19-5302; Rev 0; 8/10

Low-Power Single/Dual, Rail-to-Rail Op Amps

General Description

The MAX9614/MAX9616 are low-power precision op amps that feature precision MOS inputs.

These devices are ideal for a large number of signal processing applications such as photodiode transimpedance amplifiers and filtering/amplification of a wide variety of signals in industrial equipment. The devices also feature excellent RF immunity, making them ideal for portable applications.

The MAX9614/MAX9616 are capable of operating from a 2.5V to 5.5V supply voltage over the -40°C to +125°C automotive temperature range.

Both singles and duals are available in tiny SC70 packages. The MAX9614 features an active-low shutdown pin.

Applications

Notebooks, Portable Media Players

Industrial and Medical Sensors

General Purpose Signal Processing

Features

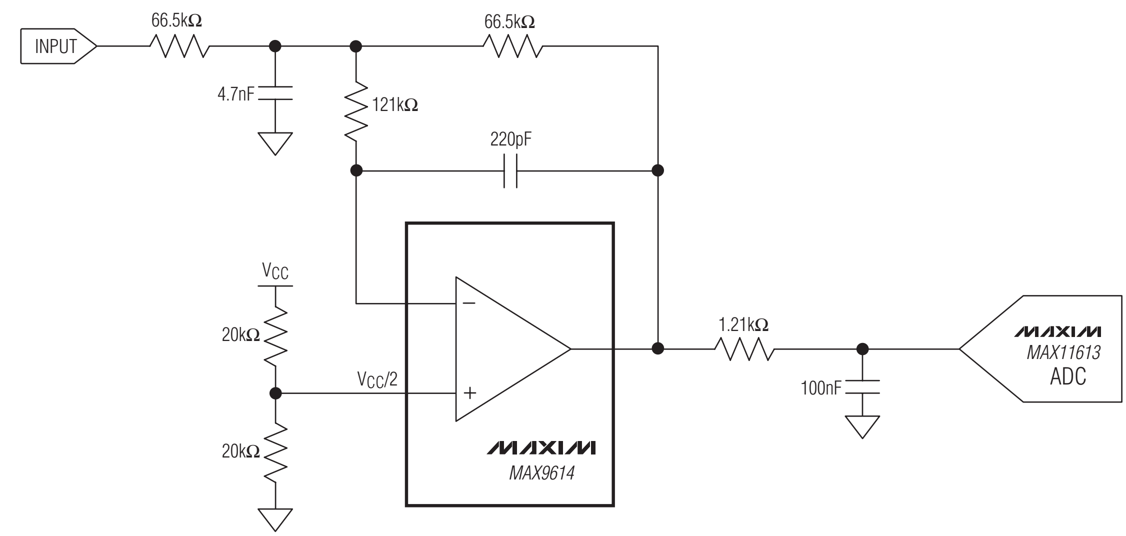
- ♦ V_{CC} = 2.5V to 5.5V (-40°C to +125°C)
- ♦ Low 100µV (max) V_{OS}
- ♦ 1µA Supply Current in Shutdown, 175µA Operating
- ♦ Small SC70 Package
- ♦ 2.8MHz Bandwidth
- ♦ Excellent RF Immunity

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	TOP MARK
MAX9614AXT+T	-40°C to +125°C	6 SC70	+ADL
MAX9616AXA+T	-40°C to +125°C	8 SC70	+AAE

+Denotes lead(Pb)-free/RoHS-compliant package.
T = Tape and reel.

Typical Application Circuit



USING THE MAX9614 OUTPUT AMPLIFIER AS AN ANTI-ALIASING FILTER (CORNER FREQUENCY = 1.3kHz) TO MAXIMIZE NYQUIST BANDWIDTH.

Low-Power Single/Dual, Rail-to-Rail Op Amps

ABSOLUTE MAXIMUM RATINGS

IN+, IN-, $\overline{SHDN}$, V_{CC} to GND.................................-0.3V to +6V
OUT to GND...-0.3V to V_{CC} + 0.3V
Short-Circuit (GND) Duration, OUT, OUTA, OUTB 5s
Continuous Input Current (any pin)................................ ±20mA
Thermal Limits (Note 1) Multilayer PCB
Continuous Power Dissipation (T_A = +70°C)
6-Pin SC70 (derate 3.1mW/°C above +70°C)............245mW
θ_{JA}..326.5°C/W
θ_{JC}..115°C/W
8-Pin SC70 (derate 3.1mW/°C above +70°C)............245mW
θ_{JA}...326°C/W
θ_{JC}...115°C/W
Operating Temperature Range....................... -40°C to +125°C
Junction Temperature ....+150°C
Lead Temperature (soldering, 10s) ....+300°C
Soldering Temperature (reflow) ....+240°C

Note 1: Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a 4-layer board. For detailed information on package thermal considerations, refer to **www.maxim-ic.com/thermal-tutorial**.

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.

