19-1437; Rev 1; 10/99

MAXIM

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

General Description

The MAX3385E 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 MAX3385E has two receivers and two drivers. It 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.

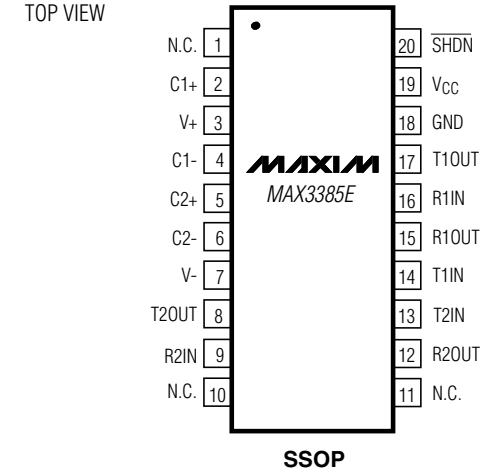
The MAX3385E is available in a space-saving SSOP package in either the commercial (0°C to +70°C) or extended-industrial (-40°C to +85°C) temperature range.

Applications

Hand-Held Equipment
Peripherals
Printers

Battery-Powered Equipment

Pin Configurations



SSOP

Pin Configurations continued at end of data sheet.

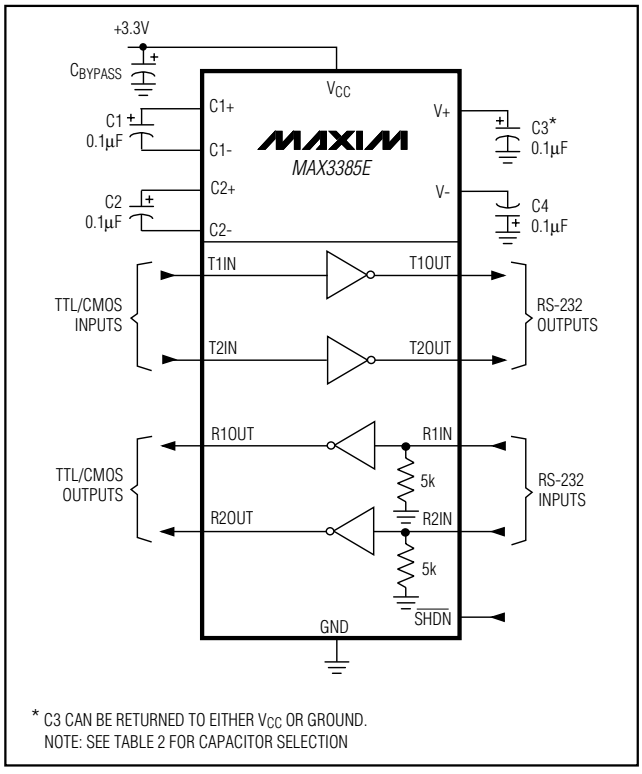
Features

- **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 with Receivers Active**
- **250kbps Guaranteed Data Rate**
- **250µs Time to Exit Shutdown with 3kΩ Load on V+**
- **6V/µs Guaranteed Slew Rate**
- **Meets EIA/TIA-232 Specifications Down to 3.0V**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX3385ECAP	0°C to +70°C	20 SSOP
MAX3385ECWN	0°C to +70°C	18 SO
MAX3385EEAP	-40°C to +85°C	20 SSOP

Typical Operating Circuit



* C3 CAN BE RETURNED TO EITHER V_{CC} OR GROUND.
NOTE: SEE TABLE 2 FOR CAPACITOR SELECTION

For free samples & the latest literature: http://www.maxim-ic.com, or phone 1-800-998-8800.
For small orders, phone 1-800-835-8769.

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

ABSOLUTE MAXIMUM RATINGS

V_{CC} to GND .....-0.3V to +6V
V+ to GND (Note 1) .....-0.3V to +7V
V- to GND (Note 1) .....+0.3V to -7V
V+ + |V-| (Note 1) .....+13V
Input Voltages
T_IN, $\overline{SHDN}$ to GND .....-0.3V to +6V
R_IN to GND .....±25V
Output Voltages
T_OUT to GND .....±13.2V
R_OUT .....-0.3V to (V_{CC} + 0.3V)
Short-Circuit Duration, T_OUT to GND .....Continuous

