19-0442; Rev 1; 11/95

EVALUATION KIT AVAILABLE

MAXIM

350MHz, Ultra-Low-Noise Op Amps

General Description

The MAX4106/MAX4107 op amps combine high-speed performance with ultra-low-noise performance. The MAX4106 is compensated for closed-loop gains of 5V/V, while the MAX4107 is stable in closed-loop gains of 10V/V or greater.

The MAX4106/MAX4107 require only 15mA of supply current while delivering a 350MHz or a 300MHz bandwidth, respectively. Voltage noise is an ultra-low $0.75nV/\sqrt{Hz}$, while a low-distortion architecture provides a spurious-free dynamic range (SFDR) of 63dB at 5MHz.

These high-speed op amps have a wide output voltage swing of ±3.2V and a high current-drive capability of 80mA.

Features

- ♦ **350MHz -3dB Bandwidth (MAX4106)**
- ♦ **275V/µs Slew Rate (MAX4106)**
  500V/µs Slew Rate (MAX4107)
- ♦ **18ns Settling Time to 0.01%**
- ♦ **$0.75nV/\sqrt{Hz}$ Voltage Noise**
- ♦ **High Output Drive: 80mA**

Applications

Ultra-Low-Noise ADC Preamp

Ultrasound

Low-Noise Preamplifier

High-Performance Receivers

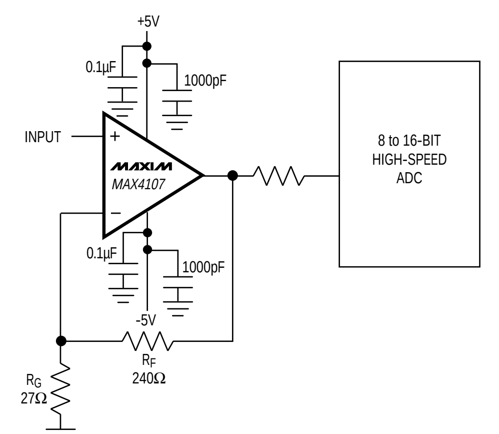
Active Filters

Pulse/RF Amplifier

Ordering Information

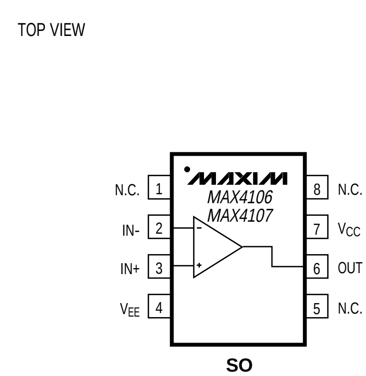
PART	TEMP. RANGE	PIN-PACKAGE
MAX4106ESA	-40°C to +85°C	8 SO
MAX4107ESA	-40°C to +85°C	8 SO

Typical Application Circuit



ADC BUFFER WITH GAIN (A_{VCL} = 10V/V)

Pin Configuration



350MHz, Ultra-Low-Noise Op Amps

ABSOLUTE MAXIMUM RATINGS

Power-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
MAX4106ESA/MAX4107ESA ....-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			0.250	3	mV
Input Offset Voltage Drift	TCV_{OS}	V_{OUT} = 0V			1.0		µV/°C
Input Bias Current	I_B	V_{OUT} = 0V, V_{IN} = $-V_{OS}$			18	26	µA
Input Offset Current	I_{OS}	V_{OUT} = 0V, V_{IN} = $-V_{OS}$			0.05	2	µA
Common-Mode Input Resistance	R_{INCM}	Either input			1		MΩ
Common-Mode Input Capacitance	C_{INCM}	Either input			1		pF
Input Voltage Noise	e_n	f = 10kHz			0.75		$nV/\sqrt{Hz}$
Integrated Voltage Noise	E_{nRMS}	f = 1MHz to 100MHz			9.5		μV_{RMS}
Input Current Noise	I_n	f = 10kHz			2.5		$pA/\sqrt{Hz}$
Integrated Current Noise	I_{nRMS}	f = 1MHz to 100MHz			31		nA_{RMS}
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		75	100		dB
Open-Loop Voltage Gain	A_{VOL}	V_{OUT} = ±2.0V, V_{CM} = 0V	R_L = ∞	80	100		dB
			R_L = 100Ω	80	100		
Supply Current	I_S	V_{IN} = 0V			15	19	mA
Output Voltage Swing	V_{OUT}	R_L = ∞		±3.2	±3.8		V
		R_L = 100Ω		±3.0	±3.5		
Output Current Drive	I_{OUT}	R_L = 30Ω, T_A = 0°C to +85°C		65	80		mA
Short-Circuit Output Current	I_{SC}	Short to ground			90		mA

