Power Electronics for Distribution Grid and WBG Opportunities

Fred Wang
University of Tennessee and Oak Ridge National Lab

NIST/DOE Workshop on MV WBG Power Electronics for Advanced Distribution Grids

NIST, Gaithersburg, MD
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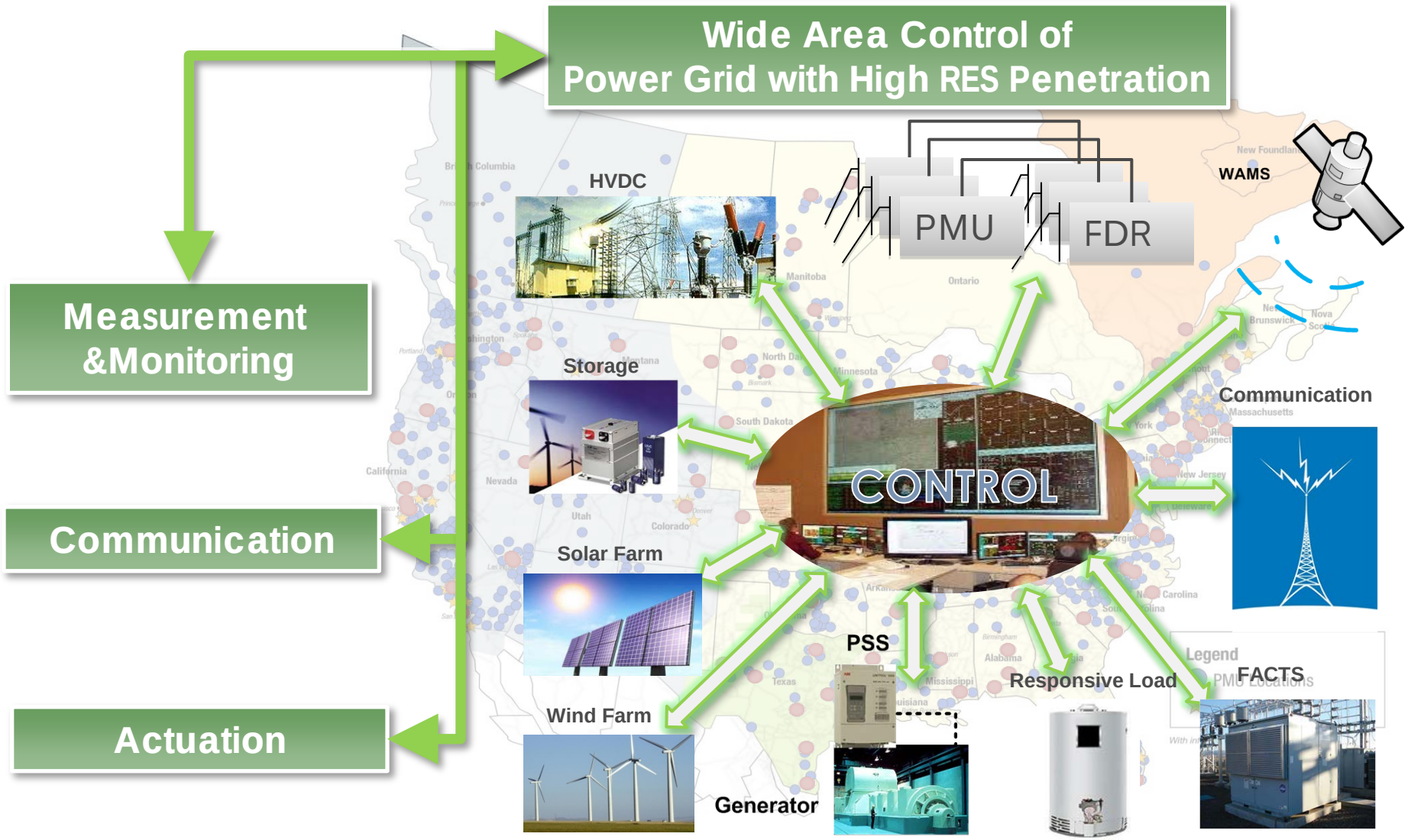
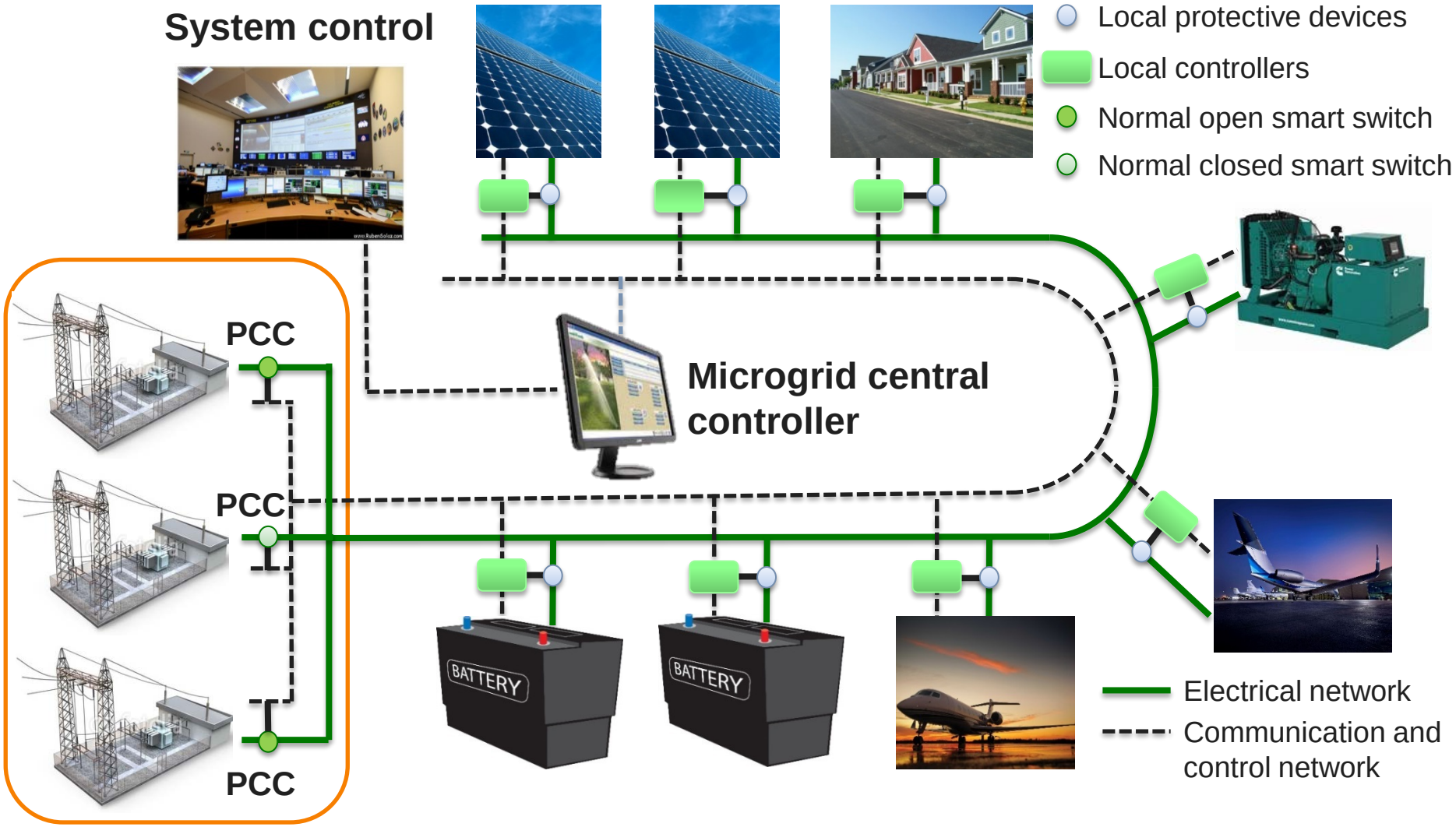
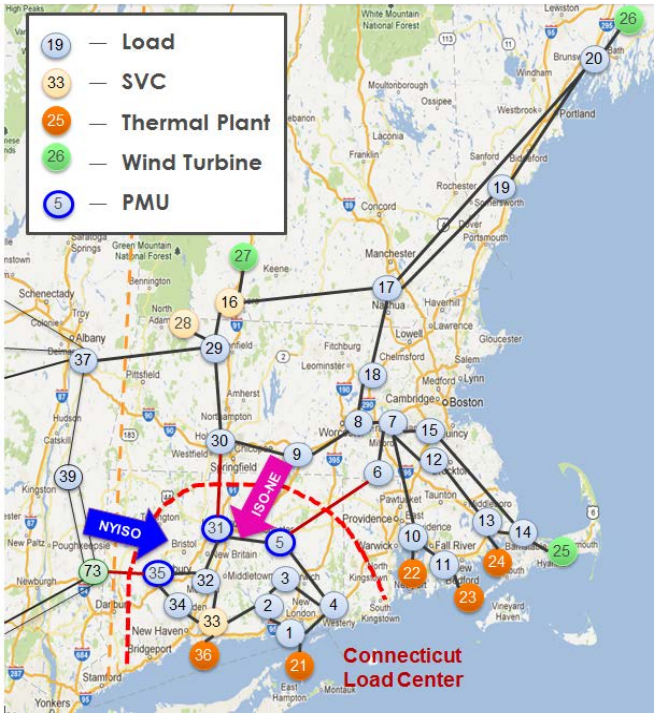
CURENT Vision

