

Single/Dual/Quad, Low-Cost, UCSP/SOT23, Low-Power, Rail-to-Rail I/O Op Amps

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V _{CC} - V _{EE})	7.5V	8-Pin μMAX (derate 4.10mW/°C above +70°C)	330mW
All Other Pins	(V _{CC} + 0.3V) to (V _{EE} - 0.3V)	10-Pin μMAX (derate 5.6mW/°C above +70°C)	444mW
Output Short-Circuit Duration	Continuous (Short to Either Supply)	14-Pin SO (derate 8.00mW/°C above +70°C)	640mW
Continuous Power Dissipation (T _A = +70°C)		Operating Temperature Range	
5-Pin SOT23 (derate 7.1mW/°C above +70°C)	571mW	MAX432_E__	-40°C to +85°C
6-Bump UCSP (derate 3.9mW/°C above +70°C)	308mW	Maximum Junction Temperature	+150°C
6-Pin SOT23 (derate 7.1mW/°C Above +70°C)	571mW	Storage Temperature Range	-65°C to +160°C
8-Pin SO (derate 5.88mW/°C above +70°C)	471mW	Bump Reflow Temperature	+235°C
		Lead Temperature (soldering, 10s)	+300°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

DC ELECTRICAL CHARACTERISTICS—T_A = +25°C

(V_{CC} = 5.0V, V_{EE} = 0V, V_{CM} = 0V, V_{OUT} = V_{CC}/2, $\overline{\text{SHDN}}$ = V_{CC}, R_L connected to V_{CC}/2, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Offset Voltage	V _{OS}	V _{CM} = V _{EE} or V _{CC}	MAX432_ESA/ MAX4327ESD		±0.7	±2.0	mV
			All other packages		±1.2	±2.50	
Input Bias Current	I _B	V _{CM} = V _{EE} or V _{CC}			±50	±150	nA
Input Offset Current	I _{OS}	V _{CM} = V _{EE} or V _{CC}			±1	±12	nA
Differential Input Resistance	R _{IN}	-1.5V < V _{DIFF} < +1.5V			500		kΩ
Common-Mode Input Voltage Range	CMVR	Inferred from CMRR test		V _{EE}		V _{CC}	V
Common-Mode Rejection Ratio	CMRR	V _{EE} ≤ V _{CM} ≤ V _{CC}	MAX432_ESA/ MAX4327ESD	62	94		dB
			All other packages	60	91		
Power-Supply Rejection Ratio	PSRR	V _{CC} = 2.4V to 6.5V		66	100		dB
Output Resistance	R _{OUT}	A _v = +1V/V			0.1		Ω
Large-Signal Voltage Gain	A _v	V _{OUT} = 0.25V to 4.75V, R _L = 100kΩ			106		dB
		V _{OUT} = 0.4V to 4.6V, R _L = 250Ω		70	86		
Output Voltage Swing	V _O	MAX4322/ MAX4323	R _L = 100kΩ	V _{CC} - V _{OH}		12	mV
				V _{OL} - V _{EE}		20	
		R _L = 250Ω	V _{CC} - V _{OH}		200	300	
			V _{OL} - V _{EE}		100	200	
		MAX4326/ MAX4327/ MAX4329	R _L = 100kΩ	V _{CC} - V _{OH}		15	
				V _{OL} - V _{EE}		25	
R _L = 250Ω	V _{CC} - V _{OH}		220	350			
	V _{OL} - V _{EE}		120	250			
Output Short-Circuit Current	I _{SC}				50		mA
$\overline{\text{SHDN}}$ Logic Threshold	V _{IL}	MAX4323/MAX4327		Low		0.8	V
	V _{IH}			High	2.0		
$\overline{\text{SHDN}}$ Input Current		MAX4323/MAX4327			±1	±4	μA

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MAX4322/MAX4323/MAX4326/MAX4327/MAX4329

DC ELECTRICAL CHARACTERISTICS— $T_A = +25^\circ\text{C}$ (continued)

($V_{CC} = 5\text{V}$, $V_{EE} = 0\text{V}$, $V_{CM} = 0\text{V}$, $V_{OUT} = V_{CC}/2$, $\overline{\text{SHDN}} = V_{CC}$, R_L connected to $V_{CC}/2$, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Operating Supply Voltage Range	V_{CC}	Inferred from PSRR test		2.4		6.5	V
Supply Current per Amplifier	I_{CC}	$V_{CM} = V_{OUT} = V_{CC}/2$	$V_{CC} = 2.4\text{V}$	650			μA
			$V_{CC} = 5\text{V}$	725	1100		
Shutdown Supply Current per Amplifier	$I_{\overline{\text{SHDN}}}$	$V_{\overline{\text{SHDN}}} \leq 0.8\text{V}$, MAX4323/MAX4327	$V_{CC} = 2.4\text{V}$	25			μA
			$V_{CC} = 5\text{V}$	40	60		

DC ELECTRICAL CHARACTERISTICS— $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$

($V_{CC} = 5\text{V}$, $V_{EE} = 0\text{V}$, $V_{CM} = 0\text{V}$, $V_{OUT} = V_{CC}/2$, $\overline{\text{SHDN}} = V_{CC}$, R_L connected to $V_{CC}/2$, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Offset Voltage	V_{OS}	$V_{CM} = V_{EE}$ or V_{CC}	MAX432_ESA/ MAX4327ESD			± 3.0	mV
			All other packages			± 6.0	
Input Offset Voltage Tempco	TCV_{OS}				± 2		$\mu\text{V}/^\circ\text{C}$
Input Bias Current	I_B	$V_{CM} = V_{EE}$ or V_{CC}				± 180	nA
Input Offset Current	I_{OS}	$V_{CM} = V_{EE}$ or V_{CC}				± 20	nA
Common-Mode Input Voltage Range	$CMVR$	Inferred from CMRR test		V_{EE}		V_{CC}	V
Common-Mode Rejection Ratio	$CMRR$	$V_{EE} \leq V_{CM} \leq V_{CC}$	MAX432_ESA/ MAX4327ESD	59			dB
			All other packages	54			
Power-Supply Rejection Ratio	$PSRR$	$V_{CC} = 2.4\text{V}$ to 6.5V		62			dB
Large-Signal Voltage Gain	A_V	$V_{OUT} = 0.4\text{V}$ to 4.6V , $R_L = 250\Omega$		66			dB
Output Voltage Swing	V_O	MAX4322/ MAX4323	$R_L = 250\Omega$	$V_{CC} - V_{OH}$	350		mV
				$V_{OL} - V_{EE}$	250		
		MAX4326/ MAX4327/ MAX4329	$R_L = 250\Omega$	$V_{CC} - V_{OH}$	400		
				$V_{OL} - V_{EE}$	300		
$\overline{\text{SHDN}}$ Logic Threshold	V_{IL}	MAX4323/MAX4327		Low	0.8		V
	V_{IH}			High	2.0		
$\overline{\text{SHDN}}$ Input Current		MAX4323/MAX4327				± 5	μA
Operating Supply Voltage Range	V_{CC}			2.4		6.5	V
Supply Current per Amplifier	I_{CC}	$V_{CM} = V_{OUT} = V_{CC}/2$				1200	μA
Shutdown Supply Current per Amplifier	$I_{\overline{\text{SHDN}}}$	$V_{\overline{\text{SHDN}}} \leq 0.8\text{V}$, MAX4323/MAX4327				70	μA

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AC ELECTRICAL CHARACTERISTICS

($V_{CC} = 5V$, $V_{EE} = 0V$, $V_{CM} = V_{OUT} = V_{CC}/2$, $\overline{SHDN} = V_{CC}$, $T_A = +25^\circ C$, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Gain-Bandwidth Product	GBWP			5		MHz
Phase Margin	ϕ_M			64		Degrees
Gain Margin	GM			12		dB
Total Harmonic Distortion	THD	$f = 10\text{kHz}$, $V_{OUT} = 2V_{P-P}$, $A_V = +1V/V$		0.003		%
Slew Rate	SR			2		V/ μs
Settling Time to 0.01%	t_S	$A_V = +1V/V$, $V_{OUT} = 2V$ step		2.0		μs
Turn-On Time	t_{ON}	$V_{CC} = 0$ to $3V$ step		1		μs
\overline{SHDN} Delay		MAX4323/MAX4327	Enable	1		μs
			Disable	0.2		
Input Capacitance	C_{IN}			3		pF
Input Noise-Voltage Density	e_n	$f = 1\text{kHz}$		22		$\text{nV}/\sqrt{\text{Hz}}$
Input Noise-Current Density	i_n	$f = 1\text{kHz}$		0.4		$\text{pA}/\sqrt{\text{Hz}}$
Amp-Amp Isolation				135		dB
Capacitive-Load Stability	C_L	$A_V = +1V/V$		250		pF

