

# 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  $\mu$ MAX package.

## Applications

ADSL Line Interface  
HDSL Line Driver

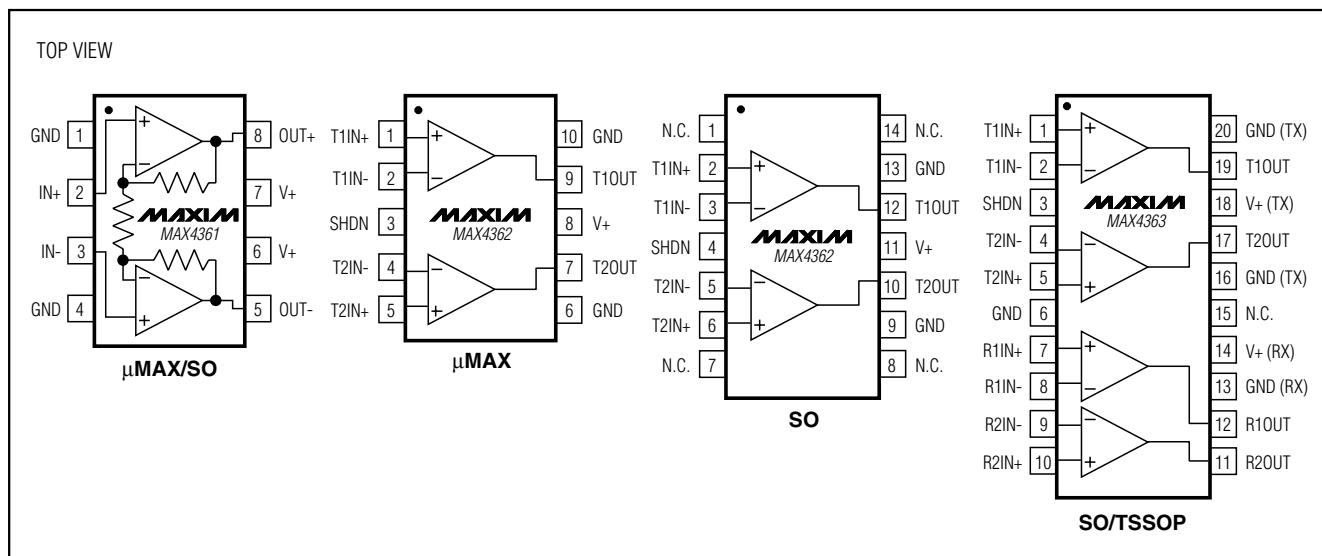
## Features

- ◆ **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  |
|-------------------|----------------|--------------|
| <b>MAX4361EUA</b> | -40°C to +85°C | 8 $\mu$ MAX  |
| MAX4361ESA        | -40°C to +85°C | 8 SO         |
| <b>MAX4362EUB</b> | -40°C to +85°C | 10 $\mu$ MAX |
| MAX4362ESD        | -40°C to +85°C | 14 SO        |
| <b>MAX4363EUP</b> | -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.

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## 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 Duration .....  | 10s                         |
| Driver Output Current .....  | 1A                          |
| Receiver Output Current .....  | 150mA                       |
| Continuous Power Dissipation ( $T_A = +70^\circ\text{C}$ )                               |                             |
| 8-Pin $\mu\text{MAX}$ (derate 4.5mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$ ) .....  | 362mW                       |
| 10-Pin $\mu\text{MAX}$ (derate 5.6mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$ ) ..... | 444mW                       |

|   |   |
|---|---|
| 8-Pin SO (derate 5.88mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$ ) .....     | 471mW   |
| 14-Pin SO (derate 8.33mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$ ) .....    | 667mW   |
| 20-Pin SO (derate 10.0mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$ ) .....    | 800mW   |
| 20-Pin TSSOP (derate 10.9mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$ ) ..... | 879mW   |
| Operating Temperature Range .....   | -40 $^\circ\text{C}$ to +85 $^\circ\text{C}$  |
| Junction Temperature .....  | +150 $^\circ\text{C}$                         |
| Storage Temperature Range .....   | -65 $^\circ\text{C}$ to +150 $^\circ\text{C}$ |
| Lead Temperature (soldering, 10s) .....   | +300 $^\circ\text{C}$                         |

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

( $V_+ = 5\text{V}$ ,  $\text{GND} = 0$ ,  $\text{VCM} = 2.5\text{V}$ ,  $\text{R}_L = 12.5\Omega$ ,  $\text{SHDN} = 0$ ,  $T_A = \text{TMIN}$  to  $\text{TMAX}$ , unless otherwise noted. Typical values specified at  $T_A = +25^\circ\text{C}$ .)

