



# 1 $\mu$ A Supply-Current, True +3V to +5.5V RS-232 Transceivers with AutoShutdown

## General Description

The MAX3221/MAX3223/MAX3243 achieve 1 $\mu$ A supply current with Maxim's revolutionary AutoShutdown™ feature. When the MAX3221/MAX3223/MAX3243 do not sense a valid signal level on their receiver inputs, the on-board power supply and drivers shut down. This occurs if the RS-232 cable is disconnected or if the transmitters of the connected peripheral are turned off. The system turns on again when a valid level is applied to any RS-232 receiver input. As a result, the system saves power without changes to the existing BIOS or operating system.

The MAX3221/MAX3223/MAX3243 transceivers are 3V-powered EIA/TIA-232 and V.28/V.24 communications interfaces intended for notebook computer applications. A proprietary, high-efficiency, dual charge-pump power supply and a low-dropout transmitter combine to deliver true RS-232 performance from a single +3.0V to +5.5V supply. A guaranteed data rate of 120kbps provides compatibility with popular software for communicating with personal computers.

The MAX3221/MAX3223/MAX3243 require only 0.1 $\mu$ F capacitors in 3.3V operation, and can operate from input voltages ranging from +3.0V to +5.5V. They are ideal for 3.3V-only systems, mixed 3.3V and 5.0V systems, or 5.0V-only systems that require true RS-232 performance.

The MAX3221 is a 1-driver/1-receiver 16-pin SSOP version of the 20-pin MAX3223 (2-driver/2-receiver). The MAX3243 3-driver/5-receiver, complete serial port is ideal for notebook or subnotebook computers. The MAX3243 includes one complementary always-active receiver. This receiver can monitor an external device (such as a modem) in shutdown, without forward biasing the protection diodes in a UART that may have VCC completely removed.

## Selector Guide

| PART    | Tx | Rx | VCC RANGE (V) | AutoShutdown |
|---------|----|----|---------------|--------------|
| MAX3221 | 1  | 1  | 3.0 to 5.5    | Yes          |
| MAX3223 | 2  | 2  | 3.0 to 5.5    | Yes          |
| MAX3243 | 3  | 5  | 3.0 to 5.5    | Yes          |

*Pin Configurations appear at end of data sheet.*

*Typical Operating Circuits appear at end of data sheet.*

†Future product—contact factory for availability.

AutoShutdown and UCSP are trademarks of Maxim Integrated Products, Inc.

## Next Generation Device Features

- ◆ **For Space-Constrained Applications:**  
MAX3228/MAX3229: +2.5V to +5.5V RS-232 Transceivers in UCSP™
- ◆ **For Integrated ESD Protection:**  
MAX3222E/MAX3232E/MAX3237E/MAX3241E/  
MAX3246E:  $\pm 15$ kV ESD-Protected, Down to 10nA, 3.0V to 5.5V, Up to 1Mbps, True RS-232 Transceivers (MAX3246E Available in UCSP Package)
- ◆ **For Low-Voltage or Data Cable Applications:**  
MAX3380E/MAX3381E: +2.5V to +5.5V, 1 $\mu$ A, 2 Tx/2 Rx RS-232 Transceivers with  $\pm 15$ kV ESD-Protected I/O and Logic Pins

## Applications

Notebook, Subnotebook, and Palmtop Computers  
Battery-Powered Equipment  
Hand-Held Equipment  
Peripherals  
Printers

## Ordering Information

| PART        | TEMP RANGE     | PIN-PACKAGE    |
|-------------|----------------|----------------|
| MAX3221CAE  | 0°C to +70°C   | 16 SSOP        |
| MAX3221CUE† | 0°C to +70°C   | 16 TSSOP       |
| MAX3221EAE  | -40°C to +85°C | 16 SSOP        |
| MAX3221EUE† | -40°C to +85°C | 16 TSSOP       |
| MAX3223CPP  | 0°C to +70°C   | 20 Plastic DIP |
| MAX3223CAP  | 0°C to +70°C   | 20 SSOP        |
| MAX3223CUP  | 0°C to +70°C   | 20 TSSOP       |
| MAX3223EPP  | -40°C to +85°C | 20 Plastic DIP |
| MAX3223EAP  | -40°C to +85°C | 20 SSOP        |
| MAX3223EUP  | -40°C to +85°C | 20 TSSOP       |
| MAX3243CWI  | 0°C to +70°C   | 28 Wide SO     |
| MAX3243CAI  | 0°C to +70°C   | 28 SSOP        |
| MAX3243CUI  | 0°C to +70°C   | 28 TSSOP       |
| MAX3243EWI  | -40°C to +85°C | 28 Wide SO     |
| MAX3243EAI  | -40°C to +85°C | 28 SSOP        |
| MAX3243EUI  | -40°C to +85°C | 28 TSSOP       |

MAX3221/MAX3223/MAX3243



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## ABSOLUTE MAXIMUM RATINGS

|                                                                             |                                   |
|-----------------------------------------------------------------------------|-----------------------------------|
| V <sub>CC</sub> .....                                                       | -0.3V to +6V                      |
| V+ (Note 1) .....                                                           | -0.3V to +7V                      |
| V- (Note 1) .....                                                           | +0.3V to -7V                      |
| V+ +  V-  (Note 1) .....                                                    | +13V                              |
| Input Voltages                                                              |                                   |
| T <sub>IN</sub> , FORCEOFF, FORCEON, $\overline{\text{EN}}$ (MAX3223) ..... | -0.3V to +6V                      |
| R <sub>IN</sub> .....                                                       | $\pm 25\text{V}$                  |
| Output Voltages                                                             |                                   |
| T <sub>OUT</sub> .....                                                      | $\pm 13.2\text{V}$                |
| R <sub>OUT</sub> , INVALID .....                                            | -0.3V to (V <sub>CC</sub> + 0.3V) |
| Short-Circuit Duration                                                      |                                   |
| T <sub>OUT</sub> .....                                                      | Continuous                        |
| Continuous Power Dissipation (T <sub>A</sub> = +70°C)                       |                                   |

|                                                          |                |
|----------------------------------------------------------|----------------|
| 16-Pin SSOP (derate 7.14mW/°C above +70°C) .....         | 571mW          |
| 16-Pin TSSOP (derate 6.70mW/°C above +70°C) .....        | 533mW          |
| 20-Pin Plastic DIP (derate 11.11mW/°C above +70°C) ..... | 889mW          |
| 20-Pin SSOP (derate 8.00mW/°C above +70°C) .....         | 640mW          |
| 20-Pin TSSOP DIP (derate 7.00mW/°C above +70°C) .....    | 559mW          |
| 28-Pin Wide SO (derate 12.50mW/°C above +70°C) .....     | 1W             |
| 28-Pin SSOP (derate 9.52mW/°C above +70°C) .....         | 762mW          |
| 28-Pin TSSOP (derate 8.70mW/°C above +70°C) .....        | 696mW          |
| Operating Temperature Ranges                             |                |
| MAX32_ _C_ .....                                         | 0°C to +70°C   |
| MAX32_ _E_ .....                                         | -40°C to +85°C |
| Storage Temperature Range .....                          |                |
| Lead Temperature (soldering, 10s) .....                  |                |
| .....                                                    |                |
| +300°C                                                   |                |

**Note 1:** V+ and V- can have maximum magnitudes of 7V, but their absolute difference cannot exceed 13V.

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> = +3.0V to +5.5V, C1–C4 = 0.1 $\mu$ F (Note 2), T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.)

