



# +2.5V to +5.5V RS-232 Transceivers in UCSP

## General Description

The MAX3228/MAX3229 are +2.5V to +5.5V powered EIA/TIA-232 and V.28/V.24 communications interfaces with low power requirements, and high data-rate capabilities, in a chip-scale package (UCSP™).

The MAX3228/MAX3229 achieve a 1µA supply current with Maxim's AutoShutdown™ feature. They save power without changes to existing BIOS or operating systems by entering low-power shutdown mode when the RS-232 cable is disconnected, or when the transmitters of the connected peripherals are off.

The transceivers have a proprietary low-dropout transmitter output stage, delivering RS-232 compliant performance from a +3.1V to +5.5V supply, and RS-232 compatible performance with a supply voltage as low as +2.5V. The dual charge pump requires only four small 0.1µF capacitors for operation from a +3.0V supply. Each device is guaranteed to run at data rates of 250kbps while maintaining RS-232 output levels.

The MAX3228/MAX3229 offer a separate power-supply input for the logic interface, allowing configurable logic levels on the receiver outputs and transmitter inputs. Operating over a +1.65V to V<sub>CC</sub> range, V<sub>L</sub> provides the MAX3228/MAX3229 compatibility with multiple logic families.

The MAX3229 contains one receiver and one transmitter. The MAX3228 contains two receivers and two transmitters. The MAX3228/MAX3229 are available in tiny chip-scale packaging and are specified across the extended industrial temperature range of -40°C to +85°C.

## Applications

Personal Digital Assistants  
Cell Phone Data Lump Cables  
Set-Top Boxes  
Hand-Held Devices  
Cell Phones

**Typical Operating Circuits continued at end of data sheet.**

**Pin Configurations appear at end of data sheet.**

UCSP is a trademark of Maxim Integrated Products, Inc.

AutoShutdown is a trademark of Maxim Integrated Products, Inc.

## Features

- ◆ 6 × 5 Chip-Scale Packaging (UCSP)
- ◆ 1µA Low-Power AutoShutdown
- ◆ 250kbps Guaranteed Data Rate
- ◆ Meets EIA/TIA-232 Specifications Down to +3.1V
- ◆ RS-232 Compatible to +2.5V Allows Operation from Single Li+ Cell
- ◆ Small 0.1µF Capacitors
- ◆ Configurable Logic Levels

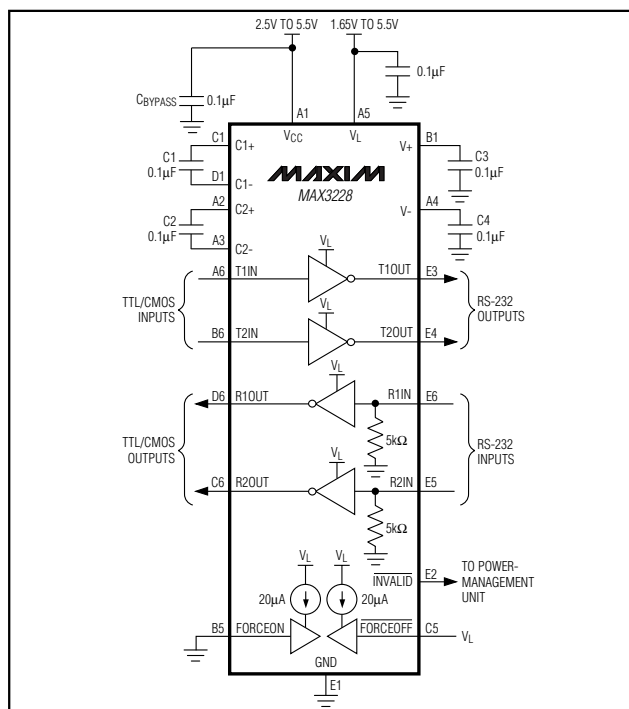
## Ordering Information

| PART       | TEMP. RANGE    | PIN-PACKAGE |
|------------|----------------|-------------|
| MAX3228EBV | -40°C to +85°C | 6 × 5 UCSP* |
| MAX3229EBV | -40°C to +85°C | 6 × 5 UCSP* |

\*Requires solder temperature profile described in the Absolute Maximum Ratings section.

\*UCSP reliability is integrally linked to the user's assembly methods, circuit board material, and environment. Refer to the UCSP Reliability Notice in the UCSP Reliability section of this data sheet for more information.

## Typical Operating Circuits



# +2.5V to +5.5V RS-232 Transceivers in UCSP

## ABSOLUTE MAXIMUM RATINGS

|                                            |                                       |
|--------------------------------------------|---------------------------------------|
| V <sub>CC</sub> to GND                     | .....-0.3V to +6.0V                   |
| V <sub>+</sub> to GND                      | .....-0.3V to +7.0V                   |
| V <sub>-</sub> to GND                      | .....+0.3V to -7.0V                   |
| V <sub>+</sub> to IV-I (Note 1)            | .....+13V                             |
| V <sub>L</sub> to GND                      | .....-0.3V to +6.0V                   |
| Input Voltages                             |                                       |
| T <sub>IN</sub> , FORCEON, FORCEOFF to GND | .....-0.3V to (V <sub>L</sub> + 0.3V) |
| R <sub>IN</sub> to GND                     | .....±25V                             |
| Output Voltages                            |                                       |
| T <sub>OUT</sub> to GND                    | .....±13.2V                           |
| R <sub>OUT</sub> to GND                    | .....-0.3V to (V <sub>L</sub> + 0.3V) |

|                                                            |                                        |
|------------------------------------------------------------|----------------------------------------|
| INVALID to GND                                             | .....-0.3V to (V <sub>CC</sub> + 0.3V) |
| Short-Circuit Duration T <sub>OUT</sub> to GND             | .....Continuous                        |
| Continuous Power Dissipation (T <sub>A</sub> = +70°C)      |                                        |
| 6 × 5 UCSP (derate 10.1mW/°C above T <sub>A</sub> = +70°C) | ...805mW                               |
| Operating Temperature Range                                | .....-40°C to +85°C                    |
| Junction Temperature                                       | .....+150°C                            |
| Storage Temperature Range                                  | .....-65°C to +150°C                   |
| Bump Temperature (Soldering) (Note 2)                      |                                        |
| Infrared (15s)                                             | .....+200°C                            |
| Vapor Phase (20s)                                          | .....+215°C                            |

**Note 1:** V<sub>+</sub> and V<sub>-</sub> can have maximum magnitudes of 7V, but their absolute difference cannot exceed 13V.

**Note 2:** This device is constructed using a unique set of packaging techniques that impose a limit on the thermal profile the device can be exposed to during board level solder attach and rework. This limit permits only the use of the solder profiles recommended in the industry-standard specification, JEDEC 020A, paragraph 7.6, Table 3 for IR/VPB and convection reflow. Pre-heating is required. Hand or wave soldering is not allowed.

