



ADSL Drivers/Receivers for Customer Premise Equipment

General Description

The MAX4361/MAX4362/MAX4363 are a family of high-performance ADSL drivers and drivers/receivers ideal for the upstream transmit path and the downstream receive path of customer premise equipment. These devices operate from a single 5V supply and deliver up to 12.5dBm average line power for DMT modulated signals, meeting the requirements of full-rate ADSL. Spurious-free dynamic range (SFDR) at full output power is typically -75dBc at 100kHz.

The MAX4361 is a differential IN/differential OUT driver with a fixed gain of 3.1V/V. The MAX4362 is a dual amplifier with shutdown intended for use as a differential IN/differential OUT driver with gain set with external resistors. The MAX4363 is a quad amplifier with shutdown intended for use as a differential IN/differential OUT driver/receiver combination with gain set with external resistors.

The MAX4361 is offered in a space-saving 8-pin μ MAX package.

Applications

ADSL Line Interface
HDSL Line Driver

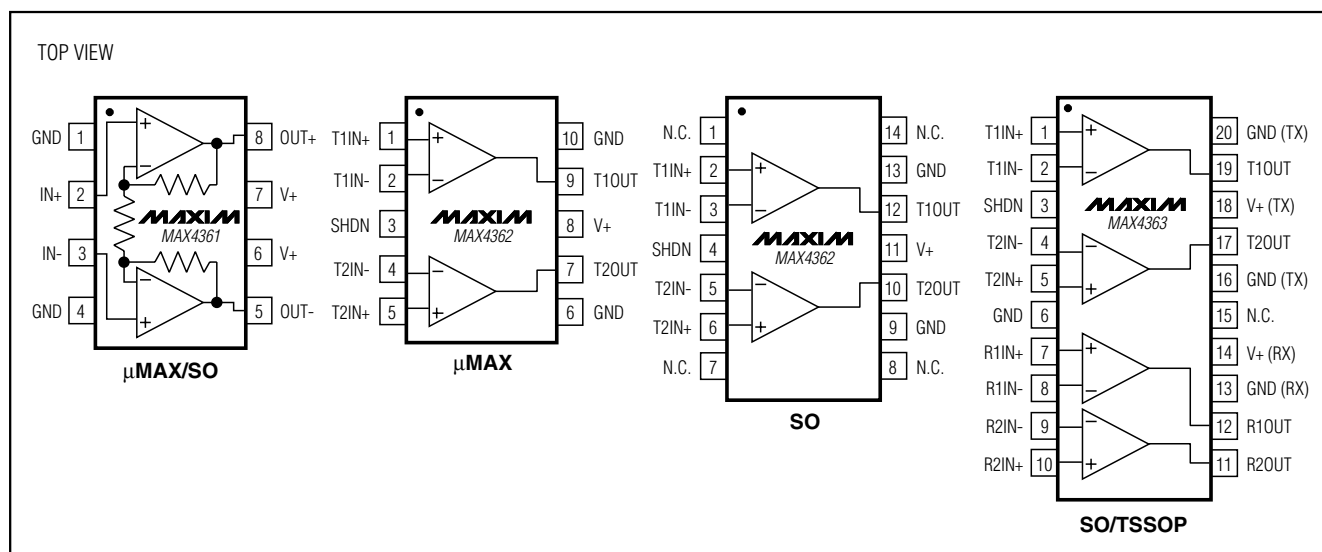
Features

- ◆ Low-Noise Driver
 - 4.8nV/ $\sqrt{\text{Hz}}$ Voltage-Noise Density
 - 1.5pA/ $\sqrt{\text{Hz}}$ Current-Noise Density
- ◆ Full-Rate ADSL ATU-R Line Drivers and Receivers
- ◆ Single 5V Supply
- ◆ -75dBc SFDR at Full Output Power at 100kHz
- ◆ -95dB Driver-to-Receiver Crosstalk (MAX4363)
- ◆ +12.5dBm Average Line Power (DMT)
- ◆ 280mA (min) Peak Output Current
- ◆ Rail-to-Rail® Output Swing
- ◆ Thermal and Short-Circuit Protection

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX4361EUA	-40°C to +85°C	8 μ MAX
MAX4361ESA	-40°C to +85°C	8 SO
MAX4362EUB	-40°C to +85°C	10 μ MAX
MAX4362ESD	-40°C to +85°C	14 SO
MAX4363EUP	-40°C to +85°C	20 TSSOP
MAX4363ESP	-40°C to +85°C	20 SO

Pin Configurations



Rail-to-Rail is a registered trademark of Nippon Motorola, Ltd.



Maxim Integrated Products 1

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.

MAX4361/MAX4362/MAX4363

ADSL Drivers/Receivers for Customer Premise Equipment

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V+ to GND)-0.3V to +6V
 Analog Input Voltage(GND - 0.3V) to (V+ + 0.3V)
 SHDN Input Voltage(GND - 0.3V) to (V+ + 0.3V)
 Output Short-Circuit Duration10s
 Driver Output Current1A
 Receiver Output Current150mA
 Continuous Power Dissipation (T_A = +70°C)
 8-Pin μ MAX (derate 4.5mW/°C above +70°C)362mW
 10-Pin μ MAX (derate 5.6mW/°C above +70°C)444mW

8-Pin SO (derate 5.88mW/°C above +70°C)471mW
 14-Pin SO (derate 8.33mW/°C above +70°C)667mW
 20-Pin SO (derate 10.0mW/°C above +70°C)800mW
 20-Pin TSSOP (derate 10.9mW/°C above +70°C)879mW
 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.