| PARAMETER                                                                    | CONDITIONS                                                   |                                                                        | MIN  | TYP                   | MAX                   | UNITS |
|------------------------------------------------------------------------------|--------------------------------------------------------------|------------------------------------------------------------------------|------|-----------------------|-----------------------|-------|
| DC CHARACTERISTICS                                                           |                                                              |                                                                        |      |                       |                       |       |
| Supply Current, AutoShutdown                                                 | V <sub>CC</sub> = 3.3V<br>or 5.0V,<br>T <sub>A</sub> = +25°C | All R <sub>IN</sub> open, FORCEON = GND,<br>FORCEOFF = V <sub>CC</sub> |      | 1.0                   | 10                    | μA    |
| Supply Current, Shutdown                                                     |                                                              | FORCEOFF = GND                                                         |      | 1.0                   | 10                    | μA    |
| Supply Current,<br>AutoShutdown Disabled                                     |                                                              | FORCEON = FORCEOFF = V <sub>CC</sub> ,<br>no load                      |      | 0.3                   | 1.0                   | mA    |
| LOGIC INPUTS AND RECEIVER OUTPUTS                                            |                                                              |                                                                        |      |                       |                       |       |
| Input Logic Threshold Low                                                    | T <sub>IN</sub> , FORCEON, FORCEOFF, EN (MAX3223)            |                                                                        |      | 0.8                   |                       | V     |
| Input Logic Threshold High                                                   | T <sub>IN</sub> , EN, FORCEON, FORCEOFF                      | V <sub>CC</sub> = 3.3V                                                 | 2.0  |                       | V                     |       |
|                                                                              |                                                              | V <sub>CC</sub> = 5.0V                                                 | 2.4  |                       |                       |       |
| Input Leakage Current                                                        | T <sub>IN</sub> , EN, FORCEON, FORCEOFF                      |                                                                        |      | ±0.01                 | ±1.0                  | μA    |
| Output Leakage Current                                                       | Receivers disabled                                           |                                                                        |      | ±0.05                 | ±10                   | μA    |
| Output Voltage Low                                                           | I <sub>OUT</sub> = 1.6mA                                     |                                                                        |      | 0.4                   |                       | V     |
| Output Voltage High                                                          | I <sub>OUT</sub> = -1.0mA                                    |                                                                        |      | V <sub>CC</sub> - 0.6 | V <sub>CC</sub> - 0.1 | V     |
| AUTOSHUTDOWN (FORCEON = GND, FORCEOFF = V <sub>CC</sub> )                    |                                                              |                                                                        |      |                       |                       |       |
| Receiver Input Thresholds to Transmitters Enabled                            | Figure 5                                                     | Positive threshold                                                     | 2.7  |                       | V                     |       |
|                                                                              |                                                              | Negative threshold                                                     | -2.7 |                       |                       |       |
| Receiver Input Thresholds to Transmitters Disabled                           | 1μA supply current, Figure 5                                 |                                                                        |      | -0.3                  | 0.3                   | V     |
| INVALID Output Voltage Low                                                   | I <sub>OUT</sub> = 1.6mA                                     |                                                                        |      | 0.4                   |                       | V     |
| INVALID Output Voltage High                                                  | I <sub>OUT</sub> = -1.0mA                                    |                                                                        |      | V <sub>CC</sub> - 0.6 |                       | V     |
| Receiver Threshold to Transmitters Enabled (t <sub>WU</sub> )                | Figure 5                                                     |                                                                        |      | 250                   |                       | μs    |
| Receiver Positive or Negative Threshold to INVALID High (t <sub>INVH</sub> ) | Figure 5                                                     |                                                                        |      | 1                     |                       | μs    |
| Receiver Positive or Negative Threshold to INVALID Low (t <sub>INVL</sub> )  | Figure 5                                                     |                                                                        |      | 30                    |                       | μs    |

# 1 $\mu$ A Supply-Current, True +3V to +5.5V RS-232 Transceivers with AutoShutdown

MAX3221/MAX3223/MAX3243

## ELECTRICAL CHARACTERISTICS (continued)

(V<sub>CC</sub> = +3.0V to +5.5V, C<sub>1</sub>–C<sub>4</sub> = 0.1 $\mu$ F (Note 2), T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.)

| PARAMETER                    | CONDITIONS                                                                                                          |                                  | MIN      | TYP  | MAX | UNITS |
|------------------------------|---------------------------------------------------------------------------------------------------------------------|----------------------------------|----------|------|-----|-------|
| RECEIVER INPUTS              |                                                                                                                     |                                  |          |      |     |       |
| Input Voltage Range          |                                                                                                                     |                                  | -25      |      | 25  | V     |
| Input Threshold Low          | T <sub>A</sub> = +25°C                                                                                              | V <sub>CC</sub> = 3.3V           | 0.6      | 1.2  |     | V     |
|                              |                                                                                                                     | V <sub>CC</sub> = 5.0V           | 0.8      | 1.5  |     |       |
| Input Threshold High         | T <sub>A</sub> = +25°C                                                                                              | V <sub>CC</sub> = 3.3V           |          | 1.5  | 2.4 | V     |
|                              |                                                                                                                     | V <sub>CC</sub> = 5.0V           |          | 1.8  | 2.4 |       |
| Input Hysteresis             |                                                                                                                     |                                  |          | 0.3  |     | V     |
| Input Resistance             | T <sub>A</sub> = +25°C                                                                                              |                                  | 3        | 5    | 7   | kΩ    |
| TRANSMITTER OUTPUTS          |                                                                                                                     |                                  |          |      |     |       |
| Output Voltage Swing         | All transmitter outputs loaded with 3kΩ to ground                                                                   |                                  | ±5.0     | ±5.4 |     | V     |
| Output Resistance            | V <sub>CC</sub> = V+ = V- = 0V, transmitter output = ±2V                                                            |                                  | 300      | 10M  |     | Ω     |
| Output Short-Circuit Current |                                                                                                                     |                                  |          | ±35  | ±60 | mA    |
| Output Leakage Current       | V <sub>OUT</sub> = ±12V, V <sub>CC</sub> = 0V or 3.0V to 5.5V, transmitters disabled                                |                                  |          |      | ±25 | μA    |
| MOUSE DRIVEABILITY (MAX3243) |                                                                                                                     |                                  |          |      |     |       |
| Transmitter Output Voltage   | T1IN = T2IN = GND, T3IN = V <sub>CC</sub> , T3OUT loaded with 3kΩ to GND, T1OUT and T2OUT loaded with 2.5mA each    |                                  | ±5       |      |     | V     |
| TIMING CHARACTERISTICS       |                                                                                                                     |                                  |          |      |     |       |
| Maximum Data Rate            | R <sub>L</sub> = 3kΩ, C <sub>L</sub> = 1000pF, one transmitter switching                                            |                                  | 120      | 235  |     | kbps  |
| Receiver Propagation Delay   | Receiver input to receiver output, C <sub>L</sub> = 150pF                                                           | t <sub>PHL</sub>                 | 0.3      |      |     | μs    |
|                              |                                                                                                                     | t <sub>PLH</sub>                 | 0.3      |      |     |       |
| Receiver Output Enable Time  | Normal operation                                                                                                    |                                  | 200      |      |     | ns    |
| Receiver Output Disable Time | Normal operation                                                                                                    |                                  | 200      |      |     | ns    |
| Transmitter Skew             | t <sub>PHL</sub> - t <sub>PLH</sub>                                                                                 | MAX3221/MAX3223                  | 200      |      |     | ns    |
|                              |                                                                                                                     | MAX3243                          | 200 1000 |      |     |       |
| Receiver Skew                | t <sub>PHL</sub> - t <sub>PLH</sub>                                                                                 | MAX3221/MAX3223                  | 100      |      |     | ns    |
|                              |                                                                                                                     | MAX3243                          | 100 500  |      |     |       |
| Transition-Region Slew Rate  | V <sub>CC</sub> = 3.3V, R <sub>L</sub> = 3kΩ to 7kΩ, T <sub>A</sub> = +25°C, measured from +3V to -3V or -3V to +3V | C <sub>L</sub> = 200pF to 2500pF | 4        | 8.0  | 30  | V/μs  |
|                              |                                                                                                                     | C <sub>L</sub> = 200pF to 1000pF | 6        |      | 30  |       |

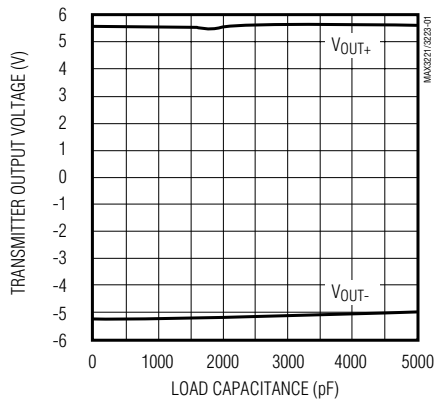
**Note 2:** C<sub>1</sub>–C<sub>4</sub> = 0.1 $\mu$ F, tested at 3.3V  $\pm$ 10%. C<sub>1</sub> = 0.047 $\mu$ F, C<sub>2</sub>–C<sub>4</sub> = 0.33 $\mu$ F, tested at 5.0V  $\pm$ 10%.

# 1 $\mu$ A Supply-Current, True +3V to +5.5V RS-232 Transceivers with AutoShutdown

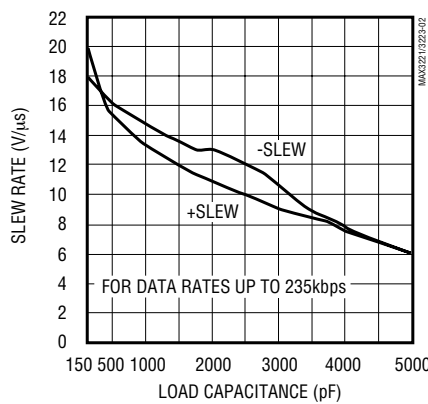
## Typical Operating Characteristics

(V<sub>CC</sub> = +3.3V, 235kbps data rate, 0.1 $\mu$ F capacitors, all transmitters loaded with 3k $\Omega$ , T<sub>A</sub> = +25°C, unless otherwise noted.)

