

# 具有 $\pm 15\text{kV}$ ESD 保护功能的 MAX3221 3V 至 5.5V RS-232 线路驱动器和接收器

## 1 特性

- 使用人体放电模型 (HBM) 时, RS-232 总线引脚 ESD 保护大于  $\pm 15\text{kV}$
- 符合或超出 TIA/EIA-232-F 和 ITU V.28 标准的要求
- 由 3V 至 5.5V  $V_{\text{CC}}$  电源供电
- 运行速率高达 250kbps
- 一个驱动器和一个接收器
- 低待机电流:  $1\ \mu\text{A}$  (典型值)
- 外部电容器:  $4 \times 0.1\ \mu\text{F}$
- 接受 5V 逻辑输入及 3.3V 电源
- 备选高速引脚兼容器件 (1Mbps)
  - SNx5C3221
- 自动断电功能可自动禁用驱动器以节省能耗

## 2 应用

- 工业 PC
- 有线网络
- 数据中心和企业级计算
- 电池供电型系统
- PDA
- 笔记本电脑
- 便携式计算机
- 掌上电脑
- 手持设备

## 3 说明

MAX3221 器件包含一个线路驱动器、一个具有专用使用引脚的线路接收器和一个具有引脚对引脚 (串行端口连接引脚, 包括 GND)  $\pm 15\text{kV}$  ESD 保护功能的双电荷泵电路。该器件符合 TIA/EIA-232-F 的要求并在异步通信控制器与串行端口连接器之间提供电气接口。电荷泵和四个小型外部电容器支持由 3V 至 5.5V 单电源供电。这些器件以高达 250kbps 的数据信号传输速率和最大值为  $30\text{V}/\mu\text{s}$  的驱动器输出压摆率运行。

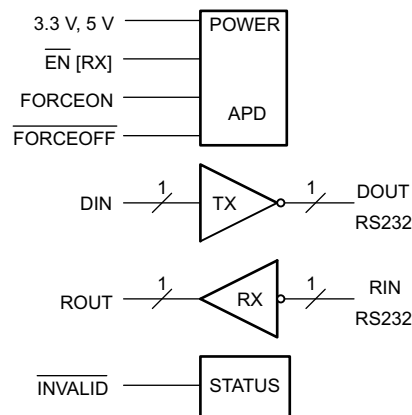
串行端口处于非活动状态时, 可提供灵活的电源管理控制选项。当  $\text{FORCEON}$  为低电平且  $\text{FORCEOFF}$  为高电平时, 自动断电功能启用。在这种运行模式下, 如果器件在接收器输入端未感应到有效的

RS-232 信号, 则会禁用驱动器输出, 且电源电流将降低至  $1\ \mu\text{A}$ 。INVALID 输出会通知用户接收器输入端是否存在 RS-232 信号。

### 器件信息

| 器件型号    | 封装 <sup>(1)</sup> | 封装尺寸 (标称值)             |
|---------|-------------------|------------------------|
| MAX3221 | SSOP (DB) (32)    | 6.20mm $\times$ 5.30mm |
|         | TSSOP (PW) (32)   | 5.00mm $\times$ 4.40mm |

(1) 如需了解所有可用封装, 请参阅数据表末尾的可订购产品附录。



简化图



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## 4 Revision History

注：以前版本的页码可能与当前版本的页码不同

|                                                                                                                                                                          |             |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| <b>Changes from Revision O (June 2015) to Revision P (July 2021)</b>                                                                                                     | <b>Page</b> |
| • 更改了 <i>应用</i> 列表.....                                                                                                                                                  | 1           |
| • Changed the values in the <i>Thermal Information</i> table for DB and PW packages.....                                                                                 | 5           |
| <b>Changes from Revision N (January 2014) to Revision O (June 2015)</b>                                                                                                  | <b>Page</b> |
| • 添加了 <i>引脚配置和功能</i> 部分、 <i>ESD</i> 等级表、 <i>特性说明</i> 部分、 <i>器件功能模式</i> 、 <i>应用和实施</i> 部分、 <i>电源相关建议</i> 部分、 <i>布局</i> 部分、 <i>器件和文档支持</i> 部分以及 <i>机械、封装和可订购信息</i> 部分..... | 1           |
| <b>Changes from Revision M (March 2004) to Revision N (January 2013)</b>                                                                                                 | <b>Page</b> |
| • 将文档更新为新的 TI 数据表格式 - 无规格变化.....                                                                                                                                         | 1           |
| • 删除了 <i>订购信息</i> 表.....                                                                                                                                                 | 1           |

## 5 Pin Configuration and Functions

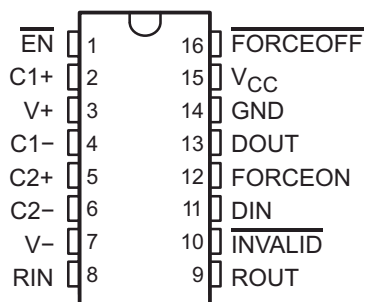


图 5-1. DB or PW Package, 16-Pin SSOP or TSSOP, Top View

表 5-1. Pin Functions

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

## 6 Specifications

### 6.1 Absolute Maximum Ratings

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

|                            |                                     |                                       | MIN   | MAX            | UNIT |
|----------------------------|-------------------------------------|---------------------------------------|-------|----------------|------|
| $V_{CC}$ to GND            |                                     |                                       | - 0.3 | 6              | V    |
| $V+$ to GND                |                                     |                                       | - 0.3 | 7              |      |
| $V-$ to GND                |                                     |                                       | 0.3   | - 7            |      |
| $V+ +  V- $ <sup>(2)</sup> |                                     |                                       |       | 13             |      |
| $V_I$                      | Input voltage                       | DIN, EN, FORCEOFF, and FORCEON to GND | - 0.3 | 6              | V    |
|                            |                                     | RIN to GND                            |       | ±25            |      |
| $V_O$                      | Output voltage                      | DOUT to GND                           |       | ±13.2          | V    |
|                            |                                     | ROUT to GND                           | - 0.3 | $V_{CC} + 0.3$ |      |
| $T_J$                      | Junction temperature <sup>(3)</sup> |                                       |       | 150            | °C   |
| $T_{stg}$                  | Storage temperature range           |                                       | - 65  | 150            |      |

- (1) Operation outside the *Absolute Maximum Ratings* may cause permanent device damage. *Absolute Maximum Ratings* do not imply functional operation of the device at these or any other conditions beyond those listed under *Recommended Operating Conditions*. If used outside the *Recommended Operating Conditions* but within the *Absolute Maximum Ratings*, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.
- (2)  $V+$  and  $V-$  can have maximum magnitudes of 7 V, but their absolute difference cannot exceed 13 V.
- (3) Maximum power dissipation is a function of  $T_J(\max)$ ,  $R_{\theta JA}$ , and  $T_A$ . The maximum allowable power dissipation at any allowable ambient temperature is  $P_D = (T_J(\max) - T_A) / R_{\theta JA}$ . Operating at the absolute maximum  $T_J$  of 150°C can affect reliability.

### 6.2 ESD Ratings

|                    |                         |                                                                                | VALUE                 | UNIT    |   |
|--------------------|-------------------------|--------------------------------------------------------------------------------|-----------------------|---------|---|
| V <sub>(ESD)</sub> | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>              | All pins except 8, 13 | ±3000   | V |
|                    |                         |                                                                                | Pins 8, 13            | ±15,000 |   |
|                    |                         | 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 Recommended Operating Conditions

(see 图 9-1)<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 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 low-level input voltage  | DIN, FORCEOFF, FORCEON, EN |                         | 0.8  |     |     | V    |
| V <sub>I</sub>  | Driver input voltage            | DIN, FORCEOFF, FORCEON, EN |                         | 0    |     |     | V    |
|                 | Receiver input voltage          |                            | - 25                    |      |     | 25  |      |
| T <sub>A</sub>  | Operating free-air temperature  | MAX3221C                   |                         | 0    |     |     | °C   |
|                 |                                 | MAX3221I                   |                         | - 40 |     |     |      |

- (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  $V_{CC} = 5 \text{ V} \pm 0.5 \text{ V}$ .

