TC6501/2/3/4

Ultra Small Temperature Switches with Pin Selectable Hysteresis

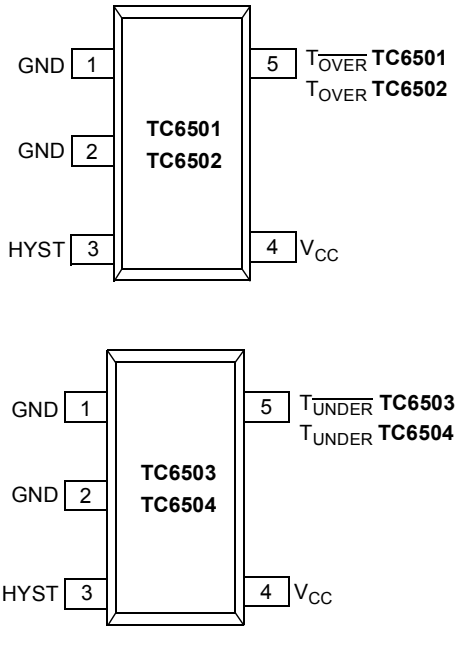
Features

- 5-Pin SOT-23A
- Factory Programmed Thresholds from -45°C to +125°C in 10°C Increments
- Pin Selectable +2°C or +10°C Hysteresis
- ± 0.5°C (Typ) Threshold Accuracy Over Full Temperature Range
- No External Components Required
- 17 µA Supply Current (Typ)

Applications

- Thermal Management in PCs and Servers
- Over-Temperature Fail Safe Circuits
- Simple Fan Controller
- Temperature Alarms
- Projectors/Printers
- Notebook Computers
- Network Boxes

Package Types



Note: 5-Pin SOT-23A is equivalent to EIAJ SC-74A

General Description

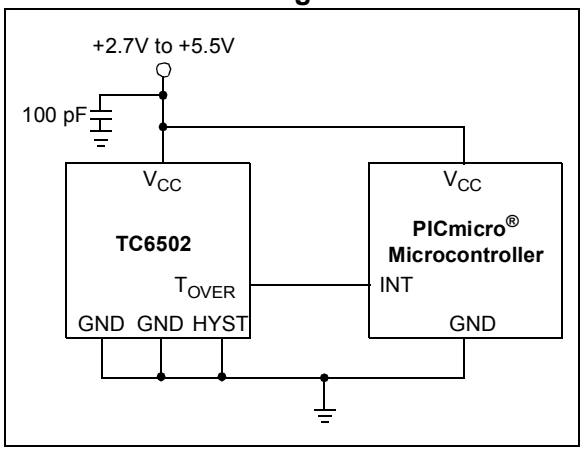
The TC6501/2/3/4 are SOT-23 temperature switches that require no external components and are available with factory programmed temperature thresholds. A choice of factory trimmed temperature trip points are also available. Pin selectable hysteresis of +2°C or +10°C allows flexibility to the design of the application. These parts typically consume only 17 µA of current and operate over the entire -55°C to +135°C temperature range, while offering accuracies of ±0.5°C (typ).

The TC6501 and TC6503 have an open-drain, active-low output, which targets microcontroller reset control. The TC6502 and TC6504 have a CMOS, active-high output designed to drive the logic level MOSFET that turns on a fan or heater element.

The TC6501/TC6502 are designed for hot temperature monitoring (+35°C to +125°C). These devices assert a logic signal when the temperature goes above the threshold. The TC6503/TC6504 are optimized for cold temperature monitoring (-45°C to +15°C) and assert a logic signal when the temperature goes below the threshold.

The TC6501/2/3/4 are offered with five standard temperature thresholds. Available in 5-Pin SOT-23A packages, these parts are ideal for applications requiring high integration, small size, low power and low installed cost.

Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings*

Supply Voltage (V_{CC}) ..... -0.3V to +7V

Input Current (All Pins).....20 mA

Output Current (All Pins).....20 mA

Operating Temperature Range.....- 55°C to +135°C

Storage Temperature Range.....- 65°C to +165°C

$T_{\overline{OVER}}$ (TC6501)..... -0.3V to +7V

T_{OVER} (TC6502)..... -0.3V to (V_{CC} + 0.3V)

$T_{\overline{UNDER}}$ (TC6503)..... -0.3V to 7V

T_{UNDER} (TC6504)..... -0.3V to (V_{CC} + 0.3V)

All Other Pins ..... -0.3V to (V_{CC} + 0.3V)

Maximum Junction Temperature, T_J ..... 150°C

Power Dissipation (T_A = +70°C):
(Derate 7.1 mW/°C Above +70°C) .....570 mW

* **Notice:** Stresses above those listed under "Maximum Ratings" may cause permanent damage to the device. This a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of the specifications is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL SPECIFICATIONS

Electrical Characteristics: Unless otherwise noted, V_{CC} = +2.7V to +5.5V, $R_{PULL-UP}$ = 100 kΩ (TC6501/TC6503 only), 100 pF decoupling capacitor from V_{CC} to GND, T_{AMB} = -55°C to +135°C. Typical values are at T_A = +25°C.

