

**MAXIM****±15kV ESD-Protected, 2.5V, 1µA, 460kbps,  
RS-232 Compatible Transceivers****General Description**

The MAX3316E-MAX3319E are 2.5V powered RS-232 compatible transceivers. These devices feature shutdown (MAX3317E), AutoShutdown Plus™ (MAX3318E/MAX3319E), and enhanced electrostatic discharge (ESD) protection integrated into the chip. All transmitter outputs and receiver inputs are protected to  $\pm 15\text{kV}$  using the IEC 1000-4-2 Air-Gap Discharge method,  $\pm 8\text{kV}$  using the IEC 1000-4-2 Contact Discharge method, and  $\pm 15\text{kV}$  using the Human Body Model.

All devices are guaranteed at a data rate of 460kbps. The transceivers have a proprietary low-dropout transmitter output stage enabling RS-232 compatible operation from a +2.25V to +3.0V supply with a dual charge pump. The charge pump requires only four 0.1 $\mu\text{F}$  capacitors. The MAX3318E/MAX3319E feature a logic-level output (READY) that asserts when the charge pump is regulating and the device is ready to begin transmitting.

The MAX3318E/MAX3319E achieve a 1 $\mu\text{A}$  supply current using Maxim's revolutionary AutoShutdown Plus feature. These devices automatically enter a low-power shutdown mode when the RS-232 cable is disconnected or the transmitters of the connected peripherals are inactive for more than 30 seconds. They turn on again when they sense a valid transition at any transmitter or receiver input. AutoShutdown Plus saves power without changes to the existing BIOS or operating system. The MAX3317E also features a 1 $\mu\text{A}$  shutdown mode that can be entered by driving SHDN low. The MAX3317E's receivers remain active while in shutdown mode, allowing external devices such as modems to be monitored using only 1 $\mu\text{A}$  supply current.

These devices are available in space-saving packages: MAX3316E (16-pin SSOP and 20-pin TSSOP), MAX3317E/MAX3318E (20-pin SSOP and 20-pin TSSOP), and MAX3319E (16-pin SSOP).

**Applications**

- Palmtop Computers
- Hand-Held Instruments
- Pagers
- Cellular Phones
- GPS
- Handy Terminals
- Hand-Held Electronic Books

**Selector Guide and Typical Application Circuits appear at end of data sheet.**

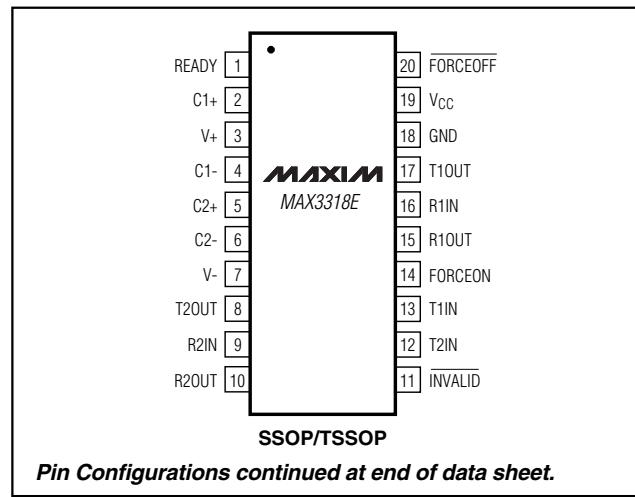
AutoShutdown Plus is a trademark of Maxim Integrated Products.

**Features**

- ♦ **ESD Protection for RS-232 I/O Pins**
  - ±15kV—Human Body Model
  - ±8kV—IEC 1000-4-2, Contact Discharge
  - ±15kV—IEC 1000-4-2, Air-Gap Discharge
- ♦ **300µA Operating Supply Current**
- ♦ **1µA Low-Power Shutdown with Receivers Active**
- ♦ **Guaranteed 460kbps Data Rate**
- ♦ **Guaranteed 4V/µs Slew Rate**
- ♦ **RS-232 Compatible Down to 2.25V**

**Ordering Information**

PART	TEMP. RANGE	PIN-PACKAGE
<b>MAX3316ECUP</b>	0°C to +70°C	20 TSSOP
MAX3316ECAE	0°C to +70°C	16 SSOP
MAX3316EEUP	-40°C to +85°C	20 TSSOP
MAX3316EEAE	-40°C to +85°C	16 SSOP
<b>MAX3317ECUP</b>	0°C to +70°C	20 TSSOP
MAX3317ECAP	0°C to +70°C	20 SSOP
MAX3317EEUP	-40°C to +85°C	20 TSSOP
MAX3317EEAP	-40°C to +85°C	20 SSOP
<b>MAX3318ECUP</b>	0°C to +70°C	20 TSSOP
MAX3318ECAP	0°C to +70°C	20 SSOP
MAX3318EEUP	-40°C to +85°C	20 TSSOP
MAX3318EEAP	-40°C to +85°C	20 SSOP
<b>MAX3319ECAE</b>	0°C to +70°C	16 SSOP
MAX3319EEAE	-40°C to +85°C	16 SSOP

**Pin Configurations****MAXIM**

Maxim Integrated Products 1

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For small orders, phone 1-800-835-8769.**

**MAX3316E-MAX3319E**

# **±15kV ESD-Protected, 2.5V, 1µA, 460kbps, RS-232 Compatible Transceivers**

## **ABSOLUTE MAXIMUM RATINGS**

V <sub>CC</sub> to GND	.....	-0.3V to +6V
V <sub>+</sub> to GND (Note 1)	.....	-0.3V to +7V
V <sub>-</sub> to GND (Note 1)	.....	-7V to +0.3V
V <sub>+</sub> + IV-I (Note 1)	.....	+13V
Input Voltages		
T <sub>_IN</sub> , EN, SHDN, FORCEON, FORCEOFF to GND	.....	-0.3V to +6V
R <sub>_IN</sub> to GND	.....	±25V
Output Voltages		
T <sub>_OUT</sub> to GND	.....	±13.2V
R <sub>_OUT</sub> , INVALID, READY to GND	.....	-0.3V to (V <sub>CC</sub> + 0.3V)

Short-Circuit Duration, T <sub>_OUT</sub> to GND	.....	Continuous
Continuous Power Dissipation (T <sub>A</sub> = +70°C)		
16-Pin SSOP (derate 7.14mW/°C above +70°C)	.....	571mW
20-Pin SSOP (derate 8.00mW/°C above +70°C)	.....	640mW
20-Pin TSSOP (derate 7.00mW/°C above +70°C)	.....	559mW
Operating Temperature Range		
MAX331_EC_	.....	0°C to +70°C
MAX331_EE_	.....	-40°C to +85°C
Storage Temperature Range	.....	-65°C to +150°C
Lead Temperature (soldering, 10s)	.....	+300°C

**Note 1:** V<sub>+</sub> and V<sub>-</sub> 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> = +2.25V to +3.0V, 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 V<sub>CC</sub> = +2.5V, T<sub>A</sub> = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>DC CHARACTERISTICS (V<sub>CC</sub> = +2.5V, T<sub>A</sub> = +25°C)</b>						
AutoShutdown Plus Supply Current		FORCEON = GND, FORCEOFF = V <sub>CC</sub> , all R <sub>_IN</sub> idle, all T <sub>_IN</sub> idle (MAX3318E/MAX3319E)		1	10	µA
Shutdown Supply Current		SHDN = GND (MAX3317E); FORCEOFF = GND (MAX3318E/MAX3319E)		1	10	µA
Supply Current		SHDN = V <sub>CC</sub> , no load (MAX3317E); FORCEON = FORCEOFF = V <sub>CC</sub> , no load (MAX3318E/MAX3319E)		0.3	1	mA
<b>LOGIC INPUTS</b>						
Input Logic Threshold Low		T <sub>_IN</sub> , EN, SHDN, FORCEON, FORCEOFF		0.3 • V <sub>CC</sub>		V
Input Logic Threshold High		T <sub>_IN</sub> , EN, SHDN, FORCEON, FORCEOFF	0.7 • V <sub>CC</sub>			V
Transmitter Input Hysteresis				0.3		V
Input Leakage Current		T <sub>_IN</sub> , EN, SHDN, FORCEON, FORCEOFF		±0.01	±1	µA
<b>RECEIVER OUTPUTS</b>						
Output Leakage Current		EN = V <sub>CC</sub> (MAX3317E), receivers disabled		±0.05	±10	µA
Output Voltage Low		I <sub>OUT</sub> = 0.5mA		0.1 • V <sub>CC</sub>		V
Output Voltage High		I <sub>OUT</sub> = -0.5mA	0.9 • V <sub>CC</sub>			V
<b>RECEIVER INPUTS</b>						
Input Voltage Range			-25		+25	V
Input Threshold Low		T <sub>A</sub> = +25°C		0.3 • V <sub>CC</sub>		V
Input Threshold High		T <sub>A</sub> = +25°C	0.7 • V <sub>CC</sub>			V
Input Hysteresis				0.3		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	±3.7	±4		V