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> = +2.5V to +5.5V, V<sub>L</sub> = +1.65V to +5.5V, C<sub>1</sub>–C<sub>4</sub> = 0.1μF, tested at +3.3V ±10%, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>. Typical values are at T<sub>A</sub> = +25°C, unless otherwise noted.) (Note 3)

| PARAMETER                                                | SYMBOL          | CONDITIONS                                                                  | MIN                   | TYP                   | MAX | UNITS |
|----------------------------------------------------------|-----------------|-----------------------------------------------------------------------------|-----------------------|-----------------------|-----|-------|
| DC CHARACTERISTICS                                       |                 |                                                                             |                       |                       |     |       |
| V <sub>L</sub> Input Voltage Range                       | V <sub>L</sub>  |                                                                             | 1.65                  | V <sub>CC</sub> + 0.3 |     | V     |
| V <sub>CC</sub> Supply Current,<br>AutoShutdown          | I <sub>CC</sub> | FORCEON = GND<br>FORCEOFF = V <sub>L</sub> , all R <sub>IN</sub> open       |                       | 10                    |     | μA    |
|                                                          |                 | FORCEOFF = GND                                                              |                       | 10                    |     | μA    |
|                                                          |                 | FORCEON, FORCEOFF floating                                                  |                       | 1                     |     | mA    |
| V <sub>CC</sub> Supply Current,<br>AutoShutdown Disabled | I <sub>CC</sub> | FORCEON = FORCEOFF = V <sub>L</sub><br>no load                              |                       | 0.3                   | 1   | mA    |
| V <sub>L</sub> Supply Current                            | I <sub>L</sub>  | FORCEON or FORCEOFF = GND, V <sub>CC</sub> =<br>V <sub>L</sub> = +5v        |                       | 85                    |     | μA    |
|                                                          |                 | FORCEON, FORCEOFF floating                                                  |                       | 1                     |     |       |
| LOGIC INPUTS                                             |                 |                                                                             |                       |                       |     |       |
| Pullup Currents                                          |                 | FORCEON, FORCEOFF to V <sub>L</sub>                                         | 20                    |                       |     | μA    |
| Input Logic Low                                          |                 | T <sub>IN</sub> , FORCEON, FORCEOFF                                         |                       | 0.4                   |     | V     |
| Input Logic High                                         |                 | T <sub>IN</sub> , FORCEON, FORCEOFF                                         | 0.66 × V <sub>L</sub> |                       |     | V     |
| Transmitter Input Hysteresis                             |                 |                                                                             |                       | 0.5                   |     | V     |
| Input Leakage Current                                    |                 | T <sub>IN</sub>                                                             | ±0.01                 | ±1                    |     | μA    |
| RECEIVER OUTPUTS                                         |                 |                                                                             |                       |                       |     |       |
| Output Leakage Currents                                  |                 | R <sub>OUT</sub> , receivers disabled, FORCEOFF =<br>GND or in AutoShutdown |                       | ±10                   |     | μA    |
| Output Voltage Low                                       |                 | I <sub>OUT</sub> = 0.8mA                                                    |                       | 0.4                   |     | V     |
| Output Voltage High                                      |                 | I <sub>OUT</sub> = -0.5mA                                                   | V <sub>L</sub> - 0.4  | V <sub>L</sub> - 0.1  |     | V     |

# **+2.5V to +5.5V RS-232 Transceivers in UCSP**

**MAX3228/MAX3229**

## **ELECTRICAL CHARACTERISTICS (continued)**

(V<sub>CC</sub> = +2.5V to +5.5V, V<sub>L</sub> = +1.65V to +5.5V, C1–C4 = 0.1μF, tested at +3.3V ±10%, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>. Typical values are at T<sub>A</sub> = +25°C, unless otherwise noted.) (Note 3)

| PARAMETER                                                      | SYMBOL            | CONDITIONS                                                                    |                                                           | MIN                                         | TYP  | MAX | UNITS |
|----------------------------------------------------------------|-------------------|-------------------------------------------------------------------------------|-----------------------------------------------------------|---------------------------------------------|------|-----|-------|
| RECEIVER INPUTS                                                |                   |                                                                               |                                                           |                                             |      |     |       |
| Input Voltage Range                                            |                   |                                                                               |                                                           | -25                                         |      | +25 | V     |
| Input Threshold Low                                            |                   | T <sub>A</sub> = +25°C                                                        | V <sub>CC</sub> = 3.3V                                    | 0.6                                         | 1.2  |     | V     |
|                                                                |                   |                                                                               | V <sub>CC</sub> = 5.0V                                    | 0.8                                         | 1.7  |     |       |
| Input Threshold High                                           |                   | T <sub>A</sub> = +25°C                                                        | V <sub>CC</sub> = 3.3V                                    |                                             | 1.3  | 2.4 | V     |
|                                                                |                   |                                                                               | V <sub>CC</sub> = 5.0V                                    |                                             | 1.8  | 2.4 |       |
| Input Hysteresis                                               |                   |                                                                               |                                                           |                                             | 0.5  |     | V     |
| Input Resistance                                               |                   |                                                                               |                                                           | 3                                           | 5    | 7   | kΩ    |
| AUTOSHUTDOWN                                                   |                   |                                                                               |                                                           |                                             |      |     |       |
| Receiver Input Threshold to <u>INVALID</u> Output High         |                   | Figure 3a                                                                     | Positive threshold                                        |                                             |      | 2.7 | V     |
|                                                                |                   |                                                                               | Negative threshold                                        | -2.7                                        |      |     |       |
| Receiver Input Threshold to <u>INVALID</u> Output Low          |                   |                                                                               |                                                           | -0.3                                        |      | 0.3 | V     |
| Receiver Positive or Negative Threshold to <u>INVALID</u> High | t <sub>INVH</sub> | V <sub>CC</sub> = +5.0V, Figure 3b                                            |                                                           | 1                                           |      |     | μs    |
| Receiver Positive or Negative Threshold to <u>INVALID</u> Low  | t <sub>INVL</sub> | V <sub>CC</sub> = +5.0V, Figure 3b                                            |                                                           | 30                                          |      |     | μs    |
| Receiver Edge to Transmitters Enabled                          | t <sub>WU</sub>   | V <sub>CC</sub> = +5.0V, Figure 3b                                            |                                                           | 100                                         |      |     | μs    |
| TRANSMITTER OUTPUTS                                            |                   |                                                                               |                                                           |                                             |      |     |       |
| V <sub>CC</sub> Mode Switch Point (V <sub>CC</sub> Falling)    |                   | T <sub>OUT</sub> = ±5.0V to ±3.7V                                             |                                                           | 2.85                                        |      | 3.1 | V     |
| V <sub>CC</sub> Mode Switch Point (V <sub>CC</sub> Rising)     |                   | T <sub>OUT</sub> = ±3.7V to ±5.0V                                             |                                                           | 3.3                                         |      | 3.7 | V     |
| V <sub>CC</sub> Mode Switch Point Hysteresis                   |                   |                                                                               |                                                           | 400                                         |      |     | mV    |
| Output Voltage Swing                                           |                   | All transmitter outputs loaded with 3kΩ to ground.                            | V <sub>CC</sub> = +3.1V to +5.5V, V <sub>CC</sub> falling | ±5                                          | ±5.4 |     | V     |
|                                                                |                   |                                                                               | V <sub>CC</sub> = +2.5V to +2.9V                          | ±3.7                                        |      |     |       |
| Output Resistance                                              |                   | V <sub>CC</sub> = V <sub>+</sub> = V <sub>-</sub> = 0, T <sub>OUT</sub> = ±2V |                                                           | 300                                         | 10M  |     | Ω     |
| Output Short-Circuit Current                                   |                   |                                                                               |                                                           |                                             |      | ±60 | mA    |
| Output Leakage Current                                         |                   | T <sub>OUT</sub> = ±12V, transmitters disabled                                |                                                           |                                             |      | ±25 | μA    |
| INVALID OUTPUT                                                 |                   |                                                                               |                                                           |                                             |      |     |       |
| Output Voltage Low                                             |                   | I <sub>OUT</sub> = 0.8mA                                                      |                                                           |                                             |      | 0.4 | V     |
| Output Voltage High                                            |                   | I <sub>OUT</sub> = -0.5mA                                                     |                                                           | V <sub>CC</sub> - 0.4 V <sub>CC</sub> - 0.1 |      |     | V     |

