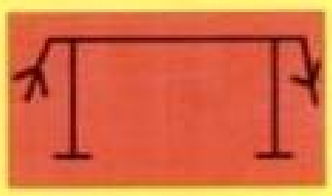
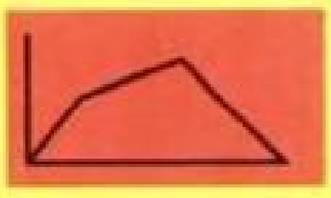
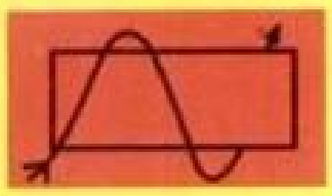
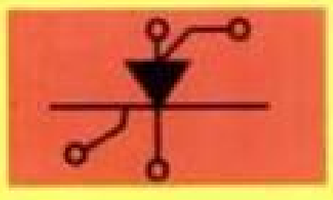
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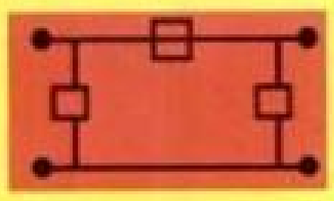
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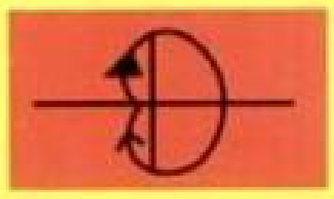

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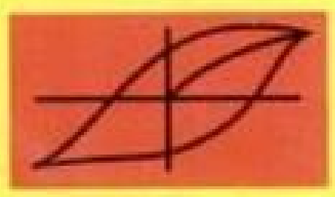

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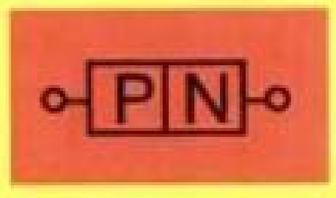

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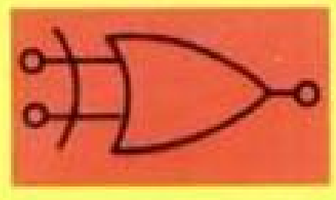

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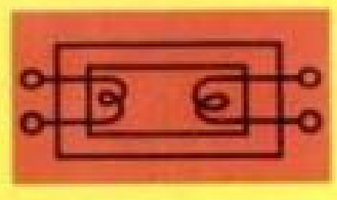

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CHAPTER 1

FUNDAMENTALS OF ELECTRICITY

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CHAPTER 1

FUNDAMENTALS OF ELECTRICITY

1.1 Unit Vectors and Their Conversion Coordinate Systems. The unit vectors for the cartesian system shown in Fig. 1.1(a) are

$$a_x, a_y, a_z$$

and all three vectors are constant. The unit vectors for the cylindrical coordinate system shown in Fig. 1.1(b) are

$$a_\rho, a_\phi, a_z$$

where a_z is constant

The unit vectors for the spherical co-ordinate system shown in Fig. 1.1(c) are

$$a_r, a_\theta, a_\phi$$

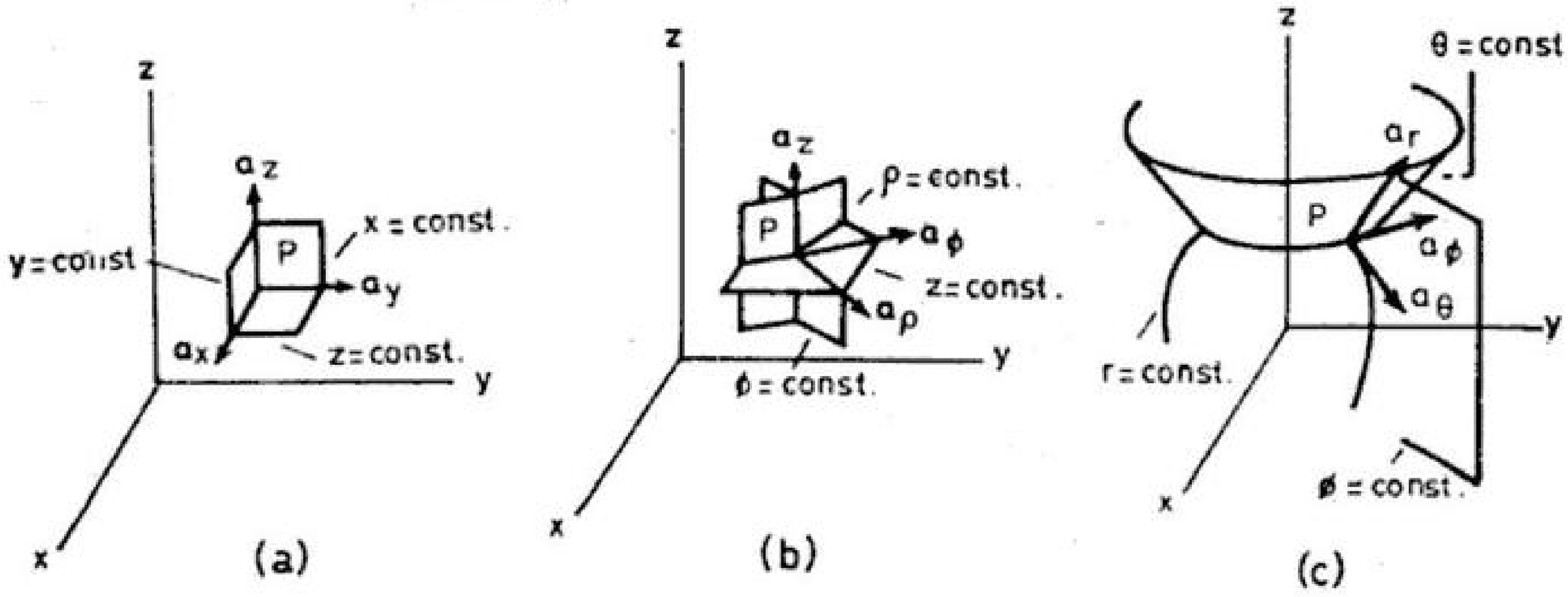


Fig. 1.1

Conversion between cartesian and cylindrical:

$$x = r\cos\phi; \qquad r = \sqrt{x^2 + y^2}$$

$$y = r\sin\phi; \qquad \phi = \tan^{-1}(y/x)$$

$$z = z; \qquad z = z$$

$$\begin{bmatrix} \hat{a}_x \\ \hat{a}_y \\ \hat{a}_z \end{bmatrix} = \begin{bmatrix} \cos\phi & -\sin\phi & 0 \\ \sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \hat{a}_r \\ \hat{a}_\phi \\ \hat{a}_z \end{bmatrix}$$

$$\begin{bmatrix} \hat{a}_r \\ \hat{a}_\phi \\ \hat{a} \end{bmatrix} = \begin{bmatrix} \cos\phi & \sin\phi & 0 \\ -\sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \hat{a}_x \\ \hat{a}_y \\ \hat{a}_z \end{bmatrix}$$

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Conversion between cartesian and spherical:

$$x = r\sin\theta.\cos\phi\,; \qquad r = (x^2+y^2+z^2)^{1/2}$$

$$x = r\sin\theta.\sin\phi\,; \qquad \theta = \tan^{-1}[(x^2+y^2)^{1/2}/z]$$

$$z = r\cos\theta\,; \qquad \phi = \tan^{-1}(y/x)$$

$$\begin{bmatrix}\hat{a}_x\\ \hat{a}_y\\ \hat{a}_z\end{bmatrix} = \begin{bmatrix}\sin\theta\cos\phi & \cos\theta\cos\phi & -\sin\phi\\ \sin\theta\sin\phi & \cos\theta\sin\phi & \cos\phi\\ \cos\theta & -\sin\theta & 0\end{bmatrix}\begin{bmatrix}\hat{a}_r\\ \hat{a}_\theta\\ \hat{a}_\phi\end{bmatrix}$$

$$\begin{bmatrix}\hat{a}_r\\ \hat{a}_\theta\\ \hat{a}_\phi\end{bmatrix} = \begin{bmatrix}\sin\theta\cos\phi & \sin\theta\sin\phi & \cos\theta\\ \cos\theta\cos\phi & \cos\theta\sin\phi & -\sin\theta\\ -\sin\phi & \cos\phi & 0\end{bmatrix}\begin{bmatrix}\hat{a}_x\\ \hat{a}_y\\ \hat{a}_z\end{bmatrix}$$

1.2 The Coulomb's Law. Charges of same polarity repel one another and that of opposite polarity attract each other. The force (F) between the two charges q_1 and q_2 as shown in Fig. 1.2 is

(*i*) directly proportional to the product of the charges q_1 and q_2 ;

(*ii*) inversely proportional to the square of distance d between them;

(*iii*) depends on the nature of medium surrounding the charges. Mathematically

$$F \propto \frac{q_1 \cdot q_2}{d^2} \cdot \bar{a}_r$$

$$F = \frac{q_1 \cdot q_2}{4\pi\,\varepsilon_r\,\varepsilon_0\,d^2}\,\bar{a}_r \text{ Newton}$$

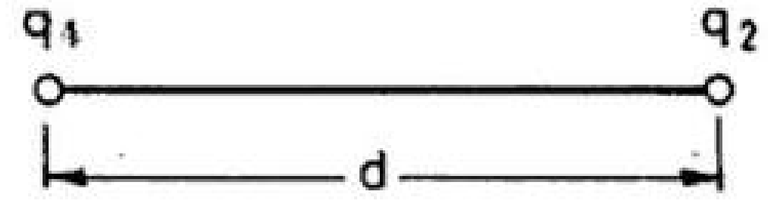


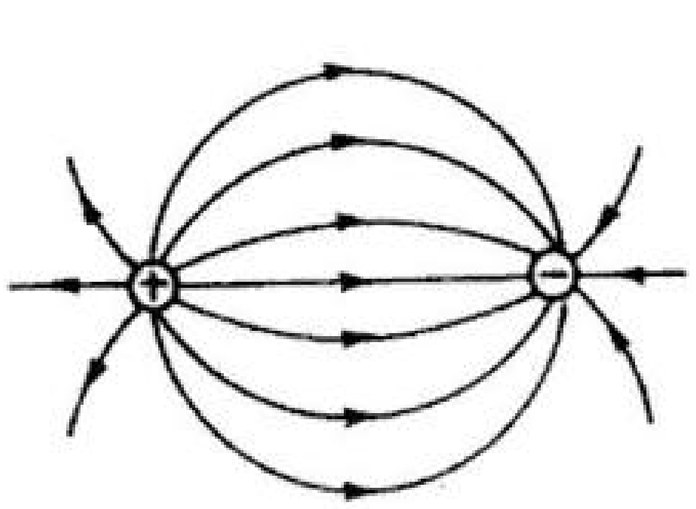
Fig. 1.2

where ε_0 is the permittivity of air and its value is $8{\cdot}854 \times 10^{-12}$ F/m, ε_r is the relative permittivity of surrounding medium with respect to air and $\bar{a}_r$ is the unit vector pointing in direction of line joining the two charges.

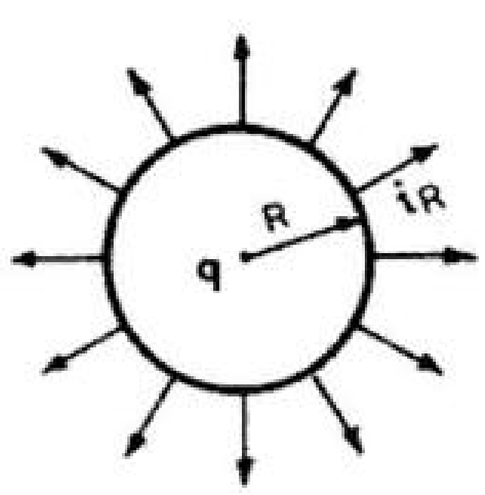
1.3 Electric Field Intensity. The space around the charge which is under stress, and experiences a force on another charge when placed there, is known as electrostatic field. This is illustrated in Fig. 1.3 (a).

If the force $\bar{F}$ experienced by a resting positive charge q_0 placed at a point as shown in Fig. 1.3 (b) at a distance R metres from the charge of q, then the field intensity is defined as:

$$\bar{E} = \frac{\bar{F}}{q_0}$$



(a)



(b)

Fig. 1.3

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Thus field intensity is a vector in the direction of the force. Its value is given by

$$\bar{E} = \frac{q}{4\pi \varepsilon_r \varepsilon_0 R^2} \bar{i}_R \text{ Newton/Coulomb}$$

where $\bar{i}_R$ is the unit factor along the distance R and directed away from the charge.

1.4 Electric Dipole Moment. It is a vector p whose magnitude is $2aq$ and direction is from the negative to positive charge.

When the dipole is placed in a uniform external electric field $\bar{E}$, as shown in Fig. 1.4, the two charges experience equal and opposite forces.

$$\bar{F} = q\bar{E}$$

Thus the net force on the dipole is zero but there is a net torque τ about an axis at point P at right angles to the plane of the paper.

$$\begin{aligned}\tau &= 2F\,(a\sin\theta)\\ &= 2\,(qE)\,(a\sin\theta)\\ &= 2aqE\sin\theta\\ &= pE\sin\theta\end{aligned}$$

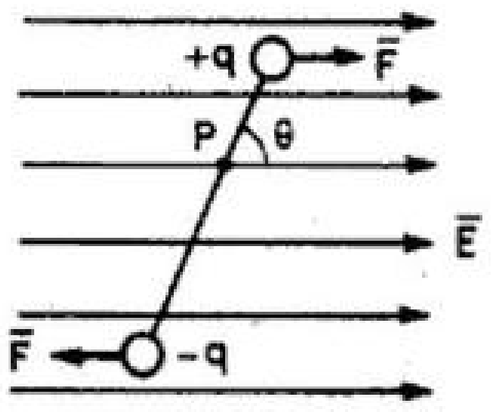


Fig. 1.4

Thus torque is the product of magnitude of force and the perpendicular distance between the forces.

In vector form,

$$\bar{\tau} = \bar{p} \times \bar{E}$$

In order to change the orientation of the electric dipole placed in an external field, some amount of work is to be done and this work is stored as potential energy in the system.

If the dipole is to be rotated from its reference vertical position (*i.e.* $\theta = 90^\circ$) to angle θ, the potential energy is given by

$$U = \int_{90^\circ}^{\theta} \tau\, d\theta = \int_{90^\circ}^{\theta} pE\sin\theta\, d\theta = -pE\cos\theta$$

or

$$U = -\bar{p} \cdot \bar{E}$$

1.5 Flux of an Electric Field. It refers to a hypothetical surface, closed or open and is measured by the numbers of lines of force cut through the surface. An arbitrary closed surface can be divided into a large number of infinitesimal surfaces represented by a vector $\Delta \bar{S}$ whose direction is at right angle to the small surface as illustrated in Fig 1.5. Then its flux can be defined as

$$\Delta \Phi_e = \bar{E} \cdot \Delta \bar{S} = E\, \Delta S \cos\theta$$

which means it is the product of ΔS and component of $\bar{E}$ parallel to vector $\Delta \bar{S}$ or at right angles to the surface. If both vectors point in the same direction, the flux is positive otherwise negative.

For the whole surface,

$$\Phi_e = \oint_S \bar{E} \cdot d\bar{S}$$

The electric field intensity of a point charge is thus directed everywhere radically away from the point charge, and on any spherical surface at the point charge, its magnitude is constant.

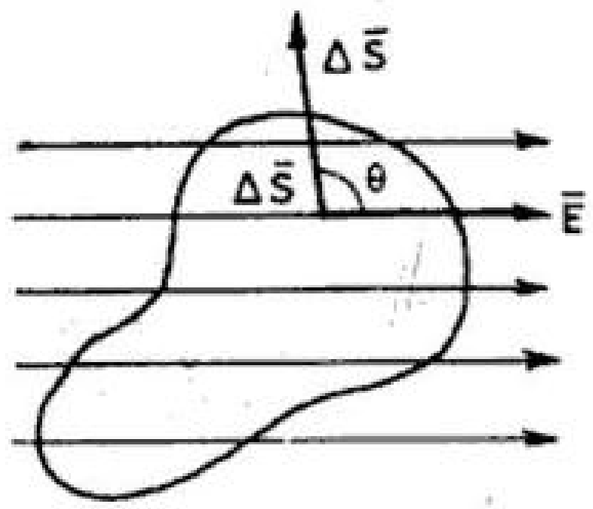


Fig. 1.5

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1.6 Electric Field of Many Charges. If there are several point charges $q_1, q_2, q_3 \ldots q_n$ located at different points, then by superposition, the force $\bar{F}$ experienced by a test charge situated at a point, is the vector sum of the forces experienced by the test charge due to the individual charges.

$$\bar{F} = \frac{q_1 q}{4\pi \varepsilon_0 R_1^2} \bar{i}_{R_1} + \frac{q_2 q}{4\pi \varepsilon_0 R_2^2} \bar{i}_{R_2} + \ldots \frac{q_n q}{4 \varepsilon_0 R_n^2} \bar{i}_{R_n}$$

The electric field intensity at point P will be

$$\bar{E} = \frac{\bar{F}}{q} = \frac{q_1}{4\pi \varepsilon_0 R_1^2} \bar{i}_{R_1} + \frac{q_2}{4\pi \varepsilon_0 R_2^2} \bar{i}_{R_2} + \ldots \frac{q_n}{4\pi \varepsilon_0 R_n^2} \bar{i}_{R_n}$$

$$= \sum_{j=1}^{n} \frac{q_j}{4\pi \varepsilon_0 R_j^2} \bar{i}_{R_j}$$

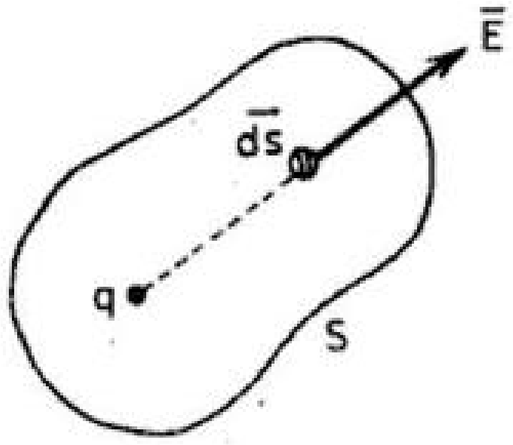


Fig. 1.6

1.7 The Gauss's Law of Electricity. The surface integral of the normal component of electric field intensity $\bar{E}$ over a closed surface containing point charge q as shown in Fig 1.6 is given by

$$\oint \bar{E} \,.\, d\bar{S} = \frac{q}{\varepsilon_0}$$

This can be interpreted as the net flux of electric field emanating from the surface S containing a point charge q is equal to q/ε_0. If this arbitrary surface does not enclose the point charge, the net electric field flux emanating from the surface must be zero, i.e.

$$\oint \bar{E} \,.\, d\bar{S} = 0$$

If there are more than one point charges enclosed, then the above equation can be generated as follows

$$\oint_S \bar{E} \,.\, d\bar{S} = \oint_S \bar{E}_1 \,.\, d\bar{S} + \oint_S \bar{E}_2 \,.\, d\bar{S} + \oint_S \bar{E}_3 \,.\, d\bar{S} + \ldots$$

$$= \frac{q_1 + q_2 + \ldots q_n}{\varepsilon_0} = \frac{\text{charge enclosed by the surface } S}{\varepsilon_0}$$

An important outcome of this law is that excess charge placed on an insulated conductor resides entirely on its outer surface.

1.8. The Gauss's Law in Differential Form. Consider a volume distribution with the charge density ρ. The charge enclosed by arbitrary closed surface S is given by the volume integral of charge density throughout the volume V enclosed by surface, that is $\int_V \rho dv$. According to Guass's law

$$\oint_S \bar{E} \,.\, d\bar{S} = \frac{1}{\varepsilon_0} \int_V \rho dv$$

If the volume is shrunk to a very small Δv, the surface area becomes very small ΔS

$$\lim_{\Delta V \to 0} \oint_{\Delta S} \frac{\bar{E} \,.\, d\bar{S}}{\Delta V} = \lim_{\Delta V \to 0} \frac{\left(\frac{1}{\varepsilon_0}\right) \oint \rho dv}{\Delta V} = \frac{1}{\varepsilon_0} \lim_{\Delta V \to 0} \frac{\rho \Delta V}{\Delta V} = \frac{1}{\varepsilon_0} \,.\, \rho$$

or

$$\Delta \bar{E} = \frac{1}{\varepsilon_0} \rho$$

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This equation is *Gauss's* law in differential form. It states that the divergence of electric field intensity at any point is equal to $1/\varepsilon_0$ times the volume charge density at that point. This is *Maxwell's divergence equation* for electric field.

1.9 Electrical Potential. The electric field is a force field so far the charges are concerned, there is work associated with the movement of the charges in an electric field. If a force exerted by the field on the charge is in the direction moved against the direction of the field, and external agent has to supply the energy to overcome the force exerted on the charge by the field. This force is opposite to the direction of movement of the charge.

Consider the displacement of test charge q by an infinitesimal distance $\bar{dl}$ from A to B at an angle with the electric field $\bar{E}$ at a point A as shown in Fig. 1.7. The force exerted on the test charge by the field has magnitude qE and is directed along E. Its component along the line from A to B is $qE\cos\alpha$. If the charge is moved from A to B, the amount of work done dW by the field is the product of force and displacement.

$$dW = qE\cos\alpha\, \bar{dl} = q\bar{E}\,.\,\bar{dl}$$

where $\bar{dl}$ is the vector from A to B.

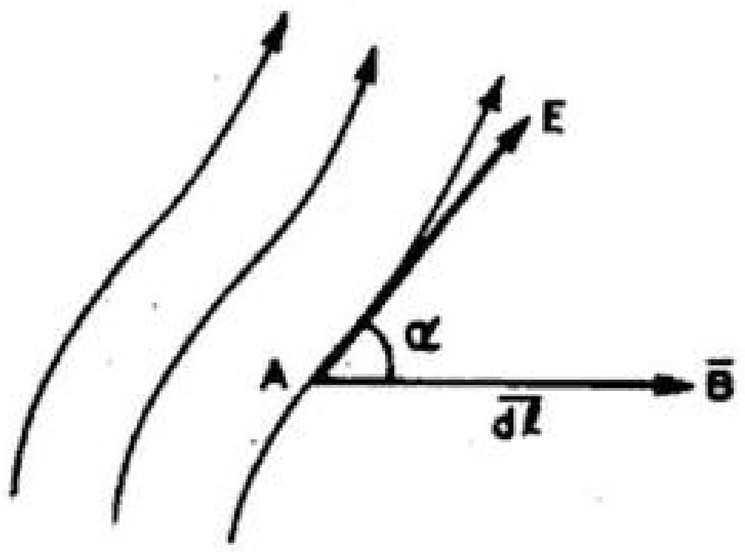


Fig. 1.7

The work done W_{AB} by the field in moving a test charge q from A to B along a given path can be obtained by dividing the path into several segments of infinitesimal length dl.

The result is a line integral expression given by

$$W_{AB} = q\int_A^B \bar{E}\,.\,\bar{dl}$$

The test charge has certain potential energy associated with it by virtue of its location in the electric field. W_{AB} as given by the above equation is then the loss of potential energy associated with the movement of the charge from A to B. Dividing W_{AB} by q gives the potential energy per unit charge. This quantity denoted by V_{AB} is known as the *potential difference* between the points A and B. Thus

$$V_{AB} = \frac{W_{AB}}{q} = \int_A^B \bar{E}\,.\,\bar{dl}$$

If V_{AB} is positive, there is a potential energy associated with the movement of the charge from A to B, that is, the field does the work. If V_{AB} is negative, there is a gain in potential energy associated with the moment of the charge from A to B, that is an external agent has to do the work.

1.10 Electric Potential due to a Charge. If point A is taken to be at infinity and potential at infinity is taken to be zero, then the potential V at a point B will be

$$V = -\int_{\infty}^{B} \bar{E}\,.\,\bar{dl} = -\int_{\infty}^{r} \frac{q}{4\pi\varepsilon_r\varepsilon_0 r^2}\,dr$$

$$= -\frac{q}{4\pi\varepsilon_r\varepsilon_0}\left[\frac{1}{r}\right]_{\infty}^{r} = \frac{q}{4\pi\varepsilon_r\varepsilon_0 r}$$

Since field intensity is the variation of potential with the distance, it can also be visualised as potential gradient. If potential for all points of space are known, the components of E and thus E itself can be found by taking the following derivatives.

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Therefore electric potential energy $U = Vq_2$

$$= \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$$

1.14 Maxwell's Curl Equations for Static Field. Since the potential difference between two points A and B is independent of the path followed from A to B, therefore for two paths ACB and ADB, as shown in Fig. 1.9.

$$\int_{ACB} \bar{E} \cdot d\bar{l} = \int_{ADB} \bar{E} \cdot d\bar{l}$$

or $$\int_{ACB} \bar{E} \cdot d\bar{l} - \int_{ADB} \bar{E} \cdot d\bar{l} = 0.$$

or $$\int_{ACB} \bar{E} \cdot d\bar{l} + \int_{BDA} \bar{E} \cdot d\bar{l} = 0$$

or $$\oint_{ACBDA} \bar{E} \cdot d\bar{l} = 0$$

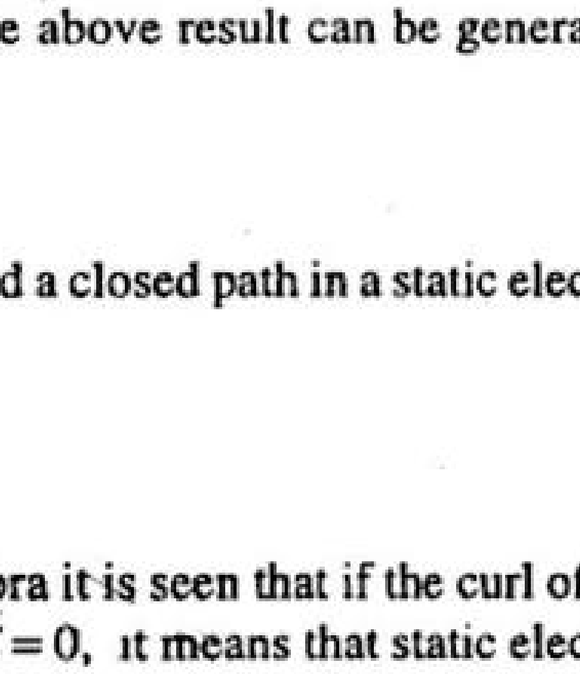


Fig. 1.9

The integral is taken around a closed path. By superposition, the above result can be generalised for discrete or continuous charges as

$$\oint \bar{E} \cdot d\bar{l} = 0$$

This implies that the work involved in moving a test charge around a closed path in a static electric field is equal to zero.

In differential form, this can be written as:

$$\nabla \times \bar{E} = 0$$

1.15 Electric Field Intensity and Potential. From vector algebra it is seen that if the curl of a vector is zero, the vector can be expressed as gradient of a scalar. Since $\nabla \times \bar{E} = 0$, it means that static electric field $\bar{E}$ can be expressed as the gradient of the scalar.

In Fig. 1.10, since E is normal to the equipotential surfaces and the direction of the gradient of the scalar function at any point is normal to the surface passing through that point and on which the scalar function is of constant value, this implies that the vector $\bar{E}$ can be expressed as the gradient of potential *i.e.* V

The potential difference between point A and B is

$$-\Delta V = \int_A^B \bar{E} \cdot d\bar{l}$$

$$= -E_A \Delta l \cdot \cos\theta = -E_A \Delta n$$

or $$E_A = \frac{\Delta V}{\Delta n}$$

and $$\bar{E}_A = \frac{\Delta V}{\Delta n}\bar{i}_n$$

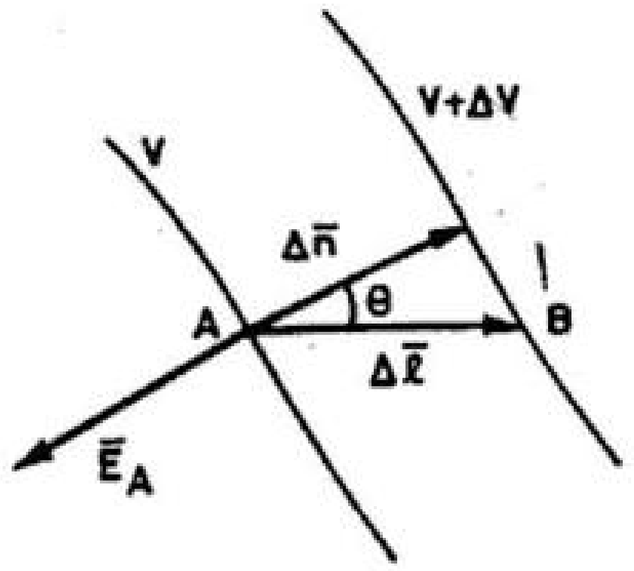


Fig. 1.10

(where $\Delta \bar{n}$ is a normal vector at right angles at point A)

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1.18 Magnetic Flux Density. $\bar{F}_1$ and $\bar{F}_2$ are two non-zero forces for two velocities v_1 and v_2 in different directions in the magnetic field $\bar{B}$. Then

$$\bar{F}_1 \times \bar{F}_2 = (qv_1 \times \bar{B}) \times (q\bar{v}_2 \times \bar{B})$$

$$= q^2 (\bar{v}_1 \times \bar{B} \,.\, \bar{B})\, \bar{v}_2 - (\bar{v}_1 \times \bar{B} \,.\, \bar{v}_2)\, \bar{B}$$

$$= -q (\bar{F}_1 \,.\, \bar{v}_2)\, \bar{B}$$

or
$$\bar{B} = \frac{\bar{F}_2 \times \bar{F}_1}{q (\bar{F}_1 \,.\, \bar{v}_2)}$$

If the maximum force on q_0 is $\bar{F}_m$ and the direction of $\bar{v}$ is $\bar{i}_m$, then

$$\bar{B} = \frac{\bar{F}_m \times \bar{i}_m}{q\,\bar{v}}$$

Therefore unit of
$$\bar{B} = \frac{\text{Newton per Coulomb}}{\text{metre per second}} = \frac{\text{Newton second}}{\text{Coulomb . metre}}$$

$$= \frac{\text{Newton . metre}}{\text{Coulomb}} \times \frac{\text{second}}{(\text{metre})^2}$$

Now since Newton metre per Coulomb is a Volt, unit of B = Volts-second per square metre, commonly known as Weber per metre^2 or Wb/m^2.

1.19 Force on a Conductor. Force on current carrying conductor in magnetic field is given by

$$\bar{F} = i\bar{l} \times \bar{B}$$

$$= BIl \sin \theta$$

The direction of force can be determined by applying Flemming's Left Hand Rule: The thumb, forefinger and middle finger of the left hand are stretched in such a way that they are at right angles to each other mutually. Then the forefinger points towards the direction of the magnetic field, middle finger towards the direction of the flow of current, and the thumb will be in the direction of force acting on the conductor (Fig. 1.12).

