19-0273; Rev 3; 1/95

MAXIM

3.0V to 5.5V, 300µA Supply Current, True RS-232 Transceivers using Four 0.1µF External Capacitors

General Description

The MAX3222/MAX3232/MAX3241 have a proprietary low-dropout transmitter output stage enabling true RS-232 performance from 3.0V to 5.5V supplies with a dual charge pump. The devices require only four small 0.1µF external capacitors and are guaranteed to run at data rates of 120kbps while maintaining RS-232 output levels.

These devices are ideal for 3.3V-only systems, mixed 3.3V and 5V systems, or 5V-only systems that require true RS-232 performance.

The MAX3222/MAX3232 have two receivers and two drivers. The MAX3222 has a 1µA shutdown mode that reduces power consumption and extends battery life in portable systems. Its receivers remain active in shutdown mode, allowing external devices such as modems to be monitored using only 1µA supply current. The MAX3222 is pin, package, and functionally compatible with the industry-standard MAX242, and the MAX3232 with the industry-standard MAX232.

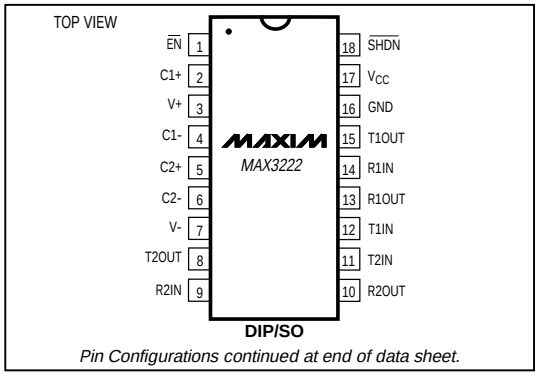
The MAX3241 is a complete serial port (3 drivers/5 receivers) designed for notebook and subnotebook computers. In shutdown, all 5 receivers can remain active while using only 1µA supply current. Receivers R1 and R2 have two extra outputs in addition to their standard outputs. These extra outputs are always active, allowing external devices such as a modem to be monitored without forward biasing the protection diodes in circuitry that may have V_{CC} completely removed.

The MAX3222 and MAX3241 are available in space-saving SSOP packages.

Applications

Notebook, Subnotebook, and Palmtop Computers
Battery-Powered Equipment
Hand-Held Equipment
Peripherals
Printers

Pin Configurations



Pin Configurations continued at end of data sheet.

Features

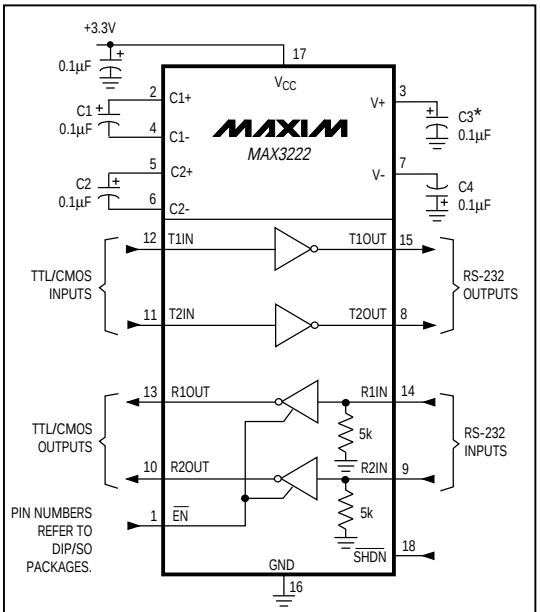
- ♦ **Low 300µA Supply Current**
- ♦ **Guaranteed 120kbps Data Rate**
- ♦ **1µA Low-Power Shutdown with Receivers Active (MAX3222/MAX3241)**
- ♦ **Flow-Through Pinout (MAX3241)**
- ♦ **Meets EIA/TIA-232 Specifications Down to 3.0V**
- ♦ **Guaranteed Mouse Driveability (MAX3241)**
- ♦ **Pin Compatible with Industry-Standard MAX232 (MAX3232)**
  Pin Compatible with Industry-Standard MAX242 (MAX3222)
- ♦ **6V/µs Guaranteed Slew Rate**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX3222CPN	0°C to +70°C	18 Plastic DIP
MAX3222CWN	0°C to +70°C	18 Wide SO
MAX3222CAP	0°C to +70°C	20 SSOP

Ordering Information continued at end of data sheet.

Typical Operating Circuits



Typical Operating Circuits continued at end of data sheet.

