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TC64X/TC64XB Fan Control Evaluation Board User's Guide

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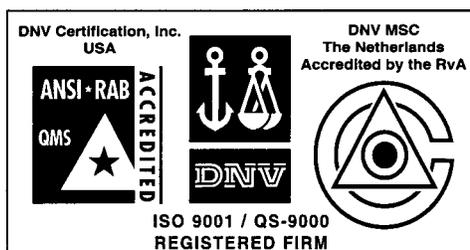
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TC64X/TC64XB FAN CONTROL EVALUATION BOARD USER'S GUIDE

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TC64X/TC64XB FAN CONTROL EVALUATION BOARD USER'S GUIDE

Chapter 1. General Information

1.1   INTRODUCTION

Thank you for purchasing the TC64X/TC64XB Fan Control Evaluation Board from Microchip Technology Inc. The TC64X/TC64XB Fan Control Evaluation Board allows the user to evaluate and prototype brushless DC fan control circuits using one of the following Microchip BDC fan controllers.

These devices will be referred to as "TC64X" in this document:

- TC642
- TC646
- TC647
- TC648
- TC649

These devices will be referred to as TC64XB in this document:

- TC642B
- TC646B
- TC647B
- TC648B
- TC649B

The fan speed control signal can be provided by an external sensor or voltage signal, or from the on-board control voltage potentiometer.

Minimum speed setting devices are:

- TC642/2B
- TC647/7B

Auto-shutdown threshold devices are:

- TC646/6B
- TC648/8B
- TC649/9B

The minimum speed setting and auto-shutdown threshold devices are conveniently set by an on-board potentiometer.

The TC64X/TC64XB Fan Control Evaluation Board has the following features:

1. Capacity for complete evaluation and prototyping for TC64X and TC64XB BDC fan controllers.
2. Works with any BDC fan.
3. User prototyping area is provided for dedicated circuity and other user-specific circuits.
4. Jumper blocks allow users to quickly configure output stage and input signal source.
5. External or internal control voltage.
6. Convenient user test points provide easy access for instrument readings at critical nodes.

1.2   THE TC64X/TC64XB FAN CONTROL EVALUATION BOARD

The TC64X/TC64XB Fan Control Evaluation Board (Figure 1-1) measures 4" x 6". The circuit board is populated with an 8-pin PDIP socket that can accommodate any of the TC64X and TC64XB devices. While the evaluation kit is pre-configured for a 100 mA, 12V fan, it can be custom-configured for a user-specific combination of control and fan requirements. A LED status indicator is also provided to give a visual indication of a fan fault condition.

The TC64X/TC64XB Fan Control Evaluation Board is powered from an external power supply (5V, 50 mA). The fan speed control signal can be provided by an external sensor, an external voltage signal or the on-board potentiometer. Minimum speed setting and auto-shutdown thresholds are conveniently set by a second potentiometer. Also included are jumper-configurable options for setting the output stage configuration, the modulation frequency and the input signal source. A SHDN/RESET switch is also available for manually shutting down the fan or resetting the system.
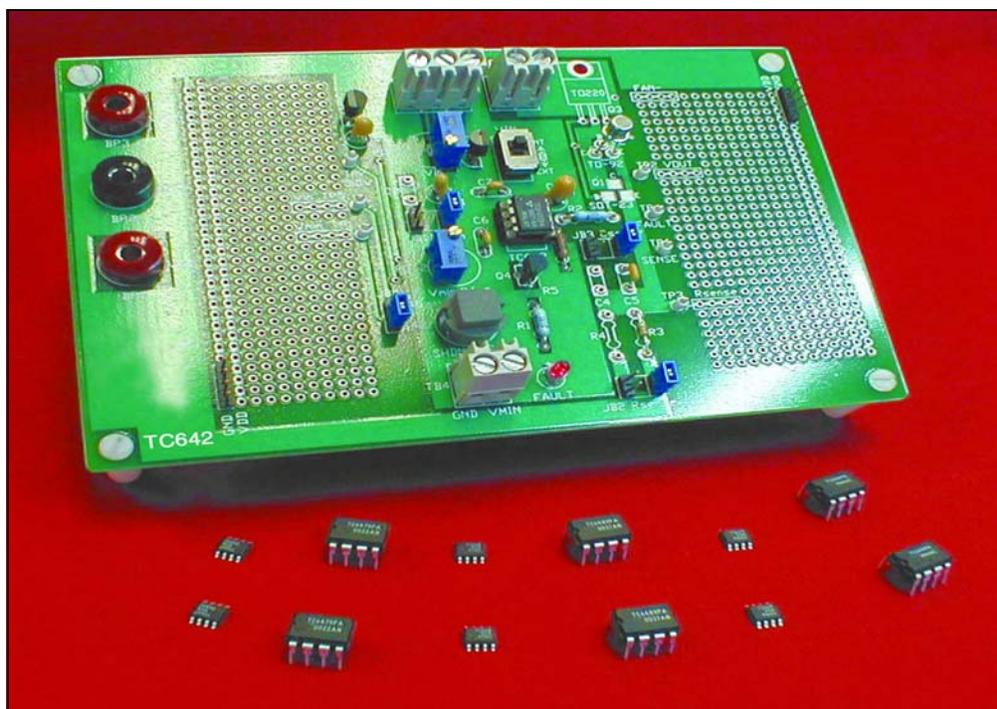
FIGURE 1-1:   *TC64X/TC64XB Fan Control Evaluation Board Kit*

