

FEATURES

- Operates With 3-V to 5.5-V V_{CC} Supply
- Operates up to 1 Mbit/s
- Low Standby Current . . . 1 μ 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 Human-Body Model (HBM)
- Auto-Powerdown Feature Automatically Disables Drivers for Power Savings

APPLICATIONS

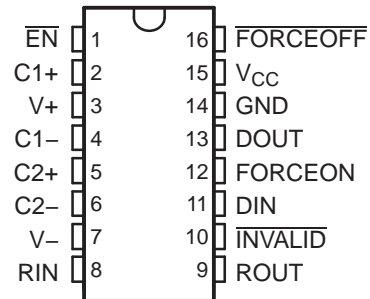
- Battery-Powered, Hand-Held, and Portable Equipment
- PDAs and Palmtop PCs
- Notebooks, Sub-Notebooks, and Laptops
- Digital Cameras
- Mobile Phones and Wireless Devices

DESCRIPTION/ORDERING INFORMATION

The TRSF3221 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 TRSF3221 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 TRSF3221 operates at data signaling rates up to 1 Mbit/s and a driver output slew rate of 24 V/ μ s to 150 V/ μ 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 TRSF3221 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 μ 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 $\overline{INVALID}$ output notifies the user if an RS-232 signal is present at the receiver input. $\overline{INVALID}$ 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 μ s. $\overline{INVALID}$ is low (invalid data) if the receiver input voltage is between -0.3 V and 0.3 V for more than 30 μ s. See Figure 5 for receiver input levels.

DB OR PW PACKAGE
(TOP VIEW)



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

ORDERING INFORMATION

| T _A | PACKAGE ⁽¹⁾⁽²⁾ | | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|----------------|---------------------------|--------------|-----------------------|------------------|
| 0°C to 70°C | SSOP – DB | Reel of 2000 | TRSF3221CDBR | RT21C |
| | TSSOP – PW | Tube of 90 | TRSF3221CPW | RT21C |
| | | Reel of 2000 | TRSF3221CPWR | |
| –40°C to 85°C | SSOP – DB | Reel of 2000 | TRSF3221IDBR | RT21I |
| | TSSOP – PW | Tube of 90 | TRSF3221IPW | RT21I |
| | | Reel of 2000 | TRSF3221IPWR | |

- (1) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.
 (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.

FUNCTION TABLES

Each Driver ⁽¹⁾

| 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 | |

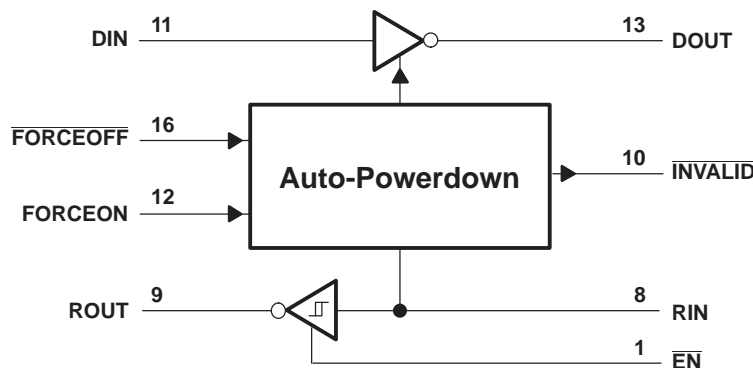
- (1) H = high level, L = low level, X = irrelevant, Z = high impedance

Each Receiver ⁽¹⁾

| INPUTS | | | OUTPUT ROUT |
|--------|-----------------|------------------------|-------------|
| RIN | \overline{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

LOGIC DIAGRAM (POSITIVE LOGIC)



