Low Cost, Low Noise, CMOS Rail-to-Rail Output Operational Amplifiers

AD8691/AD8692/AD8694

FEATURES

Offset voltage: 400 µV typ
Low offset voltage drift: 6 µV/°C max (AD8692/AD8694)
Very low input bias currents: 1 pA max
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

APPLICATIONS

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

PIN CONFIGURATIONS

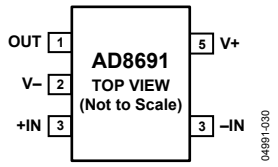

Figure 1. 5-Lead TSOT

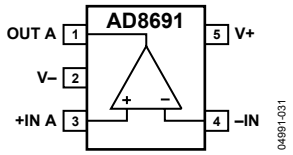

Figure 2. 5-Lead SC70

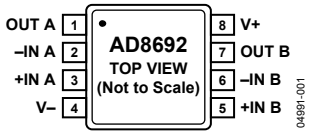

Figure 3. 8-Lead MSOP

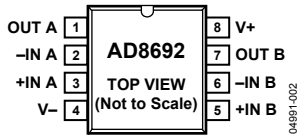

Figure 4. 8-Lead SOIC

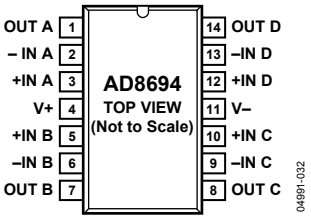

Figure 5. 14-Lead SOIC

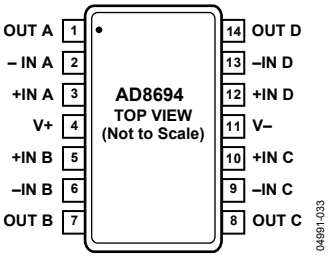

Figure 6. 14-Lead TSSOP

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 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 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.

Rev. B

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10/04—Revision 0: Initial Version

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}	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	$Ø_O$			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	$e_{n\,p-p}$	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 = 5°C, unless otherwise noted.

Table 2.

Parameter	Symbol	Conditions	A Grade Min	A Grade Typ	A Grade 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}	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
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	$Ø_O$			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.

Parameters	Ratings
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 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	°C/W
8-Lead SOIC (R)	158	43	°C/W
5-Lead TSOT (UJ-5)	207	61	°C/W
5-Lead SC70 (KS)	376	126	°C/W
14-Lead TSSOP (RU)	180	35	°C/W
14-Lead SOIC (R)	120	36	°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 V or ±2.5 V, unless otherwise noted.