ELECTRICAL CHARACTERISTICS

(V_{CC} = $V_{\overline{SHDN}}$ = 3.3V, V_{IN+} = V_{IN-} = V_{CM} = GND, R_L = 10kΩ to V_{CC}/2, T_A = -40°C to +125°C. Typical values are at T_A = +25°C, unless otherwise noted.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
DC CHARACTERISTICS						
Input Voltage Range	V_{IN+}, V_{IN-}	Guaranteed by CMRR test	-0.1		V_{CC} - 1.4	V
Input Offset Voltage	V_{OS}	T_A = +25°C		17	100	µV
		T_A = -40°C to +125°C, after power-up autocalibration			165	
		T_A = -40°C to +125°C			750	
Input Offset Voltage Drift	V_{OS} - TC			1	7.5	µV/°C
Input Bias Current (Note 3)	I_B	T_A = -40°C to +25°C		1	1.55	pA
		T_A = +70°C			45	
		T_A = +85°C			135	
		T_A = +125°C			1.55	nA
Input Offset Current (Note 3)	I_{OS}	T_A = -40°C to +25°C			0.5	pA
		T_A = +70°C			7	
		T_A = +85°C			25	
		T_A = +125°C			4000	
Common-Mode Rejection Ratio	CMRR	V_{CM} = -0.1V to V_{CC} - 1.4V, T_A = +25°C	80	95		dB
		V_{CM} = -0.1V to V_{CC} - 1.4V, T_A = -40°C to +125°C	78			
Open-Loop Gain	A_{OL}	+0.4V ≤ V_{OUT} ≤ V_{CC} - 0.4V, R_L = 10kΩ	99	115		dB
		+0.4V ≤ V_{OUT} ≤ V_{CC} - 0.4V, R_L = 600Ω	93	110		
Output Short-Circuit Current (Note 4)	I_{SC}	To V_{CC}		275		mA
		To GND		75		
Output Voltage Low	V_{OL}	R_L = 10kΩ		1	11	mV
		R_L = 600Ω		11	100	
		R_L = 32Ω		170		

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = $V_{\overline{SHDN}}$ = 3.3V, V_{IN+} = V_{IN-} = V_{CM} = GND, R_L = 10kΩ to V_{CC}/2, T_A = -40°C to +125°C. Typical values are at T_A = +25°C, unless otherwise noted.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage High	V_{OH}	R_L = 10kΩ	V_{CC} - 11	V_{CC} - 2		mV
		R_L = 600Ω	V_{CC} - 100	V_{CC} - 30		
		R_L = 32Ω		V_{CC} - 560		
AC CHARACTERISTICS						
Input Voltage Noise Density	e_n	f = 10kHz		28		$nV/\sqrt{Hz}$
Input Voltage Noise	Total noise	0.1Hz ≤ f ≤ 10Hz		5		μV_{P-P}
Input Current Noise Density	I_n	f = 10kHz		0.1		$fA/\sqrt{Hz}$
Gain Bandwidth	GBW			2.8		MHz
Slew Rate	SR			1.3		V/µs
Capacitive Loading	C_{LOAD}	No sustained oscillation		200		pF
Total Harmonic Distortion	THD	f = 10kHz, V_{OUT} = $2V_{P-P}$, A_V = 1V/V		-85		dB
POWER-SUPPLY CHARACTERISTICS						
Power-Supply Range	V_{CC}	Guaranteed by PSRR	2.5		5.5	V
Power-Supply Rejection Ratio	PSRR	T_A = +25°C	85	106		dB
		T_A = -40°C to +125°C	83			
Quiescent Current	I_{CC}	T_A = +25°C, per amplifier		170	255	µA
		T_A = -40°C to +125°C, per amplifier			350	
Shutdown Supply Current	$I_{\overline{SHDN}}$	MAX9614 only			1	µA
Shutdown Input Low	V_{IL}	MAX9614 only			0.5	V
Shutdown Input High	V_{IH}	MAX9614 only	1.4			V
Output Impedance in Shutdown	$R_{OUT\_\overline{SHDN}}$	MAX9614 only		10		MΩ
Turn-On Time from $\overline{SHDN}$	t_{ON}	MAX9614 only		20		µs
Power-Up Time	t_{UP}			10		ms

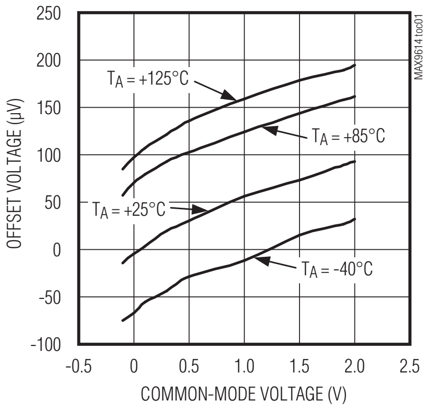
Note 2: All devices are 100% production tested at T_A = +25°C. Temperature limits are guaranteed by design.
Note 3: Guaranteed by design, not production tested.
Note 4: Do not exceeed package thermal dissipation in the *Absolute Maximum Ratings* section.

Low-Power Single/Dual, Rail-to-Rail Op Amps

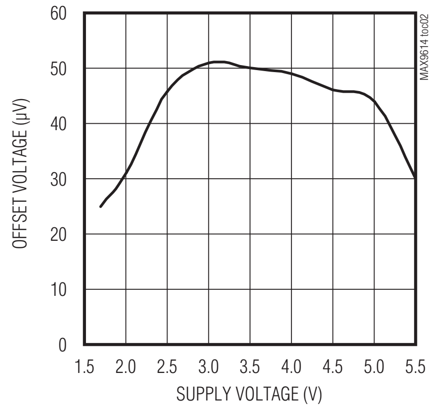
Typical Operating Characteristics

(V_{CC} = 3.3V, V_{IN+} = V_{IN-} = 0V, V_{CM} = V_{CC}/2, R_L = 10kΩ to V_{CC}/2, values are at T_A = +25°C, unless otherwise noted.)

