

## 3-V to 5.5-V Single-channel RS-232 1-Mbits Line Driver and Receiver with $\pm 15$ -kV IEC ESD Protection

### 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
- Operate with 3-V to 5.5-V  $V_{CC}$  supply
- Operate up to 1 Mbit/s
- 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
- RS-232 Bus-pin esd protection exceeds  $\pm 15$  kv using human-body model (HBM)
- 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 SN65C3221E and SN75C3221E consist 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). These devices provide the electrical interface between an asynchronous communication controller and the serial-port connector. The charge pump and four small external capacitors allow operation from a single

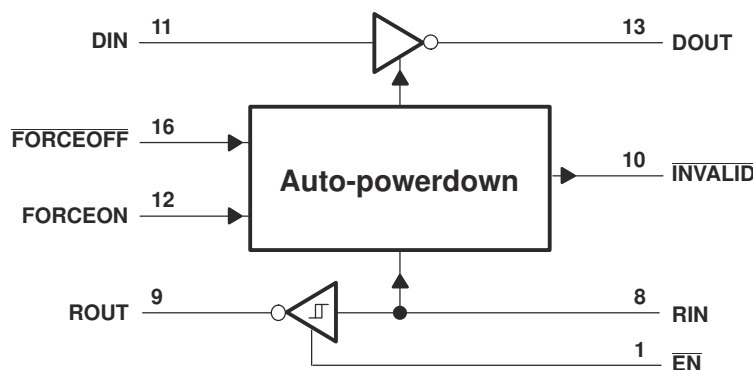
3-V to 5.5-V supply. These devices operate at data signaling rates up to 1 Mbit/s and a driver output slew rate of 24 V/ $\mu$ s to 150 V/ $\mu$ s.

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 devices do not sense a valid RS-232 signal on the receiver input, the driver output is disabled. If FORCEOFF is set low and  $\overline{\text{EN}}$  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  $\overline{\text{INVALID}}$  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. See Figure 8-5 for receiver input levels.

#### Device Information

| PART NUMBER | PACKAGE <sup>(1)</sup> | BODY SIZE (NOM)   |
|-------------|------------------------|-------------------|
| SNx5C3221E  | SSOP (DB) 16           | 6.20 mm x 5.30 mm |
|             | TSSOP (DW) 16          | 10.3 mm x 7.50 mm |

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



Logic Diagram (Positive Logic)



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## 4 Revision History

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

| <b>Changes from Revision B (April 2009) to Revision C (July 2021)</b>                                                                     | <b>Page</b> |
|-------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| • Changed the <i>Applications</i> list.....                                                                                               | <b>1</b>    |
| • Deleted the Ordering Information table.....                                                                                             | <b>1</b>    |
| • Added the <i>Device Information</i> table.....                                                                                          | <b>1</b>    |
| • Added the <i>Pin Configuration and Functions</i> .....                                                                                  | <b>4</b>    |
| • Removed the thermal information from <i>Absolute Maximum Rating</i> stable and moved the thermal information to its own table.....      | <b>5</b>    |
| • Added a table note for PW package of SN65C3221E regarding the minimum capacitance in <i>ESD Ratings - IEC Specifications</i> table..... | <b>5</b>    |
| • Changed thermal information for PW package of SN65C3221E. Added additional thermal information for other packages.....                  | <b>6</b>    |
| • Added the <i>Detailed Descriptiton</i> section.....                                                                                     | <b>13</b>   |

## 5 Device Comparison Table

**Table 5-1. 1-Mbit/s RS-232 Parts**

| PART NO.   | TEMPERATURE RANGE | DRIVER NO. | RECEIVER NO. | ESD                                       | SUPPLY V <sub>CC</sub> (V) | FEATURE                           | PIN/PACKAGE              |
|------------|-------------------|------------|--------------|-------------------------------------------|----------------------------|-----------------------------------|--------------------------|
| SN65C3221E | –40°C to 85°C     | 1          | 1            | ±15-kV Air-Gap, ±8-kV Contact, ±15-kV HBM | 3.3 or 5                   | Auto powerdown                    | 16-pin SOIC, SSOP, TSSOP |
| SN65C3232E |                   | 2          | 2            | ±15-kV Air-Gap, ±8-kV Contact, ±15-kV HBM | 3.3 or 5                   | Low pin count                     | 16-pin SOIC, SSOP, TSSOP |
| MAX3227I   |                   | 1          | 1            | ±8-kV Air-Gap, ±8-kV Contact, ±15-kV HBM  | 3.3 or 5                   | Auto powerdown plus, ready signal | 16-pin SSOP              |
| SN65C3221  |                   | 1          | 1            | ±15-kV HBM                                | 3.3 or 5                   | Auto powerdown                    | 16-pin SOIC, SSOP, TSSOP |
| SN65C3223  |                   | 2          | 2            | ±15-kV HBM                                | 3.3 or 5                   | Auto powerdown, enable signal     | 20-pin SOIC, SSOP, TSSOP |
| SN65C3222  |                   | 2          | 2            | ±15-kV HBM                                | 3.3 or 5                   | Enable, powerdown signal          | 20-pin SOIC, SSOP, TSSOP |
| SN65C3232  |                   | 2          | 2            | ±15-kV HBM                                | 3.3 or 5                   | Low pin count                     | 16-pin SOIC, SSOP, TSSOP |
| SN65C3238  |                   | 5          | 3            | ±15-kV HBM                                | 3.3 or 5                   | Auto powerdown plus               | 28-pin SOIC, SSOP, TSSOP |
| SN65C3243  |                   | 3          | 5            | ±15-kV HBM                                | 3.3 or 5                   | Auto powerdown                    | 28-pin SOIC, SSOP, TSSOP |
| SN75C3221E | 0°C to 70°C       | 1          | 1            | ±15-kV Air-Gap, ±8-kV Contact, ±15-kV HBM | 3.3 or 5                   | Auto powerdown                    | 16-pin SOIC, SSOP, TSSOP |
| SN75C3232E |                   | 2          | 2            | ±15-kV Air-Gap, ±8-kV Contact, ±15-kV HBM | 3.3 or 5                   | Low pin count                     | 16-pin SOIC, SSOP, TSSOP |
| MAX3227C   |                   | 1          | 1            | ±8-kV Air-Gap, ±8-kV Contact, ±15-kV HBM  | 3.3 or 5                   | Auto powerdown plus, ready signal | 16-pin SSOP              |
| SN75C3221  |                   | 1          | 1            | ±15-kV HBM                                | 3.3 or 5                   | Auto powerdown                    | 16-pin SOIC, SSOP, TSSOP |
| SN75C3223  |                   | 2          | 2            | ±15-kV HBM                                | 3.5 or 5                   | Auto powerdown, enable signal     | 20-pin SOIC, SSOP, TSSOP |
| SN75C3222  |                   | 2          | 2            | ±15-kV HBM                                | 3.3 or 5                   | Enable, powerdown signal          | 20-pin SOIC, SSOP, TSSOP |
| SN75C3232  |                   | 2          | 2            | ±15-kV HBM                                | 3.3 or 5                   | Low pin count                     | 16-pin SOIC, SSOP, TSSOP |
| SN75C3238  |                   | 5          | 3            | ±15-kV HBM                                | 3.3 or 5                   | Auto powerdown plus               | 28-pin SOIC, SSOP, TSSOP |
| SN75C3243  |                   | 3          | 5            | ±15-kV HBM                                | 3.3 or 5                   | Auto powerdown                    | 28-pin SOIC, SSOP, TSSOP |

