Course Textbook and Background

- Power Electronics by Daniel W. Hart

Supplementary Textbooks:
- Fundamentals of Power Electronics by Erickson
- Power Electronics by Ned Mohan

Required/Assumed Background
- Analog Circuits
- Basic Control Theory
- Semiconductor Devices (Basic)
Definition

- Power electronics is an interdisciplinary field interrelated to all of the major disciplines of electrical engineering.

Source: Elements of Power Electronics by P. Krein
Definition

- Power electronics refers to the study of electronic circuits which efficiently process and transfer the electric power using semiconductor switching devices.
Conversion Types

Block Diagram of a Power Electronics-Based System

- DC-DC Conversion
- AC-DC Rectification
- DC-AC Inversion
- AC-AC Cycloconversion
Power Electronics for Portable Electronic Devices

Source: Texas Instruments and Apple

Wind Energy → Mechanical Energy → Electrical Energy


Ref: Erickson et. al., APEC 2009
Power Electronics for Transportation: HEV and EV

Ref: “Development of small size Power Control Unit,” Hironaka et. al., EVS 2006
Power Electronics for Transportation: Traction System

Ref: “Medium Frequency Transformer for Traction Applications making use of Multilevel Converter: Small Scale Prototype Test Results,” Carpita et. al., SPEEDAM 2006
Power Electronics for Transportation: More Electric Aircraft
Power Electronics for Solid State Lighting

- Outdoor
- General ambient lighting
- Automotive
- Other
  - Backlighting in LCD TVs, laptop screens, mobile phones
  - Sinages
  - Flash lights and camera flashes
Power Electronics for Solid State Lighting
Power Electronics for Power Transmission: HVDC System
Other Applications of Power Electronics

- Mechatronics and Robotics
- All Electric Ships
- Grid Integration of Distributed Energy Resources (Fuel Cells, Micro-turbine Generators, Photovoltaic Panels, Tidal Energy Generators, Wind Turbines) and Energy Storage Devices
Considerations for the Design of Power Electronic Converters

- Efficiency
- Size and Weight
- Performance in Terms of Power Quality and Harmonic Content
Components Available to the Circuit Designers

- Resistors
- Capacitors
- Magnetics
- Linear-mode Semiconductor devices
- Switched-mode Semiconductor devices
An Essential Requirement for Conversion: Efficiency

- An important goal of converter technology is to construct converters of small size and weight, which process substantial power at high efficiency.

![Power Converter Diagram]

- Efficiency is defined as:  
  \[ \eta = \frac{P_{\text{out}}}{P_{\text{in}}} \]

- Efficiency Target:  
  \[ (P_{\text{loss}} \rightarrow 0) \implies (\eta \rightarrow 100\% ) \]
Components Available for Lossless Power Processing

- Resistors
- Capacitors
- Magnetics
- Linear-mode Semiconductor devices
- Switched-mode
Power Loss in an Ideal Switch

Switch closed: \( v_{\text{switch}} = 0 \)

Switch open: \( i_{\text{switch}} = 0 \)

In either case: \( P_{\text{switch}} = v_{\text{switch}} i_{\text{switch}} = 0 \)
Design of Power Electronic Converters

Design of power electronic converters involves:

- Design of power circuits
- Determination of control strategy and generation of gating signals
- Protection of switching power devices
- Design of logic and gating circuits
Course Topics

1. Introduction
2. DC-DC Converters
3. Rectifiers
4. Inverters
5. Interfacing Issues for Power Semiconductor Devices
6. Design of Components
Course Objectives

This course provides:

- An understanding of various AC-DC, DC-AC, and DC-DC converter circuits and principles of their operation
- A knowledge of the basic characteristics of switch types
- A knowledge of switching techniques and control of AC-DC, DC-AC, and DC-DC converters
- A knowledge of sizing of the switching and energy storage elements in AC-DC, DC-AC, and DC-DC converters
ECE 433: Simulation Tools

- Simpower Systems Toolbox

![ECE 433: Simulation Tools Diagram](image)
Marking Scheme

- Homework (5%)
- Projects (15%) – Three projects
- Quizzes (15%) – First Quiz: January 30
- Exams:  
  i) Exam I (15%) – February 22  
  ii) Exam II (15%) – March 28  
  iii) Final Exam (35%)
- Office Hours: Wednesday and Friday 3:00 -4:30 PM (by appointment)