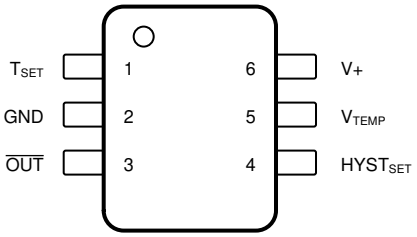
# TMP300 1.8-V, Resistor-Programmable Temperature Switch and Analog Out Temperature Sensor in SC70

## 1 Features

- Accuracy: ±1°C (typical at +25°C)
- Programmable trip point
- Programmable hysteresis: 5°C/10°C
- Open-drain outputs
- Low power: 110 µA (maximum)
- Wide voltage range: +1.8 V to +18 V
- Temperature range: –40°C to +125°C
- Analog out: 10mV/°C
- SC70-6 and SOT23-6 packages

## 2 Applications

- Power-supply systems
- DC-DC modules
- Thermal monitoring
- Electronic protection systems




Not to scale

**Pinout**

## 3 Description

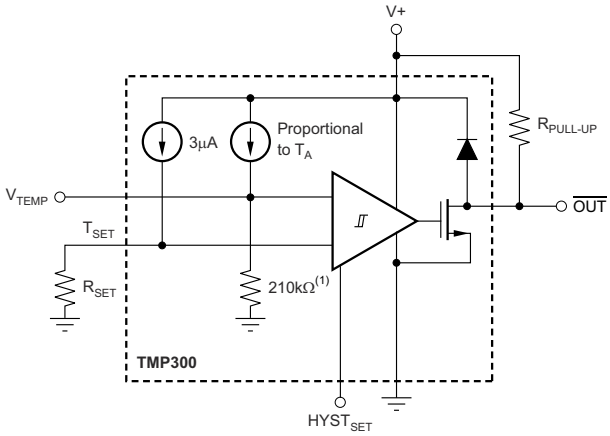
The TMP300 is a low-power, resistor-programmable, digital output temperature switch. The device allows a threshold point to be set by adding an external resistor. Two levels of hysteresis are available. The TMP300 has a $V_{TEMP}$ analog output that can be used as a testing point or in temperature-compensation loops.

Available in two micropackages with proven thermal characteristics, low current consumption, and a supply voltage as low as 1.8 V, the TMP300 is designed for power-sensitive systems that require simple and reliable thermal management.

**Package Information**(1)

| PART NUMBER | PACKAGE | BODY SIZE (NOM) |
|---|---|---|
| TMP300 | SOT-23 (6) | 2.90 mm × 1.60 mm |
| | SC70 (6) | 2.00 mm × 1.25 mm |

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




NOTE: Thinfilm resistor with approximately 10% accuracy; however, this accuracy error is trimmed out at the factory.

**Application Schematic**

# Table of Contents



## 4 Revision History

| Changes from Revision E (December 2018) to Revision F (January 2023) | Page |
|---|---|
| • Updated the numbering format for tables, figures, and cross-references throughout the document | 1 |
| • Changed *Device Information* table to *Package Information* | 1 |
| • Added parameter to the *Absolute Maximum Ratings* table: input current into any pin | 4 |

| Changes from Revision D (January 2016) to Revision E (December 2018) | Page |
|---|---|
| • Added *Pin Configuration and Functions* section | 3 |

| Changes from Revision C (January 2011) to Revision D (January 2016) | Page |
|---|---|
| • Added *Device Information* table, *ESD Ratings* table, *Feature Description* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section | 1 |
| • Changed *Temperature Range* Features bullet | 1 |
| • Added package names to pinout | 1 |
| • Deleted *Ordering Information* table | 4 |
| • Changed Temperature Range, *TA, Functional Range* parameter name in *Electrical Characteristics* table | 5 |
| • Added footnote 4 to *Electrical Characteristics* table | 5 |

| Changes from Revision B (November 2008) to Revision C (January 2011) | Page |
|---|---|
| • Deleted second sentence from *Description* section | 1 |
| • Added TMP300B grade device specifications to *Electrical Characteristics* table | 5 |

# 5 Pin Configuration and Functions

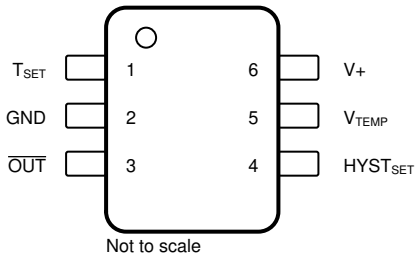



**Figure 5-1. DCK and DBV Package 6-Pin SOT-23 and SC70 Top View**

**Table 5-1. Pin Functions**

| PIN | | I/O | DESCRIPTION |
|---|---|---|---|
| NAME | NO. | | |
| $T_{SET}$ | 1 | I | Temperature set pin. Connects to a resistor to set the trip point |
| GND | 2 | — | Ground |
| $\overline{OUT}$ | 3 | O | Trip output |
| $HYST_{SET}$ | 4 | I | Hysteresis Set. Connect to Ground for 5°C hysteresis or connect to V+ for 10°C hysteresis |
| $V_{TEMP}$ | 5 | I | Analog Temperature output |
| V+ | 6 | O | Supply voltage: 1.8 V to 18 V |

# 6 Specifications

## 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| V+ | Supply voltage | | +18 | V |
| | Signal input pins, voltage(2) | –0.5 | (V+) + 0.5 | V |
| | Signal input pins, current(2) | –10 | 10 | mA |
| | Input current into any pin | | 10 | mA |
| $I_{SC}$ | Output short-circuit(3) | Continuous | | |
| | Open-drain output | | (V+) + 0.5 | V |
| $T_A$ | Functional temperature | –40 | +150 | °C |
| $T_{stg}$ | Storage temperature | –55 | +150 | °C |
| $T_J$ | Junction temperature | | +150 | °C |

(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.
(2) Input pins are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5V beyond the supply rails should be current limited to 10mA or less.
(3) Short-circuit to ground.

