19-1298; Rev 3a; 1/00

MAXIM

±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
Battery-Powered Equipment
Cell-Phone Data Cables
Smart Phones
XDSL Modems
Printers
Cell Phones

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.

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.

For free samples and the latest literature, visit www.maxim-ic.com or phone 1-800-998-8800. For small orders, phone 1-800-835-8769.

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

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, $\overline{EN}$, $\overline{SHDN}$, MBAUD to GND .....-0.3V to +6V
R_IN to GND .....±25V
Output Voltages
T_OUT to GND.....±13.2V
R_OUT, R_OUTB (MAX3241E).....-0.3V to (V_{CC} + 0.3V)
Short-Circuit Duration, T_OUT to GND.....Continuous
Continuous Power Dissipation (T_A = +70°C)
16-Pin SSOP (derate 7.14mW/°C above +70°C) 571mW
16-Pin Wide SO (derate 9.52mW/°C above +70°C) 762mW
18-Pin Wide SO (derate 9.52mW/°C above +70°C) 762mW
18-Pin PDIP (derate 11.11mW/°C above +70°C).....889mW
20-Pin TSSOP (derate 7.0mW/°C above +70°C) 559mW
20-Pin SSOP (derate 8.00mW/°C above +70°C) 640mW
28-Pin SSOP (derate 9.52mW/°C above +70°C) 762mW
28-Pin Wide SO (derate 12.50mW/°C above +70°C).....1W
Operating Temperature Ranges
MAX32_ _EC_ _ .....0°C to +70°C
MAX32_ _EE_ _.....-40°C to +85°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10s) .....+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} = +3.0V to +5.5V, C1–C4 = 0.1µF, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
DC CHARACTERISTICS (V_{CC} = +3.3V or +5.0V, T_A = +25°C)						
Supply Current	$\overline{SHDN}$ = V_{CC}, no load	MAX3222E, MAX3232E, MAX3241E		0.3	1	mA
		MAX3237E		0.5	2.0	
Shutdown Supply Current	$\overline{SHDN}$ = GND			1	10	µA
	$\overline{SHDN}$ = R_IN = GND, T_IN = GND or V_{CC} (MAX3237E)			10	300	nA
LOGIC INPUTS						
Input Logic Low	T_IN, $\overline{EN}$, $\overline{SHDN}$, MBAUD				0.8	V
Input Logic High	T_IN, $\overline{EN}$, $\overline{SHDN}$, MBAUD	V_{CC} = 3.3V	2.0			V
		V_{CC} = 5.0V	2.4			
Transmitter Input Hysteresis				0.5		V
Input Leakage Current	T_IN, $\overline{EN}$, $\overline{SHDN}$	MAX3222E, MAX3232E, MAX3241E		±0.01	±1	µA
	T_IN, $\overline{SHDN}$, MBAUD	MAX3237E (Note 3)		9	18	
RECEIVER OUTPUTS						
Output Leakage Current	R_OUT (MAX3222E/MAX3237E/MAX3241E), $\overline{EN}$ = V_{CC}, receivers disabled			±0.05	±10	µA
Output Voltage Low	I_{OUT} = 1.6mA (MAX3222E/MAX3232E/MAX3241E)				0.4	V
	I_{OUT} = 1.0mA (MAX3237E)				0.4	
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	1.1		V
		V_{CC} = 5.0V	0.8	1.5		

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = +3.0V to +5.5V, C1–C4 = 0.1µF, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
RECEIVER INPUTS						
Input Threshold High	T_A = +25°C	V_{CC} = 3.3V		1.5	2.4	V
		V_{CC} = 5.0V		2.0	2.4	
Input Hysteresis				0.5		V
Input Resistance	T_A = +25°C		3	5	7	kΩ
TRANSMITTER OUTPUTS						
Output Voltage Swing	All transmitter outputs loaded with 3kΩ to ground		±5	±5.4		V
Output Resistance	V_{CC} = 0, transmitter output = ±2V		300	50k		Ω
Output Short-Circuit Current					±60	mA
Output Leakage Current	V_{CC} = 0 or 3V to 5.5V, V_{OUT} = ±12V, transmitters disabled (MAX3222E/MAX3232E/MAX3241E)				±25	µA
MOUSE DRIVEABILITY (MAX3241E)						
Transmitter Output Voltage	T1IN = T2IN = GND, T3IN = V_{CC}, T3OUT loaded with 3kΩ to GND, T1OUT and T2OUT loaded with 2.5mA each		±5			V
ESD PROTECTION						
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, $\overline{EN}$, $\overline{SHDN}$, 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_{CC} = +3.0V to +5.5V, C1–C4 = 0.1µF, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

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		
Receiver Output Enable Time		Normal operation (except MAX3232E)			200		ns
Receiver Output Disable Time		Normal operation (except MAX3232E)			200		ns
Transmitter Skew	$\lvert t_{PHL} - t_{PLH} \rvert$	(Note 4)			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: MAX3222E/MAX3232E/MAX3241E: C1–C4 = 0.1µF tested at 3.3V ±10%; C1 = 0.047µF, C2–C4 = 0.33µF tested at 5.0V ±10%. MAX3237E: C1–C4 = 0.1µF, tested at 3.3V ±5%; C1–C4 = 0.22µF tested at 3.3V ±10%; C1 = 0.047µF, C2–C4 = 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.

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

TIMING CHARACTERISTICS—MAX3237E

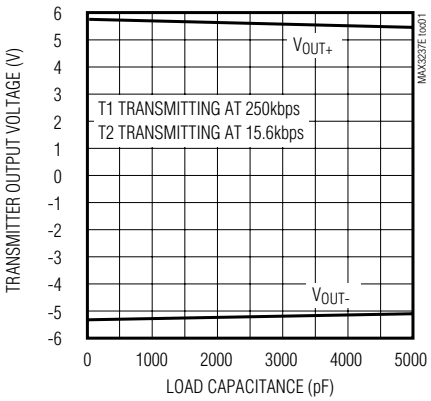
(V_{CC} = +3.0V to +5.5V, C1–C4 = 0.1µF, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	CONDITIONS			MIN	TYP	MAX	UNITS
Maximum Data Rate	R_L = 3kΩ, C_L = 1000pF, one transmitter switching, MBAUD = GND			250			kbps
	V_{CC} = 3.0V to 4.5V, R_L = 3kΩ, C_L = 250pF, one transmitter switching, MBAUD = V_{CC}			1000			
	V_{CC} = 4.5V to 5.5V, R_L = 3kΩ, C_L = 1000pF, one transmitter switching, MBAUD = V_{CC}			1000			
Receiver Propagation Delay	R_IN to R_OUT, C_L = 150pF		t_{PHL}		0.15		µs
			t_{PLH}		0.15		
Receiver Output Enable Time	Normal operation				2.6		µs
Receiver Output Disable Time	Normal operation				2.4		µs
Transmitter Skew	$\lvert t_{PHL} - t_{PLH} \rvert$, MBAUD = GND				100		ns
	$\lvert t_{PHL} - t_{PLH} \rvert$, MBAUD = V_{CC}				100		ns
Receiver Skew	$\lvert t_{PHL} - t_{PLH} \rvert$				50		ns
Transition-Region Slew Rate	V_{CC} = 3.3V, R_L = 3kΩ to 7kΩ, +3V to -3V or -3V to +3V, T_A = +25°C	C_L = 150pF to 1000pF	MBAUD = GND	6		30	V/µs
			MBAUD = V_{CC}	24		150	
		C_L = 150pF to 2500pF, MBAUD = GND		4		30	

