TMP23x Low-Power, High-Accuracy Analog Output Temperature Sensors

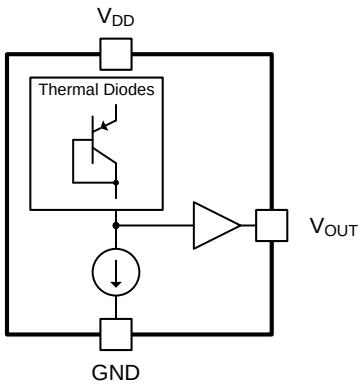
1 Features

- Cost-Effective Alternative to Thermistors
- Wide Temperature Measurement Range:
  - –40°C to +150°C (TMP235)
  - –10°C to +125°C (TMP236)
- Available in Two Accuracy Level Variants:
  - A2 Level: ±0.5°C (Typical)
  - A4 Level: ±1°C (Typical)
- Positive Slope Sensor Gain, Offset (Typical):
  - 10 mV/°C, 500 mV at 0°C (TMP235)
  - 19.5 mV/°C, 400 mV at 0°C (TMP236)
- Wide Operating Supply Voltage Range:
  - 2.3 V to 5.5 V (TMP235)
  - 3.1 V to 5.5 V (TMP236)
- 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

2 Applications

- Grid Infrastructure
- Wireless and Telecom Infrastructure
- Automotive Infotainment
- Factory Automation and Control
- Test and Measurement

Functional Block Diagram



3 Description

The TMP23x devices are a family of precision CMOS integrated-circuit linear analog temperature sensors with an output voltage proportional to temperature engineers can use in multiple analog temperature-sensing applications. These temperature sensors are more accurate than similar pin-compatible devices on the market, featuring typical accuracy from 0°C to +70°C of ±0.5°C and ±1°C. The increased accuracy of the series is designed for many analog temperature-sensing applications. The TMP235 device provides a positive slope output of 10 mV/°C over the full –40°C to +150°C temperature range and a supply range from 2.3 V to 5.5 V. The higher gain TMP236 sensor provides a positive slope output of 19.5 mV/°C from –10°C to +125°C and a supply range from 3.1 V to 5.5 V.

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 analog output temperature sensors are cost-effective alternatives to passive thermistors.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TMP235, TMP236	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

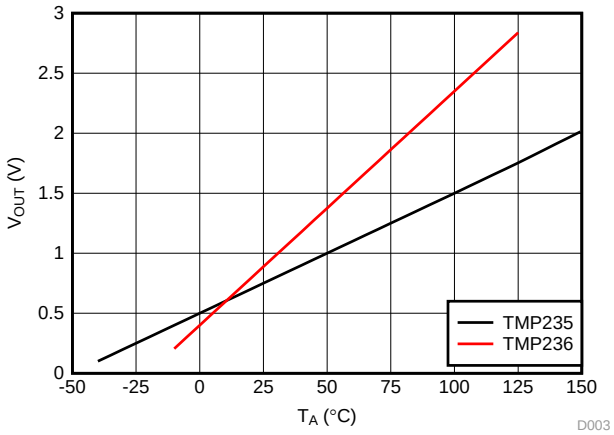


Table of Contents

4 Revision History

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

Changes from Revision C (August 2018) to Revision D — **Page**

- Changed DBZ (SOT-23) package status from preview to production data ... 1

Changes from Revision B (February 2018) to Revision C — **Page**

- Added DBZ (SOT-23) preview package ... 1
- Added TMP236 test conditions to the operating current parameters ... 5
- Added SOT-23 and SC70 package test conditions to the Accuracy Level 2 (A2) limits in the 0℃ to 70℃ range ... 5

Changes from Revision A (December 2017) to Revision B — **Page**

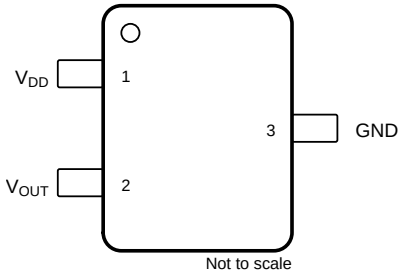
- Changed reference to typical accuracy specifications from: ±1°C and ±2°C to: ±0.5°C and ±1°C ... 1
- Deleted erroneous AOQL footnote ... 5
- Changed specification limits indicated in Figure 1 ... 6
- Added *Device Functional Modes* section ... 10

Changes from Original (September 2017) to Revision A — **Page**

- Changed document status from Advance Information to Production Data ... 1

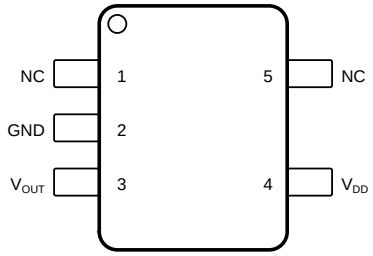
5 Pin Configuration and Functions

DBZ Package
3-Pin SOT-23
Top View



Not to scale

DCK Package
5-Pin SC70
Top View



Not to scale

NC- no internal connection

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

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. Theseare stress ratings only, which do not imply functional operation of the device at these or anyother conditions beyond those indicated under *Recommended OperatingConditions*. Exposure to absolute-maximum-rated conditions for extended periods mayaffect device reliability.

6.2 ESD Ratings

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

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
V_{DD}	Input voltage (TMP235)	2.3		5.5	V
	Input voltage (TMP236)	3.1		5.5	
T_A	Operating free-air temperature	–50		150	°C

6.4 Thermal Information

THERMAL METRIC (1) (2)		TMP235		UNIT
		DCK (SC70)	DBZ (SOT-23)	
		PINS	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
Ψ_{JT}	Junction-to-top characterization parameter	1.2	35	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	55	146	°C/W

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

6.5 Electrical Characteristics

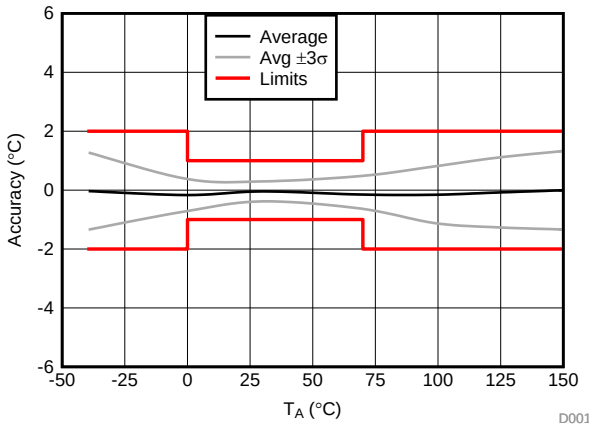
TMP235: V_{DD} = 2.3 V to 5.5 V, GND = Ground, T_A = –40°C to +125°C and no load (unless otherwise noted)
TMP236: V_{DD} = 3.1 V to 5.5 V, GND = Ground, T_A = –10°C to +125°C and no load (unless otherwise noted)

