

+5V, 1 μ A, Single RS-232 Transceiver with AutoShutdown

ABSOLUTE MAXIMUM RATINGS

V _{CC}	-0.3V to +6V	Short-Circuit Duration, T _{OUT}	Continuous
V ₊	(V _{CC} - 0.3V) to +14V	Continuous Power Dissipation (T _A = +70°C)	
V ₋	-14V to +0.3V	TSSOP (derated 6.7mW/°C above +70°C)	533mW
Input Voltages		SSOP (derated 7.1mW/°C above +70°C)	571mW
T _{IN}	-0.3V to (V ₊ + 0.3V)	Operating Temperature Range	
R _{IN}	±30V	MAX221C_	0°C to +70°C
FORCEON, FORCEOFF, $\overline{\text{EN}}$	-0.3V to (V _{CC} + 0.3V)	MAX221E_	-40°C to +85°C
Output Voltages		Maximum Junction Temperature	+150°C
T _{OUT}	(V ₋ - 0.3V) to (V ₊ + 0.3V)	Storage Temperature Range	-65°C to +150°C
ROUT, $\overline{\text{INVALID}}$	-0.3V to (V _{CC} + 0.3V)	Lead Temperature (soldering, 10sec)	+300°C

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} = +5V $\pm$ 10%, C1–C4 = 0.1 μ F, 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
DC CHARACTERISTICS						
V _{CC} Supply Current	I _{CC}	No load, T _A = +25°C		5	10	mA
Shutdown Supply Current	I _{SHDN}	T _A = +25°C, Figure 1		1	10	μ A
AutoShutdown Supply Current	I _{AS}			1	10	μ A
LOGIC INPUTS						
Input Leakage Current	I _{IN}	T _{IN} = 0 to V _{CC}			±1	μ A
Input Threshold Low	V _{IL}	T _{IN} ; $\overline{\text{EN}}$, FORCEOFF, FORCEON			0.8	V
Input Threshold High	V _{IH}	T _{IN} , $\overline{\text{EN}}$, FORCEOFF	2.4			V
Output Voltage Low	V _{OL}	ROUT; I _{SINK} = 3.2mA			0.4	V
Output Voltage High	V _{OH}	ROUT; I _{SOURCE} = 1.0mA	3.5			V
Output Leakage Current		$\overline{\text{EN}}$ = V _{CC} , 0 $\leq$ ROUT $\leq$ V _{CC}		±0.05	±10	μ A
AUTOSHUTDOWN						
Receiver Input Threshold, Transmitter Enabled		Figure 3	Positive threshold		2.7	V
			Negative threshold		-2.7	
Receiver Input Threshold, Transmitter Disabled		I _{CC} = 1 μ A, Figure 3	-0.3		0.3	V
$\overline{\text{INVALID}}$ Output Voltage Low		I _{SINK} = 1.6mA			0.4	V
$\overline{\text{INVALID}}$ Output Voltage High		I _{SOURCE} = 1.0mA	V _{CC} - 0.6			V
Receiver Threshold to Transmitter Enabled	t _{WU}	Figure 3		250		μ s
Receiver Positive or Negative Threshold to $\overline{\text{INVALID}}$ High	t _{INVH}	Figure 3		1		μ s
Receiver Positive or Negative Threshold to $\overline{\text{INVALID}}$ Low	t _{INVL}	Figure 3		30		μ s

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ELECTRICAL CHARACTERISTICS (continued)

($V_{CC} = +5V \pm 10\%$, $C1-C4 = 0.1\mu F$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ C$.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
RECEIVER INPUT						
Input Voltage Range			-25		25	V
Input Threshold Low		$T_A = +25^\circ C$, $V_{CC} = 5V$	0.8	1.2		V
Input Threshold High		$T_A = +25^\circ C$, $V_{CC} = 5V$		1.7	2.4	V
Input Hysteresis		$V_{CC} = 5V$, no hysteresis in shutdown		0.5		V
Input Resistance		$T_A = +25^\circ C$, $V_{CC} = 5V$	3	5	7	kΩ
TRANSMITTER OUTPUT						
Output Voltage Swing		Driver loaded with 3kΩ to ground	±5	±9		V
Output Resistance		$V_{CC} = V_+ = V_- = 0$, $V_{OUT} = \pm 2V$	300			Ω
Output Short-Circuit Current				±10	±60	mA

TIMING CHARACTERISTICS

($V_{CC} = +5V \pm 10\%$, $C1-C4 = 0.1\mu F$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ C$.)