General Information

The TC64X/TC64XB Evaluation Kit includes the following:

1. 4" x 6" printed circuit board with components installed.
2. TC64X/TC64XB Fan Control Evaluation Board User's Guide (DS21403).
3. Sample Devices:

Device	Part Number	
	PDIP	**SOIC**
TC642B	TC642B**EPA**	TC642B**EOA**
TC646B	TC646B**EPA**	TC646B**EOA**
TC647	TC647**VPA**	TC647**VOA**
TC647B	TC647B**EPA**	TC647B**EOA**
TC648	TC648**VPA**	TC648**VOA**
TC648B	TC648B**EPA**	TC648B**EOA**
TC649	TC649**VPA**	TC649**VOA**
TC649B	TC649B**EPA**	TC649B**EOA**

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

Certain items must be provided by the user to implement the TC64X/TC64XB Evaluation Kit:

1. A 5.0V, 50 mA regulated power supply
2. A 12.0V regulated power supply capable of supplying the required fan current
3. Small, flat-bladed screwdriver for adjusting the speed control and minimum speed/auto-shutdown potentiometers
4. Digital volt meter
5. General-purpose oscilloscope
6. Clip leads for power supply and fan connections
7. 12V, 75 mA to 100 mA brushless DC fan

> **Note:** The TC64X and TC64XB will work with any BDC fan. A 12V, 75 mA to 100 mA fan is recommended for initial start-up since the evaluation board is preconfigured for this fan rating. If a 12V, 75 mA to 100 mA BDC fan is not available, the configuration settings of the TC64X/TC64XB Fan Control Evaluation Board must be modified accordingly.

1.3   REFERENCE DOCUMENTS

Other Reference Documents may be obtained by contacting your nearest Microchip sales office or by visiting the Microchip web site at www.microchip.com.

- *Technical Library CD-ROM,* DS00161
- *Analog & Interface Families Data Book 2002*, DS00207
- *2002 Technical Documentation Analog & Interface Product Families* CD-ROM, DS51205
- AN768, *"Redundant Fan Systems Using the TC642 Fan Manager"*, DS00768, Microchip Technology Inc., 2002
- AN770, *"Linear Voltage Fan Speed Control Using Microchip's TC64x Family"*, DS00770, Microchip Technology Inc., 2003
- AN771, *"Suppressing Acoustic Noise in Pulse Width Modulation (PWM) Fan Speed Control Systems"*, DS00771, Microchip Technology Inc., 2003
- AN772, *"Speed Error in Pulse Width Modulation (PWM) Fan Control Systems"*, DS00772, Microchip Technology Inc., 2003
- *TC642 Fan Speed Control Module for TC64X Family* Sell Sheet, DS51251
- *TC642EV, Evaluation Kit for Brushless DC Fan Controllers*, DS21403
- *TC64X, TC64XB* Sell Sheet, DS51252

Other reference documents may be obtained by contacting your nearest Microchip sales office (listed on the back of this document).