3.0V to 5.5V, 300µA Supply Current, True RS-232 Transceivers using Four 0.1µF External Capacitors

ABSOLUTE MAXIMUM RATINGS

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

Continuous Power Dissipation (T_A = +70°C)
16-Pin Plastic DIP (derate 10.53mW/°C above +70°C)...842mW
16-Pin Narrow SO (derate 8.70mW/°C above +70°C) 696mW
18-Pin Plastic DIP (derate 11.11mW/°C above +70°C) ..889mW
18-Pin Wide SO (derate 9.52mW/°C above +70°C) 762mW
20-Pin SSOP (derate 8.00mW/°C above +70°C) 640mW
28-Pin Wide SO (derate 12.50mW/°C above +70°C) ...1000mW
28-Pin SSOP (derate 9.52mW/°C above +70°C) 762mW
Operating Temperature Ranges
MAX32_ _C_ _ ..... 0°C to +70°C
MAX32_ _E_ _ ..... -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 a maximum magnitude 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 (Note 2), 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} Power-Supply Current	No load, V_{CC} = 3.3V or 5.0V, T_A = +25°C			0.3	1.0	mA
Shutdown Supply Current	T_A = +25°C			1	10	µA
LOGIC						
Input Logic Threshold Low	T_IN; $\overline{EN}$, $\overline{SHDN}$ (MAX3222/MAX3241 only)				0.8	V
Input Logic Threshold High	T_IN; $\overline{EN}$, $\overline{SHDN}$ (MAX3222/MAX3241 only)	V_{CC} = 3.3V	2.0			V
		V_{CC} = 5.0V	2.4			
Input Leakage Current	T_IN; $\overline{EN}$, $\overline{SHDN}$ = 0V or V_{CC} (MAX3222/MAX3241 only)			±0.01	±1.0	µA
Output Leakage Current	$\overline{EN}$ = V_{CC} (MAX3222/MAX3241)			±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				0.3		V
Input Resistance	T_A = +25°C		3	5	7	kΩ
TRANSMITTER OUTPUTS						
Output Voltage Swing	All transmitter outputs loaded with 3kΩ to ground, V_{CC} = 3.15V to 5.5V		±5.0	±5.4		V
Output Resistance	V_{CC} = V+ = V- = 0V, V_{OUT} = ±2V		300	10M		Ω
Output Short-Circuit Current				±35	±60	mA
Output Leakage Current	V_{OUT} = ±12V, V_{CC} = 0V or 3.0V to 5.5V, transmitters disabled, $\overline{SHDN}$ = 0V (MAX3222, MAX3241)				±25	µA

ELECTRICAL CHARACTERISTICS (continued)

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

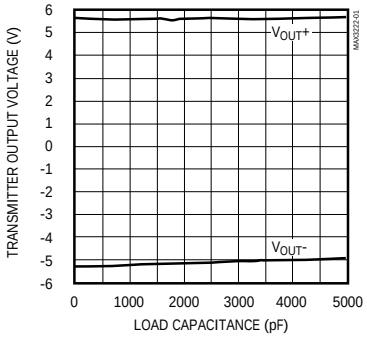
PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
MOUSE DRIVEABILITY (MAX3241)						
Transmitter Output Voltage	T1IN = T2IN = GND, T3IN = V_{CC}, T3OUT loaded with 3kΩ to GND, T1OUT and T2OUT loaded with 2.5mA each		±5			V
TIMING CHARACTERISTICS						
Maximum Data Rate	V_{CC} = 3.15V to 5.5V, R_L = 3kΩ, C_L = 1000pF, one transmitter switching		120	235		kbps
Receiver Propagation Delay	R_IN to R_OUT, C_L = 150pF	t_{PHL}		0.3		µs
		t_{PLH}		0.3		
Receiver Output Enable Time	Normal operation (MAX3222/MAX3241)			200		ns
Receiver Output Disable Time	Normal operation (MAX3222/MAX3241)			200		ns
Transmitter Skew	$\lvert t_{PHL} - t_{PLH} \rvert$			300		ns
Receiver Skew	$\lvert t_{PHL} - t_{PLH} \rvert$			300		ns
Transition-Region Slew Rate	V_{CC} = 3.3V, R_L = 3kΩ to 7kΩ, T_A = +25°C, C_L = 150pF to 2500pF, measured from +3V to -3V or -3V to +3V, Figure 1		6	8.0	30	V/µs

Note 2: C1–C4 = 0.1µF, tested at 3.3V ±10%. C1 = 0.047µF, C2–C4 = 0.33µF, tested at 5.0V ±10%.

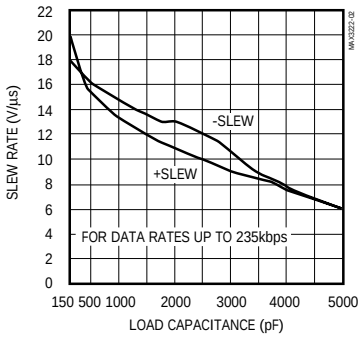
Typical Operating Characteristics

(V_{CC} = 3.3V, 235kbps data rate, 0.1µF capacitors, all transmitters loaded with 3kΩ, T_A = +25°C, unless otherwise noted.)

