

3/30/2022

HUST

TRƯỜNG ĐẠI HỌC BÁCH KHOA HÀ NỘI
HANOI UNIVERSITY OF SCIENCE AND TECHNOLOGY

ONE LOVE. ONE FUTURE.



TRƯỜNG ĐẠI HỌC
BÁCH KHOA HÀ NỘI
HANOI UNIVERSITY
OF SCIENCE AND TECHNOLOGY

EE3410E

POWER ELECTRONICS

Dr. Nguyen Kien Trung

Dept. of IA, School of EE

Advance Power Electronic Systems Laboratory (APES Lab.)

ONE LOVE. ONE FUTURE.

- **Scope / Phạm vi môn học:**

- Electric energy conversion by power converters
- Characteristics of Power devices
- Applications of power converters

- **Aim / Mục tiêu:**

- Calculate, Analyze, Assessment of Power converters
- Design simple power converters

General introduction

- **Requirements:**

- **Attendance** the lecture and study the reference books and documents
- **Simulation skills** of power converters
 - PSIM: topology, control loop, etc.
 - MATLAB & Simulink: topology, control loop, etc.
 - LTSpice: gate drive, buffer, snubber, etc.
- **Homework:** Improving the knowledge by doing the homeworks

General introduction

• Study methods

- Lectures (online/offline)
- Self-study
- Assignments
- Group discussion
- Exercises
- Simulations
- Experiments
- Q&A

• Assessments

- Midterm examination: Project → **25%**
- Final examination: writing → **75%**
- Open book examination

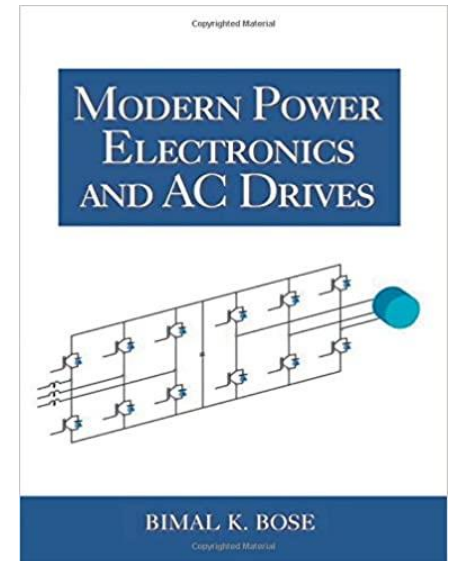
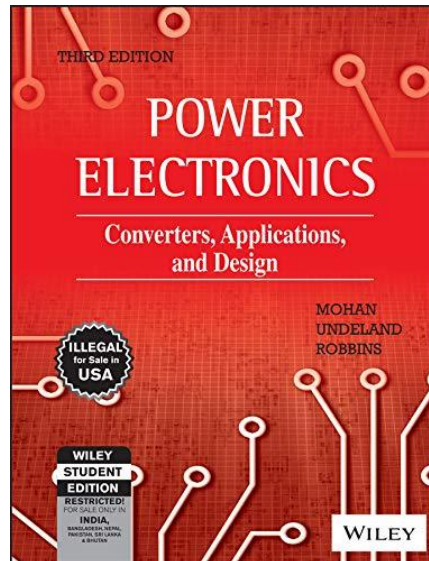
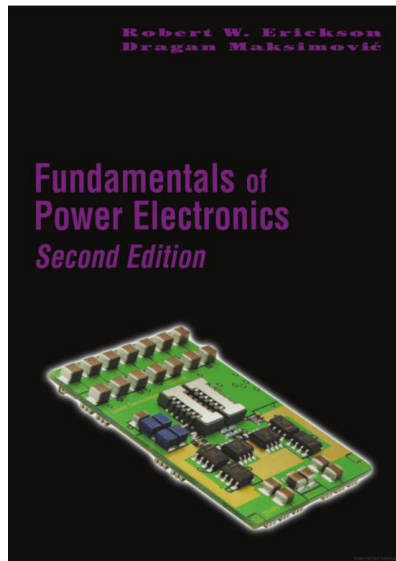
References (Vietnamese)

- [1] **Giáo trình Điện tử công suất**; Trần Trọng Minh; NXB Giáo dục Việt nam, 2012 (new).
- [2] **Điện tử công suất**; Võ Minh Chính, Phạm Quốc Hải, Trần Trọng Minh; NXB KH&KT Hà nội, 2009
- [3] **Phân tích và giải mạch Điện tử công suất**; Phạm Quốc Hải, Dương Văn Nghi; NXB KH&KT, 1999.
- [4] **Hướng dẫn thiết kế Điện tử công suất**; Phạm Quốc Hải; NXB KH&KT 2009.



References (English)

- [1] Erickson, R.W. and Maksimovic, D., 2007. **Fundamentals of power electronics**. Springer Science & Business Media.
- [2] Mohan, N., Undeland, T.M. and Robbins, W.P., 2003. **Power electronics: converters, applications, and design**. John wiley & sons.
- [3] B. K. Bose, **Modern Power Electronics and AC Drives**, Prentice Hall, 2002.



Related subjects

EE3410E Power electronic 3(3-0-1-6)

EE4336 Thiết kế hệ thống điều khiển ĐTCS 3(2-1-0-4)

EE6032 Điều khiển Điện tử công suất 3(3-0-0-6)

EE6232 Điện tử công suất nâng cao 2(2-0-0-4)

EE7xxx Những thành tựu mới của ĐTCS 2(2-0-0-4)

Table of contents

- Contents

- General introduction and definition

- Basic power semiconductor devices

- Diode, thyristor, Triac, GTO, BJT, MOSFET, IGBT

- Phase-controlled converters

- Diode/Thyristor rectifier; AC-chopper

- DC/DC converters

- DC chopper, DC-DC non-isolated/isolated/resonant converter

- Inverters

- Single phase/three phase voltage source inverter



TRƯỜNG ĐẠI HỌC
BÁCH KHOA HÀ NỘI
HANOI UNIVERSITY
OF SCIENCE AND TECHNOLOGY

EE3410 POWER ELECTRONICS GENERAL INTRODUCTION

Dr. Nguyen Kien Trung

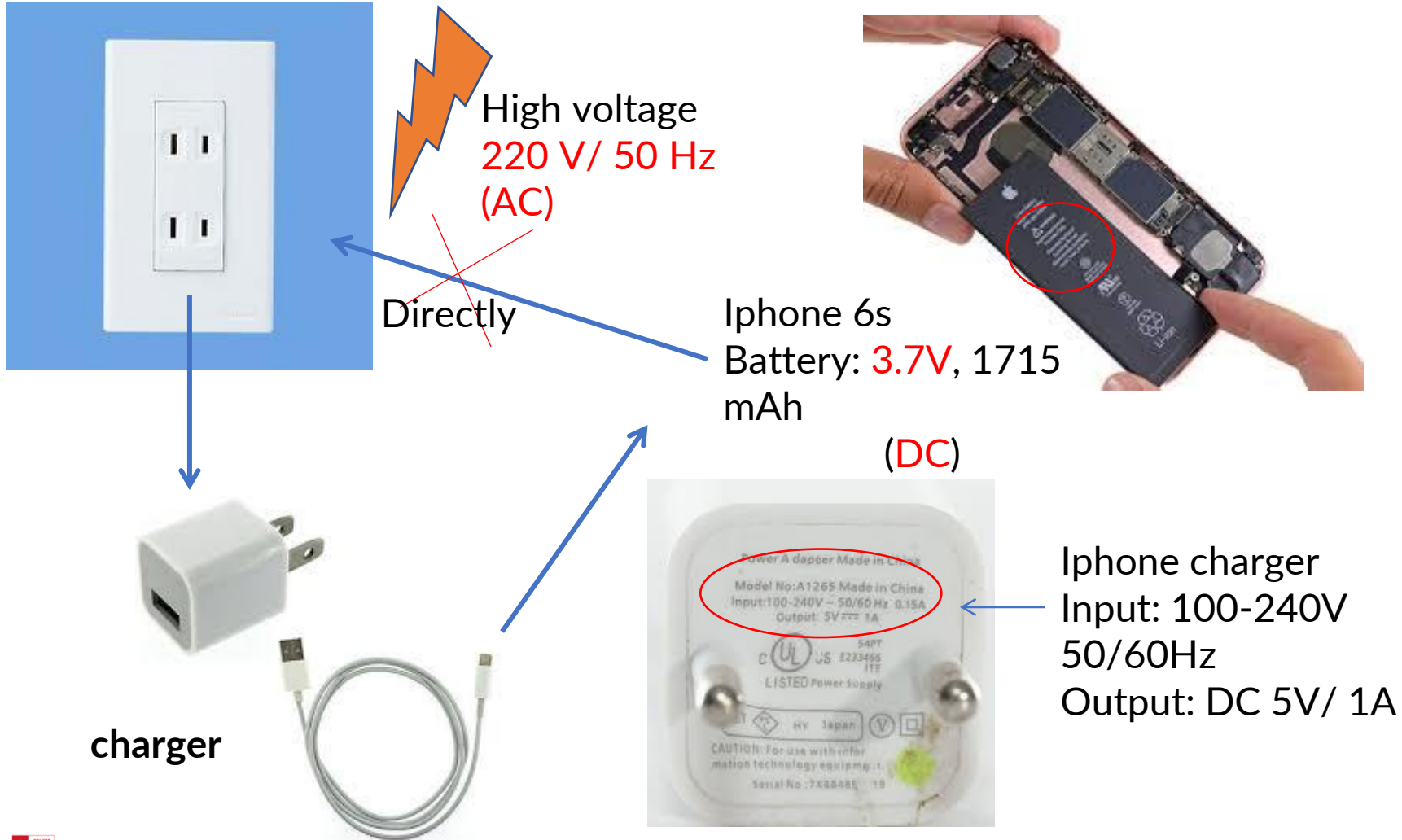
Dept. of IA, School of EE

Advance Power Electronic Systems Laboratory (APES Lab.)