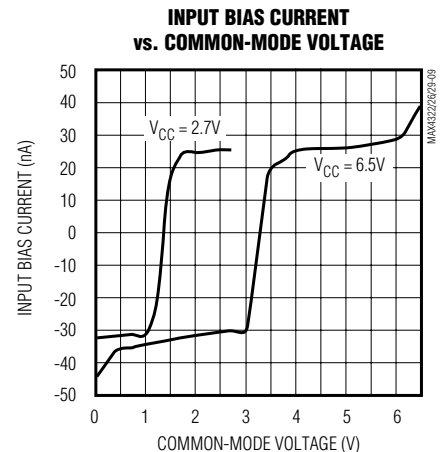
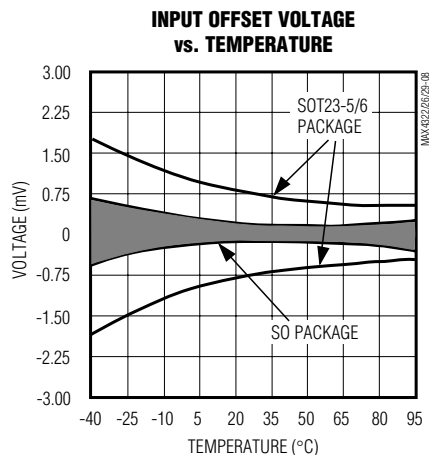
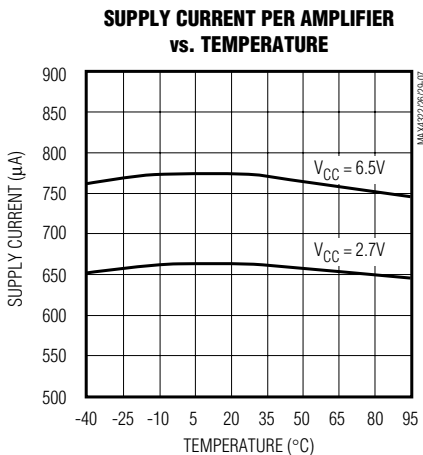
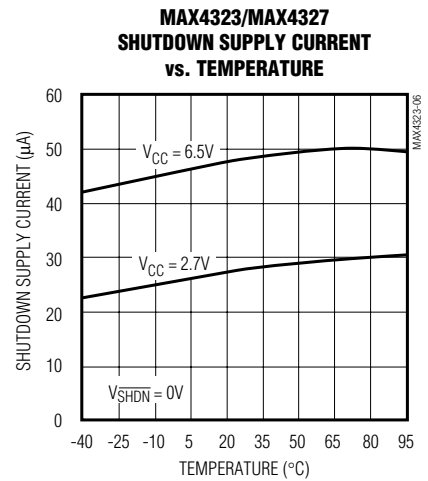
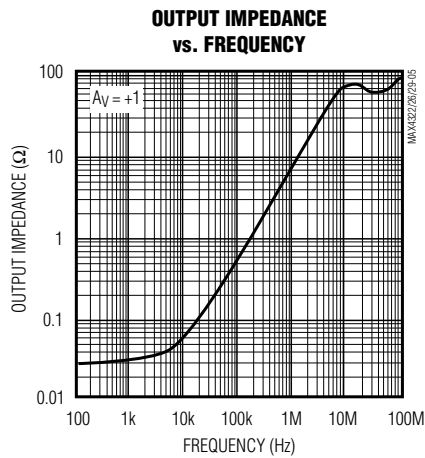
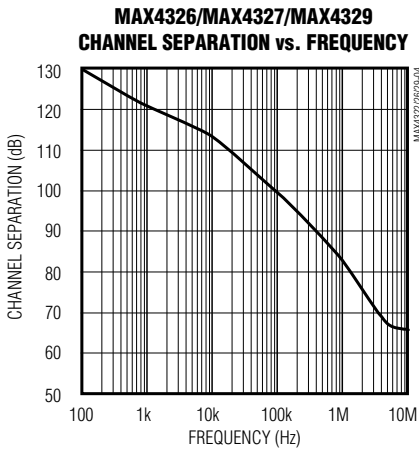
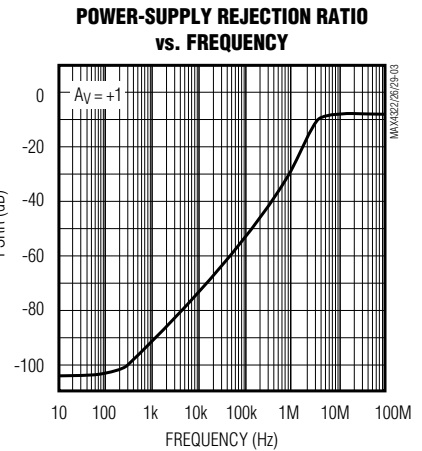
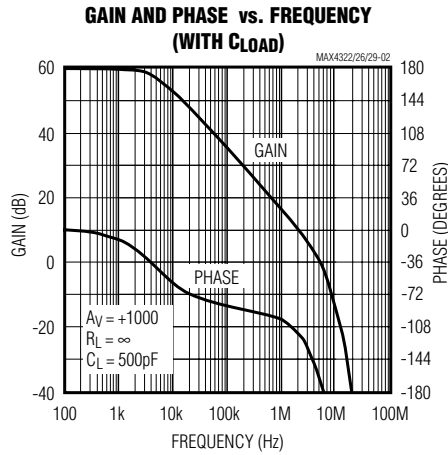
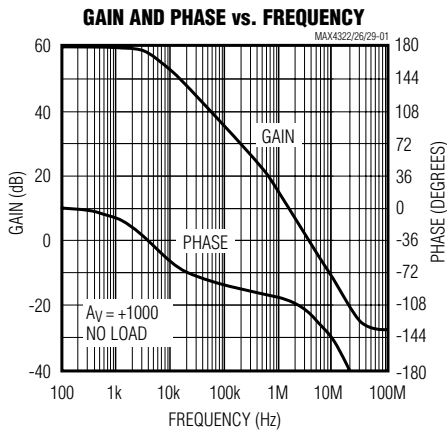
Note 1: All devices are 100% tested at $T_A = +25^\circ C$. All temperature limits are guaranteed by design.

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Typical Operating Characteristics

($V_{CC} = 5V$, $V_{EE} = 0V$, $V_{CM} = V_{CC}/2$, $\overline{SHDN} = V_{CC}$, $T_A = +25^\circ C$, unless otherwise noted.)

