TEXAS INSTRUMENTS
TMP235-Q1, TMP236-Q1
SBOS939D – APRIL 2019 – REVISED JUNE 2022

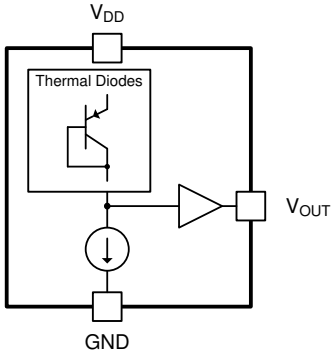
# TMP23x-Q1 Automotive Grade, High-Accuracy Analog Output Temperature Sensors

## 1 Features

- AEC-Q100 qualified for automotive applications
  - TMP235-Q1 grade 0: –40°C to +150°C
  - TMP236-Q1 grade 1: –40°C to +125°C
- Functional Safety-Capable
  - Documentation available to aid functional safety system design
- Tight accuracy across a wide temperature range:
  - ±2.5°C (maximum): –40°C to +150°C (TMP235-Q1)
  - ±2.5°C (maximum): –10°C to +125°C (TMP236-Q1)
- Positive slope sensor gain, offset (typical):
  - 10 mV/°C, 500 mV at 0°C (TMP235-Q1)
  - 19.5 mV/°C, 400 mV at 0°C (TMP236-Q1)
- Wide operating supply voltage range:
  - 2.3 V to 5.5 V (TMP235-Q1)
  - 3.1 V to 5.5 V (TMP236-Q1)
- Short-circuit protected output
- Low power: 9 µA (typical)
- Strong output for driving loads up to 1000 pF
- Available package options:
  - 5-pin SC70 (DCK) surface mount
  - 3-pin SOT-23 (DBZ) surface mount
  - Footprint compatible with industry-standard LMT8x-Q1, LM50-Q1, and LM20 temperature sensors
- Cost-effective alternative to thermistors

## 2 Applications

- Automotive head unit
- Electric power steering (EPS)
- Shifter system
- Battery management system (BMS)
- Gasoline engine




**Functional Block Diagram**

## 3 Description

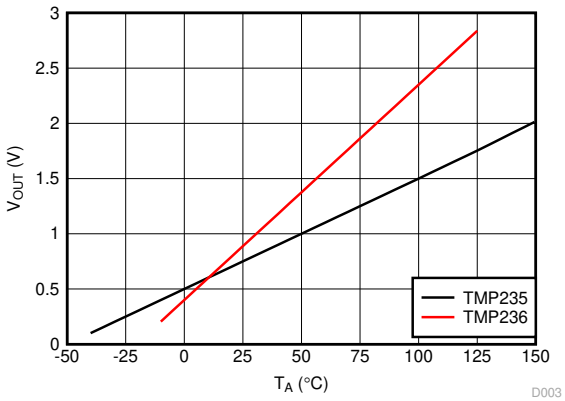
The TMP23x-Q1 devices are a family of automotive grade precision CMOS integrated-circuit linear analog temperature sensors with an output voltage proportional to temperature, serving various automotive applications from powertrain to infotainment. These temperature sensors have a typical accuracy from 0°C to +70°C of ±0.5°C. The TMP235-Q1 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-Q1 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.

The 9-µA typical quiescent current and 800-µs typical power-on time enable effective power-cycling architectures to minimize power consumption for battery-powered devices. A class-AB output driver provides a strong 500-µA maximum output to drive capacitive loads up to 1000 pF and is designed to directly interface to analog-to-digital converter sample and hold inputs. With excellent accuracy and a strong linear output driver, the TMP23x-Q1 analog output temperature sensors are cost-effective alternatives to passive thermistors.

**Device Information**(1)

| PART NUMBER | PACKAGE | BODY SIZE (NOM) |
|---|---|---|
| TMP235-Q1, TMP236-Q1 | SC70 (5) | 2.00 mm × 1.25 mm |
| | SOT-23 (3) | 2.92 mm × 1.30 mm |

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




**Output Voltage vs Ambient**

An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

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## 4 Revision History

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

| Changes from Revision C (November 2019) to Revision D (June 2022) | Page |
|---|---|
| • Updated the numbering format for tables, figures, and cross-references throughout the document | 1 |
| • Added Functional Safety bullets to the *Features* section | 1 |

| Changes from Revision B (October 2019) to Revision C (November 2019) | Page |
|---|---|
| • Added temperature accuracy specs for the TMP236-Q1 SOT-23 package | 5 |

| Changes from Revision A (May 2019) to Revision B (October 2019) | Page |
|---|---|
| • Changed document status from Advance Information to Production Data | 1 |

| Changes from Revision * (April 2019) to Revision A (May 2019) | Page |
|---|---|
| • Changed recommended operating temperature range from: –50°C to 150°C to: –40°C to 150°C | 4 |


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# 5 Pin Configuration and Functions

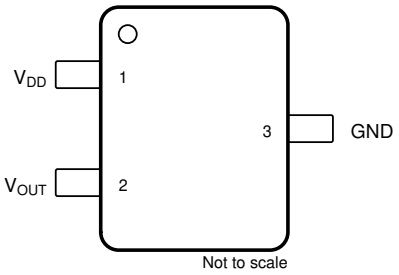
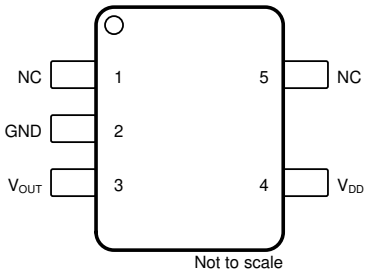



**Figure 5-1. DBZ Package 3-Pin SOT-23 Top View**




NC- no internal connection

**Figure 5-2. DCK Package 5-Pin SC70 Top View**

**Table 5-1. 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. |
| $V_{OUT}$ | 2 | 3 | O | Outputs voltage proportional to temperature |
| $V_{DD}$ | 1 | 4 | I | Positive supply input |

