



# **TC650 Fan Control Demo Board User's Guide**

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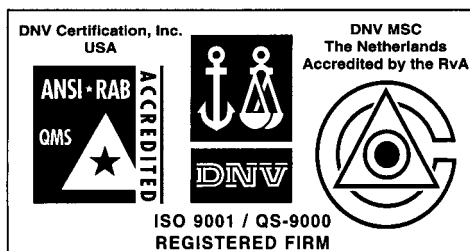
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## Chapter 1. General Information

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### 1.1 INTRODUCTION

Thank you for purchasing the TC650 Fan Control Demo Board from Microchip Technology Inc. The TC650 Fan Control Demo Board is an evaluation tool that allows the user to quickly prototype fan control circuits based on Microchip's TC650 or TC651 pulse width modulation (PWM) Fan Control ICs.

A logic level MOSFET drive device allows the fan control demo board to be used with virtually any brushless DC fan. A red LED status indicator gives a visual indication of an over temperature alert (temperature is 10°C higher (typically) than the high temperature limit).

The TC650 Demo Board has the following features:

1. Complete implementation of TC650 or TC651 fan control circuitry on a 1.0" x 1.0" board.
2. Temperature proportional fan speed control.
3. Over temperature alert.
4. Installs directly into user's end equipment.
5. Speeds up prototyping, system development and system thermal characterization.

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## 1.2 THE TC650 FAN CONTROL DEMO BOARD

The TC650 Fan Control Demo Board (Figure 1-1) measures only 1.0 inch x 1.0 inch, allowing direct installation to the user's end equipment for system evaluation. An external 2.8V to 5.5V power supply is required for the operation of the TC650.

The TC650 Demo Board is equipped with the following components:

1. 1  $\mu$ F, 1206 Chip Capacitor.
2. 1 k $\Omega$ , 1206 Chip Resistor.
3. 4.5 mA Miniature Red LED.
4. Logic Level MOSFET (Si2302).
5. TC650AEVUA Fan Control IC.

If any component is damaged or missing, please contact your nearest Microchip sales office, listed on the back of this publication.



**FIGURE 1-1** The TC650/TC651 Fan Control Demo Board

## 1.3 REFERENCE DOCUMENTS

Other Reference Documents may be obtained by contacting your nearest Microchip sales office (listed on the back of this document) or by visiting the Microchip website ([www.microchip.com](http://www.microchip.com)).

- *Technical Library CD-ROM*, (DS00161) or the individual data sheet:
  - *TC650/TC651 Data Sheet*, (DS21450)
- *Analog & Interface Families Data Book 2002*, (DS00207)
- *2002 Technical Documentation Analog & Interface Product Families CD-ROM*, (DS51205)
- *Suppressing Acoustic Noise in Pulse Width Modulation (PWM) Fan Speed Control Systems* Application Note, (AN771)
- *Speed Error in Pulse Width Modulation (PWM) Fan Control Systems* Application Note, (AN772)
- *TC65X Fan Speed Controller Family Sell Sheet*, (DS21625)
- *TC650DEMO and TC652DEMO Fan Controller Demo Boards for the TC650/1/2/3* Sell Sheet, (DS51254)

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## Chapter 2. Getting Started

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This chapter describes the TC650 Demo Board's configuration, how it functions, and lists typical fan demo board operating configurations for fan applications.

The board is equipped with a TC650AEVUA device, which features a minimum temperature limit ( $T_L$ ) of 25°C (40% duty cycle) and a maximum temperature limit ( $T_H$ ) of 45°C (100% duty cycle).

### 2.1 TC650 DEMO BOARD FUNCTIONAL DESCRIPTION

#### 2.1.1. PWM Output

The pulse width modulation (PWM) pin is designed to drive a low cost transistor or MOSFET as the low side power switching element in the system. A 2N2222 type small signal (BJT) can be used for fans up to 300 mA. For larger current fans (up to 1 amp), a logic-level N-channel MOSFET must be used. Since the system relies on pulse width modulation, rather than linear power control, the dissipation in the power switch is kept to a minimum. Generally, very small devices, such as the TO-92 or SOT, will suffice. Test Point TP<sub>1</sub> can be connected to an oscilloscope for observing PWM output characteristics.

