

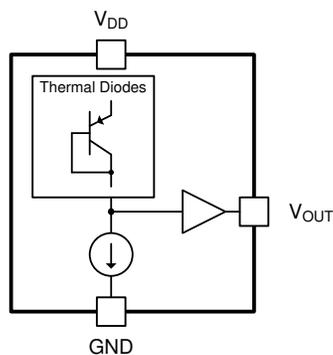
# TMP23x-Q1 Automotive Grade, High-Accuracy Analog Output Temperature Sensors

## 1 Features

- AEC-Q100 qualified for automotive applications
  - TMP235-Q1 grade 0:  $-40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$
  - TMP236-Q1 grade 1:  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$
- **Functional Safety-Capable**
  - [Documentation available to aid functional safety system design](#)
- Tight accuracy across a wide temperature range:
  - $\pm 2.5^{\circ}\text{C}$  (maximum):  $-40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$  (TMP235-Q1)
  - $\pm 2.5^{\circ}\text{C}$  (maximum):  $-10^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  (TMP236-Q1)
- Positive slope sensor gain, offset (typical):
  - 10 mV/ $^{\circ}\text{C}$ , 500 mV at  $0^{\circ}\text{C}$  (TMP235-Q1)
  - 19.5 mV/ $^{\circ}\text{C}$ , 400 mV at  $0^{\circ}\text{C}$  (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  $\mu\text{A}$  (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

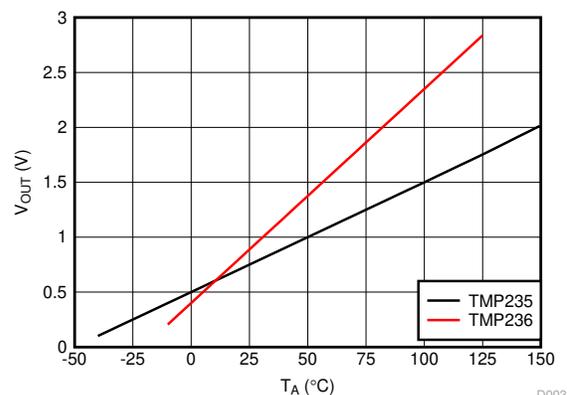
The TMP23x-Q1 devices are a family of automotive grade precision CMOS integrated-circuit linear analog temperature sensors with an output voltage proportional to temperature, serving various automotive applications from powertrain to infotainment. These temperature sensors have a typical accuracy from  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$  of  $\pm 0.5^{\circ}\text{C}$ . The TMP235-Q1 device provides a positive slope output of 10 mV/ $^{\circ}\text{C}$  over the full  $-40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$  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/ $^{\circ}\text{C}$  from  $-10^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  and a supply range from 3.1 V to 5.5 V.

The 9- $\mu\text{A}$  typical quiescent current and 800- $\mu\text{s}$  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- $\mu\text{A}$  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<sup>(1)</sup>

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

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



**Output Voltage vs Ambient**

D003



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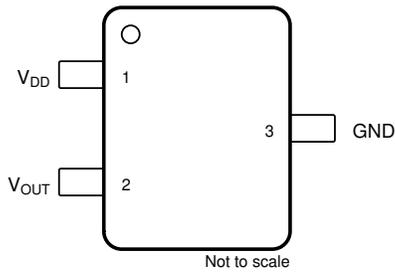
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## 4 Revision History

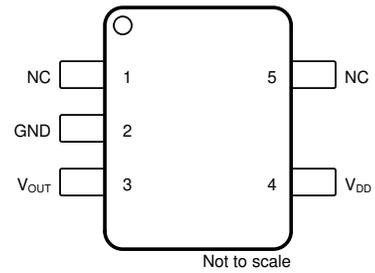
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

<b>Changes from Revision C (November 2019) to Revision D (June 2022)</b>	<b>Page</b>
• Updated the numbering format for tables, figures, and cross-references throughout the document.....	1
• Added Functional Safety bullets to the <i>Features</i> section.....	1
<hr/>	
<b>Changes from Revision B (October 2019) to Revision C (November 2019)</b>	<b>Page</b>
• Added temperature accuracy specs for the TMP236-Q1 SOT-23 package.....	5
<hr/>	
<b>Changes from Revision A (May 2019) to Revision B (October 2019)</b>	<b>Page</b>
• Changed document status from Advance Information to Production Data.....	1
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<b>Changes from Revision * (April 2019) to Revision A (May 2019)</b>	<b>Page</b>
• Changed recommended operating temperature range from: –50°C to 150°C to: –40°C to 150°C .....	4

