

# +3.0V to +5.5V, 1μA, up to 250kbps, True RS-232 Transceiver with AutoShutdown Plus

## ABSOLUTE MAXIMUM RATINGS

V <sub>CC</sub> .....	-0.3V to +6V	Short-Circuit Duration	
V+ (Note 1).....	-0.3V to +7V	T <sub>OUT</sub> (one at a time).....	Continuous
V- (Note 1).....	+0.3V to -7V	Continuous Power Dissipation (T <sub>A</sub> = +70°C)	
V+ + IV-I (Note 1).....	+13V	SSOP (derate 9.52mW/°C above +70°C).....	762mW
Input Voltages		Operating Temperature Ranges	
T <sub>IN</sub> , FORCEOFF, FORCEON.....	-0.3V to +6V	MAX3238CAI.....	0°C to +70°C
R <sub>IN</sub> .....	±25V	MAX3238EAI.....	-40°C to +85°C
Output Voltages		Storage Temperature Range.....	-65°C to +160°C
T <sub>OUT</sub> .....	±13.2V	Lead Temperature (soldering, 10s).....	+300°C
R <sub>OUT</sub> , INVALID.....	-0.3V to (V <sub>CC</sub> + 0.3V)		

**Note 1:** V+ and V- can have a maximum magnitude of +7V, but their absolute difference can not exceed +13V.

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

## ELECTRICAL CHARACTERISTICS

(V<sub>CC</sub> = +3.0V to +5.5V; C1–C4 = 0.1μF (tested at 3.3V ±5%), C1–C4 = 0.22μF (tested at 3.3V ±10%), C1 = 0.047μF and C2–C4 = 0.33μF (tested at 5.0V ±10%); T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>; unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
<b>DC CHARACTERISTICS</b>					
Supply Current, AutoShutdown Plus	V <sub>CC</sub> = 3.3V or 5.0V, T <sub>A</sub> = +25°C, receivers idle, transmitters idle, FORCEON = GND, FORCEOFF = V <sub>CC</sub>		1.0	10	μA
Supply Current, Shutdown	FORCEOFF = GND, T <sub>A</sub> = +25°C		1.0	10	μA
Supply Current, AutoShutdown Plus Disabled	FORCEON = FORCEOFF = V <sub>CC</sub> , no load		0.5	2.0	mA
<b>LOGIC INPUTS AND RECEIVER OUTPUTS</b>					
Input Logic Threshold Low	T <sub>IN</sub> , FORCEON, FORCEOFF			0.8	V
Input Logic Threshold High	V <sub>CC</sub> = 3.3V	2.0			V
	V <sub>CC</sub> = 5.0V	2.4			
Input Leakage Current	T <sub>IN</sub> , FORCEON, FORCEOFF		±0.01	±1.0	μA
Output Leakage Current	Receivers disabled		±0.05	±10	μA
Output Voltage Low	I <sub>OUT</sub> = 1.6mA			0.4	V
Output Voltage High	I <sub>OUT</sub> = -1.0mA	V <sub>CC</sub> - 0.6	V <sub>CC</sub> - 0.1		V
<b>RECEIVER INPUTS</b>					
Input Voltage Range		-25		25	V
Input Threshold Low	V <sub>CC</sub> = 3.3V	0.6	1.2		V
	V <sub>CC</sub> = 5.0V	0.8	1.5		
Input Threshold High	V <sub>CC</sub> = 3.3V		1.5	2.4	V
	V <sub>CC</sub> = 5.0V		1.8	2.4	
Input Hysteresis			0.3		V
Input Resistance	T <sub>A</sub> = +25°C	3	5	7	kΩ

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## ELECTRICAL CHARACTERISTICS (continued)

(V<sub>CC</sub> = +3.0V to +5.5V; C1–C4 = 0.1μF (tested at 3.3V ±5%), C1–C4 = 0.22μF (tested at 3.3V ±10%), C1 = 0.047μF and C2–C4 = 0.33μF (tested at 5.0V ±10%); T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>; unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.)

