19-1831; Rev 1; 1/09

Low-Cost, Low-Power, Ultra-Small, 3V/5V, 500MHz Single-Supply Op Amps with Rail-to-Rail Outputs

General Description

The MAX4412 single and MAX4413 dual operational amplifiers are unity-gain-stable devices that combine high-speed performance, low supply current, and ultra-small packaging. Both devices operate from a single +2.7V to +5.5V supply, have rail-to-rail outputs, and exhibit a common-mode input voltage range that extends from 100mV below ground to within +1.5V of the positive supply rail.

The MAX4412/MAX4413 achieve a 500MHz -3dB bandwidth and a 140V/µs slew rate while consuming only 1.7mA of supply current per amplifier. This makes the MAX4412/MAX4413 ideal for low-power/low-voltage, high-speed portable applications such as video, communications, and instrumentation.

For systems requiring tighter specifications, Maxim offers the MAX4414–MAX4419 family of operational amplifiers. The MAX4414–MAX4419 are laser trimmed versions of the MAX4412/MAX4413 and include compensated and uncompensated devices.

The MAX4412 is available in ultra-small 5-pin SC70 and SOT23 packages, while the MAX4413 is available in a space-saving 8-pin SOT23.

Features

- ♦ **Ultra-Low 1.7mA Supply Current**
- ♦ **Low Cost**
- ♦ **Single +3V/+5V Operation**
- ♦ **High Speed**
  - **500MHz -3dB Bandwidth**
  - **50MHz 0.1dB Gain Flatness**
  - **140V/µs Slew Rate**
- ♦ **Rail-to-Rail Outputs**
- ♦ **Input Common-Mode Range Extends Beyond V_{EE}**
- ♦ **Low Differential Gain/Phase: 0.01%/0.03°**
- ♦ **Low Distortion at 5MHz**
  - **-93dBc SFDR**
  - **0.003% Total Harmonic Distortion**
- ♦ **Ultra-Small SC70 and SOT23 Packages**

Applications

Battery-Powered Instruments
Portable Communications
Keyless Entry Systems
Cellular Telephones
Video Line Drivers
Baseband Applications

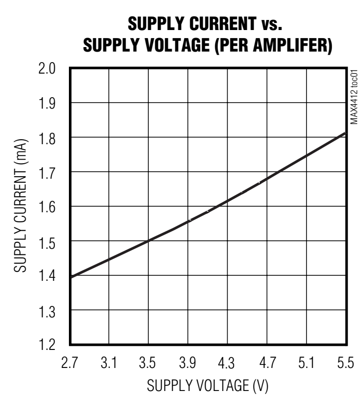
Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	TOP MARK
MAX4412EXK-T	-40°C to +85°C	5 SC70	ABH
MAX4412EUK-T	-40°C to +85°C	5 SOT23	ADOL
MAX4413EKA-T	-40°C to +85°C	8 SOT23	AADR

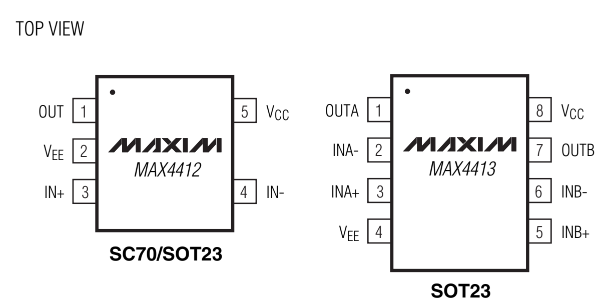
-Denotes a package containing lead(Pb).

T = Tape and reel.

Typical Operating Characteristic



Pin Configurations



Low-Cost, Low-Power, Ultra-Small, 3V/5V, 500MHz Single-Supply Op Amps with Rail-to-Rail Outputs

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{CC} to V_{EE})....................+6V
Differential Input Voltage ....±2.5V
IN_-, IN_+, OUT_....................(V_{CC} + 0.3V) to (V_{EE} - 0.3V)
Current into Input Pins ....±20mA
Output Short-Circuit Duration to V_{CC} or V_{EE} ....Continuous
Continuous Power Dissipation (T_A = +70°C)
5-Pin SC70 (derate 3.1mW/°C above +70°C)....................247mW
5-Pin SOT23 (derate 7.1mW/°C above +70°C)....................571mW
8-Pin SOT23 (derate 9.1mW/°C above +70°C)....................727mW
Operating Temperature Range ....-40°C to +85°C
Junction Temperature ....+150°C
Storage Temperature Range ....-65°C to +150°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

(V_{CC} = +2.7V to +5.5V, V_{CM} = V_{CC}/2 - 0.75V, V_{EE} = 0, R_L = ∞ to V_{CC}/2, V_{OUT} = V_{CC}/2, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Operating Supply Voltage Range	V_S	Guaranteed by PSRR test		2.7		5.5	V
Quiescent Supply Current (per amplifier)	I_S	V_{CC} = +5V			1.7	3.5	mA
		V_{CC} = +3V			1.5		
Input Common Mode Voltage Range	V_{CM}	Guaranteed by CMRR test		V_{EE} - 0.1		V_{CC} - 1.5	V
Input Offset Voltage	V_{OS}				0.4	9	mV
Input Offset Voltage Temperature Coefficient	TC_{VOS}				3		µV/°C
Input Offset Voltage Matching		MAX4413			±1		mV
Input Bias Current	I_B				1.6	4	µA
Input Offset Current	I_{OS}				0.1	0.7	µA
Input Resistance	R_{IN}	Differential mode, -0.04V ≤ (V_{IN+} - V_{IN-}) ≤ +0.04V			60		kΩ
		Common mode, V_{EE} - 0.1V < V_{CM} < V_{CC} - 1.5V			16		MΩ
Common Mode Rejection Ratio	CMRR	V_{EE} - 0.1V < V_{CM} < V_{CC} - 1.5V		60	94		dB
Open-Loop Gain	A_{VOL}	V_{CC} = +5V	+0.2V ≤ V_{OUT} ≤ +4.8V, R_L = 10kΩ	78	93		dB
			+0.4V ≤ V_{OUT} ≤ +4.6V, R_L = 1kΩ	68	80		
			+1V ≤ V_{OUT} ≤ +4V, R_L = 150Ω		65		
		V_{CC} = +3V	+0.2V ≤ V_{OUT} ≤ +2.8V, R_L = 10kΩ		90		
			+0.25V ≤ V_{OUT} ≤ +2.75V R_L = 1kΩ		78		
			+0.5V ≤ V_{OUT} ≤ +2.5V, R_L = 150Ω		62		

DC ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = +2.7V to +5.5V, V_{CM} = V_{CC}/2 - 0.75V, V_{EE} = 0, R_L = ∞ to V_{CC}/2, V_{OUT} = V_{CC}/2, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS			MIN	TYP	MAX	UNITS
Output Voltage Swing	V_{OUT}	V_{CC} = +5V	R_L = 10kΩ	V_{CC} - V_{OH}		0.085		V
				V_{OL} - V_{EE}		0.015		
			R_L = 1kΩ	V_{CC} - V_{OH}		0.105	0.275	
				V_{OL} - V_{EE}		0.035	0.125	
			R_L = 150Ω	V_{CC} - V_{OH}		0.385		
				V_{OL} - V_{EE}		0.150		
		V_{CC} = +3V	R_L = 10kΩ	V_{CC} - V_{OH}		0.06		
				V_{OL} - V_{EE}		0.01		
			R_L = 1kΩ	V_{CC} - V_{OH}		0.075		
				V_{OL} - V_{EE}		0.025		
			R_L = 150Ω	V_{CC} - V_{OH}		0.275		
				V_{OL} - V_{EE}		0.070		
Output Current	I_{OUT}	R_L = 20Ω connected to V_{CC} or V_{EE}, V_{CC} = +5V			±25	±75		mA
Output Short-Circuit Current	I_{SC}	Sinking or sourcing				±85		mA
Power Supply Rejection Ratio	PSRR	V_{CC} = +2.7V to +5.5V, V_{CM} = 0, V_{OUT} = 2V			60	77		dB