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

# ADSL Drivers/Receivers for Customer Premise Equipment

## ELECTRICAL CHARACTERISTICS—Driver (continued)

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

| 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               | $1.25V \leq V_{CM} \leq 4.5V$                                  | 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 <sub>AC</sub> | $f = 100kHz$   | 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 <sub>P-P</sub> |
| Output-Voltage Swing (Note 4)              | $V_{OH}, V_{OL}$   | $R_L = 100\Omega$  | $(V_+) - V_{OH}$         | 215       | 550 |      | mV               |
|  |                    |  | $V_{OL}$                 | 230       | 550 |      |                  |
|  |                    | $R_L = 12.5\Omega$   | $(V_+) - V_{OH}$         | 400       | 600 |      |                  |
|  |                    |  | $V_{OL}$                 | 430       | 650 |      |                  |
|  |                    | $MAX4361, R_L = 12.5\Omega, T_A = -20^\circ C$ to $85^\circ C$ | $(V_+) - V_{OH}$         | 400       | 600 |      |                  |
|  |                    |  | $V_{OL}$                 | 430       | 650 |      |                  |
| Output Short-Circuit Current               | $I_{SC}$           |  |                          | $\pm 650$ |     |      | mA               |
| Output Resistance                          | $R_{OUT}$          | MAX4361  |                          | 0.3       |     |      | $\Omega$         |
|  |                    | 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 = $V_+$                                       |                          | $\pm 10$  |     |      | $\mu A$          |
| Shutdown Output Impedance                  | $Z_{OUT(SD)}$      | $f = 1MHz$   |                          | 1.8       |     |      | $k\Omega$        |
| -3dB Bandwidth                             | BW                 | MAX4361  |                          | 40        |     |      | MHz              |
|  |                    | MAX4362/MAX4363, $G = 1$                                       |                          | 60        |     |      |                  |
| Slew Rate                                  | SR                 | $V_{OUT(DIFF)} = 7.1V_{P-P}$ step                              |                          | 30        |     |      | V/ $\mu$ s       |
| Settling Time (1%)                         | ts                 | $V_{OUT(DIFF)} = 7.1V_{P-P}$ step                              | MAX4361                  | 115       |     |      | ns               |
|  |                    |  | MAX4362/MAX4363, $G = 3$ | 165       |     |      |                  |
| Voltage-Noise Density                      | $e_n$              | $f = 100kHz$ to $1.1MHz$                                       |                          | 4.8       |     |      | nV/ $\sqrt{Hz}$  |
| Current-Noise Density                      | $i_n$              | $f = 100kHz$ to $1.1MHz$                                       |                          | 1.5       |     |      | pA/ $\sqrt{Hz}$  |
| Capacitive-Load Stability                  |                    |  |                          | 10        |     |      | nF               |
| Shutdown Delay Time                        | $t_{SHDN}$         |  |                          | 400       |     |      | ns               |
| Enable Delay Time                          | $t_{ENABLE}$       |  |                          | 2.8       |     |      | $\mu$ s          |

