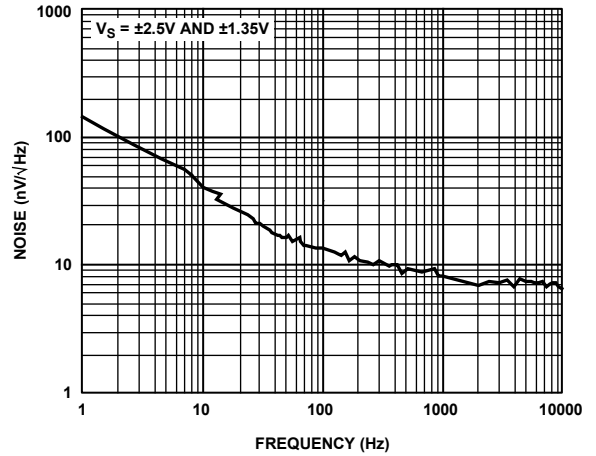


Figure 27. Voltage Noise Density

04891-023

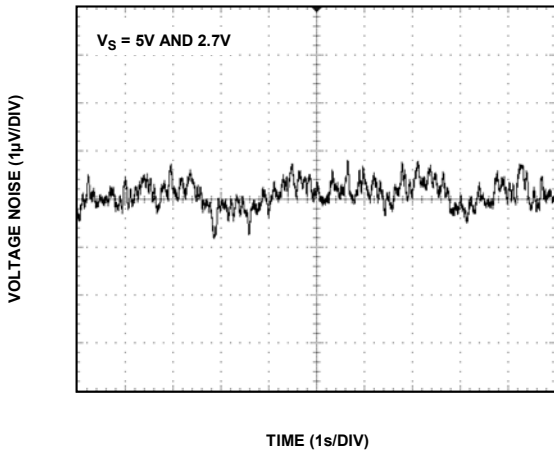


Figure 26. 0.1 Hz to 10 Hz Input Voltage Noise

04891-022

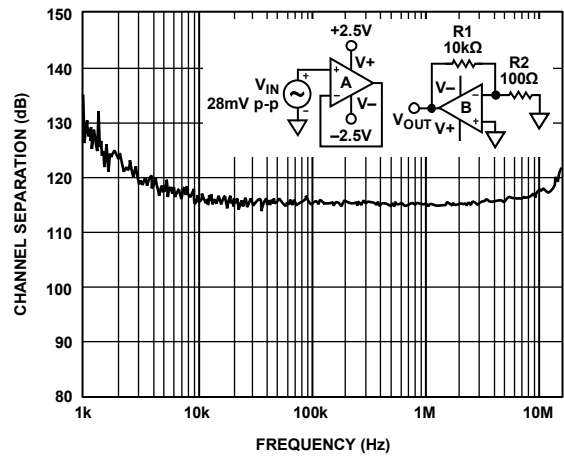


Figure 28. AD8692/AD8694 Channel Separation

04891-024

AD8691/AD8692/AD8694

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

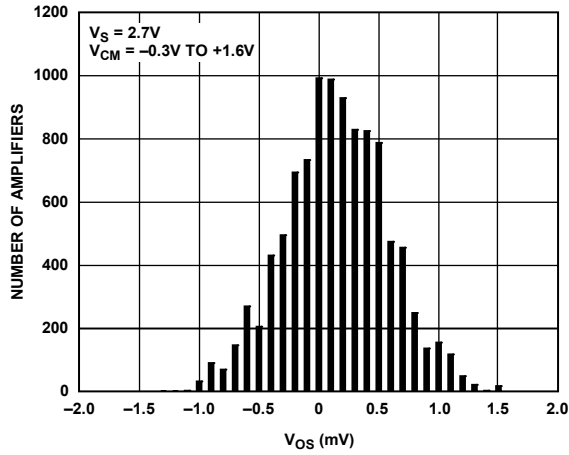


Figure 29. Input Offset Voltage Distribution

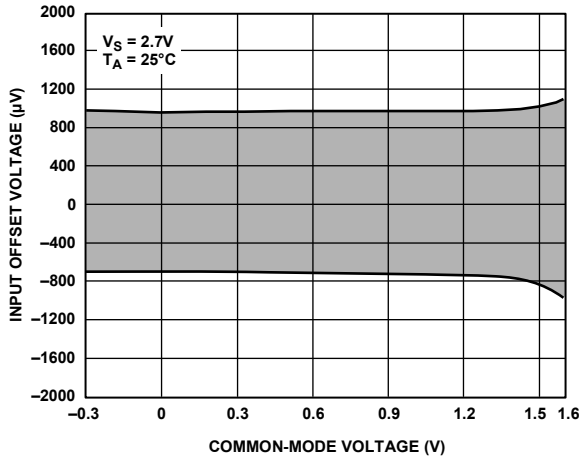


Figure 30. Input Offset Voltage vs. Common-Mode Voltage

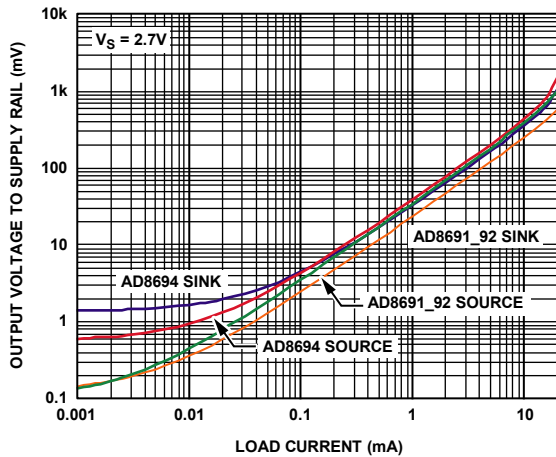


Figure 31. Output Voltage to Supply Rail vs. Load Current

