UNIT - I

INTRODUCTION TO PASSIVE ELEMENTS

PASSIVE AND ACTIVE ELEMENTS:

- An electronic circuit is comprised of two different types of components known as passive elements and active elements.

PASSIVE ELEMENTS:

- The components which are not capable of amplifying or processing an electrical signal are called passive elements.
- **Ex:** Resistors, Inductors and capacitors.

ACTIVE ELEMENTS:

- The electrical components which provide amplification or switching are called active elements.
- **Ex:** diodes, Transistors and ICs (Integrated Circuits).

RESISTOR:

1. What is resistor? Explain the types of resistors? (10M)

- The property of the substance which opposes the flow of an electric current it is called resistance.
- The resistance is expressed by letter 'R' and is measured in ohm (Ω).
- Resistors are used in electronic circuit for controlling the current or voltage.

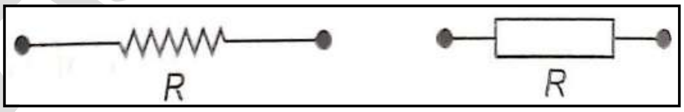
TYPES OF RESISTORS:

- They are two types of resistors.

  1. Fixed resistors   2. Variable resistors

1. FIXED RESISTORS:

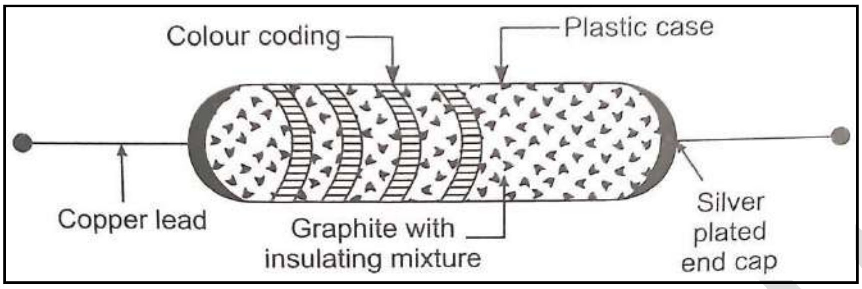
- The fixed resistors divided into four types.
  1. Carbon composition resistors.
  2. Wire-wound resistors.
  3. Metal film resistors.
  4. Carbon resistors.
- The symbols for fixed resistors used in electronic circuit are shown in fig.



1. CARBON COMPOSITION RESISTORS:

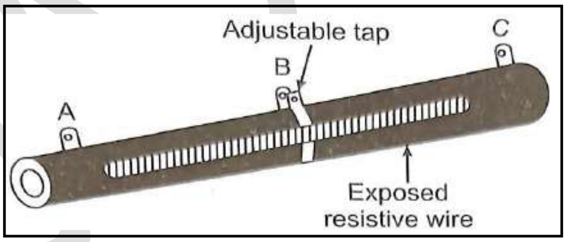
- This is a most common type of low wattage resistor.
- They are made of graphite or finely ground carbon mixed with a powdered insulating material.
- The lesser the graphite amount the higher is the resistance.
- The mixture is compressed in the form of a cylindrical rod.
- The ends of this rod are joined to silver plated end caps with leads of tinned copper wires for soldering its connection into circuit.
- The whole resistor is moulded in a plastic case with coloured bands for specifying its resistance.
- Such resistors are available in values ranging from a few ohms to about 20MΩ.

- The drawback of these resistors is that they develop electric noise when the current passes from one carbon particle to another carbon particle.
- These resistors are used where low cost is main consideration rather than performance requirements.



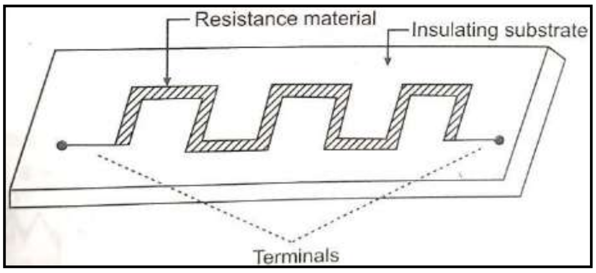
2. WIRE-WOUND RESISTORS:

- The wire wound resistors are manufactured by winding a resistance wire around an insulating hollow cylindrical core.
- The wires of materials such as constantan (60% copper, 40% nickel) and manganin are used.
- These materials have high resistivities and low temperature coefficients.
- The length and resistivity of the resistance wire determines the resistance value.
- The completed wire wound resistor is coated with an insulating material.
- The range of resistance values of wire wound resistors varies from 1Ω to 1MΩ.
- The resistors are available in power rating from 5W to several hundred watts.
- The main advantage of these types of resistors is the resistivity and size can be carefully controlled due to the adjustment of wire's length.
- The main drawback of wire wound resistors is the inductance which arises due to winding, like coil-structure.



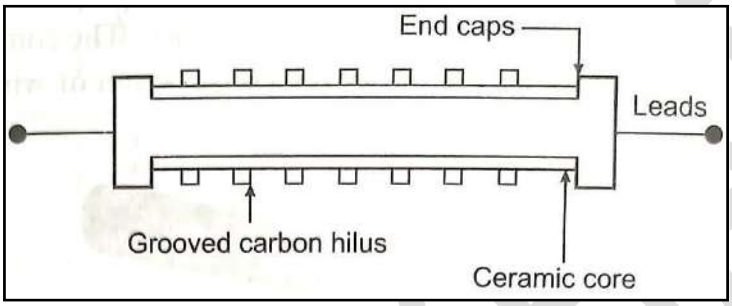
3. METAL FILM RESISTORS:

- The metal film resistors are also called as thin film resistors.
- They are constructed by deposing a thin metal coating on an insulating substance (Glass, Ceramic).
- The resistance is determined by the thickness of the film.
- The metal film resistors can range in values up to 10,000 MΩ.
- The main advantage of metal film resistors is low temperature coefficient and very low noise, high accuracy.



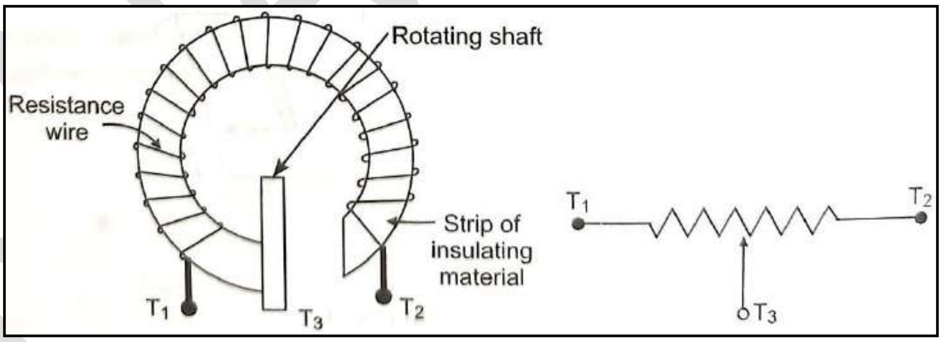
4. CARBON RESISTORS:

- The carbon film resistors are constructed by depositing a thin film of carbon on ceramic rod or core.
- The layer thickness or by cutting helical grooves of suitable pitch along its length.
- Contact caps are fitted at both the ends.
- The lead wires made of tinned copper are then soldered on both ends.
- Carbon film resistors give smaller values of resistance and low tolerance in comparison to metal film resistors.
- They possess a mildly negative temperature coefficient which is useful in certain electronic circuits.



2. VARIABLE RESISTORS:

- The resistors whose resistance can be changed between zero and a certain maximum value.
- They are used in electronic circuits to adjust the values of voltages and currents.
- They used as volume control in radio and brightness control in television.
- They can be wire wound and carbon type.
- A variable wire-wound resistor is made of a resistance wire usually copper wire for low resistance and nickel-chromium wire for high resistance wound on a ceramic core which is covered with insulating coating.
- The strip is bent round a cylindrical surface as shown in figure.



- An adjustable sliding arm rotates along the wire and make electric contact with the wire.
- The terminals T_1 and T_2 represent the end points of wire and terminal T_3 represents the adjustable point.
- If the rotating shaft moves towards the terminal T_2, then the resistance between T_1 and T_3 increases.
- If the rotating shaft moves towards the terminal T_1, then the resistance between T_2 and T_3 decreases.
- It may be noted that wire-wound resistors are not used for continuously variable control.

- They are 'preset' at a given value and that the value for an extended period of operation.
- They are available with resistance values ranging from 1 Ω to 150 KΩ.
- It is used as a gain control element in an amplifier and as brightness and contrast controls in TV receivers.
- Carbon variable resistors with resistance values ranging from 1 KΩ to 5 MΩ.
- These controls are used often combined with an OFF-ON switch and volume control of a radio receiver.

COLOR CODING:

2. Explain the colour codings in resistors? (5M)

- Resistors are coded to indicate the resistance value and tolerance.
- The colour bands are painted on one end of the resistor casing.
- The system of representing the resistor value is called colour coding.
- There are four colour bands A, B, C and D or 1, 2, 3 and 4 starting from left end on the resistor.
- The first two bands represent the first and second significant digits of the resistance value.
- The third band is the multiplier and represents the number of zeros that follows the second digit.
- The tolerance is given by the fourth band.

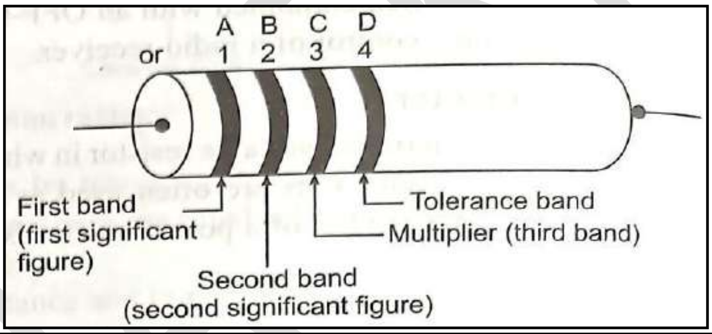


Table 1. Colour code for resistance designation

Colour	Ist band (First significant digit)	2nd band (Second significant digit)	3rd band (Multiplier)	4th band (Tolerance)
Black	0	0	$\times 1 = 10^0$	—
Brown	1	1	$\times 10 = 10^1$	$\pm 1\%$
Red	2	2	$\times 100 = 10^2$	$\pm 2\%$
Orange	3	3	$\times 1000 = 10^3$	—
Yellow	4	4	$\times 10{,}000 = 10^4$	—
Green	5	5	$\times 100000 = 10^5$	—
Blue	6	6	$\times 1000000 = 10^6$	—
Violet	7	7	$\times 10000000 = 10^7$	—
Gray	8	8	—	—
White	9	9	—	—
Gold	—	—	$0.1 = 10^{-1}$	$\pm 5\%$
Silver	—	—	—	$\pm 10\%$
No colour	—	—	—	$\pm 20\%$

EXAMPLE 1 *Determine the resistance and tolerance ratings for the following colour code : Yellow, Violet, Black and Gold*

Solution : In this case, we have

Yellow	Violet	Black	Gold
↓	↓	↓	↓
4	7	1	±5%

∴ Resistance value $= 47 \times 1 = 47\ \Omega \pm 5\%$

EXAMPLE 2 *Determine the resistane rating for the following colour code : Brown, Black, Yellow, No colour*

Solution : In this case, we have

Brown	Black	Yellow	No colour
↓	↓	↓	↓
1	0	10,000	±20%

∴ Resistance value $= 10 \times 10{,}000 = 10 \times 10^4 \pm 20\% = 100\ k\Omega \pm 20\%$

EXAMPLE 3 *A resistor has the following colour band sequence : Orange, Orange, Gold, Gold*
Find the range in which its value must lie so as to satisfy the manufacturer's tolerance.

Solution : In this case, we have

Orange	Orange	Gold	Gold
3	3	$10^{-1} = 0.1$	±5%

∴ Value of reistance $= 33 \times 10^{-1} = 3.3\ \Omega$

Tolerance $= \pm 5\%$

Now 5% of $3.3\ \Omega = \frac{5}{100} \times 3.3 = 0.165\ \Omega$

Therefore, upper range of resistance $= 3.3 + 0.165 = 3.465\ \Omega$

Lower range of resistance $= 3.3 - 0.165 = 3.135\ \Omega$

EXAMPLE 4 *Specify the colour code for the following resistor* $56\ k\Omega \pm 20\%$.

Solution :	First digit	Second digit	Multiplier	Tolerance
	5	6	10^3	±20%
Colour	Green	Blue	Orange	Plain

Thus the colour code for $56\ k\Omega \pm 20\%$ is green, blue and orange.

EXAMPLE 5 *Specify the colour code for* $2.7\ k\Omega \pm 10\% = 2700\ \Omega$ *resistor.*

Solution :	2	7	×100	±10%
Colour	Red	Violet	Red	Silver

Thus the colour code for resistor $2.7\ k\Omega \pm 10\%$ is red, violet, red and silver.

APPLICATIONS OF A RESISTOR AS A HEATING ELEMENT IN HEATERS AND AS A FUSE ELEMENT:

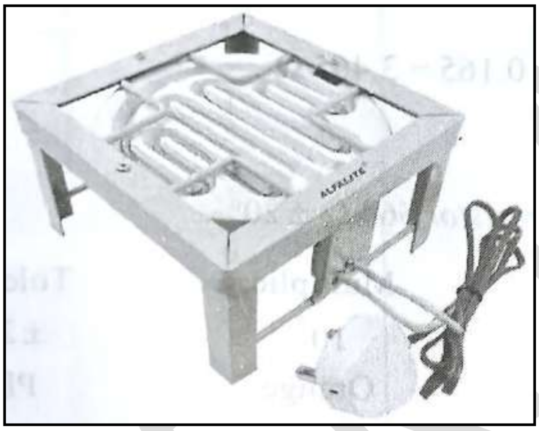
3. Explain the applications of a resistor as a heating element in heaters and as a fuse element? (10M&5M)

- An electric current flow through a conductor, the electrical energy is expended in overcoming resistance between the electrons and the molecules of the wire.
- According to law of conservation of energy, the electrical energy is converted into heat energy.

- They are two applications of a resistor.

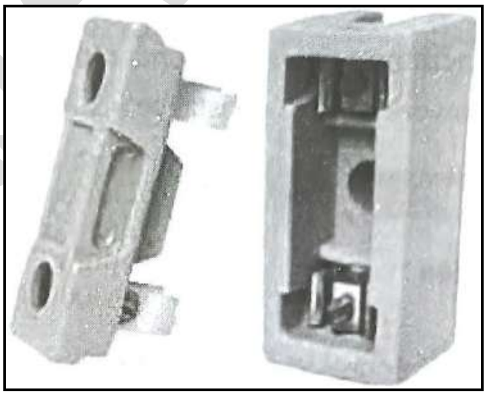
1. ELECTRIC HEATER:

- Power resistors are generally used in heater applications.
- They allow a designer to apply and control heat.
- Riedon offers a board range of theses resistors.
- Riedon power resistors are used in a variety of heater applications.
- They are very useful in situations where heat must be concentrated in small area.
- Power resistors dissipate the heat generated by current flow through the resistance.
- The heat is then transferred to the surrounding environment.
- The electrical heater is shown in figure.



2. ELECTRIC FUSE:

- A proper resistor is used as a fuse in electrical circuits.
- When there is a short circuit in the electric circuit or an excess current flow in the circuit, the resistor used as a fuse burns due to heating effect.
- So the current fuses are simplest devices to protect a circuit.
- The resistors with fusing function protect the equipment or parts from burning by breaking.

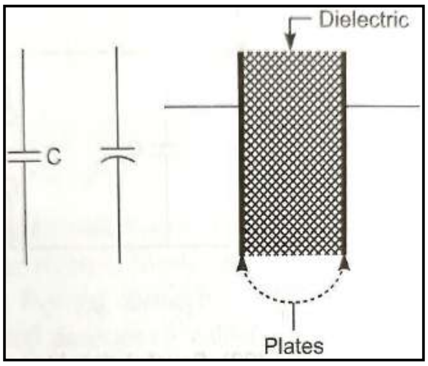


CAPACITOR:

4. What is capacitor? Explain the types of capacitors? (10M)

- A device which can store considerable amount of charge is called as condenser or capacitor.
- It is defined as a physical device which capable of storing energy by virtue of the voltage existing across it.
- The voltage applied across the capacitor sets up an electric field, the energy is stored in an electric field.

- A capacitor consists of two conducting plates separating by an insulating medium called dielectric as shown in figure.



- The capacitance is the ratio of the magnitude of charge q on either conductor to the potential V between them.
- The capacitance of a single isolated conductor is given by,

$$C = q/V$$

- The unit of capacitance is farad. ($\therefore$ 1 μf = 10^{-6} farad, 1 pf = 10^{-12} farad)

TYPES OF CAPACITORS:

- They are divided into two general categories.
  1. Fixed capacitors 2. Variable capacitors

1. FIXED CAPACITORS:

- The fixed capacitors are divided into two classes.
  1. Non-electrolytic capacitors 2. Electrolytic capacitors

1. NON-ELECTROLYTIC CAPACITORS:

- They can be connected in either direction in a circuit.
- They include paper, mica, ceramic and plastic film capacitors.

i. PAPER CAPACITORS:

- These capacitors are widely used.
- It consists of two tinfoil sheets which are separated by thin sheet of tissue paper.
- The foil and the paper are rolled into a cylindrical shape.
- This is sealed in a paper tube or in a plastic capsule.
- The leads are connected to each tinfoil and taken out at each end.
- Paper capacitors have a capacitance range from 0.001 μF to 2.0 μF.
- They can be designed to very high voltage 2000V.

ii. MICA CAPACITORS:

- Mica capacitor is several thin metal plates separated by thin sheets of mica.
- Alternate plates are connected together and leads are attached from outside.
- The total assembly is encased in a plastic or Bakelite case.
- Mica is a transparent, high dielectric strength mineral and can easily formed into uniform sheets as thin 0.0025mm.
- It has a very high breakdown voltage.
- The capacitors have small capacitance values 50 to 500pF.
- They are extensively used in radio circuits.

iii. CERAMIC CAPACITORS:

- The ceramic capacitors may be manufactured in the form of disc, hollow tubular or rectangular shaped plate.

