Power Electronics
-Syllabus and Introduction-

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Outline

1. Course syllabus
2. What is power electronics?
3. Applications areas of power electronics
4. Power electronics based power processing-an example
5. Power electronic devices

About your instructor

- ★ **Wei Jiang**, Ph.D., Member IEEE
- ► 2003 Southwest Jiaotong University, BSEE
- ► 2006 The University of Texas at Arlington, Arlington, TX, USA, Master of Science, Electric Machine
- ► 2009 The University of Texas at Arlington, Arlington, TX, USA, Doctor of Philosophy, Power Electronics
- ▲ Research Areas: Digital power electronics, microscopic analysis of electric machinery

Power Electronics: Course Description

Power Electronic Course Series are developed for junior level undergraduate and graduate students.

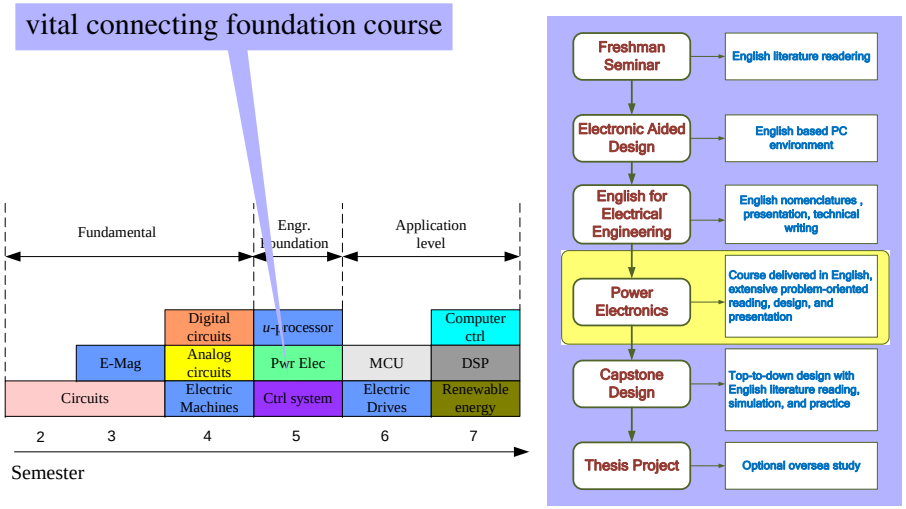
⋆Power Electronics

Fundamentals of power semiconductors, AC-DC, DC-DC, DC-AC, AC-AC power conversion circuits, power converter supporting circuits, modeling & basic control methods.

⋆Modern Power Electronics

Power electronic circuit topologies, modeling&control, the state-of-the-art power electronic systems, selected topics in power electronics.

Role in Electrical Engineering



Syllabus

- Working Schedule: 36 hours
- Syllabus

Module 1- Fundamentals of power conversion

Module 2- Power electronics for utility interface

Module 3- Power electronics for modern portable electronics and renewable energies

Module 4- Power converter modeling & control

Module 5- Power electronic system design- seminar

- Grading-60% (homework & lab)+40%(project & presentation)
- Textbook-Daniel W. Hart, *Power Electronics,* 3^{rd} *edition*, Prentice Hall, 2010
- Home page-Yangzhou Univ. EOL Web
- Office hours: Thu 13:00-14:00, Fri 13:00-14:00

Reference Books

1. Ned Mohan etc., *power electronics - converters, applications,and design*. Wiley, 2003.
2. Barry W Williams. *Principles and Elements of Power Electronics- Devices, Drivers, Applications, and Passive Components*, free on-line, 2006
3. Robert W. Erickson, *Fundamentals of Power Electronics*, Kluwer, 2004
4. Philip T. Krein, *Elements of Power Electronics*, Oxford, 1997
5. John. G. Kassakian etc., *Principles of Power Electronics*, Addison-Wesley, 1990

Course Objectives

1. To have basic knowledge of power electronic components, circuit topology and operation;
2. To connect the dots between power electronics and energy systems;
3. To demystify at least one commercial power electronic product;
4. To learn one circuit simulation software;
5. To build a power electronic circuit by yourself;
6. To identify the relevant research areas in power electronics;
7. Of course to pass the exams!

