

# TRSF3221E 3-V to 5.5-V Single-Channel RS-232 1-Mbit Line Driver and Receiver

## With $\pm 15$ -kV IEC ESD Protection in Small Package

### 1 Features

- ESD protection for RS-232 pins
  - $\pm 15$ -kV Human-body model (HBM)
  - $\pm 8$ -kV IEC 61000-4-2 Contact discharge
  - $\pm 15$ -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-speed pin-compatible device (250 kbit/s) – TRSF3221E
- Available in near chip-scale package, 16-pin VQFN (RGT, 82% smaller than TSSOP package)
- Low standby current: 1  $\mu$ A typical
- External capacitors : 4  $\times$  0.1  $\mu$ F
- Accepts 5-V logic input with 3.3-V supply
- Auto-powerdown feature automatically disables drivers for power savings

### 2 Applications

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

### 3 Description

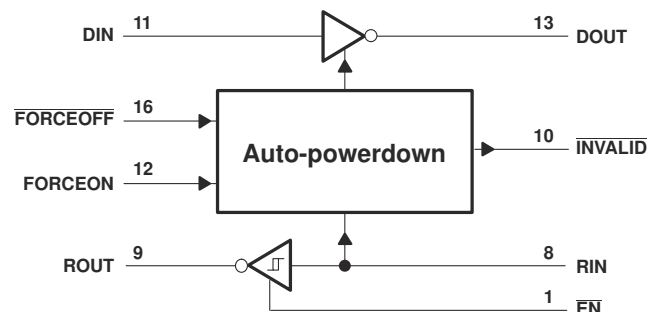
The TRSF3221E consists of one line driver, one line receiver, and a dual charge-pump circuit with  $\pm 15$ -kV IEC ESD protection pin to pin (serial-port connection pins, including GND). The TRSF3221E provides the electrical interface between an asynchronous communication controller and the serial-port 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  $\overline{INVALID}$  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  $\mu$ 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  $\mu$ s. See [Figure 7-5](#) for receiver input levels.

#### Device Information

PART NUMBER	PACKAGE <sup>(1)</sup>	BODY SIZE (NOM)
TRSF3221E	DB (SSOP)	6.20 mm x 5.30 mm
	PW (TSSOP)	5.00 mm x 4.40 mm
	RGT (VQFN)	3.00 mm x 3.00 mm

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



Logic Diagram (Positive Logic)



## Table of Contents

<b>1 Features</b> .....	<b>1</b>	<b>8 Detailed Description</b> .....	<b>12</b>
<b>2 Applications</b> .....	<b>1</b>	8.1 Overview.....	12
<b>3 Description</b> .....	<b>1</b>	8.2 Functional Block Diagram.....	12
<b>4 Revision History</b> .....	<b>2</b>	8.3 Feature Description.....	12
<b>5 Pin Configuration and Functions</b> .....	<b>3</b>	8.4 Device Functional Modes.....	13
<b>6 Specifications</b> .....	<b>4</b>	<b>9 Application and Implementation</b> .....	<b>14</b>
6.1 Absolute Maximum Ratings.....	4	9.1 Application Information.....	14
6.2 ESD Ratings.....	4	<b>10 Power Supply Recommendations</b> .....	<b>15</b>
6.3 ESD Ratings, IEC Specifications.....	4	<b>11 Layout</b> .....	<b>16</b>
6.4 Recommended Operating Conditions.....	5	11.1 Layout Guidelines.....	16
6.5 Thermal Resistance Characteristics.....	5	11.2 Layout Example.....	16
6.6 Electrical Characteristics.....	5	<b>12 Device and Documentation Support</b> .....	<b>17</b>
6.7 Electrical Characteristics, Driver.....	6	12.1 Receiving Notification of Documentation Updates..	17
6.8 Switching Characteristics, Driver.....	6	12.2 Support Resources.....	17
6.9 Electrical Characteristics, Receiver.....	7	12.3 Trademarks.....	17
6.10 Switching Characteristics, Receiver.....	7	12.4 Electrostatic Discharge Caution.....	17
6.11 Electrical Characteristics, Auto-Powerdown.....	8	12.5 Glossary.....	17
6.12 Switching Characteristics, Auto-Powerdown.....	8	<b>13 Mechanical, Packaging, and Orderable Information</b> .....	<b>17</b>
6.13 Typical Characteristics.....	8		
<b>7 Parameter Measurement Information</b> .....	<b>9</b>		

## 4 Revision History

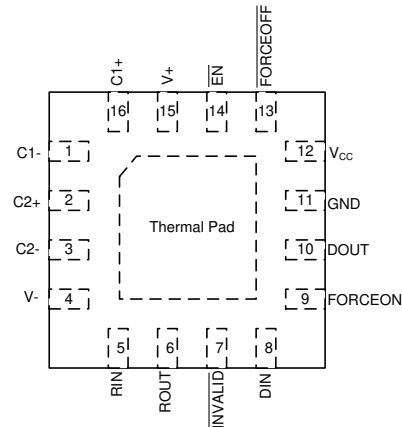
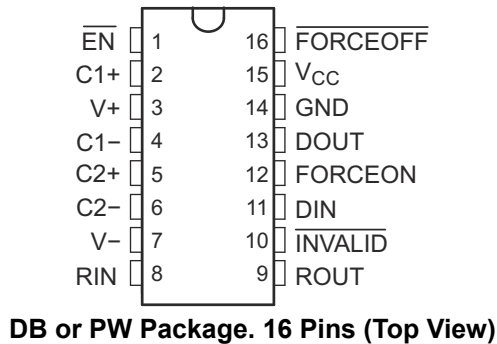
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

<b>Changes from Revision A (May 2021) to Revision B (July 2021)</b>	<b>Page</b>
• Changed the <i>Applications</i> list.....	1
• Changed the table note for the <i>ESD Ratings - IEC Specifications</i> table to make it also applicable to PW package.....	4
• Changed the thermal information for PW package.....	5

---

<b>Changes from Revision * (August 2007) to Revision A (May 2021)</b>	<b>Page</b>
• Added Device Information table, ESD Ratings table, Feature Description section, Device Functional Modes, Application and Implementation section, Power Supply Recommendations section, Layout section, Device and Documentation Support section, and Mechanical, Packaging, and Orderable Information section.....	1

## 5 Pin Configuration and Functions



**Table 5-1. Pin Functions**

PIN			I/O <sup>(1)</sup>	DESCRIPTION
NAME	DB or PW	RGT		
EN	1	14	--	
C1+	2	16	-	Positive lead of C1 capacitor
V+	3	15	O	Positive charge pump output for storage capacitor only
C1-	4	1	-	Negative lead of C1 capacitor
C2+	5	2	-	Positive lead of C2 capacitor
C2-	6	3	-	Negative lead of C2 capacitor
V-	7	4	O	Negative charge pump output for storage capacitor only
RIN	8	5	I	RS232 line data input (from remote RS232 system)
ROUT	9	6	O	Logic data output (to UART)
INVALID	10	7		
DIN	11	8	I	Logic data input (from UART)
FORCEON	12	9		
DOUT	13	10	O	RS232 line data output (to remote RS232 system)
GRD	14	11	-	Ground
V <sub>CC</sub>	15	12	-	Supply Voltage, Connect to external 3-V to 5.5-V power supply
FORCEOFF	16	13		
Thermal Pad	-	Yes	-	Exposed thermal pad. Can be connected to GND or left floating.