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# 6 Specifications

## 6.1 Absolute Maximum Ratings

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

| | 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 anyother 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 AEC Q100-002(1) HBM ESD Classification Level 2 | | ±2000 | V |
| | | Charged device model (CDM), per AEC Q100-011 CDM ESD Classification Level C4B | All Pins | ±500 | V |
| | | | Corner Pins | ±750 | V |

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification

## 6.3 Recommended Operating Conditions

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

| | | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|---|
| $V_{DD}$ | Input voltage (TMP235-Q1) | 2.3 | | 5.5 | V |
| | Input voltage (TMP236-Q1) | 3.1 | | 5.5 | |
| $T_A$ | Operating free-air temperature | –40 | | 150 | °C |

## 6.4 Thermal Information

| THERMAL METRIC (1) (2) | | TMP23X-Q1 | | UNIT |
|---|---|---|---|---|
| | | DCK (SC70) | DBZ (SOT-23) | |
| | | 5 PINS | 3 PINS | |
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance(3) (4) | 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.


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## 6.5 Electrical Characteristics

TMP235-Q1: $V_{DD}$ = 2.3 V to 5.5 V, GND = Ground, $T_A$ = –40°C to +125°C and no load (unless otherwise noted)
TMP236-Q1: $V_{DD}$ = 3.1 V to 5.5 V, GND = Ground, $T_A$ = –10°C to +125°C and no load (unless otherwise noted)

| PARAMETER | | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| **POWER SUPPLY** | | | | | | | |
| $I_{DD}$ | Operating current | | $T_A$ = 25°C, $V_{DD}$ = 2.3 V, TMP235-Q1 | | 9 | | µA |
| | | | $T_A$ = 25°C, $V_{DD}$ = 3.1 V, TMP236-Q1 | | 10 | | |
| | | | $T_A$ = –40°C to +125°C, TMP235-Q1 | | | 14.5 | |
| | | | $T_A$ = –10°C to +125°C, TMP236-Q1 | | | 15 | |
| | | | $T_A$ = 150°C, TMP235-Q1 | | | 17 | |
| Δ°C/ $\Delta V_{DD}$ | Line regulation | | | –0.1 | 0.02 | 0.1 | °C/V |
| **SENSOR ACCURACY** | | | | | | | |
| $T_{ACY}$ | Temperature accuracy(1) | | $T_A$ = 25°C | | ±0.5 | | °C |
| | | | $T_A$ = 0°C to 70°C (SC70 Package) (TMP235-Q1) | –1.5 | ±0.5 | +1.2 | |
| | | | $T_A$ = 0°C to 70°C (SOT-23 Package) (TMP235-Q1) | –1.5 | ±0.5 | +1.2 | |
| | | | $T_A$ = –40°C to 125°C (TMP235-Q1) | –2.5 | ±0.5 | +2.5 | |
| | | | $T_A$ = –40°C to 150°C (TMP235-Q1) | –2.5 | ±0.5 | +2.5 | |
| | | | $T_A$ = –10°C to 125°C (TMP236-Q1) | –2.5 | ±0.5 | +2.5 | |
| $T_{ACY}$ | Temperature accuracy(1) | | $T_A$ = 0°C to 70°C (SOT-23 Package) (TMP236-Q1) | –1.5 | ±0.5 | +1.5 | °C |
| **SENSOR OUTPUT** | | | | | | | |
| $V_{0°C}$ | Output voltage offset at 0 °C | | TMP235-Q1 | | 500 | | mV |
| | | | TMP236-Q1 | | 400 | | |
| $T_C$ | Temperature coefficient (sensor gain) | | TMP235-Q1 | | 10 | | mV/°C |
| | | | TMP236-Q1 | | 19.5 | | |
| $V_{ONL}$ | Output nonlinearity(2) | | $T_A$ = 0 °C to 70 °C, no load | | ±0.5 | | °C |
| $I_{OUT}$ | Output current | | | | | 500 | µA |
| $Z_{OUT}$ | Output impedance | | IOUT = 100 µA, f = 100 Hz | | 20 | | Ω |
| | | | IOUT = 100 µA, f = 500 Hz | | 50 | | |
| | Output load regulation | | $T_A$ = 0°C to 70°C, IOUT = 100 µA, $\Delta V_{OUT}$ / $\Delta I_{OUT}$ | | 1 | | Ω |
| $t_{ON}$ | Turn on time | | Time to reach accuracy within ±0.5°C | | 800 | | µs |
| $C_{LOAD}$ | Typical load capacitance | | | | | 1000 | pF |
| $t_{RES}$ | 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-Q1 Transfer Table and TMP236-Q1 Transfer Table at the specified conditions of supply voltage and temperature (expressed in °C). Accuracy limits include line regulation within the specified conditions. Accuracy limits do not include load regulation; they assume no DC load.
(2) Nonlinearity is defined as the deviation of the output-voltage-versus-temperature curve from the best-fit straight line, over the device's rated temperature range.

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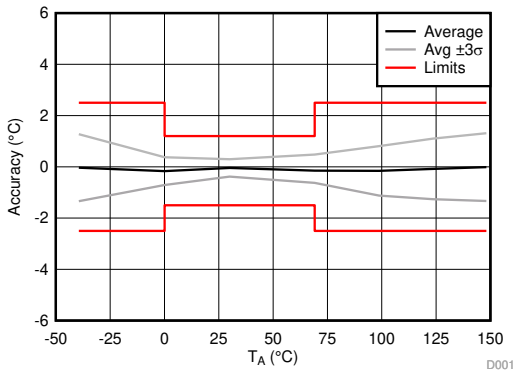
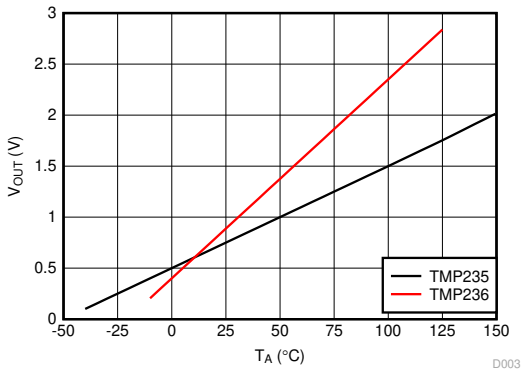
## 6.6 Typical Characteristics

at $T_A$ = 25°C, (unless otherwise noted)



