

UNIVERSITY OF Hilla		LECTURE : 1
ENGINEERING FACULTY		SUBJECT : power Electronics
Medical Device Technology Engineering		LECTURE'S TITLE: INTRODUCTION
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Power Electronics Fundamentals

Power electronics relates power semiconductor devices circuitry, its design and role includes the techniques of converting and processing high power electrical energy. The role of power electronics is shown in Fig.1.A &B

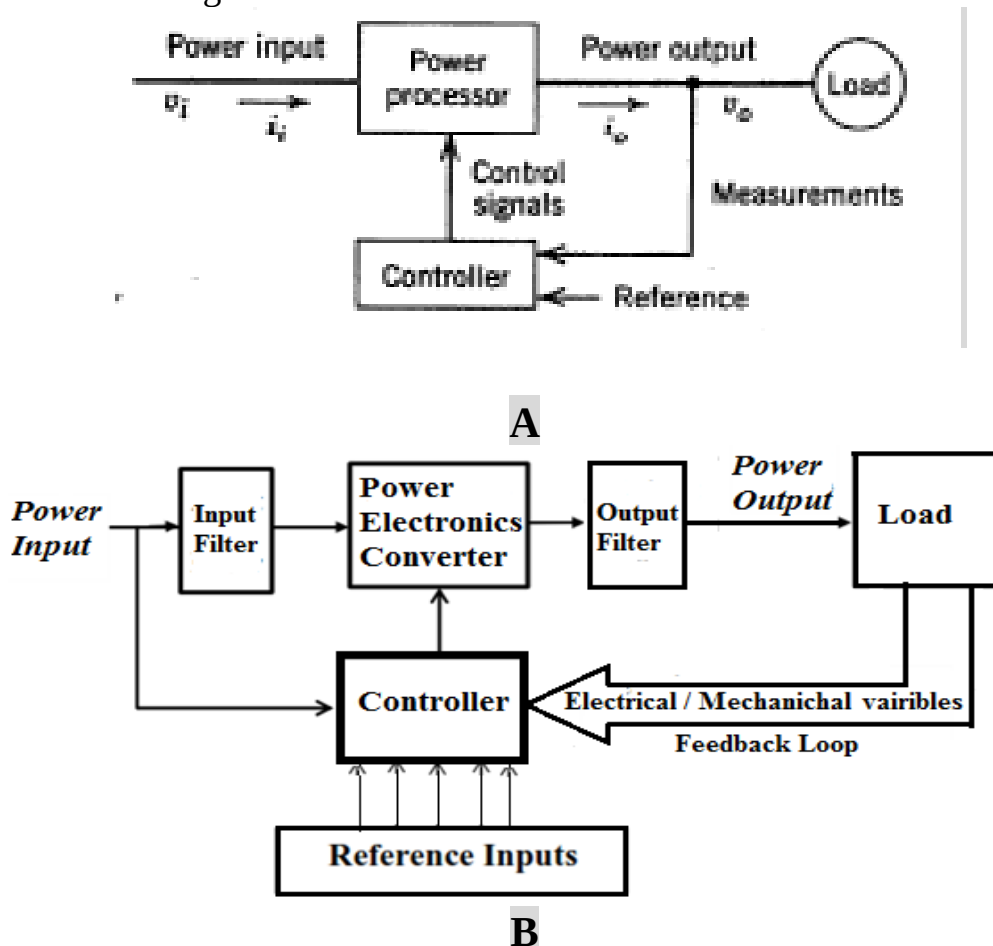


Fig. 1 Block Diagram of power electronic system

Power semiconductor devices

Power semiconductor devices are used, such as (power diodes, thyristors and power transistors). These devices are so important in modern power control. They are used in switching applications where they compete with “mechanically-operated” or “electrically-operated” switches and they give the following advantages:-

1. Faster in operation by a factor of at least a hundred times.
2. Need no routine maintenance.(since there are no moving parts)
3. Do not stick, bounce or wear
4. Give no sparking on break
5. Have a very long life expectancy when used properly
6. Are physically small.
7. Are relatively cheap.