(1) Signal Types: I = Input, O = Output, I/O = Input or Output.

## 6 Specifications

### 6.1 Absolute Maximum Ratings

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

		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)	-0.3	6	V
		Receiver	-25	25	
V <sub>O</sub>	Output voltage range	Driver	-13.2	13.2	V
		Receiver ( INVALID)	-0.3	V <sub>CC</sub> + 0.3	
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.

### 6.2 ESD Ratings

		VALUE	UNIT	
V <sub>(ESD)</sub>	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	±3000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup>	±1500	

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 6.3 ESD Ratings, IEC Specifications

PIN NAME	TEST CONDITIONS	TYP	UNIT
RIN, DOUT	HBM	±15	kV
	IEC 61000-4-2 Contact Discharge <sup>(1)</sup>	±8	
	IEC 61000-4-2 Air-Gap Discharge <sup>(1)</sup>	±15	

- (1) For the RGT and PW package only, a minimum of 1-μF capacitor is required between VCC and GND to meet the specified IEC-ESD level.

## 6.4 Recommended Operating Conditions

See [Figure 9-1](#) and <sup>(1)</sup>

			MIN	NOM	MAX	UNIT
Supply voltage		V <sub>CC</sub> = 3.3 V	3	3.3	3.6	V
		V <sub>CC</sub> = 5 V	4.5	5	5.5	
V <sub>IH</sub>	Driver and control high-level input voltage	DIN, FORCEOFF, FORCEON, EN	V <sub>CC</sub> = 3.3 V	2		V
			V <sub>CC</sub> = 5 V	2.4		
V <sub>IL</sub>	Driver 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.

## 6.5 Thermal Resistance Characteristics

THERMAL METRIC <sup>(1)</sup>		TRSF3221E			UNIT
		DB (SSOP)	PW (TSSOP)	RGT (VQFN)	
		16 Pins	16 Pins	16 Pins	
R <sub>θJA</sub>	Junction-to-ambient thermal resistance	82	110.9	58.8	°C/W
R <sub>θJC(top)</sub>	Junction-to-case (top) thermal resistance	45.7	41.7	55.8	°C/W
R <sub>θJB</sub>	Junction-to-board thermal resistance	44.4	57.2	23.8	°C/W
ψ <sub>JT</sub>	Junction-to-top characterization parameter	11.0	4.2	1.7	°C/W
ψ <sub>JB</sub>	Junction-to-board characterization parameter	43.8	56.6	23.7	°C/W
R <sub>θJC(bot)</sub>	Junction-to-case (bottom) thermal resistance	N/A	N/A	9	°C/W

(1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC package thermal metrics](#) application report.

## 6.6 Electrical Characteristics

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)  
(see [Figure 9-1](#))

PARAMETER		TEST CONDITIONS <sup>(1)</sup>	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.

## 6.7 Electrical Characteristics, Driver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)  
(see [Figure 9-1](#))

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

(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) Short-circuit durations must be controlled to prevent exceeding the device absolute power dissipation ratings, and not more than one output can be shorted at a time.

## 6.8 Switching Characteristics, Driver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)  
(see [Figure 9-1](#))

PARAMETER	TEST CONDITIONS <sup>(1)</sup>		MIN	TYP <sup>(2)</sup>	MAX	UNIT
Maximum data rate (see <a href="#">Figure 7-1</a> )	R <sub>L</sub> = 3 kΩ	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>	C <sub>L</sub> = 250 pF	R <sub>L</sub> = 3 kΩ <a href="#">Figure 7-2</a> RGT Package		25		ns
	C <sub>L</sub> = 150 pF to 2500 pF,	R <sub>L</sub> = 3 kΩ to 7 kΩ, See <a href="#">Figure 7-2</a> DB or PW package		100		
SR(tr) Slew rate, transition region (see <a href="#">Figure 7-1</a> )	V <sub>CC</sub> = 3.3 V,	R <sub>L</sub> = 3 kΩ to 7 kΩ, C <sub>L</sub> = 150 pF to 1000 pF	18		150	V/μs

(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.

## 6.9 Electrical Characteristics, Receiver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)  
(see [Figure 9-1](#))

PARAMETER		TEST CONDITIONS <sup>(1)</sup>	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.

## 6.10 Switching Characteristics, Receiver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)  
(see [Figure 9-1](#))

PARAMETER		TEST CONDITIONS <sup>(1)</sup>	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 7-3</a>	RGT package	100	ns
			DB or PW package	150	
t <sub>PHL</sub>	Propagation delay time, high- to low-level output	C <sub>L</sub> = 150 pF, See <a href="#">Figure 7-3</a>	RGT package	125	ns
			DB or PW package	150	
t <sub>en</sub>	Output enable time	C <sub>L</sub> = 150 pF, R <sub>L</sub> = 3 kΩ, See <a href="#">Figure 7-4</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 7-4</a>	200	ns	
t <sub>sk(p)</sub>	Pulse skew <sup>(3)</sup>	See <a href="#">Figure 7-3</a>	RGT package	25	ns
			DB or PW package	50	

- (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.

