19-1283; Rev 0; 10/97

MAXIM

# ±15kV ESD-Protected, 1µA, 3.0V to 5.5V, 1Mbps RS-232 Transceivers with AutoShutdown Plus



## General Description

The MAX3243E/MAX3244E/MAX3245E are 3V-powered EIA/TIA-232 and V.28/V.24 communications interfaces with automatic shutdown/wakeup features, high data-rate capabilities, and enhanced electrostatic discharge (ESD) protection. All transmitter outputs and receiver inputs are protected to ±15kV using IEC 1000-4-2 Air-Gap Discharge, ±8kV using IEC 1000-4-2 Contact Discharge, and ±15kV using the Human Body Model.

The transceivers have a proprietary low-dropout transmitter output stage enabling true RS-232 performance from a 3.0V to 5.5V supply with a dual charge pump. The MAX3243E and MAX3244E are guaranteed to run at data rates of 250kbps while maintaining RS-232 output levels. The MAX3245E is guaranteed to run at a data rate of 1Mbps using Maxim's MegaBaud™ feature. The devices are complete serial ports (3 drivers, 5 receivers) intended for notebook or subnotebook computers.

The MAX3243E/MAX3244E/MAX3245E achieve 1µA supply current using Maxim's revolutionary AutoShutdown™ and AutoShutdown Plus™ features, which automatically save power without changes to the existing BIOS or operating system.

The MAX3243E (with AutoShutdown) shuts down if the RS-232 cable is disconnected or if the transmitters of the connected peripherals are off. The device turns on again when a valid level is applied to any receiver input.

The MAX3244E/MAX3245E (with AutoShutdown Plus) shut down after 30sec if the RS-232 cable is disconnected or if the transmitters of the connected peripherals are idle. The device turns on again when a valid edge is applied to any transmitter or receiver input.

## Applications

Notebook, Subnotebook, and Palmtop Computers

Battery-Powered Equipment

Hand-Held Equipment

Peripherals

Printers

## Features

- ♦ **Enhanced ESD Protection:**
  **±15kV (Human Body Model)**
  **±8kV (IEC 1000-4-2, Contact Discharge)**
  **±15kV (IEC 1000-4-2, Air-Gap Discharge)**
- ♦ **1µA Supply Current Achieved with AutoShutdown (MAX3243E) and AutoShutdown Plus (MAX3244E/MAX3245E)**
- ♦ **Guaranteed Data Rate:**
  **250kbps (MAX3243E/MAX3244E)**
  **1Mbps (MAX3245E)**
- ♦ **Meets EIA/TIA-232 Specifications Down to 3.0V**
- ♦ **Guaranteed Slew Rate:**
  **6V/µs (MAX3243E/MAX3244E)**
  **24V/µs (MAX3245E)**
- ♦ **Guaranteed Mouse Driveability**
- ♦ **Small, 0.1µF Capacitors**

## Ordering Information

| PART | TEMP. RANGE | PIN-PACKAGE |
|---|---|---|
| **MAX3243E**CWI | 0°C to +70°C | 28 SO |
| MAX3243ECAI | 0°C to +70°C | 28 SSOP |
| MAX3243EEWI | -40°C to +85°C | 28 SO |
| MAX3243EEAI | -40°C to +85°C | 28 SSOP |
| **MAX3244E**CWI | 0°C to +70°C | 28 SO |
| MAX3244ECAI | 0°C to +70°C | 28 SSOP |
| MAX3244EEWI | -40°C to +85°C | 28 SO |
| MAX3244EEAI | -40°C to +85°C | 28 SSOP |
| **MAX3245E**CWI | 0°C to +70°C | 28 SO |
| MAX3245ECAI | 0°C to +70°C | 28 SSOP |
| MAX3245EEWI | -40°C to +85°C | 28 SO |
| MAX3245EEAI | -40°C to +85°C | 28 SSOP |

## Selector Guide

| PART | NO. OF DRIVERS/ RECEIVERS | $V_{CC}$ RANGE (V) | AUTOSHUTDOWN | AUTOSHUTDOWN PLUS | MEGABAUD | ±15kV ESD PROTECTION |
|---|---|---|---|---|---|---|
| MAX3243E | 3/5 | 3.0 to 5.5 | ✔ | | | ✔ |
| MAX3244E | 3/5 | 3.0 to 5.5 | | ✔ | | ✔ |
| MAX3245E | 3/5 | 3.0 to 5.5 | | ✔ | ✔ | ✔ |

***Typical Operating Circuit and Pin Configuration appear at end of data sheet.***

*AutoShutdown, AutoShutdown Plus and MegaBaud are trademarks of Maxim Integrated Products.*

# ±15kV ESD-Protected, 1µA, 3.0V to 5.5V, 1Mbps RS-232 Transceivers with AutoShutdown Plus

## ABSOLUTE MAXIMUM RATINGS

$V_{CC}$ .....-0.3V to +6V
V+ .....-0.3V to +7V
V- .....+0.3V to -7V
V+ + |V-| .....+13V
Input Voltages
T_IN, FORCEON, $\overline{FORCEOFF}$ .....-0.3V to +6V
R_IN .....±25V
Output Voltages
T_OUT.....±13.2V
R_OUT, R2OUTB, $\overline{INVALID}$.....-0.3V to ($V_{CC}$ + 0.3V)
Short-Circuit Duration
T_OUT (one at a time).....Continuous
Continuous Power Dissipation ($T_A$ = +70°C)
SO (derate 12.5mW/°C above +70°C).....1000mW
SSOP (derate 9.52mW/°C above +70°C) .....762mW
Operating Temperature Ranges
MAX324_EC_ I .....0°C to +70°C
MAX324_EE_ I .....-40°C to +85°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10sec) .....+300°C

*Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.*

## ELECTRICAL CHARACTERISTICS

($V_{CC}$ = +3.0V to +5.5V; C1–C4 = 0.1µF, tested at 3.3V ±10%; C1 = 0.047µF, C2–C4 = 0.33µF, tested at 5.0V ±10%; $T_A$ = $T_{MIN}$ to $T_{MAX}$; unless otherwise noted. Typical values are at $T_A$ = +25°C.)

| PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| **DC CHARACTERISTICS** ($V_{CC}$ = 3.3V or 5.0V, $T_A$ = +25°C, no load) | | | | | | |
| Supply Current | FORCEON = $\overline{FORCEOFF}$ = $V_{CC}$ | | | 0.3 | 1.0 | mA |
| Shutdown Supply Current | $\overline{FORCEOFF}$ = GND | | | 1.0 | 10.0 | µA |
| AutoShutdown Supply Current (MAX3243E) | FORCEON = GND, $\overline{FORCEOFF}$ = $V_{CC}$, all R_IN open or grounded | | | 1.0 | 10.0 | µA |
| AutoShutdown Plus Supply Current (MAX3244E/MAX3245E) | FORCEON = GND, $\overline{FORCEOFF}$ = $V_{CC}$, all R_IN idle, all T_IN idle | | | 1.0 | 10.0 | µA |
| **LOGIC INPUTS AND RECEIVER OUTPUTS** | | | | | | |
| Input Logic Threshold Low | T_IN, FORCEON, $\overline{FORCEOFF}$ | | | | 0.8 | V |
| Input Logic Threshold High | T_IN, FORCEON, $\overline{FORCEOFF}$ | $V_{CC}$ = 3.3V | 2.0 | | | V |
| | | $V_{CC}$ = 5.0V | 2.4 | | | |
| Transmitter Input Hysteresis | | | | 0.5 | | V |
| Input Leakage Current | T_IN, FORCEON, $\overline{FORCEOFF}$ | | | ±0.01 | ±1.0 | µA |
| Output Leakage Current | Receivers disabled | | | ±0.05 | ±10 | µA |
| Output Voltage Low | $I_{OUT}$ = 1.6mA | | | | 0.4 | V |
| Output Voltage High | $I_{OUT}$ = -1.0mA | | $V_{CC}$ - 0.6 | $V_{CC}$ - 0.1 | | V |
| **RECEIVER INPUTS** | | | | | | |
| Input Voltage Range | | | -25 | | 25 | V |
| Input Threshold Low | $V_{CC}$ = 3.3V | | 0.6 | 1.1 | | V |
| | $V_{CC}$ = 5.0V | | 0.8 | 1.4 | | |
| Input Threshold High | $V_{CC}$ = 3.3V | | | 1.6 | 2.4 | V |
| | $V_{CC}$ = 5.0V | | | 1.9 | 2.4 | |
| Input Hysteresis | | | | 0.5 | | V |
| Input Resistance | $T_A$ = +25°C | | 3 | 5 | 7 | kΩ |

