19-1144; Rev 0; 9/96

MAXIM

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

General Description

The MAX3238 true RS-232 transceiver achieves a 1µA supply current with Maxim's revolutionary AutoShutdown Plus feature. When the device does not sense a valid signal transition on either the receiver or transmitter inputs within 30sec, the on-board power supply and drivers shut down. This occurs if the RS-232 cable is disconnected or if the transmitters of the connected peripheral are inactive. The system turns on again when a valid transition is applied to any RS-232 receiver or transmitter input, saving power without changes to the existing BIOS or operating system.

The MAX3238 5-driver/3-receiver complete serial port is a 3V-powered EIA/TIA-232 and V.28/V.24 communications interface intended for notebook or subnotebook computer applications. A proprietary, high-efficiency, dual charge-pump power supply and a low-dropout transmitter combine to deliver true RS-232 performance from a single +3.0V to +5.5V supply. A guaranteed data rate of 250kbps provides compatibility with popular software for communicating with personal computers. The MAX3238 requires only 0.1µF capacitors in 3.3V operation. It is ideal for 3.3V-only systems, mixed 3.3V and 5.0V systems, or 5V-only systems that require true RS-232 performance.

Receiver R1 has an extra, always-active output (in addition to its standard output), which allows 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 MAX3238 is available in a space-saving SSOP package.

Applications

Notebook, Subnotebook, and Palmtop Computers

High-Speed Modems

Battery-Powered Equipment

Hand-Held Equipment

Peripherals

Printers

Typical Operating Circuit appears at end of data sheet.

AutoShutdown Plus is a trademark of Maxim Integrated Products.
**Patents Pending*

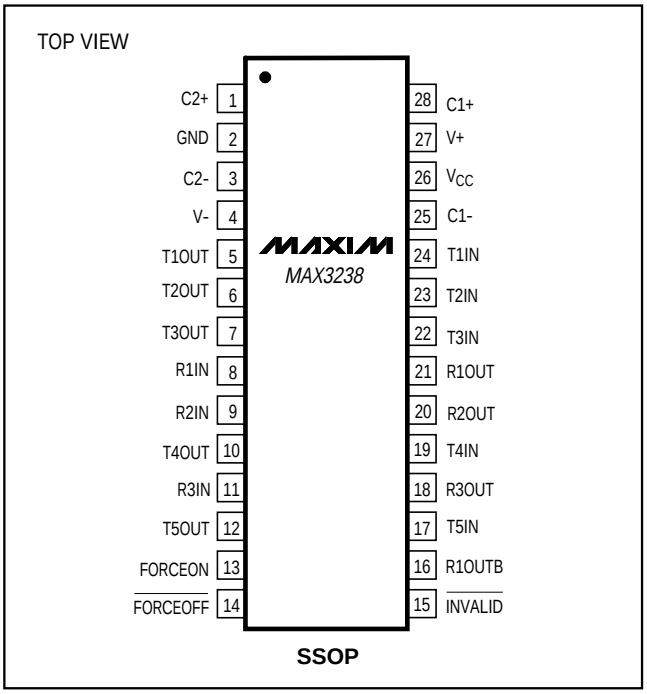
Features

- ♦ **1µA Supply Current Achieved with AutoShutdown Plus**
- ♦ **Guaranteed Data Rate: 250kbps**
- ♦ **1µA Low-Power Shutdown**
- ♦ **Receivers Active in AutoShutdown Plus Mode**
- ♦ **Flow-Through Pinout**
- ♦ **Meets EIA/TIA-232 Specifications Down to 3.0V**
- ♦ **Guaranteed 6V/µs Slew Rate**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX3238CAI	0°C to +70°C	28 SSOP
MAX3238EAI	-40°C to +85°C	28 SSOP

Pin Configuration



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

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, $\overline{FORCEOFF}$, FORCEON .....-0.3V to +6V
  R_IN .....±25V
Output Voltages
  T_OUT .....±13.2V
  R_OUT, $\overline{INVALID}$ .....-0.3V to (V_{CC} + 0.3V)

Short-Circuit Duration
  T_OUT (one at a time) .....Continuous
Continuous Power Dissipation (T_A = +70°C)
  SSOP (derate 9.52mW/°C above +70°C) 762mW
Operating Temperature Ranges
  MAX3238CAI .....0°C to +70°C
  MAX3238EAI .....-40°C to +85°C
Storage Temperature Range .....-65°C to +160°C
Lead Temperature (soldering, 10sec) .....+300°C