The Microchip web site (www.microchip.com) also contains a wealth of documentation. Individual data sheets, application notes, tutorials and user's guides are all available for easy download.

Chapter 2. Getting Started

This Chapter describes how the TC64X/TC64XB Fan Control Evaluation Board functions and how to use the various features.

The development system demonstrates the ability of the TC64X and TC64XB families to interface with virtually any brushless DC fan, control the speed of the fan according to external temperature input, indicate overtemperature conditions, and detect fan failure. A variety of test points and a user prototyping area are provided for easy and complete design evaluation. The TC64X/TC64XB Evaluation Kit's versatility and ease-of-use helps speed up prototyping and development.

2.1 TC64X/TC64XB FAN CONTROL EVALUATION BOARD FUNCTIONAL DESCRIPTION

2.1.1 Hardware Description

Various jumper options and sites for user-installed components allow the TC64X/TC64XB Fan Control Evaluation Board to operate with virtually any BDC fan.

As shown in Figure A-1 of **Appendix A. "Board Layout and Schematic"**, the TC64X/TC64XB Fan Control Evaluation Board operates with any of the TC64X and TC64XB devices installed in the 8-pin DIP socket.

The TC646/646B/648/648B/649/649B devices have an auto-shutdown mode, whereby the fan is shut off when measured temperature is below a prescribed minimum.

The TC642/2B/647/7B devices operate the fan continuously at a minimum speed when the measured temperature is low. For details, please refer to the data sheets for these devices. Shipped from the factory, the TC64X/TC64XB Fan Control Evaluation Board is configured to operate as a TC642/2B/647/7B that drives a 12V BDC fan having a 100 mA maximum operating current.

The TC64X and TC64XB devices modulate fan speed in direct proportion to the control signal applied to pin 1 (V_{IN}). This input can be supplied by an off-board sensor, or from the on-board speed control (Potentiometer 1), depending on the setting of the INT/EXT switch. The minimum fan operating speed (TC642/2B/647/7B) or auto-shutdown temperature setting (TC646/6B/648/8B/649/9B) is determined by the setting of Potentiometer 2. Additionally, the TC64X and TC64XB devices can be manually shut down (or reset) by pushing the SHDN/RESET switch or by applying a short between the two terminals of TB_4. Be sure JB_4 is set to match the TC64X and TC64XB devices currently in service. The BDC fan modulation frequency should be between 15 Hz to 30 Hz. This frequency is determined either by capacitor C_1, or the user-installed capacitor C_2, and the setting of JB_1. The default operating frequency is 30 Hz (see the TC64X and TC64XB data sheets for details).

The output drive device can be either a SOT-23, TO-92 or a TO-220 transistor/MOSFET, depending on the fan operating current and application. Resistor R_2 sets the base drive current for this transistor. The configuration, as shipped from the factory, consists of a 2N2222A transistor and a 1.1 kΩ base resistor, which will drive a BDC fan with an operating current of 100 mA or less. Larger fans can be driven with a different combination of base resistor and output transistor. Fan commutation pulses are sensed by pin 5 of the TC64X and TC64XB devices through R_3 and C_5. Table 2-2 shows suggested values for R_3 for various fan current ratings. The TC64X/TC64XB Evaluation Kit is shipped from the factory with a 4.7Ω resistor installed for R_3 and a 0.1 µF capacitor installed for C_5.

A fault visual indicator is also provided to facilitate experimentation. The FAULT LED is driven active by Q_4 whenever the $\overline{\text{FAULT}}$ output of the TC64X/TC64XB device goes low. The various jumper blocks and options are summarized in Table 2-1.