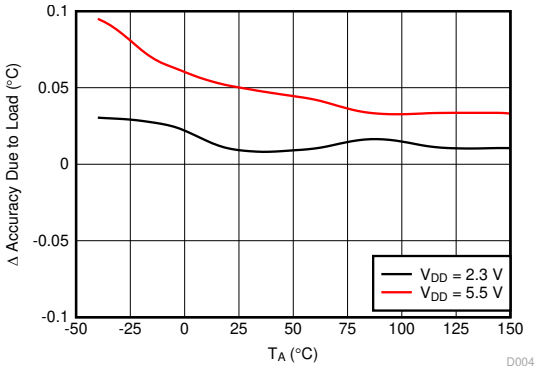

TMP235-Q1: $V_{DD}$ = 2.3 to 5.5 V, $I_{OUT}$ = 0 µA, $C_{LOAD}$ = 1000 pF

**Figure 6-1. Accuracy vs $T_A$ Temperature**



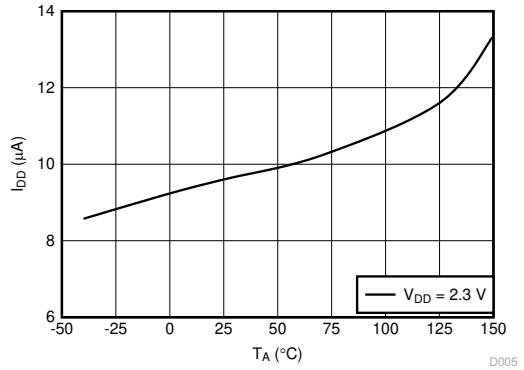

$I_{OUT}$ = 0 µA, $C_{LOAD}$ = 1000 pF

**Figure 6-2. Output Voltage vs Ambient Temperature**



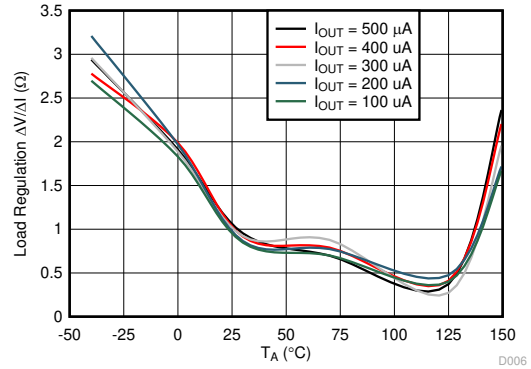

TMP23x-Q1: $I_{OUT}$ = from 0 µA to 100 µA, $C_{LOAD}$ = 1000 pF

**Figure 6-3. Changes in Accuracy vs Ambient Temperature (Due to Load)**



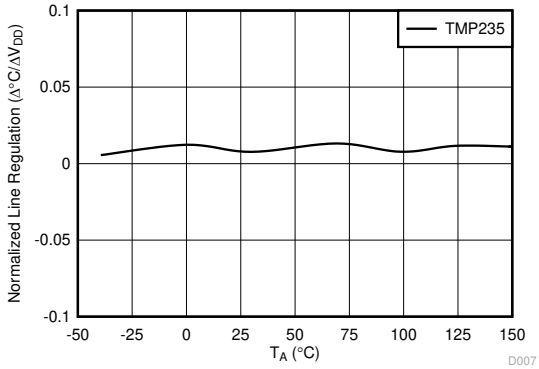

TMP23x-Q1: $I_{OUT}$ = 0 µA, $C_{LOAD}$ = 1000 pF

**Figure 6-4. Supply Current vs Temperature**




TMP23x-Q1: $V_{DD}$ = 2.3 V, $C_{LOAD}$ = 1000 pF

**Figure 6-5. Load Regulation vs Ambient Temperature**




TMP23x-Q1: $V_{DD}$ = 2.3 to 5.5 V, $I_{OUT}$ = 0 µA, $C_{LOAD}$ = 1000 pF

**Figure 6-6. Line Regulation (Δ°C / Δ$V_{DD}$) vs Ambient Temperature**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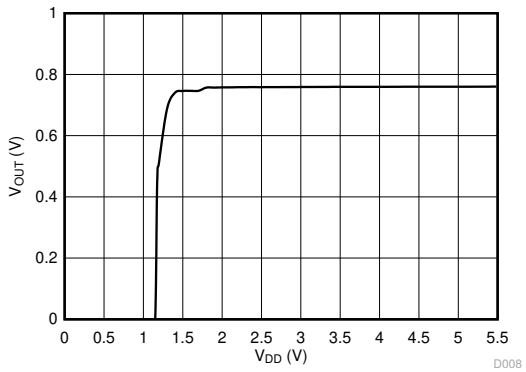
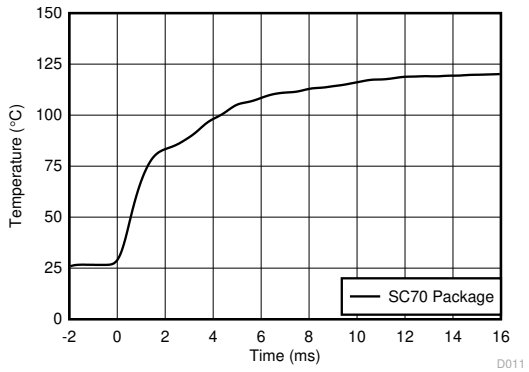