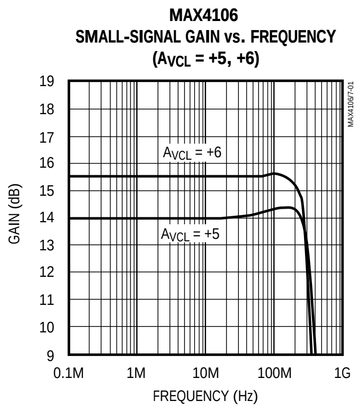
ELECTRICAL CHARACTERISTICS (continued)

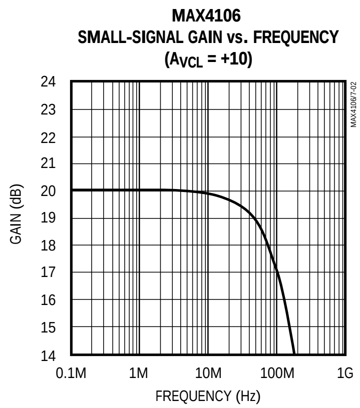
(V_{CC} = 5V, V_{EE} = -5V, T_A = T_{MIN} to T_{MAX}, typical values are at T_A = +25°C, unless otherwise noted.)

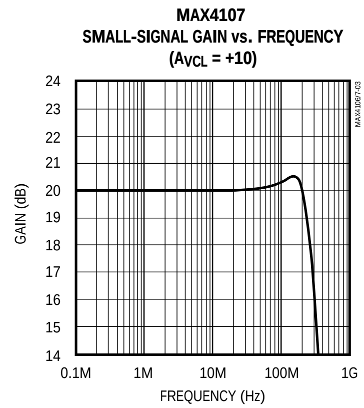
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
AC SPECIFICATIONS							
-3dB Bandwidth	BW_{-3dB}	$V_{OUT} \leq 0.1V_{RMS}$	MAX4106		350		MHz
			MAX4107		300		
0.1dB Bandwidth	$BW_{0.1dB}$	MAX4106, A_{VCL} = +5			75		MHz
		MAX4107, A_{VCL} = +10			45		
Slew Rate	SR	$-2V \leq V_{OUT} \leq 2V$	MAX4106		275		V/µs
			MAX4107		500		
Settling Time	t_S	$-1V \leq V_{OUT} \leq 1V$, $R_L = 100\Omega$, to 0.1%	MAX4106		13		ns
			MAX4107		13		
		$-1V \leq V_{OUT} \leq 1V$, $R_L = 100\Omega$, to 0.01%	MAX4106		18		
			MAX4107		18		
Rise/Fall Times	t_R, t_F	10% to 90%, $-2V \leq V_{OUT} \leq 2V$, $R_L = 100\Omega$	MAX4106		13		ns
			MAX4107		6		
		10% to 90%, $-50mV \leq V_{OUT} \leq 50mV$, $R_L = 100\Omega$	MAX4106		1		
			MAX4107		1		
Differential Gain	DG	f = 3.58MHz	MAX4106, A_{VCL} = +5		0.04		%
			MAX4107, A_{VCL} = +10		0.03		
Differential Phase	DP	f = 3.58MHz	MAX4106, A_{VCL} = +5		0.02		degrees
			MAX4107, A_{VCL} = +10		0.03		
Input Capacitance	C_{IN}				2		pF
Output Impedance	Z_{OUT}	f = 10MHz			0.7		Ω
Spurious-Free Dynamic Range	SFDR	f_C = 5MHz, V_{OUT} = 2Vp-p	MAX4106, A_{VCL} = +5		63		dBc
			MAX4107, A_{VCL} = +10		60		
Two-Tone Third-Order Intercept	IP3	f_C = 10MHz			24		dBm