## 6 Pin Configuration and Functions

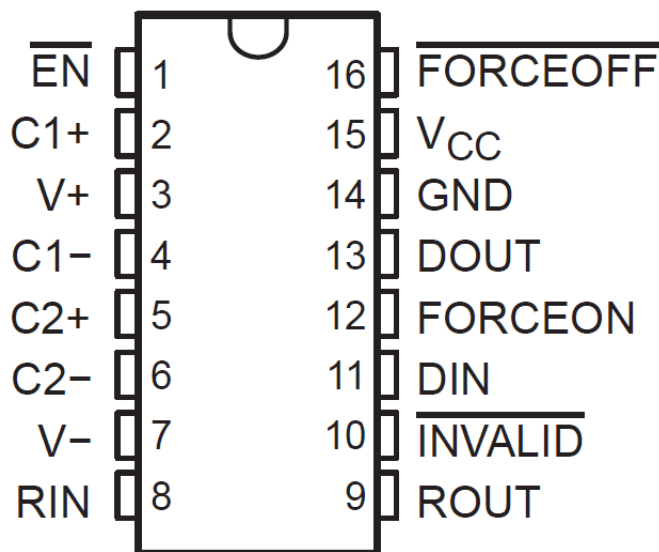


**Figure 6-1. DB or PW Package  
Top View**

**Table 6-1. Pin Configurations**

| PIN                         |    | I/O | DESCRIPTION                                                                     |
|-----------------------------|----|-----|---------------------------------------------------------------------------------|
| NAME                        | NO |     |                                                                                 |
| $\overline{\text{EN}}$      | 1  | I   | Low input enables receiver ROUT output. High input sets ROUT to high impedance. |
| C1+                         | 2  | —   | Positive terminals of the voltage-doubler charge-pump capacitors                |
| V+                          | 3  | O   | 5.5-V supply generated by the charge pump                                       |
| C1–                         | 4  | —   | Negative terminals of the voltage-doubler charge-pump capacitors                |
| C2+                         | 5  | —   | Positive terminals of the voltage-doubler charge-pump capacitors                |
| C2–                         | 6  | —   | Negative terminals of the voltage-doubler charge-pump capacitors                |
| V–                          | 7  | O   | –5.5-V supply generated by the charge pump                                      |
| RIN                         | 8  | I   | RS-232 receiver input                                                           |
| ROUT                        | 9  | O   | Receiver output                                                                 |
| $\overline{\text{INVALID}}$ | 10 | O   | Invalid output pin. Output low when all RIN inputs are unpowered.               |
| DIN                         | 11 | I   | Driver input                                                                    |
| FORCEON                     | 12 | I   | Automatic power-down control input                                              |
| DOUT                        | 13 | O   | RS-232 driver output                                                            |
| GND                         | 14 | —   | Ground                                                                          |
| V <sub>CC</sub>             | 15 | —   | 3-V to 5.5-V supply voltage                                                     |
| FORCEOFF                    | 16 | I   | Automatic power-down control input                                              |

## 7 Specifications

### 7.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) <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 ( $\overline{\text{FORCEOFF}}$ , $\overline{\text{FORCEON}}$ , $\overline{\text{EN}}$ ) | −0.3  | 6                     | V    |
|                  |                                                     | Receiver                                                                                       | −25   | 25                    |      |
| V <sub>O</sub>   | Output voltage range                                | Driver                                                                                         | −13.2 | 13.2                  | V    |
|                  |                                                     | Receiver ( $\overline{\text{INVALID}}$ )                                                       | −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.

### 7.2 ESD Ratings

|                    |                         | VALUE                                                                          | UNIT |
|--------------------|-------------------------|--------------------------------------------------------------------------------|------|
| V <sub>(ESD)</sub> | Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>              | V    |
|                    |                         | DOUT, RIN                                                                      |      |
|                    |                         | All other pins                                                                 |      |
|                    |                         | Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup> |      |

- (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.

### 7.3 ESD Ratings - IEC Specifications

|                    |                         |                                                | VALUE                  | UNIT |
|--------------------|-------------------------|------------------------------------------------|------------------------|------|
| V <sub>(ESD)</sub> | Electrostatic discharge | IEC 61000-4-2 Contact Discharge <sup>(1)</sup> | RIN and DOUT pins only | V    |
|                    |                         | IEC 61000-4-2 Air Discharge <sup>(1)</sup>     | RIN and DOUT pins only |      |

- (1) For the PW package of SN65C3221E only, a minimum of 1-μF capacitor is required between VCC and GND to meet the specified IEC-ESD level.

## 7.4 Recommended Operating Conditions

 See Figure 10-1. see <sup>(1)</sup>

|                |                                             |                                                                     |  | MIN                     | NOM | MAX | UNIT |
|----------------|---------------------------------------------|---------------------------------------------------------------------|--|-------------------------|-----|-----|------|
| Supply voltage |                                             | $V_{CC} = 3.3\text{ V}$                                             |  | 3                       | 3.3 | 3.6 | V    |
|                |                                             | $V_{CC} = 5\text{ V}$                                               |  | 4.5                     | 5   | 5.5 |      |
| $V_{IH}$       | Driver and control high-level input voltage | DIN, $\overline{\text{FORCEOFF}}$ , FORCEON, $\overline{\text{EN}}$ |  | $V_{CC} = 3.3\text{ V}$ |     | 2   | V    |
|                |                                             |                                                                     |  | $V_{CC} = 5\text{ V}$   |     | 2.4 |      |
| $V_{IL}$       | Driver and control low-level input voltage  | DIN, $\overline{\text{FORCEOFF}}$ , FORCEON, $\overline{\text{EN}}$ |  |                         |     | 0.8 | V    |
| $V_I$          | Driver and control input voltage            | DIN, $\overline{\text{FORCEOFF}}$ , FORCEON                         |  | 0                       |     | 5.5 | V    |
| $V_I$          | Receiver input voltage                      |                                                                     |  | -25                     |     | 25  | V    |
| $T_A$          | Operating free-air temperature              | SN65C3221E                                                          |  | -40                     |     | 85  | °C   |
|                |                                             | SN75C3221E                                                          |  | 0                       |     | 70  |      |

