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

1 Features

- Accuracy: ±1°C (Typical at +25°C)
- Programmable Trip Point
- Programmable Hysteresis: 5°C/10°C
- Open-Drain Outputs
- Low Power: 110μA (Max)
- Wide Voltage Range: +1.8V to +18V
- Temperature Range: –40°C to +125°C
- Analog Out: 10mV/°C
- SC70-6 and SOT23-6 Packages

2 Applications

- Power-supply Systems
- DC-DC Modules
- Thermal Monitoring
- Electronic Protection Systems

3 Description

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

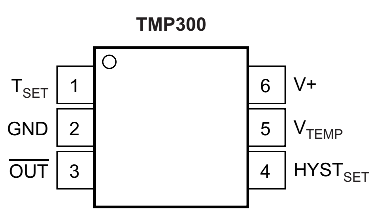
With a supply voltage as low as 1.8V and low current consumption, the TMP300 is ideal for power-sensitive systems.

Available in two micropackages that have proven thermal characteristics, this part gives a complete and simple solution for users who need simple and reliable thermal management.

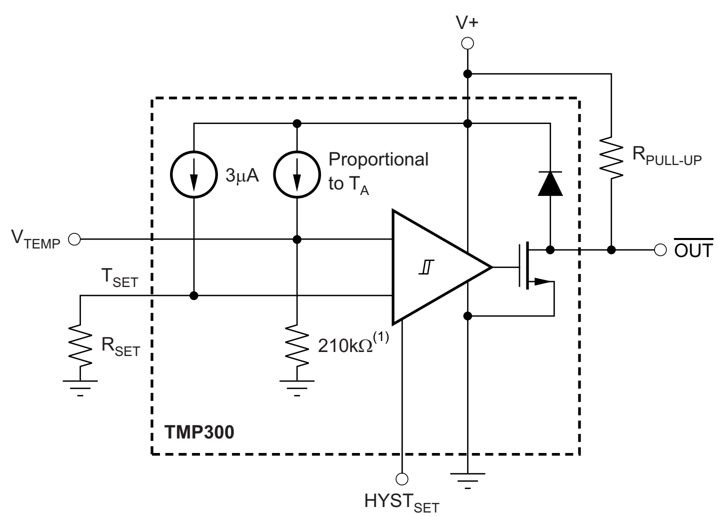
Device Information(1)

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

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



DCK (SC70-6), DBV (SOT23-6)



NOTE: (1) Thinfilm resistor with approximately 10% accuracy; however, this accuracy error is trimmed out at the factory.

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4 Revision History

Changes from Revision C (January 2011) to Revision D — **Page**

- Added *Device Information* table, *ESD Ratings* table, *Feature Description* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section 1
- Changed *Temperature Range* Features bullet 1
- Added package names to pinout 1
- Deleted *Ordering Information* table 3
- Changed Temperature Range, *TA, Functional Range* parameter name in *Electrical Characteristics* table 4
- Added footnote 4 to *Electrical Characteristics* table 4

Changes from Revision B (November 2008) to Revision C — **Page**

- Deleted second sentence from *Description* section 1
- Added TMP300B grade device specifications to *Electrical Characteristics* table 4

5 Specifications

5.1 Absolute Maximum Ratings[1]

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

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) Input pins are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5V beyond the supply rails should be current limited to 10mA or less.
(3) Short-circuit to ground.

5.2 ESD Ratings

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

5.3 Electrical Characteristics

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

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

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

5.4 Typical Characteristics

At V_S = 5V, unless otherwise noted.