Must-to-Know above the textbook

- power management ICs, devices, and passive components (TI, ST, IR, Magnetics, Coilcraft, Nippon Chemi-Con etc.);
- real sources, loads, and storages
  1. utility grid, wind, solar, fuel cell etc.
  2. battery, ultra-cap etc.
  3. electric machines, lamps, LEDs etc.
- micro-controllers
  1. TI line, TMS320F series, MSP430, ARM
  2. ST line, STM8/STM32
  3. Microchip PIC/dsPIC

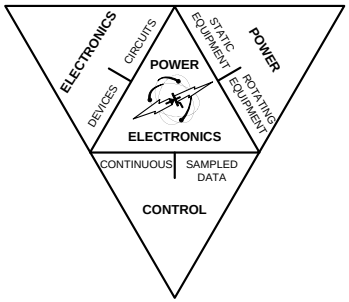
Internet Resources

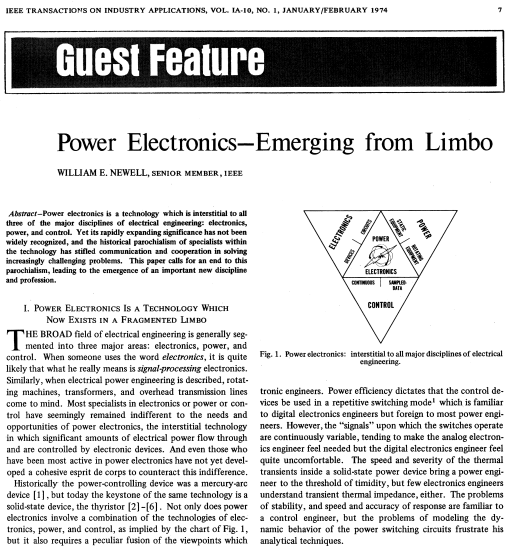
- Course web
  - China University MOOCs
  - YZU-EOL
- Recommended online resource
  1. IEEE Xplore Digital Library
  2. CNKI
  3. MOUSER
  4. Wikipedia
  5. Google

Software for this class

1. SPICE based simulation software: OrCAD and LTspice(linear Technology)
2. MATLAB
3. Mathematica and MathCAD: symbolic calculation and numerical computation
4. Excel: simple office software can make lots of things happen...
5. ... ...

What is Power Electronics?





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Guest Feature

Power Electronics—Emerging from Limbo

WILLIAM E. NEWELL, SENIOR MEMBER, IEEE

Abstract—Power electronics is a technology which is interstitial to all three of the major disciplines of electrical engineering: electronics, power, and control. Yet its rapidly expanding significance has not been widely recognized, and the historical parochialism of specialists within the technology has stifled communication and cooperation in solving increasingly challenging problems. This paper calls for an end to this parochialism, leading to the emergence of an important new discipline and profession.

I. Power Electronics Is a Technology Which Now Exists in a Fragmented Limbo

THE BROAD field of electrical engineering is generally segmented into three major areas: electronics, power, and control. When someone uses the word *electronics*, it is quite likely that what he really means is *signal-processing* electronics. Similarly, when electrical power engineering is described, rotating machines, transformers, and overhead transmission lines come to mind. Most specialists in electronics or power or control have seemingly remained indifferent to the needs and opportunities of power electronics, the interstitial technology in which significant amounts of electrical power flow through and are controlled by electronic devices. And even those who have been most active in power electronics have not yet developed a cohesive esprit de corps to counteract this indifference.

Historically the power-controlling device was a mercury-arc device [1], but today the keystone of the same technology is a solid-state device, the thyristor [2]-[6]. Not only does power electronics involve a combination of the technologies of electronics, power, and control, as implied by the chart of Fig. 1, but it also requires a peculiar fusion of the viewpoints which

Fig. 1. Power electronics: interstitial to all major disciplines of electrical engineering.

tronic engineers. Power efficiency dictates that the control devices be used in a repetitive switching mode[1] which is familiar to digital electronics engineers but foreign to most power engineers. However, the "signals" upon which the switches operate are continuously variable, tending to make the analog electronics engineer feel needed but the digital electronics engineer feel quite uncomfortable. The speed and severity of the thermal transients inside a solid-state power device bring a power engineer to the threshold of timidity, but few electronics engineers understand transient thermal impedance, either. The problems of stability, and speed and accuracy of response are familiar to a control engineer, but the problems of modeling the dynamic behavior of the power switching circuits frustrate his analytical techniques.

