

## TMP23x 低功耗高精度模拟输出温度传感器

### 1 特性

- 具有成本效益的热敏电阻替代产品
- 在宽温度范围内具有高精度：
  - $\pm 2.5^{\circ}\text{C}$  (最大值)： $-40^{\circ}\text{C}$  至  $+150^{\circ}\text{C}$  (TMP235)
  - $\pm 2.5^{\circ}\text{C}$  (最大值)： $-10^{\circ}\text{C}$  至  $+125^{\circ}\text{C}$  (TMP236)
- 提供两种精度级别型号：
  - A2 级： $\pm 0.5^{\circ}\text{C}$  (典型值)
  - A4 级： $\pm 1^{\circ}\text{C}$  (典型值)
- 正斜率传感器增益，失调电压 (典型值)：
  - $10\text{mV}/^{\circ}\text{C}$ ,  $0^{\circ}\text{C}$  下  $500\text{mV}$  (TMP235)
  - $19.5\text{mV}/^{\circ}\text{C}$ ,  $0^{\circ}\text{C}$  下  $400\text{mV}$  (TMP236)
- 宽工作电源电压范围：
  - $2.3\text{V}$  至  $5.5\text{V}$  (TMP235)
  - $3.1\text{V}$  至  $5.5\text{V}$  (TMP236)
- 输出短路保护
- 低功耗： $9\mu\text{A}$  (典型值)
- 输出强大，可驱动高达  $1000\text{pF}$  的负载
- 提供的封装选项：
  - 5 引脚 SC70 (DCK) 表面贴装
  - 3 引脚 SOT-23 (DBZ) 表面贴装
  - 封装尺寸兼容符合行业标准的 LMT8x-Q1 和 LM20 温度传感器

### 2 应用

- 电网基础设施
- 无线和电信基础设施
- 汽车信息娱乐系统

- 工厂自动化和控制
- 测试和测量

### 3 说明

TMP23x 器件是一系列精密 CMOS 集成电路线性模拟温度传感器，其输出电压与温度成正比，工程师可以将其用于多种模拟温度检测应用。这些温度传感器比市面上同类引脚兼容器件的精确度更高，在  $0^{\circ}\text{C}$  至  $+70^{\circ}\text{C}$  温度范围内  $\pm 0.5^{\circ}\text{C}$  的典型精度。该系列器件的精度经提高后，可适用于众多模拟温度检测应用。

TMP235 器件在  $-40^{\circ}\text{C}$  至  $+150^{\circ}\text{C}$  完全温度范围和  $2.3\text{V}$  至  $5.5\text{V}$  电源电压范围内提供  $10\text{mV}/^{\circ}\text{C}$  正斜率输出。具有更高增益的 TMP236 传感器在  $-10^{\circ}\text{C}$  至  $+125^{\circ}\text{C}$  温度范围和  $3.1\text{V}$  至  $5.5\text{V}$  电源电压范围内提供  $19.5\text{mV}/^{\circ}\text{C}$  正斜率输出。

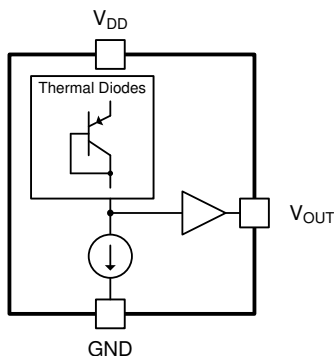
$9\mu\text{A}$  典型静态电流和  $800\mu\text{s}$  典型加电时间可实现有效的功率循环架构，以最大限度地降低电池供电设备的功率损耗。AB 类输出驱动器提供强大的  $500\mu\text{A}$  最高输出，可驱动高达  $1000\text{pF}$  的电容负载，并可直接连接到模数转换器采样保持输入端。凭借出色的精确度和强大的线性输出驱动器，TMP23x 模拟输出温度传感器是具有成本效益的无源热敏电阻替代方案。

器件信息<sup>(1)</sup>

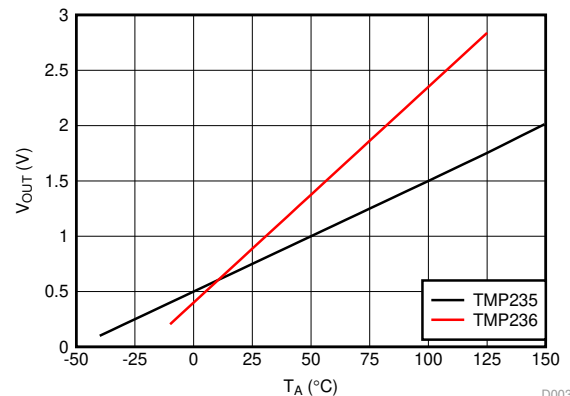
| 器件型号              | 封装         | 封装尺寸 (标称值)                           |
|-------------------|------------|--------------------------------------|
| TMP235,<br>TMP236 | SC70 (5)   | $2.00\text{mm} \times 1.25\text{mm}$ |
|                   | SOT-23 (3) | $2.92\text{mm} \times 1.30\text{mm}$ |

(1) 如需了解所有可用封装，请参阅产品说明书末尾的可订购产品附录。

功能方框图



输出电压与环境温度间的关系



D003



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## 4 修订历史记录

注：之前版本的页码可能与当前版本有所不同。

### Changes from Revision D (August 2018) to Revision E Page

|   |                                                                                                  |    |
|---|--------------------------------------------------------------------------------------------------|----|
| • | Changed recommended operating temperature range from: –50°C to 150°C to: –40°C to 150°C          | 4  |
| • | Changed power supply bypassing recommendations on how to avoid noise effect on the device output | 12 |

### Changes from Revision C (August 2018) to Revision D Page

|   |                               |   |
|---|-------------------------------|---|
| • | 将 DBZ (SOT-23) 封装状态从预览更改为生产数据 | 1 |
|---|-------------------------------|---|

### Changes from Revision B (February 2018) to Revision C Page

|   |                                                                                                            |   |
|---|------------------------------------------------------------------------------------------------------------|---|
| • | 添加了 DBZ (SOT-23) 预览封装                                                                                      | 1 |
| • | Added TMP236 test conditions to the operating current parameters                                           | 5 |
| • | Added SOT-23 and SC70 package test conditions to the Accuracy Level 2 (A2) limits in the 0°C to 70°C range | 5 |

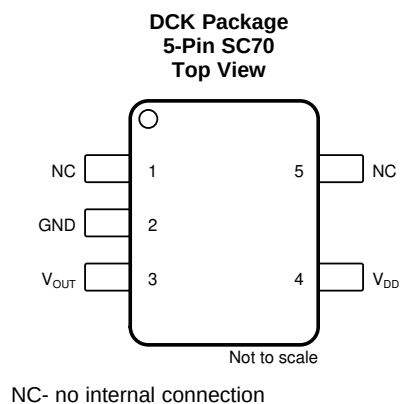
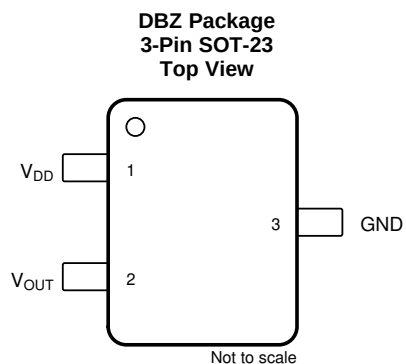
### Changes from Revision A (December 2017) to Revision B Page

|   |                                                                                                                   |    |
|---|-------------------------------------------------------------------------------------------------------------------|----|
| • | 已更改 将典型精度规格参考值从 $\pm 1^\circ\text{C}$ 和 $\pm 2^\circ\text{C}$ 更改为 $\pm 0.5^\circ\text{C}$ 和 $\pm 1^\circ\text{C}$ | 1  |
| • | Deleted erroneous AOQL footnote                                                                                   | 5  |
| • | Changed specification limits indicated in 图 1                                                                     | 6  |
| • | Added <i>Device Functional Modes</i> section                                                                      | 10 |

### Changes from Original (September 2017) to Revision A Page

|   |                            |   |
|---|----------------------------|---|
| • | 已更改 将文档状态从“预告信息”更改成了“生产数据” | 1 |
|---|----------------------------|---|

## 5 Pin Configuration and Functions



### Pin Functions

| NAME             | PIN    |      | TYPE   | DESCRIPTION                                                                |
|------------------|--------|------|--------|----------------------------------------------------------------------------|
|                  | SOT-23 | SC70 |        |                                                                            |
| GND              | 3      | 2    | Ground | Power supply ground.                                                       |
| NC               | —      | 5    | —      | No internal connection. This pin may be left floating or connected to GND. |
| NC               | —      | 1    | —      | No internal connection. This pin may be left floating or connected to GND. |
| V <sub>OUT</sub> | 2      | 3    | O      | Outputs voltage proportional to temperature                                |
| V <sub>DD</sub>  | 1      | 4    | I      | Positive supply input                                                      |