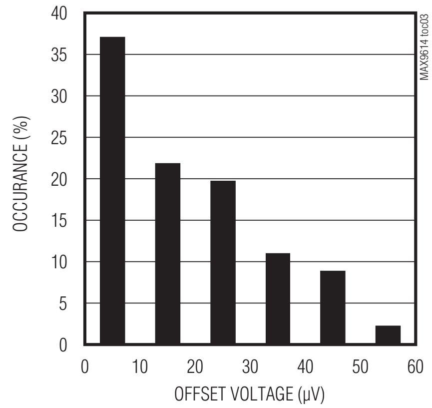
OFFSET VOLTAGE vs. COMMON-MODE VOLTAGE



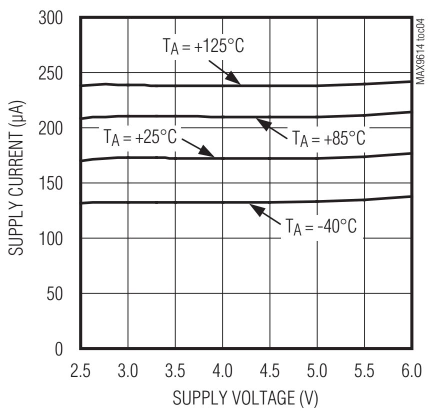
OFFSET VOLTAGE vs. SUPPLY VOLTAGE



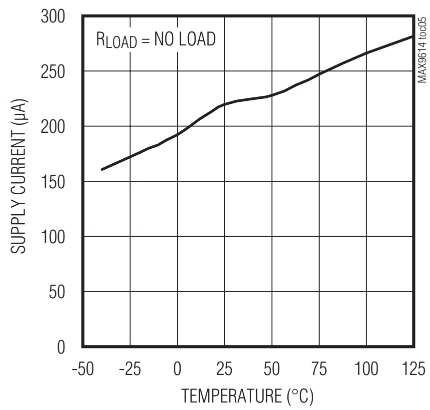
OFFSET VOLTAGE HISTOGRAM



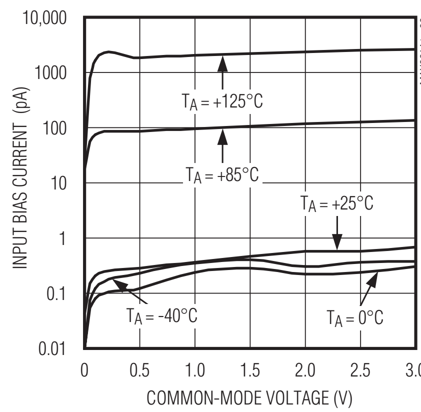
SUPPLY CURRENT vs. SUPPLY VOLTAGE



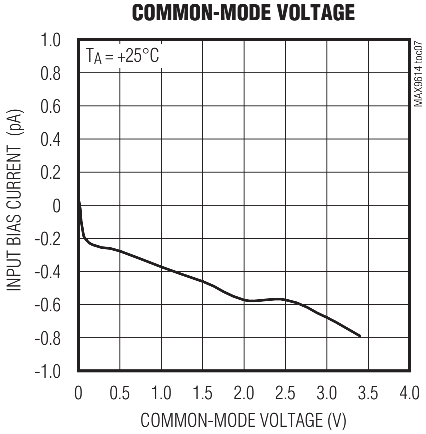
SUPPLY CURRENT vs. TEMPERATURE



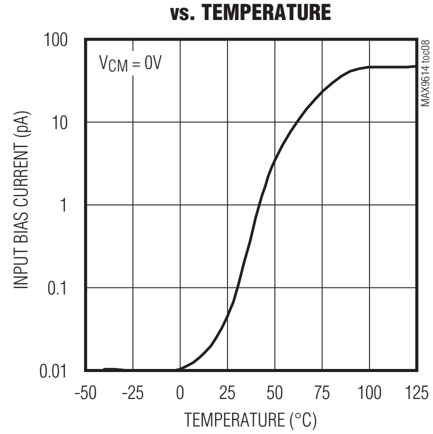
INPUT BIAS CURRENT vs. COMMON-MODE VOLTAGE



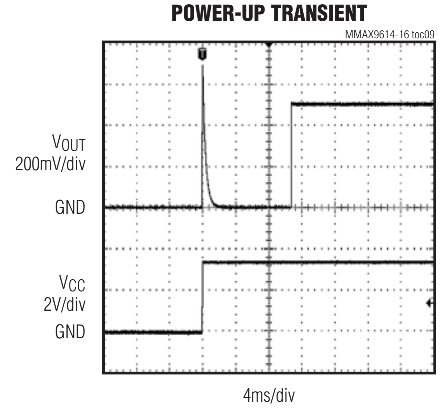
INPUT BIAS CURRENT vs. COMMON-MODE VOLTAGE



