

# MAX3221 3-V to 5.5-V RS-232 Line Driver and Receiver

## With $\pm 15$ -kV ESD Protection

### 1 Features

- RS-232 Bus-pin ESD protection exceeds  $\pm 15$  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  $V_{CC}$  supply
- Operates up to 250 kbps
- One driver and one receiver
- Low standby current: 1  $\mu$ A typical
- External capacitors:  $4 \times 0.1 \mu$ F
- 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

- [Industrial PCs](#)
- [Wired networking](#)
- [Data center and enterprise computing](#)
- [Battery-powered systems](#)
- [PDAs](#)
- [Notebooks](#)
- [Laptops](#)
- [Palmtop PCs](#)
- [Hand-held equipment](#)

### 3 Description

The MAX3221 device consists of one line driver, one line receiver with dedicated enable pin, and a dual charge-pump circuit with  $\pm 15$ -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/ $\mu$ s driver output slew rate.

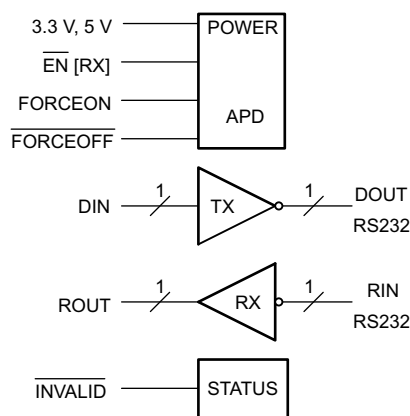
Flexible control options for power management are available when the serial port is inactive. The automatic power-down feature functions when FORCEON is low and FORCEOFF is high. During this mode of operation, if the device does not sense a valid

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

#### Device Information

| PART NUMBER | PACKAGE <sup>(1)</sup> | BODY SIZE (NOM)          |
|-------------|------------------------|--------------------------|
| MAX3221     | SSOP (DB) (32)         | 6.20 mm $\times$ 5.30 mm |
|             | TSSOP (PW) (32)        | 5.00 mm $\times$ 4.40 mm |

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



**Simplified Diagram**



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## 4 Revision History

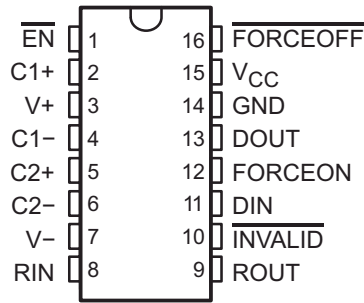
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| <b>Changes from Revision O (June 2015) to Revision P (July 2021)</b>                     | <b>Page</b> |
|--|-------------|
| • Changed the <i>Applications</i> list.....  | 1           |
| • Changed the values in the <i>Thermal Information</i> table for DB and PW packages..... | 5           |

| <b>Changes from Revision N (January 2014) to Revision O (June 2015)</b>  | <b>Page</b> |
|--|-------------|
| • Added <i>Pin Configuration and Functions</i> section, <i>ESD Ratings</i> table, <i>Feature Description</i> section, <i>Device Functional Modes</i> , <i>Application and Implementation</i> section, <i>Power Supply Recommendations</i> section, <i>Layout</i> section, <i>Device and Documentation Support</i> section, and <i>Mechanical, Packaging, and Orderable Information</i> section ..... | 1           |

| <b>Changes from Revision M (March 2004) to Revision N (January 2013)</b>       | <b>Page</b> |
|--|-------------|
| • Updated document to new TI data sheet format - no specification changes..... | 1           |
| • Deleted <i>Ordering Information</i> table.....                               | 1           |

## 5 Pin Configuration and Functions



**Figure 5-1. DB or PW Package, 16-Pin SSOP or TSSOP, Top View**

**Table 5-1. Pin Functions**

| PIN                    |     | I/O | DESCRIPTION   |
|------------------------|-----|-----|---|
| NAME                   | NO. |     |   |
| C1+                    | 2   | —   | Positive terminals of the voltage-doubler charge-pump capacitors                |
| C2+                    | 5   |     |   |
| C1-                    | 4   | —   | Negative terminals of the voltage-doubler charge-pump capacitors                |
| C2-                    | 6   |     |   |
| DIN                    | 11  | I   | Driver input  |
| DOUT                   | 13  | O   | RS-232 driver output  |
| $\overline{\text{EN}}$ | 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  | O   | Invalid output pin. Output low when all RIN inputs are unpowered.               |
| RIN                    | 8   | I   | RS-232 receiver input   |
| ROUT                   | 9   | O   | Receiver output   |
| V <sub>CC</sub>        | 15  | —   | 3-V to 5.5-V supply voltage   |
| V+                     | 3   | O   | 5.5-V supply generated by the charge pump                                       |
| V-                     | 7   | O   | -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    |
| V+ to GND                |                                     | -0.3                                  | 7   |      |
| V- to GND                |                                     | 0.3                                   | -7  |      |
| V+ +  V-  <sup>(2)</sup> |                                     |                                       | 13  |      |
| V <sub>I</sub>           | Input voltage                       | DIN, EN, FORCEOFF, and FORCEON to GND |     | V    |
|                          |                                     | RIN to GND                            |     |      |
| V <sub>O</sub>           | Output voltage                      | DOUT to GND                           |     | V    |
|                          |                                     | ROUT to GND                           |     |      |
| T <sub>J</sub>           | Junction temperature <sup>(3)</sup> |                                       | 150 | °C   |
| T <sub>stg</sub>         | Storage temperature range           | -65                                   | 150 |      |

- (1) Operation outside the *Absolute Maximum Ratings* may cause permanent device damage. *Absolute Maximum Ratings* do not imply functional operation of the device at these or any other conditions beyond those listed under *Recommended Operating Conditions*. If used outside the *Recommended Operating Conditions* but within the *Absolute Maximum Ratings*, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.
- (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<sub>J(max)</sub>, R<sub>θJA</sub>, and T<sub>A</sub>. The maximum allowable power dissipation at any allowable ambient temperature is P<sub>D</sub> = (T<sub>J(max)</sub> - T<sub>A</sub>) / R<sub>θJA</sub>. Operating at the absolute maximum T<sub>J</sub> of 150°C can affect reliability.

