ECE433
Power Electronics

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PURDUE
UNIVERSITY

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**

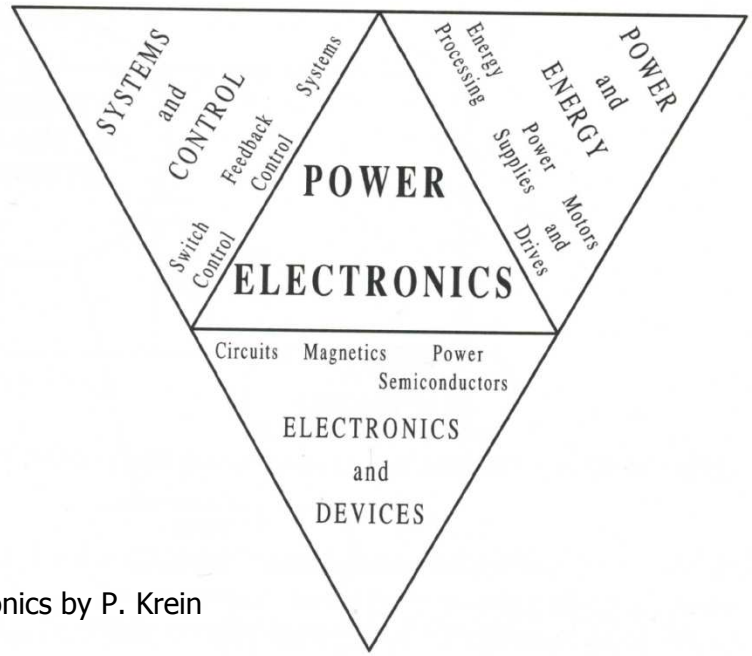
- Analog Circuits

- Basic Control Theory

- Semiconductor Devices (Basic)

Definition

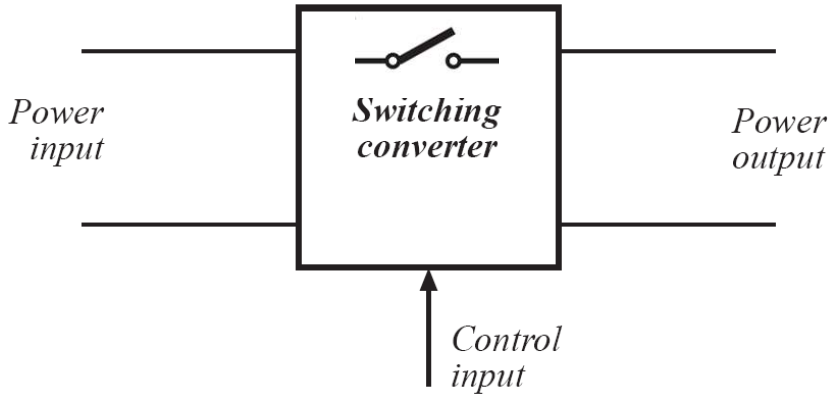
- Power electronics is an interdisciplinary field interrelated to all of the major disciplines of electrical engineering



