24 MHz Rail-to-Rail Amplifiers with Shutdown Option

Data Sheet

AD8646/AD8647/AD8648

FEATURES

Offset voltage: 2.5 mV maximum
Single-supply operation: 2.7 V to 5.5 V
Low noise: 8 nV/√Hz
Wide bandwidth: 24 MHz
Slew rate: 11 V/μs
Short-circuit output current: 120 mA
Qualified for automotive applications
No phase reversal
Low input bias current: 1 pA
Low supply current per amplifier: 2 mA maximum
Unity gain stable

APPLICATIONS

Battery-powered instruments
Multipole filters
ADC front ends
Sensors
Barcode scanners
ASIC input or output amplifiers
Audio amplifiers
Photodiode amplifiers
Datapath/mux/switch control

PIN CONFIGURATIONS

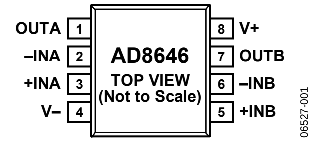

Figure 1. 8-Lead SOIC and MSOP

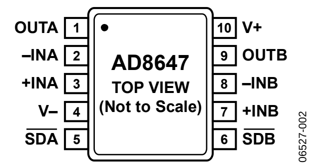

Figure 2. 10-Lead MSOP

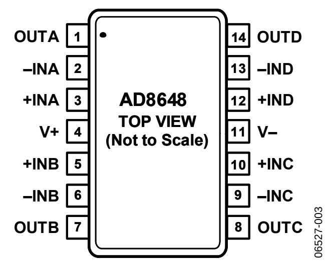

Figure 3. 14-Lead SOIC and TSSOP

GENERAL DESCRIPTION

The AD8646 and the AD8647 are the dual, and the AD8648 is the quad, rail-to-rail, input and output, single-supply amplifiers featuring low offset voltage, wide signal bandwidth, low input voltage, and low current noise. The AD8647 also has a low power shutdown function.

The combination of 24 MHz bandwidth, low offset, low noise, and very low input bias current makes these amplifiers useful in a wide variety of applications. Filters, integrators, photodiode amplifiers, and high impedance sensors all benefit from the combination of performance features. AC applications benefit from the wide bandwidth and low distortion. The AD8646/AD8647/AD8648 offer high output drive capability, which is excellent for audio line drivers and other low impedance applications. The AD8646 and AD8648 are available for automotive applications (see the Ordering Guide).

Applications include portable and low powered instrumentation, audio amplification for portable devices, portable phone headsets, barcode scanners, and multipole filters. The ability to swing rail to rail at both the input and output enables designers to buffer CMOS ADCs, DACs, ASICs, and other wide output swing devices in single-supply systems.

Rev. F Document Feedback

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 781.329.4700
Technical Support **www.analog.com**

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4/2010—Rev. C to Rev. D
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10/2007—Revision B: Initial Combined Version

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8/2007—Revision 0: Initial Version

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1/2006—Revision 0: Initial Version

SPECIFICATIONS

V_{SY} = 5 V, V_{CM} = V_{SY}/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 V to 5 V		0.6	2.5	mV
		−40°C < T_A < +125°C			3.2	mV
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	−40°C < T_A < +125°C		1.8	7.5	μV/°C
Input Bias Current	I_B			0.3	1	pA
		−40°C < T_A < +85°C			50	pA
		−40°C < T_A < +125°C			550	pA
Input Offset Current	I_{OS}			0.1	0.5	pA
		−40°C < T_A < +85°C			50	pA
		−40°C < T_A < +125°C			250	pA
Input Voltage Range	V_{CM}		0		5	V
Common-Mode Rejection Ratio	CMRR	V_{CM} = 0 V to 5 V	67	84		dB
Large Signal Voltage Gain	A_{VO}	R_L = 2 kΩ, V_O = 0.5 V to 4.5 V	104	116		dB
Input Capacitance						
Differential	C_{DIFF}			2.5		pF
Common Mode	C_{CM}			6.7		pF
OUTPUT CHARACTERISTICS						
Output Voltage High	V_{OH}	I_{OUT} = 1 mA	4.98	4.99		V
		−40°C < T_A < +125°C	4.90			V
		I_{OUT} = 10 mA	4.85	4.92		V
		−40°C < T_A < +125°C	4.70			V
Output Voltage Low	V_{OL}	I_{OUT} = 1 mA		8.4	20	mV
		−40°C < T_A < +125°C			40	mV
		I_{OUT} = 10 mA		78	145	mV
		−40°C < T_A < +125°C			200	mV
Output Current	I_{SC}	Short circuit		±120		mA
Closed-Loop Output Impedance	Z_{OUT}	At 1 MHz, A_V = 1		5		Ω
POWER SUPPLY						
Power Supply Rejection Ratio	PSRR	V_{SY} = 2.7 V to 5.5 V	63	80		dB
Supply Current per Amplifier	I_{SY}			1.5	2.0	mA
		−40°C < T_A < +125°C			2.5	mA
Supply Current Shutdown Mode (AD8647 Only)	I_{SD}	Both amplifiers shut down, V_{IN_SDA} and V_{IN_SDB} = 0 V		10		nA
		−40°C < T_A < +125°C			1	μA
SHUTDOWN INPUTS (AD8647)						
Logic High Voltage (Enabled)	V_{INH}	−40°C < T_A < +125°C	+2.0			V
Logic Low Voltage (Power-Down)	V_{INL}	−40°C < T_A < +125°C			+0.8	V
Logic Input Current (Per Pin)	I_{IN}	−40°C < T_A < +125°C			1	μA
Output Pin Leakage Current		−40°C < T_A < +125°C (shutdown active)		1		nA
DYNAMIC PERFORMANCE						
Slew Rate	SR	R_L = 2 kΩ		11		V/μs
Gain Bandwidth Product	GBP			24		MHz
Phase Margin	$Ø_m$			74		Degrees
Settling Time	t_s	To 0.1%		0.5		μs
Amplifier Turn-On Time (AD8647)	t_{on}	25°C, A_V = 1, R_L = 1 kΩ (see Figure 44)		1		μs
Amplifier Turn-Off Time (AD8647)	t_{off}	25°C, A_V = 1, R_L = 1 kΩ (see Figure 45)		1		μs

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
NOISE PERFORMANCE						
Peak-to-Peak Noise	e_n p-p	0.1 Hz to 10 Hz		2.3		μV
Voltage Noise Density	e_n	f = 1 kHz		8		nV/√Hz
		f = 10 kHz		6		nV/√Hz
Channel Separation	CS	f = 10 kHz		−115		dB
		f = 100 kHz		−110		dB
Total Harmonic Distortion Plus Noise	THD + N	V p-p = 0.1 V, R_L = 600 Ω, f = 25 kHz, T_A = 25°C				
		A_V = +1		0.010		%
		A_V = −10		0.021		%

