



# 460kbps, 1 $\mu$ A Supply Current, RS-232-Compatible Transceivers in $\mu$ MAX

## General Description

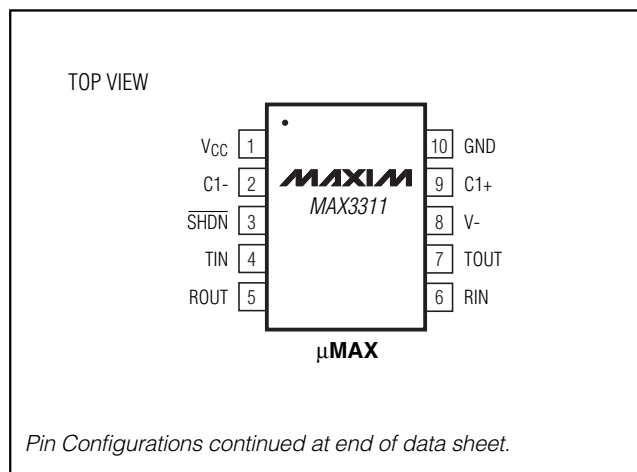
The MAX3311/MAX3313 are low-power, +5V EIA/TIA-232-compatible transceivers. Both devices have one transmitter and one receiver. The transceivers have a proprietary low-dropout transmitter output stage enabling RS-232-compatible operation from a +5V supply with a single inverting charge pump. These devices require only three 0.1 $\mu$ F capacitors and will run at data rates up to 460kbps while maintaining RS-232-compatible output levels.

The MAX3311 features a 1 $\mu$ A shutdown mode. In shutdown the device turns off the charge pump, pulls V- to ground, and the transmitter output is disabled. The MAX3313 features an **INVALID** output that asserts high when an active RS-232 cable signal is connected, signaling to the host that a peripheral is connected to the communication port.

## Applications

Digital Cameras  
PDAs  
GPS  
POS  
Telecommunications  
Handy Terminals  
Set-Top Boxes

## Pin Configurations



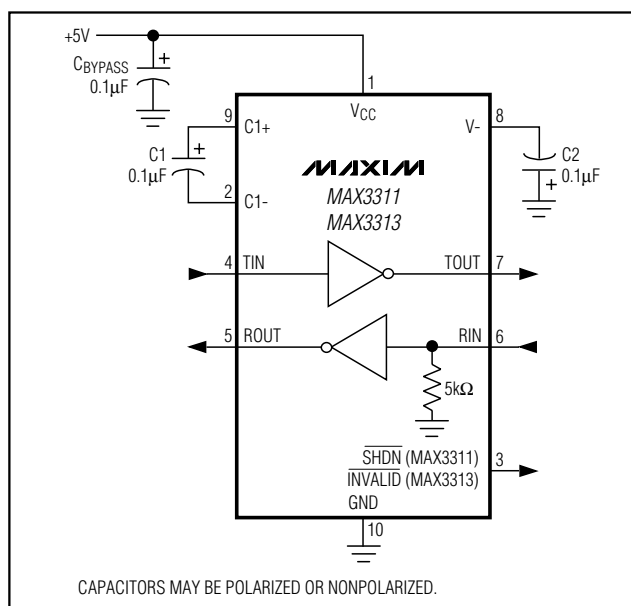
## Features

- ◆ 1 $\mu$ A Low-Power Shutdown (MAX3311)
- ◆ **INVALID** Output (MAX3313)
- ◆ Receiver Active in Shutdown (MAX3311)
- ◆ Single Transceiver (1Tx/1Rx) in 10-Pin  $\mu$ MAX
- ◆ RS-232-Compatible Operation

## Ordering Information

| PART       | TEMP. RANGE    | PIN-PACKAGE  |
|------------|----------------|--------------|
| MAX3311CUB | 0°C to +70°C   | 10 $\mu$ MAX |
| MAX3311EUB | -40°C to +85°C | 10 $\mu$ MAX |
| MAX3313CUB | 0°C to +70°C   | 10 $\mu$ MAX |
| MAX3313EUB | -40°C to +85°C | 10 $\mu$ MAX |