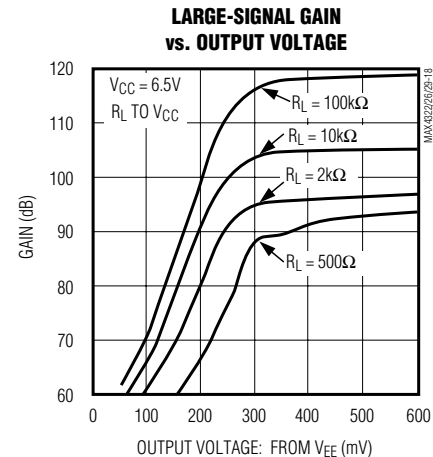
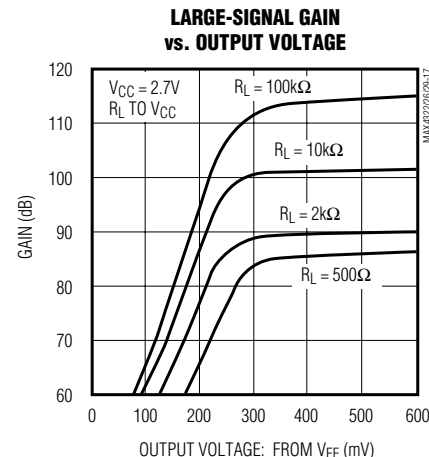
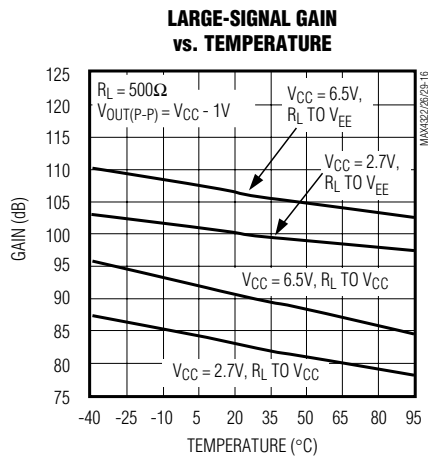
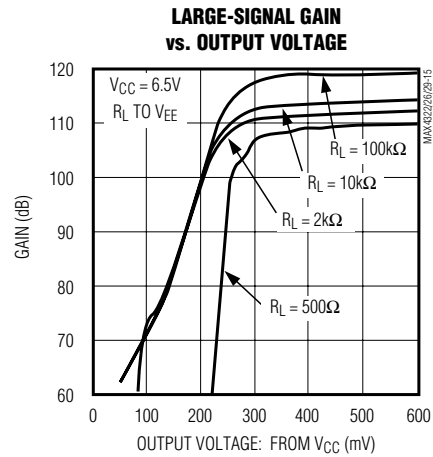
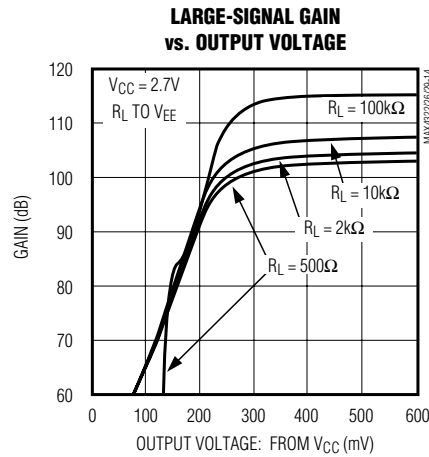
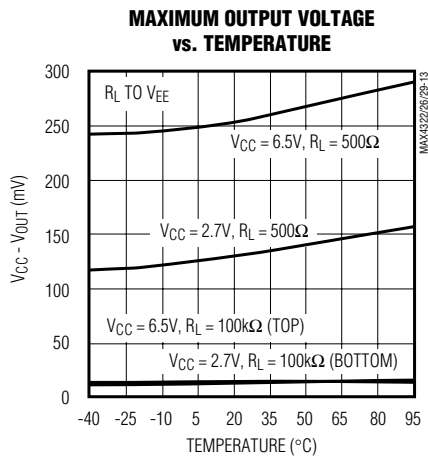
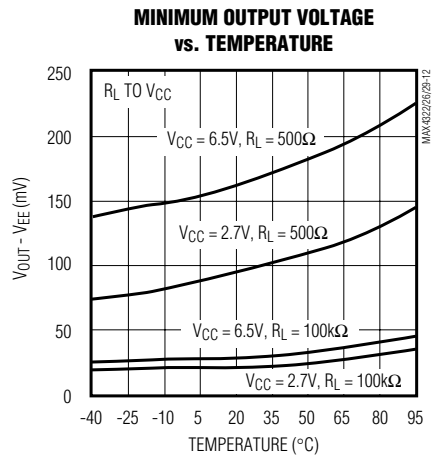
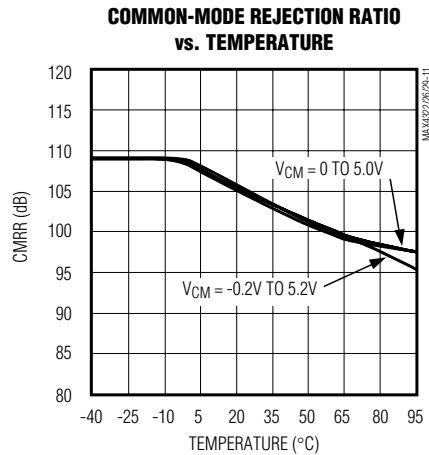
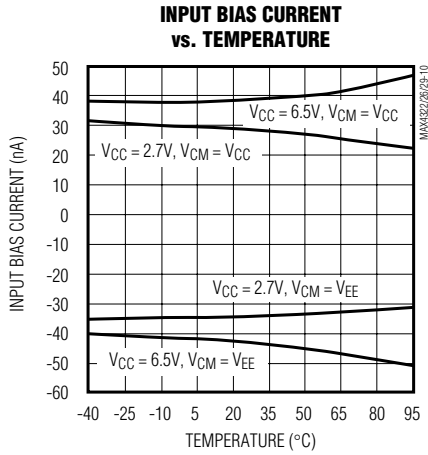
MAX4322/MAX4323/MAX4326/MAX4327/MAX4329



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Typical Operating Characteristics (continued)

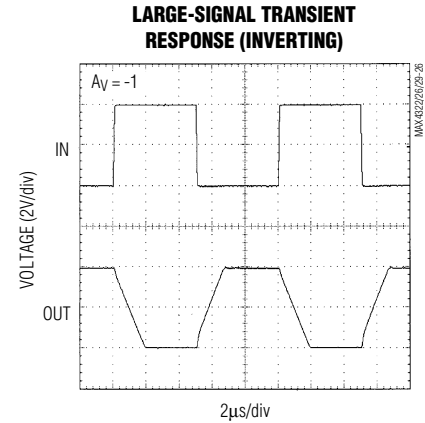
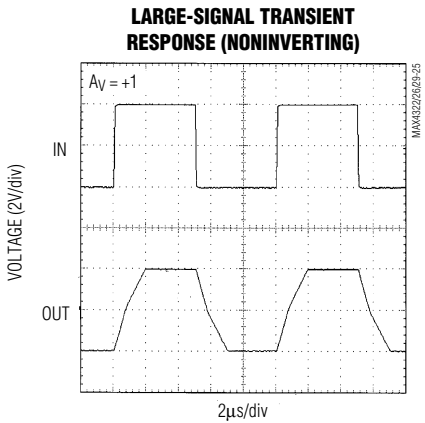
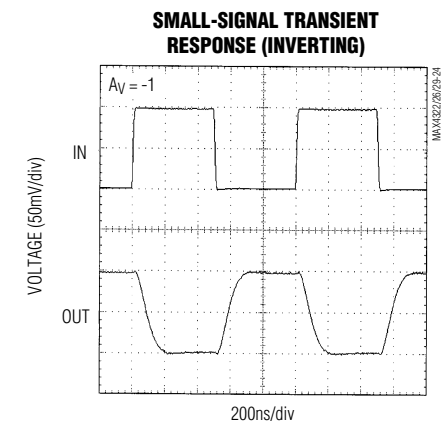
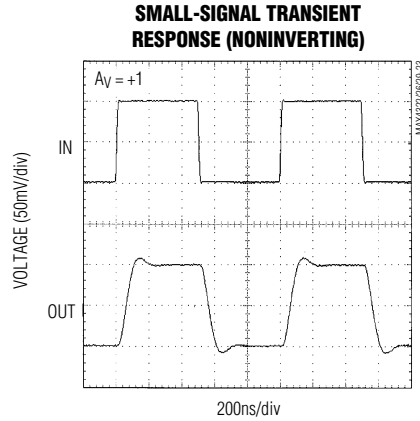
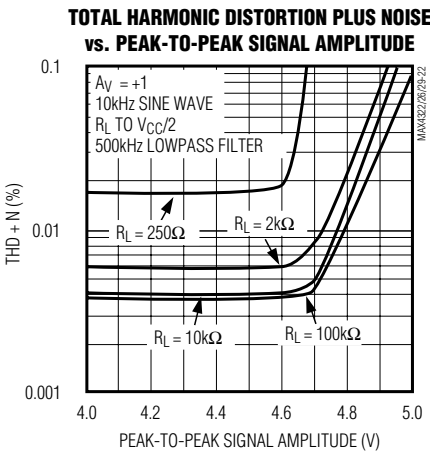
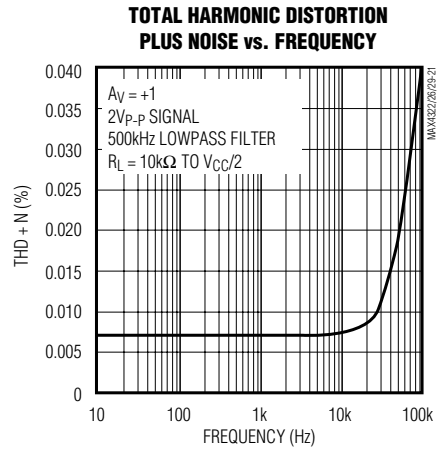
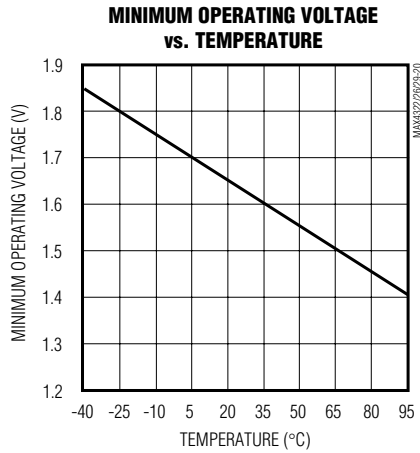
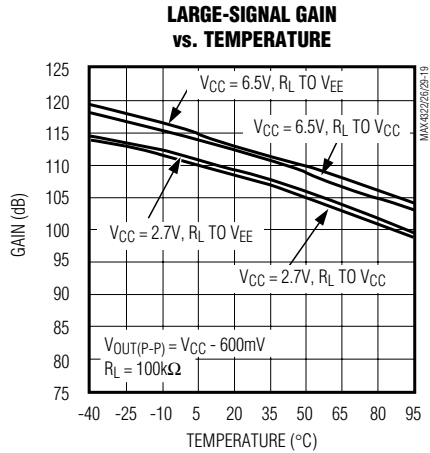
($V_{CC} = 5V$, $V_{EE} = 0V$, $V_{CM} = V_{CC}/2$, $\overline{SHDN} = V_{CC}$, $T_A = +25^\circ C$, unless otherwise noted.)