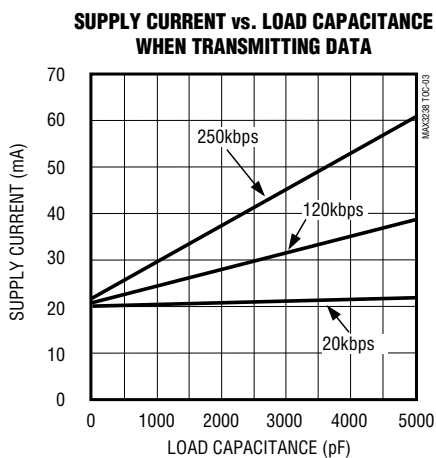
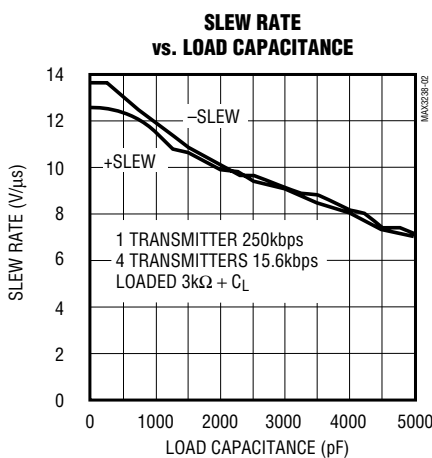
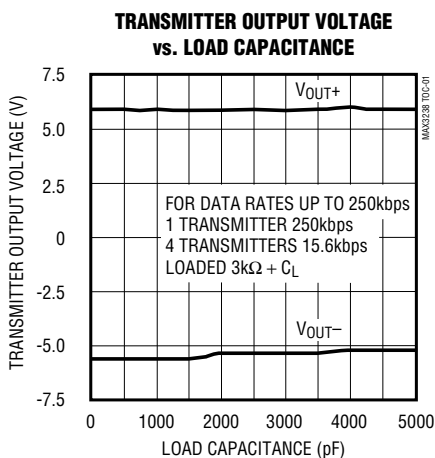
PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
AutoShutdown (FORCEON = GND, FORCEOFF = VCC)						
Receiver Input Threshold to $\overline{\text{INVALID}}$ Output High	Figure 7a	Positive threshold	2.7			V
		Negative threshold	-2.7			
Receiver Input Threshold to $\overline{\text{INVALID}}$ Output Low	Figure 4a		-0.3	0.3		V
$\overline{\text{INVALID}}$ Output Voltage Low	I <sub>OUT</sub> = 1.6mA		0.4			V
$\overline{\text{INVALID}}$ Output Voltage High	I <sub>OUT</sub> = -1.0mA		V <sub>CC</sub> - 0.6			V
Receiver Positive or Negative Threshold to $\overline{\text{INVALID}}$ High (t <sub>INVH</sub> )	V <sub>CC</sub> = 5V, Figure 4b		0.1			μs
Receiver Positive or Negative Threshold to $\overline{\text{INVALID}}$ Low (t <sub>INVL</sub> )	V <sub>CC</sub> = 5V, Figure 4b		50			μs
Receiver or Transmitter Edge to Transmitters Enabled (t <sub>WU</sub> )	V <sub>CC</sub> = 5V, Figure 4b (Note 2)		25			μs
Receiver or Transmitter Edge to Shutdown (t <sub>AUTOSHDN</sub> )	Figure 4b (Note 2)		15	30	60	sec
TRANSMITTER OUTPUTS						
Output Voltage Swing	All transmitter outputs loaded with 3kΩ to ground		±5.0	±5.4		V
Output Resistance	V <sub>CC</sub> = V+ = V- = GND, T <sub>OUT</sub> = 2V		300	10M		Ω
Output Short-Circuit Current	V <sub>CC</sub> ≤ 3.6V		±35		±60	mA
	V <sub>CC</sub> > 3.6V		±40		±100	
Output Leakage Current	V <sub>OUT</sub> = ±12V, V <sub>CC</sub> = 0V to 5.5V, transmitters disabled		±25			μA
TIMING CHARACTERISTICS						
Maximum Data Rate	R <sub>L</sub> = 3kΩ, C <sub>L</sub> = 1000pF, one transmitter switching		250			kbps
Receiver Propagation Delay	R <sub>IN</sub> to R <sub>OUT</sub> , C <sub>L</sub> = 150pF	t <sub>PHL</sub>	0.15			μs
		t <sub>PLH</sub>	0.15			
Receiver Output Enable Time	Normal operation		200			ns
Receiver Output Disable Time	Normal operation		200			ns
Transmitter Skew	t <sub>PHL</sub> - t <sub>PLH</sub>		100			ns
Receiver Skew	t <sub>PHL</sub> - t <sub>PLH</sub>		50			ns
Transition-Region Slew Rate	V <sub>CC</sub> = 3.3V, T <sub>A</sub> = +25°C, R <sub>L</sub> = 3Ω to 7kΩ, measured from +3V to -3V or -3V to +3V	C <sub>L</sub> = 150pF to 1000pF	6	30		V/μs
		C <sub>L</sub> = 150pF to 2500pF	4	30		

**Note 2:** A transmitter/receiver edge is defined as a transition through the transmitter/receiver input logic thresholds.

# **+3.0V to +5.5V, 1 $\mu$ A, up to 250kbps, True RS-232 Transceiver with AutoShutdown Plus**

## **Typical Operating Characteristics**

( $V_{CC}$  = +3.3V, 250kbps data rate, 0.1 $\mu$ F capacitors, all transmitters loaded with 3k $\Omega$ ,  $T_A$  = +25°C, unless otherwise noted.)



## **Pin Description**

PIN	NAME	FUNCTION
1	C2+	Positive Terminal of Inverting Charge-Pump Capacitor
2	GND	Ground
3	C2-	Negative Terminal of Inverting Charge-Pump Capacitor
4	V-	-5.5V Generated by the Charge Pump
5, 6, 7, 10, 12	T_OUT	RS-232 Transmitter Outputs (T1OUT–T5OUT)
8, 9, 11	R_IN	RS-232 Receiver Inputs (R1IN–R3IN)
13	FORCEON	Force-Off Input. Drive high to override AutoShutdown Plus, keeping transmitters and receivers on (FORCEOFF must be high) (Table 1).
14	FORCEOFF	Force-Off Input. Drive low to shut down transmitters, receivers (except R1OUTB), and on-board supply. This overrides AutoShutdown Plus and FORCEON (Table 1).
15	INVALID	Output of the Valid Signal Detector. A logic “1” indicates if a valid RS-232 level is present on receiver inputs.
16	R1OUTB	Noninverting Complementary Receiver Output. Always active.
17, 19, 22, 23, 24	T_IN	TTL/CMOS Transmitter Inputs (T5IN–T1IN)
18, 20, 21	R_OUT	TTL/CMOS Receiver Outputs (R3OUT–R1OUT)
25	C1-	Negative Terminal of Voltage-Doubler Charge-Pump Capacitor
26	VCC	+3.0V to +5.5V Supply Voltage
27	V+	+5.5V Generated by the Charge Pump
28	C1+	Positive Terminal of Voltage-Doubler Charge-Pump Capacitor

