



# MICROCHIP

## Fan Control Function Pack Design Guide

*Extend Fan Life, Reduce Acoustic Noise, Power Consumption  
and Increase System Uptime*

Power  
Supply



LCD Projector



Router



Printer /  
Copier



Oscilloscope



Server

Design ideas in this guide are based on many of the devices featured in Microchip Technology's "Fan Control Function Pack." A complete device list and corresponding data sheets for these products can be found at: [www.microchip.com/funpack](http://www.microchip.com/funpack)

**Single & Dual Fan Controllers**  
TC646, TC654, TC655

**Fan Fault Detector**  
TC670

**Temperature Sensors**  
TC07, TC77

**PIC® Microcontroller**  
PIC16C717

**Temperature Sensor/  
Fan Controller**  
TC652

This guide is a companion to the "Fan Control" functional sample pack (funpack). Contact your local Microchip sales office for additional information.

# Extend Fan Life, Reduce Acoustic Noise and Power Consumption, Increase System Uptime

## SIMPLE FAN CONTROL SOLUTION

### Ambient Temperature-Controlled Fan On/Off Switch

The **TC620** logic output temperature sensor can work as a local thermostat, turning the cooling fan on and off when ambient temperature levels exceed threshold values.

The programmable temperature threshold and hysteresis values make it easy to define the fan's on/off thresholds.

### TC620 Output Temperature Sensor Key Features:

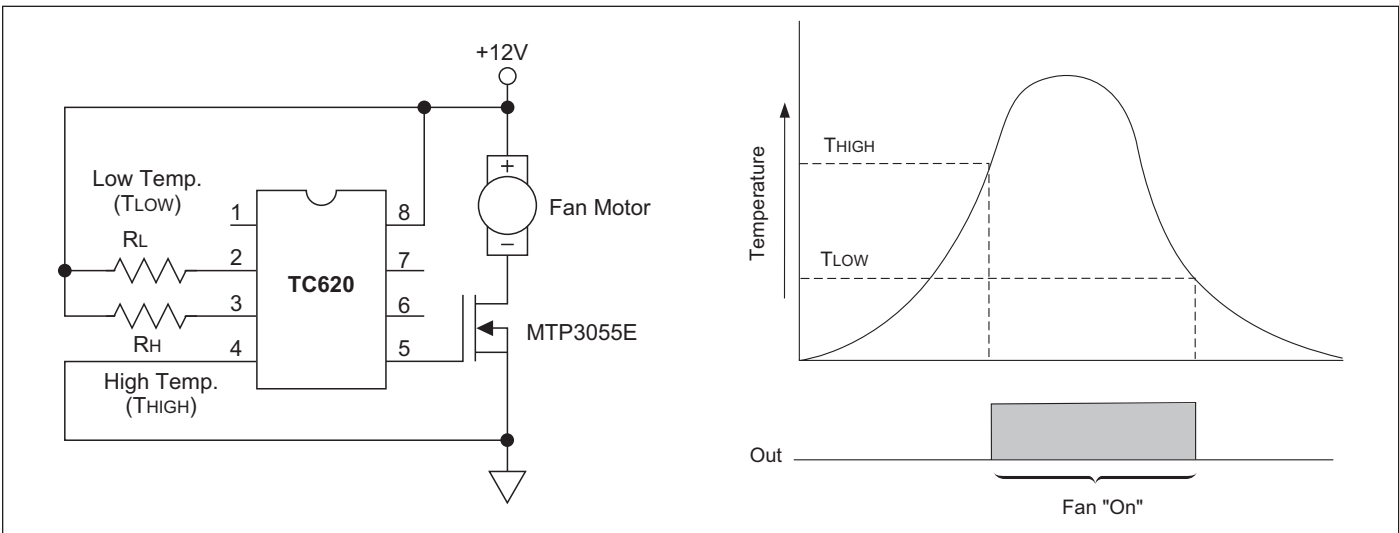
- Wide Temperature Detection Range
  - 0°C to 70°C: (TC620CCX)
  - 40°C to +125°C: (TC620CVX)
  - 40°C to +85°C: (TC620CEX)
  - 55°C to +125°C: (TC620CMX)