## 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 <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 AEC Q100-002 <sup>(1)</sup> 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 <sup>(1)</sup> <sup>(2)</sup>		TMP23X-Q1		UNIT
		DCK (SC70)	DBZ (SOT-23)	
		5 PINS	3 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance <sup>(3)</sup> <sup>(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-Q1:  $V_{DD} = 2.3\text{ V to }5.5\text{ V}$ , GND = Ground,  $T_A = -40^\circ\text{C to }+125^\circ\text{C}$  and no load (unless otherwise noted)

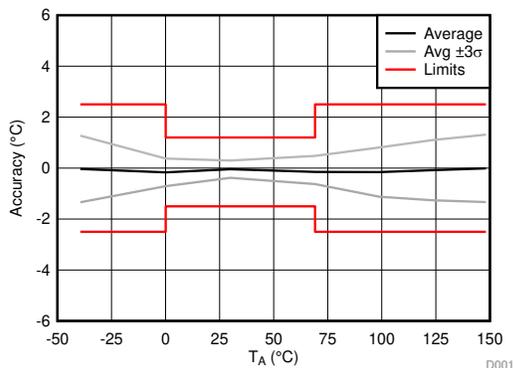
TMP236-Q1:  $V_{DD} = 3.1\text{ V to }5.5\text{ V}$ , GND = Ground,  $T_A = -10^\circ\text{C to }+125^\circ\text{C}$  and no load (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT	
<b>POWER SUPPLY</b>							
$I_{DD}$	Operating current	$T_A = 25^\circ\text{C}$ , $V_{DD} = 2.3\text{ V}$ , TMP235-Q1		9		$\mu\text{A}$	
		$T_A = 25^\circ\text{C}$ , $V_{DD} = 3.1\text{ V}$ , TMP236-Q1		10			
		$T_A = -40^\circ\text{C to }+125^\circ\text{C}$ , TMP235-Q1			14.5		
		$T_A = -10^\circ\text{C to }+125^\circ\text{C}$ , TMP236-Q1					15
		$T_A = 150^\circ\text{C}$ , TMP235-Q1					17
$\Delta^\circ\text{C}/\Delta V_{DD}$	Line regulation		-0.1	0.02	0.1	$^\circ\text{C/V}$	
<b>SENSOR ACCURACY</b>							
$T_{ACY}$	Temperature accuracy <sup>(1)</sup>	$T_A = 25^\circ\text{C}$		$\pm 0.5$		$^\circ\text{C}$	
		$T_A = 0^\circ\text{C to }70^\circ\text{C}$ (SC70 Package) (TMP235-Q1)	-1.5	$\pm 0.5$	+1.2		
		$T_A = 0^\circ\text{C to }70^\circ\text{C}$ (SOT-23 Package) (TMP235-Q1)	-1.5	$\pm 0.5$	+1.2		
		$T_A = -40^\circ\text{C to }125^\circ\text{C}$ (TMP235-Q1)	-2.5	$\pm 0.5$	+2.5		
		$T_A = -40^\circ\text{C to }150^\circ\text{C}$ (TMP235-Q1)	-2.5	$\pm 0.5$	+2.5		
		$T_A = -10^\circ\text{C to }125^\circ\text{C}$ (TMP236-Q1)	-2.5	$\pm 0.5$	+2.5		
$T_{ACY}$	Temperature accuracy <sup>(1)</sup>	$T_A = 0^\circ\text{C to }70^\circ\text{C}$ (SOT-23 Package) (TMP236-Q1)	-1.5	$\pm 0.5$	+1.5	$^\circ\text{C}$	
<b>SENSOR OUTPUT</b>							
$V_{0^\circ\text{C}}$	Output voltage offset at $0^\circ\text{C}$	TMP235-Q1		500		$\text{mV}$	
		TMP236-Q1		400			
$T_C$	Temperature coefficient (sensor gain)	TMP235-Q1		10		$\text{mV}/^\circ\text{C}$	
		TMP236-Q1		19.5			
$V_{ONL}$	Output nonlinearity <sup>(2)</sup>	$T_A = 0^\circ\text{C to }70^\circ\text{C}$ , no load		$\pm 0.5$		$^\circ\text{C}$	
$I_{OUT}$	Output current				500	$\mu\text{A}$	
$Z_{OUT}$	Output impedance	$I_{OUT} = 100\ \mu\text{A}$ , $f = 100\text{ Hz}$		20		$\Omega$	
		$I_{OUT} = 100\ \mu\text{A}$ , $f = 500\text{ Hz}$		50			
	Output load regulation	$T_A = 0^\circ\text{C to }70^\circ\text{C}$ , $I_{OUT} = 100\ \mu\text{A}$ , $\Delta V_{OUT} / \Delta I_{OUT}$		1		$\Omega$	
$t_{ON}$	Turn on time	Time to reach accuracy within $\pm 0.5^\circ\text{C}$		800		$\mu\text{s}$	
$C_{LOAD}$	Typical load capacitance				1000	$\text{pF}$	
$t_{RES}$	Thermal response to 63%	SC70	$30^\circ\text{C}$ (Air) to $+125^\circ\text{C}$ (Fluid Bath)		1.3	$\text{s}$	