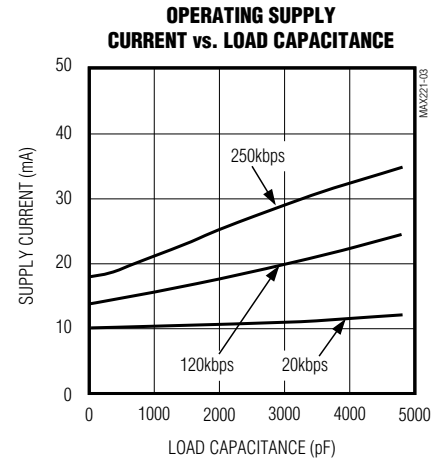
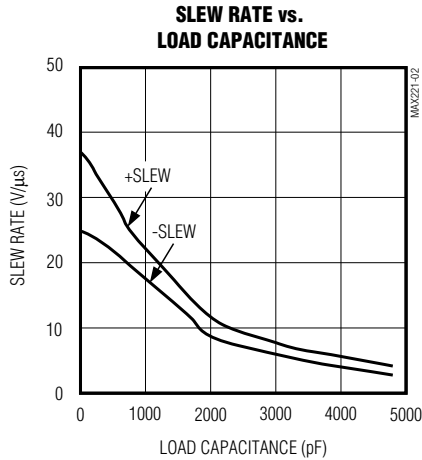
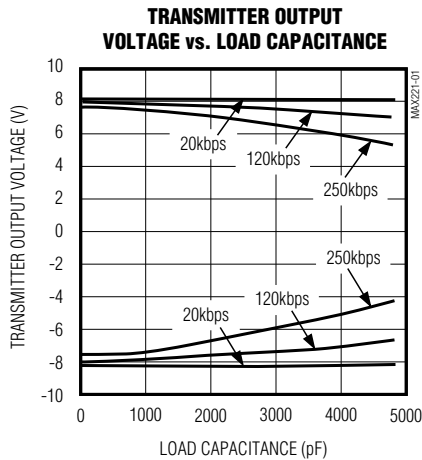
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Maximum Data Rate		$R_L = 3k\Omega$ to $7k\Omega$, $C_L = 50pF$ to $1000pF$, $V_{CC} = 4.5V$	250			kbps
Receiver Propagation Delay	t_{PHL} , t_{PLH}	$C_L = 150pF$		0.15		μs
Receiver Output Enable Time		Normal operation		300		ns
Receiver Output Disable Time		Normal operation		200		ns
Transmitter Skew	$ t_{PHL} - t_{PLH} $	(Note 1)		200		ns
Receiver Skew	$ t_{PHL} - t_{PLH} $			50		ns
Transition-Region Slew Rate		$T_A = +25^\circ C$, $V_{CC} = 5V$, $R_L = 3k\Omega$ to $7k\Omega$, $C_L = 500pF$ to $1000pF$, measured from -3V to +3V or +3V to -3V	3	6	30	V/μs

Note 1: Transmitter skew is measured at the transmitter zero crosspoints.

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Typical Operating Characteristics

(V_{CC} = +5V, 250kbps data rate, 0.1 μ F capacitors, transmitter loaded with 3k Ω and C_L, T_A = +25°C, unless otherwise noted.)



Pin Description

PIN	NAME	FUNCTION
1	$\overline{\text{EN}}$	Receiver Enable Control. Drive low for normal operation. Drive high to force the receiver output (ROUT) into a high-impedance state.
2	C1+	Positive Terminal of the Voltage Doubler Charge-Pump Capacitor
3	V+	Positive Voltage Generated by the Charge Pump
4	C1-	Negative Terminal of the Voltage Doubler Charge-Pump Capacitor
5	C2+	Positive Terminal of the Inverting Charge-Pump Capacitor
6	C2-	Negative Terminal of the Inverting Charge-Pump Capacitor
7	V-	Negative Voltage Generated by the Charge Pump
8	RIN	RS-232 Receiver Input
9	ROUT	TTL/CMOS Receiver Output
10	$\overline{\text{INVALID}}$	Output of the Invalid Signal Detector. $\overline{\text{INVALID}}$ is pulled low if no valid RS-232 level is present on the receiver input.
11	TIN	TTL/CMOS Transmitter Input
12	FORCEON	Drive high to override automatic circuitry, keeping transmitter and charge pump on. $\overline{\text{FORCEOFF}}$ must be high (Table 1).
13	TOUT	RS-232 Transmitter Output
14	GND	Ground
15	V _{CC}	+4.5V to +5.5V Supply Voltage
16	$\overline{\text{FORCEOFF}}$	Force-Off Input, active low. Drive low to shut down transmitter, receiver, and on-board charge pump. This overrides all automatic circuitry and FORCEON (Table 1).