Advantages of Power Electronic controllers(PECs)

- 1- Fast dynamic response due to static devices.
- 2- High efficiency of conversion due to low losses in electronic devices
- 3- Compact size and high weight of the controllers due to electronic devices.
- 4- Increased operating life and reduced maintenance since there are no moving parts.
- 5- PECs use digital or microprocessor based control. Hence their operation is highly flexible.
- 6- Since solid state devices are used , the electromagnetic interference and a acoustic noise is reduced .

Drawbacks of Power Electronic controllers(PECs)

- 1- The PECs generate harmonics . these harmonics affect the performance of other loads.
- 2- The power factor of some PECs is very low. Hence powewr factor correction is necessary to reduce reactive power.
- 3- For very simple conversion requirements, PECs may be costly.

Interdisciplinary Nature Of Power Electronics is illustrated in fig.2 below:

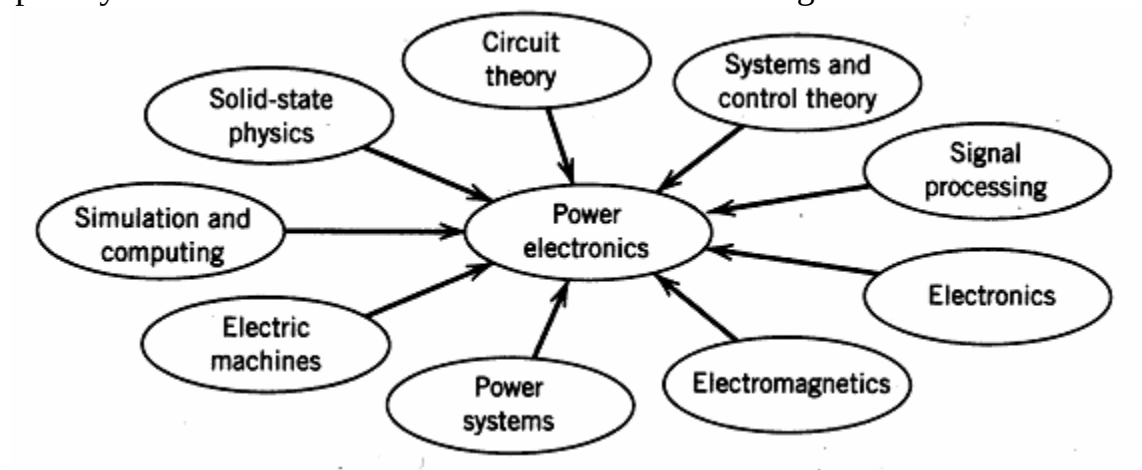


Fig.2 Interdisciplinary Nature Of Power Electronics

Goal of power electronic systems

The main goal of electronic power conversion systems is to convert electrical energy from one form to another, from the source to load using power semiconductor device with:

High efficiency, High availability, High reliability, Small size, Light weight and Low cost.

In addition to the simple on-off applications of power semiconductor devices **their speed of operation and life expectancy**, which are independent of the number of switching actions, make them possible to arrange for smooth control of the mean power from zero to maximum in most applications.

Power Electronics converters

The main fields of applications are in **Energy Processing and Drive Technology**. Power semiconductor devices are interconnected in a variety of ways to form power control units, see Fig.3 (A). These units can be classified in a variety of ways, one of the simplest being to classify them according to their input/output requirements, thus, referring to Fig. 3 (B).