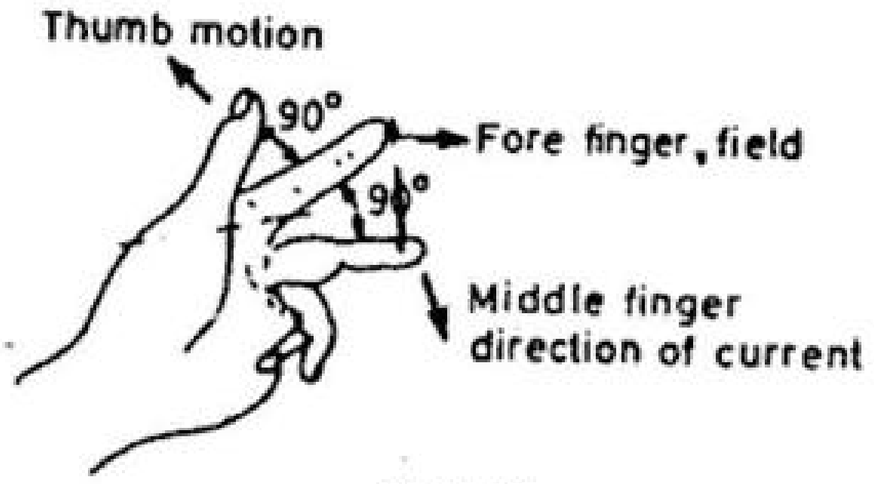


Fig. 1.12

1.20 Force on a Current Carrying Wire. The total force experienced by a filamentary wire carrying current I as shown in Fig. 1.13 is given by

$$\bar{F} = \int_{\text{wire}} (Id\bar{l} \times \bar{B})$$

$$= I \int_{\text{wire}} (d\bar{l} \times \bar{B})$$

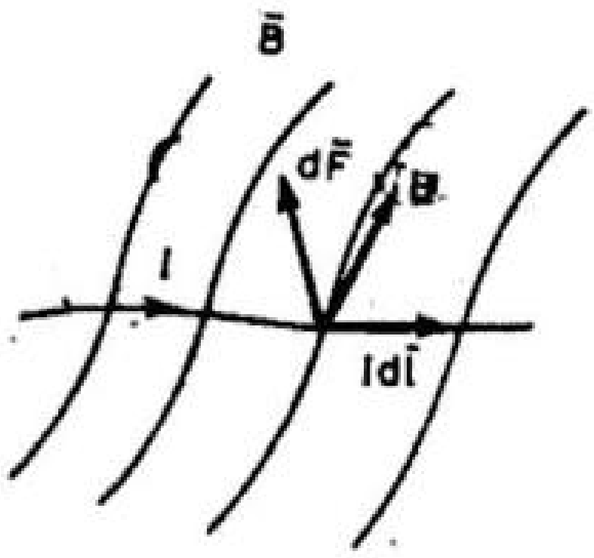


Fig. 1.13

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$$\text{Now, } |\nabla \times \bar{B}| = \text{ maximum value of } \lim_{\Delta S \to 0} \frac{\int \bar{B} \cdot d\bar{l}}{\Delta S} = \mu_0 |\bar{J}|$$

and Direction of $\nabla \times \bar{B}$ = direction of $\bar{J}$

so that $$\nabla \times \bar{B} = \mu_0 \bar{J}$$

1.28. Magnetic Field due to Current Carrying Conductor. When current flows through a conductor, magnetic field is produced around it. If the direction of current is upwards as shown by a dot in Fig. 1.18, then the direction of lines of force is anti-clockwise. On the other hand, if the current is flowing downwards (shown by a cross), the direction of force is clockwise.

The direction of magnetic field around straight current carrying conductor may be determined by Cork Screw Rule: If the right- handed cork screw held with its axis parallel to the direction of flow of current, is rotated in such a direction that the hand of the screw moves in direction of flow of current, then the direction of rotation of the head will be the direction of magnetic field.

1.29. The Gauss's Law for Magnetism. According to this law, the flux Φ_B due to the magnetic field B through any closed gaussion surface must be zero. That is

$$\Phi_B = \oint \bar{B} \cdot d\bar{S} = 0.$$

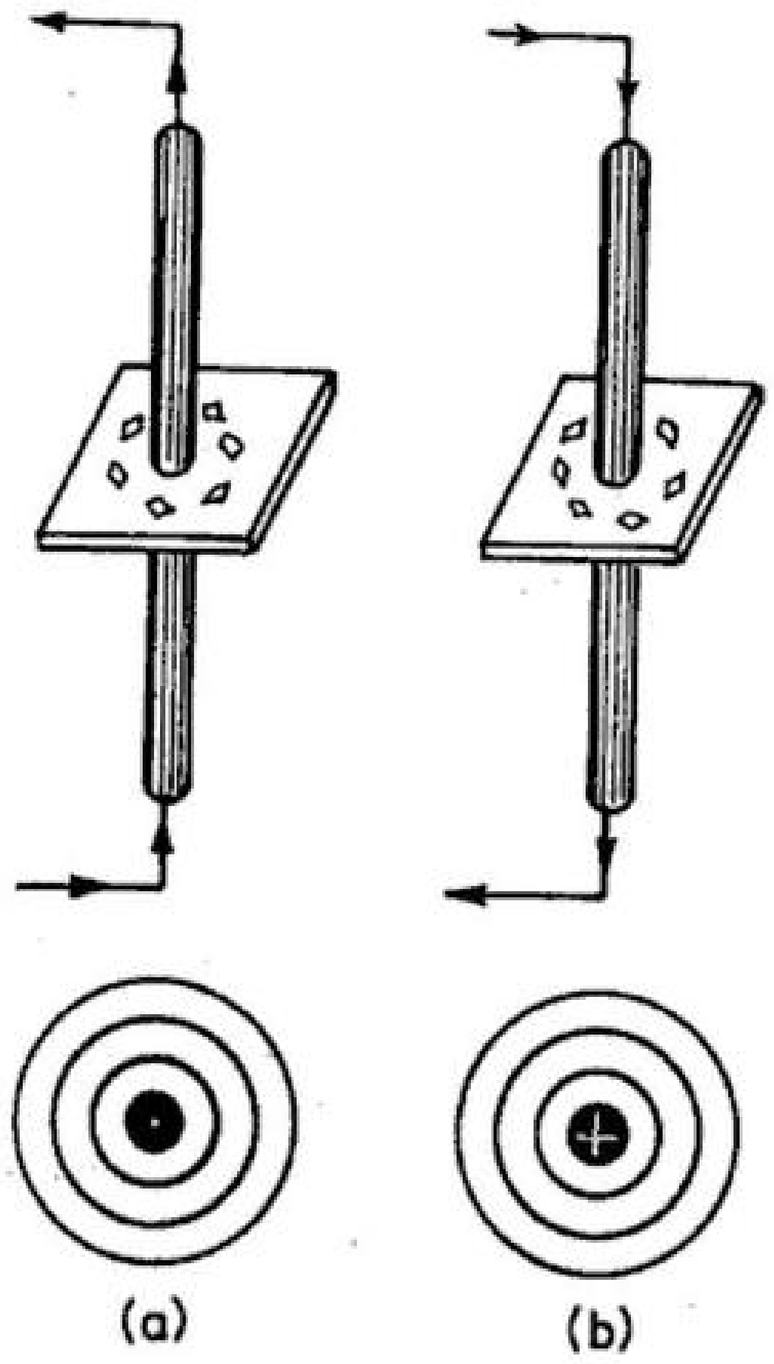


Fig. 1.18

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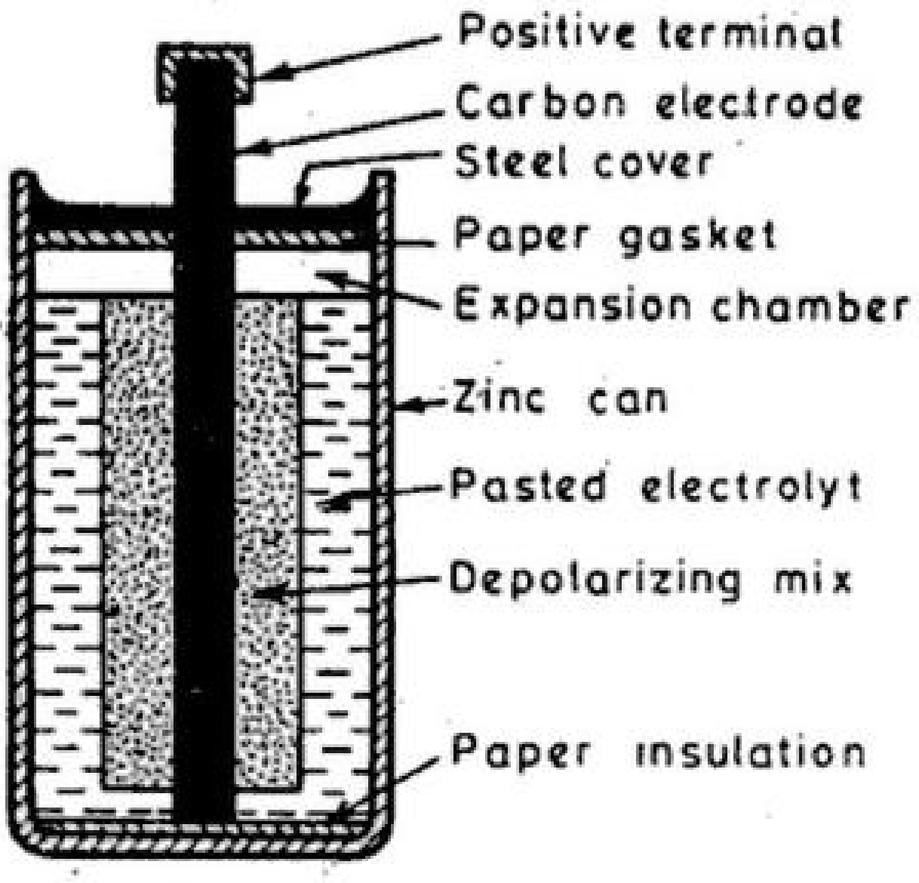
62. One Newton-meter is equal to
   A. one watt
   B. one joule-ampere
   C. one volt-ampere
   D. one joule

63. The unit of electric energy is
   A. Watt
   B. joule-second
   C. kW hr.
   D. Volt-Ampere

64. One volt is equal to
   A. one joule
   B. one coulomb per joule
   C. one joule per coulomb
   D. work done in shifting one coulomb

65. The electromotive force is
   A. the torque produced by a motor
   B. the force experienced by an electromagnet
   C. the force with which the current carrying conductors attract or repel each other
   D. the voltage produced by a voltage source

66. The cell shown in figure given below is a



   A. zinc-brass cell
   B. zinc-carbon cell
   C. depolarization cell
   D. zinc-electrolyte cell

67. The voltage is supplied by the cell shown in the above figure is
   A. approximately 0.5 V
   B. approximately 1.11 V
   C. approximately 1.5 V
   D. approximately 1. 74 V

68. The voltage supplied by one cell of a lead acid battery is
   A. approximately 0.5 V
   B. approximately 1.11 V
   C. approximately 1.6 V
   D. approximately 2 V

69. Which of the following statements about the zinc-carbon cell is true?
   A. The zinc container has a potential of 1.5 V against the carbon electrode
   B. The air in the air space is needed for the oxidation of zinc.
   C. When current is drawn from the cell the carbon rod is partly consumed.
   D. The depolarizer mainly contains brown iron ore and carbon powder

70. The function of the depolarizer in a carbon-zinc cell is that
   A. it converts the produced hydrogen into water
   B. it prevents the fast chemical action on the zinc container
   C. it synthesizes the decomposed electrolyte
   D. its absorbs the oxygen produced in the cell

71. The density of the acid in a lead acid battery gives an indication of
   A. eventual damages caused to the plates
   B. the level of the acid.
   C. the e.m.f. of the battery
   D. the charge of the battery

Answers : 62. (D), 63. (C), 64. (C), 65. (D), 66. (B), 67. (C), 68. (D), 69. (D), 70. (A), 71. (D)

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105. Which medium has highest value of dielectric strength?
   A. Mica
   B. Porcelain
   C. Quartz
   D. Glass.

106. Two capacitors of breakdown voltage 250 V are connected in series. The breakdown voltage of combination will be
   A.
   B. $125 \times \sqrt{2}$ V
   C.
   D. 500 V

107. The maximum value of potential gradient in a cable occurs in
   A. conductor
   B. insulation
   C. outer sheath
   D. None of these.

108. The minimum value of potential gradient in a cable occurs in
   A. conductor
   B. insulation
   C. outer sheath
   D. None of these.

109. Coulomb's law for the force between electric charges closely resembles with
   A. Newton's law of motion
   B. Law of conservation of energy
   C. Gauss's theorem
   D. Newton's law of gravitation

110. A charged oil drop is stationary between a pair of horizontal parallel plates. If the drop carries a charge 3.2×10^{-10} coulomb and has a mass 1.6×10^{-19} kg, then the potential difference between the plates is
   A. 50 V
   B. 80 V
   C. 100 V
   D. cannot be calculated on the basis of the information given.

111. A region around a stationary electric charge has
   A. magnetic field
   B. electric field
   C. both magnetic and electric field
   D. neither magnetic nor electric field.

112. Inside a hollow spherical conductor
   A. electric field is zero
   B. electric field is constant
   C. electric field changes with the magnitude of the charge given to the conductor
   D. electric field changes with distance from the centre of the sphere.

113. 1 Volt/metre is the same as
   A. 1 Newton metre
   B. 1 Newton/metre
   C. 1 Joule/coulomb
   D. 1 Meter/coulomb

114. One thousand electrons, each of which carries a charge of -1.6×10^{-12} coulomb are removed from an initially neutral pitch ball. The resulting charge on the pitch ball is
   A. 1.6×10^{-15} Coulomb
   B. 1.6×10^{23} Coulomb
   C. -1.6×10^{15} Coulomb
   D. -1.6×10^{23} Coulomb

115. If small charged drops are combined to give a bigger drop, the rise in potential will be
   A. directly proportional to the radius of the bigger drop
   B. directly proportional to the square of the radius of the bigger drop
   C. inversely proportional to the square of the radius of the bigger drop
   D. inversely proportional to the radius of the bigger drop.

116. Midway between two equal and similar charges, a third equal and similar charge is placed, then this third charge will
   A. remain in stable equilibrium
   B. be in unstable equilibrium
   C. not be in equilibrium
   D. will move out of the field to influence the two charges.

Answers : 105. (A), 106. (D), 107. (A), 108. (B), 109. (D), 110. (D), 111. (B), 112. (A), 113. (B), 114. (A), 115. (A), 116. (A)

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C. Metallic plate variable gang condenser

D. Matallic paper capacitor.

158. A 0.1 μF capacitor has voltage increasing linearly at the rate of 100 volts each *m sec*. The current flowing through the capacitor will be

A. zero B. 10 mA

C. 100 mA D. 1 A.

159. A 0.01 μF capacitor has its charge increasing on one plate and decreasing on the other at the rate of 0.03 coulomb/sec. The current flowing through the capacitor will be

A. zero B. 10 mA

C. 100 mA D. 1 A

160. In a capacitor, the electric charge is stored in

A. dielectric

B. metal plates

C. dielectric as well as metal plates

D. neither dielectric nor metal plates.

161. A constant current of 5 mA charges a 10 μF capacitor in 1 sec. How much is the voltage across the capacitor?

A. 50 V B. 250 V

C. 500 V D. 1000 V

162. Two plates each with an area 2 square metre are separated by 1 cm with air as dielectric. The value of capacitance will be

A. 10 μF B. 1200 μF

C. 17 μF. D. 1770 pF

163. A capacitance is charged to 100 V and has 100 micro coulombs of charge. The value of capacitance will be

A. 10 μF B. 100 μF

C. 10 pF D. 100 pF.

164. A mica capacitor and ceramic capacitor have the same physical dimensions. Which has higher value of capacitance?

A. Mica capacitor

B. Ceramic capacitor

C. Both have identical value of capacitance

D. Nothing can be concluded on the basis of the information given

165. For the same rating which capacitor is physically smaller?

A. Paper capacitor

B. Ceramic capacitors

C. Both have identical dimensions

D. None of these

166. A 10 μF capacitor charged to 10 *V* has a stored energy equal to

A. 1 μC

B. 10 μC

C. 100 μC

D. 1000 μC

167. Voltage applied across a ceramic dielectric produces an electrostatic field 100 times greater than in air. The dielectric constant ε of the ceramic equals

A. 100/3 B. 50

C. 100 D. 1/100

168. A six dot mica capacitor colour coded, white, red, green, brown, red and yellow has the capacitance value of

A. 25 pF B. 124 pF

C. 250 pF D. 925 pF

169. The charge in a 4 μF capacitor charged to 100 V will be

A. 4 μC B. 25 μC

C. 100 μC D. 400 μC

170. A capacitance has a value of 100 pico farads. It means

A. capacitor can withstand breakdown voltage of 100 kilovolts.

B. capacitor must be tubular in shape with length not more than 100 mm

Answers : 158. (A), 159. (B), 160. (A), 161. (C), 162. (D), 163. (A), 164. (B), 165. (B), 166. (C), 167. (C), 168. (C), 169. (D).

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induction and then attracted towards the charging body

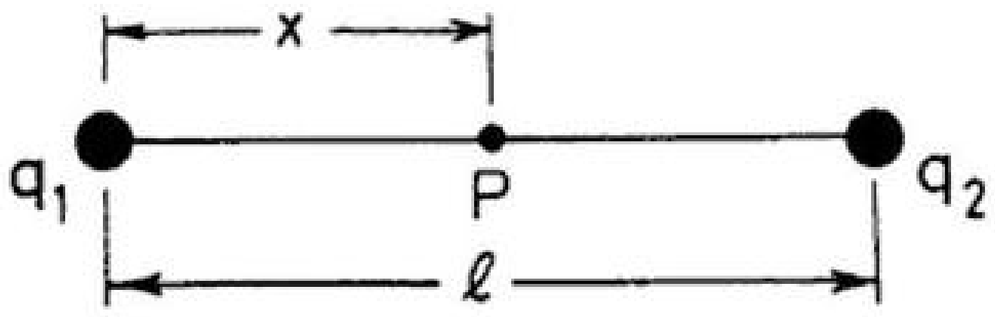
D. the uncharged conductor gets charged by conduction

208. A capacitor has capacity C, when air is present in the two plates. A dielectric of value ε is placed between the plates. The new capacity will be

A. C/ε B. εC

C. ε/C D. $1/\varepsilon C$

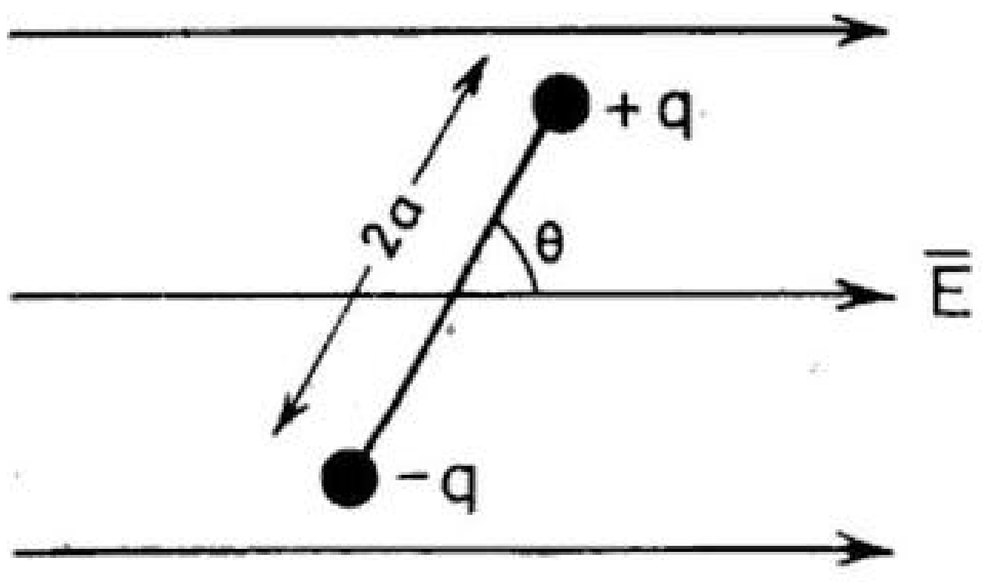
209. In the figure shown the condition for electric field to be zero at point P is



A. $\frac{q_1}{q_2} = \frac{x^3}{(l-x)^3}$ B. $\frac{q_1}{q_2} = \frac{x}{(l-x)}$

C. $\frac{q_1}{q_2} = \frac{x^2}{(l-x)^2}$ D. $\frac{q_1}{q_2} = \frac{(l-x)^2}{x^2}$

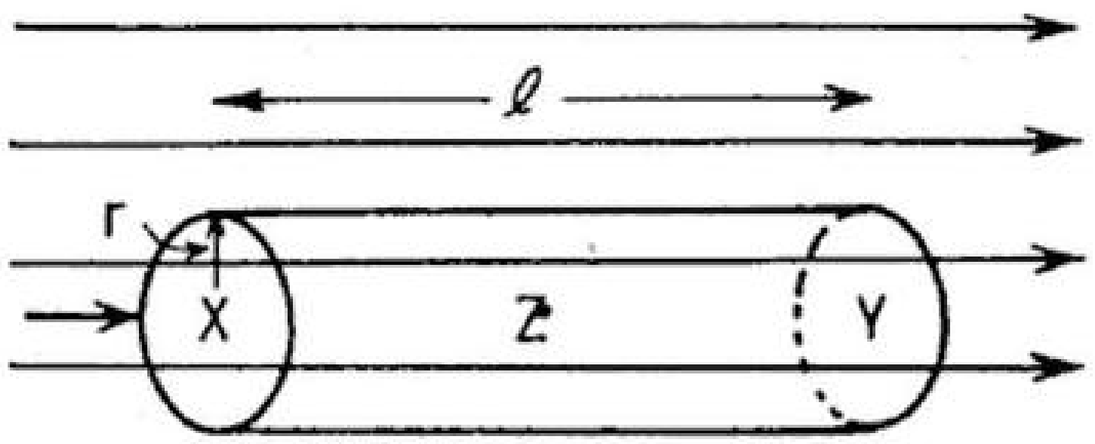
210. The work done by an external agent to turn the dipole from the position of $\theta = 0°$ to $\theta = 180°$ is



A. aqE B. $2aqE$

C. $(aqE)/2$ D. Zero.

211. A cylinder of radius r is immersed in a uniform field E, the cylinder axis is parallel to the field as shown in figure below. The flux for the surface marked X is



A. $-2E\pi r$ B. $-Er^2$

C. $+E\pi r^2$ D. Zero.

212. In the above question, the flux for the surface marked Y is

A. $-E\pi r$ B. $-E\pi r^2$

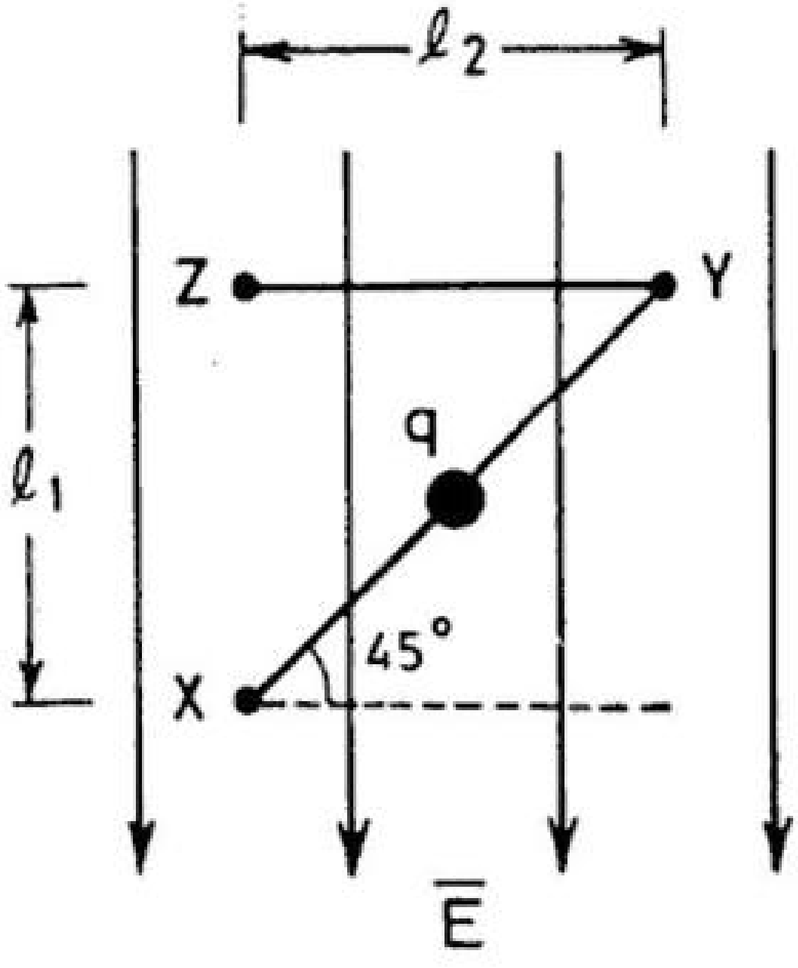
C. $+E\pi r^2$ D. Zero

213. In the same question, the flux for the whole cylinder is

A. $E\pi rl$ B. $E\,2\pi rl + 2E\pi r^2$

C. $2E\pi rl - 2E\pi r^2$ D. Zero

214. In the figure shown, a test charge q moves without acceleration from point X to Z on the path shown. The potential difference between



Answers : 208. (B), 209. (C), 210. (B), 211. (B), 212. (C), 213. (D).

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C. inside the conductor

D. None of these.

241. The electric field at a point situated at a distance 'd' from straight charged conductor is

A. proportional to d

B. inversely proportional to 'd'

C. inversely proportional to d^2.

D. None of these.

242. One coulomb charge equals the charge on

A. $6.42 \times .10^{18}$ electrons

B. $6{\cdot}24 \times 10^{18}$ atoms

C. 6.24×10^{12} electrons

D. None of these.

243. One ampere means the flow of

A. one electron each hour

B. one coulomb each second

C. one coulomb each minute

D. None of these.

244. In solids the flow of current is due to

A. atoms B. electrons

C. electrons and ions D. None of these.

245. In gases the flow of current is due to

A. electrons only

B. electrons and positive ions

C. electrons, positive ions and negative ions

D. None of these.

246. A capacitor stores 0.12 coulombs at 5 volts. Its capacitance is

A. 0.6 F B. 0.12 F

C. 0.024 F D. None of these.

247. A 0.1 μF capacitor is connected across a 2 volt battery. After a long time the current in the circuit will be

A. 0.05A B. 0.2 A

C. 0 A D. None of these.

248. If a sheet of bakelite is inserted between the plates of an air capacitor, the capacitance will

A. increase B. decrease

C. remain unchanged D. None of these.

249. A dielectric material must be

A. insulated B. good conductor

C. resistor D. None of these.

250. The capacitance of a capacitor is not affected by

A. area of plates

B. thickness of plates

C. distance between plates

D. None of these.

251. If three 30 μF capacitors are connected in series, the net capacitance is

A. 10 μF B. 60 μF

C. 90 μF D. None of these.

252. If four 10 μF capacitors are connected in parallel, the net capacitance is

A. 2.5 μF. B. 40 μF.

C. 20 μF D. None of these.

253. For making a capacitors, it is better to select a dielectric having.

A. high permittivity

B. low permittivity

C. permittivity same as that of air

D. None of these.

254. A capacitor can be represented by a capacitance and a resistance in parallel. For a good capacitor, this parallel resistance is

A. very high B. very low

C. low D. None of these.

255. An electrolytic capacitor can be used for

A. a.c. only

B. both a.c. as well as d.c.

C. d.c. only

D. None of these.

Answers : 241. (B), 242. (A), 243. (B), 244. (B), 245. (C), 246. (C), 247. (C), 248. (A), 249. (A), 250. (B), 251. (A), 252. (B), 253. (A), 254. (A), 255. (C).

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C. amp-turns D. coulombs

293. The unit of Reluctance is

A. Weber B. Amp-turn (AT)

C. Maxwell D. AT/Weber

294. The force acting on a conductor one metre long carrying a current of 50 amp. at right angles to a magnetic field of 100 mt is

A. 5 N B. 50 N

C. 500 N D. 5000 N

295. The unit of inductance is

A. ohm B. mho

C. farad D. henery

296. The law that induces e.m.f. and current always oppose the cause which produces it, is discovered by

A. Faraday B. Lenz

C. Maxwell D. Leonard

297. Air gap in the iron core prevents

A. eddy current loss B. core separation

C. hystersis D. induction effect.

298. The iron core material used at high frequencies in radio circuits is

A. ferrite

B. material of low permeability

C. material of high permeability

D. material which reduces inductance as well as losses

299. Laminated silicon cores are used for

A. reducing power input

B. reducing copper losses

C. reducing iron losses

D. leakage factor

300. The ratio of total flux to useful flux is called

A. peak factor

B. depreciation factor

C. utilisation factor

D leakage factor

301. A steel bar needs 2000 AT to magnetise it. The voltage required for the magnetising coil of 100 turns and 20 ohms resistance will be

A. 400 V B. 200 V

C. 100 V D. 10 V

302. A coil is used for producing a flux of 0.24×10^{-3} webers. If the current flowing in the coil is 2 amp and the coil has 200 turns, the total m.m.f required to produce the flux will be

A. 200 AT B. 400 AT

C. 100 AT D 40 AT

303. A magnetic ring has reluctance of 1.675×10^{6} AT weber. The flux to be produced by the coil is 800×10^{-6} webers, then the AT required for the m.m.f. will be

A. 1000 AT B. 134 AT

C. 1340 AT D. 13.4 AT

304. Which of the following material is used for making permanent magnet?

A. Brass B. Steel

C. Soft iron D. Copper

305. The only sure proof of testing the polarity of magnetism is

A. attraction and repulsion both

B. attraction

C. repulsion

D. None of these.

306. The electromagnet is made of

A. soft iron core

B. soft iron core with current passing around it

C. steel core

D. steel core with current passing around it

307. When the switch of a electro magnetic circuit is switched off, the sparking at the switch con-

Answers : 292. (C), 293. (D), 294. (A), 295. (D), 296. (B), 297. (B), 298. (A), 299. (C), 300. (D), 301. (A), 302. (B), 303. (C), 304. (B), 305. (C), 306. (B).