V_{SY} = 2.7 V, V_{CM} = V_{SY}/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 V to 2.7 V		0.6	2.5	mV
		−40°C < T_A < +125°C			3.2	mV
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	−40°C < T_A < +125°C		1.8	7.0	µV/°C
Input Bias Current	I_B			0.2	1	pA
		−40°C < T_A < +85°C			50	pA
		−40°C < T_A < +125°C			550	pA
Input Offset Current	I_{OS}			0.1	0.5	pA
		−40°C < T_A < +85°C			50	pA
		−40°C < T_A < +125°C			250	pA
Input Voltage Range	V_{CM}		0		2.7	V
Common-Mode Rejection Ratio	CMRR	V_{CM} = 0 V to 2.7 V	62	79		dB
Large Signal Voltage Gain	A_{VO}	R_L = 2 kΩ, V_O = 0.5 V to 2.2 V	95	102		dB
Input Capacitance						
Differential	C_{DIFF}			2.5		pF
Common Mode	C_{CM}			7.8		pF
OUTPUT CHARACTERISTICS						
Output Voltage High	V_{OH}	I_{OUT} = 1 mA	2.65	2.68		V
		−40°C < T_A < +125°C	2.60			V
Output Voltage Low	V_{OL}	I_{OUT} = 1 mA		11	25	mV
		−40°C < T_A < +125°C			30	mV
Output Current	I_{sc}	Short circuit		±63		mA
Closed-Loop Output Impedance	Z_{OUT}	At 1 MHz, A_V = 1		5		Ω
POWER SUPPLY						
Power Supply Rejection Ratio	PSRR	V_{SY} = 2.7 V to 5.5 V	63	80		dB
Supply Current per Amplifier	I_{SY}			1.6	2.0	mA
		−40°C < T_A < +125°C			2.5	mA
Supply Current Shutdown Mode (AD8647 Only)	I_{SD}	Both amplifiers shut down, V_{IN_SDA} and V_{IN_SDB} = 0 V		10		nA
		−40°C < T_A < +125°C			1	µA
SHUTDOWN INPUTS (AD8647)						
Logic High Voltage (Enabled)	V_{INH}	−40°C < T_A < +125°C	+2.0			V
Logic Low Voltage (Power-Down)	V_{INL}	−40°C < T_A < +125°C			+0.8	V
Logic Input Current (Per Pin)	I_{IN}	−40°C < T_A < +125°C			1	µA
Output Pin Leakage Current		−40°C < T_A < +125°C (shutdown active)		1		nA
DYNAMIC PERFORMANCE						
Slew Rate	SR	R_L = 2 kΩ		11		V/µs
Gain Bandwidth Product	GBP			24		MHz
Phase Margin	$Ø_m$			53		Degrees
Settling Time	t_s	To 0.1%		0.3		µs
Amplifier Turn-On Time (AD8647)	t_{on}	25°C, A_V = 1, R_L = 1 kΩ (see Figure 41)		1.2		µs
Amplifier Turn-Off Time (AD8647)	t_{off}	25°C, A_V = 1, R_L = 1 kΩ (see Figure 42)		1		µs
NOISE PERFORMANCE						
Peak-to-Peak Noise	e_n p-p	0.1 Hz to 10 Hz		2.3		µV
Voltage Noise Density	e_n	f = 1 kHz		8		nV/√Hz
		f = 10 kHz		6		nV/√Hz
Channel Separation	CS	f = 10 kHz		−115		dB
		f = 100 kHz		−110		dB

ABSOLUTE MAXIMUM RATINGS

Table 3.

Parameter	Rating
Supply Voltage	6 V
Input Voltage	GND to V_{SY}
Differential Input Voltage	±6 V
Output Short Circuit to GND	Indefinite
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	−40°C to +125°C
Lead Temperature (Soldering 60 sec)	300°C
Junction Temperature	150°C

Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only; functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

THERMAL RESISTANCE

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

Table 4. Thermal Resistance

Package Type	θ_{JA}	θ_{JC}	Unit
8-Lead SOIC_N	125	43	°C/W
8-Lead MSOP	210	45	°C/W
10-Lead MSOP	200	44	°C/W
14-Lead SOIC_N	120	36	°C/W
14-Lead TSSOP	180	35	°C/W