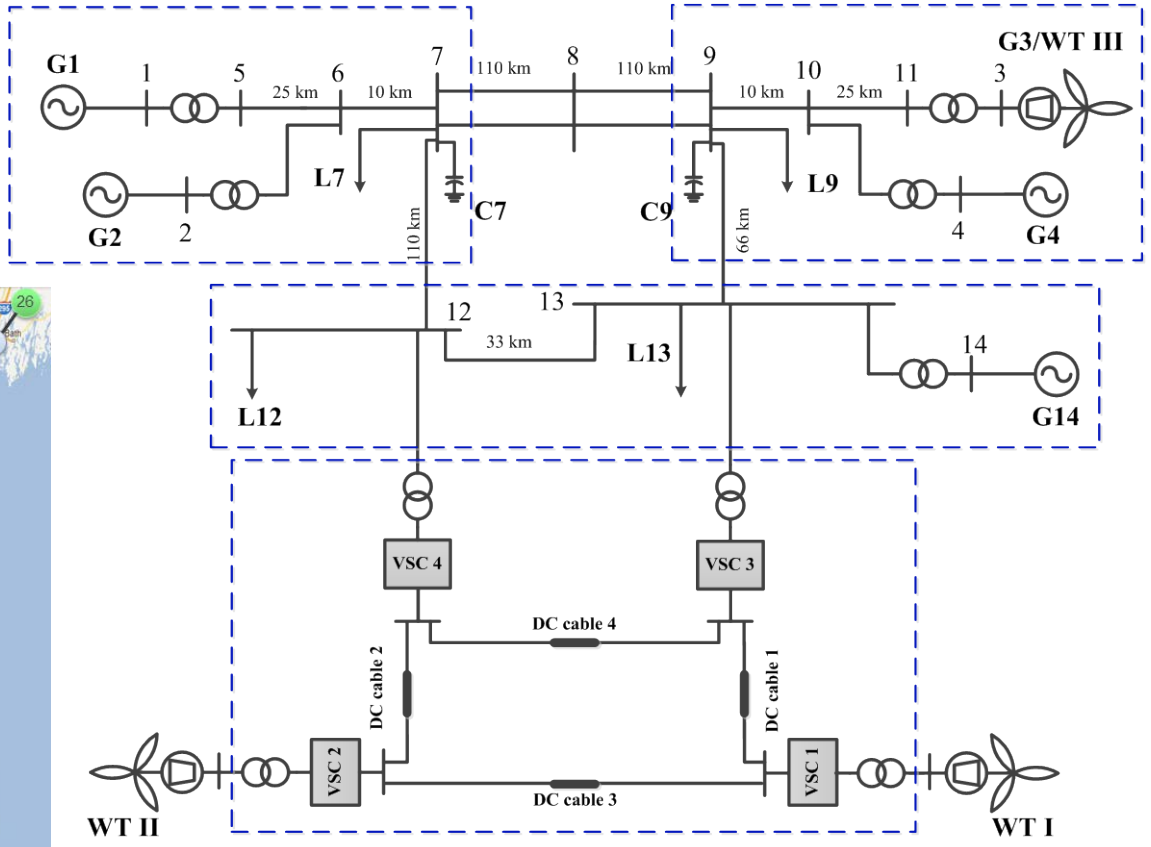


Smart and Flexible Microgrid

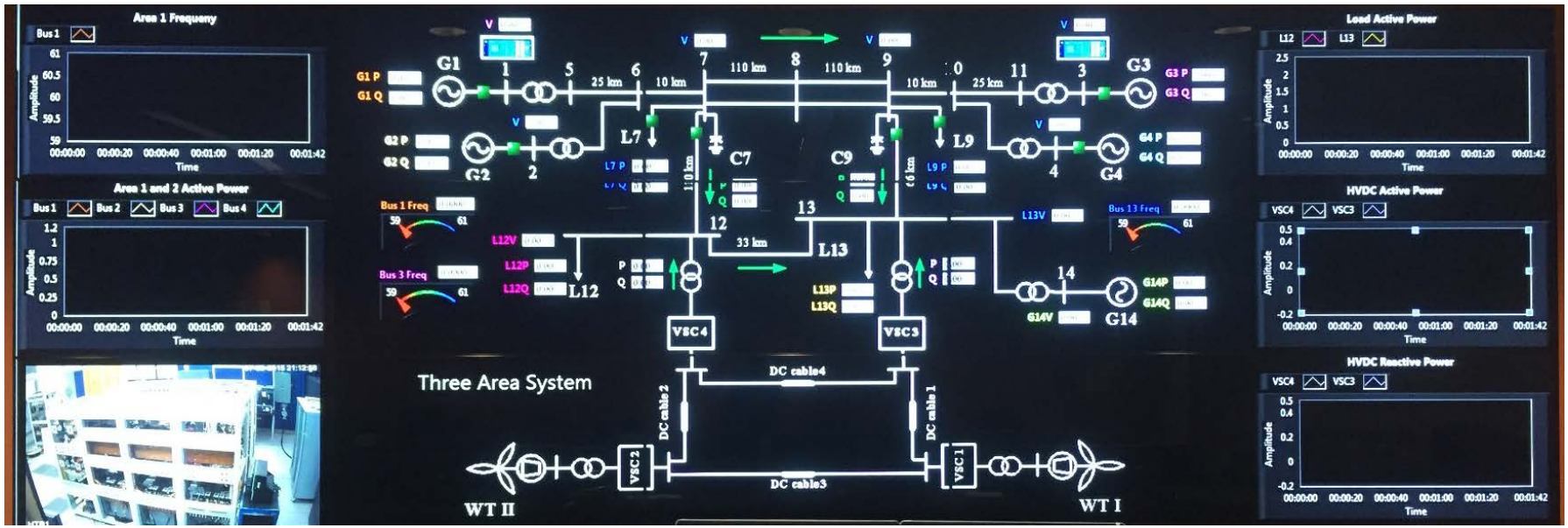


Reconfigurable Grid Emulator



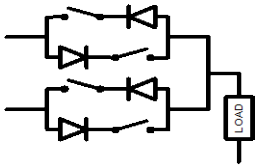


Reconfigurable Grid Emulator

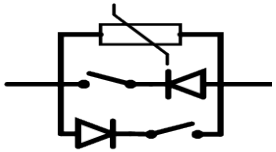


Power Electronics for Distribution Grid – Custom Power

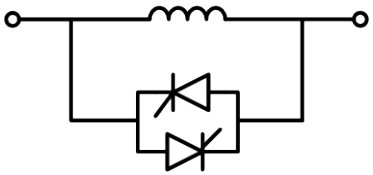
- Power flow control/interruption



SSTS

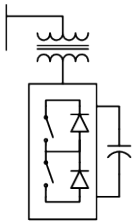


SSCB

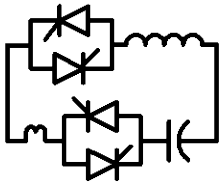


SSFCL

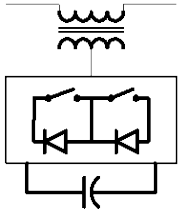
- Power system conditioning and compensation



