12V BLDC Server Fan with Sensor-less Sinusoidal Control

This reference design is a 12V 3-phase brushless DC fan, and is based around a single IC, the DRV10975. This device integrates all the essential components of sensor-less BLDC motor control: the back-EMF sensing and commutation engine, overcurrent, under-voltage, and thermal protection features, sinusoidal current control, a single-input for the speed command, and an output power stage capable of 1.5A continuous and 2A peak current.

The design is cost-optimized while high-performance, using minimal components and a form-fitting PCB. It fits well onto the Sunon BLDC fan model SG40281B1.

The tuned register settings of the DRV10975 are provided with this design in a .csv file, which can be written to the device EEPROM, or directly imported to the DRV10983-75 GUI. For information on programming the EEPROM, refer to the DRV10975 datasheet.

This test report provides typical characteristics of this BLDC fan with an applied VCC of 6V to 14V.

Figure 1: 12V BLDC server fan design
1. Input Current, Power and Speed Characterization: These tests were performed to characterize current, power, and rotational speed for each applied VCC voltage. The duty cycle was fixed at 99%, and speed was varied by changing the input VCC from 6V to 14V in 1V steps. The data shows that speed changes fairly linearly with VCC.

<table>
<thead>
<tr>
<th>VCC</th>
<th>ICC</th>
<th>Input power</th>
<th>Motor electrical speed</th>
<th>Motor physical speed (electrical /2 *60) 4-pole motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>6V</td>
<td>0.25A</td>
<td>1.5W</td>
<td>363Hz</td>
<td>10893 RPM</td>
</tr>
<tr>
<td>7V</td>
<td>0.31A</td>
<td>2.2W</td>
<td>418Hz</td>
<td>12531 RPM</td>
</tr>
<tr>
<td>8V</td>
<td>0.36A</td>
<td>2.9W</td>
<td>470Hz</td>
<td>14088 RPM</td>
</tr>
<tr>
<td>9V</td>
<td>0.41A</td>
<td>3.7W</td>
<td>529Hz</td>
<td>15876 RPM</td>
</tr>
<tr>
<td>10V</td>
<td>0.46A</td>
<td>4.6W</td>
<td>580Hz</td>
<td>17388 RPM</td>
</tr>
<tr>
<td>11V</td>
<td>0.52A</td>
<td>5.7W</td>
<td>623Hz</td>
<td>18693 RPM</td>
</tr>
<tr>
<td>12V</td>
<td>0.58A</td>
<td>7.0W</td>
<td>673Hz</td>
<td>20196 RPM</td>
</tr>
<tr>
<td>13V</td>
<td>0.65A</td>
<td>8.5W</td>
<td>724Hz</td>
<td>21714 RPM</td>
</tr>
<tr>
<td>14V</td>
<td>0.7A</td>
<td>9.8W</td>
<td>778Hz</td>
<td>23334 RPM</td>
</tr>
</tbody>
</table>

Figure 2: Input Current with respect to Vcc
Figure 3: Input power with respect to Vcc

Figure 4: Motor Speed with respect to Vcc
2. **Motor phase voltage and current waveforms**: Figures 5, 6, and 7 show the three phase voltages with respect to GND, and current flowing through the W-phase of motor.

![Waveform Diagram](image)

**Figure 4**: Motor Phase voltage and current at 6V 10983RPM

![Waveform Diagram](image)

**Figure 5**: Motor Phase voltage and current at nominal 12V 20196RPM
Figure 6: Motor Phase voltage and current at maximum 14V 23334RPM
3. **Thermal Image of test board:** Figure 7 shows a thermal image with the fan running at 12V 20196RPM. The ambient is at room temperature 25°C. The fan blades are designed to create air suction, which helps remove heat from the PCB. The temperature in the vicinity of the DRV10975 is 52°C, and the max temperature is 62°C near resistor R1.

![Figure 7: PCB top side thermal image at 12V 20196RPM](image)
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