AC ELECTRICAL CHARACTERISTICS

(V_{CC} = +5V, V_{EE} = 0, V_{CM} = +1.75V, R_L = 1kΩ connected to V_{CC}/2, C_L = 5pF, A_{VCL} = +1V/V, T_A = +25°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Small Signal -3dB Bandwidth	BW_{SS}	V_{OUT} = 100mVp-p		500		MHz
Large Signal -3dB Bandwidth	BW_{LS}	V_{OUT} = 2Vp-p		30		MHz
Bandwidth for 0.1dB Flatness	$BW_{0.1dB}$	V_{OUT} = 100mVp-p		50		MHz
		V_{OUT} = 2Vp-p		16		
Slew Rate	SR	V_{OUT} = 2V step		140		V/µs
Rise/Fall Time	t_R, t_F	V_{OUT} = 2V step, 10% to 90%		14		ns
Settling Time to 0.1%	$t_{S\ 1\%}$	V_{OUT} = 2V step		100		ns
Spurious-Free Dynamic Range	SFDR	V_{CC} = +5V, f_C = 5MHz, V_{OUT} = 1Vp-p		-84		dBc
		V_{CC} = +3V, f_C = 5MHz, V_{OUT} = 1Vp-p		-93		

Low-Cost, Low-Power, Ultra-Small, 3V/5V, 500MHz Single-Supply Op Amps with Rail-to-Rail Outputs

AC ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = +5V, V_{EE} = 0, V_{CM} = +1.75V, R_L = 1kΩ connected to V_{CC}/2, C_L = 5pF, A_{VCL} = +1V/V, T_A = +25°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
2nd Harmonic Distortion		V_{CC} = +5V, f_C = 5MHz, V_{OUT} = 1Vp-p			-84		dBc
		V_{CC} = +3V, f_C = 5MHz, V_{OUT} = 1Vp-p			-93		
3rd Harmonic Distortion		V_{CC} = +5V, f_C = 5MHz, V_{OUT} = 1Vp-p			-95		dBc
		V_{CC} = +3V, f_C = 5MHz, V_{OUT} = 1Vp-p			-95		
Total Harmonic Distortion	THD	V_{CC} = +5V, f_C = 5MHz, V_{OUT} = 1Vp-p			0.007		%
		V_{CC} = +3V, f_C = 5MHz, V_{OUT} = 1Vp-p			0.003		
Two-Tone, Third-Order Intermodulation Distortion	IP3	f_1 = 10MHz, f_2 = 9.9MHz			-67		dBc
Differential Gain Error	DG	R_L = 150Ω, NTSC	A_V = +1V/V		0.03		%
			A_V = +2V/V		0.01		
Differential Phase Error	DP	R_L = 150Ω, NTSC	A_V = +1V/V		0.13		degrees
			A_V = +2V/V		0.03		
Gain Matching		MAX4413, V_{OUT} = 100mVp-p, f ≤ 10MHz			0.1		dB
Phase Matching		MAX4413, V_{OUT} = 100mVp-p f ≤ 10MHz			0.1		degrees
Input Noise-Voltage Density	e_n	f = 10kHz			13		nV/√Hz
Input Noise-Current Density	I_n	f = 10kHz			0.7		pA/√Hz
Input Capacitance	C_{IN}				1.8		pF
Output Impedance	Z_{OUT}	f = 1MHz			0.7		Ω
Capacitive Load Drive		No sustained oscillations			120		pF
Power-Up 1% Settling Time (Note 2)					1.2	100	µs
Crosstalk	X_{TALK}	MAX4413, f = 10MHz, V_{OUT} = 2Vp-p			-82		dB

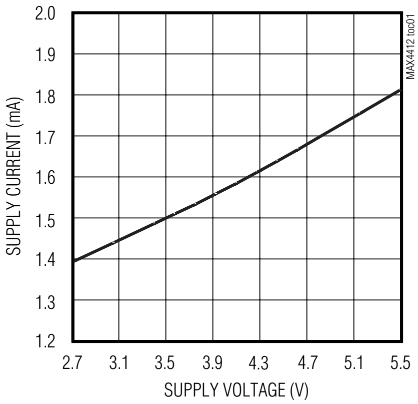
Note 1: All devices are 100% production tested at T_A = +25°C. Specifications over temperature are guaranteed by design.
Note 2: Guaranteed by design.

Low-Cost, Low-Power, Ultra-Small, 3V/5V, 500MHz Single-Supply Op Amps with Rail-to-Rail Outputs

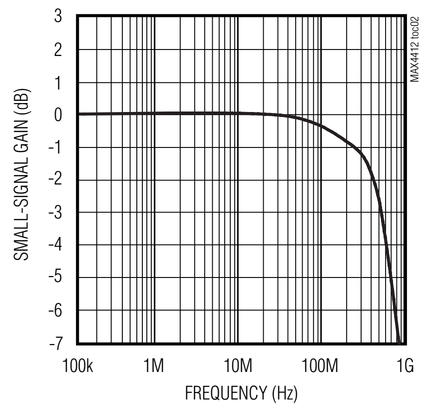
Typical Operating Characteristics

(V_{CC} = +5V, V_{EE} = 0, V_{CM} = +1.75V, A_{VCL} = +1V/V, R_F = 24Ω, R_L = 1kΩ to $V_{CC}/2$, C_L = 5pF, T_A = +25°C, unless otherwise noted.)

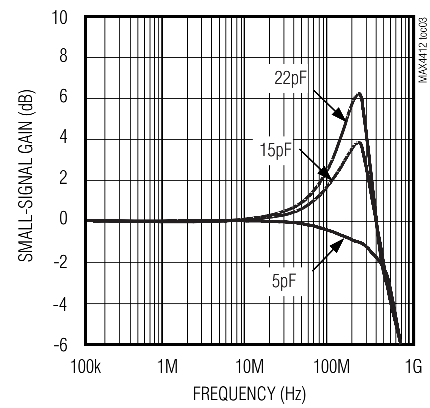
SUPPLY CURRENT vs. SUPPLY VOLTAGE (PER AMPLIFER)



