



# ±15kV ESD-Protected, 3.0V to 5.5V, Low-Power, up to 250kbps, True RS-232 Transceiver

**MAX3384E**

## General Description

The MAX3384E is a 3V-powered EIA/TIA-232 and V.28/V.24 communications interface 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 transceiver has 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.

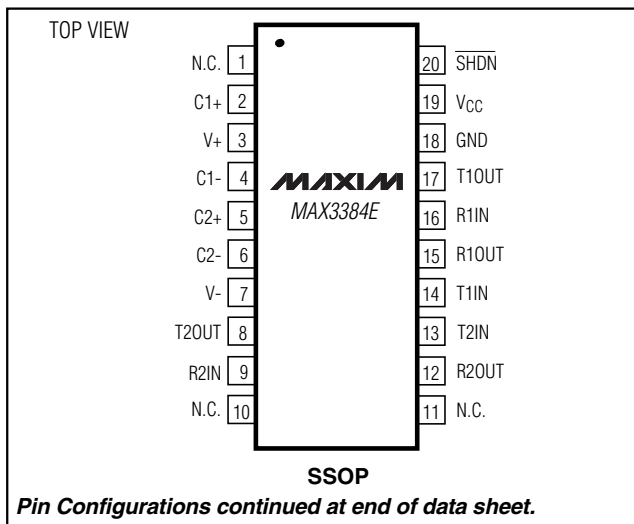
The MAX3384E has two receivers and two drivers. It features a 1µA shutdown mode that reduces power consumption and extends battery life in portable systems.

The MAX3384E is available in a space-saving SSOP package in either the commercial (0°C to +70°C) or extended temperature (-40°C to +85°C) range.

## Applications

Hand-Held Equipment	Battery-Powered Equipment
Peripherals	PDA's
Printers	

## Pin Configurations



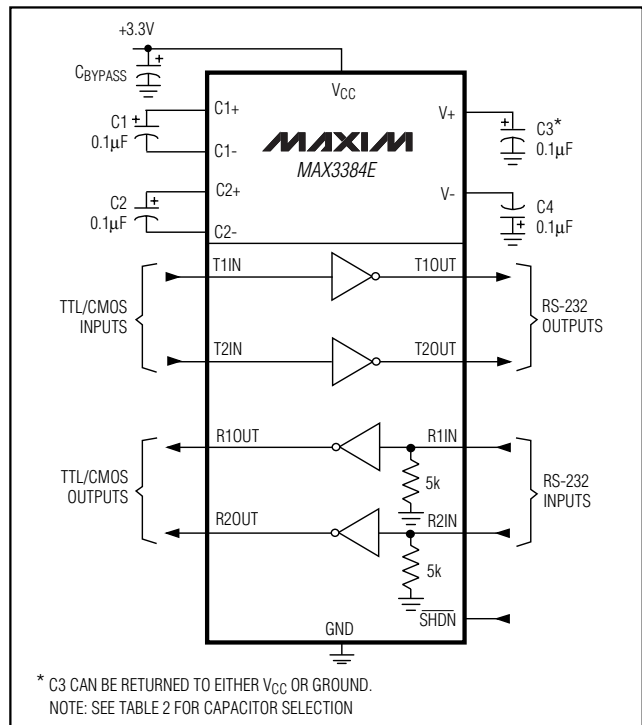
## Features

- ◆ 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
- ◆ Latchup Free
- ◆ 300µA Supply Current
- ◆ 1µA Low-Power Shutdown
- ◆ 250kbps Guaranteed Data Rate
- ◆ 250µs Time to Exit Shutdown with 3kΩ Load on V+
- ◆ 6V/µs Guaranteed Slew Rate
- ◆ Transmitter and Receiver Outputs High Impedance in Shutdown
- ◆ Meets EIA/TIA-232 Specifications Down to 3.0V

## Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX3384ECAP	0°C to +70°C	20 SSOP
MAX3384ECWN	0°C to +70°C	18 SO
MAX3384EEAP	-40°C to +85°C	20 SSOP

