Safe Startup of Brushless DC Fan with TPS2592A eFuse

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ABSTRACT

This application note describes the problem of an inrush current of the DC brushless fan during start up, and explains how this undesirable huge inrush current is lowered to be within the acceptable limits by using TI's TPS2592A e-Fuse. Bringing inrush current within safe limits helps the designer to achieve a low-cost solution.

Brushless DC fans have been an effective and easy method of cooling power electronic circuits. Brushless DC fans having the advantage of small size and high reliability are used extensively in many new applications. Because the speed and airflow of a typical DC fan is proportional to the voltage supplied, a single product can be used to meet the different applications by setting the supply voltage to provide the desired airflow. Brushless DC fans do not draw constant DC currents even under a steady state condition.

When designing the electronics that interface to a DC brushless cooling fan, it is critically important to be aware that brushless cooling fans draw substantially higher inrush current than steady state running current. The choice of the input power source and energy storage to support the inrush current drawn is affected by the type of DC fans and its motor current characteristics. To meet the large inrush current, demand of the cooling fan designer is generally left with choices such as using the oversized DC power supply which does not cause the voltage drop while the fan draws the inrush current, and selecting a driver that can safely handle the large inrush current or installing adequate current limiting – which is not the desired solution from a system cost and reliability view point.

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1 Steady-State and Inrush Current Drawn by the Fan

A brushless DC fan (Delta Model–AF0612DE) is considered for this experiment. The fan is rated for 1.8 A at 12 V, but when this is directly connected (Figure 1) with a 12-V DC power source, the fan draws huge inrush as shown in Figure 2.
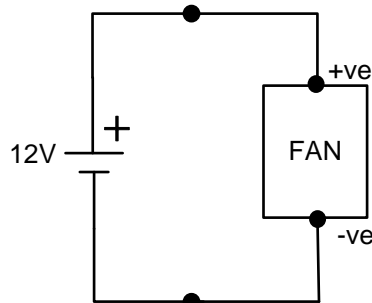

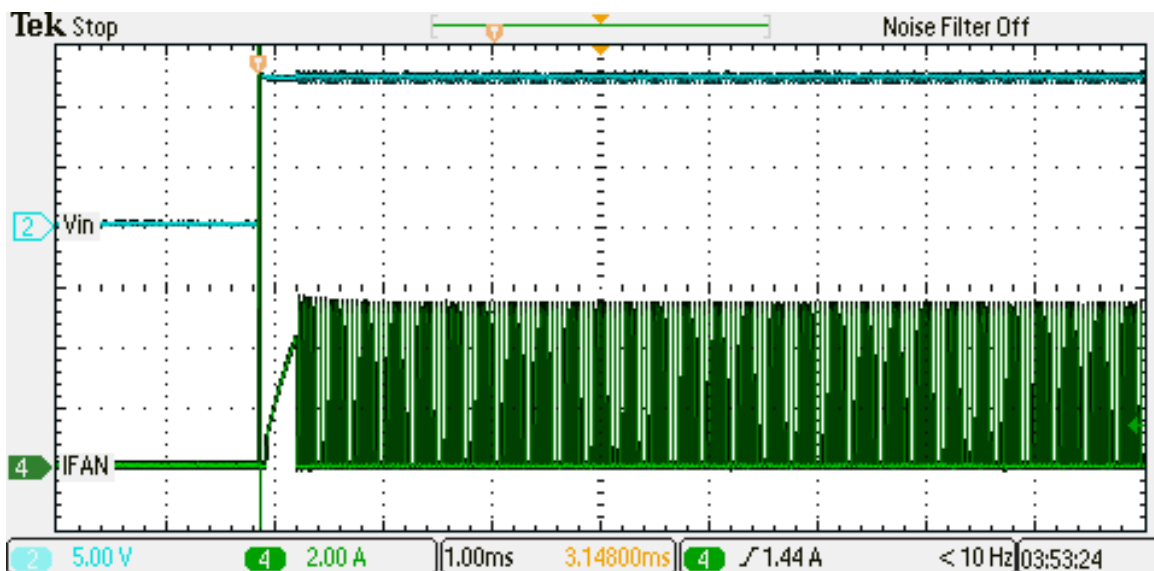**Figure 1. Direct Connection of Brushless DC Fan with 12-VDC Power Supply**

Figure 2. Start-Up Inrush Current of Brushless Fan (AF0612DE)