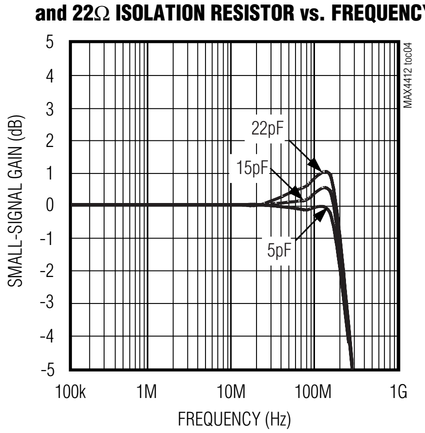
SMALL-SIGNAL GAIN vs. FREQUENCY



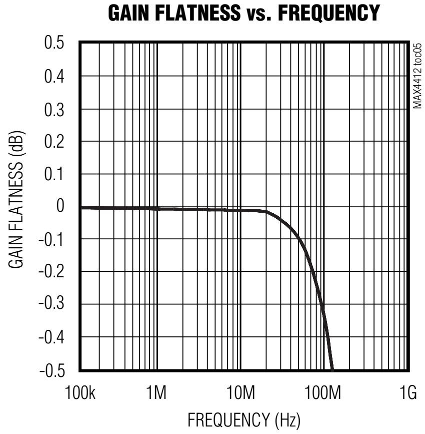
SMALL-SIGNAL GAIN WITH CAPACATIVE LOAD vs. FREQUENCY



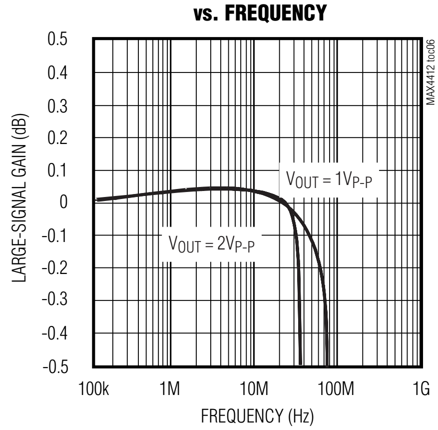
SMALL-SIGNAL GAIN WITH CAPACITIVE LOAD and 22Ω ISOLATION RESISTOR vs. FREQUENCY



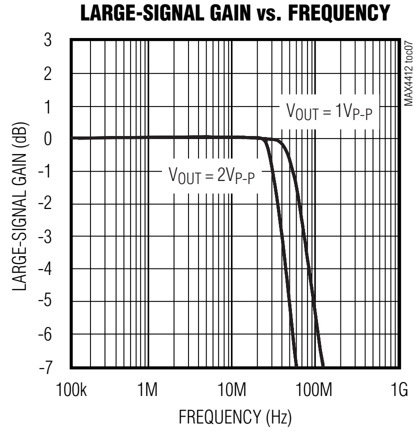
SMALL-SIGNAL GAIN FLATNESS vs. FREQUENCY



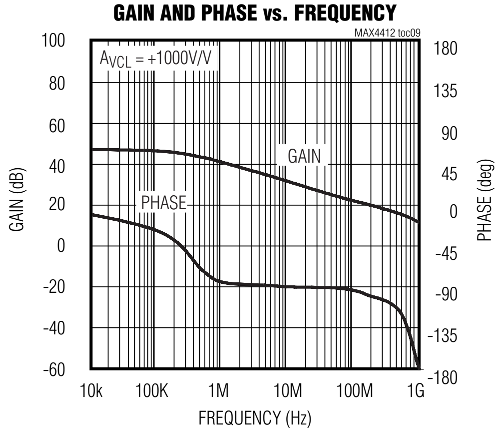
LARGE-SIGNAL GAIN FLATNESS vs. FREQUENCY



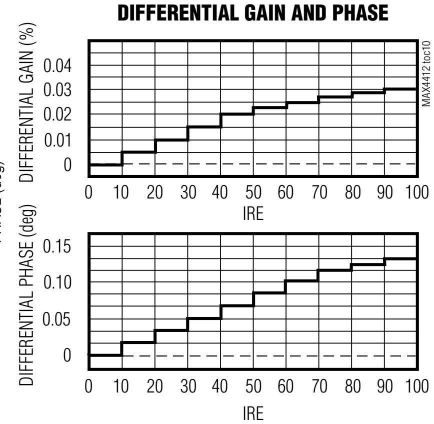
LARGE-SIGNAL GAIN vs. FREQUENCY



GAIN AND PHASE vs. FREQUENCY



DIFFERENTIAL GAIN AND PHASE

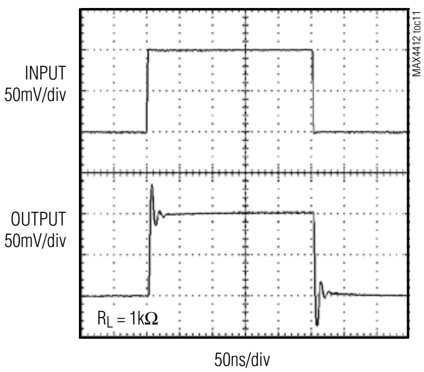


Low-Cost, Low-Power, Ultra-Small, 3V/5V, 500MHz Single-Supply Op Amps with Rail-to-Rail Outputs

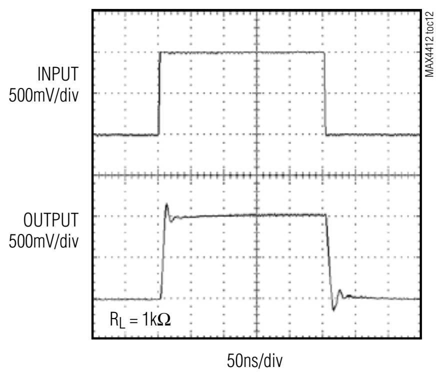
Typical Operating Characteristics (continued)

(V_{CC} = +5V, V_{EE} = 0, V_{CM} = 1.75V, A_{VCL} = +1V/V, R_F = 24Ω, R_L = 1kΩ to V_{CC}/2, C_L = 5pF, T_A = +25°C, unless otherwise noted.)

