

## Tiny Integrated Temperature Sensor & Brushless DC Fan Controller with Overtemperature Alert

### Features

- Integrated Temperature Sensing and Multi-speed Fan Control
- Built-in Overtemperature Alert ( $T_{\overline{OVER}}$ )
- Temperature-proportional Fan Speed Control for Acoustic Noise Reduction and Longer Fan Life
- Pulse Width Modulation (PWM) Output Drive for Cost and Power Savings
- Solid-state Temperature Sensing
- $\pm 1^{\circ}\text{C}$  (typ.) Accuracy from  $25^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$
- Operating Range: 2.8V – 5.5V
- **TC651** includes Automatic Fan Shutdown
- Low Operating Current: 50  $\mu\text{A}$  (typ.)

### Applications

- Thermal Protection For Personal Computers
- Digital Set-Top Boxes
- Notebook Computers
- Data Communications
- Power Supplies
- Projectors

### Related Literature

- Application Note 771 (DS00771)

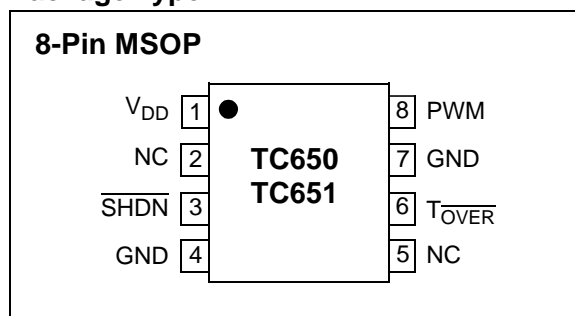
### General Description

The TC650/TC651 are integrated temperature sensors and brushless DC fan speed controllers. The TC650/TC651 measure the junction temperature and control the speed of the fan based on that temperature, making them especially suited for applications in modern electronic equipment.

Temperature data is converted from the on-chip thermal sensing element and translated into a fractional fan speed from 40% to 100%. A temperature selection guide in the data sheet is used to choose the low and high temperature limits to control the fan. The TC650/TC651 also include a single trip point overtemperature alert ( $T_{\overline{OVER}}$ ) that eliminates the need for additional temperature sensors. In addition, the TC651 features an auto fan shutdown function for additional power savings.

The TC650/TC651 are easy to use, require no software overhead and are, therefore, the ideal choice for implementing thermal management in a variety of systems.

### Package Type



# TC650/TC651

## Typical Application Circuit



## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings†

|  |                                    |
|--|------------------------------------|
| Input Voltage ( $V_{DD}$ to GND) ..... | +6V                                |
| Output Voltage (OUT to GND) .....      | 6V                                 |
| Voltage On Any Pin .....               | (GND – 0.3V) to ( $V_{DD}$ + 0.3V) |
| Operating Temperature Range .....      | –40°C to +125°C                    |
| Storage Temperature .....              | –65°C to +150°C                    |

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

### DC CHARACTERISTICS

| Electrical Specifications: Unless otherwise specified, $V_{DD} = 2.8V$ to $5.5V$ , $\overline{SHDN} = V_{DD}$ , $T_A = -40^\circ C$ to $+125^\circ C$ . |                        |                |                 |           |            |   |
|---|------------------------|----------------|-----------------|-----------|------------|---|
| Parameters  | Sym                    | Min            | Typ             | Max       | Units      | Conditions  |
| Supply Voltage  | $V_{DD}$               | 2.8            | —               | 5.5       | V          |   |
| Supply Current  | $I_{DD}$               | —              | 50              | 90        | $\mu A$    | PWM, $T_{OVER}$ are open                              |
| <b>SHDN Input</b>   |                        |                |                 |           |            |   |
| $\overline{SHDN}$ Input High Threshold  | $V_{IH}$               | 65             | —               | —         | % $V_{DD}$ |   |
| $\overline{SHDN}$ Input Low Threshold   | $V_{IL}$               | —              | —               | 15        | % $V_{DD}$ |   |
| <b>PWM Output</b>   |                        |                |                 |           |            |   |
| PWM Output Low Voltage  | $V_{OL}$               | —              | —               | 0.3       | V          | $I_{SINK} = 1\text{ mA}$                              |
| PWM Output High Voltage   | $V_{OH}$               | $V_{DD} - 0.5$ | —               | —         | V          | $I_{SOURCE} = 5\text{ mA}$                            |
| PWM Rise Time   | $t_R$                  | —              | 10              | —         | $\mu s$    | $I_{OH} = 5\text{ mA}$ , 1 nF from PWM to GND         |
| PWM Fall Time   | $t_F$                  | —              | 10              | —         | $\mu s$    | $I_{OL} = 1\text{ mA}$ , 1 nF from PWM to GND         |
| PWM Frequency   | $f_{OUT}$              | 10             | 15              | —         | Hz         |   |
| Start-up Time   | $t_{STARTUP}$          | —              | $32/f_{OUT}$    | —         | sec        | $V_{DD}$ Rises from GND or $\overline{SHDN}$ Released |
| <b>Temperature Accuracy</b>   |                        |                |                 |           |            |   |
| High Temperature Accuracy   | $T_{H\text{ ACC}}$     | $T_H - 3$      | $T_H$           | $T_H + 3$ | $^\circ C$ | <b>Note 1</b>   |
| Temperature Range Accuracy  | $(T_H - T_L)_{ACC}$    | –1.0           | —               | +1.0      | $^\circ C$ | $(T_H - T_L) \leq 20^\circ C$                         |
|   |                        | –2.5           | —               | +2.5      | $^\circ C$ | $(T_H - T_L) \geq 20^\circ C$                         |
| Auto-shutdown Hysteresis  | $T_{HYST}$             | —              | $(T_H - T_L)/5$ | —         | $^\circ C$ | <b>TC651 Only</b>                                     |
| <b><math>T_{OVER}</math> Output</b>   |                        |                |                 |           |            |   |
| $T_{OVER}$ Output High Voltage  | $V_{HIGH}$             | $V_{DD} - 0.5$ | —               | —         | V          | $I_{SOURCE} = 1.2\text{ mA}$                          |
| $T_{OVER}$ Output Low Voltage   | $V_{LOW}$              | —              | —               | 0.4       | V          | $I_{SINK} = 2.5\text{ mA}$                            |
| Absolute Accuracy   | $T_{OVER\text{ ACC}}$  | —              | $T_H + 10$      | —         | $^\circ C$ | At Trip Point   |
| Trip Point Hysteresis   | $T_{OVER\text{ HYST}}$ | —              | 5               | —         | $^\circ C$ |   |