# **+3.0V to +5.5V, 1 $\mu$ A, up to 250kbps, True RS-232 Transceiver with AutoShutdown Plus**

**Table 1. Output Control Truth Table**

FORCEON	FORCEOFF	AUTOSHUTDOWN PLUS*	OPERATION STATUS	T_OUT	R_OUT	R1OUTB
X	0	X	Shutdown (Forced Off)	High-Z	High-Z	Active
1	1	X	Normal Operation (Forced On)	Active	Active	Active
0	1	<30sec*	Normal Operation (AutoShutdown Plus)	Active	Active	Active
0	1	>30sec*	Shutdown (AutoShutdown Plus)	High-Z	Active	Active

X = Don't Care

\*Time since last receiver or transmitter input transition.

## **Detailed Description**

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

The MAX3238'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; 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 MAX3238 transmitters guarantee a 250kbps data rate with worst-case loads of  $3k\Omega$  in parallel with 1000pF, providing compatibility with PC-to-PC communication software (such as LapLink™). Transmitters can be paralleled to drive multiple receivers. Figure 1 shows a complete system connection.

When  $\overline{\text{FORCEOFF}}$  is driven to ground, the transmitters and receivers are disabled and the outputs go high impedance, except for R1OUTB. When the Auto-Shutdown Plus circuitry senses that all receiver and transmitter inputs are inactive for more than 30sec, the transmitters are disabled and the outputs go into a high-impedance state, but the receivers remain active. When the power is off, the MAX3238 permits the outputs to be driven up to  $\pm 12V$ .

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. All receivers have inverting three-state outputs and are inactive in shutdown ( $\overline{\text{FORCEOFF}}$ ) (Table 1). The MAX3238 also features an extra, always-active noninverting output, R1OUTB. This extra output monitors receiver activity while the other receivers are high impedance, 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 accommodate peripherals, such as UARTs (Figure 2).

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# **+3.0V to +5.5V, 1 $\mu$ A, up to 250kbps, True RS-232 Transceiver with AutoShutdown Plus**

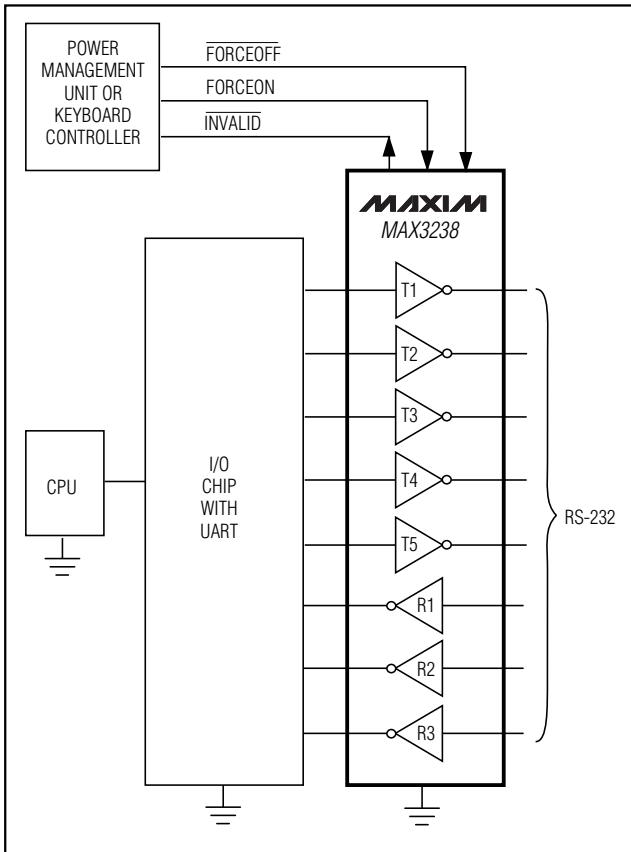


Figure 1. Interface Under Control of PMU

## **AutoShutdown Plus Mode**

1 $\mu$ A supply current is achieved with Maxim's AutoShutdown Plus feature, which operates when FORCEOFF is high and FORCEON is low. When the MAX3238 senses no valid signal transitions on all receiver and transmitter inputs for 30sec, the on-board power supply and drivers are shut off, reducing supply current to 1 $\mu$ A. This occurs if the RS-232 cable is disconnected or if the connected peripheral transmitters are turned off. The system turns on again when a valid transition is applied to any RS-232 receiver or transmitter input. As a result, the system saves power without changes to the existing BIOS or operating system. The INVALID output is high when the receivers are active. Since INVALID indicates the receiver inputs' condition, it can be used in any mode (Figure 3).