Absolute Maximum Ratings⁽¹⁾

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

| | | MIN | MAX | UNIT |
|------------------|---|--------------------------------|-----|------|
| V _{CC} | Supply voltage range ⁽²⁾ | -0.3 | 6 | V |
| V+ | Positive-output supply voltage range ⁽²⁾ | -0.3 | 7 | V |
| V- | Negative-output supply voltage range ⁽²⁾ | 0.3 | -7 | V |
| V+ - V- | Supply voltage difference ⁽²⁾ | | 13 | V |
| V _I | Input voltage range | Driver (FORCEOFF, FORCEON, EN) | | V |
| | | Receiver | | |
| V _O | Output voltage range | Driver | | V |
| | | Receiver (INVALID) | | |
| θ _{JA} | Package thermal impedance ⁽³⁾⁽⁴⁾ | DB package | | °C/W |
| | | PW package | | |
| T _J | Operating virtual junction temperature | | 150 | °C |
| T _{stg} | 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_{J(max)}, θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is P_D = (T_{J(max)} - T_A)/θ_{JA}. Operating at the absolute maximum T_J of 150°C can affect reliability.
- (4) The package thermal impedance is calculated in accordance with JESD 51-7.

Recommended Operating Conditions⁽¹⁾

See Figure 6

| | | | 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 and control high-level input voltage | DIN, FORCEOFF, FORCEON, EN | V _{CC} = 3.3 V | 2 | | V |
| | | | V _{CC} = 5 V | 2.4 | | |
| V _{IL} | Driver and control low-level input voltage | DIN, FORCEOFF, FORCEON, EN | | | 0.8 | V |
| V _I | Driver and control input voltage | DIN, FORCEOFF, FORCEON | 0 | | 5.5 | V |
| V _I | Receiver input voltage | | -25 | | 25 | V |
| T _A | Operating free-air temperature | TRSF3221I | -40 | | 85 | °C |
| | | TRSF3221C | 0 | | 70 | |

- (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.

Electrical Characteristics⁽¹⁾

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

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

- (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.

DRIVER SECTION

Electrical Characteristics⁽¹⁾

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

| PARAMETER | | TEST CONDITIONS | | MIN | TYP ⁽²⁾ | MAX | UNIT |
|------------------|---|---|--|-----|--------------------|-----|------|
| V _{OH} | High-level output voltage | DOUT at R _L = 3 kΩ to GND, DIN = GND | | 5 | 5.4 | | V |
| V _{OL} | Low-level output voltage | DOUT at R _L = 3 kΩ to GND, DIN = V _{CC} | | –5 | –5.4 | | V |
| 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 | μA |
| I _{OS} | Short-circuit output current ⁽³⁾ | V _O = 0 V | V _{CC} = 3.6 V | | ±35 | ±60 | mA |
| | | | V _{CC} = 5.5 V | | ±35 | ±90 | |
| r _o | Output resistance | V _{CC} , V+, and V– = 0 V, V _O = ±2 V | | 300 | 10M | | Ω |
| I _{off} | Output leakage current | FORCEOFF = GND | V _O = ±12 V, V _{CC} = 3 V to 3.6 V | | | ±25 | μA |
| | | | V _O = ±10 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 V.

(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.

Switching Characteristics⁽¹⁾

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

| PARAMETER | | TEST CONDITIONS | | MIN | TYP ⁽²⁾ | MAX | UNIT |
|--|---|---|------|-----|--------------------|-----|--------|
| Maximum data rate (see Figure 1) | R _L = 3 kΩ | C _L = 1000 pF | | 250 | | | kbit/s |
| | | C _L = 250 pF, V _{CC} = 3 V to 4.5 V | 1000 | | | | |
| | | C _L = 1000 pF, V _{CC} = 4.5 V to 5.5 V | 1000 | | | | |
| t _{sk(p)} | Pulse skew ⁽³⁾ | C _L = 150 pF to 2500 pF, R _L = 3 kΩ to 7 kΩ, See Figure 2 | | 100 | | | ns |
| SR(tr) | Slew rate, transition region (see Figure 1) | V _{CC} = 3.3 V, R _L = 3 kΩ to 7 kΩ, C _L = 150 pF to 1000 pF | | 18 | | 150 | V/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.