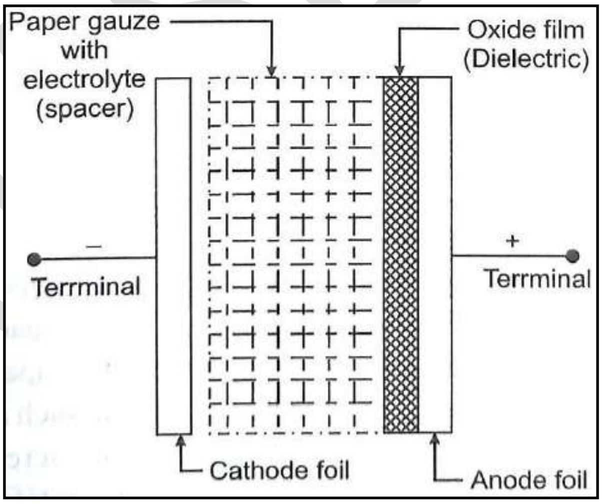
- A ceramic material such as titanium dioxide and barium titanate is taken in the form of a disc which acts as a dielectric.
- The disc is coated with silver compound on both sides which act as capacitor plates.
- The whole unit in a moisture proof coating.
- The capacitance range of these capacitors from 100 pF to 0.01 μF.

iv. PLASTIC FILM CAPACITORS:

- Plastic film capacitors are constructed in the same way as paper capacitors except that a thin sheet of plastic (Mylar, Teflon or Polystyrene).
- This dielectric improves the properties of the capacitor by minimizing leakage currents even at temperatures upto 150-200^{0}C.
- These capacitors have excellent stability, high insulation resistance and low temperature coefficient.

2. ELECTROLYTIC CAPACITORS:

- These capacitors are also called as polarized capacitors.
- They are designed for D.C. voltages only and electrodes are marked as positive or negative.
- The capacitor is connected in reverse way the capacitor will be damaged.
- Certain metals like aluminium, tantalum, and bismuth are used to form anode and cathode foils.
- The electrolytic capacitors have largest capacitance values per volume of element.
- The main drawback is that they possess very large leakage current.
- They are used only in special applications. Ex: transistor circuits.
- These capacitors are available in values raging from 1 μF to 5,00,000 μF.



2. VARIABLE CAPACITORS:

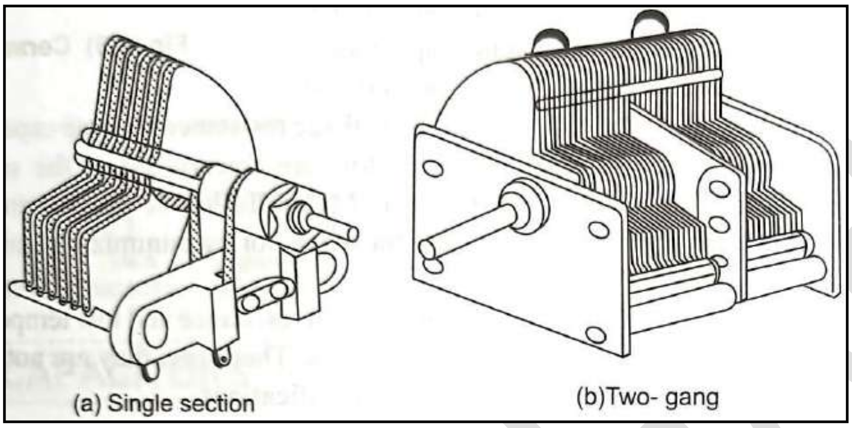
- They are divided classified into two general categories.

  1. Air gang capacitor 2. Trimmer

i. AIR GANG CAPACITOR:

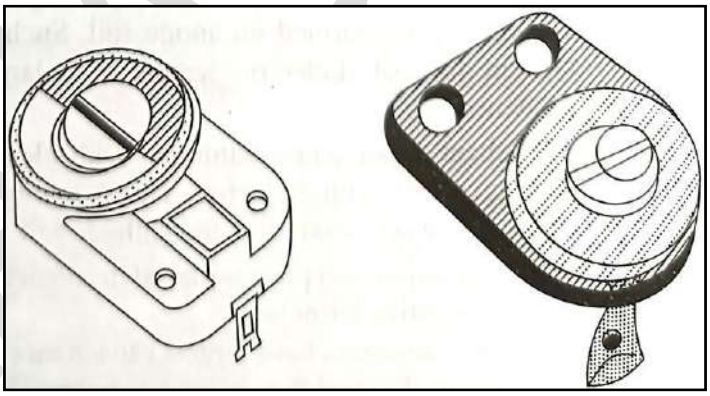
- This is most commonly used type of variable capacitors.
- The schematic of air-gang capacitor shown in fig.
- It consists of two sets of plates separated from each other by air.
- These plates are in the shape of half discs.
- One set of plates is fixed and is called stator.
- The other set of plates is connected to a shaft which can be rotated. It is called rotor.

- This set of plates can be moved in or out of fixed set of plates with the help of a knob attached to the shaft.
- When the rotor is moved in out the stator, the capacitance value varies.
- The capacitance is maximum when the moving plates are completely in and minimum when the moving plates are completely out.
- When two or more capacitors are operated by a single shaft it is called ganged capacitor.



ii. TRIMMER:

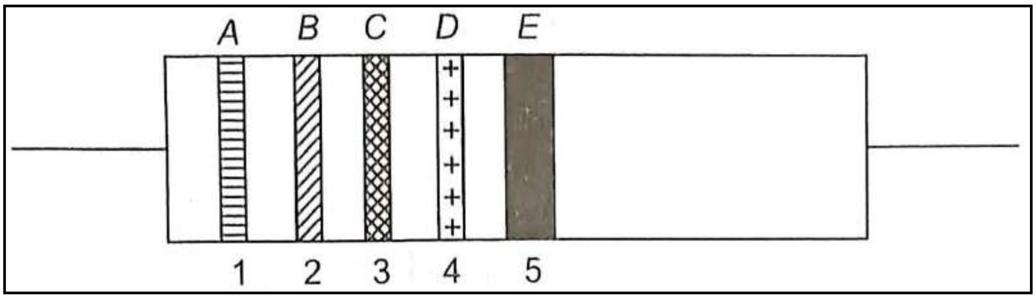
- These capacitors are variable capacitors which are exclusively used for making fine adjustments on the total capacitance of a device.
- A trimmer consists of two small flexible metal plates separated by a dielectric such as air, mica, plastic or ceramic.
- The spacing between the plates can be changed by means of screw adjustment.
- When the screw is rotated inwards, the plates are compressed and its capacitance is increased.
- This can be adjusted over a range from 10pF to 500pF.
- They are available in a number of shapes, some ceramic type shapes are shown in fig.



COLOR CODING:

5. Explain the colour codings of capacitors? (5M)

- The colour coding technique of capacitor is similar to resistor.



Colour	Strip 1	Strip 2	Multiplier (3)
Black	0	0	1 pF
Brown	1	1	—
Red	2	2	—
Orange	3	3	0.001 μF
Yellow	4	4	0.010 μF
Green	5	5	0.10 μF
Blue	6	6	—
Violet	7	7	—
Gray	8	8	0.01 pF
White	9	9	0.1 pF

Tolerance (4)		
Colour	$C > 10$ pF	$C < 10$ pF
White	±10%	—
Black	±20%	—
Green	±5%	—
Red	±2%	±0.5%
Brown	±1%	±0.25%

Operating voltage (5)	
Colour	V_{dc} (volts)
Brown	100
Red	250
Yellow	400
Blue	630

ENERGY STORED IN A CAPACITOR:

6. Explain the energy stored in a capacitor? **(10M)**

- The energy of a charged capacitor is the amount of work done in charging.
- A charged capacitor stores an electric potential energy.
- The energy can be recovered when the capacitor is allowed to discharge.
- When the charging of the capacitor is done by a battery, then the electrical energy stored in it expense of chemical energy of the battery.
- Consider a capacitor of capacitance 'C' and carrying a charge 'q' at any instant.
- The potential difference between the plates is V. Then,

V = q/C

If an additional charge dq is to be given to this capacitor then some work must be done against the potential difference.

So, work done in increasing charge by dq is given by

$$dW = V\,dq = \left(\frac{q}{C}\right) dq \qquad \ldots(2)$$

$\therefore$ Total work to charge a capacitor to a charge q_0

$$W = \int dW = \int_0^{q_0} \left(\frac{q}{C}\right) dq = \frac{q_0^{\,2}}{2C} \qquad \ldots(3)$$

Now the energy stored by a charged capacitor

$$U = W = \frac{1}{2}\frac{q^2}{C} = \frac{1}{2} C V^2 \qquad (\because\ q = CV) \qquad \ldots(4)$$

For a parallel plate capacitor of area A and plate separation d, the capacitance C is given by

$$C = \frac{\varepsilon_0 A}{d} \quad \text{and} \quad V = E\,d$$

$$\therefore \quad \text{Energy stored, } U = \frac{1}{2} \times \frac{\varepsilon_0 A}{d} \times E^2 d^2 = \frac{1}{2} \varepsilon_0 E^2 A\,d \text{ joule} \qquad \ldots(5)$$

Energy stored per unit volume

$$U = \frac{1}{2}\varepsilon_0 E^2 \text{ joule/m}^2 \quad \ldots(6)$$

If the capacitor is placed in a medium of dielectric constant k, then the energy stored per unit volume is given by

$$U = \frac{1}{2}k\varepsilon_0 E^2 = \frac{1}{2}\varepsilon E^2$$

$$\therefore \quad U = \frac{\varepsilon E^2}{2} \quad \ldots(7)$$

where ε is the permittivity of the medium.

IMPORTANT POINTS:

- The energy of a charged condenser is stored in the medium present between its plates.
- The energy is stored in the form of electric field.
- The work done in charging a condenser is stored up in the form of electric potential energy.
- Energy stored, **$U = q_0^2/2C = CV^2/2$**

EXAMPLE 1 *The capacity of a parallel plate condenser is 0.2 μF and potential difference between the plates is 2 volt. Calculate the energy stored by the charged condenser.*

Solution Energy stored $U = \frac{1}{2}CV^2$

Given that, $C = 0.2\,\mu F = 0.2 \times 10^{-6}$ F and $V = 2$ volt

$$\therefore \quad U = \frac{1}{2} \times (0.2 \times 10^{-6}) \times (2)^2 = \mathbf{4 \times 10^{-7}\ J}$$

EXAMPLE 2 *Two capacitors 5 μF, 10 μF are connected in parallel to a voltage source of 15 V. Calculate total amount of energy stored by the two capacitors.*

Solution

$$C = C_1 + C_2 = 5 + 10 = 15\,\mu F = 15 \times 10^{-6}\ F$$

$$U = \frac{1}{2}CV^2 = \frac{1}{2} \times (15 \times 10^{-6}) \times (15)^2$$

$$= 1687.5 \times 10^{-6}\ J$$

$$= \mathbf{1.6875 \times 10^{-3}\ J}$$

APPLICATIONS OF CAPACITOR IN POWER SUPPLIES, MOTORS (FANS):

7. Write the applications of capacitor in power supplies? (10M)

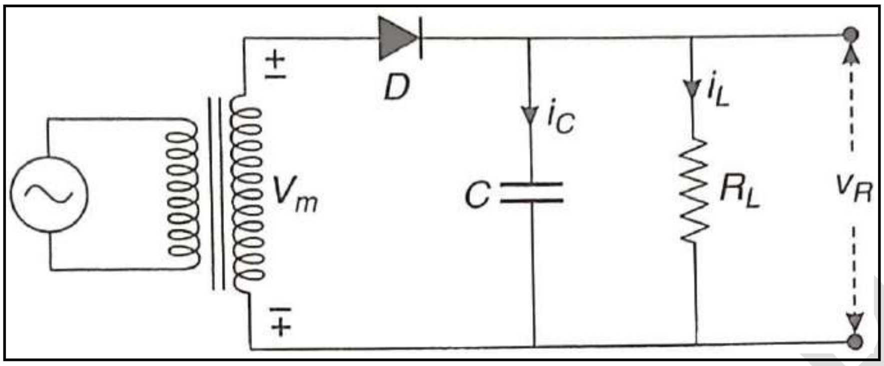
- Capacitor in power supplies are identified in rectifiers.
- There are two types of rectifiers.

  1. Half-wave rectifier 2. Full-wave rectifier

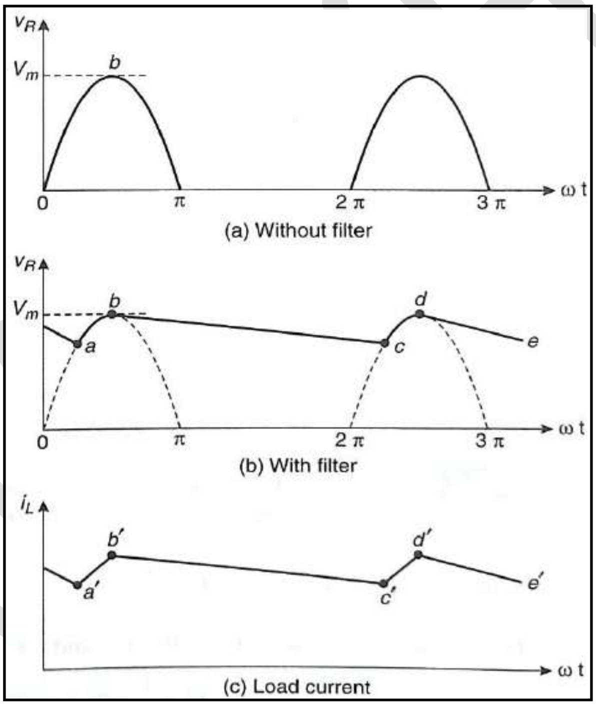
1. HALF-WAVE RECTIFIER WITH CAPACITOR FILTER:

- The half wave rectifier with a capacitor filter is shown in figure.
- The positive half cycle of A.C input, the diode D is forward biased.
- The condenser C to a voltage V_m there is no resistance in the charging path.
- When the condenser is fully charged, it holds the charge till input A.C supply to the rectifier goes negative.
- During negative half cycle, the diode D is reversed biased, it does not conduct.

- The capacitor discharges through R_L from point b to point c shown in figure (b).
- The voltage of condenser decreases slightly, during the negative half cycle the condenser maintains sufficient large voltage across R_L shown in figure.

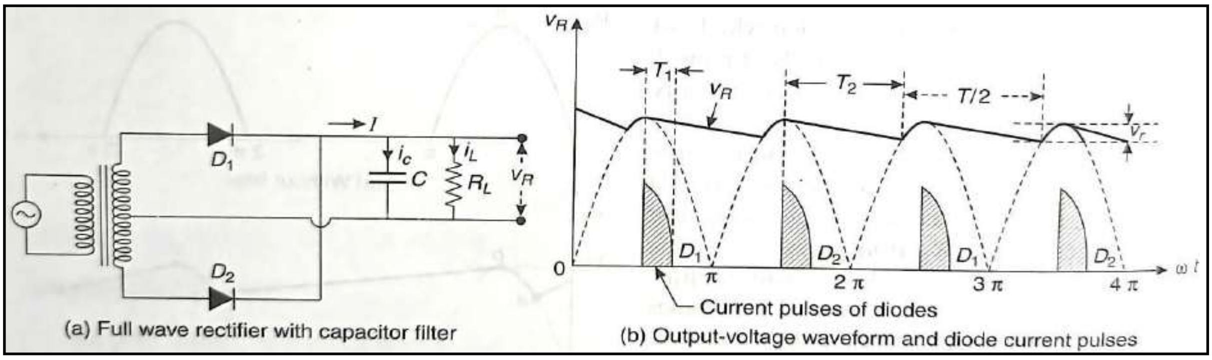


- The positive half cycle, the capacitor voltage increases from point d to V_m.
- The process is repeated load voltage variation with a.c. voltage.
- The conduction starts is called cut-in point and conduction stops is called cut-out point.
- In these points the diode current flows and diode output voltage is greater than the capacitor voltage. The diode acts as a switch.



2. FULL-WAVE RECTIFIER WITH CAPACITOR FILTER:

- The analysis of full wave rectifier with a capacitor filter is extension of half wave circuit.
- The circuit of a full wave rectifier with capacitor filter shown in figure (a&b).
- The output voltage waveform and diode current pulses.



INDUCTOR:

8. What is inductor? Explain the types of inductors? (10M)

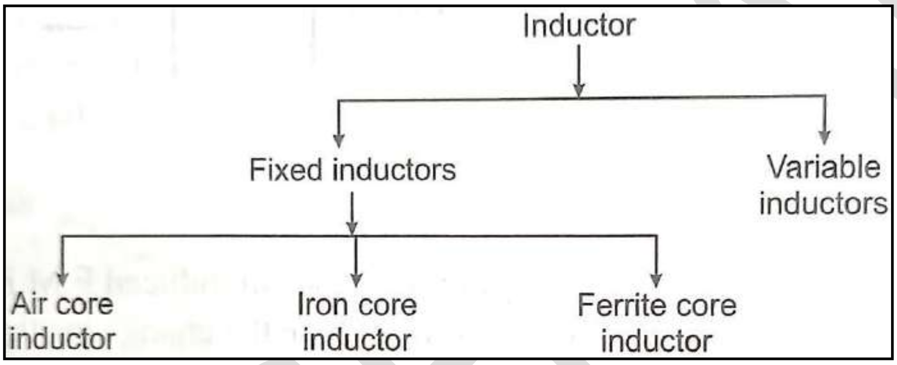
- When a current is passed through a conductor, the lines of magnetic flux are generated around it. This magnetic flux opposes any change in current due to induced e.m.f.
- The opposition to change in current is known as inductance.
- The component which produces inductance is known as inductor.
- The induced e.m.f (e) in an inductor is given by,

$$e = -L\left(\frac{dI}{dt}\right)$$

- Where L= Inductance in henry, dI/dt = Rate of change of current

TYPES OF INDUCTORS:

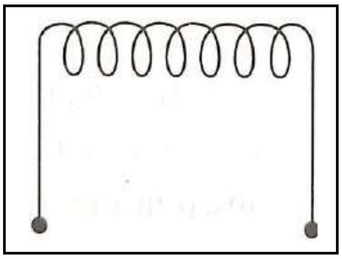
- The inductors are divided into two types. They are



1. FIXED INDUCTORS:

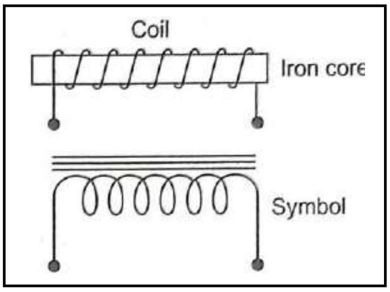
- The fixed inductors are classified into three types. They are,

i. AIR CORE INDUCTOR:



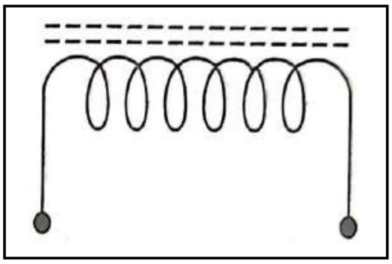
- This inductor is made of a number of turns wound on a non-ferrous material as ordinary cardboard shown in figure.
- There is air inside the coil so it is called air core inductor.
- This inductor has low inductance, they are suitable for high frequency (R.F) applications.

ii. IRON CORE INDUCTORS:



- The inductor is made of a coil of wire wound over a solid iron core shown in figure.
- By putting iron inside the inductor, the inductance is increased.
- To avoid eddy current loss, iron core is laminated consists of thin iron laminations pressed together.
- Such an inductor is called as a choke.

