

## FEATURES

- ESD Protection for RS-232 Pins
  - ±15-kV Human-Body Model (HBM)
  - ±8-kV IEC 61000-4-2 Contact Discharge
  - ±15-kV IEC 61000-4-2 Air-Gap Discharge
- Operates With 3-V to 5.5-V  $V_{CC}$  Supply
- Operates up to 1 Mbit/s
- Low Standby Current . . . 1  $\mu$ A Typ
- External Capacitors . . .  $4 \times 0.1 \mu$ F
- Accepts 5-V Logic Input With 3.3-V Supply
- RS-232 Bus-Pin ESD Protection Exceeds ±15 kV Using HBM
- Auto-Powerdown Feature Automatically Disables Drivers for Power Savings

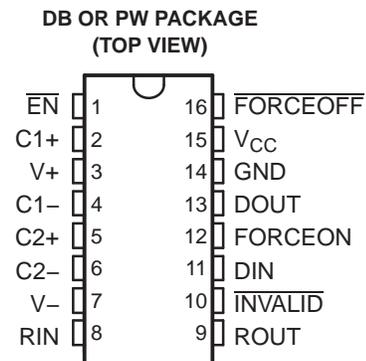
## APPLICATIONS

- Battery-Powered, Hand-Held, and Portable Equipment
- PDAs and Palmtop PCs
- Notebooks, Sub-Notebooks, and Laptops
- Digital Cameras
- Mobile Phones and Wireless Devices

## DESCRIPTION/ORDERING INFORMATION

The TRSF3221E consists of one line driver, one line receiver, and a dual charge-pump circuit with ±15-kV IEC ESD protection pin to pin (serial-port connection pins, including GND). The TRSF3221E 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. The TRSF3221E operates at data signaling rates up to 1 Mbit/s and a driver output slew rate of 24 V/ $\mu$ s to 150 V/ $\mu$ s.

Flexible control options for power management are available when the serial port is inactive. The auto-powerdown feature functions when FORCEON is low and FORCEOFF is high. During this mode of operation, if the TRSF3221E does not sense a valid RS-232 signal on the receiver input, the driver output is disabled. If FORCEOFF is set low and the enable ( $\overline{EN}$ ) input is high, both the driver and receiver are shut off, and the supply current is reduced to 1  $\mu$ A. Disconnecting the serial port or turning off the peripheral drivers causes the auto-powerdown condition to occur. Auto-powerdown can be disabled when FORCEON and FORCEOFF are high. With auto-powerdown enabled, the device is activated automatically when a valid signal is applied to the receiver input. The INVALID output notifies the user if an RS-232 signal is present at the receiver input. INVALID is high (valid data) if the 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 the receiver input voltage is between –0.3 V and 0.3 V for more than 30  $\mu$ s. See Figure 5 for receiver input levels.



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**TRSF3221E**  
**3-V TO 5.5-V SINGLE-CHANNEL RS-232 1-Mbit/s LINE DRIVER/RECEIVER**  
**WITH ±15-kV IEC ESD PROTECTION**

SLLS822–JULY 2007

**ORDERING INFORMATION**

| T <sub>A</sub> | PACKAGE <sup>(1)(2)</sup> |              | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|----------------|---------------------------|--------------|-----------------------|------------------|
| 0°C to 70°C    | SSOP – DB                 | Reel of 2000 | TRSF3221ECDBR         | RT21EC           |
|                | TSSOP – PW                | Tube of 90   | TRSF3221ECPW          | RT21EC           |
|                |                           | Reel of 2000 | TRSF3221ECPWR         |                  |
| –40°C to 85°C  | SSOP – DB                 | Reel of 2000 | TRSF3221EIDBR         | RT21EI           |
|                | TSSOP – PW                | Tube of 90   | TRSF3221EIPW          | RT21EI           |
|                |                           | Reel of 2000 | TRSF3221EIPWR         |                  |

- (1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at [www.ti.com/sc/package](http://www.ti.com/sc/package).
- (2) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at [www.ti.com](http://www.ti.com).

**FUNCTION TABLES**

**Each Driver<sup>(1)</sup>**

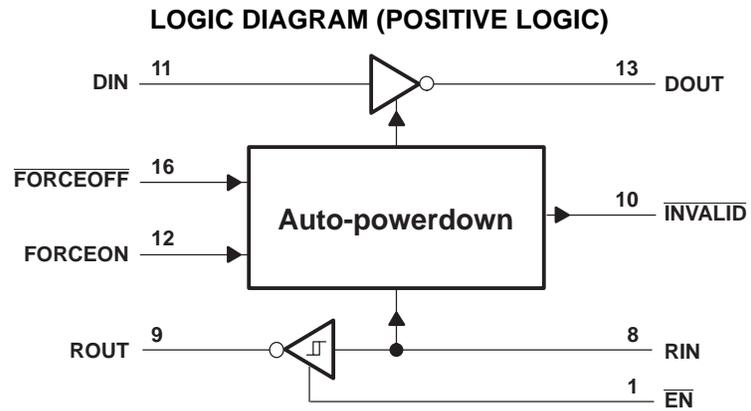
| INPUTS |         |          |                        | OUTPUT DOUT | DRIVER STATUS                                 |
|--------|---------|----------|------------------------|-------------|---|
| DIN    | FORCEON | FORCEOFF | VALID RIN RS-232 LEVEL |             |   |
| X      | X       | L        |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

- (1) H = high level, L = low level, X = irrelevant, Z = high impedance

**Each Receiver<sup>(1)</sup>**

| INPUTS |                        |                        | OUTPUT ROUT |
|--------|------------------------|------------------------|-------------|
| RIN    | $\overline{\text{EN}}$ | VALID RIN RS-232 LEVEL |             |
| L      | L                      | X                      | H           |
| H      | L                      | X                      | L           |
| X      | H                      | X                      | Z           |
| Open   | L                      | No                     | H           |

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



**TRSF3221E**  
**3-V TO 5.5-V SINGLE-CHANNEL RS-232 1-Mbit/s LINE DRIVER/RECEIVER**  
**WITH  $\pm 15$ -kV IEC ESD PROTECTION**

