BUF634A 36-V, 210-MHz, 250-mA Output, High-Speed Buffer

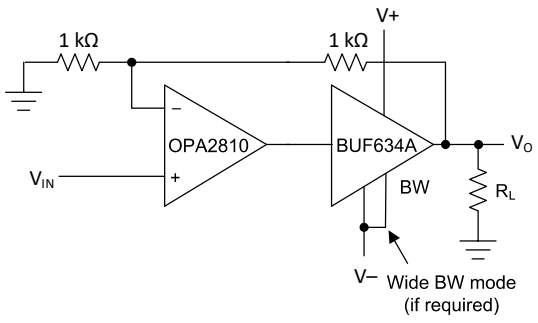
1 Features

- Pin-selected bandwidth: 35 MHz to 210 MHz
- High output current: 250 mA
- Slew rate: 3750 V/µs
- Low quiescent current: 1.5 mA (35-MHz BW)
- Wide supply range: ±2.25 V to ±18 V
- Internal output current limit
- Thermal shutdown protection
- Available in packages with thermal pad
- Extended temperature operation: –40°C to +125°C

2 Applications

- Memory, semiconductor testers
- Test equipment
- Headphone drivers
- Flight control systems
- Capacitive load drivers
- Valve drivers, solenoid drivers
- Line drivers

Boost the Output Current of Any Operational Amplifier



3 Description

The BUF634A is a high-performance, high-fidelity, open-loop buffer capable of driving 250 mA of output current. The BUF634A is a 36-V device with bandwidth adjustable from 35 MHz to 210 MHz by varying the value of an external resistor between the V– and BW pins. The BUF634A can be used as a standalone open-loop driver, or inside the feedback loop of a precision op amp to provide both high-precision as well as large output current drive with improved capacitive load drive.

For low-power applications, the BUF634A operates on a 1.5-mA quiescent current with a 250-mA output, 3750-V/µs slew rate, and 35-MHz bandwidth. The device consumes 8.5-mA quiescent current in wide-bandwidth mode with a 210-MHz bandwidth. The BUF634A is fully protected by an internal current limit in its output stage and by thermal shutdown, making the device rugged and easy to use.

The BUF634A is rated to function over the extended industrial temperature range of –40°C to +125°C. The BUF634A comes in three packages: D (SOIC), DRB (VSON), and DDA (HSOIC). The DRB (VSON) and DDA (HSOIC) packages have excellent thermal performance resulting from the thermal pad on the bottom side. The DRB package comes in a very small form factor of 3.0 mm × 3.0 mm, making the device a very suitable option for portable and size-constrained applications.

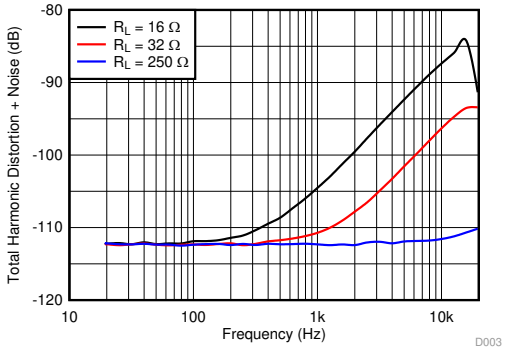
Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
BUF634A	SOIC (8)	4.90 mm × 3.90 mm
	VSON (8)(2)	3.00 mm × 3.00 mm
	HSOIC (8)(2)	4.90 mm × 3.90 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

(2) Preview package.

THD+N vs Frequency Using the BUF634A With the OPA2810 (V_O = 10 V_{PP}, 90-kHz Measurement Bandwidth)



An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

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4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision A (May 2019) to Revision B — **Page**

- Added DRB (VSON) and DDA (HSOIC) packages to document ... 1
- Changed *Applications* section ... 1
- Changed last paragraph of *Description* section ... 1
- Added discussion of V_{IN} pin to *ESD Protection* section ... 14
- Added *Power Dissipation and Thermal Considerations* section ... 20
- Added *HSOIC Layout Guidelines (DDA Package With a Thermal Pad)* section ... 22
- Changed title of *BUF634A Layout Example* image ... 23

Changes from Original (February 2019) to Revision A — **Page**

- Changed document status from Advance Information to Production Data ... 1

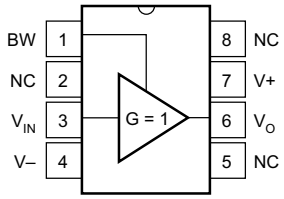
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5 Device Comparison Table

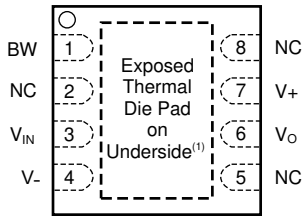
DEVICE	$V_{S\pm}$ (V)	I_Q / CHANNEL (mA)	BW (MHz)	SLEW RATE (V/µs)	VOLTAGE NOISE (nV/√Hz)	AMPLIFIER DESCRIPTION
BUF634A	±18	1.5 – 8.5	35 – 210	3750	3.4	Unity-gain, open-loop buffer
BUF634	±18	1.5 – 15	30 – 180	2000	4	Unity-gain, open-loop buffer
LMH6321	±18	11	110	1800	2.8	Unity-gain, open-loop buffer with adjustable current limit

6 Pin Configuration and Functions

D and DDA (Preview) Packages
8-Pin SOIC, 8-Pin HSOIC With Thermal Pad
Top View



DRB Package (Preview)
8-Pin VSON With Thermal Pad
Top View



Pin Functions

PIN				I/O(1)	DESCRIPTION
NAME	DDA(2)	DRB(2)	D		
BW	1	1	1	I	Bandwidth adjust pin. Connect the BW pin to the V– pin for wide-BW mode and leave the BW pin floating for low-I_Q mode. See the *Adjustable Bandwidth* section.
NC	2, 5, 8	2, 5, 8	2, 5, 8	—	No internal connection
V–	4	4	4	P	Negative power supply
V+	7	7	7	P	Positive power supply
V_{IN}	3	3	3	I	Input
V_O	6	6	6	O	Output
Thermal Pad			—	—	Thermal pad. Must be electrically shorted to V–.

(1) I = input, O = output, P = power.
(2) The DRB and DDA packages include a thermal pad on the backside of the device. The thermal pad must be connected to the same potential as V–. Connect the thermal pad and V– to a heat-spreading plane to achieve low thermal impedance. The thermal pad can also be unused (not connected to any heat-spreading plane or voltage), thus giving an overall higher thermal impedance.

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7 Specifications

7.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

		MIN	MAX	UNIT
V_S = (V+) – (V–)	Supply voltage		40 (±20)	V
V_{IN}	Input voltage		Vs ± 0.5	V
	Output short-circuit (to ground)		Continuous	
T_A	Operating ambient temperature	–40	125	°C
T_J	Junction temperature		150	°C
T_{stg}	Storage temperature	–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Rating* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Condition*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

7.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±3000	V
		Charged device model (CDM), per JEDEC specification JESD22-C101(2)	±1000	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

7.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
V_S = (V+) – (V–)	Supply voltage	±2.25	±15	±18	V
T_A	Ambient temperature	–40	25	125(1)	°C

(1) Limited by $R_{\Theta JA}$ and $T_{J,Max}$ for safe operation. See the *Output Current* section.

7.4 Thermal Information

THERMAL METRIC(1)		BUF634A			UNIT
		D (SOIC)	DRB (VSON)	DDA (HSOIC)	
		8 PINS	8 PINS	8 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	122.9	50.5	41.3	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	55.2	60	57.1	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	68.4	23.6	17.0	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	12.1	1.5	4.6	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	67.2	23.6	17.0	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	NA	6.9	5.3	°C/W

(1) For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report.

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7.5 Electrical Characteristics: Wide-Bandwidth Mode

at T_A = 25°C, V_S = ±15 V, BW pin connected to V–, and R_L = 100 Ω connected to mid-supply (unless otherwise noted).

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
AC PERFORMANCE						
BW	Bandwidth, –3 dB	R_L = 1 kΩ		210		MHz
		R_L = 100 Ω		200		
	Bandwidth for 0.1-dB flatness	V_O = 10 mV_{PP}, R_L = 100 Ω, R_S = 50 Ω		50		MHz
SR	Slew rate	V_O = 20-V step, V_{IN}-SR = 4000 V/µs		3750		V/µs
	Rise and fall time	V_O = 200-mV step		1.3		ns
	Settling time to 0.1%	V_O = 20-V step, V_{IN}-SR = 2500 V/µs		90		ns
	Settling time to 1%	V_O = 20-V step, V_{IN}-SR = 2500 V/µs		20		ns
e_n	Voltage noise	f = 1 kHz		3.4		$nV/\sqrt{Hz}$
i_n	Current noise	f = 100 kHz		0.85		$pA/\sqrt{Hz}$
HD2	2nd-harmonic distortion	V_O = 2 V_{PP}, f = 20 kHz		–77		dBc
		V_O = 10 V_{PP}, f = 20 kHz		–69		
HD3	3rd-harmonic distortion	V_O = 2 V_{PP}, f = 20 kHz		–77		dBc
		V_O = 10 V_{PP}, f = 20 kHz		–56		
DC PERFORMANCE						
V_{OS}	Input offset voltage	T_A = 25°C (see Figure 26)		36	65	mV
	Input offset voltage drift(1)	T_A = –40°C to 125°C (see Figure 28)		175		µV/°C
I_B	Input bias current	V_{IN} = 0 V		0.25	2	µA
G	Gain	V_O = ±10 V, R_L = 1 kΩ	0.95	0.99		V/V
		V_O = ±10 V, R_L = 100 Ω	0.93	0.95		
		V_O = ±10 V, R_L = 67 Ω	0.91	0.93		
INPUT						
	Linear input voltage range	R_L = 1 kΩ, I_B < 10 µA	–13		13	V
Z_{IN}	Input impedance	R_L = 100 Ω		180 || 5		MΩ || pF
OUTPUT						
	Output headroom to supplies	I_O = ±10 mA		1.6	1.8	V
		I_O = ±100 mA		2.0	2.2	
		I_O = ±150 mA		2.2	2.5	
I_O	Current output, continuous			±250		mA
I_{SC}	Short-circuit current			±375	±550	mA
Z_O	Output impedance	DC, I_O = 10 mA		5		Ω
POWER SUPPLY						
V_S	Operating voltage range		±2.25		±18	V
I_Q	Quiescent current	I_O = 0 mA		8.5	12	mA
PSRR	Power-supply rejection ratio	V_S = ±2.25 V to ±18 V	64	75		dB
THERMAL SHUTDOWN						
	Thermal shutdown temperature			180		°C

(1) Based on electrical characterization over temperature of 35 devices.

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7.6 Electrical Characteristics: Low-Quiescent Current Mode

at T_A = 25°C, V_S = ±15 V, BW pin left open, and R_L = 100 Ω connected to mid-supply (unless otherwise noted).