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

## 7.5 Thermal Information

| THERMAL METRIC <sup>1</sup> |                                              | SN65C3221E |           | SN75C3221E |           | UNIT |
|-----------------------------|----------------------------------------------|------------|-----------|------------|-----------|------|
|                             |                                              | PW (TSSOP) | DB (SSOP) | PW (TSSOP) | DB (SSOP) |      |
|                             |                                              | 16 PINS    | 16 PINS   | 16 PINS    | 16 PINS   |      |
| $R_{\theta JA}$             | Junction-to-ambient thermal resistance       | 110.9      | 82        | 108        | 82        | °C/W |
| $R_{\theta JC(top)}$        | Junction-to-case (top) thermal resistance    | 41.7       | 45.7      | 41.1       | 45.7      | °C/W |
| $R_{\theta JB}$             | Junction-to-board thermal resistance         | 57.2       | 44.4      | 51.4       | 44.4      | °C/W |
| $\Psi_{JT}$                 | Junction-to-top characterization parameter   | 4.2        | 11.0      | 3.9        | 11.0      | °C/W |
| $\Psi_{JB}$                 | Junction-to-board characterization parameter | 56.6       | 43.8      | 50.9       | 43.8      | °C/W |

## 7.6 Electrical Characteristics

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 10-1](#))

| PARAMETER |                                                | TEST CONDITIONS <sup>(1)</sup> | MIN                                                                                | TYP <sup>(2)</sup> | MAX | UNIT |
|-----------|------------------------------------------------|--------------------------------|------------------------------------------------------------------------------------|--------------------|-----|------|
| $I_I$     | Input leakage current                          | FORCEOFF, FORCEON, EN          |                                                                                    | ±0.01              | ±1  | μA   |
| $I_{CC}$  | Supply current<br>( $T_A = 25^\circ\text{C}$ ) | Auto-powerdown disabled        | No load,<br>FORCEOFF and FORCEON at $V_{CC}$                                       | 0.3                | 1   | mA   |
|           |                                                | Powered off                    | No load, FORCEOFF at GND                                                           | 1                  | 10  | μA   |
|           |                                                | Auto-powerdown enabled         | No load, FORCEOFF at $V_{CC}$ ,<br>FORCEON at GND,<br>All RIN are open or grounded | 1                  | 10  |      |

(1) Test conditions are  $C1-C4 = 0.1\ \mu\text{F}$  at  $V_{CC} = 3.3\ \text{V} \pm 0.3\ \text{V}$ ;  $C1 = 0.047\ \mu\text{F}$ ,  $C2-C4 = 0.33\ \mu\text{F}$  at  $V_{CC} = 5\ \text{V} \pm 0.5\ \text{V}$ .

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

## 7.7 Driver Section: Electrical Characteristics

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 10-1](#))

| PARAMETER |                                             | TEST CONDITIONS <sup>(1)</sup>                                       | MIN                                                                    | TYP <sup>(2)</sup> | MAX | UNIT |
|-----------|---------------------------------------------|----------------------------------------------------------------------|------------------------------------------------------------------------|--------------------|-----|------|
| $V_{OH}$  | High-level output voltage                   | DOOUT at $R_L = 3\ \text{k}\Omega$ to GND, DIN = GND                 | 5                                                                      | 5.4                |     | V    |
| $V_{OL}$  | Low-level output voltage                    | DOOUT at $R_L = 3\ \text{k}\Omega$ 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 <sup>(3)</sup> | $V_{CC} = 3.6\ \text{V}$ , $V_O = 0\ \text{V}$                       |                                                                        | ±35                | ±60 | mA   |
|           |                                             | $V_{CC} = 5.5\ \text{V}$ , $V_O = 0\ \text{V}$                       |                                                                        | ±35                | ±90 |      |
| $r_o$     | Output resistance                           | $V_{CC}$ , $V_+$ , and $V_- = 0\ \text{V}$ , $V_O = \pm 2\ \text{V}$ | 300                                                                    | 10M                |     | Ω    |
| $I_{off}$ | Output leakage current                      | FORCEOFF = GND                                                       | $V_O = \pm 12\ \text{V}$ , $V_{CC} = 3\ \text{V}$ to $3.6\ \text{V}$   |                    | ±25 | μA   |
|           |                                             |                                                                      | $V_O = \pm 10\ \text{V}$ , $V_{CC} = 4.5\ \text{V}$ to $5.5\ \text{V}$ |                    | ±25 |      |

(1) Test conditions are  $C1-C4 = 0.1\ \mu\text{F}$  at  $V_{CC} = 3.3\ \text{V} \pm 0.3\ \text{V}$ ;  $C1 = 0.047\ \mu\text{F}$ ,  $C2-C4 = 0.33\ \mu\text{F}$  at  $V_{CC} = 5\ \text{V} \pm 0.5\ \text{V}$ .

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

(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.

## 7.8 Switching Characteristics: Driver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 10-1](#))

| PARAMETER                                              |                                                                      | TEST CONDITIONS <sup>(1)</sup>                                                                                                  | MIN | TYP <sup>(2)</sup> | MAX | UNIT   |
|--------------------------------------------------------|----------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|-----|--------------------|-----|--------|
| Maximum data rate<br>(see <a href="#">Figure 8-1</a> ) | $R_L = 3\ \text{k}\Omega$                                            | $C_L = 1000\ \text{pF}$                                                                                                         |     | 250                |     | kbit/s |
|                                                        |                                                                      | $C_L = 250\ \text{pF}$ , $V_{CC} = 3\ \text{V}$ to $4.5\ \text{V}$                                                              |     | 1000               |     |        |
|                                                        |                                                                      | $C_L = 1000\ \text{pF}$ , $V_{CC} = 4.5\ \text{V}$ to $5.5\ \text{V}$                                                           |     | 1000               |     |        |
| $t_{sk(p)}$                                            | Pulse skew <sup>(3)</sup>                                            | $C_L = 150\ \text{pF}$ to $2500\ \text{pF}$ , $R_L = 3\ \text{k}\Omega$ to $7\ \text{k}\Omega$ , See <a href="#">Figure 8-2</a> |     | 100                |     | ns     |
| SR(tr)                                                 | Slew rate,<br>transition region<br>(see <a href="#">Figure 8-1</a> ) | $V_{CC} = 3.3\ \text{V}$ , $R_L = 3\ \text{k}\Omega$ to $7\ \text{k}\Omega$ , $C_L = 150\ \text{pF}$ to $1000\ \text{pF}$       | 18  |                    | 150 | V/μs   |

(1) Test conditions are  $C1-C4 = 0.1\ \mu\text{F}$  at  $V_{CC} = 3.3\ \text{V} \pm 0.3\ \text{V}$ ;  $C1 = 0.047\ \mu\text{F}$ ,  $C2-C4 = 0.33\ \mu\text{F}$  at  $V_{CC} = 5\ \text{V} \pm 0.5\ \text{V}$ .

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

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

## 7.9 Receiver Section: Electrical Characteristics

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 10-1](#))

| 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.

## 7.10 Switching Characteristics: Receiver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 10-1](#))

| 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 8-3</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 8-3</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 8-4</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 8-4</a> | 200                | ns   |
| t <sub>sk(p)</sub> | Pulse skew <sup>(3)</sup>                         | See <a href="#">Figure 8-3</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.