INPUT BIAS CURRENT vs. TEMPERATURE



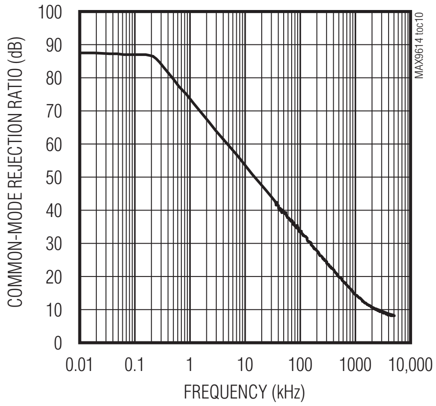
POWER-UP TRANSIENT



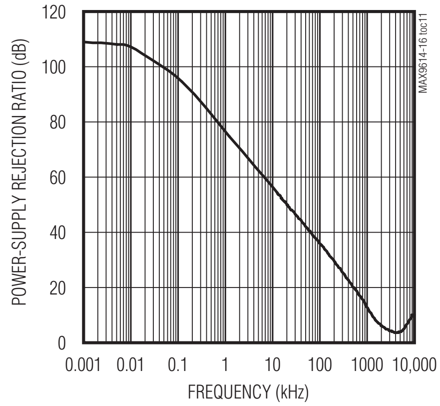
Typical Operating Characteristics (continued)

(V_{CC} = 3.3V, V_{IN+} = V_{IN-} = 0V, V_{CM} = V_{CC}/2, R_L = 10kΩ to V_{CC}/2, values are at T_A = +25°C, unless otherwise noted.)

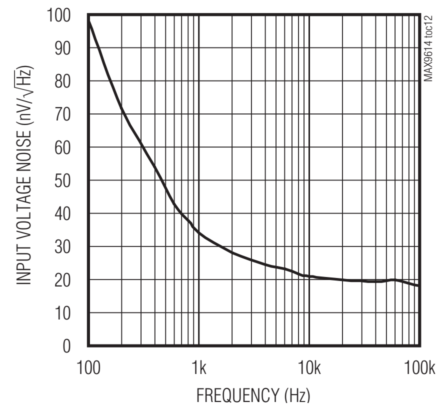
COMMON-MODE REJECTION RATIO vs. FREQUENCY



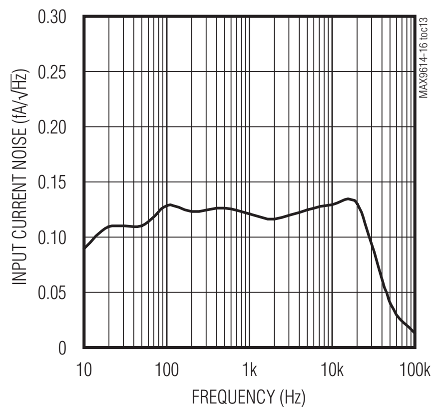
POWER-SUPPLY REJECTION RATIO vs. FREQUENCY