ELECTRICAL CHARACTERISTICS—Driver

(V+ = 5V, GND = 0, V_{CM} = 2.5V, R_L = 12.5 Ω , SHDN = 0, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values specified at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage Range (Note 1)	V _{CC}		4.5		5.5	V
Supply Current	I _Q	MAX4361, R _L = ∞		22	33	mA
		MAX4362, R _L = ∞	SHDN = 0	22	33	mA
			SHDN = 5V	60	200	μ A
		MAX4363, measured at V+ (TX), R _L = ∞	SHDN = 0	22	33	mA
			SHDN = 5V	60	200	μ A
		MAX4363, measured at V+ (RX), R _L = ∞	SHDN = 0	4	6.5	mA
			SHDN = 5V	70	200	μ A
Maximum Average Output Power (Notes 2, 3)	P _{OUT}	DMT modulation	15.5			dBm
		CAP modulation	18			
Gain	G	MAX4361 (0.7V $\leq$ V _{OUT} $\leq$ (V+) - 0.7V)	3.0	3.1	3.2	V/V
Open-Loop Gain	A _{VOL}	MAX4362/MAX4363 (0.7V $\leq$ V _{OUT} $\leq$ (V+) - 0.7V)	68	81		dB
Second Harmonic Distortion (Notes 3, 4)		G = 3.1, f = 100kHz, V _{OUT} (DIFF) = 7.1V _{P-P}	-66	-76		dBc
Third Harmonic Distortion (Notes 3, 4)		G = 3.1, f = 100kHz, V _{OUT} (DIFF) = 7.1V _{P-P}	-68	-79		dBc
Peak Output Current	I _{OUT}	Inferred from Output Voltage Swing test	280	330		mA
Input Offset Voltage	V _{OS}		$\pm$ 0.5	$\pm$ 10		mV
Input Bias Current	I _B		1.6	4.5		μ A
Input Offset Current	I _{OS}	MAX4361	$\pm$ 30	$\pm$ 600		nA
		MAX4362/MAX4363	$\pm$ 10	$\pm$ 500		
Differential Input Resistance	R _{IN} (DIFF)	MAX4361	25			M Ω
		MAX4362/MAX4363	40			k Ω

ADSL Drivers/Receivers for Customer Premise Equipment

ELECTRICAL CHARACTERISTICS—Driver (continued)

(V₊ = 5V, GND = 0, V_{CM} = 2.5V, R_L = 12.5Ω, SHDN = 0, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values specified at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Common-Mode Voltage Range	V _{CM}	Inferred from CMRR test		1.25		4.50	V
Common-Mode Rejection Ratio	CMRR	1.25V ≤ V _{CM} ≤ 4.5V	MAX4361	60	73		dB
			MAX4362/MAX4363	70	85		
Power-Supply Rejection Ratio	PSRR	V ₊ = 4.5V to 5.5V	MAX4361	60	89		dB
			MAX4362/MAX4363	60	74		
AC Power-Supply Rejection Ratio	PSRR _{AC}	f = 100kHz	MAX4361		63		dB
			MAX4362/MAX4363		49		
Differential Output-Voltage Swing (Note 4)	V _{OUT(DIFF)}	Inferred from Output Voltage Swing test		7.4	8.2		V _{P-P}
Output-Voltage Swing (Note 4)	V _{OH} , V _{OL}	R _L = 100Ω	(V ₊) - V _{OH}		215	550	mV
			V _{OL}		230	550	
		MAX4362/MAX4363 R _L = 12.5Ω	(V ₊) - V _{OH}		400	600	
			V _{OL}		430	650	
		MAX4361, R _L = 12.5Ω, T _A = -20°C to 85°C	(V ₊) - V _{OH}		400	600	
			V _{OL}		430	650	
Output Short-Circuit Current	I _{SC}				±650		mA
Output Resistance	R _{OUT}	MAX4361			0.3		Ω
		MAX4362/MAX4363, G = 1			0.001		
SHDN Logic Low	V _{IL}					0.8	V
SHDN Logic High	V _{IH}			2.0			V
SHDN Input Current	I _{IH} , I _{IL}	SHDN = 0 or SHDN = V ₊			±10		μA
Shutdown Output Impedance	Z _{OUT(SD)}	f = 1MHz			1.8		kΩ
-3dB Bandwidth	BW	MAX4361			40		MHz
		MAX4362/MAX4363, G = 1			60		
Slew Rate	SR	V _{OUT(DIFF)} = 7.1V _{P-P} step			30		V/μs
Settling Time (1%)	t _S	V _{OUT(DIFF)} = 7.1V _{P-P} step	MAX4361		115		ns
			MAX4362/MAX4363, G = 3		165		
Voltage-Noise Density	e _n	f = 100kHz to 1.1MHz			4.8		nV/√Hz
Current-Noise Density	i _n	f = 100kHz to 1.1MHz			1.5		pA/√Hz
Capacitive-Load Stability					10		nF
Shutdown Delay Time	t _{SHDN}				400		ns
Enable Delay Time	t _{ENABLE}				2.8		μs

MAX4361/MAX4362/MAX4363

ADSL Drivers/Receivers for Customer Premise Equipment

ELECTRICAL CHARACTERISTICS—Receiver (MAX4363 only)

(V₊ = 5V, GND = 0, V_{CM} = 2.5V, R_L = ∞, SHDN = 0, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values specified at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Spurious-Free Dynamic Range	SFDR	G = 1, f = 1MHz, V _{OUT} = 1V _{P-P}			-75		dBc
Gain-Bandwidth Product	GBW				190		MHz
Open-Loop Gain	A _{VOL}	1.5V ≤ V _{OUT} ≤ 3.5V		65	77		dB
Peak Output Current	I _{OUT}	R _L = 50Ω, inferred from Output-Voltage Swing test		18	25		mA
Input Offset Voltage	V _{OS}				±0.5	±10	mV
Input Bias Current	I _B				-0.75	-2	μA
Input Offset Current	I _{OS}				±20	±250	nA
Input Capacitance	C _{IN}				1.6		pF
Differential Input Resistance	R _{IN(DIFF)}				76		kΩ
Input Common-Mode Voltage Range	V _{CM}	Inferred from CMRR test		0.25		3.80	V
Common-Mode Rejection Ratio	CMRR	0.25V ≤ V _{CM} ≤ 3.8V		70	87		dB
Power-Supply Rejection Ratio	PSRR	V ₊ = 4.5V to 5.5V		60	75		dB
AC Power-Supply Rejection Ratio	PSRR _{AC}	f = 1MHz			47		dB
Output-Voltage Swing	V _{OH} , V _{OL}	R _L = ∞	(V ₊) - V _{OH}		0.64	1	V
			V _{OL}		0.73	1	
		R _L = 50Ω	(V ₊) - V _{OH}		1.27	1.5	
			V _{OL}		1.37	1.6	
Output Short-Circuit Current	I _{SC}				±130		mA
Output Resistance	R _{OUT}	G = 1			0.001		Ω
Slew Rate	SR	V _{OUT} = 1V _{P-P} step			160		V/μs
Settling Time (1%)	t _S	V _{OUT} = 100mV _{P-P} step, G = 1			40		ns
Voltage-Noise Density	e _n	f = 1MHz			8.5		nV/√Hz
Current-Noise Density	i _n	f = 1MHz			0.5		pA/√Hz
Driver-Receiver Crosstalk	X _{TALK}	f = 100kHz			95		dB

Note 1: Guaranteed by the Power-Supply Rejection Ratio (PSRR) test.