Source: Elements of Power Electronics by P. Krein

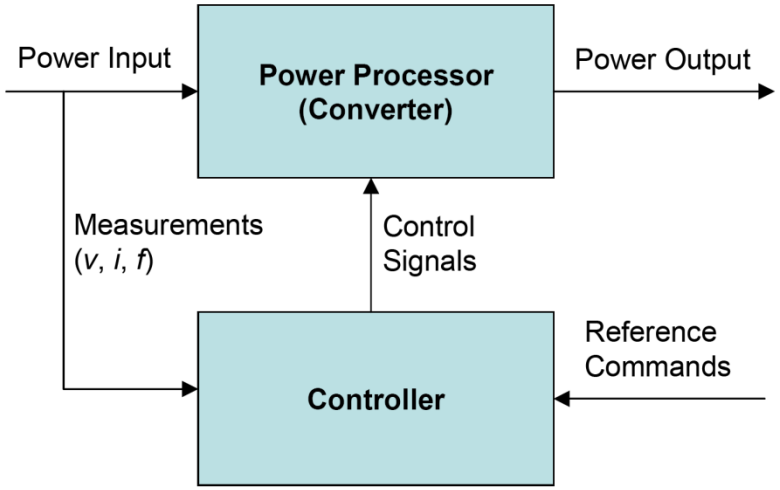
Definition

- 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

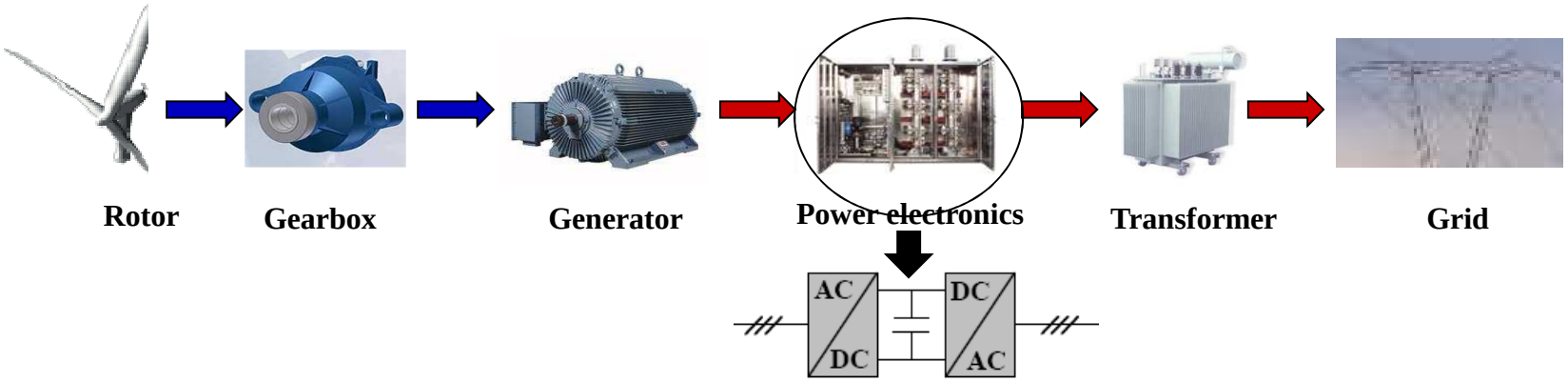


- DC-DC Conversion
- AC-DC Rectification
- DC-AC Inversion
- AC-AC Cycloconversion

Power Electronics for Portable Electronic Devices

Source: Texas Instruments and Apple

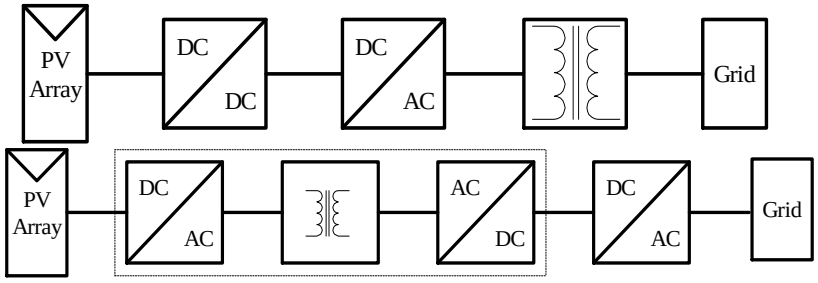
Power Electronics for Renewable Energy Systems: Wind Energy



Ref: "Power Electronics as Efficient Interface in Dispersed Power Generation Systems ," F. Blaabjerg et. al., IEEE Trans. On Power Electronics, Vol. 19, No. 5, Sep. 2004

