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**TEXAS INSTRUMENTS**

**TRS3221**

SLLS814A – JULY 2007 – REVISED JUNE 2015

# TRS3221 3-V to 5.5-V RS-232 Line Driver and Receiver With ±15-kV ESD Protection

## 1 Features

- 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 $V_{CC}$ 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 TRS3221 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 one 3-V to 5.5-V supply. The TRS3221 device operates 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 $\overline{\text{FORCEOFF}}$ 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 $\overline{\text{INVALID}}$ output notifies the user if an RS-232 signal is present at the receiver input.

**Device Information[1]**

| PART NUMBER | PACKAGE | BODY SIZE (NOM) |
|---|---|---|
| TRS3221 | SSOP (32) | 6.20 mm x 5.30 mm |
| | TSSOP (32) | 5.00 mm x 4.40 mm |

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

**Simplified Schematic**

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## 4 Revision History

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

| Changes from Original (July 2007) to Revision A | Page |
|---|---|
| • Added *Thermal Information* table, *Typical Characteristics* section, *Detailed Description* section, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section .................................................. 1 | |
| • Deleted *Ordering Information* table. ........................................................................ 1 | |
| • Changed *Typical Operating Circuit and Capacitor Values* image ............................................. 13 | |

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## 5 Pin Configuration and Functions

**DB or PW Package**
**16-Pin SSOP or TSSOP**
**Top View**

```
     ___
    EN [ 1      16 ] FORCEOFF
   C1+ [ 2      15 ] V_CC
    V+ [ 3      14 ] GND
   C1− [ 4      13 ] DOUT
   C2+ [ 5      12 ] FORCEON
   C2− [ 6      11 ] DIN
    V− [ 7      10 ] INVALID
   RIN [ 8       9 ] ROUT
```
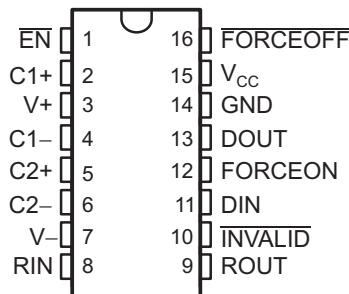
**Pin Functions**

| PIN | | TYPE | 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 |
| 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 | GND | Ground |
| INVALID | 10 | O | Invalid output pin. Output is low when all RIN inputs are unpowered. |
| RIN | 8 | I | RS-232 receiver input |
| ROUT | 9 | O | Receiver output |
| V_CC | 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 |

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## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)[1]

|  |  |  | MIN | MAX | UNIT |
|---|---|---|---|---|---|
|  | $V_{CC}$ to GND |  | −0.3 | 6 | V |
|  | V+ to GND |  | −0.3 | 7 | V |
|  | V− to GND |  | 0.3 | −7 | V |
|  | V+ + |V−|[2] |  |  | 13 | V |
| $V_I$ | Input voltage | DIN, $\overline{EN}$, $\overline{FORCEOFF}$, and FORCEON to GND | −0.3 | 6 | V |
|  |  | RIN to GND |  | ±25 |  |
| $V_O$ | Output voltage | DOUT to GND |  | ±13.2 | V |
|  |  | ROUT to GND | −0.3 | $V_{CC}$ + 0.3 |  |
| $T_J$ | Junction temperature[3] |  |  | 150 | °C |
| $T_{stg}$ | Storage temperature |  | −65 | 150 | °C |

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. 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 |
|---|---|---|---|---|---|
| $V_{(ESD)}$ | Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001[1] | All pins except Pin 8 and Pin 13 | ±3000 | V |
|  |  |  | Pin 8, Pin 13 (RS232 ports) | ±15000 |  |
|  |  | Charged-device model (CDM), per JEDEC specification JESD22-C101[2] | All pins | ±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]

|  |  |  | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|---|---|
|  | Supply voltage | $V_{CC}$ = 3.3 V | 3 | 3.3 | 3.6 | V |
|  |  | $V_{CC}$ = 5 V | 4.5 | 5 | 5.5 |  |
| $V_{IH}$ | Driver high-level input voltage | DIN, $\overline{FORCEOFF}$, FORCEON, $\overline{EN}$ | $V_{CC}$ = 3.3 V | 2 |  | V |
|  |  |  | $V_{CC}$ = 5 V | 2.4 |  |  |
| $V_{IL}$ | Driver low-level input voltage | DIN, $\overline{FORCEOFF}$, FORCEON, $\overline{EN}$ |  |  | 0.8 | V |
| $V_I$ | Driver input voltage | DIN, $\overline{FORCEOFF}$, FORCEON, $\overline{EN}$ | 0 |  | 5.5 | V |
|  | Receiver input voltage |  | −25 |  | 25 |  |
| $T_A$ | Operating free-air temperature | TRS3221C | 0 |  | 70 | °C |
|  |  | TRS3221I | −40 |  | 85 |  |

(1) Test conditions are C1–C4 = 0.1 µF at $V_{CC}$ = 3.3 V ± 0.3 V; C1 = 0.047 µF, C2–C4 = 0.33 µF at $V_{CC}$ = 5 V ± 0.5 V.

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## 6.4 Thermal Information

| | THERMAL METRIC[1] | TRS3221 | | UNIT |
|---|---|---|---|---|
| | | DB (SSOP) | PW (TSSOP) | |
| | | 16 PINS | 16 PINS | |
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | 98.0 | 106.4 | °C/W |
| $R_{\theta JC(top)}$ | 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 |
| $\psi_{JT}$ | Junction-to-top characterization parameter | 10.1 | 3.9 | °C/W |
| $\psi_{JB}$ | 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)[1]

| | PARAMETER | | TEST CONDITIONS | | MIN | TYP[2] | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| $I_I$ | Input leakage current | $\overline{FORCEOFF}$, FORCEON, $\overline{EN}$ | | | | ±0.01 | ±1 | µA |
| $I_{CC}$ | Supply current | Automatic power down disabled | No load, $V_{CC}$ = 3.3 V to 5 V | No load, $\overline{FORCEOFF}$ and FORCEON at $V_{CC}$ | | 0.3 | 1 | mA |
| | | Powered off | | No load, $\overline{FORCEOFF}$ at GND | | 1 | 10 | µA |
| | | Auto-powerdown enabled | | No load, $\overline{FORCEOFF}$ at $V_{CC}$, FORCEON at GND, All RIN are open or grounded | | 1 | 10 | |

(1) Test conditions are C1–C4 = 0.1 µF at $V_{CC}$ = 3.3 V ± 0.3 V; C1 = 0.047 µF, C2–C4 = 0.33 µF at $V_{CC}$ = 5 V ± 0.5 V.
(2) All typical values are at $V_{CC}$ = 3.3 V or $V_{CC}$ = 5 V, and $T_A$ = 25°C.