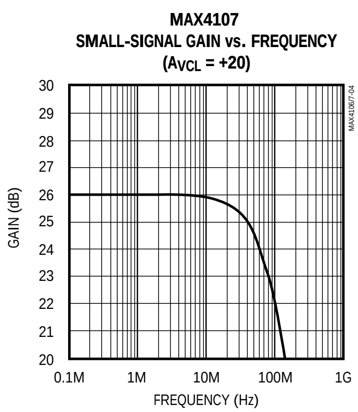
Typical Operating Characteristics

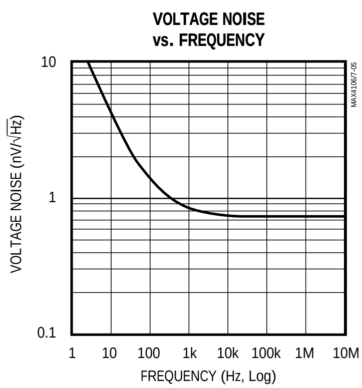
(V_{CC} = +5V, V_{EE} = -5V, R_L = 100Ω, T_A = +25°C, unless otherwise noted.)

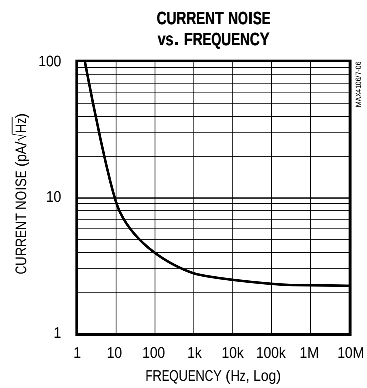


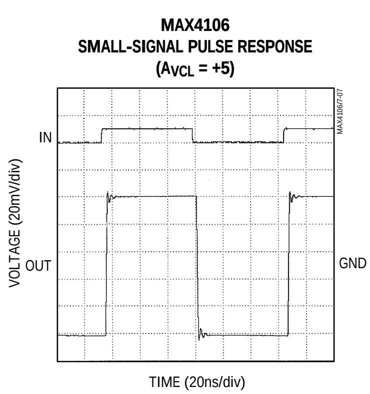


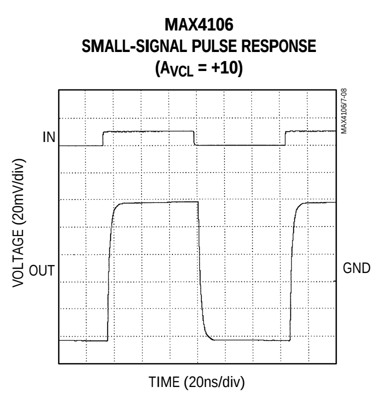


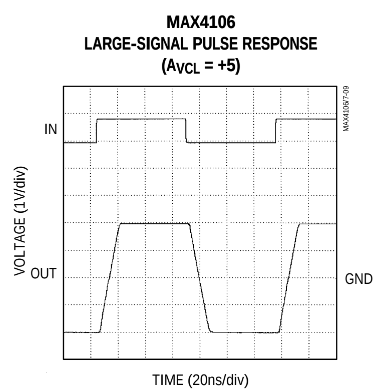








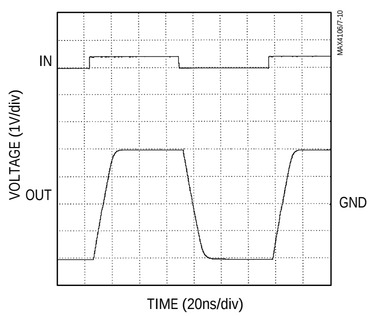




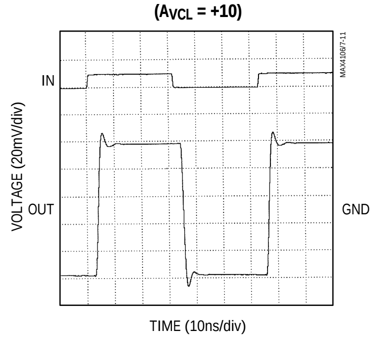
Typical Operating Characteristics (continued)