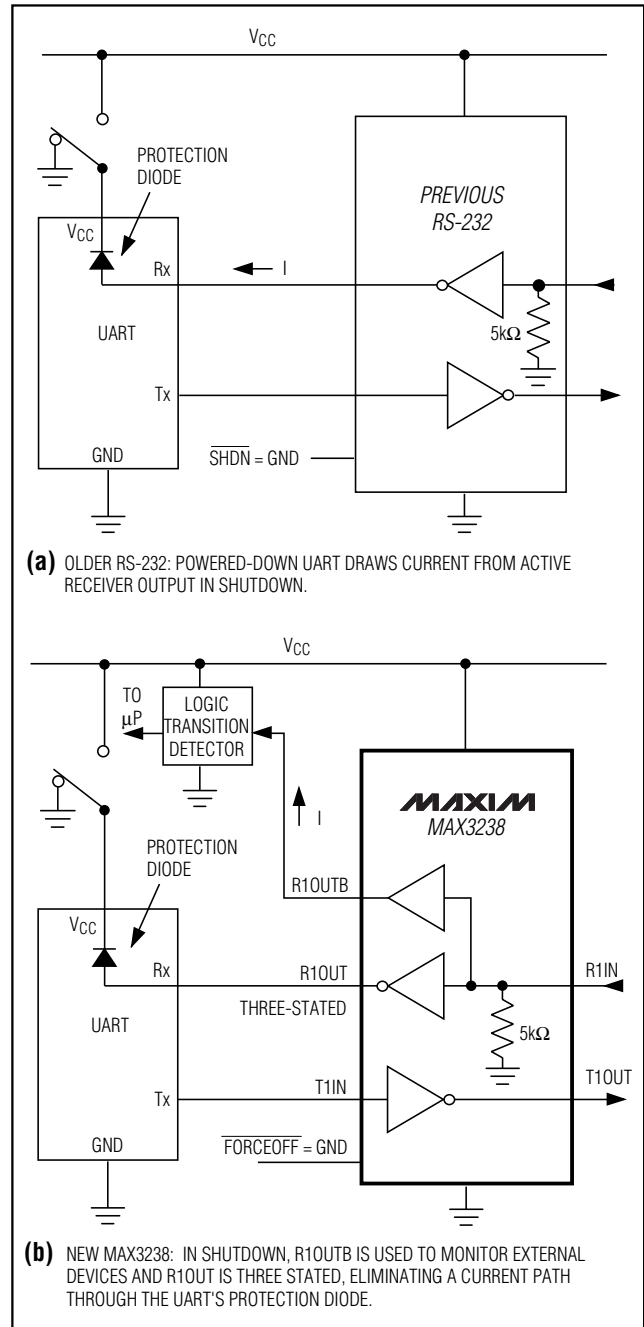


Figure 2. The MAX3238 detects RS-232 activity when the UART and interface are shut down.

# +3.0V to +5.5V, 1μA, up to 250kbps, True RS-232 Transceiver with AutoShutdown Plus

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Table 2.  $\overline{\text{INVALID}}$  Truth Table

RS-232 SIGNAL PRESENT AT ANY RECEIVER INPUT	$\overline{\text{INVALID}}$ OUTPUT
Yes	H
No	L

Tables 1 and 2 and Figure 3 summarize the MAX3238's operating modes.  $\text{FORCEON}$  and  $\overline{\text{FORCEOFF}}$  override the automatic circuitry and force the transceiver into its normal operating state or into its low-power standby state. When neither control is asserted, the IC enters AutoShutdown Plus mode and selects between these states automatically, based on the last receiver or transmitter input edge received.

When shut down, the device's charge pumps turn off,  $V_+$  decays to  $V_{CC}$ ,  $V_-$  decays to ground, and the transmitter outputs are disabled (high impedance). The time required to exit shutdown is typically 25μs (Figure 4b).

## Software-Controlled Shutdown

If direct software control is desired, use  $\overline{\text{INVALID}}$  to indicate DTR or Ring Indicator signal. Tie  $\overline{\text{FORCEOFF}}$  and  $\text{FORCEON}$  together to bypass the AutoShutdown feature so the line acts like a  $\overline{\text{SHDN}}$  input.

## 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 3 for required capacitor values. Do not use values smaller than those listed in Table 3. Increasing the capacitor values (e.g., by a factor of 2) reduces ripple on the transmitter outputs and slightly reduces power consumption. C2, C3, and C4 can be increased without changing C1's value. However, **do not increase C1 without also increasing the values of C2, C3, C4, and CBYPASS**, to maintain the proper ratios (C1 to the other capacitors).