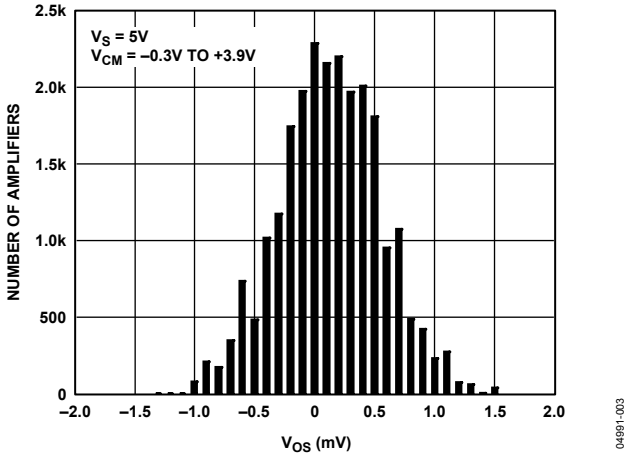

Figure 7. Input Offset Voltage Distribution

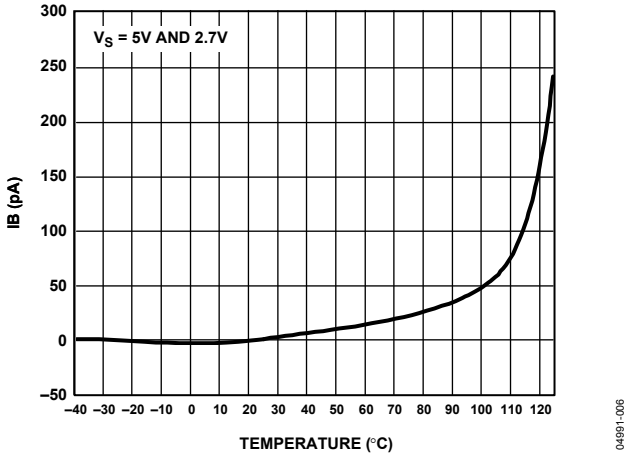

Figure 10. Input Bias Current vs. Temperature

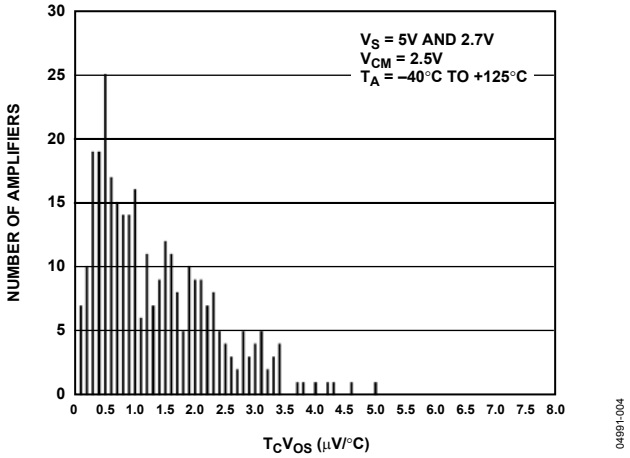

Figure 8. AD8692/AD8694 Input Offset Voltage Drift Distribution

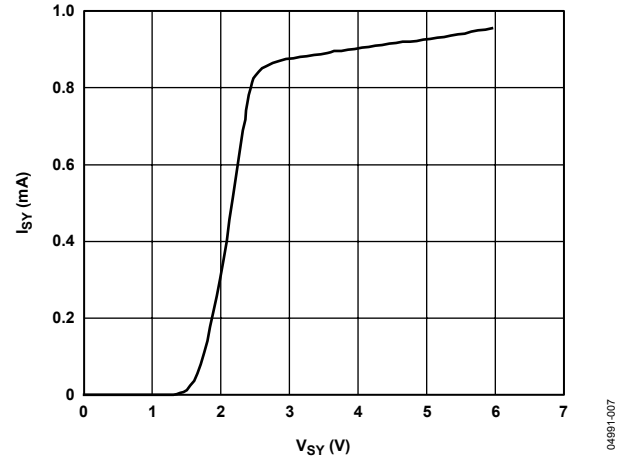

Figure 11. Supply Current vs. Supply Voltage

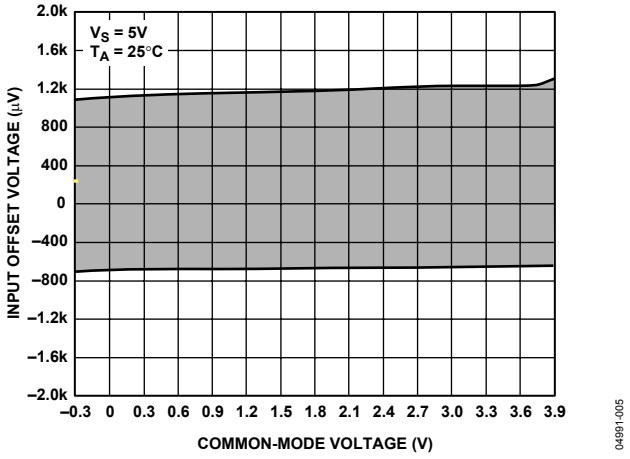

