## POWER ELECTRONICS

This is a branch of electronic that deals with power diodes transistors, thyristors and its application, controlled rectifier, inverters, choppers, AC generators, AC and DC motors devices, power supply, IC (integrated circuit), operational amplifiers, micro processors etc.

### General Precautions for Power Electronics

1. Power electronics is usually destroyed by over voltage or over current (can be protected by the use of transformer or the use specified voltage supplier)

2. Check the terminal of various power electronic devices to ensure that they are well controlled

3. Peak inverse voltage of thyristors is an important parameter (ensure it is not exceeded)

### Power Diode

Power diode is crystalline semi conductor device used to convert alternating current AC to direct current DC in a process known as rectification. It's -2 terminal P N junction semi conductor devices with terminal C-cathode and A-anode.

### Types of Power Diode

1. General power diode

2. Fast recovery power diode

3. Schottky diode

### Characteristic of Power Diode

1. It has low resistance in the forward direction and very high resistance in the reverse direction
2. it has little heat storage capacity and can burn out easily due to overload or excessive reverse voltage
3. It does not start conducting till the applied voltage overcome the barrier potentials.

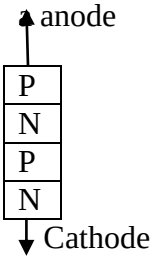
### Applications of Diode:

1. Rectification: It is a rectifier circuit that converts AC to DC. A rectifier converter that does this conversion can be burnt using a diode. The output voltage is constant if the input voltage is constant.
2. Voltage multiplier circuit: using suitable connecting diode capacitor, the magnitude of voltage can be doubled, tripled or quadrupled. Such circuits are known as voltage multiplier circuit.
3. As a switch: An ideal diode presents zero resistance (closed switch) when forward biased

and with infinite resistance (open switch) when reverse biased. Thus it works as fast acting electronic circuit

**THYRISTORS**

Thyristor is a solid state semi-conductor device with four layers of alternating P-N type material. They acts exclusively as a bi-stable switches conducting when their gates receives a convert trigger and continue to conduct while they are forward based, when the voltage across the device is not reversed. A thyristor is a versatile power electronics power electronics device also known as silicon controlled rectifier (SCR). The material is silicon doped with P and N type impurities thus forming P and N type extrinsic semiconductor.




Applications of thyristors

1. Often used to control AC (where high current and voltage are involved)
2. Can be used to control elements for phase angle triggered controllers also known as phase-timed controller's
3. It finds application on digital circuit. They are used as enhanced circuit brokers to prevent failure or fluctuating power supply from damaging components

**INVERTERS**

They are DC to AC converters. They convert DC supply to AC supply with desired magnitude and frequency. Their input supplies are in form of fuel, cells, battery, solar cells from which they can be converted into applications that requires alternating current using inverters.

Classification of Inverter

1. According to Phase:
    - Single phase
    - 3-phase
2. According to method of commutation:
    - Line commutated inverters
    - Forced commutated inverters
3. According to type of commutators:

- Series converter
- Parallel inverter

4. According to voltage and current source:
    - Voltage source inverter: This is fed by a constant voltage source system
    - Current source inverter: This is fed by a constant current source system

**Applications of Inverters**

1. Used to variety of applications in small sizes
2. Used in domestic installations as source of steady electric supply
3. In medium size, they are used in commercial installation as a source of stand by electric supply and uninterruptable power supply
4. In both medium and large size, they are used in industrial installation for variable speed AC transmission
5. One of the biggest application of inverter is in High Direct Voltage Current (HDVC) power transmission

Example 1

A series inverter has a resistance R of 90Ω, inductance L of 8.5mH and capacitance C of 1.2$F$. Check whether it can work as a series inverter. If so compare its maximum output frequency.

Solution

For it to work as a series inverter, the circuit should be under damped and for an under damped circuit

$R^2 < \frac{4L}{C}$

Resistance (R) = 90Ω

Inductance = $8.5 \times 10^{-3}$ H

Capacitance (C) = $1.25 \times 10^{-6}$ F

$90^2 = \frac{4 \times 8.5 \times 10^{-3}}{1.25 \times 10^{-6}} = 27{,}200$

8100 < 27,200

Since $R^2$ is < than $\frac{4L}{C}$, it can work as a series inverter

Maximum Frequency

$Freq_{Max} = [\frac{1}{LC} - \frac{R^2}{4L^2}]^{0.5}$

$\left[\frac{1}{8.5 \times 10^{-3} \times 1.25 \times 10^{-6}} - \frac{90^2}{4 \times (8 \times 10^{-3})^2}\right]^{0.5}$

$Freq_{Max} = 8129.57 rad/s^{-1}$

**The Difference between Inverters and Ups**

The main difference between the inverter and the ups lies in the fact that in an inverter the power is directly sent to the output which is be connected by wiring to various appliances.

The rectifier and the battery are inbuilt in the circuit of ups. The rectifier converts the AC into DC and store the energy into battery whereas the inverter has an external battery for storing the DC power.

**AC Regulators**

An AC regulator converts a constant AC voltage into a variable AC voltage of the same frequency

**Commutators**

A commutator is an attachment connected to the armature of the motor through which electrical connections is made and ensure that current flows as direct current. The commutation process involves the change from a generated AC to an externally available DC. This reversal of current in the armature coil by means of brush or commutator bars is called a commutation process and the period during which the coil remains short circuited is called the commucator period denoted by $T_C$

**Power Factor**

Power factor is a measure of how effectively you are using electricity.

In electrical engineering, a power factor is only and only related to AC circuits i.e. there is no power factor (PF) in DC circuits.

Power factor is defined as the ratio of real (working) power to apparent (total) power. Real power (kw) is the power that actually powers the equipment and performs useful, productive work. It is also called active power, active power or working power.

Reactive power (KVAR) is the power required by some equipment (e.g. transformer, motor and relays) to produce a magnetic field to enable real work to be done. It's necessary to operate certain equipment but you don't see any result for its use.

Power Factor is expressed as a value between -1 to 1 and can be either inductive (lagging) or capacitive (leading). If the power factor is 1, then all of the power supplied is being used for productive work and this called unity.

Example

An industrial plant draws 200A at 400V and the supply transformer. If the active power is 56kw. Compute

1. The power factor
2. Comment on the value of the power factor

Solution

Power factor = $\frac{P}{S} = \frac{real\ active\ power\ (watt)}{apparent\ power\ (VA)}$

P = 56KW = $56 \times 10^3$

S = 80,000

Power factor = $\frac{P}{S} = \frac{real\ active\ power\ (watt)}{apparent\ power\ (VA)} = \frac{56 \times 10^3}{80{,}000}$

= 0.7

PF < 1 that is power factor is less than 1

Power factor less than 1 meaning that the circuit wiring has to carry more current that what would be necessary with zero resistance in the circuit to deliver the same amount of true power to the resistive load. It is expensive and inefficient in some utilities and will reduce electrical system distribution capacity by increasing the current flow thereby causing voltage drop.