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19-1989; Rev 1; 10/05

MAXIM

Ultra-Small, Low-Cost, 210MHz, Dual-Supply Op Amps with Rail-to-Rail Outputs

General Description

The MAX4350 single and MAX4351 dual op amps are unity-gain-stable devices that combine high-speed performance with rail-to-rail outputs. Both devices operate from dual ±5V supplies. The common-mode input voltage range extends to the negative power-supply rail.

The MAX4350/MAX4351 require only 6.9mA of quiescent supply current per op amp while achieving a 210MHz -3dB bandwidth and a 485V/µs slew rate. Both devices are excellent solutions in low-power systems that require wide bandwidth, such as video, communications, and instrumentation.

The MAX4350 is available in an ultra-small 5-pin SC70 package and the MAX4351 is available in a space-saving 8-pin SOT23 package.

Features

- **Ultra-Small 5-Pin SC70, 5-Pin SOT23, and 8-Pin SOT23 Packages**
- **Low Cost**
- **High Speed**
  - **210MHz -3dB Bandwidth**
  - **55MHz 0.1dB Gain Flatness**
  - **485V/µs Slew Rate**
- **Rail-to-Rail Outputs**
- **Input Common-Mode Range Extends to V_{EE}**
- **Low Differential Gain/Phase: 0.02%/0.08°**
- **Low Distortion at 5MHz**
  - **-65dBc SFDR**
  - **-63dB Total Harmonic Distortion**

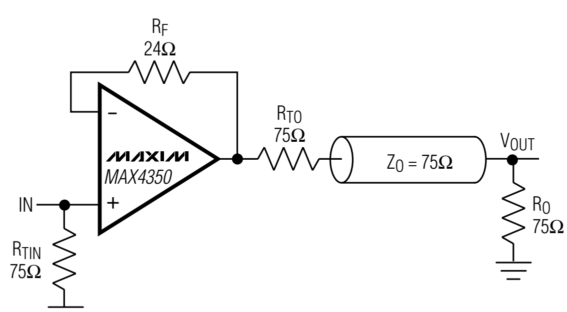
Applications

Set-Top Boxes
Surveillance Video Systems
Video Line Drivers
Analog-to-Digital Converter Interface
CCD Imaging Systems
Video Routing and Switching Systems
Digital Cameras

Ordering Information

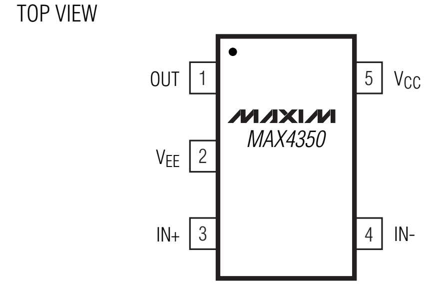
PART	TEMP. RANGE	PIN-PACKAGE	TOP MARK
MAX4350EXK-T	-40°C to +85°C	5 SC70-5	ACF
MAX4350EUK-T	-40°C to +85°C	5 SOT23-5	ADRA
MAX4351EKA-T	-40°C to +85°C	8 SOT23-8	AAIC
MAX4351ESA	-40°C to +85°C	8 SO	—

Typical Operating Circuit



UNITY-GAIN LINE DRIVER
($R_L = R_O + R_{TO}$)

Pin Configurations



SC70-5/SOT23-5

Pin Configurations continued at end of data sheet.

For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

Ultra-Small, Low-Cost, 210MHz, Dual-Supply Op Amps with Rail-to-Rail Outputs

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{CC} to V_{EE})..+12V
IN_-, IN_+, OUT_..............................(V_{EE} - 0.3V) to (V_{CC} + 0.3V)
Output Short-Circuit Current to V_{CC} or V_{EE} 150mA
Continuous Power Dissipation (T_A = +70°C)
5-Pin SC70 (derate 2.5mW/°C above +70°C) 200mW
5-Pin SOT23 (derate 7.1mW/°C above +70°C)...........571mW
8-Pin SOT23 (derate 5.26mW/°C above +70°C).........421mW
8-Pin SO (derate 5.9mW/°C above +70°C)................471mW
Operating Temperature Range ....-40°C to +85°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 at 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} = +5V, V_{EE} = -5V, R_L = ∞ to 0V, V_{OUT} = 0, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Common-Mode Voltage Range	V_{CM}	Guaranteed by CMRR test		V_{EE}		V_{CC} - 2.25	V
Input Offset Voltage	V_{OS}				1	26	mV
Input Offset Voltage Matching		MAX4351 only			1		mV
Input Offset Voltage Temperature Coefficient	TC_{VOS}				8		µV/°C
Input Bias Current	I_B				7.5	20	µA
Input Offset Current	I_{OS}				0.5	4	µA
Input Resistance	R_{IN}	Differential mode (-1V ≤ V_{IN} ≤ +1V)			70		kΩ
		Common mode (-5V ≤ V_{CM} ≤ +2.75V)			3		MΩ
Common-Mode Rejection Ratio	CMRR	V_{EE} ≤ V_{CM} ≤ (V_{CC} - 2.25V)		70	95		dB
Open-Loop Gain	A_{VOL}	-4.5V ≤ V_{OUT} ≤ +4.5V, R_L = 2kΩ		50	60		dB
		-4.25V ≤ V_{OUT} ≤ +4.25V, R_L = 150Ω		48	58		
		-3.75V ≤ V_{OUT} ≤ +3.75V, R_L = 75Ω			57		
Output Voltage Swing	V_{OUT}	R_L = 2kΩ	V_{CC} - V_{OH}		0.125	0.350	V
			V_{OL} - V_{EE}		0.065	0.170	
		R_L = 150Ω	V_{CC} - V_{OH}		0.525	0.750	
			V_{OL} - V_{EE}		0.370	0.550	
		R_L = 75Ω	V_{CC} - V_{OH}		0.925	1.550	
			V_{OL} - V_{EE}		0.750	1.7	
Output Current	I_{OUT}	R_L = 50Ω	Sourcing	55	80		mA
			Sinking	40	75		
Output Short-Circuit Current	I_{SC}	Sinking or sourcing			±120		mA
Open-Loop Output Resistance	R_{OUT}				8		Ω
Power-Supply Rejection Ratio	PSRR	V_S = ±4.5V to ±5.5V		52	66		dB
Operating Supply-Voltage Range	V_S	V_{CC}, V_{EE}		±4.5		±5.5	V
Quiescent Supply Current (Per Amplifier)	I_S				6.9	9.0	mA