## Typical Operating Circuit



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## ABSOLUTE MAXIMUM RATINGS

V <sub>CC</sub> to GND	-0.3V to +6V	Continuous Power Dissipation (T <sub>A</sub> = +70°C)	
V <sub>+</sub> to GND (Note 1)	-0.3V to +7V	20-Pin SSOP (derate 8.00mW/°C above +70°C)	640mW
V <sub>-</sub> to GND (Note 1)	+0.3V to -7V	18-Pin SO (derate 9.52mW/°C above +70°C)	762mW
V <sub>+</sub> + IV-I (Note 1)	+13V	Operating Temperature Ranges	
Input Voltages		MAX3384ECAP	0°C to +70°C
T <sub>IN</sub> , SHDN to GND	-0.3V to +6V	MAX3384ECWN	0°C to +70°C
R <sub>IN</sub> to GND	±25V	MAX3384EEAP	-40°C to +85°C
Output Voltages		Junction Temperature	150°C
T <sub>OUT</sub> to GND	±13.2V	Storage Temperature Range	-65°C to +150°C
R <sub>OUT</sub>	-0.3V to (V <sub>CC</sub> + 0.3V)	Lead Temperature (soldering, 10s)	+300°C
Maximum Current into T <sub>OUT</sub>	±100mA		
Short-Circuit Duration, T <sub>OUT</sub> to GND	Continuous		

**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> = +3V to +5.5V, for tests at 3.3V ±10%, C1–C4 = 0.1µF; for tests at +5V ±10%, C1 = 0.047µF, C2–C4 = 0.33µF; T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
<b>DC CHARACTERISTICS</b> (V <sub>CC</sub> = +3.3V or +5V, T <sub>A</sub> = +25°C)						
Supply Current	SHDN = V <sub>CC</sub> , no load			0.3	1	mA
Shutdown Supply Current	SHDN = GND			1	10	µA
<b>LOGIC INPUTS</b>						
Input Logic Threshold Low	T <sub>IN</sub> , SHDN				0.8	V
Input Logic Threshold High	T <sub>IN</sub> , SHDN	V <sub>CC</sub> = +3.3V	2.0			V
		V <sub>CC</sub> = +5V	2.4			
Transmitter Input Hysteresis				0.5		V
Input Leakage Current	T <sub>IN</sub> , SHDN			±0.01	±1	µA
<b>RECEIVER OUTPUTS</b>						
Output Leakage Current	R <sub>OUT</sub> , receivers disabled			±0.05	±10	µA
Output Voltage Low	I <sub>OUT</sub> = 1.6mA				0.4	V
Output Voltage High	I <sub>OUT</sub> = -1.0mA		V <sub>CC</sub> - 0.6	V <sub>CC</sub> - 0.1		V
<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	1.2		V
		V <sub>CC</sub> = +5V	0.8	1.5		
Input Threshold High	T <sub>A</sub> = +25°C	V <sub>CC</sub> = +3.3V		1.5	2.4	V
		V <sub>CC</sub> = +5V		1.8	2.4	
Input Hysteresis				0.5		V
Input Resistance	T <sub>A</sub> = +25°C		3	5	7	kΩ

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## ELECTRICAL CHARACTERISTICS (continued)

(V<sub>CC</sub> = +3V to +5.5V, for tests at 3.3V ±10%, C1–C4 = 0.1μF; for tests at +5V ±10%, C1 = 0.047μF, C2–C4 = 0.33μF; T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
<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	10M		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 dis-			±25	μA
<b>ESD PROTECTION</b>					
R <sub>IN</sub> , T <sub>OUT</sub>	Human Body Model		±15		kV
	IEC1000-4-2 Air Discharge		±15		
	IEC1000-4-2 Contact Discharge		±8		

## TIMING CHARACTERISTICS

(V<sub>CC</sub> = +3V to +5.5V, for tests at 3.3V ±10%, C1–C4 = 0.1μF; for tests at +5V ±10%, C1 = 0.047μF, C2–C4 = 0.33μF; T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.)

