Development of an Active Harmonic Filter using an Interleaved SiC Inverter

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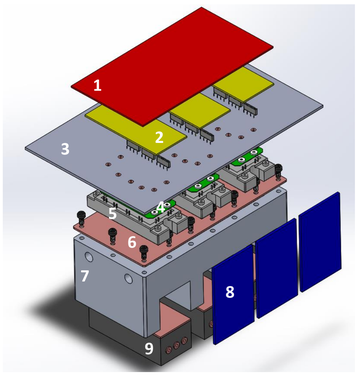
Overview

Objective:

- Develop a 150 A (50 kVAR) Active Harmonic Filter (AHF) using interleaved SiC-based inverter
- Peak system efficiency > 98% with switching frequency > 50 kHz
- Four-quadrant operation capability with up to 51th harmonic cancellation and THD < 5%
- Power density > 1 kW/L
- Prepare reference design document with all details and performance
- Skilled WBG technology workforce development
- Provide platform to evaluate fundamental concepts proposed by graduate students

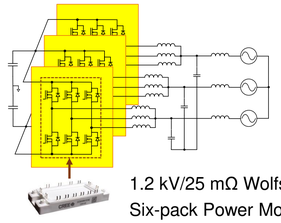


1. Controller docking board
2. Gate driver
3. Global busbar
4. Local busbar
5. Power module
6. Coldplate
7. Turbulator
8. Sensor board
9. Inductors

Interleaved SiC Inverter based Active Harmonic Filter

Method

Topology:



1.2 kV/25 mΩ Wolfspeed Six-pack Power Module

- Three-phase SiC inverter with LCL filter
- Each phase consists of three **interleaved sub-phases**
- Switching frequency: **100 kHz**

Control Strategy:

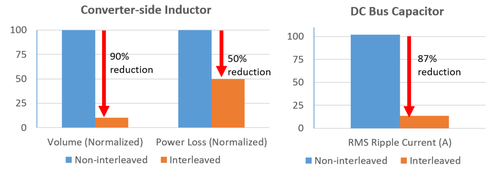
- Indirect Current Control with reduction in current sensor requirement and decreased computational burden
- Dynamic current balancing of interleaved sub-phases
- CPU +FPGA based controller (using Xilinx Zynq 7000 System on Module)

System Architecture:

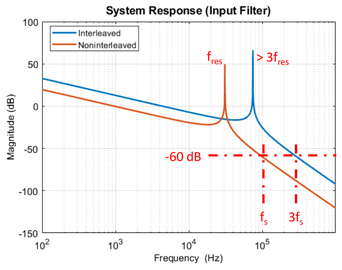
- Development of busbar based on “plug-n-play” architecture
- Low inductance **local busbar** incorporating customized high-current power connectors
- **Global busbar** for system level interconnection
- Modular voltage and shunt-based current sensor board

Results

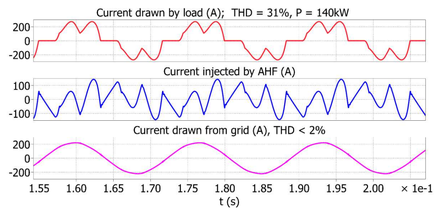
- For same grid inductance and 1% (peak-peak) current ripple injection, **interleaved topology** needs smaller converter-side inductor (**90% volume reduction and 50% power loss reduction**), and **87%** reduction in **DC bus capacitance** compared to non-interleaved counterpart



- The LCL filter self-resonance frequency shifts higher (**> 3 times**) and the **effective switching frequency** also **increases 3 times**
- Upper limit of attainable control bandwidth is increased significantly



- Grid-side current has up to 51th harmonic cancellation with <2% THD



SiC Interleaved AHF Simulation under steady-state

Future Work

- Design of passive components and gate driver
- Controller implementation
- Cooling system design
- Final system assembly and testing

Potential Impact

- Improved efficiency and power density and reduced cost compared to Si-based solution.
- Utilization of SiC-based power devices for system-level performance improvement.
- Establish viability of SiC- based AHF by providing a benchmark

Partners

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