## 6 Specifications

### 6.1 Absolute Maximum Ratings

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

|                                   | MIN  | MAX                | UNIT |
|-----------------------------------|------|--------------------|------|
| Supply voltage, $V_{DD}$          |      | +6                 | V    |
| Output voltage, $V_{OUT}$         | −0.3 | ( $V_{DD} + 0.3$ ) |      |
| Output current                    | −30  | +30                | mA   |
| Latch-up current, each pin        | −200 | +200               |      |
| Junction temperature ( $T_J$ )    |      | +150               | °C   |
| Storage temperature ( $T_{stg}$ ) | −65  | +150               |      |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

### 6.2 ESD Ratings

|             |                         | VALUE                                                                          | UNIT  |
|-------------|-------------------------|--------------------------------------------------------------------------------|-------|
| $V_{(ESD)}$ | Electrostatic discharge | Human-body model (HBM) per JESD22-A114 <sup>(1)</sup>                          | ±4000 |
|             |                         | Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup> | ±1000 |

- (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

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

|          |                                | MIN | NOM | MAX | UNIT |
|----------|--------------------------------|-----|-----|-----|------|
| $V_{DD}$ | Input voltage (TMP235)         | 2.3 |     | 5.5 | V    |
|          | Input voltage (TMP236)         | 3.1 |     | 5.5 |      |
| $T_A$    | Operating free-air temperature | −40 |     | 150 | °C   |

### 6.4 Thermal Information

| THERMAL METRIC <sup>(1)(2)</sup> |                                                          | TMP235     |              | UNIT |
|----------------------------------|----------------------------------------------------------|------------|--------------|------|
|                                  |                                                          | DCK (SC70) | DBZ (SOT-23) |      |
|                                  |                                                          | PINS       | PINS         |      |
| $R_{\theta JA}$                  | Junction-to-ambient thermal resistance <sup>(3)(4)</sup> | 275        | 167          | °C/W |
| $R_{\theta JC(top)}$             | Junction-to-case (top) thermal resistance                | 84         | 90           | °C/W |
| $R_{\theta JB}$                  | Junction-to-board thermal resistance                     | 56         | 146          | °C/W |
| $\Psi_{JT}$                      | Junction-to-top characterization parameter               | 1.2        | 35           | °C/W |
| $\Psi_{JB}$                      | Junction-to-board characterization parameter             | 55         | 146          | °C/W |

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.
- (2) For information on self-heating and thermal response time see [Layout Guidelines](#) section.
- (3) The junction to ambient thermal resistance ( $R_{\theta JA}$ ) under natural convection is obtained in a simulation on a JEDEC-standard, High-K board as specified in JESD51-7, in an environment described in JESD51-2. Exposed pad packages assume that thermal vias are included in the PCB, per JESD 51-5.
- (4) Changes in output due to self heating can be computed by multiplying the internal dissipation by the thermal resistance.

## 6.5 Electrical Characteristics

TMP235:  $V_{DD} = 2.3 \text{ V}$  to  $5.5 \text{ V}$ , GND = Ground,  $T_A = -40^\circ\text{C}$  to  $+125^\circ\text{C}$  and no load (unless otherwise noted)

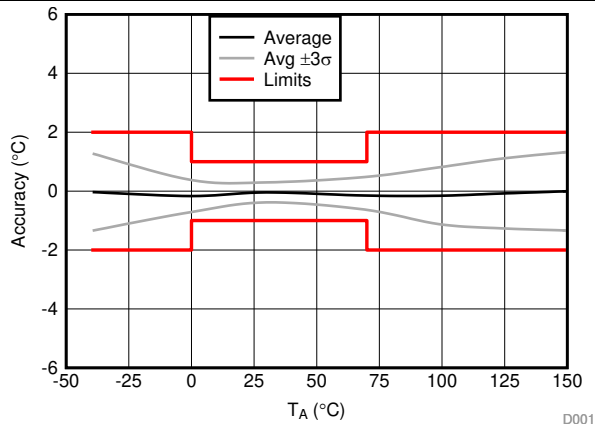
TMP236:  $V_{DD} = 3.1 \text{ V}$  to  $5.5 \text{ V}$ , GND = Ground,  $T_A = -10^\circ\text{C}$  to  $+125^\circ\text{C}$  and no load (unless otherwise noted)

| PARAMETER                |                                       |                                             | TEST CONDITIONS                                                                                | MIN                                            | TYP  | MAX  | UNIT  |      |
|--------------------------|---------------------------------------|---------------------------------------------|------------------------------------------------------------------------------------------------|------------------------------------------------|------|------|-------|------|
| POWER SUPPLY             |                                       |                                             |                                                                                                |                                                |      |      |       |      |
| I <sub>DD</sub>          | Operating current                     |                                             | T <sub>A</sub> = 25°C, V <sub>DD</sub> = 2.3 V, TMP235                                         | 9                                              |      |      | μA    |      |
|                          |                                       |                                             | T <sub>A</sub> = 25°C, V <sub>DD</sub> = 3.1 V, TMP236                                         | 10                                             |      |      |       |      |
|                          |                                       |                                             | T <sub>A</sub> = −40°C to +125°C, TMP235                                                       | 14.5                                           |      |      |       |      |
|                          |                                       |                                             | T <sub>A</sub> = −10°C to +125°C, TMP236                                                       | 15                                             |      |      |       |      |
|                          |                                       |                                             | T <sub>A</sub> = 150°C, TMP235                                                                 | 17                                             |      |      |       |      |
| Δ°C/<br>ΔV <sub>DD</sub> | Line regulation                       |                                             |                                                                                                | −0.1                                           | 0.02 | 0.1  | °C/V  |      |
| SENSOR ACCURACY          |                                       |                                             |                                                                                                |                                                |      |      |       |      |
| T <sub>ACY</sub>         | Temperature accuracy <sup>(1)</sup>   |                                             |                                                                                                | T <sub>A</sub> = 25°C                          | ±0.5 |      | °C    |      |
|                          |                                       |                                             |                                                                                                | T <sub>A</sub> = 0°C to 70°C (SC70 Package)    | −1   | ±0.5 |       | +1   |
|                          |                                       |                                             |                                                                                                | T <sub>A</sub> = 0°C to +70°C (SOT-23 Package) | −1.2 | ±0.5 |       | +1.2 |
|                          |                                       |                                             |                                                                                                | T <sub>A</sub> = −40°C to +125°C (TMP235A2)    | −2   | ±0.5 |       | +2   |
|                          |                                       |                                             |                                                                                                | T <sub>A</sub> = −10°C to +125°C (TMP236A2)    | −2   | ±0.5 |       | +2   |
|                          |                                       |                                             |                                                                                                | T <sub>A</sub> = −40°C to +150°C (TMP235A2)    | −2   | ±0.5 |       | +2   |
|                          |                                       |                                             | Accuracy Level 4 (A4)                                                                          | T <sub>A</sub> = 25°C                          | ±1   |      |       |      |
|                          |                                       |                                             |                                                                                                | T <sub>A</sub> = 0°C to 70°C                   | −2   | ±1   |       | +2   |
|                          |                                       |                                             |                                                                                                | T <sub>A</sub> = −40°C to +125°C (TMP235A4)    | −4   | ±1   |       | +4   |
|                          |                                       |                                             |                                                                                                | T <sub>A</sub> = −10°C to +125°C (TMP236A4)    | −4   | ±1   |       | +4   |
|                          |                                       | T <sub>A</sub> = −40°C to +150°C (TMP235A4) | −5                                                                                             | ±1                                             | +5   |      |       |      |
| SENSOR OUTPUT            |                                       |                                             |                                                                                                |                                                |      |      |       |      |
| V <sub>0°C</sub>         | Output voltage offset at 0 °C         |                                             | TMP235                                                                                         | 500                                            |      |      | mV    |      |
|                          |                                       |                                             | TMP236                                                                                         | 400                                            |      |      |       |      |
| T <sub>C</sub>           | Temperature coefficient (sensor gain) |                                             | TMP235                                                                                         | 10                                             |      |      | mV/°C |      |
|                          |                                       |                                             | TMP236                                                                                         | 19.5                                           |      |      |       |      |
| V <sub>ONL</sub>         | Output nonlinearity <sup>(1)</sup>    |                                             | T <sub>A</sub> = 0 °C to 70 °C, no load                                                        | ±0.5                                           |      |      | °C    |      |
| I <sub>OUT</sub>         | Output current                        |                                             |                                                                                                | 500                                            |      |      | μA    |      |
| Z <sub>OUT</sub>         | Output impedance                      |                                             | I <sub>OUT</sub> = 100 μA, f = 100 Hz                                                          | 20                                             |      |      | Ω     |      |
|                          |                                       |                                             | I <sub>OUT</sub> = 100 μA, f = 500 Hz                                                          | 50                                             |      |      |       |      |
|                          | Output load regulation                |                                             | T <sub>A</sub> = 0°C to 70°C, I <sub>OUT</sub> = 100 μA, ΔV <sub>OUT</sub> / ΔI <sub>OUT</sub> | 1                                              |      |      | Ω     |      |
| t <sub>ON</sub>          | Turn on time                          |                                             | Time to reach accuracy within ±0.5°C                                                           | 800                                            |      |      | μs    |      |
| C <sub>LOAD</sub>        | Typical load capacitance              |                                             |                                                                                                | 1000                                           |      |      | pF    |      |
| t <sub>RES</sub>         | Thermal response to 63%               | SC70                                        | 30°C (Air) to +125°C (Fluid Bath)                                                              | 1.3                                            |      |      | s     |      |

- (1) Accuracy is defined as the error between the measured and reference output voltages, tabulated in the [TMP235 Transfer Table](#) and [TMP236 Transfer Table](#) at the specified conditions of supply voltage and temperature (expressed in  $^\circ\text{C}$ ). Accuracy limits include line regulation within the specified conditions. Accuracy limits do not include load regulation; they assume no DC load.