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_{CC} = +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_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					
Supply Current, AutoShutdown Plus	V_{CC} = 3.3V or 5.0V, T_A = +25°C, receivers idle, transmitters idle, FORCEON = GND, $\overline{FORCEOFF}$ = V_{CC}		1.0	10	µA
Supply Current, Shutdown	$\overline{FORCEOFF}$ = GND, T_A = +25°C		1.0	10	µA
Supply Current, AutoShutdown Plus Disabled	FORCEON = $\overline{FORCEOFF}$ = V_{CC}, no load		0.5	2.0	mA
LOGIC INPUTS AND RECEIVER OUTPUTS					
Input Logic Threshold Low	T_IN, FORCEON, $\overline{FORCEOFF}$			0.8	V
Input Logic Threshold High	V_{CC} = 3.3V	2.0			V
	V_{CC} = 5.0V	2.4			
Input Leakage Current	T_IN, FORCEON, $\overline{FORCEOFF}$		±0.01	±1.0	µA
Output Leakage Current	Receivers disabled		±0.05	±10	µA
Output Voltage Low	I_{OUT} = 1.6mA			0.4	V
Output Voltage High	I_{OUT} = -1.0mA	V_{CC} - 0.6	V_{CC} - 0.1		V
RECEIVER INPUTS					
Input Voltage Range		-25		25	V
Input Threshold Low	V_{CC} = 3.3V	0.6	1.2		V
	V_{CC} = 5.0V	0.8	1.5		
Input Threshold High	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

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = +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_A = T_{MIN} to T_{MAX}; unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
AutoShutdown (FORCEON = GND, $\overline{FORCEOFF}$ = V_{CC})						
Receiver Input Threshold to $\overline{INVALID}$ Output High	Figure 7a	Positive threshold			2.7	V
		Negative threshold	-2.7			
Receiver Input Threshold to $\overline{INVALID}$ Output Low	Figure 4a		-0.3		0.3	V
$\overline{INVALID}$ Output Voltage Low	I_{OUT} = 1.6mA				0.4	V
$\overline{INVALID}$ Output Voltage High	I_{OUT} = -1.0mA		V_{CC} - 0.6			V
Receiver Positive or Negative Threshold to $\overline{INVALID}$ High (t_{INVH})	V_{CC} = 5V, Figure 4b			0.1		µs
Receiver Positive or Negative Threshold to $\overline{INVALID}$ Low (t_{INVL})	V_{CC} = 5V, Figure 4b			50		µs
Receiver or Transmitter Edge to Transmitters Enabled (t_{WU})	V_{CC} = 5V, Figure 4b (Note 2)			25		µs
Receiver or Transmitter Edge to Shutdown ($t_{AUTOSHDN}$)	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_{CC} = V+ = V- = GND, T_{OUT} = 2V		300	10M		Ω
Output Short-Circuit Current	$V_{CC} \leq$ 3.6V			±35	±60	mA
	V_{CC} > 3.6V			±40	±100	
Output Leakage Current	V_{OUT} = ±12V, V_{CC} = 0V to 5.5V, transmitters disabled				±25	µA
TIMING CHARACTERISTICS						
Maximum Data Rate	R_L = 3kΩ, C_L = 1000pF, one transmitter switching		250			kbps
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			200		ns
Receiver Output Disable Time	Normal operation			200		ns
Transmitter Skew	$\lvert t_{PHL} - t_{PLH} \rvert$			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 = 3Ω 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	

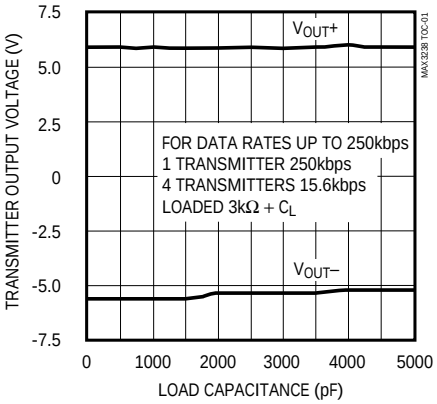
Note 2: A transmitter/receiver edge is defined as a transition through the transmitter/receiver input logic thresholds.

