19-2128; Rev 0; 8/01

+2.35V to +5.5V, 1µA, 2Tx/2Rx RS-232 Transceivers with ±15kV ESD-Protected I/O and Logic Pins

General Description

The MAX3380E/MAX3381E are +2.35V to +5.5V-powered EIA/TIA-232 and V.28/V.24 communication interfaces with low power requirements, high data-rate capabilities, and enhanced electrostatic discharge (ESD) protection on both the TTL and RS-232 sides. The MAX3380E/MAX3381E have two receivers and two transmitters. All RS-232 inputs, outputs, and logic input pins are protected to ±15kV using IEC 1000-4-2 Air-Gap Discharge method and the Human Body Model, and ±8kV using IEC 1000-4-2 Contact Discharge method.

The proprietary low-dropout transmitter output stage enables true RS-232 performance from a +3.1V to +5.5V supply with a dual charge pump. The parts reduce the transmitter output levels to RS-232-compatible levels with no increase in supply current for supplies less than +3.1V and greater than +2.35V. The +2.35V to +5.5V operating range is fully compatible with lithium-ion (Li+) batteries. The charge pump requires only four small 0.1µF capacitors for operation.

The MAX3380E/MAX3381E transceivers use Maxim's revolutionary AutoShutdown Plus™ feature to automatically enter a 1µA shutdown mode. These devices shut down the on-board power supply and drivers when they do not sense a valid signal transition for 30 seconds on either the receiver or transmitter inputs.

The MAX3380E is capable of transmitting data at rates of 460kbps while maintaining RS-232 output levels, and the MAX3381E operates at data rates up to 250kbps. The MAX3381E offers a slower slew rate for applications where noise and EMI are issues. The MAX3380E/MAX3381E have a unique V_L pin that allows interoperation in mixed-logic voltage systems down to +1.65V. Both input and output logic levels are referenced to the V_L pin. The MAX3380E/MAX3381E are available in a space-saving TSSOP package.

Applications

Cell Phone Data Lump Cables
PDA Data Lump Cables
GPS Receivers
Digital Cameras

AutoShutdown Plus is a trademark of Maxim Integrated Products

Pin Configuration appears at end of data sheet.

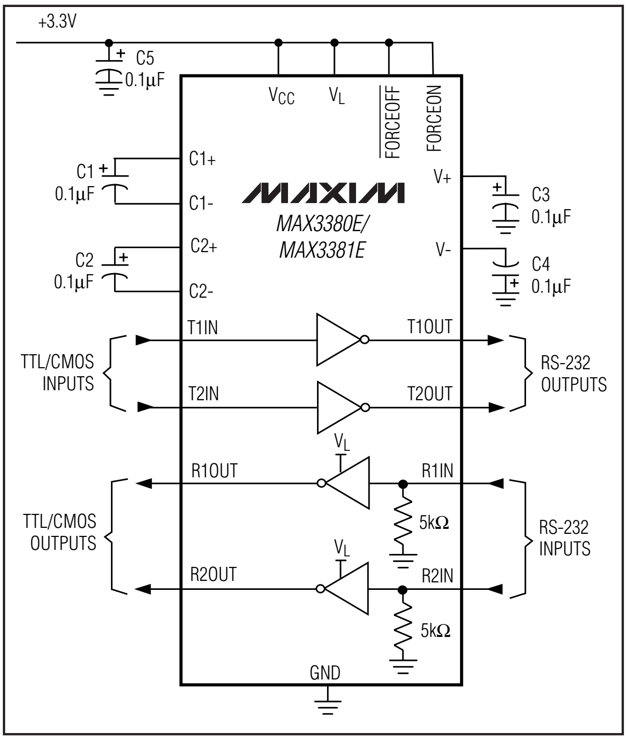
Features

- **±15kV ESD Protection on All CMOS and RS-232 Inputs and Outputs (Except $\overline{INVALID}$)**
  - **±15kV Human Body Model**
  - **±15kV IEC 1000-4-2 Air-Gap Discharge**
  - **±8kV IEC 1000-4-2 Contact Discharge**
- **Operates Over Entire Li+ Battery Range**
- **Low Logic Threshold Down to +1.65V for Compatibility with Cell Phone Logic Supply Voltages**
- **1µA Low-Power AutoShutdown Plus Mode**
- **Compatible with Next-Generation GSM Data Rates**
- **20-Pin TSSOP Package**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX3380ECUP	0°C to +70°C	20 TSSOP
MAX3380EEUP	-40°C to +85°C	20 TSSOP
MAX3381ECUP	0°C to +70°C	20 TSSOP
MAX3381EEUP	-40°C to +85°C	20 TSSOP

Typical Operating Circuit



+2.35V to +5.5V, 1µA, 2Tx/2Rx RS-232 Transceivers with ±15kV ESD-Protected I/O and Logic Pins

ABSOLUTE MAXIMUM RATINGS

V_{CC} to GND ....-0.3V to +6.0V
V_L to GND ....-0.3V to +6.0V
V+ to GND ....-0.3V to +7.0V
V- to GND ....+0.3V to -7.0V
V+ + |V-| (Note 1) ....+13V
Input Voltages
T_IN, FORCEON, $\overline{FORCEOFF}$ to GND ....-0.3V to +6.0V
R_IN to GND ....±25V
Output Voltages
T_OUT to GND ....±13.2V
R_OUT, $\overline{INVALID}$ to GND ....-0.3V to (V_L + 0.3V)

Short-Circuit Duration T_OUT to GND........................Continuous
Continuous Power Dissipation (T_A = +70°C)
20-Pin TSSOP (derate 10.9mW/°C over +70°C) 879mW
Operating Temperature Ranges
MAX3380ECUP/MAX3381ECUP........................0°C to +70°C
MAX3380EEUP/MAX3381EEUP ....-40°C to +85°C
Junction Temperature ....+150°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} = +2.35V to +5.5V, V_L = +1.65V to +5.5V. When V_{CC} < +4.5V, C1 = C2 = C3 = C4 = 0.1µF; when V_{CC} ≥ +4.5V, C1 = 0.047µF, C2 = C3 = C4 = 0.33µF; T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at V_{CC} = V_L = +3.3V, T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Current, AutoShutdown Plus	I_{CC}	Receivers idle, V_{T_IN} = V_{CC} or GND, FORCEON = GND, $\overline{FORCEOFF}$ = V_{CC}				10	µA
		$\overline{FORCEOFF}$ = GND			1	10	
Supply Current, Normal Operation	I_{CC}	FORCEON = $\overline{FORCEOFF}$ = V_L, no load			0.3	1	mA
LOGIC INPUTS (T_IN, FORCEON, $\overline{FORCEOFF}$)							
Input Logic Threshold Low	V_{IL}	V_{CC} = +5.5V, V_L = +5.5V		0.4	1.2		V
		V_{CC} = +2.5V, V_L = +1.65V		0.4			
Input Logic Threshold High	V_{IH}	V_{CC} = +5.5V, V_L = +5.5V				V_L × 0.66	V
		V_{CC} = +2.5V, V_L = +1.65V				V_L × 0.66	
Transmitter Input Hysteresis					0.5		V
Input Leakage Current					±0.01	±1	µA
RECEIVER OUTPUTS (R_OUT) AND $\overline{INVALID}$							
Output Voltage Low		I_{OUT} = 500µA				0.5	V
Output Voltage High		I_{OUT} = -500µA		V_L - 0.4	V_L - 0.2		V
RECEIVER INPUTS (R_IN)							
Input Voltage Range				-25		+25	V
Input Threshold Low		T_A = +25°C	V_L = +3.3V	0.6	1.2		V
			V_L = +5.0V	0.8	1.5		
Input Threshold High		T_A = +25°C	V_L = +3.3V		1.5	2.4	V
			V_L = +5.0V		1.8	2.4	
Input Hysteresis					0.3		V
Input Resistance		T_A = +25°C		3	5	7	kΩ

