19-1519 Rev 0; 8/99

MAXIM

6500V/µs, Wideband, High-Output-Current, Single-Ended-to-Differential Line Drivers with Enable

General Description

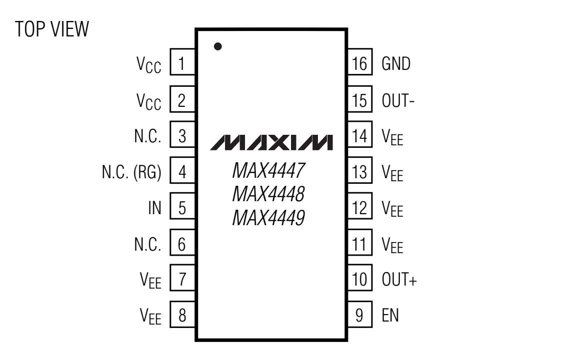
The MAX4447/MAX4448/MAX4449 single-ended-to-differential line drivers are designed for high-speed communications. Using current feedback for greater bandwidth, these devices deliver full-power bandwidths up to 405MHz and feature slew rates as high as 6500V/µs. The MAX4447 has a fixed gain of +2V/V and a small-signal bandwidth of 430MHz. The MAX4448/MAX4449 have small-signal bandwidths of 330MHz and 400MHz, respectively, and are internally compensated for minimum gain configurations of +2V/V and +5V/V, respectively. For greater design flexibility, the MAX4448/MAX4449 allow for variable gain selection using external gain-setting resistors. A low-power enable mode reduces current consumption below 5.5mA and places the outputs in a high-impedance state.

The MAX4447/MAX4448/MAX4449 can deliver differential output swings of ±6.2V from ±5V supplies with a 50Ω load. Excellent differential gain/phase and noise specifications make these amplifiers ideal for a wide variety of video and RF signal-processing and transmission applications.

Applications

Differential Line Driver
Single-Ended-to-Differential Conversion
High-Speed Differential Transmitter
Coaxial to Twisted-Pair Converter
Differential Pulse Amplifier
Differential ADC Driver
xDSL Applications
Video and RF Signal Processing and Transmission

Pin Configuration



SO

( ) ARE FOR MAX4448/MAX4449 ONLY

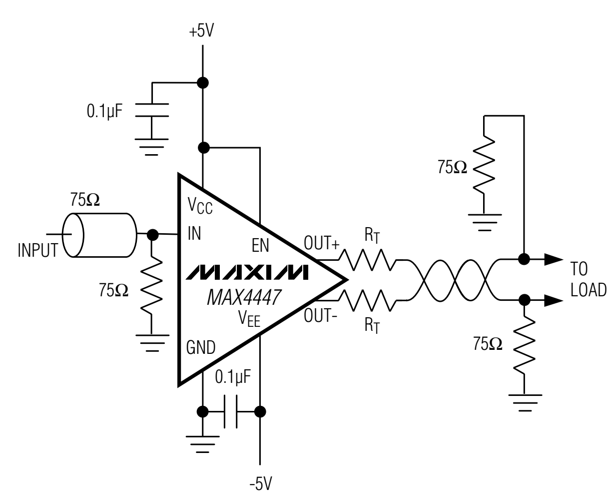
Features

- ♦ **6500V/µs Slew Rate (MAX4449)**
- ♦ **Small-Signal Bandwidth**
  - **430MHz (MAX4447)**
  - **330MHz (MAX4448)**
  - **400MHz (MAX4449)**
- ♦ **200MHz 0.1dB Gain Flatness (MAX4447)**
- ♦ **130mA Output Drive Current**
- ♦ **+2V/V Internally Fixed Gain (MAX4447)**
- ♦ **External Gain Selection**
  - **≥+2V/V (MAX4448)**
  - **≥+5V/V (MAX4449)**
- ♦ **-78dB SFDR at 100kHz**
- ♦ **Low Differential Gain/Phase: 0.01%/0.02°**
- ♦ **Ultra-Low Noise: 23nV/$\sqrt{Hz}$ at f_{IN} = 1MHz**
- ♦ **8ns Settling Time to 0.1%**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX4447ESE	-40°C to +85°C	16 Narrow SO
MAX4448ESE	-40°C to +85°C	16 Narrow SO
MAX4449ESE	-40°C to +85°C	16 Narrow SO

Typical Operating Circuit



6500V/µs, Wideband, High-Output-Current, Single-Ended-to-Differential Line Drivers with Enable

ABSOLUTE MAXIMUM RATINGS

V_{CC} to V_{EE} ....+12V
Voltage on IN, EN, OUT+, OUT-, RG ....(V_{EE} - 0.3V) to (V_{CC} + 0.3V)
Output Short-Circuit Duration to GND ....Indefinite
Continuous Power Dissipation (T_A = +70°C)
16-Pin Narrow SO (derate 20mW/°C above +70°C) ...1600mW
Operating Temperature Range ....-40°C to +85°C
Storage Temperature Range ....-65°C to +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.

DC ELECTRICAL CHARACTERISTICS

(V_{CC} = +5V, V_{EE} = -5V, V_{EN} ≥ 2V, V_{OUT} = V_{OUT+} - V_{OUT-} , R_L = ∞, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Operating Supply Voltage Range	V_{CC}	V_{CC} guaranteed by PSRR test		4.5		5.5	V
	V_{EE}	V_{EE} guaranteed by PSRR test		-5.5		-4.5	
Input Voltage Range	V_{IN}	Guaranteed by gain-error test		-6/A_V		+6/A_V	V
Input Offset Voltage	V_{OS}	V_{IN} = 0			1.3	50	mV
Input Offset Voltage Temperature Coefficient	TC_{VOS}	V_{IN} = 0			25		µV/°C
Input Bias Current	I_B	V_{IN} = 0			7	45	µA
Input Resistance	R_{IN}	-3.0V ≤ V_{IN} ≤ 3.0V			50		kΩ
Gain	A_V	-6V ≤ V_{OUT} ≤ 6V	MAX4447		2		V/V
			MAX4448/MAX4449 (Note 1)		2 • (1+300/R_G)		
Gain Error		-6V ≤ V_{OUT} ≤ 6V	MAX4447		0.1	2	%
			MAX4448/MAX4449		-0.3	5	
Gain Drift		V_{OUT} = 0	MAX4447		-0.002		%/°C
			MAX4448/MAX4449		0.01		
Output Voltage Swing	V_{OUT}	R_L = 100Ω between OUT+ and OUT-		±6.3	±7.4		V
		R_L = 50Ω between OUT+ and OUT-		±5.2	±6.2		
Output Current Drive	I_{OUT}	R_L = 20Ω between OUT+ and OUT-		90	130		mA
Output Short-Circuit Current	I_{SC}	Short circuit to GND			140		mA
Power-Supply Rejection Ratio	PSRR	V_S = ±4.5V to ±5.5V		53	75		dB
Output Leakage Current	$I_{OUT(OFF)}$	V_{EN} = 0, V_{OUT+} = V_{OUT-} = 3.15V or -3.15V			4	30	µA
EN Logic Low Threshold	V_{IL}					0.8	V
EN Logic High Threshold	V_{IH}			2			V
EN Logic Input Low Current	I_{IL}	V_{EN} = 0			-2.5	10	µA
EN Logic Input High Current	I_{IH}	V_{EN} = 5V			0.8	10	µA
Quiescent Current	I_Q	V_{IN} = 0, V_{EN} ≥ V_{IH}			46	55	mA
		V_{IN} = 0, V_{EN} ≤ V_{IL}			3.2	5.5	