## 6.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |                                              | MAX3221   |            | UNIT |
|-------------------------------|----------------------------------------------|-----------|------------|------|
|                               |                                              | DB (SSOP) | PW (TSSOP) |      |
|                               |                                              | 16 PINS   | 16 PINS    |      |
| $R_{\theta JA}$               | Junction-to-ambient thermal resistance       | 105.8     | 110.9      | °C/W |
| $R_{\theta JC(top)}$          | Junction-to-case (top) thermal resistance    | 51.9      | 41.7       | °C/W |
| $R_{\theta JB}$               | Junction-to-board thermal resistance         | 57.6      | 57.2       | °C/W |
| $\psi_{JT}$                   | Junction-to-top characterization parameter   | 14.1      | 4.2        | °C/W |
| $\psi_{JB}$                   | Junction-to-board characterization parameter | 56.8      | 56.6       | °C/W |

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, [SPRA953](#).

## 6.5 Electrical Characteristics – Power

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(2)</sup>

| PARAMETER |                       | TEST CONDITIONS               |                                                                              | MIN | TYP <sup>(1)</sup> | MAX | UNIT |
|-----------|-----------------------|-------------------------------|------------------------------------------------------------------------------|-----|--------------------|-----|------|
| $I_I$     | Input leakage current | FORCEOFF, FORCEON, EN         |                                                                              |     | ±0.01              | ±1  | µA   |
| $I_{CC}$  | Supply current        | Automatic power-down disabled | No load, FORCEOFF and FORCEON at $V_{CC}$                                    |     | 0.3                | 1   | mA   |
|           |                       | Powered off                   | No load, FORCEOFF at GND                                                     |     | 1                  | 10  | µA   |
|           |                       | Automatic power-down enabled  | No load, FORCEOFF at $V_{CC}$ , FORCEON at GND, All RIN are open or grounded |     | 1                  | 10  |      |

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

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

## 6.6 Electrical Characteristics – Driver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(3)</sup>

| PARAMETER |                                             | TEST CONDITIONS                                                     |                                                                     | MIN | TYP <sup>(1)</sup> | MAX | UNIT |
|-----------|---------------------------------------------|---------------------------------------------------------------------|---------------------------------------------------------------------|-----|--------------------|-----|------|
| $V_{OH}$  | High-level output voltage                   | $D_{OUT}$ at $R_L = 3\text{ k}\Omega$ to GND, $D_{IN} = \text{GND}$ |                                                                     | 5   | 5.4                |     | V    |
| $V_{OL}$  | Low-level output voltage                    | $D_{OUT}$ at $R_L = 3\text{ k}\Omega$ to GND, $D_{IN} = V_{CC}$     |                                                                     | – 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>(2)</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                | ±60 |      |
| $r_O$     | 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   |
|           |                                             |                                                                     | $V_O = \pm 12\text{ V}$ , $V_{CC} = 4.5\text{ V}$ to $5.5\text{ V}$ |     |                    | ±25 |      |

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

(2) 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.

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

## 6.7 Electrical Characteristics – Receiver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(2)</sup>

| PARAMETER        | TEST CONDITIONS                                         | MIN                            | TYP <sup>(1)</sup>    | MAX                   | UNIT |
|------------------|---------------------------------------------------------|--------------------------------|-----------------------|-----------------------|------|
| V <sub>OH</sub>  | High-level output voltage                               | I <sub>OH</sub> = -1 mA        | V <sub>CC</sub> - 0.6 | V <sub>CC</sub> - 0.1 | 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        | 1.5                   | 2.4                   | V    |
|                  |                                                         | V <sub>CC</sub> = 5 V          | 1.8                   | 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) 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.

(2) 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.

## 6.8 Electrical Characteristics – Status

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(2)</sup>

| PARAMETER               | TEST CONDITIONS                                                | MIN                                                                | TYP <sup>(1)</sup>    | MAX | UNIT |
|-------------------------|----------------------------------------------------------------|--------------------------------------------------------------------|-----------------------|-----|------|
| V <sub>T+(valid)</sub>  | Receiver input threshold for INVALID high-level output voltage | FORCEON = GND, FORCEOFF = V <sub>CC</sub>                          |                       | 2.7 | V    |
| V <sub>T-(valid)</sub>  | Receiver input threshold for INVALID high-level output voltage | FORCEON = GND, FORCEOFF = V <sub>CC</sub>                          | -2.7                  |     | V    |
| V <sub>T(invalid)</sub> | Receiver input threshold for INVALID low-level output voltage  | FORCEON = GND, FORCEOFF = V <sub>CC</sub>                          | -0.3                  | 0.3 | V    |
| V <sub>OH</sub>         | INVALID high-level output voltage                              | I <sub>OH</sub> = -1 mA, FORCEON = GND, FORCEOFF = V <sub>CC</sub> | V <sub>CC</sub> - 0.6 |     | V    |
| V <sub>OL</sub>         | INVALID low-level output voltage                               | I <sub>OH</sub> = -1 mA, FORCEON = GND, FORCEOFF = V <sub>CC</sub> |                       | 0.4 | V    |

(1) 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.

(2) 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.

## 6.9 Switching Characteristics – Driver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(3)</sup>

| PARAMETER          |                                             | TEST CONDITIONS                                                              |                                 | MIN | TYP <sup>(1)</sup> | MAX | UNIT   |
|--------------------|---------------------------------------------|------------------------------------------------------------------------------|---------------------------------|-----|--------------------|-----|--------|
|                    | Maximum data rate                           | C <sub>L</sub> = 1000 pF, R <sub>L</sub> = 3 kΩ,<br>see 图 7-1                |                                 | 150 | 250                |     | kbps   |
| t <sub>sk(p)</sub> | Pulse skew <sup>(2)</sup>                   | C <sub>L</sub> = 150 to 2500 pF, R <sub>L</sub> = 3 kΩ to 7 kΩ,<br>see 图 7-2 |                                 |     | 100                |     | ns     |
| SR(tr)             | Slew rate, transition region<br>(see 图 7-1) | V <sub>CC</sub> = 3.3 V,<br>R <sub>L</sub> = 3 kΩ to 7 kΩ                    | C <sub>L</sub> = 150 to 1000 pF | 6   |                    | 30  | V/ μ s |
|                    |                                             |                                                                              | C <sub>L</sub> = 150 to 2500 pF | 4   |                    | 30  |        |

(1) 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.

(2) Pulse skew is defined as |t<sub>PLH</sub> - t<sub>PHL</sub>| of each channel of the same device.

(3) 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.

## 6.10 Switching Characteristics - Receiver

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(3)</sup>

| PARAMETER                                                   | TEST CONDITIONS                                  | MIN | TYP <sup>(1)</sup> | MAX | UNIT |
|-------------------------------------------------------------|--------------------------------------------------|-----|--------------------|-----|------|
| $t_{PLH}$ Propagation delay time, low- to high-level output | $C_L = 150$ pF, see 图 7-3                        |     | 150                |     | ns   |
| $t_{PHL}$ Propagation delay time, high- to low-level output | $C_L = 150$ pF, see 图 7-3                        |     | 150                |     | ns   |
| $t_{en}$ Output enable time                                 | $C_L = 150$ pF, $R_L = 3$ k $\Omega$ , see 图 7-4 |     | 200                |     | ns   |
| $t_{dis}$ Output disable time                               | $C_L = 150$ pF, $R_L = 3$ k $\Omega$ , see 图 7-4 |     | 200                |     | ns   |
| $t_{sk(p)}$ Pulse skew <sup>(2)</sup>                       | See 图 7-3                                        |     | 50                 |     | ns   |

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

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

(3) Test conditions are  $C_1 - C_4 = 0.1$   $\mu\text{F}$  at  $V_{CC} = 3.3$  V  $\pm 0.3$  V;  $C_1 = 0.047$   $\mu\text{F}$ ,  $C_2 - C_4 = 0.33$   $\mu\text{F}$  at  $V_{CC} = 5$  V  $\pm 0.5$  V.

## 6.11 Switching Characteristics - Status

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(2)</sup>

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

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

(2) Test conditions are  $C_1 - C_4 = 0.1$   $\mu\text{F}$  at  $V_{CC} = 3.3$  V  $\pm 0.3$  V;  $C_1 = 0.047$   $\mu\text{F}$ ,  $C_2 - C_4 = 0.33$   $\mu\text{F}$  at  $V_{CC} = 5$  V  $\pm 0.5$  V.