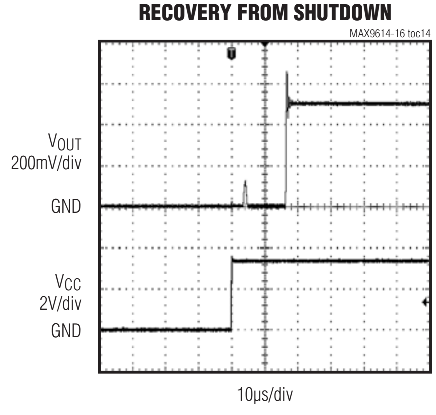
INPUT VOLTAGE NOISE vs. FREQUENCY



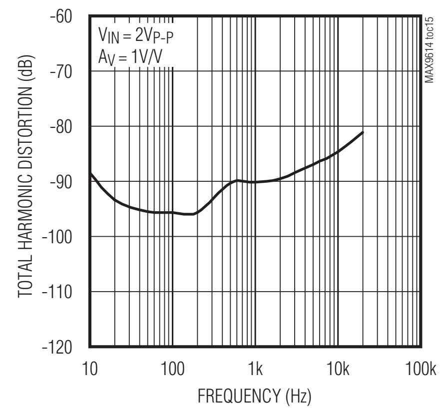
INPUT CURRENT NOISE vs. FREQUENCY



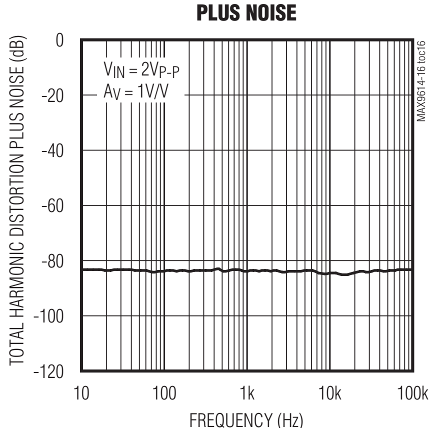
RECOVERY FROM SHUTDOWN



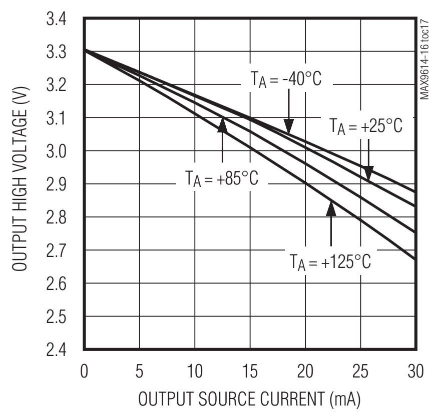
TOTAL HARMONIC DISTORTION



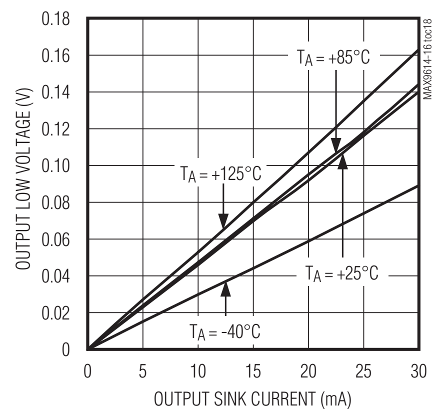
TOTAL HARMONIC DISTORTION PLUS NOISE



OUTPUT HIGH VOLTAGE vs. OUTPUT SOURCE CURRENT



OUTPUT LOW VOLTAGE vs. OUTPUT SINK CURRENT

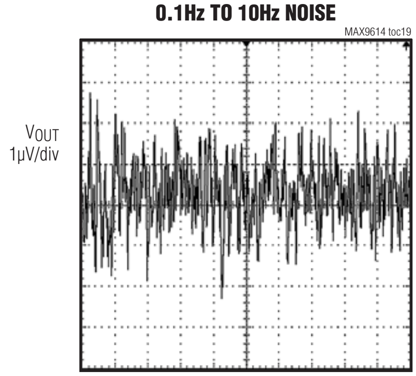


Low-Power Single/Dual, Rail-to-Rail Op Amps

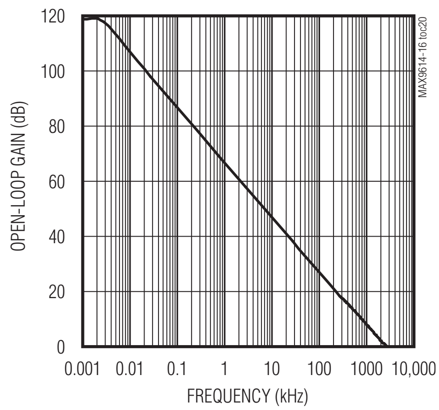
Typical Operating Characteristics (continued)

(V_{CC} = 3.3V, V_{IN+} = V_{IN-} = 0V, V_{CM} = V_{CC}/2, R_L = 10kΩ to V_{CC}/2, values are at T_A = +25°C, unless otherwise noted.)

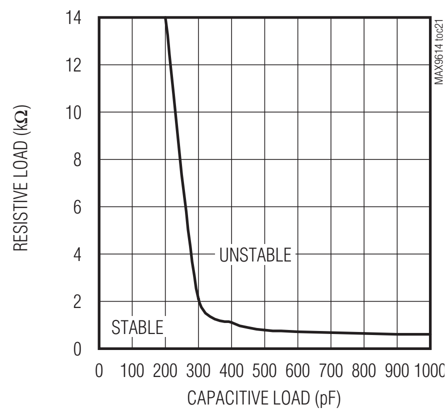
0.1Hz TO 10Hz NOISE



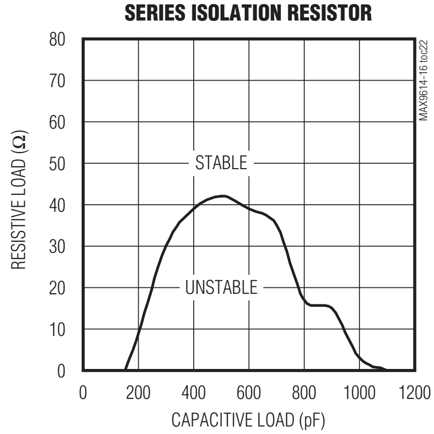
OPEN-LOOP GAIN vs. FREQUENCY



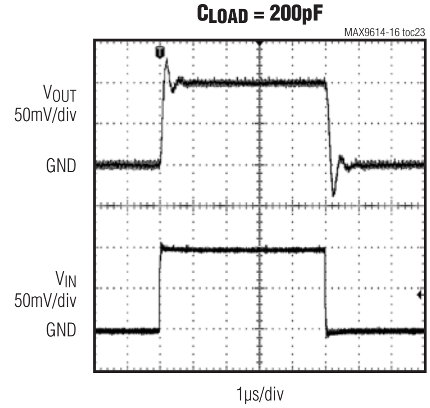
STABILITY vs. CAPACITIVE AND RESISTIVE LOAD IN PARALLEL



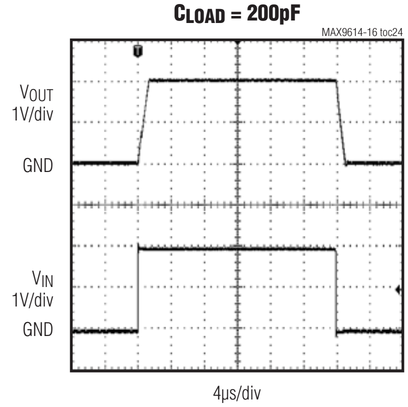
STABILITY vs. CAPACITIVE WITH SERIES ISOLATION RESISTOR