## ELECTRICAL CHARACTERISTICS (continued)

($V_{CC}$ = +3.0V to +5.5V; C1–C4 = 0.1µF, tested at 3.3V ±10%; C1 = 0.047µF, C2–C4 = 0.33µF, tested at 5.0V ±10%; $T_A$ = $T_{MIN}$ to $T_{MAX}$; unless otherwise noted. Typical values are at $T_A$ = +25°C.)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **TRANSMITTER OUTPUTS** | | | | | | | |
| Output Voltage Swing | | All transmitter outputs loaded with 3kΩ to ground | | ±5 | ±5.4 | | V |
| Output Resistance | | $V_{CC}$ = V+ = V- = 0V, transmitter output = ±2V | | 300 | 10M | | Ω |
| Output Short-Circuit Current | | | | | ±35 | ±60 | mA |
| Output Leakage Current | | $V_{CC}$ = 0V to 5.5V, transmitter output = ±12V, transmitters disabled | | | | ±25 | µA |
| **MOUSE DRIVEABILITY** | | | | | | | |
| Transmitter Output Voltage | | T1IN = T2IN = GND, T3IN = $V_{CC}$, T3OUT loaded with 3kΩ to ground, T1OUT and T2OUT loaded with 2.5mA each | | ±5 | | | V |
| **ESD CHARACTERISTICS** | | | | | | | |
| ESD Protection | | R_IN, T_OUT | Human Body Model | | ±15 | | kV |
| | | | IEC 1000-4-2 (Contact Discharge) | | ±8 | | |
| | | | IEC 1000-4-2 (Air-Gap Discharge) | | ±15 | | |
| **AUTOSHUTDOWN: MAX3243E** (FORCEON = GND, $\overline{FORCEOFF}$ = $V_{CC}$) | | | | | | | |
| Receiver Input Threshold to $\overline{INVALID}$ Output Voltage High | | Figure 4 | Positive threshold | | | 2.7 | V |
| | | | Negative threshold | -2.7 | | | |
| Receiver Input Threshold to $\overline{INVALID}$ Output Voltage Low | | 1µA supply current, Figure 4 | | -0.3 | | 0.3 | V |
| $\overline{INVALID}$ Output Voltage Low | | $I_{OUT}$ = 1.6mA | | | | 0.4 | V |
| $\overline{INVALID}$ Output Voltage High | | $I_{OUT}$ = -1.0mA | | $V_{CC}$ - 0.6 | | | V |
| Receiver Positive or Negative Threshold to $\overline{INVALID}$ High | $t_{INVH}$ | Figure 4 | | | 1 | | µs |
| Receiver Positive or Negative Threshold to $\overline{INVALID}$ Low | $t_{INVL}$ | Figure 4 | | | 30 | | µs |
| Receiver or Transmitter Edge to Transmitters Enabled | $t_{WU}$ | Figure 4 | | | 100 | | µs |
| **AUTOSHUTDOWN PLUS: MAX3244E/MAX3245E** (FORCEON = GND, $\overline{FORCEOFF}$ = $V_{CC}$) | | | | | | | |
| Receiver Input Threshold to $\overline{INVALID}$ Output Voltage High | | Figure 4 | Positive threshold | | | 2.7 | V |
| | | | Negative threshold | -2.7 | | | |
| Receiver Input Threshold to $\overline{INVALID}$ Output Voltage Low | | Figure 4 | | -0.3 | | 0.3 | V |
| $\overline{INVALID}$ Output Voltage Low | | $I_{OUT}$ = 1.6mA | | | | 0.4 | V |
| $\overline{INVALID}$ Output Voltage High | | $I_{OUT}$ = -1.0mA | | $V_{CC}$ - 0.6 | | | V |
| Receiver Positive or Negative Threshold to $\overline{INVALID}$ High | $t_{INVH}$ | Figure 5 | | | 1 | | µs |
| Receiver Positive or Negative Threshold to $\overline{INVALID}$ Low | $t_{INVL}$ | Figure 5 | | | 30 | | µs |
| Receiver or Transmitter Edge to Transmitters Enabled | $t_{WU}$ | Figure 5 | | | 100 | | µs |
| Receiver or Transmitter Edge to Transmitters Shut Down | $t_{AUTOSHDN}$ | Figure 5 | | 15 | 30 | 60 | sec |

## TIMING CHARACTERISTICS—MAX3243E/MAX3244E

($V_{CC}$ = +3.0V to +5.5V; C1–C4 = 0.1µF, tested at 3.3V ±10%; C1 = 0.047µF, C2–C4 = 0.33µF, tested at 5.0V ±10%; $T_A$ = $T_{MIN}$ to $T_{MAX}$; unless otherwise noted. Typical values are at $T_A$ = +25°C.)

| PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Maximum Data Rate | $R_L$ = 3kΩ, $C_L$ = 1000pF, one transmitter switching | | 250 | | | kbps |
| Receiver Propagation Delay | R_IN to R_OUT, $C_L$ = 150pF | $t_{PHL}$ | | 0.15 | | µs |
| | | $t_{PLH}$ | | 0.15 | | |
| Receiver Output Enable Time | Normal operation | | | 200 | | ns |
| Receiver Output Disable Time | Normal operation | | | 200 | | ns |
| Transmitter Skew | $\lvert t_{PHL} - t_{PLH} \rvert$ | | | 100 | | ns |
| Receiver Skew | $\lvert t_{PHL} - t_{PLH} \rvert$ | | | 50 | | ns |
| Transition-Region Slew Rate | $V_{CC}$ = 3.3V, $T_A$ = +25°C, $R_L$ = 3kΩ to 7kΩ, measured from +3V to -3V or -3V to +3V | $C_L$ = 150pF to 1000pF | 6 | | 30 | V/µs |
| | | $C_L$ = 150pF to 2500pF | 4 | | 30 | |

## TIMING CHARACTERISTICS—MAX3245E

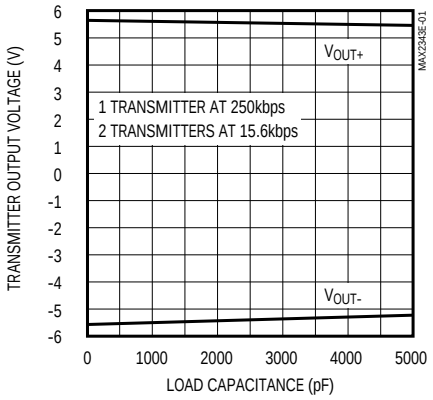
($V_{CC}$ = +3.0V to +5.5V; C1–C4 = 0.1µF, tested at 3.3V ±10%; C1 = 0.047µF, C2–C4 = 0.33µF, tested at 5.0V ±10%; $T_A$ = $T_{MIN}$ to $T_{MAX}$; unless otherwise noted. Typical values are at $T_A$ = +25°C.)

| PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Maximum Data Rate | $R_L$ = 3kΩ, $C_L$ = 1000pF, one transmitter switching | | 250 | | | kbps |
| | $V_{CC}$ = 3.0V to 4.5V, $R_L$ = 3kΩ, $C_L$ = 250pF, one transmitter switching | | 1000 | | | |
| | $V_{CC}$ = 4.5V to 5.5V, $R_L$ = 3kΩ, $C_L$ = 1000pF, one transmitter switching | | 1000 | | | |
| Receiver Propagation Delay | R_IN to R_OUT, $C_L$ = 150pF | $t_{PHL}$ | | 0.15 | | µs |
| | | $t_{PLH}$ | | 0.15 | | |
| Receiver Output Enable Time | Normal operation | | | 200 | | ns |
| Receiver Output Disable Time | Normal operation | | | 200 | | ns |
| Transmitter Skew | $\lvert t_{PHL} - t_{PLH} \rvert$ | | | 25 | | ns |
| Receiver Skew | $\lvert t_{PHL} - t_{PLH} \rvert$ | | | 50 | | ns |
| Transition-Region Slew Rate | $V_{CC}$ = 3.3V, $T_A$ = +25°C, $R_L$ = 3kΩ to 7kΩ, $C_L$ = 150pF to 1000pF, measured from +3V to -3V or -3V to +3V | | 24 | | 150 | V/µs |

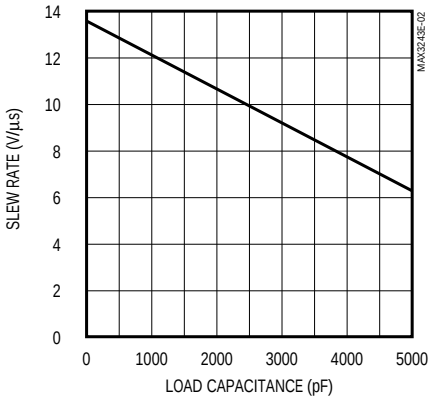
## Typical Operating Characteristics

($V_{CC}$ = +3.3V, 250kbps data rate, 0.1µF capacitors, all transmitters loaded with 3kΩ, $T_A$ = +25°C, unless otherwise noted.)