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Dual Charge-Pump Voltage Converter

RS-232 Transmitter

RS-232 Receiver

AutoShutdown

Software-Controlled Shutdown

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Table 1. Output Control Truth Table

OPERATION STATUS	FORCEON	FORCEOFF	EN	VALID RECEIVER LEVEL	TOUT	ROUT
Shutdown (Forced Off)	X	0	0	X	High-Z	Active
	X	0	1	X	High-Z	High-Z
Normal Operation (Forced On)	1	1	0	X	Active	Active
	1	1	1	X	Active	High-Z
Normal Operation (AutoShutdown)	0	1	0	Yes	Active	Active
	0	1	1	Yes	Active	High-Z
Shutdown (AutoShutdown)	0	1	0	No	High-Z	Active
	0	1	1	No	High-Z	High-Z

X = Don't care

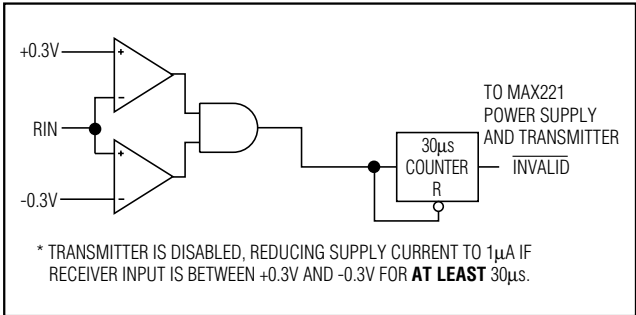


Figure 2a. Entering 1μA Supply Mode via AutoShutdown

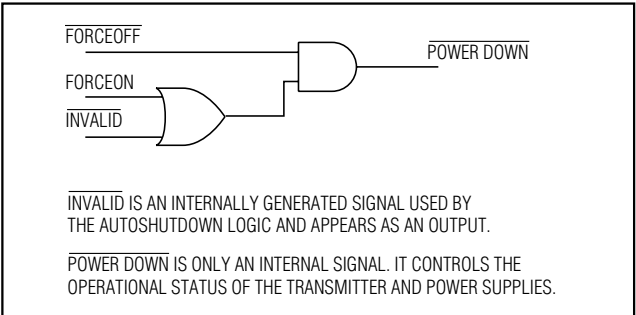


Figure 2c. AutoShutdown Logic

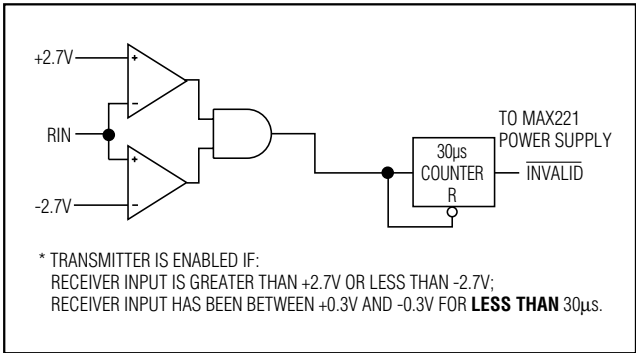


Figure 2b. Transmitter Enabled Using AutoShutdown

Table 2. INVALID Truth Table

RS-232 SIGNAL PRESENT AT RECEIVER INPUT	INVALID OUTPUT
Yes	High
No	Low

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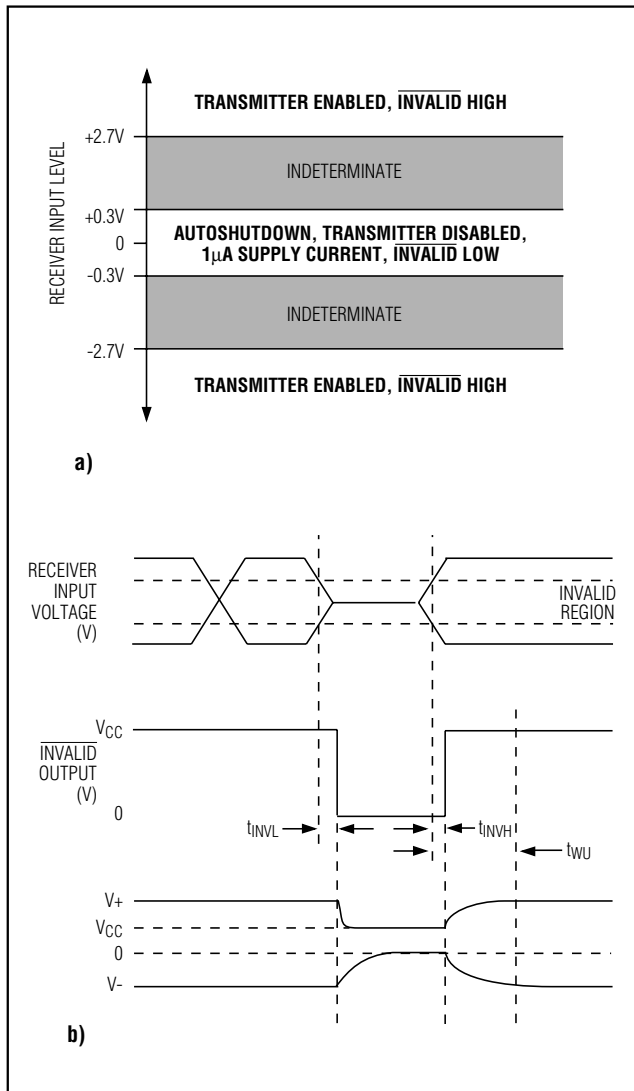


Figure 3. AutoShutdown Trip Levels

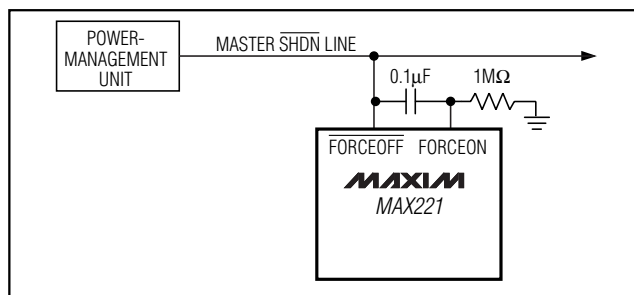


Figure 4. AutoShutdown with Initial Turn-On to Wake Up a Mouse or Another System

Applications Information

Using INVALID

INVALID indicates when an RS-232 signal is present at the receiver input, and therefore when the port is in use. INVALID can be used in alternative shutdown control schemes where it relieves the processor from constantly polling the port for activity.

Capacitor Selection