## 6.2 ESD Ratings

| | | | VALUE | UNIT |
|---|---|---|---|---|
| $V_{(ESD)}$ | Electrostatic discharge | Human-body model (HBM) | ±4000 | V |
| | | Charged-device model (CDM) | ±1000 | |

## 6.3 Electrical Characteristics

At $V_S$ = 3.3 V and $T_A$ = –40°C to +125°C, unless otherwise noted.

| PARAMETER | | | TEST CONDITIONS | TMP300 | | | TMP300B | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN(1) | TYP(1) | MAX(1) | MIN | TYP | MAX | |
| **TEMPERATURE MEASUREMENT** | | | | | | | | | | |
| | Measurement range | | $V_S$ = 2.35 V to 18 V | –40 | | +125 | –40 | | +125 | °C |
| | | | $V_S$ = 1.8 V to 2.35 V | –40 | | 100 × ($V_S$ – 0.95) | –40 | | 100 × ($V_S$ – 0.95) | |
| **TRIP POINT** | | | | | | | | | | |
| | Total accuracy | | $T_A$ = –40°C to +125°C | | ±2 | ±4(3) | | ±2 | ±6 | °C |
| | $R_{SET}$ equation | | $T_C$ is in °C | | $R_{SET}$ = 10 (50 + $T_C$)/3 | | | $R_{SET}$ = 10 (50 + $T_C$)/3 | | kΩ |
| **HYSTERESIS SET INPUT** | | | | | | | | | | |
| | LOW threshold | | | | | 0.4 | | | 0.4 | V |
| | HIGH threshold | | | $V_S$ – 0.4 | | | $V_S$ – 0.4 | | | V |
| | Threshold hysteresis | | $HYST_{SET}$ = GND | | 5 | | | 5 | | °C |
| | | | $HYST_{SET}$ = $V_S$ | | 10 | | | 10 | | |
| **DIGITAL OUTPUT** | | | | | | | | | | |
| | Logic family | | | | CMOS | | | CMOS | | |
| | Open-drain leakage current | | OUT = $V_S$ | | | 10 | | | 10 | µA |
| $V_{OL}$ | Logic levels | | $V_S$ = 1.8 V to 18 V, $I_{SINK}$ = 5 mA | | | 0.3 | | | 0.3 | V |
| **ANALOG OUTPUT** | | | | | | | | | | |
| | Accuracy | | | | ±2 | ±3 | | ±2 | ±5 | °C |
| | Temperature sensitivity | | | | 10 | | | 10 | | mV/°C |
| | Output voltage | | $T_A$ = +25°C | 720 | 750 | 780 | 720 | 750 | 780 | mV |
| | $V_{TEMP}$ pin output resistance | | | | 210 | | | 210 | | kΩ |
| **POWER SUPPLY** | | | | | | | | | | |
| $I_Q$ | Quiescent current(2) | | $V_S$ = 1.8 V to 18 V, $T_A$ = –40°C to +125°C | | | 110 | | | 110 | µA |
| **TEMPERATURE RANGE** | | | | | | | | | | |
| $T_A$ | Specified range | | $V_S$ = 2.35 V to 18 V | –40 | | +125 | –40 | | +125 | °C |
| | | | $V_S$ = 1.8 V to 2.35 V | –40 | | 100 × ($V_S$ – 0.95) | –40 | | 100 × ($V_S$ – 0.95) | |
| | Functional range(4) | | $V_S$ = 2.35 V to 18 V | –40 | | +150 | –40 | | +150 | |
| | | | $V_S$ = 1.8 V to 2.35 V | –50 | | 100 × ($V_S$ – 0.95) | –50 | | 100 × ($V_S$ – 0.95) | |
| $\theta_{JA}$ | Thermal resistance | SC70 | | | 250 | | | 250 | | °C/W |
| | | SOT23-6 | | | 180 | | | 180 | | |

(1) 100% of production is tested at $T_A$ = +85°C. Specifications over temperature range are ensured by design.
(2) See Figure 6-1 for typical quiescent current.
(3) Shaded cells indicate characteristic performance difference.
(4) The TMP300 is functional over this range and no indication of performance is implied.

## 6.4 Typical Characteristics

At $V_S$ = 5 V, unless otherwise noted.