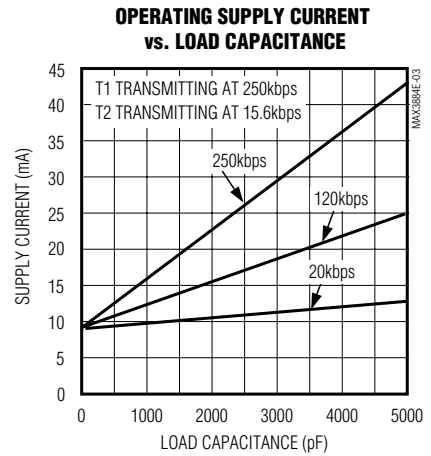
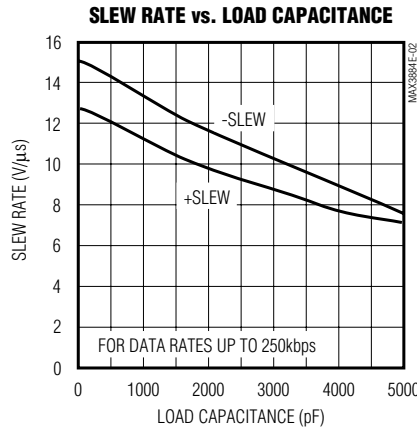
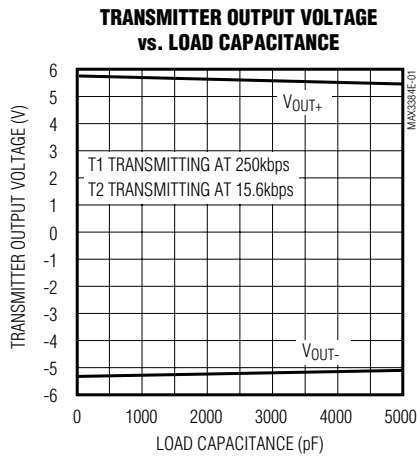
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Maximum Data Rate		R <sub>L</sub> = 3kΩ, C <sub>L</sub> = 1000pF, one transmitter switching	250			kbps
Receiver Propagation Delay	t <sub>PHL</sub>	Receiver input to receiver output, C <sub>L</sub> = 150pF		0.15		μs
	t <sub>PLH</sub>			0.15		
Receiver Output Enable Time		$\overline{\text{SHDN}}$ from GND to V <sub>CC</sub>		200		ns
Receiver Output Disable Time		$\overline{\text{SHDN}}$ from V <sub>CC</sub> to GND		200		ns
Time to Exit Shutdown		V <sub>OUT</sub> ≥ +3.7V, R <sub>LOAD</sub> at V <sub>+</sub> = 3kΩ		250		μs
Transmitter Skew	t <sub>PHL</sub> - t <sub>PLH</sub>	(Note 2)		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:** Transmitter skew is measured at the transmitter zero cross points.

# **±15kV ESD-Protected, 3.0V to 5.5V, Low-Power, up to 250kbps, True RS-232 Transceiver**

## **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.)



## **Pin Description**

PIN		NAME	FUNCTION
SO	SSOP		
1	1, 10, 11	N.C.	No Connection. Not internally connected.
2	2	C1+	Positive terminal of the voltage-doubler charge-pump capacitor.
3	3	V+	+5.5V generated by the charge pump.
4	4	C1-	Negative terminal of the voltage-doubler charge-pump capacitor.
5	5	C2+	Positive terminal of inverting charge-pump capacitor.
6	6	C2-	Negative terminal of inverting charge-pump capacitor.
7	7	V-	-5.5V generated by the charge pump.
8, 15	8, 17	T_OUT	RS-232 Transmitter Outputs. High Z when $\overline{\text{SHDN}}$ is low.
9, 14	9, 16	R_IN	RS-232 Receiver Inputs
10, 13	12, 15	R_OUT	TTL/CMOS Receiver Outputs. High Z when $\overline{\text{SHDN}}$ is low.
11, 12	13, 14	T_IN	TTL/CMOS Transmitter Inputs
16	18	GND	Ground
17	19	V <sub>CC</sub>	+3.0V to +5.5V Supply Voltage. Connect a 0.1µF capacitor to GND.
18	20	$\overline{\text{SHDN}}$	Active-Low Shutdown-Control Input. Drive low to shut down transmitters, receivers and charge pumps.