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

TYPICAL PERFORMANCE CHARACTERISTICS

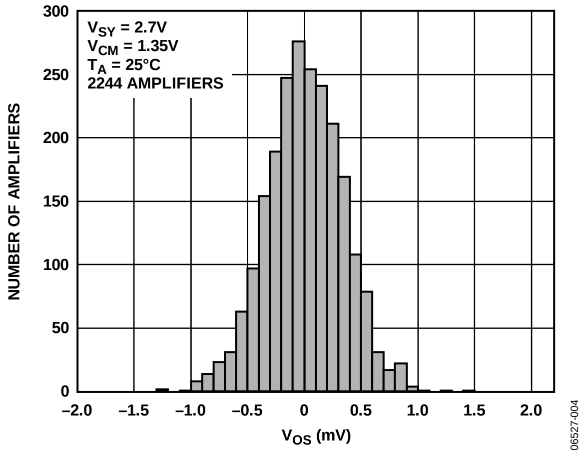


Figure 4. Input Offset Voltage Distribution

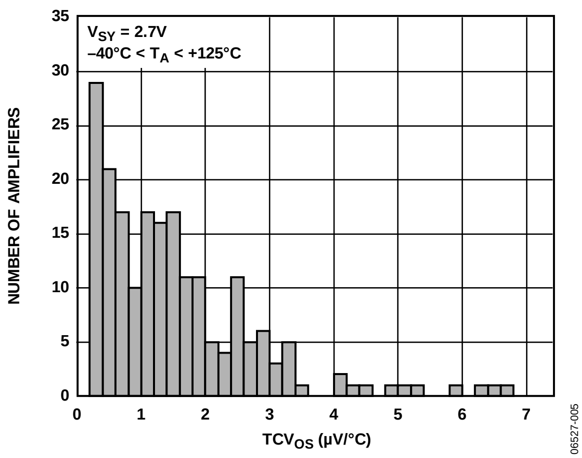


Figure 5. V_{OS} Drift (TCV_{OS}) Distribution

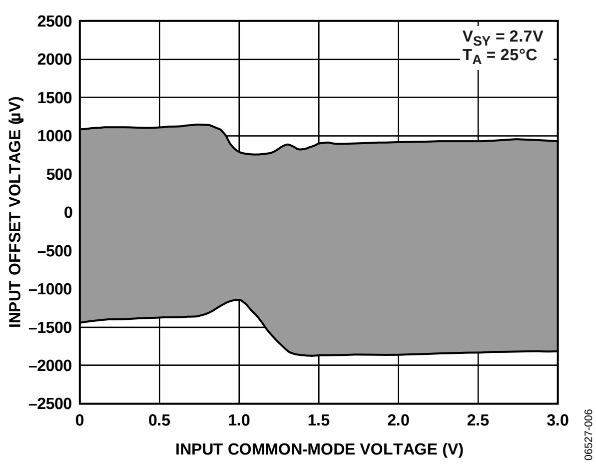


Figure 6. Input Offset Voltage vs. Input Common-Mode Voltage

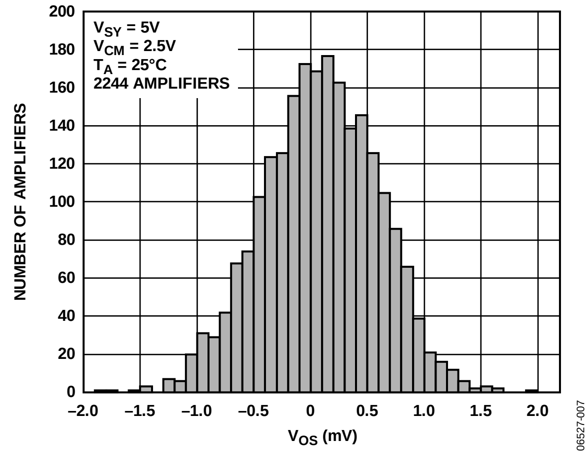


Figure 7. Input Offset Voltage Distribution

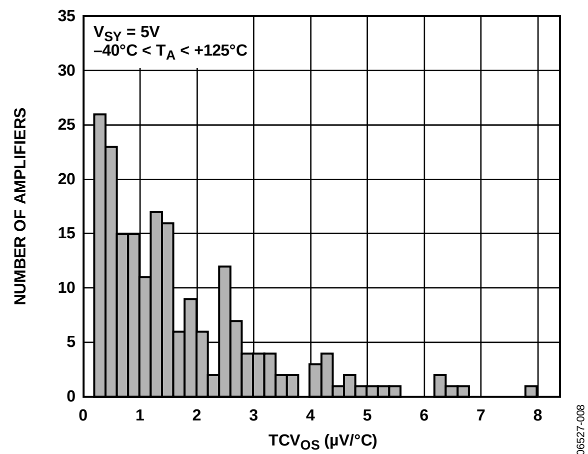


Figure 8. V_{OS} Drift (TCV_{OS}) Distribution

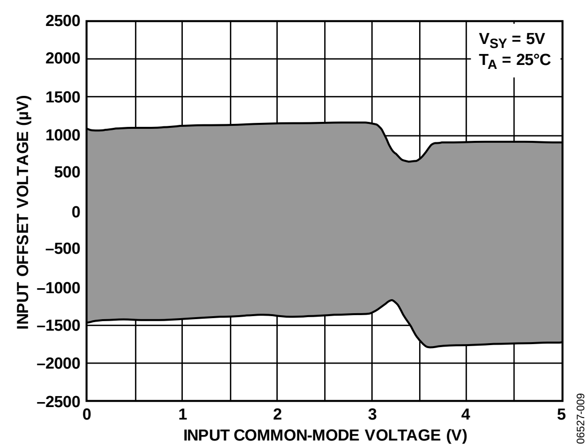


Figure 9. Input Offset Voltage vs. Input Common-Mode Voltage

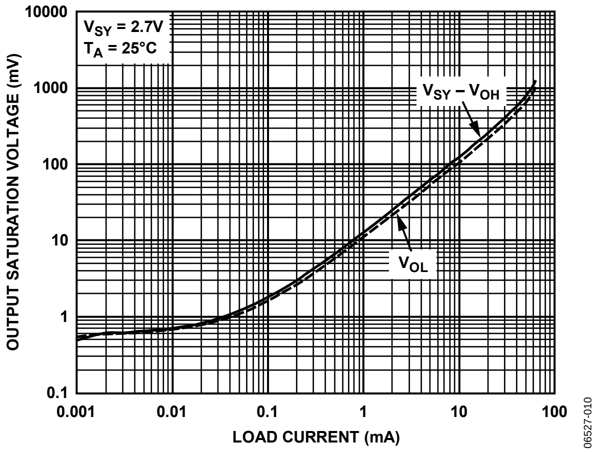
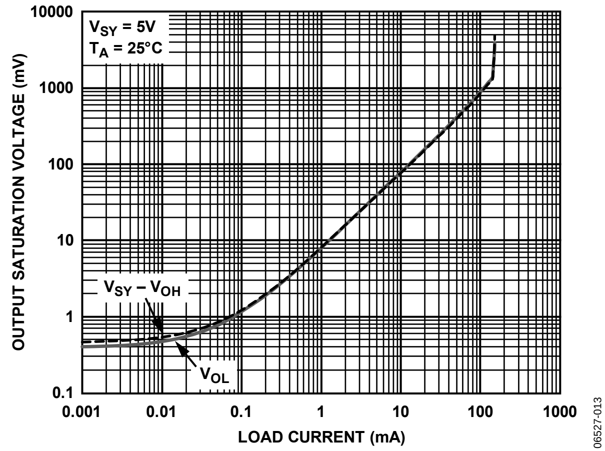


Figure 10. Output Saturation Voltage vs. Load Current



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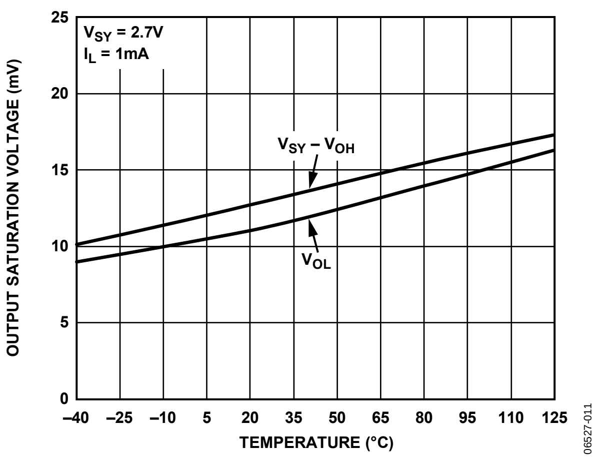