AC ELECTRICAL CHARACTERISTICS

(V_{CC} = +5V, V_{EE} = -5V, R_L = 100Ω between OUT+ and OUT-, A_{VCL} = +2V/V for MAX4447/MAX4448, A_{VCL} = +5V/V for MAX4449, V_{OUT} = V_{OUT+} - V_{OUT-}, T_A = +25°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Small-Signal -3dB Bandwidth	BW_{SS}	V_{OUT} = 100mVp-p	MAX4447		430		MHz
			MAX4448		330		
			MAX4449		400		
Large-Signal -3dB Bandwidth	BW_{LS}	V_{OUT} = 8Vp-p	MAX4449		250		MHz
		V_{OUT} = 4Vp-p	MAX4447		250		
			MAX4448		260		
			MAX4449		320		
		V_{OUT} = 2Vp-p	MAX4447		285		
			MAX4448		310		
			MAX4449		405		
0.1dB Gain Flatness		V_{OUT} = 100mVp-p	MAX4447		200		MHz
			MAX4448		40		
			MAX4449		140		
Slew Rate (Note 2)	SR	V_{OUT} = 8V step	MAX4447		5700		V/µs
			MAX4448		4300		
			MAX4449		6500		
		V_{OUT} = 4V step	MAX4447		3000		
			MAX4448		3000		
			MAX4449		3700		
		V_{OUT} = 2V step	MAX4447		1700		
			MAX4448		1900		
			MAX4449		1800		
Rise Time (Note 2)	t_{RISE}	V_{OUT} = 8V step	MAX4447		670		ps
			MAX4448		1030		
			MAX4449		850		
		V_{OUT} = 4V step	MAX4447		720		
			MAX4448		820		
			MAX4449		660		
		V_{OUT} = 2V step	MAX4447		720		
			MAX4448		520		
			MAX4449		740		

6500V/µs, Wideband, High-Output-Current, Single-Ended-to-Differential Line Drivers with Enable

AC ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = +5V, V_{EE} = -5V, R_L = 100Ω between OUT+ and OUT-, A_{VCL} = +2V/V for MAX4447/MAX4448, A_{VCL} = +5V/V for MAX4449, V_{OUT} = V_{OUT+} - V_{OUT-}, T_A = +25°C, unless otherwise noted.)

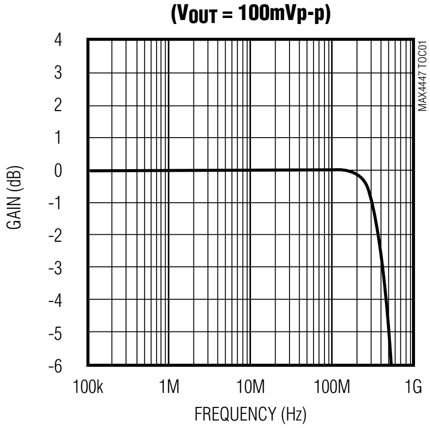
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Fall Time (Note 2)	t_{FALL}	V_{OUT} = 8V step	MAX4447		1100		ps
			MAX4448		900		
			MAX4449		900		
		V_{OUT} = 4V step	MAX4447		900		
			MAX4448		810		
			MAX4449		780		
		V_{OUT} = 2V step	MAX4447		800		
			MAX4448		770		
			MAX4449		660		
Settling Time					8		ns
Spurious-Free Dynamic Range	SFDR	V_{OUT} = 2Vp-p	f_C = 100kHz		-78		dBc
			f_C = 5MHz		-78		
			f_C = 20MHz		-62		
			f_C = 100MHz		-46		
2nd Harmonic Distortion		V_{OUT} = 2Vp-p	f_C = 100kHz		-78		dBc
			f_C = 5MHz		-78		
			f_C = 20MHz		-62		
			f_C = 100MHz		-46		
3rd Harmonic Distortion		V_{OUT} = 2Vp-p	f_C = 100kHz		-86		dBc
			f_C = 5MHz		-86		
			f_C = 20MHz		-71		
			f_C = 100MHz		-54		
Differential Phase Error	DP	NTSC, R_L = 150Ω			0.02		degrees
Differential Gain Error	DG	NTSC, R_L = 150Ω			0.01		%
Input Noise Voltage Density	e_N	f = 1MHz (Note 3)			24		nV/√Hz
Input Noise Current Density	i_N	f = 1MHz			1.8		pA/√Hz
Output Impedance	$Z_{OUT±}$	f = 10MHz, each output to ground			1.0		Ω
Enable Time		V_{IN} = 1V, V_{OUT} settle to within 1%			55		ns
Disable Time		V_{IN} = 1V, V_{OUT} settle to within 1%			0.4		µs
Power-Up Time	t_{ON}	V_{IN} = 1V, V_{OUT} settle to within 1%			0.08		µs
Power-Down Time	t_{OFF}	V_{IN} = 1V, V_{OUT} settle to within 1%			0.5		µs

Note 1: R_G is the gain resistor. See Figure 1.
Note 2: Input step voltage has <100ps rise (fall) time. Measured at the output from 10% to 90% (90% to 10%) levels.
Note 3: Includes the current noise contribution through the on-die feedback resistor.