## 6.6 Electrical Characteristics—Driver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)[1]

| | PARAMETER | TEST CONDITIONS | | MIN | TYP[2] | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $V_{OH}$ | High-level output voltage | $D_{OUT}$ at $R_L$ = 3 kΩ to GND, | $D_{IN}$ = GND | 5 | 5.4 | | V |
| $V_{OL}$ | Low-level output voltage | $D_{OUT}$ at $R_L$ = 3 kΩ to GND, | $D_{IN}$ = $V_{CC}$ | −5 | −5.4 | | |
| $I_{IH}$ | High-level input current | $V_I$ = $V_{CC}$ | | | ±0.01 | ±1 | µA |
| $I_{IL}$ | Low-level input current | $V_I$ at GND | | | ±0.01 | ±1 | |
| $I_{OS}$ | Short-circuit output current[3] | $V_{CC}$ = 3.6 V | $V_O$ = 0 V | | ±35 | ±60 | mA |
| | | $V_{CC}$ = 5.5 V | $V_O$ = 0 V | | ±35 | ±60 | |
| $r_O$ | Output resistance | $V_{CC}$, V+, and V− = 0 V | $V_O$ = ±2 V | 300 | 10M | | Ω |
| $I_{off}$ | Output leakage current | $\overline{FORCEOFF}$ = GND | $V_O$ = ±12 V, $V_{CC}$ = 3 V to 3.6 V | | | ±25 | µA |
| | | | $V_O$ = ±12 V, $V_{CC}$ = 4.5 V to 5.5 V | | | ±25 | |

(1) Test conditions are C1–C4 = 0.1 µF at $V_{CC}$ = 3.3 V ± 0.3 V; C1 = 0.047 µF, C2–C4 = 0.33 µF at $V_{CC}$ = 5 V ± 0.5.
(2) All typical values are at $V_{CC}$ = 3.3 V or $V_{CC}$ = 5 V, and $T_A$ = 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)[1]

| PARAMETER | | TEST CONDITIONS | MIN | TYP[2] | MAX | UNIT |
|---|---|---|---|---|---|---|
| $V_{OH}$ | High-level output voltage | $I_{OH} = -1$ mA | $V_{CC} - 0.6$ | $V_{CC} - 0.1$ | | V |
| $V_{OL}$ | Low-level output voltage | $I_{OL} = 1.6$ mA | | | 0.4 | |
| $V_{IT+}$ | Positive-going input threshold voltage | $V_{CC} = 3.3$ V | | 1.5 | 2.4 | V |
| | | $V_{CC} = 5$ V | | 1.8 | 2.4 | |
| $V_{IT-}$ | Negative-going input threshold voltage | $V_{CC} = 3.3$ V | 0.6 | 1.1 | | |
| | | $V_{CC} = 5$ V | 0.8 | 1.4 | | V |
| $V_{hys}$ | Input hysteresis ($V_{IT+} - V_{IT-}$) | | | 0.5 | | |
| $I_{off}$ | Output leakage current | $\overline{FORCEOFF} = 0$ V | | ±0.05 | ±10 | µA |
| $r_i$ | Input resistance | $V_I = \pm3$ to ±25 V | 3 | 5 | 7 | kΩ |

(1) Test conditions are C1–C4 = 0.1 µF at $V_{CC}$ = 3.3 V ± 0.3 V; C1 = 0.047 µF, C2–C4 = 0.33 µF at $V_{CC}$ = 5 V ± 0.5 V.
(2) All typical values are at $V_{CC}$ = 3.3 V or $V_{CC}$ = 5 V, and $T_A$ = 25°C.

## 6.8 Electrical Characteristics—Status

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)[1]

| PARAMETER | | TEST CONDITIONS | MIN | TYP[2] | MAX | UNIT |
|---|---|---|---|---|---|---|
| $V_{T+(valid)}$ | Receiver input threshold for $\overline{INVALID}$ high-level output voltage | FORCEON = GND, $\overline{FORCEOFF} = V_{CC}$ | | | 2.7 | V |
| $V_{T-(valid)}$ | Receiver input threshold for $\overline{INVALID}$ high-level output voltage | FORCEON = GND, $\overline{FORCEOFF} = V_{CC}$ | −2.7 | | | V |
| $V_{T(invalid)}$ | Receiver input threshold for $\overline{INVALID}$ low-level output voltage | FORCEON = GND, $\overline{FORCEOFF} = V_{CC}$ | −0.3 | | 0.3 | V |
| $V_{OH}$ | $\overline{INVALID}$ high-level output voltage | $I_{OH} = -1$ mA, FORCEON = GND, $\overline{FORCEOFF} = V_{CC}$ | $V_{CC} - 0.6$ | | | V |
| $V_{OL}$ | $\overline{INVALID}$ low-level output voltage | $I_{OH} = -1$ mA, FORCEON = GND, $\overline{FORCEOFF} = V_{CC}$ | | | 0.4 | V |

(1) Test conditions are C1–C4 = 0.1 µF at $V_{CC}$ = 3.3 V ± 0.3 V; C1 = 0.047 µF, C2–C4 = 0.33 µF at $V_{CC}$ = 5 V ± 0.5 V.
(2) All typical values are at $V_{CC}$ = 3.3 V or $V_{CC}$ = 5 V, and $T_A$ = 25°C.

## 6.9 Switching Characteristics—Driver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)[1]

| PARAMETER | | TEST CONDITIONS | | MIN | TYP[2] | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| | Maximum data rate | $C_L$ = 1000 pF, $R_L$ = 3 kΩ, (see Figure 3) | | 150 | 250 | | kbps |
| $t_{sk(p)}$ | Pulse skew[3] | $C_L$ = 150 to 2500 pF, $R_L$ = 3 kΩ to 7 kΩ, (see Figure 4) | | | 100 | | ns |
| $SR(tr)$ | Slew rate, transition region (see Figure 3) | $V_{CC}$ = 3.3 V, $R_L$ = 3 kΩ to 7 kΩ | $C_L$ = 150 to 1000 pF | 6 | | 30 | V/µs |
| | | | $C_L$ = 150 to 2500 pF | 4 | | 30 | |

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

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## 6.10 Switching Characteristics—Receiver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)[1]

| PARAMETER | | TEST CONDITIONS | MIN | TYP[2] | MAX | UNIT |
|---|---|---|---|---|---|---|
| $t_{PLH}$ | Propagation delay time, low- to high-level output | $C_L$ = 150 pF, (see Figure 5) | | 150 | | ns |
| $t_{PHL}$ | Propagation delay time, high- to low-level output | $C_L$ = 150 pF, (see Figure 5) | | 150 | | ns |
| $t_{en}$ | Output enable time | $C_L$ = 150 pF, $R_L$ = 3 kΩ, (see Figure 6) | | 200 | | ns |
| $t_{dis}$ | Output disable time | $C_L$ = 150 pF, $R_L$ = 3 kΩ, (see Figure 6) | | 200 | | ns |
| $t_{sk(p)}$ | Pulse skew[3] | See Figure 5 | | 50 | | ns |

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

## 6.11 Switching Characteristics—Status

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)[1]

| PARAMETER | | MIN | TYP[2] | MAX | UNIT |
|---|---|---|---|---|---|
| $t_{valid}$ | Propagation delay time, low- to high-level output | | 1 | | µs |
| $t_{invalid}$ | Propagation delay time, high- to low-level output | | 30 | | µs |
| $t_{en}$ | Supply enable time | | 100 | | µs |

(1)   Test conditions are C1–C4 = 0.1 µF at $V_{CC}$ = 3.3 V ± 0.3 V; C1 = 0.047 µF, C2–C4 = 0.33 µF at $V_{CC}$ = 5 V ± 0.5 V.
(2)   All typical values are at $V_{CC}$ = 3.3 V or $V_{CC}$ = 5 V, and $T_A$ = 25°C.