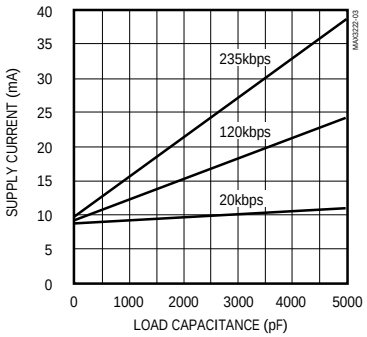
MAX3222/MAX3232
TRANSMITTER OUTPUT VOLTAGE
vs. LOAD CAPACITANCE



MAX3222/MAX3232
SLEW RATE
vs. LOAD CAPACITANCE



MAX3222/MAX3232
SUPPLY CURRENT vs. LOAD CAPACITANCE
WHEN TRANSMITTING DATA

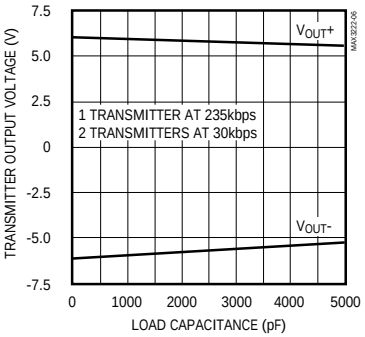


3.0V to 5.5V, 300µA Supply Current, True RS-232 Transceivers using Four 0.1µF External Capacitors

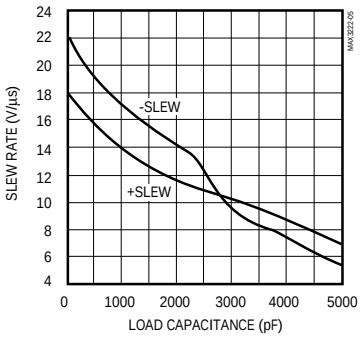
Typical Operating Characteristics (continued)

(V_{CC} = 3.3V, 235kbps data rate, 0.1µF capacitors, all transmitters loaded with 3kΩ, T_A = +25°C, unless otherwise noted.)

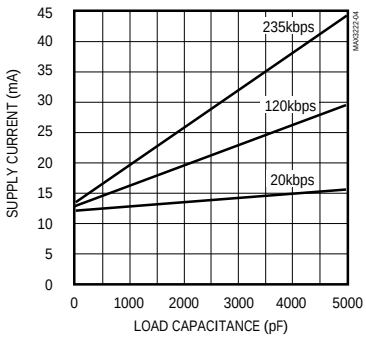
MAX3241
TRANSMITTER OUTPUT VOLTAGE vs. LOAD CAPACITANCE



MAX3241
SLEW RATE vs. LOAD CAPACITANCE



MAX3241
SUPPLY CURRENT vs. LOAD CAPACITANCE WHEN TRANSMITTING DATA



Pin Description

PIN				NAME	FUNCTION
MAX3222		MAX3232	MAX3241		
DIP/SO	SSOP				
5	5	4	1	C2+	Positive terminal of inverting charge-pump capacitor
6	6	5	2	C2-	Negative terminal of inverting charge-pump capacitor
7	7	6	3	V-	-5.5V generated by the charge pump
9, 14	9, 16	8, 13	4–8	R_IN	RS-232 Receiver Inputs
8, 15	8, 17	7, 14	9, 10, 11	T_OUT	RS-232 Transmitter Outputs
11, 12	12, 13	10, 11	12, 13, 14	T_IN	TTL/CMOS Transmitter Inputs
10, 13	10, 15	9, 12	15–19	R_OUT	TTL/CMOS Receiver Outputs
—	—	—	20, 21	R_OUTB	Noninverting Complementary Receiver Outputs—always active
18	20	—	22	$\overline{SHDN}$	Shutdown Control—active low
1	1	—	23	$\overline{EN}$	Receiver Enable—active low
4	4	3	24	C1-	Negative terminal of the voltage doubler charge-pump capacitor
16	18	15	25	GND	Ground
17	19	16	26	V_{CC}	+3.0V to +5.5V Supply Voltage
3	3	2	27	V+	+5.5V generated by the charge pump
2	2	1	28	C1+	Positive terminal of the voltage doubler charge-pump capacitor
—	11, 14	—	—	N.C.	No Connection

Detailed Description

Dual Charge-Pump Voltage Converter

The MAX3222/MAX3232/MAX3241'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), regardless of the input voltage (V_{CC}) over the 3.0V to 5.5V range. The charge pumps operate in a discontinuous mode; if the output voltages are less than 5.5V, the charge pumps are enabled, and if the output voltages exceed 5.5V, the charge pumps are disabled. Each charge pump requires a flying capacitor (C1, C2) and a reservoir capacitor (C3, C4) to generate the V+ and V- supplies.

RS-232 Transmitters

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

The transmitters guarantee a 120kbps data rate with worst-case loads of 3kΩ in parallel with 1000pF, providing compatibility with PC-to-PC communication software (such as LapLink™). Typically, these three devices can operate at data rates of 235kbps. Transmitters can be paralleled to drive multiple receivers or mice.

The MAX3222/MAX3241's output stage is turned off (high impedance) when the device is in shutdown mode. When the power is off, the MAX3222/MAX3232/MAX3241 permit the outputs to be driven up to ±12V.

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. The MAX3222/MAX3241 receivers have inverting three-state outputs. In shutdown, the receivers can be active or inactive (see Table 1).

The MAX3241's two complementary outputs (R1OUTB, R2OUTB) are always active, regardless of the state of $\overline{EN}$ or $\overline{SHDN}$ allowing Ring Indicator to be monitored without forward biasing other devices connected to the receiver outputs. This is ideal for systems where V_{CC} is set to 0V in shutdown to accomodate peripherals, such as UARTs (Figure 2).

