BASIC ELECTRICAL AND ELECTRONICS ENGINEERING

UNIT – I ELECTRICAL

CIRCUITS AND MEASUREMENTS

PART - A

1. **What is charge?**

   The charge is an electrical property of the atom particles of which matter consists. The unit of charge is coulomb.

2. **Define current.**

   The flow of free electron in a metal is called electric current. The unit current is ampere.

   Current (I) = Q / t unit is C/s (or) Amps Where, Q is the total charge transferred in coulomb.

   t is the time required to transfer the charge.

3. **Under what condition AC circuit said to be resonant?**

   If the inductive reactance of the circuit is equal to capacitive reactance then the circuit is said to be resonance. XL=XC

4. **Define voltage.**

   The potential difference between two points in an electric circuit called voltage. The unit of voltage is the volt. Voltage represented by V

5. **Define electric potential.**

   Capacity of charged body to do work is electric potential.

   Electric potential = Work done / Charge = W/Q

   When one joule of work is done to charge a body to one coulomb, the body is said to have an electric potential of one volt. The unit of electric potential is volt; symbol is V. Smaller values of electric potentials are measured by mill volts and micro volts.

AMSCE - 1101

6. Define power.

The rate of doing work by electrical energy or energy supplied per unit time is called the power. Its unit is watts $P = V*I$; $P = I^2R$; $P = E^2 / R$. P = Energy / time = W/t

7. Define resistance.

Resistance is the property of a substance, which opposes the flow of electric current. Also it

can be considered as electric friction. Whenever current flows through a resistor, a voltage drop occurs in it and it is dissipated in the form of heat. Unit of resistance is ohm. Symbol is R measured with a help of ohmmeter.

8. Define international ohm.

International ohm is defined as the resistance offered to the flow of current by a column of mercury of length 106.3cm; 14.452gm in mass with uniform cross section at 0 C.

9. What are the factors affecting resistance?

(i) Length - $R \alpha L / a$

(ii) Area of cross section - $R \alpha L / a$

(iii) Nature and property of the material - $R \alpha \rho$

(iv) Conductance and conductivity - $G = 1/R$

10. What is meant by electrical energy?

Energy is the total amount of work done and hence is the product of power and time. $W = Pt = E\ I\ t = I^2Rt = E^2 / R\ t$ Joules (watt – second)

11. Write down the expression for effective resistance when three resistances are connected in series and parallel.

For series connection (for three resistors) $\mathbf{R_{eq} = R1 + R2 + R3}$

For parallel connection (for two resistors) $\mathbf{R_{eq} = R1 * R2 / (R1 + R2)12}$.

AMSCE - 1101

12. State Kirchhoff's laws. (Nov/Dec 2014) (April/May 2015) (April/May 2017)

Kirchhoff's current law (KCL)

The sum of currents flowing towards the junction is equal to the sum of the currents flowing away from it.

Kirchhoff's voltage law (KVL)

In a closed circuit, the sum of the potential drops is equal to the sum of the potential rises.

13. Write the general form of mesh analysis.

[R][I] = [V] ohms law

14. What is series circuit?

When the resistors connected in a circuit such that the current flowing through them is same is called as series circuit.

15. What is parallel circuit?

When resistors are connected across one another so that same voltage applied to each, then they are said to be in parallel the circuit is called as parallel circuit.

16. What does alternating quantity mean?

It is one which magnitude and direction changes with respect to time.

17. State Ohm's law. Dec 2015 , (Nov/Dec 2016)

When temperature remains constant, current flowing through a circuit is directly proportional to potential difference across the conductor. $E \alpha I$

18. What is meant by cycle?

The time taken to complete set of positive and negative values of an alternating quantity.

19. Define frequency.

AMSCE - 1101

The number cycles occurring per second is called frequency f = 1/T Hz.

AMSCE - 1101

20. What is meant by average value?

Average value = Area under the curve over one complete cycle / Base (Time period)

21. Define form factor.

Form factor = RMS value / Average value

22. Define crest (peak) factor.

Crest (peak) factor = Maximum value / RMS value

23. Give the voltage and current equation for a purely resistance circuit.

$e = E_m \sin \omega t$

$i = I_m \sin \omega t$ where,

e, i are instantaneous value of voltage and current respectively.

E_m, I_m are maximum voltage and current respectively.

ω - Angular velocity, T – Time period.

24. Define inductance.

'When a time varying current passes through circuit varying flux is produced because of this change in flux, a voltage is induced in the circuit proportional to rate of change of flux or current'(i.e) Emf induced α di/dt = L di/dt

where L, the constant proportionality has come to be called as self-inductance of the circuit The self-inductance is the property of coil by which it oppose any change of current. It is well known that the unit of inductance is Henry.

25. Define capacitance.

A capacitor is a circuit element that, like the inductor, stores energy during periods of time and return the energy during others. In the capacitor, storage takes place in an electric field unlike the inductance where storage is magnetic field. Two parallel plates separated by an insulating medium form a capacitor.

The emf across the capacitor is proportional to the charge in it

(i.e) $e \,\alpha\, q$ or $e = q/C$,

where, C is constant called capacitance.

AMSCE - 1101

26. Define power factor. (April/May 2017)

The power factor is the cosine of the phase angle between voltage and current.

Cos = Resistance / Impedance

Cos = Real power / Apparent power

27. What are the three types of power used in a.c circuit?

(i) Real power or Active power P = EI cos Watts

(ii) Reactive power Q = EI sin VAR (iii) Apparent power S = EI VA

28. Define real power.

The actual power consumed in an ac circuit is called real power. If E and I are rms value of voltage and current respectively and q is the phase angle between V and I. P = EI cos. Watts

29. Define reactive power.

The power consumed by pure reactance (XL or XC) in an a.c circuit is called reactiven power. The unit is VAR. Q = VI Sin. VAR.

30. Define apparent power.

The maximum power consumed by the circuit is called apparent power. The unit VA.
S = VI.

31. Define RMS value.

It is the mean of the squares of the instantaneous value of current over one complete cycle.

32. State the limitations of Ohm's Law (June 2014, Dec 2015)

a. Ohm's Law does not apply to all non- metallic conductors.

b. It also does not apply to all non- linear devices such as zener diode. Voltage regulator tubes etc.

AMSCE - 1101

c. It is true for metal conductors at constant temperature. If the temperature changes, the law is not applicable.

33. State the principle of operation of moving coil instruments.

If a current carrying conductor placed in a magnetic field then it experiences a force. The deflecting torque developed in the coil is proportional to the force developed and hence proportional to the current to be measured.

34. State the different type of instruments based on their operating principles.(June 2012)

- Moving – iron
- Permanent magnet moving coil
- Dynamometer type
- Induction type
- Hot wire type
- Electrolytic meter
- Electrostatic

35. Name the essential torques required for the proper operation of indicating instruments. (May 2015)

- Deflecting torque
- Controlling torque
- Damping torque

36. State the principle of moving iron instrument.(May 2014)

A soft iron piece if brought near the magnet gets attracted by the magnets, is the principle of moving iron attraction type instrument.

While like polarities of magnet, face each other, they experience a force of repulsion is the principle of moving iron repulsion type instrument.

AMSCE - 1101

37. What are the advantages of electromechanical measuring instruments?(May 2012, Dec 2012)

- Operating current is small
- Sensitivity is high
- Consumes less power.
- Can cover wide range

38. List the types of indicating instruments.(Dec 2010)

- Moving – iron
- Moving - coil

38. What is loading effect?

An ideal measuring instrument will not draw any current from the measuring circuit. But all practical instruments will draw small current. The amount of current drawn by the measuring instrument is loading effect.

39. What are the two types of moving iron instruments?

- Attraction type
- Repulsion type

40. Why cannot a moving coil instrument be used in AC circuits?

The deflecting torque of the instrument reverses if the current reverse. If the instrument is connected to AC, the pointer cannot follow the rapid reversals and the deflection corresponds to mean torque, which is zero. So these instruments cannot be used for AC.

41. List the various methods to provide damping torque.

- Air friction method
- Fluid friction method
- Eddy current method

42. State the advantages and disadvantages of PMMC instrument.

Advantages:

- The scale is linear and uniform
- The aluminium former in the moving system provides effective damping

AMSCE - 1101

- Operating at high efficiency
- No hysteresis loss
- Negligible interference due to external magnetic field
- Reliable and accurate while compared with other methods.
- Torque to weight ratio is very high

Disadvantages:

- The sensitivity is high.
- Suitable for DC measurements only
- Ageing of permanent magnet and control spring introduces the errors
- The cost is high due to delicate construction and accurate

43. State the advantages and disadvantages of moving iron instruments.

Advantages:

- Used for both ac and dc measurements
- Range of instruments can be extended
- Errors due to friction are very less
- Cheaper than other types of instruments
- Robust construction since no current carrying moving parts.

Disadvantages:

- Appreciable error occurs in DC measurements due to hysteresis effect.
- The scale is not uniform and is cramped at the lower end and therefore readings are inaccurate at this end.
- These instruments are subjected to serious errors due to frequency changes, hysteresis and stray magnetic effects

44. State the advantages and disadvantages of electrodynamometer type wattmeter.

Advantages:

- The scale is uniform
- High degree of accuracy can be obtained by careful design hence used for calibration purposes

AMSCE - 1101

Disadvantages:

- The error due to the inductance of pressure coil at a low power factor is very serious
- Stray field may affect the reading of the instrument. To reduce it, magnetic shielding is provided by enclosing it in iron case.

45. What is creeping? How it is minimized?

Without any current through current coil, disc has a tendency to rotate due to the supply voltage exciting its pressure coil. This is called creeping.

This creeping may be because of over friction compensation.

To eliminate creeping, two holes are drilled in the disc 180° opposite to each other. When this hole comes under the shunt magnet pole, it gets acted upon by a torque opposite to its rotation. This restricts its rotation on its no load condition.

46. Why eddy current damping is not used in moving iron instrument?

The operating magnetic field in moving iron instrument is very weak due to which eddy

current damping cannot be effective.

47. A 120 Ω resistor has a specified maximum power dissipation of 1 W. Calculate themaximum current level. June 2014

Power dissipation P = 1 W

Resistor R = 120 Ω I^2R

$$I^2 = \frac{P}{R}$$

$\therefore$ I = 0.091A

48. Two resistances of 4 Ω and 6 Ω are connected in parallel across 10 V battery. Determine the current through 6 Ω resistance.(Nov 2013)

Current through 6Ω resistor is 10/6 = 1.666A

AMSCE-1101

49. Electro-magnetic force(E.M.F):

Electromotive Force is, the voltage produced by an electric battery or generator in an electrical circuit or, more precisely, the energy supplied by a source of electric power in driving a unit charge around the circuit. The unit is the volt. A difference in charge between two points in a material can be created by an external energy source such as a battery. This causes electrons to move so that there is an excess of electrons at one point and a deficiency of electrons at a second point. This difference in charge is stored as electrical potential energy known as emf. It is the emf that causes a current to flow through a circuit.

50. Distinguish between a mesh and a loop of a circuit. June 2009

A loop is any closed path of a network. Mesh is also a loop.

A mesh is the most elementary form of the loop that has shortest path and cannot be further divided into other loops.

AMSCE - 101

PART – B

1. (a) State and explain Kirchoff's law. (April/May 2015)

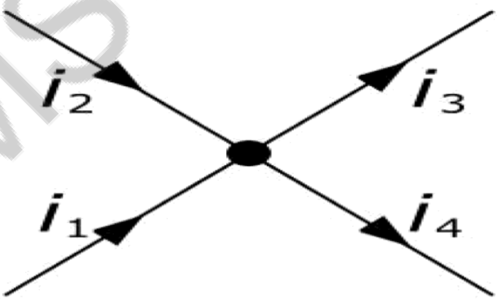
Kirchhoff's Current Law:

First law (Current law or Point law):

Statement:

The sum of the currents flowing towards any junction in an electric circuit equal to the sum of currents flowing away from the junction.

Kirchhoff's Current law can be stated in words as the sum of all currents flowing into a node is zero. Or conversely, the sum of all currents leaving a node must be zero. As the image below demonstrates, the sum of currents Ib, Ic, and Id, must equal the total current in Ia. Current flows through wires much like water flows through pipes. If you have a definite amount of water entering a closed pipe system, the amount of water that enters the system must equal the amount of water that exists the system. The number of branching pipes does not change the net volume of water (or current in our case) in the system.



$$i_1 + i_2 = i_3 + i_4$$

Kirchhoff's Voltage Law:

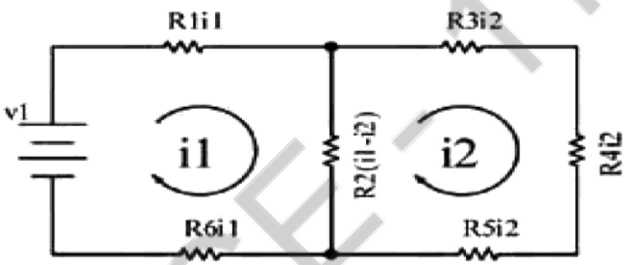
Second law (voltage law or Mesh law): Statement:

In any closed circuit or mesh, the algebraic sum of all the electromotive forces and the voltage drops is equal to zero.

AMSCE-1101

Kirchhoff's voltage law can be stated in words as the sum of all voltage drops and rises in a closed loop equals zero. As the image below demonstrates, loop 1 and loop 2 are both closed loops within the circuit. The sum of all voltage drops and rises around loop 1 equals zero, and the sum of all voltage drops and rises in loop 2 must also equal zero. A closed loop can be defined as any path in which the originating point in the loop is also the ending point for the loop. No matter how the loop is defined or drawn, the sum of the voltages in the loop must be zero

Figure 2. Kirchoff's Voltage Law



$$-v1 + R1i1 + R2(i1-i2) + R6i2 = 0$$

$$R2(i2-i1) + R3i2 + R4i2 + R5i2 = 0$$

2. Explain the working of a Dynamometer wattmeter with a neat sketch. (April/May 2015) (April/May 2017)

In general, a watt meter is used to measure the electric power of a circuit, or sometime it also measures the rate of energy transferred from one circuit to another circuit. When a moving coil (that is free to rotate) is kept under the influence of a current carrying conductor, then automatically a mechanical force will be applied to the moving coil, and this force will make a little deflection of the moving coil. If a pointer is connected with the moving coil, which will move of a scale, then the deflection can be easily measured by connecting the moving coil with that pointer. This is the principle of operation of all dynamo meter type instruments, and this principle is equally applicable for dynamo meter type watt meter also.

AMSCE 1401

This type of watt meter consists of two types of coil, more specifically current coil and voltage coil. There are two current coils which are kept at constant position and the measurable current will flow through those current coils. A voltage coil is placed inside those two current coils, and this voltage coil is totally free to rotate. The current coils are arranged such a way, that they are connected with the circuit in series. And the voltage coil is connected in parallel with the circuit.

Construction and Working Principle of Electrodynamometer Type Wattmeter

Now let us look at constructional details of electrodynamometer. There are two types of coils present in the electrodynamometer. They are :

(a) Moving coil : Moving coil moves the pointer with the help of spring control instrument. A limited amount of current flows through the moving coil so as to avoid heating. So in order to limit the current we have connect the high value resistor in series with the moving coil. The moving is air cored and is mounted on a pivoted spindle and can moves freely. In **electrodynamometer type wattmeter**, moving coil works as pressure coil. Hence moving coil is connected across the voltage and thus the current flowing through this coil is always proportional to the voltage.

(b) Fixed coil: The fixed coil is divided into two equal parts and these are connected in series with the load, therefore the load current will flow through these coils. Now the reason is very obvious of using two fixed coils instead of one, so that it can be constructed to carry considerable amount of electric current. These coils are called the current coils of electrodynamometer type wattmeter. Earlier these fixed coils are designed to carry the current of about 100 amperes but now the modern wattmeter are designed to carry current of about 20 amperes in order to save power.

AMSCE-1101

Unit Wise Solved Question Paper 15

(c) Control system: Out of two controlling systems i.e. (1). Gravity control

(2) Spring control, only spring controlled systems are used in these types of wattmeter. Gravity controlled system cannot be employed because they will appreciable amount of errors.

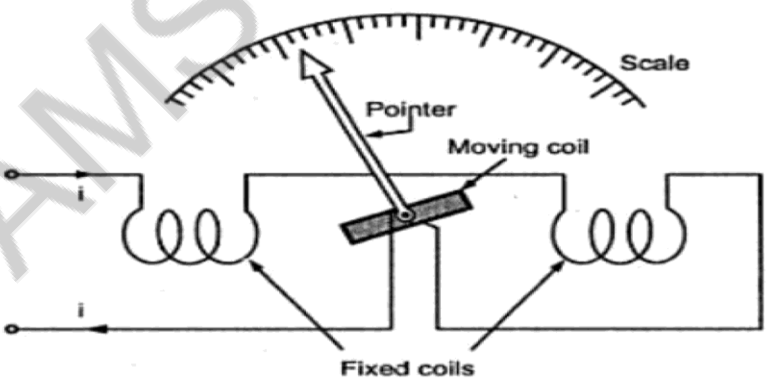
(d) Damping system: Air friction damping is used, as eddy current damping will distort the weak operating magnetic field and thus it may leads to error.

(e) Scale: There is uniform scale is used in these types of instrument as moving coil moves

linearly over a range of 40 degrees to 50 degrees on either sides.

Now let us derive the expressions for the controlling torque and deflecting torques. In order to derive these expressions let us consider the circuit diagram given below:

We know that instantaneous torque in electro dynamic type instruments is directly proportional to product of instantaneous values of currents flowing through both the coils and the rate of change of flux linked with the circuit.



Let I_1 and I_2 be the instantaneous values of currents in pressure and current coils respectively. So the expression for the torque can be written as: $T = I1*I2*(dM / dx)$

Where x is the angle

AMSCE-1101

Now let the applied value of voltage across the pressure coil be $V = V \sin \omega t$

Assuming the electrical resistance of the pressure coil be very high hence we can neglect reactance with respect to its resistance. In this the impedance is equal to its electrical resistance therefore it is purely resistive The expression for instantaneous current can be written as $I_2 = v / R_p$ where R_p is the resistance of pressure coil.

$I2 = V \sin \omega t / Rp$

If there is phase difference between voltage and electric current, then expression for instantaneous current through current coil can be written as $I1 = I(t) = I \sin (\omega t - \Phi)$

As current through the pressure coil in very small compare to current through current coil hence current through the current coil can be considered as equal to total load current.

Hence the instantaneous value of torque can be written as $V \sin \omega t / Rp * I \sin (\omega t - \Phi) * (dM / dx)$

Average value of deflecting torque can be obtained by integrating the instantaneous torque from limit to T where T is the time period of the cycle Td = deflecting torque $= VI \cos\Phi / Rp * (dM / dx)$ Controlling torque is given by $T_c = K_x$ where K is spring constant and x is final steady state value of deflection.

Advantages of Electrodynamometer Type Wattmeter

Following are the advantages of electrodynamometer type wattmeters and they are written as follows:(a). Scale is uniform up to certain limit

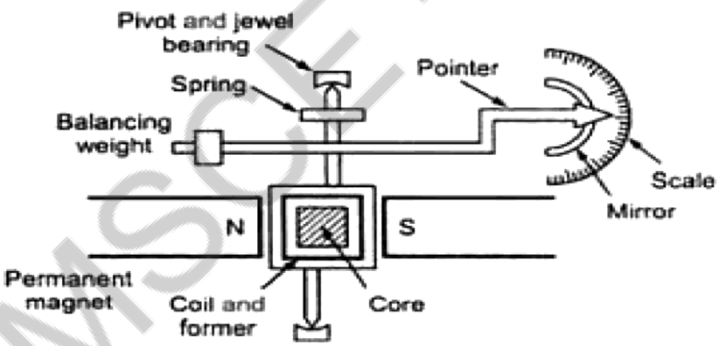
(b). They can be used for both to measure AC as well as DC quantities as scale is calibrated for both

Errors in Electrodynamometer Type Wattmeter

Following are the errors in the electrodynamometer type watt meters:

(a) Errors in the pressure coil inductance. (b) Errors may be due to pressure coil capacitance. (c) Errors may be due to mutual inductance effects. (d) Errors may be due connections.(i.e. pressure coil is connected after current coil) (e) Error due to Eddy currents. (f) Errors caused by vibration of moving system. (g) Temperature error. (h) Errors due to stray magnetic field

3. Explain the working principle of PMMC instruments. (April/May 2015) (Nov/ Dec 2017) .



The permanent magnet moving coil instrument or PMMC type instrument uses two permanent magnets in order to create stationary magnetic field. These types of instruments are only used for measuring the dc quantities as if we apply ac current to these type of instruments the direction of current will be reversed during negative half cycle and hence the direction of torque will also be reversed which gives average value of torque zero. The pointer will not deflect due to high frequency from its mean position showing zero reading. However it can measure the direct current very accurately.

Construction of permanent magnet moving coil instruments.

AMSCE - 1101

Unit Wise Solved Question Paper 18

Stationary part or magnet system: In the present time we use magnets of high field intensities, high coercive force instead of using U shaped permanent magnet having soft iron pole pieces. The magnets which we are using nowadays are made up of materials like alcomax and alnico which provide high field strength.

AMSCE - 1101

Unit Wise Solved Question Paper 19

Moving coil: The moving coil can freely moves between the two permanent magnets as shown in the figure given below. The coil is wound with many turns of copper wire and is placed on rectangular aluminum which is pivoted on jeweled bearings.

Control system: The spring generally acts as control system for PMMC instruments. The spring also serves another important function by providing the path to lead current in and out of the coil. Damping system: The damping force hence torque is provided by movement of aluminum former in the magnetic field created by the permanent magnets.

Meter: Meter of these instruments consists of light weight pointer to have free movement and scale which is linear or uniform and varies with angle

Deflecting torque Equation:

Let us derive a general expression for torque in permanent magnet moving coil instruments or

PMMC instruments. We know that in moving coil instruments the deflecting torque is given by the expression:

$T_d = N B l dI$

where N is number of turns, B is magnetic flux density in air gap, l is the length of moving coil, d is the width of the moving coil, And I is the electric current.

Now for a moving coil instruments deflecting torque should be proportional to current, mathematically we can write $T_d = GI$. Thus on comparing we say G = NBIdl.

At steady state we have both the controlling and deflecting torques are equal.

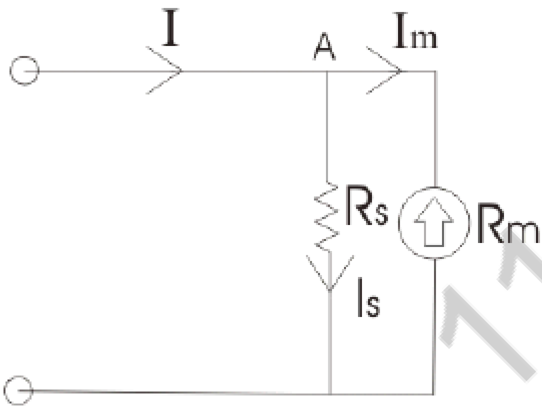
T_c is controlling torque, on equating controlling torque with deflection torque we have GI = K.x where x is deflection thus current is given by **I = K / G x**

AMSCE - 1101

Since the deflection is directly proportional to the current therefore we need a uniform scale on the meter for measurement of current.

AMSCE - 1101

Now we are going to discuss about the basic circuit diagram of the ammeter. Let us consider a circuit as shown below



.

The current I is shown which breaks into two components at the point A. The two components are I_s and I_m. Before I comment on the magnitude values of these currents, let us know more about the construction of shunt resistance. The electrical resistance of these shunts should not differ at higher temperature, it they should posses very low value of temperature coefficient. Also the resistance should be time independent. Last and the most important property they should posses is that they should be able to carry high value of current without much rise in temperature. Usually manganin is used for making dc resistance. Thus we can say that the value of I_s much greater than the value of I_m as resistance of shunt is low. From the we have, $I_s . R_s = I_m R_m$

Where R_s is resistance of shunt and R_m is the electrical resistance of the coil. Is = I – Im

M= I / Im = 1+ (Rm + Rs)

Where m is the magnifying power of the shunt.

AMSCE-1101

 22

Errors in Permanent Magnet Moving Coil Instruments

There are three main types of errors **(a) Errors due to permanent magnets**:

Due to temperature effects and aging of the magnets the magnet may lose their magnetism to some extent. The magnets are generally aged by the heat and vibration treatment.

(b) Error may appear in PMMC Instrument due to the aging of the spring.

However the error caused by the aging of the spring and the errors caused due to permanent magnet are opposite to each other, hence both the errors are compensated with each other.

(c) **Change in the resistance of the moving coil with the temperature:**

Generally the temperature coefficients of the value of coefficient of copper wire in moving coil is 0.04 per degree Celsius rise in temperature. Due to lower value of temperature coefficient the temperature rises at faster rate and hence the resistance increases. Due to this significant amount of error is caused.

Advantages of Permanent Magnet Moving Coil Instruments

(1)The scale is uniformly divided as the current is directly proportional to deflection of the pointer.

Hence it is very easy to measure quantities from these instruments. (2)Power consumption is also very low in these types of instruments. (3)Higher value of torque is to weight ratio.

(4)These are having multiple advantages, a single instrument can be used for measuring various quantities by using different values of shunts and multipliers.

Disadvantages of Permanent Magnet Moving Coil Instruments

(1) These instruments cannot measure ac quantities.

(2) Cost of these instruments is high as compared to moving iron instruments

AMSCE-1101

4. Explain the working principle of MI instruments. (Nov/Dec 2014) (April/May 2015) (Nov/Dec 2017)

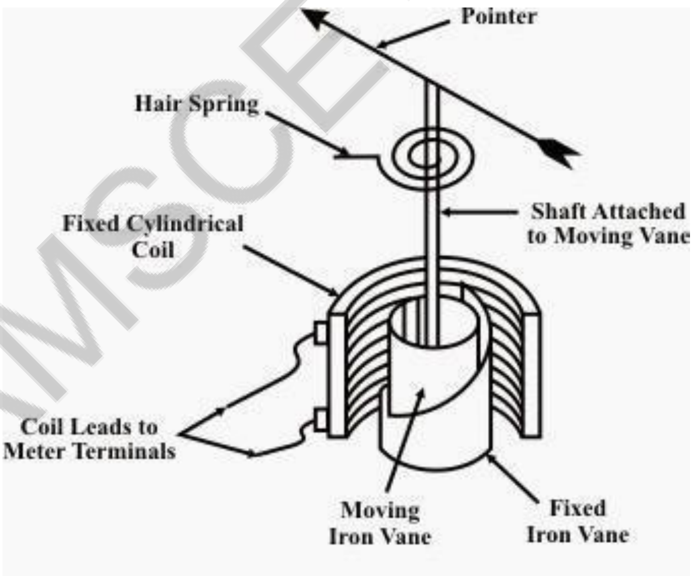
Moving Iron instruments

Moving-iron instruments are generally used to measure alternating voltages and currents. In

moving-iron instruments the movable system consists of one or more pieces of specially-shaped soft iron, which are so pivoted as to be acted upon by the magnetic field produced by the current in coil.

There are two general types of moving-iron instruments namely:

1. Repulsion (or double iron) type (figure 1) 2. Attraction (or single-iron) type (figure 2) The brief description of different components of a moving-iron instrument is given below: **Repulsion type**



Repulsion type.

AMSCE - 1101

Moving element: A small piece of soft iron in the form of a vane or rod.

Coil: To produce the magnetic field due to current flowing through it and also to magnetize the iron pieces.

In repulsion type, a **fixed** vane or rod is also used and magnetized with the same polarity.

Control torque is provided by spring or weight (gravity).

Damping torque is normally pneumatic, the damping device consisting of an air chamber and a moving vane attached to the instrument spindle.

Deflecting torque produces a movement on an aluminum pointer over a graduated scale.

The deflecting torque in any moving-iron instrument is due to forces on a small piece of magnetically 'soft' iron that is magnetized by a coil carrying the operating current. In repulsion type moving–iron instrument consists of two cylindrical soft iron vanes mounted within a fixed current-carrying coil. One iron vane is held fixed to the coil frame and other is free to rotate, carrying with it the pointer shaft. Two irons lie in the magnetic field produced by the coil that consists of only few turns if the instrument is an ammeter or of many turns if the instrument is a voltmeter.

Current in the coil induces both vanes to become magnetized and repulsion between the similarly magnetized vanes produces a proportional rotation. The deflecting torque is proportional to the square of the current in the coil, making the instrument reading is a true 'RMS' quantity Rotation is opposed by a hairspring that produces the restoring torque. Only the fixed coil carries load current, and it is constructed so as to withstand high transient current. Moving iron instruments having scales that are nonlinear and somewhat crowded in the lower range of calibration

Measurement of Electric Voltage and Current

Moving iron instruments are used as Voltmeter and Ammeter only. Both can work on AC as well as on DC.

Ammeter

Instrument used to measure current in the circuit.

Always connected in series with the circuit and carries the current to be measured. This current flowing through the coil produces the desired deflecting torque.

It should have low resistance as it is to be connected in series.

Voltmeter

Instrument used to measure voltage between two points in a circuit.

Current flowing through the operating coil of the meter produces deflecting torque.

It should have high resistance. Thus a high resistance of order of kilo ohms is connected in series with the coil of the instrument.

Ranges of Ammeter and Voltmeter

For a given moving-iron instrument the ampere-turns necessary to produce full-scale deflection are constant. One can alter the range of ammeters by providing a shunt coil with the moving coil. Voltmeter range may be altered connecting a resistance in series with the coil. Hence the same coil

winding specification may be employed for a number of ranges.

Advantages

1. The instruments are suitable for use in AC and DC circuits.
2. The instruments are robust, owing to the simple construction of the moving parts.
3. The stationary parts of the instruments are also simple.
4. Instrument is low cost compared to moving coil instrument.
5. Torque/weight ratio is high, thus less frictional error.

Errors

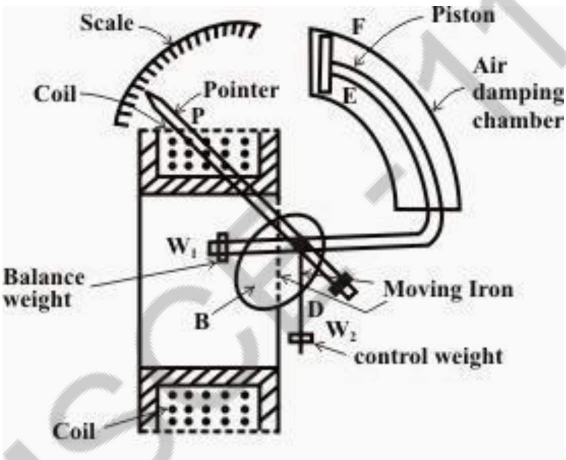
(i). Error due to variation in temperature.

(ii). Error due to friction is quite small as torque-weight ratio is high in moving coil instruments. (iii). Stray fields cause relatively low values of magnetizing force produced by the coil. Efficient magnetic screening is essential to reduce this effect.

(iv). Error due to variation of frequency causes change of reactance of the coil and also changes the eddy currents induced in neighboring metal.

(v). Deflecting torque is not exactly proportional to the square of the current due to non-linear characteristics of iron material.

Attraction type



Attraction type

The basic construction of attraction type moving iron instrument is illustrated bellow

A thin disc of soft iron is eccentrically pivoted in front of a coil. This iron tends to move inward that is from weaker magnetic field to stronger magnetic field when current flowing through the coil. In attraction moving instrument gravity control was used previously but now gravity control method is replaced by spring control in relatively modern instrument. By adjusting balance weight null deflection of the pointer is achieved. The required damping force is provided in this instrument by air friction. The figure shows a typical type of damping system provided in the instrument, where damping is achieved by a moving piston in an air syringe.

AMSCE-1101

Theory of Attraction Type Moving Iron Instrument

Suppose when there is no current through the coil, the pointer is at zero, the angle made by the axis of the iron disc with the line perpendicular to the field is ϕ. Now due current I and corresponding magnetic field strength, the iron piece is deflected to an angle θ. Now component of H in the direction of defected iron disc axis is Hcos{90 - ($\theta + \phi$) or Hsin($\theta + \phi$). Now force F acting on the disc inward to the coil is thus proportional to $H^2\sin(\theta + \phi)$ hence the force is also proportional to $I^2\sin(\theta + \phi)$ for constant permeability. If this force is acting on the disc at a distance l from the pivot, then deflection torque,

$T_d = Fl \cos(\theta+\Phi)$

Thus $T_d = I^2 \sin(\theta+\Phi) \cos(\theta+\Phi)$ $T_d = kI^2 \sin 2(\theta+\Phi)$

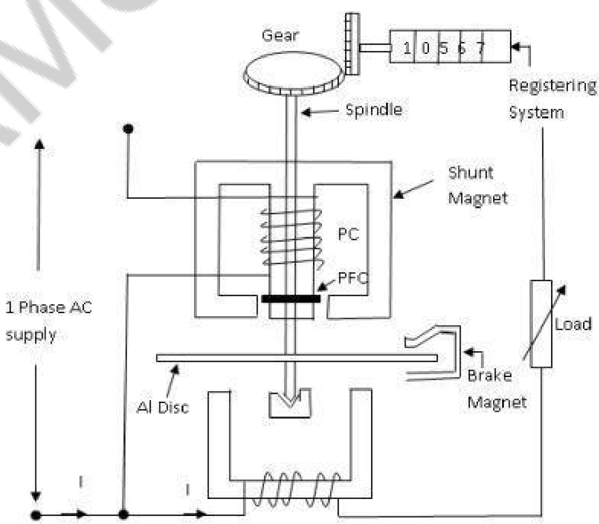
Where k is constant.