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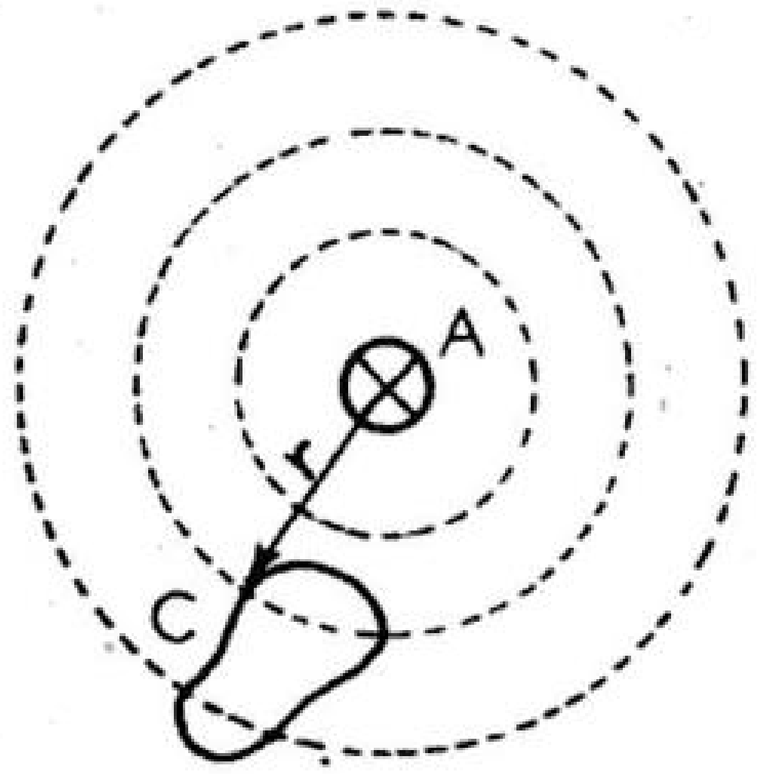


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formed for the counter C will e equal to



A. $\mu_0 I$ B. $\frac{\mu_0}{2\pi r}$

C. $\frac{I}{\mu_0}$ D. Zero.

331. A charge q_0 moving with velocity experiences no force in a region of electric and magnetic fields. If $v = (\bar{i} + \bar{j})$ m/sec
$\bar{B} = (\bar{i} - 2\bar{k})$ Wb/m^2, the electric field $\bar{E}$ will be

A. $(\bar{i} + 2\bar{j} + 2\bar{k})$ V/m

B. $(2\bar{i} - 2\bar{j} + \bar{k})$ V/m

C. $(\bar{i} - \bar{j} + \bar{k})$ V/m

D. None of these

332. The force acting on a charge q moving with velocity in a region of electric field $\bar{E}$ and magnetic field $\bar{B}$ is

A. q B. $q(\bar{B} + \bar{v} \times \bar{E})$

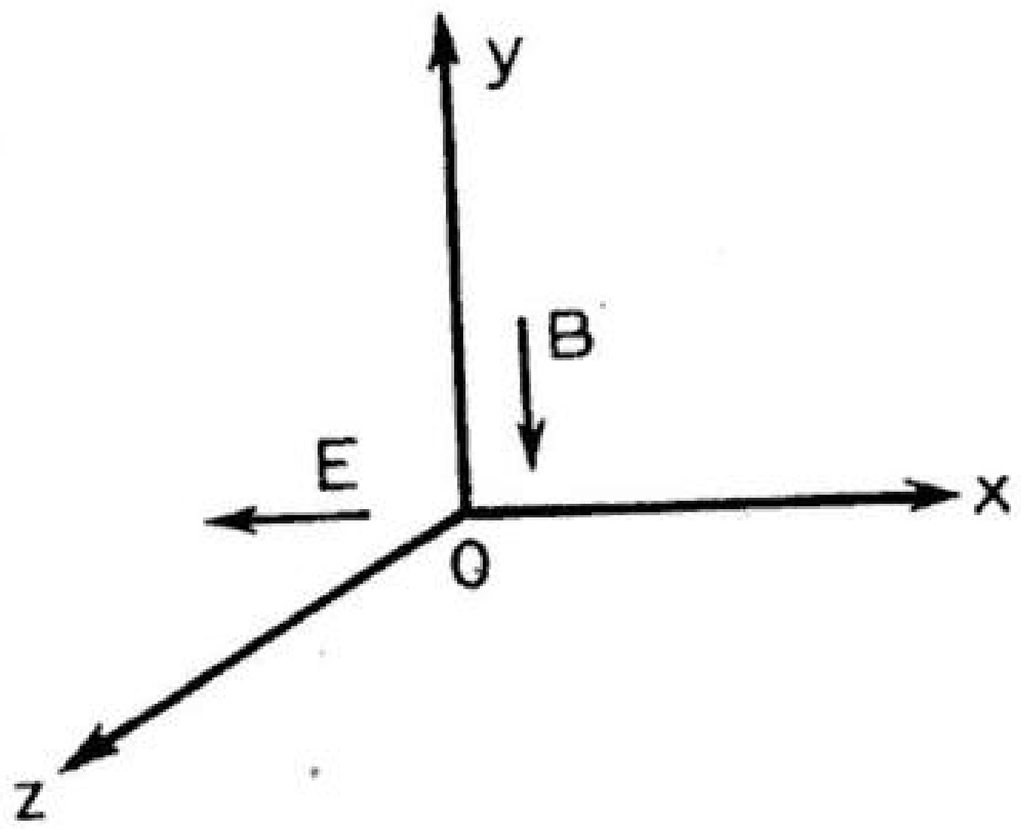
C. $q(\bar{E} + \bar{v} \times \bar{B})$ D. None of these

333. An electric field is parallel but opposed to a magnetic field. Electrons with some initial velocity enter the region of the fields at an angle α along the direction of the electric field. The electron path will be

A. circular B. cycloidal

C. helical D. straight.

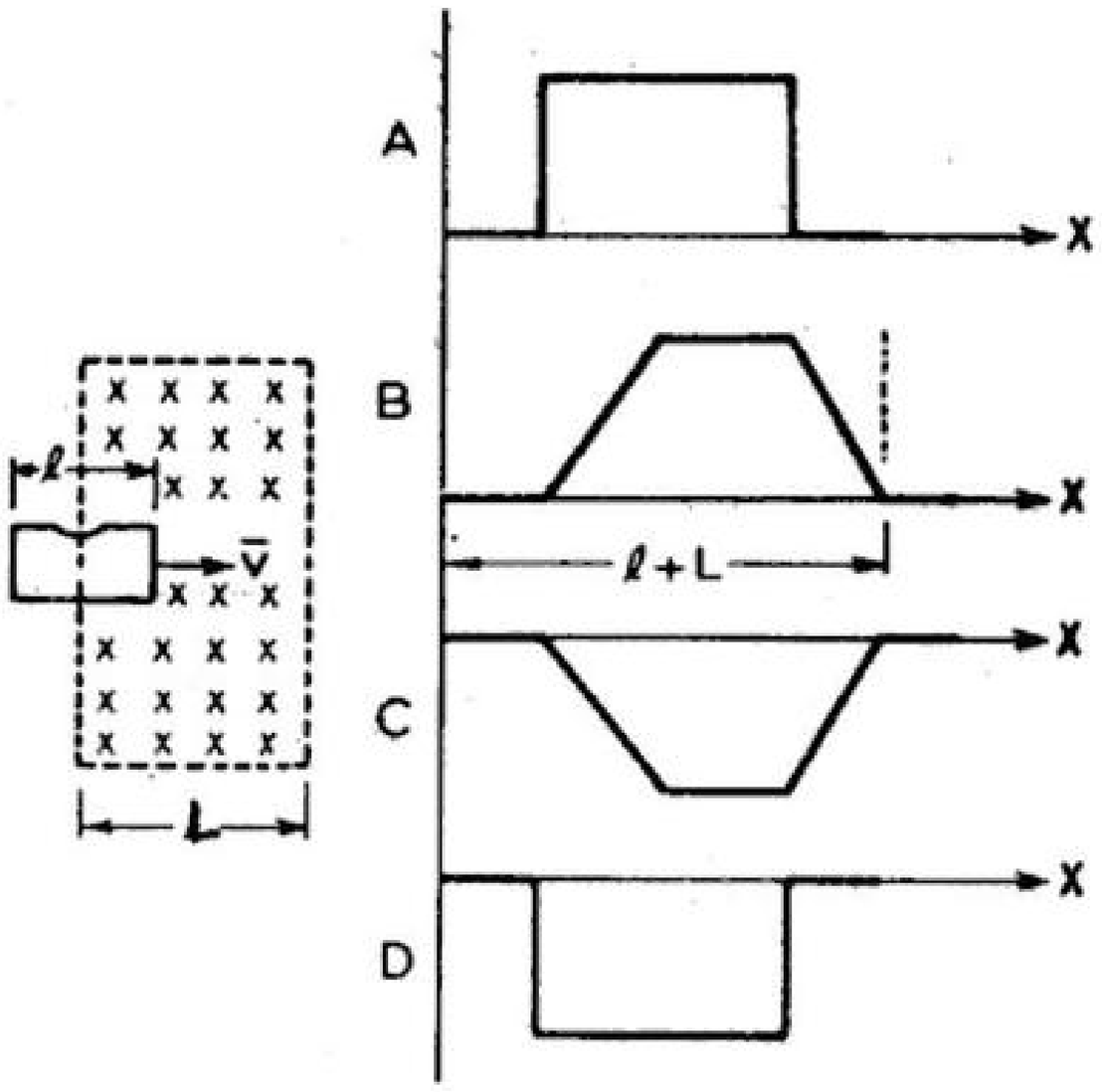
334. A magnetic field $\bar{B}$ and an electric field $\bar{E}$ are at right angles to one another as shown in the figure below. The path of the electron, which starts at rest at the origin with be



A. circular B. cycloidal

C. helical D. straight.

335. Rectangular loop of length l is pulled at constant speed through a region of uniform magnetic field of length L. If l < L, the flux through the loop will be of the form



Answers : 330. (D), 331. (B), 332. (C), 333. (C), 334. (B), 335. (B).

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B. Nickel-hydrate and iron-oxide
C. Manganese-dioxide and carbon
D. None of these.

371. During discharge of a battery
A. the voltage of cell decreases
B. the voltage of cell increases
C. voltage does not change
D. None of these.

372. The watt-hour efficiency is always
A. more than ampere hour efficiency
B. equal to ampere-hour efficiency
C. less than ampere-hour efficiency
D. None of these.

373. The electrolyte used in Edision cell is
A. Sulphuric acid
B. Potassium Hydroxide
C. Nickel Hydrate
D. Nitric Acid

374. Internal resistance per cell of Lead Acid cell is always
A. less than Edision cell
B. more than Edision cell
C. equal to Edision cell
D. None of these.

375. Average e.m.f. per cell of Lead acid cell is
A. 1.2 V B. 1.08 V
C. 1.5 V D. 2.2 V

376. During charging of a battery, specific gravity of electrolyte
A. decreases B. increases
C. does not change D. None of these

377. When the weight of an iron liberated during electrolysis is increased, the quantity of electricity produced
A. increases B. decreases
C. remains the same D. None of these.

378. The specific gravity of a charged cell is
A. 1.25 B. 1.20
C. 1.10 D. 1.0

379. The specific gravity of electrolyte solution of a discharged cell is
A. 1.25 B. 1.20
C. 1.28 D. 1.30

380. The supply required for charging a Lead acid cell is
A. A.C B. D.C.
C. Pulsating D.C. D. None of these.

381. The method of charging Lead acid cell (Commercially) is
A. constant current method
B. constant voltage method
C. constant resistance method
D. None of these

382. The colour of plates after discharging of a battery will be
A. Red B. Choclate
C. Greyish D. Yellowish

383. The colour of +ve plate of a battery after charging will be
A. Black B. Greyish
C. Choclate D. Yellowish

384. The colour of -ve plate of a battery after charging will be
A. Black B. Grey
C. Choclate D. Yellow

385. The condition of the battery can be determined by
A. Voltmeter
B. High rate discharger
C. Ammeter
D. Ohmmeter

Answers : 370. (B), 371. (A), 372. (C), 373. (B), 374. (A), 375. (D), 376. (B), 377. (A), 378. (A), 379. (B), 380, (B), 381. (B), 382. (C), 383. (C), 384. (B), 385. (B).

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B. proton current

C. ionization current

D. polarization current

406. A 45-V source with an internal resistance of 2 ohm is connected across a wire wound resistor. Maximum power will be dissipated in the resistor when its R is

A. zero B. 2 ohm

C. 45 ohm D. infinitely large.

407. Cells are connected in series in order to

A. increase the current rating

B. increase the voltage rating

C. increase the life of the cells

D. None of these.

408. The storage battery generally used in electric power stations is

A. lead acid battery

B. zinc carbon battery

C. nickel cadmium battery

D. None of these.

409. Four 1.5 V cells are connected in parallel. The output voltage is

A. 1.5 V B. 6 V

C. 0. 375 V D. None of these.

410. During charging, the specific gravity of the electrolyte of a lead acid battery

A. decreases B. remains the same

C. increases D. None of these.

411. The active materials on the positive and negative plates of a fully charged lead acid battery are

A. lead sulphate and lead

B. lead peroxide and lead

C. lead and lead peroxide

D. None of these.

412. In a lead acid battery

A. the number of positive plates is more than the number of negative plates

B. The number of both positive and negative plates is equal.

C. the number of negative plates is more than the number of positive plates.

D. None of these.

413. The capacity of a battery is expressed in terms of

A. current rating B. Ah rating

C. voltage rating D. None of these.

414. When a lead acid battery is in fully charged condition, the colour of its positive plate is

A. brown B. dark brown

C. dark grey D. None of these.

415. The best indication about the state of charge on a lead acid battery is given by

A. specific gravity of electrolyte

B. temperature of electrolyte

C. output voltage

D. None of these.

416. The output voltage of a charger is

A. the same as battery voltage.

B. less than the battery voltage.

C. higher than battery voltage

D. None of these.

417. Three resistors have the following ratings.

R1 = 200 ohm ± 5%

R2 = 100 ohm ± 5%

R3 = 50 ohm ± 5%

The percentage error when the resistors are connected in series, would be

A. +5% B. ± 5 %

C. +5/3% D. ± 15%

Answers : 405. (D), 406. (B), 407. (B), 408. (A), 409. (A), 410. (C), 411. (B), 412. (C), 413. (B), 414. (B), 415. (A). 416. (C), 417. (B).

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CHAPTER 2

ELECTRO-MAGNETICS

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This defect can be avoided by amalgamating the zinc plate by which a thin layer of mercury amalgam deposited over the impure zinc does not permit this impurities to come to the surface.

Polarisation. During the chemical action in the cell, hydrogen gas is librated and few of the hydrogen bubbles get deposited on the copper plate with the result that it gets gradually covered with hydrogen gas layer. Due to this, the cell is weakened. This phenomenon can be avoided either by corrugating the positive plate or agitating of the liquid or of the positive plate so that accumlation of hydrogen on positive plate is avoided. Using a depolarising agent or substituting the hydrogen by some other substance which does not give counter *emf* are other methods to minimise polarisation.

The characteristics of a good cell are high and constant voltage, small internal resistance, constant current and it should be cheap and does not give corrosive fumes.

2.10. Grouping of Cells. Cells can be grouped either in series or in parallel as shown in Fig. 2.2. In series grouping, the current flowing through the external circuit of n cells connected in series is given by

$$i = \frac{nE}{R + nr}$$

where r is the internal resistance of a single cell.

In the parallel grouping shown in Fig. 1.2(b), the current in the external circuit is

$$i = \frac{E}{R + \frac{r}{n}}$$

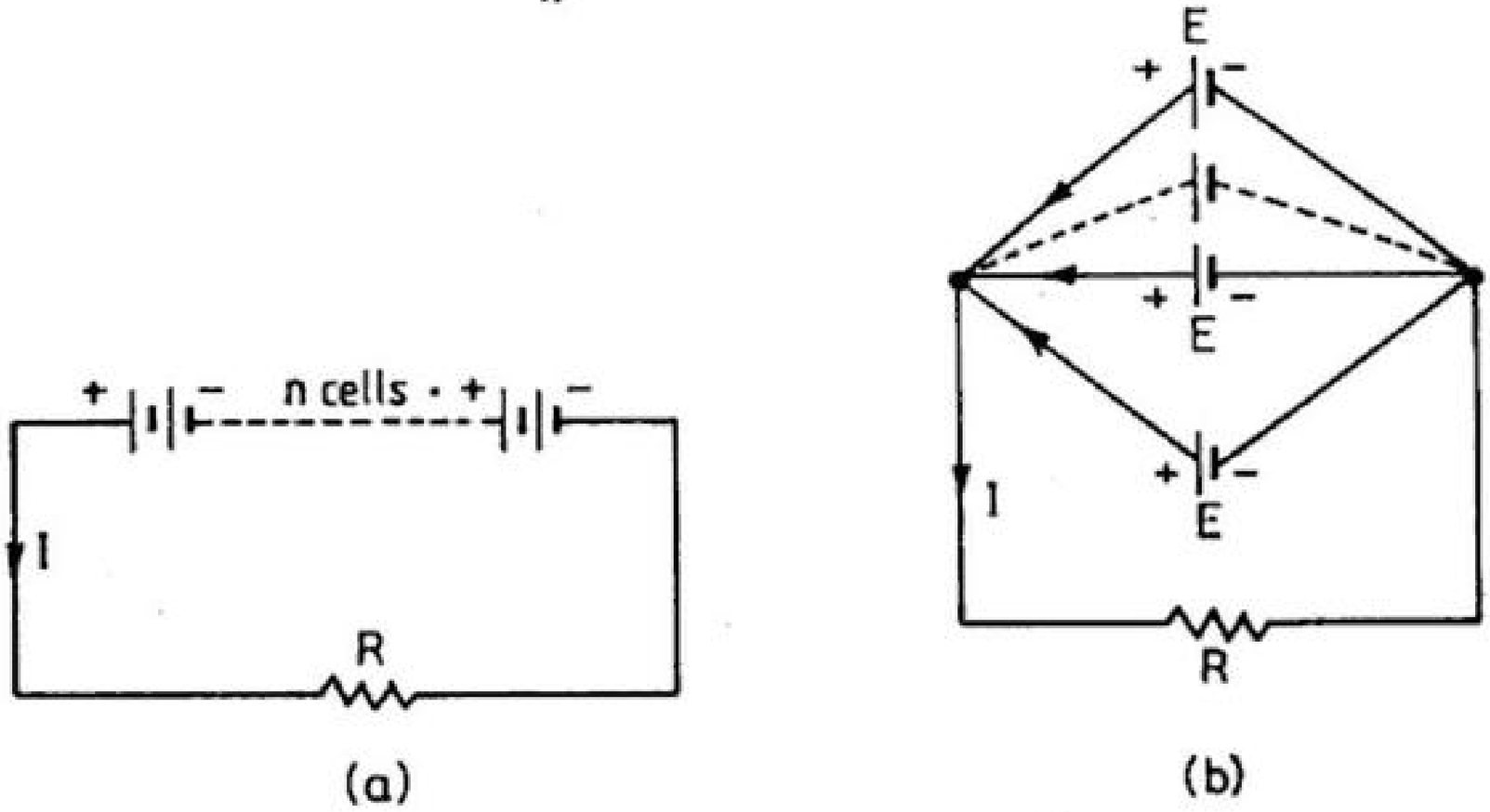


Fig. 2.2

2.11. Secondary Cell (or Storage Cell). The action of secondary cell is essentially the same as that of primary cells except that the secondary cells are charged by supplying electrical energy, the electrical energy supplied is converted into chemical energy and then stored. The charged secondary cells are capable of supplying electrical energy. During discharging,the chemical energy stored is converted into electrical energy.

2.12. The Concept of Capacitance. Consider a conducting sphere of radius R with charge q and no conducting or non- conducting bodies nearby. Its potential will be

$$V_+ = \frac{1}{4\pi\,\varepsilon_0} \cdot \frac{q}{R}$$

Another similar sphere with charge $-q$ and at large distance from first sphere will have potential of

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2.16. Capacitors in Series and in Parallel. The equivalent capacitance of capacitors in series is given by

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + ...$$

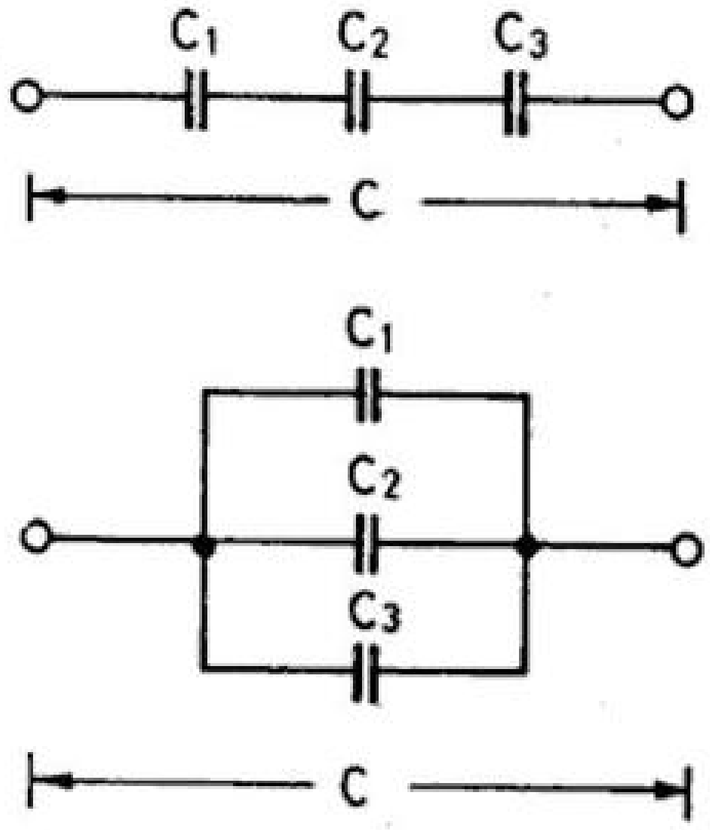


Fig. 2.7

The equivalent capacitance in a parallel system is given by

$$C = C_1 + C_2 + C_3 + ...$$

2.17. Capacitance of Various Systems. Capacitance of a capacitor depends upon the geometry and medium inside it. Few examples are shown in Fig 2.8.

Capacitance of an isolated sphere of radius r in a medium of relative permitivity ε_r is

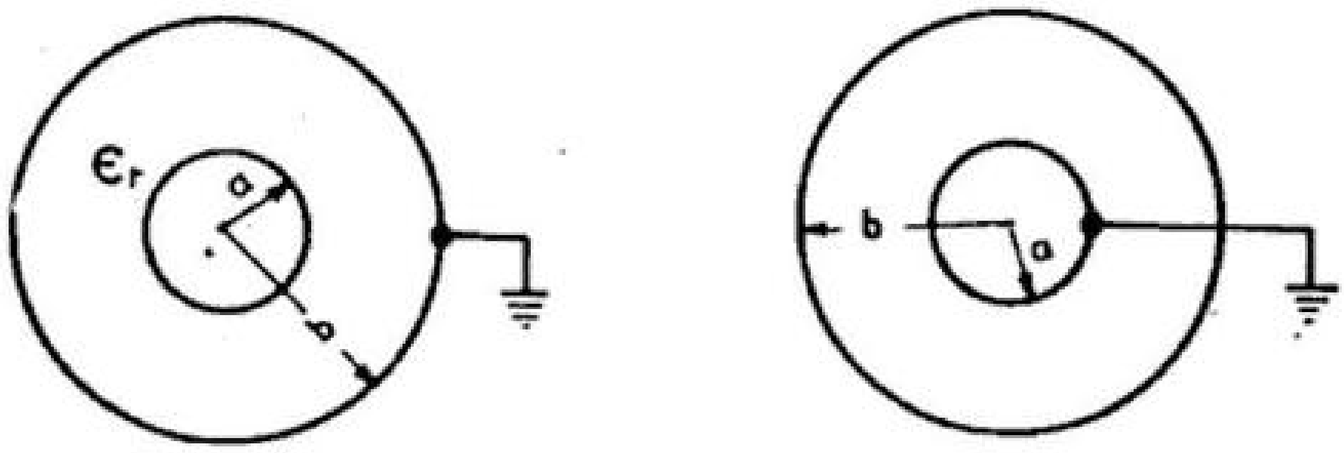
$$= 4\pi \varepsilon_0 \varepsilon_r r \text{ Farad}$$

Capacitance of a spherical shell with outer sphere earthed as shown in Fig 2.8 *(a)* is given by

$$= 4\pi \varepsilon_0 \varepsilon_r . \frac{ab}{b-a} \text{ Farad}$$

Spherical capacitor with inner sphere earthed as shown in Fig 2.8 *(b)* is given by

$$= 4\pi \varepsilon_0 \varepsilon_r \frac{ab}{b-a} + 4\pi \varepsilon_0 b \text{ Farad}$$



(b) (c)

Fig. 2.8

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2.25 Magnetic Energy Stored in an Inductance. By applying *KVL* to the circuit shown in Fig 2.11, a differential equation is obtained which describes the growth of current in this circuit. That is

$$E = iR + L\frac{di}{dt}$$

Multiply each side by i,

$$Ei = i^2 R + \frac{Ldi}{dt} i$$

Since $i = \frac{dq}{dt}$, the above equation implies that if a charge dq passes through the *emf* source in time dt, the work done on it is Edq and the rate of doing work is Edq/dt or Ei. In other words, it is the rate at which the *emf* source delivers energy to the circuit. The second term i^2R represents the rate at which energy appears as heat in the resistance R.

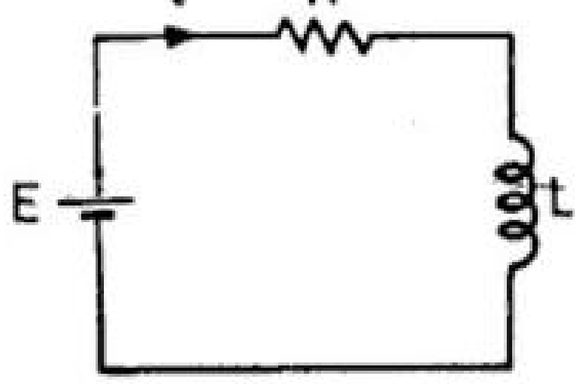


Fig. 2.11

Energy which is not converted into heat is stored in the magnetic field of the inductor L. Thus, Edi/dt is the rate dU_B/dt at which energy is stored in the magnetic field. That is

$$\frac{dU_B}{dt} = Li\frac{di}{dt}$$

or $$dU_B = Li\,di$$

or $$U_B = \int_0^i Li\,di = \frac{1}{2}Li^2$$

Thus,in an electric circuit, energy is required to maintain the flow of current but in magnetic circuit no energy is required to maintain the magnetic flux. Energy is only required in creating the magnetic flux and energy supplied to create a flux is stored in magnetic field.

2.26 AC Circuits. In ac circuits the relationship $I = V/R$ does not hold good. The variations in current and applied voltage set up magnetic and electrostatic effects respectively. The effects must be taken into account in these circuits. With comparatively low voltage, heavy current circuits, magnetic effects may be very large but electrostatic effects are negligible. With high voltage circuits, electrostatic effects are of appreciable magnitude. This may lead to variation in resistance thus defying $I = V/R$ relationship.

Purely Resistive Circuit: When the current flowing through a pure resistance, no back *emf* is set up and the applied voltage has to overcome the ohmic drop of iR only. The instantaneous current is

$$i = \frac{V_m \sin \omega t}{R} = I_m \sin \omega t$$

The applied voltage and current are in phase with each other.

Periodic Time and Frequency: The time taken in seconds by an alternating quantity to complete one cycle is known as periodic time (T).

The number of cycles per second by an alternating quantity is known as frequency.

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QUESTION BANK IN ELECTROMAGNETICS

1. The rate of movement of charge through any conductor is known as
   A. voltage B. resistance
   C. current D. e.m.f.
2. The force tending to move the electricity is called
   A. current B. resistance
   C. e.m.f. D. potential difference
3. The ratio of voltage and current in a closed circuit
   A. varies B. remains constant
   C. increases D. decreases
4. The meter which measures current is known as
   A. voltmeter B. avometer
   C. ohm-meter D. ammeter
5. The meter which measures voltage is known as
   A. avometer B. ampere-meter
   C. voltmeter D. multimeter
6. The meter which measures resistance is known as
   A. ohm meter B. multimeter
   C. voltmeter D. ohm-meter
7. The unit of resistance is
   A. ohm B. volt
   C. ampere D. milli-volt
8. For long transmission lines, voltage is measured in
   A. volts B. micro-volts
   C. kilo-volts D. milli-volts
9. With the increase in length of conductor, the value of resistance
   A. decreases B. increases
   C. remains same D. None of these
10. With the increase in cross-sectional area of the conductor, the value of resistance
    A. increases B. remains same
    C. decreases D. None of these.
11. Specific resistance of a conductor depends upon
    A. composition of the conductor
    B. length of the conductor
    C. area of cross-section of the conductor
    D. resistance of the conductor
12. With the increase in temperature, the resistance of copper
    A. decreases B. increases
    C. becomes zero D. remains constant
13. With the increase in temperature, the resistance of carbon
    A. increases B. become zero
    C. remains constant D. decreases
14. Which of the following insulator is most affected by heat
    A. P.V.C. B. mica
    C. paper D. leatheriod
15. With the increase in temperature, the insulating property of insulator
    A. weakens B. gains
    C. remains same D. None of these
16. The specific resistance of mica is
    A. very high B. zero
    C. very low D. low
17. With the rise of temperature, the temperature co-efficient of resistance
    A. increases B. remains constant
    C. becomes zero D. decreases

Answers : 1. (C), 2. (C), 3. (B), 4. (D), 5. (C), 6. (D), 7. (A), 8. (C), 9. (B), 10. (C), 11. (A), 12. (B), 13. (D), 14. (A), 15. (A), 16. (C), 17. (D).

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C. across both lamps

D. None of these

57. In which of the following voltage sources is the movement of conductors in a magnetic field used to produce voltage ?

A. In a thermo couple

B. In a zinc copper element

C. In a D.C. generator

D. In a transformer

58. Which of the following statements is correct ?

A. The resistance of a wire does not depend upon its material.

B. The resistance of a conductor is the hindrance by which the conductor opposes the flow of the current.

C. The resistance of most of the materials is independent of the temperature.

D. The resistance does not play an important role in electrical engineering.

59. Which is the unit and symbol for resistance ?

A. Unit: Ampere (A); symbol: I

B. Unit: Ohm (Ω); symbol: R

C. Unit: ohm (Ω); symbol: V

D. Unit: ohm (Ω); symbol: I

60. What do you understand by specific resistance ρ?

A. Resistance of a conductor which has a length of 1 m and a cross-section of 1 mm^2 at 20°C.

B. Resistance of any conductor at 20°C

C. Resistance of any conductor at 25°C

D. Resistance of a conductor which has a length of 1 m and a cross-section of 1 cm^2 at 20°C.

61. Upon which factors does the specific resistance depend ? It depends upon

A. the area of cross-section and the length of the conductor

B. the area of cross-section of the conductor only.

C. the length of the conductor only.

D. the nature of the material of the conductor only.

62. Which of the following statements is true ?

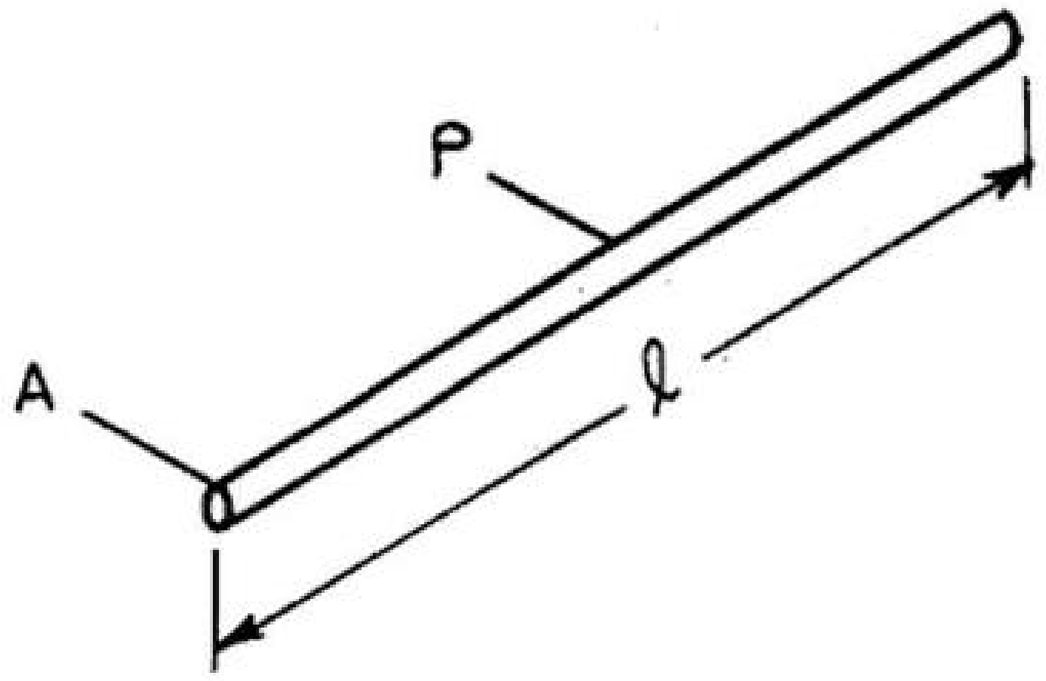
A. The longer the conductor, the greater its resistance.