™ LapLink is a trademark of Traveling Software.

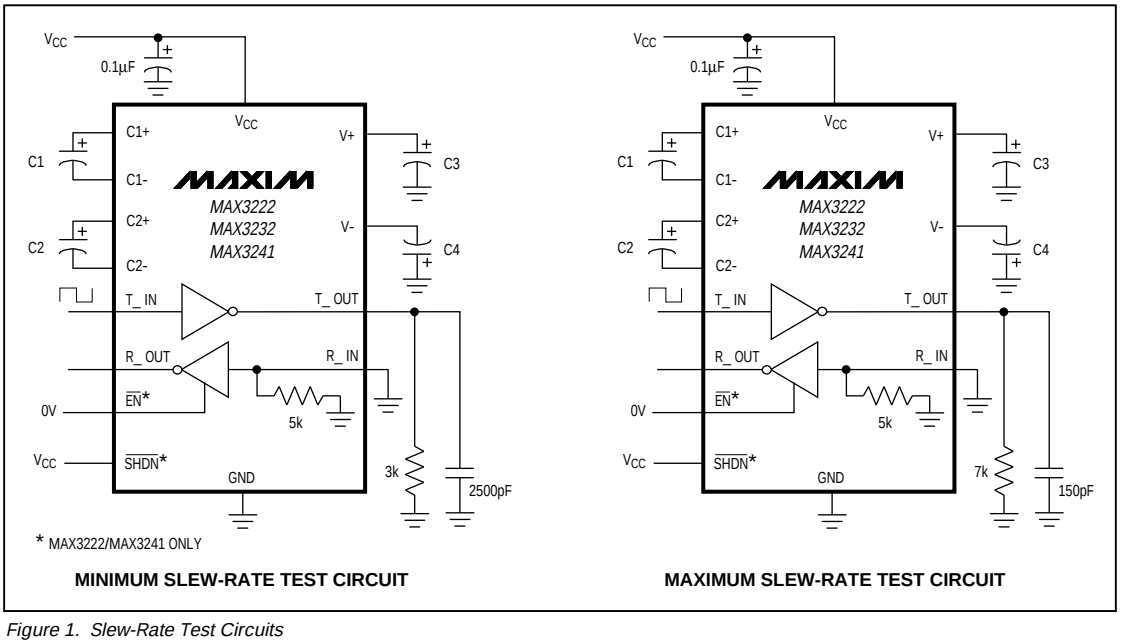


Figure 1. Slew-Rate Test Circuits

3.0V to 5.5V, 300µA Supply Current, True RS-232 Transceivers using Four 0.1µF External Capacitors

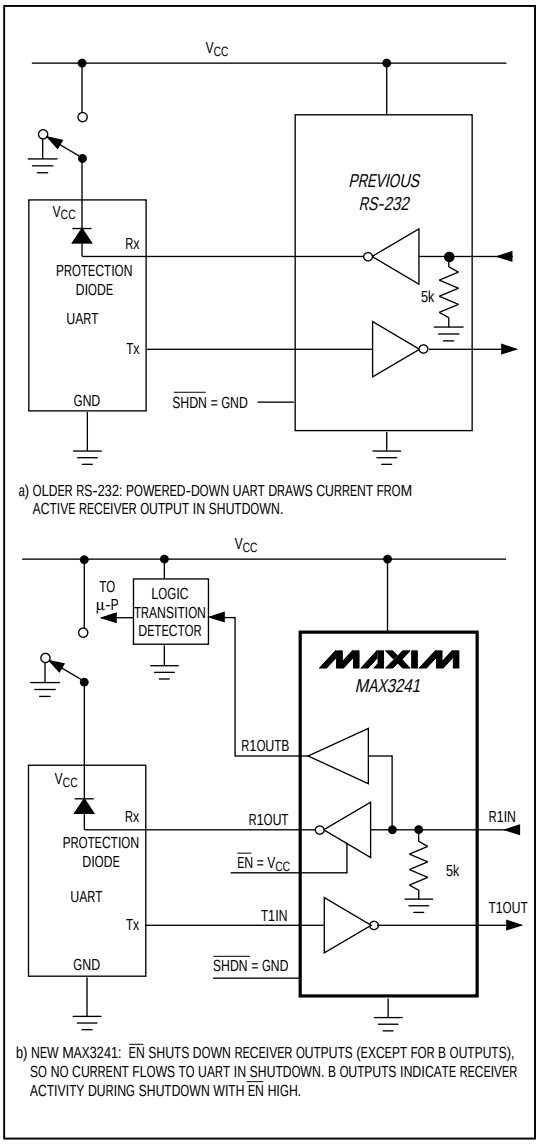


Figure 2. Detection of RS-232 Activity when the UART and Interface are Shut Down; Comparison of MAX3241 (b) with Previous Transceivers (a).

MAX3222/MAX3241 Shutdown Mode

Supply current reduces to less than 1µA in shutdown mode ($\overline{SHDN}$ = low). When shut down, the device's charge pumps are turned 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 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.