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions
Supply Voltage Range	V_{CC}	2.7	—	5.5	V	
Supply Current	I_{CC}	—	17	40	µA	
HYST Input Threshold	V_{IH}	0.8 x V_{CC}	—	—	V	
HYST Input Threshold	V_{IL}	—	—	0.2 x V_{CC}	V	
Temperature Threshold Accuracy **(Note 1)**	ΔT_{TH}	-6	±0.5	6	°C	-45°C to -25°C
		-4	±0.5	4	°C	-15°C to +15°C
		-4	±0.5	4	°C	+35°C to +65°C
		-6	±0.5	6	°C	+75°C to +125°C
Temperature Threshold Hysteresis	T_{HYST}	—	2.0	—	°C	HYST = GND
		—	10	—	°C	HYST = V_{CC}
Output Voltage High	V_{OH}	0.8 x V_{CC}	—	—	V	I_{SOURCE} = 500 µA, V_{CC} > 2.7V (TC6502/TC6504 Only)
		V_{CC} - 1.5	—	—	V	I_{SOURCE} = 800 µA, V_{CC} > 4.5V (TC6502/TC6504 Only)
Output Voltage Low	V_{OL}	—	—	0.3	V	I_{SINK} = 1.2 mA, V_{CC} > 2.7V
		—	—	0.4	V	I_{SINK} = 3.2 mA, V_{CC} > 4.5V
Open-Drain Output Leakage Current		—	10	—	nA	V_{CC} = 2.7V, $T_{\overline{UNDER}}$ = 5.5V (TC6503); $T_{\overline{OVER}}$ = 5.5V (TC6501)

Note 1: The TC6501/2/3/4 are available with internal, factory programmed temperature trip thresholds from -45°C to +125°C in +10°C increments.

2.0 TYPICAL PERFORMANCE CURVES

Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

Note: Unless otherwise noted, V_{CC} = 5.0V, $R_{PULL-UP}$ = 100 kΩ (TC6501/TC6503 only), 100 pF decoupling capacitor from V_{CC} to GND, T_{AMB} = +25°C.