**Note 1:** Transition from 90% to 100% Duty Cycle.

# TC650/TC651

## TEMPERATURE CHARACTERISTICS

| <b>Electrical Specifications:</b> Unless otherwise noted, $V_{DD} = 2.8V$ to $5.5V$ , $\overline{SHDN} = V_{DD}$ , $T_A = -40^{\circ}C$ to $+125^{\circ}C$ . |               |     |       |      |               |            |
|--|---------------|-----|-------|------|---------------|------------|
| Parameters   | Sym           | Min | Typ   | Max  | Units         | Conditions |
| <b>Temperature Ranges</b>  |               |     |       |      |               |            |
| Specified Temperature Range  | $T_A$         | -40 | —     | +125 | $^{\circ}C$   |            |
| Maximum Junction Temperature   | $T_J$         | —   | —     | +150 | $^{\circ}C$   |            |
| Storage Temperature Range  | $T_A$         | -65 | —     | +150 | $^{\circ}C$   |            |
| <b>Package Thermal Resistances</b>   |               |     |       |      |               |            |
| Thermal Resistance, 8L-MSOP  | $\theta_{JA}$ | —   | 206.3 | —    | $^{\circ}C/W$ |            |

## 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 indicated,  $V_{DD} = 2.8V$  to  $5.5V$ ,  $\overline{SHDN} = V_{DD}$ ,  $T_A = -40^{\circ}C$  to  $+125^{\circ}C$ .



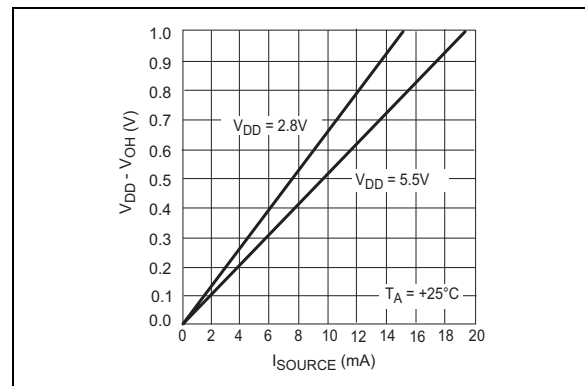
**FIGURE 2-1:**  $I_{DD}$  vs. Temperature.



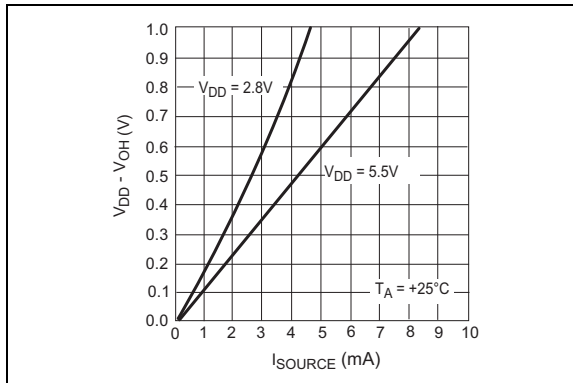
**FIGURE 2-4:** Temperature Accuracy vs.  $V_{TH}$ .



**FIGURE 2-2:** PWM,  $I_{SINK}$  vs.  $V_{OL}$ .



**FIGURE 2-5:** PWM,  $I_{SOURCE}$  vs.  $(V_{DD} - V_{OH})$ .



**FIGURE 2-3:**  $T_{OVER}$ ,  $I_{SOURCE}$  vs.  $(V_{DD} - V_{OH})$ .

# TC650/TC651

---

## 3.0 PIN DESCRIPTION

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

**TABLE 3-1: PIN FUNCTION TABLE**

| Pin No. | Symbol                   | Description  |
|---------|--------------------------|--|
| 1       | V <sub>DD</sub>          | Power Supply Input   |
| 2       | NC                       | No Internal Connect  |
| 3       | $\overline{\text{SHDN}}$ | Fan Shutdown, Active-low Input<br>1 = Fan in normal operation<br>0 = Fan in shutdown   |
| 4       | GND                      | Ground   |
| 5       | NC                       | No Connect   |
| 6       | T <sub>OVER</sub>        | Overtemperature Alert, Active-low Output<br>1 = Overtemperature condition does not exist<br>0 = The device is in the overtemperature condition. The fan is driven at 100%.<br>Potential exists for system over-heating |
| 7       | GND                      | Ground   |
| 8       | PWM                      | PWM Fan Drive Output   |

### 3.1 Power Supply Input

May be independent of fan power supply.