- (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  $^\circ\text{C}$ ). 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.

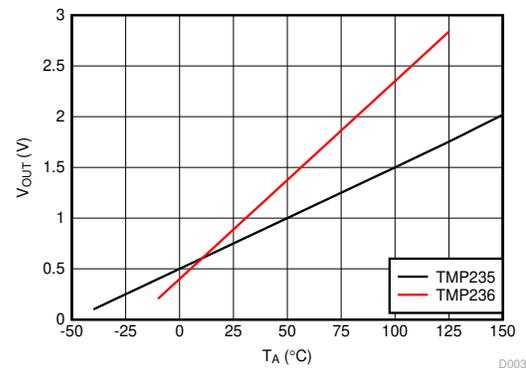
## 6.6 Typical Characteristics

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



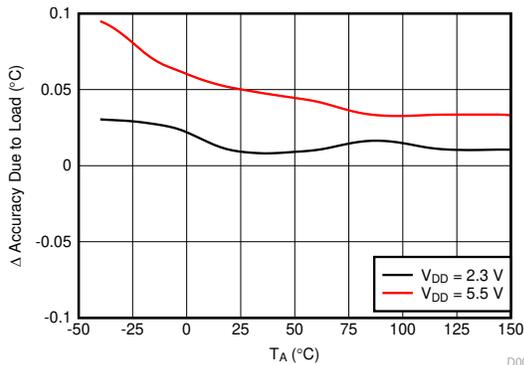
TMP235-Q1:  $V_{DD} = 2.3$  to  $5.5$  V,  $I_{OUT} = 0$   $\mu\text{A}$ ,  $C_{LOAD} = 1000$  pF

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



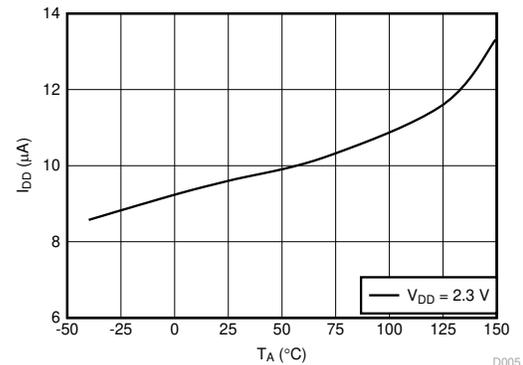
$I_{OUT} = 0$   $\mu\text{A}$ ,  $C_{LOAD} = 1000$  pF

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



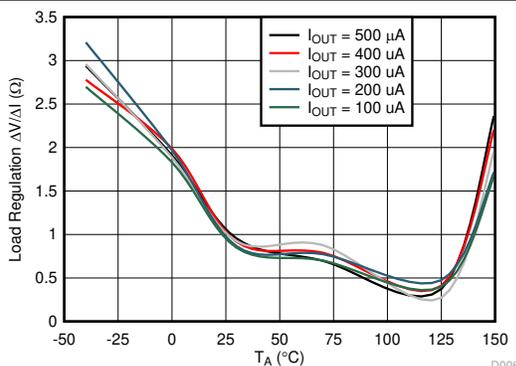
TMP23x-Q1:  $I_{OUT}$  = from  $0$   $\mu\text{A}$  to  $100$   $\mu\text{A}$ ,  $C_{LOAD} = 1000$  pF

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



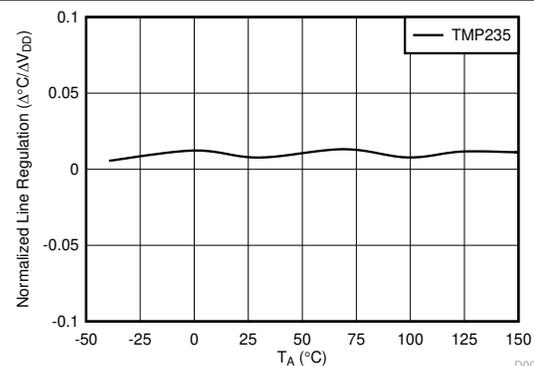
TMP23x-Q1:  $I_{OUT} = 0$   $\mu\text{A}$ ,  $C_{LOAD} = 1000$  pF