## 6.12 Typical Characteristics

$V_{CC}$ = 3.3 V



Figure 1. DOUT $V_{OH}$ vs Load Current



Figure 2. DOUT $V_{OL}$ vs Load Current

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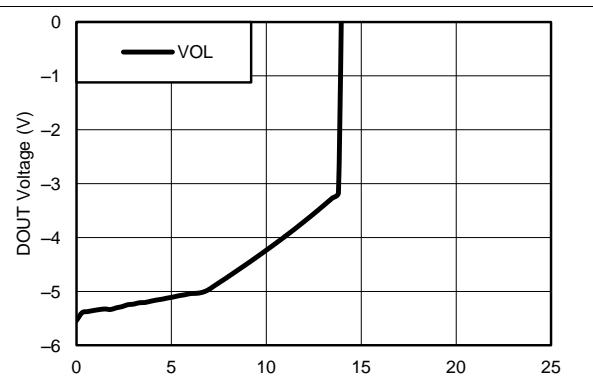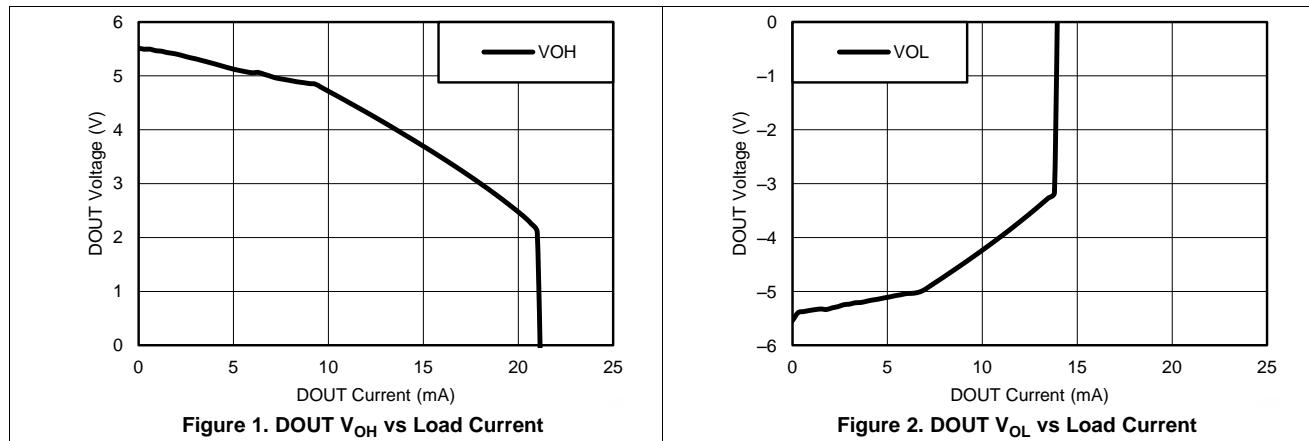
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# 7 Parameter Measurement Information
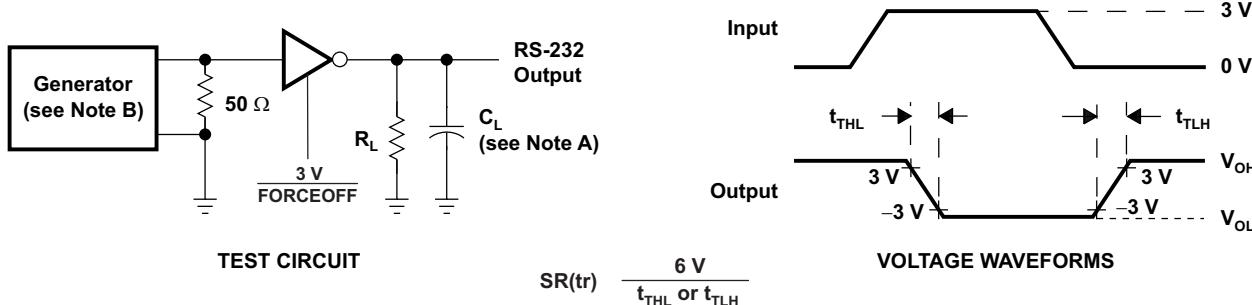