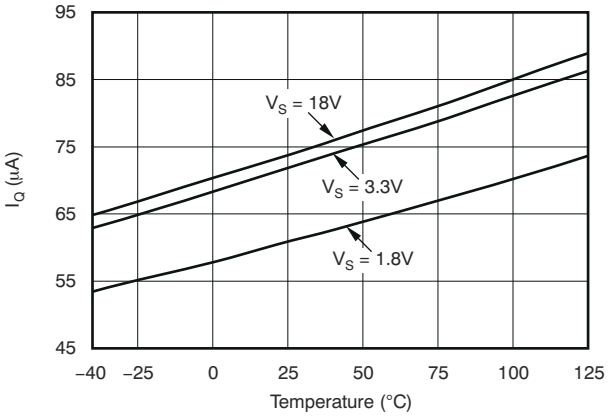



**Figure 6-1. Quiescent Current Over Temperature and Supply**

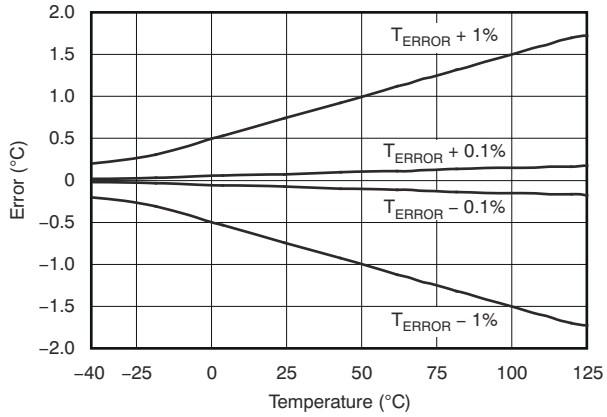



**Figure 6-2. $R_{SET}$ Shift Resulting From $R_{SET}$ Tolerance**

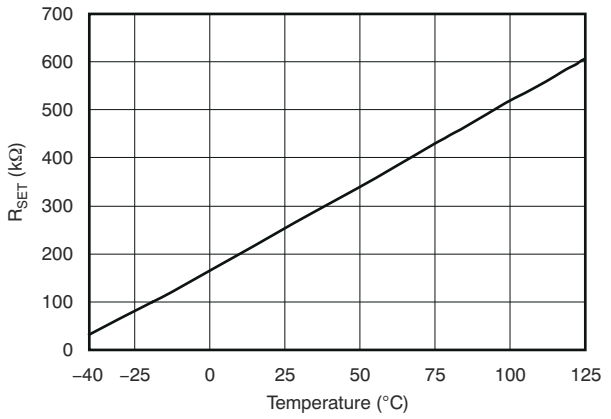



**Figure 6-3. $R_{SET}$ vs Temperature**

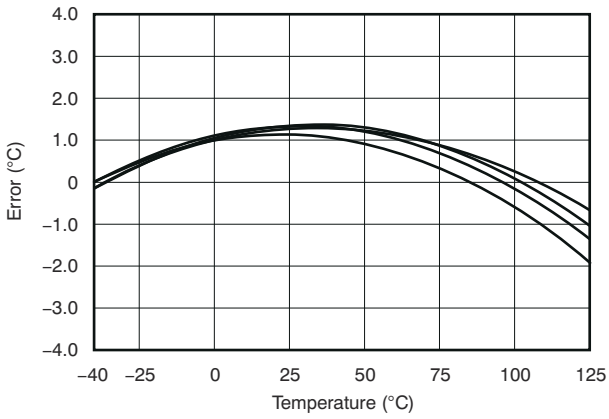



**Figure 6-4. Typical Trip Error**

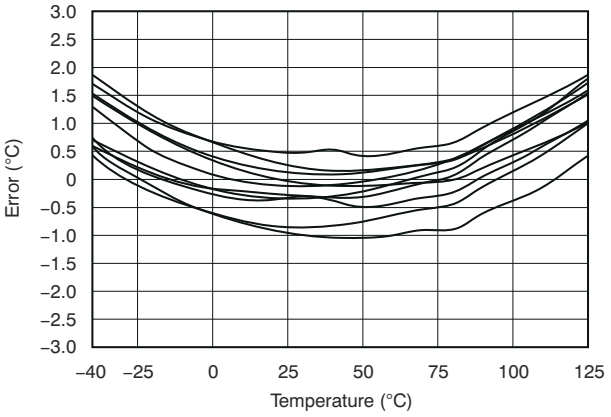



**Figure 6-5. Typical Analog Output Error**

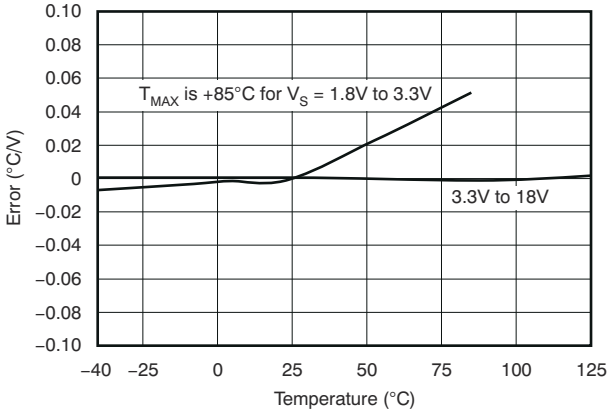



**Figure 6-6. Analog PSR Over Temperature**

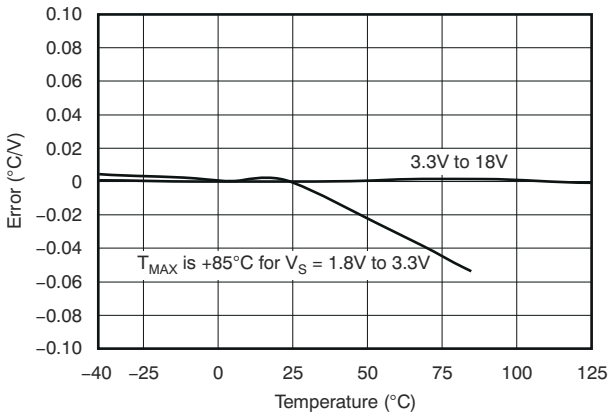



**Figure 6-7. Trip PSR Over Temperature**

# 7 Detailed Description

## 7.1 Overview

The TMP300 is a thermal sensor designed for overtemperature protection circuits in electronic systems. The TMP300 uses a set resistor to program the trip temperature of the digital output. An additional high-impedance (210 kΩ) analog voltage output provides the temperature reading.

## 7.2 Feature Description

### 7.2.1 Calculating $R_{SET}$

The set resistor ($R_{SET}$) provides a threshold voltage for the comparator input. The TMP300 trips when the $V_{TEMP}$ pin exceeds the $T_{SET}$ voltage. The value of the set resistor is determined by the analog output function and the 3-µA internal bias current.

To set the TMP300 to trip at a preset value, calculate the $R_{SET}$ resistor value according to Equation 1 or Equation 2:

$$R_{SET} = \frac{(T_{SET} \times 0.01 + 0.5)}{3e^{-6}} \quad (1)$$

where

- $T_{SET}$ is in °C; or

$$R_{SET} \text{ in } k\Omega = \frac{10(50 + T_{SET})}{3} \quad (2)$$

where

- $T_{SET}$ is in °C.

### 7.2.2 Using $V_{TEMP}$ to Trip the Digital Output

The analog voltage output can also serve as a voltage input that forces a trip of the digital output to simulate a thermal event. This simulation facilitates easy system design and test of thermal safety circuits, as shown in Figure 7-1.

