19-0461; Rev 1; 3/96

EVALUATION KIT AVAILABLE

400MHz, Ultra-Low-Distortion Op Amps

General Description

The MAX4108/MAX4109 op amps combine ultra-high-speed performance with low-distortion operation. The MAX4108 is compensated for unity-gain stability, while the MAX4109 is compensated for a closed-loop gain (A_{VCL}) of 2V/V or greater.

The MAX4108 delivers a 400MHz unity-gain bandwidth with a 1200V/µs slew rate, while the MAX4109 provides a 225MHz gain bandwidth with a 1200V/µs slew rate. The low-distortion design provides an unprecedented spurious-free dynamic range of -81dBc and -80dBc, respectively, at 20MHz (V_O = 2Vp-p, R_L = 100Ω), making these amplifiers ideal for high-performance RF signal processing.

These high-speed op amps have a wide output voltage swing and a high current-drive capability of 90mA.

Features

- **400MHz Unity-Gain Bandwidth (MAX4108)**
  225MHz -3dB Bandwidth (MAX4109)
- **1200V/µs Slew Rate**
- **-81dBc SFDR at f_C = 20MHz (MAX4108)**
  -80dBc SFDR at f_C = 20MHz (MAX4109)
- **300MHz Full-Power Bandwidth (MAX4108, V_O = 2Vp-p)**
  200MHz Full-Power Bandwidth (MAX4109, V_O = 2Vp-p)
- **Voltage Feedback Architecture**
- **High Output Drive: 90mA**
- **Output Short-Circuit Protected**

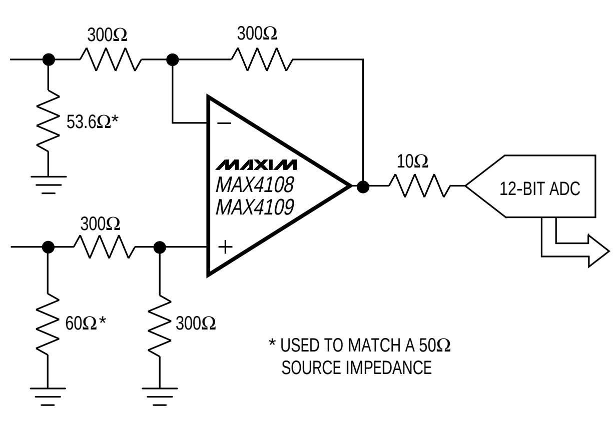
Applications

RGB and Composite Video
High-Performance Receivers
Pulse/RF Amplifier
ADC/DAC Preamp
Active Filters

Ordering Information

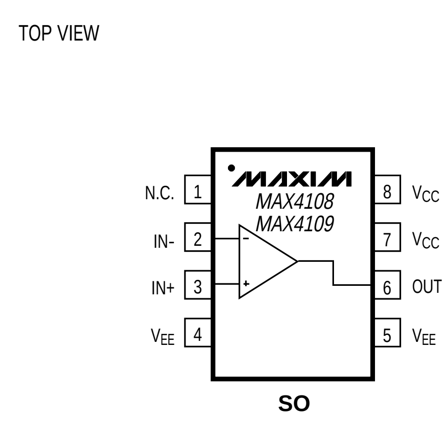
PART	TEMP. RANGE	PIN-PACKAGE
MAX4108ESA	-40°C to +85°C	8 SO
MAX4109ESA	-40°C to +85°C	8 SO

Typical Application Circuit



DIFFERENCE AMPLIFIER/ADC PREAMPLIFIER

Pin Configuration



ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{CC} to V_{EE})....................12V
Voltage on Any Pin to Ground or Any Other Pin.........V_{CC} to V_{EE}
Short-Circuit Duration (V_{OUT} to GND)....................Continuous
Continuous Power Dissipation (T_A = +70°C)
SO (derate 5.88mW/°C above +70°C)....................471mW
Operating Temperature Range
MAX4108ESA/MAX4109ESA....................-40°C to +85°C
Storage Temperature Range....................-65°C to +160°C
Junction Temperature....................+150°C
Lead Temperature (soldering, 10sec)....................+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.

ELECTRICAL CHARACTERISTICS

(V_{CC} = 5V, V_{EE} = -5V, T_A = T_{MIN} to T_{MAX}, typical values are at T_A = +25°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
DC SPECIFICATIONS							
Input Offset Voltage	V_{OS}	V_{OUT} = 0V			1	8	mV
Input Offset Voltage Drift	TCV_{OS}	V_{OUT} = 0V			13		µV/°C
Input Bias Current	I_B	V_{OUT} = 0V, V_{IN} = $-V_{OS}$			12	25	µA
Input Offset Current	I_{OS}	V_{OUT} = 0V, V_{IN} = $-V_{OS}$			0.05	1.0	µA
Common-Mode Input Resistance	R_{INCM}	Either input			1.5		MΩ
Common-Mode Input Capacitance	C_{INCM}	Either input			1		pF
Input Voltage Noise	e_n	f_O = 10kHz	MAX4108		8		$nV/\sqrt{Hz}$
			MAX4109		6		
Integrated Voltage Noise	E_{nRMS}	f_B = 1MHz to 100MHz	MAX4108		100		μV_{RMS}
			MAX4109		75		
Input Current Noise	I_n	f_O = 10kHz	MAX4108		2		$pA/\sqrt{Hz}$
			MAX4109		2		
Integrated Current Noise	I_{nRMS}	f_B = 1MHz to 100MHz	MAX4108		25		nA_{RMS}
			MAX4109		25		
Common-Mode Input Voltage	V_{CM}			-2.5		2.5	V
Common-Mode Rejection	CMR	V_{CM} = ±2.5V		70	100		dB
Power-Supply Rejection	PSR	V_S = ±4.5V to ±5.5V		70	90		dB
Open-Loop Voltage Gain	A_{OL}	V_{OUT} = ±2.0V, V_{CM} = 0V, R_L = 100Ω		70	100		dB
Quiescent Supply Current	I_{SY}	V_{IN} = 0V			20	25	mA
Output Voltage Swing	V_{OUT}	R_L = ∞		2.5 to -3.1	2.9 to -3.8		V
		R_L = 100Ω		2.5 to -3.1	2.7 to -3.7		
Output Current Drive	I_{OUT}	R_L = 33Ω, T_A = 0°C to +85°C		65	90		mA
Short-Circuit Output Current	I_{SC}	Short to ground			100		mA