Note 2: Implied by worst-case output-voltage swing (V_{OUT(DIFF)}), crest factor (C_r) and load resistance (R_L):

$$P_{\text{Driver}} = 10 \log((250 \times (V_{\text{OUT(DIFF)}})^2 / ((C_r)^2 \times R_L)) \text{ dBmW}$$

Note 3: Guaranteed by design.

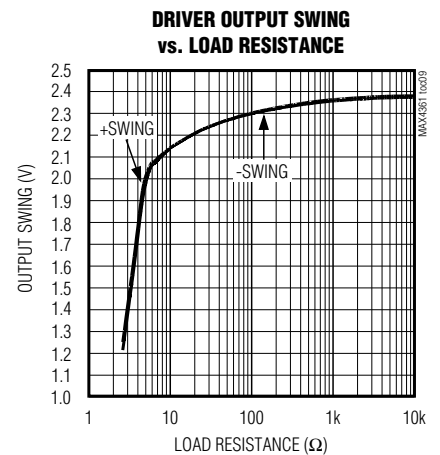
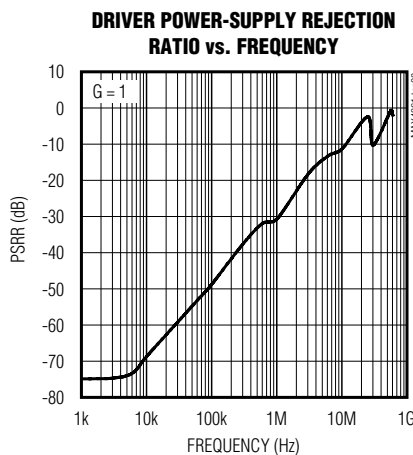
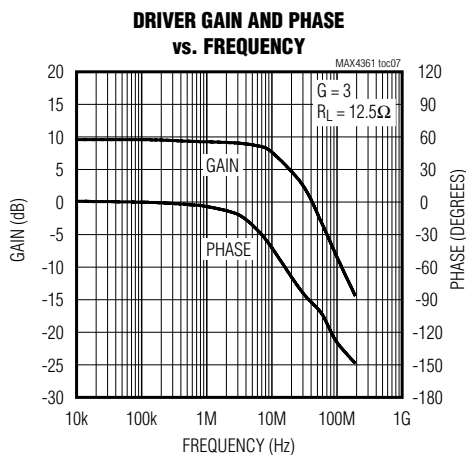
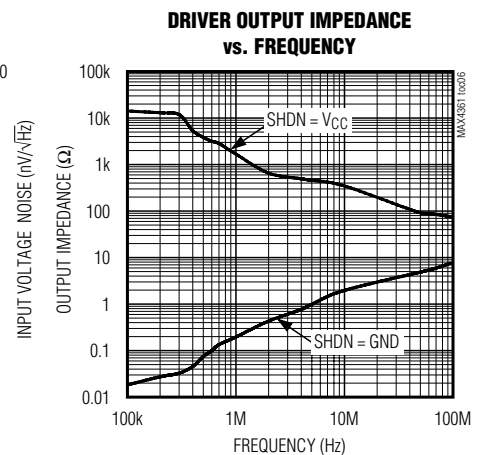
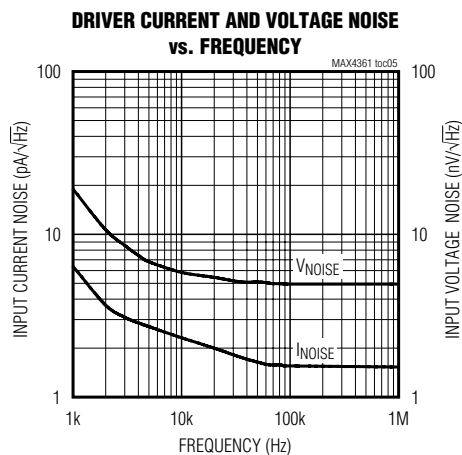
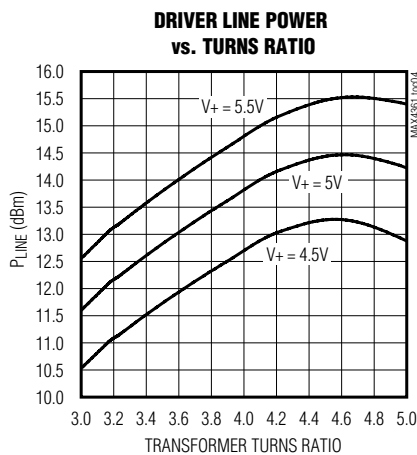
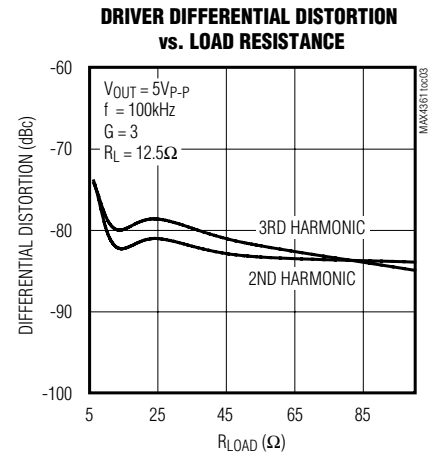
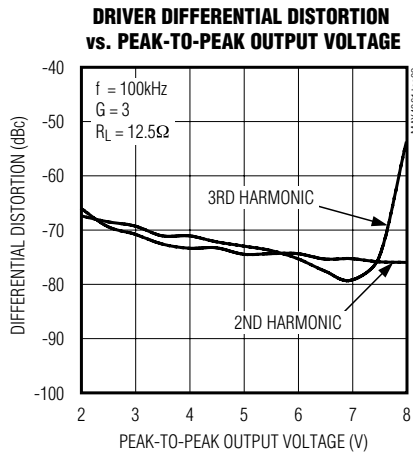
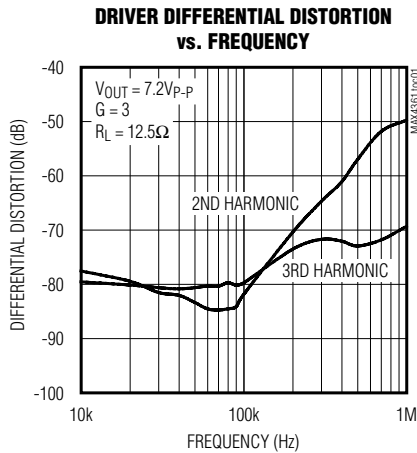
Note 4: May exceed absolute maximum ratings for power dissipation if unit is subject to full-scale sinusoids for long periods (see *Applications Information* section).