TABLE 2-1: TC64X/TC64XB EVALUATION BOARD JUMPER OPTIONS

Jumper Block	Shorting Block Installed	Function	Factory Setting
JB$_1$	1 to 2	TC64X/TC64XB, 30 Hz timebase enabled.	Shorted
	3 to 4	TC64X/TC64XB timebase determined by user-installed capacitor C_2.	Open
JB$_2$	1 to 2	4.7Ω sense resistor selected.	Shorted
	3 to 4	User-installed sense resistor R_4 selected.	Open
JB$_3$	1 to 2	0.1 µF sense capacitor selected (adequate for nearly all BDC fans).	Shorted
	3 to 4	User-installed sense capacitor C_4 selected.	Open
JB$_4$	2 to TC642	TC64X/TC64XB Fan Control Evaluation Board configured for TC642/2B, TC647/7B.	Shorted
	2 to TC646	TC64X/TC64XB Fan Control Evaluation Board configured for TC646/6B, TC648/8B, TC649/9B.	Open

2.2 IMPLEMENTING THE TC64X/TC64XB FAN CONTROL EVALUATION BOARD

Initial start-up of the TC64X/TC64XB Fan Control Evaluation Board is simplified by using a 12V BDC fan with an operating current between 75 mA to 100 mA. The TC64X/TC64XB Fan Control Evaluation Board is shipped pre-configured for such a fan. If such a fan is available, please proceed to Step 1 below.

If such a fan is unavailable, the TC64X/TC64XB Fan Control Evaluation Board will require modification to certain component values and jumper settings. Proceed to **Section 2.3, "Operation in the Adjustable Output Voltage"**.

1. The TC64X/TC64XB Fan Control Evaluation Board is shipped from the factory configured as outlined in Table 2-1. Inspect the jumper settings on the board to ensure they match those listed in Table 2-1. Also be sure that a 4.7Ω resistor is installed for R_3, a 1.1 kΩ resistor is installed for R_2, a 0.1 µF capacitor is installed for C_5 and a 2N2222A transistor is installed for Q_2.

2. Connect the positive side of a 5V DC supply to V_{DD} (BP_1) and the negative side of the supply to GND (BP_2).

3. Connect the positive lead of a 12V, 100 mA (max) BDC fan to the FAN + terminal. Connect the negative lead of the fan to the FAN - terminal.

4. Connect the positive lead of a 12V DC supply to V_{FAN} (BP_3). Connect the negative lead from the 12V DC supply to ground (BP_2).

5. Set the INT/EXT switch to INT (Internal Control Voltage). Turn Potentiometer 1 (Speed Control) fully clockwise. Turn Potentiometer 2 (min speed/auto-shutdown level) fully clockwise.

6. Turn both DC supplies on. The fan should immediately run to full speed and the FAULT LED should be lit. If this is not the case, check the configuration settings and repeat steps 1 through 5.

7. Connect the positive lead of a DC voltmeter to test point TP_1 and the negative voltmeter lead to ground. This is the minimum speed setting voltage. Adjust Potentiometer 2 until a reading of 1.9V is achieved. This voltage corresponds to a minimum speed setting of approximately 40 percent of full speed.

8. Verify proper operation of the TC642/2B/647/7B by rotating Potentiometer 1 counterclockwise. The fan speed decreases and the FAULT LED goes off. Fan speed will decrease as Potentiometer 1 is rotated counterclockwise until the voltage on the wiper of Potentiometer 1 is less than the voltage on the wiper of Potentiometer 2, at which time the fan will operate continuously at 40 percent of full speed. Verify the minimum speed circuit is operating by adjusting Potentiometer 2 clockwise, while Potentiometer 1 is fully counterclockwise.

9. Verify open fan detection by disconnecting one lead of the fan while it is running. The FAULT LED will light after a disconnect time of about two seconds.

10. Verify locked rotor detection by stopping the fan blades during operation. The FAULT LED will light approximately two seconds after the fan blades are stopped.

The TC64X/TC64XB circuit board may now be custom-configured for your particular combination of control and fan requirements.

