



# ±15kV ESD-Protected, Down to 10nA, 3.0V to 5.5V, Up to 1Mbps, True RS-232 Transceivers

## General Description

The MAX3222E/MAX3232E/MAX3237E/MAX3241E are 3V-powered EIA/TIA-232 and V.28/V.24 communications interfaces with low power requirements, 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 MAX3237E's logic and receiver I/O pins are protected to the above standards, while the transmitter output pins are protected to ±15kV using the Human Body Model.

The transceivers have a proprietary low-dropout transmitter output stage, delivering true RS-232 performance from a +3.0V to +5.5V supply with a dual charge pump. The charge pump requires only four small 0.1µF capacitors for operation from a +3.3V supply. Each device is guaranteed to run at data rates of 250kbps while maintaining RS-232 output levels. The MAX3237E is guaranteed to run at data rates of 250kbps in the normal operating mode and 1Mbps in the MegaBaud™ operating mode while maintaining RS-232-compliant output levels.

The MAX3222E/MAX3232E have two receivers and two drivers. The MAX3222E features a 1µA shutdown mode that reduces power consumption and extends battery life in portable systems. Its receivers can remain active in shutdown mode, allowing external devices such as modems to be monitored using only 1µA supply current. Both the MAX3222E and MAX3232E are pin, package, and functionally compatible with the industry-standard MAX242 and MAX232, respectively.

The MAX3241E is a complete serial port (three drivers/five receivers) designed for notebook and subnotebook computers. The MAX3237E (five drivers/three receivers) is ideal for peripheral applications that require fast data transfer. Both devices feature a shutdown mode in which all receivers can remain active while using a supply current of only 1µA (MAX3241E) or 10nA (MAX3237E). The MAX3237E/MAX3241E have additional receiver outputs that always remain active.

The MAX3222E and MAX3232E are available in space-saving SO, SSOP, and TSSOP packages. The MAX3241E is available in SO and SSOP packages. The MAX3237E is available in an SSOP package.

## Applications

|  |              |
|--|--------------|
| Notebooks, Subnotebooks, and Palmtop Computers | Smart Phones |
| Battery-Powered Equipment                      | XDSL Modems  |
| Cell-Phone Data Cables                         | Printers     |
|  | Cell Phones  |

MegaBaud is a trademark of Maxim Integrated Products.

† Covered by U.S. Patent numbers 4,636,930; 4,679,134; 4,777,577; 4,797,899; 4,809,152; 4,897,774; 4,999,761; and other patents pending.



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## Features

- ◆ ESD Protection for RS-232 I/O Pins (MAX3222E/MAX3232E/MAX3241E)
  - ±15kV—Human Body Model
  - ±8kV—IEC 1000-4-2, Contact Discharge
  - ±15kV—IEC 1000-4-2, Air-Gap Discharge
- ◆ ESD Protection for All Logic and Receiver I/O Pins (MAX3237E)
  - ±15kV—Human Body Model
  - ±8kV—IEC 1000-4-2, Contact Discharge
  - ±15kV—IEC 1000-4-2, Air-Gap Discharge
- ◆ ESD Protection for Transmitter Output Pins (MAX3237E)
  - ±15kV—Human Body Model
- ◆ Guaranteed Data Rate
  - 250kbps (MAX3222E/MAX3232E/MAX3241E and MAX3237E, normal operation)
  - 1Mbps (MAX3237E, MegaBaud operation)
- ◆ Latchup Free
- ◆ Low-Power Shutdown with Receivers Active
  - 1µA (MAX3222E/MAX3241E)
  - 10nA (MAX3237E)
- ◆ Flow-Through Pinout (MAX3237E)
- ◆ Guaranteed Mouse Driveability (MAX3241E)
- ◆ Meets EIA/TIA-232 Specifications Down to 3.0V

## Ordering Information

| PART        | TEMP. RANGE  | PIN-PACKAGE |
|-------------|--------------|-------------|
| MAX3222ECUP | 0°C to +70°C | 20 TSSOP    |
| MAX3222ECAP | 0°C to +70°C | 20 SSOP     |

Ordering Information continued at end of data sheet.

## Selector Guide

| PART                | NO. OF DRIVERS/RECEIVERS | LOW-POWER SHUTDOWN | GUARANTEED DATA RATE (kbps) |
|---------------------|--------------------------|--------------------|-----------------------------|
| MAX3222E            | 2/2                      | ✓                  | 250                         |
| MAX3232E            | 2/2                      | —                  | 250                         |
| MAX3237E (Normal)   | 5/3                      | ✓                  | 250                         |
| MAX3237E (MegaBaud) | 5/3                      | ✓                  | 1M                          |
| MAX3241E            | 3/5                      | ✓                  | 250                         |

Pin Configurations appear at end of data sheet.

Typical Operating Circuits appear at end of data sheet.

MAX3222E/MAX3232E/MAX3237E/MAX3241E†

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## ABSOLUTE MAXIMUM RATINGS

|  |                                   |  |                      |
|--|-----------------------------------|--|----------------------|
| V <sub>CC</sub> to GND   | -0.3V to +6V                      | 16-Pin Wide SO (derate 9.52mW/°C above +70°C)  | .....762mW           |
| V+ to GND (Note 1)   | -0.3V to +7V                      | 18-Pin Wide SO (derate 9.52mW/°C above +70°C)  | .....762mW           |
| V- to GND (Note 1)   | +0.3V to -7V                      | 18-Pin PDIP (derate 11.11mW/°C above +70°C)    | .....889mW           |
| V+ +  V-  (Note 1)   | +13V                              | 20-Pin TSSOP (derate 7.0mW/°C above +70°C)     | .....559mW           |
| Input Voltages   |                                   | 20-Pin SSOP (derate 8.00mW/°C above +70°C)     | .....640mW           |
| T <sub>IN</sub> , $\overline{\text{EN}}$ , $\overline{\text{SHDN}}$ , MBAUD to GND | -0.3V to +6V                      | 28-Pin SSOP (derate 9.52mW/°C above +70°C)     | .....762mW           |
| R <sub>IN</sub> to GND   | ±25V                              | 28-Pin Wide SO (derate 12.50mW/°C above +70°C) | .....1W              |
| Output Voltages  |                                   | Operating Temperature Ranges                   |                      |
| T <sub>OUT</sub> to GND  | ±13.2V                            | MAX32_ _EC_ _                                  | .....0°C to +70°C    |
| R <sub>OUT</sub> , R <sub>OUTB</sub> (MAX3241E)                                    | -0.3V to (V <sub>CC</sub> + 0.3V) | MAX32_ _EE_ _                                  | .....-40°C to +85°C  |
| Short-Circuit Duration, T <sub>OUT</sub> to GND                                    | Continuous                        | Storage Temperature Range                      | .....-65°C to +150°C |
| Continuous Power Dissipation (T <sub>A</sub> = +70°C)                              |                                   | Lead Temperature (soldering, 10s)              | .....+300°C          |
| 16-Pin SSOP (derate 7.14mW/°C above +70°C)   | .....571mW                        |  |                      |

**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 = 0.1µF, 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.) (Note 2)

| PARAMETER  | CONDITIONS   | MIN                          | TYP                   | MAX | UNITS |
|--|--|------------------------------|-----------------------|-----|-------|
| <b>DC CHARACTERISTICS</b> (V <sub>CC</sub> = +3.3V or +5.0V, T <sub>A</sub> = +25°C) |  |                              |                       |     |       |
| Supply Current   | $\overline{\text{SHDN}}$ = V <sub>CC</sub> , no load   | MAX3222E, MAX3232E, MAX3241E | 0.3                   | 1   | mA    |
|  |  | MAX3237E                     | 0.5                   | 2.0 |       |
| Shutdown Supply Current  | $\overline{\text{SHDN}}$ = GND   |                              | 1                     | 10  | µA    |
|  | $\overline{\text{SHDN}}$ = R <sub>IN</sub> = GND, T <sub>IN</sub> = GND or V <sub>CC</sub> (MAX3237E)        |                              | 10                    | 300 | nA    |
| <b>LOGIC INPUTS</b>  |  |                              |                       |     |       |
| Input Logic Low  | T <sub>IN</sub> , $\overline{\text{EN}}$ , $\overline{\text{SHDN}}$ , MBAUD                                  |                              |                       | 0.8 | V     |
| Input Logic High   | T <sub>IN</sub> , $\overline{\text{EN}}$ , $\overline{\text{SHDN}}$ , MBAUD                                  | V <sub>CC</sub> = 3.3V       | 2.0                   |     | V     |
|  |  | V <sub>CC</sub> = 5.0V       | 2.4                   |     |       |
| Transmitter Input Hysteresis   |  |                              | 0.5                   |     | V     |
| Input Leakage Current  | T <sub>IN</sub> , $\overline{\text{EN}}$ , $\overline{\text{SHDN}}$  | MAX3222E, MAX3232E, MAX3241E | ±0.01                 | ±1  | µA    |
|  | T <sub>IN</sub> , $\overline{\text{SHDN}}$ , MBAUD   | MAX3237E (Note 3)            | 9                     | 18  |       |
| <b>RECEIVER OUTPUTS</b>  |  |                              |                       |     |       |
| Output Leakage Current   | R <sub>OUT</sub> (MAX3222E/MAX3237E/MAX3241E), $\overline{\text{EN}}$ = V <sub>CC</sub> , receivers disabled |                              | ±0.05                 | ±10 | µA    |
| Output Voltage Low   | I <sub>OUT</sub> = 1.6mA (MAX3222E/MAX3232E/MAX3241E)  |                              |                       | 0.4 | V     |
|  | I <sub>OUT</sub> = 1.0mA (MAX3237E)  |                              |                       | 0.4 |       |
| Output Voltage High  | I <sub>OUT</sub> = -1.0mA  | V <sub>CC</sub> - 0.6        | V <sub>CC</sub> - 0.1 |     | V     |
| <b>RECEIVER INPUTS</b>   |  |                              |                       |     |       |
| Input Voltage Range  |  | -25                          |                       | +25 | V     |
| Input Threshold Low  | T <sub>A</sub> = +25°C   | V <sub>CC</sub> = 3.3V       | 0.6                   | 1.1 | V     |
|  |  | V <sub>CC</sub> = 5.0V       | 0.8                   | 1.5 |       |

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MAX3222E/MAX3232E/MAX3237E/MAX3241E