ADSL Drivers/Receivers for Customer Premise Equipment

Typical Operating Characteristics

($V_+ = 5V$, $GND = 0$, $V_{CM} = 2.5V$, $R_L = 12.5\Omega$, $SHDN = 0$, $T_A = +25^\circ C$.)

MAX4361/MAX4362/MAX4363

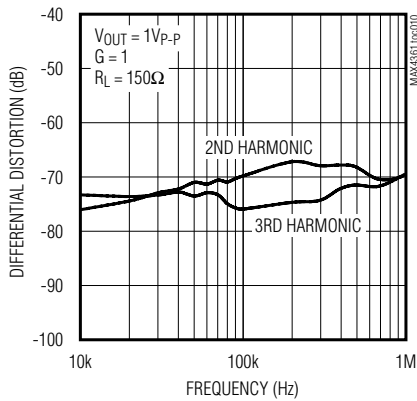


ADSL Drivers/Receivers for Customer Premise Equipment

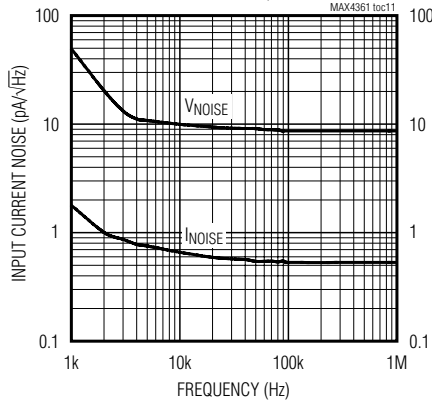
Typical Operating Characteristics (continued)

($V_+ = 5V$, $GND = 0$, $V_{CM} = 2.5V$, $R_L = 12.5\Omega$, $SHDN = 0$, $T_A = +25^\circ C$.)

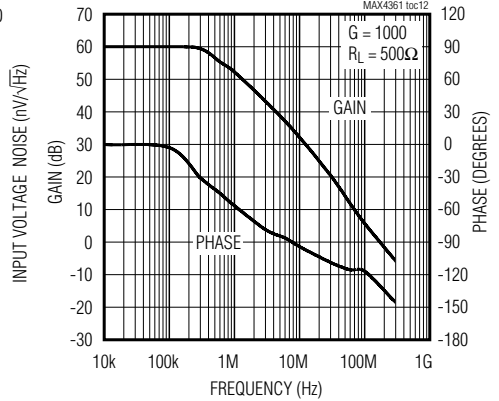
RECEIVER DIFFERENTIAL DISTORTION vs. FREQUENCY



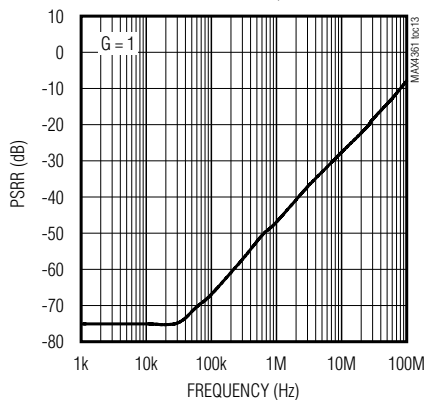
RECEIVER CURRENT AND VOLTAGE NOISE vs. FREQUENCY



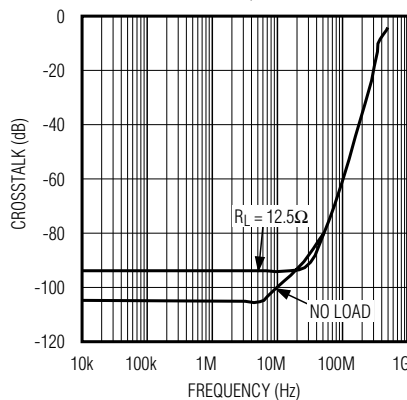
RECEIVER GAIN AND PHASE vs. FREQUENCY



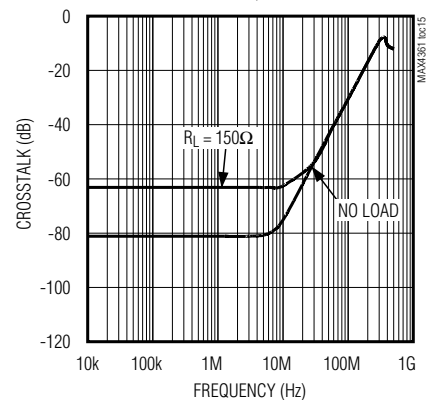
RECEIVER POWER-SUPPLY REJECTION RATIO vs. FREQUENCY



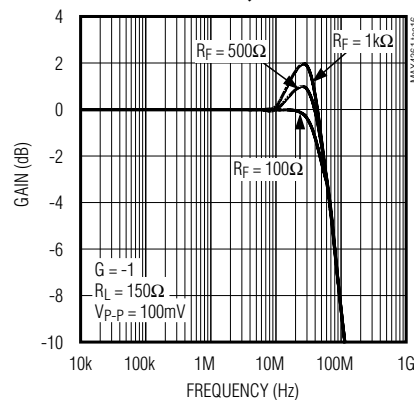
DRIVER-TO-RECEIVER CROSSTALK vs. FREQUENCY



