



# **TC652 Fan Control Demo Board User's Guide**

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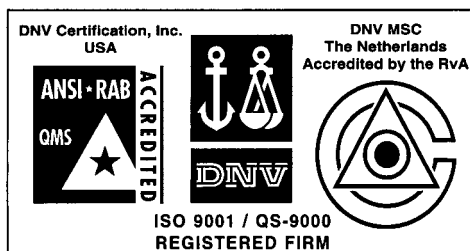
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## Chapter 1. General Information

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### 1.1 INTRODUCTION

Thank you for purchasing the TC652 Fan Control Demo Board from Microchip Technology Inc. The Fan Control Demo Board is an evaluation tool that allows the user to quickly prototype fan control circuits based on Microchip's TC652 or TC653 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 a fan fault condition (open stator or blocked rotor). A green LED status indicator gives a visual indication of an over temperature alert (temperature is approximately 10°C higher than the high temperature limit).

The TC652 Fan Control Demo Board has the following features:

1. Complete implementation of TC652 or TC653 fan control circuitry on a 1.0" x 1.2" 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 TC652 FAN CONTROL DEMO BOARD

The TC652 Fan Control Board (Figure 1-1) measures only 1.0 inch x 1.2 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 TC652.

The TC652 Demo Board is equipped with the following components:

1. 1  $\mu$ F, 1206 Chip Capacitor.
2. 1 k $\Omega$ , 1206 Chip Resistor ( $R_1$ ).
3. 1 k $\Omega$ , 1206 Chip Resistor ( $R_2$ ).
4. 4.5 mA Miniature Red LED.
5. 4.5 mA Miniature Green LED.
6. Logic Level MOSFET ( $Q_1$ ).
7. 4.7 $\Omega$  Leaded Resistor ( $R_{SENSE}$ ).
8. 0.01  $\mu$ F, 1206 Chip Capacitor ( $C_{SENSE}$ ).
9. TC652AEVUA 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 TC652 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 downloading via the Microchip website ([www.microchip.com](http://www.microchip.com)).

- *Technical Library CD-ROM*, (DS00161), or individual data sheet:
  - *TC652/TC653 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 Boards for the TC65X PWM Fan Control ICs* Sell Sheet, (DS51254)

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## Chapter 2. Getting Started

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This chapter describes the TC652 Demo Board's configuration and how it functions. It also provides information on typical fan demo board operating configurations for fan applications.

The board is equipped with a TC652AEVUA 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 TC652 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 TP1 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>, and then grounding pin 3. For details see Figure A-2, in the Appendix A section.

#### 2.1.3 $\overline{\text{FAULT}}$

During normal fan operation, commutation occurs as each pole of the fan is energized. This causes brief interruptions in the fan current, seen as pulses across the sense resistor R3. If the device is not in shutdown or auto-shutdown (TC653), and pulses are not appearing at the SENSE input, a fault exists. In this case, the LED1 light turns on to indicate the fan failure.

#### 2.1.4 SENSE Input

The sense network, comprised by  $R_{\text{SENSE}}$  and  $C_{\text{SENSE}}$ , allows the TC652/TC653 to detect and monitor commutation of the fan motor (and therefore fan operation). A 0.01  $\mu\text{F}$  capacitor is recommended for  $C_{\text{SENSE}}$  ( $C_2$ ). The TC652 Demo Board is populated with a 4.7 $\Omega$  current sense resistor ( $R_{\text{SENSE}}$ ). This resistor value should be scaled based on the current rating of the fan. This resistor is socketed on the demo board to allow for easy value changes (see Table 2-1 for resistor value selections).

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Table 2-1 lists various resistor value selections for  $R_{SENSE}$  vs. Fan Current.

**TABLE 2-1:  $R_{SENSE}$  VS. FAN CURRENT**

| Nominal Fan Current<br>(mA) | $R_{SENSE}$<br>( $\Omega$ ) |
|-----------------------------|-----------------------------|
| 50 mA                       | 9.1                         |
| 100 mA                      | 4.7                         |
| 150 mA                      | 3.0                         |
| 200 mA                      | 2.4                         |
| 250 mA                      | 2.0                         |
| 300 mA                      | 1.8                         |
| 350 mA                      | 1.5                         |
| 400 mA                      | 1.3                         |
| 450 mA                      | 1.2                         |
| 500 mA                      | 1.0                         |

## 2.1.5 Over-Temperature Alert

The TC652/TC653 devices include an on-chip, over temperature alarm signal ( $T_{OVER}$ ) 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  $T_{OVER}$  signal is asserted and the green LED light turns on.