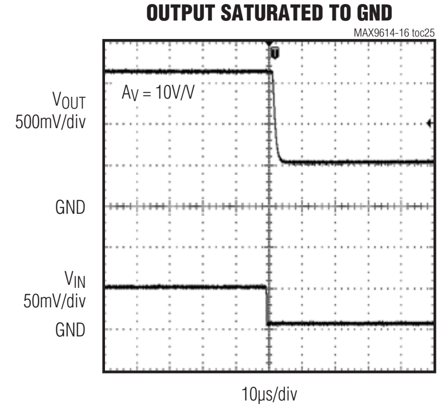
100mV STEP RESPONSE C_{LOAD} = 200pF



2V STEP RESPONSE C_{LOAD} = 200pF



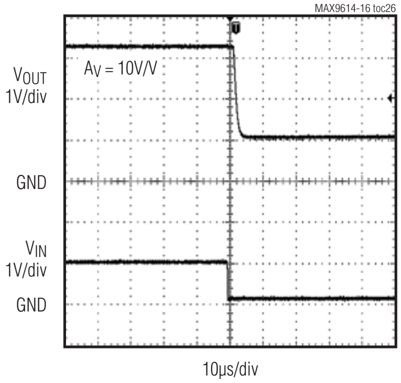
RECOVERY FROM SATURATION OUTPUT SATURATED TO GND



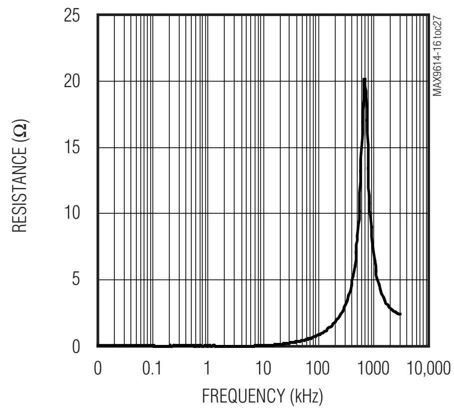
Typical Operating Characteristics (continued)

(V_{CC} = 3.3V, V_{IN+} = V_{IN-} = 0V, V_{CM} = V_{CC}/2, R_L = 10kΩ to V_{CC}/2, values are at T_A = +25°C, unless otherwise noted.)

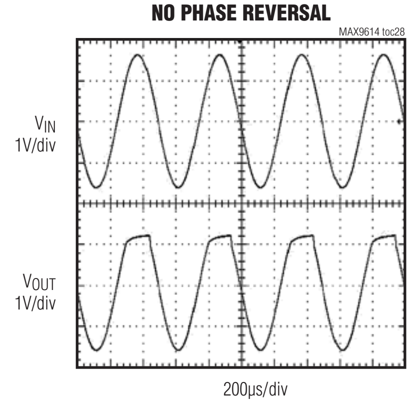
RECOVERY FROM SATURATION OUTPUT SATURATED TO V_{CC}



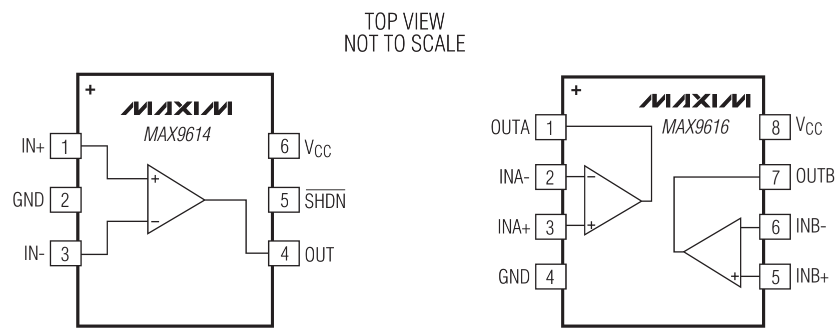
OUTPUT IMPEDANCE vs. FREQUENCY



NO PHASE REVERSAL



Pin Configuration



6 SC70 **8 SC70**

Pin Description

PIN		NAME	FUNCTION
MAX9614	MAX9616		
1	—	IN+	Positive Input
—	3	INA+	Positive Input A
—	5	INB+	Positive Input B
2	4	GND	Ground
3	—	IN-	Negative Input
—	2	INA-	Negative Input A
—	6	INB-	Negative Input B
4	—	OUT	Output
—	1	OUTA	Output A
—	7	OUTB	Output B
5	—	$\overline{SHDN}$	Active-Low Shutdown
6	8	V_{CC}	Positive Power Supply. Bypass with a 0.1µF capacitor to ground.

Low-Power Single/Dual, Rail-to-Rail Op Amps

Detailed Description

The MAX9614/MAX9616 are low-power op amps ideal for signal processing applications due to the devices' high precision and CMOS inputs.

The MAX9614 also features a low-power shutdown mode that greatly reduces quiescent current while the device is not operational.

The MAX9614/MAX9616 self-calibrate on power-up to eliminate effects of temperature and power-supply variation.

RF Immunity

The MAX9614/MAX9616 feature robust internal EMI filters that reduce the devices' susceptibility to high-frequency RF signals such as from wireless and mobile devices. This, combined with excellent DC and AC specifications, makes these devices ideal for a wide variety of portable audio and sensitive signal-conditioning applications.