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Typical Operating Characteristics (continued)

($V_{CC} = 5V$, $V_{EE} = 0V$, $V_{CM} = V_{CC}/2$, $\overline{SHDN} = V_{CC}$, $T_A = +25^\circ C$, unless otherwise noted.)



MAX4322/MAX4323/MAX4326/MAX4327/MAX4329

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Pin Description

PIN									NAME	FUNCTION
MAX4322		MAX4323			MAX4326	MAX4327		MAX4329		
SOT23	SO/ μ MAX	SOT23	SO/ μ MAX	UCSP		μ MAX	SO			
1	6	1	6	A2	—	—	—	—	OUT	Output
2	4	2	4	A1	4	4	4	11	V _{EE}	Negative Supply. Ground for single-supply operation.
3	—	3	3	B1	—	—	—	—	IN+	Noninverting Input
4	—	4	2	B2	—	—	—	—	IN-	Inverting Input
5	7	6	7	A3	8	10	14	4	V _{CC}	Positive Supply
—	1, 5, 8	—	1, 5	—	—	—	5, 7, 8, 10	—	N.C.	No Connection. Not internally connected.
—	—	5	8	B3	—	—	—	—	$\overline{\text{SHDN}}$	Shutdown Control. Connected high or leave floating to enable amplifier.
—	—	—	—	—	1, 7	1, 9	1, 13	1, 7	OUT1, OUT2	Outputs for Amps 1 and 2
—	2	—	—	—	2, 6	2, 8	2, 12	2, 6	IN1-, IN2-	Inverting Inputs for Amps 1 and 2
—	3	—	—	—	3, 5	3, 7	3, 11	3, 5	IN1+, IN2+	Noninverting Inputs for Amps 1 and 2
—	—	—	—	—	—	5, 6	5, 9	—	$\overline{\text{SHDN1}}$, $\overline{\text{SHDN2}}$	Shutdown Control for Amps 1 and 2. Connected high or leave floating to enable amplifier.
—	—	—	—	—	—	—	—	8, 14	OUT3, OUT4	Outputs for Amps 3 and 4
—	—	—	—	—	—	—	—	9, 13	IN3-, IN4-	Inverting Inputs for Amps 3 and 4
—	—	—	—	—	—	—	—	10, 12	IN3+, IN4+	Noninverting Inputs for Amps 3 and 4

MAX4322/MAX4323/MAX4326/MAX4327/MAX4329

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Applications Information

Rail-to-Rail Input Stage

Devices in the MAX4322/MAX4323/MAX4326/MAX4327/MAX4329 family of high-speed amplifiers have rail-to-rail input and output stages designed for low-voltage, single-supply operation. The input stage consists of separate NPN and PNP differential stages, which combine to provide an input common-mode range extending to the supply rails. The PNP stage is active for input voltages close to the negative rail, and the NPN stage is active for input voltages near the positive rail. The input offset voltage is typically below 250µV. The switchover transition region, which occurs near $V_{CC}/2$, has been extended to minimize the slight degradation in CMRR caused by the mismatch of the input pairs. Their low offset voltage, high bandwidth, and rail-to-rail common-mode range make these op amps excellent choices for precision, low-voltage, data-acquisition systems.

Since the input stage switches between the NPN and PNP pairs, the input bias current changes polarity as the input voltage passes through the transition region. To reduce the offset error caused by input bias currents flowing through external source impedances, match the effective impedance seen by each input (Figures 1a, 1b). High-source impedances, together with the input capacitance, can create a parasitic pole that produces an underdamped signal response. Reducing the input impedance or placing a small (2pF to 10pF) capacitor across the feedback resistor improves the response.

The MAX4322/MAX4323/MAX4326/MAX4327/MAX4329s' inputs are protected from large differential input voltages by 1kΩ series resistors and back-to-back triple diodes across the inputs (Figure 2). For differential input voltages less than 1.8V, the input resistance is typically 500kΩ. For differential input voltages greater than 1.8V, the input resistance is approximately 2kΩ, and the input bias current is determined by the following equation:

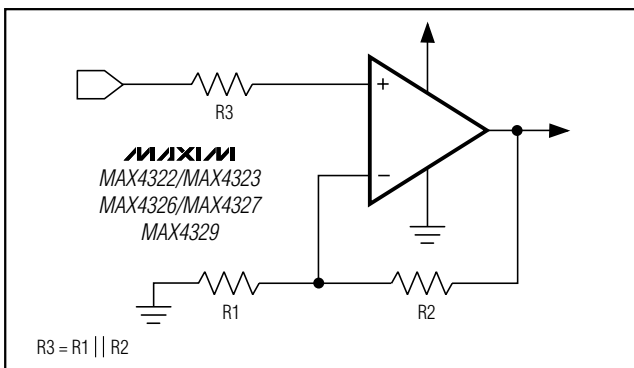


Figure 1a. Reducing Offset Error Due to Bias Current (Noninverting)

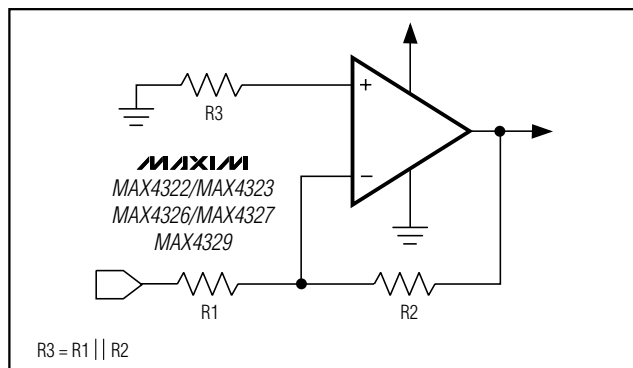


Figure 1b. Reducing Offset Error Due to Bias Current (Inverting)

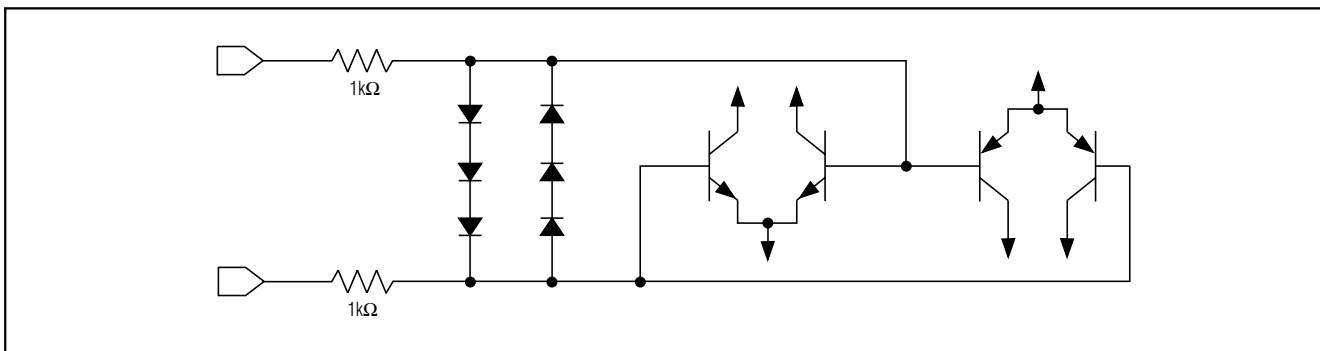


Figure 2. Input Protection Circuit

MAX4322/MAX4323/MAX4326/MAX4327/MAX4329

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$$I_{BIAS} = \frac{V_{DIFF} - 1.8V}{2k\Omega}$$

Rail-to-Rail Output Stage

The minimum output voltage is within millivolts of ground for single-supply operation where the load is referenced to ground (V_{EE}). Figure 3 shows the input voltage range and output voltage swing of a MAX4322 connected as a voltage follower. With a 3V supply and the load tied to ground, the output swings from 0 to 2.90V. The maximum output voltage swing depends on the load, but is within 350mV of a 5V supply, even with the maximum load (500 Ω to ground).

