GOVT. TOOL ROOM AND TRAINING CENTRE
KARNATAKA

REFERENCE NOTES
BASIC ELECTRICAL AND ELECTRONICS ENGINEERING

FOR
: DIPLOMA IN TOOL AND DIE MAKING : II SEMESTER
: DIPLOMA IN PRECISION MANUFACTURING : II SEMESTER

MAJOR TOPICS

Major Topics	
Total Hours: 48h	
1.0 Introduction to Electronics	03h
2.0 Electronic Components	02h
3.0 Computers	03h
4.0 Electronic Circuits	09h
5.0 Measuring Instruments	02h
6.0 Display devices	01h
7.0 Digital Electronics	04h
8.0 D.C. Circuits	05h
9.0 Industrial Safety devices	01h
10.0 Effects of Electric Current	01h
11.0 Alternating Current Theory	05h
12.0Transformers	03h
13.0 D.C. Motor	03h
14.0Generation, transmission, and distribution	02h
Tests/Exam	04h

SUBJECT CONTENT

Introduction to Electronics

- Importance & scope of Electronics
- Introduction to Electronics, basic structure of Atom Conductors, Insulators and semiconductors.
- Energy band diagram for 3 types of material

Electronic Components

- Types of electronic components Application of components
- Classification & characteristics of resistors, capacitors and inductors.

Computers

- Various parts of a Computer Working of a computer

Electronic Circuits

- Semiconductor physics
- N type P type PN junction
- Applying voltage across PN junction Characteristics of PN junction diode

Rectifiers

- Introduction
- Half wave rectifier
- Center tap rectifier
- Bridge rectifier
- Regulated power supplies
- Transistors & Amplifier

Introduction

- Junction transistor structure
- Working principle of transistor
- Transistor amplifying action Classification of amplifiers

Measuring instruments.

- Multi meter
- Types of Multi meter
- Uses

Display Devices.

- LEDs
- Seven segment display
- LCD displays

Digital electronics

- Introduction
- Types of numbering systems
- Conversion from decimal number system to binary number system and vice versa.
- Logic gates: OR, AND & NOT
- Operation of Logic gates with the help of CKT diagram and truth table.

D.C. Circuit

- Introduction: Electromotive Force, Electrical, Resistance Laws of resistance: Ohm ‘s law electric current Resistance in series & parallel

- Solving related problems
- Kirchhoff's laws
- Solving related problems

Industrial Safety Devices

Industrial safety devices and their Applications.

Effects of Electric Current

- Magnetic effect.
- Chemical effect.
- Heating effect.
- Lighting effect. Shock effect.

Alternating Current Theory

- Fundamental of voltage & current
- Generation
- Equation of A. C current & voltage.
- Peak Average and R.M.S of sine wave
- Frequency, time period, wavelength, amplitude, form factor and peak factor.
- Concept of reactance and power factor

Transformer

- Principle of operation Construction
- Types of transformers
- E. M. F Equation
- Solving related problems

D.C. Motor

- Motor principle Construction
- Types of D.C. Motors
- Operation of 3-phase induction motors

Generation, Transmission and Distribution:

- Brief explanation about various modes of power generation, transmission and distribution.

Reference Books

1. Electrical Technology - B.L Theraja
2. Electrical Technology - H Cotton
3. Electrical Engineering Theory - K Mehta
4. Worked out examples - B L Theraja
5. Basic Electricity - H Cotton
6. Basic Electrical and Electronics - B L Theraja
7. Inside Auto CAD - Racker & Rice
8. Principles of Electrical & Electronics - V .K Metha

INTRODUCTION TO ELECTRONICS

- Importance & scope of Electronics
- Introduction to Electronics, basic structure of Atom
- Conductors, Insulators and semiconductors.
- Energy band diagram for 3 types of material

Importance & scope of Electronics

We are now living in the age of electronics. Electronics are tied into so many different aspects of our life. It is hard to find an electrical item in your home that does not have electronics partnered with it ‘

Almost everything that surrounds us has direct link to Electronics, from the very computers we use whether it be laptops, or notebooks which has millions of tiny electronic components on it like resistors, inductors, capacitors, logic gates and the likes to the calculators, appliances, measuring devices. Electronics truly molded our lives we have today. Electronics is the barometer of how far humans have gone through if we use the advancement in technology as a yardstick of progress. Electronics today provides the world with an infinite amount of information at a much faster speed than that information would ever have been available before.

Electronics is the study of electrons and its behavior. Electronics finds more importance in daily life and applications are continuously increasing.

Applications of electronics:

1. Electronics in Communications.
2. Entertainment electronics.
3. Electronics in Defense.
4. Electronics in Industry.
5. Electronics in medical.
6. Electronics in instrumentation.
7. Electronics in Navigation and Aircraft. Etc….

Electronics essentially deals with electronic devices and their utilization

Introduction to Electronics, basic structure of an Atom

Atomic Structure

Atom is the basic building block of all the elements. It consists of the central nucleus of positive charge around which small negatively charged particles called electrons revolve in different paths or orbits.

An Electrostatic force of attraction between electrons and the nucleus holds up electrons in different orbits.

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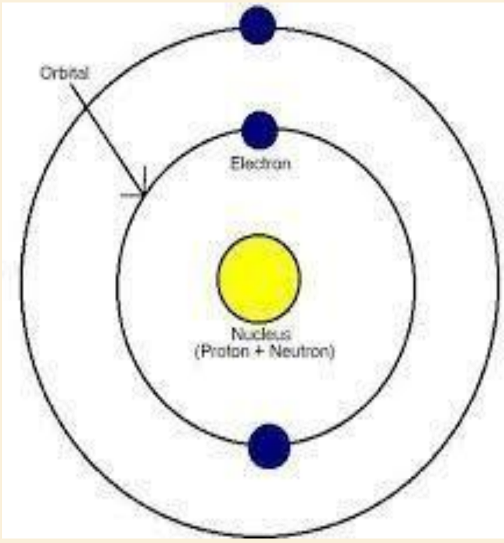
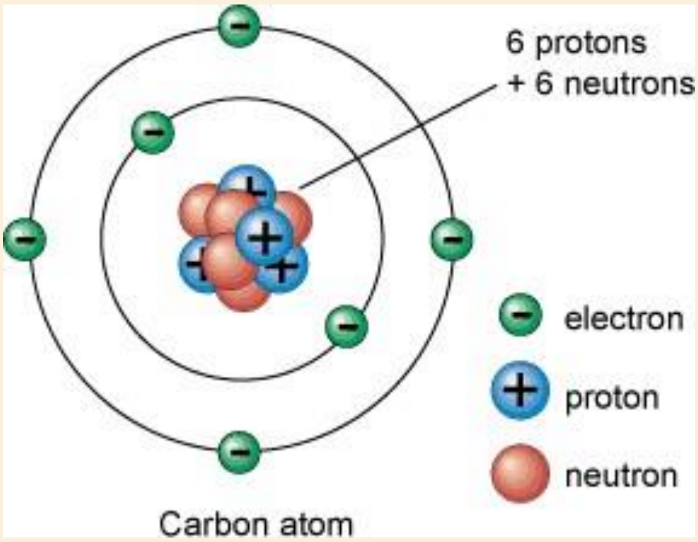
Structure of an Atom





Nucleus is the central part of an atom and contains protons and neutrons.

A proton is positively charged particle, while the neutron has the same mass as the proton, but has no charge. Therefore, nucleus of an atom is positively charged.

Atomic weight = no. of protons + no. of neutrons

An electron is a negatively charged particle having negligible mass. The charge of an electron is equal but opposite to that on a proton. Also the number of electrons are equal to the number of protons in an atom under ordinary conditions.

Therefore, an atom is neutral as a whole.

Atomic number = no. of protons or electrons in an atom

Orbit

Electrons are revolving round the nucleus in a path. The path is called an orbit

1. The number of electrons in any orbit is given by $2n^2$ where n is the number of the orbit.

For example,

I orbit contains $2x1^2$ =2 electrons
II orbit contains $2x2^2$ = 8 electrons
III orbit contains $2x3^2$ = 18 electrons and so on

The last orbit cannot have more than 8 electrons.
The last but one orbit cannot have more than 18 electrons.

<u>Positive and negative ions</u>

Protons and electrons are equal in number hence if atom losses an electron it has lost negative charge therefore it becomes positively charged and is referred as positive ion. If an atom gains an electron it becomes negatively charged and is referred as negative ion.

Valence Electrons

The electrons in the outer most orbit of an atom are known as valence electrons.

The outer most orbit can have a maximum of 8 electrons. The valence electron determines the physical and chemical properties of a material.

Conductors, Insulators and semiconductors.

Based on the electrical conductivity the materials are mainly classified into three; they are conductors, insulators and semiconductors.

Conductors

Conductors are those substances which allow electric current to pass through them.

Example: copper, aluminum, water etc.

When the number of valence electrons of an atom is more than four, the material is usually a metal and a conductor. Examples are Sodium, magnesium and aluminum, which have 1, 2, 3 valence electrons respectively.

Insulators

Insulators are those substances, which do not allow electric current to pass through them.

Example: rubber, glass, wood, etc.

When the number of valence electrons of an atom is less than four, the material is usually a non-metal and an insulator. Examples are Nitrogen, Sulphur and neon, which have 5, 6, 8 valence electrons respectively.

Semiconductors

Semiconductors are those substances whose conductivity lies in between that of a conductor and insulator.

Example: silicon, germanium, gallium etc.

When the number of valence electrons of an atom is four, the material has both metal and nonmetal properties and is usually a semiconductor. Examples are carbon, silicon and germanium, which have 4 valence electron.

Free electrons

The valence electrons of different material possess different energies. the greater the energy of a valence electron, the lesser it is bound to the nucleus. In certain substances, particularly metals, the valence electrons possess so much energy that they are very loosely attached to the nucleus. The loosely attached valence electrons move at random within the material and are called free electrons.

The valence electrons, which are loosely attached to the nucleus, are known as free electrons.

Energy Bands

In case of a single isolated atom an electron in any orbit has definite energy. When atoms are brought together as in solids, an atom is influenced by the forces from other atoms. Hence an electron in any orbit can have a range of energies rather than single energy. These ranges of energy levels are known as energy bands.

Within any material there are two distinct energy bands in which electrons may exist viz valence band conduction band

Valence Band

The range of energies possessed by valence electrons is called valence band.

Conduction Band

The range of energies possessed by free electrons is called conduction band.

Forbidden energy gap

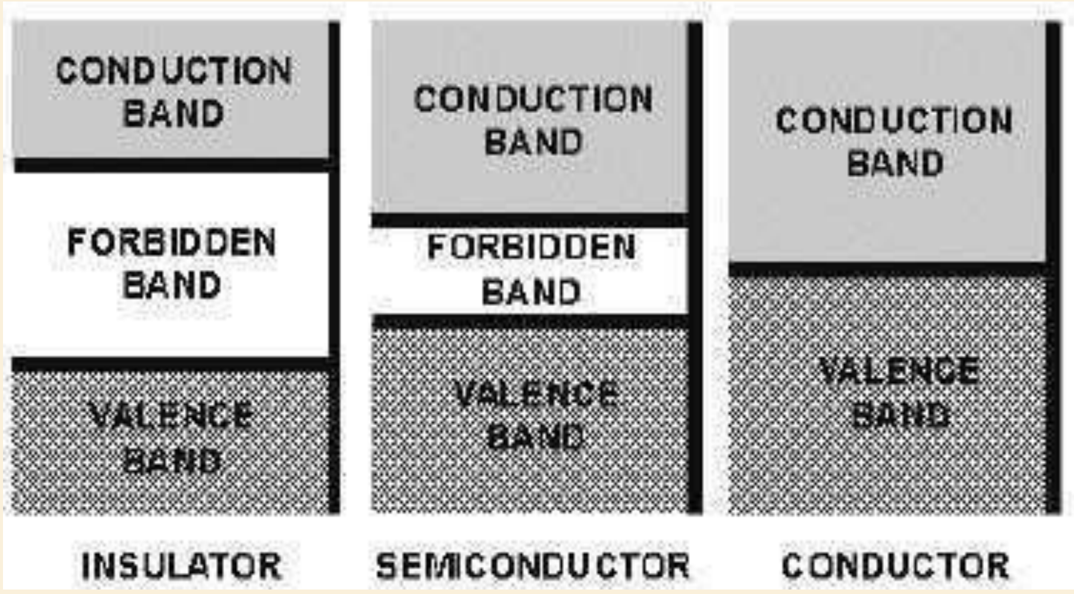
Valence band and conduction band are separated by an energy gap, in which no electrons normally exist. This gap is called forbidden energy gap.

Electrons in conduction band are either escaped from their atoms (free electrons) or only weakly held to the nucleus. Thereby the electrons in the conduction band may be easily moved around within the material by applying relatively small amount of energy. This is the reason why the conductivity of the material increases with increase in temperature.

But much larger amount of energy must be applied in order to extract an electron from the valence band because electrons in valence band are usually in the normal orbit around a nucleus. For any given material, the forbidden gap may be large, small or non-existent.

Energy band diagram for 3 types of material

Based on the width of forbidden gap, materials are broadly classified as conductors, insulators and semiconductors.



Conductors

In terms of energy bands, conductors are those substances in which there is no forbidden gap. Valence and conduction band overlap as shown in figure. For this reason, very large number of electrons is available for conduction even at extremely low temperature. Thus, conduction is possible even by a very weak electric field.

Insulators

In terms of energy bands, insulators are those substances in which the forbidden gap is very large. Thus valence and conduction band are widely separated as shown in figure.

Therefore, insulators do not conduct electricity even with the application of a large electric field or by heating or at very high temperatures.

Semiconductors

In terms of energy bands, semiconductors are those substances in which the forbidden gap is narrow. Thus valence and conduction bands are moderately separated as shown in figure.

In semiconductors, the valence band is partially filled, the conduction band is also partially filled, and the energy gap between conduction band and valence band is narrow. Usually 1ev.Therefore, comparatively smaller electric field is required to push the electrons from valence band to conduction band. At low temperatures the valence band is completely filled and conduction band is completely empty. Therefore, at very low temperature a semiconductor actually behaves as an insulator.

ELECTRONIC COMPONENTS

- Types of electronic components
- Application of components
- Classification & characteristics of Resistors, Capacitors and Inductors

Electronic components:

An electronic device or appliance is composed of different parts known as electronic components. An electronic component is a basic electronic element usually packaged in a discrete form with two or more connecting leads or metallic pads. These basic electronics components are assembled together using a circuit diagram to create a device, tool or appliance.

Types of electronic components

There are two major types of basic electronic components

1. Passive components
2. Active components

Passive components

A passive component is an electrical component that does not generate power, but instead dissipates, stores, and/or releases it.

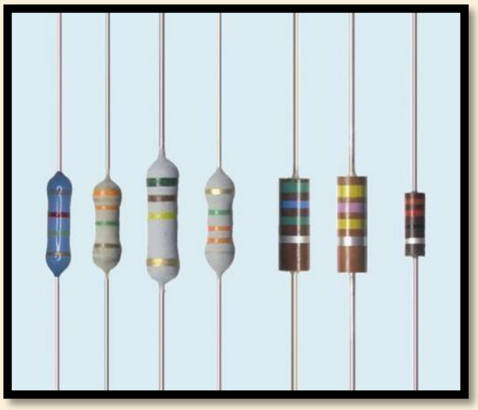
Example: Resistor, Capacitor, Inductor.

Active components

- Active components require power to function.
- Active components are those that have gain.

Example: Diode, transistor, IC

Classification & characteristics of resistors, capacitors and Inductors.



Resistors: A "resistor" is an electronic component that resists or opposes the flow of current through it. The common uses of resistors are

1. To establish proper values of circuit voltages due to voltage drops
2. To limit current
3. To provide load

Resistors are mainly of two types and can be either of fixed or variable type.

i) Wire wound Resistors

ii) Carbon Resistors

a) Carbon composition type

b) Carbon film type

c) Cermet-film type

d) Metal thin film

Wire–Wound Resistors: They are constructed from a long fine wire wound on a ceramic core. The length of the wire used and its resistivity determine the resistance of the unit. These can be either fixed or variable type. Wire wound resistors are used where

1) Large power dissipation is necessary

2) Precise and stable resistance values are required

Carbon – Film Resistors: They consists of a high grade ceramic rod on which is deposited a thin resistive film of carbon

Cermet Film resistors: They consist of thin carbon coating fired on to a solid ceramic substrate.

Metal Film Resistors: They consist of a thin metal coating deposited on a cylindrical insulating support.

Variable Resistors: These are the resistors whose resistance can be changed between zero and a certain maximum value. They can be wire wound or carbon type. They are of mainly two types

a) Potentiometer
b) Rheostats

Characteristics of resistors: The two main characteristics of resistors are its resistance and power rating. The power rating of a resistor is given by the maximum wattage it can dissipate without getting damaged.

Capacitors: A capacitor is a device which has the ability to store charge. It opposes any change of voltage in the circuit in which it is connected. It blocks the passage of direct current through it. Usually a capacitor consists of two conducting plates separated by an insulating medium called dielectric.

Capacitance: It measures the ability of a capacitor to store charge. It may have defined as the amount of charge required to create a unit potential difference between it plates. The capacitance of a capacitor depends on following factors

1) Plate area

2) Plate separation
3) Type of die electric

Types of Capacitors: The capacitors may be divided into two general classes

1) Fixed
2) Variable

Fixed Capacitors: They can be grouped into two classes

a) Non – electrolytic type: no polarity requirement
   i) Paper Capacitor
   ii) Mica Capacitor
b) Electrolytic Capacitor: These capacitors are called electrolytic because they use an electrolyte as negative plate. They are polarity sensitive

Characteristics of Capacitors

The two main characteristics of capacitors are its capacitance and voltage rating. The voltage rating of a capacitor is given by the maximum potential difference that can be applied across the plates without puncturing its dielectric.

Inductor

An inductor is a passive electrical component that can store energy in a magnetic field created by the electric current passing through it. An inductor's ability to store magnetic energy is measured by its inductance. Its unit is Henry. Typically an inductor is a conducting wire shaped as a coil, the loops helping to create a strong magnetic field inside the coil due to Faraday's Law of Induction An inductor opposes change of current in the circuit in which it is connected.

Classification of Inductors

Inductors are mainly divided into three

a) Air-core Inductor
b) Iron-Core Inductor
c) Ferrite-core Inductor

Air-core Inductor

It consists of number of turns of a wire wound on a former made of ordinary card board. The air acts as a core.

Iron-Core Inductor

In this type of inductor, a coil of wire is wound over a solid or laminated iron core

Ferrite-core Inductor

In this type, coil of wire is wound on a solid core made of highly ferromagnetic substance called ferrite.

Characteristics of Inductors

The two main characteristics of Inductors are its inductance and Maximum DC Current rating.

COMPUTERS

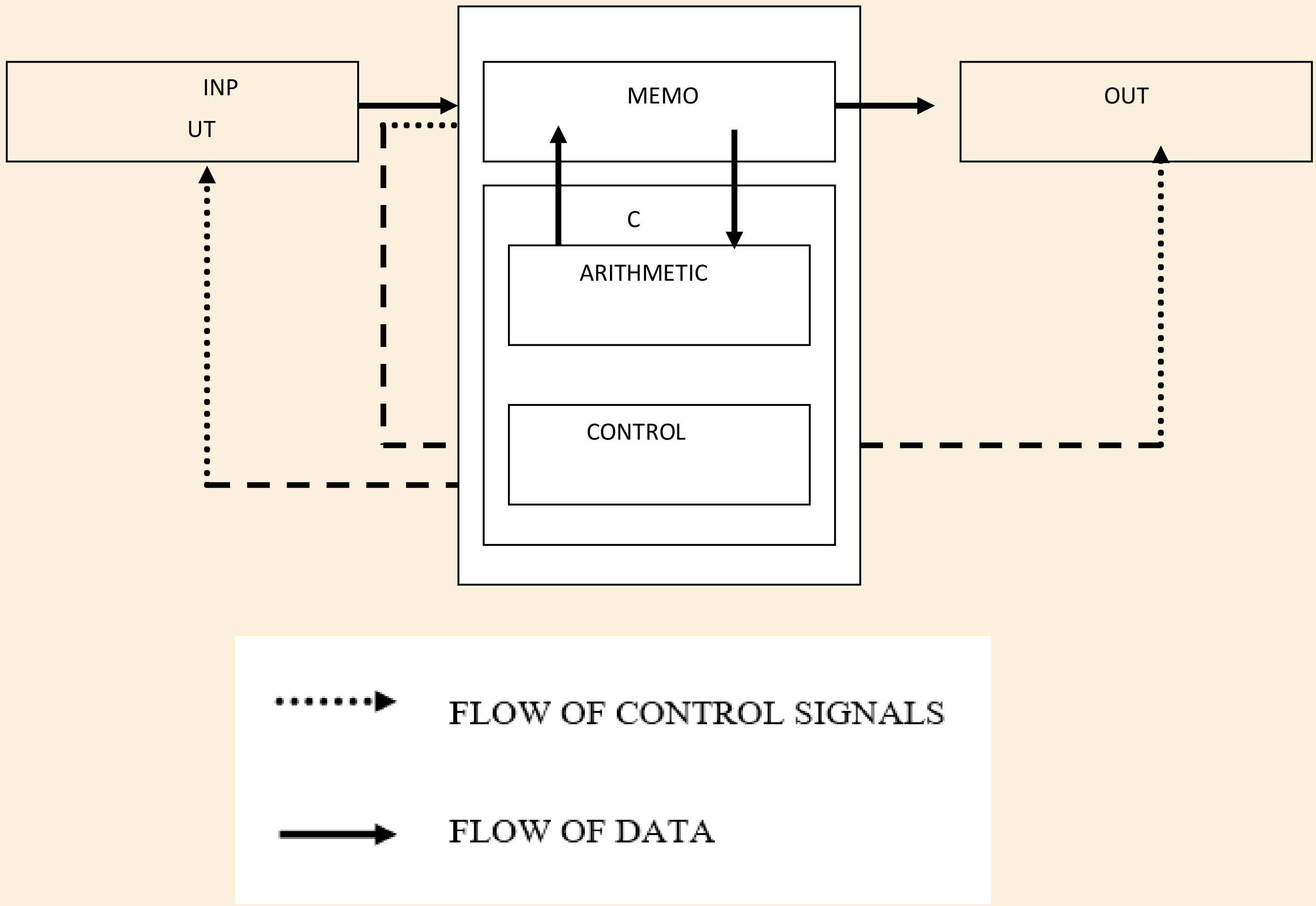
- Various parts of a computer
- Working of a computer

INTRODUCTION

Computer is an electronic device, which is used to store the data and retrieve the data at higher speed. It is most flexible electronic machine man has ever created. The presence of computer is very important in our day to day life. Like Home, hospitals, colleges, schools, industries, banks, railways everywhere computer became the common. We can see computer everywhere and it can help us to do our daily tasks. A computer can be used for a large amount of things to do such as: connecting people to the Internet and to email, writing letters, making presentations, creating flyers and cards, etc. Computers are also used in the majority of work places. Knowing how to use a computer can really help you in your work place or can enhance your leisure time.

The word ―Computer‖ comes from the word compute, which means to calculate. Charles Babbage is known as father of modern computers.

VARIOUS PARTS OFA COMPUTER



INPUT UNIT

The input unit is formed by the input devices attached to the computer. An input unit takes the input and converts it into binary form so that it can be understood by the computer. The computer input also consists of data and instructions.

