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**MAX3221** 

SLLS348O-JUNE 1999-REVISED JUNE 2015

# MAX3221 3-V to 5.5-V RS-232 Line Driver and Receiver With ±15-kV ESD Protection

#### Features 1

- RS-232 Bus-Pin ESD Protection Exceeds ±15 kV Using Human Body Model (HBM)
- Meets or Exceeds the Requirements of • TIA/EIA-232-F and ITU V.28 Standards
- Operates With 3-V to 5.5-V V<sub>CC</sub> Supply •
- Operates up to 250 kbps
- One Driver and One Receiver
- Low Standby Current: 1 µA Typical
- External Capacitors: 4 × 0.1 µF
- Accepts 5-V Logic Input With 3.3-V Supply
- Alternative High-Speed Pin-Compatible Device (1 Mbps)
  - SNx5C3221
- Automatic Power-Down Feature Automatically **Disables Drivers for Power Savings**

## 2 Applications

- Battery-Powered, Hand-Held, and Portable Equipment
- Notebooks, Subnotebooks, and Laptops
- **Digital Cameras**
- Mobile Phones and Wireless Devices

## 3 Description

The MAX3221 device consists of one line driver, one line receiver with dedicated enable pin, and a dual charge-pump circuit with ±15-kV ESD protection pin to pin (serial-port connection pins, including GND). The device meets the requirements of TIA/EIA-232-F and provides the electrical interface between an asynchronous communication controller and the serial-port connector. The charge pump and four small external capacitors allow operation from a single 3-V to 5.5-V supply. These devices operate at data signaling rates up to 250 kbps and a maximum of 30-V/µs driver output slew rate.

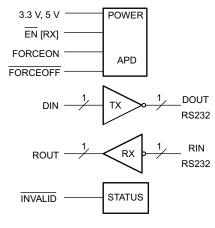
Flexible control options for power management are available when the serial port is inactive. The automatic power-down feature functions when FORCEON is low and FORCEOFF is high. During this mode of operation, if the device does not sense a valid

RS-232 signal on the receiver input, the driver output is disabled and the supply current is reduced to 1 µA. The INVALID output notifies the user if an RS-232 signal is present at the receiver input.

#### Device Information<sup>(1)</sup>

| PART NUMBER | PACKAGE    | BODY SIZE (NOM)   |
|-------------|------------|-------------------|
| MAX3221xDB  | SSOP (32)  | 6.20 mm × 5.30 mm |
| MAX3221xPW  | TSSOP (32) | 5.00 mm × 4.40 mm |

(1) For all available packages, see the orderable addendum at the end of the data sheet.



### Simplified Diagram



# **Table of Contents**

8

9

10 11

12

| 1 | Features                                  | 1   |
|---|---|-----|
| 2 | Applications                              | 1   |
| 3 | Description                               | 1   |
| 4 | Revision History                          | 2   |
| 5 | Pin Configuration and Functions           | 3   |
| 6 | Specifications                            | . 4 |
|   | 6.1 Absolute Maximum Ratings              | 4   |
|   | 6.2 ESD Ratings                           | 4   |
|   | 6.3 Recommended Operating Conditions      |     |
|   | 6.4 Thermal Information                   | 5   |
|   | 6.5 Electrical Characteristics – Power    | 5   |
|   | 6.6 Electrical Characteristics – Driver   | 5   |
|   | 6.7 Electrical Characteristics – Receiver | 6   |
|   | 6.8 Electrical Characteristics - Status   | 6   |
|   | 6.9 Switching Characteristics – Driver    | 6   |
|   | 6.10 Switching Characteristics – Receiver | 7   |
|   | 6.11 Switching Characteristics – Status   |     |
|   | 6.12 Typical Characteristics              | 7   |
| 7 | Parameter Measurement Information         | 8   |
|   |   |     |

| 4 | Revision | History |
|---|----------|---------|

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

#### Changes from Revision N (January 2014) to Revision O

| C | hanges from Revision M (March 2004) to Revision N                        | Page |  |
|---|--|------|--|
| • | Updated document to new TI data sheet format - no specification changes. | 1    |  |
| • | Deleted Ordering Information table.                                      | 1    |  |

| Deta | ailed Description               | 11   |
|------|---------------------------------|------|
| 8.1  | Overview                        | 11   |
| 8.2  | Functional Block Diagram        | 11   |
| 8.3  | Feature Description             | 11   |
| 8.4  | Device Functional Modes         | 12   |
| Арр  | lication and Implementation     | 13   |
| 9.1  | Application Information         | 13   |
| 9.2  | Typical Application             | 13   |
| Pow  | ver Supply Recommendations      | . 14 |
| Lay  | out                             | 15   |
| 11.1 | Layout Guidelines               | 15   |
| 11.2 | Layout Example                  | 15   |
| Dev  | vice and Documentation Support  | . 16 |
| 12.1 | Community Resources             | 16   |
| 12.2 | Trademarks                      | 16   |
| 12.3 | Electrostatic Discharge Caution | 16   |
| 12.4 | Glossary                        | 16   |

|    | 12.4 Glossary                        | 16 |
|----|--------------------------------------|----|
| 13 | Mechanical, Packaging, and Orderable |    |
|    | Information                          | 16 |

EXAS

Page



#### MAX3221 SLLS3480-JUNE 1999-REVISED JUNE 2015

# 5 Pin Configuration and Functions

| DB or PW Package<br>16-Pin SSOP or TSSOP<br>Top View      |                                      |  |  |  |  |  |
|---|--------------------------------------|--|--|--|--|--|
| EN [<br>C1+ [<br>C1- [<br>C2+ [<br>C2- [<br>V- [<br>RIN ] | 1<br>2<br>3<br>4<br>5<br>6<br>7<br>8 | 16 FORCEOFF<br>15 V <sub>CC</sub><br>14 GND<br>13 DOUT<br>12 FORCEON<br>11 DIN<br>10 INVALID<br>9 ROUT |  |  |  |  |