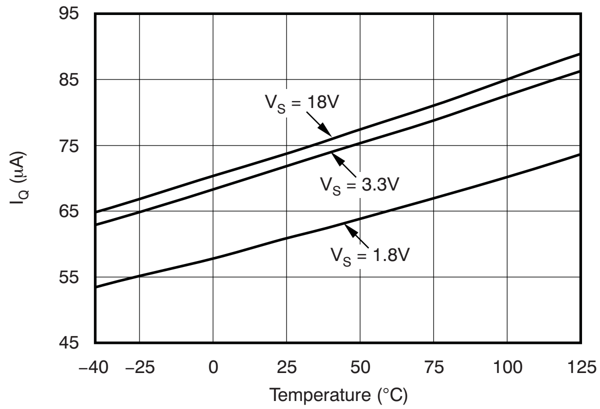

Figure 1. Quiescent Current Over Temperature and Supply

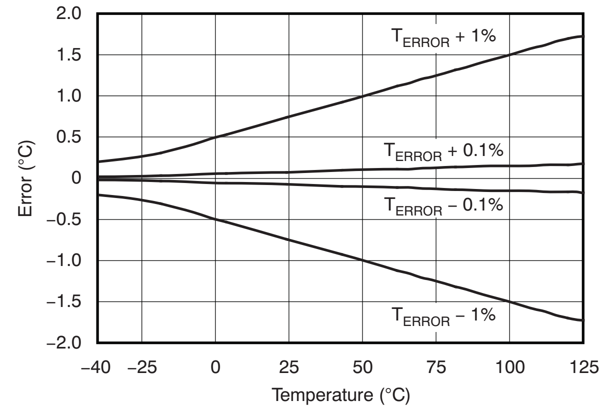

Figure 2. R_{SET} Shift Resulting From R_{SET} Tolerance

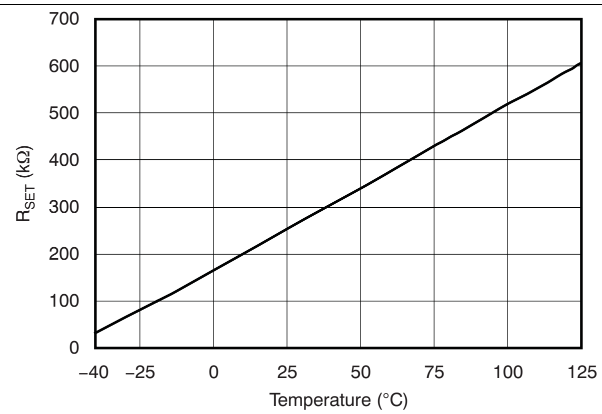

Figure 3. R_{SET} vs Temperature

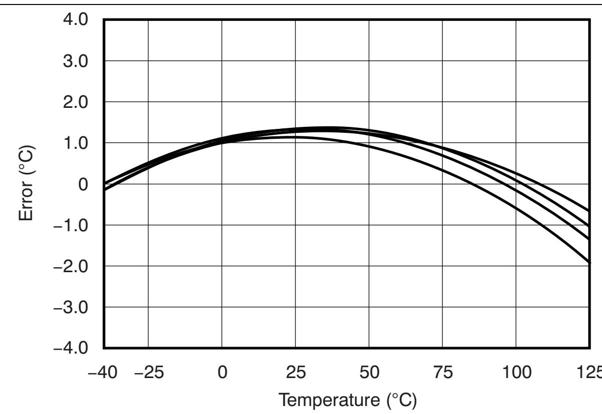

Figure 4. Typical Trip Error

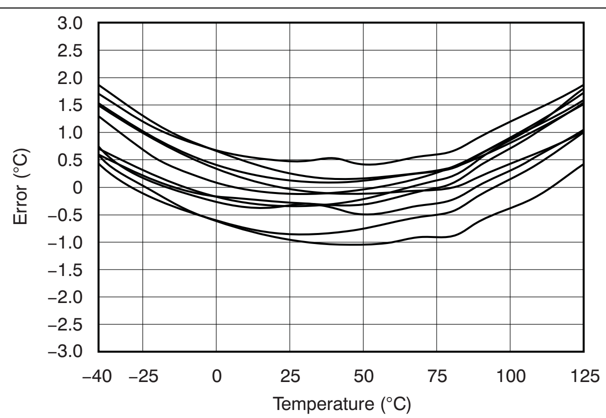

Figure 5. Typical Analog Output Error

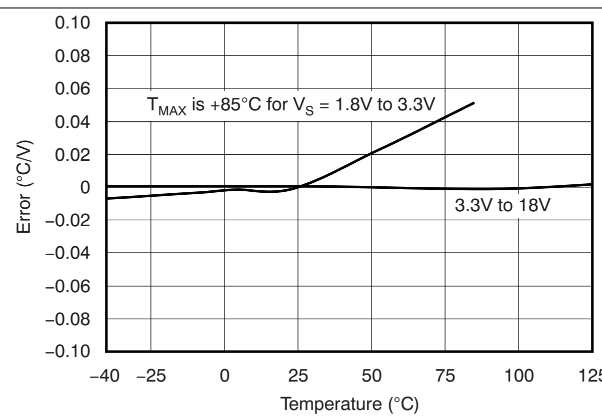

Figure 6. Analog PSR Over Temperature

Typical Characteristics (continued)

At V_S = 5V, unless otherwise noted.

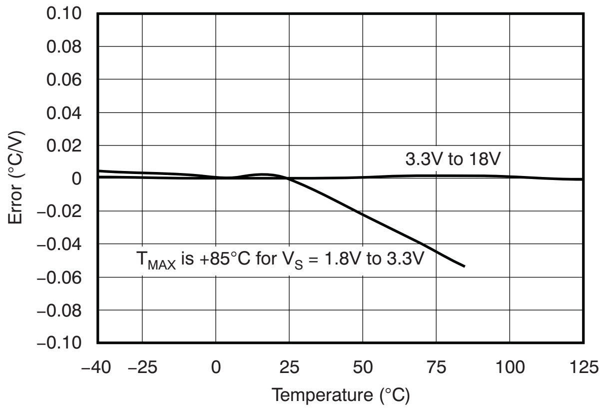

Figure 7. Trip PSR Over Temperature

6 Detailed Description

6.1 Overview

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

6.2 Feature Description

6.2.1 Calculating R_{SET}

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

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

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

where

- T_{SET} is in °C; or (1)

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

where

- T_{SET} is in °C. (2)

6.2.2 Using V_{TEMP} to Trip the Digital Output

The analog voltage output can also serve as a voltage input that forces a trip of the digital output to simulate a thermal event. This simulation facilitates easy system design and test of thermal safety circuits, as shown in Figure 8.