Figure 9. Input Offset Voltage vs. Common-Mode Voltage

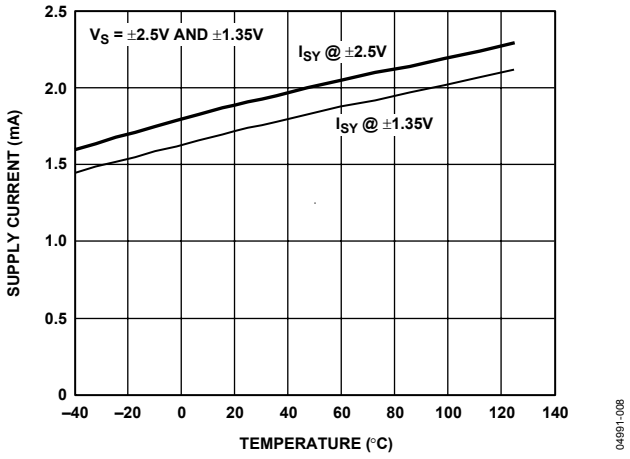

Figure 12. Supply Current vs. Temperature

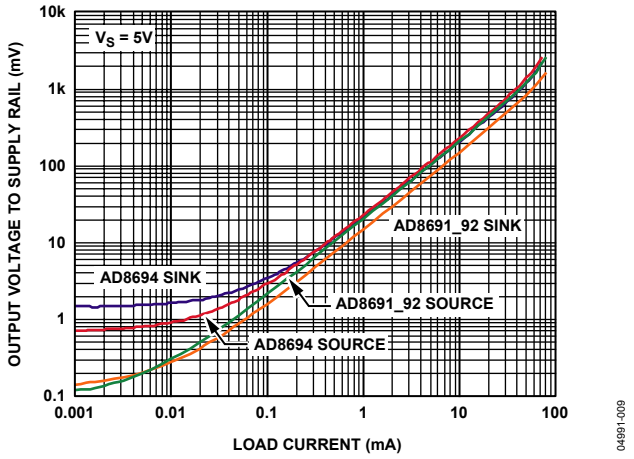

Figure 13. Output Voltage to Supply Rail vs. Load Current

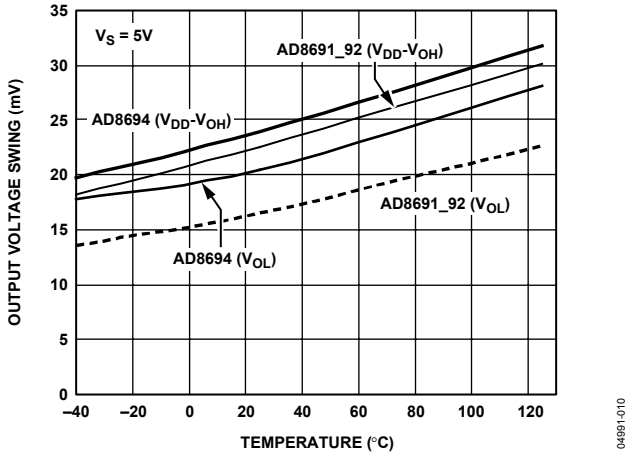

Figure 14. Output Voltage Swing vs. Temperature (I_L = 1 mA)

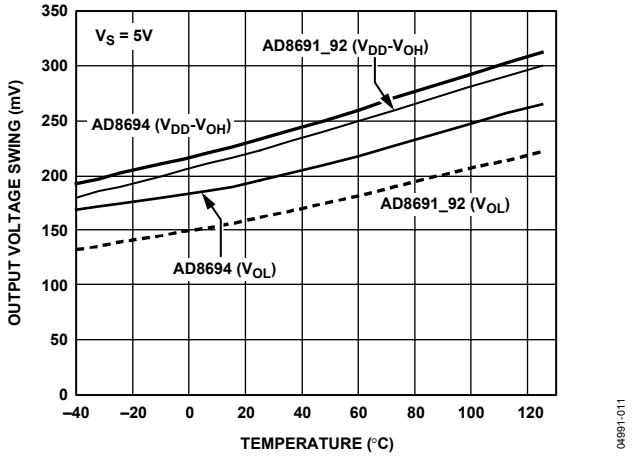

Figure 15. Output Voltage Swing vs. Temperature (I_L = 10 mA)