SLLS822–JULY 2007

**Table 1. 1-Mbit/s RS-232 Parts**

| PART NO.  | TEMPERATURE RANGE | DRIVER NO.    | RECEIVER NO. | ESD   | SUPPLY $V_{CC}$ (V)   | FEATURE                              | PIN/PACKAGE                 |
|-----------|-------------------|---------------|--------------|---|---|--------------------------------------|-----------------------------|
| TRSF3221E | 0°C to 70°C       | 1             | 1            | $\pm 15$ -kV Air-Gap,<br>$\pm 8$ -kV Contact,<br>$\pm 15$ -kV HBM | 3.3 or 5  | Auto-powerdown                       | 16-pin SOIC,<br>SSOP, TSSOP |
| TRSF3232E |                   | 2             | 2            | $\pm 15$ -kV Air-Gap,<br>$\pm 8$ -kV Contact,<br>$\pm 15$ -kV HBM | 3.3 or 5  | Low pin count                        | 16-pin SOIC,<br>SSOP, TSSOP |
| TRS3227   |                   | 1             | 1            | $\pm 8$ -kV Air-Gap,<br>$\pm 8$ -kV Contact,<br>$\pm 15$ -kV HBM  | 3.3 or 5  | Auto-powerdown plus,<br>ready signal | 16-pin SSOP                 |
| TRSF3221  |                   | 1             | 1            | $\pm 15$ -kV HBM  | 3.3 or 5  | Auto-powerdown                       | 16-pin SOIC,<br>SSOP, TSSOP |
| TRSF3223  |                   | 2             | 2            | $\pm 15$ -kV HBM  | 3.5 or 5  | Auto-powerdown,<br>enable signal     | 20-pin SOIC,<br>SSOP, TSSOP |
| TRSF3222  |                   | 2             | 2            | $\pm 15$ -kV HBM  | 3.3 or 5  | Enable,<br>powerdown signal          | 20-pin SOIC,<br>SSOP, TSSOP |
| TRSF3232  |                   | 2             | 2            | $\pm 15$ -kV HBM  | 3.3 or 5  | Low pin count                        | 16-pin SOIC,<br>SSOP, TSSOP |
| TRSF3238  |                   | 5             | 3            | $\pm 15$ -kV HBM  | 3.3 or 5  | Auto-powerdown plus                  | 28-pin SOIC,<br>SSOP, TSSOP |
| TRSF3243  |                   | 3             | 5            | $\pm 15$ -kV HBM  | 3.3 or 5  | Auto-powerdown                       | 28-pin SOIC,<br>SSOP, TSSOP |
| TRSF3221E |                   | –40°C to 85°C | 1            | 1   | $\pm 15$ -kV Air-Gap,<br>$\pm 8$ -kV Contact,<br>$\pm 15$ -kV HBM | 3.3 or 5                             | Auto-powerdown              |
| TRSF3232E | 2                 |               | 2            | $\pm 15$ -kV Air-Gap,<br>$\pm 8$ -kV Contact,<br>$\pm 15$ -kV HBM | 3.3 or 5  | Low pin count                        | 16-pin SOIC,<br>SSOP, TSSOP |
| TRS3227   | 1                 |               | 1            | $\pm 8$ -kV Air-Gap,<br>$\pm 8$ -k V Contact,<br>$\pm 15$ -kV HBM | 3.3 or 5  | Auto-powerdown plus,<br>ready signal | 16-pin SSOP                 |
| TRSF3221  | 1                 |               | 1            | $\pm 15$ -kV HBM  | 3.3 or 5  | Auto-powerdown                       | 16-pin SOIC,<br>SSOP, TSSOP |
| TRSF3223  | 2                 |               | 2            | $\pm 15$ -kV HBM  | 3.3 or 5  | Auto-powerdown,<br>enable signal     | 20-pin SOIC,<br>SSOP, TSSOP |
| TRSF3222  | 2                 |               | 2            | $\pm 15$ -kV HBM  | 3.3 or 5  | Enable,<br>powerdown signal          | 20-pin SOIC,<br>SSOP, TSSOP |
| TRSF3232  | 2                 |               | 2            | $\pm 15$ -kV HBM  | 3.3 or 5  | Low pin count                        | 16-pin SOIC,<br>SSOP, TSSOP |
| TRSF3238  | 5                 |               | 3            | $\pm 15$ -kV HBM  | 3.3 or 5  | Auto-powerdown plus                  | 28-pin SOIC,<br>SSOP, TSSOP |
| TRSF3243  | 3                 |               | 5            | $\pm 15$ -kV HBM  | 3.3 or 5  | Auto-powerdown                       | 28-pin SOIC,<br>SSOP, TSSOP |

### Absolute Maximum Ratings<sup>(1)</sup>

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

|                  |   | MIN                            | MAX | UNIT |
|------------------|---|--------------------------------|-----|------|
| V <sub>CC</sub>  | Supply voltage range <sup>(2)</sup>                 | –0.3                           | 6   | V    |
| V+               | Positive output supply voltage range <sup>(2)</sup> | –0.3                           | 7   | V    |
| V–               | Negative output supply voltage range <sup>(2)</sup> | 0.3                            | –7  | V    |
| V+ – V–          | Supply voltage difference <sup>(2)</sup>            |                                | 13  | V    |
| V <sub>I</sub>   | Input voltage range                                 | Driver (FORCEOFF, FORCEON, EN) |     | V    |
|                  |   | Receiver                       |     |      |
| V <sub>O</sub>   | Output voltage range                                | Driver                         |     | V    |
|                  |   | Receiver (INVALID)             |     |      |
| θ <sub>JA</sub>  | Package thermal impedance <sup>(3)(4)</sup>         | DB package                     |     | °C/W |
|                  |   | PW package                     |     |      |
| T <sub>J</sub>   | Operating virtual junction temperature              |                                | 150 | °C   |
| T <sub>stg</sub> | Storage temperature range                           | –65                            | 150 | °C   |

- (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) All voltages are with respect to network GND.
- (3) Maximum power dissipation is a function of T<sub>J</sub>(max), θ<sub>JA</sub>, and T<sub>A</sub>. The maximum allowable power dissipation at any allowable ambient temperature is P<sub>D</sub> = (T<sub>J</sub>(max) – T<sub>A</sub>)/θ<sub>JA</sub>. Operating at the absolute maximum T<sub>J</sub> of 150°C can affect reliability.
- (4) The package thermal impedance is calculated in accordance with JESD 51-7.

### Recommended Operating Conditions<sup>(1)</sup>

See [Figure 6](#)

|                 |   | 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 and control high-level input voltage | DIN, FORCEOFF, FORCEON, EN |     | V   |      |   |
|                 |   | V <sub>CC</sub> = 3.3 V    | 2   |     |      |   |
|                 |   | V <sub>CC</sub> = 5 V      | 2.4 |     |      |   |
| V <sub>IL</sub> | Driver and control low-level input voltage  | DIN, FORCEOFF, FORCEON, EN |     | 0.8 | V    |   |
| V <sub>I</sub>  | Driver and control input voltage            | DIN, FORCEOFF, FORCEON     |     | 0   | 5.5  | V |
| V <sub>I</sub>  | Receiver input voltage                      | –25                        |     | 25  | V    |   |
| T <sub>A</sub>  | Operating free-air temperature              | TRSF3221EI                 | –40 | 85  | °C   |   |
|                 |   | TRSF3221EC                 | 0   | 70  |      |   |

- (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.