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## **ELECTRICAL CHARACTERISTICS (continued)**

( $V_{CC} = +2.25V$  to  $+3.0V$ ,  $C1-C4 = 0.1\mu F$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $V_{CC} = +2.5V$ ,  $T_A = +25^\circ C$ .)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Output Resistance		$V_{CC} = 0$ , transmitter output = $\pm 2V$	300	10M		$\Omega$
Output Short-Circuit Current				$\pm 25$	$\pm 60$	mA
Output Leakage Current		$V_{CC} = 0$ or $2.25V$ to $3.0V$ , $V_{OUT} = \pm 12V$ , transmitters disabled			$\pm 25$	$\mu A$
<b>ESD PROTECTION</b>						
R_IN, T_OUT		Human Body Model		$\pm 15$		kV
		IEC 1000-4-2 Air-Gap Discharge method		$\pm 15$		
		IEC 1000-4-2 Contact Discharge method		$\pm 8$		
<b>AutoShutdown Plus</b> (FORCEON = GND, FORCEOFF = V <sub>CC</sub> ) (MAX3318E/MAX3319E)						
Receiver Input Threshold to $\overline{INVALID}$ Output High		Figure 4a	Positive threshold		2.7	V
			Negative threshold		-2.7	
Receiver Input Threshold to $\overline{INVALID}$ Output Low		Figure 4a		-0.3	0.3	V
$\overline{INVALID}$ , READY Output Voltage Low		$I_{OUT} = 0.5mA$			$0.1 \cdot V_{CC}$	V
$\overline{INVALID}$ , READY Output Voltage High		$I_{OUT} = -0.5mA$			$0.9 \cdot V_{CC}$	V
Receiver Positive or Negative Threshold to $\overline{INVALID}$ High	t <sub>INVH</sub>	$V_{CC} = 2.5V$ , Figure 4b			1	$\mu s$
Receiver Positive or Negative Threshold to $\overline{INVALID}$ Low	t <sub>INVL</sub>	$V_{CC} = 2.5V$ , Figure 4b			30	$\mu s$
Receiver or Transmitter Edge to Transmitters Enabled	t <sub>WU</sub>	$V_{CC} = 2.5V$ , Figure 4b (Note 2)			100	$\mu s$
Receiver or Transmitter Edge to Transmitters Shutdown	t <sub>AUTO-SHDN</sub>	$V_{CC} = 2.5V$ , Figure 4b (Note 2)	15	30	60	s

## **TIMING CHARACTERISTICS**

( $V_{CC} = +2.25V$  to  $+3.0V$ ,  $C1-C4 = 0.1\mu F$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $V_{CC} = +2.5V$ ,  $T_A = +25^\circ C$ .)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Maximum Data Rate		$R_L = 3k\Omega$ , $C_L = 1000pF$ , one transmitter switching	460			kbps
Receiver Propagation Delay	t <sub>PHL</sub>	$R_{IN}$ to $R_{OUT}$ , $C_L = 150pF$		0.175		$\mu s$
	t <sub>PLH</sub>			0.175		
Receiver Output Enable Time		Normal operation (MAX3317E)		250		ns
Receiver Output Disable Time		Normal operation (MAX3317E)		250		ns
Transmitter Skew	$ t_{PHL} - t_{PLH} $	(Note 3)		100		ns
Receiver Skew	$ t_{PHL} - t_{PLH} $			50		ns

**MAX3316E-MAX3319E**

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## **TIMING CHARACTERISTICS (continued)**

( $V_{CC} = +2.25V$  to  $+3.0V$ ,  $C1-C4 = 0.1\mu F$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $V_{CC} = +2.5V$ ,  $T_A = +25^\circ C$ .)

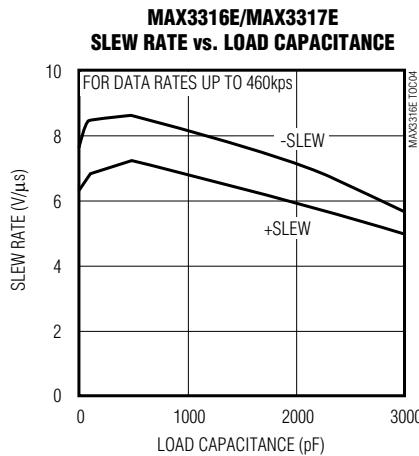
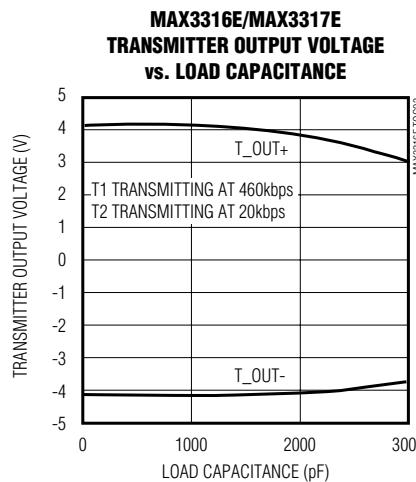
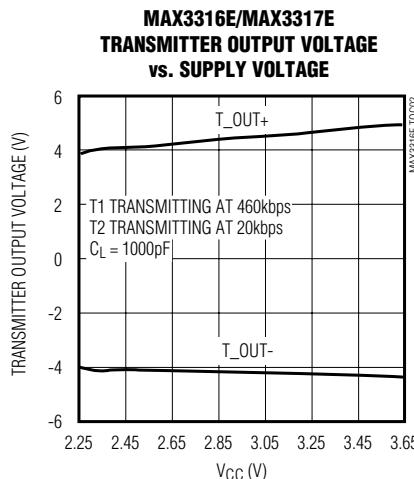
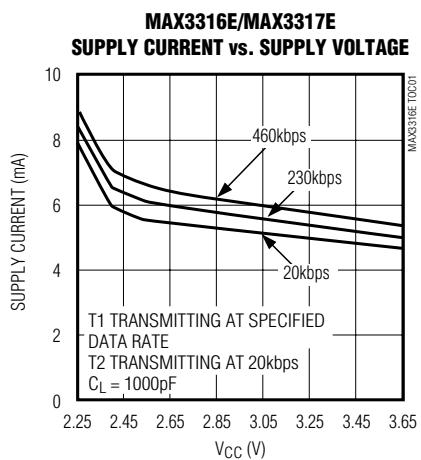
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Transition-Region Slew Rate		$V_{CC} = 2.5V$ , $T_A = +25^\circ C$ , $R_L = 3k\Omega$ to $7k\Omega$ , measured from $+3V$ to $-3V$ or $-3V$ to $+3V$ , $C_L = 150pF$ to $2500pF$	4	30	30	V/ $\mu$ s

**Note 2:** A transmitter/receiver edge is defined as a transition through the transmitter/receiver input logic thresholds.