#### 2.1.2. $\overline{\text{SHDN}}$

The fan can be unconditionally shut down by pulling the  $\overline{\text{SHDN}}$  pin low. This function can be implemented by removing jumper JP<sub>1</sub>, then grounding pin 3. For details, see Figure A-2 in the Appendix A section.

#### 2.1.3. Over Temperature Alert

The TC650/TC651 devices include an on-chip over temperature alarm signal ( $T_{\text{OVER}}$ ) that goes low when the temperature of the chip exceeds  $T_H$  by 10°C (typical). When the junction temperature rises to approximately 55°C ( $= T_H + 10^\circ\text{C} = 45^\circ\text{C} + 10^\circ\text{C}$ ), the  $T_{\text{OVER}}$  signal is asserted and the red LED light turns on.

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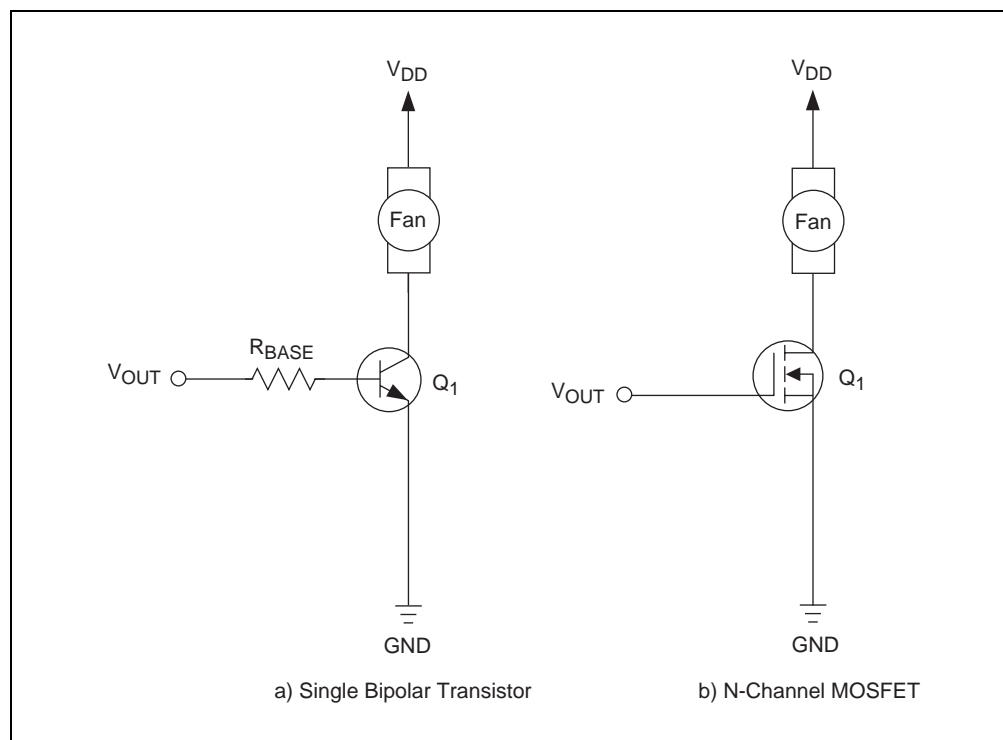
## 2.2 TYPICAL MODULE CONFIGURATIONS

The TC650/TC651 integrated temperature sensors and brushless DC fan speed controllers are designed to drive an external transistor or MOSFET for modulating power to the fan. The PWM pin has a minimum source current of 5 mA and a minimum sink current of 1 mA. Bipolar transistors or MOSFETs may be used as the power switching element.

Table 2-1 lists the suggested output drive device vs. fan motor current. Additionally, see Figure 2-1 for output drive configuration options.