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

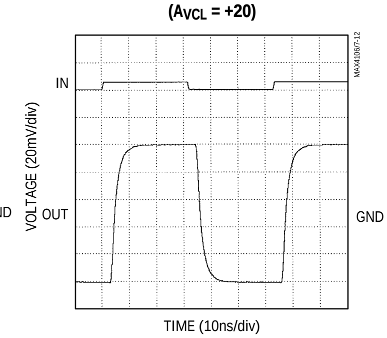
MAX4106
LARGE-SIGNAL PULSE RESPONSE
(A_{VCL} = +10)



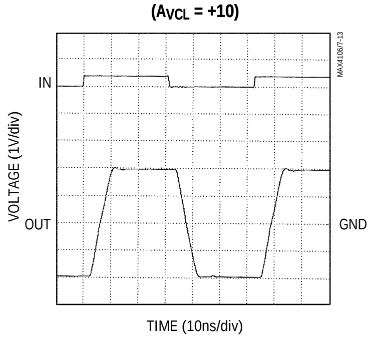
MAX4107
SMALL-SIGNAL PULSE RESPONSE
(A_{VCL} = +10)



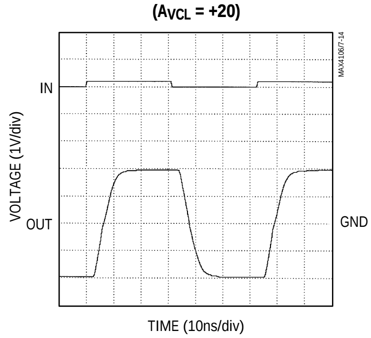
MAX4107
SMALL-SIGNAL PULSE RESPONSE
(A_{VCL} = +20)



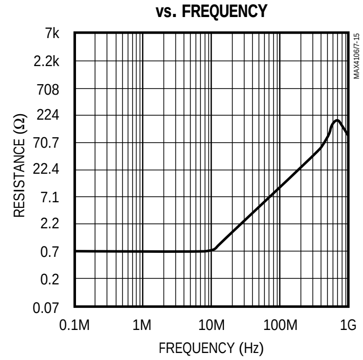
MAX4107
LARGE-SIGNAL PULSE RESPONSE
(A_{VCL} = +10)



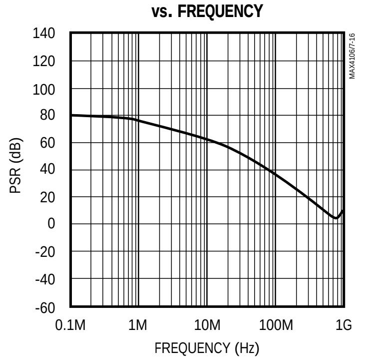
MAX4107
LARGE-SIGNAL PULSE RESPONSE
(A_{VCL} = +20)



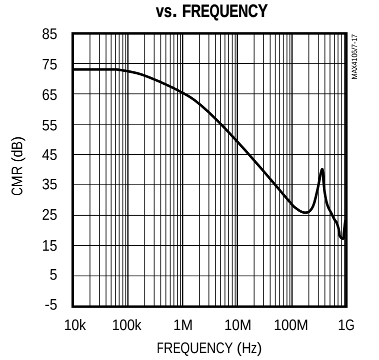
CLOSED-LOOP OUTPUT IMPEDANCE
vs. FREQUENCY



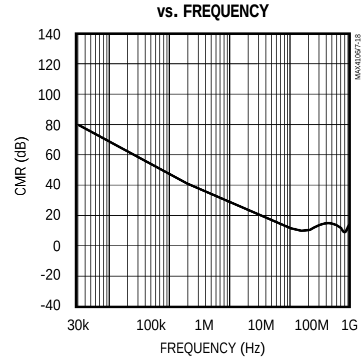
POWER-SUPPLY REJECTION
vs. FREQUENCY



MAX4106
COMMON-MODE REJECTION
vs. FREQUENCY



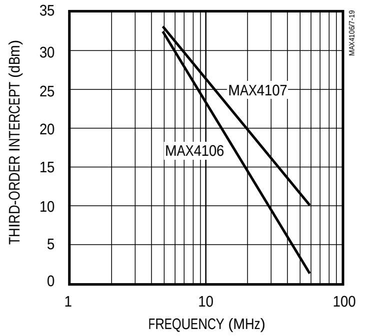
MAX4107
COMMON-MODE REJECTION
vs. FREQUENCY