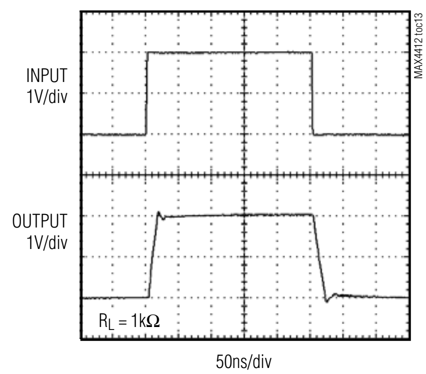
SMALL-SIGNAL PULSE RESPONSE



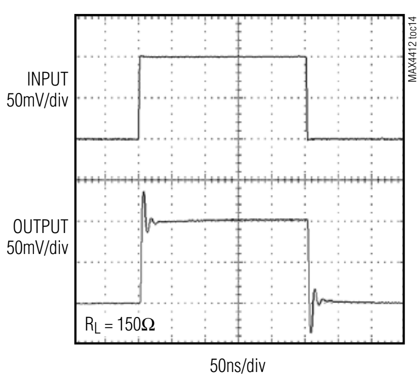
LARGE-SIGNAL PULSE RESPONSE



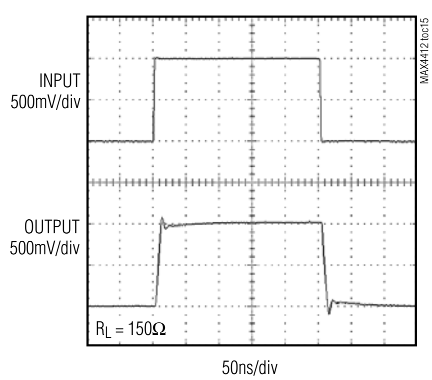
LARGE-SIGNAL PULSE RESPONSE



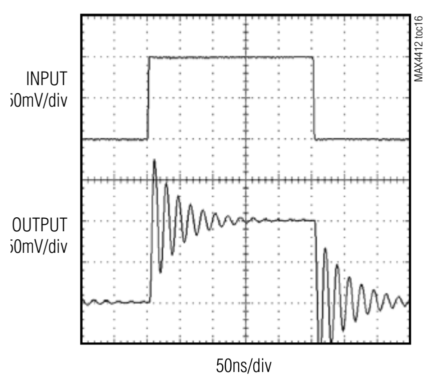
SMALL-SIGNAL PULSE RESPONSE



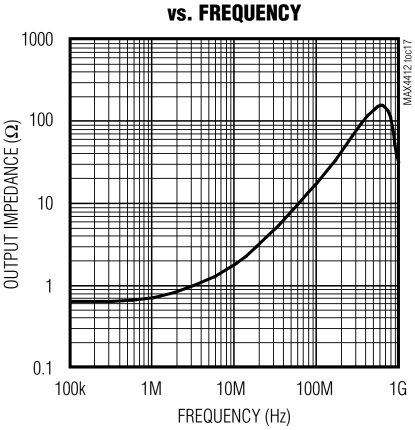
LARGE-SIGNAL PULSE RESPONSE



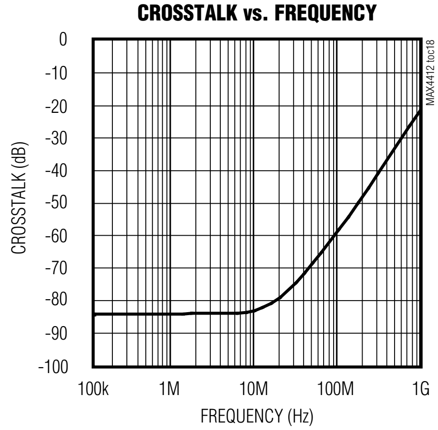
SMALL-SIGNAL PULSE RESPONSE (C_L = 15pF)



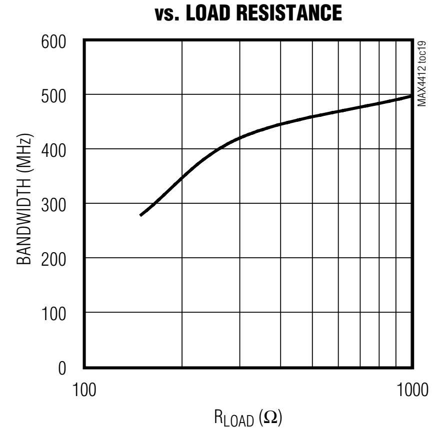
MAX4412/MAX4413 CLOSED-LOOP OUTPUT IMPEDANCE vs. FREQUENCY



MAX4413 CROSSTALK vs. FREQUENCY



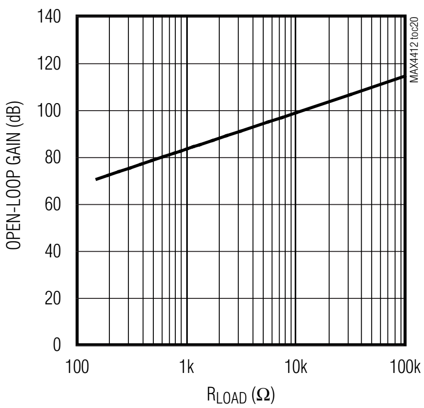
MAX4412/MAX4413 SMALL SIGNAL BANDWIDTH vs. LOAD RESISTANCE



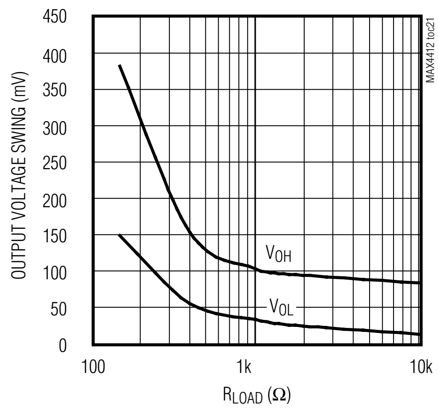
Typical Operating Characteristics (continued)

(V_{CC} = +5V, V_{EE} = 0, V_{CM} = 1.75V, A_{VCL} = +1V/V, R_F = 24Ω, R_L = 1kΩ to V_{CC}/2, C_L = 5pF, T_A = +25°C, unless otherwise noted.)

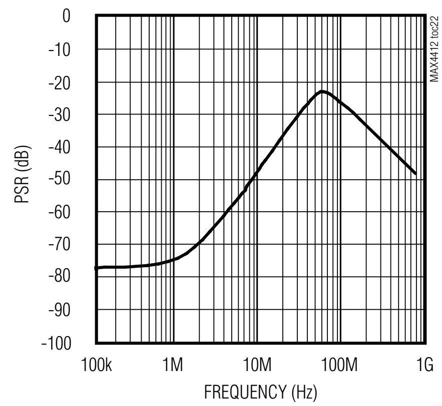
OPEN-LOOP GAIN vs. LOAD RESISTANCE



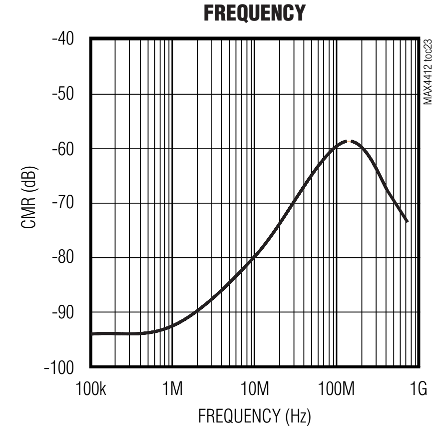
OUTPUT VOLTAGE SWING vs. LOAD RESISTANCE