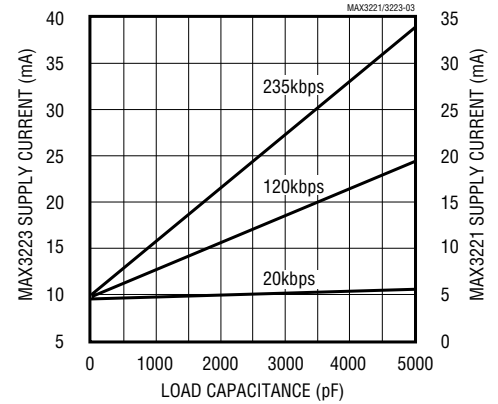
**MAX3221/MAX3223  
TRANSMITTER OUTPUT VOLTAGE  
vs. LOAD CAPACITANCE**



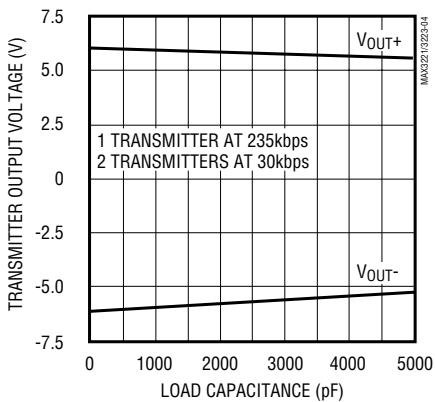
**MAX3221/MAX3223  
SLEW RATE  
vs. LOAD CAPACITANCE**



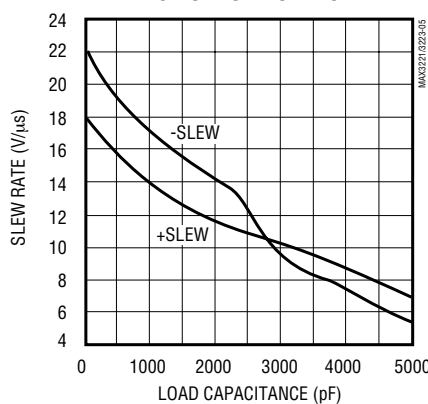
**MAX3221/MAX3223  
SUPPLY CURRENT vs. LOAD CAPACITANCE  
WHEN TRANSMITTING DATA**



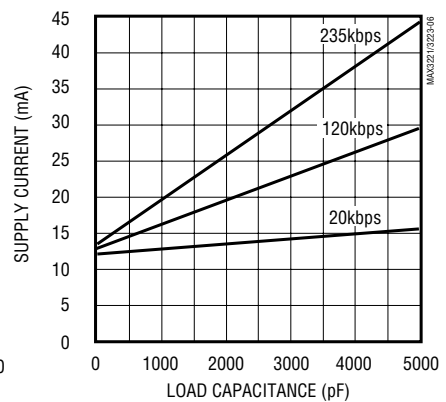
**MAX3243  
TRANSMITTER OUTPUT VOLTAGE  
vs. LOAD CAPACITANCE**



**MAX3243  
SLEW RATE  
vs. LOAD CAPACITANCE**



**MAX3243  
SUPPLY CURRENT vs. LOAD  
CAPACITANCE WHEN TRANSMITTING DATA**



# 1 $\mu$ A Supply-Current, True +3V to +5.5V RS-232 Transceivers with AutoShutdown

## Pin Description

MAX3221/MAX3223/MAX3243

| PIN     |         |            | NAME                         | FUNCTION                                                                                                                     |
|---------|---------|------------|------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| MAX3221 | MAX3223 | MAX3243    |                              |                                                                                                                              |
| 1       | 1       | —          | $\overline{\text{EN}}$       | Receiver Enable Control. Drive low for normal operation. Drive high to force the receiver outputs into a high-Z state.       |
| 5       | 5       | 1          | C2+                          | Positive terminal of inverting charge-pump capacitor                                                                         |
| 6       | 6       | 2          | C2-                          | Negative terminal of inverting charge-pump capacitor                                                                         |
| 7       | 7       | 3          | V-                           | -5.5V generated by the charge pump                                                                                           |
| 8       | 9, 16   | 4–8        | R_IN                         | RS-232 Receiver Inputs                                                                                                       |
| 13      | 8, 17   | 9, 10, 11  | T_OUT                        | RS-232 Transmitter Outputs                                                                                                   |
| 11      | 12, 13  | 12, 13, 14 | T_IN                         | TTL/CMOS Transmitter Inputs                                                                                                  |
| 9       | 10, 15  | 15–19      | R_OUT                        | TTL/CMOS Receiver Outputs                                                                                                    |
| —       | —       | 20         | R2OUTB                       | Noninverting Receiver Output—active in shutdown                                                                              |
| 10      | 11      | 21         | $\overline{\text{INVALID}}$  | Output of the valid signal detector. Indicates if a valid RS-232 level is present on receiver inputs logic “1”.              |
| 16      | 20      | 22         | $\overline{\text{FORCEOFF}}$ | Drive low to shut down transmitters and on-board power supply. This overrides all automatic circuitry and FORCEON (Table 1). |
| 12      | 14      | 23         | FORCEON                      | Drive high to override automatic circuitry keeping transmitters on (FORCEOFF must be high) (Table 1).                        |
| 4       | 4       | 24         | C1-                          | Negative terminal of the voltage doubler charge-pump capacitor                                                               |
| 14      | 18      | 25         | GND                          | Ground                                                                                                                       |
| 15      | 19      | 26         | VCC                          | +3.0V to +5.5V Supply Voltage                                                                                                |
| 3       | 3       | 27         | V+                           | +5.5V generated by the charge pump                                                                                           |
| 2       | 2       | 28         | C1+                          | Positive terminal of the voltage doubler charge-pump capacitor                                                               |

## Detailed Description

### Dual Charge-Pump Voltage Converter

The MAX3221/MAX3223/MAX3243's internal power supply consists of a regulated dual charge pump that provides output voltages of +5.5V (doubling charge pump) and -5.5V (inverting charge pump), regardless of the input voltage (VCC) over the +3.0V to +5.5V range. The charge pumps operate in a discontinuous mode: if the output voltages are less than 5.5V, the charge pumps are enabled; if the output voltages exceed 5.5V, the charge pumps are disabled. Each charge pump requires a flying capacitor (C1, C2) and a reservoir capacitor (C3, C4) to generate the V+ and V- supplies.

### RS-232 Transmitters

The transmitters are inverting level translators that convert CMOS-logic levels to 5.0V EIA/TIA-232 levels. They guarantee a 120kbps data rate with worst-case loads of 3k $\Omega$  in parallel with 1000pF, providing compatibility with PC-to-PC communication software (such as Laplink™). Typically, the MAX3221/MAX3223/MAX3243 can operate at data rates of 235kbps. Transmitters can be paralleled to drive multiple receivers or mice (MAX3243). Figure 1 shows a complete system connection.

When  $\overline{\text{FORCEOFF}}$  is driven to ground, or the Auto-Shutdown circuitry senses invalid voltage levels at all receiver inputs, the transmitters are disabled and the outputs are forced into a high-impedance state.

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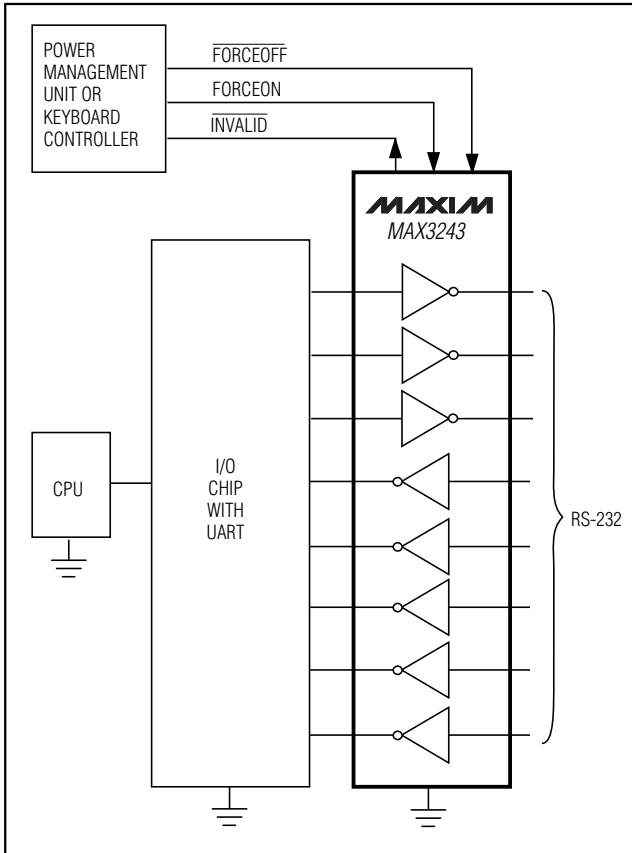


Figure 1. Interface Under Control of PMU

## RS-232 Receivers

The MAX3221/MAX3223/MAX3243's receivers convert RS-232 signals to CMOS-logic output levels. All receivers have one inverting three-state output. In shutdown ( $\overline{\text{FORCEOFF}} = \text{low}$ ) or in AutoShutdown, the MAX3221/MAX3223's receivers are active (Table 1). Driving  $\overline{\text{EN}}$  high places the receiver(s) in a high-impedance state. The MAX3243's receivers are high impedance when the part is shut down.

