Multi-Scale Control of Power Electronics for Power Systems

Sudip K. Mazumder, Fellow, IEEE
Distinguished Lecturer, IEEE Power Electronics Society
Editor-at-Large, IEEE Transactions on Power Electronics
Chair, IEEE PELS TC on Sustainable Energy Systems
Director, Lab for Energy and Switching-Electronics Systems (LESES)
Professor, Department of Electrical and Computer Engineering
University of Illinois at Chicago
President, NextWatt LLC

Acknowledgements: NSF, ONR, ARPA-E, DOE

NSF Workshop
IIT, Chicago, Illinois
2019
Power Electronics for Power Systems: Overview

- Power Quality
- Smart / Micro Grid
- DERs / Energy Storage
- Solid-State Transformer
- HVDC / MVDC
- Electric Vehicles
- Fault Isolation and Protection
- Naval and Aerospace Power Systems
- Power Electronics for Power Systems
Some Basic Background about Power-Electronic Systems (PES) Control

Why is PES control multi-scale even if the control objective(s) typically evolve(s) on mono-scale?

Because the semiconductor devices are switched under near-impulse transition that triggers almost broad-band response.

Fast scale accounts for switching loss, EMI noise, device dv/dt and di/dt stress, edge-control bandwidth.

Control objectives: voltage, current, power, …..
Multi-scale Control Vision?

Temporal Scalability
PEN Control
- Hardware Layer (50 ns – 1 µs)
- Switching Layer (1 µs – 10 µs)
- Converter Layer (10 µs – 1 ms)

Spatial Scalability
PEN Control
- Conversion Layer (1 ms – 1 s)
- System/Cyber Layer (> 1 s)

Multi-scale control of PE Network
- Converter Layer (10 µs – 1 ms)
- Hardware Layer (50 ns – 1 µs)
- Switching Layer (1 µs – 10 µs)

THANK YOU!

Sudip K. Mazumder (mazumder@uic.edu; +1 312-355-1315)
Fellow, IEEE
Distinguished Lecturer, IEEE Power Electronics Society
Editor-at-Large, IEEE Transactions on Power Electronics
Chair, IEEE PELS TC on Sustainable Energy Systems

Professor, Department of Electrical and Computer Engineering
Director, Laboratory for Energy and Switching-Electronic Systems
University of Illinois at Chicago

President, NextWatt LLC
Multi-scale Control of Power-electronic / Solid-state Transformer

Dual-objective multi-scale control

VR: Voltage regulation
VR+SLR: Voltage regulation and switching loss reduction

WBG/NBG: Wide/Narrow Bandgap

Switching Loss Reduction

Grid Connected
Standalone

PES Averaged Model of the PES
Continuous Control Modulation

Conventional PES Control Design Approach

Multi-scale with multiple feasible switching sequences

Slow scale Fixed switching sequence; modulation not an integral part

PES Discontinuous Model of the PES
Switching Sequence Generation

Multi-scale PES Control Design Approach


Stability Prediction of the W/NBG-PES Feasible Switching Sequences

WBG/NBG-PES Power Stage

WBG/NBG-PES Discontinuous Dynamical Model

Offline Optimal Switching Sequences

Sensor Output Feedback and/or Estimated Feedback

Online Optimal Switching Sequences

Feedback and/or Estimated Feedback

Feasible switching sequences