$$SR(tr) \quad \frac{6\ V}{t_{THL}\ or\ t_{TLH}}$$

A. $C_L$ includes probe and jig capacitance.

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

**Figure 3. Driver Slew Rate**
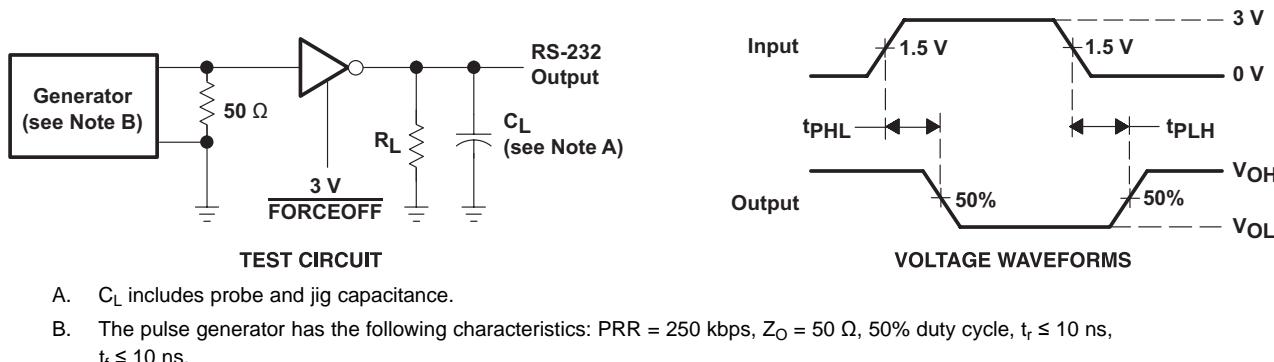


A. $C_L$ includes probe and jig capacitance.

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

**Figure 4. Driver Pulse Skew**
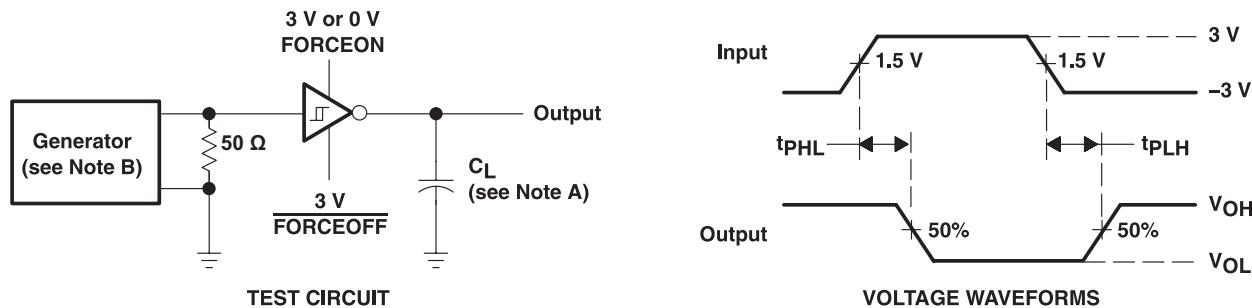


A. $C_L$ includes probe and jig capacitance.

B. The pulse generator has the following characteristics: $Z_O$ = 50 Ω, 50% duty cycle, $t_r$ ≤ 10 ns, $t_f$ ≤ 10 ns.

**Figure 5. Receiver Propagation Delay Times**

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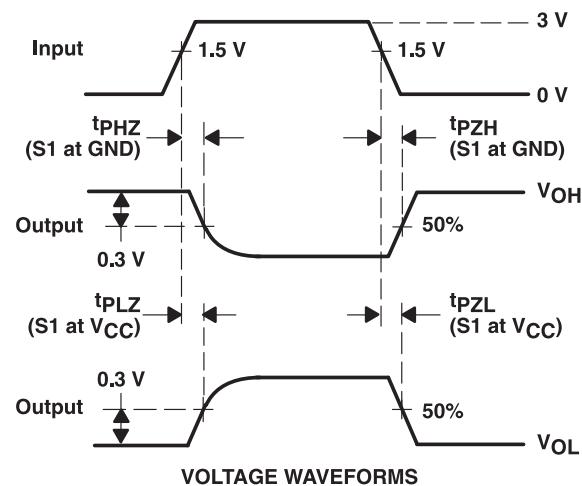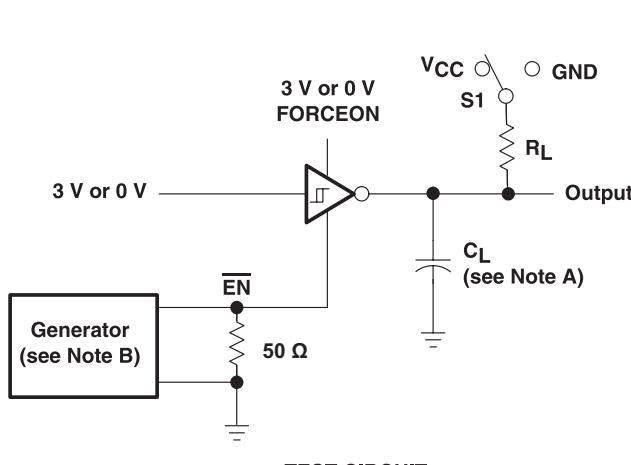
## Parameter Measurement Information (continued)



A.  $C_L$ includes probe and jig capacitance.

B.  The pulse generator has the following characteristics: $Z_O$ = 50 Ω, 50% duty cycle, $t_r$ ≤ 10 ns, $t_f$ ≤ 10 ns.

C.  $t_{PLZ}$ and $t_{PHZ}$ 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**

## Parameter Measurement Information (continued)



**TEST CIRCUIT**

**VOLTAGE WAVEFORMS**
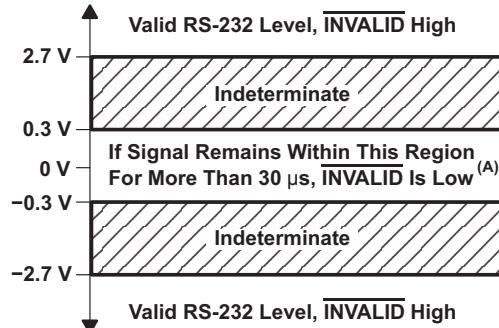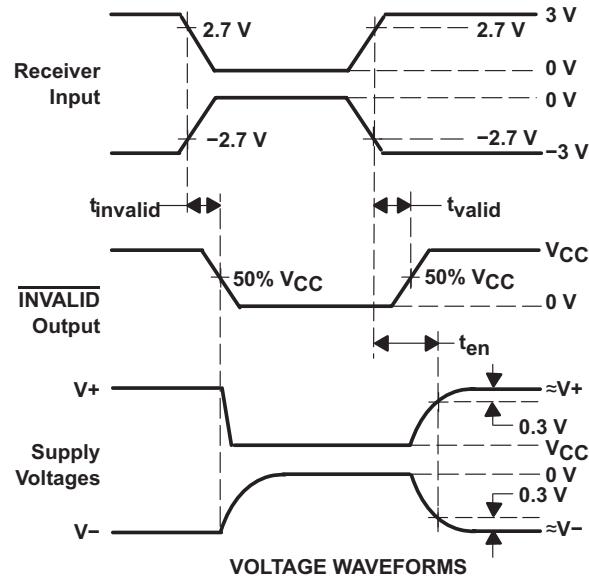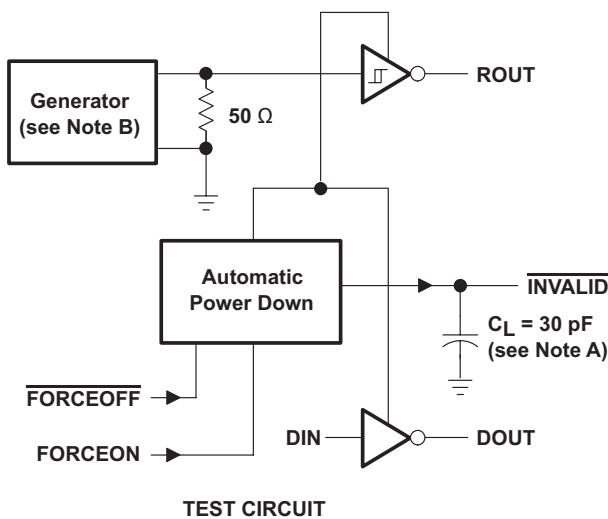
A. Automatic Power Down disables drivers and reduces supply current to 1 µA.
B. $C_L$ includes probe abnd jig capacitance.
C. The pulse generator has the following characteristics: PRR = 5 kbps, $Z_O$ = 50 Ω, 50% duty cycle, $t_r$ ≤ 10 ns, $t_f$ ≤ 10 ns.

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

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# 8 Detailed Description

## 8.1 Overview

The TRS3221 device is a one-driver and one-receiver RS-232 interface device. All RS-232 inputs and outputs are protected up to ±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 TRS3221 device 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 µs. INVALID is low (invalid data) if receiver input voltages are between –0.3 V and 0.3 V for more than 30 µs. Refer to Figure 7 for receiver input levels.

## 8.2 Functional Block Diagram
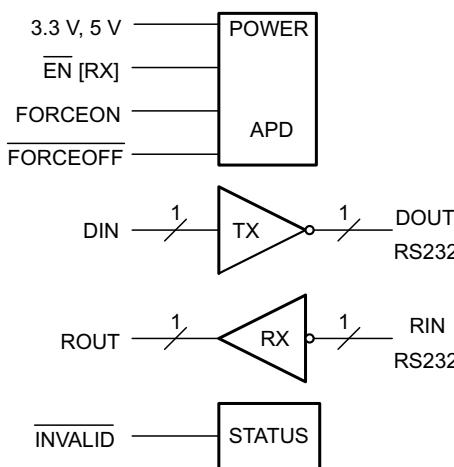


## 8.3 Feature Description

### 8.3.1 Power

The power block increases, inverts, and regulates voltage at V+ and V– pins using a charge pump that requires four external capacitors. The automatic power-down feature for the driver is controlled by FORCEON and FORCEOFF inputs. The receiver is controlled by the EN input (see Table 1 and Table 2).

