GE Electrical Machines-Integration of SiC Power Devices into High-Power Motor Drives

NIST/DOE Workshop on HMW Direct-Drive Motors and Front-End Power Electronics

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GE Global research
9/4/2014
GE Electrical Machines Portfolio

GE Businesses

Joint Technology Development

Global Research
Technology incubation & prototyping

GE Global Research
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GE Electrical Machines Portfolio

develop ➤ design ➤ manufacture ➤ monitor ➤ service

Broad capability across infrastructure domain
Enabling New Solutions with SiC
High-Speed Oil & Gas Machines: Integrated Compressor Line (ICL)

- Direct-drive high-speed Induction motor / Permanent Magnet motor
- MV drives typically limited to fundamental frequency in the range of 100 Hz; typical switching frequency of 1 kHz
- High-speed direct drives in compression systems require up to 1kHz fundamental
- Requires multi-level topologies and filtering with Si devices
- Simpler 2L or 3L topologies using high switching frequency of SiC devices can enable this application
SiC Power Electronics Building Block

AC ➞ DC ➞ HF AC ➞ DC ➞ AC

Power-electronics transformer for AC/AC or DC/DC applications

Integrated HF Transformer as enabler for 10x size reduction
Via 10 – 100 kHz

System benefits
- Compactness
- Efficiency
- Controllability
SiC Power Electronics Building Block
GE Examples

3 MW 4160 V AC / 1000 V DC
1/10 weight

50 kW 1/5 kV DC @ 100 kV DC offset
Significant size & weight reduction for off-shore HVDC terminal

Substantial benefits at the SYSTEMS level accomplished through
tight integration of advanced HF transformers with SiC bridges
GE SC Machine Experience

Topologies

- **Conductors:** LTS, HTS, MgB$_2$
- **Machine Type:** Wound field synchronous, Homopolar Inductor Alternator
- **Magnetics:** Iron core, Airgap winding, Air core
- **Mechanical Configuration:** rotating field winding stationary field winding

**SC machines if cost-effective can benefit from SiC-based drives similar to conventional machines**
**Advanced Materials is a Key Enabler**

**Advanced lower-cost high-performance permanent magnets**

![Graph showing energy product vs. demagnetizing field](image1)

**Advanced soft magnetic material:**
Dual-phase motor laminates with locally patterned low $\mu$ regions for flux path control

**Advanced Insulation Systems:**
- High thermal stability/temp.
- High voltage, thin film insulation
- High $dV/dt$ pulse resistant
- High thermal conductivity
- Chemical resistant

**Operating temp.**

- Aviation > 220°C
- Locomotive > 180°C
- Industrial > 130°C
- Down hole drill > 250°C
- geothermal > 350°C
Different Thermal Management Solutions

Cooling System Complexity

Performance

Micro-channel cooling jacket

Micro-channel cooling jacket & slot cooling tubes

Micro-channel cooling jacket & EW spray

Spray Nozzle
Endwinding

Cooling tube
Alumina wedge
Alumina separator

Branches
Manifold

Endwinding
Spray Nozzle
Synergy with other applications and leveraging other federal funding will accelerate risk mitigation and adoption of technology
GE has been partnering with the DoE to achieve these targets.
Advanced electrical machiness and SiC are key enablers of this roadmap.