ECE 592-112
Grid Interactive Power Electronics

Instructor(s): Srdjan Lukic (smlukic@ncsu.edu)

Objective or Description:
This course focuses on grid-interactive power electronics, emphasizing the key features of inverter-interfaced distributed generators compared to traditional synchronous generators. A primary focus will be the design of grid-forming inverters, an emerging technology crucial for accelerating solar and wind deployments in weak grids and inverter dominated grids. The course is tailored to bridge the gap between power electronics and power systems, introducing power electronics analysis tools in a context relevant to students interested in power systems. The course will highlight ongoing research initiatives at NCSU related to the design of grid-forming inverters for interoperability and microgrid development.

Prerequisites: The prerequisite for this course is familiarity with ECE305, ECE 434 or equivalent courses taken at another university.

Textbook:

Yazdani, Amirnaser, and Reza Iravani. Voltage-sourced converters in power systems: modeling, control, and applications. John Wiley & Sons, 2010, eBook. https://ieeexplore.ieee.org/book/6739364

Xinbo Ruan, Xuehua Wang, Donghua Pan, Dongsheng Yang, Weiwei Li, and Chenlei Bao. Control techniques for LCL-type grid-connected inverters. Springer Singapore, 2018.
https://catalog.lib.ncsu.edu/catalog/NCSU4528164

Topics:

- Modeling and control of grid-connected inverters
- Average and switching models of power converters
- Converter modulation schemes
- Grid-following (current source) and grid-forming (voltage source) control for grid-connected inverters
- Equivalence between synchronous generators and grid-forming inverter-based resources
- Challenges and solutions related to low-inertia grids
- Hierarchical grid control and concepts of microgrid control

Grading:
The course includes eight project-based assignments, accounting for 70% of the overall grade, focusing on various aspects of inverter-based resource modeling and control. These assignments will be conducted using MATLAB/Simulink and will require students to submit written reports. A final project, worth 30% of the grade, will be assigned mid-semester, allowing students to delve deeper into a specific topic, agreed upon with the instructor. Examples of potential projects include implementing a digital controller for an inverter-based resource or developing a microgrid controller. Term projects will take advantage of the hardware-in-the-loop capabilities available in the FREEDM lab, providing hands-on experience with real-world applications.