When the TRS3221 device 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 results in a high output on ROUT. RIN input includes an internal standard RS232 load. A logic high input on the EN pin shuts down the receiver output.

### 8.3.4 RS232 Status

The INVALID output goes low when RIN input is unpowered for more than 30 µs. The INVALID output goes high when the receiver has a valid input. The INVALID output is active when $V_{cc}$ is powered regardless of FORCEON and FORCEOFF inputs (see Table 3).

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## 8.4 Device Functional Modes

**Table 1. Driver[1]**

| INPUTS | | | | OUTPUT | DRIVER STATUS |
|--------|--------|---------|-----------------------------|--------|---------------|
| DIN | FORCEON | $\overline{\text{FORCEOFF}}$ | 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 V, No = |RIN| < 0.3 V

**Table 2. Receiver[1]**

| INPUTS | | | OUTPUT | RECEIVER STATUS |
|--------|-----|------------------------|--------|-----------------|
| RIN | $\overline{\text{EN}}$ | 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 3. $\overline{\text{INVALID}}$[1]**

| INPUTS | | | | OUTPUT |
|--------|---------|------------------------------|-----|--------|
| RIN | FORCEON | $\overline{\text{FORCEOFF}}$ | $\overline{\text{EN}}$ | $\overline{\text{INVALID}}$ |
| 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.  Logic Diagram**

Product Folder Links: *TRS3221*
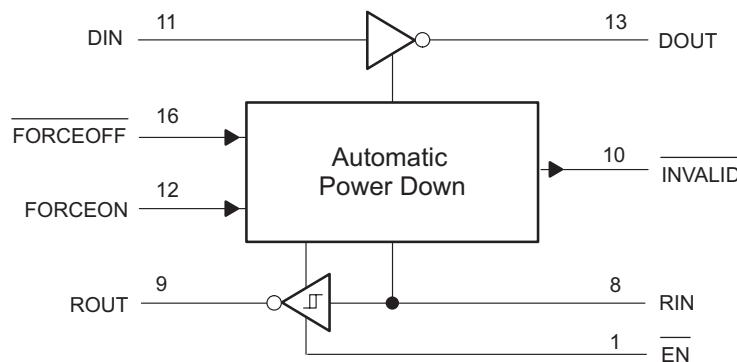
# 9 Application and Implementation

> **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 TRS3232 device is designed to convert single-ended signals into RS232-compatible signals, and vice-versa.

This device can be used in any application where an RS232 line driver or receiver is required. One benefit of this device is its ESD protection, which helps protect other components on the board when the RS232 lines are tied to a physical connector.

## 9.2 Typical Application
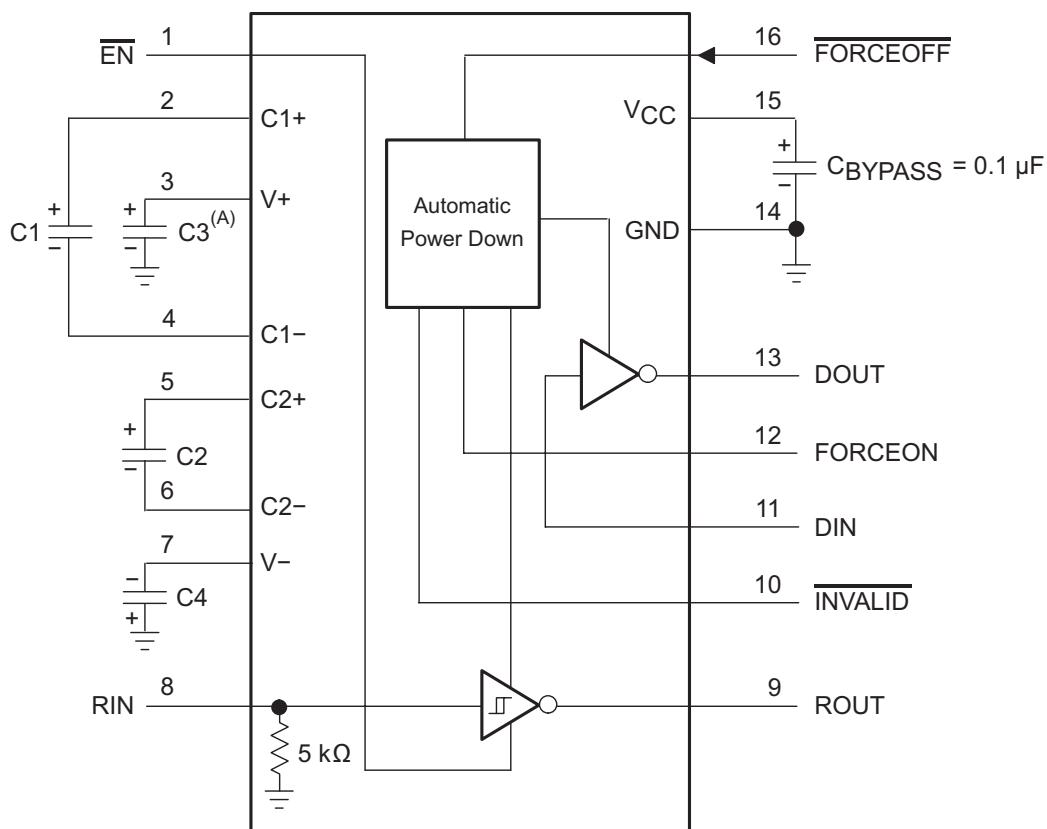


A.  C3 can be connected to $V_{CC}$ or GND.
B.  Resistor values shown are nominal.
C.  Nonpolarized ceramic capacitors are acceptable. If polarized tantalum or electrolytic capacitors are used, they must be connected as shown.
D.  See Table 4 for capacitor values.

**Figure 9.  Typical Operating Circuit**

## Typical Application (continued)

### 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 and Table 4

**Table 4. $V_{CC}$ versus Capacitor Values**

| $V_{CC}$ | 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 |

### 9.2.2 Detailed Design Procedure

For proper operation, add capacitors as shown in Figure 9 and Table 4.

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

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.

### 9.2.3 Application Curve

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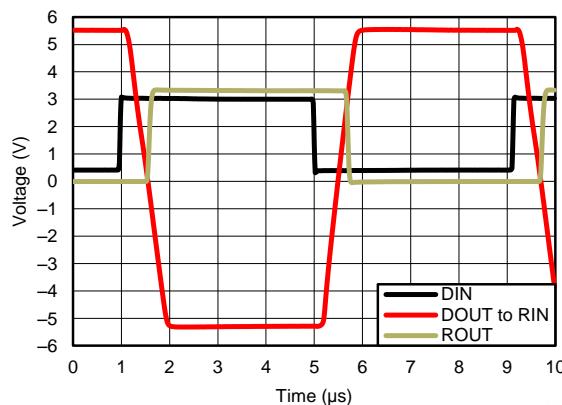


**Figure 10. 250 kbps Driver to Receiver Loopback Timing Waveform,**
**$V_{CC}$= 3.3 V**

Product Folder Links: *TRS3221*

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**TRS3221**

# 10  Power Supply Recommendations

$V_{CC}$ must be between 3 V and 5.5 V. Charge pump capacitors must be chosen using Table 4.