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



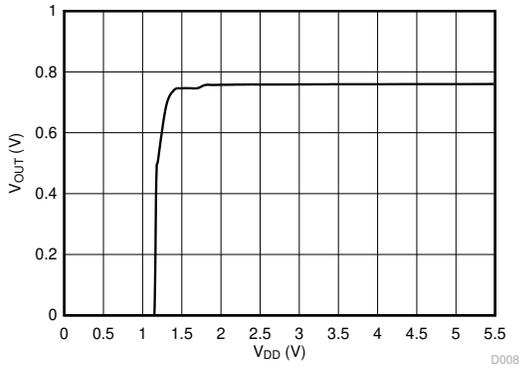
TMP23x-Q1:  $V_{DD} = 2.3$  V,  $C_{LOAD} = 1000$  pF

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

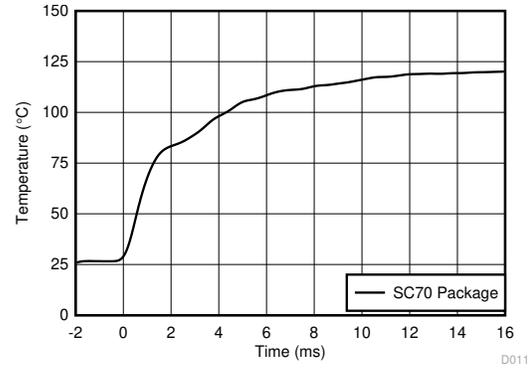


TMP23x-Q1:  $V_{DD} = 2.3$  to  $5.5$  V,  $I_{OUT} = 0$   $\mu\text{A}$ ,  $C_{LOAD} = 1000$  pF

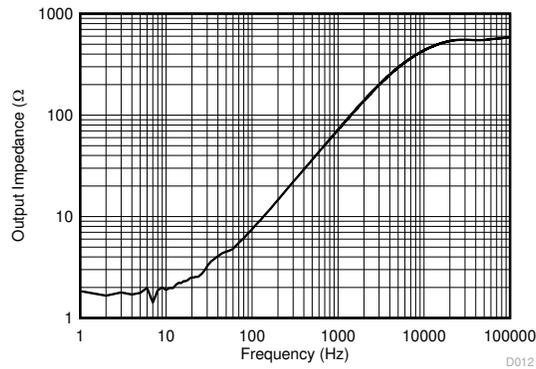
**Figure 6-6. Line Regulation ( $\Delta^\circ\text{C} / \Delta V_{DD}$ ) vs Ambient Temperature**



TMP23x-Q1:  $T_A = 25^\circ\text{C}$   
**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)**



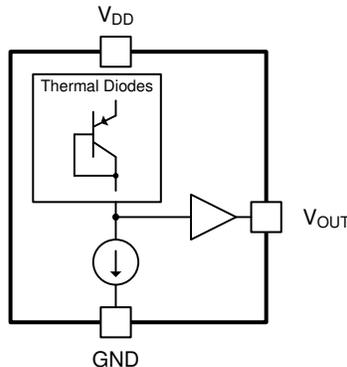
TMP23x-Q1:  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 5\text{ V}$ ,  $I_{OUT} = 100\ \mu\text{A}$   
**Figure 6-9. Output Impedance vs Frequency**

## 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

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

T <sub>A</sub> RANGE (°C)	V <sub>RANGE</sub> (mV)	T <sub>INFL</sub> (°C)	T <sub>C</sub> (mV/°C)	V <sub>OFFS</sub> (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 <sub>OUT</sub> (mV) IDEAL LINEAR VALUES	V <sub>OUT</sub> (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

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

TEMPERATURE (°C)	V <sub>OUT</sub> (mV) IDEAL LINEAR VALUES	V <sub>OUT</sub> (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.

## 8 Application and Implementation

### Note

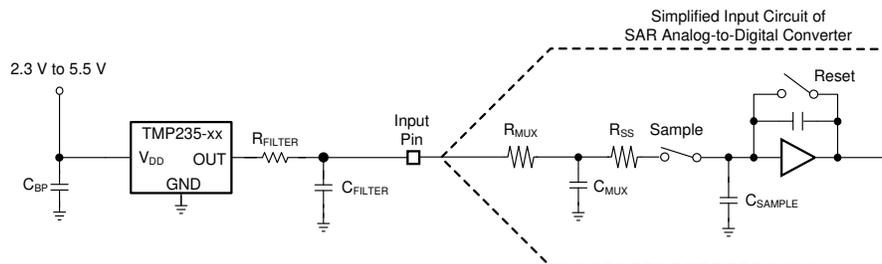
Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation 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- $\mu$ A 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.