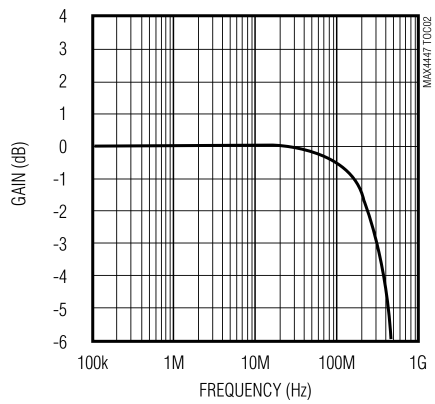
Typical Operating Characteristics

(V_{CC} = +5V, V_{EE} = -5V, V_{EN} = +5V, V_{OUT} = V_{OUT+} - V_{OUT-}, R_L = 100Ω between OUT+ and OUT-, A_V = +2V/V for MAX4447/MAX4448, A_V = +5V/V for MAX4449, T_A = +25°C, unless otherwise noted.)

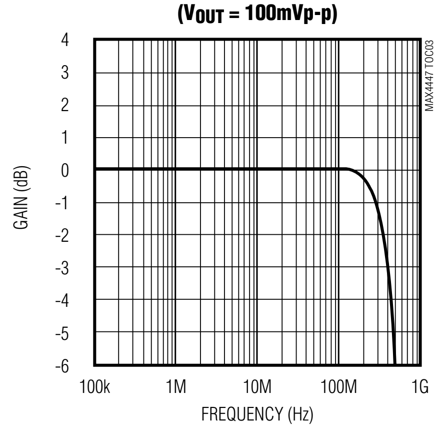
MAX4447 SMALL-SIGNAL GAIN vs. FREQUENCY (V_{OUT} = 100mVp-p)



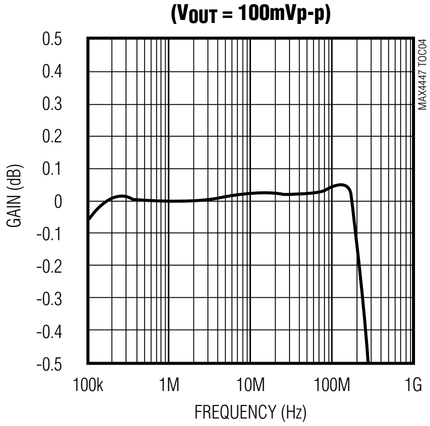
MAX4448 SMALL-SIGNAL GAIN vs. FREQUENCY (V_{OUT} = 100mVp-p)



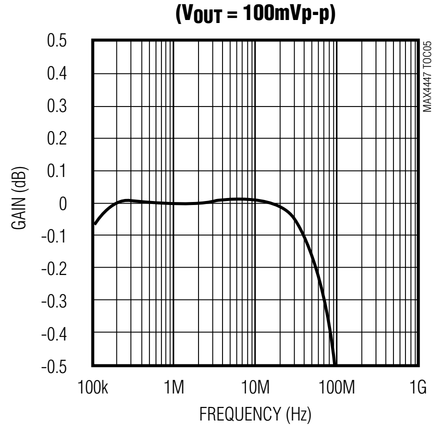
MAX4449 SMALL-SIGNAL GAIN vs. FREQUENCY (V_{OUT} = 100mVp-p)



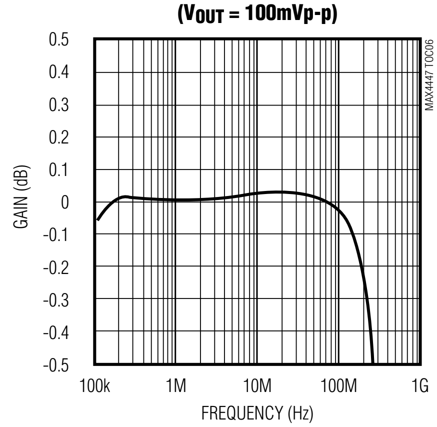
MAX4447 GAIN FLATNESS vs. FREQUENCY (V_{OUT} = 100mVp-p)



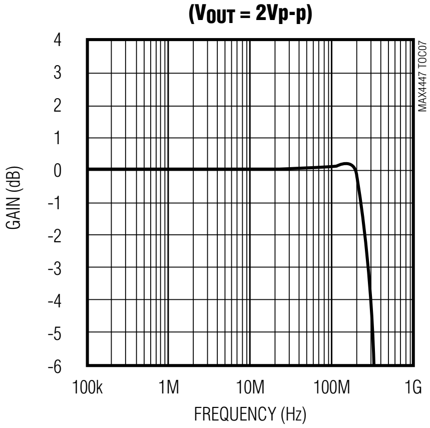
MAX4448 GAIN FLATNESS vs. FREQUENCY (V_{OUT} = 100mVp-p)



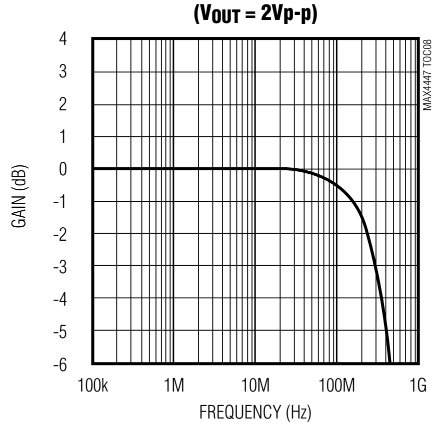
MAX4449 GAIN FLATNESS vs. FREQUENCY (V_{OUT} = 100mVp-p)



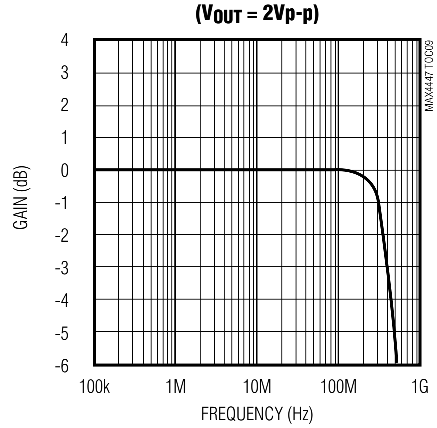
MAX4447 LARGE-SIGNAL GAIN vs. FREQUENCY (V_{OUT} = 2Vp-p)



MAX4448 LARGE-SIGNAL GAIN vs. FREQUENCY (V_{OUT} = 2Vp-p)