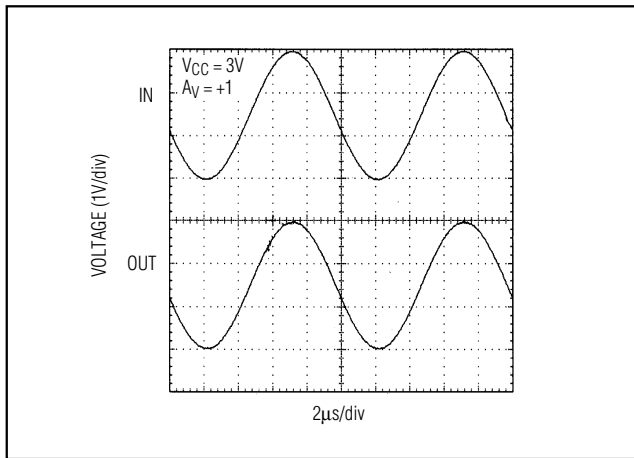


Figure 3. Rail-to-Rail Input/Output Voltage Range

Driving a capacitive load can cause instability in most high-speed op amps, especially those with low quiescent current. The MAX4322/MAX4323/MAX4326/MAX4327/MAX4329 have a high tolerance for capacitive loads. They are stable with capacitive loads up to 500pF. Figure 4 gives the stable operating region for capacitive loads. Figures 5 and 6 show the response with capacitive loads and the results of adding an isolation resistor in series with the output (Figure 7). The resistor improves the circuit's phase margin by isolating the load capacitor from the op amp's output.

Power-Up and Shutdown Mode

The MAX4322/MAX4323/MAX4326/MAX4327/MAX4329 amplifiers typically settle within 1 μ s after power-up.

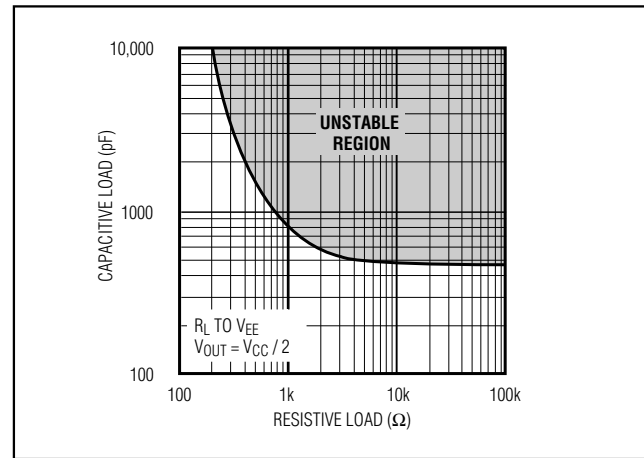


Figure 4. Capacitive-Load Stability

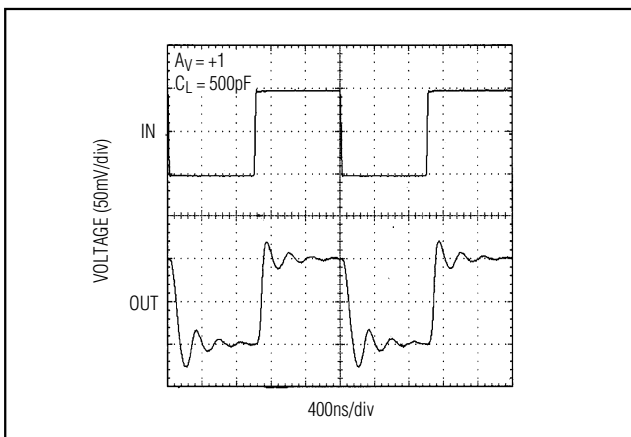


Figure 5. Small-Signal Transient Response with Capacitive Load

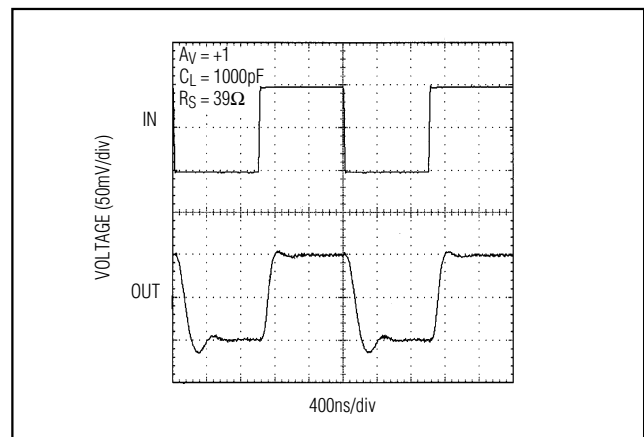


Figure 6. Transient Response to Capacitive Load with Isolation Resistor

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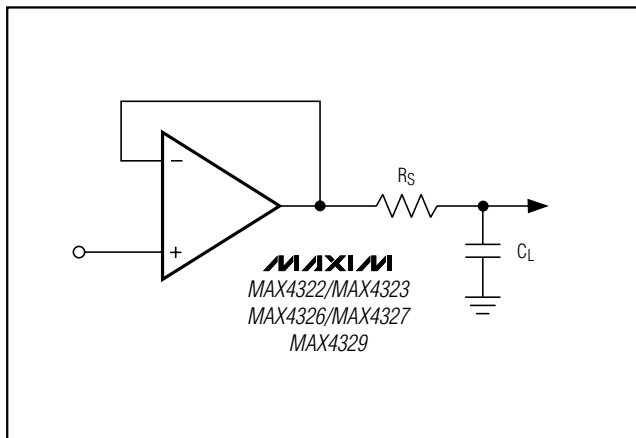


Figure 7. Capacitive-Load-Driving Circuit

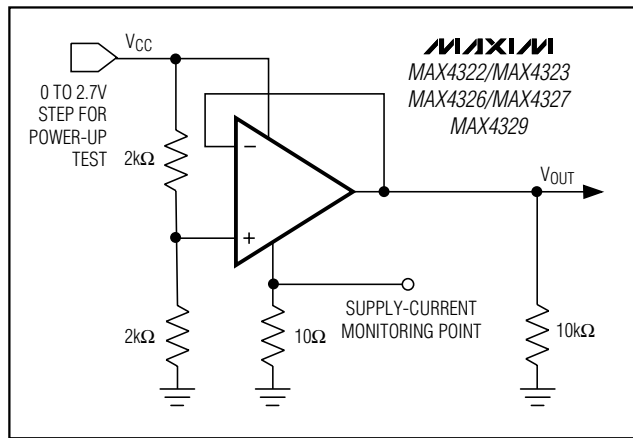


Figure 8. Power-Up Test Circuit

Figures 9 and 10 show the output voltage and supply current on power-up of the test circuit in Figure 8.

The MAX4323 and MAX4327 have a shutdown option. When shutdown (SHDN) is pulled low, the supply current drops to 25µA per amplifier and the amplifiers are disabled with the outputs in a high-impedance state. Pulling SHDN high or leaving it floating (1µA internal pullup) enables the amplifier. In the dual-amplifier MAX4327, the shutdown functions operate independently. Figures 11 and 12 show the output voltage and supply current responses of the MAX4323 to a shutdown pulse.