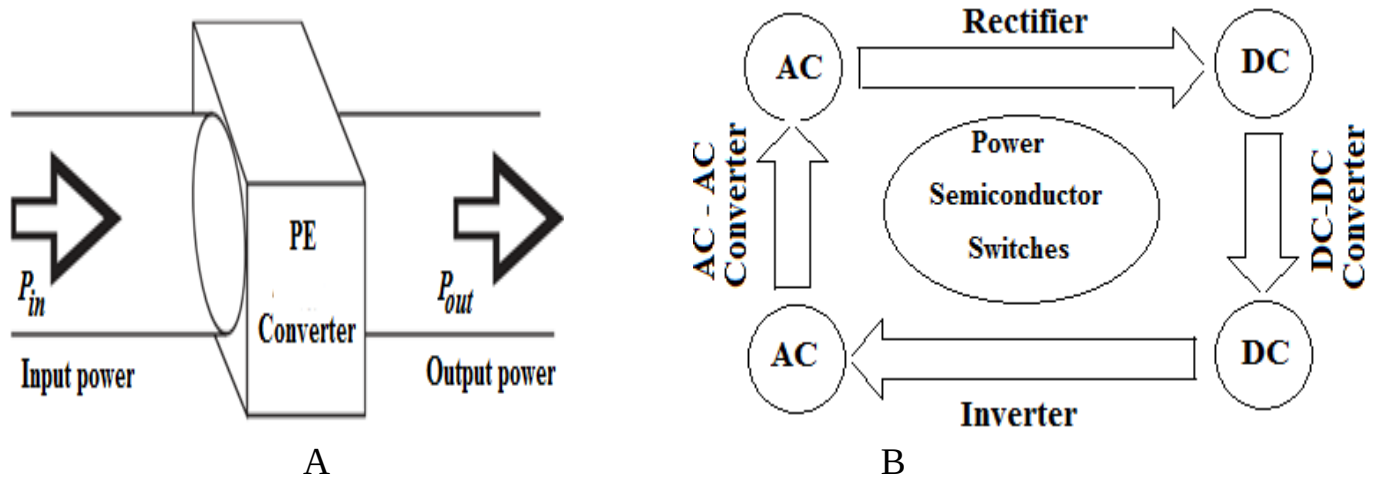


Fig.3 Power processing through power electronics converters

(A) **Rectifiers** — circuits for changing ac voltage to dc voltage or transfer of power from an alternating current (ac) supply to direct current (dc) form. These circuits can be of two main types: AC - DC (uncontrolled) & AC - DC (controlled) .

(B) **DC - DC Converters** — Circuits which change a fixed d.c. voltage into a variable dc supply, i.e., transfer of power from a direct current supply directly into a direct current load of different voltage level. These types of converters are usually called DC choppers.

(C) **Inverters** — Circuits for changing a d.c. voltage to an alternating one or transfer of power from a direct current supply to alternating current form. This type of converter is usually called DC – AC converter or inverter.

(D) **AC-AC Converters** - Circuits which change a fixed a.c. voltage into a variable a.c. supply, i.e., transfer of power from an alternating current supply directly into an alternating current load of different voltage level at fixed frequency or variable frequency. These converters are usually of two types:

- * **AC Voltage Controller**: change the a.c. supply voltage magnitude only keeping the frequency unchanged.
- * **Cycloconverters** or matrix converters: change the a.c. supply directly to a variable a.c. supply both in magnitude and frequency (also called frequency changers).

CONVERSION FROM/TO	NAME	FUNCTION	SYMBOL
DC to DC	Chopper	Constant to variable DC or variable to constant DC	
DC to AC	Inverter	DC to AC of desired voltage and frequency	
AC to DC	Rectifier	AC to unipolar (DC) current	
AC to AC	Cycloconverter, AC-PAC, Matrix converter	AC of desired frequency and/or magnitude from generally line AC	

Fig.4 Power electronics converters

Power Electronics Applications

The development of power semiconductors with very high voltage and current ratings has enabled the use of power electronic converters for many applications, such as,

Residential

Lighting, Space heating, Air conditioning, Cooking, Refrigeration, Power supplies for consumer products and Computers.

Transportation

Electric trains, Trams, Hybrid electric and all-electric vehicles also utilize controlled power electronic converters for interfacing the battery and motor/generator, Battery chargers, Subways, Conveyor systems, and Rapid transit systems.

Commercial

Heating, ventilating, and air-conditioning (HVAC) , Refrigeration , Lighting
Computers & office equipment, Uninterruptible power supplies (UPS) and Elevators.

Utility Systems

High-voltage DC transmission (HVDC) , Static VAR compensation, Renewable energy sources (wind, PV, fuel cells), Boiler feed systems , and Energy storage.

Industrial

Lighting, Pumps, Compressors, AC & DC motor drives, paper industries , steel industries, Gas analysers , Electro plating , Induction heating ,Machine tools, Arc and induction furnaces, Welding, Blowers and fans, Robotic applications, and Process plants.

Aerospace

Satellite power systems, Aircraft power systems, and Aircraft controls.

Communications and Telecommunications

Battery chargers, UPS systems, Satellite antenna drive systems in ground station, High power transmitters and receivers, and Power supplies.

