Hardware Design of a Integrated Modular Motor Drive (IMMD)

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Chapter 1

Introduction

1.1 Motivation

Reliability and Redundancy

EMI Containment

1.2 Previous Research

Chapter 2

Abstract Design

2.1 Control Topology

Non-synchronized PWM

While control states may be managed between modular drive processors with only moderate difficulty, the classical assumption that all PWM carriers are synchronized presents significant difficulty as a delay of only a few microseconds represents a significant phase delay. Thankfully, at normal carrier to fundamental ratios, the phase of the PWM carrier is unimportant to a first order as the machine inductance filters out the high frequency switching components. Quartz crystal-based main oscillators are quite stable and allow frequency tolerance below 100ppm without any special calibration. For a 20kHz PWM system, the beat frequency between PWM carriers will be at a frequency of 2Hz. This beat frequency will manifest as a peaking of the $\frac{dV}{dt}$ applied to the machine windings relative to the frame every 0.5s. While this phenomenon has little effect on the control of the machine, the effects on bearing currents and insulation lifetime have not been investigated.

Fault Management

2.2 DC-Link Design

Interconnect Design

Capacitor Sizing

2.3 Peak Ratings

Electric machine and drive system ratings are influenced by a variety of factors. While continuous ratings for rated operating conditions are well defined and easily modeled and tested, peak ratings are dependent on definitions. The determination of peak ratings is further complicated by marketing influences in that a large "peak power" number is an easily quoted figure of merit even if it has little real-world backing.

The peak rating of an electric drive system is driven by a number of factors depending on the peak time required. For peak times on the order of one electrical cycle, the power limit is driven by the saturation current allowed by the power switches and the demagnetization limit of the permanent magnets in the electric machine. Both of these limits are effected by the starting temperature of the electrical drive system, but are largely independent of other thermal effects as the peak time is too short.

Chapter 3

Detailed Design

3.1 Gate Drivers

3.2 Power Module

3.3 Current Sensing

3.4 DSP

3.5 Communications

Chapter 4

Discussion

4.1 Hardware Performance

4.2 Scaling

Chapter 5

Conclusions

5.1 Future Work

Multi-phase IMMD

EMI analysis

Control Development

High-temperature Testing