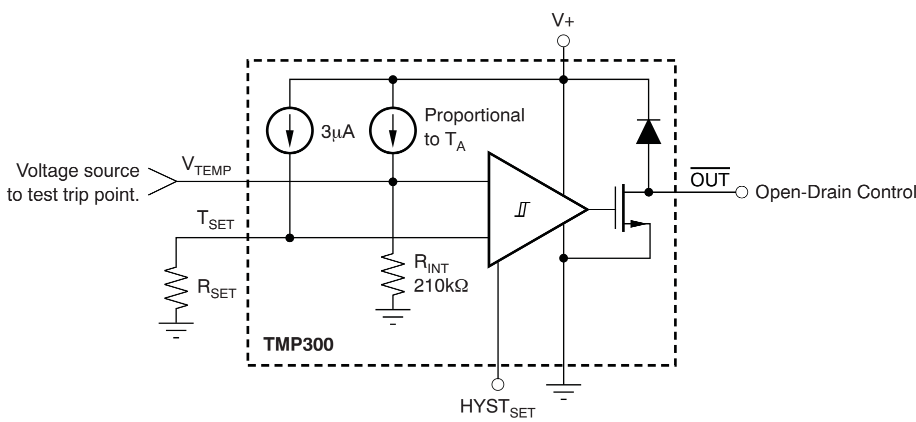

Figure 8. Applying Voltage to Trip Digital Output

Feature Description (continued)

6.2.3 Analog Temperature Output

The analog out or V_{TEMP} pin is high-impedance (210kΩ). Avoid loading this pin to prevent degrading the analog out value or trip point. Buffer the output of this pin when used for direct thermal measurement. Figure 9 shows buffering of the analog output signal.

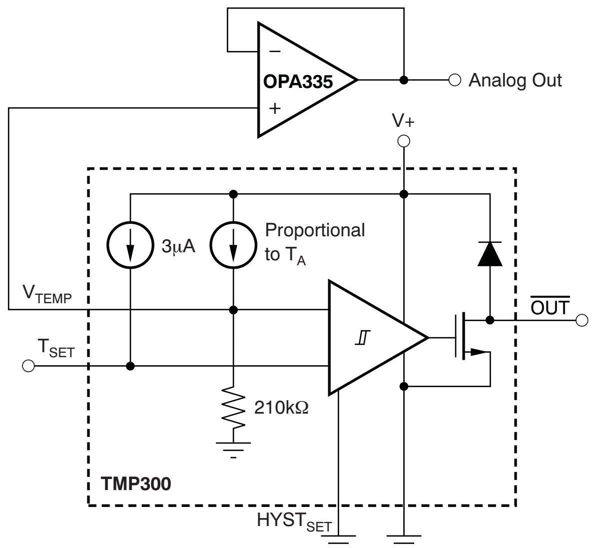

Figure 9. Buffering the Analog Output Signal

6.2.4 Using a DAC to Set the Trip Point

The trip point is easily converted by changing the digital-to-analog converter (DAC) code. This technique can be useful for control loops where a large thermal mass is being brought up to the set temperature and the $\overline{OUT}$ pin is used to control the heating element. The analog output can be monitored in a control algorithm that adjusts the set temperature to prevent overshoot. Trip set voltage error versus temperature is shown in Figure 10, which shows error in °C of the comparator input over temperature. An alternative method of setting the trip point by using a DAC is illustrated in Figure 11.

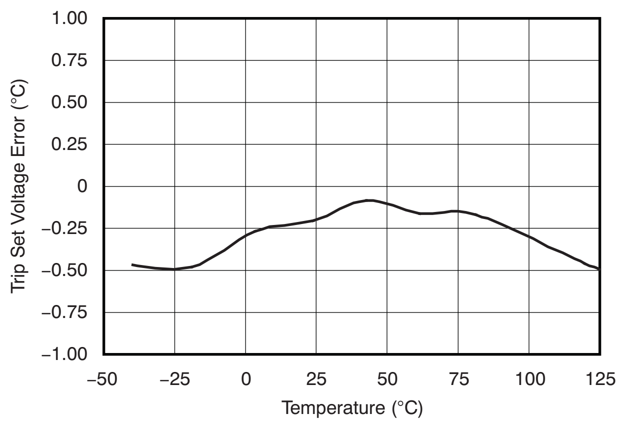

Figure 10. Trip Set Voltage Error vs Temperature

Feature Description (continued)