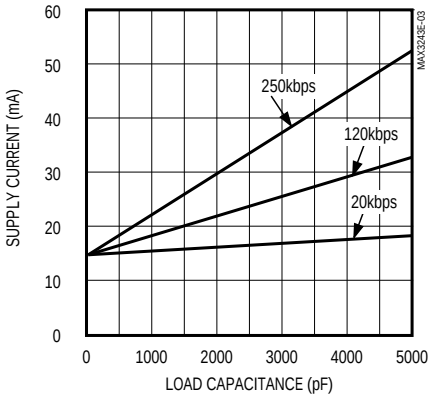
**TRANSMITTER OUTPUT VOLTAGE vs. LOAD CAPACITANCE**



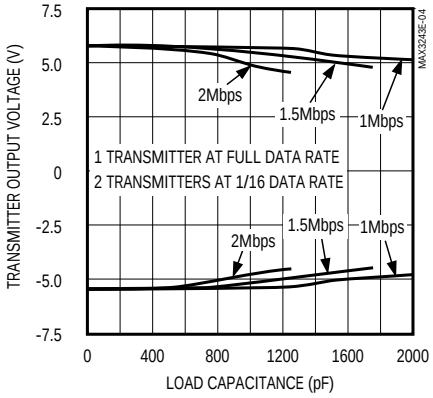

**MAX3243E/MAX3244E SLEW RATE vs. LOAD CAPACITANCE**



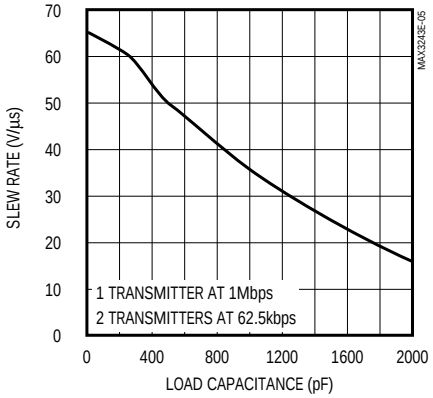

**MAX3243E/MAX3244E SUPPLY CURRENT vs. LOAD CAPACITANCE**



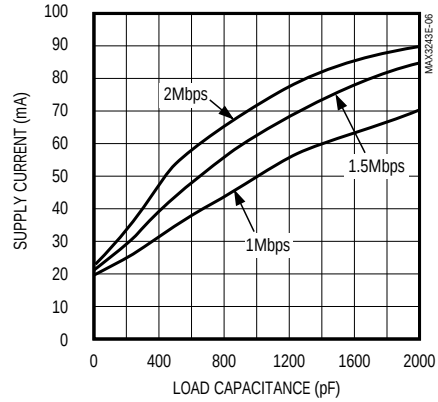

**MAX3245E TRANSMITTER OUTPUT VOLTAGE vs. LOAD CAPACITANCE**



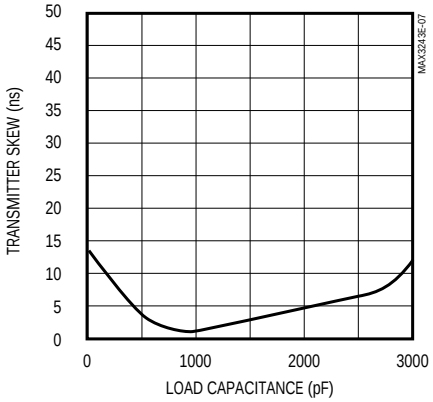

**MAX3245E SLEW RATE vs. LOAD CAPACITANCE**




**MAX3245E SUPPLY CURRENT vs. LOAD CAPACITANCE**




**MAX3245E TRANSMITTER SKEW vs. LOAD CAPACITANCE**



## Pin Description

| PIN | NAME | FUNCTION |
|---|---|---|
| 1 | C2+ | Positive Terminal of Inverting Charge-Pump Capacitor |
| 2 | C2- | Negative Terminal of Inverting Charge-Pump Capacitor |
| 3 | V- | -5.5V Generated by the Charge Pump |
| 4–8 | R1IN–R5IN | RS-232 Receiver Inputs |
| 9, 10, 11 | T1OUT, T2OUT, T3OUT | RS-232 Transmitter Outputs |
| 12, 13, 14 | T3IN, T2IN, T1IN | TTL/CMOS Transmitter Inputs |
| 15–19 | R5OUT–R1OUT | TTL/CMOS Receiver Outputs |
| 20 | R2OUTB | Noninverting Complementary Receiver Output, always active |
| 21 | $\overline{\text{INVALID}}$ | Active-Low Output of the Valid Signal Detector. A logic high indicates that a valid RS-232 level is present on a receiver input. |
| 22 | $\overline{\text{FORCEOFF}}$ | Active-Low Force-Off Input. Drive low to shut down transmitters, receivers (except R2OUTB), and on-board supply. This overrides AutoShutdown and FORCEON (Table 1). |
| 23 | FORCEON | Force-On Input. Drive high to override AutoShutdown, keeping transmitters and receivers on ($\overline{\text{FORCEOFF}}$ must be high) (Table 1). |
| 24 | C1- | Negative Terminal of Voltage-Doubler Charge-Pump Capacitor |
| 25 | GND | Ground |
| 26 | $V_{CC}$ | +3.0V to +5.5V Supply Voltage |
| 27 | V+ | +5.5V Generated by the Charge Pump |
| 28 | C1+ | Positive Terminal of Voltage-Doubler Charge-Pump Capacitor |

## Detailed Description

### Dual Charge-Pump Voltage Converter

The MAX3243E/MAX3244E/MAX3245E'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) for input voltages ($V_{CC}$) 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

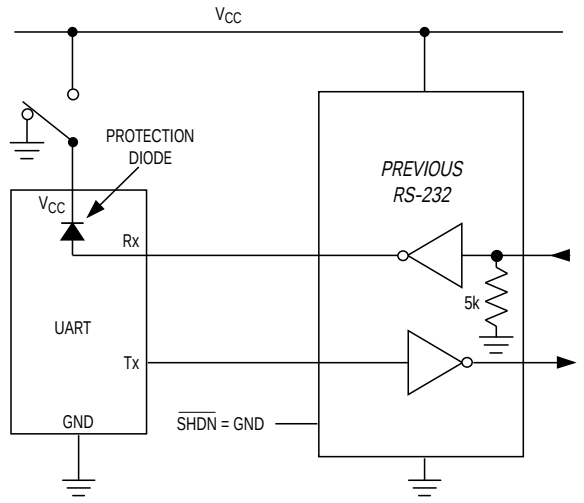
The transmitters are inverting level translators that convert CMOS-logic levels to 5.0V EIA/TIA-232 levels. The MAX3243E/MAX3244E transmitters guarantee a 250kbps data rate (1Mbps for the MAX3245E) with worst-case loads of 3kΩ in parallel with 1000pF, providing compatibility with PC-to-PC communication software (such as LapLink™). Transmitters can be paralleled to drive multiple receivers.

When FORCEON = GND and $\overline{FORCEOFF}$ = $V_{CC}$ in the MAX3243E, if the AutoShutdown circuitry does not sense a valid voltage level at any receiver input, the part shuts down and the transmitter outputs are high impedance. When FORCEON = GND and $\overline{FORCEOFF}$ = $V_{CC}$ in the MAX3244E/MAX3245E, if the AutoShutdown Plus circuitry does not sense a valid transition on any receiver or transmitter for 30sec, the part shuts down and the transmitter outputs are high impedance.

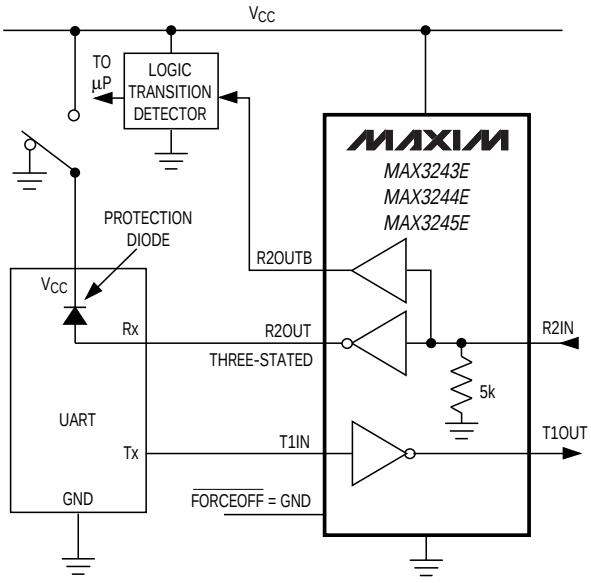
When powered off or shut down, the MAX3243E/MAX3244E/MAX3245E permit the outputs to be driven up to ±12V. The transmitter inputs do not have pull-up resistors. Connect unused inputs to GND or $V_{CC}$.

### RS-232 Receivers

The receivers convert RS-232 signals to CMOS-logic output levels. All receivers have inverting three-state outputs, and can be active or inactive (Table 1). The devices feature an extra, always-active noninverting output, R2OUTB. This allows ring indicator applications 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 1).




**a)** OLDER RS-232: POWERED-DOWN UART DRAWS CURRENT FROM ACTIVE RECEIVER OUTPUT IN SHUTDOWN.




**b)** NEW MAX324_E: IN SHUTDOWN, R2OUTB IS USED TO MONITOR EXTERNAL DEVICES AND R2OUT IS THREE STATED, ELIMINATING A CURRENT PATH THROUGH THE UART'S PROTECTION DIODE.