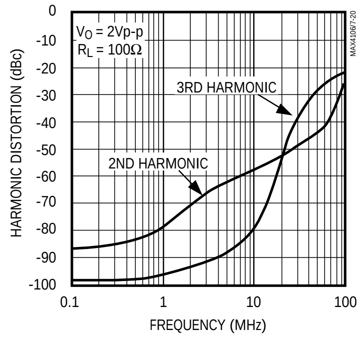
Typical Operating Characteristics (continued)

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

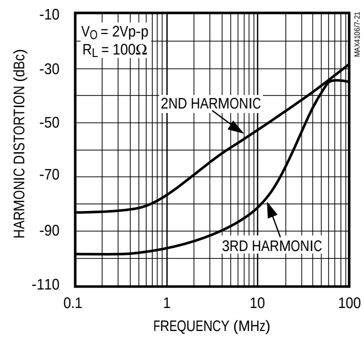
TWO-TONE THIRD-ORDER INTERCEPT vs. FREQUENCY



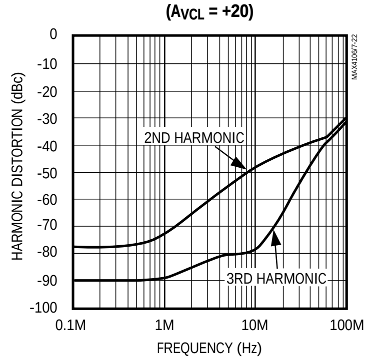
MAX4106 HARMONIC DISTORTION vs. FREQUENCY (A_{VCL} = +5)



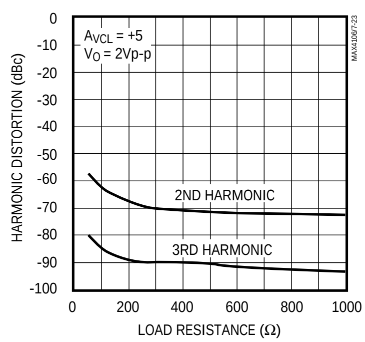
MAX4107 HARMONIC DISTORTION vs. FREQUENCY (A_{VCL} = +10)



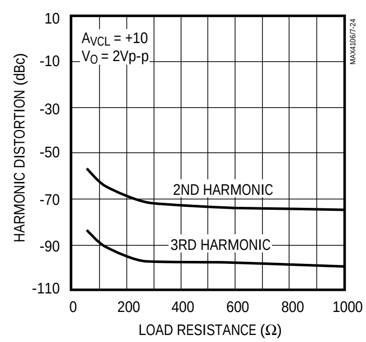
MAX4107 HARMONIC DISTORTION vs. FREQUENCY (A_{VCL} = +20)



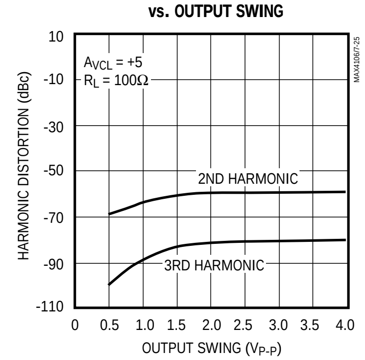
MAX4106 5MHz HARMONIC DISTORTION vs. LOAD RESISITANCE



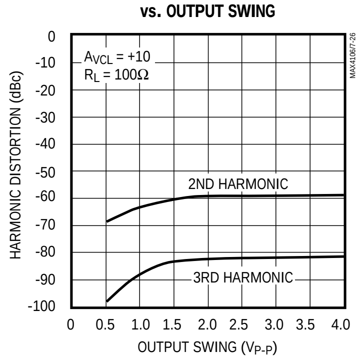
MAX4107 5MHz HARMONIC DISTORTION vs. LOAD RESISTANCE