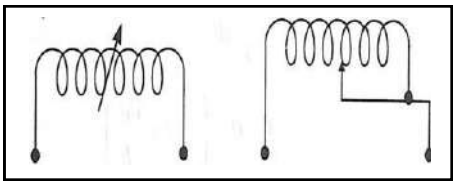
iii. FERRITE CORE INDUCTORS:



- A ferrite is an insulator having very high permeability.
- This inductor consists of a coil of wire wound on a ferrite core.
- The ferrite core has minimum eddy current loss even at high frequencies is shown in figure.

2. VARIABLE INDUCTORS:

- It is required to vary the inductance from a minimum value to a maximum value.
- These inductors are similar to fixed ferrite-core inductors but the core is adjustable.
- A variable inductor is made of a long coil wound on a ferrite core provided with a slider contact shown in figure.

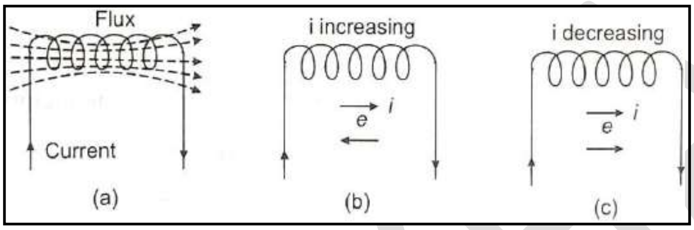


- The slider contact can be used to vary the inductance of the coil.

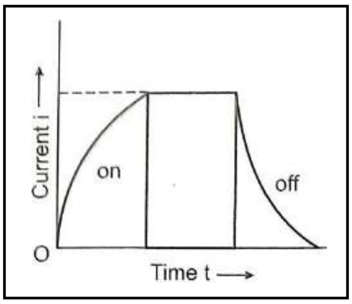
EMF INDUCED IN AN INDUCTOR:

9. Explain the e.m.f induced in an inductor? (5M)

- When a current flows in a coil, magnetic field is developed in it as shown in figure.



- If the current passing through the coil changes with time, an induced e.m.f is set up in the coil.
- Lenz's law, the direction of induced e.m.f as to oppose the change in current.
- When the current is increasing, the induced e.m.f is against the current.
- When the current is decreasing, it is in the direction of current.
- The induced e.m.f opposes any change of the original current.
- This phenomenon is called self induction.
- The property of the circuit by any change in the magnetic flux linked with it, induces an e.m.f is called inductance.
- The induced e.m.f is called back e.m.f.
- When the current in a coil is switched on, self induction opposes the growth of the current.
- When current is switched off, the self induction opposes the decay of current shown.



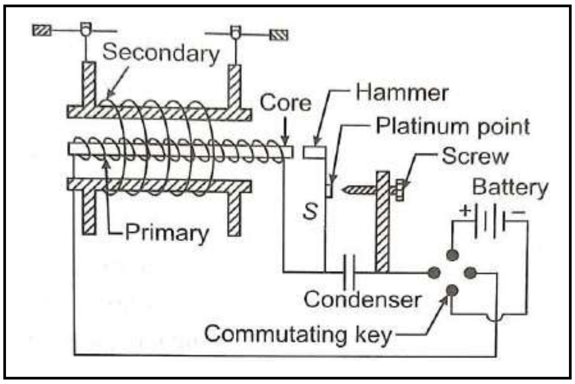
APPLICATIONS OF INDUCTOR:

10. Write the application of inductor? (10M)

- Induction coil is a device used for transforming low potential between terminals of a primary coil into a high voltage between the terminals of a secondary coil.
- It works on the principle of mutual induction shown in figure.

CONSTRUCTION:

- Primary coil consists of insulated copper wire wound on a soft iron core.
- One end of the core projects outside the coil and opposite end a hammer fixed to the upper end of a metallic spring is placed.
- Secondary coil consists of insulated copper wire wound over the primary coil but separated.



- Between the two layers of secondary some insulating material such as mica or wax is placed.
- It is an arrangement of making and breaking the primary circuit is provided by the screw and hammer called interrupter.
- The heavy current is provided by the battery and changing the direction of the current commutating key is used.

WORKING:

- The screw is adjusted it makes a clear contact with the platinum point.
- When the current is put in the primary coil, the soft iron core is magnetised and hammer is attracted towards the iron core.
- The hammer is attracted by the core the contact between the platinum point and screw is broken and the current in the primary is stopped.
- The iron core is demagnetized and the attracting force on the hammer disappears.
- The spring brings back the hammer again in contact with the platinum point and again currents starts flowing in primary coil.
- In this way in primary coil if current is set once it flow through primary frequency depends upon the strength.
- The number of force linked with secondary increases and an inverse e.m.f is produced in the secondary coil.
- When the circuit is broken off, the magnetic flux linked with the secondary coil decreases induced e.m.f is produced.
- When current in the primary circuit is broken off an induced e.m.f is developed in due to self induction.
- The efficiency of the coil increases we place a condenser in parallel with contact breaker of the primary circuit.
- The current in the primary increases due to self inductance, an induced e.m.f in the opposite direction is produced which decreases the current in primary.

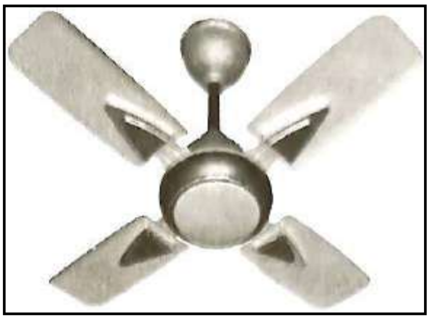
APPLICATION OF CHOKE IN A FAN AND IN A RADIO TUNING CIRCUIT:

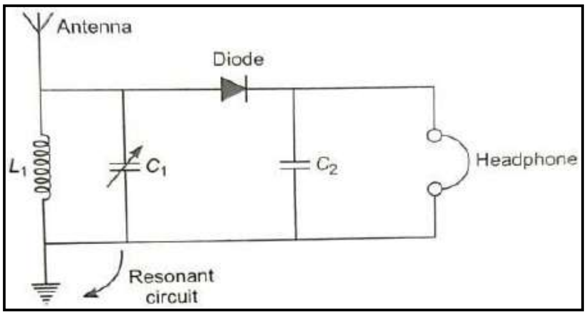
11. Explain the application of choke in a fan and a radio tuning circuit? (10M)

- Choke is a passive device that adds inductance to a circuit.
- When the current flowing through the coil increases, the magnetic field of the coil produces a voltage or e.m.f.

A CHOKE IS USED IN A FAN:

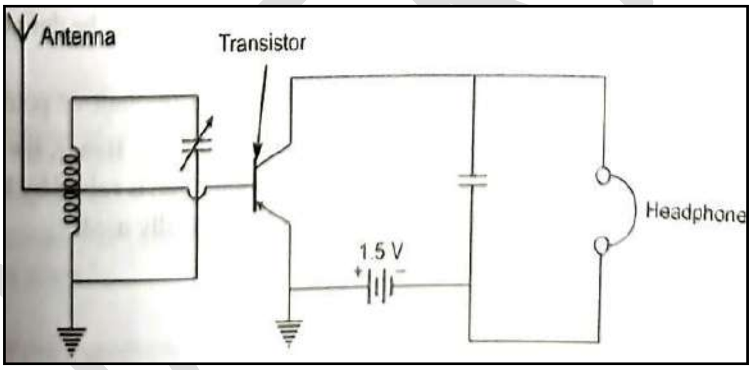
- The principle of working of a ceiling fan has a motor.
- The motor converts the electric energy to mechanical energy.
- The capacitor of the ceiling fan torques up the electric motor.
- This causes the motor to start and run.
- The electric current reaches the motor, it enters in coils of wire that are wrapped around a metal box.
- When the current passes through the wire, it creates a magnetic field exerts force in clockwise motion.
- The electric energy is converted into mechanical energy, this causes motor coils to spin.
- The blades attached to the motor start rotating shown in figure.
- This is used in resonant circuit as shown in figure.





A CHOKE IS USED IN A RADIO TUNING CIRCUIT:

- The circuit consists of antenna grounded system, tank circuit, peak detector and head-phone.
- The antenna absorbs transmitted radio signals.
- The radio signals flow to the ground via other components.
- The combination L_1 and C_1 comprise a resonant circuit. This circuit is called tank circuit.
- The function of resonant circuit is to select a particular signal received from many signals received by antenna.
- The diode passes the positive half cycles of the R.F removing the half negative cycle.
- The capacitor C_2 sized to filter the radio frequencies from the R.F envelope and passes audio frequencies.
- Finally, signal is transmitted to headset is shown in figure.

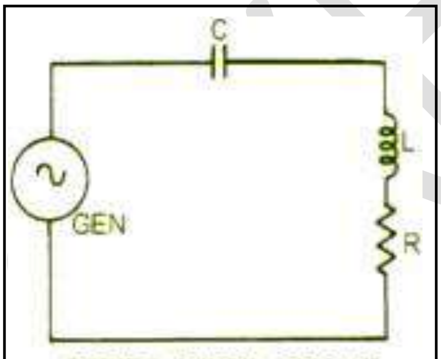


SERIES RESONANCE CIRCUIT AS A RADIO TUNING CIRCUIT:

12. Explain the series resonance circuit as a radio tuning circuit? (10M)

- A very important circuit used in a wide variety of electrical and electronic systems (Radio & Television tuners) is called the resonant (or) tuned circuit.
- The resonant electrical circuit must have both inductance and capacitance.
- When resonance occurs due to the application of the proper frequency.
- The energy absorbed by one reactive element is the same as that released by another reactive element.
- When a radio or television set is turned on, many events take place within the "receiver" before we hear the sound or see the picture sent by the transmitting station.
- A tuned circuit consists of a coil and a capacitor connected in series or parallel.
- The frequency applied to an LCR circuit causes XL and XC to be equal and the circuit is resonant.
- If XL and XC are equal only at one frequency is called resonant frequency.
- The principle that enables tuned circuits in the radio receiver to select one particular frequency and reject all other.

- The basic tuned circuit consists of a coil and a capacitor connected either in series shown in figure.
- The resistance in the circuit is usually limited to the particularly resistance of the coil.
- In series resonant circuit, the frequency $f = 1/2\pi \sqrt{LC}$.
- When the circuits are in resonance, the impedance of the circuit is at a minimum and is equal to the circuit resistance.
- The current flowing in the circuit is at its highest possible point and in phase with the applied voltage.
- The circuit acts as a purely resistive circuit.
- The voltage across the inductance is equal to the voltage across the capacitance and is relatively high.
- These e.m.f's have opposite polarity and the resultant voltage is zero.
- The circuit will operate the voltage ratings of the coils and capacitors must be carefully selected.
- The series resonant circuit is in a state of resonance when the inductive reactance and the capacitive reactance are exactly equal.



SERIES TUNED CIRCUIT

UNIT - II

POWER SOURCES (BATTERIES)

TYPES OF POWER SOURCES-DC & AC SOURCES:

1. Write the types of power sources? (5M)

- The power sources are divided into two types,
  1. A.C. power sources 2. D.C. Power sources
- A.C. power supply is a type of power supply used to supply alternating current power to a load.
- The power input may be in A.C. or D.C. form.
- Alternating current is a form of electricity in which the flow of electric current periodically reverses direction.
- The voltage also changes with time.
- A.C. generator is generates A.C current by the principle of electromagnetic induction.
- Direct current is a form of electricity in which the flow of electric current in specified direction.
- The voltage also constant with time.
- D.C. generator is generates D.C current by the principle of electromagnetic induction.

DIFFERENT TYPES OF BATTERIES:

2. Write the different types of batteries? (5M)

- A battery consists of two more cells connected in series or parallel or both.
- The cells are two types,
  1. Primary cells 2. Secondary cells

1. PRIMARY CELLS:

- The reactions in primary cells are irreversible.
- The generation electrical energy, consumes materials which cannot recharging.
- The primary cells cannot be recharged back its original conditions.

2. SECONDARY CELLS:

- In these batteries, the chemical reactions are reversible.
- After discharge, these can be restored to original conditions by passing an electric current in opposite direction.
- There are a number of rechargeable batteries.
  1. Lead acid batteries
  2. Nickel-metal hydride batteries
  3. Lithium-ion batteries
  4. Lithium polymer batteries

RECHARGEABLE BATTERIES:

3. Explain the working of rechargeable batteries? (10M&5M)

- A rechargeable battery is a type of electrical battery which can be charged many times after discharging into a load.
- It is composed of one or more electrochemical cells.
- It stores energy through a reversible electrochemical reaction.
- They have many different shapes and sizes.
- In primary cells, positive and negative electrodes are known as cathode and anode.

- In rechargeable cells, the positive electrode is cathode on discharge and anode on charge.
- The active components in secondary cell are chemicals that make the positive and negative materials and the electrode.
- The positive electrode exhibits a reduction potential and negative electrodes shows an oxidation potential.
- The sum of the potentials from these half reactions is standard cell potential or voltage.
- During charging, the positive active material is oxidized and produces electrons.
- The negative material is reduced, consuming electrons.
- The electrons constitute the current flow in the external circuit.
- The electrolyte may buffer for internal ion flow between electrodes as in Lithium-ion and Nickel-cadmium cells.
- The energy comes from a battery charger using A.C mains electricity.
- The voltage source must be higher than that of battery to force current to flow into the battery.
- It should not be too much to damage the battery.
- If a cell is brought to a fully discharged state, this may damage.
- They are used in Automobile starters, Light vehicles, Road vehicles and Battery storage power stations.

LEAD ACID BATTERIES (OR) ACCUMULATORS:

4. Explain the construction and working of lead acid batteries? (10M)

- Lead acid battery is a wet secondary cell.
- These batteries are mostly used for making automobile batteries.

CONSTURCTION:

- This accumulator was first discovered by Planet in 1859.
- The electrodes of litharge PbO, dipped in dilute solution of H_2SO_4.
- On charging the accumulator one plate becomes oxidized and other reduced.
- On repeated charging the layer of spongy lead becomes thicker and increasing the storage capacity of the cell.
- Initial charging the positive plate was PbO_2 and the negative plate of spongy lead.
- Lead peroxide and spongy lead form the positive and negative active materials of a fully charged acid cell.
- The supports are given to the plates which are made of pure lead or alloy of lead and antimony.
- The plates (cathode and anode) are immersed in a solution of dilute sulphuric acid (electrolyte).
- The containers of these batteries are made of glass, hard rubber or ceramic materials of moulded plastic.

CHARGING THE CELL:

- When a current is passed it is followed by the evolution of hydrogen at the cathode lead colour remains unchanged.
- The anode becomes dark brown in colour, due to the formation of lead peroxide on it.
- The hydrogen ions being positively charged move towards the cathode and oxygen ions being negatively charged move towards the anode.

DISCHARGING THE CELL:

- The external supply is disconnection the anode and cathode are connected through a resistance.
- A current will flow in the direction opposite to the direction in which current flows during the charging process.
- The rate of discharge will depend upon the resistance.
- During the discharge process the positive H^+ ions of sulphuric acid move towards anode and negative SO_4^{--} ions move towards the cathode.

$$H_2SO_4 \rightarrow 2H^+ + SO_4^{--}$$

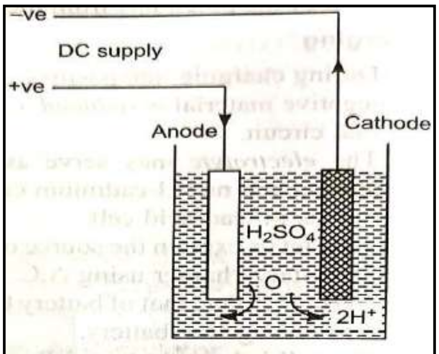


Fig. (1) Initial charging

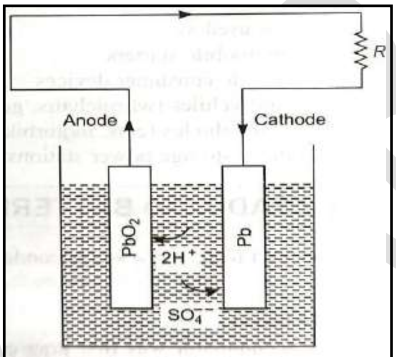


Fig. (2) Discharging

RECHARGING THE CELL:

- The cell can be again charged is called recharging.
- During recharging H^+ ions will be produced at the cathode and SO_4^{--} ions at the anode.

At the cathode

$$PbSO_4 + 2H^+ \longrightarrow Pb + H_2SO_4$$

At the anode

$$PbSO_4 + SO_4^{--} + 2H_2O \longrightarrow PbO_2 + 2H_2SO_4$$

- This charging result in the conversion of the anode to dark brown PbO_2 from lead sulphate layer on the cathode is reduced.

Efficiency of the Battery

1. *The Quantity or Ampere-Hour (AH) Efficiency* : *The ratio of the output to input is defined as the effeiciency.*

The efficiency can be measured in two units depending upon which input or output are measured. In case if the input or output is measured as the quantity of electricity, *i.e.*, ampere hour efficiency, thus

$$\textit{Quantity effiency } \eta_{AH} = \frac{\text{amp. hours of discharge}}{\text{amp. hours of charge}} \times 100$$

or

$$\eta_{AH} = \frac{I_d \times T_d}{I_c \times T_c} \times 100 \quad \ldots(1)$$

2. *Energy or Watt-Hour (W-H) Efficiency* : In case if the output and input are measured in units of energy, *i.e.*, watt hours, then efficiency is called energy efficiency or watt-hour efficiency. Hence, we have

$$\textit{Energy efficiency } \eta_{W-H} = \frac{\text{watt - hours of discharge}}{\text{watt - hours of charge}} \times 100 \quad \ldots(2)$$

$$\eta_{WH} = \frac{I_d \times T_d \times V_d}{I_c \times T_c \times V_c} \times 100$$

$$= \left(\frac{I_d \times T_d}{T_c \times T_c}\right) \times 100 \times \frac{V_d}{V_c}$$

$$= \eta_{AH} \times \frac{V_d}{V_c}$$

- The ampere-hour efficiency of this battery is form 90 to 96% and watt-hour efficiency is from 75 to 85%.

APPLICATIONS OF Li-ACID BATTERIES:

- For local lighting in generating for odd time of break down.
- Compensation for feeder drop.
- Preventive against shut down.
- For supplying the whole load during the period of minimum load.
- For supply the peak load during the period of maximum demand.

EXAMPLE *Calculate the ampere-hour and watt-hour efficiencies of a secondary cell having* 70 hour *charge rate of* 10 amp. *and delivery rate of* 5 amp. *for* 36 hours *with a mean terminal voltage of* 1.96 V. *The terminal voltage during charging has a mean value of* 2.35 V.