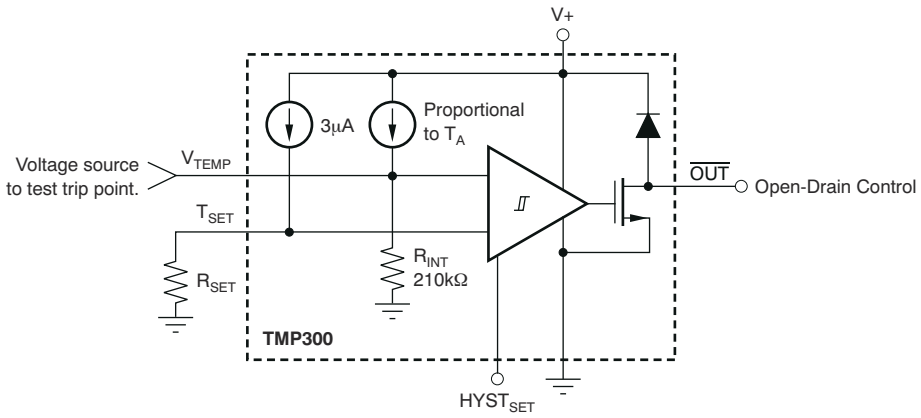



**Figure 7-1. Applying Voltage to Trip Digital Output**

### 7.2.3 Analog Temperature Output

The analog out or $V_{TEMP}$ pin is high-impedance (210 kΩ). Avoid loading this pin to prevent degrading the analog out value or trip point. Buffer the output of this pin when used for direct thermal measurement. Figure 7-2 shows buffering of the analog output signal.

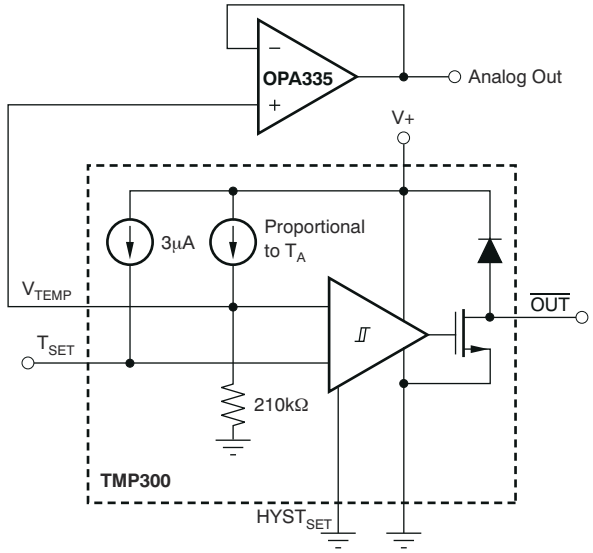



**Figure 7-2. Buffering the Analog Output Signal**

### 7.2.4 Using a DAC to Set the Trip Point

The trip point is easily converted by changing the digital-to-analog converter (DAC) code. This technique can be useful for control loops where a large thermal mass is being brought up to the set temperature and the $\overline{OUT}$ pin is used to control the heating element. The analog output can be monitored in a control algorithm that adjusts the set temperature to prevent overshoot. Figure 7-3 shows the trip set voltage error versus temperature, which shows error in °C of the comparator input over temperature. Figure 7-4 shows an alternative method of setting the trip point by using a DAC.

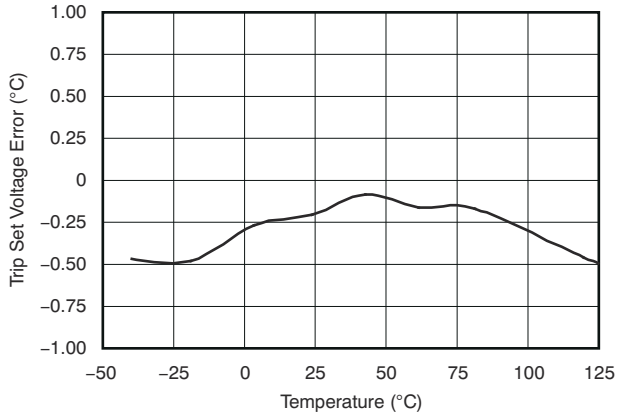



**Figure 7-3. Trip Set Voltage Error vs Temperature**

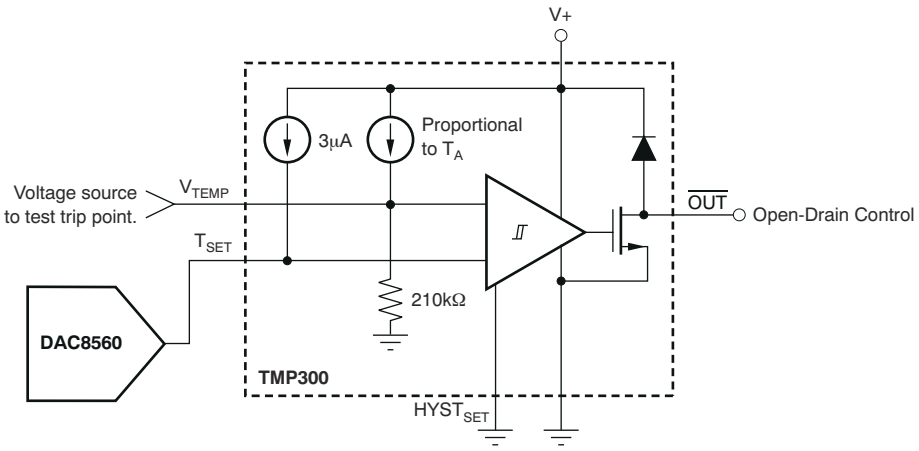



**Figure 7-4. DAC Generates the Voltage-Driving $T_{SET}$ Pin**

### 7.2.5 Hysteresis

The hysteresis pin has two settings. Grounding $HYST_{SET}$ results in 5°C of hysteresis. Connecting $HYST_{SET}$ to $V_S$ results in 10°C of hysteresis. Figure 7-5 and Figure 7-6 show the hysteresis error variation over temperature.