*Figure 1. Detection of RS-232 Activity when the UART and Interface are Shut Down*

*LapLink is a trademark of Traveling Software.*

**Table 1a. MAX3243E Output Control Truth Table**

| FORCEON | $\overline{\text{FORCEOFF}}$ | VALID RECEIVER LEVEL | OPERATION STATUS | T_OUT | R_OUT | R2OUTB |
|---|---|---|---|---|---|---|
| X | 0 | X | Shutdown (Forced Off) | High-Z | High-Z | Active |
| 1 | 1 | X | Normal Operation (Forced On) | Active | Active | Active |
| 0 | 1 | Yes | Normal Operation (AutoShutdown) | Active | Active | Active |
| 0 | 1 | No | Shutdown (AutoShutdown) | High-Z | Active | Active |

**Table 1b. MAX3244E/MAX3245E Output Control Truth Table**

| FORCEON | $\overline{\text{FORCEOFF}}$ | TRANSMITTER OR RECEIVER EDGE WITHIN 30sec | OPERATION STATUS | T_OUT | R_OUT | R2OUTB |
|---|---|---|---|---|---|---|
| X | 0 | X | Shutdown (Forced Off) | High-Z | High-Z | Active |
| 1 | 1 | X | Normal Operation (Forced On) | Active | Active | Active |
| 0 | 1 | Yes | Normal Operation (AutoShutdown Plus) | Active | Active | Active |
| 0 | 1 | No | Shutdown (AutoShutdown Plus) | High-Z | Active | Active |

**Table 2. $\overline{\text{INVALID}}$ Truth Table**

| RS-232 SIGNAL PRESENT AT ANY RECEIVER INPUT | $\overline{\text{INVALID}}$ OUTPUT |
|---|---|
| Yes | H |
| No | L |

*AutoShutdown Mode (MAX3243E)*

The MAX3243E achieves a 1µA supply current with Maxim's AutoShutdown feature, which operates when FORCEON is low and $\overline{\text{FORCEOFF}}$ is high. When the MAX3243E does not sense a valid voltage level on any receiver input 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 off. The device turns on again when a valid level is applied to any 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 is independent of FORCEON and $\overline{\text{FORCEOFF}}$ states (Figure 2).

Figure 2 and Tables 1a and 2 summarize the MAX3243E's operating modes. FORCEON and $\overline{\text{FORCEOFF}}$ override the AutoShutdown circuitry. When neither control is asserted, the IC selects between these states automatically, based on the receiver input levels. Figures 2a and 2b depict valid and invalid RS-232 receiver levels. Figure 4 shows the input levels and timing diagram for AutoShutdown operation.

A mouse or other system with AutoShutdown may need time to wake up. Figure 3 shows a circuit that forces the transmitters on for 100ms, allowing enough time for the other system to realize that the MAX3243E 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+ is pulled to $V_{CC}$, V- is pulled to ground, and the transmitter outputs are high impedance. The time required to exit shutdown is typically 100µs (Figure 10).

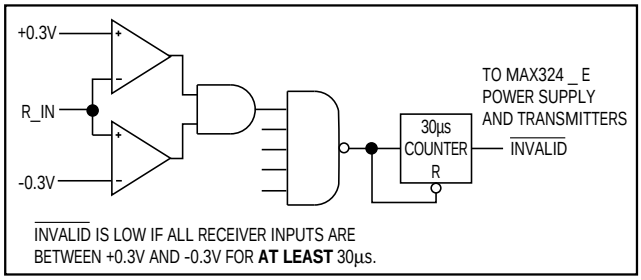



*Figure 2a. Invalid Receiver Levels*

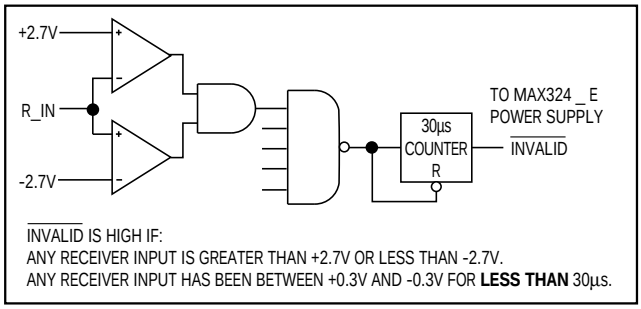



*Figure 2b. Valid Receiver Levels*

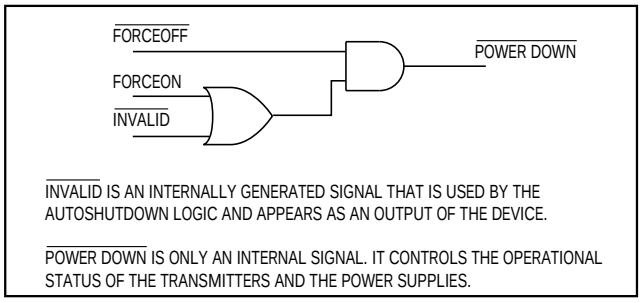



*Figure 2c. AutoShutdown Logic*

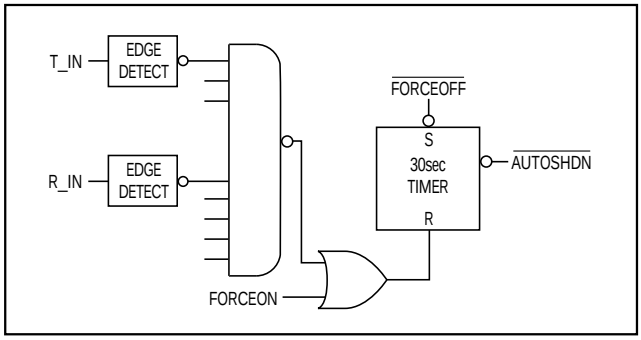



*Figure 2d. AutoShutdown Plus Edge Detection*

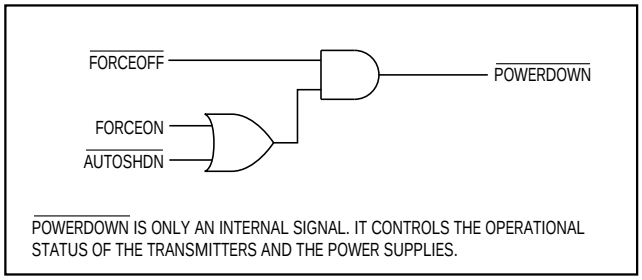



*Figure 2e. AutoShutdown Plus Logic*

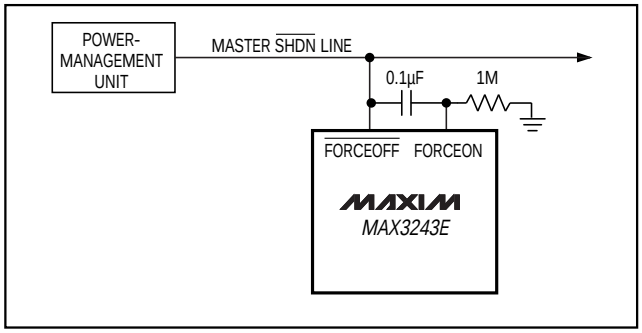



*Figure 3. AutoShutdown with Initial Turn-On to Wake up a Mouse or Another System*

### AutoShutdown Plus Mode (MAX3244E/MAX3245E)

The MAX3244E/MAX3245E achieve a 1µA supply current with Maxim's AutoShutdown Plus feature, which operates when FORCEON is low and FORCEOFF is high. When the MAX3244E/MAX3245E do not sense a valid signal transition on any receiver or transmitter input for 30sec, the on-board power supply and drivers are shut off, reducing supply current to 1µA. This occurs if all transmitter and receiver inputs are idle. The system turns on again when a valid transition is applied to any receiver or transmitter input. As a result, the system saves power without changes to the existing BIOS or operating system.

Figures 2a and 2b depict valid and invalid RS-232 receiver levels. INVALID indicates the receiver inputs' condition, and it is independent of the FORCEON and FORCEOFF states. Figure 2 and Tables 1b and 2 summarize the MAX3244E/MAX3245E operating modes. FORCEON and FORCEOFF override the AutoShutdown Plus circuitry. When neither control is asserted, the IC selects between these states automatically based on the last receiver or transmitter input edge received.