### 3.2 Fan Shutdown, Active-low Input

During Shutdown mode, the chip still monitors temperature. T<sub>OVER</sub> is low if temperature rises above factory set point.

### 3.3 Ground

Ground return for all TC650/TC651 functions.

### 3.4 Overtemperature Alert

Active-low output.

### 3.5 PWM Fan Drive Output

Pulse width modulated rail-to-rail logic output. Nominal frequency is 15 Hz.

## 4.0 DETAILED DESCRIPTION

The TC650/TC651 acquire and convert their junction temperature ( $T_J$ ) information from an on-chip, solid-state sensor with a typical accuracy of  $\pm 1^\circ\text{C}$ . The temperature data is digitally stored in an internal register. The register is compared with pre-defined threshold values. The six threshold values are equally distributed over a pre-defined range of temperatures (see Table 4-1). The TC650/TC651 control the speed of a DC brushless fan using a fractional speed-control scheme. The output stage requires only a 2N2222-type, small-signal BJT for fans up to 300 mA. For larger current fans (up to 1 amp), a logic-level N-channel MOSFET may be used. In addition to controlling the speed of the fan, the TC650/TC651 include an on-chip overtemperature alarm ( $\overline{T_{\text{OVER}}}$ ) that gives a low signal when the temperature of the chip exceeds  $T_H$  by  $10^\circ\text{C}$  (typical). This feature eliminates the need for a separate temperature sensor for overtemperature monitoring. Figure 4-1 shows the block diagram of the device.



**FIGURE 4-1:** Functional Block Diagram.

### 4.1 PWM Output

The PWM pin is designed to drive a low-cost transistor or MOSFET as the low-side, power-switching element in the system. This output has an asymmetric complementary drive and is optimized for driving NPN transistors or N-channel MOSFETs. Since the system relies on PWM rather than linear power control, the dissipation in the power switch is kept to a minimum. Generally, very small devices (TO-92 or SOT packages) will suffice. The frequency of the PWM is about 15 Hz. The PWM is also the time base for the Start-up Timer (see **Section 4.2 “Start-Up Timer”**). The PWM duty cycle has a range of 40% to 100% for the TC650 and 50% to 100% for the TC651.

### 4.2 Start-Up Timer

To ensure reliable fan start-up, the Start-up Timer turns PWM high for about 2 seconds whenever the fan is started from the off state. This occurs at power-up and when coming out of Shutdown mode.

### 4.3 Overtemperature Alert ( $\overline{T_{\text{OVER}}}$ )

This pin goes low when the  $T_H$  set point is exceeded by  $10^\circ\text{C}$  (typical). This indicates that the fan is at maximum drive and the potential exists for system overheating; either heat dissipation in the system has gone beyond the cooling system's design limits or some fault exists (such as fan bearing failure or an air-flow obstruction). This output may be treated as a “System Overheat” warning and be used to either trigger system shutdown or bring other fans in the system to full speed. The fan will continue to run at full speed while  $\overline{T_{\text{OVER}}}$  is asserted. Built-in hysteresis prevents  $\overline{T_{\text{OVER}}}$  from “chattering” when the measured temperature is at or near the  $T_H + 10^\circ\text{C}$  trip point. As temperature falls through the  $T_H + 10^\circ\text{C}$  trip point, hysteresis maintains the  $\overline{T_{\text{OVER}}}$  output low until the measured temperature is  $5^\circ\text{C}$  above the trip point setting.

### 4.4 Shutdown ( $\overline{\text{SHDN}}$ )

The fan can be unconditionally shut down by pulling the  $\overline{\text{SHDN}}$  pin low. During shutdown, the PWM output is low; ideal for notebook computers and other portable applications where you need to change batteries and must not have the fan running at that time. Thermal monitoring and  $\overline{T_{\text{OVER}}}$  are still in operation during shutdown.  $I_{\text{DD}}$  shutdown current is around  $50\ \mu\text{A}$ .

### 4.5 Auto-shutdown Mode

The TC651 features auto-shutdown. When the temperature is below the factory set point at minimum speed ( $T_L$ ), PWM is low and the fan is automatically shut off (Auto-shutdown mode). This feature is ideal for notebook computers and other portable equipment that need to conserve as much battery power as possible and, thus, run a fan when it is only absolutely needed. The TC651 will continue to be active in order to monitor temperature for  $\overline{T_{\text{OVER}}}$ . The TC651 exits Auto-shutdown mode when the temperature rises above the factory set point ( $T_1$ ).

# TC650/TC651

## 4.6 Temperature Selection Guide (Minimum Fan Speed/Full Speed)

There are two temperature thresholds that determine the characteristics of the device. The minimum fan speed temperature ( $T_L$ ) and the full fan speed temperature ( $T_H$ ). Depending on the TC65X device selected, when the temperature is below the  $T_L$  trip point, the PWM output will perform a different operation. For the TC650, the PWM will be driven at the minimum PWM frequency, while the TC651 will shut down the PWM ( $PWM = L$ ).