Input devices are used to feed the data to the computer and proposed result can be obtained using the different output devices as explained below.

Communication with the PC is mainly done by using two primary input devices, the keyboard and the mouse.

KEY BOARD:

The keyboard remains the most efficient way to enter text into applications faster.

MOUSE: The Mouse is a pointing device.

SCANNER: It is used to transfer images to your PC, a Scanner copies graphics into bit-images.

PUNCH CARDS

This is a very popular types of input device used in a computer. This is set of instructions and data are typed on cards in the form of holes by a machine known as card punching machine.

MAGNETIC INK CHARACTER READER: These types of input devices are also called the document processor.

TOUCH SCREEN: This is also an input device where the user can enter the data just by touching some sensitive area of the screen.

BAR CODE READER: Bar code readers are special devices used to read bar coded data. Bar code is a specialized code used for fast identification of items. It consists of series of small lines, Known as bars.

TRACK BALL: It is a pointing device. The track ball has a ball, which can be rotated by hand in any direction, the cursor moves accordingly.

JOY STICK

A joystick is also a pointing device. It is used to move the cursor position on a monitor. Its function is similar to that of mouse and is used for playing games.

WEB CAMERA: A Web camera allows a computer to accept input just by focusing on an object.

OUTPUT UNIT: The Output Unit is formed by the output devices attached to the computer. The output coming from the CPU is in the form of electronic binary signals which needs conversion in some form which can be easily understood by human beings.

An output device is used to display, print or read the results of the information processed by the computer. A most convenient and useful method by which the computer can deliver information is by means of printed characters.

Common output devices are

- Printers,
- Monitors
- Speakers
- Plotter

MONITOR (VIDEO DISPLAY UNIT): A monitor is use to display the output from a computer.

PRINTER: A printer is a device that accepts an image output from a computer and transfers the information to paper. This image can be text and/or graphics and can be produced in either color or black and white.

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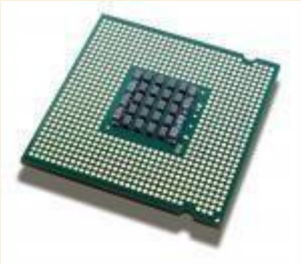
Plotter: Plotters are large-scale printers that are very accurate at reproducing line drawings. They are commonly used for technical drawings such as engineering drawings or architectural blueprints.

CENTRAL PROCESSING UNIT (CPU): The most important electronic component in the PC is the microprocessor,



The CPU processes instructs, performs calculations and manages the flow of information through a computer system. The CPU communicates with input, output and storage devices to perform tasks. It does the actual thinking inside the computer.

The CPU is the control Centre for a computer. It directs and controls the performance. It is the brain of the computer. The CPU has two components which are responsible for different functions. These two components are its Control Unit (CU) and Arithmetic Logic Unit (ALU).

Arithmetic Logic Unit (ALU) performs all the four arithmetical (+, -, *, /) and some logical operations. When two numbers are required to be added, these numbers are sent from memory to ALU where addition takes place and the result is put back in the memory.

Control Unit (CU) controls and guides the interpretation, flow and manipulation of all data and information. The Control Unit sends control signals until the required operations are done properly by ALU and memory. Another important function of Control Unit is the program execution i.e. carrying out all the instructions stored in the program. The CU gets program instructions from memory and executes them one after the other.

The control unit even controls the flow of data from input devices to memory and from memory to output devices.

The processor is also known as the CPU or Central Processing Unit.

MEMORY

Memory is the place where data is stored and the program execution is takes place.

The function of the memory is to store information. It stores program, data, results or any other kind of information.

Three types of memory

- Main memory (Primary memory)

- Secondary memory
- Cache Memory

The Main memory is fast memory. It stores necessary programs along with the data, which are to be executing the user ‘s program. It also stores necessary programs of System software, which are required to execute user ‘s program.

The Secondary (auxiliary) memory stores operating system, data, application programs etc. The secondary memory is a mass storage memory. It is slow but cheap. It is a permanent memory while the main memory (RAM) is volatile (Once power goes whatever data stored on the memory will be vanished) memory. The capacity of main memory is smaller than secondary memory. The cache memory is placed in between the CPU and the main memory. It is very faster than the main memory. It stores the instructions and data which are to be executed immediately.

The primary memory can be classified again into two main groups, such as:

(1) ROM

(2) RAM

ROM – (Read Only Memory)

ROM stands for Read only memory. ROM memory is used only to read the existing data & information stored by the manufacture. When we switch on the computer, ROM does some tasks automatically before going to the operating system. The main task is to check all the hardware connected to the computer and whether it is properly powered (POST (Power on self-test)).

ROM is a non-volatile memory. There are different types of ROM are available

PROM: PROM stands for programmable read only memory, where data can be stored occasionally.

EPROM stands for _Erasable programmable Read only memory ‘, In EPROM the data stored already can be erased and the new programs can be stored using some technology.

RAM:

RAM stands for random access memory and it is used to store programs & data currently being executed. RAM is a volatile memory
i.e. when the power goes whatever data stored on this memory will be erased.

STORAGE DEVICE

It is used to place information on storage media. Popular examples of storage devices include a

- Hard drive,

- Floppy drive,
- Tape drive
- Zip Drive and DVD-ROM drive.
- Pen Drive

Hard Disk

CD ROM Drive

Pen Drive or USB Drive

FLOPPY DISK: The Diskette enables you to save what you are working on. The diskette is inserted in the CPU in the smallest slot

MAGNETIC DISK (Hard disk): A magnetic disk is a disk on which you can store computer data. The term *hard* is used to distinguish it from a soft, or floppy, disk. Hard disks hold more data and are faster than floppy disks

WORKING OF A COMPUTER: A computer program, which consists of both instructions & data will be fed into the computer through the input unit & stored in the memory. In order to execute it, the instructions have to be fetched from memory one by one. Control unit does the fetching of instruction & decodes it. According to the instruction the control unit issues control signals to other units. After an instruction is executed, the result is stored in the memory or stored temporarily in the control unit/ ALU, so that this can be used by next instruction. The result of a program is taken out through the output unit such as monitor, printer, speaker etc.

ALU contains necessary electronic circuits to perform arithmetic operations (add, subtract, multiply, divide, etc.) & logical operations.

UNIT: ELECTRONIC CIRCUITS

Semiconductor physics

- N type P type PN junction
- Applying voltage across PN junction
- Characteristics of PN junction diode
- Rectifiers
- Introduction
- Half wave rectifier
- Center tap rectifier
- Bridge rectifier
- Regulated power supplies

Transistors & Amplifier

- Introduction
- Junction transistor structure
- Working principle of transistor
- Transistor amplifying action
- Classification of amplifiers

Semiconductor physics: Conduction in given material occurs when a voltage of suitable magnitude is applied to it, which causes the charge carries within the material to move in a desired direction. This may be due to electron motion or hole transfer or both.

Electron motion: Free electrons in the conduction band are moved under the influence of the applied electric field. Since electrons have negative charge they are repelled by the negative terminal of the applied voltage and attracted towards the positive terminal.

Hole Transfer: Hole transfer involves the movement of holes. Holes may be thought of positive charged particles and as such they move through an electric field in a direction opposite to that of electrons.

In a good conductor or metal the current flow is due to free electrons only. In a semiconductor the current flow is due to both holes and electrons moving in opposite direction.

Classification of semiconductors are classified into two types

1) Intrinsic semiconductors
2) Extrinsic semiconductors

Intrinsic semiconductors

A semiconductor in an extremely pure form is called intrinsic semiconductors.

Example: silicon and germanium

- Both silicon and germanium are tetravalent atoms (four valence electrons)
- Each atom forms a covalent bond or electron pair bond with the electrons of neighboring atom.

At room temperature, some of the valence electrons gain enough thermal energy to break up the covalent bonds. This breaking up of covalent bonds sets the electrons free and is available for conduction. Hence an electron escapes from a covalent bond and becomes free electron a vacancy is created in a covalent bond. Such a vacancy is called hole. It carries positive charge and moves under the influence of an electric field in the direction of the electric field applied.

Number of holes is equal to the number of electrons since; a hole is nothing but an absence of electron.

Extrinsic semiconductor:

When an impurity is added to an intrinsic semiconductor, its conductivity changes.

Doping

- The process of adding impurity to a pure semiconductor is called Doping.
- The doped semiconductor is called extrinsic semiconductor.

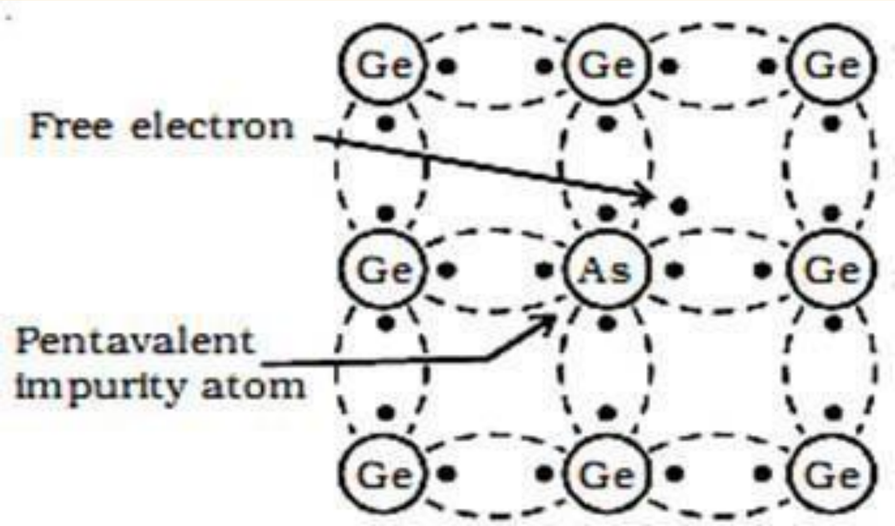
Depending on the type of impurity added, extrinsic semiconductors are further classified as

1) N-type semiconductor
2) P-type Semiconductor N type semiconductor

When a small amount of pentavalent impurity is added to a pure semiconductor it is called as n-type semiconductor.

Examples of pentavalent impurities are Antimony, Arsenic, phosphorus, etc.

Addition of pentavalent impurity provides a large number of free electrons in a semiconductor crystal. Such impurities which produce n type semiconductors are known as donor impurities. They provide or donate free electrons to the semiconductor crystal.



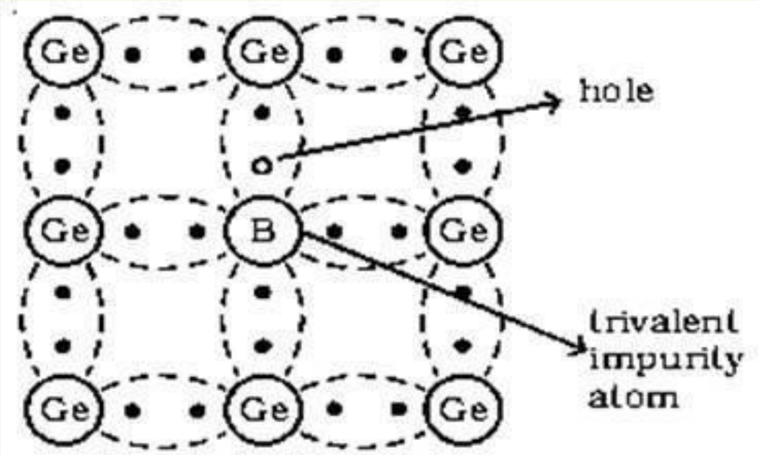
Due to thermal energy electron hole pairs are generated but the number of free electrons are very large in number compared to holes. So in n type semiconductors electrons are the majority carriers and holes are the minority carriers. Since the current conduction is predominantly by free electrons (negative charges) it is called an n type semiconductor.

P type Semiconductor

When a small amount of trivalent impurity is added to a pure semiconductor it is called as p-type semiconductor.

Examples of trivalent impurities are gallium, Indium, Boron, etc.

The addition of trivalent impurity provides a large number of holes in a semiconductor crystal. Such impurities which produce p type semiconductors are known as acceptor impurities because the hole created can accept the electrons in the semiconductor crystal.

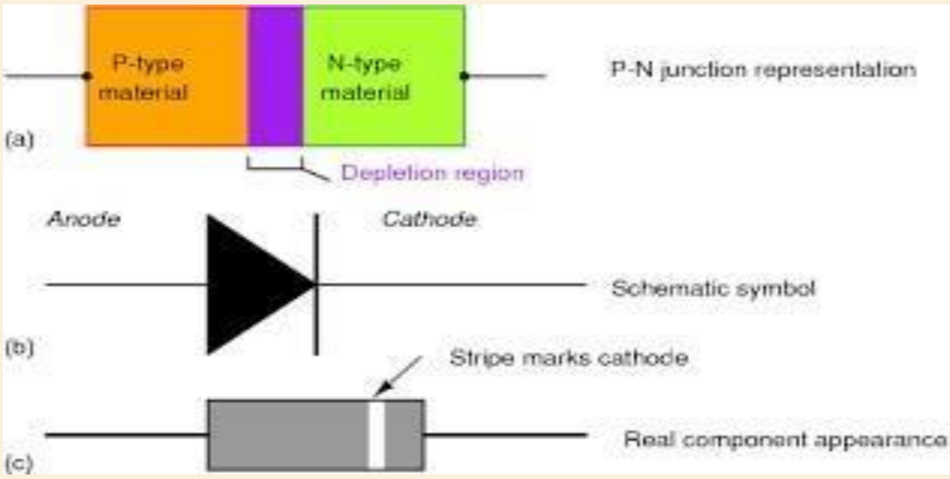


Due to thermal energy electron hole pairs are generated but the number of holes are very large in number compared to free electrons. So in p type semiconductors holes are the majority carriers and electrons are the minority carriers. Since the current conduction is predominantly by holes (positive charges) it is called a p type semiconductor

N type P type PN junction

Semiconductor diode

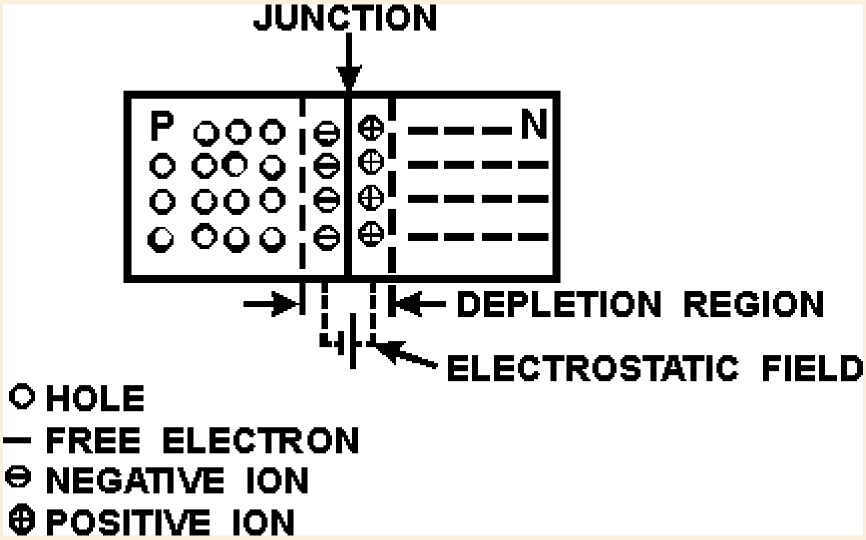
When a p type semiconductor material is suitably joined to n type semiconductor the contact surface is called a p-n junction. The p-n junction is also called as semiconductor diode.



The process involved in the formation of PN junction is as follows

1) Holes from P–side diffuse into N-side where they combine with free electrons.
2) Free electrons from N–side diffuse into P-side where they combine with holes
3) The diffusion current decays exponentially both with time and distance from the junction.
4) A thin depletion layer is set up on both sides of the junction due to the recombination of holes and electrons and is so called because it is depleted of charge carriers.
5) The width of the depletion layer depends on the doping level

6) A junction or barrier potential is developed across the junction whose value is about 0.3 V for Ge and 0.7 V for Si.



Applying voltage across PN junction

Biasing

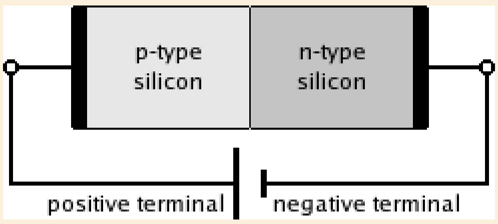
Connecting a p-n junction to an external dc voltage source is called Biasing

The biasing is mainly divided into two

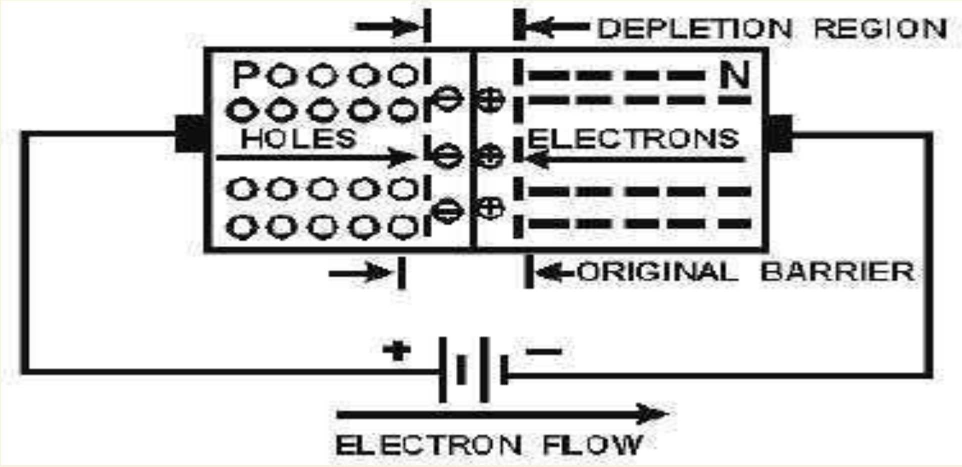
1) Forward Biasing
2) Reverse Biasing

Forward biasing

When positive terminal of the battery is connected to P type and negative terminal of battery is connected to n-type it is called forward biasing.



The forward biasing cancels the potential barrier and current flows in forward biasing



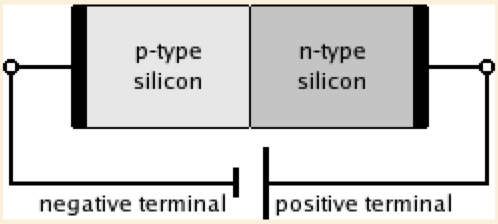
The applied forward potential establishes the electric field which acts against the field due to potential barrier. Therefore, the resultant field is weakened and the barrier height is reduced at the junction.

Since the potential barrier voltage is very small, small forward voltage is sufficient to completely eliminate the barrier. Once the potential barrier is eliminated by the forward voltage, junction resistance become almost zero and a low resistance path is established for the entire circuit. Therefore, current flows in the circuit and is called forward current.

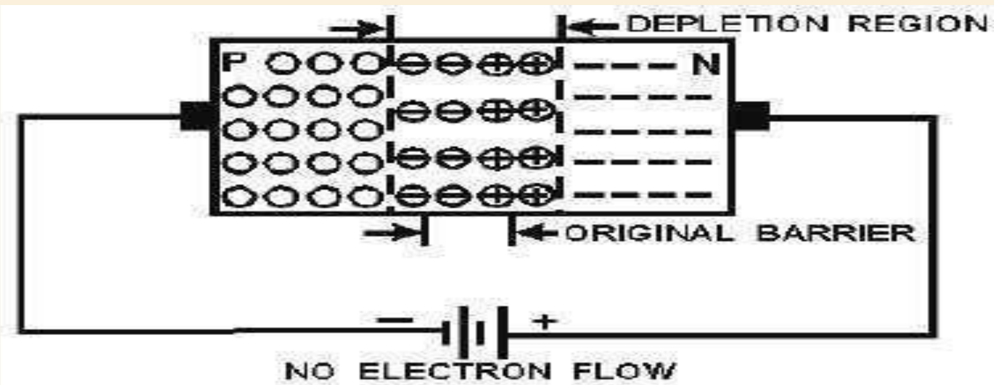
Reverse biasing

When negative terminal of the battery is connected to P type and positive terminal of battery is connected to n-type it is called reverse biasing.

The reverse biasing increases the potential barrier and current does not flow.



The reverse biasing increases the potential barrier and current does not flow.



The applied reverse potential establishes the electric field which acts in the same direction as the applied field due to potential barrier. Therefore, the resultant field at the junction is strengthened and the barrier height is increased at the junction.

The increased potential barrier prevents the flow of charge carriers across the junction. Thus a high resistance path is established for the entire circuit. And hence current does not flow.

Characteristics of PN junction diode

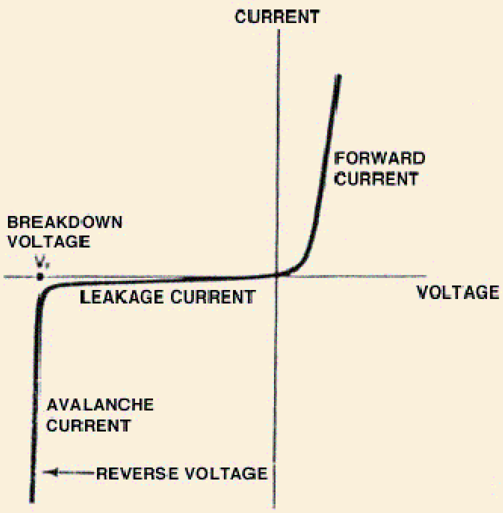
A PN junction diode is one-way device offering low resistance when forward biased and behaving almost as an insulator when reverse biased.
Application: Switch, rectifier.

Forward Characteristics

When the diode is forward biased and the applied voltage is increased from zero, hardly any current flows through the device in the beginning. It is so the external voltage is opposed by the internal barrier voltage whose value is 0.3 V for Ge and 0.7 V for Si. As soon as forward voltage is neutralized current through the diode is increases rapidly with increase in applied battery voltage.

Reverse Characteristic

When the diode is reverse biased majority carriers are blocked and only a small current (due to minority carriers) flows through the diode. As the reverse voltage is increased from zero, the reverse current (leakage current) very quickly reaches its maximum or saturation. When reverse voltage exceeds a certain value called break down voltage, the leakage current suddenly and sharply increases.