Now, as the instrument is gravity controlled, controlling torque will be

$T_c = k' \sin\theta$

Where k 'is constant

5. **Explain the construction and principle of operation of single phase energy meter. (16) (May/June 2016) (Nov/Dec 2016)**



AMSCE - 1101

Unit Wise Solved Question Paper 28

Single phase induction type energy meter is also popularly known as **watt-hour meter**. This name is given to it. This article is only focused about its constructional features and its working. Induction type energy meter essentially consists of following components:

1. Driving system 2. Moving system 3. Braking system and 4. Registering system

Driving system

It consists of two electromagnets, called **"shunt" magnet** and **"series" magnet**, of laminated construction. A coil having large number of turns of fine wire is wound on the middle limb of the shunt magnet.

This coil is known as "**pressure or voltage**" coil and is connected across the supply mains. This voltage coil has many turns and is arranged to be as highly inductive as possible. In other words, the voltage coil produces a high ratio of inductance to resistance. This causes the current and therefore the flux, to lag the supply voltage by nearly 90 degree. Adjustable copper shading rings are provided on the central limb of the shunt magnet to make the phase angle displacement between magnetic field set up by shunt magnet and supply voltage is approximately 90 degree.

The copper shading bands are also called the power factor compensator or compensating loop. The series electromagnet is energized by a coil, known as **"current"** ***coil*** which is connected in series with the load so that it carry the load current. The flux produced by this magnet is proportional to, and in phase with the load current.

Moving system

The moving system essentially consists of a light rotating aluminum disk mounted on a vertical spindle or shaft. The shaft that supports the aluminum disk is connected by a gear arrangement to the clock mechanism on the front of the meter to provide information that consumed energy by the load. The time varying (sinusoidal) fluxes produced by shunt and series magnet

AMSCE - 1101

29

induce eddy currents in the aluminum disc The interaction between these two magnetic fields and eddy currents set up a

AMSCE - 1101

driving torque in the disc. The number of rotations of the disk is therefore proportional to the energy consumed by the load in a certain time interval and is commonly measured in **kilowatt-hours (Kwh)**.

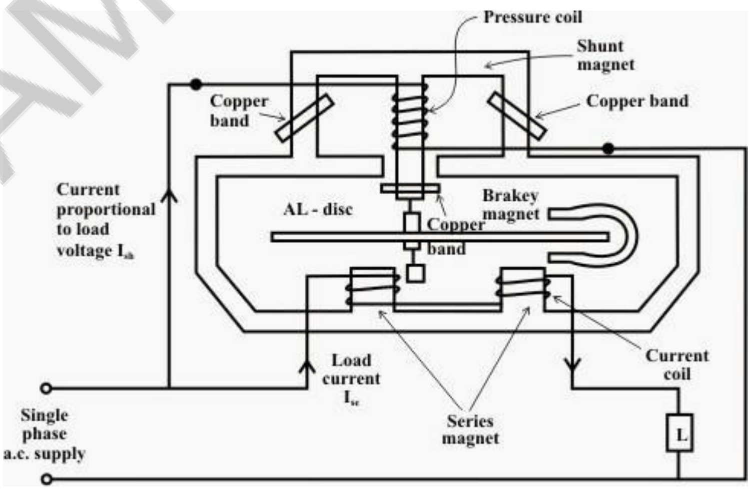
Braking system

Damping of the disk is provided by a **small permanent magnet**, located diametrically opposite to

the a.c magnets. The disk passes between the magnet gaps. The movement of rotating disc through the magnetic field crossing the air gap sets up eddy currents in the disc that reacts with the magnetic field and exerts a braking torque.

By changing the position of the brake magnet or diverting some of the flux there form, the speed of the rotating disc can be controlled.

The registering or counting system essentially consists of gear train, driven either by worm or pinion gear on the disc shaft, which turns pointers that indicate on dials the number of times the disc has turned. The energy meter thus determines and adds together or integrates all the **instantaneous power values** so that total energy used over a period is thus known. Therefore, this type of meter is also called an **“integrating” meter**.



AMSCE - 1101

Working of Single phase induction type Energy Meter

The basic working of Single phase induction type Energy Meter is only focused on two mechanisms:

1. Mechanism of rotation of an aluminum disc which is made to rotate at a speed proportional to the power.
2. Mechanism of counting and displaying the amount of energy transferred.

Mechanism of rotation of an aluminum disc

The metallic disc is acted upon by two coils. One coil is connected 0r arranged in such a way that it produces a magnetic flux in proportion to the voltage and the other produces a magnetic flux in proportion to the current. The field of the voltage coil is delayed by 90 degrees using a lag coil.

This produces eddy currents in the disc and the effect is such that a force is exerted on the disc in proportion to the product of the instantaneous current and voltage.

A permanent magnet exerts an opposing force proportional to the speed of rotation of the disc – this act as a brake which causes the disc to stop spinning when power stops being drawn rather thanallowing it to spin faster and faster. This causes the disc to rotate at a speed proportional to the power being used.

Mechanism of displaying the amount of energy transferred

The aluminum disc is supported by a spindle which has a worm gear which drives the register. The register is a series of dials which record the amount of energy used. The dials may be of the cyclometer type, an odometer-like display that is easy to read where for each dial a single digit is shown through a window in the face of the meter, or of the pointer type where a pointer indicates each digit. It should be noted that with the dial pointer type, adjacent pointers generally rotate in opposite directions due to the gearing mechanism.

AMSCE-1101

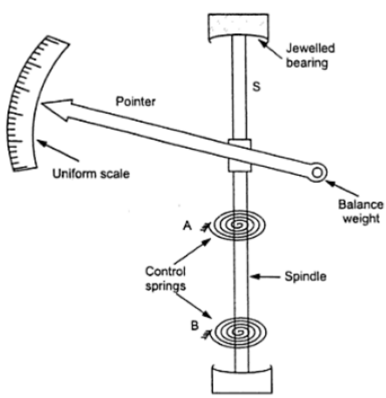
6. Explain how following torque are produced in PMMC instrument and attracted type moving iron instruments

1. Deflecting torque 2. Control torque 3. Damping torque

Deflecting torque:- The deflecting torque is produced by making use of one of the magnetic, chemical, electrostatic and electromagnetic induction effects of current or voltage and causes the moving system of the instrument to move from its zero position when the instrument is connected in an electrical circuit to measure the electrical quantity. The method of producing this torque depends upon the type of instrument. In attracting the type of instrument, this torque to equal to Td = 1/2 I2 dL/dU Whereas in PMMC instruments Td = Bilur

Where B - magnetic density; i - current flowing; l - length of coil;u - number of turn; r - radius of coil

2. **Controlling torque:-** The magnitude of the movement to the moving system would be somewhat indefinite under the influence of deflecting torque unless some controlling torque exist. This torque opposes the deflecting torque and increases with increase in deflection of the moving system without controlling system the irrespective magnitude of current and moreover, once deflected it would not return to its zero position on removing the current. In attraction type instrument it is produced by spring control and in PMMC too it would be produced by spring control.



AMSCE-1101

The arrangement for spring control consists of two phosphor bronze spiral hair springs attached to a moving system. The springs are made of materials which (i). are not affected by fatigue. (ii). Have low temp-coefficient of resistance (iii). Have low specific resistance (iv). Are non-magnetic

As the pointer deflects the springs get twisted in the opposite direction. The combined twist produces the necessary controlling torque which is proportional to angle of deflection of moving system θ. If we consider a permanent magnet moving coil meter with spring control system the deflecting torque will be proportional to the current passing through it and the controlling torque will be proportional to the angle of deflection

Thus $T_D \alpha I$

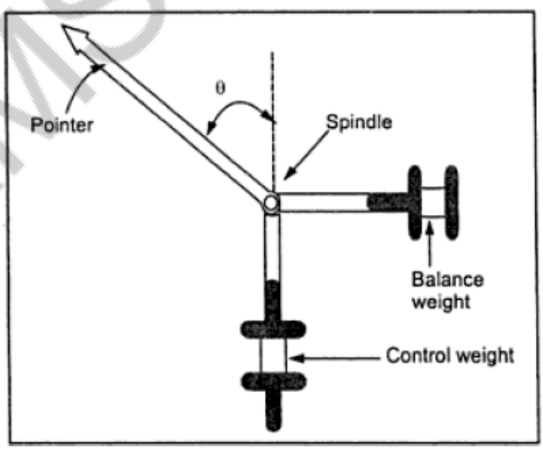
$T_C \alpha \theta$

Since $T_D = T_C$

We have $\theta \alpha I$

Thus the spring controlled instruments having uniform scale

GRAVITY CONTROL



In gravity controlled instruments, as shown in Fig. 12.2 (a) a small adjustable weight is attached to the spindle of the moving system

AMSCE - 1101

such that the deflecting torque produced by the instrument has to act against the action of gravity. Thus a controlling torque is obtained. This weight is called the control weight. Another adjustable weight is also attached is the moving system for zero adjustment and balancing purpose. This weight is called Balance weight.

When the control weight is in vertical position as shown in Fig. 12.2 (a), the controlling torque is zero and hence the pointer must read zero. However, if the deflecting torque lifts the controlling weight from position A to B as shown in Fig. 12.2 (b) such that the spindle rotates by an angle θ, then due to gravity a restoring (or controlling) torques in exerted on the moving system.

The controlling (or restoring) torque, Tc, is given by

$Tc = Wl \sin\theta = k\ g \sin\theta$

Where W is the control weight;

l is the distance of the control weight from the axis of rotation of the moving system;

and k g is the gravity constant.

Equation shows the controlling torque can be varied quite simply by adjustment of the position of the control weight upon the arm which carries it. Again, if the deflecting torque is directly proportional to the current,

i.e., $Td = kI$

we have at the equilibrium position

$Td = Tc$

$kI = k\ g \sin\theta$

$I = g\ k \sin\theta / k$

This relation shows that current I is proportional to sin θ and not θ. Hence in gravity controlled instruments the scale is not uniform. It is cramped for the lower readings, instead of being

AMSCE - 1101

35

uniformly divided, for the deflecting torque assumed to be directly proportional to the quantity being measured.

AMSCE - 1101

Advantages of Gravity Control

1. It is cheap and not affected by temperature variations.
2. It does not deteriorate with time.

Disadvantages of Gravity Control

1. Since the controlling torque is proportional to the sine of the angle of deflection, the scale is not uniformly divided but cramped at its lower end.
2. It is not suitable for use in portable instruments (in which spring control is always preferred).
3. Gravity control instruments must be used in vertical position so that the control weight may operate and also must be leveled otherwise they will give zero error. In view of these reasons, gravity control is not used for indicating instruments in general and portable instruments in particular.

Damping Torque

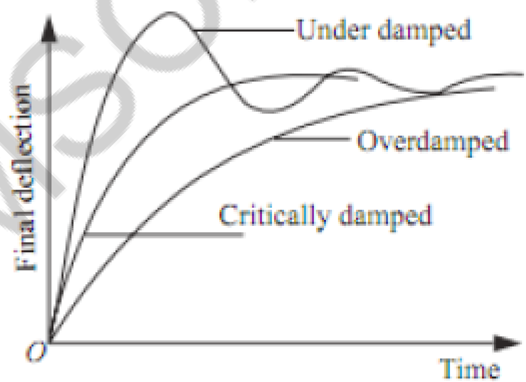


Fig. 12.3 *Dynamic response of a measuring instrument*

We have already seen that the moving system of the instrument will tend to move under the action of the deflecting torque. But

AMSCE-1101

on account of the control torque, it will try to occupy a position of rest when the two torques are equal and opposite. However,

AMSCE - 1101

38

due to inertial of the moving system, the pointer will not come to rest immediately but oscillate about its final deflected position as shown in Fig and takes appreciable time to come to steady state. To overcome this difficulty a damping torque is to be developed by using a damping device attached to the moving system.

The damping torque is proportional to the speed of rotation of the moving system, that is $Tv = dv \; d \; dt \; \theta$

Where kv = damping torque constant

$d \; dt \; \theta$ = speed of rotation of the moving system

Depending upon the degree of damping introduced in the moving system, the instrument may have any one of the following conditions as depicted in Fig.

1. Under damped condition: The response is oscillatory

2. Over damped condition: The response is sluggish and it rises very slowly from its zero position to final position.

3. Critically damped condition: When the response settles quickly without any oscillation, the system is said to be critically damped.

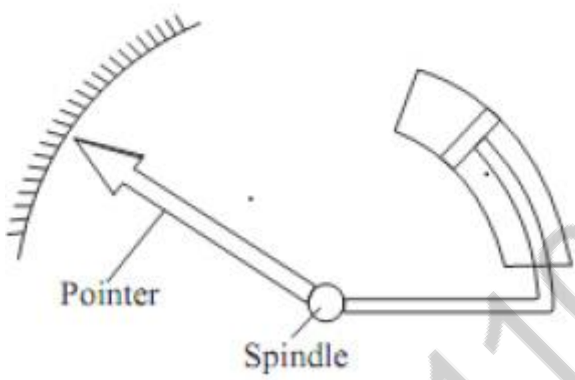
In practice, the best response is slightly obtained when the damping is below the critical value i.e., the instrument is slightly under damped.

The damping torque is produced by the following methods: Air Friction Damping & Fluid friction damping

Air Friction Damping

In this type of damping a light vane or vanes having considerable area is attached to the moving system to develop a frictional force opposing the motion by reason of the air they displace. Two methods of damping by air friction are depicted in Fig.

AMSCE - 1101



(*b*)

The arrangement shown in Fig consists of a light aluminum vane which moves in a quadrant (sector) shaped air chamber. The chamber also carries a cover plate at the top. The vane is mounted on the spindle of the moving system. The aluminum vane should not touch the air-chamber walls otherwise a serious error in the deflection of the instrument will be introduced. Now, with the motion, the vane displaces air and thereby a damping force is created on the vane that produces a torque (damping) on the spindle. When the movement id quicker the damping force is greater; when the spindle is at rest, the damping force is zero.

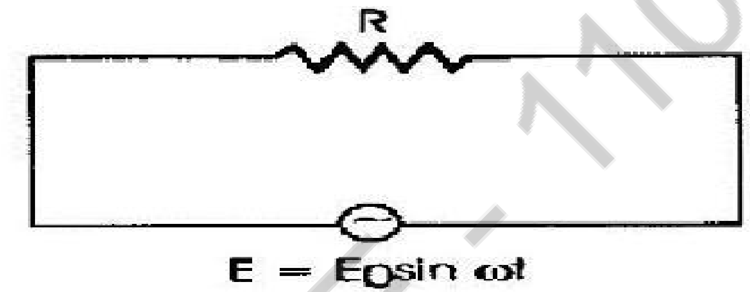
The arrangement of Fig. consists of a light aluminum piston which is attached to the moving system. This piston moves in a fixed chamber which is closed at one end. Either circular or rectangular chamber may be used. The clearance (or gap) between the piston and chamber walls should be uniform throughout and as small as possible. When the piston and chamber walls should be uniform throughout and as small as possible. When the piston move rapidly into the chamber the air in the closed space is compressed and the pressure of air thus developed opposes the motion of the piston and thereby the whole moving system. If the piston is moving out of the chamber, rapidly, the pressure in the closed space falls and the pressure on the open side of the system care must be taken to ensure that the arm carrying the piston

AMSCE - 1101

should not touch the sides of the chamber during its movement. The friction which otherwise would occur may introduce a serious error in the deflection.

The air friction damping is very simple and cheap. But care must be taken to ensure that the piston is not bent or twisted. This method is used in moving iron and hot wire instruments.

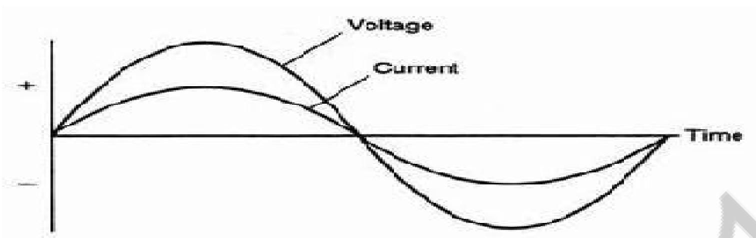
7. Derive the expression for pure resistive circuit (JUN/JULY2009)



Resistors are “passive” devices that are they do not produce or consume any electrical energy, but convert electrical energy into heat. In DC circuits the linear ratio of voltage to current in a resistor is called its resistance. However, in AC circuits this ratio of voltage to current depends upon the frequency and phase difference or phase angle (ϕ) of the supply. So when using resistors in AC circuits the term **Impedance**, symbol **Z** is the generally used and we can say that DC resistance = AC impedance, R = Z.It is important to note, that when used in AC circuits, a resistor will always have the same resistive value no matter what the supply frequency from DC to very high frequencies, unlike capacitor and inductors.

For resistors in AC circuits the direction of the current flowing through them has no effect on the behavior of the resistor so will rise and fall as the voltage rises and falls. The current and voltage reach maximum, fall through zero and reach minimum at exactly the same time. i.e, they rise and fall simultaneously and are said to be “in-phase” as shown below

AMSCE - 1101



We can see that at any point along the horizontal axis that the instantaneous voltage and current are in-phase because the current and the voltage reach their maximum values at the same time, that is their phase angle θ is 0o. Then these instantaneous values of voltage and current can be compared to give the ohmic value of the resistance simply by using ohms law. Consider below the circuit consisting of an AC source and a resistor.

The instantaneous voltage across the resistor, V_R is equal to the supply voltage, V_t and is given as: $V_R = V_{max} \sin\omega t$

The instantaneous current flowing in the resistor will therefore be: $I_R = V_R / R$

$= V_{max} \sin\omega t / R$

$= I_{max} \sin\omega t$

In purely resistive series AC circuits, all the voltage drops across the resistors can be added together to find the total circuit voltage as all the voltages are in-phase with each other. Likewise, in a purely resistive parallel AC circuit, all the individual branch currents can be added together to find the total circuit current because all the branch currents are in-phase with each other

Since for resistors in AC circuits the phase angle ϕ between the voltage and the current is zero, then the power factor of the circuit is given as cos 0o = 1.0. The power in the circuit at any instant in time can be found by multiplying the voltage and current at that instant.Then the power (P), consumed by the circuit is given as P = Vrms I cos Φ in watt's. But since cos Φ = 1 in a purely resistive circuit, the power consumed is simply given as, P = Vrms **I** the same as for Ohm's Law.

AMSCE - 1101

 42

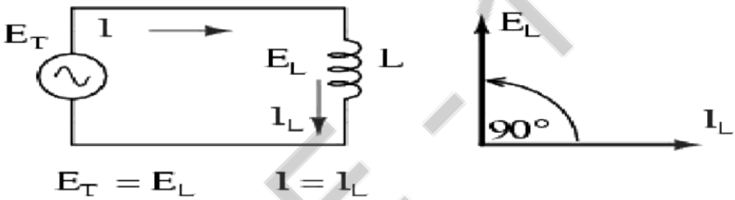
This then gives us the "Power" waveform and which is shown below as a series of positive pulses because when the voltage and

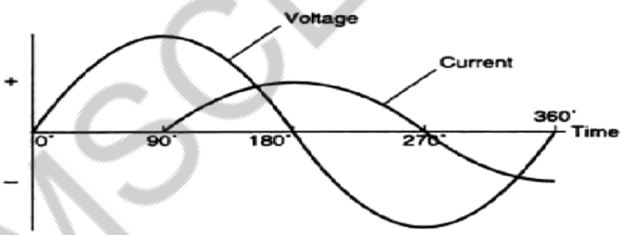
AMSCE - 1101

current are both in their positive half of the cycle the resultant power is positive. When the voltage and current are both negative, the product of the two negative values gives a positive power pulse.

Then the power dissipated in a purely resistive load fed from an AC rms supply is the same as that for a resistor connected to a DC supply and is given as:P = V rms * I rms = I 2 rms * R = V 2 rms / R

8. Derive the expression for Pure resistive circuit and Pure Capacitive circuits: (NOV 2007)





This simple circuit above consists of a pure inductance of L Henries (H), connected across a sinusoidal voltage given by the expression: V(t) = Vmax sin ωt. When the switch is closed this sinusoidal voltage will cause a current to flow and rise from zero to its maximum value. This rise or change in the current will induce a magnetic field within the coil which in turn will oppose or restrict this change in the current.But before the current has had time to reach its maximum value as it would in a DC circuit, the voltage changes polarity causing the current to change direction. This change in the other direction once again being delayed by the self-induced back emf in the coil, and in a circuit containing a pure inductance only, the current is delayed

AMSCE - A101

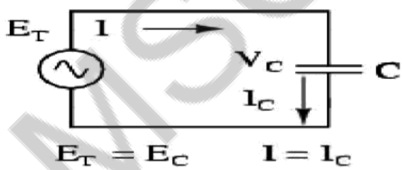
by 90o.The applied voltage reaches its maximum positive value a quarter (1/4*f*) of a cycle earlier than the current reaches its maximum positive value, in other words, a voltage applied to a purely inductive circuit "LEADS" the current by a quarter of a cycle or 90o as shown below.The instantaneous voltage across the resistor, V_R is equal to the supply voltage, V_t and is given as: $V_L = V_{max} \sin(\omega t + 90)$

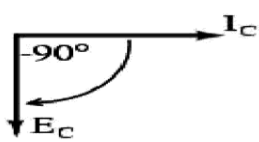
$I_L = V / X_L$

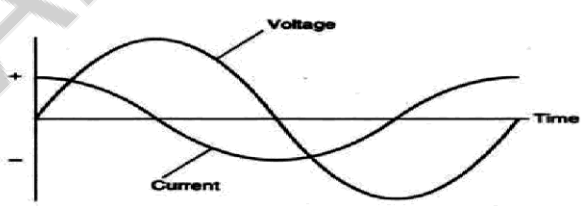
$X_L = 2\pi fL$

Pure Capacitive circuits:

When the switch is closed in the circuit above, a high current will start to flow into the capacitor as there is no charge on the plates at t = 0. The sinusoidal supply voltage, V is increasing in a positive direction at its maximum rate as it crosses the zero reference axis at an instant in time given as 0o. Since the rate of change of the potential difference across the plates is now at its maximum value, the flow of current into the capacitor will also be at its maximum rate as the maximum amount of electrons are moving from one plate to the other.







As the sinusoidal supply voltage reaches its 90o point on the waveform it begins to slow down and for a very brief instant in time the potential difference across the plates is neither increasing nor decreasing therefore the current decreases to

AMSCE-1101

zero as there is no rate of voltage change. At this 90opoint the potential difference across the capacitor is at its maximum (Vmax), no current flows into the capacitor as the capacitor is now fully charged and its plates saturated with electrons.

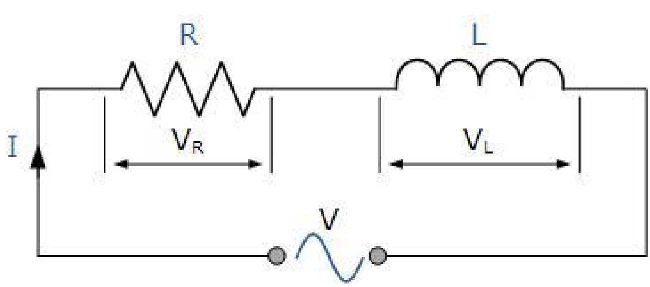
At the end of this instant in time the supply voltage begins to decrease in a negative direction down towards the zero reference line at 180o. Although the supply voltage is still positive in nature the capacitor starts to discharge some of its excess electrons on its plates in an effort to maintain a constant voltage. These results in the capacitor current flowing in the opposite or negative direction.

When the supply voltage waveform crosses the zero reference axis point at instant 180o, the rate of change or slope of the sinusoidal supply voltage is at its maximum but in a negative direction, consequently the current flowing into the capacitor is also at its maximum rate at that instant. Also at this 180o point the potential difference across the plates is zero as the amount of charge is equally distributed between the two plates.

Then during this first half cycle 0o to 180o, the applied voltage reaches its maximum positive value a quarter (1/4*f*) of a cycle after the current reaches its maximum positive value, in other words, a voltage applied to a purely capacitive circuit "LAGS" the current by a quarter of a cycle or 90^{o} as shown below. $I_C = I_{max} \sin(\omega t + 90)$ $I_L = V / X_C$ $X_C = 1 / 2\pi fC$

8. Explain the expression for RL series and RC series Circuit

RL Series circuit:



AMSCE - 1101

In other words, an Inductor in an electrical circuit opposes the flow of current, (i) through it. While this is perfectly correct, we made the assumption in the tutorial that it was an ideal inductor which had no resistance or capacitance associated with its coil windings. However, in the real world "ALL" coils whether they are chokes, solenoids, relays or any wound component will always have a certain amount of resistance no matter how small associated with the coils turns of wire being used to make it as the copper wire will have a resistive value. Then for real world purposes we can consider our simple coil as being an "Inductance", L in series with a "Resistance", R. In other words forming an **RL Series Circuit.**

A **RL Series Circuit** consists basically of an inductor of inductance L connected in series with a resistor of resistance R. The resistance R is the DC resistive value of the wire turns or loops that goes into making up the inductors coil. The above **RL series circuit** is connected across a constant voltage source, (the battery) and a switch. Assume that the switch, S is open until it is closed at a time t = 0, and then remains permanently closed producing a "step response" type voltage input. The current, i begins to flow through the circuit but does not rise rapidly to its maximum value of Imax as determined by the ratio of V / R(Ohms Law).This limiting factor is due to the presence of the self induced emf within the inductor as a result of the growth of magnetic flux, (Lenz's Law). After a time the voltage source neutralizes the effect of the self induced emf, the current flow becomes constant and the induced current and field are reduced to zero.

We can use Kirchoffs Voltage Law, (KVL) to define the individual voltage drops that exist around the circuit and then hopefully use it to give us an expression for the flow of current.Vt = VR + VL VR = I*R VL = i dL / dt V(t) = I*R + i dL / dt

Since the voltage drop across the resistor, VR is equal to IxR (Ohms Law), it will have the same exponential growth and shape as the current. However, the voltage drop across the inductor, VL will have a value equal to: Ve(-Rt/L). Then the voltage across the inductor, VL will have an initial value equal to the battery

AMSCE-1701

47

voltage at time t = 0 or when the switch is first closed and then decays exponentially to zero as represented in the above curves.

The time required for the current flowing in the LR series circuit to reach its maximum steady state value is equivalent to about **5 time constants** or 5τ. This time constant τ, is measured by τ = L/R, in seconds, were R is the value of the resistor in ohms and L is the value of the inductor in Henries. This then forms the basis of an RL charging circuit were 5τ can also be thought of as "5 x L/R" or the *transient time* of the circuit.

The transient time of any inductive circuit is determined by the relationship between the inductance and the resistance. For example, for a fixed value resistance the larger the inductance the slower will be the transient time and therefore a longer time constant for the LR series circuit. Likewise, for a fixed value inductance the smaller the resistance value the longer the transient time. However, for a fixed value inductance, by increasing the resistance value the transient time and therefore the time constant of the circuit becomes shorter. This is because as the resistance increases the circuit becomes more and more resistive as the value of the inductance becomes negligible compared to the resistance. If the value of the resistance is increased sufficiently large compared to the inductance the transient time would effectively be reduced to almost zero.

Series circuit:

The fundamental passive linear circuit elements are the resistor (R), capacitor (C) and inductor (L). These circuit elements can be combined to form an electrical circuit in four distinct ways: the RC circuit, the RL circuit, the LC circuit and the RLC circuit with the abbreviations indicating which components are used. These circuits exhibit important types of behaviour that are fundamental to analogue electronics. In particular, they are able to act as passive filters. This article considers the RL circuit in both series and parallel as shown in the diagrams.

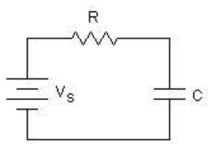
In practice, however, capacitors (and RC circuits) are usually preferred to inductors since they can be more easily

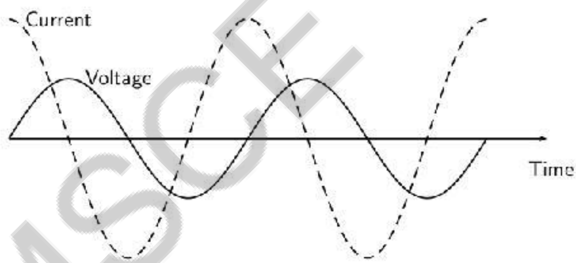
AMSCE - 1101

manufactured and are generally physically smaller, particularly for higher values of components.

Both RC and RL circuits form a single-pole filter. Depending on whether the reactive element (C or L) is in series with the load, or parallel with the load will dictate whether the filter is low-pass or high-pass.

Frequently RL circuits are used for DC power supplies to RF amplifiers, where the inductor is used to pass DC bias current and block the RF getting back into the power supply.

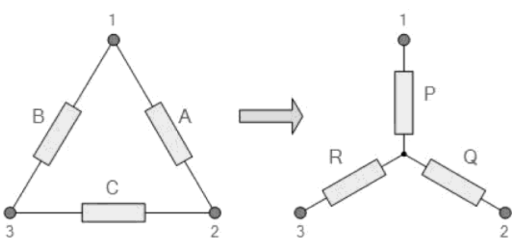




AMSCE - 1101

9. Explain the different transformation in three phase balanced circuit

Delta to Star Transformation



Compare the resistances between terminals 1 and 2. P+Q= A in parallel with (B+C)

P+Q = A(B+C) / A+B+C……………….(1) Resistance between the terminals 2 and 3. Q+R = C in parallel with (A+B) Q+R=C(A+B) / A+B+C……………….(2) Resistance between the terminals 1 and 3. P+R = B in parallel with (A+C)

P+R = B(A+C) / A+B+C………………(3)

This now gives us three equations and taking equation 3 from equation 2 gives: P+R-Q-R = (B(A+C)) –(C(A+B)) / A+B+C

P-Q =(BA + BC – CA – BC) / A+B+C

P-Q = BA – CA / (A+B+C)…………….(4)

Then, re-writing Equation 1 will give us:

P+Q = (AB+AC) / A+B+C …………………….(5)

Equ (4) + Equ (5)

P+Q+ P-Q = (AB+AC) / A+B+C + (BA – CA) / A+B+C

2P = (AB+AC+BA-CA) / A+B+C 2P = 2AB / A+B+C P = AB / A+B+C

Then to summarize a little about the above maths, we can now say that resistor P in a Star network can be found as Equation 1 plus (Equation 3 minus Equation 2) or Eq1 + (Eq3 – Eq2). Similarly, to find resistor Q in a star network, is equation 2 plus the result of equation 1 minus equation 3 or Eq2 + (Eq1 – Eq3) and this gives us the transformation of Q as: Q = AC / A+B+C and again, to find resistor R in a Star network, is equation 3 plus the result of equation 2 minus equation 1 or Eq3 + (Eq2 – Eq1) and this gives us the transformation of R as: R = BC / A+B+C When converting a delta network into a star network the denominators of all of the transformation formulas are the same: A + B + C, and which is the sum of ALL the delta resistances. Then to convert any delta connected network to an equivalent star network

If the three resistors in the delta network are all equal in value then the resultant resistors in the equivalent star network will be equal to one third the value of the delta resistors, giving

AMSCE-1101

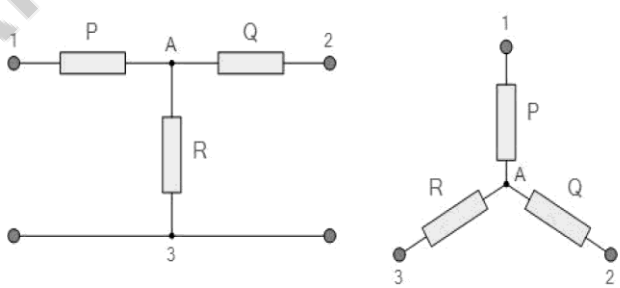
each branch in the star network as: $R_{STAR} = 1/3R_{DELTA}$

Star Delta Transformations allow us to convert impedances connected together from one type of connection to another. We can now solve simple series, parallel or bridge type resistive networks using Kirchhoff´s Circuit Laws, mesh current analysis or nodal voltage analysis techniques but in a balanced 3-phase circuit we can use different mathematical techniques to simplify the analysis of the circuit and thereby reduce the amount of math's involved which in itself is a good thing.

Standard 3-phase circuits or networks take on two major forms with names that represent the way in which the resistances are connected, a **Star** connected network which has the symbol of the letter, Υ (wye) and a **Delta** connected network which has the symbol of a triangle, (delta).

If a 3-phase, 3-wire supply or even a 3-phase load is connected in one type of configuration, it can be easily transformed or changed it into an equivalent configuration of the other type by using either the **Star Delta Transformation** or **Delta Star Transformation** process.

A resistive network consisting of three impedances can be connected together to form a T or "Tee" configuration but the network can also be redrawn to form a Star or Υ type network as shown below.



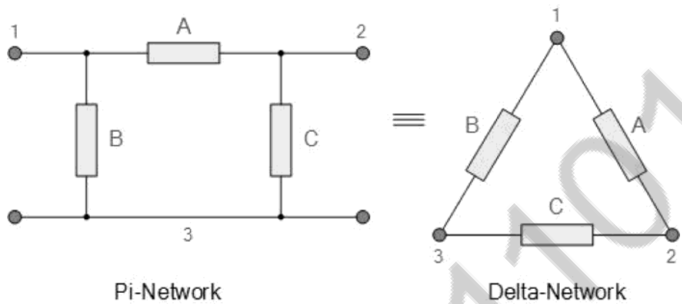
T-Network Star-Network

As we have already seen, we can redraw the T resistor network to produce an equivalent Star or Υ type network. But we can

AMSCE - 1104

also convert a Pi or π type resistor network into an equivalent Delta or type network as shown below.