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

ESD Protection

| TERMINAL | | TEST CONDITIONS | TYP | UNIT |
|----------|-----|-----------------|-----|------|
| NAME | NO. | | | |
| DOUT | 13 | HBM | ±15 | kV |

RECEIVER SECTION

Electrical Characteristics⁽¹⁾

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

| 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 |
| V _{IT+} | Positive-going input threshold voltage | V _{CC} = 3.3 V | | 1.6 | 2.4 | V |
| | | V _{CC} = 5 V | | 1.9 | 2.4 | |
| V _{IT-} | Negative-going input threshold voltage | V _{CC} = 3.3 V | 0.6 | 1.1 | | V |
| | | V _{CC} = 5 V | 0.8 | 1.4 | | |
| V _{hys} | Input hysteresis (V _{IT+} - V _{IT-}) | | | 0.5 | | V |
| I _{off} | Output leakage current | FORCEOFF = 0 V | | ±0.05 | ±10 | µA |
| r _i | Input resistance | V _i = ±3 V 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.

Switching Characteristics⁽¹⁾

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

| PARAMETER | | TEST CONDITIONS | TYP ⁽²⁾ | UNIT |
|--------------------|---|--|--------------------|------|
| t _{PLH} | Propagation delay time, low- to high-level output | C _L = 150 pF, See Figure 3 | 150 | ns |
| t _{PHL} | Propagation delay time, high- to low-level output | C _L = 150 pF, See Figure 3 | 150 | ns |
| t _{en} | Output enable time | C _L = 150 pF, R _L = 3 kΩ, See Figure 4 | 200 | ns |
| t _{dis} | Output disable time | C _L = 150 pF, R _L = 3 kΩ, See Figure 4 | 200 | ns |
| t _{sk(p)} | Pulse skew ⁽³⁾ | See Figure 3 | 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.

ESD Protection

| TERMINAL | | TEST CONDITIONS | TYP | UNIT |
|----------|-----|-----------------|-----|------|
| NAME | NO. | | | |
| RIN | 8 | HBM | ±15 | kV |

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 |

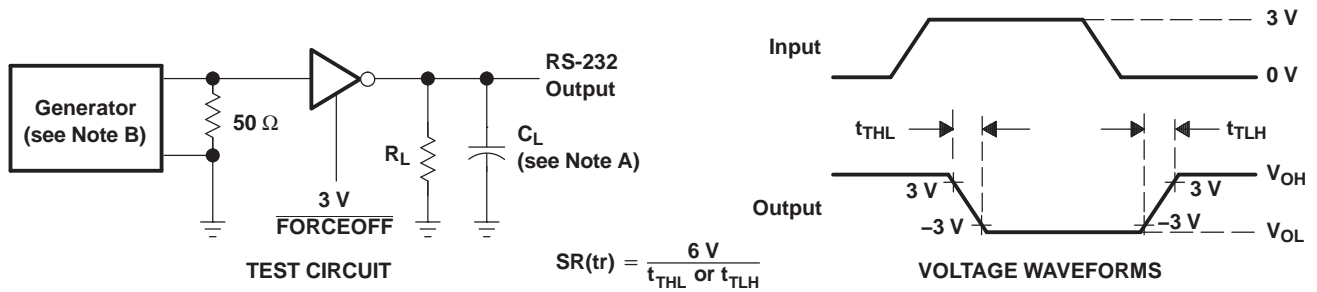
Switching Characteristics

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

| PARAMETER | | TYP ⁽¹⁾ | 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 |

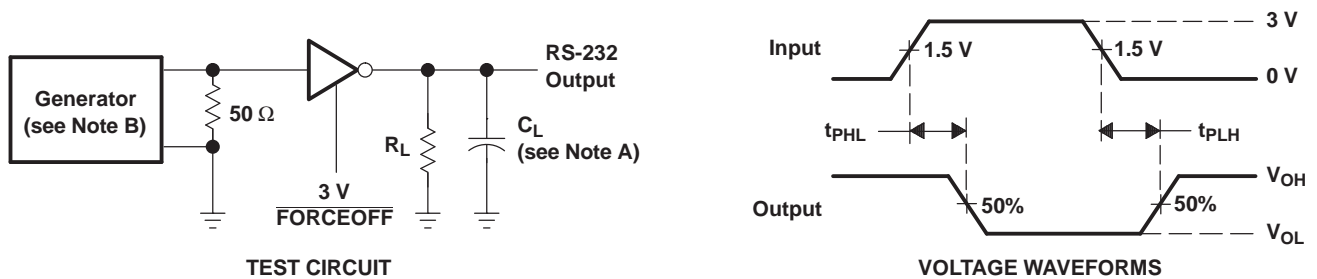
(1) All typical values are at $V_{CC} = 3.3$ V or $V_{CC} = 5$ V, and $T_A = 25^\circ\text{C}$.