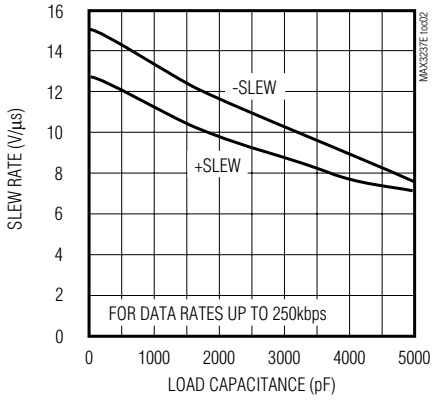
Typical Operating Characteristics

(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.)

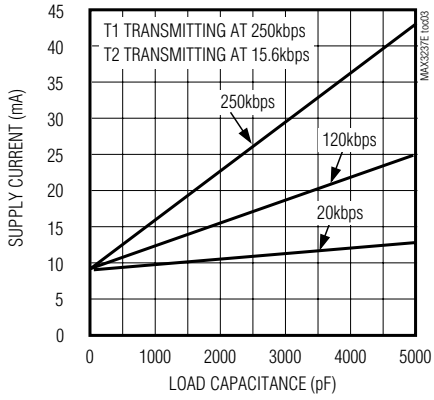
MAX3222E/MAX3232E TRANSMITTER OUTPUT VOLTAGE vs. LOAD CAPACITANCE



MAX3222E/MAX3232E SLEW RATE vs. LOAD CAPACITANCE



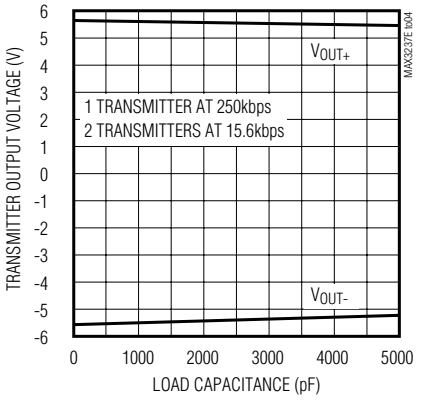
MAX3222E/MAX3232E OPERATING SUPPLY CURRENT vs. LOAD CAPACITANCE



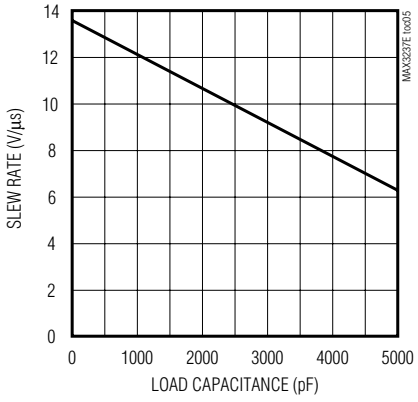
Typical Operating Characteristics (continued)

(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.)

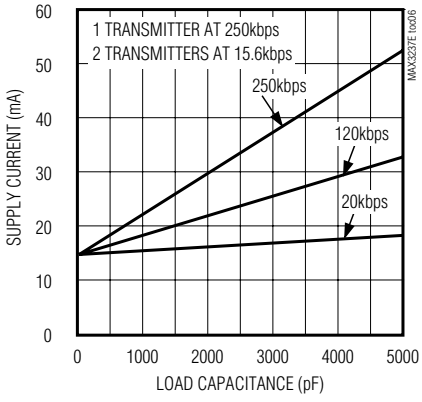
MAX3241E
TRANSMITTER OUTPUT VOLTAGE vs. LOAD CAPACITANCE



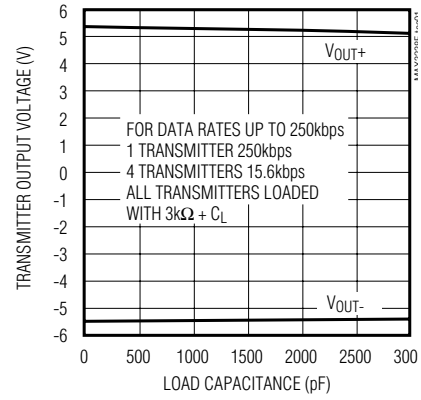
MAX3241E
SLEW RATE vs. LOAD CAPACITANCE



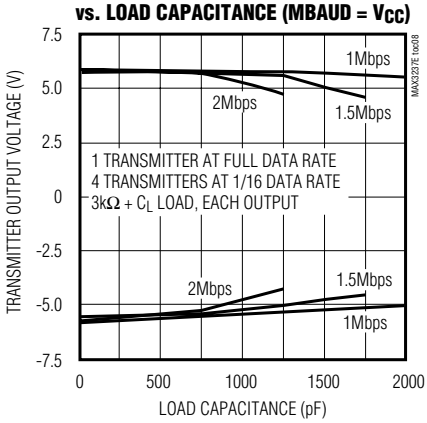
MAX3241E
OPERATING SUPPLY CURRENT vs. LOAD CAPACITANCE



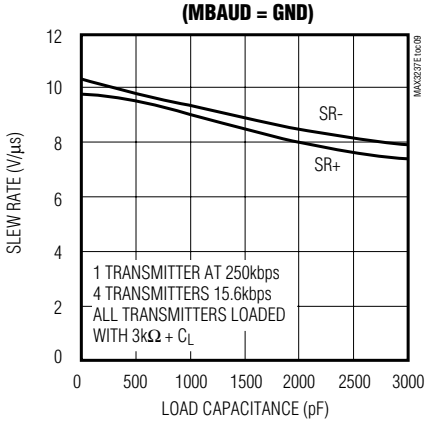
TRANSMITTER OUTPUT VOLTAGE vs. LOAD CAPACITANCE



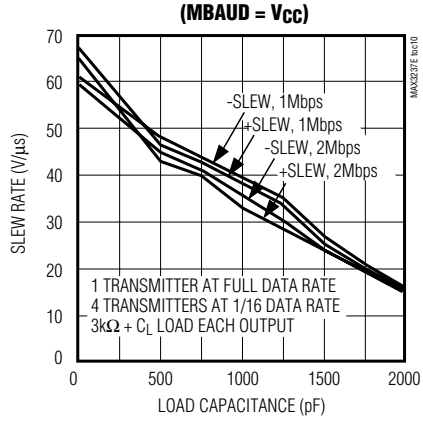
MAX3237E
TRANSMITTER OUTPUT VOLTAGE vs. LOAD CAPACITANCE (MBAUD = VCC)