Applications Information

Power-Up Autotrim

The MAX9614/MAX9616 feature an automatic power-up autotrim that self-calibrates the V_{OS} of these devices to less than 100μV of input offset voltage. The autotrim sequence takes approximately 10ms to complete, and is triggered by an internal power-on reset (POR) circuitry. During this time, the inputs and outputs are put into high impedance and left unconnected. This self-calibration feature allows the device to eliminate input offset voltage effects due to power supply and operating temperature variation simply by cycling its power.

Take care to ensure that the power supply settles within 0.4ms of power-up after it crosses a POR threshold of 0.5V to ensure that a stable power supply is present when it steps through its autotrim sequence. If the power supply glitches below the 0.5V threshold, the POR circuitry reactivates during next power-up.

Shutdown Operation

The MAX9614 features an active-low shutdown mode that puts both inputs and outputs into a high-impedance state. In this mode, the quiescent current is less than 1μA. Putting the output in high-impedance allows multiple signal outputs to be multiplexed onto a single output line without the additional external buffers. The device does not self-calibrate when exiting shutdown mode, and retains its power-up trim settings. The device also instantly recovers from shutdown.

The shutdown logic levels of the device are independent of supply allowing the shutdown to operate by either a 1.8V or 3.3V microcontroller.

Interfacing with the MAX11613

The MAX9616 dual amplifier's low power and tiny size is ideal for driving multichannel analog-to-digital converters (ADCs) such as the MAX11613 (see the *Typical Application Circuit*). The MAX11613 is a low-power, 12-bit I²C ADC that measures either four single-ended or two differential channels in an 8-pin μMAX® package. Operating from a single 3V or 3.3V supply, the MAX11613 draws a low 380μA supply current when sampling at 10ksps.The MAX11613 family also offers pin-compatible 5V ADCs (MAX11612) and 8-bit (MAX11601) and 10-bit (MAX11607) options.

The MAX9614/MAX9616's output voltage low is designed to be especially close to ground—it is only 11mV above ground, allowing maximum dynamic range in single-supply applications. High output current and capacitance drive capability of the part help it to be useful in ADC driver and line-driver.

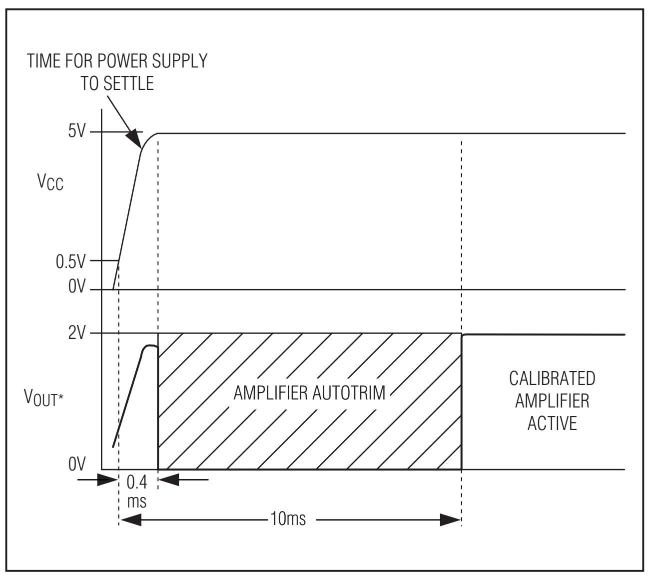


Figure 1. Autotrim Timing Diagram

μMAX is a registered trademark of Maxim Integrated Products, Inc.

Input Bias Current

The MAX9614/MAX9616 feature a high-impedance CMOS input stage and a specialized ESD structure that allows low input bias current operation at low input common-mode voltages. Low input bias current is useful when interfacing with high-ohmic sensors. It is also beneficial for designing transimpedance amplifiers for photodiode sensors. This makes the MAX9614/MAX9616 ideal for ground referenced medical and industrial sensor applications.

Active Filters

The MAX9614/MAX9616 are ideal for a wide variety of active filter circuits that make use of their rail-to-rail output stages and high impedance CMOS inputs. The *Typical Application Circuit* shows an example multiple feedback active filter circuit with a corner frequency of 1.3kHz. At low frequencies, the amplifier behaves like a simple low-distortion inverting amplifier of gain = -1, while its high bandwidth gives excellent stopband attenuation above its corner frequency. See the *Typical Application Circuit*.

Chip Information

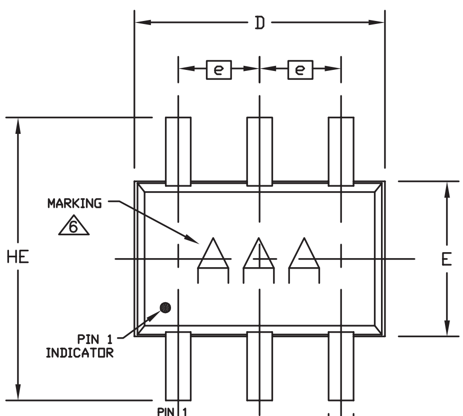
PROCESS: BiCMOS

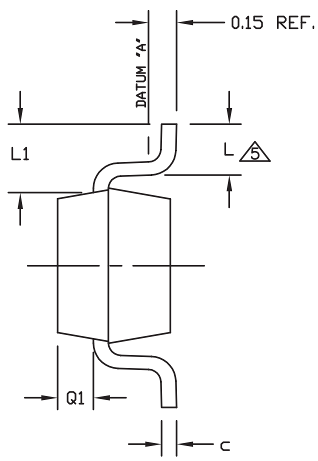
Low-Power Single/Dual, Rail-to-Rail Op Amps