### Electrical Characteristics<sup>(1)</sup>

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 6](#))

| PARAMETER       |  | TEST CONDITIONS         | MIN   | TYP <sup>(2)</sup> | MAX | UNIT |
|-----------------|--|-------------------------|---|--------------------|-----|------|
| I <sub>I</sub>  | Input leakage current                  | FORCEOFF, FORCEON, EN   |   | ±0.01              | ±1  | μA   |
| I <sub>CC</sub> | Supply current (T <sub>A</sub> = 25°C) | Auto-powerdown disabled | No load, FORCEOFF and FORCEON at V <sub>CC</sub>                                    | 0.3                | 1   | mA   |
|                 |  | Powered off             | No load, FORCEOFF at GND  | 1                  | 10  |      |
|                 |  | Auto-powerdown enabled  | No load, FORCEOFF at V <sub>CC</sub> , FORCEON at GND, All RIN are open or grounded | 1                  | 10  | μA   |

- (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.
- (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.

# TRSF3221E

## 3-V TO 5.5-V SINGLE-CHANNEL RS-232 1-Mbit/s LINE DRIVER/RECEIVER WITH $\pm 15$ -kV IEC ESD PROTECTION

SLLS822–JULY 2007

### DRIVER SECTION

#### Electrical Characteristics<sup>(1)</sup>

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 6](#))

| PARAMETER        | TEST CONDITIONS   | MIN   | TYP <sup>(2)</sup> | MAX      | UNIT     |
|------------------|---|---|--------------------|----------|----------|
| V <sub>OH</sub>  | High-level output voltage<br>DOUT at R <sub>L</sub> = 3 k $\Omega$ to GND, DIN = GND  | 5   | 5.4                |          | V        |
| V <sub>OL</sub>  | Low-level output voltage<br>DOUT at R <sub>L</sub> = 3 k $\Omega$ to GND, DIN = V <sub>CC</sub>   | –5  | –5.4               |          | V        |
| I <sub>IH</sub>  | High-level input current<br>V <sub>I</sub> = V <sub>CC</sub>  |   | $\pm 0.01$         | $\pm 1$  | $\mu$ A  |
| I <sub>IL</sub>  | Low-level input current<br>V <sub>I</sub> at GND  |   | $\pm 0.01$         | $\pm 1$  | $\mu$ A  |
| I <sub>OS</sub>  | Short-circuit output current <sup>(3)</sup><br>V <sub>CC</sub> = 3.6 V, V <sub>O</sub> = 0 V<br>V <sub>CC</sub> = 5.5 V, V <sub>O</sub> = 0 V |   | $\pm 35$           | $\pm 60$ | mA       |
|                  |   |   | $\pm 35$           | $\pm 90$ |          |
| r <sub>o</sub>   | Output resistance<br>V <sub>CC</sub> , V+, and V– = 0 V, V <sub>O</sub> = $\pm 2$ V   | 300   | 10M                |          | $\Omega$ |
| I <sub>off</sub> | Output leakage current<br>FORCEOFF = GND  | V <sub>O</sub> = $\pm 12$ V, V <sub>CC</sub> = 3 V to 3.6 V   |                    | $\pm 25$ | $\mu$ A  |
|                  |   | V <sub>O</sub> = $\pm 10$ V, V <sub>CC</sub> = 4.5 V to 5.5 V |                    | $\pm 25$ |          |

(1) 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.

(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.

#### Switching Characteristics<sup>(1)</sup>

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 6](#))

| PARAMETER  | TEST CONDITIONS  | MIN  | TYP <sup>(2)</sup> | MAX | UNIT       |
|--|--|--|--------------------|-----|------------|
| Maximum data rate<br>(see <a href="#">Figure 1</a> ) | R <sub>L</sub> = 3 k $\Omega$  | C <sub>L</sub> = 1000 pF                                   | 250                |     | kbit/s     |
|  |  | C <sub>L</sub> = 250 pF, V <sub>CC</sub> = 3 V to 4.5 V    | 1000               |     |            |
|  |  | C <sub>L</sub> = 1000 pF, V <sub>CC</sub> = 4.5 V to 5.5 V | 1000               |     |            |
| t <sub>sk(p)</sub>                                   | Pulse skew <sup>(3)</sup><br>C <sub>L</sub> = 150 pF to 2500 pF, R <sub>L</sub> = 3 k $\Omega$ to 7 k $\Omega$ , See <a href="#">Figure 2</a>                                  |  | 100                |     | ns         |
| SR(tr)   | Slew rate, transition region<br>(see <a href="#">Figure 1</a> )<br>V <sub>CC</sub> = 3.3 V, R <sub>L</sub> = 3 k $\Omega$ to 7 k $\Omega$ , C <sub>L</sub> = 150 pF to 1000 pF | 18   |                    | 150 | V/ $\mu$ s |

(1) 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.

(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<sub>PLH</sub> – t<sub>PHL</sub>| of each channel of the same device.

#### ESD Protection

| TERMINAL |     | TEST CONDITIONS                 | TYP      | UNIT |
|----------|-----|---------------------------------|----------|------|
| NAME     | NO. |                                 |          |      |
| DOUT     | 13  | HBM                             | $\pm 15$ | kV   |
|          |     | IEC 61000-4-2 Contact Discharge | $\pm 8$  |      |
|          |     | IEC 61000-4-2 Air-Gap Discharge | $\pm 15$ |      |

## RECEIVER SECTION

### Electrical Characteristics<sup>(1)</sup>

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 6](#))

| PARAMETER        |   | TEST CONDITIONS                | MIN                     | TYP <sup>(2)</sup>      | MAX | UNIT |
|------------------|---|--------------------------------|-------------------------|-------------------------|-----|------|
| V <sub>OH</sub>  | High-level output voltage                               | I <sub>OH</sub> = –1 mA        | V <sub>CC</sub> – 0.6 V | V <sub>CC</sub> – 0.1 V |     | 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        |                         | 1.6                     | 2.4 | V    |
|                  |   | V <sub>CC</sub> = 5 V          |                         | 1.9                     | 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) 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.

(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.

### Switching Characteristics<sup>(1)</sup>

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 6](#))

| PARAMETER          |   | TEST CONDITIONS  | TYP <sup>(2)</sup> | UNIT |
|--------------------|---|--|--------------------|------|
| t <sub>PLH</sub>   | Propagation delay time, low- to high-level output | C <sub>L</sub> = 150 pF, See <a href="#">Figure 3</a>                        | 150                | ns   |
| t <sub>PHL</sub>   | Propagation delay time, high- to low-level output | C <sub>L</sub> = 150 pF, See <a href="#">Figure 3</a>                        | 150                | ns   |
| t <sub>en</sub>    | Output enable time                                | C <sub>L</sub> = 150 pF, R <sub>L</sub> = 3 kΩ, See <a href="#">Figure 4</a> | 200                | ns   |
| t <sub>dis</sub>   | Output disable time                               | C <sub>L</sub> = 150 pF, R <sub>L</sub> = 3 kΩ, See <a href="#">Figure 4</a> | 200                | ns   |
| t <sub>sk(p)</sub> | Pulse skew <sup>(3)</sup>                         | See <a href="#">Figure 3</a>   | 50                 | ns   |

(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.