ELECTRICAL CHARACTERISTICS (continued)

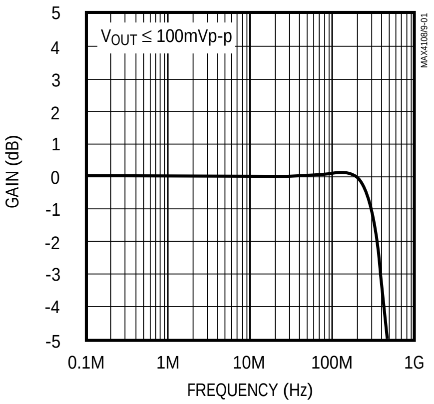
(V_{CC} = 5V, V_{EE} = -5V, T_A = T_{MIN} to T_{MAX}, typical values are at T_A = +25°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
AC SPECIFICATIONS							
-3dB Bandwidth	BW_{-3dB}	V_{OUT} ≤ $0.1V_{RMS}$	MAX4108		400		MHz
			MAX4109		225		
Full-Power Bandwidth	FPBW	V_{OUT} = 2Vp-p	MAX4108		300		MHz
			MAX4109		200		
0.1dB Bandwidth	$BW_{0.1dB}$	MAX4108, A_{VCL} = +1			100		MHz
		MAX4109, A_{VCL} = +2			25		
Slew Rate	SR	-2V ≤ V_{OUT} ≤ 2V	MAX4108		1200		V/µs
			MAX4109		1200		
Settling Time	t_S	to 0.1%, -1V ≤ V_{OUT} ≤ 1V, R_L = 100Ω	MAX4108		8		ns
			MAX4109		8		
		to 0.01%, -1V ≤ V_{OUT} ≤ 1V, R_L = 100Ω	MAX4108		12		
			MAX4109		12		
Rise/Fall Times	t_R, t_F	-2V ≤ V_{OUT} ≤ 2V, 10% to 90%, R_L = 100Ω	MAX4108		3		ns
			MAX4109		3		
		-50mV ≤ V_{OUT} ≤ 50mV, 10% to 90%, R_L = 100Ω	MAX4108		2		
			MAX4109		2		
Differential Gain	DG	f = 3.58MHz	MAX4108, A_{VCL} = +1		0.002		%
			MAX4109, A_{VCL} = +2		0.008		
Differential Phase	DP	f = 3.58MHz	MAX4108, A_{VCL} = +1		0.002		degrees
			MAX4109, A_{VCL} = +2		0.002		
Input Capacitance	C_{IN}				2		pF
Output Resistance	R_{OUT}	f = 10MHz			1		Ω
Spurious-Free Dynamic Range	SFDR	MAX4108, A_{VCL} = +1, V_{OUT} = 2Vp-p	f_C = 5MHz		-93		dBc
			f_C = 20MHz		-81		
		MAX4109, A_{VCL} = +2, V_{OUT} = 2Vp-p	f_C = 5MHz		-90		
			f_C = 20MHz		-80		
Third-Order Intercept	IP3	f_C = 10MHz	MAX4108, A_{VCL} = +1		39		dBm
			MAX4109, A_{VCL} = +2		36		

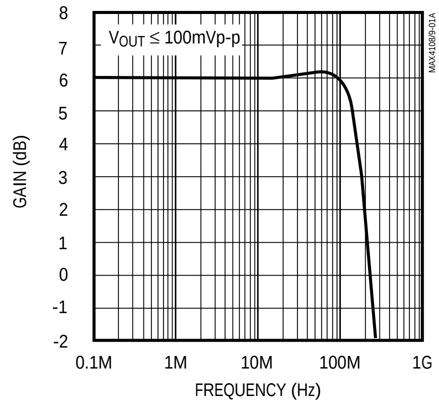
Typical Operating Characteristics

(V_{CC} = +5V, V_{EE} = -5V, R_L = 100Ω, T_A = +25°C, unless otherwise noted.)

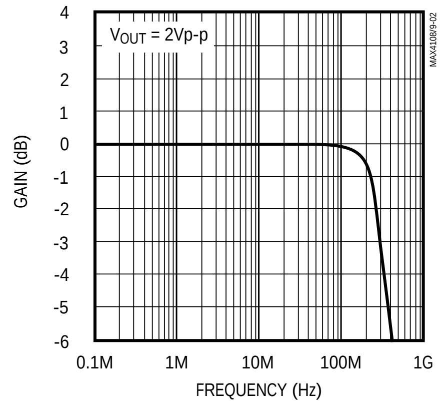
MAX4108
SMALL-SIGNAL GAIN vs. FREQUENCY
(A_{VCL} = +1)