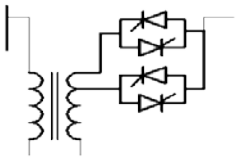
DSTATCOM



SVC

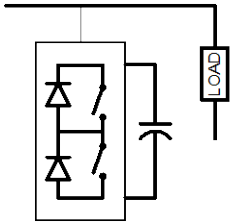


DVR

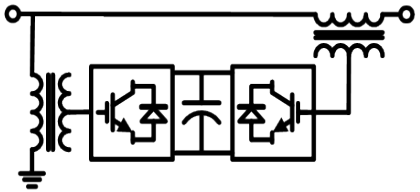


TCVR

- Active filters



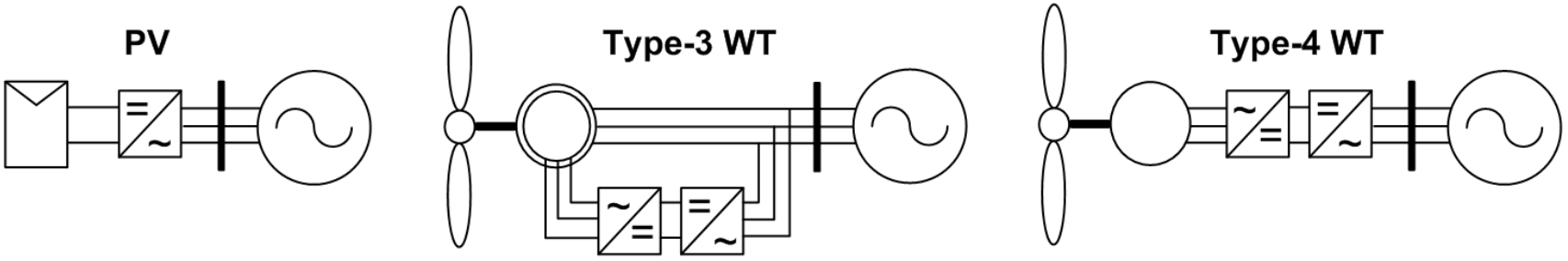
Shunt AF



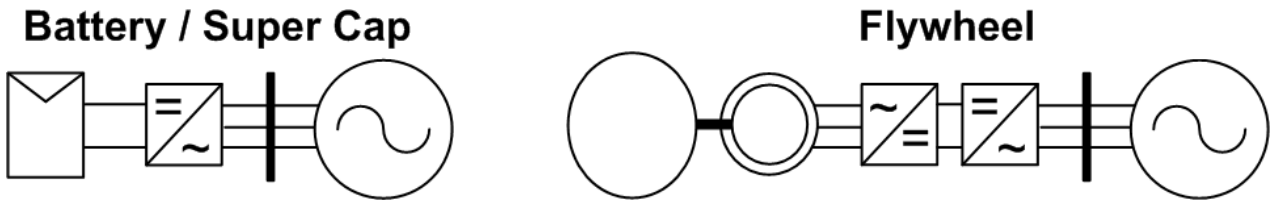
UPQC

Power Electronics for Distribution Grid – Emerging Needs

- RES Interface

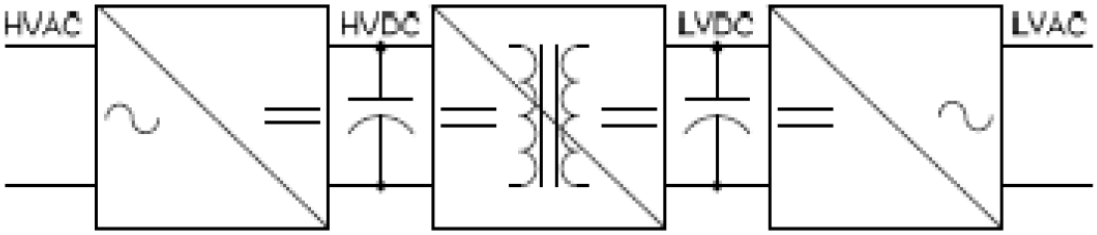


- Energy Storage/Charging

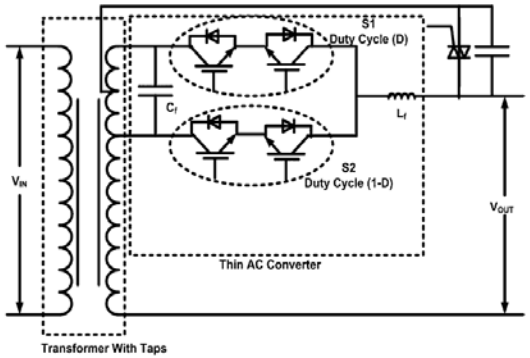


- Microgrid (AC or DC)

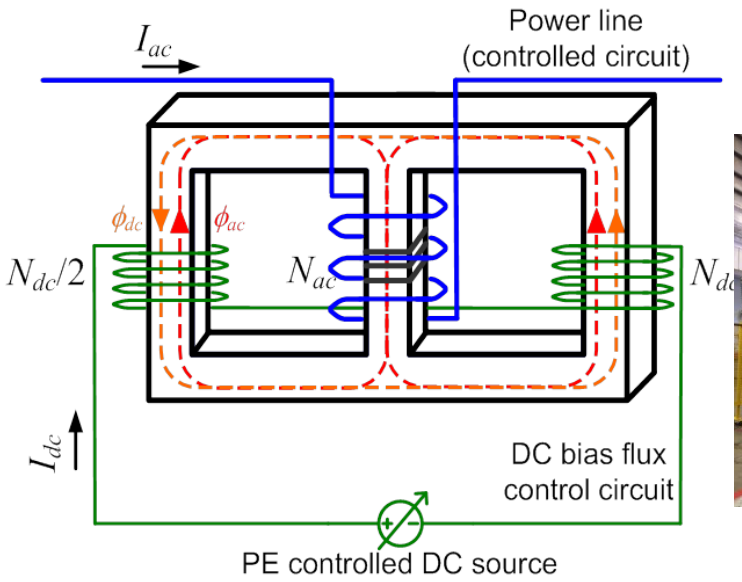
Power Electronics for Distribution Grid – More Recent Development