AC ELECTRICAL CHARACTERISTICS

(V_{CC} = +5V, V_{EE} = -5V, V_{CM} = 0V, R_F = 24Ω, R_L = 100Ω to 0, A_{VCL} = +1V/V, T_A = +25°C, unless otherwise noted.)

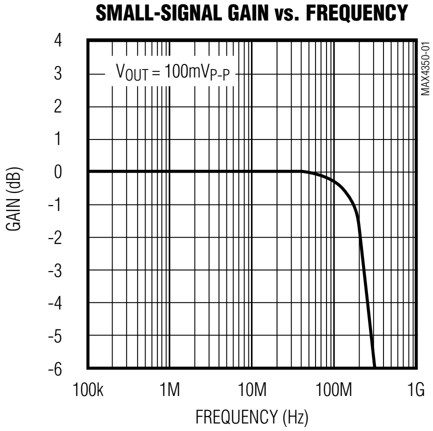
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Small-Signal -3dB Bandwidth	BW_{SS}	V_{OUT} = 100mV$_{P-P}$			210		MHz
Large-Signal -3dB Bandwidth	BW_{LS}	V_{OUT} = 2V$_{P-P}$			175		MHz
Bandwidth for 0.1dB Gain Flatness	$BW_{0.1dB}$	V_{OUT} = 100mV$_{P-P}$			55		MHz
		V_{OUT} = 2V$_{P-P}$			40		
Slew Rate	SR	V_{OUT} = 2V step			485		V/µs
Settling Time to 0.1%	t_S	V_{OUT} = 2V step			16		ns
Rise/Fall Time	t_R, t_F	V_{OUT} = 100mV$_{P-P}$			4		ns
Spurious-Free Dynamic Range	SFDR	f_C = 5MHz, V_{OUT} = 2V$_{P-P}$			-65		dBc
Harmonic Distortion	HD	f_C = 5MHz, V_{OUT} = 2V$_{P-P}$	2nd harmonic		-65		dBc
			3rd harmonic		-58		
			Total harmonic distortion		-63		
Two-Tone, Third-Order Intermodulation Distortion	IP3	f1 = 4.7MHz, f2 = 4.8MHz, V_{OUT} = 1V$_{P-P}$			66		dBc
Channel-to-Channel Isolation	CH_{ISO}	Specified at DC, MAX4351 only			102		dB
Input 1dB Compression Point		f_C = 10MHz, A_{VCL} = +2V/V			14		dBm
Differential Phase Error	DP	NTSC, R_L = 150Ω			0.08		degrees
Differential Gain Error	DG	NTSC, R_L = 150Ω			0.02		%
Input Noise-Voltage Density	e_N	f = 10kHz			10		nV/√Hz
Input Noise-Current Density	i_N	f = 10kHz			1.8		pA/√Hz
Input Capacitance	C_{IN}				1		pF
Output Impedance	Z_{OUT}	f = 10MHz			1.5		Ω

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

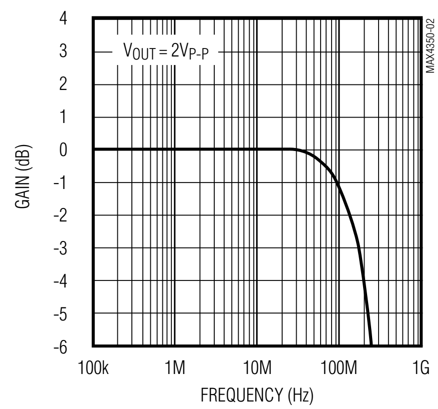
Typical Operating Characteristics

(V_{CC} = +5V, V_{EE} = -5V, V_{CM} = 0V, A_{VCL} = +1V/V, R_F = 24Ω, R_L = 100Ω to 0, T_A = +25°C, unless otherwise noted.)