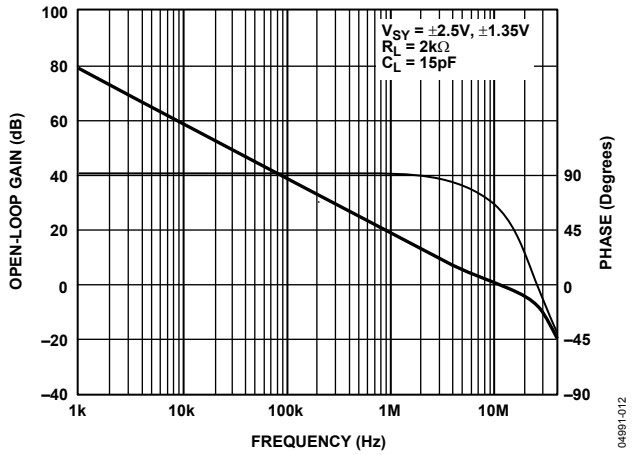

Figure 16. Open-Loop Gain and Phase vs. Frequency

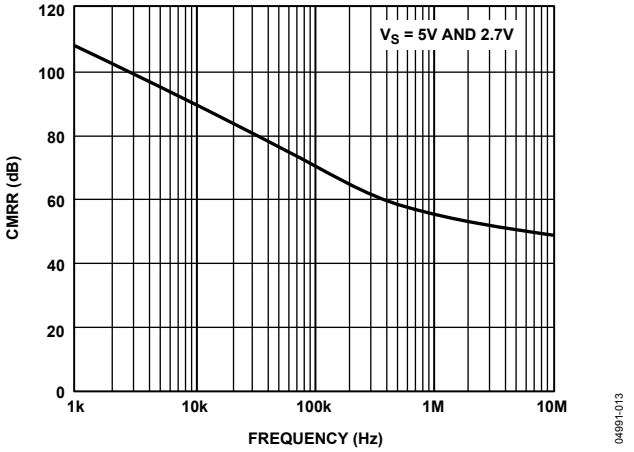

Figure 17. CMRR vs. Frequency

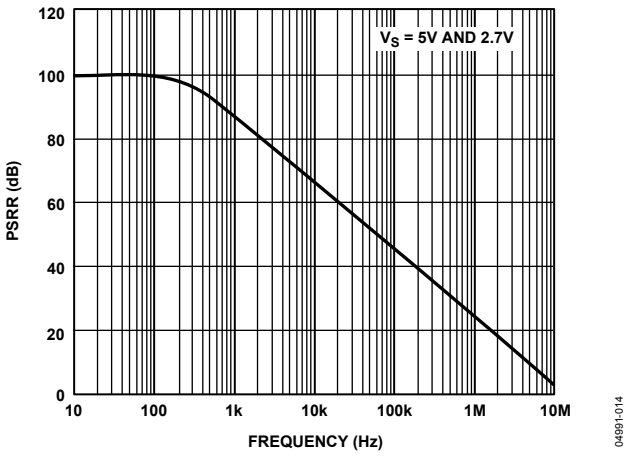

Figure 18. PSRR vs. Frequency

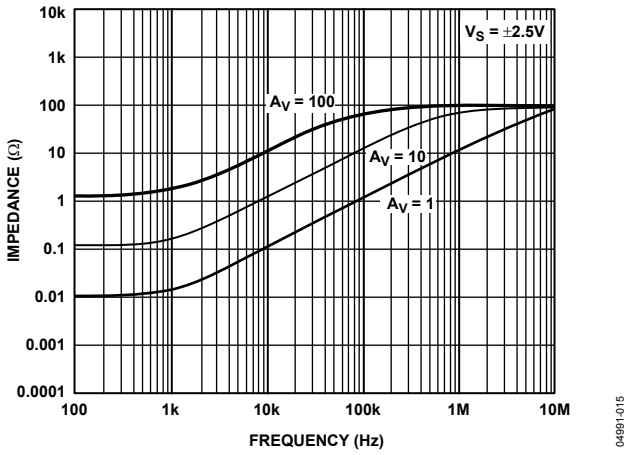

Figure 19. Closed-Loop Output Impedance vs. Frequency

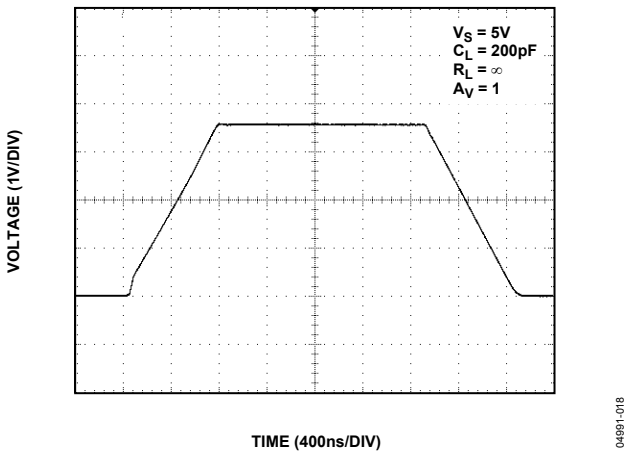

Figure 22. Large Signal Transient Response

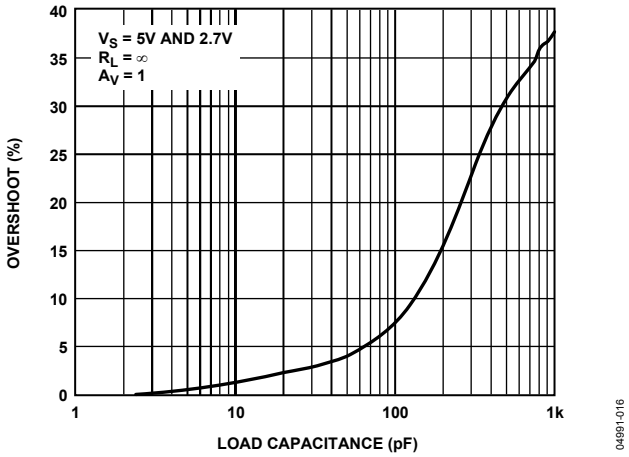