### TC620 Output Temperature Sensor Key Features (Cont.):

- User-Programmable Hysteresis and Temperature Set Point
- Easily Programs with Two External Resistors
- Onboard Temperature Sensing Applications
- Available in 8-Pin PDIP and SOIC Packages
- ±3°C Accuracy (Max)

### TC620 Applications:

- Power Supply Over-Temperature Detection
- Consumer Equipment
- Temperature Regulators
- CPU Thermal Protection



### Product Specifications

Device	Output Type	Typical Accuracy	Maximum Accuracy @ 25°C	Maximum Temperature Range	V <sub>DD</sub> Range	Maximum Supply Current
TC620	Logic Output	±1°C	±3°C	-40°C to +125°C	+4.5V to +18V	400 µA

# Extend Fan Life, Reduce Acoustic Noise and Power Consumption, Increase System Uptime

## SMBus COMMUNICATION INTERFACE MAKES TALKING TO YOUR FAN SIMPLE

### Control Fan Speed, Measure Fan RPM, Predict Fan Failure and Communicate All this Information to Your System

The **TC654/TC655** and **TC664/TC665** (Single and Dual Fan Controllers) work with your system controller and remote temperature sensing devices to control and monitor fan speed.

These devices can increase system uptime by giving a predictive indication of a fan failure, allowing service action to occur before the system goes down unexpectedly.

#### TC654/TC655 Fan Controller Key Features:

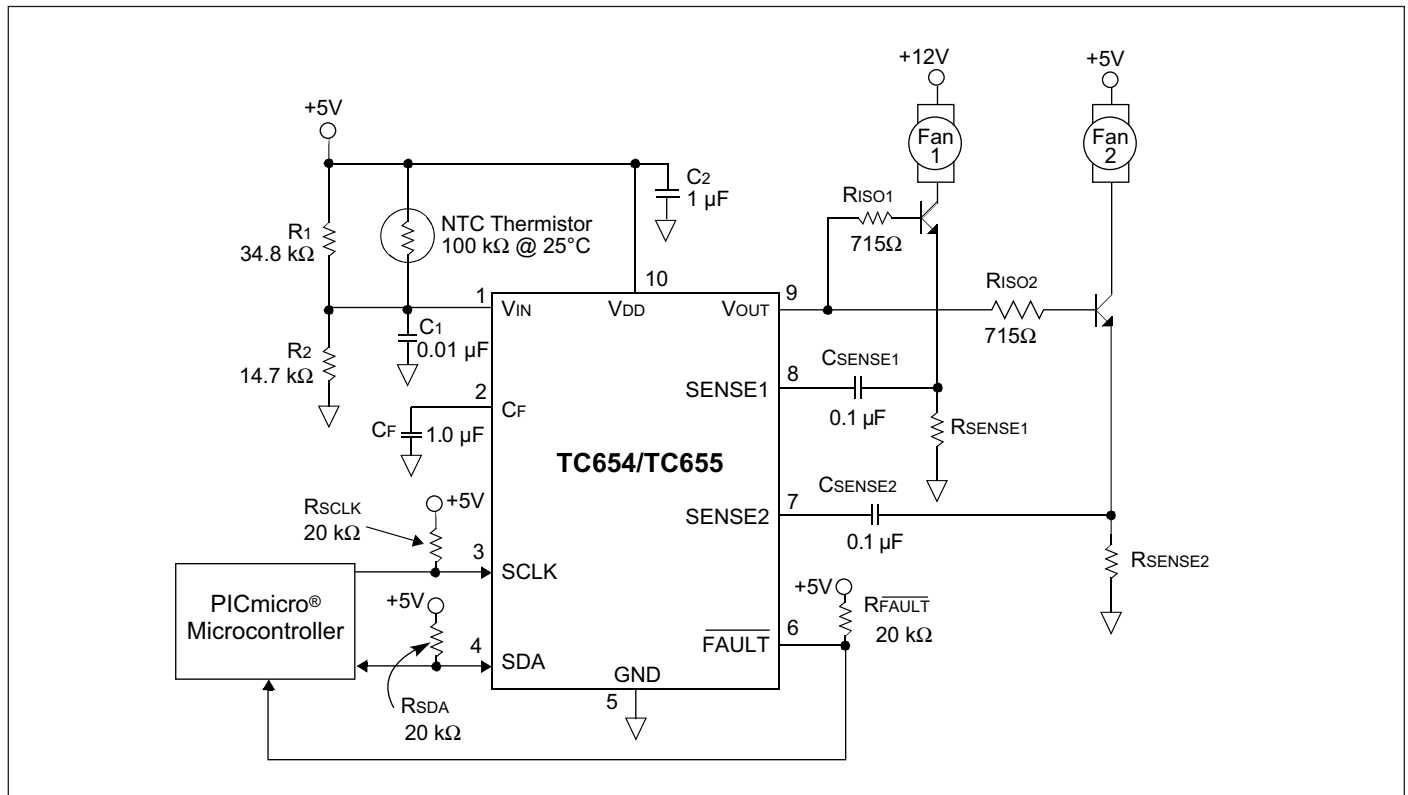
- Efficient PWM Fan Drive
- Provides RPM Data
- 2-Wire SMBus-Compatible Interface
- Supports Any Fan Voltage