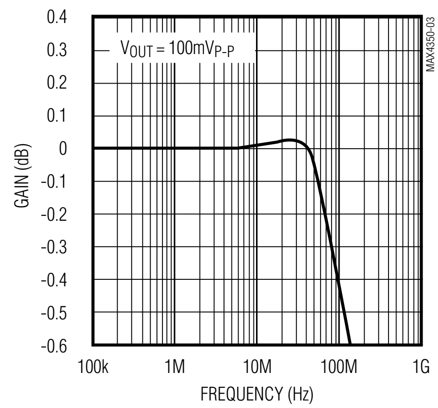
SMALL-SIGNAL GAIN vs. FREQUENCY



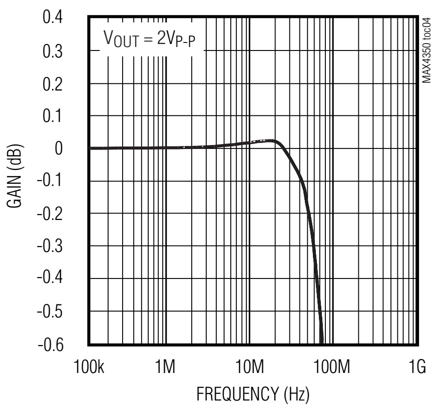
LARGE-SIGNAL GAIN vs. FREQUENCY



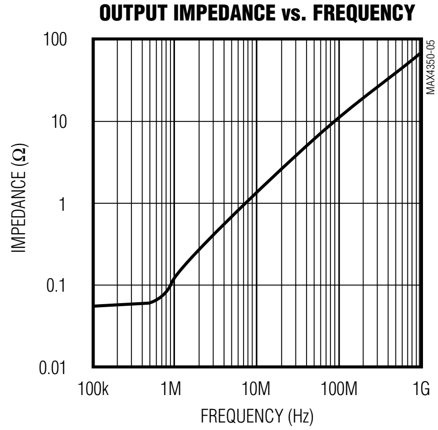
GAIN FLATNESS vs. FREQUENCY



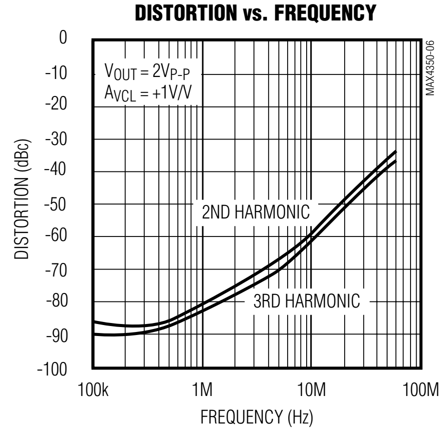
GAIN FLATNESS vs. FREQUENCY



OUTPUT IMPEDANCE vs. FREQUENCY



DISTORTION vs. FREQUENCY



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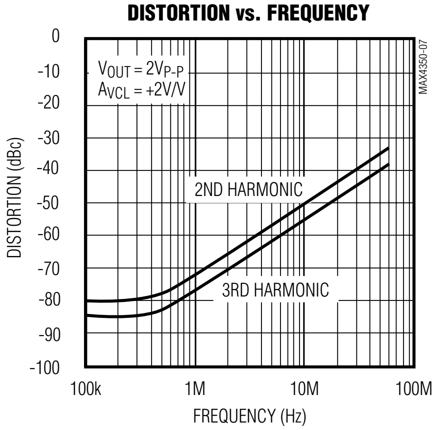

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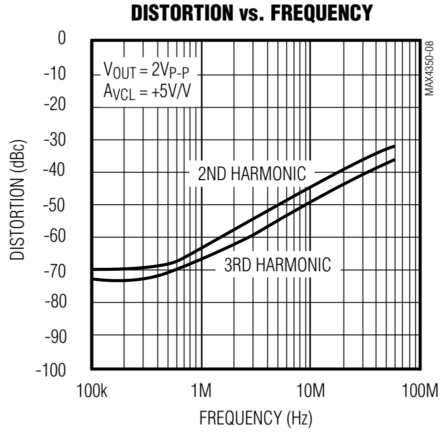
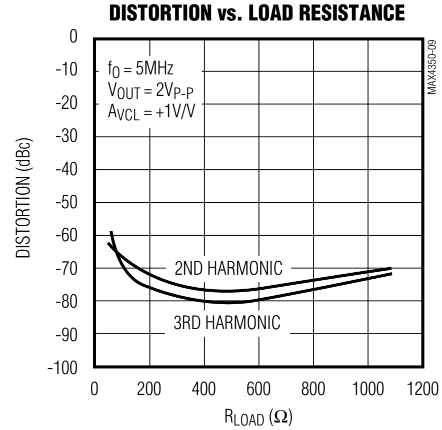


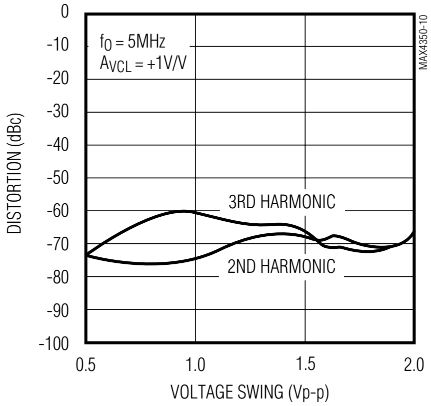
DISTORTION vs. LOAD RESISTANCE



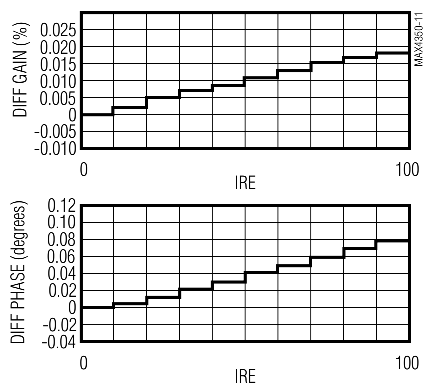
Typical Operating Characteristics (continued)

(V_{CC} = +5V, V_{EE} = -5V, V_{CM} = 0V, A_{VCL} = +1V/V, R_F = 24Ω, R_L = 100Ω to 0, T_A = +25°C, unless otherwise noted.)