Continuous Power Dissipation (T_A = +70°C)
20-Pin SSOP (derate 8.00mW/°C above +70°C) 640mW
18-Pin SO (derate 9.52mW/°C above +70°C) 762mW
Operating Temperature Ranges
MAX3385ECAP .....0°C to +70°C
MAX3385ECWN .....0°C to +70°C
MAX3385EEAP .....-40°C to +85°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10sec) .....+300°C

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

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

ELECTRICAL CHARACTERISTICS

(V_{CC} = +3V to +5.5V, C1–C4 = 0.1µF, tested at 3.3V ±10%; C1 = 0.047µF, C2–C4 = 0.33µF, tested at 5.0V ±10%; T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
DC CHARACTERISTICS (V_{CC} = +3.3V or +5V, T_A = +25°C)						
Supply Current	$\overline{SHDN}$ = V_{CC}, no load			0.3	1	mA
Shutdown Supply Current	$\overline{SHDN}$ = GND			1	10	µA
LOGIC INPUTS						
Input Logic Threshold Low	T_IN, $\overline{SHDN}$				0.8	V
Input Logic Threshold High	T_IN, $\overline{SHDN}$	V_{CC} = 3.3V	2.0			V
		V_{CC} = 5.0V	2.4			
Transmitter Input Hysteresis				0.5		V
Input Leakage Current	T_IN, $\overline{SHDN}$			±0.01	±1	µA
RECEIVER OUTPUTS						
Output Leakage Current	R_OUT, receivers disabled			±0.05	±10	µA
Output Voltage Low	I_{OUT} = 1.6mA				0.4	V
Output Voltage High	I_{OUT} = -1.0mA		V_{CC} - 0.6	V_{CC} - 0.1		V
RECEIVER INPUTS						
Input Voltage Range			-25		+25	V
Input Threshold Low	T_A = +25°C	V_{CC} = 3.3V	0.6	1.2		V
		V_{CC} = 5.0V	0.8	1.5		
Input Threshold High	T_A = +25°C	V_{CC} = 3.3V		1.5	2.4	V
		V_{CC} = 5.0V		1.8	2.4	
Input Hysteresis				0.5		V
Input Resistance	T_A = +25°C		3	5	7	kΩ

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = +3V to +5.5V, C1–C4 = 0.1µF, tested at 3.3V ±10%; C1 = 0.047µF, C2–C4 = 0.33µF, tested at 5.0V ±10%; T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
TRANSMITTER OUTPUTS					
Output Voltage Swing	All transmitter outputs loaded with 3kΩ to ground	±5	±5.4		V
Output Resistance	V_{CC} = V+ = V- = 0, transmitter output = ±2V	300	10M		Ω
Output Short-Circuit Current				±60	mA
Output Leakage Current	V_{CC} = 0 or 3V to 5.5V, V_{OUT} = ±12V, transmitters disabled			±25	µA
ESD PROTECTION					
R_IN, T_OUT	Human Body Model		±15		kV
	IEC1000-4-2 Air Discharge		±15		
	IEC1000-4-2 Contact Discharge		±8		

TIMING CHARACTERISTICS

(V_{CC} = +3V to +5.5V, C1–C4 = 0.1µF, tested at 3.3V ±10%; C1 = 0.047µF, C2–C4 = 0.33µF, tested at 5.0V ±10%; T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Maximum Data Rate		R_L = 3kΩ, C_L = 1000pF, one transmitter switching		250			kbps
Receiver Propagation Delay	t_{PHL}	Receiver input to receiver output, C_L = 150pF			0.15		µs
	t_{PLH}				0.15		
Time to Exit Shutdown		V_{OUT} ≥ +3.7V, R_{LOAD} at V+ = 3kΩ			250		µs
Transmitter Skew	$\lvert t_{PHL} - t_{PLH} \rvert$	(Note 2)			100		ns
Receiver Skew	$\lvert t_{PHL} - t_{PLH} \rvert$				50		ns
Transition-Region Slew Rate		V_{CC} = 3.3V, T_A = +25°C, R_L = 3kΩ to 7kΩ, measured from +3V to -3V or -3V to +3V	C_L = 150pF to 1000pF	6		30	V/µs
			C_L = 150pF to 2500pF	4		30	

Note 2: Transmitter skew is measured at the transmitter zero cross points.