Pi-connected and Equivalent Delta Network.



Having now defined exactly what is a Star and Delta connected network it is possible to transform the **I** into an equivalent circuit and also to convert a into an equivalent **I** circuit using a the transformation process.

10. Explain the procedure of nodal and mesh analysis with example

Nodal Circuit Analysis Procedure

(1) Choose one node as the common (or datum) node

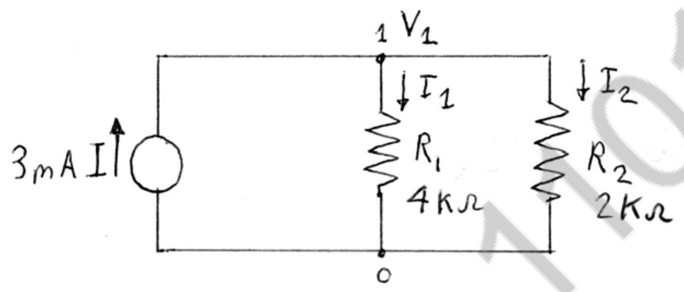
- Number (label) the nodes
- Designate a voltage for each node number
- Each node voltage is with respect to the common or datum node
- Number of nodes used = number of nodes – 1 = n-1
- Note: number of nodes = branches – 1 = b-1
- Thus less equations with node analysis than mesh analysis
- (2) For each node write the KCL for current flows in each node
- Use differences in the node voltages to calculate currents
- Assume the current directions and write the KCL
- Generally assume the node is a positive V relative to all others

AMSCE - 1101

- Current directions different for same branch in each node
- Often better to use conductance equations

(3) Solve the equations for the node voltages

- Get currents in each branch from the voltage differences



I=IR1+IR2=V/R1+V/R2=V[1/R1+1/R2]

Consider the 2 node, 3 loop circuit below

(1) Setting the base node, and node voltages

- Set the common node to ground
- Label voltages on the others

(2) For each node write KCL for current flows

- For node 1,
- Defining the current directions for I1 as into the node
- Use differences in the node voltages for currents

Mesh Analysis

Procedure

(1) Define a current loop

- Set a direction for each simple closed path
- Number of loops needed = number of branches – 1 = b-1
- Loop currents can overlap: often many possible combinations
- Must cover all branches with the loop set
- Each loop is called a Mesh

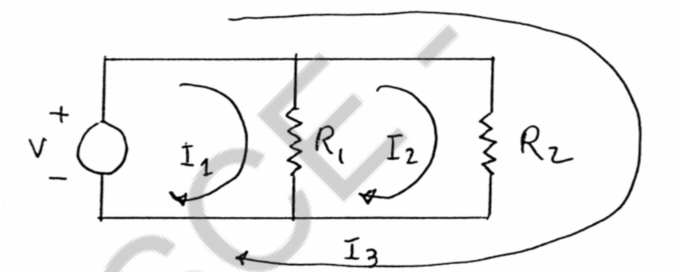
AMSCE - 1101

(2) For each mesh write the KVL equation for the loops

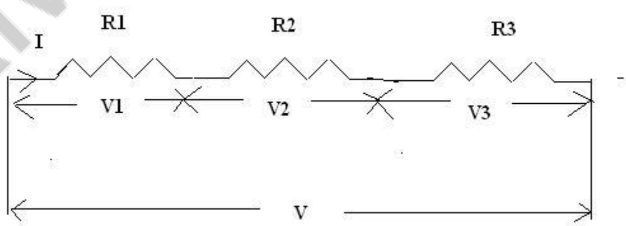
- When loop currents overlap:
- Add currents if in same direction
- Subtract currents if in opposite direction
- Voltage sources add if in the direction of loop current
- Voltage sources subtract if opposite to the loop current
- *V =VR2 = I3R2*

(3) Solve the simultaneous equations for the loop currents

- Get currents in each branch from the loop currents
- Voltages calculated from the currents



11. Explain Resistance in series and parallel connection with neat diagram



The resistors R1, R2, R3 are connected in series across the supply voltage "V". The total current flowing through the circuit is denoted as "I". The voltage across the resistor R1, R2 and R3 is V1, V2, and V3 respectively. = I*R1 (as per ohms law) V2=

AMSCE-1101

54

$I*R2$ $V3 = I*R3$ $V = V1+V2+V3 = IR1+IR2+IR3 = (R1+R2+R3)$ $IIR = (R1+R2+R3) I$ $R = R1+R2+R3$

Resistance in parallel connection:

V / R (as per ohms law) $I_1 = V_1 / R_1$ $I_2 = V_2 / R_2$

$I_3 = V_3 / R_3$

$V_1 = V_2 = V_3 = V$

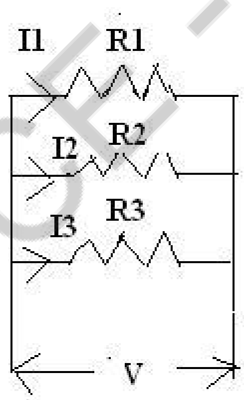
From the above diagram

$I = I_1+I_2+I_3$

$= V1 / R1 + V2 / R2 + V3 / R3$

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

$I = V (1/R_1 +1/R_2 +1/R_3)$



$V / R = V (1/R_1 +1/R_2 +1/R_3)$ $\mathbf{1/R = 1/R_1 +1/R_2 +1/R_3}$

The resistors R_1, R_2, R_3 are connected in parallel across the supply voltage "V". The total current flowing through the circuit is denoted as "I". The current flowing through the resistor R_1, R_2 and R_3 is I_1, I_2, and I_3 respectively.

AMSCE - 1101

UNIT – II ELECTRICAL MACHINES PART – A

1. **What is an electric generator?**

   An electrical machine, which converts mechanical energy into electrical Energy, is called as electric generator.

2. **What is an electric motor?**

   An electrical machine, which converts electrical energy into mechanical Energy, is calledas electric motor.

3. **What is meant by magnetic flux?**

   The magnetic lines of force existing around a magnet is called magnetic flux. It's unit is Weber. $1wb=10^8$ magnetic flux lines

4. **State faraday's law of electromagnetic induction.**

   Whenever a conductor cuts the magnetic lines of force an emf is induced in it.

5. **State Fleming's Right hand rule.**

   If three fingers of right hand, namely thumb, index finger and middle finger are outstretched so that everyone of them is at right angles with the remaining two, and the index finger is made to point in the direction of lines of flux, thumb in the direction of the relative motion of the conductor and the middle finger gives the direction of the induced emf in the conductor.

6. **What is the use of commutator?**

   A device is used in a dc generator to convert the alternating emf into unidirectional emf is called commutator.

7. **What is the function yoke? Dec 2010 , June 2012**

   It serves the purpose of outermost cover of the dc machine. So that the insulating material get protected from harmful

AMSCE - 1101

atmospheric elements like moisture, dust and various gases like SO2, acidic fumes etc.

It provides mechanical support to the poles.

8. What is the choice of material for the following?

1.Yoke 2.pole 3.Field winding 4.Armature winding

1.Yoke: It is prepared by using cast iron because it is cheapest.

2.Pole: It is made up of cast iron or cast steel.

3.Field winding: It is made up of aluminum or copper.

4.Armatuer winding: It is made up of cast iron or cast steel.

9. What is the function of brush?

To collect current from commutator and make it available to the stationary external circuit.

10. Give the emf equation of dc generator. (May/June 2016)

E=ØZNP/60A

where E ⇒ Generated emf in volts f ⇒Flux produced per pole in Weber Z ⇒ Total no. of conductors

N ⇒ Speed of armature in rpm

E=ØZN/60 for lap winding A=P

E=ØZNP/120 for wave winding A=2

11. What are all the two types of excitation?

i. Separate excitation

When the field winding is supplied from external, separate dc supply i.e. Excitation of field winding is separate then the generator is called separately excited generator.

ii. Self excitation

When the field winding is supplied from the armature of the generator itself then it is called as self-excitation.

12. What is meant by residual magnetism?

Practically though the generator is not working, without any current through field

AMSCE - 1101

winding, the field poles posses some magnetic flux. This is called as residual magnetism.

13. Give the types of DC generator.

1.Self excited generator

- Series Generator
- Shunt Generator
- Compound Generator
- Long shunt compound generator
- Short shunt compound generator
- Cumulative and differential compound Generator

2. Separately excited generator

14. List out the applications of various types of generators. (April/May 2017)

Separatelyexcited generator

As a separate supply is required to excite the field, the use is restricted to some special applications like electroplating, electro refining of materials etc

Shunt generator

Commonly used in battery charging and ordinary lighting purposes.

Series Generators

Commonly used as boosters on dc feeders, as a constant current generators for welding

generator and arc lamps.

Cumulatively compound generators

These are used for domestic lighting purposes and to transmit energy over long distance.

Differential compound generator

The use of this type of generators is very rare and it is used for special application like

electric arc welding.

AMSCE - 1101

15. What is the principle of DC motor?

Whenever a current carrying conductor placed in a magnetic field, it experiences a mechanical force.

16. State that the Fleming's left hand rule.

The rules states that outstretch the three fingers of the left hand namely the first finger, middle finger and thumb such that they are mutually perpendicular to each other. Now point the first finger in the direction of magnetic field and the middle finger in the direction of the current then the thumb gives the direction of the force experienced by the conductor.

17. What is Lenz's law?

Lenz's law states the direction of induced emf is always so as to oppose the cause producing it.

18. Give the torque equation of a DC motor.

$T_a = 0.159 Ø I_a . PZ/A$ N-m

Ia ⇒ Armature current

P ⇒ Number of poles

Z ⇒ Total number of conductors

A ⇒ Number of parallel paths

19. List the different types of DC motor.

- DC series motor
- DC Shunt motor
- DC Compound motor
    - Long shunt compound motor
    - Short shunt compound motor

20. What do you meant by speed regulation?

The speed regulation of a DC motor is defined as the ratio of change in speed corresponding to no load and full load condition to speed corresponding to full load. It's expressed as

AMSCE - 1101

$$\%\text{Speed regulation} = \frac{N_{\text{no load}} - N_{\text{full load}}}{N_{\text{full load}}} * 100$$

21. List out the characteristics of DC motor.

i. Torque-Armature current characteristics (T VS Ia)

ii. Speed-Armature current characteristics (N VS Ia)

22. Why series motor is never started on no load?

On light load or no load the armature current drawn by the motor is verysmall. In DC series motor, f µ Ia and the speed equation is N µ 1/f. On very light load, as flux is very small, the motor tries to run at dangerously high speed, which may damage the motor mechanically. This can be seen from the speed – armature current and the speed –torque characteristics that on low armature current and low torque condition motor shows a tendency to rotate with dangerously high speed.

23. What are all the applications of DC motor? (Nov/Dec 2014) (April/ May 2015) DC Shunt motor:

- Blowers and fans
- Centrifugal and reciprocating pumps
- Lathe machines
- Machine tools
- Milling machines
- Drilling machines

DC Series motor:

- Cranes
- Hoists, Elevators
- Trolleys
- Conveyors
- Electric locomotives

DC Cumulative compound motor:

- Rolling mills
- Punches

AMSCE - 1101

- Shears
- Heavy planers
- Elevators

24. What is the necessity of starter?

To restrict high starting armature current, a variable resistance is connected in series with the armature at start. This resistance is called starter.

25. What are all the factors affecting the speed of a DC motor?

- The flux
- The voltage across the armature
- The applied voltage

26. What is meant by Swinburne's test?

Without actually loading the motor the losses and hence efficiency at different loads can be found out.

27. Why single phase induction motor not self starting? (Nov/Dec2014) (April/May 2015) (April/May 2017)

When a single phase supply is fed to the single phase induction motor. Its stator winding produces a flux which only alternates along one space axis. It is not a synchronously revolving field, as in the case of a 2 or 3phase stator winding, fed from 2 or 3 phase supply

28. What is meant by transformer? Dec 2011

The transformers a static piece of apparatus by means of which electrical energy is transformed from one circuit to another with desired change in voltage and current , without any change in the frequency. It works on the principle of mutual induction.

29. What are the different types of single phase motor?

i) Single phase induction motor ii)Single phase synchronous motor.

iii) Single phase series motor

AMSCE - 1101

30. What are the two types of rotors of an induction motor?

i) Squirrel cage rotor

ii)Slip ring or wound rotor

31. Write voltage equation of the DC motor (June 2009)

$V = E_b + I_a R_a$

Where V is the supply voltage, volts

Eb is the Back EMF,volts

Ia is the armature current, amperes

Ra is the armature resistance ,Ω

32. What is back emf ? May 2011, Dec 2012

When a motor rotates , the conductors housed in the armature also rotate and cut the magnetic lines of force. So an emf is induced in the armature conductors and this induced emf opposes the supply voltage as per Lenz's law. This induced emf is called back emf or counter emf.

33. A 220V DC motor has an armature resistance of 0.5Ω . The full load armature current is 20A. Find the induced Back emf. Dec 2009

V = 220V , Ra = 0.5Ω , Ia = 20A

$V = E_b + I_a R_a$

Eb = 220 – 20 x 0.5 = 210 V

34. What is the EMF equation of a transformer ? June 2009

$$E_1 = 4.44 f\phi_m N_1;\ E_2 = 4.44 f\phi_m N_2$$

Where ϕ_m - Maximum value of flux

f – frequency of the supply voltage

N_1 – Number of primary winding turns

N_2 – Number of secondary winding turns

E_1 – RMS value of the primary EMF

E_2 – RMS value of the secondary EMF

AMSCE-1101

35. What are the types of transformers based on construction? May 2011, Dec 2012

Based on the construction , various types of transformers are,

- Core type
- Shell type
- Berry type

36. Define voltage transformation ratio of transformer. Also write the condition for step up transformer. Dec 2009, Dec 2012

The voltage transformation ratio of transformer is,

$$\frac{E_2}{E_1} = \frac{N_2}{N_1} = K$$

where N1 – Number of primary winding turns

N2 – Number of secondary winding turns

E1 – RMS value of the primary EMF

E2 – RMS value of the secondary EMF

37. Name the methods adopted to make the single phase induction motor self start. (OR)

What are the different types of single phase induction motors? May 2014, Dec 2010, Dec 2015

- Split phase induction motor
- Capacitor start induction motor
- Capacitor start capacitor run induction motor
- Shaded pole induction motor

38. What are the two types of rotors of an induction motor?

i) Squirrel cage rotor ii)Slip ring or wound rotor

39. Calculate the emf generated by a 4 pole , wave wound armature having 45 slots with 18 conductors per slot when driven at 1200 rpm and the flux per pole is 0.016 Wb. May 2014, Dec 2015

P = 4 ; 45 slots and 18 conductors per slot ; ϕ =0.016 Wb ; N = 1200 rpm;

A = 2 since wave wound

AMSCE-1101

$$Z = 45 \times 18 = 810$$

$$E = \frac{\varphi Z N}{60} \cdot \frac{P}{A}$$

$$E = \frac{0.016 - 4 - 1200 - 810}{60 - 2} = 518.4V$$

40. In a single phase transformer, Np = 350 turns, Ns = 1050 turns Ep = 400V . Find Es May 2013

$$\frac{E_s}{E_p} = \frac{N_s}{N_p} = K$$

$$E_s = \frac{N_s \cdot E_p}{N_p} = \frac{1050 - 400}{350} = 1200v$$

AMSCE - 1101

PART – B

1. **With the neat sketches , Explain the construction and the working principle of DC generator. May 2011, Dec 2012, May 2015, Dec 2014 ,April/May 2017**

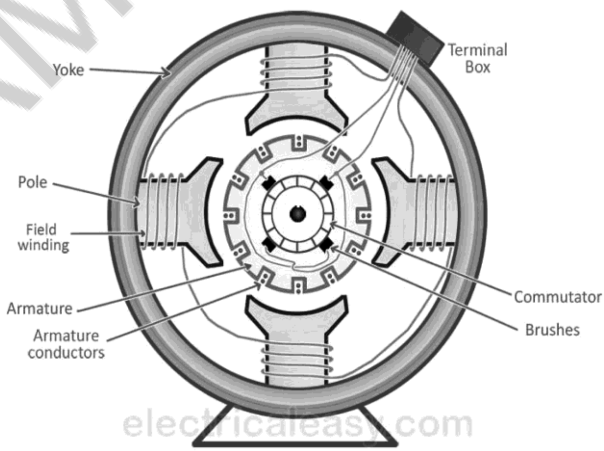
Basic Construction And Working Of A DC Generator.

DC Generator: A dc generator is an electrical machine which converts mechanical energy into direct current electricity**.** This energy conversion is based on the principle of production of dynamically induced emf. This article outlines basic construction and working of a DC generator**.**

Construction Of A DC Machine:

Note: A DC generator can be used as a DC motor without any constructional changes and vice

versa is also possible. Thus, a DC generator or a DC motor can be broadly termed as a **DC machine**. These basic constructional details are also valid for the **construction of a DC motor**. Hence, let’s call this point as **construction of a DC machine** instead of just ‘construction of a dc generator’.



AMSCE - 1101

The above figure shows the constructional details of a simple **4-pole DC machine**. A DC machine consists two basic parts; stator and rotor. Basic constructional parts of a DC machine are described below.

AMSCE - 1101

1. **Yoke:** The outer frame of a dc machine is called as yoke. It is made up of cast iron or steel. It not only provides mechanical strength to the whole assembly but also carries the magnetic flux produced by the field winding.
2. Poles and pole shoes: Poles are joined to the yoke with the help of bolts or welding. They carry field winding and pole shoes are fastened to them. Pole shoes serve two purposes; (i) they support field coils and (ii) spread out the flux in air gap uniformly.
3. **Field winding:** They are usually made of copper. Field coils are former wound and placed on each pole and are connected in series. They are wound in such a way that, when energized, they form alternate North and South poles.
4. **Armature core:** Armature core is the rotor of the machine. It is cylindrical in shape with slots to carry armature winding. The armature is built up of thin laminated circular steel disks for reducing eddy current losses. It may be provided with air ducts for the axial air flow for cooling purposes. Armature is keyed to the shaft.
5. **Armature winding:** It is usually a former wound copper coil which rests in armature slots. The armature conductors are insulated from each other and also from the armature core. Armature winding can be wound by one of the two methods; lap winding or wave winding. Double layer lap or wave windings are generally used. A double layer winding means that each armature slot will carry two different coils.

Commutator and brushes: Physical connection to the armature winding is made through a commutator-brush arrangement. The function of a commutator, in a dc generator, is to collect the current generated in armature conductors. Whereas, in case of a dc motor, commutator helps in providing current to the armature conductors. A commutator consists of a set of copper segments which are insulated from each other. The number of segments is equal to the number of armature coils. Each segment is connected to an armature coil and the commutator is keyed to the shaft. Brushes are usually made from carbon or graphite.

AMSCE - 7101

They rest on commutator segments and slide on the segments when the commutator rotates keeping the physical contact to collect or supply the current.

2. Derive the EMF equation of DC generator (8) May 2011, (April/May 2017)

EMF Equation Of A DC Generator

P = number of field poles

Ø = flux produced per pole in Wb (weber) Z = total no. of armature conductors

A = no. of parallel paths in armature

N = rotational speed of armature in revolutions per min. (rpm) Now,

Average emf generated per conductor is given by $d\Phi/dt$ (Volts) ... eq. 1

- Flux cut by one conductor in one revolution = $d\Phi = P\Phi$ (Weber),
- Number of revolutions per second (speed in RPS) = N/60
- Therefore, time for one revolution = dt = 60/N (Seconds)
- From eq. 1, emf generated per conductor = $d\Phi/dt = P\Phi N/60$ (Volts) …..(eq. 2)

Above equation-2 gives the emf generated in one conductor of the generator. The conductors are connected in series per parallel path, and the emf across the generator terminals is equal to the generated emf across any parallel path.

Therefore, $E_g = P\Phi NZ / 60A$

For simplex lap winding, number of parallel paths is equal to the number of poles (i.e. A=P), Therefore, for simplex lap wound dc generator, $E_g = P\Phi NZ / 60P$

For simplex wave winding, number of parallel paths is equal to 2 (i.e P=2), Therefore, for simplex wave wound dc generator, $E_g = P\Phi NZ / 120$

AMSCE-1101

3. Derive torque and speed equation of DC motor (8) May 2015 May 2014 Dec 2015 Nov/Dec 2016

Torque Equation of A DC Motor

When armature conductors of a DC motor carry current in the presence of stator field flux, a mechanical torque is developed between the armature and the stator. Torque is given by the product of the force and the radius at which this force acts.

Torque T = F × r (N-m) …where, F = force and r = radius of the armature Work done by this force in once revolution = Force × distance = F × 2πr (where, 2πr = circumference of the armature)

Net power developed in the armature = word done / time = (force × circumference × no. of revolutions) / time = (F × 2πr × N) / 60 (Joules per second) .... eq. 2.1

But, F × r = T and 2πN/60 = angular velocity ω in radians per second. Putting these in the above equation

Net power developed in the armature = P = T × ω (Joules per second)

Armature Torque (Ta)

- The power developed in the armature can be given as, Pa = Ta × ω = Ta × 2πN/60
- The mechanical power developed in the armature is converted from the electrical power, Therefore, mechanical power = electrical power
- That means, Ta × 2πN/60 = Eb.Ia
- We know, Eb = PΦNZ / 60A
- Therefore, Ta × 2πN/60 = (PΦNZ / 60A) × Ia
- Rearranging the above equation,

Ta = (PZ / 2πA) × Φ**.Ia** (N-m)

The term (PZ / 2πA) is practically constant for a DC machine. Thus, armature torque is directly proportional to the product of the flux and the armature current i.e. Ta ∝ Φ.Ia

Shaft Torque (Tsh)

AMSCE - 1401

Due to iron and friction losses in a dc machine, the total developed armature torque is not available at the shaft of the

AMSCE - 1101

machine. Some torque is lost, and therefore, shaft torque is always less than the armature torque.

Shaft torque of a DC motor is given as,

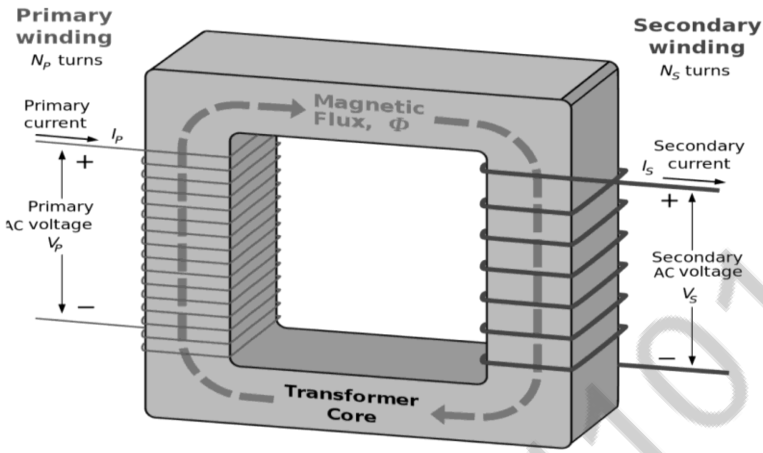
Tsh = output in watts / (2πN/60) ....(where, N is speed in RPM)

4. Explain the principle of operation of a single phase transformer (8) June 2009, Dec 2010, June 2012, May 2015, Dec 2014,May 2014, (April/May 2017)

Transformer is a static device (and doesn't contain on rotating parts, hence no friction losses), which convert electrical power from one circuit to another without changing its frequency. it Step up (or Step down) the level of AC Voltage and Current. Transformer works on the principle of mutual induction of two coils or Faraday Law's Of Electromagnetic induction. When current in the primary coil is changed the flux linked to the secondary coil also changes. Consequently an EMF is induced in the secondary coil due to Faraday law's of electromagnetic induction.

The transformer is based on two principles: first, that an electric current can produce a magnetic field (electromagnetism), and, second that a changing magnetic field within a coil of wire induces a voltage across the ends of the coil (electromagnetic induction). Changing the current in the primary coil changes the magnetic flux that is developed. The changing magnetic flux induces a voltage in the secondary coil

AMSCE-1401

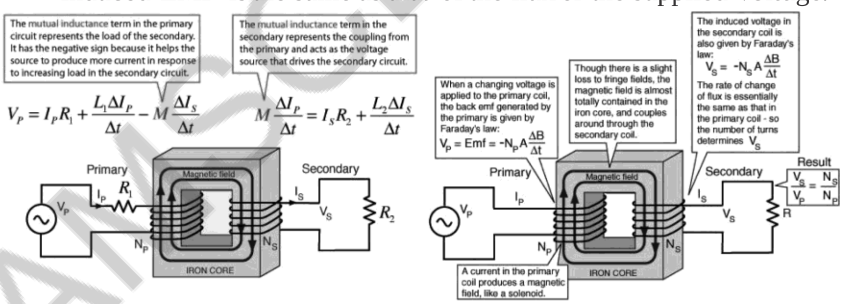

Primary winding
N_P turns
Primary current
I_P
+
Primary AC voltage
V_P
–
Magnetic Flux, Φ
Transformer Core
Secondary winding
N_S turns
Secondary current
I_S
+
Secondary AC voltage
V_S
–

AMSCE - 1101

A simple transformer has a soft iron or silicon steel core and windings placed on it(iron core). Both the core and the windings are insulated from each other. The winding connected to the main supply is called the primary and the winding connected to the load circuit is called the secondary.Winding (coil) connected to higher voltage is known as high voltage winding while the winding connected to low voltage is known as low voltage winding. In case of a step up transformer, the primary coil (winding) is the low voltage winding, the number of turns of the windings of the secondary is more than that of the primary. Vice versa for step down transformer.

EMF is induced only by variation of the magnitude of the flux.

When the primary winding is connected to ac mains supply, a current flows through it. Since the winding links with the core, current flowing through the winding will produce an alternating flux in the core. EMF is induced in the secondary coil since the alternating flux links the two windings. The frequency of the induced EMF is the same as that of the flux or the supplied voltage.



By so doing (variation of flux) energy is transferred from the primary coil to the secondary coil by means of electromagnetic induction without the change in the frequency of the voltage supplied to the transformer. During the process, a self induced EMF is produced in the primary coil which opposes the applied voltage. The self induced EMF is known as back EMF.

Limitation of the Transformer

To understand the main points, we have to discuss some basic terms related to transformer operation. So lets back to basic for a while.

A transformer is an AC machine that steps up or steps down an alternating voltage or current. A transformer being an AC machine however cannot step up or down a DC voltage or DC current. It sounds a bit weird though. You might be thinking "so are there not DC transformers?"

To answer the two questions whether there are or there are not DC transformers and know "why transformer cannot step up or step down a DC voltage" it's necessary we know how electric current and magnetic field interact with each other in transformer operation.

Electromagnetism

The interaction between magnetic field and electric current is termed electromagnetism. Current carrying conductors produces magnetic field when current passes through it. Movement of electrons in a conductor will result to electric current (drifted electrons) which occurs as a result of the EMF set up across the conductor.

The EMF set up across the conductor can be in form of that stored in chemical energy or magnetic field. Current carrying conductor placed in a magnetic fields will experience mechanical force while a conductor placed in a magnetic field will have its electrons drifted which will results to electric current.

Field Flux

Two magnets of unlike poles will attract each other while magnets of like poles will repel each

other (so it is with electric charges). Every magnet is surrounded by a force field and is represented by imaginary lines emanating from the north pole of a magnet going into the south pole of the same magnet.

Electromagnetic Induction

Electromagnetic induction is a phenomenon that explains how EMF and current is or can be induced in a coil when a coil and a magnetic field interact. This phenomenon"electromagnetic

AMSCE - 1101

induction"is explained by Faraday's laws of electromagnetic induction. The direction of induced EMF in a coil is explained by Lenz's law and Fleming's right hand rule.

Faraday's Laws Of Electromagnetic Induction

After Ampere and others investigated the magnetic effect of current, Michael Faraday tried the opposite. In the course of his work he discovered that when there was change in a magnetic field in which a coil was placed, EMF was induced in the coil.This happened only whenever he moved either the coil or the magnet he used in the experiment. EMF was induced in the coil only when there was change in the field flux (if the coil is fixed, moving the magnet towards or away from the coil causes EMF to be induced). Thus Faraday's laws of electromagnetic induction states as follows;

Faraday's First Law

Faraday's first law of electromagnetic induction states that "EMF is induced in a coil when there is a change in the flux linking the coil".

Faraday's Second Law

Faraday's second law of electromagnetic induction states that "the magnitude of induced EMF in a coil is directly proportional to the rate of change of flux linking the coil". $e = N\, d\Phi/dt$ Where e = Induced EMF N = the number of turns dI = Change in flux dt = Change in time

Lenz's Law

Lenz's law entails how the direction of an induced EMF in a coil can be determined. "It thus states that the direction of induced EMF is such that it opposes the change causing it.

In other words, When an E.M.F is induced in a circuit, the current setup always opposes the motion, or change in current, which produces it. OR

An induced EMF will cause a current to flow in a close circuit in such a direction what its magnetic effect will oppose the change that produced it.

AMSCE - 701

According to this law (which introduced by Lens in 1835), the

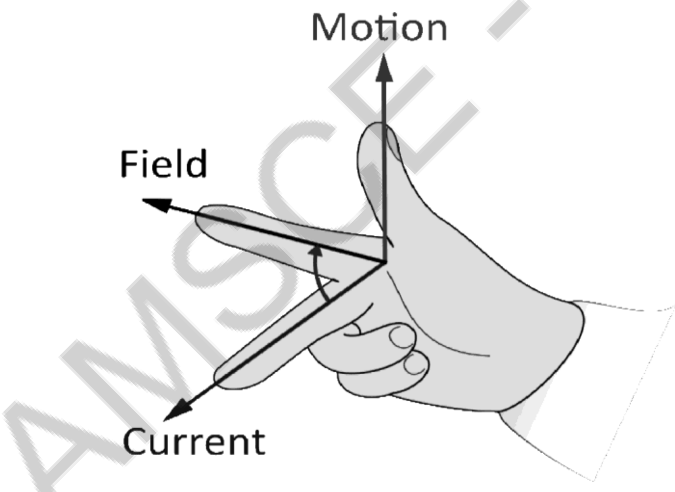
AMSCE - 1101

direction of current can be found. when the current through a coil changes magnetic field, the voltage is created as a result of changing magnetic field, the direction of the induced voltage is such that it always opposes the change in current.

in very simple words, lenz's law stating that the induced effect is always such as to oppose the cause that produced it.

Fleming's Right Hand Rule

It states that "if the thumb, the forefinger and the middle finger are held in such a way that they are mutually perpendicular to each other (makes 90° of Angles), then the forefinger points the direction of the field, the thumb points the direction of motion of the conductor and the middle finger points the direction of the induced Current (from EMF).



Fleming's Right-Hand Rule

AMSCE - 1101

5. Derive EMF equation of a transformer (8) Dec 2010, Dec2011

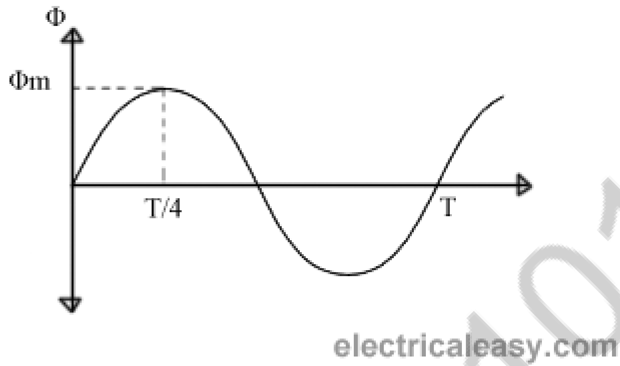
Let,

N_1 = Number of turns in primary winding

N_2 = Number of turns in secondary winding

Φ_m = Maximum flux in the core (in Wb) = (B_m x A)

f = frequency of the AC supply (in Hz)



As, shown in the fig., the flux rises sinusoidally to its maximum value Φm from 0. It reaches to the maximum value in one quarter of the cycle i.e in T/4 sec (where, T is time period of the sin wave of the supply = 1/f).

Therefore,

average rate of change of flux = Φm /(T/4) = Φm /(1/4f)

Therefore,

average rate of change of flux = 4f Φm .... (Wb/s). Now,

Induced emf per turn = rate of change of flux per turn Therefore, average emf per turn = 4f Φm ....(Volts). Now, we know, Form factor = RMS value / average value Therefore, RMS value of emf per turn = Form factor X average emf per turn.

As, the flux Φvaries sinusoidally, form factor of a sine wave is 1.11

Therefore, RMS value of emf per turn = 1.11 x 4f Φm = 4.44f Φm.

RMS value of induced emf in whole primary winding (E1) = RMS value of emf per turn X Number of turns in primary winding

E1 = 4.44f N1 Φm .... eq 1

Similarly, RMS induced emf in secondary winding (E2) can be given as

AMSCE - 1101

E2 = 4.44f N2 Φm. .... eq 2 from the above equations 1 and 2,

$$\frac{E_1}{N_1} = \frac{E_2}{N_2} = 4.44f\varphi_m$$

This is called the **emf equation of transformer**, which shows, emf / number of turns is same for both primary and secondary winding.

