Brushless DC Fans

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Brushless DC fans are usually available at three nominal voltages: 12V, 24V and 48V. If the system has regulated power supply in one of these, then a brushless DC fan may be selected which will give the exact performance required, regardless of the AC input variables which plague AC fans.

Because the speed and airflow of a typical DC fan is proportional to the voltage supplied, a single product may be used to meet different applications by setting the supply voltage to what will give the desired airflow.

Figure 1 describes that result of varying the DC voltage supplied to a given fan. If, for example, a fan supplies 110 CFM of air at free delivery, 28V may yield 127 CFM, should that be needed. On the other hand, 24V operation may provide too much flow; the supply voltage might then be reduced to a level that yields the desired airflow.

The voltage range that may be applied to the fan to assure satisfactory operation is dependent upon the individual fan design and may be as small as 10-14V for 12V units and up to 12-56V for 48V units.

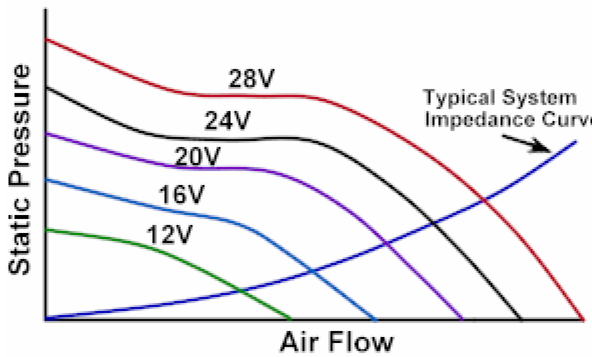

Figure 1: Results of Varying DC Fan Voltage

Current

Brushless DC fans do not draw constant currents. The choice of the power source along with the addition of other peripheral devices will be affected by the type and number of DC fans and their motor current characteristics. Throughout the rotational cycle and particularly at commutation, the currents will fluctuate from minimum to maximum.

The wave form and level of ripple current will vary significantly between fans and motor designs, marking specifications in narrow terms difficult. An understanding of the power source limitations and how they may be impacted by various brushless DC fans early in the design phase will help prevent problems and allow maximum system flexibility.

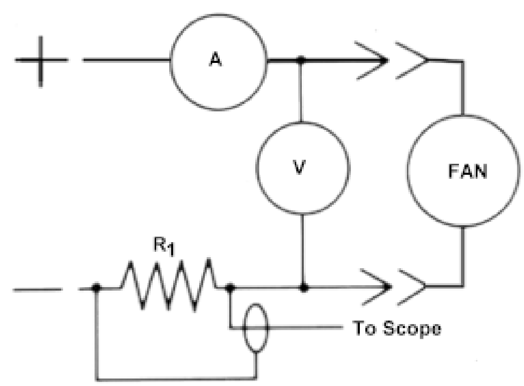

Figure 2: Measurement Circuit for Fan

Current ripple may be analyzed by wave form measurements using a laboratory-quality oscilloscope and a suitable series resistance (R_1), typically 1 ohm. Note that the current excursions vary from a minimum of 20 mA to a maximum approaching 800 mA while the motor is in a running condition. See Figures 2, 3, and 4.