RECEIVER-TO-RECEIVER CROSSTALK vs. FREQUENCY



RECEIVER OUTPUT AMPLITUDE vs. FREQUENCY



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Pin Descriptions

MAX4361

PIN	NAME	FUNCTION
1, 4	GND	Ground
2	IN+	First Driver Input
3	IN-	Second Driver Input
5	OUT-	Second Driver Output
6, 7	V+	Positive Power-Supply Voltage. Bypass V+ to GND with a 0.1μF capacitor.
8	OUT+	First Driver Output

MAX4362

PIN		NAME	FUNCTION
μMAX	SO		
1	2	T1IN+	First Driver Noninverting Input
2	3	T1IN-	First Driver Inverting Input
3	4	SHDN	Shutdown. Connect to GND for normal operation.
4	5	T2IN-	Second Driver Inverting Input
5	6	T2IN+	Second Driver Noninverting Input
6, 10	9, 13	GND	Ground
7	10	T2OUT	Second Driver Output
8	11	V+	Positive Power-Supply Voltage. Bypass V+ to GND with a 0.1μF capacitor.
9	12	T1OUT	First Driver Output
—	1, 7, 8, 14	N.C.	No Connection. Not internally connected.

MAX4361/MAX4362/MAX4363

ADSL Drivers/Receivers for Customer Premise Equipment

Pin Descriptions (continued)

MAX4363

PIN	NAME	FUNCTION
1	T1IN+	First Driver Noninverting Input
2	T1IN-	First Driver Inverting Input
3	SHDN	Shutdown. Connect to GND for normal operation.
4	T2IN-	Second Driver Inverting Input
5	T2IN+	Second Driver Noninverting Input
6	GND	Ground
7	R1IN+	First Receiver Noninverting Input
8	R1IN-	First Receiver Inverting Input
9	R2IN-	Second Receiver Inverting Input
10	R2IN+	Second Receiver Noninverting Input
11	R2OUT	Second Receiver Output
12	R1OUT	First Receiver Output
13	GND (RX)	Ground for Receiver Amplifiers
14	V+ (RX)	Positive Power-Supply Voltage for Receiver Amplifiers. Bypass V+ (RX) to GND (RX) with a separate 0.1 μ F capacitor.
15	N.C.	No Connection. Not internally connected.
16, 20	GND (TX)	Ground for Driver Amplifier
17	T2OUT	Second Driver Output
18	V+ (TX)	Positive Power-Supply Voltage for Driver Amplifiers. Bypass V+ (TX) to GND (TX) with a separate 0.1 μ F capacitor.
19	T1OUT	First Driver Output

Detailed Description

The MAX4361/MAX4362/MAX4363 are a family of high-performance ADSL drivers and drivers/receivers ideal for the upstream transmit path and the downstream receive path of customer premise equipment. These devices operate from a single 5V supply and deliver up to 12.5dBm average line power for DMT modulated signals, meeting the requirements of full-rate ADSL. SFDR at full output power is typically -75dBc at 100kHz.

Differential In/Differential Out ADSL Driver (MAX4361)

The MAX4361 is a differential line driver with a fixed gain of 3.1V/V. The gain is set by three internal resistors.

Uncommitted Dual Amplifier for ADSL Driver (MAX4362)

The MAX4362 is a dual amplifier with shutdown intended for use as a differential IN/differential OUT driver with gain set with external resistors.

Uncommitted Quad Amplifier for ADSL Driver/Receiver (MAX4363)

The MAX4363 is a quad amplifier with shutdown intended for use as a differential IN/differential OUT driver/receiver combination with gain set with external resistors.

Shutdown

The MAX4362/MAX4363 feature a low-power shutdown mode. When the SHDN pin is pulled high, the supply current drops to 70 μ A, and the amplifier's outputs are placed in a high-impedance disable mode. Connect SHDN to GND for normal operation.

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Applications Information

Power Supply and Decoupling

The MAX4361/MAX4362/MAX4363 should be powered from a well-regulated, low-noise, 4.5V to 5.5V supply in order to optimize the ADSL upstream drive capability to +12.5dBm and maintain the best SFDR.

High-quality capacitors with low equivalent series resistance (ESR) such as multilayer ceramic capacitors (MLCCs) should be used to minimize supply voltage ripple and power dissipation. A larger capacitor located in proximity to the MAX4361/MAX4362/MAX4363 improves decoupling for lower frequency signals.

In addition, 0.1 μ F MLCC decoupling capacitors should be located as close as possible to each of the power-supply pins, no more than 1/8 inch away. An additional large (4.7 μ F to 10 μ F) tantalum capacitor should be placed on the board near the supply terminals to supply current for fast, large-signal changes at the MAX4361/MAX4362/MAX4363 outputs.

MAX4361/MAX4362

The MAX4361/MAX4362 require a single 0.1 μ F bypass from V+ to ground located as close as possible to the IC leads.

MAX4363

The MAX4363 features separate supply and ground pins for the receiver and driver amplifiers. Bypass the V+ (RX) supply to the GND (RX) pin with a 0.1 μ F capacitor. Bypass the V+ (TX) supply to the GND (TX) pin with a separate 0.1 μ F capacitor. Both capacitors should be placed as close as possible to their respective IC leads.

USB Applications

The 5V supplied at the universal serial bus (USB) port may be poorly regulated or unable to supply the peak currents required by an ADSL modem. Improving the quality of the supply will optimize the performance of the MAX4361/MAX4362/MAX4363 in a USB-supplied CPE ADSL modem. This can be accomplished through the use of a step-up DC-to-DC converter or switching power supply followed by a low-dropout (LDO) regulator. Careful attention must be paid to decoupling the power supply at the output of the DC-to-DC converter, the output of the LDO regulator and the supply pins of the MAX4361/MAX4362/MAX4363.