+2.35V to +5.5V, 1µA, 2Tx/2Rx RS-232 Transceivers with ±15kV ESD-Protected I/O and Logic Pins

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = +2.35V to +5.5V, V_L = +1.65V to +5.5V. When V_{CC} < +4.5V, C1 = C2 = C3 = C4 = 0.1µF; when V_{CC} ≥ +4.5V, C1 = 0.047µF, C2 = C3 = C4 = 0.33µF; T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at V_{CC} = V_L = +3.3V, T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
AutoShutdown Plus (FORCEON = GND, $\overline{\text{FORCEOFF}}$ = V_L)							
Receiver Input Threshold to $\overline{\text{INVALID}}$ Output High		Figure 3	Positive threshold			2.7	V
			Negative threshold	-2.7			
Receiver Input Threshold to $\overline{\text{INVALID}}$ Output Low		Figure 3		-0.3		0.3	V
Receiver Positive or Negative Threshold to $\overline{\text{INVALID}}$ High	t_{INVL}	V_{CC} = +5.0V, Figure 4			0.3		µs
Receiver Positive or Negative Threshold to $\overline{\text{INVALID}}$ Low	t_{INVH}	V_{CC} = +5.0V, Figure 4			30		µs
Receiver or Transmitter Edge to Transmitters Enabled	t_{WU}	V_{CC} = +5.0V, Figure 4			15		µs
Receiver or Transmitter Edge to Transmitters Shutdown	$t_{AUTOSHDN}$	V_{CC} = +5.0V, Figure 4			30		s
TRANSMITTER OUTPUTS							
V_{CC} Mode Switch Point (V_{CC} Falling)		T_OUT = ±5.0V to ±3.7V		2.95	3.1	3.25	V
V_{CC} Mode Switch Point (V_{CC} Rising)		T_OUT = ±3.7V to ±5.5V		3.3	3.5	3.7	V
V_{CC} Mode Switch Point Hysteresis					400		mV
Output Voltage Swing		All transmitter outputs loaded with 3kΩ to ground	V_{CC} = +3.25V to +5.5V, V_{CC} falling	±5	±5.4		V
			V_{CC} = +2.5V to +2.95V, V_{CC} falling	±3.7			
Output Resistance		V_{CC} = 0, transmitter output = ±2.0V		300	10M		Ω
Output Short-Circuit Current						±60	mA
Output Leakage Current		V_{OUT} = ±12V, transmitters disabled				±25	µA
ESD PROTECTION							
R_IN, T_OUT, R_OUT, T_IN, FORCEON, $\overline{\text{FORCEOFF}}$		Human Body Model			±15		kV
		IEC 1000-4-2 Air-Gap Discharge Method			±15		
		IEC 1000-4-2 Contact Discharge Method			±8		

+2.35V to +5.5V, 1µA, 2Tx/2Rx RS-232 Transceivers with ±15kV ESD-Protected I/O and Logic Pins

TIMING CHARACTERISTICS

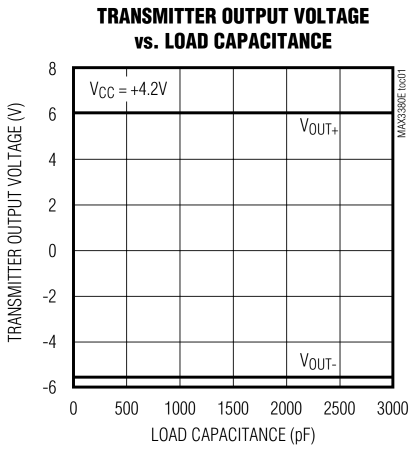
(V_{CC} = +2.35V to +5.5V, V_L = +1.65V to +5.5V. When V_{CC} < +4.5V, C1 = C2 = C3 = C4 = 0.1µF; when V_{CC} ≥ +4.5V, C1 = 0.047µF, C2 = C3 = C4 = 0.33µF; T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at V_{CC} = V_L = +3.3V, T_A = +25°C.)

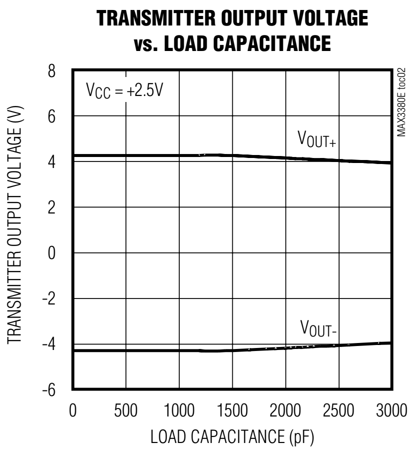
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Maximum Data Rate		R_L = 3kΩ, C_L = 1000pF, one transmitter switching	MAX3381E	250			kbps
			MAX3380E	460			
Receiver Propagation Delay	t_{PLH}	Receiver input to receiver output, C_L = 100pF			0.15		µs
	t_{PHL}				0.15		
Transmitter Skew	$\|t_{PHL} - t_{PLH}\|$	(Note 2)			200		ns
Receiver Skew	$\|t_{PHL} - t_{PLH}\|$				50		ns
Transition Region Slew Rate (MAX3380E)		V_{CC} = +4.2V, -3.0V < T_OUT< +3.0V, R_L = 3kΩ, C_L = 250pF to 1000pF, T_A = +25°C		20		100	V/µs
Transition Region Slew Rate (MAX3381E)		V_{CC} = +4.2V, -3.0V < T_OUT< +3.0V, R_L = 3kΩ, C_L = 150pF to 1000pF, T_A = +25°C		6		30	V/µs
Transition Region Slew Rate (MAX3380E)		V_{CC} = +2.35V, -3.0V < T_OUT< +3.0V, R_L = 3kΩ, C_L = 250pF to 1000pF, T_A = +25°C			30		V/µs
Transition Region Slew Rate (MAX3381E)		V_{CC} = +2.35V, -3.0V < T_OUT< +3.0V, R_L = 3kΩ, C_L = 250pF to 1000pF, T_A = +25°C			10		V/µs

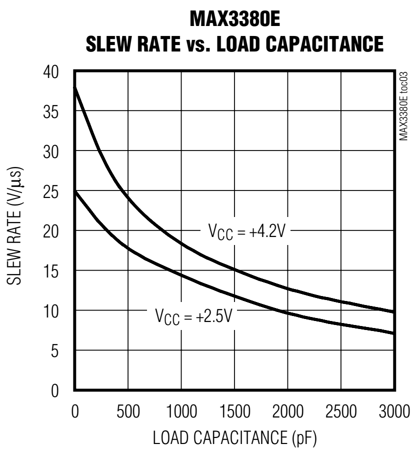
Note 2: Transmitter skew is measured at the transmitter zero crosspoint.

