LM85

Autonomous Fan Control For Processor Systems Using The LM85

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Application Brief

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To lower cost, many embedded processor systems include a hardware monitor for rudimentary system diagnostics. This helps ensure that the right person is sent to fix the problem with proper replacement parts. The system diagnostics include detection of power supply over/under voltage, system fan malfunction, and system component overheating.

Many processor systems require fans because of the heat produced by the processor and other components. The noise from these fans can be a nuisance to users. Many methods can be used to control noise level, the most obvious being controlling the fan speed.

The LM85 hardware monitor includes three PWM outputs that can be used to control fan drive circuitry. In addition, the LM85 features the ability to monitor five different power supply voltages, four fan tachometer outputs, and one set of processor voltage regulator module VID outputs.

The PWM outputs can be automatically controlled using three different temperature zones. The temperature of two of these zones is sensed by two remote thermal diode connected transistors, while the third zone is the LM85 die temperature.

A system error can be determined by polling the LM85's status registers. The LM85 includes high and low-limit registers for all measured values. Comparison of a measured value with its high and low-limit automatically sets or clears a bit in the status register.

Figure 1 shows the typical connection of an LM85 in a system. The LM85 communicates with the system using a simple 2-wire serial interface that is compatible with the SMBus 2.0 interface. Note that one of the remote thermal diodes is on the processor die. This diode is the parasitic PNP found in all CMOS processes. This particular one has been characterized to work with the LM85. The diode thermal sensor can be implemented on any CMOS ASIC and made to work after careful characterization of the thermal diode.

For more information on the error sources when using diode thermal sensors see the archived seminar titled "Thermal Management for High-Performance Processor Systems" found at: **www.national.com/onlineseminar/**.

The PWM fan drive uses a simple 2N2222 NPN transistor. Since the LM85 has four tach inputs and only three PWM outputs, PWM3 is shared by two fans.

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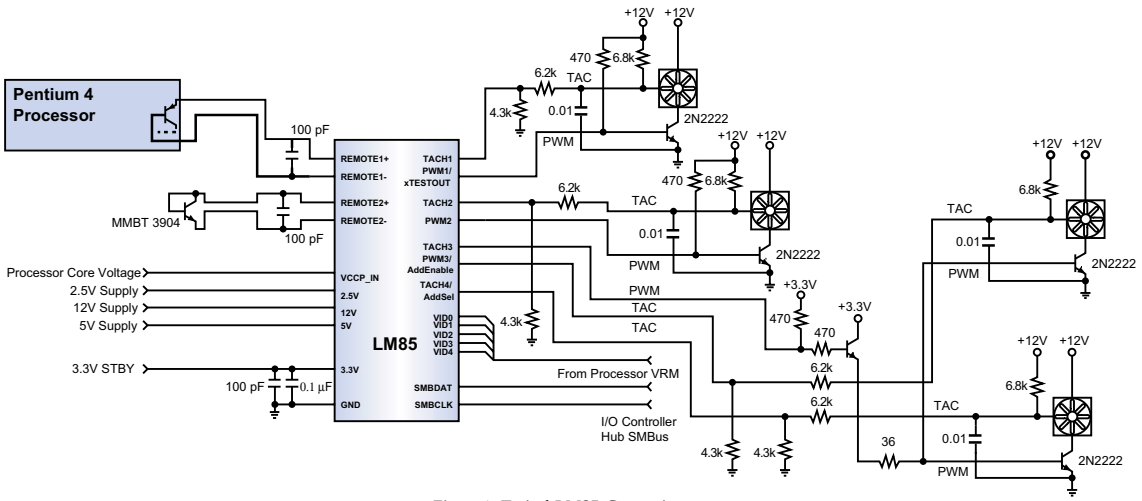

Figure 1: Typical LM85 Connection

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The only drawback of this circuit is that the voltage drop across the 2N2222 in saturation will cause a lower maximum speed on the fan because the fan will not see a full 12V. This can be improved by replacing the bipolar transistor with a MOSFET, but then the cost goes up. Placing a slightly larger fan in the system is another solution, and it will also lower the noise generated by the fan. Another issue crops up when trying to monitor the speed when using the fan's tachometer output. Chopping the power supply of the fan with the PWM output can also distort the tach signal, particularly at the high PWM frequencies and/or low duty cycles. Since the GND will be going to a very high impedance when the 2N2222 is turned off, at high PWM frequencies and/or low duty cycle the tachometer signal will get distorted. *Figure 2* shows what happens when the PWM frequency is too high. The top trace shows the PWM 2N2222 collector drive to the fan. The bottom trace is the fan's tachometer output.

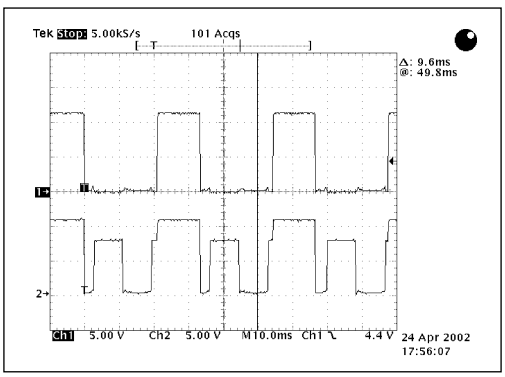

Figure 2: Fan Tachometer Output with PWM Fan Speed Control

The LM85 has two techniques for overcoming this problem. For example, when using a 30 Hz PWM frequency the minimum accurate speed that can be measured is approximately 2500 RPM. With the LM85's special circuitry, this is extended much lower, to approximately 420 RPM.

The LM85's autonomous fan control is based on a linear relationship between the measured temperature and a PWM output. The registers that are used for fan control are shown in *Figure 3*. The Fan Temp Limit sets the temperature at which the PWM output will start to increase. The Range sets the temperature at which 100% PWM is achieved. The PWM will change linearly from a minimum (set at Fan Temp Limit) to 100% (at Fan Temp Limit + Range). As temperature decreases, the PWM output will be at the minimum setting when the temperature reading is less than (Fan Temp Limit – Hysteresis). The minimum PWM can be set to any level. When the Absolute Limit is exceeded, the other two PWM outputs will be set to 100% duty cycle. Each PWM output can be assigned to any temperature zone, the hottest of one, two, or all three.

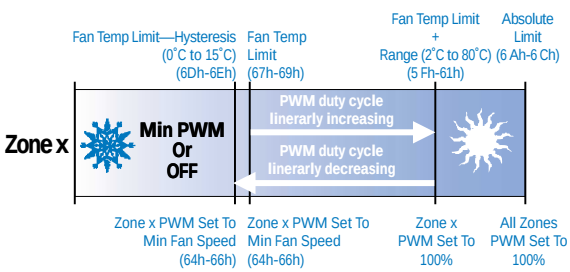

Figure 3: LM85 Fan Control Registers

Additional Information

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