Concept brought up by Dr. William E. Newell as "noted authority on power electronics".

Types of Power Conversion Process

Types of power sources

utility grid, electrical generators, dc power supply, batteries, fuel cell, PV etc

Types of load

utility grid, electrical machines, light blub, batteries, heaters, electronic/power circuits etc

- How to connect the sources and the loads?
  1. AC/DC conversion
  2. DC/DC conversion
  3. DC/AC conversion
  4. AC/AC conversion

What is in there?

1. Electronics
   - Basic electronics and op-amp circuit for power electronic circuit & its control
   - Solid-state semiconductor device for power conversion: IGBT, Power MOSFET etc.
   - Analytical method for electronic circuits: KCL, KVL, small signal analysis
2. Power systems
   - Static power conversion systems
   - Electro-magneto-mechanical conversion
   - Energy transfer methods in $50Hz/60Hz$ power systems
3. Control Systems
   - Continuous and discrete control system
   - Linear and nonlinear control systems

Power Electronics in Residential Applications

- **Residential**: computer, lighting, cooking




Power Electronics in Transportation

- **Transportation**: e-bike, hybrid electric, electric and fuel cell vehicle, electric multiple unit (EMU)



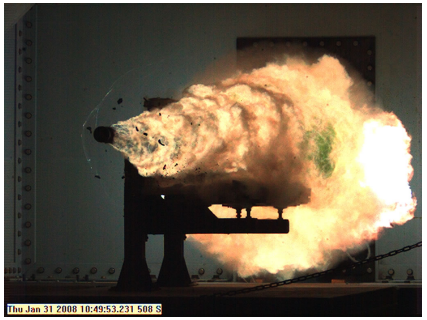
Power Electronics in Utility Systems

- **Utility systems**: FACTS, HVDC, renewable energy, energy storage

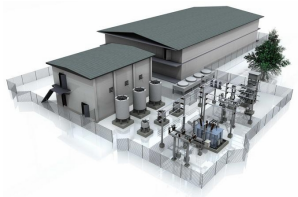



Power Electronics for Non-peaceful Things

- **Military**: taser, rail gun



Power Electronics for Smart Energy

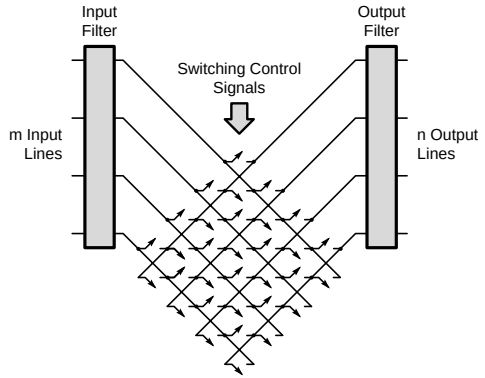


← ABB SVC Light Project

→ Smart Grid 2030 by DOE

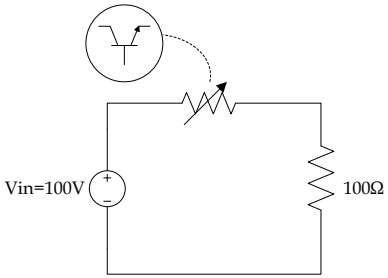
Structure of generic power electronic converter

The generic power electronic converter consist of three power stages: input filters, switching matrix, and output filters.



Why do we need filters? What types of filters?

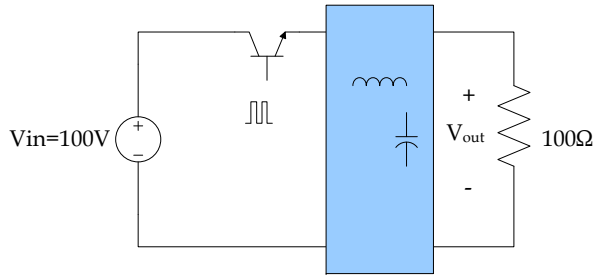
A voltage divider example



Questions:

1. How to achieve $V_{out} = 50V$? And what is the efficiency of the circuit?
2. This is obviously a voltage divider, how to get a output voltage higher than input?