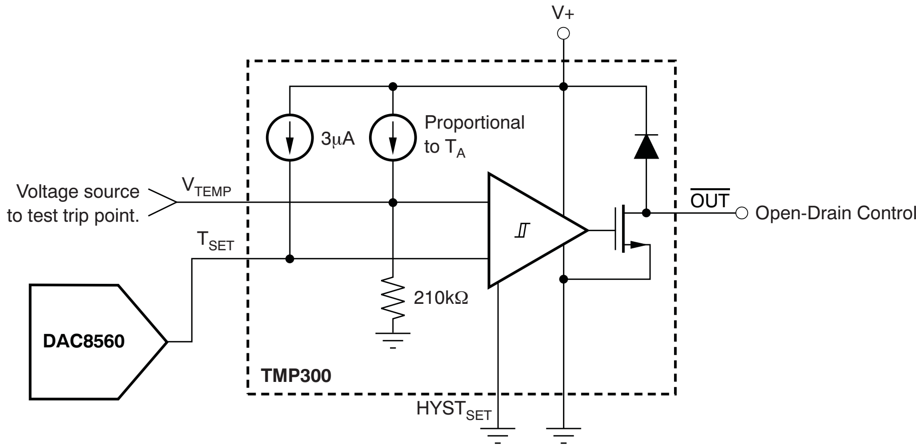

Figure 11. DAC Generates the Voltage-Driving T_{SET} Pin

6.2.5 Hysteresis

The hysteresis pin has two settings. Grounding $HYST_{SET}$ results in 5°C of hysteresis. Connecting $HYST_{SET}$ to V_S results in 10°C of hysteresis. Hysteresis error variation over temperature is shown in Figure 12 and Figure 13.

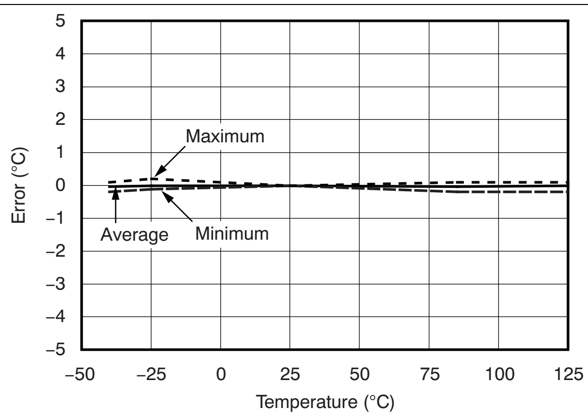

Figure 12. 5°C Hysteresis Error vs Temperature

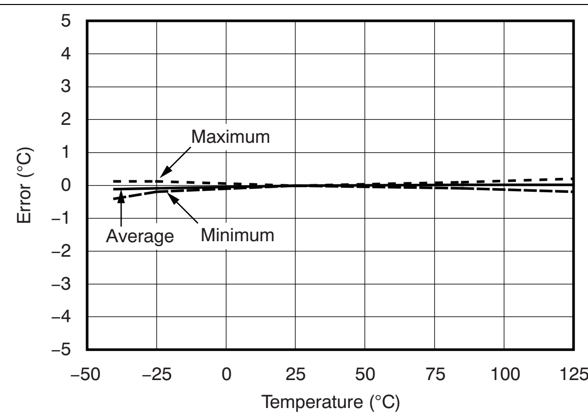

Figure 13. 10°C Hysteresis Error vs Temperature

Feature Description (continued)

Use bypass capacitors on the supplies as well as on the R_{SET} and analog out (V_{TEMP}) pins when in noisy environments, as shown in Figure 14. These capacitors reduce premature triggering of the comparator.

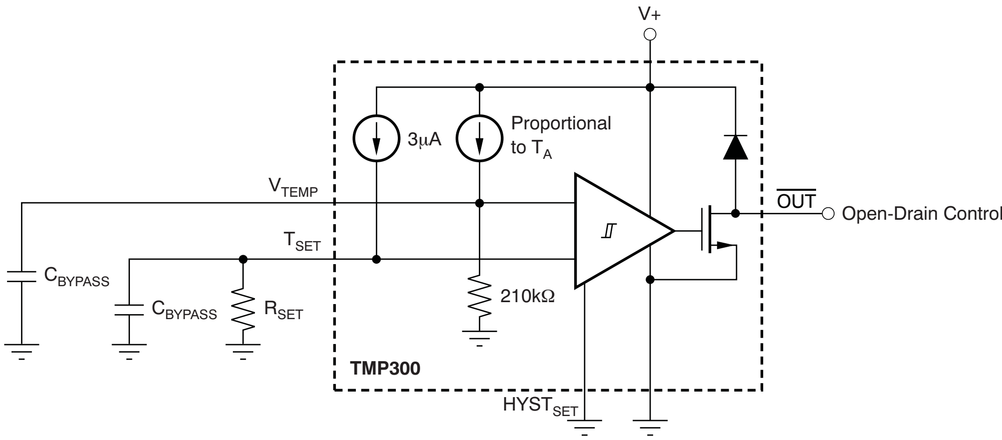

Figure 14. Bypass Capacitors Prevent Early Comparator Toggling Due to Circuit Board Noise

7 Device and Documentation Support

7.1 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.

7.2 Trademarks

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

7.3 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

7.4 Glossary

SLYZ022 — *TI Glossary*.

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

8 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
TMP300AIDBVR	NRND	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	T300	
TMP300AIDBVT	NRND	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	T300	
TMP300AIDCKR	NRND	SC70	DCK	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	BPN	
TMP300AIDCKRG4	NRND	SC70	DCK	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	BPN	
TMP300AIDCKT	NRND	SC70	DCK	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	BPN	
TMP300AIDCKTG4	NRND	SC70	DCK	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	BPN	
TMP300BIDBVR	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	DUDC	Samples
TMP300BIDBVT	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	DUDC	Samples
TMP300BIDCKR	ACTIVE	SC70	DCK	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	QWL	Samples
TMP300BIDCKT	ACTIVE	SC70	DCK	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	QWL	Samples

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

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

[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.