## 2.2 TYPICAL MODULE CONFIGURATIONS

The TC652/TC653 are designed to drive an external transistor or MOSFET for modulating power to the fan. The pulse width modulation (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 2-2 lists the suggested output drive device vs. fan motor currents. See Figure 2-1 for output driver configuration options.

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

| Full Speed Fan Motor<br>Current | Logic MOSFET<br>( $Q_1$ Standard) | Bipolar Transistor<br>(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                                 | —                                |

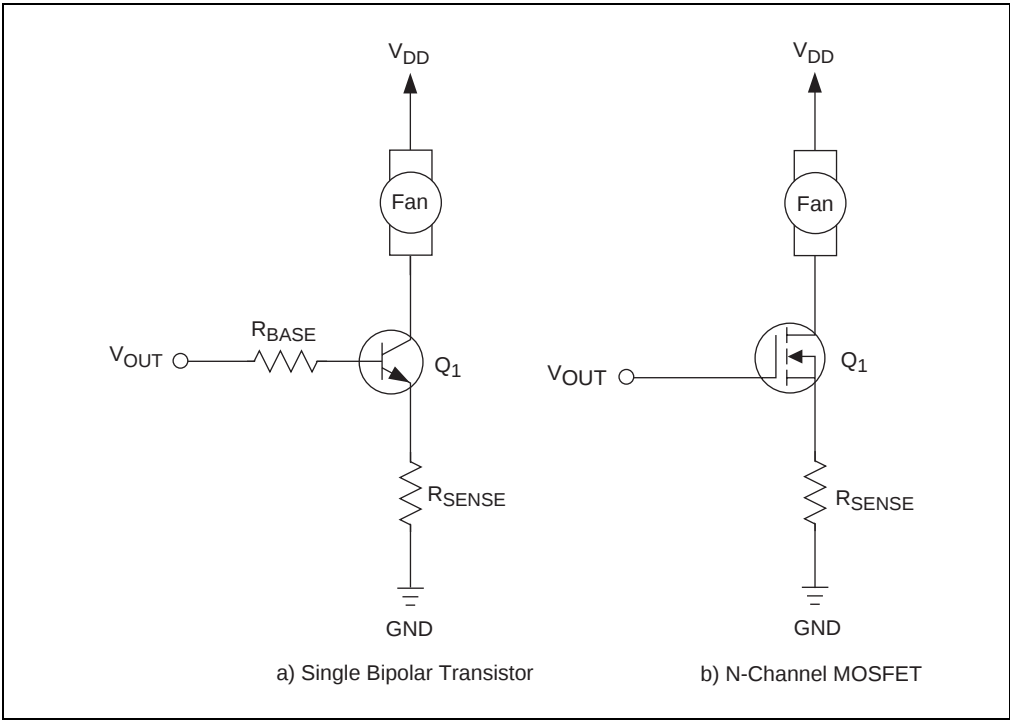


FIGURE 2-1: Output Driver Configuration Options

2.2.1 Using Logic Level MOSFETs

The TC652 Board is equipped with a logic level MOSFET (Si2302). Using this type of drive device results in low system voltage losses and reduced output loading on the TC652/TC653. The low  $R_{DS(ON)}$  of this MOSFET ( $0.085\Omega$ ) enables it to be used in high current fan applications ( $>200\text{ mA}$ ). Table 2-3 lists examples of MOSFETs that can be utilized for  $Q_1$ .

TABLE 2-3: MOSFETS FOR  $Q_1$

| Device    | $V_{DS}$<br>(V) | $V_{GS(TH)}$<br>(V) | $I_D$<br>(A) | $R_{DS(ON)}$<br>( $\Omega$ ) |
|-----------|-----------------|---------------------|--------------|------------------------------|
| 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

Fan motors of 50 mA to 300 mA can be driven using a single bipolar transistor. The main requirement for this transistor is that it have a minimum  $h_{FE}$  of 50. This will ensure that the minimum PWM output current of the TC652/TC653 device is enough to saturate the transistor for the given fan current range. 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:

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

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Table 2-4 lists suggested Bipolar transistors for  $Q_1$ .

