EEE572 - Advanced Power Electronics

Scope: Power electronics is a critical enabling technology that covers a truly wide spectrum of applications including power supplies for all electronic equipment ranging from cell phones to mainframe computers, motion control, interface of renewable energy resources such as solar and wind, automotive applications and efficient lighting. The major focus of this course is on design-oriented analysis of topologies and control methods for various power electronic converters used for dc-dc, dc-ac and ac-dc power conversions in important and current applications. This course is intended as a second course in power electronics. However, several lectures will be devoted initially to the fundamentals of switch-mode power conversion such that students without a formal course on power electronics can also follow the course easily. PSpice based simulations will be used extensively to reinforce the basic concepts, and as a design tool as well. Power semiconductor devices such as MOSFETs and IGBTs will be discussed briefly.

The instructor will attempt to balance the lecture hours between the two distinct areas of „dc- dc converters and power management" and „PWM dc-ac/ac-dc converters at relatively higher power levels", depending on student interest and background. Students will also be given an opportunity to specialize in one of the two areas through the required mini-project.

Pre-requisite: Open to electrical engineering graduate students

Course topics:

- **Basic principles of switch-mode power conversion**
  Concept of steady state in switching converters, volt-second and ampere-second balance, ideal switches, concept of power pole
- **DC-DC converters**
  - Analysis and detailed design of buck, boost, buck-boost, Cuk and
  - SEPIC converters Analysis and detailed design of isolated dc-dc converters including forward, flyback, push-pull, full bridge and dual-active bridge topologies
  - Continuous and discontinuous current modes of
  - operation Linearized, small-signal average models
  - of dc-dc converters Voltage mode and current
  - mode control design methods Design of magnetics for dc-dc converters

- **Power management**
  - Switching regulators for modern processors – multi-phase voltage regulators, design for high dynamic performance, switched capacitor converters, features of power management integrated circuits
- **Digital control of power electronic converters**
  - Review of digital control systems
  - Digital control techniques for power converters; modeling and simulation
  - Design examples of multi-phase VR, and PWM dc-ac converter
- **AC-DC PWM rectifiers**
  - Power quality issues
  - Boost and flyback converter based power factor correction circuits (PFC)
  - Models, design and control of PFC
  - Full bridge bi-directional PWM rectifiers, applications in front end of motor drives
- **DC-AC PWM inverters**
  - Voltage source inverters - topology and PWM techniques
  - Models of single phase and three phase inverters and control methods
  - Applications in low frequency AC synthesis
  - Three-phase PWM techniques
- **Grid interface of renewable energy resources**
  - Power converters and control for interfacing solar and wind energy to grid
  - Distributed generation and impact on power distribution systems
  - Microgrids and smart grid technologies using power electronic converters
- **Soft switching and resonant converters**
  - Concept of ZVS and ZCS
  - Zero voltage transition converters
  - Resonant converters and applications in lighting
- **Practical issues in power electronic converters**
  - Selection criteria for diodes, MOSFETs and IGBTs; gate drive circuits
  - Thermal management
  - EMI and layout issues