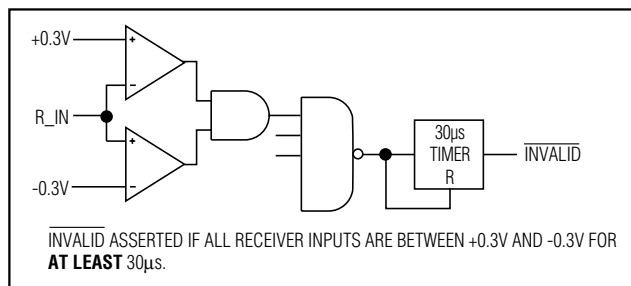


Figure 3a.  $\overline{\text{INVALID}}$  Functional Diagram,  $\overline{\text{INVALID}}$  Low

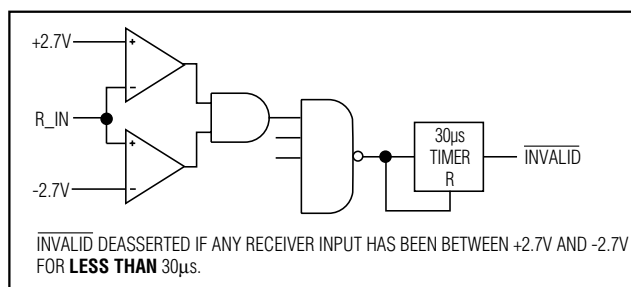


Figure 3b.  $\overline{\text{INVALID}}$  Functional Diagram,  $\overline{\text{INVALID}}$  High

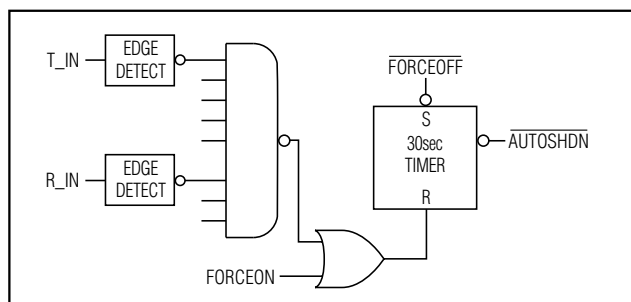


Figure 3c. AutoShutdown Plus Logic

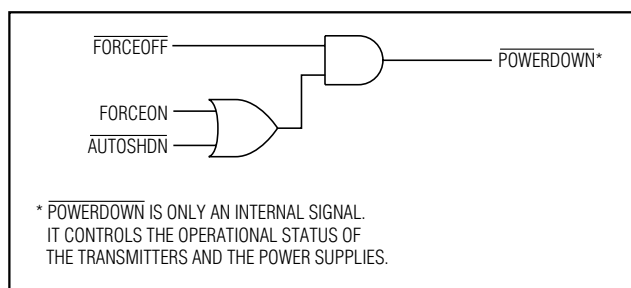


Figure 3d. Power-Down Logic

# **+3.0V to +5.5V, 1μA, up to 250kbps, True RS-232 Transceiver with AutoShutdown Plus**

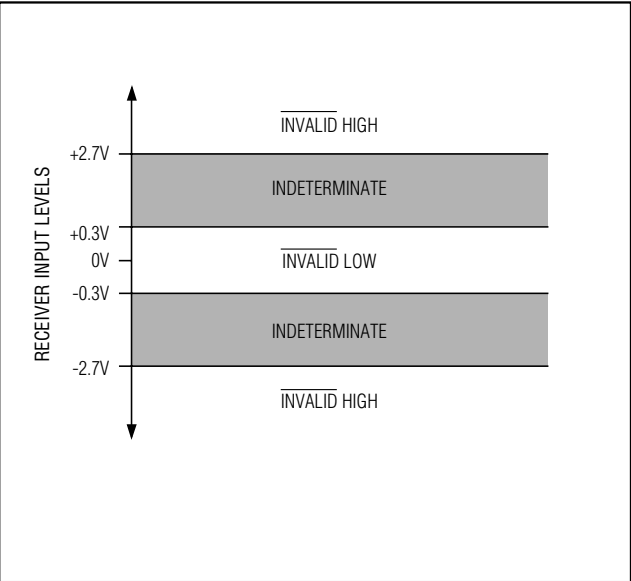


Figure 4a. Receiver Positive/Negative Thresholds for  $\overline{\text{INVALID}}$

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  $V_-$ .

**Table 3. Required Minimum Capacitance Values**

$V_{CC}$ (V)	C1 (μF)	C2, C3, C4, CBYPASS (μF)
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