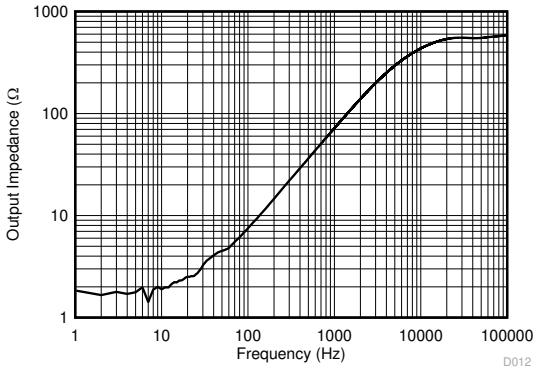

TMP23x-Q1: $T_A$ = 25°C

**Figure 6-7. Output Voltage vs Power Supply**




TMP23x-Q1: 1 × 1 (inches) PCB, Air 26°C to Fluid Bath 123°C

**Figure 6-8. Thermal Response (Air-to-Fluid Bath)**




TMP23x-Q1: $T_A$ = 25°C, $V_{DD}$ = 5 V, $I_{OUT}$ = 100 µA

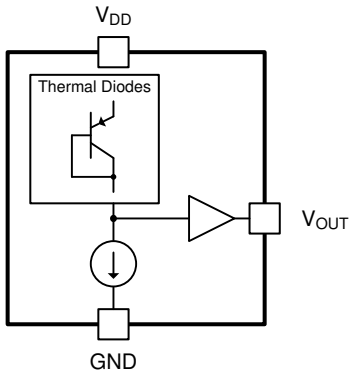
**Figure 6-9. Output Impedance vs Frequency**

# 7 Detailed Description

## 7.1 Overview

The TMP23x-Q1 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 ±1.5°C. The TMP235-Q1 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-Q1 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 Figure 6-2, the TMP23x-Q1 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-Q1 devices across the full operating temperature range are listed in Table 7-3 and Table 7-4. 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 Table 7-1 and Table 7-2. In equation form, the voltage output $V_{OUT}$ of the TMP23x-Q1 is calculated by Equation 1:

$$V_{OUT} = (T_A - T_{INFL}) \times T_C + V_{OFFS} \quad (1)$$

where

- $V_{OUT}$ is the TMP23x-Q1 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-Q1 temperature coefficient or gain
- $V_{OFFS}$ is the TMP23x-Q1 voltage offset

Therefore, the $T_A$ temperature for a given $V_{OUT}$ voltage output within a piecewise voltage range ($V_{RANGE}$) is calculated in Equation 2. For applications where the accuracy enhancement above 100°C is not required, use the first row of Table 7-1 and Table 7-2 for all voltages.

$$T_A = (V_{OUT} - V_{OFFS}) / T_C + T_{INFL} \quad (2)$$

**Table 7-1. TMP235-Q1 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 |


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**Table 7-2. TMP236-Q1 Piecewise Linear Function Summary**

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

**Table 7-3. TMP235-Q1 Transfer Table**

| TEMPERATURE (°C) | $V_{OUT}$ (mV) IDEAL LINEAR VALUES | $V_{OUT}$ (mV) 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 |

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**Table 7-4. TMP236-Q1 Transfer Table**

| TEMPERATURE (°C) | $V_{OUT}$ (mV) IDEAL LINEAR VALUES | $V_{OUT}$ (mV) 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-Q1 is an analog output directly proportional to temperature.


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# 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, as well as validating and testing their design implementation to confirm system functionality.

## 8.1 Application Information

The features of the TMP235-Q1 make the series of devices designed for various general temperature-sensing applications. The TMP235-Q1 and TMP236-Q1 devices can operate down to a 2.3-V and a 3.1-V supply with 9-µA power consumption, respectively. The TMP23x-Q1 series is mounted in two surface mount technology packages (SC70 and SOT-23.)

## 8.2 Typical Application

### 8.2.1 Connection to an ADC

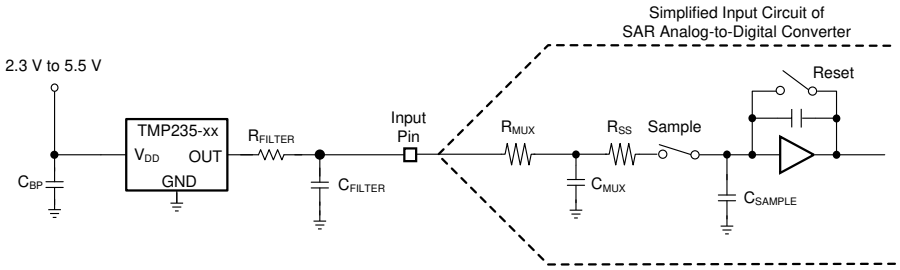


**Figure 8-1. Suggested Connections to an ADC Input Stage**

#### *8.2.1.1 Design Requirements*

See Figure 8-1 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 TMP235-Q1. 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 TMP235-Q1 is specified and characterized with a 1000-pF maximum capacitive load ($C_{LOAD}$). Figure 8-1 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 8-1 shows a general ADC application as an example only.

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#### 8.2.1.3 Application Curve

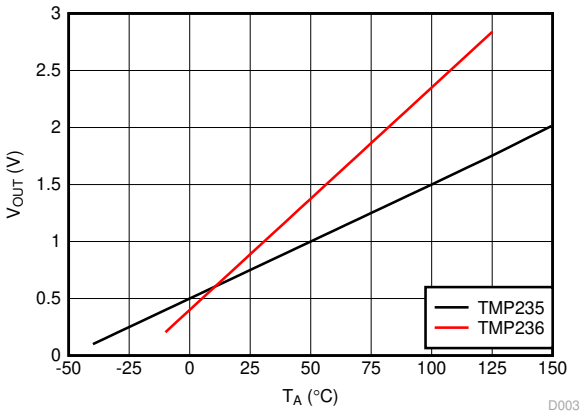


**Figure 8-2. Output Voltage vs. Ambient**

## 9 Power Supply Recommendations

The low supply current and supply range of the TMP23x-Q1 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 $V_{DD}$ 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-Q1 series is simple. If a power supply bypass capacitor is used, the capacitor must be connected as *Layout Examples* shows.