$T_L$  and  $T_H$  can be selected in 5°C increments.  $T_L$  can range from 25°C to 35°C.  $T_H$  can range from 35°C to 55°C and must be 10°C (or more) than the specified  $T_L$ .

The five temperature regions defined by the six thresholds are defined in the TC650/TC651 by means of factory trimming. Once a  $T_L$  and  $T_H$  are set, the  $T_1 - T_4$  thresholds are automatically equally spaced between  $T_L$  and  $T_H$ . Table 4-1 shows these 5 regions and what the corresponding PWM duty cycle is.

**TABLE 4-1: TEMPERATURE RANGE DEFINITION**

| Temperature<br>( $T = T_J$ )<br>(Note 1) | PWM Duty Cycle  |                                  |
|--|---|----------------------------------|
|  | TC650<br>(Minimum<br>Speed mode)                      | TC651<br>(Auto-shutdown<br>mode) |
| $T < T_L$                                | 40%   | Off                              |
| $T_L \leq T < T_1$                       | 50%   | 50%                              |
| $T_1 \leq T < T_2$                       | 60%   | 60%                              |
| $T_2 \leq T < T_3$                       | 70%   | 70%                              |
| $T_3 \leq T < T_4$                       | 80%   | 80%                              |
| $T_4 \leq T < T_H$                       | 90%   | 90%                              |
| $T_H \leq T < T_{OV}$                    | 100%  | 100%                             |
| $T_{OV} \leq T$                          | 100% with Overtemperature Alert<br>( $T_{OVER} = L$ ) |                                  |

**Note 1:** The temperature regions defined by the six temperature thresholds are pre-defined in the TC650/TC651 by means of factory trimming. Once a  $T_L$  and  $T_H$  are programmed, the  $T_1 - T_4$  thresholds are automatically equally spaced between  $T_L$  and  $T_H$ .

Table 4-2 shows the device codes that specify the  $T_H$  and  $T_L$  temperature thresholds. The following examples are given to assist in understanding the device-ordering nomenclature.

**Example 1:** Suppose you wanted the fan to **run at 40% speed at 25°C** or less and go to **full-speed at 45°C**. You would order the part number TC650AEVUA.

**Example 2:** Suppose you wanted the fan to **turn on at 30°C** and go to **full speed at 45°C**. You would order the part number TC651BEVUA.

**TABLE 4-2: DEVICE CODES FOR TEMPERATURE THRESHOLDS**

| Temp. Threshold Difference | $T_L$ | $T_H$ | Threshold Limits Code |
|----------------------------|-------|-------|-----------------------|
| 10°C                       | 25    | 35    | AC <sup>(1)</sup>     |
|                            | 30    | 40    | BD <sup>(2)</sup>     |
|                            | 35    | 45    | CE <sup>(2)</sup>     |
| 15°C                       | 25    | 40    | AD <sup>(2)</sup>     |
|                            | 30    | 45    | BE <sup>(1)</sup>     |
|                            | 35    | 50    | CF <sup>(2)</sup>     |
| 20°C                       | 25    | 45    | AE <sup>(1)</sup>     |
|                            | 30    | 50    | BF <sup>(2)</sup>     |
|                            | 35    | 55    | CG <sup>(1)</sup>     |
| 30°C                       | 25    | 55    | AG <sup>(1)</sup>     |

- Note 1:** This temperature threshold option is available for ordering.
- 2:** This is a custom temperature threshold option. Please contact the factory for more information.



## 5.0 TYPICAL APPLICATIONS

### 5.1 Reducing Switching Noise

For fans consuming more than 300 mA, a slowdown capacitor ( $C_{SLOW}$ ) is recommended for reducing switching PWM induced noise (see Figure 5-1). The value of this capacitor should be 4.7  $\mu\text{F}$  to 47  $\mu\text{F}$ , depending on the fan current consumption.

See Application Note 771, "Suppressing Acoustic Noise in PWM Fan Speed Control Systems" (DS00771), for more information.



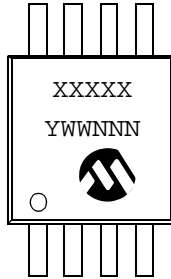
**FIGURE 5-1:** Reducing Switching Noise.

# TC650/TC651

## 6.0 PACKAGING INFORMATION

### 6.1 Package Marking Information

8-Lead MSOP



Example:

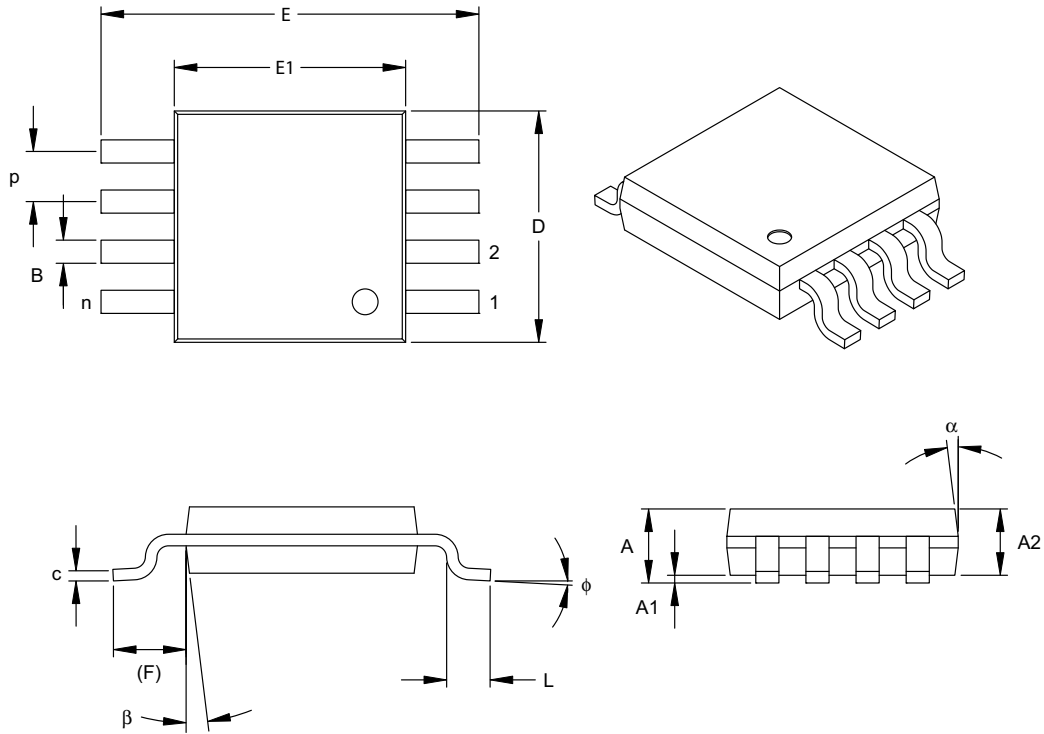


|                |        |  |
|----------------|--------|--|
| <b>Legend:</b> | XX...X | Customer-specific information  |
|                | Y      | Year code (last digit of calendar year)  |
|                | YY     | Year code (last 2 digits of calendar year)   |
|                | WW     | Week code (week of January 1 is week '01')   |
|                | NNN    | Alphanumeric traceability code   |
|                | (e3)   | Pb-free JEDEC designator for Matte Tin (Sn)  |
|                | *      | This package is Pb-free. The Pb-free JEDEC designator (e3) can be found on the outer packaging for this package. |

**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.

## 8-Lead Plastic Micro Small Outline Package (MS) (MSOP)

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



| Dimension Limits         | Units | INCHES    |      |      | MILLIMETERS* |      |      |
|--------------------------|-------|-----------|------|------|--------------|------|------|
|                          |       | MIN       | NOM  | MAX  | MIN          | NOM  | MAX  |
| Number of Pins           | n     |           | 8    |      |              | 8    |      |
| Pitch                    | p     | .026 BSC  |      |      | 0.65 BSC     |      |      |
| Overall Height           | A     | -         | -    | .043 | -            | -    | 1.10 |
| Molded Package Thickness | A2    | .030      | .033 | .037 | 0.75         | 0.85 | 0.95 |
| Standoff                 | A1    | .000      | -    | .006 | 0.00         | -    | 0.15 |
| Overall Width            | E     | .193 TYP. |      |      | 4.90 BSC     |      |      |
| Molded Package Width     | E1    | .118 BSC  |      |      | 3.00 BSC     |      |      |
| Overall Length           | D     | .118 BSC  |      |      | 3.00 BSC     |      |      |
| Foot Length              | L     | .016      | .024 | .031 | 0.40         | 0.60 | 0.80 |
| Footprint (Reference)    | F     | .037 REF  |      |      | 0.95 REF     |      |      |
| Foot Angle               | φ     | 0°        | -    | 8°   | 0°           | -    | 8°   |
| Lead Thickness           | c     | .003      | .006 | .009 | 0.08         | -    | 0.23 |
| Lead Width               | B     | .009      | .012 | .016 | 0.22         | -    | 0.40 |
| Mold Draft Angle Top     | α     | 5°        | -    | 15°  | 5°           | -    | 15°  |
| Mold Draft Angle Bottom  | β     | 5°        | -    | 15°  | 5°           | -    | 15°  |

\*Controlling Parameter

Notes:

Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" (0.254mm) per side.