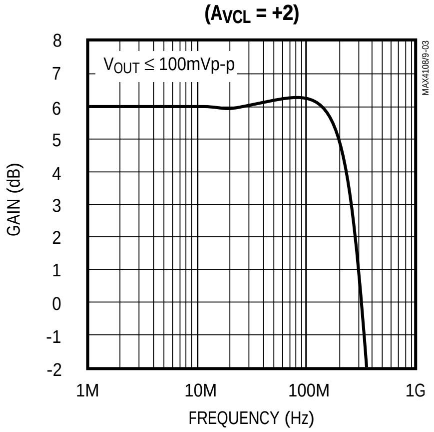
MAX4108
SMALL-SIGNAL GAIN vs. FREQUENCY
(A_{VCL} = +2)



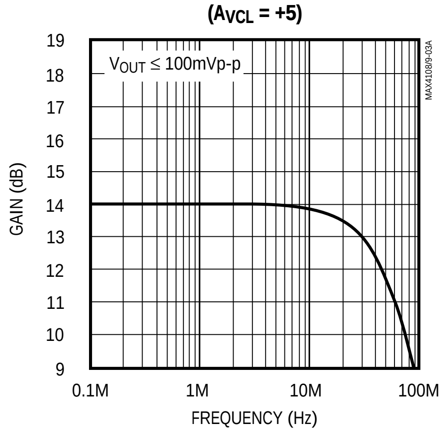
MAX4108
LARGE-SIGNAL GAIN vs. FREQUENCY
(A_{VCL} = +1)



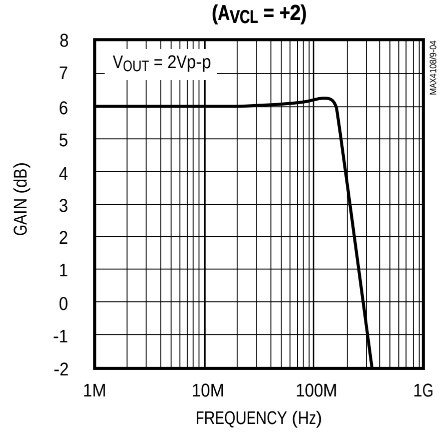
MAX4109
SMALL-SIGNAL GAIN vs. FREQUENCY
(A_{VCL} = +2)



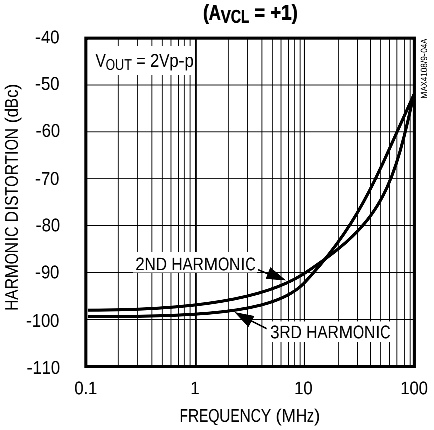
MAX4109
SMALL-SIGNAL GAIN vs. FREQUENCY
(A_{VCL} = +5)



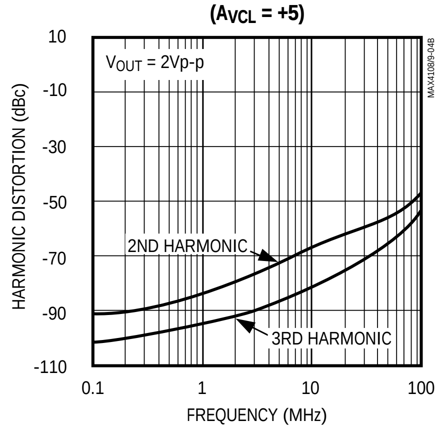
MAX4109
LARGE-SIGNAL GAIN vs. FREQUENCY
(A_{VCL} = +2)



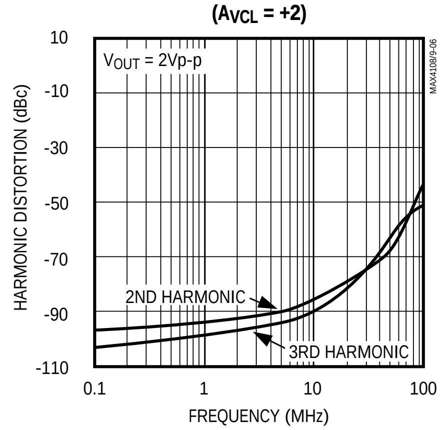
MAX4108
HARMONIC DISTORTION vs. FREQUENCY
(A_{VCL} = +1)



MAX4108
HARMONIC DISTORTION vs. FREQUENCY
(A_{VCL} = +5)



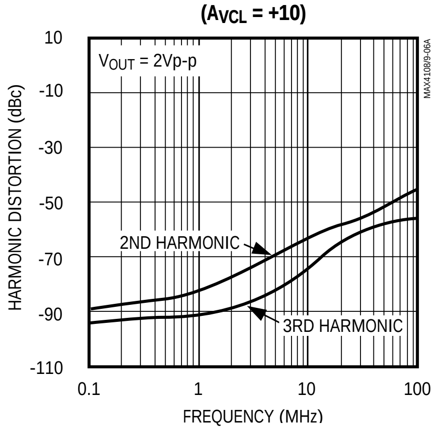
MAX4109
HARMONIC DISTORTION vs. FREQUENCY
(A_{VCL} = +2)



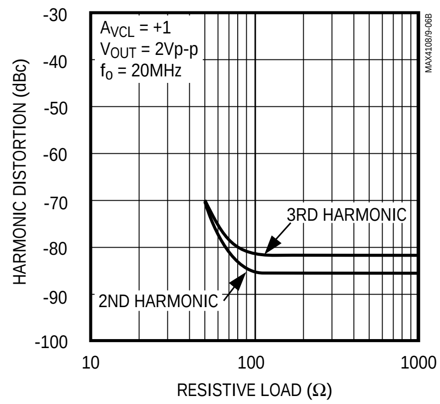
Typical Operating Characteristics (continued)

(V_{CC} = +5V, V_{EE} = -5V, R_L = 100Ω, T_A = +25°C, unless otherwise noted.)