## 7.11 Auto-powerdown Section: Electrical Characteristics

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 8-5](#))

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

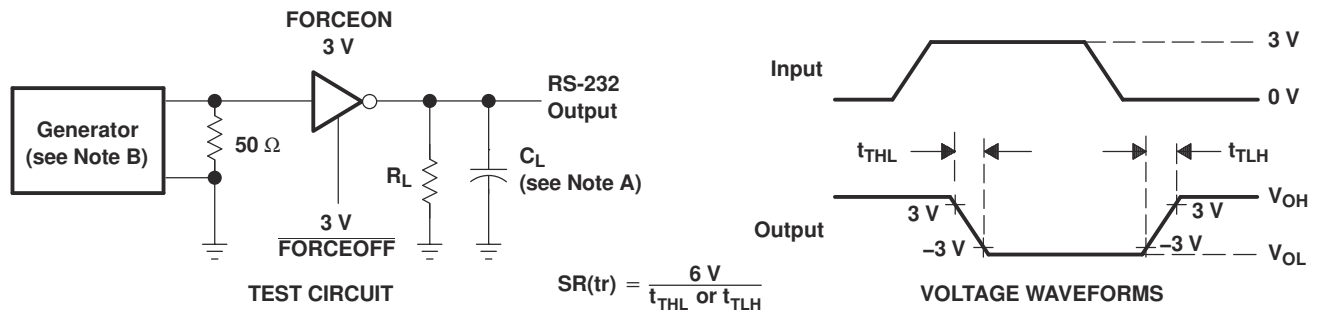
## 7.12 Switching Characteristics: Auto-powerdown

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 8-5](#))