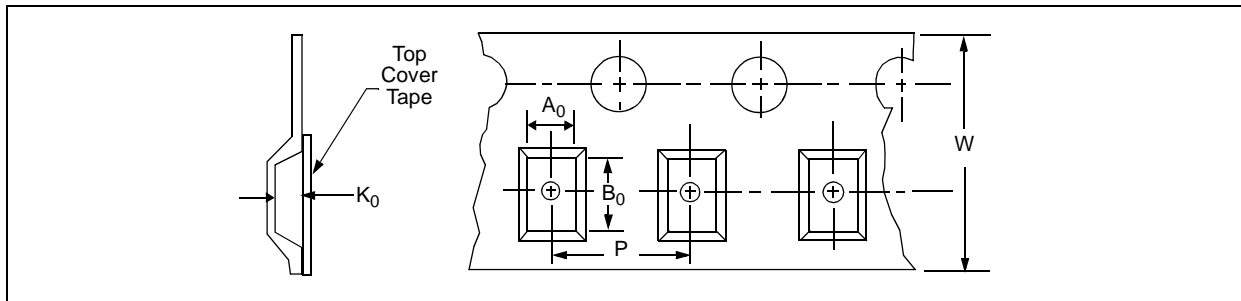
JEDEC Equivalent: MO-187

Drawing No. C04-111

# TC650/TC651

## 6.2 Product Tape and Reel Specifications

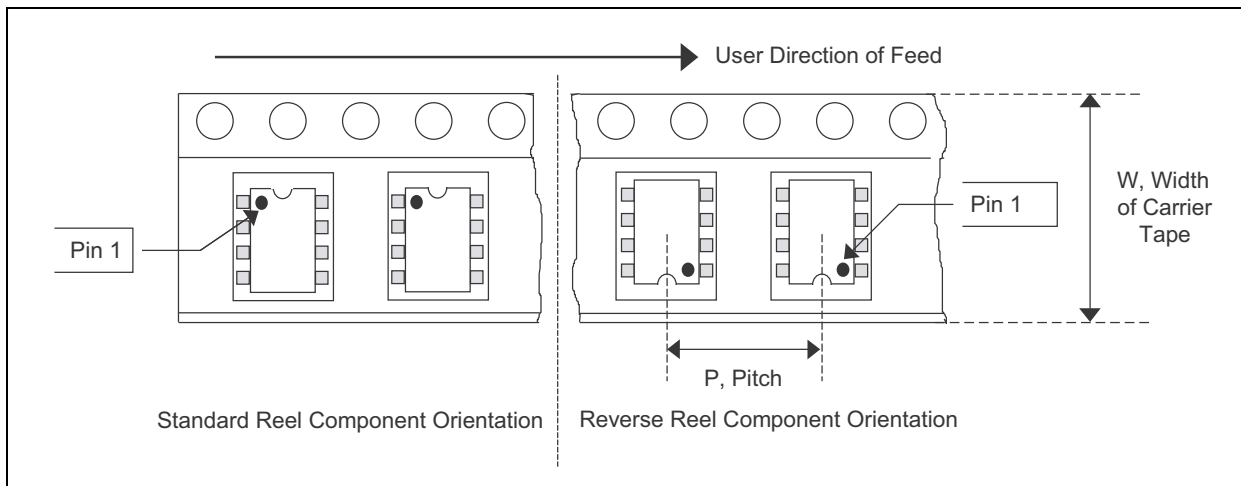
**FIGURE 6-1: EMBOSSED CARRIER DIMENSIONS**



**TABLE 1: CARRIER TAPE/CAVITY DIMENSIONS**

| Case Outline | Package Type |    | Carrier Dimensions |      | Cavity Dimensions |       |       | Output Quantity Units | Reel Diameter in mm |
|--------------|--------------|----|--------------------|------|-------------------|-------|-------|-----------------------|---------------------|
|              |              |    | W mm               | P mm | A0 mm             | B0 mm | K0 mm |                       |                     |
| MS           | MSOP         | 8L | 12                 | 8    | 5.3               | 3.6   | 1.4   | 2500                  | 330                 |

**FIGURE 1: MSOP DEVICES**



## 7.0 REVISION HISTORY

### Revision D (December 2012)

Added a note to the package outline drawing.

# TC650/TC651

---

NOTES:

## 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.   | XX  | X                    | XX          |                         |
|--|---|----------------------|-------------|-------------------------|
| Device   | Temperature<br>Threshold<br>Limit   | Temperature<br>Range | Package     |                         |
| Device:  | TC650: Temp Sensor & Brushless DC Fan Controller /<br>Overtemperature Alert (minimum speed) |                      |             |                         |
|  | TC651: Temp Sensor & Brushless DC Fan Controller /<br>Overtemperature Alert (auto shutdown) |                      |             |                         |
| Temperature<br>Threshold Limit:  | Temperature<br>Difference   | $T_L$ (1,2)          | $T_H$ (1,3) | Threshold<br>Limit Code |
|  | 10°C  | 25                   | 35          | AC                      |
|  |   | 30                   | 40          | BD                      |
|  |   | 35                   | 45          | CE                      |
|  | 15°C  | 25                   | 40          | AD                      |
|  |   | 30                   | 45          | BE                      |
|  |   | 35                   | 50          | CF                      |
|  | 20°C  | 25                   | 45          | AE                      |
|  |   | 30                   | 50          | BF                      |
|  |   | 35                   | 55          | CG                      |
|  | 30°C  | 25                   | 55          | AG                      |
|  |   |                      |             |                         |
| 1. $T_L$ and $T_H$ can be selected in 5°C increments.                              |   |                      |             |                         |
| 2. $T_L$ can range from 25°C to 35°C.  |   |                      |             |                         |
| 3. $T_H$ can range from 35°C to 55°C and must be at least 10°C higher than $T_L$ . |   |                      |             |                         |
| Temperature Range: V = -40°C to +125°C (Extended)                                  |   |                      |             |                         |
| Package:   | UA = Plastic Micro Small Outline (MSOP), 8-lead   |                      |             |                         |
|  | UATR = Plastic Micro Small Outline (MSOP), 8-lead<br>(Tape and Reel)                        |                      |             |                         |

**Examples:**

a) TC650ACVUA: Temp Sensor  
 $T_L = 25, T_H = 35$

b) TC651ACVUATR: Temp Sensor  
 $T_L = 25, T_H = 35$   
Tape and Reel

c) TC650AEVUA: Temp Sensor  
 $T_L = 25, T_H = 45$

d) TC651AGVUA: Temp Sensor  
 $T_L = 25, T_H = 55$

e) TC650BEVUA: Temp Sensor  
 $T_L = 30, T_H = 45$

f) TC651CGVUA: Temp Sensor  
 $T_L = 35, T_H = 55$

g) TC650CGVUATR: Temp Sensor  
 $T_L = 35, T_H = 55$   
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:

1. Your local Microchip sales office
2. The Microchip Worldwide Site ([www.microchip.com](http://www.microchip.com))

Please specify which device, revision of silicon and Data Sheet (include Literature #) you are using.