## Typical Operating Circuit



# 460kbps, 1 $\mu$ A Supply Current, RS-232-Compatible Transceivers in $\mu$ MAX

## ABSOLUTE MAXIMUM RATINGS

|                                                |                                   |
|------------------------------------------------|-----------------------------------|
| V <sub>CC</sub> to GND .....                   | -0.3V to +6V                      |
| V <sub>-</sub> to GND .....                    | +0.3V to -7V                      |
| V <sub>CC</sub> +  V <sub>-</sub>   .....      | +13V                              |
| Input Voltages                                 |                                   |
| TIN, $\overline{\text{SHDN}}$ to GND .....     | -0.3V to +6V                      |
| RIN to GND .....                               | $\pm 25\text{V}$                  |
| Output Voltages                                |                                   |
| TOUT to GND .....                              | $\pm 13.2\text{V}$                |
| ROUT, $\overline{\text{INVALID}}$ to GND ..... | -0.3V to (V <sub>CC</sub> + 0.3V) |
| Short-Circuit Duration                         |                                   |
| TOUT to GND .....                              | Continuous                        |

|                                                      |                 |
|------------------------------------------------------|-----------------|
| Continuous Power Dissipation                         |                 |
| 10-Pin $\mu$ MAX (derate 5.6mW/°C above +70°C) ..... | 444mW           |
| Operating Temperature Ranges                         |                 |
| MAX331_CUB .....                                     | 0°C to +70°C    |
| MAX331_EUB .....                                     | -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

(V<sub>CC</sub> = +5V, C1 and C2 = 0.1 $\mu$ F, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>. Typical values are at T<sub>A</sub> = +25°C.)

| PARAMETER                                                                   | SYMBOL          | CONDITIONS                                                | MIN                   | TYP                   | MAX     | UNITS         |
|-----------------------------------------------------------------------------|-----------------|-----------------------------------------------------------|-----------------------|-----------------------|---------|---------------|
| <b>DC CHARACTERISTICS</b>                                                   |                 |                                                           |                       |                       |         |               |
| Supply Operation Range                                                      | V <sub>CC</sub> |                                                           | 4.5                   | 5                     | 5.5     | V             |
| Supply Current                                                              |                 | $\overline{\text{SHDN}} = \text{V}_{\text{CC}}$ , no load |                       | 100                   | 250     | $\mu\text{A}$ |
| Shutdown Supply Current                                                     |                 | $\overline{\text{SHDN}} = \text{GND}$ (MAX3311 only)      |                       | 1                     | 10      | $\mu\text{A}$ |
| <b>LOGIC INPUTS (TIN, <math>\overline{\text{SHDN}}</math>)</b>              |                 |                                                           |                       |                       |         |               |
| Input Logic Threshold Low                                                   | V <sub>IL</sub> |                                                           | 0.8                   |                       |         | V             |
| Input Logic Threshold High                                                  | V <sub>IH</sub> |                                                           |                       |                       | 2.4     | V             |
| Transmitter Input Hysteresis                                                |                 |                                                           |                       | 0.5                   |         | V             |
| Input Leakage Current                                                       |                 |                                                           |                       | $\pm 0.01$            | $\pm 1$ | $\mu\text{A}$ |
| <b>RECEIVER OUTPUT</b>                                                      |                 |                                                           |                       |                       |         |               |
| Output Voltage Low                                                          | V <sub>OL</sub> | I <sub>OUT</sub> = 1.6mA                                  |                       |                       | 0.4     | V             |
| Output Voltage High                                                         | V <sub>OH</sub> | I <sub>OUT</sub> = -1.0mA                                 | V <sub>CC</sub> - 0.6 | V <sub>CC</sub> - 0.1 |         | V             |
| <b>INVALID OUTPUT (MAX3313 ONLY)</b>                                        |                 |                                                           |                       |                       |         |               |
| Receiver Input Threshold to $\overline{\text{INVALID}}$ Output High         |                 | Figure 5, positive threshold                              |                       |                       | 2.7     | V             |
|                                                                             |                 | Figure 5, negative threshold                              | -2.7                  |                       |         |               |
| Receiver Input Threshold to $\overline{\text{INVALID}}$ Output Low          |                 | Figure 5                                                  | -0.3                  |                       | 0.3     | V             |
| $\overline{\text{INVALID}}$ Output Low                                      | V <sub>OL</sub> | I <sub>OUT</sub> = 1.6mA                                  |                       |                       | 0.4     | V             |
| $\overline{\text{INVALID}}$ Output High                                     | V <sub>OH</sub> | I <sub>OUT</sub> = -1.0mA                                 | V <sub>CC</sub> - 0.6 |                       |         | V             |
| Receiver Positive or Negative Threshold to $\overline{\text{INVALID}}$ High |                 | Figure 5                                                  |                       | 0.1                   |         | $\mu\text{s}$ |
| Receiver Positive or Negative Threshold to $\overline{\text{INVALID}}$ Low  |                 | Figure 5                                                  |                       | 30                    |         | $\mu\text{s}$ |