### 6.2 ESD Ratings

|                    |                         | VALUE  | UNIT                           |   |
|--------------------|-------------------------|--|--------------------------------|---|
| V <sub>(ESD)</sub> | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>              | All pins except 8, 13<br>±3000 | V |
|                    |                         |  | Pins 8, 13<br>±15,000          |   |
|                    |                         | Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup> | ±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 9-1](#))<sup>(1)</sup>

|                 |                                 | MIN                        | NOM | MAX                     | UNIT |   |
|-----------------|---------------------------------|----------------------------|-----|-------------------------|------|---|
| Supply voltage  |                                 | V <sub>CC</sub> = 3.3 V    | 3   | 3.3                     | 3.6  | V |
|                 |                                 | V <sub>CC</sub> = 5 V      | 4.5 | 5                       | 5.5  |   |
| V <sub>IH</sub> | Driver high-level input voltage | DIN, FORCEOFF, FORCEON, EN |     | V <sub>CC</sub> = 3.3 V | 2    | V |
|                 |                                 |                            |     | V <sub>CC</sub> = 5 V   | 2.4  |   |
| V <sub>IL</sub> | Driver low-level input voltage  | DIN, FORCEOFF, FORCEON, EN |     |                         | 0.8  | V |
| V <sub>I</sub>  | Driver input voltage            | DIN, FORCEOFF, FORCEON, EN |     | 0                       | 5.5  | V |
|                 | Receiver input voltage          |                            |     | -25                     | 25   |   |
| T <sub>A</sub>  | Operating free-air temperature  | MAX3221C                   | 0   | 70                      | °C   |   |
|                 |                                 | MAX3221I                   | -40 | 85                      |      |   |

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

## 6.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |  | MAX3221   |            | UNIT |
|-------------------------------|--|-----------|------------|------|
|                               |  | DB (SSOP) | PW (TSSOP) |      |
|                               |  | 16 PINS   | 16 PINS    |      |
| R <sub>θJA</sub>              | Junction-to-ambient thermal resistance       | 105.8     | 110.9      | °C/W |
| R <sub>θJC(top)</sub>         | Junction-to-case (top) thermal resistance    | 51.9      | 41.7       | °C/W |
| R <sub>θJB</sub>              | Junction-to-board thermal resistance         | 57.6      | 57.2       | °C/W |
| ψ <sub>JT</sub>               | Junction-to-top characterization parameter   | 14.1      | 4.2        | °C/W |
| ψ <sub>JB</sub>               | Junction-to-board characterization parameter | 56.8      | 56.6       | °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>(2)</sup>

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

(1) 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.

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

## 6.6 Electrical Characteristics – Driver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(3)</sup>

| PARAMETER        |   | TEST CONDITIONS   |  | MIN | TYP <sup>(1)</sup> | MAX | UNIT |
|------------------|---|---|--|-----|--------------------|-----|------|
| V <sub>OH</sub>  | High-level output voltage                   | D <sub>OUT</sub> at R <sub>L</sub> = 3 kΩ to GND, D <sub>IN</sub> = GND             |  | 5   | 5.4                |     | V    |
| V <sub>OL</sub>  | Low-level output voltage                    | D <sub>OUT</sub> at R <sub>L</sub> = 3 kΩ to GND, D <sub>IN</sub> = V <sub>CC</sub> |  | –5  | –5.4               |     | V    |
| I <sub>IH</sub>  | High-level input current                    | V <sub>I</sub> = V <sub>CC</sub>  |  |     | ±0.01              | ±1  | µA   |
| I <sub>IL</sub>  | Low-level input current                     | V <sub>I</sub> at GND   |  |     | ±0.01              | ±1  | µA   |
| I <sub>OS</sub>  | Short-circuit output current <sup>(2)</sup> | V <sub>CC</sub> = 3.6 V   | V <sub>O</sub> = 0 V                                     |     | ±35                | ±60 | mA   |
|                  |   | V <sub>CC</sub> = 5.5 V   | V <sub>O</sub> = 0 V                                     |     | ±35                | ±60 |      |
| r <sub>O</sub>   | Output resistance                           | V <sub>CC</sub> , V+, and V– = 0 V  | V <sub>O</sub> = ±2 V                                    | 300 | 10M                |     | Ω    |
| I <sub>off</sub> | Output leakage current                      | FORCEOFF = GND  | V <sub>O</sub> = ±12 V, V <sub>CC</sub> = 3 V to 3.6 V   |     |                    | ±25 | µA   |
|                  |   |   | V <sub>O</sub> = ±12 V, V <sub>CC</sub> = 4.5 V to 5.5 V |     |                    | ±25 |      |

(1) 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.

(2) 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.

(3) Test conditions are C1–C4 = 0.1 µF at V<sub>CC</sub> = 3.3 V ± 0.3 V; C1 = 0.047 µF, C2–C4 = 0.33 µF at V<sub>CC</sub> = 5 V ± 0.5

## 6.7 Electrical Characteristics – Receiver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(2)</sup>

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

(1) 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.

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

## 6.8 Electrical Characteristics – Status

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(2)</sup>

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

(1) 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.

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

## 6.9 Switching Characteristics – Driver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(3)</sup>

| PARAMETER          |   | TEST CONDITIONS   | MIN                             | TYP <sup>(1)</sup> | MAX | UNIT |
|--------------------|---|---|---------------------------------|--------------------|-----|------|
|                    | Maximum data rate   | C <sub>L</sub> = 1000 pF, R <sub>L</sub> = 3 kΩ,<br>see <a href="#">Figure 7-1</a>                | 150                             | 250                |     | kbps |
| t <sub>sk(p)</sub> | Pulse skew <sup>(2)</sup>   | C <sub>L</sub> = 150 to 2500 pF, R <sub>L</sub> = 3 kΩ to 7 kΩ,<br>see <a href="#">Figure 7-2</a> |                                 | 100                |     | ns   |
| SR(tr)             | Slew rate, transition region<br>(see <a href="#">Figure 7-1</a> ) | V <sub>CC</sub> = 3.3 V,<br>R <sub>L</sub> = 3 kΩ to 7 kΩ   | C <sub>L</sub> = 150 to 1000 pF | 6                  | 30  | V/µs |
|                    |   |   | C <sub>L</sub> = 150 to 2500 pF | 4                  | 30  |      |

(1) 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.