PARAMETER MEASUREMENT INFORMATION



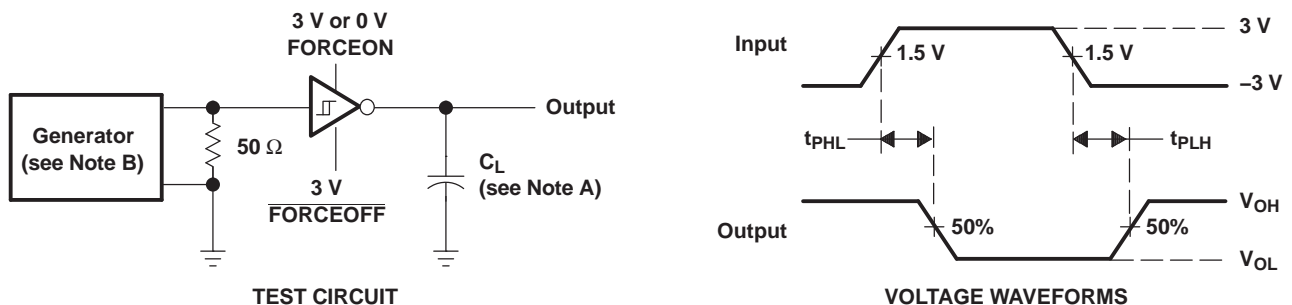
NOTES: A. C_L includes probe and jig capacitance.
B. The pulse generator has the following characteristics: PRR = 250 kbit/s, $Z_0 = 50 \Omega$, 50% duty cycle, $t_r \leq 10$ ns, $t_f \leq 10$ ns.

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, $t_r \leq 10$ ns, $t_f \leq 10$ ns.