**TABLE 2-1: SUGGESTED OUTPUT DRIVE DEVICE VS. FAN MOTOR CURRENT**

Full Speed Fan Motor Current	Logic MOSFET (Q1- Standard)	Bipolar Transistor (Optional)
100 mA	—	X
200 mA	X	X
300 mA	X	X
400 mA	X	—
500 mA	X	—
600 mA	X	—
700 mA	X	—
800 mA	X	—
900 mA	X	—
1A	X	—



**FIGURE 2-1:** Output Driver Configuration Options

## 2.2.1 Using Logic Level MOSFETs

The TC650 Demo Board is equipped with a logic level MOSFET (Si2302). Using a MOSFET results in low system voltage losses and reduced output loading on the TC650/651. The low  $R_{DS(ON)}$  of this MOSFET ( $0.085\Omega$ ) enables it to be used in high current fan applications ( $>200$  mA). Table 2-2 lists examples of MOSFETs that can be utilized for  $Q_1$ .

**TABLE 2-2: MOSFETs FOR  $Q_1$**

Device	$V_{DS}$ (V)	$V_{GS(TH)}$ (V)	$I_D$ (A)	$R_{DS(ON)}$ ( $\Omega$ )
Si2302	20	1.5	2.8	0.085
Si4410	30	3.0	8	0.02
MGSF1N02E	20	1.5	0.75	0.10

## 2.2.2 Using Bipolar Driver Transistors

Fans with operating currents of 50 mA to 300 mA can be driven using a single bipolar transistor. The transistor must have sufficient gain ( $h_{FE}$ ) in order to reach saturation when the base is driven with 5 mA of current (minimum output current spec of TC650/651) and the collector is conducting full fan current. A 2N2222A is a good choice. A base current limiting resistor is required with bipolar transistors.

The correct value for this resistor can be determined as follows:

**EQUATION:**

$$R_{BASE} = \frac{V_{OH} - V_{BE(SAT)}}{I_{R(BASE)}}$$

Table 2-3 lists suggested Bipolar transistors for  $Q_1$ .

**TABLE 2-3: BIPOLAR TRANSISTORS FOR  $Q_1$  ( $V_{DD} = 5.0V$ ,  $I_{BASE} = 5$  mA)**

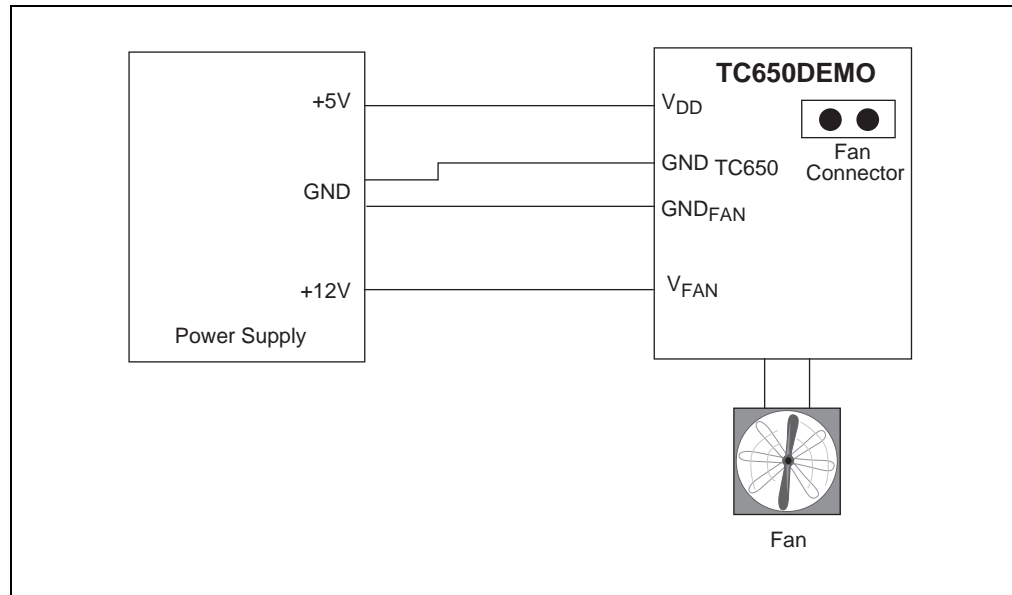
Device	$V_{CE(SAT)}$ (mV)	$h_{FE}$	$V_{BR(CEO)}$ (V)	$I_C$ (mA)	$R_{BASE}$ ( $\Omega$ )
MPS2222	100	30	30	150	800
MPS2222A	100	30	40	150	800
2N4400	150	20	40	100	820
2N4401	150	20	40	100	820
MPS6601	180	50	25	250	780
MPS6602	180	50	40	250	780