**Note 3:** Transmitter skew is measured at the transmitter zero crosspoints.

## **Typical Operating Characteristics**

( $V_{CC} = +2.5V$ ,  $C1-C4 = 0.1\mu F$ , 460kbps data rate, all transmitters loaded with  $3k\Omega$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

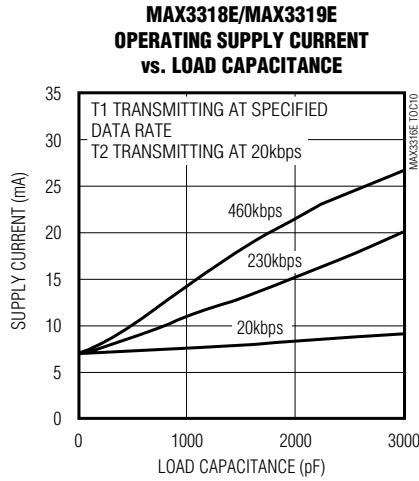
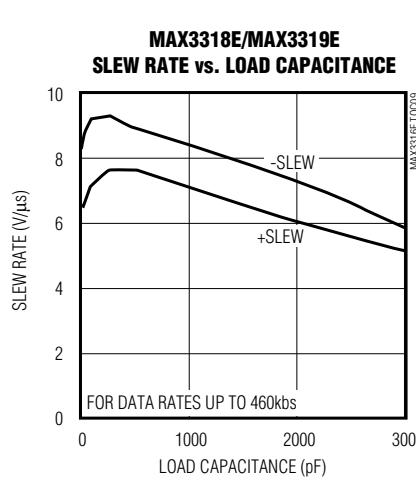
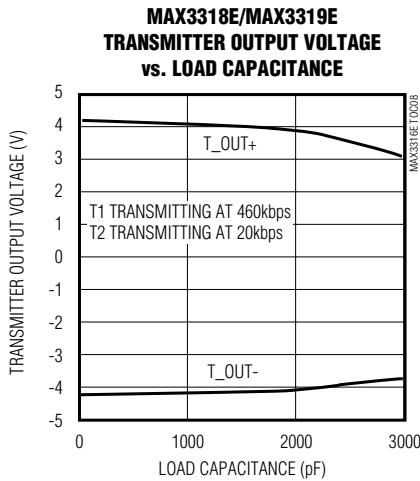
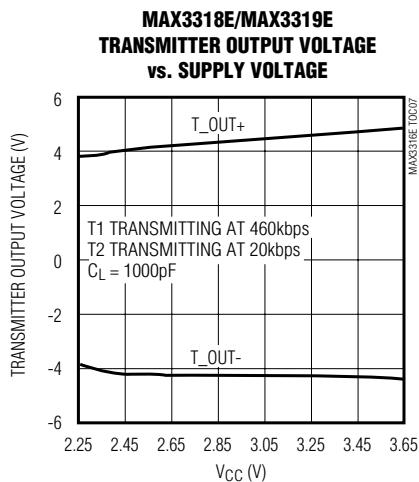
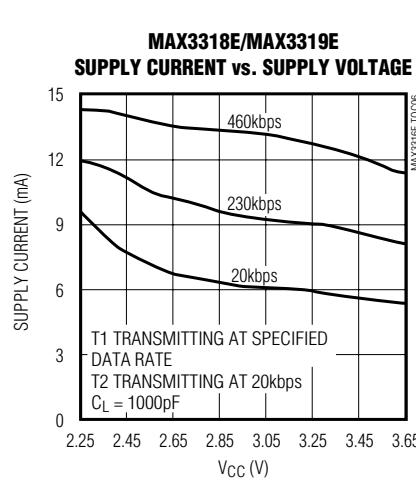
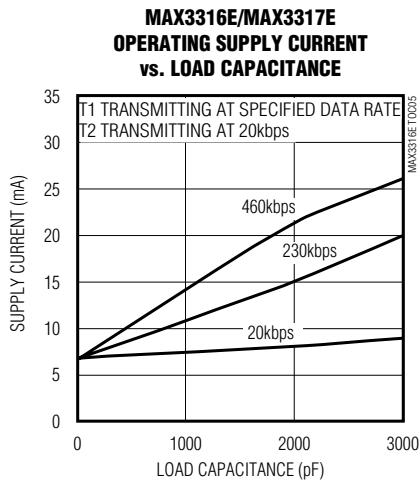


# **$\pm 15kV$ ESD-Protected, 2.5V, 1 $\mu$ A, 460kbps, RS-232 Compatible Transceivers**

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

( $V_{CC} = +2.5V$ ,  $C1-C4 = 0.1\mu F$ , 460kbps data rate, all transmitters loaded with  $3k\Omega$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

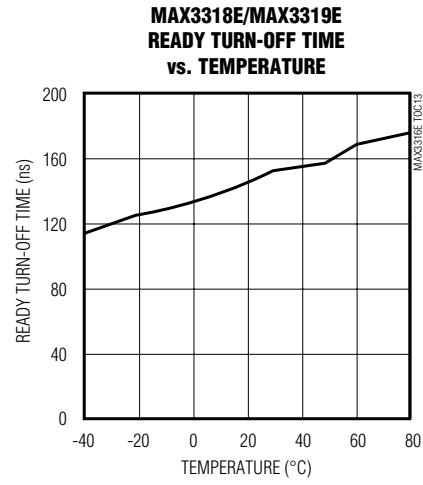
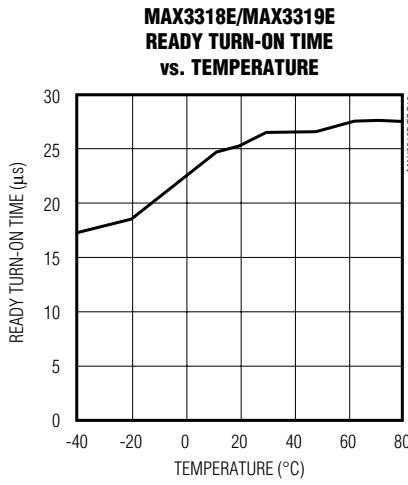
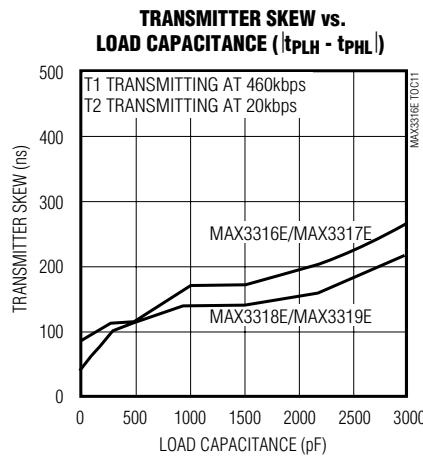
**MAX3316E-MAX3319E**



# **$\pm 15kV$ ESD-Protected, 2.5V, 1 $\mu$ A, 460kbps, RS-232 Compatible Transceivers**

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

( $V_{CC} = +2.5V$ ,  $C1-C4 = 0.1\mu F$ , 460kbps data rate, all transmitters loaded with  $3k\Omega$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



## **Pin Description**

PIN					NAME	FUNCTION
MAX3316E		MAX3317E	MAX3318E	MAX3319E		
SSOP	TSSOP					
1	2	2	2	2	C1+	Positive Terminal of Voltage-Doubler Charge-Pump Capacitor
2	3	3	3	3	V+	+2 • $V_{CC}$ Generated by the Charge Pump
3	4	4	4	4	C1-	Negative Terminal of Voltage-Doubler Charge-Pump Capacitor
4	5	5	5	5	C2+	Positive Terminal of Inverting Charge-Pump Capacitor
5	6	6	6	6	C2-	Negative Terminal of Inverting Charge-Pump Capacitor
6	7	7	7	7	V-	-2 • $V_{CC}$ Generated by the Charge Pump
7, 14	8, 17	8, 17	8, 17	13	T_OUT	RS-232 Transmitter Outputs
8, 13	9, 16	9, 16	9, 16	8	R_IN	RS-232 Receiver Inputs
9, 12	12, 15	10, 15	10, 15	9	R_OUT	CMOS Receiver Outputs
10, 11	13, 14	12, 13	12, 13	11	T_IN	CMOS Transmitter Inputs
15	18	18	18	14	GND	Ground
16	19	19	19	15	VCC	+2.25V to +3.0V Single-Supply Voltage
—	—	1	—	—	EN	Receiver Enable, Active Low
—	1, 10, 11, 20	11, 14	—	—	N.C.	No Connection

# **$\pm 15kV$ ESD-Protected, 2.5V, 1 $\mu$ A, 460kbps, RS-232 Compatible Transceivers**

## **Pin Description (continued)**

PIN					NAME	FUNCTION
MAX3316E		MAX3317E	MAX3318E	MAX3319E		
SSOP	TSSOP					
—		20	—	—	SHDN	Shutdown Control, Active Low
—		—	1	1	READY	Ready to Transmit Output, Active High. READY is enabled high when V- goes below -3.5V and the device is ready to transmit.
—		—	11	10	INVALID	Valid Signal Detector Output, Active Low. A logic high indicates that a valid RS-232 level is present on a receiver input.
—		—	14	12	FORCEON	Force-On Input, Active High. Drive high to override AutoShutdown Plus, keeping transmitters and receivers on (FORCEOFF must be high) (Table 1).
—		—	20	16	FORCEOFF	Force-Off Input, Active Low. Drive low to shut down transmitters, receivers, and charge pump. This overrides AutoShutdown Plus and FORCEON (Table 1).