(2) Pulse skew is defined as |t<sub>PLH</sub> – t<sub>PHL</sub>| of each channel of the same device.

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

## 6.10 Switching Characteristics – Receiver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(3)</sup>

| PARAMETER   |   | TEST CONDITIONS                                       | MIN | TYP <sup>(1)</sup> | MAX | UNIT |
|-------------|---|---|-----|--------------------|-----|------|
| $t_{PLH}$   | Propagation delay time, low- to high-level output | $C_L = 150$ pF, see Figure 7-3                        |     | 150                |     | ns   |
| $t_{PHL}$   | Propagation delay time, high- to low-level output | $C_L = 150$ pF, see Figure 7-3                        |     | 150                |     | ns   |
| $t_{en}$    | Output enable time                                | $C_L = 150$ pF, $R_L = 3$ k $\Omega$ , see Figure 7-4 |     | 200                |     | ns   |
| $t_{dis}$   | Output disable time                               | $C_L = 150$ pF, $R_L = 3$ k $\Omega$ , see Figure 7-4 |     | 200                |     | ns   |
| $t_{sk(p)}$ | Pulse skew <sup>(2)</sup>                         | See Figure 7-3  |     | 50                 |     | ns   |

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

(2) Pulse skew is defined as  $|t_{PLH} - t_{PHL}|$  of each channel of the same device.

(3) Test conditions are  $C_1$ – $C_4 = 0.1$   $\mu\text{F}$  at  $V_{CC} = 3.3$  V  $\pm$  0.3 V;  $C_1 = 0.047$   $\mu\text{F}$ ,  $C_2$ – $C_4 = 0.33$   $\mu\text{F}$  at  $V_{CC} = 5$  V  $\pm$  0.5 V.

## 6.11 Switching Characteristics – Status

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(2)</sup>

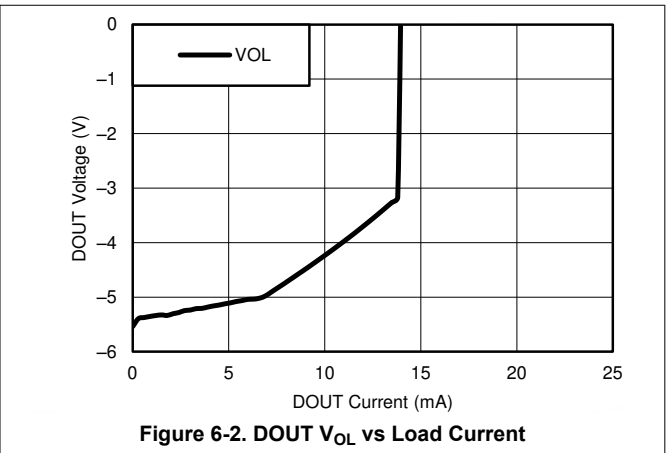
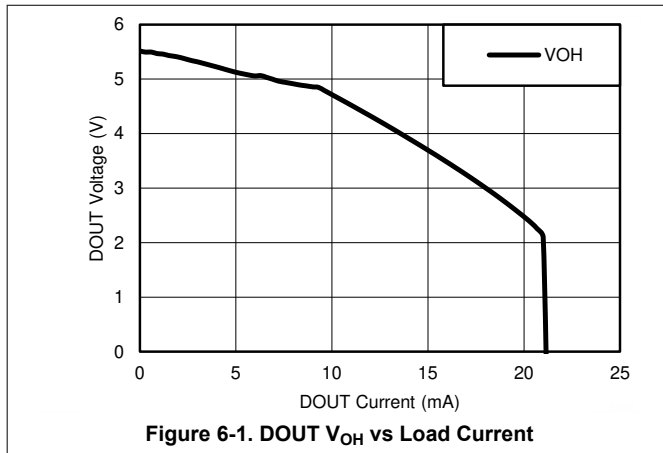
| PARAMETER     |   | MIN | TYP <sup>(1)</sup> | MAX | UNIT          |
|---------------|---|-----|--------------------|-----|---------------|
| $t_{valid}$   | Propagation delay time, low- to high-level output |     | 1                  |     | $\mu\text{s}$ |
| $t_{invalid}$ | Propagation delay time, high- to low-level output |     | 30                 |     | $\mu\text{s}$ |
| $t_{en}$      | Supply enable time                                |     | 100                |     | $\mu\text{s}$ |

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

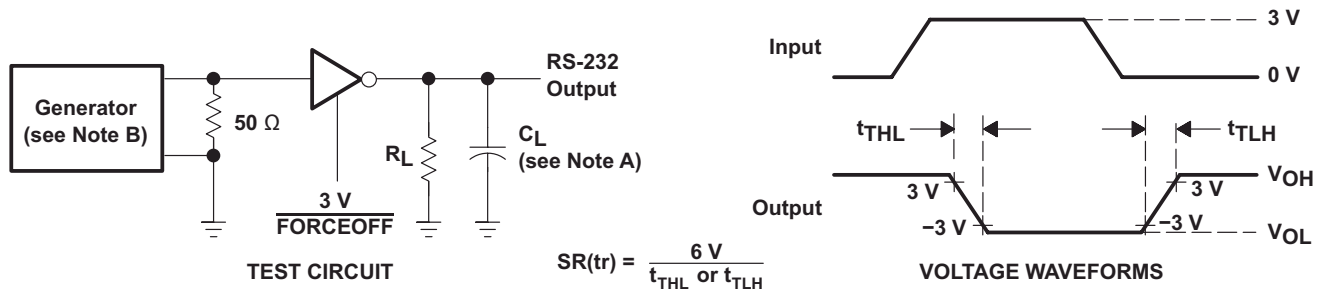
(2) Test conditions are  $C_1$ – $C_4 = 0.1$   $\mu\text{F}$  at  $V_{CC} = 3.3$  V  $\pm$  0.3 V;  $C_1 = 0.047$   $\mu\text{F}$ ,  $C_2$ – $C_4 = 0.33$   $\mu\text{F}$  at  $V_{CC} = 5$  V  $\pm$  0.5 V.