### Customer Notification System

Register on our web site ([www.microchip.com/cn](http://www.microchip.com/cn)) to receive the most current information on our products.

# TC650/TC651

---

NOTES:



---

**Note the following details of the code protection feature on Microchip devices:**

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as “unbreakable.”

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

---

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights.

#### **Trademarks**

The Microchip name and logo, the Microchip logo, dsPIC, FlashFlex, KEELOQ, KEELOQ logo, MPLAB, PIC, PICmicro, PICSTART, PIC<sup>32</sup> logo, rPIC, SST, SST Logo, SuperFlash and UNI/O are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

FilterLab, Hampshire, HI-TECH C, Linear Active Thermistor, MTP, SEEVAL and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Silicon Storage Technology is a registered trademark of Microchip Technology Inc. in other countries.

Analog-for-the-Digital Age, Application Maestro, BodyCom, chipKIT, chipKIT logo, CodeGuard, dsPICDEM, dsPICDEM.net, dsPICworks, dsSPEAK, ECAN, ECONOMONITOR, FanSense, HI-TIDE, In-Circuit Serial Programming, ICSP, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, mTouch, Omniclient Code Generation, PICC, PICC-18, PICDEM, PICDEM.net, PICkit, PICtail, REAL ICE, rLAB, Select Mode, SQI, Serial Quad I/O, Total Endurance, TSHARC, UniWinDriver, WiperLock, ZENA and Z-Scale are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

GestIC and ULPP are registered trademarks of Microchip Technology Germany II GmbH & Co. & KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2001-2012, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

 Printed on recycled paper.

ISBN: 9781620768310

*Microchip received ISO/TS-16949:2009 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC<sup>®</sup> MCUs and dsPIC<sup>®</sup> DSCs, KEELOQ<sup>®</sup> code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.*

**QUALITY MANAGEMENT SYSTEM**  
**CERTIFIED BY DNV**  
**== ISO/TS 16949 ==**



# MICROCHIP

## Worldwide Sales and Service

### AMERICAS

**Corporate Office**  
2355 West Chandler Blvd.  
Chandler, AZ 85224-6199  
Tel: 480-792-7200  
Fax: 480-792-7277  
Technical Support:  
<http://www.microchip.com/support>  
Web Address:  
[www.microchip.com](http://www.microchip.com)

**Atlanta**  
Duluth, GA  
Tel: 678-957-9614  
Fax: 678-957-1455

**Boston**  
Westborough, MA  
Tel: 774-760-0087  
Fax: 774-760-0088

**Chicago**  
Itasca, IL  
Tel: 630-285-0071  
Fax: 630-285-0075

**Cleveland**  
Independence, OH  
Tel: 216-447-0464  
Fax: 216-447-0643

**Dallas**  
Addison, TX  
Tel: 972-818-7423  
Fax: 972-818-2924

**Detroit**  
Farmington Hills, MI  
Tel: 248-538-2250  
Fax: 248-538-2260

**Indianapolis**  
Noblesville, IN  
Tel: 317-773-8323  
Fax: 317-773-5453

**Los Angeles**  
Mission Viejo, CA  
Tel: 949-462-9523  
Fax: 949-462-9608

**Santa Clara**  
Santa Clara, CA  
Tel: 408-961-6444  
Fax: 408-961-6445

**Toronto**  
Mississauga, Ontario,  
Canada  
Tel: 905-673-0699  
Fax: 905-673-6509

### ASIA/PACIFIC

**Asia Pacific Office**  
Suites 3707-14, 37th Floor  
Tower 6, The Gateway  
Harbour City, Kowloon  
Hong Kong  
Tel: 852-2401-1200  
Fax: 852-2401-3431