Power Electronics for Renewable Energy Systems: Solar Energy

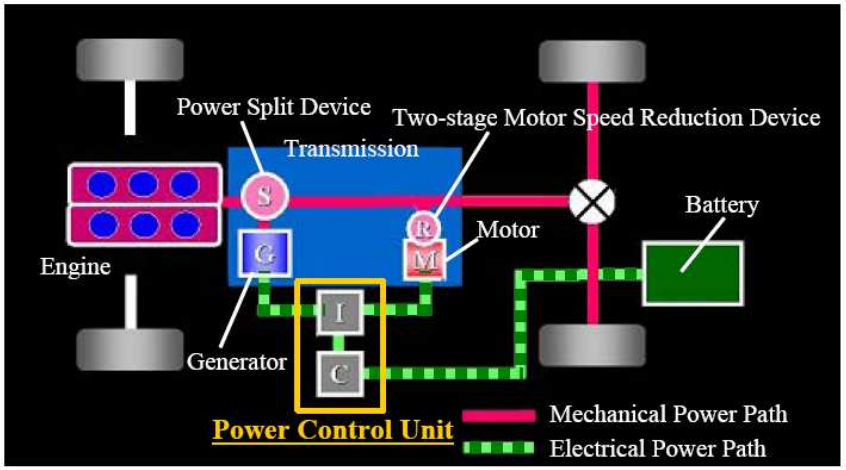
Ref: Erickson et. al., APEC 2009

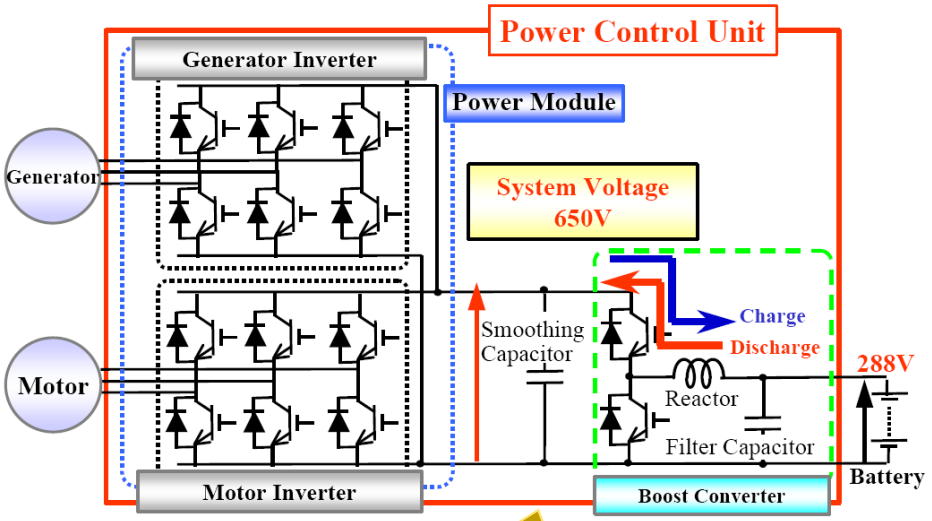


Power Electronics for Transportation: HEV and EV