## 6.12 Typical Characteristics

$V_{CC} = 3.3$  V



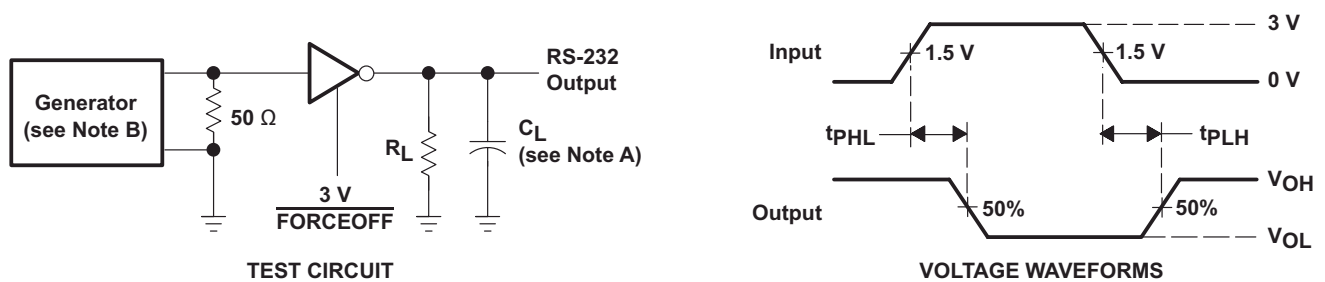
## 7 Parameter Measurement Information



A.  $C_L$  includes probe and jig capacitance.

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

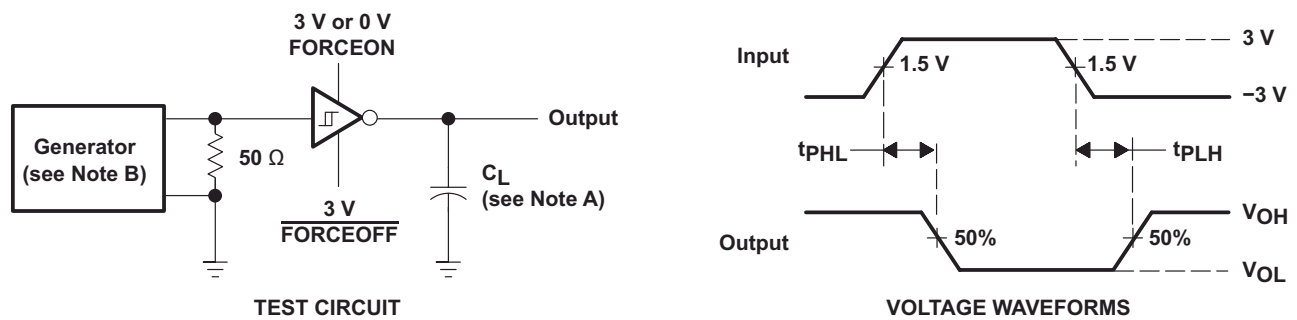
**Figure 7-1. Driver Slew Rate**



A.  $C_L$  includes probe and jig capacitance.

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

**Figure 7-2. Driver Pulse Skew**

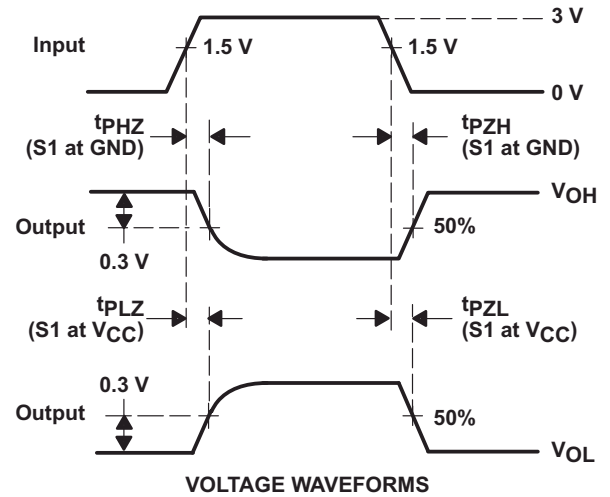
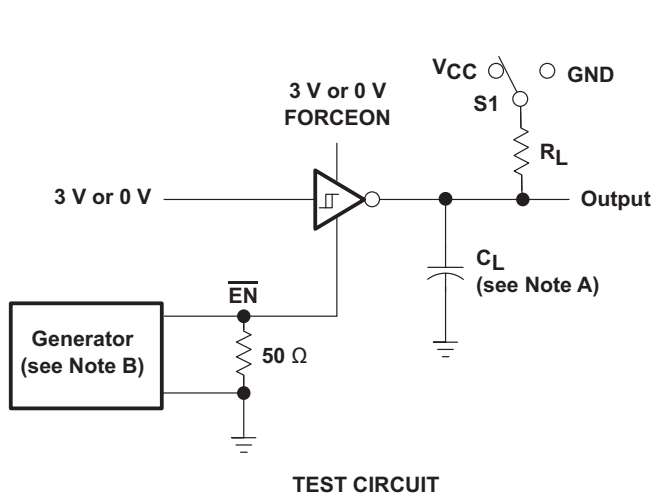


A.  $C_L$  includes probe and jig capacitance.

B. The pulse generator has the following characteristics:  $Z_O = 50\ \Omega$ , 50% duty cycle,  $t_r \leq 10\text{ ns}$ ,  $t_f \leq 10\text{ ns}$ .