Figure 20. Small Signal Overshoot vs. Load Capacitance

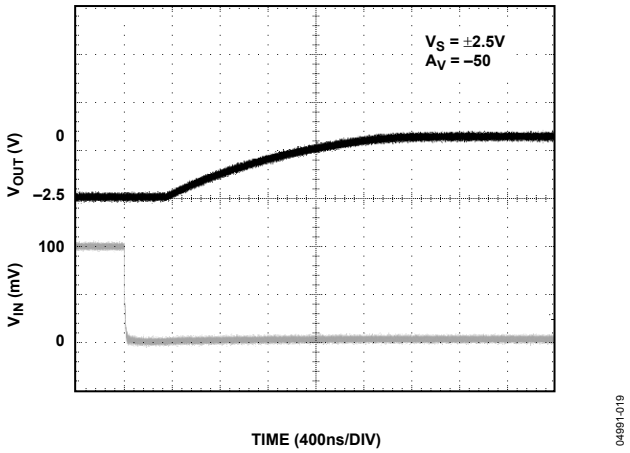

Figure 23. Positive Overload Recovery

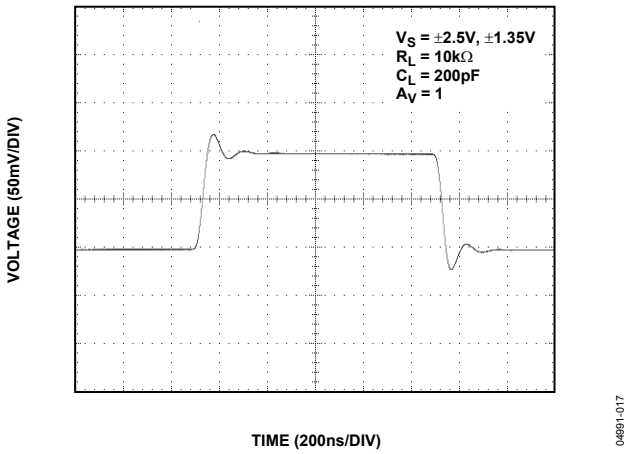

Figure 21. Small Signal Transient Response

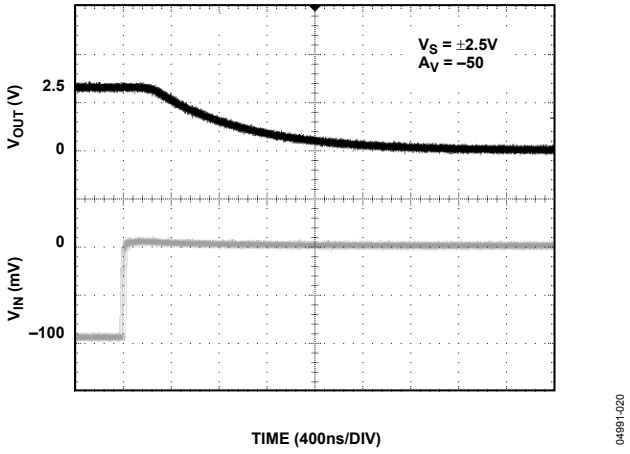

Figure 24. Negative Overload Recovery

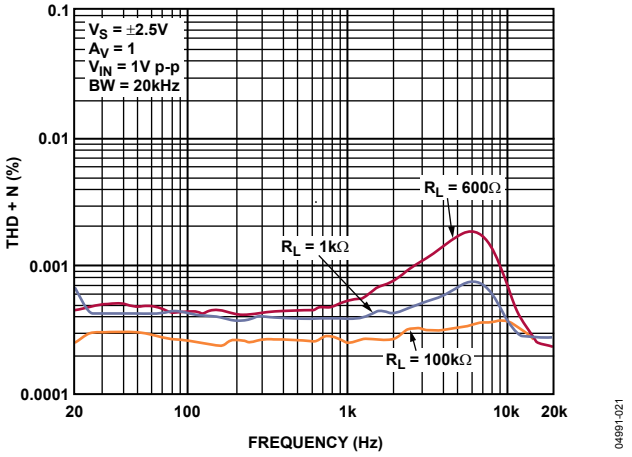

Figure 25. THD + N vs. Frequency

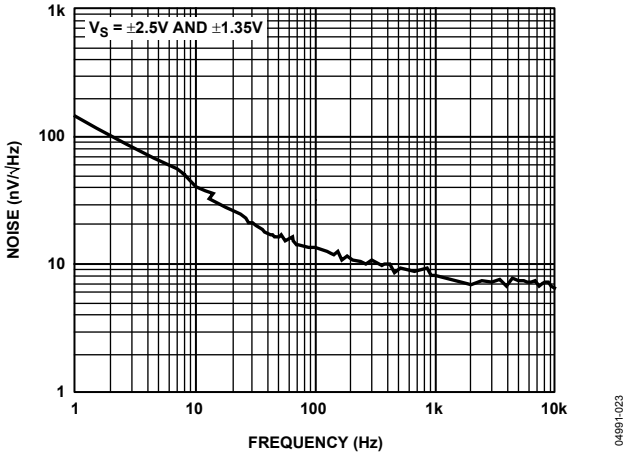