## **Detailed Description**

### **Dual Charge-Pump Voltage Converter**

The MAX3316E–MAX3319Es' internal power supply consists of a regulated dual charge pump that provides output voltages of +4.4V (doubling charge pump) and -4.3V (inverting charge pump), over the +2.25V to +3.0V range. The charge pump operates in discontinuous mode: if the output voltages are less than 4.4V, the charge pump is enabled; if the output voltages exceed 4.4V, the charge pump is disabled. Each charge pump requires a flying capacitor (C1, C2) and a reservoir capacitor (C3, C4) to generate the V+ and V- supplies.

The READY output (MAX3318E/MAX3319E) is low when the charge pumps are disabled in shutdown mode. The READY signal asserts high when V- goes below -2.75V.

### **RS-232 Compatible Transmitters**

The MAX3316E–MAX3319Es' transmitters are inverting level translators that convert CMOS-logic levels to RS-232 compatible voltage levels. They guarantee a 460kbps data rate with worst-case loads of 3k $\Omega$  in parallel with 1000pF, providing compatibility with PC-to-PC communication software (such as LapLink™).

The MAX3317E's transmitters are turned off (high impedance) when SHDN is asserted low, putting the device in shutdown mode. The MAX3318E/MAX3319Es'

*LapLink* is a trademark of Traveling Software.

transmitters are turned off (high impedance) when FORCEOFF is asserted low, or when the AutoShutdown Plus circuitry senses that all receiver and transmitter inputs are inactive for more than 30 seconds.

The transmitter outputs can be driven to  $\pm 12V$  when power is off. The transmitter inputs do not have internal pull-up resistors. Connect unused inputs to GND or Vcc.

### **RS-232 Receivers**

The MAX3316E–MAX3319Es' receivers convert  $\pm 3.7V$  to  $\pm 13.2V$  RS-232 signal levels into CMOS-logic output levels. The receivers are rated to receive signals up to  $\pm 25V$ . The MAX3316E/MAX3318E/MAX3319Es' receivers feature inverting outputs that always remain active (Table 1). The MAX3317E's receivers have inverting, three-state outputs. In shutdown, the receivers can be active or inactive (Table 2).

The MAX3318E/MAX3319E feature an INVALID output that is asserted low when no valid RS-232 voltage levels have been detected on all receiver inputs. Because INVALID indicates the receiver's input condition, it is independent of the states of FORCEON and FORCEOFF.

### **MAX3317E Shutdown Mode**

Supply current falls to less than 1 $\mu$ A in shutdown mode (SHDN = low). When shut down, the device's charge pumps are turned off, V+ is pulled down to Vcc, V- is pulled to ground, and the transmitter outputs are disabled (high impedance). The time required to exit shut-

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**Table 1. Output Control Truth Table (MAX3318E/MAX3319E)**

OPERATION STATUS	FORCEON	FORCEOFF	VALID RECEIVER LEVEL	RECEIVER OR TRANSMITTER EDGE WITHIN 30s	T_OUT	R_OUT
Shutdown (Forced Off)	X	0	X	X	High-Z	Active
Normal Operation (Forced On)	1	1	X	X	Active	Active
Normal Operation (AutoShutdown Plus)	0	1	X	Yes	Active	Active
Shutdown (AutoShutdown Plus)	0	1	X	No	High-Z	Active
Normal Operation	INVALID*	1	Yes	X	Active	Active
Normal Operation	INVALID*	1	X	Yes	Active	Active
Shutdown	INVALID*	1	No	No	High-Z	Active
Normal Operation (AutoShutdown)	INVALID**	INVALID**	Yes	X	Active	Active
Shutdown (AutoShutdown)	INVALID**	INVALID**	No	X	High-Z	Active

X = Don't care

\*INVALID connected to FORCEON

\*\*INVALID connected to FORCEON and FORCEOFF

**Table 2. Shutdown and Enable Control Truth Table (MAX3317E)**

SHDN	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

down is typically 30 $\mu$ s, as shown in Figure 2. Connect SHDN to V<sub>CC</sub> if the shutdown mode is not used; SHDN has no effect on R\_OUT.

## **MAX3318E/MAX3319E AutoShutdown Plus Mode**

Maxim's AutoShutdown Plus feature on the MAX3318E/MAX3319E allows the supply current to fall to 1 $\mu$ A. These devices will enter the AutoShutdown Plus mode if FORCEOFF is high, FORCEON is low, and they do not

sense a valid signal transition on any receiver or transmitter input for 30 seconds. This may occur if the RS-232 cable is disconnected or if the peripheral transmitters are turned off, and the UART driving the transmitter inputs is inactive. The system turns on again when a valid transition is applied to any RS-232 receiver or transmitter input. As a result, the system saves power without changes to the existing BIOS or operating system.

Figure 4a depicts valid and invalid RS-232 receiver voltage levels. INVALID indicates the receiver input's condition and is independent of FORCEON and FORCEOFF states. Figure 3 and Table 1 summarize the operating modes of the MAX3318E/MAX3319E. FORCEON and FORCEOFF override AutoShutdown Plus circuitry. When neither control is asserted, the IC selects between these states automatically based on the last receiver or transmitter edge received.

When shut down, the device's charge pumps turn off, V<sub>+</sub> is pulled to V<sub>CC</sub>, V<sub>-</sub> is pulled to ground, the transmitter outputs are high impedance, and READY is driven low. The time required to exit shutdown is typically 30 $\mu$ s (Figure 2).