# **±15kV ESD-Protected, 3.0V to 5.5V, Low-Power, up to 250kbps, True RS-232 Transceiver**

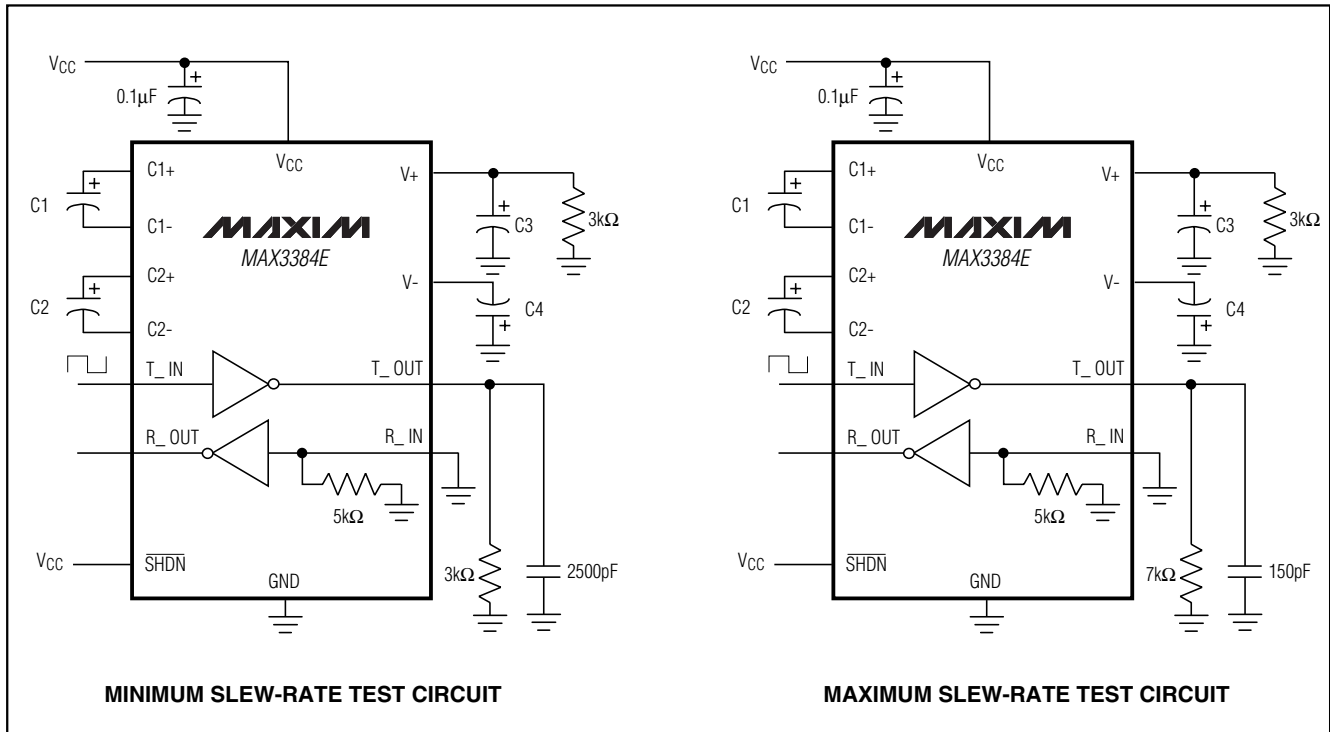


Figure 1. Slew-Rate Test Circuits

## **Detailed Description**

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

The MAX3384E'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 VCC 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+ and V- supplies (Figure 1).