Figure 27. Voltage Noise Density

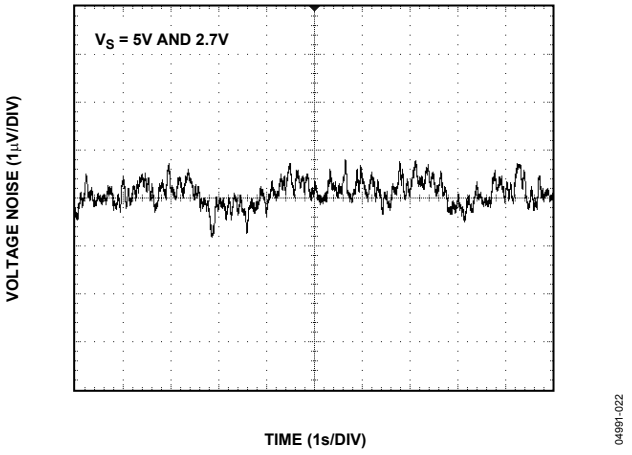

Figure 26. 0.1 Hz to 10 Hz Input Voltage Noise

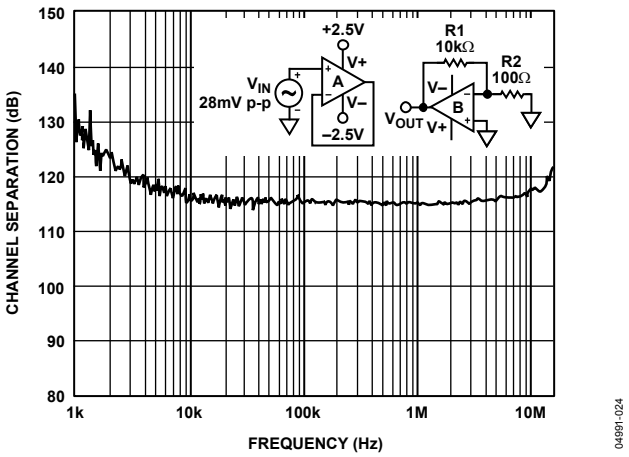

Figure 28. AD8692/AD8694 Channel Separation

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

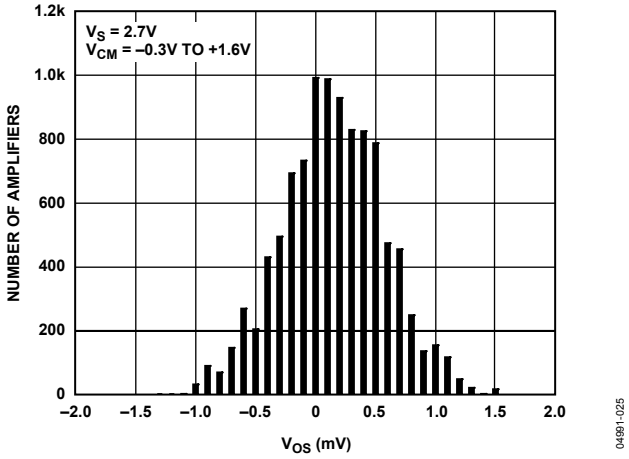

Figure 29. Input Offset Voltage Distribution

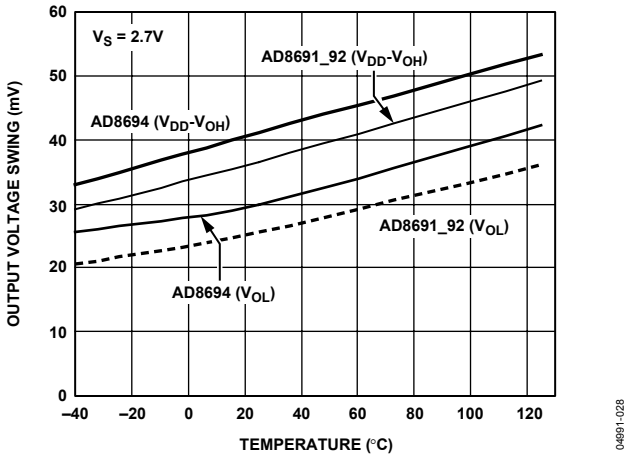

Figure 32. Output Voltage Swing vs. Temperature (I_L = 1 mA)