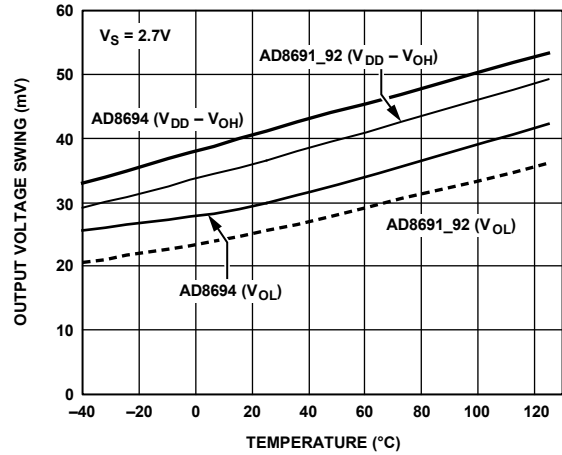


Figure 32. Output Voltage Swing vs. Temperature ($I_L = 1\text{ mA}$)

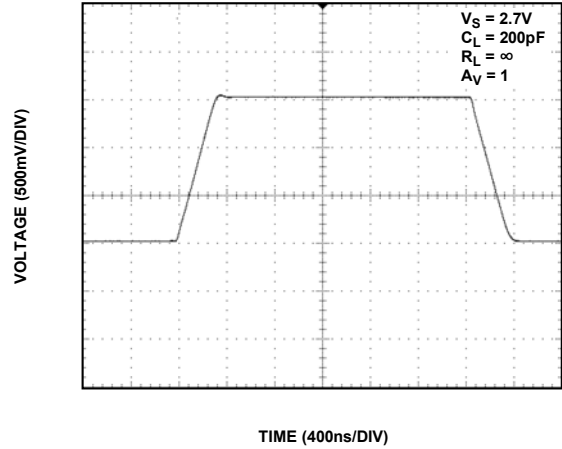


Figure 33. Large Signal Transient Response

04991-025

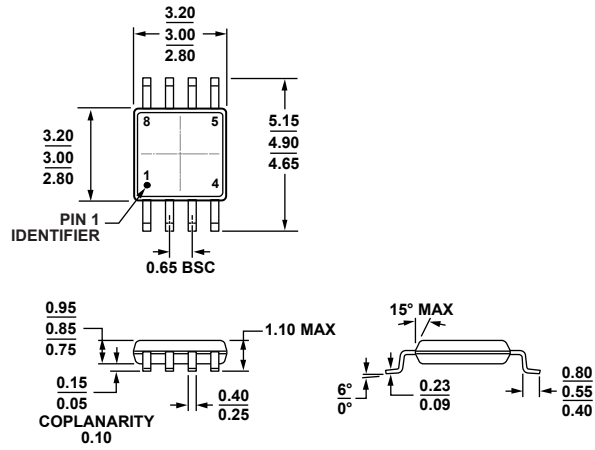
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04991-026

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04991-027

OUTLINE DIMENSIONS

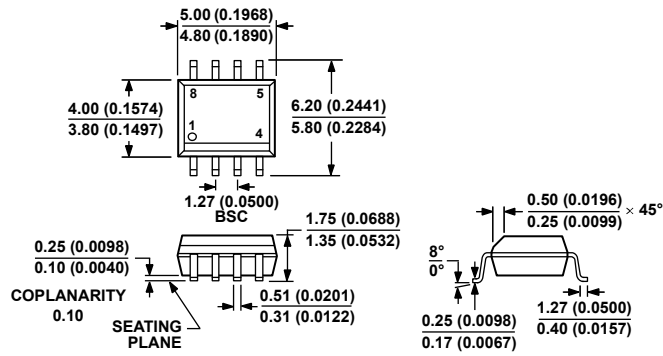


COMPLIANT TO JEDEC STANDARDS MO-187-AA

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

Dimensions shown in millimeters

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COMPLIANT TO JEDEC STANDARDS MS-012-AA