Power Supplies and Layout

The MAX4322/MAX4323/MAX4326/MAX4327/MAX4329 operate from a single 2.4V to 6.5V power supply, or from dual supplies of ±1.2V to ±3.25V. For single-supply operation, bypass the power supply with a 0.1µF ceramic capacitor in parallel with at least 1µF. For dual supplies, bypass each supply to ground.

Good layout improves performance by decreasing the amount of stray capacitance at the op amp's inputs and outputs. To decrease stray capacitance, minimize trace lengths and resistor leads by placing external components close to the op amp.

UCSP Information

Layout Issues

Design the layout for the device to be as compact as possible to minimize parasitics. The UCSP uses a bump pitch of 0.5mm (19.7mil) and a bump diameter of 0.33mm (~12mil). Therefore, lay out the solder-pad spacing on 0.5mm (19.7mil) centers, using a pad size of 0.25mm (~10mil) and a solder mask opening of

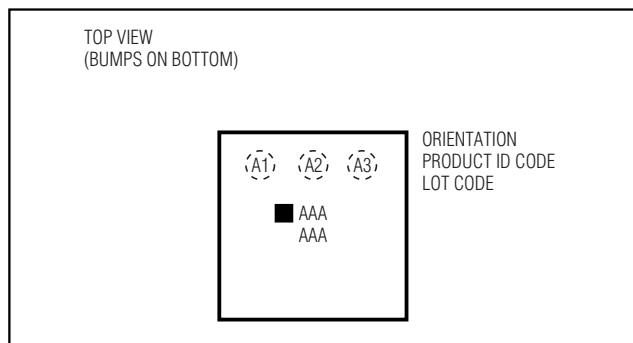
0.33mm (13mil). Round or square pads are permissible. Connect multiple vias from the ground plane as close to the ground connections as possible.

Install capacitors as close as possible to the device supply voltage input. Place the ground end of these capacitors near the ground plane to provide a low-impedance return path for the signal current.

Prototype Chip Installation

Alignment keys on the PC board, around the area where the chip is located, are helpful in the prototype assembly process. It is better to align the chip on the board before any other components are placed, and then place the board on a hot plate or hot surface until the solder starts melting. Remove the board from the hot plate without disturbing the position of the chip and let it cool down to room temperature before processing the board further.

MAX4323EBT (UCSP) Marking Information



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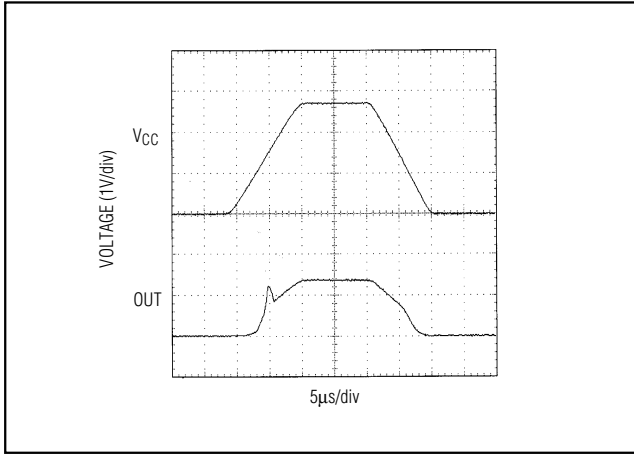


Figure 9. Power-Up Output Voltage

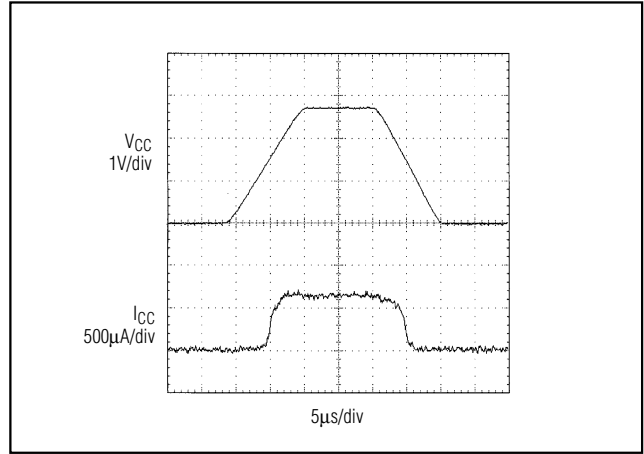


Figure 10. Power-Up Supply Current

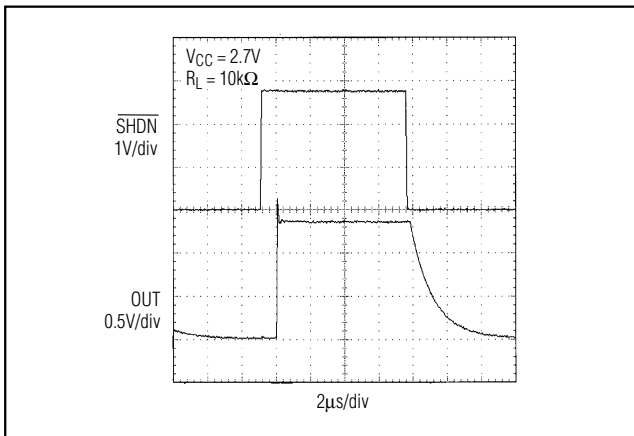


Figure 11. Shutdown Output Voltage

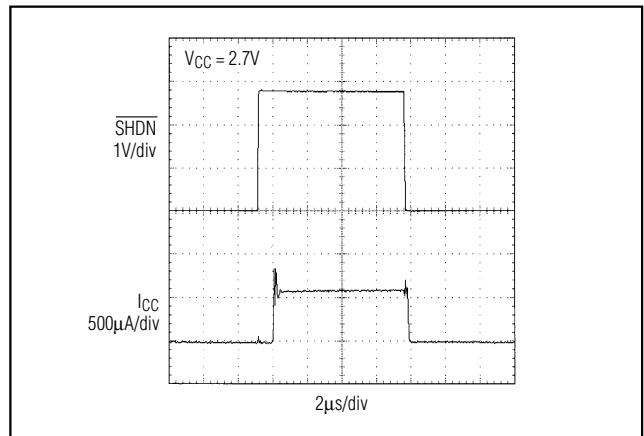
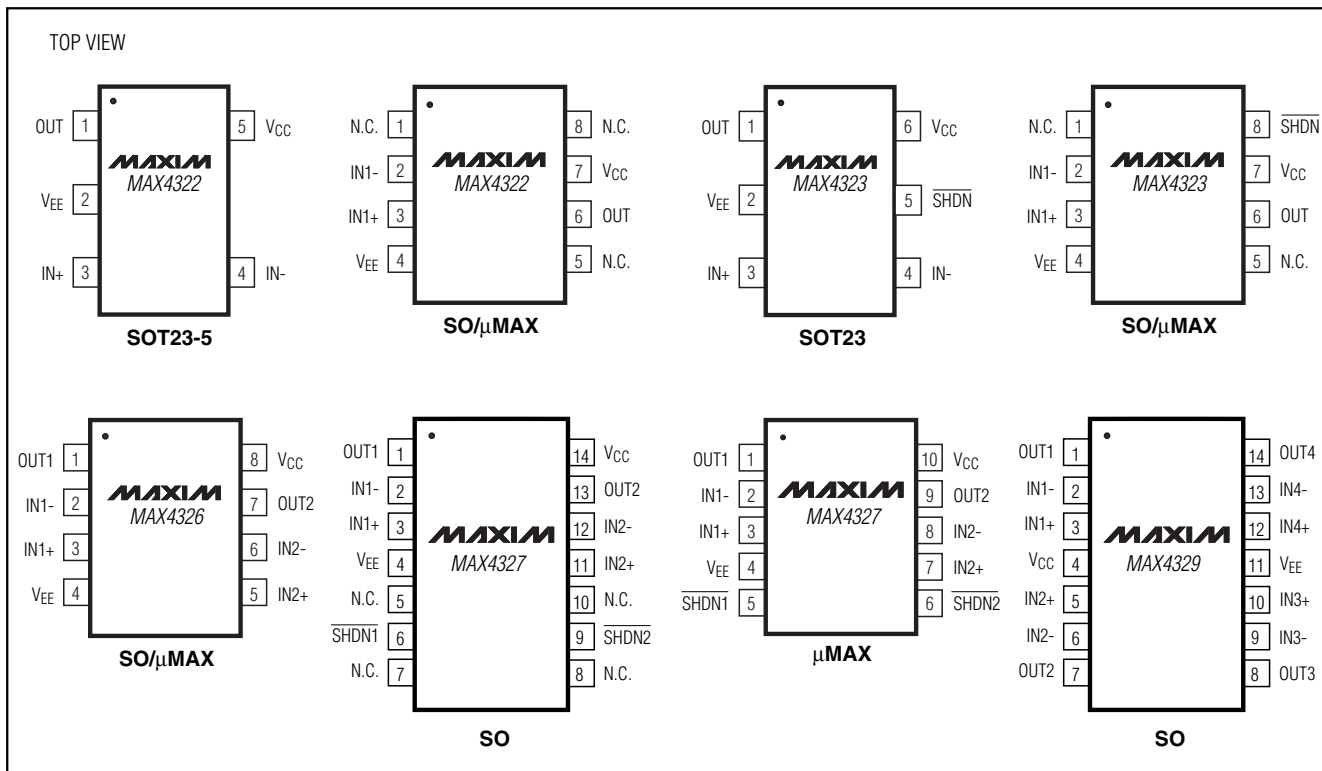