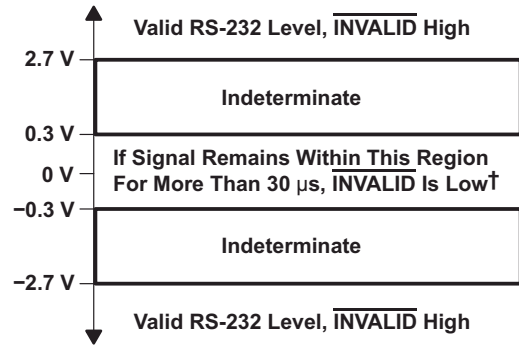
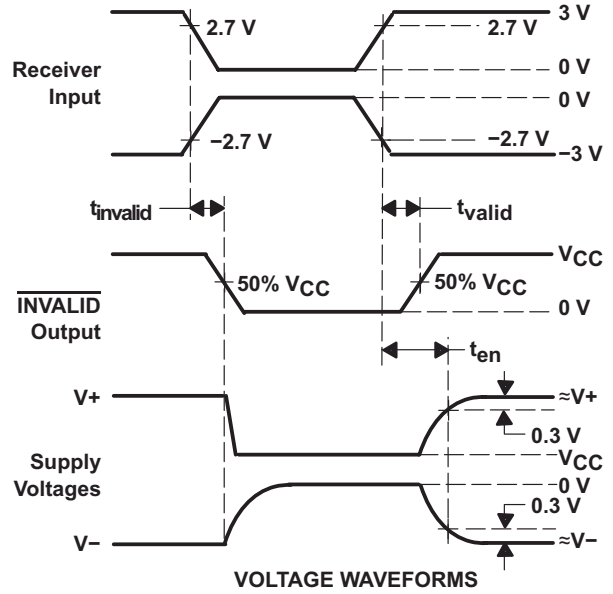
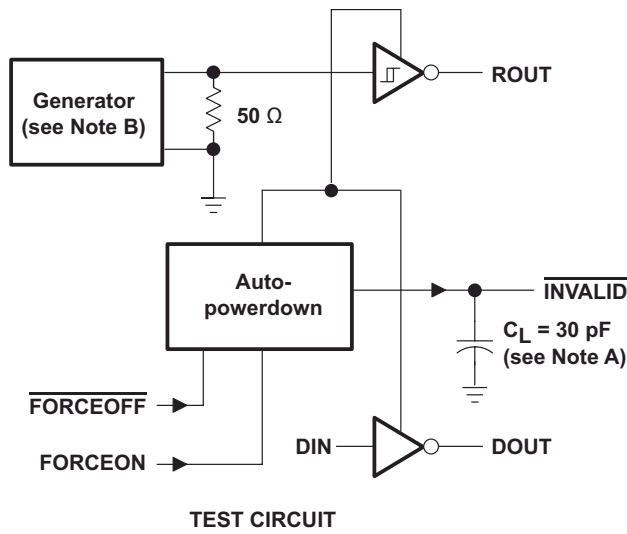
**Figure 7-3. Receiver Propagation Delay Times**





- A. C<sub>L</sub> includes probe and jig capacitance.  
 B. The pulse generator has the following characteristics: Z<sub>O</sub> = 50 Ω, 50% duty cycle, t<sub>r</sub> ≤ 10 ns, t<sub>f</sub> ≤ 10 ns.  
 C. t<sub>PLZ</sub> and t<sub>PHZ</sub> are the same as t<sub>dis</sub>.  
 D. t<sub>PZL</sub> and t<sub>PZH</sub> are the same as t<sub>en</sub>.

Figure 7-4. Receiver Enable and Disable Times



† Auto-powerdown disables drivers and reduces supply current to 1  $\mu$ A.

**Figure 7-5.  $\overline{\text{INVALID}}$  Propagation Delay Times and Driver Enabling Time**

## 8 Detailed Description

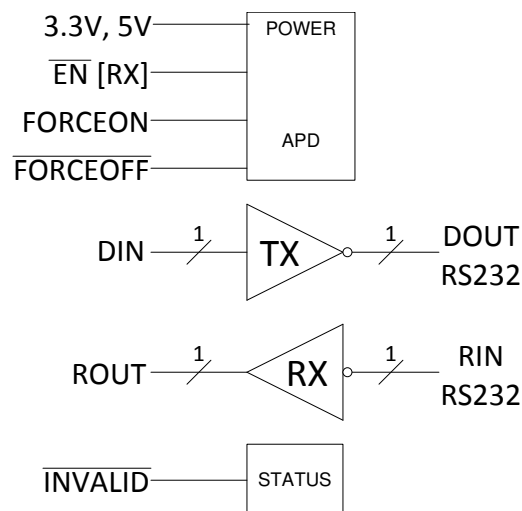
### 8.1 Overview

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- $\mu$ F 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  $\overline{\text{FORCEON}}$  and  $\overline{\text{FORCEOFF}}$  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.

$\overline{\text{INVALID}}$  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.  $\overline{\text{INVALID}}$  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 7-5](#) 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 pump that requires four external capacitors. Auto-power-down feature for driver is controlled by  $\overline{\text{FORCEON}}$  and  $\overline{\text{FORCEOFF}}$  inputs. Receiver is controlled by  $\overline{\text{EN}}$  input. See [Table 8-1](#) and [Table 8-2](#).

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  $\overline{\text{EN}}$  pin will shutdown the receiver output.

#### 8.3.4 RS232 Status

The  $\overline{\text{INVALID}}$  output goes low when RIN input is unpowered for more than 30  $\mu$ s. The  $\overline{\text{INVALID}}$  output goes high when receiver has a valid input. The  $\overline{\text{INVALID}}$  output is active when V<sub>CC</sub> is powered irregardless of  $\overline{\text{FORCEON}}$  and  $\overline{\text{FORCEOFF}}$  inputs (see [Table 8-3](#)).

## 8.4 Device Functional Modes

Table 8-1, Table 8-2, and Table 8-3 show the behavior of the driver, receiver, and INVALID(activelow) features under all possible relevant combinations of inputs.