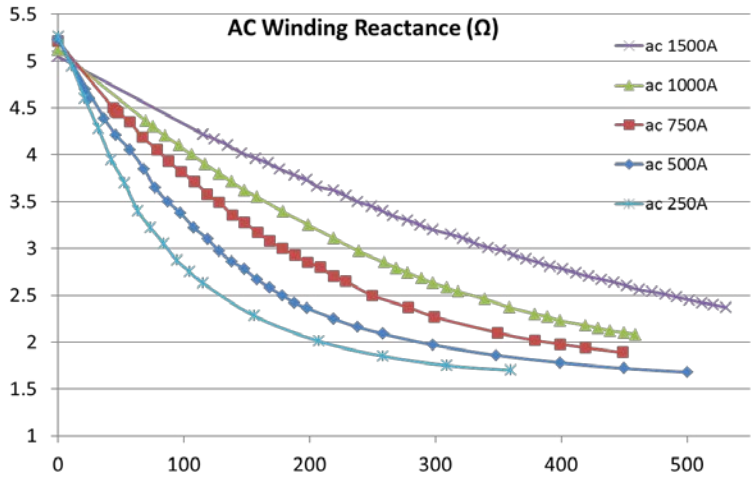


Solid-state Transformer



Controllable Network Transformer



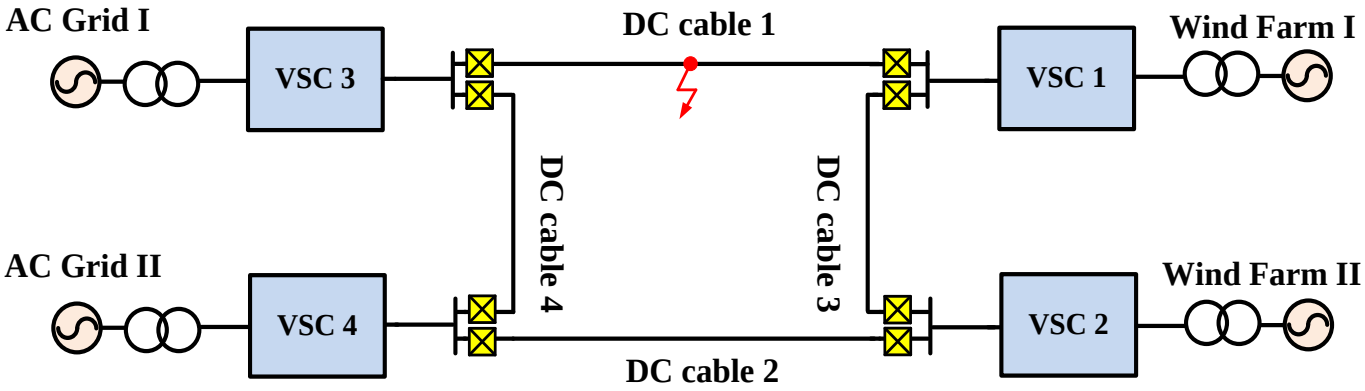


Continuously Variable Series Reactor

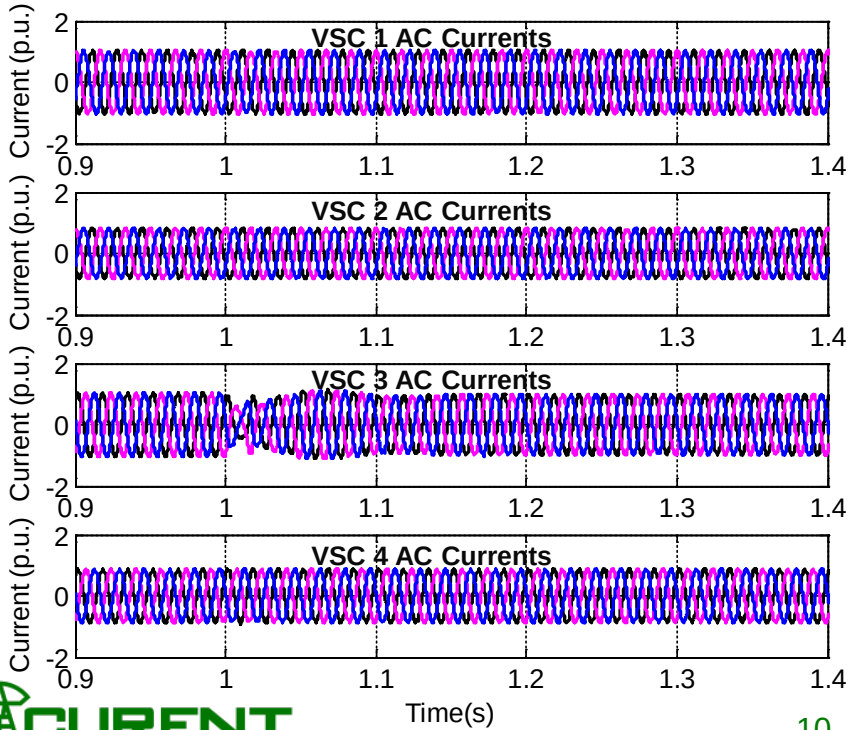
HV WBG Devices in MV Applications

- **Wide band-gap (WBG) vs. Silicon**
  - High breakdown electric field, high voltage rating, low conduction loss
  - Fast switching speed, high switching frequency
  - Superior thermal characteristics
- **Applications should take advantages of**
  - Low loss
  - Fast switching speed
  - High frequency application
- **Benefits of HV SiC can be realized in several ways**
  - Direct substitution – improved efficiency and power density
  - Simplified topology – further loss reduction and increased power density
  - Enable new capability and functionality for system-level
  - Enable new applications or replace the non-PE equipment