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

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

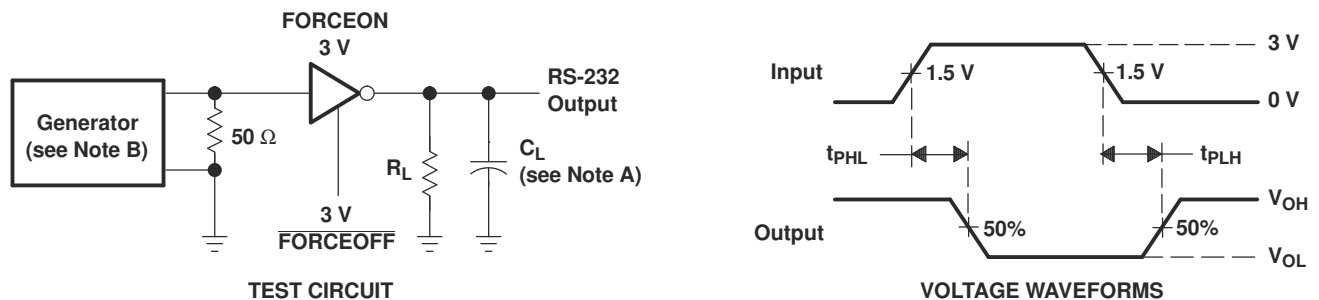
## 8 Parameter Measurement Information



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

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

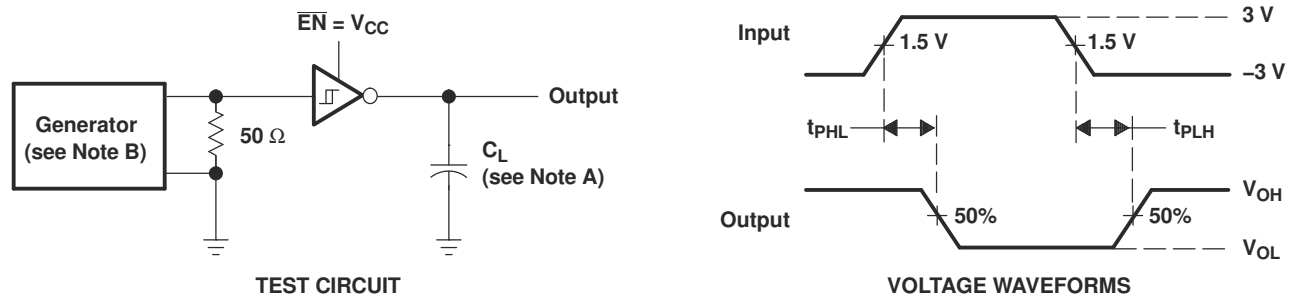
**Figure 8-1. Driver Slew Rate**



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

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

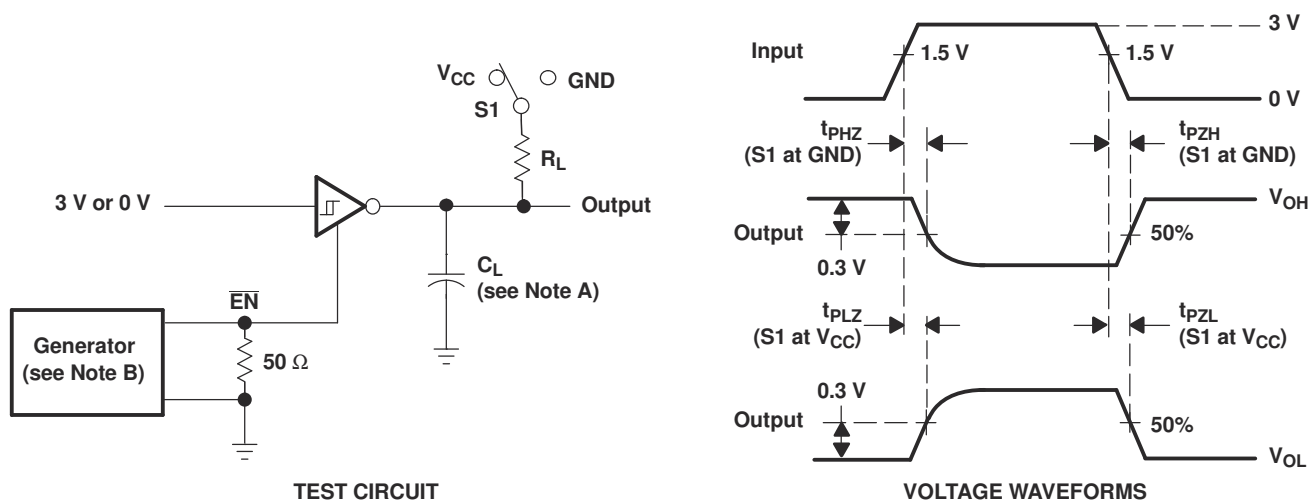
**Figure 8-2. Driver Pulse Skew**



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

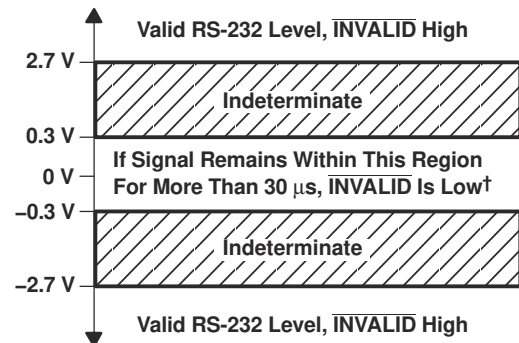
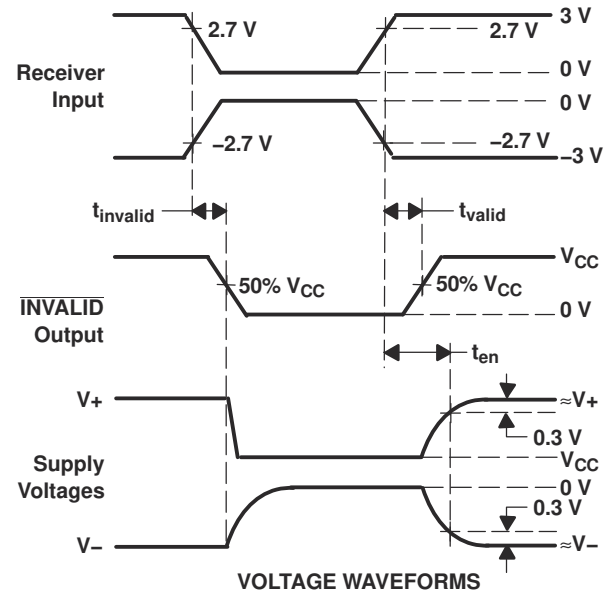
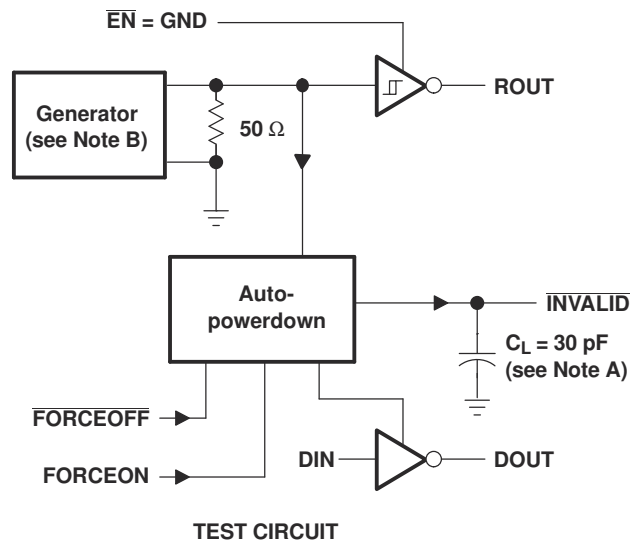
B. The pulse generator has the following characteristics:  $Z_O = 50\ \Omega$ , 50% duty cycle,  $t_r \leq 10\text{ ns}$ ,  $t_f \leq 10\text{ ns}$ .

**Figure 8-3. 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 8-4. Receiver Enable and Disable Times**



<sup>†</sup> 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 8-5. INVALID Propagation Delay Times and Driver Enabling Time

## 9 Detailed Description

### 9.1 Device Functional Modes

**Table 9-1. Each Driver**

| INPUTS <sup>(1)</sup> |         |          |                           | OUTPUT<br>DOUT | DRIVER STATUS                                    |
|-----------------------|---------|----------|---------------------------|----------------|--------------------------------------------------|
| DIN                   | FORCEON | FORCEOFF | VALID RIN<br>RS-232 LEVEL |                |                                                  |
| X                     | X       | L        | X                         | Z              | Powered off                                      |
| L                     | H       | H        | X                         | H              | Normal operation with<br>auto-powerdown disabled |
| H                     | H       | H        | X                         | L              |                                                  |
| L                     | L       | H        | Yes                       | H              | Normal operation with<br>auto-powerdown enabled  |
| H                     | L       | H        | Yes                       | L              |                                                  |
| L                     | L       | H        | No                        | Z              | Powered off by<br>auto-powerdown feature         |
| H                     | L       | H        | No                        | Z              |                                                  |

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

**Table 9-2. Each Receiver**

| INPUTS <sup>(1)</sup> |                        |                           | OUTPUT<br>ROUT |
|-----------------------|------------------------|---------------------------|----------------|
| RIN                   | $\overline{\text{EN}}$ | VALID RIN<br>RS-232 LEVEL |                |
| L                     | L                      | X                         | H              |
| H                     | L                      | X                         | L              |
| X                     | H                      | X                         | Z              |
| Open                  | L                      | No                        | H              |

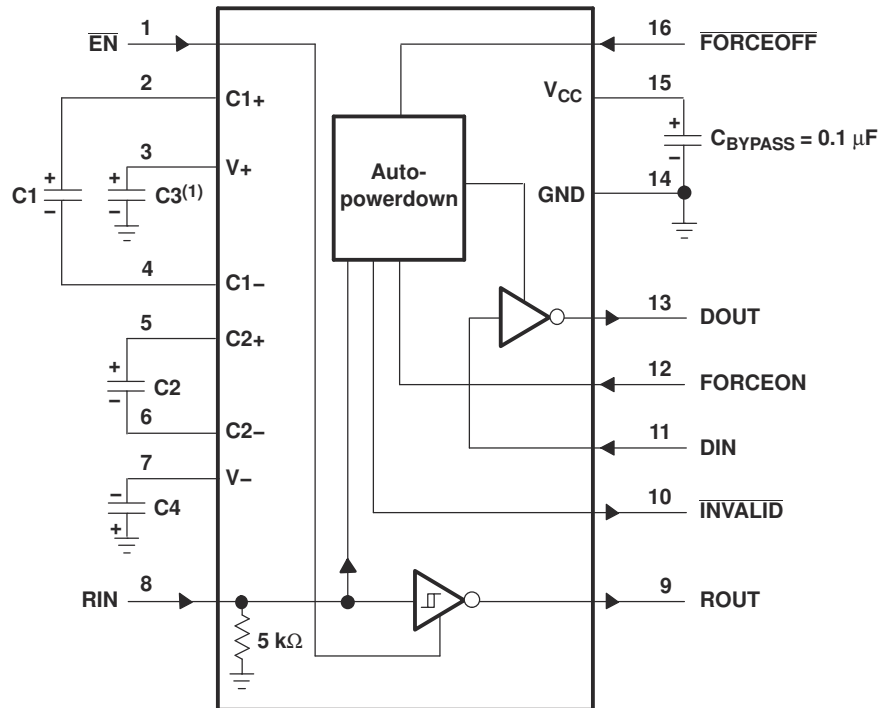
(1) H = high level, L = low level, X = irrelevant, Z = high impedance (off), Open = disconnected input or connected driver off

## 10 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.

### 10.1 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 10-1. Typical Operating Circuit and Capacitor Values**

## 11 Device and Documentation Support

TI offers an extensive line of development tools. Tools and software to evaluate the performance of the device, generate code, and develop solutions are listed below.

### 11.1 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.

### 11.2 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](#).

### 11.3 Trademarks

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### 11.4 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.