## ELECTRICAL CHARACTERISTICS (continued)

(V<sub>CC</sub> = +3.0V to +5.5V, C<sub>1</sub>–C<sub>4</sub> = 0.1μF, 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.) (Note 2)

| PARAMETER  | CONDITIONS   |                                | MIN | TYP  | MAX | UNITS |
|--|--|--------------------------------|-----|------|-----|-------|
| <b>RECEIVER INPUTS</b>   |  |                                |     |      |     |       |
| 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         |     | 2.0  | 2.4 |       |
| Input Hysteresis   |  |                                |     | 0.5  |     | V     |
| Input Resistance   | T <sub>A</sub> = +25°C   |                                | 3   | 5    | 7   | kΩ    |
| <b>TRANSMITTER OUTPUTS</b>   |  |                                |     |      |     |       |
| Output Voltage Swing   | All transmitter outputs loaded with 3kΩ to ground  |                                | ±5  | ±5.4 |     | V     |
| Output Resistance  | V <sub>CC</sub> = 0, transmitter output = ±2V  |                                | 300 | 50k  |     | Ω     |
| Output Short-Circuit Current   |  |                                |     |      | ±60 | mA    |
| Output Leakage Current   | V <sub>CC</sub> = 0 or 3V to 5.5V, V <sub>OUT</sub> = ±12V, transmitters disabled (MAX3222E/MAX3232E/MAX3241E)   |                                |     |      | ±25 | μA    |
| <b>MOUSE DRIVEABILITY (MAX3241E)</b>   |  |                                |     |      |     |       |
| 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     |
| <b>ESD PROTECTION</b>  |  |                                |     |      |     |       |
| R_IN, T_OUT  | Human Body Model   |                                |     | ±15  |     | kV    |
|  | IEC 1000-4-2 Air-Gap Discharge (except MAX3237E)   |                                |     | ±15  |     |       |
|  | IEC 1000-4-2 Contact Discharge (except MAX3237E)   |                                |     | ±8   |     |       |
| T_IN, R_IN, R_OUT, $\overline{\text{EN}}$ , $\overline{\text{SHDN}}$ , MBAUD | MAX3237E   | Human Body Model               |     | ±15  |     | kV    |
|  |  | IEC 1000-4-2 Air-Gap Discharge |     | ±15  |     |       |
|  |  | IEC 1000-4-2 Contact Discharge |     | ±8   |     |       |

## TIMING CHARACTERISTICS—MAX3222E/MAX3232E/MAX3241E

(V<sub>CC</sub> = +3.0V to +5.5V, C<sub>1</sub>–C<sub>4</sub> = 0.1μF, 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.) (Note 2)

| PARAMETER                    | SYMBOL                              | CONDITIONS  |                                  | MIN | TYP  | MAX | UNITS |
|------------------------------|-------------------------------------|---|----------------------------------|-----|------|-----|-------|
| Maximum Data Rate            |                                     | R <sub>L</sub> = 3kΩ, C <sub>L</sub> = 1000pF, one transmitter switching  |                                  | 250 |      |     | kbps  |
| Receiver Propagation Delay   | t <sub>PHL</sub>                    | Receiver input to receiver output, C <sub>L</sub> = 150pF   |                                  |     | 0.15 |     | μs    |
|                              | t <sub>PLH</sub>                    |   |                                  |     | 0.15 |     |       |
| Receiver Output Enable Time  |                                     | Normal operation (except MAX3232E)  |                                  |     | 200  |     | ns    |
| Receiver Output Disable Time |                                     | Normal operation (except MAX3232E)  |                                  |     | 200  |     | ns    |
| Transmitter Skew             | t <sub>PHL</sub> - t <sub>PLH</sub> | (Note 4)  |                                  |     | 100  |     | ns    |
| Receiver Skew                | t <sub>PHL</sub> - t <sub>PLH</sub> |   |                                  |     | 50   |     | ns    |
| Transition-Region Slew Rate  |                                     | V <sub>CC</sub> = 3.3V, T <sub>A</sub> = +25°C, R <sub>L</sub> = 3kΩ to 7kΩ, measured from +3V to -3V or -3V to +3V | C <sub>L</sub> = 150pF to 1000pF | 6   |      | 30  | V/μs  |
|                              |                                     |   | C <sub>L</sub> = 150pF to 2500pF | 4   |      | 30  |       |

**Note 2:** MAX3222E/MAX3232E/MAX3241E: C<sub>1</sub>–C<sub>4</sub> = 0.1μF tested at 3.3V ±10%; C<sub>1</sub> = 0.047μF, C<sub>2</sub>–C<sub>4</sub> = 0.33μF tested at 5.0V ±10%. MAX3237E: C<sub>1</sub>–C<sub>4</sub> = 0.1μF, tested at 3.3V ±5%; C<sub>1</sub>–C<sub>4</sub> = 0.22μF tested at 3.3V ±10%; C<sub>1</sub> = 0.047μF, C<sub>2</sub>–C<sub>4</sub> = 0.33μF tested at 5.0V ±10%.

**Note 3:** The MAX3237E logic inputs have an active positive feedback resistor. The input current goes to zero when the inputs are at the supply rails.

**Note 4:** Transmitter skew is measured at the transmitter zero crosspoints.

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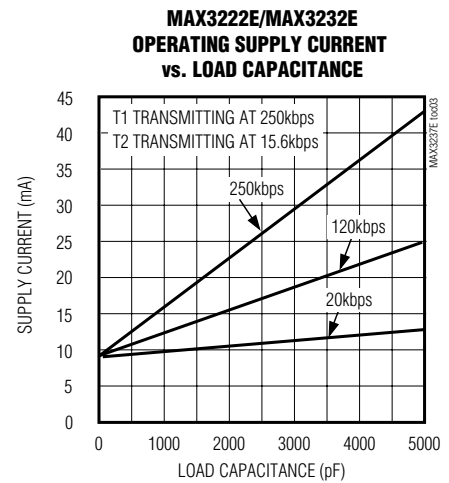
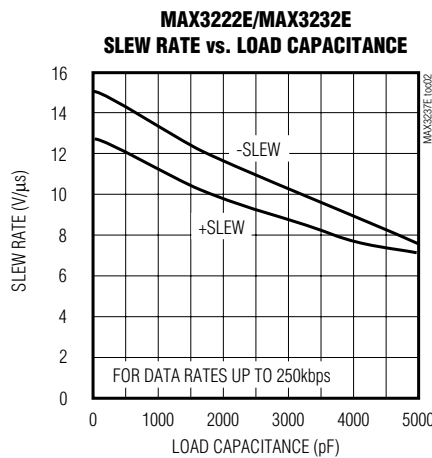
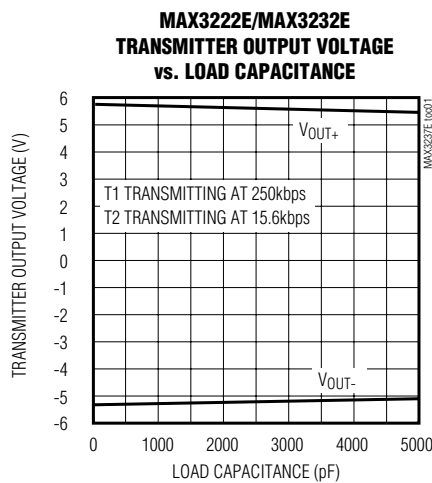
## TIMING CHARACTERISTICS—MAX3237E

(V<sub>CC</sub> = +3.0V to +5.5V, C<sub>1</sub>–C<sub>4</sub> = 0.1μF, 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.) (Note 2)

| PARAMETER                    | CONDITIONS  |   | MIN                     | TYP | MAX | UNITS |
|------------------------------|---|---|-------------------------|-----|-----|-------|
| Maximum Data Rate            | R <sub>L</sub> = 3kΩ, C <sub>L</sub> = 1000pF, one transmitter switching, MBAUD = GND   |   | 250                     |     |     | kbps  |
|                              | V <sub>CC</sub> = 3.0V to 4.5V, R <sub>L</sub> = 3kΩ, C <sub>L</sub> = 250pF, one transmitter switching, MBAUD = V <sub>CC</sub>  |   | 1000                    |     |     |       |
|                              | V <sub>CC</sub> = 4.5V to 5.5V, R <sub>L</sub> = 3kΩ, C <sub>L</sub> = 1000pF, one transmitter switching, MBAUD = V <sub>CC</sub> |   | 1000                    |     |     |       |
| Receiver Propagation Delay   | R <sub>IN</sub> to R <sub>OUT</sub> , C <sub>L</sub> = 150pF  | t <sub>PHL</sub>                              | 0.15                    |     |     | μs    |
|                              |   | t <sub>PLH</sub>                              | 0.15                    |     |     |       |
| Receiver Output Enable Time  | Normal operation  |   | 2.6                     |     |     | μs    |
| Receiver Output Disable Time | Normal operation  |   | 2.4                     |     |     | μs    |
| Transmitter Skew             | t <sub>PHL</sub> - t <sub>PLH</sub>  , MBAUD = GND  |   | 100                     |     |     | ns    |
|                              | t <sub>PHL</sub> - t <sub>PLH</sub>  , MBAUD = V <sub>CC</sub>  |   | 100                     |     |     | ns    |
| Receiver Skew                | t <sub>PHL</sub> - t <sub>PLH</sub>   |   | 50                      |     |     | ns    |
| Transition-Region Slew Rate  | V <sub>CC</sub> = 3.3V, R <sub>L</sub> = 3kΩ to 7kΩ, +3V to -3V or -3V to +3V, T <sub>A</sub> = +25°C                             | C <sub>L</sub> = 150pF to 1000pF              | MBAUD = GND             | 6   | 30  | V/μs  |
|                              |   |   | MBAUD = V <sub>CC</sub> | 24  | 150 |       |
|                              |   | C <sub>L</sub> = 150pF to 2500pF, MBAUD = GND |                         | 4   | 30  |       |

## Typical Operating Characteristics

(V<sub>CC</sub> = +3.3V, 250kbps data rate, 0.1μF capacitors, all transmitters loaded with 3kΩ and C<sub>L</sub>, T<sub>A</sub> = +25°C, unless otherwise noted.)