The MAX3243 has an always-active complementary output (R2OUTB). R2OUTB is an extra output that monitors receiver activity while the other receivers are high impedance. This allows Ring Indicator to be monitored without forward biasing other devices connected to the receiver outputs. This is ideal for systems where  $V_{CC}$  is set to 0V in shutdown to accommodate peripherals, such as UARTs (Figure 2).

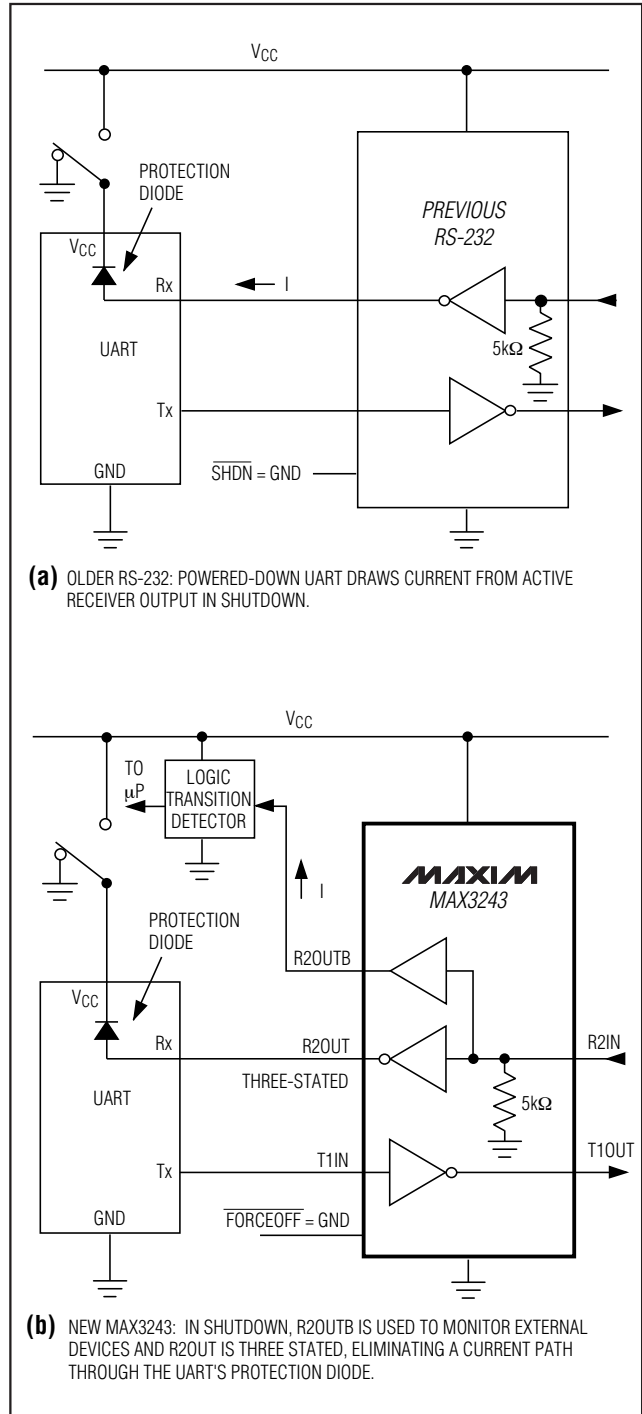


Figure 2. The MAX3243 detects RS-232 activity when the UART and interface are shut down.

# 1μA Supply-Current, True +3V to +5.5V RS-232 Transceivers with AutoShutdown

**Table 1a. MAX3221/MAX3223 FORCEOFF and Enable Control Truth Table**

| FORCEOFF | EN | T_OUT   | R_OUT  |
|----------|----|---------|--------|
| 0        | 0  | High-Z  | Active |
| 0        | 1  | High-Z  | High-Z |
| 1        | 0  | Active* | Active |
| 1        | 1  | Active* | High-Z |

**Table 1b. MAX3243 FORCEOFF Control Truth Table**

| FORCEOFF | T_OUT   | R_OUT   | R2OUTB |
|----------|---------|---------|--------|
| 0        | High-Z  | High-Z  | Active |
| 1        | Active* | Active* | Active |

\*Note: If the part is in AutoShutdown mode ( $\overline{\text{FORCEOFF}} = V_{CC}$ ,  $\text{FORCEON} = \text{GND}$ ), it is shut down if no valid RS-232 levels are present on all receiver inputs.

## AutoShutdown

A 1μA supply current is achieved with Maxim's new AutoShutdown feature, which operates when  $\overline{\text{FORCEON}}$  is low and  $\overline{\text{FORCEOFF}}$  is high. When the MAX3221/MAX3223/MAX3243 sense no valid signal levels on all receiver inputs for 30μs, the on-board power supply and drivers are shut off, reducing supply current to 1μA. This occurs if the RS-232 cable is disconnected or the connected peripheral transmitters are turned off. The system turns on again when a valid level is applied to any RS-232 receiver input. As a result, the system saves power without changes to the existing BIOS or operating system. When using AutoShutdown, the  $\overline{\text{INVALID}}$  output is high when the device is on and low when the device is shut down. Because  $\overline{\text{INVALID}}$  indicates the receiver inputs' condition, it can be used in any mode (Figure 3).

Table 2 and Figure 3c summarize the MAX3221/MAX3223/MAX3243 operating modes.  $\overline{\text{FORCEON}}$  and  $\overline{\text{FORCEOFF}}$  override the automatic circuitry and force the transceiver into its normal operating state or into its low-power standby state. When neither control is asserted, the IC selects between these states automatically based on receiver input levels. Figures 3a, 3b, and 5a depict valid and invalid RS-232 receiver levels.

A mouse or other system with AutoShutdown may need time to wake up. Figure 4 shows a circuit that forces the transmitters on for 100ms, allowing enough time for the

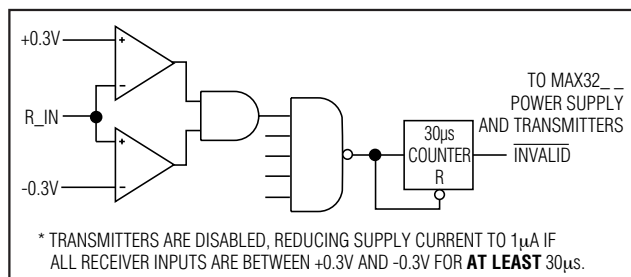


Figure 3a. MAX3221/MAX3223 Entering 1μA Supply Mode via AutoShutdown

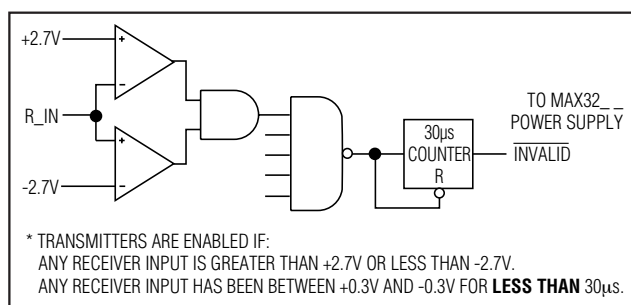


Figure 3b. MAX3221/MAX3223 with Transmitters Enabled Using AutoShutdown

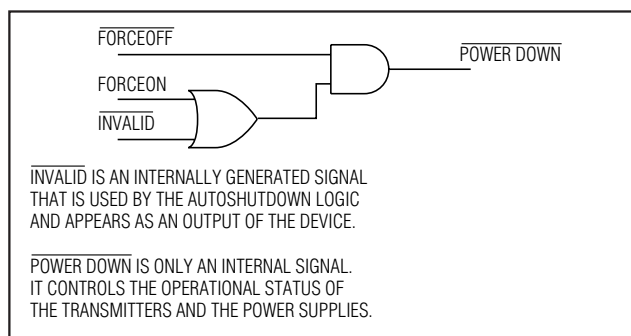


Figure 3c. AutoShutdown Logic

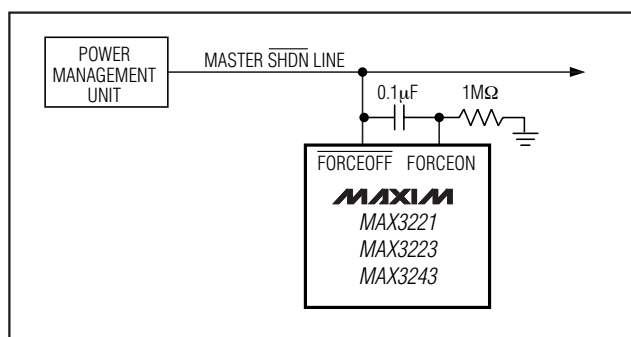


Figure 4. AutoShutdown with Initial Turn-On to Wake Up a Mouse or Another System

# 1μA Supply-Current, True +3V to +5.5V RS-232 Transceivers with AutoShutdown

Table 2. AutoShutdown Logic

| RS-232 SIGNAL PRESENT AT RECEIVER INPUT | FORCEOFF INPUT | FORCEON INPUT | INVALID OUTPUT | TRANSCIEVER STATUS           |
|-----------------------------------------|----------------|---------------|----------------|------------------------------|
| Yes                                     | H              | X             | H              | Normal Operation             |
| No                                      | H              | H             | L              | Normal Operation (Forced On) |
| No                                      | H              | L             | L              | Shutdown (AutoShutdown)      |
| Yes                                     | L              | X             | H              | Shutdown (Forced Off)        |
| No                                      | L              | X             | L              | Shutdown (Forced Off)        |

other system to realize that the MAX3221/MAX3223/MAX3243 is awake. If the other system outputs valid RS-232 signals within that time, the RS-232 ports on both systems remain enabled.