V-I characteristics of a real diode

Rectifiers

Introduction

In our day to day electrical applications we prefer to use dc than ac. Generation of dc with large power is not economical. And conversion of dc to ac is also a difficult process. But we can generate ac with large power and it's conversion to dc is convenient too. This process is called as rectification

Rectifiers are the circuits which converts AC to DC. Rectifiers are mainly classified into

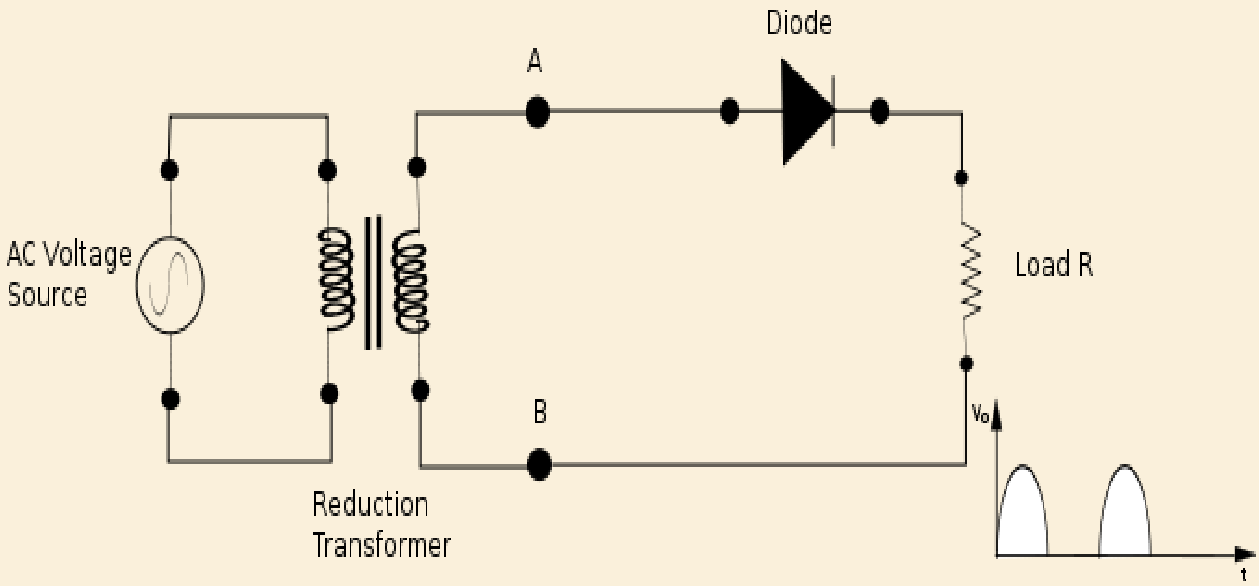
1) Half wave Rectifier
2) Full Wave rectifier
    a) Centre tapped Rectifier

b) Bridge rectifier

Half Wave rectifier:

The basic half wave rectifier is shown in figure along with input and output wave forms

Circuit Diagram



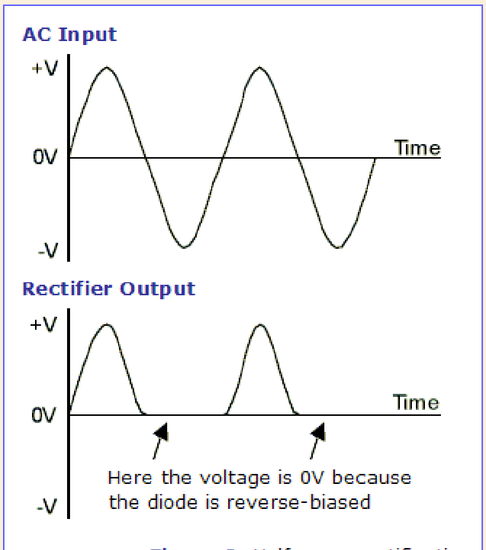


Figure 2: Half-wave rectification

Figure: Wave forms

The circuit diagram and wave forms of half wave rectifier are shown in figure. The transformer is employed in order to step down the supply voltage and also to provide isolation from the supply. The diode is used to rectify the ac signal; the pulsating dc is taken across the load resistor.

Working

During the positive half cycle of the input ac voltage the diode is forward biased (ON) and conducts. The current flows through the load resistance and a voltage is developed across it.

During the negative half cycle of the input ac voltage the diode is reverse biased (OFF) and does not conduct. There is no current flow through the load resistance and the output voltage is zero.

Center tap rectifier

This is called a Centre tap full wave rectifier as it produces an output pulse for each half cycle of the input sine wave.

The circuit diagram is shown in figure. It employs two diodes and a Centre tap transformer. The ac signal to be rectified is applied to the primary of the transformer and the DC output is taken across the load RL

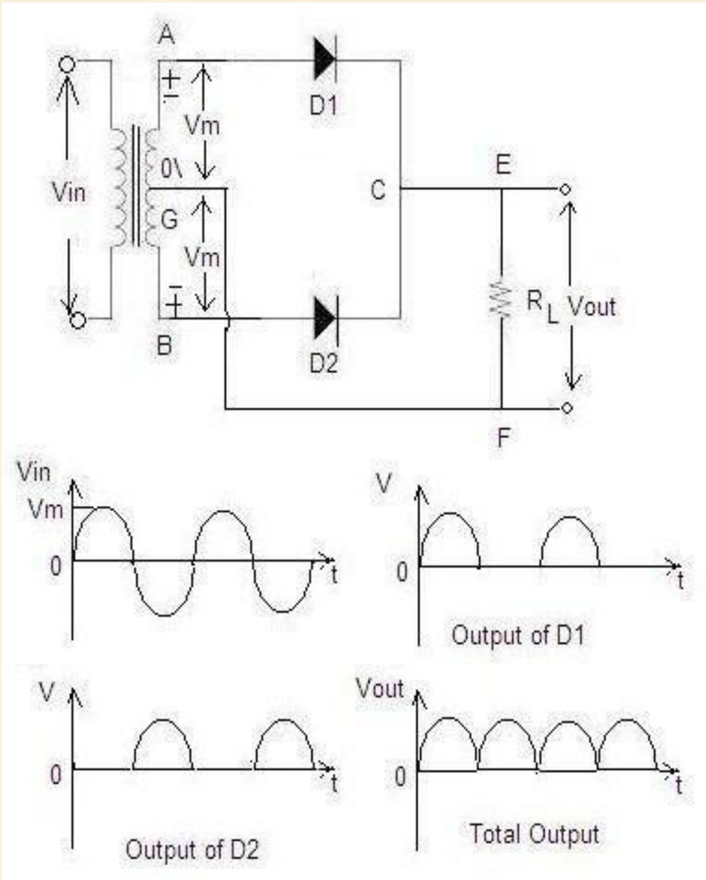


Fig. Circuit diagram and waveforms

Working

During the positive half cycle of the input signal the point A is Positive and B is negative this makes diode D1forward biased and thus a current flow through the load resistor RL and a voltage is developed across it. Diode D2 is reverse biased and it will not conduct and the current through it is zero.

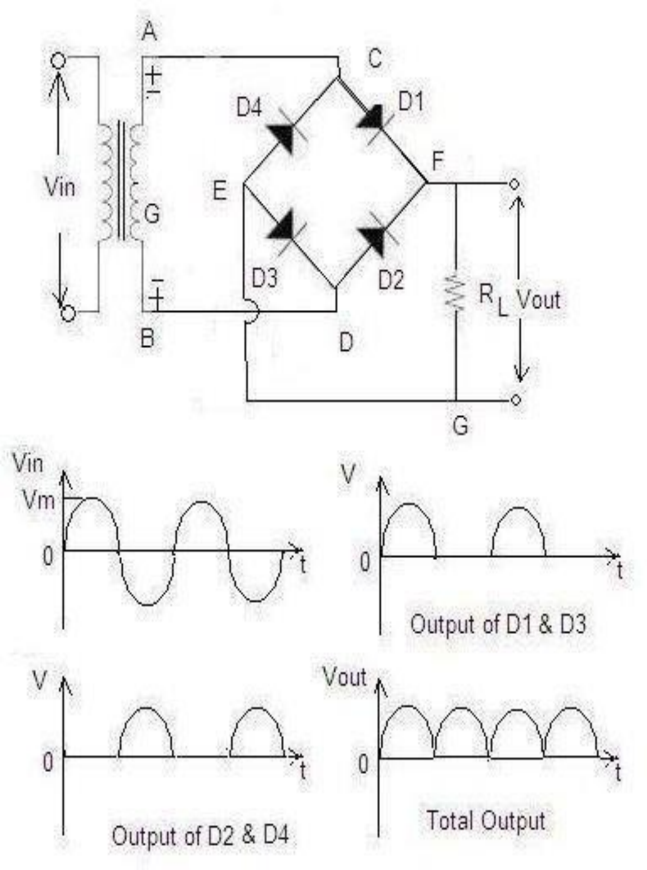
During the negative half cycle of the input signal the point A is negative and B is positive this makes diode D2forward biased and thus a current flow through the load resistor RL and a voltage is developed across it. Diode D1 is reverse biased and it will not conduct and the current through it is zero.

Bridge Rectifier

The circuit diagram and waveforms of a bridge rectifier is shown in figure. It is a full wave rectifier as it produces an output pulse for each half cycle of the input sine wave. It uses four diodes and a transformer.

Working

During the positive half cycle of the input waveforms end A is positive and end B is negative thus diodes D1 and D3 are forward biased and diode D2 and D4 are reverse biased. A current flow through diode D1 and D3 (C to D) and a voltage is developed across the load resistance RL.



During the Negative half cycle of the input waveforms end A is negative and end B is positive thus diodes D2 and D4 are forward biased and diode D1 and D3 are reverse biased. A current flow through diode D2 and D4 (D to C) and a voltage is developed across the load resistance RL

Advantages

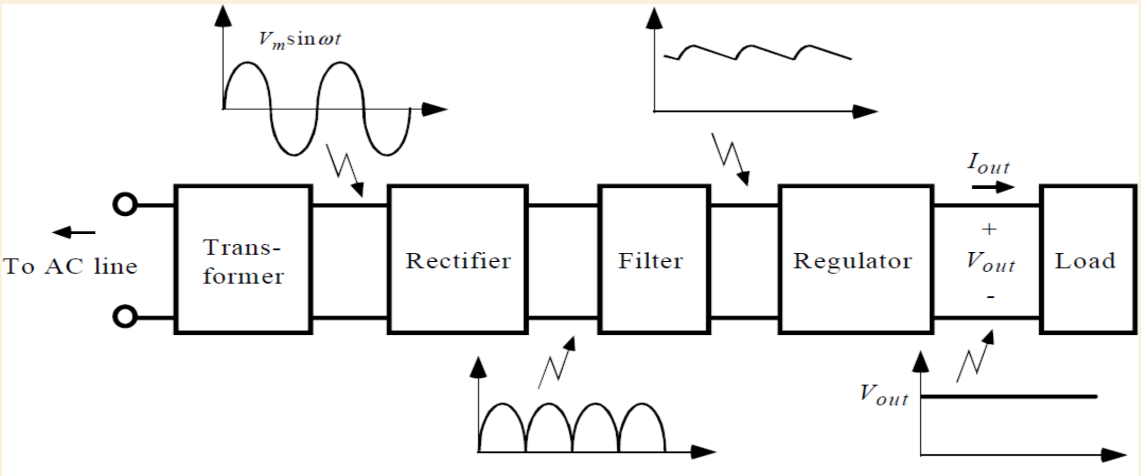
- The need for Centre tap transformer is eliminated
- The output is twice when compared to Centre tap rectifier.
- Can be used where large amount of power is required.

Disadvantages

- It requires four diodes
- The use of two extra diodes causes an additional voltage drop there by reducing the output voltage.

Regulated power supplies

It is a power supply whose terminal voltage remains almost constant regardless of the amount of current drawn from it, limited to the rated current .



Components of a typical linear power supply

A typical DC power supply consists of four stages as shown in figure.

1. TRANSFORMER

It is used to step up or step down the ac supply voltage to suit the requirement of the solid state electronic devices and circuits fed by the dc power supply. It also

provides isolation from the supply line-a n important safety consideration

2. RECTIFIER

It is a circuit which employs one or more diodes to convert AC voltages into pulsating DC voltages

3. FILTER

The function of the circuit element is to remove the fluctuations (ripples) present in the output voltage supplied by the rectifier.

4. VOLTAGE REGULATOR

Its main function is to keep the terminal voltage of the DC supply constant even when AC input to the transformer varies or the load varies.

UNIT: TRANSISTORS & AMPLIFIER

Introduction

A transistor is a semiconductor device used to amplify and switch electronic signals and electrical power. Transistors are active components and are the fundamental building block of modern electronic devices. It is composed of semiconductor material with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals changes the current through another pair of terminals. Because the controlled (output) power can be higher than the controlling (input) power, a transistor can amplify a signal.

Junction transistor structure

A junction transistor consists of two back to back P-N junctions manufactured in a single piece of semiconductor crystal. These two junctions give rise to three regions called emitter, base and collector. The junction between emitter and base is called base emitter junction while the junction between the collector and base is called collector base junction.

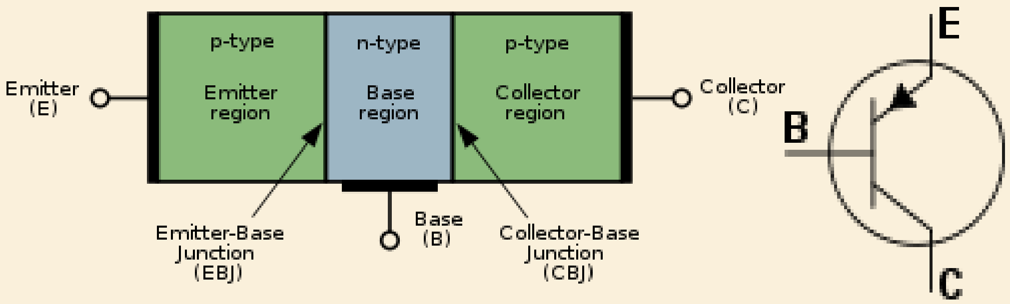
A transistor is a sandwich of one type of semiconductor material between two layers of the other type as shown in figure. The most common type of transistor is called bipolar

1) PNP transistor

2) NPN transistor

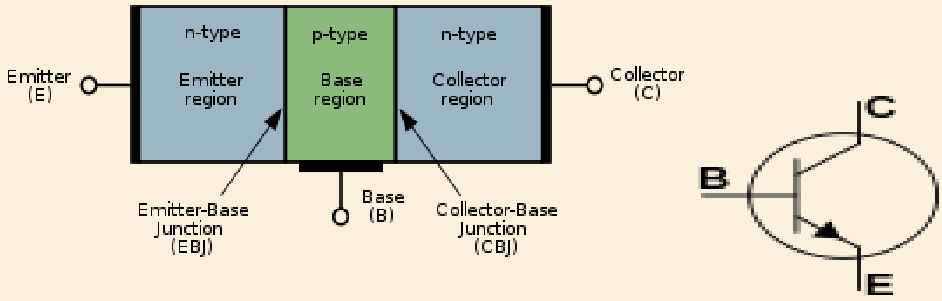
PNP transistor

A layer of N type material sandwiched between two layers of P type material



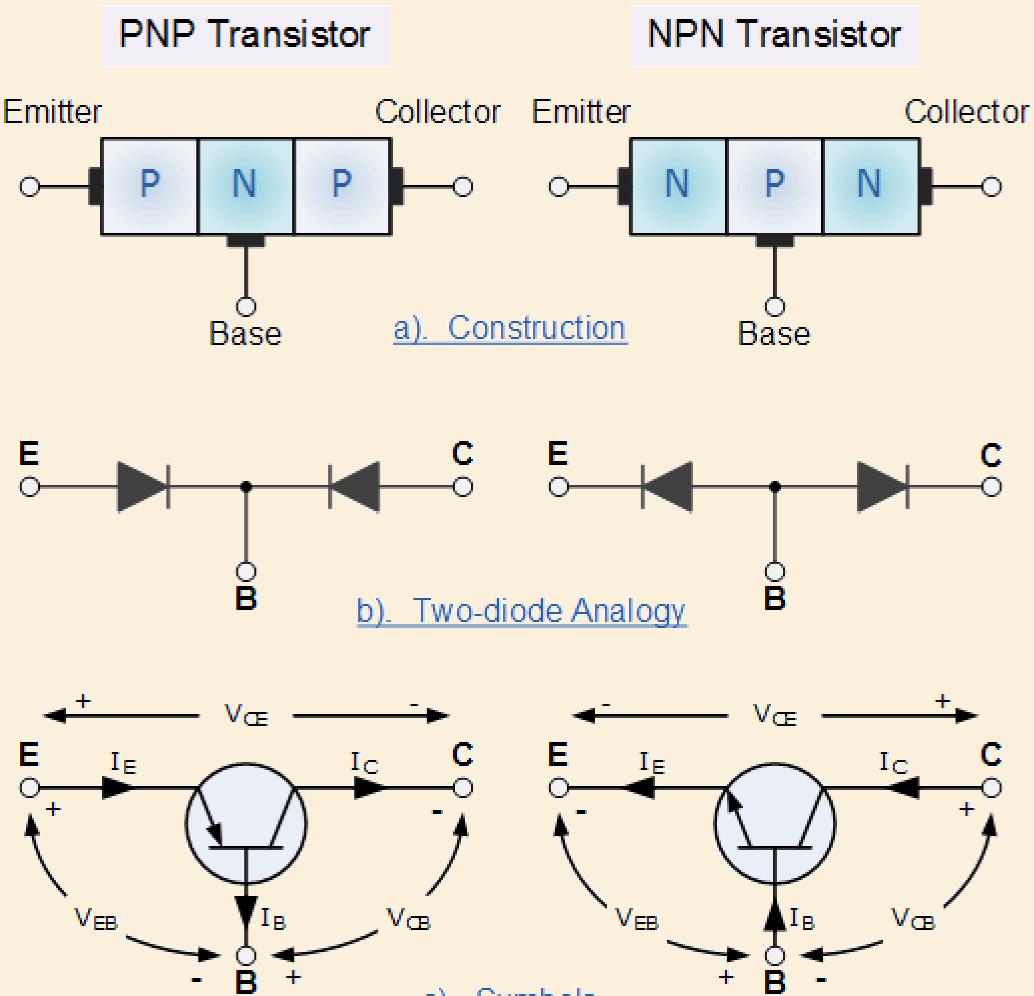
NPN transistor

A layer of P type material sandwiched between two layers of N type material



The base is thin and lightly doped, the emitter is heavily doped and it is wider when compared to base, the width of collector is more when compared to base and emitter and is moderately doped.

In order to distinguish between emitter and collector an arrow is included in the emitter.



a). Construction

b). Two-diode Analogy

c). Symbols

Bipolar Transistor Configurations:

As the **Bipolar Transistor** is a three terminal device, there are basically three possible ways to connect it within an electronic circuit with one terminal being common to both the input and output. Each method of connection responding differently to its input signal within a circuit as the static characteristics of the transistor varies with each circuit arrangement.

- 1. Common Base Configuration
- 2. Common Emitter Configuration
- 3. Common Collector Configuration

Then bipolar transistors have the ability to operate within three different regions:

1) Active region
2) Saturation Region
3) Cut off region

Active Region: The transistor operates as an amplifier. Emitter base junction is forward biased and collector base junction is reverse biased

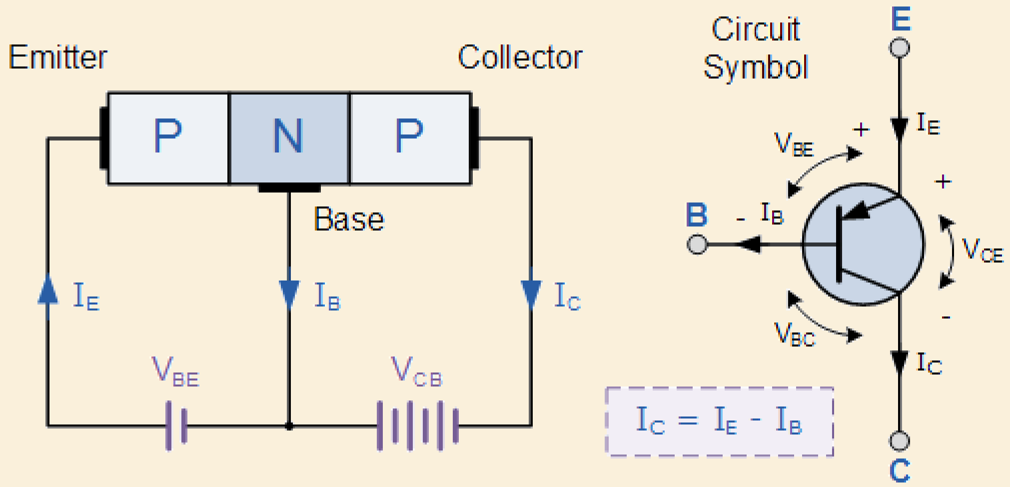
Saturation: The transistor is ―fully-ON‖ operating as a switch. Both emitter base and collector base junction is forward biased

Cut-off: The transistor is ―fully-OFF‖ operating as a switch. Both emitter base and collector base junction is reverse biased

Working principle of transistor

A small current into the base controls a large current flow from the collector to the emitter. The current at the base is typically one hundredth of the collector-emitter current. Moreover, the large current flow is almost independent of the voltage across the transistor from collector to emitter. This makes it possible to obtain a large amplification of voltage by taking the output voltage from a resistor in series with the collector.

PNP transistor:



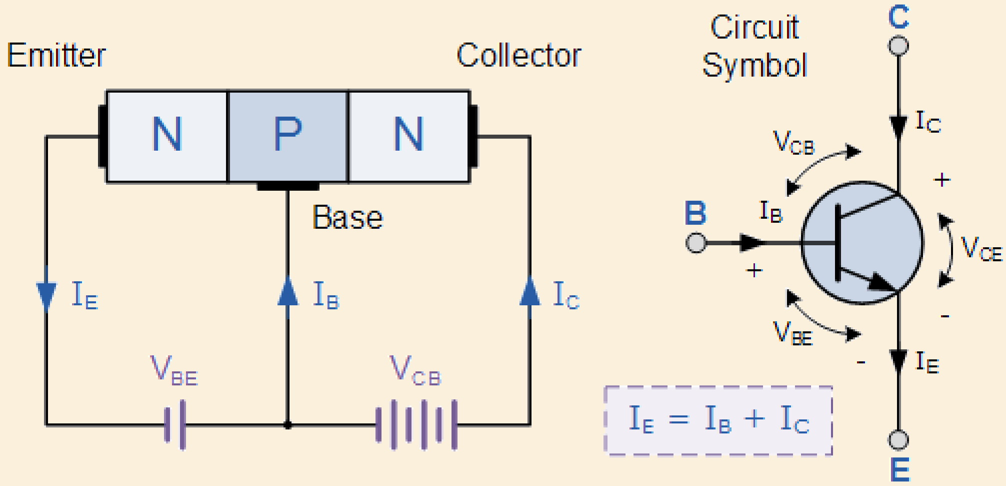
Consider a PNP transistor operated in active region as shown in figure. Since the emitter base junction is forward biased large number of holes present in the emitter as majority carriers are repelled by the positive potential of the supply voltage and they move towards the base region causing emitter current IE.

Since the base is thin and lightly doped very few of the holes coming from the emitter recombine with the electrons causing base current IB and all the remaining holes move towards the collector. Since the collector base junction is reverse biased all the holes are immediately attracted by the negative potential of the supply. There by giving collector current IE.

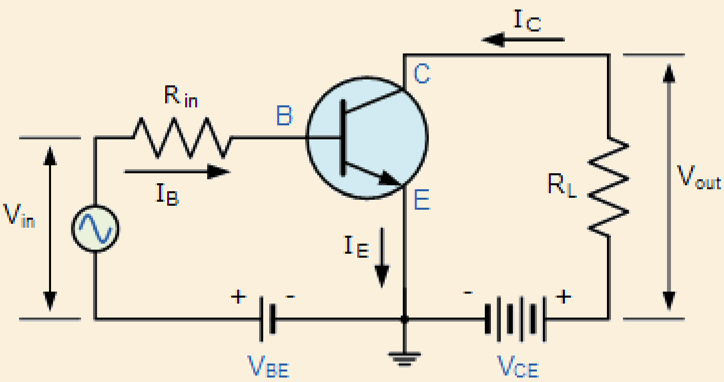
Thus we see that

$$\mathbf{I_E = I_B + I_C}$$

NPN Transistor:



<u>Transistor as an amplifier</u>



Consider a NPN transistor in CE configuration as shown above along with its input characteristics. A transistor raises the strength of a weak input signal and thus acts as an amplifier. The weak signal to be amplified is applied between emitter and base and the output is taken across the load resistor RL connected in the circuit.