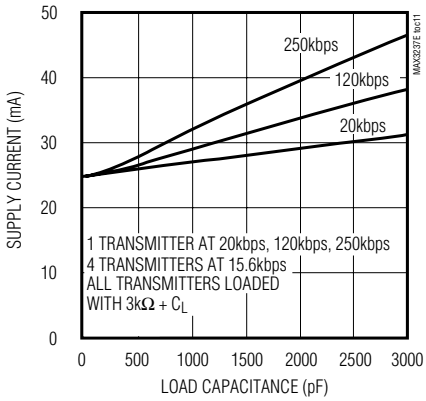
MAX3237E
SLEW RATE vs. LOAD CAPACITANCE (MBAUD = GND)



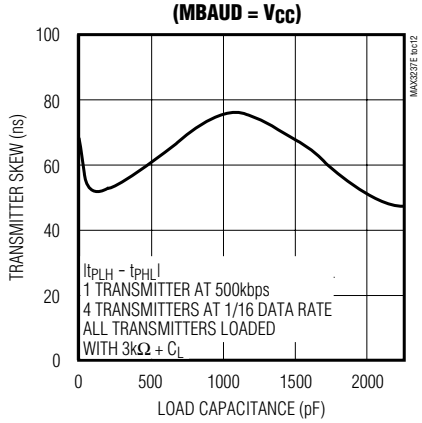
MAX3237E
SLEW RATE vs. LOAD CAPACITANCE (MBAUD = VCC)



MAX3237E
SUPPLY CURRENT vs. LOAD CAPACITANCE WHEN TRANSMITTING DATA (MBAUD = GND)



MAX3237E
TRANSMITTER SKEW vs. LOAD CAPACITANCE (MBAUD = VCC)

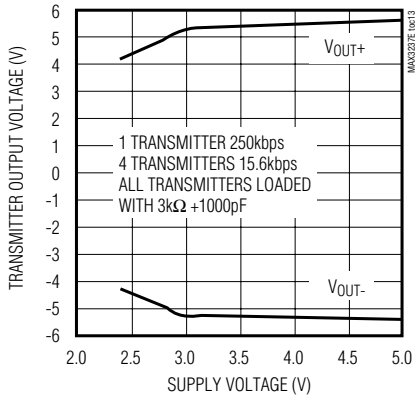


±15kV ESD-Protected, Down to 10nA, 3.0V to 5.5V, Up to 1Mbps, True RS-232 Transceivers

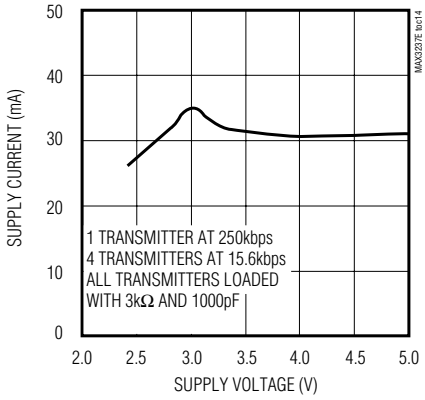
Typical Operating Characteristics (continued)

(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.)

MAX3237E
TRANSMITTER OUTPUT VOLTAGE vs.
SUPPLY VOLTAGE (MBAUD = GND)



MAX3237E
SUPPLY CURRENT vs.
SUPPLY VOLTAGE (MBAUD = GND)



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

Pin Description (continued)

PIN						NAME	FUNCTION
MAX3222E		MAX3232E		MAX3237E	MAX3241E		
SO/DIP	TSSOP/ SSOP	SO/DIP	TSSOP/ SSOP				
17	19	16	19	26	26	V_{CC}	+3.0V to +5.5V Supply Voltage
18	20	—	—	14*	22	$\overline{SHDN}$	Shutdown Control. Active low.
—	11, 14	—	1, 10, 11, 20	—	—	N.C.	No Connection
—	—	—	—	15*	—	MBAUD	MegaBaud Control Input. Connect to GND for normal operation; connect to V_{CC} 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_{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 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-impedance state when the device is in shutdown mode ($\overline{SHDN}$ = 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 VCC. 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_{CC}), the MAX3237E transmitters guarantee a 1Mbps data rate with worst-case loads of 3kΩ in parallel with 250pF for 3.0V < V_{CC} < 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 $\overline{EN}$ high to place the receiver(s) into a high-impedance state. Receivers can be either active or inactive in shutdown (Table 1).

LapLink is a trademark of Traveling Software.