Power semiconductor devices (Power switches)

Power semiconductor switches are the work-horses of power electronics (PE). There are several power semiconductors devices currently involved in several industrial applications. PE switches works in two states only: Fully on (conducting), and Fully off (blocking) . Switches are very important and crucial components in power electronic systems

Q) What is a good power switch?

- No power loss when ON

- No power loss when OFF

- No power loss during turning ON or OFF

- Little power required to turn it ON or OFF

- Bi- directional?

- Adequate voltage and current ratings

- Low Turn-on and Turn-off times

Basic ratings of Power Semiconductors

- 1- Carrying current , Blocking voltage.
- 2- Speed. Any real device requires a definite time to switch.
- 3- Second-order ratings: di/dt , dv/dt , momentary capabilities.
- 4- Power loss
- 5- Thermal ratings –from power switching devices to heat sink
- 6-Control ratings: how to operate the switch

Types of Power semiconductor switches

The main types of power semiconductor switches in common use are

1. Power Diodes **(600V,4500A)**
2. Thyristor devices **(10KV,300A,30MW)**
 - a. Silicon controlled rectifier (SCR)
 - b. Static induction thyristor (SITH)
 - c. Triac (Triode ac switch)
 - d. Gate turn-off thyristor (GTO)
 - e. Mos- controlled thyristor (MCT)
 - f. integrated gated-commutated thyristor (IGCTs)
3. Power transistors
 - a. Bipolar junction transistor (BJT)
 - b. Metal oxide semiconductor field effect transistor (MOSFET)
 - c. Insulated gate bipolar transistor (IGBT)
 - d. Static induction transistor (SIT)

Q:what are the selection criteria for switches using?