The capacitor type used for C1–C4 is not critical for proper operation; either polarized or nonpolarized capacitors are acceptable. If polarized capacitors are used, connect polarity as shown in the *Typical Operating Circuit*. The charge pump requires 0.1 μ F capacitors. Increasing the capacitor values (e.g., by a factor of 2) reduces ripple on the transmitter output and slightly reduces power consumption. C2, C3, and C4 can be increased without changing C1's value. However, do not increase C1's value without also increasing the values of C2, C3, and C4 to maintain the proper ratios (C1 to the other capacitors).

When using the minimum 0.1 μ F capacitors, make sure the capacitance does not degrade excessively with temperature. If in doubt, use capacitors with a larger nominal value. The capacitor's equivalent series resistance (ESR) usually rises at low temperatures and influences the amount of ripple on V+ and V-.

Power-Supply Decoupling

In most circumstances, a 0.1 μ F VCC bypass capacitor is adequate. In applications that are sensitive to power-supply noise, use a capacitor of the same value as the charge-pump capacitor C1. Connect bypass capacitors as close to the IC as possible.

Transmitter Output when Exiting Shutdown

Figure 5 shows the transmitter output when exiting shutdown mode. The transmitter is loaded with 3k Ω in parallel with 250pF. The transmitter output displays no ringing or undesirable transients as the MAX221 comes out of shutdown. Note that the transmitter is enabled only when the magnitude of V- exceeds approximately 3V.

High Data Rates

The MAX221 maintains the RS-232 ± 5.0 V minimum transmitter output voltage even at high data rates. Figure 6 shows a transmitter loopback test circuit. Figure 7 shows the loopback test result at 120kbps, and Figure 8 shows the same test at 250kbps.