(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<sub>PLH</sub> – t<sub>PHL</sub>| of each channel of the same device.

## ESD Protection

| TERMINAL |     | TEST CONDITIONS                 | TYP | UNIT |
|----------|-----|---------------------------------|-----|------|
| NAME     | NO. |                                 |     |      |
| RIN      | 8   | HBM                             | ±15 | kV   |
|          |     | IEC 61000-4-2 Contact Discharge | ±8  |      |
|          |     | IEC 61000-4-2 Air-Gap Discharge | ±15 |      |

## AUTO-POWERDOWN SECTION

### Electrical Characteristics

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 5](#))

| PARAMETER         |  | TEST CONDITIONS   | MIN            | MAX | UNIT |
|-------------------|--|---|----------------|-----|------|
| $V_{T+}$ (valid)  | Receiver input threshold for $\overline{\text{INVALID}}$ high-level output voltage | FORCEON = GND, $\overline{\text{FORCEOFF}} = V_{CC}$                    |                | 2.7 | V    |
| $V_{T-}$ (valid)  | Receiver input threshold for $\overline{\text{INVALID}}$ high-level output voltage | FORCEON = GND, $\overline{\text{FORCEOFF}} = V_{CC}$                    | -2.7           |     | V    |
| $V_{T}$ (invalid) | Receiver input threshold for $\overline{\text{INVALID}}$ low-level output voltage  | FORCEON = GND, $\overline{\text{FORCEOFF}} = V_{CC}$                    | -0.3           | 0.3 | V    |
| $V_{OH}$          | $\overline{\text{INVALID}}$ high-level output voltage                              | $I_{OH} = -1$ mA, FORCEON = GND, $\overline{\text{FORCEOFF}} = V_{CC}$  | $V_{CC} - 0.6$ |     | V    |
| $V_{OL}$          | $\overline{\text{INVALID}}$ low-level output voltage                               | $I_{OL} = 1.6$ mA, FORCEON = GND, $\overline{\text{FORCEOFF}} = V_{CC}$ |                | 0.4 | V    |

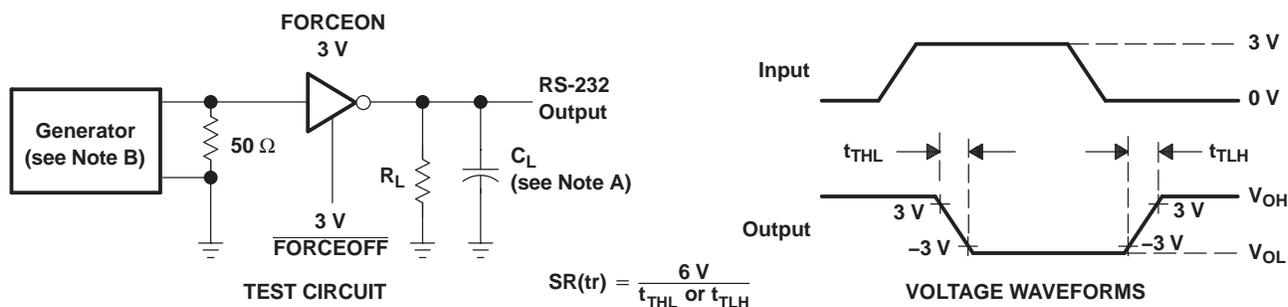
### Switching Characteristics

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 5](#))

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

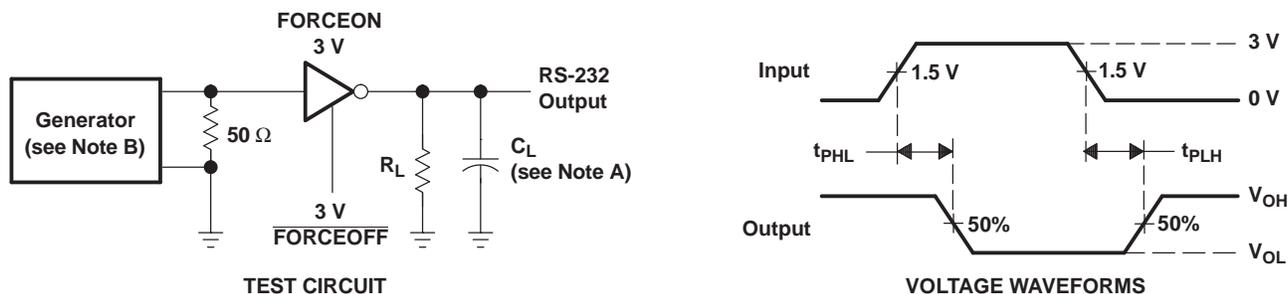
(1) All typical values are at  $V_{CC} = 3.3$  V or  $V_{CC} = 5$  V, and  $T_A = 25^\circ\text{C}$ .

PARAMETER MEASUREMENT INFORMATION



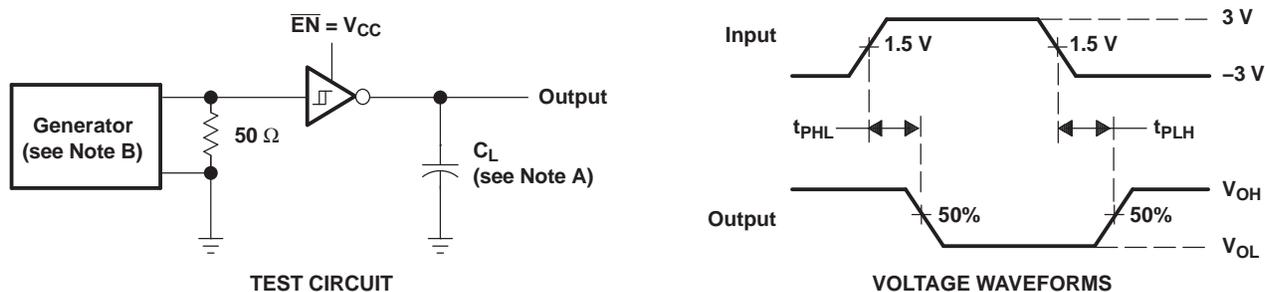
NOTES: A.  $C_L$  includes probe and jig capacitance.  
B. The pulse generator has the following characteristics: PRR = 250 kbit/s,  $Z_0 = 50\ \Omega$ , 50% duty cycle,  $t_r \leq 10\text{ ns}$ ,  $t_f \leq 10\text{ ns}$ .

Figure 1. Driver Slew Rate



NOTES: A.  $C_L$  includes probe and jig capacitance.  
B. The pulse generator has the following characteristics: PRR = 250 kbit/s,  $Z_0 = 50\ \Omega$ , 50% duty cycle,  $t_r \leq 10\text{ ns}$ ,  $t_f \leq 10\text{ ns}$ .