### 6.11 Electrical Characteristics, Auto-Powerdown

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Figure 7-5)

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

### 6.12 Switching Characteristics, Auto-Powerdown

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Figure 7-5)

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

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

### 6.13 Typical Characteristics

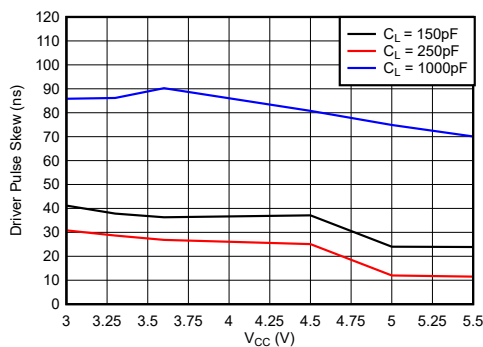


Figure 6-1. Driver Pulse Skew vs Load Capacitance and Supply Voltage at  $T_A = 25^\circ$  C (RGT Package)

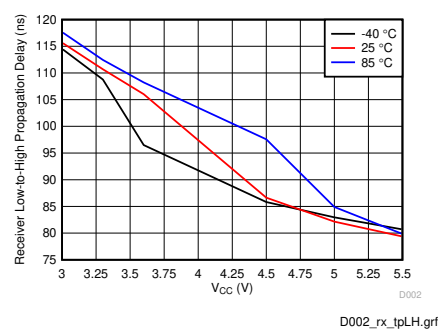


Figure 6-2. Receiver Path Low-to-High Propagation Delay vs  $T_A$  and Supply Voltage (RGT Package)

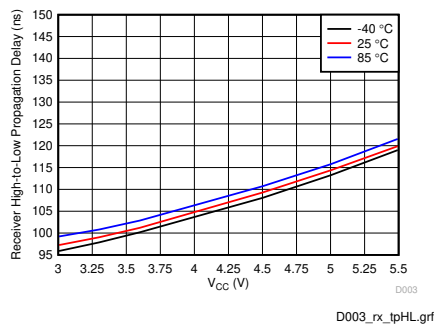


Figure 6-3. Receiver Path High-to-Low Propagation Delay vs  $T_A$  and Supply Voltage (RGT Package)

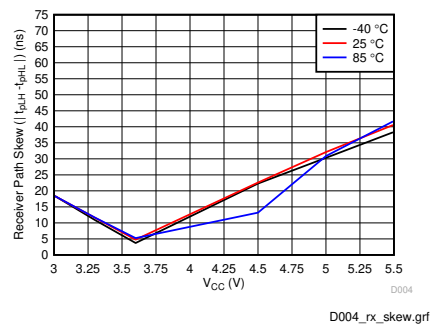
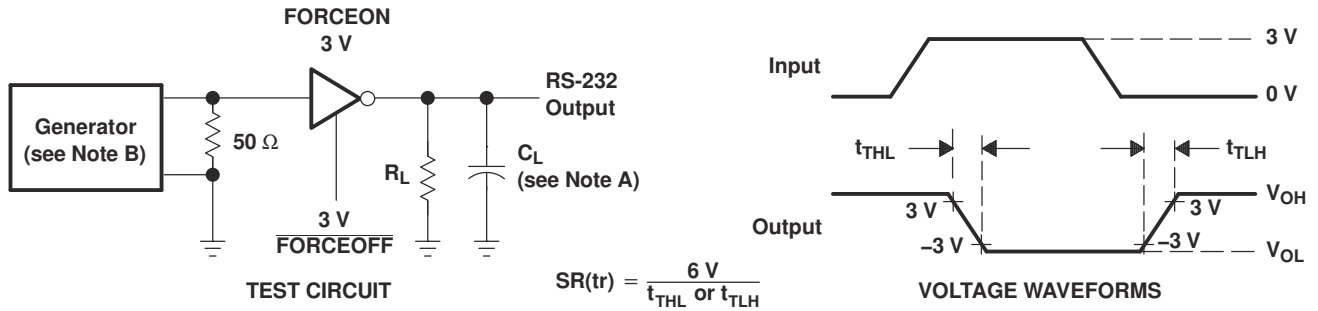


Figure 6-4. Receiver Pulse Skew ( $|t_{pLH} - t_{pHL}|$ ) vs  $T_A$  and Supply Voltage (RGT Package)

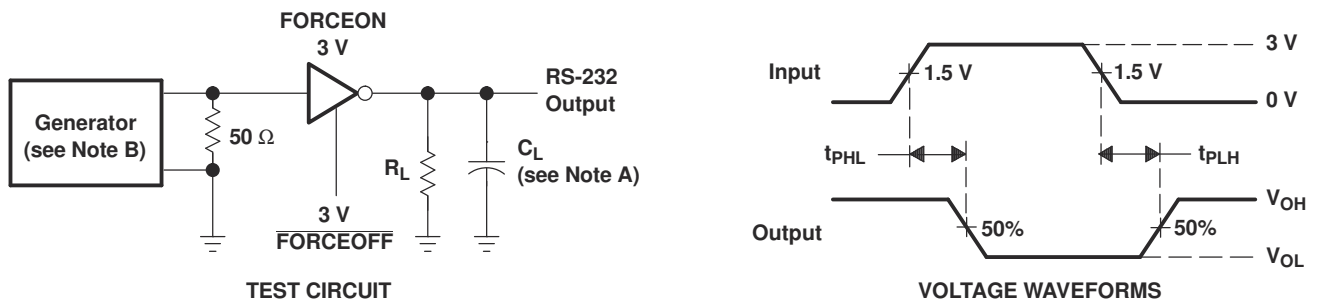


## 7 Parameter Measurement Information



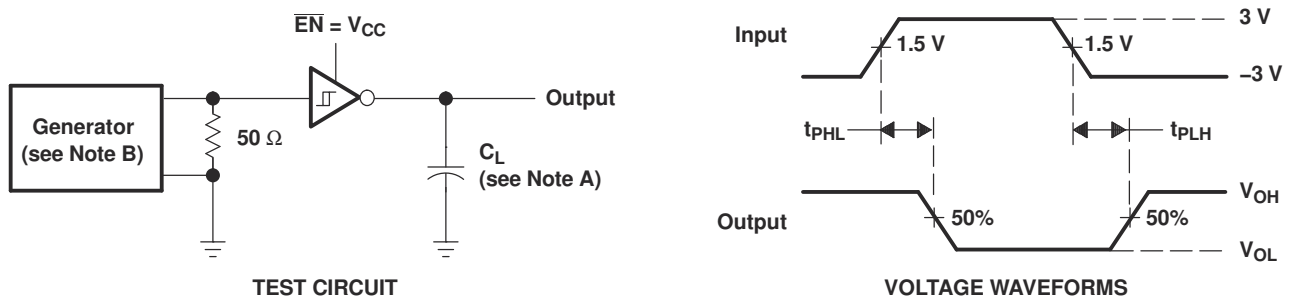
- NOTES: A.  $C_L$  includes probe and jig capacitance.  
B. The pulse generator has the following characteristics: PRR = 250 kbit/s,  $Z_0 = 50\ \Omega$ , 50% duty cycle,  $t_r \leq 10\text{ ns}$ ,  $t_f \leq 10\text{ ns}$ .