# 11  Layout

## 11.1  Layout Guidelines

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

## 11.2  Layout Example
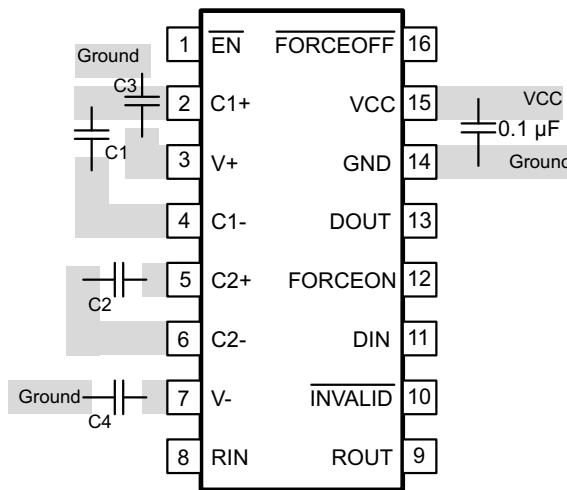


**Figure 11.  Layout Diagram**

Product Folder Links: *TRS3221*

**TRS3221**
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# 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™ 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.

Product Folder Links: *TRS3221*

**PACKAGE OPTION ADDENDUM**

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17-Jun-2015

## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TRS3221CDB | ACTIVE | SSOP | DB | 16 | 80 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | RS21C | Samples |
| TRS3221CDBG4 | ACTIVE | SSOP | DB | 16 | 80 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 85 | RS21C | Samples |
| TRS3221CDBR | ACTIVE | SSOP | DB | 16 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | RS21C | Samples |
| TRS3221CPWR | ACTIVE | TSSOP | PW | 16 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 85 | RS21C | Samples |
| TRS3221CPWRG4 | ACTIVE | TSSOP | PW | 16 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | RS21C | Samples |
| TRS3221IDBR | ACTIVE | SSOP | DB | 16 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 85 | RS21I | Samples |
| TRS3221IPW | ACTIVE | TSSOP | PW | 16 | 90 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 85 | RS21I | Samples |
| TRS3221IPWR | ACTIVE | TSSOP | PW | 16 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 85 | RS21I | Samples |

**(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)** 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 leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
**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)

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

**PACKAGE OPTION ADDENDUM**

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

**(5)** 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.

**(6)** 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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# PACKAGE MATERIALS INFORMATION

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## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

**TAPE DIMENSIONS**

| A0 | Dimension designed to accommodate the component width |
| B0 | Dimension designed to accommodate the component length |
| K0 | Dimension designed to accommodate the component thickness |
| W | Overall width of the carrier tape |
| P1 | Pitch between successive cavity centers |

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**
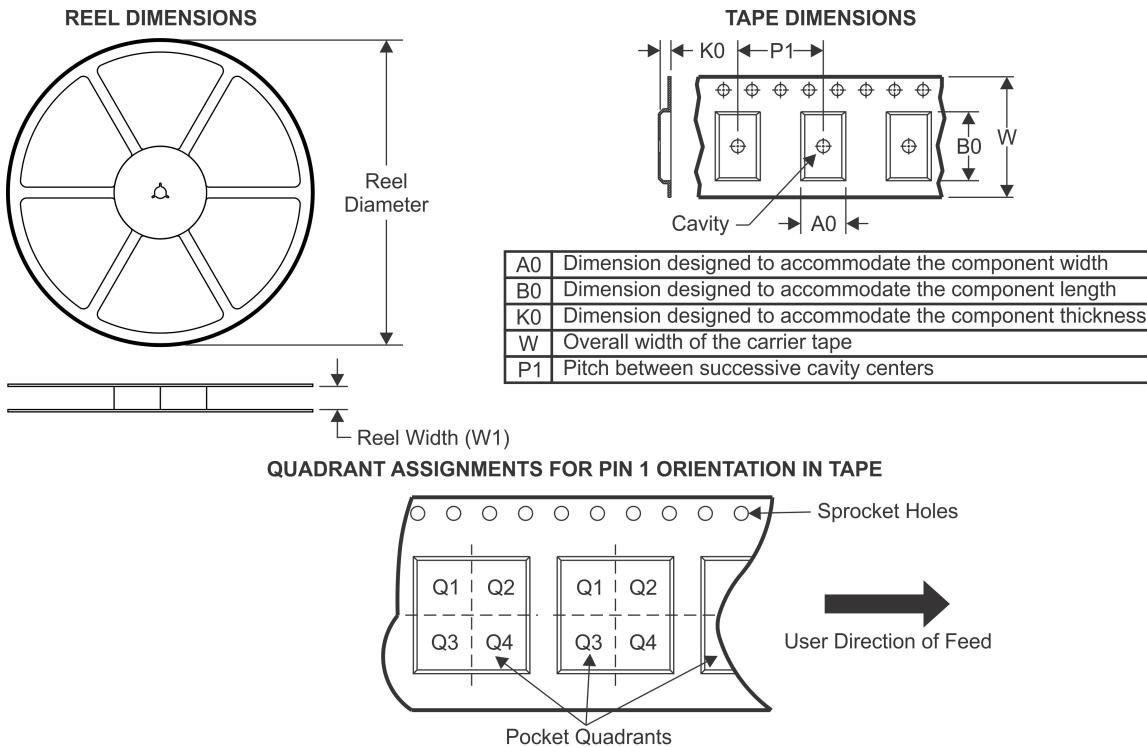
*All dimensions are nominal

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TRS3221CDBR | SSOP | DB | 16 | 2000 | 330.0 | 16.4 | 8.2 | 6.6 | 2.5 | 12.0 | 16.0 | Q1 |
| TRS3221CPWR | TSSOP | PW | 16 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| TRS3221IDBR | SSOP | DB | 16 | 2000 | 330.0 | 16.4 | 8.2 | 6.6 | 2.5 | 12.0 | 16.0 | Q1 |
| TRS3221IPWR | TSSOP | PW | 16 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |

# PACKAGE MATERIALS INFORMATION

**TAPE AND REEL BOX  DIMENSIONS**
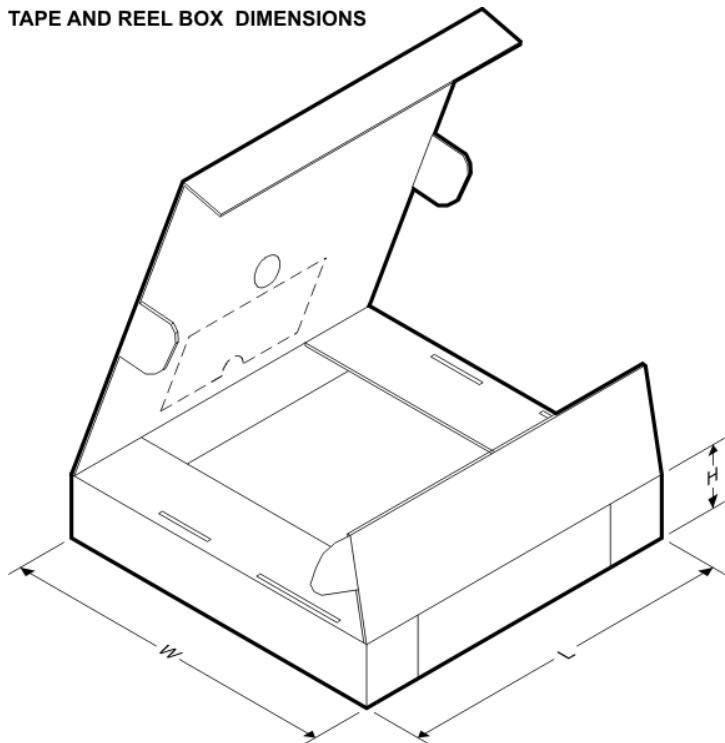
*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|--------|-------------|-----------------|------|-----|-------------|------------|-------------|
| TRS3221CDBR | SSOP | DB | 16 | 2000 | 367.0 | 367.0 | 38.0 |
| TRS3221CPWR | TSSOP | PW | 16 | 2000 | 367.0 | 367.0 | 35.0 |
| TRS3221IDBR | SSOP | DB | 16 | 2000 | 367.0 | 367.0 | 38.0 |
| TRS3221IPWR | TSSOP | PW | 16 | 2000 | 367.0 | 367.0 | 35.0 |

