



# 1.8V, Resistor-Programmable TEMPERATURE SWITCH and ANALOG OUT TEMPERATURE SENSOR in SC70

Check for Samples: [TMP300B-Q1](#)

## FEATURES

- **ACCURACY:**  $\pm 1^{\circ}\text{C}$  (typical at  $+25^{\circ}\text{C}$ )
- **PROGRAMMABLE TRIP POINT**
- **PROGRAMMABLE HYSTERESIS:**  $5^{\circ}\text{C}/10^{\circ}\text{C}$
- **OPEN-DRAIN OUTPUTS**
- **LOW-POWER:**  $110\mu\text{A}$  (max)
- **WIDE VOLTAGE RANGE:**  $+1.8\text{V}$  to  $+18\text{V}$
- **OPERATION:**  $-40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$
- **ANALOG OUT:**  $10\text{mV}/^{\circ}\text{C}$
- **SC70-6 PACKAGE**

## APPLICATIONS

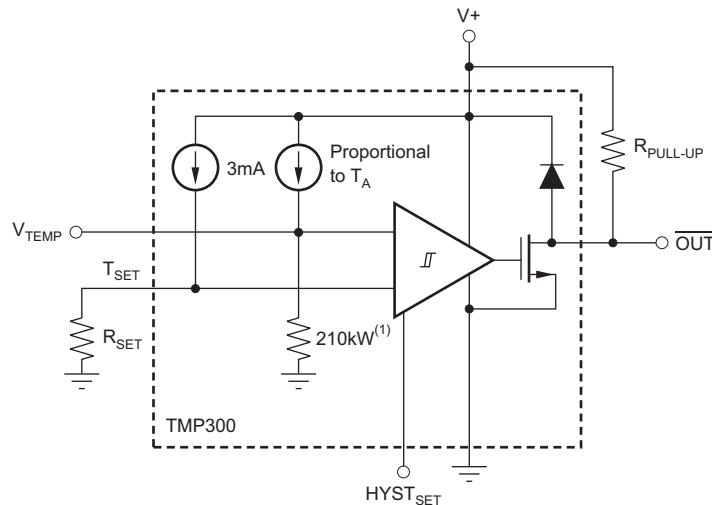
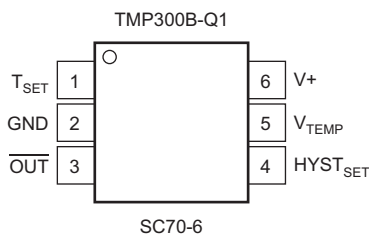
- **QUALIFIED FOR** for **AUTOMOTIVE APPLICATIONS**
- **POWER-SUPPLY SYSTEMS**
- **DC-DC MODULES**
- **THERMAL MONITORING**
- **ELECTRONIC PROTECTION SYSTEMS**

## DESCRIPTION

The TMP300B-Q1 is a low-power, resistor-programmable, digital output temperature switch. It allows a threshold point to be set by adding an external resistor. Two levels of hysteresis are available. The TMP300B-Q1 has a  $V_{\text{TEMP}}$  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 TMP300B-Q1 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.



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



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.

## ORDERING INFORMATION<sup>(1)</sup>

ORDERABLE P/N	T <sub>A</sub>	PACKAGE	TOP SIDE SYMBOL
TMP300BQDCKRQ1 or TMP300B-Q1	-40°C to 125°C	SC70 - DCK   Reel of 3000	SBG

(1) For the most current package and ordering information see the Package Option Addendum at the end of this document, or see the TI web site at [www.ti.com](http://www.ti.com).

## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

		VALUE	UNIT
Supply Voltage	V+	+18	V
Signal Input Terminals, Voltage <sup>(2)</sup>		-0.5 to (V+) + 0.5	V
Signal Input Terminals, Current <sup>(2)</sup>		±10	mA
Output Short-Circuit <sup>(3)</sup>	I <sub>sc</sub>	Continuous	
Open-Drain Output		(V+) + 0.5	V
Operating Temperature	T <sub>A</sub>	-40 to +150	°C
Storage Temperature	T <sub>A</sub>	-55 to +150	°C
Junction Temperature	T <sub>J</sub>	+150	°C
ESD Rating	Human Body Model (HBM)	4000	V
	Charged Device Model (CDM)	1000	V
	Machine Model (MM)	200	V

- (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not supported.
- (2) Input terminals 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.