Typical Operating Characteristics

(V_{CC} = V_L = +4.2V, C1 = 0.22µF, C2 = C3 = C4 = 1µF, C5 = 0.1µF parallel with 47µF, R_L = 3kΩ, C_L = 1000pF, data rate is 250kbps, T_A = +25°C, unless otherwise noted.)





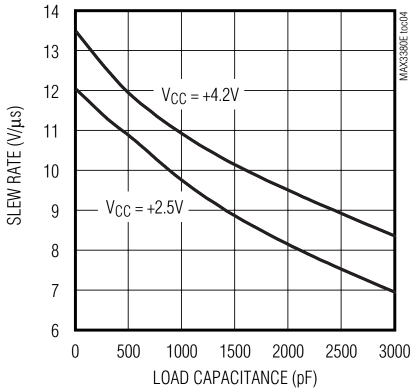


+2.35V to +5.5V, 1µA, 2Tx/2Rx RS-232 Transceivers with ±15kV ESD-Protected I/O and Logic Pins

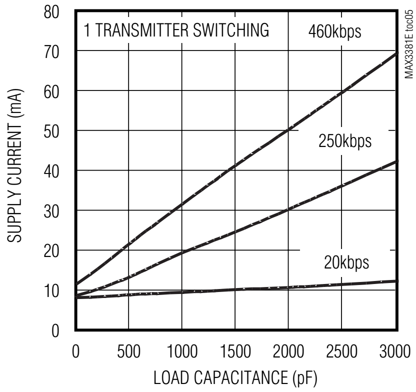
Typical Operating Characteristics (continued)

(V_{CC} = V_L = +4.2V, C1 = 0.22µF, C2 = C3 = C4 = 1µF, C5 = 0.1µF parallel with 47µF, R_L = 3kΩ, C_L = 1000pF, data rate is 250kbps, T_A = +25°C, unless otherwise noted.)

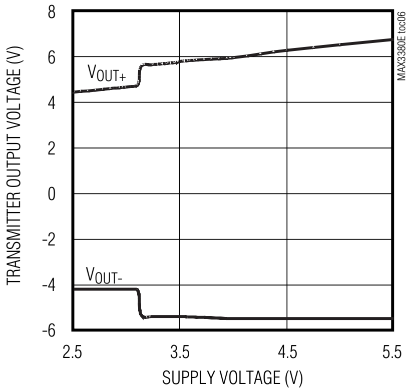
MAX3381E
SLEW RATE vs. LOAD CAPACITANCE



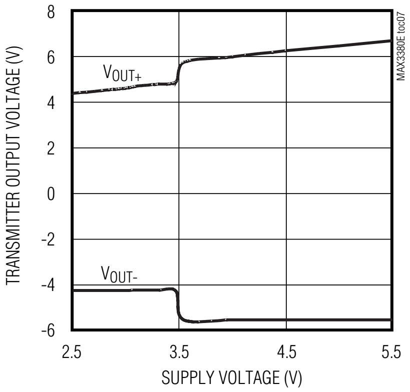
SUPPLY CURRENT vs. LOAD CAPACITANCE WHEN TRANSMITTING DATA



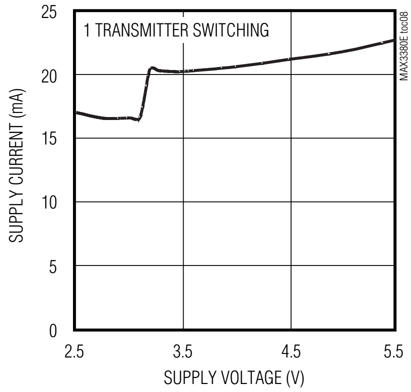
TRANSMITTER OUTPUT VOLTAGE vs. SUPPLY VOLTAGE (V_{CC} FALLING)



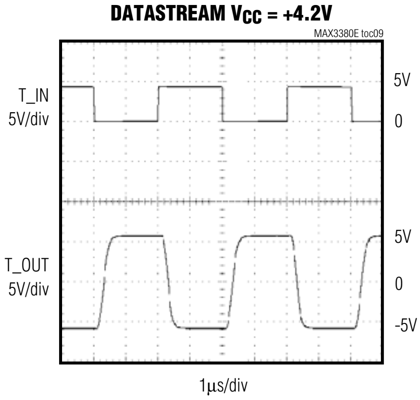
TRANSMITTER OUTPUT VOLTAGE vs. SUPPLY VOLTAGE (V_{CC} RISING)



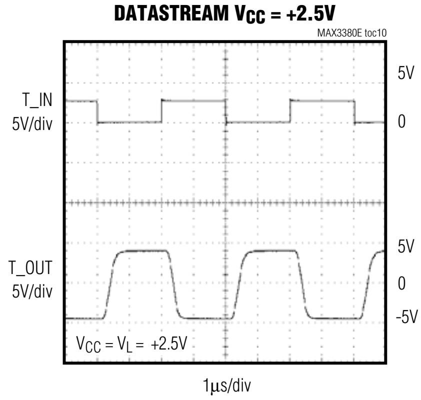
SUPPLY CURRENT vs. SUPPLY VOLTAGE (V_{CC} FALLING)



MAX3380E
DATASTREAM V_{CC} = +4.2V



MAX3380E
DATASTREAM V_{CC} = +2.5V



Pin Description

PIN	NAME	FUNCTION	ESD PROTECTED
1	C1+	Positive Terminal of Voltage-Doubler Charge-Pump Capacitor	—
2	V+	+5.5V/+4.0V Generated by the Charge Pump	—
3	C1-	Negative Terminal of Voltage-Doubler Charge-Pump Capacitor	—
4	C2+	Positive Terminal of Inverting Charge-Pump Capacitor	—
5	C2-	Negative Terminal of Inverting Charge-Pump Capacitor	—
6	V-	-5.5V/-4.0V Generated by the Charge Pump	—
7	$\overline{\text{INVALID}}$	$\overline{\text{INVALID}}$ is asserted if any inputs of the receivers are in an invalid state; $-0.3V < V_{R\_IN} < +0.3V$	—
8, 9	T_IN	TTL/CMOS Transmitter Inputs Referenced to V_L (T1IN, T2IN)	✔
10, 11	R_OUT	TTL/CMOS Receiver Outputs Referenced to V_L (R2OUT, R1OUT)	✔
12	FORCEON	Force-On Input. Drive high to override automatic circuitry keeping transmitters on ($\overline{\text{FORCEOFF}}$ must be high) (Table 1).	✔
13	V_L	Logic Level Supply. +1.65V to +5.5V, sets CMOS logic thresholds and CMOS outputs.	—
14, 15	R_IN	RS-232 Receiver Inputs (R2IN, R1IN)	✔
16, 17	T_OUT	RS-232 Transmitter Outputs (T2OUT, T1OUT)	✔
18	GND	Ground	—
19	$\overline{\text{FORCEOFF}}$	Force-Off Input. Drive low to shut down transmitters and on-board power supply. This overrides all automatic circuitry and FORCEON (Table 1).	✔
20	V_{CC}	+2.35V to +5.5V Supply Voltage	—