Solution We know that ampere-hour efficiency

$$\eta_{AH} = \frac{I_d\, T_d}{I_c \times T_c} \times 100$$

Given, I_d = Discharging current = 5 A T_d = Discharging period = 36 hours

I_c = Charging current = 10 A T_c = Charging period = 20 hours

$$\therefore \quad \eta_{AH} = \frac{5 \times 36}{10 \times 20} \times 100 = \mathbf{90\%}$$

The watt-hour efficiency is given by $\eta_{WH} = \eta_{AH} \times \frac{V_d}{V_c}$

Here, V_d = Discharging mean voltage = 1.96 V

and V_c = Charging mean voltage = 2.35 V

$$\therefore \quad \eta_{WH} = 90 \times \frac{1.96}{2.35} = \mathbf{75\%}$$

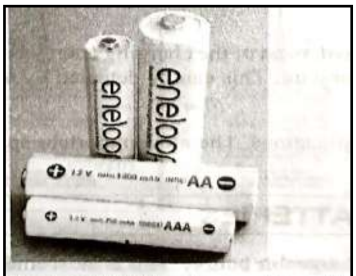
NI-MH BATTERIES:

5. Describe the construction and electrochemistry of Ni-MH battery? (10M)

- A nickel metal hydride battery is a type of rechargeable battery.
- In this cell the positive anode is a steel mesh coated with solid nickel hydroxide [$Ni(OH)_2$].
- The action material cadmium in powder form is pressed into perforated steel plates which then form the negative electrode of the cell.
- The electrolyte is potassium hydroxide.

CONSTRUCTION:

- The positive electrode is similar to nickel-cadmium cell (Ni-Cd) using nickel oxide hydroxide NiO (OH).
- The negative electrode is a hydrogen absorbing alloy instead of cadmium.
- The electrolyte is potassium hydroxide.
- Ni-MH batteries can have two or three times the capacity of Ni-Cd batteries of same size.
- A nickel-metal hydride battery is shown in figure.



Modern Ni-MH rechargeable cells

- They are typically used a substitute for similarly shaped non-rechargeable alkaline batteries.

ELECTROCHEMISRTY:

The reaction occurring at negative electorde is

$$H_2O + M + e^- \rightleftarrows OH^- + MH$$

The reaction on positive electrode is

$$Ni(OH)_2 + OH^- \rightleftarrows NiO(OH) + H_2O + e^-$$

Here nickel oxyhydroxide NiO(OH) is formed.
The reactions proceed left to right during charging and opposite during discharge.

CHARGING PROCESS:

- The following charges processes are used,

1. Trickle charging 2. ΔV charging 3. ΔT charging

1. TRICKLE CHARGING METHOD:

- A fixed low current with or without a timer is used that over-charging is safe at low currents.
- The Panasonic Ni-MH charging manual suggests that overcharging for a long time may damage the battery.

2. ΔV CHARGING METHOD:

- This method is monitor to change of voltage with time.
- When the battery is fully charged, the voltage across its terminals slightly drops.
- The charger detects this drop and stop charging.

3. ΔT CHARGING METHOD:

- When the cell is fully charged, most of the charging energy is converted into heat.
- The rate of change of battery temperature can be detected by a sensor as a thermistor.

APPLICATIONS:

- The most important applications are in consumer electronics and electric vehicles.

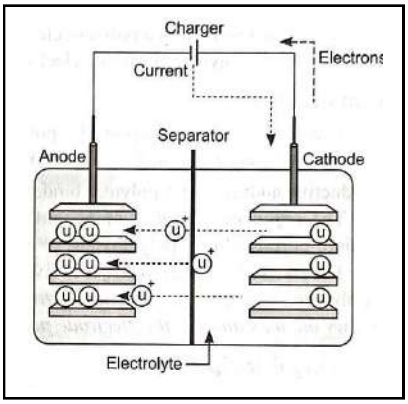
LI-ION BATTERIES:

6. Describe the construction and electrochemistry of Li-ion battery? (10M)

- Lithium-ion battery is rechargeable battery.
- The electrodes of a lithium-ion battery are made of light weight lithium and carbon.
- Lithium is highly reactive element a lot of energy can be stored in atomic bonds.

WORKING:

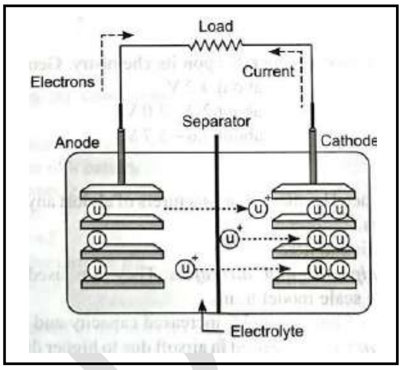
CHARGING:



- During charging, an external electric power source is connected between cathode and anode as shown in fig.
- The external electric power source is of a higher voltage then the battery produces of the same polarity.
- The lithium atoms in the cathode are ionized and separated from their electrons.
- The lithium ions move from cathode to anode they recombine with their electrons and electrically neutralize.
- The lithium ions are small and capable to pass from cathode to anode.

DISCHARGING:

- During discharging, the lithium ions move back to $LiCoO_2$ from the carbon.
- The lithium ions carry the current within the battery from the negative to positive electrode through electrolyte as shown in figure.



APPLICATIONS:

- They last two to three years, even if they are sitting on a self unused.
- Most energetic rechargeable batteries.
- They are extremely sensitive to high temperature.
- The battery pack fails there is a small change that it will be burst into flame.
- They are used in laptops, PC's, cell phones, etc.

LI-PO BATTERIES:

7. Describe the construction and electrochemistry of Li-Po battery? (10M)

- Lithium polymer battery or lithium-ion polymer battery is a rechargeable battery of lithium-ion technology.
- In battery a polymer electrolyte is used instead of liquid electrolyte.
- High conductivity semisolid polymers form the electrolyte.

CONSTRUCTION:

- There are four main components,

  1. Positive electrode   2. Negative electrode
  3. Separator   4. Electrolyte

- Positive electrode consists of lithium-transition-metal-oxide ($LiCoO_2$ or $LiMn_2O_4$) or a polymer binder vinylidene fluoride (PVdF).
- The negative electrode is the same type as carbon.
- The separator may be polymer such as micro-porous film of polyethylene (PE) or polypropylene (PP).
- The electrolyte used is a polymer. When the cell has used a liquid electrolyte contain a polymer.

WORKING PRINCIPLE:

- The working principle of lithium-polymer (Li-Po) battery is the same as that lithium-ion (Li-ion) battery.
- To insert between other of lithium ion from positive electrode material and dis-insert between other from negative electrode material through liquid electrolyte providing a conductive material.

VOLTAGES:

- The voltage of a single Li-Po cell depends upon its electro chemistry.
- Fully charged: 4.2V
- Fully discharged: 2.7–3.0V
- Normal voltage: 3.6 – 3.7V

APPLICATIONS:

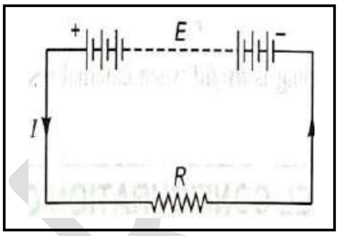
- Radio controlled equipment and aircraft.
- Widespread use in aircraft.

- Personal electronics, Electric vehicles.
- Uninterruptible power supply systems.

SERIES AND PARALLEL:

8. Explain about series and parallel configuration of batteries? (5M)

SERIES CONFIGURATION OF BATTERIES:



- The series grouping, the negative electrode of first battery is connected to the positive electrode of second battery.
- The output is taken from the positive electrode of first battery and negative electrode of second battery.
- In a number of batteries, the negative electrode of first battery is connected to the positive electrode of second battery and negative electrode of second battery is connected to the positive electrode of third battery is shown in figure.

Let, $n=$ number of batteries connected in series
$r=$ internal resistance of a battery
$R=$ external load connected
$E=$ e.m.f. of each cell.
Total e.m.f. of n batteries $= nE$
Total internal resistance of batteries $= nr$
Total circuit reistance $= R + nr$

$\therefore$ Current in the circuit $I = \dfrac{nE}{R+nr}$ ...(1)

(i) If R is negligible as compard to nr, then

$$I' = \frac{nE}{nr} = \frac{E}{r} \quad ...(2)$$

Therefore, there is ***no increase of the current.***

(ii) If nr is neglible to load resistance R, then

$$I'' = \frac{nE}{R} = n \times \frac{E}{R} = nI' \quad ...(3)$$

or $I'' = n \times$ current due to single battery

In this case, the ***current*** delivered by the battery has ***increased by n times.***

PARALLEL CONFIGURATION OF BATTERIES:

In this combination, all the positive electrodes are connected to each other to give a positive electrode while all the negative electrodes are connected to each other to give a negative electrode as shown in Fig. (9).

Let, e.m.f. of each battery $= E$
Internal resistance of battery $= r/n$
$\therefore$ Total resistance of the circuit $= R + (r/n)$

Current in the circuit $I = \dfrac{E}{R+(r/n)}$ ...(1)

(i) If r/n is negligible to R, then current

$$I' = \frac{E}{R} \quad ...(2)$$

This shows that this grouping is ***not useful.***

(ii) If R is negligible in comparison to r/n, then

$$I'' = \frac{nE}{r} = n \text{ times to } I' \quad ...(3)$$

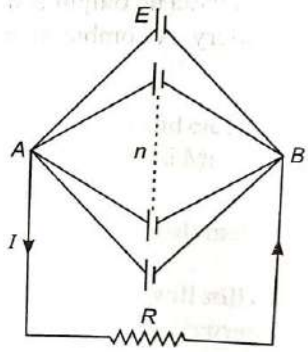


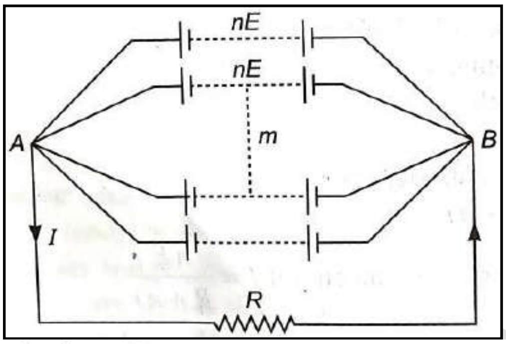
Fig. (9) Parallel combination of n batteries

Therefore, this type of grouping is ***useful*** when external resistance is small as compared to the internal resistance of battery.

SERIES-PARALLEL CONFIGURATION OF BATTERIES:

9. Describe the series and parallel configurations of batteries? (10M)

- In this grouping, first some batteries are connected in series and then a combination of such batteries is connected in parallel as shown in figure.



Let, number of batteries in series $= n$

number of series batteries in parallel $= m$

resistance of series combination $= nr$

total resistance connected in the circuit $= R$

e.m.f. of batteries in one row $= nE$

Equivalent resistance of m rows connected in parallel $= \frac{nr}{m}$

$$\therefore \quad \text{Total circuit resistance} = R + \left(\frac{nr}{m}\right)$$

Therefore,

$$\text{current in circuit } I = \frac{nE}{R + \left(\frac{nr}{m}\right)} = \frac{mnE}{mR + nr}$$

$$\therefore \quad I = \frac{NE}{mR + nr} \qquad \ldots(1)$$

- In equation (1) the current will be maximum when denominator is minimum.
- Therefore series-parallel combination will give maximum current when load resistance R is equal to internal resistance of battery.

Efficiency of Battery

The efficiency of a battery is defined as

$$\eta = \frac{\text{output}}{\text{input}} \times 100 \text{ per cent}$$

Let, e.m.f. of battery $= E$, internal resistance $= r$

external resistance $= R$, circuit current $= I$

$$\therefore \quad \text{Power developed} = I^2 R \text{ watt}$$

$$\text{Power lost within battery} = I^2 r \text{ watt}$$

$$\text{Total power developed} = I^2 R + I^2 r = EI \text{ watt}$$

$$\text{Efficiency, } \eta = \frac{I^2 R}{I^2 R + I^2 r} = \frac{R}{R + r}$$

or

$$\eta = \frac{\text{useful power}}{\text{total power produced}}$$

The efficiency is higher when R is greater.

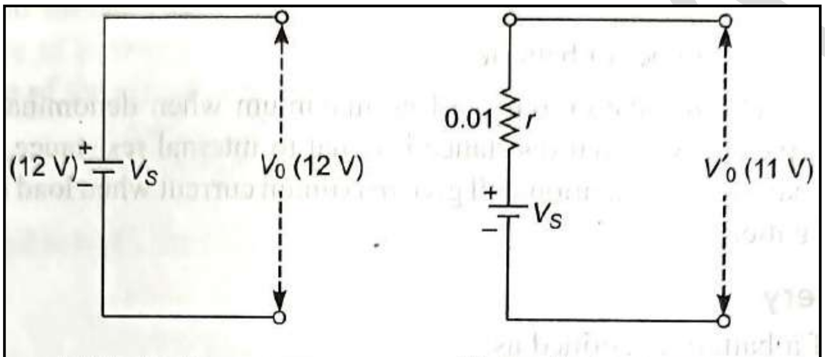
CONSTANT VOLTAGE AND CURRENT SOURCES:

10. Discuss the constant voltage source and constant current source? (5M)

- A source is a device which converts mechanical, chemical, thermal and some other form of energy into electrical energy.
- The source is an active network element for generating electrical energy.
- There different types of sources available are voltage sources and current sources.
- Example of voltage sources are batteries and alternators.
- Example of current sources is photo electric cells, collector current of transistors.

CONSTANT (OR) IDEAL VOLTAGE SOURCE:

- A constant voltage source is a two terminal device whose voltage at any instant of time is constant and is independent of the current is called constant or ideal voltage sources.
- An ideal voltage source cannot be obtained.
- The smaller the internal resistance (r) of a voltage source shown in figure.



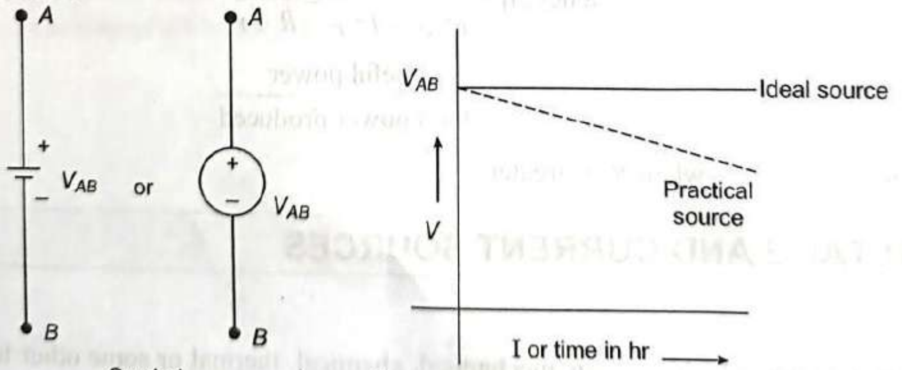
(a) Ideal voltage source (b) Practical voltage source

Let the ideal voltage of the voltage source be 12 V (No load current). If its internal resistance is 0.01 Ω and the load current increases to 100 A, then

$$\text{voltage of ideal voltage source, } V_0 = 12 \text{ volt}$$

and $$\text{voltage of practical voltage source } V_0' = 12 - 1$$
$$= 11 \text{ volt.}$$

Figure (12 a) shows the symbol and Fig. (12 b) shows the characteristics of an ideal voltage source and practical source.



Symbol

Characteristics of an ideal voltage source

Fig. (12a) Fig. (12b)

CONSTANT (OR) IDEAL CURRENT SOURCE:

- An ideal current source is a two terminal circuit element which supplies the same current to any load resistance connected across its terminals.
- The current supplied by the current source is independent of the voltage of source terminals.

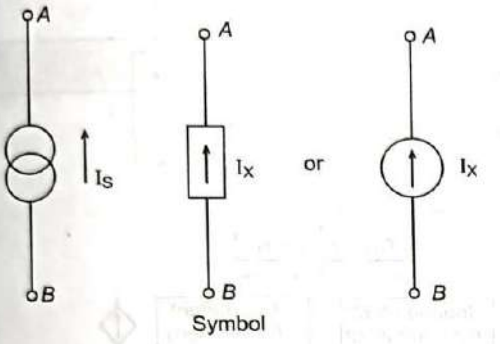


Fig. (13a)

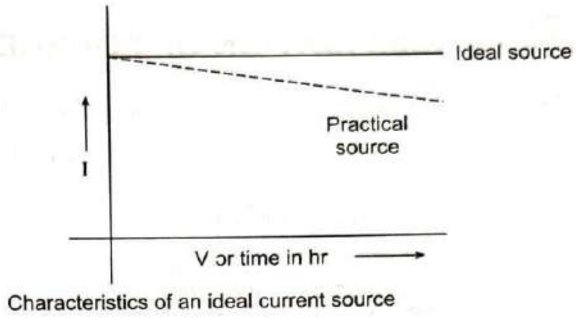


Fig. (13b)

Figure (13 a) shows the symbol and Fig. (13 b) shows the characteristics of an ideal and practical current source.

APPLICATIONS OF CURRENT SOURCES & VOLTAGE SOURCES:

11. Write the applications of current and voltage sources? (5M)

Independent Sources

The ideal voltage source and ideal current source discussed in previous article come under the category of ***independent sources.***

The independent source is one which does not depend on any other quantity in the circuit. It has a constant value, *i.e.*, the strength of voltage or current is not changed by any variation in the connected circuit. Thus, the voltage or current is fixed and is not adjustable.

Dependent Sources

The source whose output voltage or current is not fixed but depends on the voltage or current in another part of the circuit is called as dependent or controlled source.

The dependent source is basically a three terminal device. The three terminals are paired with one common terminal. One pair is referred to as input while the other pair as output. For example, in a transistor, the output voltage depends upon the input voltage.

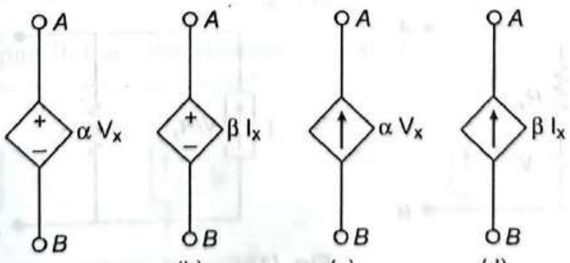


Fig. (14)

The dependent sources are represented by diamond shaped box as shown in Fig. 14.