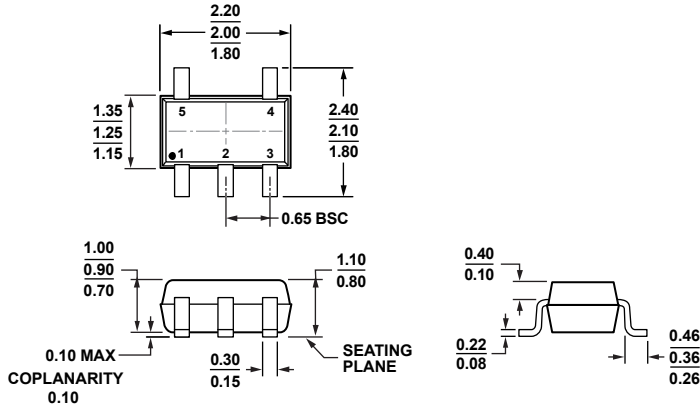
CONTROLLING DIMENSIONS ARE IN MILLIMETERS; INCH DIMENSIONS (IN PARENTHESES) ARE ROUNDED-OFF MILLIMETER EQUIVALENTS FOR REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN.

Figure 35. 8-Lead Standard Small Outline Package [SOIC_N] Narrow Body (R-8)

Dimensions shown in millimeters and (inches)

012407-A

AD8691/AD8692/AD8694

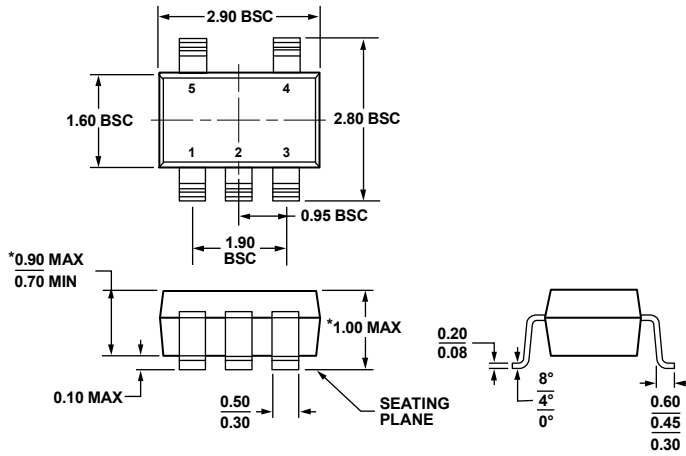


COMPLIANT TO JEDEC STANDARDS MO-203-AA

Figure 36. 5-Lead Thin Shrink Small Outline Package [SC70] (KS-5)

Dimensions shown in millimeters

072809-A

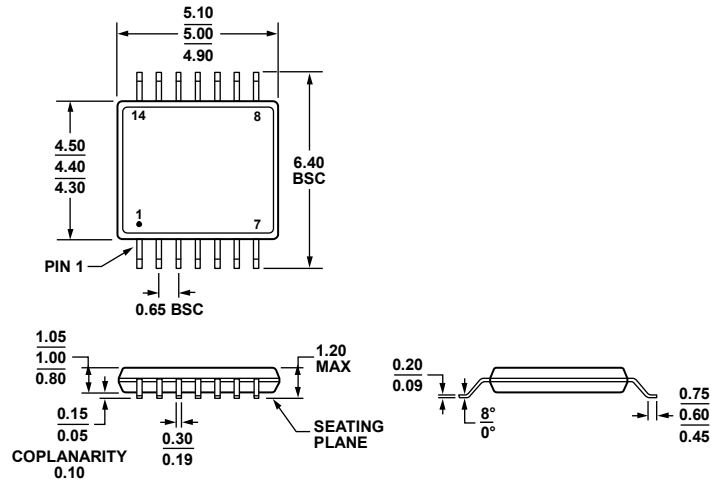


*COMPLIANT TO JEDEC STANDARDS MO-193-AB WITH THE EXCEPTION OF PACKAGE HEIGHT AND THICKNESS.

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

Dimensions shown in millimeters

100708-A

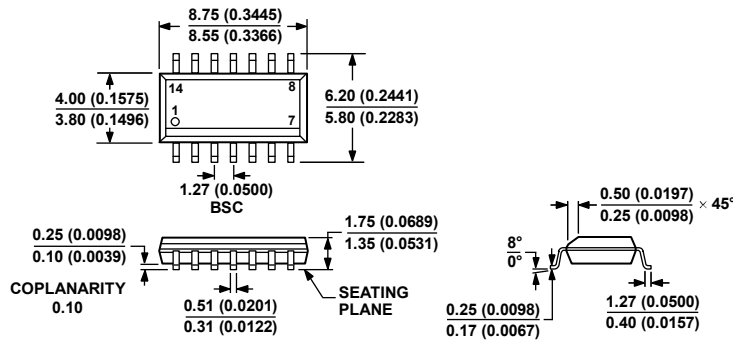


COMPLIANT TO JEDEC STANDARDS MO-153-AB-1

Figure 38. 14-Lead Thin Shrink Small Outline Package [TSSOP] (RU-14)

Dimensions shown in millimeters

061508-A



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 39. 14-Lead Standard Small Outline Package [SOIC_N] Narrow Body (R-14)

Dimensions shown in millimeters and (inches)

060606-A

AD8691/AD8692/AD8694

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

AD8691/AD8692/AD8694

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