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

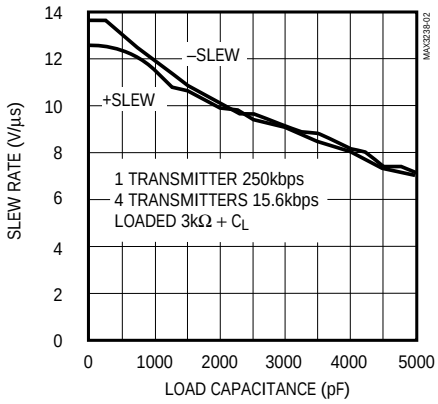
Typical Operating Characteristics

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

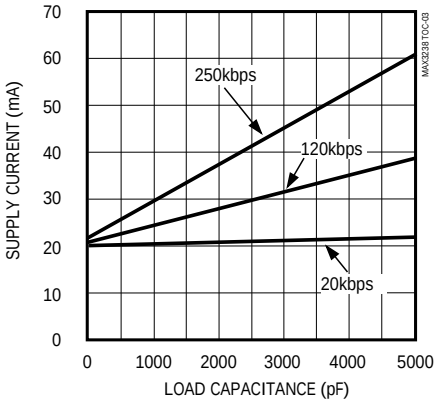
TRANSMITTER OUTPUT VOLTAGE vs. LOAD CAPACITANCE



SLEW RATE vs. LOAD CAPACITANCE



SUPPLY CURRENT vs. LOAD CAPACITANCE WHEN TRANSMITTING DATA



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 ($\overline{\text{FORCEOFF}}$ must be high) (Table 1).
14	$\overline{\text{FORCEOFF}}$	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	$\overline{\text{INVALID}}$	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	V_{CC}	+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

Table 1. Output Control Truth Table

FORCEON	$\overline{\text{FORCEOFF}}$	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 3kΩ 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 ±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).

LapLink is a trademark of Traveling Software.

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

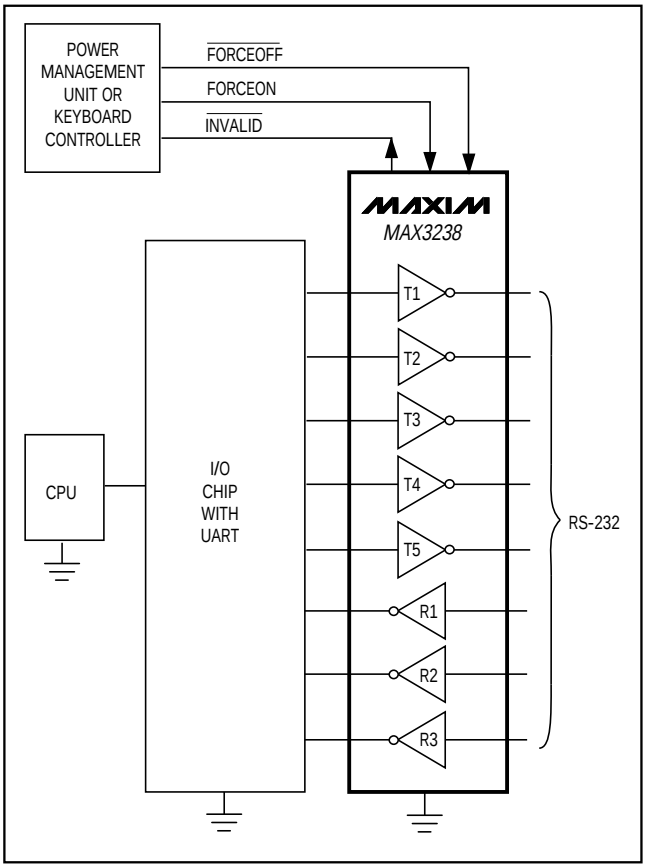


Figure 1. Interface Under Control of PMU

AutoShutdown Plus Mode

1µA supply current is achieved with Maxim's AutoShutdown Plus feature, which operates when FORCEOFF is low and FORCEON is high. 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 1µA. 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).