PARAMETER			TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER SUPPLY							
I_{DD}	Operating current		T_A = 25℃, V_{DD} = 2.3 V, TMP235		9		µA
			T_A = 25℃, V_{DD} = 3.1 V, TMP236		10		
			T_A = –40℃ to +125℃, TMP235			14.5	
			T_A = –10℃ to +125℃, TMP236			15	
			T_A = 150℃, TMP235			17	
Δ℃/ ΔV_{DD}	Line regulation			–0.1	0.02	0.1	℃/V
SENSOR ACCURACY							
T_{ACY}	Temperature accuracy (1)	Accuracy Level 2 (A2)	T_A = 25°C		±0.5		℃
			T_A = 0°C to 70°C (SC70 Package)	–1	±0.5	+1	
			T_A = 0°C to +70°C (SOT-23 Package)	–1.2	±0.5	+1.2	
			T_A = –40°C to +125°C (TMP235A2)	–2	±0.5	+2	
			T_A = –10°C to +125°C (TMP236A2)	–2	±0.5	+2	
			T_A = –40°C to +150°C (TMP235A2)	–2	±0.5	+2	
		Accuracy Level 4 (A4)	T_A = 25°C		±1		
			T_A = 0°C to 70°C	–2	±1	+2	
			T_A = –40°C to +125°C (TMP235A4)	–4	±1	+4	
			T_A = –10°C to +125°C (TMP236A4)	–4	±1	+4	
			T_A = –40°C to +150°C (TMP235A4)	–5	±1	+5	
SENSOR OUTPUT							
$V_{0℃}$	Output voltage offset at 0 °C		TMP235		500		mV
			TMP236		400		
T_C	Temperature coefficient (sensor gain)		TMP235		10		mV/℃
			TMP236		19.5		
V_{ONL}	Output nonlinearity (1)		T_A = 0 °C to 70 °C, no load		±0.5		℃
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, ΔV_{OUT} / ΔI_{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 Transfer Table and TMP236 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.

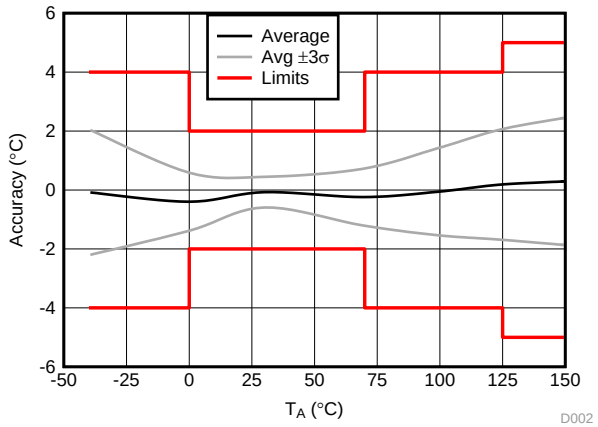
6.6 Typical Characteristics

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



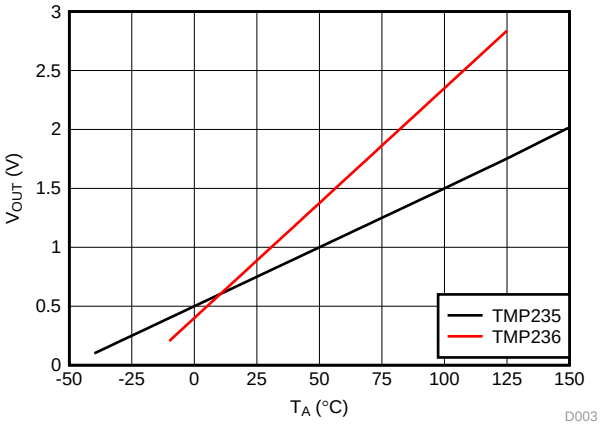
TMP235: V_{DD} = 2.3 to 5.5 V, I_{OUT} = 0 µA, C_{LOAD} = 1000 pF

Figure 1. Accuracy vs. T_A Temperature (A2 Accuracy Level)



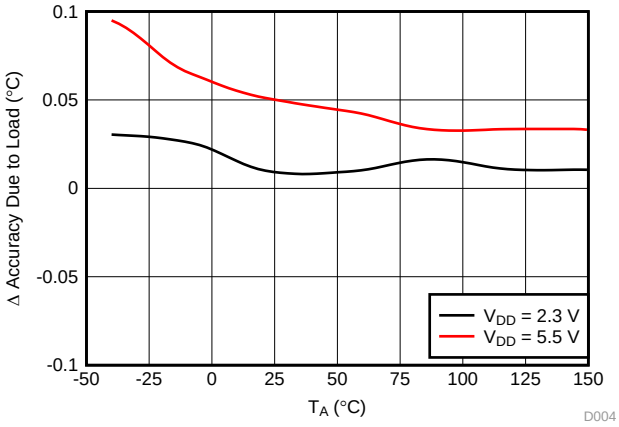
TMP235: V_{DD} = 2.3 to 5.5 V, I_{OUT} = 0 µA, C_{LOAD} = 1000 pF

Figure 2. Accuracy vs. T_A Temperature (A4 Accuracy Level)



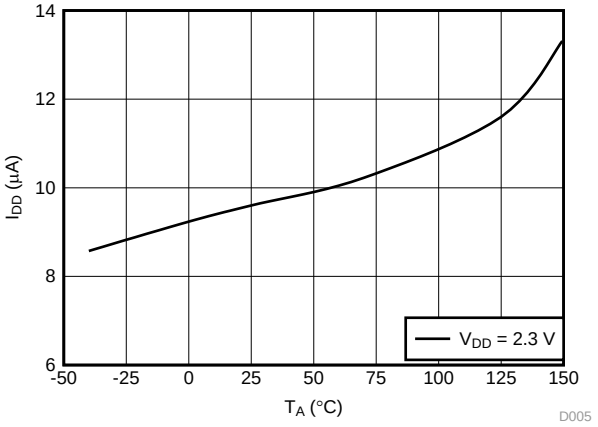
I_{OUT} = 0 µA, C_{LOAD} = 1000 pF

Figure 3. Output Voltage vs. Ambient Temperature



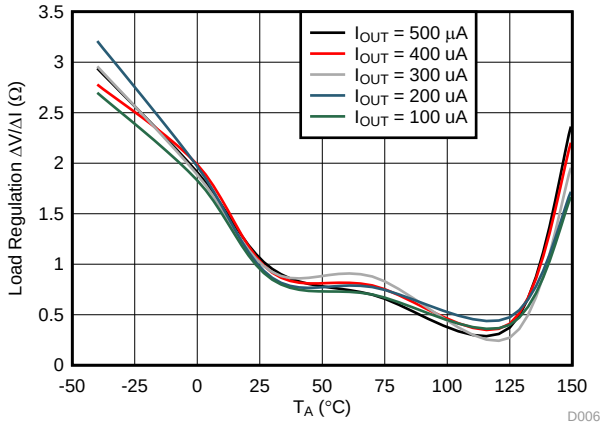
TMP235: I_{OUT} = from 0 µA to 100 µA, C_{LOAD} = 1000 pF