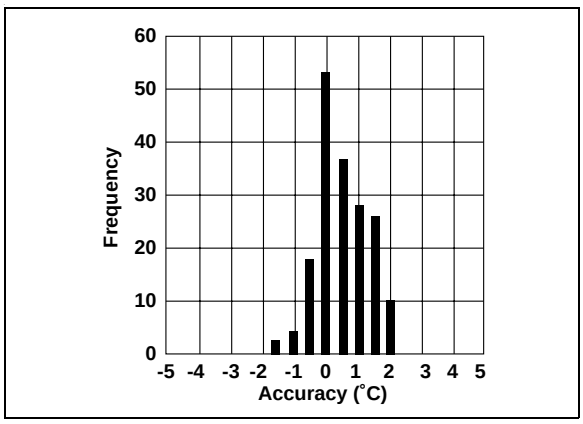


FIGURE 2-1: *Trip Threshold Accuracy.*

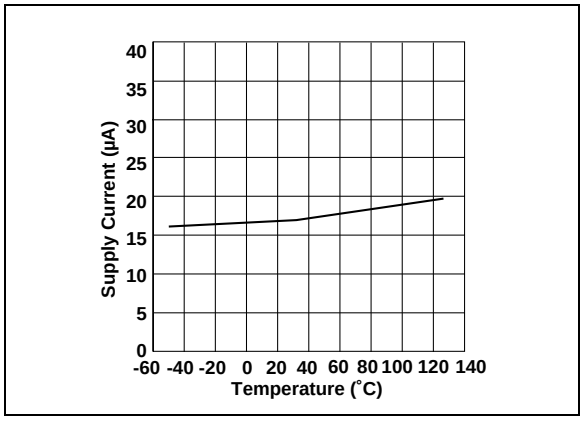


FIGURE 2-4: *Supply Current vs. Temperature.*

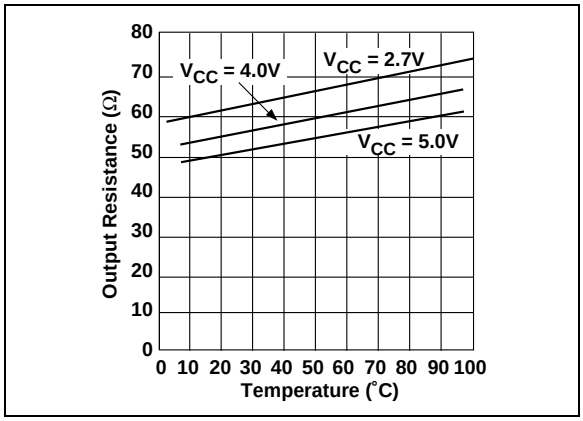


FIGURE 2-2: *Output Sink Resistance vs. Temperature.*

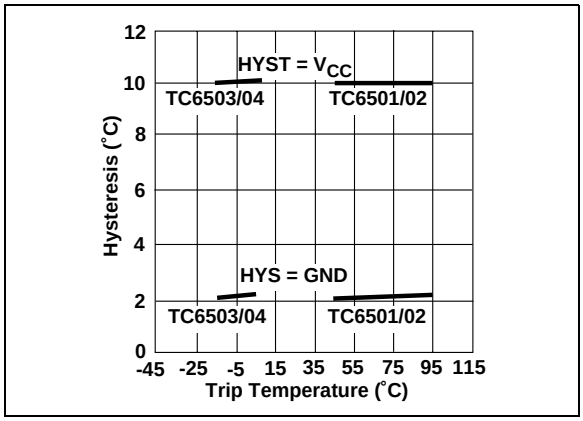


FIGURE 2-5: *Hysteresis vs. Trip Temperature.*

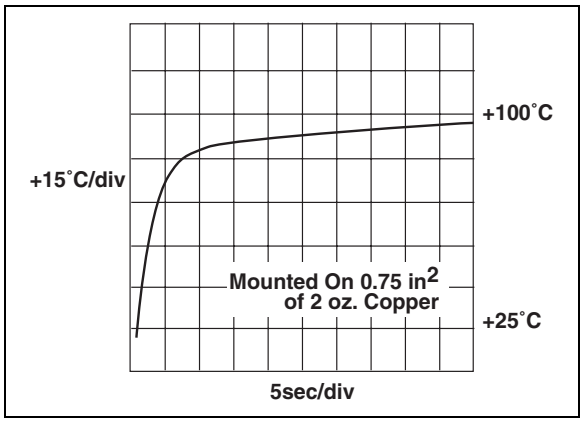


FIGURE 2-3: *Thermal Step Response in Perfluorinated Fluid (SOT-23).*

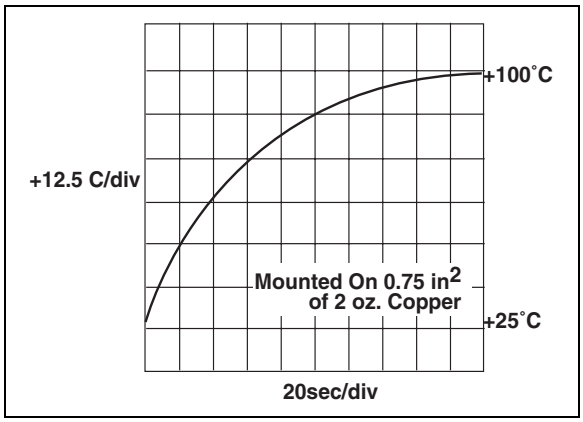


FIGURE 2-6: *Thermal Step Response in Still Air (SOT-23).*

Note: Unless otherwise noted, V_{CC} = 5.0V, $R_{PULL-UP}$ = 100 kΩ (TC6501/TC6503 only), 100 pF decoupling capacitor from V_{CC} to GND, T_{AMB} = +25°C.

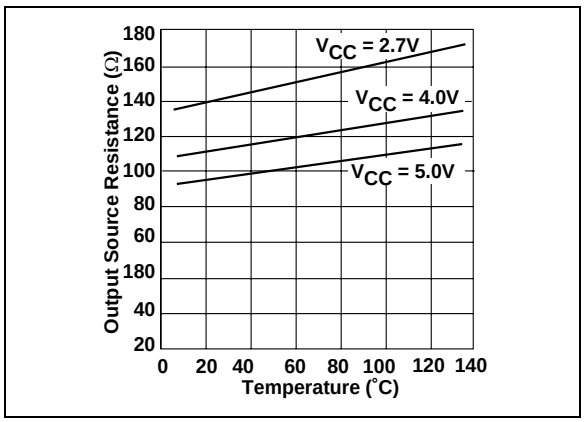


FIGURE 2-7: *Output Source Resistance vs. Temperature (TC6502).*

3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1.