**MECHANICAL DATA**

PW (R−PDSO−G16)                                    PLASTIC SMALL OUTLINE
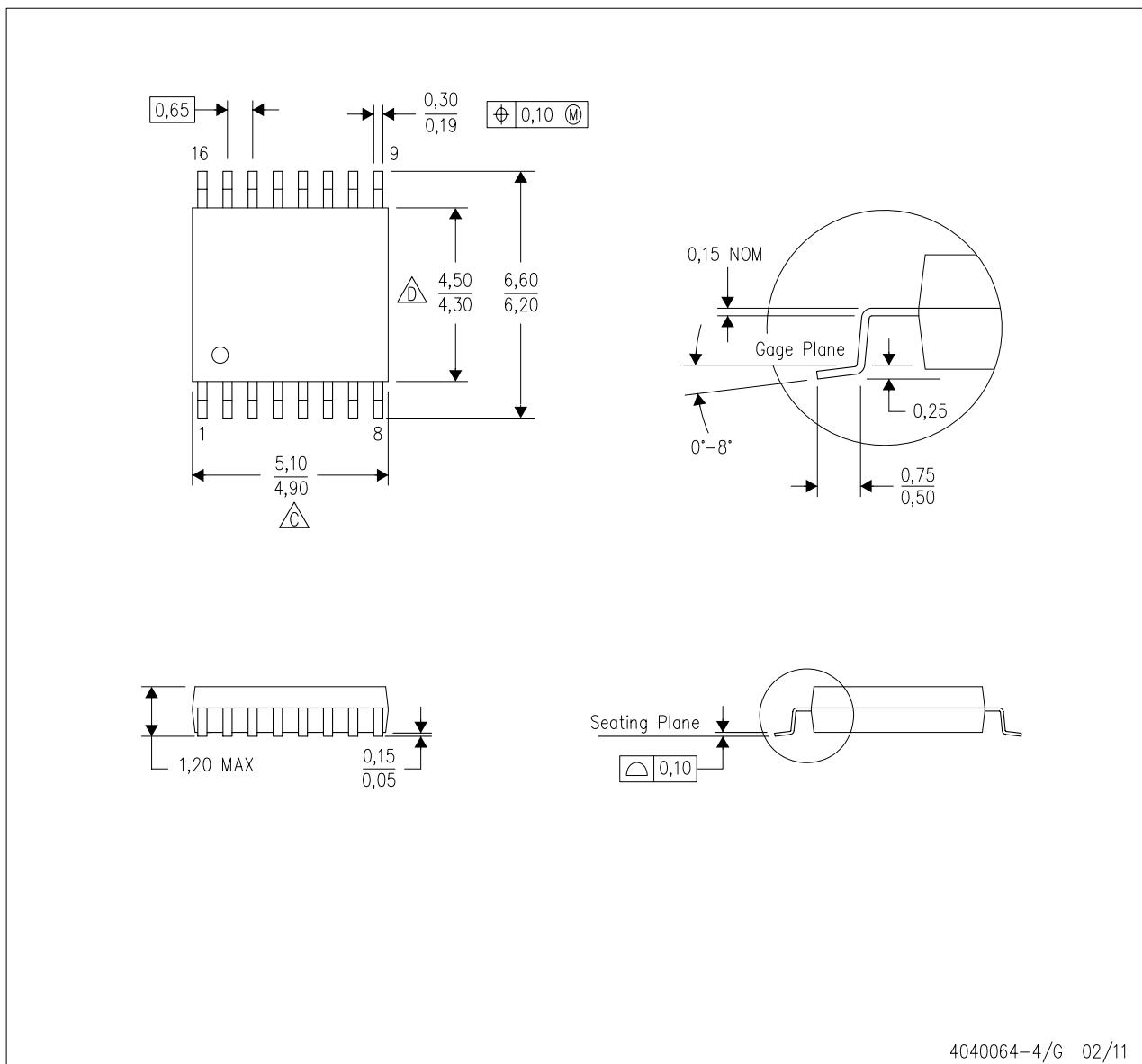


4040064−4/G  02/11

NOTES:    A.  All linear dimensions are in millimeters.  Dimensioning and tolerancing per ASME Y14.5M−1994.
          B.  This drawing is subject to change without notice.
          C.  Body length does not include mold flash, protrusions, or gate burrs.  Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.
          D.  Body width does not include interlead flash.  Interlead flash shall not exceed 0,25 each side.
          E.  Falls within JEDEC MO−153