Driving a Capacitive Load

The MAX4361/MAX4362/MAX4363 are capable of driving capacitive loads up to 2nF. Most hybrid circuits are well under this limit. For additional capacitive-drive capability use isolation resistors between the output

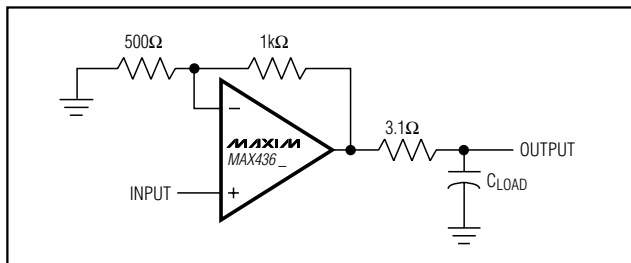


Figure 1. Driving Capacitive Load

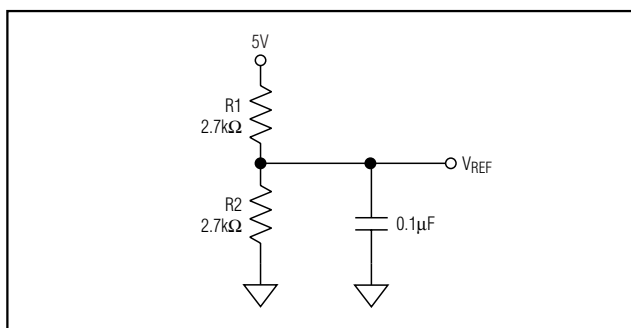


Figure 2. Voltage-Divider Reference

and the load to reduce ringing on the output signal. In a typical hybrid the back-matching resistors provide sufficient isolation for most any capacitive-loading condition (see Figure 1).

Method for Generating a Midsupply Voltage

To operate an amplifier on a single-voltage supply, a voltage midway between the supply and ground must be generated to properly bias the inputs and the outputs.

A voltage divider can be created with two equal-value resistors (Figure 2). There is a trade-off between the power consumed by the divider and the voltage drop across these resistors due to the positive input bias currents. Selecting 2.7k Ω for R1 and R2 will create a voltage divider that draws less than 1mA from a 5V supply. Use a decoupling capacitor (0.1 μ F) at the node where VREF is generated.

Power Dissipation

It is important to consider the total power dissipation of the MAX4361/MAX4362/MAX4363 in order to properly size the heat sink area of an application. With some simplifying assumptions we can estimate the total power dissipated in the driver (see *Typical Operating*

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Circuit). If the output current is large compared to the quiescent current, computing the dissipation in the output devices and adding it to the quiescent power dissipation will give a close approximation of the total power dissipation in the package.

For a 12.5dBm average line power on a 100Ω line, the RMS current is 13.4mA. With a one-to-four transformer the driver therefore supplies 53.6mA RMS. It can be shown for a DMT signal the ratio of RMS current to the average rectified current is 0.8. The total power consumption is approximately

$$P_{CONS} = 0.8 \times 53.6 \times 5V = 214mW$$

of which 18mW is delivered as line power and 18mW is dissipated in the back-matching resistors. Hence the average power consumption of the IC is approximately 178mW + quiescent power (110mW), or 288mW. For the MAX4361 in an 8-pin μMAX package, this corresponds to a temperature rise of 64°C. With an ambient temperature of +85°C this corresponds to a junction temperature of +148°C, just below the absolute maximum of +150°C.

Please note the part is capable of over 200mA RMS, which could cause thermal shutdown in applications with elevated ambient temperatures and/or signals with low crest factors. See Figure 3 for a guide to power derating for each of the MAX4361/MAX4362/MAX4363 packages.

Transformer Selection

Full-rate, customer premise ADSL requires the transmission of a +12.5dBm (18mW) DMT signal. The DMT signal has a typical crest factor of 5.3, requiring the line driver to provide peak line power of 27.5dBm (560mW). The 27.5dBm peak line power translates into a 28.4V peak-to-peak differential voltage on the 100Ω telephone line. The maximum low-distortion output swing available from the MAX4361/MAX4362/MAX4363 line driver on a 5V supply is 3.8V and, taking into account the power lost due to the back-matching resistance, a step-up transformer with turns ratio of 3.8 or greater is needed. In the *Typical Operating Circuit*, the MAX4363 is coupled to the phone line through a step-up transformer with a 1:4 turns ratio. R1 and R2 are back-matching resistors, each 3.1Ω (100Ω / (2 × 4²)), where 100Ω is the approximate phone-line impedance. The total differential load for the MAX4361/MAX4362/MAX4363, including the termination resistors, is therefore 12.5Ω. Even under these conditions the MAX4361/MAX4362/MAX4363 provide low distortion signals to within 0.6V of the power rails.

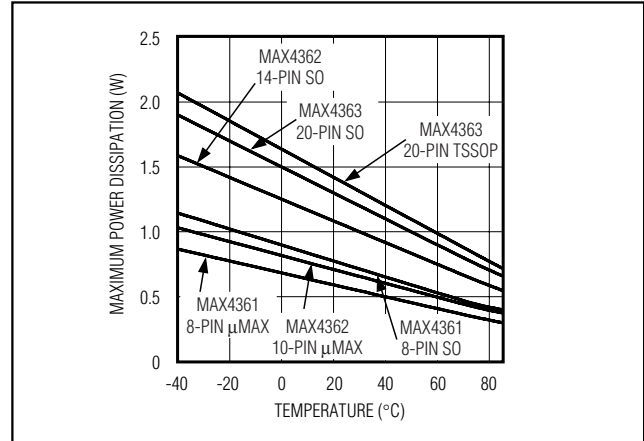


Figure 3. Maximum Power Dissipation vs. Temperature

Receive Channel Considerations

A transformer used at the output of the differential line driver to step up the differential output voltage to the line has the inverse effect on signals received from the line. A voltage reduction or attenuation equal to the inverse of the turns ratio is realized in the receive channel of a typical bridge hybrid. The turns ratio of the transformer may also be dictated by the ability of the receive circuitry to resolve low-level signals in the noisy, twisted-pair telephone plant. Higher turns-ratio transformers effectively reduce the received signal-to-noise ratio due to the reduction in the received signal strength.

The MAX4363 includes an amplifier with typical voltage noise of only 8.5nV/√Hz and a low-supply current of 2mA/amplifier to be used as the receive channel.

Layout Considerations

Good layout techniques optimize performance by decreasing the amount of stray capacitance at the amplifier's inputs and outputs. Excess capacitance will produce peaking in the amplifier's frequency response. To decrease stray capacitance, minimize trace lengths by placing external components as close to the amplifier as possible.