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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 TMP300 :

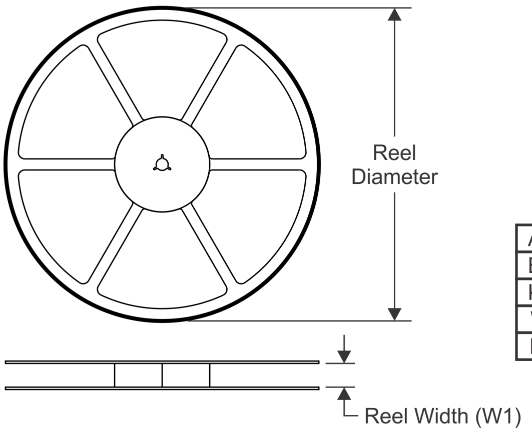
- Automotive: TMP300-Q1

NOTE: Qualified Version Definitions:

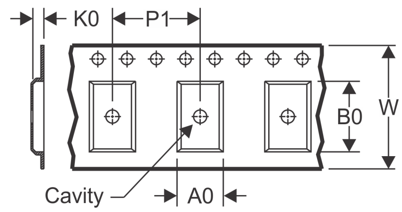
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION

REEL DIMENSIONS

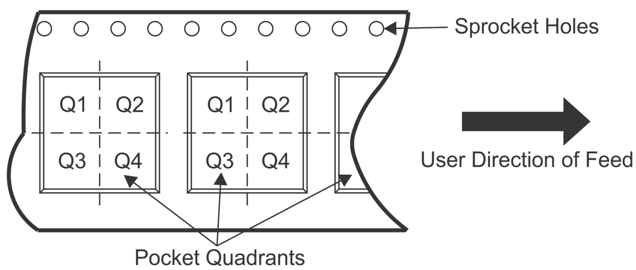


TAPE DIMENSIONS



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

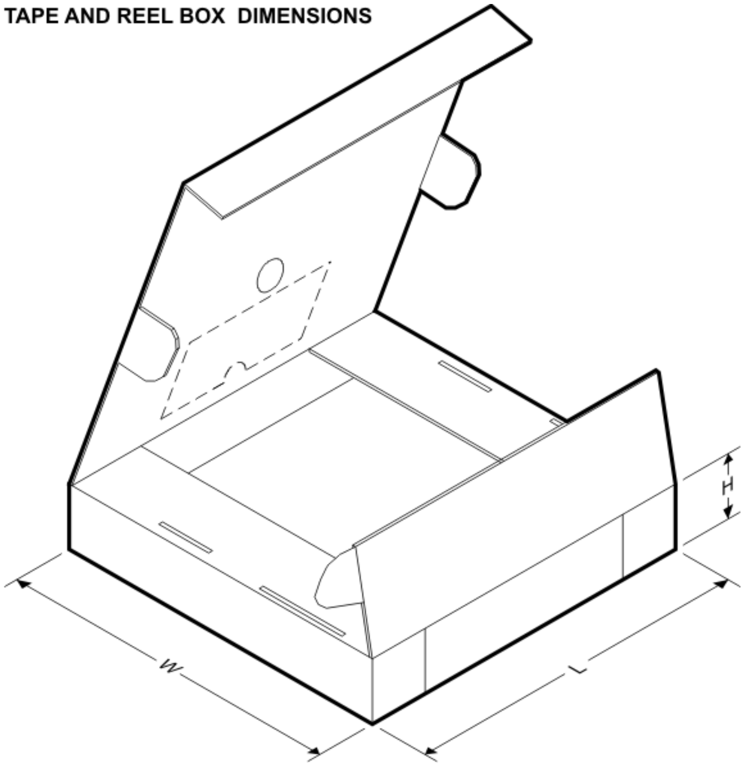
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TMP300AIDBVT	SOT-23	DBV	6	250	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TMP300AIDCKR	SC70	DCK	6	3000	179.0	8.4	2.2	2.5	1.2	4.0	8.0	Q3
TMP300AIDCKT	SC70	DCK	6	250	179.0	8.4	2.2	2.5	1.2	4.0	8.0	Q3
TMP300BIDBVR	SOT-23	DBV	6	3000	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TMP300BIDBVT	SOT-23	DBV	6	250	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TMP300BIDCKR	SC70	DCK	6	3000	179.0	8.4	2.2	2.5	1.2	4.0	8.0	Q3
TMP300BIDCKT	SC70	DCK	6	250	179.0	8.4	2.2	2.5	1.2	4.0	8.0	Q3

