Electronics and Computer Science

ELEC2208 Power Electronics and Drives

Module overview

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SEMS Smart Electronic Materials and Systems

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ELEC2208 Power Electronics and Drives

Part I: Power Electronics

- Devices: Diodes, Thyristors, and Transistors
- Thermal management
- Converters and Inverters

Part II: Drive Systems

- Electromagnetic and mechanical fundamentals
- DC motor drives
- AC induction motor drives

Lecturers

Part I: Power Electronics

Dr Yoshi Tsuchiya (Module leader)
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https://www.ecs.soton.ac.uk/people/yt1p07

Part II: Drive Systems

Prof Frederic Gardes
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https://www.orc.soton.ac.uk/people/fg2y10

Dr Zehor Belkhatir
Z.Belkhatir@soton.ac.uk

Tutorials

- Tutorial sessions are planned along with the lecture series
- Question sheets will be given in advance to the tutorial sessions.

Tutors

Power Electronics: Yoshi Tsuchiya

Drive Systems: TBA

Assessment

1. Conventional 2h paper split in 2 parts: 80%
   - Part A - 2 questions over 3 to answer on Power electronics
   - Part B - 2 questions over 3 to answer on Drive systems

2. Design exercise coursework: 15%
   - Made available on blackboard in the week before Easter
   - To be handed in the week after Easter

3. Laboratory: 5% (Mid to late March)

All lectures and tutorial material are made available on blackboard only: https://blackboard.soton.ac.uk/

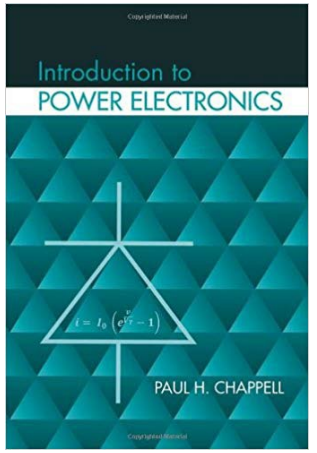
Recommended books

Power Electronics

"Introduction to Power Electronics"

Author: Paul Chappell

Publisher: Artech House, First edition (1 Jan 2014)

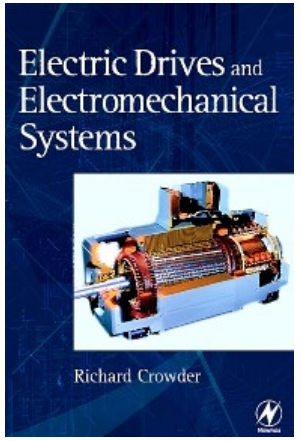


Drive Systems

"Electric Drives and Electromechanical Systems"

Author: Richard Crowder

Publisher: Elsevier



Further Textbooks ⟶ See Reading List on Blackboard

Power Electronics: Definition

Power electronics is a technical field dedicated to study, analyze, construct, and maintain electronic circuits capable of **controlling electric energy flow**.

Power electronic circuits include:

- **Switches** often commutated at a high rate of kHz or faster.
- **Energy storage components** such as capacitors and inductors

Two main group of power electronic applications

- **Static applications:** Output is primarily electric power.
- **Dynamic/mobile applications:** Output is primarily mechanical power.

Power supply: DC vs AC in 1880s

Direct Current (DC) vs Alternative Current (AC) **Won!**

Edison | Tesla

- Relatively small power plants (e.g. Pearl Street Station).
- No voltage transformation.
- Short distribution loops – No transmission
- Loads were incandescent lamps and possibly dc motors (traction).

Pearl Street Station:
6 "Jumbo" 100 kW, 110 V generators

"Eyewitness to dc history"
Lobenstein, R.W. Sulzberger, C.

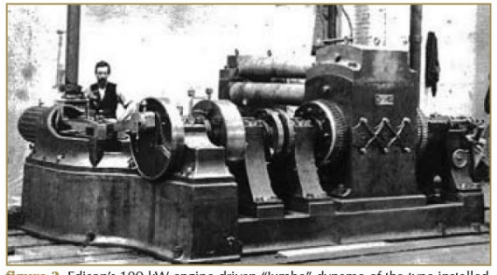
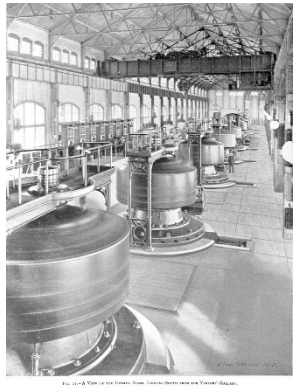


figure 3. Edison's 100-kW engine-driven "Jumbo" dynamo of the type installed at the Pearl Street station (photo courtesy of the Edison National Historical Site, U.S. Department of the Interior, National Park Service).

- **Large** power plants (e.g. Niagara Falls)
- Voltage transformation.
- Transmission of electricity over **long** distances
- Loads were incandescent lamps and **induction motors**.

