Session 2b
Hingorani
High-Megawatt Converter Technology Workshop

DOE Office of Clean Power Systems, U.S. Army Construction Engineering Research and Development Center (ERDC), and National Institute of Standards and Technology (NIST)

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Nari Hingorani,
26480 Weston Drive,
LOS ALTOS HILLS, CA 94022
nhingorani@aol.com
# High MW Power Electronics - Areas of Applications

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<th>Storage</th>
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<td>Fuel Cell</td>
<td>Flywheel</td>
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<td>Variable Speed Hydro</td>
<td>Super Capacitor</td>
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<td>Superconducting-Magnet</td>
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<td>Bases</td>
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North America AC Power Systems and HVDC Interconnections
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Current Sourced Converter System, which requires unidirectional current flow

Voltage Sourced Converter System which requires unidirectional dc voltage
Suspended Thyristor Based Quadruple Valves making a 12-Pulse Converter rated 500kV (Pacific DC Intertie) (Siemens)
Building block for HVDC application including up-to thirty series Thyristor levels (Siemens).
Cross Sound Cable Interconnector
Connecticut and Long Island, USA

Converter Station at Shoreham. 330MW. + -150kV.
80m x 25m x 11m  (ABB)
Constraints on Useable Transmission Capacity – FACTS

System Dynamics:
Transient and Dynamic Stability
Subsynchronous Oscillations
Dynamic Overvoltages and Undervoltages
Voltage Collapse
Frequency Collapse

System Steady State:
Uneven Power Flow
Excess Reactive Power Flows

Natural Limits
Insulation Voltage Capability
Conductor Thermal Capability
FACTS and Custom Power Concepts

- May be active static switch or impedance converter or a combination thereof.
- When in shunt, cause current injection into the line, and when in series, causes voltage injection in series with the line.
HVDC and FACTS: Complementary Solutions

**HVDC:**
- Power control, voltage control, stability control
- Independent frequency and control

**FACTS:**
- Power control, voltage control, stability control

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<th>Throughput MW</th>
<th>HVDC 2 Terminals (M)</th>
<th>FACTS (M)</th>
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<tr>
<td>200 MW</td>
<td>40-50</td>
<td>5-10</td>
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<tr>
<td>500 MW</td>
<td>75-100</td>
<td>10-20</td>
</tr>
<tr>
<td>1000 MW</td>
<td>120-170</td>
<td>20-30</td>
</tr>
<tr>
<td>2000 MW</td>
<td>200-300</td>
<td>30-50</td>
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Kayenta TCSC
Fig. 1. Holly STATCOM single line diagram.

Fig. 2. Holly STATCOM layout
1) Valve hall
2) Enclosed 32 kV equipment

Fig. 3. Holly STATCOM
Feeder

PWM Converter

Interface

Storage, Fuel Cell, Wind generation
Makes the electrical conversion needed via software programming.

Senses what they are plugged into...

Senses what is plugged into them...

Like a child’s set of blocks
Power Electronic Building Blocks PEBB

* PEBB defined by IEEE (Power Engineering Society)
MV IGCT PEBB based Power Conditioning Systems

- **Frequency Changers (FC)**
  - DB Energie (Germany), 11 units installed to date, 18 MVA each

- **Chip Manufacturing Plant**
  - DVRs (Dynamic Voltage Restorer) installed: 2 units, 22 MVA each

- **Regenerative Fuel Cell (RFC)**
  - Power Quality for Columbus AFB, Mississippi Delivery 2002, 15MVA

- **BESS - Golden Valley Electric**
  - World’s Largest Battery Energy Storage System (BESS) installed at GVEA, Fairbanks, Alaska, 40MW / 60MVA

- **9MVA IGCT PEBB**
  - with a leading power density in MV applications
Future Power Electronics Needs

Significant Reduction in:
• Cost
• Losses
• Size
• Weight

Significant Improvement in Switching Frequency
A Perfect Power Semiconductor Switch

- Turn on and off instantaneously on command
- Zero switching losses
- Zero conduction losses
- Zero gate power requirements (accept digital signal for turn-on turn-off)
Need High-Voltage High-Power Building Blocks

- Packaged Building Blocks with Functional Specifications
- Programmable to serve multiple applications
- Can be connected in series and parallel to achieve higher ratings
Press-Pack High Power Devices
Advanced Power Devices

Reduce Losses and Raise Switching Frequency

- **Advanced Silicon Devices**
  
  Low Losses; Fast Switching; Low Thermal Resistance; Bidirectional; Integration of Passives

- **Wide Band Gap Devices**
  
  Silicon Carbide

\[ SiC \]
HVDC Transmission for Integration of Wind Generation Farms in Transmission Grid

• Obtaining Transmission ROW takes much longer than Building Wind Farms

• Underground DC Transmission with Voltage Sourced Converters could have
  • Lower Cost
  • Improved System Integration
  • Much smaller Permit and Construction time

Narain G. Hingorani
Proposed Conceptual Sub-transmission or Distribution System

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