### 11.5 Glossary

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

## 12 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 part number         | Status<br>(1) | Material type<br>(2) | Package   Pins  | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|-------------------------------|---------------|----------------------|-----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">SN65C3221EDB</a>  | Obsolete      | Production           | SSOP (DB)   16  | -                     | -           | Call TI                              | Call TI                           | -40 to 85    | MU221E              |
| <a href="#">SN65C3221EDBR</a> | Active        | Production           | SSOP (DB)   16  | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | MU221E              |
| SN65C3221EDBR.A               | Active        | Production           | SSOP (DB)   16  | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | MU221E              |
| SN65C3221EDBRG4.A             | Active        | Production           | SSOP (DB)   16  | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | MU221E              |
| <a href="#">SN65C3221EPWR</a> | Active        | Production           | TSSOP (PW)   16 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | MU221E              |
| SN65C3221EPWR.A               | Active        | Production           | TSSOP (PW)   16 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | MU221E              |
| SN65C3221EPWRG4.A             | Active        | Production           | TSSOP (PW)   16 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | MU221E              |
| <a href="#">SN75C3221EDB</a>  | Obsolete      | Production           | SSOP (DB)   16  | -                     | -           | Call TI                              | Call TI                           | 0 to 70      | MY221E              |
| <a href="#">SN75C3221EDBR</a> | Obsolete      | Production           | SSOP (DB)   16  | -                     | -           | Call TI                              | Call TI                           | 0 to 70      | MY221E              |

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

<sup>(2)</sup> **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.

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

<sup>(4)</sup> **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.

<sup>(5)</sup> **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.

<sup>(6)</sup> **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.

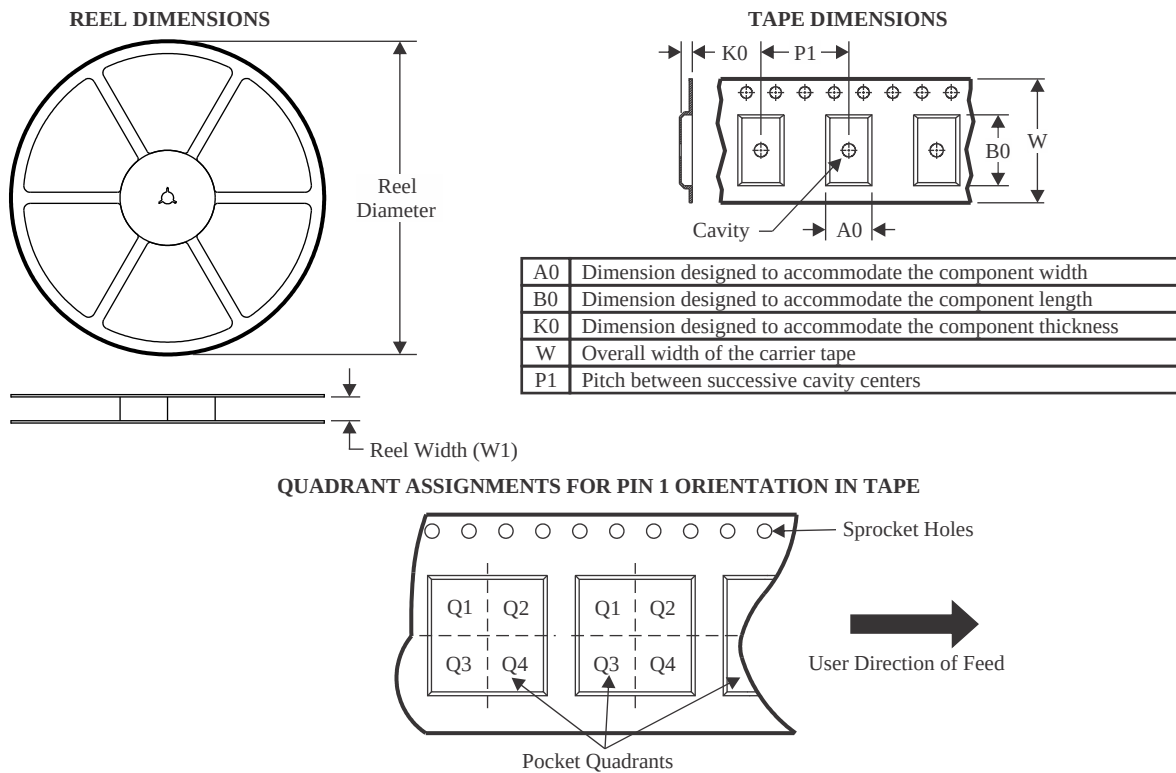
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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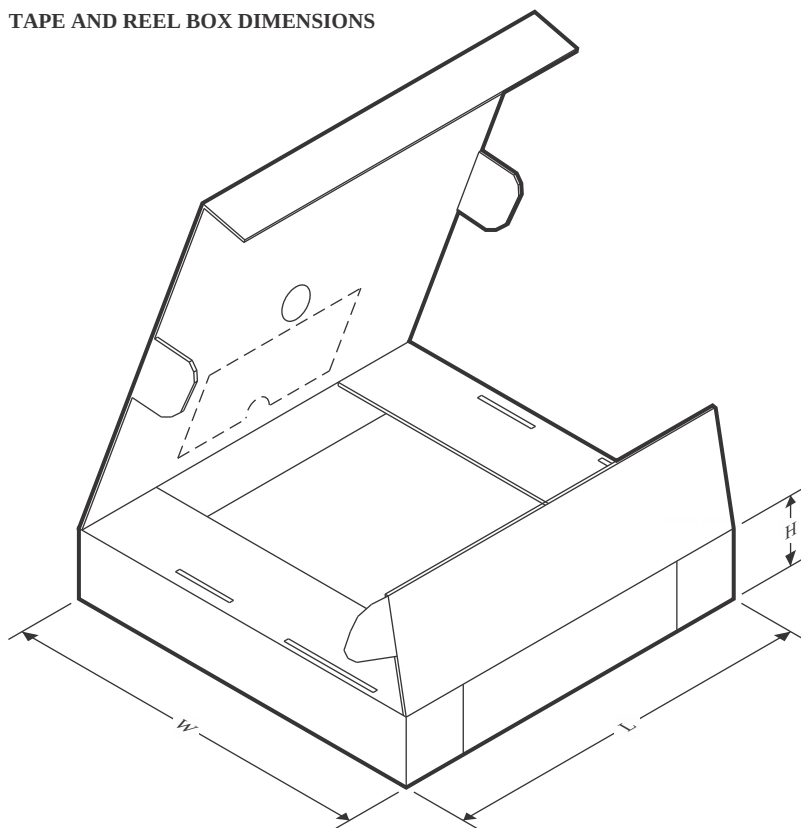
## TAPE AND REEL INFORMATION