Figure 11. Output Saturation Voltage vs. Temperature

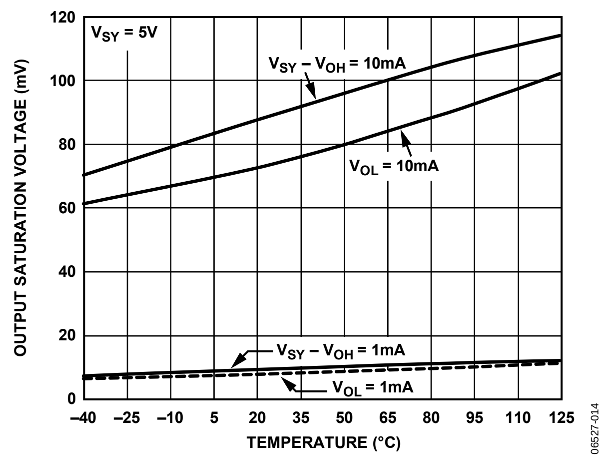


Figure 14. Output Saturation Voltage vs. Temperature

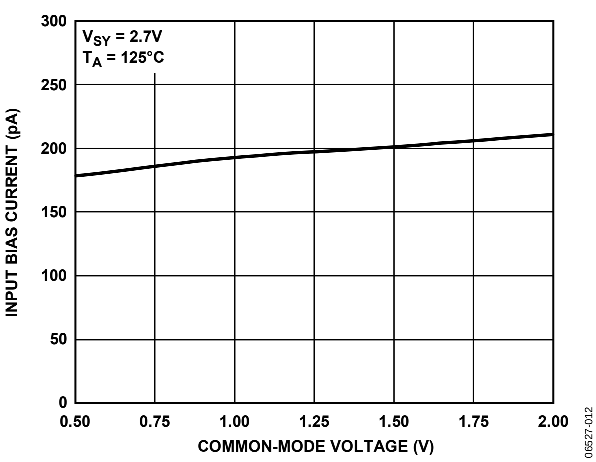


Figure 12. Input Bias Current vs. Common-Mode Voltage

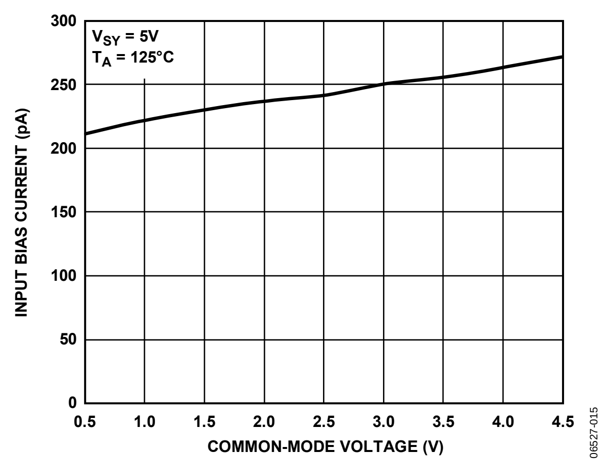


Figure 15. Input Bias Current vs. Common-Mode Voltage

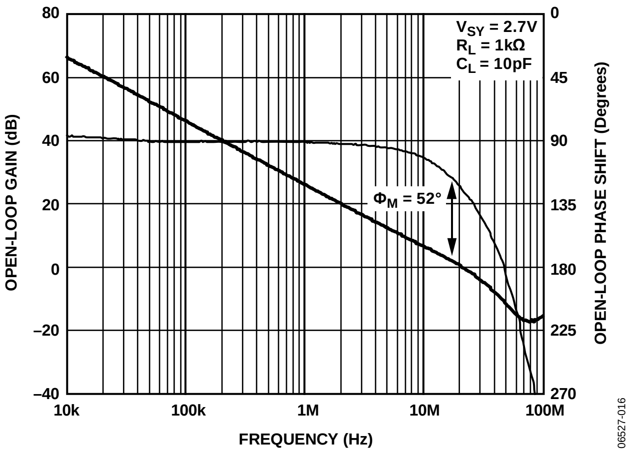


Figure 16. Open-Loop Gain and Phase vs. Frequency

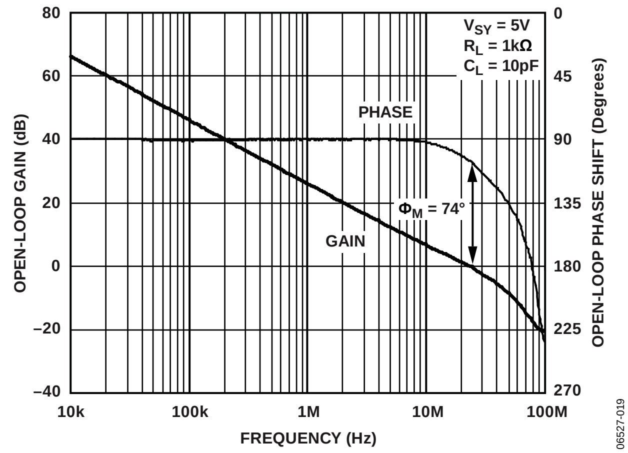


Figure 19. Open-Loop Gain and Phase vs. Frequency

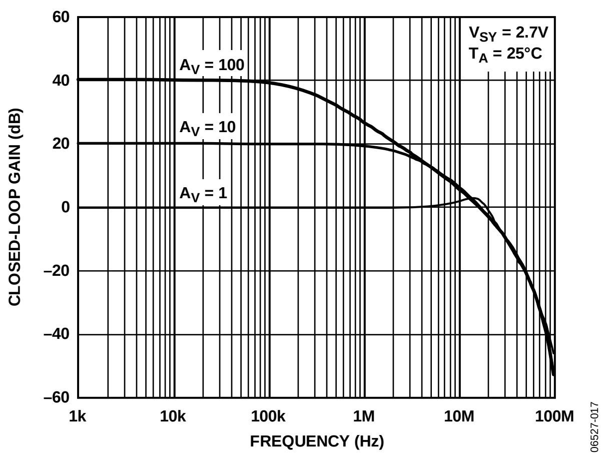


Figure 17. Closed-Loop Gain vs. Frequency

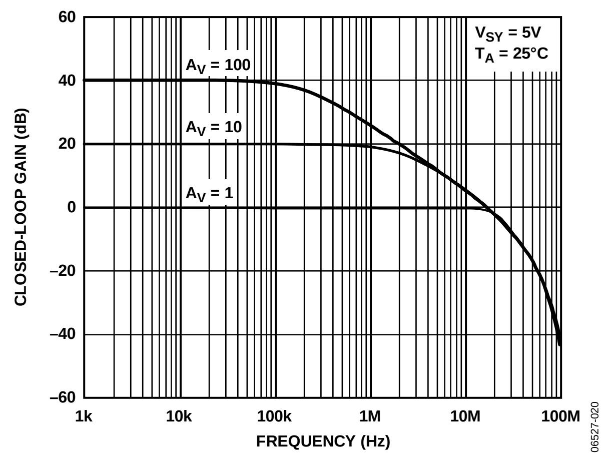
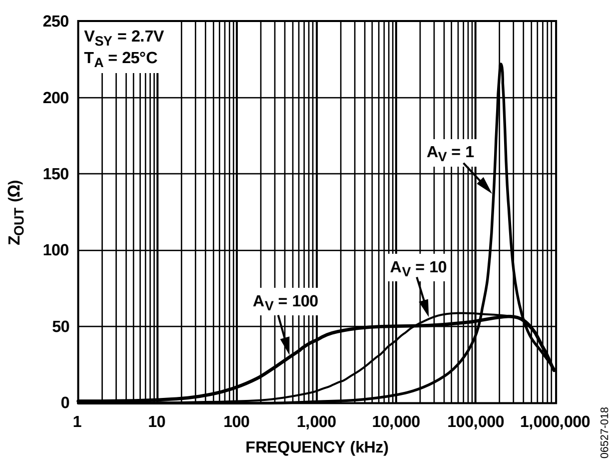


Figure 20. Closed-Loop Gain vs. Frequency



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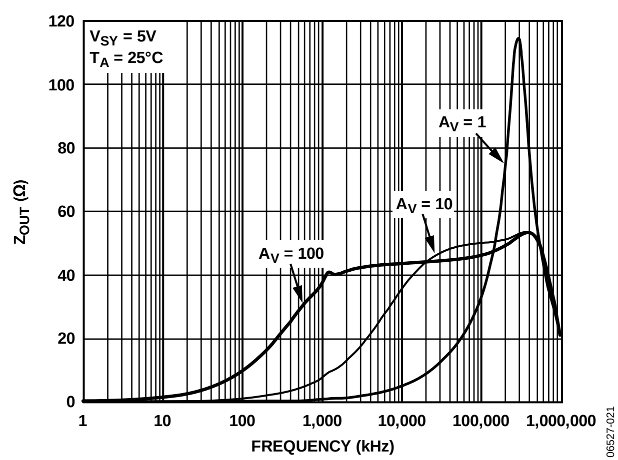