**Table 8-1. Driver<sup>(1)</sup>**

| INPUTS |         |          |                        | OUTPUT | DRIVER STATUS                                       |
|--------|---------|----------|------------------------|--------|---|
| DIN    | FORCEON | FORCEOFF | VALID RIN RS-232 LEVEL | DOUT   |   |
| X      | X       | L        | X                      | Z      | Powered off   |
| L      | H       | H        | X                      | H      | Normal operation with automatic power down disabled |
| H      | H       | H        | X                      | L      |   |
| L      | L       | H        | Yes                    | H      | Normal operation with automatic power down enabled  |
| H      | L       | H        | Yes                    | L      |   |
| L      | L       | H        | No                     | Z      | Powered off by automatic power down feature         |
| H      | L       | H        | No                     | Z      |   |

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

**Table 8-2. Receiver<sup>(1)</sup>**

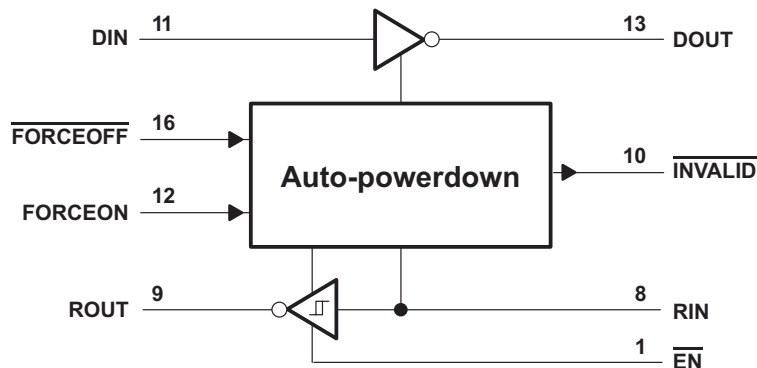
| INPUTS |    |                        | OUTPUT | RECEIVER STATUS  |
|--------|----|------------------------|--------|------------------|
| RIN    | EN | VALID RIN RS-232 LEVEL | ROUT   |                  |
| X      | H  | X                      | Z      | Output off       |
| L      | L  | X                      | H      | Normal operation |
| H      | L  | X                      | L      |                  |
| Open   | L  | No                     | H      |                  |

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

**Table 8-3. INVALID<sup>(1)</sup>**

| INPUTS |         |          |    | OUTPUT  |
|--------|---------|----------|----|---------|
| RIN    | FORCEON | FORCEOFF | EN | INVALID |
| L      | X       | X        | X  | H       |
| H      | X       | X        | X  | H       |
| Open   | X       | X        | X  | L       |

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



**Figure 8-1. Logic Diagram**

## 9 Application and Implementation

### Note

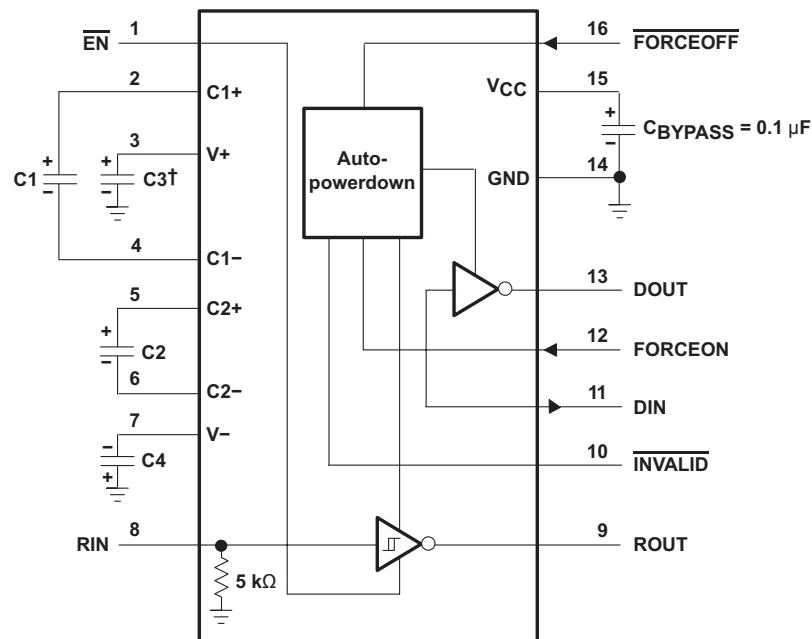
Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation 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 9-1](#).

### 9.2 Typical Application

ROUT and DIN connect to UART or general purpose logic lines. FORCEON and  $\overline{\text{FORCEOFF}}$  may be connected general purpose logic lines or tied to ground or  $V_{CC}$ .  $\overline{\text{INVALID}}$  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  $\overline{\text{FORCEOFF}}$  inputs must not be left unconnected.



† C3 can be connected to  $V_{CC}$  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.

$V_{CC}$  vs CAPACITOR VALUES

| $V_{CC}$          | C1            | C2, C3, and C4 |
|-------------------|---------------|----------------|
| 3.3 V $\pm$ 0.3 V | 0.1 $\mu$ F   | 0.1 $\mu$ F    |
| 5 V $\pm$ 0.5 V   | 0.047 $\mu$ F | 0.33 $\mu$ F   |
| 3 V to 5.5 V      | 0.1 $\mu$ F   | 0.47 $\mu$ F   |

Figure 9-1. Typical Operating Circuit and Capacitor Values

### 9.2.1 Design Requirements

- Recommended  $V_{CC}$  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 9-1](#).

### 9.2.2 Detailed Design Procedure

- $\overline{DIN}$ ,  $\overline{FORCEOFF}$  and  $\overline{FORCEON}$  inputs must be connected to valid low or high logic levels.
- Select capacitor values based on  $V_{CC}$  level for best performance.