## 6.12 Typical Characteristics

$V_{CC} = 3.3$  V

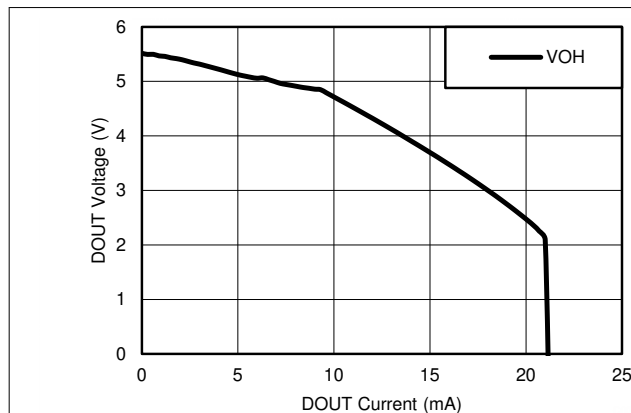


图 6-1. DOUT  $V_{OH}$  vs Load Current

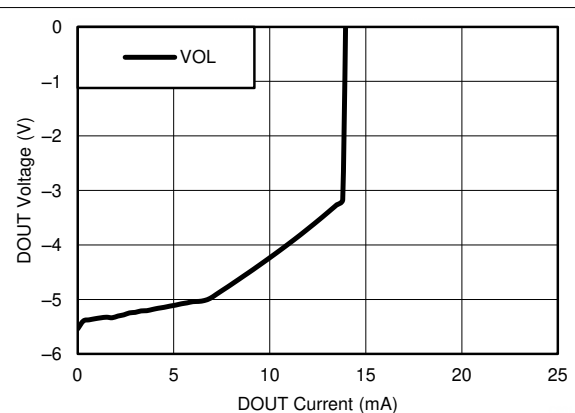
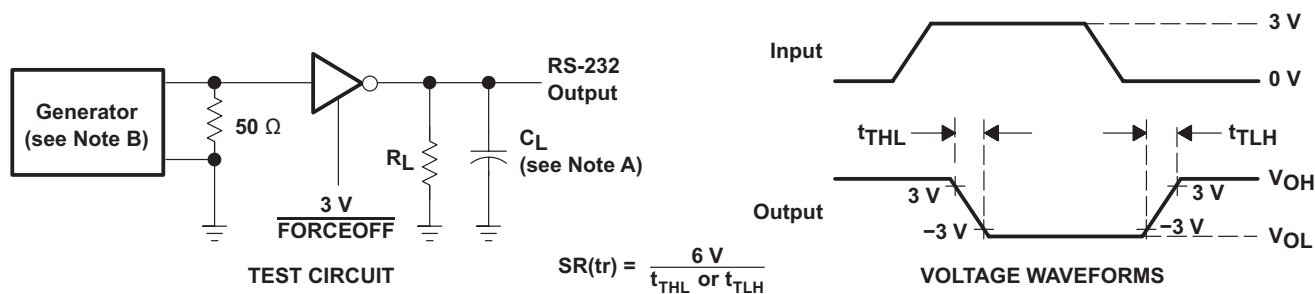


图 6-2. DOUT  $V_{OL}$  vs Load Current

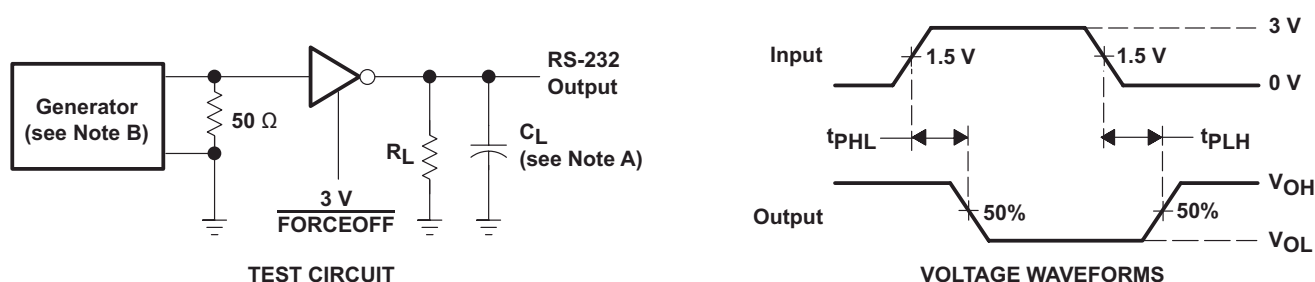
## 7 Parameter Measurement Information



A.  $C_L$  includes probe and jig capacitance.

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

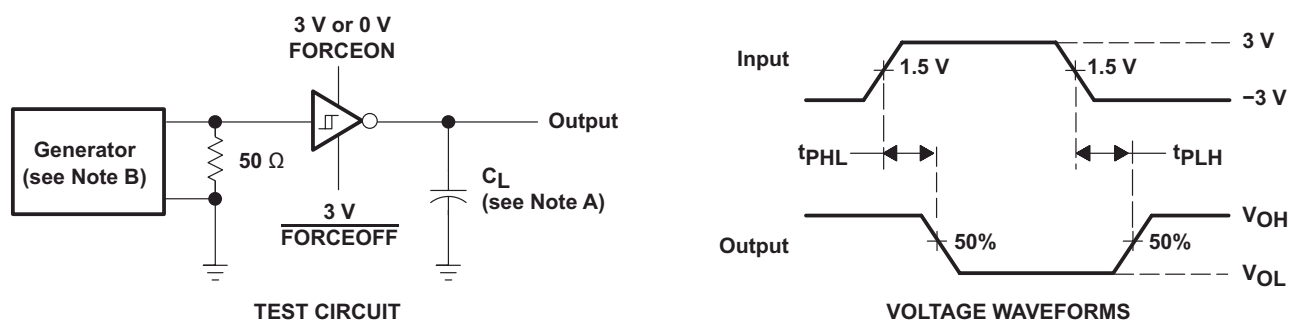
图 7-1. Driver Slew Rate



A.  $C_L$  includes probe and jig capacitance.

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

图 7-2. Driver Pulse Skew

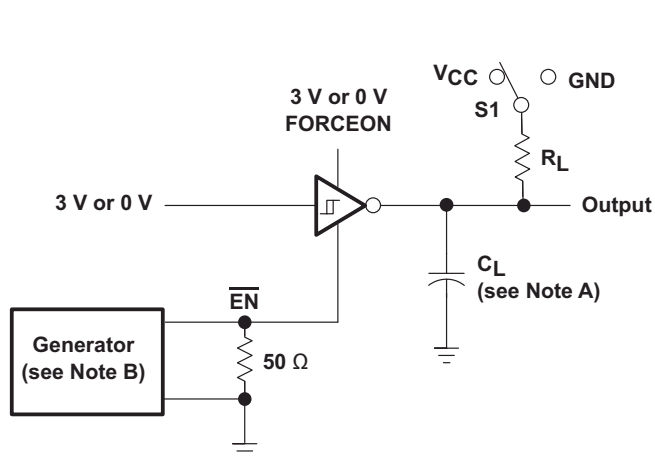


A.  $C_L$  includes probe and jig capacitance.

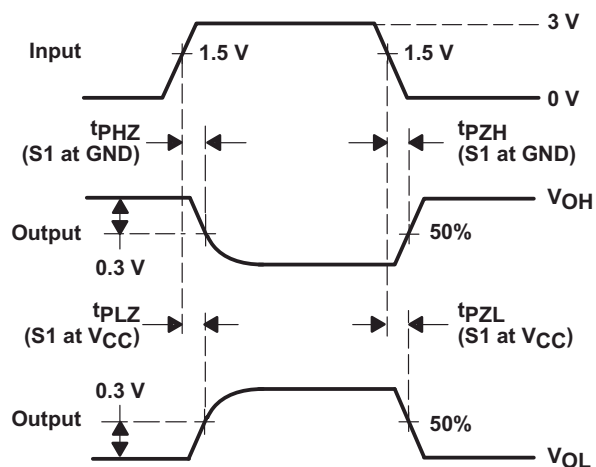
B. The pulse generator has the following characteristics:  $Z_O = 50\ \Omega$ , 50% duty cycle,  $t_r \leq 10\text{ ns}$ ,  $t_f \leq 10\text{ ns}$ .