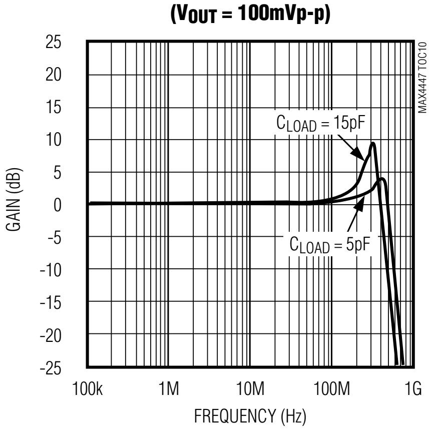
MAX4449 LARGE-SIGNAL GAIN vs. FREQUENCY (V_{OUT} = 2Vp-p)



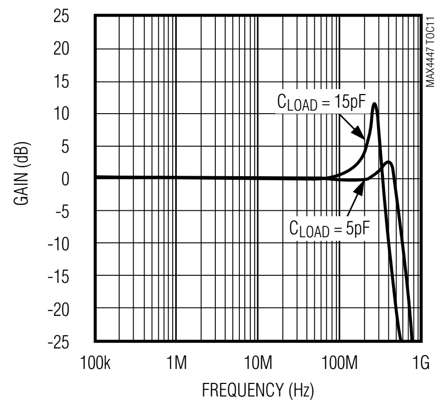
Typical Operating Characteristics (continued)

(V_{CC} = +5V, V_{EE} = -5V, V_{EN} = +5V, V_{OUT} = V_{OUT+} - V_{OUT-}, R_L = 100Ω between OUT+ and OUT-, A_V = +2V/V for MAX4447/MAX4448, A_V = +5V/V for MAX4449, T_A = +25°C, unless otherwise noted.)

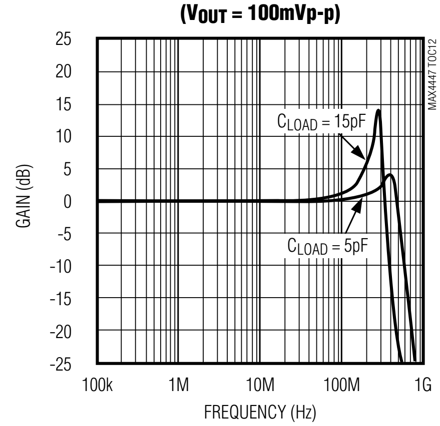
MAX4447
SMALL-SIGNAL GAIN vs. FREQUENCY
(V_{OUT} = 100mVp-p)



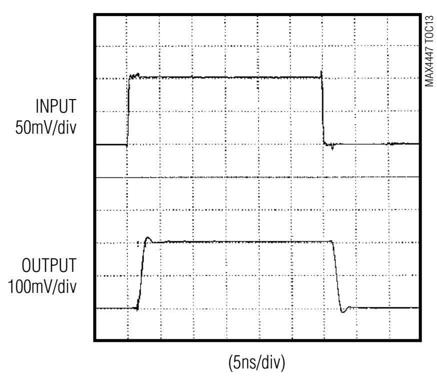
MAX4448
SMALL-SIGNAL GAIN vs. FREQUENCY
(V_{OUT} = 100mVp-p)



MAX4449
SMALL-SIGNAL GAIN vs. FREQUENCY
(V_{OUT} = 100mVp-p)

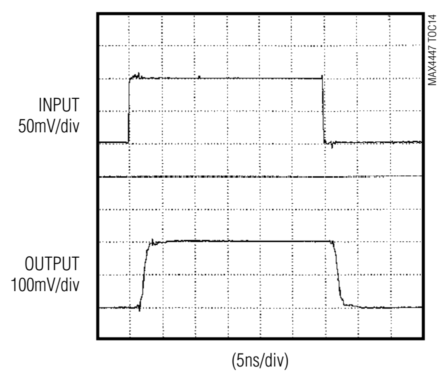


MAX4447
SMALL-SIGNAL PULSE RESPONSE



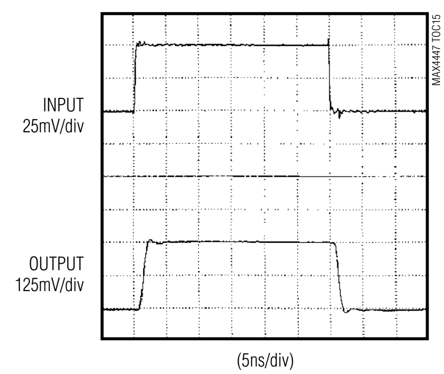
(5ns/div)

MAX4448
SMALL-SIGNAL PULSE RESPONSE



(5ns/div)

MAX4449
SMALL-SIGNAL PULSE RESPONSE



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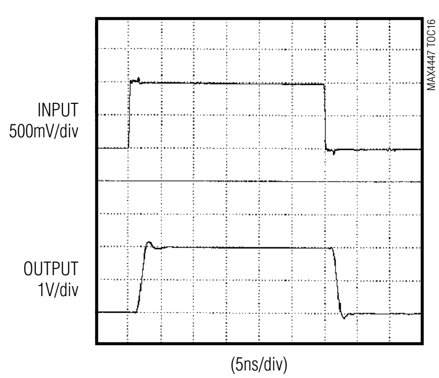
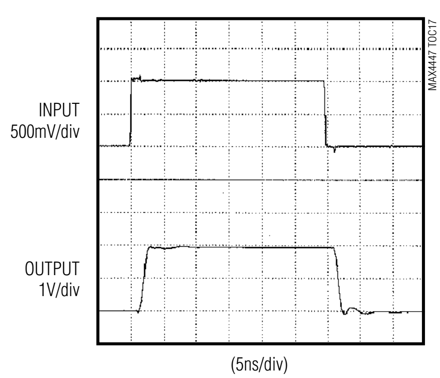
MAX4447
LARGE-SIGNAL PULSE RESPONSE



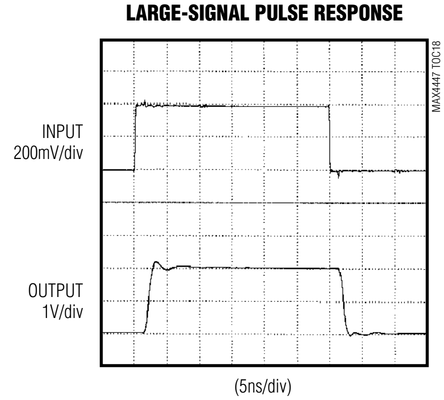
(5ns/div)

MAX4448
LARGE-SIGNAL PULSE RESPONSE



(5ns/div)