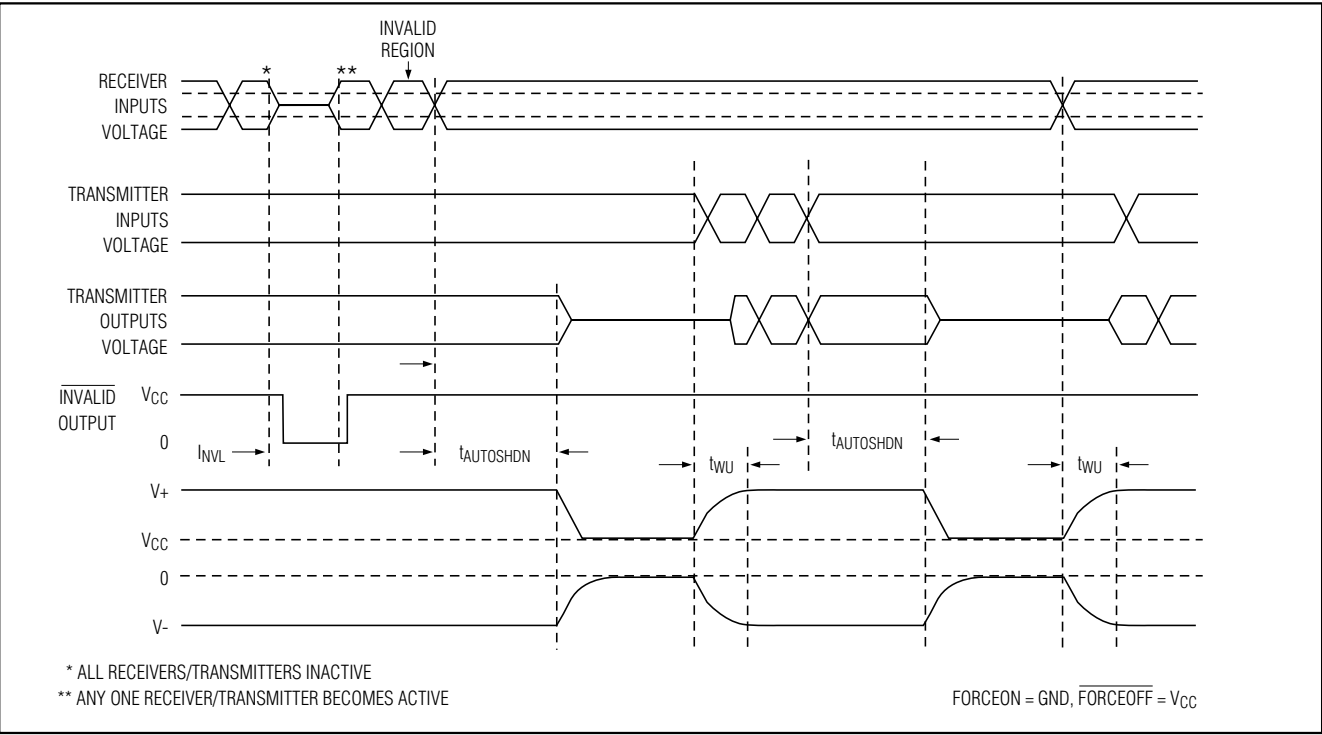


Figure 4b. AutoShutdown Plus and  $\overline{\text{INVALID}}$  Timing Diagram

# +3.0V to +5.5V, 1 $\mu$ A, up to 250kbps, True RS-232 Transceiver with AutoShutdown Plus

## Power-Supply Decoupling

In applications that are sensitive to power-supply noise, decouple  $V_{CC}$  to ground with a capacitor of the same value as capacitors C2, C3, and C4. Connect the bypass capacitor as close to the IC as possible.

## Transmitter Outputs when Exiting Shutdown

Figure 5 shows two transmitter outputs when exiting shutdown mode. As they become active, the outputs are shown going to opposite RS-232 levels (one transmitter input is high, the other is low). Each transmitter is loaded with  $3k\Omega$  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 MAX3238 maintains the RS-232  $\pm 5.0V$  minimum transmitter output voltage even at high data rates. Figure 6 shows a transmitter loopback test circuit. Figure 7 shows a loopback test result at 120kbps, and Figure 8 shows the same test at 250kbps. For Figure 7, all transmitters were driven simultaneously at 120kbps into RS-232 loads in parallel with  $1000pF$ . For Figure 8, a single transmitter was driven at 250kbps, and all transmitters were loaded with an RS-232 receiver in parallel with  $1000pF$ .

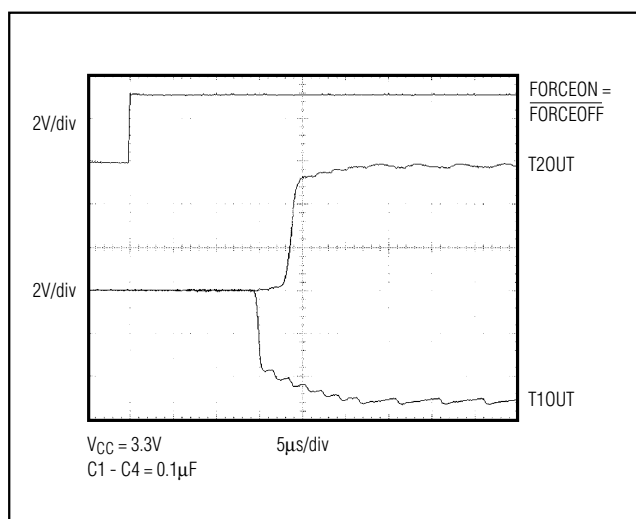


Figure 5. Transmitter Outputs when Exiting Shutdown or Powering Up

## Interconnection with 3V and 5V Logic

The MAX3238 can directly interface with various 5V-logic families, including ACT and HCT CMOS. See Table 4 for more information on possible combinations of interconnections.

Table 4. Logic Family Compatibility with Various Supply Voltages

SYSTEM POWER-SUPPLY VOLTAGE (V)	V <sub>CC</sub> SUPPLY VOLTAGE (V)	COMPATIBILITY
3.3	3.3	Compatible with all CMOS families.
5	5	Compatible with all TTL and CMOS families.
5	3.3	Compatible with ACT and HCT CMOS, and with AC, HC, or CD4000 CMOS.