B. The shorter the conductor, the greater its resistance.

C. The lesser the specific resistance, the greater the resistance.

D. The higher the conductivity, the greater the resistance.

63. With which of the following formula can the resistance of the conductor shown in the figure be calculated ?



A. $R = \frac{\rho \times l}{A}$

B. $R = \rho \times l \times A$

C. $R = \frac{\rho \times A}{l}$

D. $R = \frac{l}{\rho \times A}$

64. How does the resistance of unalloyed metals change with the change in temperature ?

A. The resistance does not change.

B. The resistance increases with decreasing temperature.

C. The resistance changes only in case of very high temperature variations which do not

Answers : 57. (C), 58. (B), 59. (B), 60. (A), 61. (D), 62. (A), 63. (A).

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85. If the current in a 1 $k\,\Omega$ resistor is 2 mA, the potential across the resistor is

A. 1 V B. 20 V

C. 2 V D. 200 V

86. In a series connection of two resistors

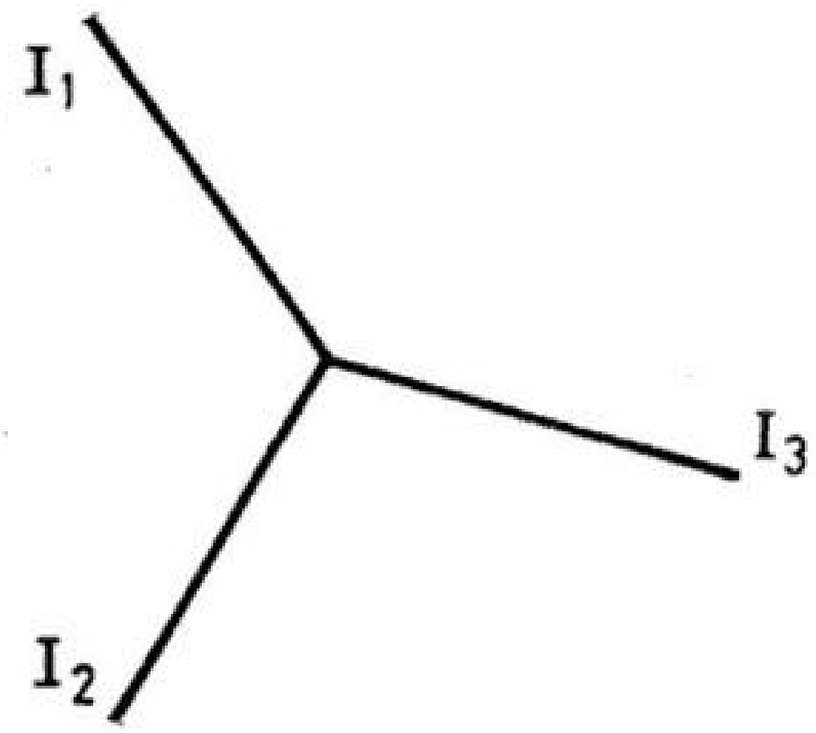
A. the current is, at every point of the circuit, the same.

B. the voltage is the same at both the resistors.

C. the total current is the sum of two currents

D. the total resistance is less than the smallest individual resistance.

87. At a junction point



A. all currents have the same magnitude.

B. the sum of all coming is not equal to the sum of all going currents.

C. the going current is equal to the highest coming current.

D. the sum of all currents (coming = + ; going = –) is equal to zero.

88. In a parallel connection

A. the current is the same at every point of the connection

B. the total esistance is the sum of all single resistances.

C. the voltage is the same at all resistances.

D. the total voltage is the sum of all part voltages.

89. If a series circuit consists of three resistors and a battery which of the following statements is always true ?

A. The voltage drop across each resistor is the same.

B. The current through each resistor is the same.

C. 'The power dissipated in each resistor is the same.

D. The energy consumption in each resistor is the same.

90. Two wires with different cross-sectional areas are connected in series. The heat produced by the current is greater in the thinner wire because

A. there is a higher voltage drop on it.

B. there is a higher current through it.

C. there are fewer collisions of electrons with the atoms in it.

D. it has low resistance value.

91. An air-conditioner at the end of a long feeding line does not work properly because of too low voltage. Which is the *correct* way to increase the voltage ?

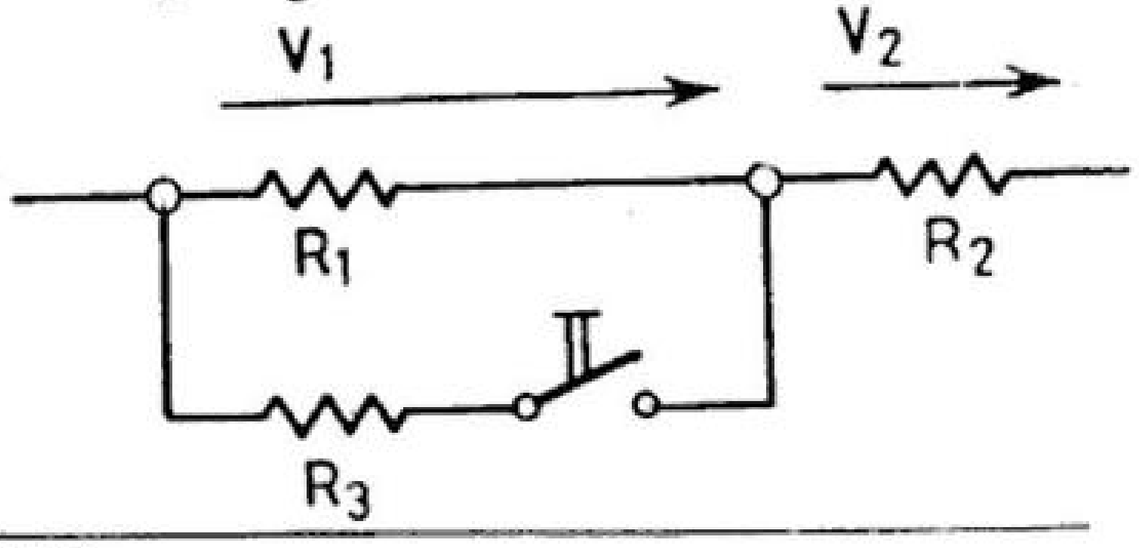
A. Put the air-conditioner close to the main switchboard.

B. Connect it with a flexible cable using the shortest possible distance.

C. Replace the feeding lines with thicker ones.

D. Replace the compressor motor with a smaller one.

92. The connection shown here is supplied by a stable voltage V. How will the voltage V_1 and V_2 change when the switch is closed ?



Answers : 85. (C), 86. (A), 87. (D), 88. (C), 89. (B), 90. (B), 91. (C).

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B. connect it with a flexible cable using the shortest possible distance

C. replace the feeding lines with thicker one

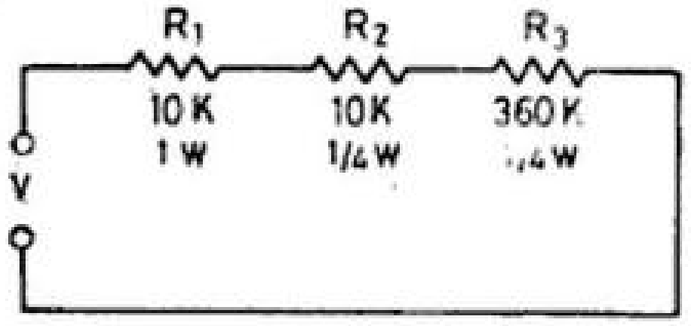
D. replace the compressor motor with a smaller one.

123. A resistance of 4 ohms is connected across 100 V supply. When another resistor of '*R*' ohms is connected in parallel with 4 ohms, the total current taken from supply was found to be 50 A. The value of resistance '*R*' is

A. 4 ohms B. 2 ohms

C. 3 ohms D. 5 ohms

124. In the circuit given below, the current must not exceed the value of.



A. 10 mA B. 5 mA

C. 0.83 mA D. 1.2 mA

125. The maximum current, which can pass through a 10 K, 1/4 W resistor in the above circuit is

A. 5 mA B. 10 mA

C. 15 mA D. 20 mA

126. The voltage applied across electric press was reduced by 50%. The power consumed by the press will be reduced by

A. 50% B. 60%

C. 75% D. 25%

127. Four identical bulbs are connected in series and supplied with 400 V battery. The current through the third bulb if battery is supplying one ampere, is

A. 1.5 amps B. 1.0 amps

C. 2.0 amps D. 1.2 amps.

128. In the above problem, the voltage rating of the second bulb is

A. 200 V B. 150 V

C. 100 V

D. same as battery voltage.

129. In the same problem, the value of resistance of the first bulb, if current supplied is one ampere is

A. 100 ohms B. 150 ohms

C. 120 ohms D. 200 ohms

130. Two electric presses are connected in parallel. The resistance of the first press is 100 ohms and that of the second is 300 ohms. The total current taken by both the presses is 4 A. The ratio of currents taken by first: second will be equal to

A. 1 : 3 B. 2 : 3

C. 3 : 1.2 D. 3 : 1.

131. A 230 *V*, 100 *W* bulb and a 230 *V*, 25 *W* bulb are connected in series across 230 *V*. D.C. supply. The bulb, which burns brighter is

A. 100 W bulbs B. 25 W bulb

C. both will have some brightness

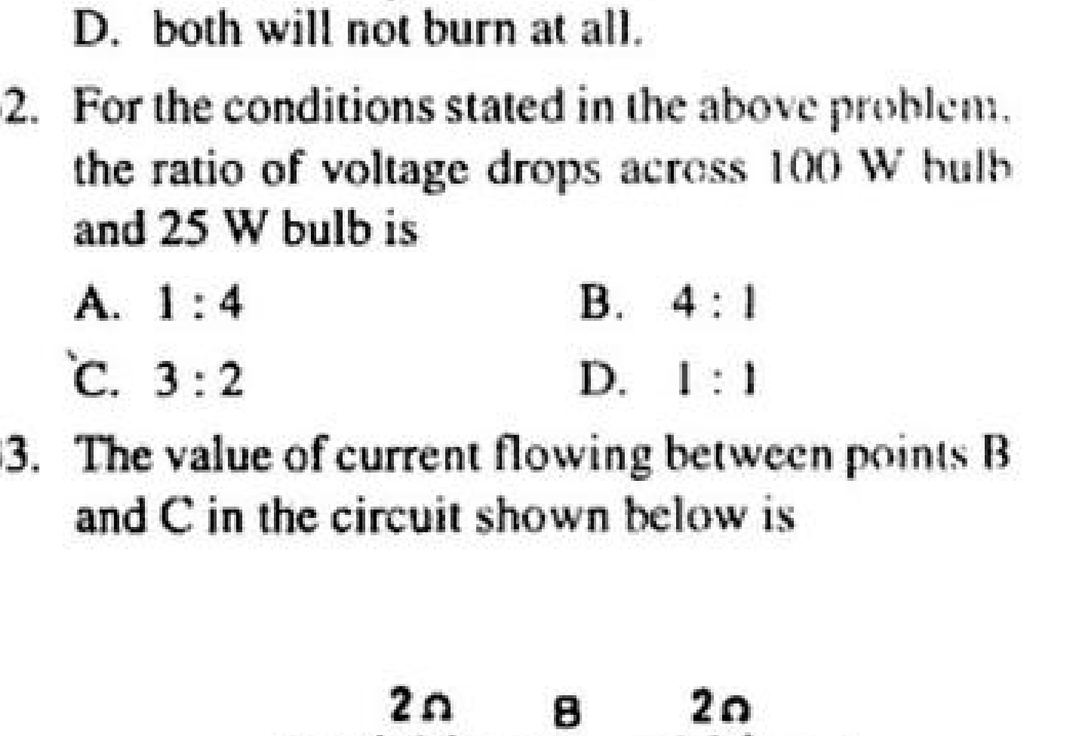
D. both will not burn at all.

132. For the conditions stated in the above problem, the ratio of voltage drops across 100 W bulb and 25 W bulb is

A. 1 : 4 B. 4 : 1

C. 3 : 2 D. 1 : 1

133. The value of current flowing between points B and C in the circuit shown below is



A. one ampere B. 0.5 ampere

C. 0.2 ampere D. Zero ampere

Answers : 122. (C), 123. (A), 124. (C), 125. (A), 126. (D), 127. (B), 128. (C), 129. (A), 130. (D), 131. (B), 132. (A). 133. (D).

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strength H for a dynamo sheet ?

A. Curve 'A' B. Curve 'B'

C. Curve 'C' D. Curve 'D'

154. What is meant by magnetic saturation of iron?

A. Strengthening of the magnetic field by using iron (permeabiiity).

B. The part of the magnetization curve in which the change in magnetic field strength H causes a little change in the magnetic flux density B.

C. The losses during magnetization.

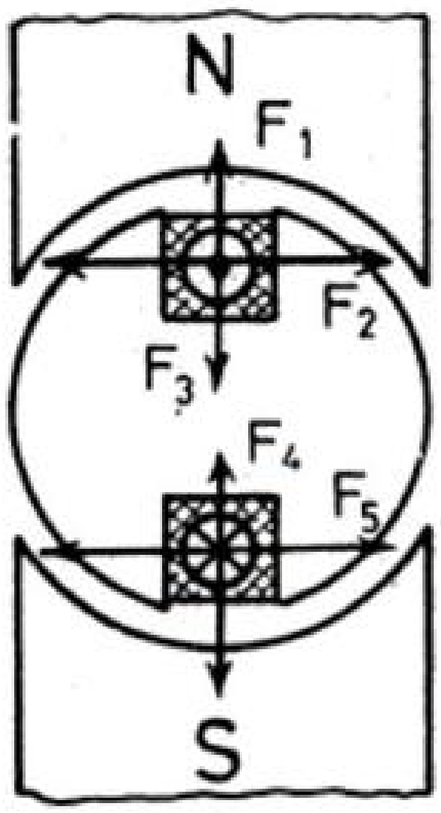
D. In the region of saturation the elementary magnets are not yet arranged fully.

155. A current carrying conductor of length l is under the influence of a magnetic field having a magnetic flux density B. If I is the current flowing throght the conductor. which of the following formula is correct for calculating the force exerted on it ?

A. $F = B \times l \times I^2$ B. $F = \dfrac{B \times I}{l}$

C. $F = \dfrac{I \times l}{B}$ D. $F = B \times l \times I$

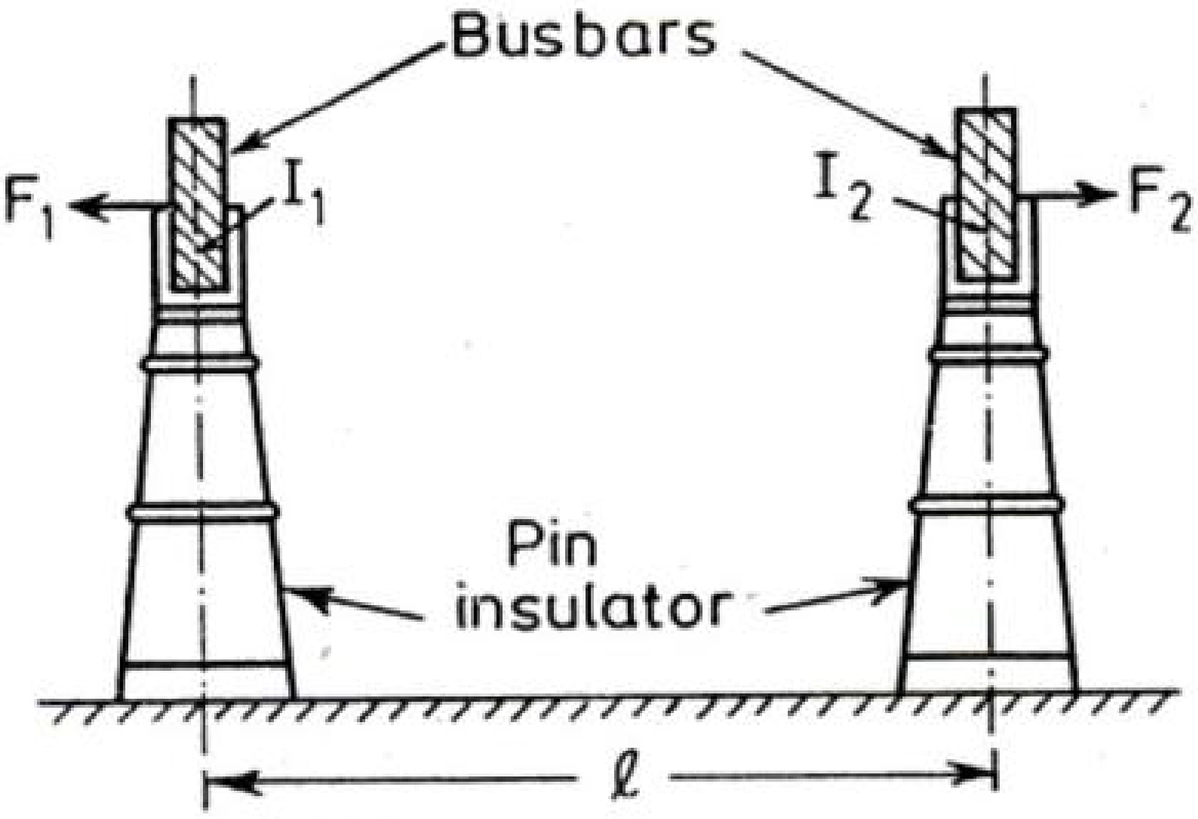
156. Which of the arrows represents the correct direction of force in the shown figure ?



A. Arrow F_1 B. Arrow F_2

C. Arrow F_3 D. Arrow F_4

157. Which of the values shown in the figure influence the repulsive forces F_1 and F_2 ?



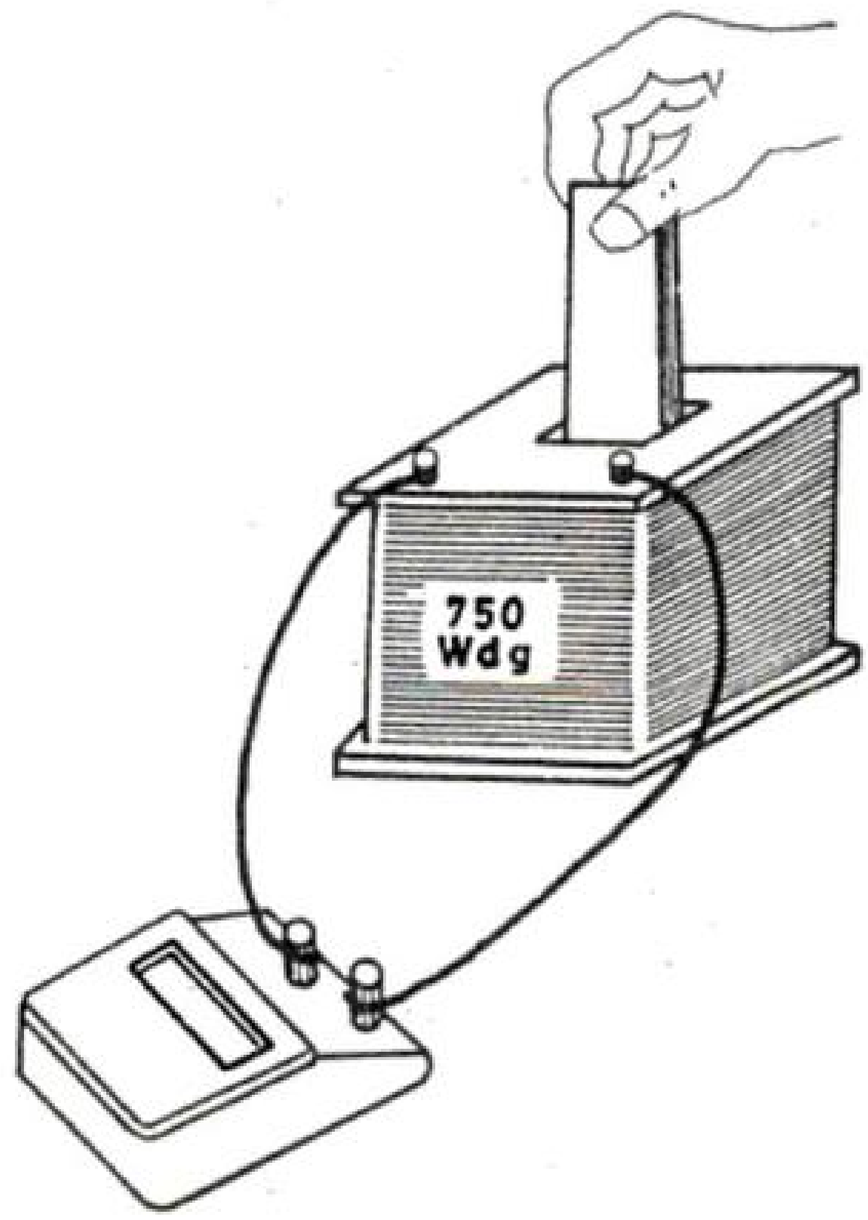
A. Only the current I_1

B. Only the current I_2

C. Only the sum of currents I_1 and I_2

D. The product of I_1 and I_2 and the distance l.

158. Which of the following statements for the experimental arrangement shown in the figure is true ?



Answers : 153. (D), 154. (B), 155. (D), 156. (B), 157. (D).

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232. In the above figure, the power factor of the circuit can be obtained by
   A. dividing voltmeter reading by ammeter reading
   B. dividing wattmeter reading by voltmeter reading
   C. dividing wattmeter reading by ammeter reading
   D. dividing wattmeter reading by product of voltmeter and ammeter readings

233. In a pure inductive circuit, the current will
   A. lag the voltage by 90°
   B. lead the voltage by 90°
   C. remains in phase
   D. makes same angle with the voltage

234. In a pure capacitive circuit, the voltage will
   A. lag the current by 90°
   B. lead the current by 90°
   C. remains in phase
   D. makes same angle with the voltage.

235. The power factor is the ratio of
   A. Z/R B. R/Z
   C. X_L/Z D. X_C/Z

236. Which of the following statement is correct ?
   A. $W = V \times I$
   B. $W = V_1 \sin \theta$
   C. $kW = kVA \cos \theta$
   D. $kW = kVA \sin \theta$

237. Which of the following statement is correct for a d.c. circuit ?
   A. $W = VI$
   B. $W = VI \sin \theta$
   C. $kW = kVA \cos \theta$
   D. $kW = kVA \sin \theta$

238. With the reduction of frequency, the inductive reactance of the circuit will
   A. decreases B. increases
   C. remains same D. None of these

239. With the increase of frequency, the capacitive reactance of the circuit
   A. decreases B. increases
   C. remains same D. None of these

240. If the frequency of the pure inductive circuit is half, the current of the circuit will be
   A. same B. doubled
   C. halved D. four times

241. The reactance offered by a capacitor to an alternating current of frequency 100 c/s is 10 ohms. If the frequency is reduced to 50 c/s., the reactance becomes
   A. 5 ohms B. 10 ohms
   C. 15 ohms D. 20 ohms

242. Q-factor of a circuit is given by
   A. ratio of R/Z B. ratio of Z/R
   C. ratio of X_L/Z D. ratio of X_C/Z

243. The input to an a.c. circuit is 10 kVA at 0.6 power factor lagging, the power drawn by the circuit in kW will be
   A. 6 B. 12
   C. 8 D. 16

244. The apparent power drawn by an a.c. circuit is 20 kVA and reactive power is 12 kVA. The real power in the circuit in kW will be
   A. 20 B. 12
   C. 16 D None of these

245. A R-L circuit has 6 ohms resistance and 8 ohms inductive reactance. Its impedance will be
   A. 6 ohms B. 10 ohms
   C. 8 ohms D. 8/6 ohms

246. A R-L-C circuit has a resistance of 6 ohms, inductive reactance of 8 ohms and capacitive reactance of 16 ohms. The impedance of the circuit will be
   A. 10 ohms B. 16 ohms
   C. 8 ohms D. 6 ohms

247. A capacitor of capacitive reactance 100 ohms is connected across 100 V, 50 Hz supply, the

Answers : 232. (D), 233. (A), 234. (A), 235. (B), 236. (C), 237. (A), 238. (A), 239. (A), 240. (B), 241. (D), 242. (D), 243. (A), 244. (C) 245. (B), 246. (A).

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A. 0.9 B. less than 0.9

C. more than 0.9 D. 0

352. In an a.c. circuit the fundamental component of the current lags the fundamental component of voltage by 10°. The third harmonic component of the current will lag the third harmonic component of the voltage by

A. 10°

B. an angle which is less than 10°

C. an angle which is more than 10°.

D. 0°

353. A wave is expressed as $e = 10 + 15 \sin \omega t$. Its r.m.s. value is

A. 25 V B. 14.58 V

C. 18.3 V D. 1.5 V

354. If two waves are expressed as

$e_1 = 10 \sin \omega t + 25 \sin (3\omega t + 30°)$

and $e_2 = 10 \sin \omega t + 25 \sin (3\omega t + 30°)$

A. r.m.s. value of the two waves are equal

B. r.m.s. value of e_1 is higher than that of e_2

C. r.m.s. of e_2 is higher than that of e_1.

D. None of these.

355. A function $f(\theta)$ satisfies the relation $f(-\theta)=-f(\theta)$ This function contains

A. only sine terms B. only cosine terms

C. both sine and cosine terms

D. None of these.

356. In the double script notion E_{ab} represents

A. A voltage of terminal *a with respect to that of b.*

B. A voltage of terminal *b* with respect to that of *a*.

C. A voltage rise or drop from terminal *a* to terminal *b*.

D. None of these

357. In a 3 phase star system of voltages, the three phase voltage are $100 \angle 0°$, $100 \angle -120°$ and $100 \angle -240°$. Then the three line voltages will be

A. $173.2 \angle 0°$, $173.2 \angle -120°$, $173.2 \angle -240°$.

B. $173.2 \angle 30°$, $173.2 \angle -90°$, $173.2 \angle -210°$.

C. $173.2 \angle 30°$, $173.2 \angle -150°$, $173.2 \angle -270°$.

D. None of these.

358. In a three phase star connected load, the three phase currents are $10 \angle -30°$, $10 \angle -150°$, $10 \angle -270°$ A. Then the three line currents must be

A. $10 \angle 0°$, $10 \angle -120°$, $10 \angle -240°$ A

B. $10 \angle 30°$, $10 \angle -90°$, $10 \angle -210°$ A

C. $10 \angle 30°$, $10 \angle -150°$, $10 \angle -270°$ A

D. None of these

359. In a 3-phase system with phase sequence abc, the phase currents drawn by a balanced delta connected load are $20\angle 0°$, $20\angle -120°$ and $20\angle 120°$

Then the three line currents will be

A. $34.64 \angle 0$, $34.64 \angle -120°$, $34.64 \angle -120°$ A

B. $34.64 \angle 150$, $34.64 \angle 30°$, $34.64 \angle -90°$ A

C. $34.64 \angle -30$, $34.64 \angle -150°$, $34.64 \angle -270°$ A

D. None of these.

360. A 3 phase 4 wire system supplies a balanced star load. The current in each phase is 5 A. The current in the neutral wire will be

A. 5 A B. $5\sqrt{3}$ A

C. 0 D. 15 A.

361. Three star connected impedance $4\angle 30°$ each and three delta connected impedance $12\angle 30°$ each are connected in parallel on a 3–phase system. The equivalent star impedance across each phase is

A. $2 \angle 30°$ ohm B. $3 \angle 30°$ ohm

C. $1.197 \angle 30°$ ohm D. $16 \angle 30°$ ohm

Answers : 351. (C), 352. (C), 353. (B), 354. (A), 355. (A), 356. (A), 357. (B), 358. (D), 359. (C), 360. (C), 361. (A).

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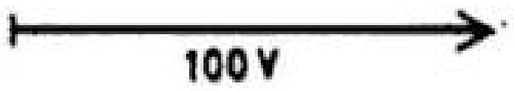
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B. 50 rotations per sec.

C. 100 rotations per sec.

D. 314 rotations per sec.

390. Which value of the voltage is normally represented by the length of a vector in a vector diagram?



A. The peak value.

B. The effective value.

C. The arithmetical average value.

D. Half the peak value.

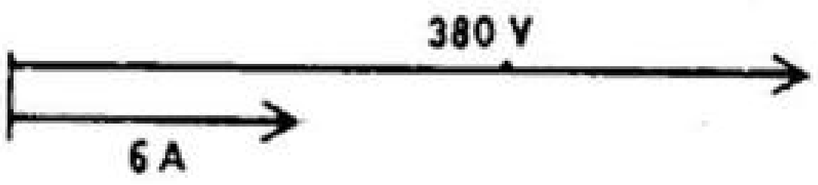
391. Voltage and current in a circuit are represented by vectors as shown in the figure. Which of the following statements is true about them ?