For an ideal transformer on no load, E1 = V1 and E2 = V2 . where, V1 = supply voltage of primary winding

V2 = terminal voltage of secondary winding

Voltage Transformation Ratio (K) As derived above,

$$\frac{E_1}{N_1} = \frac{E_2}{N_2} = K$$

constant

This constant K is known as **voltage transformation ratio**.

- If N2 > N1, i.e. K > 1, then the transformer is called step-up transformer.
- If N2 < N1, i.e. K < 1, then the transformer is called step-down transformer.

6. Explain why single phase induction motor is not self starting?. (8) Dec 2011

Why Single Phase Induction Motor Is Not Self Starting?

The stator of a single phase induction motor is wound with single phase winding. When the stator is fed with a single phase supply, it produces alternating flux (which alternates along one space axis only). Alternating flux acting on a squirrel cage rotor cannot produce rotation, only revolving flux can. That is why a single phase induction motor is not self starting.

How To Make Single Phase Induction Motor Self Starting?

As explained above, single phase induction motor is not self-starting. To make it self-starting, it can be temporarily converted into a two-phase motor while starting. This can be achieved by introducing an additional ‘starting winding’ also called as auxillary winding.Hence, stator of a single phase motor has two windings: (i) Main winding and (ii) Starting winding (auxillary winding). These two windings are connected in parallel across a single phase supply and are spaced 90 electrical degrees apart. Phase difference of 90 degree can be achieved by connecting a capacitor in series with the starting winding.

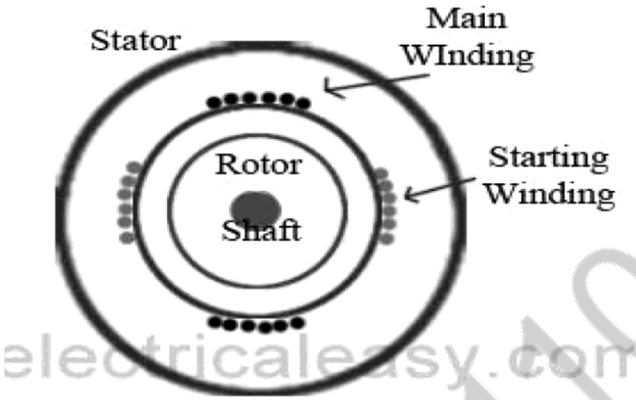
Hence the motor behaves like a two-phase motor and the stator produces revolving magnetic field which causes rotor to run. Once motor gathers speed, say upto 80 or 90% of its normal speed, the starting winding gets disconnected form the circuit by means of a centrifugal switch, and the motor runs only on main winding.

7 With neat diagrams explain the construction and principles of operation of a single phase induction motor . (Nov/Dec 2016)

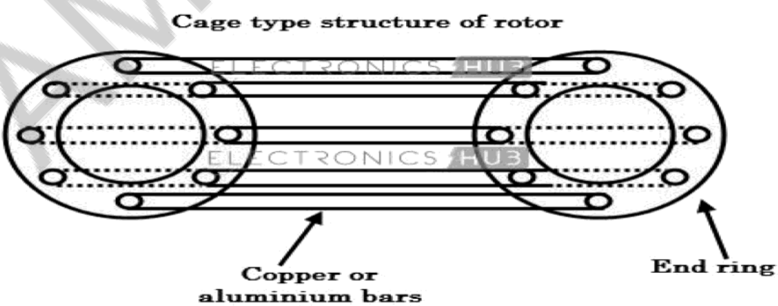
Construction of a single phase induction motor having squirrel cage rotor, except that the stator is wound for single phase supply. Stator is also provided with a 'starting winding' which is used only for starting purpose. Working Principle Of Single Phase Induction Motor

When the stator of a single phase motor is fed with single phase supply, it produces alternating flux in the stator winding. The alternating current flowing through stator winding causes induced current in the rotor bars (of the squirrel cage rotor) according to Faraday's law of electromagnetic induction. This induced current in the rotor will also produce alternating flux. Even after both alternating fluxes are set up, the motor fails to start (the reason is explained below). However, if the rotor is given a initial start by external force in either direction, then motor accelerates to its final speed and keeps running with its rated speed. This behavior of a single phase motor can be explained by double-field revolving theory.

AMSCE - 1101



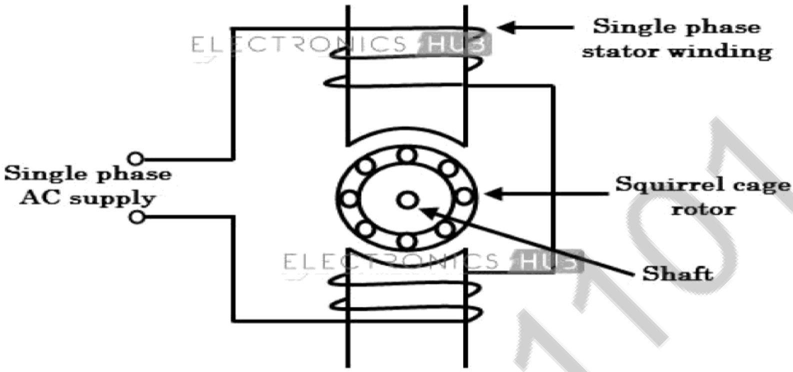
Single phase induction motors consist of two main parts; stator and rotor. The construction of these motors is more or less similar to a three-phase squirrel-cage induction motor.The stator is a stationary part and it has laminated construction, which is made up of stampings. These stampings consists of slots on its periphery to carry the stator winding. This winding is excited with a single phase AC supply.The rotor is a rotating part and its construction is of squirrel cage type. The rotor consists of uninsulated aluminum or copper bars which are placed in the slots.These rotor bars are permanently shorted at both ends with the help of end rings as shown in figure.



There is no physical connection between the stator and rotor, but there is a small and uniform gap between them. The rotor acts as a conductor which when placed in the stator magnetic field,

AMSCE-1101

an emf is induced in it, produces its own magnetic field which further interacts with stator field to produce the torque.



Whenever a single phase AC supply is given to the stator winding, an alternating magnetic field is produced around the stator. Due to the pulsating nature of the field which reverses for every half-cycle, cannot produce rotation in a stationary squirrel cage rotor. In case of three phase induction motor, the field produced by the supply is of rotating type and hence they are self starting motors.But in case of single phase motors, the field produced by the stator is not rotating (but alternating only) and hence single phase motors are not self starting.

But, if the rotor is rotated by any other means (by hand or any tool), the induced currents in the rotor will assist with stator currents to produce revolving field. This field causes the motor to run in the direction it is started even with a single winding. However, it is not possible to give initial rotation every time externally if the motors are attached to loads. This problem can be avoided by converting single phase motor into a two-phase motor temporarily in order produce revolving flux. This is achieved by providing a starting winding in addition to main or running winding. The auxiliary or starting winding is made highly resistive whereas the main or running winding is made highly inductive.

Due to the large phase difference between these two, the torque produced by the rotor is high enough to start it. Once the motor

AMSCE-1101

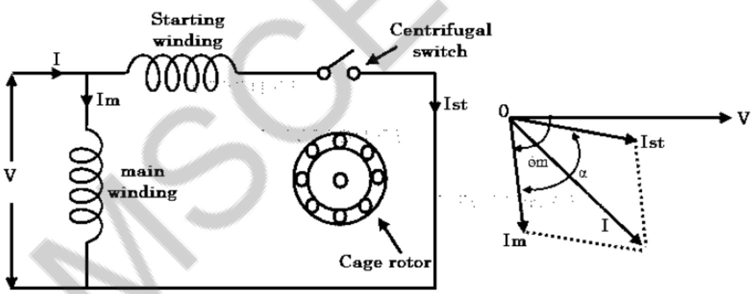
reaches 75 percent of its speed, the auxiliary winding may be disconnected by a centrifugal switch and the motor able to run on a single main winding.

Single phase induction motors are used primarily for domestic and light-industrial applications where three-phase supply is generally not available.

8. Explain the working of split phase capacitor start induction motor. (8) Dec 2011

Split Phase Induction Motor

This is one of the most widely used types of single phase induction motors. The essential parts of the split phase motor include main winding, auxiliary winding and a centrifugal switch. This is the simplest arrangement to set up a rotating magnetic field by providing two winding on the same stator core as shown in figure.



Circuit diagram of split phase motor

Phasor diagram

The auxiliary or starting winding carries a series resistance such that its impedance becomes highly resistive in nature.It is not wound identical to the main winding but contains fewer turns of much smaller diameter as compared to main winding. This will reduce the amount of start current lags the voltage. The main winding is inductive in nature in such that current lags the voltage by some angle. This winding is designed for the operation of 75 % of synchronous speed and above. These two windings are connected in parallel across the supply. Due to the inductive nature, current through main winding lags the supply voltage

AMSCE - 1101

by a large angle while the current through starting winding is almost in phase with voltage due to resistive nature.

Hence there exists a phase difference between these currents and thereby phase difference between the fluxes produced by these currents. The resultant of these two fluxes produce rotating magnetic field and hence the starting torque. The centrifugal switch is connected in series with the starting winding. When the motor reaches 75 to 80 percent of synchronous speed, the centrifugal switch is opened mechanically and thereby auxiliary winding is out of the circuit. Therefore, the motor runs only with main winding.

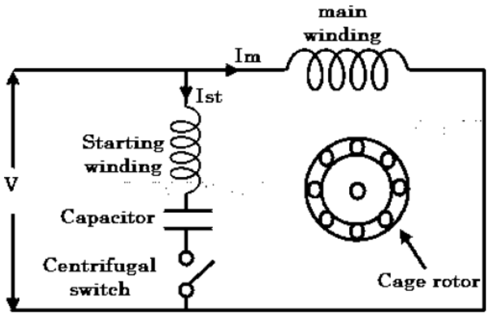
Split phase motors give poor starting torque due to small phase difference between main and auxiliary currents. Also, the power factor of these motors is poor. These are mainly used for easily started loads such as blowers, fans, washing machines, grinders, etc.

9. Explain the working of capacitor start and capacitor run induction motor. (16) Dec 2011

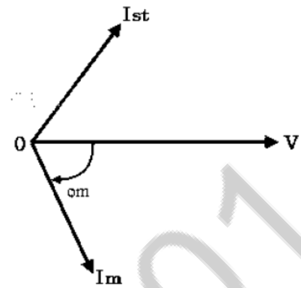
Capacitor Start Induction Motor

This motor is similar to the split phase motor, but in addition a capacitor is connected in series to auxiliary winding. This is a modified version of split phase motor. Since the capacitor draws a leading current, the use of a capacitor increases the phase angle between the two currents (main and auxiliary) and hence the starting torque. This is the main reason for using a capacitor in single phase induction motors. Here the capacitor is of dry-type electrolytic one which is designed only for alternating current use. Due to the inexpensive type of capacitors, these motors become more popular in wide applications. These capacitors are designed for definite duty cycle, but not for continuous use. The schematic diagram of capacitor start motor is shown in figure below.

AMSCE - 1101



Circuit diagram of capacitor start motor



Phasor diagram

The operation of this motor is similar to the split phase motor where the starting torque is provided by additional winding. Once the speed is picked up, the additional winding along with capacitor is removed from the circuit with the help of centrifugal switch. But, the difference is that the torque produced by this motor is higher than split phase motor due to the use of capacitor. Due to the presence of a capacitor, the current through auxiliary winding will leads the applied voltage by some angle which is more than that of split case type. Thus, the phase difference between main and auxiliary currents is increased and thereby starting torque. The performance of this motor is identical to the split phase motor when it runs near full load RPM. Due to the capacitor, the inrush currents are reduced in this motor.These motors have very high starting torque up to 300% full load torque. However the power factor is low at rated load and rated speed.Owing to the high starting torque, these motors are used in domestic as well as industrial applications such as water pumps, grinders, lathe machines, compressors, drilling machines, etc.

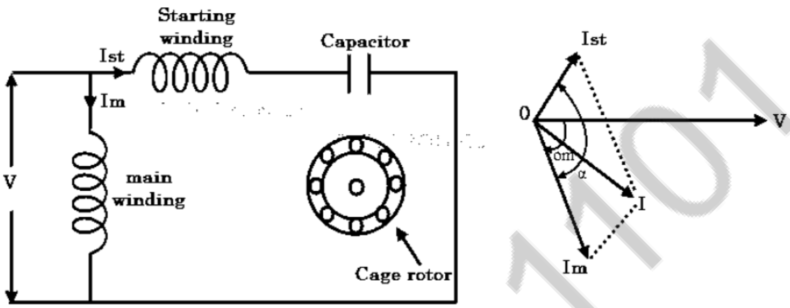
Permanent Capacitor Induction Motor

This motor is also called as a capacitor run motor in which a low capacitor is connected in series with the starting winding and is not removed from the circuit even in running condition. Due to this arrangement, centrifugal switch is not required.

Here the capacitor is capable of running continuously. The low value capacitor produces more leading phase shift bur less total

AMSCE - 1101

starting current as shown in phasor diagram.Hence, the starting torque produced by these motors will be considerably lower than that of capacitor start motor. The schematic circuit of this motor is shown in figure below.



Circuit diagram of capacitor run motor

Phasor diagram

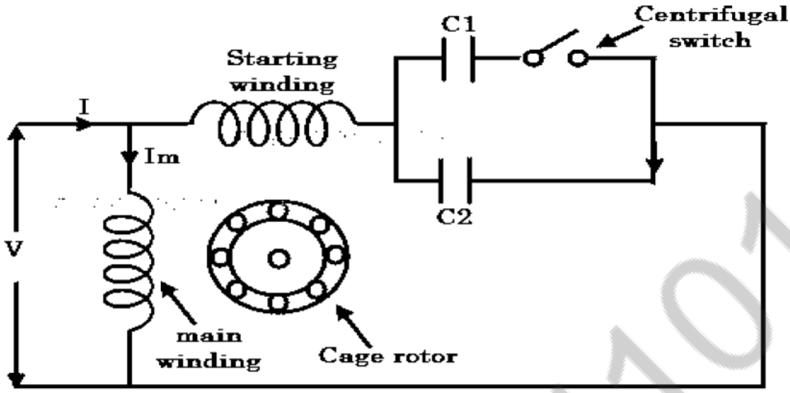
In this, the auxiliary winding and capacitor remains in circuit permanently and produce an approximate two phase operation at rated load point. This is the key strength of these motors. This will result better power factor and efficiency. However, the starting torque is much lower in these motors, typically about 80 percent of full load torque. Due to the continuous duty of auxiliary winding and capacitor, the rating of these components should withstand running conditions and hence permanent capacitor motor is more than equivalent split phase or capacitor start motors. These motors are used in exhaust and intake fans, unit heaters, blowers, etc.

Capacitor Start and Capacitor Run Induction Motor

These motors are also called as two-value capacitor motors. It combines the advantages of capacitor start type and permanent capacitor type induction motors.This motor consists of two capacitors of different value of capacitance for starting and running. A high value capacitor is used for starting conditions while a low value is used for running conditions.It is to be noted that this motor uses same winding arrangement as capacitor-start motor during startup and permanent capacitor motor during running conditions. The schematic arrangement of this motor is shown in figure below.

AMSCE-1101

86



Circuit diagram of capacitor start capacitor run motor

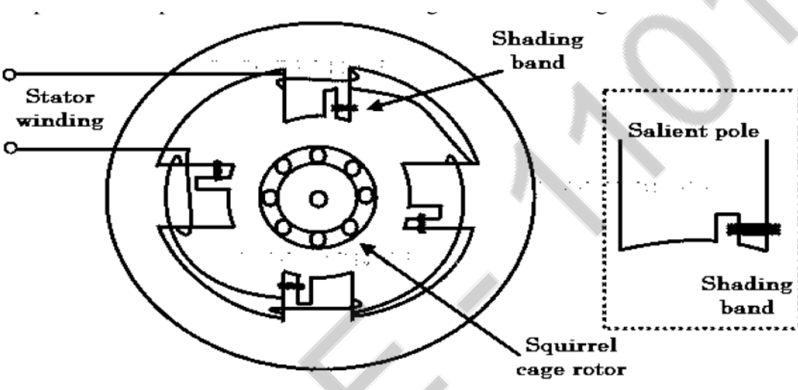
At starting, both starting and running capacitors are connected in series with the auxiliary winding. Thus the motor starting torque is more compared with other types of motors. Once the motor reaches some speed, the centrifugal switch disconnects the starting capacitor and leaves the running capacitor in series with auxiliary winding. Thus, both running and auxiliary windings remain during running condition, thereby improved power factor and efficiency of the motor. These are the most commonly used single phase motors due to high starting torque and better power factor. These are used in compressors, refrigerators, air conditioners, conveyors, ceiling fans, air circulators, etc.

10. Explain the working of shaded pole induction motor. (8) Dec 2011

This motor uses entirely different technique to start the motor as compared with other motors so far we have discussed now. This motor doesn't use any auxiliary winding or even it doesn't have a rotating field, but a field that sweeps across the pole faces is enough to drive the motor. So the field moves from one side of the pole to another side of the pole.Although these motors are of small ratings, inefficient and have low starting torque, these are used in a variety of applications due to its outstanding features like ruggedness, low initial cost, small size and simple construction.

AMSCE - 1101

A shaded pole motor consists of a stator having salient poles (or projected poles), and a rotor of squirrel cage type. In this, stator is constructed in a special way to produce moving magnetic field. Stator poles are excited with its own exciting coils by taking the supply from a single phase supply. A 4-pole shaded pole motor construction is given in below figure.



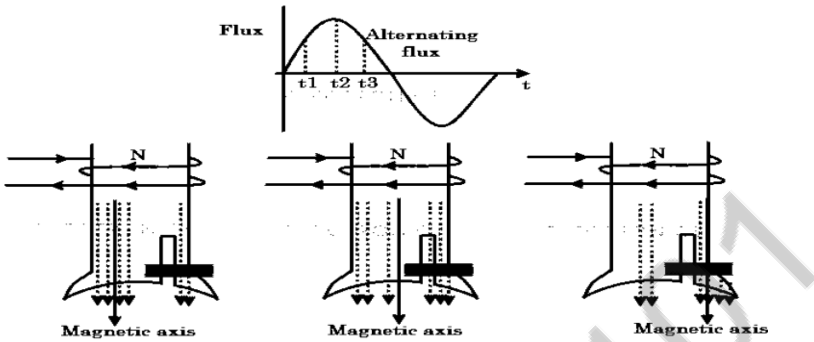
4-Pole Shaded pole motor construction

Each salient pole is divided into two parts; shaded and un-shaded. A shading portion is a slot cut across the laminations at about one third distance from one edge, and around this a heavy copper ring (also called as shading coil or copper shading band) is placed.This part where shading coil is placed is generally termed as shaded part of the pole and remaining portion is called as un- shaded part as shown in figure.

Let us discuss how the sweeping action of the field takes place.When an alternating supply is given to the stator coils, an alternating flux will be produced. The distribution of flux in the pole face area is influenced by the presence of copper shading band.Let us consider the three instants, t1, t2, and t3 of alternating flux for an half cycle of the flux as shown in figure.

AMSCE-1101

Unit Wise Solved Question Paper 88



(a) t= t1 (b) t= t2 (c) t= t3

1. At instant t= t1, the rate of change of flux (rising) is very high. Due to this flux, an emf is induced in the copper shading band and as the copper shading band is shorted, current circulates through it. This causes current to create its own field. According to Lenz's law, the current through copper shading band opposes the cause, i.e., rise of supply current (and hence rise of main flux). Therefore the flux produced by shading ring opposes the main flux. So there is weakening of flux in the shaded part while crowding of flux in un-shaded part. So the axis of overall flux shifts to non-shaded part of the pole as shown in the figure.
2. At instant t=t2, the rate of rise of flux is almost zero, and hence very little emf is induced in the shaded band. It results negligible shaded ring flux and hence there is no much affect on distribution of main flux. Therefore, the distribution of flux is uniform and the overall flux axis lies at the center of the pole as shown in figure.
3. At instant t=t3, the rate of change of flux (decreasing) is very high, and induces emf in copper shading band. The flux produced by the shading ring is now opposes the cause according to Lennz's law. Here, the cause is decreasing flux, and opposing means its direction is same as that of main flux. Hence, this flux strengthens the main flux. So there will be crowding of flux in the shaded part compared to the non shaded part. Due to this overall flux axis shifts to the middle of shaded part.This

AMSCE - 1101

sequence will repeat for negative cycle too and consequently it produce moving magnetic field for every cycle from non shaded part of the pole to shaded part of the pole. Due to this field, motor produces the starting torque. This starting torque is low about 40 to 50 percent of full load torque. Therefore, these motors are used in low starting torque applications such as fans, toy motors, blowers, hair dryers, photocopy machines, film projectors, advertising displays, etc.

11. Explain the characteristics of DC motor with neat sketch (16) May/June 2016

Generally, three characteristic curves are considered important for DC motors which are, (i) Torque vs. armature current, (ii) Speed vs. armature current and (iii) Speed vs. torque. These are explained below for each type of DC motor. These characteristics are determined by keeping the following two relations .Ta ∝.Ia and N∝Eb/

These above equations can be studied at - emf and torque equation of dc machine. For a DC motor, magnitude of the back emf is given by the same emf equation of a dc generator i.e.

Eb = PNZ / 60A. For a machine, P, Z and A are constant, therefore, N∝Eb/

Characteristics Of DC Series Motors

Torque Vs. Armature Current (Ta-Ia)

This characteristic is also known as electrical characteristic. We know that torque is directly proportional to the product of armature current and field flux, Ta ∝.Ia. In DC series motors, field winding is connected in series with the armature, i.e. Ia = If. Therefore, before magnetic saturation of the field, flux is directly proportional to Ia. Hence, before magnetic saturation Ta α Ia2. Therefore, the Ta-Ia curve is parabola for smaller values of Ia.After magnetic saturation of the field poles, flux is independent of armature current Ia. Therefore, the torque varies proportionally to Ia only, T∝Ia.Therefore, after magnetic saturation, Ta-Ia curve becomes a straight line.

AMSCE-1101

Unit Wise Solved Question Paper 90

The shaft torque (Tsh) is less than armature torque (Ta) due to stray losses. Hence, the curve Tsh vs Ia lies slightly lower.

AMSCE - 1101

In DC series motors, (prior to magnetic saturation) torque increases as the square of armature current, these motors are used where high starting torque is required.

Speed Vs. Armature Current (N-Ia)

We know the relation, N Eb/

For small load current (and hence for small armature current) change in back emf Eb is small and it may be neglected. Hence, for small currents speed is inversely proportional to as we know, flux is directly proportional to Ia, speed is inversely proportional to Ia. Therefore, when armature current is very small the speed becomes dangerously high. That is why a series motor should never be started without some mechanical load.But, at heavy loads, armature current Ia is large. And hence, speed is low which results in decreased back emf Eb. Due to decreased Eb, more armature current is allowed. Speed Vs. Torque (N-Ta). This characteristic is also called as mechanical characteristic. From the above two characteristics of DC series motor, it can be found that when speed is high, torque is low and vice versa.

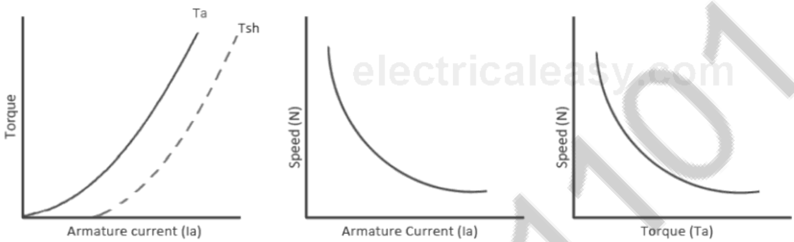
Characteristics Of DC Shunt Motors

Torque Vs. Armature Current (Ta-Ia)

In case of DC shunt motors, we can assume the field flux Φ to be constant. Though at heavy loads, Φ decreases in a small amount due to increased armature reaction. As we are neglecting the change in the flux Φ, we can say that torque is proportional to armature current. Hence, the Ta-Ia characteristic for a dc shunt motor will be a straight line through the origin. Since heavy starting load needs heavy starting current, shunt motor should never be started on a heavyload.

Speed Vs. Armature Current (N-Ia)

As flux is assumed to be constant, we can say N α Eb. But, as back emf is also almost constant, the speed should remain constant. But practically, as well as Eb decreases with increase in load. Back emf Eb decreases slightly more than **I**, therefore, the speed decreases slightly. Generally, the speed decreases only by 5 to 15% of full load speed. Therefore, **a shunt motor can be assumed as a constant speed motor**. In speed vs. armature current characteristic in the following figure, the straight horizontal line represents the ideal characteristic and the actual characteristic is shown by the dotted line.



Characteristics of DC series motor

Characteristics of DC Compound Motor

DC compound motors have both series as well as shunt winding. In a compound motor, if series and shunt windings are connected such that series flux is in direction as that of the shunt flux then the motor is said to be cumulatively compounded. And if the series flux is opposite to the direction of the shunt flux, then the motor is said to be differentially compounded. Characteristics of both these compound motors are explained below. **(a) Cumulative compound motor**

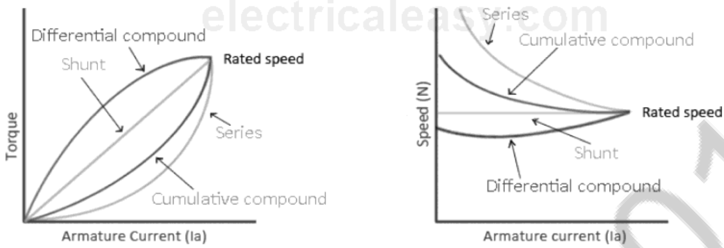
Cumulative compound motors are used where series characteristics are required but the load is likely to be removed completely. Series winding takes care of the heavy load, whereas the shunt winding prevents the motor from running at dangerously high speed when the load is suddenly removed. These motors have generally employed a flywheel, where sudden and temporary loads are applied like in rolling mills.

(b) Differential compound motor Since in differential field motors, series flux opposes shunt flux, the total flux decreases with increase in load. Due to this, the speed remains almost constant or even it may increase slightly

with increase in load (N Eb/). Differential compound motors

AMSCE - 1101

are not commonly used, but they find limited applications in experimental and research work.



Characteristics of DC compound motor

12. Draw the circuit diagram of the following three types of DC generator and write the relationships among the current and voltages: i) Separately excited motor (ii) Series motor(iii) Shunt motor (8) May/June 2016

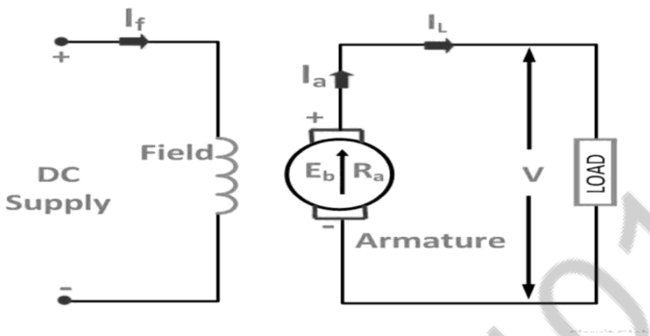
The magnetic flux in a DC machine is produced by the field coils carrying current. The circulating current in the field windings produces a magnetic flux, and the phenomenon is known as **Excitation**. DC Generator is generally classified according to the methods of their field excitation.On the basis of excitation, the DC Generators are classified as **Separately excited** DC Generators and **Self-excited** DC Generators. There is also **Permanent magnet type** DC generators.

The self-excited DC Generators are further classified as **Shunt wound** DC generators; **Series wound** DC generators and **Compound wound** DC generators. The Compound Wound DC generators are further divided as long shunt wound DC generators, and short shunt wound DC generators.

Separately Excited DC Generator

A DC generators whose field winding or coil is energized by a separate or external DC source is called a separately excited DC Generator. The flux produced by the poles depends upon the field current with the unsaturated region of magnetic material of the poles. i.e. flux is directly proportional to the field current. But in the saturated region, the flux remains constant.

AMSCE - 1101



Voltage drop in the armature = Ia × Ra (R/sub>a is the armature resistance) Let, Ia = IL = I (say); Voltage across the load, V = IRa Power generated,

Pg = Eg×I Power delivered to the external load, PL = V×I.Self Excited DC Generator

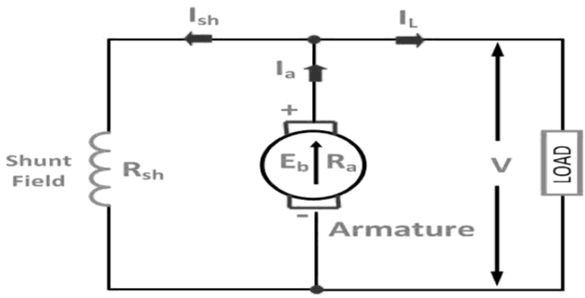
Self-excited **DC Generator** is a device, in which the current to the field winding is supplied by the generator itself. In this the field coils mat be connected in parallel with the armature in the series, or it may be connected partly in series and partly in parallel with the armature windings.

Shunt Wound Generator

In a shunt wound generator, the field winding is connected across the armature winding forming a parallel or shunt circuit. Therefore, full terminal voltage is applied across it. A very small field current Ish, flows through it because this winding has many turns of fine wire having very high resistance Rsh of the order of 100 ohms.

The connection diagram of shunt wound generator is shown below.

AMSCE - 1101



AMSCE - 1101

In these type of DC generators the field windings are connected in parallel with armature conductors as shown in figure below. In shunt wound generators the voltage in the field winding is same as the voltage across the terminal. Let, Rsh = Shunt winding resistance Ish = Current flowing through the shunt field Ra = Armature resistance Ia = Armature current IL = Load current V = Terminal voltage Eg = Generated emf

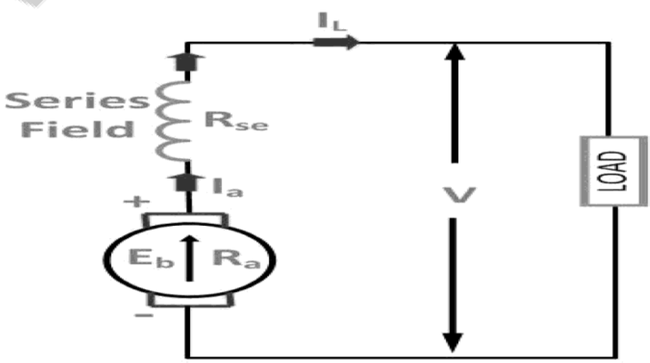
Here armature current Ia is dividing in two parts, one is shunt field current Ish and another is load current IL. So, Ia=Ish + IL The effective power across the load will be maximum when IL will be maximum. So, it is required to keep shunt field current as small as possible. For this purpose the resistance of the shunt field winding generally kept high (100 Ω) and large no of turns are used for the desired emf. Shunt field current, Ish = V/Rsh Voltage across the load, V = Eg-Ia Ra Power generated,

$P_g = E_g \times I_a$ Power delivered to the load, $P_L = V \times I_L$

Series Wound Generator

A **series-wound generator** the field coils are connected in series with the armature winding. The series field winding carries the armature current. The series field winding consists of a few turns of wire of thick wire of larger cross-sectional area and having low resistance usually of the order of less than 1 ohm because the armature current has a very large value.

Its convectional diagram is shown below.



AMSCE-1101

 97

In these type of generators, the field windings are connected in series with armature conductors as shown in figure below. So, whole current flows through the field coils as well as the load. As series field winding carries full load current it is designed with relatively few turns of thick wire. The electrical resistance of series field winding is therefore very low (nearly 0.5Ω). Let, Rsc = Series winding resistance Isc = Current flowing through the series field Ra = Armature resistance Ia = Armature current IL = Load current V = Terminal voltage Eg = Generated emf

Then, Ia = Isc = IL=I (say) Voltage across the load, V = Eg -I(Ia×Ra) Power generated, Pg = Eg×I

Power delivered to the load, PL = V×I

Compound Wound Generator

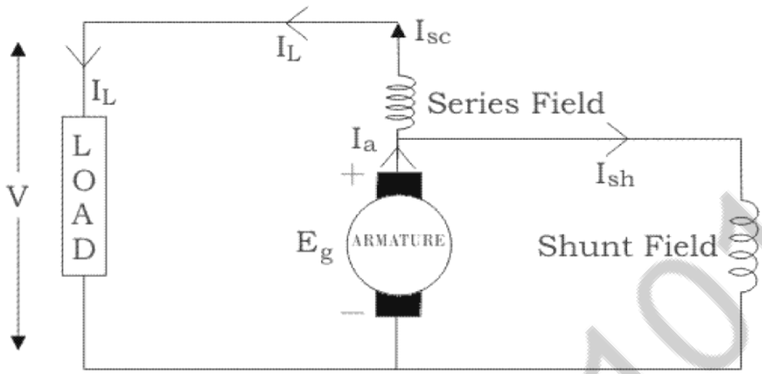
In series wound generators, the output voltage is directly proportional with load current. In shunt wound generators, output voltage is inversely proportional with load current. A combination of these two types of generators can overcome the disadvantages of both. This combination of windings is called compound wound DC generator. Compound wound generators have both series field winding and shunt field winding. One winding is placed in series with the armature and the other is placed in parallel with the armature. This type of DC generators may be of two types- short shunt compound wound generator and long shunt compound wound generator.

In a compound-wound generator, there are two field windings. One is connected in series, and another is connected in parallel with the armature windings. There are two types of compound-wound generator.