TABLE 3-1: PIN FUNCTION TABLE

TC6501	TC6502	TC6503	TC6504	Symbol	Description
1, 2	1, 2	1, 2	1, 2	GND	Ground
3	3	3	3	HYST	Hysteresis Input
4	4	4	4	V_{CC}	Supply Input (+2.7V to +5.5V)
5	—	—	—	$T_{\overline{OVER}}$	Open-Drain, Active-Low Output
—	5	—	—	T_{OVER}	Push/Pull Active-High Output
—	—	5	—	$T_{\overline{UNDER}}$	Open-Drain, Active-Low Output
—	—	—	5	T_{UNDER}	Push/Pull Active-High Output

3.1 Ground

Connect the IC ground pins directly to the PCB ground and minimize the length of the connection. The thermal resistance to the die is at a minimum at Pin 2.

3.2 Hysteresis Input (HYST)

Either 2°C (GND) or 10°C (V_{CC}) of hysteresis is selected by connecting Pin 3 to GND or V_{CC}.

3.3 Supply Input (V_{CC})

A 100 pF or greater decoupling capacitor from V_{CC} to GND is recommended.

3.4 Open-Drain, Active-Low Output (TC6501) ($T_{\overline{OVER}}$)

The voltage at the $T_{\overline{OVER}}$ pin is equal to a logic low level if the sensor detects a temperature that is greater than the factory programmed threshold temperature. Because this is an open-drain output, a external pull-up resistor is required (a 100 kΩ pull-up resistor is recommended). The voltage on this pin can be higher than V_{CC}, though the voltage must not exceed the absolute maximum input voltage of 7.0V.

3.5 Push/Pull Active-High Output (TC6502) (T_{OVER})

The voltage at T_{OVER} is equal to a logic high level if the sensor detects a temperature greater than the factory programmed threshold temperature.

3.6 Open-Drain, Active-Low Output (TC6503) (T_{UNDER})

The voltage at the T_{UNDER} pin is equal to a logic low level if the sensor detects a temperature that is less than the factory programmed threshold temperature. Because this is an open-drain output, an external pull-up resistor is required (a 100 kΩ pull-up resistor is recommended). The voltage on this pin can be higher than V_{CC}, though the voltage must not exceed the absolute maximum input voltage of 7.0V

3.7 Push/Pull Active-High Output (TC6504) (T_{UNDER})

The voltage at T_{UNDER} is equal to a logic high level if the sensor detects a temperature less than the factory programmed threshold temperature.

4.0 DETAILED DESCRIPTION

The TC6501/2/3/4 integrate a temperature sensor with a factory programmed threshold switch (see Functional Block Diagrams in Figure 5-4 through Figure 5-7). A logic signal is asserted when the die temperature crosses the factory programmed threshold. An external hysteresis input pin allows the user to select either 2°C or 10°C hysteresis to give further flexibility to the design of the application. The TC6501 and TC6502 are intended for a temperature range of 35°C to 125°C in a 10°C increment. The TC6501 has an open-drain output, while the TC6502 has a push/pull output stage.

The TC6503 and TC6504 are intended for a cold temperature range of -45°C to +15°C in 10°C increments. The TC6503 has an open-drain output, while the TC6504 has a push/pull output stage. The TC6501 and TC6503 are intended for applications with a microcontroller reset input. The TC6502 and TC6504 are intended for applications where a fan or heater element is turned on.

Please contact Microchip Technology for the availability of a particular temperature threshold not included in Table 4-1.

4.1 Hysteresis Input

To prevent the output from “chattering” at or near the trip point temperature, a selectable HYST input pin is provided. Hysteresis can be externally selected at 2°C (HYST = GND) or 10°C (HYST = V_{CC}) by means of the CMOS compatible HYST input pin. Do not let the HYST pin float, as this could cause an increase in supply current. The hysteresis does not depend on the part’s programmed trip threshold.

TABLE 4-1: FACTORY PROGRAMMED THRESHOLD RANGE

Part Number	Threshold (T_{TH}) Range
TC6501	+35°C < T_{TH} < +125°C
TC6502	+35°C < T_{TH} < +125°C
TC6503	-45°C < T_{TH} < +15°C
TC6504	-45°C < T_{TH} < +15°C

4.2 Thermal Considerations

With a 17 µA typical supply current, the TC6501/2/3/4 dissipates very little power. Thus, the die temperature is basically the same as the package temperature. To minimize the error in temperature readings, the load current should be limited to a few milliamps. For example, the typical thermal resistance of a 5-Pin SOT-23A package is 140°C/W. If, for instance, the TC6501 had to sink 1 mA and the output voltage is ensured to be less than 0.3V, an additional 0.3 mW of power is dissipated within the temperature sensor. This corresponds to a 0.042°C rise in die temperature.