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
AC PERFORMANCE						
BW	Bandwidth, –3 dB	R_L = 1 kΩ		35		MHz
		R_L = 100 Ω		31		
	Bandwidth for 0.1-dB flatness	V_O = 10 mV_{PP}, R_L = 100 Ω, R_S = 50 Ω		2.3		MHz
SR	Slew rate	V_O = 20-V step, V_{IN}-SR = 4000 V/µs		3750		V/µs
	Rise and fall time	V_O = 200-mV step		4		ns
	Settling time to 0.1%	V_O = 20-V step, V_{IN}-SR = 2500 V/µs		400		ns
	Settling time to 1%	V_O = 20-V step, V_{IN}-SR = 2500 V/µs		90		ns
e_n	Voltage noise	f = 1 kHz		8.1		nV/√Hz
i_n	Current noise	f = 10 kHz		0.3		pA/√Hz
HD2	2nd-harmonic distortion	V_O = 2 V_{PP}, f = 20 kHz		–54		dBc
		V_O = 10 V_{PP}, f = 20 kHz		–65		
HD3	3rd-harmonic distortion	V_O = 2 V_{PP}, f = 20 kHz		–40		dBc
		V_O = 10 V_{PP}, f = 20 kHz		–44		
DC PERFORMANCE						
V_{OS}	Input offset voltage	T_A = 25°C (see Figure 26)		36	65	mV
	Input offset voltage drift(1)	T_A = –40°C to 125°C (see Figure 28)		175		µV/°C
I_B	Input bias current	V_{IN} = 0 V		0.03	0.25	µA
G	Gain	V_O = ±10 V, R_L = 1 kΩ	0.95	0.99		V/V
		V_O = ±10 V, R_L = 100 Ω	0.93	0.95		
		V_O = ±10 V, R_L = 67 Ω	0.91	0.93		
INPUT						
	Linear input voltage range	R_L = 1 kΩ, I_B < 10 µA	–13		13	V
Z_{IN}	Input impedance	R_L = 100 Ω		1400 || 5		MΩ || pF
OUTPUT						
	Output headroom to supplies	I_O = ±10 mA		1.6	1.8	V
		I_O = ±100 mA		2.0	2.2	
		I_O = ±150 mA		2.2	2.5	
I_O	Current output, continuous			±250		mA
I_{SC}	Short-circuit current			±350	±550	mA
Z_O	Output impedance	DC, I_O = 10 mA		7		Ω
POWER SUPPLY						
V_S	Operating voltage range		±2.25		±18	V
I_Q	Quiescent current	I_O = 0		1.5	2.3	mA
PSRR	Power-supply rejection ratio	V_S = ±2.25 V to ±18 V	64	80		dB
THERMAL SHUTDOWN						
	Thermal shutdown temperature			180		°C

(1) Based on electrical characterization over temperature of 35 devices.

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7.7 Typical Characteristics

at T_A = 25°C, V_S = ±15 V, R_S = 50 Ω, and R_L = 100 Ω (unless otherwise noted)

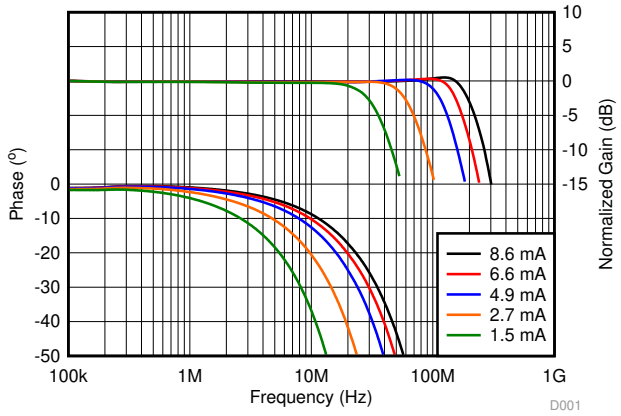
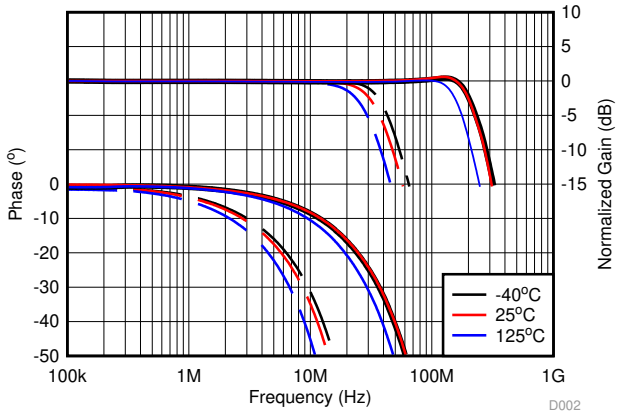
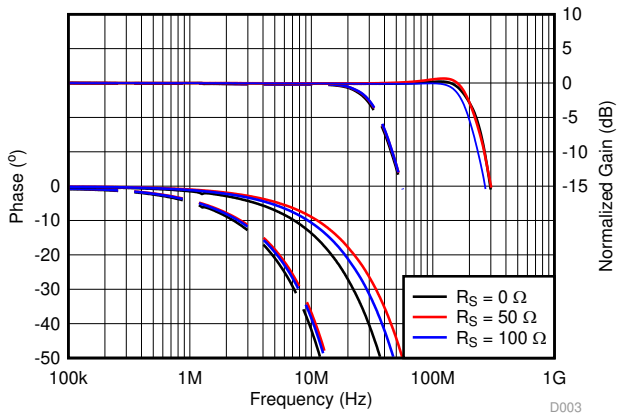


Figure 1. Gain and Phase vs Frequency and Quiescent Current



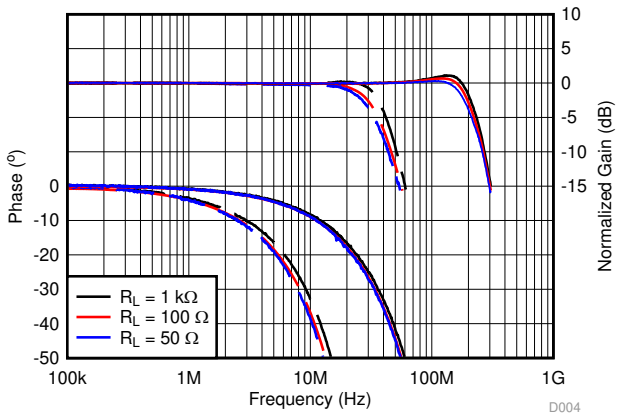
Solid lines indicate wide-BW mode, dashed lines indicate low-I_Q mode

Figure 2. Gain and Phase vs Frequency and Temperature



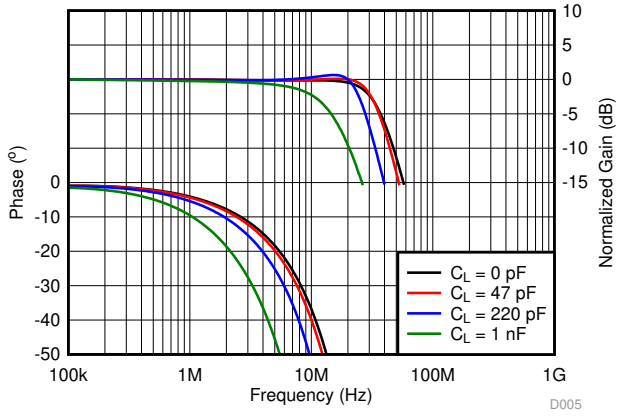
Solid lines indicate wide-BW mode, dashed lines indicate low-I_Q mode

Figure 3. Gain and Phase vs Frequency and Source Resistance



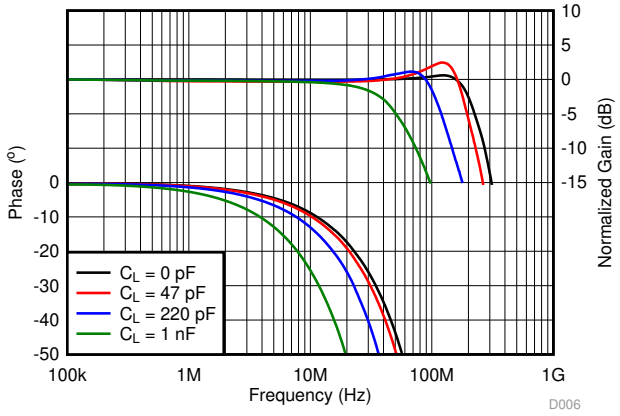
Solid lines indicate wide-BW mode, dashed lines indicate low-I_Q mode

Figure 4. Gain and Phase vs Frequency and Load Resistance



Low-I_Q mode

Figure 5. Gain and Phase vs Frequency and Load Capacitance



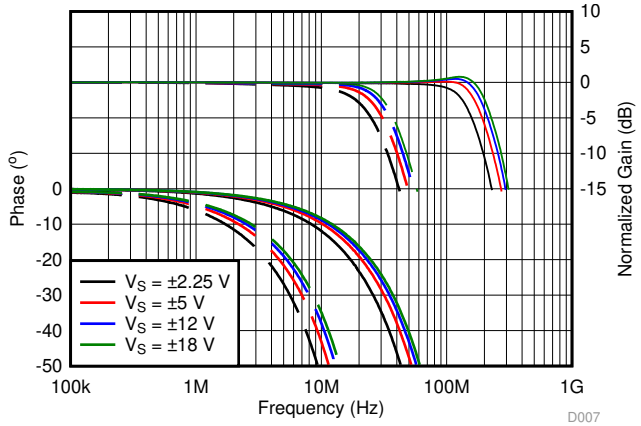
Wide-BW mode

Figure 6. Gain and Phase vs Frequency and Load Capacitance

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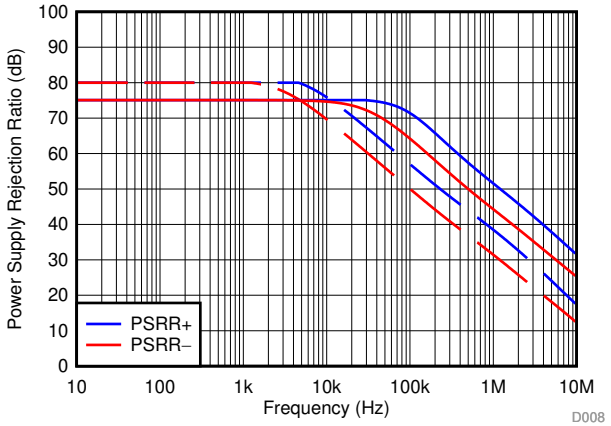
Typical Characteristics (continued)

at T_A = 25°C, V_S = ±15 V, R_S = 50 Ω, and R_L = 100 Ω (unless otherwise noted)