MAX3222/MAX3241 Enable Control

The inverting receiver outputs (R_OUT) are put into a high-impedance state when $\overline{EN}$ is high. The complementary outputs R1OUTB and R2OUTB are always active, regardless of the state of $\overline{EN}$ and $\overline{SHDN}$ (Table 1). $\overline{EN}$ has no effect on T_OUT.

Applications Information

Capacitor Selection

The capacitor type used for C1–C4 is not critical for proper operation; polarized or non-polarized 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 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, and C4, 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 bypass capacitor is adequate. In applications that are sensitive to power-supply noise, decouple V_{CC} to ground with a capacitor of the same value as the 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.

Table 1. MAX3222/MAX3241 Shutdown and Enable Control Truth Table

$\overline{SHDN}$	$\overline{EN}$	T_OUT	R_OUT	R_OUTB (MAX3241)
0	0	High-Z	Active	Active
0	1	High-Z	High-Z	Active
1	0	Active	Active	Active
1	1	Active	High-Z	Active

Table 2. Required Minimum Capacitor Values

V_{CC} (V)	C1 (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

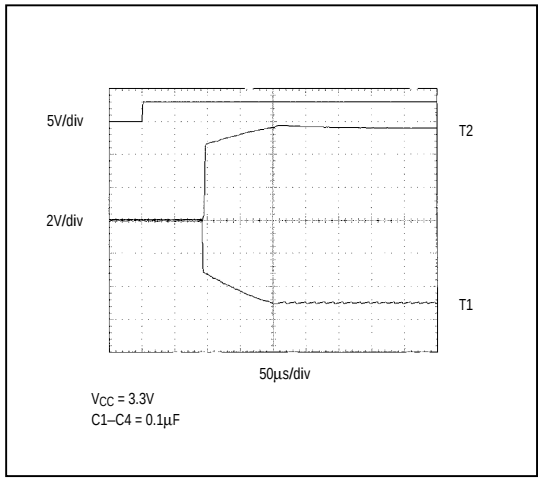


Figure 3. Transmitter Outputs when Exiting Shutdown or Powering Up

Transmitter Outputs when Exiting Shutdown

Figure 3 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- exceeds approximately 3V.

Mouse Driveability

The MAX3241 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 MAX3241 successfully drove all serial mice tested and met their respective current and voltage requirements. Figure 4a shows the transmitter output voltages under increasing load current at 3.0V. Figure 4b shows a typical mouse connection using the MAX3241.