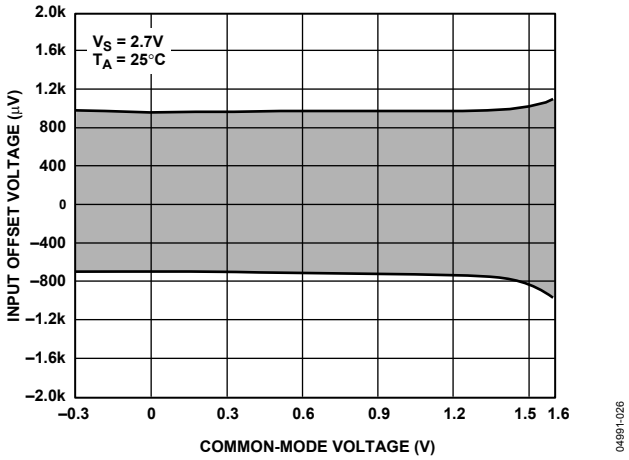

Figure 30. Input Offset Voltage vs. Common-Mode Voltage

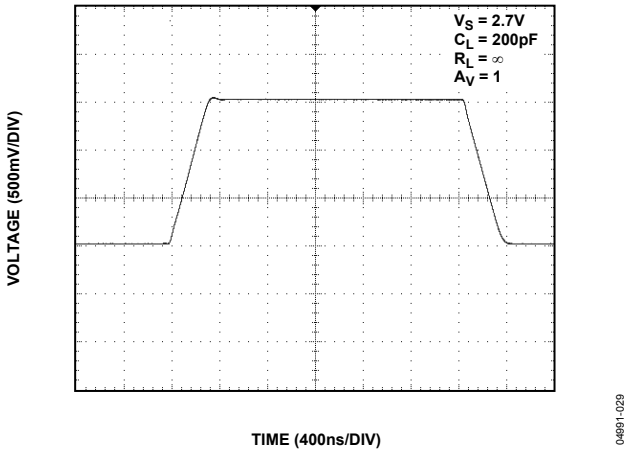

Figure 33. Large Signal Transient Response

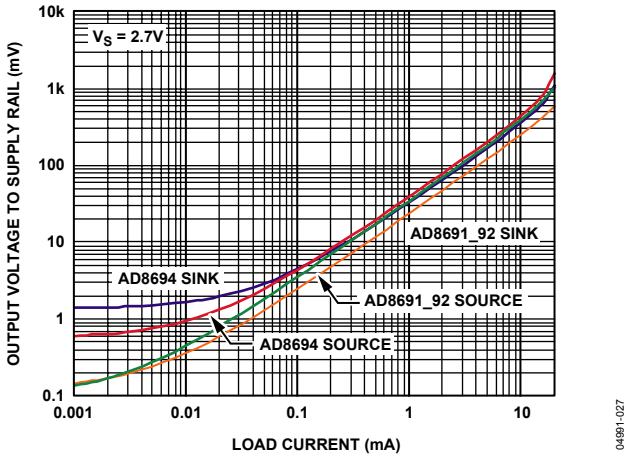

Figure 31. Output Voltage to Supply Rail vs. Load Current

OUTLINE DIMENSIONS

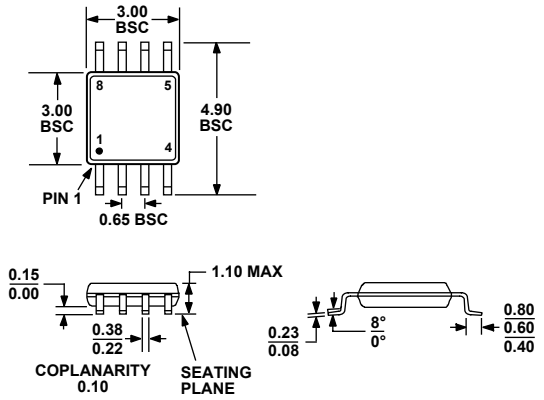

Figure 34. 8-Lead Mini Small Outline Package [MSOP]
(RM-8)
Dimensions shown in millimeters