MAX4449
LARGE-SIGNAL PULSE RESPONSE

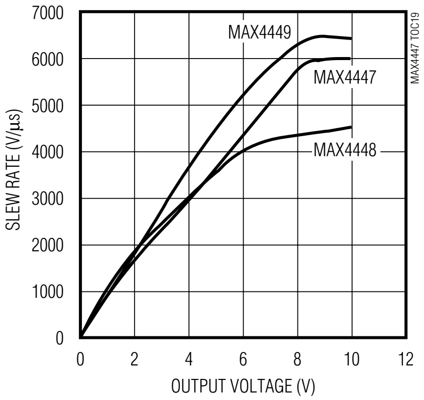


(5ns/div)

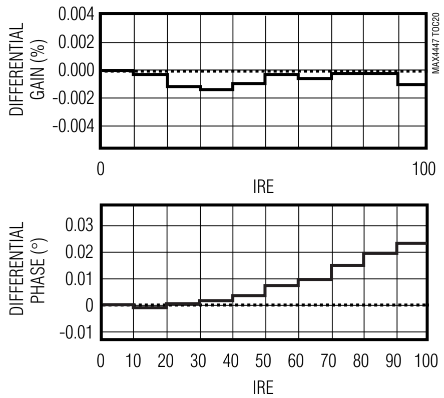
Typical Operating Characteristics (continued)

(V_{CC} = +5V, V_{EE} = -5V, V_{EN} = +5V, V_{OUT} = V_{OUT+} - V_{OUT-}, R_L = 100Ω between OUT+ and OUT-, A_V = +2V/V for MAX4447/MAX4448, A_V = +5V/V for MAX4449, T_A = +25°C, unless otherwise noted.)

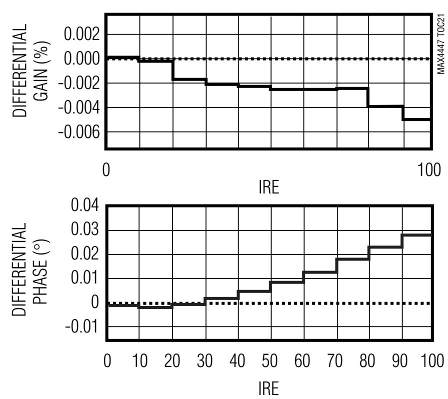
SLEW RATE vs. OUTPUT VOLTAGE



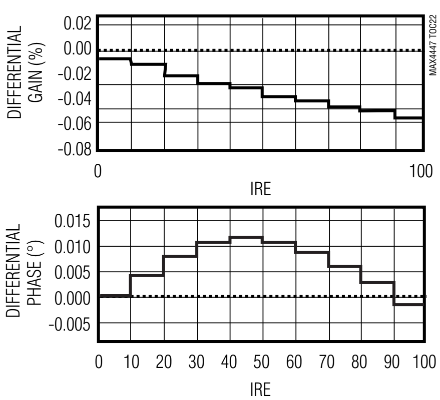
MAX4447 DIFFERENTIAL GAIN AND PHASE



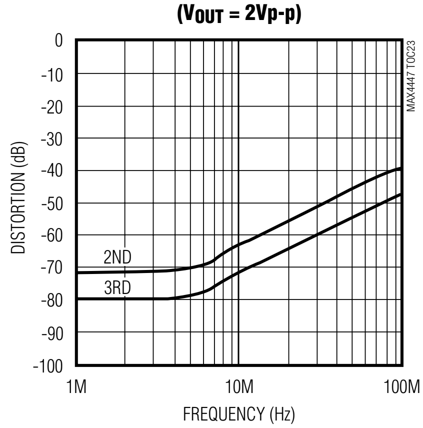
MAX4448 DIFFERENTIAL GAIN AND PHASE



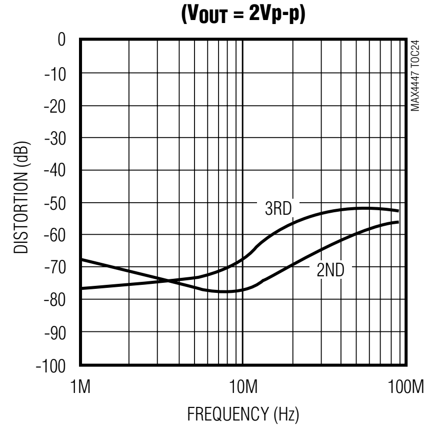
MAX4449 DIFFERENTIAL GAIN AND PHASE



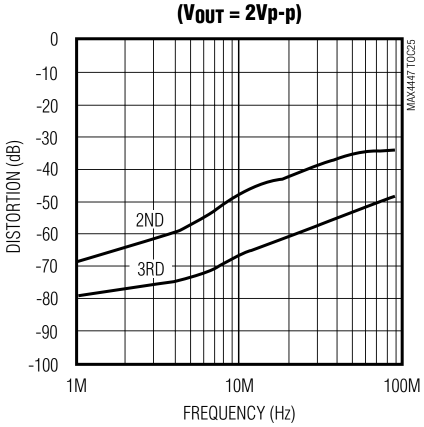
MAX4447 HARMONIC DISTORTION vs. FREQUENCY (V_{OUT} = 2Vp-p)



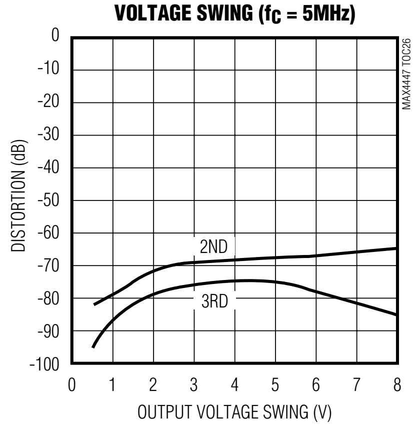
MAX4448 HARMONIC DISTORTION vs. FREQUENCY (V_{OUT} = 2Vp-p)



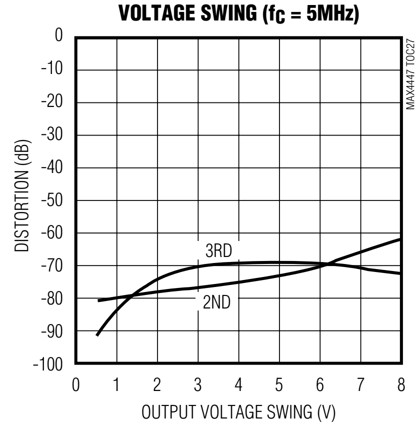
MAX4449 HARMONIC DISTORTION vs. FREQUENCY (V_{OUT} = 2Vp-p)



MAX4447 HARMONIC DISTORTION vs. OUTPUT VOLTAGE SWING (f_C = 5MHz)