Long shunt compound-wound generator
Short shunt compound-wound generator
Short Shunt Compound Wound DC Generator

The generators in which only shunt field winding is in parallel with the armature winding as shown in figure.

AMSCE - 1101



Short Shunt Compound Wound Generator

Series field current, Isc = IL

Shunt field current, $I_{sh} = (V+I_{sc}\ R_{sc})/R_{sh}$

Armature current, $I_a = I_{sh} + I_L$

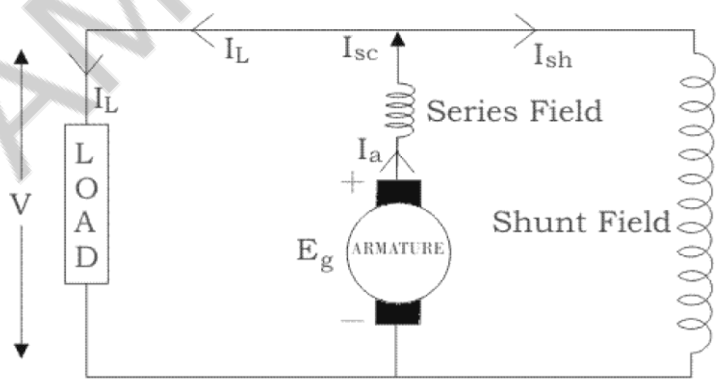
Voltage across the load, $V = E_g - I_a\ R_a - I_{sc}\ R_{sc}$

Power generated, $P_g = E_g \times I_a$

Power delivered to the load, $P_L = V \times I_L$

Long Shunt Compound Wound DC Generator

The generators in which shunt field winding is in parallel with both series field and armature winding as shown in figure.



Long Shunt Compound Wound Generator

AMSCE - 1101

99

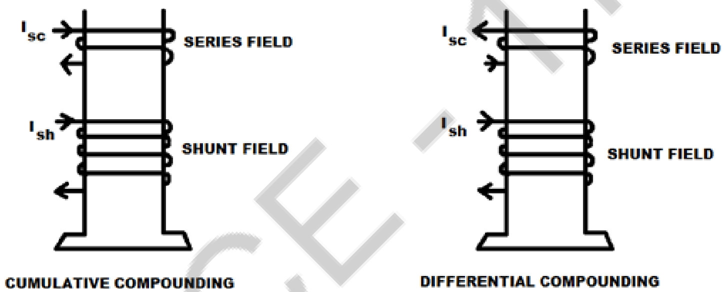
Shunt field current, $I_{sh}=V/R_{sh}$

Armature current, $I_a=$ series field current, $I_{sc}= I_L+I_{sh}$

Voltage across the load, $V=E_g-I_a R_a-I_{sc} R_{sc}=E_g-I_a (R_a+R_{sc})$ [$\because I_a=I_{cs}$] Power generated, $P_g= E_g \times I_a$

Power delivered to the load, $P_L=V\times I_L$

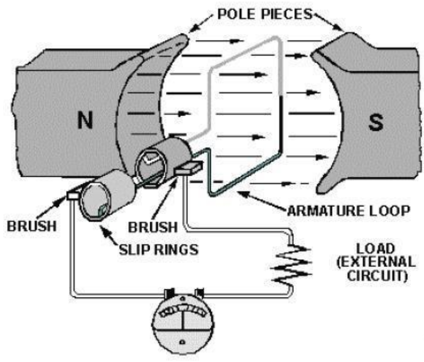
In a compound wound generator, the shunt field is stronger than the series field. When the series field assists the shunt field, generator is said to be commutatively compound wound. On the other hand if series field opposes the shunt field, the generator is said to be differentially compound wound.



13 Explain the principle of operation of DC generator. Dec 2011

DC generator converts mechanical energy into electrical energy. when a conductor move in a magnetic field in such a way conductors cuts across a magnetic flux of lines and emf produces in a generator and it is defined by faradays law of electromagnetic induction emf causes current to flow if the conductor circuit is closed.

100

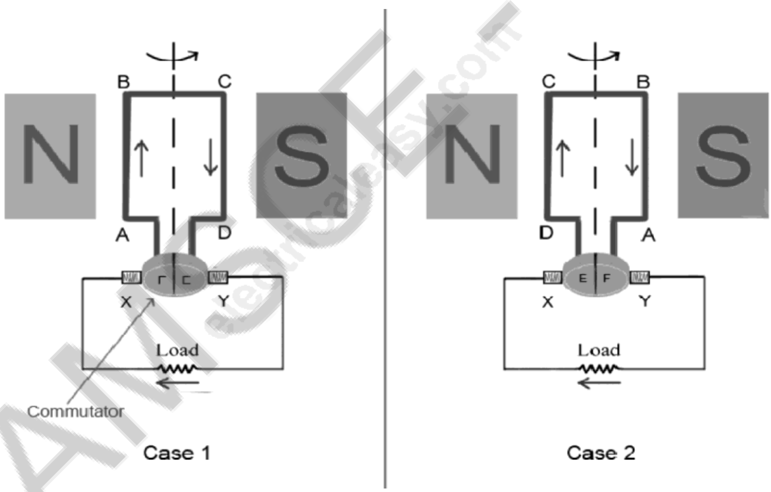


AMSCE - 1101

Working Principle Of A DC Generator:

According to Faraday's laws of electromagnetic induction, whenever a conductor is placed in a varying magnetic field (OR a conductor is moved in a magnetic field), an emf (electromotive force) gets induced in the conductor. The magnitude of induced emf can be calculated from the emf equation of dc generator. If the conductor is provided with the closed path, the induced current will circulate within the path. In a DC generator, field coils produce an electromagnetic field and the armature conductors are rotated into the field. Thus, an electromagnetically induced emf is generated in the armature conductors. The direction of induced current is given by Fleming's right hand rule.

Need of a Split ring commutator:



According to Fleming's right hand rule, the direction of induced current changes whenever the direction of motion of the conductor changes. Let's consider an armature rotating clockwise and a conductor at the left is moving upward. When the armature completes a half rotation, the direction of motion of that particular conductor will be reversed to downward. Hence, the direction of current in every armature conductor will be alternating. If you look at the above figure, you will know how the direction of the induced current is alternating in an armature

102

conductor. But with a split ring commutator, connections of the armature conductors also gets reversed when the current reversal occurs. And therefore, we get unidirectional current at the terminals.

14. Explain Voltage Regulation of Transformer

The voltage regulation is the percentage of voltage difference between no load and full load voltages of a transformer with respect to its full load voltage. Say an electrical power transformer is open circuited, means load is not connected with secondary terminals. In this situation, the secondary terminal voltage of the transformer will be its secondary induced emf E2. Whenever full load is connected to the secondary terminals of the transformer, rated current I2 flows through the secondary circuit and voltage drop comes into picture. At this situation, primary winding will also draw equivalent full load current from source. The voltage drop in the secondary is I2Z2 where Z2 is the secondary impedance of transformer. Now if at this loading condition, any one measures the voltage between secondary terminals, he or she will get voltage V2 across load terminals which is obviously less than no load secondary voltage E2and this is because of I2Z2 voltage drop in the transformer.Expression of Voltage Regulation of Transformer, represented in percentage, is

$$\text{Voltage regulation}\,(\%) = \frac{E_2 - V_2}{V_2} \times 100\%$$

15. Explain the principle of operation of DC generator. Dec 2011

It is based on the principle that when a current-carrying conductor is placed in a magnetic field, it experiences a mechanical force whose direction is given by Fleming's Left-hand rule and whose magnitude is given by

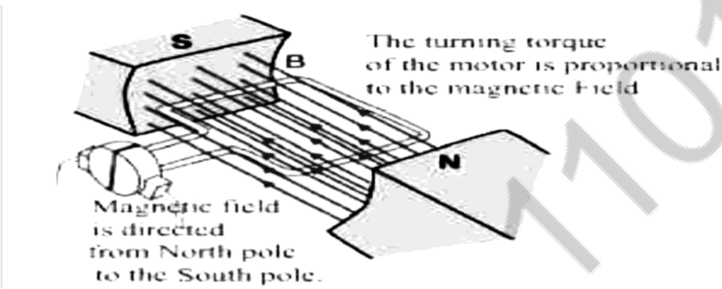
Force, F = B I l newton

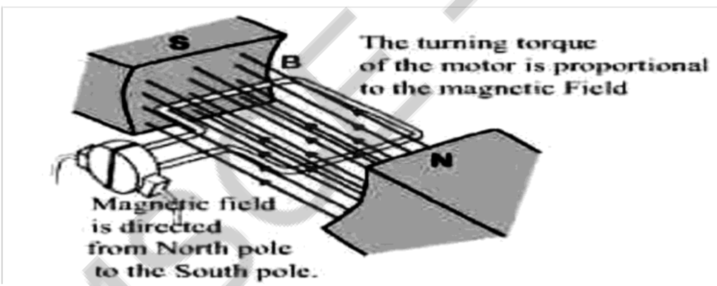
Where B is the magnetic field in weber/m^2. I is the current in amperes and

l is the length of the coil in meter.

The force, current and the magnetic field are all in different directions.

If an Electric current flows through two copper wires that are between the poles of a magnet, an upward force will move one wire up and a downward force will move the other wire down.





AMSOE - 1101

UNIT – III

SEMICONDUCTOR DEVICES AND APPLICATIONS PART – A

1 What are the applications of a diode? [June 2009]

In rectification, clampers, clippers, switching circuits, comparators, voltage doublers and diode gates

2. What are the biasing conditions for base – emitter and base – collector junction for a transistor to operate as an amplifier? [June 2009, Dec 2010, June 2012]

The active region is normally used for operating the transistor as an amplifier. In this region, the emitter – base junction is forward biased while the collector – base junction is reverse biased.

3. What is Avalanche breakdown? [Dec 2009]

When a pn junction diode is reverse biased, the thermally generated minority carriers constitute the flow of reverse saturation current through the diode. These carriers acquire energy from the applied potential and collide with crystal ions. As a result, the covalent bonds are disrupted and new electron – hole pairs are generated. The additional pairs generated in this way also pickup sufficient energy from the applied potential and generate additional electron-hole pairs by collision. Thus each new charge carriers in turn produce additional charge carrier by breaking covalent bonds. As a result, the number of charge carriers avalanche increases to peak level and results in avalanche breakdown.

4. What is Early effect? [Dec 2009, May 2011, Dec 2012]

In the active region of a common –base transistor, the emitter junction is forward biased and the collector junction is reverse biased. When the reverse bias applied to collector junction increased the depletion region at the collector junction increases. Since the base is lightly doped, when compared to the collector, the depletion

AMSCE - 1101

region penetrates deeply into the base of the transistor. Since the penetration of the depletion region into base is much larger than into the collector, collector depletion region is neglected. If the actual base width is W_B and the width of the depletion region is W , then the effective electrical base width is W_B –W. This dependency of base width on the applied reverse bias to collector voltage is known as Early effect.

5. For a certain transistor IC = 5.505mA, IB = 50μA, ICO = 5 μA, determine the value of β

and I_E . June 2010

$I_C = \beta I_B + (1 + \beta) I_C 0$

$5.505 \times 10^{-3} = \beta \times 50 \times 10^{-6} + (1 + \beta) \times 5 \times 10^{-6}$

$5.505 \times 10^{-3} = 5.5 \times 10^{-5} \beta$

$\beta = 100$

$I_E = I_C + I_B = 5.555mA$

6. Write the difference between the PN junction diode and zener diode. Dec 2010, June 2012, May 2015

S.No	PN junction	Zener diode
1	Diode can conduct only in forward direction	Zener diode allows conduction in both directions
2	A normal diode will be damaged for a large reverse current	Zener diode does not get damaged like PN diode
3	Amount of doping for P and N semiconductor layers are not high compared to zener diode.	Amount of doping is high compared to PN diode
4	Used for rectification	Used in voltage regulation

7. State the advantages of bridge rectifiers. May 2011

i. The current in both the primary and secondary of the power transformer flows for the entire cycle and hence for a given

AMSCE - 1101

power output, power transformer of a small size and less cost may be used.

ii. No center tap transformer is required

iii. The current in the secondary of the transformer is in opposite direction in two half cycles. Hence net DC component flowing is zero which reduces the losses and danger of saturation

iv. Due to pure alternating current in secondary of transformer, the transformer utilization factor is high. Hence the circuit is suitable for applications where large powers are required.

v. As two diodes are conduct in series in each half cycle, inverse voltage appearing across diodes gets shared. Hence the circuit can be used for high voltage applications.

8. Define Peak Inverse Voltage of a PN junction diode. Dec 2011

Peak Inverse Voltage (PIV) or Peak Reverse Voltage (PRV) refer to the maximum voltage a diode or any other device can withstand in the reverse biased direction.

9. Define current amplification factor for CE configuration in transistor Dec 2011

It is defined as the ratio of change in output current to the change in input current. For CE configuration, It is defined as the ratio of the collector current to the base current.

$$\beta = \left.\frac{I_C}{I_B}\right|_{\text{constant} V_{CB}}$$

10. What is meant by Zener effect? Dec 2012

The application of reverse bias voltage (less than 6V) causes a electric field across the depletion region at pn junction of the order of 3 x 10 ^{5} V/cm. An electric field of such high magnitude exerts a large force on the valence electrons of the atom , tending to separate them from their respective nuclei. Hence , electron – hole pairs are generated in large numbers ,

Unit Wise Solved Question Paper 107

and a sudden increase of current is observed. Such a breakdown is called Zener break down and effect is called Zener effect.

11. Write any two salient points on a PN junction. June 2013

i. A depletion region is formed in unbiased pn junction and a potential is developed across it is called barrier potential

ii. When biased it conducts only in one direction. It conducts when forward biased and acts as an open circuit when reverse biased.

12. When should a transistor be biased? Name two common biasing circuits. June 2013 (April/May 2017)

Transistor Biasing is the process of setting a transistors DC operating voltage or current conditions to the correct level so that any AC input signal can be amplified correctly by the transistor. A transistors steady state of operation depends a great deal on its base current, collector voltage, and collector current and therefore, if a transistor is to operate as a linear amplifier, it must be properly biased to have a suitable operating point.

Two common biasing circuits are (i) Fixed bias (ii) Voltage Divider Bias

13. What is operating point? Nov 2014

The AC signal applied to them is superposed on this DC bias current or voltage.

The **operating point** of a device, also known as bias **point**,**quiescent point**, or **Q-point**, is the steady-state voltage or current at a specified terminal of an active device (a **transistor**) with no input signal applied.

14. Explain cut-off region and saturation region Nov 2014

Saturation Region:

Emitter-Base junction is forward biased

Collector- base junction is forward biased

AMSCE-1101

In this mode transistor has a very large value of current. The transistor is operated in this mode, when it is used as a closed switch.

Cut- off Region:

Emitter-Base junction is reverse biased

Collector- base junction is reverse biased

In this region both the junctions are Reverse Biased. In this mode transistor has zero current. The transistor is operated in this mode, when it is used as an open switch.

15 Find the values of IC, IB and β. Transistor values are α =0.95 and IE = 1mA. May 2015, Dec 2015

$\alpha = 0.95$; $IC = \alpha\ IE$; $\beta = \frac{\alpha}{1-\alpha} = \frac{0.95}{1-0.95} = 19$

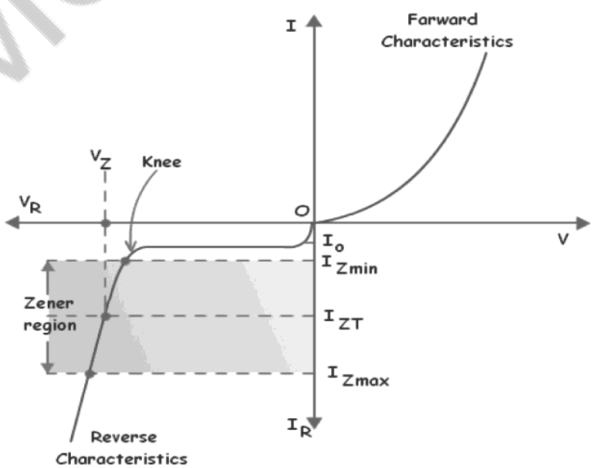
$\beta = \frac{I_C}{I_B} \Rightarrow I_C = \beta I_B$

$I_E = I_C + I_B = \beta\ I_B + I_B = 20\ I_B = 1mA$

$I_B = \frac{1}{20} = 0.05mA$

$IC = IE - IB = 1 - 0.05 = 0.95\ mA$

16. Draw the characteristics of Zener Diode . May 2015



AMSCE - 101

17. What is the effect of saturation in transistor? May 2015

Emitter-Base junction is forward biased
Collector- base junction is forward biased
In this mode transistor has a very large value of current. The transistor is operated in this mode, when it is used as a closed switch.

18. Define the two breakdown conditions in Zener diode. May 2014

i. Zener breakdown
ii. Avalanche break down.

19. Give the applications of Zener diode:

Voltage regulator and voltage limiters

20. State the three operating regions of transistor.

i. Active region

ii. Cut-off Region

iii. Saturation region.

21. Define Transistor

Transistor consists of two junctions formed by sandwiching either P-type or N-type semiconductor between a pair of opposite types.

22. Write the current amplification factor for a CB transistor.

$$\alpha = \frac{\text{Change in Collector Current}}{\text{Change in emitter current}}\Bigg|_{\text{at constant } V_{CB}}$$

23. Write the formula for input resistance in a CB transistor

$$\text{Input resistance} = \frac{\text{Change in base - emitter voltage}}{\text{Change in emitter current}}\Bigg|_{\text{at constant } V_{CB}}$$

24 Define transistor action.

A transistor consists of 2 coupled PN junctions. The base is a common region to both junctions and makes a coupling between

AMSCE - 1101

110

them. Since the base regions are smaller, a significant interaction between junctions will be available. This is called transistor actions.

25. Define hybrid parameters.

Any linear circuit having input and output terminals can be analyzed by four parameters(one measured on ohm, one in mho and two dimensionless) called hybrid or h parameters.

26. What are the uses of h - Parameters? Nov/Dec 2017

It perfectly isolates the input and output circuits. Its source and load currents are taken into account.

27. Define power transistors

Power transistors are those which handles a large amount of current and also dissipates large amount of power across collector base junction.

28. Which is the most commonly used transistor configuration? Why?

The CE Configuration is most commonly used. The reasons are

- High Current gain
- High voltage gain
- High power gain
- Moderate input to output ratio

29. What are the values of input resistance in CB, CE & CC Configuration

CB - Low about 75

CE - Medium About 750

CC - Very high about 750

30. Write the voltage and current equation for hybrid parameters.

$V1 = h11i1 + h12V2$

$I2 = h21i1 + h22V2$

31. What are the values of h-parameters?

$h_{11} = V_1 / i_1$ $h_{12} = V_1 / v_2$ $h_{21} = i_2 / i_1$ $h_{22} = i_2 / v_2$

32. What are the advantages of transistors?

1. Low operating voltage.
2. Higher efficiency.
3. Small size and ruggedness

33. What are the basic techniques used to construct a transistor?

- Grown type.
- Alloy type.
- Electro chemically etched type
- Diffusion type.
- Epitaxial type.

34. What is mean by characteristics of transistor?

The interrelation of the various currents and voltages can be plotted graphically which are Commonly known as the characteristics of transistor.

35. Define the following terms related with rectifier i) ripple factor ii) efficiency iii)peak inverse voltage (PIV) (Nov/Dec 2016)

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification.

Ripple factor can be defined as the variation of the amplitude of DC (Direct current) due to improper filtering of AC power supply. it can be measured by

$$\gamma = \frac{\text{Ripple Voltage}}{\text{D.C.Voltage}} = \frac{\text{rms value of a.c component}}{\text{Average or d.c component}}$$

$$\gamma = \frac{I'_{rms}}{I_{dc}}$$

$$= \frac{\sqrt{I_{rms}^{2} - I_{dc}^{2}}}{I_{dc}} = \sqrt{\frac{(I_m/2)^2}{(I_m/\pi)^2} - 1}$$

Rectifier efficiency is the ratio of the DC output power to the AC input power

The peak inverse voltage is either the specified maximum voltage

AMSCE - 1101

112

that a diode rectifier can block, or, alternatively, the maximum that a rectifier needs to block in a given application

36. Valence electrons

The electrons present in the outer most orbit that are loosely bound to the nucleus are called valence electrons.

37. Conduction electrons

When an electric field is applied, the valence electrons get detached themselves from the nucleus, constituting the flow of current. These electrons are called conduction electrons.

38. Energy band

The (range of) energy possessed by the electrons in an atom is called energy band.

39. Conduction band

The (range of) energy possessed by the conduction electrons is called conduction band.

40. Forbidden energy gap

The gap between the valence band and the conduction band is called forbidden energy gap.

41. Conductors

Conductor is materials that easily conducts or pass the current. There are plenty of free electrons available for electric conduction. In terms of energy band theory, the conductors have overlapping of valence band and conductive band. **Example:** Copper, Aluminum, iron, etc

42. Semiconductors

Semiconductor is a material with partially filled conduction band and valence band. The current in the semiconductor is due to the movement of el ectrons and holes. As the temperature increases the conduction increases.

43. Insulators

In the case of insulators, the valence electrons are very tightly bound to their parent atom. The valence band and conduction

AMSCE - 1101

113

band are separated by a large forbidden energy gap. The insulators have full valence band and an empty conduction band.

44. Intrinsic Semiconductor

An intrinsic semiconductor also called an undoped semiconductor or i- type semiconductor.

It is a pure semiconductor without any significant dopant species present.

The number of charge carriers determined by the properties of the m aterial itself instead of the amount of impurities.

In intrinsic semiconductors the number of excited electrons and the number of holes are equal: n= p.

45. Extrinsic Semiconductor

The electrical conductivity of a pure semiconductor is very small. To increase the conductivity, impurities are added.

The impurity added semiconductor is called extrinsic semiconductor. The process of adding impurity is called doping. The added impurity is called dopant.

Usually one or two atoms of impurity is added per 10^6 atoms of a semiconductor.

AMSCE - 1101

Unit Wise Solved Question Paper 114

PART – B

1. Describe the working of a PN junction diode with neat diagrams. Also explain its V-I characteristics (April/May 2015) (April/May 2017) (Nov/Dec 2017) (16)

PN Junction diode

If one side of a single crystal of pure semiconductor (Ge or Si) is doped with acceptor impurity atoms and the other side is doped with donor impurity atoms, a PN junction is formed as shown in Fig. P region has a high concentration of holes and N region contains a large number of electrons.

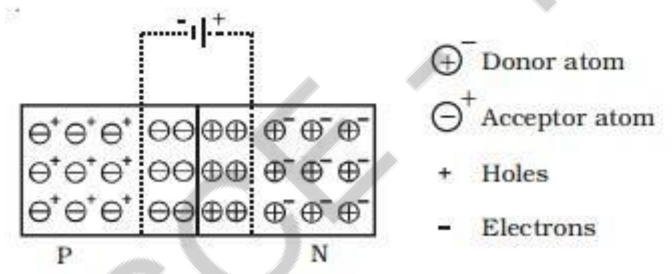


Fig P N Junction diode

As soon as the junction is formed, free electrons and holes cross through the junction by the process of diffusion. During this process, the electrons crossing the junction from N-region into the P region, recombine with holes in the P-region very close to the junction. Similarly holes crossing the junction from the P-region into the N-region, recombine with electrons in the N-region very close to the junction. Thus a region is formed, which does not have any mobile charges very close to the junction. This region is called depletion region. In this region, on the left side of the junction, the acceptor atoms become negative ions and on the right side of the junction, the donor atoms become positive ions (Fig).

AMSCE - 1101

Unit Wise Solved Question Paper 115

An electric field is set up, between the donor and acceptor ions in the depletion region. The potential at the N-side is higher than the potential at P-side. Therefore electrons in the N-side

AMSCE - 1101

are prevented to go to the lower potential of P-side. Similarly, holes in the P-side find themselves at a lower potential and are prevented to cross to the N-side. Thus, there is a barrier at the junction which opposes the movement of the majority charge carriers. The difference of potential from one side of the barrier to the other side is called potential barrier. The potential barrier is approximately 0.7V for a silicon PN junction and 0.3V for a germanium PN junction. The distance from one side of the barrier to the other side is called the width of the barrier, which depends upon the nature of the material.

Forward biased PN junction diode

When the positive terminal of the battery is connected to P-side and negative terminal to the N- side, so that the potential difference acts in opposite direction to the barrier potential, then the PN junction diode is said to be forward biased.

When the PN junction is forward biased (Fig), the applied positive potential repels the holes in the P-region, and the applied negative potential repels the electrons in the N-region, so the charges move towards the junction. If the applied potential difference is more than the potential barrier, some holes and free electrons enter the depletion region.

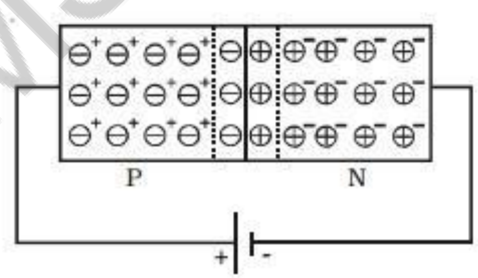


Fig Forward biased PN junction diode

Hence, the potential barrier as well as the width of the depletion region are reduced. The positive donor ions and negative acceptor ions within the depletion region regain electrons and holes respectively. As a result of this, the depletion region

AMSCE - 1101

117

disappears and the potential barrier also disappears. Hence, under the action of the forward potential difference, the majority charge carriers flow across the junction in opposite direction and constitute current flow in the forward direction.

Reverse biased PN junction diode

When the positive terminal of the battery is connected to the N-side and negative terminal to the P-side, so that the applied potential difference is in the same direction as that of barrier potential, the junction is said to be reverse biased.

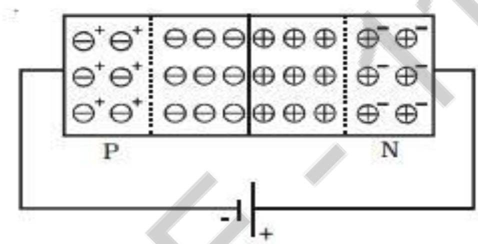


Fig Reverse biased PN junction diode.

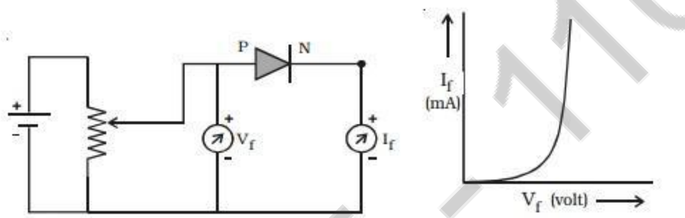
When the PN junction is reverse biased (Fig), electrons in the N region and holes in the P- region are attracted away from the junction. Because of this, the number of negative ions in the P-region and positive ions in the N-region increases. Hence the depletion region becomes wider and the potential barrier is increased.

Since the depletion region does not contain majority charge carriers, it acts like an insulator. Therefore, no current should flow in the external circuit. But, in practice, a very small current of the order of few microamperes flows in the reverse direction. This is due to the minority carriers flowing in the opposite direction. This reverse current is small, because the number of minority carriers in both regions is very small. Since the major source of minority carriers is, thermally broken covalent bonds, the reverse current mainly depends on the junction temperature

Unit Wise Solved Question Paper 118

Forward bias characteristics

The circuit for the study of forward bias characteristics of PN junction diode is shown in Fig a. The voltage between P–end and N–end is increased from zero in suitable equal steps and the corresponding currents are noted down. Fig b shows the forward bias characteristic curve of the diode. Voltage is the independent variable. Therefore, it is plotted along X–axis. Since, current is the dependent variable, it is plotted against Y–axis.



(a) Diode circuit–Forward bias *(b) Forward characteristics*

Fig Forward bias characteristics of a diode

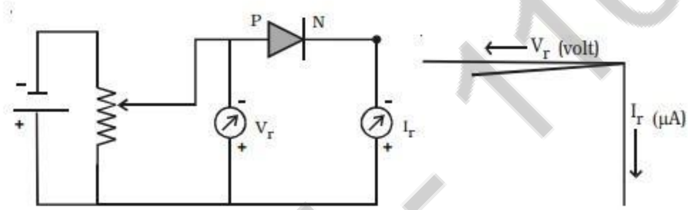
From the characteristic curve, the following conclusions can be made. (i) The forward characteristic is not a straight line. Hence the ratio V/I is not a constant (i.e) the diode does not obey Ohm's law. This implies that the semiconductor diode is a non-linear conductor of electricity. (ii) It can be seen from the characteristic curve that initially, the current is very small. This is because, the diode will start conducting, only when the external voltage overcomes the barrier potential (0.7V for silicon diode). As the voltage is increased to 0.7 V, large number of free electrons and holes start crossing the junction. Above 0.7V, the current increases rapidly. The voltage at which the current starts to increase rapidly is known as cut-in voltage or knee voltage of the diode.

Reverse bias characteristics

The circuit for the study of reverse bias characteristics of PN junction diode is shown in Fig a. The voltage is increased from zero in suitable steps. For each voltage, the corresponding current readings are noted down. Fig b shows the reverse bias

AMSCE - 1101

characteristic curve of the diode. From the characteristic curve, it can be concluded that, as voltage is increased from zero, reverse current (in the order of microamperes) increases and reaches the maximum value at a small value of the reverse voltage. When the voltage is further increased, the current is almost independent of the reverse voltage upto a certain critical value. This reverse current is known as the reverse saturation current or leakage current. This current is due to the minority charge carriers, which depends on junction temperature.



(a) Diode circuit–Reverse bias   (b) Reverse characteristics

Fig   Reverse bias characteristics of a diode

2. What is a Zener diode? Explain the operation of Zener diode and draw its characteristics. (April/May 2015) (May/June 2016) (Nov/Dec 2016) (16)

Zener Diode:

The diodes designed to work in breakdown region are called zener diode. If the reverse voltage

exceeds the breakdown voltage, the zener diode will normally not be destroyed as long as the current does not exceed maximum value and the device closes not over load.When a thermally generated carrier (part of the reverse saturation current) falls down the junction and acquires energy of the applied potential, the carrier collides with crystal ions and imparts sufficient energy to disrupt a covalent bond. In addition to the original carrier, a new electron-hole pair is generated. This pair may pick up sufficient energy from the applied field to collide with another crystal ion and create still another electron-hole pair. This action continues and thereby disrupts the covalent bonds. The process

AMSCE - 1101

120

is referred to as impact ionization, avalanche multiplication or avalanche breakdown.

There is a second mechanism that disrupts the covalent bonds. The use of a sufficiently strong electric field at the junction can cause a direct rupture of the bond. If the electric field exerts a strong force on a bound electron, the electron can be torn from the covalent bond thus causing the number of electron-hole pair combinations to multiply. This mechanism is called high field emission or Zener breakdown. The value of reverse voltage at which this occurs is controlled by the amount ot doping of the diode. A heavily doped diode has a low Zener breakdown voltage, while a lightly doped diode has a high Zener breakdown voltage.

At voltages above approximately 8V, the predominant mechanism is the avalanche breakdown. Since the Zener effect (avalanche) occurs at a predictable point, the diode can be used as a voltage reference. The reverse voltage at which the avalanche occurs is called the breakdown or Zener voltage.A typical Zener diode characteristic is shown in fig. 1. The maximum reverse current, IZ(max), which the Zener diode can withstand is dependent on the design and construction of the diode. A design guideline that the minimum Zener current, where the characteristic curve remains at V_Z (near the knee of the curve), is 0.1/ $I_{Z(max)}$.

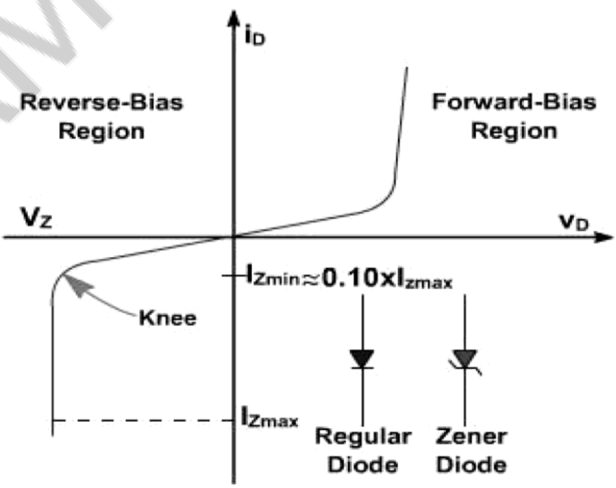


Fig 1 - Zener diode characteristic

AMSCE - 1101

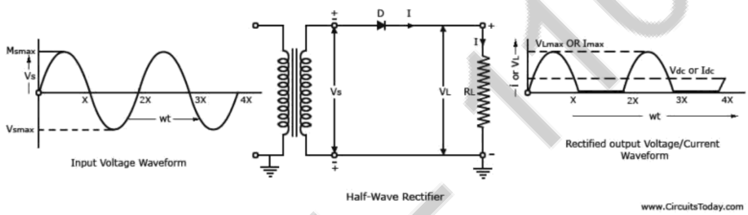
122

The power handling capacity of these diodes is better. The power dissipation of a zener diode

equals the product of its voltage and current. $P_Z = V_Z I_Z$

The amount of power which the zener diode can withstand ($V_Z . I_{Z(max)}$) is a limiting factor in power supply design.