Selection Criteria

Voltage Rating

Current Rating

Switching Speeds

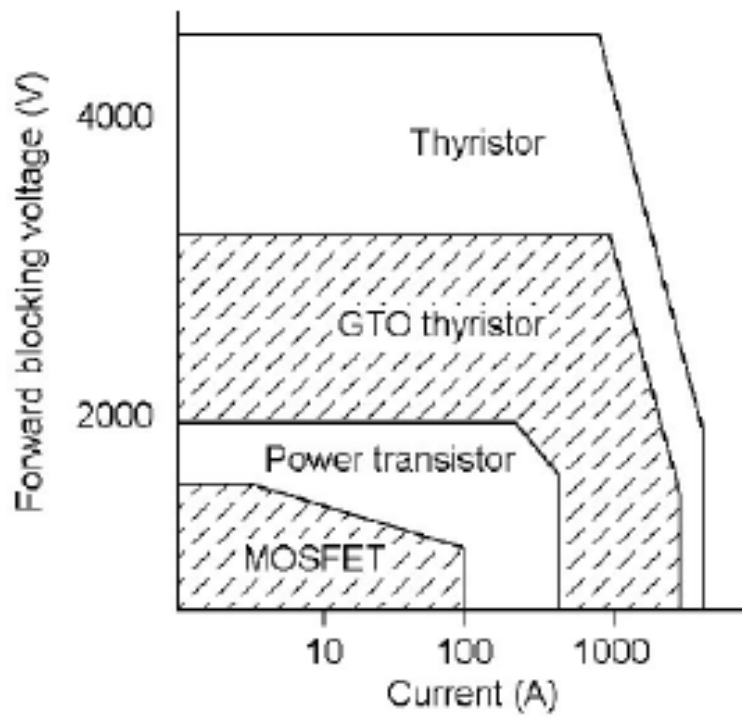
On-State Voltage

Switching Frequency

Transistor or Diode

Magnetic Components

Capacitor Selection



Comparisons of power electronics devices

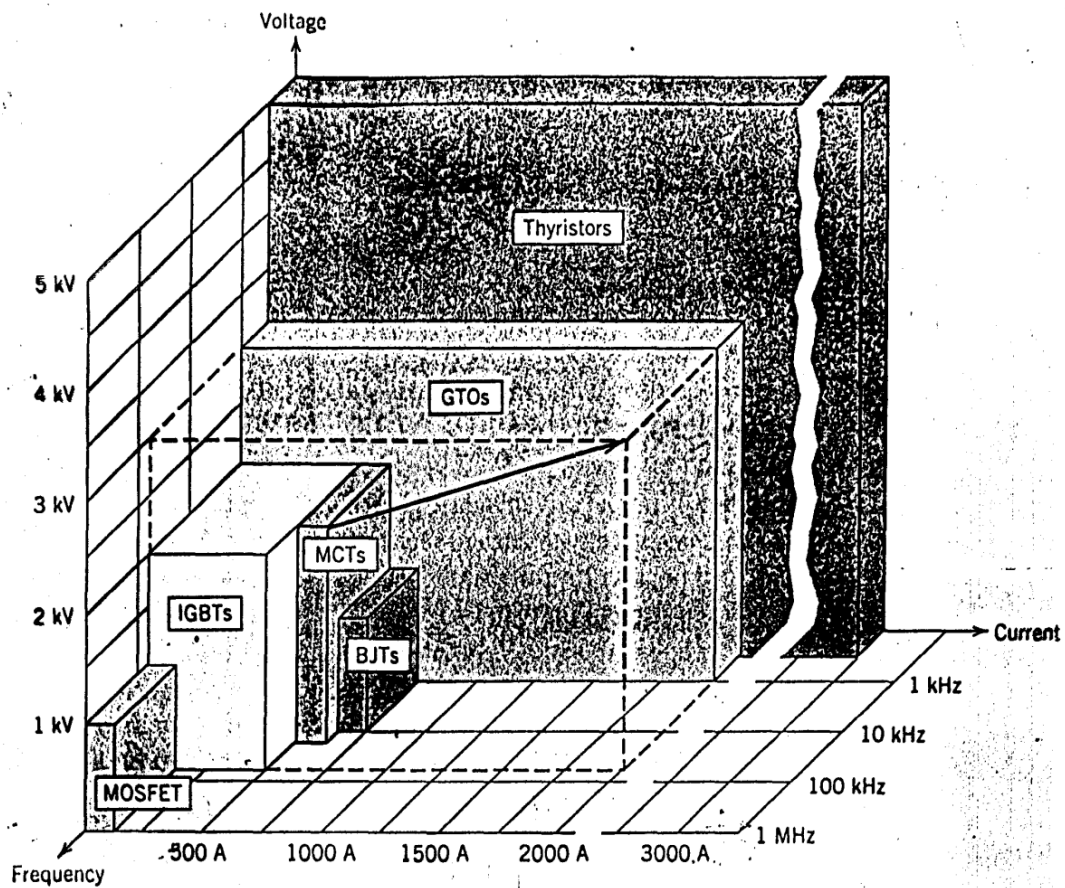


Fig.5 A B a summary of power semiconductor device capabilities by the year 2016.