The zoomed version of Figure 2 is shown in Figure 3, which shows the peak current value drawn during start-up time. It is clear from these waveforms that inrush current is much higher (> 5.5 A) than the average-run current (1.8 A). Actually, the ratio of inrush to average-run current is 3.
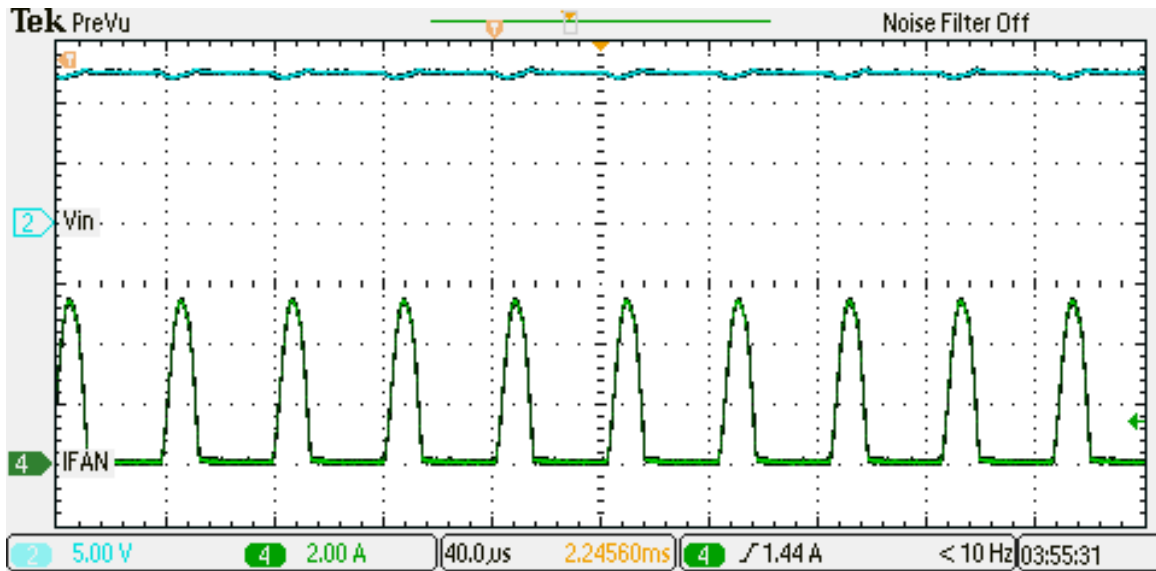
Figure 3. Zoomed Inrush Current Waveform Shows > 5.5-A Peak Current

Also, start-up to steady state operation of the fan is shown in Figure 4. This shows that it this takes approximately 750 ms before the fan reaches its final speed, and the fan current comes to the final settling value.
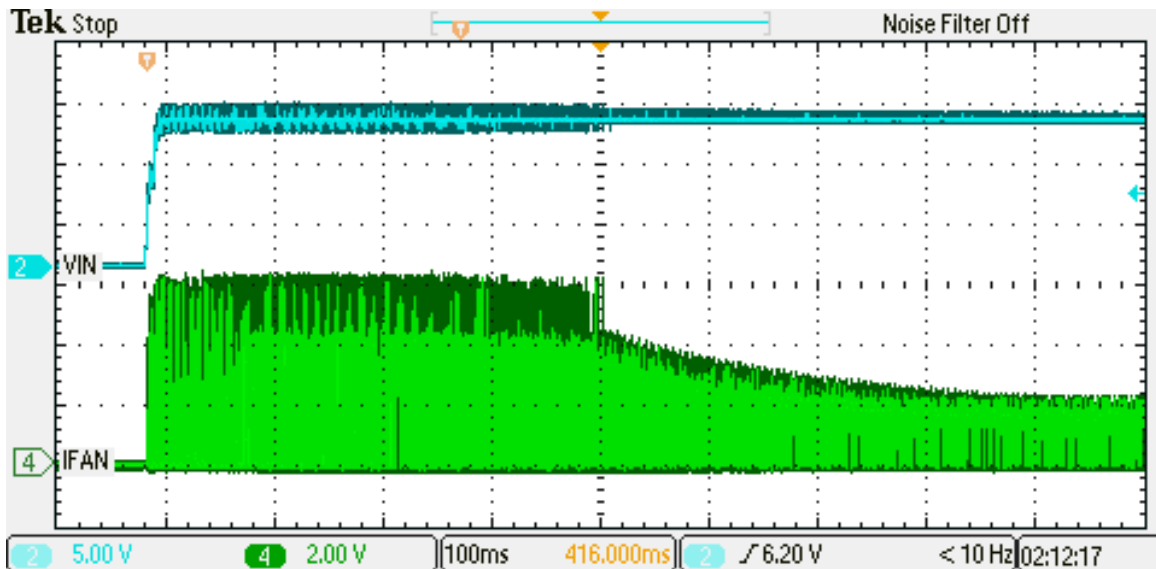