Figure 7-1. Driver Slew Rate



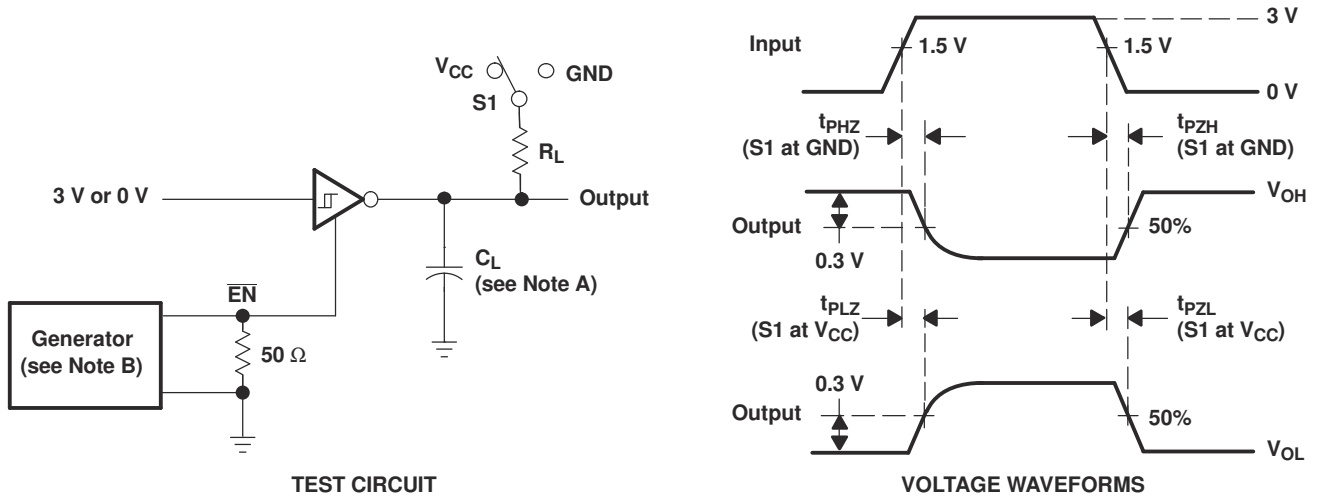
- NOTES: A.  $C_L$  includes probe and jig capacitance.  
B. The pulse generator has the following characteristics: PRR = 250 kbit/s,  $Z_0 = 50\ \Omega$ , 50% duty cycle,  $t_r \leq 10\text{ ns}$ ,  $t_f \leq 10\text{ ns}$ .

Figure 7-2. Driver Pulse Skew



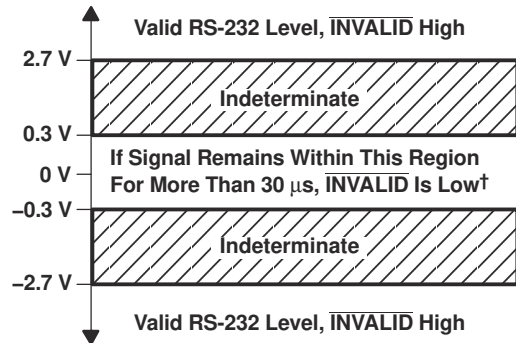
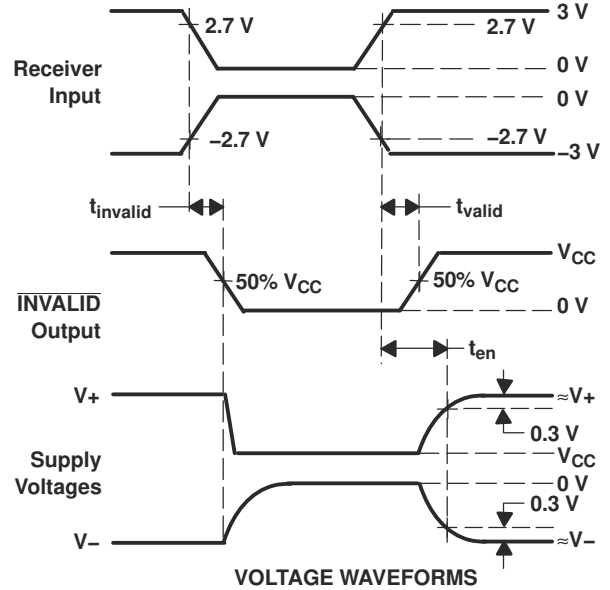
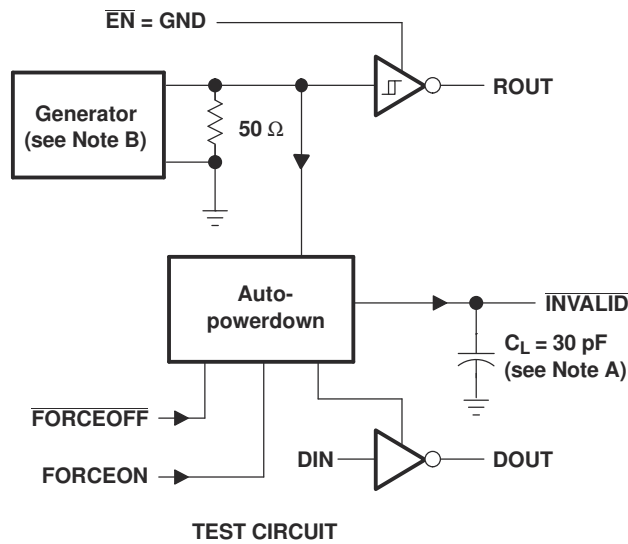
- NOTES: A.  $C_L$  includes probe and jig capacitance.  
B. The pulse generator has the following characteristics:  $Z_0 = 50\ \Omega$ , 50% duty cycle,  $t_r \leq 10\text{ ns}$ ,  $t_f \leq 10\text{ ns}$ .

Figure 7-3. Receiver Propagation Delay Times



- 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  $t_{PHZ}$  are the same as  $t_{dis}$ .
  - D.  $t_{PZL}$  and  $t_{PZH}$  are the same as  $t_{en}$ .

**Figure 7-4. Receiver Enable and Disable Times**



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

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

## 8 Detailed Description

### 8.1 Overview

The TRSF3221E consists of one line driver, one line receiver, and a dual charge-pump circuit with  $\pm 15$ -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  $\overline{\text{FORCEON}}$  is low and  $\overline{\text{FORCEOFF}}$  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  $\overline{\text{FORCEOFF}}$  is set low and the enable ( $\overline{\text{EN}}$ ) 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  $\overline{\text{FORCEON}}$  and  $\overline{\text{FORCEOFF}}$  are high. With auto-powerdown enabled, the device is activated automatically when a valid signal is applied to the receiver input. The  $\overline{\text{INVALID}}$  output notifies the user if an RS-232 signal is present at the receiver input.  $\overline{\text{INVALID}}$  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.  $\overline{\text{INVALID}}$  is low (invalid data) if the receiver input voltage is between  $-0.3$  V and 0.3 V for more than 30  $\mu$ s.