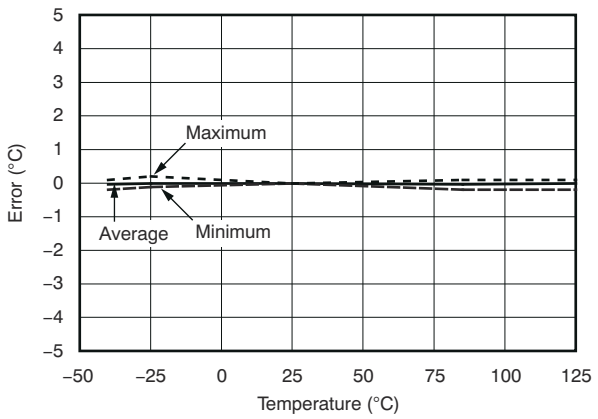



**Figure 7-5. 5°C Hysteresis Error vs Temperature**

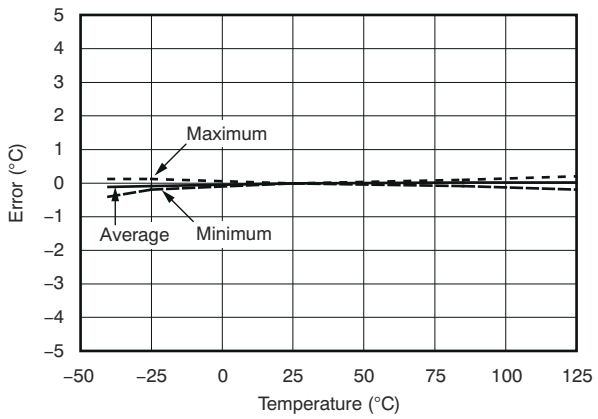



**Figure 7-6. 10°C Hysteresis Error vs Temperature**

Use bypass capacitors on the supplies as well as on the $R_{SET}$ and analog out ($V_{TEMP}$) pins when in noisy environments, as shown in Figure 7-7. These capacitors reduce premature triggering of the comparator.

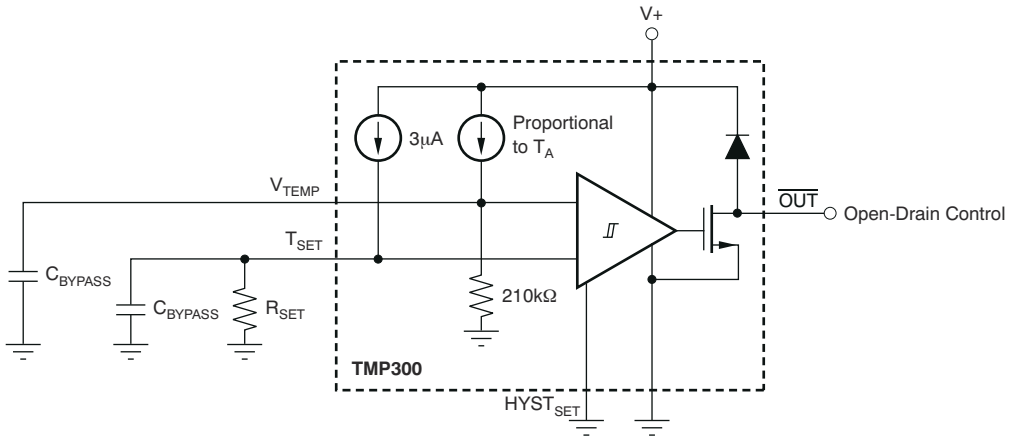



**Figure 7-7. Bypass Capacitors Prevent Early Comparator Toggling Due to Circuit Board Noise**

# 8 Device and Documentation Support

## 8.1 Receiving Notification of Documentation Updates

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

## 8.2 Support Resources

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

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## 8.3 Trademarks

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

## 8.4 Electrostatic Discharge Caution

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

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

## 8.5 Glossary

| | |
|---|---|
| TI Glossary | This glossary lists and explains terms, acronyms, and definitions. |

# 9 Mechanical, Packaging, and Orderable Information

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

## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TMP300AIDBVR | NRND | SOT-23 | DBV | 6 | 3000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | T300 | |
| TMP300AIDCKR | NRND | SC70 | DCK | 6 | 3000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | BPN | |
| TMP300BIDBVR | ACTIVE | SOT-23 | DBV | 6 | 3000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | DUDC | Samples |
| TMP300BIDCKR | ACTIVE | SC70 | DCK | 6 | 3000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | QWL | Samples |

(1) The marketing status values are defined as follows:
**ACTIVE:** Product device recommended for new designs.
**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.
**OBSOLETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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 TMP300 :**

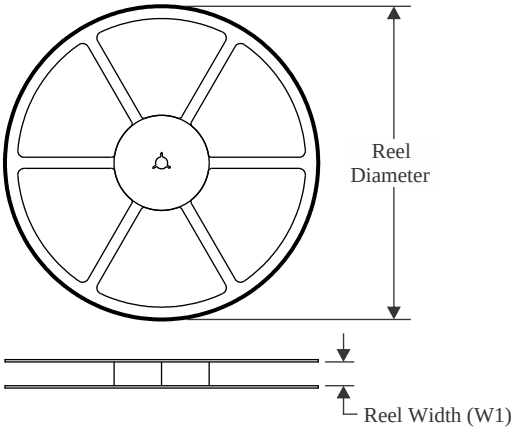
- Automotive : TMP300-Q1

NOTE: Qualified Version Definitions:

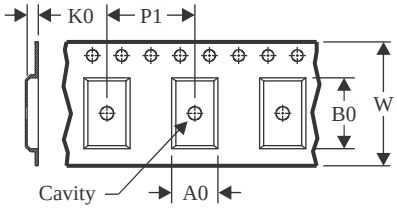
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

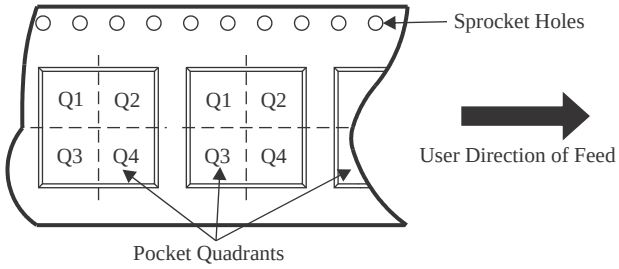



**TAPE DIMENSIONS**




| | |
|---|---|
| A0 | Dimension designed to accommodate the component width |
| B0 | Dimension designed to accommodate the component length |
| K0 | Dimension designed to accommodate the component thickness |
| W | Overall width of the carrier tape |
| P1 | Pitch between successive cavity centers |