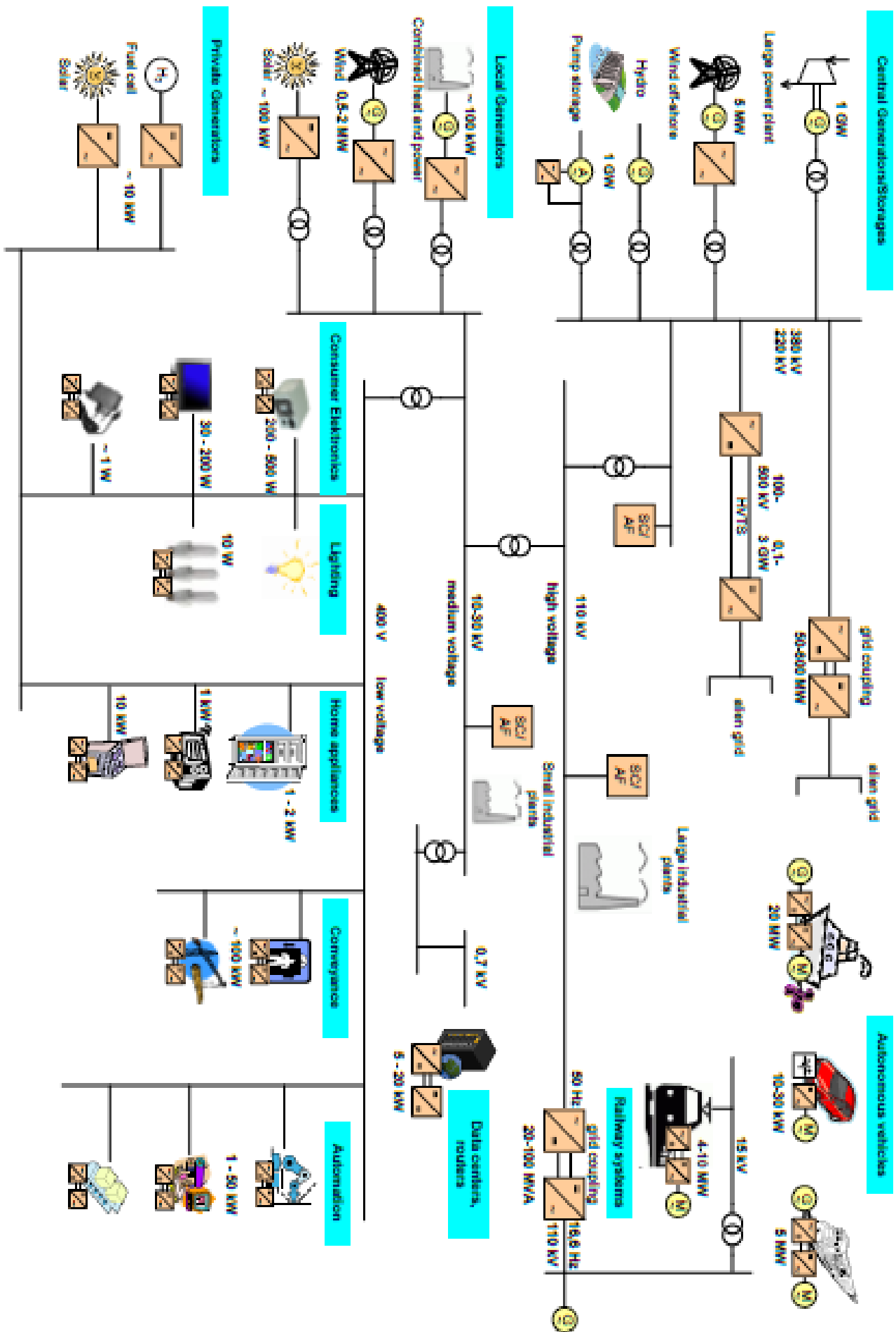


Fig.6 Power electronics Applications of energy generation

Table of Characteristic and Symbol of Power Electronic Devices

Devices	Symbols	Characteristics
Diode		
Thyristor		
SITH		
GTO		
MCT		
MTO		
ETO		