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



TMP235: I_{OUT} = 0 µA, C_{LOAD} = 1000 pF

Figure 5. Supply Current vs. Temperature

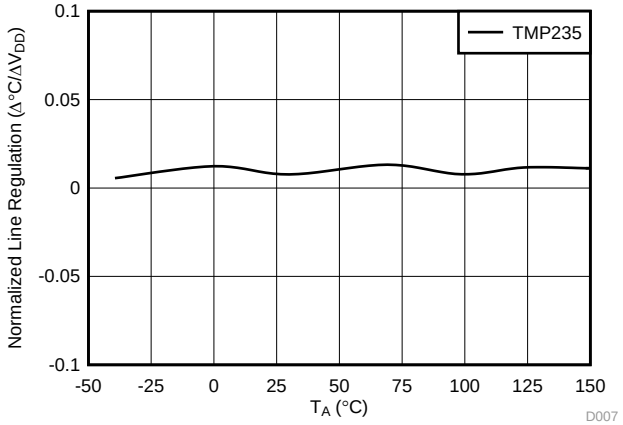


TMP235: V_{DD} = 2.3 V, C_{LOAD} = 1000 pF

Figure 6. Load Regulation vs. Ambient Temperature

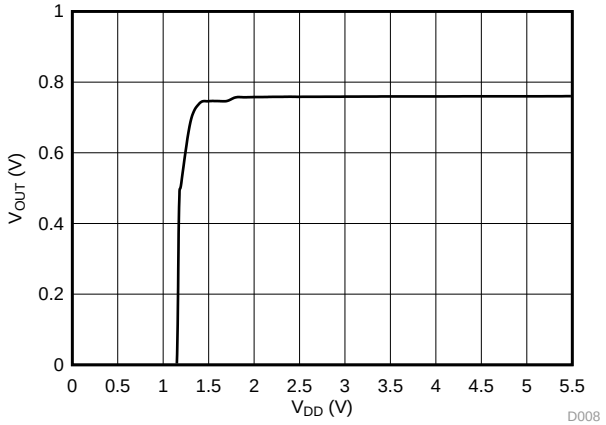
Typical Characteristics (continued)

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



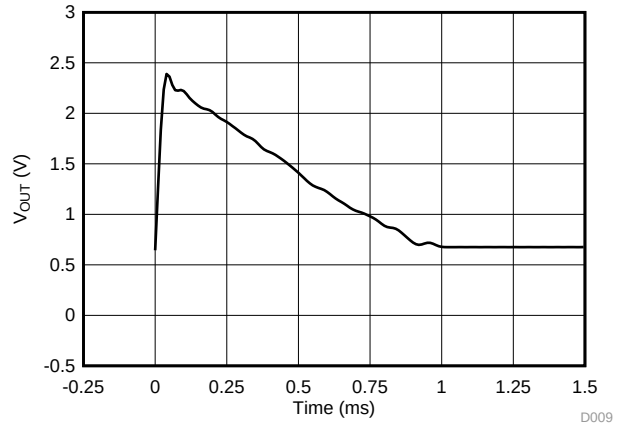
TMP235: V_{DD} = 2.3 to 5.5 V, I_{OUT} = 0 µA, C_{LOAD} = 1000 pF

Figure 7. Line Regulation (Δ°C / ΔV_{DD}) vs. Ambient Temperature



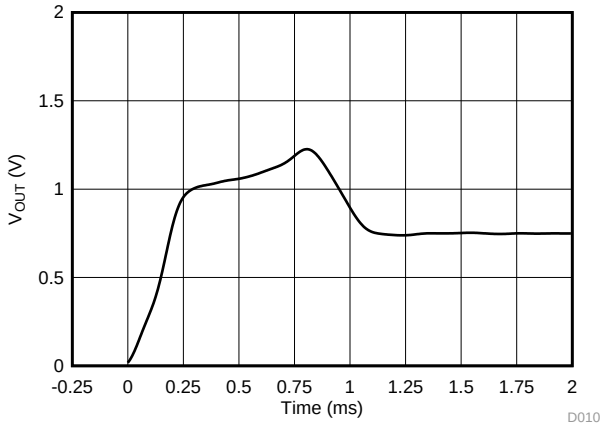
TMP235: T_A = 25°C

Figure 8. Output Voltage vs. Power Supply



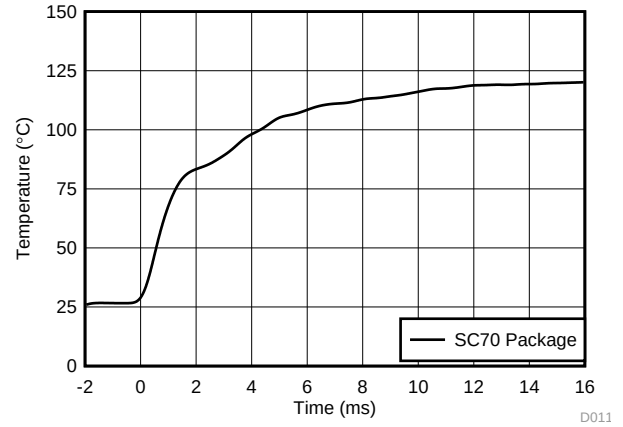
TMP235: T_A = 25°C

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



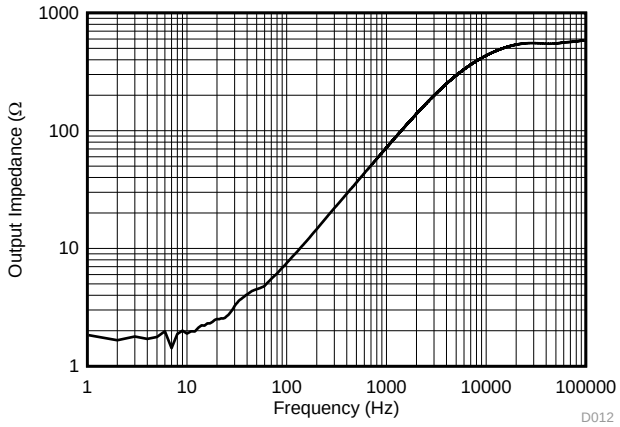
TMP235: T_A = 25°C, V_{DD} Ramp Rate = 5 V/ms