Temperature monitoring accuracy depends on the thermal resistance between the device being monitored and the temperature switch die. Heat flows primarily through the leads onto the die. Pin 2 provides the lowest thermal resistance to the die. To achieve the best temperature monitoring results, the TC6501/2/3/4 should be placed closest to the device being monitored. Additionally, a short and wide copper trace from Pin 2 to the device should be used. In some cases, the 5-Pin SOT-23A package can be placed directly under the socketed microcontroller for improved thermal contact.

5.0 APPLICATIONS

The TC6501 and TC6503 have open-drain outputs and are, therefore, intended to interface as microcontroller reset inputs. Moreover, the combination of these two devices can be used to implement a temperature window alarm by wire-ORing the outputs and using an external pull-up resistor (see Figure 5-1).

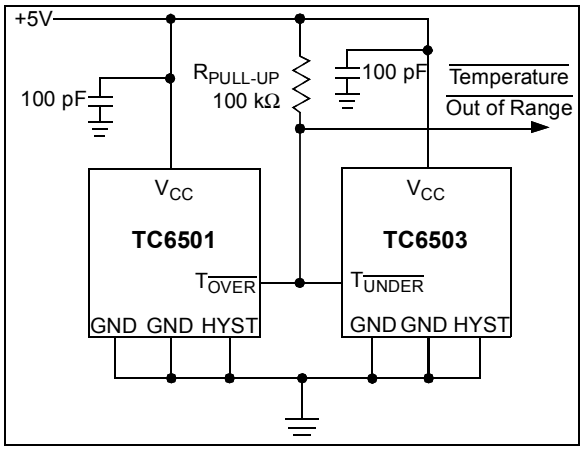


FIGURE 5-1: *Over and Under Temperature Alarm.*

The TC6502 can be used to control a DC fan. The fan turns on when the sensed temperature rises above the factory set threshold and remains on until the temperature falls below threshold minus the hysteresis selected. An additional fail safe measure could be designed by using a second TC6502 with a higher temperature threshold to alert the user of an impending thermal shutdown, should the temperature continue to rise (see Figure 5-2).

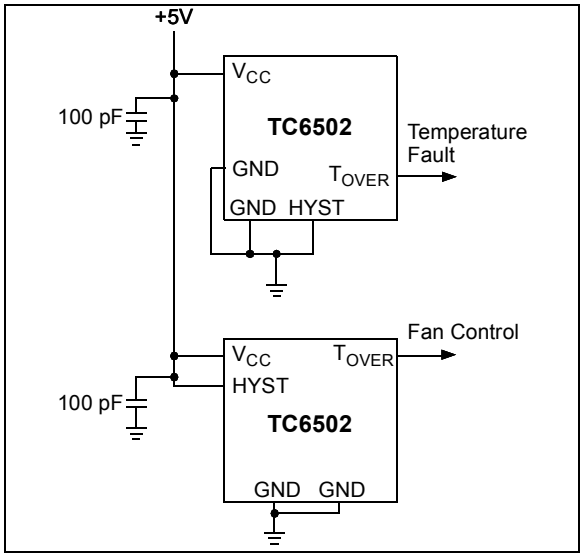


FIGURE 5-2: *Fan Control with Overtemperature Alert.*

The TC6504, with its push/pull output, may be used in a similar fashion to turn on a heater element at cold temperatures (see Figure 5-3).