# +2.5V to +5.5V RS-232 Transceivers in UCSP

## TIMING CHARACTERISTICS

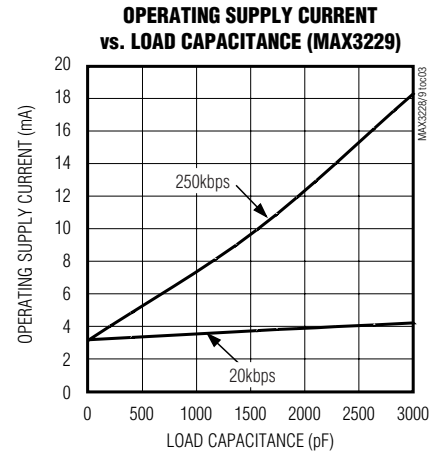
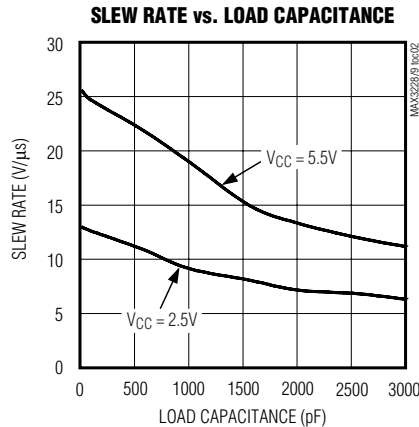
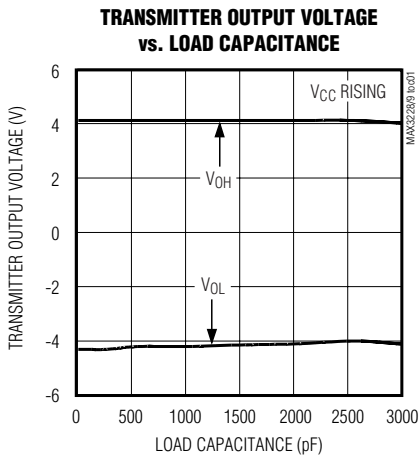
( $V_{CC} = +2.5V$  to  $+5.5V$ ,  $V_L = +1.65V$  to  $+5.5V$ ,  $C_1$ – $C_4 = 0.1\mu F$ , tested at  $+3.3V \pm 10\%$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ . Typical values are at  $T_A = +25^\circ C$ , unless otherwise noted.) (Note 3)

| PARAMETER                    | SYMBOL                | CONDITIONS                                                                       | MIN | TYP  | MAX | UNITS     |
|------------------------------|-----------------------|----------------------------------------------------------------------------------|-----|------|-----|-----------|
| Maximum Data Rate            |                       | $R_L = 3k\Omega$ , $C_L = 1000pF$ , one transmitter switching                    | 250 |      |     | kbps      |
| Receiver Propagation Delay   |                       | Receiver input to receiver output, $C_L = 150pF$                                 |     | 0.15 |     | $\mu s$   |
| Receiver Output Enable-Time  |                       | $V_{CC} = V_L = +5V$                                                             |     | 200  |     | ns        |
| Receiver Output Disable-Time |                       | $V_{CC} = V_L = +5V$                                                             |     | 200  |     | ns        |
| Transmitter Skew             | $ t_{PHL} - t_{PLH} $ |                                                                                  |     | 100  |     | ns        |
| Receiver Skew                | $ t_{PHL} - t_{PLH} $ |                                                                                  |     | 50   |     | ns        |
| Transition Region Slew Rate  |                       | $R_L = 3k\Omega$ to $7k\Omega$ , $C_L = 150pF$ to $1000pF$ , $T_A = +25^\circ C$ | 6   |      | 30  | $V/\mu s$ |

**Note 3:**  $V_{CC}$  must be greater than  $V_L$ .

## Typical Operating Characteristics

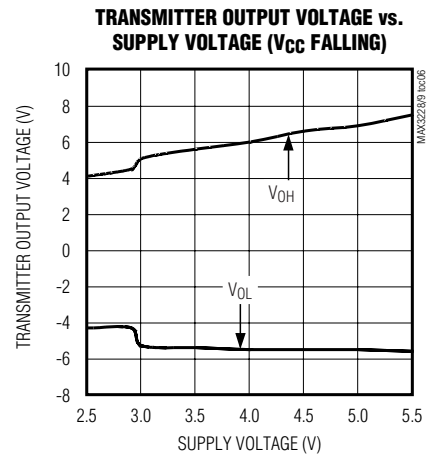
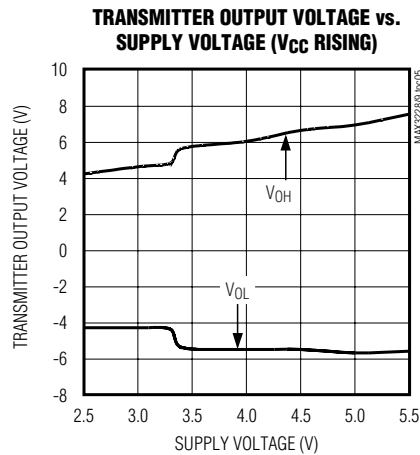
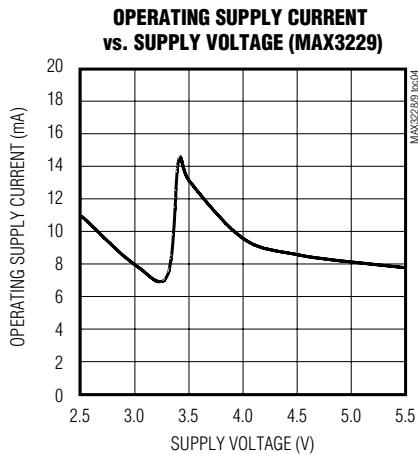
( $V_{CC} = +3.3V$ , 250kbps data rate,  $0.1\mu F$  capacitors, all transmitters loaded with  $3k\Omega$  and  $C_L$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



# +2.5V to +5.5V RS-232 Transceivers in UCSP

## Typical Operating Characteristics (continued)

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



MAX3228/MAX3229

## Pin Description

| PIN                                    |                                        | NAME     | FUNCTION                                                                                                                                                                 |
|----------------------------------------|----------------------------------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MAX3228                                | MAX3229                                |          |                                                                                                                                                                          |
| A1                                     | A1                                     | $V_{CC}$ | +2.5V to +5.5V Supply Voltage                                                                                                                                            |
| A2                                     | A2                                     | C2+      | Positive Terminal of Inverting Charge-Pump Capacitor                                                                                                                     |
| A3                                     | A3                                     | C2-      | Negative Terminal of Inverting Charge-Pump Capacitor                                                                                                                     |
| A4                                     | A4                                     | V-       | -5.5V/-4.0V Generated by Charge Pump                                                                                                                                     |
| A5                                     | A5                                     | $V_L$    | Logic-Level Input for Receiver Outputs and Transmitter Inputs. Connect $V_L$ to the system logic supply voltage or $V_{CC}$ if no logic supply is required.              |
| A6, B6                                 | A6                                     | T_IN     | Transmitter Input(s)                                                                                                                                                     |
| B1                                     | B1                                     | V+       | +5.5V/+4.0V Generated by Charge Pump. If charge pump is generating +4.0V, the part has switched from RS-232 compliant to RS-232 compatible mode.                         |
| B2, B3, B4, C2, C3, C4, D2, D3, D4, D5 | B2, B3, B4, C2, C3, C4, D2, D3, D4, D5 | N.C.     | No Connection. These locations are not populated with solder bumps.                                                                                                      |
| B5                                     | B5                                     | FORCEON  | FORCEON Input, Active-High. Drive FORCEON high to override automatic circuitry, keeping transmitters and charge pumps on. Pulls itself high internally if not connected. |
| —                                      | B6, D6, E4, E6                         | N.C.     | No Connection. These locations are populated with solder bumps, but are electrically isolated.                                                                           |
| C1                                     | C1                                     | C1+      | Positive Terminal of Positive Regulated Charge-Pump Capacitor                                                                                                            |