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



TMP235: 1 × 1 (inches) PCB, Air 26°C to Fluid Bath 123°C

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



TMP235: T_A = 25°C, V_{DD} = 5 V, I_{OUT} = 100 µA

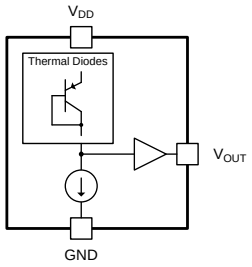
Figure 12. Output Impedance vs. Frequency

7 Detailed Description

7.1 Overview

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

7.2 Functional Block Diagram



7.3 Feature Description

As shown in Figure 3, the TMP23x devices are linear; however, a small V_{OUT} gain shift is present at temperatures above 100°C. When small shifts are expected, a piecewise linear function provides the best accuracy and is used for the device accuracy specifications (see *Specifications*.). Typical output voltages of the TMP23x devices across the full operating temperature range are listed in Table 3 and Table 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 1 and Table 2. In equation form, the voltage output V_{OUT} of the TMP23x is calculated by Equation 1:

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

where

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

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

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

Table 1. TMP235 Piecewise Linear Function Summary

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

Table 2. TMP236 Piecewise Linear Function Summary

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

Table 3. TMP235 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

Table 4. TMP236 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 is an analog output directly proportional to temperature.

8 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

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

8.2 Typical Application

8.2.1 Connection to an ADC

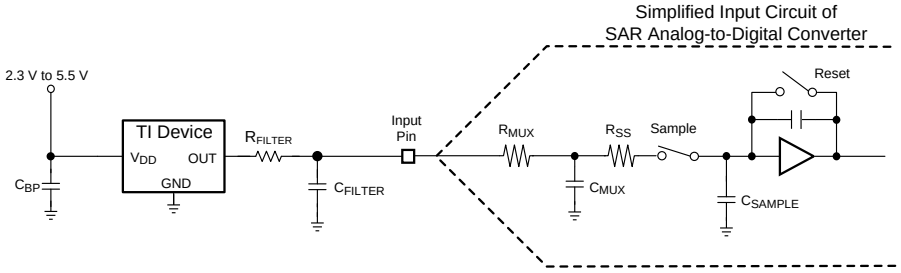


Figure 13. Suggested Connections to an ADC Input Stage

8.2.1.1 Design Requirements

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

8.2.1.2 Detailed Design Procedure

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

Typical Application (continued)

8.2.1.3 Application Curve

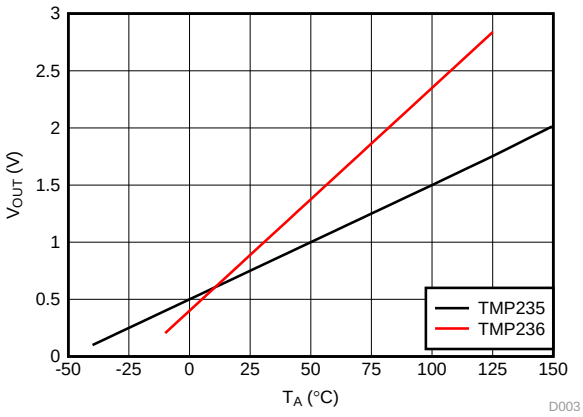


Figure 14. Output Voltage vs. Ambient

9 Power Supply Recommendations

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

Power supply bypassing is optional and is mainly dependent on the noise of the power supply. In noisy environments, TI recommends adding a 0.1-µF capacitor from V+ to GND to bypass the power supply voltage. Larger capacitances may be required and are dependent on the noise of the power supply.

10 Layout

10.1 Layout Guidelines

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

10.2 Layout Examples

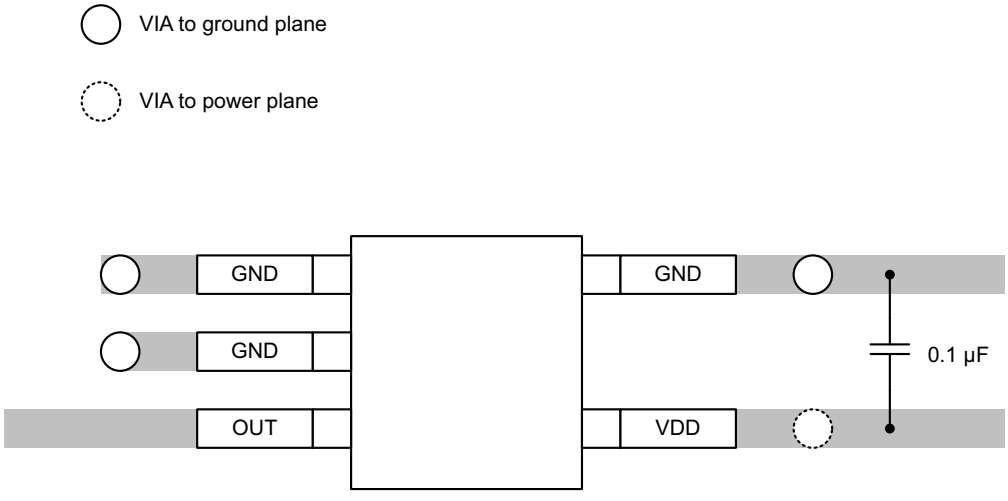


Figure 15. Recommended Layout: SC70 Package

11 Device and Documentation Support

11.1 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 5. Related Links

PARTS	PRODUCT FOLDER	ORDER NOW	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
TMP235	Click here	Click here	Click here	Click here	Click here
TMP236	Click here	Click here	Click here	Click here	Click here

11.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* 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.

11.3 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

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

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

11.4 Trademarks

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

11.5 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.