\*All dimensions are nominal

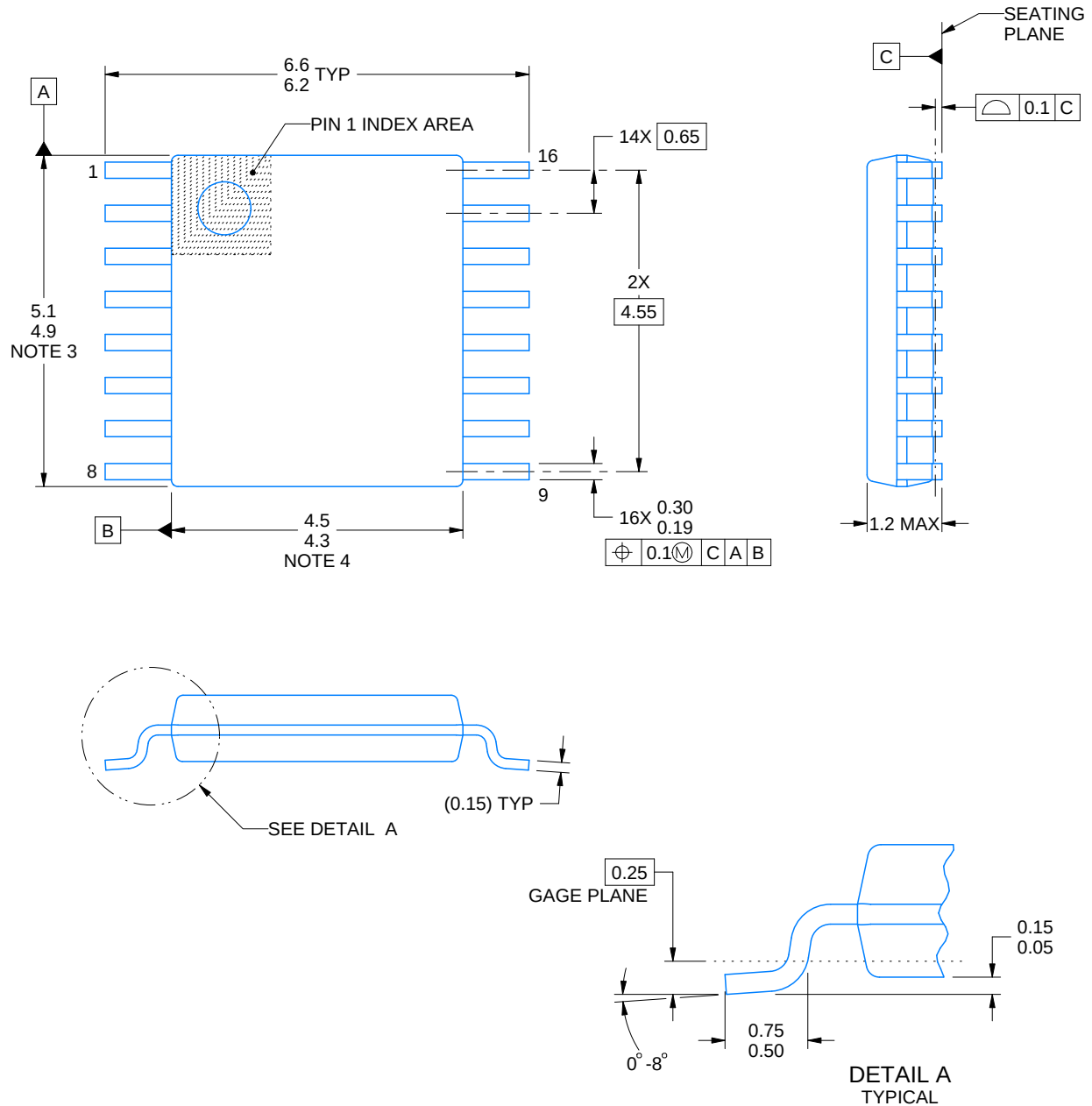
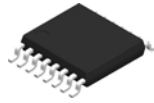
| Device        | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| SN65C3221EDBR | SSOP         | DB              | 16   | 2000 | 330.0              | 16.4               | 8.35    | 6.6     | 2.4     | 12.0    | 16.0   | Q1            |
| SN65C3221EPWR | 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) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| SN65C3221EDBR | SSOP         | DB              | 16   | 2000 | 356.0       | 356.0      | 35.0        |
| SN65C3221EPWR | TSSOP        | PW              | 16   | 2000 | 356.0       | 356.0      | 35.0        |



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## NOTES:

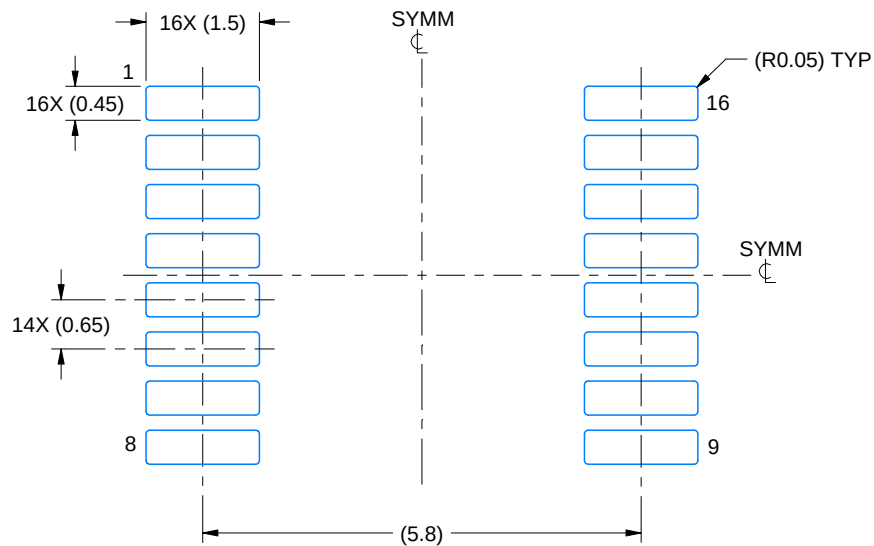
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or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

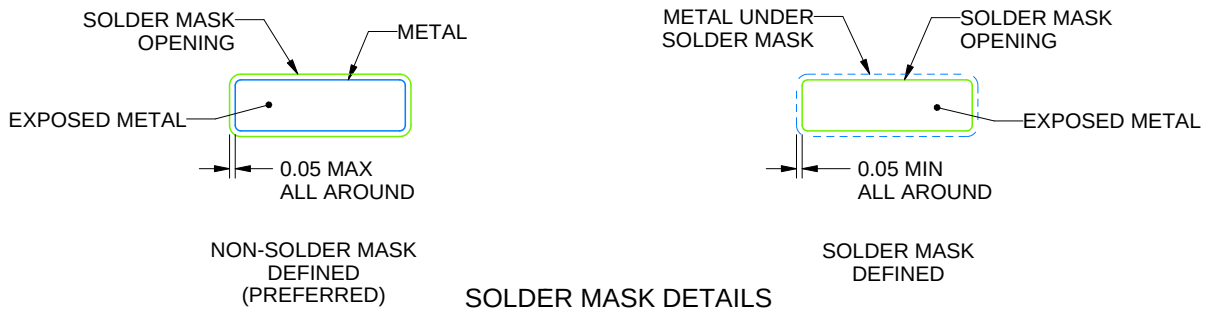
PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 10X



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NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