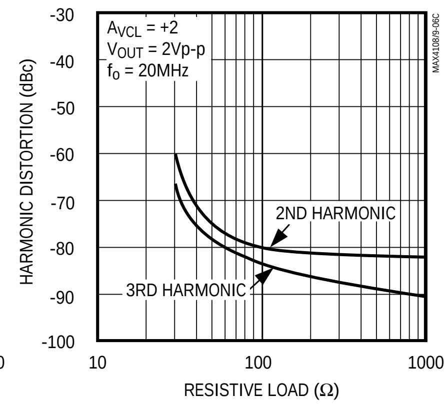
MAX4109
HARMONIC DISTORTION vs. FREQUENCY (A_{VCL} = +10)



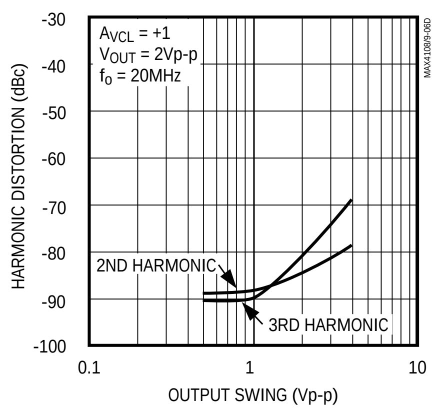
MAX4108
HARMONIC DISTORTION vs. LOAD



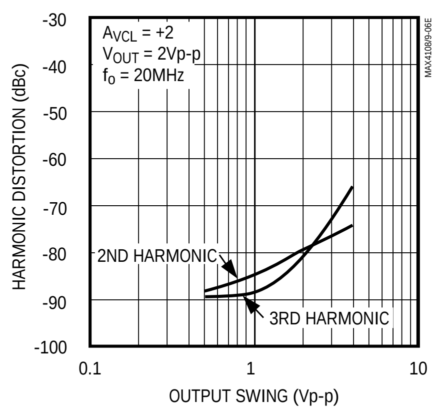
MAX4109
HARMONIC DISTORTION vs. LOAD



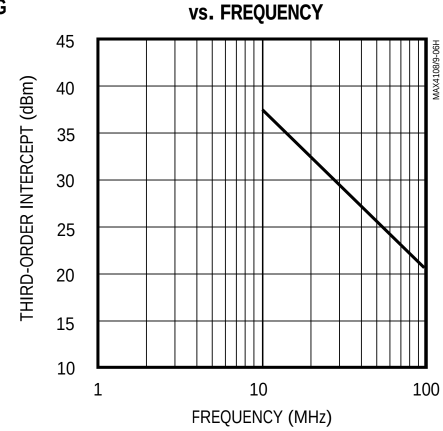
MAX4108
HARMONIC DISTORTION vs. OUTPUT SWING



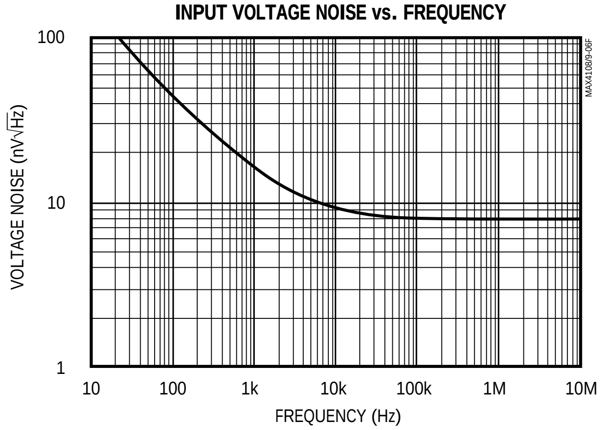
MAX4109
HARMONIC DISTORTION vs. OUTPUT SWING



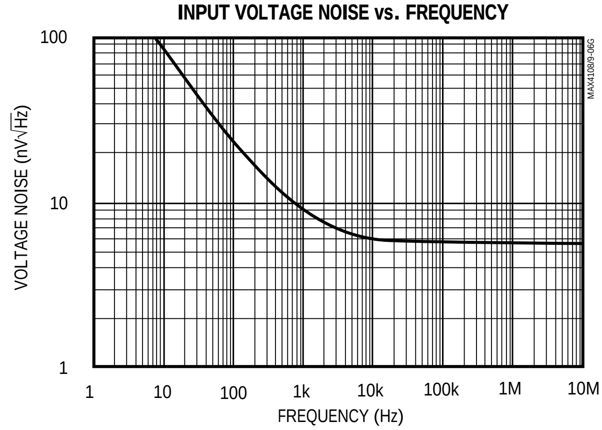
MAX4109
TWO-TONE THIRD-ORDER INTERCEPT vs. FREQUENCY



MAX4108
INPUT VOLTAGE NOISE vs. FREQUENCY



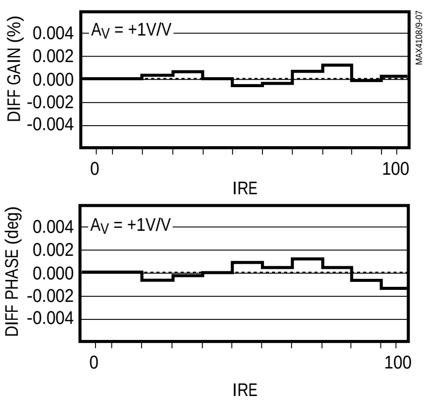
MAX4109
INPUT VOLTAGE NOISE vs. FREQUENCY



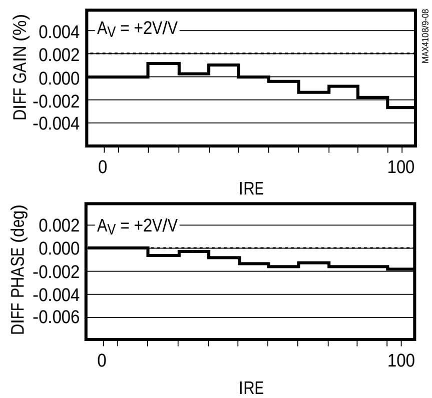
Typical Operating Characteristics (continued)

(V_{CC} = +5V, V_{EE} = -5V, R_L = 100Ω, T_A = +25°C, unless otherwise noted.)