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**MAX3316E-MAX3319E**

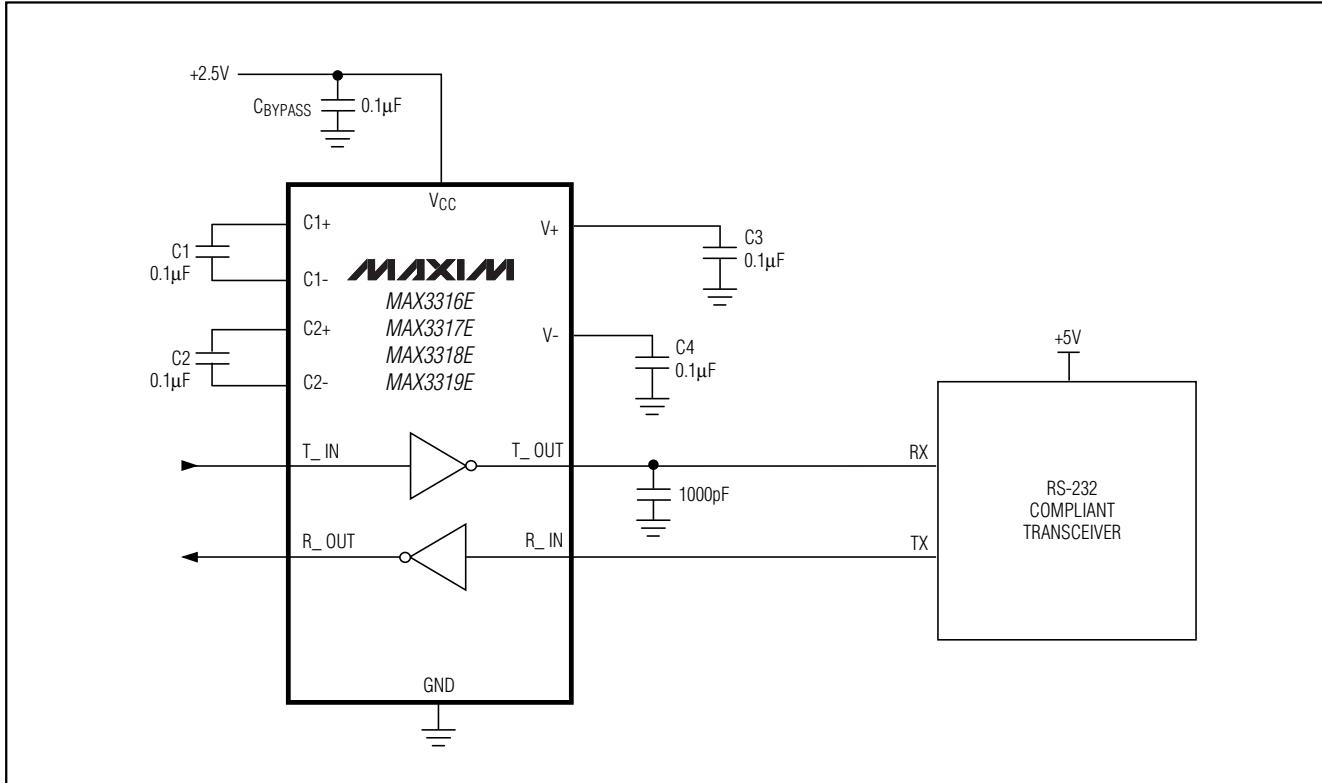


Figure 1a. RS-232 Compatibility Circuit

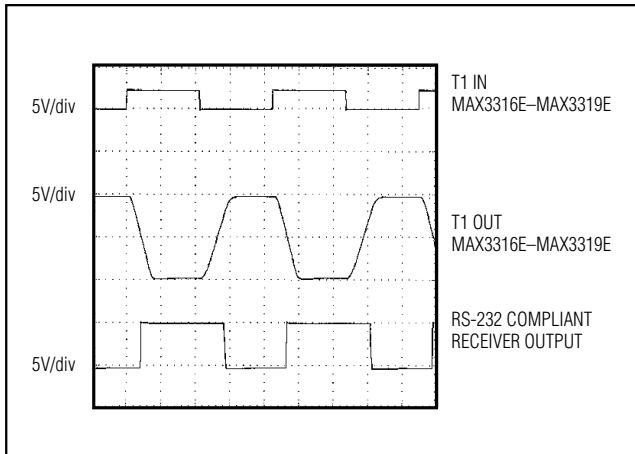


Figure 1b. MAX3316E-MAX3319E Transmitter Output Compatibility with an RS-232 Receiver

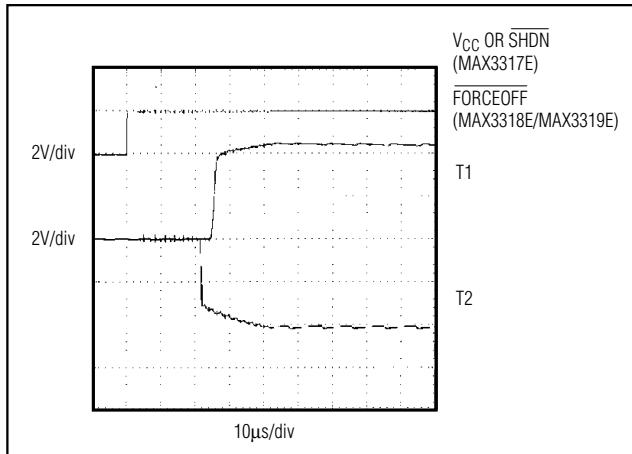


Figure 2. Transmitter Outputs when Exiting Shutdown or Powering Up

# **$\pm 15kV$ ESD-Protected, 2.5V, 1 $\mu$ A, 460kbps, RS-232 Compatible Transceivers**

By connecting FORCEON to  $\overline{\text{INVALID}}$ , the MAX3318E/MAX3319E shut down when no valid receiver level is detected and wake up when a valid receiver level is detected.

A system with AutoShutdown Plus may need time to wake up. Figure 5 shows a circuit that forces the transmitters on for 100ms, allowing enough time for the other system to realize that the MAX3318E/MAX3319E is awake. If the other system outputs valid RS-232 signal transitions within that time, the RS-232 ports on both systems remain enabled.

## **Connecting to the PC (MAX3318E/MAX3319E)**

If direct software control is desired, use  $\overline{\text{INVALID}}$  to indicate DTR or ring indicator (RI) signal. This can be used to connect a hand-held device to a PC. One example is using the Hot Sync™ function on a personal digital assistant (PDA). The transmitter and receiver signals ( $\text{T\_OUT}$  and  $\text{R\_IN}$ ) are used for communication, while  $\overline{\text{INVALID}}$  causes a change of state on RI. The change of state on RI will trigger an interrupt on the PC and allow communication to begin between the device and the PC. This eliminates the need for the PC to poll constantly the receiver or transmitter lines to determine if the device is connected.

## **$\pm 15kV$ ESD Protection**

All the pins on the MAX3316E-MAX3319E are protected against ESDs encountered during handling and assembly. The driver outputs and receiver inputs have extra protection against static electricity. Maxim's engineers have developed state-of-the-art structures to protect these pins against ESD of  $\pm 15kV$  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 products can latch and must be powered down to remove latchup.

ESD protection can be tested in various ways; the transmitter outputs and receiver inputs of the product family are characterized for protection to the following limits:

- $\pm 15kV$  using the Human Body Model
- $\pm 8kV$  using the IEC 1000-4-2 Contact Discharge method
- $\pm 15kV$  using IEC 1000-4-2 Air-Gap method

## **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.

*Hot Sync* is a trademark of 3Com.

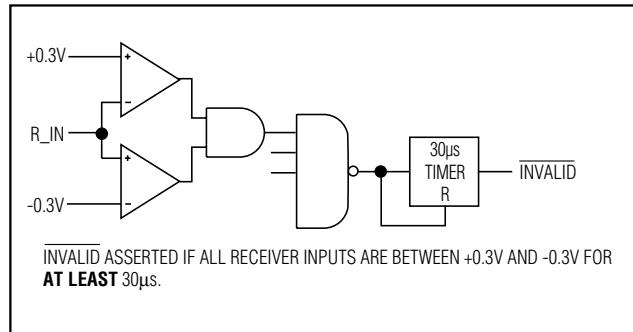


Figure 3a.  $\overline{\text{INVALID}}$  Functional Diagram,  $\overline{\text{INVALID}}$  Low

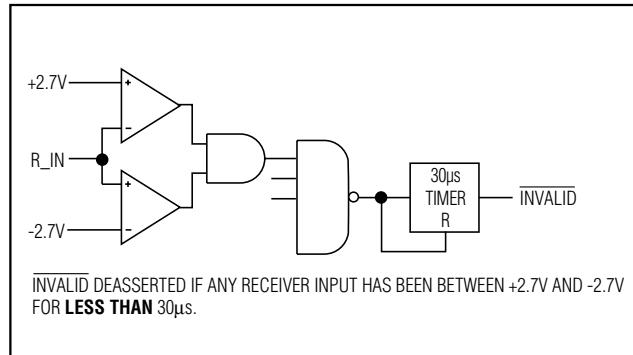


Figure 3b.  $\overline{\text{INVALID}}$  Functional Diagram,  $\overline{\text{INVALID}}$  High

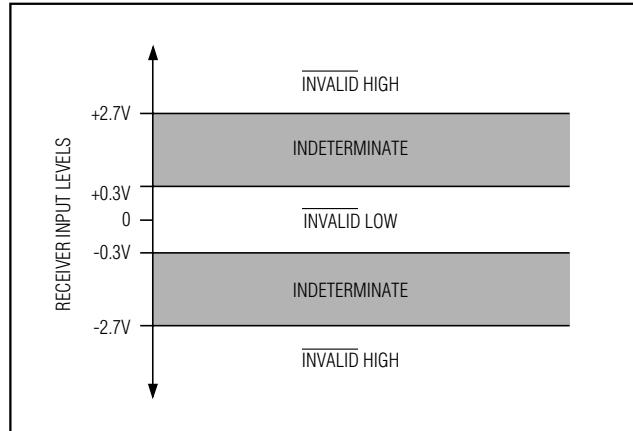


Figure 4a. Receiver Positive/Negative Thresholds for  $\overline{\text{INVALID}}$

## **Human Body Model**

Figure 6a shows the Human Body Model, and Figure 6b shows the current waveform it generates when discharged into 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 1.5k $\Omega$  resistor.