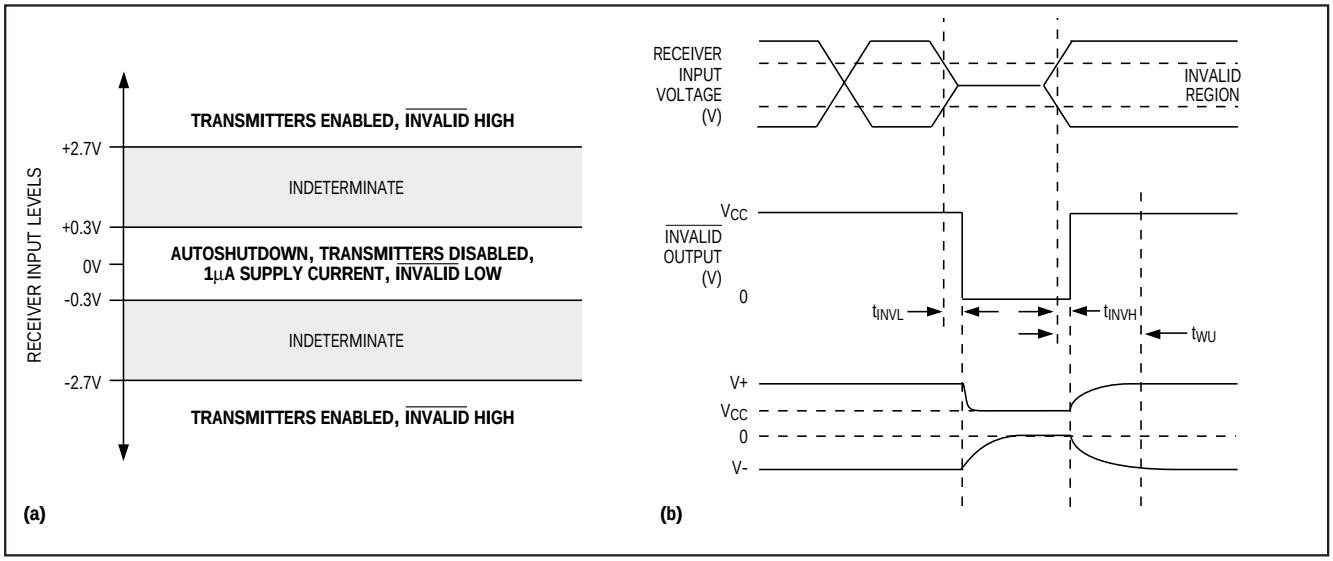



*Figure 4. AutoShutdown Input Levels and Timing*

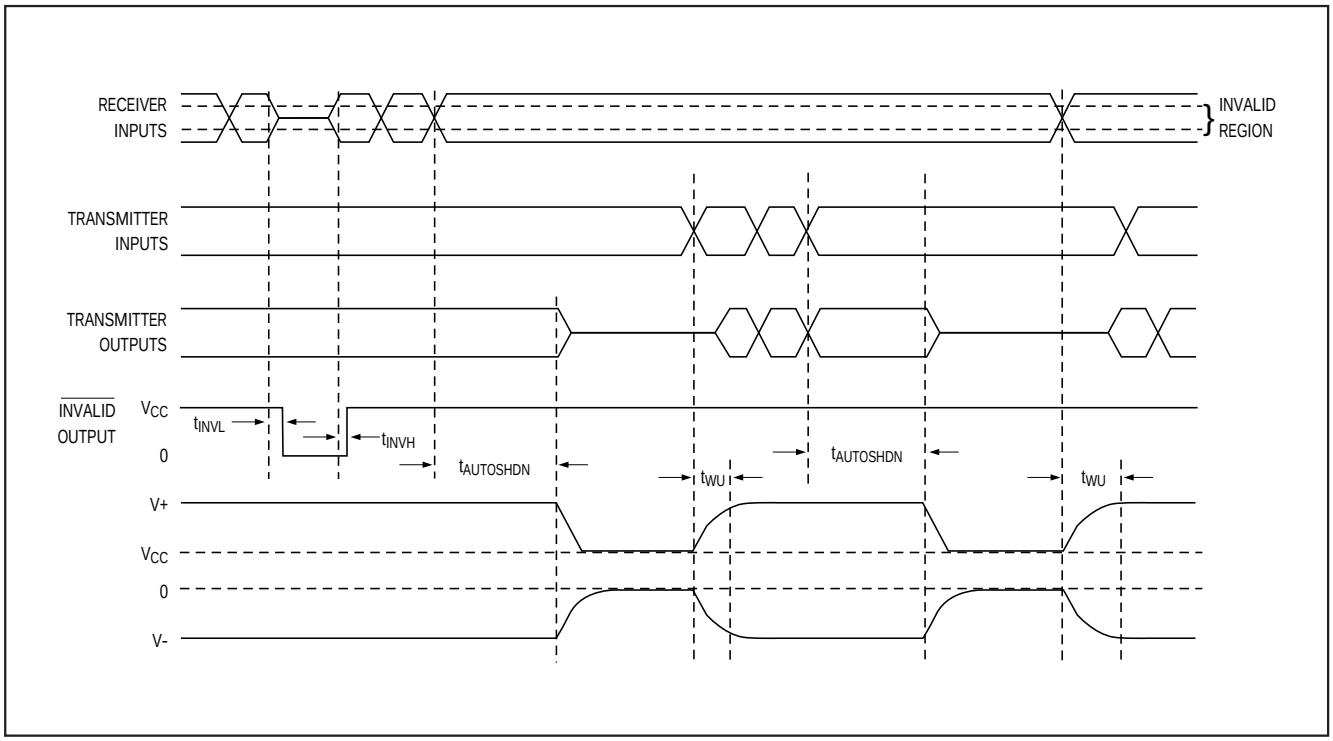



*Figure 5. AutoShutdown Plus and INVALID Timing Diagram*

Figure 5 shows a timing diagram for AutoShutdown Plus operation. The time required to exit shutdown is typically 100µs (Figure 10).

When shut down, the device's charge pumps are turned off, V+ is pulled to $V_{CC}$, V- is pulled to ground, and the transmitter outputs are disabled (high impedance).

By connecting $\overline{\text{INVALID}}$ to FORCEON, the MAX3244E/MAX3245E shut down when no valid receiver level and no receiver or transmitter edge is detected for 30sec, and wake up when a valid receiver level or receiver or transmitter edge is detected.

By connecting $\overline{\text{INVALID}}$ to FORCEON and $\overline{\text{FORCEOFF}}$, the MAX3244E/MAX3245E shut down when no valid receiver level is detected, and wake up when a valid receiver level is detected (same as AutoShutdown operation).

### *Software-Controlled Shutdown*

If direct software control is desired, $\overline{\text{INVALID}}$ can be used to indicate DTR or ring indicator signal. Tie $\overline{\text{FORCEOFF}}$ and FORCEON together to bypass AutoShutdown so the line acts like a $\overline{\text{SHDN}}$ input.

### *±15kV ESD Protection*

As with all Maxim devices, ESD protection structures are incorporated on all pins to protect against electrostatic discharges encountered during handling and assembly. The MAX3243E/MAX3244E/MAX3245E transmitter outputs and receiver inputs have extra protection against static electricity found in normal operation. Maxim's engineers have developed state-of-the-art structures to protect these pins against ESD of ±15kV without damage.

ESD protection can be tested in various ways. Transmitter outputs and receiver inputs are characterized for protection to the following:

1) ±15kV using the Human Body Model
2) ±8kV using the Contact Discharge method specified in IEC 1000-4-2 (formerly IEC 801-2)
3) ±15kV using the Air-Gap Discharge method specified in IEC 1000-4-2 (formerly IEC 801-2).

#### ESD Test Conditions

Contact Maxim for a reliability report that documents test setup, methodology, and results.

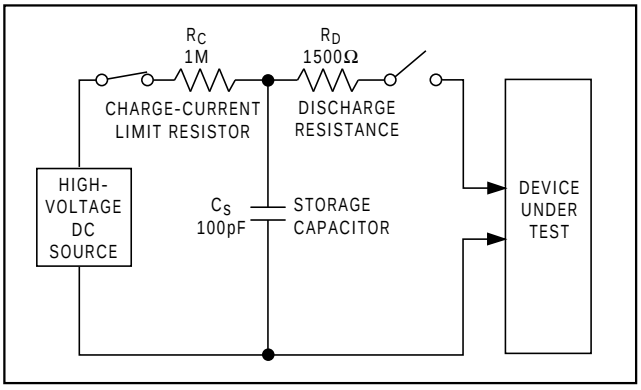



*Figure 6. Human Body ESD Test Model*

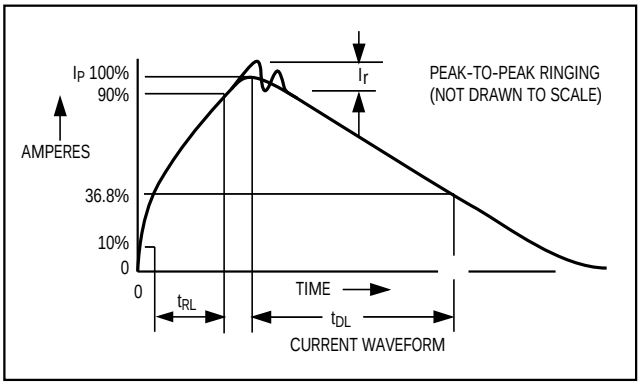



*Figure 7. Human Body Model Current Waveform*

#### Human Body Model

Figure 6 shows the Human Body Model, and Figure 7 shows the current waveform it generates when discharged into a low impedance. This model consists of a 100pF capacitor charged to the ESD voltage of interest, which is then discharged into the test device through a 1.5kΩ resistor.

#### IEC 1000-4-2

The IEC 100-4-2 standard covers ESD testing and performance of finished equipment; it does not specifically refer to integrated circuits. The MAX3243E/MAX3244E/MAX3245E enable the design of equipment that meets Level 4 (the highest level) of IEC 1000-4-2, without additional ESD protection components.

The major difference between tests done using the Human Body Model and IEC 1000-4-2 is higher peak current in IEC 1000-4-2. Because series resistance is

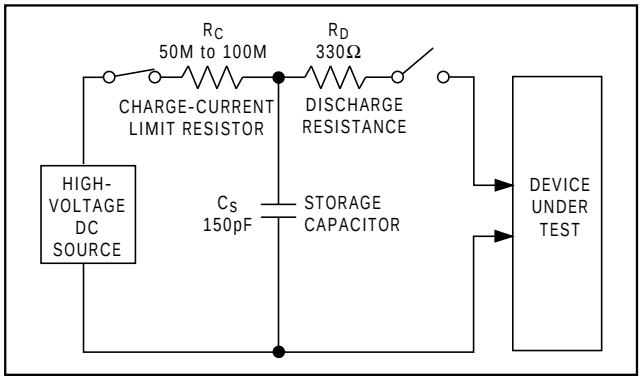



*Figure 8. IEC 1000-4-2 ESD Test Model*

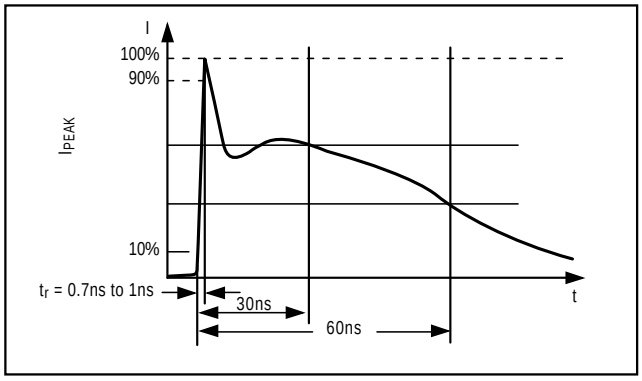



*Figure 9. IEC 1000-4-2 ESD Generator Current Waveform*

lower in the IEC 1000-4-2 ESD test model (Figure 8), the ESD withstand voltage measured to this standard is generally lower than that measured using the Human Body Model. Figure 9 shows the current waveform for the ±8kV IEC 1000-4-2 Level 4 ESD Contact Discharge test.