#### **Pin Functions**

| PIN             |     | 1/0 | DESCRIPTION   |  |
|-----------------|-----|-----|---|--|
| NAME            | NO. | 1/0 | DESCRIPTION   |  |
| C1+             | 2   |     |   |  |
| C2+             | 5   |     | Positive terminals of the voltage-doubler charge-pump capacitors                |  |
| C1–             | 4   |     | Nagative terminals of the veltage devider charge nump conscience                |  |
| C2-             | 6   | _   | Negative terminals of the voltage-doubler charge-pump capacitors                |  |
| DIN             | 11  | I   | Driver input  |  |
| DOUT            | 13  | 0   | RS-232 driver output  |  |
| EN              | 1   | I   | Low input enables receiver ROUT output. High input sets ROUT to high impedance. |  |
| FORCEOFF        | 16  | I   | Automatic power-down control input  |  |
| FORCEON         | 12  | I   | Automatic power-down control input  |  |
| GND             | 14  | —   | Ground  |  |
| INVALID         | 10  | 0   | Invalid output pin. Output low when all RIN inputs are unpowered.               |  |
| RIN             | 8   | I   | RS-232 receiver input   |  |
| ROUT            | 9   | 0   | Receiver output   |  |
| V <sub>CC</sub> | 15  | _   | 3-V to 5.5-V supply voltage   |  |
| V+              | 3   | 0   | 5.5-V supply generated by the charge pump                                       |  |
| V–              | 7   | 0   | -5.5-V supply generated by the charge pump                                      |  |

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

|                  |                                     |                                       | MIN  | MAX                   | UNIT |
|------------------|-------------------------------------|---------------------------------------|------|-----------------------|------|
|                  | V <sub>CC</sub> to GND              |                                       | -0.3 | 6                     |      |
|                  | V+ to GND                           |                                       | -0.3 | 7                     | v    |
|                  | V- to GND                           |                                       | 0.3  | -7                    | v    |
|                  | V+ +  V-  <sup>(2)</sup>            |                                       |      | 13                    |      |
| V                | Input voltage                       | DIN, EN, FORCEOFF, and FORCEON to GND | -0.3 | 6                     | V    |
| VI               |                                     | RIN to GND                            |      | ±25                   | v    |
| V                | Output voltage                      | DOUT to GND                           |      | ±13.2                 | V    |
| Vo               |                                     | ROUT to GND                           | -0.3 | V <sub>CC</sub> + 0.3 | v    |
| TJ               | Junction temperature <sup>(3)</sup> |                                       |      | 150                   | °C   |
| T <sub>stg</sub> | Storage temperature range           |                                       | -65  | 150                   |      |

(1) 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 under Recommended Operating Conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) V+ and V- can have maximum magnitudes of 7 V, but their absolute difference cannot exceed 13 V.

(3) Maximum power dissipation is a function of  $T_J(max)$ ,  $R_{\theta JA}$ , and  $T_A$ . The maximum allowable power dissipation at any allowable ambient temperature is  $P_D = (T_J(max) - T_A) / R_{\theta JA}$ . Operating at the absolute maximum  $T_J$  of 150°C can affect reliability.

### 6.2 ESD Ratings

|                    |                         |  |                           | VALUE   | UNIT |
|--------------------|-------------------------|--|---------------------------|---------|------|
|                    |                         | Human body model (HBM), per                            | All pins except 8, 13     | ±3000   |      |
| V <sub>(ESD)</sub> | Electrostatic discharge | ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>                  | Pins 8, 13                | ±15,000 | V    |
| (ESD)              |                         | Charged-device model (CDM), per JE C101 <sup>(2)</sup> | DEC specification JESD22- | ±1500   | •    |

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 6.3 Recommended Operating Conditions

#### (see Figure 8)<sup>(1)</sup>

|                 |   |                               |                  | MIN | NOM | MAX | UNIT |
|-----------------|---|-------------------------------|------------------|-----|-----|-----|------|
|                 | Supply voltogo                                      |                               | $V_{CC} = 3.3 V$ | 3   | 3.3 | 3.6 | V    |
|                 | Supply voltage                                      |                               | $V_{CC} = 5 V$   | 4.5 | 5   | 5.5 | v    |
| V               | Driver high level input veltage                     | DIN, FORCEOFF,                | $V_{CC} = 3.3 V$ | 2   |     |     |      |
| V <sub>IH</sub> | Driver high-level input voltage                     | FORCEON, EN                   | $V_{CC} = 5 V$   | 2.4 |     |     | V    |
| VIL             | Driver low-level input voltage                      | DIN, FORCEOFF,<br>FORCEON, EN |                  |     |     | 0.8 | V    |
| VI              | Driver input voltage                                | DIN, FORCEOFF,<br>FORCEON, EN |                  | 0   |     | 5.5 | V    |
| -               | Receiver input voltage                              |                               |                  | -25 |     | 25  |      |
| Ŧ               | Operating free-air temperature MAX3221C<br>MAX3221I |                               | MAX3221C         | 0   |     | 70  | °C   |
| T <sub>A</sub>  |   |                               | -40              |     | 85  |     |      |

(1) Test conditions are C1–C4 = 0.1  $\mu$ F at V<sub>CC</sub> = 3.3 V ± 0.3 V; C1 = 0.047  $\mu$ F, C2–C4 = 0.33  $\mu$ F at V<sub>CC</sub> = 5 V ± 0.5 V.

### 6.4 Thermal Information

|                       |  | M         | MAX3221    |      |  |
|-----------------------|--|-----------|------------|------|--|
|                       | THERMAL METRIC <sup>(1)</sup>                | DB (SSOP) | PW (TSSOP) | UNIT |  |
|                       |  | 16 PINS   | 16 PINS    |      |  |
| $R_{\theta JA}$       | Junction-to-ambient thermal resistance       | 98.0      | 106.4      | °C/W |  |
| R <sub>0JC(top)</sub> | Junction-to-case (top) thermal resistance    | 48.3      | 41.1       | °C/W |  |
| $R_{\theta JB}$       | Junction-to-board thermal resistance         | 48.7      | 51.4       | °C/W |  |
| Ψ <sub>JT</sub>       | Junction-to-top characterization parameter   | 10.1      | 3.9        | °C/W |  |
| Ψ <sub>JB</sub>       | Junction-to-board characterization parameter | 48.1      | 50.9       | °C/W |  |

(1) For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report, SPRA953.