Figure 4. 5 Fan Start-up to Steady–state Operation When Directly Driven with a 12-V Source

Figure 4 also shows that the fan continues to draw more than 5-A peak current until 400 ms. These times and current limits are compared later in this document when the fan is operated with the safe start-up technique.

When the fan attains full speed, its current comes down to the steady-state value and its waveform is shown in Figure 5.
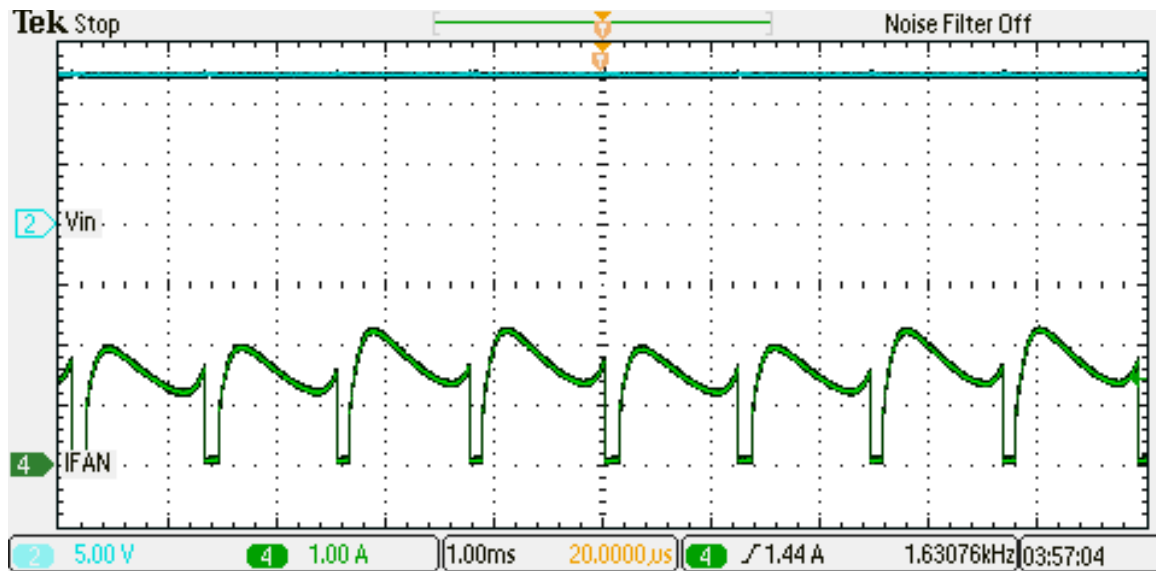
Figure 5. Steady-state Current Waveform Brushless Fan (AF0612DE)

High inrush current comes with some system-level disadvantages:
- Expensive, high-current rated connectors are needed to support huge start up.
- The PCB traces can burn or get weaker over time.
- May require a larger input capacitor to feed inrush demand, if the input DC source is not capable of meeting the demand.