图 7-3. Receiver Propagation Delay Times





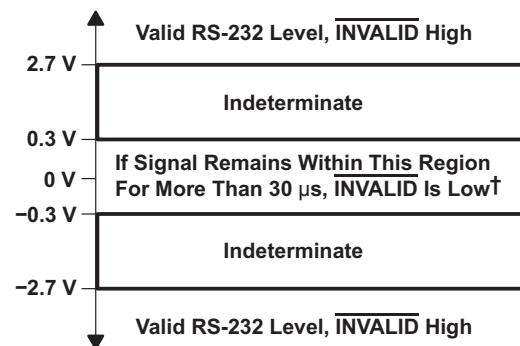
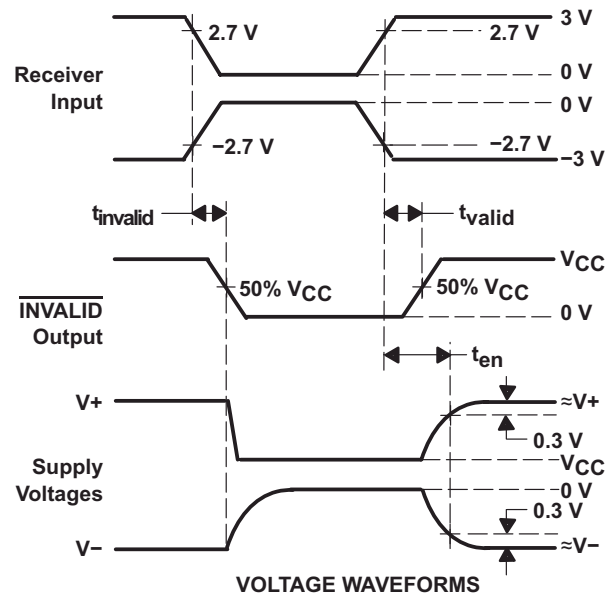
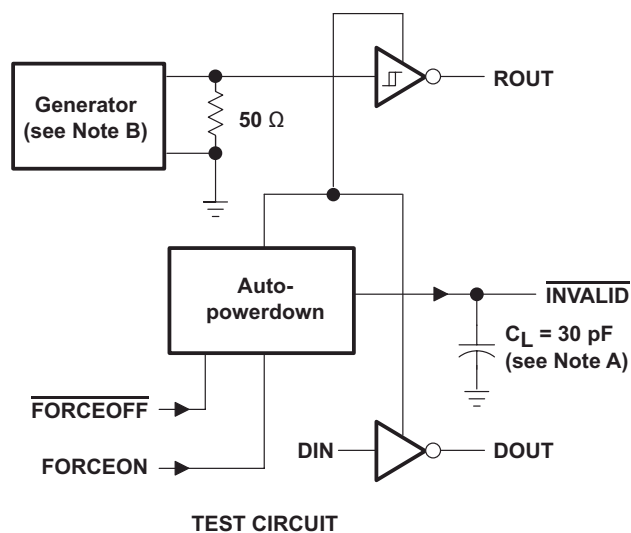
TEST CIRCUIT



VOLTAGE WAVEFORMS

- A.  $\text{C}_\text{L}$  includes probe and jig capacitance.
- B. The pulse generator has the following characteristics:  $\text{Z}_\text{O} = 50\ \Omega$ ,  $50\%$  duty cycle,  $t_\text{r} \leq 10\ \text{ns}$ ,  $t_\text{f} \leq 10\ \text{ns}$ .
- C.  $t_\text{PLZ}$  and  $t_\text{PHZ}$  are the same as  $t_\text{dis}$ .
- D.  $t_\text{PZL}$  and  $t_\text{PZH}$  are the same as  $t_\text{en}$ .

图 7-4. Receiver Enable and Disable Times



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

### 7-5. INVALID Propagation Delay Times and Driver Enabling Time

## 8 Detailed Description

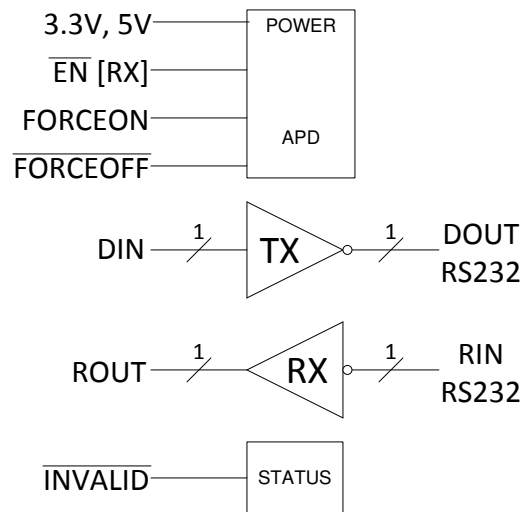
### 8.1 Overview

The MAX3221 device is a one-driver and one-receiver RS-232 interface device. All RS-232 inputs and outputs are protected to  $\pm 15$  kV using the Human Body Model. The charge pump requires only four small 0.1- $\mu$ F capacitors for operation from a 3.3-V supply. The MAX3221 is capable of running at data rates up to 250 kbps, while maintaining RS-232-compliant output levels.

Automatic power-down can be disabled when  $\overline{\text{FORCEON}}$  and  $\overline{\text{FORCEOFF}}$  are high. With automatic power-down plus enabled, the device activates automatically when a valid signal is applied to any receiver input. The device can automatically power down the driver to save power when the RIN input is unpowered.

$\overline{\text{INVALID}}$  is high (valid data) if receiver input voltage is greater than 2.7 V or less than -2.7 V, or has been between -0.3 V and 0.3 V for less than 30  $\mu$ s.  $\overline{\text{INVALID}}$  is low (invalid data) if receiver input voltages are between -0.3 V and 0.3 V for more than 30  $\mu$ s. Refer to [Figure 7-5](#) for receiver input levels.

### 8.2 Functional Block Diagram



### 8.3 Feature Description

#### 8.3.1 Power

The power block increases, inverts, and regulates voltage at V+ and V- pins using a charge pump that requires four external capacitors. 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. See [Table 8-1](#) and [Table 8-2](#).

When MAX3221 is unpowered, it can be safely connected to an active remote RS232 device.

#### 8.3.2 RS232 Driver

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

#### 8.3.3 RS232 Receiver

One receiver interfaces RS232 levels to standard logic levels. An open input will result in a high output on ROUT. RIN input includes an internal standard RS232 load. A logic high input on the  $\overline{\text{EN}}$  pin will shutdown the receiver output.

#### 8.3.4 RS232 Status

The  $\overline{\text{INVALID}}$  output goes low when RIN input is unpowered for more than 30  $\mu$ s. The  $\overline{\text{INVALID}}$  output goes high when receiver has a valid input. The  $\overline{\text{INVALID}}$  output is active when  $V_{CC}$  is powered regardless of  $\overline{\text{FORCEON}}$  and  $\overline{\text{FORCEOFF}}$  inputs (see [Table 8-3](#)).

## 8.4 Device Functional Modes

表 8-1, 表 8-2, and 表 8-3 show the behavior of the driver, receiver, and INVALID(active-low) features under all possible relevant combinations of inputs.

表 8-1. Driver<sup>(1)</sup>

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

(1) H = high level, L = low level, X = irrelevant, Z = high impedance, Yes =  $|RIN| > 2.7\text{ V}$ , No =  $|RIN| < 0.3\text{ V}$

表 8-2. Receiver<sup>(1)</sup>

| INPUTS |    |                        | OUTPUT | RECEIVER STATUS  |
|--------|----|------------------------|--------|------------------|
| RIN    | EN | VALID RIN RS-232 LEVEL | ROUT   |                  |
| X      | H  | X                      | Z      | Output off       |
| L      | L  | X                      | H      | Normal operation |
| H      | L  | X                      | L      |                  |
| Open   | L  | No                     | H      |                  |

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

表 8-3. INVALID<sup>(1)</sup>

| INPUTS |         |          |    | OUTPUT  |
|--------|---------|----------|----|---------|
| RIN    | FORCEON | FORCEOFF | EN | INVALID |
| L      | X       | X        | X  | H       |
| H      | X       | X        | X  | H       |
| Open   | X       | X        | X  | L       |