### 6.5 Electrical Characteristics – Power

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(1)</sup>

|                                | PARAMETER                     |  | TEST CONDITIONS   |                          | MIN | TYP <sup>(2)</sup> | MAX | UNIT |
|--------------------------------|-------------------------------|--|---|--------------------------|-----|--------------------|-----|------|
| I <sub>1</sub>                 | Input leakage<br>current      | FORCEOFF, FORCEON, EN                            |   |                          |     | ±0.01              | ±1  | μΑ   |
|                                | Automatic power-down disabled |  | No load, $\overline{\text{FORCEOFF}}$ and $\overline{\text{FORCEON}}$ at $V_{\text{CC}}$  |                          | 0.3 | 1                  | mA  |      |
| lee                            | Supply current                | Powered off                                      | No load,  | No load, FORCEOFF at GND |     | 1                  | 10  |      |
| I <sub>CC</sub> Supply current | Automatic power-down enabled  | $V_{CC} = 3.3 \text{ V} \text{ to } 5 \text{ V}$ | No load, FORCEOFF at V <sub>CC</sub> ,<br>FORCEON at GND,<br>All RIN are open or grounded |                          | 1   | 10                 | μΑ  |      |

Test conditions are C1–C4 = 0.1  $\mu$ F at V<sub>CC</sub> = 3.3 V  $\pm$  0.3 V; C1 = 0.047  $\mu$ F, C2–C4 = 0.33  $\mu$ F at V<sub>CC</sub> = 5 V  $\pm$  0.5 V. All typical values are at V<sub>CC</sub> = 3.3 V or V<sub>CC</sub> = 5 V, and T<sub>A</sub> = 25°C. (1)

(2)

### 6.6 Electrical Characteristics – Driver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(1)</sup>

|                  | PARAMETER                                   | TEST CONDITIONS                        |   | MIN | TYP <sup>(2)</sup> | MAX | UNIT |
|------------------|---|--|---|-----|--------------------|-----|------|
| V <sub>OH</sub>  | High-level output voltage                   | $D_{OUT}$ at $R_L = 3 k\Omega$ to GND, | D <sub>IN</sub> = GND                                     | 5   | 5.4                |     | V    |
| V <sub>OL</sub>  | Low-level output voltage                    | $D_{OUT}$ at $R_L = 3 k\Omega$ to GND, | $D_{IN} = V_{CC}$   | -5  | -5.4               |     | V    |
| I <sub>IH</sub>  | High-level input current                    | $V_{I} = V_{CC}$                       |   |     | ±0.01              | ±1  | μA   |
| IIL              | Low-level input current                     | V <sub>I</sub> at GND                  |   |     | ±0.01              | ±1  | μA   |
|                  |   | V <sub>CC</sub> = 3.6 V                | $V_0 = 0 V$   |     | ±35                | ±60 | ~ ^  |
| I <sub>OS</sub>  | Short-circuit output current <sup>(3)</sup> | V <sub>CC</sub> = 5.5 V                | $V_0 = 0 V$   |     | ±35                | ±60 | mA   |
| r <sub>O</sub>   | Output resistance                           | $V_{CC}$ , V+, and V- = 0 V            | $V_0 = \pm 2 V$   | 300 | 10M                |     | Ω    |
|                  |   |  | V <sub>O</sub> = ±12 V,<br>V <sub>CC</sub> = 3 V to 3.6 V |     |                    | ±25 |      |
| l <sub>off</sub> | Output leakage current                      | FORCEOFF = GND                         | $V_{O} = \pm 12 V,$<br>$V_{CC} = 4.5 V \text{ to } 5.5 V$ |     |                    | ±25 | μA   |

(1) Test conditions are C1–C4 = 0.1  $\mu$ F at V<sub>CC</sub> = 3.3 V ± 0.3 V; C1 = 0.047  $\mu$ F, C2–C4 = 0.33  $\mu$ F at V<sub>CC</sub> = 5 V ± 0.5 (2) All typical values are at V<sub>CC</sub> = 3.3 V or V<sub>CC</sub> = 5 V, and T<sub>A</sub> = 25°C. (3) Short-circuit durations should be controlled to prevent exceeding the device absolute power dissipation ratings, and not more than one output should be shorted at a time.

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### 6.7 Electrical Characteristics – Receiver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(1)</sup>

|                              | PARAMETER   | TEST CONDITIONS                     | MIN            | TYP <sup>(2)</sup> | MAX | UNIT |
|------------------------------|---|-------------------------------------|----------------|--------------------|-----|------|
| V <sub>OH</sub>              | High-level output voltage                               | $I_{OH} = -1 \text{ mA}$            | $V_{CC} - 0.6$ | $V_{CC} - 0.1$     |     | V    |
| V <sub>OL</sub>              | Low-level output voltage                                | I <sub>OL</sub> = 1.6 mA            |                |                    | 0.4 | V    |
| V                            | Desitive going input threshold veltage                  | $V_{CC} = 3.3 V$                    |                | 1.5                | 2.4 | V    |
| V <sub>IT+</sub> Positive-go | Positive-going input threshold voltage                  | $V_{CC} = 5 V$                      |                | 1.8                | 2.4 | v    |
| V                            |   | $V_{CC} = 3.3 V$                    | 0.6            | 1.1                |     | V    |
| V <sub>IT</sub>              | Negative-going input threshold voltage                  | $V_{CC} = 5 V$                      | 0.8            | 1.4                |     | v    |
| V <sub>hys</sub>             | Input hysteresis (V <sub>IT+</sub> – V <sub>IT–</sub> ) |                                     |                | 0.5                |     | V    |
| I <sub>off</sub>             | Output leakage current                                  | $\overline{FORCEOFF} = 0 \text{ V}$ |                | ±0.05              | ±10 | μA   |
| r <sub>i</sub>               | Input resistance  | $V_1 = \pm 3 V$ to $\pm 25 V$       | 3              | 5                  | 7   | kΩ   |