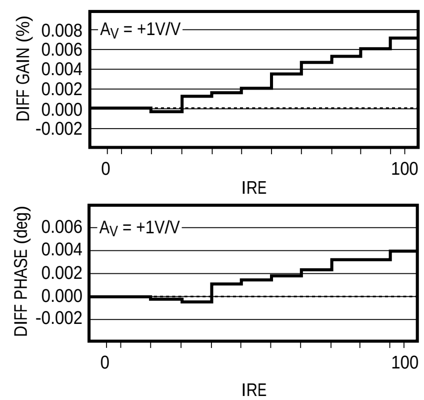
MAX4108
DIFFERENTIAL GAIN AND PHASE
(R_L = 150Ω)



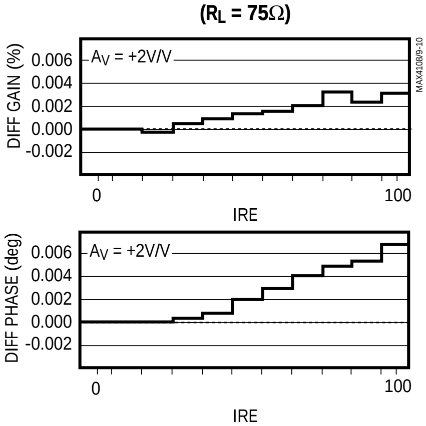
MAX4109
DIFFERENTIAL GAIN AND PHASE
(R_L = 150Ω)



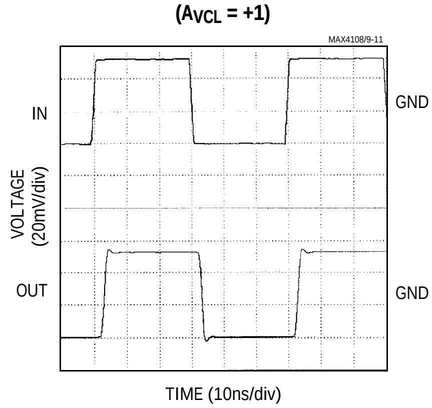
MAX4108
DIFFERENTIAL GAIN AND PHASE
(R_L = 75Ω)



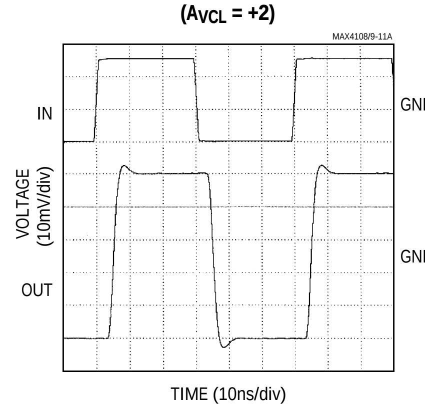
MAX4109
DIFFERENTIAL GAIN AND PHASE
(R_L = 75Ω)



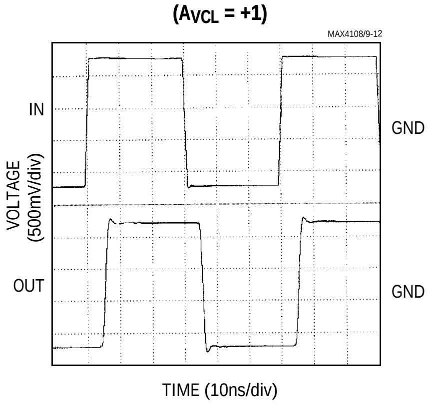
MAX4108
SMALL-SIGNAL PULSE RESPONSE
(A_{VCL} = +1)



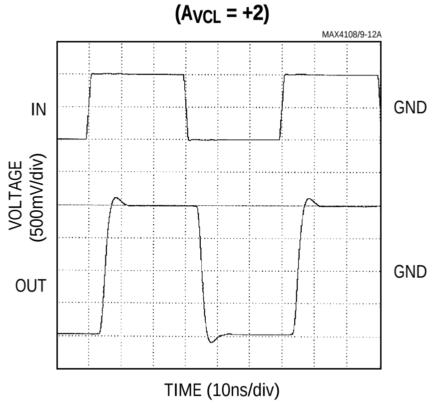
MAX4108
SMALL-SIGNAL PULSE RESPONSE
(A_{VCL} = +2)



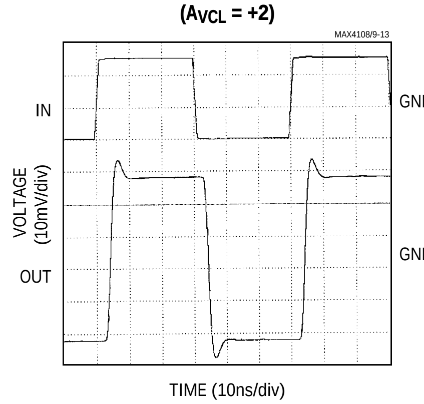
MAX4108
LARGE-SIGNAL PULSE RESPONSE
(A_{VCL} = +1)