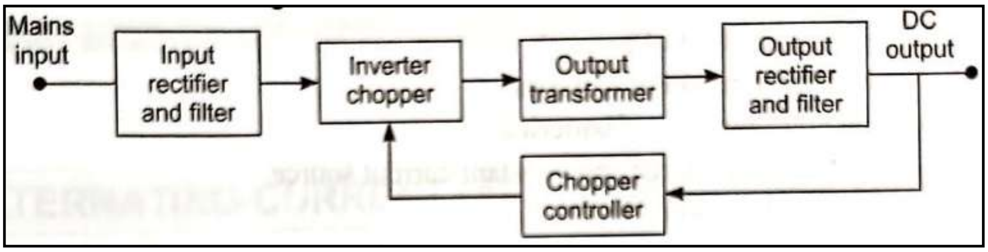
SMPS USED IN COMPUTERS: (10M)

12. Describe the switched-mode power supply (SMPS). How is it used in computers?

- Switched-Mode-Power-Supply (SMPS) in an electronic device that provide power to electronic devices and circuits (Computer, Laptop).
- These devices require low power D.C voltage much less than we use in our houses.
- If the same supply voltage is given to these devices directly, every part will burn.
- SMPS converts high voltage A.C to low voltage D.C.
- This supplies power to various system components of the computer.
- The main parts of SMPS are power connectors and power supply.
- Power connectors provide D.C voltage to all system components.
- The power supply fan is used to keep SMPS fresh.

WORKING:

- The block diagram of working of SMPS shown in figure.



- The main parts are, 1. Input rectifier and filter
  2. Inverter chopper
  3. Output transformer
  4. Output rectifier and filter

1. INPUT RECTIFIER AND FILTER:

- This stage converts the input A.C to D.C is called rectification.
- The SMPS with D.C input does not require this stage.
- The rectifier produces an unregulated D.C. voltage which is then sent to a large filter capacitor.

2. INVERTER CHOPPER:

- This inverter stage converts D.C to A.C by running through a power oscillator.
- The output transformer of power oscillator is very small with few windings.

3. OUTPUT TRANSFORMER:

- The output is required to be isolated from the input, the inverted A.C is used to drive the primary winding of a high frequency transformer.
- This converts the voltage up or down to the required output level on its secondary winding.

4. OUTPUT RECTIFIER AND FILTER:

- The rectified output is then smoothed by filter consisting of inductors and capacitors.
- For higher switching frequencies, components with lower capacitance and inductance are required.

APPLICATIONS:

- The most significant advantage of SMPS is smaller size or lighter weight.
- It has higher efficiency.
- It emits much less heat than a transformer, but it depends on its ability to function.
- The switching currents can cause electrical noise.
- The simple design of SMPS may have a poor power factor.
- It may hurt our health because it produces high frequency.

UNIT - III
ALTERNATING CURRENTS

A.C POWER SOURCE-GENERATOR:

1. Explain the principle of alternating current genitor? (10M)

- A device used to convert the mechanical energy into electrical energy is called generator.
- Alternate current periodically reverse direction, the voltage also changes with time.
- AC generator through the principle of electromagnetic induction.

CONSTRUCTION:

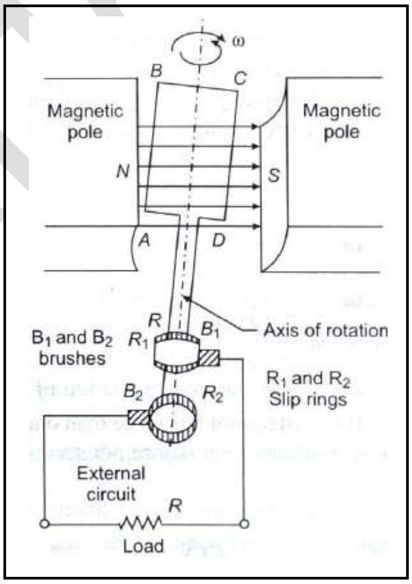
- An alternating generator consists of the following parts.

1. ARMATURE:

- It is a rectangular coil ABCD having large number of turns of insulated copper wire over a soft iron core.
- The core increases the magnetic flux linked with the coil (Armature).

2. FIELD MAGNET:

- It is a power fed permanent magnet having concave pole-piece N and S.
- The armature rotates between the two poles of magnets an axis perpendicular to the magnetic field lines.



3. SLIP RINGS:

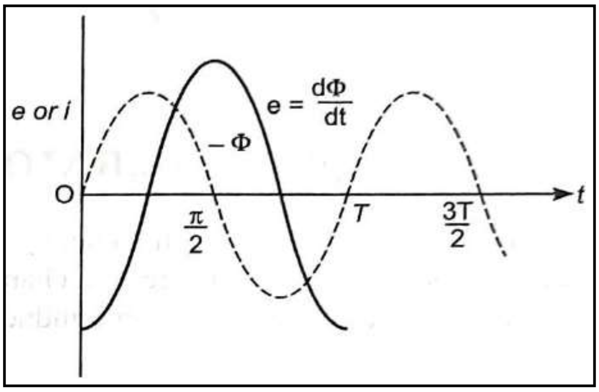
- The armature coil is connected to two copper rings R_1 and R_2 separately.
- These rings help to provide movable contact, so they are called slip rings.
- These rings are concentric with the axis of the armature coil and rotate with it.

4. BRUSHES:

- These are two carbon pieces B_1 and B_2 called brushes remains stationary pressing against the slip-rings.
- The brushes are connected to external circuit the current is to be supplied by the generator.

WORKING PRINCIPLE:

- When the armature coil is made to rotate with a uniform angular velocity 'ω' and e.m.f is setup in the coil due to increasing and decreasing flux through the coil as shown in figure.



When the circuit is closed through R, a current flows through R, a current flows in the coil.

Let at an instant, the coil be oriented at an angle θ to the magnetic field B.

The flux Φ through the coil $\quad \Phi = NAB\cos\theta$

or $\quad \Phi = NAB\cos\omega t \quad \ldots(1)$

where, N = number of turns in the coil

A = area of the coil

B = strength of magnetic field

The current i through the coil is given by

$$i = \frac{e}{R} = -\frac{1}{R}\frac{d\Phi}{dt}$$

or

$$i = \frac{NAB\,\omega}{R}\sin\omega t$$

or

$$i = i_0 \sin\omega t \quad \ldots(2)$$

where, $i_0 = \dfrac{NAB\,\omega}{R}$.

Due to the nature of variation of current i with time t, the device is also called as alternator.

If the alternator has more than one pair of poles, the frequency of rotation is equal to the product of the revolutions of armature per second (n) and the number of pole pairs (p). Therefore

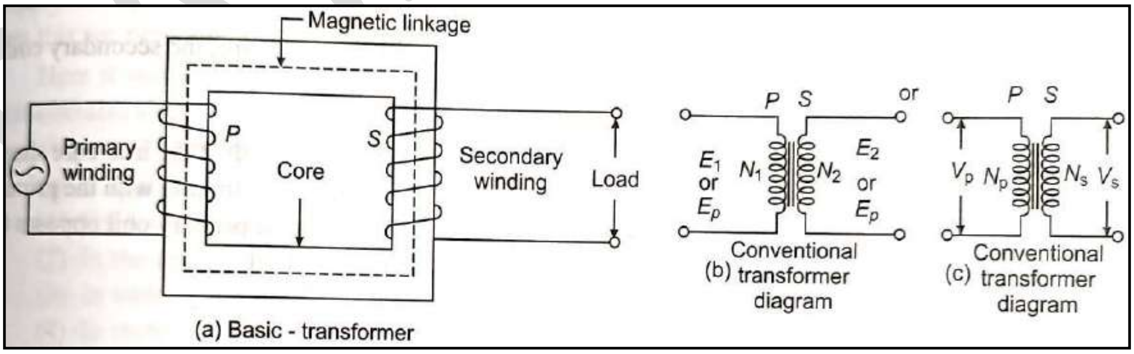
$$f = \frac{n\,p}{2} \quad \ldots(3)$$

Here a factor $\left(\frac{1}{2}\right)$ is introduced due to the pairs of poles.

TRANSFORMERS:

2. Describe the construction and working principle of transformer? (10M)

- A transformer is an AC static device which transfers electric power from one circuit to another without changing its frequency.
- Electrical energy has to be transmitted over long distances.
- A transformer has two coils electrically insulated from one another and wound on a common core.
- The energy from one coil is transferred to other coil by magnetic coupling.
- The coil which receives energy from an AC source is called primary (P) and the coil which delivers the energy to the load is called secondary.



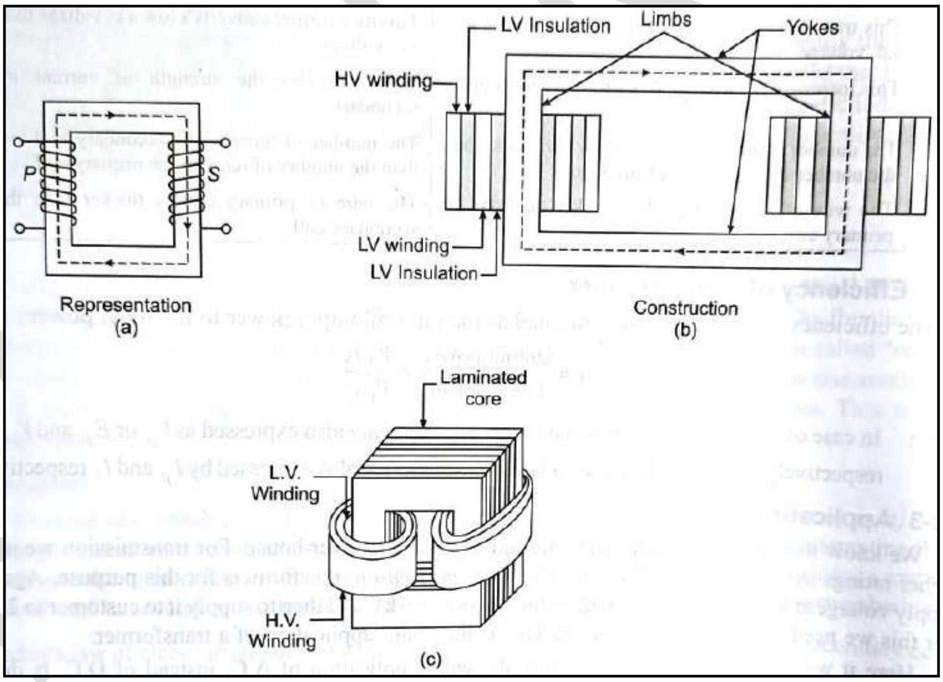
CONSTRUCTION:

- The main element of a transformer is two coils and a laminated steel core.
- The two coils are insulated from each other as well as from steel core.
- The core construction and primary and secondary coils are placed around it.
- There are two types of transformers,

1. Core type
2. Shell type

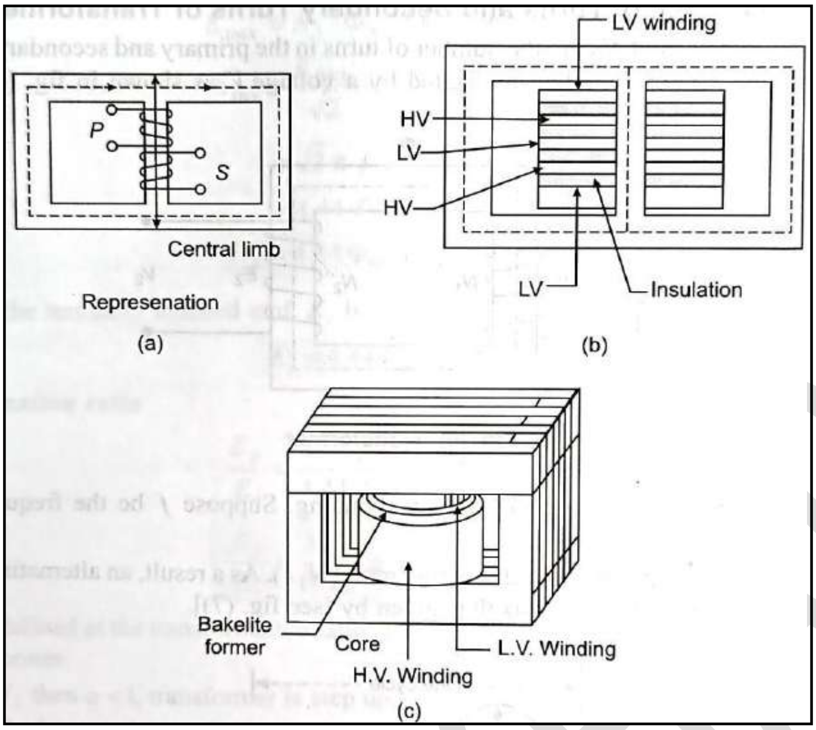
CORE TYPE TRANSFORMER:

- The construction of a single phase core type transformer is shown in figure.
- In core type transformer, there is a single magnetic circuit.
- The core is in rectangular shape, there are two vertical members are called limbs and two horizontal members called the yokes.
- The limbs and yokes are connected to each other.
- The L-shaped punching is employed to assemble cores whose overall dimensions are not very large.
- Steel sheet laminations are used as core materials.
- The magnetic sheet materials are normally alloy steels containing silicon and carbon in small quantities.
- The coils used of cylindrical type.
- The two vertical bars are used to signify tight magnetic coupling between the windings.
- One winding is connected to A.C supply and the other winding is connected to load.
- The winding with higher number of turns is called high voltage (HV) while the winding with lower number of turns is called low voltage (LV).
- Low voltage coil is placed inside near the core while high voltage coil surrounds the low voltage coil.
- The conductor used for winding is a copper wire of circular section for small currents and straps of rectangular section for large currents.



SHELL TYPE TRANSFORMER:

- The construction of a single phase shell type is shown in figure.
- In shell type transformer, the magnetic circuit is divided into two or more parts.
- In this case, the core has three limbs.
- The high voltage and low voltage windings are placed on the central limb.
- The coils used are multilayer disc type or sandwich type.
- The high voltage coils are placed between the low voltage coils.
- The low voltage coils are near to top and bottom of yokes.
- The shell type transformer, unlike the core type has thin coil.



TYPES OF TRANSFORMERS:

3. Explain the types of transformers? (10&5M)

- They are two types of transformers.
  1. Step-down transformer
  2. Step-up transformer

1. STEP-DOWN TRANSFORMERS:

- When the energy is received at a higher voltage and delivered at a lower voltage is called a step-down transformer.
- If the **primary coil** has **larger number** of turns of a thick wire while the **secondary coil** has a **smaller number** of turns of thin wire it is a step-up transformer.
- In a step-down transformer the primary is the high-voltage winding the secondary is the low-voltage winding.
- This transformer converts a high A.C voltage to low A.C voltage.
- This transformer increases the strength of current in secondary.

2. STEP-UP TRANSFORMERS:

- When the energy is received at a lower voltage and delivered at a higher voltage is called a step-up transformer.
- If the **primary coil** has **smaller number** of turns of a thick wire while the **secondary coil** has a **larger number** of turns of thin wire it is a step-up transformer.
- In a step-up transformer the primary is the low-voltage winding the secondary is the high-voltage winding.
- This transformer converts a low A.C voltage to high A.C voltage.
- This transformer decreases the strength of current in secondary.

WORKING PRINCIPLE:

- Transformer operates on the principle of mutual induction.
- According to Faraday's law of electromagnetic induction, the rate of change of flux is directly proportional to induced e.m.f.

- According to Lenz's law gives the direction of induced e.m.f to be the opposite of the cause producing it.
- When an alternating current is applied to the primary, an alternating current is setup.
- The winding is linked with a magnetic core it produces an alternating flux in the core.
- This alternating flux is linked with the turns of the secondary coil.
- It induces a mutually induced e.m.f in secondary of the same frequency.
- The flux is linking with the primary coil also and produces an e.m.f called the back e.m.f.

EFFICIENCY OF A TRANSFORMAER:

- The efficiency of a transformer is defined as the ratio of output power to the input power.

$$\eta = \frac{\text{Output power}}{\text{Input power}}$$

$$= \frac{V_S I_S}{V_P I_P}$$

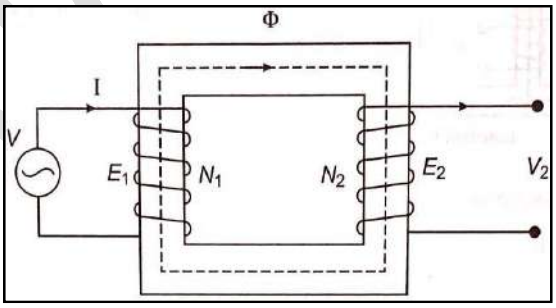
APPLICATIONS:

- For long distance transmission of electricity.
- In the manufacture of radio transmitters, tape recorders, etc.
- In welding.
- In rectification of A.C into D.C.
- Radio communication, electronic circuits, etc.

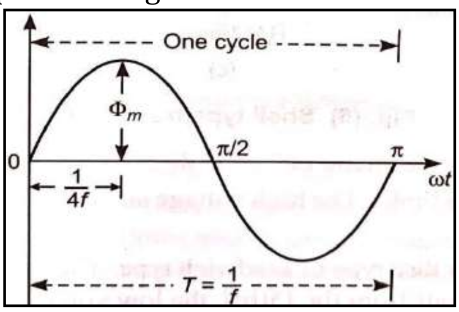
RELATION BETWEEN PRIMARY TURNS AND SECONDARY TURNS OF THE TRANSFORMER WITH EMF:

4. What is a transformer? Derive the relation between primary turns and secondary turns of the transformer with E.M.F? (10M)

- Consider that N_1 and N_2 are the number of turns in the primary and secondary respectively of a transformer.
- The primary winding is excited by a voltage V shown in figure.



- This voltage circulates an alternating current I_1 in the primary winding, f is the frequency of supply voltage.
- An alternating flux setup in the magnetic core.



- The instantaneous flux Φ is given by,

$$\Phi = \Phi_m \sin \omega t = \sin 2\pi f t \text{ weber} \quad \ldots(1)$$

where, Φ_m is the maximum value of flux in the core.

This alternating flux induces :

(i) A self-induced emf in primary winding

(ii) A mutually induced emf in the secondary winding.

$$E_1 = -N_1 \frac{d\Phi}{dt} = -N_1 \frac{d}{dt}(\Phi_m \sin 2\pi f t)$$

$$= -N_1 \cdot \Phi_m \cdot 2\pi f \cdot \cos 2\pi f t$$

$$= N_1 \cdot \Phi_m \cdot 2\pi f \cdot \sin\left(2\pi f t - \frac{\pi}{2}\right) \text{ volt} \quad \ldots(2)$$

Thus we see that the emf induced in a coil lags the flux induced by an angle of 90° or $\frac{\pi}{2}$ radian.