ONE LOVE. ONE FUTURE.

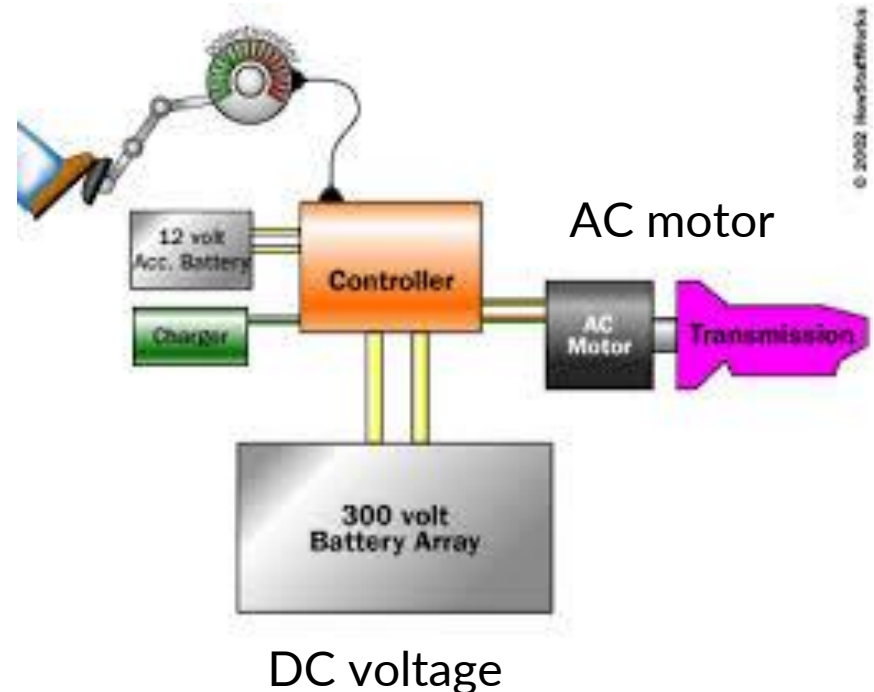
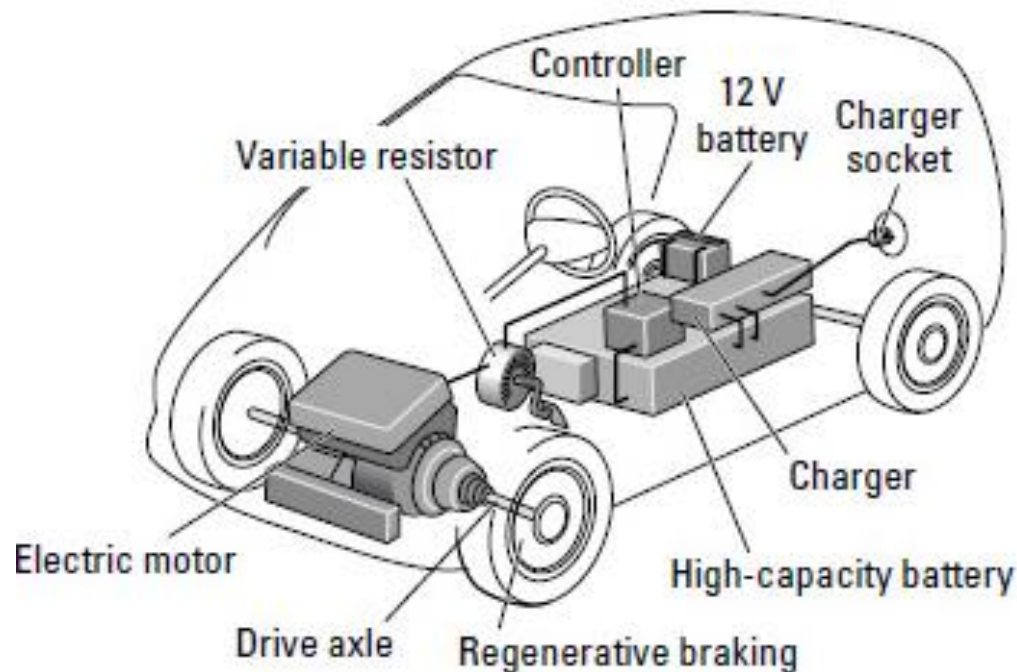
What is Power Electronics ?

How can your phone be charged by 220 V/ 50 Hz ?



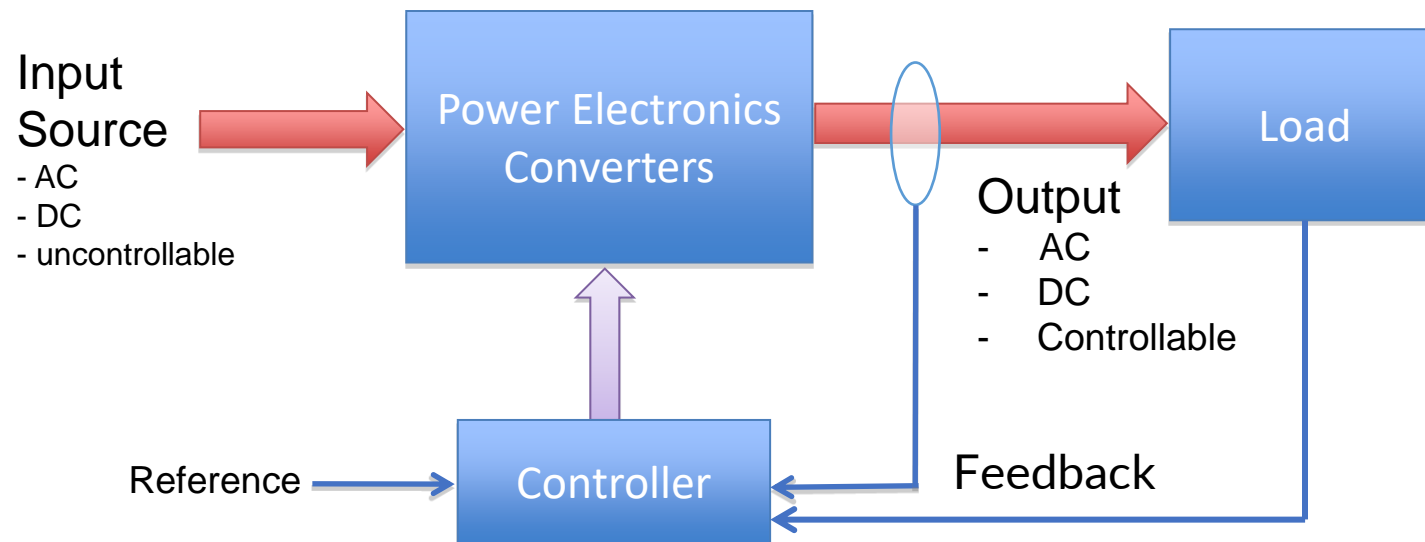
What is Power Electronics ?

How can people speed up/down the electric car?



What is Power Electronics ?