In order to use a transistor as an amplifier it should operate in active region. Therefore, in addition to the AC input voltage two DC voltages are applied as shown in the figure. This DC voltage is called bias voltage.

As the input circuit has low resistance, a small change in the signal voltage causes a large change in the base current thereby causing the same change in collector current.

The collector current flowing through a high load resistance RL produces a large voltage across it. Thus a weak signal applied at the input circuit appears in the amplified form at the output. In this way transistor acts as an amplifier.

CLASSIFICATION OF AMPLIFIERS

An amplifier is a circuit meant to amplify a signal with a minimum distortion, so as to make it so useful. An amplifier can be classified into different types based on the following parameters

1) Active devices used
2) Frequency range of operation
3) Coupling scheme used
4) Ultimate purpose of the circuit
5) Conditions of bias and magnitude of signal.

Based on the frequency range of operation the amplifier may be classified as

1) DC amplifiers
2) Audio amplifiers
3) Video amplifiers
4) RF amplifiers

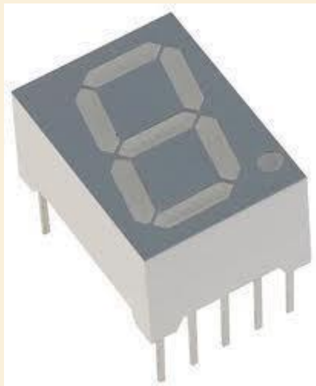
Usually in an amplifier system, a number of stages are used. Based on the coupling used the amplifiers can be classified into

1) Direct coupled amplifiers
2) RC coupled amplifiers
3) Transformer coupled amplifiers
4) LC coupled amplifiers

Depending upon the ultimate purpose of an amplifier, it may be classified as

1) Voltage Amplifier
2) Power amplifier

- LEDs
- Seven segment display
- LCD displays

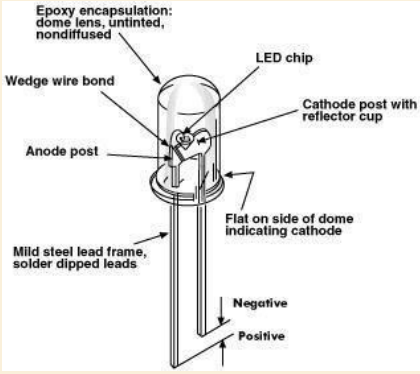


DISPLAY DEVICES

A display device is an output device for presentation of information in visual form. The examples of display devices are LED, seven segment display and LCD.

LED (LIGHT EMITTING DIODES)

These are diodes which emit light when they allow direct current (DC) to pass through them. These are made of gallium arsenide phosphide (GaAs P) and by alternating the proportions of arsenic and phosphorous, different colors can be obtained. LEDs come in different colors like Red, Green, Yellow and Orange. The positive terminal (anode) can be identified by a longer lead and the negative terminal (cathode) can be identified by a smaller lead. LEDs are encapsulated in a transparent casing.



Unlike regular diodes, LEDs have threshold voltage of 1.6V to 2.4V depending on the color of the LED. The current that should be allowed through the diode to emit light of sufficient brightness should lie between 10mA and 30mA. Therefore, while connecting it in a circuit; a resistance is connected in series with the diode to limit the current flow. The resistance can be calculated for the LED to be connected to any supply voltage by using the following relation.

R = (Supply voltage – Drop across LED)/ current flowing through LED

Normally the drop across the LED is taken as 2V. The current flowing through the LED can be about 10mA.

LEDs are used as indicators in instruments, digital clock etc.

SEVEN SEGMENT DISPLAY:

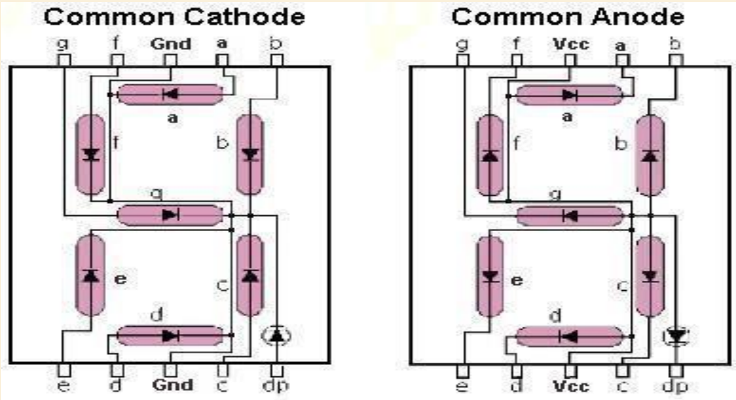
In this the number to be shown is split into seven segments (lines) A to G (Fig 6.2). If a number 8 is to be shown, all these will be brightly lit. If a number 0 is to be shown, all except G will be lit. If a number 4 is to be shown, F, G, B, C, alone will be lit. Any number 0 to 9 can thus be indicated. A decimal point can also be in gas discharge type of seven segments. The number designed is displayed by approximately switching the required segments.

Light emitting diode displays are very popular. These are seven segment types; each segment can be either made to glow or not by biasing the corresponding diode. A single LED is used for each bar or dot of the segment. To drive an LED seven segment display it is necessary to connect the particular segment with a current limit resistor to a +5v supply. Two types of constructions are available.

1. Common anode type
2. Common cathode type

In the first type, the seven LED diodes have a common joint for their anodes. In second types, the cathode ends of the diodes from the common connection. Current limit- resistors of 100 to 220 ohms may be added in series.

Application of display devices: in digital voltmeter, Calculators, Frequency counters and LED clocks etc.



L C D (LIQUID CRYSTAL DISPLAYS)

The LCD has the distinct advantage of having a low power requirement than the LED. It is typically in the order of microwatts for LED.

A liquid crystal is a material (normally organic for LCDs) that will flow like a liquid but whose molecular structure has some properties normally associated with solids. For the light scattering unit, the greatest interest is in the pneumatic liquid crystal, having the crystal structure. The indium oxide conducting surface is transparent and under the condition shown in the Fig. the incident-light will simply pass through and liquid crystal structure will appear clear. If a voltage (6-20 V) is applied across the conducting surface, the molecular arrangement is disturbed, with the result the regions will be established with different indices of refraction. The incident light is therefore, reflected in different directions at the interface between regions of different indices of refraction with the result that the scattered light has a frosted glass appearance.

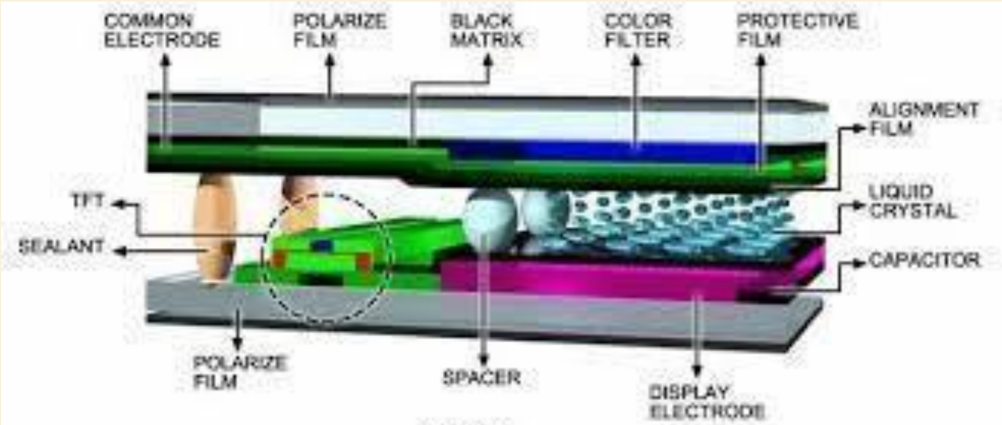


Figure A

UNIT: DIGITAL ELECTRONICS

- Introduction
- Types of numbering systems
- Conversion from decimal number system to binary number system and vice versa.
- Logic gates: OR, AND & NOT
- Operation of Logic gates with the help of CKT diagram and truth table

INTRODUCTION: The study of number systems is useful to the student of computing due to the fact that number systems other than the familiar decimal (Base 10) number system are used in the computer field. There are four systems of arithmetic which are often used in digital circuits. These systems are decimal, binary, octal and hexadecimal. Decimal systems are used to represent quantities which are outside the digital system. Binary system is extensively used by digital systems like digital computers which operate on binary information. Octal system has certain advantages in digital work because it requires less circuitry to get information into and out of a digital system. Moreover, it is easier to read record and print out octal numbers than binary numbers. Hexadecimal number system is particularly suited for microcomputers.

TYPES OF NUMBERING SYSTEMS

DECIMAL NUMBER SYSTEM

The decimal number system that we are all familiar with is a positional number system. The actual number of symbols used in a positional number system depends on its base (also called the radix). The highest numerical symbol always has a value of one less than the base. The decimal number system has a base of 10, so the numeral with the highest value is 9; the octal number system has a base of 8, so the numeral with the highest value is 7, the binary number system has a base of 2, so the numeral with the highest value is 1, etc.

Any number can be represented by arranging symbols in specific positions. You know that in the decimal number system, the successive positions to the left of the decimal point represent units (ones), tens, hundreds, thousands, etc. Put another way, each position represents a specific power of base 10. For example, the decimal number 1,275 (written $1,275_{10}$) can be expanded as follows:

$(1\ 2\ 7\ 5)_{10}$

$5 \times 10^0 = 5 \times 1 = \quad 5$

$7 \times 10^1 = 7 \times 10 = \quad 70$

$2 \times 10^2 = 2 \times 100 = \quad 200$

$1 \times 10^3 = 1 \times 1000 = \quad 1000 \quad = 1275_{10}$

For fractional numbers the weights are negative powers of ten that decrease from left to right beginning with 10^{-1}

$10^2\ 10^1\ 10^0.\ 10^{-1}\ 10^{-2}\ 10^{-3}$…………

The position of each digit in a decimal number indicates the magnitude of the quantity represented and can be assigned a weight.

BINARY NUMBER SYSTEM

The same principles of positional number systems we applied to the decimal number system can be applied to the binary number system. However, the base of the binary number system is two, so each position of the binary number represents a successive power of two. From right to left, the successive positions of the binary number are weighted 1, 2, 4, 8, 16, 32, 64, etc. A list of the first several powers of 2 follows:

$2^0 = 1$ $2^1 = 2$ $2^2 = 4$ $2^3 = 8$ $2^4 = 16$ $2^5 = 32$

$2^6 = 64$ $2^7 = 128$ $2^8 = 256$ $2^9 = 512$ $2^{10} = 1024$ $2^{11} = 2048$

DECIMAL	BINARY
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	1010
11	1011
12	1100
13	1101
14	1110
15	1111

OCTAL NUMBER SYSTEM

The same principles of positional number systems we applied to the decimal and binary number systems can be applied to the octal number system. However, the base of the octal number system is eight, so each position of the octal number represents a successive power of eight. From right to left, the successive positions of the octal number are weighted 1, 8, 64, 512, etc. A list of the first several powers of 8 follows:

$8^0 = 1$ $8^1 = 8$ $8^2 = 64$ $8^3 = 512$ $8^4 = 4096$ $8^5 = 32768$

DECIMAL	OCTAL
0	0
1	1
2	2
3	3

4	4
5	5
6	6
7	7
8	10
9	11
10	12
11	13
12	14
13	15
14	16
15	17

.THE HEXADECIMAL NUMBER SYSTEM

The hexadecimal (base 16) number system is a positional number system as are the decimal number system and the binary number system. Recall that in any positional number system, regardless of the base, the highest numerical symbol always has a value of one less than the base. Furthermore, one and only one symbol must ever be used to represent a value in any position of the number. For number systems with a base of 10 or less, a combination of Arabic numerals can be used to represent any value in that number system. The decimal number system uses the Arabic numerals 0 through 9; the binary number system uses the Arabic numerals 0 and 1; the octal number system uses the Arabic numerals 0 through 7; and any other number system with a base less than 10 would use the Arabic numerals from 0 to one less than the base of that number system.

However, if the base of the number system is greater than 10, more than 10 symbols are needed to represent all of the possible positional values in that number system. The hexadecimal number system uses not only the Arabic numerals 0 through 9, but also uses the letters A, B, C, D, E, and F to represent the equivalent of10_{10} through 15_{10}, respectively.

DECIMAL	HEXADECIMAL
0	0
1	1
2	2
3	3
4	4
5	5
6	6

7	7
8	8
9	9
10	A
11	B
12	C
13	D
14	E
15	F

CONVERSION FROM DECIMAL NUMBER SYSTEM TO BINARY AND VICE VERSA

1. Converting a Binary Number to a Decimal Number

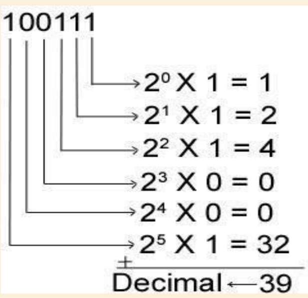
Step1. Write the binary number i.e., all its bits in a row

Step2. Directly under the bits, write 1, 2, 4, 8, 16, 32 starting from right to left

Step3. Cross out the decimal weights which lie under 0 bits Step4. Add the remaining weights to get the decimal equivalent

To determine the value of a binary number (1001_2, for example), we can expand the number using the positional weights as follows:

a)



$(100111)_2 = (39)_{10}$

b) $(1001)_2$ =

$1 \times 2^0 = 1 \times 1 = 1$

$0 \times 2^1 = 0 \times 2 = 0$

$0 \times 2^2 = 0 \times 4 =$ 0

$1 \times 2 = 1 \times 8 = 8$

$= 1+0+0+8 = (9)_{10}$

c) $(1101010)_2$
=

$0 \times 2^0 = 0 \times 1 = 0$
$1 \times 2^1 = 1 \times 2 = 2$
$0 \times 2^2 = 0 \times 4 = 0$
$1 \times 2^3 = 1 \times 8 = 8$
$0 \times 2^4 = 0 \times 16 = 0$
$1 \times 2^5 = 1 \times 32 = 32$
$1 \times 2^6 = 1 \times 64 = 64$
$= 2+8+32+64 = (106)_{10}$

$(1101010)_2 = (106)_{10}$

Convert the binary numbers into decimal numbers

1. $11 = 1*2^1 + 1*2^0$

   $= 2 + 1$

   $= 3$

2. 101

   $= 1*2^2 + 0*2^1 + 1*2^0$
   $= 4 + 1$
   $= 5$

3. 1111

   $= 1*2^3 + 1*2^2 + 1*2^1 + 1*2^0$
   $= 8 + 4 + 2 + 1$
   $= 15$

4. 110111011

   $= 1*2^8 + 1*2^7 + 0*2^6 + 1*2^5 + 1*2^4 + 1*2^3 + 0*2^2 + 1*2^1 + 1*2^0$
   $= 256 + 128 + 32 + 16 + 8 + 2 + 1$
   $= 443$

2. Converting a Decimal Number to a Binary Number

To convert a decimal number to its binary equivalent, the remainder method can be used. (This method can be used to convert a decimal number into any other base.) The remainder method involves the following four steps:

(1) Divide the decimal number by the base (in the case of binary, divide by 2).

(2) Indicate the remainder to the right.

(3) Continue dividing into each quotient (and indicating the remainder) until the divide operation produces a zero quotient.

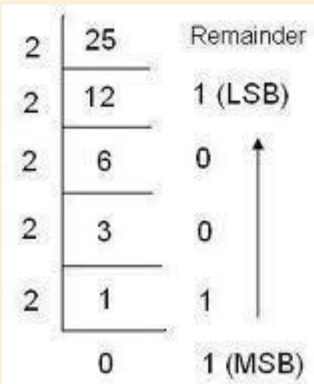
(4) The base 2 number is the numeric remainder reading from the last division to the first (if you start at the bottom, the answer will read from top to bottom).

a) $(99)_{10}$

(In order to convert a decimal number to its binary equivalent, we will repeatedly divide the decimal number by 2, the base of the binary system. Division by 2 will either give a remainder of 1 (dividing an odd number) or no remainder (dividing an even number). Collecting the remainders from our repeated divisions will give us the binary answer.)

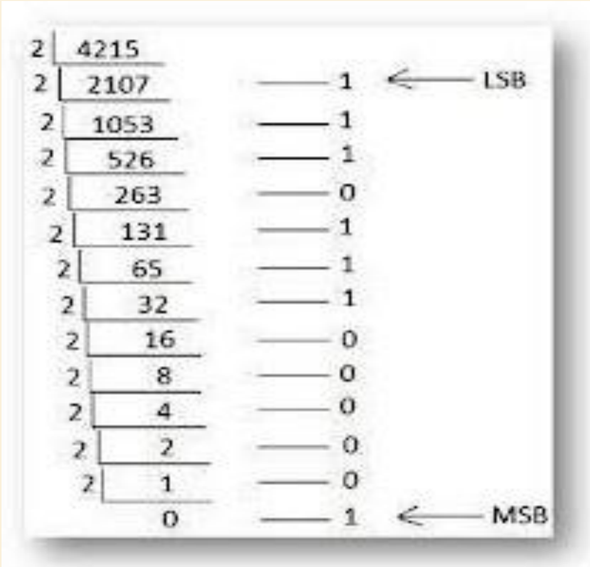
Convert the decimal numbers into binary numbers

a) $(25)_{10}$



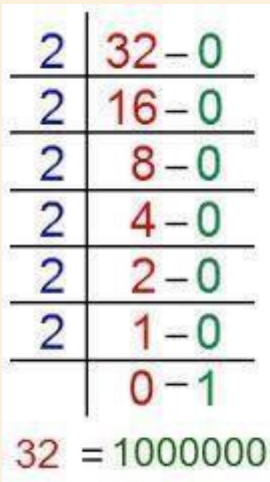
$(25)_{10} = (11001)_2$

b) $(4215)_{10}$



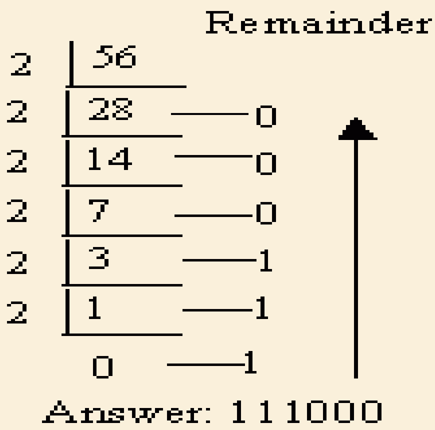
$(4215)_{10} = (1000001110111)_2$

c) $(32)_{10}$



$(32)_{10} = (1000000)_2$

d) $(56)_{10}$



$(56)_{10} = (111000)_2$

LOGIC GATES

Digital Logic Gate is an electronic device that makes logical decisions based on the different combinations of digital signals present on its inputs. A digital logic gate may have more than one input but only has one digital output. Logic gates are used in digital circuits for the purpose of logical decisions. The three basic logic gates are AND, OR, NOT (Inverter).

AND GATE

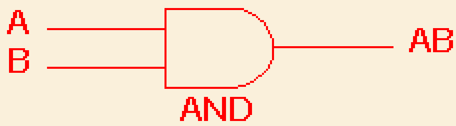
The AND gate performs logical multiplication, more commonly known as the AND function.

The operation of the AND gate is such that the output is HIGH only when all of the inputs are HIGH. When any of the inputs are low, the output is LOW

TRUTH TABLE

A	B	Y=AB

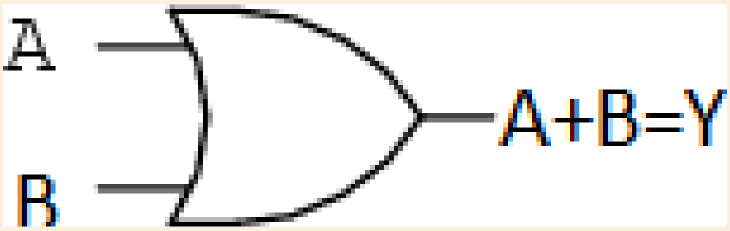
0	0	0
0	1	0
1	0	0
1	1	1



OR GATE

The OR gate performs logical addition, more commonly known as the OR function

The operation of the OR gate is such that a HIGH on the output is produced when any of the inputs are HIGH. The output is LOW only when all the inputs are LOW.



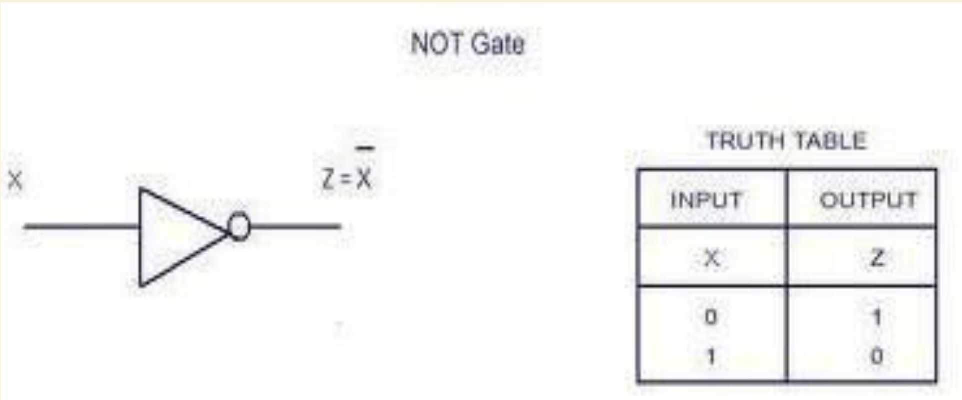
A	B	Y=A+B

0	0	0
0	1	1
1	0	1
1	1	1

NOT GATE

It is also called inverter. It performs a logic function called inversion or complementation.

When a HIGH level is applied to an inverter input, a LOW level will appear on its output. When a LOW level is applied to an inverter input, a HIGH level will appear on its output.



If X = 1

Z = X=

0 If X = 0

Z = X= 1

Operation of Logic gates with the help of CKT diagram and truth table.

Digital gate circuits using Diode

AND gate

Its logic operation is follows

1. When A is at 0V, diode DA conducts and the supply voltage of +5V drops across R. Consequently, point Q is driven to 0V. Therefore, the output Q is 0V.
2. Similarly, when B is at 0V, DB conducts thereby driving Q to ground.
3. Obviously, when both A and B are at 0V, both diodes conduct and, again, the output Q is 0V.
4. There is no supply current and hence no drops across R only when both A and B are at +5V. Only in that case, the output Q goes to supply voltage of +5V

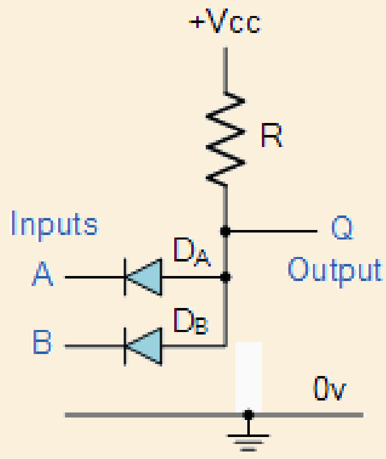


Figure: AND gate using Diodes

A	B	C=AB
0	0	0
0	1	0
1	0	0
1	1	1

TRUTH TABLE

OR gate

The circuit of a two-input OR gate is shown below.