Outputs are protected against shorts to ground.

### 8.2 Functional Block Diagram

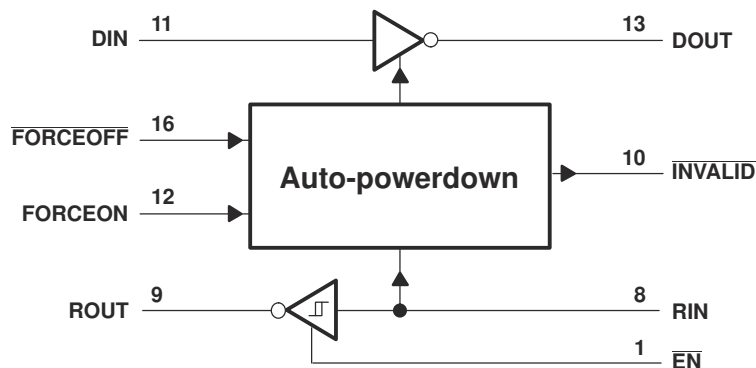


Figure 8-1. Logic Diagram (Positive Logic)

### 8.3 Feature Description

The power block increases, inverts, and regulates voltage at V+ and V– pins using a charge pump that requires four external capacitors. Auto-power-down feature for driver is controlled by  $\overline{\text{FORCEON}}$  and  $\overline{\text{FORCEOFF}}$  inputs. Receiver is controlled by  $\overline{\text{EN}}$  input. When MAX3221E is unpowered, it can be safely connected to an active remote RS-232 device.

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

The receiver interfaces RS-232 levels to standard logic levels. An open input results in a high output on ROUT. RIN input includes an internal standard RS-232 load. A logic high input on the  $\overline{\text{EN}}$  pin shuts down the receiver output.

## 8.4 Device Functional Modes

**Functional Tables, Each Driver**

INPUTS <sup>(1)</sup>				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**

INPUTS <sup>(1)</sup>			OUTPUT ROUT
RIN	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

## 9 Application and Implementation

### Note

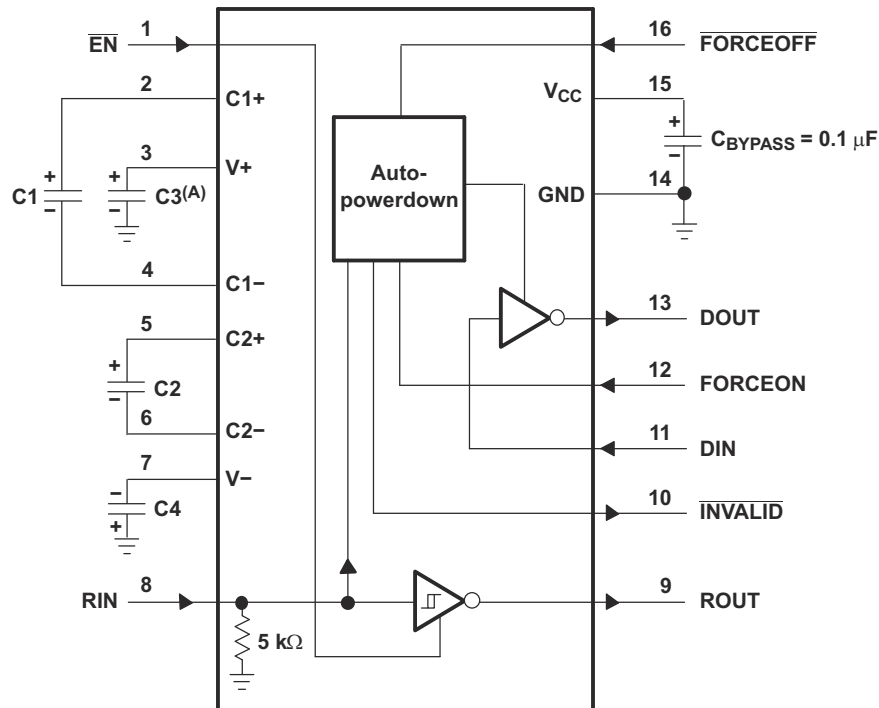
Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation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

### 9.1 Application Information

The TRSF3221E line driver and receiver is a specialized device for 3-V to 5.5-V RS-232 communication applications. This application is a generic implementation of this device with all required external components. For proper operation, add capacitors as shown in Table 9-1.

#### 9.1.1 Typical Application

ROUT and DIN connect to UART or general purpose logic lines. FORCEON and  $\overline{\text{FORCEOFF}}$  may be connected general purpose logic lines or tied to ground or VCC. INVALID may be connected to a general purpose logic line or left unconnected. RIN and DOUT lines connect to a RS-232 connector or cable. DIN, FORCEON, and  $\overline{\text{FORCEOFF}}$  inputs must not be left unconnected.



- A. C3 can be connected to V<sub>CC</sub> 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.

Figure 9-1. Typical Operating Circuit and Capacitor Values

Table 9-1. V<sub>CC</sub> vs Capacitor Values

V <sub>CC</sub>	C1	C2, C3, 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

### 9.1.1.1 Design Requirements

- Recommended VCC is 3.3 V or 5 V – 3 V to 5.5 V is also possible
- Maximum recommended bit rate is 1 Mbps
- Use capacitors as shown in [Figure 9-1](#) and [Table 9-1](#)

### 9.1.1.2 Detailed Design Procedure

For proper operation:

- DIN,  $\overline{\text{FORCEOFF}}$  and FORCEON inputs must be connected to valid low or high logic levels
- Select capacitor values based on VCC 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 VCC.  $\overline{\text{INVALID}}$  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.