Test conditions are C1–C4 = 0.1  $\mu$ F at V<sub>CC</sub> = 3.3 V ± 0.3 V; C1 = 0.047  $\mu$ F, C2–C4 = 0.33  $\mu$ F at V<sub>CC</sub> = 5 V ± 0.5 V. All typical values are at V<sub>CC</sub> = 3.3 V or V<sub>CC</sub> = 5 V, and T<sub>A</sub> = 25°C. (1)

(2)

### 6.8 Electrical Characteristics – Status

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(1)</sup>

|                         | PARAMETER  | TEST CONDITIONS  | MIN                   | TYP <sup>(2)</sup> | MAX | UNIT |
|-------------------------|--|--|-----------------------|--------------------|-----|------|
| V <sub>T+(valid)</sub>  | Receiver input threshold for INVALID high-level output voltage | $\frac{\text{FORCEON} = \text{GND},}{\text{FORCEOFF} = V_{CC}}$                  |                       |                    | 2.7 | V    |
| V <sub>T-(valid)</sub>  | Receiver input threshold for INVALID high-level output voltage | $\frac{FORCEON}{FORCEOFF} = V_{CC}$  | -2.7                  |                    |     | V    |
| V <sub>T(invalid)</sub> | Receiver input threshold for INVALID low-level output voltage  | $\frac{\text{FORCEON} = \text{GND},}{\text{FORCEOFF} = V_{CC}}$                  | -0.3                  |                    | 0.3 | V    |
| V <sub>OH</sub>         | INVALID high-level output voltage                              | $I_{OH} = -1 \text{ mA},$<br>FORCEON = GND,<br>$FORCEOFF = V_{CC}$               | V <sub>CC</sub> – 0.6 |                    |     | V    |
| V <sub>OL</sub>         | INVALID low-level output voltage                               | $I_{OH} = -1 \text{ mA},$<br><u>FORCEON</u> = GND,<br>FORCEOFF = V <sub>CC</sub> |                       |                    | 0.4 | V    |

Test conditions are C1–C4 = 0.1  $\mu$ F at V<sub>CC</sub> = 3.3 V ± 0.3 V; C1 = 0.047  $\mu$ F, C2–C4 = 0.33  $\mu$ F at V<sub>CC</sub> = 5 V ± 0.5 V. All typical values are at V<sub>CC</sub> = 3.3 V or V<sub>CC</sub> = 5 V, and T<sub>A</sub> = 25°C. (1)(2)

### 6.9 Switching Characteristics – Driver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(1)</sup>

|                    | PARAMETER                    | TEST CONDITIONS   |   | MIN | TYP <sup>(2)</sup> | MAX | UNIT |
|--------------------|------------------------------|---|---|-----|--------------------|-----|------|
|                    | Maximum data rate            | $C_L = 1000 \text{ pF}, R_L = 3 \text{ k}\Omega,$<br>see Figure 3                               |   | 150 | 250                |     | kbps |
| t <sub>sk(p)</sub> | Pulse skew <sup>(3)</sup>    | $C_L$ = 150 to 2500 pF, $R_L$ = 3 k $\Omega$ to 7 k $\Omega$ , see Figure 4                     |   |     | 100                |     | ns   |
|                    | Slew rate, transition region | V <sub>CC</sub> = 3.3 V,  | $C_{L} = 150 \text{ to } 1000 \text{ pF}$ | 6   |                    | 30  |      |
| SR(tr)             | (see Figure 3)               | $R_L = 3 \text{ k}\Omega \text{ to } 7 \text{ k}\Omega$ $C_L = 150 \text{ to } 2500 \text{ pF}$ |   | 4   |                    | 30  | V/µs |

(1) Test conditions are C1–C4 = 0.1  $\mu$ F at V<sub>CC</sub> = 3.3 V ± 0.3 V; C1 = 0.047  $\mu$ F, C2–C4 = 0.33  $\mu$ F at V<sub>CC</sub> = 5 V ± 0.5 V. (2) All typical values are at V<sub>CC</sub> = 3.3 V or V<sub>CC</sub> = 5 V, and T<sub>A</sub> = 25°C. (3) Pulse skew is defined as  $|t_{PLH} - t_{PHL}|$  of each channel of the same device.



### 6.10 Switching Characteristics – Receiver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(1)</sup>

|                    | PARAMETER   | MIN TYP <sup>(2)</sup>   | MAX | UNIT |    |  |  |  |
|--------------------|---|--|-----|------|----|--|--|--|
| t <sub>PLH</sub>   | Propagation delay time, low- to high-level output | C <sub>L</sub> = 150 pF,<br>see Figure 5                         | 150 |      | ns |  |  |  |
| t <sub>PHL</sub>   | Propagation delay time, high- to low-level output | C <sub>L</sub> = 150 pF,<br>see Figure 5                         | 150 |      | ns |  |  |  |
| t <sub>en</sub>    | Output enable time                                | $C_L = 150 \text{ pF}, R_L = 3 \text{ k}\Omega,$<br>see Figure 6 | 200 |      | ns |  |  |  |
| t <sub>dis</sub>   | Output disable time                               | $C_L = 150 \text{ pF}, R_L = 3 \text{ k}\Omega,$<br>see Figure 6 | 200 |      | ns |  |  |  |
| t <sub>sk(p)</sub> | Pulse skew <sup>(3)</sup>                         | See Figure 5   | 50  |      | ns |  |  |  |

Test conditions are C1–C4 = 0.1  $\mu$ F at V<sub>CC</sub> = 3.3 V ± 0.3 V; C1 = 0.047  $\mu$ F, C2–C4 = 0.33  $\mu$ F at V<sub>CC</sub> = 5 V ± 0.5 V. All typical values are at V<sub>CC</sub> = 3.3 V or V<sub>CC</sub> = 5 V, and T<sub>A</sub> = 25°C. Pulse skew is defined as |t<sub>PLH</sub> - t<sub>PHL</sub>| of each channel of the same device. (1)

(2)

(3)