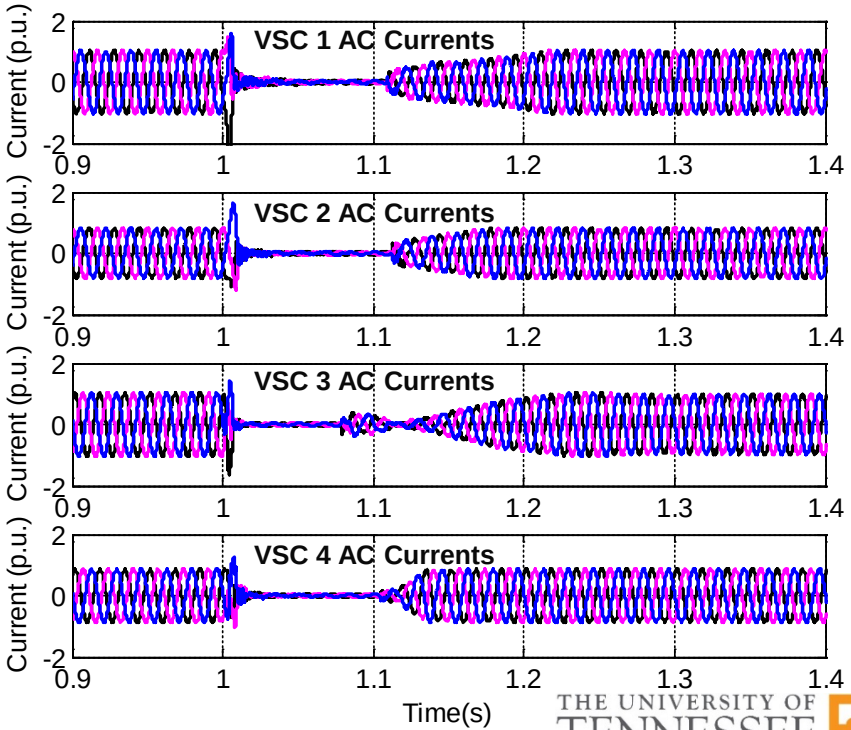
Impact of DC Breaker Speed



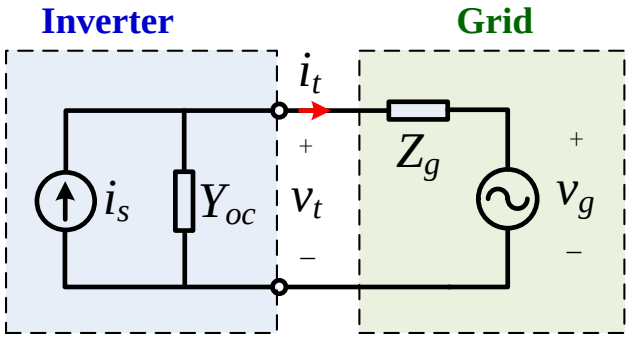
With Fast DC Breaker

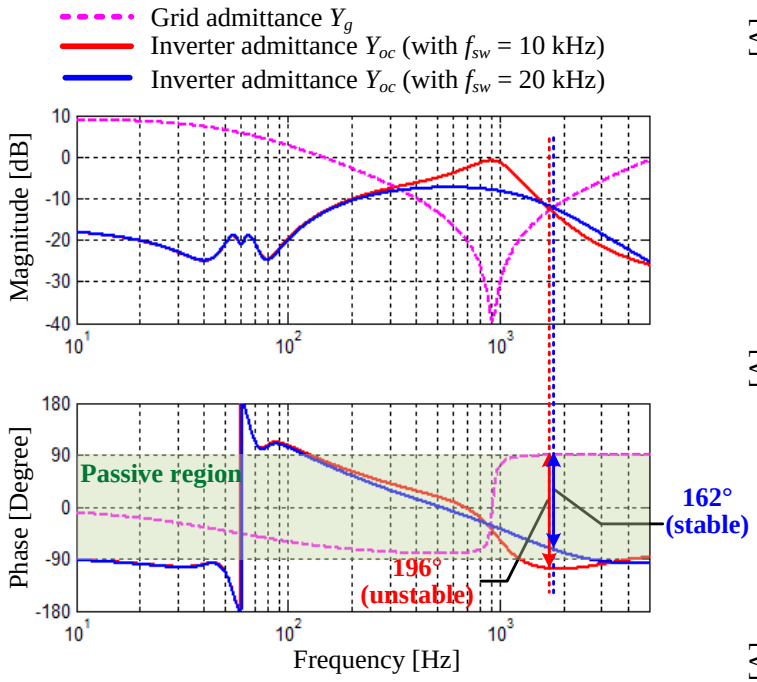


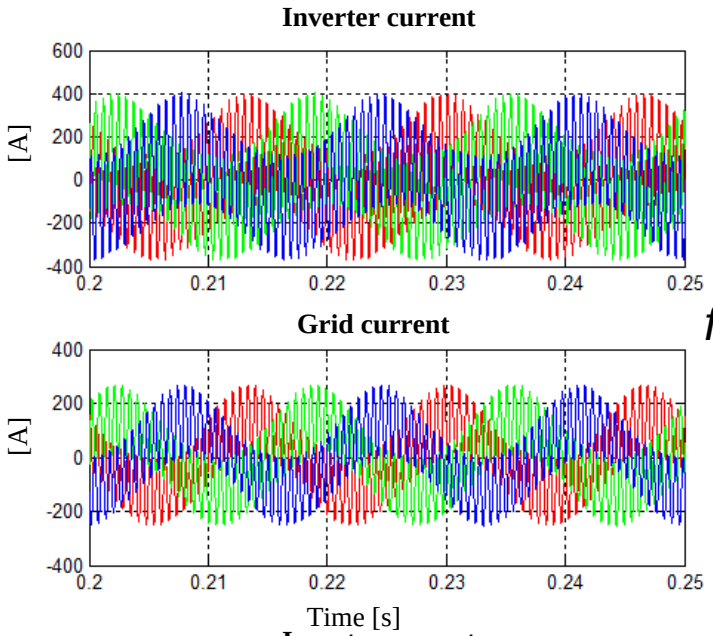
With Slow DC Breaker



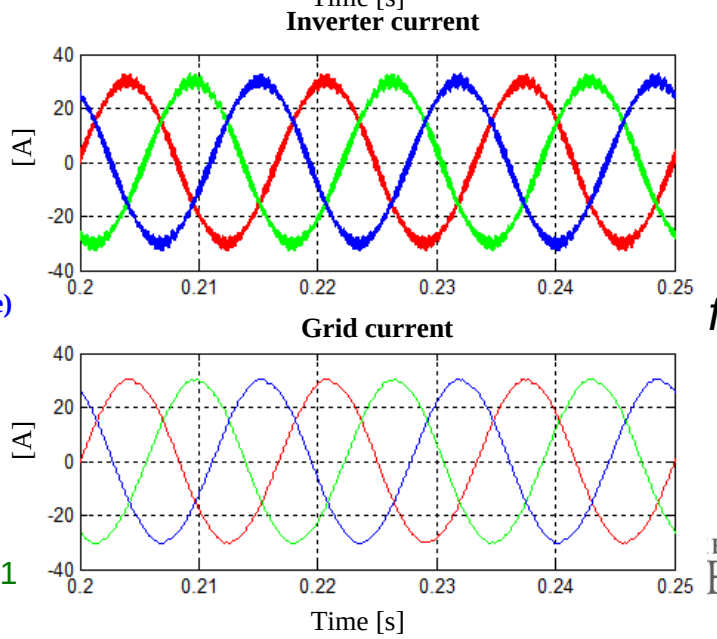
Impact of Switching Frequency on Stability







f_{sw} = 10 kHz



f_{sw} = 20 kHz

WBG Potential Applications in Distribution Grid

- Improve the performance of the existing PE equipment
  - Efficiency improvement for all; density improvement for some; performance improvement (e.g. CB)
- Replace non-PE equipment
  - SST
- Enhance functionality/capability
  - Smart inverter
- Enable new applications
  - DC grid
  - high bandwidth conditioner
  - direct-tied PV inverter

Potential Research Needs

- A benchmark study to understand the system benefits of HV SiC for distribution grid applications and help to identify the potential early adopters and killer applications.
- System architecture, topology and control of the identified applications
- Identify the required performance characteristics of HV SiC and associated components and subsystems for grid applications:
  - Required and/or desired SiC device characteristics and performance (normal and abnormal conditions)
  - Control and protection
  - Passive components and filters (for dv/dt, di/dt, EMI etc.)
  - Thermal management
- Standardization/building block for cost and reliability?

Acknowledgements

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Thank You!