# +2.5V to +5.5V RS-232 Transceivers in UCSP

## Pin Description (continued)

| PIN     |         | NAME                         | FUNCTION                                                                                                                                                                                                                              |
|---------|---------|------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MAX3228 | MAX3229 |                              |                                                                                                                                                                                                                                       |
| C5      | C5      | $\overline{\text{FORCEOFF}}$ | FORCEOFF Input, Active-Low. Drive $\overline{\text{FORCEOFF}}$ low to shut down transmitters, receivers, and on-board charge pump. This overrides all automatic circuitry and FORCEON. Pulls itself high internally if not connected. |
| C6, D6  | C6      | R_OUT                        | Receiver Output(s)                                                                                                                                                                                                                    |
| D1      | D1      | C1-                          | Negative Terminal of Positive Regulated Charge-Pump Capacitor.                                                                                                                                                                        |
| E1      | E1      | GND                          | Ground                                                                                                                                                                                                                                |
| E2      | E2      | $\overline{\text{INVALID}}$  | Output of Valid Signal Detector. $\overline{\text{INVALID}}$ is enabled low if no valid RS-232 level is present on any receiver input.                                                                                                |
| E3, E4  | E3      | T_OUT                        | RS-232 Transmitter Output(s)                                                                                                                                                                                                          |
| E5, E6  | E5      | R_IN                         | RS-232 Receiver Input(s)                                                                                                                                                                                                              |

**Table 1. Operating Supply Options**

| SYSTEM SUPPLY (V)                                   | V <sub>CC</sub> (V) | V <sub>L</sub> (V)       | RS-232 MODE          |
|-----------------------------------------------------|---------------------|--------------------------|----------------------|
| 1 Li+ Cell                                          | +2.4 to +4.2        | Regulated System Voltage | Compliant/Compatible |
| 3 NiCad/NiMH Cells                                  | +2.4 to +3.8        | Regulated System Voltage | Compliant/Compatible |
| Regulated Voltage Only<br>(V <sub>CC</sub> falling) | +3.0 to +5.5        | +3.0 to +5.5             | Compliant            |
| Regulated Voltage Only<br>(V <sub>CC</sub> falling) | +2.5 to +3.0        | +2.5 to +3.0             | Compatible           |

## Detailed Description

### Dual-Mode Regulated Charge-Pump Voltage Converter

The MAX3228/MAX3229 internal power supply consists of a dual-mode regulated charge pump. For supply voltages above +3.7V, the charge pump will generate +5.5V at V<sub>+</sub> and -5.5V at V<sub>-</sub>. 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 +2.85V, the charge pump will generate +4.0V at V<sub>+</sub> and -4.0V at V<sub>-</sub>. The charge pumps operate in a discontinuous mode. If the output voltages are less than ±4.0V, the charge pumps are enabled, if the output voltages exceed ±4.0V, the charge pumps are disabled.

Each charge pump requires a flying capacitor (C1, C2) and a reservoir capacitor (C3, C4) to generate the V<sub>+</sub> and V<sub>-</sub> supply voltages.

### Voltage Generation in the Switchover Region

The MAX3228/MAX3229 include a switchover circuit between these two modes that have approximately 400mV of hysteresis around the switchover point. The hysteresis is shown in Figure 1. This large hysteresis eliminates mode changes due to power-supply bounce.

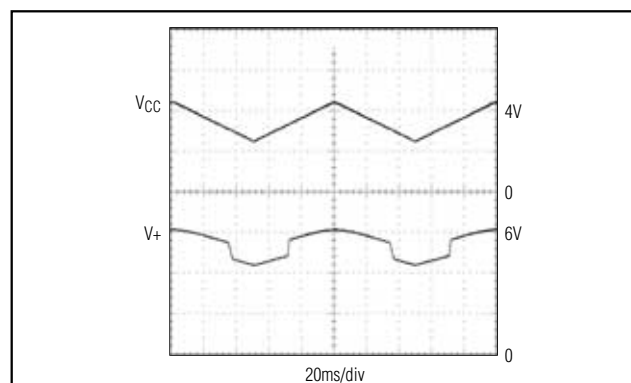


Figure 1. V<sub>+</sub> Switchover for Changing V<sub>CC</sub>

# +2.5V to +5.5V RS-232 Transceivers in UCSP

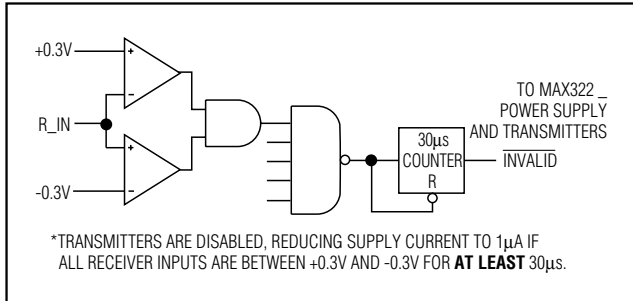


Figure 2a. MAX322\_ Entering 1µA Supply Mode via AutoShutdown

For example, a three-cell NiMh battery system starts at  $V_{CC} = +3.6V$ , and the charge pump will generate an output voltage of  $\pm 5.5V$ . As the battery discharges, the MAX3228/MAX3229 maintain the outputs in regulation until the battery voltage drops below  $+3.1V$ . Then the output regulation points change to  $\pm 4.0V$ .

When  $V_{CC}$  is rising, the charge pump will generate an output voltage of  $\pm 4.0V$ , 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 modes to generate an output of  $\pm 5.5V$ .

Table 1 shows different supply schemes and their operating voltage ranges.

## RS-232 Transmitters

The transmitters are inverting level translators that convert CMOS-logic levels to RS-232 levels. The MAX3228/MAX3229 will automatically reduce the RS-232 compliant levels ( $\pm 5.5V$ ) to RS-232 compatible levels ( $\pm 4.0V$ ) when  $V_{CC}$  falls below approximately  $+3.1V$ . The reduced levels also reduce supply current requirements, extending battery life. 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 ( $\pm 5.5V$ ) when  $V_{CC}$  rises above approximately  $+3.5V$ .

The MAX3228/MAX3229 transmitters guarantee a 250kbps data rate with worst-case loads of  $3k\Omega$  in parallel with  $1000pF$ .