11.6 Glossary

SLYZ022 — *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 Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TMP235A2DBZR	PREVIEW	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU | CU SN	Level-1-260C-UNLIM	-40 to 150	2352	
TMP235A2DBZT	PREVIEW	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU | CU SN	Level-1-260C-UNLIM	-40 to 150	2352	
TMP235A2DCKR	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU | CU NIPDAUAG	Level-1-260C-UNLIM	-40 to 150	19L	Samples
TMP235A2DCKT	ACTIVE	SC70	DCK	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU | CU NIPDAUAG	Level-1-260C-UNLIM	-40 to 150	19L	Samples
TMP235A4DBZR	PREVIEW	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU | CU SN	Level-1-260C-UNLIM	-40 to 150	2354	
TMP235A4DBZT	PREVIEW	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU | CU SN	Level-1-260C-UNLIM	-40 to 150	2354	
TMP235A4DCKR	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU | CU NIPDAUAG	Level-1-260C-UNLIM	-40 to 150	19M	Samples
TMP235A4DCKT	ACTIVE	SC70	DCK	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU | CU NIPDAUAG	Level-1-260C-UNLIM	-40 to 150	19M	Samples
TMP236A2DBZR	PREVIEW	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU | CU SN	Level-1-260C-UNLIM	-10 to 125	2362	
TMP236A2DBZT	PREVIEW	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU | CU SN	Level-1-260C-UNLIM	-10 to 125	2362	
TMP236A2DCKR	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU | CU NIPDAUAG	Level-1-260C-UNLIM	-10 to 125	1BS	Samples
TMP236A2DCKT	ACTIVE	SC70	DCK	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU | CU NIPDAUAG	Level-1-260C-UNLIM	-10 to 125	1BS	Samples
TMP236A4DBZR	PREVIEW	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU | CU SN	Level-1-260C-UNLIM	-10 to 125	2364	
TMP236A4DBZT	PREVIEW	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU | CU SN	Level-1-260C-UNLIM	-10 to 125	2364	
TMP236A4DCKR	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU | CU NIPDAUAG	Level-1-260C-UNLIM	-10 to 125	1BT	Samples
TMP236A4DCKT	ACTIVE	SC70	DCK	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU | CU NIPDAUAG	Level-1-260C-UNLIM	-10 to 125	1BT	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.

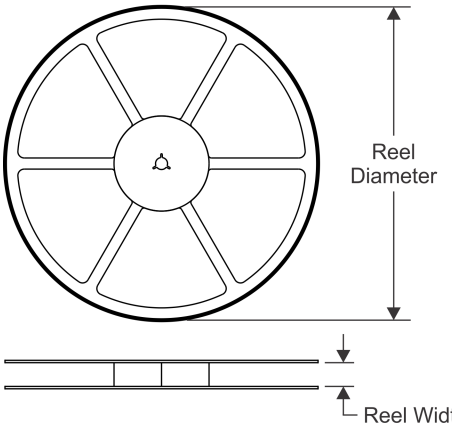
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(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.

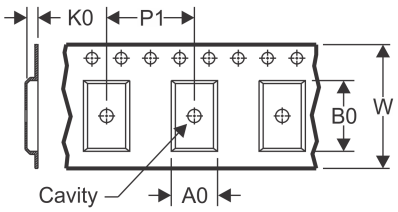
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

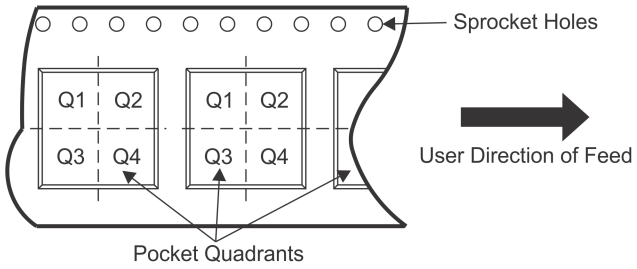


TAPE DIMENSIONS



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

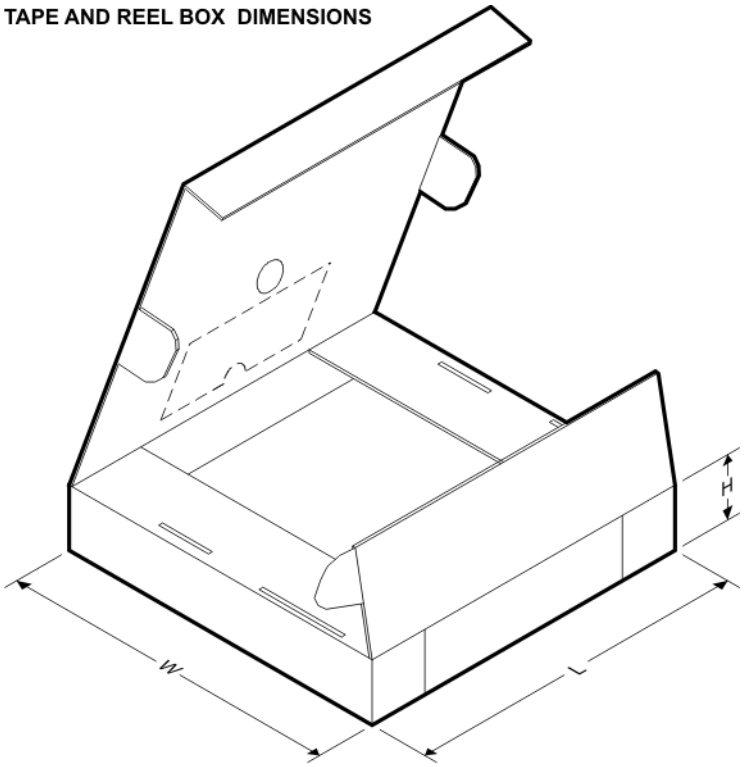


*All dimensions are nominal

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
TMP235A2DCKR	SC70	DCK	5	3000	180.0	8.4	2.47	2.3	1.25	4.0	8.0	Q3
TMP235A2DCKR	SC70	DCK	5	3000	178.0	9.0	2.4	2.5	1.2	4.0	8.0	Q3
TMP235A2DCKT	SC70	DCK	5	250	180.0	8.4	2.47	2.3	1.25	4.0	8.0	Q3
TMP235A2DCKT	SC70	DCK	5	250	178.0	9.0	2.4	2.5	1.2	4.0	8.0	Q3
TMP235A4DCKR	SC70	DCK	5	3000	180.0	8.4	2.47	2.3	1.25	4.0	8.0	Q3
TMP235A4DCKR	SC70	DCK	5	3000	178.0	9.0	2.4	2.5	1.2	4.0	8.0	Q3
TMP235A4DCKT	SC70	DCK	5	250	178.0	9.0	2.4	2.5	1.2	4.0	8.0	Q3
TMP235A4DCKT	SC70	DCK	5	250	180.0	8.4	2.47	2.3	1.25	4.0	8.0	Q3
TMP236A2DBZR	SOT-23	DBZ	3	3000	178.0	9.0	3.15	2.77	1.22	4.0	8.0	Q3
TMP236A2DBZT	SOT-23	DBZ	3	250	178.0	9.0	3.15	2.77	1.22	4.0	8.0	Q3
TMP236A2DCKR	SC70	DCK	5	3000	180.0	8.4	2.47	2.3	1.25	4.0	8.0	Q3
TMP236A2DCKR	SC70	DCK	5	3000	178.0	9.0	2.4	2.5	1.2	4.0	8.0	Q3
TMP236A2DCKT	SC70	DCK	5	250	180.0	8.4	2.47	2.3	1.25	4.0	8.0	Q3
TMP236A2DCKT	SC70	DCK	5	250	178.0	9.0	2.4	2.5	1.2	4.0	8.0	Q3
TMP236A4DBZR	SOT-23	DBZ	3	3000	178.0	9.0	3.15	2.77	1.22	4.0	8.0	Q3
TMP236A4DBZT	SOT-23	DBZ	3	250	178.0	9.0	3.15	2.77	1.22	4.0	8.0	Q3
TMP236A4DCKR	SC70	DCK	5	3000	180.0	8.4	2.47	2.3	1.25	4.0	8.0	Q3
TMP236A4DCKR	SC70	DCK	5	3000	178.0	9.0	2.4	2.5	1.2	4.0	8.0	Q3

