JMC

The Fan Company
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Microcontroller Fan

Prepared by

JMC Engineering

July 2013

Introduction:

New thermal cooling challenges need new and innovative cooling solutions. Controlling electronics temperatures is becoming more challenging as systems are becoming smaller, generating more power, requiring lower energy consumption and low noise emissions. The use of DC fans is still by far the most efficient solution to cool electronics enclosures. To be able to meet all the new challenges, the JMC engineering team developed an intelligent DC fan control and drive. This design incorporates a microcontroller inside the fan, enabling the fan to provide efficient power consumption, closed loop control, various alarms and speed feedback, health prediction and many additional safety features.

Standard Vs. Microcontroller fans:

Standard DC fans use an Application Specific Integrated Circuit (ASIC) for the control and drive of the brushless DC motor. Different ICs with various characteristics and capabilities are available from various semiconductor manufacturers, like On Semi, Diodes Inc, Rohm etc. These ASICs come in preloaded from the factory with all the commutation and protection needed to control and drive the motor.

In contrast, a microcontroller-based design has parameters that are defined by the DC fan designer. This allows custom tuning for the drive and control of the motor in order to reduce power, eliminate spiking of the drivers' output, and offer additional protection and alarm signals.

Using a microcontroller in a DC fan versus an ASIC motor controller offers the following advantages:

- Achieve higher speeds and performance with lower power consumption: Because it is software driven, the switching times are controlled by the designer. Current and voltage spikes can be eliminated by choosing switch times efficiently. This allows the use of lower voltage rated drivers, which provide low ON resistance that minimizes voltage drops and thus lowers power consumption in the driving circuit. This is in contrast to an ASIC solution where the commutation timing is already fixed and implemented by the manufacturer.

- Superior electrical specifications: Soft start, current limit, low current and motor temperature in locked rotor operation.
  When it is first energized or when it is locked, a standard DC fan will draw a large amount of current, which can expose internal electronics and external power supplies to over current and voltage stress. In a microcontroller DC fan, a starting delay and starting ramp is programmed into the control software.

- Wide range of Auto-Restart ON/OFF times: In An ASIC solution, the Auto restart ON/OFF times and frequency are either fixed by use of a capacitor in the chip itself or by an external capacitor. Wide ranges of auto restart frequency are then limited by the space available within the fan PCB. In a microcontroller-based fan, those times are set by software and digital counters.

- Easy to maintain and upgrade: The flexibility of the microcontroller allows many features to be easily implemented with changes in the firmware.

- Communication interface capability (future release): A microcontroller fan can be equipped with a communication Bus like the I2C/SM bus to allow transfer of commands and data between the fan and the system mother board or between the fan and other fans in the system.

Novel features

On top of all the characteristics listed above, JMC's microcontroller fans come with two additional JMC features:

- **Closed loop PWM control – Speed Stabilization (Available Now)**

  This enables the fan to maintain its PWM to RPM relationship regardless of the fan's operating static pressure or power supply voltage levels.

  A block diagram illustrating the closed loop PWM control is shown in figure 1 below.
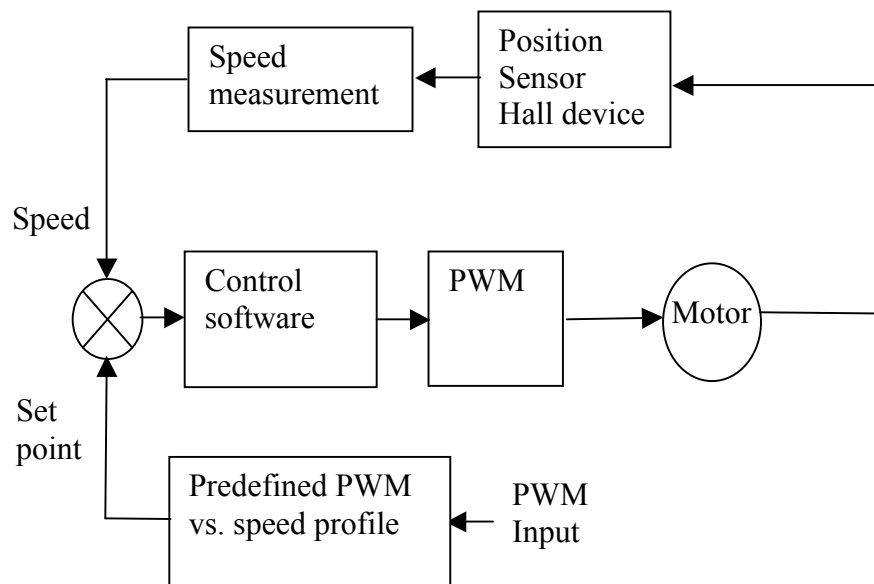