### **RS-232 Transmitters**

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

The MAX3384E 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.

*Laplink is a trademark of Traveling Software.*

The MAX3384E's transmitters are disabled and the outputs are forced into a high-impedance state when the device is in shutdown (SHDN = GND). The MAX3384E permits the outputs to be driven up to ±12V in shutdown.

The transmitter inputs do not have pullup resistors. Connect unused inputs to GND or VCC.

### **RS-232 Receivers**

The receivers convert RS-232 signals to CMOS-logic output levels (Table 1). The receiver outputs are forced into a high-impedance state when the device is in shutdown (SHDN = GND). This allows a single UART to multiplex between different protocols.

### **Shutdown Mode**

Supply current falls to less than 1µA in shutdown mode (SHDN = low). When shut down, the device's charge

**Table 1. Shutdown Truth Table**

SHDN	T_OUT	R_OUT
0	High-Z	High-Z
1	Active	Active

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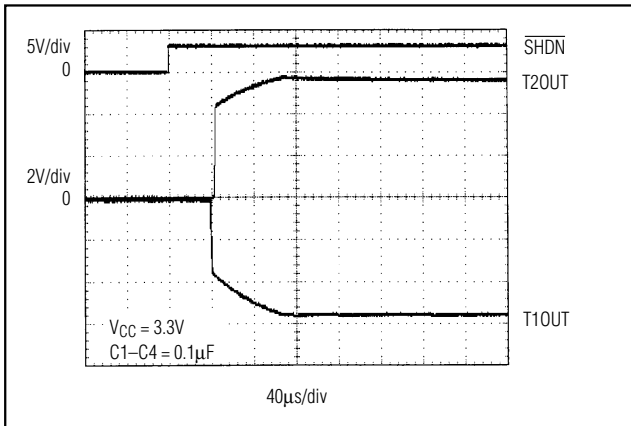


Figure 2. Transmitter Outputs Exiting Shutdown or Powering Up

pumps are shut off, V+ is pulled down to V<sub>CC</sub>, V- is pulled to ground, and the transmitter and receiver outputs are disabled (high impedance). The time required to exit shutdown is typically 100µs, as shown in Figure 2. Connect  $\overline{\text{SHDN}}$  to V<sub>CC</sub> if the shutdown mode is not used.

### ±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 driver outputs and receiver inputs of the MAX3384E 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.

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

- 1) ±15kV using the Human Body Model
- 2) ±8kV using the contact-discharge method specified in IEC 1000-4-2
- 3) ±15kV using IEC 1000-4-2's 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.

### Human Body Model

Figure 3a shows the Human Body Model, and Figure 3b 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 1000-4-2 standard covers ESD testing and performance of finished equipment; it does not specifically refer to integrated circuits. The MAX3384E helps 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 4a shows the IEC 1000-4-2 model, and Figure 4b 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.

### 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. Of course, 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

### Capacitor Selection

The capacitor type used for C1–C4 is not critical for proper operation; polarized or nonpolarized capacitors

**Table 2. Required Minimum Capacitance Values**

V <sub>CC</sub> (V)	C1, C <sub>BYPASS</sub> (µF)	C2, C3, C4 (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

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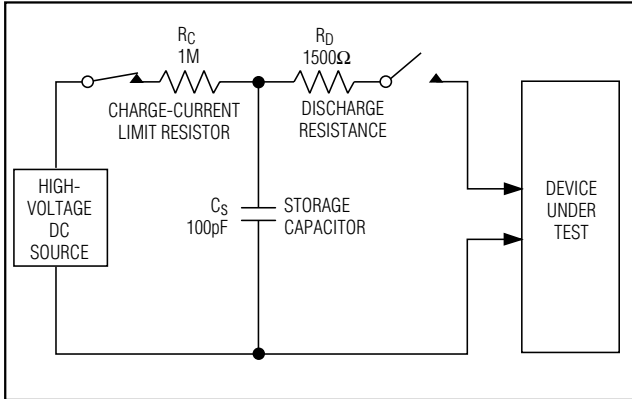