Detailed Description

The MAX3380E/MAX3381E are RS-232 transceivers that maximize battery life by reducing current consumption at low battery levels. When the supply voltage is above +3.7V, the RS-232 outputs are at ±5.5V, which is compliant with the RS-232 standard. As the supply voltage drops below the +3.1V set point, the RS-232 outputs change to ±3.7V, which is compatible with the RS-232 standard. The outputs will remain at the compatible levels until the supply voltage rises above +3.5V, where they return to compliant levels. 400mV of hysteresis protects against power-supply bounce that may cause numerous mode changes.

Most devices that use charge pumps to double and invert voltages consume higher current when the supply voltage is less than half of the required output voltage. This is due to the fact that the charge pump is constantly operating because the output voltage is below the regulation voltage. This requires more supply current because the output will never reach the regulation voltage and switch off. The MAX3380E/MAX3381E reduce the output voltage requirement allowing the charge pump to operate with supply voltages down to +2.35V.

Dual-Mode Regulated Charge-Pump Voltage Converter

The MAX3380E/MAX3381Es' internal power supply is a dual-mode regulated charge pump. The output regulation point depends on V_{CC} and the direction in which V_{CC} moves through the switchover region of $+2.95V < V_{CC} < +3.7V$.

For supply voltages above +3.7V, the charge pump will generate +5.5V at V+ and -5.5V at V-. 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.

For supply voltages below +2.95V, the charge pump will generate +4.0V at V+ and -4.0V at V-. The charge pumps operate in a discontinuous mode.

Each charge pump requires a flying capacitor (C1, C2) and a reservoir capacitor (C3, C4) to generate the V+ and V- supplies (see *Typical Operating Circuit*).

+2.35V to +5.5V, 1µA, 2Tx/2Rx RS-232 Transceivers with ±15kV ESD-Protected I/O and Logic Pins

Voltage Generation in the Switchover Region

The MAX3380E/MAX3381E include a switchover circuit between RS-232-compliant and RS-232-compatible modes that has approximately 400mV of hysteresis around the switchover point. The hysteresis is shown in Figure 1. This large hysteresis helps to avoid mode change under battery or power-supply bounce.

Under a decaying V_{CC}, the charge pump will generate an output voltage of ±5.5V with a V_{CC} input range between +3.1V and +5.5V. When V_{CC} drops below the switchover point of +3.1V, the charge pump switches into RS-232-compatible mode generating ±4V.

When V_{CC} is rising, the charge pump will generate an output voltage of ±4.0V, while V_{CC} is between +2.5V and +3.5V. When V_{CC} rises above the switchover voltage of +3.5V, the charge pump switches to RS-232-compliant mode to generate an output voltage of ±5.5V.

RS-232 Transmitters

The transmitters are inverting level translators that convert CMOS-logic levels to RS-232-compatible levels. The MAX3380E/MAX3381E will automatically reduce the RS-232-compliant levels from ±5.5V to ±3.7V when V_{CC} falls below approximately +3.1V. The reduced levels are RS-232-compatible and reduce supply current requirements that help preserve the battery. Built-in hysteresis of approximately 400mV for V_{CC} ensures that the RS-232 output levels do not change if V_{CC} is noisy or has a sudden current draw causing the supply voltage to drop slightly. The outputs will return to RS-232-compliant levels (±5.5V) when V_{CC} rises above approximately +3.5V.

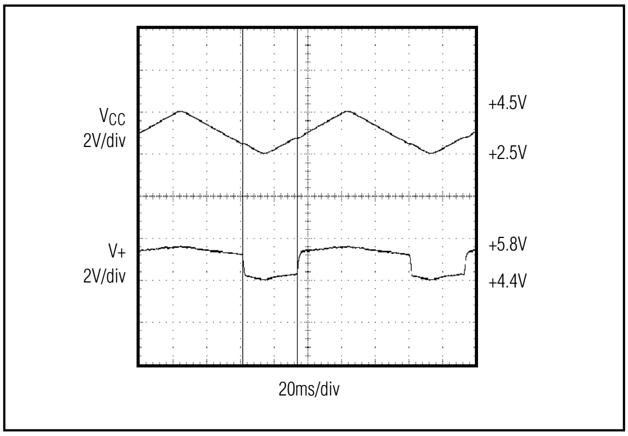


Figure 1. V+ Switchover for Changing Vcc

The MAX3380E/MAX3381E transmitters guarantee a data rate of 460kbps/250kbps, respectively, with worst-case loads of 3kΩ in parallel with 1000pF. Transmitters can be paralleled to drive multiple receivers.

When $\overline{FORCEOFF}$ is driven to ground, the transmitters are disabled and the outputs go into high impedance; receivers remain active. When the AutoShutdown Plus circuitry senses that all receiver and transmitter inputs are inactive for more than 30s, the transmitters are disabled and the outputs go into a high-impedance state, and the receivers remain active. When the power is off, the MAX3380E/MAX3381E permit the outputs to be driven up to ±12V.

The transmitter inputs have a 400kΩ active positive feedback resistor. They will retain a valid logic level if the driving signal is removed or goes high impedance. Connect unused transmitter inputs to V_{CC} or ground.

RS-232 Receivers

The receivers convert RS-232 signals to logic levels referred to V_L. Both receivers are active in shutdown (Table 1).

AutoShutdown Plus Mode

The MAX3380E/MAX3381E achieve a 1µA supply current with Maxim's AutoShutdown Plus feature, which operates when $\overline{FORCEOFF}$ is high and FORCEON is low. When these devices do not sense a valid signal transition on any receiver and transmitter input for 30s, the on-board charge pumps are shut down, reducing supply current to 1µA. This occurs if the RS-232 cable is disconnected or if the connected peripheral transmitters are turned off, and if the UART driving the transmitter inputs is inactive. 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.

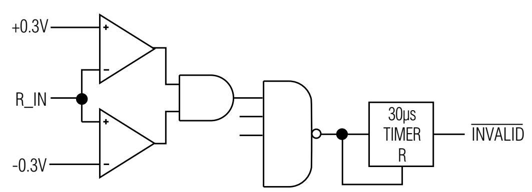
Figures 2a and 2b show valid and invalid RS-232 receiver voltage levels. $\overline{INVALID}$ indicates the receiver input's condition, and is independent of the FORCEON and $\overline{FORCEOFF}$ states. Figure 2 and Table 1 summarize the MAX3380E/MAX3381E's operating modes. FORCEON and $\overline{FORCEOFF}$ override AutoShutdown Plus circuitry. When neither control is asserted, the IC selects between these states automatically based on the last receiver or transmitter input edge received.