MAX4361/MAX4362/MAX4363

# ADSL Drivers/Receivers for Customer Premise Equipment

## ELECTRICAL CHARACTERISTICS—Receiver (MAX4363 only)

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

| 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                  | Avol                              | $1.5V \leq V_{OUT} \leq 3.5V$                              |                                     | 65    | 77        |           | dB              |
| Peak Output Current             | I <sub>OUT</sub>                  | $R_L = 50\Omega$ , inferred from Output-Voltage Swing test |                                     | 18    | 25        |           | mA              |
| Input Offset Voltage            | V <sub>OS</sub>                   |  |                                     |       | $\pm 0.5$ | $\pm 10$  | mV              |
| Input Bias Current              | I <sub>B</sub>                    |  |                                     | -0.75 | -2        |           | $\mu A$         |
| Input Offset Current            | I <sub>OS</sub>                   |  |                                     |       | $\pm 20$  | $\pm 250$ | nA              |
| Input Capacitance               | C <sub>IN</sub>                   |  |                                     |       | 1.6       |           | pF              |
| Differential Input Resistance   | R <sub>IN(DIFF)</sub>             |  |                                     | 76    |           |           | k $\Omega$      |
| Input Common-Mode Voltage Range | V <sub>CM</sub>                   | Inferred from CMRR test                                    |                                     | 0.25  | 3.80      |           | V               |
| Common-Mode Rejection Ratio     | CMRR                              | $0.25V \leq V_{CM} \leq 3.8V$                              |                                     | 70    | 87        |           | dB              |
| Power-Supply Rejection Ratio    | PSRR                              | $V_+ = 4.5V$ to $5.5V$                                     |                                     | 60    | 75        |           | dB              |
| AC Power-Supply Rejection Ratio | PSRR <sub>AC</sub>                | $f = 1MHz$   |                                     |       | 47        |           | dB              |
| Output-Voltage Swing            | V <sub>OH</sub> , V <sub>OL</sub> | $R_L = \infty$   | (V <sub>+</sub> ) - V <sub>OH</sub> | 0.64  | 1         |           | V               |
|                                 |                                   |  | V <sub>OL</sub>                     | 0.73  | 1         |           |                 |
|                                 |                                   | $R_L = 50\Omega$   | (V <sub>+</sub> ) - V <sub>OH</sub> | 1.27  | 1.5       |           |                 |
|                                 |                                   |  | V <sub>OL</sub>                     | 1.37  | 1.6       |           |                 |
| Output Short-Circuit Current    | I <sub>SC</sub>                   |  |                                     |       | $\pm 130$ |           | mA              |
| Output Resistance               | R <sub>OUT</sub>                  | $G = 1$  |                                     |       | 0.001     |           | $\Omega$        |
| Slew Rate                       | SR                                | $V_{OUT} = 1V_{P-P}$ step                                  |                                     | 160   |           |           | V/ $\mu$ s      |
| Settling Time (1%)              | t <sub>S</sub>                    | $V_{OUT} = 100mV_{P-P}$ step, $G = 1$                      |                                     | 40    |           |           | ns              |
| Voltage-Noise Density           | e <sub>n</sub>                    | $f = 1MHz$   |                                     |       | 8.5       |           | nV/ $\sqrt{Hz}$ |
| Current-Noise Density           | i <sub>n</sub>                    | $f = 1MHz$   |                                     |       | 0.5       |           | pA/ $\sqrt{Hz}$ |
| Driver-Receiver Crosstalk       | X <sub>TALK</sub>                 | $f = 100kHz$   |                                     |       | 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 ( $R_L$ ):