The Air-Gap test involves approaching the device with a charged probe. The Contact Discharge method connects the probe to the device before the probe is energized.

## Applications Information

### Capacitor Selection

The capacitor type used for C1–C4 is not critical for proper operation; polarized or nonpolarized capacitors can 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 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, C4, and $C_{BYPASS}$, to maintain the proper ratios (C1 to the other capacitors).**

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

### Power-Supply Decoupling

In applications that are sensitive to power-supply noise, decouple $V_{CC}$ to ground with a capacitor of the same value as reservoir capacitors C2, C3, and C4. Connect the bypass capacitor as close to the IC as possible.

### Transmitter Outputs when Exiting Shutdown

Figure 10 shows two transmitter outputs when exiting shutdown mode. As they become active, the two transmitter outputs are shown going to opposite RS-232 levels (one transmitter input is high, the other is low). Each transmitter is loaded with 3kΩ in parallel with 1000pF.

**Table 3. Required Minimum Capacitance Values**

| SUPPLY VOLTAGE (V) | C1 (µF) | C2, C3, C4, $C_{BYPASS}$ (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 |

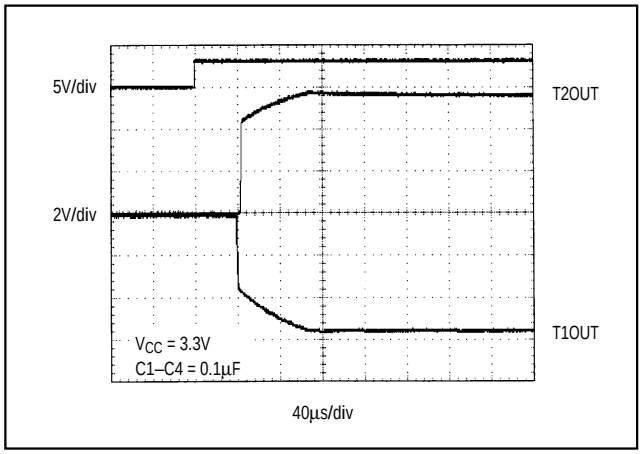



*Figure 10. Transmitter Outputs Exiting Shutdown or Powering Up*

The transmitter outputs display no ringing or undesirable transients as they come out of shutdown. Note that the transmitters are enabled only when V- exceeds approximately -3V.

### *High Data Rates*

The MAX3243E/MAX3244E maintain the RS-232 ±5.0V minimum transmitter output voltage even at high data rates. Figure 11 shows a transmitter loopback test circuit. Figure 12 shows a loopback test result at 120kbps, and Figure 13 shows the same test at 250kbps. For Figure 12, all transmitters were driven simultaneously at 120kbps into RS-232 loads in parallel with 1000pF. For Figure 13, a single transmitter was driven at 250kbps, and all transmitters were loaded with an RS-232 receiver in parallel with 1000pF.

The MAX3245E maintains the RS-232 ±5.0V minimum transmitter output voltage with data rates up to 1Mbps (MegaBaud). Figure 14 shows a loopback test result with a single transmitter driven at 1Mbps, and all transmitters loaded with an RS-232 receiver in parallel with 250pF.

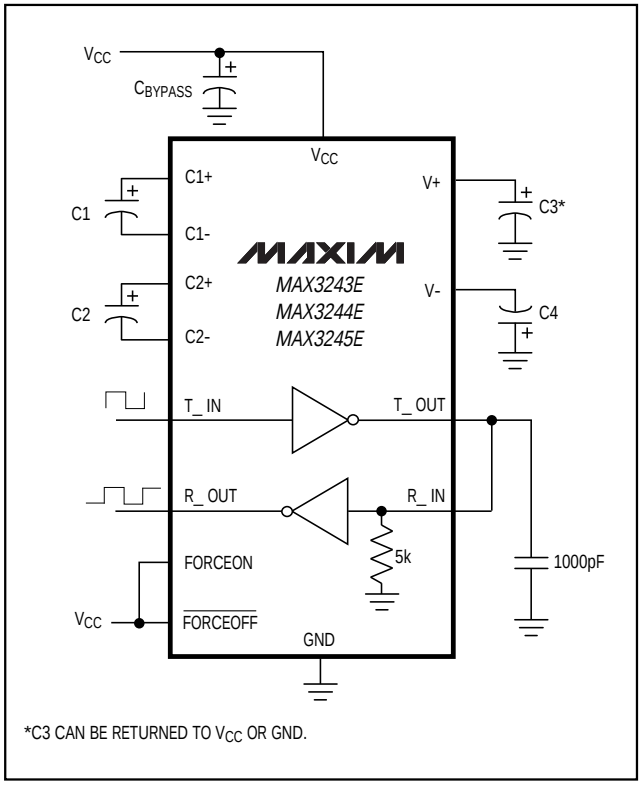



*Figure 11. Loopback Test Circuit*

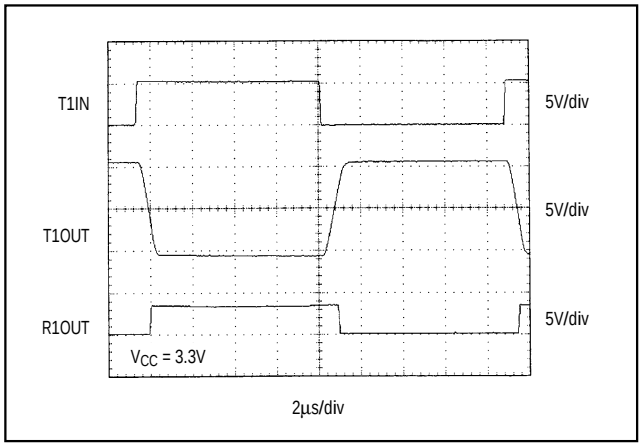



*Figure 12. MAX3243E/MAX3244E Loopback Test Result at 120kbps*

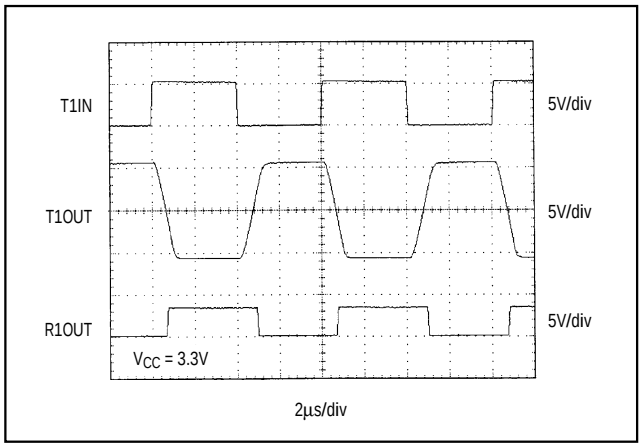



*Figure 13. MAX3243E/MAX3244E Loopback Test Result at 250kbps*

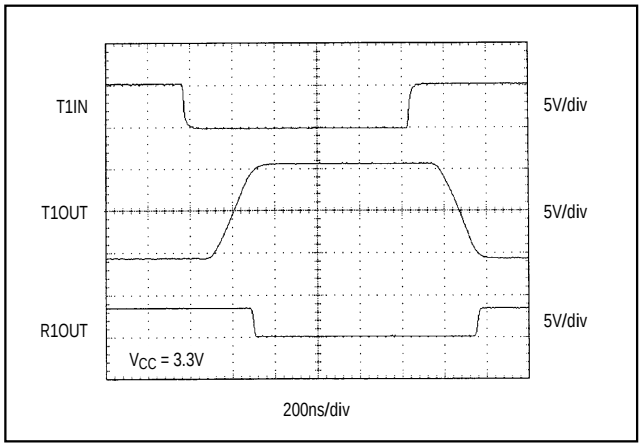



*Figure 14. MAX3245E Loopback Test Result at 1Mbps*

**Table 4. Logic Family Compatibility with Various Supply Voltages**

| SYSTEM POWER-SUPPLY VOLTAGE (V) | $V_{CC}$ SUPPLY VOLTAGE (V) | COMPATIBILITY |
|---|---|---|
| 3.3 | 3.3 | Compatible with all CMOS families. |
| 5 | 5 | Compatible with all TTL and CMOS families |
| 5 | 3.3 | Compatible with ACT and HCT CMOS, and with AC, HC, or CD4000 CMOS. |

### *Interconnection with 3V and 5V Logic*

The MAX3243E/MAX3244E/MAX3245E can directly interface with various 5V logic families, including ACT and HCT CMOS. See Table 4 for more information on possible combinations of interconnections.