By connecting FORCEON to $\overline{INVALID}$, the MAX3380E/MAX3381E is shut down when no valid receiver level and no receiver or transmitter edge is detected for 30s, and wakes up when a receiver or transmitter edge is detected (Figure 2c).

Table 1. AutoShutdown Plus Truth Table

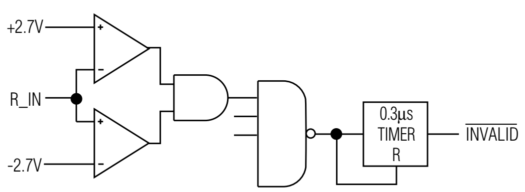
OPERATION STATUS	FORCEON	FORCEOFF	VALID RECEIVER LEVEL	RECEIVER OR TRANSMITTER EDGE WITHIN 30s	T_OUT	R_OUT
Shutdown (Forced Off)	X	0	X	X	High-Z	Active
Normal Operation (Forced On)	1	1	X	X	Active	Active
Normal Operation (AutoShutdown Plus)	0	1	X	Yes	Active	Active
Shutdown (AutoShutdown Plus)	0	1	X	No	High-Z	Active
Normal Operation	INVALID	1	Yes	X	Active	Active
Normal Operation	INVALID	1	X	Yes	Active	Active
Shutdown	INVALID	1	No	No	High-Z	Active
Normal Operation (AutoShutdown)	INVALID	INVALID	Yes	X	Active	Active
Shutdown (AutoShutdown)	INVALID	INVALID	No	X	High-Z	Active

X = Don't care



INVALID ASSERTED IF ALL RECEIVER INPUTS ARE BETWEEN +0.3V AND -0.3V FOR **AT LEAST** 30µs.

Figure 2a. INVALID Functional Diagram, INVALID Low



INVALID DEASSERTED IF ANY RECEIVER INPUT HAS BEEN BETWEEN +2.7V AND -2.7V FOR **LESS THAN** 30µs.

Figure 2b. INVALID Functional Diagram, INVALID High

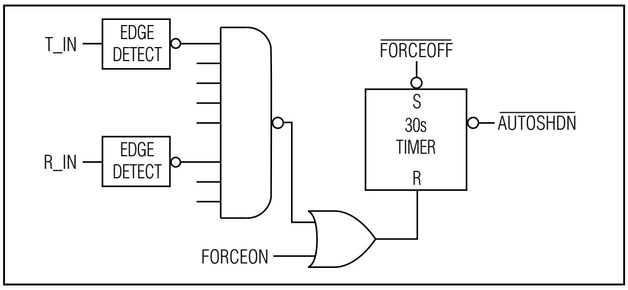


Figure 2c. AutoShutdown Plus Logic

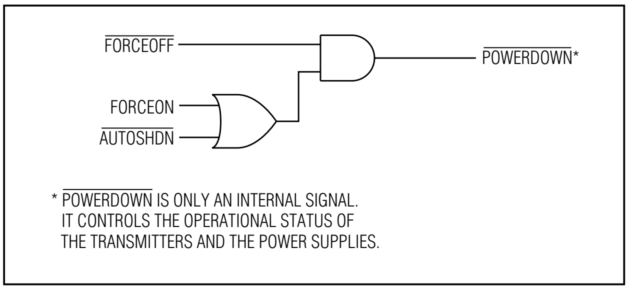


Figure 2d. Power-Down Logic

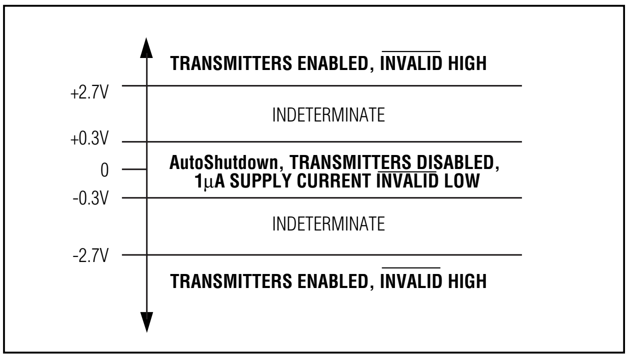


Figure 3. AutoShutdown Trip Levels

By connecting FORCEON and FORCEOFF to INVALID, the MAX3380E/MAX3381E are shut down when no valid receiver level is detected.

V_L Logic Supply Input

Unlike other RS-232 interface devices where the receiver outputs swing between 0 and V_{CC}, the MAX3380E/MAX3381E feature a separate logic supply input (V_L) that sets V_{OH} for the receiver and INVALID outputs. V_L also sets the threshold for the transmitter inputs, FORCEON and FORCEOFF. This feature allows a great deal of flexibility in interfacing to many different types of systems with different logic levels. Connect this input to