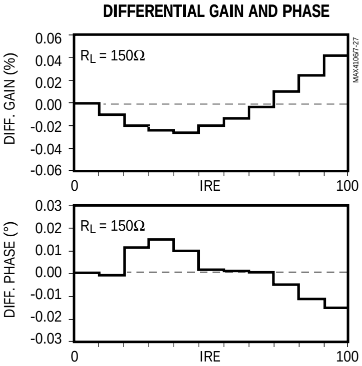
MAX4106 5MHz HARMONIC DISTORTION vs. OUTPUT SWING



MAX4107 5MHz HARMONIC DISTORTION vs. OUTPUT SWING



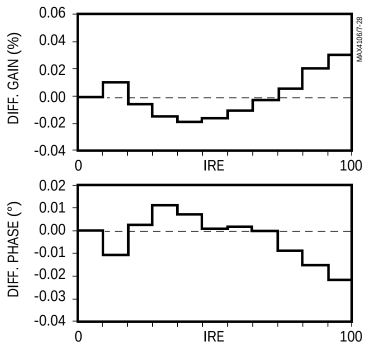
MAX4106 DIFFERENTIAL GAIN AND PHASE



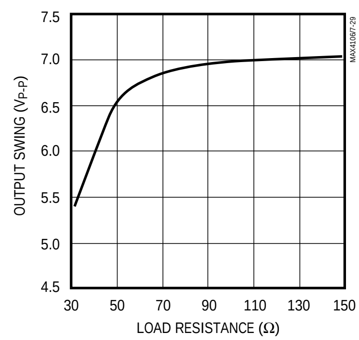
Typical Operating Characteristics (continued)

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

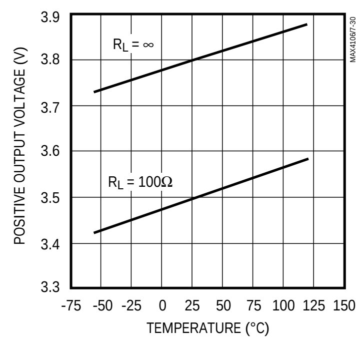
MAX4107
DIFFERENTIAL GAIN AND PHASE



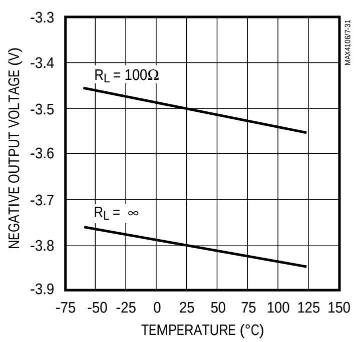
OUTPUT SWING
vs. LOAD RESISTANCE



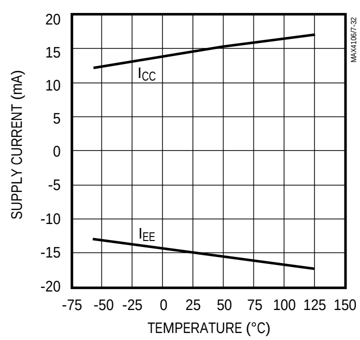
POSITIVE OUTPUT VOLTAGE SWING
vs. TEMPERATURE



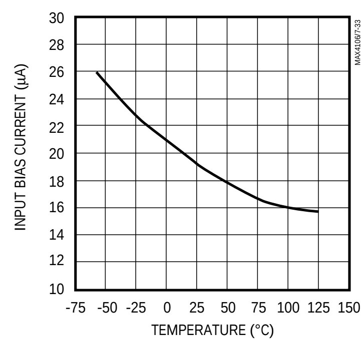
NEGATIVE OUTPUT VOLTAGE SWING
vs. TEMPERATURE