1. When A is at +5V, Diode1 is forward biased and hence conducts. The circuit current flows via R dropping 5V across it. In this way, the output achieves potential of +5V.

2. When +5V is applied to B, Diode2 conducts causing output to go to +5V.

3. When both A and B are +5V, the drop across R is 5V because voltages of A and B are in parallel.

4. Obviously, when there is no voltage either at A or B, output remains zero.

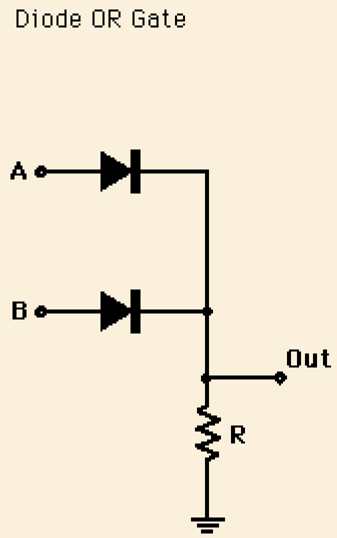
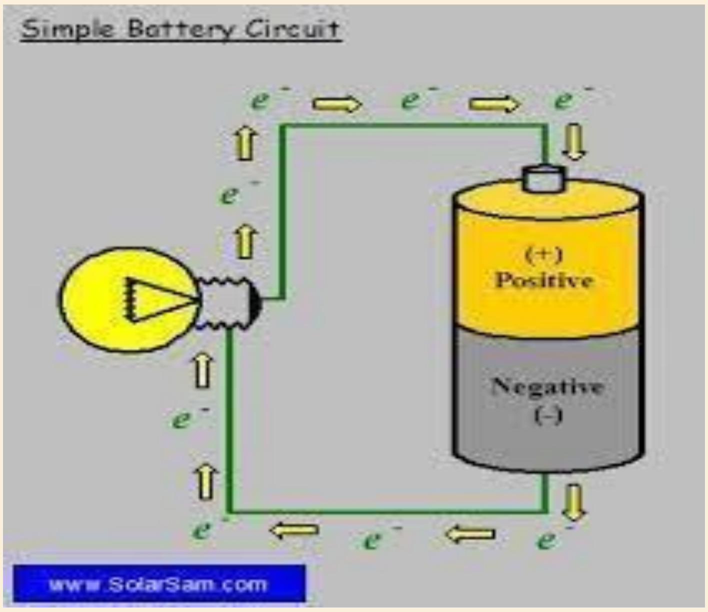


Figure: OR gate using Diodes

A	B	C=A+B
0	0	0
0	1	1
1	0	1
1	1	1

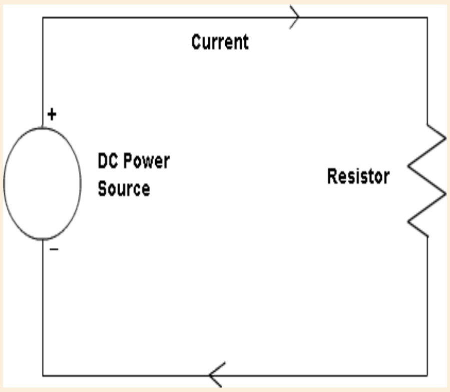
UNIT : DC CIRCUIT

- Introduction: Electromotive Force, Electrical Resistance
- Laws of resistance: Ohm 's law electric current
- Resistance in series & parallel
- Solving related problems
- Kirchhoff's laws
- Solving related problems



Introduction: Electromotive Force,Electrical Resistance

DC stands for direct current, which can refer to either voltage or current in a constant polarity or direction, respectively. A direct current circuit is an electrical circuit that consists of any combination of constant voltage sources, constant current sources and one or more electronic component.



ELECTRIC CURRENT

The electric current is the flow of free electrons OR

The controlled flow of electrons through a substance is called current. It is the rate at which electrons move.

The unit of current is **ampere (A)** or **Coulomb / second1**
amp = 1 coulomb/sec = 6x10^{18} electrons/sec

VOLTAGE (V) or EMF

- Electromotive Force (E or V)

Force which causes electrons to move from one location to another OR the force which drives the flow of free electron is known as emf or potential difference, or voltage

- Unit is volt (V)

RESISTANCE (R)

The opposition to flow of electron is called electrical resistance

Or

The property of the electric circuit which opposes the current Unit – **Ohm (Ω)**

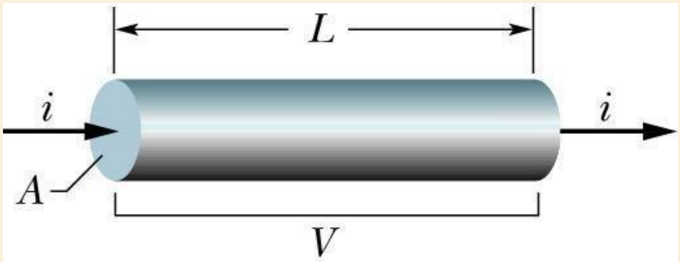
Symbol-

LAWS OF RESISTANCE AND OHM'S LAW

LAWS OF RESISTANCE

The resistance of a conductor is

1) Directly proportional to the length (L)
2) Inversely proportional to Area of cross section(A)
3) Depends on the temperature
4) Depends on the nature of the material R= R = ρL/A



Where

ρ is the SPECIFIC RESISTANCE or RESISTIVITY

It is the resistance between the opposite faces of a meter cube of that material.

Unit of resistivity- Ω-m

CONDUCTANCE (G)

It is the reciprocal of resistance G=1/R

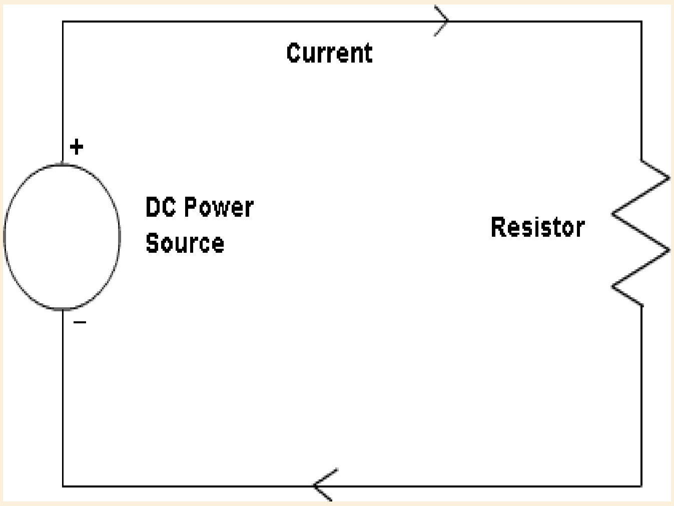
Unit - mho (1/Ω)

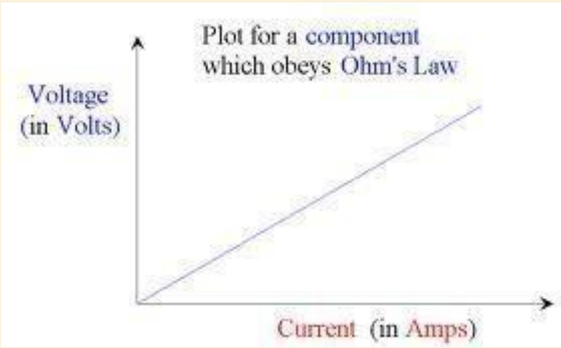
OHM'S LAW

For a fixed metal conductor, the temperature and other conditions remaining constant the current (I) through it is proportional the potential difference (V) between its ends.

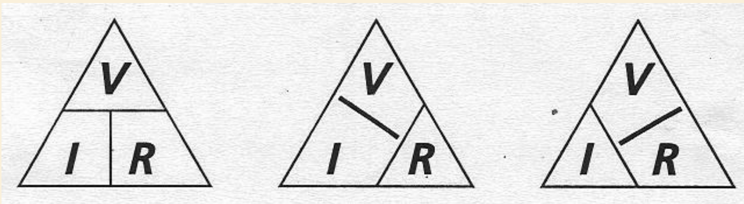
V/I = constant or V/I = R V= IR

I = V/R

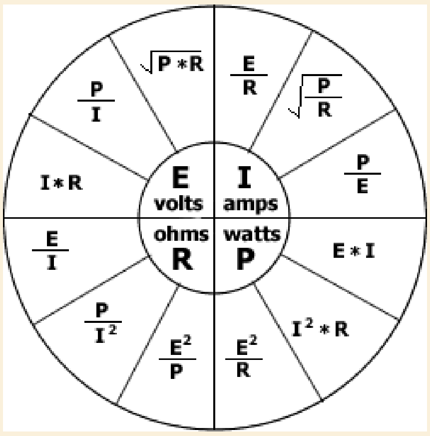




An easy way to remember the relationship of Ohms law is as shown in the three triangles below



POWER = voltage* current   P=VI



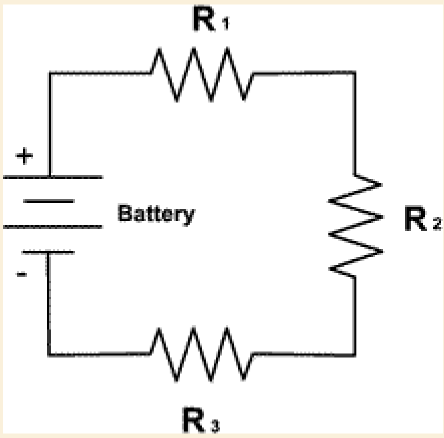
LIMITATIONS OF OHMS LAW

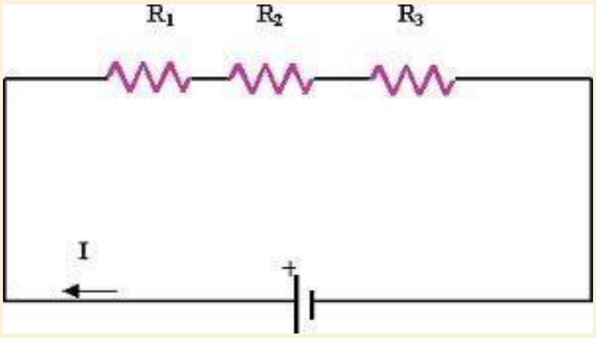
Does not apply under the following conditions

1) Nonlinear resistors
2) Arc lamps
3) Metals which get heated up due to flow of current

RESISTORS IN SERIES AND PARALLEL

RESISTORS IN SERIES





When the resistors are connected end to end they are said to be connected in series. The main characteristics of series c circuit are

1) Same current flows through all parts of the circuit
2) Different resistors have their individual voltage drops
3) Voltage drops are additive
4) Applied voltage + the sum of different voltage drops
5) Resistances are additive V =
   V1+ V2 + V3
   IR = IR1+ IR2+ IR3
   R = R1+ R2+ R3

Application

Voltage divider

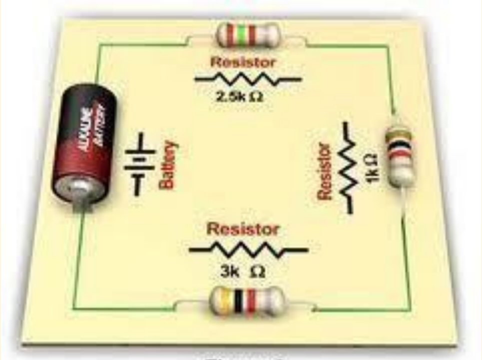


Figure 3

RESISTORS IN PARALLEL

When the resistors are connected side by side in a circuit it is said to be connected in parallel

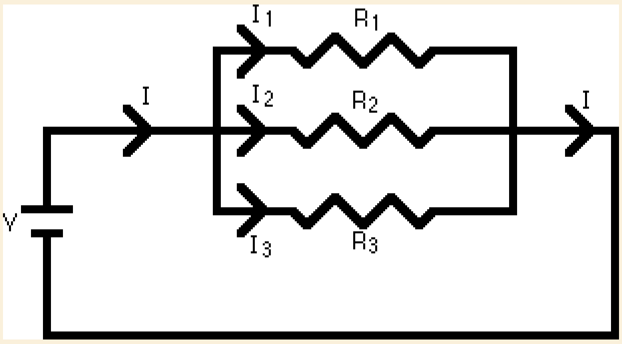
The main characteristics of Parallel circuit are

1) Same voltage acts across all parts of the circuit
2) Different resistors are having their individual current
3) Branch currents are additive
4) Reciprocal of total resistance + sum of the reciprocal of the resistance of individual resistors

$I = I1 + I2 + I3$

$V/R = V/R1 + V/R2 + V/R3$ $1/R =$

$1/R1 + 1/R2 + 1/R3$



EQUIVALENT RESISTANCE

Equivalent Resistance:

For the special case of two resistors in parallel:

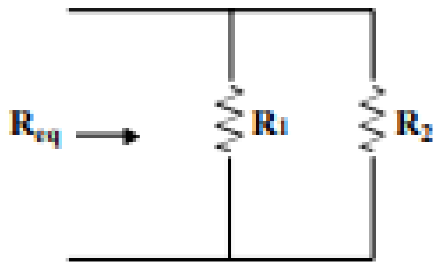
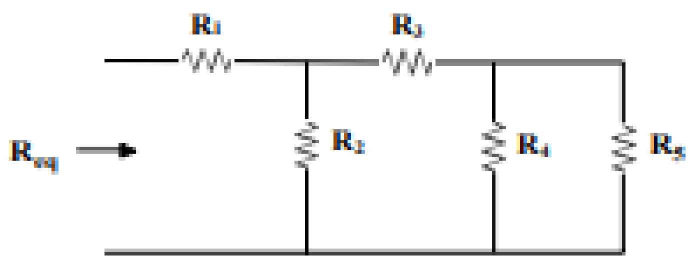


Figure 5.3: Two resistors in parallel.

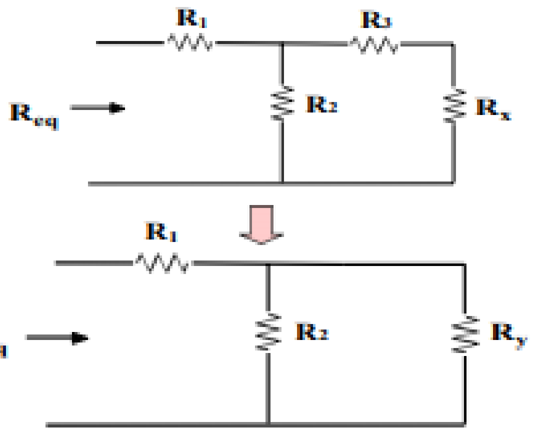
$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$

3

Equivalent Resistance: Resistors in combination.



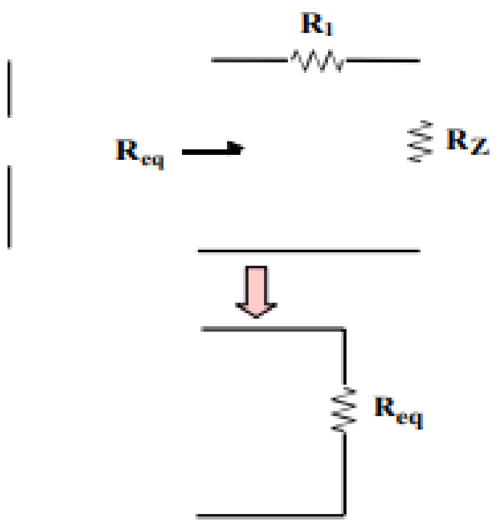
Resistors In Series – Parallel Combination



$$R_x = \frac{R_4 R_5}{R_4 + R_5}$$

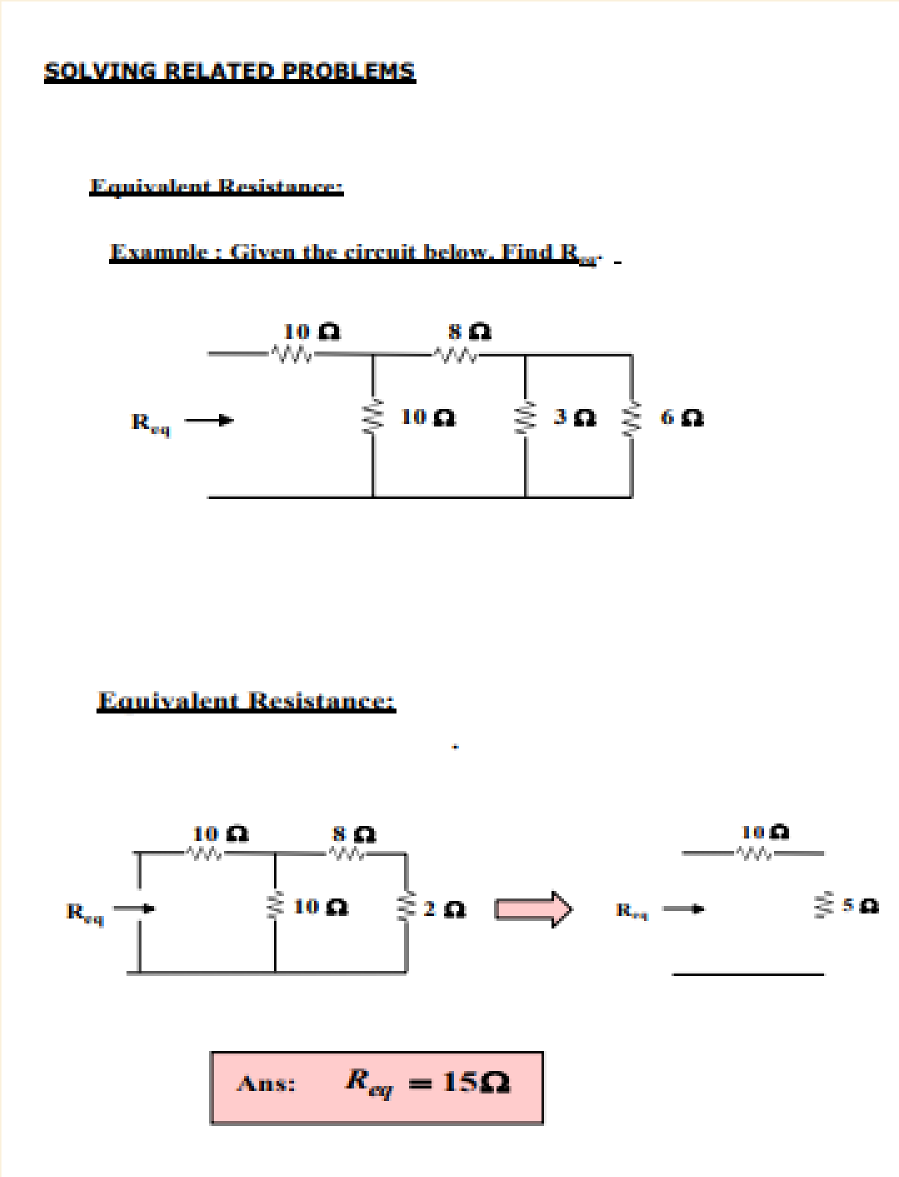
$$R_y = R_x + R_3$$

Equivalent Resistance:



$$R_Z = \frac{R_2 R_Y}{R_2 + R_Y}$$

$$R_{eq} = R_Z + R_1$$



SOLVING RELATED PROBLEMS

Equivalent Resistance:

Example : Given the circuit below. Find R_{eq}.

Equivalent Resistance:

Ans: $R_{eq} = 15\Omega$

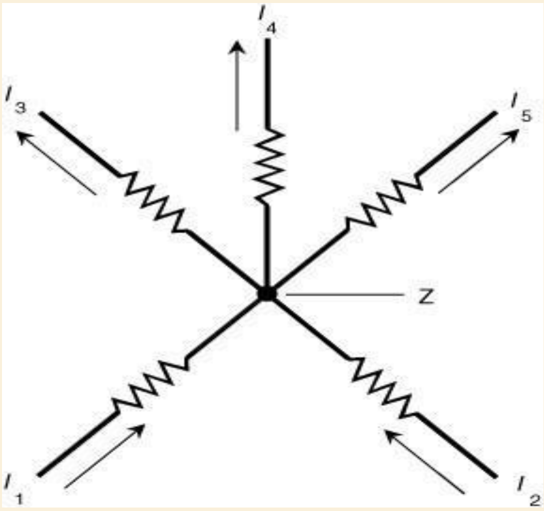
KIRCHOFF'S LAWS

<u>KIRCHOFF'S CURRENT LAW</u>

It states that in any network of conductors the algebraic sum of currents meeting a point or junction is zero.

The total current entering a junction = total current leaving a junction I in =I out

In practice all current entering a junction can be taken as positive where as those leaving would be taken as negative.



$$I1 + I2 + (-I3) + (-I4) + (-I5) = 0$$

$$\sum I = 0$$

$$I1+I2 = I3+I4+I5$$

KIRCHOFF 'S VOLTAGE LAW

The algebraic sum of all EMFs and voltage drops in any closed loop of a network is zero.

$$\sum EMF = \sum IR$$

$$\sum EMF - \sum IR = 0$$

DETERMINATION OF ALGEBRAIC SIGN

Battery EMF

A rise in voltage can be considered as positive and a fall in voltage can be considered as negative

Positive terminal of a battery → negative terminal→ Fall in potential→ Negative EMF

Negative terminal of a battery → Positive terminal→ Rise in potential→ Positive EMF

IR drops on Resistors

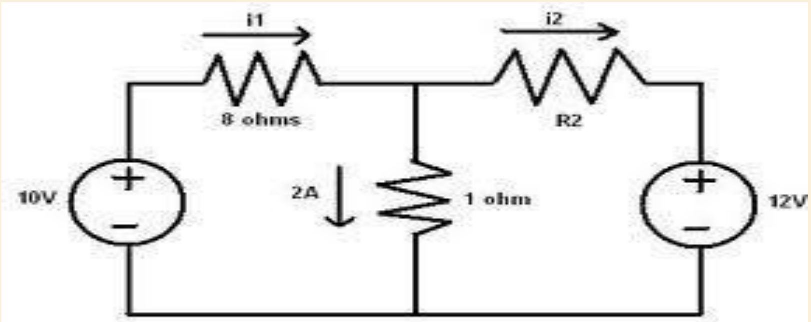
If we go through a resistor in the same direction a current flow, there is a fall in potential. So sign is negative. If we go through a resistor in the direction opposite to that of current flow, there is a rise in potential. So sign is positive

Same direction as its current →fall in potential→ Negative IR drop Direction opposite to that of current → rise in potential→ positive IR drop

SOLVING RELATED PROBLEMS

1) Using Kirchhoff's law calculate the current in the network

A ***B*** ***C***



F ***E*** ***G***

As shown in the figure we consider the currents I_1 and I_2 as originating from the positive terminal of the batteries. We will consider the following two closed loops

i) Loop ABEFA

Starting from point A and going clock wise around the loop, we have

$-4I1- 8(I1+I2) +12 = 0$

Or

$3I1 +2 I2 = 3$.................................... (1)

ii) Loop BCDEB

Starting from point B and again going clockwise around the loop

$+2I2 -10 + 8(I1+I2) = 0$

or

$4I1+ 5I2 = 5$....................................(2)

Multiplying Eq. (i) by 5 and Eq. (ii) by 2 and subtracting one from another, we get

$15 I1 – 8 I1= 15- 10$ or $7I1= 5$

$I1=5/7$ A

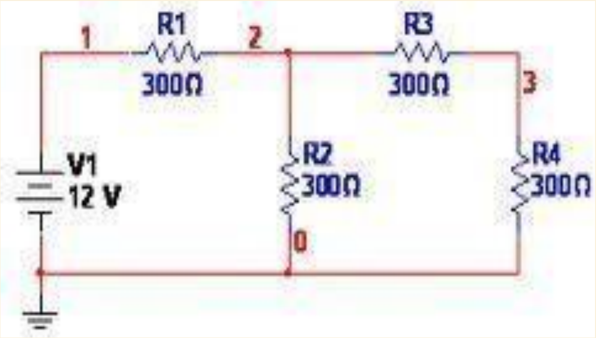
Substituting this value in Eqn (I) $3*(5/7)$

$+ 2I2 =3$

Or

I2 = 3/7 A I3 =
I1 + I 2
=1*1/7 A

2) Calculate the total circuit current total resistance and voltage drop across each resistor?