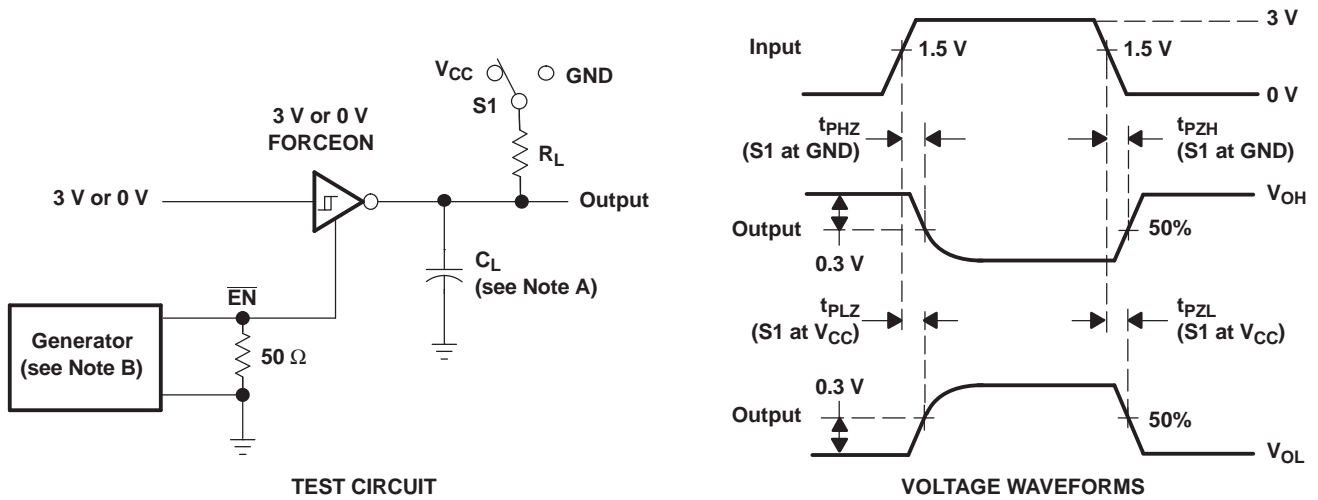
Figure 2. Driver Pulse Skew



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

Figure 3. Receiver Propagation Delay Times

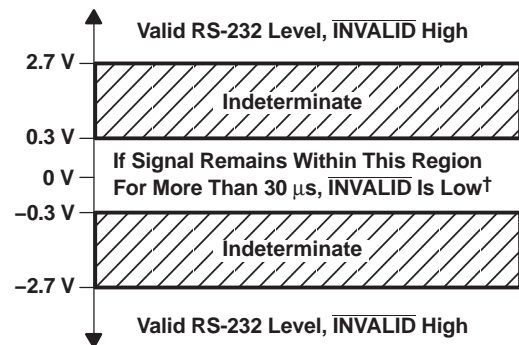
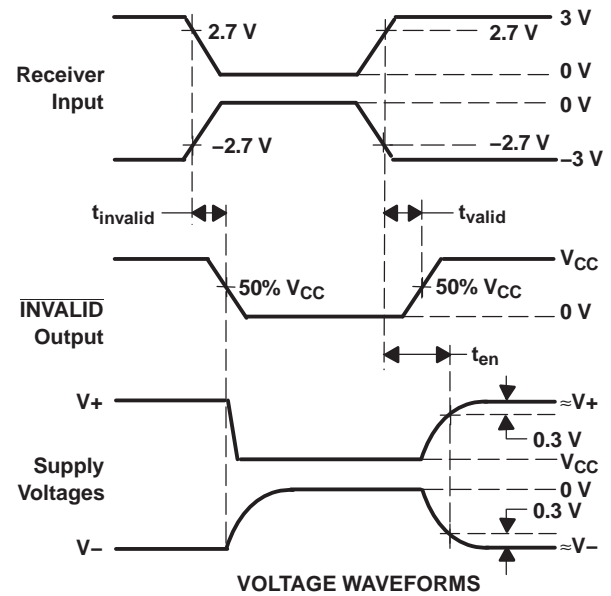
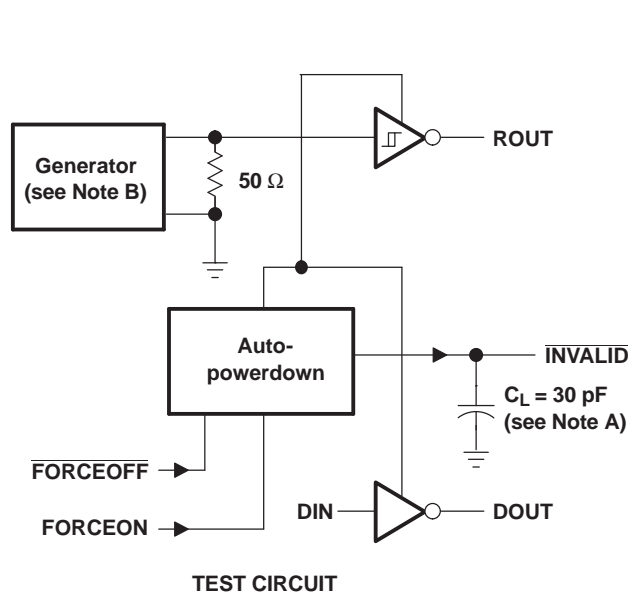
PARAMETER MEASUREMENT INFORMATION (continued)