When shut down, the device's charge pumps are turned off, V+ decays to VCC, V- decays to ground, and the transmitter outputs are disabled (high impedance). The time required to exit shutdown is typically 100μs (Figure 5b).

## Software-Controlled Shutdown

If direct software control is desired, INVALID can be used to indicate DTR or Ring Indicator signal. Tie FORCEOFF and FORCEON together to bypass Auto-Shutdown so the line acts like a SHDN input.

## Applications Information

### Capacitor Selection

The capacitor type used for C1–C4 is not critical for proper operation; either polarized or nonpolarized capacitors may be used. The charge pump requires 0.1μF capacitors for 3.3V operation. For other supply voltages, refer to Table 3 for required capacitor values. Do not use values smaller than those listed in Table 3. Increasing the capacitor values (e.g., by a factor of 2) reduces ripple on the transmitter outputs and slightly reduces power consumption. C2, C3, and C4 can be increased without changing C1's value. **However, do not increase C1 without also increasing the values of C2, C3, and C4 to maintain the proper ratios (C1 to the other capacitors).**

When using the minimum required capacitor values, make sure the capacitor value 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+ and V-.

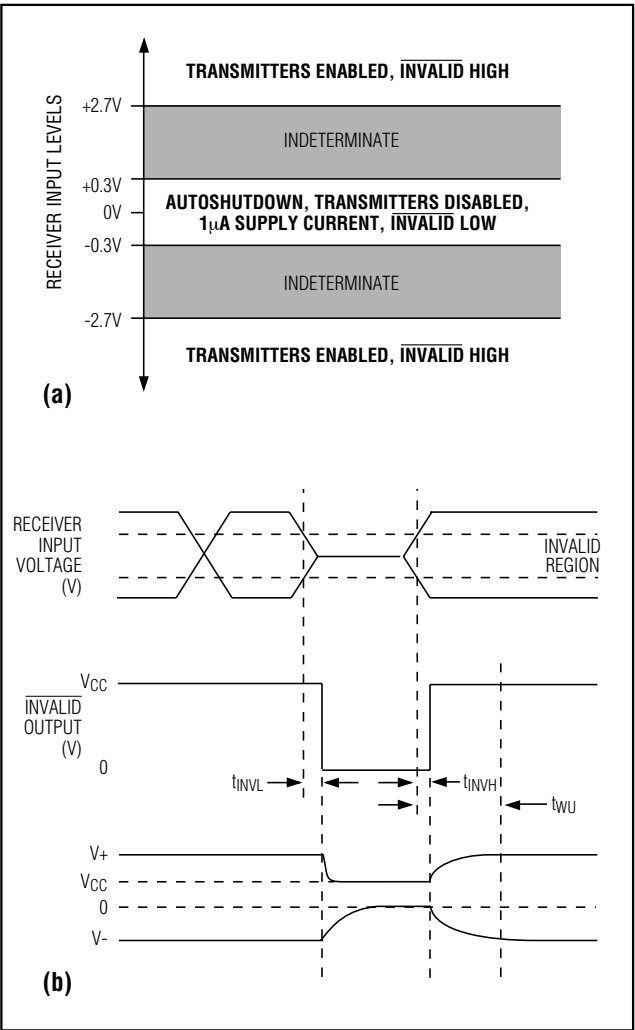


Figure 5. AutoShutdown Trip Levels

# 1 $\mu$ A Supply-Current, True +3V to +5.5V RS-232 Transceivers with AutoShutdown

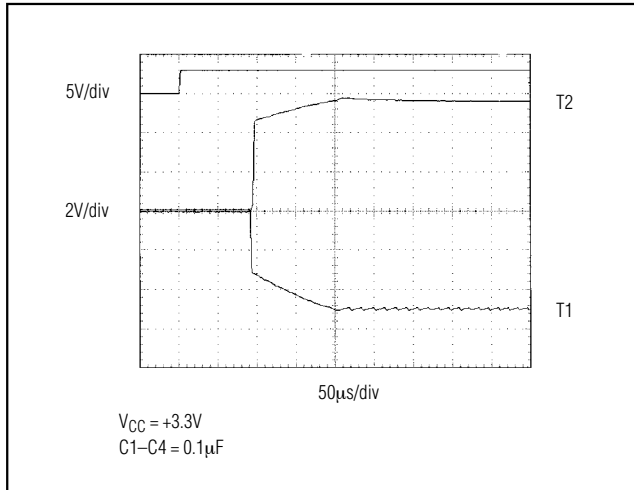


Figure 6. Transmitter Outputs when Exiting Shutdown or Powering Up

## Power-Supply Decoupling

In most circumstances a 0.1 $\mu$ F bypass capacitor is adequate. In applications that are sensitive to power-supply noise, decouple VCC to ground with a capacitor of the same value as the charge-pump capacitor C1. Connect bypass capacitors as close to the IC as possible.

## Transmitter Outputs when Exiting Shutdown

Figure 6 shows two transmitter outputs when exiting shutdown mode. As they become active, the two transmitter outputs are shown going to opposite RS-232 levels. Each transmitter is loaded with 3k $\Omega$  in parallel with 250pF. The transmitter outputs display no ringing or undesirable transients as they come out of shutdown. Note that the transmitters are enabled only when the magnitude of V<sub>-</sub> exceeds approximately 3V. Figure 7a shows the MAX3243's transmitter output voltage vs. current per transmitter. Figure 7b is a mouse driver test circuit.

## Mouse Driveability (MAX3243)

The MAX3243 has been specifically designed to power serial mice while operating from low-voltage power supplies. It has been tested with samples of ten major mouse models from six manufacturers including the leading three: Logitech (5 models), Mouse Systems, and

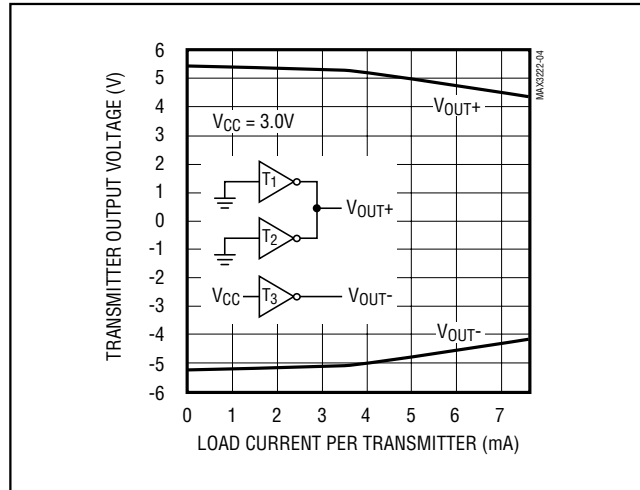


Figure 7a. MAX3243 Transmitter Output Voltage vs. Load Current per Transmitter

Microsoft. The MAX3243 successfully drove all serial mice and met their respective current and voltage requirements. Figure 7a shows the transmitter outputs under increasing load current. The MAX3243's switching regulator ensures the transmitters will supply at least  $\pm 5$ V during worst-case conditions. The AutoShutdown feature does not work with a mouse, so FORCEOFF and FORCEON should be connected to VCC.

## High Data Rates

The MAX3221/MAX3223/MAX3243 maintain the RS-232  $\pm 5.0$ V minimum transmitter output voltage even at high data rates. Figure 8 shows a transmitter loopback test circuit. Figure 9 shows a loopback test result at 120kbps, and Figure 10 shows the same test at 235kbps. For Figure 9, all three transmitters were driven simultaneously at 120kbps into RS-232 loads in parallel with 1000pF. For Figure 10, a single transmitter was driven at 235kbps, but all three transmitters were loaded with an RS-232 receiver in parallel with 1000pF.

## Interconnection with 3V and 5V Logic

The MAX3221/MAX3223/MAX3243 can directly interface with various 5V logic families, including ACT and HCT CMOS. See Table 4 for more information on possible combinations of interconnections.