# 460kbps, 1μA Supply Current, RS-232-Compatible Transceivers in μMAX

MAX3311/MAX3313

## ELECTRICAL CHARACTERISTICS (continued)

(V<sub>CC</sub> = +5V, C1 and C2 = 0.1μF, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>. Typical values are at T<sub>A</sub> = +25°C.)

| PARAMETER                    | SYMBOL          | CONDITIONS                                    | MIN  | TYP | MAX | UNITS |
|------------------------------|-----------------|-----------------------------------------------|------|-----|-----|-------|
| <b>RECEIVER INPUT</b>        |                 |                                               |      |     |     |       |
| Input Threshold Low          | V <sub>IL</sub> |                                               | 0.8  |     |     | V     |
| Input Threshold High         | V <sub>IH</sub> |                                               |      |     | 2.4 | V     |
| Input Hysteresis             |                 |                                               |      | 0.5 |     | V     |
| Input Resistance             |                 |                                               |      | 5   |     | kΩ    |
| <b>TRANSMITTER OUTPUT</b>    |                 |                                               |      |     |     |       |
| Output Voltage Swing         |                 | Transmitter output loaded with 3kΩ to ground  | ±3.7 |     |     | V     |
| Output Resistance (Note 1)   |                 | V <sub>CC</sub> = 0, transmitter output = ±2V | 300  |     |     | Ω     |
| Output Short-Circuit Current |                 |                                               |      |     | ±60 | mA    |
| Output Leakage Current       |                 | V <sub>OUT</sub> = ±12V, transmitter disabled |      |     | ±25 | μA    |

**Note 1:** Not tested—guaranteed by design.

## TIMING CHARACTERISTICS

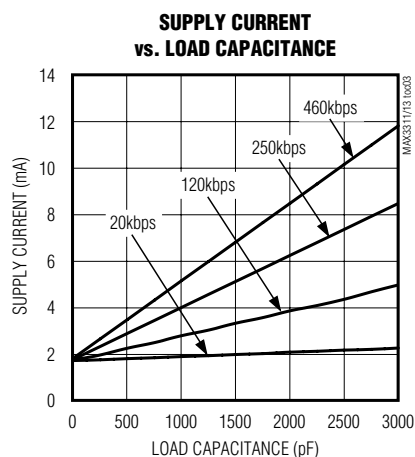
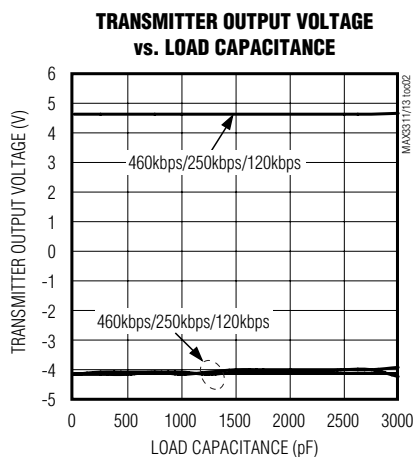
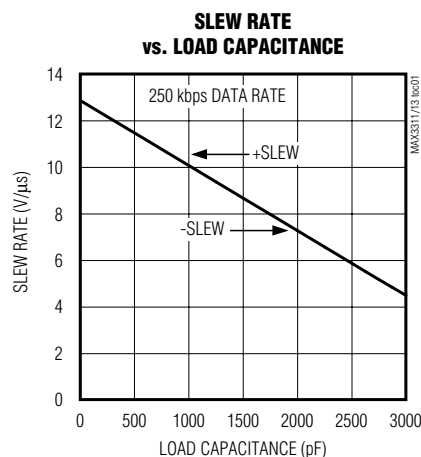
(V<sub>CC</sub> = +5V, C1 and C2 = 0.1μF, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>. Typical values are at T<sub>A</sub> = +25°C.)

