TB067

Temperature Sensor Strategies Keep System Thermal Problems in Check

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INTRODUCTION

Various concerns must be addressed when dealing with temperature sensing applications, which fall into two broad categories: precision temperature measurement and system thermal management. Precision temperature measurement applications (such as those encountered in the process control industry) require highly accurate temperature sensors. Applications of this type frequently use a thermocouple (or higher precision sensor) in concert with low offset/low drift analog interface circuits to acquire and condition the temperature signal with minimum error. Sensor absolute accuracy and linearity are primary considerations; sensor cost is a secondary issue.

System thermal management schemes, on the other hand, regulate the creation (and/or disposal) of heat within the system. Examples of system thermal management applications are CPU over-temperature detectors in personal computers and thermal shutdown circuits in power systems. The temperature sensor must be accurate enough to detect when temperature is approaching the upper boundry of the “safe” operating limit. Typically, full scale sensor measurement errors of 2°C to 5°C are adequate for such applications. The primary concerns in sensor selection are sensor cost, size, and ease of interface to the processor.

OVER-TEMPERATURE SHUTDOWN

Heat sinking the high power dissipation devices in a system is the simplest thermal management strategy. In this case, only the system must be monitored for catastrophic over-temperature conditions due to a malfunction or excessive external ambient temperature. Temperature is sensed within the system enclosure (internal system ambient) or at the heat sink itself. When measured temperature exceeds a preset limit, a fault is indicated and the system shuts down.

Figure 1 illustrates a simple power supply over-temperature shutdown circuit using Microchip’s TC622 temperature switch. This device integrates a solid-state temperature sensor and user-programmable limit detector in a single TO-220 package, allowing direct attachment to the heat sink surface. The device operates from power supply voltages between 4.5V and 18.0V, and has both high true and low true logic outputs (OUT, $\overline{OUT}$). These outputs are driven active when measured temperature equals (or exceeds) the temperature setting determined by the value of external programming resistor, R_{SET}. In the example of Figure 1, the TC622 outputs are driven active when the heatsink temperature equals the trip point temperature set by R_{SET}. When this occurs, the crowbar circuit is activated, causing the supply output to fold back to zero. The TC622 outputs remain active until the heatsink temperature falls a minimum of 2°C (built-in hysteresis) below the trip point temperature, at which time the device again allows normal supply operation.

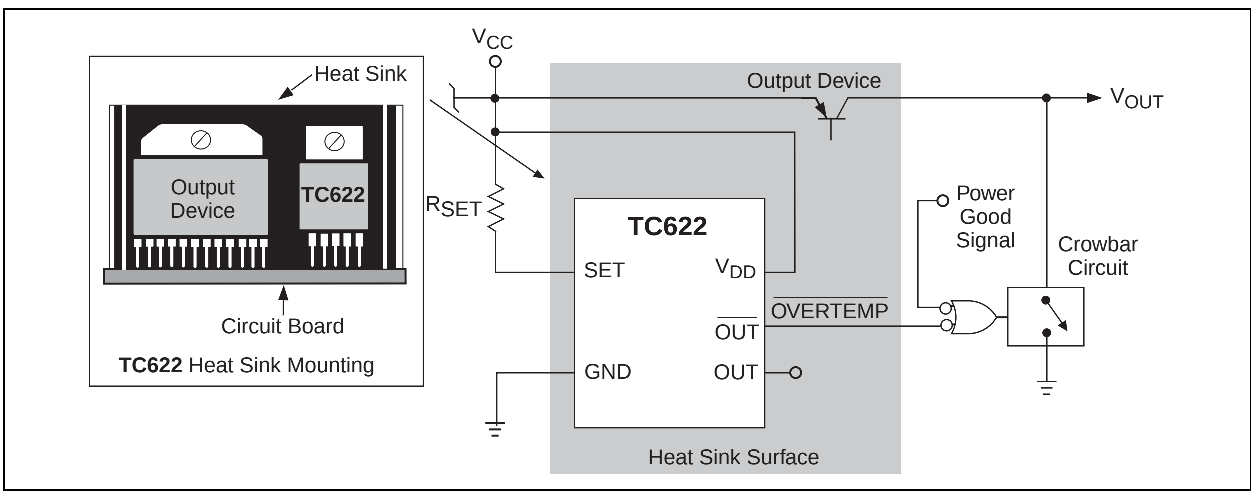

FIGURE 1: *TC622 Power Supply Over Temperature Shutdown*

FAN ON/OFF CONTROL

Although fans commonly are used to remove heat from a system, running a fan continuously not only creates objectionable acoustic noise, but also reduces the service life of the fan motor. It is more efficient to design the system thermal characteristics so the fan operates intermittently during high system load conditions. Figure 2 demonstrates an ambient temperature regulator using the TC07 thermostat chip.