### 10.2 Layout Examples

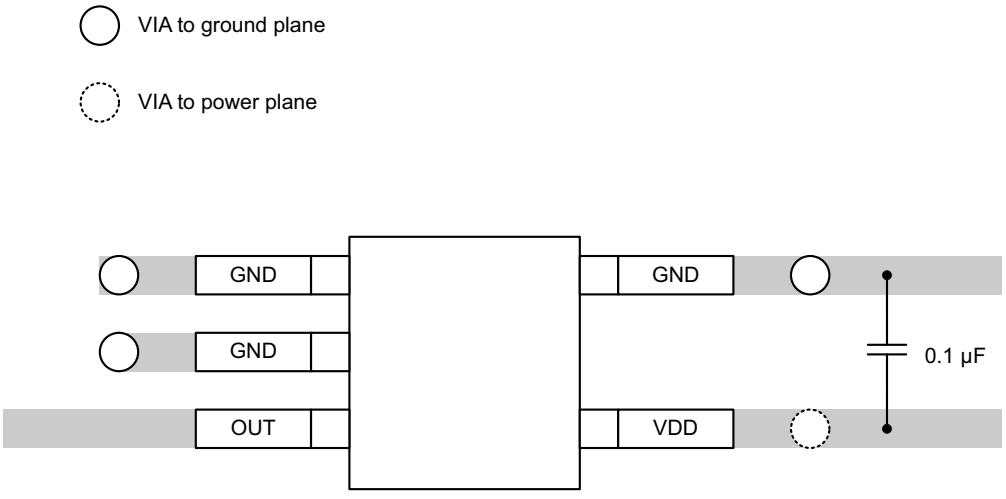


**Figure 10-1. Recommended Layout: SC70 Package**


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# 11 Device and Documentation Support

## 11.1 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.

## 11.2 Support Resources

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

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## 11.3 Trademarks

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## 11.4 Electrostatic Discharge Caution

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

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

## 11.5 Glossary

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

# 12 Mechanical, Packaging, and Orderable Information

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

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## 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TMP235AEDBZRQ1 | ACTIVE | SOT-23 | DBZ | 3 | 3000 | RoHS & Green | NIPDAUAG | Level-2-260C-1 YEAR | -40 to 150 | 235E | Samples |
| TMP235AEDCKRQ1 | ACTIVE | SC70 | DCK | 5 | 3000 | RoHS & Green | NIPDAUAG | Level-2-260C-1 YEAR | -40 to 150 | 1CF | Samples |
| TMP235AQDBZRQ1 | ACTIVE | SOT-23 | DBZ | 3 | 3000 | RoHS & Green | NIPDAUAG | Level-2-260C-1 YEAR | -40 to 125 | 235Q | Samples |
| TMP235AQDCKRQ1 | ACTIVE | SC70 | DCK | 5 | 3000 | RoHS & Green | NIPDAUAG | Level-2-260C-1 YEAR | -40 to 125 | 1CG | Samples |
| TMP236AQDBZRQ1 | ACTIVE | SOT-23 | DBZ | 3 | 3000 | RoHS & Green | NIPDAUAG | Level-2-260C-1 YEAR | -40 to 125 | 236Q | 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.

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**OTHER QUALIFIED VERSIONS OF TMP235-Q1, TMP236-Q1 :**

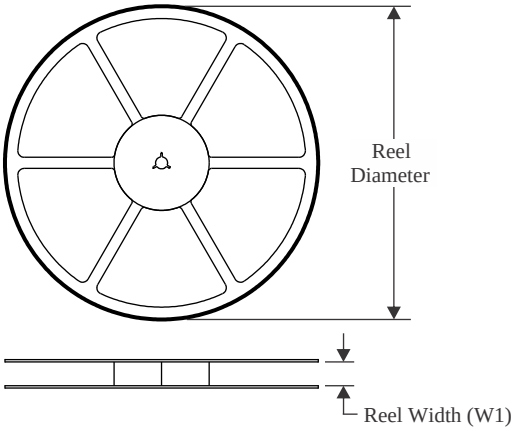
- Catalog : TMP235, TMP236

NOTE: Qualified Version Definitions:

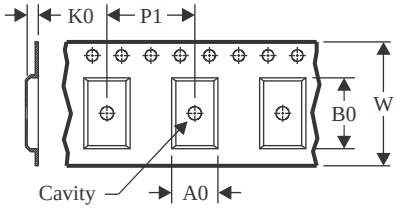
- Catalog - TI's standard catalog product