MAX4108
LARGE-SIGNAL PULSE RESPONSE
(A_{VCL} = +2)

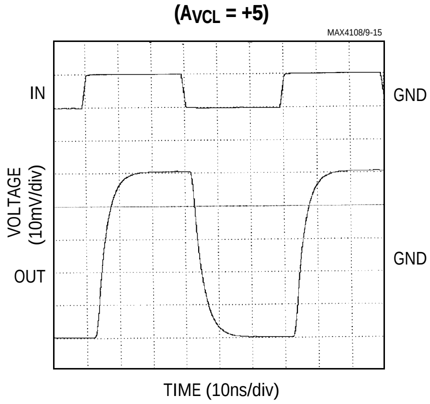


MAX4109
SMALL-SIGNAL PULSE RESPONSE
(A_{VCL} = +2)

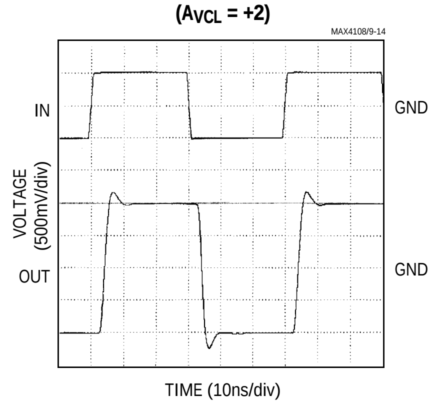


Typical Operating Characteristics (continued)

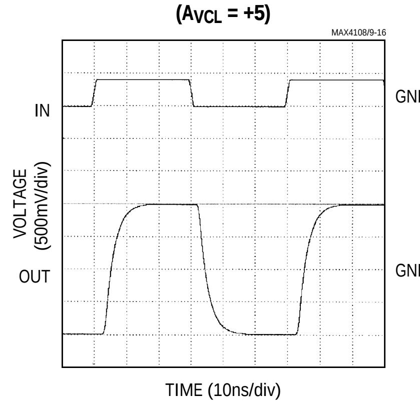
MAX4109
SMALL-SIGNAL PULSE RESPONSE
(A_{VCL} = +5)



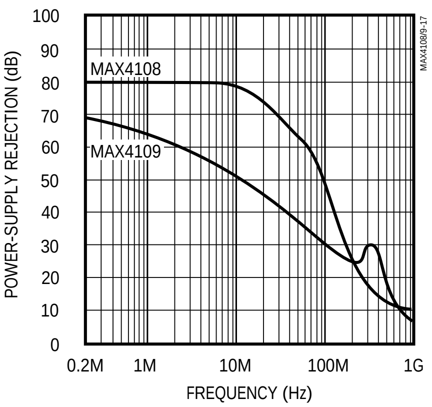
MAX4109
LARGE-SIGNAL PULSE RESPONSE
(A_{VCL} = +2)



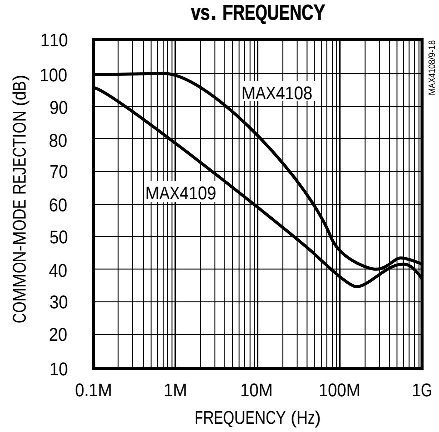
MAX4109
LARGE-SIGNAL PULSE RESPONSE
(A_{VCL} = +5)