#### **Switching Characteristics – Status** 6.11

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(1)</sup>

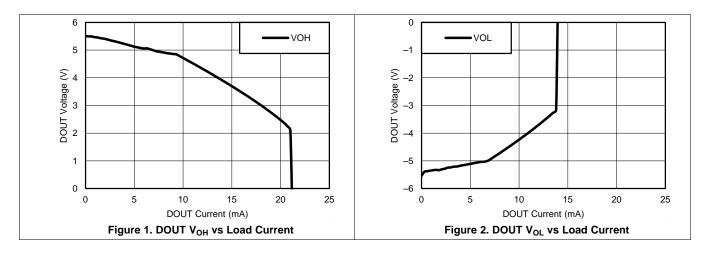
|                      | PARAMETER   | MIN | TYP <sup>(2)</sup> | MAX | UNIT |
|----------------------|---|-----|--------------------|-----|------|
| t <sub>valid</sub>   | Propagation delay time, low- to high-level output |     | 1                  |     | μs   |
| t <sub>invalid</sub> | Propagation delay time, high- to low-level output |     | 30                 |     | μs   |
| t <sub>en</sub>      | Supply enable time                                |     | 100                |     | μs   |

Test conditions are C1–C4 = 0.1  $\mu$ F at V<sub>CC</sub> = 3.3 V ± 0.3 V; C1 = 0.047  $\mu$ F, C2–C4 = 0.33  $\mu$ F at V<sub>CC</sub> = 5 V ± 0.5 V. (1)

(2) All typical values are at  $V_{CC} = 3.3$  V or  $V_{CC} = 5$  V, and  $T_A = 25^{\circ}C$ .

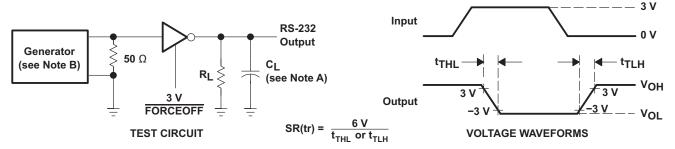
### 6.12 Typical Characteristics

 $V_{CC} = 3.3 V$ 





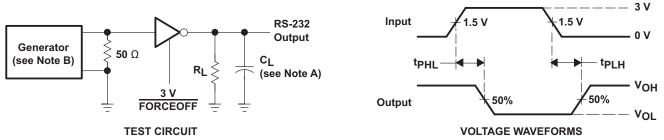
### 7 Parameter Measurement Information



A. C<sub>L</sub> includes probe and jig capacitance.

B. The pulse generator has the following characteristics: PRR = 250 kbps,  $Z_O = 50 \Omega$ , 50% duty cycle,  $t_r \le 10$  ns,  $t_f \le 10$  ns.

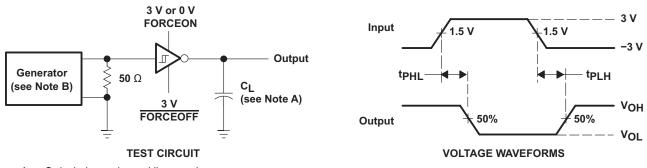
#### Figure 3. Driver Slew Rate



A. C<sub>L</sub> includes probe and jig capacitance.

B. The pulse generator has the following characteristics: PRR = 250 kbps,  $Z_0$  = 50  $\Omega$ , 50% duty cycle,  $t_r \le 10$  ns,  $t_f \le 10$  ns.

#### Figure 4. Driver Pulse Skew

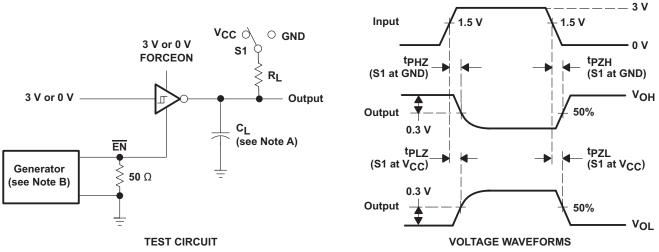


A. C<sub>L</sub> includes probe and jig capacitance.

B. The pulse generator has the following characteristics:  $Z_0 = 50 \Omega$ , 50% duty cycle,  $t_r \le 10$  ns.  $t_f \le 10$  ns.

Figure 5. Receiver Propagation Delay Times





### Parameter Measurement Information (continued)

- A. C<sub>L</sub> includes probe and jig capacitance.
- B. The pulse generator has the following characteristics:  $Z_0 = 50 \ \Omega$ , 50% duty cycle,  $t_r \le 10 \ ns$ ,  $t_f \le 10 \ ns$ .
- $\label{eq:C.total} C. \quad t_{PLZ} \text{ and } t_{PHZ} \text{ are the same as } t_{dis}.$
- D.  $t_{PZL}$  and  $t_{PZH}$  are the same as  $t_{en}$ .

#### Figure 6. Receiver Enable and Disable Times

3 V 2.7 V 0 V Receiver Input 0 V ROUT Π -2.7 V 2.7 V -3 V Generator ξ **50** Ω (see Note B) tvalid tinvalid <sup>-</sup> Vcc -50% V<sub>CC</sub> 50% V<sub>CC</sub> INVALID 0 V Output Auto-INVALID ۲en powerdown C<sub>L</sub> = 30 pF V+ V+ (see Note A) 0.3 V FORCEOFF -۷сс Supply 0 V Voltages DIN DOUT 0.3 V FORCEON v-**TEST CIRCUIT VOLTAGE WAVEFORMS** Valid RS-232 Level, INVALID High 2.7 V Indeterminate 0.3 V If Signal Remains Within This Region 0 V For More Than 30 µs, INVALID Is Low<sup>†</sup> -0.3 V Indeterminate -2.7 V Valid RS-232 Level, INVALID High

Parameter Measurement Information (continued)

Figure 7. INVALID Propagation Delay Times and Driver Enabling Time

<sup>†</sup> Auto-powerdown disables drivers and reduces supply

current to 1 µA.

EXAS

STRUMENTS

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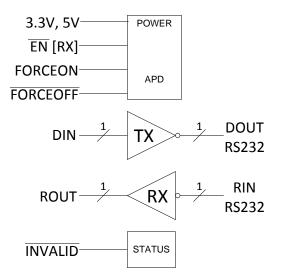
## 8 Detailed Description

The MAX3221 device is a one-driver and one-receiver RS-232 interface device. All RS-232 inputs and outputs are protected to  $\pm 15$  kV using the Human Body Model. The charge pump requires only four small 0.1-µF capacitors for operation from a 3.3-V supply. The MAX3221 is capable of running at data rates up to 250 kbps, while maintaining RS-232-compliant output levels.