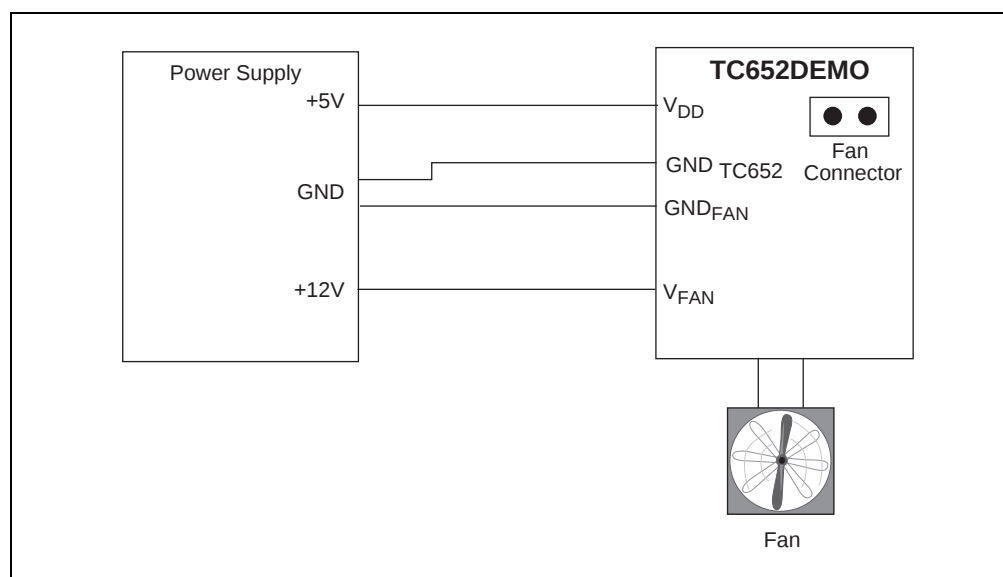
**TABLE 2-4: BIPOLAR TRANSISTORS FOR  $Q_1$  ( $V_{DD} = 5.0V$ ,  $I_{BASE} = 5\text{ mA}$ )**

| Device   | $V_{CE(SAT)}$<br>(mV) | $h_{FE}$ | $V_{BR(CEO)}$<br>(V) | $I_C$<br>(mA) | $R_{BASE}$<br>( $\Omega$ ) |
|----------|-----------------------|----------|----------------------|---------------|----------------------------|
| 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  $T_A = 25^\circ\text{C}$ .

## 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  $V_{DD}$  supply should be tied together at the power supply.

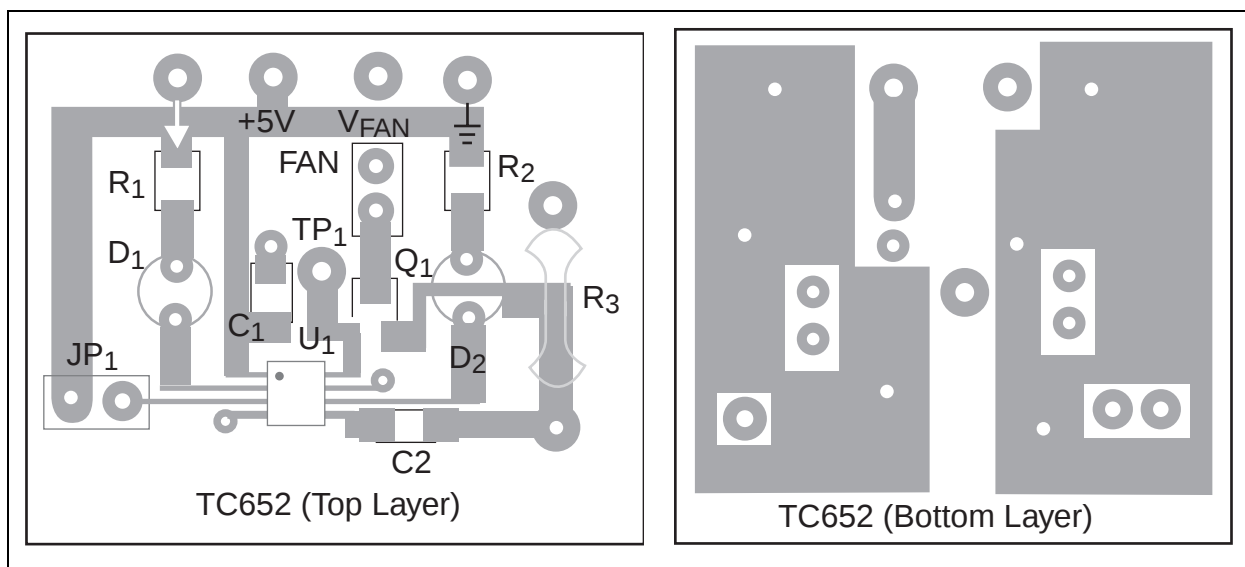
## Appendix A. Board Layout

### A.1 INTRODUCTION

This appendix contains general information concerning the layout, schematics and components for the TC652 Demo Board.