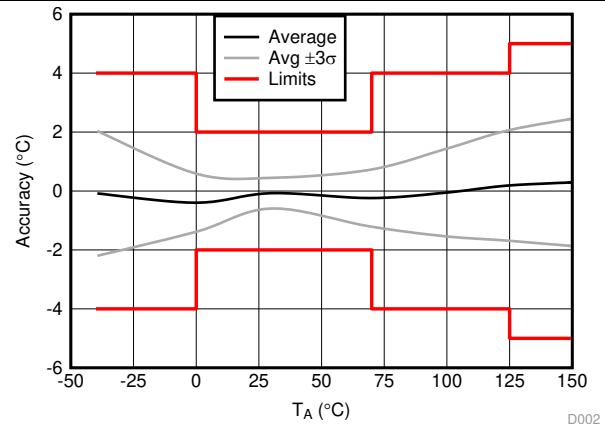
## 6.6 Typical Characteristics

at  $T_A = 25^\circ\text{C}$ , (unless otherwise noted)



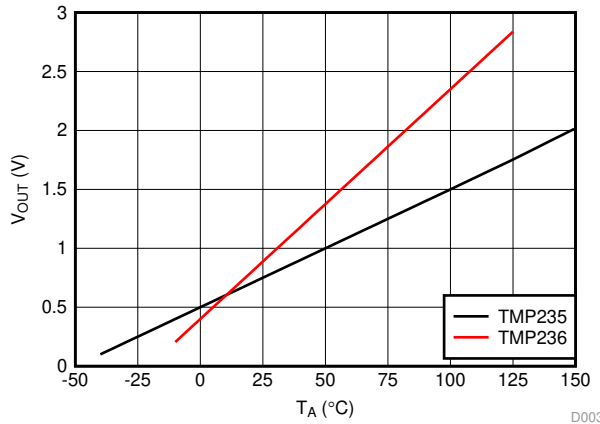
TMP235:  $V_{DD} = 2.3$  to  $5.5$  V,  $I_{OUT} = 0$   $\mu\text{A}$ ,  $C_{LOAD} = 1000$  pF

图 1. Accuracy vs.  $T_A$  Temperature (A2 Accuracy Level)



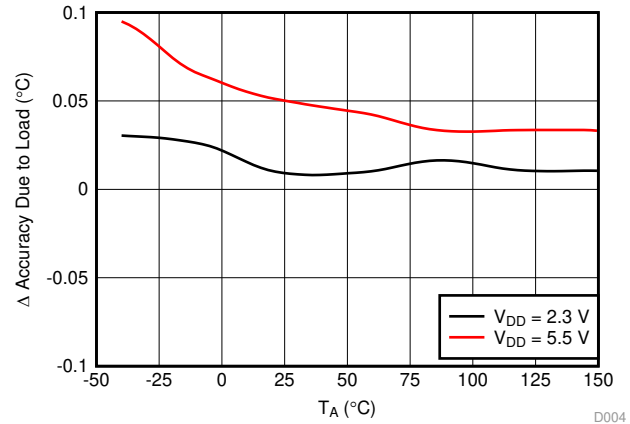
TMP235:  $V_{DD} = 2.3$  to  $5.5$  V,  $I_{OUT} = 0$   $\mu\text{A}$ ,  $C_{LOAD} = 1000$  pF

图 2. Accuracy vs.  $T_A$  Temperature (A4 Accuracy Level)



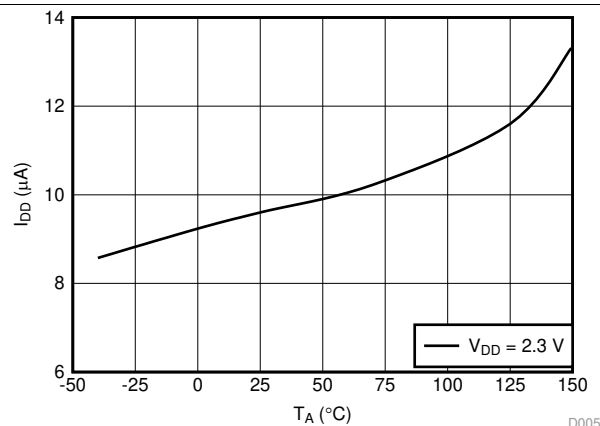
$I_{OUT} = 0$   $\mu\text{A}$ ,  $C_{LOAD} = 1000$  pF

图 3. Output Voltage vs. Ambient Temperature



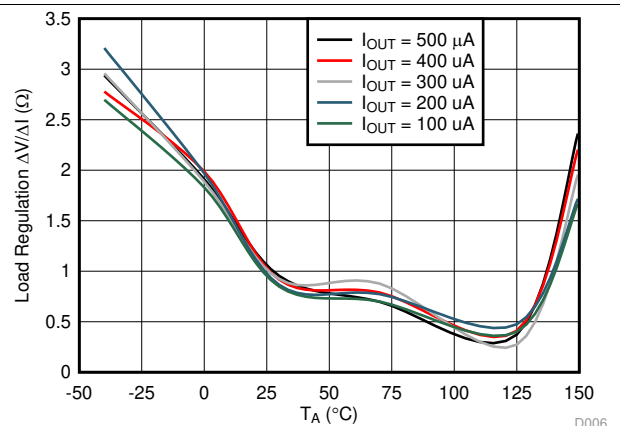
TMP235:  $I_{OUT}$  = from 0  $\mu\text{A}$  to 100  $\mu\text{A}$ ,  $C_{LOAD} = 1000$  pF

图 4. Changes in Accuracy vs. Ambient Temperature (Due to Load)



TMP235:  $I_{OUT} = 0$   $\mu\text{A}$ ,  $C_{LOAD} = 1000$  pF

图 5. Supply Current vs. Temperature



TMP235:  $V_{DD} = 2.3$  V,  $C_{LOAD} = 1000$  pF

图 6. Load Regulation vs. Ambient Temperature

## Typical Characteristics (接下页)

at  $T_A = 25^\circ\text{C}$ , (unless otherwise noted)

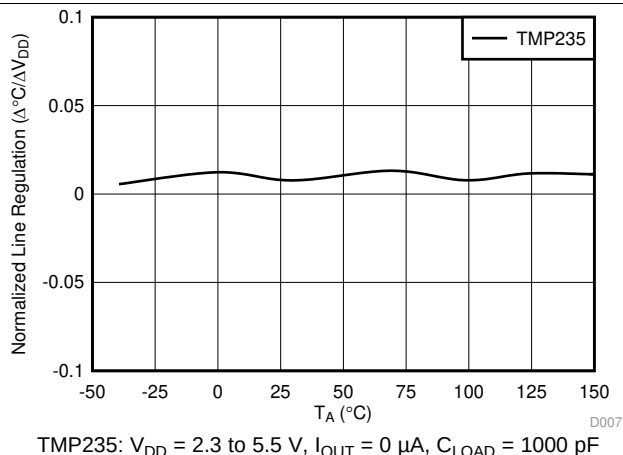


图 7. Line Regulation ( $\Delta^\circ\text{C} / \Delta V_{DD}$ ) vs. Ambient Temperature