### 8.2.1.3 Application Curve

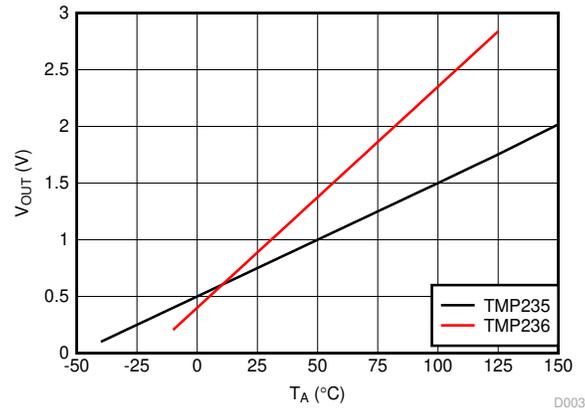


Figure 8-2. Output Voltage vs. Ambient

## 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- $\mu$ F capacitor and 100- $\Omega$  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

-  VIA to ground plane
-  VIA to power plane

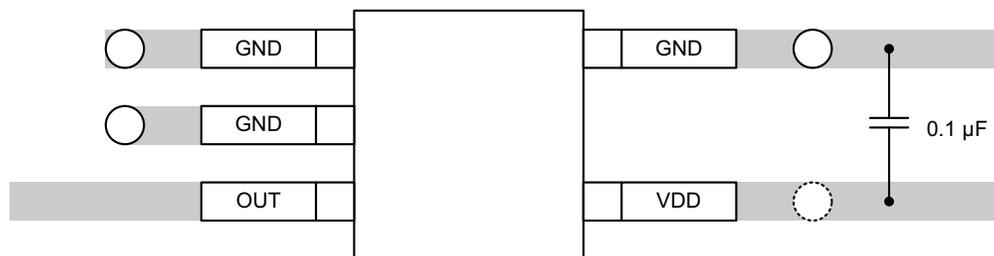


Figure 10-1. Recommended Layout: SC70 Package

## 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](http://ti.com). Click on *Subscribe to updates* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 11.2 Support Resources

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

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### 11.3 Trademarks

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

### 11.4 Electrostatic Discharge Caution



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

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

### 11.5 Glossary

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

## 12 Mechanical, Packaging, and Orderable Information

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

**PACKAGING INFORMATION**

Orderable part number	Status (1)	Material type (2)	Package   Pins	Package qty   Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
<a href="#">TMP235AEDBZRQ1</a>	Active	Production	SOT-23 (DBZ)   3	3000   LARGE T&R	Yes	NIPDAU   NIPDAUAG	Level-2-260C-1 YEAR	-40 to 150	235E
TMP235AEDBZRQ1.A	Active	Production	SOT-23 (DBZ)   3	3000   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 150	235E
<a href="#">TMP235AEDBZTQ1</a>	Obsolete	Production	SOT-23 (DBZ)   3	-	-	Call TI	Call TI	-40 to 150	235E
<a href="#">TMP235AEDCKRQ1</a>	Active	Production	SC70 (DCK)   5	3000   LARGE T&R	Yes	NIPDAUAG	Level-2-260C-1 YEAR	-40 to 150	1CF
TMP235AEDCKRQ1.A	Active	Production	SC70 (DCK)   5	3000   LARGE T&R	Yes	NIPDAUAG	Level-2-260C-1 YEAR	-40 to 150	1CF
<a href="#">TMP235AQDBZRQ1</a>	Active	Production	SOT-23 (DBZ)   3	3000   LARGE T&R	Yes	NIPDAU   SN   NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	235Q
TMP235AQDBZRQ1.A	Active	Production	SOT-23 (DBZ)   3	3000   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	235Q
<a href="#">TMP235AQDBZTQ1</a>	Obsolete	Production	SOT-23 (DBZ)   3	-	-	Call TI	Call TI	-40 to 125	235Q
<a href="#">TMP235AQDCKRQ1</a>	Active	Production	SC70 (DCK)   5	3000   LARGE T&R	Yes	NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	1CG
TMP235AQDCKRQ1.A	Active	Production	SC70 (DCK)   5	3000   LARGE T&R	Yes	NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	1CG
<a href="#">TMP235AQDCKTQ1</a>	Obsolete	Production	SC70 (DCK)   5	-	-	Call TI	Call TI	-40 to 125	1CG
<a href="#">TMP236AQDBZRQ1</a>	Active	Production	SOT-23 (DBZ)   3	3000   LARGE T&R	Yes	NIPDAU   SN   NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	236Q
TMP236AQDBZRQ1.A	Active	Production	SOT-23 (DBZ)   3	3000   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	236Q
<a href="#">TMP236AQDBZTQ1</a>	Obsolete	Production	SOT-23 (DBZ)   3	-	-	Call TI	Call TI	-40 to 125	236Q

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

(2) **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.