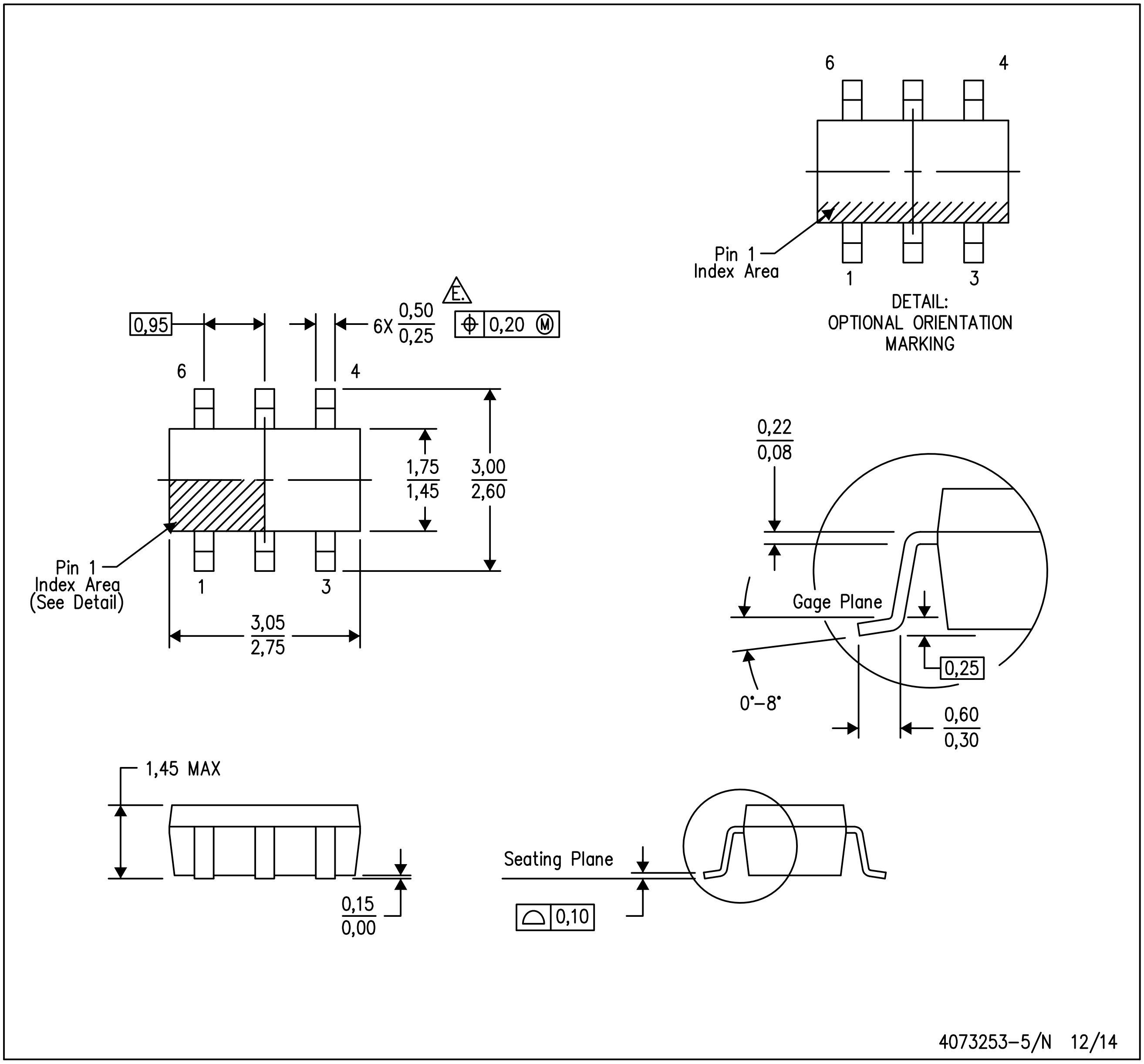
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