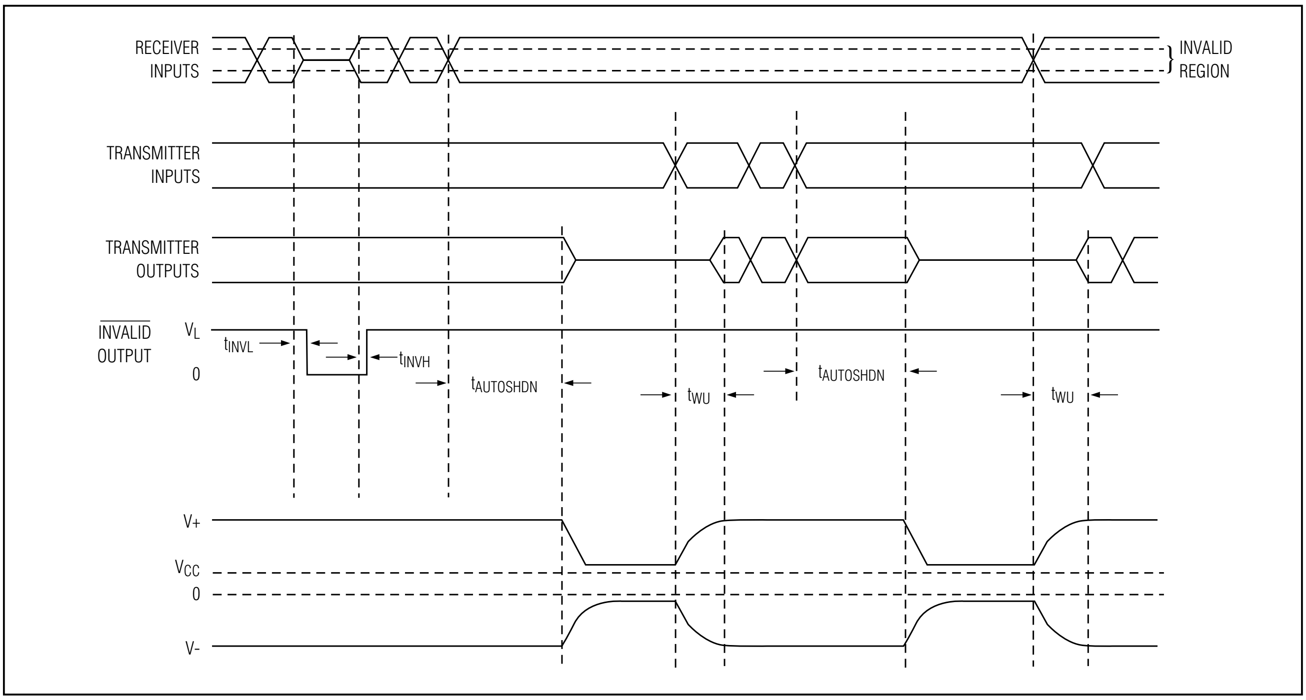


Figure 4. AutoShutdown Plus/INVALID Timing Diagram

+2.35V to +5.5V, 1µA, 2Tx/2Rx RS-232 Transceivers with ±15kV ESD-Protected I/O and Logic Pins

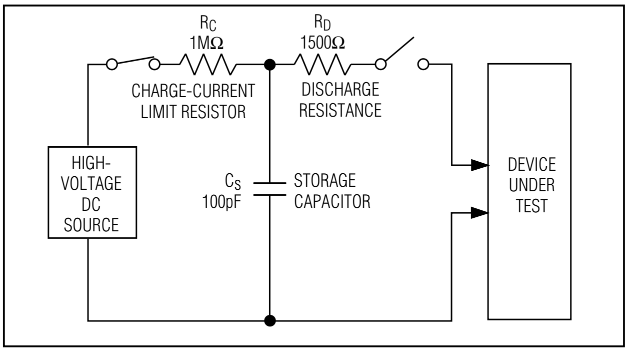


Figure 5a. Human Body ESD Test Model

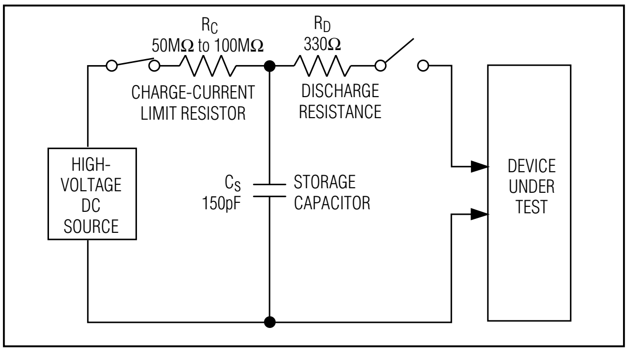


Figure 6a. IEC 1000-4-2 ESD Test Model

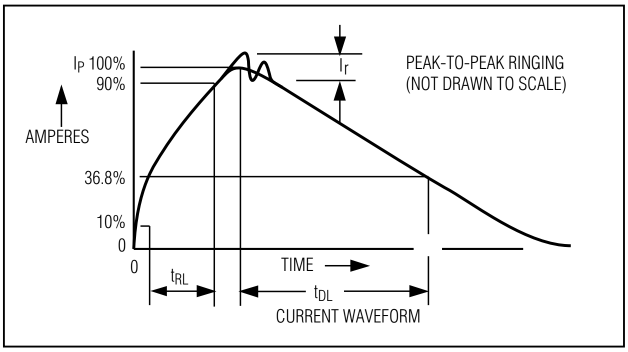


Figure 5b. Human Body Current Waveform

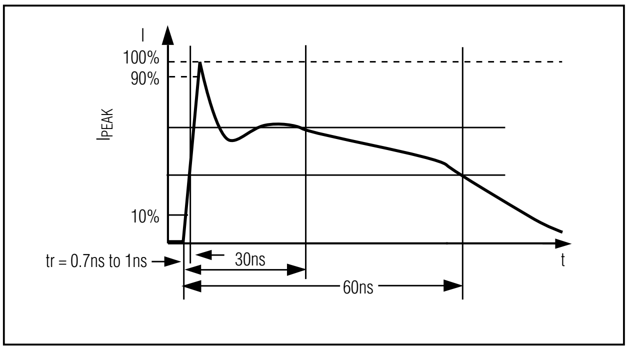


Figure 6b. IEC 1000-4-2 ESD Generator Current Waveform

the host logic supply (+1.65V to +5.5V). The V_L input will draw a maximum current of 20µA with receiver outputs unloaded.

±15kV ESD Protection

Maxim has developed state-of-the-art structures to protect these pins against an ESD of ±15kV without damage. The ESD structures withstand high ESD in all states: normal operation, shutdown, and power-down. After an ESD event, Maxim's "E" version devices keep working without latch-up, whereas competing RS-232 products can latch and must be powered down to remove latch-up. ESD protection can be tested in various ways. The transmitter and receiver outputs and receiver and logic inputs of this product family 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

ESD Test Conditions

ESD performance depends on a variety of conditions. Contact Maxim for a reliability report that documents test setup, methodology, and results.

Human Body Model

Figure 5a shows the Human Body Model, and Figure 5b 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.

IEC 1000-4-2

The IEC 1000-4-2 standard covers ESD testing and performance of finished equipment; it does not specifically refer to ICs. The MAX3380E/MAX3381E 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 voltages measured

+2.35V to +5.5V, 1µA, 2Tx/2Rx RS-232 Transceivers with ±15kV ESD-Protected I/O and Logic Pins

to IEC 1000-4-2 are generally lower than that measured using the Human Body Model. Figure 6a shows the IEC 1000-4-2 model, and Figure 6b shows the current waveform for the ±8kV IEC 1000-4-2 Level 4 ESD Contact Discharge test.

The Air-Gap 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.

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 C5 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 large nominal value. The capacitor's equivalent series resistance (ESR) usually rises at low temperatures and influences the amount of ripple on V+ and V-.

Table 2. Minimum Required Capacitor Values

V_{CC} (V)	C1, C5 (µF)	C2, C3, C4 (µF)
+2.35 to +3.6	0.1	0.1
+4.5 to +5.5	0.047	0.33
+2.35 to +5.5	0.22	1

Power-Supply Decoupling

In most circumstances, connect a 0.1µF capacitor from V_{CC} to GND. This capacitor is for noise reduction. If the MAX3380E/MAX3381E are used in a data cable application, add a 47µF capacitor from V_{CC} to ground. The 47µF capacitor is used to ensure that the current needed during power-up is supplied to the device. In applications that are sensitive to power-supply noise, decouple V_{CC} to ground with a capacitor of the same value as charge-pump capacitor C1. Connect bypass capacitors as close to the IC as possible.