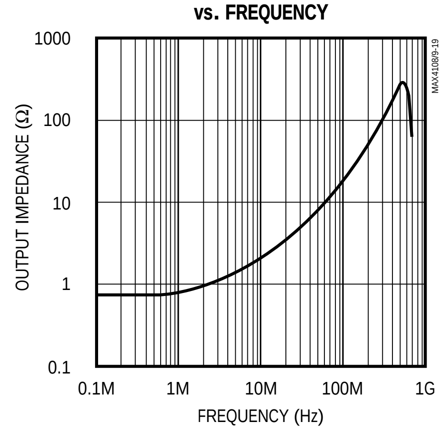
POWER-SUPPLY REJECTION vs. FREQUENCY



COMMON-MODE REJECTION vs. FREQUENCY

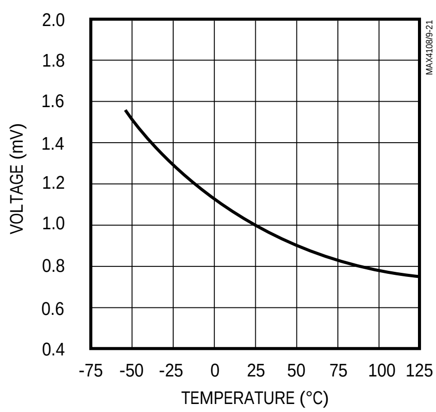


CLOSED-LOOP OUTPUT IMPEDANCE vs. FREQUENCY

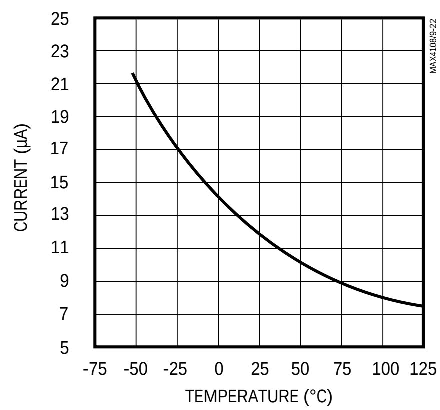


MAX4108
OUTPUT SWING vs. LOAD RESISTANCE

INPUT OFFSET VOLTAGE vs. TEMPERATURE



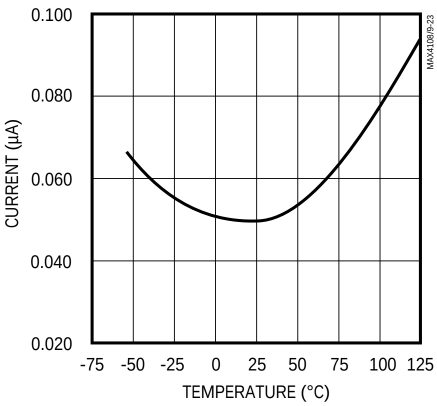
INPUT BIAS CURRENT vs. TEMPERATURE



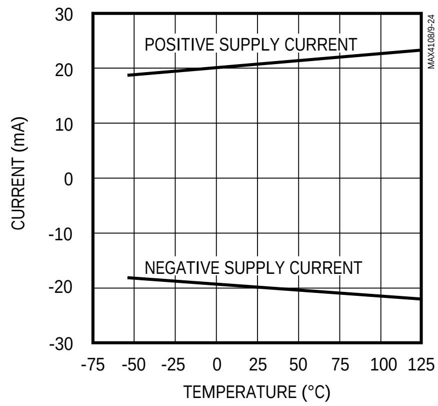
Typical Operating Characteristics (continued)

(V_{CC} = +5V, V_{EE} = -5V, R_L = 100Ω, T_A = +25°C, unless otherwise noted.)

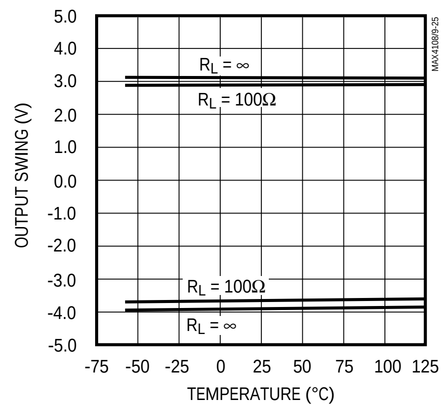
INPUT OFFSET CURRENT vs. TEMPERATURE



POWER SUPPLY CURRENT vs. TEMPERATURE



OUTPUT SWING vs. TEMPERATURE



Pin Description

PIN	NAME	FUNCTION
1	N.C.	No Connection. Not internally connected.
2	IN-	Inverting Input
3	IN+	Noninverting Input
4, 5	V_{EE}	Negative Power Supply, connect to -5V
6	OUT	Amplifier Output
7, 8	V_{CC}	Positive Power Supply, connect to +5V

Detailed Description

Choosing Resistor Values

Unity-Gain Configuration

The MAX4108 is internally compensated for unity gain. When configured for unity gain, the device requires a small resistor (typically 24Ω) in series with the feedback path. This resistor provides better AC response by reducing the Q of the tank circuit formed by parasitic feedback inductance and capacitance.

Inverting and Noninverting Configurations

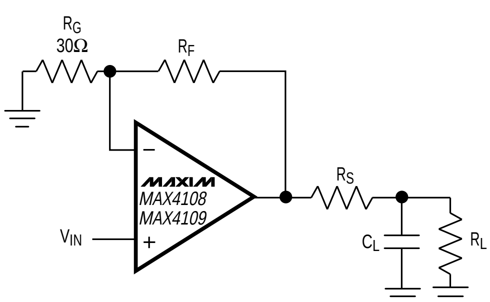
The values of the gain-setting feedback and input resistors are important design considerations. Large resistor values will increase voltage noise, and will interact with the amplifier's input and PC board capacitance to generate undesirable poles and zeros, which can decrease bandwidth or cause oscillations. For example, a noninverting gain of +2, using 1kΩ resistors combined with 2pF of input capacitance and 0.5pF of board capacitance, will cause a feedback pole at 128MHz. If this pole is within the anticipated amplifier bandwidth, it will jeopardize stability. Reducing these 1kΩ resistors to 100Ω will extend the pole frequency to 1.28GHz, but could limit output swing by adding 200Ω in parallel with the amplifier's load. Clearly, the selection of resistor values must be tailored to the specific application.

The MAX4108/MAX4109 are ultra-low-distortion, high-bandwidth op amps. The output distortion will be degraded as the total load resistance seen by the amplifier decreases. To minimize distortion products, keep the input and gain-setting resistors relatively large. A 500Ω feedback resistor combined with an appropriate input resistor to set the gain will provide excellent AC performance without significantly increasing distortion.

Driving Capacitive Loads

The MAX4108/MAX4109 are optimized for AC performance. They are not designed to drive highly reactive loads. Reactive loads will decrease phase margin and may produce excessive ringing and oscillation. Figure 1a shows a circuit that eliminates this problem, and Figure 1b is a graph of the optimal isolation resistor (R_S) vs. capacitive load. Figures 2a and 2b show how a capacitive load causes excessive peaking of the amplifier's bandwidth if the capacitive load is not isolated (R_S) from the amplifier. A small isolation resistor (usually 10Ω to 20Ω) placed before the reactive load prevents ringing and oscillation. At higher capacitive loads, AC performance will be controlled by the interaction of the load capacitance and isolation resistor. Figures 3a and 3b show the effect of an isolation resistor on the MAX4108/MAX4109 closed-loop response.

Coaxial cable and other transmission lines are easily driven when terminated at both ends with their characteristic impedance. When driving back-terminated transmission lines, the capacitance of the transmission line is essentially eliminated.



