ENERGY STORAGE: ADVANCED INVERTER ISSUES AND RESEARCH

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System Requirements for Power Converter

Technical Drivers:

- Power (500kW … 10MW ….)
- Speed (1000s of Hz)
- Quality
- Size (for mobile apps.)

Market Drivers:

- Reliability
- Cost !!!

The Power Conversion System represents a sizable part of the cost of an Energy Storage or DG System:

- Energy Device: ~ 25%
- Power Device: up to 65%

ISSUES and RESEARCH:

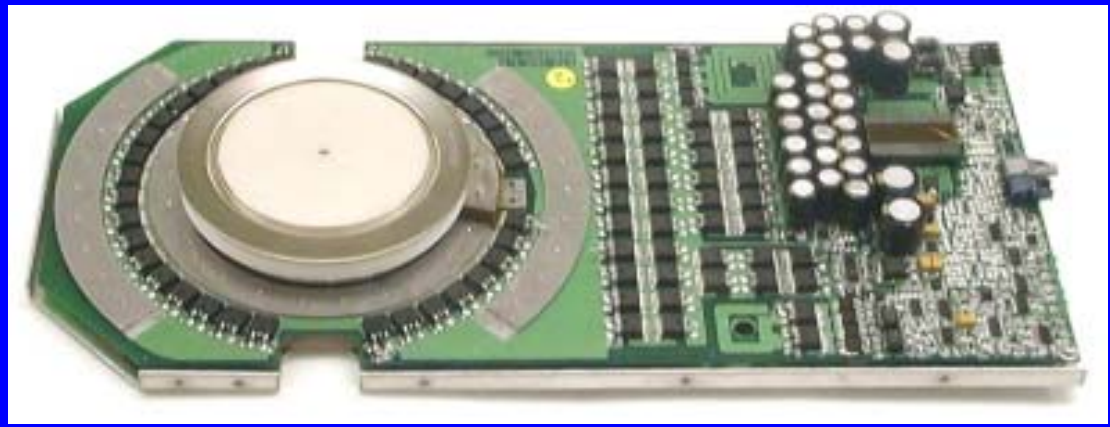
- *Devices*: ETO Development
  WBG Applications
- *Controls*: Optical Sensors and Controls
- *Passive Elements*:
  Adv. Capacitor Development
- *Thermal Management*:
  Advanced Composites
- *Manufacturability*: ETO Gen3

Devices (1):
Advanced Switch Design

- <750K Off Shelf IGBT Switches
  Controls are Main Issue
- >750K Needed:
  - Faster than GTO
  - More Power than IGBT
  - Cheaper

Devices:
16 MW Emitter Turn-off Thyristor (ETO) Switch

- Developed at Virginia Tech
- 15-20 times faster than GTO
- 3 times the power and less expensive than IGBT
- Development of Transmission Stabilization Device Planned with TVA
- 2003 R&D 100 Award



Emitter Turn Off Thyristor
R&D 100 Award Winner

Devices (2):
Wide Band Gap Materials (SiC)

- Advantages
  - High Frequency Operation
  - Less Switching Losses
  - Higher Blocking Voltages
  - Higher Operating Temperature
- Disadvantages
  - Expensive
  - Limited Current Level

Devices:
Wide Band Gap
Power Converter Applications

- FY 2005 SBIR Solicitation
- Design of PCS using available WBG devices
- Improve performance, manufacturablity, thermal management, cost
- 100 - 500kW Power converter Phase II

Controls:
Optically Isolated Inverter

- Built by Airak, Inc.
- 1.7 MW per phase
- Optical Interface for Controls
- Optical Voltage, Current and Temperature Sensors
- Smaller, more reliable Inverters
- 2003 R&D 100 Award

Optical Current Sensor
R&D 100 Award Winner

Passive Elements:
Improved Capacitor Lifetime

- FY 2005 SBIR Solicitation
- Capacitors have highest failure rate of any Converter Component !
- Needed: Advanced, high reliability Capacitors (e.g. polymeric film?)
- Design Converter with advanced Capacitors demonstrating increased Reliability and Manufacturability, as well as lower Cost

Thermal Management:
Advanced Inverter Packaging

- Built by Rhinehardt Motion Systems
- Low cost, high,current 100-500kW Inverter with Integral Liquid Cooling
- Non-uniform pin Topology
- Advanced composite Materials (Al-C) for high heat Conductivity at key points
- Low cost Injection Molding elsewhere

Manufacturability:
ETO Gen 3

- While Gen 4/5 is being designed, ETO Gen 3 is being prepared for commercialization
- Improved Packaging
- Manufacturability

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SBIR Solicitation

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… and with thanks to Sandia:

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