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

(4) **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.

(5) **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.

(6) **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-Q1, TMP236-Q1 :**

- Catalog : [TMP235](#), [TMP236](#)

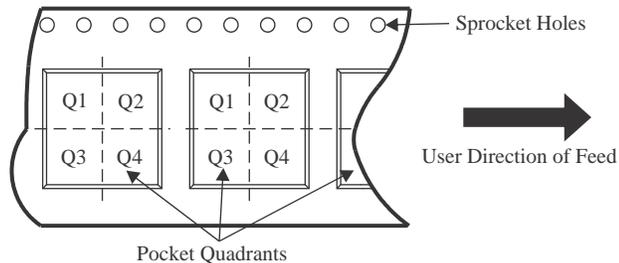
NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

## 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
TMP235AEDBZRQ1	SOT-23	DBZ	3	3000	180.0	8.4	3.15	2.77	1.22	4.0	8.0	Q3
TMP235AEDBZRQ1	SOT-23	DBZ	3	3000	180.0	8.4	2.9	3.35	1.35	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	3.2	2.85	1.3	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	2.9	3.35	1.35	4.0	8.0	Q3
TMP236AQDBZRQ1	SOT-23	DBZ	3	3000	180.0	8.4	3.2	2.85	1.3	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
TMP235AEDBZRQ1	SOT-23	DBZ	3	3000	210.0	185.0	35.0
TMP235AEDCKRQ1	SC70	DCK	5	3000	213.0	191.0	35.0
TMP235AQDBZRQ1	SOT-23	DBZ	3	3000	210.0	185.0	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	210.0	185.0	35.0
TMP236AQDBZRQ1	SOT-23	DBZ	3	3000	210.0	185.0	35.0

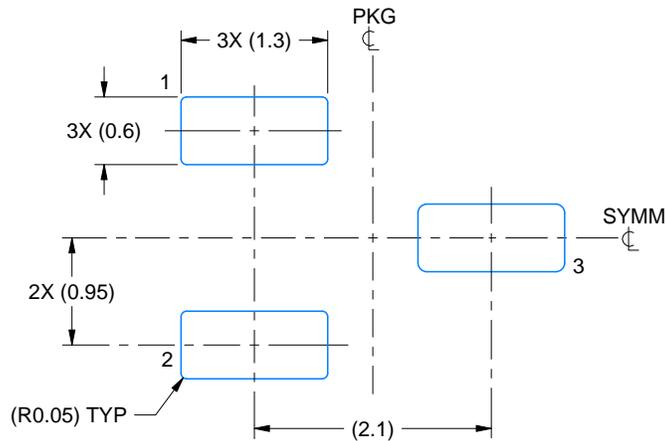


# EXAMPLE BOARD LAYOUT

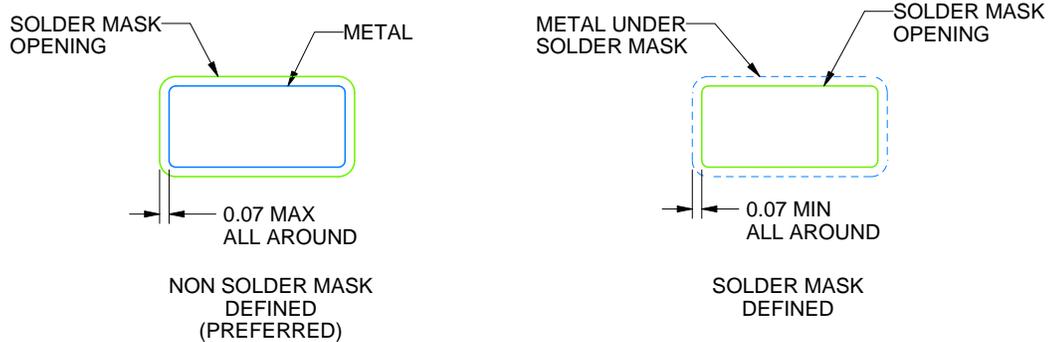
DBZ0003A

SOT-23 - 1.12 mm max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE  
SCALE:15X