# **$\pm 15kV$ ESD-Protected, 2.5V, 1 $\mu$ A, 460kbps, RS-232 Compatible Transceivers**

**MAX3316E-MAX3319E**

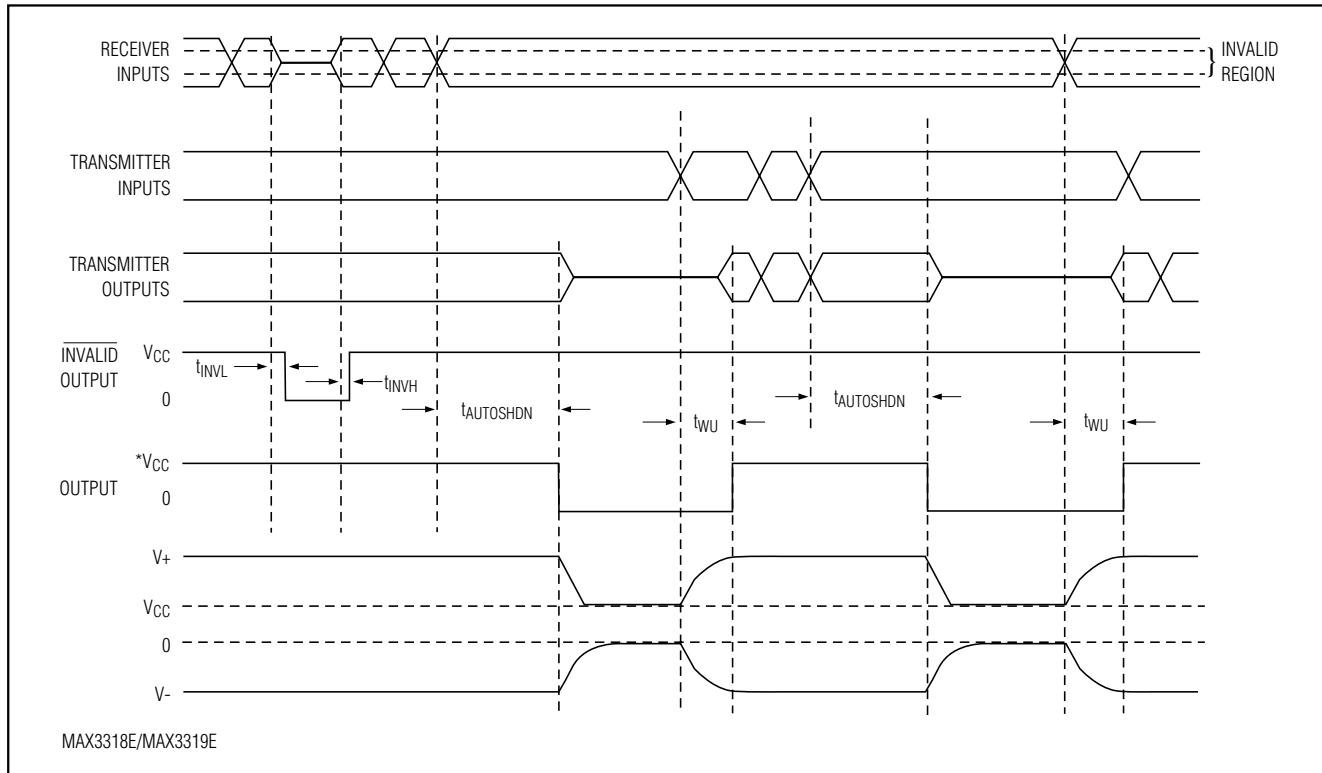


Figure 4b. AutoShutdown Plus, INVALID, and READY Timing Diagram

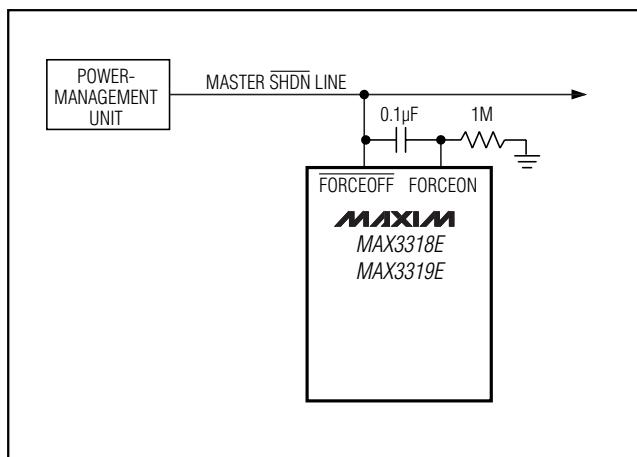


Figure 5. AutoShutdown Plus Initial Turn-On to Wake Up a Mouse or Another System

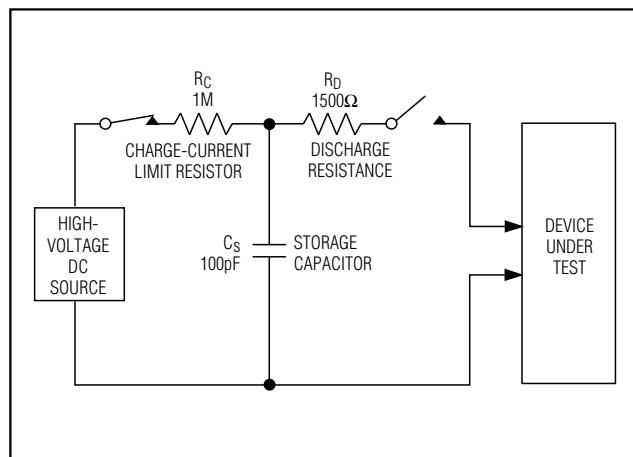


Figure 6a. Human Body ESD Test Model

# **$\pm 15kV$ ESD-Protected, 2.5V, 1 $\mu$ A, 460kbps, RS-232 Compatible 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 ICs. The MAX3316E–MAX3319E 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 7a shows the IEC 1000-4-2 model, and Figure 7b 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.

## **Applications Information**

### **RS-232 Compatible Operation**

The MAX3316E–MAX3319E do not meet EIA-232 requirements for transmitter output voltage levels. EIA-232 compliance specifies transmitter output voltage swings of  $\pm 5V$  when loaded with  $3k\Omega$  and 2500pF.

The receiver inputs are fully EIA-232 compliant.

The MAX3316E–MAX3319E will function properly with most modern RS-232 interfaces. This allows RS-232 compatible communication in low-voltage systems without the added expense of a voltage tripler or switched-mode power supply.