A. The current leads the voltage.

B. The voltage leads the current.

C. Current and voltage are in a phase

D. The current vector rotates at a higher speed than the voltage vector.



392. What is meant by "current and voltage are in a phase"?

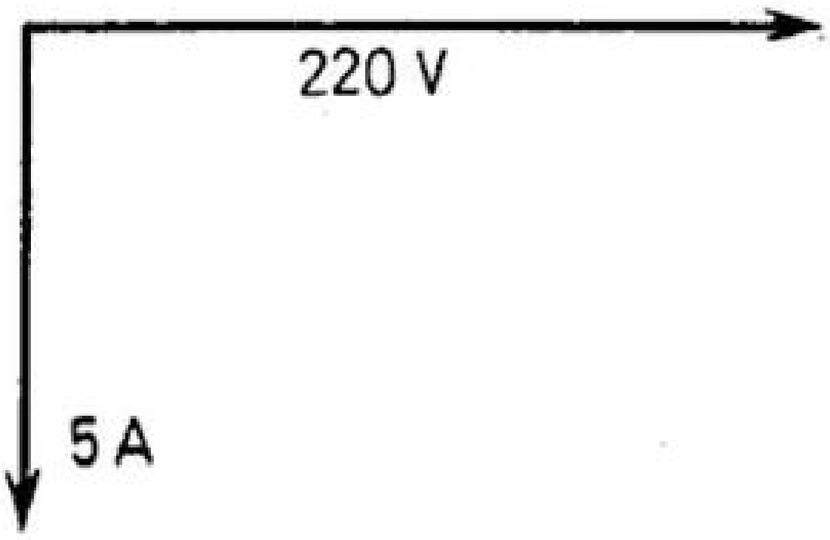
A. Voltage and current are of the same magnitude.

B. Voltage and current have the same frequency.

C. The voltage leads the current in time.

D. Voltage and current reach their maximum and zero value at the same time.

393. Which of the following statements about the vector diagram shown in the figure is true ?



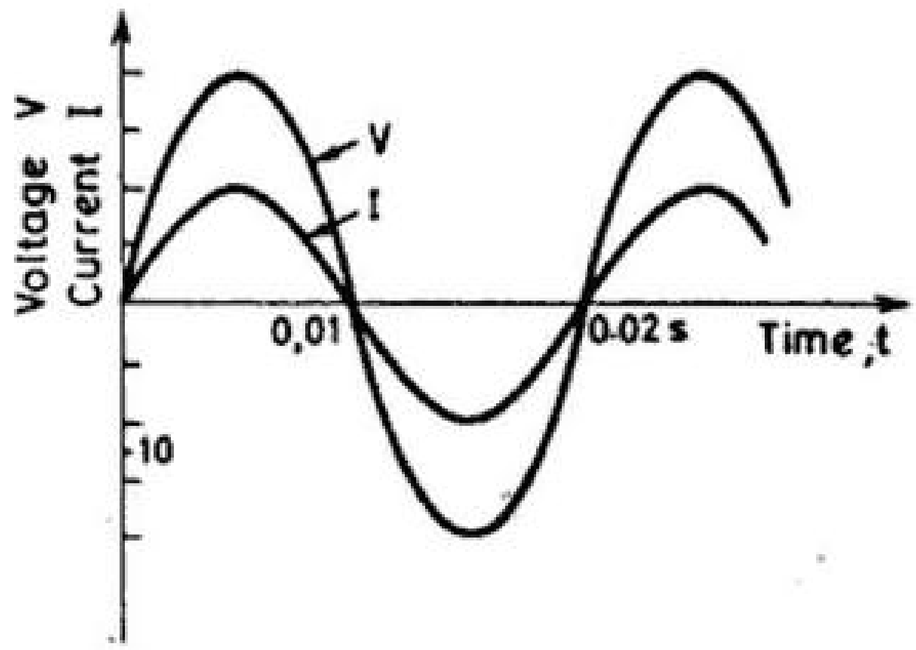
A. The voltage lags behind the current by 90°.

B. The current leads the voltage by 90°.

C. The current lags behind the voltage by 90°.

D. Current and voltage are in phase.

394. Current and voltage of a circuit element are shown in the figure. What circuit element is used ?



A. A capacitor.

B, A coil with very high inductance.

C. A coil with high inductance.

D. An ohmic resistance.

Answers : 389. (B), 390. (B), 391. (C), 392. (D), 393. (C), 394. (D).

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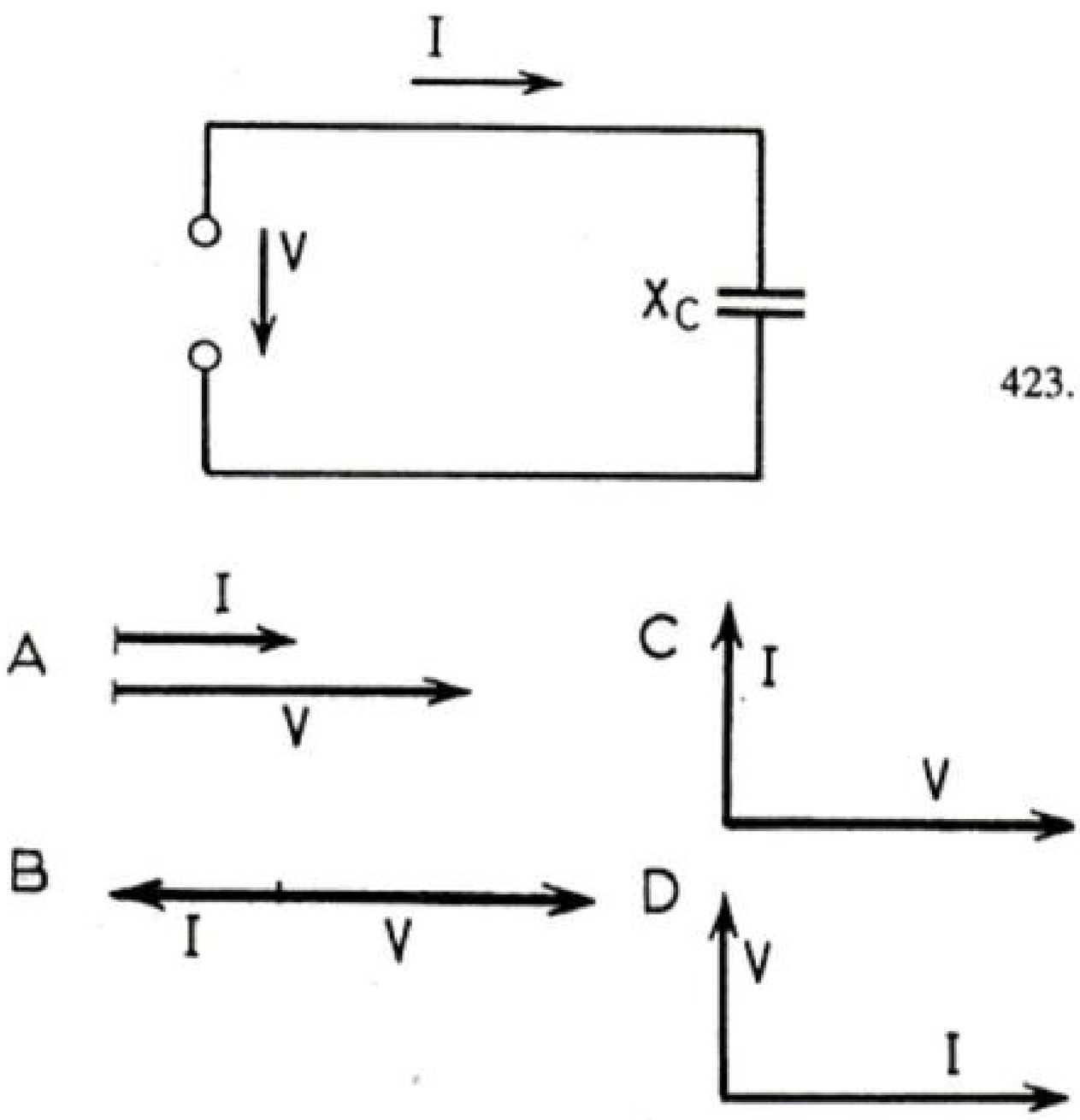
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C. $\cos \phi = \frac{P_r}{P}$ D. $\cos \theta = \frac{P}{P_r}$

419. Which of the following vector diagrams is correct for the circuit shown in the figure?



420. By adding more resistance to an RC circuit

A. the true power increases

B. the true power decreases.

C. the powér factor decreases.

D. the angle of phase difference increases.

421. When alternating voltage is applied across a pure capacitive circuit.

A. the current lags behind the voltage by 90°

B. the current leads the voltage by a quarter cycle.

C. current and voltage are in phase.

D. the voltage lags behind the current by half a cycle.

422. Which of the following statements about the influence of frequency in resistance in an A.C. circuit is true?

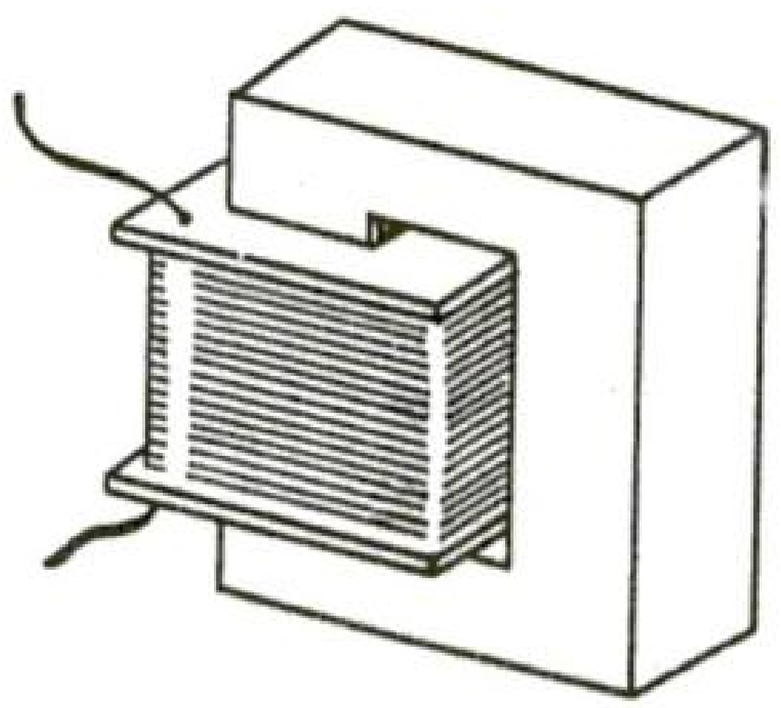
A. An ohmic resistance increased with increasing frequency.

B. An ohmic resistance decreases with increasing frequency.

C. The inductive reactance of a coil decreases with increasing frequency.

D. The capacitive reactance of a capacitor decreases with increasing frequency.

423. How can the apparent resistance of the coil shown in the figure be determined by measurement?



A. The resistance measured with the help of a Wheatstone bridge is equal to the apparent resistance of the coil.

B. A direct circuit is passed through the coil, circuit and voltage are measured and Z is calculated by using ohm's law.

C. An alternating current of corresponding frequency is passed through the coil, current and voltage are measured and Z is calculated by using ohm's law.

D. The inductance of the coil is measured by using an appropriate measuring bridge.

424. Which of the following formula is generally used to calculate the impedance?

A. $Z = \sqrt{R^2 + X^2}$ B. $Z = R^2 + X^2$

C. $Z = R - X$ D. $Z = R + X$

Answers : 419. (C), 420. (A), 421. (B), 422. (D), 423. (C), 424. (A).

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C. $P_a = \dfrac{V \times I}{\sin \phi}$

D. $P_a = V \times I \times \cos \phi$

447. What is the relation between the true power P, the reactive power Pr and the apparent power Pa?

A. $P_a = P + P_r$ B. $P_a = P - P_r$

C. $P_a^2 = P^2 - P_r^2$ D. $P_a = P^2 + P_r^2$

448. Which of the following powers is shown on the name plate of a transformer?

A. The true power which it can supply.

B. The true power drawn by the transformer.

C. The apparent power which it can supply

D. The apparent power drawn by the transformer.

449. How can the apparent power drawn by a consumer be determined?

A. By using an apparent power meter.

B. By using a watt meter which directly indicates the apparent power.

C. By using a watt meter and a power factor meter. Their readings have to be multiplied to get the apparent power.

D. By measuring the voltage *V and the current I. The values have to be multiplied to get the apparent power.*

450. How can the true power P drawn by a consumer be measured?

A. The voltage V and the current I are measured and their product is calculated.

B. The voltage V the current I and the power factor cos ϕ are measured and the true power is calculated according to the formula $P = \dfrac{V \times I}{\cos \phi}$

C. The true power is measured directly with the help to a watt meter.

D. The reactive power is measured and the true power is calculated from it.

451. Which power is measured with the help of an induction watt meter?

A. The reactive power.

C. The true power and the reactive power.

D. Only the true power.

452. Which of the following consumers draws also inductive reactive power?

A. An electrical heater

B. A filament lamp

C. An electrolysis system which draws the current via transformers and rectifiers.

D. A three phase induction motor.

453. Across what type of voltage can the capacitor be connected?

A. Only across a constant direct voltage.

B. Across a constant and pulsating direct voltage.

C. Only across an alternating voltage.

D. Across an alternating voltage and a constant direct voltage.

454. Which of the following comparison between the metallic paper (MP) capacitor and the electrolytic capacitor is true?

A. The MP capacitor cures itself after any puncture, which the electrolytic capacitor does not

B. For the same volume the MP-capacitor can have much more capacitance as compared to the electrolytic capacitor.

C. MP capacitors are only suitable for direct voltage, while unpoled electrolytic capacitors can be used for alternating as well as for direct voltage.

D. A small current always flows through the dielectric of an MP capacitor, which is not the case with an electrolytic capacitor.

455. How should capacitors be discharged?

A. Through a resistor

B. Through a good conductor (at least 4 mm^2 Cu).

Answers : 447. (D), 448. (C), 449. (D), 450. (C), 451. (D), 452. (D), 453. (D), 454. (A), 455. (A).

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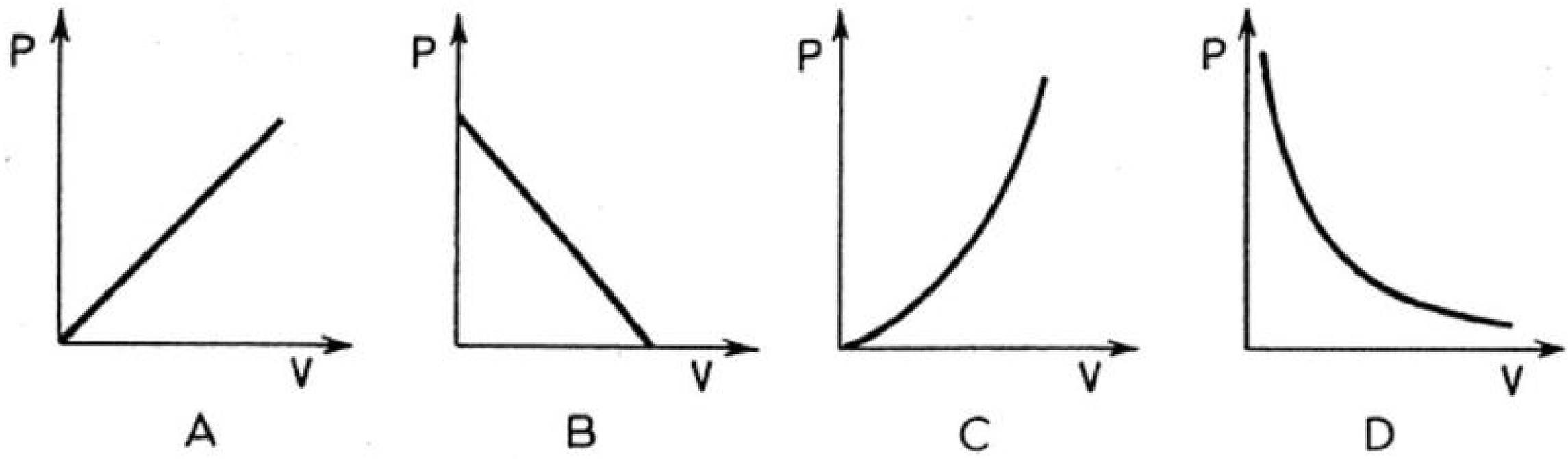


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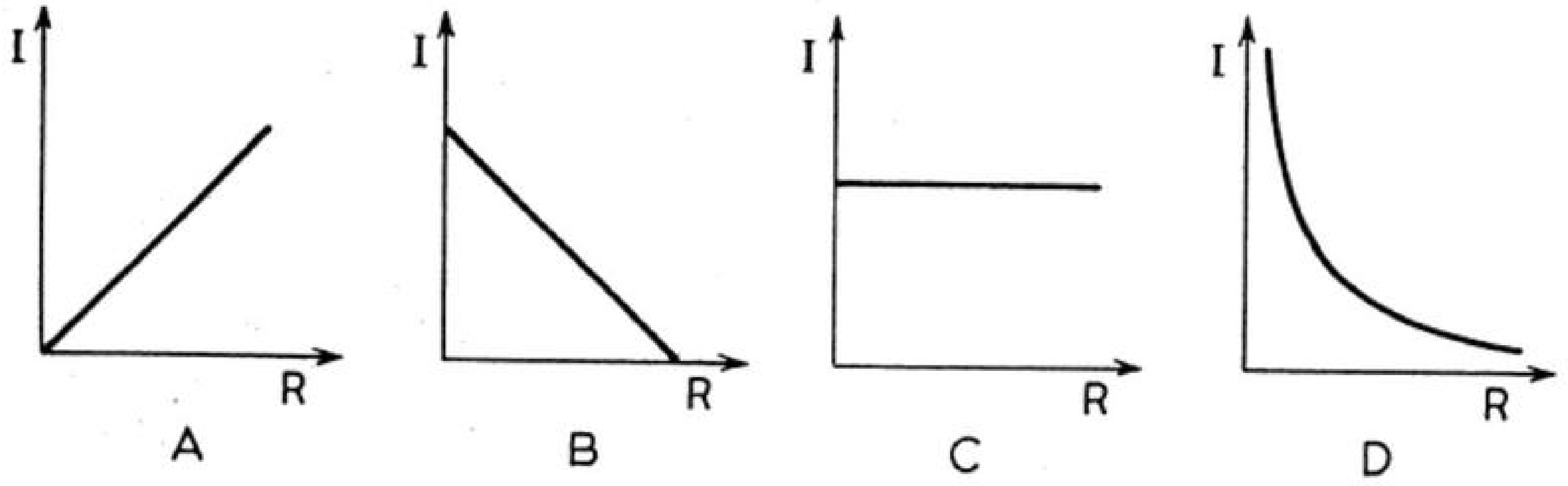


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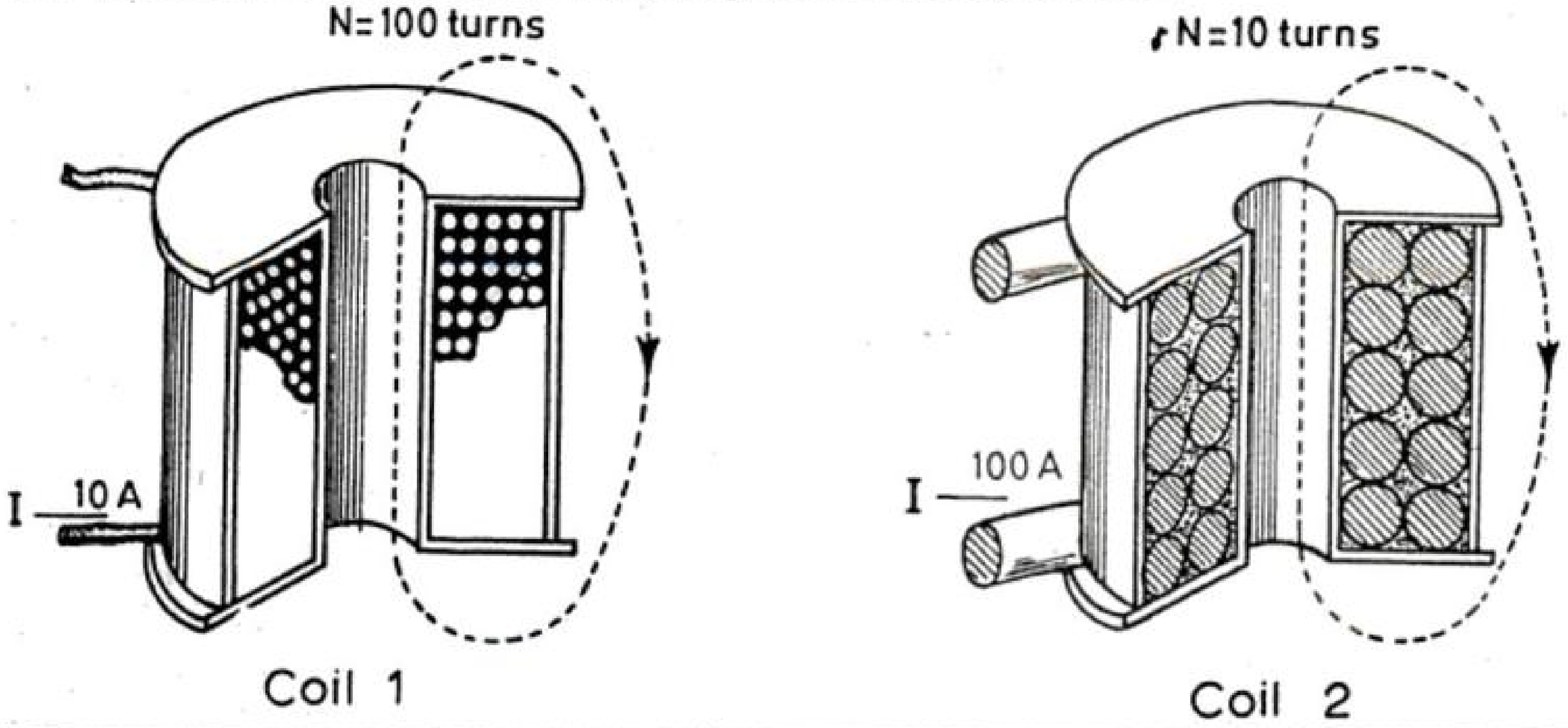
483. A resistance is connected across a D.C. supply. The value of the voltage was gradually increased. The curve which represents the relationship between power and voltage is



484. A variable resistance is connected across a constant voltage E volts. The value of resistance is gradually increased. The graph which shows the relationship between current (I) and resistance (R) is



485. Which of the two coils shown in the figure produces more magnetic flux ?



Answers : 483. (C), 484. (D).

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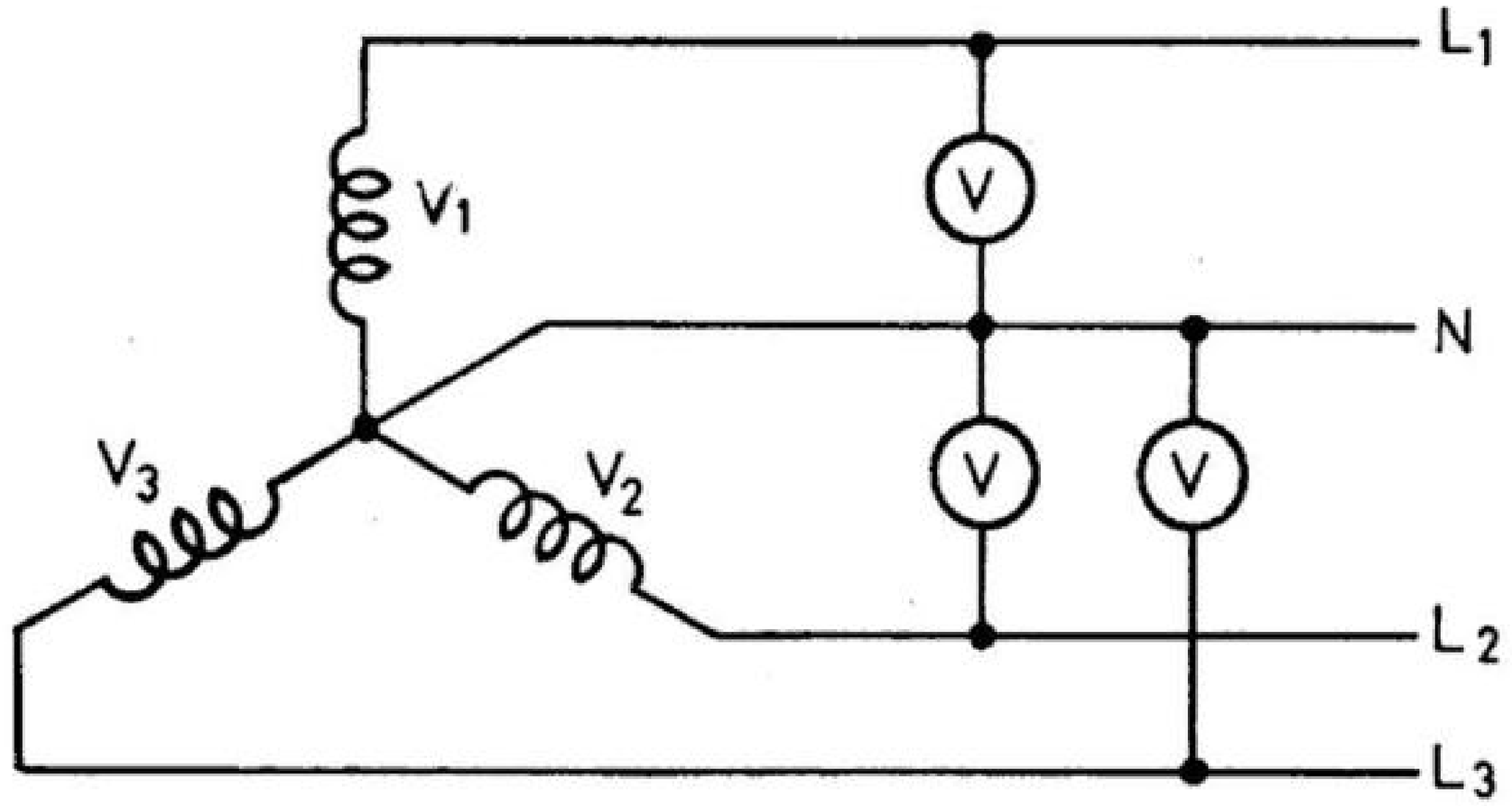


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502. The figure shows a circuit diagram of a three-phase generator. In each of the three coils an alternating voltage having an effective value of 220 V is induced! Which of the following values is indicated by voltmeters



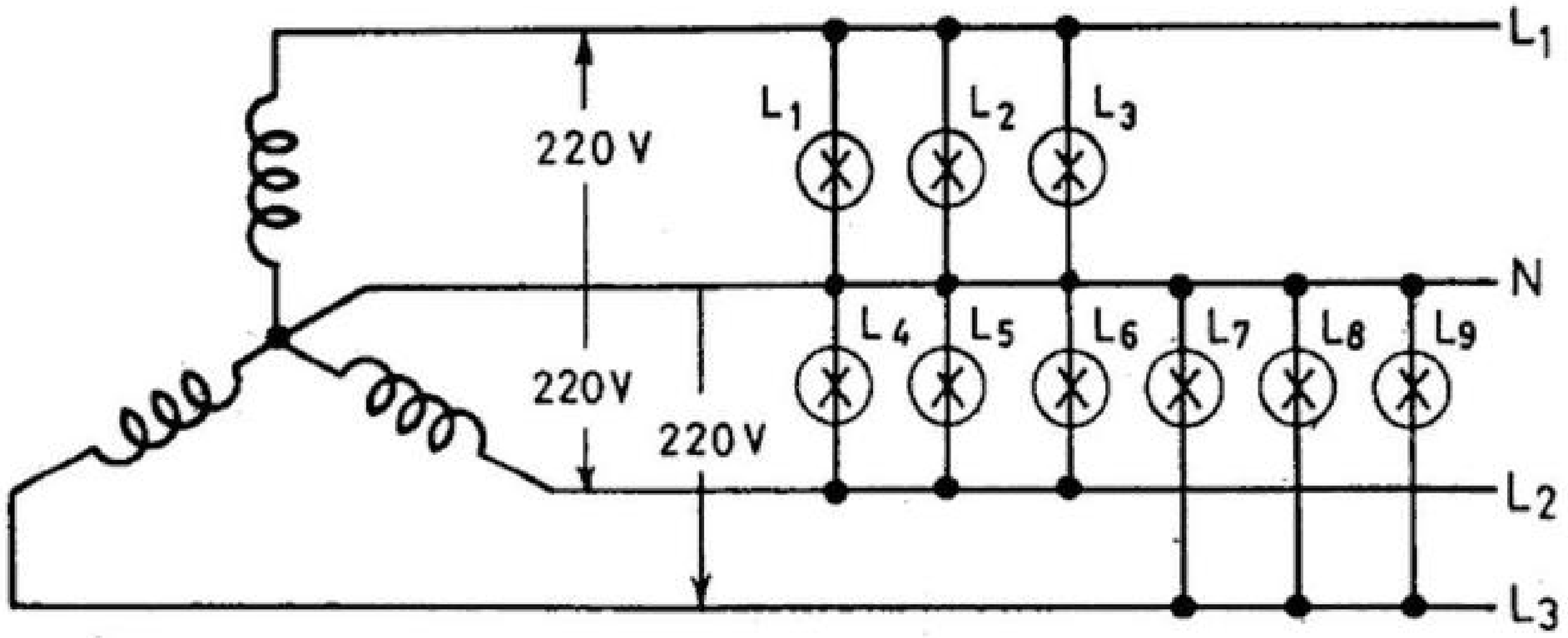
A. $220\ V \times \sqrt{3} = 380\ V$

B. $220\ V$

C. $\frac{220\ V}{\sqrt{3}} = 127\ V$

D. $220\ V \times \sqrt{2} = 310\ V$

503. The same number of lamps are connected between the conductors L_1 and N, L_2 and L_3 and N. What is this type of load called ?



A. A co-phasal load

B. A unit load

C. A parallel load

D. A balanced load

Answers : 502. (B), 503. (D).

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by $W_M = 1/2\, Li^2$. As the current through an inductance changes (di/dt), an *emf* of self-induction, e_L, is induced in it, such that it opposes the change (according to Lenz's law), and expressed mathematically by

$$e_L = -Ldi/dt$$

or $$v_L = -e_L = Ldi/dt$$

where v_L is the applied voltage.

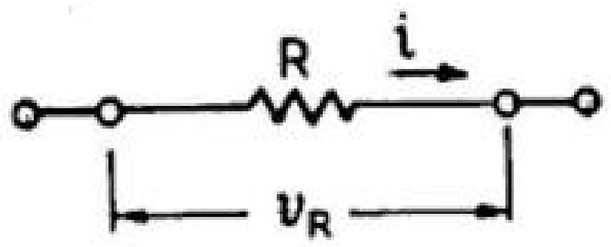


Fig. 3.3

Capacitance: The capacitance C is that characteristic of a device which accounts for the storage of energy in the associated electric field. The stored energy is given by $CV_c^2/2$. The charge q taken by electrodes of the capacitance is, $q = Cv_c$, where v_c is the voltage across the capacitor.