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
TMP236A4DCKT	SC70	DCK	5	250	178.0	9.0	2.4	2.5	1.2	4.0	8.0	Q3
TMP236A4DCKT	SC70	DCK	5	250	180.0	8.4	2.47	2.3	1.25	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS

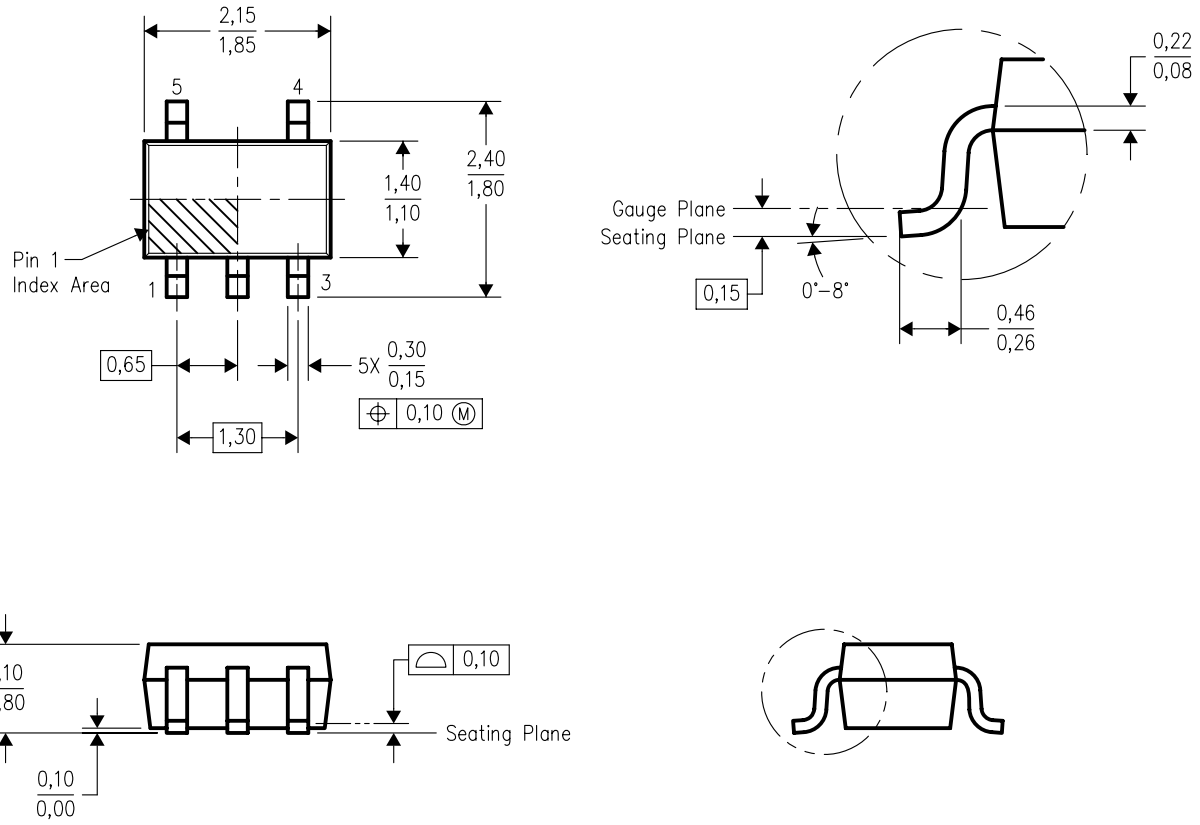


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TMP235A2DCKR	SC70	DCK	5	3000	183.0	183.0	20.0
TMP235A2DCKR	SC70	DCK	5	3000	180.0	180.0	18.0
TMP235A2DCKT	SC70	DCK	5	250	183.0	183.0	20.0
TMP235A2DCKT	SC70	DCK	5	250	180.0	180.0	18.0
TMP235A4DCKR	SC70	DCK	5	3000	183.0	183.0	20.0
TMP235A4DCKR	SC70	DCK	5	3000	180.0	180.0	18.0
TMP235A4DCKT	SC70	DCK	5	250	180.0	180.0	18.0
TMP235A4DCKT	SC70	DCK	5	250	183.0	183.0	20.0
TMP236A2DBZR	SOT-23	DBZ	3	3000	180.0	180.0	18.0
TMP236A2DBZT	SOT-23	DBZ	3	250	180.0	180.0	18.0
TMP236A2DCKR	SC70	DCK	5	3000	183.0	183.0	20.0
TMP236A2DCKR	SC70	DCK	5	3000	180.0	180.0	18.0
TMP236A2DCKT	SC70	DCK	5	250	183.0	183.0	20.0
TMP236A2DCKT	SC70	DCK	5	250	180.0	180.0	18.0
TMP236A4DBZR	SOT-23	DBZ	3	3000	180.0	180.0	18.0

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TMP236A4DBZT	SOT-23	DBZ	3	250	180.0	180.0	18.0
TMP236A4DCKR	SC70	DCK	5	3000	183.0	183.0	20.0
TMP236A4DCKR	SC70	DCK	5	3000	180.0	180.0	18.0
TMP236A4DCKT	SC70	DCK	5	250	180.0	180.0	18.0
TMP236A4DCKT	SC70	DCK	5	250	183.0	183.0	20.0