| PARAMETER                   | SYMBOL                                 | CONDITIONS                                                                                                    | MIN | TYP  | MAX | UNITS |
|-----------------------------|----------------------------------------|---------------------------------------------------------------------------------------------------------------|-----|------|-----|-------|
| Maximum Data Rate           |                                        | R <sub>L</sub> = 3kΩ, C <sub>L</sub> = 1000pF                                                                 | 460 |      |     | kbps  |
| Receiver Propagation Delay  | t <sub>PLH</sub> ,<br>t <sub>PHL</sub> | Receiver input to receiver output<br>C <sub>L</sub> = 150pF                                                   |     | 0.15 |     | μs    |
| Transmitter Skew            |                                        |                                                                                                               |     | 100  |     | ns    |
| Receiver Skew               |                                        |                                                                                                               |     | 50   |     | ns    |
| Transition Region Slew Rate |                                        | R <sub>L</sub> = 3kΩ to 7kΩ, C <sub>L</sub> = 150pF to 1000pF,<br>measured from +3V to -3V or from -3V to +3V |     | 11   |     | V/μs  |

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## Typical Operating Characteristics

( $V_{CC}$  = +5V, 0.1 $\mu$ F capacitors, transmitter loaded with 3k $\Omega$  and  $C_L$ ,  $T_A$  = +25°C, unless otherwise noted.)



## Pin Description

| PIN     |         | NAME                 | FUNCTION                                                                                                                     |
|---------|---------|----------------------|------------------------------------------------------------------------------------------------------------------------------|
| MAX3311 | MAX3313 |                      |                                                                                                                              |
| 1       | 1       | $V_{CC}$             | +5V External Power Supply. Decouple with a 0.1 $\mu$ F capacitor to ground.                                                  |
| 2       | 2       | C1-                  | Negative Terminal of the Voltage Inverter Charge-Pump Capacitor                                                              |
| 3       | —       | $\overline{SHDN}$    | Shutdown Active-Low (0 = off, 1 = on)                                                                                        |
| —       | 3       | $\overline{INVALID}$ | Valid Signal Detector Output, Active-Low. A logic high indicates that a valid RS-232 level is present on the receiver input. |
| 4       | 4       | TIN                  | TTL/CMOS Transmitter Input                                                                                                   |
| 5       | 5       | ROUT                 | TTL/CMOS Receiver Output                                                                                                     |
| 6       | 6       | RIN                  | RS-232 Receiver Input                                                                                                        |
| 7       | 7       | TOUT                 | RS-232-Compatible Transmitter Output                                                                                         |
| 8       | 8       | V-                   | -4.3V generated by the charge pump. Connect a 0.1 $\mu$ F capacitor to ground.                                               |
| 9       | 9       | C1+                  | Positive Terminal of the Voltage Inverter Charge-Pump Capacitor                                                              |
| 10      | 10      | GND                  | Ground                                                                                                                       |

# 460kbps, 1 $\mu$ A Supply Current, RS-232-Compatible Transceivers in $\mu$ MAX

## Detailed Description

### Single Charge-Pump Voltage Converter

The MAX3311/MAX3313 internal power supply has a single inverting charge pump that provides a negative voltage from a single +5V supply. The charge pump operates in a discontinuous mode and requires a flying capacitor (C1) and a reservoir capacitor (C2) to generate the V- supply.

### RS-232-Compatible Driver

The transmitter is an inverting level translator that converts CMOS-logic levels to EIA/TIA-232-compatible levels. It guarantees data rates up to 460kbps with worst-case loads of 3k $\Omega$  in parallel with 1000pF. When  $\overline{\text{SHDN}}$  is driven low, the transmitter is disabled and put into three state. The transmitter input does not have an internal pullup resistor.