Figure 1: Closed loop PWM diagram, Fan speed regulation

Figure 2 below shows a PQ curve of a microcontroller fan where speed is constant regardless of the pressure applied while figure 3 shows a PQ curve of a standard fan where the speed changes with pressure.
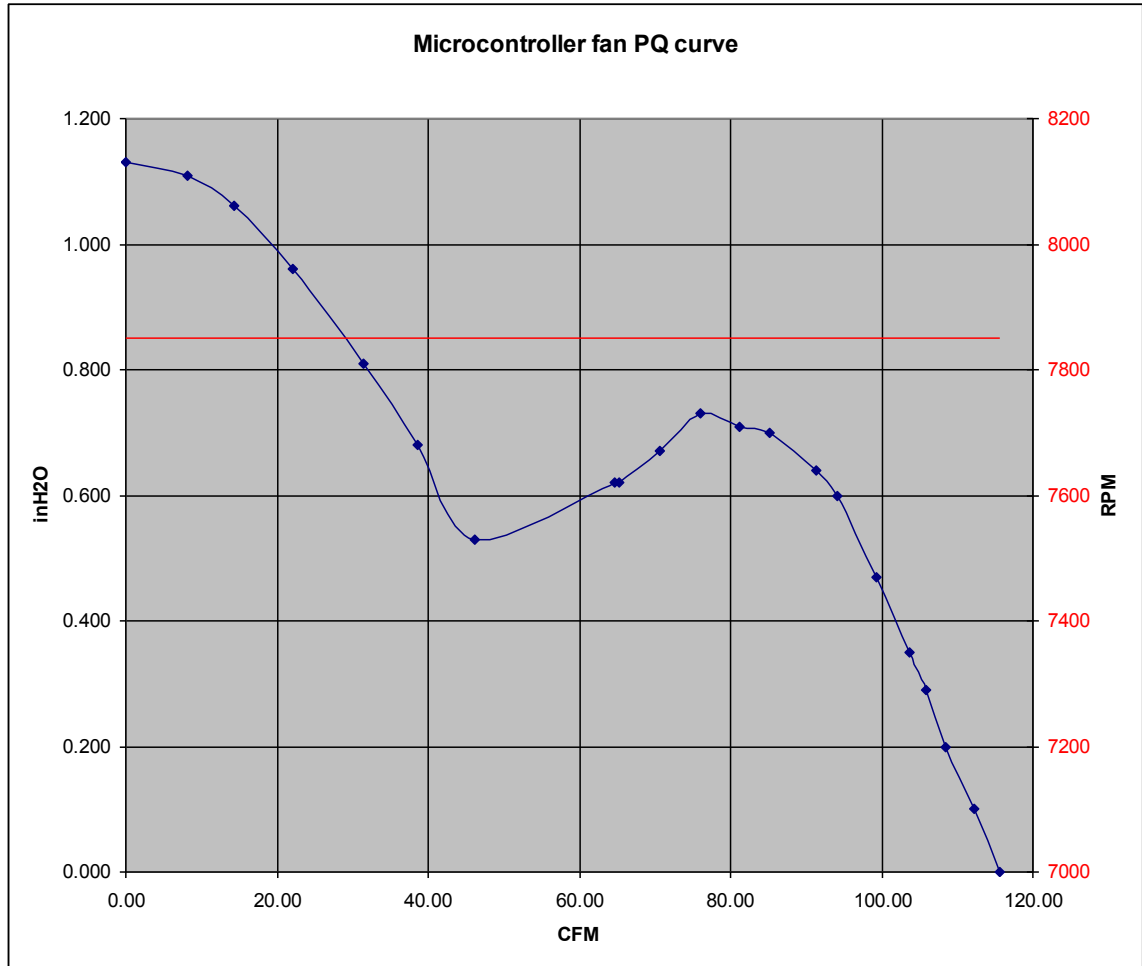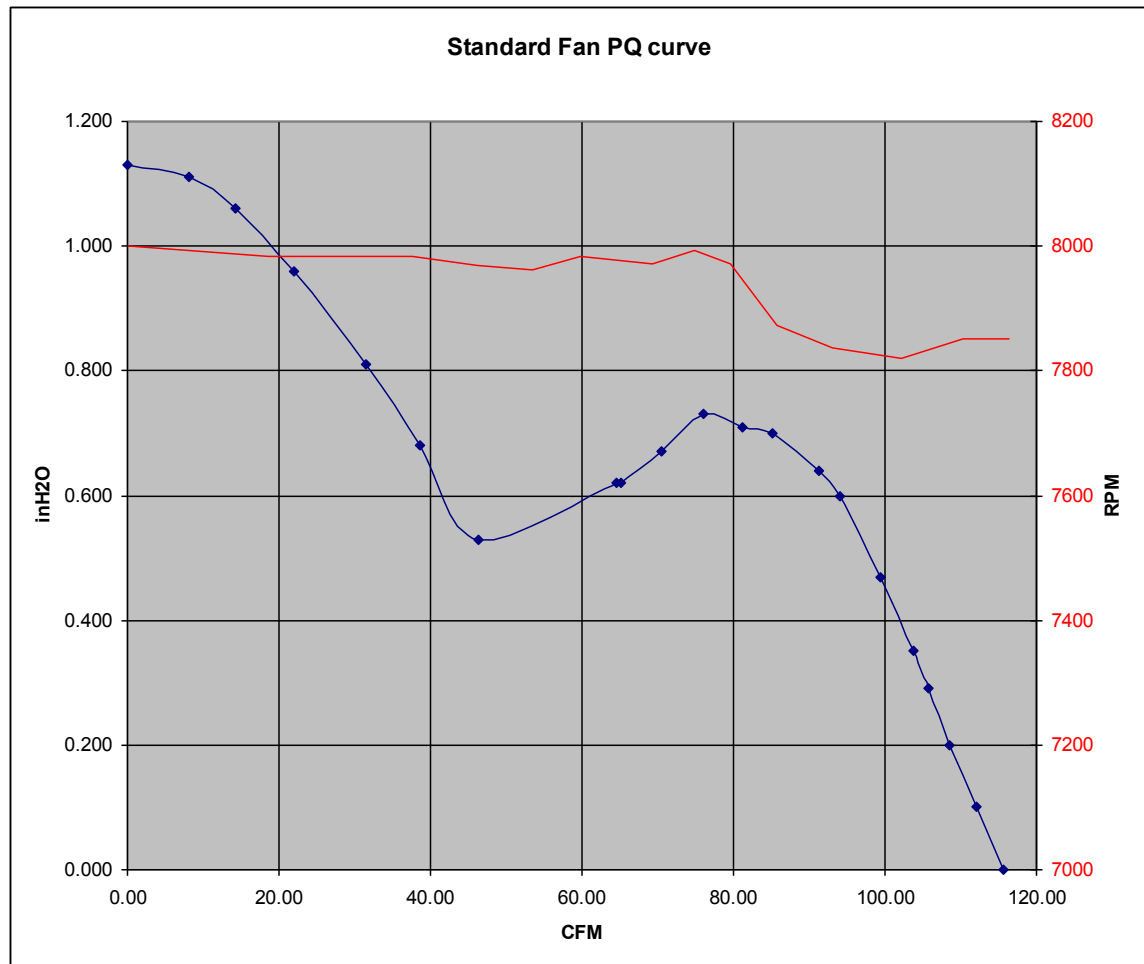