3. Explain the operation of half wave rectifier with neat sketch and derive the necessary expression.(16) (Nov/Dec 2016)



Half Wave Rectifier Operation

The operation of a half wave rectifier is similar as pn junction diode, it conducts current only in 1 direction. In other words, a pn junction diode conducts current only when it is forward biased. The same principle is made use of in a half wave rectifier to convert AC to DC. The input we give here is an alternating current. This input voltage is stepped down using a transformer. The reduced voltage is fed to the diode 'D' and load resistance RL. During the positive half cycles of the input wave, the diode 'D' will be forward biased and during the negative half cycles of input wave, the diode 'D' will be reverse biased. We take the output across load resistor RL. Since the diode passes current only during one half cycle of the input wave, we get an output as shown in diagram. The output is positive and significant during the positive half cycles of input wave. At the same time output is zero or insignificant during negative half cycles of input wave. This is called *half wave rectification*.

Working of a Half wave rectifier

The half-wave rectifier circuit using a semiconductor diode (D) with a load resistance RL but no smoothing filter is given in

AMSCE - IA01

figure. The diode is connected in series with the secondary of the transformer and the load resistance RL. The primary of the transformer is being connected to the ac supply mains.

The ac voltage across the secondary winding changes polarities after every half cycle of input wave. During the positive half-cycles of the input ac voltage i.e. when upper end of the secondary winding is positive w.r.t. its lower end, the diode is forward biased and therefore conducts current. If the forward resistance of the diode is assumed to be zero (in practice, however, a small resistance exists) the input voltage during the positive half-cycles is directly applied to the load resistance RL, making its upper end positive w.r.t. its lower end. The waveforms of the output current and output voltage are of the same shape as that of the input ac voltage.

During the negative half cycles of the input ac voltage i.e. when the lower end of the secondary winding is positive w.r.t. its upper end, the diode is reverse biased and so does not conduct. Thus during the negative half cycles of the input ac voltage, the current through and voltage across the load remains zero. The reverse current, being very small in magnitude, is neglected. Thus for the negative half cycles no power is delivered to the load.

Thus the output voltage (VL) developed across load resistance RL is a series of positive half cycles of alternating voltage, with intervening very small constant negative voltage levels, It is obvious from the figure that the output is not a steady dc, but only a pulsating dc wave. To make the output wave smooth and useful in a DC power supply, we have to use a filter across the load. Since only half-cycles of the input wave are used, it is called a half wave rectifier.

4. Explain the operation of centre tapped and bridge full wave rectifier with neat diagram. (16) (May/June 2016) (April/May 2017)

Full Wave Rectifiers Operation

A full-wave rectifier is as same as the half-wave rectifier circuit, but the difference is a full wave rectifier allows unidirectional

Unit Wise Solved Questions Paper 124

current through the load during the entire sinusoidal cycle (as opposed to only half the cycle in the half-wave). In other words, for both the positive and negative half cycles of the input sinusoidal wave, the full wave rectifier conducts current through the load resistance. This will leads to a constant dc voltage through out the input wave (sinusoidal wave).

Average value of output of the full wave rectifier becomes twice that of the half wave rectifier output:

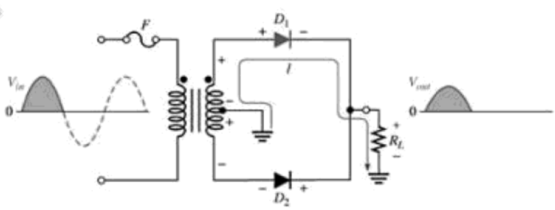
$V_A = 2V_{pi}/p$

Full wave rectifiers are of two types:

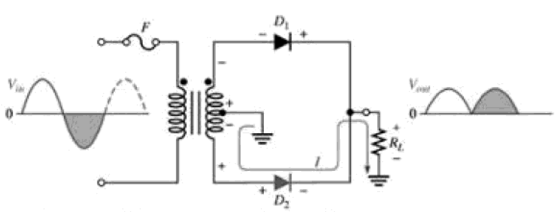
i) Center-tapped Full-Wave Rectifier:

To the secondary of a center-tapped transformer, two diodes connected. Between the center tap and each secondary half of Vin is shows up. Only one of the diodes is forward biased, at any point in time.

A continuous conduction of current through load will flows due to this.



(a) During positive half-cycles, D_1 is forward-biased and D_2 is reverse-biased.



(b) During negative half-cycles, D_2 is forward-biased and D_1 is reverse-biased.

AMSCE - 1101

125

The peak inverse voltage (PIV) across then diode D2 is: PIV = (Vpi(sec)/2 – 0.7) – (-Vpi(sec)/2)

= (Vpi(sec)/2 + Vpi(sec)/2 – 0.7)

= Vpi(sec) – 0.7

Since we know that, Vpi(out) = Vpi(sec)/2 – 0.7, we get: Vpi(sec) = 2Vp(out) + 1.4

So the PIV across each diode will be:

PIV = $2V_{pi(out)} + 0.7$ V

ii) Bridge Full-Wave Rectifier:

The diodes D1 and D2 are forward biased during the positive half cycle of the input.

The diodes D3 and D4 are the conducing diodes during the negative half cycle of the input. The output voltage can be written as:

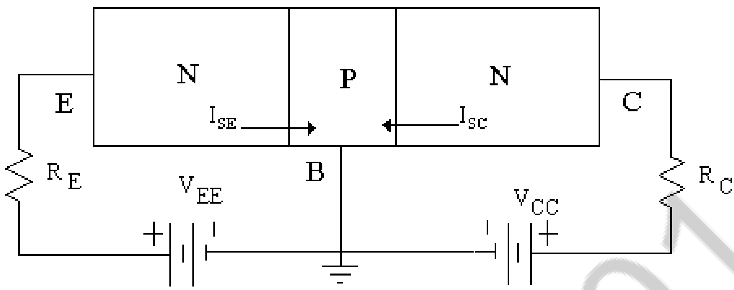
The PIV is a lot smaller, we can use a full bridge rectifier than a center-tap: PIV = $V_{pi(out)} + 0.7$ Volts

5. Explain the working of the CB configuration of a BJT. (April/May 2015) (16)

A bipolar junction transistor, BJT, is a single piece of silicon with two back-to-back P-N junctions. However, it cannot be made with two independent back-to-back diodes. BJTs can be made either as PNP or as NPN. The circuit symbols and representations of their configuration are given below. They have three regions and three terminals, emitter, base, and collector represented by E, B, and C respectively. The difference in the circuit symbols is the direction of the arrow. As we shall see shortly, the direction of the arrow indicates the direction of the current in the emitter when the transistor is conducting normally.

AMSCE - 1101

126



CUTOFF REGION (Both junction reverse biased)

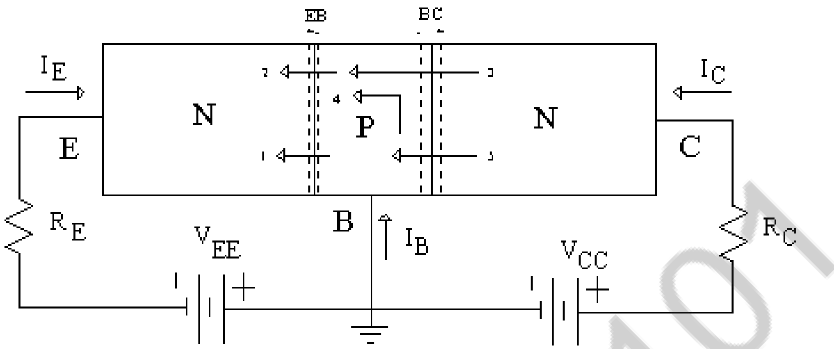
Let us start with the cutoff region, both junctions reverse biased as shown in Figure 1.

With reverse biasing, we can assume that all currents are zero. We know that there are leakage currents associated with reverse biased junctions, but these currents are small and will be ignored.

FORWARD-ACTIVE REGION (BE junction forward biased, BC junction reverse biased)

The biasing condition for the forward active region of operation is shown in the Figure 4. The BE junction is forward biased and the BC junction is reverse biased. In this case, the forward bias of the BE junction will cause the injection of both holes and electrons across the junction. The holes are of little consequence because the doping levels are adjusted to minimize the hole current. The electrons are the carriers of interest. The electrons are injected into the base region where they are called the minority carrier even though they greatly outnumber the holes. They “pile up” at the BE junction. From there they diffuse across the base region due to the concentration gradient. Some are lost due to hole electron recombination, but the majority reach the BC junction. At the BC junction, the electrons encounter a potential gradient (due to the depletion region) and are swept across the junction into the collector region.

AMSCE - 1101



There are several components of current:

1. Holes injected from B-E. This is small and is ignored.
2. Electrons injected from base to emitter.
3. Electrons that reach the collector.
4. Collector reverse saturation current IC0 , which we will usually neglect. SATURATION REGION (Both junctions forward biased)

In the active region, the collector current is proportional to the emitter current (plus the leakage current, IC0). This implies that the voltage bias across the base-collector junction is unimportant. we see a resistor in series with the collector lead. If the current increases to a point that the voltage drop across the resistor plus the collector supply voltage begins to forward bias the collector junction, then holes will be injected into the collector region from the base. This hole current will counteract increases in electrons coming from the emitter, effectively limiting the transistor current. The base-collector voltage VBC at which this limiting effect begins is at about VBC =0.4

Volts, and becomes fully limiting at about 0.6 Volts. This region of operation is known as saturation. Please note that our terminology can get a little confusing. In this case, saturation refers to the circuit, not the transistor. The transistor could carry more current but the external circuit, the voltage source and resistor in the collector circuit, limits the current.

AMSCE - 1101

REVERSE ACTIVE REGION (BE junction reverse biased, BC junction forward biased)

In this case, the biasing arrangement is just the reverse of the forward active region. The collector junction is forward biased, while the emitter junction is reverse biased. The operation is just the same as the forward active region, except all voltage sources, and hence collector and emitter currents, are the reverse of the forward bias case. This configuration is rarely used because most transistors are doped selectively to give forward current transfer ratios very near unity, which automatically causes the reverse current transfer ratio to be very low.

(6) Small Signal Amplifier

When the input signal is so weak as to produce small fluctuations in the collector current compared to its quiescent value, the amplifier is known as Small Signal Amplifier.

In other words, as the name indicates, the input applied to the circuit is $V_{in} << V_{th}$. It has only one amplifying device. $\alpha = I_C / I_E$ $IC = IE + ICBO$

Voltage and current equation for hybrid parameters:

$$V1 = h11i1 + h12V2$$

$$I2 = h21i1 + h22V2$$

The values of h-parameters:

$$h11 = V1 / i1$$

$$h12 = V1 / V2$$

$$h21 = i2 / i1$$

$$h22 = i2 / V2$$

AMSCE-1101

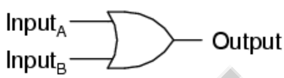
UNIT – IV DIGITAL ELECTRONICS PART – A

1. Convert the binary fraction (0.101)2 into decimal equivalent. June 2009

$1 \times 2^{-1} + 0 \times 2^{-2} + 1 \times 2^{-3} = 0.5 + 0.00 + 0.125 = (0.625)_{10}$

2. Draw the symbol for OR gate and write its truth table. June 2009

2-input OR gate



A	B	Output
0	0	0
0	1	1
1	0	1
1	1	1

3. Simplify $\overline{\left(\left(\overline{A}\cdot B.\overline{C}\right)\right)+\left(A\cdot\overline{B}\cdot C\right)}$ **using Boolean laws. Dec 2009**

$$\overline{\left(\left(\overline{A}\cdot B.\overline{C}\right)\right)+\left(A\cdot\overline{B}\cdot C\right)} = \overline{\left(\overline{A}\cdot B.\overline{C}\right)\left(A\cdot\overline{B}\cdot C\right)}$$

$$= \overline{\overline{A}\cdot B\cdot\overline{C}\cdot A\cdot\overline{B}.C} = \overline{A}\cdot A\cdot B\cdot\overline{B}\cdot\overline{C}\cdot C = 0\cdot\overline{0\cdot 0} = \overline{0} = 1$$

4. Prove that $A+\overline{A}B=A+B$ **June 2010 , May 2014**

$A+\overline{A}B = A+AB+\overline{A}B \qquad \because A+AB=A$

$= A+B\left(A+\overline{A}\right) = A+B\cdot 1 = A+B$

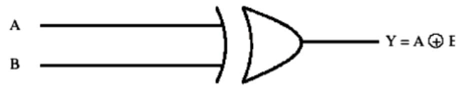
5. Why divide by n counter called so? June 2010

A mod N counter divides the input frequency by N. hence it is called as Divide - by - N counter.

AMSCE-1101

6. Write the truth table of an exclusive – OR gate. Dec 2010, Dec 2012

Logic Symbol



Truth Table

Inputs		Output
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

7. Express the following binary numbers in ts equivalent number [Dec 2010

a. 10.01
b. 101.11]

a. 10.01

$1X\ 2^{1} + 0\ X\ 2^{0} + 0X\ 2^{-1} + 1X\ 2^{-2} = 2.0 + 0.0 + 0.0 + 0.25 = (2.25)_{10}$

b) 101.11

$1\ X\ 2^{2} + 0\ X\ 2^{1} + 1\ X\ 2^{0} + 1\ X\ 2^{-1} + 1\ X\ 2^{-2} = 4 + 0 + 1 + 0.5 + 0.25 = (5.75)_{10}$

8. Name four different flip flops commonly available. May 2011

- RS - FLIP FLOP
- JK - FLIP FLOP
- D - FLIP FLOP
- T – FLIP FLOP

9. What is decade counter? May 2011, Dec 2011

A counter which counts from 0 to 9 is called decade counter

AMSCE - 1101

10. What are universal gates? Why do we call them so? What are its advantages? June 2012, May 2015, (Nov/Dec 2016)

NAND and NOR gates are universal gates. Any gate can be derived from the any one of these gates. Hence NAND and NOR gates are called Universal gates.

Advantages of using universal gate are that single type of gate can be used to design any complex circuit. Hence fabrication of IC becomes simple.

11. What is a shift register? How is it classified? June 2012

The binary information in a register can be moved from stage to stage within the register or into or out of the register upon the application of clock pulses. This type of bit movement or shifting is essential for certain arithmetic and logic operations used in microprocessors. This gives rise to group of registers called shift registers.

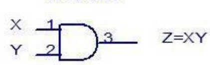
Types:

- Serial In Serial Out shift register
- Serial In Parallel Out shift register
- Parallel In Serial Out shift register
- Parallel In Parallel Out shift register.
- Bidirectional Shift register.

12. Draw the symbol of AND gate and write its truth table. Dec 2011

2 Input AND Gate

AND Gate



TRUTH TABLE

INPUTS		OUTPUT
X	Y	Z
0	0	0
0	1	0
1	0	0
1	1	1

13. Mention two types of D/A converter. Dec 2012

- Binary weighted resistor D/A converter
- R/2R ladder D/A converter

AMSCE - 1401

132

14. Find the following binary difference: 1011010 - 0101110 June 2013

1011010
<u>0101110</u>
0101100

15. An active high SR latch has a 1 on S input and 0 on the R input. What state is the latch in?

Q = 1 (SET STATE)

16. Convert (634) 8 to binary. May 2015, Dec 2015

6	3	4
110	011	100

Ans = 110011100

17. Convert (7F8) H into decimal. May 2015

$$7 \times 16^{2} + 15 \times 16^{1} + 8 \times 16^{0} = 1792+240+8 = (2040)_{10}$$

18. What is flip flop? May 2015, Dec 2014

The basic unit for storage is flip flop. A flip flop maintains its output state either at 1 or 0 until directed by an input signal to change its state.

19. What are the different sources of errors in DAC? Dec 2014

- Gain Error
- Offset Error
- Full Scale Error
- Linearity
- Non-Monotonic Output Error
- Settling Time and Overshoot
- Resolution

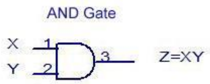
20. Define the logic operation of AND gate with Boolean equation. May 2014, Dec 2015

The output is true when inputs are true otherwise the output is false.

AMSCE - 1101

Unit Wise Solved Question Paper 133

2 Input AND Gate



TRUTH TABLE

INPUTS		OUTPUT
X	Y	Z
0	0	0
0	1	0
1	0	0
1	1	1

21. Define binary logic?

A Binary logic consists of binary variables and logical operations. The variables are designated by the alphabets such as A, B, C, x, y, z, etc., with each variable having only two distinct values: 1 and 0. There are three basic logic operations: AND, OR, and NOT.

22. Convert (9B2 . 1A) H to its decimal equivalent.

N = 9 x 16^{2} + B x 16^{1} + 2 x 16^{0} + 1 x 16^{-1} + A (10) x 16^{-2}

= 2304 + 176 + 2 + 0.0625 + 0.039

= 2482.1 10

23. State the different classification of binary codes?

a. Weighted codes

b. Non - weighted codes c. Reflective codes

d. Sequential codes

e. Alphanumeric codes

f. Error ecting and correcting codes. g.

24. Convert 0.1289062 decimal number to its hex equivalent

0.1289062 x 16 = 2.0625

0.0625 x 16 = 1.0

ANS: $(0.1289062)_{10}$ = 0.21_{16}

AMSCE - 101

134

25. Convert 22.64 to hexadecimal number.

÷ By 16	Dividend	Quotient
	22	1
Remainder	6	

0.64 x 16 = 10.24

24 x 16 = 3.84

4 x 16 = 13.44

44 x 16 = 7.04

Ans = $(16.A3D7)_{16}$

26. What is meant by bit?

A binary digit is called bit

27. Define byte?

Group of 8 bits.

28. List the different number systems?

i) Decimal Number system ii) Binary Number system iii) Octal Number system

iv) Hexadecimal Number system

29. Write the names of basic logical operators.

- NOT / INVERT
- AND
- OR

30. What are basic properties of Boolean algebra?

The basic properties of Boolean algebra are commutative property, associative property and distributive property.

31. State the associative property of boolean algebra.

The associative property of Boolean algebra states that the OR ing of several variables results in the same regardless of the grouping of the variables. The associative property is stated as

AMSCE - 1101

follows:

$A + (B+C) = (A+B) + C$

32. State the commutative property of Boolean algebra.

The commutative property states that the order in which the variables are OR ed makes no difference. The commutative property is: $A+B=B+A$

33. State the distributive property of Boolean algebra.

The distributive property states that AND ing several variables and OR ing the result with a single variable is equivalent to OR ing the single variable with each of the the several variables and then AND ing the sums. The distributive property is:

$A+BC= (A+B)(A+C)$

34. State the absorption law of Boolean algebra.

The absorption law of Boolean algebra is given by $X+XY=X$, $X(X+Y) =X$.

35. Simplify the following using De Morgan's theorem [((AB)'C)'' D]'

$[((AB)'C)'' D]' = ((AB)'C)'' + D'$ $[(AB)' = A' + B']$

$= (AB)' C + D'$

$= (A' + B')C + D'$

36. State De Morgan's theorem. (May/June 2016) (April/May 2017)

De Morgan suggested two theorems that form important part of Boolean algebra. They are,

1. The complement of a product is equal to the sum of the complements. $(AB)' = A' + B'$
2. The complement of a sum term is equal to the product of the complements. $(A + B)' = A'B'$

37. Reduce A(A + B)

$A(A + B) = AA + AB$

$= A(1 + B)$ $[1 + B = 1]$

AMSCE - 1401

Unit Wise Solved Question Paper 136

= A.

AMSCE - 1101

38. Reduce A’B’C’ + A’BC’ + A’BC (APR 2005)

A’B’C’ + A’BC’ + A’BC = A’C’(B’ + B) + A’B’C = A’C’ + A’BC [A + A’ = 1] = A’(C’ + BC)

= A’(C’ + B) [A + A’B = A + B]

39. Reduce AB + (AC)’ + AB’C(AB + C)

AB + (AC)’ + AB’C(AB + C) = AB + (AC)’ + AAB’BC + AB’CC

= AB + (AC)’ + AB’CC [A.A’ = 0]

= AB + (AC)’ + AB’C [A.A = 1]

= AB + A’ + C’ =AB’C [(AB)’ = A’ + B’]

= A’ + B + C’ + AB’C [A + AB’ = A + B]

= A’ + B’C + B + C’ [A + A’B = A + B]

= A’ + B + C’ + B’C

=A’ + B + C’ + B’

=A’ + C’ + 1

= 1' [A + 1 =1]

40. Simplify the following expression Y = (A + B)(A + C’)(B’ + C’)

Y = (A + B)(A + C’)(B’ + C’)

= (AA’ + AC +A’B +BC)(B’ + C’) [A.A’ = 0]

= (AC + A’B + BC)(B’ + C’)

= AB’C + ACC’ + A’BB’ + A’BC’ + BB’C + BCC’ = AB’C + A’BC’

41. Show that (X + Y’ + XY)(X + Y’)(X’Y) = 0

(X + Y’ + XY)(X + Y’)(X’Y) = (X + Y’ + X)(X + Y’)(X’ + Y) [A + A’B = A + B]

AMSCE - 1101

Unit Wise Solved Question Paper 138

= (X + Y’)(X + Y’)(X’Y) [A + A = 1]

= (X + Y’)(X’Y) [A.A = 1]

= X.X’ + Y’.X’.Y

= 0 [A.A’ = 0]

42. Prove that ABC + ABC’ + AB’C + A’BC = AB + AC + BC

ABC + ABC’ + AB’C + A’BC=AB(C + C’) + AB’C + A’BC

=AB + AB’C + A’BC

=A(B + B’C) + A’BC

=A(B + C) + A’BC

=AB + AC + A’BC

=B(A + C) + AC

=AB + BC + AC

=AB + AC +BC ...Proved

43. Convert the given expression in canonical SOP form Y = AC + AB + BC

Y = AC + AB + BC

=AC(B + B’) + AB(C + C’) + (A + A’)BC

=ABC + ABC’ + AB’C + AB’C’ + ABC + ABC’ + ABC

=ABC + ABC’ +AB’C + AB’C’ [A + A =1]

44. Define duality property.

Duality property states that every algebraic expression deducible from the postulates of Boolean algebra remains valid if the operators and identity elements are interchanged. If the dual of an algebraic expression is desired, we simply interchange OR and AND operators and replace 1’s by 0’s and 0’s by 1’s.

45. Find the complement of the functions F1 = x’yz’ + x’y’z and F2 = x(y’z’ + yz). By applying De-Morgan’s theorem.

AMSCE-1101

Unit Wise Solved Question Paper 139

$$F1' = (x'yz' + x'y'z)' = (x'yz')'(x'y'z)' = (x + y' + z)(x + y + z')$$

$$F2' = [x(y'z' + yz)]' = x' + (y'z' + yz)'$$

$$= x' + (y'z')'(yz)'$$

$$= x' + (y + z)(y' + z')$$

46. Simplify the following expression

Y = (A + B) (A = C) (B + C)

= (A A + A C + A B + B C) (B + C)

= (A C + A B + B C) (B + C)

= A B C + A C C + A B B + A B C + B B C + B C C

= A B C

47. What is a Logic gate?

Logic gates are the basic elements that make up a digital system. The electronic gate is a circuit that is able to operate on a number of binary inputs in order to perform a particular logical function.

48. What are the basic digital logic gates?

The three basic logic gates are

- AND gate
- OR gate
- NOT gate

49. Define combinational logic

When logic gates are connected together to produce a specified output for certain specified combinations of input variables, with no storage involved, the resulting circuit is called combinational logic.

50. Define Half adder and full adder

The logic circuit that performs the addition of two bits is a half adder. The circuit that performs the addition of three bits is a full adder.

AMSCE - 1101

51. Define Decoder?

A decoder is a multiple - input multiple output logic circuit that converts coded. inputs into coded outputs where the input and output codes are different.

52. What is binary decoder?

A decoder is a combinational circuit that converts binary information from n input lines to a maximum of 2n out puts lines.

53. Define Encoder?

An encoder has 2n input lines and n output lines. In encoder the output lines generate the binary code corresponding to the input value.

54. What is priority Encoder?

A priority encoder is an encoder circuit that includes the priority function. In priority encoder, if 2 or more inputs are equal to 1 at the same time, the input having the highest priority will take precedence.

55. Define multiplexer?

Multiplexer is a digital switch. If allows digital information from several sources to be routed onto a single output line.

56. What do you mean by comparator

A comparator is a special combinational circuit designed primarily to compare the relative magnitude of two binary numbers.

57. Which gates are called as the universal gates? What are its advantages? (April/May 2015)

The NAND and NOR gates are called as the universal gates. These gates are used to perform any type of logic application.

AMSCE - 1101

Unit Wise Solved Question Paper 141

58. State the limitations of karnaugh map.

i) Generally it is limited to six variable map (i.e) more then six variable involving expression are not reduced.

ii) The map method is restricted in its capability since they are useful for simplifying only Boolean expression represented in standard form.

59. What is a karnaugh map?

A karnaugh map or k map is a pictorial form of truth table, in which the map diagram is made up of squares, with each squares representing one minterm of the function. encoder, if 2 or more inputs are equal to 1 at the same time, the input having the highest priority will take precedence.

60. Write the maxterms corresponding to the logical expression

Y = (A + B + C’)(A + B’ + C’)(A’ + B’ + C)

= (A + B + C’)(A + B’ + C’)(A’ + B’ + C)

=M1.M3.M6

=π M(1,3,6)

AMSCE - 101

Unit Wise Solved Question Paper 142

PART – B

1. Explain the working of half adder with truth table (16)

Half Adder

Half adder is a circuit that will add two bits & produce a sum & a carry bit. It needs two input bits & two output bits.Fig. shows the block diagram of a half adder.

Ex-OR gate will only produce an output “1” when “EITHER” input is at logic “1”, so we need an additional output to produce a carry output, “1” when “BOTH” inputs “A” and “B” are at logic “1” and a standard AND Gate fits the bill nicely. By combining the Ex-OR gate with the AND gate results in a simple digital binary adder circuit known commonly as the “Half Adder” circuit.

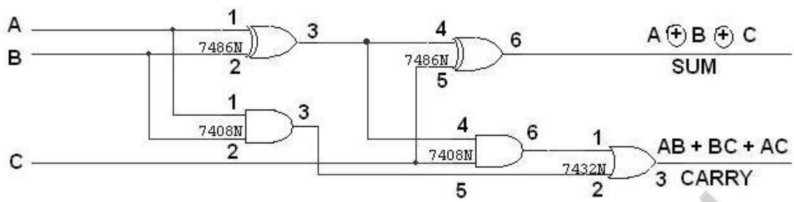
INPUTS		OUTPUTS	
A	B	SUM	CARRY
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

2. Design a full adder and implement it using logic gates. (16) (Nov/Dec 2016) (May/June 2016)

A half adder has only two inputs &there is no provision to add a carry coming from the lower order bits when multi addition is performed. For this purpose, a full adder is designed.

The 1-bit Full Adder circuit is basically two half adders connected together and consists of three Ex-OR gates, two AND gates and an OR gate, six logic gates in total. The truth table for the full adder includes an additional column to take into account the Carry-in input as well as the summed output and carry-output.

Unit Wise Solved Question Paper 143



Inputs			Outputs	
A	B	C	Carry	Sum
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

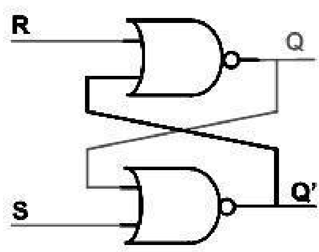
3. Write short notes on: (April/May 2015) (April/May 2017) (16)

i). RS-flip flop
ii). D-flip flop
iii). T-flip flop
iv) JK-flipflop

RS Flip Flop

RS Flip Flop have two inputs, S and R. S is called set and R is called reset. The S input is used to produce HIGH on Q (i.e. store binary 1 in flip-flop). The R input is used to produce LOW on Q (i.e. store binary 0 in flip-flop). Q' is Q complementary output, so it always holds the opposite value of Q. The output of the S-R Flip Flop depends on current as well as previous inputs or state, and its state (value stored) can change as soon as its inputs change. The circuit and the truth table of RS Flip Flop is shown below. The circuit and Truth table of RS Flip Flop using NAND is shown below.

AMSCE - 1101



S	R	Q	Q+
0	0	0	0
0	0	1	1
0	1	X	0
1	0	X	1
1	1	X	0

The operation has to be analyzed with the 4 inputs combinations together with the 2 possible previous states. When S = 0 and R = 0: If we assume Q = 1 and Q’ = 0 as initial condition, then output Q after input is applied would be Q = (R + Q’)’ = 1 and Q’ = (S + Q)’ = 0. Assuming Q = 0 and Q’ = 1 as initial condition, then output Q after the input applied would be Q = (R + Q’)’ = 0 and Q’ = (S + Q)’ = 1. So it is clear that when both S and R inputs are LOW, the output is retained as before the application of inputs. (i.e. there is no state change). When S = 1 and R = 0: If we assume Q = 1 and Q’ = 0 as initial condition, then output

- after input is applied would be Q = (R + Q’)’ = 1 and Q’ = (S + Q)’ = 0. Assuming Q = 0 and Q’ = 1 as initial condition, then output Q after the input applied would be Q = (R + Q’)’ = 1 and Q’ = (S + Q)’ = 0. So in simple words when S is HIGH and R is LOW, output Q is HIGH.
- When S = 0 and R = 1: If we assume Q = 1 and Q’ = 0 as initial condition, then output Q after input is applied would be Q = (R + Q’)’ = 0 and Q’ = (S + Q)’ = 1. Assuming Q = 0 and Q’ = 1 as initial condition, then output Q after the input applied would be Q = (R + Q’)’ = 0 and Q’ = (S + Q)’ = 1. So in simple words when S is LOW and R is HIGH, output Q is LOW.

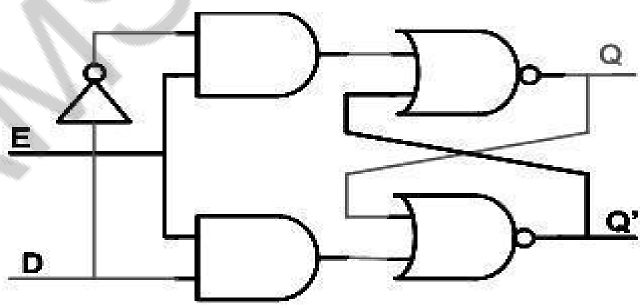
AMSCE - 1101

* When S = 1 and R =1 : No matter what state Q and Q' are in, application of 1 at input of NOR gate always results in 0 at output of NOR gate, which results in both Q and Q' set to LOW (i.e. Q = Q'). LOW in both the outputs basically is wrong, so this case is invalid.

It is possible to construct the RS Flip Flop using NAND gates (of course as seen in Logic gates section). The only difference is that NAND is NOR gate dual form (Did I say that in Logic gates section?). So in this case the R = 0 and S = 0 case becomes the invalid case.

D Flip Flop

The RS Flip Flop seen earlier contains ambiguous state; to eliminate this condition we can ensure that S and R are never equal. This is done by connecting S and R together with an inverter. Thus we have D Flip Flop: the same as the RS Flip Flop, with the only difference that there is only one input, instead of two (R and S). This input is called D or Data input. D Flip Flop is called D transparent Flip Flop for the reasons explained earlier. Delay flip-flop or delay latch is another name used. Below is the truth table and circuit of D Flip Flop.



D	Q	Q+
1	X	1
0	X	0

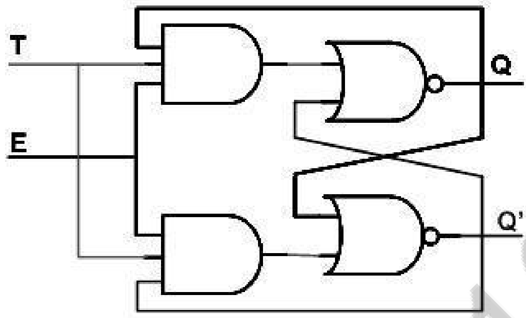
T Flip Flop

AMSCE - 1101

When the two inputs of JK Flip Flop are shorted, a T Flip Flop is formed. It is called

AMSCE - 1101

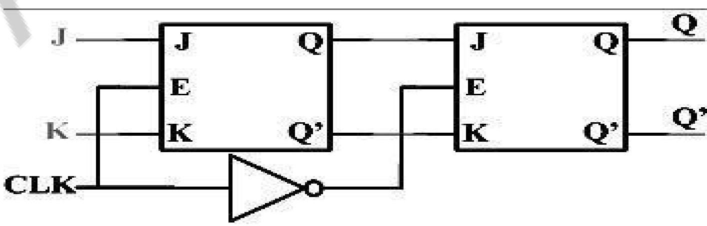
T Flip Flop as, when input is held HIGH, output toggles.



T	Q	Q+
1	0	1
1	1	0
0	1	1
0	0	0

JK-master slave flip flop

All sequential circuits that we have seen in the last few pages have a problem (All level sensitive sequential circuits have this problem). Before the enable input changes state from HIGH to LOW (assuming HIGH is ON and LOW is OFF state), if inputs changes, then another state transition occurs for the same enable pulse. This sort of multiple transition problem is called racing.If we make the sequential element sensitive to edges, instead of levels, we can overcome this problem, as input is evaluated only during enable/clock edges.