### RS-232 Receiver

The MAX3311/MAX3313 receiver converts RS-232 signals to CMOS-logic output levels. The MAX3311 receiver will remain active during shutdown mode. The MAX3313  $\overline{\text{INVALID}}$  indicates when an RS-232 signal is present at the receiver input, and therefore when the port is in use.

The MAX3313  $\overline{\text{INVALID}}$  output is pulled low when no valid RS-232 signal level is detected on the receiver input.

### MAX3311 Shutdown Mode

In shutdown mode, the charge pump is turned off, V- is pulled to ground, and the transmitter output is disabled (Table 1). This reduces supply current typically to 1 $\mu$ A. The time required to exit shutdown is typically less than 100 $\mu$ s.

## Applications Information

### Capacitor Selection

The capacitor type used for C1 and C2 is not critical for proper operation; either polarized or nonpolarized capacitors are acceptable. If polarized capacitors are used, connect polarity as shown in the *Typical Operating Circuit*. The charge pump requires 0.1 $\mu$ F capacitors. Increasing the capacitor values (e.g., by a

factor of 2) reduces power consumption. C2 can be increased without changing C1's value. However, do not increase C1's value without also increasing the value of C2 and CBYPASS to maintain the proper ratios (C1 to the other capacitors).

When using the minimum 0.1 $\mu$ F capacitors, make sure the capacitance does not degrade excessively with temperature. If in doubt, use capacitors with a larger nominal value. The capacitor's equivalent series resistance (ESR) usually rises at low temperatures and influences the amount of ripple on V-.

To reduce the output impedance at V-, use larger capacitors (up to 10 $\mu$ F).

Bypass VCC to ground with at least 0.1 $\mu$ F. In applications sensitive to power-supply noise generated by the charge pump, decouple VCC to ground with a capacitor the same size as (or larger than) charge-pump capacitors C1 and C2.

### Transmitter Output when Exiting Shutdown

Figure 1 shows the transmitter output when exiting shutdown mode. The transmitter is loaded with 3k $\Omega$  in parallel with 1000pF. The transmitter output displays no ringing or undesirable transients as the MAX3311 comes out of shutdown. Note that the transmitter is enabled only when the magnitude of V- exceeds approximately -3V.

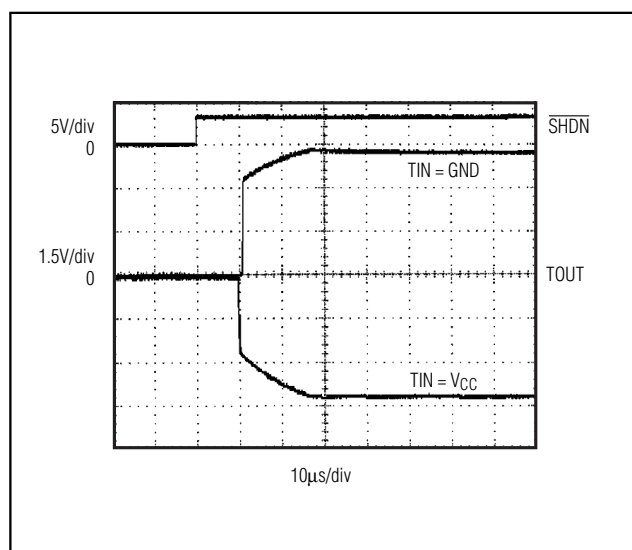


Figure 1. Transmitter Output when Exiting Shutdown or Powering Up

Table 1. MAX3311 Shutdown Logic Truth Table

| $\overline{\text{SHDN}}$ | TRANSMITTER OUTPUT | RECEIVER OUTPUT | CHARGE PUMP |
|--------------------------|--------------------|-----------------|-------------|
| L                        | High Z             | Active          | Inactive    |
| H                        | Active             | Active          | Active      |