Solid lines indicate wide-BW mode, dashed lines indicate low-I_Q mode

Figure 7. Gain and Phase vs Frequency and Power-Supply Voltage



Solid lines indicate wide-BW mode, dashed lines indicate low-I_Q mode

Figure 8. PSRR vs Frequency

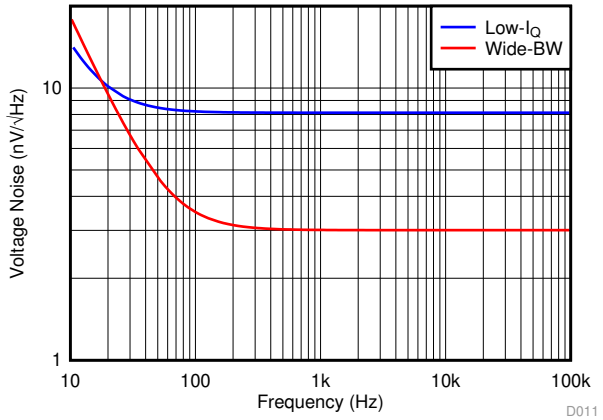


Figure 9. Voltage Noise Density vs Frequency

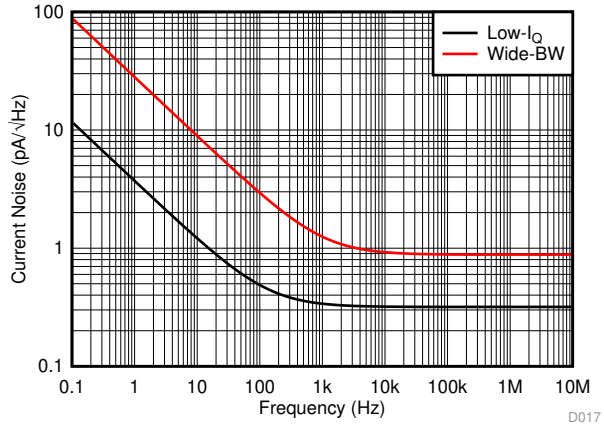
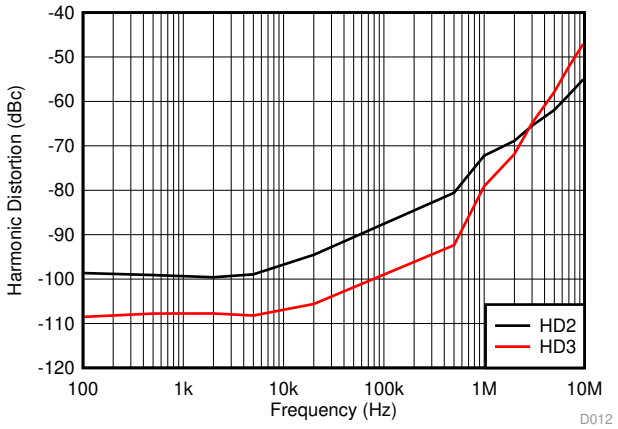
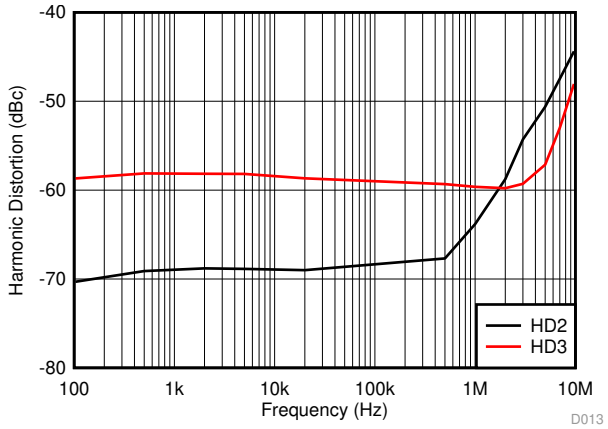


Figure 10. Current Noise Density vs Frequency



Wide-BW mode, V_{IN} = 10 V_{PP}, R_L = 1 kΩ

Figure 11. Harmonic Distortion vs Frequency



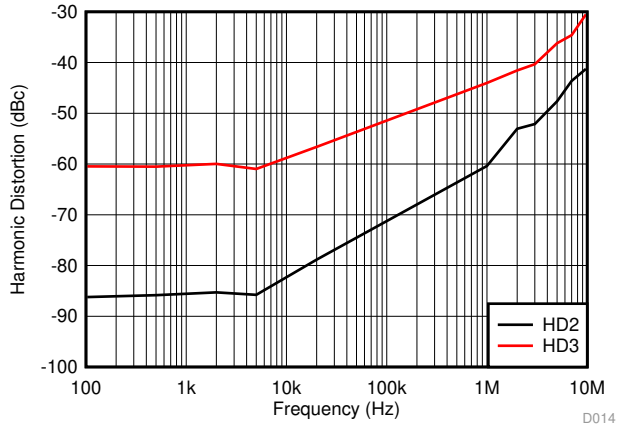
Wide-BW mode, V_{IN} = 10 V_{PP}, R_L = 100 Ω

Figure 12. Harmonic Distortion vs Frequency

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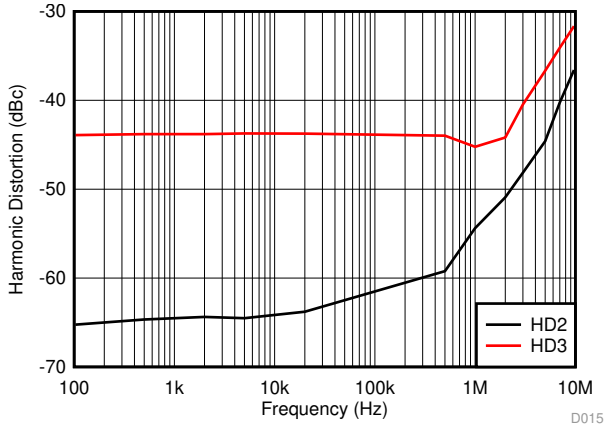
Typical Characteristics (continued)

at T_A = 25°C, V_S = ±15 V, R_S = 50 Ω, and R_L = 100 Ω (unless otherwise noted)



Low-I_Q mode, V_{IN} = 10 V_{PP}, R_L = 1 kΩ

Figure 13. Harmonic Distortion vs Frequency



Low-I_Q mode, V_{IN} = 10 V_{PP}, R_L = 100 Ω

Figure 14. Harmonic Distortion vs Frequency

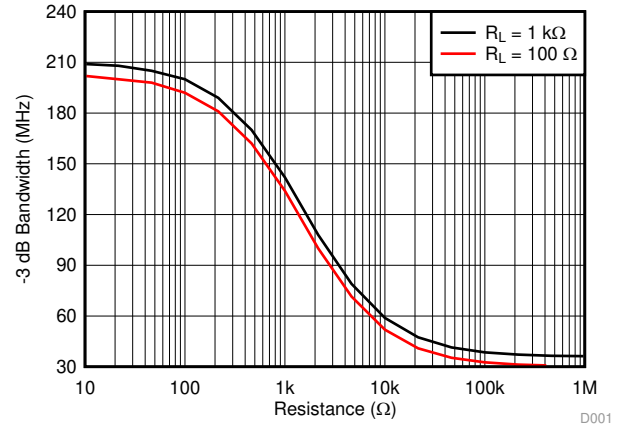


Figure 15. Small-Signal Bandwidth vs Bandwidth Adjustment Resistance

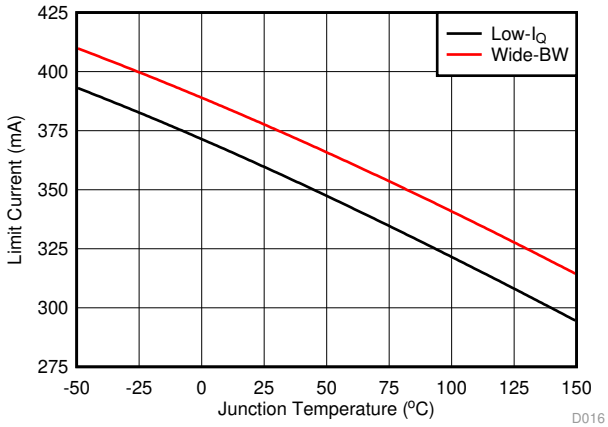
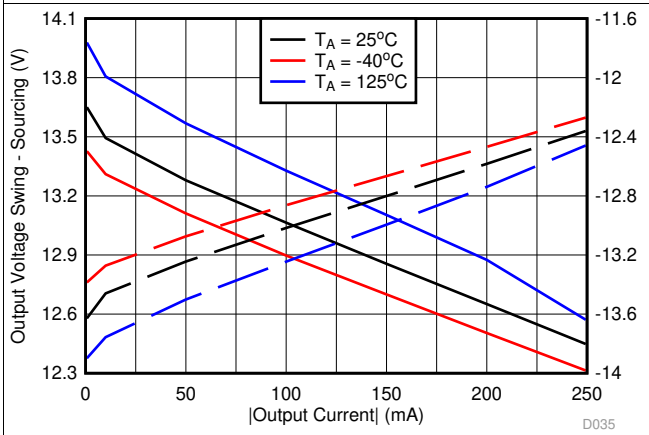
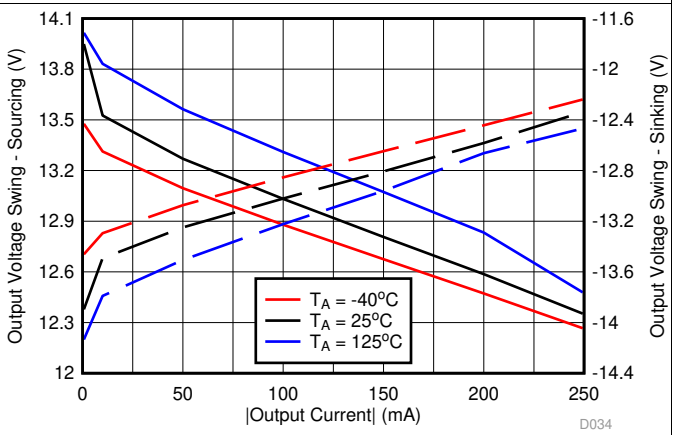


Figure 16. Short-Circuit Current vs Temperature



Wide-BW mode (solid lines indicate sourcing current, dashed lines indicate sinking current)

Figure 17. Output Voltage Swing vs Output Current



Low-I_Q mode (solid lines indicate sourcing current, dashed lines indicate sinking current)

Figure 18. Output Voltage Swing vs Output Current

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Typical Characteristics (continued)

at T_A = 25°C, V_S = ±15 V, R_S = 50 Ω, and R_L = 100 Ω (unless otherwise noted)