**Australia - Sydney**  
Tel: 61-2-9868-6733  
Fax: 61-2-9868-6755

**China - Beijing**  
Tel: 86-10-8569-7000  
Fax: 86-10-8528-2104

**China - Chengdu**  
Tel: 86-28-8665-5511  
Fax: 86-28-8665-7889

**China - Chongqing**  
Tel: 86-23-8980-9588  
Fax: 86-23-8980-9500

**China - Hangzhou**  
Tel: 86-571-2819-3187  
Fax: 86-571-2819-3189

**China - Hong Kong SAR**  
Tel: 852-2943-5100  
Fax: 852-2401-3431

**China - Nanjing**  
Tel: 86-25-8473-2460  
Fax: 86-25-8473-2470

**China - Qingdao**  
Tel: 86-532-8502-7355  
Fax: 86-532-8502-7205

**China - Shanghai**  
Tel: 86-21-5407-5533  
Fax: 86-21-5407-5066

**China - Shenyang**  
Tel: 86-24-2334-2829  
Fax: 86-24-2334-2393

**China - Shenzhen**  
Tel: 86-755-8864-2200  
Fax: 86-755-8203-1760

**China - Wuhan**  
Tel: 86-27-5980-5300  
Fax: 86-27-5980-5118

**China - Xian**  
Tel: 86-29-8833-7252  
Fax: 86-29-8833-7256

**China - Xiamen**  
Tel: 86-592-2388138  
Fax: 86-592-2388130

**China - Zhuhai**  
Tel: 86-756-3210040  
Fax: 86-756-3210049

### ASIA/PACIFIC

**India - Bangalore**  
Tel: 91-80-3090-4444  
Fax: 91-80-3090-4123

**India - New Delhi**  
Tel: 91-11-4160-8631  
Fax: 91-11-4160-8632

**India - Pune**  
Tel: 91-20-2566-1512  
Fax: 91-20-2566-1513

**Japan - Osaka**  
Tel: 81-6-6152-7160  
Fax: 81-6-6152-9310

**Japan - Tokyo**  
Tel: 81-3-6880-3770  
Fax: 81-3-6880-3771

**Korea - Daegu**  
Tel: 82-53-744-4301  
Fax: 82-53-744-4302

**Korea - Seoul**  
Tel: 82-2-554-7200  
Fax: 82-2-558-5932 or  
82-2-558-5934

**Malaysia - Kuala Lumpur**  
Tel: 60-3-6201-9857  
Fax: 60-3-6201-9859

**Malaysia - Penang**  
Tel: 60-4-227-8870  
Fax: 60-4-227-4068

**Philippines - Manila**  
Tel: 63-2-634-9065  
Fax: 63-2-634-9069

**Singapore**  
Tel: 65-6334-8870  
Fax: 65-6334-8850

**Taiwan - Hsin Chu**  
Tel: 886-3-5778-366  
Fax: 886-3-5770-955

**Taiwan - Kaohsiung**  
Tel: 886-7-213-7828  
Fax: 886-7-330-9305

**Taiwan - Taipei**  
Tel: 886-2-2508-8600  
Fax: 886-2-2508-0102

**Thailand - Bangkok**  
Tel: 66-2-694-1351  
Fax: 66-2-694-1350

### EUROPE

**Austria - Wels**  
Tel: 43-7242-2244-39  
Fax: 43-7242-2244-393

**Denmark - Copenhagen**  
Tel: 45-4450-2828  
Fax: 45-4485-2829

**France - Paris**  
Tel: 33-1-69-53-63-20  
Fax: 33-1-69-30-90-79

**Germany - Munich**  
Tel: 49-89-627-144-0  
Fax: 49-89-627-144-44

**Italy - Milan**  
Tel: 39-0331-742611  
Fax: 39-0331-466781

**Netherlands - Drunen**  
Tel: 31-416-690399  
Fax: 31-416-690340

**Spain - Madrid**  
Tel: 34-91-708-08-90  
Fax: 34-91-708-08-91

**UK - Wokingham**  
Tel: 44-118-921-5869  
Fax: 44-118-921-5820

11/29/12

Компания «Океан Электроники» предлагает заключение долгосрочных отношений при поставках импортных электронных компонентов на взаимовыгодных условиях!

Наши преимущества:

- Поставка оригинальных импортных электронных компонентов напрямую с производств Америки, Европы и Азии, а так же с крупнейших складов мира;
- Широкая линейка поставок активных и пассивных импортных электронных компонентов (более 30 млн. наименований);
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Помощь Конструкторского Отдела и консультации квалифицированных инженеров;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Поставка электронных компонентов под контролем ВП;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- При необходимости вся продукция военного и аэрокосмического назначения проходит испытания и сертификацию в лаборатории (по согласованию с заказчиком);
- Поставка специализированных компонентов военного и аэрокосмического уровня качества (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Actel, Aeroflex, Peregrine, VPT, Syfer, Eurofarad, Texas Instruments, MS Kennedy, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Компания «Океан Электроники» является официальным дистрибьютором и эксклюзивным представителем в России одного из крупнейших производителей разъемов военного и аэрокосмического назначения «JONHON», а так же официальным дистрибьютором и эксклюзивным представителем в России производителя высокотехнологичных и надежных решений для передачи СВЧ сигналов «FORSTAR».



## JONHON

«JONHON» (основан в 1970 г.)

Разъемы специального, военного и аэрокосмического назначения:

(Применяются в военной, авиационной, аэрокосмической, морской, железнодорожной, горно- и нефтедобывающей отраслях промышленности)

«FORSTAR» (основан в 1998 г.)

ВЧ соединители, коаксиальные кабели, кабельные сборки и микроволновые компоненты:

(Применяются в телекоммуникациях гражданского и специального назначения, в средствах связи, РЛС, а так же военной, авиационной и аэрокосмической отраслях промышленности).



Телефон: 8 (812) 309-75-97 (многоканальный)

Факс: 8 (812) 320-03-32

Электронная почта: [ocean@oceanchips.ru](mailto:ocean@oceanchips.ru)

Web: <http://oceanchips.ru/>

Адрес: 198099, г. Санкт-Петербург, ул. Калинина, д. 2, корп. 4, лит. А