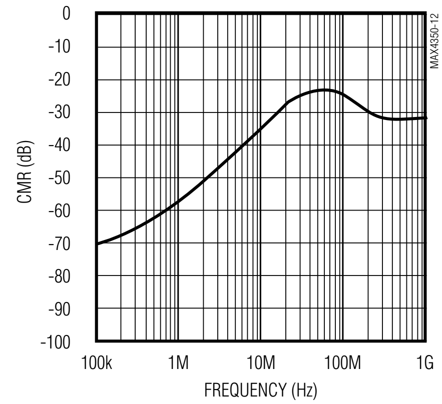
DISTORTION vs. VOLTAGE SWING



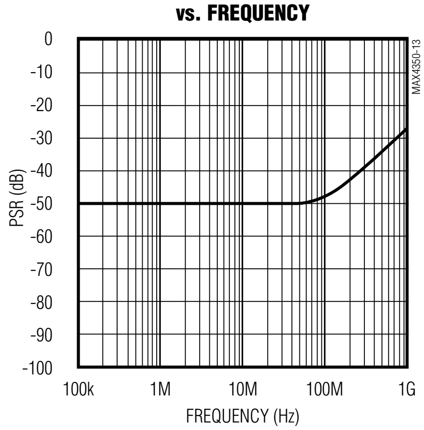
DIFFERENTIAL GAIN AND PHASE



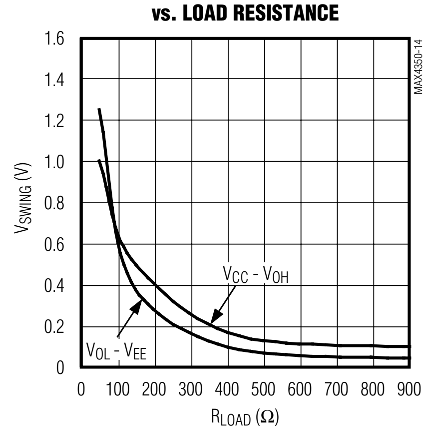
COMMON-MODE REJECTION vs. FREQUENCY



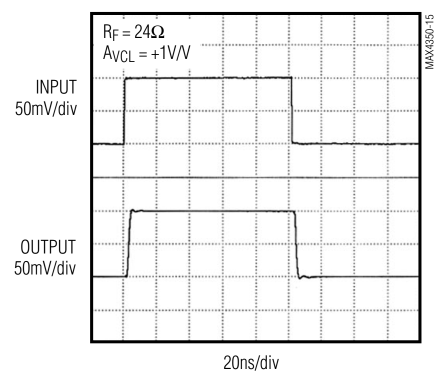
POWER-SUPPLY REJECTION vs. FREQUENCY



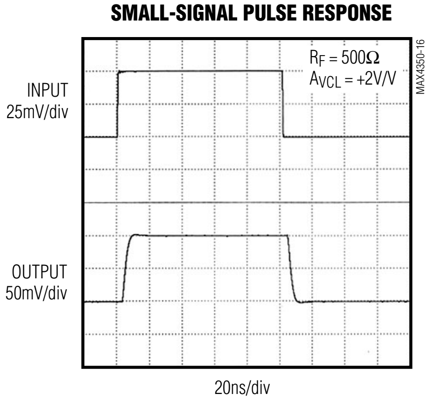
OUTPUT VOLTAGE SWING vs. LOAD RESISTANCE