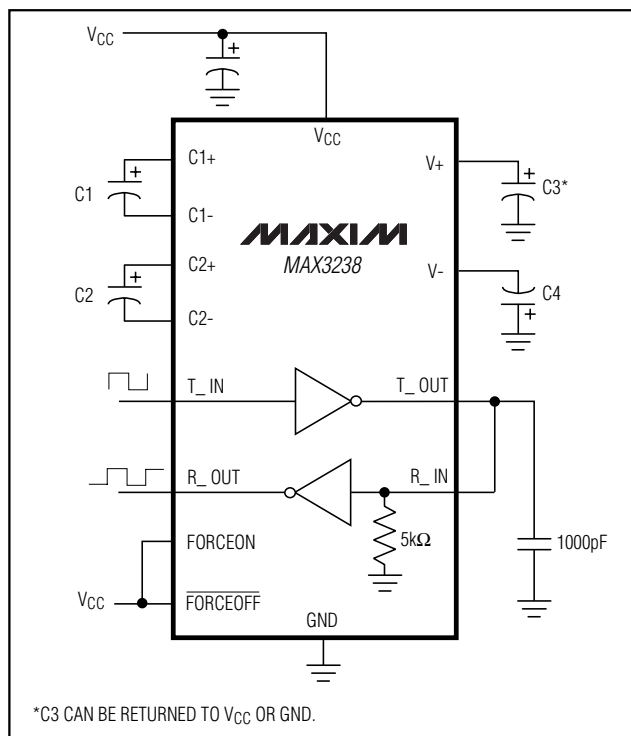


Figure 6. Loopback Test Circuit



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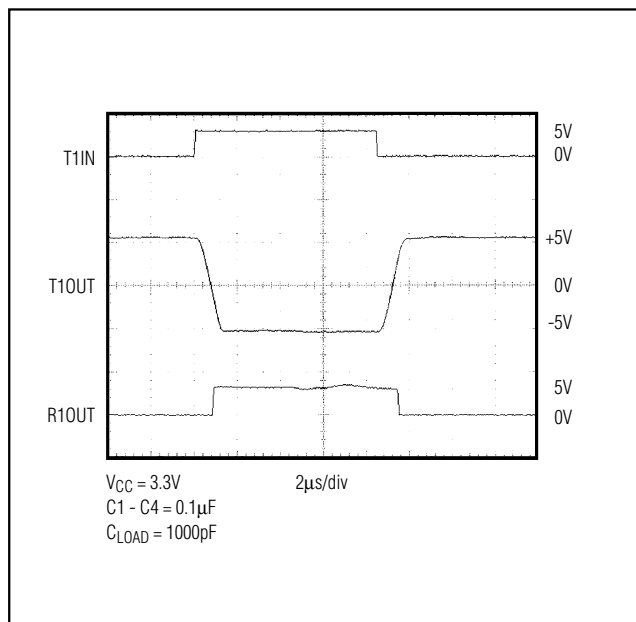