Toyota HEV

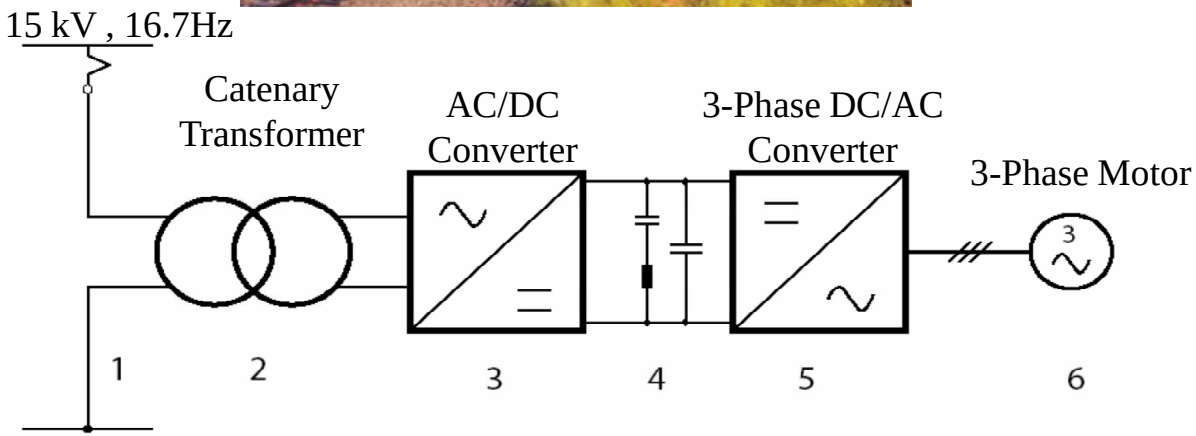
Tesla Motors EV





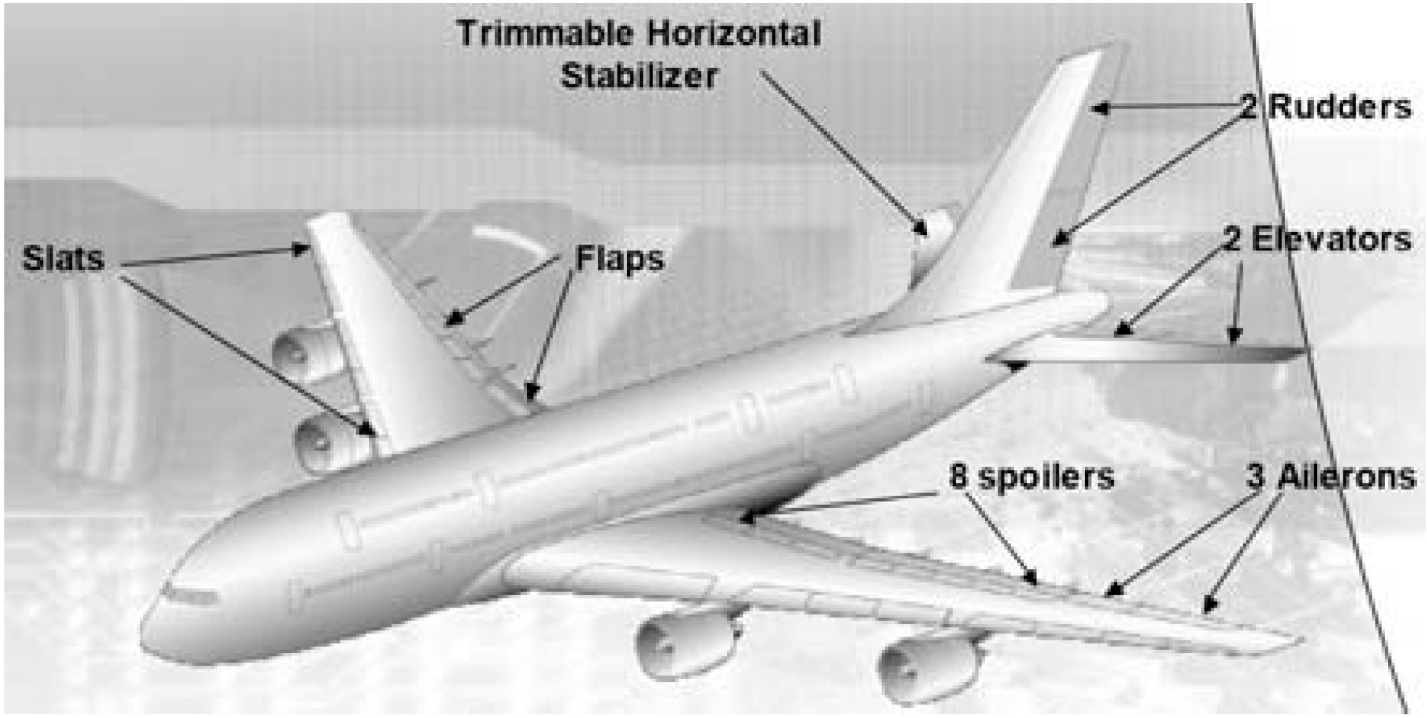
Ref: "**Development of small size Power Control Unit** ," Hironaka et. al., EVS 2006