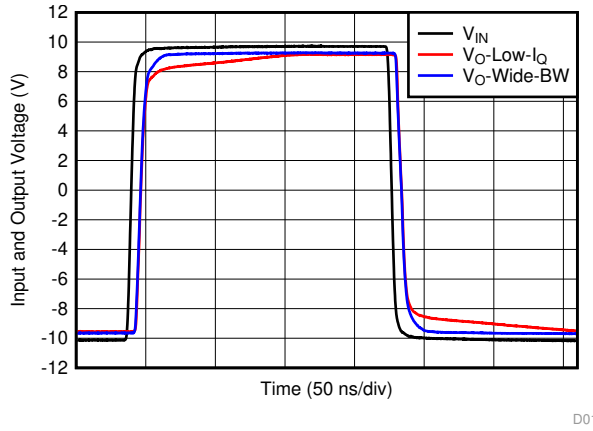


Figure 19. Large-Signal Transient Response

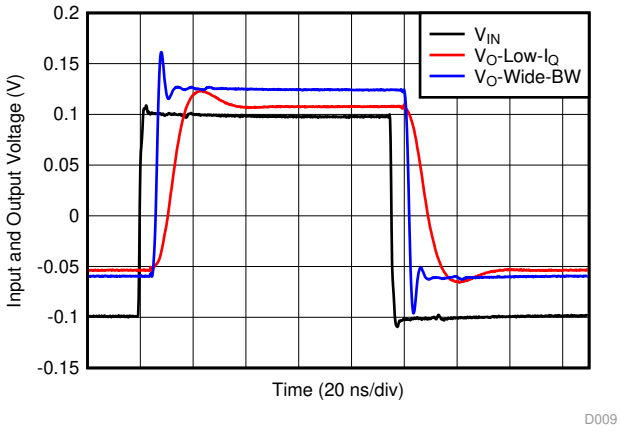


Figure 20. Small-Signal Transient Response

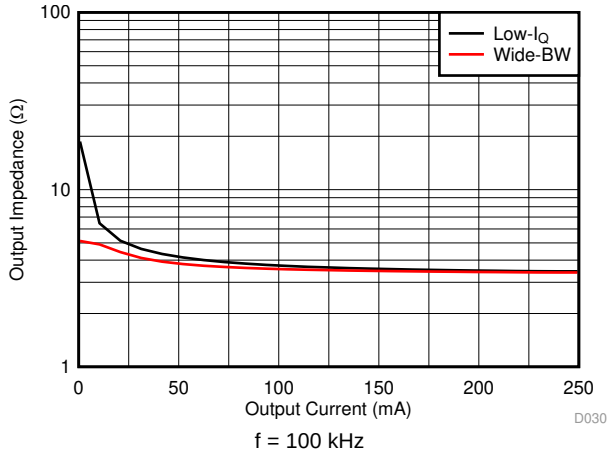


Figure 21. Output Impedance vs Output Current

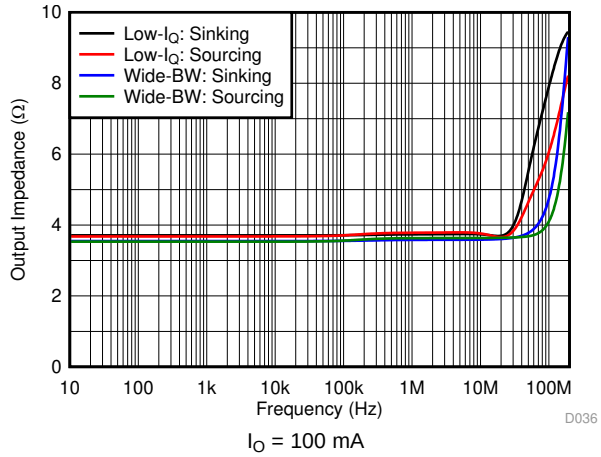


Figure 22. Output Impedance vs Frequency

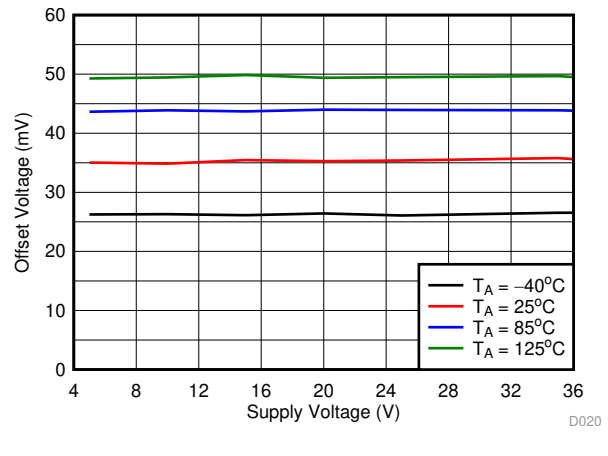


Figure 23. Offset Voltage vs Supply Voltage

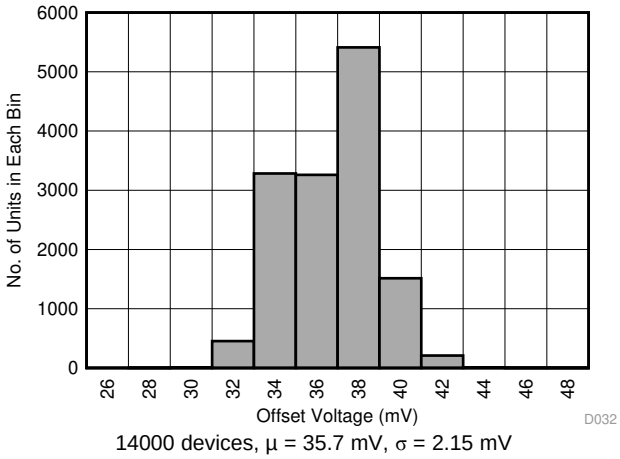


Figure 24. Offset Voltage Distribution Histogram

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Typical Characteristics (continued)

at T_A = 25°C, V_S = ±15 V, R_S = 50 Ω, and R_L = 100 Ω (unless otherwise noted)

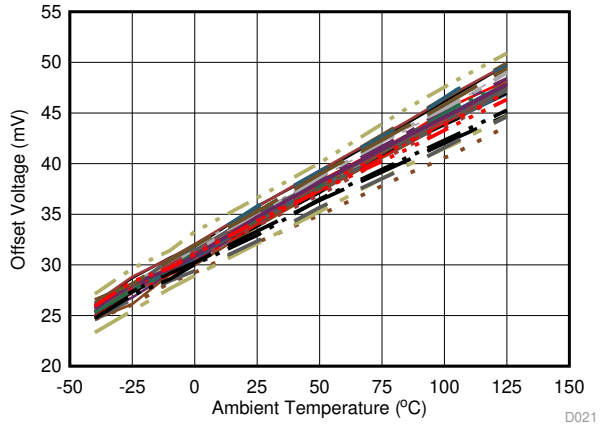
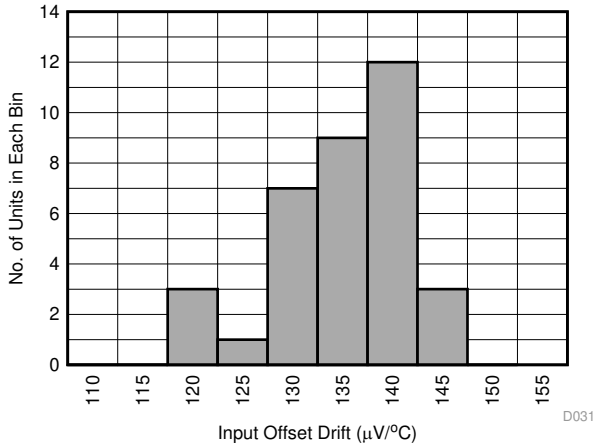


Figure 25. Offset Voltage vs Temperature



T_A = –40°C to +125°C, 35 devices, µ = 134 µV/°C, σ = 7.4 µV/°C

Figure 26. Offset Voltage Drift Distribution Histogram

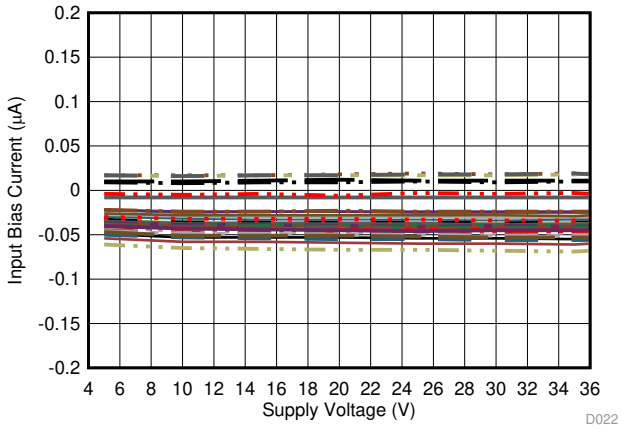


Figure 27. Input Bias Current vs Supply Voltage

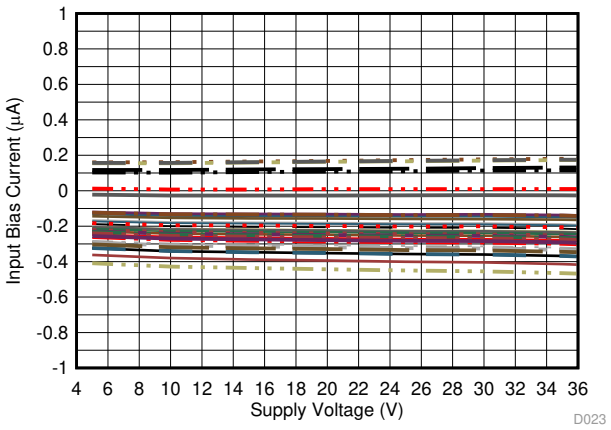


Figure 28. Input Bias Current vs Supply Voltage

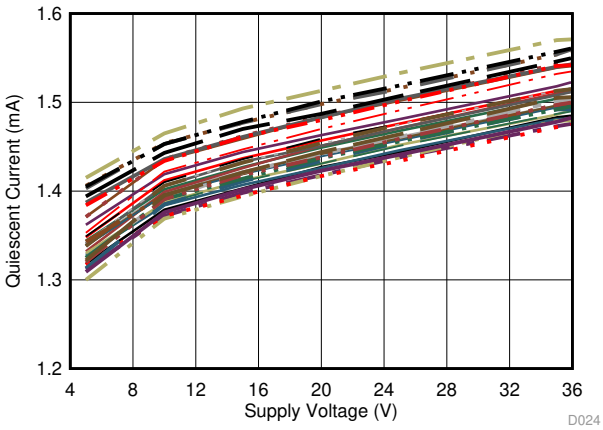


Figure 29. Quiescent Current vs Supply Voltage

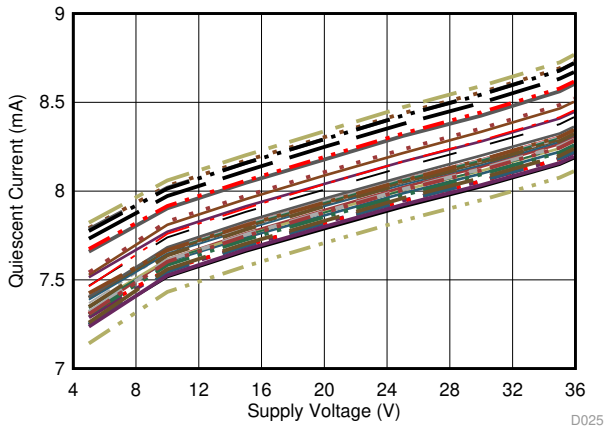
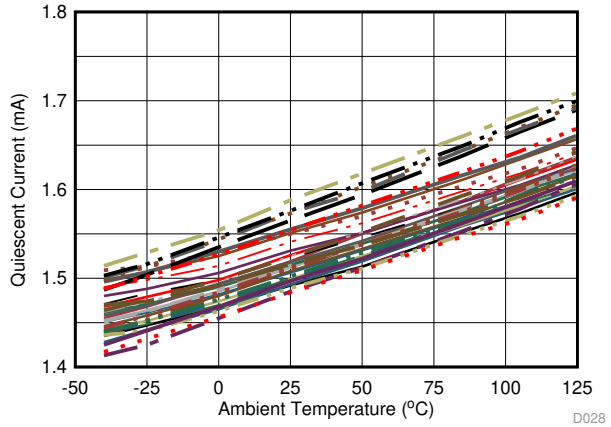