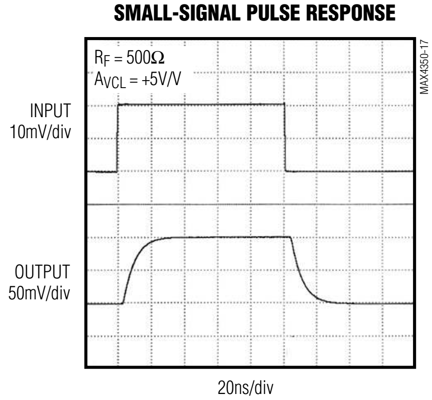
SMALL-SIGNAL PULSE RESPONSE



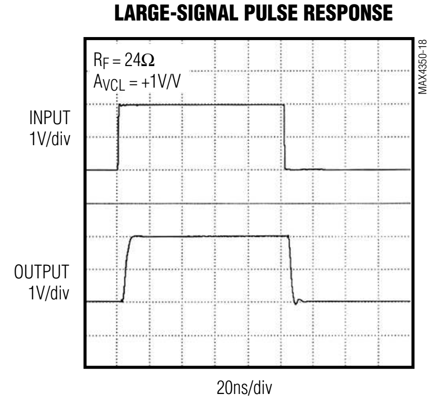
SMALL-SIGNAL PULSE RESPONSE



SMALL-SIGNAL PULSE RESPONSE



LARGE-SIGNAL PULSE RESPONSE

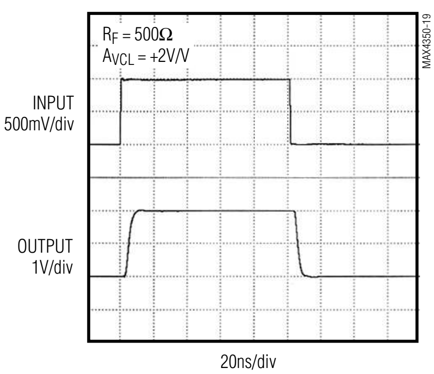


Ultra-Small, Low-Cost, 210MHz, Dual-Supply Op Amps with Rail-to-Rail Outputs

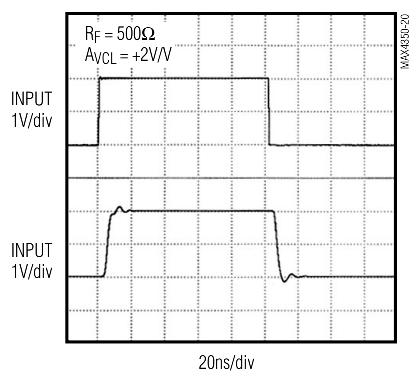
Typical Operating Characteristics (continued)

(V_{CC} = +5V, V_{EE} = -5V, V_{CM} = 0V, A_{VCL} = +1V/V, R_F = 24Ω, R_L = 100Ω to 0, T_A = +25°C, unless otherwise noted.)

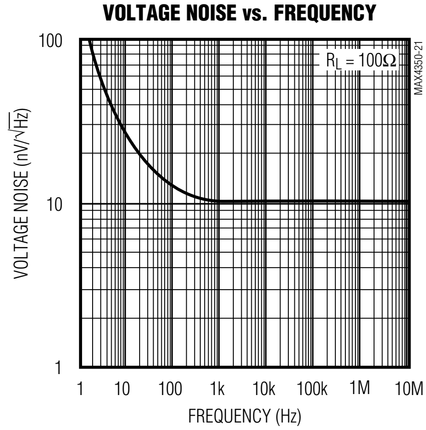
LARGE-SIGNAL PULSE RESPONSE



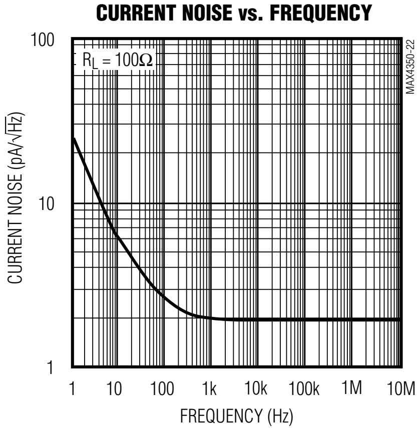
LARGE-SIGNAL PULSE RESPONSE



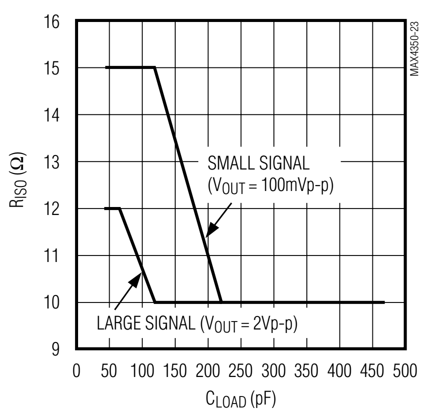
VOLTAGE NOISE vs. FREQUENCY



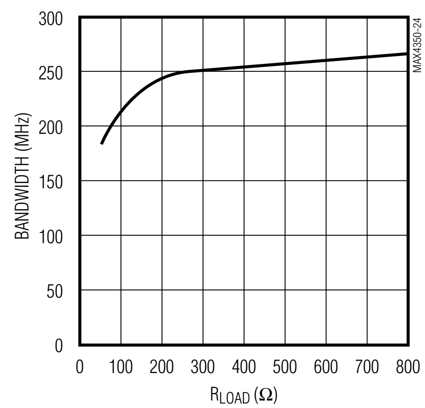
CURRENT NOISE vs. FREQUENCY



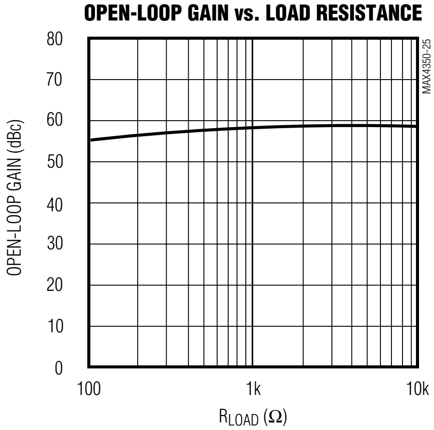
ISOLATION RESISTANCE vs. CAPACITIVE LOAD



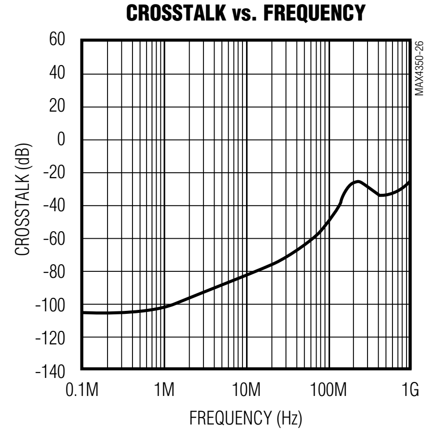
SMALL-SIGNAL BANDWIDTH vs. LOAD RESISTANCE