Chip Information

MAX4361 TRANSISTOR COUNT: 1400

MAX4362 TRANSISTOR COUNT: 1400

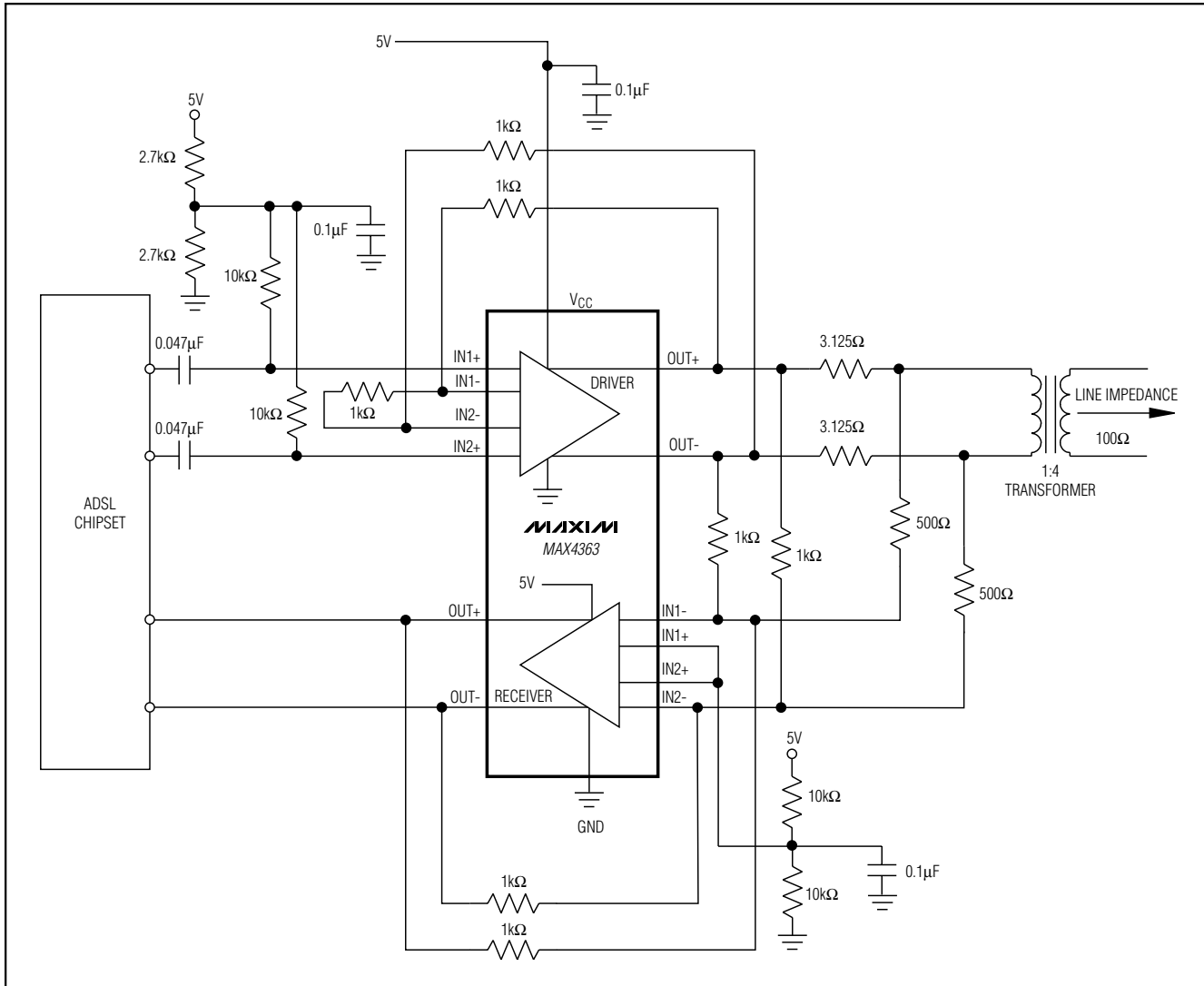
MAX4363 TRANSISTOR COUNT: 1750

PROCESS: Bipolar

ADSL Drivers/Receivers for Customer Premise Equipment

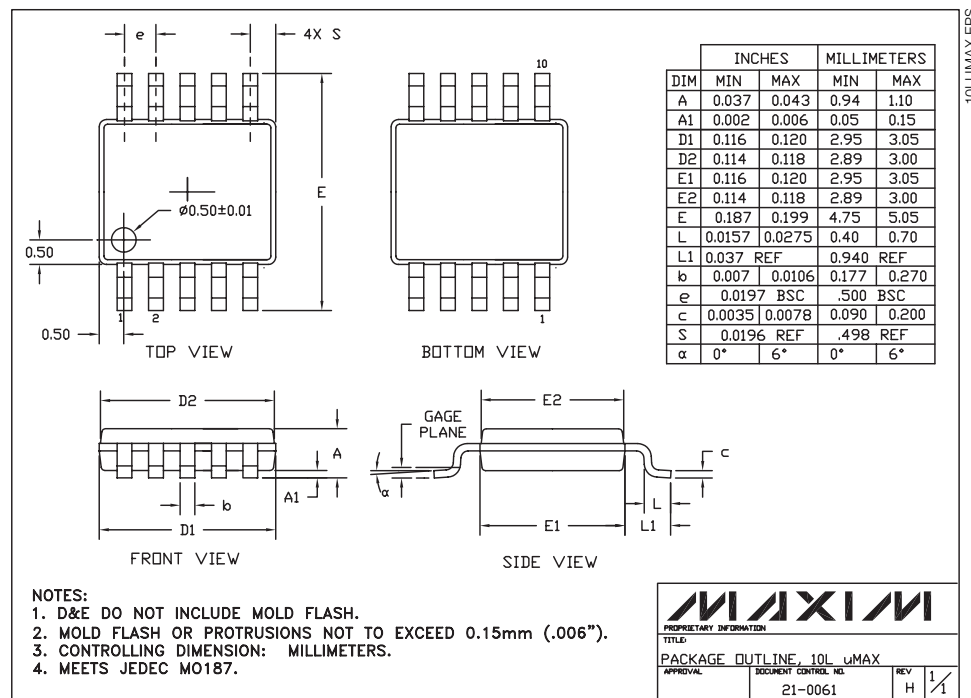
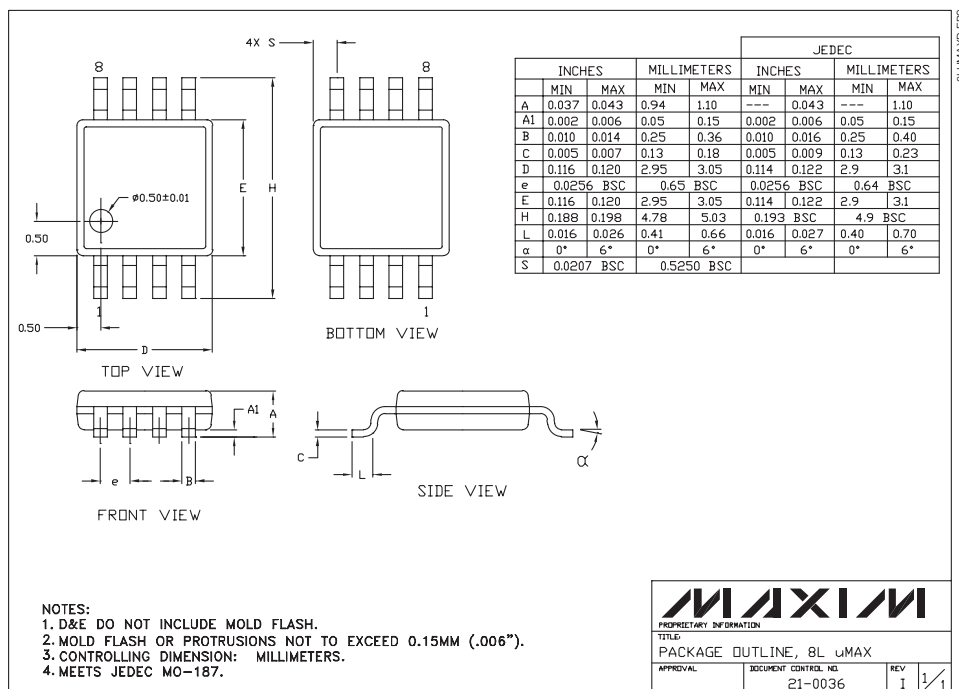
Typical Operating Circuit