Figure 30. Quiescent Current vs Supply Voltage

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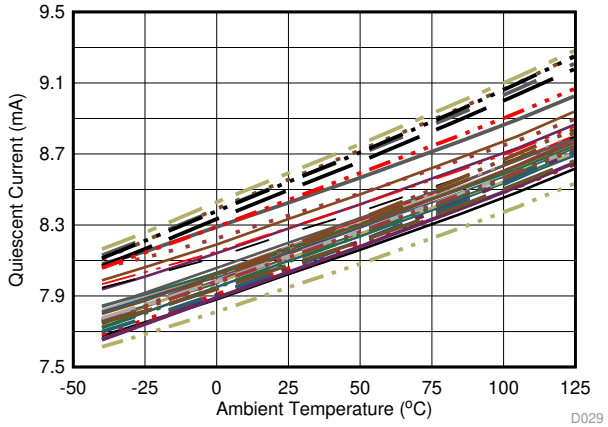
Typical Characteristics (continued)

at T_A = 25°C, V_S = ±15 V, R_S = 50 Ω, and R_L = 100 Ω (unless otherwise noted)



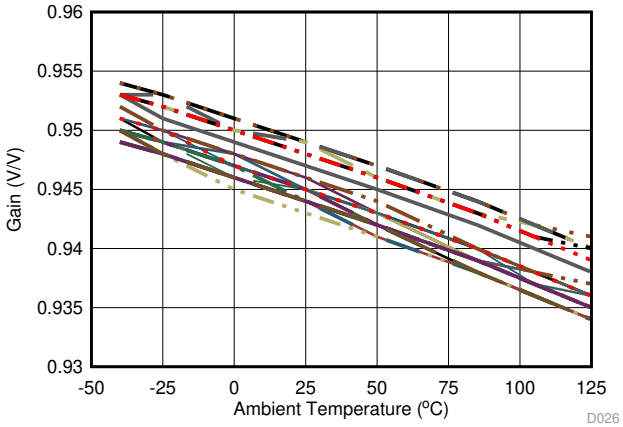
Low-I_Q mode, 35 devices

Figure 31. Quiescent Current vs Temperature



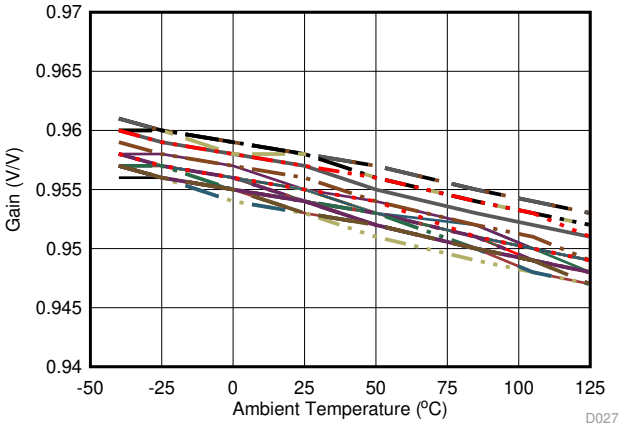
Wide-BW mode, 35 devices

Figure 32. Quiescent Current vs Temperature



Low-I_Q mode, 35 devices

Figure 33. Buffer Gain vs Temperature



Wide-BW mode, 35 devices

Figure 34. Buffer Gain vs Temperature

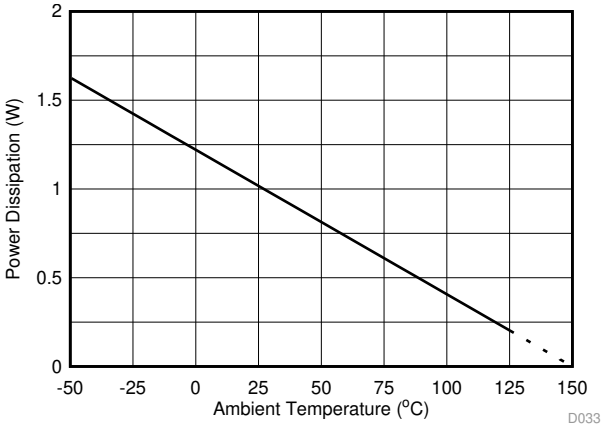


Figure 35. Maximum Power Dissipation vs Temperature

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8 Detailed Description

8.1 Overview

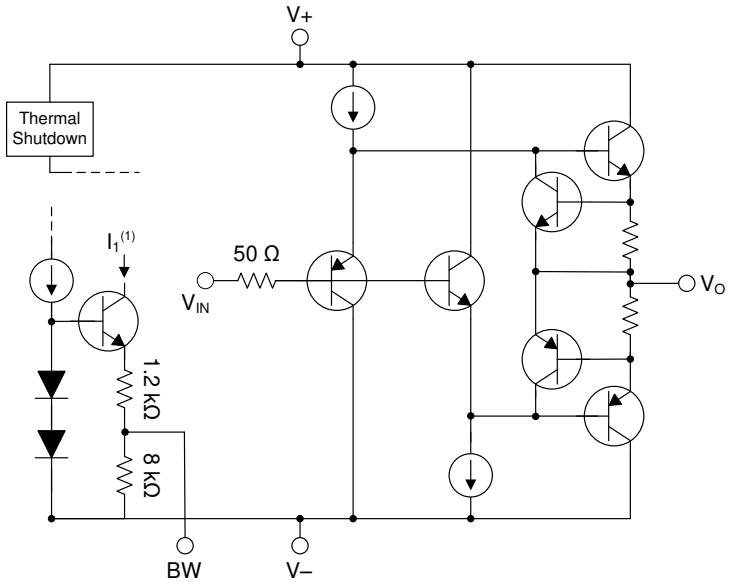
The BUF634A is a high-speed, unity-gain, open-loop buffer that can be used in a wide range of applications requiring large output current drive or large slew rates. The BUF634A can operate on power supplies ranging from 4.5 V to 36 V and includes an internal output current limiting feature as well as thermal shutdown, thereby making the device rugged and easy to use.

The bandwidth of the BUF634A can be adjusted by connecting a resistor between the V– and BW pins. Its power scaling with bandwidth makes the device suitable for use in portable battery-powered applications. See the *Adjustable Bandwidth* section for a description of the relationship between bandwidth adjustment resistance and the device –3-dB bandwidth.

The BUF634A can be used in a composite loop (inside the feedback loop of op amps) to increase output current, eliminate thermal feedback, and improve capacitive load drive. See Figure 44 for this circuit. Decoupling the high-power output current stage from the precision amplifier gives high precision performance by eliminating thermal effects on input offset of the composite circuit. With a large slew rate of 3750 V/µs, the BUF634A can quickly reproduce its input signal at its output without adding considerable delay when used in a composite loop. When used in a composite loop, the outer amplifier controls the circuit precision and distortion performance and the buffer augments the circuit output current drive capability.

See the *Functional Block Diagram* section for a simplified circuit diagram of the open-loop complementary follower design of the BUF634A.

8.2 Functional Block Diagram



NOTE: Stage currents are set by I_1.

8.3 Feature Description

8.3.1 Output Current

The BUF634A can deliver up to ±250-mA continuous output current. Internal circuitry limits the output current to approximately ±350 mA. Care must be taken to limit the output voltage swing for a given load resistance to avoid limiting the output current and degrading linearity; see Figure 45. For many applications, however, the continuous output current is limited by thermal effects. The output voltage swing capability varies with junction temperature and output current; see Figure 17 and Figure 18. Care must be taken to operate the device below the maximum-recommended junction temperature in applications using this buffer in wide-bandwidth mode with a wide supply voltage and large output current to avoid permanent damage to the device.

8.3.2 Thermal Shutdown

Power dissipated in the BUF634A causes the junction temperature to rise. A thermal protection circuit in the BUF634A disables the output when the junction temperature reaches approximately 180°C. When the thermal protection is activated, the output stage is disabled and the output current is limited, allowing the device to cool. Quiescent current is approximately 12 mA during thermal shutdown. When the junction temperature cools to approximately 160°C, the output circuitry is again enabled. This process can cause the protection circuit to cycle on and off with a period ranging from a fraction of a second to several minutes or more, depending on package type, signal, load, and thermal environment.

The thermal protection circuit is designed to prevent damage during abnormal conditions. Any tendency to activate the thermal protection circuit during normal operation is a sign of an inadequate heat sink or excessive power dissipation for the package type.

8.3.3 ESD Protection

As shown in Figure 36, all device pins are protected with internal ESD protection diodes to the power supplies. These diodes provide moderate protection to input overdrive voltages above the supplies. The protection diodes can typically support 10-mA continuous currents. Current limiting series resistors must be added at the inputs if common-mode voltages higher than the supply voltages are possible. Keep these resistor values as low as possible because using high values degrades noise performance and frequency response. V_{IN} is a non fail-safe pin. Ensure V+ and V– are powered up before applying a signal to the V_{IN} pin. Failure to do so results in current flowing through the ESD diode. Restrict any current flowing through the ESD diodes to less than 10 mA.

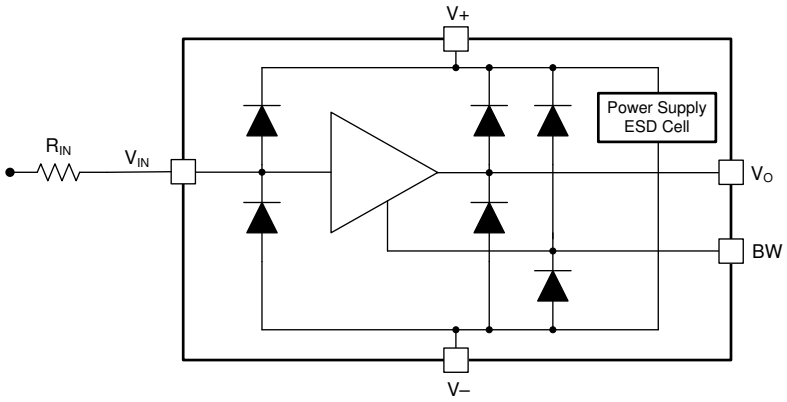


Figure 36. Internal ESD Protection

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8.4 Device Functional Modes

8.4.1 Adjustable Bandwidth

The BUF634A –3-dB bandwidth can be adjusted from 35 MHz to 210 MHz for a 1-kΩ load resistance, as shown in Figure 37, by connecting a resistor between the V– and BW pins. The bandwidth is set to 210 MHz with the BW pin connected to V– and to 35 MHz with the BW pin left floating. The –3-dB bandwidth also changes with the value of the load resistance for a given bandwidth adjustment resistance. The device quiescent current varies from 1.5 mA (typ) to 8.5 mA (typ) with variation in bandwidth from 35 MHz to 210 MHz, respectively.

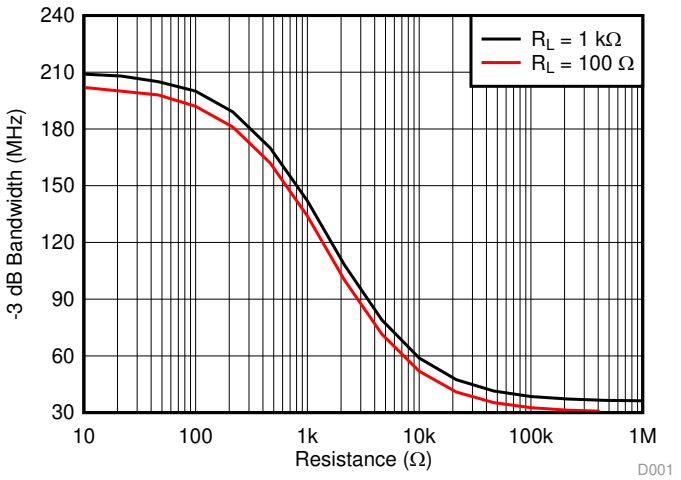


Figure 37. Small-Signal Bandwidth versus Bandwidth Adjustment Resistance

9 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

9.1 Application Information

Figure 38 shows the BUF634A connected as an open-loop buffer. The source impedance and optional input resistor, R_S, influence the frequency response; see Figure 3. Bypass the power supplies with capacitors connected close to the device pins. Capacitor values as low as 0.1 µF assure stable operation in most applications, but high output current and fast output slewing can demand large current transients from the power supplies, requiring the use of solid tantalum 10-µF capacitors. High-frequency, open-loop applications benefit from special bypassing and layout considerations. See the *High-Frequency Applications* section for more information. If the BUF634A input is left floating, the device output can swing to either of the supplies based on the input bias current polarity.