Housed in a tiny MSOP package (consuming only one-half the board area of an 8-pin SOIC package), the TC07 consists of a temperature sensor and user-programmable dual limit detection circuit. As shown in Figure 2, the output of the TC07 controls the fan through an N-Channel logic-level MOSFET.

The value of the R_{SET} resistor determines the temperature at which the fan turns on. Once started, the fan runs continuously until temperature drops below the set point determined by R_{HYST}. The fan cycles on and off (as required) to maintain system temperature within the range programmed by R_{SET} and R_{HYST}.

INTELLIGENT FAN MANAGEMENT

Temperature-proportional fan speed control (operating the fan only as fast as required to maintain a safe system temperature) maximizes fan life and minimizes power consumption and acoustic noise. The TC646 (see Figure 3) combines this fan management methodology with fan off/on control and fault detection for the ultimate in fan management.

The TC646 uses efficient pulse-width modulation drive to control fan speed. A low cost NTC thermistor connected to V_{IN} increases the positive duty cycle of V_{OUT} (and, therefore, fan speed) as temperature rises. Should temperature fall low enough to cause the voltage on V_{IN} to be less than the voltage on the auto-shutdown threshold input (V_{AS}), the TC646 automatically suspends fan operation. The fan is automatically restarted and temperature-proportional speed control resumes when increasing temperature causes V_{IN} to exceed V_{AS}.

When the BDC fan is operating normally, brief commutation pulses are present on the SENSE input as each pole of the fan is energized. The TC646 uses the presence (or absence) of these pulses to detect a stuck, disconnected, or otherwise inoperative fan. If such a condition is detected, fan operation is suspended and a $\overline{FAULT}$ interrupt is generated. The $\overline{FAULT}$ output also is asserted (but fan operation is uninterrupted) if the voltage on V_{IN} is greater than required for full speed, indicating a bad fan bearing, blocked air intake, or system thermal runaway.