When  $\overline{FORCEOFF}$  is driven to ground, the transmitters and receivers are disabled and the outputs become high impedance. When the AutoShutdown circuitry senses that all receiver and transmitter inputs are inactive for more than  $30\mu s$ , the transmitters are disabled and the outputs go to a high-impedance state. When

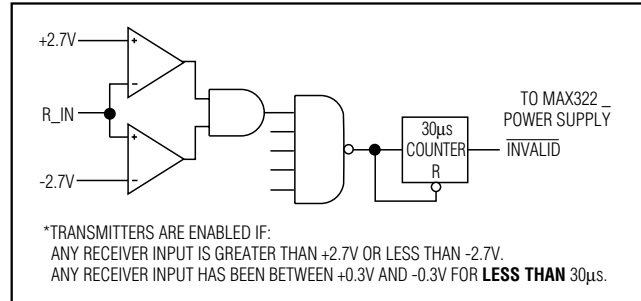


Figure 2b. MAX322\_ with Transmitters Enabled Using AutoShutdown

the power is off, the MAX3228/MAX3229 permit the transmitter outputs to be driven up to  $\pm 12V$ .

The transmitter inputs do not have pullup resistors. Connect unused inputs to GND or  $V_L$ .

## RS-232 Receivers

The MAX3228/MAX3229 receivers convert RS-232 signals to logic output levels. All receivers have inverting three-state outputs and can be active or inactive. In shutdown ( $\overline{FORCEOFF} = \text{low}$ ) or in AutoShutdown, the MAX3228/MAX3229 receivers are in a high-impedance state (Table 3).

The MAX3228/MAX3229 feature an  $\overline{INVALID}$  output that is enabled low when no valid RS-232 signal levels have been detected on any receiver inputs.  $\overline{INVALID}$  is functional in any mode (Figures 2 and 3).

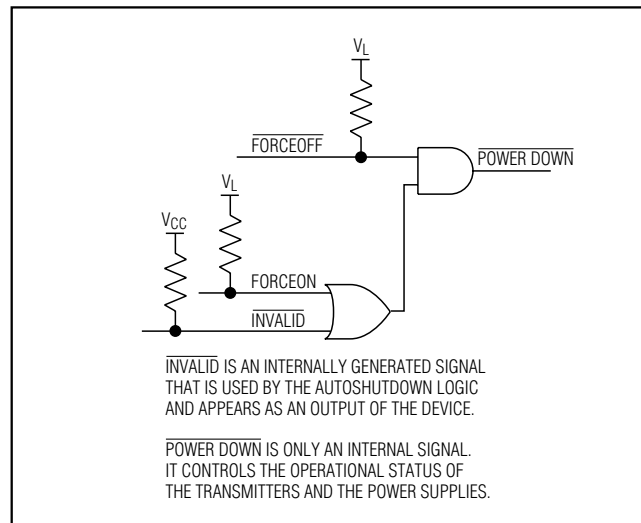


Figure 2c. MAX322\_ AutoShutdown Logic



# +2.5V to +5.5V RS-232 Transceivers in UCSP

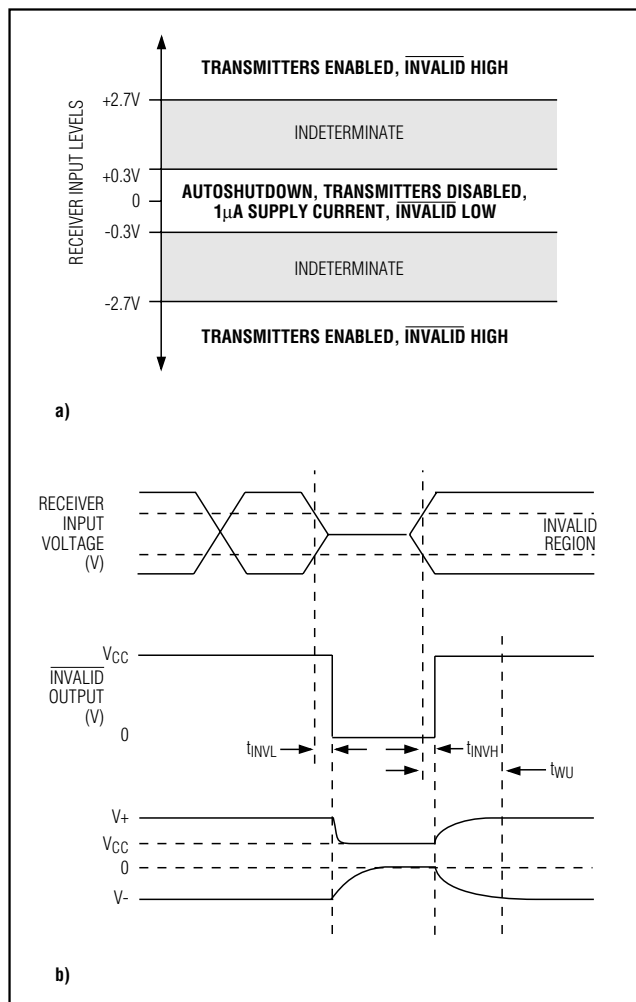


Figure 3. AutoShutdown Trip Levels

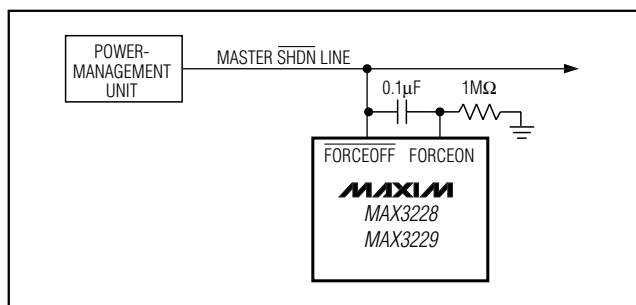


Figure 4. AutoShutdown with Initial Turn-On to Wake Up a System

## AutoShutdown

The MAX3228/MAX3229 achieve a 1μA supply current with Maxim's AutoShutdown feature, which operates when FORCEON is low and FORCEOFF is high. When these devices sense no valid signal levels on all receiver inputs for 30μs, the on-board charge pump and drivers are shut off, reducing V<sub>CC</sub> supply current to 1μA. This occurs if the RS-232 cable is disconnected or the connected peripheral transmitters are turned off. The device turns on again when a valid level is applied to any RS-232 receiver input. As a result, the system saves power without changes to the existing BIOS or operating system.

Table 3 and Figure 2c summarize the MAX3228/MAX3229 operating modes. FORCEON and FORCEOFF override AutoShutdown. When neither control is asserted, the IC selects between these states automatically, based on receiver input levels. Figures 2a, 2b, and 3a depict valid and invalid RS-232 receiver levels. Figures 3a and 3b show the input levels and timing diagram for AutoShutdown operation.

A system with AutoShutdown may need time to wake up. Figure 4 shows a circuit that forces the transmitters on for 100ms, allowing enough time for the other system to realize that the MAX3228/MAX3229 are active. If the other system transmits valid RS-232 signals within that time, the RS-232 ports on both systems remain enabled.

When shut down, the devices' charge pumps are off, V<sub>+</sub> is pulled to V<sub>CC</sub>, V<sub>-</sub> is pulled to ground, and the transmitter outputs are high-impedance. The time required to exit shutdown is typically 100μs (Figure 3b).

## FORCEON and FORCEOFF

In case FORCEON and FORCEOFF are inaccessible, these pins have 60kΩ (typ) pullup resistors connected to V<sub>L</sub> (Table 2). Therefore, if FORCEON and FORCEOFF are not connected, the MAX3228 and MAX3229 will always be active. Pulling these pins to ground will draw current from the V<sub>L</sub> supply. This current can be calculated from the voltage supplied at V<sub>L</sub> and the 60kΩ (typ) pullup resistor.