### *Mouse Driveability*

The MAX3243E/MAX3244E/MAX3245E have been specifically designed to power serial mice while operating from low-voltage power supplies. They have been tested with leading mouse brands from manufacturers such as Microsoft and Logitech. The MAX3243E/MAX3244E/MAX3245E successfully drove all serial mice tested and met their respective current and voltage requirements. Figure 15a shows the transmitter outputs under increasing load current. The MAX3243E/MAX3244E/MAX3245E switching regulator ensures the transmitters will supply at least ±5V under worst-case conditions. Figure 15b shows a typical mouse connection.

The AutoShutdown Plus feature does not work with a mouse; connect FORCEON and $\overline{\text{FORCEOFF}}$ to $V_{CC}$.

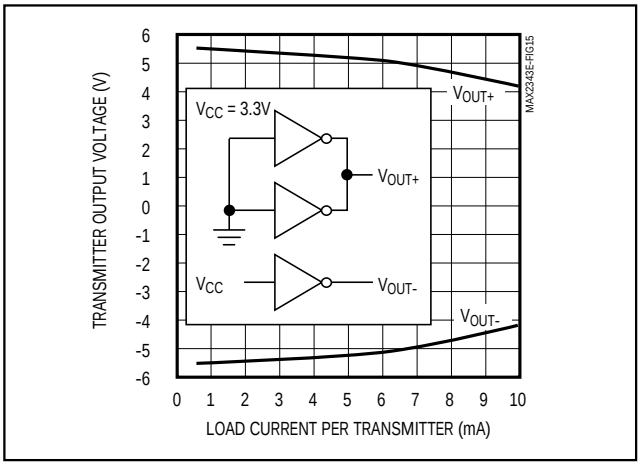



*Figure 15a. MAX324_E Transmitter Output Voltage vs. Load Current per Transmitter*

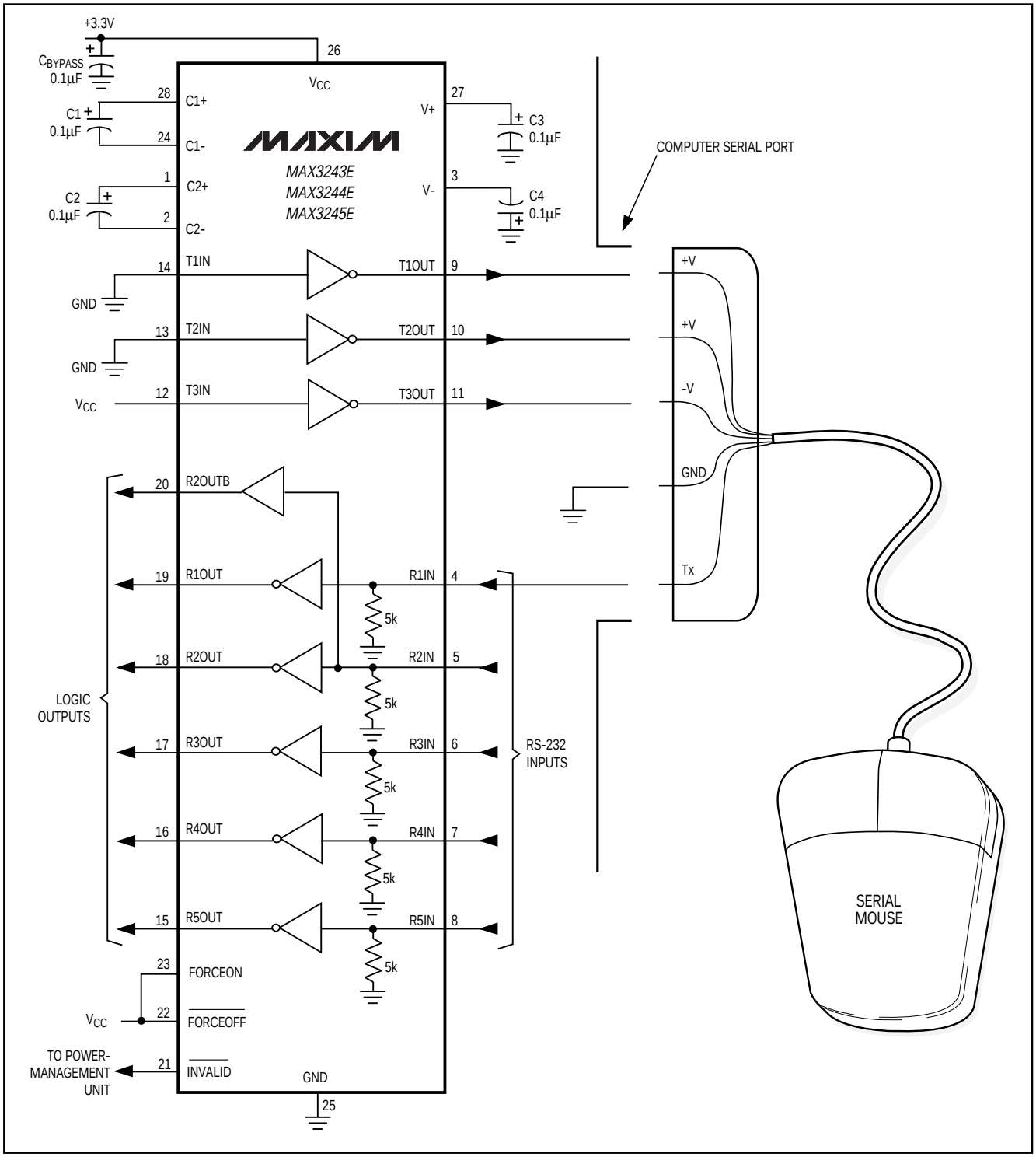
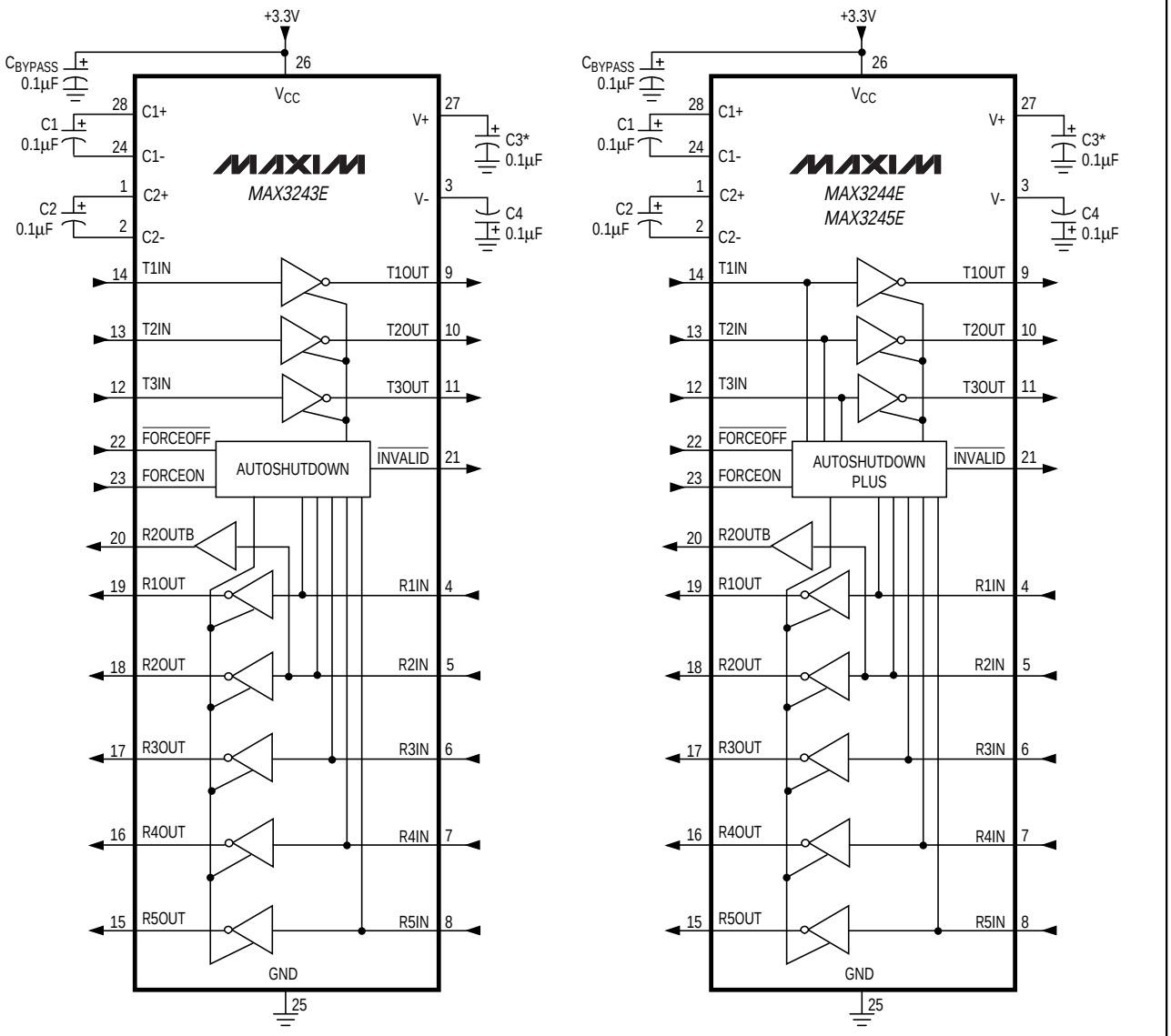