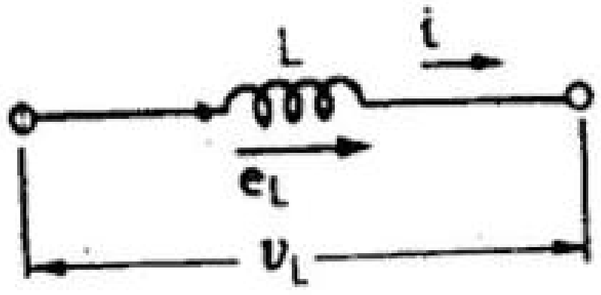


Fig. 3.4

The current entering the capacitance is

$$i = dq/dt$$

or $$i = Cdv_c/dt$$

or $$v_c = \frac{1}{C}\int idt$$

3.6 The AC Signal. An alternating signal is time-dependent or frequency-dependent. The sinusoidal variation is most commonly used alternating signal that can be represented by $i = I_m \sin(\omega t + \phi)$ for alternating current signal and $v = V_m \sin(\omega t + \phi)$ for alternating voltage signal, where i is the instantaneous value of the current, I_m is the peak value and ω is termed as radiant frequency ($\omega = 2\pi f$), where is the frequency and ϕ is the phase angle.

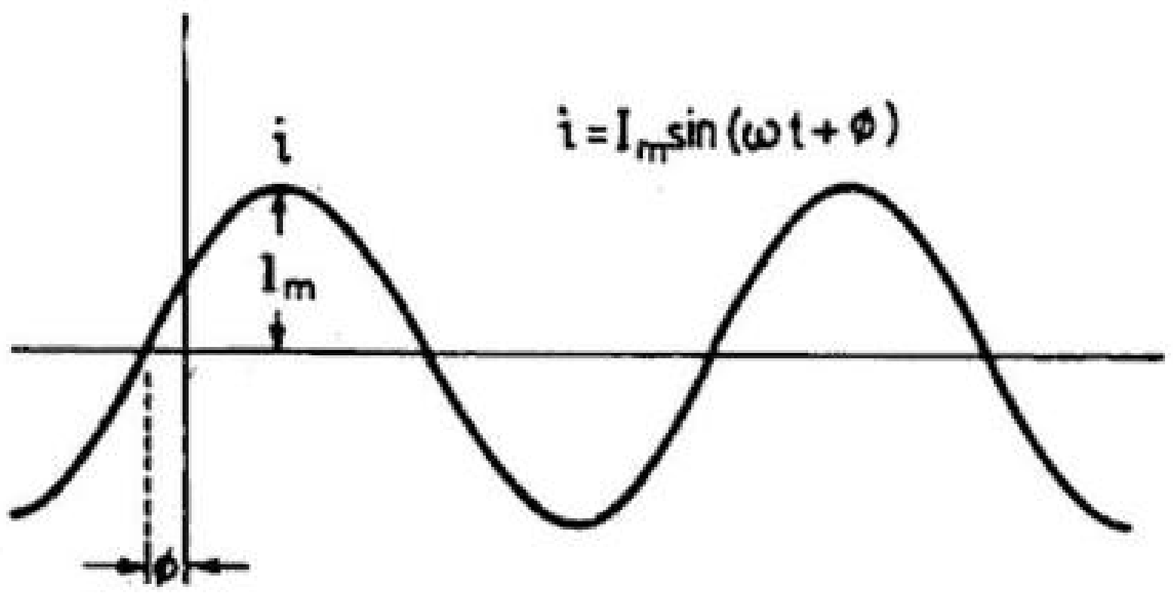


Fig. 3.5 (a)

3.7. Vector. Representation of a vector in case of ac analysis can be given by any one of the following ways:

$\dot{V} = V \angle \phi$ Polar form

$\dot{V} = Ve^{j\phi}$ Exponential form

$\dot{V} = V(\cos\phi + j\sin\phi)$ Trigonometric form

$\dot{V} = V_A + jV_B$ Rectangular form

where $j = \sqrt{-1}$

Now $V_A = \dot{V}\cos\phi$ and $V_B = \dot{V}\sin\phi$

$$|V| = \sqrt{V_A^2 + V_B^2}$$

and $$\phi = \tan^{-1}\left(\frac{V_B}{V_A}\right),$$

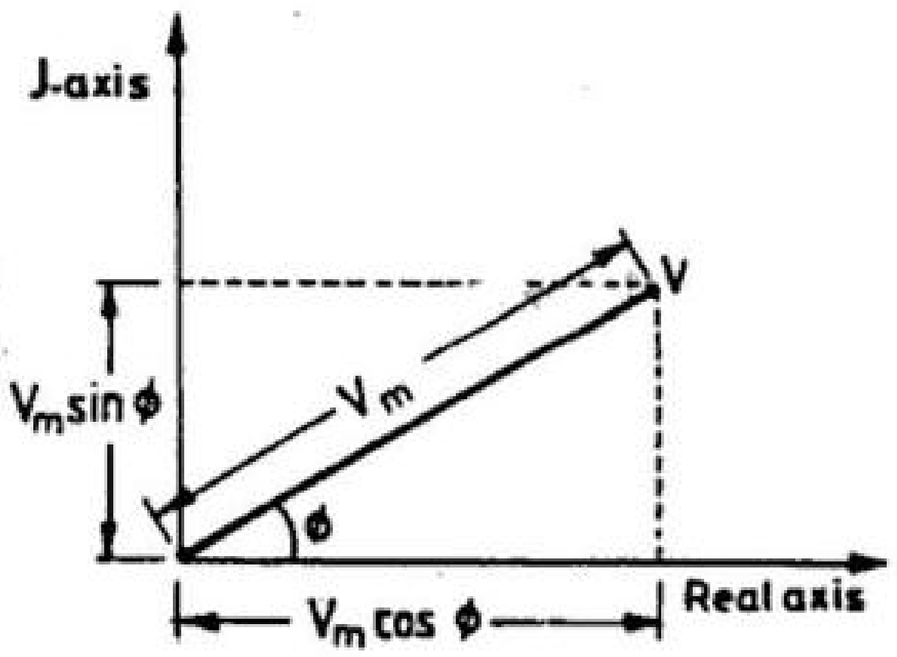


Fig. 3.5 (b)

Phasor diagram, a graphical representation, of a vector $\dot{V}_m$ with magnitude V_m and phase angle ϕ (as in case of sinusoidal voltage $v = V_m \sin(\omega t + \phi)$ is shown in Fig. 3.5 (b).

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3.17. Nodal Method of Analysis. In this method at every node, KCL is applied assuming the possible directions of the branch currents. One of the node is assumed to be a reference node or in other words, one of the node is assumed to be at zero potential. This assumption does not change the statement of the problem, since the branch currents are decided by the potential differences between respective nodes and not by the absolute values of the node potentials. By Ohm's law, the equation for every branch current is now written and substituted into the KCL equations. Thus if there are n number of nodes, there shall be $(n-1)$ number of nodal equations in terms of $(n-1)$ number of unknown variables of nodal voltages. By solving these equations, nodal voltages are known to calculate the branch currents.

3.18. Thevenin Theorem. Thevenin theorem reduces a linear electrical network to a voltage generator circuit which is called '*Thevenin Equivalent Circuit*'. According to this theorem, any linear active network to which a load is connected can be reduced to a voltage generator whose generated voltage is equal to the open-circuit voltage that appears across the load terminals when load is disconnected and whose internal impedance is equal to the impedance of the network looking back into the load terminals when all the generators are replaced by their internal impedances. Or in others words, Thevenin equivalent circuit consists of a Thevenin voltage generator (E_{TH}) whose value is equal to the open-circuit voltage across the load terminals, along with a Thevenin equivalent resistance (R_{TH}) in series. The Thevenin equivalent resistance is the resistance of the network when all voltage sources are short-circuited. A Thevenin equivalent circuit is shown in Fig 3.8.

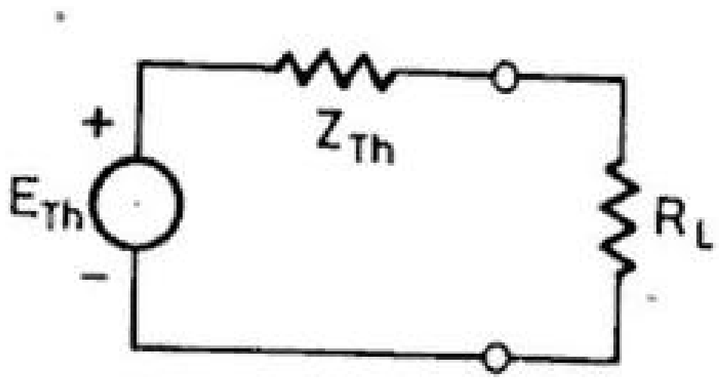


Fig. 3.8

3.19. Norton's Theorem. This theorem is the dual of Thevenin theorem. The theorem states that any linear active network to which a load is connected, can be reduced to a current source equal to the short-circuit current that flows through the load terminals when they are short-circuited and having a resistance in parallel to the current source equal to the resistance of the active network. Likewise the Thevenin equivalent resistance, the Norton equivalent resistance is also equal to the resistance of the network when all voltage sources are short- circuited. A Norton's equivalent circuit is shown in Fig 3.9.

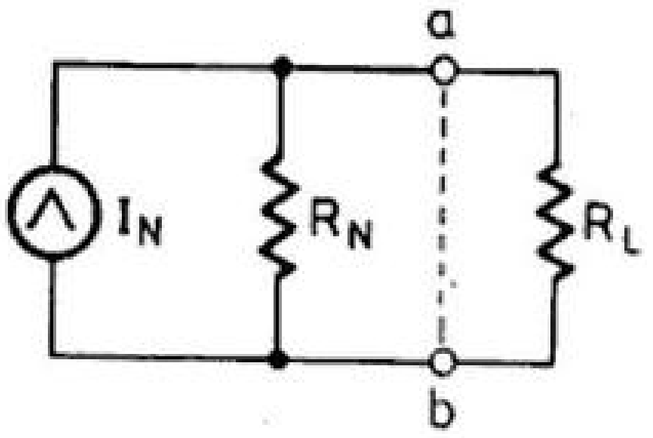


Fig. 3.9

Thus, the current through the load resistance remains unchanged.

3.20. Compensation Theorem. Compensation theorem states that any resistance in a network may be replaced by a voltage source that has zero internal resistance and a generated voltage which is equal to the potential drop across the replaced resistance by current flowing through it and directed against this current.

As shown in Fig 3.10 (a), the resistance R through which current I flows can be replaced by voltage source E [Fig 3.10 (b)] whose generated value is $E = I \times R$ and directed against the direction of current I.

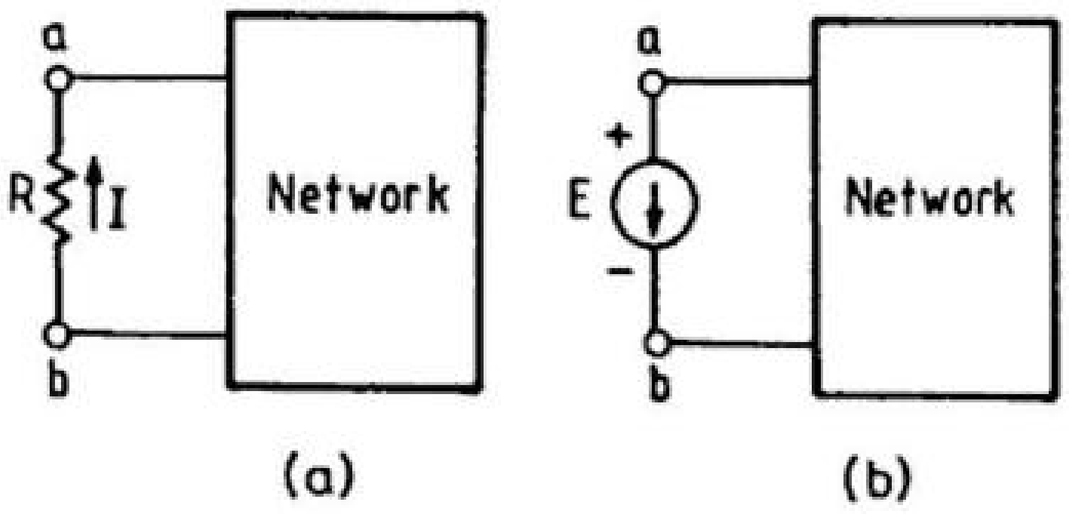


Fig. 3.10

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$$v_R + v_L + v_C = v$$

where

$$v_R = R \times i = R \times I_m \sin (\omega t + \phi_i)$$

$$v_L = L \frac{di}{dt} = \omega L \, I_m \cos (\omega t + \phi_i)$$

$$= \omega L I_m \sin (\omega t + \phi_i + \pi/2)$$

$$v_C = \frac{1}{C} \int i dt$$

$$= - (I_m / \omega C) \cos (\omega t + \phi_i)$$

$$= \frac{I_m}{\omega C} \sin (\omega t + \phi_i - \pi/2)$$

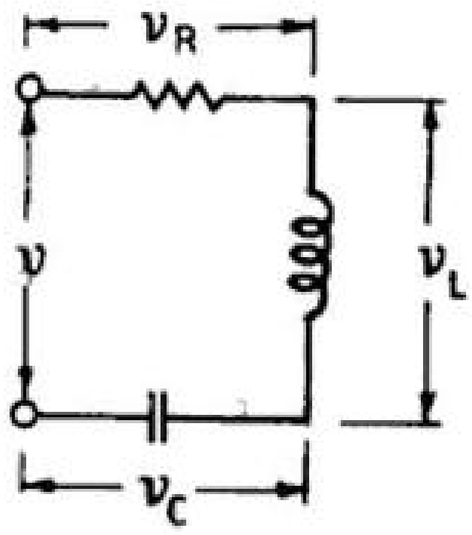


Fig. 3.14 (a)

In vectorial form, it can also be written

$$\dot{V}_R + \dot{V}_l + \dot{V}_c = \dot{V}$$

It can also be represented by phasor-diagram as shown in Fig 3.14 (*b*) as

$$R\dot{I} + j\omega L\dot{I} + \dot{I}/j\omega C = \dot{V}$$

Therefore

$$\dot{V} = \left[R + j \left(\omega L - \frac{1}{\omega C} \right) \right] \times \dot{I}$$

where

$$V = I \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C} \right)^2}$$

or

$$I = \frac{V}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C} \right)^2}}$$

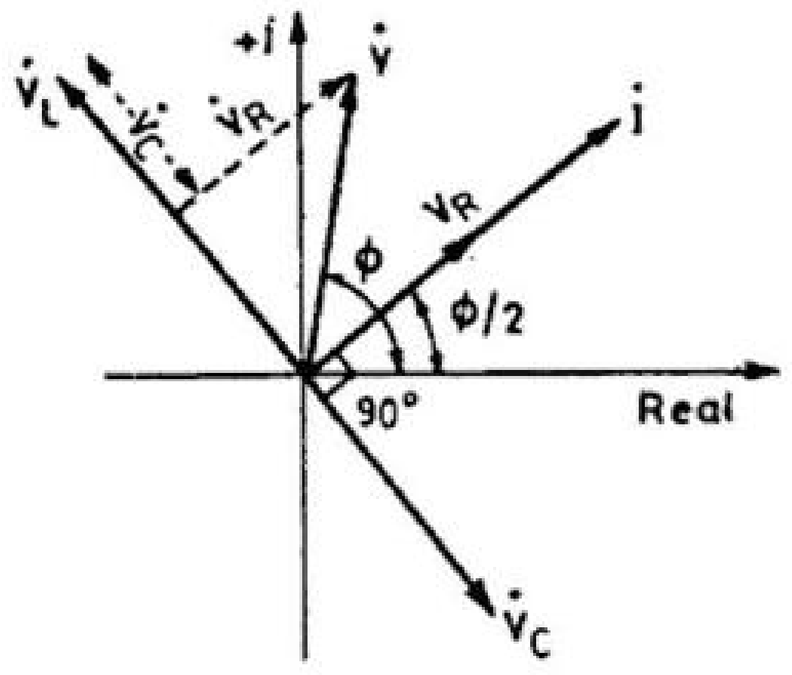


Fig. 3.14 (b)

and

$$\phi = \text{arc tan} \left(\frac{\omega L - 1/\omega C}{R} \right) = \tan^{-1} \left(\frac{X_L - X_C}{R} \right)$$

where ϕ is the phase single introduced by the impedance.

Therefore

$$v = V_m \sin (\omega t + \phi_i + \phi)$$

where

$$V_m = I_m \times \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C} \right)^2}$$

3.27 RLC in Parallel. In the circuit shown in Fig. 3.15 (*a*) applying *KCL*,

$$i_R + i_L + i_C = i \text{ or } \dot{I}_R + \dot{I}_L + \dot{I}_C = \dot{I}$$

$$\dot{I}_R = \dot{V}/R, \; \dot{I}_L = \dot{V}/j\omega L, \; \dot{I}_C = \dot{V} (j\omega C)$$

$$v = V_m \sin (\omega t + \phi_v)$$

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are the corresponding frequencies f_1 and f_2 at the value of current $I = I_0/\sqrt{2}$, where I_0 is the current at resonance in the *RLC* series circuit. This is shown in Fig 3.20.

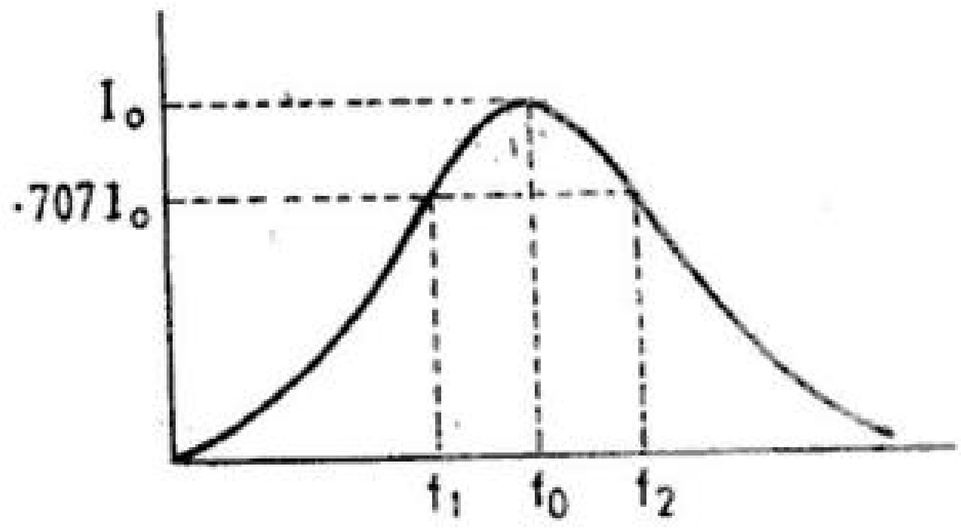


Fig. 3.20

Therefore, power in the circuit at resonance

$$= I_0^2 \times R$$

Power in the circuit at f_1

$$= \left(\frac{I_0}{\sqrt{2}} \right)^2 \times R = \frac{1}{2} I_0^2 R$$

Power in the circuit at f_2

$$= \left(\frac{I_0}{\sqrt{2}} \right)^2 \times R = \frac{1}{2} I_0^2 R$$

3.33 Selectivity and Bandwidth. The bandwidth of the circuit is the difference $(f_2 - f_1)$. The ratio of the bandwidth to the resonance frequency is defined as *selectivity* of the circuit.

Thus selectivity $= \dfrac{(f_2 - f_1)}{f_0}$

When frequency is varied in an *RLC* series circuit, the selectivity becomes

$$\frac{(f_2 - f_1)}{f_0} = \frac{1}{Q_0}$$

where Q_0 is *Quality Factor* of the circuit at resonance.

3.34. Mutual Inductance. If the variation of current in one of two separate circuit sets up an induced emf in the other, the two circuits are said to be inductively coupled and the induced emf is called the emf of mutual induction.

The amount of coupling between the two circuit is expressed in terms of the coefficient of coupling defined as

$$k = \frac{M}{\sqrt{L_1 L_2}}$$

where M = mutual inductance of the two circuit ;

L_1 = self-inductance of the first circuit ; and

L_2 = self-inductance of the second circuit.

3.35. Series Connections. Two kinds of series connections are possible, series aiding and series opposition (or series bucking) as illustrated in Fig 3.21.

In case of series aiding, the currents in both circuit elements are in the same direction relative to like terminals. For this reason, the magnetic fluxes of self-induction ϕ_{11} (or ϕ_{22}) and of mutual induction ϕ_{12} (or ϕ_{21}) linking with each element *add together.*

In case of series opposition, the currents in the two circuit elements are in opposite directions relative to like terminals. Therefore, the magnetic flux of self and mutual induction linking with each element are always opposite sign *(i.e., they subtract from each other).*

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variable expression to the time expression is called an inverse transformation. The notation for the inverse transformation is L^{-1}, so that

$$L^{-1}[F(s)] = f(t)$$

Mathematically

$$f(t) = \frac{1}{2\pi j}\int_{c-j\infty}^{c+j\infty} F(s)\, e^{-st}\, ds \quad (t > 0)$$

3.40. Fourier Analysis. Any periodic function $f(t)$ can be expressed as a sum of a fundamental and harmonic terms. A Fourier series can be written for this expression if $f(t)$ is periodic and satisfies the Dirichlet conditions, which mainly reveals that $f(t)$ must be absolutely convergent, *i.e.*,

$$\int_0^T |f(t)|\, dt < \infty$$

The other conditions require that in each period the function has a finite number of discontinuities and possesses a finite number of maxima and minima.

3.41. Periodic Function. A signal $f(t)$ is said to be periodic of period T if

$$f(t) = f(t+T) \text{ for all } t.$$

In the simplest form, the Fourier series can be expressed as

$$f(t) = a_0 + a_1 \cos \omega_0 t + a_2 \cos 2\omega_0 t + \ldots + a_n \cos n\omega_0 t + \ldots + b_1 \sin \omega_0 t + b_2 \sin 2\omega_0 t + \ldots + b_n \sin n\omega_0 t + \ldots$$

or

$$f(t) = a_0 + \sum_{n=1}^{\infty} a_n \cos(n\omega_0 t) + \sum_{n=1}^{\infty} b_n \sin(n\omega_0 t)$$

where $n\omega_0 = \frac{2\pi n}{T}$ is said to be the n th harmonic of the fundamental frequency ω_0,

and

$$a_0 = \frac{1}{T}\int_{-T/2}^{T/2} f(t)\, dt$$

$$a_n = \frac{2}{T}\int_{-T/2}^{T/2} f(t)\cos(n\omega_0 t)\, dt$$

$$b_n = \frac{2}{T}\int_{-T/2}^{T/2} f(t)\sin(n\omega_0 t)\, dt$$

Further if $a_n \cos(n\omega_0 t) + b_n \sin(n\omega_0 t) = c_n \cos(n\omega_0 t + \theta_n)$

where

$$c_n = \sqrt{a_n^2 + b_n^2}$$

and

$$\theta_n = -\tan^{-1}\left(\frac{b_n}{a_n}\right)$$

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The set of all remaining branches of a graph which are not in tree form are called the complement of the *tree* or the *co-tree*. The branches of the tree are called *twigs* and the branches of the co-tree are called *links*..

Cut-Sets. A cut-set is a set of branches whose removal causes a connected graph to have two separate parts. If any branch of the cut-set is replaced, the graph can be connected. For the example given in Fig 3.24, following are some of the cut-sets:

[1, 2], [4, 5], [1, 3, 4], [1, 3, 5 [, [2, 3, 4], [2, 3, 5] .

3.45. Duality. In electrical circuit analysis, a number of characteristics, quantities or ideas are found dual to each other. The duality is used in drawing the topological graphs to aid the circuit analysis. For example, voltage and current are dual to each other. The energy stored in an inductor is $1/2\ Li^2$. If L is replaced by C and i is replaced by v, then energy stored in capacitor is $1/2\ Cv^2$. Thus inductance and capacitance are dual to each other. The table below gives the set of various duals.

Quantity/Concept	*Dual*
Current	Voltage
Resistance	Conductance
Inductance	Capacitance
Loop	Node pair
No. of loops	No. of node pairs
Loop current	Node pair voltage
Mesh current	Node potential
Tie set	Cut-set
Link	Tree branch
Short-circuit	Open circuit
Series path	Parallel path

3.46. Two-Port Variable Relationships. In the two-port network shown in Fig 3.25, there are four variables-two voltages and two currents. The quantities V_1 and I_1 as variables at the input port, V_2 and I_2 are the variables at the output port 2. Only two of the four variables are independent, and the specification of any two determines the remaining two variables. The dependence of two of the four variables of the other two can be described in a number of ways as described below.

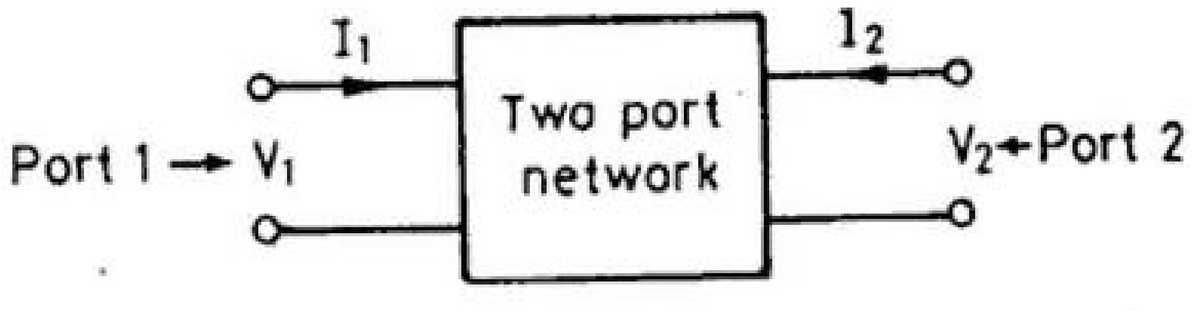


Fig. 3.25

(a) Open-Circuit Impedance Parameters. The network is described by the equations for voltages V_1 and V_2 as

$$V_1 = z_{11}\, I_1 + z_{12}\, I_2$$

$$V_2 = z_{21}\, I_1 + z_{22}\, I_2$$

where z_{11}, z_{12}, z_{21} and z_{22} are called the open-circuit impedances.

If either I_1 or I_2 is zero, each of the four parameters can be defined as a ratio of voltage and current.

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Condition for *symmetry*	Condition for *reciprocity*
$z_{11} = z_{22}$	$z_{12} = z_{21}$
$y_{11} = y_{22}$	$y_{12} = y_{21}$
$\Delta h = 1$	$h_{12} = -h_{21}$
$\Delta g = 1$	$g_{12} = -g_{21}$
$A = D$	$AD - BC = 1$

Relationship among Various parameters. The relationships in matrix form are given below:

$$\begin{vmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{vmatrix} = \begin{vmatrix} \frac{y_{22}}{\Delta y} & \frac{-y_{12}}{\Delta y} \\ -\frac{y_{21}}{\Delta y} & \frac{y_{11}}{\Delta y} \end{vmatrix} = \begin{vmatrix} \frac{A}{C} & \frac{\Delta T}{C} \\ \frac{1}{C} & \frac{D}{C} \end{vmatrix} = \begin{vmatrix} \frac{\Delta g}{h_{22}} & \frac{h_{12}}{h_{22}} \\ -\frac{h_{21}}{h_{22}} & \frac{1}{h_{22}} \end{vmatrix} = \begin{vmatrix} \frac{-1}{g_{11}} & \frac{-g_{12}}{g_{11}} \\ \frac{g_{21}}{g_{11}} & \frac{\Delta g}{g_{11}} \end{vmatrix}$$

$$\begin{vmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{vmatrix} = \begin{vmatrix} \frac{z_{22}}{\Delta z} & \frac{-z_{12}}{\Delta z} \\ \frac{-z_{21}}{\Delta z} & \frac{z_{11}}{\Delta z} \end{vmatrix} = \begin{vmatrix} \frac{D}{B} & \frac{-\Delta T}{B} \\ -\frac{1}{B} & \frac{A}{B} \end{vmatrix} = \begin{vmatrix} \frac{1}{h_{11}} & \frac{-h_{12}}{h_{11}} \\ \frac{h_{21}}{h_{11}} & \frac{\Delta h}{h_{11}} \end{vmatrix} = \begin{vmatrix} \frac{\Delta g}{g_{22}} & \frac{g_{12}}{g_{22}} \\ -\frac{g_{21}}{g_{22}} & \frac{1}{g_{22}} \end{vmatrix}$$

$$\begin{vmatrix} A & B \\ C & D \end{vmatrix} = \begin{vmatrix} \frac{z_{11}}{z_{21}} & \frac{\Delta z}{z_{11}} \\ \frac{1}{z_{21}} & \frac{z_{22}}{z_{21}} \end{vmatrix} = \begin{vmatrix} -\frac{y_{22}}{y_{21}} & \frac{-1}{y_{21}} \\ \frac{y}{y_{21}} & -\frac{y_{11}}{y_{21}} \end{vmatrix} = \begin{vmatrix} -\frac{\Delta h}{h_{21}} & \frac{-h_{11}}{h_{21}} \\ -\frac{h_{22}}{h_{21}} & \frac{-1}{h_{21}} \end{vmatrix} = \begin{vmatrix} \frac{1}{g_{21}} & \frac{g_{22}}{g_{21}} \\ \frac{g_{11}}{g_{21}} & \frac{\Delta g}{g_{21}} \end{vmatrix}$$

$$\begin{vmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{vmatrix} = \begin{vmatrix} \frac{\Delta z}{z_{22}} & \frac{z_{12}}{z_{22}} \\ -\frac{z_{21}}{z_{22}} & \frac{1}{z_{22}} \end{vmatrix} = \begin{vmatrix} \frac{1}{y_{11}} & -\frac{y_{12}}{y_{11}} \\ \frac{y_{21}}{y_{11}} & \frac{\Delta y}{y_{11}} \end{vmatrix} = \begin{vmatrix} \frac{B}{D} & \frac{\Delta T}{D} \\ -\frac{1}{D} & \frac{C}{D} \end{vmatrix} = \begin{vmatrix} \frac{g_{22}}{\Delta g} & \frac{-g_{12}}{\Delta g} \\ -\frac{g_{21}}{\Delta g} & \frac{g_{11}}{\Delta g} \end{vmatrix}$$

$$\begin{vmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{vmatrix} = \begin{vmatrix} \frac{1}{z_{11}} & \frac{-z_{12}}{z_{11}} \\ \frac{z_{21}}{z_{11}} & \frac{-\Delta z}{z_{11}} \end{vmatrix} = \begin{vmatrix} \frac{\Delta y}{y_{22}} & \frac{y_{12}}{y_{22}} \\ -\frac{y_{21}}{y_{22}} & \frac{1}{y_{22}} \end{vmatrix} = \begin{vmatrix} \frac{C}{A} & -\frac{\Delta T}{A} \\ \frac{1}{A} & \frac{B}{A} \end{vmatrix} = \begin{vmatrix} \frac{h_{22}}{\Delta h} & \frac{-h_{12}}{\Delta h} \\ -\frac{h_{21}}{\Delta h} & \frac{h_{11}}{\Delta h} \end{vmatrix}$$

3.49. ABCD parameters for Cascaded Network. The *ABCD* parameters are very helpful in the case of cascaded networks. Two cascaded networks N_1 and N_2 are shown in Fig 3.30. For network N_1

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} \begin{bmatrix} V \\ -I_2 \end{bmatrix}.$$

Similarly, for network N_2

$$\begin{bmatrix} V \\ I_1 \end{bmatrix} = \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

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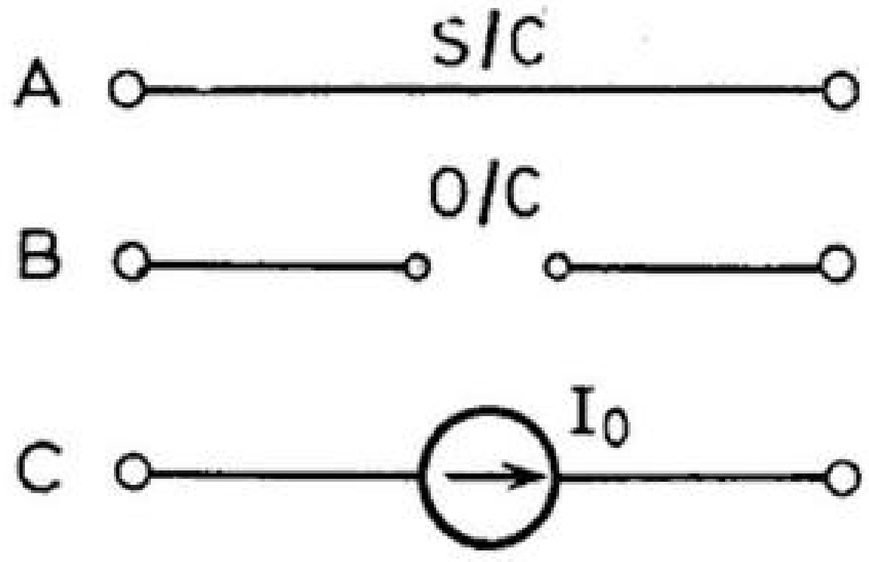
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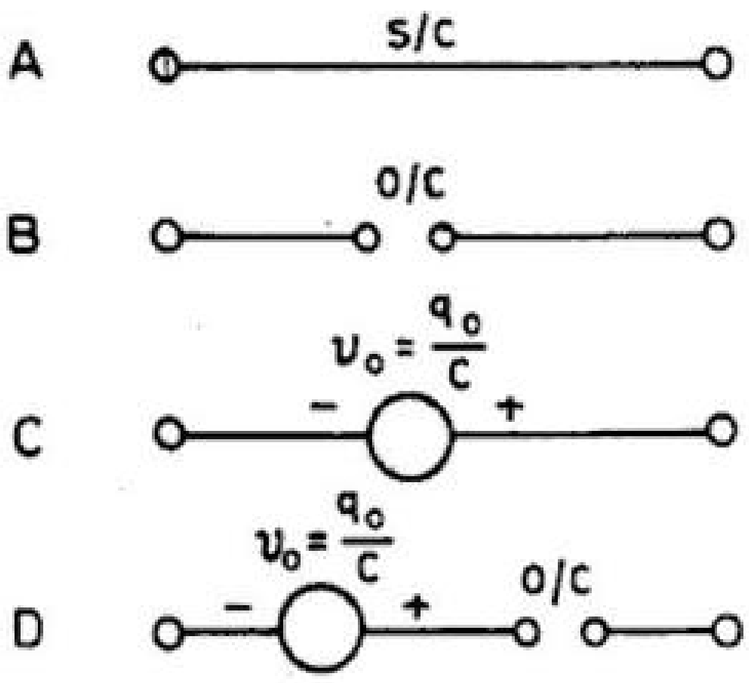


9. An capacitor with zero initial condition at $t = 0^+$ acts as a
   A. short circuit. B. open circuit.
   C. current source. D. voltage source.