OPEN-LOOP GAIN vs. LOAD RESISTANCE



MAX4351
CROSSTALK vs. FREQUENCY



Pin Description

PIN		NAME	FUNCTION
MAX4350	MAX4351		
1	—	OUT	Amplifier Output
2	4	V_{EE}	Negative Power Supply or Ground (in single-supply operation)
3	—	IN+	Noninverting Input
4	—	IN-	Inverting Input
5	8	V_{CC}	Positive Power Supply
—	1	OUTA	Amplifier A Output
—	2	INA-	Amplifier A Inverting Input
—	3	INA+	Amplifier A Noninverting Input
—	7	OUTB	Amplifier B Output
—	6	INB-	Amplifier B Inverting Input
—	5	INB+	Amplifier B Noninverting Input

Detailed Description

The MAX4350/MAX4351 are single-supply, rail-to-rail, voltage-feedback amplifiers that employ current-feedback techniques to achieve 485V/µs slew rates and 210MHz bandwidths. 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.

The output voltage swings to within 125mV of each supply rail. Local feedback around the output stage ensures low open-loop output impedance to reduce gain sensitivity to load variations. The input stage permits common-mode voltages beyond the negative supply and to within 2.25V of the positive supply rail.

Applications Information

Choosing Resistor Values

Unity-Gain Configuration

The MAX4350/MAX4351 are internally compensated for unity gain. When configured for unity gain, a 24Ω resistor (R_F) in series with the feedback path optimizes AC performance. This resistor improves AC response by reducing the Q of the parallel LC circuit formed by the parasitic feedback capacitance and inductance.

Inverting and Noninverting Configurations

Select the gain-setting feedback (R_F) and input (R_G) resistor values to fit your application (Figures 1a and 1b). 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 1pF of amplifier input capacitance and 1pF of PC board capacitance, causes a pole at 159MHz. Since this pole is within the amplifier bandwidth, it jeopardizes stability. Reducing the 1kΩ resistors to 100Ω extends the pole frequency to 1.59GHz, but could limit output swing by adding 200Ω in parallel with the amplifier's load resistor.

Layout and Power-Supply Bypassing

These amplifiers operate from dual ±5V supplies. Bypass each supply with a 0.1µF capacitor to ground.

Maxim recommends using microstrip and stripline techniques to obtain full bandwidth. To ensure that the PC board does not degrade the amplifier's performance, design it for a frequency greater than 1GHz. Pay care-

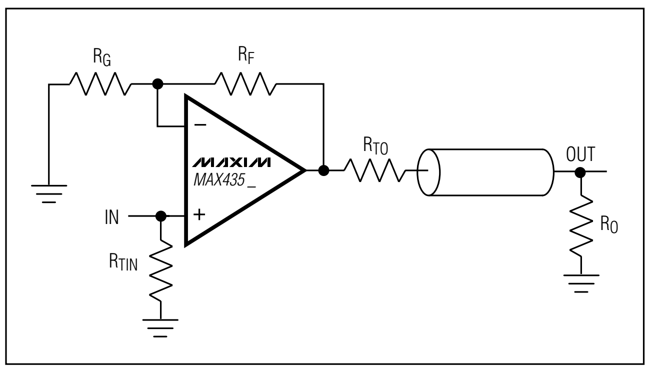


Figure 1a. Noninverting Gain Configuration

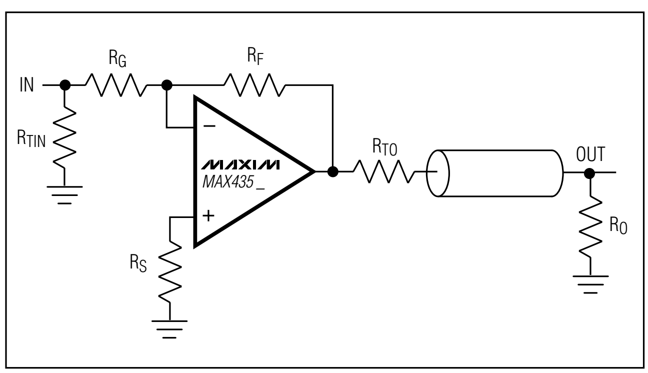


Figure 1b. Inverting Gain Configuration

ful attention to inputs and outputs to avoid large parasitic capacitance. Whether or not you use a constant-impedance board, observe the following design guidelines:

- Don't use wire-wrap boards; they are too inductive.
- Don't use IC sockets; they increase 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.

Rail-to-Rail Outputs, Ground-Sensing Input

The input common-mode range extends from V_{EE} to (V_{CC} - 2.25V) 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 125mV of either power-supply rail with a 2kΩ load.

Output Capacitive Load and Stability

The MAX4350/MAX4351 are optimized for AC performance. They are not designed to drive highly reactive loads, which decrease phase margin and may produce excessive ringing and oscillation. Figure 2 shows a circuit that eliminates this problem. Figure 3 is a graph of the Isolation Resistance (R_{ISO}) vs. Capacitive Load. Figure 4 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. Figure 5 shows the effect of a 27Ω 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.