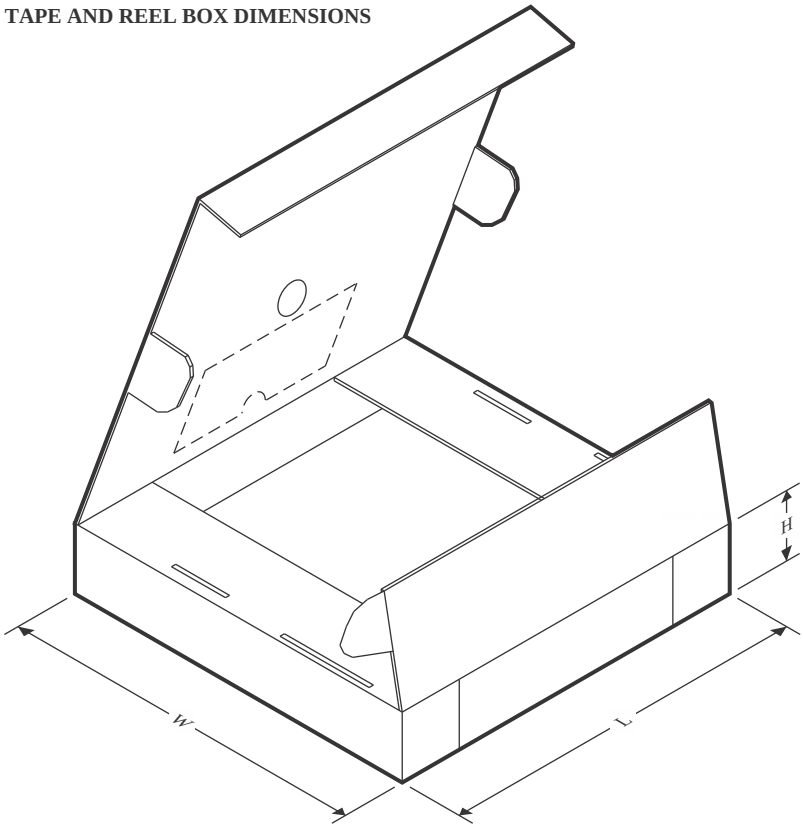
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TMP300AIDBVR | SOT-23 | DBV | 6 | 3000 | 180.0 | 8.4 | 3.2 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TMP300AIDCKR | SC70 | DCK | 6 | 3000 | 179.0 | 8.4 | 2.2 | 2.5 | 1.2 | 4.0 | 8.0 | Q3 |
| TMP300BIDBVR | SOT-23 | DBV | 6 | 3000 | 179.0 | 8.4 | 3.2 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TMP300BIDCKR | SC70 | DCK | 6 | 3000 | 179.0 | 8.4 | 2.2 | 2.5 | 1.2 | 4.0 | 8.0 | Q3 |

TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

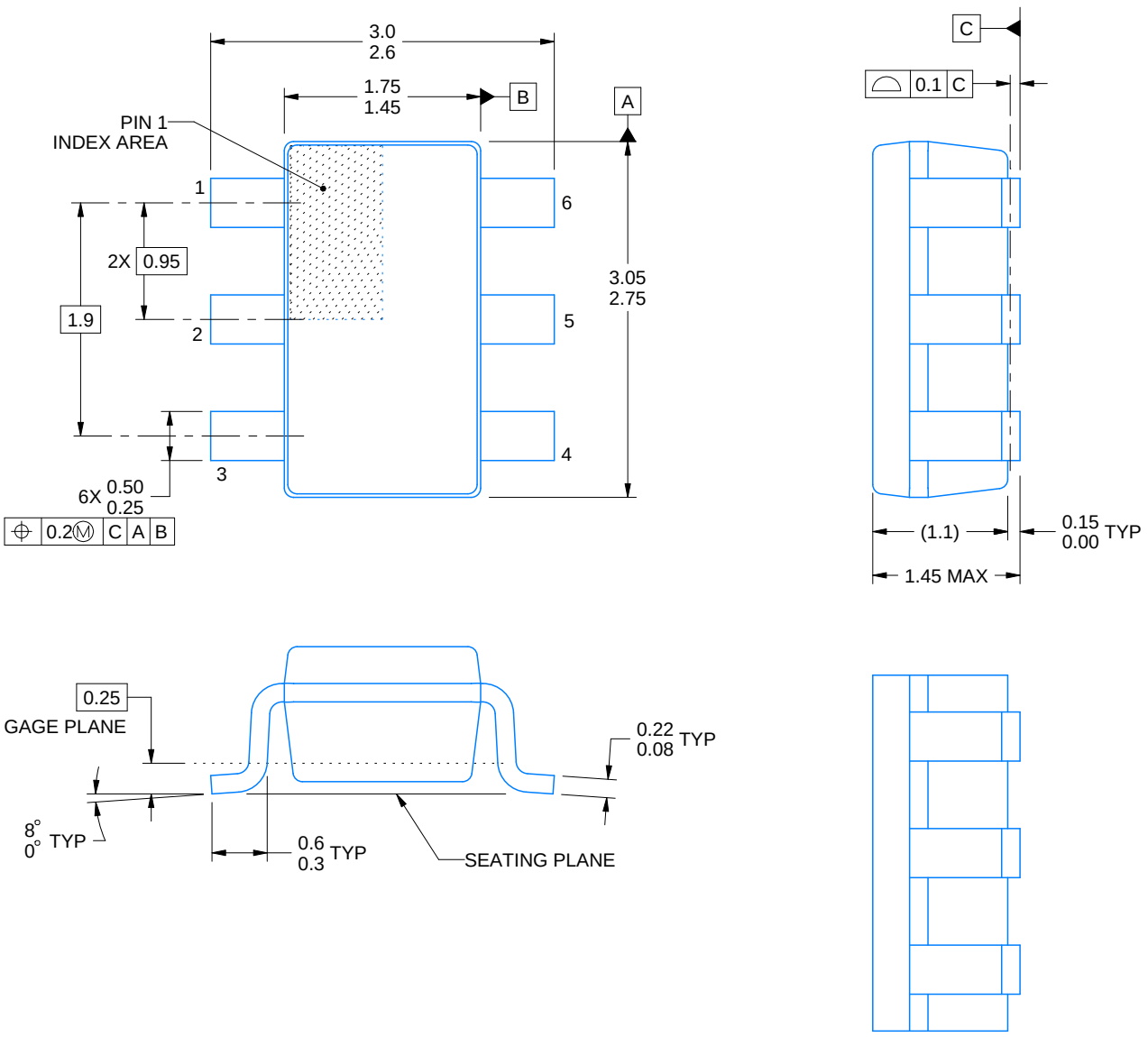
| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| TMP300AIDBVR | SOT-23 | DBV | 6 | 3000 | 200.0 | 183.0 | 25.0 |
| TMP300AIDCKR | SC70 | DCK | 6 | 3000 | 200.0 | 183.0 | 25.0 |
| TMP300BIDBVR | SOT-23 | DBV | 6 | 3000 | 200.0 | 183.0 | 25.0 |
| TMP300BIDCKR | SC70 | DCK | 6 | 3000 | 200.0 | 183.0 | 25.0 |