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

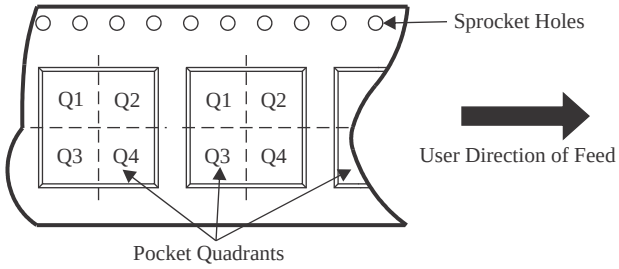



**TAPE DIMENSIONS**




| | |
|---|---|
| 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 |

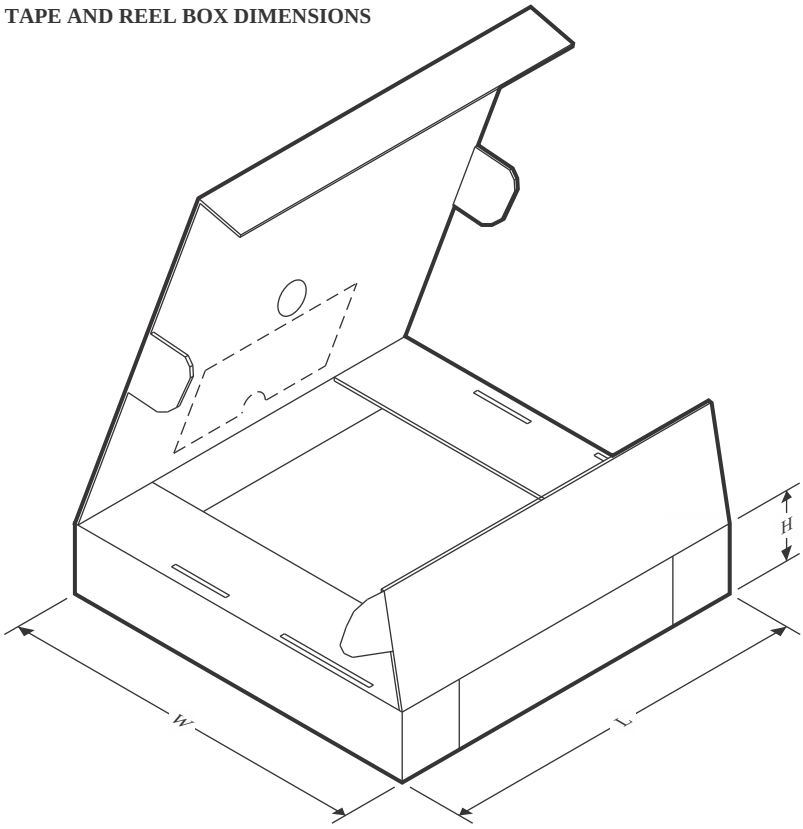
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TMP235AEDBZRQ1 | SOT-23 | DBZ | 3 | 3000 | 180.0 | 8.4 | 3.15 | 2.77 | 1.22 | 4.0 | 8.0 | Q3 |
| TMP235AEDCKRQ1 | SC70 | DCK | 5 | 3000 | 180.0 | 8.4 | 2.47 | 2.3 | 1.25 | 4.0 | 8.0 | Q3 |
| TMP235AQDBZRQ1 | SOT-23 | DBZ | 3 | 3000 | 180.0 | 8.4 | 3.15 | 2.77 | 1.22 | 4.0 | 8.0 | Q3 |
| TMP235AQDCKRQ1 | SC70 | DCK | 5 | 3000 | 180.0 | 8.4 | 2.47 | 2.3 | 1.25 | 4.0 | 8.0 | Q3 |
| TMP236AQDBZRQ1 | SOT-23 | DBZ | 3 | 3000 | 180.0 | 8.4 | 3.15 | 2.77 | 1.22 | 4.0 | 8.0 | Q3 |

TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

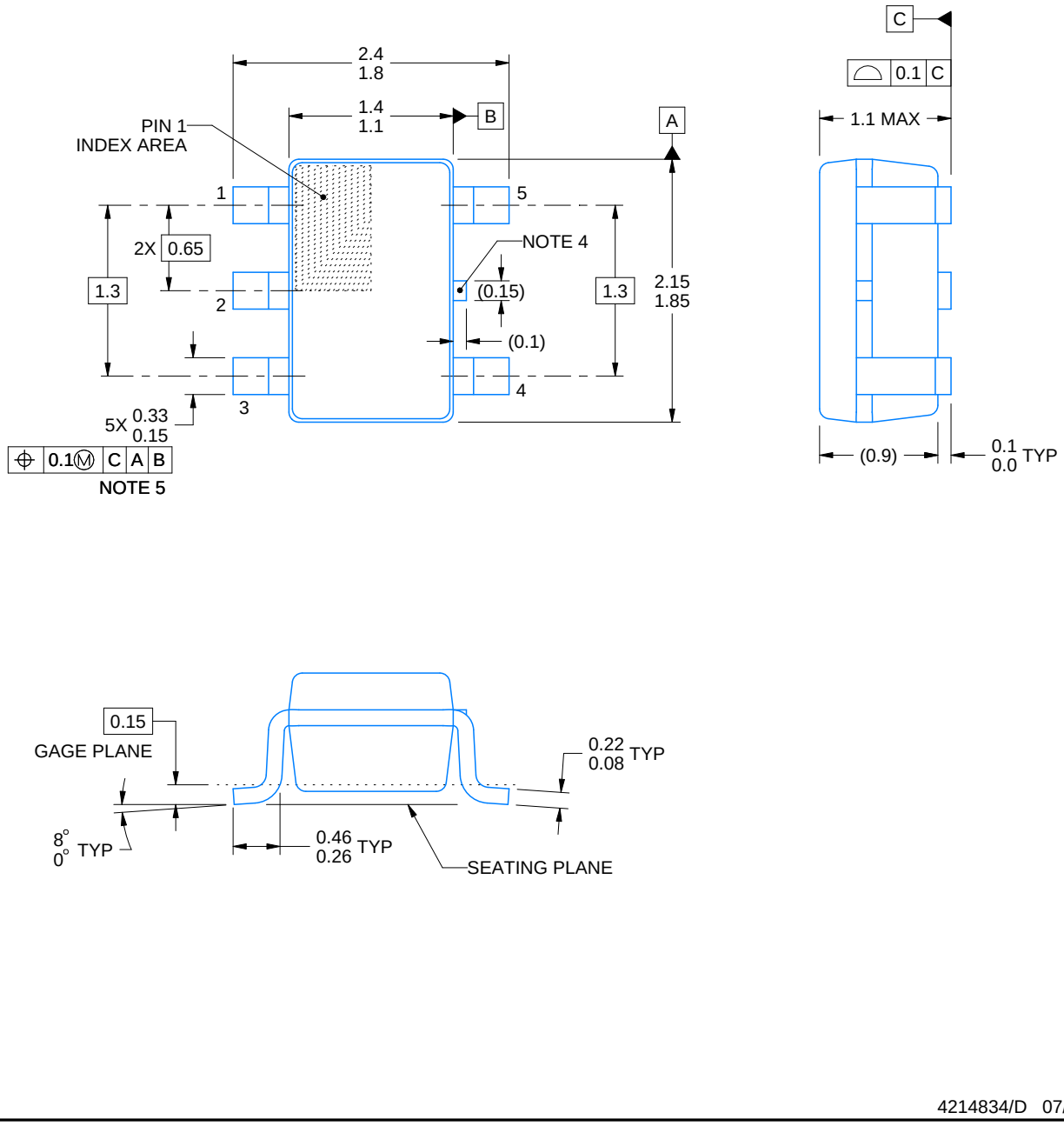
| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| TMP235AEDBZRQ1 | SOT-23 | DBZ | 3 | 3000 | 213.0 | 191.0 | 35.0 |
| TMP235AEDCKRQ1 | SC70 | DCK | 5 | 3000 | 213.0 | 191.0 | 35.0 |
| TMP235AQDBZRQ1 | SOT-23 | DBZ | 3 | 3000 | 213.0 | 191.0 | 35.0 |
| TMP235AQDCKRQ1 | SC70 | DCK | 5 | 3000 | 213.0 | 191.0 | 35.0 |
| TMP236AQDBZRQ1 | SOT-23 | DBZ | 3 | 3000 | 213.0 | 191.0 | 35.0 |