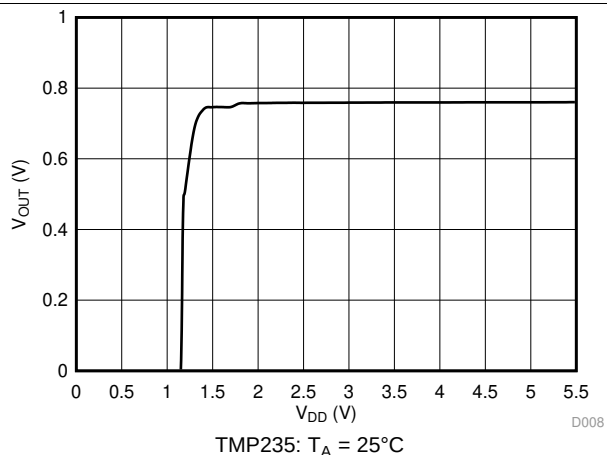


图 8. Output Voltage vs. Power Supply

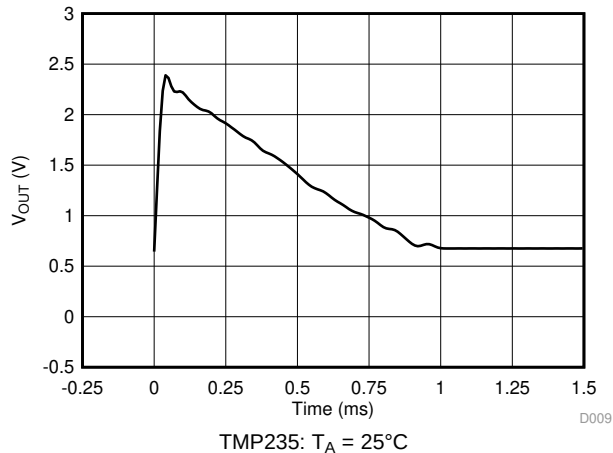


图 9. Output vs. Settling Time to Step  $V_{DD}$

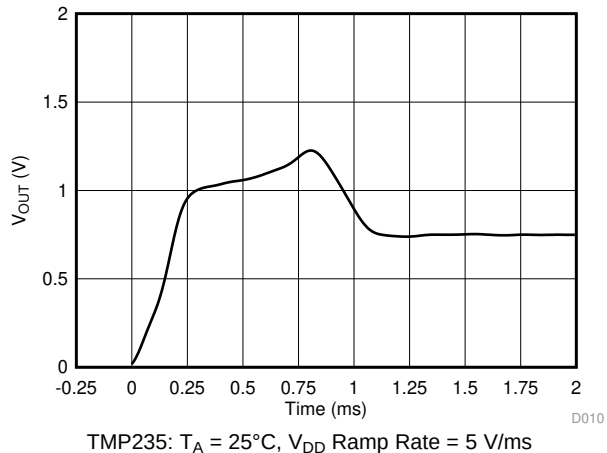


图 10. Output vs. Settling Time to Ramp  $V_{DD}$

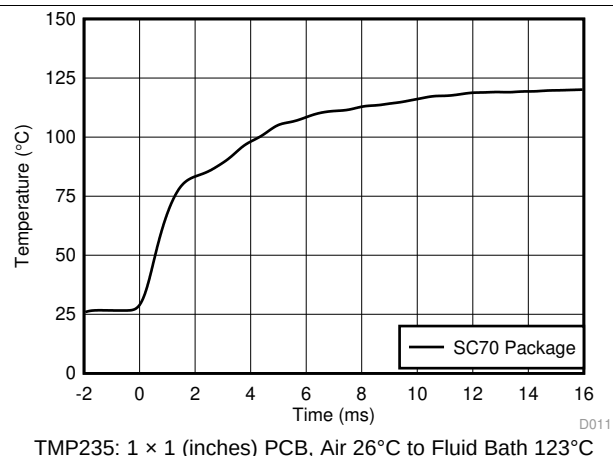


图 11. Thermal Response (Air-to-Fluid Bath)

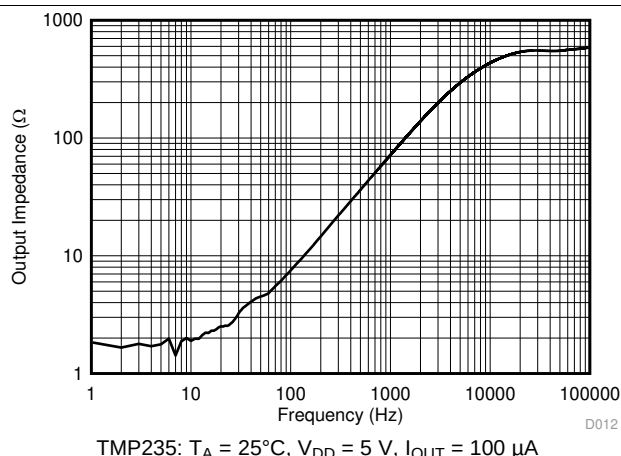


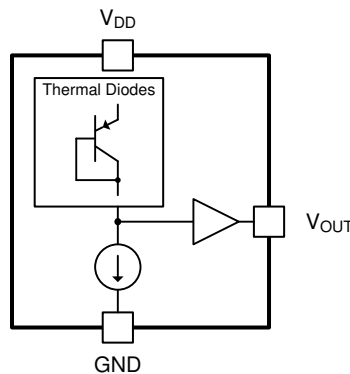
图 12. Output Impedance vs. Frequency

## 7 Detailed Description

### 7.1 Overview

The TMP23x devices are a family of linear analog temperature sensors with an output voltage proportional to temperature. These temperature sensors have an accuracy from 0°C to 70°C of ±1.25°C (TMP23xA2) and ±2°C (TMP23xA4). The TMP235 device provides a positive slope output of 10 mV/°C over the full –40°C to +150°C temperature range and a supply range from 2.3 V to 5.5 V. The higher gain TMP236 sensor provides a positive slope output of 19.5 mV/°C from –10°C to +125°C and a supply range from 3.1 V to 5.5 V. A class-AB output driver provides a maximum output of 500 µA to drive capacitive loads up to 1000 pF.

### 7.2 Functional Block Diagram



### 7.3 Feature Description

As shown in 图 3, the TMP23x devices are linear. A small  $V_{OUT}$  gain shift, however, is present at temperatures above 100°C. When small shifts are expected, a piecewise linear function provides the best accuracy and is used for the device accuracy specifications (see [Specifications](#)). Typical output voltages of the TMP23x devices across the full operating temperature range are listed in 表 3 and 表 4. The ideal linear columns represent the ideal linear  $V_{OUT}$  output response with respect to temperature, while the piecewise linear columns indicate the small voltage shift at elevated temperatures.

The piecewise linear function uses three temperature ranges listed in 表 1 and 表 2. In equation form, the voltage output  $V_{OUT}$  of the TMP23x is calculated by 公式 1:

$$V_{OUT} = (T_A - T_{INFL}) \times T_C + V_{OFFS}$$

where

- $V_{OUT}$  is the TMP23x voltage output for a given temperature
  - $T_A$  is the ambient temperature in °C
  - $T_{INFL}$  is the temperature inflection point for a piecewise segment in °C
  - $T_C$  is the TMP23x temperature coefficient or gain
  - $V_{OFFS}$  is the TMP23x voltage offset
- (1)

Therefore, the  $T_A$  temperature for a given  $V_{OUT}$  voltage output within a piecewise voltage range ( $V_{RANGE}$ ) is calculated in 公式 2. For applications where the accuracy enhancement above 100°C is not required, use the first row of 表 1 and 表 2 for all voltages.

$$T_A = (V_{OUT} - V_{OFFS}) / T_C + T_{INFL}$$

(2)

表 1. TMP235 Piecewise Linear Function Summary

| $T_A$ RANGE (°C) | $V_{RANGE}$ (mV) | $T_{INFL}$ (°C) | $T_C$ (mV/°C) | $V_{OFFS}$ (mV) |
|------------------|------------------|-----------------|---------------|-----------------|
| –40 to +100      | < 1500           | 0               | 10            | 500             |
| 100 to 125       | 1500 to 1752.5   | 100             | 10.1          | 1500            |
| 125 to 150       | > 1752.5         | 125             | 10.6          | 1752.5          |

**表 2. TMP236 Piecewise Linear Function Summary**

| $T_A$ RANGE (°C) | $V_{RANGE}$ (mV) | $T_{INFL}$ (°C) | $T_C$ (mV/°C) | $V_{OFFS}$ (mV) |
|------------------|------------------|-----------------|---------------|-----------------|
| –40 to +100      | $\leq 2350$      | 0               | 19.5          | 400             |
| 100 to 125       | $> 2350$         | 100             | 19.7          | 2350            |
| 125 to 150       | —                | —               | —             | —               |

**表 3. TMP235 Transfer Table**

| TEMPERATURE (°C) | $V_{OUT}$ (mV)<br>IDEAL LINEAR VALUES | $V_{OUT}$ (mV)<br>PIECEWISE LINEAR VALUES |
|------------------|---------------------------------------|-------------------------------------------|
| –40              | 100                                   | 100                                       |
| –35              | 150                                   | 150                                       |
| –30              | 200                                   | 200                                       |
| –25              | 250                                   | 250                                       |
| –20              | 300                                   | 300                                       |
| –15              | 350                                   | 350                                       |
| –10              | 400                                   | 400                                       |
| –5               | 450                                   | 450                                       |
| 0                | 500                                   | 500                                       |
| 5                | 550                                   | 550                                       |
| 10               | 600                                   | 600                                       |
| 15               | 650                                   | 650                                       |
| 20               | 700                                   | 700                                       |
| 25               | 750                                   | 750                                       |
| 30               | 800                                   | 800                                       |
| 35               | 850                                   | 850                                       |
| 40               | 900                                   | 900                                       |
| 45               | 950                                   | 950                                       |
| 50               | 1000                                  | 1000                                      |
| 55               | 1050                                  | 1050                                      |
| 60               | 1100                                  | 1100                                      |
| 65               | 1150                                  | 1150                                      |
| 70               | 1200                                  | 1200                                      |
| 75               | 1250                                  | 1250                                      |
| 80               | 1300                                  | 1300                                      |
| 85               | 1350                                  | 1350                                      |
| 90               | 1400                                  | 1400                                      |
| 95               | 1450                                  | 1450                                      |
| 100              | 1500                                  | 1500                                      |
| 105              | 1550                                  | 1550.5                                    |
| 110              | 1600                                  | 1601                                      |
| 115              | 1650                                  | 1651.5                                    |
| 120              | 1700                                  | 1702                                      |
| 125              | 1750                                  | 1752.5                                    |
| 130              | 1800                                  | 1805.5                                    |
| 135              | 1850                                  | 1858.5                                    |
| 140              | 1900                                  | 1911.5                                    |
| 145              | 1950                                  | 1964.5                                    |
| 150              | 2000                                  | 2017.5                                    |