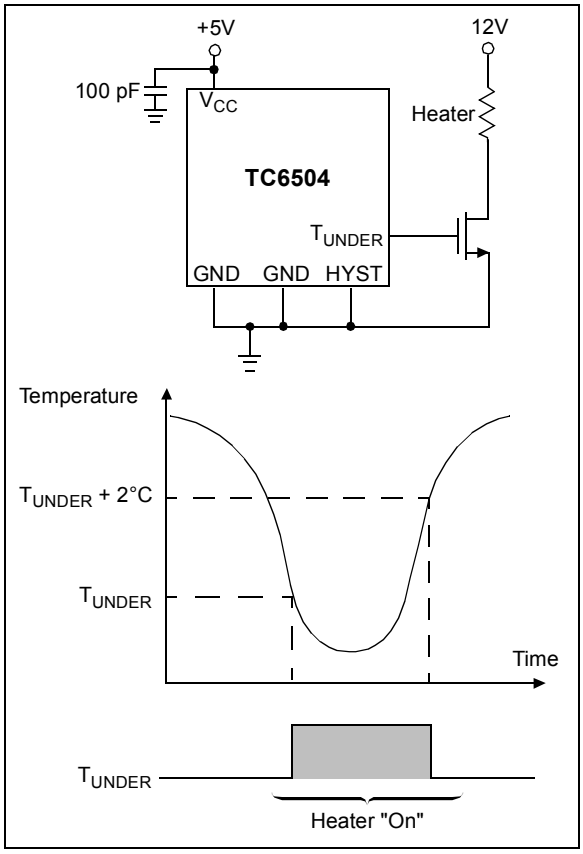


FIGURE 5-3: *TC6504 As Heater Thermostat.*

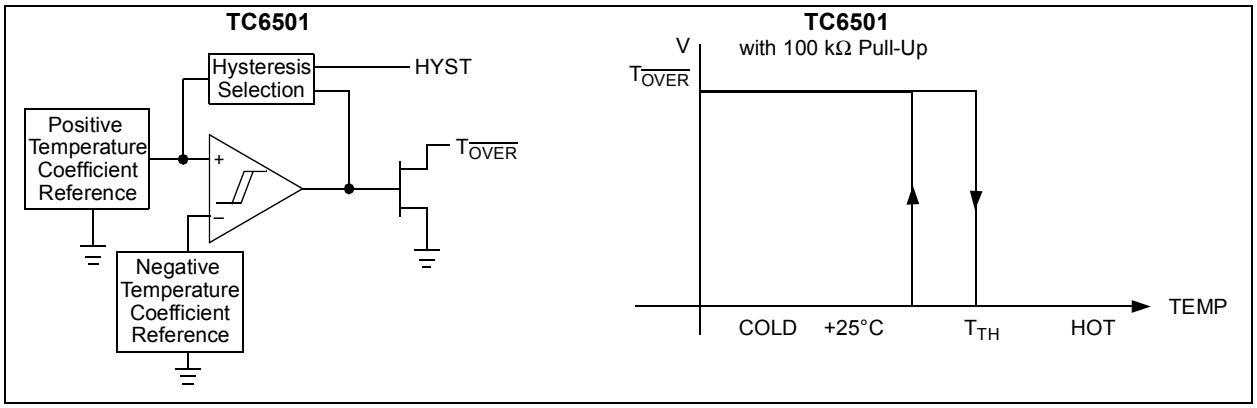


FIGURE 5-4: *TC6501 Functional Block Diagram.*

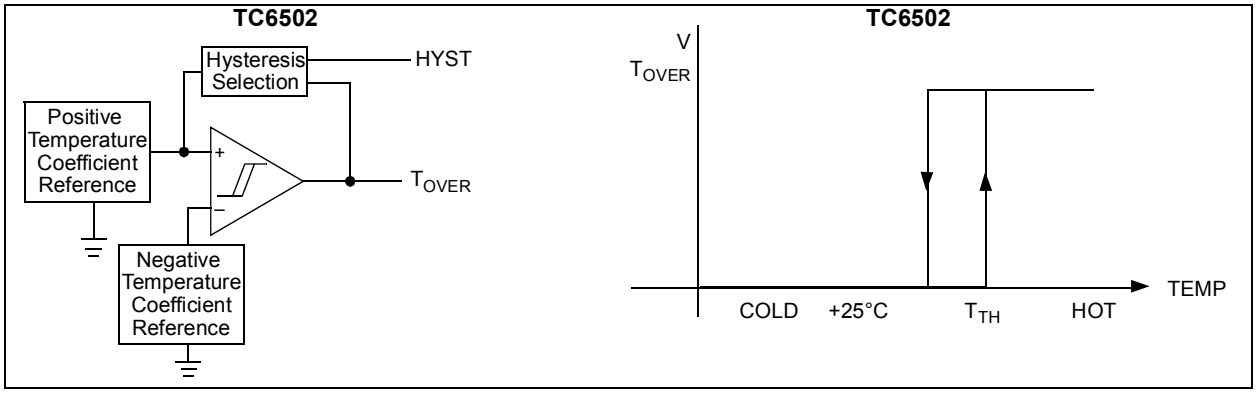


FIGURE 5-5: *TC6502 Functional Block Diagram.*

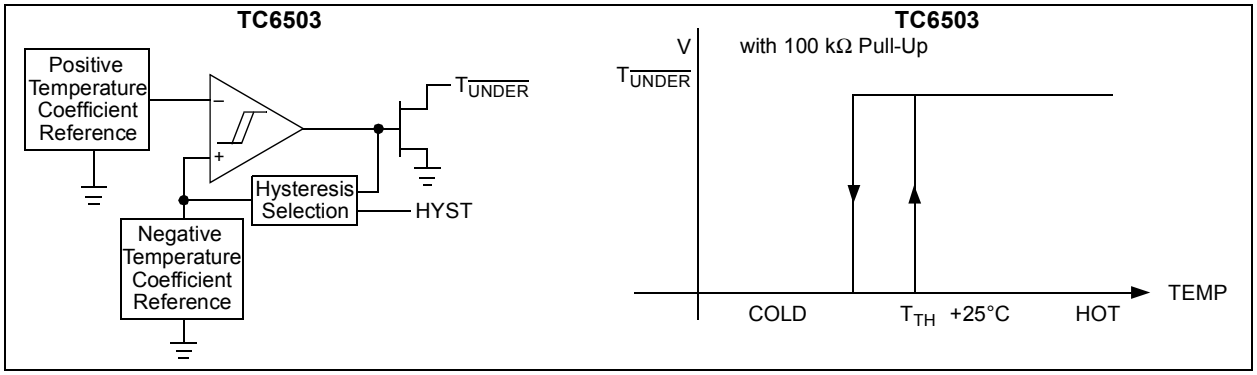


FIGURE 5-6: *TC6503 Functional Block Diagram.*

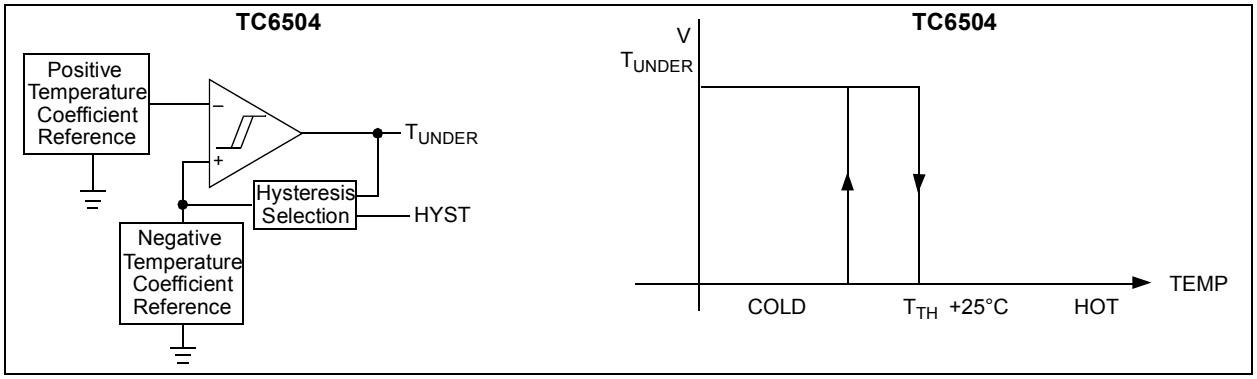
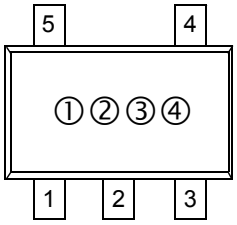


FIGURE 5-7: *TC6504 Functional Block Diagram.*

6.0 PACKAGING INFORMATION

6.1 Package Marking Diagram



Part Number	Marking Code
TC6501P045VCT	HA
TC6501P065VCT	HC
TC6501P075VCT	HD
TC6501P095VCT	HF
TC6501P105VCT	HG
TC6501P115VCT	HH
TC6501P125VCT	HJ
TC6502P045VCT	JA
TC6502P065VCT	JC
TC6502P075VCT	JD
TC6502P095VCT	JF
TC6502P115VCT	JH
TC6503N015VCT	KA
TC6503P005VCT	KB
TC6504N015VCT	LA
TC6504P005VCT	LB

Note: Please contact Microchip Technology for the availability of a particular temperature threshold not included in Table 4-1.

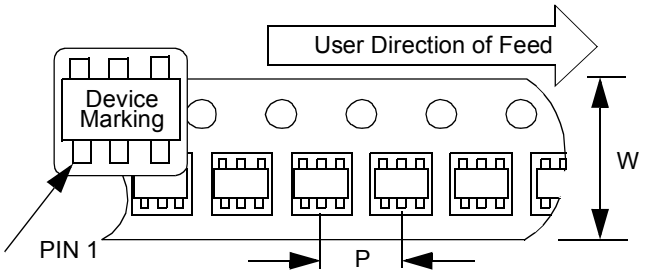
Legend:	1-2	Part Number code*
	3	Year and two-month period code
	4	Lot ID

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line thus limiting the number of available characters for customer specific information.

*Standard OTP marking consists of Microchip part number, year code, week code, and traceability code.