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

**Note 3:** Guaranteed by design.

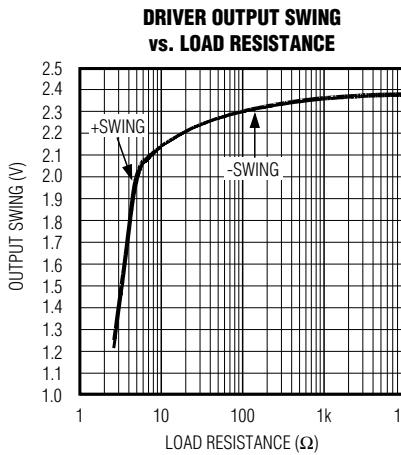
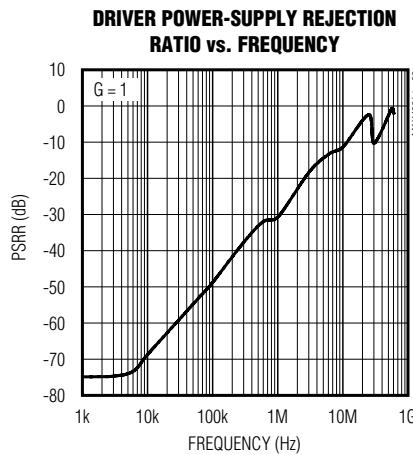
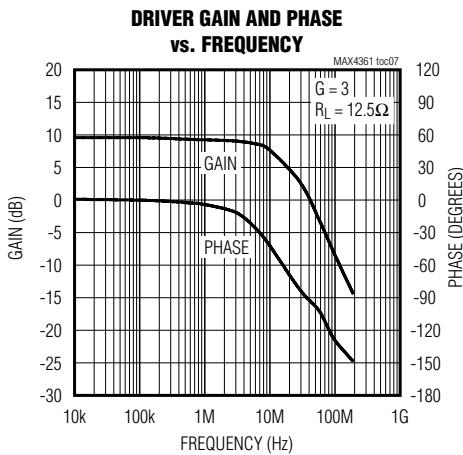
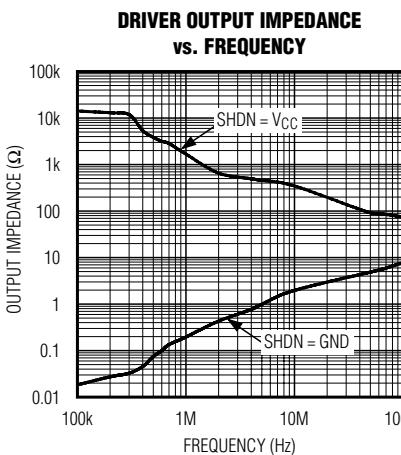
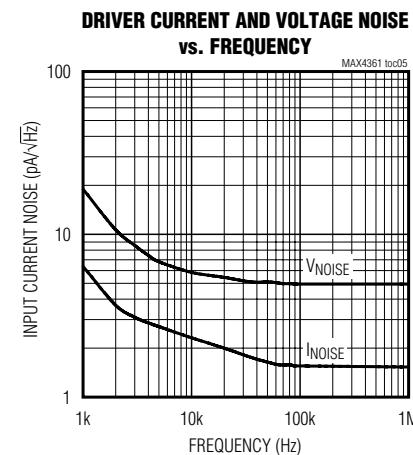
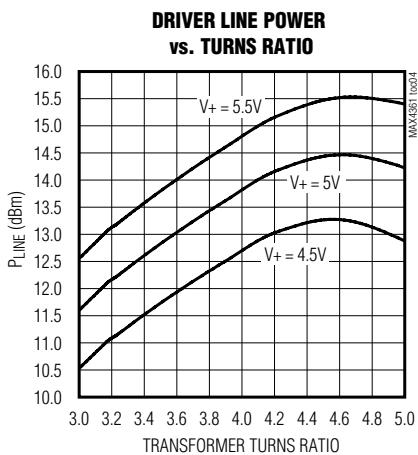
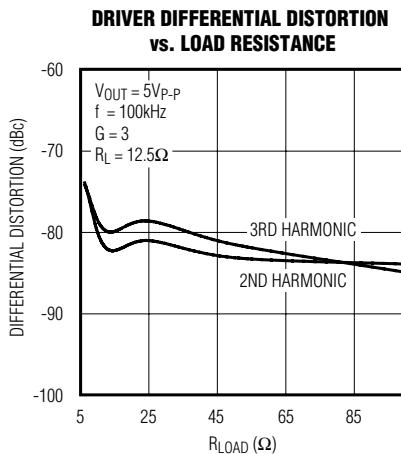
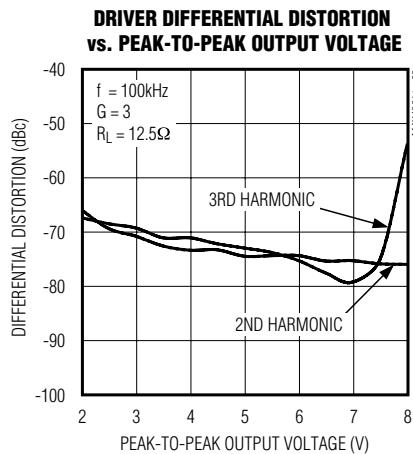
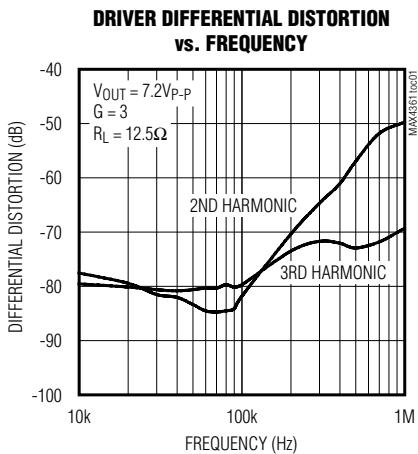
**Note 4:** May exceed absolute maximum ratings for power dissipation if unit is subject to full-scale sinusoids for long periods (see *Applications Information* section).

