Spring 2017

EEL 5291 Distributed Control and Optimization for Smart Grids[1]

(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:

- J. J. Grainger and W. D. Stevenson Jr., *Power Systems Analysis*, McGraw Hill, 1994
- P. Kundur, *Power System Stability and Control*, McGraw Hill, 1994.
- P. Sauer and M. A. Pai, *Power System Dynamics and Stability*, Prentice Hall, 1998.
- A. Keyhani, *Design of Smart Power Grid Renewable Energy Systems*, Wiley, 2011.
- Stuart Borlase, *Smart Grids: Infrastructure, Technology, and Solutions*, CRC Press, 2012
- G. M. Masters, *Renewable and Efficient Electric Power Systems*, John Wiley & Sons, Inc. 2004.

Transmission and distribution networks:

- Turan Gonen, *Electric Power Distribution System Engineering*, Second Edition, CRC Press, 2007
- Turan Gonen, *Electrical Power Transmission System Engineering: Analysis and Design*, 2nd Edition, CRC Press, 2009.

Power system control:

- A. J. Wood and B. F. Wollenberg, *Power Generation, Operation, and Control*, 2nd edition, John Wiley & Sons, Inc, 1996.
- James Northcote-Green, Robert G. Wilson, James Northcote-Green, Robert G. Wilson, *Control and Automation of Electrical Power Distribution Systems*, CRC Press, 2006.

Distributed control and optimization:

- Zhihua Qu, *Cooperative Control of Dynamical Systems*, Springer Verlag, London 2009

[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.

- N. S. Rau, *Optimization Principles: Practical Applications to the Operation and Markets of the Electric Power Industry*, Wiley-IEEE Press, 2003.
- U. Diwekar, *Introduction to Applied Optimization*, Springer, 2008.
- James A. Momoh, *Electric Power System: Applications of Optimization*, Second Edition, CRC Press, 2008

Economics of power systems:

- D. S. Kirschen and G. Strbac, *Fundamentals of Power System Economics*, reprinted edition, John Wiley & Sons Ltd. 2009.
- S. Stoft, *Power System Economics: Designing Markets for Electricity*, Wiley-Interscience, 2002.
- A. Mazer, *Electric Power Planning for Regulated and Deregulated Markets*, John Wiley & Sons, Inc, 2007.

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 resourses (DERs) and their grid integration
  - Solar photovoltaic arrays
  - Wind turbines
  - Microturbine
  - Fuel cell
  - Engery 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*													
ABET *a-k* ⇨ / **Student Outcome** ⇩	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**12**	**13**
1	x												
5					x								
11											x		
12												x	
13													X

Prepared by: Dr. Zhihua Qu **Date:** Jan. 12, 2014