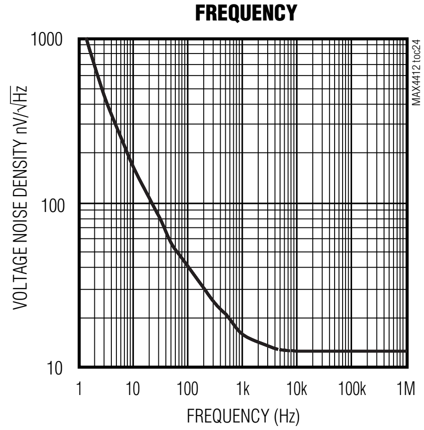
POWER SUPPLY REJECTION vs. FREQUENCY



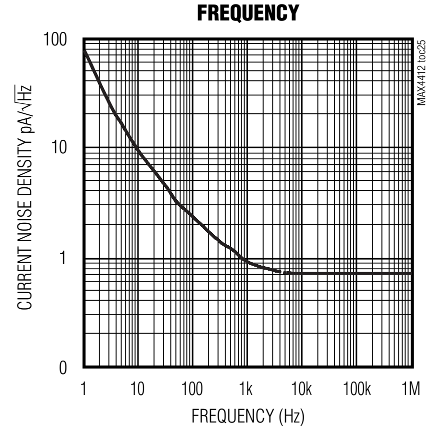
COMMON-MODE REJECTION vs. FREQUENCY



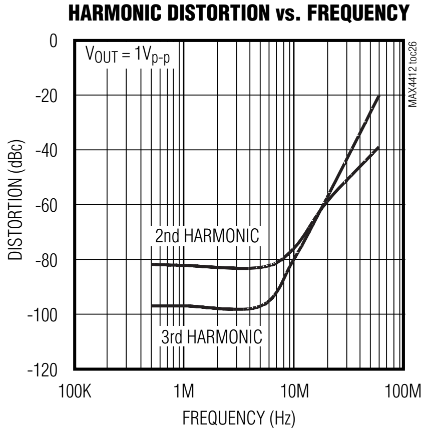
VOLTAGE NOISE DENSITY vs. FREQUENCY



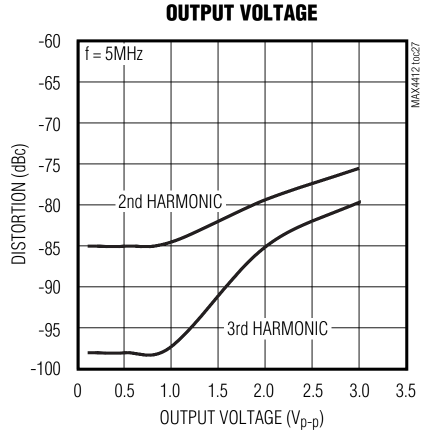
CURRENT NOISE DENSITY vs. FREQUENCY



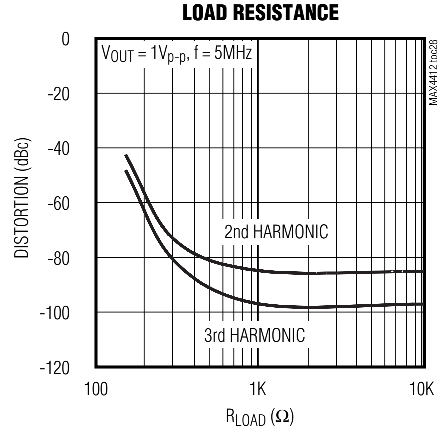
HARMONIC DISTORTION vs. FREQUENCY



HARMONIC DISTORTION vs. OUTPUT VOLTAGE



HARMONIC DISTORTION vs. LOAD RESISTANCE

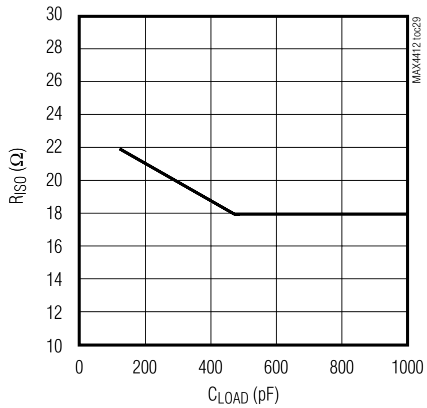


Low-Cost, Low-Power, Ultra-Small, 3V/5V, 500MHz Single-Supply Op Amps with Rail-to-Rail Outputs

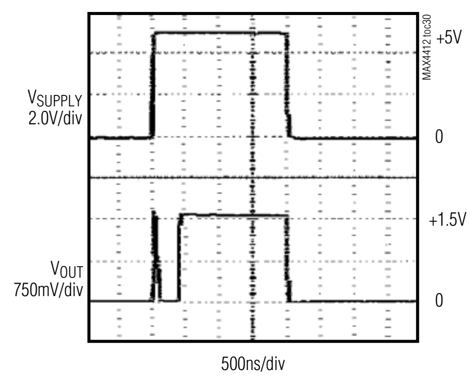
Typical Operating Characteristics (continued)

(V_{CC} = +5V, V_{EE} = 0, V_{CM} = 1.75V, A_{VCL} = +1V/V, R_F = 24Ω, R_L = 1kΩ to V_{CC}/2, C_L = 5pF, T_A = +25°C, unless otherwise noted.)

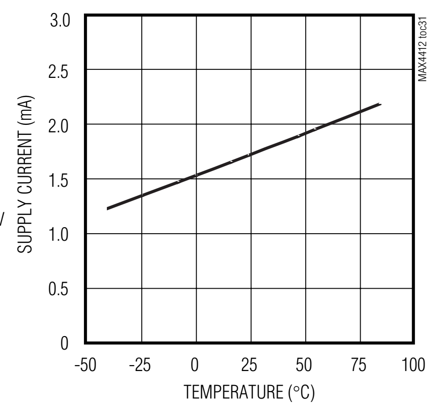
ISOLATION RESISTANCE vs. CAPACITIVE LOAD



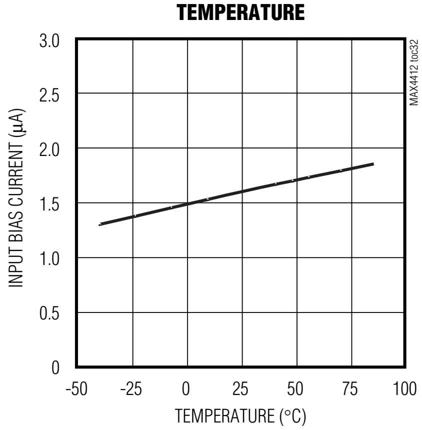
POWER-UP RESPONSE TIME



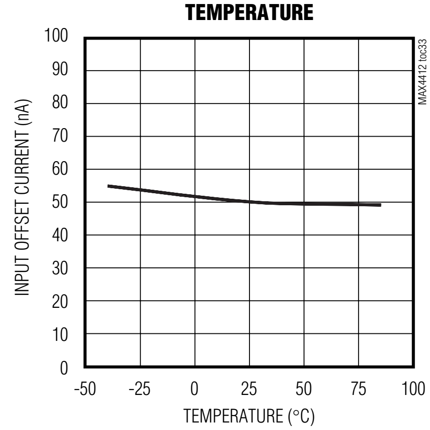
SUPPLY CURRENT (PER AMPLIFIER) vs. TEMPERATURE



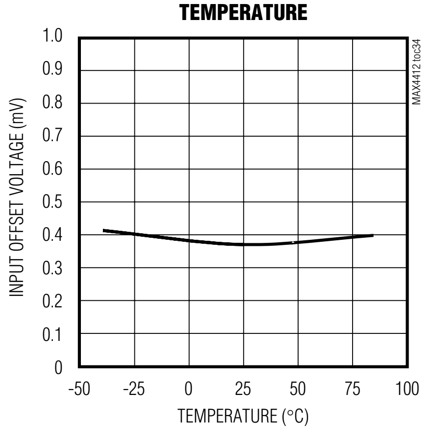
INPUT BIAS CURRENT vs. TEMPERATURE



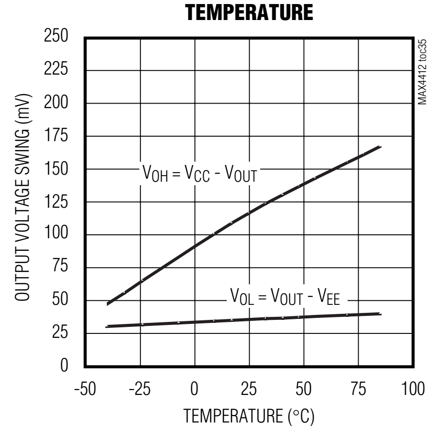
INPUT OFFSET CURRENT vs. TEMPERATURE



INPUT OFFSET VOLTAGE vs. TEMPERATURE



OUTPUT VOLTAGE SWING vs. TEMPERATURE



Pin Description

PIN		NAME	FUNCTION
MAX4412	MAX4413		
1	—	OUT	Amplifier Output
—	1	OUTA	Amplifier A Output
—	7	OUTB	Amplifier B Output
2	4	V_{EE}	Negative Power Supply
3	—	IN+	Amplifier Noninverting Input
—	3	INA+	Amplifier A Noninverting Input
—	5	INB+	Amplifier B Noninverting Input
4	—	IN-	Amplifier Inverting Input
—	2	INA-	Amplifier A Inverting Input
—	6	INB-	Amplifier B Inverting Input
5	8	V_{CC}	Positive Power Supply