## V<sub>L</sub> Logic Supply Input

Unlike other RS-232 interface devices, where the receiver outputs swing between 0 and V<sub>CC</sub>, the

Table 2. Power-On Default States

| PIN NAME | POWER-ON DEFAULT | MECHANISM       |
|----------|------------------|-----------------|
| FORCEON  | High             | Internal pullup |
| FORCEOFF | High             | Internal pullup |



# **+2.5V to +5.5V RS-232 Transceivers in UCSP**

**Table 3. Output Control Truth Table**

| TRANSCIEVER STATUS              | FORCEON | FORCEOFF | RECEIVER STATUS | INVALID |
|---------------------------------|---------|----------|-----------------|---------|
| Shutdown (AutoShutdown)         | Low     | High     | High-Z          | L       |
| Shutdown (Forced Off)           | X       | Low      | High-Z          | †       |
| Normal Operation (Forced On)    | High    | High     | Active          | †       |
| Normal Operation (AutoShutdown) | Low     | High     | Active          | H       |

X = Don't care.

† = INVALID output state is determined by R<sub>IN</sub> input levels.

MAX3228/MAX3229 feature a separate logic supply input (V<sub>L</sub>) that sets V<sub>OH</sub> for the receiver and INVALID outputs. The transmitter inputs (T<sub>IN</sub>), FORCEON and FORCEOFF, are also referred to V<sub>L</sub>. This feature allows maximum flexibility in interfacing to different systems and logic levels. Connect V<sub>L</sub> to the system's logic supply voltage (+1.65V to +5.5V), and bypass it with a 0.1μF capacitor to GND. If the logic supply is the same as V<sub>CC</sub>, connect V<sub>L</sub> to V<sub>CC</sub>. Always enable V<sub>CC</sub> before enabling the V<sub>L</sub> supply. V<sub>CC</sub> must be greater than or equal to the V<sub>L</sub> supply.

## **Software-Controlled Shutdown**

If direct software control is desired, connect FORCEOFF and FORCEON together to disable AutoShutdown. The microcontroller then drives FORCEOFF and FORCEON like a SHDN input, INVALID can be used to alert the microcontroller to indicate serial data activity.

## **Applications Information**

### **Capacitor Selection**

The capacitor type used for C1–C4 is not critical for proper operation; either polarized or nonpolarized capacitors may be used. However, ceramic chip capacitors with an X7R or X5R dielectric work best. The charge pump requires 0.1μF capacitors for 3.3V operation. For other supply voltages, refer to Table 4 for required capacitor values. Do not use values smaller than those listed in Table 4. 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) usually rises at low temperatures and influences the amount of ripple on V<sub>+</sub> and V<sub>-</sub>.

### **Power-Supply Decoupling**

In most circumstances, a 0.1μF V<sub>CC</sub> 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.

**Table 4. Required Capacitor Values**

| V <sub>CC</sub> (V) | C1, C <sub>BYPASS</sub> (μF) | C2, C3, C4 (μF) |
|---------------------|------------------------------|-----------------|
| 2.5 to 3.0          | 0.22                         | 0.22            |
| 3.0 to 3.6          | 0.1                          | 0.1             |
| 4.5 to 5.5          | 0.047                        | 0.33            |
| 3.0 to 5.5          | 0.22                         | 1               |

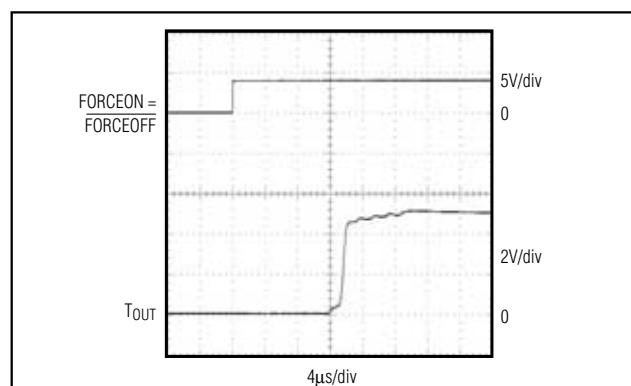


Figure 5. Transmitter Outputs Exiting Shutdown or Powering Up

## +2.5V to +5.5V RS-232 Transceivers in UCSP

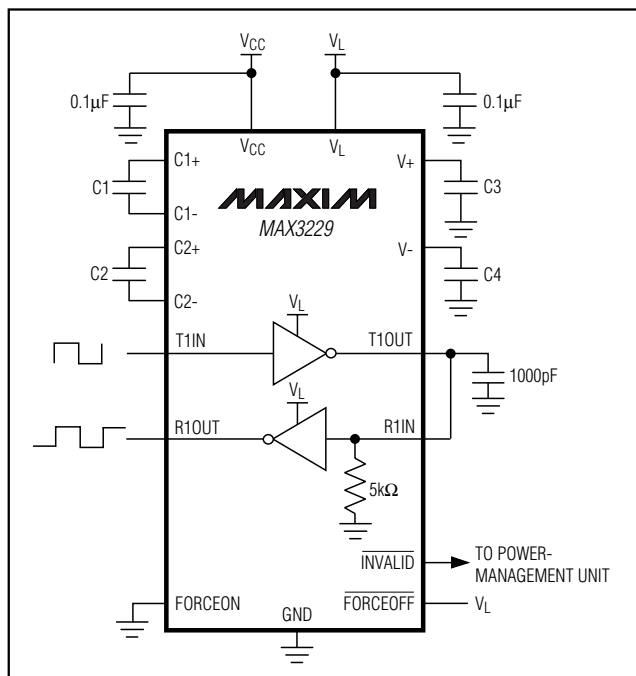


Figure 6. Transmitter Loopback Test Circuit

### Transmitter Outputs when Exiting Shutdown

Figure 5 shows a transmitter output when exiting shutdown mode. The transmitter is loaded with  $3k\Omega$  in parallel with  $1000pF$ . The transmitter output displays no ringing or undesirable transients as it comes out of shutdown, and is enabled only when the magnitude of  $V_-$  exceeds approximately  $-3V$ .

### High Data Rates

The MAX3228/MAX3229 maintain the RS-232  $\pm 5.0V$  minimum transmitter output voltage even at high data rates. Figure 6 shows a transmitter loopback test circuit.

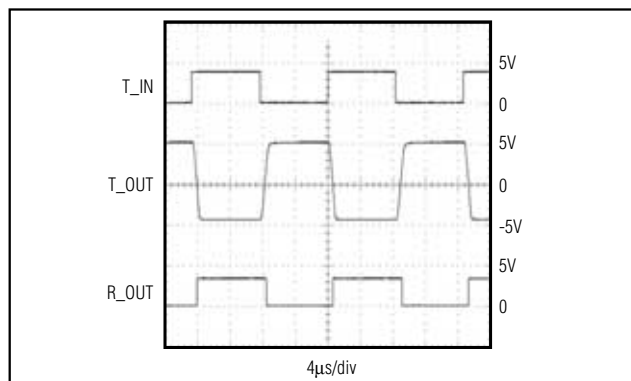


Figure 7. Loopback Test Result at 120kbps

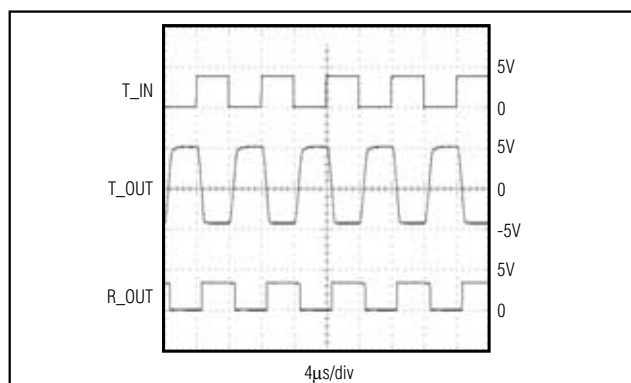


Figure 8. Loopback Test Result at 250kbps

Figure 7 shows a loopback test result at 120kbps, and Figure 8 shows the same test at 250kbps. For Figure 7, the transmitter was driven at 120kbps into an RS-232 load in parallel with  $1000pF$ . For Figure 8, a single transmitter was driven at 250kbps, and loaded with an RS-232 receiver in parallel with  $1000pF$ .