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

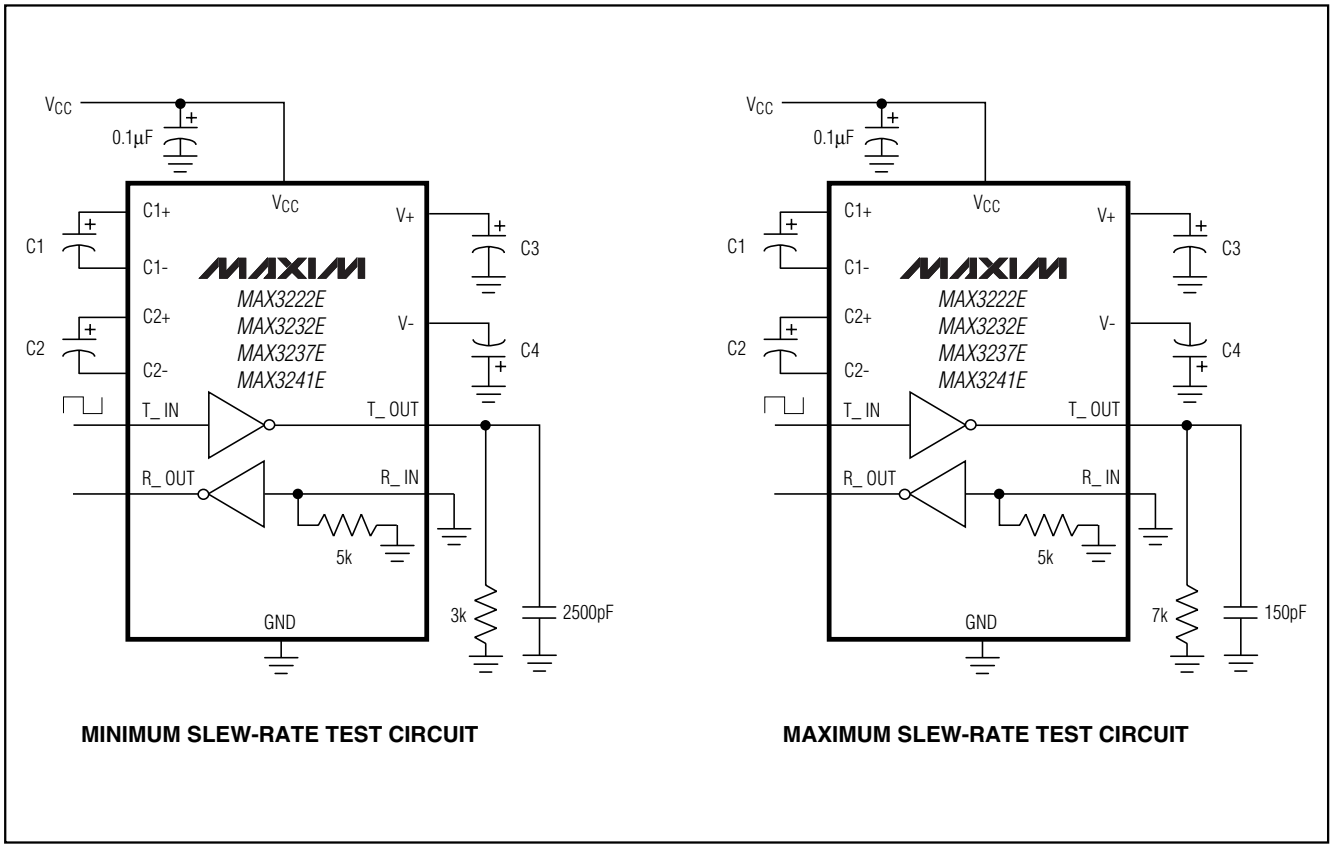


Figure 1. Slew-Rate Test Circuits

The complementary outputs on the MAX3237E/MAX3241E (R_OUTB) are always active, regardless of the state of $\overline{EN}$ or $\overline{SHDN}$. 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 ($\overline{SHDN}$ = low). The MAX3237E's supply current falls to 10nA (typ) when all receiver inputs are in the invalid range (-0.3V < R_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 $\overline{SHDN}$ to V_{CC} if the shutdown mode is not used. $\overline{SHDN}$ 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

$\overline{SHDN}$	$\overline{EN}$	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

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.

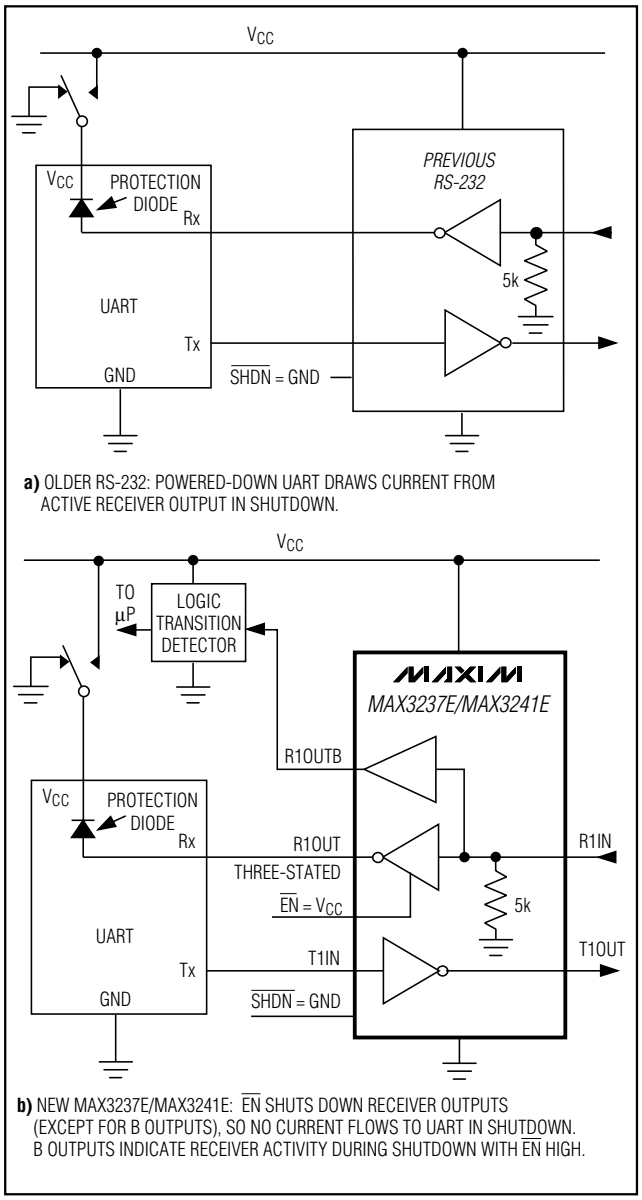


Figure 2. Detection of RS-232 Activity when the UART and Interface are Shut Down; Comparison of MAX3237E/ MAX3241E (b) with Previous Transceivers (a)

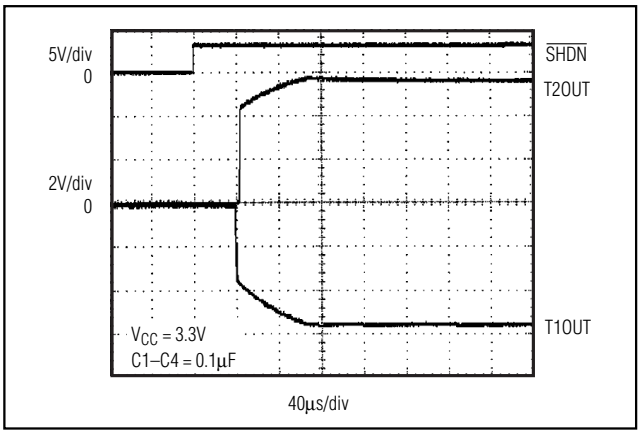


Figure 3. Transmitter Outputs Recovering from Shutdown or Powering Up

±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.