#### TC654/TC655 Fan Controller Key Features (Cont.):

- Software-Controlled Shutdown Mode for “Green” Systems
- Supports Low Cost NTC/PTC Thermistors
- Space-Saving 10-Pin MSOP Package
- Temperature Range: -40°C to +85°C

#### TC654/TC655 Applications:

- Personal Computers and Servers
- LCD Projectors
- Datacom and Telecom Equipment
- Fan Trays
- File Servers
- Workstations
- General Purpose Fan Speed Control



#### Product Specifications

Device(1)	Vcc Range	Temperature Range	Typical Iq	Over-Temp Alert	SMBus Interface	Min Fan Speed	# of Fans Monitored	RPM Data	Predictive Fan-Fault Detection	Package
TC654	+3.0V to +5.5V	-40°C to +85°C	150 μA	—	X	X	2	X	X	10 MSOP
TC655	+3.0V to +5.5V	-40°C to +85°C	150 μA	X	X	X	2	X	X	10 MSOP
TC664	+3.0V to +5.5V	-40°C to +85°C	150 μA	—	X	X	1	X	X	10 MSOP
TC665	+3.0V to +5.5V	-40°C to +85°C	150 μA	X	X	X	1	X	X	10 MSOP

**Note 1.** These devices use an external sensor. Accuracy of the total solution is a function of the accuracy of the external sensor.

# Extend Fan Life, Reduce Acoustic Noise and Power Consumption, Increase System Uptime

## LISTEN TO WHAT YOUR FAN IS TELLING YOU

### Predicting the Failure of Your Fan Brings Many Advantages

As a fan wears out, it slows down and circulates less air. This can eventually cause an overheating condition and possibly an unexpected thermal shutdown. The **TC670** predictive fan failure device monitors the speed of a fan and allows you to set a fan speed threshold at which you receive a fan warning indication, allowing service action to take place on your schedule instead of the fan's.

### TC670 Fan Failure Detector Key Features:

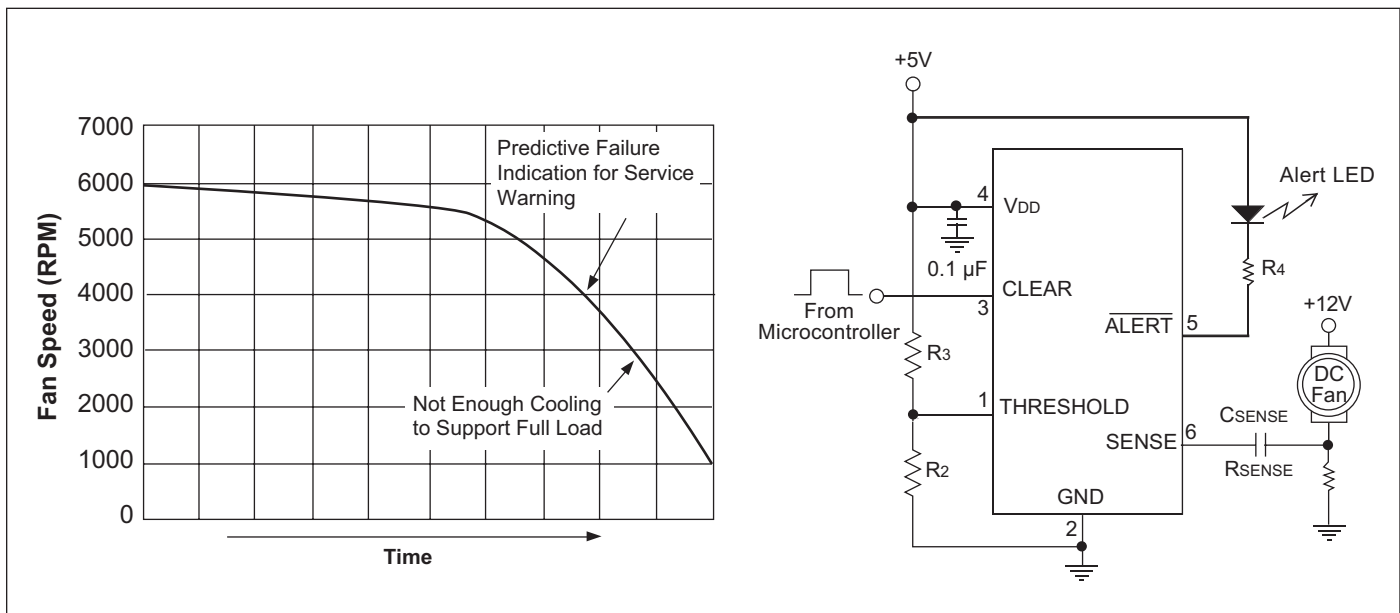
- Fan Wear-out Detection for 2-Wire Linear-Controlled Fans
- Replacement System for 3-Wire Fans
- Fan-Alert Signal when Fan Speed is below Programmed Threshold