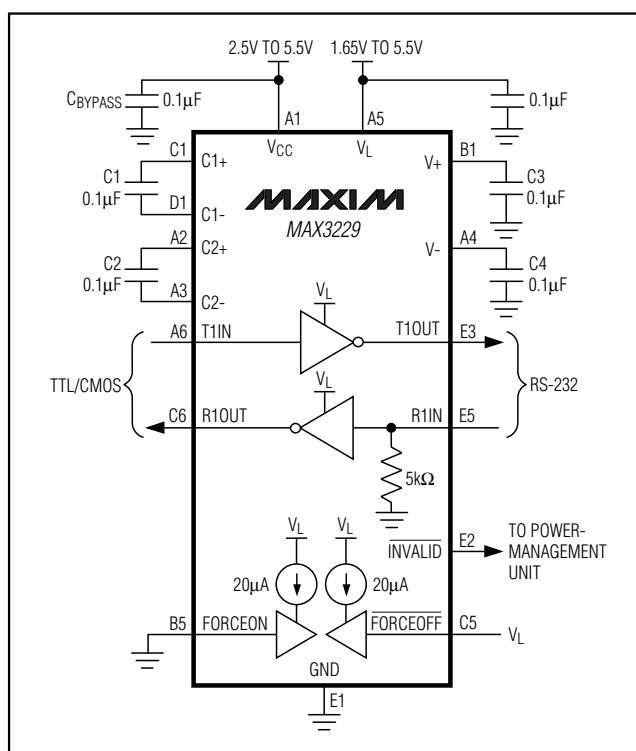
# **+2.5V to +5.5V RS-232 Transceivers in UCSP**

**MAX3228/MAX3229**

**Table 5. Reliability Test Data**

| TEST                            | CONDITIONS                         | DURATION                  | NO. OF FAILURES PER SAMPLE SIZE |
|---------------------------------|------------------------------------|---------------------------|---------------------------------|
| Temperature Cycle               | -35°C to +85°C,<br>-40°C to +100°C | 150 cycles,<br>900 cycles | 0/10,<br>0/200                  |
| Operating Life                  | T <sub>A</sub> = +70°C             | 240hr                     | 0/10                            |
| Moisture Resistance             | +20°C to +60°C, 90% RH             | 240hr                     | 0/10                            |
| Low-Temperature Storage         | -20°C                              | 240hr                     | 0/10                            |
| Low-Temperature Operational     | -10°C                              | 24hr                      | 0/10                            |
| Solderability                   | 8hr steam age                      | —                         | 0/15                            |
| ESD                             | ±2000V, Human Body Model           | —                         | 0/5                             |
| High-Temperature Operating Life | T <sub>J</sub> = +150°C            | 168hr                     | 0/45                            |

## **Typical Operating Circuits (continued)**



## **UCSP Reliability**

The UCSP represents a unique packaging form factor that may not perform equally to a packaged product through traditional mechanical reliability tests. CSP reliability is integrally linked to the user's assembly methods, circuit board material, and usage environment. The user should closely review these areas when considering use of a CSP package. Performance through Operating Life Test and Moisture Resistance remains uncompromised as it is primarily determined by the wafer-fabrication process.

Mechanical stress performance is a greater consideration for a CSP package. CSPs are attached through direct solder contact to the user's PC board, foregoing the inherent stress relief of a packaged product lead frame. Solder joint contact integrity must be considered. Table 5 shows the testing done to characterize the CSP reliability performance. In conclusion, the UCSP is capable of performing reliably through environmental stresses as indicated by the results in the table. Additional usage data and recommendations are detailed in the UCSP application note, which can be found on Maxim's website at [www.maxim-ic.com](http://www.maxim-ic.com).

