Spring 2017

EEL 5291 Distributed Control and Optimization for Smart Grids
(A course that can be taken by both graduate and undergraduate students)

Designation: UG Elective and Graduate

2014-15 Catalog Description: Electric power systems, transmission and distribution networks, distributed generation and smart grid components, voltage stability and VAR control, dispatch of distributed generation, distributed optimization for loss minimization, frequency control, electricity markets and incentive controls.

Pre-requisite(s): EEL3657 Linear Control Systems
EEL4216 Fundamental of Electric Power Systems
Or consent of instructor

Textbook: Selected topics and chapters from the references and research papers

References:

Power systems and smart grid:
- Stuart Borlase, Smart Grids: Infrastructure, Technology, and Solutions, CRC Press, 2012

Transmission and distribution networks:

Power system control:

Distributed control and optimization:
- Zhihua Qu, Cooperative Control of Dynamical Systems, Springer Verlag, London 2009

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1 This course will be offered jointly by University of Central Florida (UCF) and University of Kentucky (UK). For the purpose of implementing FEEDER Course Sharing Agreement, UCF will act as the hosting institution.

Economics of power systems:

**Topics:**
- Introduction to electric power systems and their controls
  - Transmission networks (AC and HVDC)
  - Distribution networks
  - Operational requirements: Economic dispatch, steady-state analysis, and dynamic analysis
  - Supervisory control and data acquisition (SCADA) and energy management system (EMS)
- Distributed energy resources (DERs) and their grid integration
  - Solar photovoltaic arrays
  - Wind turbines
  - Microturbine
  - Fuel cell
  - Energy storage and electric vehicles
- Smart grid components and emerging technologies
  - Sensors (PMUs and IEDs)
  - Communication and wide area monitoring
- Autonomous control, dispatch and optimization for distribution networks
  - Inverter controls
  - Voltage/Var control
  - Dispatch of aggregate active power
  - Distributed optimization for loss minimization
  - Self-healing by fault detection, isolation, and restoration (FDIR)
  - Islanding detection
  - Microgrid operations and frequency control
- Electricity markets: incentive based controls
  - Electricity market design at various time scales
  - Demand response
• Smart behaviors using leader-follower optimization
• Resiliency of power systems and robustification of distributed controls

Course Objectives: Fundamentals and operation of electric grids are investigated from the perspective of cyber-physical systems. The principles and state-of-the-art approaches from sensing/communication, control and optimization are applied to make grid operation smart in the presence of intermittent and distributed generation from renewables. Specifically, how to make grid operation autonomous, optimal and robust by the means of control and optimization is addressed. The goal is to expose students to emerging technologies in this broad field of smart grid and energy systems, in particular, distributed control and optimization for electric grids with renewables so the students become prepared for employment as well as research opportunities.

Contribution of course to meeting the Professional Component: Math & Science Topics (10%), Engineering Topics (80%), General Education (energy, 10%)

Prepared by: Dr. Zhihua Qu  
Original Date: Jan. 12, 2014
## Relationship of the course to Program Outcomes:

| Description of the Program’s Student Outcomes addressed by the course |
|--------------------------|---------------------|
| **Outcome** | **Description** |
| 1 | Graduates will have the ability to apply knowledge of mathematics, science and engineering |
| 5 | Graduates will have the ability to identify, formulate, and solve engineering problems |
| 11 | Graduates will have the ability to use the techniques, skills and modern engineering tools necessary for engineering practice |
| 12 | Graduates will have the ability to use differential equation for solving practical engineering problems |
| 13 | Graduates will have the ability to use complex numbers for solving practical engineering problems |

### Relationship of the Student Outcomes and ABET a-k

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