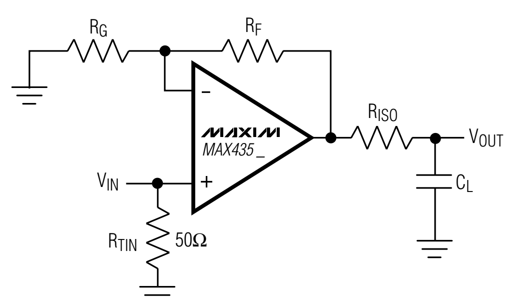


Figure 2. Driving a Capacitive Load Through an Isolation Resistor

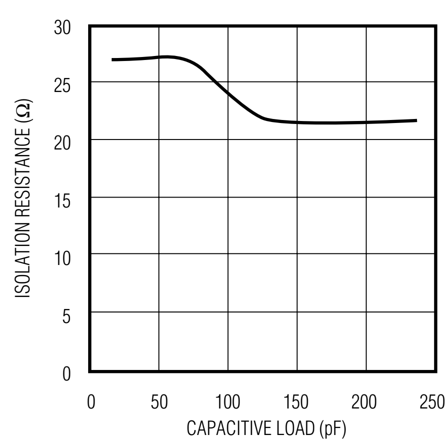


Figure 3. Isolation Resistance vs. Capacitive Load

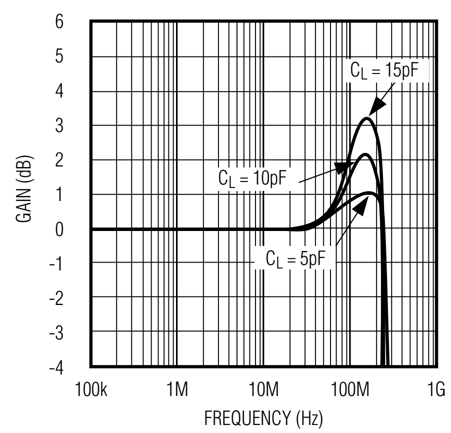


Figure 4. Small-Signal Gain vs. Frequency with Load Capacitance and No Isolation Resistor

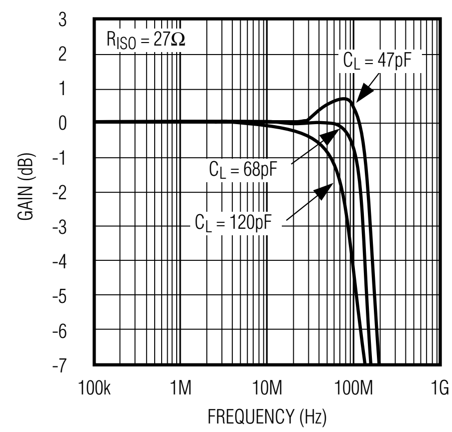
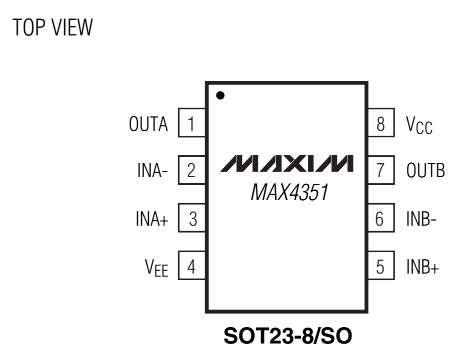


Figure 5. Small-Signal Gain vs. Frequency with Load Capacitance and 27Ω Isolation Resistor

Pin Configurations (continued)



Chip Information

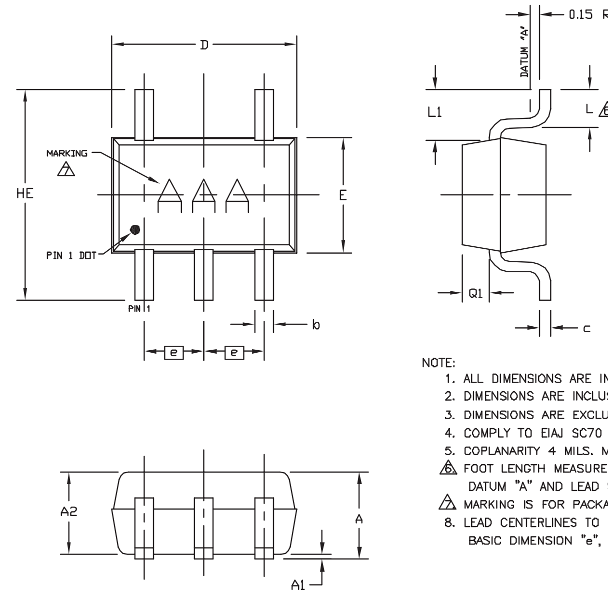
MAX4350 TRANSISTOR COUNT: 86

MAX4351 TRANSISTOR COUNT: 170

Ultra-Small, Low-Cost, 210MHz, Dual-Supply Op Amps with Rail-to-Rail Outputs

Package Information

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



COMMON DIMENSIONS		
SYMBOL	MIN	MAX
A	0.80	1.10
A1	0.00	0.10
A2	0.80	1.00
b	0.15	0.30
c	0.10	0.18
D	1.80	2.20
e	0.65 BSC.	
E	1.15	1.35
HE	1.80	2.40
L	0.10	0.40
L1	0.425 TYP.	
Q1	0.10	0.40