# ADSL Drivers/Receivers for Customer Premise Equipment

## Typical Operating Characteristics

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

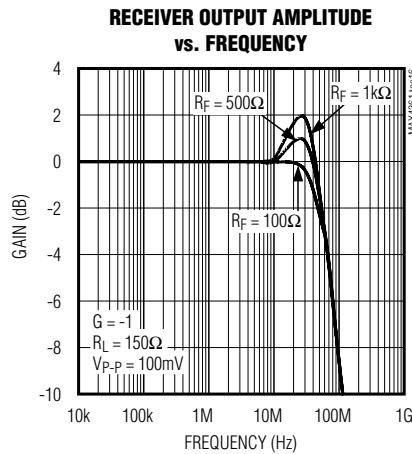
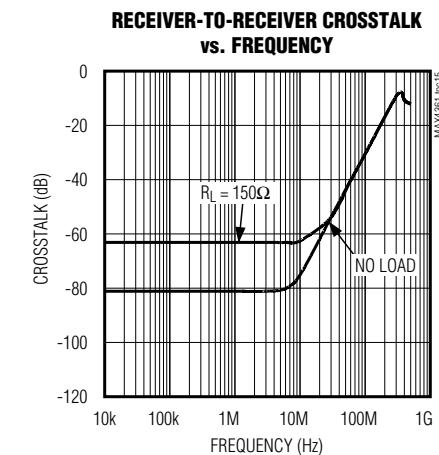
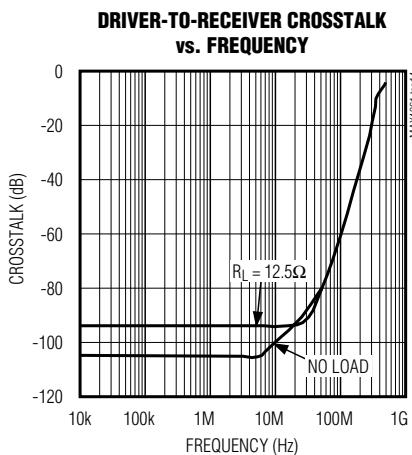
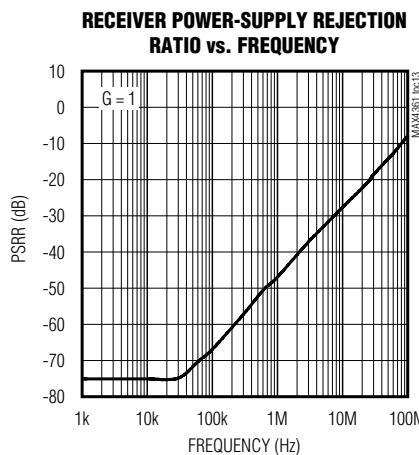
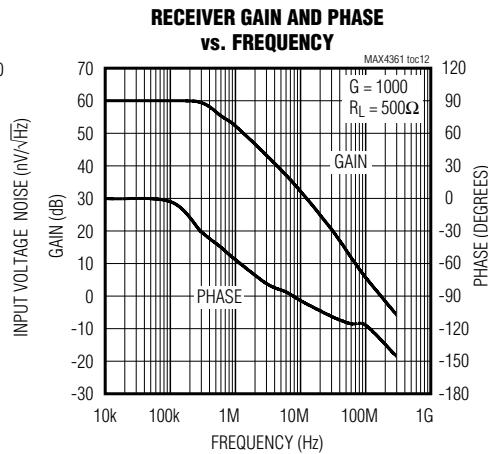
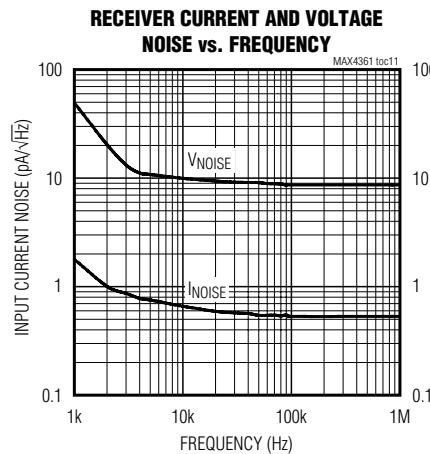
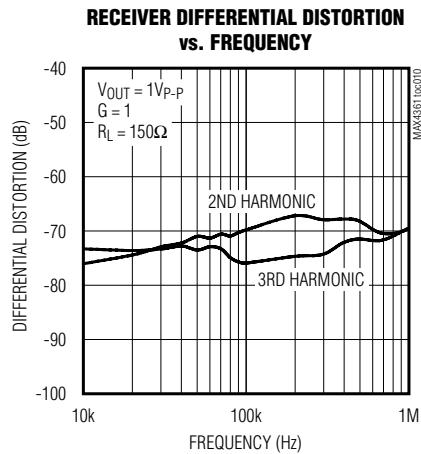
**MAX4361/MAX4362/MAX4363**



## ADSL Drivers/Receivers for Customer Premise Equipment

### Typical Operating Characteristics (continued)

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



# **ADSL Drivers/Receivers for Customer Premise Equipment**

## **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 $\mu$ 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 $\mu$ 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 $\mu$ A, and the amplifier's outputs are placed in a high-impedance disable mode. Connect SHDN to GND for normal operation.