Figure 3a. Human Body ESD Test Model

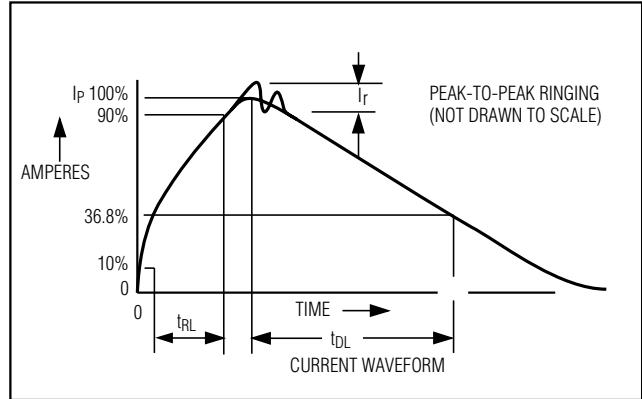


Figure 3b. Human Body Model Current Waveform

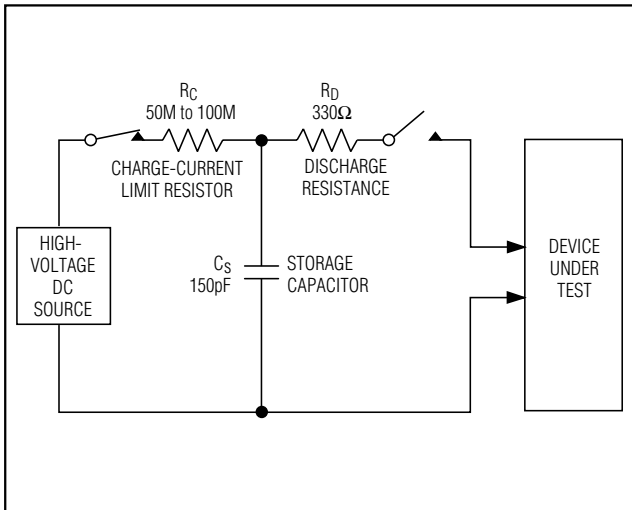


Figure 4a. IEC 1000-4-2 ESD Test Model

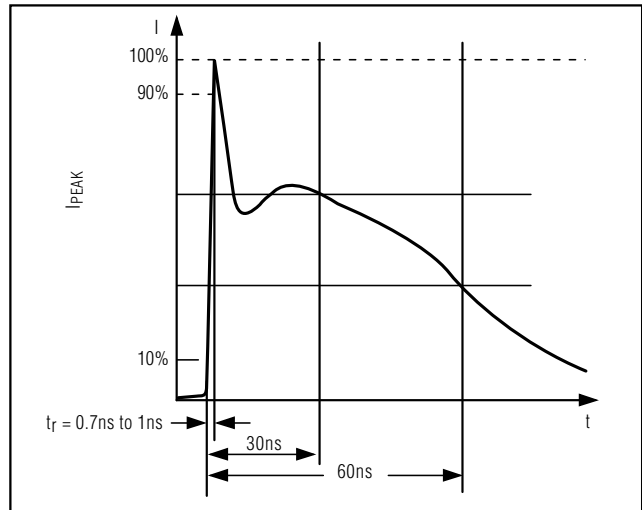


Figure 4b. IEC 1000-4-2 ESD Generator Current Waveform

can be used. The charge pump requires 0.1μF capacitors for 3.3V operation. For other supply voltages, refer to 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 VCC 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.

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## 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 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<sub>-</sub> exceeds approximately -3V.

## High Data Rates

The MAX3384E maintains the RS-232 ±5.0V minimum transmitter output voltage even at high data rates. Figure 6 shows a transmitter loopback test circuit. Figure 7 shows a loopback test result at 120kbps, and Figure 8 shows the same test at 250kbps. For Figure 7, all transmitters were driven simultaneously at 120kbps into RS-232 loads in parallel with 1000pF. For Figure 8, a single transmitter was driven at 250kbps, and all transmitters were loaded with an RS-232 receiver in parallel with 1000pF.