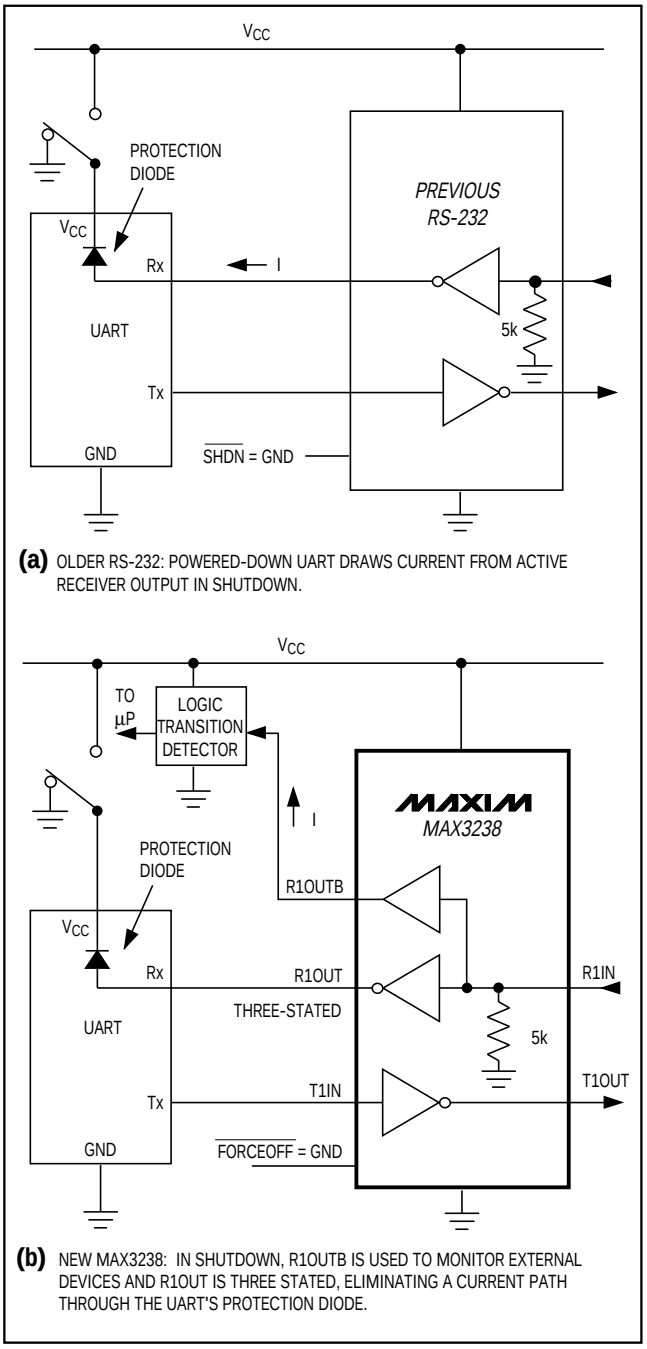


Figure 2. The MAX3238 detects RS-232 activity when the UART and interface are shut down.

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. 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 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 C_{BYPASS},** to maintain the proper ratios (C1 to the other capacitors).

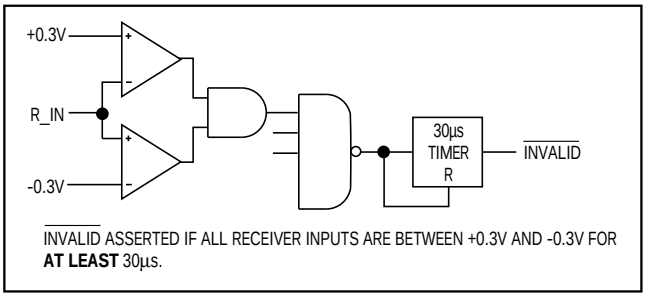


Figure 3a. $\overline{\text{INVALID}}$ Functional Diagram, $\overline{\text{INVALID}}$ Low

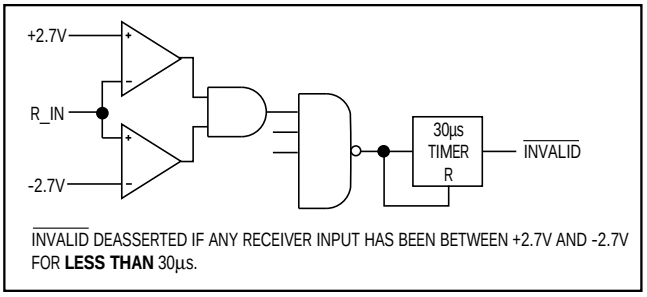


Figure 3b. $\overline{\text{INVALID}}$ Functional Diagram, $\overline{\text{INVALID}}$ High