**表 4. TMP236 Transfer Table**

| TEMPERATURE (°C) | V <sub>OUT</sub> (mV)<br>IDEAL LINEAR VALUES | V <sub>OUT</sub> (mV)<br>PIECEWISE LINEAR VALUES |
|------------------|----------------------------------------------|--------------------------------------------------|
| –40              | —                                            | —                                                |
| –35              | —                                            | —                                                |
| –30              | —                                            | —                                                |
| –25              | —                                            | —                                                |
| –20              | —                                            | —                                                |
| –15              | —                                            | —                                                |
| –10              | 205                                          | 205                                              |
| –5               | 303                                          | 303                                              |
| 0                | 400                                          | 400                                              |
| 5                | 498                                          | 498                                              |
| 10               | 595                                          | 595                                              |
| 15               | 693                                          | 693                                              |
| 20               | 790                                          | 790                                              |
| 25               | 888                                          | 888                                              |
| 30               | 985                                          | 985                                              |
| 35               | 1083                                         | 1083                                             |
| 40               | 1180                                         | 1180                                             |
| 45               | 1278                                         | 1278                                             |
| 50               | 1375                                         | 1375                                             |
| 55               | 1473                                         | 1473                                             |
| 60               | 1570                                         | 1570                                             |
| 65               | 1668                                         | 1668                                             |
| 70               | 1765                                         | 1765                                             |
| 75               | 1863                                         | 1863                                             |
| 80               | 1960                                         | 1960                                             |
| 85               | 2058                                         | 2058                                             |
| 90               | 2155                                         | 2155                                             |
| 95               | 2253                                         | 2253                                             |
| 100              | 2350                                         | 2350                                             |
| 105              | 2448                                         | 2448.5                                           |
| 110              | 2545                                         | 2547                                             |
| 115              | 2643                                         | 2645.4                                           |
| 120              | 2740                                         | 2743.9                                           |
| 125              | 2838                                         | 2842.4                                           |
| 130              | —                                            | —                                                |
| 135              | —                                            | —                                                |
| 140              | —                                            | —                                                |
| 145              | —                                            | —                                                |
| 150              | —                                            | —                                                |

## 7.4 Device Functional Modes

The singular functional mode of the TMP23x is an analog output directly proportional to temperature.

## 8 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. Customers should validate and test their design implementation to confirm system functionality.

### 8.1 Application Information

The features of the TMP235 make the series of devices designed for various general temperature-sensing applications. The TMP235 and TMP236 devices can operate down to a 2.3-V and a 3.1-V supply with 9- $\mu$ A power consumption, respectively. As a result, the series is designed for battery-powered applications. The TMP23x series is mounted in two surface mount technology packages (SC70 and SOT-23.)

### 8.2 Typical Application

#### 8.2.1 Connection to an ADC

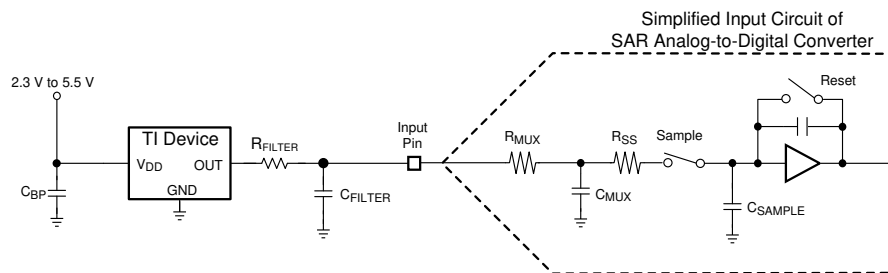


**Figure 13. Suggested Connections to an ADC Input Stage**

##### 8.2.1.1 Design Requirements

See Figure 13 for suggested connections to an ADC input stage. Most CMOS-based ADCs have a sampled data comparator input structure. When the ADC charges the sampling capacitor ( $C_{SAMPLE}$ ), the capacitor requires instantaneous charge from the output of the analog source temperature sensor, such as the TMP23x. Therefore, the output impedance of the temperature sensor can affect ADC performance. In most cases, adding an external capacitor ( $C_{FILTER}$ ) mitigates design challenges. The TMP23x is specified and characterized with a 1000-pF maximum capacitive load ( $C_{LOAD}$ ). Figure 13 shows  $C_{LOAD}$  as the sum of  $C_{FILTER} + C_{MUX} + C_{SAMPLE}$ . TI recommends maximizing the  $C_{FILTER}$  value while allowing for the maximum specified ADC input capacitance ( $C_{MUX} + C_{SAMPLE}$ ) to limit the total  $C_{LOAD}$  at 1000 pF. In most cases, a 680-pF  $C_{FILTER}$  provides a reasonable allowance for ADC input capacitance to minimize ADC sampling error and reduce noise coupling. An optional series resistor ( $R_{FILTER}$ ) and  $C_{FILTER}$  provides additional low-pass filtering to reject system level noise. TI recommends placing  $R_{FILTER}$  and  $C_{FILTER}$  as close as possible to the ADC input for optimal performance.

##### 8.2.1.2 Detailed Design Procedure

Depending on the input characteristics of the ADC, an external  $C_{FILTER}$  may be required. The value of  $C_{FILTER}$  depends on the size of the sampling capacitor ( $C_{SAMPLE}$ ) and the sampling frequency while observing a maximum  $C_{LOAD}$  of 1000 pF. The capacitor requirements can vary because the input stages of all ADCs are not identical. Figure 13 shows a general ADC application as an example only.

## Typical Application (continued)

### 8.2.1.3 Application Curve

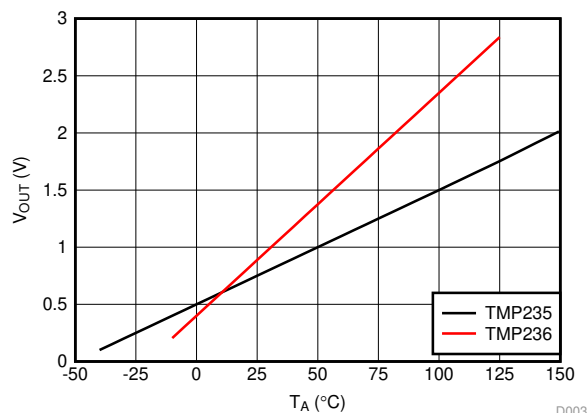


**Figure 14. Output Voltage vs. Ambient**

## 9 Power Supply Recommendations

The low supply current and supply range of the TMP23x allow the device to be easily powered from many sources.

Power supply bypassing is strongly recommended. In noisy environments, TI recommends to add a filter with 0.1-μF capacitor and 100-Ω resistor between external supply and V<sub>DD</sub> to limit the power supply noise. Larger capacitances may be required and are dependent on the noise of the power supply.

## 10 Layout

### 10.1 Layout Guidelines

The layout of the TMP23x series is simple. If a power supply bypass capacitor is used, the capacitor must be connected as [Layout Examples](#) shows.

### 10.2 Layout Examples

-  VIA to ground plane
-  VIA to power plane

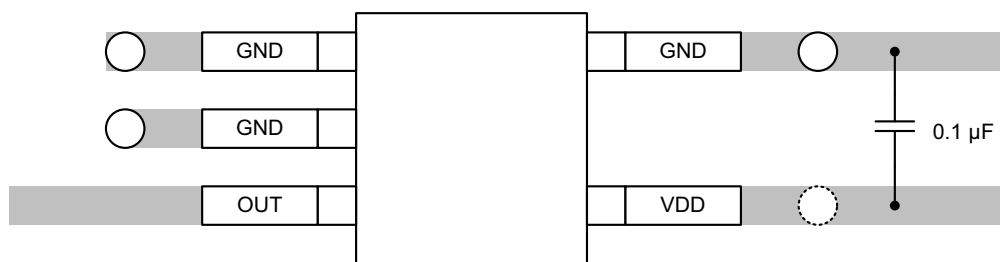


**Figure 15. Recommended Layout: SC70 Package**

## 11 器件和文档支持

### 11.1 相关链接

下表列出了快速访问链接。类别包括技术文档、支持和社区资源、工具和软件，以及立即订购快速访问。

表 5. 相关链接

| 器件     | 产品文件夹                | 立即订购                 | 技术文档                 | 工具与软件                | 支持和社区                |
|--------|----------------------|----------------------|----------------------|----------------------|----------------------|
| TMP235 | <a href="#">单击此处</a> | <a href="#">单击此处</a> | <a href="#">单击此处</a> | <a href="#">单击此处</a> | <a href="#">单击此处</a> |
| TMP236 | <a href="#">单击此处</a> | <a href="#">单击此处</a> | <a href="#">单击此处</a> | <a href="#">单击此处</a> | <a href="#">单击此处</a> |

### 11.2 接收文档更新通知

要接收文档更新通知，请导航至 [TI.com.cn](#) 上的器件产品文件夹。单击右上角的 [通知我](#) 进行注册，即可每周接收产品信息更改摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

### 11.3 社区资源

The following links connect to TI community resources. Linked contents are 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](#).