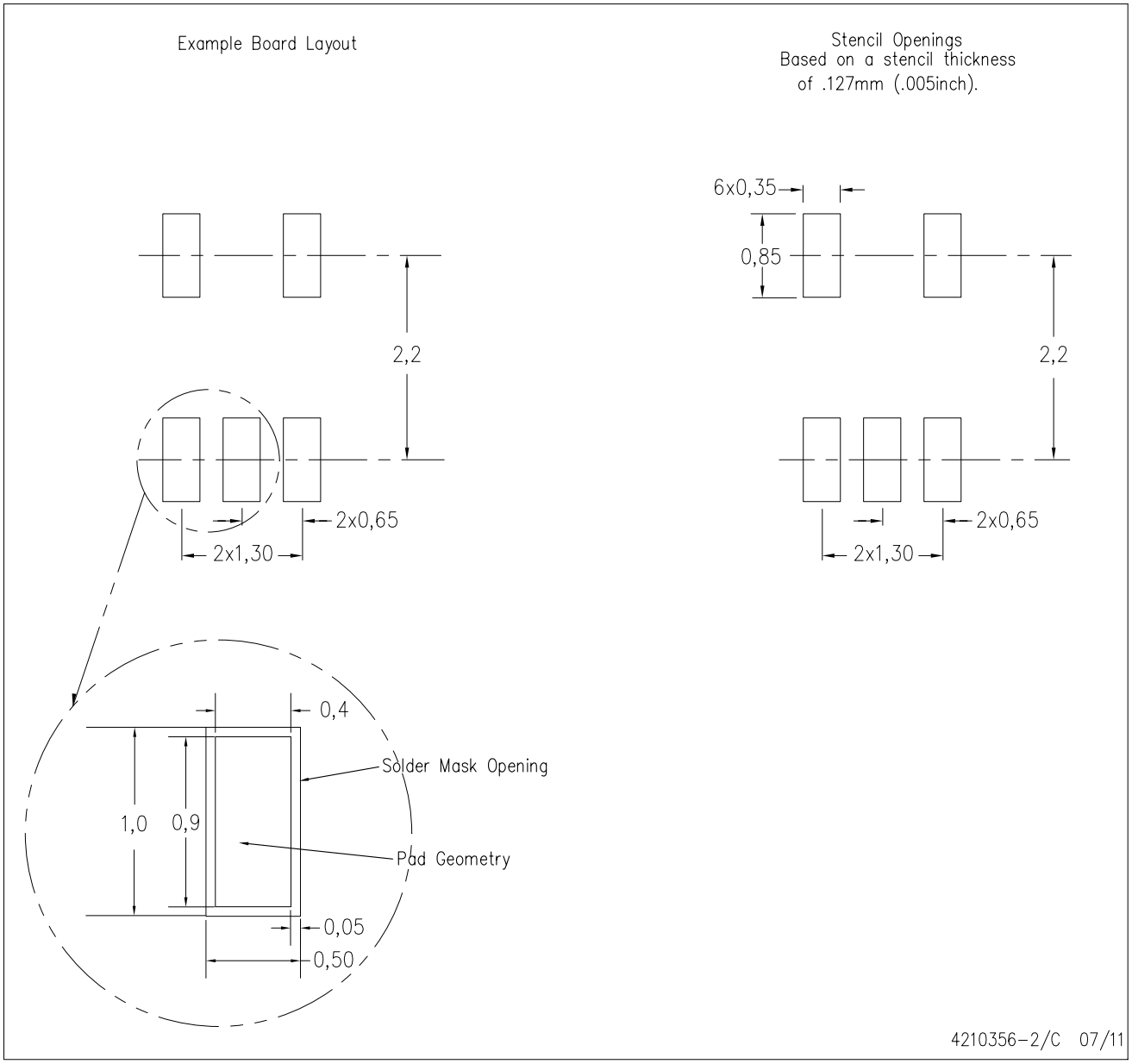
DCK (R–PDSO–G5) PLASTIC SMALL–OUTLINE PACKAGE



4093553–3/G 01/2007

NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
D. Falls within JEDEC MO–203 variation AA.

DCK (R–PDSO–G5) PLASTIC SMALL OUTLINE

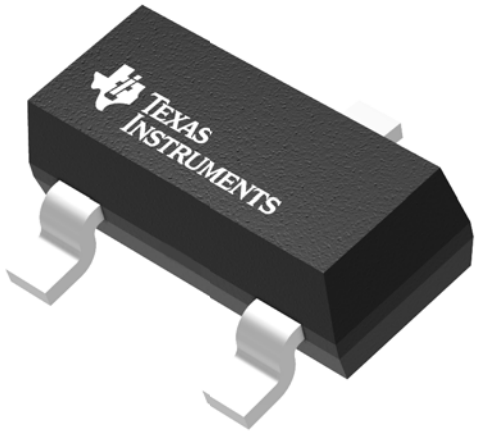


NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
D. Publication IPC–7351 is recommended for alternate designs.
E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC–7525 for other stencil recommendations.