### 9.2.3 Application Curve

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

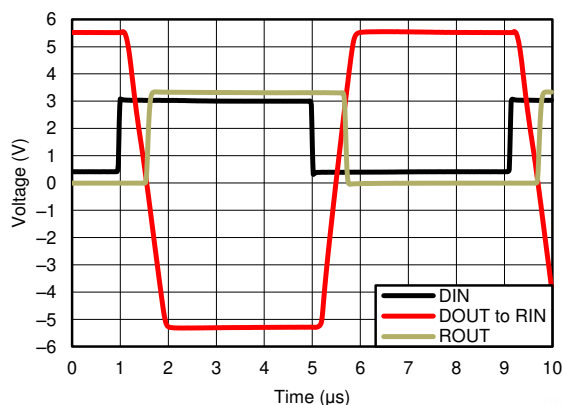


Figure 9-2. 250-kbps Driver to Receiver Loopback Timing Waveform,  $V_{CC} = 3.3$  V

## 10 Power Supply Recommendations

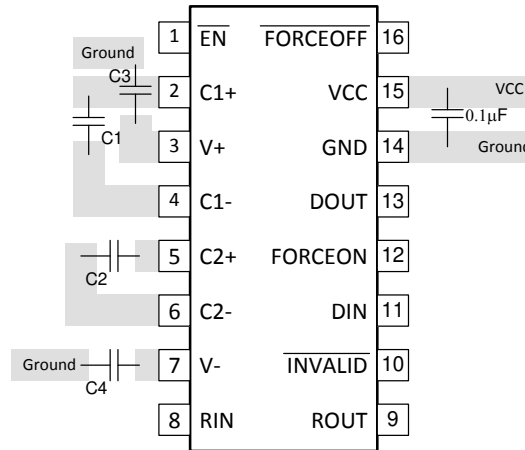
TI recommends a 0.1- $\mu$ F capacitor to filter noise on the power supply pin. For additional filter capability, a 0.01- $\mu$ F capacitor may be added in parallel as well. Power supply input voltage is recommended to be any valid level in [Recommended Operating Conditions](#).

## 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 11-1. Layout Diagram**

## 12 Device and Documentation Support

### 12.1 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is 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](#).

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### 12.3 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

### 12.4 Glossary

[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.



**PACKAGING INFORMATION**

| Orderable Device | Status<br>(1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan<br>(2) | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|-----------------|------|-------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| MAX3221CDBR      | ACTIVE        | SSOP         | DB              | 16   | 2000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | 0 to 70      | MA3221C                 | <a href="#">Samples</a> |
| MAX3221CDBRG4    | ACTIVE        | SSOP         | DB              | 16   | 2000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | 0 to 70      | MA3221C                 | <a href="#">Samples</a> |
| MAX3221CPWR      | ACTIVE        | TSSOP        | PW              | 16   | 2000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | 0 to 70      | MA3221C                 | <a href="#">Samples</a> |
| MAX3221CPWRE4    | ACTIVE        | TSSOP        | PW              | 16   | 2000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | 0 to 70      | MA3221C                 | <a href="#">Samples</a> |
| MAX3221CPWRG4    | ACTIVE        | TSSOP        | PW              | 16   | 2000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | 0 to 70      | MA3221C                 | <a href="#">Samples</a> |
| MAX3221IDBR      | ACTIVE        | SSOP         | DB              | 16   | 2000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 85    | MB3221I                 | <a href="#">Samples</a> |
| MAX3221IDBRE4    | ACTIVE        | SSOP         | DB              | 16   | 2000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 85    | MB3221I                 | <a href="#">Samples</a> |
| MAX3221IDBRG4    | ACTIVE        | SSOP         | DB              | 16   | 2000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 85    | MB3221I                 | <a href="#">Samples</a> |
| MAX3221IPWR      | ACTIVE        | TSSOP        | PW              | 16   | 2000        | RoHS & Green    | NIPDAU   SN                          | Level-1-260C-UNLIM   | -40 to 85    | MB3221I                 | <a href="#">Samples</a> |
| MAX3221IPWRG4    | ACTIVE        | TSSOP        | PW              | 16   | 2000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 85    | MB3221I                 | <a href="#">Samples</a> |

(1) 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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

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

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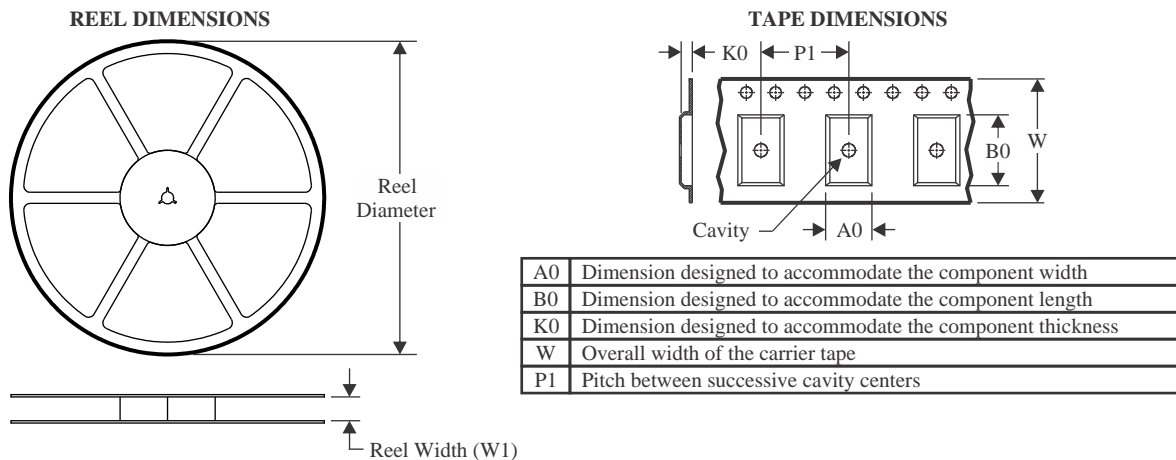
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

**OTHER QUALIFIED VERSIONS OF MAX3221 :**

- Enhanced Product : [MAX3221-EP](#)

NOTE: Qualified Version Definitions:

