ESE 586 Microgrids

Syllabus

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 hierachical control, microgrid stability, fault management, resilient microgrids through programmable networks, reliable networked microgrids, and cyber security.

Instructor

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Office hours: Monday 1-2 pm, or by appointment.

Prerequisite

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

Location and Time

Location TBD Monday 5:30-8:20 pm

Outline

Topic 1: Introduction (1 week)

- Power systems resilience
- The concept of microgrids

Topic 2: Microgrid Modelling and Analysis (4 weeks)

- Distributed energy resources (DERs) modelling I: PV system, MPPT, and grid-tied interface
- Distributed energy resources modelling II: Microturbine, energy storage and other DERs
- Microgrid inverter structures
- Distribution power flow
- Stability modelling and computation

Topic 3: Microgrid Control (1 week)

- Centralized control
- Hierarchical principle: Primary, secondary and tertiary control
- Distributed control

Topic 4: Enhanced Microgrid Power Flow (1 week)

- Microgrid power flow
- Networked microgrid power flow

Topic 5: Resilient Microgrids through Software Defined Networking (1 week)

- SDN-enabled control and communication architecture
- Distributed regulation of networked microgrids
- Hardware-in-the-loop testbed

Topic 6: Formal Analysis of Networked Microgrids Dynamics (1 week)

- Formal analysis of microgrid dynamics
- Stability margin analysis on networked microgrids

Topic 7: Active Fault Management for Networked Microgrids (1 week)

- Fault ride through
- Multi-functional Active Fault Management (AFM)

Topic 8: Cyber Security in Microgrids (1 week)

- Introduction to cyber attacks
- Active detection of cyber attacks

Topic 9: DC Microgrids (1 week)

- Overview of DC microgrids
- Stability of DC microgrids

Topic 10: Future Perspectives (1 week)

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.

Course Notes

Lecture notes are developed from part of a book written by Prof. Zhang. All course materials will be available online.

Reference

[1] P. Zhang, *Networked Microgrids.* Cambridge University Press, 2020.

Experimental and Computing Tools

RSCAD (RTDS NovaCor), Matlab/Simulink

Evaluation Scheme

Homework Assignments: 50%
Term Project: 50%

Grading Scale

Score	Grade	Score	Grade
≥90	A	70-74	B−
85-89	A−	65-69	C
80-84	B+	60-64	D
75-79	B	<60	F

Policy

1. No cheating. Even though discussion and study groups are encouraged, students who copy answers or procedures in homework assignments or who allow their answers or procedures to be copied will be considered to be cheating and corresponding penalties will be applied.

2. Late homework is not accepted unless extenuating circumstances are present.

3. Projects can be done individually or by teams of two or three. If the homework is done by a team, both students need to submit the report and source files individually but the teamwork should be declared in the report. Projects done individually will receive a 5% bonus.