Detailed Description

The MAX4412/MAX4413 single-supply, rail-to-rail, voltage-feedback amplifiers achieve 140V/µs slew rates and 500MHz -3dB bandwidths, while consuming only 1.7mA of supply current per amplifier. Excellent harmonic distortion and differential gain/phase performance make these amplifiers an ideal choice for a wide variety of video and RF signal-processing applications.

Internal feedback around the output stage ensures low open-loop output impedance, reducing gain sensitivity to load variations. This feedback also produces demand-driven current bias to the output transistors.

Rail-to-Rail Outputs, Ground-Sensing Input

The MAX4412/MAX4413 input common-mode range extends from (V_{EE} - 0.1V) to (V_{CC} - 1.5V) with excellent common-mode rejection. Beyond this range, the amplifier output is a nonlinear function of the input, but does not undergo phase reversal or latchup.

The output swings to within 105mV of either power-supply rail with a 1kΩ load. Input ground sensing and rail-to-rail outputs substantially increase the dynamic range. With a symmetric input in a single +5V application, the input can swing 3.6Vp-p, and the output can swing 4.6Vp-p with minimal distortion.

Output Capacitive Loading and Stability

The MAX4412/MAX4413 are optimized for AC performance. They are not designed to drive highly reactive loads. Such loads decrease phase margin and may produce excessive ringing and oscillation. The use of an isolation resistor eliminates this problem (Figure 1). Figure 2 is a graph of the Optimal Isolation Resistor (R_{ISO}) vs. Capacitive Load.

The Small Signal Gain vs. Frequency with Capacitive Load and No Isolation Resistor graph in the *Typical Operating Characteristics* shows how a capacitive load causes excessive peaking of the amplifier's frequency response if the capacitor is not isolated from the amplifier by a resistor. A small isolation resistor (usually 20Ω to 30Ω) placed before the reactive load prevents ringing and oscillation. At higher capacitive loads, AC performance is controlled by the interaction of the load capacitance and the isolation resistor. The Small-Signal Gain vs. Frequency with Capacitive Load and 22Ω Isolation Resistor graph shows the effect of a 22Ω isolation resistor on closed-loop response.

Coaxial cable and other transmission lines are easily driven when properly terminated at both ends with their characteristic impedance. Driving back-terminated transmission lines essentially eliminates the line's capacitance.

Applications Information

Choosing Resistor Values

Unity-Gain Configuration

The MAX4412/MAX4413 are internally compensated for unity gain. When configured for unity gain, the devices require a 24Ω feedback resistor (R_F). This resistor improves AC response by reducing the Q of the parallel LC circuit formed by the parasitic feedback capacitance and inductance.

Low-Cost, Low-Power, Ultra-Small, 3V/5V, 500MHz Single-Supply Op Amps with Rail-to-Rail Outputs

Inverting and Noninverting Configurations

Select the gain-setting feedback (R_F) and input (R_G) resistor values that best fit the application. Large resistor values increase voltage noise and interact with the amplifier's input and PC board capacitance. This can generate undesirable poles and zeros and decrease bandwidth or cause oscillations. For example, a noninverting gain-of-two configuration ($R_F = R_G$) using 1kΩ resistors, combined with 1.8pF of amplifier input capacitance and 1pF of PC board capacitance, causes a pole at 114MHz. Since this pole is within the amplifier bandwidth, it jeopardizes stability. Reducing the 1kΩ resistors to 100Ω extends the pole frequency to 1.14GHz, but could limit output swing by adding 200Ω in parallel with the amplifier's load resistor.

Note: For high-gain applications where output offset voltage is a consideration, choose R_S to be equal to the parallel combination of R_F and R_G (Figures 3a and 3b):

$$R_S = \frac{R_F \times R_G}{R_F + R_G}$$

Video Line Driver

The MAX4412/MAX4413 are designed to minimize differential gain error and differential phase error to 0.01%/0.03° respectively, making them ideal for driving video loads.

Active Filters

The low distortion and high bandwidth of the MAX4412/MAX4413 make them ideal for use in active filter circuits. Figure 4 is a 15MHz lowpass, multiple-feedback active filter using the MAX4412.