A field of Electrical Engineering that deals with the application of power semiconductor devices for the control and conversion of electric power

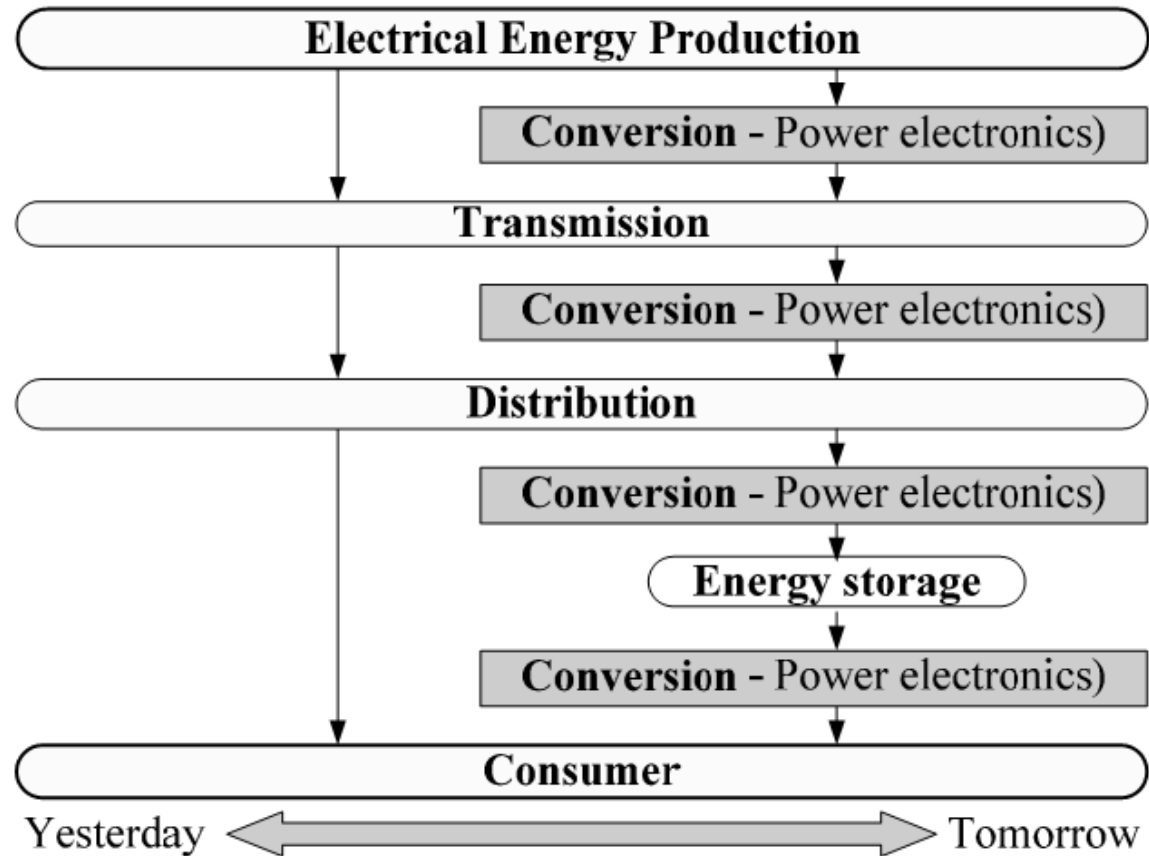


Power electronic converter / Power converter/ **converter** is a **tool** to control electric load

Range of power scale :

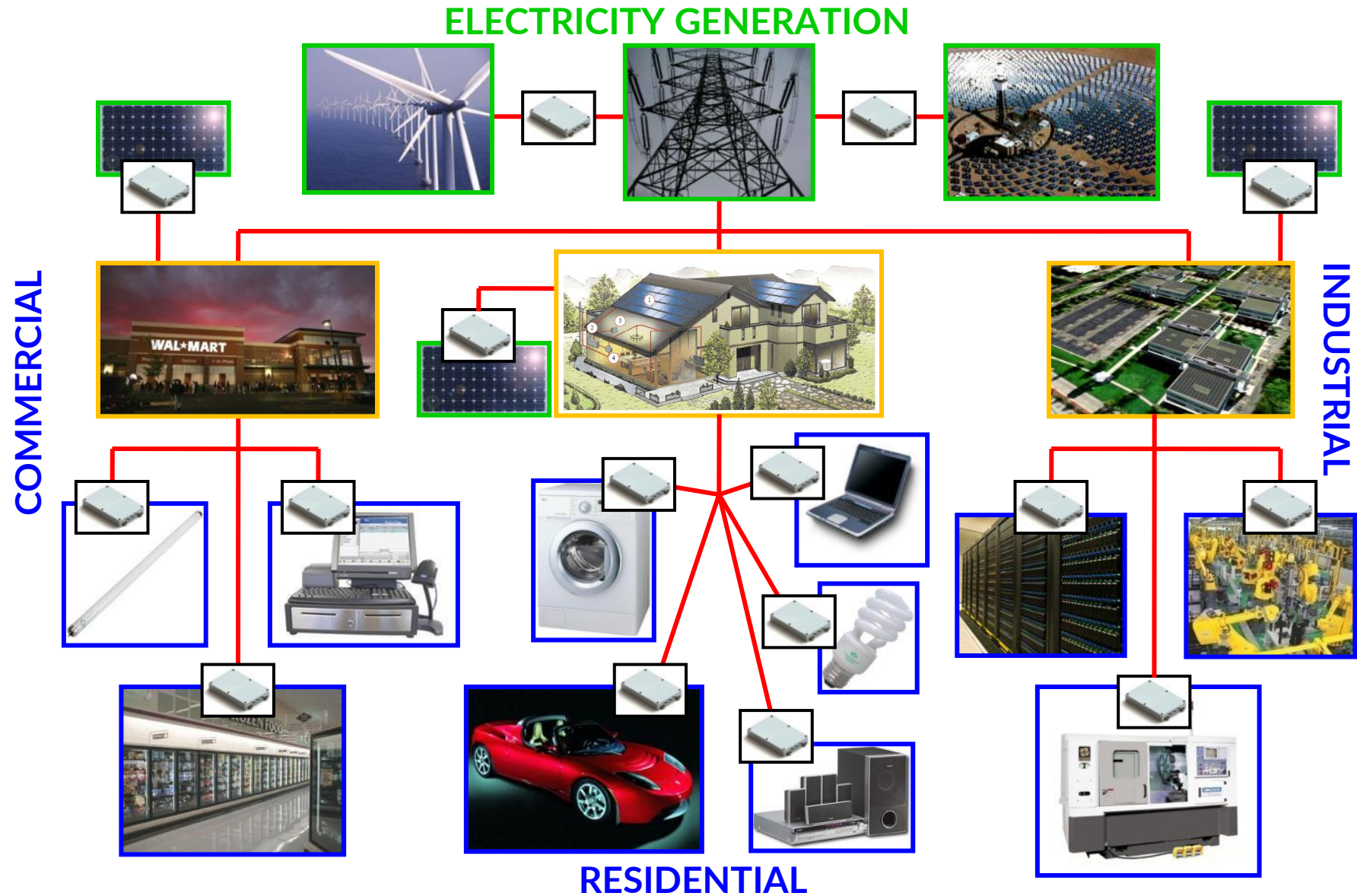
milliwatts(mW) → megawatts(MW) → gigawatts(GW)

What is Power Electronics ?




Application of power electronic

What is Power Electronics ?



What is Power Electronics ?