2.3   OPERATION IN THE ADJUSTABLE OUTPUT VOLTAGE MODE

2.3.1   Output Driver

Transistors such as 2N2222A are recommended for use as the output driver. These transistors are low cost, multiple sourced and have a high enough Beta for BDC fan applications of 200 mA or less operating current. If a single transistor is used, care must be taken to select a transistor having a minimum h_{FE} of 50 to ensure that the minimum output current specification (5 mA) of the TC64X and TC64XB devices are not exceeded. For large BDC fans, a logic level MOSFET is a good choice for the drive device. All component selections should be made based on information in the "Applications" section of the TC64X and TC64XB data sheets.

Table 2-2 provides a list of typical fan module operating configurations for 12V fan applications. The values in Table 2-2 assume the use of low-cost, bipolar transistors (such as the 2N2222A).

Substituting a logic level MOSFET, such as a BS170, for Q_2, results in lower system voltage losses and significantly reduces output loading on the TC64X and TC64XB devices. The low R_{DSON} of the MOSFET (1Ω in the case of the BS170) enables it to be used in place of the Darlington in high current fan applications (See the TC64X and TC64XB individual data sheets' "Applications" section for details). The pinout of many logic level MOSFETs is reversed from that of bipolar junction transistors, so care must be taken to properly orient the MOSFET.

TABLE 2-2:   OUTPUT DRIVE DEVICE CONFIGURATIONS

Full Speed Fan Motor Current	Darlington Pair/MOSFET*	Single Transistor	R_2 (Ω)	R_3 (Ω)
50 mA	—	X	2.4 k	9.1
100 mA	—	X	1.1 k	4.7
150 mA	—	X	750	3.0
200 mA	—	X	620	2.4
200 mA	X	—	5.6 k	2.4
250 mA	X	—	4.7 k	2.0
300 mA	X	—	3.9 k	1.8
350 mA	X	—	3.3 k	1.5
400 mA	X	—	3.0 k	1.3
450 mA	X	—	2.4 k	1.2

*R_2 is not necessary when using a MOSFET as the drive device.

2.3.2   Sensor Interface Circuit

The TC64X and TC64XB data sheets provide detailed information relating to the design of a temperature sensor based on a low cost thermistor.

Appendix A. Board Layout and Schematic

A.1   INTRODUCTION

This appendix contains general information concerning the layout, schematic and components associated with the TC64X/TC64XB Fan Control Evaluation Board.