$$GAIN = \frac{R2}{R1}$$

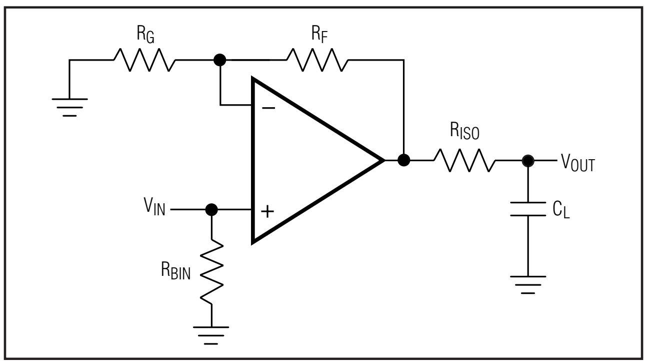


Figure 1. Driving a Capacitive Load Through an Isolation Resistor

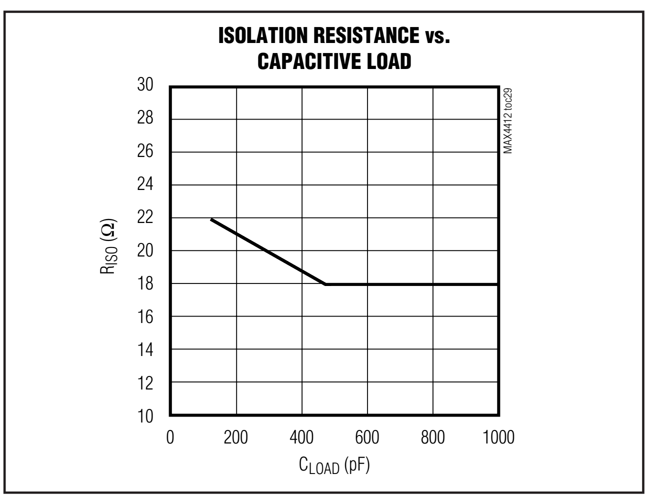


Figure 2. Isolation Resistance vs. Capacitive Load

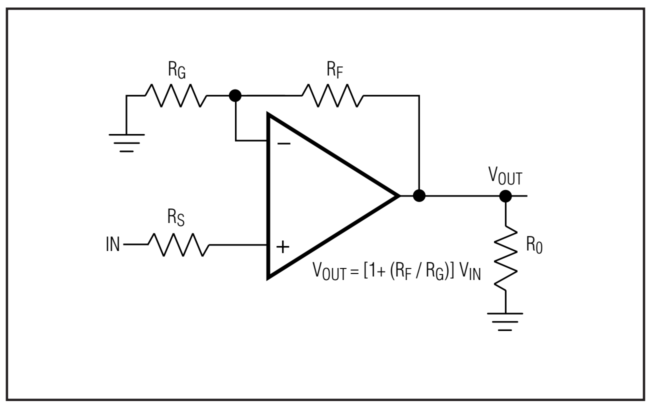


Figure 3a. Noninverting Gain Configuration

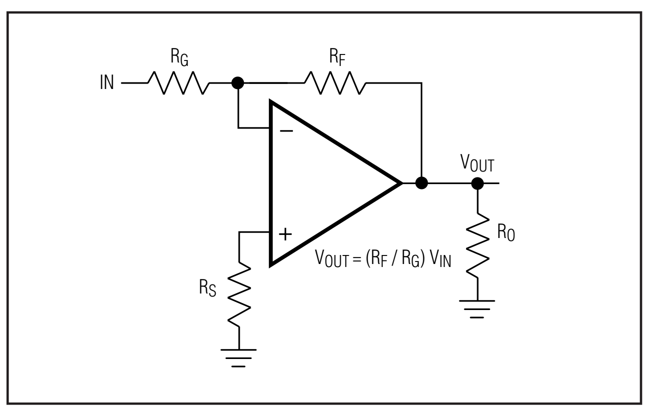


Figure 3b. Inverting Gain Configuration

$$f_0 = \frac{1}{2\pi} \times \sqrt{\frac{1}{R2 \times R3 \times C1 \times C2}}$$

$$Q = \frac{\dfrac{C2}{\sqrt{C1 \times C2 \times R2 \times R3}}}{\dfrac{1}{R1} + \dfrac{1}{R2} + \dfrac{1}{R3}}$$

ADC Input Buffer

Input buffer amplifiers can be a source of significant errors in high-speed analog-to-digital converter (ADC) applications. The input buffer is usually required to rapidly charge and discharge the ADC's input, which is often capacitive (see *Output Capacitive Loading and Stability*). In addition, since a high-speed ADC's input impedance often changes very rapidly during the conversion cycle, measurement accuracy must be maintained using an amplifier with very low output impedance at high frequencies. The combination of high speed, fast slew rate, low noise, and a low and stable distortion overload makes the MAX4412/MAX4413 ideally suited for use as buffer amplifiers in high-speed ADC applications.

Layout and Power-Supply Bypassing

These amplifiers operate from a single +2.7V to +5.5V power supply. Bypass V_{CC} to ground with a 0.1µF capacitor as close to the pin as possible.

Maxim recommends using microstrip and stripline techniques to obtain full bandwidth. Design the PC board for a frequency greater than 1GHz to prevent amplifier performance degradation due to board parasitics. Avoid large parasitic capacitances at inputs and outputs. Whether or not a constant-impedance board is used, observe the following guidelines:

- Do not use wire-wrap boards due to their high inductance.
- Do not use IC sockets because of the increased parasitic capacitance and inductance.
- Use surface-mount instead of through-hole components for better high-frequency performance.
- Use a PC board with at least two layers; it should be as free from voids as possible.
- Keep signal lines as short and as straight as possible. Do not make 90° turns; round all corners.

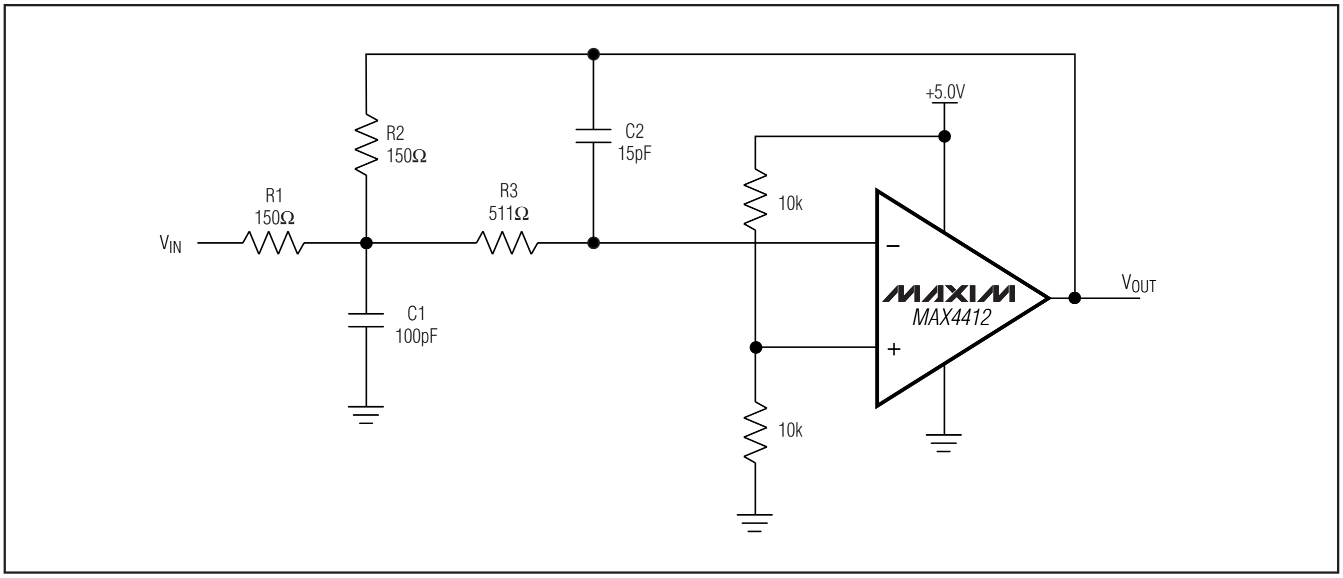


Figure 4. Multiple-Feedback Lowpass Filter

Chip Information

MAX4412 TRANSISTOR COUNT: 99

MAX4413 TRANSISTOR COUNT: 192

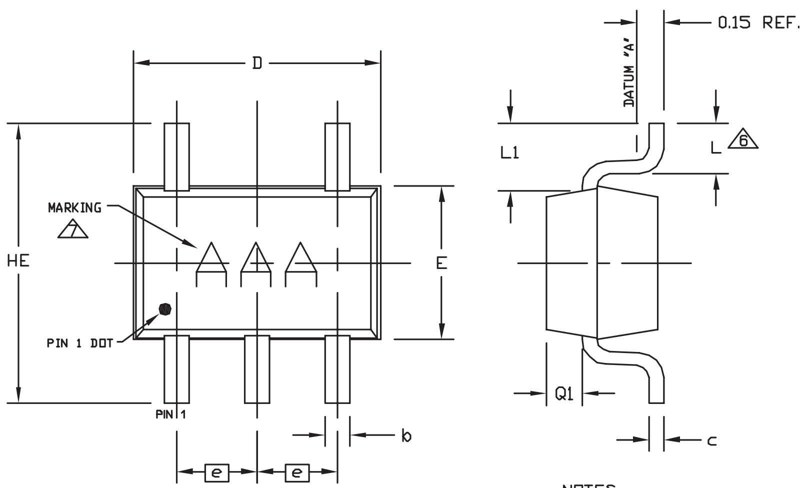
PROCESS: Bipolar

Package Information

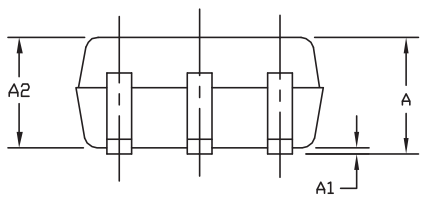
For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**.