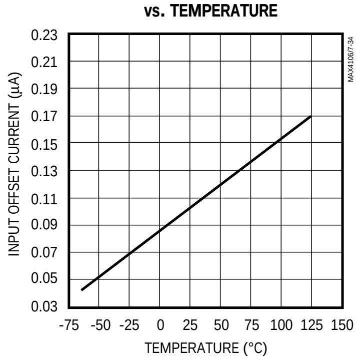
POWER-SUPPLY CURRENT
vs. TEMPERATURE



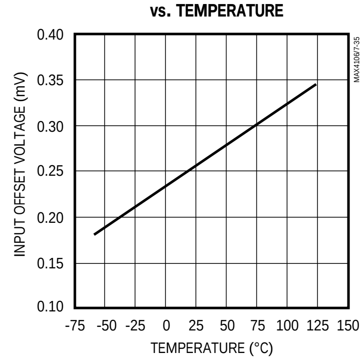
INPUT BIAS CURRENT
vs. TEMPERATURE



INPUT OFFSET CURRENT
vs. TEMPERATURE



INPUT OFFSET VOLTAGE
vs. TEMPERATURE



Pin Description

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

General Description

Choosing Resistor Values

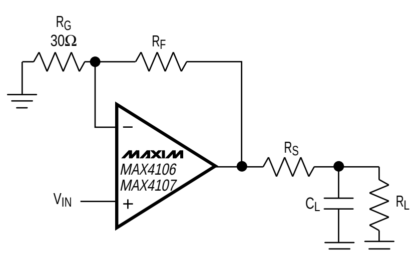
The values of the gain-setting feedback and input resistors are important design considerations. Large resistor values will increase voltage noise, and will interact with the amplifier's input and PC board capacitance to generate undesirable poles and zeros, which can decrease bandwidth or cause oscillations. For example, a noninverting gain of +5 (MAX4106), using a 1kΩ feedback resistor combined with 2pF of input capacitance and 0.5pF of board capacitance, will cause a feedback pole at 318MHz. If this pole is within the anticipated amplifier bandwidth, it will jeopardize stability. Reducing the 1kΩ feedback resistor to 40Ω will extend the pole frequency to 8GHz, but could limit output swing by adding 50Ω in parallel with the amplifier's load. Clearly the selection of resistor values must be tailored to the specific application.

The MAX4106/MAX4107 are ultra-low-noise, high-bandwidth op amps. The output noise voltage can be dominated by resistor thermal noise, so keep the feedback and input resistors small. Setting the input resistor to 30Ω and choosing the feedback resistor to suit the gain will provide excellent AC performance without significantly degrading noise performance.

Driving Capacitive Loads

The MAX4106/MAX4107 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 MAX4106/MAX4107 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)
MAX4106	120	+5
MAX4107	270	+10

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

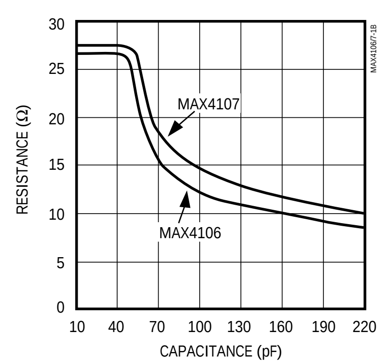


Figure 1b. Optimal Isolation Resistor (R_S) vs. Capacitive Load

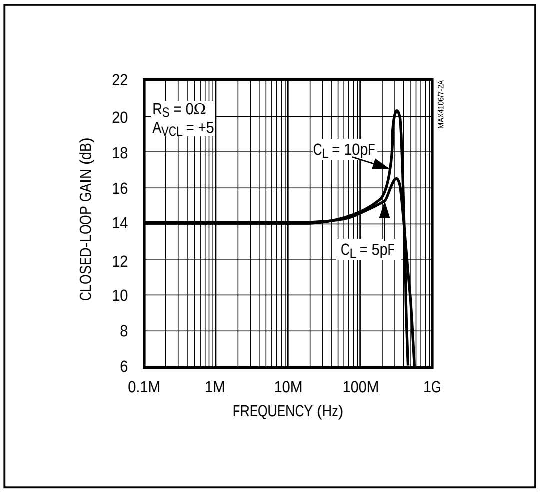


Figure 2a. MAX4106 Response vs. Capacitive Load—No Resistive (R_S) Isolation (circuit shown in Figure 1)