Transmitter Outputs when Recovering from Shutdown

Figure 7 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 1000pF. 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 MAX3380E/MAX3381E maintain the RS-232 ±5.0V minimum transmitter output voltage even at high data rates. Figure 8 shows a transmitter loopback test circuit. Figure 9 shows a loopback test result for the MAX3380E at 460kbps with true RS-232 output voltage levels (V_{CC} = +4.2V). Figure 10 shows the same test with RS-232-compatible levels (V_{CC} = +2.5V). With data rates as high as 460kbps, the MAX3380E is compatible with 2.5-Generation GSM standards.

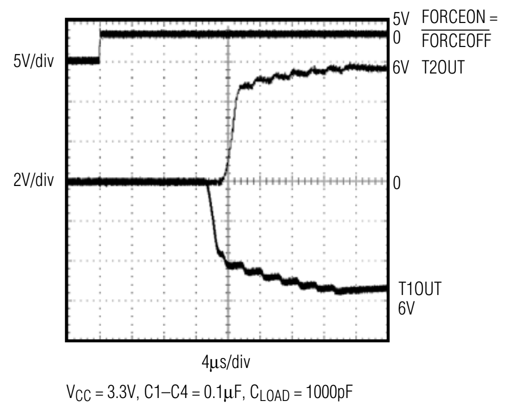


Figure 7. Transmitter Outputs when Recovering from Shutdown or Powering Up

+2.35V to +5.5V, 1µA, 2Tx/2Rx RS-232 Transceivers with ±15kV ESD-Protected I/O and Logic Pins

For Figure 9 and Figure 10, a single transmitter was driven at 460kbps, and all transmitters were loaded with an RS-232 receiver in parallel with 1000pF.

Data Cable Applications

The MAX3380E/MAX3381Es' ±15kV ESD protection on both the RS-232 I/Os as well as the logic I/Os makes them ideal candidates for data cable applications. A data cable is both an electrical connection and a level translator, allowing ultra-miniaturization of cell phones and other small portable devices.

Previous data cable approaches suffered from complexity due to the required protection circuits on both the logic side of the cable, as well as on the RS-232 connections. The example shown in Figure 11 shows the ease of using the MAX3380E/MAX3381E in data cable applications. For best performance, keep the logic level lines short and use the RS-232 level lines to span any distance.

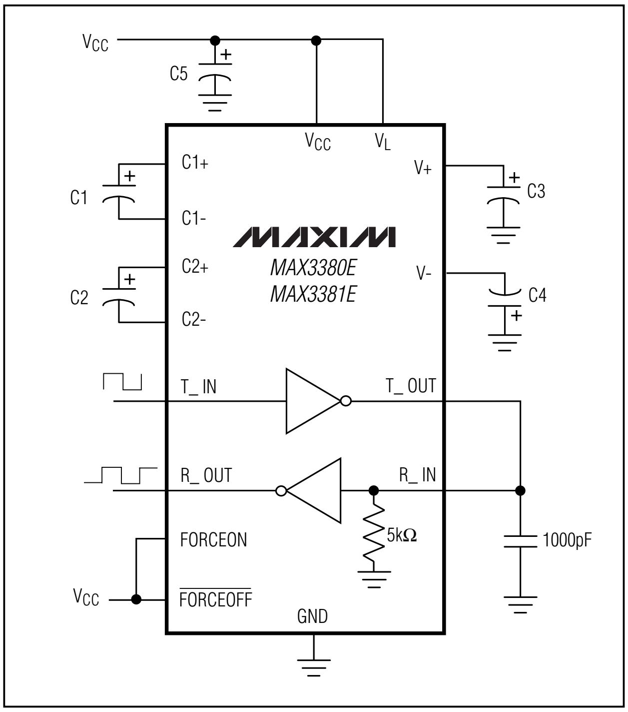


Figure 8. Loopback Test Circuit

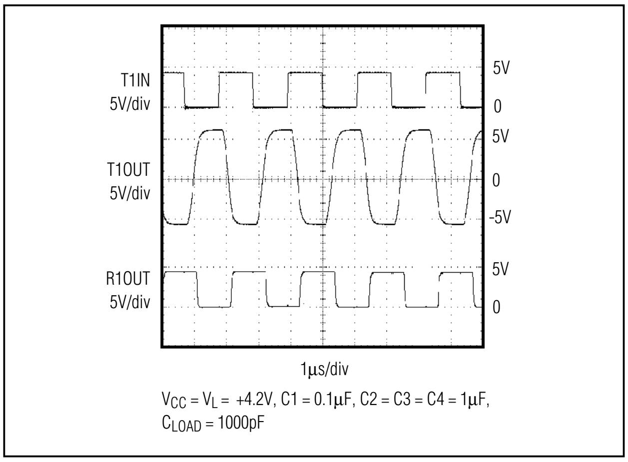


Figure 9. Loopback Test Results at 460kbps (V_{CC} = +4.2V)

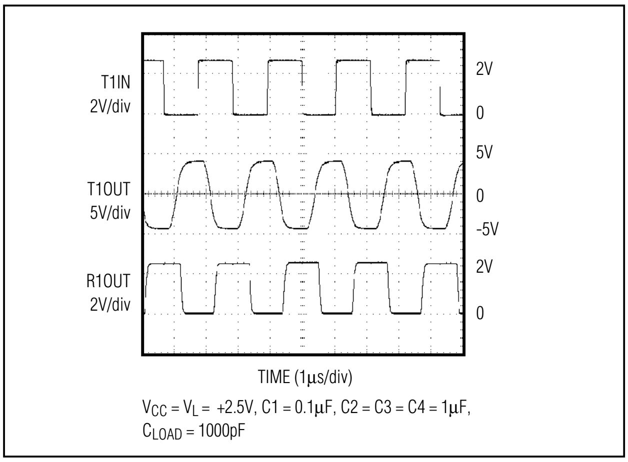


Figure 10. Loopback Test Results at 460kbps (V_{CC} = +2.5V)