Package Information

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

PACKAGE TYPE	PACKAGE CODE	OUTLINE NO.	LAND PATTERN NO.
6 SC70	X6SN-1	21-0077	90-0189
8 SC70	X8SN-1	21-0460	—

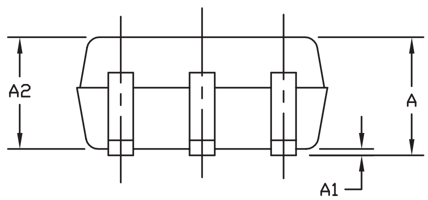




COMMON DIMENSIONS			
SYMBOL	MIN	NOM	MAX
A	0.80	0.95	1.10
A1	0.00	0.07	0.10
A2	0.80	0.90	1.00
b	0.15	0.22	0.30
c	0.10	0.14	0.18
D	1.80	2.00	2.20
e	0.65 BSC.		
E	1.15	1.25	1.35
HE	1.80	2.20	2.40
L	0.26	0.34	0.46
L1	0.425 TYP.		
Q1	0.10	0.25	0.40
PKG. CODES	X6SN-1		

SC70, 6L.EPS

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONS ARE INCLUSIVE OF PLATING.
3. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH & METAL BURR.
4. COPLANARITY 4 MILS. MAX.
5. FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM 'A' AND LEAD SURFACE.
6. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.
7. LEAD CENTERLINES TO BE AT TRUE POSITION AS DEFINED BY BASIC DIMENSION 'e', ±0.05.
8. ALL DIMENSIONS COMPLY TO JEDEC MO-203.
9. ALL DIMENSIONS APPLY TO BOTH LEADED (-) AND LEAD FREE (+) PACKAGE CODES.



MAXIM

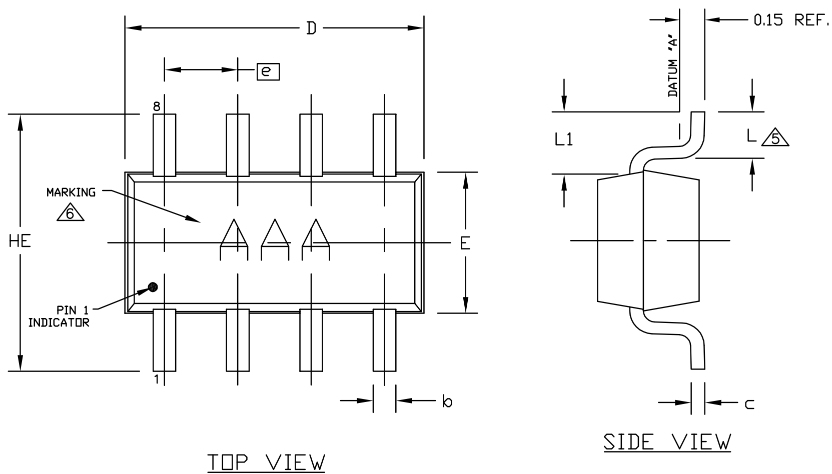
TITLE: PACKAGE OUTLINE, 6L SC70

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0077	G	1/1

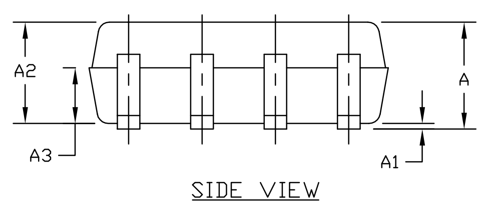
-DRAWING NOT TO SCALE-

Package Information (continued)

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.



COMMON DIMENSIONS			
SYMBOL	MIN	NOM	MAX
A	0.80	0.95	1.10
A1	0.00	0.07	0.10
A2	0.80	0.90	1.00
A3	0.40	0.47	0.55
b	0.15	0.21	0.27
c	0.10	0.14	0.18
D	1.80	2.00	2.20
e	0.50 BSC.		
E	1.15	1.25	1.35
HE	1.80	2.20	2.40
L	0.26	0.34	0.46
L1	0.425 TYP.		
PKG. CODE	X8C-1		



NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONS ARE INCLUSIVE OF PLATING.
3. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH & METAL BURR.
4. COPLANARITY 4 MILS. MAX.
5. FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM "A" AND LEAD SURFACE.
6. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.
7. LEAD CENTERLINES TO BE AT TRUE POSITION AS DEFINED BY BASIC DIMENSION "e", ±0.05.
8. ALL DIMENSIONS COMPLY TO JEDEC MO-203.
9. ALL DIMENSIONS APPLY TO BOTH LEADED (-) AND LEAD FREE (+) PACKAGE CODES.

-DRAWING NOT TO SCALE-

MAXIM

TITLE: PACKAGE OUTLINE, 8L SC70, COL PKG.

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0460	A	1/1

Low-Power Single/Dual, Rail-to-Rail Op Amps

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	8/10	Initial release	—