**Note:** The values that are listed in the table represent typical values for  $T_A = 25^\circ C$ .

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## 2.2.3 System Connection for +5V Operation

Figure 2-2 shows typical wiring connections to the Fan Control Demo Board. The fan operating voltage is +12V while the Fan Control Board operates from a supply voltage of +5V.



**FIGURE 2-2:** Typical Wiring Connections to Fan Module for 12V Fan and 5V Demo Board Supply

**Note:** The grounds for the 12V fan supply and the 5V V<sub>DD</sub> supply should be tied together at the power supply.

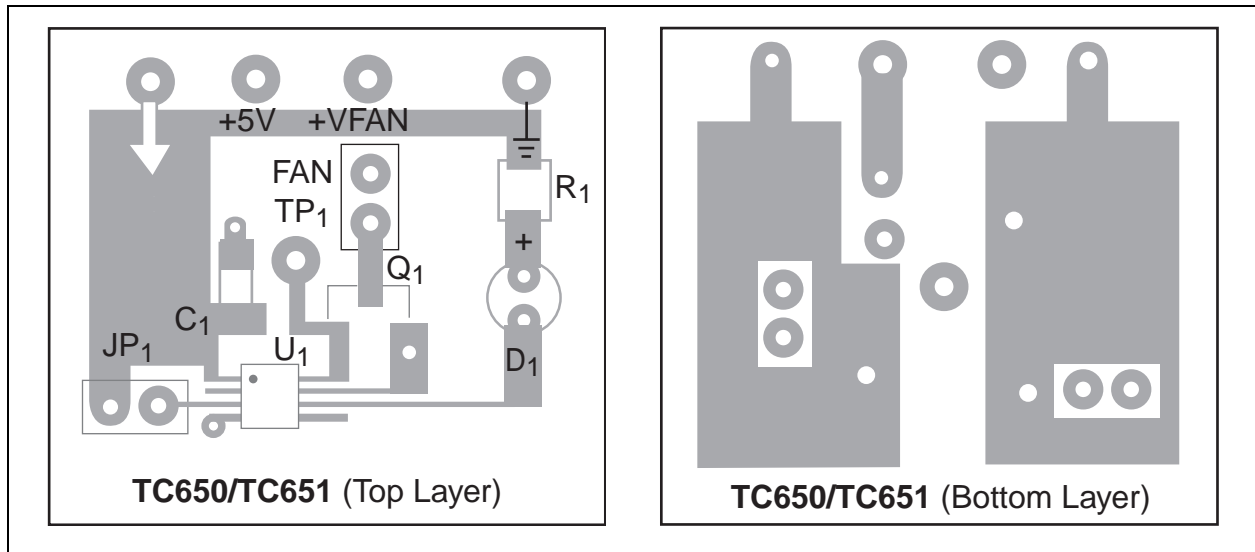
**Appendix A. Board Layout**

**A.1 INTRODUCTION**

This appendix contains general information concerning the schematics, layout and components for the TC650 Demo Board.