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

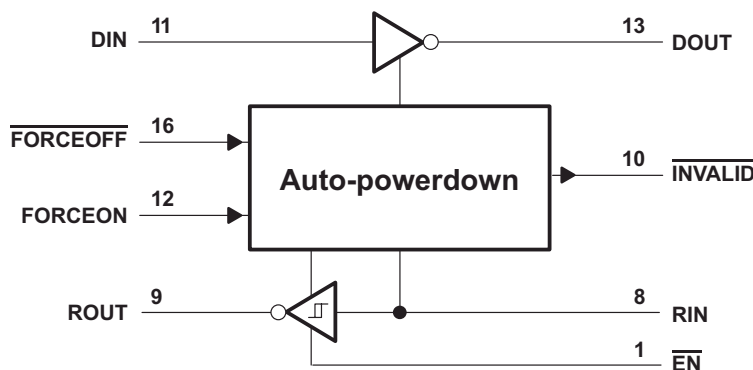


图 8-1. Logic Diagram

## 9 Application and Implementation

### Note

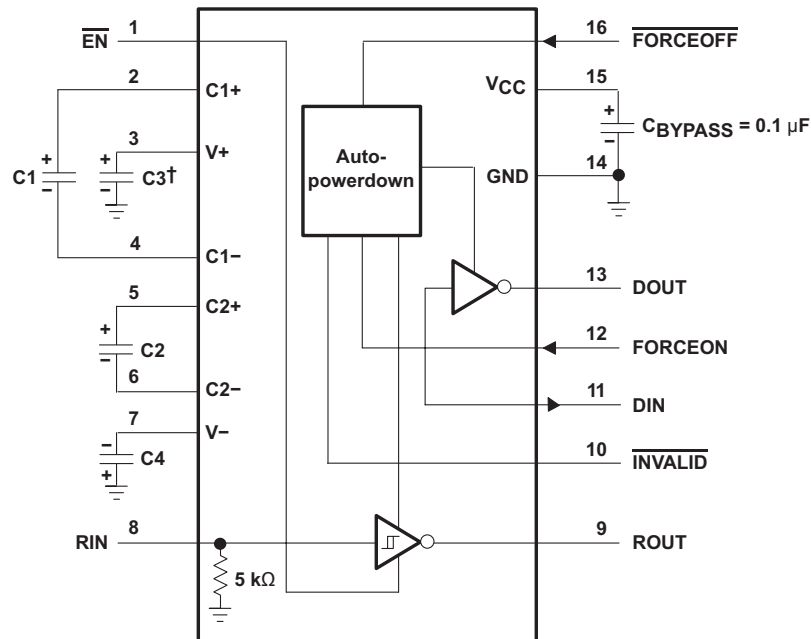
以下应用部分中的信息不属于 TI 器件规格的范围，TI 不担保其准确性和完整性。TI 的客户应负责确定器件是否适用于其应用。客户应验证并测试其设计，以确保系统功能。

### 9.1 Application Information

The MAX3221 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 图 9-1.

### 9.2 Typical Application

ROUT and DIN connect to UART or general purpose logic lines. FORCEON and FORCEOFF may be connected to general purpose logic lines or tied to ground or V<sub>CC</sub>. 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 FORCEOFF inputs must not be left unconnected.



† C3 can be connected to V<sub>CC</sub> 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<sub>CC</sub> vs CAPACITOR VALUES

| V <sub>CC</sub> | C1       | C2, C3, and C4 |
|-----------------|----------|----------------|
| 3.3 V ± 0.3 V   | 0.1 μF   | 0.1 μF         |
| 5 V ± 0.5 V     | 0.047 μF | 0.33 μF        |
| 3 V to 5.5 V    | 0.1 μF   | 0.47 μF        |

图 9-1. Typical Operating Circuit and Capacitor Values

### 9.2.1 Design Requirements

- Recommended  $V_{CC}$  is 3.3 V or 5 V.
  - 3 V to 5.5 V is also possible
- Maximum recommended bit rate is 250 kbps.
- Use capacitors as shown in 图 9-1.

### 9.2.2 Detailed Design Procedure

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

### 9.2.3 Application Curve

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

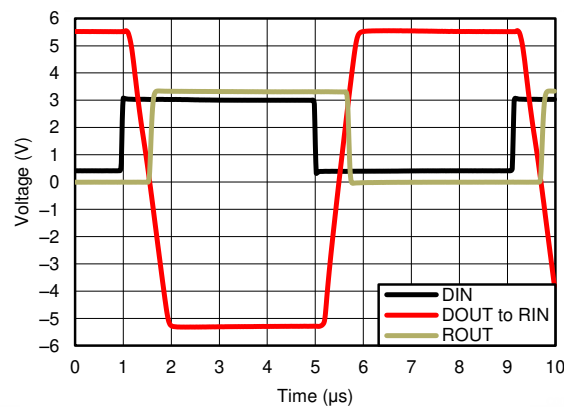


图 9-2. 250-kbps Driver to Receiver Loopback Timing Waveform,  $V_{CC} = 3.3 \text{ V}$

## 10 Power Supply Recommendations

TI recommends a 0.1-  $\mu\text{F}$  capacitor to filter noise on the power supply pin. For additional filter capability, a 0.01-  $\mu\text{F}$  capacitor may be added in parallel as well. Power supply input voltage is recommended to be any valid level in [Recommended Operating Conditions](#).

## 11 Layout

### 11.1 Layout Guidelines

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

### 11.2 Layout Example

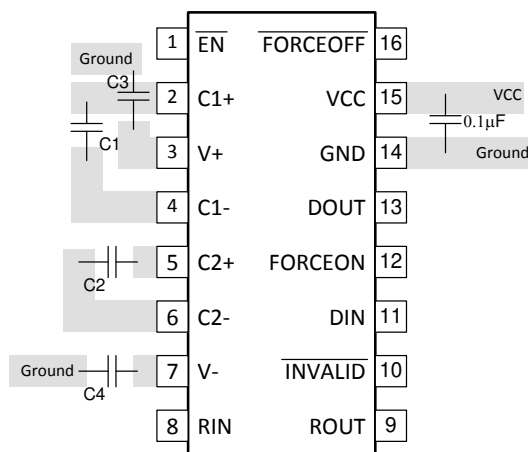


图 11-1. Layout Diagram

## 12 Device and Documentation Support

### 12.1 支持资源

[TI E2E™ 支持论坛](#)是工程师的重要参考资料，可直接从专家获得快速、经过验证的解答和设计帮助。搜索现有解答或提出自己的问题可获得所需的快速设计帮助。

链接的内容由各个贡献者“按原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参阅 TI 的《使用条款》。

### 12.2 Trademarks

TI E2E™ is a trademark of Texas Instruments.

所有商标均为其各自所有者的财产。

### 12.3 静电放电警告



静电放电 (ESD) 会损坏这个集成电路。德州仪器 (TI) 建议通过适当的预防措施处理所有集成电路。如果不遵守正确的处理和安装程序，可能会损坏集成电路。

ESD 的损坏小至导致微小的性能降级，大至整个器件故障。精密的集成电路可能更容易受到损坏，这是因为非常细微的参数更改都可能会导致器件与其发布的规格不相符。

### 12.4 术语表

[TI 术语表](#) 本术语表列出并解释了术语、首字母缩略词和定义。

## 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 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="#">MAX3221CDBR</a>   | Active        | Production           | SSOP (DB)   16  | 2000   LARGE T&R      | Yes         | NIPDAU   NIPDAU                      | Level-1-260C-UNLIM                | 0 to 70      | MA3221C             |
| MAX3221CDBR.A                 | Active        | Production           | SSOP (DB)   16  | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | MA3221C             |
| MAX3221CDBRG4                 | Active        | Production           | SSOP (DB)   16  | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | 0 to 70      | MA3221C             |
| <a href="#">MAX3221CPWR</a>   | Active        | Production           | TSSOP (PW)   16 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | 0 to 70      | MA3221C             |
| MAX3221CPWR.A                 | Active        | Production           | TSSOP (PW)   16 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | MA3221C             |
| MAX3221CPWRE4                 | Active        | Production           | TSSOP (PW)   16 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | 0 to 70      | MA3221C             |
| MAX3221CPWRG4                 | Active        | Production           | TSSOP (PW)   16 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | 0 to 70      | MA3221C             |
| <a href="#">MAX3221IDBR</a>   | Active        | Production           | SSOP (DB)   16  | 2000   LARGE T&R      | Yes         | NIPDAU   NIPDAU                      | Level-1-260C-UNLIM                | -40 to 85    | MB3221I             |
| MAX3221IDBR.A                 | Active        | Production           | SSOP (DB)   16  | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | MB3221I             |
| MAX3221IDBRE4                 | Active        | Production           | SSOP (DB)   16  | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | MB3221I             |
| MAX3221IDBRG4                 | Active        | Production           | SSOP (DB)   16  | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | MB3221I             |
| <a href="#">MAX3221IPWR</a>   | Active        | Production           | TSSOP (PW)   16 | 2000   LARGE T&R      | Yes         | NIPDAU   SN                          | Level-1-260C-UNLIM                | -40 to 85    | MB3221I             |
| MAX3221IPWR.A                 | Active        | Production           | TSSOP (PW)   16 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | MB3221I             |
| <a href="#">MAX3221IPWRG4</a> | Active        | Production           | TSSOP (PW)   16 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | MB3221I             |
| MAX3221IPWRG4.A               | Active        | Production           | TSSOP (PW)   16 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | MB3221I             |

<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.