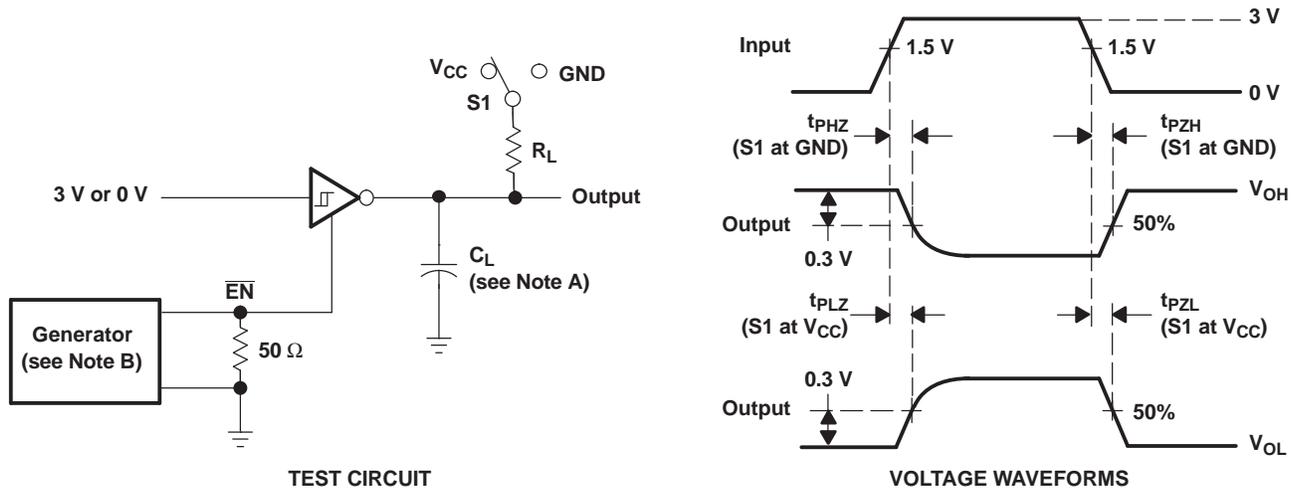
Figure 2. Driver Pulse Skew



NOTES: A.  $C_L$  includes probe and jig capacitance.  
B. The pulse generator has the following characteristics:  $Z_0 = 50\ \Omega$ , 50% duty cycle,  $t_r \leq 10\text{ ns}$ ,  $t_f \leq 10\text{ ns}$ .

Figure 3. Receiver Propagation Delay Times

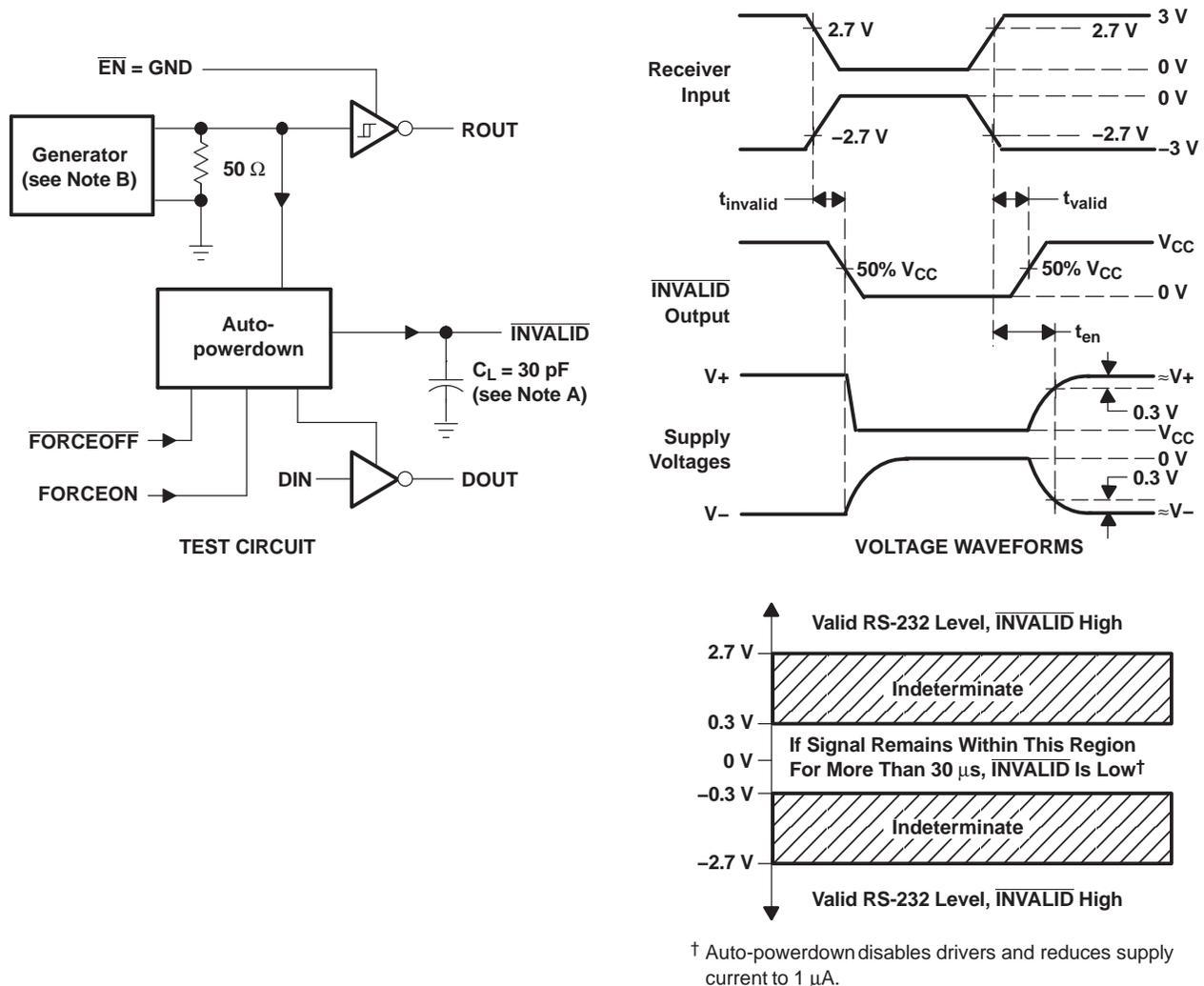
PARAMETER MEASUREMENT INFORMATION (continued)



- NOTES: A.  $C_L$  includes probe and jig capacitance.  
 B. The pulse generator has the following characteristics:  $Z_O = 50 \Omega$ , 50% duty cycle,  $t_r \leq 10$  ns,  $t_f \leq 10$  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 4. Receiver Enable and Disable Times

PARAMETER MEASUREMENT INFORMATION (continued)