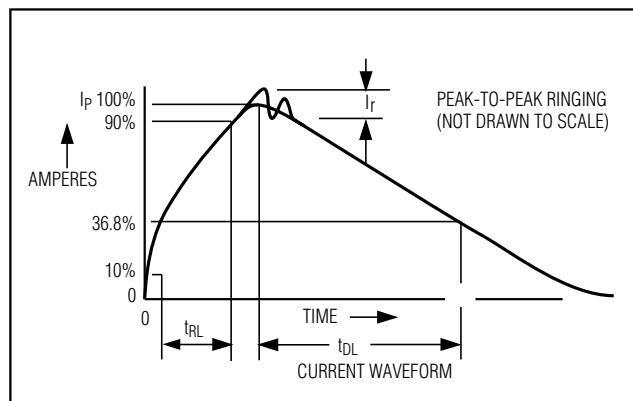


Figure 6b. Human Body Current Waveform

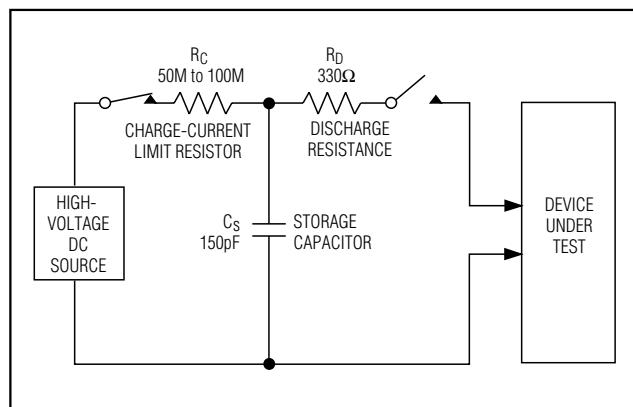


Figure 7a. IEC 1000-4-2 ESD Test Model

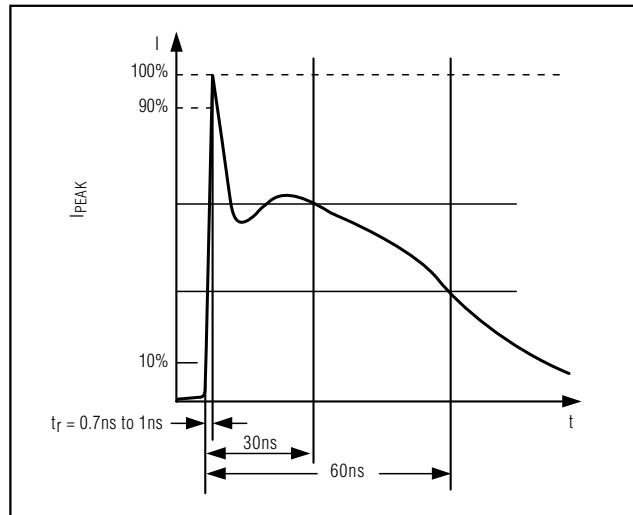


Figure 7b. IEC 1000-4-2 ESD Generator Current Waveform

# **$\pm 15kV$ ESD-Protected, 2.5V, 1 $\mu$ A, 460kbps, RS-232 Compatible Transceivers**

**MAX3316E-MAX3319E**

## **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 0.1 $\mu$ F capacitors. 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 C<sub>BYPASS</sub> to maintain proper ratios (C1 to 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 higher 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 0.1 $\mu$ F bypass capacitor is adequate. In applications that are sensitive to power-supply noise, decouple V<sub>CC</sub> to ground with a capacitor of the same value as charge pump capacitor C1. Connect bypass capacitors as close to the IC as possible.

## **Transmitter Outputs when Exiting Shutdown**

Figure 2 shows two transmitter outputs when exiting shutdown mode. As they become active, the two transmitter outputs are shown going to opposite RS-232 compatible levels (one transmitter input is high, the other is low). Each transmitter is loaded with 3k $\Omega$  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.

## **High Data Rates**

The MAX3316E–MAX3319E maintain RS-232 compatible  $\pm 3.7V$  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 230kbps. For Figure 9, all transmitters were driven simultaneously at 230kbps into EIA/TIA-562 loads in parallel with 1000pF.

## **Chip Information**

TRANSISTOR COUNT: 1130

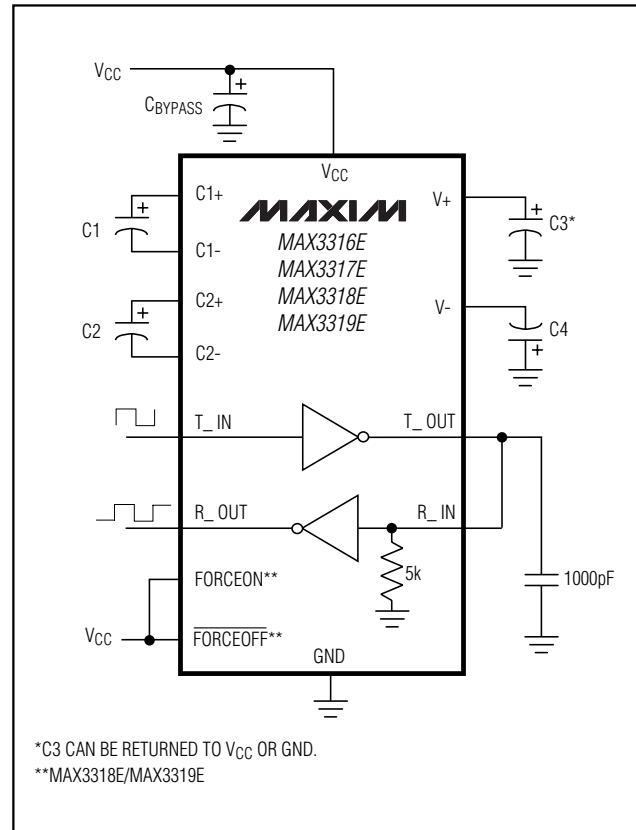


Figure 8. Loopback Test Circuit

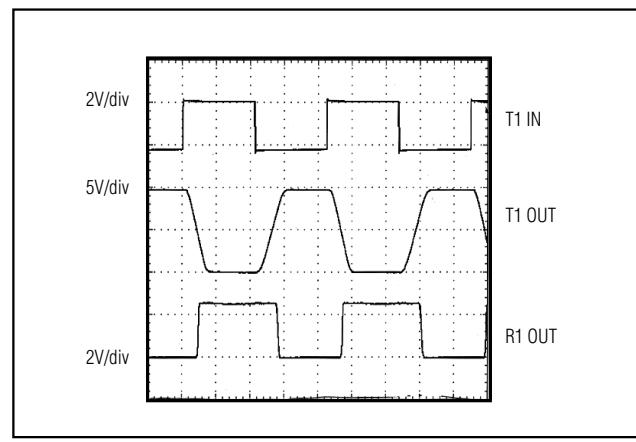
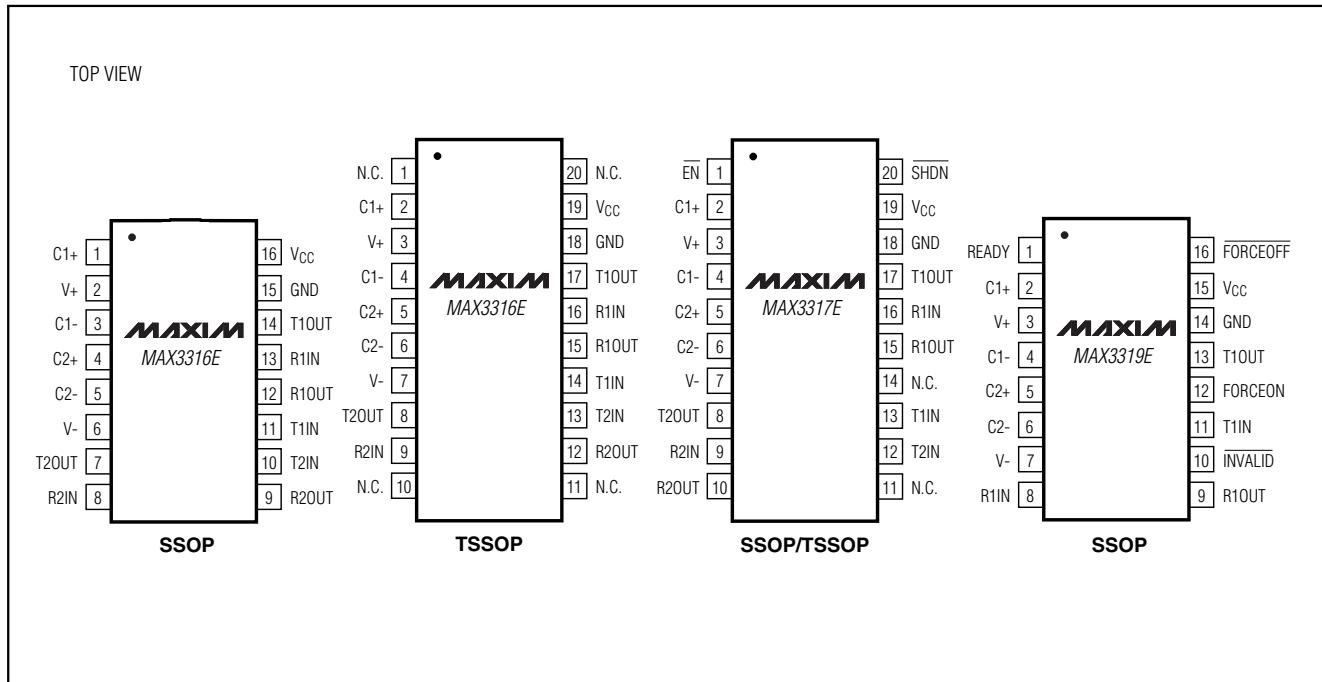


