Vector Controller (FOC) for BLDC Motors

Field-Oriented Control (FOC) is an important technology for motor systems, particularly those using permanent magnets (PM). In general, FOC provides an efficient way to control BLDC motor in adjustable speed drive applications that have quickly changing loads, and can improve the power efficiency of an AC induction motor, especially at lower speeds. For this reason, some designers mistakenly associate FOC for use only with AC motors. While it is true that today’s brushless DC (BLDC) motors tend to very efficient, up to 96 percent even without FOC, the value FOC brings to these systems is reduced torque ripple, resulting in smoother motor performance and quieter operation.

In simple terms, FOC is a motor control technique where the system is trying to orient the stationary or “stator” flux vector to a specific degree relative to the rotor flux vector (see Figure 1). The optimal degree of orientation depends upon what characteristic of the motor needs to be maximized. The most common use of FOC is to maximize the motor’s torque per amp. This is achieved when the stator flux vector is 90 degrees to the rotor flux vector unless the motor has a variable reluctance, such as a motor with a magnet buried inside it. In this case, the degree of orientation is typically 115 to 120 degrees.

![Diagram showing field-oriented control techniques orient the stator flux vector to a specific degree relative to the rotor flux vector.](Source: Texas Instruments. Used with permission.)
Field Oriented Controller (vector control)
Best Tuned for BLDC Motor HPM10KW (48/72/96V 10KW)

- State of Art Technology
- Most Reliable
- High Efficiency
- Smooth Control
- Programmable
- Responsive

Model: VEC500
Voltage: 48V/72V/96V
Max Current: 500A

Field Oriented Controller (vector control)
Best Tuned for BLDC Motor HPM5000 (48/72V 5KW)

- State of Art Technology
- Most Reliable
- High Efficiency
- Smooth Control
- Programmable
- Responsive

Model: VEC300
Voltage: 48V/72V
Max Current: 300A
Golden Motor’s FOC controller products are specially designed for high power rating brushless dc (BLDC) motors from 1KW up to 20KW with voltages between 48V and 96V. The product series use the FOC(Field Oriented Control/Sine Wave) algorithm in which SVPWM is used to drive the power device so that it injects sinusoidal current to the three-phase of motor. Meanwhile, by using a 32-bit microprocessor which incorporates the latest ARM core, it exhibits excellent operational capability. The system handles several close loops which include torque, flux and speed loop and at the same time other high demand of real-time task operation is possible. By advanced control solution the system can achieve the following performance: maximum torque control, constant power control, speed closed loop control and regenerative braking. Compared with traditional square wave motor controller, the PMSM controller has the following obvious advantages:

**Smooth driving**

- Direct torque control, smooth start-up, excellent acceleration performance, especially in slow speed.

**Low noise**

- Vector control sinusoidal current injection and smooth motor output torque, which fully suppress the low frequency noise caused by the fluctuations of motor torque.

**Programmable via PC**

- Provide PC software(GUI) to program motor and control parameters to fine tune the drive system.
- Operating status can be monitored in real-time
- Support UART(standard)or CAN bus (optional)

**Perfect protection functions**

- Signal integrity detection (motor interface signal, control signal, etc.)
- Over-current protection, over or under voltage protection and over-temperature protection.
- Provide motor temperature-control interface

**Main features**

- On-site parameters tuning (Provide PC software)
- System power-on self-checking function
- Regenerative braking
- Brake, cruise, and three-mode speed selection interface
- Display interface
- LED for operation and fault status indication
- Compact design, which is convenient for vehicle installation