Figure 12. Shutdown Enable/Disable Supply Current

Single/Dual/Quad, Low-Cost, UCSP/SOT23, Low-Power, Rail-to-Rail I/O Op Amps

Pin Configurations (continued)



UCSP Reliability

The UCSP represents a unique packaging form factor that may not perform as well as a packaged product through traditional mechanical reliability tests. UCSP reliability is integrally linked to the user's assembly methods, circuit board material, and usage environment. The user should closely review these areas when considering use of a UCSP.

Performance through operating-life test and moisture resistance remains uncompromised. The wafer-fabrication process primarily determines the performance. Mechanical stress performance is a greater consideration for UCSPs. UCSPs are attached through direct solder contact to the user's PC board, foregoing the inherent stress relief of a packaged product lead frame. Solder-joint contact integrity must be considered. Comprehensive reliability tests have been performed and are available upon request. In conclusion, the UCSP performs reliably through environmental stresses.

Ordering Information (continued)

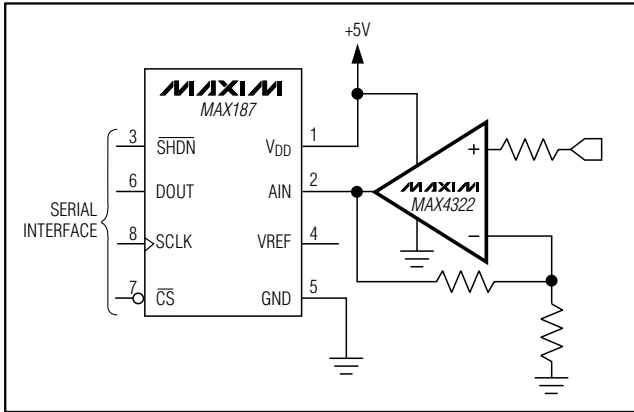
PART	TEMP RANGE	PIN/BUMP-PACKAGE	TOP MARK
MAX4323EBT-T*	-40°C to +85°C	6 UCSP-6	AAW
MAX4323EUT-T	-40°C to +85°C	6 SOT23-6	AAEC
MAX4323EUA	-40°C to +85°C	8 μ MAX	—
MAX4323ESA	-40°C to +85°C	8 SO	—
MAX4326EUA	-40°C to +85°C	8 μ MAX	—
MAX4326ESA	-40°C to +85°C	8 SO	—
MAX4327EUB	-40°C to +85°C	10 μ MAX	—
MAX4327ESD	-40°C to +85°C	14 SO	—
MAX4329ESD	-40°C to +85°C	14 SO	—

*UCSP reliability is integrally linked to the user's assembly methods, circuit board material, and environment. See the UCSP Reliability Notice in the UCSP Reliability section of this data sheet for more information.

MAX4322/MAX4323/MAX4326/MAX4327/MAX4329

Single/Dual/Quad, Low-Cost, UCSP/SOT23, Low-Power, Rail-to-Rail I/O Op Amps

Typical Operating Circuit



Chip Information

MAX4322 TRANSISTOR COUNT: 170
 MAX4323 TRANSISTOR COUNT: 170
 MAX4326 TRANSISTOR COUNT: 340
 MAX4327 TRANSISTOR COUNT: 340
 MAX4329 TRANSISTOR COUNT: 680
 PROCESS: Bipolar
 SUBSTRATE CONNECTED TO VEE

Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to www.maxim-ic.com/packages.)

10LUMAX.EPS

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	-	0.043	-	1.10
A1	0.002	0.006	0.05	0.15
A2	0.030	0.037	0.75	0.95
D1	0.116	0.120	2.95	3.05
D2	0.114	0.118	2.89	3.00
E1	0.116	0.120	2.95	3.05
E2	0.114	0.118	2.89	3.00
H	0.187	0.199	4.75	5.05
L	0.0157	0.0275	0.40	0.70
L1	0.037 REF		0.940 REF	
b	0.007	0.0106	0.177	0.270
e	0.0197 BSC		0.500 BSC	
c	0.0035	0.0078	0.090	0.200
S	0.0196 REF		0.498 REF	
α	0°	6°	0°	6°

NOTES:
 1. D&E DO NOT INCLUDE MOLD FLASH.
 2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm (.006").
 3. CONTROLLING DIMENSION: MILLIMETERS.
 4. MEETS JEDEC MO-187C-BA.

PROPRIETARY INFORMATION

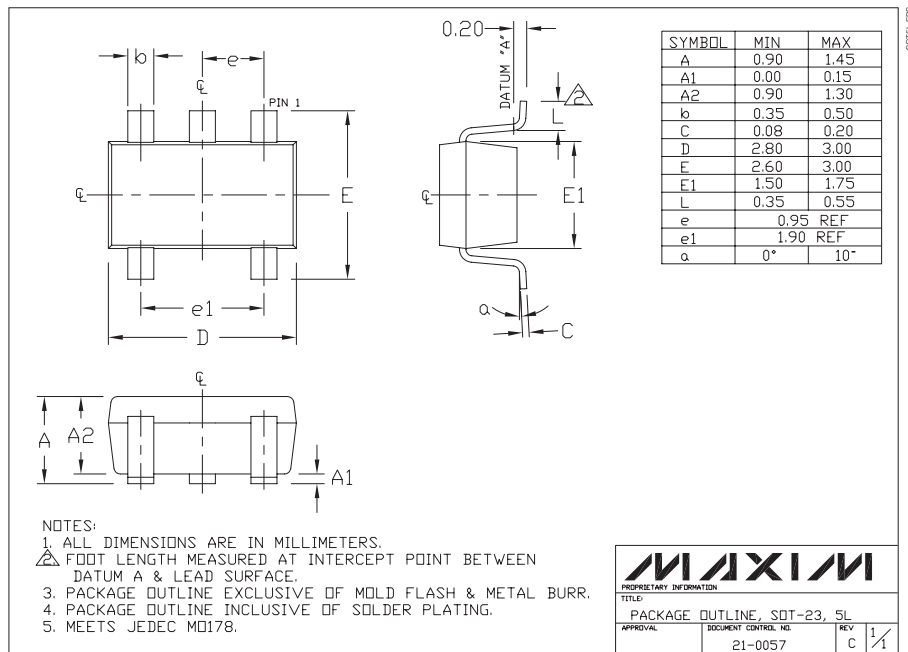
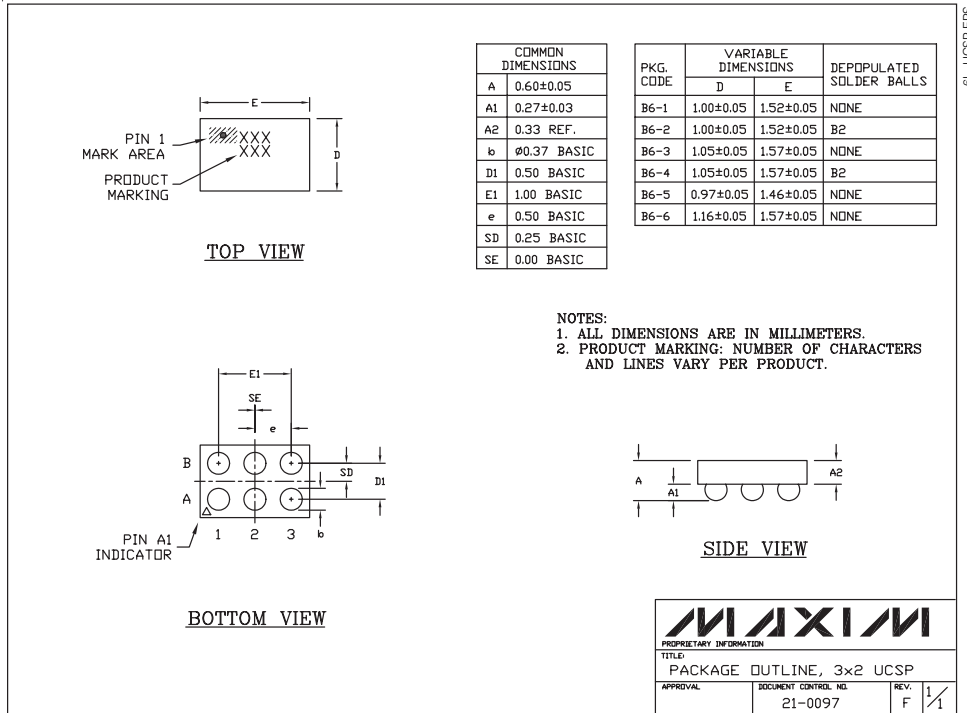
TITLE:
PACKAGE OUTLINE, 10L uMAX/uSOP