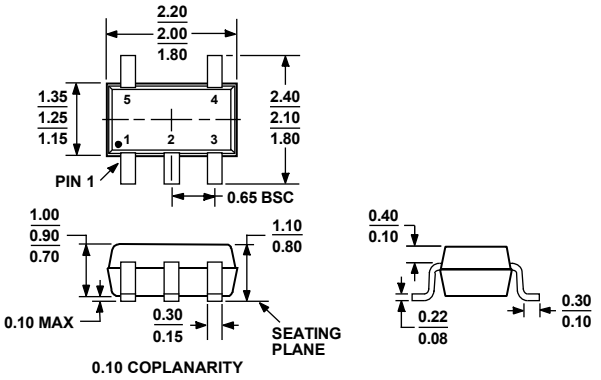

Figure 35. 5-Lead Thin Shrink Small Outline Package [SC70]
(KS-5)
Dimensions shown in millimeters

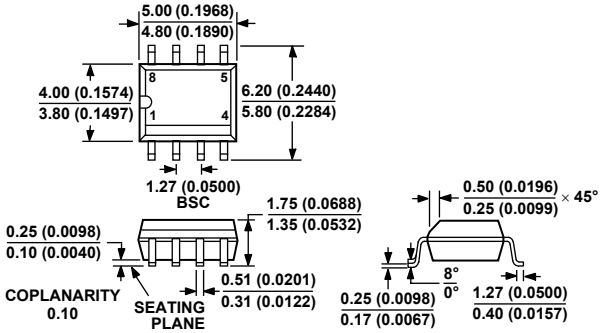

Figure 36. 8-Lead Standard Small Outline Package [SOIC]
Narrow Body (R-8)
Dimensions shown in millimeters and (inches)

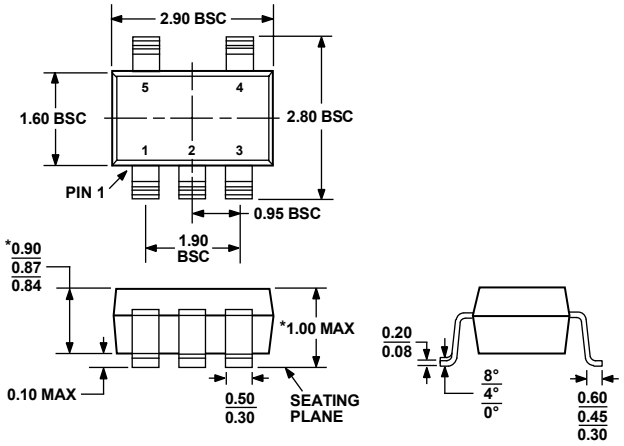

Figure 37. 5-Lead Thin Small Outline Transistor Package [TSOT]
(UJ-5)
Dimensions shown in millimeters

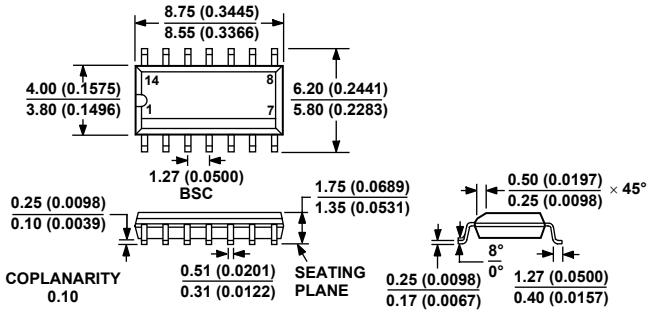

Figure 38. 14-Lead Standard Small Outline Package [SOIC]
Narrow Body (R-14)
Dimensions shown in millimeters

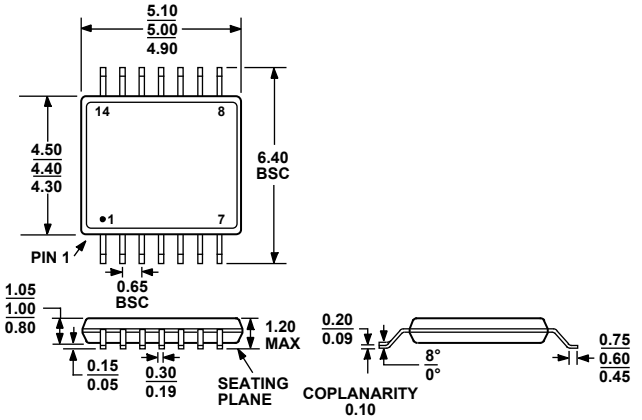

Figure 39. 14-Lead Thin Shrink Small Outline Package [TSSOP]
(RU-14)
Dimensions shown in millimeters

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.

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