# ADSL Drivers/Receivers for Customer Premise Equipment

## 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 $\mu$ 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 $\mu$ F to 10 $\mu$ 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 $\mu$ 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 $\mu$ F capacitor. Bypass the V+ (TX) supply to the GND (TX) pin with a separate 0.1 $\mu$ 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

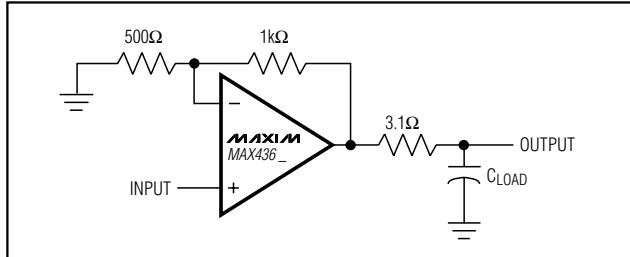


Figure 1. Driving Capacitive Load

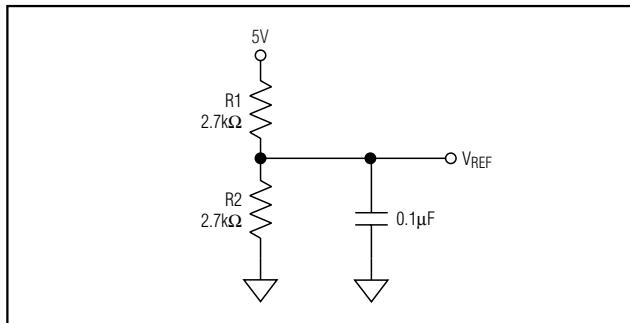


Figure 2. Voltage-Divider Reference

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 $\Omega$  for R1 and R2 will create a voltage divider that draws less than 1mA from a 5V supply. Use a decoupling capacitor (0.1 $\mu$ 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*

# ADSL Drivers/Receivers for Customer Premise Equipment

*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  $100\Omega$  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

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

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  $\mu$ MAX 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  $100\Omega$  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  $3.1\Omega$  ( $100\Omega / (2 \times 4^2)$ ), where  $100\Omega$  is the approximate phone-line impedance. The total differential load for the MAX4361/MAX4362/MAX4363, including the termination resistors, is therefore  $12.5\Omega$ . Even under these conditions the MAX4361/MAX4362/MAX4363 provide low distortion signals to within 0.6V of the power rails.

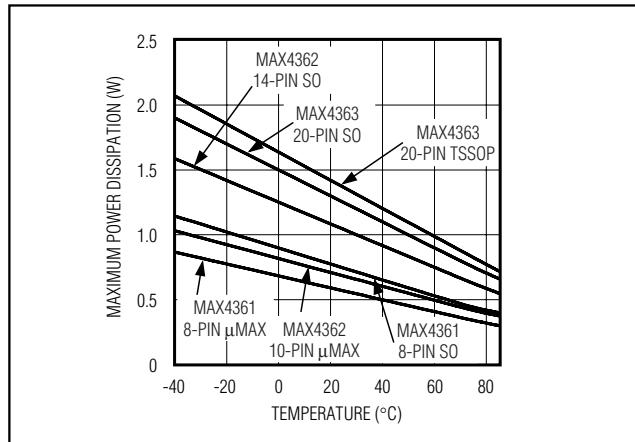


Figure 3. Maximum Power Dissipation vs. Temperature

## 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  $8.5\text{nV}/\sqrt{\text{Hz}}$  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