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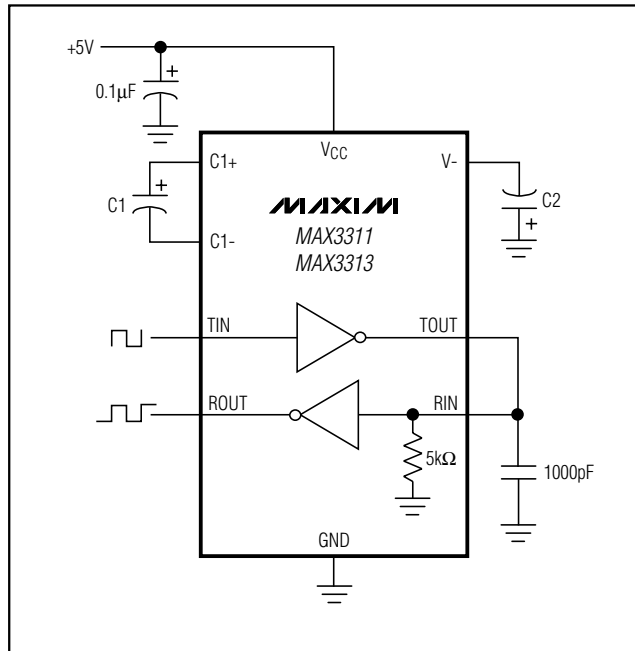