### 9.1.2 Application Performance Plot

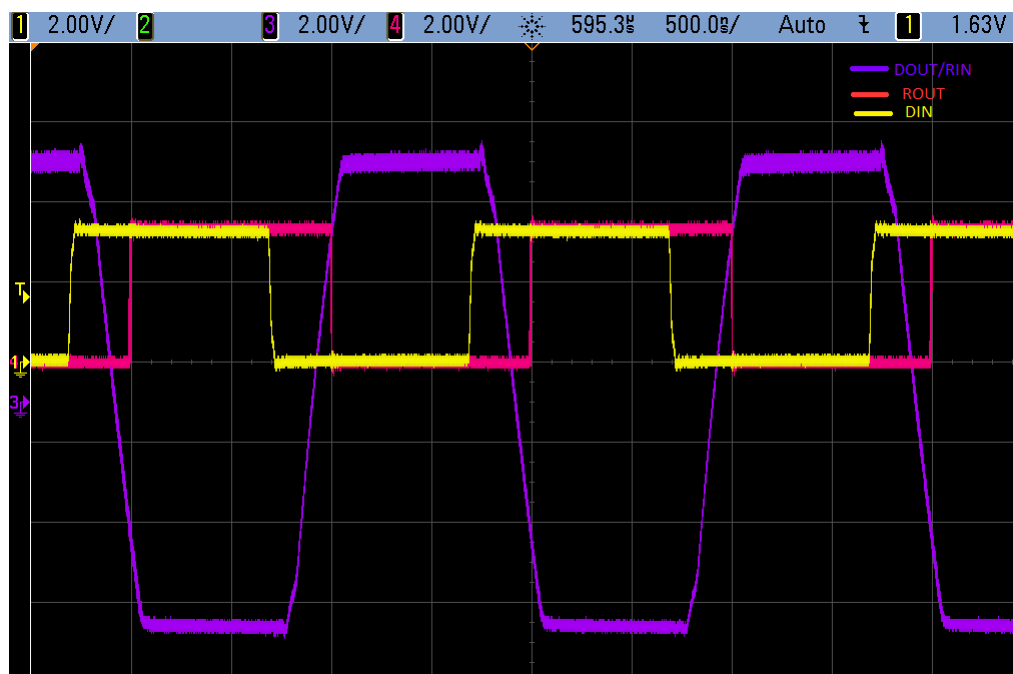


Figure 9-2. 1 Mbps Driver to Receiver Loopback Timing Waveform, VCC = 3.3 V

## 10 Power Supply Recommendations

VCC must be between 3 V and 5.5 V. Charge pump capacitors must be chosen using [VCC vs Capacitor Values](#).

## 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

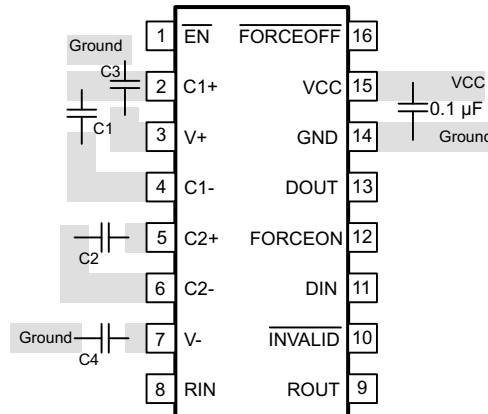


Figure 11-1. Layout Diagram



## 12 Device and Documentation Support

### 12.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](http://ti.com). Click on *Subscribe to updates* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 12.2 Support Resources

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

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

### 12.3 Trademarks

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

### 12.4 Electrostatic Discharge Caution



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

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

### 12.5 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

## 13 Mechanical, Packaging, and Orderable Information

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

## PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TRSF3221ECDB	ACTIVE	SSOP	DB	16	80	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	RT21EC	<a href="#">Samples</a>
TRSF3221ECDBG4	ACTIVE	SSOP	DB	16	80	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	RT21EC	<a href="#">Samples</a>
TRSF3221ECDBR	ACTIVE	SSOP	DB	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	RT21EC	<a href="#">Samples</a>
TRSF3221ECDBRG4	ACTIVE	SSOP	DB	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	RT21EC	<a href="#">Samples</a>
TRSF3221ECPW	NRND	TSSOP	PW	16	90	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	RT21EC	
TRSF3221ECPWR	ACTIVE	TSSOP	PW	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	0 to 70	RT21EC	<a href="#">Samples</a>
TRSF3221EIDBR	ACTIVE	SSOP	DB	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	RT21EI	<a href="#">Samples</a>
TRSF3221EIPW	NRND	TSSOP	PW	16	90	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	RT21EI	
TRSF3221EIPWR	ACTIVE	TSSOP	PW	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	RT21EI	<a href="#">Samples</a>
TRSF3221EIPWRG4	ACTIVE	TSSOP	PW	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	RT21EI	<a href="#">Samples</a>
TRSF3221EIRGTR	ACTIVE	VQFN	RGT	16	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	F3221	<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.

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

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

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

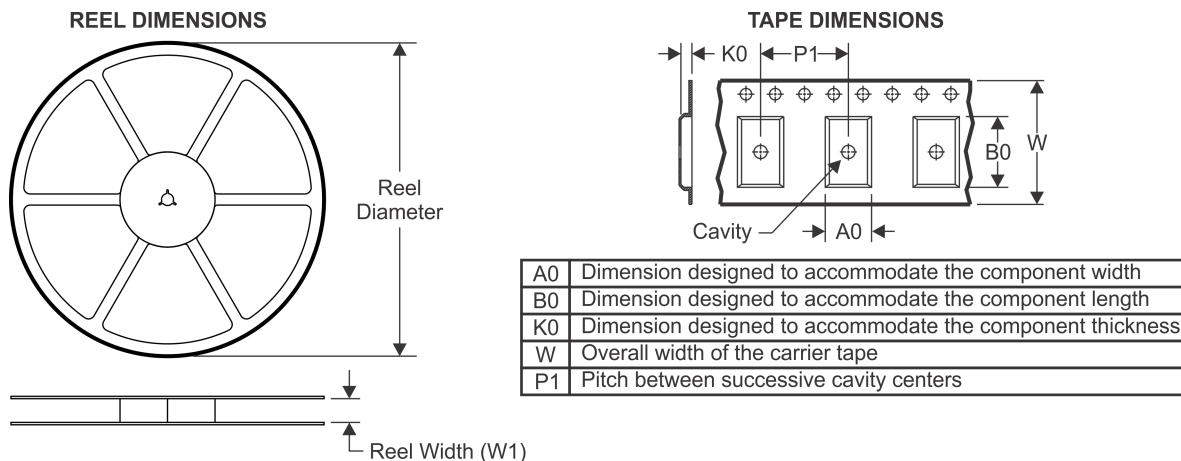
**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

- (4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.
- (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 finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

**Important Information and Disclaimer:**The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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

**TAPE AND REEL INFORMATION**

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


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TRSF3221ECDBR	SSOP	DB	16	2000	330.0	16.4	8.35	6.6	2.4	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	8.35	6.6	2.4	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
TRSF3221EIRGTR	VQFN	RGT	16	3000	330.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