### TC670 Fan Failure Detector Key Features (Cont.):

- Clear Capability for Eliminating False Alarm
- Low Operating Current, 90  $\mu\text{A}$  (typ.)
- $V_{DD}$  Range: 3.0V to 5.5V
- Available in a 6-Pin SOT-23 Package

### TC670 Applications:

- Protection for Linear-Controlled Fans
- Power Supplies
- Industrial Equipment
- PCs and Notebooks
- Data Storage
- Data Communications Equipment
- Instrumentation



### Product Specifications

Device	V <sub>CC</sub> Range	Temperature Range	Maximum I <sub>Q</sub>	Typical Accuracy	Package
TC670	+3.0V to +5.5V	-40°C to +85°C	150 $\mu\text{A}$	$\pm 5\%$	6 SOT-23

# Extend Fan Life, Reduce Acoustic Noise and Power Consumption, Increase System Uptime

## USING THE TC646 FAN SPEED CONTROLLER

### Simple, 8-pin Fan Speed Controller/Monitor Makes Systems Quiet and Intelligent

Using a low-cost NTC thermistor in conjunction with the **TC646** Pulse Width Modulation (PWM) fan speed controller/monitor, provides a simple, low-cost, small footprint fan speed control solution. The TC646 device uses Microchip's patented FanSense™ Technology, which allows you to use a lower cost 2-wire fan in place of a 3-wire fan and still detect fan failure. The PWM method of speed control dissipates less power in the fan drive device, allowing smaller, less expensive devices to be used, compared to the linear speed control method.