- Enhanced Product - Supports Defense, Aerospace and Medical Applications

**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*All dimensions are nominal

| Device        | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| MAX3221CDBR   | SSOP         | DB              | 16   | 2000 | 330.0              | 16.4               | 8.35    | 6.6     | 2.4     | 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            |
| 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               | 8.35    | 6.6     | 2.4     | 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            |
| MAX3221IPWRG4 | TSSOP        | PW              | 16   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

| Device        | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| MAX3221CDBR   | SSOP         | DB              | 16   | 2000 | 356.0       | 356.0      | 35.0        |
| MAX3221CPWR   | TSSOP        | PW              | 16   | 2000 | 356.0       | 356.0      | 35.0        |
| MAX3221CPWR   | TSSOP        | PW              | 16   | 2000 | 356.0       | 356.0      | 35.0        |
| MAX3221IDBR   | SSOP         | DB              | 16   | 2000 | 356.0       | 356.0      | 35.0        |
| MAX3221IPWR   | TSSOP        | PW              | 16   | 2000 | 356.0       | 356.0      | 35.0        |
| MAX3221IPWR   | TSSOP        | PW              | 16   | 2000 | 356.0       | 356.0      | 35.0        |
| MAX3221IPWRG4 | TSSOP        | PW              | 16   | 2000 | 356.0       | 356.0      | 35.0        |
| MAX3221IPWRG4 | TSSOP        | PW              | 16   | 2000 | 356.0       | 356.0      | 35.0        |



4220204/A 02/2017

NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.

# EXAMPLE BOARD LAYOUT

PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 10X



SOLDER MASK DETAILS

4220204/A 02/2017

NOTES: (continued)

- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE: 10X

4220204/A 02/2017

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

# DB0016A



# PACKAGE OUTLINE

## SSOP - 2 mm max height

SMALL OUTLINE PACKAGE



4220763/A 05/2022

### NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. Reference JEDEC registration MO-150.



# EXAMPLE BOARD LAYOUT

DB0016A

SSOP - 2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 10X



4220763/A 05/2022

NOTES: (continued)

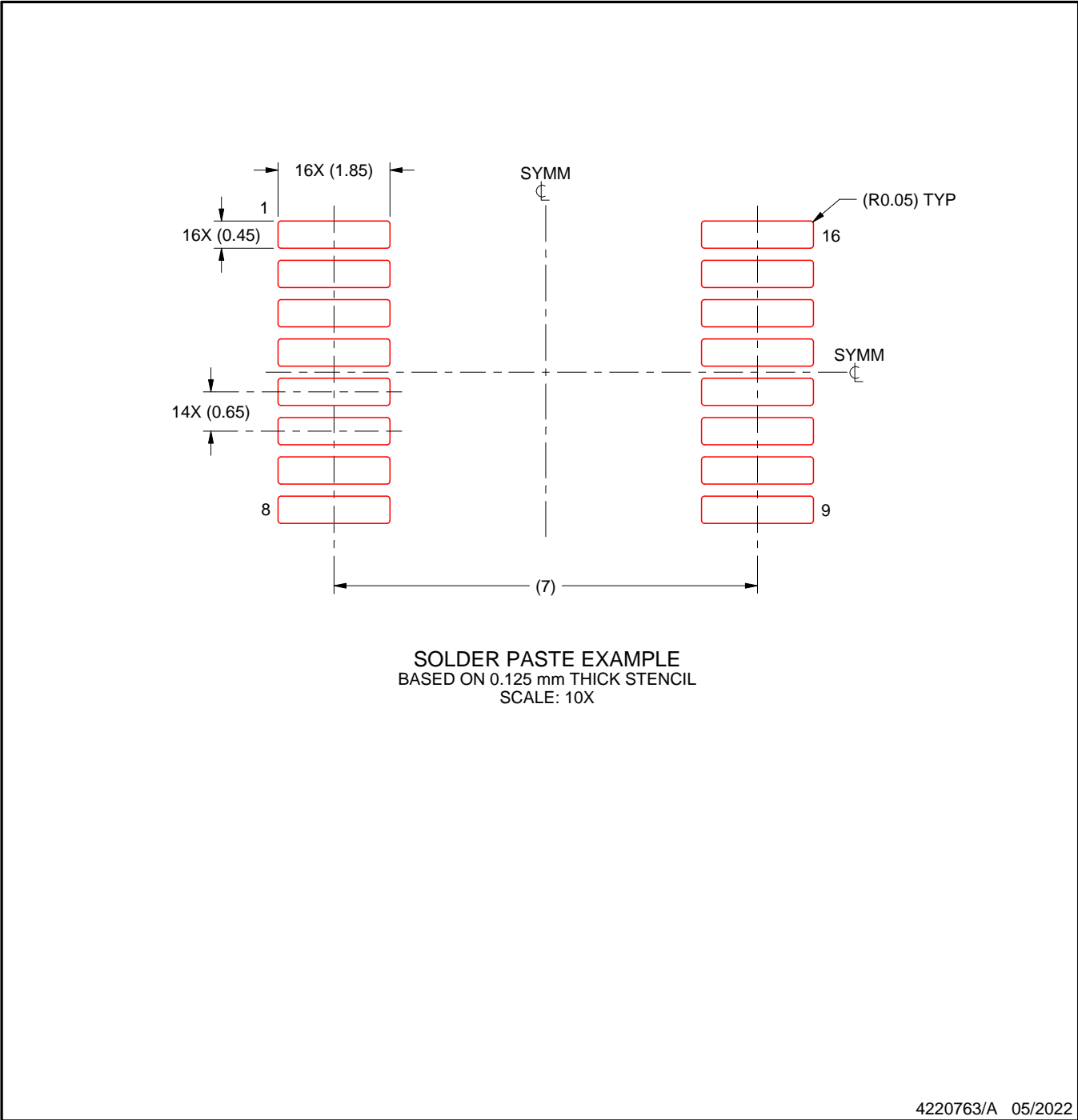
- 5. Publication IPC-7351 may have alternate designs.
- 6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

DB0016A

SSOP - 2 mm max height

SMALL OUTLINE PACKAGE



NOTES: (continued)

- 7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
- 8. Board assembly site may have different recommendations for stencil design.

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