**Title:** Optimization of an Integrated Modular Motor Drive System

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**Preferred topic area:** C4 - Integrated drives

**Abstract:** (up to 1,000 words plus an additional 250 words for references / appendices)

Conventional variable frequency motor drive systems are composed of two distinct parts: drive and motor where drive units are placed in separate cabinets and connected to the corrsponding motors with long cables. This causes reduction in power density, cost increase and electromagnetic interference (EMI) problems. In integrated modular motor drive (IMMD) systems, the drive is integrated into the motor back iron forming a single package so that the power density of the overall system is enhanced and the connection cables are eliminated. Furthermore, each pole of the motor is driven by its own drive module which are then connected on the DC link. By doing so, the fault tolerance of the system is increased, heat dissipation is spread on a wider surface area and voltage stress on windings and power semiconductor devices are reduced.

In this paper, optimization of an IMMD system is presented considering both the motor and drive parameters to obtain the highest power density and efficiency. A high torque, permanent magnet synchronous motor (PMSM) having a stator with fractional slot concentrated windings (FSCWs) is utilized for its superior torque density, low cogging torque and fault tolerance capability which make them especially suitable for IMMD applications. Gallium Nitride (GaN) power semiconductor devices are used with high switching frequency in the drive inverters to meet the system requirements and design challenges caused by the integration. It is well-known that in an average power converter, passive components and heatsinks are the components constituting the largest portion of the overall volume. With high drive efficiency values, which are achievable thanks to the fast switching capability of GaNs, heatsink size can be reduced. Moreover, size of the passive components, especially the DC link capacitor which is also the tallest component on the drive system, can be decreased with high switching frequencies applied to GaNs as well as with the utilization of interleaving technique which is now applicable thanks to the modular motor drive structure.

The integration of the drive onto the motor poses several challenges such as volume reduction, cooling both units simultaneously, vibration due to the motor etc. which are difficult to address without a broad scope work including all the components and an optimization process. Modularity of the system also increases the possibilities making the design more flexible which can be performed easiest with the help of an optimization procedure. A multi-stage nonlinear optimization program is developed which starts with the main decisions effecting the system architecture such as the number of modules,

A three-phase passive diode bridge rectifier is used in front of the IMMD system and its effects to the DC link are kept out of the scope of this study. The system constants are the DC link voltage, the total mechanical output power, rated speed of the motor, topology of each motor drive inverter module, pulse width modulation (PWM) technique and type of the motor. The aim of the optimization program is to obtain a drive efficiency of 98%, motor efficiency of 94%, drive power density of 15 W/cm3, motor power density of 5 W/cm3 with minimum possible system cost.

System modeling includes:

General: number of modules

DC link capacitor bank: current requirement, capacitance, lifetime etc.

Inverter: GaN selection, loss calculation

Motor: torque, torque ripple, cogging torque, loss calculation

Methods/approach:

Outcomes:

Conclusions:

In the final paper,