*Figure 15b. Mouse Driver Test Circuit*

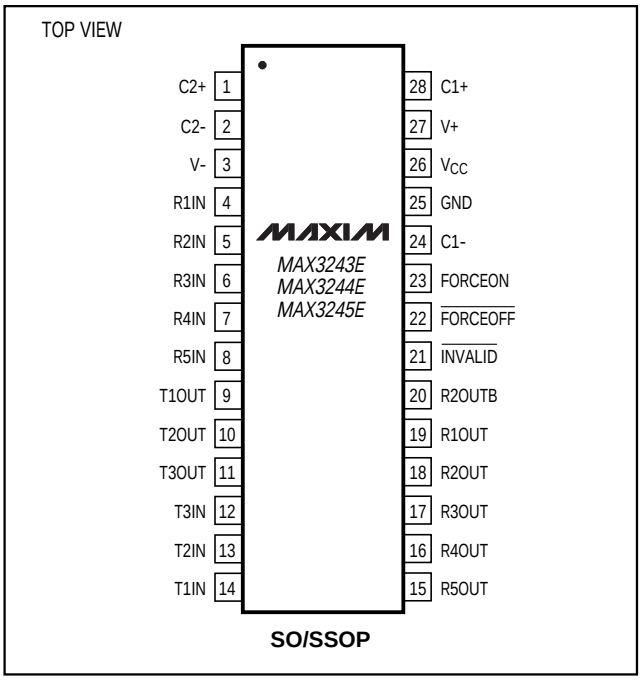
# ±15kV ESD-Protected, 1µA, 3.0V to 5.5V, 1Mbps RS-232 Transceivers with AutoShutdown Plus

## Typical Operating Circuit




*C3 CAN BE RETURNED TO $V_{CC}$ OR GND.

## Pin Configuration

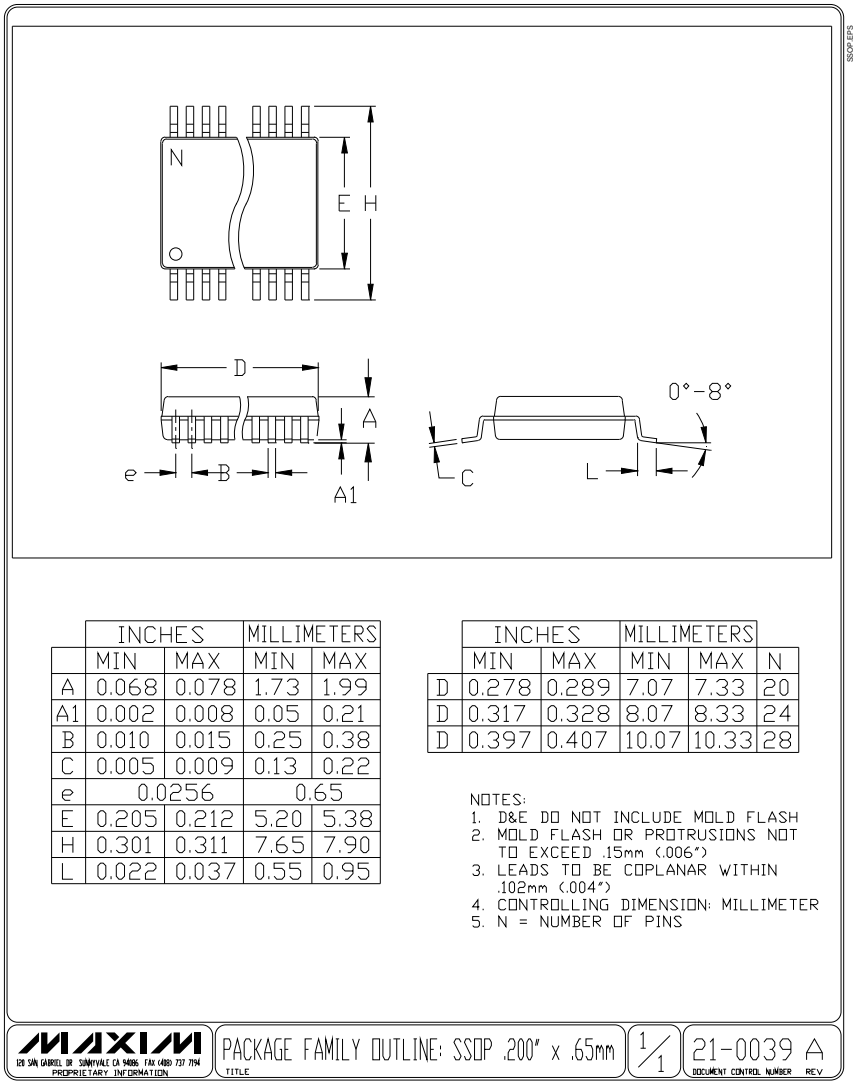



## Chip Information

TRANSISTOR COUNT: 1335

# ±15kV ESD-Protected, 1µA, 3.0V to 5.5V, 1Mbps RS-232 Transceivers with AutoShutdown Plus

## Package Information




| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 0.068 | 0.078 | 1.73 | 1.99 |
| A1 | 0.002 | 0.008 | 0.05 | 0.21 |
| B | 0.010 | 0.015 | 0.25 | 0.38 |
| C | 0.005 | 0.009 | 0.13 | 0.22 |
| e | 0.0256 | | 0.65 | |
| E | 0.205 | 0.212 | 5.20 | 5.38 |
| H | 0.301 | 0.311 | 7.65 | 7.90 |
| L | 0.022 | 0.037 | 0.55 | 0.95 |

| | INCHES | | MILLIMETERS | | |
|---|---|---|---|---|---|
| | MIN | MAX | MIN | MAX | N |
| D | 0.278 | 0.289 | 7.07 | 7.33 | 20 |
| D | 0.317 | 0.328 | 8.07 | 8.33 | 24 |
| D | 0.397 | 0.407 | 10.07 | 10.33 | 28 |

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. N = NUMBER OF PINS

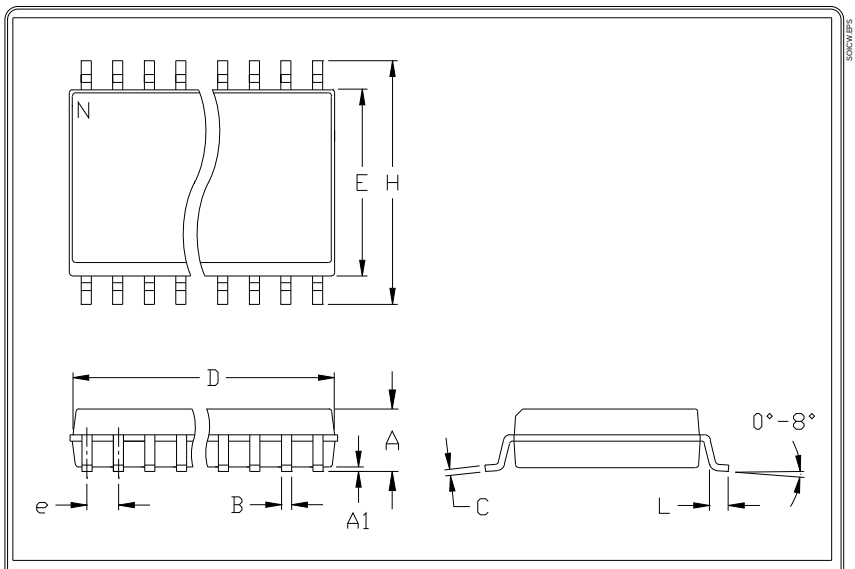
MAXIM 120 SAN GABRIEL DR SUNNYVALE CA 94086 FAX (408) 737 7194
PROPRIETARY INFORMATION

PACKAGE FAMILY OUTLINE: SSOP .200" x .65mm
TITLE

1/1

21-0039 A
DOCUMENT CONTROL NUMBER REV

## Package Information (continued)




| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 0.093 | 0.104 | 2.35 | 2.65 |
| A1 | 0.004 | 0.012 | 0.10 | 0.30 |
| B | 0.014 | 0.019 | 0.35 | 0.49 |
| C | 0.009 | 0.013 | 0.23 | 0.32 |
| e | 0.050 | | 1.27 | |
| E | 0.291 | 0.299 | 7.40 | 7.60 |
| H | 0.394 | 0.419 | 10.00 | 10.65 |
| h | 0.010 | 0.030 | 0.25 | 0.75 |
| L | 0.016 | 0.050 | 0.40 | 1.27 |

| | INCHES | | MILLIMETERS | | | |
|---|---|---|---|---|---|---|
| | MIN | MAX | MIN | MAX | N | MS013 |
| D | 0.398 | 0.413 | 10.10 | 10.50 | 16 | AA |
| D | 0.447 | 0.463 | 11.35 | 11.75 | 18 | AB |
| D | 0.496 | 0.512 | 12.60 | 13.00 | 20 | AC |
| D | 0.598 | 0.614 | 15.20 | 15.60 | 24 | AD |
| D | 0.697 | 0.713 | 17.70 | 18.10 | 28 | AE |

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 MS013-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 .300" — TITLE

1/1

21-0042 A — DOCUMENT CONTROL NUMBER — REV.

**NOTES**