# 1μA Supply-Current, True +3V to +5.5V RS-232 Transceivers with AutoShutdown

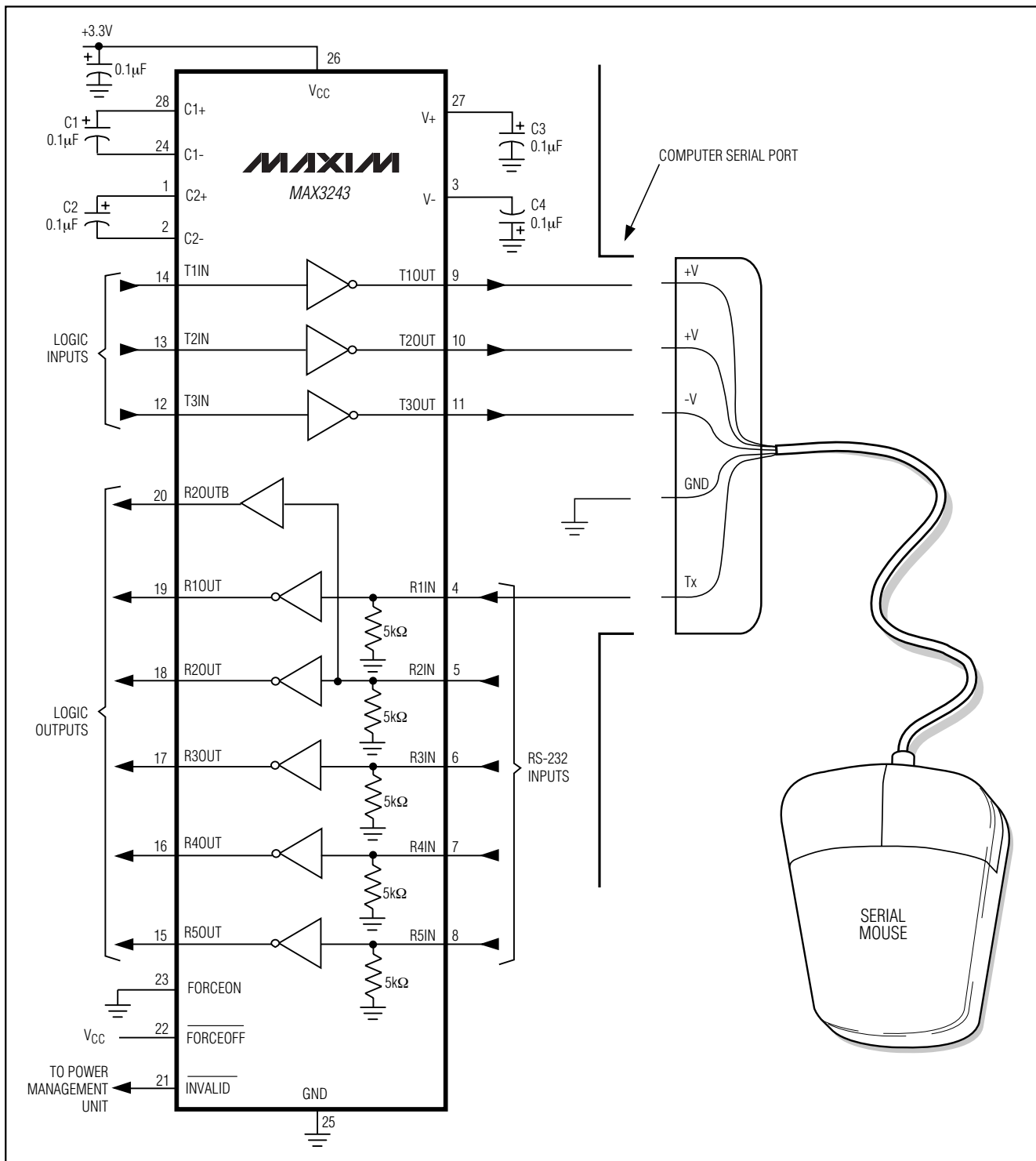


Figure 7b. Mouse Driver Test Circuit

# 1μA Supply-Current, True +3V to +5.5V RS-232 Transceivers with AutoShutdown

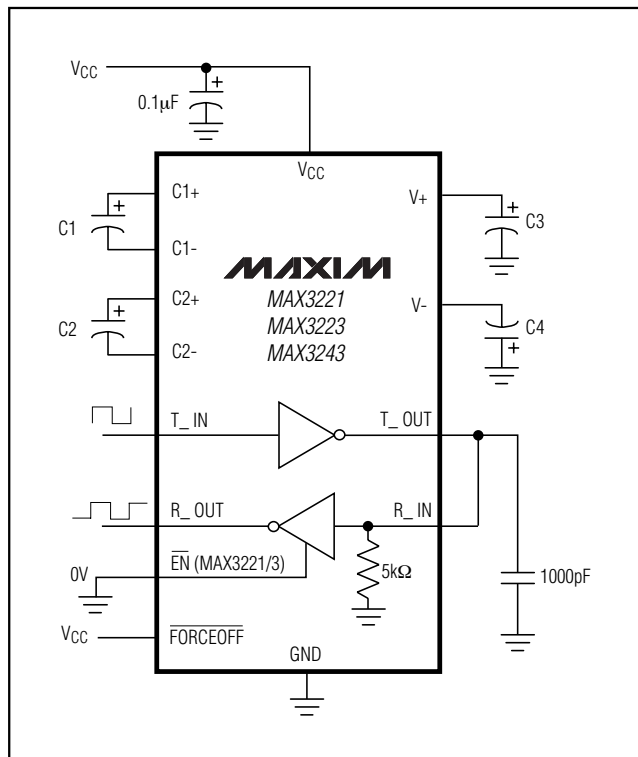


Figure 8. Loopback Test Circuit

Table 3. Required Capacitor Values

| V <sub>CC</sub><br>(V) | C1<br>(μF) | C2, C3, C4<br>(μF) |
|------------------------|------------|--------------------|
| 3.0 to 3.6             | 0.1        | 0.1                |
| 4.5 to 5.5             | 0.047      | 0.33               |
| 3.0 to 5.5             | 0.1        | 0.47               |

Table 4. Logic Family Compatibility with Various Supply Voltages

| SYSTEM POWER-SUPPLY VOLTAGE (V) | V <sub>CC</sub> SUPPLY VOLTAGE (V) | COMPATIBILITY                                                                             |
|---------------------------------|------------------------------------|-------------------------------------------------------------------------------------------|
| 3.3                             | 3.3                                | Compatible with all CMOS families.                                                        |
| 5                               | 5                                  | Compatible with all TTL and CMOS-logic families.                                          |
| 5                               | 3.3                                | Compatible with ACT and HCT CMOS, and with TTL. Incompatible with AC, HC, or CD4000 CMOS. |