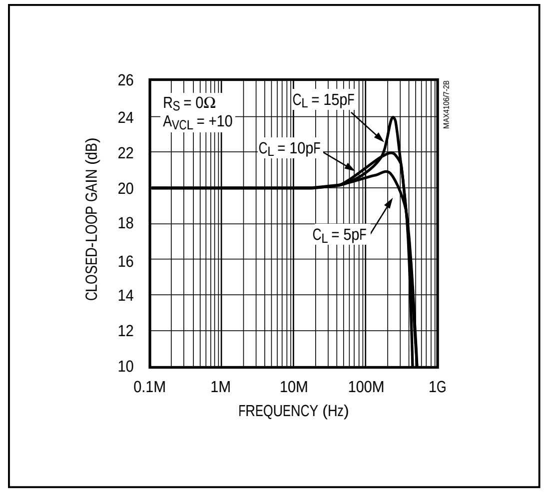


Figure 2b. MAX4107 Response vs. Capacitive Load—No Isolation (R_S) Resistor (circuit shown in Figure 1)

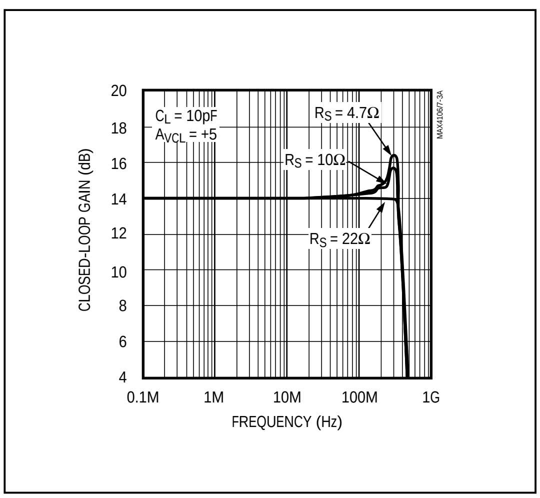


Figure 3a. MAX4106 Response vs. Capacitive Load with Resistive (R_S) Isolation (circuit shown in Figure 1)

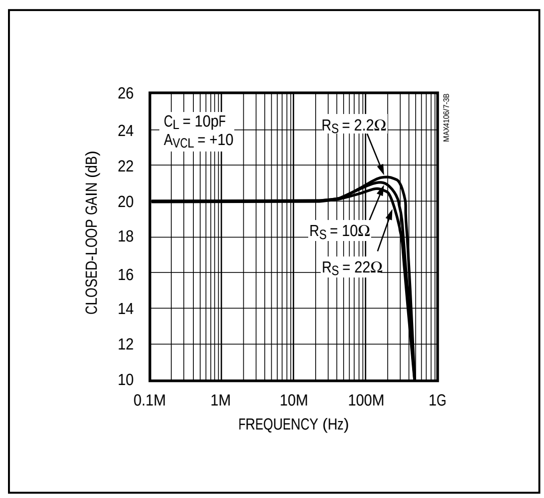
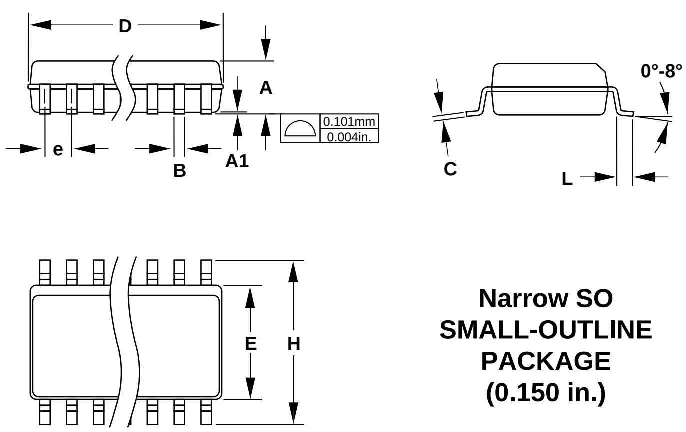


Figure 3b. MAX4107 Response vs. Capacitive Load with Resistive (R_S) Isolation (circuit shown in Figure 1)

Chip Information

TRANSISTOR COUNT: 55

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