6.2 Taping Form

Component Taping Orientation for 5-Pin SOT-23A (EIAJ SC-74A) Devices



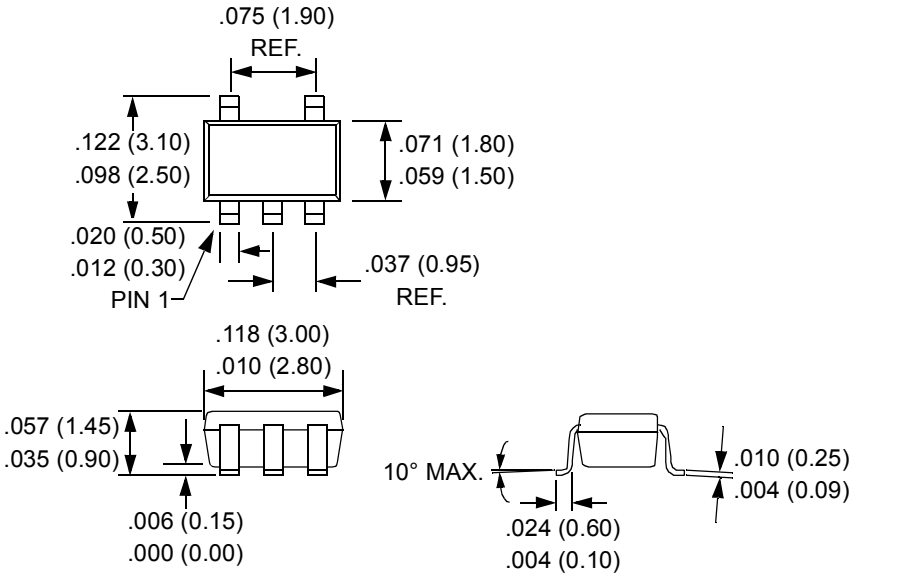
Standard Reel Component Orientation
for TR Suffix Device
(Mark Right Side Up)

Carrier Tape, Number of Components Per Reel and Reel Size:

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
5-Pin SOT-23A	8 mm	4 mm	3000	7 in.

6.3 Package Dimensions

SOT-23A-5



Dimensions: inches (mm)

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- Device Errata
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Device: TC6501/2/3/4 Literature Number: DS21451C

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4. What additions to the document do you think would enhance the structure and subject?

5. What deletions from the document could be made without affecting the overall usefulness?

6. Is there any incorrect or misleading information (what and where)?

7. How would you improve this document?

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

PART NO.	XXXX	XXXXX
Device	Standard Temperature Threshold	Package

Device:	TC6501:	Ultra Small Temp Switch with Pin-Selectable Hysteresis
	TC6502:	Ultra Small Temp Switch with Pin-Selectable Hysteresis
	TC6503:	Ultra Small Temp Switch with Pin-Selectable Hysteresis
	TC6504:	Ultra Small Temp Switch with Pin-Selectable Hysteresis
Standard Temperature Threshold:	N015	= -15°C (TC6503, TC6504)
	P005	= 5°C (TC6503, TC6504
	P045	= 45°C (TC6501, TC6502)
	P065	= 65°C (TC6501, TC6502)
	P075	= 75°C (TC6501, TC6502)
	P095	= 95°C (TC6501, TC6502)
	P105	= 105°C (TC6501)
	P115	= 115°C (TC6501, TC6502)
	P125	= 125°C (TC6501)
Package:	VCTTR	= SOT-23, 5-lead (Tape and Reel)

Examples:

a) TC6501P045VCTTR: 5-Pin SOT-23A, 45°C, Open-Drain, tape and reel.
b) TC6501P065VCTTR: 5-Pin SOT-23A, 65°C, Open-Drain, tape and reel.
c) TC6501P095VCTTR: 5-Pin SOT-23A, 95°C, Open-Drain, tape and reel.

a) TC6502P045VCTTR: 5-Pin SOT-23A, 45°C, Push-Pull, tape and reel.
b) TC6502P065VCTTR: 5-Pin SOT-23A, 65°C, Push-Pull, tape and reel.
c) TC6502P095VCTTR: 5-Pin SOT-23A, 95°C, Push-Pull, tape and reel.

a) TC6503N015VCTTR: 5-Pin SOT-23A, -15°C, Open-Drain, tape and reel.
b) TC6503P005VCTTR: 5-Pin SOT-23A, 5°C, Open-Drain, tape and reel.

a) TC6504N015VCTTR: 5-Pin SOT-23A, -15°C, Push-Pull, tape and reel.
b) TC6504P005VCTTR: 5-Pin SOT-23A, 5°C, Push-Pull, tape and reel.

Sales and Support

Data Sheets
Products supported by a preliminary Data Sheet may have an errata sheet describing minor operational differences and recommended workarounds. To determine if an errata sheet exists for a particular device, please contact one of the following:

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2. The Microchip Corporate Literature Center U.S. FAX: (480) 792-7277
3. The Microchip Worldwide Site (www.microchip.com)

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