Automatic power-down can be disabled when FORCEON and FORCEOFF are high. With automatic power-down plus enabled, the device activates automatically when a valid signal is applied to any receiver input. The device can automatically power down the driver to save power when the RIN input is unpowered.

INVALID is high (valid data) if receiver input voltage is greater than 2.7 V or less than -2.7 V, or has been between -0.3 V and 0.3 V for less than 30  $\mu$ s. INVALID is low (invalid data) if receiver input voltages are between -0.3 V and 0.3 V for more than 30  $\mu$ s. Refer to Figure 7 for receiver input levels.

### 8.2 Functional Block Diagram



### 8.3 Feature Description

#### 8.3.1 Power

The power block increases, inverts, and regulates voltage at V+ and V- pins using a charge <u>pump that requires</u> four external capacitors. <u>Auto-power-down feature for driver is controlled by FORCEON and FORCEOFF inputs</u>. Receiver is controlled by <u>EN input</u>. See <u>Table 1</u> and <u>Table 2</u>

When MAX3221 is unpowered, it can be safely connected to an active remote RS232 device.

#### 8.3.2 RS232 Driver

One driver interfaces standard logic level to RS232 levels. DIN input must be valid high or low.

#### 8.3.3 RS232 Receiver

One receiver interfaces RS232 levels to standard logic levels. An open input will result in a high output on ROUT. RIN input includes an internal standard RS232 load. A logic high input on the EN pin will shutdown the receiver output.

#### 8.3.4 RS232 Status

The INVALID output goes low when RIN input is unpowered for more than 30  $\mu$ s. The INVALID output goes high when receiver has a valid input. The INVALID output is active when V<sub>cc</sub> is powered irregardless of FORCEON and FORCEOFF inputs (see Table 3).

MAX3221 SLLS3480 – JUNE 1999 – REVISED JUNE 2015

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#### 8.4 Device Functional Modes

Table 1, Table 2, and Table 3 show the behavior of the driver, receiver, and INVALID(activelow) features under all possible relevant combinations of inputs.

|     |         | OUTPUT   |                           |      |                               |  |  |  |
|-----|---------|----------|---------------------------|------|-------------------------------|--|--|--|
| DIN | FORCEON | FORCEOFF | VALID RIN RS-232<br>LEVEL | DOUT | DRIVER STATUS                 |  |  |  |
| Х   | Х       | L        | Х                         | Z    | Powered off                   |  |  |  |
| L   | Н       | Н        | Х                         | Н    | Normal operation with         |  |  |  |
| Н   | Н       | Н        | Х                         | L    | automatic power down disabled |  |  |  |
| L   | L       | Н        | Yes                       | Н    | Normal operation with         |  |  |  |
| Н   | L       | Н        | Yes                       | L    | automatic power down enabled  |  |  |  |
| L   | L       | Н        | No                        | Z    | Powered off by                |  |  |  |
| Н   | L       | Н        | No                        | Z    | automatic power down feature  |  |  |  |

Table 1. Driver<sup>(1)</sup>

(1) H = high level, L = low level, X = irrelevant, Z = high impedance, Yes = |RIN| > 2.7 V, No = |RIN| < 0.3 V

### Table 2. Receiver<sup>(1)</sup>

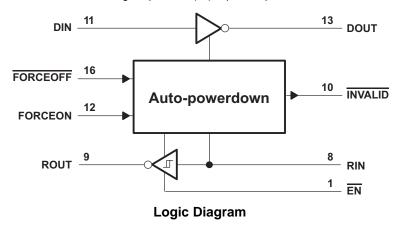
|      | INPUTS | 3                         | OUTPUT | RECEIVER STATUS  |  |  |
|------|--------|---------------------------|--------|------------------|--|--|
| RIN  | EN     | VALID RIN RS-232<br>LEVEL | ROUT   | RECEIVER STATUS  |  |  |
| Х    | Н      | Х                         | Z      | Output off       |  |  |
| L    | L      | Х                         | Н      |                  |  |  |
| Н    | L      | Х                         | L      | Normal operation |  |  |
| Open | L      | No                        | Н      |                  |  |  |

(1) H = high level, L = low level, X = irrelevant, Z = high impedance (off), Open = input disconnected or connected driver off

#### Table 3. INVALID<sup>(1)</sup>

|      | INPUTS  |          |    |         |  |
|------|---------|----------|----|---------|--|
| RIN  | FORCEON | FORCEOFF | EN | INVALID |  |
| L    | Х       | Х        | Х  | Н       |  |
| Н    | Х       | Х        | Х  | Н       |  |
| Open | Х       | Х        | Х  | L       |  |

(1) H = high level, L = low level, X = irrelevant, Z = high impedance (off), Open = input disconnected or connected driver off





### 9 Application and Implementation

#### NOTE

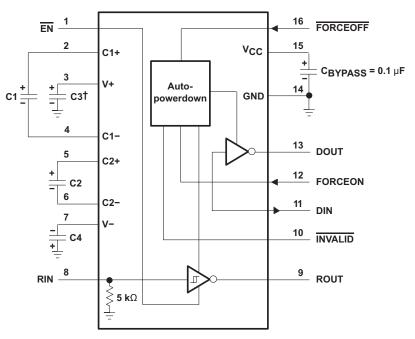
Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

#### 9.1 Application Information

The MAX3221 line driver and receiver is a specialized device for 3-V to 5.5-V RS-232 communication applications. This application is a generic implementation of this device with all required external components. For proper operation, add capacitors as shown in Figure 8.

## 9.2 Typical Application

ROUT and DIN connect to UART or general purpose logic lines. FORCEON and FORCEOFF may be connected general purpose logic lines or tied to ground or  $V_{CC}$ . INVALID may be connected to a general purpose logic line or left unconnected. RIN and DOUT lines connect to a RS232 connector or cable. DIN, FORCEON, and FORCEOFF inputs must not be left unconnected.



<sup>†</sup>C3 can be connected to V<sub>CC</sub> or GND.

NOTES: A. Resistor values shown are nominal.