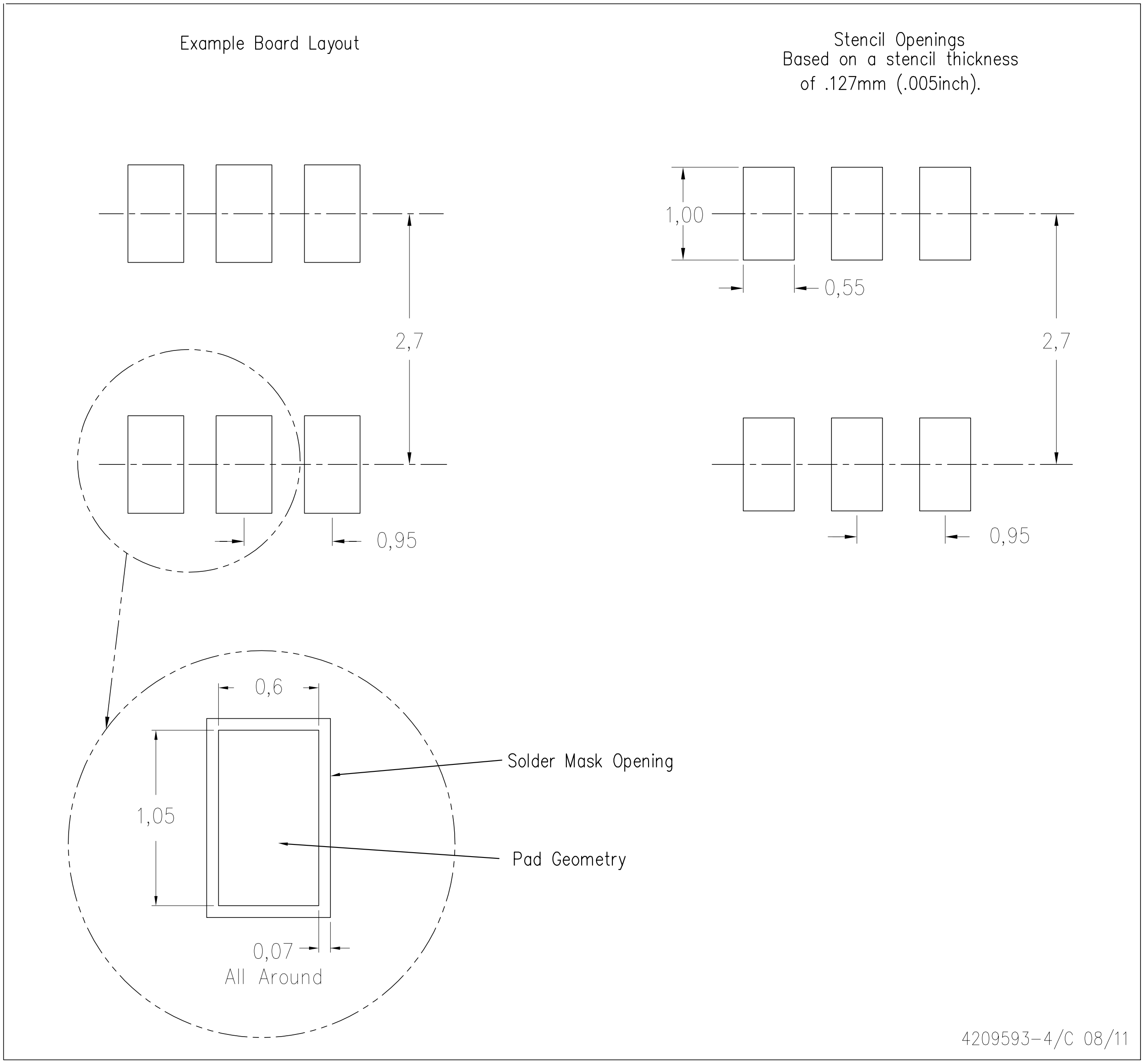
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TMP300AIDBVT	SOT-23	DBV	6	250	203.0	203.0	35.0
TMP300AIDCKR	SC70	DCK	6	3000	203.0	203.0	35.0
TMP300AIDCKT	SC70	DCK	6	250	203.0	203.0	35.0
TMP300BIDBVR	SOT-23	DBV	6	3000	203.0	203.0	35.0
TMP300BIDBVT	SOT-23	DBV	6	250	203.0	203.0	35.0
TMP300BIDCKR	SC70	DCK	6	3000	203.0	203.0	35.0
TMP300BIDCKT	SC70	DCK	6	250	203.0	203.0	35.0

DBV (R-PDSO-G6) PLASTIC SMALL-OUTLINE PACKAGE



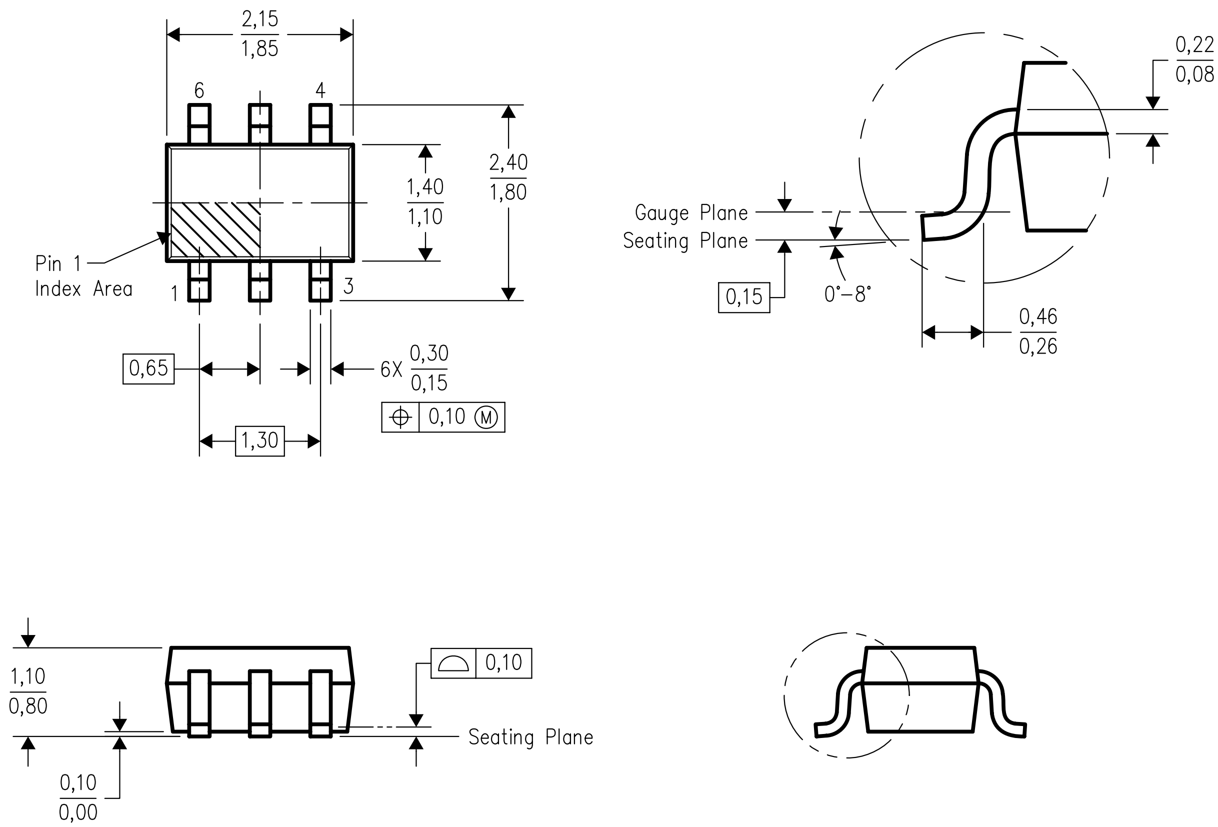
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
D. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
E. Falls within JEDEC MO-178 Variation AB, except minimum lead width.