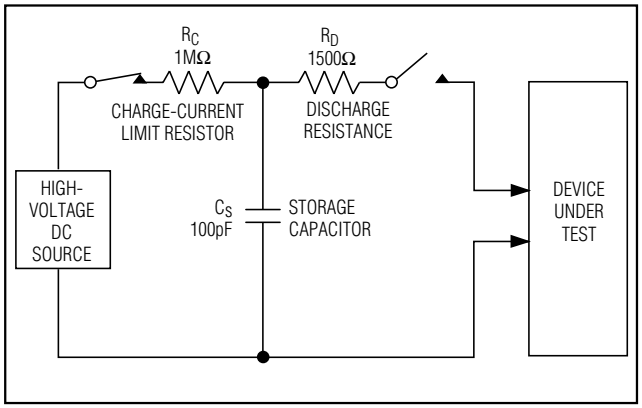


Figure 4a. Human Body ESD Test Model

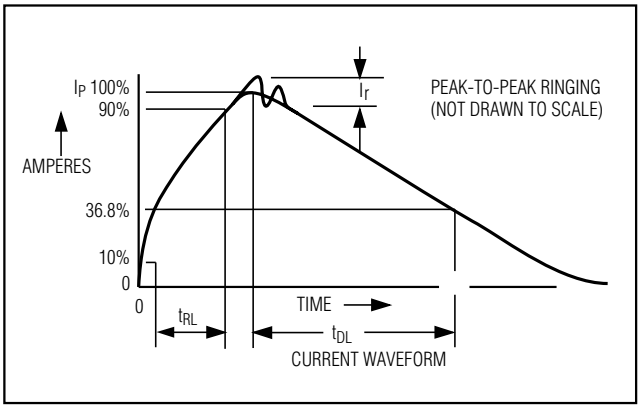


Figure 4b. Human Body Model Current Waveform

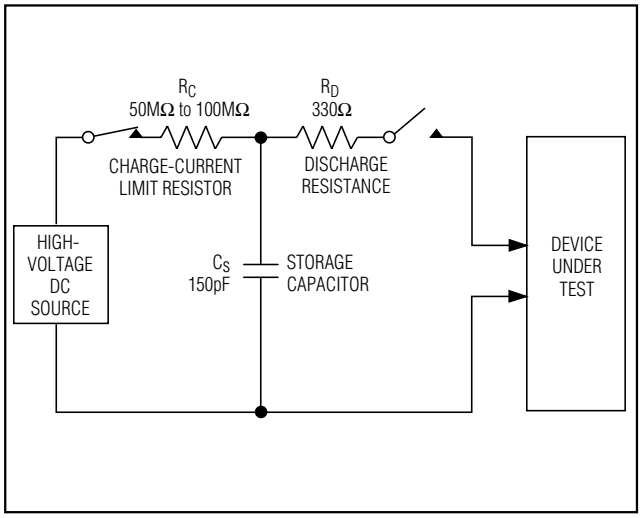


Figure 5a. IEC 1000-4-2 ESD Test Model

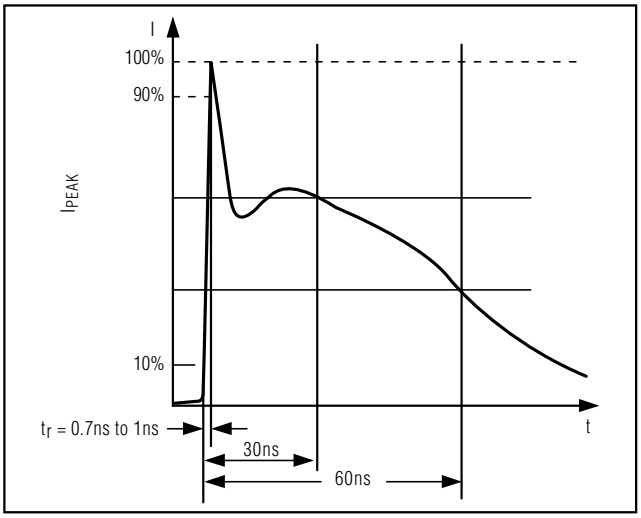


Figure 5b. IEC 1000-4-2 ESD Generator Current Waveform

Table 2. Required Minimum Capacitor Values

V_{CC} (V)	C1 (µF)	C2, C3, C4 (µF)
MAX3222E/MAX3232E/MAX3241E		
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
MAX3237E		
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 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.

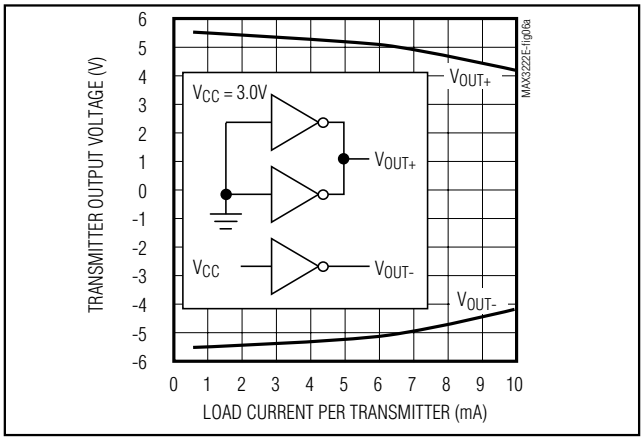


Figure 6a. MAX3241E Transmitter Output Voltage vs. Load Current per Transmitter

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.

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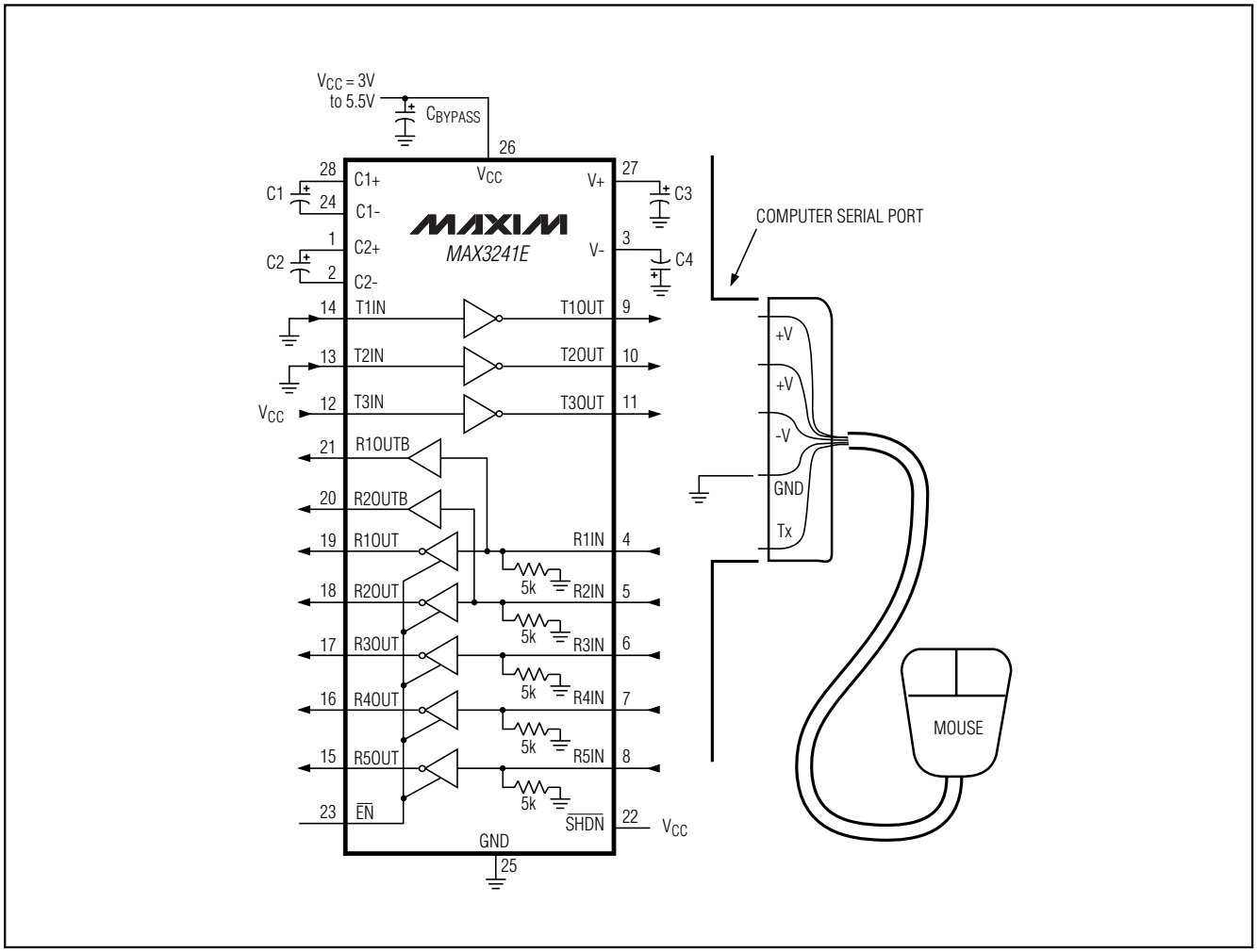