# PACKAGE OUTLINE

## DBV0006A

## SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR

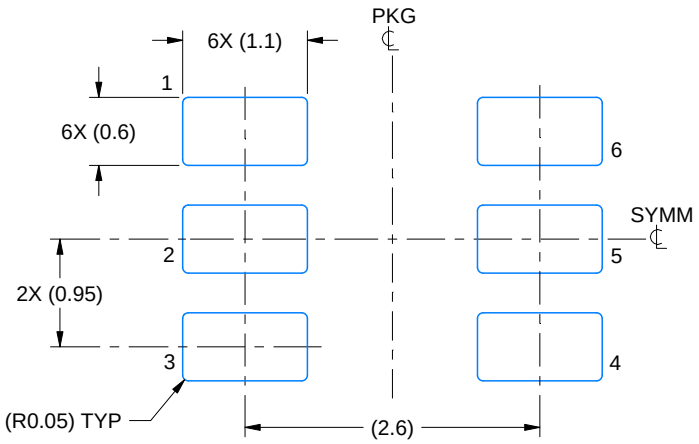



ALTERNATIVE PACKAGE SINGULATION VIEW

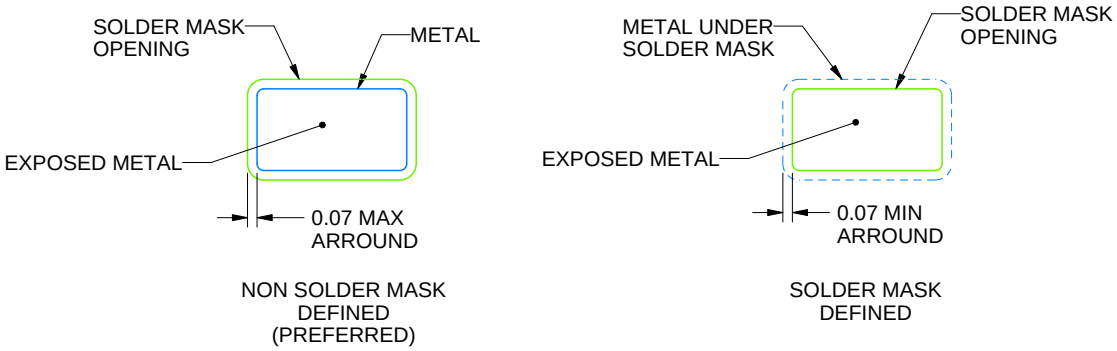
4214840/E 02/2024

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. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.25 per side.
4. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
5. Refernce JEDEC MO-178.




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X

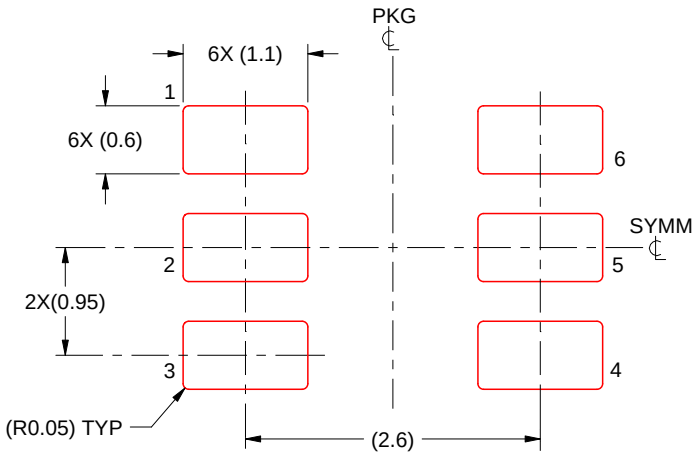



SOLDER MASK DETAILS

4214840/E 02/2024

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.




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

4214840/E 02/2024

NOTES: (continued)