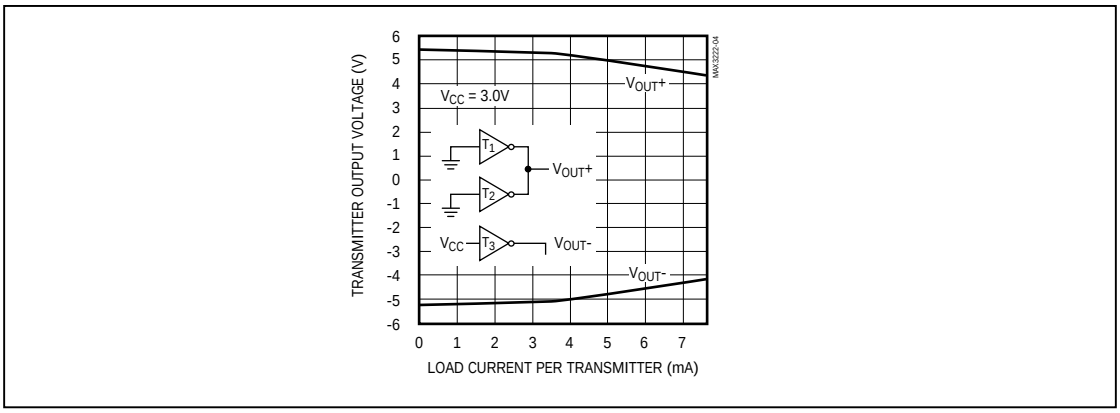


Figure 4a. MAX3241 Transmitter Output Voltage vs. Load Current per Transmitter

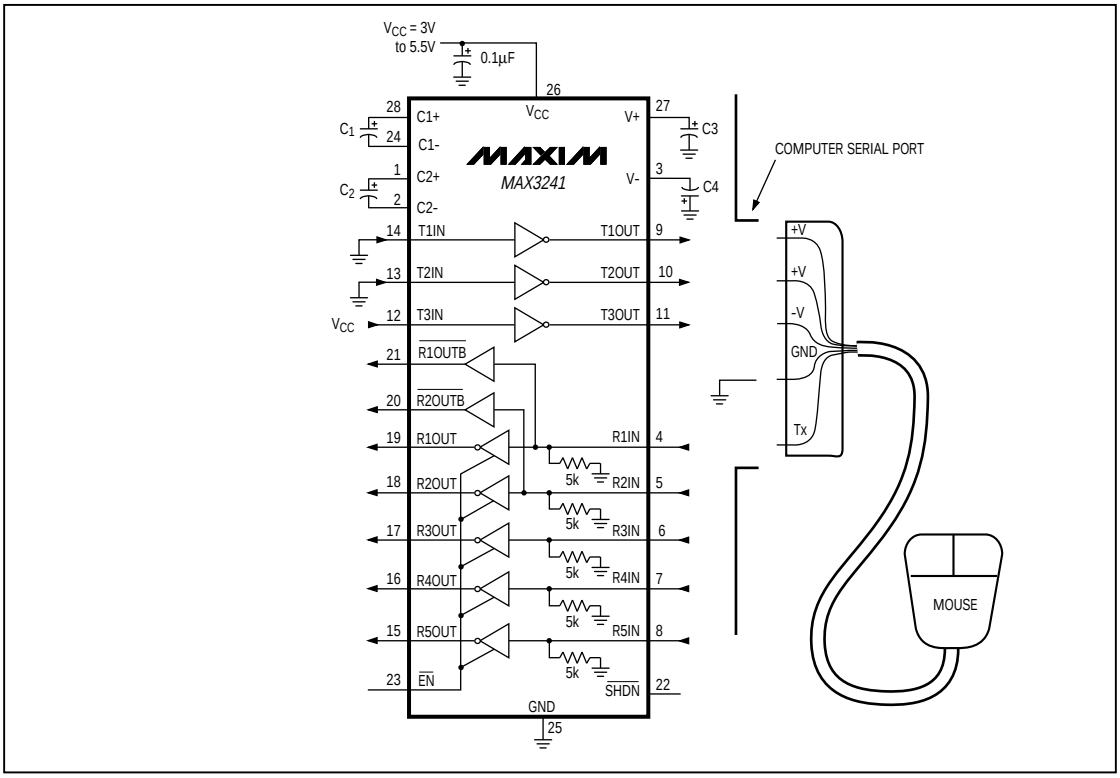


Figure 4b. Mouse Driver Test Circuit

Table 3. Logic Family Compatibility with Various Supply Voltages

SYSTEM POWER-SUPPLY VOLTAGE (V)	MAX32_ _ V_{CC} SUPPLY VOLTAGE (V)	COMPATIBILITY
3.3	3.3	Compatible with all CMOS families.
5	5	Compatible with all TTL and CMOS-logic families.
5	3.3	Compatible with ACT and HCT CMOS, and with TTL. Incompatible with AC, HC, or CD4000 CMOS.

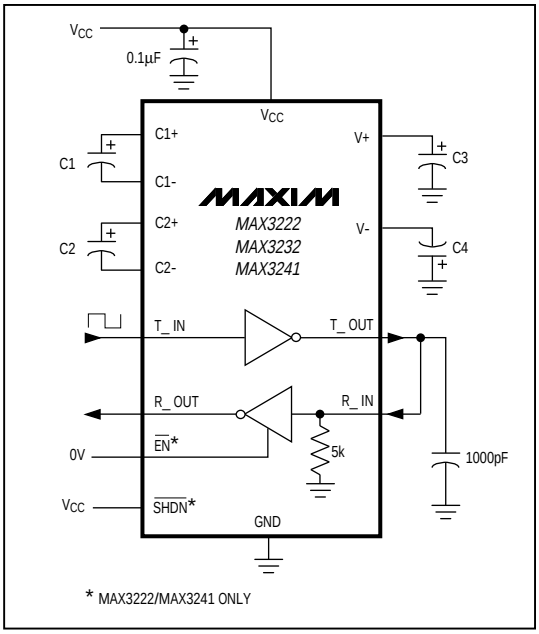


Figure 5. Loopback Test Circuit

High Data Rates

The MAX3222/MAX3232/MAX3241 maintain the RS-232 ±5.0V minimum transmitter output voltage even at high data rates. Figure 5 shows a transmitter loopback test circuit. Figure 6 shows a loopback test result at 120kbps, and Figure 7 shows the same test at 235kbps. For Figure 6, all transmitters were driven simultaneously at 120kbps into RS-232 loads in parallel with 1000pF. For Figure 7, a single transmitter was driven at 235kbps, and all transmitters were loaded with an RS-232 receiver in parallel with 1000pF.

Interconnection with 3V and 5V Logic

The MAX3222/MAX3232/MAX3241 can directly interface with various 5V logic families, including ACT and HCT CMOS. See Table 3 for more information on possible combinations of interconnections.