DBV (R-PDSO-G6) 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.

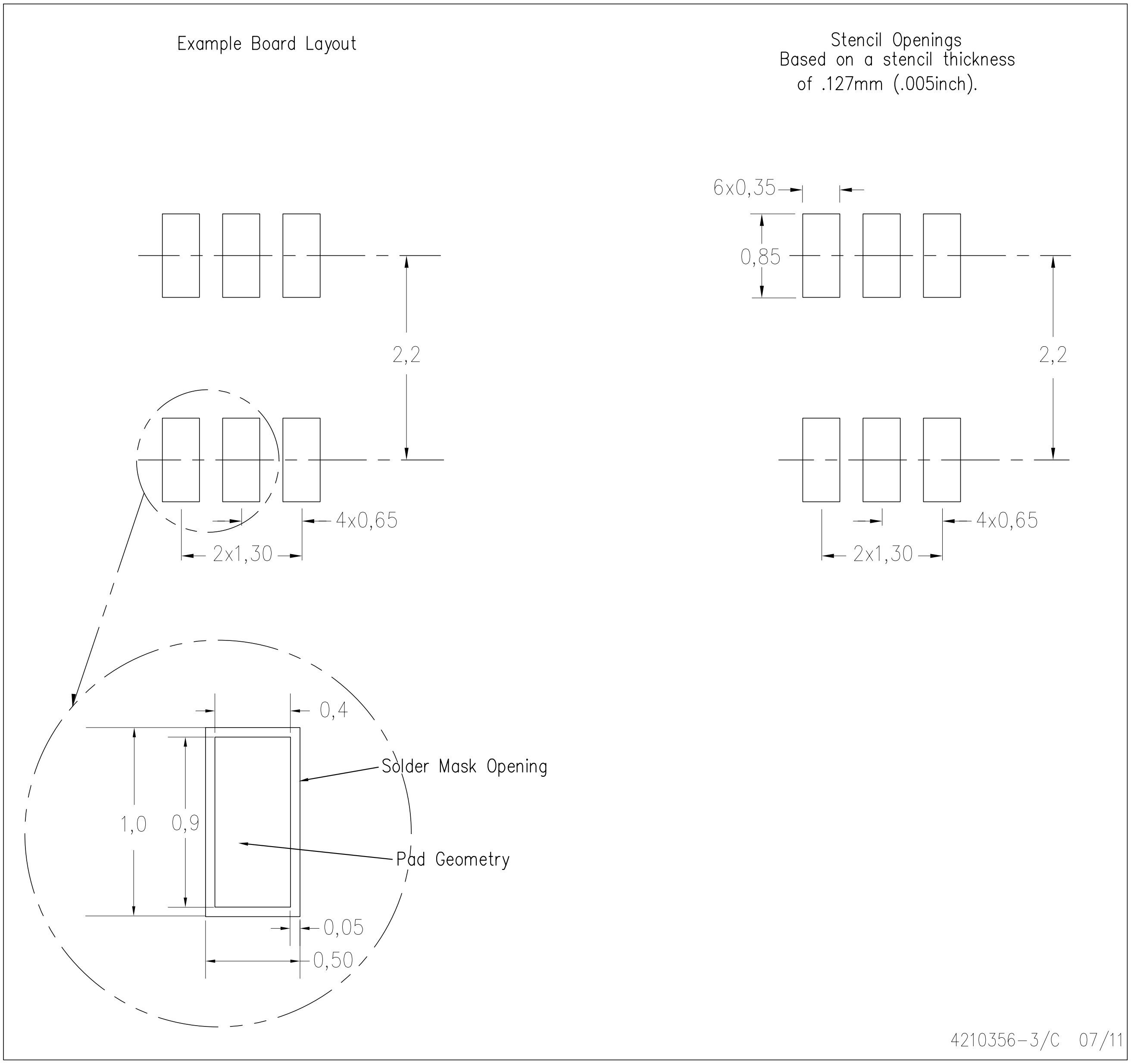
DCK (R–PDSO–G6) PLASTIC SMALL–OUTLINE PACKAGE



4093553–4/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 AB.

DCK (R–PDSO–G6) 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.

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