Table of Characteristic and Symbol of Power Electronic Devices

IGCT		
TRIAC		
LASCR		
NPN BJT		
IGBT		
N-Channel MOSFET		
SIT		

Fig.7 Power semiconductors symbols & characteristics

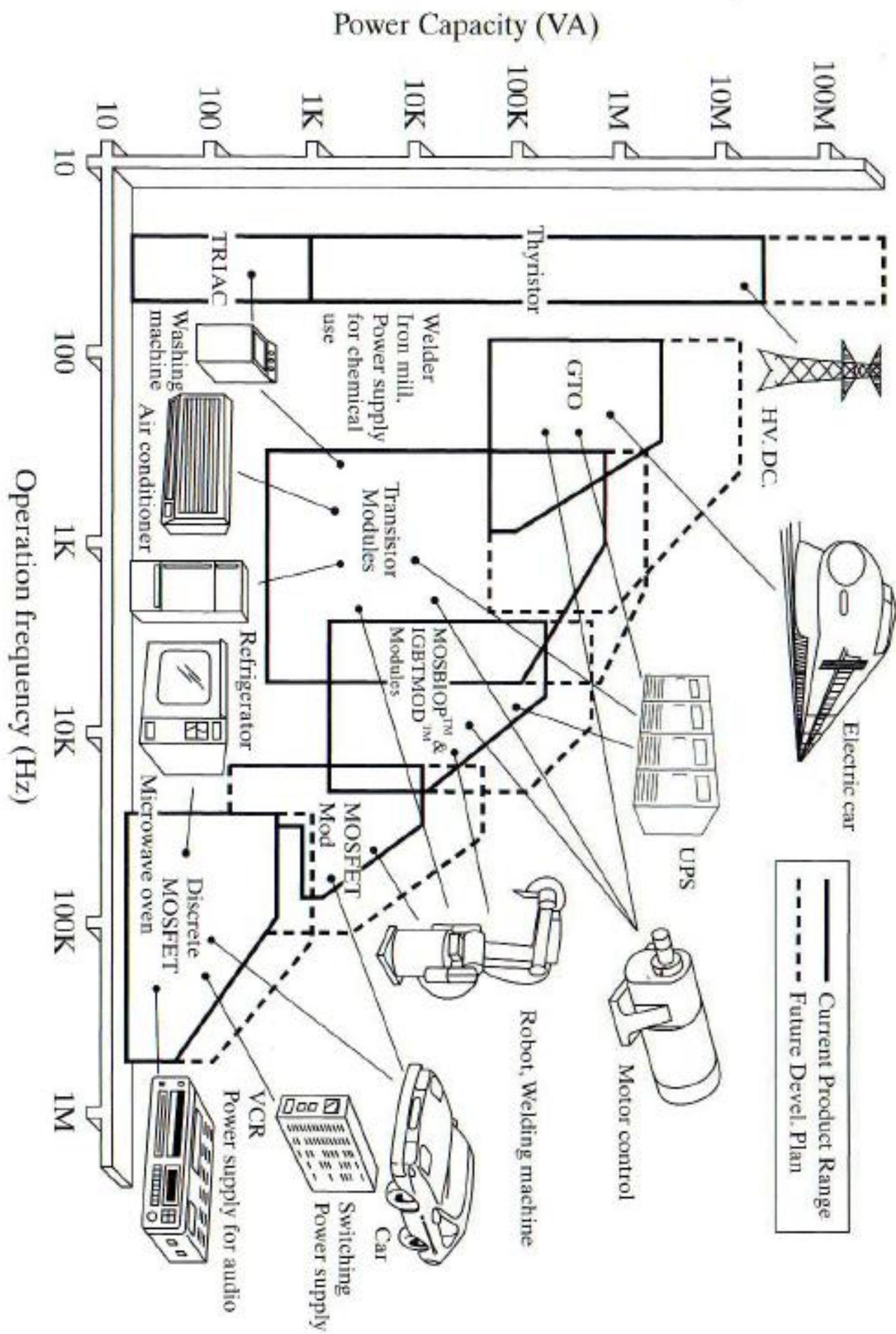
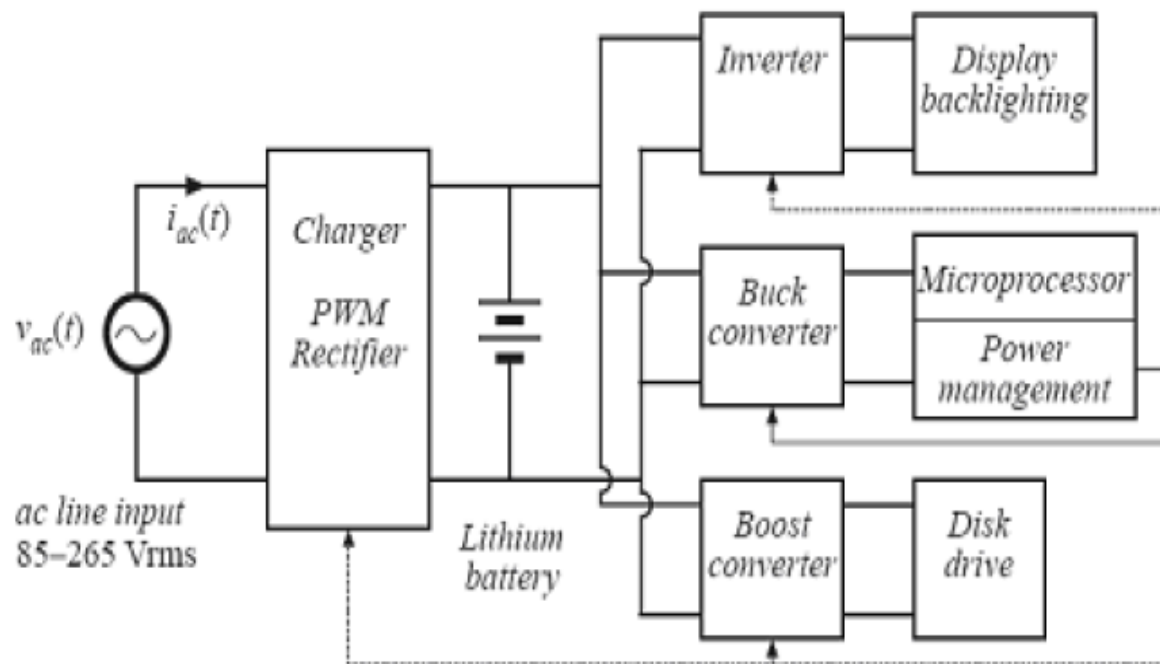