Niagara Falls historic power plant:
38 x 65,000 kVA, 23 kV, 3-phase generators

http://spiff.rit.edu/classes/phys213/lectures/niagara/niagara.html



Electric Grid – Power transfer

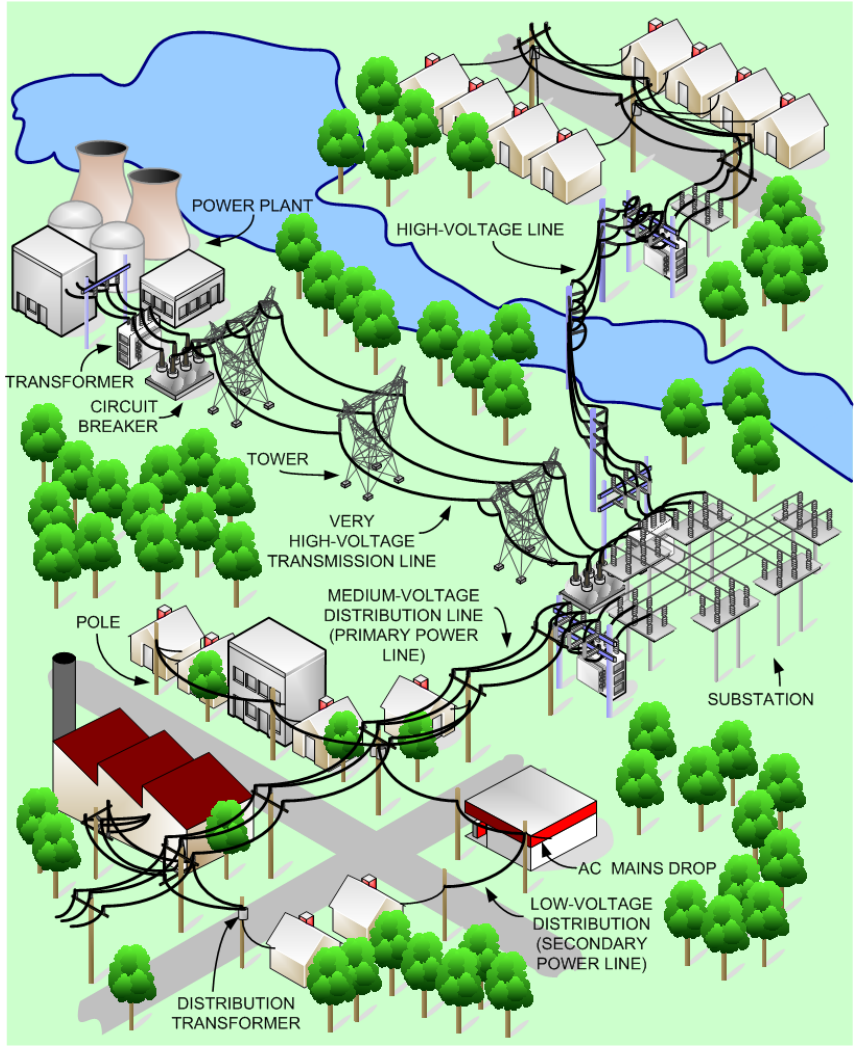
AC power transmission network

Pros

- Generation, transmission, and distribution.
- Centralized and passive architecture.
- Extensive and very complex system.
- Unique, fixed frequency.
- Vulnerable.

Cons

- Less flexible
- Energy inefficiency
- Not reliable enough for some applications.



Power distribution in recent years

Existing grid not suitable for dc loads (e.g., computers) or to operate induction motors at different speeds. **Power electronics allows varying speeds in induction motors and to feed dc loads.**

In addition,

- Voltage and current signals to be transformed (flexibility).
- Transportation electrification needs.
- Can use renewable and alternative power sources.
- Can integrate energy storage.

Power electronics is the one single technology that Edison needed in the late 1800s.

Applications – Developed since 1980s

- AC-DC power conversion by processing electric power to expected voltage, current and / or frequency with semiconductor devices

  - Switched Mode Power Supplies (SMPS)

    DC-DC convertor

  - Inverter (DC-AC convertor)

Applications

- **Industrial, commercial and residential**
- **Electrical vehicles, aerospace and space technologies**

Drive systems

45% of ALL electrical energy used is converted into **mechanical energy** through the use of motors or actuators.

Applications

- Automotive
  - Average number per car 25 (small size).
  - Propulsion system (1 or more AC motors)
- Packaging
- HVAC (heating, ventilating, and air conditioning)
- White goods (all washing machines, fridge freezers, cookers and other appliances)

Part 1: Power Electronics

Dr Yoshi Tsuchiya

1. Introduction

2. Diode
3. Thyristor
4. Transistor

Individual devices

5. Heating and Cooling

Thermal management

6. Phase-Controlled Thyristor Converter and Diode Rectifier
7. Cycloconverter
8. Inverter
9. DC-to-DC Converter

Convertors

Part 2: Drive Systems Contents

Prof Frederic Gardes and Dr Zehor Belkhatir

1. **Electromagnetic and mechanical fundamentals**
    1. Inertial, path control
    2. Power transmission
    3. Rotational motion dynamics
2. **Power electronic control of DC motor drives**
    1. Fundamentals
    2. Speed control, chopper control of DC machines
3. **Power electronic control of AC induction motor drives**
    1. Fundamentals
    2. Speed control, Inverter control of induction machines using PWM
4. **Sizing of electric drives**