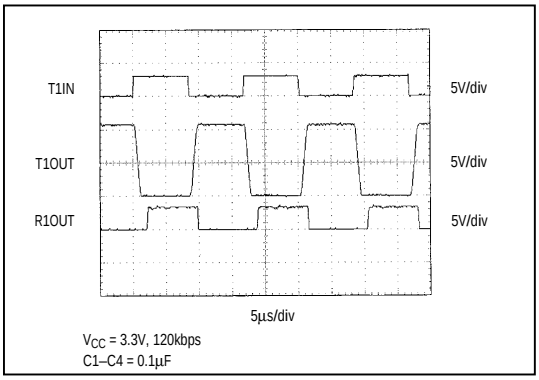


Figure 6. Loopback Test Result at 120kbps

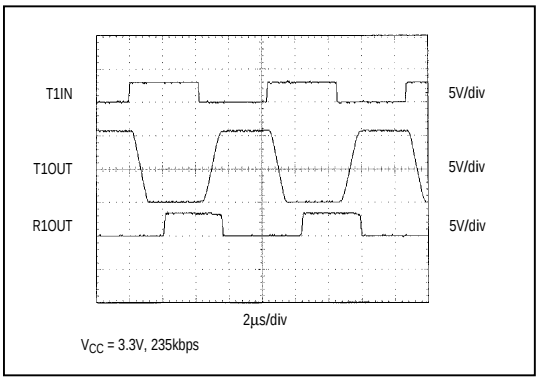
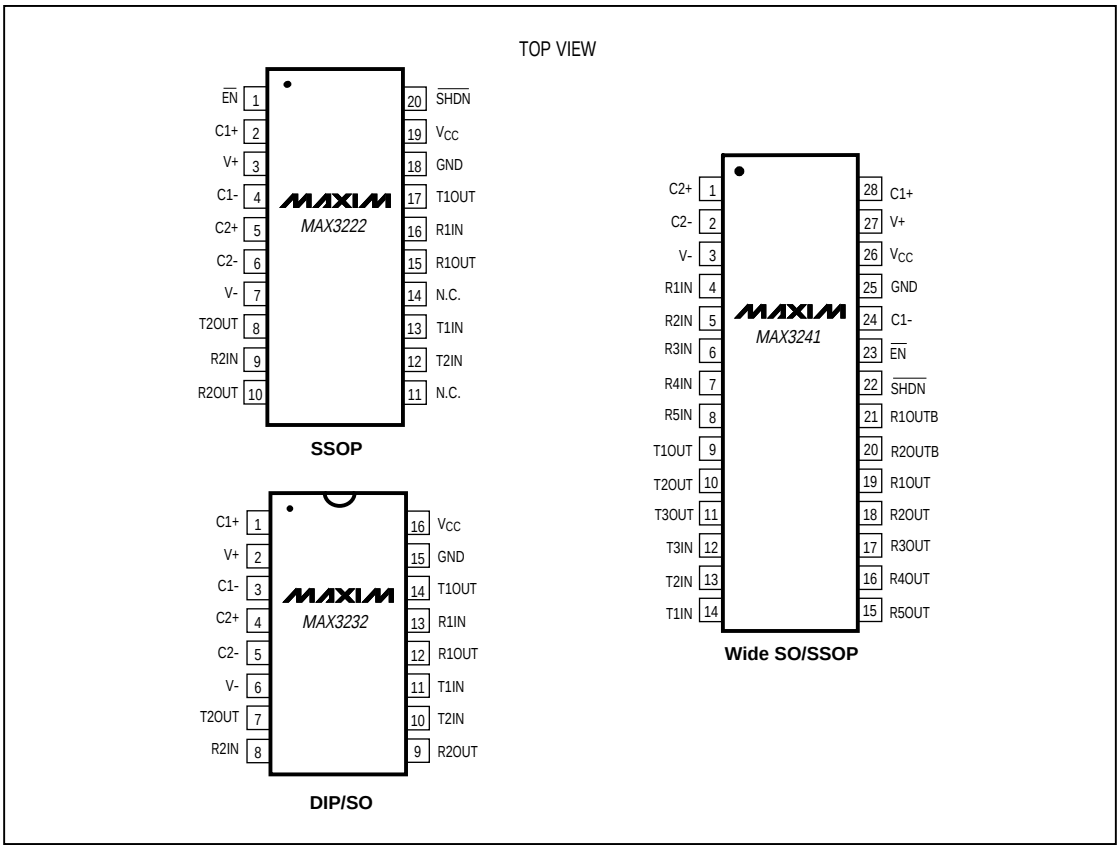


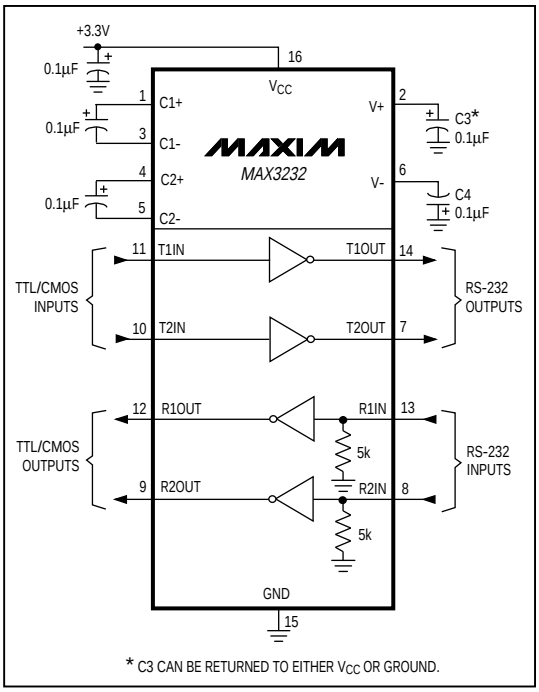
Figure 7. Loopback Test Result at 235kbps