A.2   BOARD LAYOUT AND SCHEMATICS

Figure A-1 depicts the layout for the TC64X/TC64XB Fan Control Evaluation Board. Figure A-2 shows the schematic for the Fan Control Module.
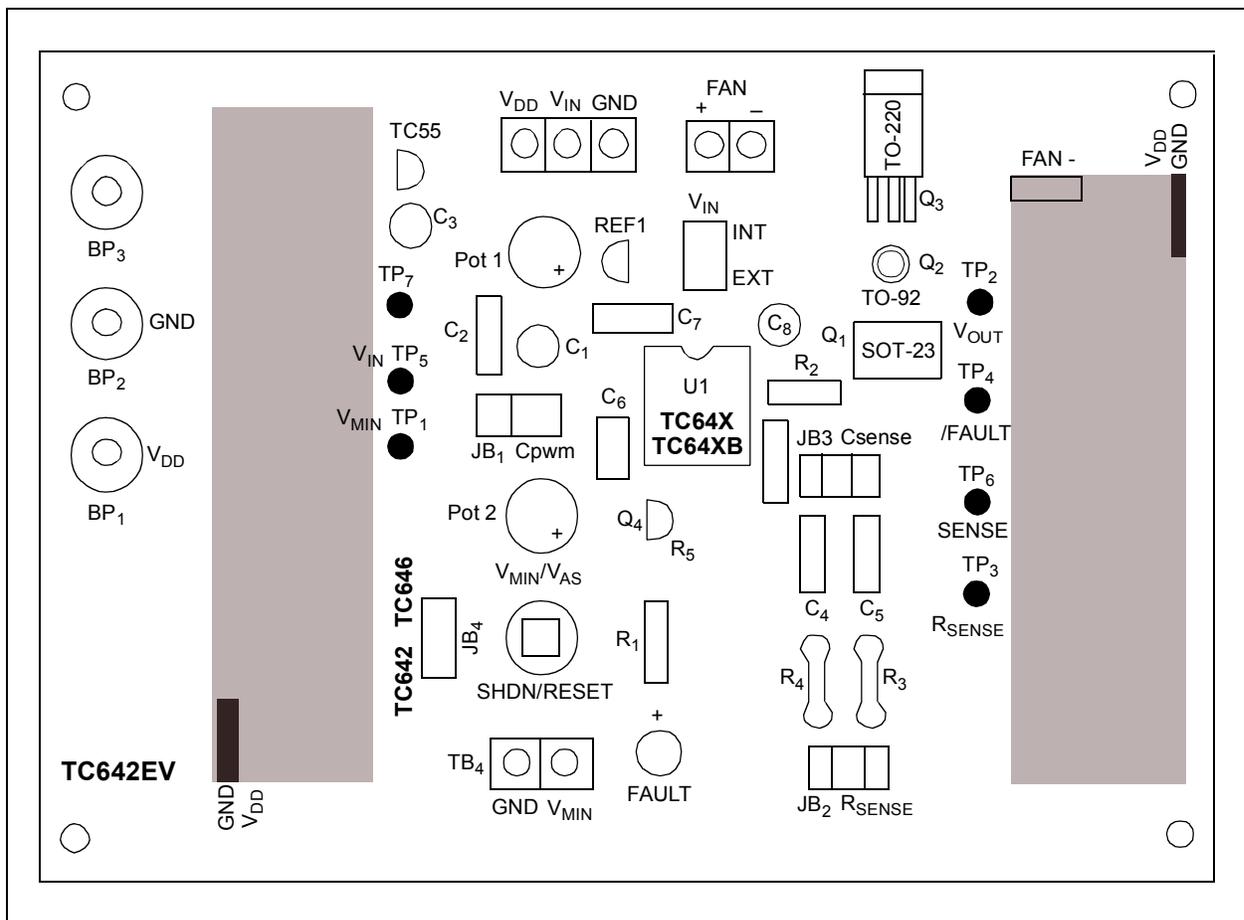
FIGURE A-1:   *TC64X/TC64XB Fan Control Evaluation Board Layout*
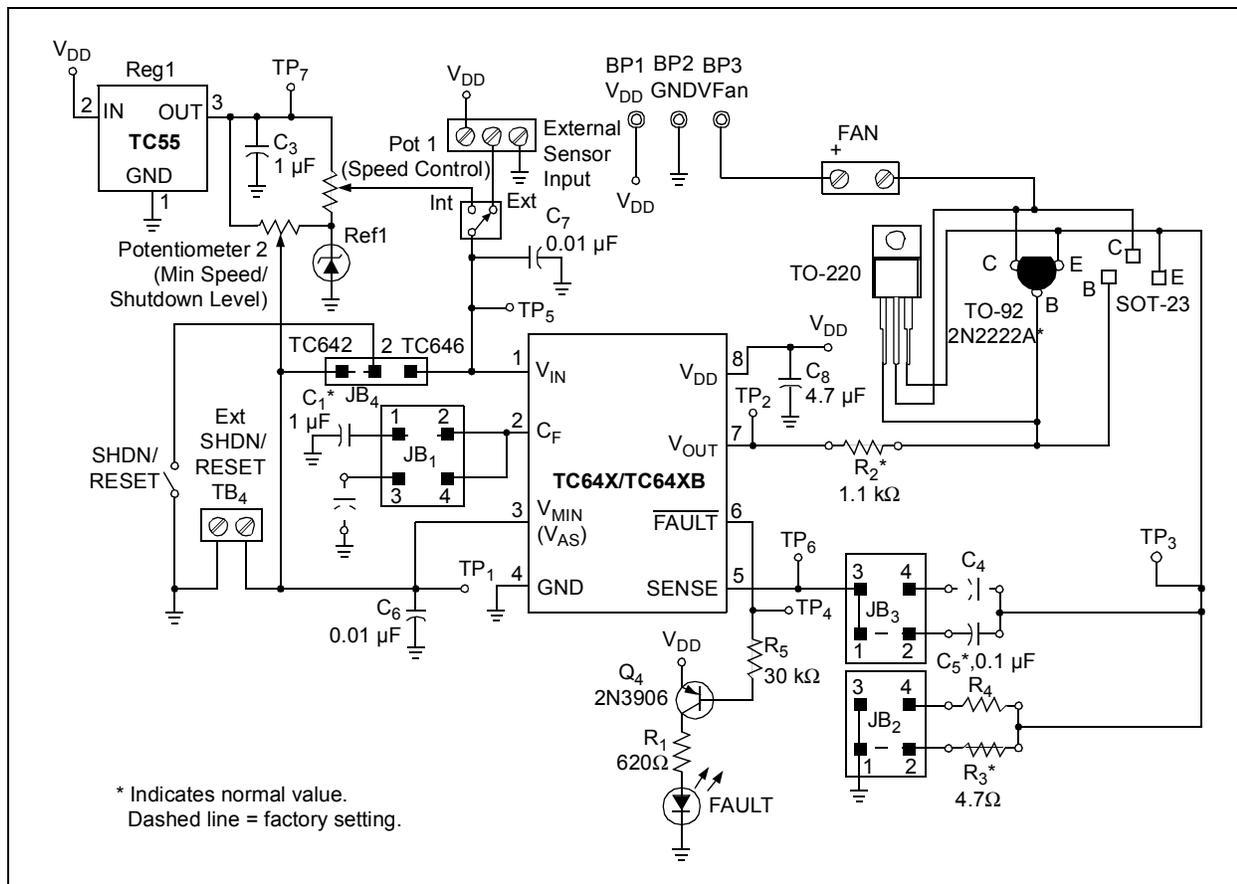
FIGURE A-2:   *Fan Control Module Schematic*