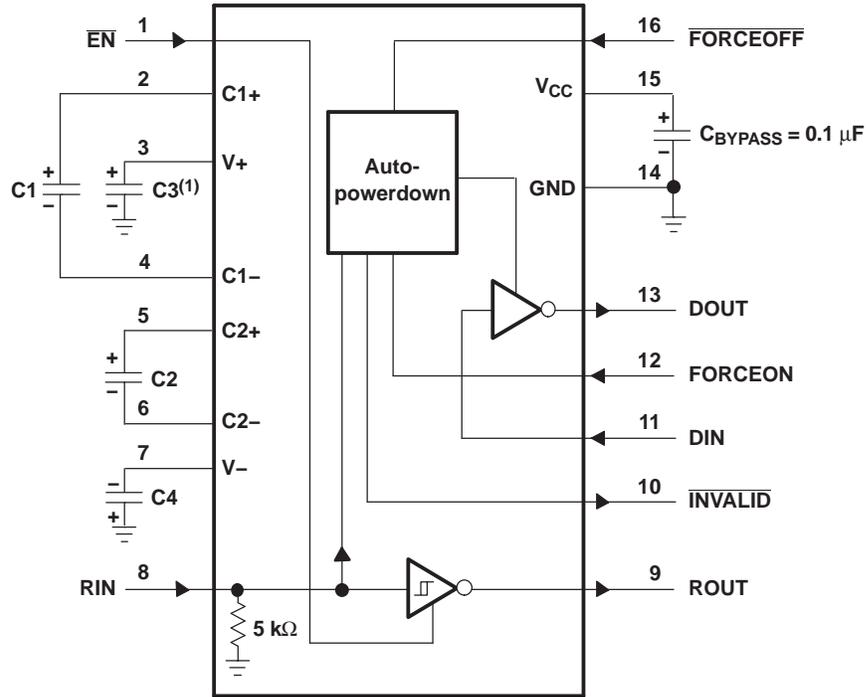


NOTES: A.  $C_L$  includes probe and jig capacitance.

B. The pulse generator has the following characteristics: PRR = 5 kbit/s,  $Z_O = 50 \Omega$ , 50% duty cycle,  $t_r \leq 10$  ns,  $t_f \leq 10$  ns.

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

**APPLICATION INFORMATION**



(1) 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 6. Typical Operating Circuit and Capacitor Values**

**PACKAGING INFORMATION**

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| TRSF3221ECDB     | ACTIVE        | SSOP         | DB                 | 16   | 80             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | RT21EC                  | <a href="#">Samples</a> |
| TRSF3221ECDBG4   | ACTIVE        | SSOP         | DB                 | 16   | 80             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | RT21EC                  | <a href="#">Samples</a> |
| TRSF3221ECDBR    | ACTIVE        | SSOP         | DB                 | 16   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | RT21EC                  | <a href="#">Samples</a> |
| TRSF3221ECDBRG4  | ACTIVE        | SSOP         | DB                 | 16   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | RT21EC                  | <a href="#">Samples</a> |
| TRSF3221ECPW     | ACTIVE        | TSSOP        | PW                 | 16   | 90             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | RT21EC                  | <a href="#">Samples</a> |
| TRSF3221ECPWR    | ACTIVE        | TSSOP        | PW                 | 16   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | RT21EC                  | <a href="#">Samples</a> |
| TRSF3221EIDB     | OBSOLETE      | SSOP         | DB                 | 16   |                | TBD                        | Call TI                 | Call TI              | -40 to 85    |                         |                         |
| TRSF3221EIDBG4   | OBSOLETE      | SSOP         | DB                 | 16   |                | TBD                        | Call TI                 | Call TI              | -40 to 85    |                         |                         |
| TRSF3221EIDBR    | ACTIVE        | SSOP         | DB                 | 16   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | RT21EI                  | <a href="#">Samples</a> |
| TRSF3221EIPW     | ACTIVE        | TSSOP        | PW                 | 16   | 90             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | RT21EI                  | <a href="#">Samples</a> |
| TRSF3221EIPWR    | ACTIVE        | TSSOP        | PW                 | 16   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | RT21EI                  | <a href="#">Samples</a> |
| TRSF3221EIPWRG4  | ACTIVE        | TSSOP        | PW                 | 16   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | RT21EI                  | <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) 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.

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**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)

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

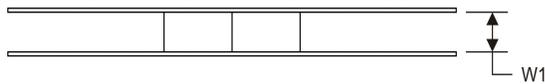
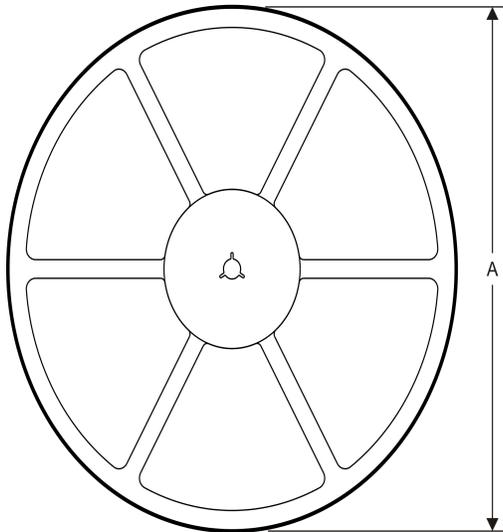
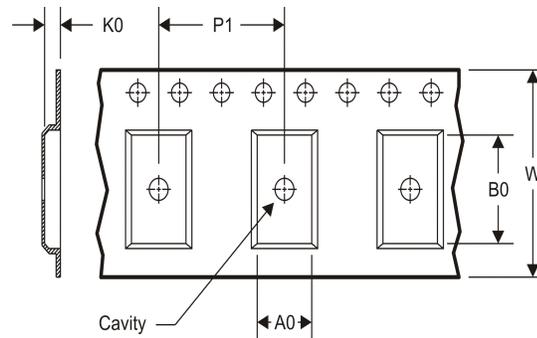
<sup>(4)</sup> There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

<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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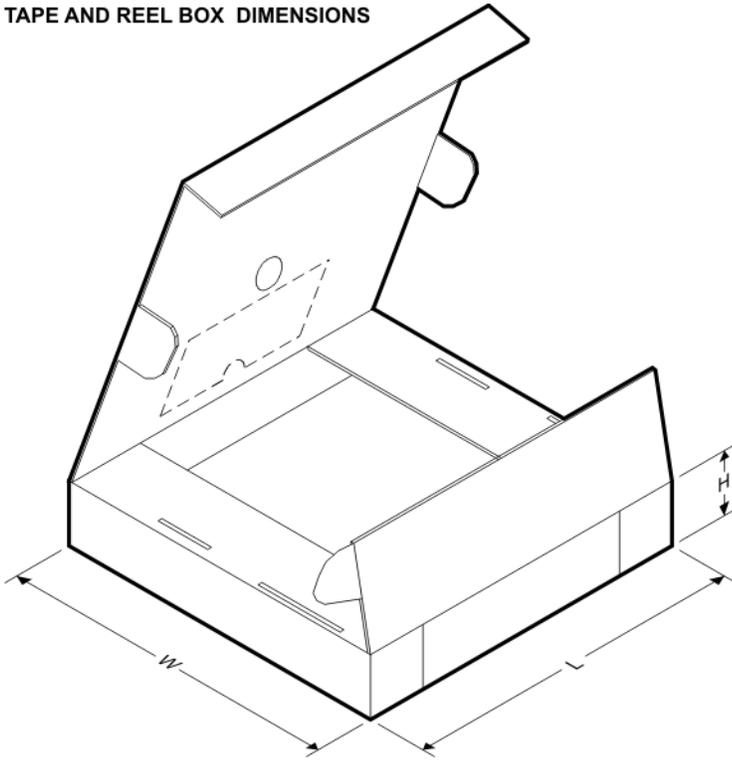
**TAPE AND REEL INFORMATION**
**REEL DIMENSIONS**