SOLDER MASK DETAILS

4214838/F 08/2024

NOTES: (continued)

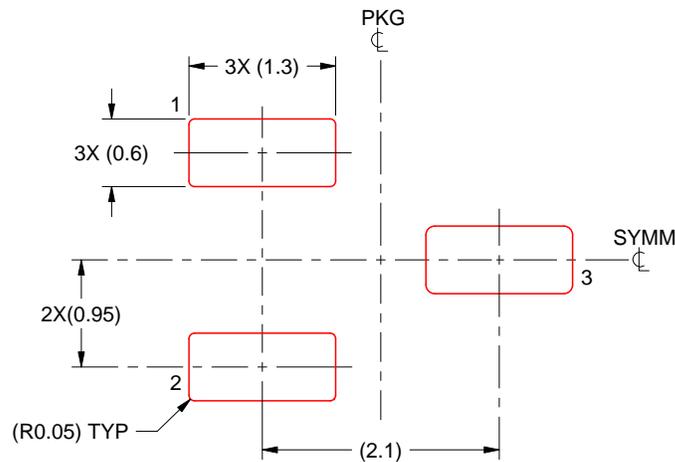
5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# 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.

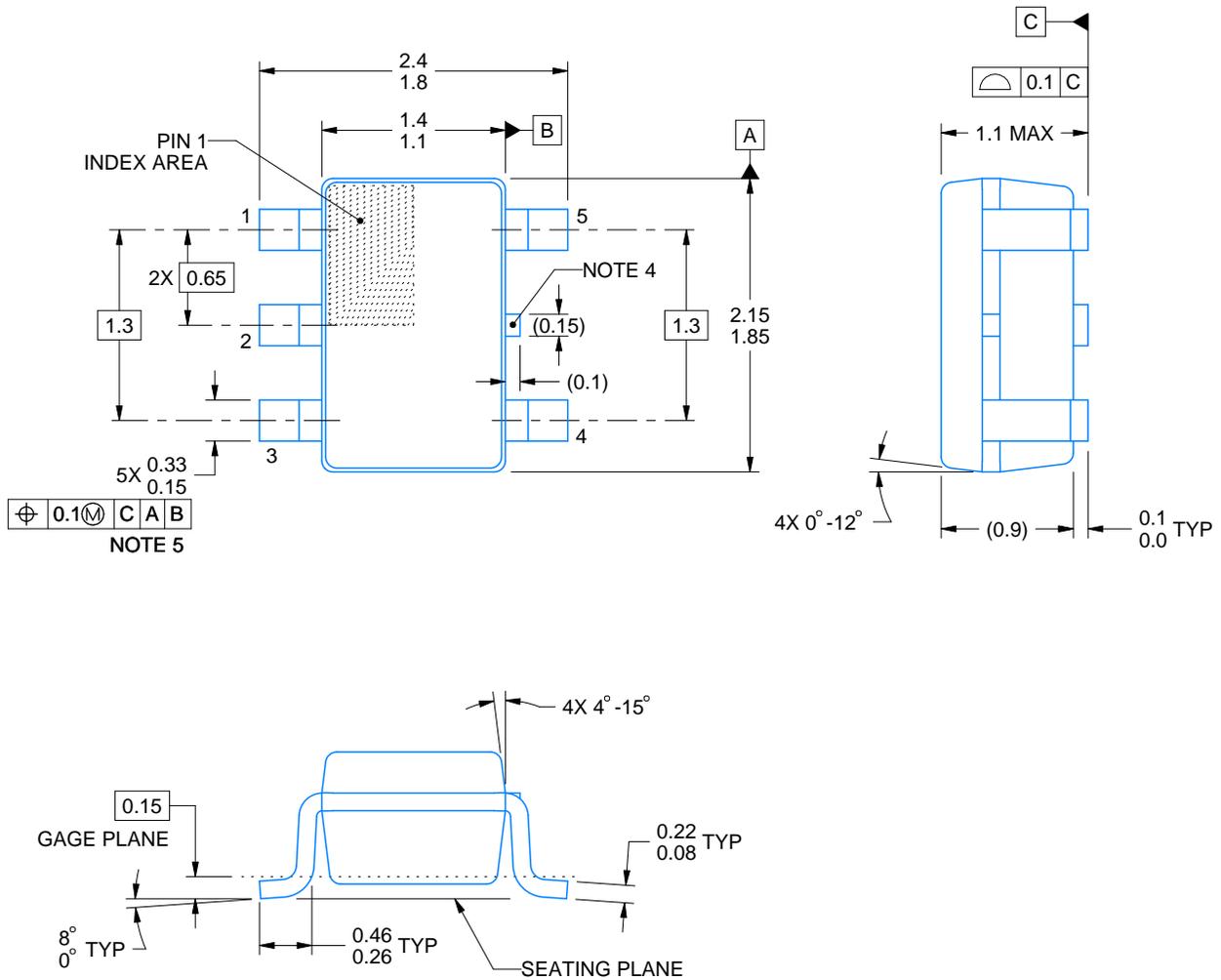
# DCK0005A



# PACKAGE OUTLINE

SOT - 1.1 max height

SMALL OUTLINE TRANSISTOR



4214834/G 11/2024

**NOTES:**

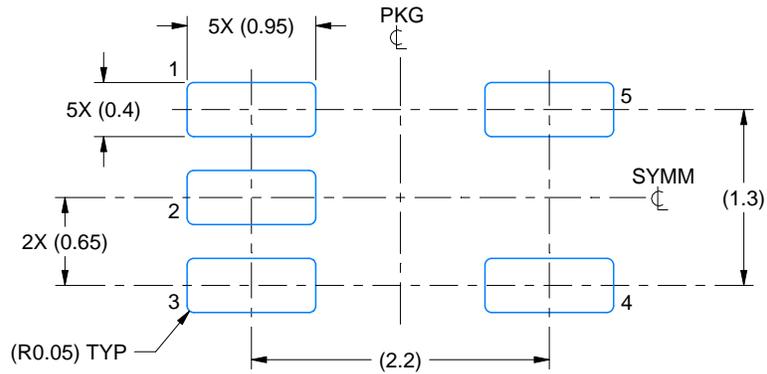
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC MO-203.
4. Support pin may differ or may not be present.
5. Lead width does not comply 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