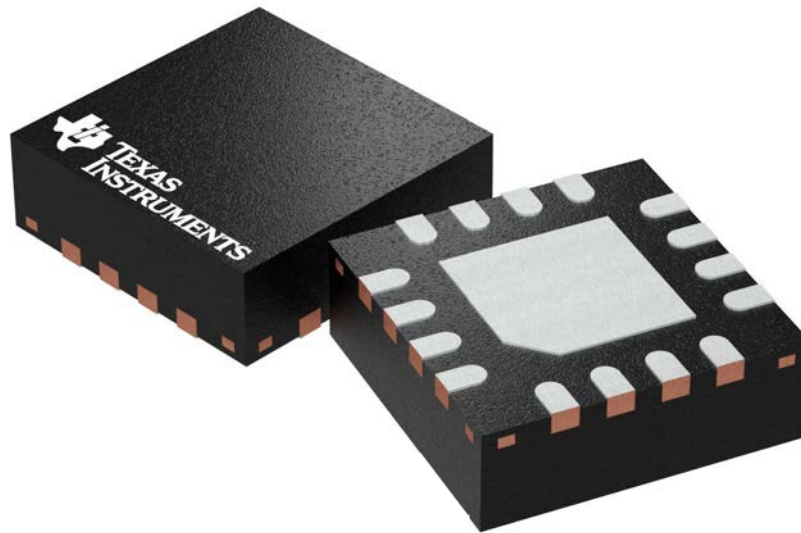
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TRSF3221ECDBR	SSOP	DB	16	2000	853.0	449.0	35.0
TRSF3221ECPWR	TSSOP	PW	16	2000	853.0	449.0	35.0
TRSF3221EIDBR	SSOP	DB	16	2000	853.0	449.0	35.0
TRSF3221EIPWR	TSSOP	PW	16	2000	853.0	449.0	35.0
TRSF3221EIRGTR	VQFN	RGT	16	3000	367.0	367.0	35.0

**RGT 16**

**GENERIC PACKAGE VIEW**

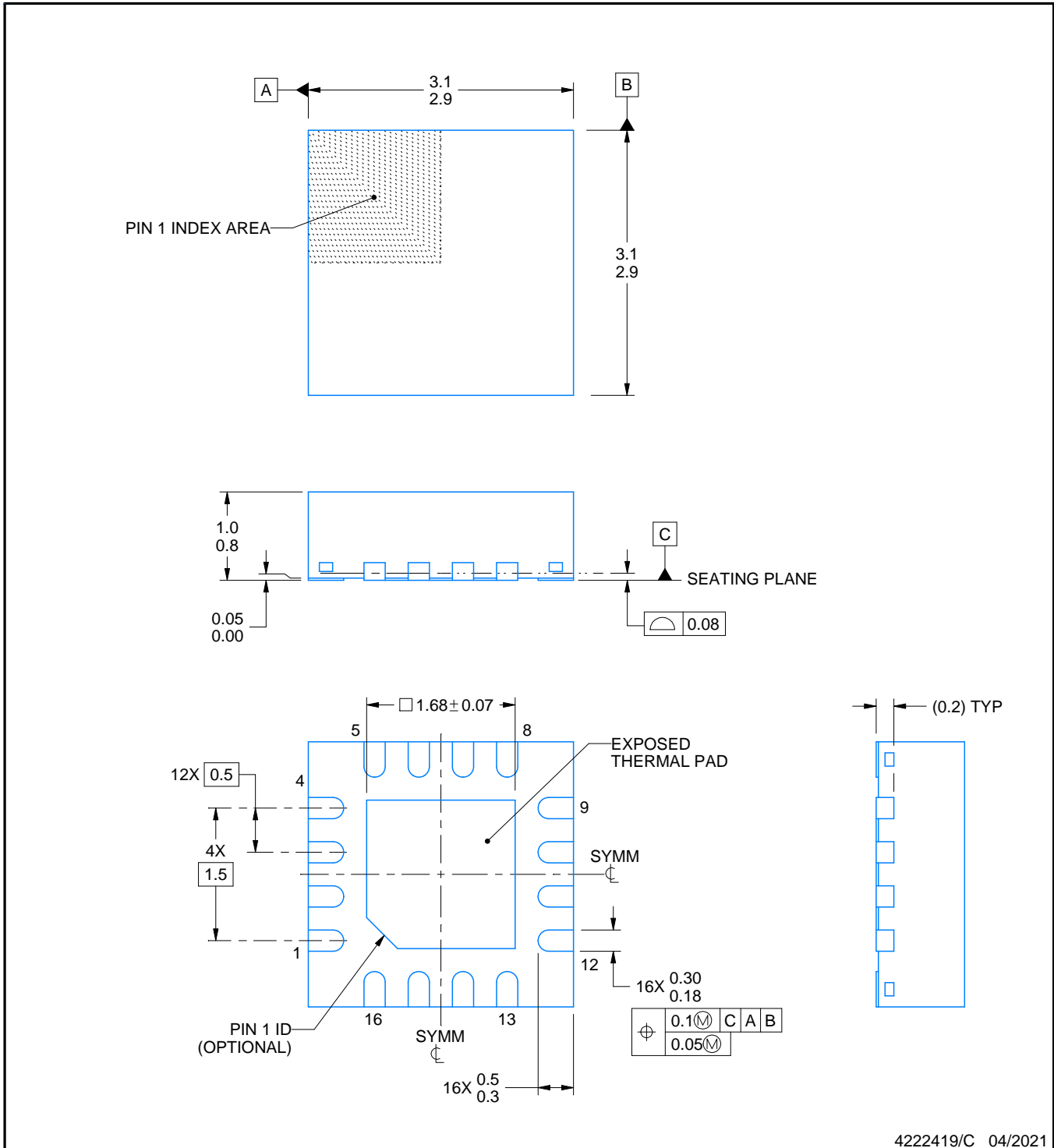
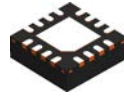
**VQFN - 1 mm max height**

PLASTIC QUAD FLATPACK - NO LEAD



Images above are just a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.