Now, $$E_{max} = N_1 \cdot \Phi_m \cdot 2\pi f \text{ volt}$$

and $$E_{rms} = \frac{E_{max}}{\sqrt{2}} = E_p = \frac{2\pi f}{\sqrt{2}} N_1 \Phi_m$$

$$= \sqrt{2}\pi f N_1 \Phi_m$$

$$= 4.44 f N_1 \Phi_m$$

$\therefore$ $$E_p = 4.44 \Phi_m N_1 f \text{ volt} \quad \ldots(3)$$

Similarly, the mutually induced emf, E_s is

$$E_s = 4.44 \Phi_m N_2 f \text{ volt} \quad \ldots(4)$$

Transformation ratio

$$\frac{E_p}{E_s} = \frac{4.44 f \cdot N_1 \cdot \Phi_m}{4.44 f \cdot N_2 \cdot \Phi_m} = \frac{N_1}{N_2} = a$$

or $$\frac{E_p}{E_s} = \frac{N_1}{N_2} = a \quad \ldots(5)$$

Here a is defined as the transformation ratio. The transformation ratio gives us information about the type of transformer.

If $N_2 > N_1$ then $a < 1$, transformer is step up.

If $N_1 > N_2$ then $a > 1$, transformer is step down.

For ideal transformer, input $V A$ = output $V A$

$$E_1 I_1 = E_2 I_2$$

or $$\frac{E_1}{E_2} = \frac{I_2}{I_1} = \frac{1}{a}$$

PROBLEMS:

EXAMPLE 1 *A transformer converts 100 V A.C. into 1000 V A.C. Find the ratio of number of turns of primary to the secondary.*

Solution : For a transformer $$\frac{V_p}{V_s} = \frac{N_p}{N_s} \quad \text{or} \quad \frac{100}{1000} = \frac{N_p}{N_s}$$

or $$\frac{N_p}{N_s} = \frac{\mathbf{1}}{\mathbf{10}}$$

EXAMPLE 2 *A step down transformer having 2200 turns in primary is used to reduce the main supply of 2200 V to 220 V. Calculate the number of turns in the secondary.*

Solution : We know that $$\frac{V_s}{V_p} = \frac{N_s}{N_p} \quad \text{or} \quad N_s = N_p \times \left(\frac{V_s}{V_p}\right)$$

$\therefore$ $$N_s = 2200 \times \left(\frac{220}{2200}\right) = \mathbf{220}$$

EXAMPLE 3 *In a transformer, there are 200 turns in primary coil and 400 turns in secondary coil. If current in primary coil is 2 amp, find current in secondary coil.*

Solution: In case of a transformer, $\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{i_p}{i_s}$ or $i_s = i_p \times \left(\frac{N_p}{N_s}\right)$

$\therefore$ $$i_s = 2 \times \left(\frac{200}{400}\right) = \mathbf{1\ amp.}$$

EXAMPLE 4 *A transformer contains 1000 turns in the primary and 2000 turns in the secondary. If the voltage of primary coil is 250 V, find the voltage across the secondary.*

Solution: For a transformer $\frac{V_s}{V_p} = \frac{N_s}{N_p}$ or $V_s = \frac{N_s}{N_p} \times V_p$

$\therefore$ $$V_s = \frac{2000}{1000} \times 250 = \mathbf{500\ volt}$$

EXAMPLE 6 *A step-down transformer is used to reduce the main supply of 220 V to 10 V. The primary draws a current of 5 A, while secondary draws a current of 100 A. Calculate the efficiency of the transformer.*

Solution: Given, $V_p = 220$ V, $i_p = 5$ A, $V_s = 10$ V and $i_s = 100$ A.

$\therefore$ Power input $P_{in} = V_p\, i_p = 220\text{ V} \times 5\text{ A} = 1100$ W

Power output $P_{out} = V_s\, i_s = 10\text{ V} \times 100\text{ A} = 1000$ W

Efficiency of transformer

$$\eta = \frac{\text{power output}}{\text{power input}} = \frac{1000}{1100} = 0.91 = \mathbf{91\%}$$

EXAMPLE 7 *A transformer working with 50 Hz, 220/300 V, has cross-sectional area of core 400 cm^2. If the peak value of flux density in the core is 1.24 Wb/m^2, calculate the suitable value for the number of turns on the primary and secondary winding.*

Solution: Given that frequency $f = 50$ Hz

Voltage applied to primary $V_1 = 220$ V

Induced voltage at secondary winding $V_2 = 300$ V

Cross-sectional area of core $A_i = 400\text{ cm}^2 = 400 \times 10^{-4}\text{ m}^2$

Peak value of flux density $\Phi_p = 1.24\text{ Wb/m}^2$

Now, $$V_1 = 4.44\, f\, \Phi_p\, A_i\, N_1$$

or $$240 = 4.44 \times 50 \times 1.24 \times 400 \times 10^{-4} \times N_p$$

Solving, we get $$N_p = \mathbf{20}$$

Further $$\frac{V_s}{V_p} = \frac{N_s}{N_p} \text{ or } N_s = N_p \times \left(\frac{V_s}{V_p}\right)$$

$\therefore$ $$N_s = 20 \times \left(\frac{300}{220}\right) = \mathbf{27}$$

EXAMPLE 8 *A single phase, 50 Hz transformer has 80 turns on primary winding and 280 turns in the secondary winding. The voltage applied across the primary winding is 240 V. Calculate :*

(i) the maximum flux density in the core

(ii) induced e.m.f. in the secondary winding.

The net cross-sectional area of the core can be taken as 200 cm².

Solution : Given $V_p = 240$ V, induced e.m.f. in primary, $E_p = 240$ V

$$N_p = 80,\ A_i = 200\,\text{cm}^2 = 200 \times 10^{-4}\ \text{m}^2 \text{ and } f = 50 \text{ Hz}$$

(i) Induced e.m.f. induced in primary

$$E_p = 4.44\, f\, B_m\, A_i\, N_p$$

or $$240 = 4.44 \times 50 \times B_m \times 200 \times 10^{-4} \times 80$$

∴ $$B_m = \frac{240}{4.44 \times 50 \times (2 \times 10^{-4}) \times 80}$$

or $$B_m = \mathbf{0.676}\ \text{Wb/m}^2$$

(ii) For a transformer, $$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

∴ $$V_s = V_p \times \left(\frac{N_s}{N_p}\right)$$

$$= 240 \times \frac{280}{80} = \mathbf{840\ V}$$

EXAMPLE 9 *A single phase 50 Hz transformer has a rating of 80 kVA and voltage ratio of 3200/400 volt. It is known that there are 111 turns on the secondary winding. Calculate :*

(a) number of primary turns

(b) full load primary current

(c) full load secondary current

(d) maximum value of mutual flux in the core.

Solution : Given, $f = 50$ Hz, $V_1 = E_1 = 3200$ V and $V_2 = 400$ V, $N_2 = 111$

(a) Assuming an ideal transformer

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} \quad \text{or} \quad N_1 = N_2 \cdot \frac{V_1}{V_2}$$

or $$N_1 = \frac{111 \times 3200}{400} = \mathbf{888\ turns}$$

(b) We know that, input VA = output VA

or $$V_1 I_1 = V_2 I_2 = 80 \times 10^3 \text{ volt-ampere}$$

or $$I_1 = \frac{80 \times 10^3}{3200} = \mathbf{25\ amp}$$

(c) Similarly, $$I_2 = \frac{80 \times 10^3}{400} = \mathbf{200\ amp}$$

(d) $$E_1 = 4.44\, \Phi_m \cdot N_1\, f \text{ volt}$$

$$3200 = 4.44 \cdot \Phi_m \times 888 \times 50$$

or $$\Phi_m = 0.0162 \text{ weber} \quad \text{or} \quad \mathbf{16.2\ m\ Wb}$$

USE OF A TRANSFORMER IN A REGULATED POWER SUPPLIES:

5. Explain the function of a transformer in a regulated power supply? (10&5M)

- Many electronic devices need D.C power but the electricity obtained from power lines is A.C.
- We require to convert the A.C into D.C. a regulated power supply is needed.
- The regulated power supply consists of the following two parts.

  1. Full-wave rectifier
  2. Filter

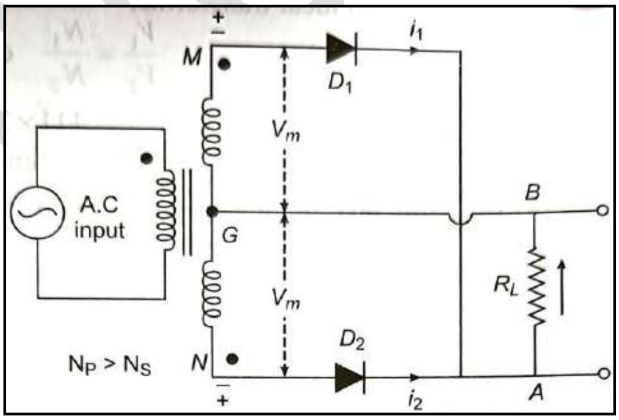
1. FULL-WAVE RECTIFIER:

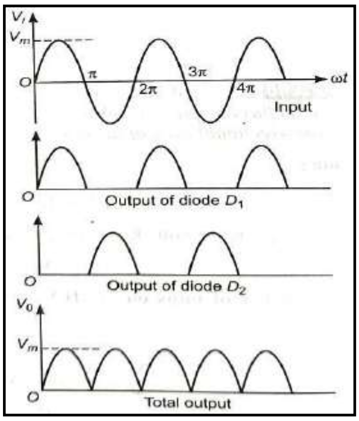
CONSTRUCTION:

- A rectifier circuit converts A.C power directly to D.C.
- The rectifier begins with a transformer.
- The electricity flows through the primary coil of transformer that has a secondary coil of wire.
- It has iron element called the core.
- In full-wave rectifier, both half cycle of the input are utilized with the help of two diodes working alternately shown in figure.
- The circuit is seen to comprise of two half wave circuits.

WORKING:

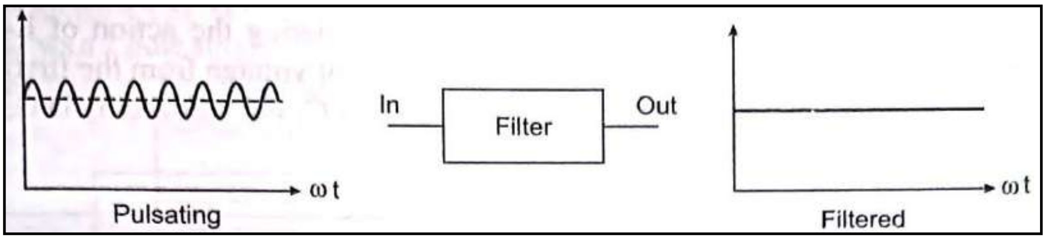
- When input A.C supply is switched on, the ends M and N of the transformer secondary become positive and negative alternately.
- During positive half of A.C input, terminal M is positive G is at zero potential and W is at negative potential.
- Now diode D_1 is forward biased, it conducts and causes a current i_1 in load resistor R_L.
- Diode D_2 remains non-conducting being reversed biased.
- During the negative half cycle, terminal N becomes positive G is at zero potential and M is at negative potential.
- Diode D_2 conducts and current i_2 flows in the circuit through load resistor R_L.
- Diode D_1 is non-conducting, the current flows through R_L in the same direction in both half cycles of the A.C input shown in figure.



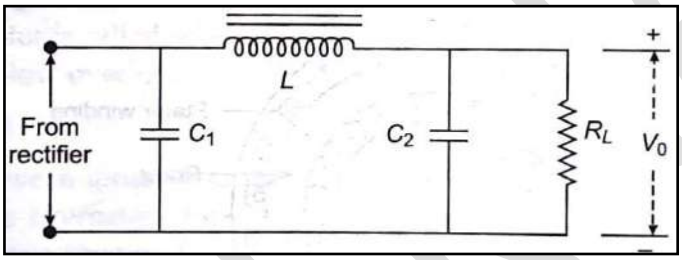


2. CLC (Or) π FILTER:

- The output of a rectifier is pulsing it has a D.C value and some A.C variations known as ripples shown in figure.
- The electronic circuits or devices a very steady D.C output is required.
- This is achieved with the help of a device known as filter.



- A device that converts the pulsating output of a rectifier into a steady D.C. level is known as filter.
- Following filter circuits are commonly used,
  1. Series inductor filter,
  2. Shunt capacitor filter,
  3. LC filter,
  4. CLC or π filter.
- A very smooth output may be obtained by a filter consisting of one inductance and two capacitors connected across its each and as shown in figure.



- The three components are arranged in the form of Greek letter π, the filter is called π filter.
- This filter is used when a given transformer higher voltage and lower ripple is required then that obtained by L-section filter.
- In this filter, C_1 is selected to offer very low reactance to the ripple frequency.
- The major part of the filtering is done by C_1, the remaining ripple is removed by L-section filter consisting of choke L and capacitor C_2.
- Capacitor C_1 offer a low reactance path to A.C component while offers an infinite resistance to D.C component.
- Inductor L offers a high reactance to A.C component of rectifier output while approximately zero resistance to D.C component.
- Capacitor C_2 is similar that of capacitor C_1.

SINGLE PHASE MOTOR:

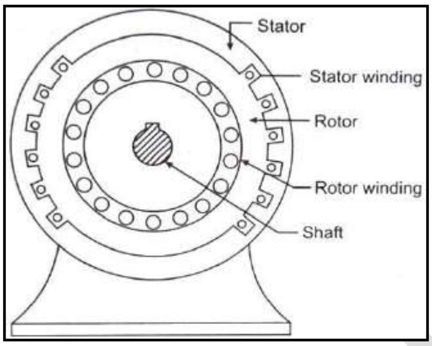
6. Explain the construction and working principle of single phase motor? (10M)

- Single phase induction motors are similar to three phase motors except for the fact the stator has a single phase winding instead of three phase winding.
- Single phase induction motors are less satisfactory than three phase induction motors.
- Single phase induction motors are not self starting.
- Hence certain extra circuits or mechanical devices are used to make them self starting.
- These motors work quite satisfactory in fractional horse power ratings and very popular in domestic use.

CONSTRUCTION:

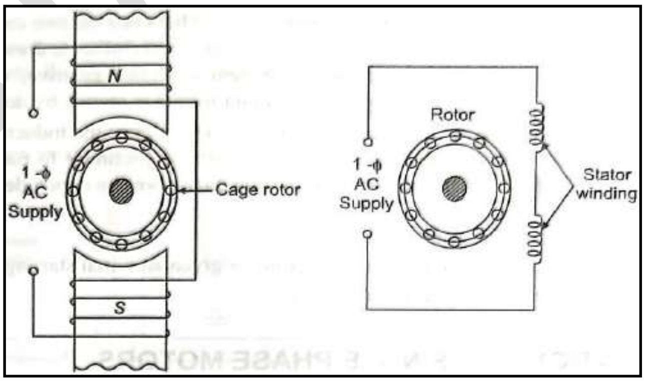
- The construction of a single phase induction motor is very similar to a three phase induction motor.

- The rotor is always squirrel cage, while the stator carries a single phase winding.
- The stator winding is wound in slots around the inner periphery of a laminated ring is shown in figure.
- The stator also carries an auxiliary winding for providing the starting torque, the motor become self starting.
- There is no physical connection between the rotor and stator but uniform air gaps exists between them.



WORKING PRINCIPLE:

- When an alternating current is supplied to the stator winding, a sinusoidally pulsating magnetic field, varying with time is produced.
- The turns produce a pulsating current in the rotor.
- This pulsating current is incapable of producing a rotating torque in the stationary rotor.
- A rotating magnetic field, the stator is generally provided with two windings.
- The main winding and a starting winding.
- Starting winding is also called auxiliary winding.
- A 90^0 phase difference between two winding is obtained by splitting the single phase.
- A two pole single phase induction motor shown in figure.
- The combined effect of the fields set up by the two windings is more or less a rotating field.

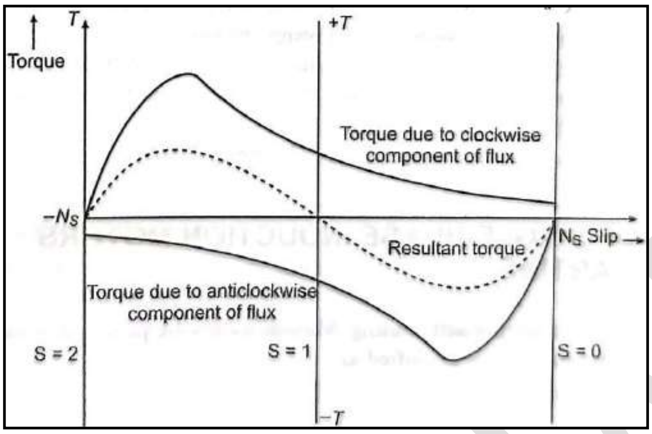


- After starting of the motor, rotation of the field is carried out by currents set up in the main winding and the starting winding is switched out of the stator circuit.
- Such motors are called split phase induction motor.
- Single phase motors have several drawbacks low overload capacity, low efficiency and low power factor.

CHARACTERISTICS:

- It is a curve drawn between torque and slip is known as torque slip characteristics of single phase induction motor.

- The alternating flux set up by the stator winding of a single phase induction motor can be resolved into two rotating fluxes.
- Each half the value of the maximum amplitude of the alternating flux, rotating in opposite directions at speed N_S.



APPLICATIONS OF MOTORS: (LIKE WATER PUMP, FAN ETC.)

7. Write the applications of motors? (5M)

- The applications of different types of induction motors are given at the end of each type of motor.

S. No	Applications	Type of motor suitable for the application
1.	Mixer, hair drier, electric shaver, sewing machine, vacuum cleaner, etc.	Small universal motors.
2.	Washing machine, room coolers.	Capacitor start capacitor run single phase motors.
3.	Domestic refrigerator.	Capacitor start single phase motors.
4.	Ceiling and table fans.	Permanent split capacitor type and shaded pole single phase motors.
5.	Room air conditioners.	Capacitor start single phase motors.
6.	Small domestic water pumps.	Capacitor type single phase motors.
7.	Electric clock and other timing devices.	Stepper motors.
8.	Electric traction.	Single phase A.C. series motors for main line services.
9.	Sound recording and sound reprodu-cing systems. **Ex:** Tape recorders.	Shaded pole type single phase motors
10.	Textile industries.	Reluctance motors.

UNIT - IV
POWER SUPPLIES

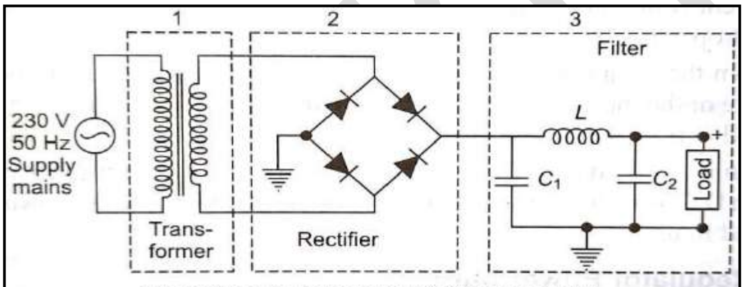
WORKING OF A D.C. REGULATED POWER SUPPLY:

1. What is a D.C regulated power supply? (10&5M)

- The objective of a power supply is to power the load with proper voltage and current.
- All electronic devices used in electronic circuits need D.C source of power.
- Then D.C power supply is properly connected to each and every stage in the electronic circuit.
- A D.C power supply consists of electronic circuits which provide a constant regulated D.C voltage of A.C mains load variations.
- A regulated power supply consists of the following sections,
  1. Unregulated power supply
  2. Regulated power supply

1. UNREGULATED POWER SUPPLY:

- An unregulated power supply or ordinary D.C power supply consists of a transformer, a rectifier and a filter circuit.
- These are shown in figure.

