Key Questions to address at

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

(September 4, 2014)

The previous April 2014 HMW workshop goal was to "identify the applications and approaches where advanced HMW machine technologies, front end power electronics, and their integration might provide substantial benefit" (see http://www.nist.gov/pml/high_megawatt/april-2014_workshop.cfm). The September 2014 workshop (detailed goals defined in a separate document) will focus on defining: 1) the cost/performance metrics that would quantify the benefits of an integrated direct-drive high-speed motor system solution (grid interface, high-speed MV drive, and gearless high-speed motor) versus today's baseline solution; 2) key milestones for the required HMW power electronics/machine technology development needs; and 3) considerations for subsequent scaling of the integrated high-speed direct-drive motor solution to high manufacturing volume and higher MW levels (from initially ~1 MW to >30 MW).

Application types and performance metrics at interface

grid interface(base, AFE, SST) – chart 10 of Fred Leon

high-speed MV drive (topologies, semiconductor type and voltage) – chart 12, 13

Machine types

gearless high-speed motor (10,000 -20,000 rpm) Fred Leon Chart 20

Anant's discussion points

Limit to cost and performance

PM or IM machine, materials challenge

Footprint

Power rating of initial system demonstration.

NGEN (Zia Charts)

13.8 to 2kv

Vsd 5khz

Motor electrical frequency >500 Hz

1MW, 15000 rpm

Key Questions:

1) What are cost/performance metrics that would quantify the benefits of megawatt scale integrated direct-drive high-seed motor system solutions (grid interface, high-speed MV drive, and gearless high-speed motor, 10,000 -20,000 rpm) versus today's baseline solution?

    1a) What are representative cost per megawatt metrics for each stage of today's baseline solution, and what is the expected total cost reduction for an integrated system and how would it be quantified in a proposed demonstration?

    1b) What are maintenance requirements and lifecycle cost issues for today's baseline solution, and how might proposed integrated solutions quantify lifecycle cost benefits?

    1c) What are energy loss components of today's baseline solution, and how might proposed integrated solutions quantify efficiency benefits?

    1d) What are footprint reduction metrics that would best quantify the benefits of the integrated solution?

        Drive is largest part and SiC reduces this!

    1e) What are factors that would need to be demonstrated to insure scalability of new solutions to high-volume low-cost manufacturing?

        Scalability of drive system

2) What are key milestones for the required HMW power electronics/machine technology development needs?

    Secondary effects of high-frequency on the machine

    Stress management

    - Technology for magnet retention

    - Magnetic bearings rotating

    PM machine

    Transformerless

    MagBearings

    Insulation: dvdt, high temperature, harsh environment

    Multi-discipline integration (GE chart 12)

    Advanced magnetic material

    Sustainability/availability of magnetic material

    High speed motor design considerations (Teco)

Power quality and high efficiency machine are critical.

Litz wire

Skin effect losses in leads

IEEE 519 does not necessarily provide high machine efficiency

Interleaving

SiC and Power Modules:

Standards and Application engineering device selection need to be reevaluated.

SiC current 300 A equiv to 600 A Si (chart 14)

Cosmic ray derating for Fit rate is not necessary 4.5 kV equiv to 6.5 kV Si.

3rd gen Die shrinking will not change reliability, but thermals. What are impacts of thermals and what is optimal design considering circuit Fault Condition SOA?

6" will be a game changer since power devices are still made on 6"

Anup, For high voltage Epi takes over for 10 kV (>80%)

For device rating of 4.5 kV to 15kV, we do not know market requirements

Above 3.3kV we need technology solution to bring down cost (epi too costly)

Monolith:

Fables model – own device design process IP, HV testing, product qualification. Capital investment is low

Convincing Si fab to run SiC processes

Lack of flexibility

Lack of SiC tools

IP control issues

APEI,

More than a scaled up strike, creep (8 kV – 25 kV modules)

Higher voltage DBC

Capacitance to baseplate

Qualification standards

Power electronics technologies, gate drives, and integration of the power electronics technologies

Materials aspects

Baseplate 15 kV not DC

Magnetics materials for motors and integration

Most high power magnetics are soft magnetics materials

ARPA E is developing alternative rare earth elements

3) How will integrated direct-drive high-speed motor systems scale to high-megawatt (>30MW) and what are future markets (10 years) for these systems?

3a) What are the applications for >10 MW motors (e.g., in oil and gas)?

3b) What are system specifications and performance requirements for larger >10MW motors (e.g., application speed requirement might be 3,000-4,000 rpm versus 10,000-20,000 rpm for 1 MW applications?

3c) What are additional technology needs to ensure scalability to high MW (e.g., higher voltage semiconductors >15 kV, power electronics topologies, machine types, etc.)?
Anant

Chemical and OG are fast growing MW HS drive opportunities

NG network CO2 injections 25 MW gas turbine 30%, Compressor 82% = 25% efficient. Can we electrify this and what would be the losses. Store NG, use 100 MW gas turbine which is more efficient 50%, then could use variable speed = 40%. But can we electrify existing infrastructure.

Electrifying in current system will require large drive. Conventional way to electrify. 20-40% energy wasted.

From last workshop, came up with new workshop. 5X smaller, more efficient. Don't necessarily need, transformer is not an essential piece.

Harsh environment, down hole etc. – cabling cost

High temperature >250°C, >350°C

Power electronics inside of machine

Super conducting machine + SiC (20yr roadmap)

Synergy with other application to mitigate risk (DOE VTP, aerospace engineering)