#### TC646 Fan Speed Controller Key Features:

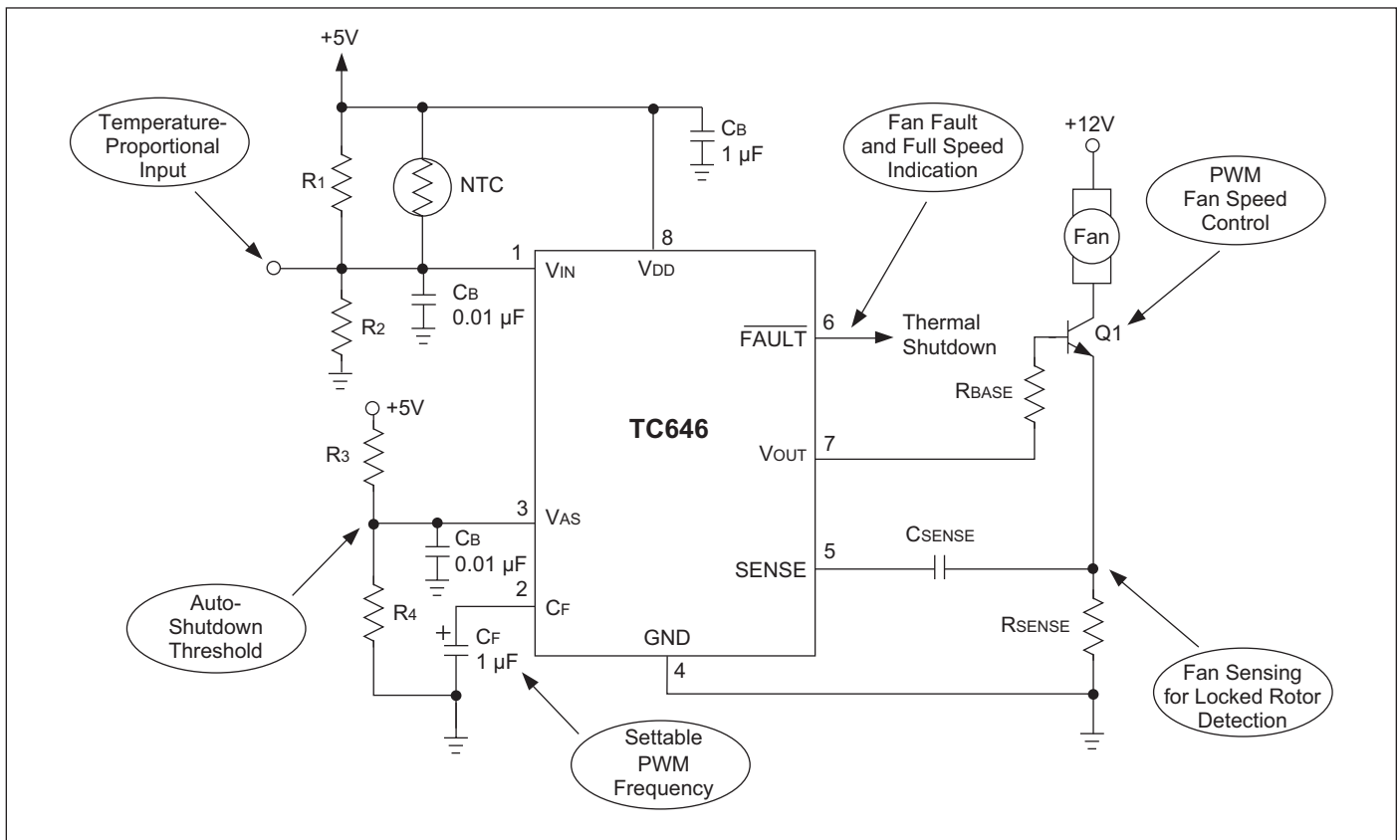
- Temperature-Proportional Fan Speed for Acoustic Control and Longer Fan Life
- Efficient PWM Fan Drive
- Supply Range: 3.0V to 5.5V

#### TC646 Fan Speed Controller Key Features (Cont.):

- Fan Voltage Independent of TC646 Supply Voltage
- Supports any Fan Voltage
- FanSense Fault Detection Circuits Protect Against Fan Failure and Aid System Testing
- Shutdown Mode for “Green” Systems
- Supports Low Cost NTC/PTC Thermistors
- Over-Temperature Detection

#### TC646 Applications:

- Power Supplies
- Computers
- File Servers
- Portable Computers
- Telecom Equipment
- UPS, Power Amps
- General Purpose Fan Speed Control



#### Product Specifications

Device(1)	Vcc Range	Temp. Range	Typical Iq	Over-Temp Alert	SMBus Interface	Min Fan Speed	Temp Auto-Shutdown	# of Fans Monitored	RPM Data	Predictive Fan Fault Detection	Fan Auto-Restart	Package
TC646	+3.0V to +5.5V	-40°C to +85°C	500 μA	X	-	-	X	1	-	-	-	8 PDIP, MSOP, SOIC

**Note 1.** These devices use an external sensor. Accuracy of the total solution is a function of the accuracy of the external sensor.

# Extend Fan Life, Reduce Acoustic Noise and Power Consumption, Increase System Uptime

## USING THE TC652 TEMPERATURE SENSOR/FAN SPEED CONTROLLER

### Integrated Temperature Sensor and Fan Speed Controller/Monitor Provides Eloquent Fan Control Solution

The **TC652** device integrates a temperature sensor, fan speed controller, fan speed monitor/fault detector and over-temperature indication, all into one small 8-pin MSOP package, making it ideal for your fan speed control solution. The TC652 device uses Microchip's patented FanSense™ Technology, which allows you to use a lower cost 2-wire fan in place of a 3-wire fan and still detect fan failure. Multiple factory-set temperature ranges allow you to select the appropriate minimum and maximum speed temperature thresholds for your application.