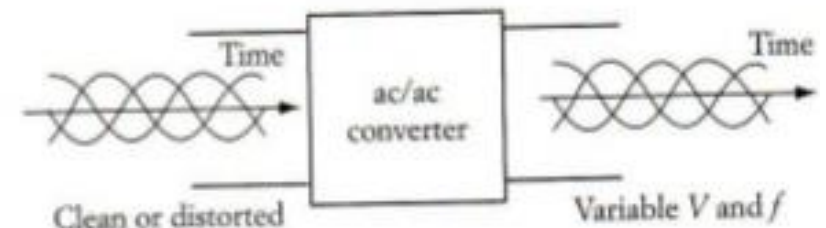
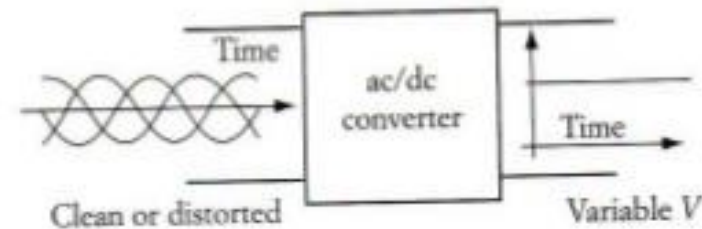
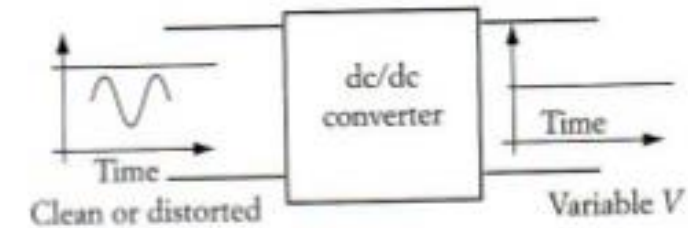
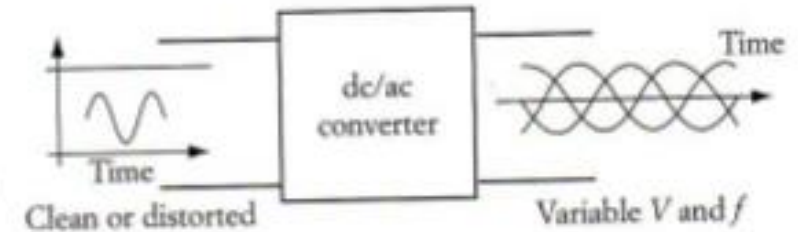
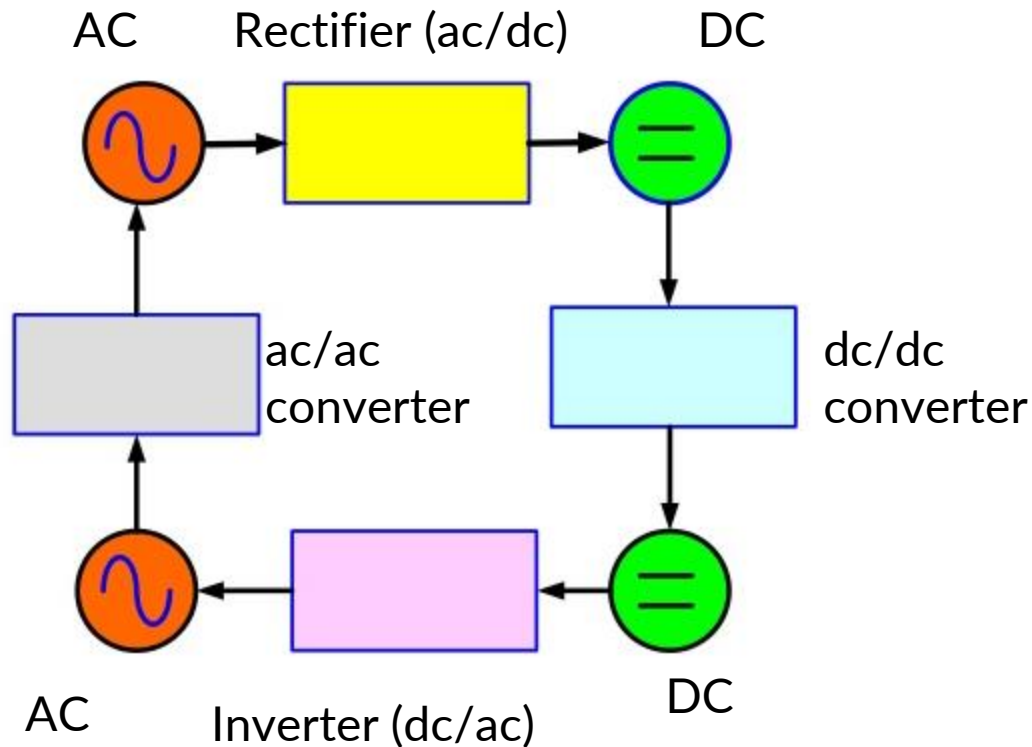
- ⊕ It is estimated that in developed countries now 60% of the electric energy goes through some kind of power electronics converters before it is finally used.
- ⊕ Power electronics has been making major contributions to:
 - better performance of power supplies and better control of electric equipment
 - energy saving
 - environment protection



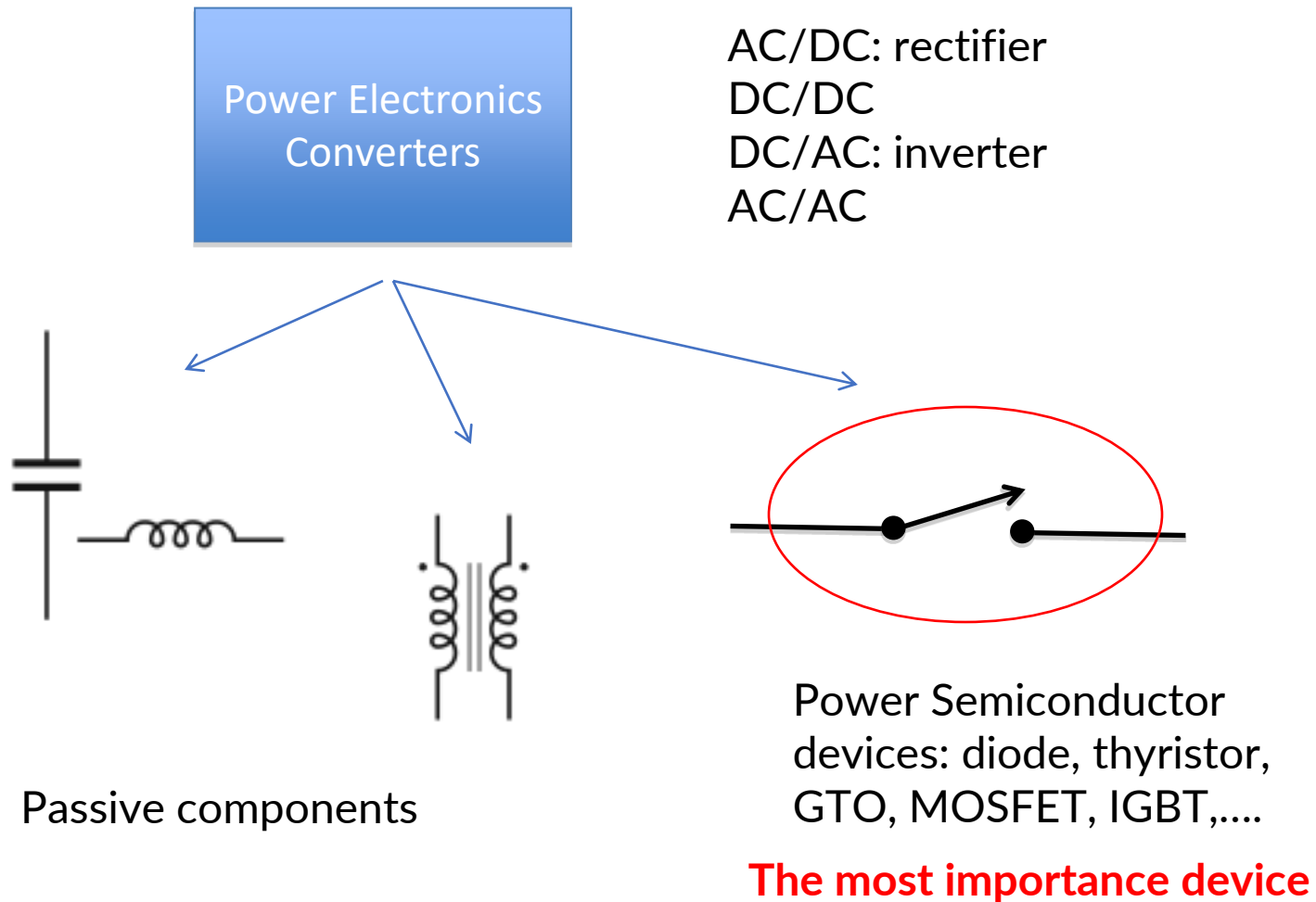
Why? How?

What is Power Electronics ?

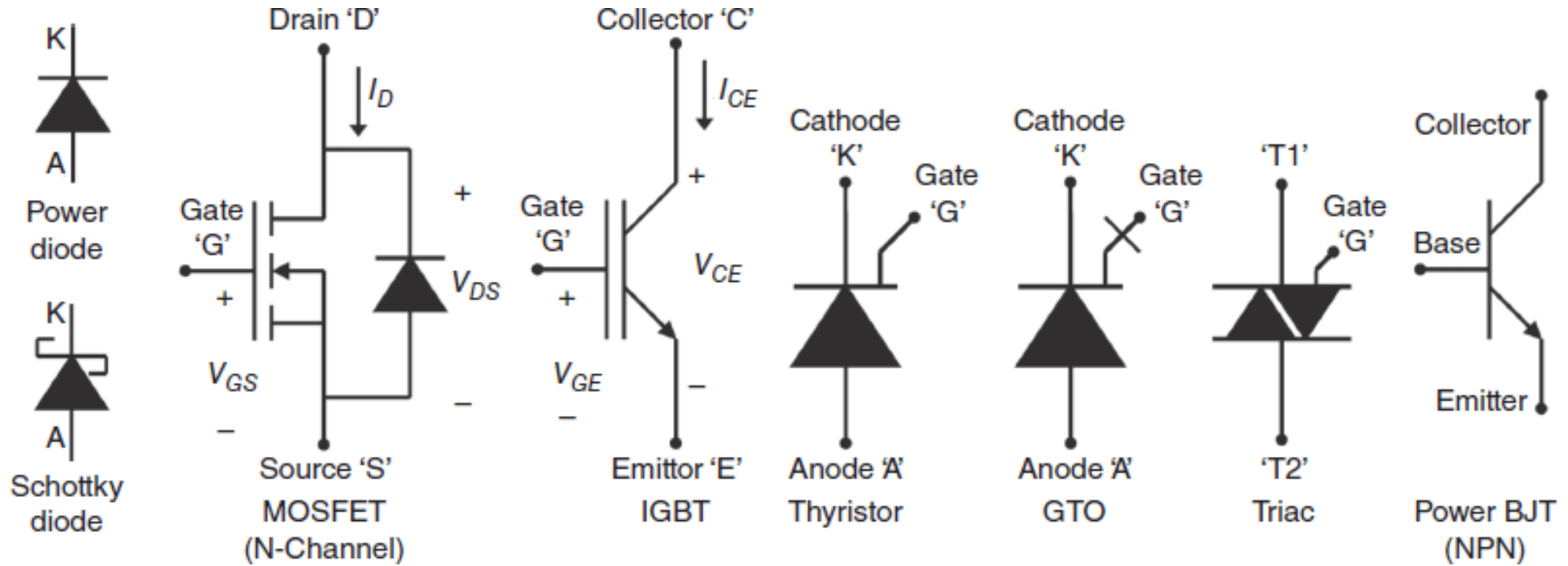
Main types of power electronic converters