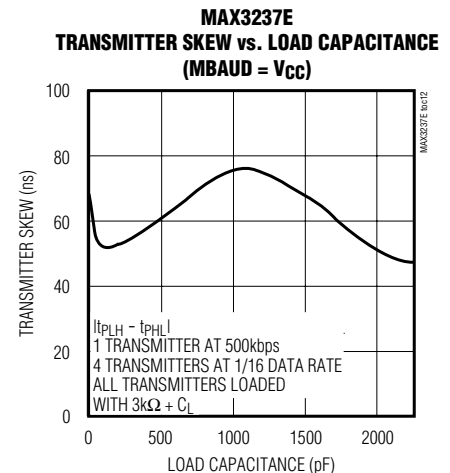
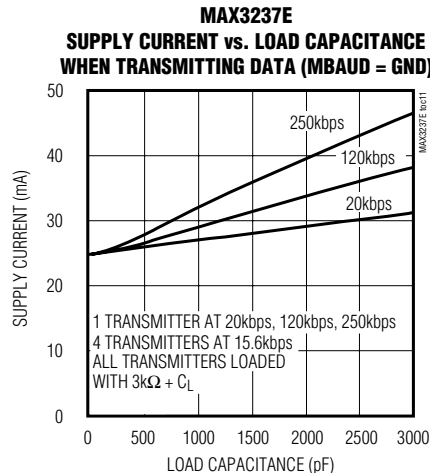
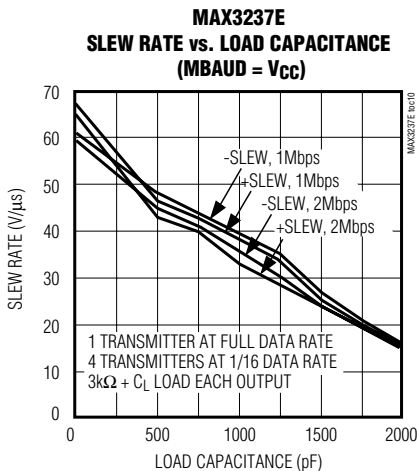
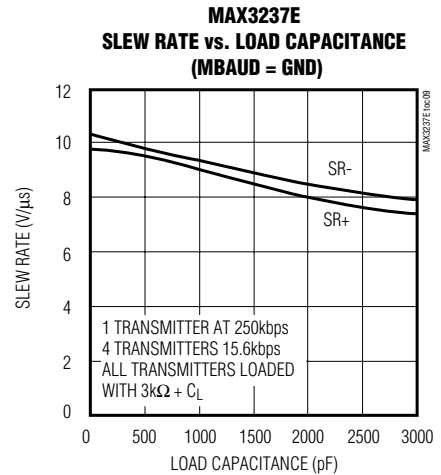
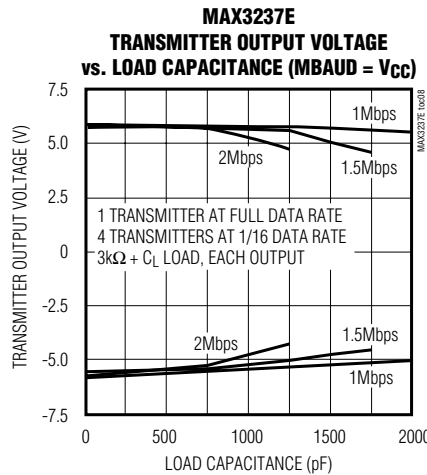
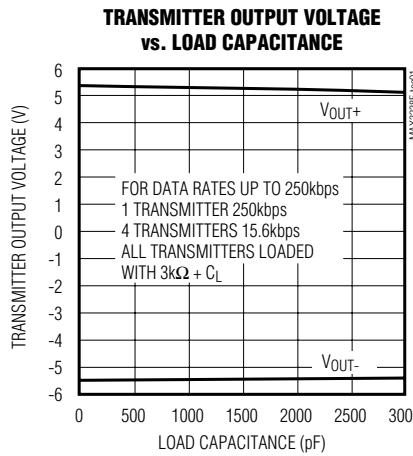
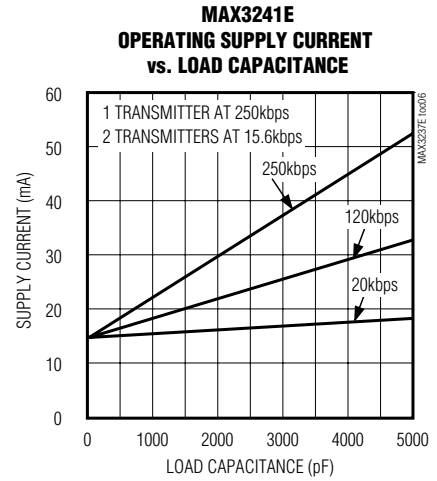
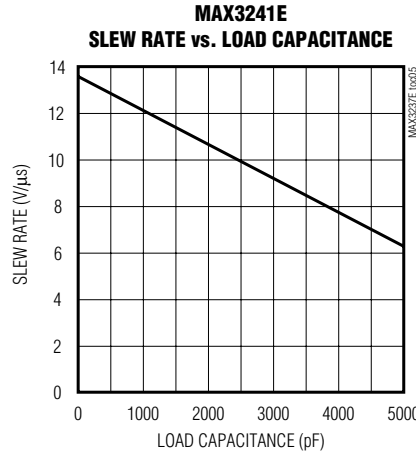
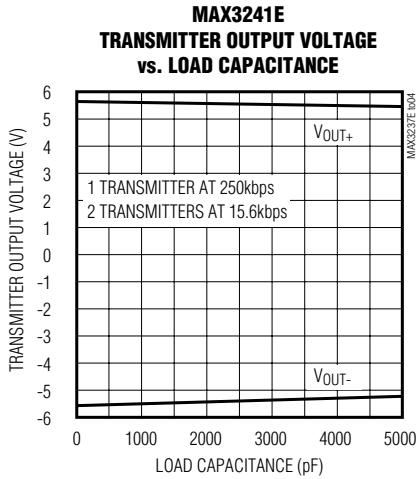


# **$\pm 15\text{kV}$ ESD-Protected, Down to 10nA, 3.0V to 5.5V, Up to 1Mbps, True RS-232 Transceivers**

## **Typical Operating Characteristics (continued)**

( $V_{CC} = +3.3\text{V}$ , 250kbps data rate, 0.1 $\mu\text{F}$  capacitors, all transmitters loaded with 3k $\Omega$  and  $C_L$ ,  $T_A = +25^\circ\text{C}$ , unless otherwise noted.)

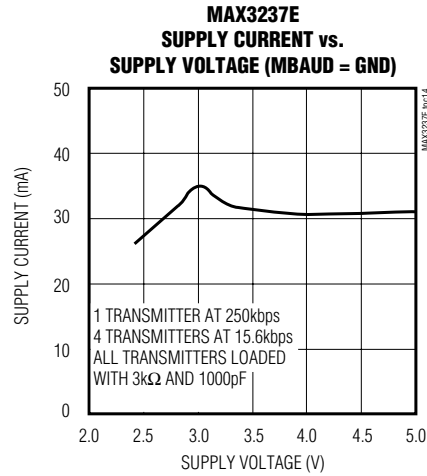
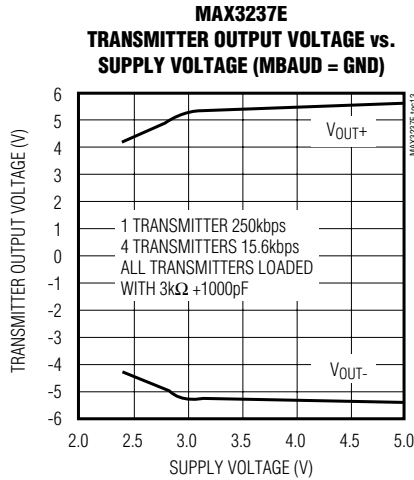
**MAX3222E/MAX3232E/MAX3237E/MAX3241E**



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## Typical Operating Characteristics (continued)

(V<sub>CC</sub> = +3.3V, 250kbps data rate, 0.1µF capacitors, all transmitters loaded with 3kΩ and C<sub>L</sub>, T<sub>A</sub> = +25°C, unless otherwise noted.)



## Pin Description

| PIN      |            |          |            |                         |            | NAME            | FUNCTION   |
|----------|------------|----------|------------|-------------------------|------------|-----------------|--|
| MAX3222E |            | MAX3232E |            | MAX3237E                | MAX3241E   |                 |  |
| SO/DIP   | TSSOP/SSOP | SO/DIP   | TSSOP/SSOP |                         |            |                 |  |
| 1        | 1          | —        | —          | 13*                     | 23         | $\overline{EN}$ | Receiver Enable. Active low.                               |
| 2        | 2          | 1        | 2          | 28                      | 28         | C1+             | Positive Terminal of Voltage-Doubler Charge-Pump Capacitor |
| 3        | 3          | 2        | 3          | 27                      | 27         | V+              | +5.5V Generated by the Charge Pump                         |
| 4        | 4          | 3        | 4          | 25                      | 24         | C1-             | Negative Terminal of Voltage-Doubler Charge-Pump Capacitor |
| 5        | 5          | 4        | 5          | 1                       | 1          | C2+             | Positive Terminal of Inverting Charge-Pump Capacitor       |
| 6        | 6          | 5        | 6          | 3                       | 2          | C2-             | Negative Terminal of Inverting Charge-Pump Capacitor       |
| 7        | 7          | 6        | 7          | 4                       | 3          | V-              | -5.5V Generated by the Charge Pump                         |
| 8, 15    | 8, 17      | 7, 14    | 8, 17      | 5, 6, 7, 10, 12         | 9, 10, 11  | T_OUT           | RS-232 Transmitter Outputs                                 |
| 9, 14    | 9, 16      | 8, 13    | 9, 16      | 8, 9, 11                | 4–8        | R_IN            | RS-232 Receiver Inputs                                     |
| 10, 13   | 10, 15     | 9, 12    | 12, 15     | 18, 20, 21              | 15–19      | R_OUT           | TTL/CMOS Receiver Outputs                                  |
| 11, 12   | 12, 13     | 10, 11   | 13, 14     | 17*, 19*, 22*, 23*, 24* | 12, 13, 14 | T_IN            | TTL/CMOS Transmitter Inputs                                |
| 16       | 18         | 15       | 18         | 2                       | 25         | GND             | Ground   |

# ±15kV ESD-Protected, Down to 10nA, 3.0V to 5.5V, Up to 1Mbps, True RS-232 Transceivers

## Pin Description (continued)

| PIN      |                |          |                  |          |          | NAME                     | FUNCTION  |
|----------|----------------|----------|------------------|----------|----------|--------------------------|---|
| MAX3222E |                | MAX3232E |                  | MAX3237E | MAX3241E |                          |   |
| SO/DIP   | TSSOP/<br>SSOP | SO/DIP   | TSSOP/<br>SSOP   |          |          |                          |   |
| 17       | 19             | 16       | 19               | 26       | 26       | V <sub>CC</sub>          | +3.0V to +5.5V Supply Voltage   |
| 18       | 20             | —        | —                | 14*      | 22       | $\overline{\text{SHDN}}$ | Shutdown Control. Active low.   |
| —        | 11, 14         | —        | 1, 10, 11,<br>20 | —        | —        | N.C.                     | No Connection   |
| —        | —              | —        | —                | 15*      | —        | MBAUD                    | MegaBaud Control Input. Connect to GND for normal operation; connect to V <sub>CC</sub> for 1Mbps transmission rates. |
| —        | —              | —        | —                | 16       | 20, 21   | R_OUTB                   | Noninverting Complementary Receiver Outputs. Always active.   |

\*These pins have an active positive feedback resistor internal to the MAX3237E, allowing unused inputs to be left unconnected.