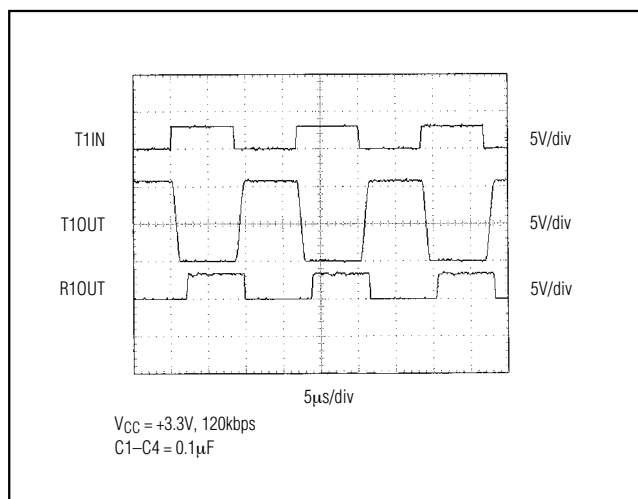


Figure 9. Loopback Test Result at 120kbps

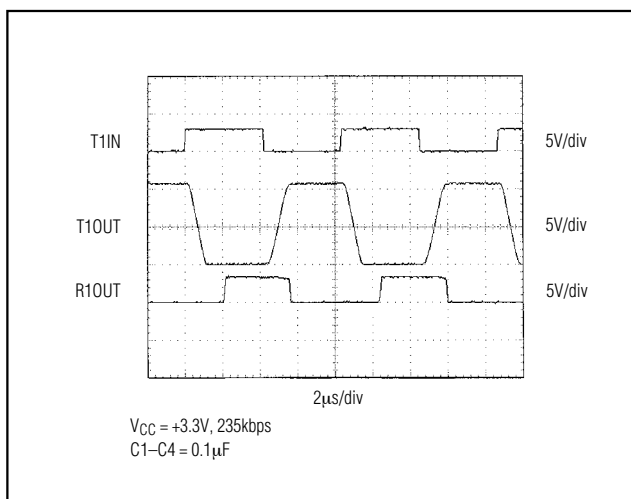
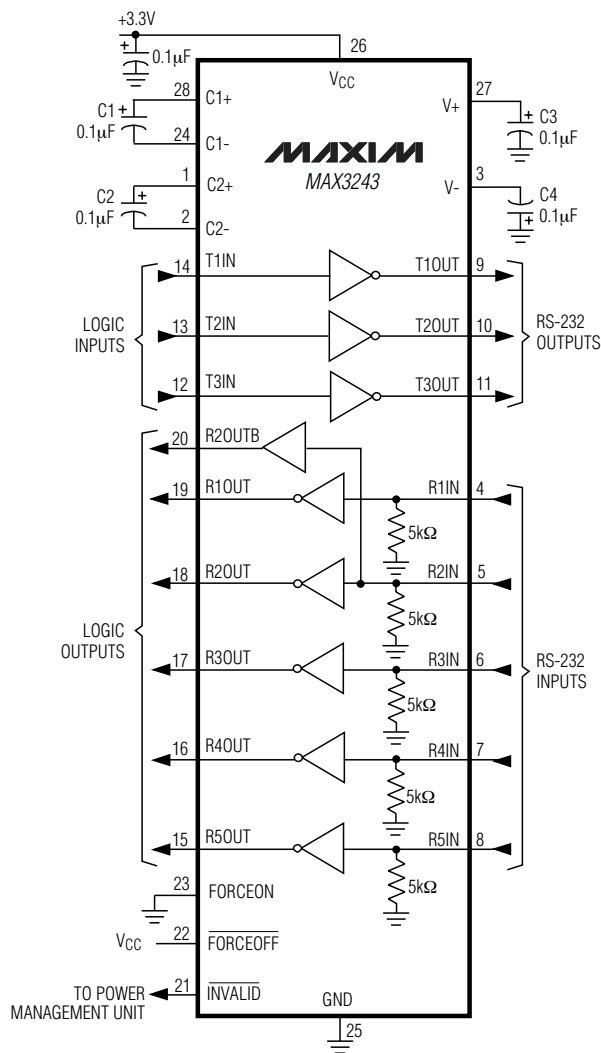
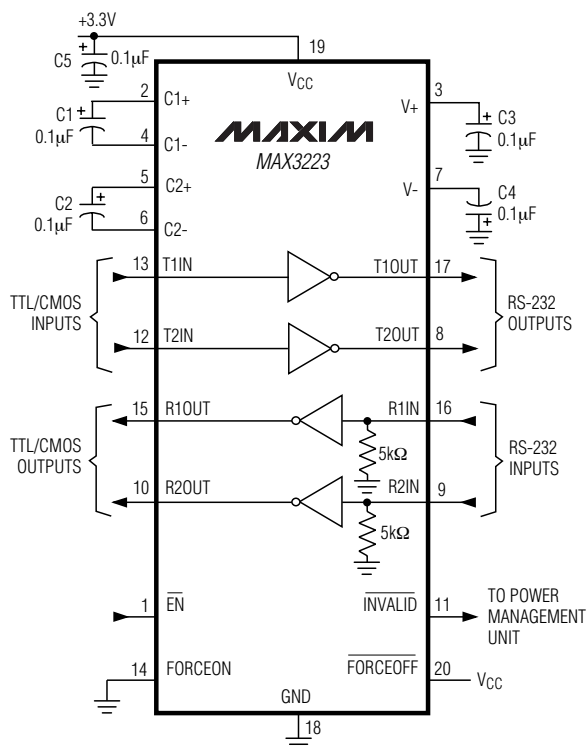
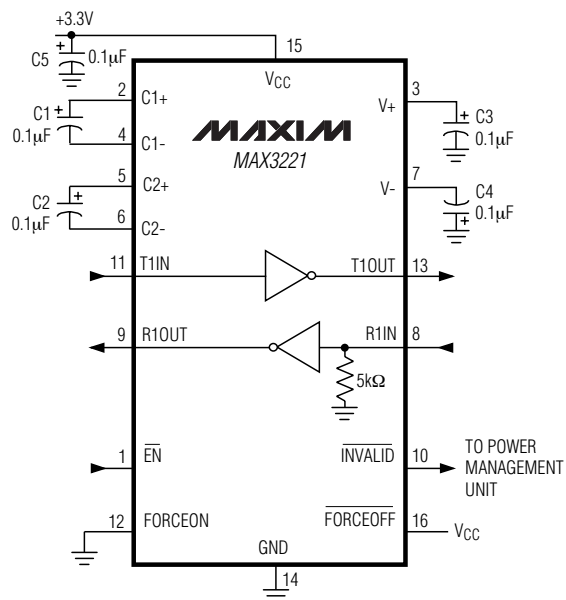


Figure 10. Loopback Test Result at 235kbps

# 1µA Supply-Current, True +3V to +5.5V RS-232 Transceivers with AutoShutdown

## Typical Operating Circuits



# 1 $\mu$ A Supply-Current, True +3V to +5.5V RS-232 Transceivers with AutoShutdown

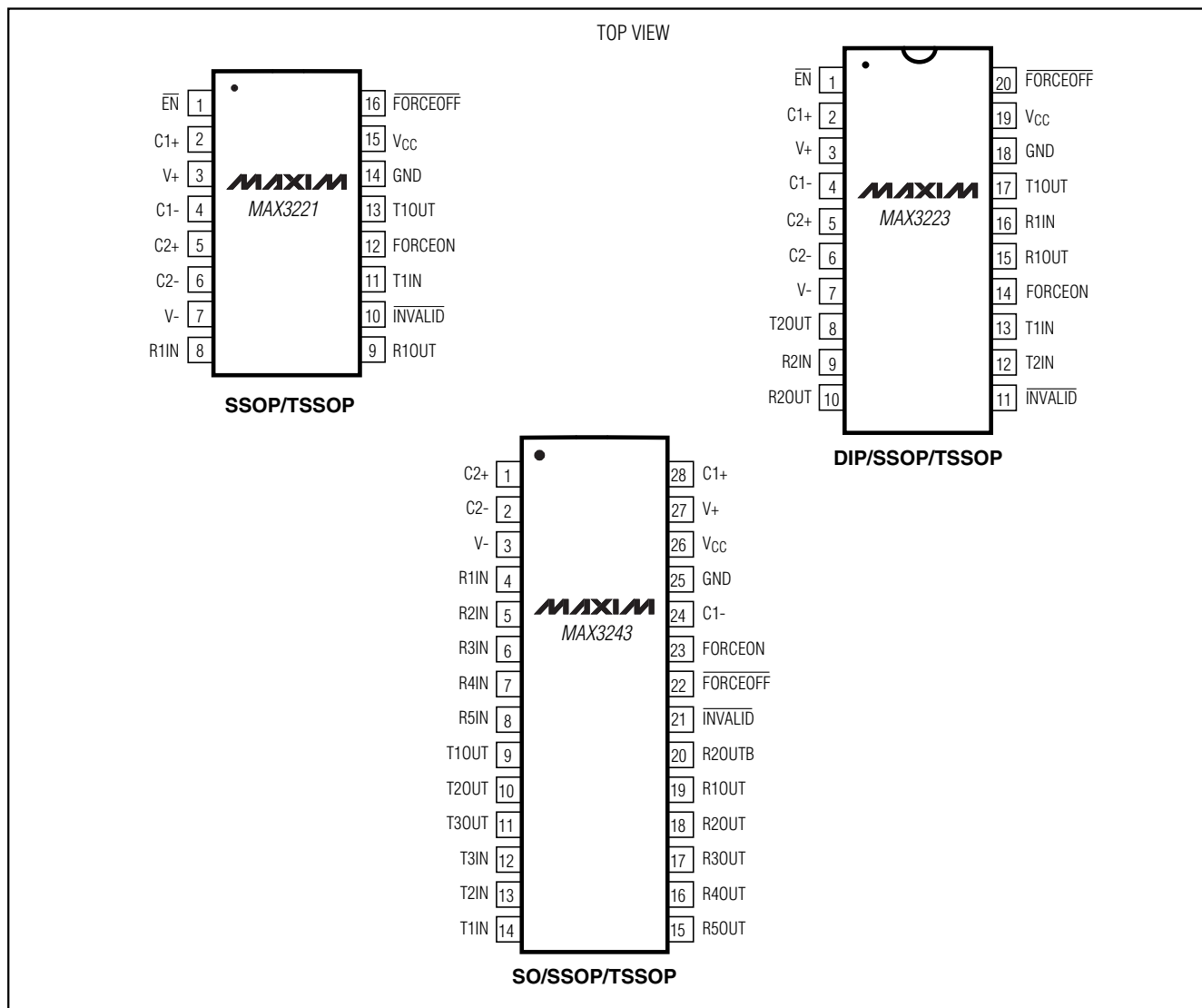
## 3V-Powered EIA/TIA-232 and EIA/TIA-562 Transceivers from Maxim