UNIT: INDUSTRIAL SAFETY DEVICES

Industrial Safety Devices

Industrial safety devices and their Applications.

Machinery and equipment generally have moving parts which perform rotating, sliding or reciprocating motion or a combination of these movements. These have the potential to cause injury to employees and those in the vicinity of the machine. With all electrical equipment operations, there is the threat of shock and/or electrocution. Electrical workers are potentially exposed to variety of hazards such as electric shock (the most common hazard), arc flashes, falls, and thermal burns

When you receive an electrical shock, an electric current runs through your body because the body has become the conductor of electricity. Electrocution occurs when enough current flows through your body to cease the functions of vital organs and to causes burns to muscular tissues and skin tissues.

The following are the most common electrical safety related hazards

1) Exposed wires and energized parts
2) Faulty or broken wiring/equipment's
3) Damaged outlets and missing covers
4) Worn / damaged electrical cords
5) Working under wet conditions

ELECTRICAL PROTECTIVE DEVICES

Using proper protective devices such as fuses and circuit breakers, grounding, and GFCI 's is extremely important in all electrical works in order to eliminate the danger of shock and electrocution.

Fuses and Circuit Breakers

Both fuses and circuit breakers are "over- current" devices used to prevent fires and damage to wiring and equipment caused by an excessive flow of current. The current ratings of fuses and circuit breakers are so high that they cannot protect against shock. When the current flow exceeds the rated levels, the fuse melts or the circuit breaker is tripped. In either case, the circuit is broken and current can no longer flow.

Grounding

Electrical systems, equipment and tools that are not grounded or double insulated can be dangerous. Grounded or double-insulate equipment protect the operator from beings shocked. The ground conductor connects the metal case of a tool or equipment to the ground. Under normal conditions, there is no current running through the ground conductor. However, if there is a fault in the tool or equipment the ground conductor takes the fault current safely to the ground. If the ground conductor connectivity has been lost (such as a missing or broken ground prong on an electric cord), the worker ‘s body might become the best path to the ground and the fault current would pass through the worker causing shock or electrocution.

Ground Fault Circuit Interrupters (GFCI)

The GFCI is an inexpensive device which measures the difference in current levels going to and returning from a piece of electrical equipment.

When there is a ground fault in the equipment a certain amount of current may flow through the operator to the ground. The GFCI senses this leakage, trips, and breaks the circuit within1/40th of a second. Instead of possible electrocution, the worst effect on the operator will be a shock before the circuit is broken

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Personal Protective Equipment (PPE) provides protection to workers from hazards. Depending on the job task to be performed, PPE for electrical workers generally includes safety glasses, flame-resistant (FR) face shields, hard hats, safety shoes, insulating (rubber) gloves with leather protectors, insulating sleeves, and clothing. Additional PPE, such as fall protection equipment, respirators, chemical-resistant and cut resistant gloves may be needed, depending on the potential hazard in the job.

Goggles- Eye and face Protection

Employees can be exposed to a large number of hazards that pose danger to their eyes and face. Employees should wear goggles to protect themselves.

- Flying objects and particles;
- Molten metal;
- Liquid chemicals;
- Acids or caustic liquids;
- Chemical gases or vapors;
- Potentially infected material;
- Glare;
- Injurious radiation;
- Electrical flash.

Safety helmet – Head protection

A head injury can impair an employee for life or can be fatal. Protecting employees from potential head injuries by wearing a safety helmet or hard hat is one of the easiest ways to protect an employee ‘s head from injury.

Protective Footwear- Foot and Leg Protection

Employees who all face possible foot or leg injuries from falling or rolling objects / from crushing or penetrating materials, should wear protective footwear. Also, employees whose work involves exposure to hot substances, corrosive, or poisonous materials must have protective gear to cover exposed body parts, including legs and feet. If an employee 's feet may be exposed to electrical hazards, non-conductive footwear should be worn.

Examples of situations in which an employee should wear foot and/or leg protection include:

- When heavy objects such as barrels or tools might roll onto or fall on the employee 's feet;
- Working with sharp objects such as nails or spikes that could pierce the soles or uppers of ordinary shoes;
- Exposure to molten metal that might splash on feet or legs
- Working on or around hot, wet or slippery surfaces; and
- Working when electrical hazards are present.

Protective Gloves- Hand and Arm Protection

Where potential injury to hands and arms cannot be eliminated through engineering and work practice controls, the employees should wear appropriate protective gloves. Potential hazards include:

- Skin absorption of harmful substances Chemical or thermal burns;
- Electrical dangers; and
- Bruises, abrasions, cuts, puncture.

UNIT: EFFECTS OF ELECTRIC CURRENT

- Magnetic effect.
- Chemical effect.
- Heating effect.
- Lighting effect.
- Shock effect

10. EFFECTS OF ELECTRIC CURRENTS

Energy exists in various forms such as mechanical energy, heat energy, chemical energy, electrical energy, light energy and nuclear energy. According to the law of conservation of energy, energy can be transformed from one form to another.

MAGNETIC EFFECT

When electric current passes through current carrying conductor or coil then a magnetic field is produced around it. This effect is called magnetic effect of electric current.

This effect is used in the fans, electric bells etc

CHEMICAL EFFECT

The phenomenon of electrolysis is an important chemical effect of electric current. In ionic solutions (electrolytes), the electric current is due to the movement of ions and there are associated chemical changes. In a typical experiment of electrolysis, two metal rods are immersed in an ionic solution and connected to the two ends of a battery. The dissociated ions appear at the two plates.

This effect is used in charging and discharging of batteries and electroplating etc.

Electrolysis

Electrolysis is the dissociation of electrolyte into ions at the electrodes by the passage of electric current.

Electrolytes are substances that conduct electricity due to the drifting of ions. The positive ions are called cations, and the negative ions anions. That is, it is the conduction of electric current through an electrolyte together with the resulting chemical changes.

HEATING EFFECT

When an electric current is passed through a metallic wire (like the filament of an electric heater, oven etc.,) it gets heated up and here the electrical energy is converted into heat energy. This is known as the 'heating effect of current'.

Such effects are used in heater, electric Iron electric lamps and soldering iron etc.

A metallic conductor has a large number of free electrons in it. When a potential difference is applied across the ends of a metallic wire, the free electrons begin to drift from a region of low potential to a region of high potential. These electrons collide with the positive ions (the atoms which have lost their electrons). In these collisions, the energy of the electron is transferred to the positive ions and they begin to vibrate more violently. As a result, heat is produced. The greater the number of electrons flowing per second, the greater will be the rate of collisions and so greater is the heat produced

An 'electric fuse' is an important application of the heating effect of current. When the current drawn in a domestic electric circuit increases beyond a certain value, the fuse wire gets over heated, melts and breaks the circuit

The heating effect of electric current is utilized in electric bulbs for producing light. When electric current passes through a thin high resistance tungsten filament of an electric bulb, the filament becomes white hot and emits light.

Application

1) Electric iron,
2) Room heaters,
3) Water heaters, etc.

LIGHTING EFFECT

When electric current flows through some special type of materials, the electric energy is converted in to light energy. E.g.: Fluorescent lamp, LED, etc.

- **Fluorescent** – In a fluorescent light, the electricity passes through mercury vapor in a glass tube. This gives off invisible light that interacts with the coating in the glass, and this in turn emits visible light.
- **Incandescent** – The electrical current passes through the metal filament until it becomes incandescent, giving off light and heat.

- **Halogen** – Halogen lighting is similar to incandescent, except that there is a measure of halogen gas inside the glass insert.
- **LED** – The current passes through electric components called diodes, which emit light and then become Light Emitting Diodes.

SHOCK EFFECT

Our body is a good conductor. Electric current can easily pass through it. When the body touches the bare conductor carrying current, it flows through our body to ground, and body get shock. The perception of electric shock can be different depending on the voltage, duration, current, path taken, etc.

- Electrical Shock Dynamics

Current	**Effect**
3+ mA	Shock
10+ mA	Muscular contractions
30+ mA	Respiratory paralysis
50+ mA	Heart paralysis (can be fatal)
100+ mA	Ventricular fibrillation (usually fatal)
200+ mA	Heart clamps tight
1500+ mA	Tissue and organs burn

UNIT: ALTERNATING CURRENT THEORY

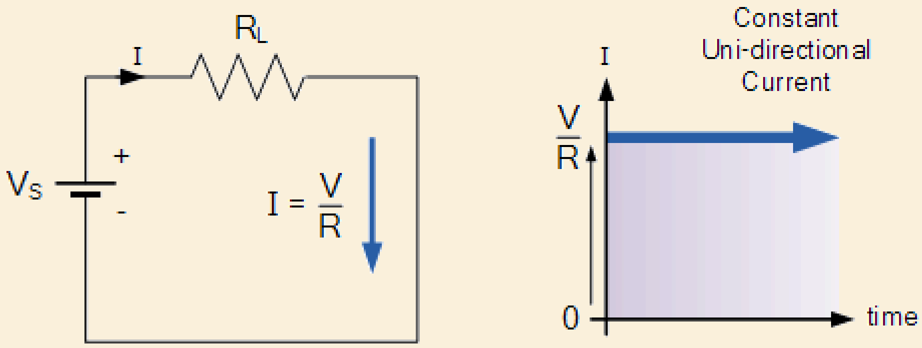
- Fundamental of voltage & current
- Generation
- Equation of A. C current & voltage.
- Peak, Average and R.M.S of sine wave
- Frequency, time period, wavelength, amplitude, form. factor and peak factor
- Concept of reactance and power factor

FUNDAMENTALS OF VOLTAGE AND CURRENT

Direct Current or **D.C** is a form of current or voltage that flows around an electrical circuit in one direction only. A DC voltage or current has a fixed magnitude (amplitude) and a definite direction associated with it.

A DC power supply do not change their value with regards to time, they are a constant value flowing in a continuous steady state direction. In other words, DC maintains the same value for all times and a constant uni - directional DC supply. An example of a simple DC or direct current circuit is shown below.

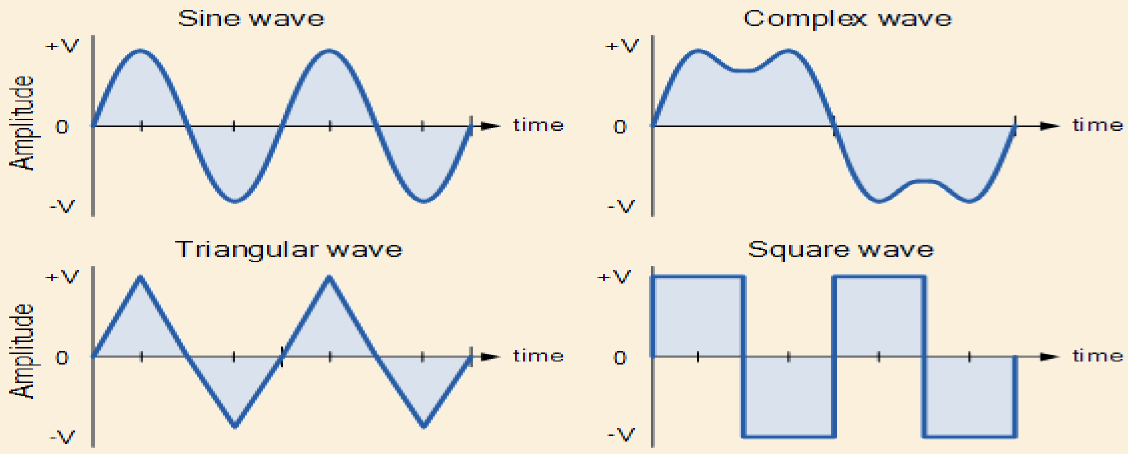
DC Circuit and Waveform



An alternating function or AC waveform on the other hand is defined as one that varies in both magnitude and direction in more or less an even manner with respect to time making it a "Bi-directional" waveform. The terms AC or to give it its full description of Alternating Current.

An AC waveform is constantly changing its polarity every half cycle alternating between a positive maximum value and a negative maximum value respectively with regards to time. The ac waveform is a time dependent wave form and is a periodic wave form.

Types of Periodic Waveform



ADVANDAGES OF A.C OVER D.C :

1. High voltages of A.C can be generated.
2. A.C voltages can be increased or decreased without power loss by means of statics transformers.
3. Transmission cost of A.C is low.
4. Transmission efficiency of A.C is high.
5. A.C induction motors are cheap, efficiency and required less maintenance.
6. A.C instruments are cheap and A.C can be converted to D.C easily.

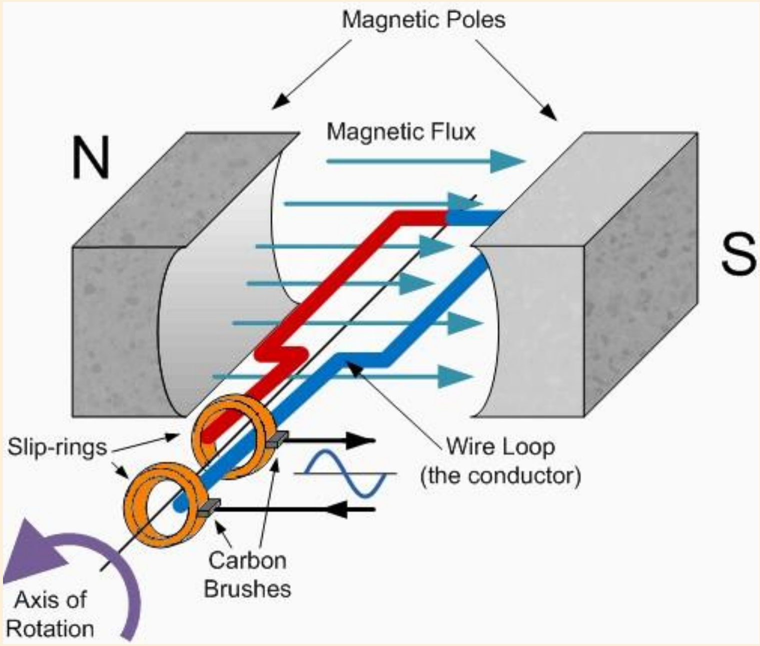
DISADVANTAGES OF A.C. OVER D.C:

1. A.C is more dangerous than D.C.
2. A.C required more efficient insulation to minimize shock hazard.
3. A.C required better earthling for safety.

GENERATION OF ALTERNATING VOLTAGE & CURRENT:

An AC generator uses the principle of Faraday ‘s Law of electromagnetic induction to convert a mechanical energy such as rotation, into electrical energy, a Sinusoidal Waveform.

A simple generator consists of a pair of permanent magnets producing a fixed magnetic field between a north and a south pole. Inside this magnetic field is a single rectangular loop of wire that can be rotated around a fixed axis allowing it to cut the magnetic flux at various angles as shown below.



As the coil rotates anticlockwise around the central axis which is perpendicular to the magnetic field, the wire loop cuts the lines of magnetic force set up between the north and south poles at different angles as the loop rotates. The amount of induced EMF in the loop at any instant of time is proportional to the angle of rotation of the wire loop.

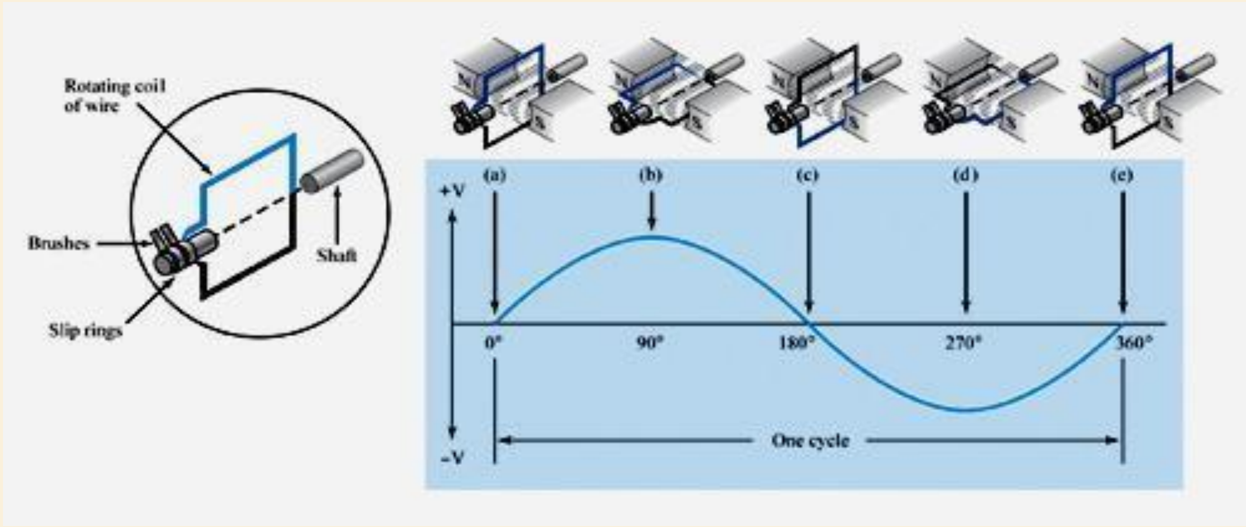
As this wire loop rotates, electrons in the wire flow in one direction around the loop. When the wire loop has rotated past 180^o point and moves across the magnetic lines of force in the opposite direction; the electrons in the wire loop changes and flows in the opposite direction. Then the direction of the electron movement determines the polarity of the induced voltage.

So we can see that when the loop or coil physically rotates one complete revolution, or 360^o, one full sinusoidal waveform is produced with one cycle of the waveform being produced for each revolution of the coil. As the coil rotates within the magnetic field, the electrical connections are made to the coil by means of carbon brushes and slip- rings which are used to transfer the electrical current induced in the coil.

The amount of EMF induced into a coil cutting the magnetic lines of force is determined by the following three factors.

- Speed – the speed at which the coil rotates inside the magnetic field.
- Strength – the strength of the magnetic field.
- Length – the length of the coil or conductor passing through the magnetic field.

Sinusoidal Waveform Construction



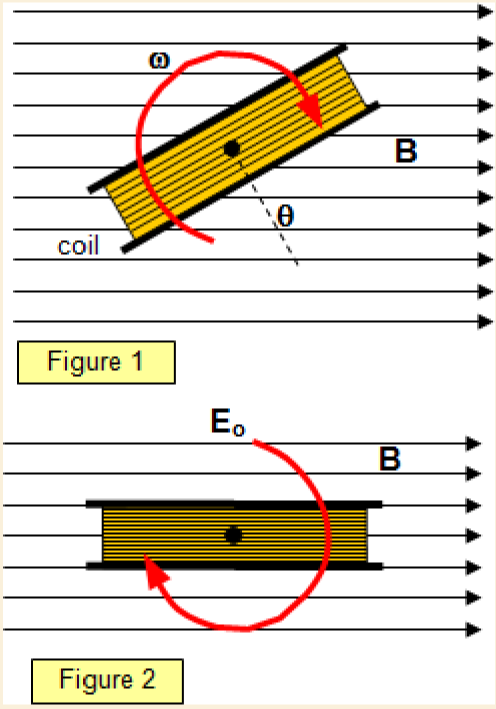
The points on the sinusoidal waveform are obtained by projecting across from the various positions of rotation between 0^o and 360^o to the ordinate of the waveform that corresponds to the angle, θ and when the wire loop or coil rotates one complete revolution, or 360^o, one full waveform is produced. From the plot of the sinusoidal waveform we can see that when θ is equal to 0^o, 180^o or 360^o, the generated EMF is zero as the coil cuts the minimum amount of lines of flux. But when θ is equal to 90^o and 270^o the generated EMF is at its maximum value as the maximum amount of flux is cut. The sinusoidal waveform has a positive peak at 90^o and a negative peak at $270^{o.}$ The instantaneous value of generated EMF is corresponding to the formula

V instantaneous = Vmax * sinθ.

Then the waveform shape produced by simple single loop generator is commonly referred to as a sine wave as it is said to be sinusoidal in its shape

<u>EQUATION OF ALTERNATING E.M.F:</u>

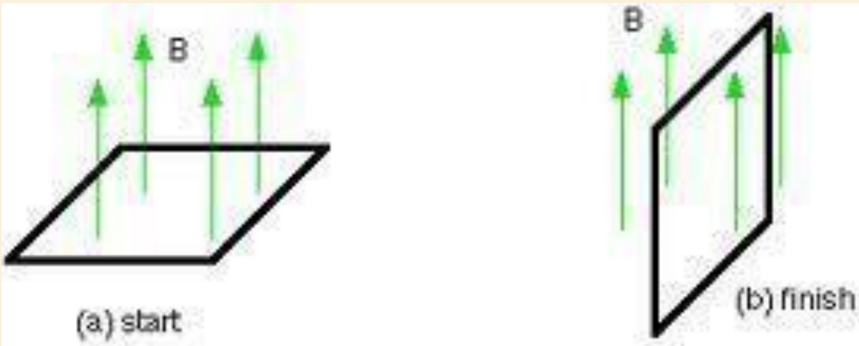
Consider a rectangular coil of n turns rotating in anti-clockwise direction with an angular



Let, the time is measured from the instant when the plane of the coil coincides with X-axis as shown in fig.

In this position maximum flux Φ_{max} is linking the coil. As the coil rotates, flux linking with it changes and hence emf is induced in it. Let the coil turn through an angle ‗ θ‗ in time ‗t‘ seconds and assume the position as shown in fig.

Clearly ‘θ ‗=Wt



In this position of the coil, maximum flux Φ_{max} acting vertically outwards can be resolved in to two perpendicular components namely:

1. Components $\Phi_{max} \sin \omega t$ parallel to the plane of the coil. This component induces no emf as is the parallel to the plane of the coil.
2. Components $\Phi_{max} \cos \omega t$. Perpendicular to the plane of the coil. This

component induces Emf of the coil.

Flux linkages of the Coil at the constant=NO.OF Turns x flux linking

$$= n\,\Phi_{max} \cos \omega t$$

According to faraday 's law of electromagnetic induction EMF induced in a coil is equal to the rate of change of flux linkages of the coil. Therefore, instantaneous EMF induced in the coil at this instant is given by:

$$E = -d/dt \text{ flux linkages}$$

$$= -d/dt\,(n\,\Phi_{max} \cos \omega t)$$

$$= -n\,\Phi_{max}\,\omega\,(-\sin \omega t)$$

$$= n\,\Phi_{max}\,\omega \sin \omega t$$

The value of e will be maximum (Em) when $\sin \omega t = 1$ (When the coil has turned through 90° in anti-clockwise direction from the reference axis)

$$Em = n\,\Phi_{max} \cos \omega$$

$$e = Em \sin \omega t$$

$$= Em \sin \theta$$

$$Em = n\,\Phi_{max}\,\omega$$

It is clear that e.m.f induced in the coil is sinusoidal. If the alternating voltage ($e = Em \sin \omega t$) is applied across a load, alternating current flow through the circuit which would also varies sinusoidal.