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

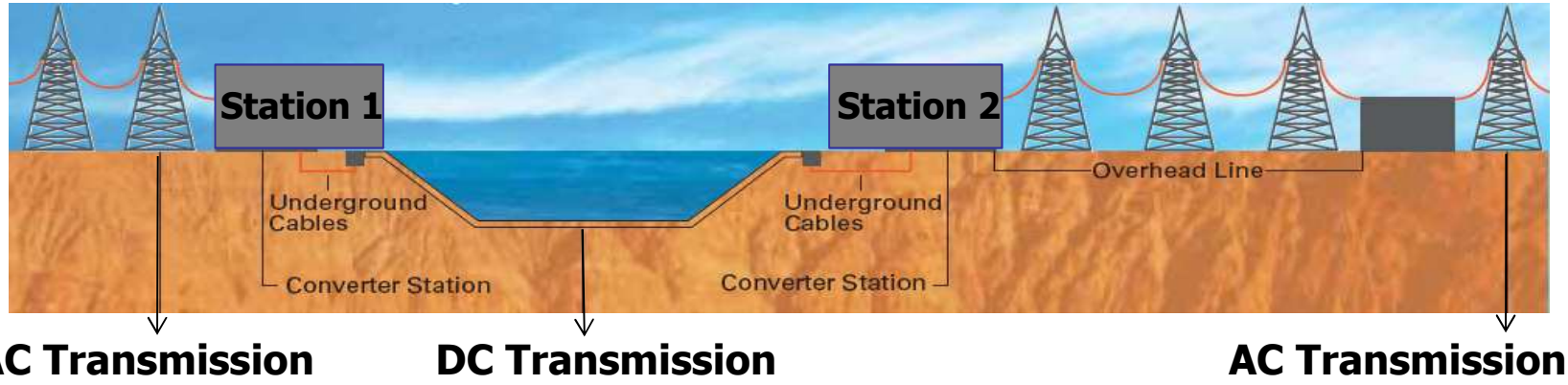


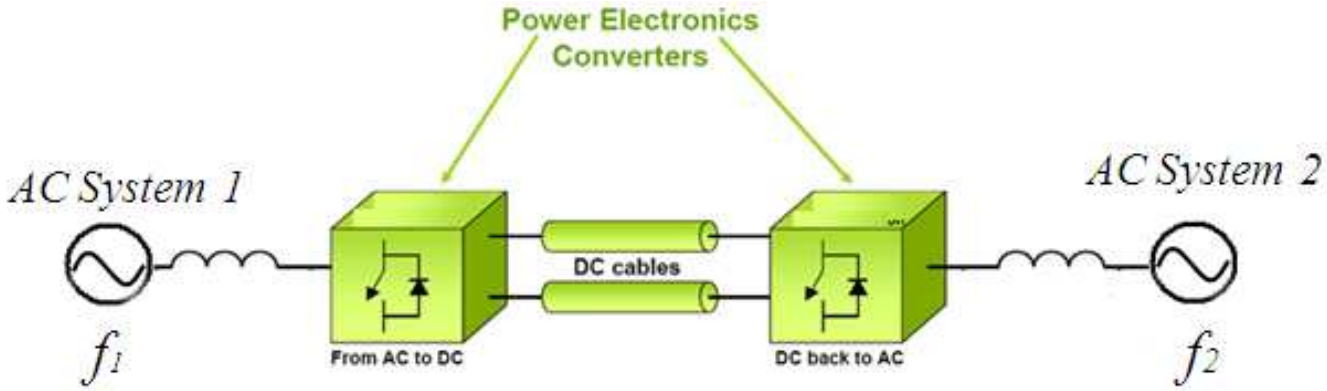
Power Electronics for Solid State Lighting