4203495/1



4222419/C 04/2021

NOTES:

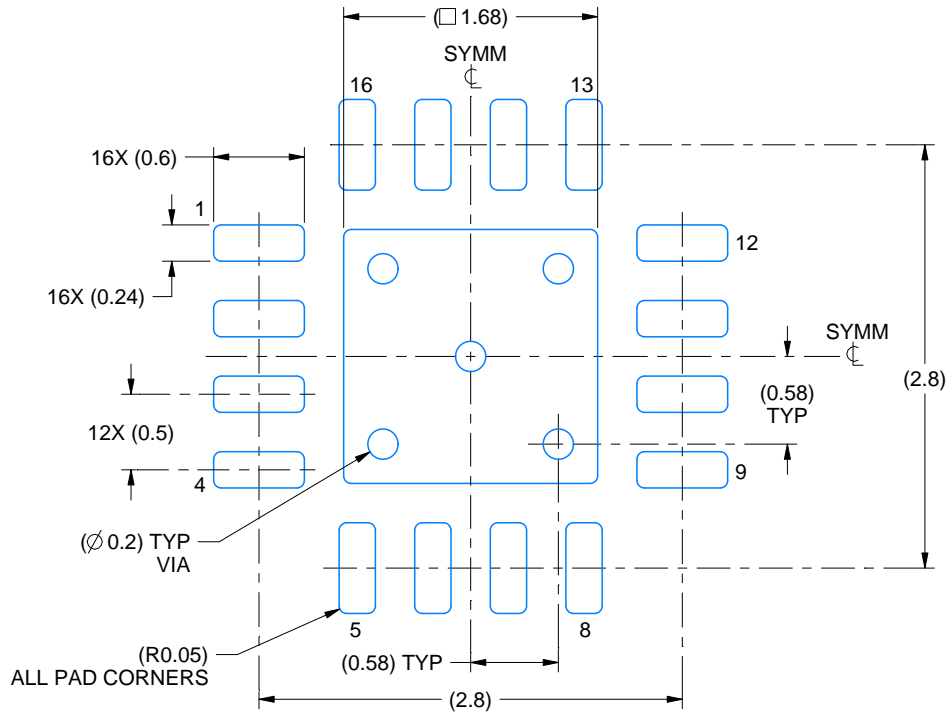
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

# EXAMPLE BOARD LAYOUT

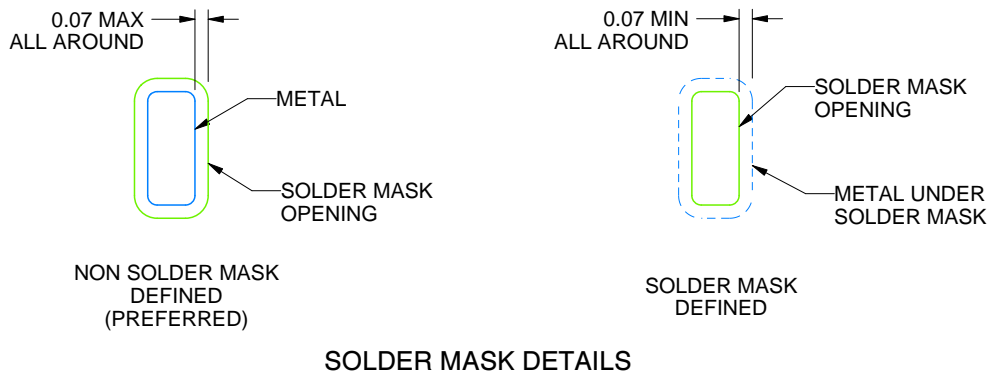
RGT0016C

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE  
SCALE:20X



SOLDER MASK DETAILS

4222419/C 04/2021

NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/sluea271](http://www.ti.com/lit/sluea271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

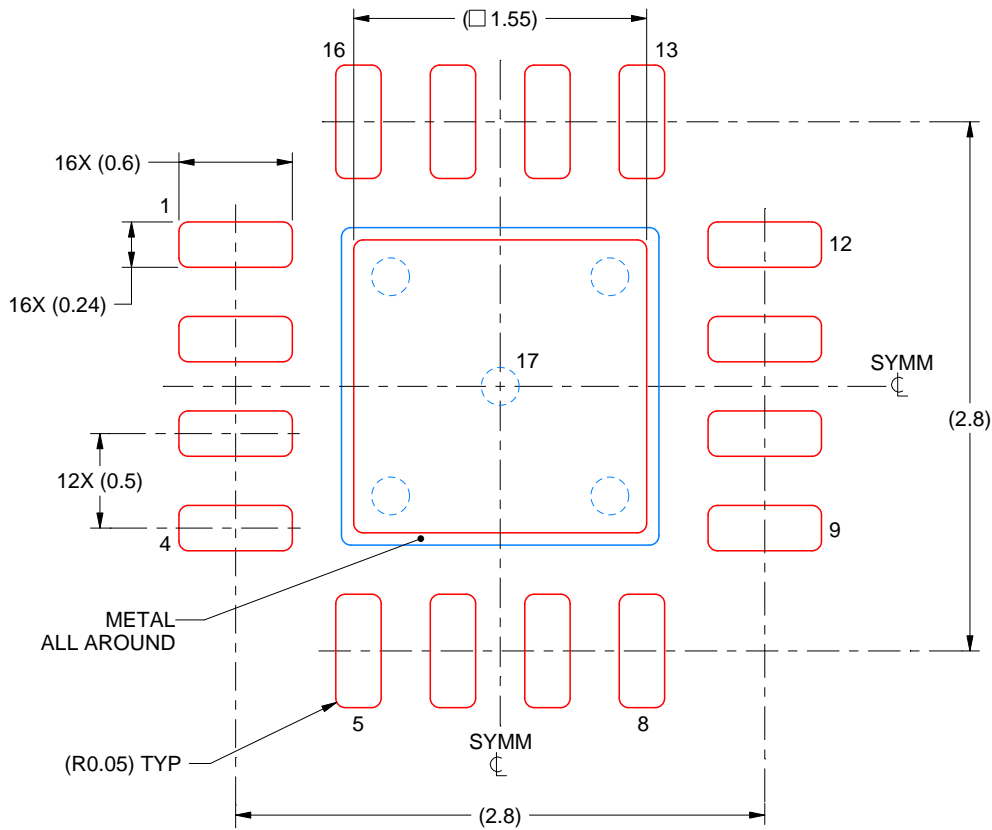


# EXAMPLE STENCIL DESIGN

RGT0016C

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



**SOLDER PASTE EXAMPLE**  
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 17:  
85% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE  
SCALE:25X

4222419/C 04/2021

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.



4220204/A 02/2017

NOTES:

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

# EXAMPLE BOARD LAYOUT

PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 10X



SOLDER MASK DETAILS

4220204/A 02/2017

NOTES: (continued)

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

# EXAMPLE STENCIL DESIGN

PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



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

4220204/A 02/2017

NOTES: (continued)

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

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

## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to TI's Terms of Sale (<https://www.ti.com/legal/termsofsale.html>) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2021, Texas Instruments Incorporated