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Appendix B. Bill-of-Materials (BOM)

B.1 TC64X/TC64XB FAN CONTROL EVALUATION BOARD COMPONENTS

Table B-1 lists typical components and associated values that comprise the TC64X/TC64XB Fan Control Evaluation Board.

TABLE B-1: FAN CONTROL MODULE COMPONENTS

Component	Typical Value
BP1 – BP3	Banana receptacle
C_1	1 µF tantalum capacitor.
C_2	Not installed
C_3	1 µF tantalum capacitor
C_4	Not installed
C_5	0.1 µF ceramic capacitor
C_6, C_7	0.01 µF ceramic capacitor
C_8	4.7 µF tantalum capacitor
JB_1 – JB_4	SIP header terminal strips
LED -1	Miniature LED
Pot 1, Pot 2	1 kΩ, on-board potentiometer
Q_1	Not installed (SOT-23 site)
Q_2	2N2222A NPN bipolar transistor
Q_3	Not installed (TO-220 site)
Q_4	2N3906 PNP bipolar transistor
R_1	620Ω, 1/4 watt, 5% carbon resistor
R_2	1.1 kΩ, 1/4 watt, 5% carbon resistor
R_3	4.7Ω, 1/4 watt, 5% carbon resistor
R_4	Not installed
R_5	30 kΩ, 1/4 watt, 5% carbon resistor
REF-1	LM385, 1.2V reference
REG-1	TC55RP3002EZB 3.0V, 2% regulator
SW-1	Miniature SPDT toggle switch (INT/EXT Switch)
SW-2	Miniature SPDT push button switch (SHDN/RESET switch)
U1	TC642B, TC646B, TC647/7B, TC648/8B, TC649/9B (Two, each provided as samples)

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Fax: 765-864-8387

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San Jose, CA 95131
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Fax: 905-673-6509

ASIA/PACIFIC

Australia
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Australia
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Fax: 61-2-9868-6755

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Fax: 86-21-6275-5060

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Fax: 86-755-8295-1393

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Fax: 33-1-69-30-90-79

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Fax: 49-89-627-144-44

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Milan, Italy
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Netherlands
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NL-5152 SC Drunen, Netherlands
Tel: 31-416-690399
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