## Detailed Description

### Dual Charge-Pump Voltage Converter

The MAX3222E/MAX3232E/MAX3237E/MAX3241E'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), over the 3.0V to 5.5V V<sub>CC</sub> range. The charge pump operates in discontinuous mode; if the output voltages are less than 5.5V, the charge pump is enabled, and if the output voltages exceed 5.5V, the charge pump is disabled. Each charge pump requires a flying capacitor (C1, C2) and a reservoir capacitor (C3, C4) to generate the V<sub>+</sub> and V<sub>-</sub> supplies (Figure 1).

### RS-232 Transmitters

The transmitters are inverting level translators that convert TTL/CMOS-logic levels to ±5.0V EIA/TIA-232-compliant levels.

The MAX3222E/MAX3232E/MAX3237E/MAX3241E transmitters guarantee a 250kbps data rate 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 or mice.

The MAX3222E/MAX3237E/MAX3241E's transmitters are disabled and the outputs are forced into a high-imped-

ance state when the device is in shutdown mode ( $\overline{\text{SHDN}}$  = GND). The MAX3222E/MAX3232E/MAX3237E/MAX3241E permit the outputs to be driven up to ±12V in shutdown.

The MAX3222E/MAX3232E/MAX3241E transmitter inputs do not have pull-up resistors. Connect unused inputs to GND or V<sub>CC</sub>. The MAX3237E transmitter inputs have a 400kΩ active positive feedback resistor, allowing unused inputs to be left unconnected.

### MAX3237E MegaBaud Operation

For higher-speed serial communications, the MAX3237E features MegaBaud operation. In MegaBaud operating mode (MBAUD = V<sub>CC</sub>), the MAX3237E transmitters guarantee a 1Mbps data rate with worst-case loads of 3kΩ in parallel with 250pF for 3.0V < V<sub>CC</sub> < 4.5V. For 5V ±10% operation, the MAX3237E transmitters guarantee a 1Mbps data rate into worst-case loads of 3kΩ in parallel with 1000pF.

### RS-232 Receivers

The receivers convert RS-232 signals to CMOS-logic output levels. The MAX3222E/MAX3237E/MAX3241E receivers have inverting three-state outputs. Drive  $\overline{\text{EN}}$  high to place the receiver(s) into a high-impedance state. Receivers can be either active or inactive in shutdown (Table 1).

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# ±15kV ESD-Protected, Down to 10nA, 3.0V to 5.5V, Up to 1Mbps, True RS-232 Transceivers

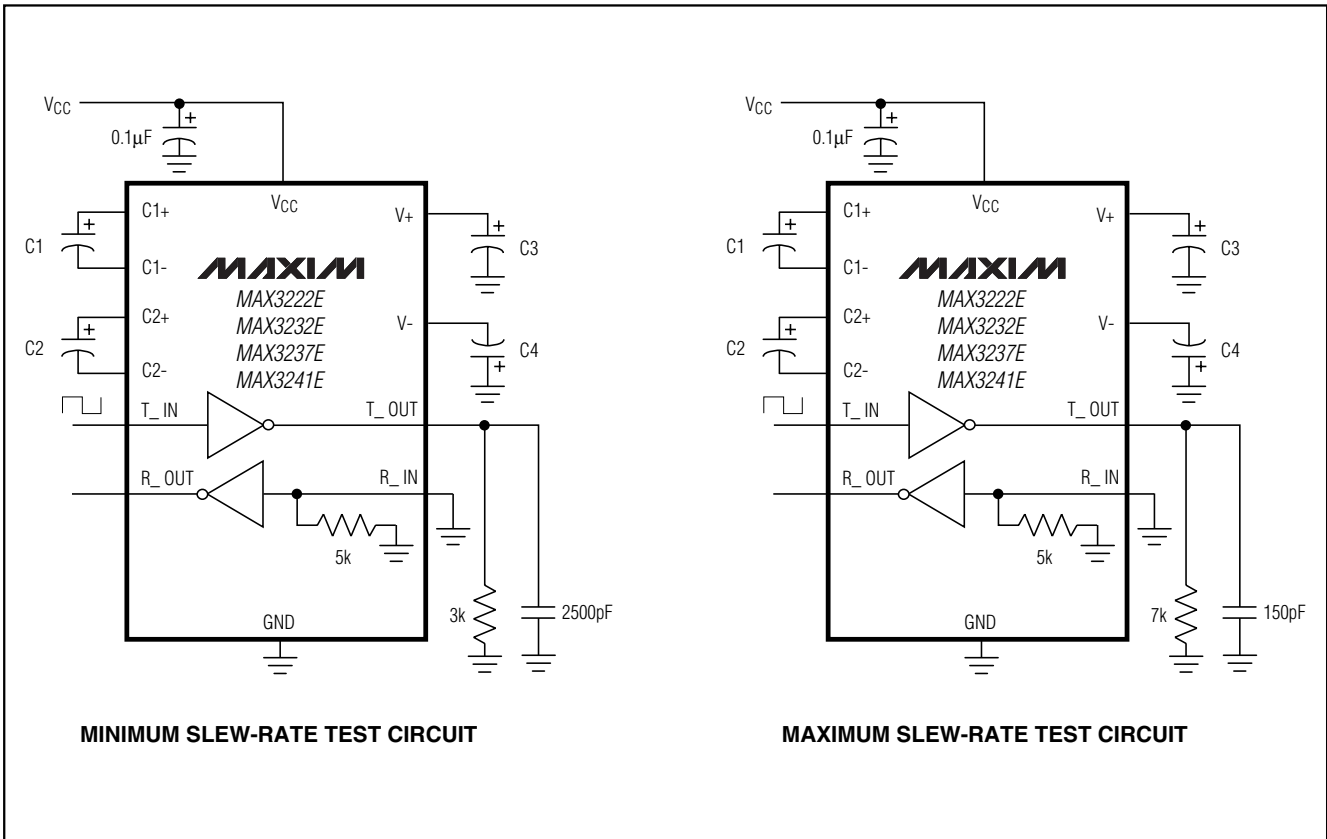


Figure 1. Slew-Rate Test Circuits

The complementary outputs on the MAX3237E/MAX3241E (R\_OUTB) are always active, regardless of the state of  $\overline{\text{EN}}$  or  $\overline{\text{SHDN}}$ . This allows the device to be used for ring indicator applications without forward biasing other devices connected to the receiver outputs. This is ideal for systems where  $V_{CC}$  drops to 0 in shutdown to accommodate peripherals such as UARTs (Figure 2).

### MAX3222E/MAX3237E/MAX3241E Shutdown Mode

Supply current falls to less than 1μA in shutdown mode ( $\overline{\text{SHDN}} = \text{low}$ ). The MAX3237E's supply current falls to 10nA (typ) when all receiver inputs are in the invalid range ( $-0.3\text{V} < R_{\text{IN}} < +0.3$ ). When shut down, the device's charge pumps are shut off,  $V_+$  is pulled down to  $V_{CC}$ ,  $V_-$  is pulled to ground, and the transmitter outputs are disabled (high impedance). The time required to recover from shutdown is typically 100μs, as shown in Figure 3. Connect  $\overline{\text{SHDN}}$  to  $V_{CC}$  if the shut-

down mode is not used.  $\overline{\text{SHDN}}$  has no effect on R\_OUT or R\_OUTB (MAX3237E/MAX3241E).

### ±15kV ESD Protection

As with all Maxim devices, ESD-protection structures are incorporated to protect against electrostatic discharges encountered during handling and assembly. The driver outputs and receiver inputs of the

Table 1. MAX3222E/MAX3237E/MAX3241E Shutdown and Enable Control Truth Table

| $\overline{\text{SHDN}}$ | $\overline{\text{EN}}$ | T_OUT  | R_OUT  | R_OUTB (MAX3237E/MAX3241E) |
|--------------------------|------------------------|--------|--------|----------------------------|
| 0                        | 0                      | High-Z | Active | Active                     |
| 0                        | 1                      | High-Z | High-Z | Active                     |
| 1                        | 0                      | Active | Active | Active                     |
| 1                        | 1                      | Active | High-Z | Active                     |



# ±15kV ESD-Protected, Down to 10nA, 3.0V to 5.5V, Up to 1Mbps, True RS-232 Transceivers

MAX3222E/MAX3232E/MAX3237E/MAX3241E have extra protection against static electricity. Maxim's engineers have developed state-of-the-art structures to protect these pins against ESD of ±15kV without damage. The ESD structures withstand high ESD in all states: normal operation, shutdown, and powered down. After an ESD event, Maxim's E versions keep working without

latchup, whereas competing RS-232 products can latch and must be powered down to remove latchup.

Furthermore, the MAX3237E logic I/O pins also have ±15kV ESD protection. Protecting the logic I/O pins to ±15kV makes the MAX3237E ideal for data cable applications.

ESD protection can be tested in various ways; the transmitter outputs and receiver inputs for the MAX3222E/MAX3232E/MAX3241E are characterized for protection to the following limits:

- ±15kV using the Human Body Model
- ±8kV using the Contact Discharge method specified in IEC 1000-4-2
- ±15kV using IEC 1000-4-2's Air-Gap Discharge method

For the MAX3237E, all logic and RS-232 I/O pins are characterized for protection to ±15kV per the Human Body Model.

### ESD Test Conditions

ESD performance depends on a variety of conditions. Contact Maxim for a reliability report that documents test setup, test methodology, and test results.

### Human Body Model

Figure 4a shows the Human Body Model, and Figure 4b 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.