**TI E2E™ Online Community** *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At [e2e.ti.com](#), you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

**Design Support** *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

### 11.4 商标

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ESD 可能会损坏该集成电路。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措施和安装程序，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。

### 11.6 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

## 12 机械、封装和可订购信息

以下页面包含机械、封装和可订购信息。这些信息是指定器件的最新可用数据。数据如有变更，恕不另行通知，且不会对此文档进行修订。如需获取此数据表的浏览器版本，请查阅左侧的导航栏。

**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="#">TMP235A2DBZR</a> | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | NIPDAU   SN<br>  NIPDAUAG                        | Level-1-260C-UNLIM                | -40 to 150   | 2352                |
| TMP235A2DBZR.A               | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | NIPDAU                                           | Level-1-260C-UNLIM                | -40 to 150   | 2352                |
| TMP235A2DBZRG4.A             | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | -           | Call TI                                          | Call TI                           | -40 to 150   | 2352                |
| <a href="#">TMP235A2DCKR</a> | Active        | Production           | SC70 (DCK)   5   | 3000   LARGE T&R      | Yes         | NIPDAU   SN  <br>POST-PLAT AG<br>SPOT   NIPDAUAG | Level-1-260C-UNLIM                | -40 to 150   | 19L                 |
| TMP235A2DCKR.A               | Active        | Production           | SC70 (DCK)   5   | 3000   LARGE T&R      | Yes         | SN                                               | Level-1-260C-UNLIM                | -40 to 150   | 19L                 |
| <a href="#">TMP235A2DCKT</a> | Obsolete      | Production           | SC70 (DCK)   5   | -                     | -           | Call TI                                          | Call TI                           | -40 to 150   | 19L                 |
| <a href="#">TMP235A4DBZR</a> | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | NIPDAU   SN<br>  NIPDAUAG                        | Level-1-260C-UNLIM                | -40 to 150   | 2354                |
| TMP235A4DBZR.A               | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | NIPDAU                                           | Level-1-260C-UNLIM                | -40 to 150   | 2354                |
| TMP235A4DBZRG4               | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | NIPDAU                                           | Level-1-260C-UNLIM                | -40 to 150   | 2354                |
| TMP235A4DBZRG4.A             | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | NIPDAU                                           | Level-1-260C-UNLIM                | -40 to 150   | 2354                |
| <a href="#">TMP235A4DBZT</a> | Obsolete      | Production           | SOT-23 (DBZ)   3 | -                     | -           | Call TI                                          | Call TI                           | -40 to 150   | 2354                |
| <a href="#">TMP235A4DCKR</a> | Active        | Production           | SC70 (DCK)   5   | 3000   LARGE T&R      | Yes         | NIPDAU   SN  <br>POST-PLAT AG<br>SPOT   NIPDAUAG | Level-1-260C-UNLIM                | -40 to 150   | 19M                 |
| TMP235A4DCKR.A               | Active        | Production           | SC70 (DCK)   5   | 3000   LARGE T&R      | Yes         | SN                                               | Level-1-260C-UNLIM                | -40 to 150   | 19M                 |
| <a href="#">TMP236A2DBZR</a> | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | NIPDAU   SN<br>  NIPDAUAG                        | Level-1-260C-UNLIM                | -10 to 125   | 2362                |
| TMP236A2DBZR.A               | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | NIPDAU                                           | Level-1-260C-UNLIM                | -10 to 125   | 2362                |
| <a href="#">TMP236A2DBZT</a> | Obsolete      | Production           | SOT-23 (DBZ)   3 | -                     | -           | Call TI                                          | Call TI                           | -10 to 125   | 2362                |
| <a href="#">TMP236A2DCKR</a> | Active        | Production           | SC70 (DCK)   5   | 3000   LARGE T&R      | Yes         | NIPDAU   POST-PLAT<br>AG SPOT   NIPDAUAG         | Level-1-260C-UNLIM                | -10 to 125   | 1BS                 |
| TMP236A2DCKR.A               | Active        | Production           | SC70 (DCK)   5   | 3000   LARGE T&R      | Yes         | POST-PLAT AG SPOT                                | Level-1-260C-UNLIM                | -10 to 125   | 1BS                 |
| <a href="#">TMP236A2DCKT</a> | Obsolete      | Production           | SC70 (DCK)   5   | -                     | -           | Call TI                                          | Call TI                           | -10 to 125   | 1BS                 |
| <a href="#">TMP236A4DBZR</a> | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | NIPDAU   SN<br>  NIPDAUAG                        | Level-1-260C-UNLIM                | -10 to 125   | 2364                |
| TMP236A4DBZR.A               | Active        | Production           | SOT-23 (DBZ)   3 | 3000   LARGE T&R      | Yes         | NIPDAU                                           | Level-1-260C-UNLIM                | -10 to 125   | 2364                |
| <a href="#">TMP236A4DBZT</a> | Obsolete      | Production           | SOT-23 (DBZ)   3 | -                     | -           | Call TI                                          | Call TI                           | -10 to 125   | 2364                |

| 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="#">TMP236A4DCKR</a> | Active        | Production           | SC70 (DCK)   5 | 3000   LARGE T&R      | Yes         | NIPDAU   POST-PLAT<br>AG SPOT   NIPDAUAG | Level-1-260C-UNLIM                | -10 to 125   | 1BT                 |
| TMP236A4DCKR.A               | Active        | Production           | SC70 (DCK)   5 | 3000   LARGE T&R      | Yes         | POST-PLAT AG SPOT                        | Level-1-260C-UNLIM                | -10 to 125   | 1BT                 |
| <a href="#">TMP236A4DCKT</a> | Obsolete      | Production           | SC70 (DCK)   5 | -                     | -           | Call TI                                  | Call TI                           | -10 to 125   | 1BT                 |

<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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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.

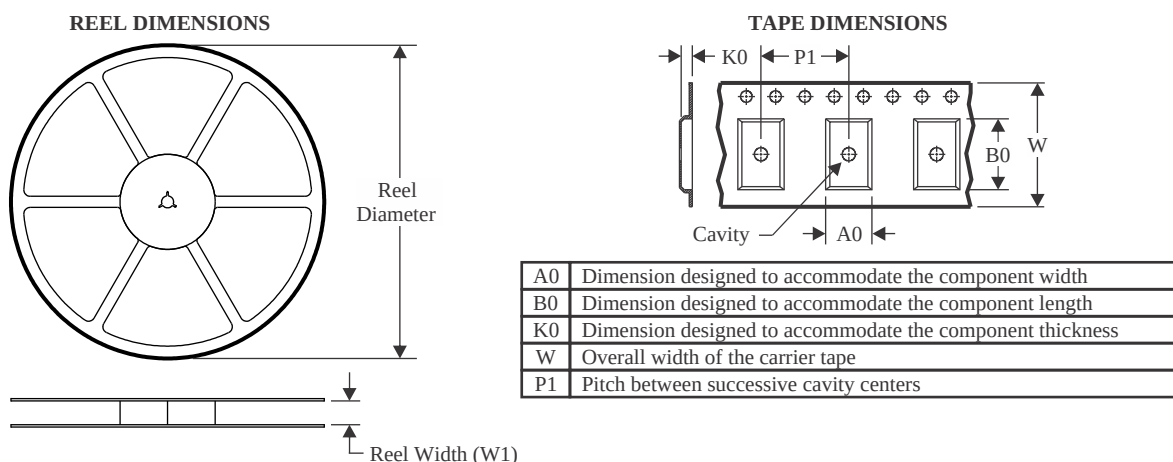
## OTHER QUALIFIED VERSIONS OF TMP235, TMP236 :

- Automotive : [TMP235-Q1](#), [TMP236-Q1](#)