Figure 21. Z_{OUT} vs. Frequency

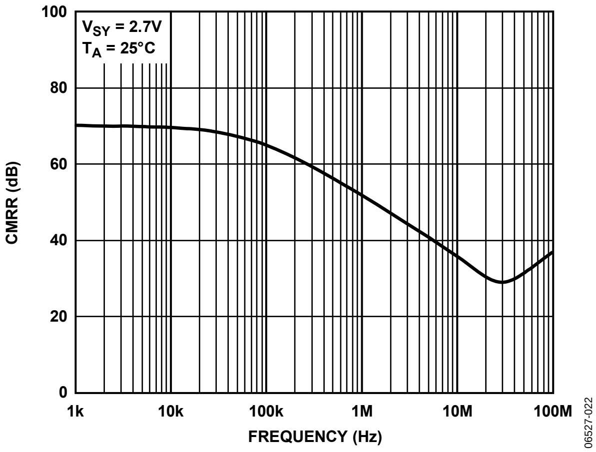


Figure 22. CMRR vs. Frequency

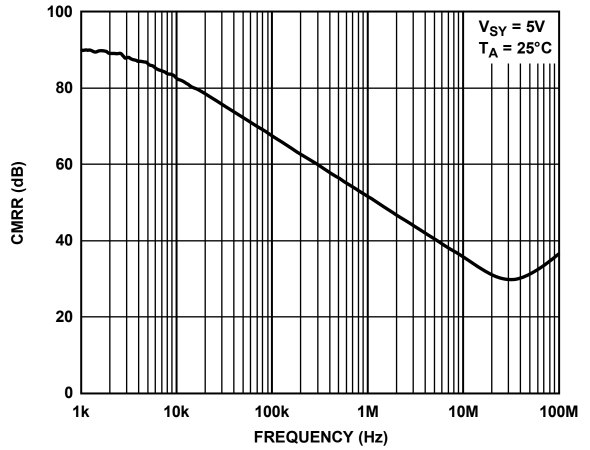


Figure 25. CMRR vs. Frequency

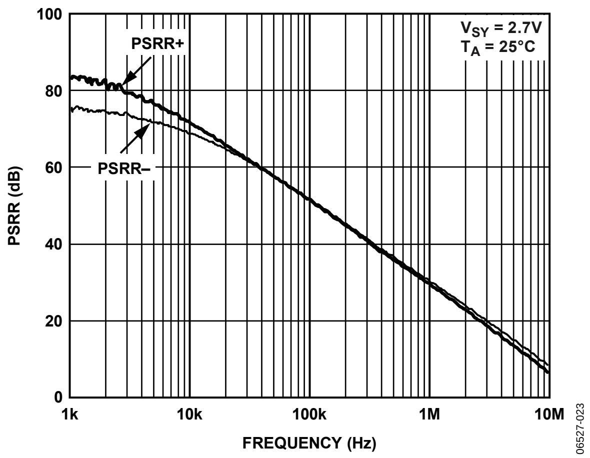


Figure 23. PSRR vs. Frequency

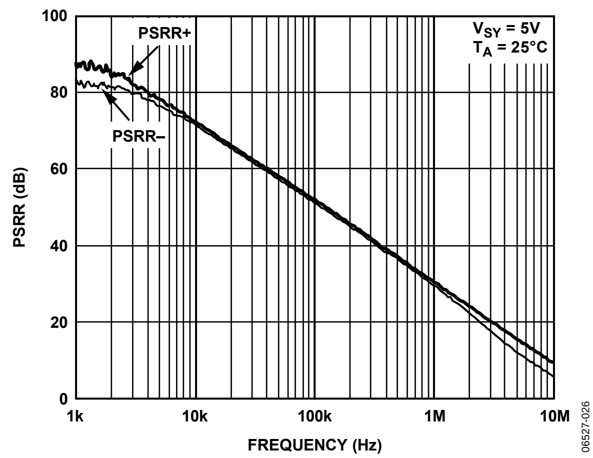


Figure 26. PSRR vs. Frequency

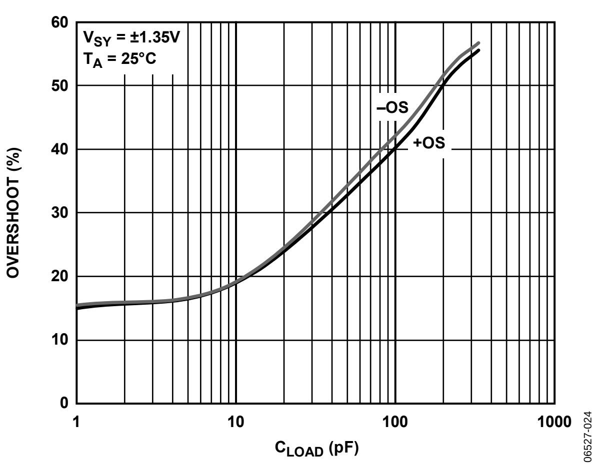


Figure 24. Overshoot vs. Load Capacitance

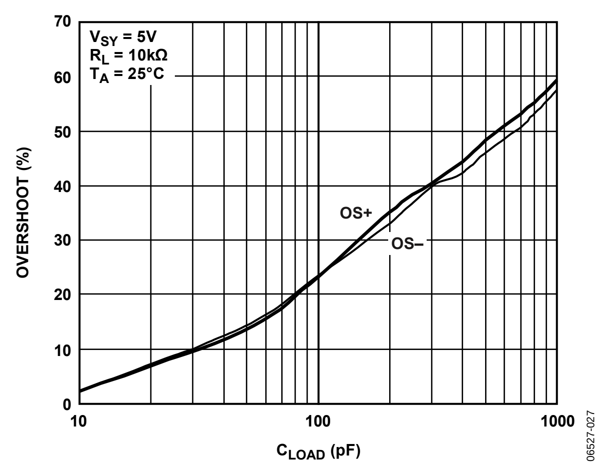


Figure 27. Overshoot vs. Load Capacitance

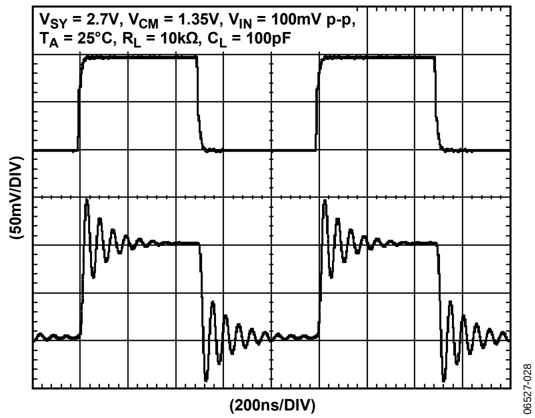


Figure 28. Small-Signal Transient Response

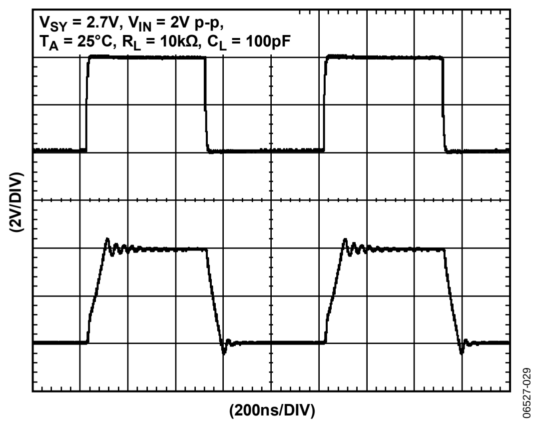


Figure 29. Large-Signal Transient Response

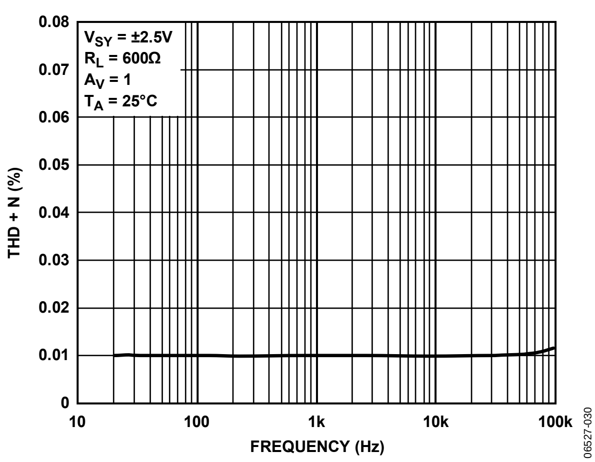


Figure 30. THD + Noise vs. Frequency

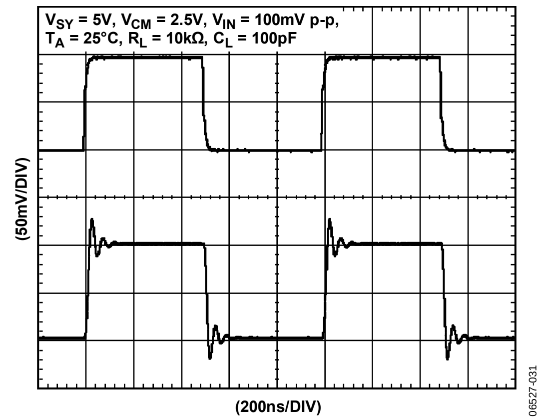


Figure 31. Small-Signal Transient Response

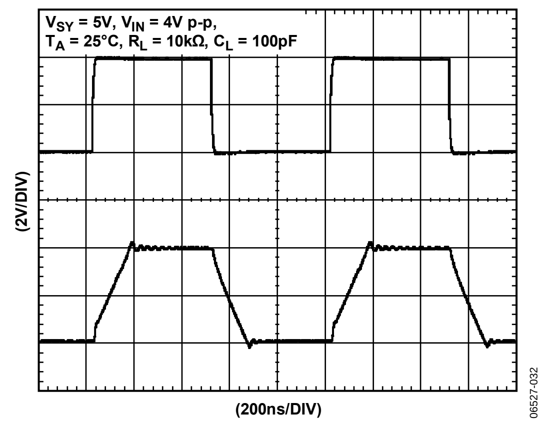


Figure 32. Large-Signal Transient Response

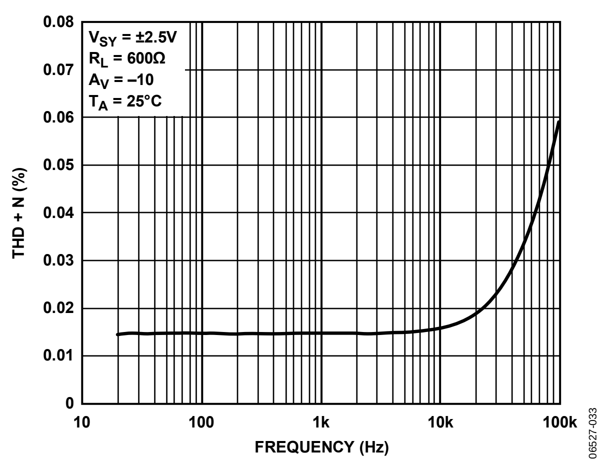


Figure 33. THD + Noise vs. Frequency

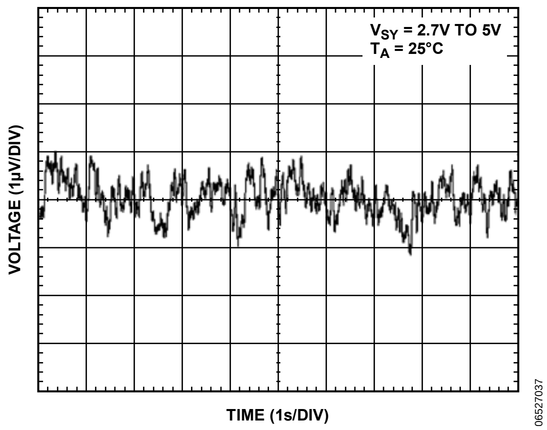


Figure 34. 0.1 Hz to 10 Hz Voltage Noise

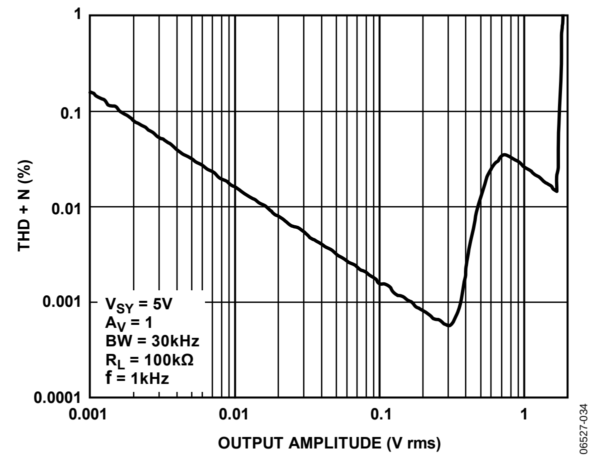


Figure 37. THD + Noise vs. Output Amplitude