#### TC652 Key Features:

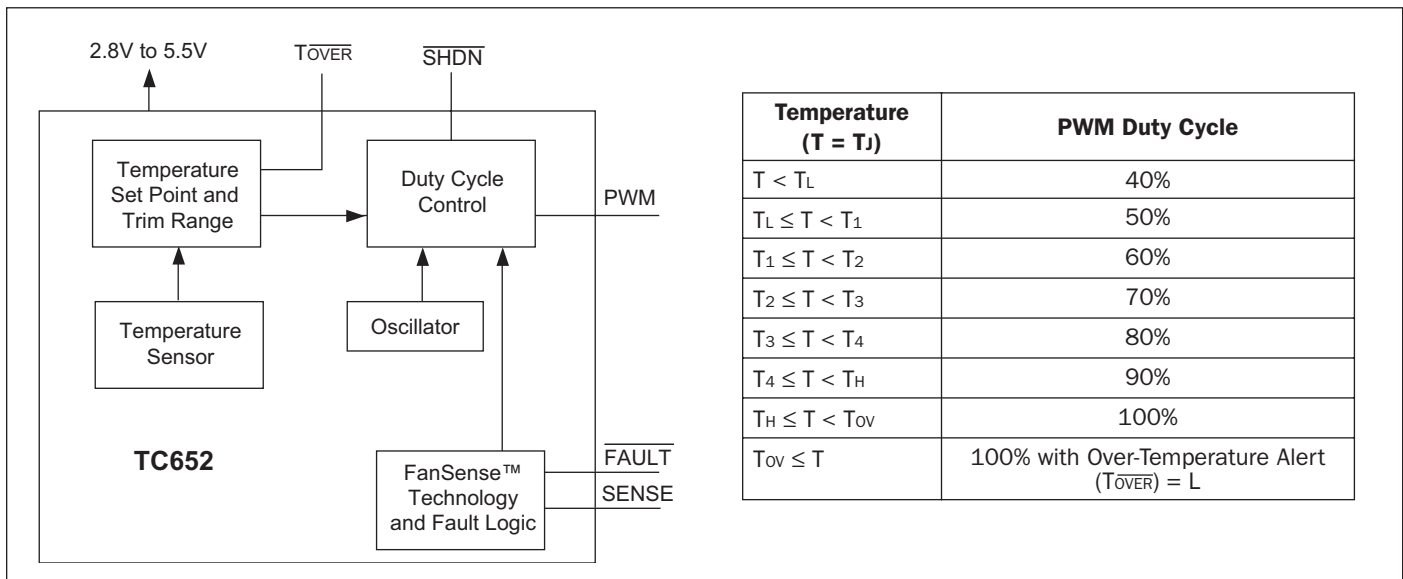
- Integrated Temperature Sensing and Multi-speed Fan Control
- FanSense™ Fan Fault Detect Circuitry
- Built-in Over-Temperature Alert ( $T_{OVER}$ )

#### TC652 Key Features (Cont.):

- Temperature-Proportional Fan Speed Control for Acoustic Noise Reduction and Longer Fan Life
- Pulse Width Modulation 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 to 5.5V
- TC651 and TC653 include Auto Fan Shutdown
- Low Operating Current: 50  $\mu\text{A}$  (Typ.)

#### TC652 Applications:

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



### Product Specifications

Device	Minimum Speed Setting	Auto-Shutdown Setting	Fan Fault Indication	On-Board Temperature Sensing	Over-Temperature Alert
TC650	X	-	-	X	X
TC651	-	X	-	X	X
TC652	X	-	X	X	X
TC653	-	X	X	X	X

# Extend Fan Life, Reduce Acoustic Noise and Power Consumption, Increase System Uptime

## THE PIC16C819 MCU PAIRED WITH THE TC77 TEMPERATURE SENSOR

### PICmicro® MCU Plus Temperature Sensor Provides a Highly Flexible, Accurate and Intelligent Solution to Fan Speed Control/Fan Fault Detection and Temperature Monitoring