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

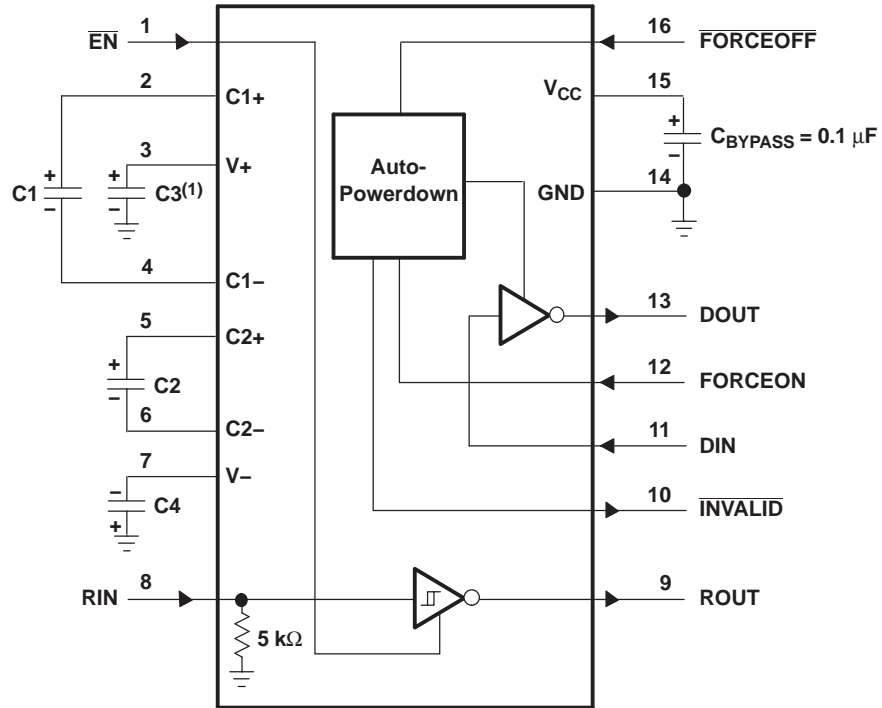


† Auto-powerdown disables drivers and reduces supply current to 1 μA.

- NOTES: A. C_L includes probe and jig capacitance.
B. The pulse generator has the following characteristics: PRR = 5 kbit/s, Z_O = 50 Ω, 50% duty cycle, t_r ≤ 10 ns, t_f ≤ 10 ns.

Figure 5. 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.

V_{CC} vs 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 |

Figure 6. Typical Operating Circuit and Capacitor Values

PACKAGING INFORMATION

| Orderable part number | Status (1) | Material type (2) | Package Pins | Package qty Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|------------------------------|---------------|----------------------|----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| TRSF3221CDBR | Obsolete | Production | SSOP (DB) 16 | - | - | Call TI | Call TI | 0 to 70 | RT21C |

(1) **Status:** For more details on status, see our [product life cycle](#).

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

(4) **Lead finish/Ball material:** Parts 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.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "-" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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DB0016A



PACKAGE OUTLINE

SSOP - 2 mm max height

SMALL OUTLINE PACKAGE



4220763/A 05/2022

NOTES:

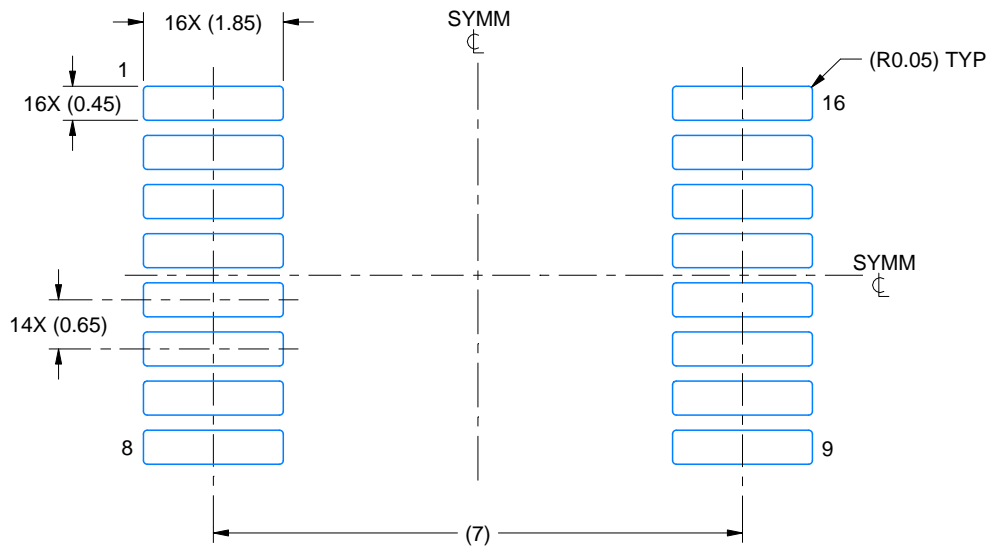
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or 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



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

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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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