Figure 6b. Mouse Driver Test Circuit

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 = V_{CC}. 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.

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

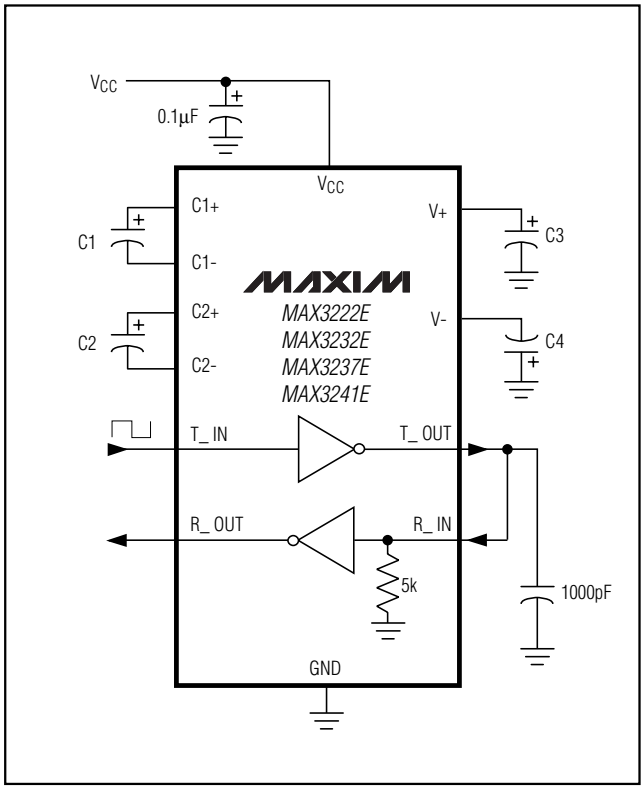

Figure 7. Loopback Test Circuit

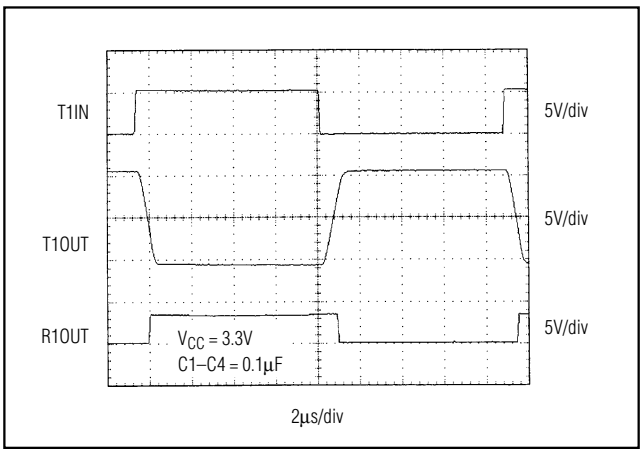

Figure 8. MAX3241E Loopback Test Result at 120kbps

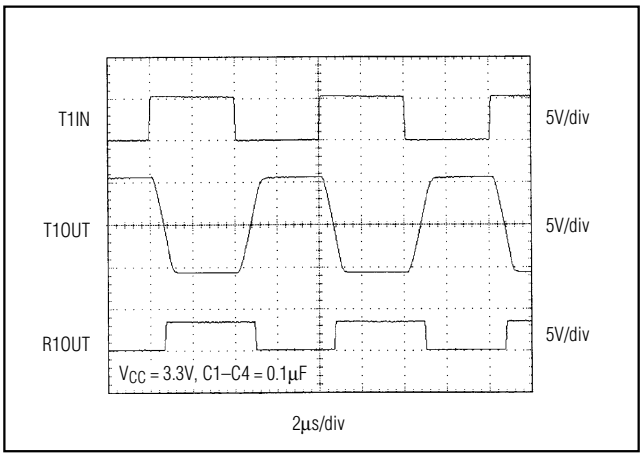

Figure 9. MAX3241E Loopback Test Result at 250kbps

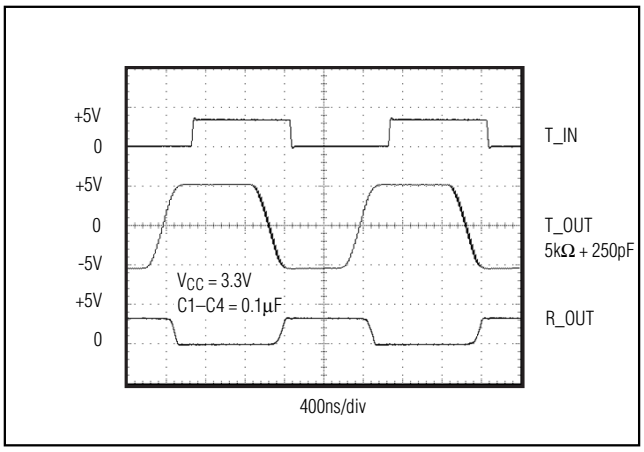

Figure 10. MAX3237E Loopback Test Result at 1000kbps (MBAUD = V_{CC})

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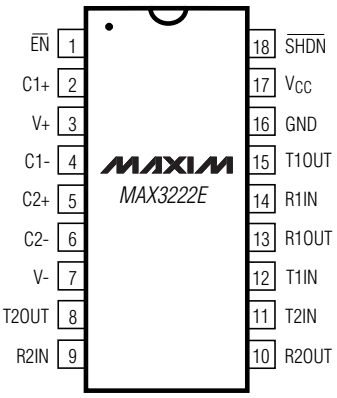
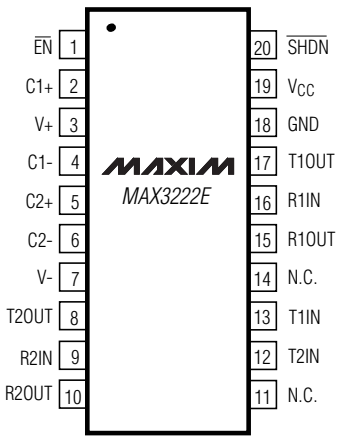
Pin Configurations

