New DC Motor Drive Method Reduces Cost while Improving Performance

Billions of small electric motors are sold and put into service each year. Together, they consume multiple megawatt hours of electricity. Many of those motors do not run very efficiently and expire before their full life expectancy has been reached, because of the methods used to drive them and control their speed. More efficient motor drive and speed control techniques could be an excellent opportunity to save energy, especially if their implementation realised cost, size and weight reductions as well. **John Jovalusky, Power Integrations, San Jose, USA**

One of the most common uses for small electric motors is driving fans. Many fans are driven at constant speeds by AC motors. This wastes power, particularly if lower speeds could be used whenever full speed is not required. When AC motors are speed controlled, Triac drivers are often used. When controlling fan speed, Triac-driven AC motors do not operate as efficiently as equivalent DC motors, which can be seen in Figure 1.

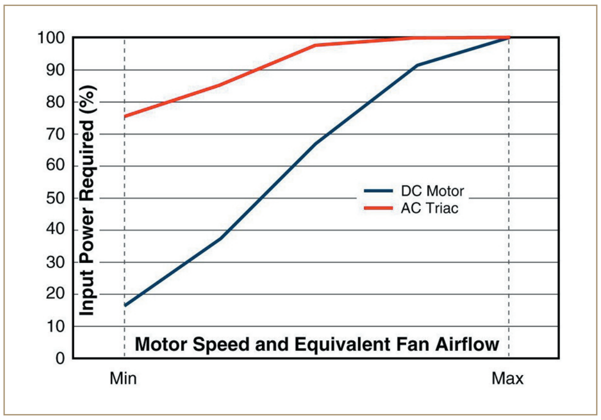

Figure 1: Comparison of AC Triac versus variable DC voltage motor speed control methods that shows the power required by each for a wide range of equivalent motor speeds and fan airflow

However, the most commonly used techniques for driving DC motors and controlling their speed requires large, heavy power supply and speed control units. For instance, the simplest type of drive uses a linear power supply and a chopper circuit for speed control (see Figure 2a). Linear power supplies are inefficient and require bulky, mains transformers, which have increased in cost, due to the amount of copper they contain.

Replacing the linear with a smaller, lighter and more efficient switch mode power supply (SMPS) would be an improvement, but the chopper circuit would still be required for motor speed control.

Up until now, the size and weight of these simple DC motor drive circuits have generally made Triac-controlled AC motors more desirable. However, in March 2006, Power Integrations (PI) announced a new highly integrated power conversion IC family, the PeakSwitch, that promises to improve performance while reducing the size, weight and cost of AC/DC motor-drive/speed-control units. PeakSwitch has a 700V power MOSFET, control and protection circuitry all integrated onto a single, monolithic chip.

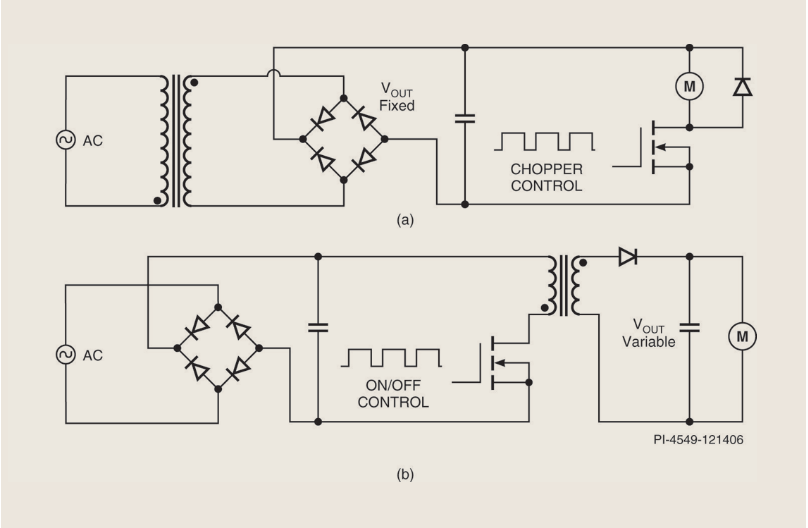

Figure 2: Typical approach for driving small, DC motors at variable speeds (a), the proposed, single-circuit approach reduces component count and improves operating efficiency (b)

With this new IC, the normally separate power supply and DC motor speed-control functions can be combined in one circuit. The PeakSwitch based SMPS replaces the linear supply, and its control scheme enables motor speed control to be easily and cost-effectively implemented within the power supply (see Figure 2b), which eliminates the chopper circuit. This not only reduces the component count, cost, size and weight of the entire