**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.

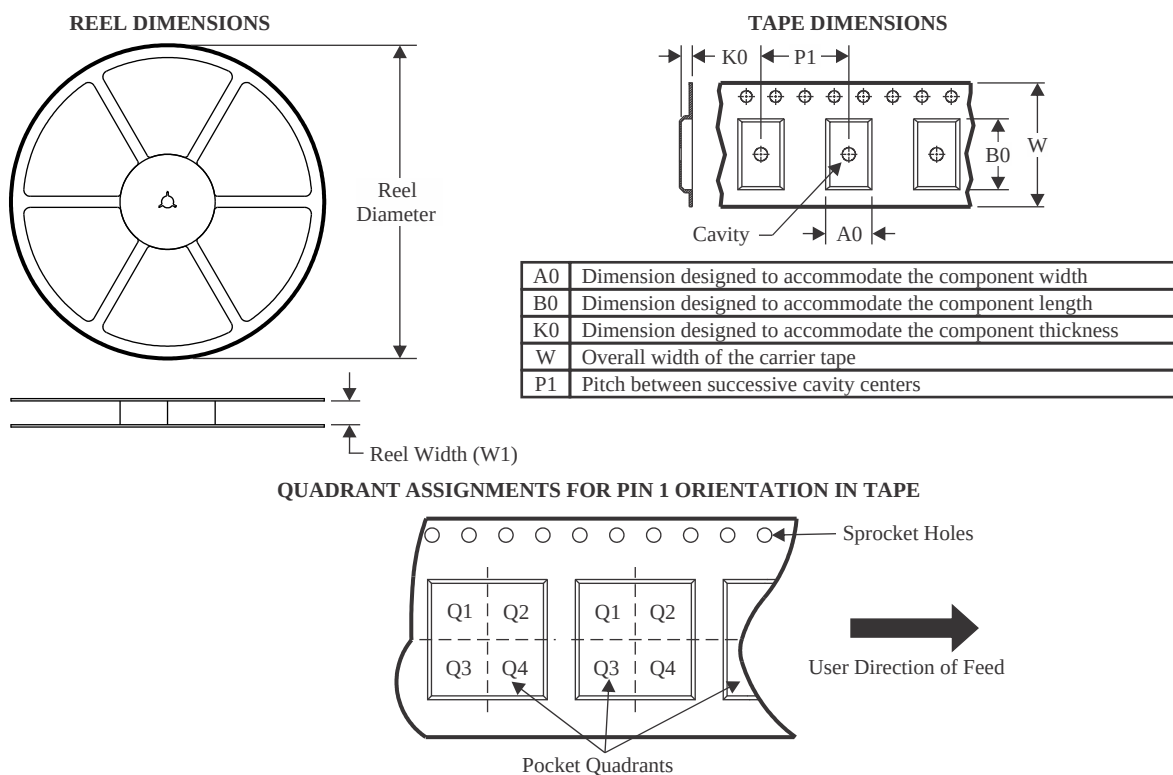
**OTHER QUALIFIED VERSIONS OF MAX3221 :**

- Enhanced Product : [MAX3221-EP](#)

NOTE: Qualified Version Definitions:

- Enhanced Product - Supports Defense, Aerospace and Medical Applications

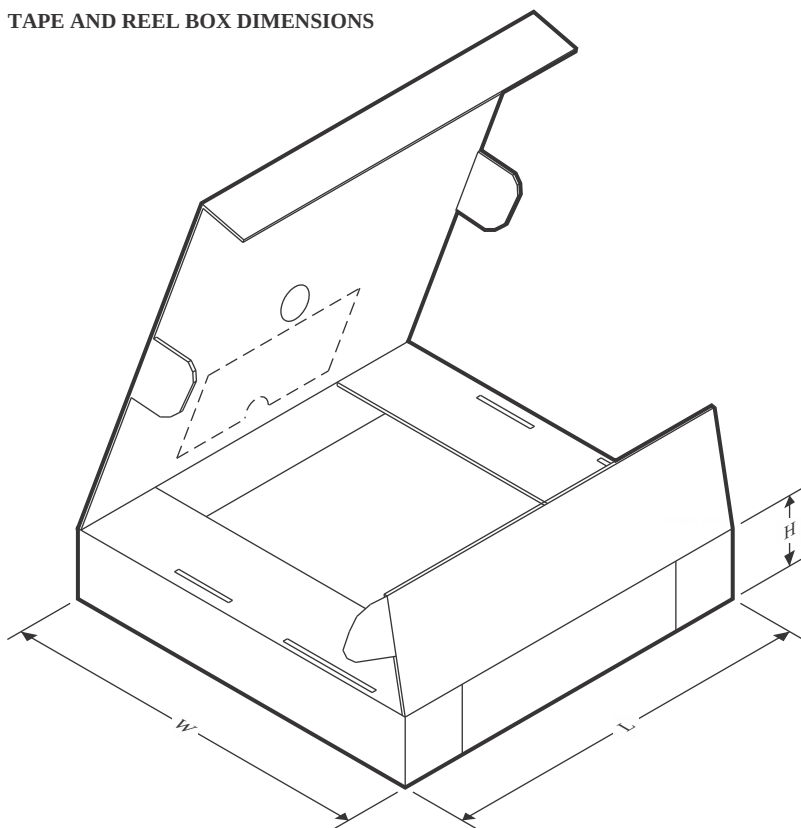
## TAPE AND REEL INFORMATION



\*All dimensions are nominal

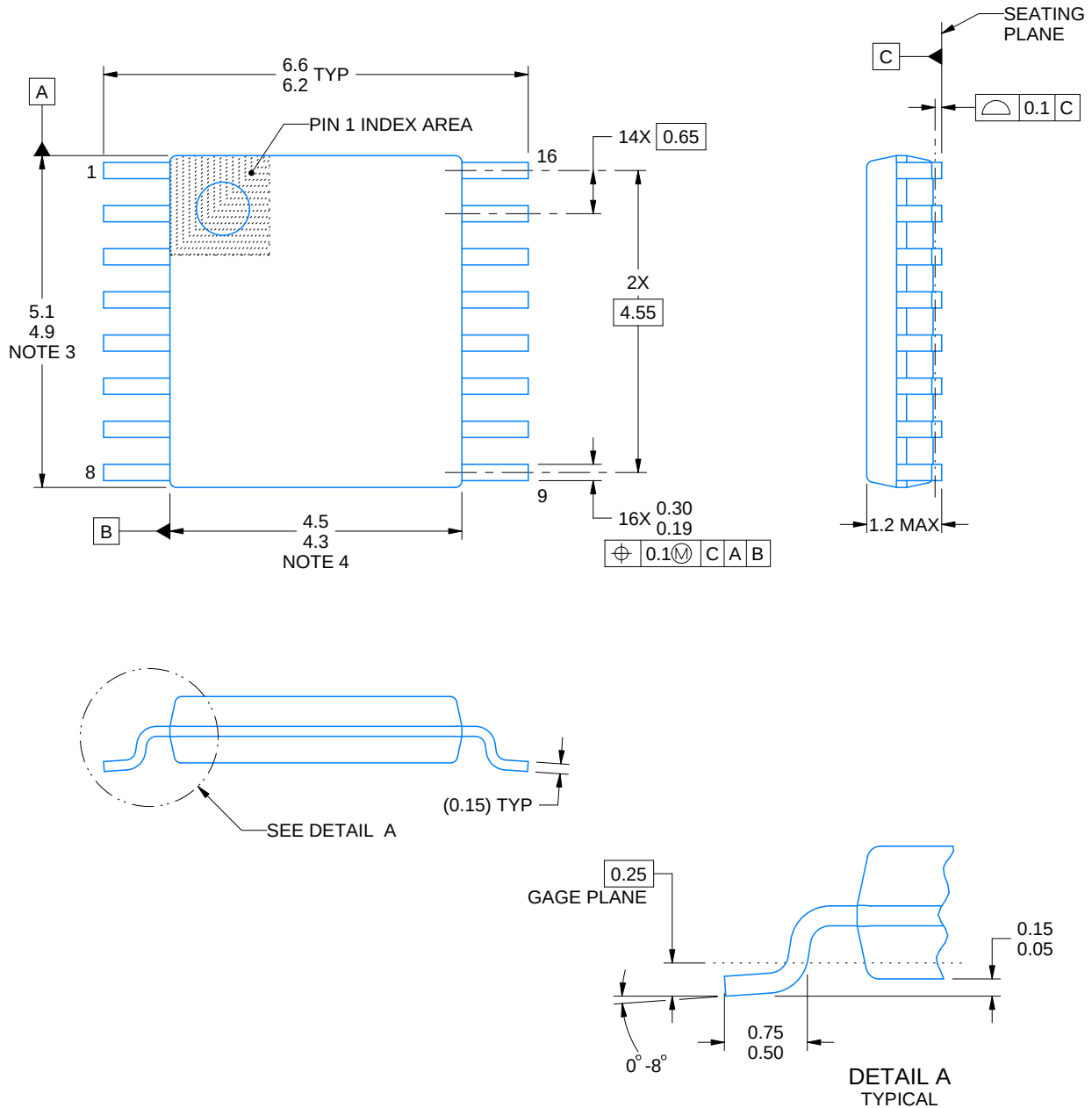
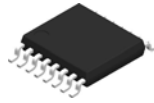
| Device        | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| MAX3221CDBR   | SSOP         | DB              | 16   | 2000 | 330.0              | 16.4               | 8.35    | 6.6     | 2.4     | 12.0    | 16.0   | Q1            |
| MAX3221CDBR   | SSOP         | DB              | 16   | 2000 | 330.0              | 16.4               | 8.35    | 6.6     | 2.4     | 12.0    | 16.0   | Q1            |
| MAX3221CPWR   | TSSOP        | PW              | 16   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| MAX3221CPWR   | TSSOP        | PW              | 16   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| MAX3221IDBR   | SSOP         | DB              | 16   | 2000 | 330.0              | 16.4               | 8.35    | 6.6     | 2.4     | 12.0    | 16.0   | Q1            |
| MAX3221IDBR   | SSOP         | DB              | 16   | 2000 | 330.0              | 16.4               | 8.35    | 6.6     | 2.4     | 12.0    | 16.0   | Q1            |
| MAX3221IPWR   | TSSOP        | PW              | 16   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| MAX3221IPWRG4 | TSSOP        | PW              | 16   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| MAX3221IPWRG4 | 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) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| MAX3221CDBR   | SSOP         | DB              | 16   | 2000 | 356.0       | 356.0      | 35.0        |
| MAX3221CDBR   | SSOP         | DB              | 16   | 2000 | 356.0       | 356.0      | 35.0        |
| MAX3221CPWR   | TSSOP        | PW              | 16   | 2000 | 356.0       | 356.0      | 35.0        |
| MAX3221CPWR   | TSSOP        | PW              | 16   | 2000 | 356.0       | 356.0      | 35.0        |
| MAX3221IDBR   | SSOP         | DB              | 16   | 2000 | 356.0       | 356.0      | 35.0        |
| MAX3221IDBR   | SSOP         | DB              | 16   | 2000 | 356.0       | 356.0      | 35.0        |
| MAX3221IPWR   | TSSOP        | PW              | 16   | 2000 | 356.0       | 356.0      | 35.0        |
| MAX3221IPWRG4 | TSSOP        | PW              | 16   | 2000 | 356.0       | 356.0      | 35.0        |
| MAX3221IPWRG4 | TSSOP        | PW              | 16   | 2000 | 356.0       | 356.0      | 35.0        |



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## NOTES:

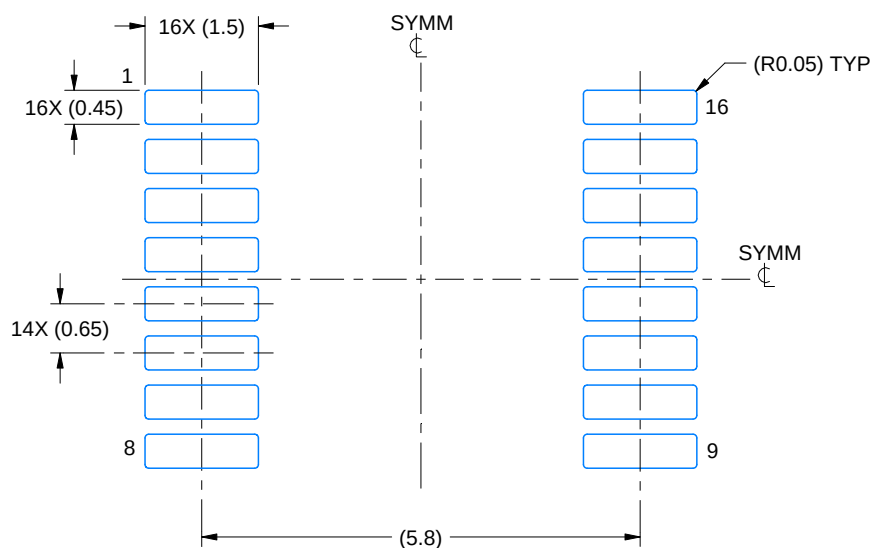
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or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

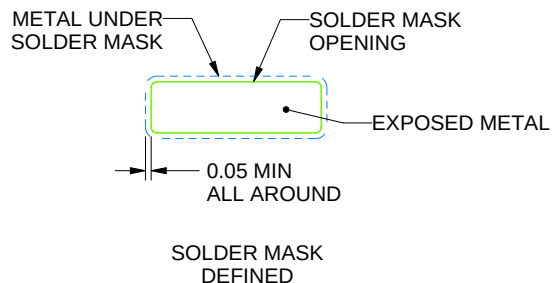
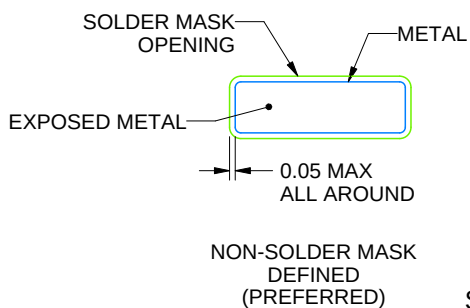
PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 10X



SOLDER MASK DETAILS

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NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

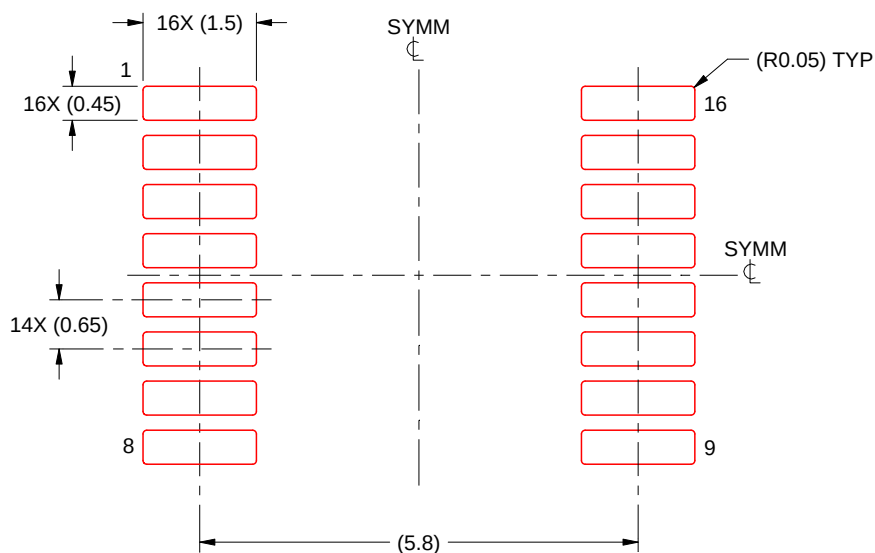
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE