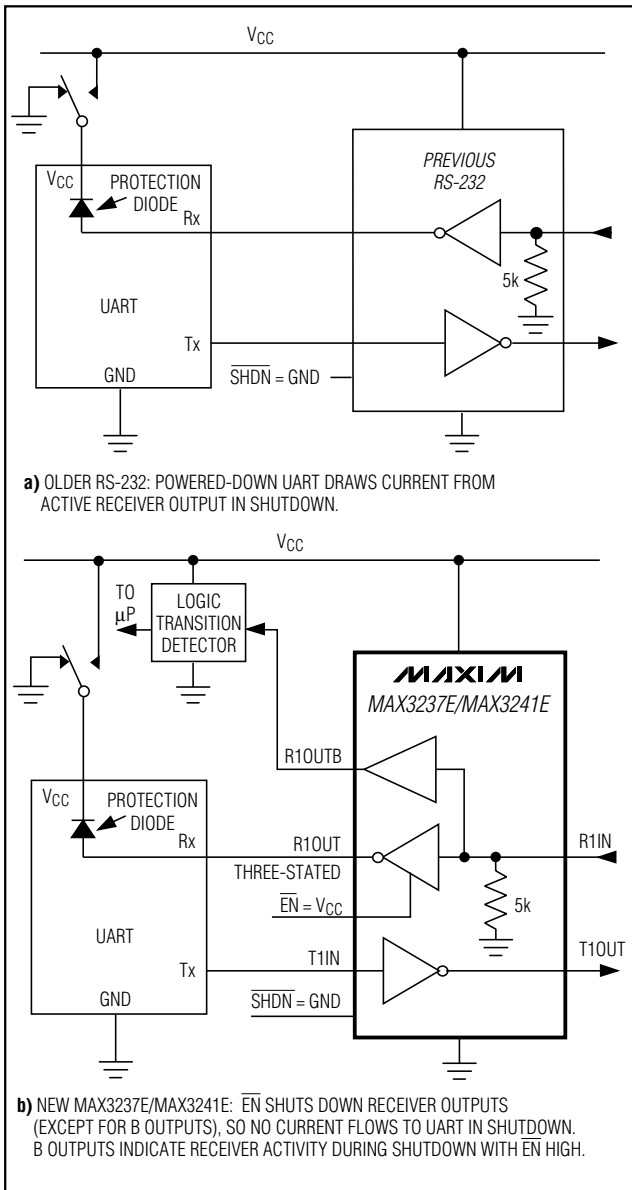


Figure 2. Detection of RS-232 Activity when the UART and Interface are Shut Down; Comparison of MAX3237E/MAX3241E (b) with Previous Transceivers (a)

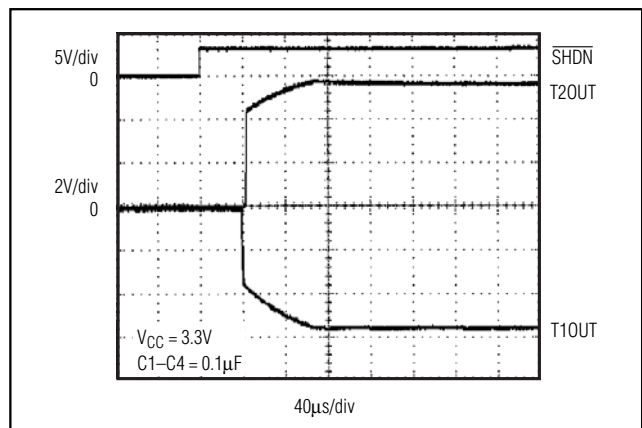


Figure 3. Transmitter Outputs Recovering from Shutdown or Powering Up

MAX3222E/MAX3232E/MAX3237E/MAX3241E

# ±15kV ESD-Protected, Down to 10nA, 3.0V to 5.5V, Up to 1Mbps, True RS-232 Transceivers

## IEC 1000-4-2

The IEC 1000-4-2 standard covers ESD testing and performance of finished equipment; it does not specifically refer to integrated circuits. The MAX3222E/MAX3232E/MAX3237E/MAX3241E help you design equipment that meets Level 4 (the highest level) of IEC 1000-4-2, without the need for 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 lower in the IEC 1000-4-2 model. Hence, the ESD withstand voltage measured to IEC 1000-4-2 is generally lower than that measured using the Human Body Model. Figure 5a shows the IEC 1000-4-2 model, and Figure 5b shows the current waveform for the ±8kV IEC 1000-4-2 Level 4 ESD Contact Discharge test.

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

## Machine Model

The Machine Model for ESD tests all pins using a 200pF storage capacitor and zero discharge resistance. Its objective is to emulate the stress caused by contact that occurs with handling and assembly during manufacturing. All pins require this protection during manufacturing, not just RS-232 inputs and outputs. Therefore, after PC board assembly, the Machine Model is less relevant to I/O ports.

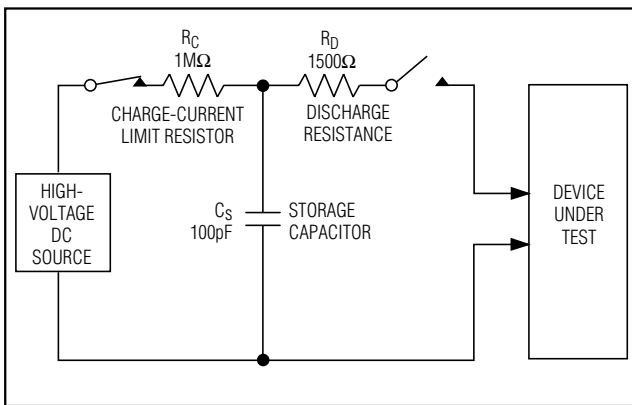


Figure 4a. Human Body ESD Test Model

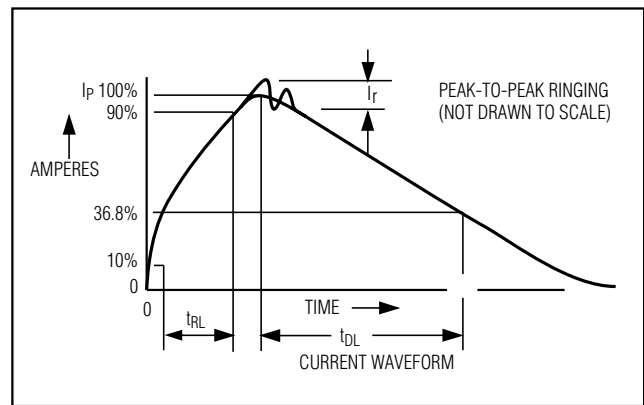


Figure 4b. Human Body Model Current Waveform

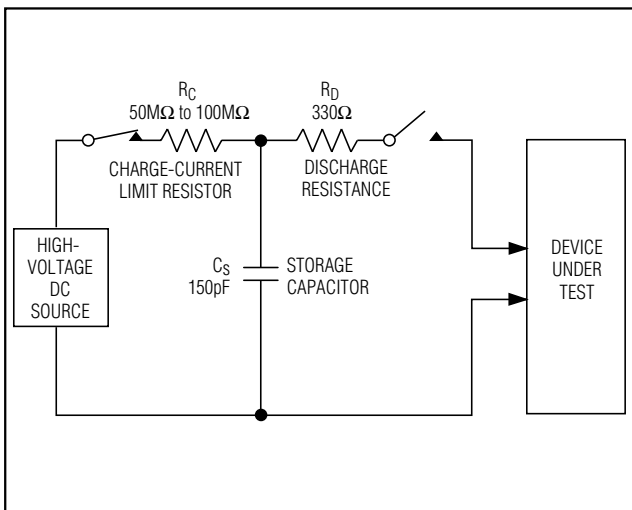


Figure 5a. IEC 1000-4-2 ESD Test Model

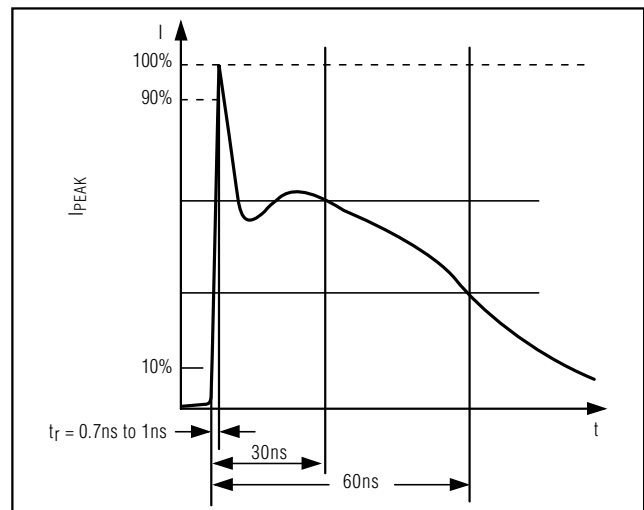


Figure 5b. IEC 1000-4-2 ESD Generator Current Waveform

# ±15kV ESD-Protected, Down to 10nA, 3.0V to 5.5V, Up to 1Mbps, True RS-232 Transceivers

**Table 2. Required Minimum Capacitor Values**

| V <sub>CC</sub> (V)               | C1 (μF) | C2, C3, C4 (μF) |
|-----------------------------------|---------|-----------------|
| <b>MAX3222E/MAX3232E/MAX3241E</b> |         |                 |
| 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            |
| <b>MAX3237E</b>                   |         |                 |
| 3.0 to 3.6                        | 0.22    | 0.22            |
| 3.15 to 3.6                       | 0.1     | 0.1             |
| 4.5 to 5.5                        | 0.047   | 0.33            |
| 3.0 to 5.5                        | 0.22    | 1.0             |

## 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, see Table 2 for required capacitor values. Do not use values smaller than those listed in Table 2. 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, C4, and CBYPASS 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), which usually rises at low temperatures, influences the amount of ripple on V+ and V-.

### Power-Supply Decoupling

In most circumstances, a 0.1μF V<sub>CC</sub> bypass capacitor is adequate. In applications that are sensitive to power-supply noise, use a capacitor of the same value as charge-pump capacitor C1. Connect bypass capacitors as close to the IC as possible.

### Operation Down to 2.7V

Transmitter outputs will meet EIA/TIA-562 levels of ±3.7V with supply voltages as low as 2.7V.

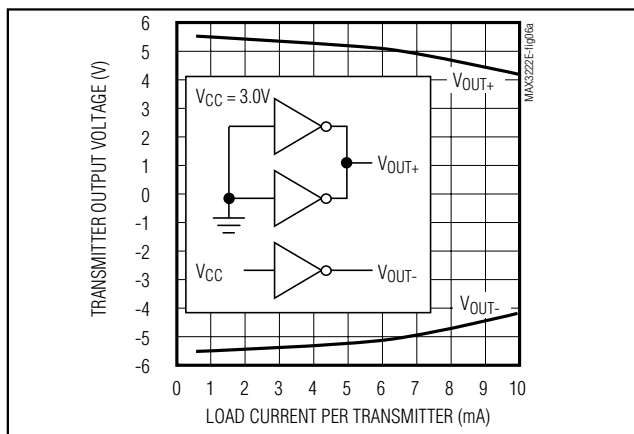


Figure 6a. MAX3241E Transmitter Output Voltage vs. Load Current per Transmitter

### Transmitter Outputs when Recovering from Shutdown

Figure 3 shows two transmitter outputs when recovering from 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 2500pF. 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- exceeds approximately -3V.

### Mouse Driveability

The MAX3241E has been specifically designed to power serial mice while operating from low-voltage power supplies. It has been tested with leading mouse brands from manufacturers such as Microsoft and Logitech. The MAX3241E successfully drove all serial mice tested and met their respective current and voltage requirements. Figure 6a shows the transmitter output voltages under increasing load current at 3.0V. Figure 6b shows a typical mouse connection using the MAX3241E.

