AN764

Implementing Temperature-Based Variable Fan Speed Control in NLX Power Supplies

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INTRODUCTION

The NLX Power Supply Specification released by Intel® Corporation defines the requirements for next-generation PC system power supplies. There are several enhancements outlined in this specification as compared to the "old" PS/2 power supply form factor. One of these features is control and monitoring of the cooling fan(s) inside the NLX power supply. The NLX specification designates two interface fan control signals:

1. **FanM** signal is an output from the NLX-compliant power supply. This signal allows the host (typically a system management ASIC) to monitor fan RPM. FanM is an open-collector signal consisting of two pulses per fan rotation.
2. **FanC** is an input to the NLX-compliant power supply used by the motherboard to regulate fan speed and to shut the fan down. FanC is a 0V to 12V analog signal.

BRUSHLESS DC FAN BASICS

Brushless DC (BDC) fans are popular for cooling electronics and come in many voltage, current and CFM ratings. The most common versions in PCs are +5V and +12V. The nominal voltage rating is typically the input voltage at which the fan runs at approximately 100% RPM. Some fans have a third terminal that outputs pulses as a tachometer signal.

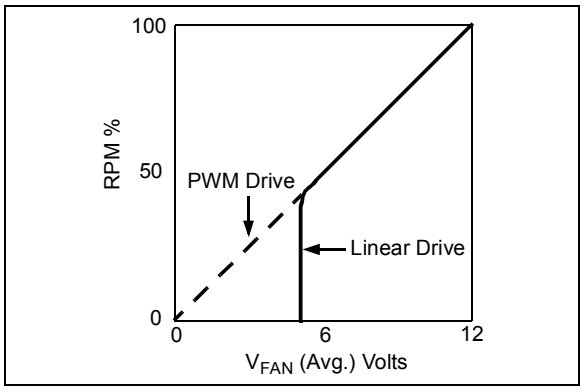

FIGURE 1: *Linear Voltage Control vs. Pulse-Width Modulation.*

1. **Linear Voltage Control:** This method varies the DC voltage at the V_{DD} terminal of the fan in a linear manner. For example, a +12V nominal fan modulated linearly to +8V would theoretically run at 66.7% RPM. Though this seems relatively simple, there are drawbacks. All BDC fans have a "stall voltage" that can vary from 35% to 60% of nominal voltage, making wide-range speed control impossible. Additionally, there is considerable start-up hysteresis after a stall, complicating matters further. Lastly, linear speed control is inefficient, generating excessive heat.
2. **Pulse Width Modulation**: This method applies the full DC nominal voltage to the fan, but only for a duty cycle that corresponds to the desired speed. The average energy delivered to the fan is, therefore, varied over a wide range and stall voltage is not an issue.

APPLICATION CIRCUIT

The application circuit using the Microchip TC646 is shown in Figure 2. Please refer to the TC646 datasheet (DS21446) for details on pin descriptions. The overall circuit can be broken down into five basic functional blocks, plus the TC646 itself:

1. **FanC "Y-Network" Input From Motherboard**: This section accepts the 0V–12 VDC signal from an NLX-compliant motherboard. The Y-network formed by R_{12}, R_1 and R_2 performs level shifting and range compression to match the 1.25V–2.65V analog input range of the TC646. The FanC signal indicates a shutdown request at or below +1 VDC. Above that, the signal is used for proportional fan speed control. If FanC becomes disconnected or is not present, the fan will be driven at full speed via the R_{13} pull-up resistor.
2. **Thermistor-Controlled Fan Override**: T_1 (thermistor 10 kΩ at 25°C), R_6 and Q_1 form the "thermal override function". This circuit provides a local override in the event of high ambient temperature. Under normal operation, Q_1 is off.
3. **Output Stage**: This section consists of the fan and its drive components: R_5, Q_2. The signal output from the V_{OUT} pin is a 30 Hz nominal 5 V_{p-p} PWM waveform. Q_2 is a 2N2222A small-signal BJT. The fan is driven to a full +12V (minus Q_2 saturation voltage).

4. **FanM Signal**: To fully comply with NLX specification, the power supply must provide a signal back to the motherboard (FanM). The NLX specification requires this signal to be an open-collector output from the tachometer of a 3-wire fan.
5. **Minimum Speed and Auto-Shutdown**: R_3 and R_4 form a divider network that defines the shutdown threshold of the circuit. This corresponds to the +1V NLX-specification for fan shutdown.