Figure 7. Loopback Test Result at 120kbps

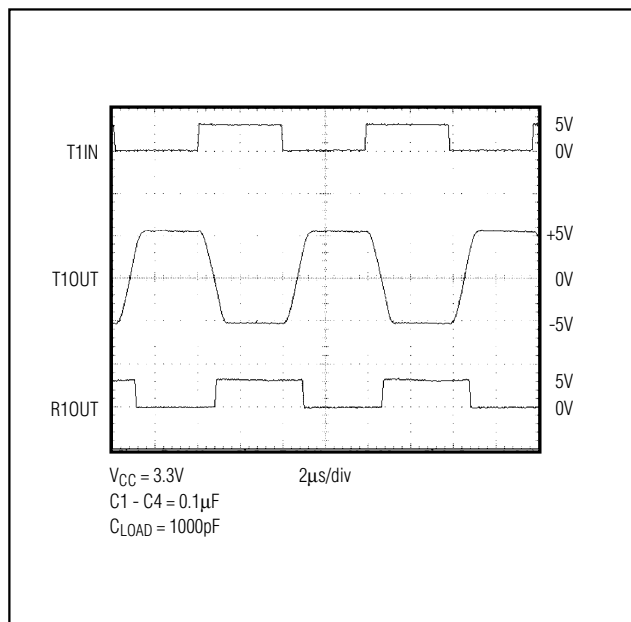


Figure 8. Loopback Test Result at 250kbps

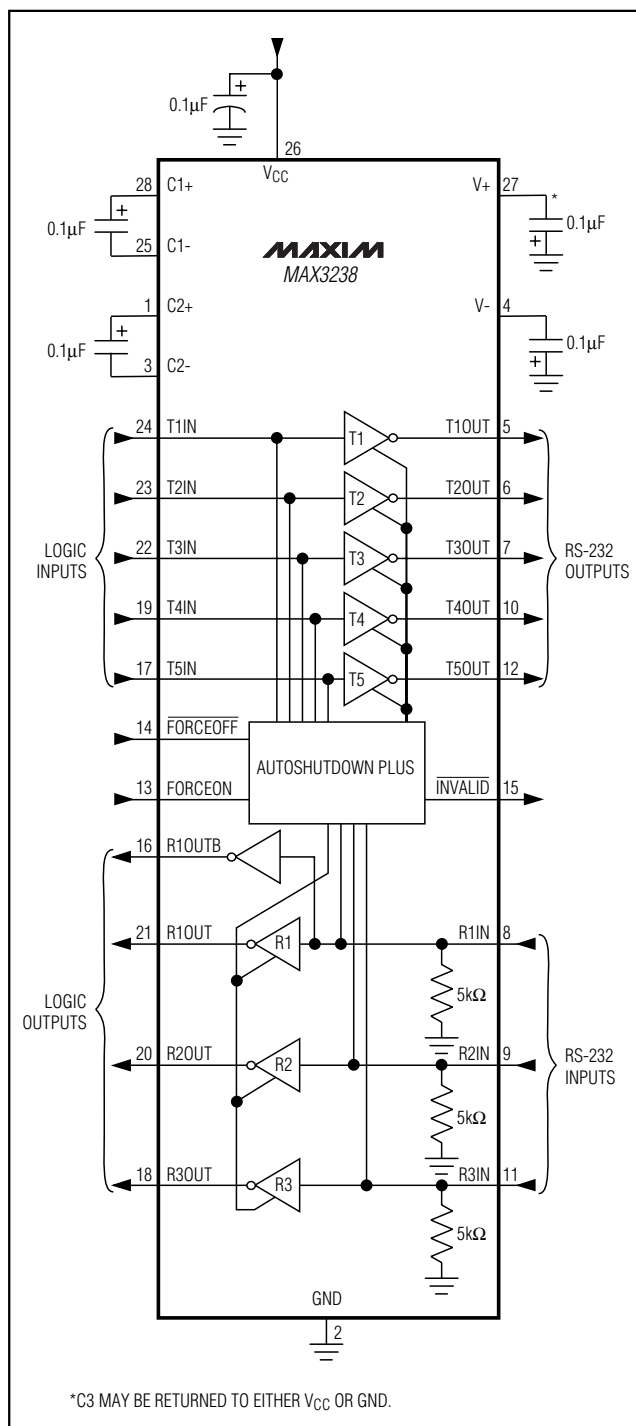
## **Chip Information**

TRANSISTOR COUNT: 1404

# **+3.0V to +5.5V, 1 $\mu$ A, up to 250kbps, True RS-232 Transceiver with AutoShutdown Plus**

## **Typical Operating Circuit**

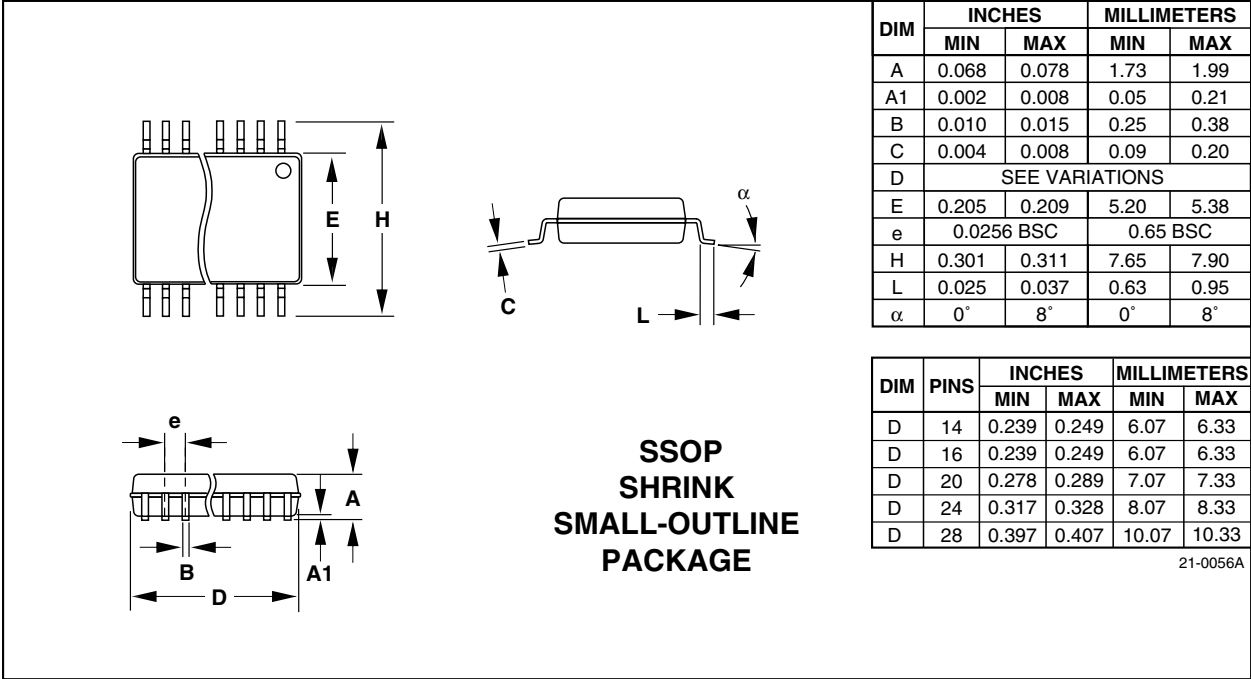
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**+3.0V to +5.5V, 1μA, up to 250kbps, True RS-232 Transceiver with AutoShutdown Plus**

**Package Information**

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)



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