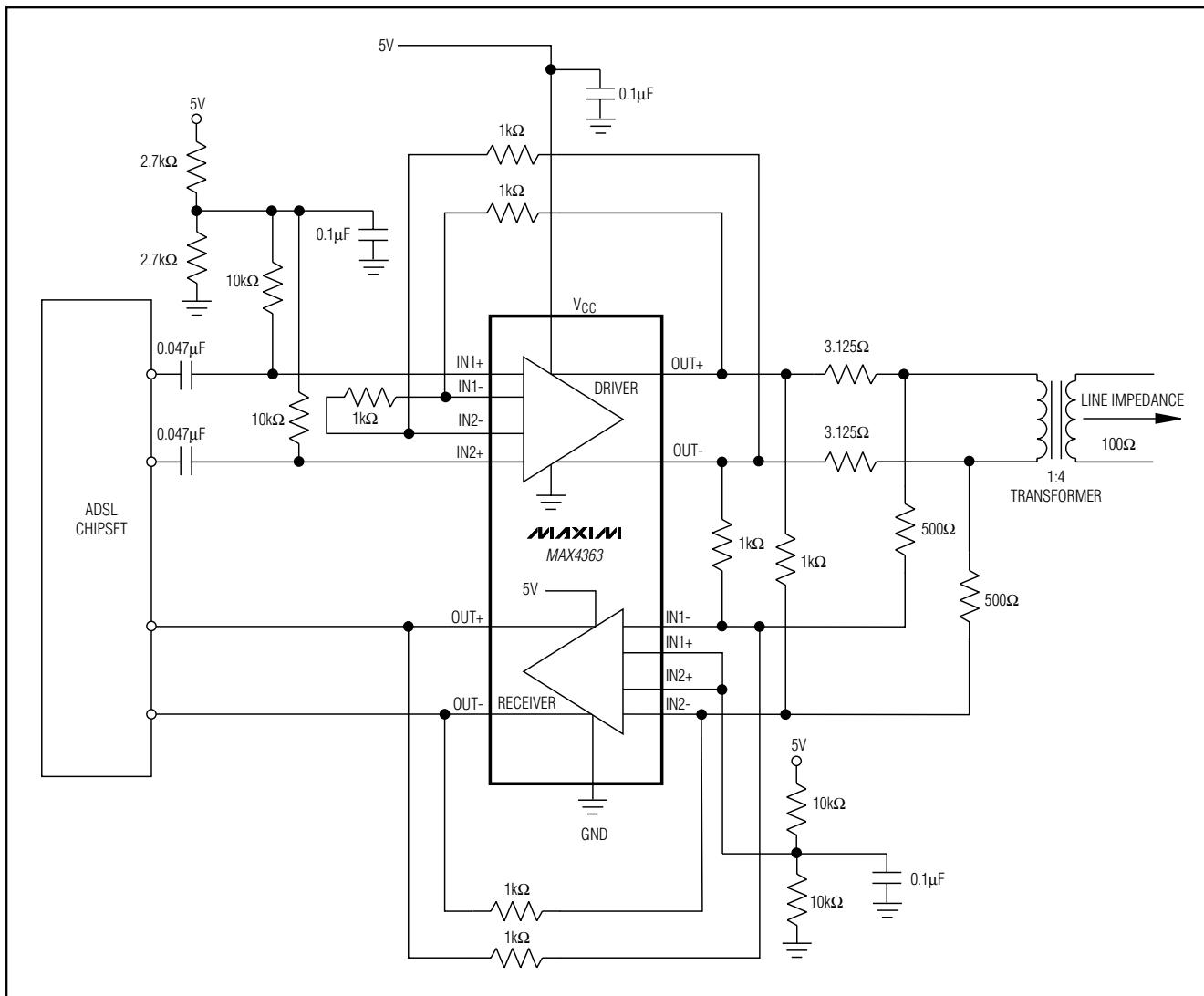
MAX4363 TRANSISTOR COUNT: 1750

PROCESS: Bipolar

# ADSL Drivers/Receivers for Customer Premise Equipment

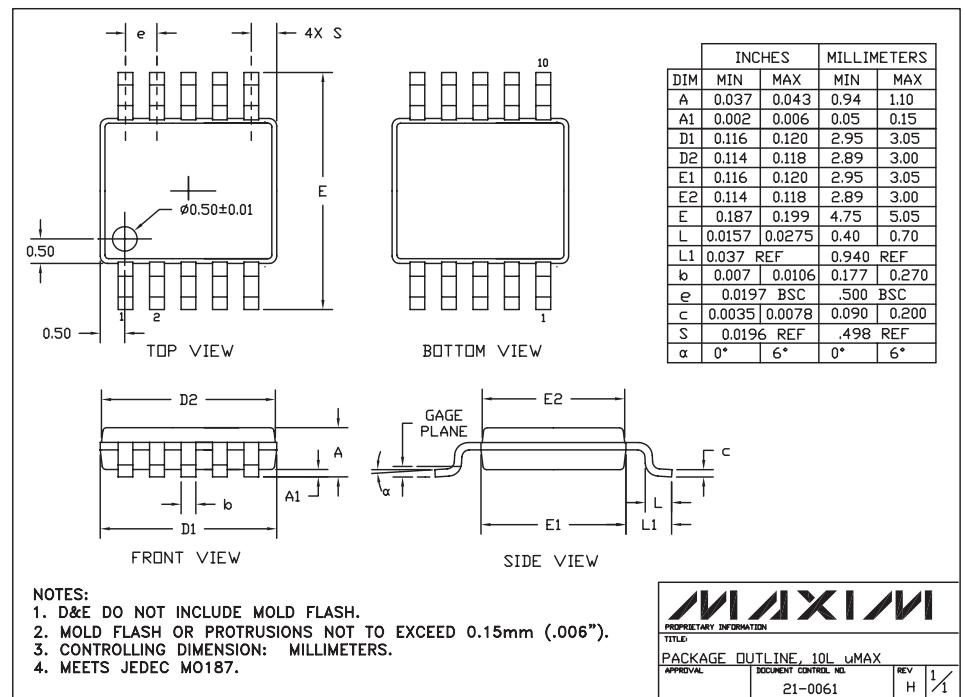
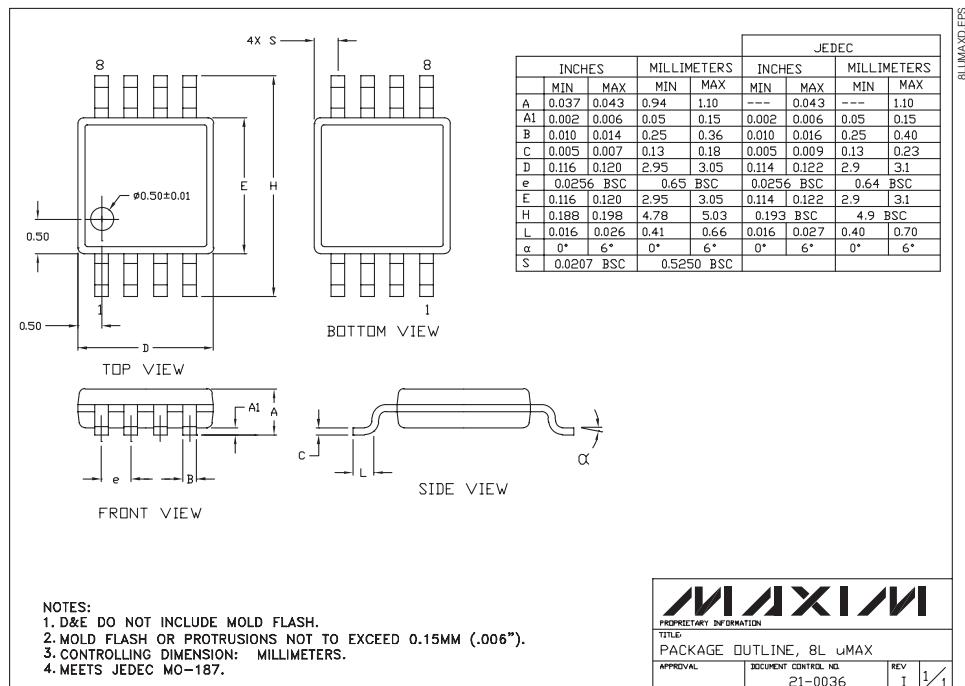
## Typical Operating Circuit