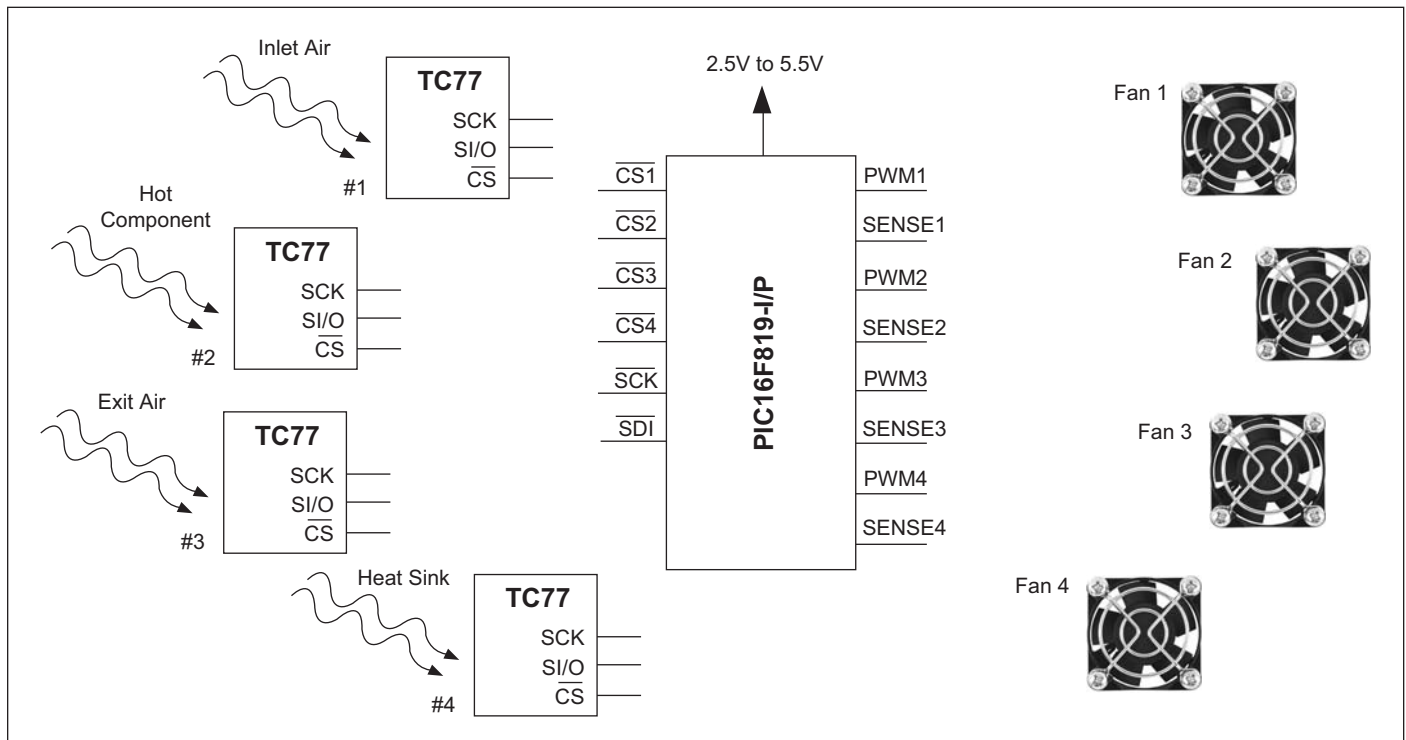
The **PIC16F819** 8-bit microcontroller paired with the **TC77** temperature sensor allows you to implement just about any fan speed control algorithm you can think of. The PIC16F819 can monitor multiple TC77 devices over the 3-wire SPI™ interface, allowing you to sense system ambient or component temperatures in multiple locations with high accuracy ( $\pm 1^\circ\text{C}$ ). Using the I/O pins of the PIC16F819, PWM output drive signals can be generated to control the speed of multiple fans, either independently or all at the same speed. The A/D inputs can be used to monitor the fan speed and assess the health of the fans, making the system more intelligent.