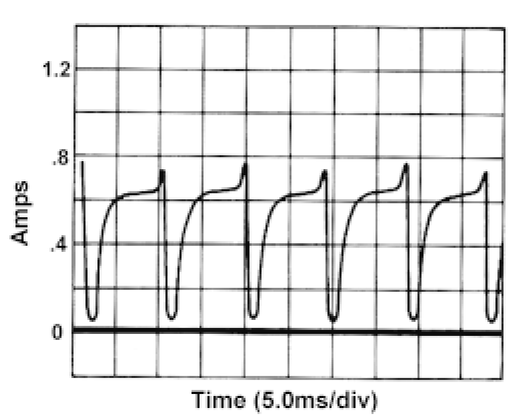

Figure 3: Current Ripple of DC Fan Motor

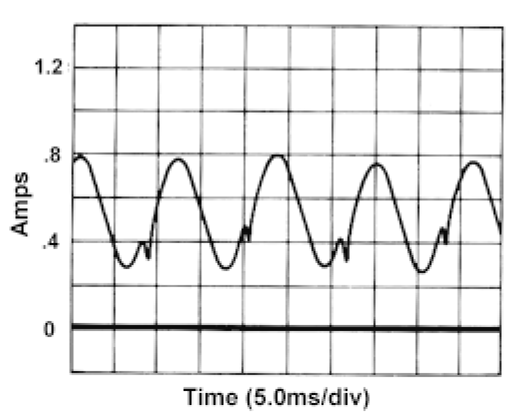

Figure 4: Alternate Motor Design Current Ripple

Measuring Running Current

The use of a lab-quality digital multimeter to measure the DC running current will present a small error due to the AC ripple component of the DC motor. While the measured DC current value is an acceptable indicator of running measurement would be to measure the current's true root mean square (TRMS), i.e., to measure both the AC and DC current components. For example:

$$TRMS = (DC^2 + AC^2)^{1/2}$$

Peak Starting Current

The peak in rush/peak starting current of a brushless DC fan typically will be a function of circuit resistance and power resource. However, many brushless DC fans incorporate additional filter capacitance for electromagnetic interference (EMI) suppression. Depending on the circuit location, the capacitance may represent a very high instantaneous in-rush current spike. Figure 5 represents the effect of a 47 µF aluminum electrolytic capacitor across the input of a brushless DC fan.

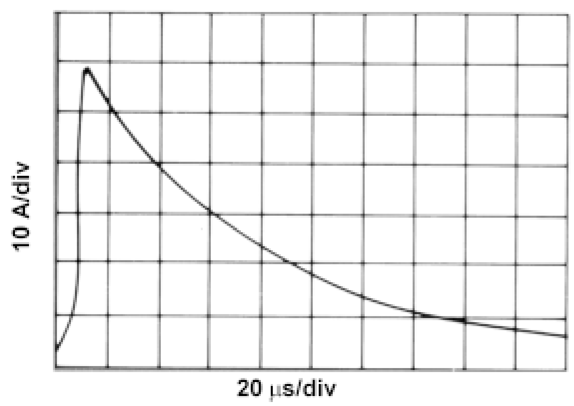

Figure 5: Typical Peak Starting Current

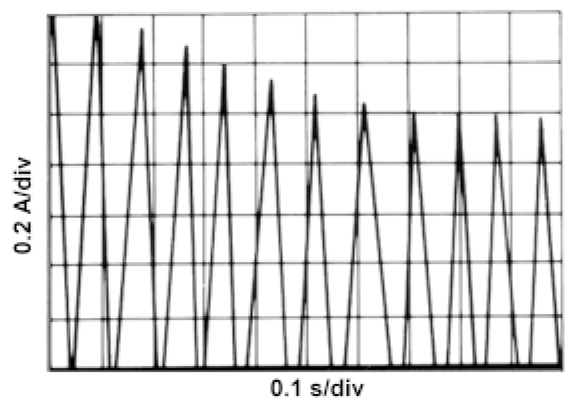

Figure 6: Peak Starting Current Less Capacitor

Measuring the peak starting current of a brushless DC fan requires that the motor stator be at ambient room temperature prior to the application of power, the rated operative voltage selected and the storage oscilloscope set to trigger on the leading edge of the current wave form using the test of the current wave form using the test circuit shown earlier. Figure 6 illustrates the peak starting currents upon application of power to the brushless DC fan in Figure 5, less the 47 µF filter capacitor. The peak currents are one-quarter of Figure 5.

Current Limiting

The power supply limitations must be considered when DC fans are used. Many power supplies incorporate current limiting current fold-back, or current shutdown protection circuits. Knowing the peak starting currents and maximum ripple currents during motor operation is essential in determining the power supply reserves necessary to maintain other peripherals which may be sharing the same power bus, and to avoid nuisance problems associated with the power supply protection circuitry. Depending on the size and design of brushless DC fan motors, the ratio of peak starting current to running current can be quite large, eg., 4:1 or 5:1. To overcome the stress that would be placed on the power supply, many brushless DC motors incorporate a form of current limit, usually linear of pulse width modulated (PWM). With current limiting, peak current draw typically will be limited to values of 2.5 to 1 or less, as shown in Figure 7. The limiting of current to the brushless DC fan motor will also limit the starting torque of the motor, which will extend the time needed for the fan to reach full speed.