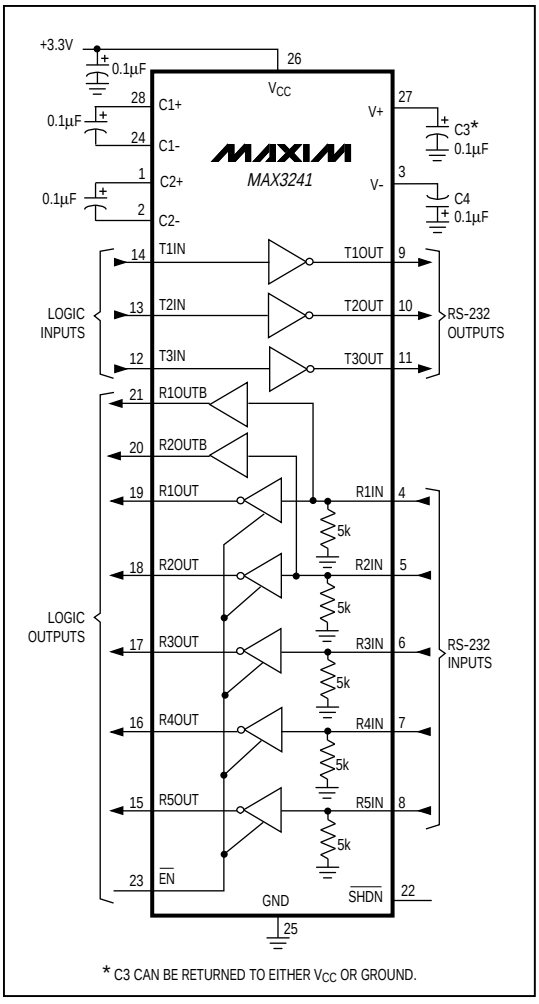
Pin Configurations (continued)



3.0V to 5.5V, 300µA Supply Current, True RS-232 Transceivers using Four 0.1µF External Capacitors

Typical Operating Circuits (continued)





Ordering Information (continued)

PART	TEMP. RANGE	PIN-PACKAGE
MAX3222C/D	0°C to +70°C	Dice*
MAX3222EPN	-40°C to +85°C	18 Plastic DIP
MAX3222EWN	-40°C to +85°C	18 Wide SO
MAX3222EAP	-40°C to +85°C	20 SSOP
MAX3232CPE	0°C to +70°C	16 Plastic DIP
MAX3232CSE	0°C to +70°C	16 Narrow SO
MAX3232CWE	0°C to +70°C	16 Wide SO
MAX3232EPE	-40°C to +85°C	16 Plastic DIP
MAX3232ESE	-40°C to +85°C	16 Narrow SO
MAX3232EWE	-40°C to +85°C	16 Wide SO
MAX3241CWI	0°C to +70°C	28 Wide SO
MAX3241CAI	0°C to +70°C	28 SSOP
MAX3241EWI	-40°C to +85°C	28 Wide SO
MAX3241EAI	-40°C to +85°C	28 SSOP

** Dice are tested at T_A = +25°C, DC parameters only.*

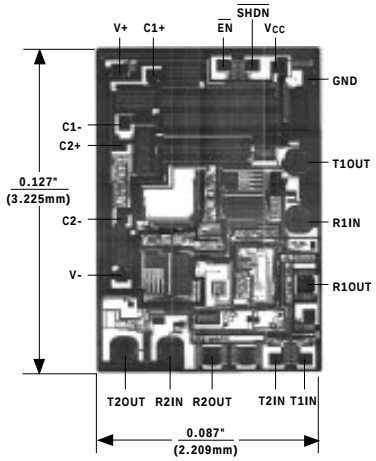
3.0V to 5.5V, 300µA Supply Current, True RS-232 Transceivers using Four 0.1µF External Capacitors

3V-Powered EIA/TIA-232 and EIA/TIA-562 Transceivers from Maxim

PART	POWER-SUPPLY VOLTAGE (V)	No. OF TRANSMITTERS/ RECEIVERS	No. OF RECEIVERS ACTIVE IN SHUTDOWN	GUAR-ANTEED DATA RATE (kbps)	EIA/TIA-232 OR 562	FEATURES
MAX212	3.0 to 3.6	3/5	5	120	232	Drives mice
MAX218	1.8 to 4.25	2/2	2	120	232	Operates directly from batteries without a voltage regulator
MAX562	2.7 to 5.25	3/5	5	230	562	Wide supply range
MAX563	3.0 to 3.6	2/2	2	230	562	0.1µF capacitors
MAX3212	2.7 to 3.6	3/5	5	235	232	AutoShutdown, complementary receiver, drives mice, transient detection
MAX3222	3.0 to 5.5	2/2	2	120	232	0.1µF capacitors
MAX3223	3.0 to 5.5	2/2	2	120	232	0.1µF capacitors, AutoShutdown
MAX3232	3.0 to 5.5	2/2	N/A	120	232	0.1µF capacitors
MAX3241	3.0 to 5.5	3/5	5	120	232	0.1µF capacitors, 2 complementary receivers, drives mice
MAX3243	3.0 to 5.5	3/5	1	120	232	0.1µF capacitors, AutoShutdown, complementary receiver, drives mice

Chip Topography

MAX3222



TRANSISTOR COUNT: 339
SUBSTRATE CONNECTED TO GND