### High Data Rates

The MAX3222E/MAX3232E/MAX3237E/MAX3241E maintain the RS-232 ±5.0V minimum transmitter output voltage even at high data rates. Figure 7 shows a transmitter loopback test circuit. Figure 8 shows a loopback test result at 120kbps, and Figure 9 shows the same test at 250kbps. For Figure 8, all transmitters were driven simultaneously at 120kbps into RS-232 loads in parallel with 1000pF. For Figure 9, a single transmitter was driven at 250kbps, and all transmitters were loaded with an RS-232 receiver in parallel with 1000pF.

MAX3222E/MAX3232E/MAX3237E/MAX3241E

**±15kV ESD-Protected, Down to 10nA, 3.0V to 5.5V, Up to 1Mbps, True RS-232 Transceivers**

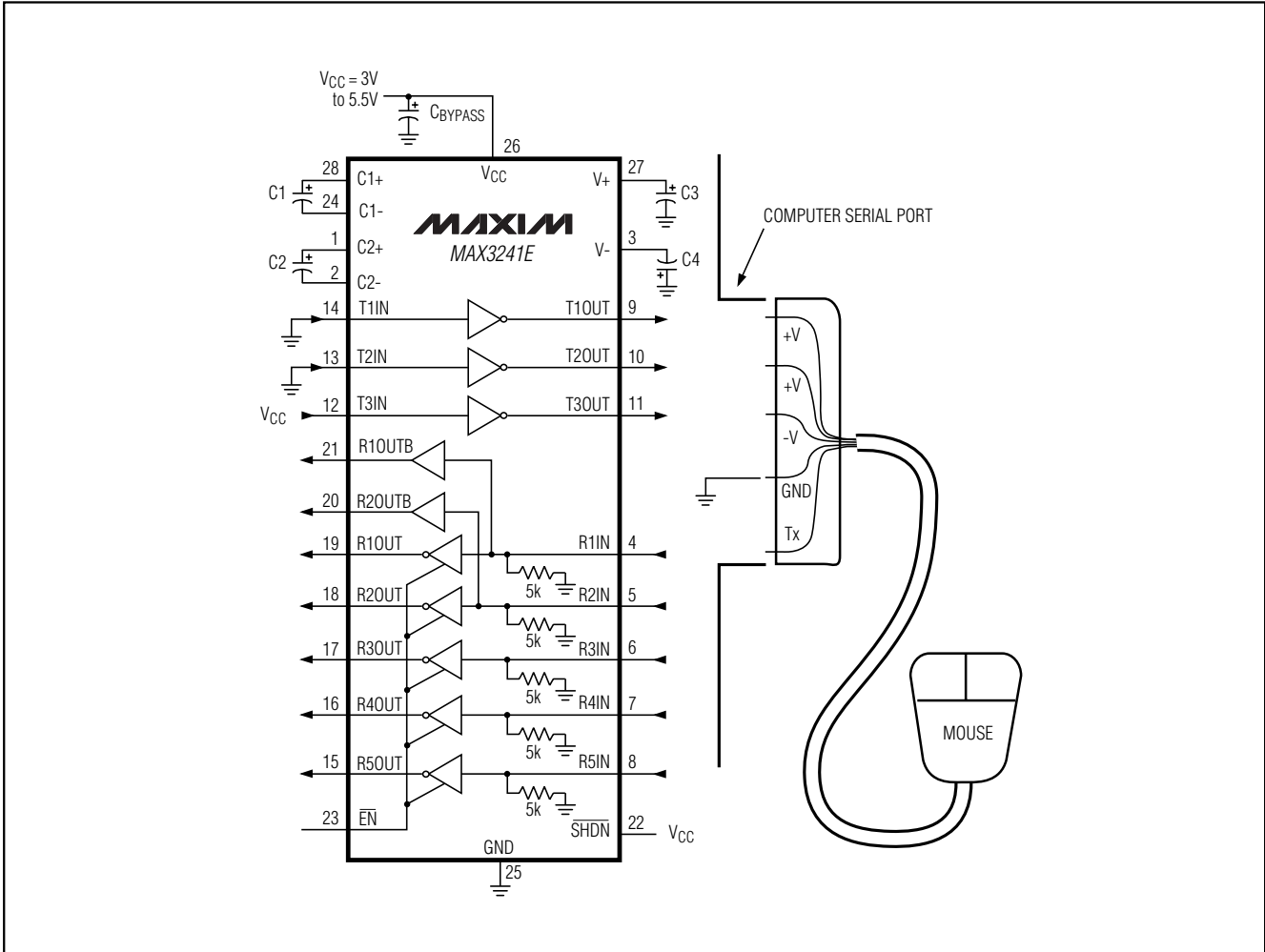


Figure 6b. Mouse Driver Test Circuit

The MAX3237E maintains the RS-232 ±5.0V minimum transmitter output voltage at data rates up to 1Mbps. Figure 10 shows a loopback test result at 1Mbps with MBAUD = VCC. For Figure 10, all transmitters were loaded with an RS-232 receiver in parallel with 250pF.

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

The MAX3222E/MAX3232E/MAX3237E/MAX3241E can directly interface with various 5V logic families, including ACT and HCT CMOS. See Table 3 for more information on possible combinations of interconnections.

# ±15kV ESD-Protected, Down to 10nA, 3.0V to 5.5V, Up to 1Mbps, True RS-232 Transceivers

**Table 3. 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 families                         |
| 5                               | 3.3                                | Compatible with ACT and HCT CMOS, and with AC, HC, or CD4000 CMOS |