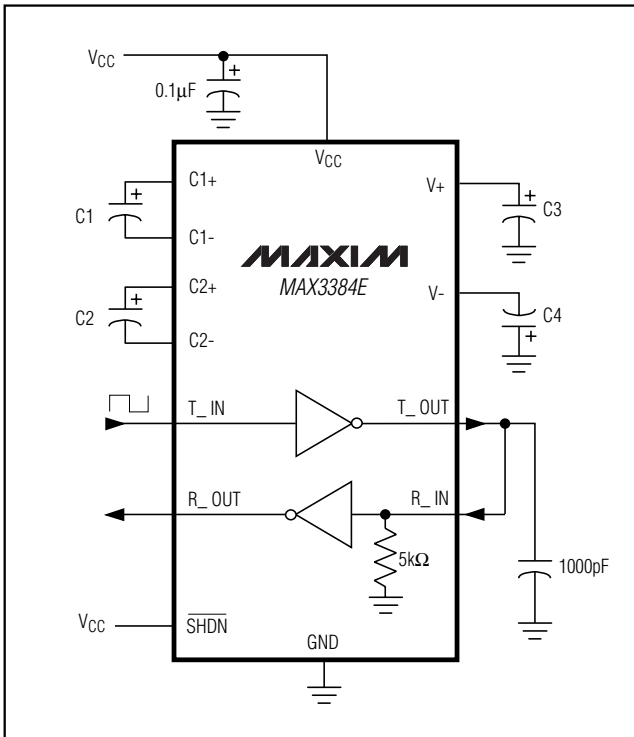


Figure 6. Loopback Test Circuit

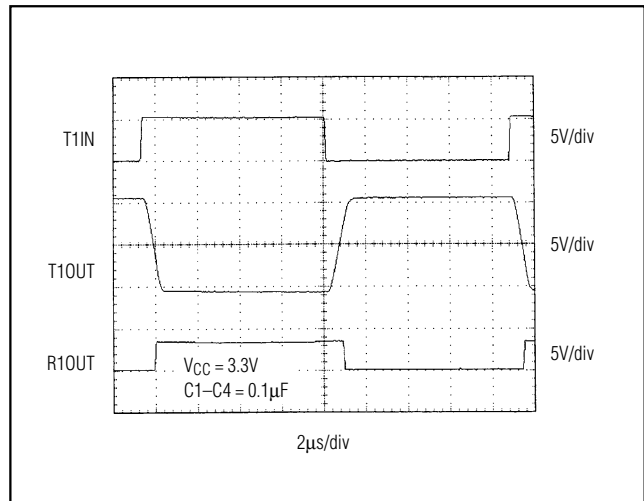


Figure 7. MAX3384E Loopback Test Result at 120kbps

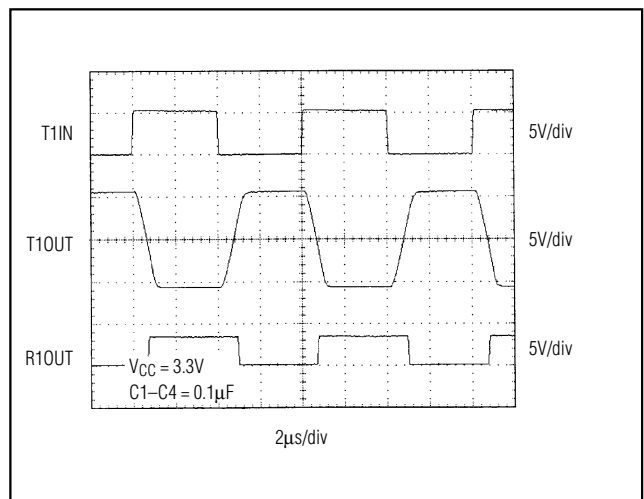


Figure 8. MAX3384E Loopback Test Result at 250kbps



# **$\pm 15\text{kV}$ ESD-Protected, 3.0V to 5.5V, Low-Power, up to 250kbps, True RS-232 Transceiver**

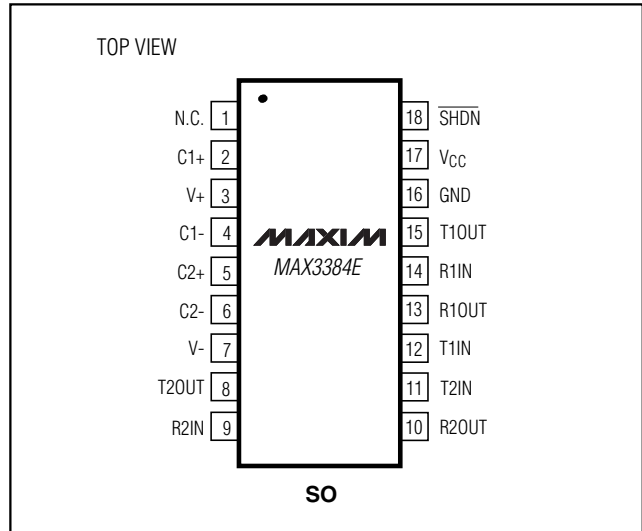
**Table 3. Logic-Family Compatibility with Various Supply Voltages**

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

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

The MAX3384E can directly interface with various 5V logic families, including ACT and HCT CMOS. See Table 3 for more information on possible combinations of interconnections.

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



**MAX3384E**

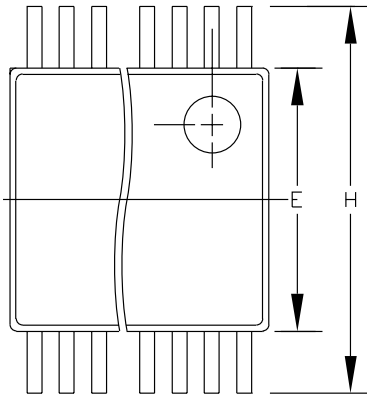
### **Chip Information**

TRANSISTOR COUNT: 1129