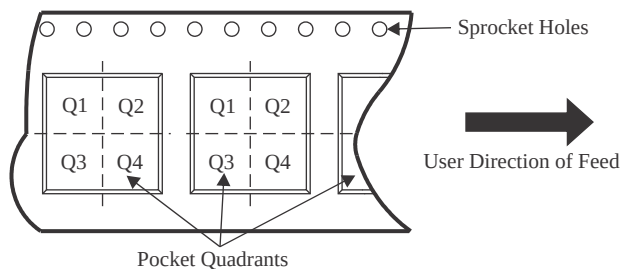
NOTE: Qualified Version Definitions:

- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

## TAPE AND REEL INFORMATION



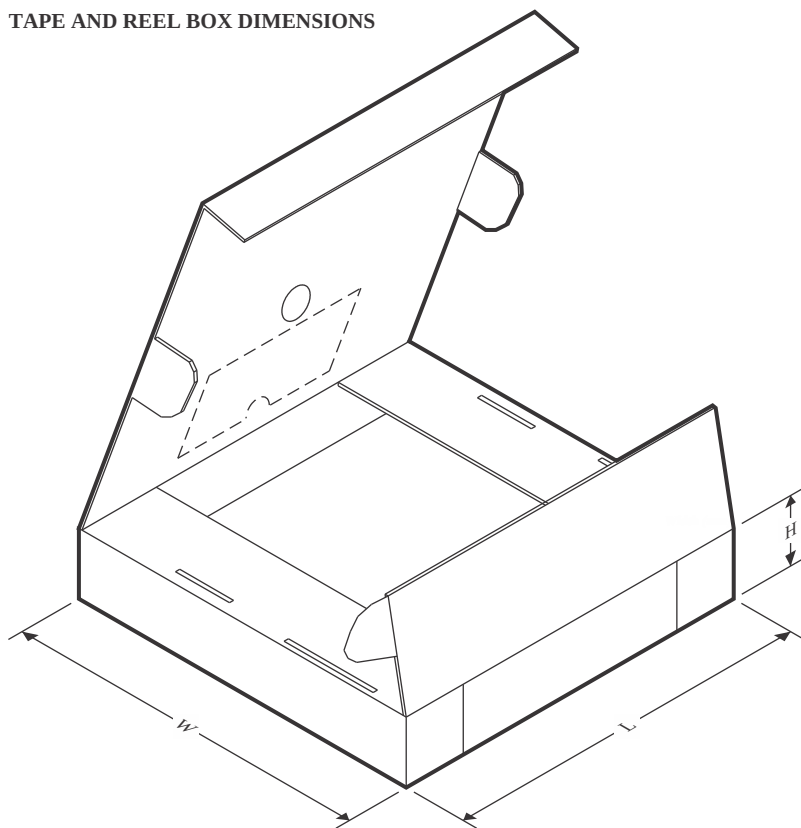
### QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



\*All dimensions are nominal

| Device         | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TMP235A2DBZR   | SOT-23       | DBZ             | 3    | 3000 | 180.0              | 8.4                | 3.2     | 2.85    | 1.3     | 4.0     | 8.0    | Q3            |
| TMP235A2DBZR   | SOT-23       | DBZ             | 3    | 3000 | 180.0              | 8.4                | 3.15    | 2.77    | 1.22    | 4.0     | 8.0    | Q3            |
| TMP235A2DBZR   | SOT-23       | DBZ             | 3    | 3000 | 180.0              | 8.4                | 2.9     | 3.35    | 1.35    | 4.0     | 8.0    | Q3            |
| TMP235A2DCKR   | SC70         | DCK             | 5    | 3000 | 178.0              | 8.4                | 2.25    | 2.45    | 1.2     | 4.0     | 8.0    | Q3            |
| TMP235A4DBZR   | SOT-23       | DBZ             | 3    | 3000 | 178.0              | 9.0                | 3.15    | 2.77    | 1.22    | 4.0     | 8.0    | Q3            |
| TMP235A4DBZR   | SOT-23       | DBZ             | 3    | 3000 | 180.0              | 8.4                | 3.2     | 2.85    | 1.3     | 4.0     | 8.0    | Q3            |
| TMP235A4DBZR   | SOT-23       | DBZ             | 3    | 3000 | 180.0              | 8.4                | 2.9     | 3.35    | 1.35    | 4.0     | 8.0    | Q3            |
| TMP235A4DBZRG4 | SOT-23       | DBZ             | 3    | 3000 | 180.0              | 8.4                | 2.9     | 3.35    | 1.35    | 4.0     | 8.0    | Q3            |
| TMP235A4DCKR   | SC70         | DCK             | 5    | 3000 | 178.0              | 8.4                | 2.25    | 2.45    | 1.2     | 4.0     | 8.0    | Q3            |
| TMP236A2DBZR   | SOT-23       | DBZ             | 3    | 3000 | 180.0              | 8.4                | 2.9     | 3.35    | 1.35    | 4.0     | 8.0    | Q3            |
| TMP236A2DCKR   | SC70         | DCK             | 5    | 3000 | 180.0              | 8.4                | 2.3     | 2.55    | 1.2     | 4.0     | 8.0    | Q3            |
| TMP236A4DBZR   | SOT-23       | DBZ             | 3    | 3000 | 180.0              | 8.4                | 2.9     | 3.35    | 1.35    | 4.0     | 8.0    | Q3            |
| TMP236A4DCKR   | SC70         | DCK             | 5    | 3000 | 180.0              | 8.4                | 2.3     | 2.55    | 1.2     | 4.0     | 8.0    | Q3            |

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device         | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TMP235A2DBZR   | SOT-23       | DBZ             | 3    | 3000 | 210.0       | 185.0      | 35.0        |
| TMP235A2DBZR   | SOT-23       | DBZ             | 3    | 3000 | 183.0       | 183.0      | 20.0        |
| TMP235A2DBZR   | SOT-23       | DBZ             | 3    | 3000 | 210.0       | 185.0      | 35.0        |
| TMP235A2DCKR   | SC70         | DCK             | 5    | 3000 | 208.0       | 191.0      | 35.0        |
| TMP235A4DBZR   | SOT-23       | DBZ             | 3    | 3000 | 180.0       | 180.0      | 18.0        |
| TMP235A4DBZR   | SOT-23       | DBZ             | 3    | 3000 | 210.0       | 185.0      | 35.0        |
| TMP235A4DBZR   | SOT-23       | DBZ             | 3    | 3000 | 210.0       | 185.0      | 35.0        |
| TMP235A4DBZRG4 | SOT-23       | DBZ             | 3    | 3000 | 210.0       | 185.0      | 35.0        |
| TMP235A4DCKR   | SC70         | DCK             | 5    | 3000 | 208.0       | 191.0      | 35.0        |
| TMP236A2DBZR   | SOT-23       | DBZ             | 3    | 3000 | 210.0       | 185.0      | 35.0        |
| TMP236A2DCKR   | SC70         | DCK             | 5    | 3000 | 210.0       | 185.0      | 35.0        |
| TMP236A4DBZR   | SOT-23       | DBZ             | 3    | 3000 | 210.0       | 185.0      | 35.0        |
| TMP236A4DCKR   | SC70         | DCK             | 5    | 3000 | 210.0       | 185.0      | 35.0        |

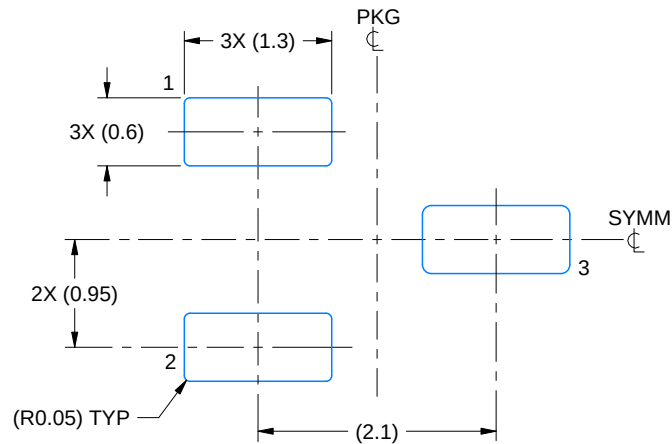


# EXAMPLE BOARD LAYOUT

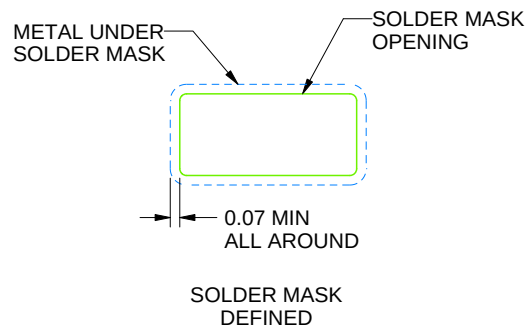
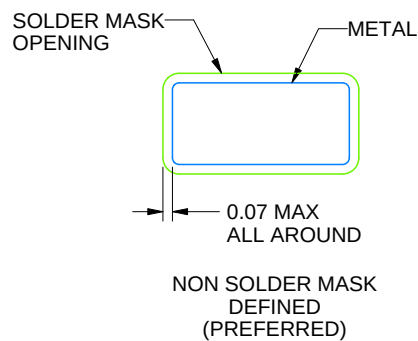
DBZ0003A