10. A capacitor with initial charge q_0 at $t = 0^+$ acts as a
   A. short circuit B. open circuit
   C. current source D. voltage source.

11. A capacitor with no initial charge at $t = \infty$ acts as
   A. short circuit B. open circuit
   C. current source D. voltage source

12. The equivalent circuit of a capacitor with initial charge q_0 at $t=\infty$ will be



13. A passive network has
   A. no emf source.
   B. no current source.
   C. neither emf source nor current source.
   D. None of these.

14. A cut set has
   A. only one tree branch
   B always more than one tree branch
   C. only one tree link
   D. None of these.

15. Tellengen's theorem is applicable to
   A. linear networks only
   B. non-linear networks only
   C. linear and non-linear networks
   D. None of these.

16. If there are b branches and n nodes, the number of KCL equations required will be
   A. b B. n
   C. $(n-1)$ D. $b-n+1$

17. For the same peak value of voltage, which wave form will have the least rms value?
   A. Sine wave B. Triangular wave
   C. Square wave D. None of these

18. An inductor stores energy in
   A. electrostatic field
   B. electromagnetic field
   C. magnetic field
   D. core

19. Milliman's theorem yields
   A. equivalent voltage source
   B. equivalent voltage or current source
   C. equivalent resistance
   D. equivalent impedance.

20. If a 220V, Hz source is connected to a circuit having resistance, inductance and capacitance, all of which are 16 ohms each, the current is most nearly

Answers : 8. (D), 9. (A), 10. (D), 11. (B), 12. (D), 13. (C), 14. (A), 15. (C), 16. (C), 17. (B), 18. (C), 19. (B).

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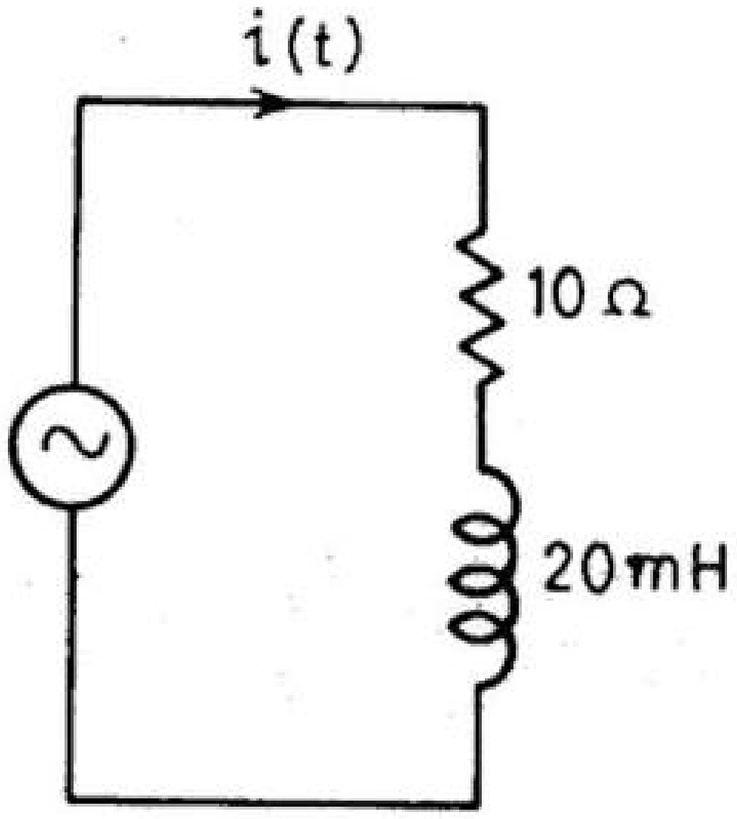
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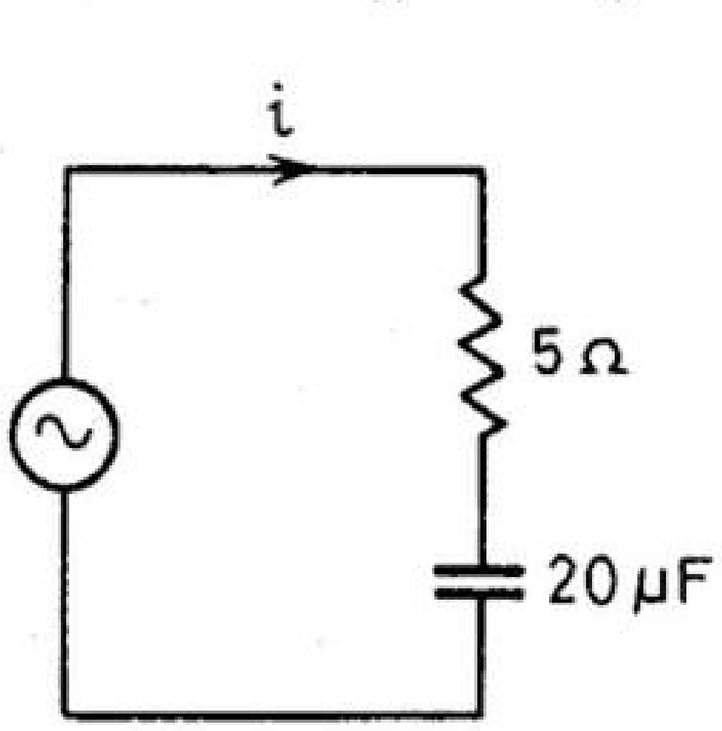
A. 20 sin 500 t V.

B. 20 cos 500 tV

C. 28.28 sin (500 t + 45°) V

D. 30.5 cos (500 t + 30°)V.

50. The series circuit shown below has a current $i = 2 \cos 5{,}000\ t$ A. The applied voltage will be



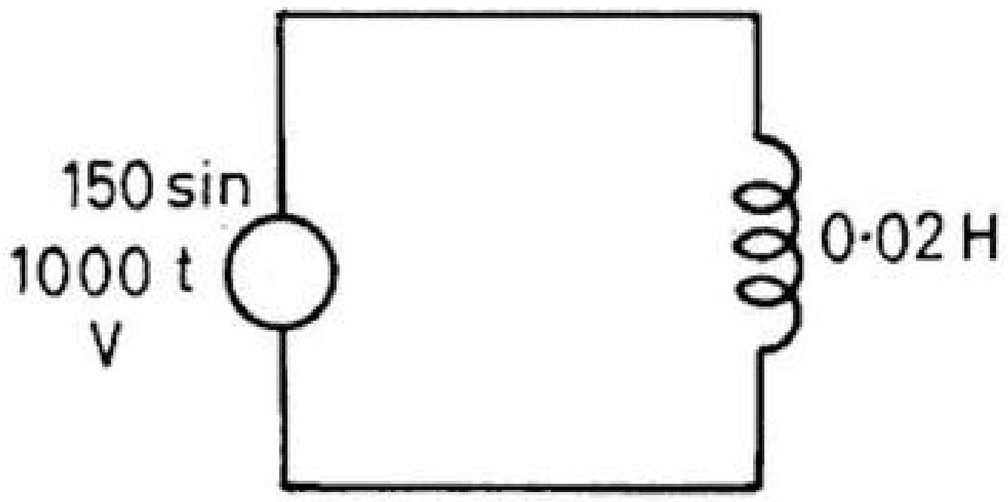
A. 22.4 sin (5,000 t + 63.4°)V.

B. 22.4 cos (5,000 t –63.4°) V.

C. 22.4 sin (500 t – 63.4°) V.

D. None of these.

51. For the circuit shown below, the current $i(t)$ will be



A. 7.5 sin (1,000 t) A.

B. –7.5 sin (1,000 t) A.

C. 7.5 cos (1,000 t) A.

D. –7.5 cos (1,000 t) A.

52. In the above problem, the average power will be

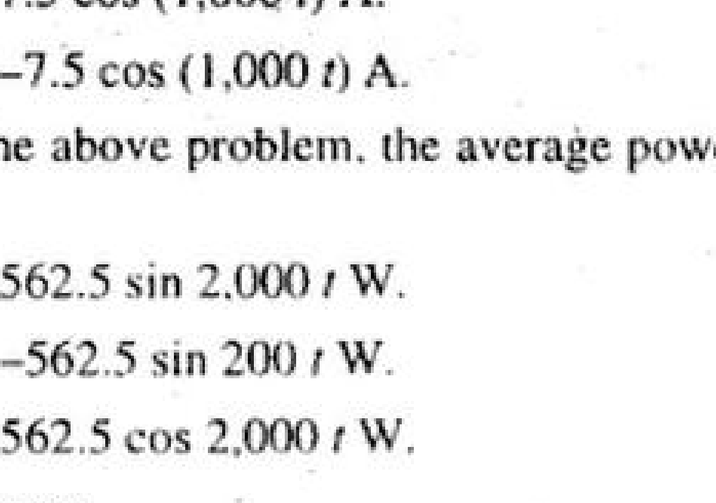
A. 562.5 sin 2,000 t W.

B. –562.5 sin 200 t W.

C. 562.5 cos 2,000 t W.

D. zero.

53. The instantaneous voltage e = 346.4 sin 314 t volts is given to the circuit. The reading of the ammeter will be



A. 1 A B. 10 A

C. 20 A D. 30 A

54. The supply voltage V = 230 V, AC, 50 Hz is given to the circuit shown below. The ammeter reading will be

Answers : 49. (C), 50. (B), 51. (D), 52. (D), 53. (C).

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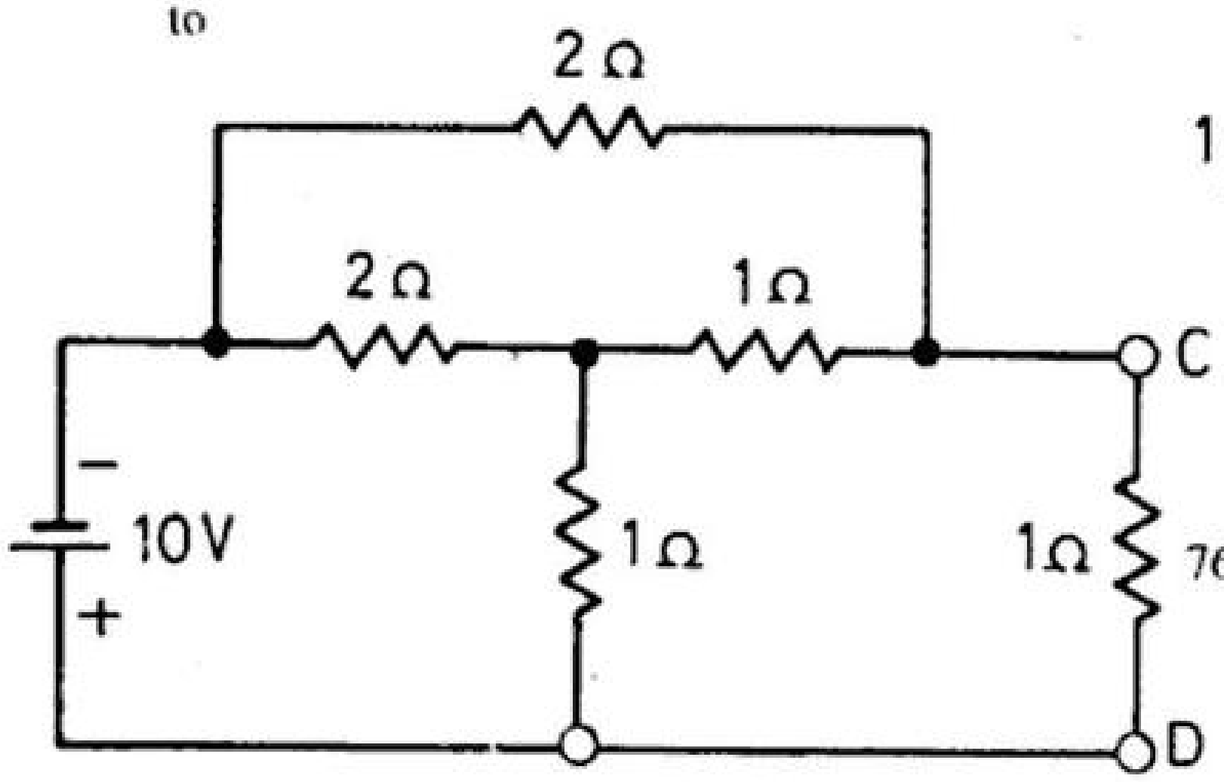
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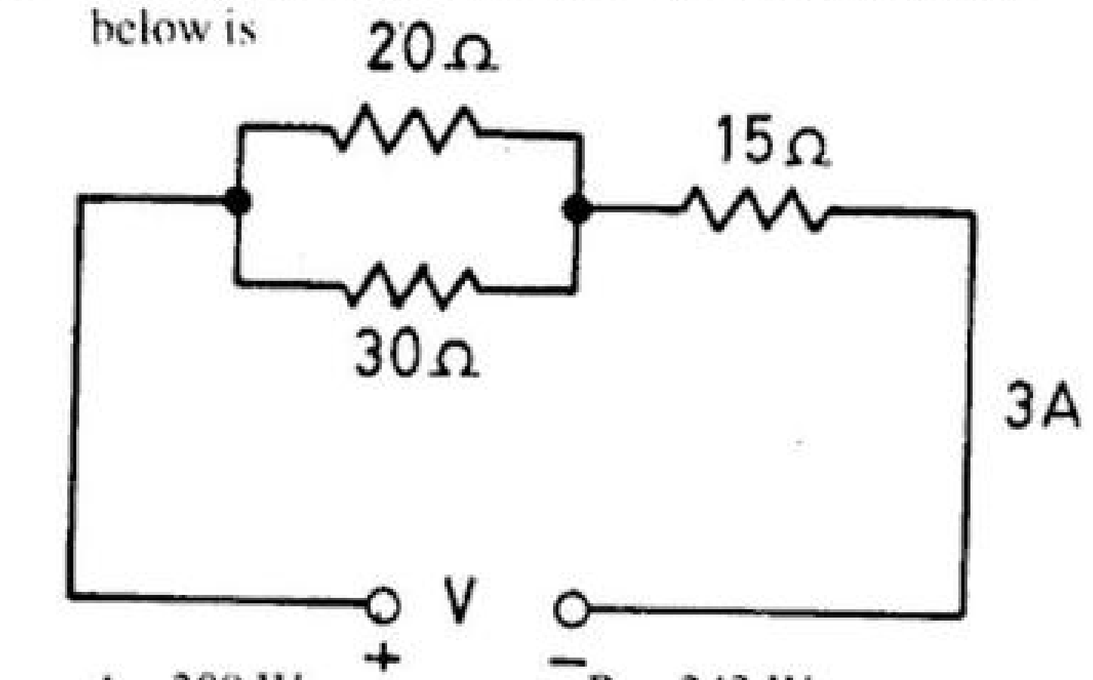
A. 3 *V* B. 4 *V*
C. 5 *V* D. 10 *V*.

72. The current flowing in the branch CD is equal to



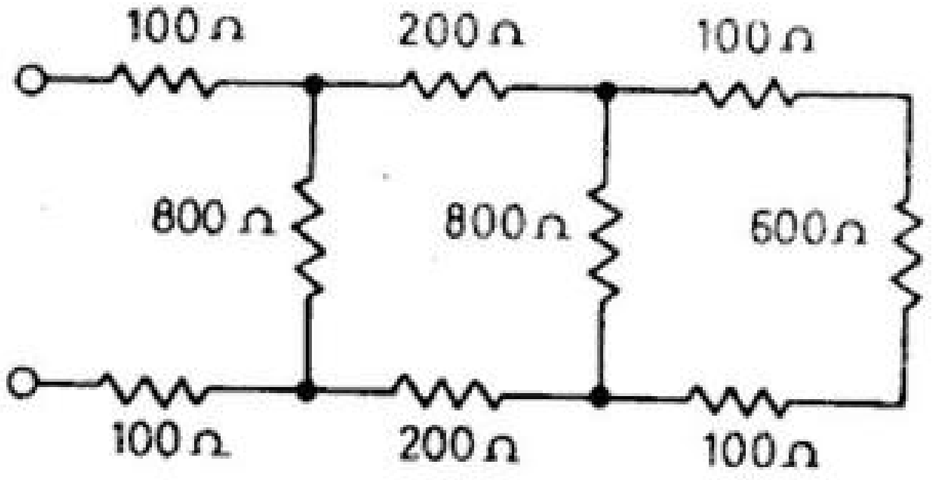
A. 10 *A*. B. 5 *A*
C. 3.33 *A*. D. 2.3 *A*.

73. The power consumed for the circuit shown below is



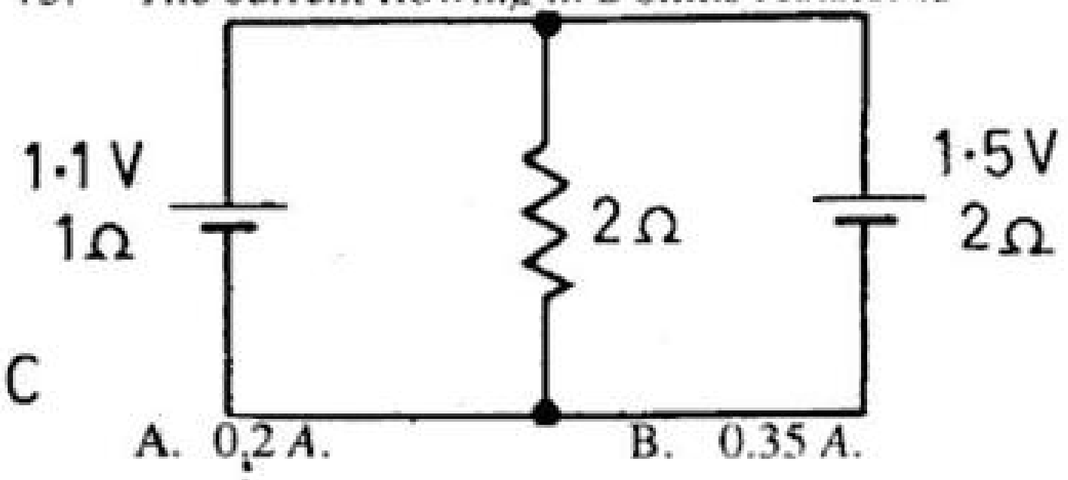
A. 200 W. B 243 W.
C. 400 W. D. 440 W.

74. The equivalent resistance of the network is



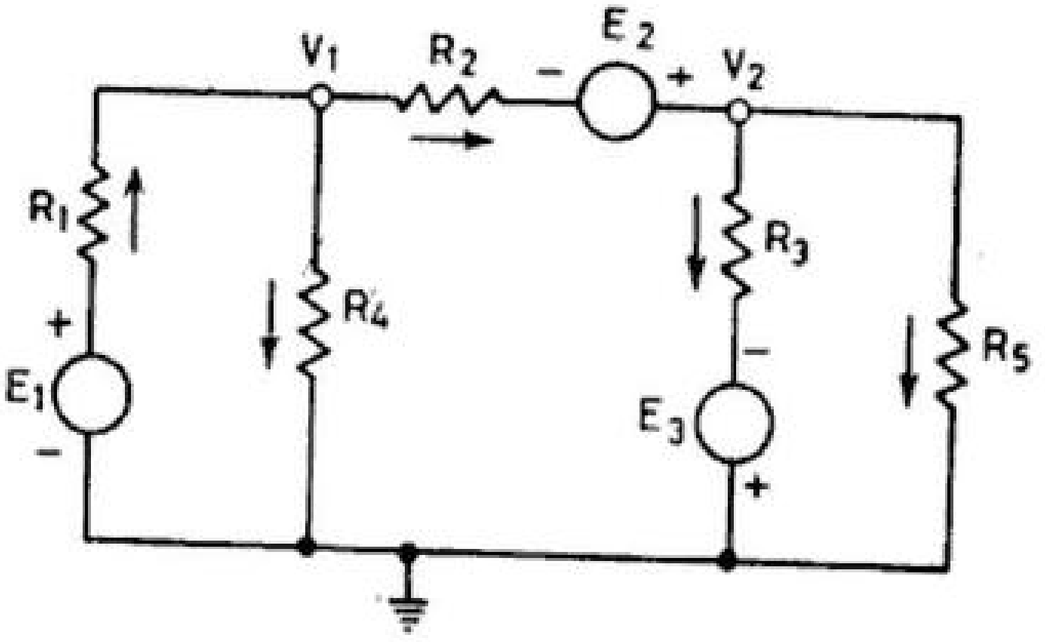
A. 200 ohm. B. 400 ohm
C. 600 ohm D. 1600 ohm.

75. The current flowing in 2 ohms resistor is



A. 0.2 *A*. B. 0.35 *A*.
C. 0.4625 *A*. D. 0.6 *A*.

76. The nodal equation for the circuit shown for branch R_1 will be



A. $\frac{E_1 - V_1}{R_1}$ B. $\frac{V_1 - E_1}{R_1}$

C. $(E_1 + V_1)/R_1$ D. E_1/R_1

77. The nodal equation for the same circuit for branch R_2 will be

A. E_2/R_2
B. $(V_1 - V_2)/R_1$
C. $(V_1 - V_2 + E_2)/R_2$.
D. $(V_1 - V_2 - E_2)/R_2$

78. The nodal equation for the same circuit for branch R_3 will be

A. E_3/R_3. B. $(V_2 - E_3)R_3$
C. $(E_3 - V_2)/R_3$ D. $(V_2 + E_3)/R_3$.

79. Regarding Thevenin equivalent, which of the following is *not* correct ?

Answers : 71. (C), 72. (C), 73. (B), 74. (C), 75. (C), 76. (A), 77. (C), 78. (D).

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168. In Fourier series the coefficient a_n can be found by

A. $a_n = \frac{1}{2T}\int_{-T/2}^{T/2} f(t)\cos(n\omega t)\,dt.$

B. $a_n = \frac{2}{T}\int_{-T/2}^{T/2} f(t)\cos\omega t\,dt.$

C. $a_n = \frac{1}{2T}\int_{-T/2}^{T/2} n f(t)\cos(n\omega t)\,dt.$

D. $a_n = \frac{2}{T}\int_{-T/2}^{T/2} f(t)\cos(n\omega t)\,dt.$

169. In Foulrier series the coefficient b_n can be found by

A. $b_n = \frac{2}{T}\int_{-T/2}^{T/2} nf(t)\sin(n\omega t)\,dt.$

B. $b_n = \frac{2}{T}\int_{-T/2}^{T/2} f(t)\sin(n\omega t)\,dt.$

C. $b_n = \frac{1}{2T}\int_{-T/2}^{T/2} f(t)\sin\omega t\,dt.$

D. $b_n = \frac{2}{T}\int_{-T/2}^{T/2} f(t)\sin\omega t\,dt.$

170. In exponential terms, the Fourier series can be written as

A. $\sum_{n=-\infty}^{+\infty} \overline{C}_n e^{jnwt}$

where $\overline{C}_n = \frac{1}{T}\int_{-T/2}^{T/2} f(t)\,e^{-jnwt}\,dt$

B. $\sum_{n=-\infty}^{\infty} \overline{C}_n e^{-jnwt}$

where $\overline{C}_n = \frac{1}{T}\int_{-T/2}^{T/2} f(t)\,e^{-jnwt}\,dt$

C. $\sum_{n=-\infty}^{\infty} \overline{C}_n e^{-jnwt}$

where $\overline{C}_n = \frac{1}{T}\int_{-T/2}^{T/2} f(t)\,e^{-jnwt}\,dt$

D. $\sum_{n=-\infty}^{\infty} \overline{C}_n e^{jnwt}$

where $\overline{C}_n = \frac{1}{T}\int_{-T/2}^{T/2} f(t)\,e^{-jnwt}\,dt$

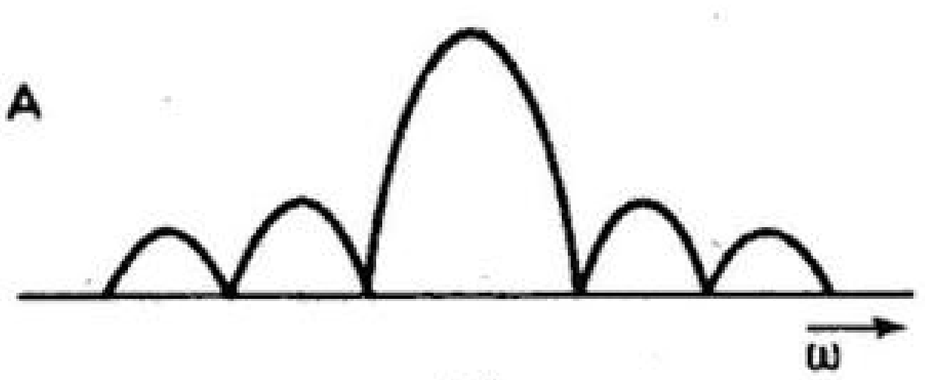
171. The Fourier transform of a unit step function is given by

A. $F(j\omega) = 1/\omega$ B. $F(j\omega) = j/\omega$

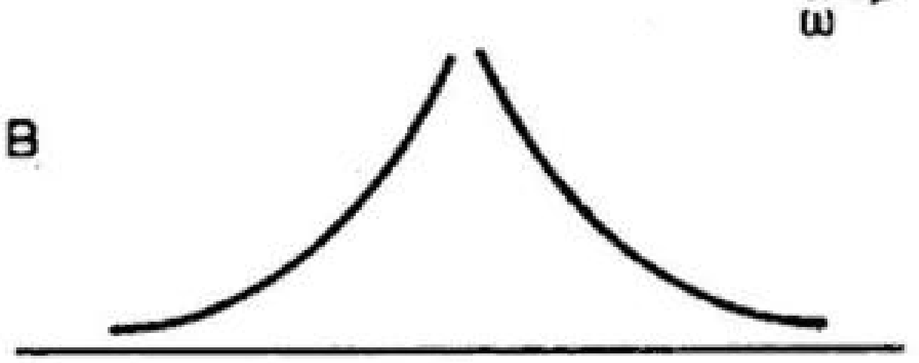
C. $F(j\omega) = j\omega$ D. $F(j\omega) = 1/j\omega$

172. The Amplitude spectrum of a unit step waveform is given by

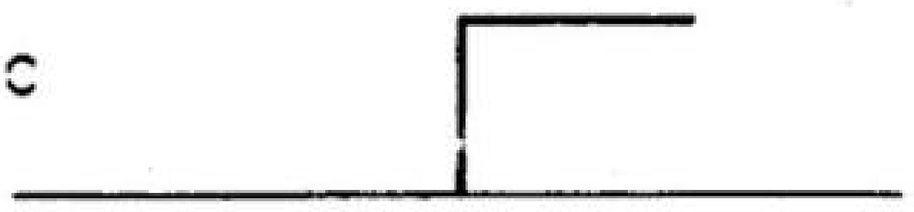
A



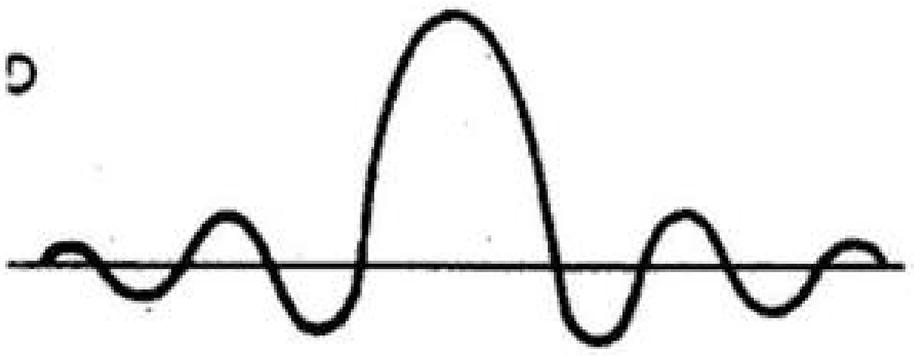
B



C



D



Answers : 168. (D), 169. (B), 170. (A), 171. (D), 172. (B).