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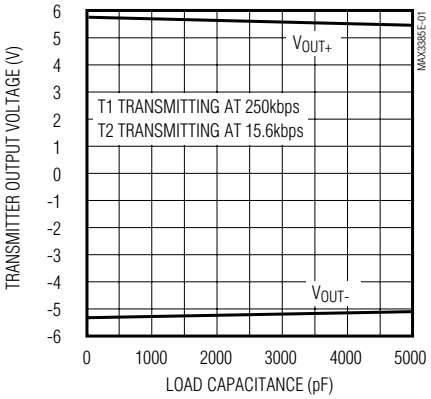
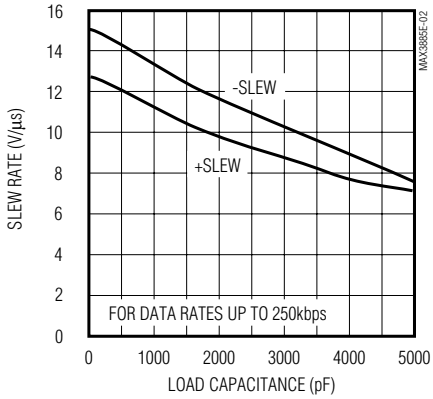
Typical Operating Characteristics

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

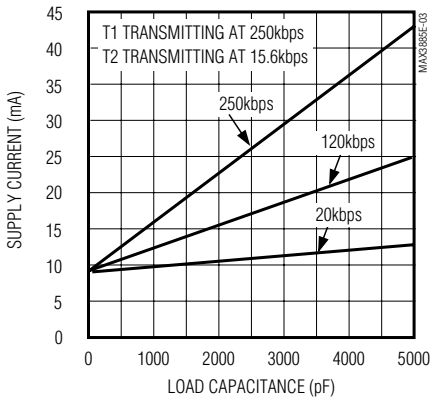
TRANSMITTER OUTPUT VOLTAGE vs. LOAD CAPACITANCE



SLEW RATE vs. LOAD CAPACITANCE



OPERATING SUPPLY CURRENT vs. LOAD CAPACITANCE



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
9, 14	9, 16	R_IN	RS-232 Receiver Inputs
10, 13	12, 15	R_OUT	TTL/CMOS Receiver Outputs
11, 12	13, 14	T_IN	TTL/CMOS Transmitter Inputs
16	18	GND	Ground
17	19	V_{CC}	+3.0V to +5.5V Supply Voltage
18	20	$\overline{SHDN}$	Active-Low Shutdown-Control Input. Drive low to shut down transmitters and charge