SOT-23 - 1.12 mm max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE  
SCALE:15X



SOLDER MASK DETAILS

4214838/F 08/2024

NOTES: (continued)

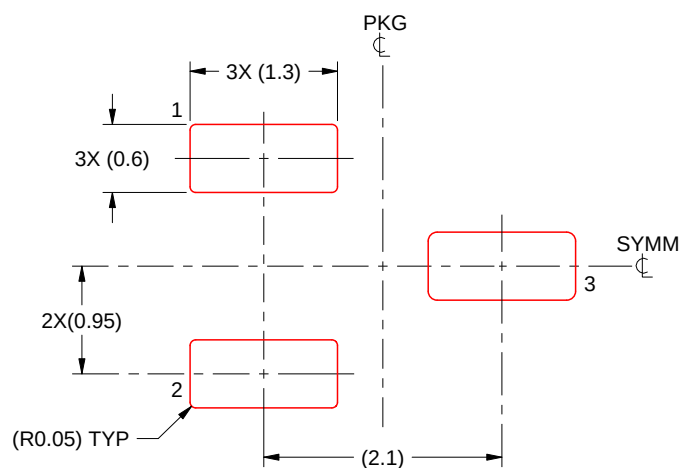
5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

DBZ0003A

SOT-23 - 1.12 mm max height

SMALL OUTLINE TRANSISTOR

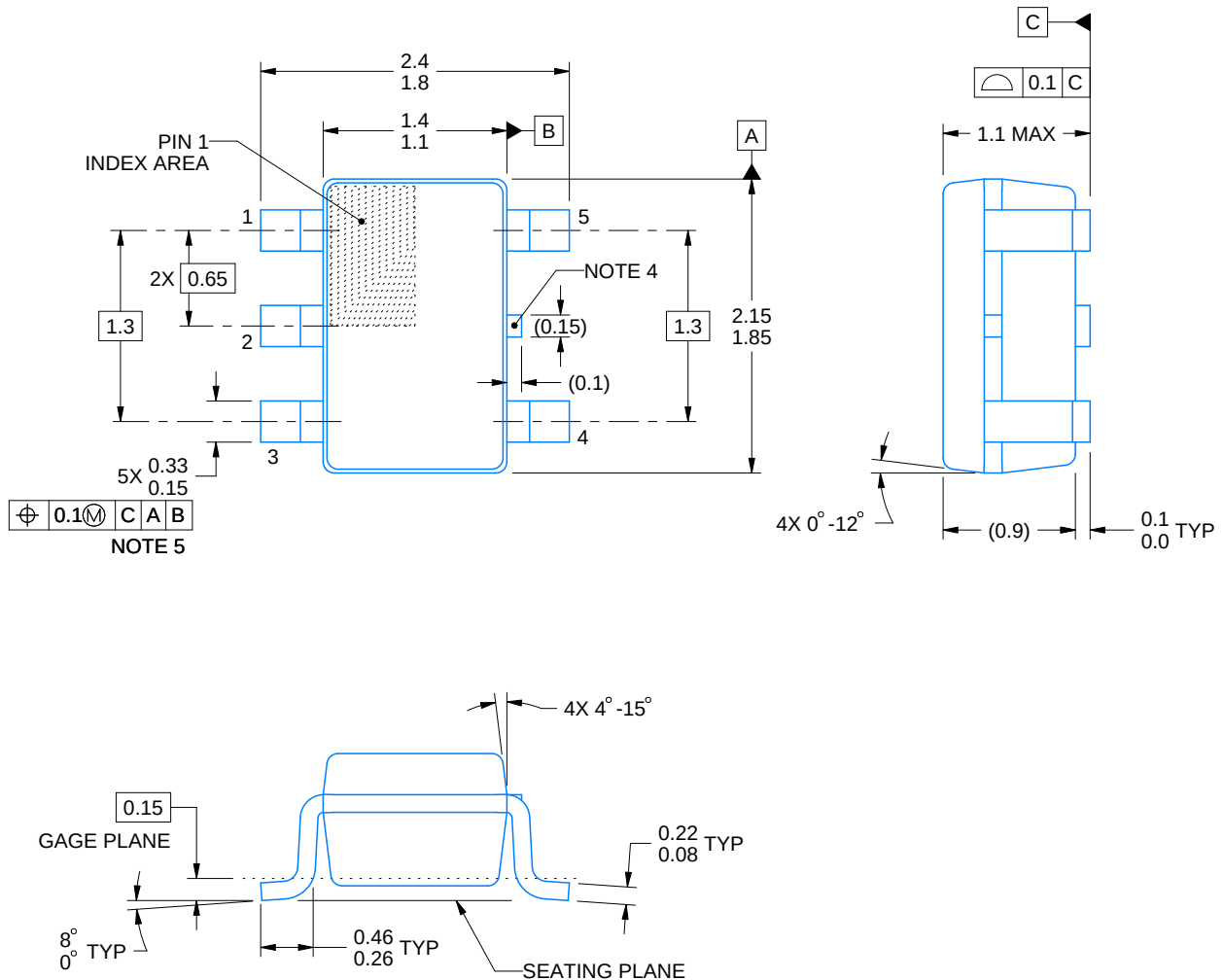


SOLDER PASTE EXAMPLE  
BASED ON 0.125 THICK STENCIL  
SCALE:15X

4214838/F 08/2024

NOTES: (continued)

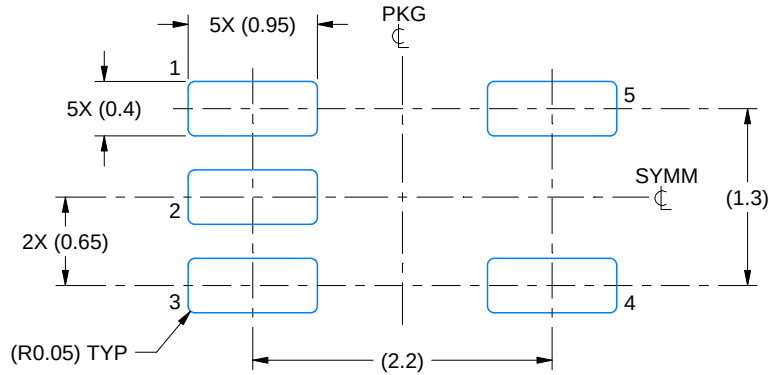
7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.



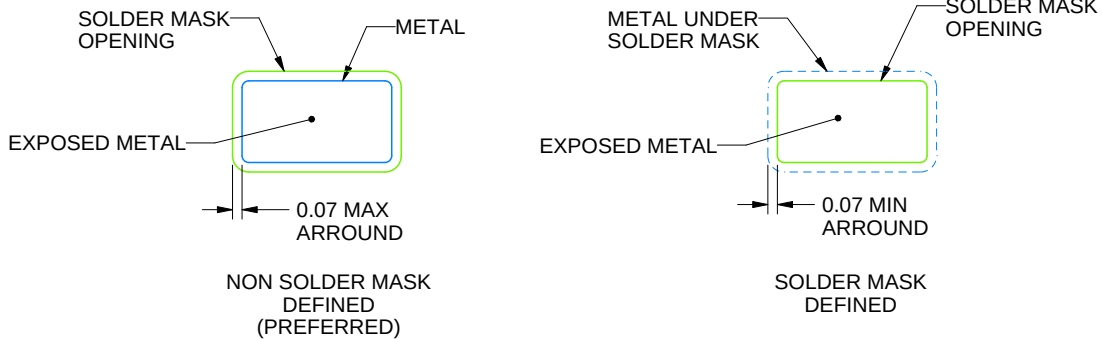
4214834/G 11/2024

## 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. Reference JEDEC MO-203.
4. Support pin may differ or may not be present.
5. Lead width does not comply with JEDEC.
6. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25mm per side



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:18X

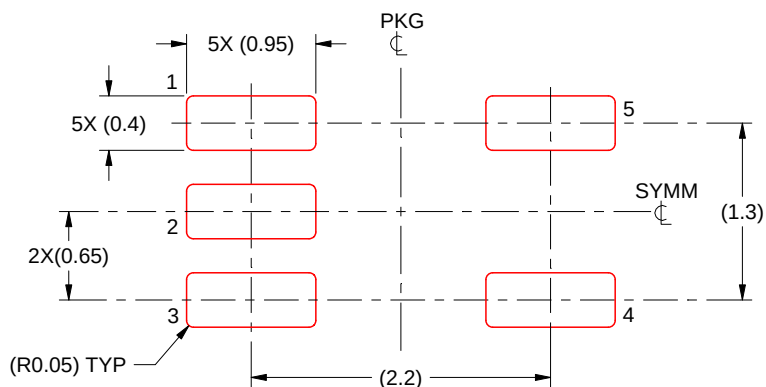


SOLDER MASK DETAILS

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NOTES: (continued)

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



SOLDER PASTE EXAMPLE  
BASED ON 0.125 THICK STENCIL  
SCALE:18X

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NOTES: (continued)

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

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