MAX4361/MAX4362/MAX4363



ADSL Drivers/Receivers for Customer Premise Equipment

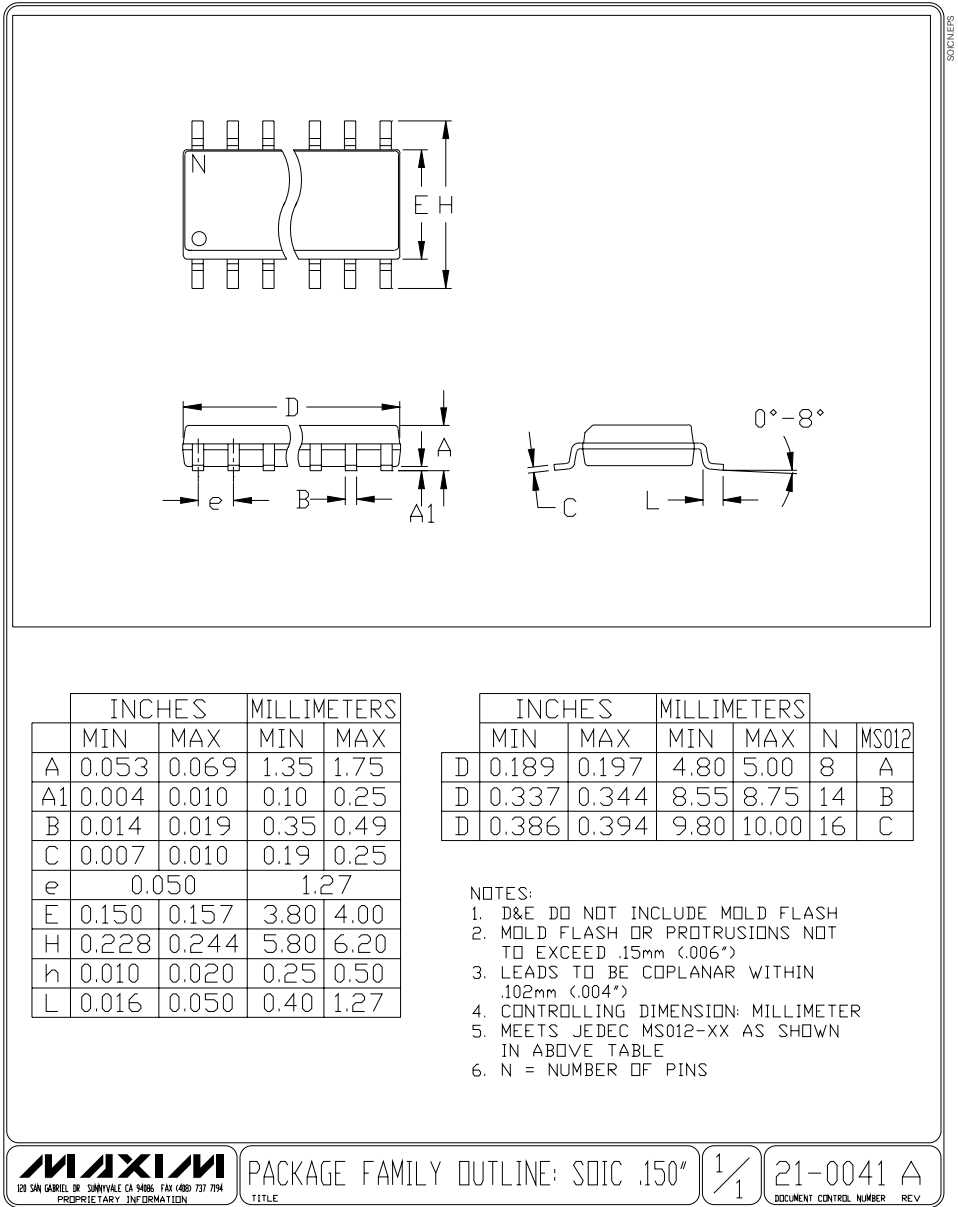
Package Information



ADSL Drivers/Receivers for Customer Premise Equipment

Package Information (continued)

MAX4361/MAX4362/MAX4363



Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

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