The equation of alternating current is given by: $I = Im \sin \omega t$

DIFFERENT FORMS OF ALTERNATING VOLTAGE EQUATION:

The standard equation for the alternating voltage is given by: v =V max sin

$$v = V\,max \sin \omega t$$
$$v = V\,max \sin 2\pi f t$$

VALUE OF ALTERNATING VOLTAGE & CURRENT:

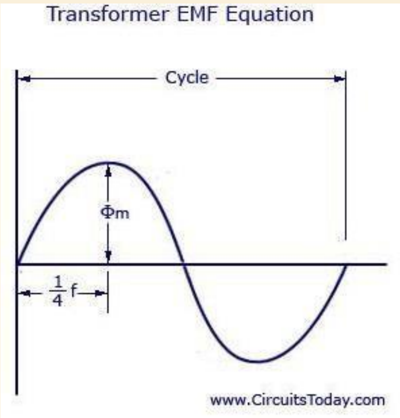
Alternating voltage or current changes the amplitude from instant to instant over one cycle. In order to compare one voltage or current, the following are generally used in A.C. circuit analysis.

1. Instantaneous value
2. Peak value
3. Average value
4. RMS or effective value

Peak, Average and R.M.S of sine wave

PEAK VALUE:

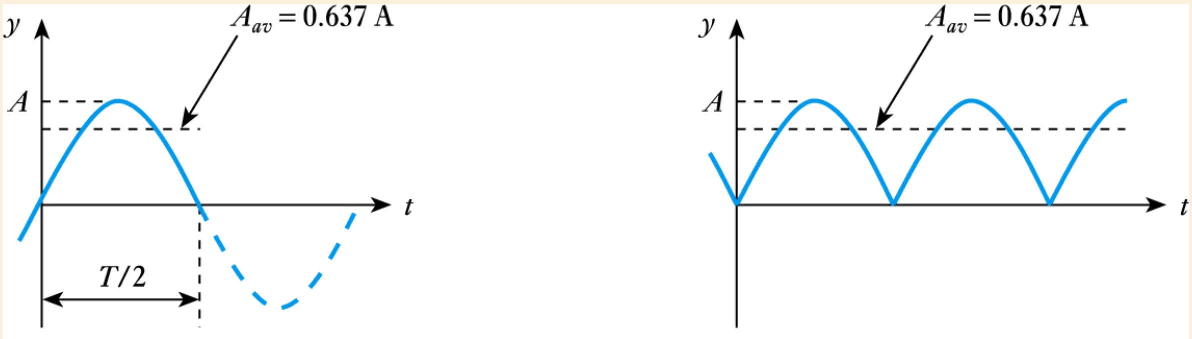
The max value (+ve or –ve) attained by an alternating voltage or current is called peak value or max value or amplitude.



AVERAGE VALUE:

It is the arithmetical average of all instantaneous values in one half cycle of a wave.

V avg =.637xV max where, Vmax is the peak value



(a) Average value over half a cycle of a sine wave

(b) Average value of a rectified sine wave

In this case of a symmetrical wave e.g.: Sinusoidal voltage or current wave, the positive wave is exactly equal to negative half. So that the average value of amplitudes, regardless of sign is not zero. In other words, here the terms average means the average of positive half or negative half, it follows, therefore, that for symmetrical wave, the average means over half cycle or one alternation.

RMS VALUE

- The RMS or effective value of a sinusoidal voltage or current corresponds to the equivalent DC value producing the same heating power. The abbreviation RMS stands for *root-mean-square*, and is determined by:
- $V_{rms} = 0.707\ V$ maxor
- $I_{rms} = 0.707\ I$max

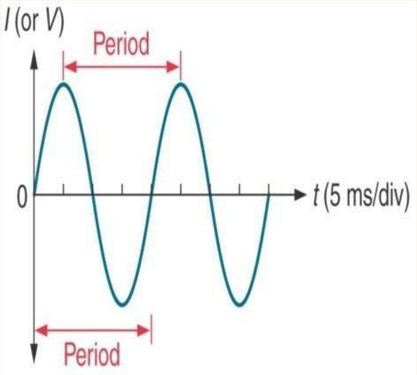
Frequency, time period, wavelength, amplitude, form factor and peak factor

Amplitude

The maximum value positive or negative of an alternating quantity is known as amplitude.

Time period

It is the time taken by the alternating voltage to complete one cycle. Its unit is second.



Frequency

The number of cycle / second made by an alternating voltage or current is called its frequency. Its unit is cycles / second or Hertz (Hz). It is the reciprocal of time period.

Frequency (f) = 1/ Time period

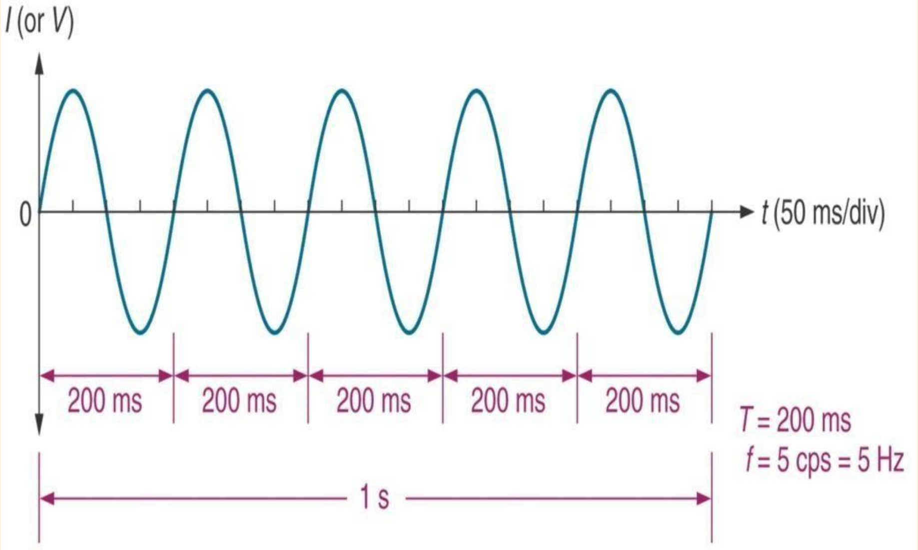
= 1/T

Time period (t) = 1/ Frequency

= 1/F

Wave Length

It is the distance occupied by one complete cycle of a sine wave



Form Factor

It is defined as the ratio of rms value to the average value Form factor =

rms value / average value

= 0.707 V max / 0.637 V max

= 1.11

Peak Factor (Crest factor)

It is defined as the ratio of maximum value to the rms value Peak factor =

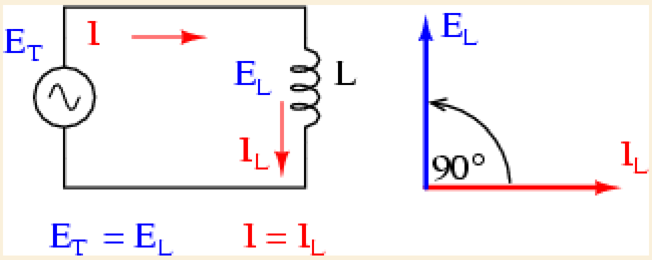
Maximum value / rms value

= V max / 0.707 V max

= 1.414

CONCEPT OF REACTANCE AND POWER FACTOR

Reactance of an inductor, X_L is the opposition that an inductor has to the flow of ac. We know that reactive loads such as inductors and capacitors dissipate zero power, only resistor dissipates power.



In dc circuits, the product of voltage and current gives the power in watts drawn by the circuit. But in AC circuits, the product VI gives the apparent power and not the real power because in AC circuits voltage and current are not phase in each other

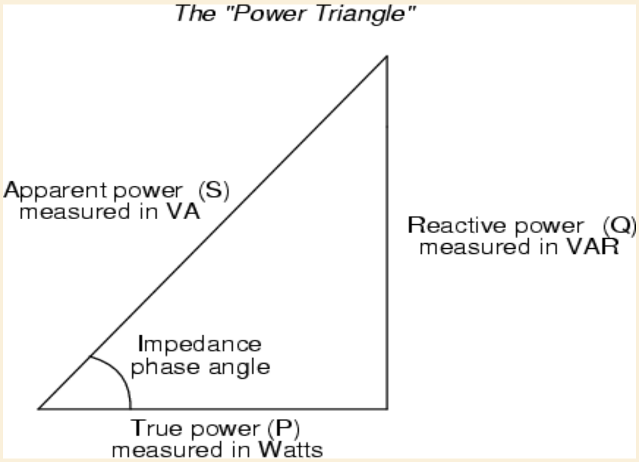
Current in phase with the voltage produces true or active power where as current 90 out of phase with voltage contributes to reactive power

True Power = Voltage * Current in phase with voltage

Reactive power = Voltage * Current 90° out of phase with voltage

True power is a function of a circuit's dissipative elements, usually resistances (R). Reactive power is a function of a circuit's reactance (X). Apparent power is a function of a circuit's total impedance (Z).

- Power dissipated by a load is referred to as *true power*. True power is symbolized by the letter P and is measured in the unit of Watts (W).
- Power merely absorbed and returned in load due to its reactive properties is referred to as *reactive power*. Reactive power is symbolized by the letter Q and is measured in the unit of Volt- Amps-Reactive (VAR).
- Total power in an AC circuit, both dissipated and absorbed/returned is referred to as *apparent power*. Apparent power is symbolized by the letter S and is measured in the unit of Volt-Amps (VA).
- These three types of power are trigonometrically related to one another. In a right triangle, P = adjacent length, Q = opposite length, and S = hypotenuse length. The opposite angle is equal to the circuit's impedance (Z) phase angle.



Power factor

The power factor of an AC electrical power system is defined as the ratio of the real power flowing to the load, to the apparent power in the circuit

Power factor = Real Power /Apparent Power

UNIT: TRANSFORMER

- Principle of operation
- Construction
- Types of transformers
- E. M. F Equation
- Solving related problems

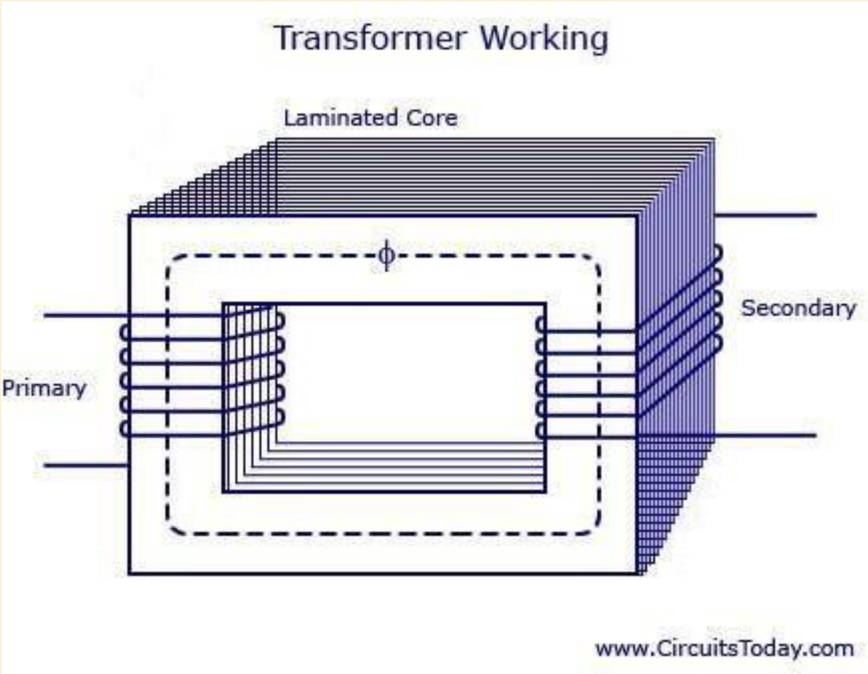
INTRODUCTION:

One important reason for the wide spread use of alternating current is performance to direct current is the fact that alternating voltage can be conveniently changed in magnitude by means of a transformer. Transformer has made it possible to transmit A.C. power at high voltage and utilized it at a safe potential, without a change in voltage level, electric power system would have quite restricted in size.

PRINCIPLE OF OPERATION

A transformer can be defined as a static device which helps in the transformation of electric power in one circuit to electric power of the same frequency in another circuit. The voltage can be raised or lowered in a circuit, but with a proportional increase or decrease in the current ratings.

The main principle of operation of a transformer is mutual inductance between two circuits which is linked by a common magnetic flux. A basic transformer consists of two coils that are electrically separate and inductive, but are magnetically linked through a path of reluctance. The working principle of the transformer can be understood from the figure below.



As shown above the transformer has primary and secondary windings. The core laminations are joined in the form of strips in between the strips there are some narrow gaps right through the cross-section of the core. Both the coils have high mutual inductance. A mutual electro- motive force is induced in the transformer from the alternating flux that is set up in the laminated core, due to the coil that is connected to a source of alternating voltage. Most of the alternating flux developed by this coil is linked with the other coil and thus produces the mutual induced electro- motive force.

If the second coil circuit is closed, a current flow in it and thus electrical energy is transferred magnetically from the first to the second coil.

The alternating current supply is given to the first coil and hence it can be called as the primary winding. The energy is drawn out from the second coil and thus can be called as the secondary winding.

In short, a transformer carries the operations shown below:

1. Transfer of electric power from one circuit to another.
2. Transfer of electric power without any change in frequency.
3. Transfer with the principle of electromagnetic induction.
4. The two electrical circuits are linked by mutual induction.

CONSTRUCTION

The transformer consists of soft iron core or the silicon steel core and two windings attached to it i.e. primary winding and the secondary winding such that core and the windings are insulated from one another. To prevent insulation lamination is done on the core to provide low reluctance path for the magnetic flux.

The winding provided to the AC source is known as primary winding and winding across which load is taken out is known as secondary winding.

TYPES OF TRANSFORMERS

a) According to arrangement of iron cores.
b) According to phase.
c) According to location.
d) According to transformation.
e) According to cooling.

a) According to arrangement of iron cores: They are three types.

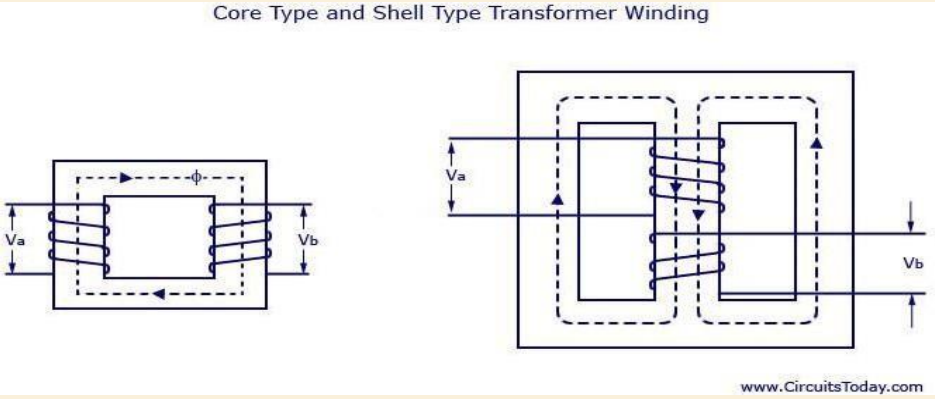
1. Core- Type Transformer

In core-type transformer, the windings are given to a considerable part of the core. The coils used for this transformer are form-wound and are of cylindrical type.

2. Shell-Type Transformer

In shell-type transformers the core surrounds a considerable portion of the windings.

3) Distributed core –having distributed magnetic circuits



b) According to phase:

- Single phase transformers.
- Three phase transformers.

c) According to location:

1) Indoor
2) Outdoor

d) According to transformation:

1) Step up
2) Step down

e) According to cooling:

1) Self-cooled
2) Air cooled
3) Oil self-cooled
4) Oil cooled with air or water

Ratios

Voltage Transformation Ratio (K) From

the above equations we get

$$E_S / E_P = V_S / V_P = N_S / N_P = K$$

This constant K is known as voltage transformation ratio.

(1) If $N_S > N_P$, that is $K>1$, then transformer is called step-up transformer.

(2) If $N_S < 1$, that is $K<1$, then transformer is known as step-down transformer.

Again for an ideal transformer, Input

V_A = output V_A

$V_P I_P = V_S I_S$

Or, $I_S/I_P = V_P/V_S = 1/K$

Hence, currents are in the inverse ratio of the (voltage) transformation ratio.

SOLVING RELATED PROBLEMS

1. A transformer has 200 turns in the primary, 50 turns in the secondary, and 120 volts applied to the primary (E_P). What is the voltage across the secondary (E_s)?

Given: $N_P = 200$ turns
$N_S = 50$ turns
$E_P = 120$ volts
$E_S = ?$ volts

Solution: $$E_S = \frac{E_P N_S}{N_P}$$

Substitution: $$E_S = \frac{120 \text{ volts} \times 50 \text{ turns}}{200 \text{ turns}}$$
$$E_S = 30 \text{ volts}$$

2. There are 400 turns of wire in an iron-core coil. If this coil is to be used as the primary of a transformer, how many turns must be wound on the coil to form the secondary winding of the transformer to have a secondary voltage of one volt if the primary voltage is five volts?

Given: $N_P = 400$ turns
$E_P = 5$ volts
$E_S = 1$ volt
$N_S = ?$ turns

Solution: $$E_P N_S = E_S N_P$$

Transposing for N_S:
$$N_S = \frac{E_S N_P}{E_P}$$

Substitution: $$N_S = \frac{1 \text{ volt} \times 400 \text{ turns}}{5 \text{ volts}}$$
$$N_S = 80 \text{ turns}$$

3. A transformer with a turns ratio of 1:12 has 3 amperes of current in the secondary. What is the value of current in the primary?

Given:
$$N_P = 1\text{ turn (assumed)}$$
$$N_S = 12\text{ turns}$$
$$I_S = 3\text{ A}$$
$$L_P = ?$$

Solution:
$$\frac{N_P}{N_S} = \frac{I_S}{I_P}$$

Transposing for I_P:
$$I_P = \frac{N_S I_S}{N_P}$$

Substitution:
$$I_P = \frac{12\text{ turns} \times 3\text{ A}}{1\text{ turn}}$$
$$I_P = 36\text{ A}$$

Hence, primary & secondary currents are inversely proportional to their respective turns.

UNIT: DC MOTOR

- Motor principle
- Construction
- Types of D.C. Motors
- Operation of 3-phase
- induction motors

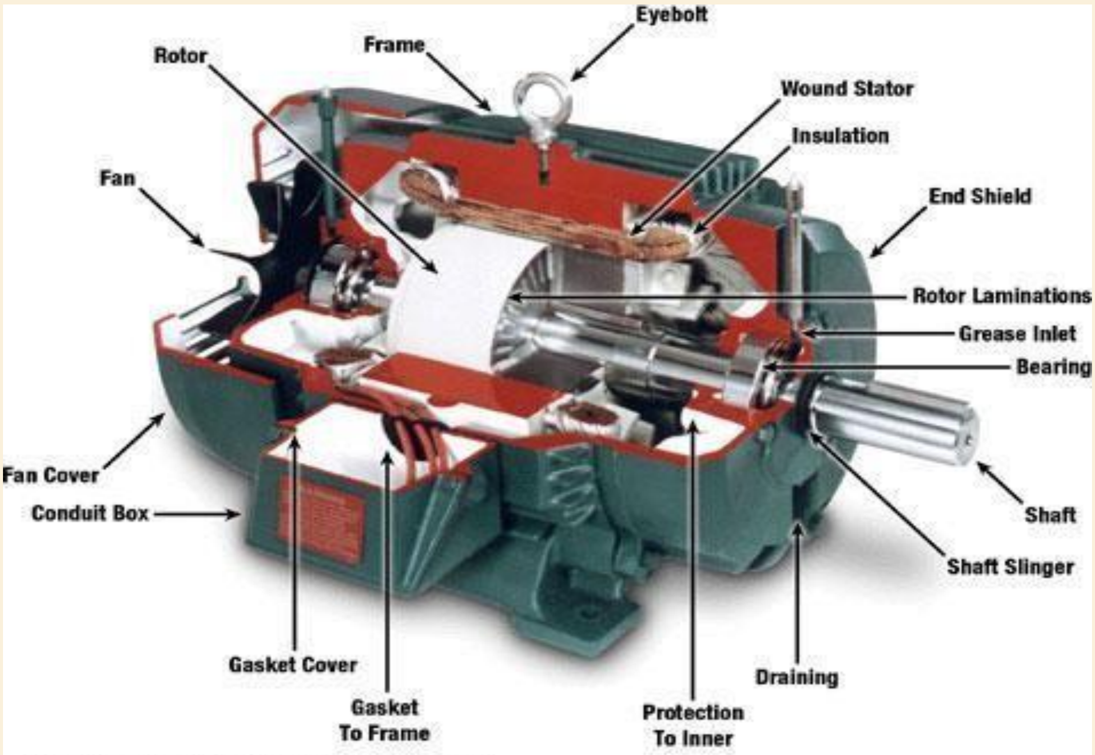


Figure 8 – Motor Construction

INTRODUCTION

Although a far greater percentage of the electric machines in service are A.C. motors, the motors are of considerable industrial importance. The principle advantage of a D.C. motor is its adaptability to different methods of speed control to provide a wide range of speeds and good speed regulation.

D.C. MOTORS

A machine that converts D.C. power into mechanical power is known as d c. motor

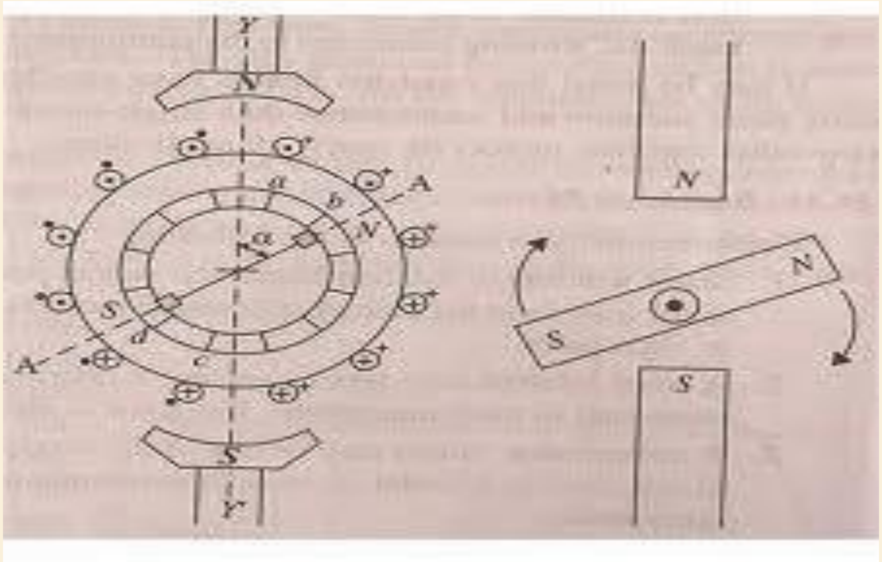
Its operation is based on the principle that when a current carrying conductor is placed in a magnetic field, the conductors experience a mechanical force. The direction of this force is given by Flemings left hand. Basically, there is no constructional difference between a D.C. Motor and a D.C. generator. The same D.C. machine can be used as a generator or motor. When the m/c is being used to convert electrical energy into mechanical power, it is called a D.C. generator.