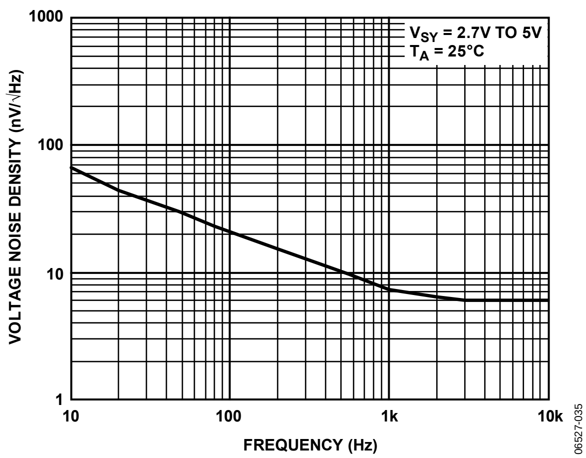


Figure 35. Voltage Noise Density vs. Frequency

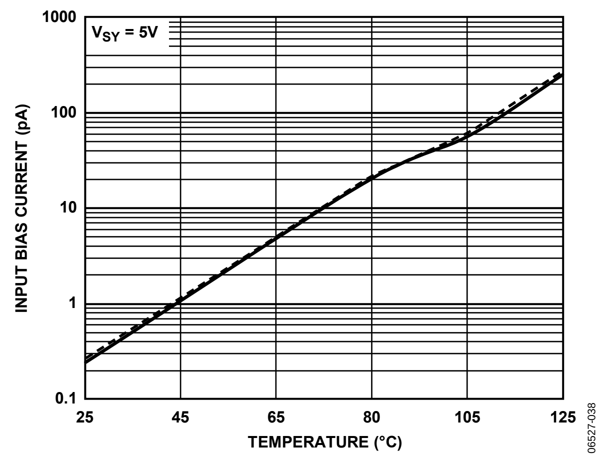


Figure 38. Input Bias Current vs. Temperature

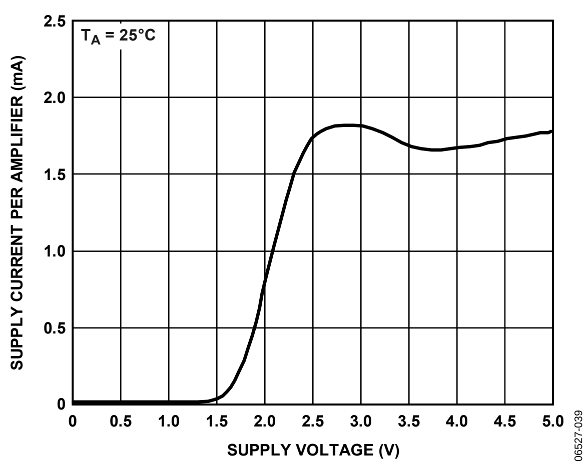


Figure 36. Supply Current per Amplifier vs. Supply Voltage

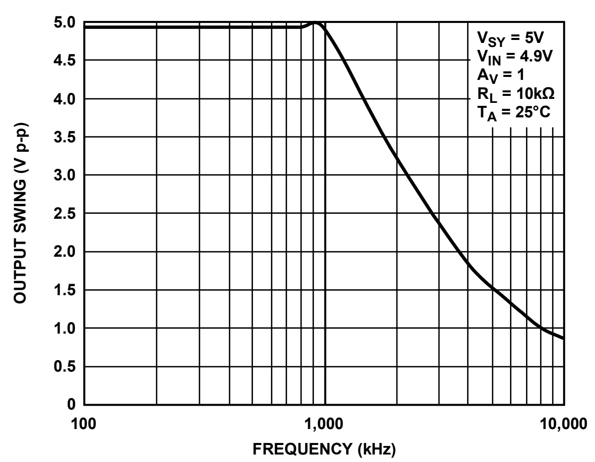


Figure 39. Maximum Output Swing vs. Frequency

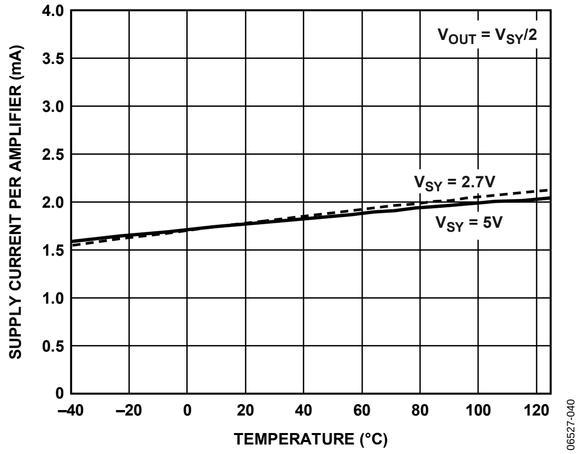


Figure 40. Supply Current per Amplifier vs. Temperature

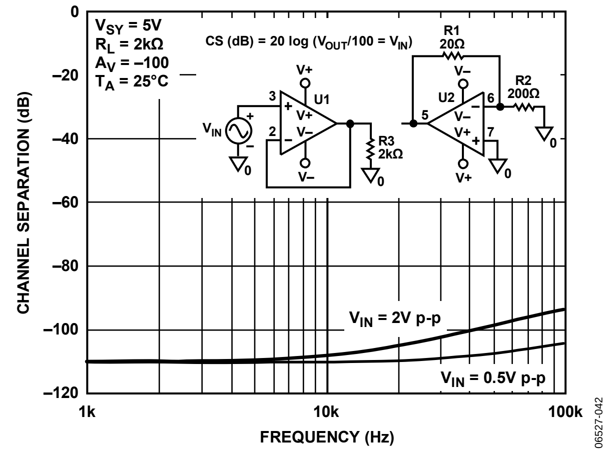


Figure 43. Channel Separation

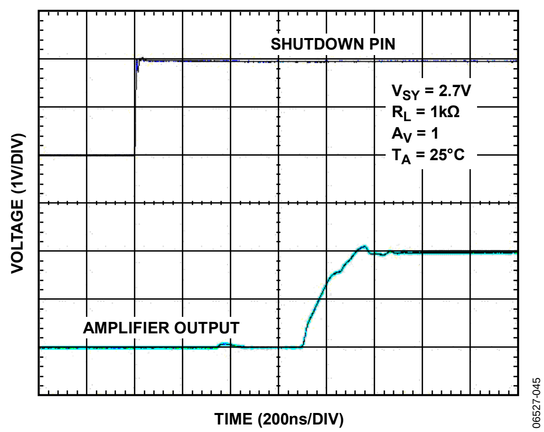


Figure 41. Turn-On Time

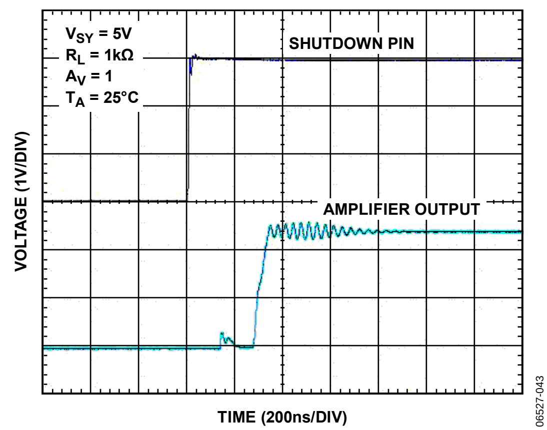


Figure 44. Turn-On Time

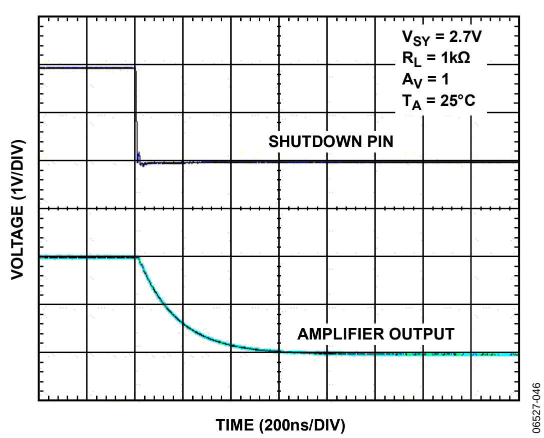


Figure 42. Turn-Off Time

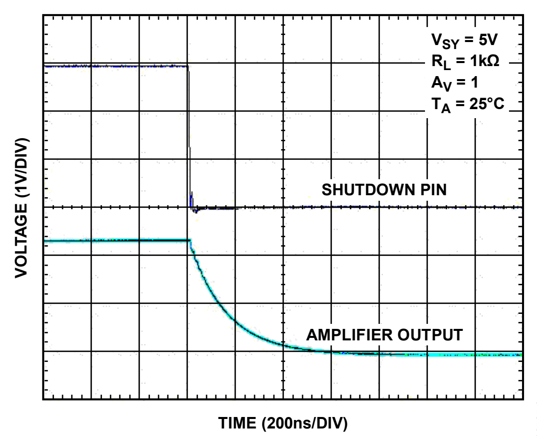


Figure 45. Turn-Off Time

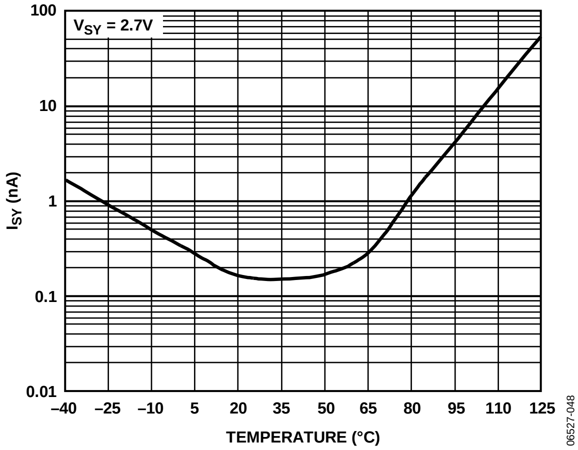


Figure 46. Supply Current with Op-Amp Shutdown vs. Temperature

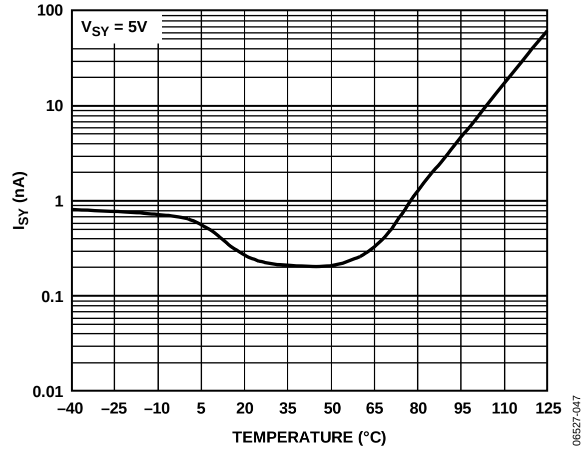


Figure 47. Supply Current with Op-Amp Shutdown vs. Temperature

THEORY OF OPERATION

POWER-DOWN OPERATION