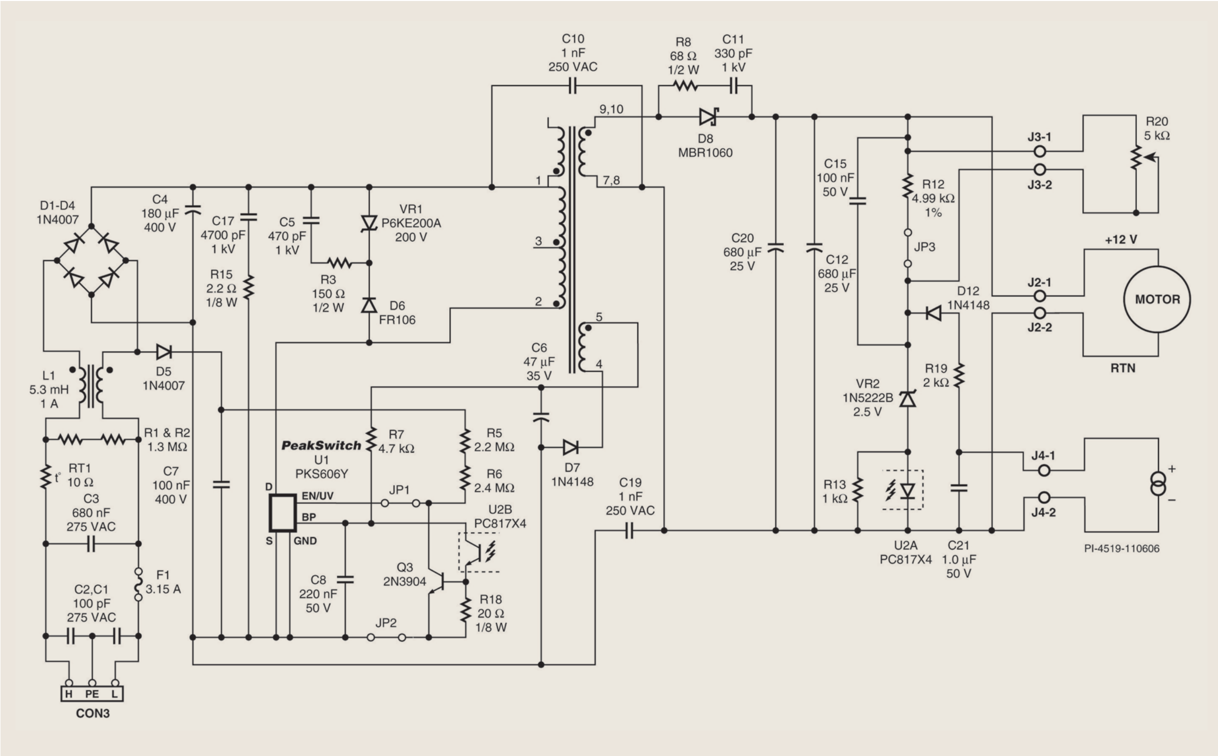

Figure 3: **A typical PeakSwitch based switched mode power supply designed to power and control the speed of a small DC motor**

solution, but also improves its overall efficiency.

The current required to accelerate a motor from standstill is typically much higher (two to three times) than that required to run at a constant speed. A pulse-width modulated (PWM) power supply that can deliver the high, peak load currents typically requires an over-sized transformer and capacitors. The ON/OFF control scheme used in the PeakSwitch skips switching cycles, which makes its effective switching frequency vary according to the load demand. By designing the supply so that it delivers the continuous load at about a third of the IC's maximum switching frequency (277kHz), it can supply peak power pulses of up to three times the continuous rated power from a transformer and capacitors that are only sized for the continuous load delivery.

Performance improvement

In the DC motor power supply shown in Figure 2a, the power supply provides a constant voltage higher than that required by the motor. The motor speed is controlled by adjusting the duty cycle of the chopper circuit. Although this technique has been used for many years, it has drawbacks. The chopped motor current generates EMI, increases temperature rise within the motor (versus being driven by a constant DC voltage), can produce audible noise, and can reduce the useful lifespan of the motor. These issues are compounded in stepper motors which often have four windings and require four chopper circuits.

The PeakSwitch supply avoids these issues by supplying a DC voltage to the motor. Speed control is accomplished by simply varying the output voltage of the supply.

The IC regulates the output of the supply based on the signal on its EN/UV pin (Figure 3). The feedback loop is closed by an optocoupler (U2) that delivers a signal, derived from the output voltage, to the EN/UV pin of the IC (U1). A low-voltage control signal is used to adjust the output voltage sense and feedback circuit. Likewise, a small potentiometer can be used to implement manual motor speed control.

The PeakSwitch control scheme not only enables peak power delivery, but also provides consistently high efficiency across most of the supply's load range (see Figure 4). When load demand is very low, most switching cycles are skipped, which results in low standby power consumption and relatively high efficiency.

Conclusion

The linear supply and chopper method of driving and controlling the speed of DC motor driven fans has made them less attractive than fans driven by AC motors. A PeakSwitch based solution can drive a DC fan motor more efficiently than a linear/ chopper solution can. It uses fewer components and results in a smaller, lighter and lower cost solution. Growing energy efficiency awareness and the benefits of the PeakSwitch solution should cause engineers to reconsider using DC motor driven fans as a way of lowering cost, while reducing the energy consumption of their applications.

Figure 4: **Efficiency curve of the PeakSwitch based DC motor drive circuit shown in Figure 3**