Power Electronics components



Power Electronics components



GaN FET



TO263



TO220



TO247



Disk
thyristor



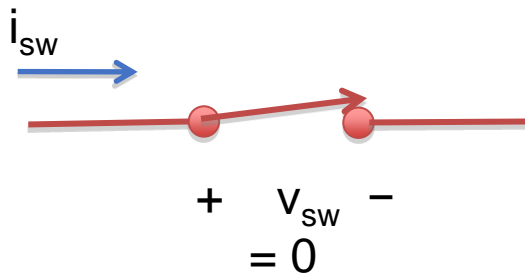
Thyristor
power
module



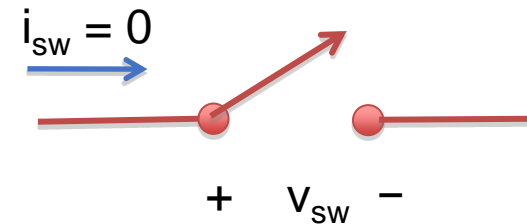
IGBT
power
module

Power Electronics components

Power semiconductor devices ↔ **Power switches**



ON or OFF

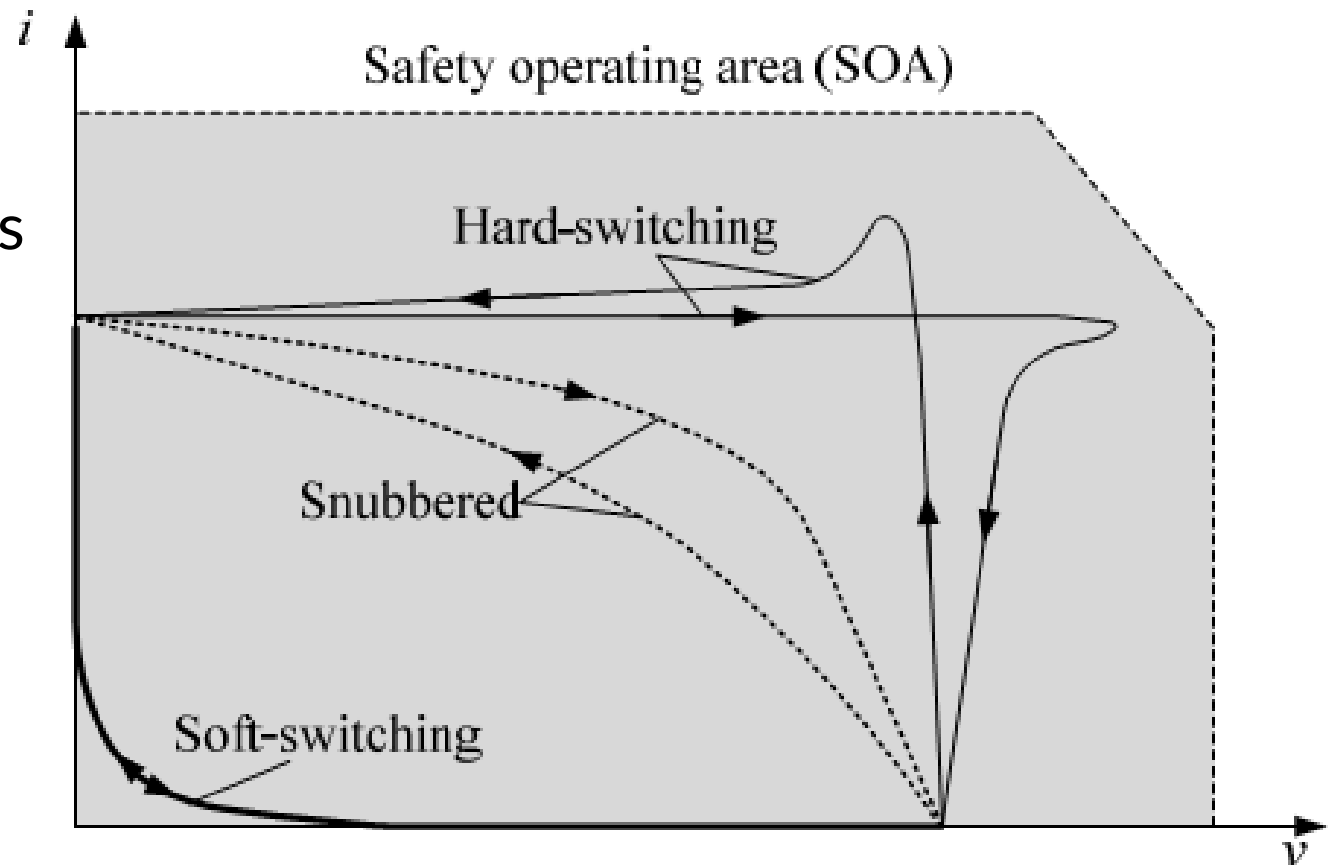


$$P_{loss} = v_{sw} \times i_{sw} = 0$$

Losses ideally ZERO !

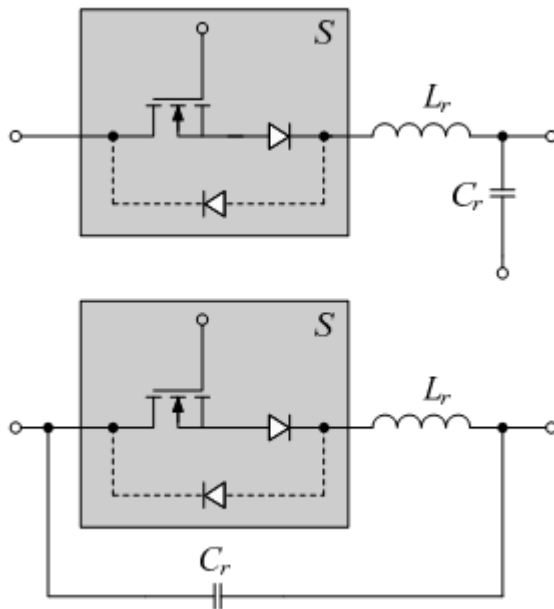
Power Electronics components

Power loss on
switching device:
+ Conduction loss
+ **Switching loss**
+ Gate drive loss