**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                   |

**TAPE AND REEL INFORMATION**

\*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 |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TRSF3221ECDBR | SSOP         | DB              | 16   | 2000 | 330.0              | 16.4               | 8.2     | 6.6     | 2.5     | 12.0    | 16.0   | Q1            |
| TRSF3221ECPWR | TSSOP        | PW              | 16   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| TRSF3221EIDBR | SSOP         | DB              | 16   | 2000 | 330.0              | 16.4               | 8.2     | 6.6     | 2.5     | 12.0    | 16.0   | Q1            |
| TRSF3221EIPWR | TSSOP        | PW              | 16   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |

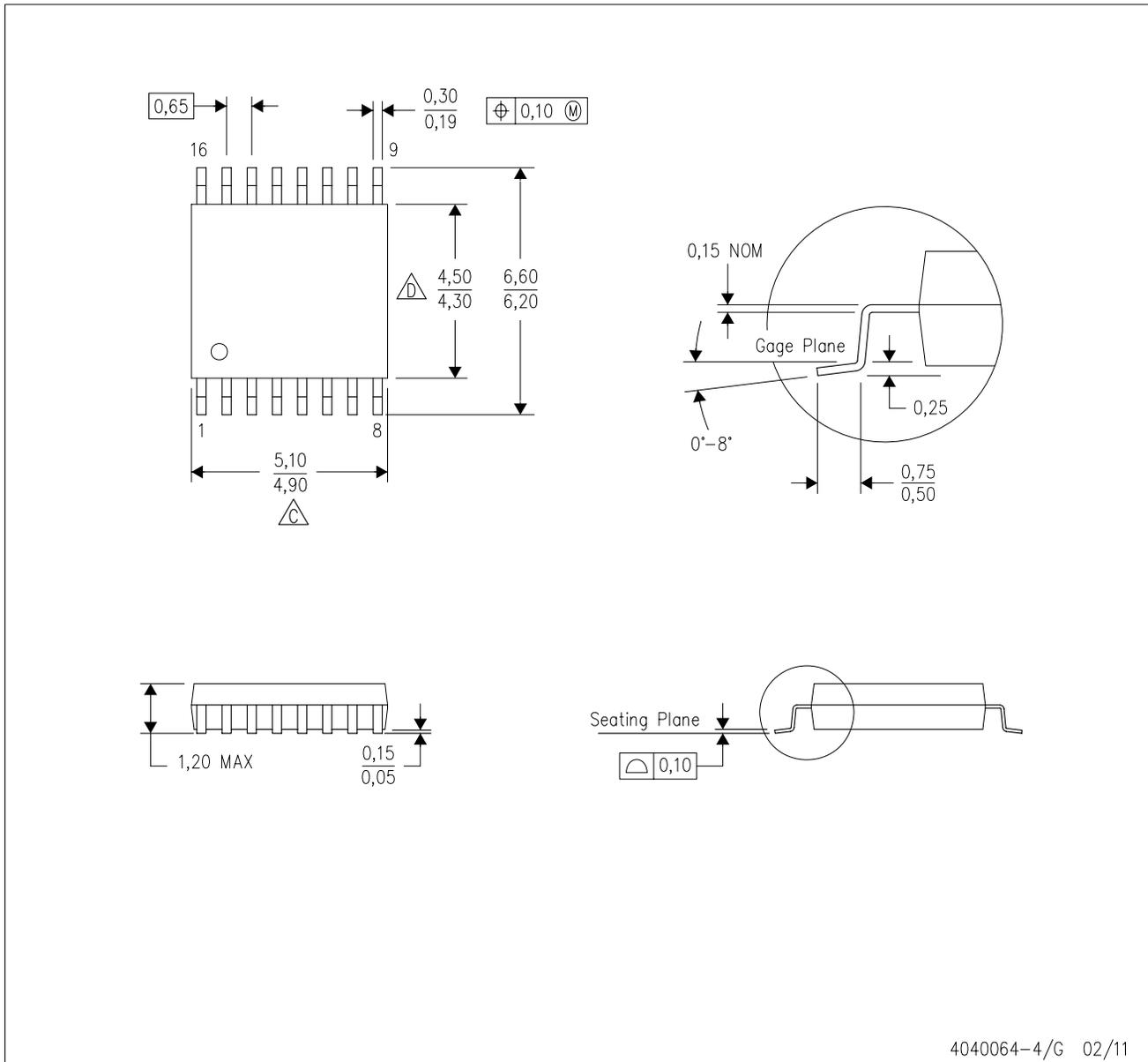
**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

| Device        | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TRSF3221ECDBR | SSOP         | DB              | 16   | 2000 | 367.0       | 367.0      | 38.0        |
| TRSF3221ECPWR | TSSOP        | PW              | 16   | 2000 | 367.0       | 367.0      | 35.0        |
| TRSF3221EIDBR | SSOP         | DB              | 16   | 2000 | 367.0       | 367.0      | 38.0        |
| TRSF3221EIPWR | TSSOP        | PW              | 16   | 2000 | 367.0       | 367.0      | 35.0        |

PW (R-PDSO-G16)