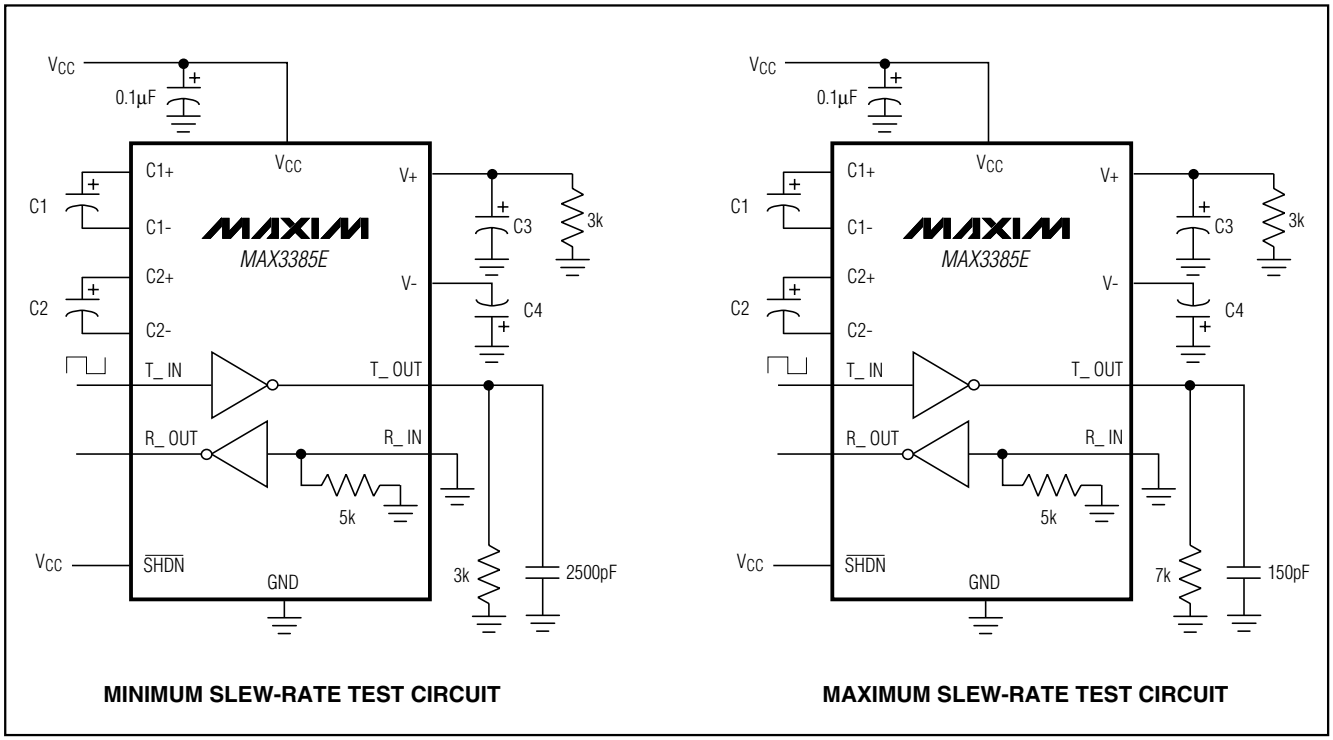


Figure 1. Slew-Rate Test Circuits

Detailed Description

Dual Charge-Pump Voltage Converter

The MAX3385E'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_{CC} 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 MAX3385E 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 MAX3385E's transmitters are disabled and the outputs are forced into a high-impedance state when the device is in shutdown ($\overline{SHDN}$ = GND). The MAX3385E permits the outputs to be driven up to ±12V in shutdown.

The transmitter inputs do not have pull-up resistors. Connect unused inputs to GND or V_{CC}.

RS-232 Receivers

The receivers convert RS-232 signals to CMOS-logic output levels (Table 1).

Shutdown Mode

Supply current falls to less than 1µA in shutdown mode ($\overline{SHDN}$ = low). 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 exit shut-

Table 1. Shutdown Truth Table

$\overline{SHDN}$	T_OUT	R_OUT
0	High-Z	Active
1	Active	Active

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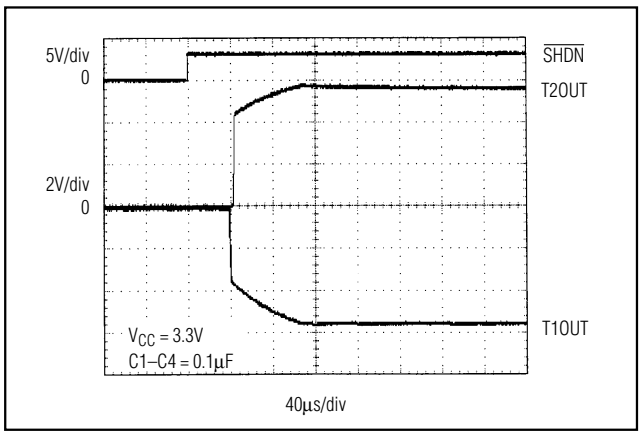


Figure 2. Transmitter Outputs Exiting Shutdown or Powering Up

down is typically 100µs, as shown in Figure 2. Connect $\overline{SHDN}$ to V_{CC} 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 MAX3385E 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 MAX3385E 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 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 val-