# PACKAGE OUTLINE

## DCK0005A

## SOT - 1.1 max height

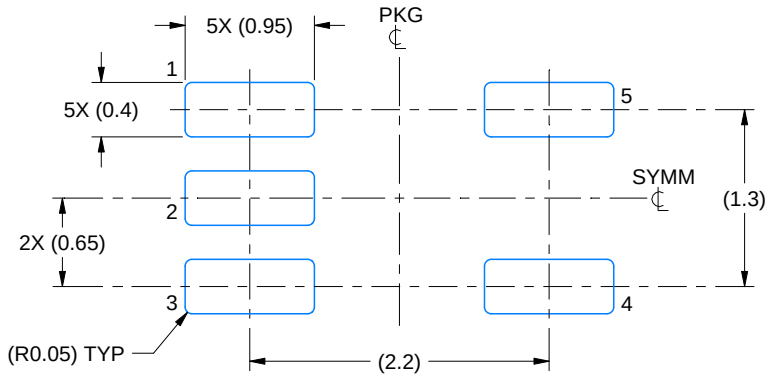
SMALL OUTLINE TRANSISTOR



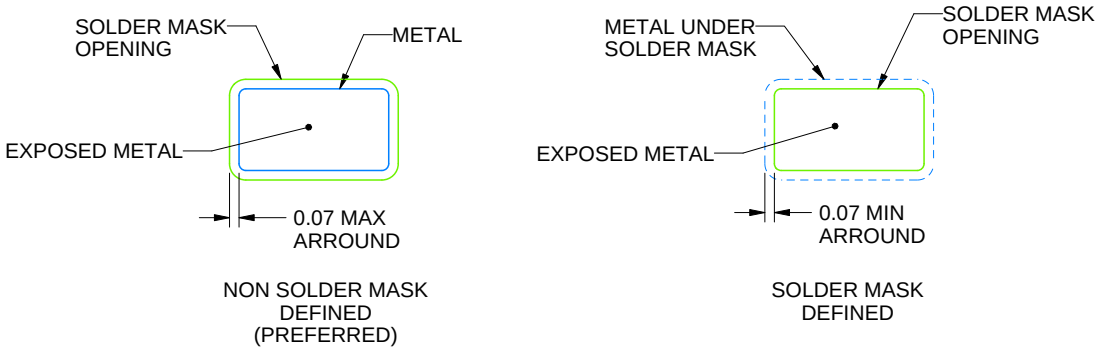

4214834/D 07/2023

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. Refernce JEDEC MO-203.
4. Support pin may differ or may not be present.
5. Lead width does not comply with JEDEC.




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:18X

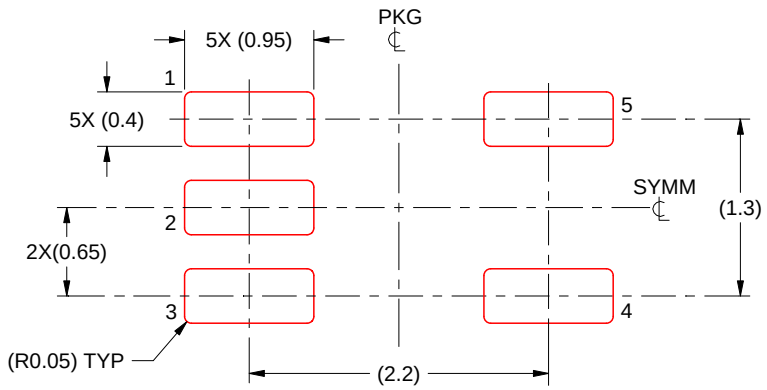



SOLDER MASK DETAILS

4214834/D 07/2023

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 THICK STENCIL
SCALE:18X

4214834/D 07/2023

NOTES: (continued)