www.goldenmotor.com

Version 1.05 11/11/2014

Page 3 of 8
Applications

- Electric Cars
- Electric Motorcycles
- Electric Golf Buggies
- Electric Boats

FOC Controller Series

<table>
<thead>
<tr>
<th>Model</th>
<th>Rated Voltage</th>
<th>Rated Current</th>
<th>Max Phase Current</th>
<th>Dimensions L<em>W</em>H</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>VEC300-48</td>
<td>48V</td>
<td>120A</td>
<td>300A</td>
<td>190<em>180</em>50mm</td>
<td>2.5kg</td>
</tr>
<tr>
<td>VEC300-72</td>
<td>72V</td>
<td>100A</td>
<td>300A</td>
<td>190<em>180</em>50mm</td>
<td>2.5kg</td>
</tr>
<tr>
<td>VEC300-96</td>
<td>96V</td>
<td>80A</td>
<td>250A</td>
<td>190<em>180</em>50mm</td>
<td>2.5kg</td>
</tr>
<tr>
<td>VEC500-48</td>
<td>48V</td>
<td>200A</td>
<td>500A</td>
<td>200<em>190</em>58mm</td>
<td>3.2kg</td>
</tr>
<tr>
<td>VEC500-72</td>
<td>72V</td>
<td>150A</td>
<td>500A</td>
<td>200<em>190</em>58mm</td>
<td>3.2kg</td>
</tr>
<tr>
<td>VEC500-96</td>
<td>96V</td>
<td>120A</td>
<td>450A</td>
<td>200<em>190</em>58mm</td>
<td>3.2kg</td>
</tr>
</tbody>
</table>

Main Technical Parameters And Operation Characteristics

<table>
<thead>
<tr>
<th>Main Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated operation voltage</td>
</tr>
<tr>
<td>Rated DC BUS current</td>
</tr>
<tr>
<td>Rated output power</td>
</tr>
<tr>
<td>Motor control mode</td>
</tr>
<tr>
<td>Quiescent operation current</td>
</tr>
<tr>
<td>Speed limit</td>
</tr>
<tr>
<td>Driving method</td>
</tr>
<tr>
<td>System Protection Characteristics</td>
</tr>
<tr>
<td>-----------------------------------------------------------</td>
</tr>
<tr>
<td>Over-voltage protection</td>
</tr>
<tr>
<td>Under-voltage protection</td>
</tr>
<tr>
<td>Motor over-current protection</td>
</tr>
<tr>
<td>Motor over-heat protection</td>
</tr>
<tr>
<td>Stalling protection</td>
</tr>
<tr>
<td>HALL protection</td>
</tr>
<tr>
<td>MOSFET protection</td>
</tr>
<tr>
<td>Phase winding disconnect protection</td>
</tr>
<tr>
<td>Self-checking error protection</td>
</tr>
<tr>
<td>Controller over-heat protection</td>
</tr>
<tr>
<td>Throttle protection</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Communication Characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>UART communication</td>
<td>UART interface: parameter configuration and working state monitoring</td>
</tr>
<tr>
<td>CAN communication</td>
<td>CAN interface: parameter configuration and working state monitoring</td>
</tr>
<tr>
<td>Bluetooth communication</td>
<td>Bluetooth wireless interface: parameter configuration and working state monitoring</td>
</tr>
<tr>
<td>LED indicator light</td>
<td>Indicate current working state or fault state</td>
</tr>
</tbody>
</table>
VEC Controller functional pins definitions

**S1—Programming**

1. GND (Black)
2. RX (Green&Yellow)
3. TX (Green)
4. +5V (Red)

**S3—Function control wiring harness**

- 01—Motor Temperature (White)
- 02/GND
- 03—Cruise (Gray)
- 04—Electric Lock (Orange)
- 05—Hall C (Blue)
- 06—Hall B (Green)
- 07—Hall A (Yellow)
- 08—+5V (Red)
- 09—+12V Brake(Yellow&White)
- 10—Brake (Blue&White)
- 20—High Speed (Blue)
- 21—GND (Black)
- 24—Low Speed (Blue)
- 26—GND (Black&White)
- 27—Throttle (Green&White)
- 28—+5V (Red&White)
Best tuned for BLDC Motors:

电驱动电机(水冷)
无刷直流 5-20KW
48V-120Vdc
国家授权发明专利
仿冒必究！

Electric Car Motor
BLDC, 48V-120Vdc, 5-20KW
Liquid Cooling
Efficiency > 92%

Diameter: 206mm
Length: 170mm
weight: 17kg

KTY84 series
temperature sensor
installed to prevent overheat
电动摩托车电机
无刷直流 3-7KW
48V-120Vdc
3000-5000rpm

BLDC Motor
3-7KW
48V-120Vdc
3000-5000rpm