PACKAGE TYPE	PACKAGE CODE	DOCUMENT NO.
5 SC70	X5-1	21-0076
5 SOT23	U5-2	21-0057
8 SOT23	K8-5	21-0078

SC70, 5L.EPS



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. CODE	X5-1		



NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONS ARE INCLUSIVE OF PLATING.
3. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH & METAL BURR.
4. COMPLY TO JEITA SC-88A EXCEPT FOR DIMENSION "L". ALL DIMENSIONS COMPLY TO JEDEC MO-203.
5. COPLANARITY 4 MILS. MAX.
6. FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM "A" AND LEAD SURFACE.
7. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.
8. LEAD CENTERLINES TO BE AT TRUE POSITION AS DEFINED BY BASIC DIMENSION "e", ±0.05.

DALLAS SEMICONDUCTOR MAXIM

TITLE: PACKAGE OUTLINE, 5L SC70			
APPROVAL	DOCUMENT CONTROL NO. 21-0076	REV. E	1/1

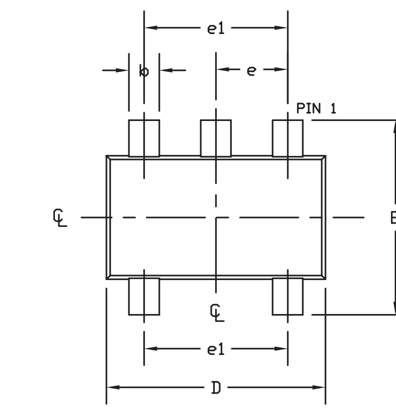
-DRAWING NOT TO SCALE-

Low-Cost, Low-Power, Ultra-Small, 3V/5V, 500MHz Single-Supply Op Amps with Rail-to-Rail Outputs

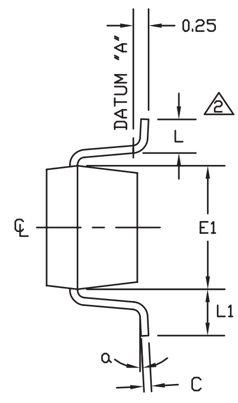
Package Information (continued)

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**.

SOT-23 5L .EPS

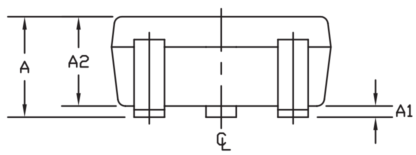


TOP VIEW



SIDE VIEW

SYMBOL	MIN	NOM	MAX
A	0.90	1.25	1.45
A1	0.00	0.05	0.15
A2	0.90	1.10	1.30
b	0.35	0.40	0.50
C	0.08	0.15	0.20
D	2.80	2.90	3.00
E	2.60	2.80	3.00
E1	1.50	1.625	1.75
L	0.35	0.45	0.60
L1	0.60 REF		
e	0.95 BSC.		
e1	1.90 BSC.		
a	0°	2.5°	8°
PKG CODES: U5-1, U5-2			



FRONT VIEW

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM A & LEAD SURFACE.
3. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & METAL BURR. MOLD FLASH, PROTRUSION OR METAL BURR SHOULD NOT EXCEED 0.25 MM.
4. PACKAGE OUTLINE INCLUSIVE OF SOLDER PLATING.
5. MEETS JEDEC MO178, VARIATION AA.
6. LEADS TO BE COPLANAR WITHIN 0.10 mm.
7. SOLDER THICKNESS MEASURED AT FLAT SECTION OF LEAD BETWEEN 0.08mm AND 0.15mm FROM LEAD TIP.

DALLAS SEMICONDUCTOR MAXIM

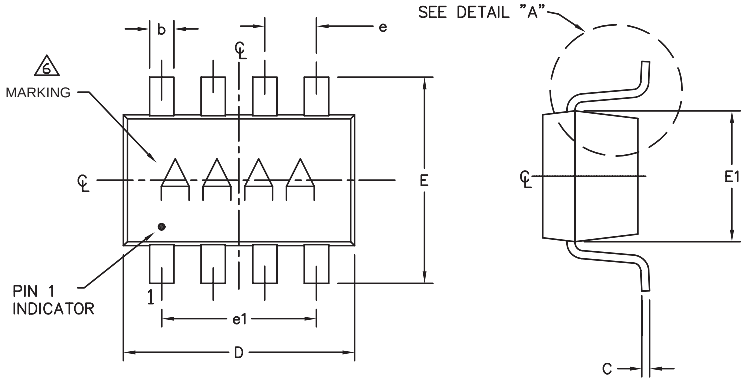
PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, SOT-23, 5L

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0057	F	1/1

Package Information (continued)

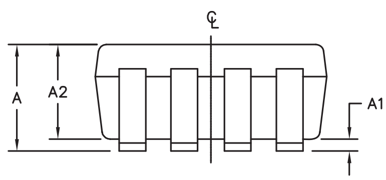
For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**.

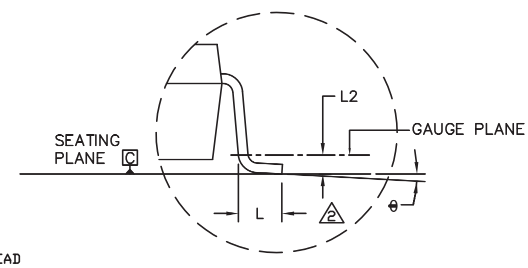


SYMBOL	MIN	NOM	MAX
A	0.90	1.25	1.45
A1	0.00	0.06	0.15
A2	0.90	1.10	1.30
b	0.22	0.30	0.38
C	0.08	0.15	0.22
D	2.80	2.90	3.00
E	2.60	2.80	3.00
E1	1.50	1.625	1.75
L	0.30	0.45	0.60
L2	0.25 BSC.		
e	0.65 BSC.		
e1	1.95 REF.		
θ	0°	3°	8°

PKG CODES:
K8-1, K8-2, K8F-4, K8FH-4, K8-5, K8C-6; K8SN-1

SOT23, 8L.EPS





DETAIL "A"

NOTE:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. FOOT LENGTH MEASURED FROM LEAD TIP TO UPPER RADIUS OF HEEL OF THE LEAD PARALLEL TO SEATING PLANE C.
3. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & METAL BURR.
4. PACKAGE OUTLINE INCLUSIVE OF SOLDER PLATING.
5. COPLANARITY 4 MILS. MAX.
6. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.
7. SOLDER THICKNESS MEASURED AT FLAT SECTION OF LEAD BETWEEN 0.08mm AND 0.15mm FROM LEAD TIP.
8. MEETS JEDEC MO178 VARIATION BA.
9. ALL DIMENSIONS APPLY TO BOTH LEADED (-) AND LEAD FREE (+) PACKAGE CODES.

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MAXIM

TITLE: PACKAGE OUTLINE, SOT-23, 8L BODY

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0078	H	1/1

Low-Cost, Low-Power, Ultra-Small, 3V/5V, 500MHz Single-Supply Op Amps with Rail-to-Rail Outputs

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	11/00	Initial release	—
1	1/09	Corrected slew rate value	1, 3, 9