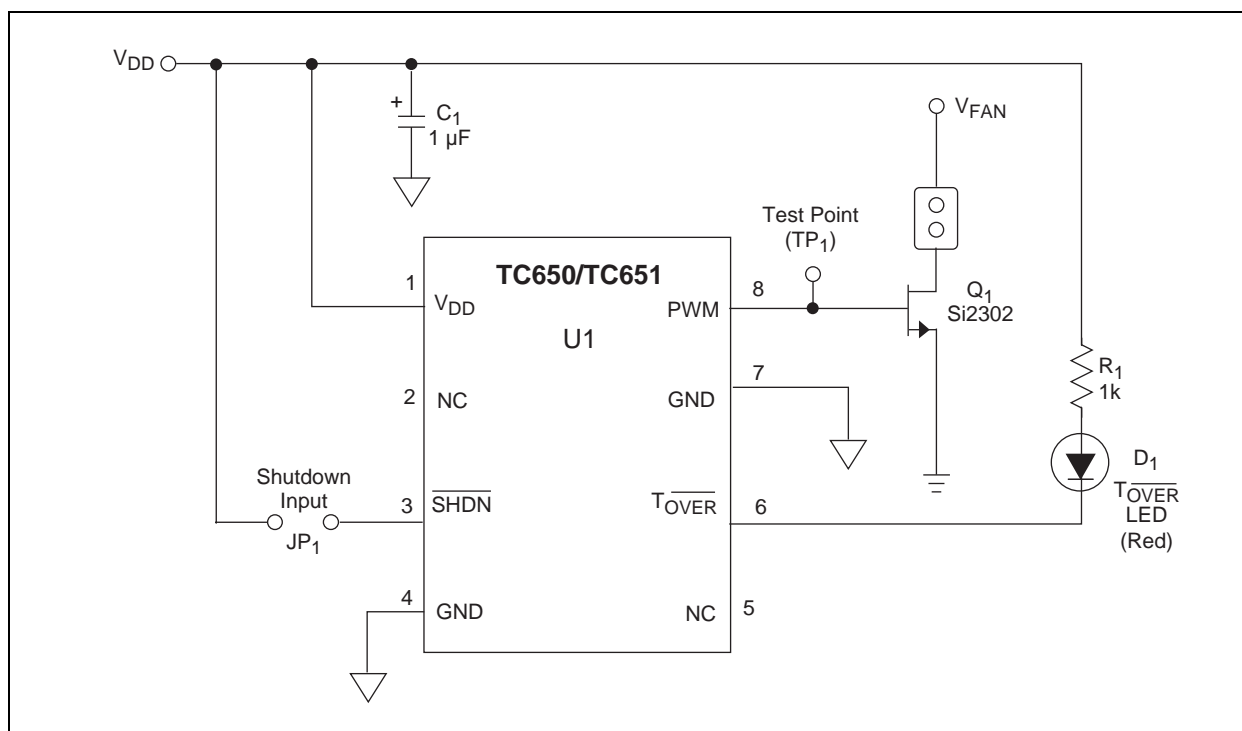
**A.2 BOARD SCHEMATIC AND LAYOUT**

Figure A-1 depicts the layout for the top and bottom layers of the TC650 Demo Board. Figure A-2 shows a functional block diagram for the TC650 Demo Board.



**FIGURE A-1:** TC650/TC651 Demo Board, Top and Bottom Layers

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**FIGURE A-2:** TC650 Demo Board Functional Block Diagram

## A.3 DEMO BOARD COMPONENTS

Table A-1 lists the various components and associated values that comprise the TC650 Demo Board.

**TABLE A-1: FAN CONTROL DEMO BOARD COMPONENTS AND VALUES**

Component	Typical Value	Comments
C <sub>1</sub>	1 μF, 1206 chip capacitor	Power supply filter.
D <sub>1</sub>	4.5 mA miniature red LED	LED lights when T <sub>OVER</sub> output is LOW (active).
Q <sub>1</sub>	Logic Level MOSFET	Transistor output option. A logic level MOSFET (Si2302) is used on the TC650 to accommodate various types of fans. The output drive device can also be an NPN transistor, depending on cost constraints and fan current.
R <sub>1</sub>	1 kΩ, 1206 chip resistor	D <sub>1</sub> current limiting resistor.
U <sub>1</sub>	TC650AEVUA; low temperature limit: T <sub>L</sub> 25°C, high temperature limit: T <sub>H</sub> 45°C	TC650 or TC651 fan control ICs.

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