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**LAND PATTERN DATA**

PW (R−PDSO−G16)                                    PLASTIC SMALL OUTLINE
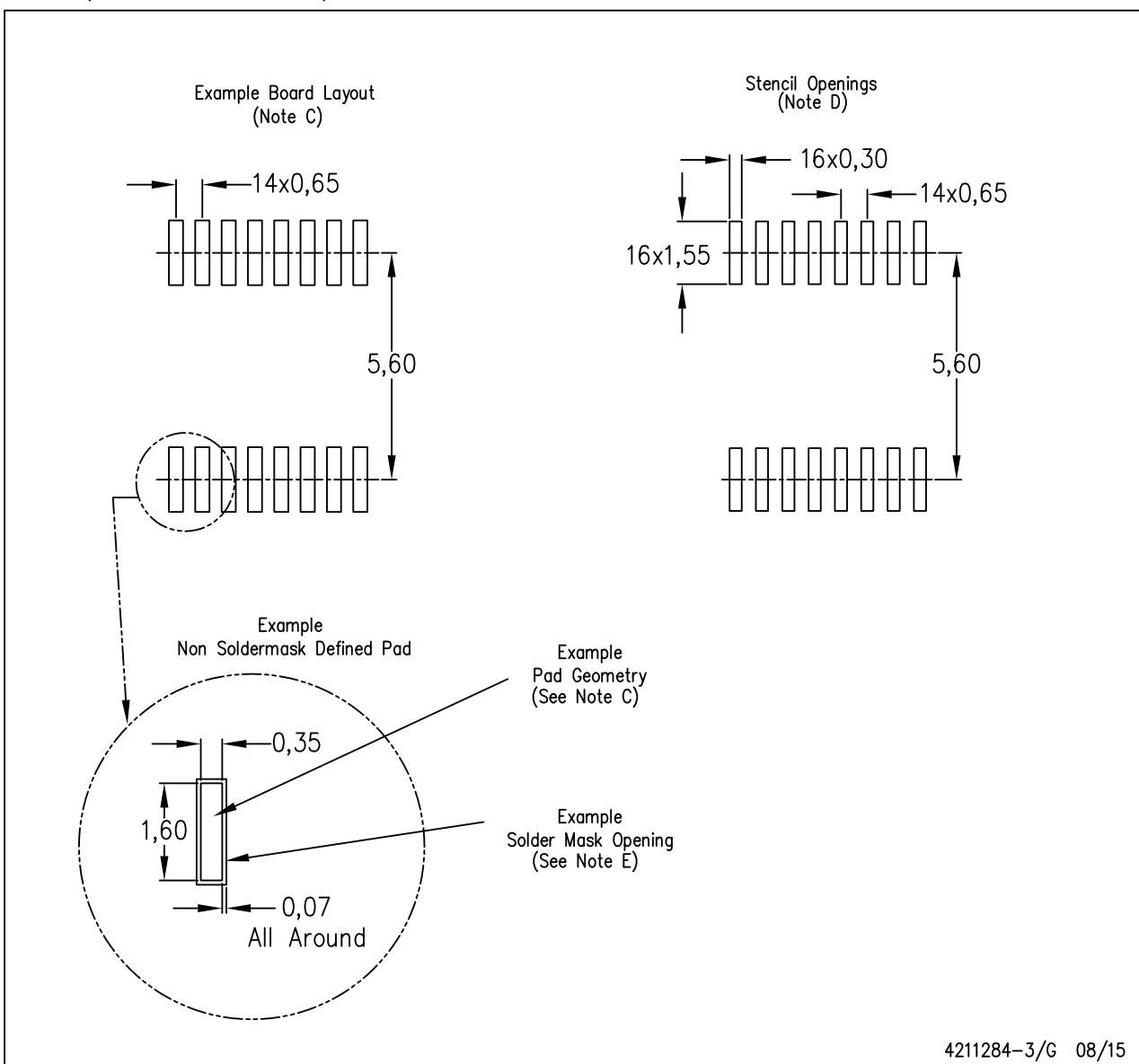
Example Board Layout
(Note C)

Stencil Openings
(Note D)

14x0,65

16x0,30

14x0,65

16x1,55

5,60

5,60

Example
Non Soldermask Defined Pad

Example
Pad Geometry
(See Note C)

0,35

1,60

Example
Solder Mask Opening
(See Note E)

0,07
All Around

4211284−3/G   08/15

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.

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# MECHANICAL DATA

MSSO002E – JANUARY 1995 – REVISED DECEMBER 2001

**DB (R-PDSO-G**)**                                         **PLASTIC SMALL-OUTLINE**
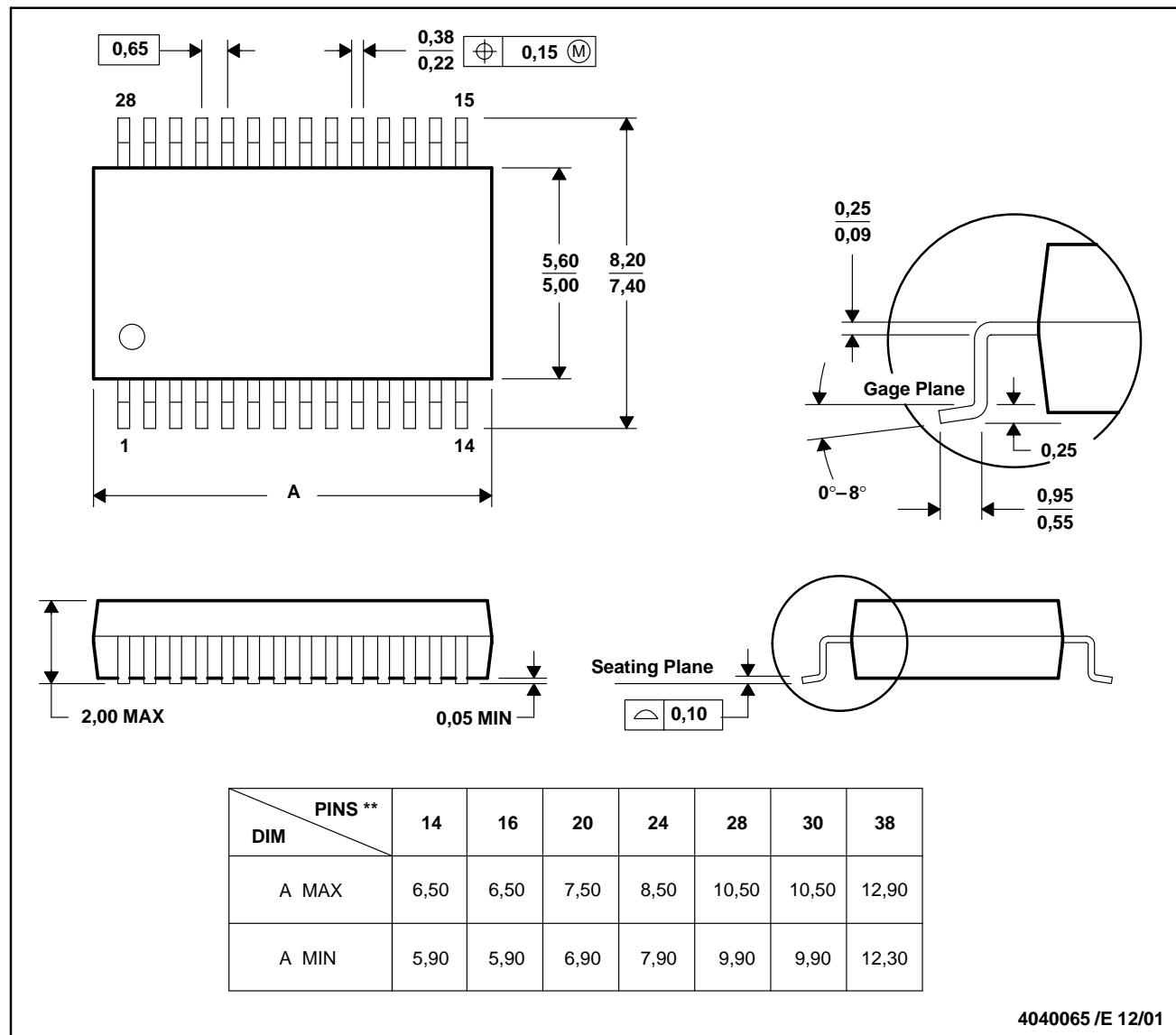
**28 PINS SHOWN**



| PINS ** | 14 | 16 | 20 | 24 | 28 | 30 | 38 |
| --- | --- | --- | --- | --- | --- | --- | --- |
| A MAX | 6,50 | 6,50 | 7,50 | 8,50 | 10,50 | 10,50 | 12,90 |
| A MIN | 5,90 | 5,90 | 6,90 | 7,90 | 9,90 | 9,90 | 12,30 |

4040065 /E 12/01

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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| RFID | www.ti-rfid.com | | |
| OMAP Applications Processors | www.ti.com/omap | **TI E2E Community** | e2e.ti.com |
| Wireless Connectivity | www.ti.com/wirelessconnectivity | | |