The shutdown function of the AD8647 is referenced to the negative supply voltage of the operational amplifier. A logic level high (> 2.0 V) enables the device, while a logic level low (< 0.8 V) disables the device and places the output in a high impedance condition. Several outputs can be wire-OR'ed, thus eliminating a multiplexer. The logic input is a high impedance CMOS input. If dual or split supplies are used, the logic signals must be properly referred to the negative supply voltage.

MULTIPLEXING OPERATION

Because each op amp has a separate logic input enable pin, the outputs can be connected together if it can be guaranteed that only one op amp is active at any time. By connecting the op amps as shown in Figure 48, a multiplexer can be eliminated. With the reasonably short turn-on and turn-off times, low frequency signal paths can be smoothly selected. The turn-off time is slightly faster than the turn-on time so, even when using sections from two different packages, the overlap is less than 300 nanoseconds.

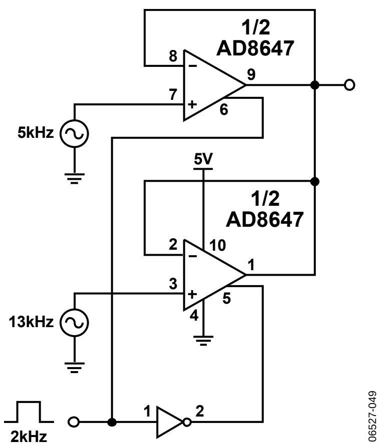


Figure 48. AD8647 Output Switching

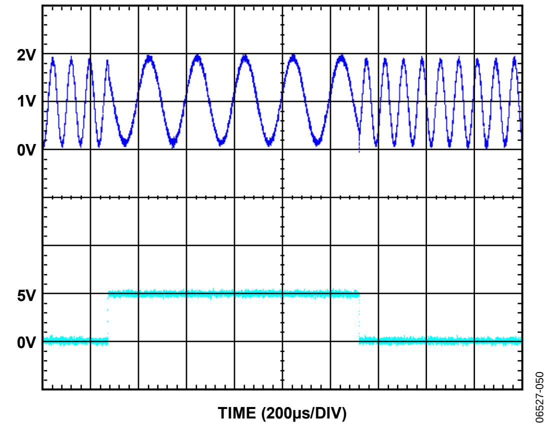


Figure 49. Switching Waveforms

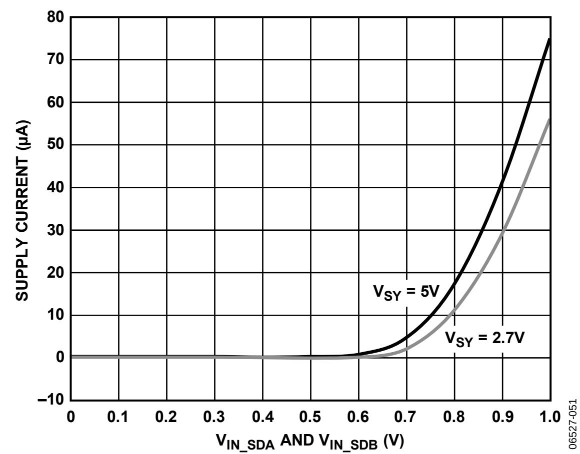
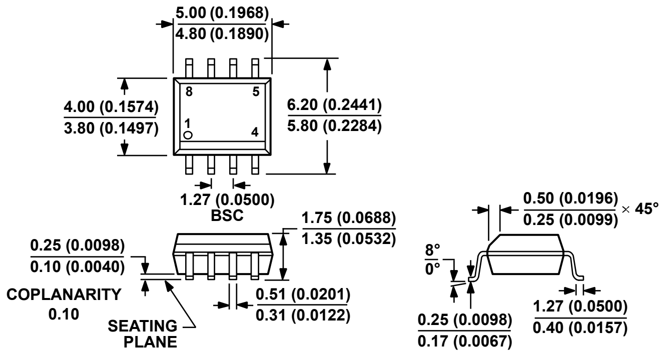