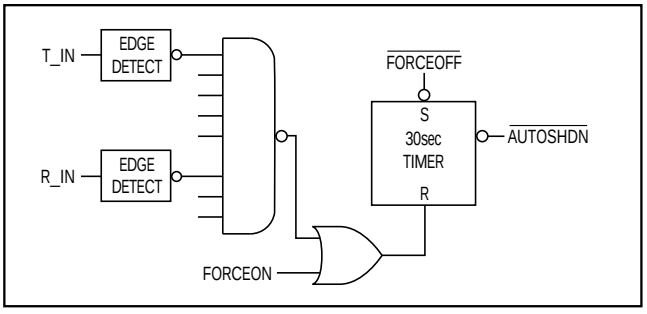


Figure 3c. AutoShutdown Plus Logic

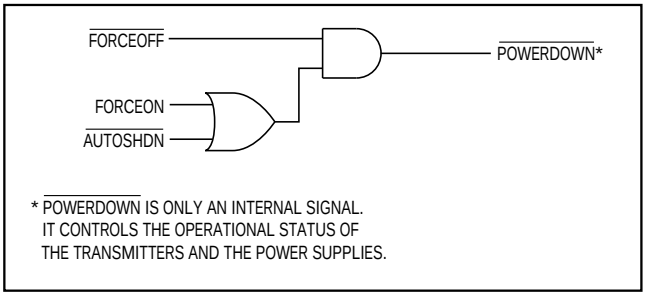


Figure 3d. Power-Down Logic

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

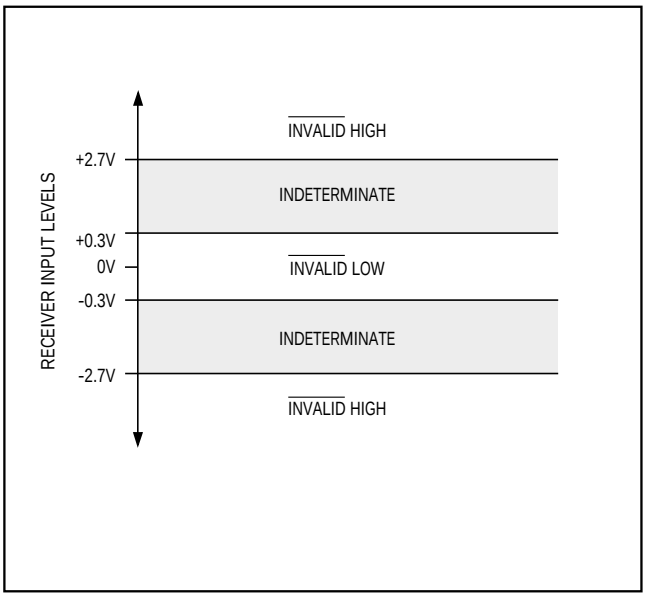


Figure 4a. Receiver Positive/Negative Thresholds for $\overline{INVALID}$

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, C_{BYPASS} (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