2   Cooling Fan Inrush Current Control by Using TPS2592A

All disadvantages and issues (previously discussed) caused by the higher start-up inrush current of the fan are addressed by using the simple and low-part-count application circuit shown in Figure 6, which is used between the 12-V input supply and the fan to be controlled. TI's TPS2592A is used here to control the inrush current flow into the cooling fan. The resistor R_{ILIM} sets the limit on the maximum current allowed from input to output. In this case, the current limit is set to 2.5 A.
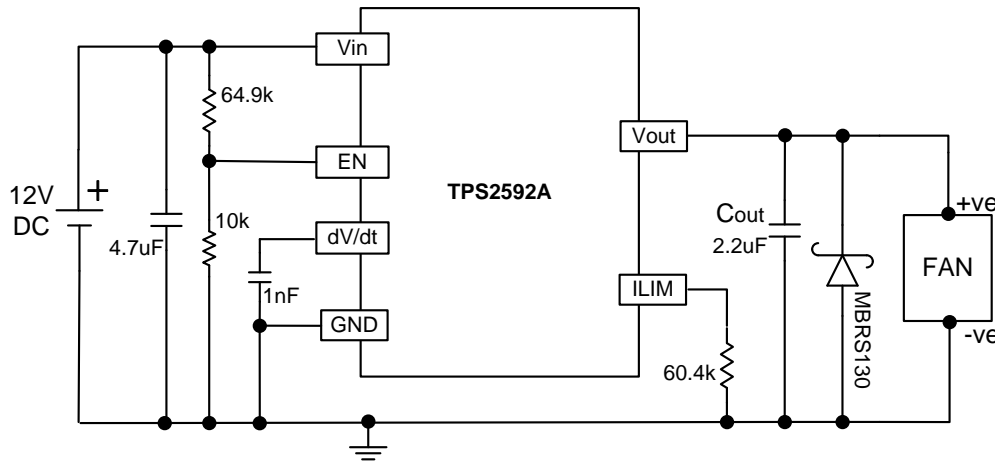
Figure 6. Typical Circuit Diagram with TPS2592A for Safe Start-Up of Fan

When the fan was ran through TPS2592A, the input voltage and fan current behavior is depicted in Figure 7. This shows that the TPS2592A controls the inrush current to nearly steady-state running current without drawing any unwanted current peak.
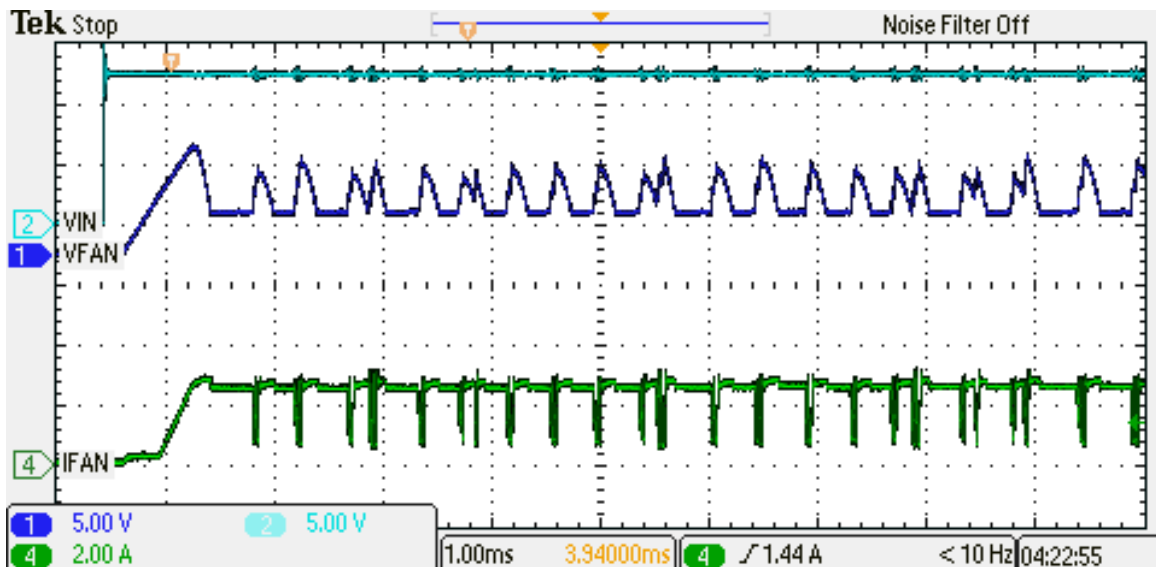
Figure 7. Fan Input Voltage and Startup Current with TPS2592A