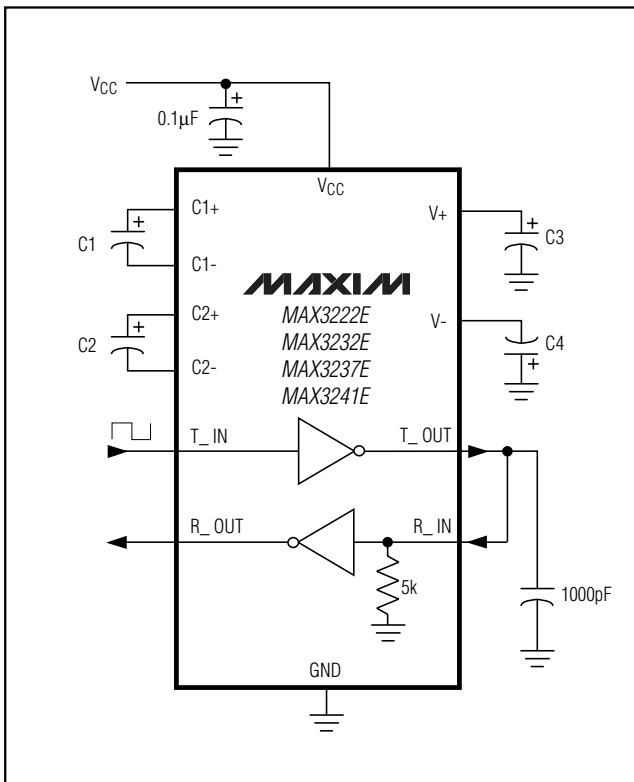


Figure 7. Loopback Test Circuit

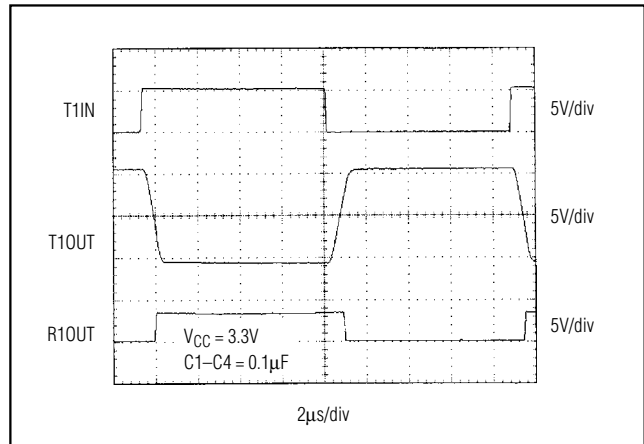


Figure 8. MAX3241E Loopback Test Result at 120kbps

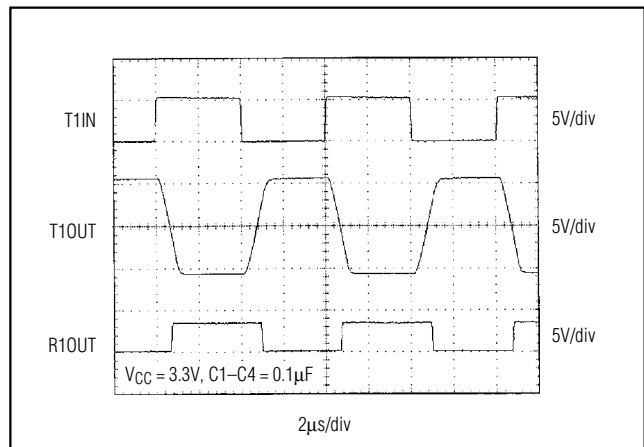


Figure 9. MAX3241E Loopback Test Result at 250kbps

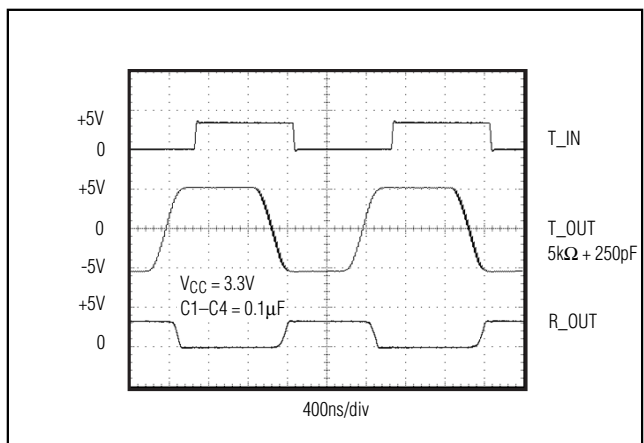
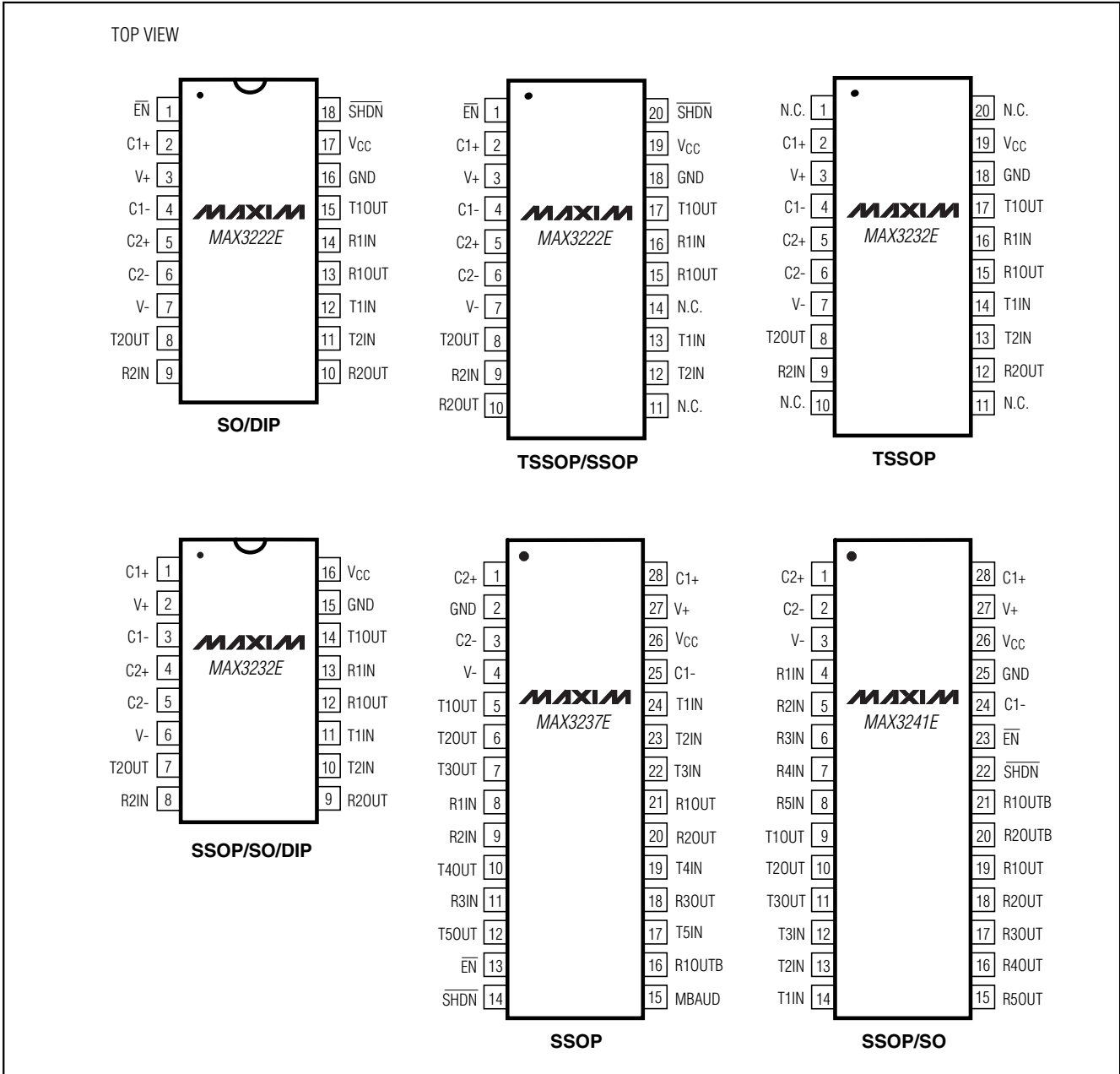


Figure 10. MAX3237E Loopback Test Result at 1000kbps (MBAUD = V<sub>CC</sub>)

MAX3222E/MAX3232E/MAX3237E/MAX3241E

# ±15kV ESD-Protected, Down to 10nA, 3.0V to 5.5V, Up to 1Mbps, True RS-232 Transceivers

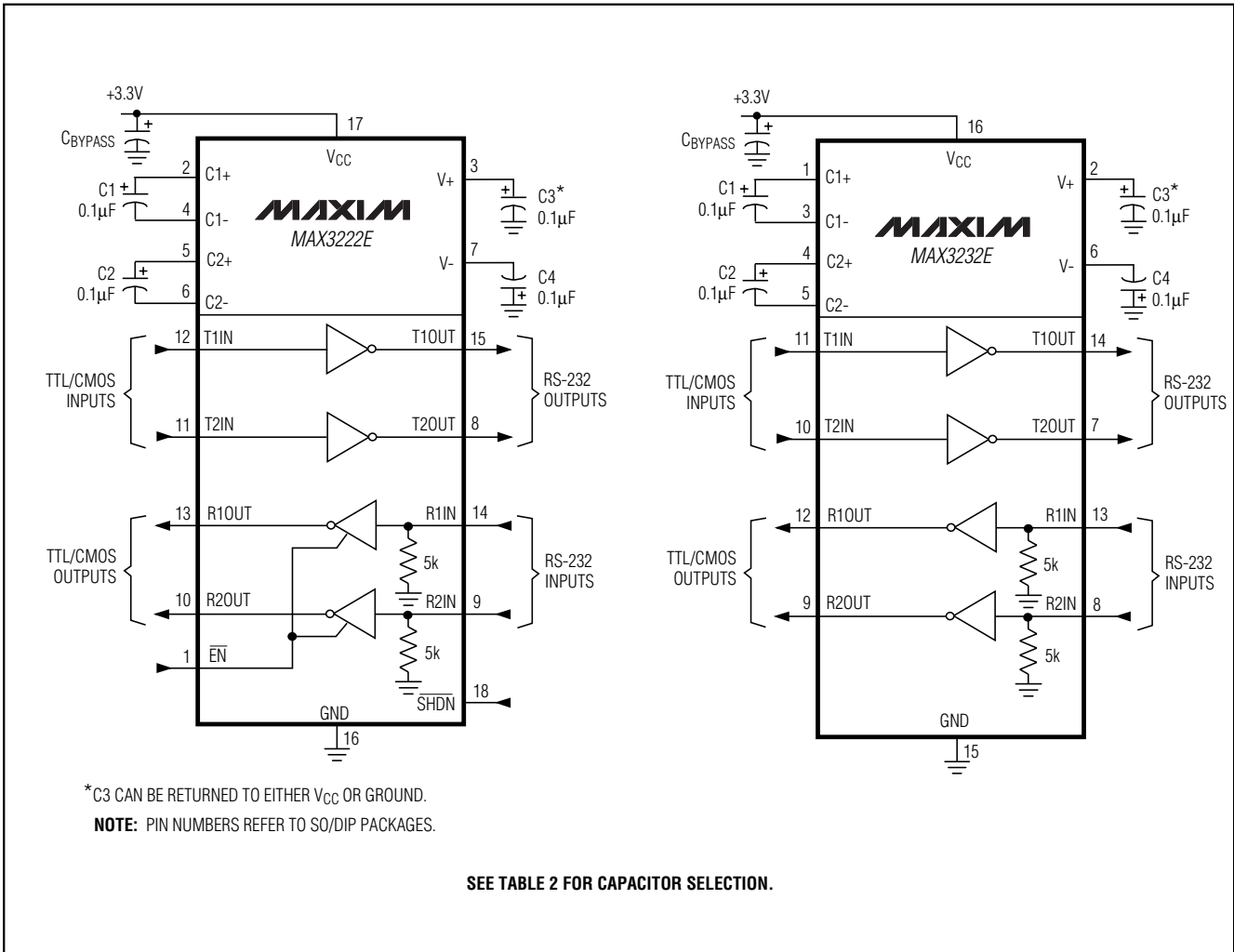
## Pin Configurations



# ±15kV ESD-Protected, Down to 10nA, 3.0V to 5.5V, Up to 1Mbps, True RS-232 Transceivers

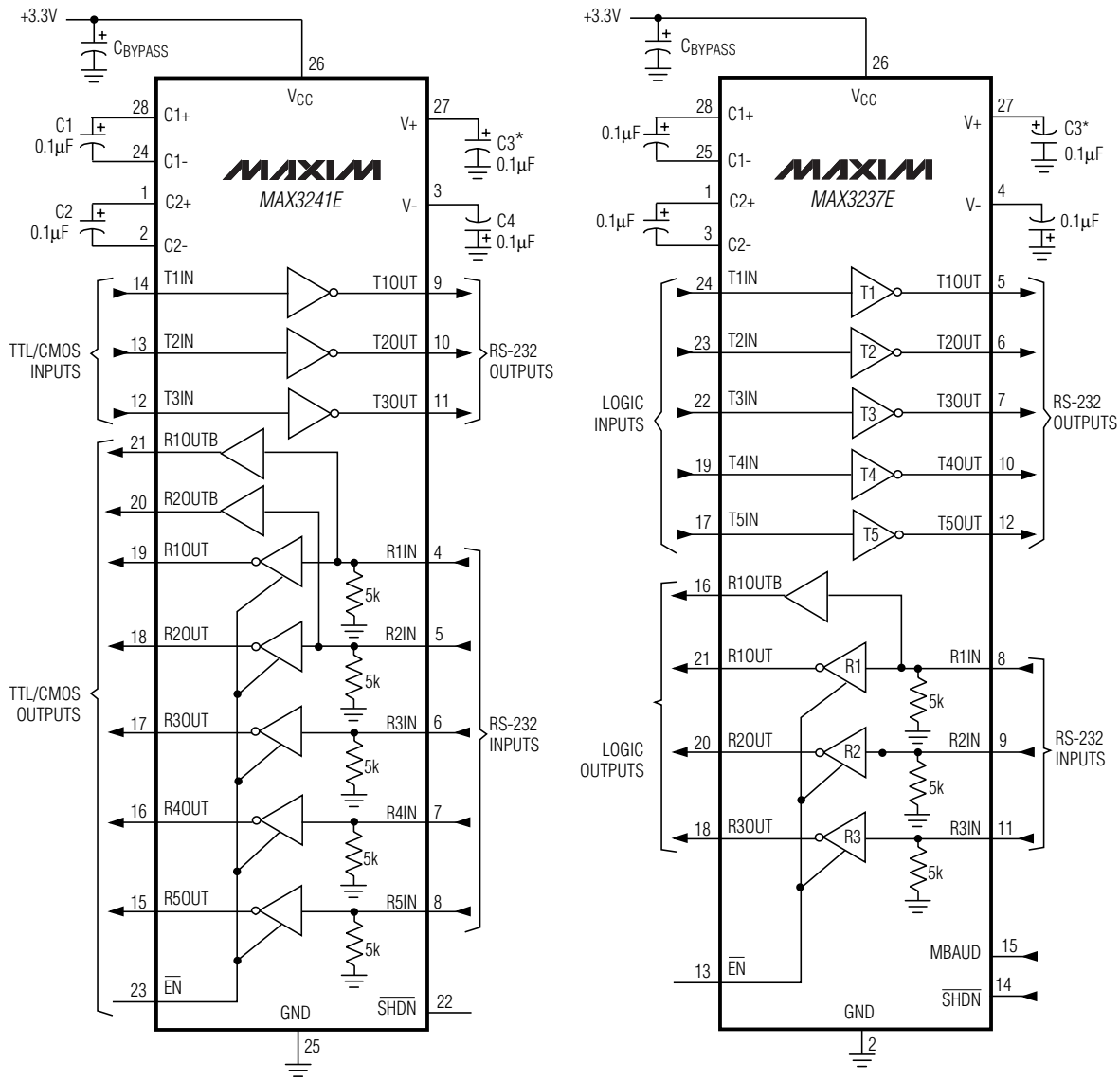
## Typical Operating Circuits

MAX3222E/MAX3232E/MAX3237E/MAX3241E



**±15kV ESD-Protected, Down to 10nA, 3.0V to 5.5V, Up to 1Mbps, True RS-232 Transceivers**

**Typical Operating Circuits (continued)**



\*C3 CAN BE RETURNED TO EITHER V<sub>CC</sub> OR GROUND.