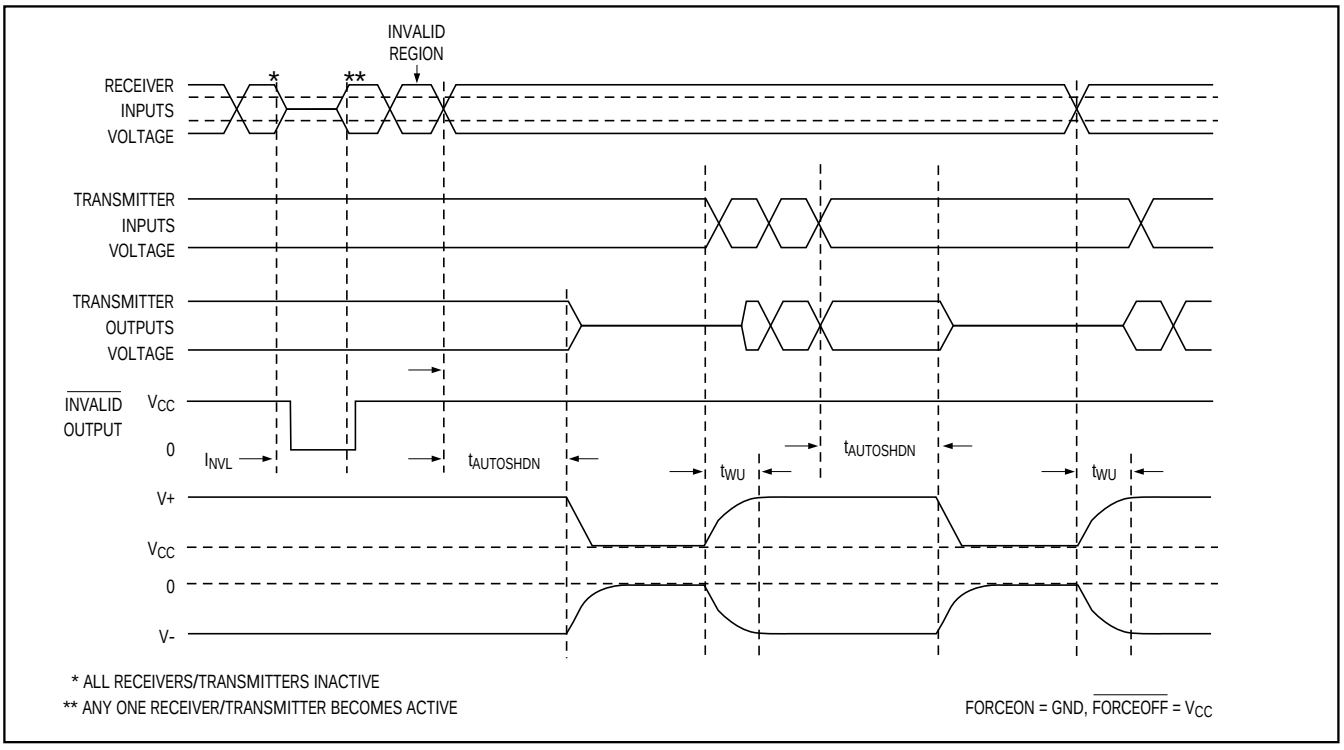


Figure 4b. AutoShutdown Plus and $\overline{INVALID}$ Timing Diagram

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 3kΩ in parallel with 2500pF. The transmitter outputs display no ringing or undesirable transients as they come out of shutdown. Note that the transmitters are enabled only when the magnitude of V- exceeds approximately 3V.

High Data Rates

The MAX3238 maintains the RS-232 ±5.0V minimum transmitter output voltage even at high data rates. Figure 6 shows a transmitter loopback test circuit. Figure 7 shows a loopback test result at 120kbps, and Figure 8 shows the same test at 250kbps. For Figure 7, all transmitters were driven simultaneously at 120kbps into RS-232 loads in parallel with 1000pF. For Figure 8, a single transmitter was driven at 250kbps, and all transmitters were loaded with an RS-232 receiver in parallel with 1000pF.

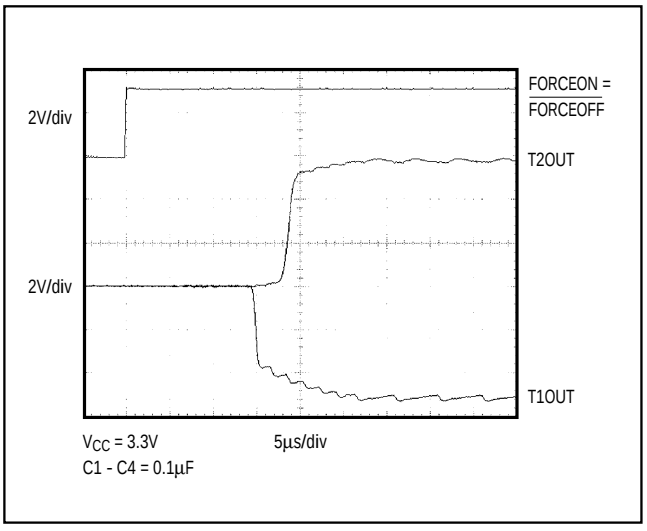


Figure 5. Transmitter Outputs when Exiting Shutdown or Powering Up

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_{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.