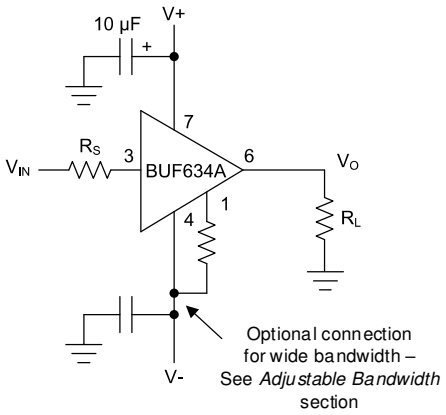


Figure 38. Buffer Connections

9.1.1 High-Frequency Applications

The excellent bandwidth and fast slew rate of the BUF634A are useful in a variety of high-frequency, open-loop applications. When operated in an open-loop application, printed circuit board (PCB) layout and bypassing techniques can affect dynamic performance. Figure 39 through Figure 43 illustrate various application circuit examples for the BUF634A.

For best results, use a ground-plane-type circuit board layout and bypass the power supplies with 0.1-µF ceramic chip capacitors at the device pins in parallel with solid tantalum 10-µF capacitors. Source resistance affects high-frequency peaking, step-response overshoot, and ringing. Best response is usually achieved with a series input resistor of 25 Ω to 200 Ω, depending on the signal source. Response with some loads (especially capacitive) can be improved with a resistor of 10 Ω to 150 Ω in series with the output. When driving multiple device under test (DUT) inputs in automatic test equipment (ATE) testers (large capacitive load), as illustrated in Figure 40, place an isolation resistor at the output of the BUF634A for adequate phase margin and stability.

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Application Information (continued)

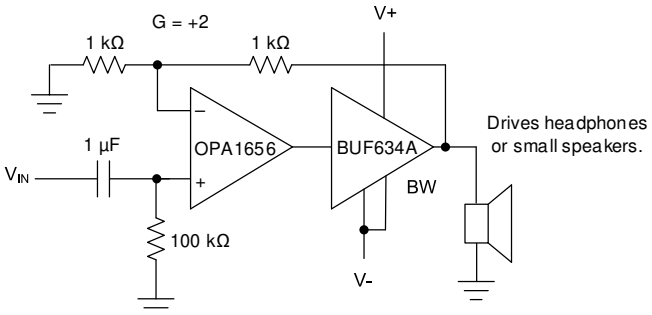


Figure 39. High-Performance Headphone Driver

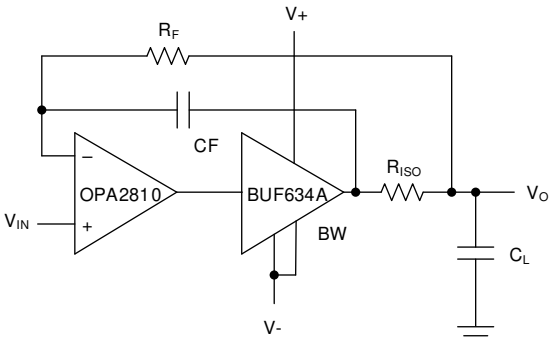


Figure 40. ATE and Test Pin Driver

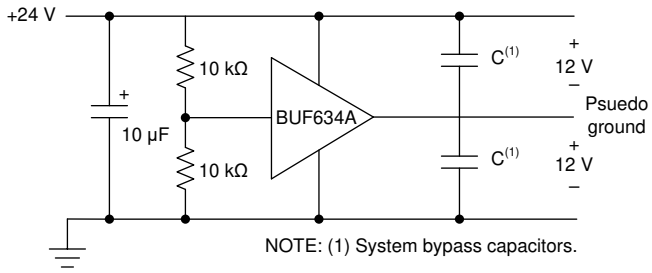


Figure 41. Pseudo-Ground Driver

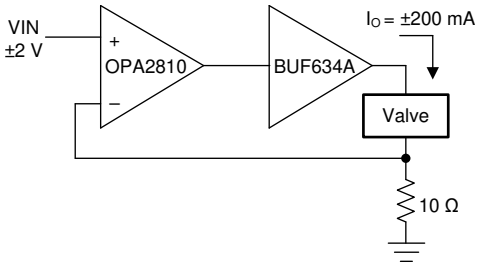


Figure 42. Current-Output Valve Driver

Application Information (continued)

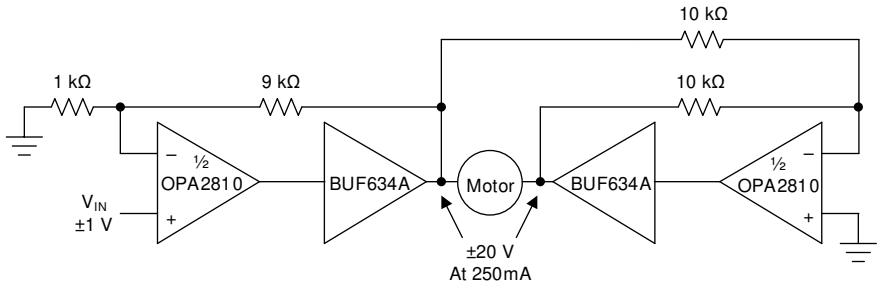
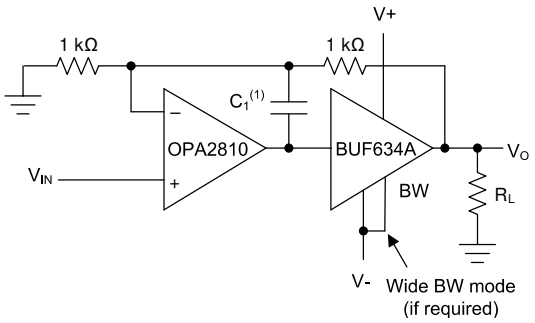


Figure 43. Bridge-Connected Motor Driver

9.2 Typical Application

The BUF634A can be connected inside the feedback loop, as shown in Figure 44, of most op amps to increase output current. When connected inside the feedback loop, the offset voltage of the BUF634A and other errors are corrected by the open-loop gain and feedback of the op amp.



NOTE: C_1 is not required for most common op amps. Use C_1 with unity-gain stable, high-speed op amps.

Figure 44. Boosting Op Amp Output Current

9.2.1 Design Requirements

- Boost the output current of an OPA2810
- Operate from ±12-V power supplies
- Operate from –40°C to +125°C
- Gain = 2 V/V
- Output current = ±250 mA
- Bandwidth greater than 100 kHz

9.2.2 Detailed Design Procedure

To assure that the composite amplifier remains stable, the phase shift of the BUF634A must remain small throughout the loop gain of the circuit. For a G = +1 op-amp circuit, the BUF634A must contribute little additional phase shift (approximately 20° or less) at the unity-gain frequency of the op amp. Phase shift is affected by various operating conditions that can affect the stability of the op amp.

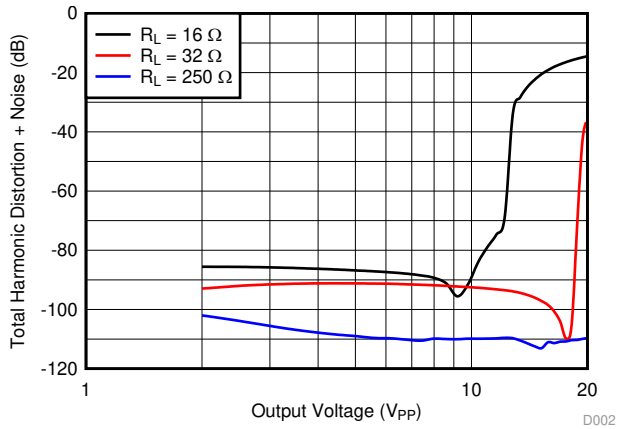
For the circuit in Figure 44, most general-purpose or precision op amps remain unity-gain stable with the BUF634A connected inside the feedback loop. Large capacitive loads may require the BUF634A to be connected for wide bandwidth for stable operation. High-speed or fast-settling op amps generally require wide-bandwidth mode to remain stable and to assure good dynamic performance. Check for oscillations or excessive ringing on signal pulses with the intended load and worst-case conditions that affect phase response of the buffer to determine stability with an op amp. Connect the circuit as shown in Figure 44. Choose resistors to provide a voltage gain of 2 V/V. Select the feedback resistor to be 1 kΩ. Choose the input resistor to be 1 kΩ and C_1 to be 10 pF. Figure 45 and Figure 46 illustrate the THD+N plots for the BUF634A used with the OPA2810 in a gain of

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Typical Application (continued)

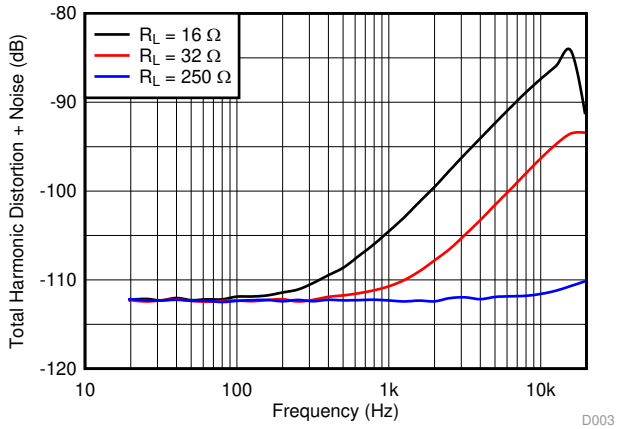
2-V/V composite loop. The THD+N performance is superior in a composite loop when compared with a standalone BUF634A because of the negative feedback and open-loop gain of the OPA2810. In Figure 45, the signal distortion degrades for large output voltages with 16-Ω and 32-Ω loads because of the device internal short-circuit protection.

9.2.3 Application Curves



f = 20 kHz, 90-kHz measurement bandwidth

Figure 45. THD+N vs Output Voltage Using the BUF634A With the OPA2810



V_O = 10 V_{PP}, 90-kHz measurement bandwidth

Figure 46. THD+N vs Frequency Using the BUF634A With the OPA2810

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10 Power Supply Recommendations

The BUF634A is intended for operation on supplies ranging from 4.5 V to 36 V (±2.25 V to ±18 V). At low power-supply conditions, such as ±2.25 V, the output swing may be limited. See the output voltage range specifications in the *Electrical Characteristics* tables for additional information. The BUF634A can be operated on single-sided supplies, split, and balanced bipolar supplies or unbalanced bipolar supplies. Operating from a single supply can have numerous advantages. With the negative supply at ground, the DC errors resulting from the –PSRR term can be minimized. Minimize the distance (< 0.1") from the power-supply pins to high-frequency, 0.1-µF decoupling capacitors. A larger capacitor (10 µF typical) is used along with a high-frequency, 0.1-µF supply-decoupling capacitor at the device supply pins. For single-supply operation, only the positive supply has these capacitors. When a split-supply is used, use these capacitors from each supply to ground. If necessary, place the larger capacitors further from the device and share these capacitors among several devices in the same area of the PCB.