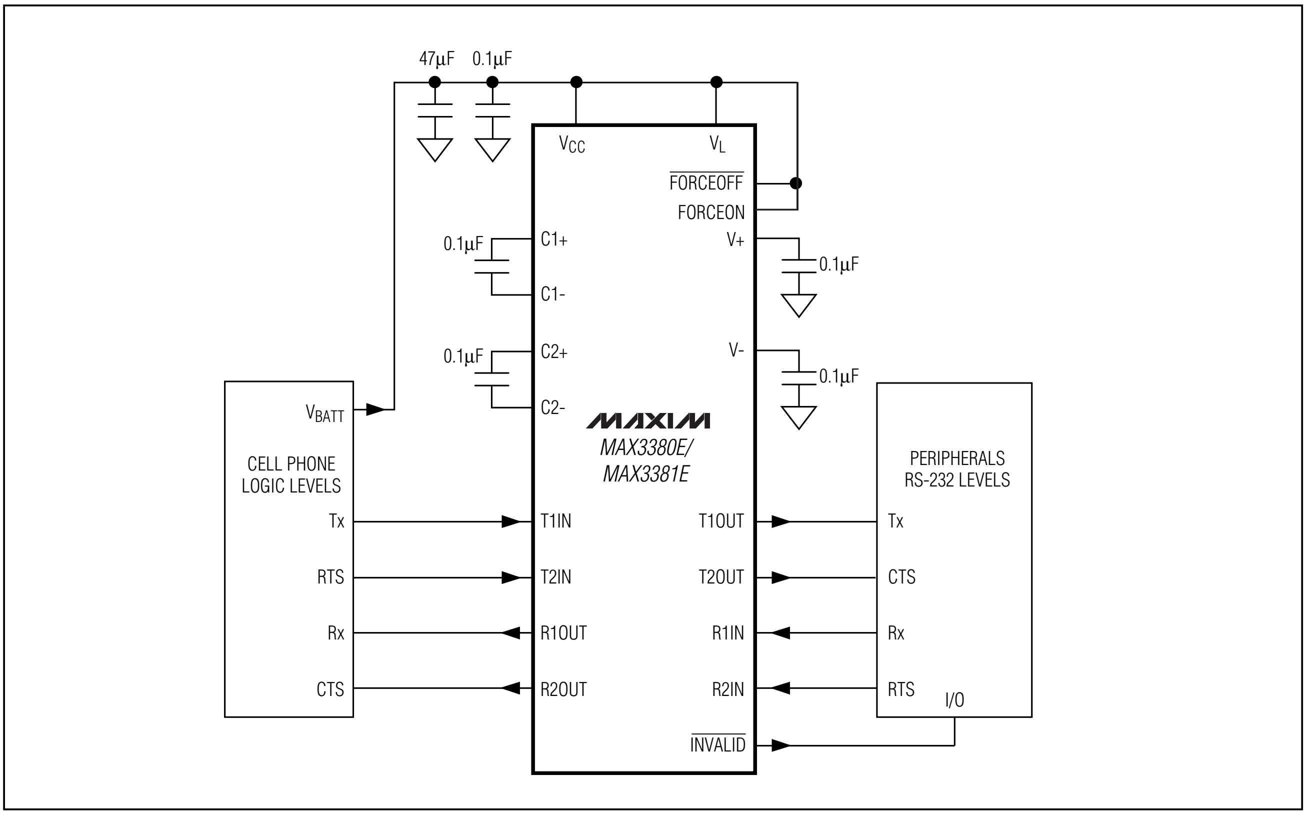
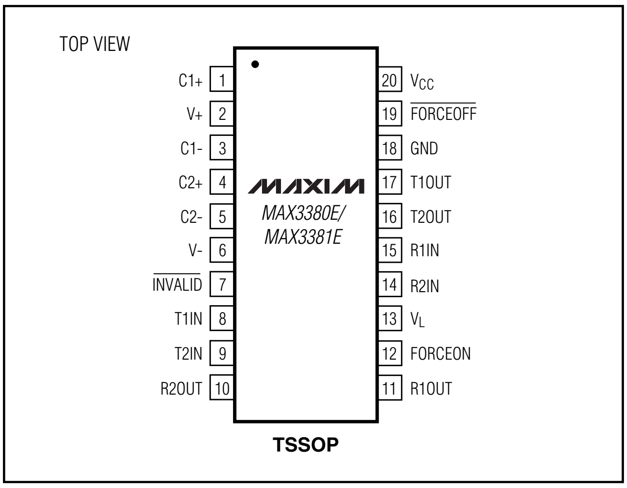


Figure 11. Typical Application Circuit

Pin Configuration



Chip Information

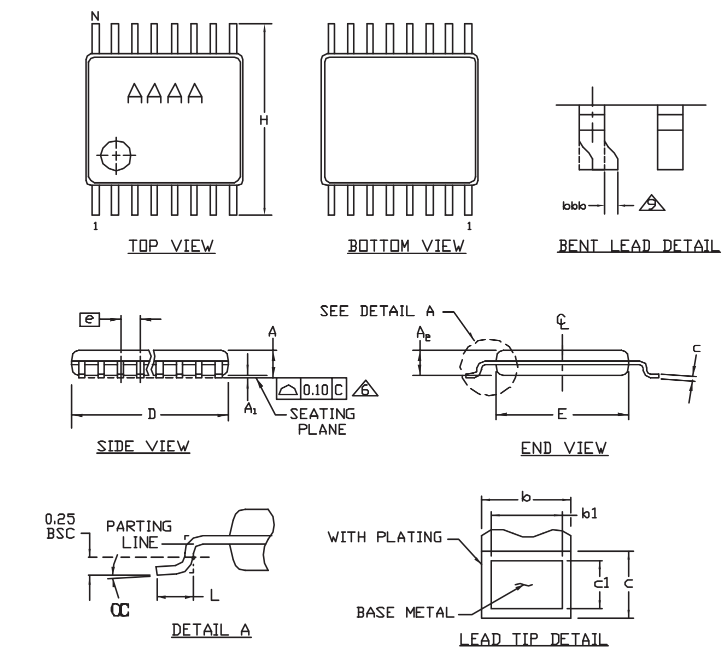
TRANSISTOR COUNT: 1467

PROCESS: BiCMOS

+2.35V to +5.5V, 1µA, 2Tx/2Rx RS-232 Transceivers with ±15kV ESD-Protected I/O and Logic Pins

Package Information (continued)

(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**.)



TSSOP4.40mm.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
b_1	0.19	0.25	.007	.010
c	0.09	0.20	.004	.008
c_1	0.09	0.14	.004	.006
D	SEE VARIATIONS		SEE VARIATIONS	
E	4.30	4.50	.169	.177
e	0.65 BSC		.026 BSC	
H	6.25	6.55	.246	.258
L	0.50	0.70	.020	.028
N	SEE VARIATIONS		SEE VARIATIONS	
α	0°	8°	0°	8°
bbb	0.10 MAX			

JEDEC MO-153	N		PKG. CODES	VARIATIONS			
				MILLIMETERS		INCHES	
				MIN.	MAX.	MIN.	MAX.
AB-1	14	D	U14-1, U14-2	4.90	5.10	.193	.201
AB	16	D	U16-1, U16-2	4.90	5.10	.193	.201
AC	20	D	U20-2, U20-3	6.40	6.60	.252	.260
AD	24	D	U24-1	7.70	7.90	.303	.311
AE	28	D	U28-1, U28-2, U28-3	9.60	9.80	.378	.386

NOTES
1. DIMENSIONS D AND E DO NOT INCLUDE FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm PER SIDE
3. CONTROLLING DIMENSION: MILLIMETER
4. MEETS JEDEC OUTLINE MO-153. SEE JEDEC VARIATIONS TABLE
5. "N" REFERS TO NUMBER OF LEADS
6. LEAD COPLANARITY 0.10 MM MAX.
7. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY
8. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY
9. BENT LEAD 0.10 MM MAX.

-DRAWING NOT TO SCALE-

DALLAS SEMICONDUCTOR MAXIM
TITLE: PACKAGE OUTLINE, TSSOP 4.40mm BODY
APPROVAL | DOCUMENT CONTROL NO. 21-0066 | REV. I | 1/1