## ELECTRICAL CHARACTERISTICS

At  $V_S = 3.3V$  and  $T_A = -40^{\circ}C$  to  $+125^{\circ}C$ , unless otherwise noted.

PARAMETER	TEST CONDITIONS	TMP300B-Q1			UNIT	
		MIN	TYP	MAX		
<b>TEMPERATURE MEASUREMENT</b>						
Measurement Range	$V_S = 2.35V$ to $18V$	-40		+125	$^{\circ}C$	
	$V_S = 1.8V$ to $2.35V$	-40		$100 \times (V_S - 0.95)$	$^{\circ}C$	
<b>TRIP POINT</b>						
Total Accuracy	$T_A = -40^{\circ}C$ to $+125^{\circ}C$		$\pm 2$	$\pm 6$	$^{\circ}C$	
$R_{SET}$ Equation	$T_C$ is in $^{\circ}C$	$R_{SET} = 10 (50 + T_C)/3$			$k\Omega$	
<b>HYSTERESIS SET INPUT</b>						
LOW Threshold <sup>(1)</sup>				0.4	V	
HIGH Threshold <sup>(1)</sup>		$V_S - 0.4$			V	
Threshold Hysteresis	$HYST_{SET} = GND$		5		$^{\circ}C$	
	$HYST_{SET} = V_S$		10		$^{\circ}C$	
<b>DIGITAL OUTPUT</b>						
Logic Family			CMOS			
Open-Drain Leakage Current <sup>(1)</sup>	$OUT = V_S$			10	$\mu A$	
Logic Levels						
$V_{OL}$	$V_S = 1.8V$ to $18V$ , $I_{SINK} = 5mA$			0.3	V	
<b>ANALOG OUTPUT</b>						
Accuracy			$\pm 2$	$\pm 5$	$^{\circ}C$	
Temperature Sensitivity			10		$mV/^{\circ}C$	
Output Voltage <sup>(1)</sup>	$T_A = +25^{\circ}C$	720	750	780	mV	
$V_{TEMP}$ Pin Output Resistance			210		$k\Omega$	
<b>POWER SUPPLY</b>						
Quiescent Current <sup>(2)</sup>	$I_Q$ , $V_S = 1.8V$ to $18V$ , $T_A = -40^{\circ}C$ to $+125^{\circ}C$			110	$\mu A$	
<b>TEMPERATURE RANGE</b>						
Specified Range	$T_A$	$V_S = 2.35V$ to $18V$	-40		+125	$^{\circ}C$
		$V_S = 1.8V$ to $2.35V$	-40		$100 \times (V_S - 0.95)$	$^{\circ}C$
Operating Range	$T_A$	$V_S = 2.35V$ to $18V$	-40		+150	$^{\circ}C$
		$V_S = 1.8V$ to $2.35V$	-50		$100 \times (V_S - 0.95)$	$^{\circ}C$
Thermal Resistance	$\theta_{JA}$					
SC70				250	$^{\circ}C/W$	
SOT23-6				180	$^{\circ}C/W$	

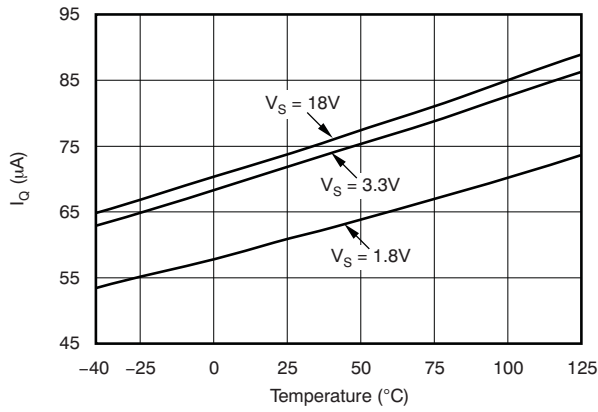
(1) Specified by design. Not production tested.

(2) See [Figure 1](#) for typical quiescent current.