MAX4448 HARMONIC DISTORTION vs. OUTPUT VOLTAGE SWING (f_C = 5MHz)

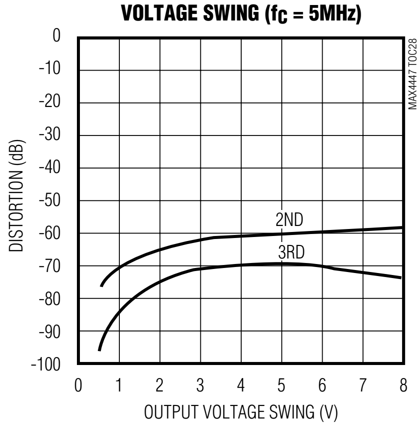


6500V/µs, Wideband, High-Output-Current, Single-Ended-to-Differential Line Drivers with Enable

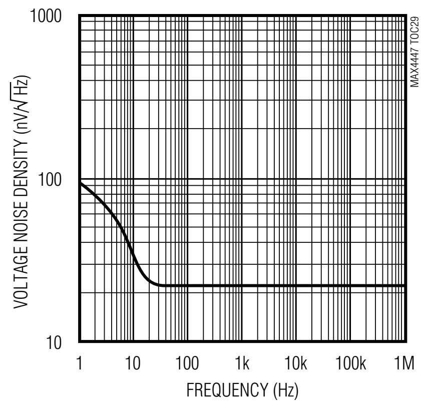
Typical Operating Characteristics (continued)

(V_{CC} = +5V, V_{EE} = -5V, V_{EN} = +5V, $V_{OUT} = V_{OUT+} - V_{OUT-}$, R_L = 100Ω between OUT+ and OUT-, A_V = +2V/V for MAX4447/MAX4448, A_V = +5V/V for MAX4449, T_A = +25°C, unless otherwise noted.)

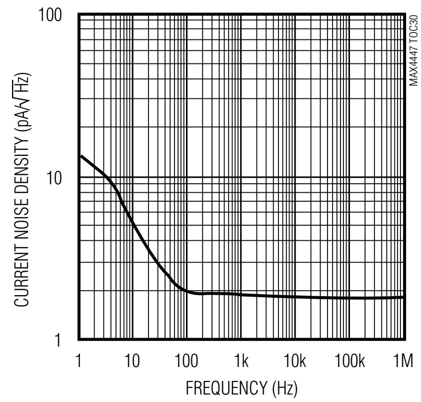
MAX4449 HARMONIC DISTORTION vs. OUTPUT VOLTAGE SWING (f_C = 5MHz)



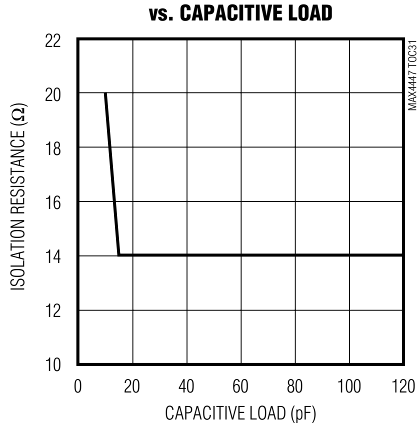
VOLTAGE NOISE DENSITY vs. FREQUENCY



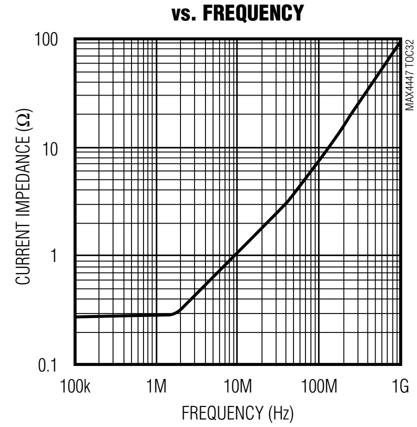
CURRENT NOISE DENSITY vs. FREQUENCY



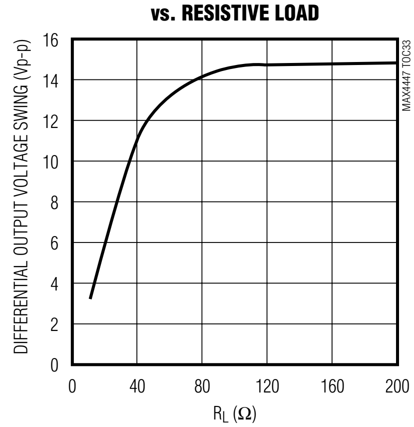
ISOLATION RESISTANCE vs. CAPACITIVE LOAD



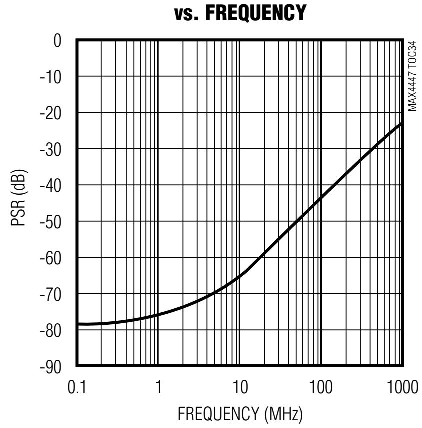
OUTPUT IMPEDANCE vs. FREQUENCY



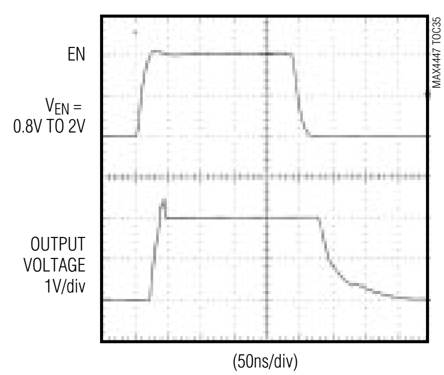
DIFFERENTIAL OUTPUT VOLTAGE SWING vs. RESISTIVE LOAD