Figure 2. Loopback Test Circuit

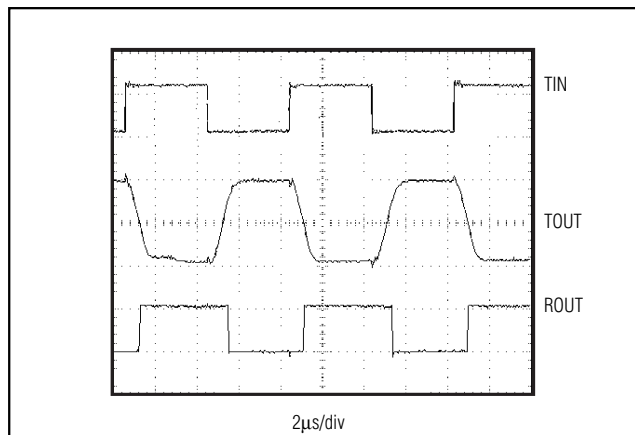


Figure 4. Loopback Test Results at 250kbps

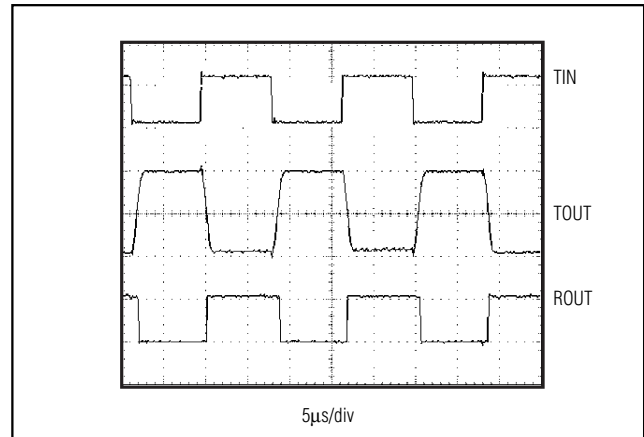


Figure 3. Loopback Test Results at 120kbps

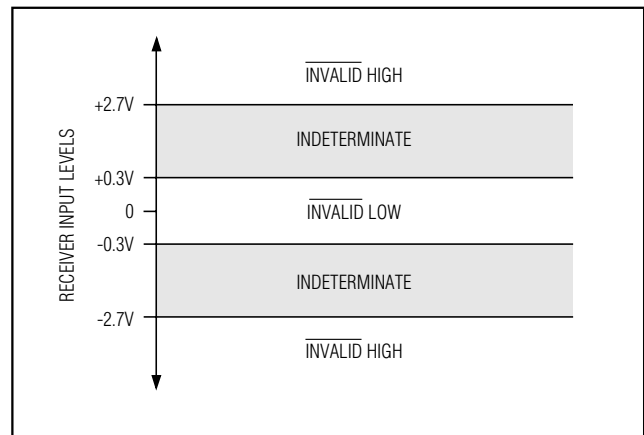


Figure 5. Receiver Positive/Negative Thresholds for  $\overline{\text{INVALID}}$

## High Data Rates

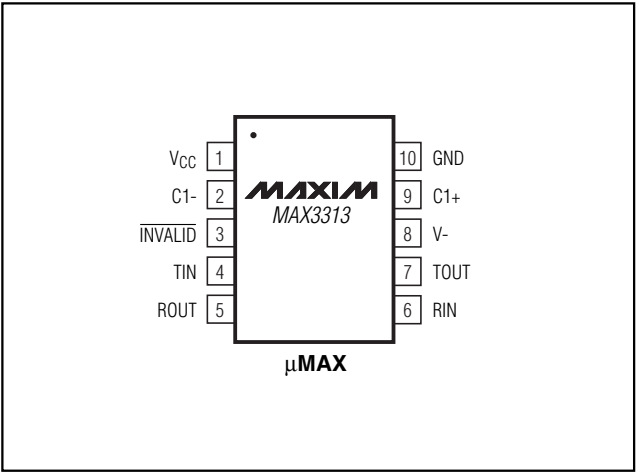
The MAX3311/MAX3313 maintain RS-232-compatible transmitter output voltage ( $\pm 3.7\text{V}$  minimum) even at high data rates. Figure 2 shows a transmitter loopback test circuit. Figure 3 shows the loopback test result at 120kbps, and Figure 4 shows the same test at 250kbps.

# 460kbps, 1 $\mu$ A Supply Current, RS-232-Compatible Transceivers in $\mu$ MAX

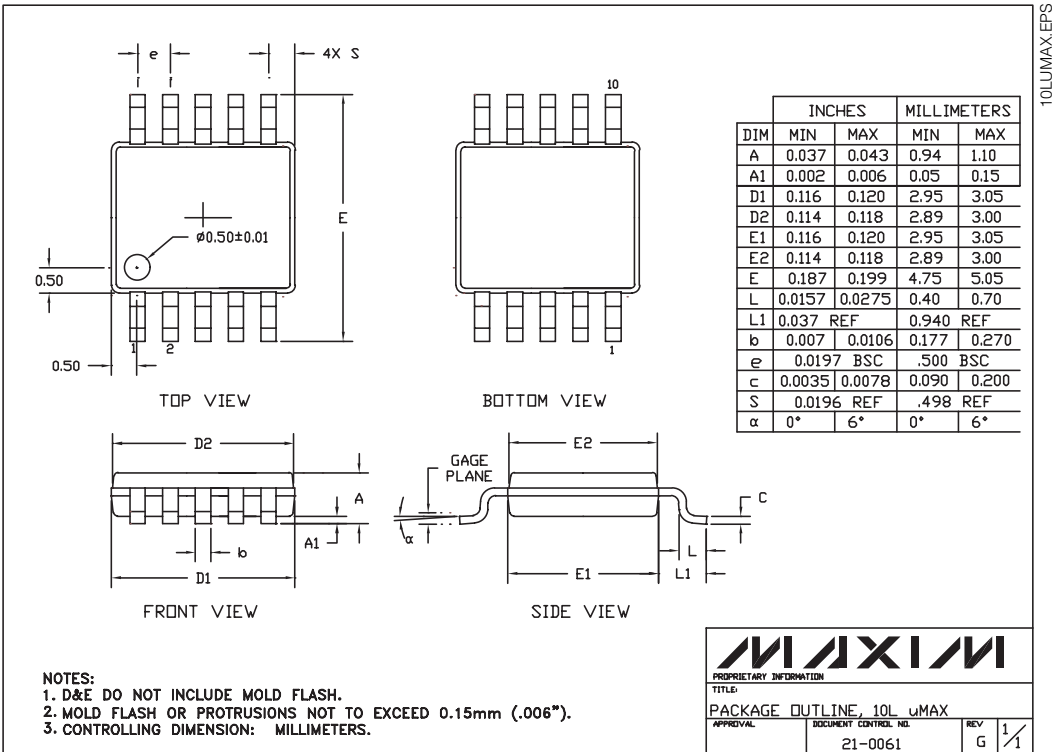
## Chip Information

TRANSISTOR COUNT: 278

## Pin Configurations (continued)



## Package Information



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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