**TYPICAL CHARACTERISTICS**

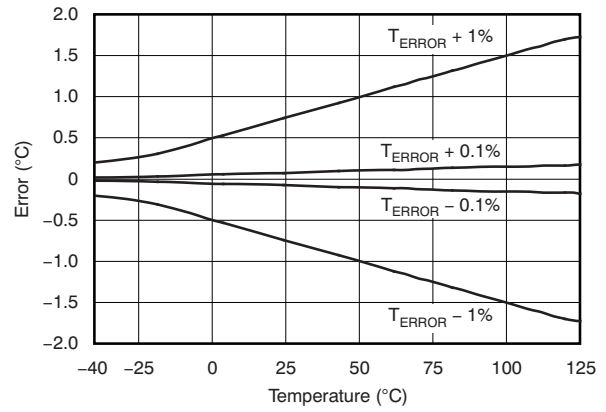
At  $V_S = 5V$ , unless otherwise noted.

**QUIESCENT CURRENT OVER TEMPERATURE AND SUPPLY**



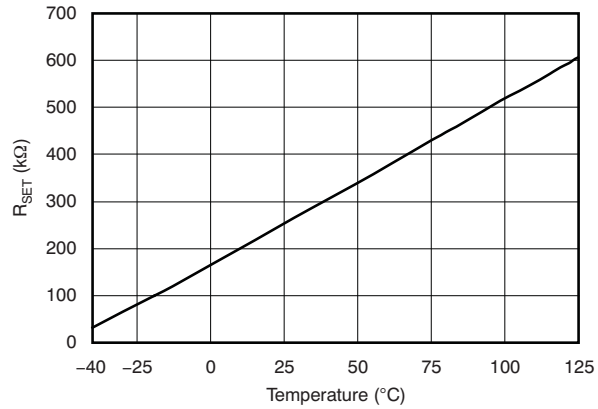
**Figure 1.**

**R<sub>SET</sub> SHIFT DUE TO R<sub>SET</sub> TOLERANCE**



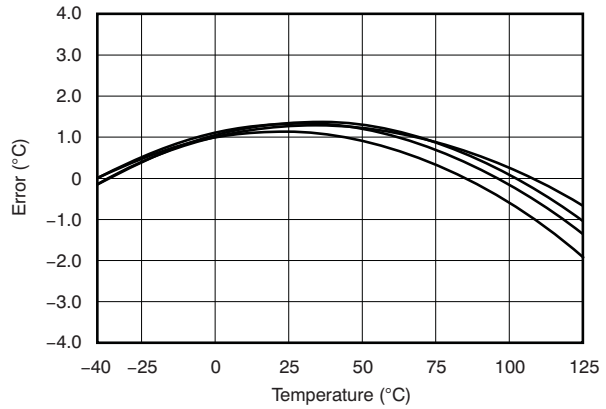
**Figure 2.**

**R<sub>SET</sub> VS TEMPERATURE**



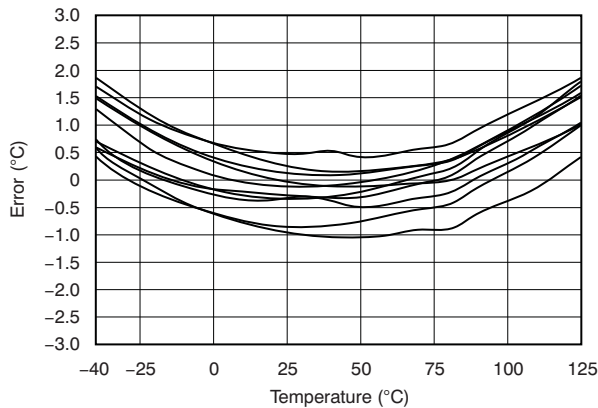
**Figure 3.**

**TYPICAL TRIP ERROR**



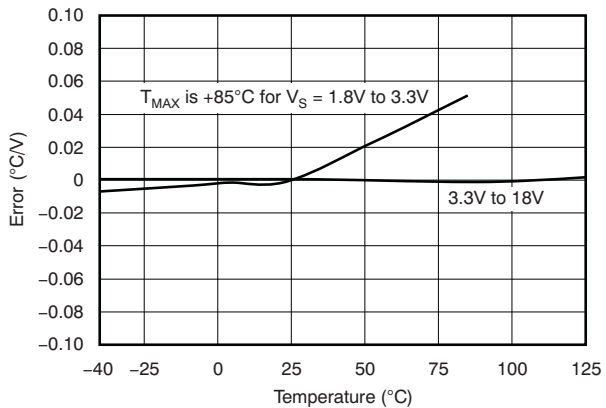
**Figure 4.**

**TYPICAL ANALOG OUTPUT ERROR**



**Figure 5.**

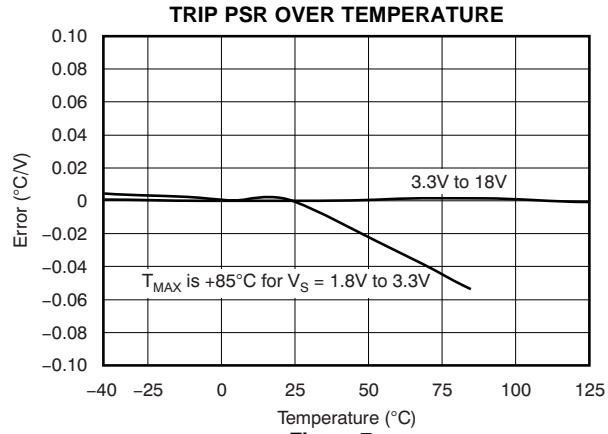
**ANALOG PSR OVER TEMPERATURE**



**Figure 6.**

**TYPICAL CHARACTERISTICS (continued)**

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