# EXAMPLE BOARD LAYOUT

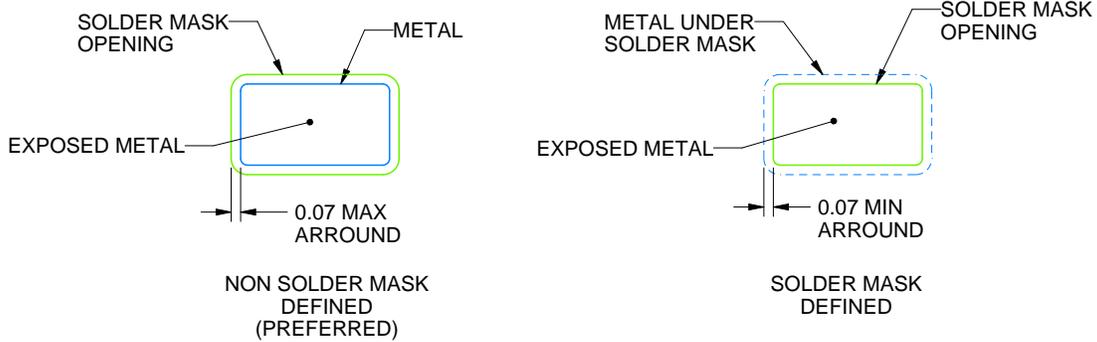
DCK0005A

SOT - 1.1 max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:18X



SOLDER MASK DETAILS

4214834/G 11/2024

NOTES: (continued)

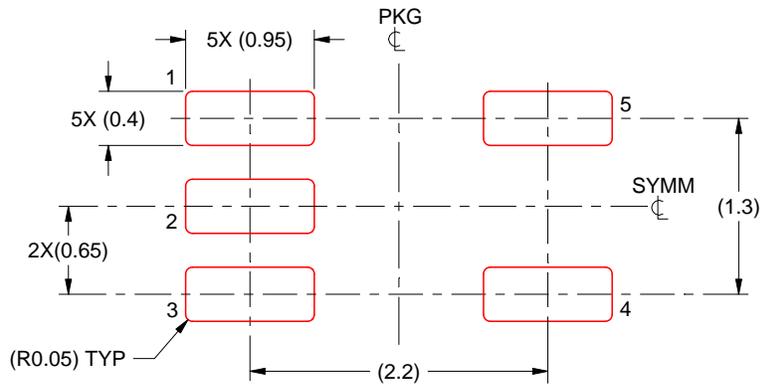
- 7. Publication IPC-7351 may have alternate designs.
- 8. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

DCK0005A

SOT - 1.1 max height

SMALL OUTLINE TRANSISTOR



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

4214834/G 11/2024

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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