### Multi-Fan Management Solution Key Features:

- Minimum Speed or Auto-Shutdown Mode
- Fan Speed Sensing
- Built-in Over-Temperature Alert ( $\overline{\text{TOVER}}$ )
- Accurate Temperature Sensing ( $\pm 1^\circ\text{C}$ )
- Settable Fan Fault Thresholds
- Adjustable PWM Frequency
- Staggered Fan Startup for Reduced Current Draw
- Adjustable Fan Startup Time

### Multi-Fan Management Applications:

- Thermal Protection for Hard Disk Drives and Other PC Peripherals
- PC Card Devices for Notebook Computers
- Low-Cost Thermostat Controls
- Industrial Control
- Office Equipment
- Cellular Phones



### Product Specifications

Device	Interface	Max Accuracy (+25°C to +65°C)	Temperature Range	Vcc Range	Typical Iq	Typical ISHDN	Resolution	Package
TC77	3-wire SPI™	$\pm 1^\circ\text{C}$	-55°C to +125°C	2.7V to 5.5V	250 $\mu\text{A}$	0.1 $\mu\text{A}$	0.0625°C	8 SOIC, 5 SOT-23

## RELATED SUPPORT MATERIAL

The following Application Notes, Technical Briefs and User's Guides are available at: [www.microchip.com](http://www.microchip.com).

### Application Notes

- AN764:** *Implementing Temperature-Based Variable Fan Speed Control in NLX Power Supplies*
- AN768:** *Redundant Fan Systems Using the TC647 Fan Manager*
- AN770:** *Linear Voltage Fan Speed Control Using Microchip's TC64X Family*
- AN771:** *Suppressing Acoustic Noise in PWM Fan Speed Control Systems*
- AN772:** *Speed Error in PWM Fan Control Systems*

### Technical Briefs

- TB063:** *An Integrated Fan Speed Control Solution Can Lower System Costs, Reduce Acoustic Noise, Power Consumption and Enhance System Reliability*
- TB064:** *Intelligent Thermal Management Using Brushless DC Fans*

### Demonstration/Evaluation Boards and User Guides

Microchip offers a number of boards, along with User Guides, to help evaluate device families. Contact your local Microchip Sales Office for more information.

- TC642 Fan Control Demo Board:** This fan control circuit board allows the user to quickly evaluate and prototype Microchip's TC64X and TC64XB Pulse Width Modulation (PWM) Fan Control ICs. (User's Guide - DS21401)
- TC642 Fan Control Evaluation Board:** This fully assembled 4" x 6" circuit board allows the user to evaluate and prototype fan control circuits based on Microchip's TC64X and TC64XB DC brushless fan controllers. (User's Guide - DS21403)
- TC650 Fan Control Demo Board:** 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. (User's Guide - DS51304)
- TC652 Fan Control Demo Board:** 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. (User's Guide - DS21506)
- TC670 Fan Speed Sensor Demo Board:** An evaluation tool that provides an optimal way to evaluate the TC670 integrated fan speed sensor. (User's Guide - DS51273)

## Analog and Interface Families

Thermal Management	Power Management	Interface	Mixed-Signal	Linear
Temperature Sensors	LDO & Switching Regulators	CAN Peripherals	A/D Converter Families	Op Amps
Fan Speed Controllers/ Fan Fault Detectors	Charge Pump DC/DC Converters	Infrared Peripherals	Digital Potentiometers	Programmable Gain Amplifiers
	Power MOSFET Drivers	LIN Transceiver	System D/A Converters	Comparators
	PWM Controllers	Serial Peripherals	V/F and F/V Converters	Linear Integrated Devices
	System Supervisors			
	Voltage Detectors			
	Voltage References			
	<b>Battery Management</b>			
	Li-Ion/Li-Polymer Battery Chargers			
	Smart Battery Managers			



**MICROCHIP**  
[www.microchip.com](http://www.microchip.com)

Microchip Technology Inc. • 2355 W. Chandler Blvd. • Chandler, AZ 85224-6199

MICROCONTROLLERS • DIGITAL SIGNAL CONTROLLERS • ANALOG • SERIAL EEPROMS

Information subject to change. The Microchip name and logo, the Microchip logo, PIC and PICmicro are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries. FanSense, Select Mode, MXLAB and MXDEV are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries. All other trademarks mentioned herein are property of their respective companies. © 2005, Microchip Technology Incorporated. All Rights Reserved. Printed in the U.S.A. 8/05 DS21835C