**APPLICATIONS INFORMATION**

The TMP300B-Q1 is a thermal sensor designed for over-temperature protection circuits in electronic systems. The TMP300B-Q1 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.

**CALCULATING R<sub>SET</sub>**

The set resistor (R<sub>SET</sub>) provides a threshold voltage for the comparator input. The TMP300B-Q1 trips when the V<sub>TEMP</sub> pin exceeds the T<sub>SET</sub> voltage. The value of the set resistor is determined by the analog output function and the 3μA internal bias current.

To set the TMP300B-Q1 to trip at a preset value, calculate the R<sub>SET</sub> resistor value according to [Equation 1](#) or [Equation 2](#):

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

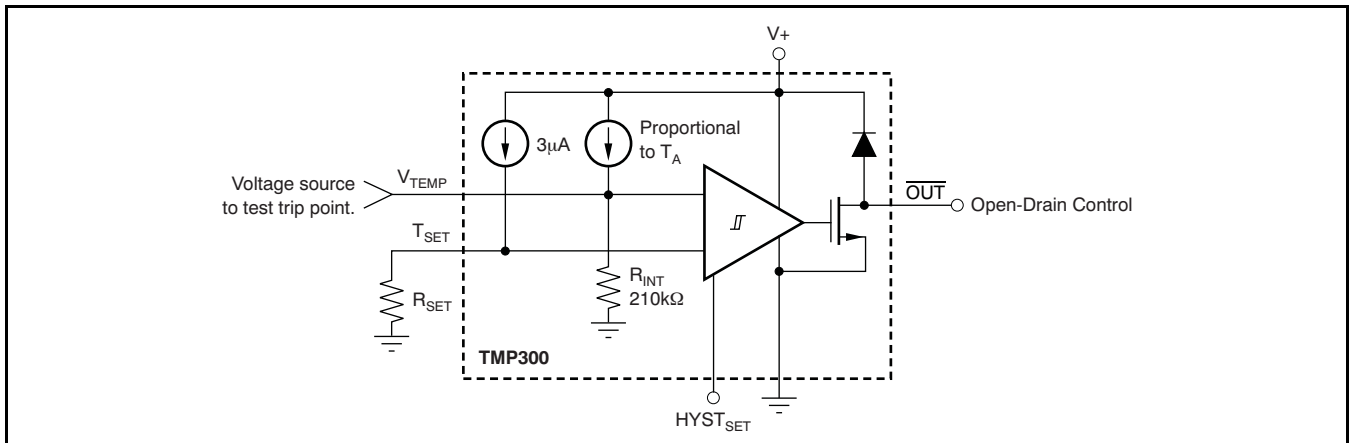
Where T<sub>SET</sub> is in °C; or

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

Where T<sub>SET</sub> is in °C.