Figure 8 shows the steady-state fan current waveform when it is driven through the TPS2592A. This shows that the TPS2592A does not impact the fan performance under normal operation.
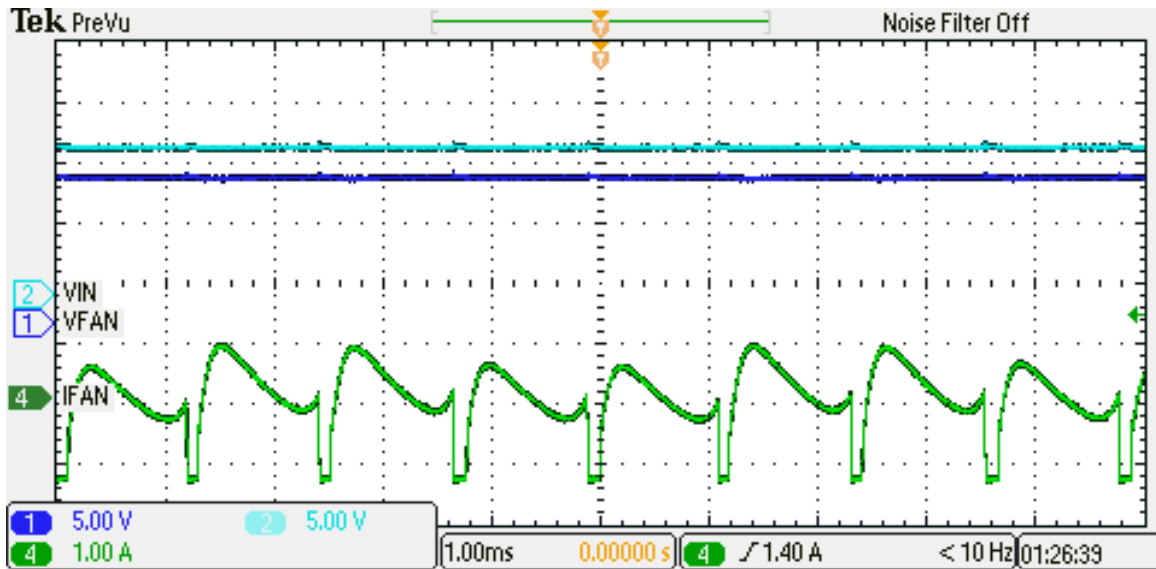
Figure 8. Steady-state Fan Current Waveform with TPS2592A

Again start-up to steady-state operation is shown in Figure 9 when the fan is driven through the TPS2592A. Since the fan start-up current is limited to 2.5 A, the time fan takes to achieve the final speed and settling current is larger (≈1200 ms) as expected.
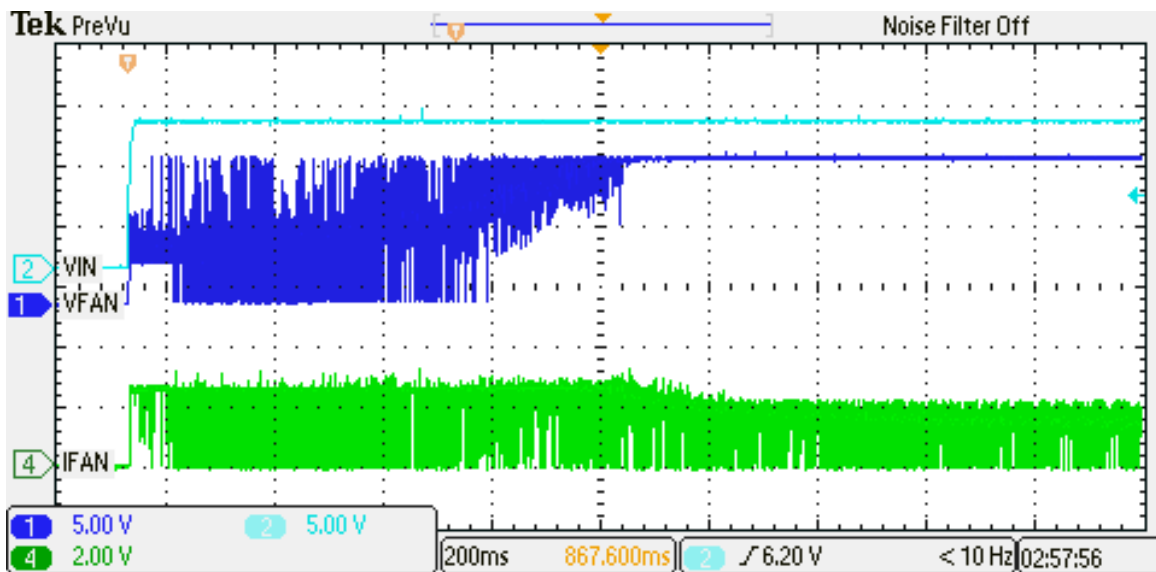
Figure 9. Fan Start-up to Steady-state Operation with TPS2592A

3   Conclusion

When the TPS2592A e-fuse is used with cooling fan or even larger fans such as in server application, it avoids the large inrush current and enables safe start-up of the fans, without getting an input power source trip or shutdown. This helps reduce the on board connector cost and increase the life of PCB traces.

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