B. Nonpolarized ceramic capacitors are acceptable. If polarized tantalum or electrolytic capacitors are used, they should be connected as shown.

| V <sub>CC</sub> vs CAPACITOR VALUES |          |                |  |  |  |  |  |  |
|-------------------------------------|----------|----------------|--|--|--|--|--|--|
| Vcc                                 | C1       | C2, C3, and C4 |  |  |  |  |  |  |
| 3.3 V ± 0.3 V                       | 0.1 µF   | 0.1 µF         |  |  |  |  |  |  |
| 5 V ± 0.5 V                         | 0.047 μF | 0.33 µF        |  |  |  |  |  |  |
| 3 V to 5.5 V                        | 0.1 μF   | 0.47 μF        |  |  |  |  |  |  |

| Vcc | vs C | APA | CITOR | VALUES |  |
|-----|------|-----|-------|--------|--|

| Figure 8. | Typical Operating ( | Circuit and Capacitor Values |
|-----------|---------------------|------------------------------|
|-----------|---------------------|------------------------------|



### **Typical Application (continued)**

### 9.2.1 Design Requirements

- Recommended V<sub>CC</sub> is 3.3 V or 5 V.
  3 V to 5.5 V is also possible
- Maximum recommended bit rate is 250 kbps.
- Use capacitors as shown in Figure 8.

### 9.2.2 Detailed Design Procedure

- DIN, FORCEOFF and FORCEON inputs must be connected to valid low or high logic levels.
- Select capacitor values based on VCC level for best performance.

### 9.2.3 Application Curve

Curves for  $V_{\text{CC}}$  of 3.3 V and 250 kbps alternative bit data stream.

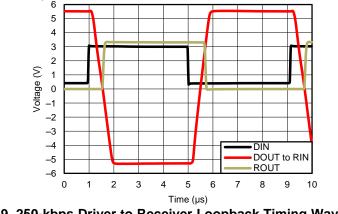


Figure 9. 250-kbps Driver to Receiver Loopback Timing Waveform,  $V_{CC}\text{=}$  3.3 V

### **10 Power Supply Recommendations**

TI recommends a 0.1-µF capacitor to filter noise on the power supply pin. For additional filter capability, a 0.01-µF capacitor may be added in parallel as well. Power supply input voltage is recommended to be any valid level in *Recommended Operating Conditions*.



### 11 Layout

### 11.1 Layout Guidelines

Keep the external capacitor traces short. This is more important on C1 and C2 nodes that have the fastest rise and fall times.

### 11.2 Layout Example

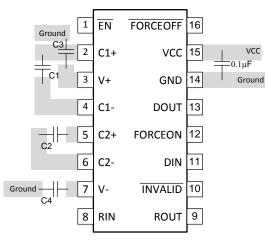


Figure 10. Layout Diagram

## **12 Device and Documentation Support**

### 12.1 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

TI E2E<sup>™</sup> Online Community *TI's Engineer-to-Engineer (E2E) Community.* Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

**Design Support TI's Design Support** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

### 12.2 Trademarks

E2E is a trademark of Texas Instruments. All other trademarks are the property of their respective owners.

### 12.3 Electrostatic Discharge Caution



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

### 12.4 Glossary

SLYZ022 — TI Glossary.

This glossary lists and explains terms, acronyms, and definitions.

### 13 Mechanical, Packaging, and Orderable Information

The following pages include mechanical packaging and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser based versions of this data sheet, refer to the left hand navigation.



1-Sep-2016

# PACKAGING INFORMATION

| Orderable Device | Status | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish | MSL Peak Temp      | Op Temp (°C) | Device Marking<br>(4/5) | Samples |
|------------------|--------|--------------|--------------------|------|----------------|----------------------------|------------------|--------------------|--------------|-------------------------|---------|
| MAX3221CDB       | ACTIVE | SSOP         | DB                 | 16   | 80             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM | 0 to 70      | MA3221C                 | Samples |
| MAX3221CDBE4     | ACTIVE | SSOP         | DB                 | 16   | 80             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM | 0 to 70      | MA3221C                 | Samples |
| MAX3221CDBG4     | ACTIVE | SSOP         | DB                 | 16   | 80             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM | 0 to 70      | MA3221C                 | Samples |
| MAX3221CDBR      | ACTIVE | SSOP         | DB                 | 16   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM | 0 to 70      | MA3221C                 | Samples |
| MAX3221CDBRG4    | ACTIVE | SSOP         | DB                 | 16   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM | 0 to 70      | MA3221C                 | Samples |
| MAX3221CPW       | ACTIVE | TSSOP        | PW                 | 16   | 90             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM | 0 to 70      | MA3221C                 | Samples |
| MAX3221CPWE4     | ACTIVE | TSSOP        | PW                 | 16   | 90             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM | 0 to 70      | MA3221C                 | Samples |
| MAX3221CPWG4     | ACTIVE | TSSOP        | PW                 | 16   | 90             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM | 0 to 70      | MA3221C                 | Samples |
| MAX3221CPWR      | ACTIVE | TSSOP        | PW                 | 16   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM | 0 to 70      | MA3221C                 | Samples |
| MAX3221CPWRE4    | ACTIVE | TSSOP        | PW                 | 16   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM | 0 to 70      | MA3221C                 | Samples |
| MAX3221CPWRG4    | ACTIVE | TSSOP        | PW                 | 16   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM | 0 to 70      | MA3221C                 | Samples |
| MAX3221IDB       | ACTIVE | SSOP         | DB                 | 16   | 80             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM | -40 to 85    | MB3221I                 | Samples |
| MAX3221IDBE4     | ACTIVE | SSOP         | DB                 | 16   | 80             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM | -40 to 85    | MB3221I                 | Samples |
| MAX3221IDBG4     | ACTIVE | SSOP         | DB                 | 16   | 80             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM | -40 to 85    | MB3221I                 | Samples |
| MAX3221IDBR      | ACTIVE | SSOP         | DB                 | 16   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM | -40 to 85    | MB3221I                 | Samples |
| MAX3221IDBRE4    | ACTIVE | SSOP         | DB                 | 16   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM | -40 to 85    | MB3221I                 | Samples |
| MAX3221IDBRG4    | ACTIVE | SSOP         | DB                 | 16   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM | -40 to 85    | MB3221I                 | Samples |