PART	RF (Ω)	GAIN (V/V)
MAX4108	120	+1
MAX4109	270	+2

Figure 1a. Using an Isolation Resistor for High Capacitive Loads

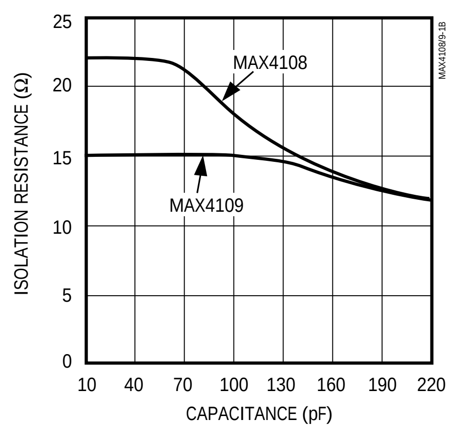


Figure 1b. Optimal Isolation Resistor (RS) vs. Capacitive Load

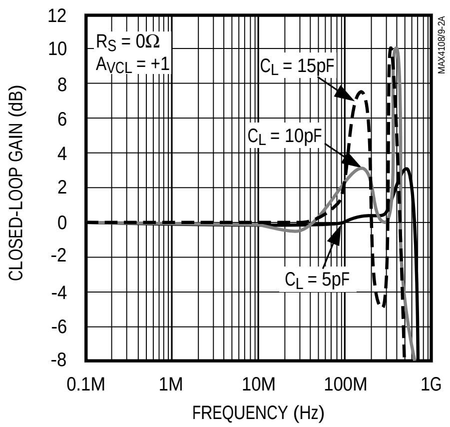


Figure 2a. MAX4108 Response vs. Capacitive Load—No Resistive (R_S) Isolation (circuit shown in Figure 1)

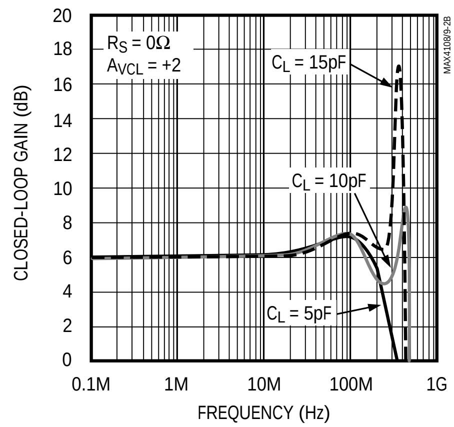


Figure 2b. MAX4109 Response vs. Capacitive Load—No Isolation (R_S) Resistor (circuit shown in Figure 1)

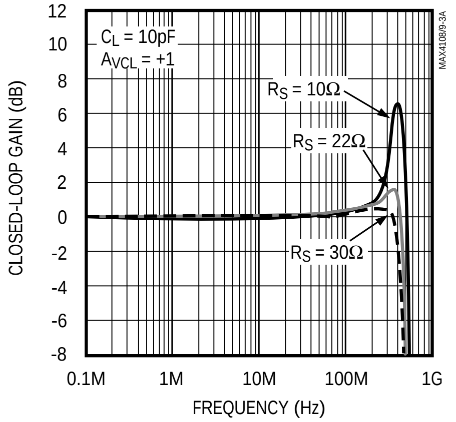


Figure 3a. MAX4108 Response vs. Capacitive Load with Resistive (R_S) Isolation (circuit shown in Figure 1)

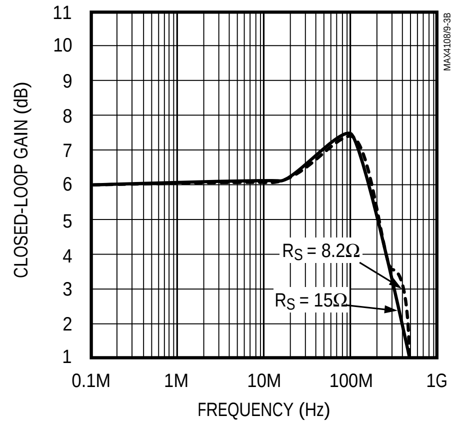


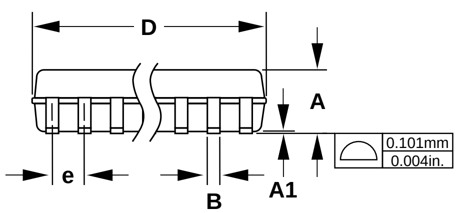
Figure 3b. MAX4109 Response vs. Capacitive Load with Resistive (R_S) Isolation (circuit shown in Figure 1)

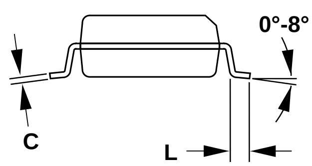
Chip Information

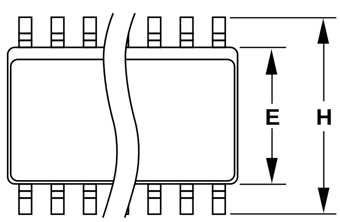
TRANSISTOR COUNT: 57

SUBSTRATE CONNECTED TO V_{EE}

Package Information







DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
E	0.150	0.157	3.80	4.00
e	0.050		1.27	
H	0.228	0.244	5.80	6.20
L	0.016	0.050	0.40	1.27

Narrow SO SMALL-OUTLINE PACKAGE (0.150 in.)

DIM	PINS	INCHES		MILLIMETERS	
		MIN	MAX	MIN	MAX
D	8	0.189	0.197	4.80	5.00
D	14	0.337	0.344	8.55	8.75
D	16	0.386	0.394	9.80	10.00

21-0041A