**USING V<sub>TEMP</sub> 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**

### ANALOG TEMPERATURE OUTPUT

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

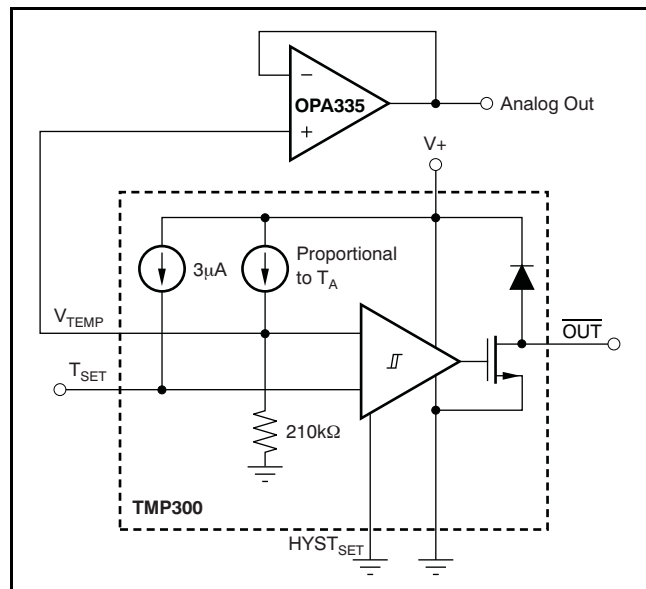


Figure 9. Buffering the Analog Output Signal

### 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  $^{\circ}\text{C}$  of the comparator input over temperature. An alternative method of setting the trip point by using a DAC is shown in Figure 11.

