Fact Sheet

PMSM FOC of Industrial Drives Reference Design

Target Applications

- Servo drives
- Compressors
- Pumps
- Fans
- Industrial drives
- Appliances

Field-Oriented Control (FOC)

Field-oriented control (FOC) is an advanced control technique used to drive permanent magnet synchronous motors (PMSMs). FOC provides maximum torque from zero to nominal speed and protects against overload by providing superb current regulation in the transient state.

The key to FOC is to control the motor torque and field excitation (the motor magnetic flux) independently from one another. In order to obtain this current control, it is necessary to know the actual rotor position, which is typically measured by incremental sensors (quadrature encoder), absolute sensors, or resolvers.

Permanent Magnet Synchronous Motors (PMSM)

PMSMs are desirable due to their higher efficiency and better power density than traditional motors. There is no excitation needed because the motor magnetic flux is generated by permanent magnets placed on the rotor.

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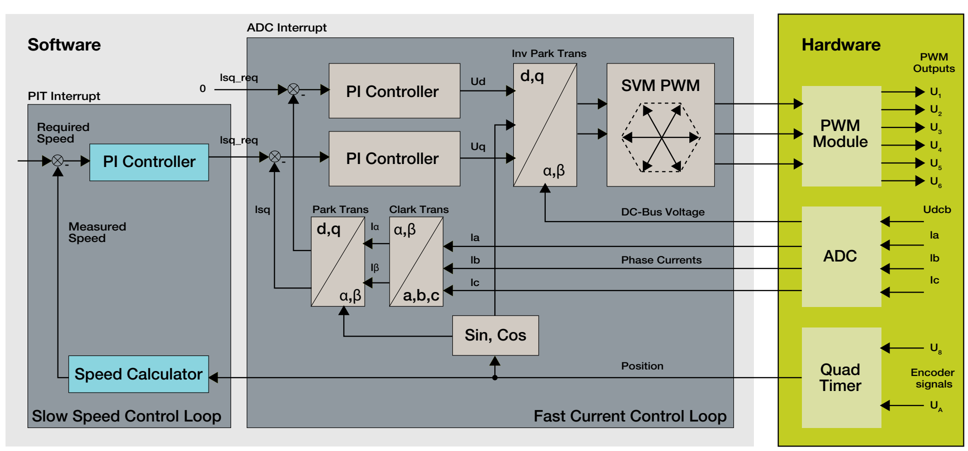

Freescale Technology

Features

- Speed and current closed loop are implemented
- Speed is processed as combination of time between encoder pulses and number of pulses during slow loop period
- Bi-directional rotation
- Application speed ranges from 0 to 100 percent of nominal speed (no field weakening)
- Four state machine
- Fault protection for driver DC-bus overcurrent, SW overcurrent, overvoltage and overspeed
- DSC built around the high performance, cost optimized DSP56800EX 32-bit core
- Control algorithm based on the Freescale Embedded Software and Motor Control Libraries
- FreeMASTER runtime debugging tool used for application control and monitoring
- Supported by MCAT (Motor Control Application Tuning) Tool
- Industrial PMSM with encoder
- Hardware built on the Tower System
- Current control loop execution time: 17 us @ 100 MHz MCU speed
- Flash: 13,204 bytes, RAM: 30,972 bytes
- PMSM vector control using the quadrature encoder

Freescale Embedded Software and Motor Control Libraries

All application code for the reference design is based on the Freescale Embedded Software and Motor Control Libraries. The control structure is comprised of two control loops - fast (current), which is executed once per 62.5 μ, and slow (speed), which is executed once per 1 ms. In the fast control loop, the FOC of the motor is performed.

FreeMASTER

Freescale has provided both manual buttons on the board and a GUI to operate this reference design. The GUI to control the demo was created using Freescale's FreeMASTER software. This interface is based on an HTML page and includes ActiveX components such as gauges, knobs and graphs. Most of these elements are interactive, which means that it is possible to control them by clicking or dragging the mouse. The principle of such control is that the ActiveX component calls the needed function and changes the FreeMASTER variable, which is connected by serial communication to the memory address of the corresponding MCU control variables. This provides a real-time debug capability needed for optimization of both the system and associated code structures.

Motor Control Application Tuning Tool

FreeMASTER also supports the Motor Control Application Tuning (MCAT) Tool that enables the control parameters of the application to be set up easily. Using this tool, the user can modify parameters of control loops which will change the properties of control process. The control reaction for these parameter changes can be triggered and visualized using FreeMASTER recorder functionality.

The application supports a state machine, which is comprised of four basic states: Initialization, Stop, Run and Fault. In addition, the run state consists of five sub-states: Calibration, Ready, Alignment, Rotation, and Automatic Demo. The state switching is executed using transitional states.

Peripherals

Timers

- 2x PIT—time base for slow loop and demo autonomous mode
- 6x PWM—generation PWM signal for inverter
- QuadTimer—Quadrature encoder processing

Analog

- 2x ADC—4-phase current and DC-bus voltage measurement

Communication

- QSPI—MOSFET driver communication
- QSCI—FreeMASTER communication

Crossbar

- Driver fault and ADC-PWM synchronization routing

Reference Design Operation

For this particular reference design, encoders are connected with shafts to provide the rotor position in the speed range. Encoders are not absolute sensors, as they only show the position difference measured. Therefore, alignment after reset is necessary for vector control. The encoder generates three signals for this:

- A, B - the signals from optical sensors shifted about 90 degrees used for relative position recognition.
- Index signal - generates an impulse per revolution that can be used for counter synchronization. (The index signal is not used in this application.)

The hardware of the demo was built using the Freescale Tower System, a modular development platform.

For current information about Freescale motor control products and documentation, please visit freescale.com/motorcontrol

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