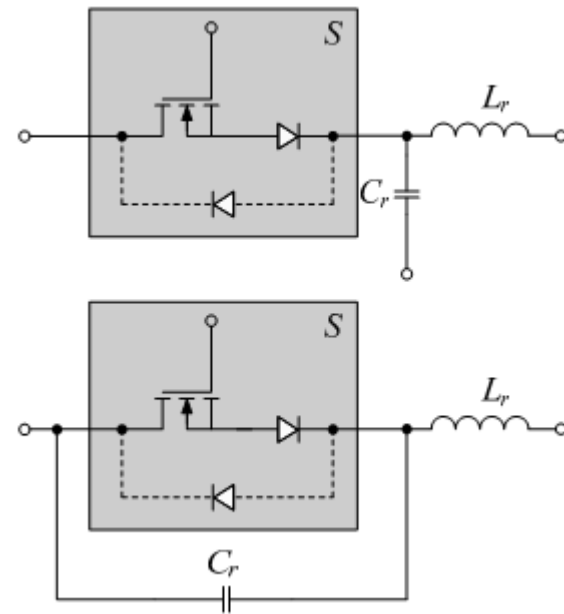


Power Electronics components

- Zero voltage switch - ZVS



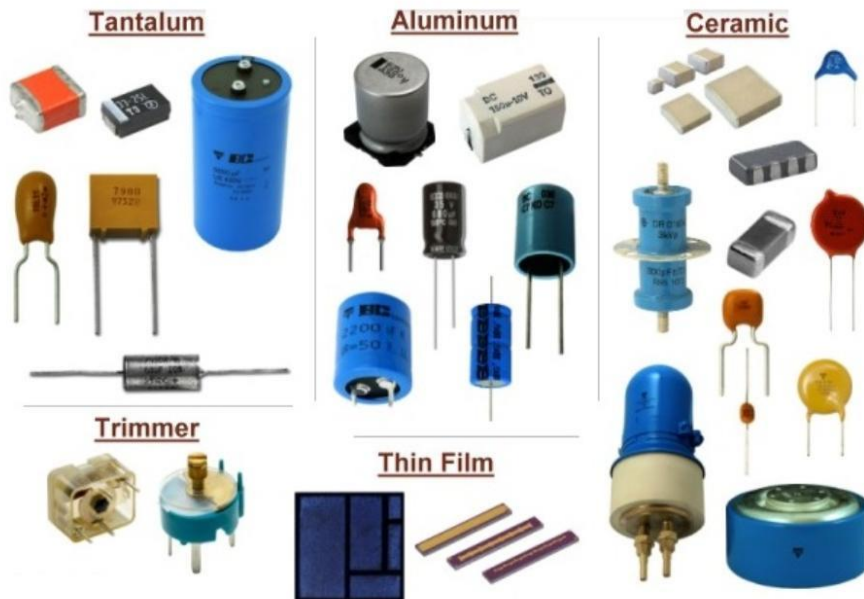
- Zero current switch - ZCS



Advance: ZdVS: Zero dv/dt switching

Magnetics Components

Choke, Coupled inductor,
Power inductor,
Transformer,
Planar magnetics



Capacitors

Electrolytic Caps. (eCap)
Ceramic Caps. (MLCC)
Film Caps. (MKP, MPP, etc.)
Tantalum Caps.

Power Electronics components

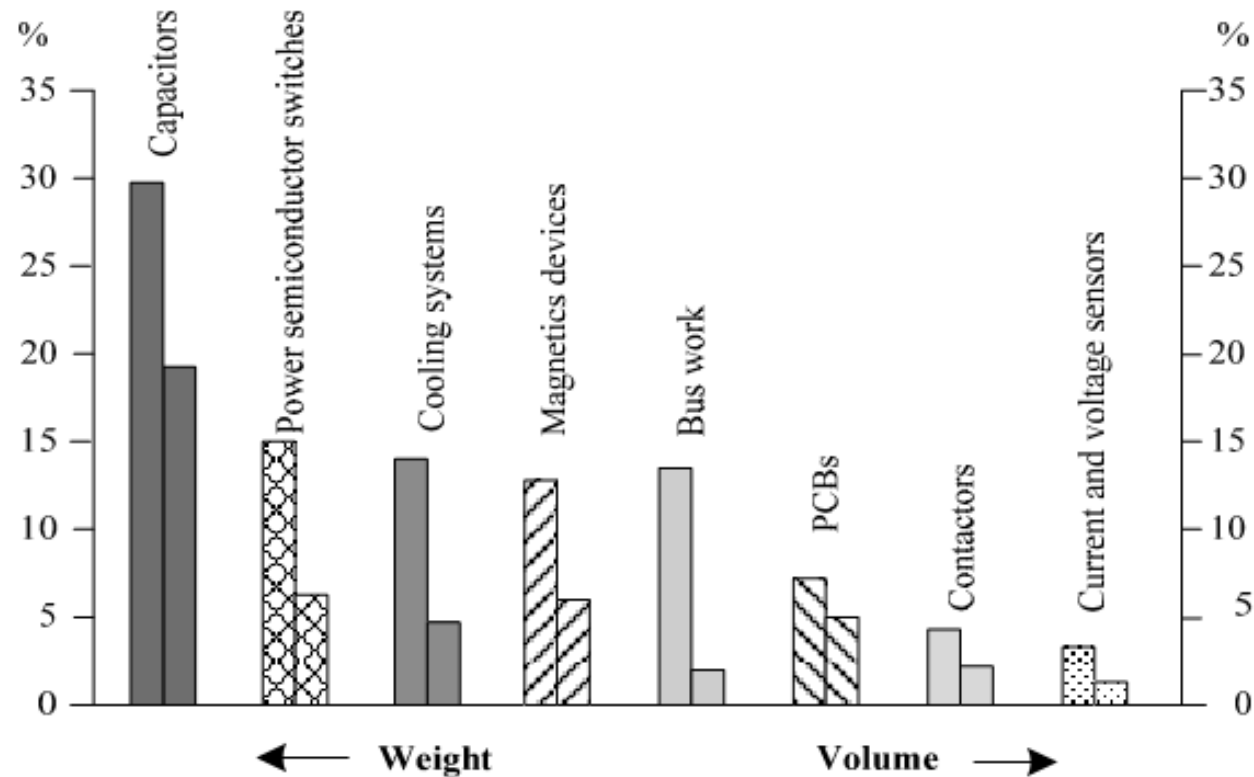
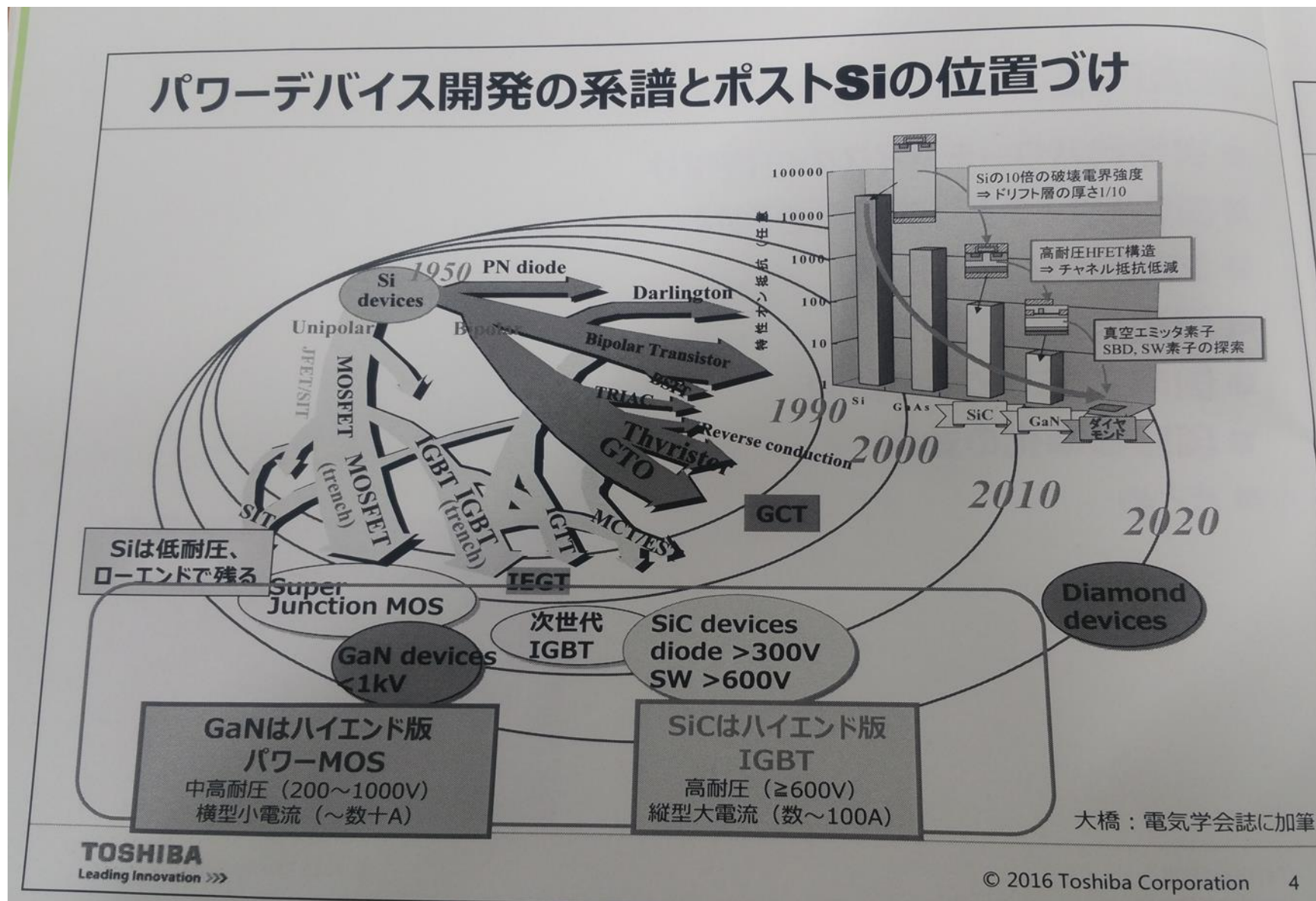