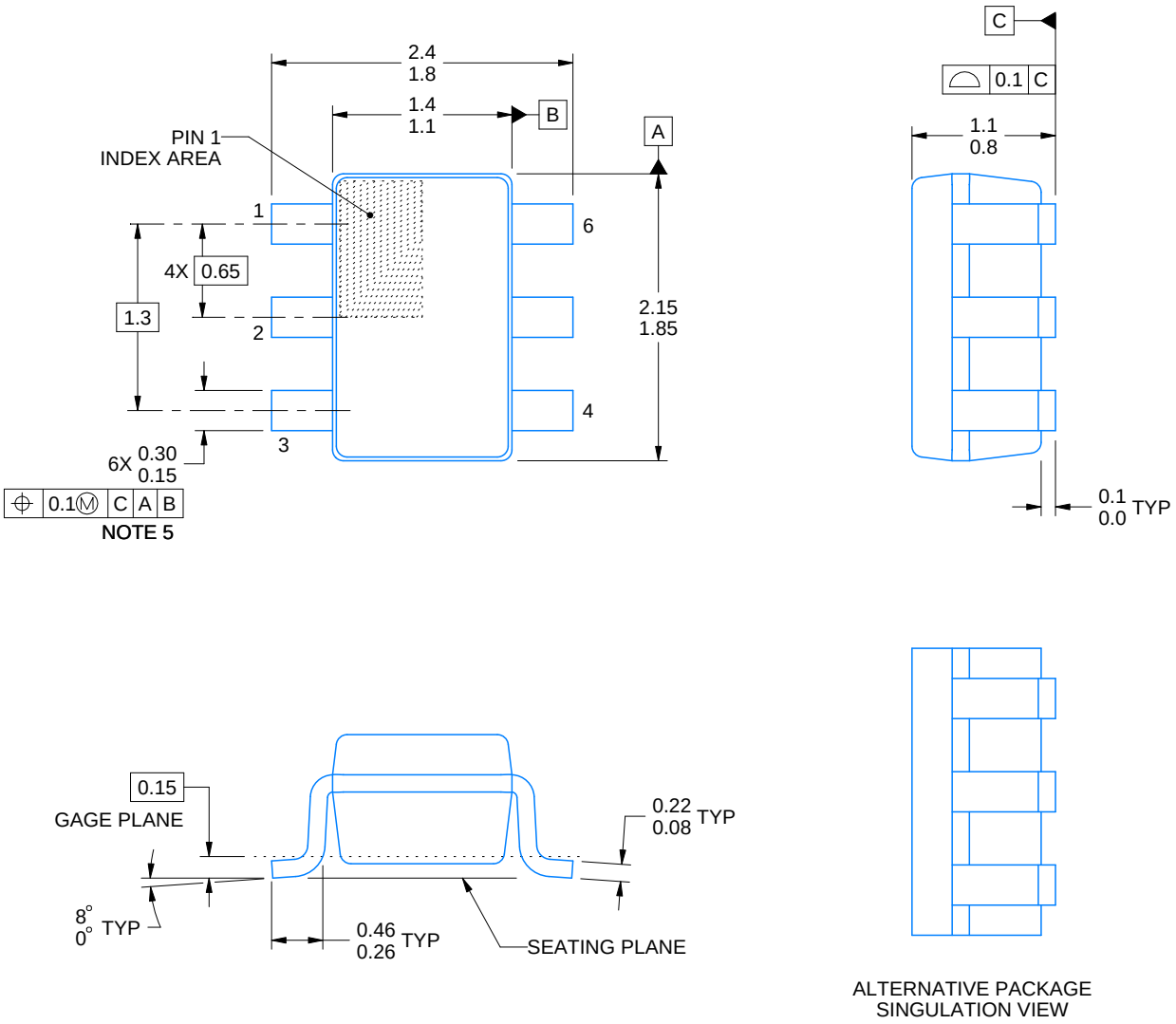
8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

# PACKAGE OUTLINE

## DCK0006A

## SOT - 1.1 max height

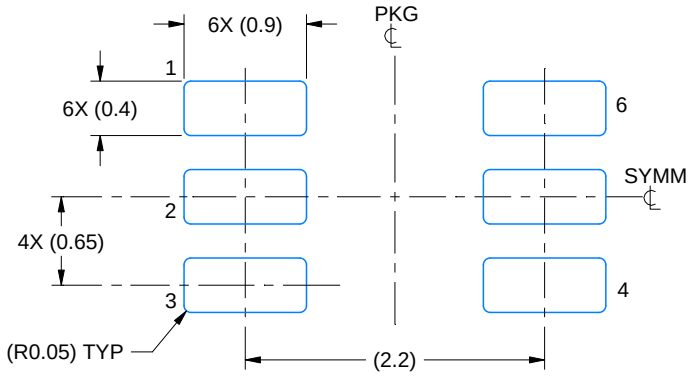
SMALL OUTLINE TRANSISTOR



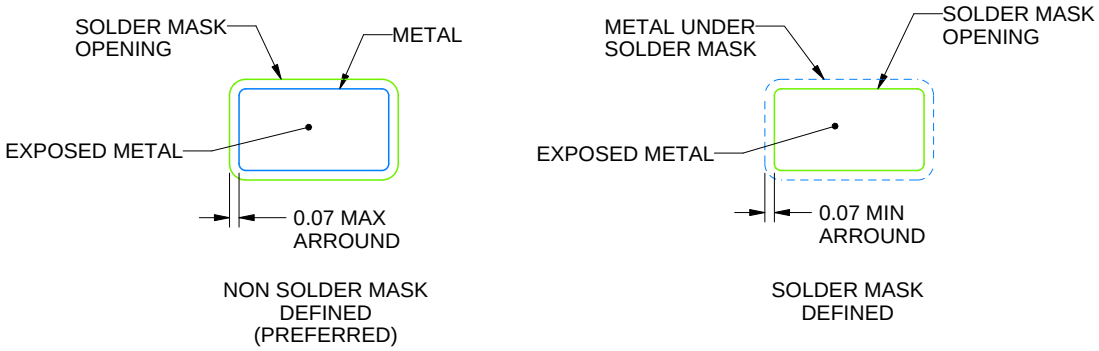

4214835/B 04/2024

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. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
4. Falls within JEDEC MO-203 variation AB.




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:18X

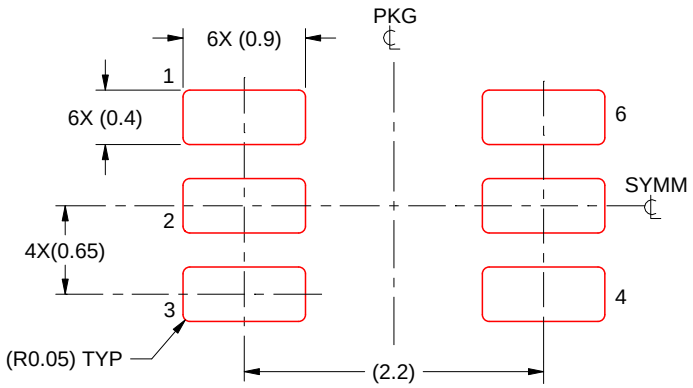



SOLDER MASK DETAILS

4214835/B 04/2024

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.




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

4214835/B 04/2024

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.

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