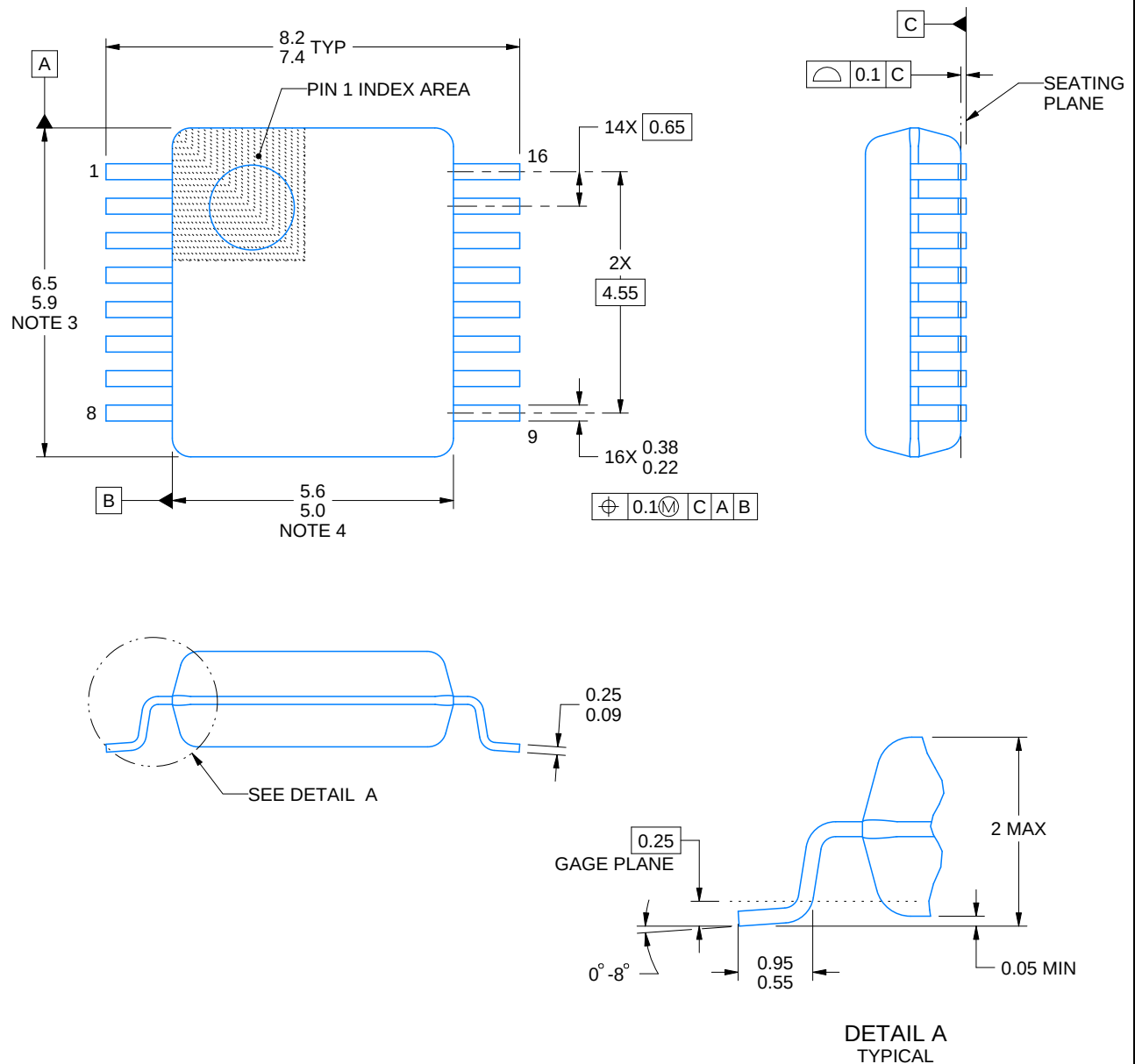


SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE: 10X

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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.

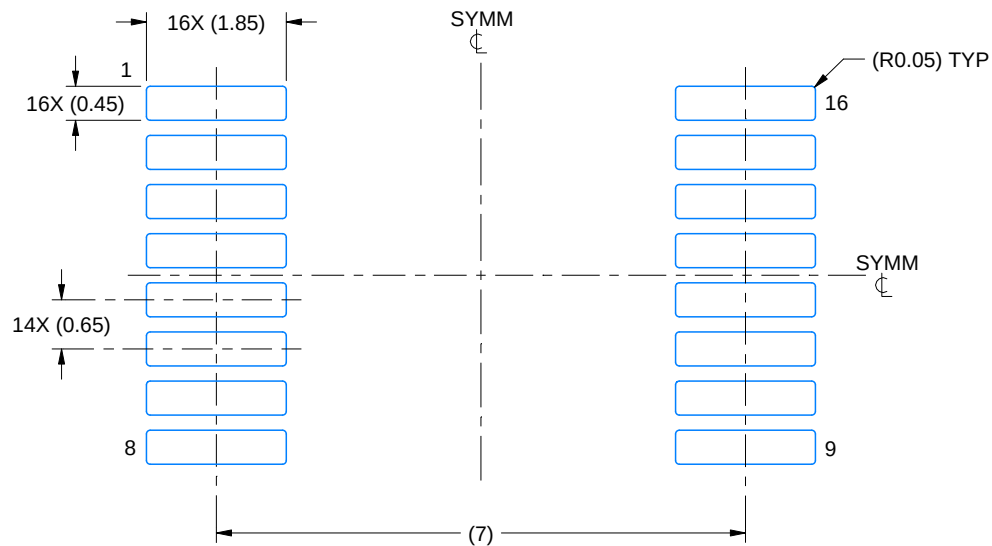


# EXAMPLE BOARD LAYOUT

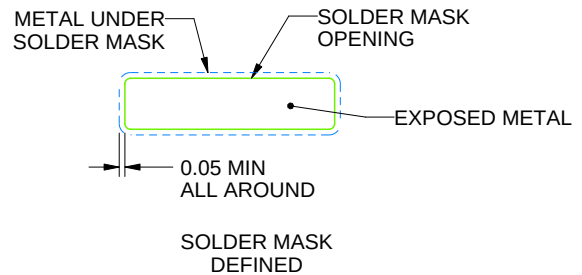
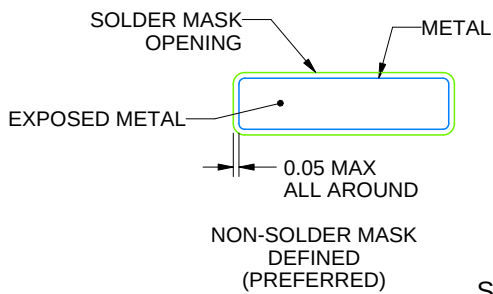
DB0016A

SSOP - 2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 10X



SOLDER MASK DETAILS

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NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.

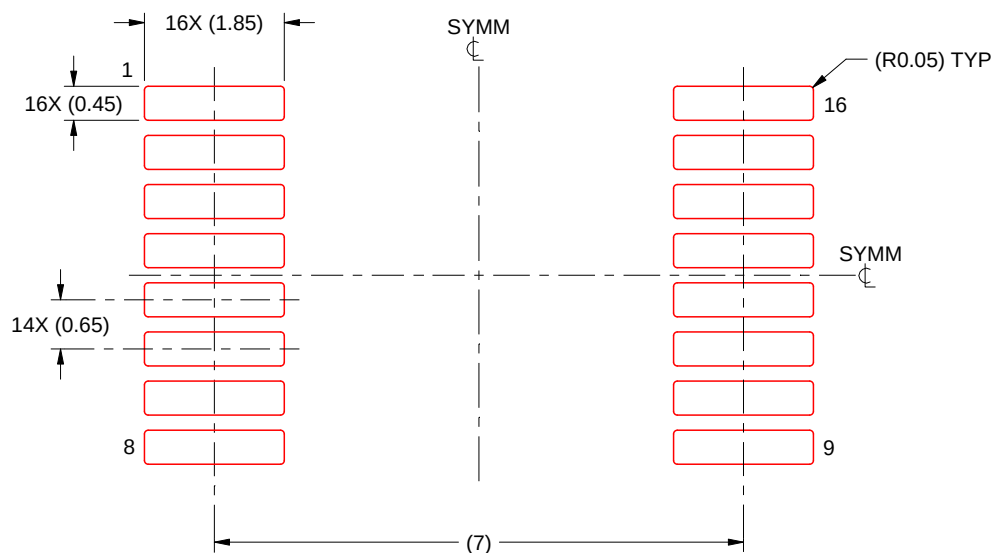
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

DB0016A

SSOP - 2 mm max height

SMALL OUTLINE PACKAGE



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

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NOTES: (continued)

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

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