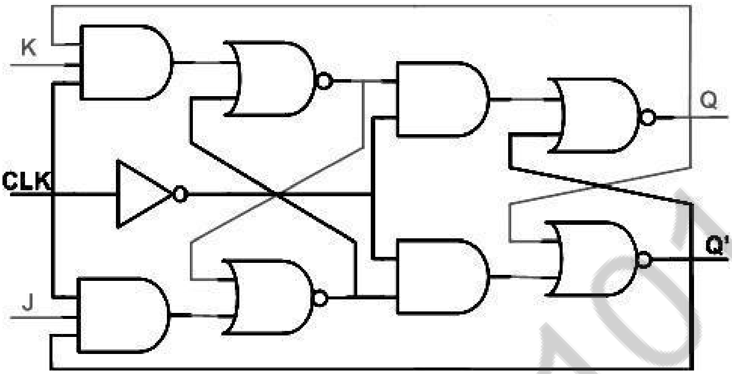


In the Figure above there are two Flip Flop, the first Flip Flop on the left is called master Flip Flop and the one on the right is

AMSCE - 1101

called slave Flip Flop. Master Flip Flop is positively clocked and slave Flip Flop is negatively clocked.

AMSCE - 1101



4. What is a counter? Discuss the types of counter.(16)

COUNTERS (Nov/Dec 2017)

- Counters are a specific type of sequential circuit.
- Like registers, the state, or the flip-flop values themselves, serves as the "output."
- The output value increases by one on each clock cycle.
- After the largest value, the output "wraps around" back to 0.

Counter Types

Synchronous Counter

There is a problem with the ripple counter just discussed. The output stages of the flip-flops further down the line (from the first clocked flip-flop) take time to respond to changes that occur due to the initial clock signal. This is a result of the internal propagation delay that occurs within a given flip-flop.

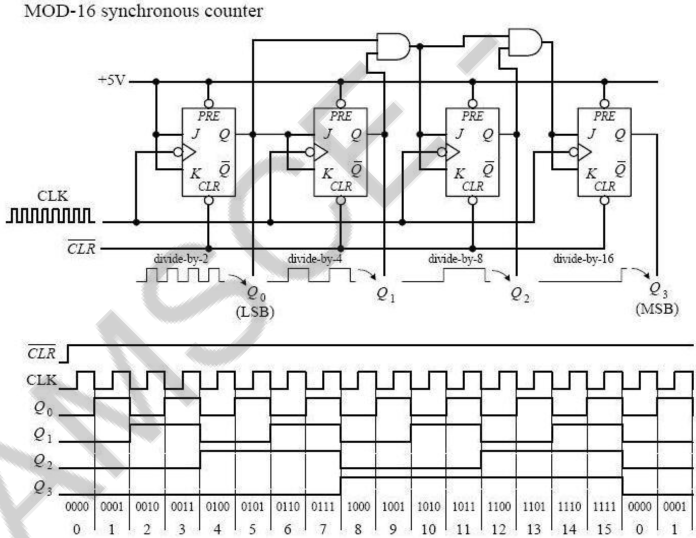
A standard TTL flip-flop may have an internal propagation delay of 30 ns. If you join four flip-flops to create a MOD-16 counter, the accumulative propagation delay at the highest- order output will be 120 ns. When used in high-precision synchronous systems, such large delays can lead to timing problems.To avoid large delays, you can create what is called a synchronous counter. Synchronous counters, unlike ripple (asynchronous) counters, contain flip-flops whose clock inputs are driven at the same time by a common clock line. This means that output transitions for

AMSCE - 1101

each flip-flop will occur at the same time. Now, unlike the ripple counter, you must use some additional logic circuitry placed between various flip-flop inputs and outputs to give the desired count waveform.

For example, to create a 4-bit MOD-16 synchronous counter requires adding two additional AND gates, as shown below. The AND gates act to keep a flip-flop in hold mode (if both input of the gate are low) or toggle mode (if both inputs of the gate are high). So, during the 0–1 count, the first flip-flop is in toggle mode (and always is); all the rest are held in hold mode. When it is time for the 2–4 count, the first and second flip-flops are placed in toggle mode; the last two are held in hold mode.

MOD-16 synchronous counter



When it is time for the 4–8 count, the first AND gate is enabled, allowing the third flip- flop to toggle. When it is time for the 8–15 count, the second AND gate is enabled, allowing the last flip-flop to toggle

The ripple (asynchronous) and synchronous counters discussed so far are simple but hardly ever used. In practice, if you need a counter, be it ripple or synchronous, you go out and purchase a counter IC. These ICs are often MOD-16 or MOD-10 counters and usually come with many additional features. For example, many ICs allow you to preset the count to a desired number via parallel input lines.

Synchronous Up /Down Counter

The down counter counts in reverse from 1111 to 0000 and then goes to 1111. If we inspect the count cycle, we find that each flip-flop will complement when the previous flip- flops are all 0 (this is the opposite of the up counter). The down counter can be implemented similar to the up counter, except that the AND gate input is taken from Q' instead of Q. This is shown in the following Figure of a 4-bit up-down counter using T flip-flops.

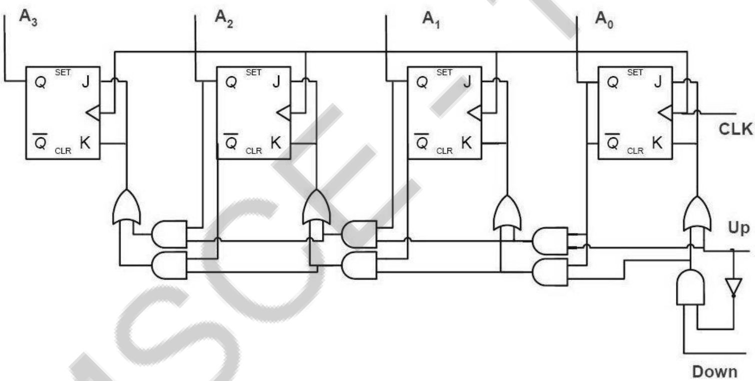


Figure: Synchronous Up /Down Counter

4.7.2 Asynchronous Up /Down Counter:

In certain applications, a counter must be able to count both up and down. The circuit below is a 3-bit up-down counter. It counts up or down depending on the status of the control signals UP and DOWN. When the UP input is at 1 and the DOWN input is at 0, the NAND network between FF0 and FF1 will gate the non-inverted output (Q) of FF0 into the clock input of FF1. Similarly, Q of FF1 will be gated through the other NAND network into the clock input of FF2. Thus the counter will count up.

Unit Wise Solved Question Paper 152

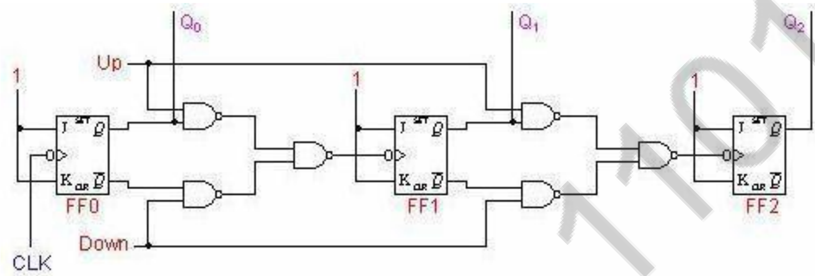
When the control input UP is at 0 and DOWN is at 1, the inverted outputs of FF0 and FF1 are gated into the clock inputs of FF1 and FF2 respectively. If the flip-flops are initially y reset to 0's,

AMSCE - 1101

153

then the counter will go through the following sequence as input pulses are applied

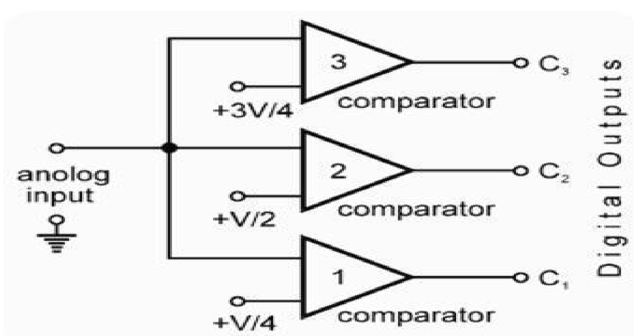
Notice that an asynchronous up-down counter is slower than an up counter or a down counter because of the additional propagation delay introduced by the NAND networks.



5. **Explain in details about Analog Digital and Digital to Analog conversion.(16) (Nov/Dec 2017) (Nov/Dec 2016)**

Analog to digital conversion

A comparator compares the unknown voltage with a known value of voltage and then produces proportional output (i.e. it will produce either a 1 or a 0). this principle is basically used in the above circuit. here three comparators are used. each has two inputs. one input of each comparator is connected to analog input voltage. the other input terminals are connected to fixed reference voltage like +3/4v, +v/2 and +v/4. now the circuit can convert analog voltage into equivalent digital signal. since the analog output voltage is connected in parallel to all the comparators, the circuit is also called as parallel A/D converter.



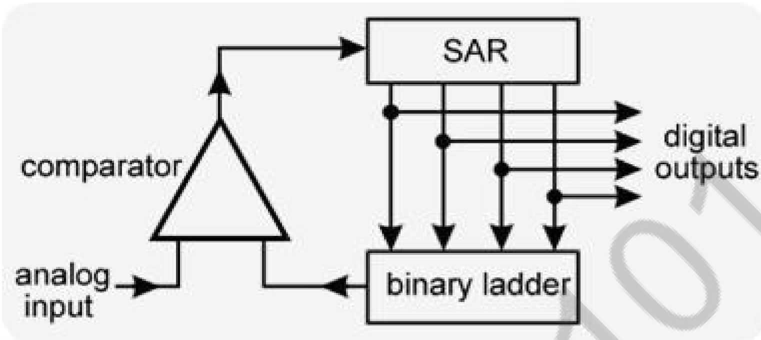
AMSCE - 1101

154

Figure: ADC Conversion

AMSCE - 1101

1) Successive Approximation Technique



The basic drawback of counter method (given above) is that it has longer conversion time. Because it always starts from 0000 at every measurement, until the analog voltage is matched. This drawback is removed in successive approximation method. In the adjacent figure, the method of successive approximation technique is shown. When unknown voltage (Va) is applied, the circuit starts up from 0000, as shown above. The output of SAR advances with each MSB. The output of SAR does not increase step–by–step in BCD bus pattern, but individual bit becomes high–starting from MSB. Then by comparison, the bit is fixed or removed. Thus, it sets first MSB (1000), then the second MSB (0100) and so on. Every time, the output of SAR is converted to equivalent analog voltage by binary ladder. It is then compared with applied unknown voltage (Va). The comparison process goes on, in binary search style, until the binary equivalent of analog voltage is obtained. In this way following steps are carried out during conversion. Technique now refer the following figure and the given steps -

The unknown analog voltage (Va) is applied. Starts up from 0000 and sets up first MSB 1000. If Va >= 1000, the first MSB is fixed.

If Va < 1000, the first MSB is removed and second MSB is set

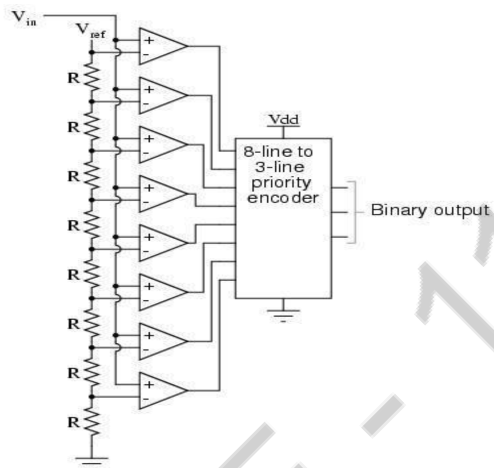
The fixing and removing the MSBs continues up to last bit (LSB), until equivalent binary output is obtained.

AMGOE-1101

Unit Wise Solved Question Paper 156

2)Flash ADC

Also called the parallel A/D converter, this circuit is the simplest to understand. It is formed of a



series of comparators, each one comparing the input signal to a unique reference voltage. The comparator outputs connect to the inputs of a priority encoder circuit, which then produces a binary output.

The following illustration shows a 3-bit flash ADC circuit:

V_{ref} is a stable reference voltage provided by a precision voltage regulator as part of the converter circuit, not shown in the schematic. As the analog input voltage exceeds the reference voltage at each comparator, the comparator outputs will sequentially saturate to a high state. The priority encoder generates a binary number based on the highest-order active input, ignoring all other active inputs.

Digital To Analog Converter (Dac):

The process of converting digital signal into equivalent analog signal is called D/A conversion. The electronics circuit, which does this process, is called D/A converter. The circuit has „n' number of digital data inputs with only one output. Basically,

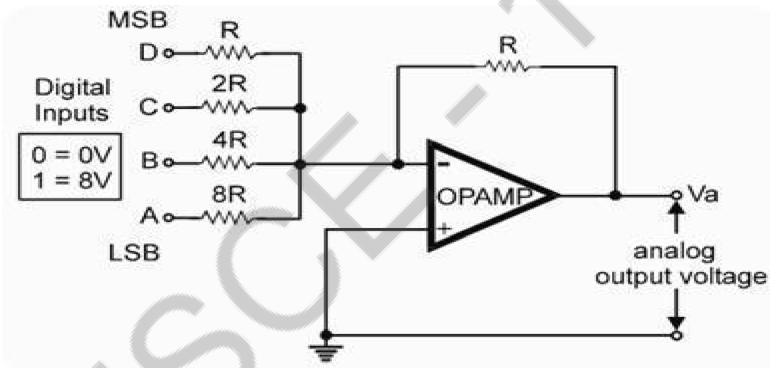
AMSCE - 1101

Unit Wise Solved Question Paper 157

there are two types of D/A converter circuits: Weighted resistors D/A converter circuit and Binary ladder or R–2R ladder D/A converter circuit.

1 Weighted resistors D/A converter

Here an OPAMP is used as summing amplifier. There are four resistors R, 2R, 4R and 8R at the input terminals of the OPAMP with R as feedback resistor. The network of resistors at the input terminal of OPAMP is called as variable resistor network. The four inputs of the circuit are D, C, B & A. Input D is at MSB and A is at LSB. Here we shall connect 8V DC voltage as logic–1 level. So we shall assume that 0 = 0V and 1 = 8V.



Now the working of the circuit is as follows. Since the circuit is summing amplifier, its output is given by the following equation

$$v_0 = R\left\{\frac{D}{R} + \frac{C}{2R} + \frac{B}{4R} + \frac{A}{8R}\right\}$$

Working of the circuit

When input DCBA = 0000, then putting these value in above equation (1) we get –

$$v_0 = R\left\{\frac{0}{R} + \frac{0}{2R} + \frac{0}{4R} + \frac{0}{8R}\right\} = 0V$$

When digital input of the circuit DCBA = 0001, then putting these value in above equation (1) we get

AMSCE-1101

$$v_0 = R\left\{\frac{0}{R} + \frac{0}{2R} + \frac{0}{4R} + \frac{8V}{8R}\right\} = R\,\frac{8V}{8R} = 1V$$

When digital input of the circuit DCBA = 0010, then putting these value in above equation (1) we get

$$v_0 = R\left\{\frac{0}{R} + \frac{0}{2R} + \frac{8V}{4R} + \frac{0}{8R}\right\} = R\,\frac{8V}{4R} = 2V$$

…………… so on.

In this way, when digital input changes from 0000 to 1111 (in BCD style), output voltage (Vo) changes proportionally. This is given in the conversion chart. There are some main disadvantages of the circuit.

They are

1. Each resistor in the circuit has different value.
2. So error in value of each resistor adds up.
3. The value of resistor at MSB is the lowest. Hence, it draws more current.
4. Also, its heat & power dissipation is very high.
5. There is the problem of impedance matching due to different values of resistors.

2 R–2R Ladder D/A Converter

It is modern type of resistor network. It has only two values of resistors the R and 2R. These values repeat throughout in the circuit. The OPAMP is used at output for scaling the output voltage. The working of the circuit can be understood as follows. For simplicity, we ignore the OPAMP in the above circuit (this is because its gain is unity). Now consider the circuit, without OPAMP. Suppose the digital input is DCBA = 1000. Then the circuit is reduced to a small circuit.

$$\text{output} = \left\{\frac{2R}{2R + 2R}\right\} \cdot (+V) = \frac{V}{2}$$

Its output is given by –

AMSCE - 1101

Reduced circuit of R-2R ladder, when we consider that all inputs=0

Now suppose digital input of the same circuit is changed to DCBA = 0100. Then the output voltage will be V/4, when DCBA = 0010, output voltage will be V/8, for DCBA = 0001, output voltage will be V/16 and so on. The general formula for the above circuit of R–2R ladder, including the OPAMP also, will be –

$$v_0 = R\left\{\frac{D}{2R} + \frac{C}{4R} + \frac{B}{8R} + \frac{A}{16R}\right\}$$

You can take (R) common from the above formula and simplify it. With the help of this formula, we can calculate any combination of digital input into its equivalent analog voltage at the output terminals.

AMSCE - 101

UNIT – V

FUNDAMENTALS OF COMMUNICATION ENGINEERING

PART – A

1. Define modulation. What are the different types of modulation? June 2009, Dec 2013

Modulation is a process of super imposing the signal to be transmitted on a carrier signal. It is a process of changing some parameters of high frequency carrier signal in accordance with instantaneous variations of the message signal.

Types:

- Amplitude modulation
- Frequency modulation
- Phase modulation

2. Define the term modulation index for frequency modulation? June 2009

It is defined as the ratio of maximum frequency deviation due to modulation to the modulating frequency.

$$m_f = \frac{\delta}{f_m} = \frac{\text{Max.frequency deviation}}{\text{Modulating frequency}}$$

3. Define the term modulation index for Amplitude modulation. Dec 2009

It is the ratio of maximum amplitude of modulating signal to maximum amplitude of carrier signal.

$$m = \frac{V_m}{V_c}$$

4. List any 4 important advantages of FM over AM. Dec 2009

i. FM is immune to noise

ii. FM has larger bandwidth than AM

161

iii. FM has more transmission efficiency than AM

iv. Because of guard band in between FM stations, there is less adjacent channel interference in FM.

5. Mention the need of modulating the information signals. June 2010

- To reduce the antenna size
- To avoid interference message signal with noise
- Increases the range of communication
- Allows multiplexing of signals
- Allows adjustment in the Bandwidth
- Improves quality of reception.

6. Define total internal reflection .June 2010, May 2015

When a ray passes from denser medium (medium with higher refractive index) to rarer medium it

bends or refracts away from the imaginary line, called normal, perpendicular to the surface. As the angle of incidence in denser medium becomes greater with respect to normal, the refracted ray bends further away from it. At one particular angle, called critical angle, the refracted light does not enter rarer medium but instead travels along the surface between the two media. If the ray is incident at greater than critical angle, then the refracted ray reflects back into the denser medium resulting into total internal reflection. Thus, we can define total internal reflection as an optical phenomenon that happens when a ray of light strikes a medium boundary at an angle larger than a particular critical angle with respect to the normal to the surface.

7. State any two differences between analog and digital signals? Dec 2010, Dec 2012, June2014, May 2015

Analog signal magnitude has continuous magnitude with respect to time without aqwny discontinuity. The value of the signal is available at any point of time. Where as in the discrete time signal, the magnitude is not continuous with respect to time and the magnitude is available for at particular instants of time.

AMSCE-1101

8. What are the applications of microwave communications? Dec 2010 May 2015

a. Terrestial microwave links are used to carry telephony,data and T.V signals.

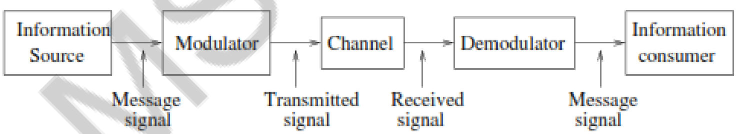
b. Satellite communication uses microwave frequencies for their oprerations.

c. Microwave radiation has also found some medical applications for heating tumours. d. Microwave can be used for material cutting.

9. Define the term demodulation. May 2011

Demodulation is the reverse process of modulation. The information signal superimposed in the modulated signal is separated from carrier signal in the demodulation. In other words, separation of signal and carrier of modulated signal is called demodulation.

10. Sketch the block diagram of basic communication system. May 2011



11. Mention two advantages of modulation when compared to transmission of unmodulated signal. Dec 2011

- Easy transmission
- Reduction in antenna height
- Avoids mixing of signals
- Reduction of noise and interferences
- Increase the range of communication
- Improves the quality of reception
- To overcome equipment limitations
- Adjustment of bandwidth

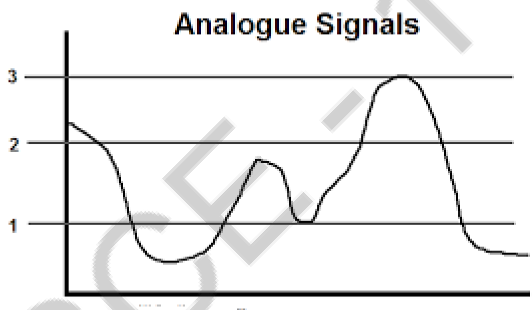
AMSCE - 1101

163

12. What is the basic function of a communication satellite? Dec 2011

It is basically a microwave relay station placed precisely at 36000km above the equator where its orbit speed exactly matches the earth's rotation speed. Since a satellite is positioned in geosynchronous orbit, it appears to be stationary with relative to the earth and always stays over the same point with respect to earth. This allows ground station to aim its antenna at a fixed point in the sky.

13. State the basic characteristic of an analog signal, with an example. June2012



- It is a continuous signal without any break. Continuous values of voltage or current in a wire with respect to time is an example of analog signal.
- Analog signal is a continuous – time signal and the values are existing for all values of time and it is represented by A(t) , X(t), Y(t) etc.,
- The output of microphone , output of a thermometer are examples of analog signal.

14. Give the typical uplink frequency and downlink frequency in satellite communication. June 2012

In the satellite ,C – Band is the portion of the RF Spectrum that is typically 3.625GHz to 4.2 GHz on the satellite's downlink and 5.85 to 6.425 GHz on the satellite's uplink.

164

15. As related to amplitude modulation, what is over modulation, under modulation and 100% modulation? June 2013

The classification is based on modulation index m

- When Vm > Vc (i.e.,) m > 1 , then it is called over modulation
- When Vm < Vc (i.e.,) m < 1 , then it is called under modulation
- When Vm = Vc (i.e.,) m = 1 , then it is called 100% modulation

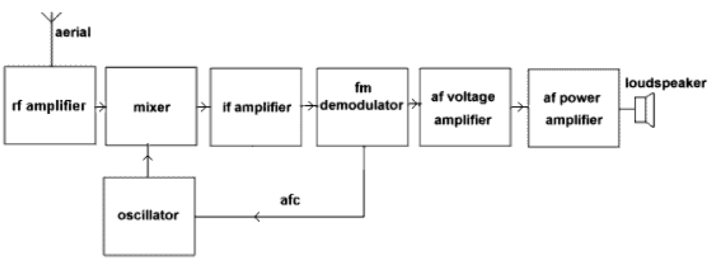
16. Why digital signals are said to be noise immune? June 2013

Super imposing of noise on the digital signal will not affect the value of digital signal. It is due to the fact that in digital systems , the exact value of trhe voltage is not important, as long as the noise is not large enough to distinguish a high voltage level from a low voltage level.

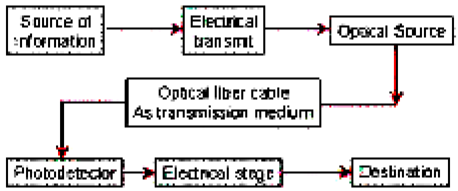
17. What are the advantages of optical fibre communication? June 2014 , Dec 2015

- Long distance signal transmission
- Cost effective diffusers and concentrators
- Cost effective coupling techniques between light sources and fibers
- Multi use fibers
- Large bandwidth , light weight and small diameter
- Large information carrying capacity
- Resistivity to temperature and environmental changes
- Immune to interference

18. Sketch the block diagram of FM receiver. Dec 2014



19. Draw the block diagram of optical fiber communication. May 2015



20. State the functions of satellite transponder. Dec 2012, (April/May 2017)

It receives the modulated signal from earth station. Amplify and modulate at different carrier frequency and send back to other earth stations in the earth.

21. What is communication?

Transfer of information from one place to another is called communication.

22. What are the types of signals? (Nov/Dec 2017)

1. Analog signals
2. Digital signals

23. Give few examples of Analog signals?

1. Telephone signal
2. Radio broadcast signal
3. T.V signal

24. Give few examples of Digital signals?

1. Telegraph signal
2. Radar signal
3. Tele printer signal

25 What are the process involved in analog to digital conversion?

1. Sampling
2. Quantization
3. Encoding

AMSCE - 1101

 166

26. Write down few waveform coding technique.

1. PCM- Pulse code modulation
2. DCPH- Differential pulse code modulation
3. DM- Delta modulation
4. ADM- Adaptive delta modulation.

27. Classify Radio receivers.

1. TRF-Tuned radio frequency receiver
2. SHR-Super heterodyne receiver.

28. What are the two types of T.V

1. Monochrome system
2. Color T.V system

29. What is facsimile?

In facsimile process the effective transmission and exact reproduction of still photographs, documents and other maps have to be done.

30. What is microwave?

Electromagnetic waves in the frequency range of 1GHz to 50 GHz are referred as microwaves.

31. List few advantages of microwave communication.

1. Mmicrowave communication offers wide bandwidth hence more number of channels can be obtained.
2. .Line of sight proropagation is move reliable when compared to software communication.
3. Improved directivity with an aerial array.
4. Low power requirements in the order of milliwatts and microwaves.

32. What is communication ?

Transfer of information from one place to another is called communication.

AMSCE - 1101

Unit Wise Solved Question Paper 167

33. Define modulation;

Modulation is the process of changing some parameters of a high frequency carrier signal in according with the instantaneous variation of the message signal

34. Write down few waveform coding technique.

1. PCM- Pulse code modulation
2. DCPH- Differential pulse code modulation
3. DM- Delta modulation
4. ADM- Adaptive delta modulation.

35. Define angle modulatin.

Angle modulation is the process by which the angle of the carrier signal is varied in accordance with the amplitude variation of the message signal.

10.Classify angle modulation.
1.Frequency modulation
2.Plane modulation.

36. What is Radio communication?

Radio communication is transmission of speech,music, entertainment programmer. These informations are transmitted as radio waves.

37. List few advantages of microwave communication. (April/May 2015)

1. Microwave communication offers wide bandwidth hence more number of channels can be obtained.
2. Line of sight proropagation is move reliable when compared to software communication.
3. Improved directivity with an aerial array.
4. Low power requirements in the order of mill watts and microwaves.

38. List few applications of microwaves communication.

1. Terrestial microwave links are used to carry telephony,data and

AMSCE - 1101

 168

T.V signals.

2. Satellite communication uses microwave frequencies for their oprerations.
3. microwave radiation has aiso found some medical applications for heatig tumours.
4. Microwave can be used for material cutting.

39. Write down the formula for time taken by the satellite for encircling the earth

t = 2 (r+h)/v
v=velocity of the satellite
g=gravitational acceleration
r=radius of earth.

40. Define Analog signal

It is any continuous signal for which the time varying feature (variable) of the signal is a representation of some other time varying quantity, i.e., analogous to another time varying signal. It differs from a digital signal in terms of small fluctuations in the signal which are meaningful.

41. Define digital signal

A **digital signal** uses discrete (discontinuous) values. By contrast, non-digital (or analog) systems use a continuous range of values to represent information. Although digital representations are discrete, the information represented can be either discrete, such as numbers or letters, or continuous, such as sounds, images, and other measurements of continuous systems

42. What are the properties of digital signal?

Synchronization – digital communication uses specific synchronization sequences for determining synchronization.

Language – digital communications requires a language which should be possessed by both sender and receiver and should specify meaning of symbol sequences.

AMSCE - 1101

Unit Wise Solved Question Paper 169

Errors – disturbances in analog communication causes errors in actual intended communication but disturbances in digital communication does not cause errors enabling error free communication. Errors should be able to substitute, insert or delete symbols to be expressed.

Copying – analog communication copies are quality wise not as good as their originals while due to error free digital communication, copies can be made indefinitely.

Granularity – for a continuously variable analog value to be represented in digital form there occur quantization error which is difference in actual analog value and digital representation and this property of digital communication is known as granularity.

AMSCE - 101

170

PART – B

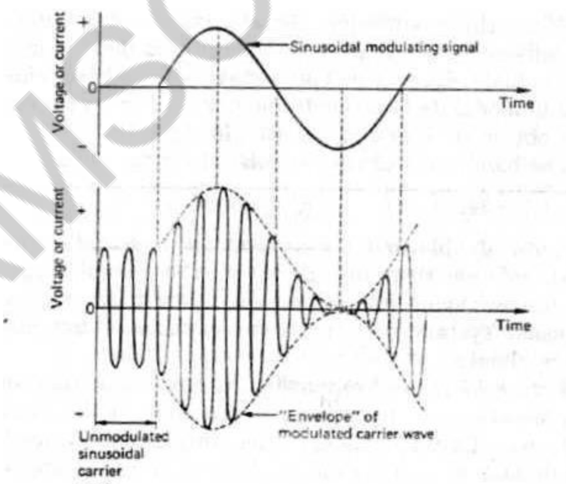
1. (a) With neat diagram, explain the principle of operation of Amplitude Modulation. Derive its power relations. (April/May 2015) (May/June 2016) (16)

Principles of Amplitude modulation

Amplitude Modulation (AM) plus frequency division multiplexing (FDM) is one way of solving above problem. Each conversation is shifted to a different part of the frequency spectrum by using a high-frequency waveform to “carry” each individual speech signal. These high frequencies are called carrier frequencies.

Amplitude modulation is the process of varying the amplitude of the sinusoidal carrier wave by the amplitude of the modulating signal, and is illustrated in Fig.

The unmodulated carrier wave has a constant peak value and a higher frequency than the modulating signal , but, when the modulating signal is applied,



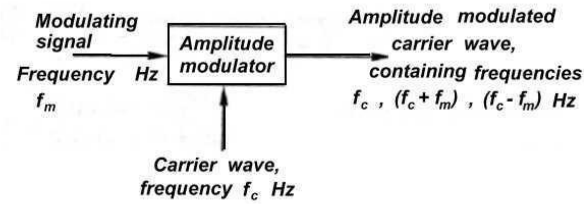
the peak value of the carrier varies in accordance with the instantaneous value of the modulating signal, and the outline wave shape or “envelope” of the modulated wave’s peak values is the

AMSCE - 1101

same as the original modulating signal wave shape. The modulating signal waveform has been superimposed on the carrier wave.

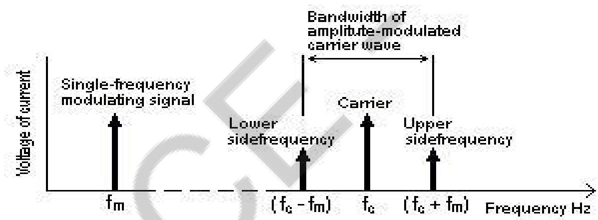
AMSCE - 1101

172



It should be noted that two of these frequencies are new, being produced by the amplitude-modulation process, and are called side-frequencies.

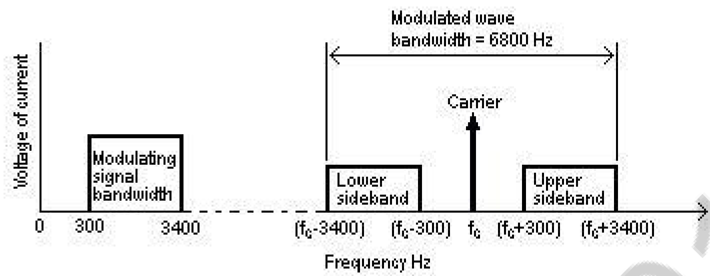
The sum of carrier and modulating signal frequencies is called the upper side-frequency. The difference between carrier and modulating signal frequency is called the lower side-frequency. This is illustrated in the frequency spectrum diagram of Fig.



The bandwidth of the modulated carrier wave is (fc + fm) - (fc - fm) = 2 fm

i.e. double the modulating signal frequency

The complete amplitude-modulated wave band of lower sideband plus carrier plus upper sideband shown in Fig. 8 takes up more frequency bandwidth than is really necessary to transmit the information signal since all the information is carried by either one of the sidebands alone . The carrier component is of constant amplitude and frequency so does not carry any of the informat ion signal at all . It is possible by using special equipment to suppress both the carrier and one sideband and to transmit just the other sideband with no loss of information. This method of working is called single sideband working (SSB) . This method is not used for domestic radio broadcasting , but it is used for some long-distance radio telephony systems and for multi-channel carrier systems used in national telephone networks.



2. **Explain frequency modulation with necessary supporting diagrams. (April/May 2015) (May/June 2016) (16)**

Principle of frequency modulation

Frequency modulation uses the information signal, Vm(t) to vary the carrier frequency within some small range about its original value. Here are the three signals in mathematical form:

Information: Vm(t)

Carrier: Vc(t) = Vco sin (2 p fc t + f)

FM: VFM (t) = Vco sin (2 p [fc + (Df/Vmo) Vm (t)] t + f)

We have replaced the carrier frequency term, with a time-varying frequency. We have also introduced a new term: Df, the peak frequency deviation. In this form, you should be able to see that the carrier frequency term: fc + (Df/Vmo) Vm (t) now varies between the extremes of fc - Df and fc + Df. The interpretation of Df becomes clear: it is the farthest away from the original frequency that the FM signal can be. Sometimes it is referred to as the “swing” in the frequency.

We can also define a modulation index for FM, analogous to AM: b = Df/fm , where fm is the maximum modulating frequency used.