Voltage divider with power electronic switch



1. Very low loss chopping process generates pulse output;
2. Lossless passive filtering components for low ripple output.

Si-based power semiconductors VI range

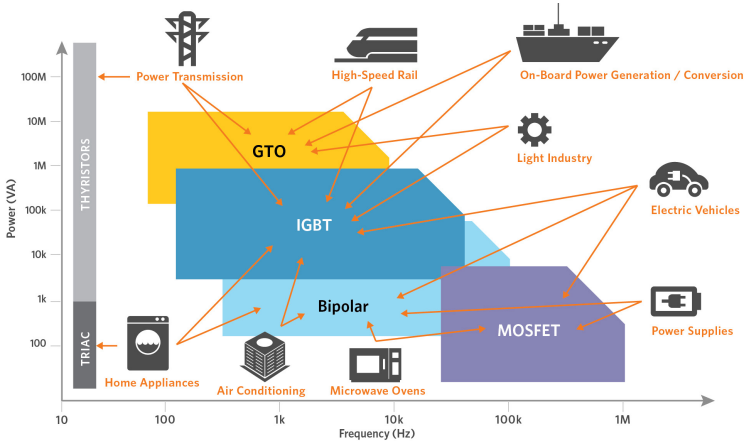
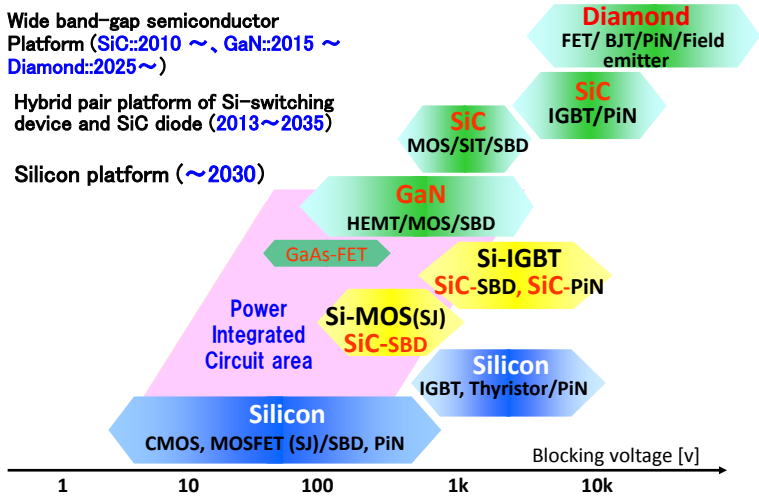
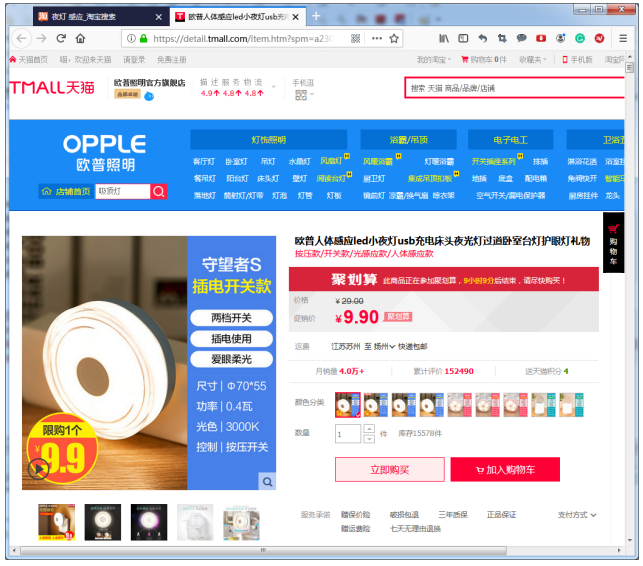


Figure: Power v.s. Switching-frequency Chart for Power Electronic Devices

advanced power semiconductors road map



Why can this happen?



End of this class!

Have Fun!

Any Questions!