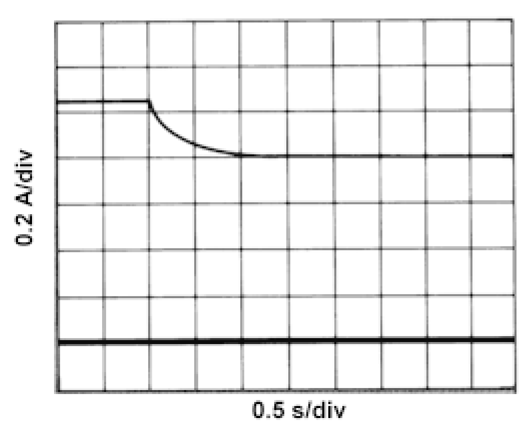

Figure 7: Peak Starting Current w/ Limiter

Since DC fans have much higher starting torque that their AC counterparts, the time to reach full speed with the use of current limit will be less than equivalent AC models.

When operating more than one fan on the same power bus, the imposed ripple current can become significantly more complex as the currents of each fan add and subtract with each other. Figure 8 illustrates the running current of three fans sharing the same power bus. Under certain operating conditions, this complex ripple current could pose a potential for interference within the system. Bus isolation filtering may be required to assure adequate buffering.

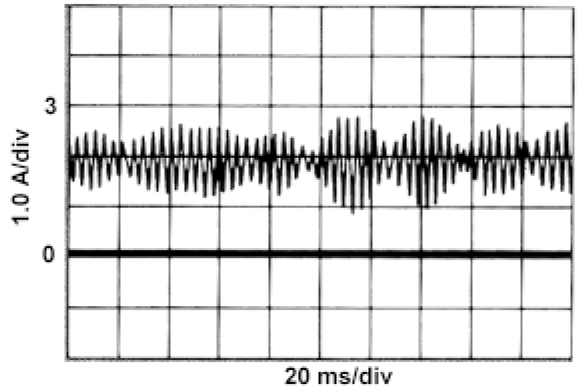

Figure 8: Current Ripple of Multiple Fans

Ripple Current

In brushless DC fans, ripple current is a function of the motor design, electronic switching circuitry, operating voltage and current. The motor does not represent a constant load and may vary considerably from I_{AVG} as seen in Figure 9.

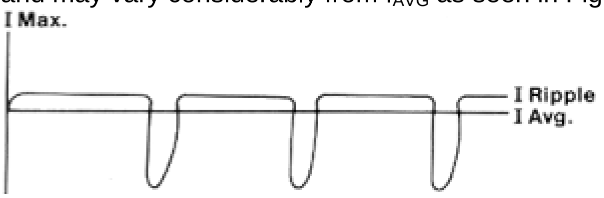

Figure 9: Typical Ripple Current

Figure 10 describes various methods of dealing with motor ripple current.

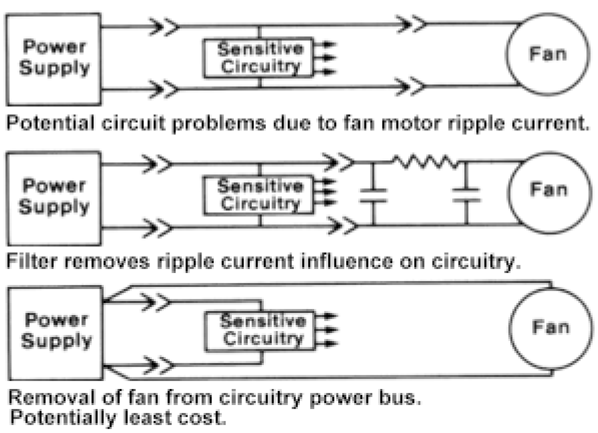

Figure 10:
Methods of Dealing w/ Motor Ripple Current