10.1 Power Dissipation and Thermal Considerations

The BUF634A includes automatic thermal shutoff protection. This protection circuitry shuts down the amplifier if the junction temperature exceeds approximately 180°C. When the junction temperature decreases to approximately 160°C, the buffer turns on again. The package and the PCB dictate the thermal characteristics of the device. Maximum power dissipation for a particular package is calculated using the following formula.

$$P_{Dmax} = \frac{T_{max} - T_A}{\theta_{JA}}$$

where

- PD_{max} is the maximum power dissipation in the amplifier (W).
- T_{max} is the absolute maximum junction temperature (°C).
- T_A is the ambient temperature (°C).
- $\theta_{JA} = \theta_{JC} + \theta_{CA}$
- θ_{JC} is the thermal coefficient from the silicon junctions to the case (°C/W).
- θ_{CA} is the thermal coefficient from the case to ambient air (°C/W). (1)

The thermal coefficient for the thermal pad integrated circuit packages are substantially improved over the traditional SOIC package. The data for the thermal pad packages assume a board layout that follows the thermal pad package layout guidelines referenced above and detailed in the *PowerPAD™ Thermally Enhanced Package* application report. If the thermal package integrated circuit package is not soldered to the PCB, the thermal impedance increases substantially and may cause serious heat and performance issues.

When determining whether or not the device satisfies the maximum power dissipation requirement, make sure to consider not only quiescent power dissipation, but dynamic power dissipation. Often times, this dissipation is difficult to quantify because the signal pattern is inconsistent, but an estimate of the RMS power dissipation provides visibility into a possible problem.

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11 Layout

11.1 Layout Guidelines

11.1.1 SOIC Layout Guidelines (D Package Without a Thermal Pad)

For best operational performance of the device, use good PCB layout practices, including:

- Noise can propagate into analog circuitry through the power pins of the circuit. Bypass capacitors are used to reduce the coupled noise by providing low-impedance power sources local to the analog circuitry.
  - Connect low-ESR, 0.1-µF ceramic bypass capacitors between each supply pin and ground, placed as close to the device as possible. A single bypass capacitor from V+ to ground is applicable for single-supply applications.
- Separate grounding for analog and digital portions of circuitry is one of the simplest and most effective methods of noise suppression. One or more layers on multilayer PCBs are usually devoted to ground planes. A ground plane helps distribute heat and reduces electromagnetic interference (EMI) noise pickup. Make sure to physically separate digital and analog grounds, paying attention to the flow of the ground current.
- In order to reduce parasitic coupling, run the input traces as far away from the supply or output traces as possible. If these traces cannot be kept separate, crossing the sensitive trace perpendicular is much better as opposed to in parallel with the noisy trace.
- Place the external components as close to the device as possible, as illustrated in Figure 48.
- Keep the length of input traces as short as possible. Always remember that the input traces are the most sensitive part of the circuit.
- Cleaning the PCB following board assembly is recommended for best performance.
- Any precision integrated circuit can experience performance shifts resulting from moisture ingress into the plastic package. Following any aqueous PCB cleaning process, baking the PCB assembly is recommended to remove moisture introduced into the device packaging during the cleaning process. A low-temperature, post-cleaning bake at 85°C for 30 minutes is sufficient for most circumstances.

The SOIC-8 surface-mount package is excellent for applications requiring high output current with low average power dissipation. To achieve the best possible thermal performance with the SOIC-8 package, solder the device directly to a circuit board. Sockets degrade thermal performance because much of the heat is dissipated by conduction through the package pins. Use wide circuit board traces on all device pins, including pins that are not connected. For more information on designing the circuit board, see the *BUF634AD Evaluation module* user's guide.

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Layout Guidelines (continued)

11.1.2 HSOIC Layout Guidelines (DDA Package With a Thermal Pad)

Figure 47 shows the DDA package top-side etch and via pattern.

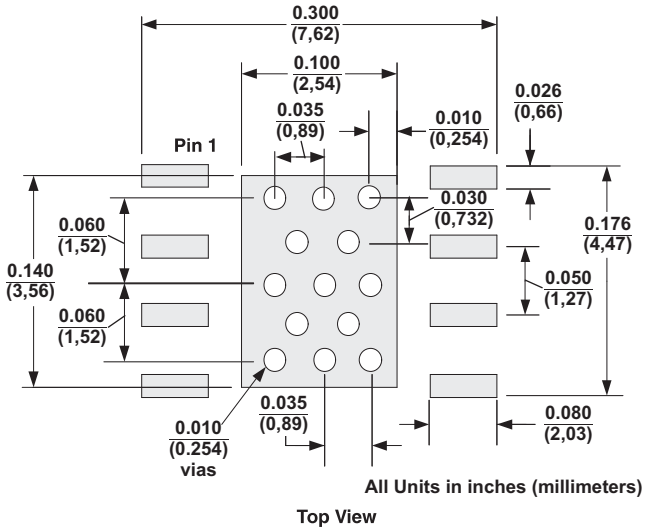


Figure 47. DDA Thermal Pad Integrated Circuit Package PCB Etch and Via Pattern

1. Use an etch for the leads and the thermal pad.
2. Place 13 vias in the thermal pad area. These vias must be 0.01 inch (0.254 mm) in diameter. Keep the vias small so that solder wicking through the vias is not a problem during reflow.
3. Additional vias may be placed anywhere along the thermal plane outside of the thermal pad area, and help dissipate the heat generated by the BUF634A. These additional vias may be larger than the 0.01-inch (0.254 mm) diameter vias directly under the thermal pad because they are not in the area that requires soldering. As a result, wicking is not a problem.
4. The thermal pad is internally connected with V–. Therefore, always short the thermal pad to the same potential as V– externally as well.
5. Connect all vias used under the thermal pad to remove heat to the V– plane.
6. When connecting these vias to the V– plane, do not use the typical web or spoke connection methodology. Web and spoke connections have a high thermal resistance that slows the heat transfer during soldering. The vias under the BUF634A thermal pad must connect to the internal thermal plane or thermal pour with a complete connection around the entire circumference of the plated-through hole.
7. The top-side solder mask must leave the pins of the package and the thermal pad area with the 13 vias exposed.
8. Apply solder paste to the exposed thermal pad area and all of the device pins.
9. With these preparatory steps in place, the device is placed in position and run through the solder reflow operation as any standard surface-mount component.

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11.2 Layout Example

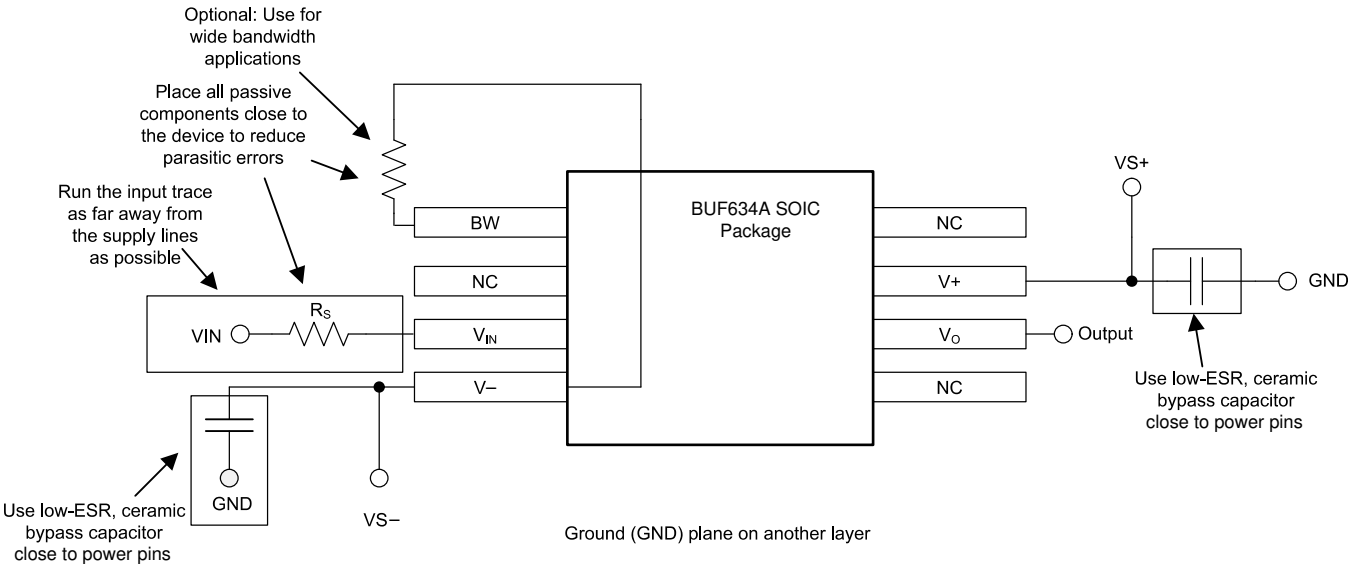


Figure 48. BUF634A Layout Example (SOIC)

12 Device and Documentation Support

12.1 Device Support

12.1.1 Development Support

12.1.1.1 TINA-TI™ (Free Software Download)

TINA™ is a simple, powerful, and easy-to-use circuit simulation program based on a SPICE engine. TINA-TI is a free, fully-functional version of the TINA software, preloaded with a library of macromodels in addition to a range of both passive and active models. TINA-TI provides all the conventional DC, transient, and frequency domain analysis of SPICE, as well as additional design capabilities.

Available as a free download from the Analog eLab Design Center, TINA-TI offers extensive post-processing capability that allows users to format results in a variety of ways. Virtual instruments offer the ability to select input waveforms and probe circuit nodes, voltages, and waveforms, creating a dynamic quick-start tool.

NOTE

These files require that either the TINA software (from DesignSoft™) or TINA-TI software be installed. Download the free TINA-TI software from the TINA-TI folder.

12.1.1.2 TI Precision Designs

The BUF634A is featured in several TI Precision Designs, available online at www.ti.com. TI Precision Designs are analog solutions created by TI's precision analog applications experts and offer the theory of operation, component selection, simulation, complete PCB schematic and layout, bill of materials, and measured performance of many useful circuits.