Figure 50. Supply Current Shutdown Mode, AD8647

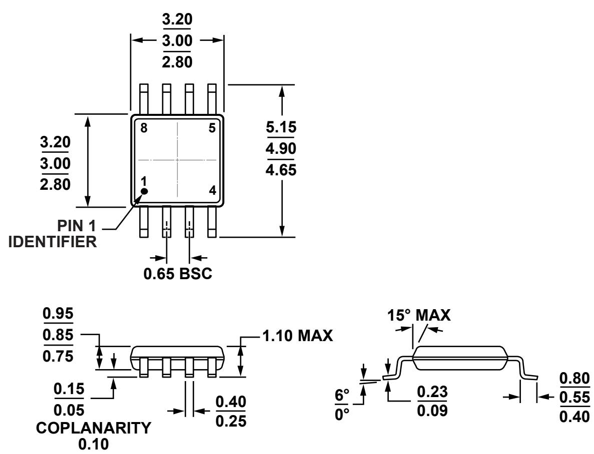
OUTLINE DIMENSIONS



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.

012407-A

Figure 51. 8-Lead Standard Small Outline Package [SOIC_N]
Narrow Body
(R-8)
Dimensions shown in millimeters and (inches)



100709-B

COMPLIANT TO JEDEC STANDARDS MO-187-AA

Figure 52. 8-Lead Mini Small Outline Package [MSOP]
(RM-8)
Dimensions shown in millimeters

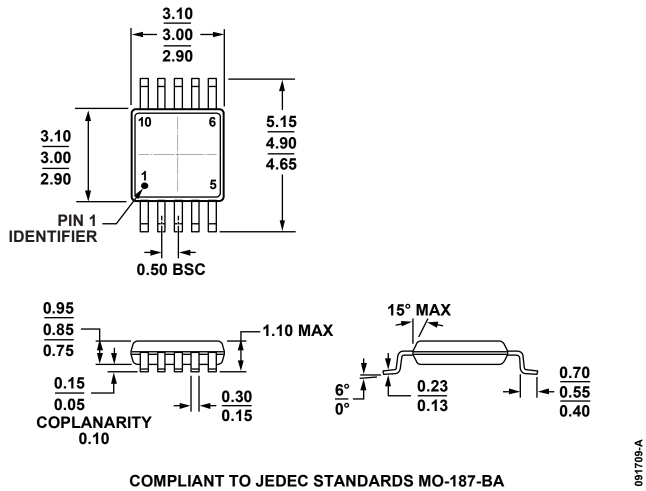


Figure 53. 10-Lead Mini Small Outline Package [MSOP]
(RM-10)
Dimensions shown in millimeters

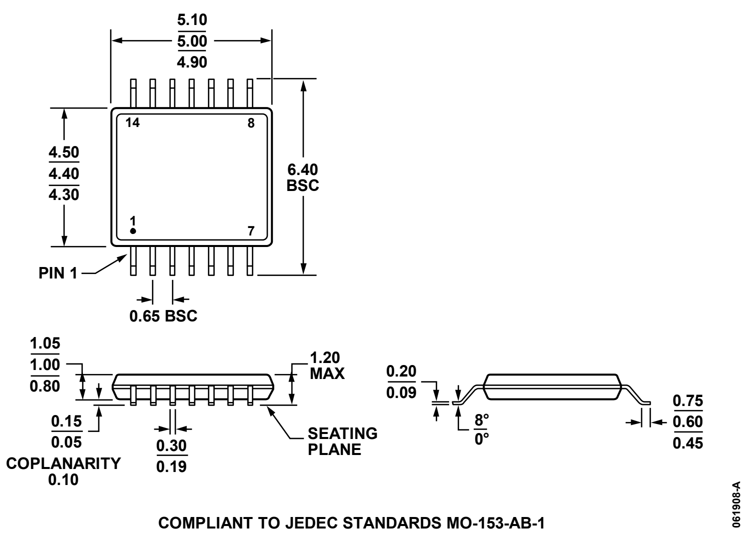


Figure 54. 14-Lead Thin Shrink Small Outline Package [TSSOP]
(RU-14)
Dimensions shown in millimeters

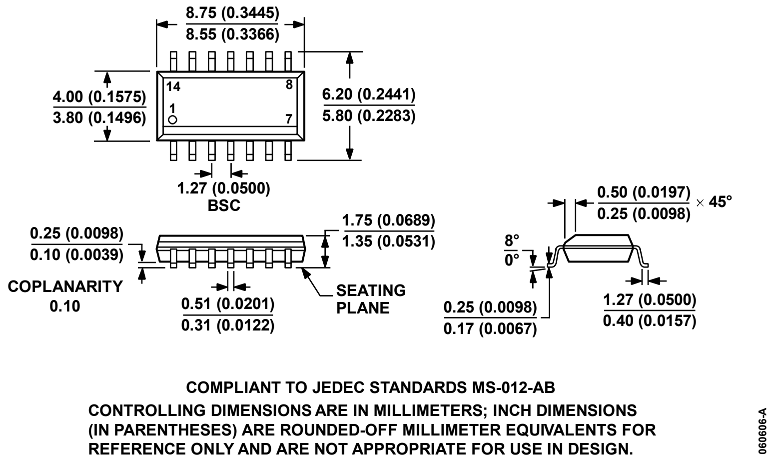


Figure 55. 14-Lead Standard Small Outline Package [SOIC_N]
Narrow Body
(R-14)
Dimensions shown in millimeters and (inches)

ORDERING GUIDE

Model[1, 2]	Temperature Range	Package Description	Package Option	Branding
AD8646ARZ	−40°C to +125°C	8-Lead SOIC_N	R-8	
AD8646ARZ-REEL	−40°C to +125°C	8-Lead SOIC_N	R-8	
AD8646ARZ-REEL7	−40°C to +125°C	8-Lead SOIC_N	R-8	
AD8646ARMZ	−40°C to +125°C	8-Lead MSOP	RM-8	A1V
AD8646ARMZ-REEL	−40°C to +125°C	8-Lead MSOP	RM-8	A1V
AD8646WARZ-RL	−40°C to +125°C	8-Lead SOIC_N	R-8	
AD8646WARZ-R7	−40°C to +125°C	8-Lead SOIC_N	R-8	
AD8646WARMZ-RL	−40°C to +125°C	8-Lead MSOP	RM-8	A1V
AD8646WARMZ-R7	−40°C to +125°C	8-Lead MSOP	RM-8	A1V
AD8647ARMZ	−40°C to +125°C	10-Lead MSOP	RM-10	A1W
AD8647ARMZ-REEL	−40°C to +125°C	10-Lead MSOP	RM-10	A1W
AD8648ARZ	−40°C to +125°C	14-Lead SOIC_N	R-14	
AD8648ARZ-REEL	−40°C to +125°C	14-Lead SOIC_N	R-14	
AD8648ARZ-REEL7	−40°C to +125°C	14-Lead SOIC_N	R-14	
AD8648ARUZ	−40°C to +125°C	14-Lead TSSOP	RU-14	
AD8648ARUZ-REEL	−40°C to +125°C	14-Lead TSSOP	RU-14	
AD8648WARUZ	−40°C to +125°C	14-Lead TSSOP	RU-14	
AD8648WARUZ-RL	−40°C to +125°C	14-Lead TSSOP	RU-14	

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

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