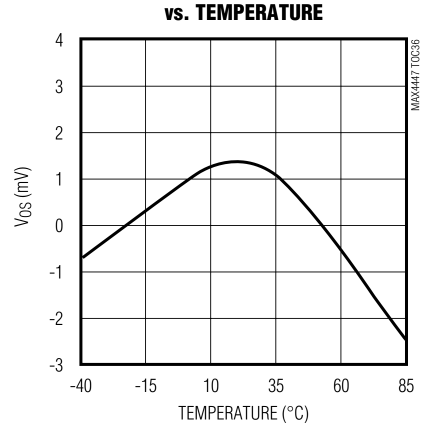
POWER-SUPPLY REJECTION vs. FREQUENCY



SHUTDOWN RESPONSE TIME

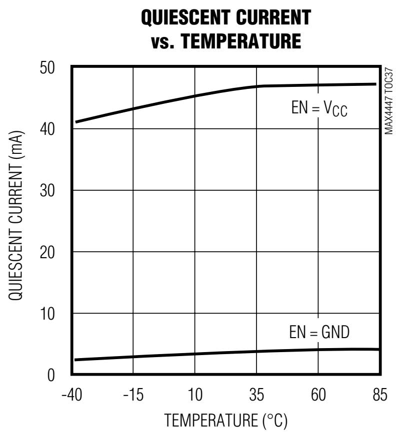


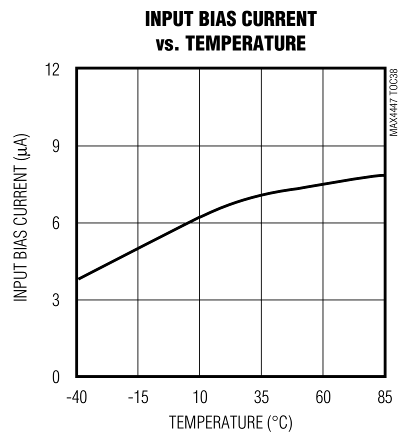
OFFSET VOLTAGE vs. TEMPERATURE



Typical Operating Characteristics (continued)

(V_{CC} = +5V, V_{EE} = -5V, V_{EN} = +5V, V_{OUT} = V_{OUT+} - V_{OUT-}, R_L = 100Ω between OUT+ and OUT-, A_V = +2V/V for MAX4447/MAX4448, A_V = +5V/V for MAX4449, T_A = +25°C, unless otherwise noted.)





Pin Description

PIN		NAME	FUNCTION
MAX4447	MAX4448 MAX4449		
1, 2	1, 2	V_{CC}	Positive Power Supply. Bypass with a 0.1µF capacitor to GND.
3, 4, 6	3, 6	N.C.	No Connection. Not internally connected. Connect to GND for best AC performance.
—	4	RG	Gain-Set Resistor. Connect gain-setting resistor from RG to GND.
5	5	IN	Amplifier Noninverting Input
7, 8, 11, 12, 13, 14	7, 8, 11, 12, 13, 14	V_{EE}	Negative Power-Supply Input. Bypass with a 0.1µF capacitor to GND.
9	9	EN	Active-High, TTL-Compatible, Enable Input. Connect to V_{CC} for normal operation. Connect to GND for low-power operation.
10	10	OUT+	Positive Polarity Output
15	15	OUT-	Negative Polarity Output
16	16	GND	Ground

6500V/µs, Wideband, High-Output-Current, Single-Ended-to-Differential Line Drivers with Enable

Detailed Description

The MAX4447/MAX4448/MAX4449 single-ended-to-differential converters are capable of transmitting high-speed signals such as T1 or xDSL over twisted-pair cable. Excellent gain and phase characteristics, along with low distortion, make these devices suitable for video and RF signal processing and transmission. These converters can be interfaced directly to some of Maxim's wireless products, such as the MAX2450/MAX2451.

The MAX4447/MAX4448/MAX4449 offer wide small-signal bandwidths of 430MHz, 330MHz, and 400MHz, respectively. Internally trimmed resistors minimize gain errors to under 2% over the full output range. Other features include a high slew rate up to 6500V/µs and high output current (130mA), which allow these amplifiers to be used in numerous high-speed communications applications.

Applications Information

Grounding and Bypassing

Use high-frequency design techniques when designing the PC board for the MAX4447/MAX4448/MAX4449:

- Use a multilayer board with one layer dedicated as the ground plane.
- Do not wire-wrap or use breadboards, due to high inductance.
- Avoid IC sockets, due to high parasitic capacitance and inductance.
- Bypass supplies with 0.1µF. Use surface-mount capacitors to minimize lead inductance.
- Keep signal lines as short and straight as possible. Do not make 90° turns; round all corners. Do not cross signals if possible.
- Ensure that the ground plane is free from voids.

Output Short-Circuit Protection

Output short-circuit protection typically limits the current to 140mA when shorted to GND, thereby keeping the power dissipation under the absolute maximum power dissipating rating. However, when shorted to either supply, the short-circuit current can be significantly higher and cause damage to the device.

Low-Power Enable Mode

The MAX4447/MAX4448/MAX4449 are disabled when EN goes low. This reduces supply current to only 3.2mA and places the outputs into a higher impedance.