12.2 Documentation Support

12.2.1 Related Documentation

For related documentation see the following:

- Texas Instruments, *OPA2810 Dual-channel, 27-V, rail-to-rail input/output FET-Input operational amplifier* data sheet
- Texas Instruments, *BUF634AD Evaluation module* user's guide
- Texas Instruments, *Combining an amplifier with the BUF634* application note
- Texas Instruments, *Add current limit to the BUF634* application note
- Texas Instruments, *Power amplifier stress and power handling limitations* application note
- Texas Instruments, *Shelf-life evaluation of lead-free component finishes* application report

12.3 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

12.4 Community Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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12.6 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

12.7 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

13 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

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PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
BUF634AIDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	BF634A	Samples
BUF634AIDRBT	PREVIEW	SON	DRB	8	250	TBD	Call TI	Call TI	-40 to 125		
XBUF634AIDRBT	ACTIVE	SON	DRB	8	250	TBD	Call TI	Call TI	-40 to 125		Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

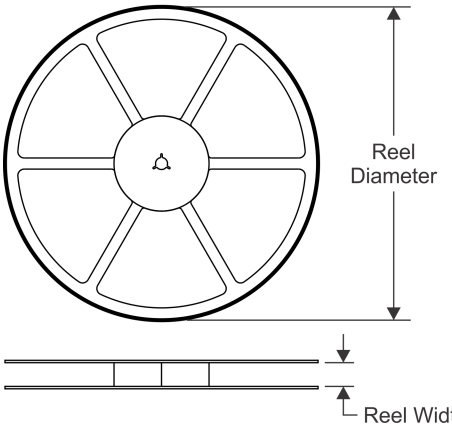
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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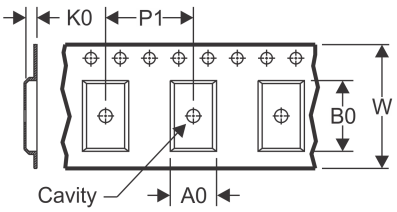
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TAPE AND REEL INFORMATION

REEL DIMENSIONS

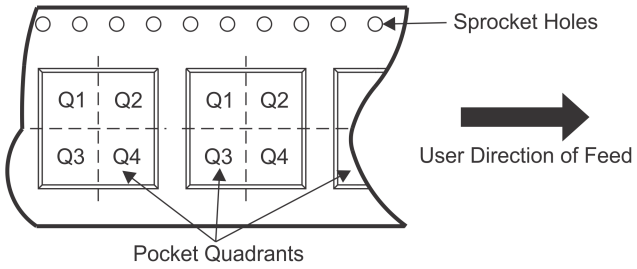


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

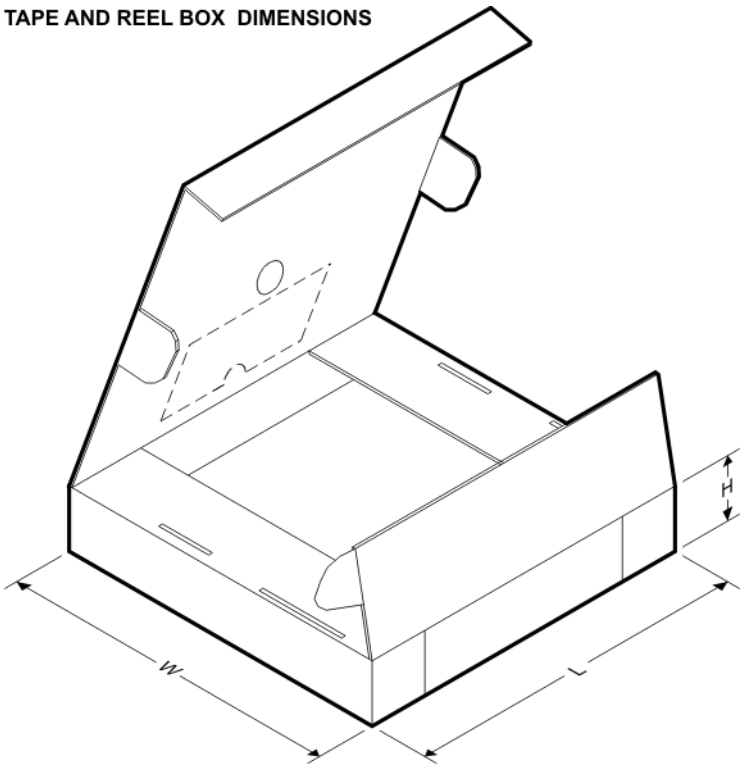
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
BUF634AIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
BUF634AIDR	SOIC	D	8	2500	367.0	367.0	35.0

GENERIC PACKAGE VIEW

DRB 8

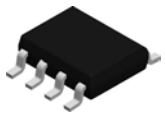
VSON - 1 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

4203482/L

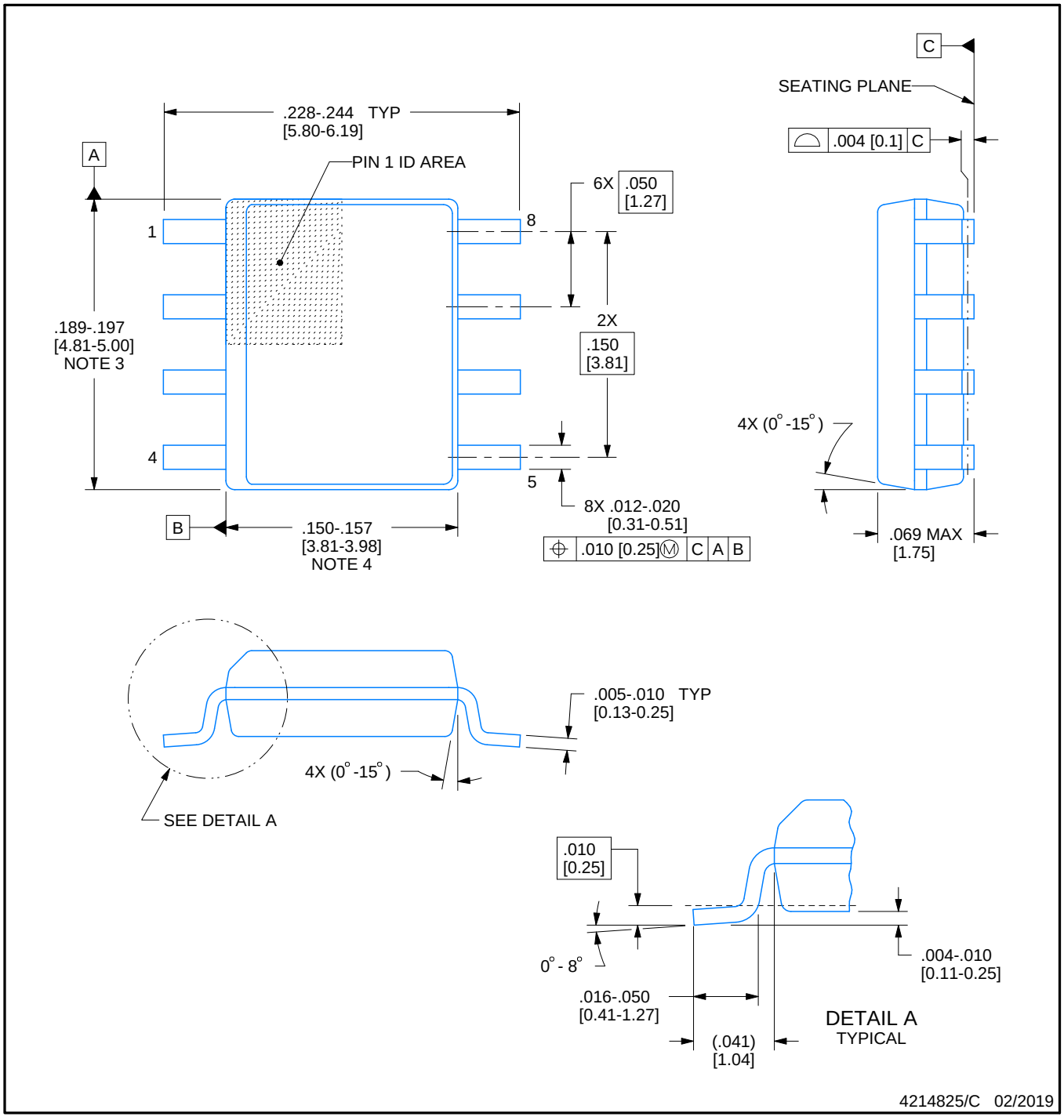


PACKAGE OUTLINE

D0008A

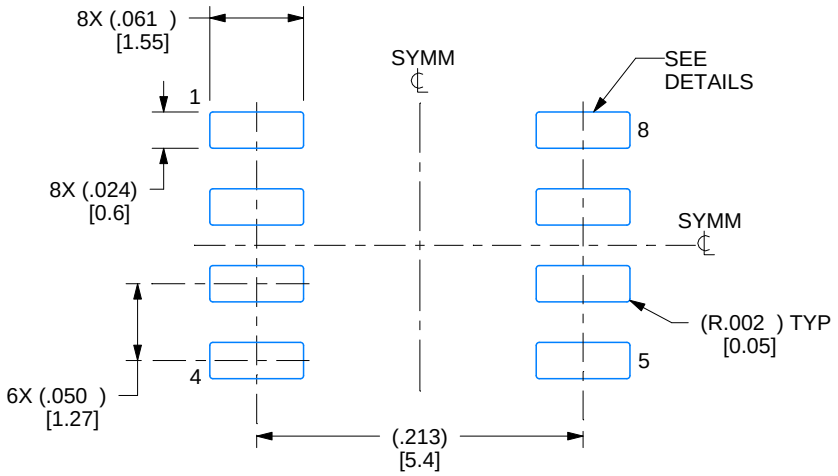
SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT

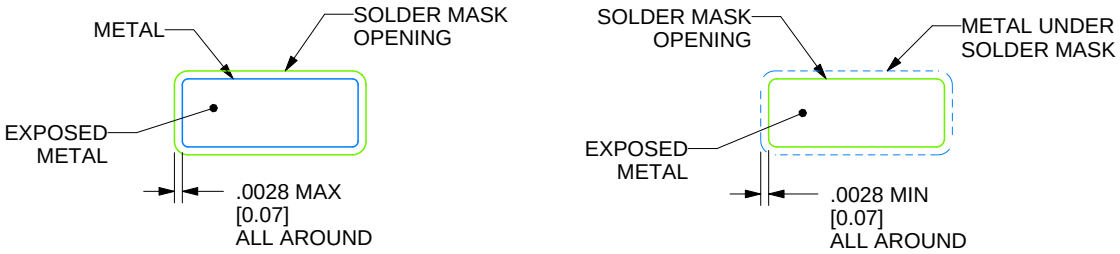


NOTES:

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

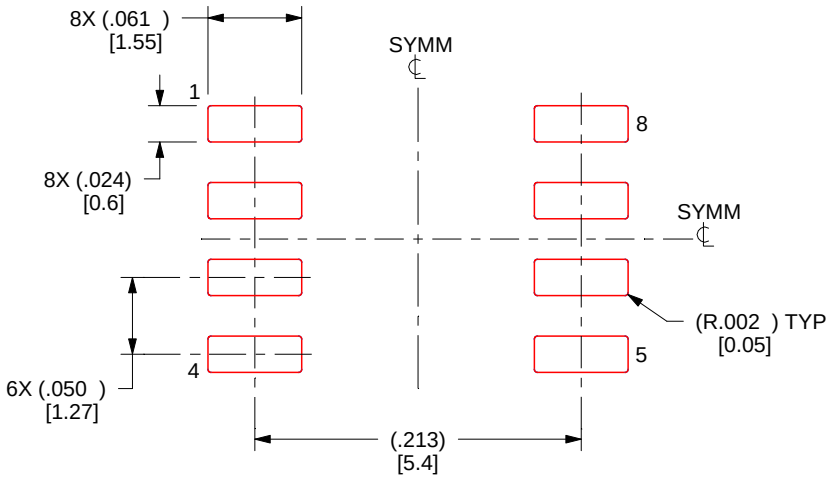
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

4214825/C 02/2019

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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