The simplest interpretation of the modulation index, b, is as a measure of the peak frequency deviation, Df. In other words, b represents a way to express the peak deviation frequency as a multiple of the maximum modulating frequency, fm, i.e. Df = b fm.

FM Spectrum

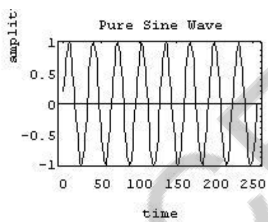
AMSCE - 1101

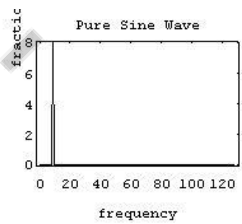
A spectrum represents the relative amounts of different frequency components in any signal. Its like the display on the

AMSCE - 1101

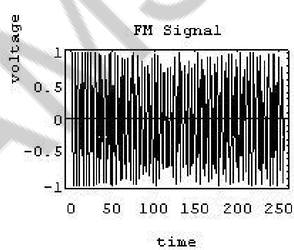
Unit Wise Solved Question Paper 175

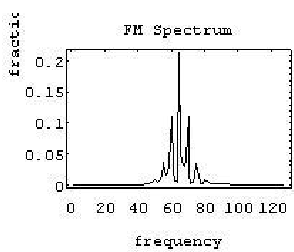
graphic-equalizer in your stereo which has leds showing the relative amounts of bass, midrange and treble. These correspond directly to increasing frequencies (treble being the high frequency components). It is a well-know fact of mathematics, that any function (signal) can be decomposed into purely sinusoidal components (with a few pathological exceptions) . In technical terms, the sines and cosines form a complete set of functions, also known as a basis in the infinite- dimensional vector space of real-valued functions (gag reflex). Given that any signal can be thought to be made up of sinusoidal signals, the spectrum then represents the “recipe card” of how to make the signal from sinusoids. Like: 1 part of 50 Hz and 2 parts of 200 Hz. Pure sinusoids have the simplest spectrum of all, just one component:





The FM spectrum is considerably more complicated. The spectrum of a simple FM signal looks like:



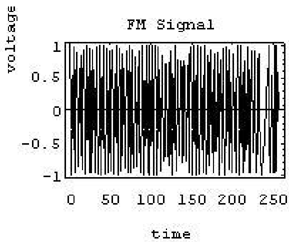


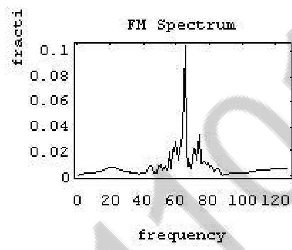
What we see are multiple side-bands (spikes at other than the carrier frequency) separated by the modulating frequency, 5 Hz. There are roughly 3 side-bands on either side of the carrier. The shape of the spectrum may be explained using a simple heterodyne argument: when you mix the three frequencies (fc, fm and Df) together you get the sum and difference frequencies. The largest combination is fc + fm + Df, and the smallest is fc -

176

fm - Df. Since Df = b fm, the frequency varies (b + 1) fm above and below the carrier.

A more realistic example is to use an audio spectrum to provide the modulation:





In this example, the information signal varies between 1 and 11 Hz. The carrier is at 65 Hz and the modulation index is 2. The individual side-band spikes are replaced by a more-or-less continuous spectrum. However, the extent of the side-bands is limited (approximately) to (b + 1) fm above and below. Here, that would be 33 Hz above and below, making the bandwidth about 66 Hz. We see the side-bands extend from 35 to 90 Hz, so out observed bandwidth is 65 Hz.

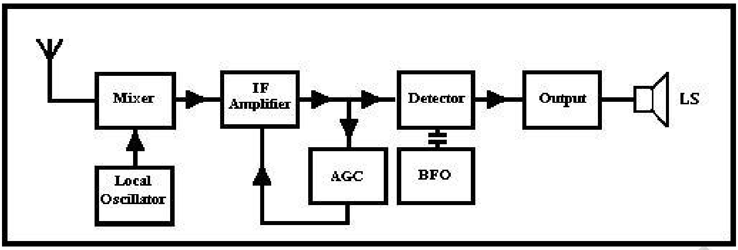
You may have wondered why we ignored the smooth humps at the extreme ends of the spectrum. The truth is that they are in fact a by-product of frequency modulation (there is no random noise in this example). However, they may be safely ignored because they are have only a minute fraction of the total power. In practice, the random noise would obscure them anyway.

3. Draw the block diagram of radio broadcasting and reception system and explain the function of each block.

Block diagram of radio

AMSCE - 1101

Unit Wise Solved Question Paper 177



AMSCE - 1101

Unit Wise Solved Question Paper 178

AM Transmitter

In order to better understand the way the radio transmitter works, block - diagram of a simple AM (amplitude modulated) signal transmitter is shown on Pic. The amplitude modulation is being performed in a stage called the modulator. Two signals are entering it: high frequency signal called the carrier (or the signal carrier), being created into the HF oscillator and amplified in the HF amplifier to the required signal level, and the low frequency (modulating) signal coming from the microphone or some other LF signal source (cassette player, record player, CD player etc.), being amplified in the LF amplifier. On modulator's output the amplitude modulated signal UAM is acquired. This signal is then amplified in the power amplifier, and then led to the emission antenna.

FM Transmitter

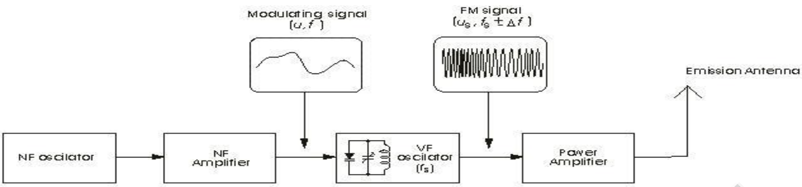
Block diagram of an FM (frequency modulated) transmitter is given on Pic.2.4. Information being transferred, i.e. the modulating signal, is a signal from some LF source. it is being amplified in LF amplifier and then led into the HF oscillator, where the carrier signal is being created. The carrier is a HF voltage of constant amplitude, whose frequency is, in the absence of modulating signal, equal to the transmitter's carrier frequency fS. In the oscillatory circuit of the HF oscillator a varicap (capacitive) diode is located. It is a diode whose capacitance depends upon the voltage between its ends, so when being exposed to LF voltage, its capacitance is changing in accordance with this voltage. Due to that frequency of the oscillator is also changing, i.e. the frequency modulation is being obtained. The FM signal from the HF oscillator is being proceeded to the power amplifier that provides the necessary output power of the transmission signal. Voltage shapes in FM transmitter are given on Pic.2.5. Pic.2.5- a shows the LF modulating signal. The frequency modulation begins at moment t0 and the transmission frequency begins to change, as shown on Pic.2.5-b: Whilst current value of the LF signal is raising so is the trasmitter frequency, and when it is falling the frequency is also falling. As

AMSCE - 4101

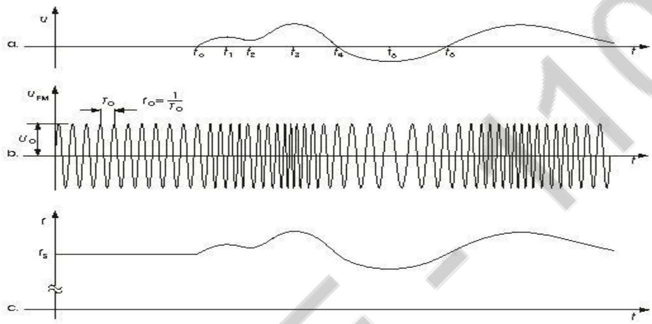
seen on Pic.2.5-c, the information (LF signal) is being implied in frequency change of the carrier.

AMSCE - 1101

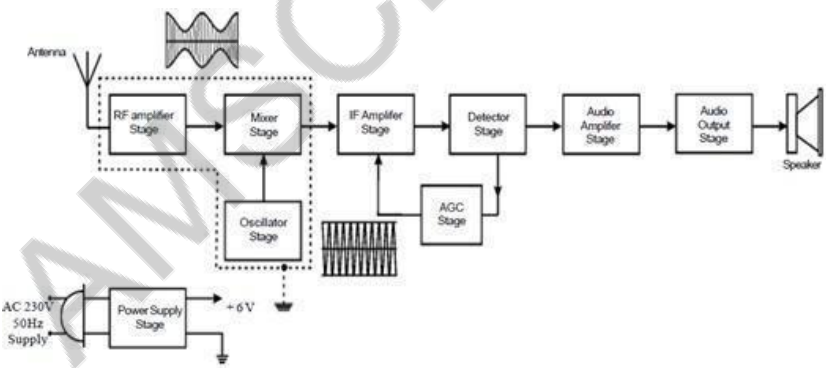
180



Picture 2.4. FM transmmiter Block diagram



AM radio broad cast transmitter



AM radio technology is simpler than frequency modulated (FM) radio, Digital Audio Broadcasting (DAB), satellite radio or HD (digital) radio. An AM receiver detects amplitude variations in the radio waves at a particular frequency. It then amplifies changes in the signal voltage to drive aloud speaker or earphones. The earliest crystal radio receivers used a crystal diode detector with no amplification, and required no power source other than the radio signal itself.

AMSCE - 101

Radio receiver

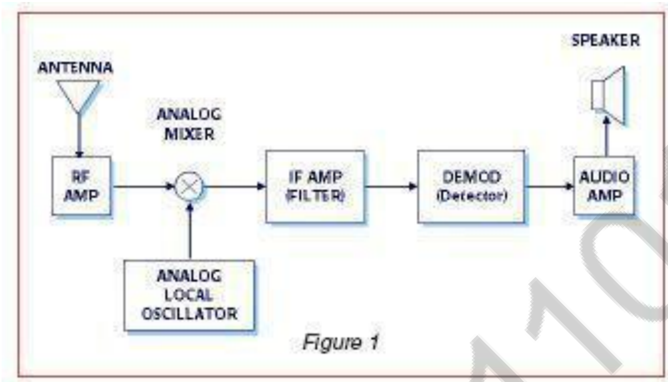


Figure 1

In the early days of what is now known as early radio transmissions, say about 100 years ago, signals were generated by various means but only up to the L.F. region.

Communication was by way of more code much in the form that a short transmission denoted a dot

(dit) and a longer transmission was a dash (dah). This was the only form of radio transmission until the 1920's and only of use to the military, commercial telegraph companies and amateur experimenters.

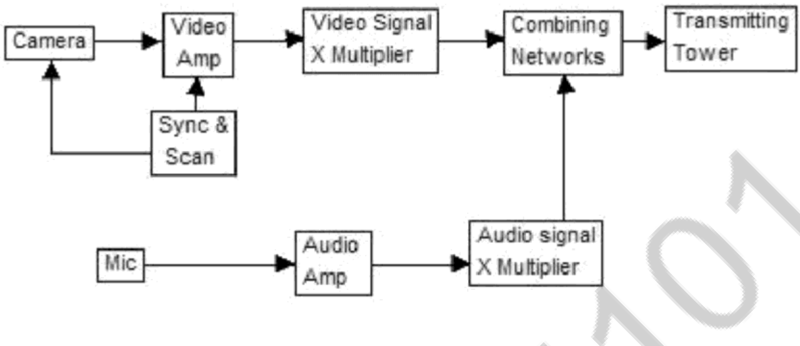
Then it was discovered that if the amplitude (voltage levels - plus and minus about zero) could be controlled or varied by a much lower frequency such as A.F. then real intelligence could be conveyed e.g. speech and music. This process could be easily reversed by simple means at the receiving end by using diode detectors. This is called modulation and obviously in this case amplitude modulation or A.M.

This discovery spawned whole new industries and revolutionized the world of communications. Industries grew up manufacturing radio parts, receiver manufacturers, radio stations, news agencies, recording industries etc.

4. Draw and explain the functional block diagram of Monochrome TV transmitter and receiver. (April/May 2015)

AMSCE - 1101

Block diagram of television transmitter



Basic Television Transmitter

The basic television Broadcast transmitter block diagram is shown in figure (a).

The block diagram can be broadly divided into two separate section, viz., one that - Generates an electronic signal (called video signal) corresponding to the actual picture and then uses this video signal to modulate an R-F carrier so as to be applied to the transmitting antenna for transmission, other that generates an electronic signal (called audio signal) containing sound information and then uses this signal to modulate another RF carrier and then applied to the transmitting antenna for transmission. However only one antenna is used for transmission of the video as well as audio signals. Thus these modulated signals have to be combined together in some appropriate network. In addition there are other accessories also. For instance, video as well as audio signals have to be amplified to the desired degree before they modulate their respective RF carriers.

This function is performed by video and audio amplifiers. The block picture signal transmitter and audio signal transmitter shown in figure (a) may consist of modulators as the essential component; Video signal transmitter employs an AM transmitter as amplitude-modulation is used for video signals whereas audio signal transmitter employs FM modulator as frequency modulation is used for sound information.

AMSCE - 1101

((May/June 2016) (16)

Scanning circuits are used to mike the electron beam scan the actual picture to produce the corresponding video signal. The scanning by electron beam is in the receiver too. The beam scans the picture tube to reproduce the original picture from the video signal and this scanning at the receiver must be matched properly to the scanning at the transmitter. It is for this reason that synchronizing Circuits are used at the transmitter as well as receiver.

Complete TV transmitter Block Diagram

Figure (b) depicts the complete block diagram of a Television Broadcast Transmitter. The important block have already been discussed individually in the preceding sections. that makes understanding of the diagram shown here much more simple. A brief explanation is given ahead. The block diagram can be broadly divided into two -sections, viz., an amplitude modulated transmitter and a frequency modulated transmitter. Former is used for video modulation whereas latter is used for audio modulation.

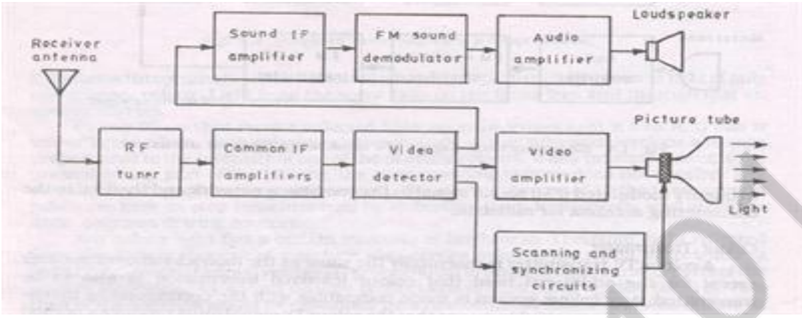
Master oscillator in both generates an RF carrier frequency. Generally, a master oscillator generates a sub multiple of carrier and then drives harmonic generators (frequency multipliers) to achieve correct value carrier. Harmonic generators are nothing but class C tuned amplifiers whose output tuned circuit is to tuned to some harmonic of the input signal. In actual practice, master oscillator and harmonic generator are s crated or isolated by a buffer stage to av214Joactrrig of the harmonic generator on the oscillator output. The carrier is then fed to an amplitude modulator in video transmitter and a frequency modulator in audio transmitter. Into-the modulator, the modulation signal is also fed with proper amplitude. Since low-level modulation is employed, the modulating signal is amplified by linear amplifiers up-to the desired degree required for transmission. Video and audio

AMSCE-1101

signals on separate carriers are then combined together so as to be fed to the transmitting antenna as on signal

AMSCE - 1101

Block diagram of television receiver



Television Receiver

A radio receiver designed to amplify and convert the video and audio radio-frequency signals of a television broadcast that have been picked up by a television antenna; the receiver reproduces the visual image broadcast and the accompanying sound. Television receivers are designed for color or black-and- white operation; both non portable and portable models are produced. Those manufactured in the USSR are capable of receiving signals from television stations transmitting in specifically assigned portions of the very-high-frequency (VHF) band (48.5–100 megahertz and 174– 230 megahertz; 12 channels) and ultrahigh-frequency (UHF) band (470–638 megahertz; several tens of channels).

Television receivers must simultaneously amplify and convert video and audio radio- frequency signals. They are usually designed with a super heterodyne circuit, and versions differ in the methods used to extract and amplify the audio signal. The principal components of a television receiver are shown in Figure1.

The tuner selects the signals of the desired channel and converts them to a lower frequency within intermediate-frequency pass band. The signal-processing circuits include an intermediate-frequency amplifier for the video signal, an amplitude detector, a video amplifier for the brightness signal, and, in color receivers, a color-processing circuit for the chrominance signal. The processing circuit produces a brightness signal and a color-

AMSCE - 1101

difference signal, which are fed to the control electrodes of a kinescope; an audio signal, which is fed to the audio channel;

AMSCE - 1101

187

and horizontal and vertical synchronizing pulses (or a composite television signal), which are fed to a scanning generator. In the color television system used in the USSR , the color-processing circuit for the chrominance signal consists of a band-pass amplifier, in which the chrominance signal is extracted, channels for the direct and delayed signals, an electronic switching device, two frequency detectors for the color- difference signals, a matrix circuit, and amplifiers for the three color-difference signals. The color processing circuit has provisions for the extraction and decoding of the chrominance signal and for line selection, as well as chrominance disconnect circuits that operate when black-and-white transmissions are received.

The scanning generators include horizontal and vertical scanning circuits that produce saw tooth currents in the horizontal and vertical scanning coils of the deflection system.

The high voltage for feeding the second anode of the kinescope is derived from a special high voltage winding of the line transformer or by rectifying pulses from the transformer; the volt age for the focusing electrode is similarly derived.

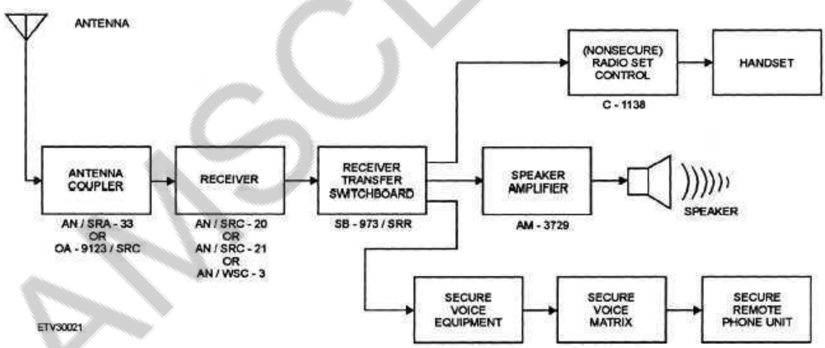
The kinescope's interface includes static and dynamic white balance controls, switches for extinguishing the electron guns, and regulators for focusing the beams.The demagnetizing circuit for a color kinescope creates a damped alternating current in a demagnetizing loop that circles the kin scope screen. The current demagnetizes the shadow mask and tube rim, which are made of steel. The audio section consists of an amplifier for the difference frequency, which in the USSR is 6.5 megahertz, a frequency detector for the audio signal, and a low-frequency amplifier from which the audio signal is fed to a high- quality acoustical system, usually composed of several loudspeakers. The power- supply section converts mains voltage into the supply voltages for all components of the television set, including the kinescope and vacuum tube heaters.

5. Explain microwave communication system, with help of a neat diagram (16) (April/May 2017) (Nov/Dec 2017)

Microwave transmission refers to the technology of transmitting information or energy by the use of electromagnetic waves

AMSCE - 1101

whose wavelengths are conveniently measured in small numbers of centimeter; these are called microwaves. This part of the radio spectrum ranges across frequencies of roughly 1.0 gigahertz (GHz) to 30 GHz. These correspond to wavelengths from 30 centimeters down to 1.0 cm. Microwaves are widely used for point-to-point communications because their small wavelength allows conveniently-sized antennas to direct them in narrow beams, which can be pointed directly at the receiving antenna. This allows nearby microwave equipment to use the same frequencies without interfering with each other, as lower frequency radio waves do. Another advantage is that the high frequency of microwaves gives the microwave band a very large information-carrying capacity; the microwave band has a bandwidth 30 times that of all the rest of the radio spectrum below it. A disadvantage is that microwaves are limited to line of sight propagation; they cannot pass around hills or mountains as lower frequency radio waves can.



Microwave radio transmission is commonly used in point-to-point communication systems on the surface of the Earth, in satellite communications, and in deep space radio communications. Other parts of the microwave radio band are used for radars, radio navigation systems, sensor systems, and radio astronomy.

The next higher part of the radio electromagnetic spectrum, where the frequencies are above 30 GHz and below 100 GHz, are called “millimeter waves” because their wavelengths are conveniently

AMSCE - 1101

measured in millimeters, and their wavelengths range from 10 mm down to 3.0 mm. Radio waves in this band are usually strongly attenuated by the Earthly atmosphere and particles contained in it, especially during wet weather. Also, in wide band of frequencies around 60 GHz, the radio waves are strongly attenuated by molecular oxygen in the atmosphere. The electronic technologies needed in the millimeter wave band are also much more difficult to utilize than those of the microwave band.

6. With help of a neat diagram explain the basic components of satellite communication. (16)

A **communications satellite** is an artificial satellite sent to space for the purpose of telecommunications. Modern communications satellites use a variety of orbits including geostationary orbits, elliptical orbits and low (polar and non-polar) Earth orbits.

For fixed (point-to-point) services, communications satellites provide a microwave radio relay technology complementary to that of communication cables. They are also used for mobile applications such as communications to ships, vehicles, planes and hand-held terminals, and for TV and radio broadcasting.

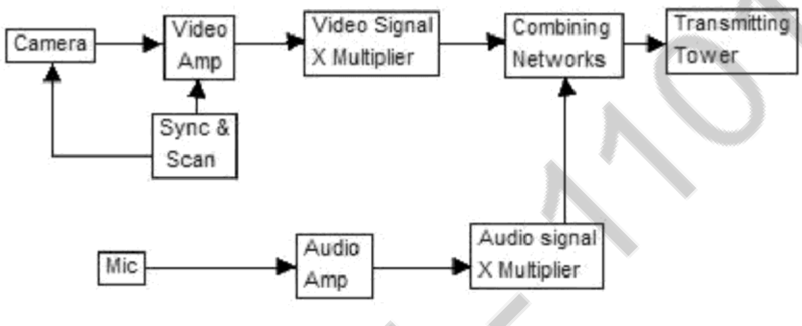
Communications Satellites are usually composed of the following subsystems:

Communication Payload, normally composed of transponders, antenna, and switching systems Engines used to bring the satellite to its desired orbit

Station Keeping Tracking and stabilization subsystem used to keep the satellite in the right orbit, with its antennas pointed in the right direction, and its power system pointed towards the sun Power subsystem, used to power the Satellite systems, normally composed of solar cells, and batteries that maintain power during solar eclipse

Command and Control subsystem, which maintains communications with ground control stations. The ground control earth stations monitor the satellite performance and control its functionality during various phases of its life-cycle.

The bandwidth available from a satellite depends upon the number of transponders provided by the satellite. Each service (TV, Voice, Internet, radio) requires a different amount of bandwidth for transmission. This is typically known as link budgeting and a network simulator can be used to arrive at the exact value.



Basic Television Transmitter

7. Explain the block diagram of optical fiber communication systems. (8) (May/June 2016) (April/May 2017)

Fiber-optic communication is a method of transmitting information from one place to another by sending pulses of light through an optical fiber. The light forms an electromagnetic carrier wave that Is modulated to carry information. First developed in the 1970s, fiber- optic communication systems have revolutionized the telecommunications industry and have played a major role in the advent of the Information Age. Because of its advantages over electrical transmission, optical fibers have largely replaced copper wire communications in core networks in the developed world. Optical fiber is used by many telecommunications companies to transmit telephone signals, Internet communication, and cable television signals. Researchers at Bell Labs have reached internet speeds of over 100 petabits per second using fiber-optic communication.

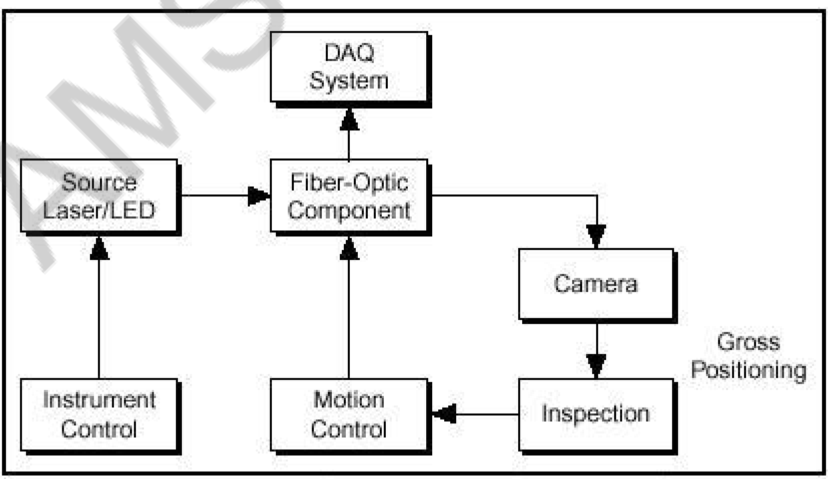
192

The process of communicating using fiber-optics involves the following basic steps: Creating the optical signal involving the use of a transmitter, relaying the signal along the fiber, ensuring

AMSCE - 1101

that the signal does not become too distorted or weak, receiving the optical signal, and converting it into an electrical signal. Optical fiber is used by many telecommunications companies to transmit telephone signals, Internet communication, and cable television signals.

Due to much lower attenuation and interference, optical fiber has large advantages over existing copper wire in long-distance and high-demand applications. However, infrastructure development within cities was relatively difficult and time-consuming, and fiber-optic systems were complex and expensive to install and operate. Due to these difficulties, fiber-optic communication systems have primarily been installed in long-distance applications, where they can be used to their full transmission capacity, offsetting the increased cost. Since 2000, the prices for fiber-optic communications have dropped considerably. The price for rolling out fiber to the home has currently become more cost-effective than that of rolling out a copper based network. Prices have dropped to $850 per subscriber in the US and lower in countries like The Netherlands, where digging costs are low and housing density is high.



UNIT I

1. List the operating forces present in indicating instruments. (May/June 2016)
   - i) Deflecting force: The force required for moving the pointer from its zero position.
   - ii) Controlling force: The force required to bring the pointer to final steady state position without overshoot and to bring back the pointer to zero when deflecting force is absent.
   - iii) Damping force: The force required to bring the pointer to final steady state position quickly without oscillations.

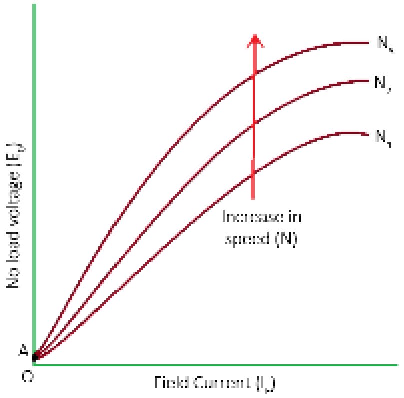
2. Compare the moving coil and moving iron instruments. (Nov/Dec 2016)

	Moving Coil Instrument	*Moving Iron Instrument*
1.	Scale is uniform.	Scale is not uniform.
2.	High cost.	Low cost.
3.	It is used only in measurement of DC.	Measurement of AC and DC is possible.

AMSCE - 1101

Unit-II

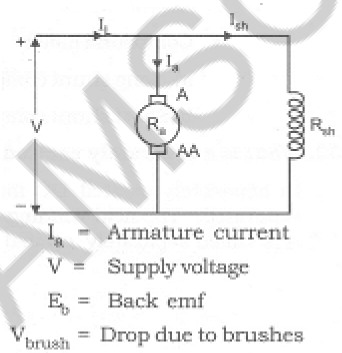
1. Sketch the OCC of DC shunt generator. (May/June 2016)



Open Circuit Characteristic (O.C.C.)

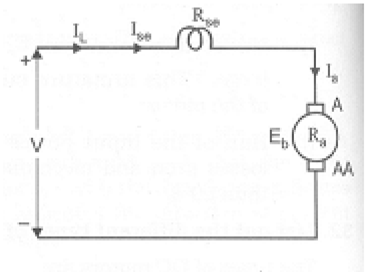
2. Draw the circuit for various types of DC motors. (Nov/Dec 2016)

DC Shunt motor



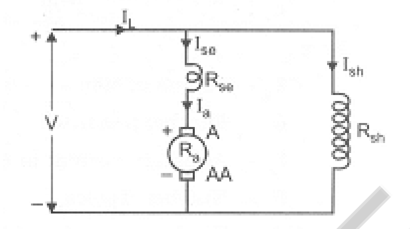
DC Series motor

AMSCE - 1101

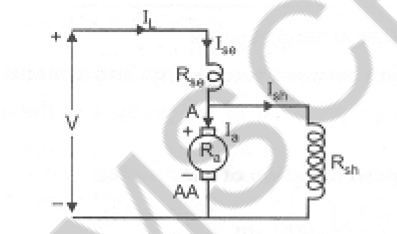


DC Compound motor

Long Shunt Compound motor



Short Shunt Compound motor



3. Define voltage regulation of a transformer. (Nov/Dec 2016)

The regulation of a transformer is defined as, reduction in magnitude of the terminal voltage, due to load, with respect to the no-load terminal voltage.

$$\% \text{ Regulation} = \frac{V_{20} - V_2}{V_{20}} \times 100$$

where,

V_{20} = no-load terminal voltage

V_2 = load voltage

AMSCE - 1101

197

4. Write the output voltage equation of single phase transformer. (Nov/Dec 2017)

$V_1=E_1=4.44f\Phi_mN_1$ for primary winding transformer

$V_2=E_2=4.44f\Phi_mN_2$ for secondary winding transformer

Where V_1 ,V_2-Supply voltage across primaryand secondary in volts

E_1 ,E_2-Emf induced in the primary winding and secondary Winding in volts.

f-Frequency in Hz, Φ_m-Maximum value of flux in the core in wb, N_1, N_2 -No. of primary and secondary winding turns.

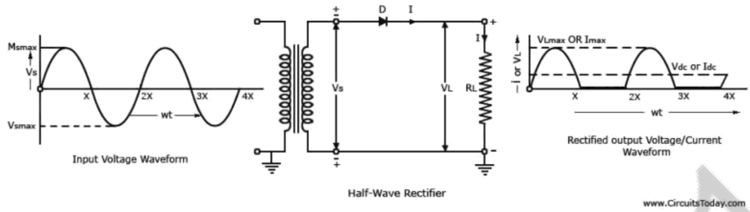
Unit-III

1. Give difference between the half wave and full wave rectifiers. (Nov/Dec 2017)

Sl. No.	Parameter	HWR	Centre tapped FWR
1.	Number of diodes	1	2
2.	RMS load current	$\frac{I_m}{2}$	$\frac{I_m}{\sqrt{2}}$
3.	Average DC output voltage	$\frac{V_m}{\pi}$	$\frac{2V_m}{\pi}$
4.	Average DC current	$\frac{I_m}{\pi}$	$\frac{2I_m}{\pi}$
5.	Rectification efficiency	40.6%	81%
6.	Ripple factor	1.21	0.482
7.	Fundamental ripple frequency	f	2f
8.	Peak inverse voltage	V_m	$2V_m$
9.	TUF	0.286	0.692
10.	Cost	Economic	Costly

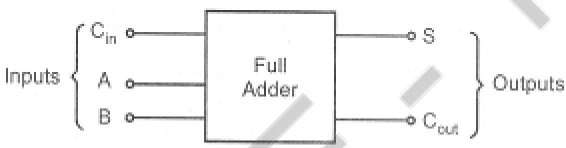
AMSCE - 1101

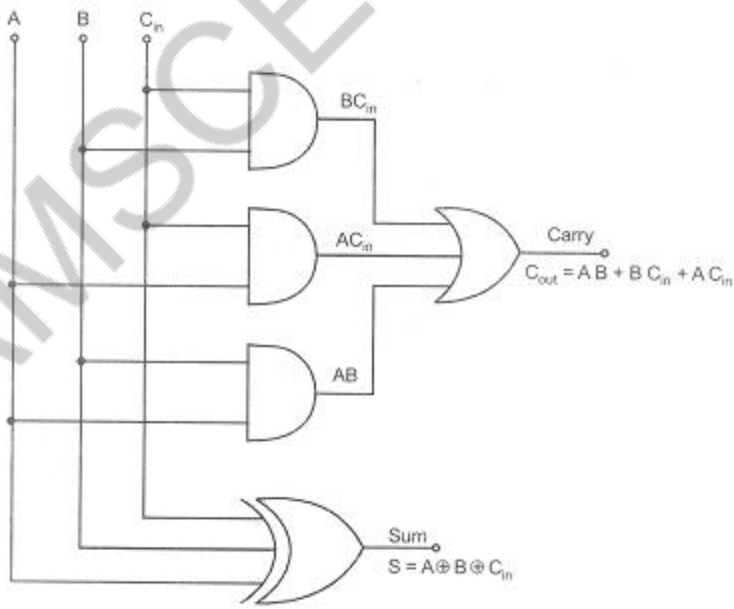
2. Draw the circuit diagram of halfwave rectifier. (May/June 2016)



Unit-IV

1. Draw the Full Adder circuit. (Nov/Dec 2017)





AMSCE - 1101

2. What is register in digital system? (May/June 2016)

A memory element capable of containing one binary word.It consists of a group of flip-flops which store the binary information.

<u>UNIT-V</u>

1. What is ISDN? (May/June 2016)

   Integrated Services Digital Network is a digital communications interface designed to replace the local analog loop new used in the public switched network. It supports digital voice telephones as well as fax machines,computers,video and other digital data sources.It allows computers to access online services directly without a modem.

AMSCE - 101