# **±15kV ESD-Protected, Down to 10nA, 3.0V to 5.5V, Up to 1Mbps, True RS-232 Transceivers**

## **Ordering Information (continued)**

| <b>PART</b>        | <b>TEMP. RANGE</b> | <b>PIN-PACKAGE</b> |
|--------------------|--------------------|--------------------|
| MAX3222ECWN        | 0°C to +70°C       | 18 Wide SO         |
| MAX3222ECPN        | 0°C to +70°C       | 18 Plastic DIP     |
| MAX3222EC/D        | 0°C to +70°C       | Dice*              |
| MAX3222EEUP        | -40°C to +85°C     | 20 TSSOP           |
| MAX3222EEAP        | -40°C to +85°C     | 20 SSOP            |
| MAX3222EEWN        | -40°C to +85°C     | 18 Wide SO         |
| MAX3222EEPN        | -40°C to +85°C     | 18 Plastic DIP     |
| <b>MAX3232ECUP</b> | 0°C to +70°C       | 20 TSSOP           |
| MAX3232ECAE        | 0°C to +70°C       | 16 SSOP            |
| MAX3232ECWE        | 0°C to +70°C       | 16 Wide SO         |
| MAX3232ECPE        | 0°C to +70°C       | 16 Plastic DIP     |
| MAX3232EEUP        | -40°C to +85°C     | 20 TSSOP           |
| MAX3232EEAE        | -40°C to +85°C     | 16 SSOP            |
| MAX3232EEWE        | -40°C to +85°C     | 16 Wide SO         |
| MAX3232EEPE        | -40°C to +85°C     | 16 Plastic DIP     |
| <b>MAX3237ECAI</b> | -0°C to +70°C      | 28 SSOP            |
| MAX3237EEAI        | -40°C to +85°C     | 28 SSOP            |
| <b>MAX3241ECAI</b> | 0°C to +70°C       | 28 SSOP            |
| MAX3241ECWI        | 0°C to +70°C       | 28 Wide SO         |
| MAX3241EEAI        | -40°C to +85°C     | 28 SSOP            |
| MAX3241EEWI        | -40°C to +85°C     | 28 Wide SO         |

\*Dice are tested at  $T_A = +25^\circ\text{C}$ , DC parameters only.

## **Chip Information**

TRANSISTOR COUNTS:

MAX3222E/MAX3232E: 1129

MAX3237E: 2110

MAX3241E: 1335

**MAX3222E/MAX3232E/MAX3237E/MAX3241E**

# ±15kV ESD-Protected, Down to 10nA, 3.0V to 5.5V, Up to 1Mbps, True RS-232 Transceivers

## Package Information

| Symbol         | COMMON DIMENSIONS |       |                |       |
|----------------|-------------------|-------|----------------|-------|
|                | MILLIMETERS       |       | INCHES         |       |
| A              | MIN.              | MAX.  | MIN.           | MAX.  |
| A <sub>1</sub> | 0.05              | 0.15  | .002           | .006  |
| A <sub>2</sub> | 0.85              | 0.95  | .033           | .037  |
| b              | 0.19              | 0.30  | .007           | .012  |
| b <sub>1</sub> | 0.19              | 0.25  | .007           | .010  |
| c              | 0.090             | 0.20  | .0035          | .008  |
| c <sub>1</sub> | 0.090             | 0.135 | .0035          | .0053 |
| D              | SEE VARIATIONS    |       | SEE VARIATIONS |       |
| E              | 4.30              | 4.50  | .169           | .177  |
| e              | .065 BSC          |       | .026 BSC       |       |
| H              | 6.25              | 6.50  | .246           | .256  |
| L              | 0.50              | 0.70  | .020           | .028  |
| N              | SEE VARIATIONS    |       | SEE VARIATIONS |       |
| Y              | 2.85              | 3.15  | .112           | .124  |
| X              | 0*                | 8*    | 0*             | 8*    |

| JEDEC  | N  | VARIATIONS  |      |        |      |      |
|--------|----|-------------|------|--------|------|------|
|        |    | MILLIMETERS |      | INCHES |      |      |
| MD-153 |    | MIN.        | MAX. | MIN.   | MAX. |      |
| AB     | 14 | D           | 4.90 | 5.10   | .193 | .201 |
| AC     | 16 | D           | 4.90 | 5.10   | .193 | .201 |
| AC-EP  | 16 | D           | 4.90 | 5.10   | .193 | .201 |
|        |    | X           | 2.85 | 3.15   | .112 | .124 |
| AD     | 20 | D           | 6.40 | 6.60   | .252 | .260 |
| AD-EP  | 20 | D           | 6.40 | 6.60   | .252 | .260 |
|        |    | X           | 4.00 | 4.34   | .157 | .171 |
| AE     | 24 | D           | 7.70 | 7.90   | .303 | .311 |
| AF     | 28 | D           | 9.60 | 9.80   | .378 | .386 |
| AF-EP  |    | D           | 9.60 | 9.80   | .378 | .386 |
|        |    | X           | 5.35 | 5.65   | .211 | .222 |

**NOTES:**

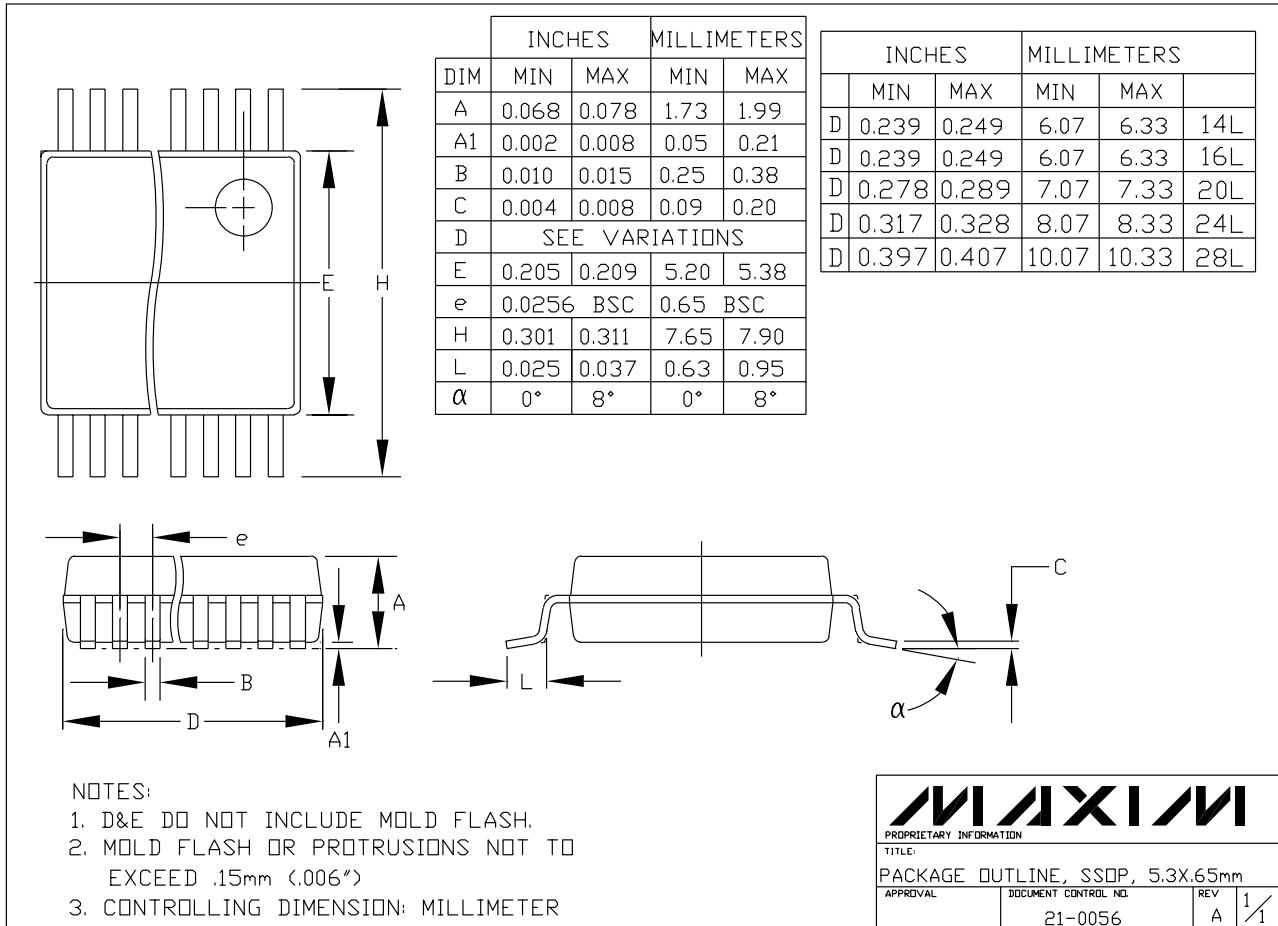
1. DIMENSIONS D AND E DO NOT INCLUDE FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15 mm PER SIDE.
3. CONTROLLING DIMENSION: MILLIMETER.
4. MEETS JEDEC OUTLINE MD-153 VARIATIONS AB, AC, AD, AE, AF.
5. DIMENSIONS X AND Y APPLY TO EXPOSED PAD (EP) VERSIONS ONLY.
6. EXPOSED PAD FLUSH WITH BOTTOM OF PACKAGE WITHIN .002".

|   |                      |     |     |
|---|----------------------|-----|-----|
| <b>MAXIM</b>  |                      |     |     |
| PROPRIETARY INFORMATION                                     |                      |     |     |
| TITLE:<br>PACKAGE OUTLINE, TSSOP, 4.40mm BODY, 0.65mm PITCH |                      |     |     |
| APPROVAL  | DOCUMENT CONTROL NO. | REV | 1/1 |
|   | 21-0066              | C   |     |

TSSOP/EP

# ±15kV ESD-Protected, Down to 10nA, 3.0V to 5.5V, Up to 1Mbps, True RS-232 Transceivers

## Package Information (continued)



SSOP

MAX3222E/MAX3232E/MAX3237E/MAX3241E

**MAX3222E/MAX3232E/MAX3237E/MAX3241E**

**$\pm 15\text{kV}$  ESD-Protected, Down to 10nA, 3.0V to 5.5V,  
Up to 1Mbps, True RS-232 Transceivers**

**NOTES**

*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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