Figure 3.13. Typical components in the construction of the PE arrangements

The history



Power Electronic converters

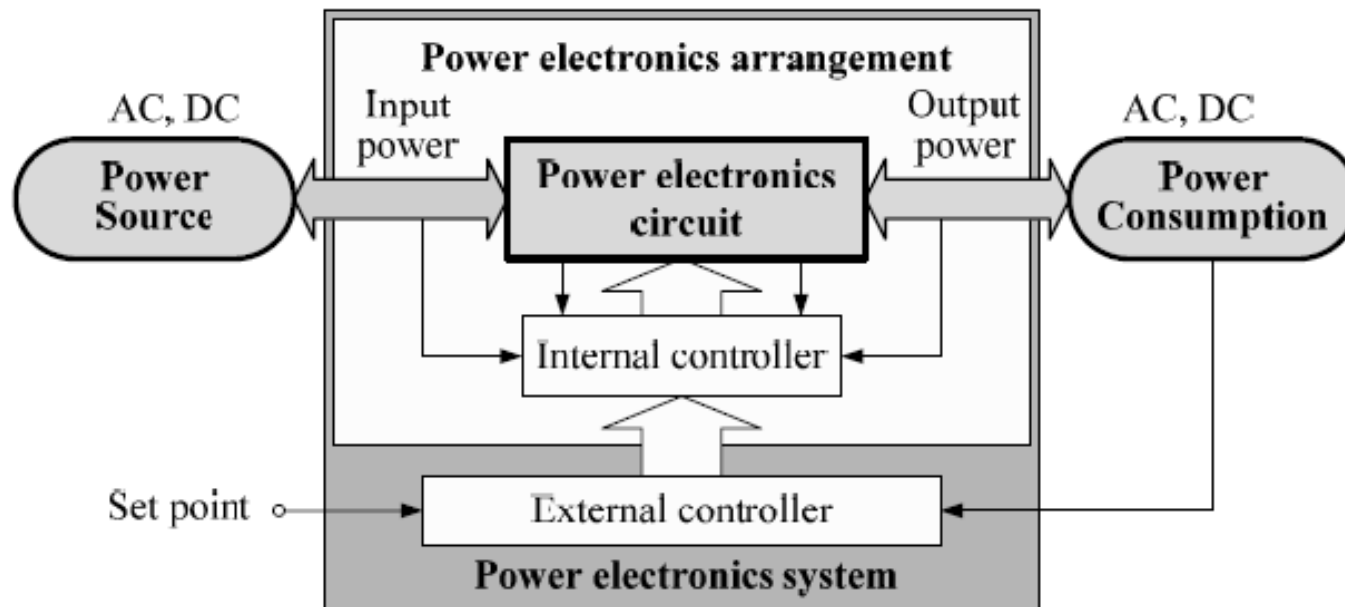


Figure 3.5. Block diagram of a power electronics system

Power Electronic converters

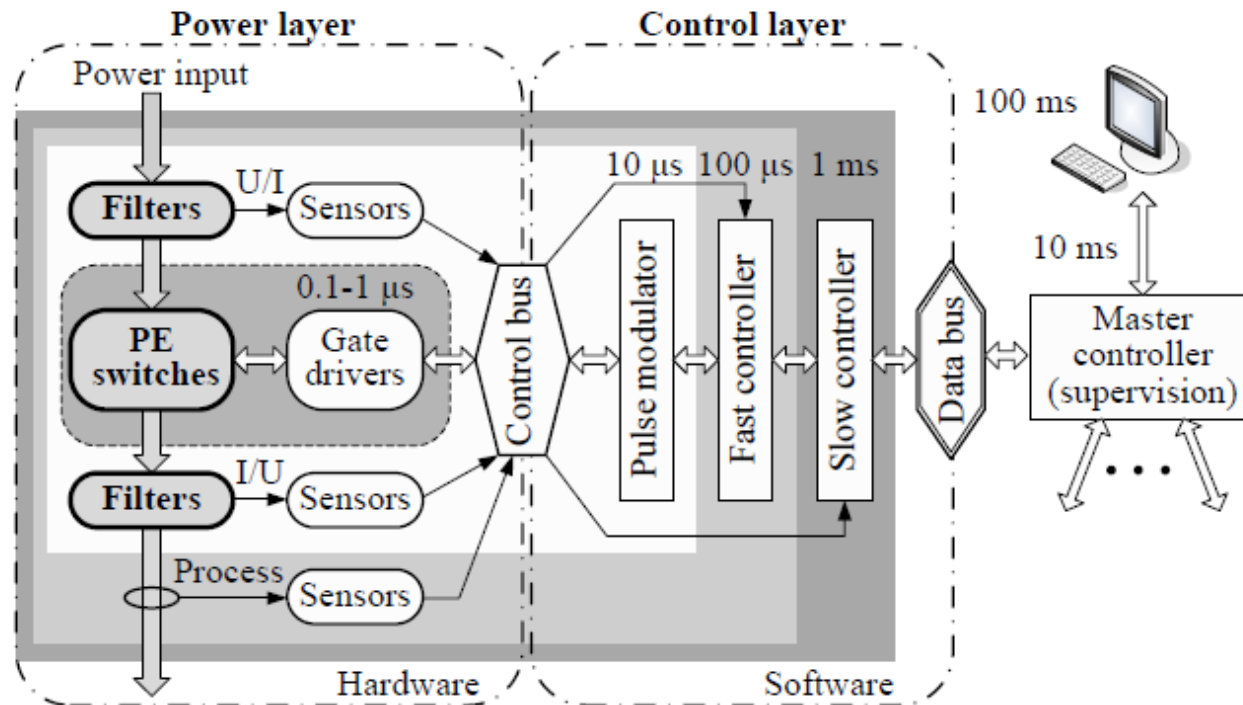
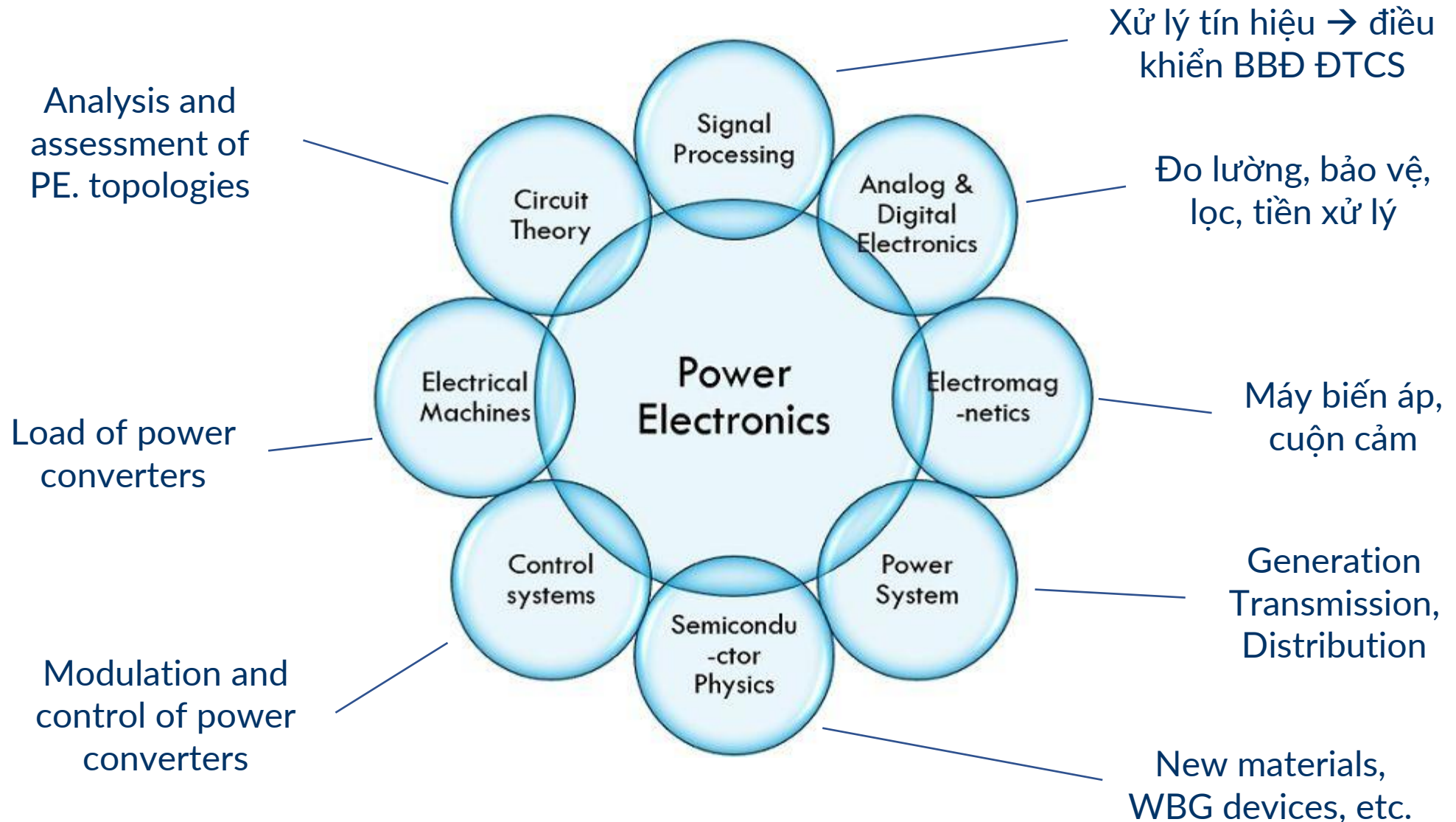