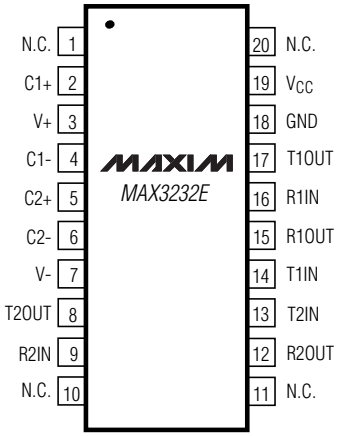
TOP VIEW



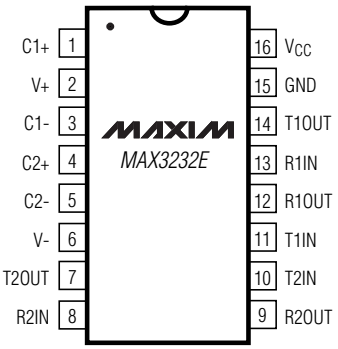
SO/DIP



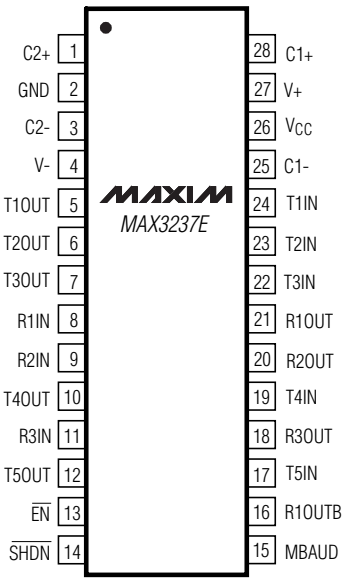
TSSOP/SSOP



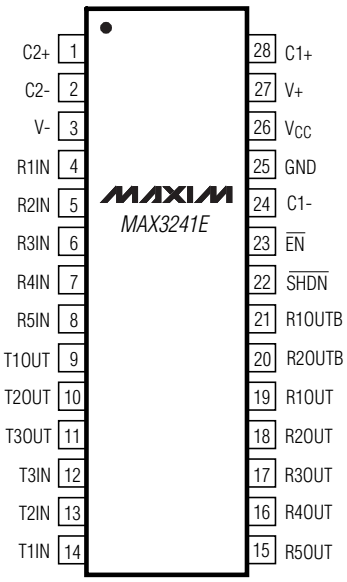
TSSOP



SSOP/SO/DIP

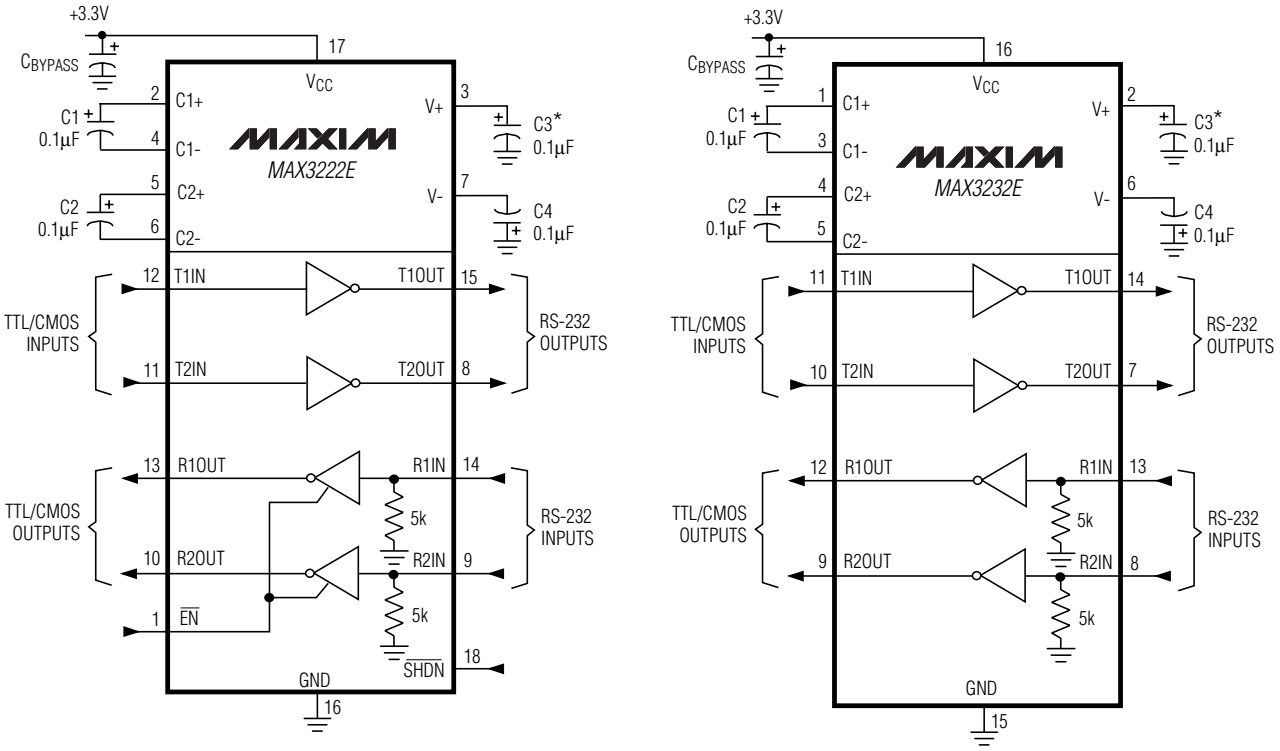


SSOP



SSOP/SO

Typical Operating Circuits



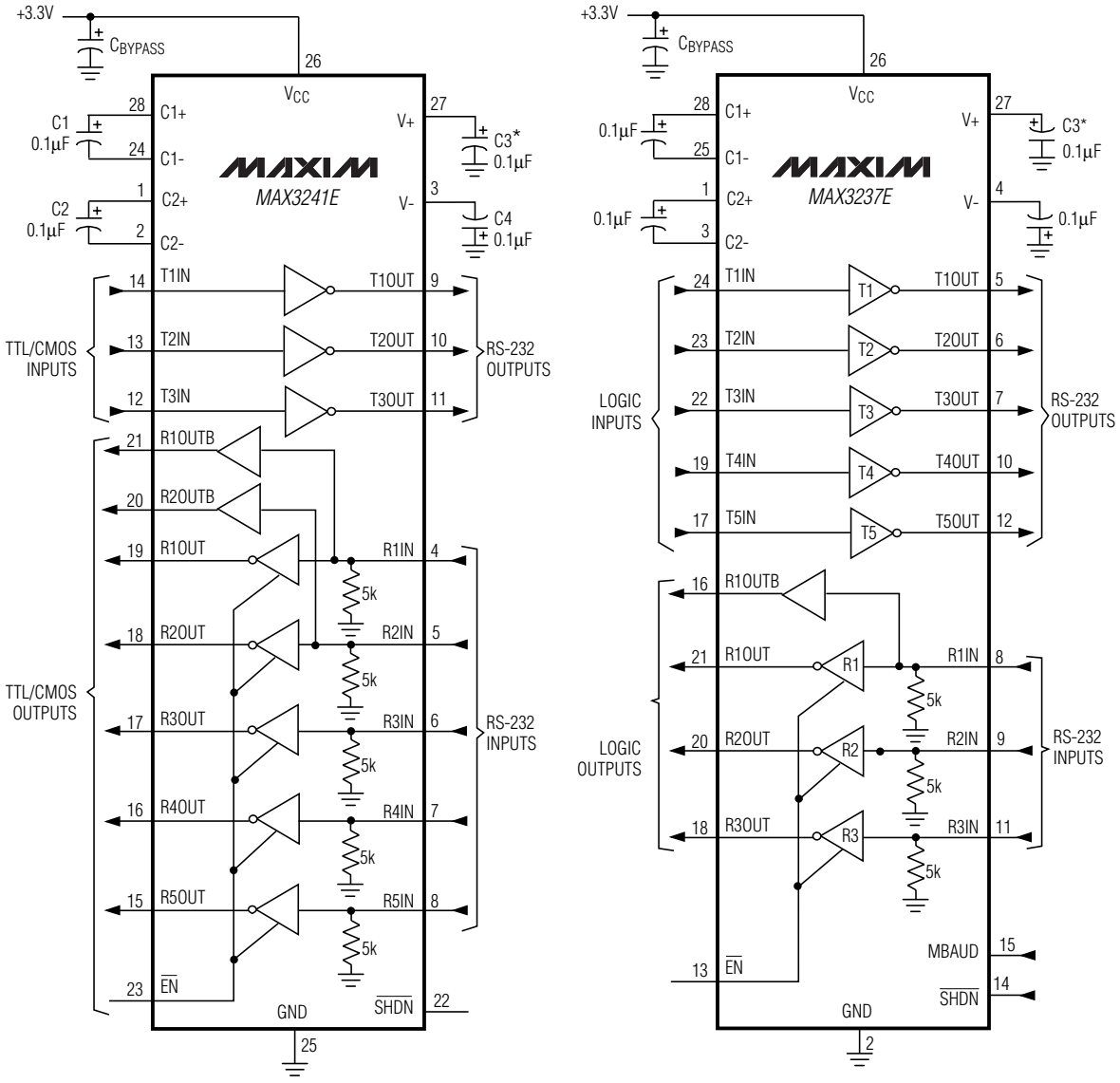
*C3 CAN BE RETURNED TO EITHER V_{CC} OR GROUND.

NOTE: PIN NUMBERS REFER TO SO/DIP PACKAGES.

SEE TABLE 2 FOR CAPACITOR SELECTION.

±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_{CC} OR GROUND.

Ordering Information (continued)

PART	TEMP. RANGE	PIN-PACKAGE
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
MAX3232ECUP	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
MAX3237ECAI	-0°C to +70°C	28 SSOP
MAX3237EEAI	-40°C to +85°C	28 SSOP
MAX3241ECAI	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°C, DC parameters only.*

Chip Information

TRANSISTOR COUNTS:

MAX3222E/MAX3232E: 1129

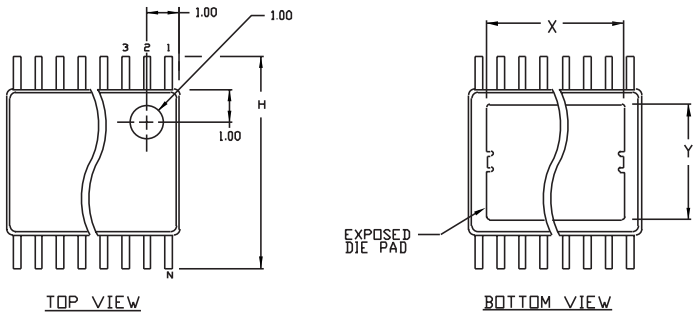
MAX3237E: 2110

MAX3241E: 1335

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

Package Information

TSSOP.EPS