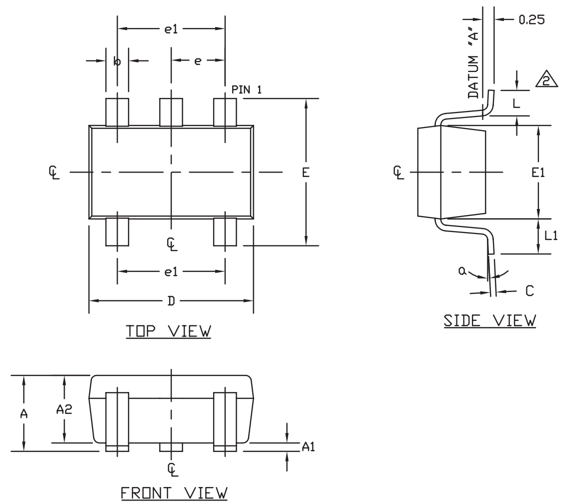
NOTE:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONS ARE INCLUSIVE OF PLATING.
3. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH & METAL BURR.
4. COMPLY TO EIAJ SC70 EXCEPT FOR PIN COUNT AND DIMENSION "b".
5. COPLANARITY 4 MILS. MAX.
6. FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM "A" AND LEAD 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.

-DRAWING NOT TO SCALE-

DALLAS SEMICONDUCTOR MAXIM

TITLE: PACKAGE OUTLINE, 5L SC70

APPROVAL | DOCUMENT CONTROL NO. 21-0076 | REV. C | 1/1



SYMBOL	MIN	MAX
A	0.90	1.45
A1	0.00	0.15
A2	0.90	1.30
b	0.35	0.50
C	0.08	0.20
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.75
L	0.35	0.60
L1	0.60 REF	
e	0.95 BSC.	
e1	1.90 BSC.	
α	0°	8°

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

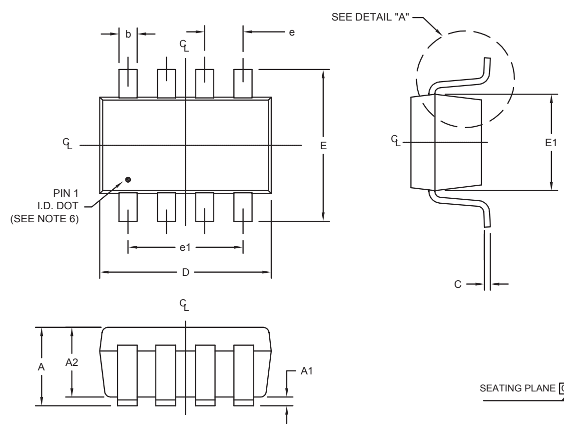
PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, SOT-23, 5L

APPROVAL | DOCUMENT CONTROL NO. 21-0057 | REV. E | 1/1

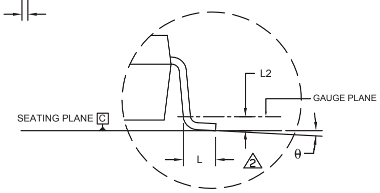
Package Information (continued)

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



SYMBOL	MIN	MAX
A	0.90	1.45
A1	0.00	0.15
A2	0.90	1.30
b	0.28	0.45
C	0.09	0.20
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.75
L	0.30	0.60
L2	0.25 BSC.	
e	0.65 BSC.	
e1	1.95 REF.	
θ	0∞	8∞

SOT23, 8L .EPS



DETAIL "A"

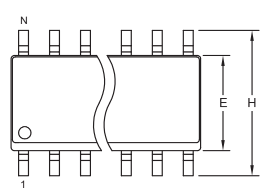
NOTE:

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. PIN 1 I.D. DOT IS 0.3 MM ÿ MIN. LOCATED ABOVE PIN 1.
7. SOLDER THICKNESS MEASURED AT FLAT SECTION OF LEAD BETWEEN 0.08mm AND 0.15mm FROM LEAD TIP.
8. MEETS JEDEC MO178.

DALLAS SEMICONDUCTOR MAXIM
PROPRIETARY INFORMATION
TITLE:
PACKAGE OUTLINE, SOT-23, 8L BODY
APPROVAL | DOCUMENT CONTROL NO. 21-0078 | REV. D | 1/1

SOICN .EPS

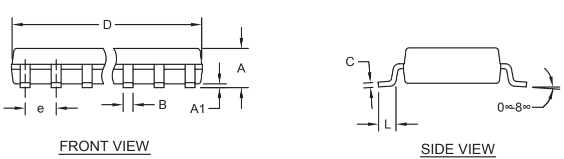
	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
e	0.050 BSC		1.27 BSC	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
L	0.016	0.050	0.40	1.27



TOP VIEW

VARIATIONS:

	INCHES		MILLIMETERS			
DIM	MIN	MAX	MIN	MAX	N	MS012
D	0.189	0.197	4.80	5.00	8	AA
D	0.337	0.344	8.55	8.75	14	AB
D	0.386	0.394	9.80	10.00	16	AC



FRONT VIEW

SIDE VIEW

NOTES:

1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm (.006").
3. LEADS TO BE COPLANAR WITHIN 0.10mm (.004").
4. CONTROLLING DIMENSION: MILLIMETERS.
5. MEETS JEDEC MS012.
6. N = NUMBER OF PINS.

DALLAS SEMICONDUCTOR MAXIM
PROPRIETARY INFORMATION
TITLE:
PACKAGE OUTLINE, .150" SOIC
APPROVAL | DOCUMENT CONTROL NO. 21-0041 | REV. B | 1/1

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