Fig.8 Power electronics Applications

A Power Electronics of a Laptop Power Supply System



B An Electric Vehicle Power and Drive System

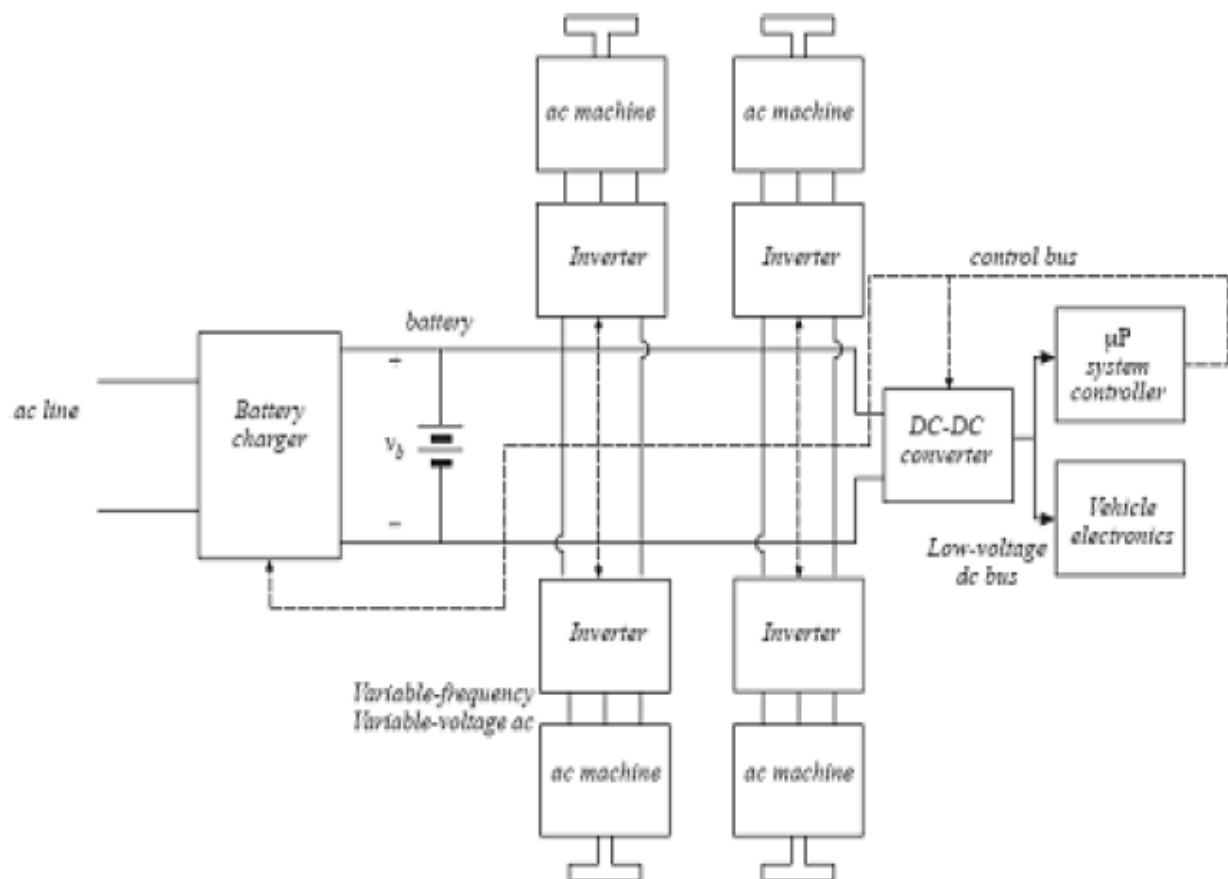


Fig. 9