GENERIC PACKAGE VIEW

DBZ 3 SOT-23 - 1.12 mm max height

SMALL OUTLINE TRANSISTOR



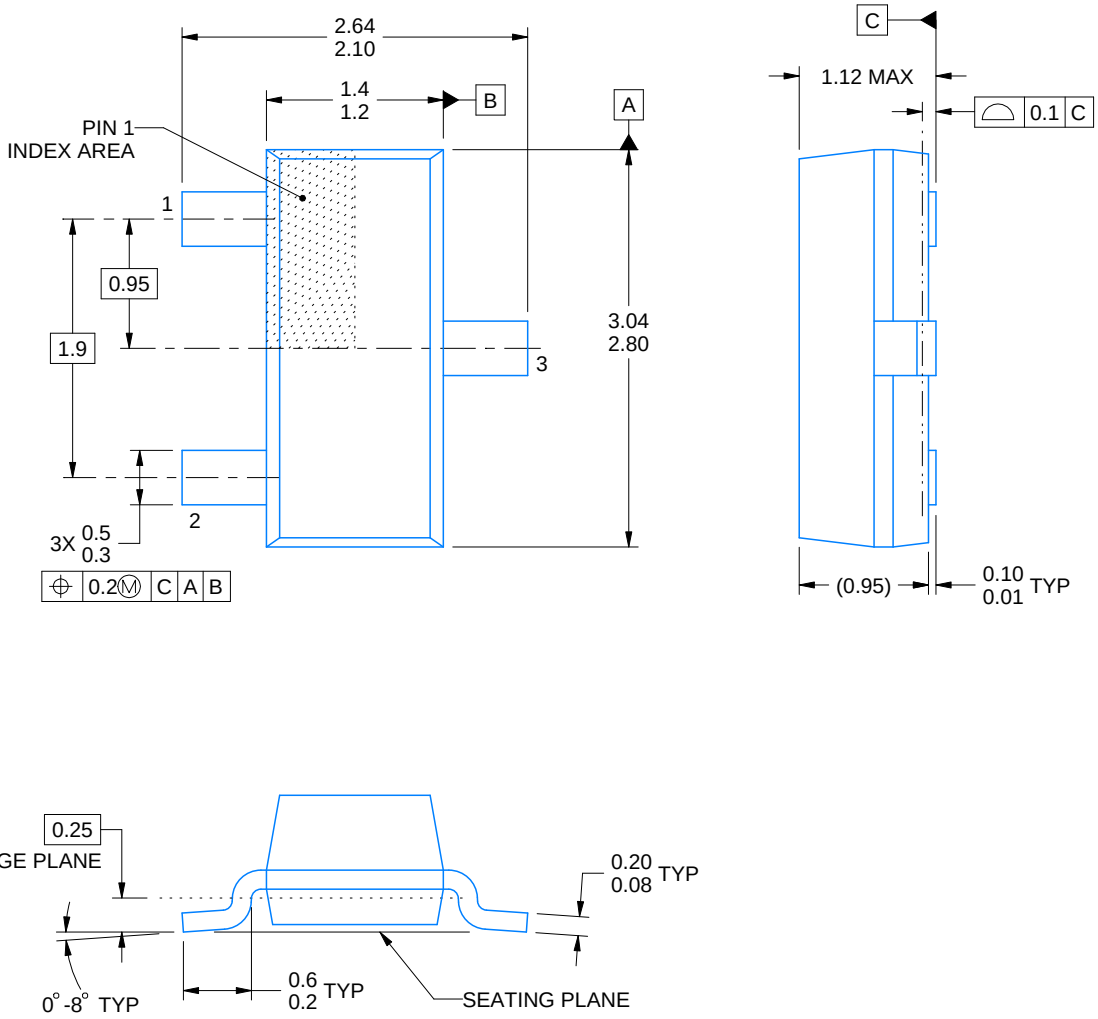
Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

PACKAGE OUTLINE

DBZ0003A

SOT-23 - 1.12 mm max height

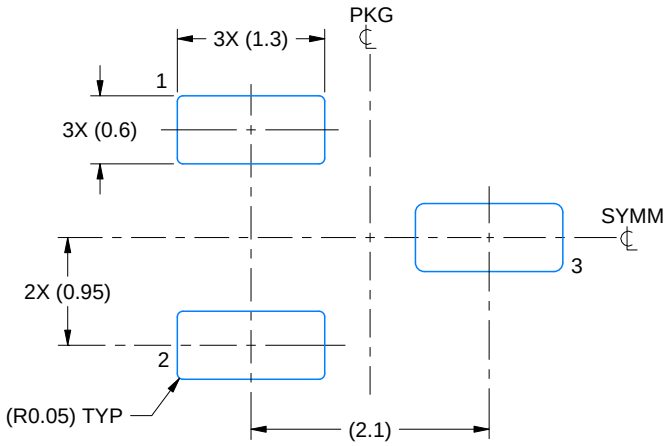
SMALL OUTLINE TRANSISTOR



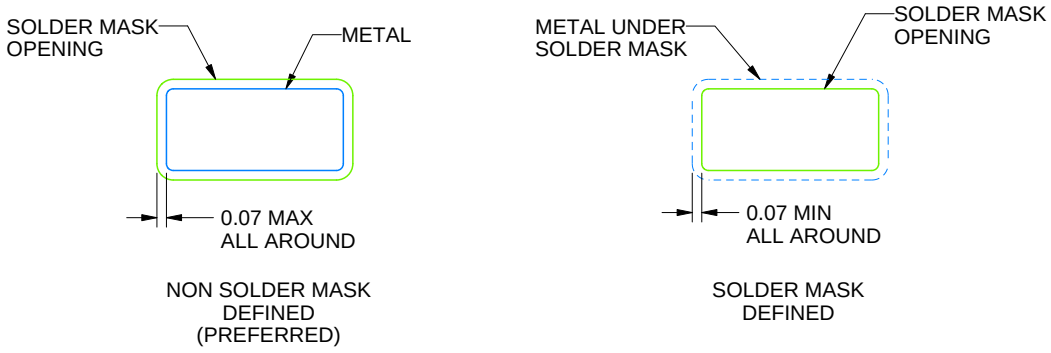
4214838/C 04/2017

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.



LAND PATTERN EXAMPLE
SCALE:15X

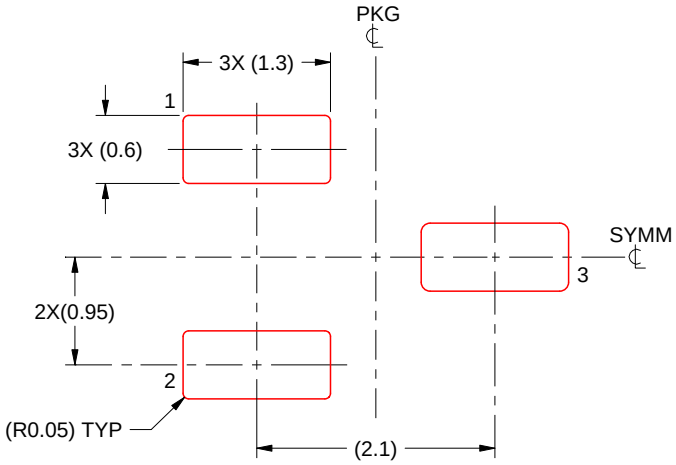


SOLDER MASK DETAILS

4214838/C 04/2017

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/C 04/2017

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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Where TI specifically promotes products as facilitating functional safety or as compliant with industry functional safety standards, such products are intended to help enable customers to design and create their own applications that meet applicable functional safety standards and requirements. Using products in an application does not by itself establish any safety features in the application. Designers must ensure compliance with safety-related requirements and standards applicable to their applications. Designer may not use any TI products in life-critical medical equipment unless authorized officers of the parties have executed a special contract specifically governing such use. Life-critical medical equipment is medical equipment where failure of such equipment would cause serious bodily injury or death (e.g., life support, pacemakers, defibrillators, heart pumps, neurostimulators, and implantables). Such equipment includes, without limitation, all medical devices identified by the U.S. Food and Drug Administration as Class III devices and equivalent classifications outside the U.S.

TI may expressly designate certain products as completing a particular qualification (e.g., Q100, Military Grade, or Enhanced Product). Designers agree that it has the necessary expertise to select the product with the appropriate qualification designation for their applications and that proper product selection is at Designers' own risk. Designers are solely responsible for compliance with all legal and regulatory requirements in connection with such selection.

Designer will fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of Designer's non-compliance with the terms and provisions of this Notice.

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