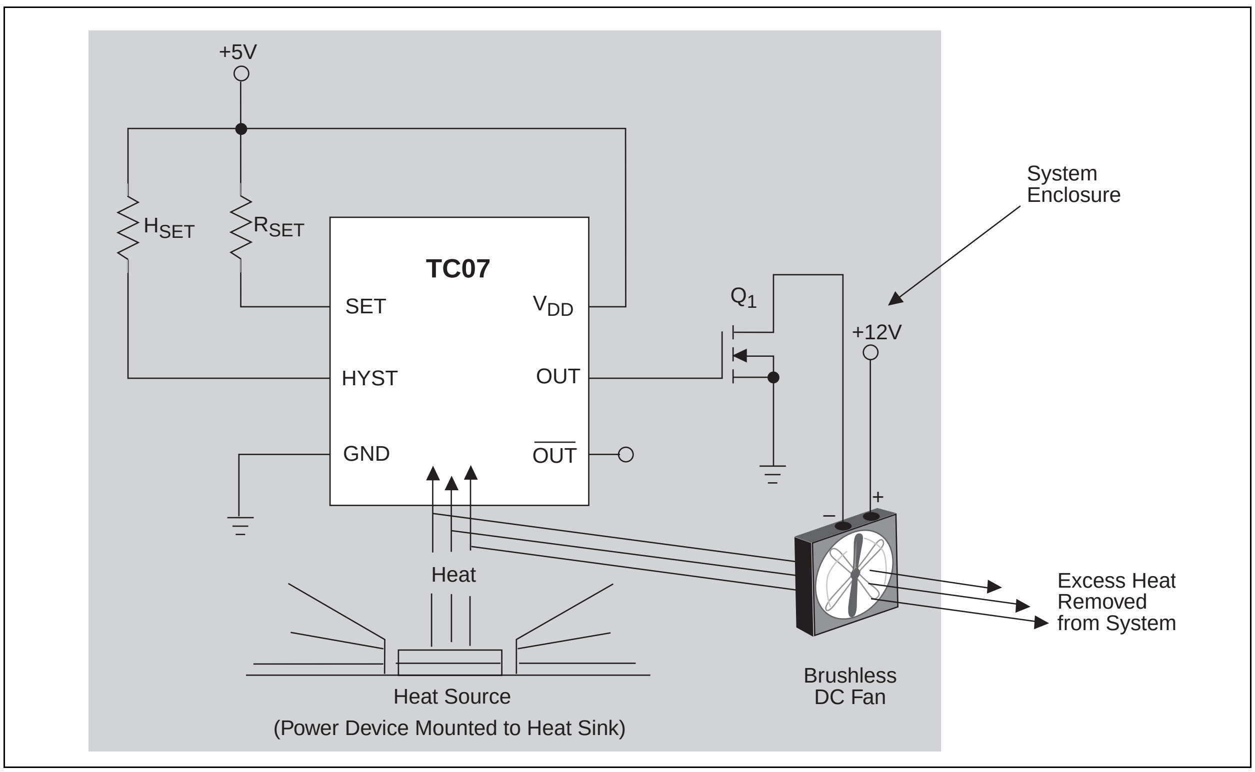

FIGURE 2: *Ambient Temperature Sensor*

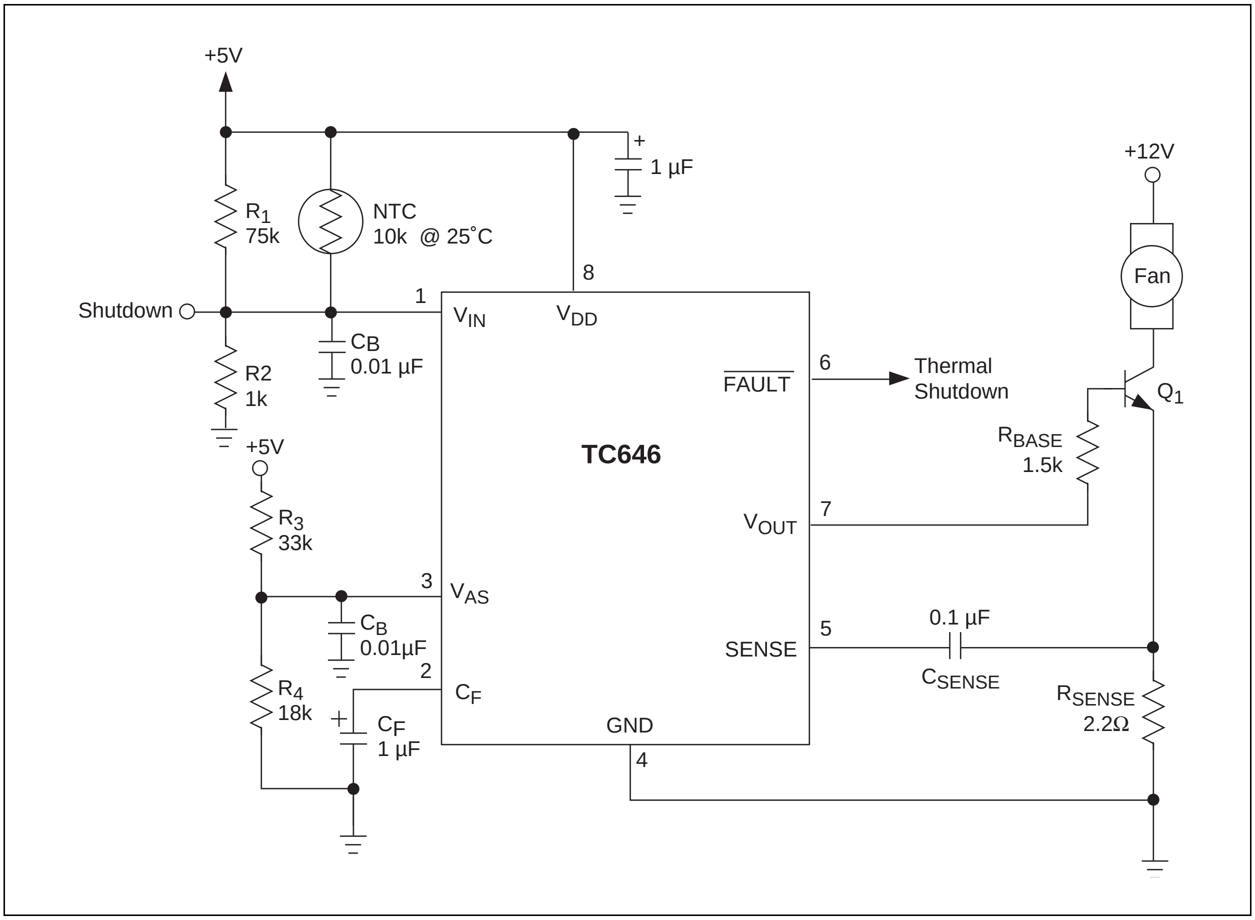

FIGURE 3: *Intelligent Fan Management*

SUMMARY

Thermal management is essential to safeguard systems from failure caused by sustained over-temperature conditions. Many thermal management strategies have proven effective in controlling heat generation and removal. Microchip's thermal management products, such as the devices discussed here, help designers implement these strategies effectively.

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