- 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





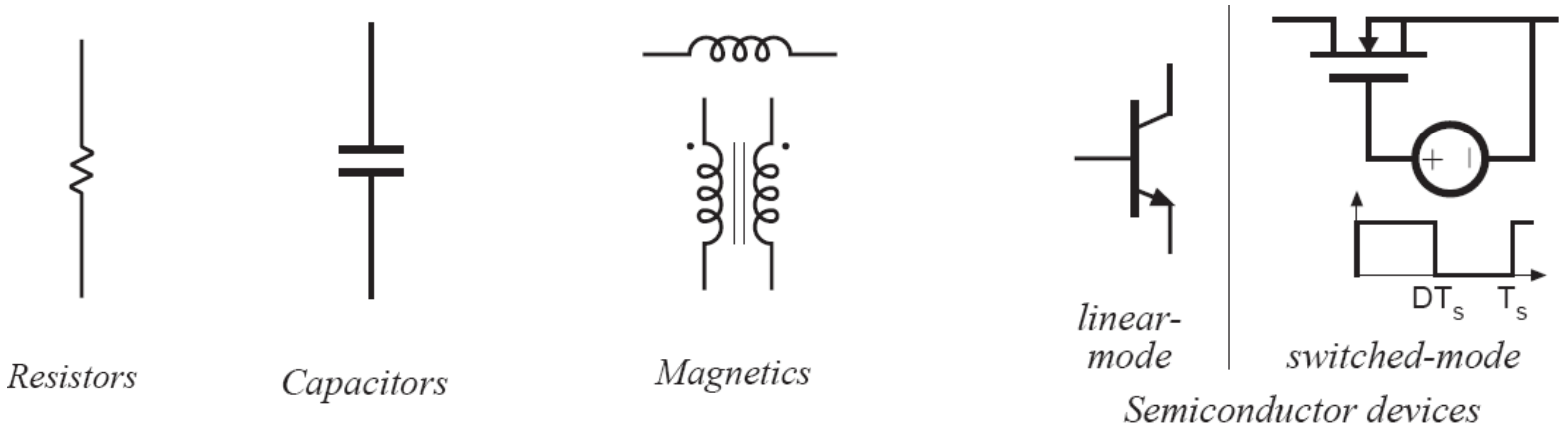
Other Applications of Power Electronics

- 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* *switched-mode*

Semiconductor devices

An Essential Requirement for Conversion: Efficiency

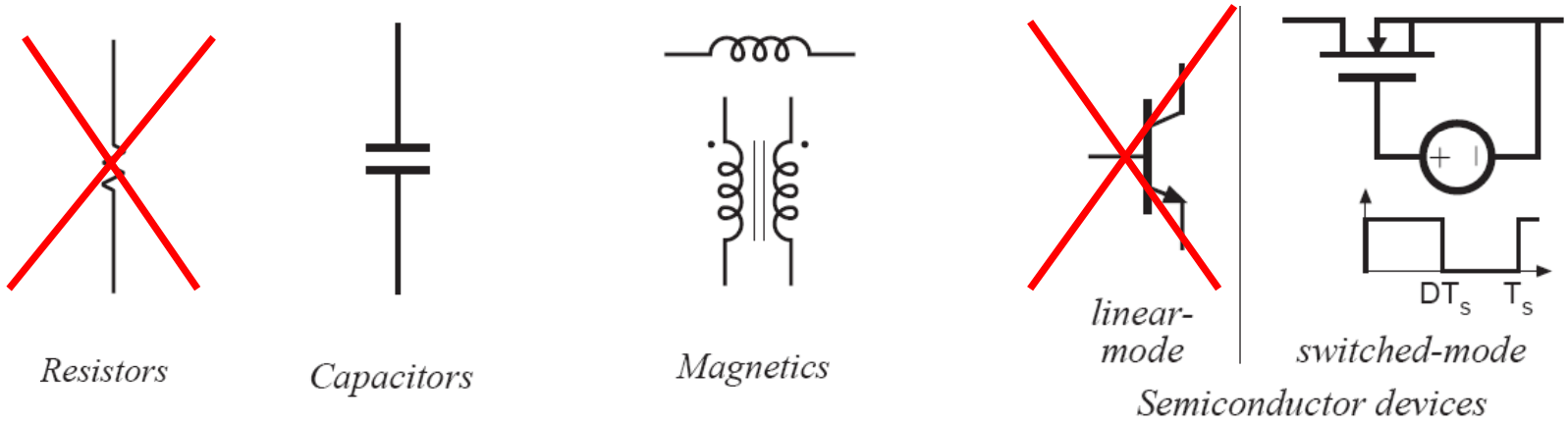
- An important goal of converter technology is to construct converters of small size and weight, which process substantial power at high efficiency