PLASTIC SMALL OUTLINE

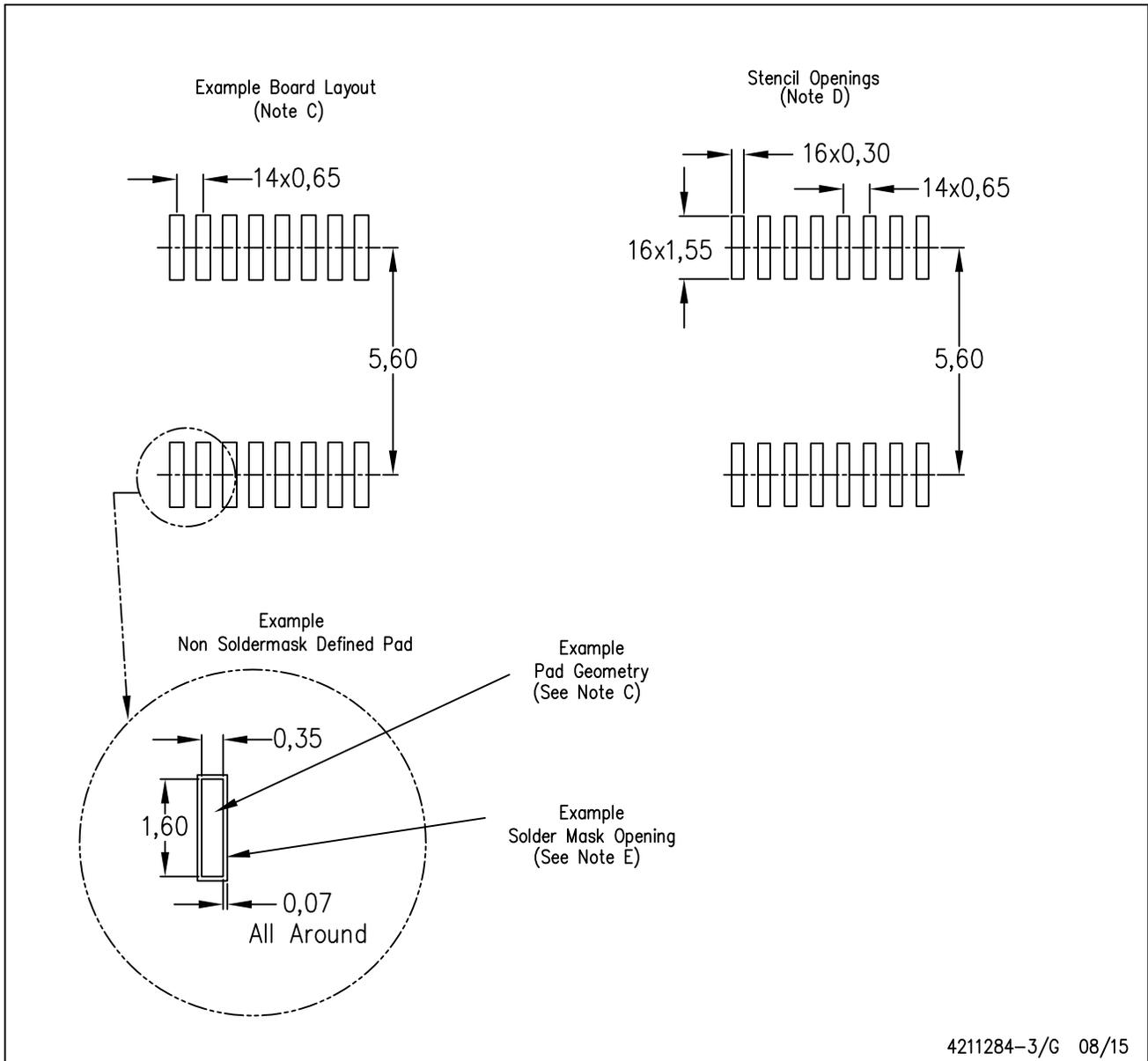


4040064-4/G 02/11

- 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.
  -  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

PW (R-PDSO-G16)

PLASTIC SMALL OUTLINE

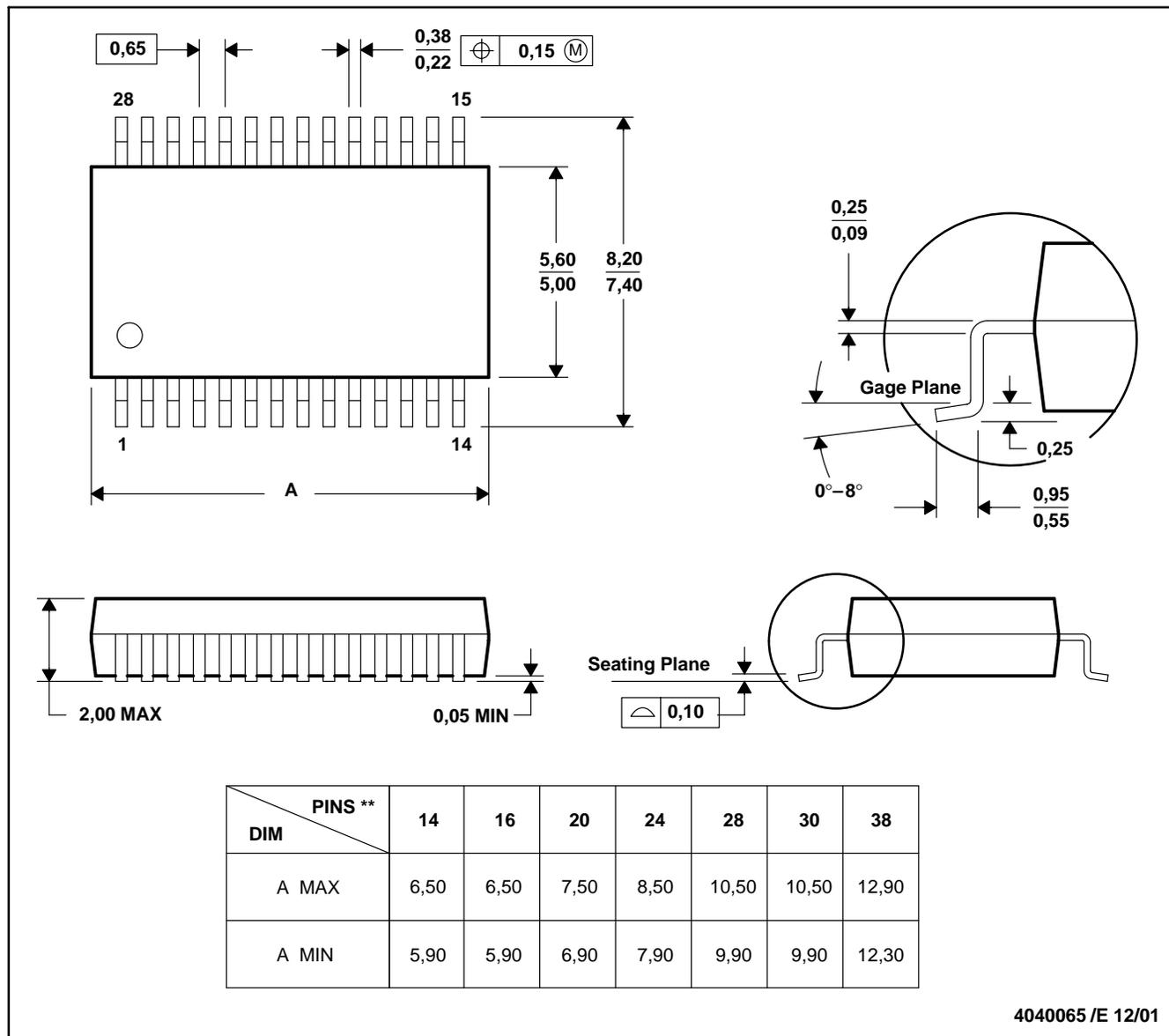


- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact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

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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