SYMBOL	COMMON DIMENSIONS			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	———	1.10		.043
A_1	0.05	0.15	.002	.006
A_2	0.85	0.95	.033	.037
b	0.19	0.30	.007	.012
b1	0.19	0.25	.007	.010
c	0.090	0.20	.0035	.008
c1	0.090	0.135	.0035	.0053
D	SEE VARIATIONS		SEE VARIATIONS	
E	4.30	4.50	.169	.177
e	0.65 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
α	0°	8°	0°	8°

JEDEC			VARIATIONS			
MO-153	N		MILLIMETERS		INCHES	
			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 MO-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".

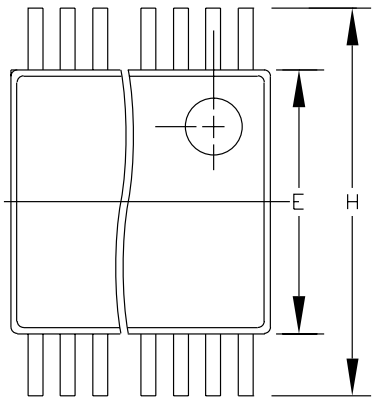
MAXIM
PROPRIETARY INFORMATION

TITLE:
PACKAGE OUTLINE, TSSOP, 4.40mm BODY, 0.65mm PITCH

APPROVAL	DOCUMENT CONTROL NO.	REV	
	21-0066	C	1/1

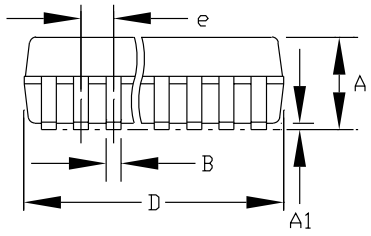
Package Information (continued)

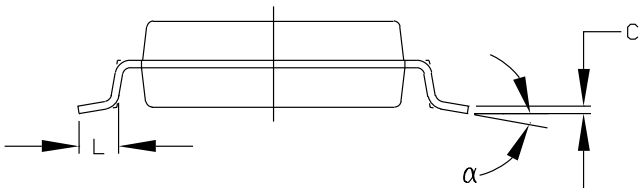
SSOP.EPS



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS 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 MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS 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

NOTES

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