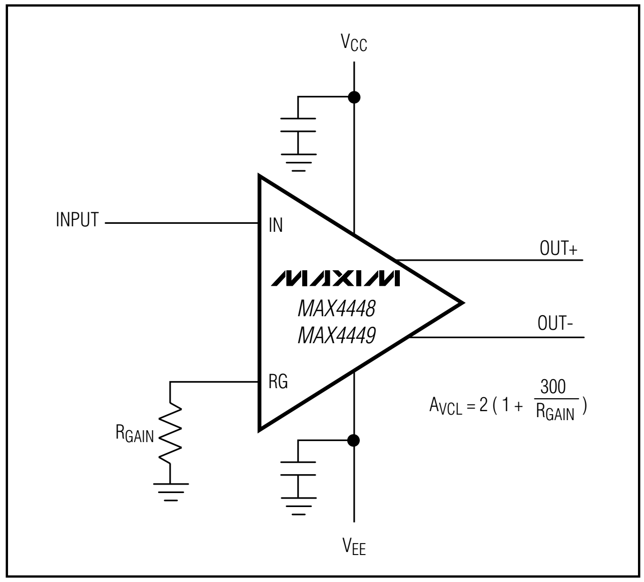


Figure 1. Setting the Amplifier Gain

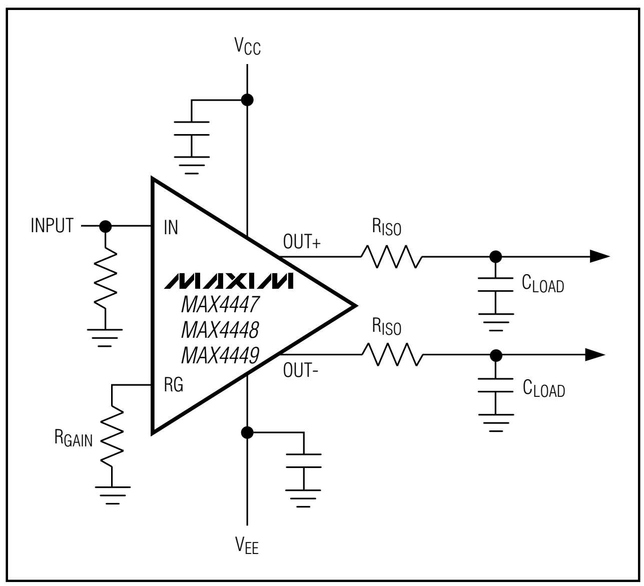


Figure 2. Using an Isolation Resistor for High Capacitive Loads

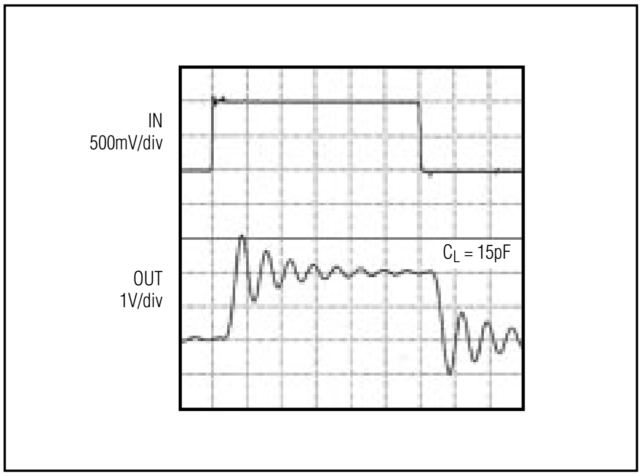


Figure 3. Capacitive-Loaded Output Step Response Without Isolation Resistor

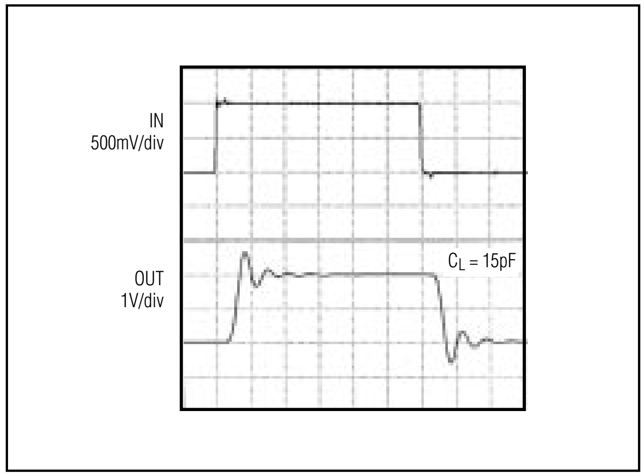


Figure 4. Capacitive-Loaded Output Step Response with 14Ω Isolation Resistor

Setting Gain

The MAX4448/MAX4449 are stable with minimum gain of +2V/V and +5V/V, respectively. An external resistor, R_{GAIN}, connected between RG and GND sets the gain of these devices. Calculate the gain as follows:

$$\text{Gain} = 2 (1 + 300 / R_{GAIN})$$

R_{GAIN} for the MAX4449 must be ≤200Ω.

Driving Capacitive Loads

The MAX4447/MAX4448/MAX4449 are designed to drive capacitive loads. However, excessive capacitive loads may cause ringing or instability at the output as phase margin is reduced. Adding a small series isolation resistor at the output helps reduce the ringing but slightly increases gain error.

Twisted-Pair Line Driver

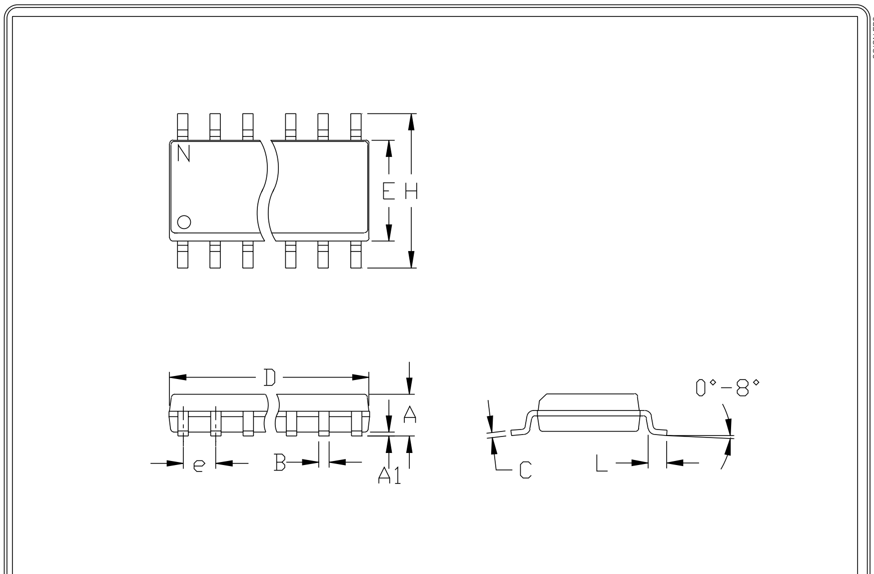
The MAX4447/MAX4448/MAX4449 are well-suited to drive twisted-pair cables. The 24AWG telephone wire widely used produces losses at the higher frequencies. Compensate for these losses by increasing the gain slightly.

Chip Information

TRANSISTOR COUNT: 291

6500V/µs, Wideband, High-Output-Current, Single-Ended-to-Differential Line Drivers with Enable

Package Information



	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	0.050		1.27	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
h	0.010	0.020	0.25	0.50
L	0.016	0.050	0.40	1.27

	INCHES		MILLIMETERS			
	MIN	MAX	MIN	MAX	N	MS012
D	0.189	0.197	4.80	5.00	8	A
D	0.337	0.344	8.55	8.75	14	B
D	0.386	0.394	9.80	10.00	16	C

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
3. LEADS TO BE COPLANAR WITHIN .102mm (.004")
4. CONTROLLING DIMENSION: MILLIMETER
5. MEETS JEDEC MS012-XX AS SHOWN IN ABOVE TABLE
6. N = NUMBER OF PINS

MAXIM
120 SAN GABRIEL DR. SUNNYVALE CA 94086 FAX (408) 737 7194
PROPRIETARY INFORMATION

TITLE: PACKAGE FAMILY OUTLINE: SOIC .150"

1/1

21-0041 A
DOCUMENT CONTROL NUMBER REV