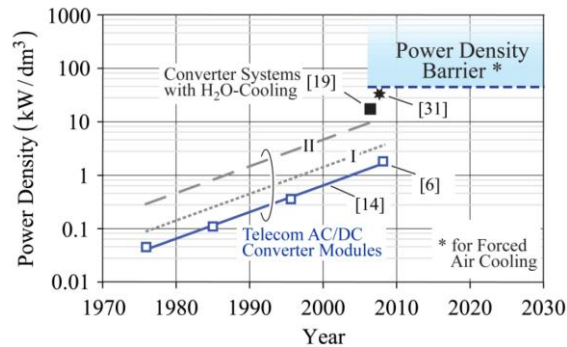
Figure 3.6. Block diagram of a modern power electronics arrangements

Related fields



Challenges of Power Electronics

► Power Electronics Converters Performance Trends

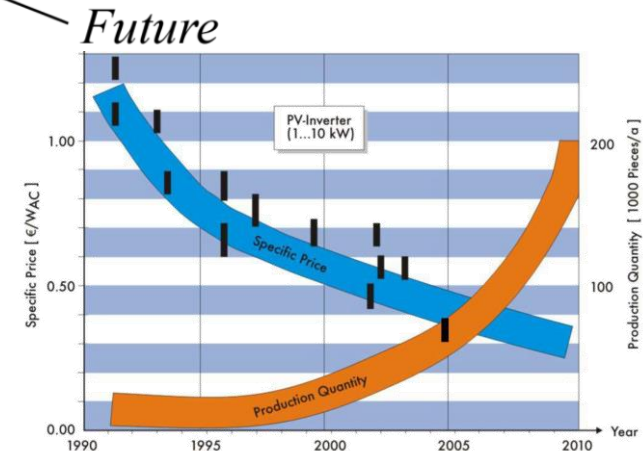
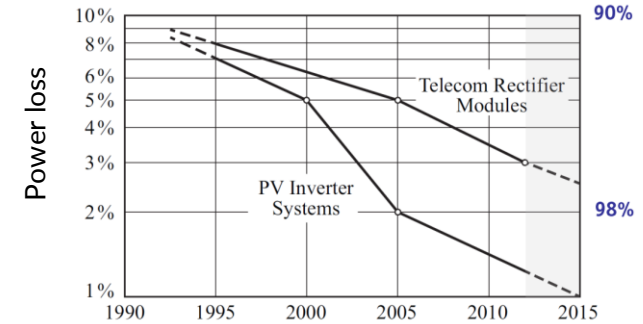
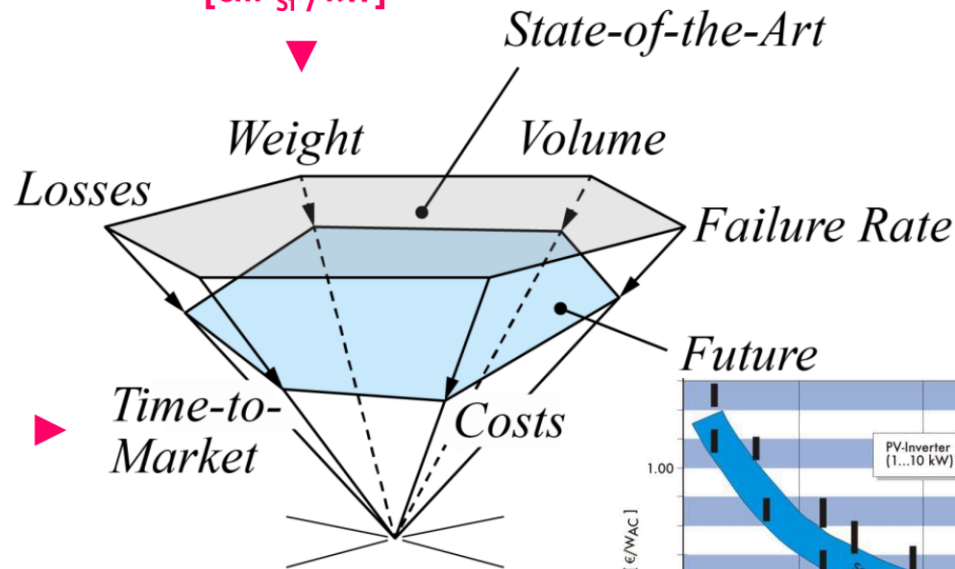


■ Performance Indices

- Power Density [kW/dm³]
- Power per Unit Weight [kW/kg]
- Relative Costs [kW/\$]
- Relative Losses [%]
- Failure Rate [h⁻¹]

Environmental Impact...

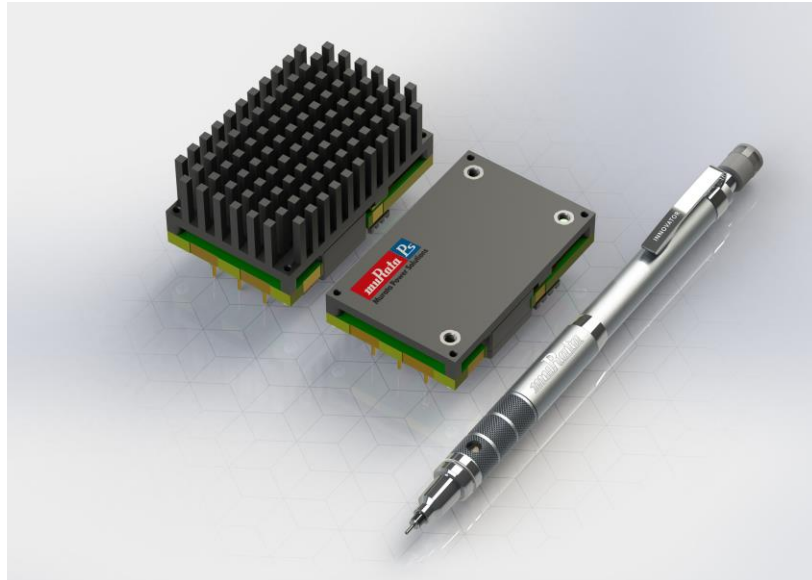
[kg_{Fe} /kW]
[kg_{Cu} /kW]
[kg_{Al} /kW]
[cm²_{Si} /kW]



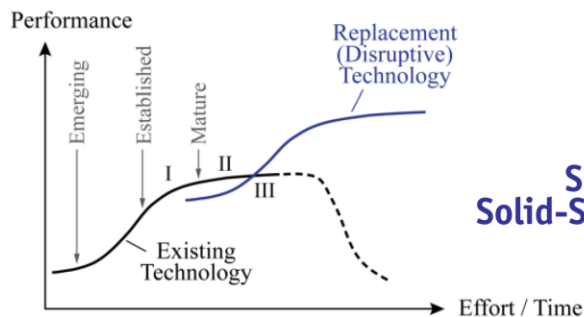
Kolar, J.W., Krismer, F. and Nee, H.P., 2014. What are the "Big CHALLENGES" in Power Electronics?. In 8th International Conference on Integrated Power Electronics Systems (CIPS 2014).

Future trends of PE.

► Power Electronics Technology S-Curve



600W quarter brick DC/DC converter



...after Switches and Topologies

Packaging Magnetics Advanced Design "Systems"

- Super-Junct. Techn. / WBG
- Digital Power Modeling & Simulation
- Power MOSFETs/IGBTs
- Microelectronics Circuit Topologies
- Modulation Concepts
- Control Concepts

SCRs / Diodes
Solid-State Devices

Paradigm Shift

★
2010

2025



HUST

THANKS
FOR
ATTENTIONS