Process: BiCMOS

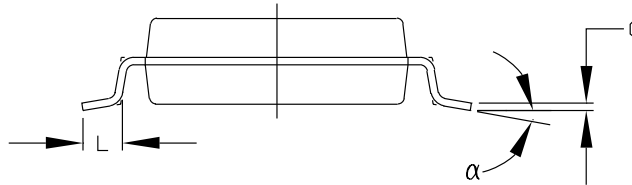
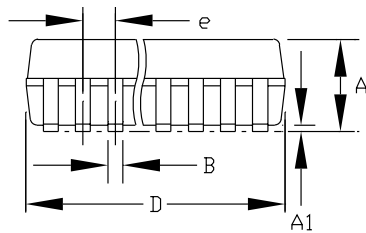
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**Package Information**



DIM	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	0.004	0.008	0.09	0.20
D	SEE VARIATIONS			
E	0.205	0.209	5.20	5.38
e	0.0256	BSC	0.65	BSC
H	0.301	0.311	7.65	7.90
L	0.025	0.037	0.63	0.95
α	0°	8°	0°	8°

	INCHES		MILLIMETERS		
	MIN	MAX	MIN	MAX	
D	0.239	0.249	6.07	6.33	14L
D	0.239	0.249	6.07	6.33	16L
D	0.278	0.289	7.07	7.33	20L
D	0.317	0.328	8.07	8.33	24L
D	0.397	0.407	10.07	10.33	28L



NOTES:

1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
3. CONTROLLING DIMENSION: MILLIMETER

<b>MAXIM</b>		
<small>PROPRIETARY INFORMATION</small>		
<small>TITLE:</small>		
PACKAGE OUTLINE, SSOP, 5.3X.65mm		
<small>APPROVAL</small>	<small>DOCUMENT CONTROL NO.</small>	<small>REV</small>
	21-0056	A 1/1

SSOPFS