System operation is straight-forward: fan speed ranges from approximately 30% to 100% for a FanC voltage range of 1V to 10.5V. The fan will be held in shutdown when FanC is less than 1V. FanM is returned to the motherboard as prescribed in the NLX specification. FanM also is monitored by the TC646. $\overline{\text{FAULT}}$ is asserted if the fan fails to operate (see TC646 datasheet for details). Additionally, C_4 sets the 30 Hz PWM frequency and R_7 is the pull-up resistor for the $\overline{\text{FAULT}}$ output.

SUMMARY

The Microchip TC646 Fan Speed Controller allows a computer designer to implement a robust system-cooling design and be fully NLX-compliant. Additionally, the PWM control mode is superior to traditional linear control methods. The low cost of the TC646, and its supporting components, make it the ideal choice for high-volume applications.

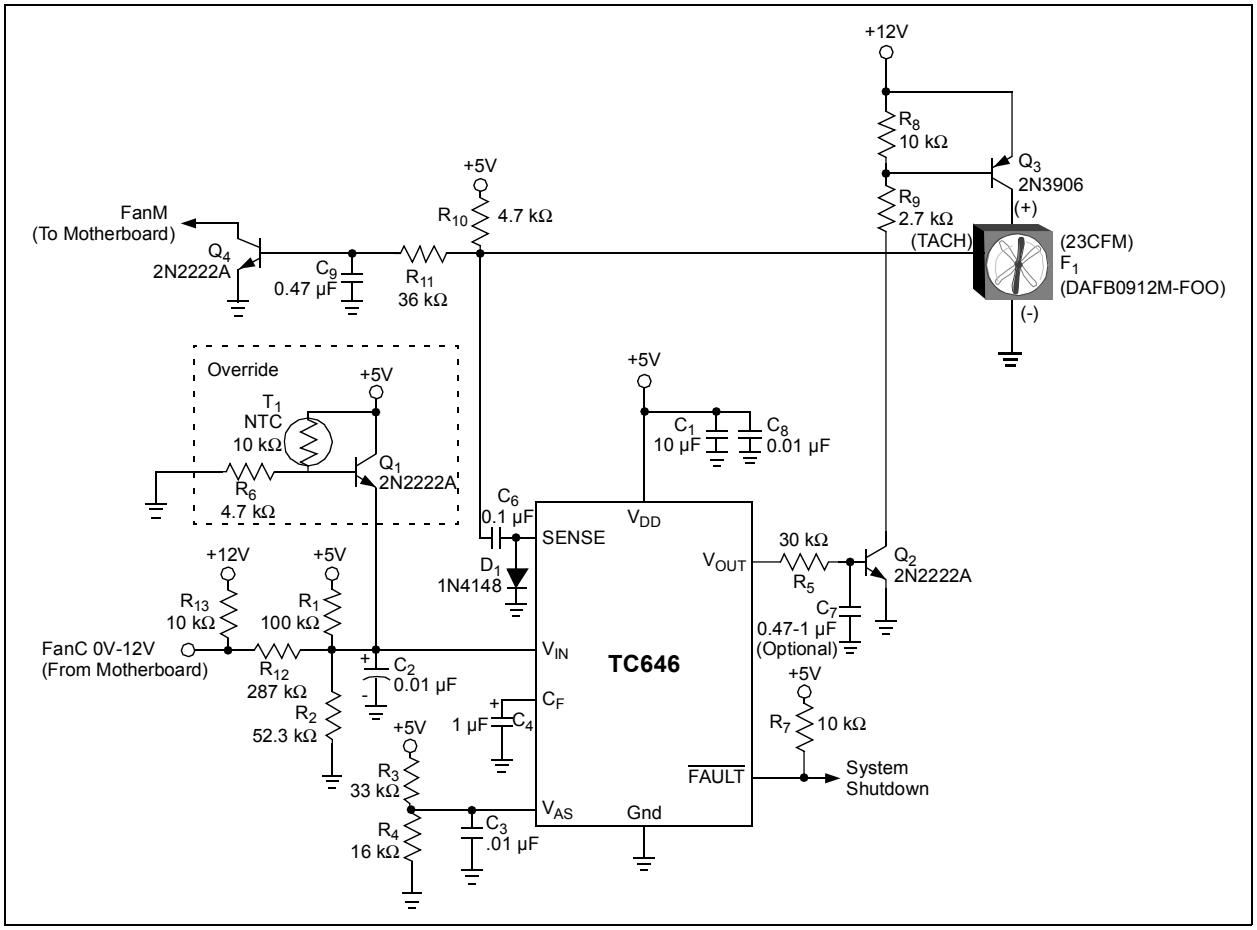

FIGURE 2: *BDC fan control for NLX power supply (3-wire fan).*

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