ESE 586: Microgrids

Syllabus

1. Course Staff

Instructor: Yifan Zhou
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Light Engineering 215

Office Hours: Tuesday and Wednesday 8:30 am-10:30 am (Online)

2. Course Description

Advanced modeling, control, resilience and security technologies useful for the grid modernization from a unique angle of microgrid design, analysis and operation. Smart inverters, microgrid architectures, distributed energy resources modeling, microgrid hierarchical control, microgrid stability, fault management, resilient microgrids through programmable networks, reliable networked microgrids, and cyber security.

Prerequisites: Undergraduate courses in circuits and power systems, or consent of instructor.

Credits: 3

3. Reference

- Lecture notes
- P. Zhang, *Networked Microgrids*. Cambridge University Press, 2021

4. Course Learning Objectives

The course aims to help students build a solid foundation for analyzing modern power systems. Basic concepts and knowledge for power system modeling, steady-state analysis, dynamic and stability analysis, optimal operation, and control will be introduced, along with lucid examples and hands-on experiments. Homework assignments are designed to improve students' skills in using mathematical algorithms to analyze power systems.

Upon completing this course, students will understand fundamental analytics of modern power system operations, which are particularly useful for power industry applications, and will gain experience in analyzing benchmark power systems. This course will also significantly enhance students' skills in using applied mathematical knowledge and programming technologies to solve engineering problems.

5. Student Learning Outcomes

By the time the course is completed, students will have acquired knowledge and skills with microgrids which include the ability to:

- Understand the concepts of microgrids, and networked microgrids;
- Model PV power systems and standard grid-tied inverter;
- Analyze distribution grid power flow;

- Understand centralized control and distributed control in microgrids, especially primary, secondary and tertiary control;
- Conduct power flow analysis for droop-control-based microgrids and networked microgrids;
- Use RTDS for real-time simulation of microgrids;
- Understand fault ride-through and active fault management for microgrids;
- Understand basics of cybersecurity in microgrids and active defense strategy.

6. Schedule

Week 1	**Introduction** – Concept of microgrids – Operation mode and architecture of microgrids
Weeks 2-3	**Microgrid Modelling** – Distributed energy resources (DERs) modelling I: PV system, MPPT, and energy storage – Distributed energy resources modelling II: Wind Turbine, Microturbine, and other DERs – Microgrid inverter structures
Week 4	**Microgrid Control** – Centralized control – Hierarchical principle: Primary, secondary and tertiary control – Distributed control
Weeks 5-6	**Enhanced Microgrid Power Flow** – Power flow – Distribution power flow – Networked microgrid power flow
Week 7	**Microgrid Stability** – Small-signal stability analysis and modal analysis – Large-signal stability analysis and time-domain simulation – Stability of inverter-based microgrids
Week 8	**DC Microgrids** – Overview of DC microgrids – DC microgrid control
Week 9	**Formal Analysis of Networked Microgrids** – Introduction to reachability theory – Reachability analysis of microgrids
Week 10	**Active Fault Management for Networked Microgrids** – Fault ride through – Multi-functional Active Fault Management (AFM)
Week 11	**Resilient Microgrids through Software Defined Networking** – SDN-enabled control and communication architecture – Distributed regulation of networked microgrids – Hardware-in-the-loop testbed

Week 12	**Cyber Security in Microgrids** – Introduction to cyber attacks – Active detection of cyber attacks
Weeks 13-14	**Advanced Computing Techniques of Microgrids** – Learning-based analytics of microgrids – Quantum computing in microgrid analysis
Week 15	**Prepare term projects**

7. Grading

Homework Assignments: 40%
Term Project (for graduate only): 40%
Weekly Quiz, Participation: 20%

Student Accessibility Support Center Statement

If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact the Student Accessibility Support Center, Stony Brook Union Suite 107, (631) 632-6748, or at sasc@stonybrook.edu. They will determine with you what accommodations are necessary and appropriate. All information and documentation are confidential.

Academic Integrity Statement

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty is required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology and Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty please refer to the academic judiciary website at
http://www.stonybrook.edu/commcms/academic_integrity/index.html.

Critical Incident Management

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of University Community Standards any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures. Further information about most academic matters can be found in the Undergraduate Bulletin, the Undergraduate Class Schedule, and the Faculty-Employee Handbook.