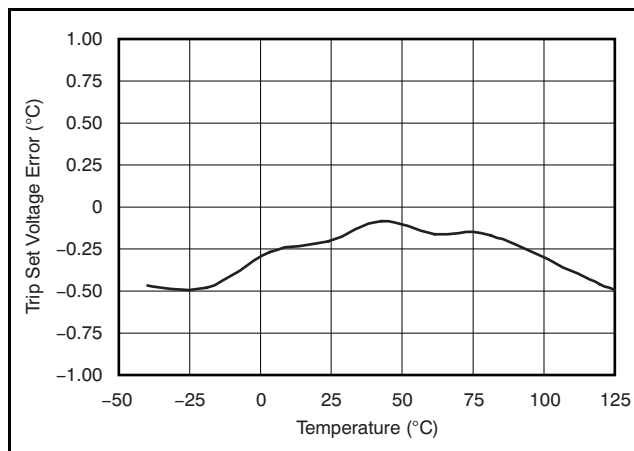


Figure 10. Trip Set Voltage Error vs Temperature

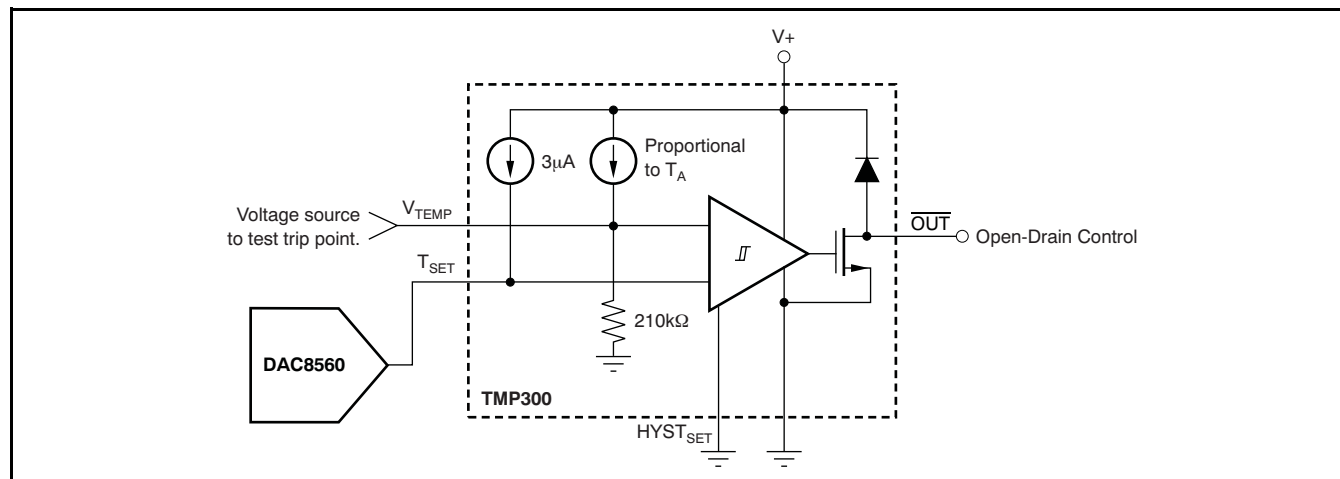


Figure 11. DAC Generates the Voltage-Driving  $T_{SET}$  Pin

**HYSTERESIS**

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

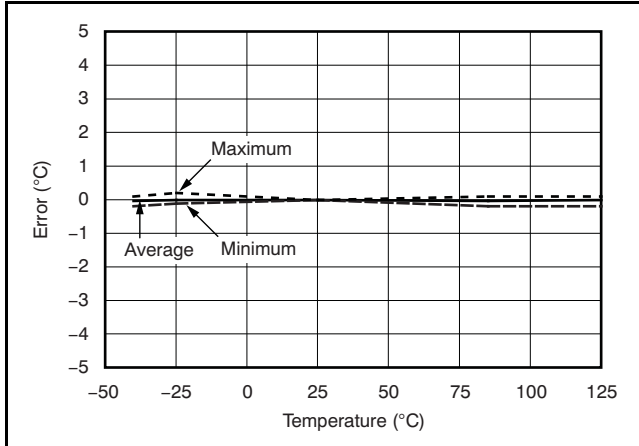


Figure 12. 5°C Hysteresis Error vs Temperature

Bypass capacitors should be used 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.

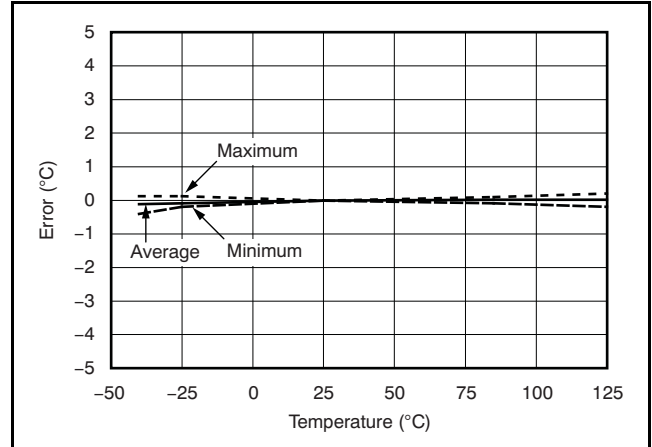


Figure 13. 10°C Hysteresis Error vs Temperature

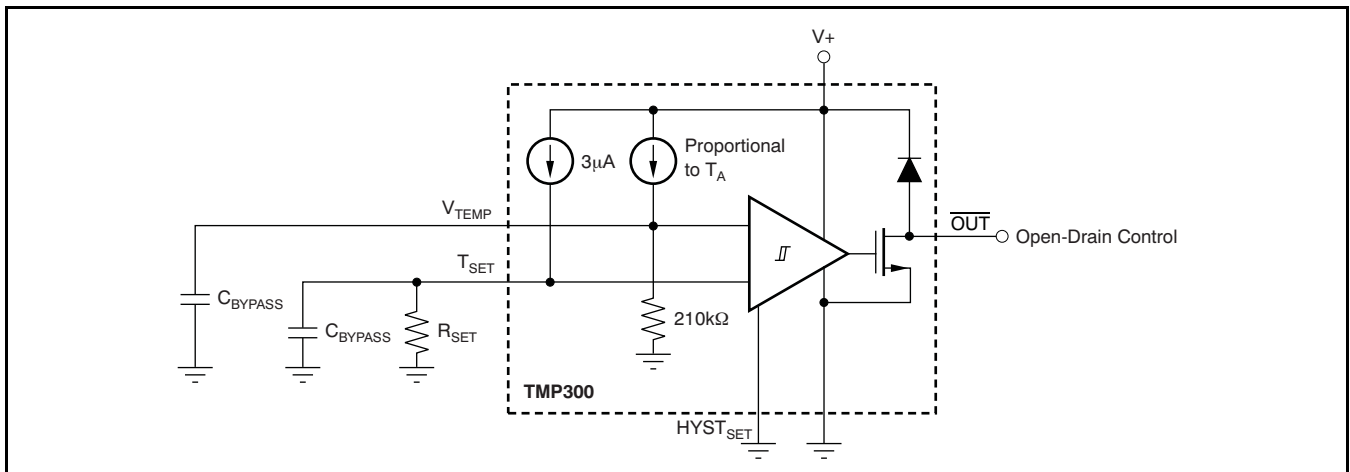


Figure 14. Bypass Capacitors Prevent Early Comparator Toggling Due to Circuit Board Noise

**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/ Ball Finish	MSL Peak Temp <sup>(3)</sup>	Samples (Requires Login)
TMP300BQDCKRQ1	ACTIVE	SC70	DCK	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	

<sup>(1)</sup> 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.