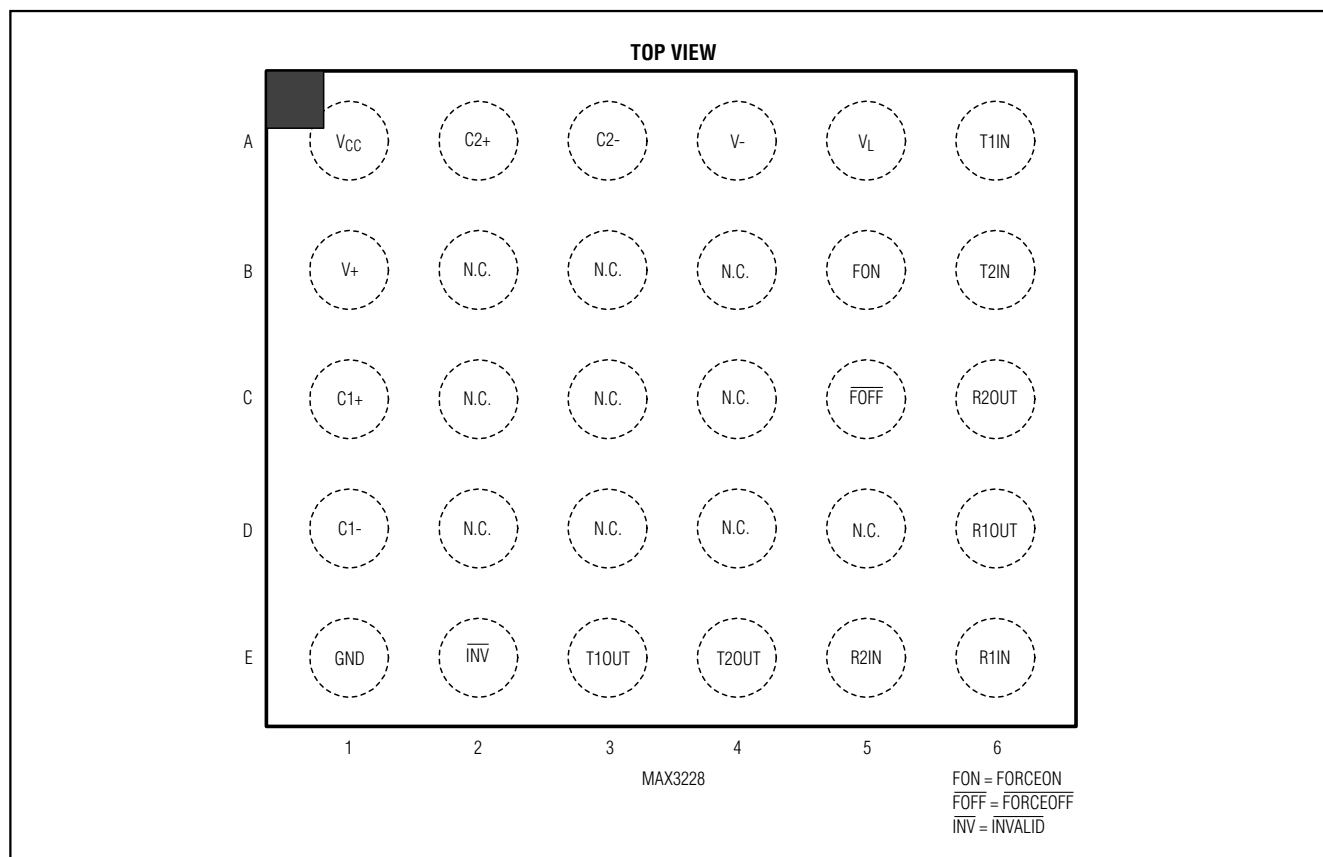
## **Chip Information**

TRANSISTOR COUNT: 698

PROCESS TECHNOLOGY: CMOS

# +2.5V to +5.5V RS-232 Transceivers in UCSP

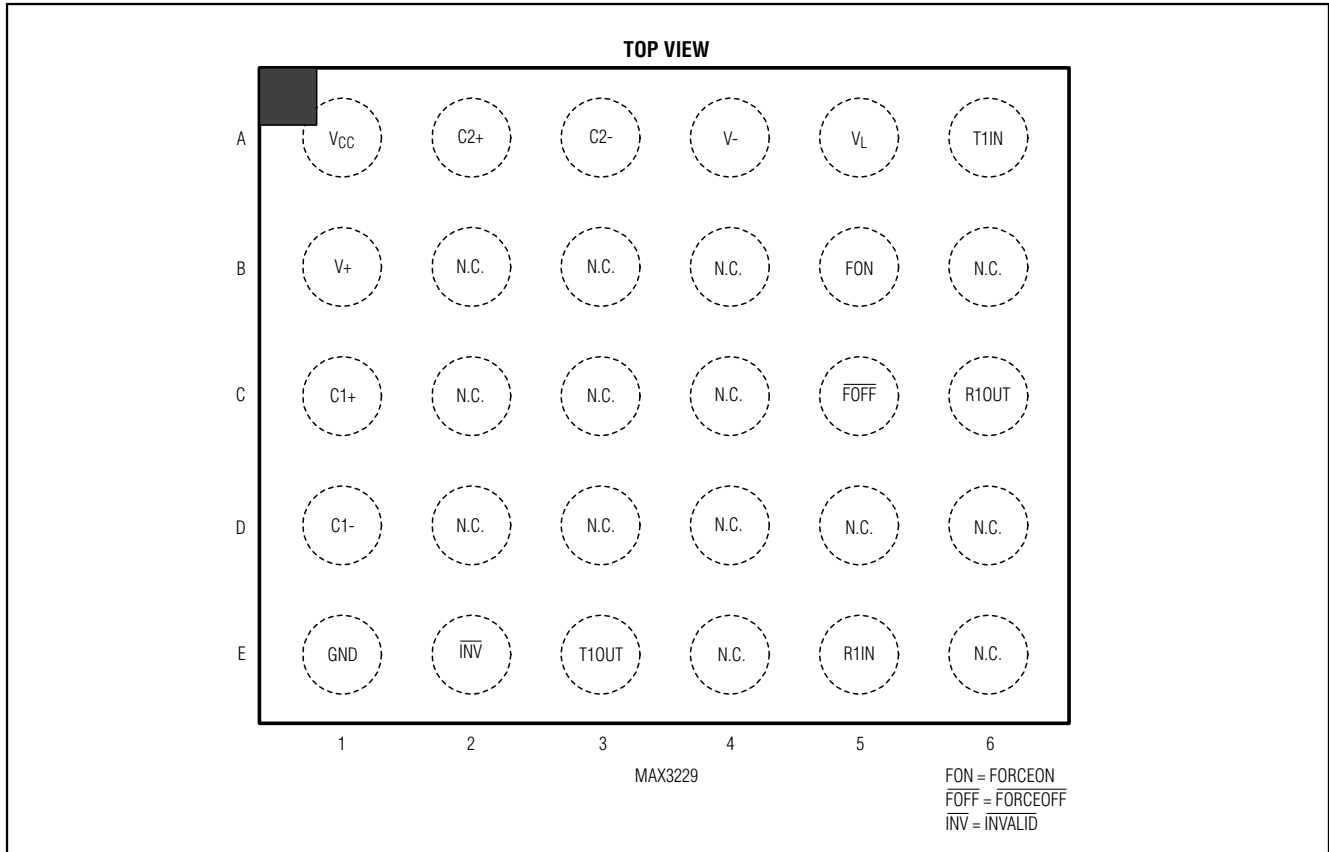
## Pin Configurations



# **+2.5V to +5.5V RS-232 Transceivers in UCSP**

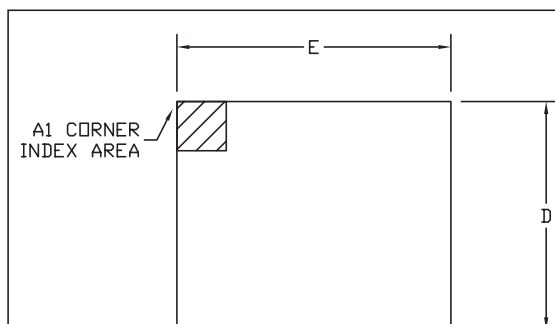
## **Pin Configurations (continued)**

**MAX3228/MAX3229**



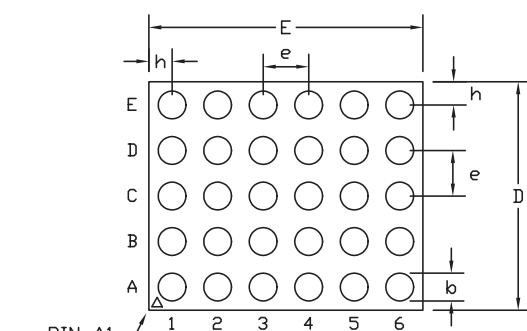
# +2.5V to +5.5V RS-232 Transceivers in UCSP

## Package Information

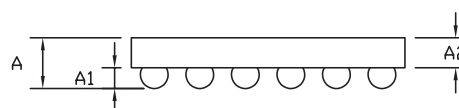


TOP VIEW

| SYMBOL | DIMENSIONS     |
|--------|----------------|
| A      | 0.022 ±.002    |
| D      | 0.0988 ±.002   |
| E      | 0.1185 ±.002   |
| e      | 0.0197 BASIC   |
| b      | ∅ 0.0120 BASIC |
| A1     | 0.009±.0015    |
| A2     | 0.013 Ref.     |
| h      | 0.010 Ref.     |



BOTTOM VIEW



SIDE VIEW

- NOTES:
1. ALL DIMENSIONS ARE IN INCHES.
  2. MEETS JEDEC M0195.

|                                |                      |      |     |
|--------------------------------|----------------------|------|-----|
| <b>MAXIM</b>                   |                      |      |     |
| PROPRIETARY INFORMATION        |                      |      |     |
| TITLE:                         |                      |      |     |
| PACKAGE OUTLINE, 30L UCSP, 6x5 |                      |      |     |
| APPROVAL                       | DOCUMENT CONTROL NO. | REV. | 1/1 |
|                                | 21-0123              | A    |     |

30L UCSP 6x5 .EPS

Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

14 **Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086 408-737-7600**