Figure 9. Loopback Test Result at 230kbps

## **$\pm 15kV$ ESD-Protected, 2.5V, 1 $\mu$ A, 460kbps, RS-232 Compatible Transceivers**

### ***Pin Configurations (continued)***



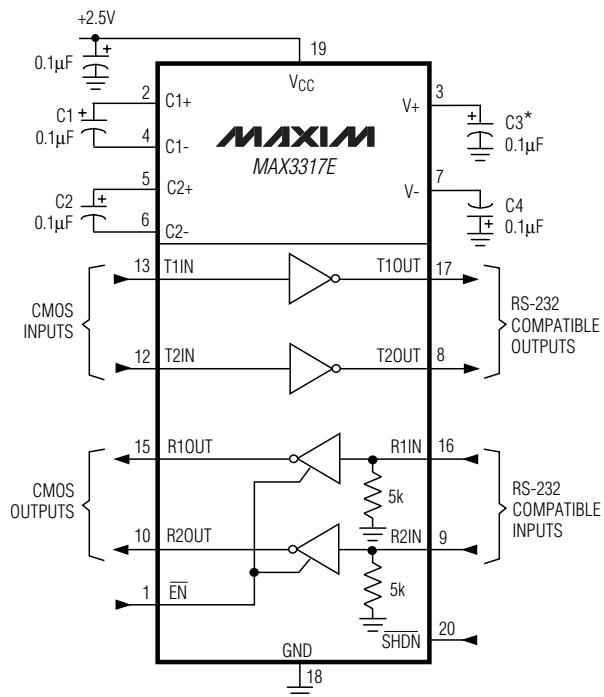
# **$\pm 15kV$ ESD-Protected, 2.5V, 1 $\mu$ A, 460kbps, RS-232 Compatible Transceivers**

## **Selector Guide**

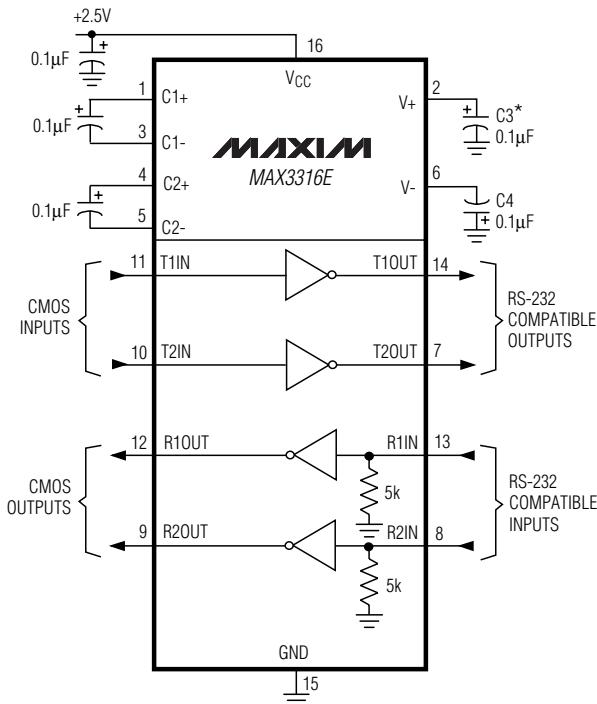
PART	NO. OF DRIVERS/ RECEIVERS	GUARANTEED DATA RATE (kbps)	READY OUTPUT	SHUTDOWN	AutoShutdown Plus
MAX3316E	2/2	460	—	—	—
MAX3317E	2/2	460	—	✓	—
MAX3318E	2/2	460	✓	—	✓
MAX3319E	1/1	460	✓	—	✓

**MAX3316E-MAX3319E**

## **Typical Application Circuits**



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

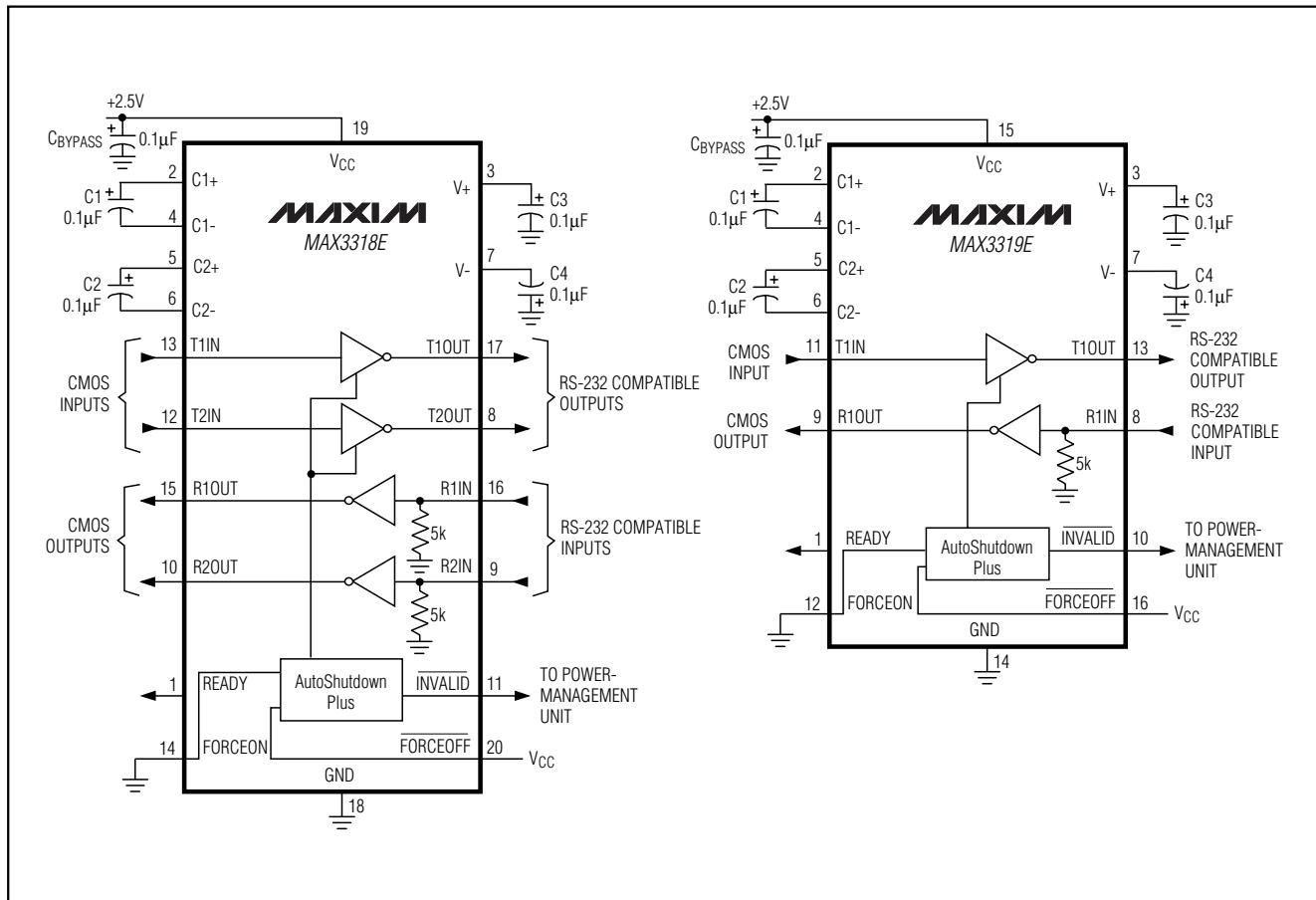


CIRCUIT SHOWN IS FOR THE 16-PIN SSOP.

Typical Application Circuits continue on next page.

## ***±15kV ESD-Protected, 2.5V, 1µA, 460kbps, RS-232 Compatible Transceivers***

### ***Typical Application Circuits (continued)***



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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