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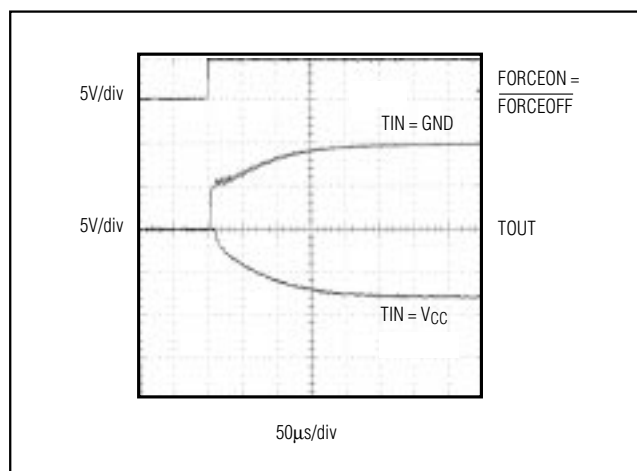


Figure 5. Transmitter Output Exiting Shutdown or Powering Up

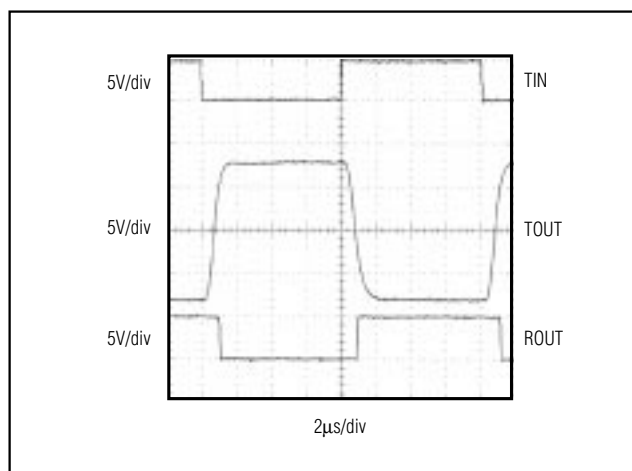


Figure 7. Loopback Test Result at 120kbps

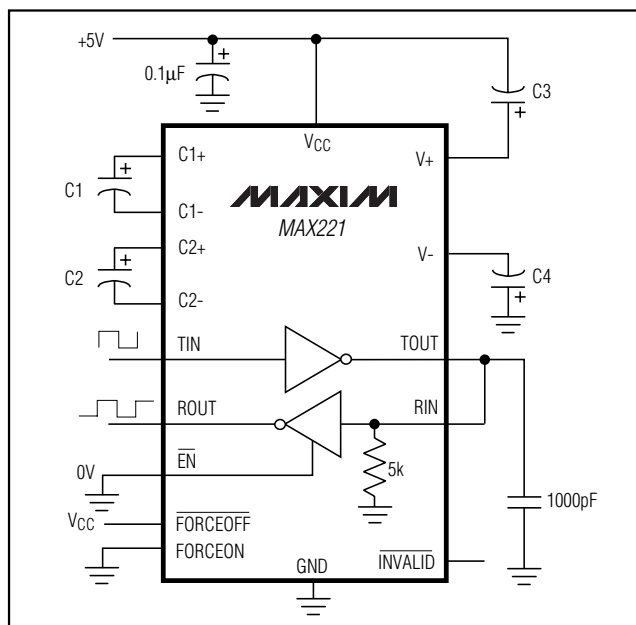


Figure 6. Loopback Test Circuit

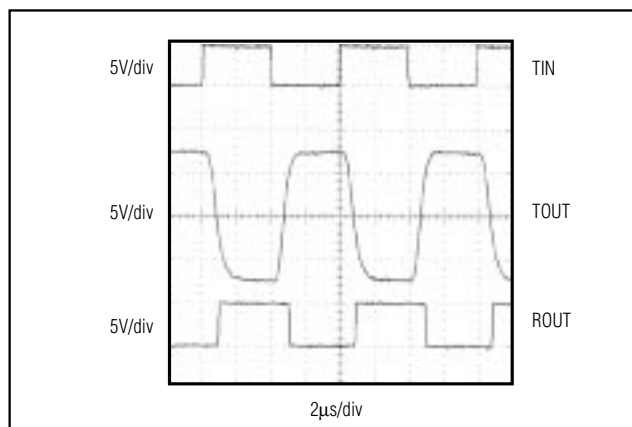


Figure 8. Loopback Test Result at 250kbps

Chip Information

TRANSISTOR COUNT: 157

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