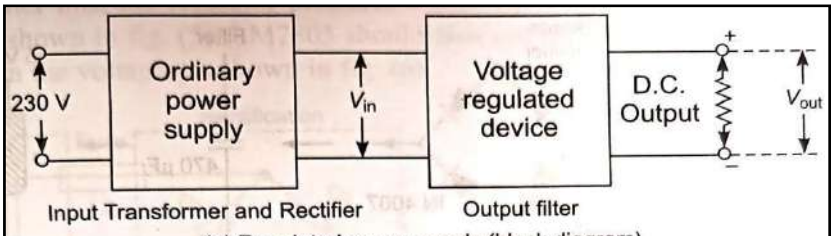


Block diagram of an unregulated power supply

- A small D.C voltage in the range of 2-24 volt is required for the operation of different electronic circuits.
- A step-down transformer is used which able to reduce the voltage level.
- A rectifier is used which converts the sinusoidal A.C voltage into pulsating D.C.
- A bridge rectifier in used having four diodes.
- A filter section is attached to bridge rectifier. A π or CLC filter is initially used to remove the A.C harmonics from D.C. obtained from bridge rectifier.

2. REGULATED POWER SUPPLY:

- A regulated circuit is used after filter section.
- This has the following two functions,
  1. The output of regulated circuit has much less ripple voltage.
  2. The output voltage remains constant even if the input D.C voltage varies or the load connected at the output D.C voltage changes.
- A transistor regulation of D.C voltage is required for operation of electronic circuit.

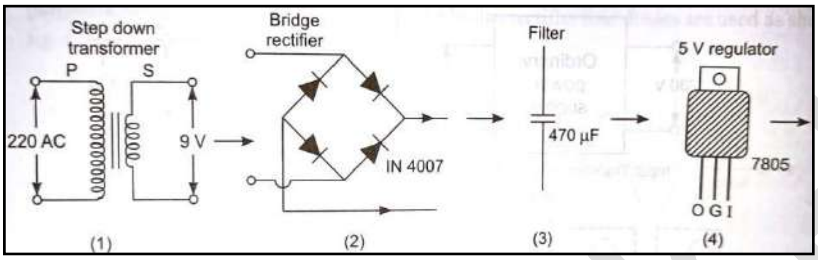


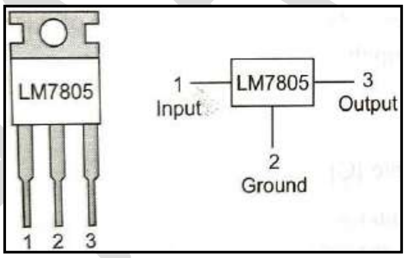
(a) Regulated power supply (block diagram)

CONSTRUCTION OF A 5 VOLTS REGULATED POWER SUPPLY:

2. Describe the construction of 5 volt regulated power supply? (10M)

- Power supply converts the output from an alternating current power to a steady direct current output.
- A.C voltage is rectified to give a pulsating D.C. then it is filtered to give a smooth voltage.
- The voltage is regulated to give a constant D.C output of required level.
- The construction of a 5 volt regulated power supply dividing four components,
  1. Step down transformer (9V)
  2. Bridge rectifier (4 diodes)
  3. Capacitive filter (470 μF, 0.1 μF)
  4. Voltage regulator circuit (IC LM7805)
- A block diagram of regulated power supply shown in figure.





1. STEP DOWN TRANSFORMER (9V):

- The step down transformer is used to transform the incoming line voltage (220V AC) down to required level (9 volts).

2. BRIDGE RECTIFIER (4 DIODES):

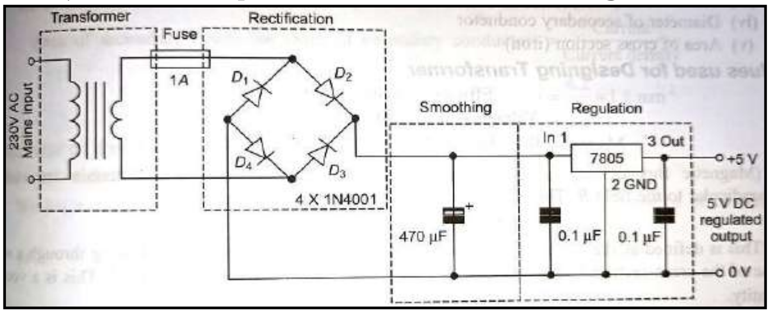
- A rectifier circuit is the combination of four diodes arranged in a manner that it converts A.C into D.C voltage level.
- The bridge rectifier consists of four IN 4007 diodes.
- These diodes have the ability of a higher feedback voltage.
- The function of bridge rectifier an I.C may be used.
- The selected diode must have a current rating more than the load current and peak reverse voltage (P.I.V) more than peak secondary voltage.

3. CAPACITIVE FILTER (470 μF, 0.1 μF):

- The rectifier circuit converts the incoming A.C to D.C but it does not make a pure D.C.
- The rectified D.C has some ripples.
- The function of the filter is to filter out these ripples.
- The filter removes the ripples and smoothens the signal.

4. VOLTAGE REGULATOR CIRCUIT (IC LM7805):

- A regulator is the linear integrated circuit used to provide constant output voltage.
- The regulator produces a constant output. They use an I.C LM7805 shown in figure.
- The capacitor 0.1μF at the output to avoid transient changes in the voltages.



DESIGN OF A STEP-DOWN TRANFORMER (RANGE 220-12V):

3. Give the calculation of design of step-down transformer (range 220-12V)? (10M)

- For designing, power rating is 50VA.

Primary voltage = 220 V

Secondary voltage = 12 V

SECONDARY SIDE CALCULATION:

Secondary winding current = Voltage rating/secondary voltage

∴ Secondary winding current $= 50/12 = 4.2$ A

We know that Current density = Current/Area of conductor

∴ Area of secondary conductor (Size of secondary conductor) $= \dfrac{\text{Current}}{\text{Current density}}$

$$= \frac{4.2}{2.3} = 1.8 \text{ mm}^2$$

Diameter of Secondary Conductor

Now, we shall calculate the diameter of secondary conductor

We know that $A = \pi r^2$ (r = radius of conductor)

or $$A = \pi \left(\frac{d}{2}\right)^2 = \frac{\pi d^2}{4}$$

or $$d^2 = \frac{4A}{\pi}$$

or $$d = \sqrt{\left(\frac{4A}{\pi}\right)}$$

∴ $$d = \sqrt{\left(\frac{4 \times 1.8}{3.14}\right)} = \sqrt{2.2930} = \mathbf{1.5426 \text{ mm}}$$

From this value we select standard wire gauge.

Primary Side Calculation

Primary winding current = (Voltage rating)/(Primary voltage)

∴ $$\text{Primary winding current} = \frac{50 \text{ VA}}{220 \text{ V}}$$

$$\text{Primary winding current} = 0.22727 \approx 0.23 \text{ A}$$

$$\text{Size (or area) of primary conductor} = \frac{\text{Current}}{\text{Current density}}$$

$$= \frac{0.23}{2.3} = 0.1 \text{ mm}^2$$

Diameter of Primary Conductor

We know that $$A = \pi r^2 = \pi \left(\frac{d}{2}\right)^2 = \frac{\pi d^2}{4}$$

∴ $$d^2 = \frac{4A}{\pi} \quad \text{or} \quad d = \sqrt{\left(\frac{4A}{\pi}\right)}$$

or $$d = \sqrt{\left(\frac{4 \times 0.1}{3.14}\right)} = \sqrt{0.1274} = \mathbf{0.357 \text{ mm}}$$

Calculation of number of turns in primary and secondary.

We shall use e.m.f. per turn formula

$$\text{e.m.f. per turn} = 4.44 \times N \times B_m \times f \times A$$

$$\text{Turns per volt} = \frac{1}{4.44 \times B_m \times f \times A}$$

$$\text{Area } A = 0.00145161 \text{ m}^2$$

Substituting the values, we get

$$\text{Turns per volt} = \frac{1}{(4.44 \times 2.3 \times 50 \times 0.00145161)}$$

$$= 2.6 \text{ turns/volt}$$

$$\text{Number of turns} = (\text{turns/volt}) \times \text{volt}$$

∴ $$\text{Number of turns in primary} = 2.6 \times 220 = \mathbf{572 \text{ turns}}$$

$$\text{Number of turns in secondary} = 2.6 \times 12 = \mathbf{32 \text{ turns}}$$

DESIGN OF A STEP-UP TRANFORMER (RANGE 120-240V):

4. Give the calculation of design of step-up transformer (range 120-240V)? (10M)

Let power rating be 120 VA.

Primary Side Calculations

$$\text{Primary winding current} = (\text{Voltage rating})/\text{Primary voltage}$$
$$= \frac{120\text{ VA}}{120\text{ V}} = 1\text{ A}$$

$$\text{Size (or area) of primary conductor} = \frac{\text{Current}}{\text{Current density}} = \frac{1}{2.5} = 0.4\text{ mm}^2$$

We know that $A = \pi r^2 = \pi \left(\frac{d}{2}\right)^2$

or $4A = \pi d^2$ or $d^2 = \frac{4A}{\pi}$

$\therefore$ $d = \sqrt{\left(\frac{4A}{\pi}\right)} = \sqrt{\left(\frac{4 \times 0.4}{\pi}\right)} = \sqrt{0.5096}$

or $d = \mathbf{0.71\ mm}$

Secondary Side Calculation

$$\text{Secondary current} = \frac{\text{Voltage rating}}{\text{Secondary voltage}}$$
$$= \frac{120\text{ VA}}{240\text{ V}} = 0.5\text{ A}$$

$$\text{Area of secondary conductor} = \frac{\text{current}}{\text{current density}}$$
$$= \frac{0.5}{2.5} = 0.2\text{ mm}^2$$

$$\text{Diameter of secondary, } d = \sqrt{\left(\frac{4A}{\pi}\right)} = \sqrt{\left(\frac{4 \times 0.2}{3.14}\right)}$$
$$= \mathbf{0.5048\ mm}$$

Number of Turns in Primary and Secondary

For Primary

We shall use the formula, emf per turn $= 4.44 \times N \times B_{\max} \times A \times f$

For A, $\text{Primary (VA)} = \frac{\text{Secondary VA}}{\text{Efficiency}} = \frac{120}{0.8} = 150\text{ (VA)}$

$$\text{Net area of cross section} = \sqrt{[\text{Primary (VA)}]} = \sqrt{150}$$
$$= 12.25\text{ mm}^2$$

$\therefore$ $N_p = \frac{\text{emf}}{4.40 \times B_{max} \times A \times f}$

$$= \frac{120}{4.44 \times 1.2 \times 12.25\text{ mm}^2 \times 50}$$

Changing $(\text{mm})^2$ into $(\text{m})^2$ and solving, we get

$$N_p = \mathbf{368}$$

For secondary $N_s = \frac{240}{4.44 \times 1.2 \times 1225\text{ mm}^2 \times 50}$

Solving, we get $N_s = \mathbf{736}$

EXAMPLE 1 *A single phase* 2300/230 V, 50 Hz *type transformer has core section area* 0.05 m^2. *If flux density is* 1.1 Wb/m^2, *calculate the number of turns on primary and secondary.*

Solution : We know that $N_p = \frac{V_p}{4.44 \times B_{\max} \times A \times f}$

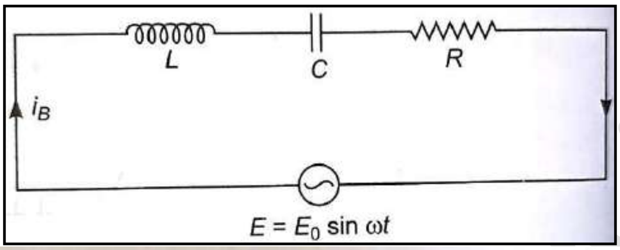
$$= \frac{2300}{4.44 \times 1.1 \times 0.05 \times 50}$$
$$= 188.37 \simeq \mathbf{188}$$

$$N_s = \frac{230}{4.44 \times 1.1 \times 0.05 \times 50}$$
$$= 18.83 \simeq \mathbf{19}$$

TRANSFORMERS- SIMPLE DESIGN OF FM RADIO CIRCUIT USING LCR SERIES RESONANCE (TUNING) CIRCUIT:

5. Explain LCR series resonant circuit? (10M)

- An electronic LCR contains a resistor of 'R' ohms, a capacitor of 'C' farad and inductance of 'L' henry, all connected in series.
- They are connected in series, the current passing through each of them is the same.
- LCR series circuit is shown in figure.



Let an alternating $E = E_0 \sin \omega t$ is applied to this circuit. The peak value (or r.m.s. value) of the current in the circuit is given by

$$i_0 = \frac{E_0}{\left[R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2\right]^{1/2}} \quad \ldots(1)$$

The phase difference ϕ between the applied e.m.f. and the resultant current is given by

$$\tan \phi = \left\{\frac{\omega L - (1/\omega C)}{R}\right\}. \quad \ldots(2)$$

The impedance Z of the circuit is given by

$$Z = \left[R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2\right]^{1/2}. \quad \ldots(3)$$

$\omega = 2\pi f$ where f = frequency

- The LCR series circuit has very large capacitive reactance ($1/\omega C$) at low frequencies and a very large inductive resistance (ωL) at high frequencies.
- The particular frequency of A.C at which impedance of a series LCR circuit becomes minimum is called the resonant frequency.

At resonant frequency

$$\omega L = (1/\omega C)$$

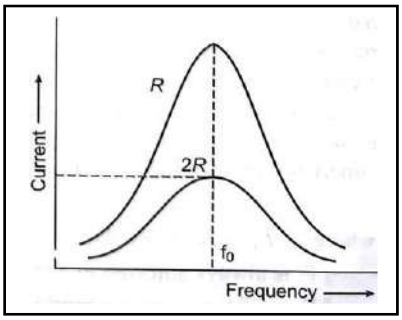
$$\omega = \{1/\sqrt{(LC)}\}$$

The resonant frequency f_0 of the series resonant circuit is given by

$$2\pi f_0 = 1/\sqrt{(LC)}$$

$$f_0 = \frac{1}{2\pi\sqrt{(LC)}}. \quad \ldots(4)$$

- The natural frequency when the oscillations have greatest amplitude is called resonant frequency.
- A resonant frequency depends on the product of L and C.
- The variation of the peak value of current with the frequency of the applied e.m.f is shown in figure.
- In the graph two curves are plotted, one is the circuit resistance is low (R) and the other circuit resistance is high (2R).



CHECKING THE OUTPUT VOLTAGE OF A BATTERY ELIMINATOR USING A MULTI MATER:

6. What is a battery eliminator? How the output voltage of battery eliminator is measured by multimeter? (10&5M)

BATTERY ELIMINATOR:

- Battery eliminator is a device used to convert high voltage alternating current into low voltage direct current.
- A circuit arrangement is used with 220V alternating current is converted into 5V direct current.
- A battery eliminator is shown in figure.
- It is used in place of ordinary dry batteries power sources for equipments like receivers, tape recorders, calculators, etc.
- It consists of a transformer and a rectifier.

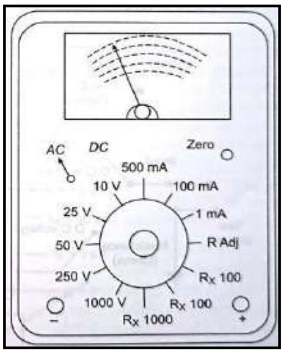
OUTPUT VOLTAGE OF A BATTERY ELIMINATOR USING A MULTI MATER:

- Multimeter is an electronic instrument which is used to measure voltages, current and resistances.
- It is also called as volt-ohm-milliammeter or VOM.
- The multimeter consists of an ordinary type moving coil galvanometer.
- The measurement of voltages, currents and resistances proper circuits is incorporated with the galvanometer.
- Multimeter is divided into two types,

  1. Analog multimeter   2. Digital multimeter

1. CONSTRUCTION OF ANALOG MULTIMETER:

- It consists of an ordinary type moving coil galvanometer often known as d'Arsonval galvanometer.
- The galvanometer consists of a coil which is suspended in the magnetic field of permanent magnet in the shape of a horse shoe.
- The coil is suspended in it can rotate freely in the magnetic field.
- An aluminium pointer is attached to the coil which moves over a calibrated scale.
- When a D.C current flow in the coil, electromagnetic torque is developed and the coil is deflected.
- This electromagnetic torque is counter balanced by the mechanical torque of control springs attached to the coil.
- When these two torques are balanced, the pointer comes to rest.
- The position of pointer on the scale indicates the amount of current passing through the coil.
- The multimeter can also measure A.C voltage by the use of rectifier.
- With the help of a rotary selector switch, the various ranges are used.



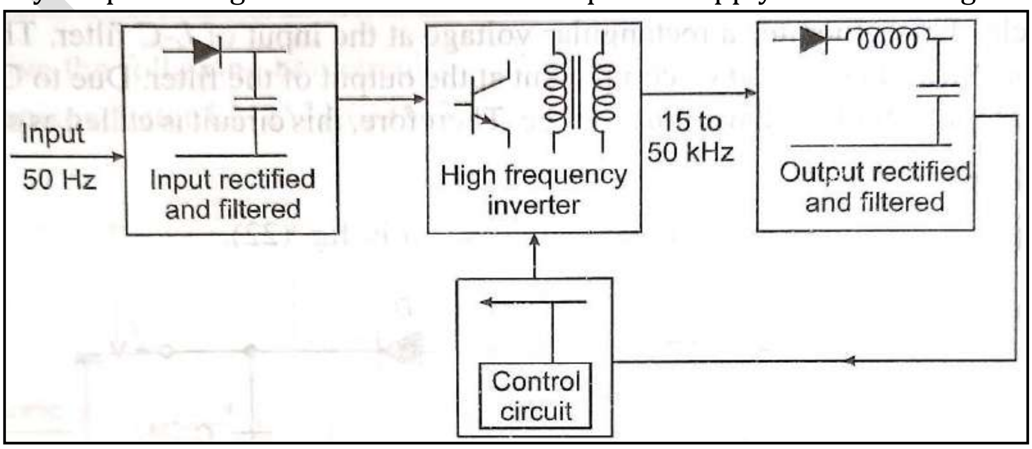
DESIGN OF A SIMPLE 5 VOLTS D.C. CHARGER POWER SUPPLY FOR COMPUTERS: (SMPS)

7. What is a switched mode power supply? Describe it in detail? (10&5M)

- All electronic circuits need D.C power supply.
- Many types of equipment contain circuits which convert A.C supply voltage into D.C voltage at required level.
- The circuit is known as linear mode power supply (LPS).
- A.C is converted into D.C using a rectifier.
- The unwanted ripple contents of the pulsating D.C are removed by a filter to obtain pure D.C.
- The D.C supply from battery is converted into required A.C voltage for electronic system for their operations.
- The power supply used to convert D.C into A.C or D.C into D.C is called as switched mode power supply.
- The various types of voltage regulators used in linear mode power supply fall in the category of dissipative regulator.
- The dissipative power is equal to the voltage difference between an unregulated input voltage and a fixed output voltage multiplied by current flowing through it.
- A linear voltage regulator has the following limitations,
  1. The efficiency is very low,
  2. Large values of filter capacitors are needed to reduce the ripples,
  3. The step-down transformer is bulky and become most expensive because of low line frequency of 50 Hz.