Table 2. Required Minimum Capacitance Values

V_{CC} (V)	C1, C_{BYPASS} (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

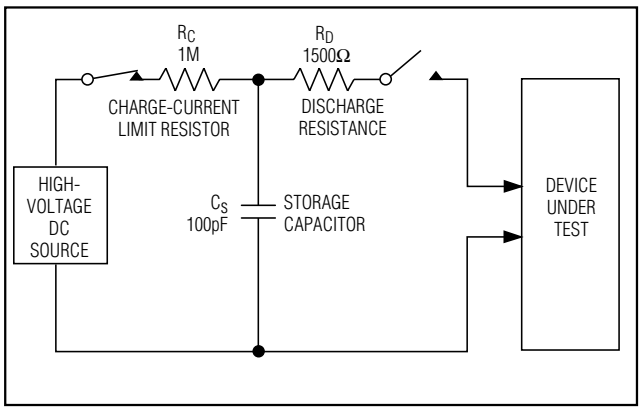


Figure 3a. Human Body ESD Test Model

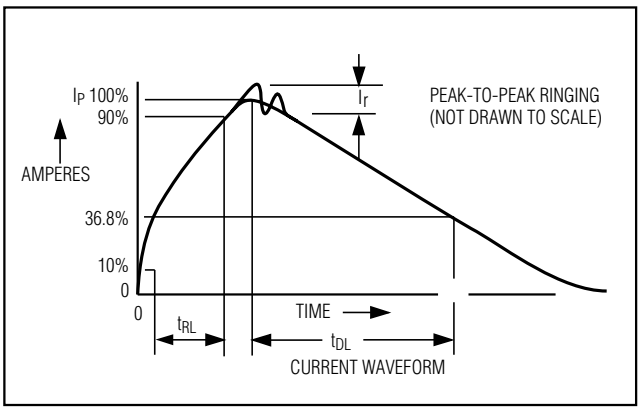


Figure 3b. Human Body Model Current Waveform

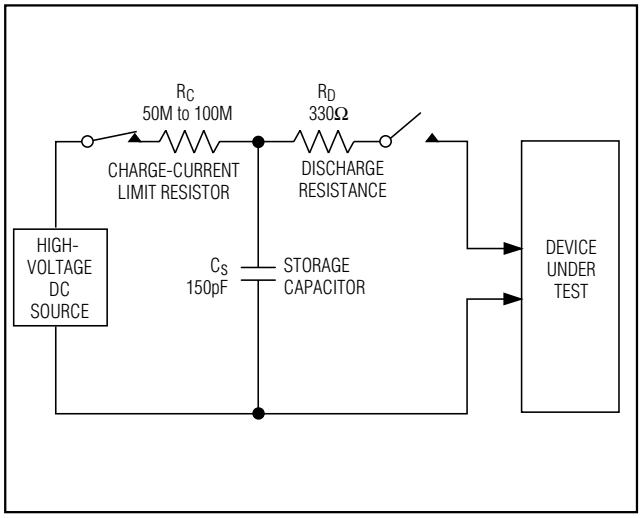


Figure 4a. IEC 1000-4-2 ESD Test Model

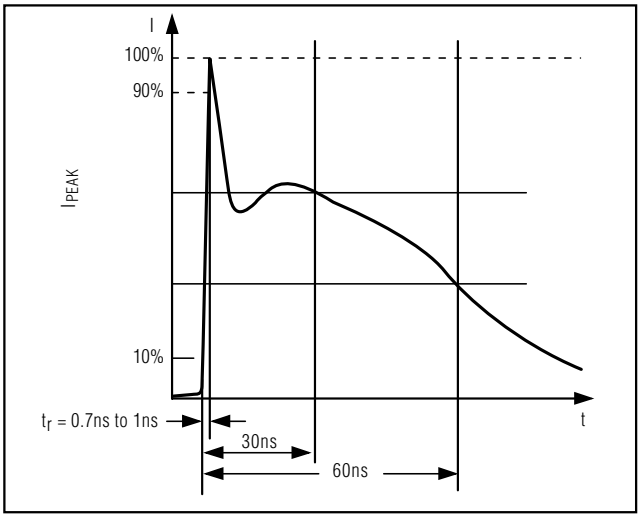


Figure 4b. IEC 10000-4-2 ESD Generator Current Waveform

ues 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 C_{BYPASS} 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_{CC} 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.

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 lev-

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

els (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.

High Data Rates

The MAX3385E 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.

Interconnection with 3V and 5V Logic

The MAX3385E can directly interface with various 5V logic families, including ACT and HCT CMOS. See Table 3 for more information on possible combinations of interconnections.