- Efficiency is defined as: $\eta = \dfrac{P_{out}}{P_{in}}$

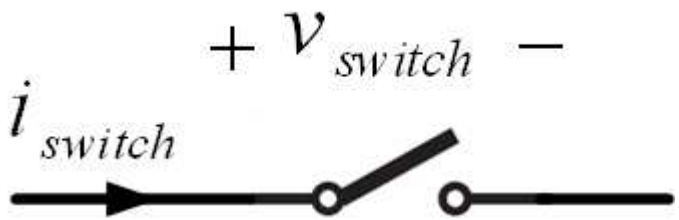
$$P_{loss} = P_{in} - P_{out}$$

- Efficiency Target: $(P_{loss} \rightarrow 0) \Rightarrow (\eta \rightarrow 100\ \%)$

Components Available for Lossless Power Processing



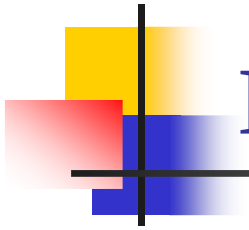
Power Loss in an Ideal Switch



Switch closed: $v_{switch} = 0$

Switch open: $i_{switch} = 0$

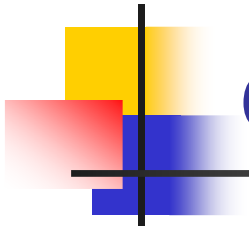
In either case: $p_{switch} = v_{switch} i_{switch} = 0$



Design of Power Electronic Converters

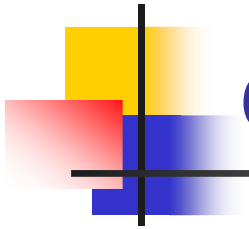
Design of power electronic converters involves:

- **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**



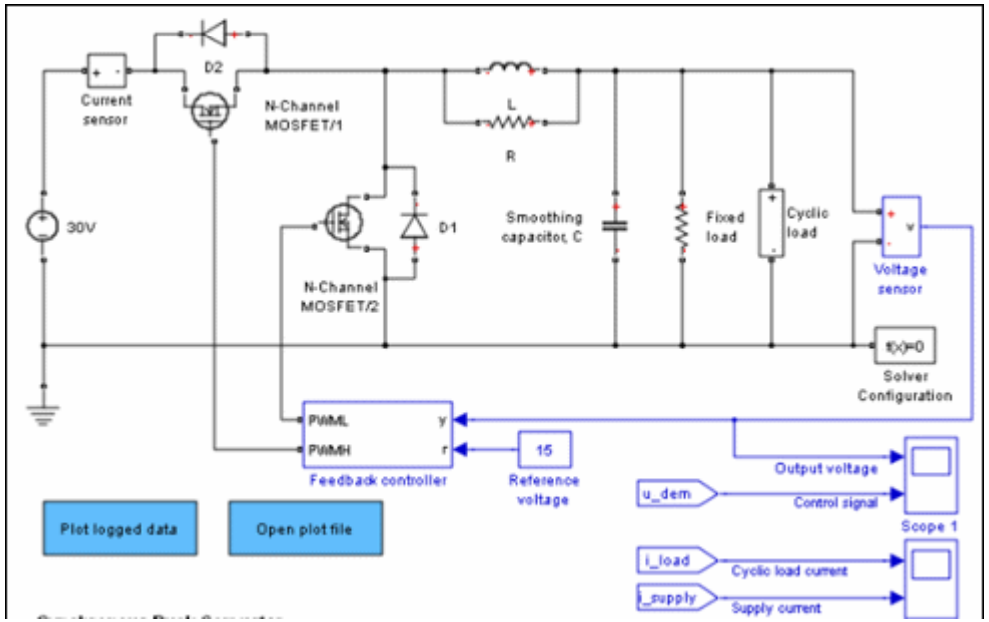
Course Objectives

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

- MATLAB SIMULINK
- Simpower Systems Toolbox



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)**