WORKING AND CIRCUIT BLOCKS:

- The working of SMPS differs from the conventional series regulator.
- In series regulator, a pass transistor is used to obtain a controlled voltage drop whereas in SMPS.
- The pass transistor can be used as a controlled switch.
- It can be operated either in saturated state or cut-off state.
- If the pass device is at cut-off condition, there will be no current.
- If the pass device is in saturated state, a very small voltage drop occurs across it.
- It dissipates only a small amount of average power and hence gives maximum current to the load.
- The power wasted in transistor is very small.
- So, most of the power is transmitted to the load.
- A very simple arrangement of switched mode power supply is shown in figure.



- It consists of the following parts,
  1. Input rectifier and filter
  2. Chopper (High frequency inverter)
  3. Output rectifier
  4. Control circuit
- The 50 Hz input line voltage is rectified and filtered.
- The filtered D.C voltage is chopped at a very high frequency using an active device and a converter transformer.
- The output of the transformer is again rectified and filtered to get required D.C voltage.
- The output voltage is sensed by a control circuit.
- The control circuit supplies a correction signal to the driver circuit to vary the ON/OFF time of the switch.
- The control element usually consists of a transistor switch, an inductor and diode.
- By varying the frequency of switching, we can vary the stored energy in each cycle. Thus we can control the output voltage.

UNIT - V

APPLICATIONS OF ELECTROMAGNETIC INDUCTION

DC MOTOR–CONSTRUCTION AND OPERATING PRINCIPLE:

1. Explain the construction and principle of D.C. motors? (10M)

- A DC motor is an electromechanical energy conversion device.
- It is convert electrical energy into mechanical energy.
- **The DC motor is based on the principle when a current carrying conductor is placed in a magnetic field, a mechanical force acts on the conductor.**

CONSTRUCTION:

- A DC motor consists of six main parts,

1. YOKE OR MAGNETIC FRAME:

- The outer frame of a DC motor is a hollow cylinder made up of cast steel or rolled steel is known as yoke.
- Functions of yoke are,
  1. Acts as a protective covering for the machine.
  2. Provides mechanical support for the machine.
  3. Carries the magnetic flux produced by poles.

2. FIELD POLES:

- The magnetic field poles of a DC motor is the stationary part of the machine.
- It produces the magnetic flux in the motor.
- The poles core has a pole shoe having a curved surface.
- It provides support to the field coils.
- They spread out the flux in the air gap and large cross-section reduces the reluctance of the magnetic path.

3. ARMATURE CORE:

- The armature core of DC motor is mounted on the shaft and rotates between the field poles.
- It has slots on its outer surface.
- The armature core is a made up soft steel laminations which are insulated from each other and tightly clamped together.
- Functions of armature core,
  1. If the armature coil is rotates them in magnetic flux.
  2. To provide a path of very low reluctance to flux through armature poles.

4. ARMATURE WINDINGS:

- The insulated conductors are into the slots of the armature core.
- The connected arrangement of conductors is known as armature winding.
- There are two types of armature windings are used,

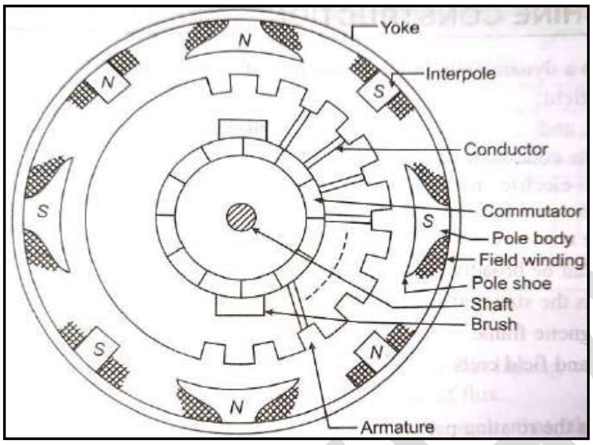
  1. Wave winding, 2. Lap winding.

5. COMMUTATOR:

- A Commutator is a mechanical rectifier which converts the direct current input to the motor from the DC source into alternating current in the armature winding.
- The Commutator is made of wedge-shaped copper segments insulated from each other.
- Each segment of commutator is connected to the ends of the armature coils.

6. BRUSHES:

- The brushes are mounted on the commutator and used to inject the current from the DC source into the armature windings.
- The brushes are made of carbon and supported by a metal box called brush holder.
- The pressure exerted by the brushes on the commutator is adjusted and maintained at constant value.



CALCULATION OF POWER, VOLTAGE AND CURRENT IN A DC MOTOR:

2. Write the calculation of power voltage and current in a D.C. motor? (5M)

POWER EQUATION OF A DC MOTOR:

- Multiplying both sides of voltage equation by I_a, we get the power equation of a DC motor,

$$V I_a = E_b I_a + I_a^2 R_a$$

$V I_a$ = Input power supply. (Armature Input)

$E_b I_a$ = Mechanical power developed in armature. (Armature output)

$I_a^2 R_a$ = Power loss in armature.

- The above relation is known as "Voltage equation of the DC motor".

VOLTAGE AND CURRENT EQUATION OF A DC MOTOR:

- Input voltage provided to the motor armature performs the following two types,
  1. Controls the induced back E.M.F "E_b" of the motor.
  2. Provides supply to the ohmic $I_a R_a$ drop.

$$V = E_b + I_a R_a$$

E_b = Back E.M.F

$I_a R_a$ = Armature currents X Armature resistance.

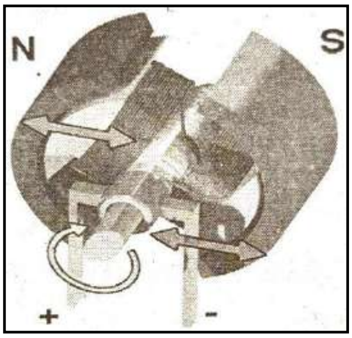
- The above relation is known as "Voltage equation of the DC motor".

DESIGN OF A SIMPLE MOTOR WITH SUITABLE TURNS OF COIL:

3. Explain the design of a simple motor (fan) with suitable turns of coil? (10M)

- An electric motor is one kind of machine used to convert the energy from electrical and mechanical.
- The motor work through the communication among the electrical current and magnetic field of the motors winding for generating force in the form of shaft rotation.
- These motors can be trigged by a DC source or AC source.
- The electric motor is shown in figure.
- The classification of electric motors based on power source, construction and output type.

- They are AC type, DC type, brushless, brushed, single phase, two or three phase motors.
- These motors are applicable in pumps, industrial fans, machine tools, blowers, disk drives.



CONSTRUCTION:

- The electric motor construction can be using the rotor, bearings, stator, air gap, windings, commutator etc.

1. ROTOR:

- The rotor in an electric motor is the moving part and the main function is to rotate the shaft for generating the mechanical power.
- The rotor includes conductors which are carry currents and communicate with the magnetic field in the stator.

2. BEARINGS:

- The bearings in the motor mainly give the support to the rotor its axis.
- The shaft of the motor expands with the help of bearings to the load of the motor.

3. STATOR:

- The stator in the motor is the inactive part of the electromagnetic circuit.
- It includes permanent magnets or windings.
- The stator can be built with different thin metal sheets known as laminators.
- These are mainly used for reducing energy losses.

4. AIR GAP:

- The air gap is the space among the stator and the rotor.
- It is the major source for the low power factor of the motor.
- Once the air gap increases between the stator and rotor then magnetizing current also increases.

5. WINDINGS:

- Windings in the motors are wires that are inside of the coils, covered around a flexible iron magnetic core.
- To make magnetic poles while energized with the current.
- Copper is the most common material for windings and aluminium is also used.

6. COMMUTATOR:

- The commutator is a half ring in the motor which is fabricated with copper.
- The main function is to link the brushes toward the coil.
- The commutator rings are used to the flow of current direction within the coil reverses each half time.
- The one surface of the coil is frequently pushed upwards and the other coil is pushed downwards.

WORKING OF ELECTRIC MOTOR:

- The electric motors work on the electromagnetic induction principle.
- There are different types of motors which uses other electromechanical methods namely piezoelectric effect and electrostatic force.
- The basic working principle of electromagnetic motors can depends on the mechanical energy that works to the flow of electric current.
- The mechanical force direction is perpendicular towards the magnetic field.

TYPES OF MOTORS AND APPLICATIONS:

4. Write the types of electric motors and its applications? (5M)

TYPES OF MOTORS:

- There are two types of electric motors,

1. AC MOTOR:

- AC motors are classified into three types namely induction, synchronous and linear motors.
- Induction motors are classified into two types namely single phase and three phase motors.
- Synchronous motors are classified into two types namely hysteresis and reluctance motors.

2. DC MOTOR:

- DC motors are classified into two types namely self-excited and separately excited motors.
- Self-excited motors are classified into three types namely series, compound and shunt motors.
- Separately excited motors are classified into two types namely short shunt and long shunt motors.

APPLICATIONS:

- The applications of motors mainly include blowers, fans, machine tools, pumps, turbines, power tools, alternators, compressors, rolling mills, ships, movers, paper mills.
- The electric motor is an essential device in different applications HVAC- heating ventilating and cooling equipment, home appliances and motor vehicles.

DC GENERATOR-CONSTRUCTION OPERATING PRINCIPLE AND EMF EQUATION:

5. What is DC generator? Explain its working and give EMF equation? (10M)

- A DC generator is an electrical machine it is convert mechanical energy into electricity.
- The electromotive force can cause a flow of current when the conductor circuit is closed.

CONSTRUCTION:

- A DC generator can also used as a DC motor without changing its construction.

1. STATOR:

- The main function of the stator is to provide magnetic fields where the coil spins.
- A stator includes two magnets with opposite polarities each other.
- These magnets are located to fit in the region of the rotor.

2. ROTOR:

- A rotor in a DC machine includes slotted iron laminations with slots that are stacked to shape a cylindrical armature core.

- The function of the lamination is to decrease the loss caused due to eddy current.

3. ARMATURE WINDINGS:

- Armature windings are in a closed circuit are connected in series to parallel to the produced current sum.

4. YOKE:

- The external structure of the DC generator is known as yoke.
- It is made of cast iron or steel.
- It provides the mechanical power for carrying the magnetic flux given the poles.

5. POLES:

- The function of pole is to hold the field windings.
- These windings are wound on poles and connected in series or parallel by the armature windings.

6. POLE SHOE:

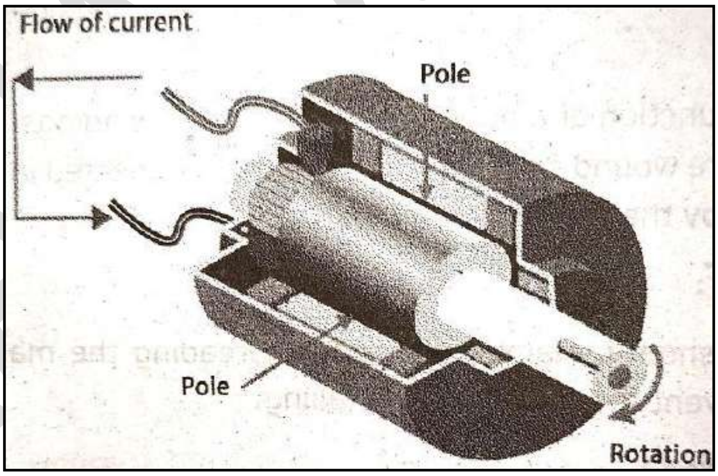
- Pole shoe is mainly utilized for spreading the magnetic flux to prevent the field coil.

7. COMMUTATOR:

- A commutator works as a rectifier that changes AC voltage to DC voltage within the armature winding.
- It is designed with a copper segment protected from the mica sheets.
- It is located on the shaft of the machine.

8. BRUSHES:

- The electrical connections between commutator and the exterior load circuit with the help of brushes.



WORKINGS:

- According to Faraday's law of electromagnetic induction, when a current carrying conductor is placed in a varying magnetic field an e.m.f is induced in the conductor.
- According to Fleming's right hand rule, the direction of the induced current changes the direction of motion of the conductor changes.
- Consider an armature rotating clockwise and a conductor at the left moving upwards.
- When the armature completes a half rotation, the direction of the motion of the conductor will be reversed downward.
- The direction of the current in every armature will be alternating.

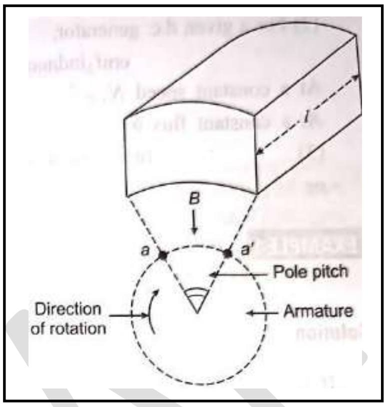
- A split ring commutator connection of the armature get reversed, we get a unidirectional current at the terminals.

EMF EQUATION OF DC GENERATOR:

- Let 'B' is the average flux density and 'l' is the axial length of the pole shown in figure.
- Dynamically induced e.m.f in a conductor is given by

$$\mathbf{e = B\, \boldsymbol{l}\, v}$$

- Consider a particular armature conductor which is at position 'a'.
- The time it travels to a position 'al' total flux by the conductor is equal to the flux density multiplied by the area.
- 'P' is the number of poles in the machine,
- 'N' is the speed of armature in rpm,
- 'Z' is the total number of conductors on armature and
- 'A' is the number of parallel paths through the armature.



$\therefore$ emf induced in each conductor $= B \times l \times \left(\dfrac{\text{distance } aa'}{\text{time taken to move } aa'}\right)$ volt ...(1)

[For N revolutions time taken $= 60$ sec

For 1 revolution time taken will be $= 60/N$ sec

$\therefore$ For $1/P$ revolution time taken $= 60/N \times P$ sec

$\therefore$ Time taken to move from a to $a' = 60/NP$ sec ...(2)

Now, consider area of each pole $= l \times (aa')$

total flux per pole, $\phi = B \times l \times (aa')$ wb ...(3)

Putting values from eq. (2) and (3) in eq. (1), we get

$$\text{emf induced in each conductor} = \frac{\phi N P}{60} \text{ volt}$$

$\therefore$ emf induced in all the Z conductors is given by

$$e = \frac{\phi N P Z}{60} \text{ volt}$$

If these Z conductors are divided into A parallel paths, the emf induced in each path is equal to emf induced between brushes or

$$E_g = \frac{1}{A} \times \left[\frac{\phi N P Z}{60}\right] \text{ volt}$$

Rearranging $\quad E_g = \dfrac{\phi Z N}{60} \times \dfrac{P}{V}$ volt

EXAMPLE 1 *What will be the change in emf induced in a d.c. generator if flux is reduced by 20% and the speed is increased by 20%?*

Solution We know that $\quad E_g = \dfrac{\phi Z N}{60} \times \dfrac{P}{A}$ volt

If follows that $\quad E_g \propto \phi N$

$\Rightarrow \quad \dfrac{E_{g2}}{E_{g1}} = \dfrac{\phi_2}{\phi_1} \times \dfrac{N_2}{N_1}$

or $\quad \dfrac{E_{g2}}{E_{g1}} = \dfrac{(0.8\,\phi)\,(1.2\,N)}{\phi\, N}$

$\Rightarrow \quad E_{g2} = 0.96\, E_{g1}$

Hence emf reduces by 4%.

EXAMPLE 2 *An 8-pole d.c. generator has 500 armature conductors and a useful flux of 0.05 wb. What will be the emf generated, if it lap-connected and runs at 1200 rpm? What must be the speed at which it is to be driven to produce the same emf if it is wave-wound?*

Solution In lap winding $A = P = 8$ (given)

$$\therefore \quad E_g = \frac{\phi Z N}{60} \times \frac{P}{A}$$

$$= \frac{0.05 \times 500 \times 1200}{60} \times \frac{8}{8}$$

$$= \mathbf{500} \text{ volt}$$

For *wave connected* armature winding to generate 500 V emf, let the speed be N. For wave winding $A = 2$.

$$\therefore \quad 500 = \frac{0.05 \times 500 \times N}{60} \times \frac{8}{2}$$

or $$N = \mathbf{300} \text{ rpm}$$

DIFFERENCE BETWEEN DC AND AC GENERATORS:

6. Write the differences between D.C and A.C generator? (10&5M)

- An AC & DC generators works on the principle of "Electromagnetic induction".

S. No	PROPERTY	AC GENERATOR	DC GENERATOR
1.	Definition	AC generator is a device that converts mechanical energy into AC electrical power	DC generator is a device that converts mechanical energy into DC electrical power
2.	Direction of current	The electrical current reverses direction periodically.	The electrical current flows only one direction.
3.	Basic Design	The coil through which the current flows is fixed field but the construction is simple and costs are less.	The coil through which the current flows rotate in fixed field but the construction is complex due to commutators and slip rings.
4.	Commutators	AC generators does not have Commutators.	DC generators have Commutators.
5.	Rings	AC generators have slip-rings.	DC generators does not have slip-rings.
6.	Efficiency of brushes	Since slip rings have a smooth and uninterrupted surface, they do not wear quickly and highly efficient.	Both brushes and commutators of DC generator wear out quickly and less efficient.
7.	Output voltage	AC generators produce a high voltage which varies in amplitude and frequency.	DC generators produce a low voltage compared to AC generator which constant in amplitude and frequency is zero.
8.	Transmission	The output from AC generators is easy to distribute using a transformer.	The output from DC generators is difficult to distribute cannot be used transformers.
9.	Efficiency	AC generators are very efficient as the energy losses are less.	DC generators are less efficient and other losses are less.
10.	Applications	It is used to power smaller motors and electrical appliances at homes.	DC generators power very large electric motors those needed for subway systems.