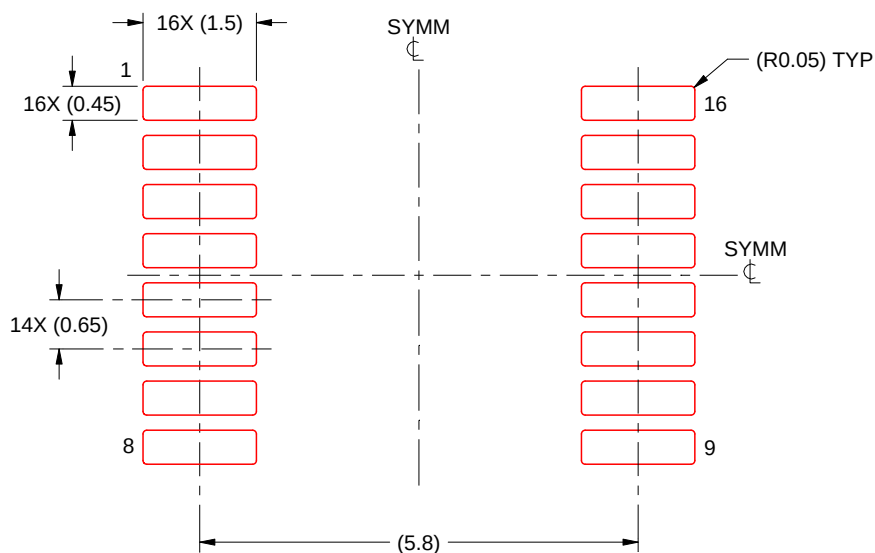
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE

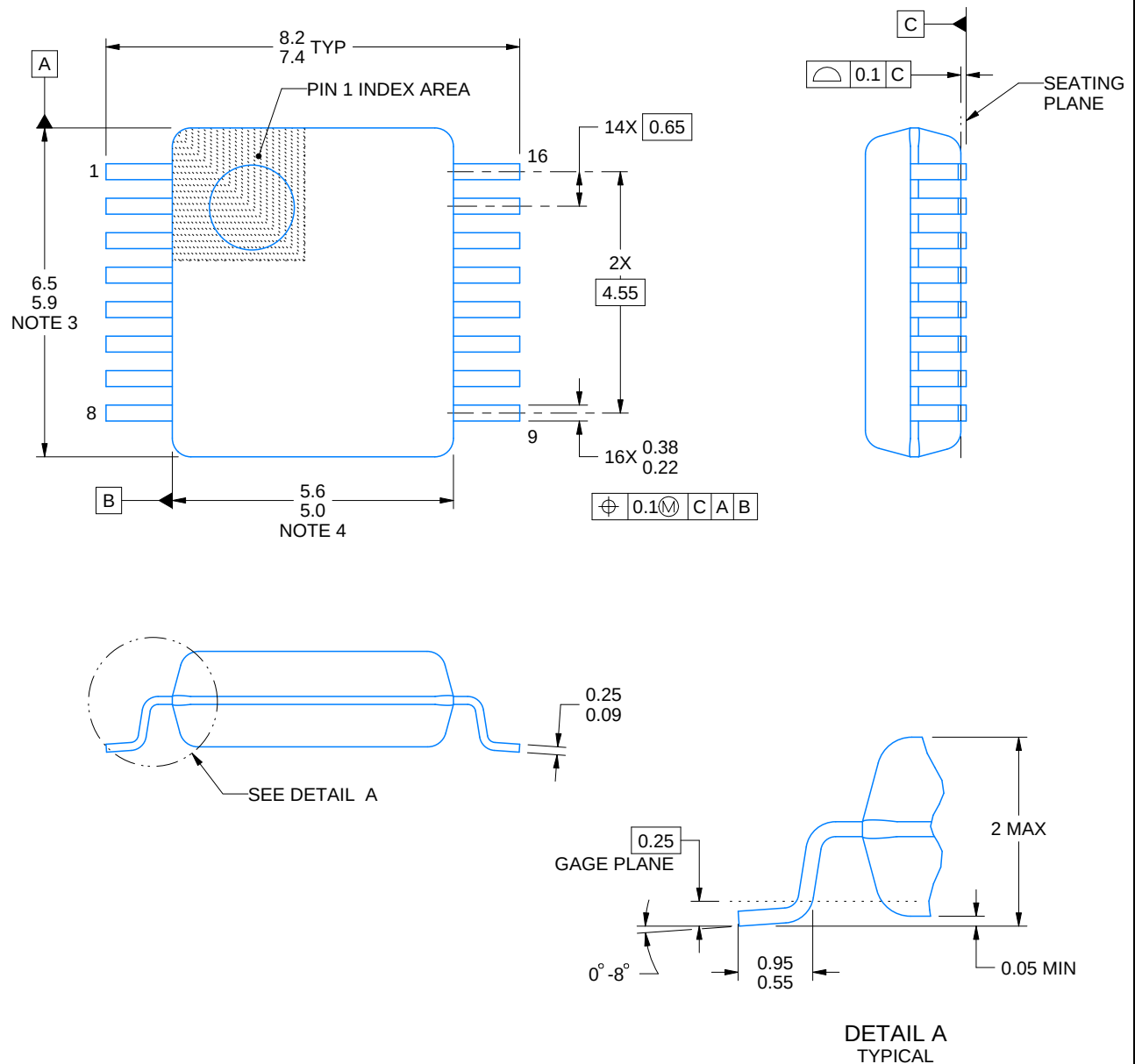


SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE: 10X

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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.



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## 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.

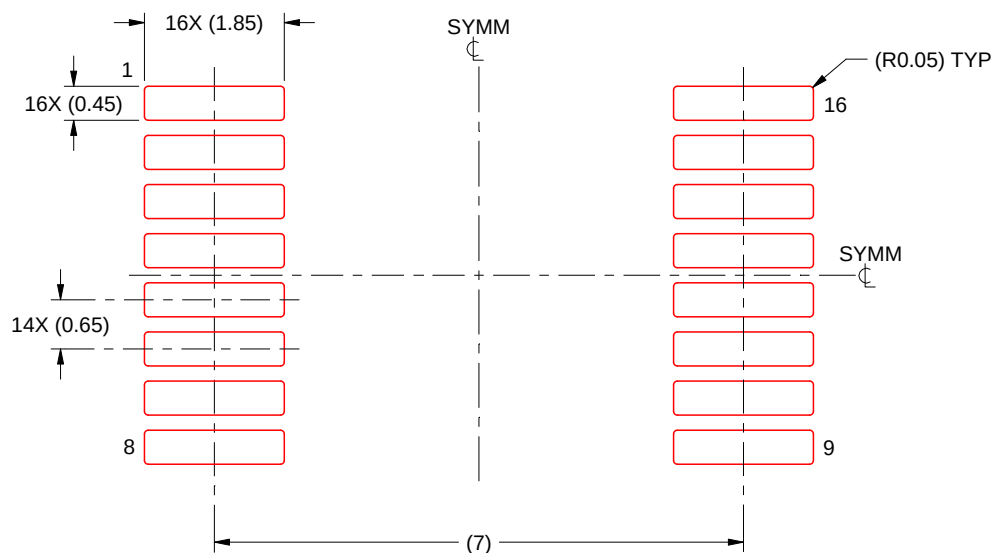


# EXAMPLE STENCIL DESIGN

DB0016A

SSOP - 2 mm max height

SMALL OUTLINE PACKAGE



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

4220763/A 05/2022

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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