<sup>(2)</sup> 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)

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

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**OTHER QUALIFIED VERSIONS OF TMP300-Q1 :**

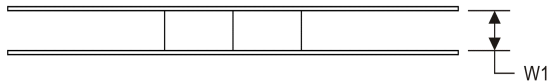
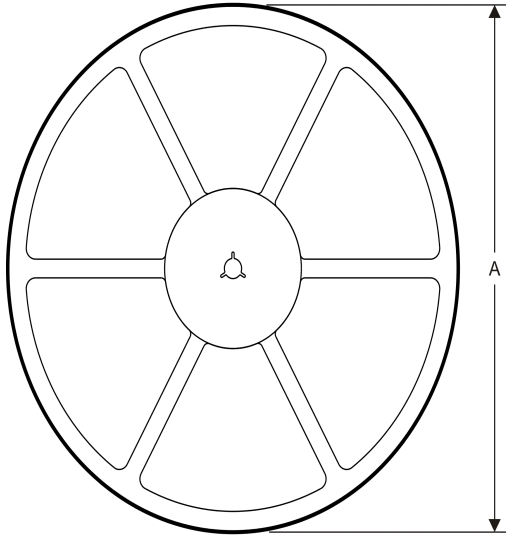
- Catalog: [TMP300](#)

NOTE: Qualified Version Definitions:

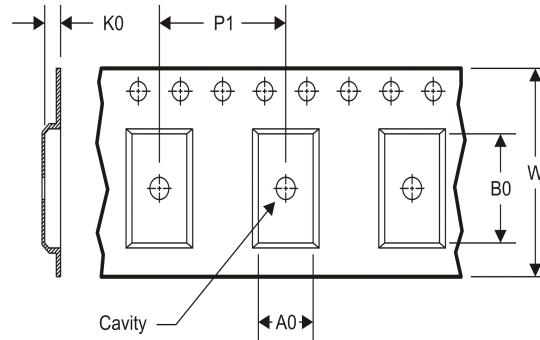
- Catalog - TI's standard catalog product

## TAPE AND REEL INFORMATION

### REEL DIMENSIONS



### TAPE DIMENSIONS



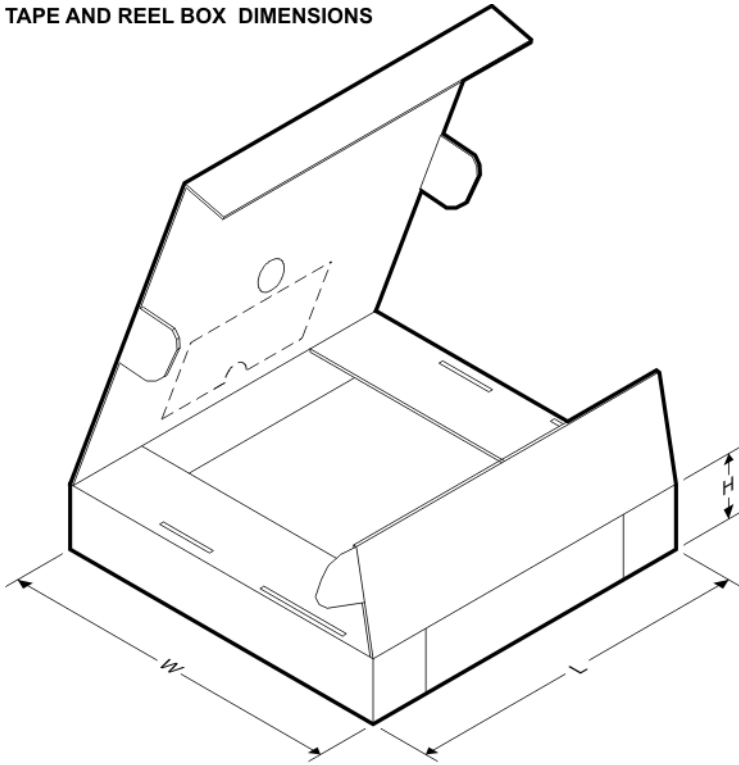
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