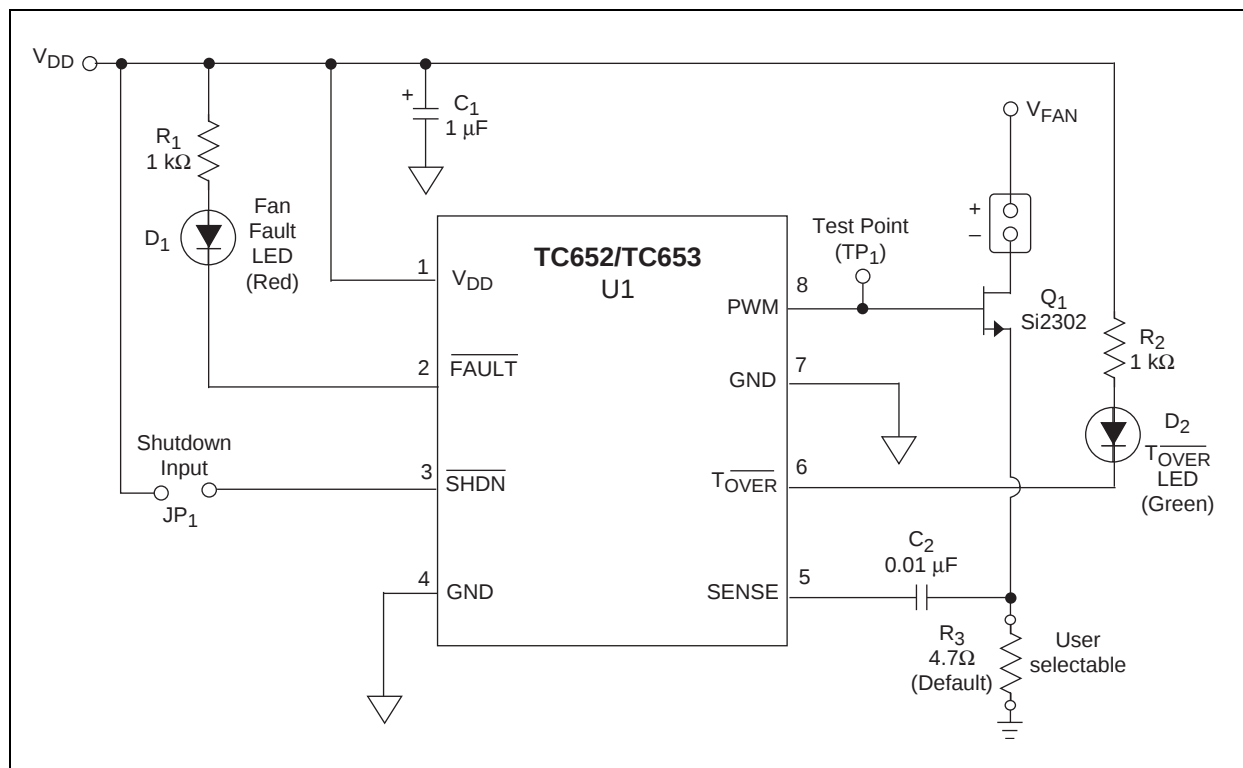
### A.2 BOARD LAYOUT AND SCHEMATICS

Figure A-1 depicts the top and bottom layers of the TC652 board. Figure A-2 shows a functional block diagram for the TC652 Demo Board.



**FIGURE A-1:** TC652 Demo Board, Top and Bottom Layer

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**FIGURE A-2:** TC652 Demo Board Functional Block Diagram

## A.3 DEMO BOARD COMPONENTS

Table A-1 lists the various components and values associated with the TC652 demonstration 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.                                                                                                                                                                                                     |
| C <sub>2</sub> | 0.01 μF, 1206 chip capacitor                                                                              | SENSE input coupling capacitor.                                                                                                                                                                                          |
| D <sub>1</sub> | 4.5 mA miniature red LED                                                                                  | D <sub>1</sub> lights when $\overline{\text{FAULT}}$ output is LOW (active).                                                                                                                                             |
| D <sub>2</sub> | 4.5 mA miniature green LED                                                                                | D <sub>2</sub> lights when $\overline{\text{T\_OVER}}$ output is LOW (active).                                                                                                                                           |
| Q1             | Logic Level MOSFET                                                                                        | Transistor output option. A logic level MOSFET (Si2302) is used on the TC652 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> (red LED) current limiting resistor.                                                                                                                                                                      |
| R <sub>2</sub> | 1 kΩ, 1206 chip resistor                                                                                  | D <sub>2</sub> (green LED) current limiting resistor.                                                                                                                                                                    |
| R <sub>3</sub> | 4.7Ω leaded resistor                                                                                      | Fan current sensing resistor. Value depends on full speed fan current. Typical values appear in Table 2-1.                                                                                                               |
| U <sub>1</sub> | TC652AEVUA;<br>low temperature limit: T <sub>L</sub> 25°C,<br>high temperature limit: T <sub>H</sub> 45°C | TC652 or TC653 fan control IC.                                                                                                                                                                                           |

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