D.C. MOTOR PRINCIPLE

When a DC motor is connected to a DC voltage source, direct current flows through the armature conductors. The flow of current produces the armature field.

Now, there are two magnetic fields in the air gap present between the field shoes and the armature core. These two field react with each other to rotate the armature. The commutator reverses the direction of flow of armature current at regular intervals so that armature field is always repelled by the pole field. Since the armature is continuously repelled the field poles, it keeps rotating in the same direction thus producing the armature torque.

Fig.13.1



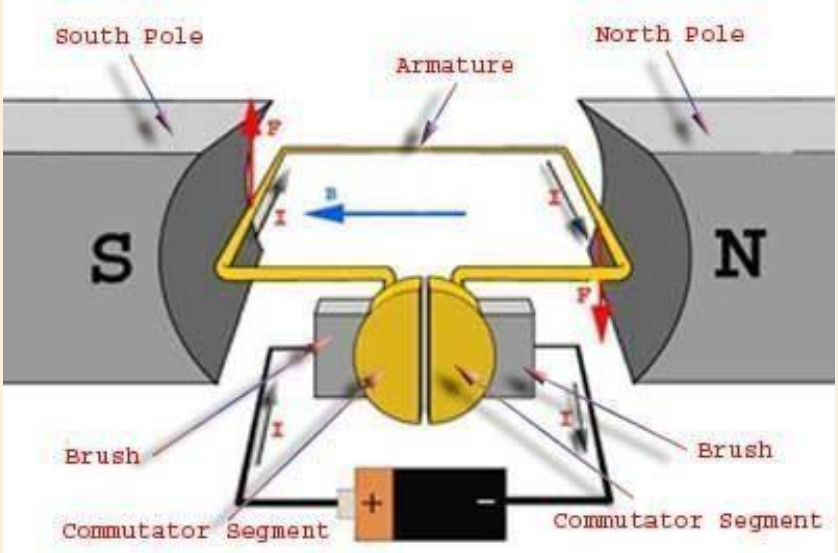
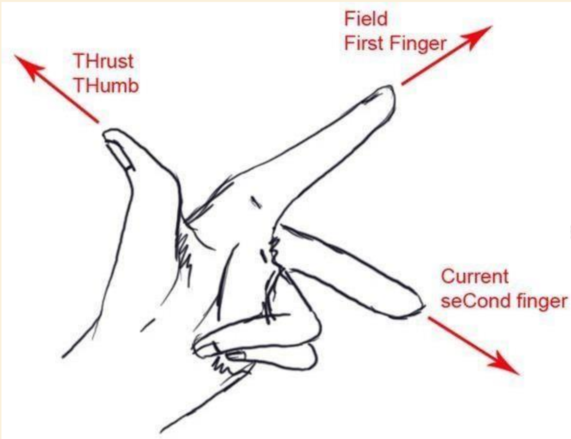


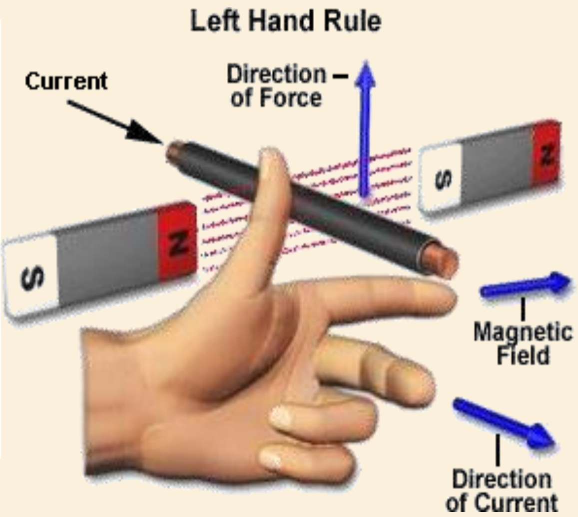
Fig.13.2

Fig.13.2

FLEMINGS LEFT HAND RULE

This rule is applied to find out the direction of rotation of an armature in the motor. According to this rule, spread the fore finger, middle finger and the force finger, middle finger and the thumb of your hand in such a way that each should be at 90° to each other. Then if the forefinger represents the field direction, middle finger the current direction, then the thumb will show the direction of rotation of conductor or armature

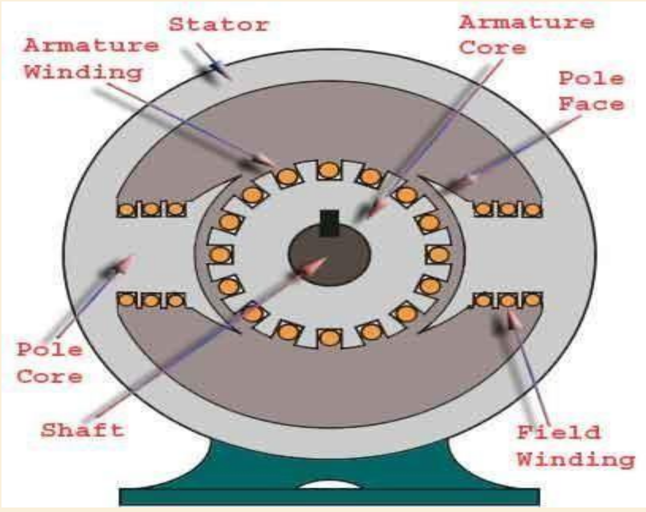




CONSTRUCTION OF DC MOTOR

A three phase induction motor essentially consists of the following two parts:

1) Stator
2) Rotor.



Other than rotor and stator a motor consists of other parts like Yoke, Poles, Field windings, armature windings, commutator and Brushes. All these parts put together configures the total construction of a dc motor**.** Now let 's does a detailed discussion about all the essential parts of dc motor.

Yoke of DC Motor

The magnetic frame or the yoke of dc motor made up of cast iron or steel and forms an integral part of the stator or the static part of the motor. Its main function is to form a protective covering over the inner sophisticated parts of the motor and provide support to the armature. It also supports the field system by housing the magnetic poles and field windings of the dc motor.

Poles of dc motor

The magnetic poles of DC motor are structures fitted onto the inner wall of the yoke with screws. its function is to just hold the pole shoe over the yoke. The pole shoe also carries slots for the field windings that produce the field flux.

Field Winding

The field winding of dc motor are made with field coils (copper wire) wound over the slots of the pole shoes in such a manner that when field current flows through it, then adjacent poles have opposite polarity are produced.

Armature winding

The armature winding of dc motor is attached to the rotor. Commutator

The commutator of dc motor is a cylindrical structure made up of copper segments stacked together, but insulated from each other by mica. Its main function as far as the dc motor is concerned is to commute or relay the supply current from the mains to the armature windings housed over a rotating structure through the brushes of dc motor**.**

Brushes

The brushes of dc motor are made with carbon or graphite structures, making sliding contact over the rotating commutator. The brushes are used to relay the electric current from external circuit to the rotating commutator form where it flows into the armature windings.

TYPES OF DC MOTOR:

There are 3 main types of DC motors characterized by the connection of field winding in relation to the armature.

SHUNT WOUND:

In this the field winding is connected in parallel with the armature as shown in fig. The field winding is of high value resistance with more turns practically at constant speed at almost all loads. Its starting torque is 1.5 to 2 times greater than the full load torque. The variations of speed of the motor can be well achieved by a shunt regulator.

USES:

These types of motor are useful for driving line shaft to which a number of machines are belted. These are also useful for driving pumps, lathe, drill, printing press etc.

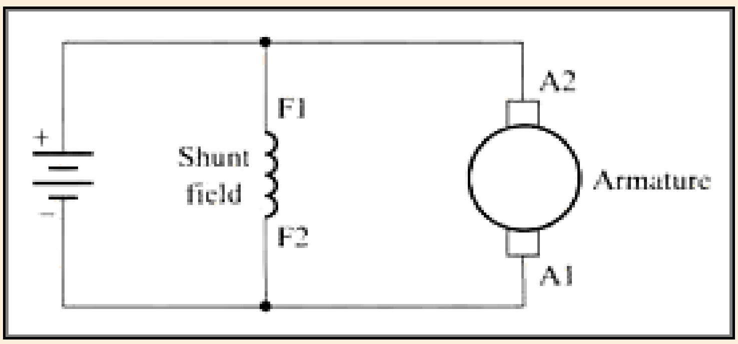


Fig.13.5

SERIES WOUND:

In this type of motor, the field has few turns of heavy conductor which is connected in series with armature, so that the load current flows from the field and armature. This motor has the characteristic of the speed for increasing the load. So when there is no load on this motor, the speed is very high. Hence, this type of motor is never used without load.

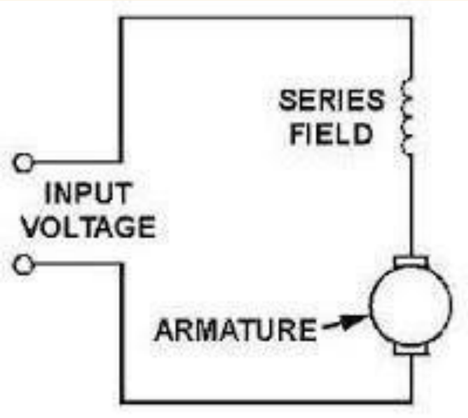


Fig.13.6

USES:

This type of motor is useful for cranes, trains, pumps, trolley cars etc., due to its very high starting torque at starting and constant speed.

COMPOUND WOUND MOTOR**:**

In this, two windings series and shunt are used. According to their field connection, there are two types:

1) Cumulative compound
2) Differential compound

CUMULATIVE COMPOUND:

Cumulative motor is one in which series field is so connected that it assists the field due to the shunt winding.

DIFFERENTIAL COMPOUNDS**:**

Motor is one in which series winding is so connected that the field due to/opposes that due to shunt winding.

USES:

The motor is seldom used since the shunt motor usually satisfies the equipment of constant speed.

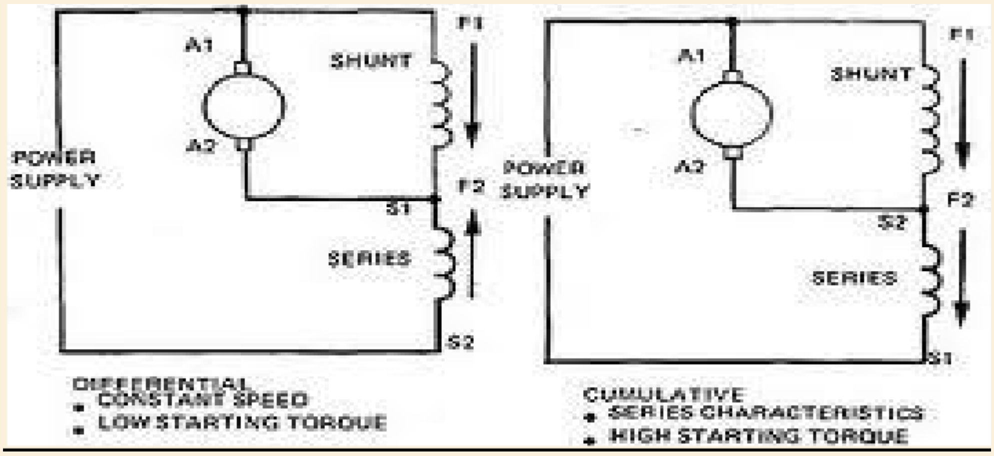


Fig.13.7

OPERATION OF 3- PHASE INDUCTION MOTOR

INTRODUCTION:

Of all AC motors, the three phase induction motor is the one which is extensively used for various kinds of industrial drives. By far the greater part of all the mechanical power used in industry is provided by 3-phase inductor motors.

THREE PHASE INDUCTION MOTOR:

It is the 3-phase AC motor in which electrical energy is converted into mechanical energy.

When a 3 _ phase stator windings of an induction motor are fed by 3-phase supply, a magnetic field of constant magnitude but rotating at synchronous speed is set up. This rotating field cuts the rotor conductors and hence induces currents in them. These rotor current produce their own rotating magnetic field. Thus we have two rotating magnetic field in the air gap which rotate at synchronous speed with respect to the stator but are stationary with respect to each other. The two magnetic fields react with each other and force the rotor to rotate in the direction of the rotating stator field.

The electric power is transferred from stator to rotor by induction and not by conduction. Hence the name induction motor.

ADVANTAGES:

1. It has a very simple and extremely rugged construction
2. Its cost is low and is very reliable
3. It is very efficient.
4. It is easy to maintain.

CONSTRUCTION OF 3-PHASE INDUCTION MOTOR:

A three phase induction motor essentially consists of the following two parts:

1) Stator 2) Rotor.

1) STATOR:

It is the stationary part of the motor. It consists of frame, stator core and stator winding. It is built up of thin lamination of silicon steel to reduce the hysteresis and eddy current loss. The insulated conductors are placed in the stator slot and are suitably connected to form a balanced 3 phase star or delta connected circuit. The 3 phase stator winding is wound for a definite number of poles, as per the requirement of speed. Greater the number of poles, lesser the speed of motor and vice versa. When a 3 phase supply is given to the starter, winding a rotating magnetic field of constant magnitude is produced. This rotating field induces currents in the rotor by electromagnetic induction.

2) ROTOR**:**

It is the rotating part of the motor and consists of cylindrical laminated core. The rotor is mounted on bearings and is separated from the stator by an air gap. The following are 2 types of induction motors.

1) Squirrel cage motor 2) Wound rotor. PRINCIPLE OF

OPERATION**:**

When 3 phase stator winding is fed from 3-phase supply, rotating magnetic field id set up, which rotates around the stator at synchronous speed. This rotating flux passes through the air gap and cuts the rotator conductors, which are, as yet stationary. Due to the relative motion between rotating flux and stationary rotor, e.m.f.s are induced in rotor conductors. The frequency of rotating emf is same as that of supply frequency when the rotor is stationary. Since the rotor circuit is closed, current starts flowing in rotor conductors.

Now the rotor conductors are carrying currents and are in the magnetic field produced by the stator. Therefore, mechanical force or torque acts on the rotor tending it to move in the same direction as that of a stator field. The fact that rotor is urged to follow the stator field (i.e., rotor moves in the direction of stator field) can be explained by Lenz ‘s law. According to this law, the rotor currents will be such that they tend to oppose the cause producing them. Now the cause producing the rotor currents is the relative speed between the rotating field and stationary rotor. Hence to reduce this relative speed, rotors starts running in same direction as that of the stator field and tries to catch it.

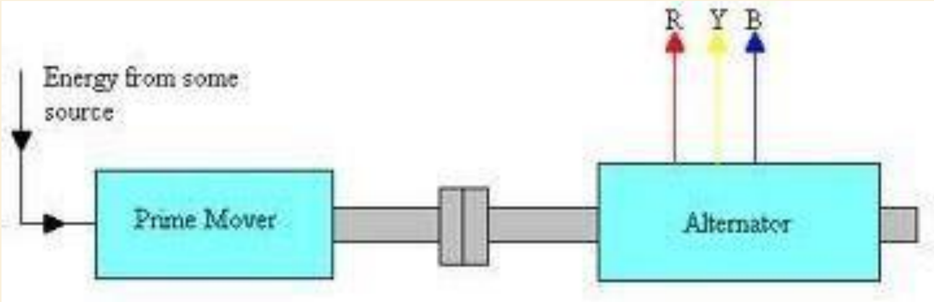
UNIT: GENERATION, TRANSMISSION AND **DISTRIBUTION**

- Brief explanation about various modes of power generation, transmission and distribution

GENERATION OF ELECTRICAL ENERGY

The conversion of energy available in different forms in nature into electrical energy is known as generation of electrical energy.

Electrical energy is available in various forms from different natural sources such as pressure head of water, chemical energy of fuels, nuclear energy of radioactive substances etc. All these forms of energy can be converted into electrical energy by the use of suitable arrangements. These arrangements usually employ an alternator coupled to a prime mover. The prime mover is driven by the energy obtained from various sources such as burning of fuel, pressure of water, force of wind etc.



SOURCES OF ENERGY

The various sources of energy are as follows

1) The Sun:

The sun is the primary source of energy. The heat energy radiated by sun can be focused over a small area by means of reflectors. The heat can be used to raise steam and electrical energy can be produced with the help of turbine- alternator combination

2) The Wind

This method can be used where wind flows for a considerable length of time. The wind energy is used to run the wind mill which drives a small generator

3) Water

When water is stored at a suitable place, (dams) it possess the potential energy. This water energy can be converted into mechanical energy with the help of water turbines. The water turbine drives the alternator which converts mechanical energy into electrical energy.

4) Fuels

The main sources of energy are fuels such as solid fuel as coal, liquid fuel as oil and gas fuel as natural gas. The heat energy of these fuels is converted into mechanical energy by suitable prime movers such as steam engines, steam turbines etc. The prime mover drives the alternator which converts mechanical energy into electrical energy.

5) Nuclear Energy

The heat produced by nuclear fission can be utilized to raise steam with suitable arrangements. The steam can run the steam turbine which in turn can drive the alternator to produce electrical energy.

GENERATING STATIONS

Bulk electric power is produced by special plants known as generating stations or power plants.

A generating station essentially employs a prime mover coupled to an alternator for the production of electric power. The prime mover converts energy from some other form into mechanical energy. The alternator converts mechanical energy of the prime mover to electrical energy. The electrical energy produced by the generating station is transmitted and distributed with the help of conductors to various consumers. Depending upon the form of energy converted to electrical energy, the generating stations are classified as

1) Steam Power Stations
2) Hydroelectric Power Stations
3) Diesel Power Stations
4) Nuclear Power Stations

1) Steam (Thermal) Power Station

A generating station which converts heat energy of coal combustion into electrical energy is known as steam power station.

Steam produced in the boiler by utilizing the heat of coal combustion. The steam is expanded in the prime mover and is condensed in a condenser to be fed into the oiler again. The steam turbine drives the alternator which converts mechanical energy into electrical energy.

Hydro – electric Power Station

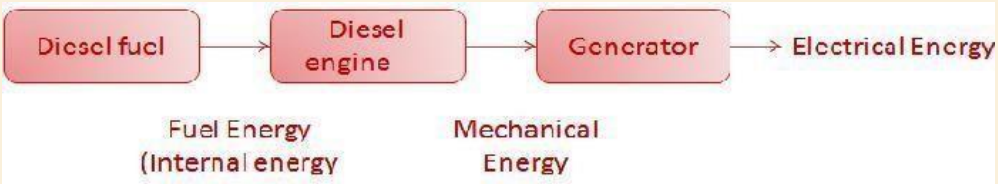
A generating station which utilizes the potential energy of water at high level for the generation of electrical energy is known as a hydroelectric power station.

In a hydroelectric power station, water head is created by constructing a dam across a river or lake. From the dam, water is led to a water turbine. The water turbine captures the energy in the falling water and changes the hydro electric energy into mechanical energy at the turbine shaft. The turbine drives the alternator which converts mechanical energy to electrical energy.

Diesel Power station

A generating power station in which diesel engine is used as the prime mover for the generation of electrical energy is known as diesel power station.

In diesel power station, diesel engine is used as the prime mover. The diesel burns inside the engine. The diesel engine drives the alternator which converts mechanical energy to electrical energy.

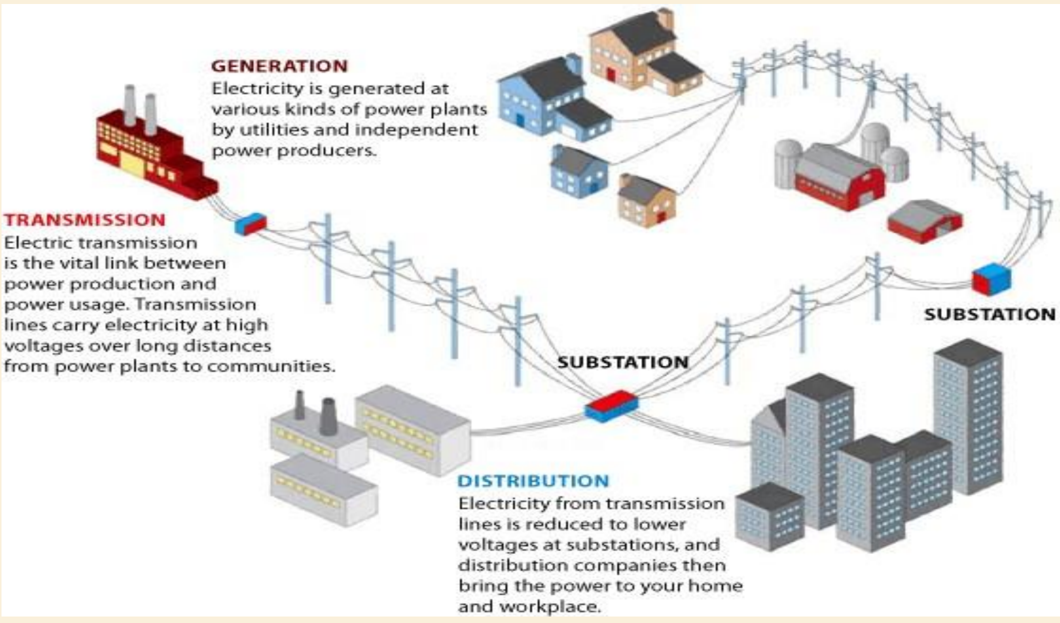


Nuclear Power Station

A generating power station in which nuclear energy is converted into electrical energy is known as a nuclear power station.

In nuclear power station, heavy elements such as Uranium and Thorium are subjected to nuclear fission in a special apparatus known as reactor. The heat energy thus released is utilized in raising steam at high temperature and pressure. The steam runs the steam turbine which converts steam energy into mechanical energy. The turbine drives the alternator which converts mechanical energy to electrical energy.

TRANSMISSION AND DISTRIBUTION



The function of an electric power system is to connect the power station to consumers ‘loads by means of interconnected system of transmission and distribution networks. Therefore, an electric power system consists of three principal components; the power station, the transmission lines and the distribution system. The transmission lines are the connecting link between the power station and the distribution system. A distribution System connects all the individual loads in a given locality to transmission lines. At many places in the line of the power system, it may be desirable and necessary to change some characteristics (voltage) of electrical supply. This is accomplished by suitable apparatus called substation.

The large network of conductors between the power station and consumers can be broadly divided in to transmission system and distribution system. Each part can be further divided into

i) Primary transmission

The electric power at 132KV is transmitted by 3 phase, 3 wire overhead system to the outskirts of city.

ii) Secondary transmission

The primary transmission lines terminate at the receiving stations. At receiving stations, the voltage is reduced to 33KV by step down transformers. From this station electrical power is transmitted at 33KV by 3 phase 3 wire overhead system to various substations.

iii) Primary distribution

The secondary transmission terminates at the substation where voltages is reduced from 33 KV to11kV, 3 phase 3 wire. The 11kv lines run along the important road sides of the city. This forms the primary distribution.

iv) Secondary distribution.

The electric power from primary distribution line (11kV) is delivered to distribution substation. These substations are located near the consumer ‘s localities and step down the voltage to 400V and between any phase and neutral is 230V.