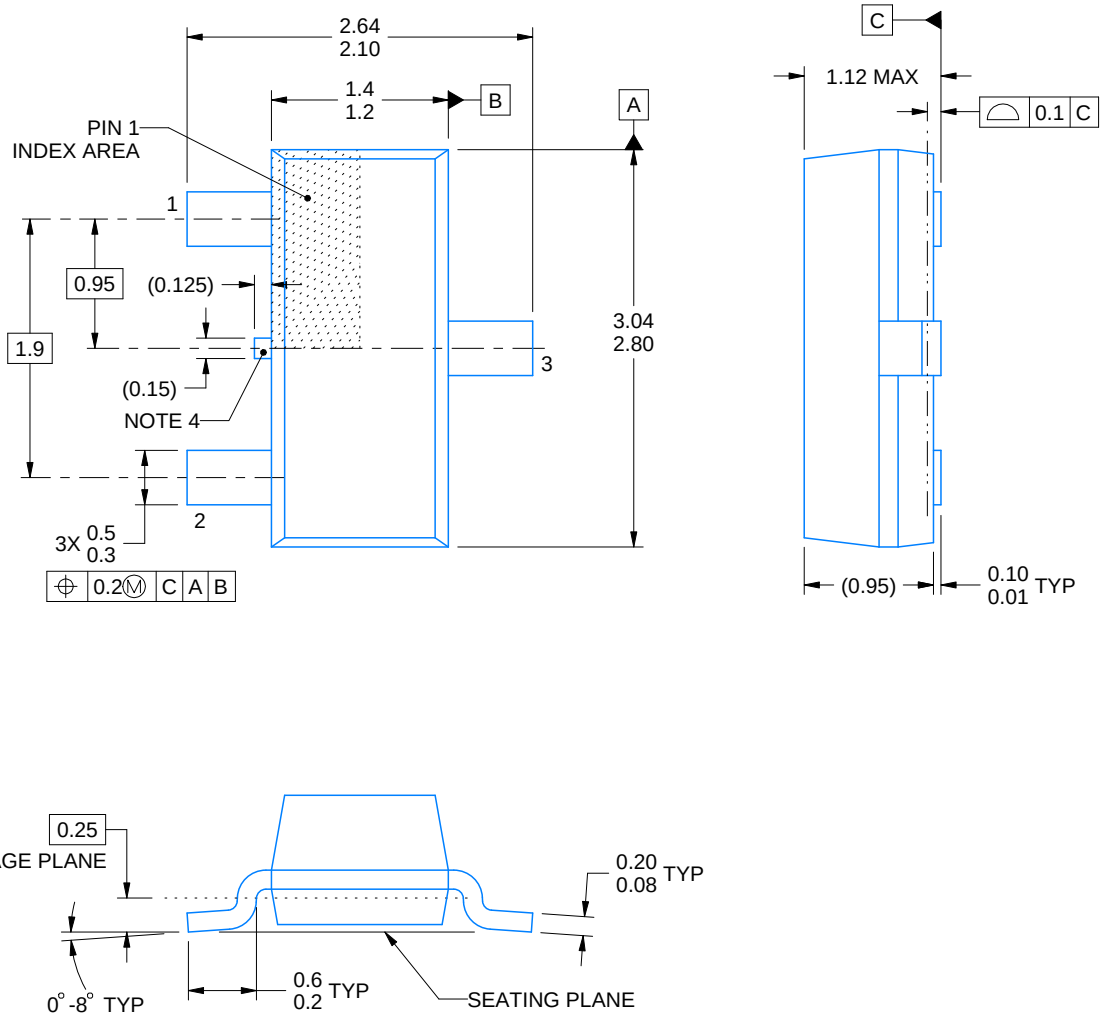
8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

# PACKAGE OUTLINE

## DBZ0003A

## SOT-23 - 1.12 mm max height

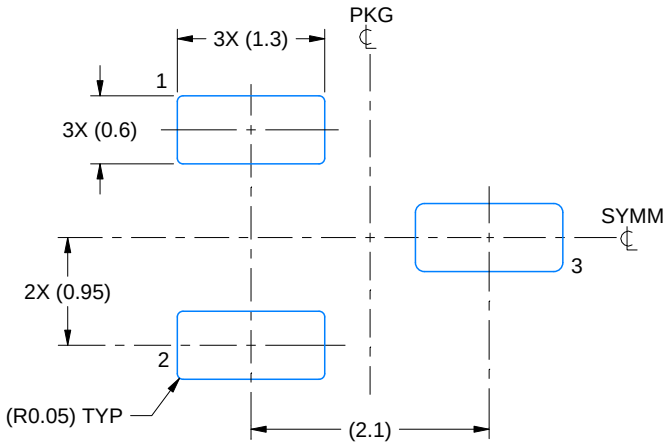
SMALL OUTLINE TRANSISTOR



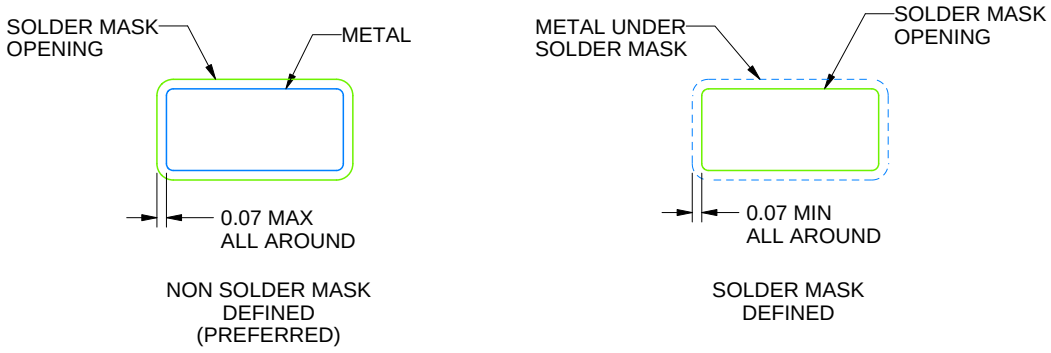

4214838/D 03/2023

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 registration TO-236, except minimum foot length.
4. Support pin may differ or may not be present.




LAND PATTERN EXAMPLE
SCALE:15X

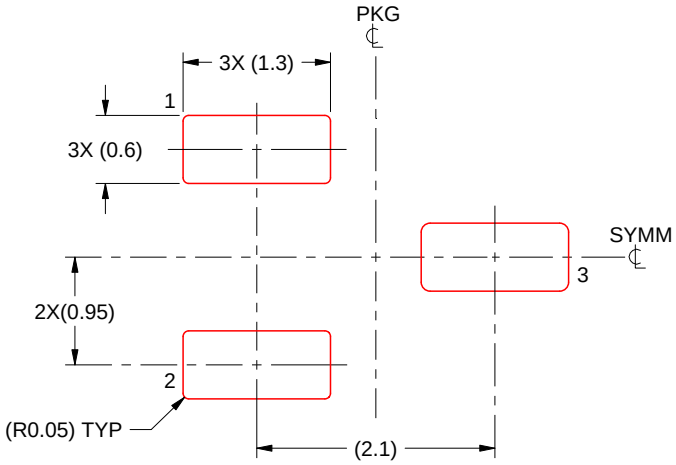



SOLDER MASK DETAILS

4214838/D 03/2023

NOTES: (continued)

4. Publication IPC-7351 may have alternate designs.
5. 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:15X

4214838/D 03/2023

NOTES: (continued)

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

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