APPROVAL: _____ DOCUMENT CONTROL NO: 21-0061 REV: I 1/1

Single/Dual/Quad, Low-Cost, UCSP/SOT23, Low-Power, Rail-to-Rail I/O Op Amps

Package Information (continued)

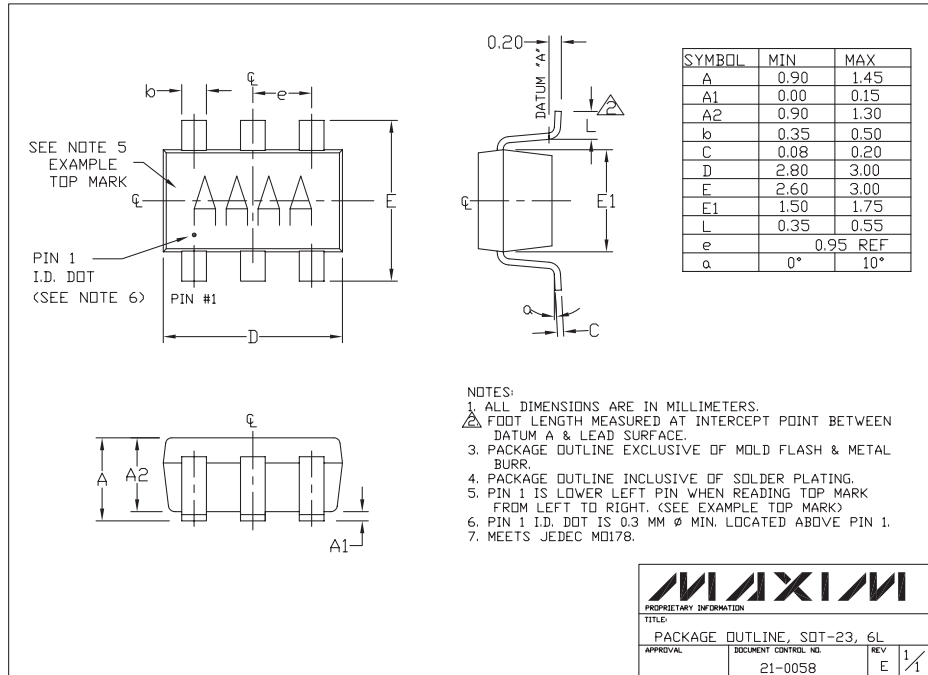
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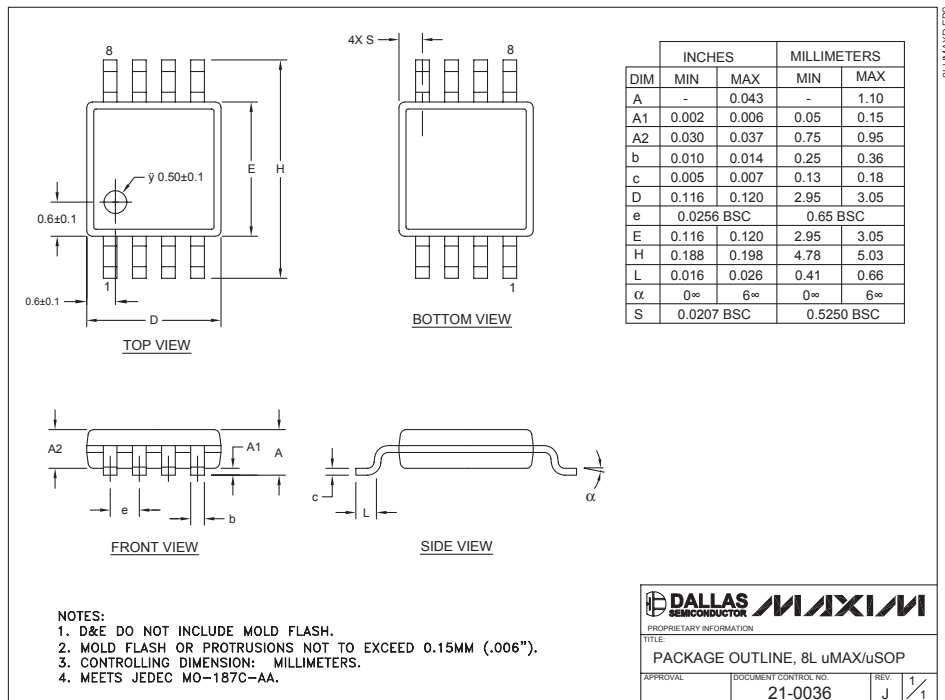
Single/Dual/Quad, Low-Cost, UCSP/SOT23, Low-Power, Rail-to-Rail I/O Op Amps

Package Information (continued)

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8LSOT.EPS

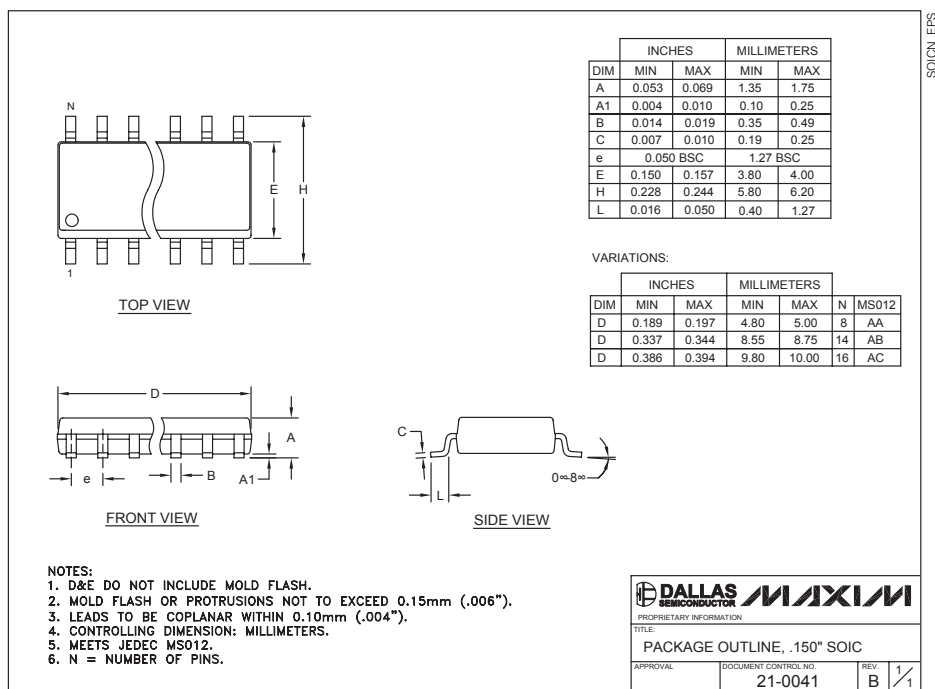


8LUMAXD.EPS

Single/Dual/Quad, Low-Cost, SOT23, Low-Power, Rail-to-Rail I/O Op Amps

Package Information (continued)

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MAX4322/MAX4323/MAX4326/MAX4327/MAX4329

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