**MAX4361/MAX4362/MAX4363**



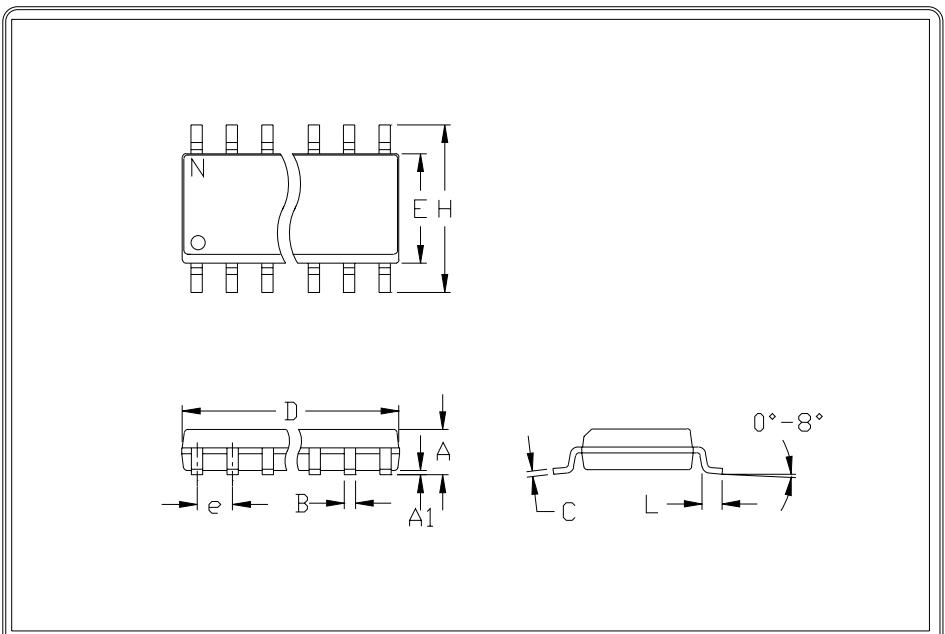
# **ADSL Drivers/Receivers for Customer Premise Equipment**

## Package Information



# **ADSL Drivers/Receivers for Customer Premise Equipment**

## **Package Information (continued)**



| 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 |      | N     | MS012 |
|--------|-------|-------------|------|-------|-------|
| MIN    | MAX   | MIN         | MAX  |       |       |
| 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

PACKAGE FAMILY OUTLINE: SOIC .150" TITLE 1/1 21-0041 A  
DOCUMENT CONTROL NUMBER REV

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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