Figure 2: PQ curve of a microcontroller fan

Figure 3: PQ curve of a standard fan

- **Fan health monitoring - Predictive wear-out (future release)**

  In systems that require maximum reliability, such as servers and network equipment, it can be advantageous to predict fan wear-out, alerting the system before wear-out occurs, thus minimizing down-time and increasing reliability. Preempting fan wear-out is achieved by performing an RPM and current test to compare against a predefined percentage of fan RPM and current specification to detect early bearing wear-out then alerts users when fan crosses performance

thresholds. Predicting fan wear-out is also accomplished by keeping count of fan service hours (Time ON) and/or total number of revolutions (RPM life), the fan then sends an alert signal when a predefined life time is reached.
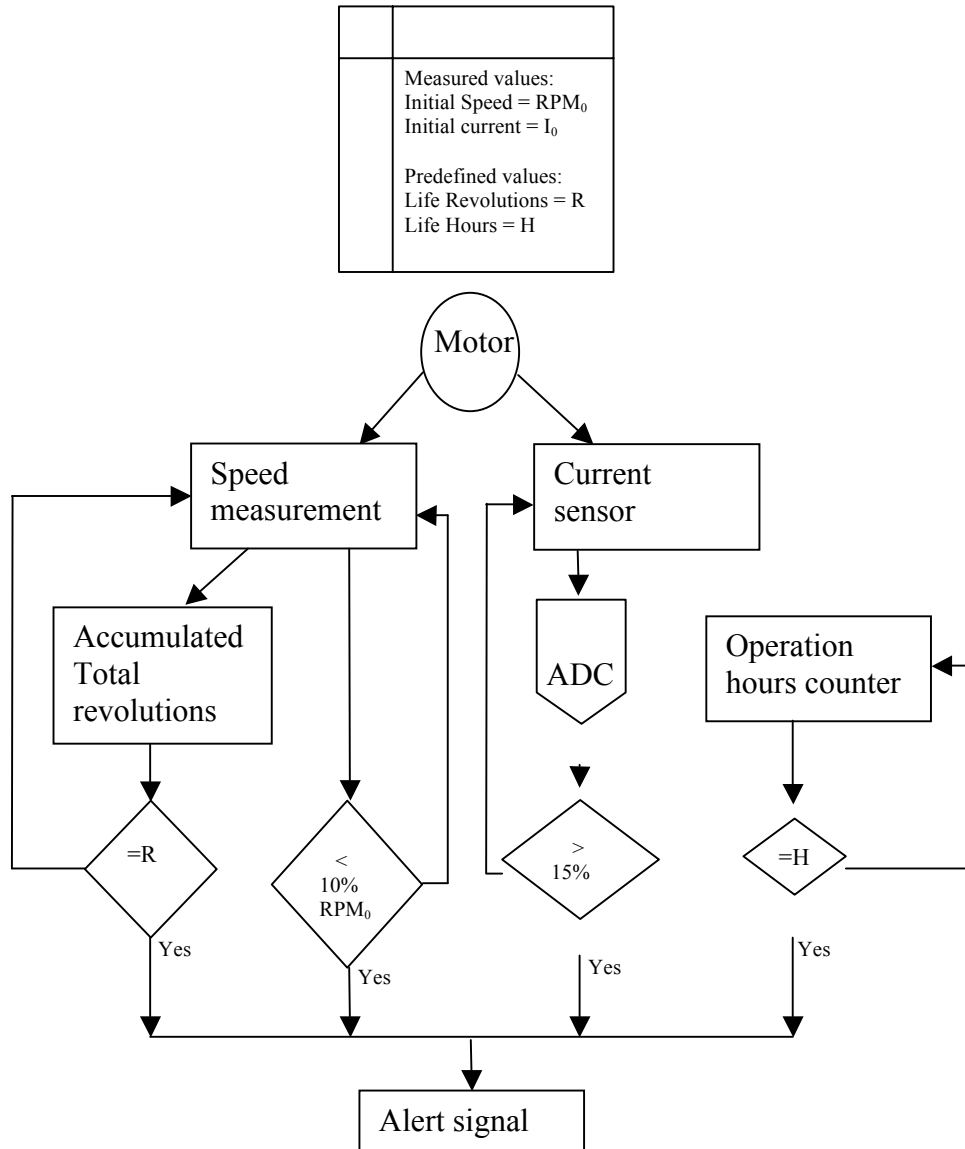
A flow chart describing this feature is shown in figure 4

Figure 4: Fan Health monitoring