1-Sep-2016

| Orderable Device | Status | Package Type |         | Pins | Package | Eco Plan                   | Lead/Ball Finish  | MSL Peak Temp      | Op Temp (°C) | Device Marking | Samples |
|------------------|--------|--------------|---------|------|---------|----------------------------|-------------------|--------------------|--------------|----------------|---------|
|                  | (1)    |              | Drawing |      | Qty     | (2)                        | (6)               | (3)                |              | (4/5)          |         |
| MAX3221IPW       | ACTIVE | TSSOP        | PW      | 16   | 90      | Green (RoHS<br>& no Sb/Br) | CU NIPDAU         | Level-1-260C-UNLIM | -40 to 85    | MB3221I        | Samples |
| MAX3221IPWG4     | ACTIVE | TSSOP        | PW      | 16   | 90      | Green (RoHS<br>& no Sb/Br) | CU NIPDAU         | Level-1-260C-UNLIM | -40 to 85    | MB3221I        | Samples |
| MAX3221IPWR      | ACTIVE | TSSOP        | PW      | 16   | 2000    | Green (RoHS<br>& no Sb/Br) | CU NIPDAU   CU SN | Level-1-260C-UNLIM | -40 to 85    | MB3221I        | Samples |
| MAX3221IPWRG4    | ACTIVE | TSSOP        | PW      | 16   | 2000    | Green (RoHS<br>& no Sb/Br) | CU NIPDAU         | Level-1-260C-UNLIM | -40 to 85    | MB3221I        | Samples |

<sup>(1)</sup> The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes. **Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and package die adhesive used between the die and package die adhesive used between the die adhesive used between the die adhesive us

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

<sup>(4)</sup> There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

<sup>(5)</sup> Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

<sup>(6)</sup> Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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1-Sep-2016

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#### OTHER QUALIFIED VERSIONS OF MAX3221 :

• Enhanced Product: MAX3221-EP

NOTE: Qualified Version Definitions:

• Enhanced Product - Supports Defense, Aerospace and Medical Applications

# PACKAGE MATERIALS INFORMATION

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## TAPE AND REEL INFORMATION





## QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



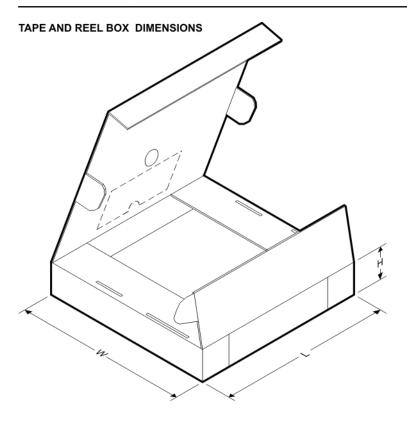
| Device        | Package<br>Type                         | Package<br>Drawing |    | SPQ  | Reel<br>Diameter | Reel<br>Width | A0<br>(mm) | B0<br>(mm) | K0<br>(mm) | P1<br>(mm) | W<br>(mm) | Pin1<br>Quadrant |
|---------------|---|--------------------|----|------|------------------|---------------|------------|------------|------------|------------|-----------|------------------|
|               | .,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,, | Draming            |    |      |                  | W1 (mm)       | · · /      | ()         | ()         | ()         | ()        | quadrant         |
| MAX3221CDBR   | SSOP                                    | DB                 | 16 | 2000 | 330.0            | 16.4          | 8.2        | 6.6        | 2.5        | 12.0       | 16.0      | Q1               |
| MAX3221CPWR   | TSSOP                                   | PW                 | 16 | 2000 | 330.0            | 12.4          | 6.9        | 5.6        | 1.6        | 8.0        | 12.0      | Q1               |
| MAX3221IDBR   | SSOP                                    | DB                 | 16 | 2000 | 330.0            | 16.4          | 8.2        | 6.6        | 2.5        | 12.0       | 16.0      | Q1               |
| MAX3221IPWR   | TSSOP                                   | PW                 | 16 | 2000 | 330.0            | 12.4          | 6.9        | 5.6        | 1.6        | 8.0        | 12.0      | Q1               |
| MAX3221IPWR   | TSSOP                                   | PW                 | 16 | 2000 | 330.0            | 12.4          | 6.9        | 5.6        | 1.6        | 8.0        | 12.0      | Q1               |
| MAX3221IPWRG4 | TSSOP                                   | PW                 | 16 | 2000 | 330.0            | 12.4          | 6.9        | 5.6        | 1.6        | 8.0        | 12.0      | Q1               |

TEXAS INSTRUMENTS

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# PACKAGE MATERIALS INFORMATION

29-Apr-2014



\*All dimensions are nominal

| Device        | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| MAX3221CDBR   | SSOP         | DB              | 16   | 2000 | 367.0       | 367.0      | 38.0        |
| MAX3221CPWR   | TSSOP        | PW              | 16   | 2000 | 367.0       | 367.0      | 35.0        |
| MAX3221IDBR   | SSOP         | DB              | 16   | 2000 | 367.0       | 367.0      | 38.0        |
| MAX3221IPWR   | TSSOP        | PW              | 16   | 2000 | 364.0       | 364.0      | 27.0        |
| MAX3221IPWR   | TSSOP        | PW              | 16   | 2000 | 367.0       | 367.0      | 35.0        |
| MAX3221IPWRG4 | TSSOP        | PW              | 16   | 2000 | 367.0       | 367.0      | 35.0        |

PW (R-PDSO-G16)

PLASTIC SMALL OUTLINE



NOTES:

A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.  $\beta$ . This drawing is subject to change without notice.

Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.

Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.

E. Falls within JEDEC MO-153





NOTES: A. All linear dimensions are in millimeters.

- B. This drawing is subject to change without notice.
- C. Publication IPC-7351 is recommended for alternate designs.
- D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
- E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.



# **MECHANICAL DATA**

MSSO002E - JANUARY 1995 - REVISED DECEMBER 2001

## DB (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE

28 PINS SHOWN



NOTES: A. All linear dimensions are in millimeters.

- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
- D. Falls within JEDEC MO-150



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