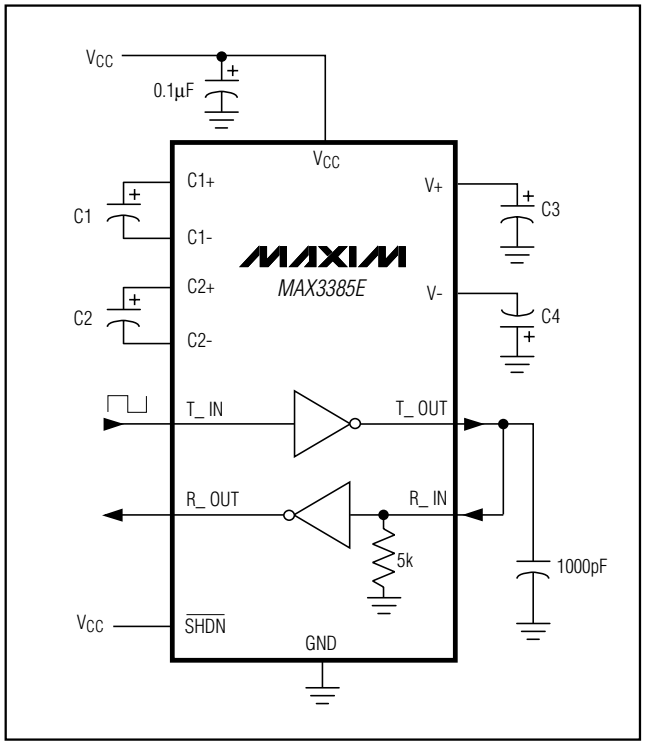


Figure 6. Loopback Test Circuit

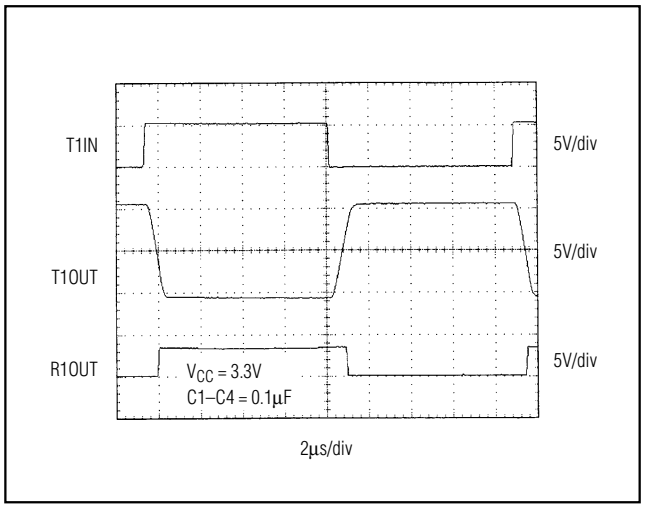


Figure 7. MAX3385E Loopback Test Result at 120kbps

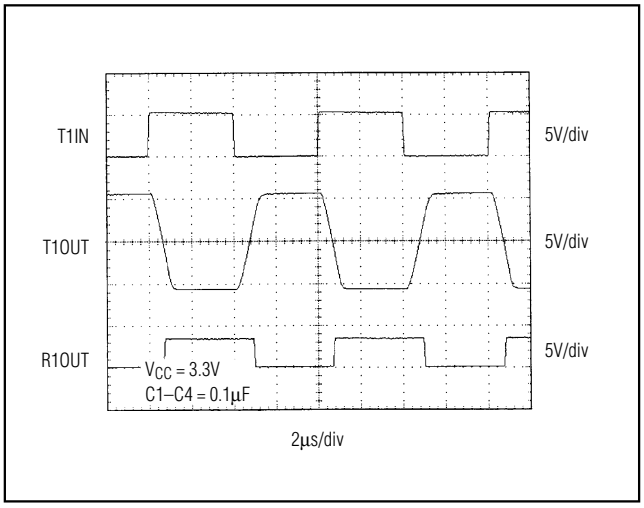
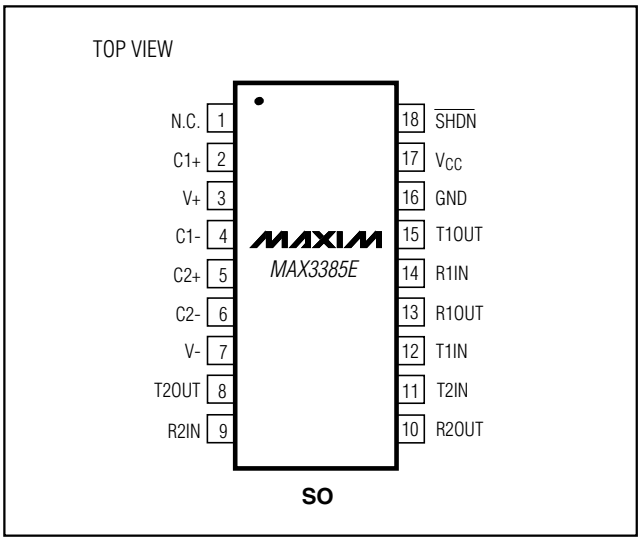