| PART    | POWER-SUPPLY VOLTAGE (V) | No. OF TRANSMITTERS/RECEIVERS | No. OF RECEIVERS ACTIVE IN SHUTDOWN | GUAR-ANTEED DATA RATE (kbps) | EIA/TIA-232 OR 562 | FEATURES                                                                 |
|---------|--------------------------|-------------------------------|-------------------------------------|------------------------------|--------------------|--------------------------------------------------------------------------|
| MAX212  | 3.0 to 3.6               | 3/5                           | 5                                   | 120                          | 232                | Drives mice                                                              |
| MAX218  | 1.8 to 4.25              | 2/2                           | 2                                   | 120                          | 232                | Operates directly from batteries without a voltage regulator             |
| MAX562  | 2.7 to 5.25              | 3/5                           | 5                                   | 230                          | 562                | 230kbps guaranteed data rate                                             |
| MAX563  | 3.0 to 3.6               | 2/2                           | 2                                   | 120                          | 562                | 0.1 $\mu$ F capacitors                                                   |
| MAX3212 | 2.7 to 3.6               | 3/5                           | 5                                   | 235                          | 232                | AutoShutdown, complementary receiver, drives mice, transient detection   |
| MAX3221 | 3.0 to 5.5               | 1/1                           | 1                                   | 120                          | 232                | 0.1 $\mu$ F capacitors, 16-pin SSOP                                      |
| MAX3222 | 3.0 to 5.5               | 2/2                           | 2                                   | 120                          | 232                | 0.1 $\mu$ F capacitors, MAX242 pinout                                    |
| MAX3223 | 3.0 to 5.5               | 2/2                           | 2                                   | 120                          | 232                | 0.1 $\mu$ F capacitors, AutoShutdown                                     |
| MAX3232 | 3.0 to 5.5               | 2/2                           | N/A                                 | 120                          | 232                | 0.1 $\mu$ F capacitors, MAX232 pinout                                    |
| MAX3241 | 3.0 to 5.5               | 3/5                           | 5                                   | 120                          | 232                | 0.1 $\mu$ F capacitors, 2 complementary receivers, drives mice           |
| MAX3243 | 3.0 to 5.5               | 3/5                           | 1                                   | 120                          | 232                | 0.1 $\mu$ F capacitors, AutoShutdown complementary receiver, drives mice |

MAX3221/MAX3223/MAX3243

# 1 $\mu$ A Supply-Current, True +3V to +5.5V RS-232 Transceivers with AutoShutdown

## Pin Configurations



## Chip Information

MAX3221 TRANSISTOR COUNT: 269

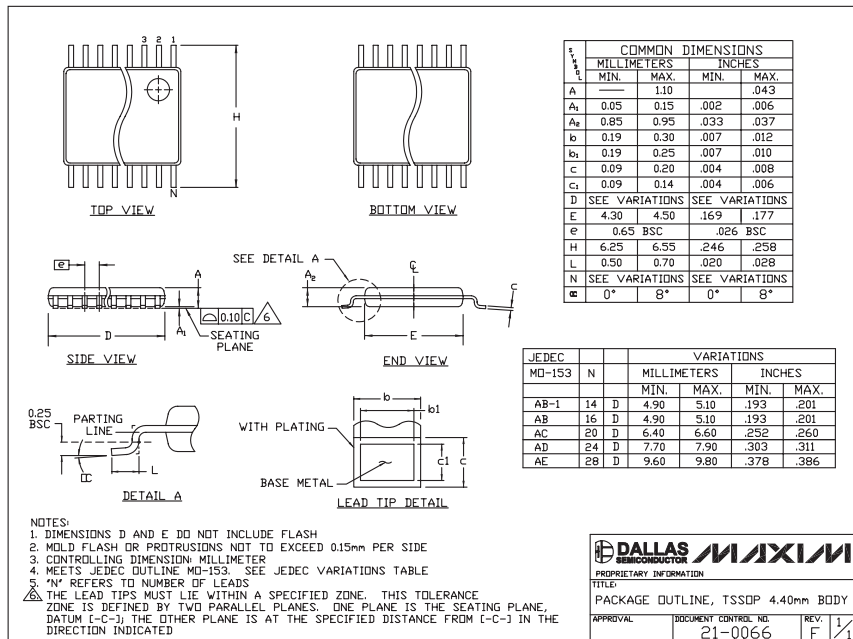
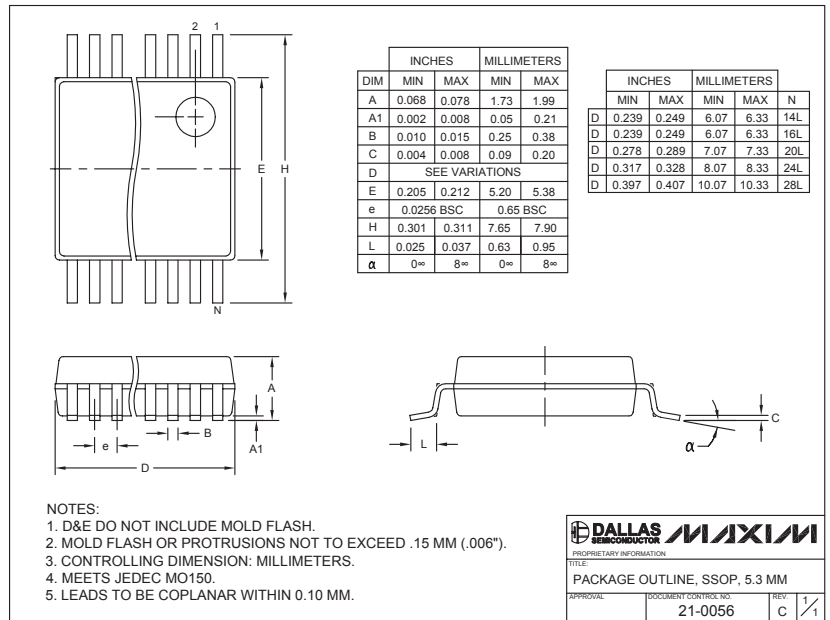
MAX3223 TRANSISTOR COUNT: 339

MAX3243 TRANSISTOR COUNT: 476

# 1 $\mu$ A Supply-Current, True +3V to +5.5V RS-232 Transceivers with AutoShutdown

## Package Information

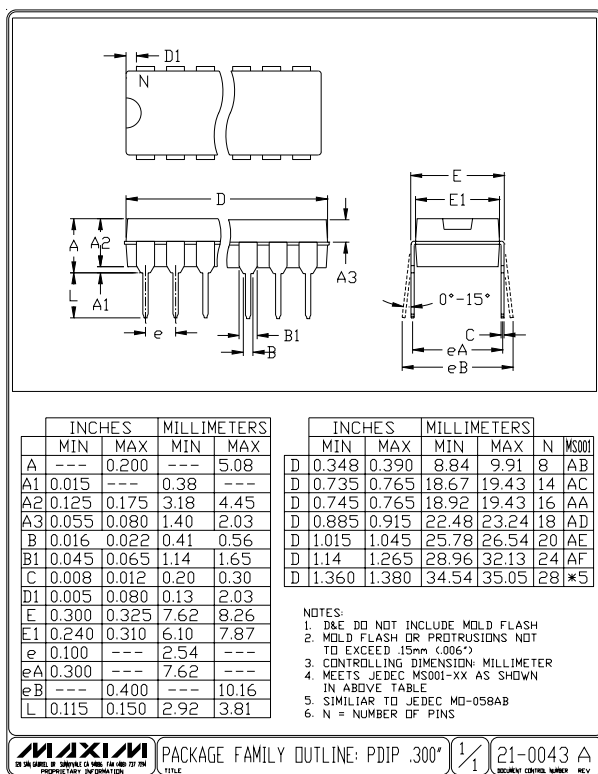
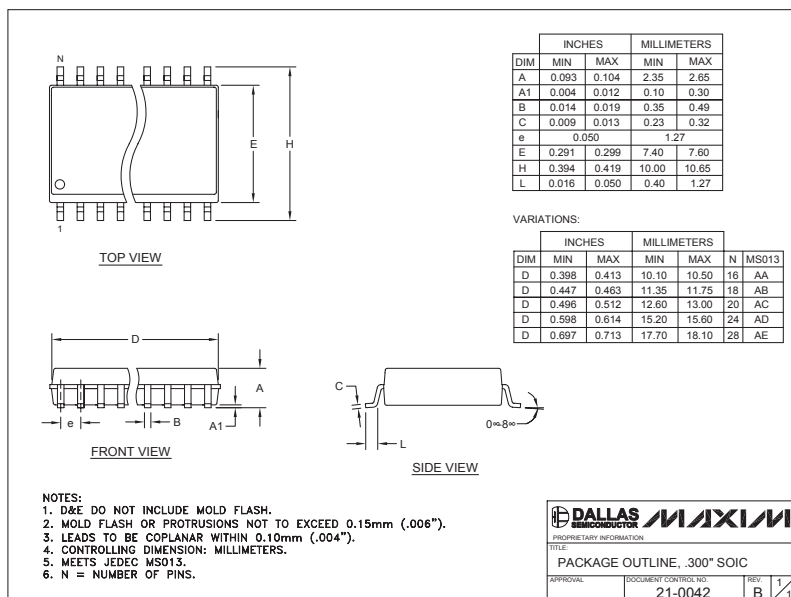
(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)



# 1 $\mu$ A Supply-Current, True +3V to +5.5V RS-232 Transceivers with AutoShutdown

## Package Information (continued)

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



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