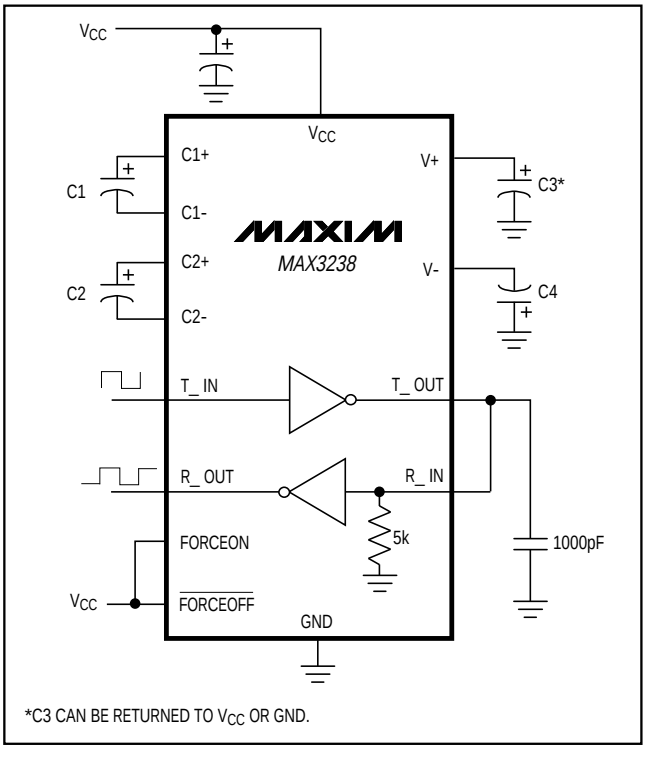


Figure 6. Loopback Test Circuit

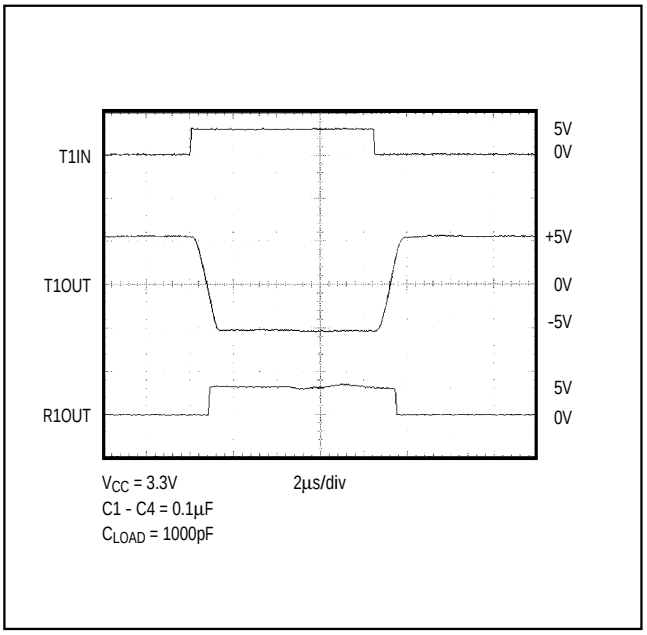


Figure 7. Loopback Test Result at 120kbps

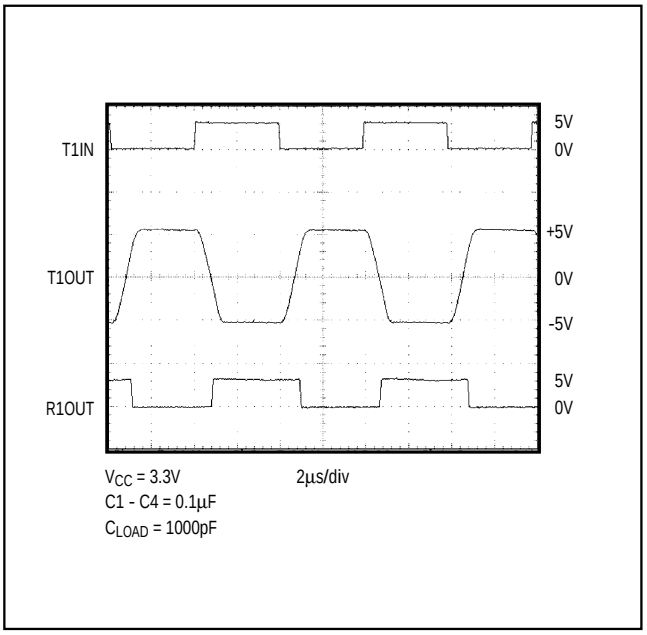
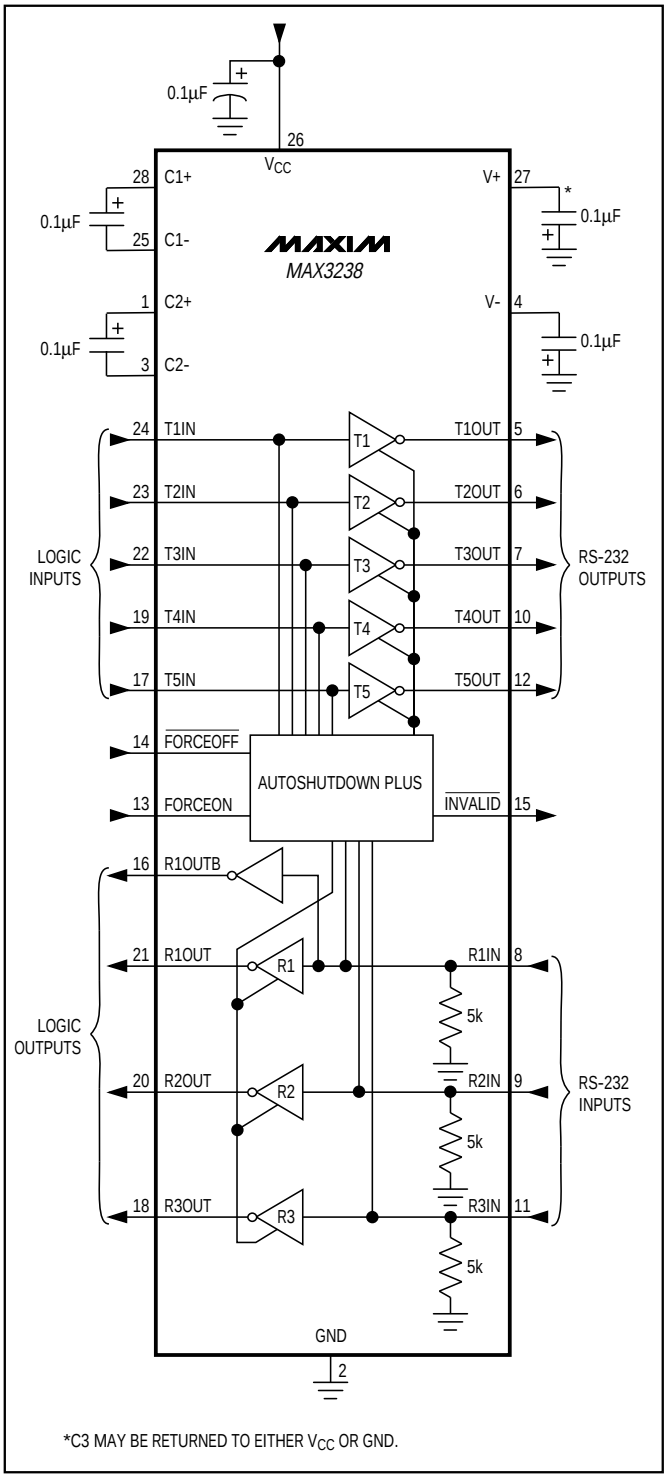


Figure 8. Loopback Test Result at 250kbps

Chip Information

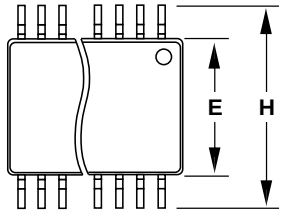
TRANSISTOR COUNT: 1404

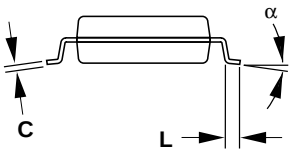
Typical Operating Circuit

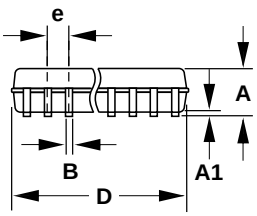


+3.0V to +5.5V, 1µA, up to 250kbps, True RS-232 Transceiver with AutoShutdown Plus™

Package Information







SSOP
SHRINK
SMALL-OUTLINE
PACKAGE

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.068	0.078	1.73	1.99
A1	0.002	0.008	0.05	0.21
B	0.010	0.015	0.25	0.38
C	0.004	0.008	0.09	0.20
D	SEE VARIATIONS			
E	0.205	0.209	5.20	5.38
e	0.0256 BSC		0.65 BSC	
H	0.301	0.311	7.65	7.90
L	0.025	0.037	0.63	0.95
α	0°	8°	0°	8°

DIM	PINS	INCHES		MILLIMETERS	
		MIN	MAX	MIN	MAX
D	14	0.239	0.249	6.07	6.33
D	16	0.239	0.249	6.07	6.33
D	20	0.278	0.289	7.07	7.33
D	24	0.317	0.328	8.07	8.33
D	28	0.397	0.407	10.07	10.33

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