Figure 8. MAX3385E Loopback Test Result at 250kbps

Table 3. Logic-Family Compatibility with Various Supply Voltages

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

Pin Configurations (continued)



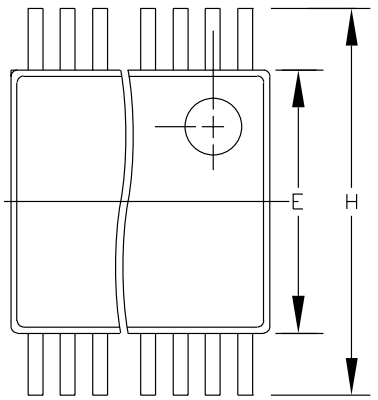
Chip Information

TRANSISTOR COUNT: 1129

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

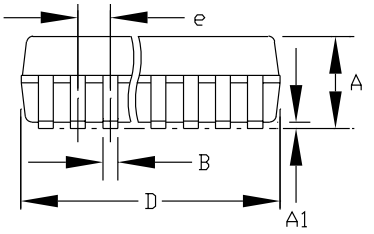
Package Information

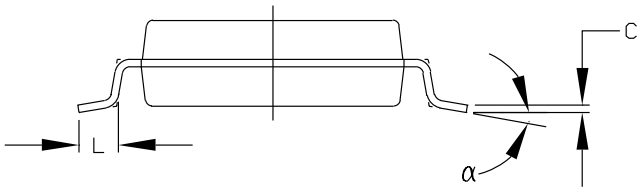
SSOP.EPS



	INCHES		MILLIMETERS	
DIM	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

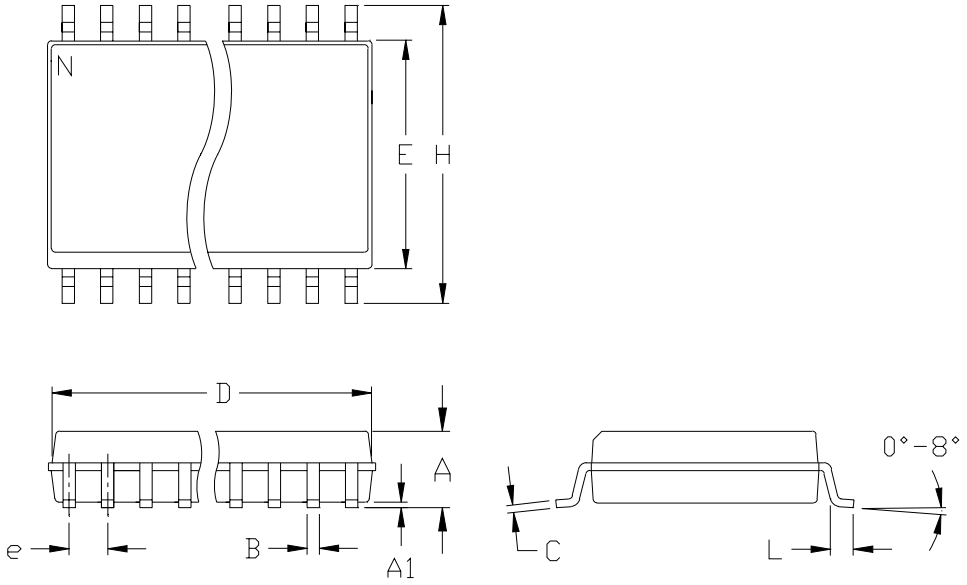
MAXIM
PROPRIETARY INFORMATION

TITLE:
PACKAGE OUTLINE, SSOP, 5.3X.65mm

APPROVAL	DOCUMENT CONTROL NO.	REV	
	21-0056	A	1/1

Package Information (continued)

SOICW.EPS



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

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

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
3. LEADS TO BE COPLANAR WITHIN .102mm (.004")
4. CONTROLLING DIMENSION: MILLIMETER
5. MEETS JEDEC MS013-XX AS SHOWN IN ABOVE TABLE
6. N = NUMBER OF PINS

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

PACKAGE FAMILY OUTLINE: SOIC .300"
TITLE

1/1

21-0042 A
DOCUMENT CONTROL NUMBER REV

NOTES

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