### TAPE AND REEL INFORMATION

\*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
TMP300BQDCKRQ1	SC70	DCK	6	3000	179.0	8.4	2.2	2.5	1.2	4.0	8.0	Q3

## TAPE AND REEL BOX DIMENSIONS



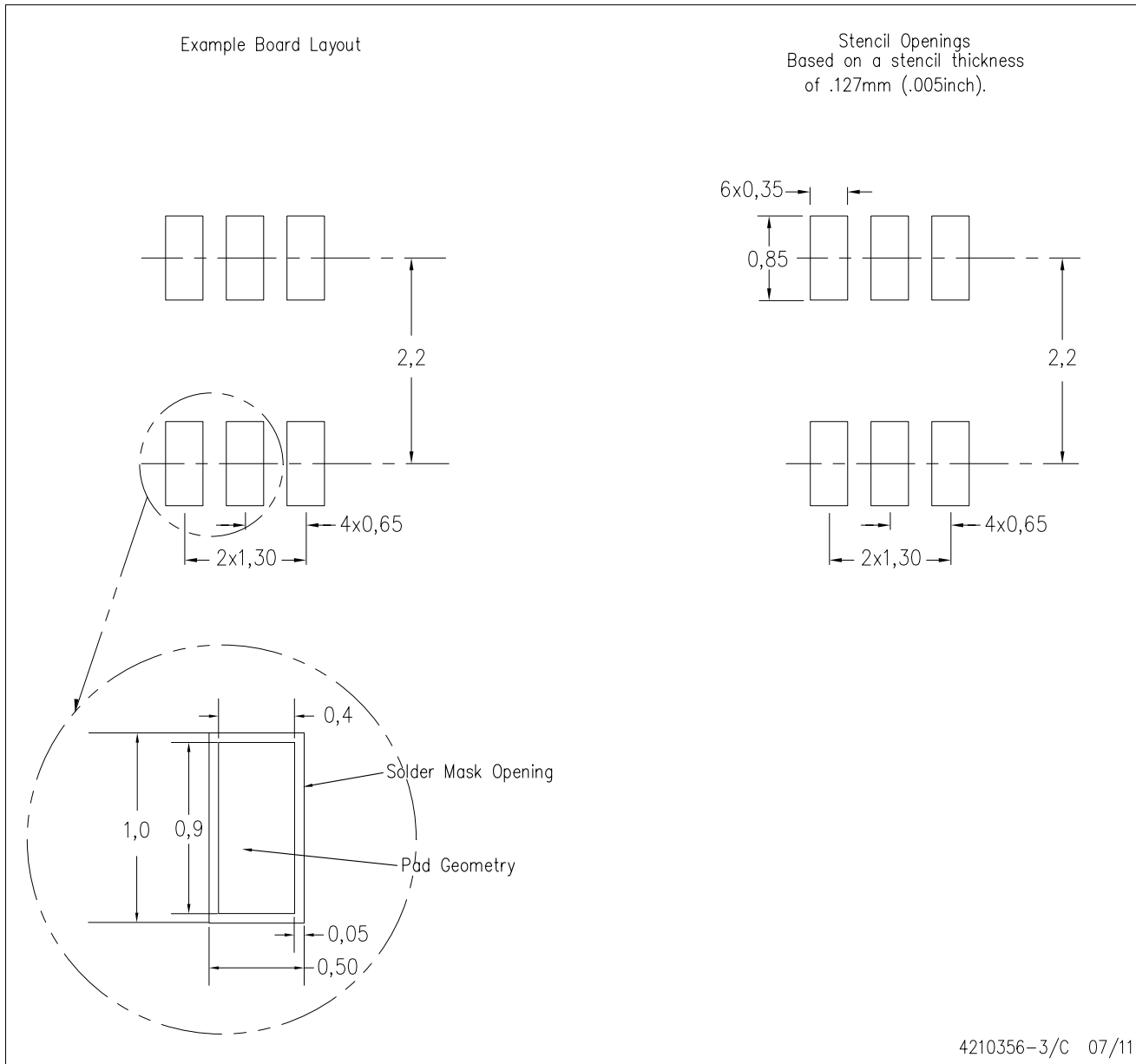
\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TMP300BQDCKRQ1	SC70	DCK	6	3000	203.0	203.0	35.0



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.