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A. $Y_A + Y_B + Y_C$ B. $Y_A + Y_B$

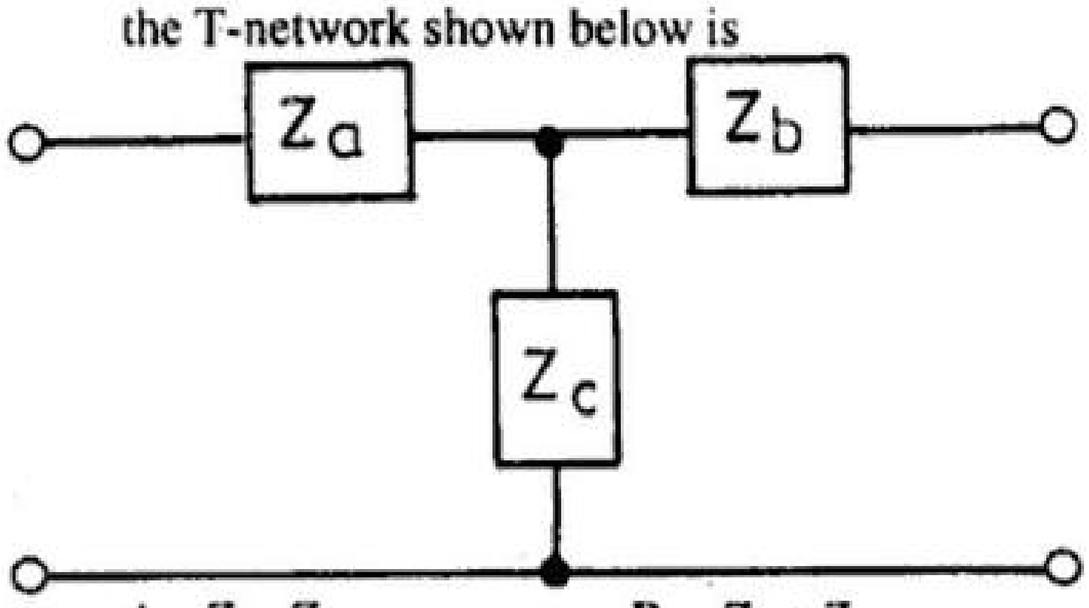
C. $Y_A + Y_C$ D. $Y_B + Y_C$

201. The short-circuit admittance parameter y_{22} of the above network is

A. $Y_A + Y_B + Y_C$ B. $Y_A + Y_B$

C. $Y_A + Y_C$ D. $Y_B + Y_C$

202. The open-circuit impedance parameter z_{11} for the T-network shown below is



A. $Z_a + Z_b$ B. $Z_a + Z_c$

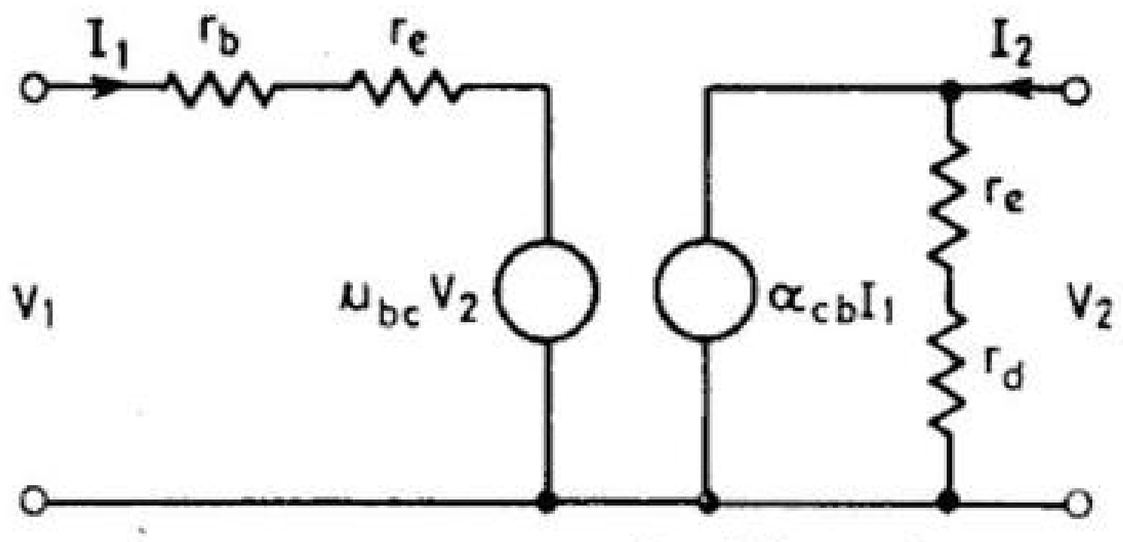
C. $Z_b + Zc$ D. $Z_a + Z_b + Z_c$.

203. The open circuit impedance parameter z_{12} for the above T-network is

A. Z_a B. Z_b

C. Z_c D. $Z_a + Z_b + Z_c$

204. For the model of a transistor in the common-emitter connection shown below, the hybrid h_{22} is given by



A. $r_b + r_e$ B. $1/(r_e + r_d)$

C. α_{cb} D. μ_{bc}

205. In the above question, h-parameter h_{11} will be

A. $r_b + r_e$ B. $1/(r_e + r_d)$

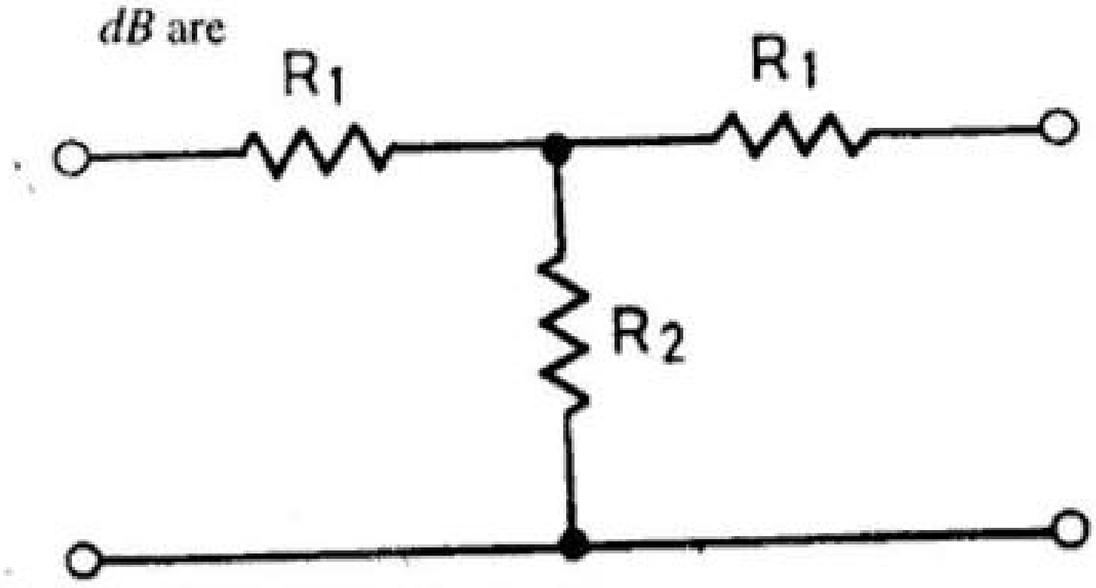
C. α_{cb} D. μ_{cb}

206. In the same question, h-parameter h_{21} will be

A. $r_b + r_e$ B. $1/(r_e + r_d)$

C. α_{cb} D. μ_{bc}

207. The values of the resistors R_1 and R_2 of the T-section attenuator which will have an iterative impedance of 600 ohms and a loss of 10 *dB* are



A. 312 ohms, 421.6 ohms

B. 491 ohms, 121 ohms

C. 622 ohms, 93 ohms

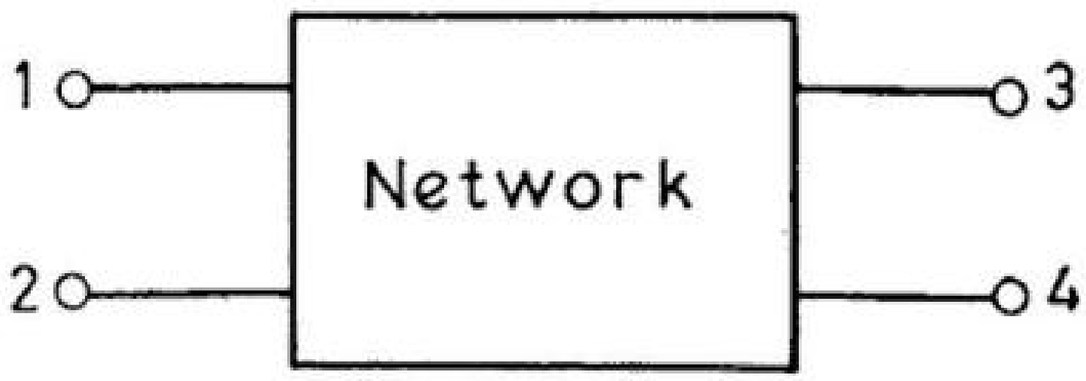
D. 715 ohms, 85 ohms.

208. For an *H* - type attenuator matched to a transmission line of 600 ohms impedance, each of the series resistance is 240 ohms. The value of the shunt resistance will be

A. 95 ohms B. 135 ohms

C. 216 ohms D. 840 ohms

209. Following measurements were made on the four terminal network shown below



Answers : 200. (C), 201. (D), 202. (B), 203. (C), 204. (B), 205. (A), 206. (C), 207. (A), 208. (B).

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A. 1 A B. 2 A

C. 3 A D. $\frac{4}{3}$ A

236. A parallel R-L-C circuit has R = 10,000 ohms L = 10 mH and C = 1 μF. The resonant frequency ω_0 (rad/sec) and Q are respectively given by

A. 10^4 and 200 B. 10^2 and 1

C. 10^4 and 100 D. 10^2 and 100

237. For a 2 port network the output short circuit current was measured with a 1V source at the input. The value of the current gives

A. h_{12} B. y_{12}

C. h_{21} D. y_{21}

238. A voltage source V_s = 200 cos ωt has impedance across it. The reactive power is 200 VARs and the power factor is 0.866. The power (P_{av}) drawn from the source is

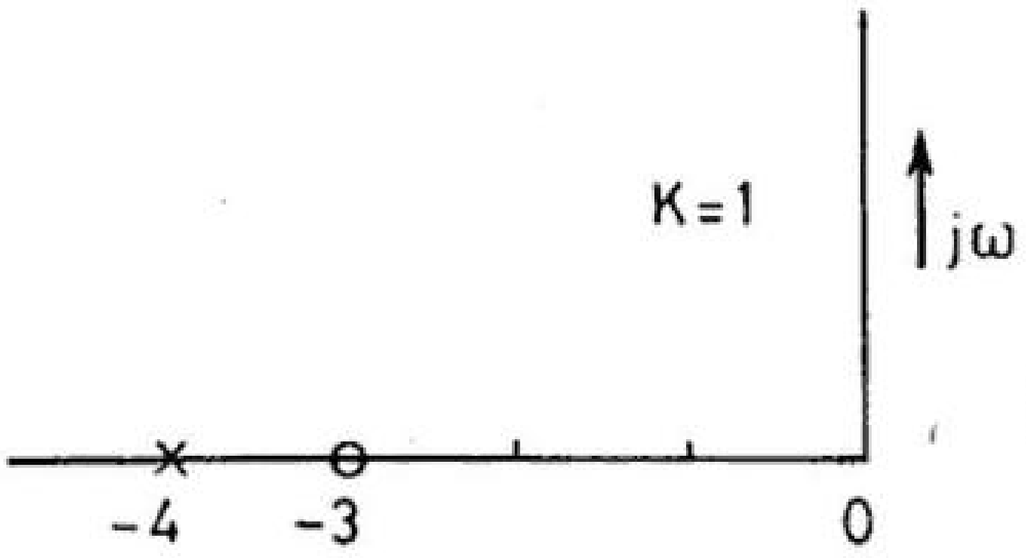
A. 430 watts

B. 400 watts

C. 344 watts

D. 200 watts

239. The pole zero diagram of an impedance Z has a pole at s = -4 and zero at s = -3 as shown in figure. the constant multiplier K = 1. For a signal $I_s = \cos 4t$, the steady state voltage across Z is given in magnitude as under.



A. $\frac{5}{4\sqrt{2}}$ B. $\frac{3}{4}$

C. $\frac{4\sqrt{2}}{5}$ D. $\frac{4}{3}$

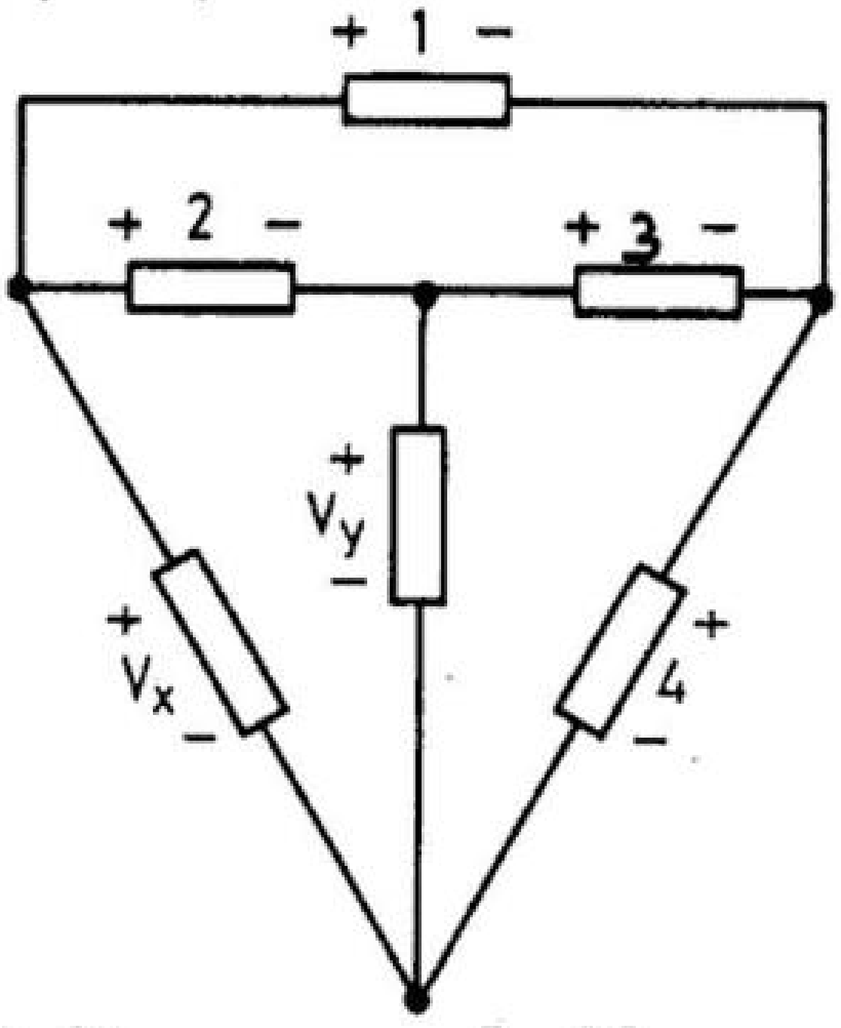
240. A system function is $H(s) = \frac{V(s)}{I(s)} = \frac{s}{s+3}$

The system is at rest for $t < 0$. $i(t) = 2\,u(t)$ where u(t) is a unit step. $v(t)$ for $t > 0$ is given by

A. $2(1 - e^{-3t})$ B. $\frac{2}{3}(1 - e^{-3t})$

C. $2e^{-3t}$ D. $\frac{2}{3}e^{-3t}$.

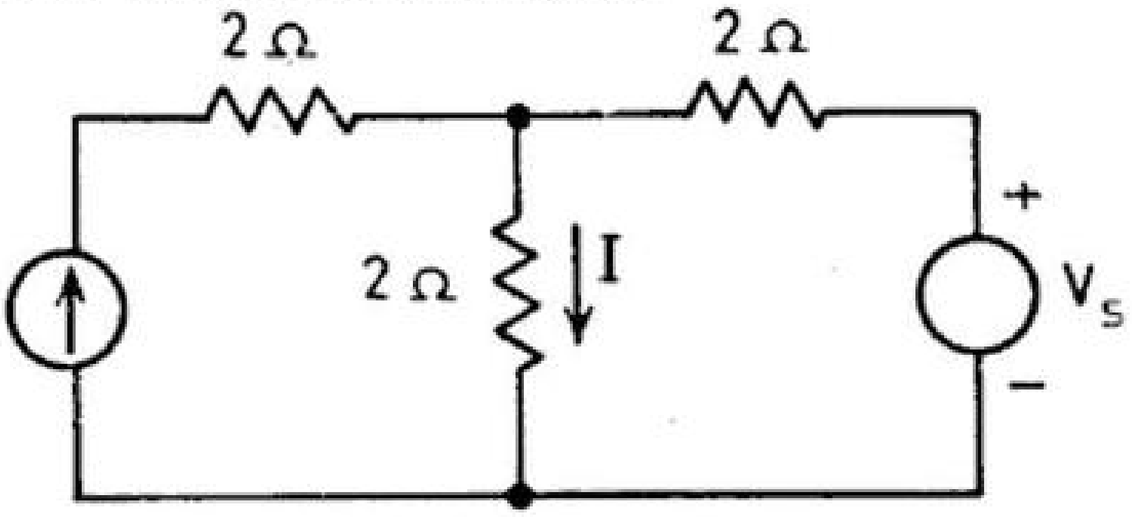
241. In the circuit shown the voltage across some elements are given. The values of V_x and V_y respectively are



A. 3,1 B. 3,5

C. 5,3 D. 5.7.

242. In the circuit shown below



When $V_s = 0$, I = 3A. When V_s = 12 V, the value of I becomes

A. 3A B. 6 A

C. 7A D. 9 A.

Answers : 235. (A), 236. (C), 237. (B), 238. (C), 239. (A), 240. (C), 241. (C), 242. (B).

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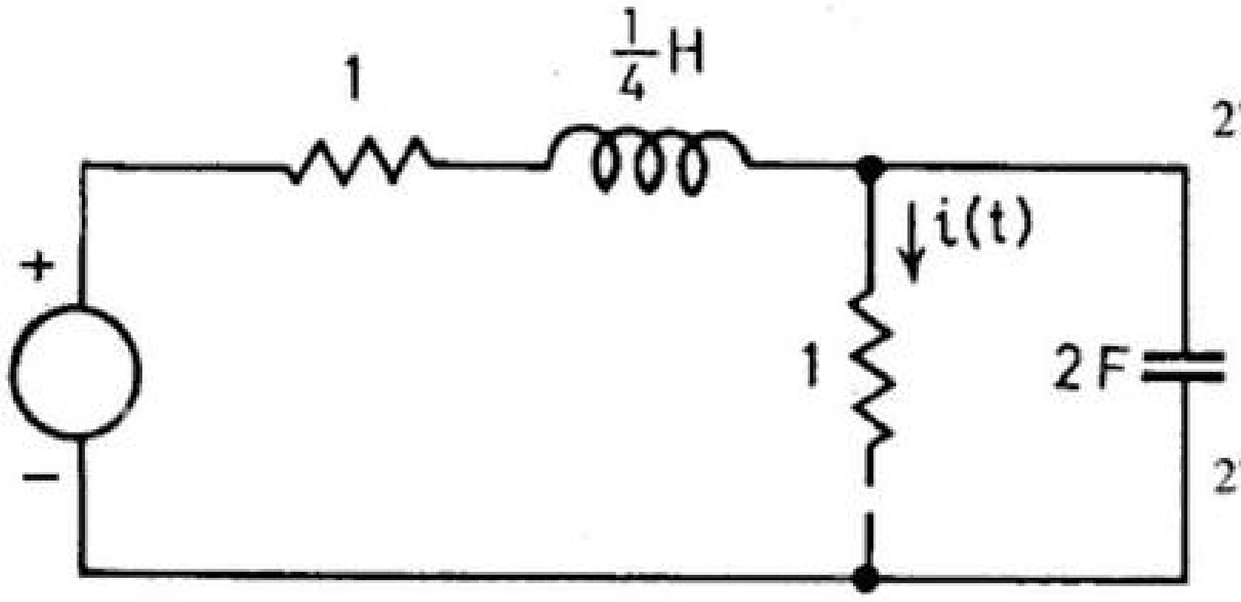
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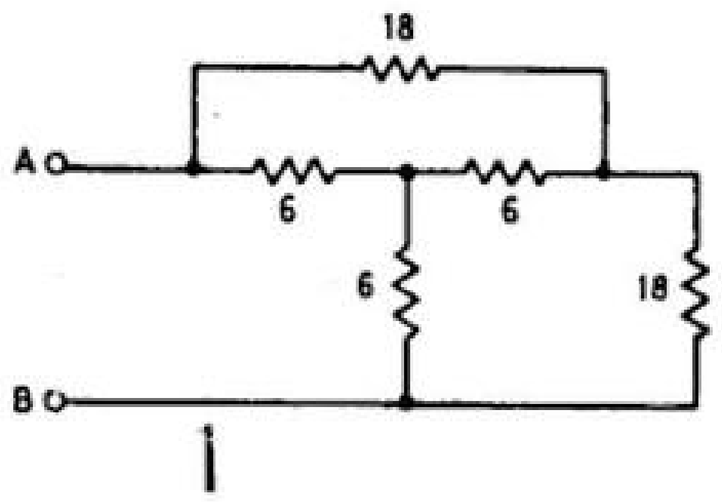
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A. $10e^{-2t}$ V B. 10 V

C. $-20e^{-2t}$ V D. $30\,e^{-2t}$ V.

267. The resistance R_{AB} in the circuit is



A. 12 Ω B. 10.8 Ω

C. 6.75 Ω D. 9 Ω

268. A series resistive-inductive circuit is to be converted to an equivalent parallel circuit. The equations are

A. $\frac{1}{R + j\omega L}$

B. $\frac{R}{R^2 + X_L^2} - j\frac{X_L}{R^2 + X_L^2}$

C. $G + jB$

D. $\frac{V_m}{\sqrt{R^2 + X_L^2}} \sin\left(\omega t - \tan^{-1}\omega\frac{L}{R}\right)$

269. In an unloaded transformer, the flux linking the primary and secondary are 25m *Wb* and 15 m*Wb*. The coefficient of coupling is

A. cannot be calculated

B. $\frac{5}{3}$

C. $\frac{3}{5}$ D. 25 : 15

270. A loudspeaker transformer has a turns ratio of 20 : 1. The speaker impedance is 12 ohms. The primary impedance of transformer is

A. 4800 Ω B. 0.03 Ω

C. 240 Ω D. 0.004 Ω

271. Pick the correct statement

A. Delta connection draws same current as star connection

B. Delta connection draws 3 times as much current as star connection

C. Delta connection draws $\frac{1}{\sqrt{3}}$ times as much current as star connection

D. Delta connection draws $\frac{1}{3}$ times as much current as star connection.

272. Frequency multiplication by a resistor can be achieved if

A. it is carbon B. wire wound

C. it is a diode D. it is nichrome

273. At time $t = 0^+$ with zero initial condition, which of the following acts as an open circuit?

A. Inductor B. Capacitor

C. Resistor D. All of the above

274. The Laplace transform e^{-at} is

A. $1/s$ B. $1/(s + a)$

C. $1/s - a$ D. s/a.

275. The elements in RCL series circuit are

A. Resistance only

B. Inductance only

C. Capacitance only

D. Resistance, inductance and capacitance

276. Kirchoff's voltage law applies to circuit with

A. linear elements only

B. non-linear elements only

C. linear, non-linear, active and passive elements.

D. linear, non-linear, active, passive, time varying as well as time invariant elements

Answers : 266. (A), 267. (D), 268. (B), 269. (C), 270. (A), 271. (B), 272. (C), 273. (A), 274. (B), 275. (D), 276. (D).

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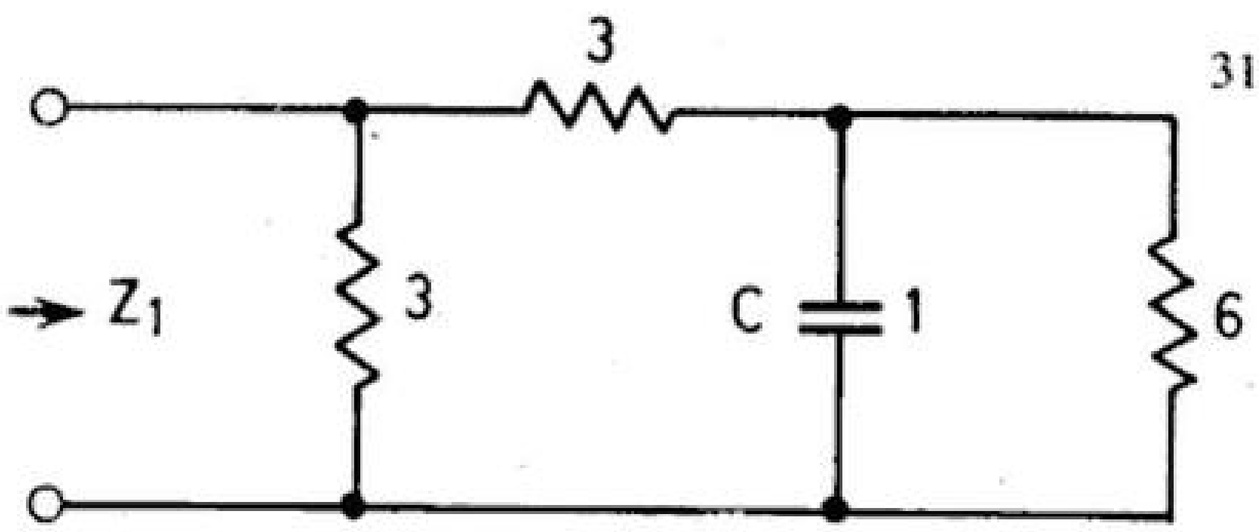


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A. $\frac{3}{2}\left(\frac{s+\frac{1}{2}}{s+\frac{1}{3}}\right)$ B. $\frac{3}{2}\left(\frac{s+\frac{1}{3}}{s+\frac{1}{2}}\right)$

C. $3\left(\frac{s+\frac{1}{2}}{s+\frac{1}{3}}\right)$ D. $3\left(\frac{s+\frac{1}{3}}{s+\frac{1}{2}}\right)$

308. The driving point impedance Z_1 for the circuit shown is given by



A. $K_1\left(\frac{s+2}{s+3}\right)$ B. $K_2\left(\frac{s+3}{s+2}\right)$

C. $K_3\left(\frac{s+\frac{1}{2}}{s+\frac{1}{3}}\right)$ D. $K_4\left(\frac{s+\frac{1}{3}}{s+\frac{1}{2}}\right)$

309. $H(s)=\frac{V(s)}{I(s)}=\frac{4s+6}{s+2}$ when $i(t)$ is a unit step function, as t tends to infinity is given by the value of $v(t)$

A. 0 B. 3

C. 4 D. ∞

310. $H(s)=\frac{V(s)}{I(s)}=\frac{s+3}{(s+2)^3}$ when $i(t)$ is a unit step function. The value of $v(t)$ in the steady state is given by

A. $\frac{3}{2}$ B. $\frac{3}{4}$

C. 1 d. 0

311. System function $H(s)=\frac{1}{(s+2)}$ For a signal $\cos 2t$, the steady state response is

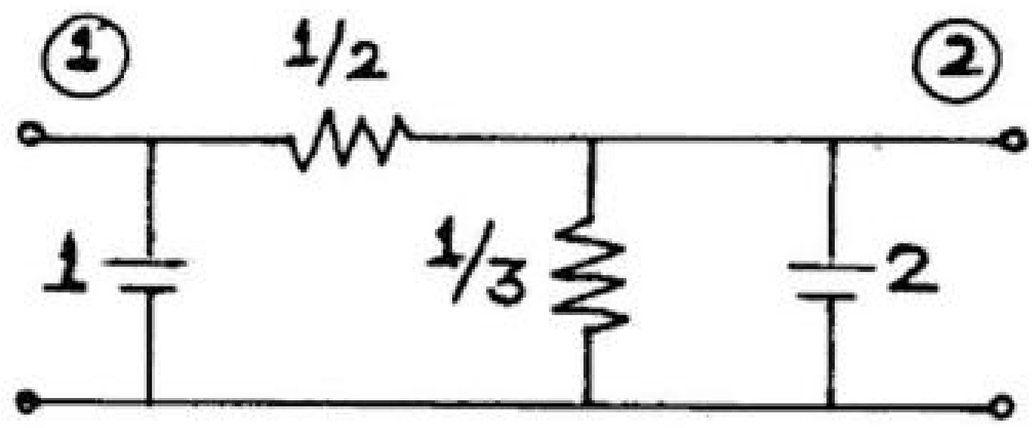
A. $\frac{1}{2}\cos 2t$

B. $\frac{1}{2\sqrt{2}}\cos(2t-45^\circ)$

C. $\frac{1}{2\sqrt{2}}\cos(2t+45^\circ)$

D. $\frac{1}{2\sqrt{2}}\cos 2t$

312. The short circuit natural frequency at port (1) for the shown circuit is given by



A. $s+5=0$ B. $2s+5=0$

C. $s+\frac{3}{2}=0$ D. $s+10=0$

313. A load $Z_L=R_L+jX_L$ is to be matched using an ideal transformer to a generator of internal impedance $Z_S=R_S+jX_S$. The ratio of the transformer required is

A. $\sqrt{\left|\frac{Z_L}{Z_S}\right|}$ B. $\sqrt{\left|\frac{R_L}{R_S}\right|}$

C. $\sqrt{\left|\frac{R_L}{Z_S}\right|}$ D. $\sqrt{\frac{|Z_L|}{R_S}}$

314. Maximum power from a source having internal resistance R_i is delivered to a resistive load R_L if

A. $R_i=R_L$ B. $R_i>R_L$

C. $R_i<R_L$ D. $R_i=R_L^2$

Answers : 307. (A), 308. (C), 309. (B), 310. (B), 311. (B), 312. (B), 313. (A), 314. (A).

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CHAPTER 4

ENGINEERING MATERIALS

4.1. Atomic Structure. According to the modern theory, the basic constituent of all the matter, whether elements or compound, is an atom. According to electron theory, atom consists of three main particles (*i*) *proton*- having a positive charge, (*ii*) *electron* - having a negative charge, and (*iii*) *neutron* - having no charge.

The central part of atom consists of a large number of protons and neutrons packed together around which a large number of electrons revolve in different orbits. The orbits of electrons shown are circles but they are actually shells. These shells may be circular or ellipitcal and are numbered as *K, L, M, N, O,* P and Q: *K* being nearest to the nucleus.

Each electron has a negative charge - *Q* of $1{\cdot}59 \times 10^{-19}$ coulombs and each proton has a positive charge equal to the magnitude of the charge of electron. In an atom, the number of electrons is equal to the number of protons so that the atom is electrically neutral. The mass of the proton is about 1840 times the mass of electron. Thus the whole mass is concentrated in the nucleus.

Since the electron rotates around the nucleus, it possesses not only kinetic energy but also a definite potential energy by virtue of its position with respect to nucleus. Each orbit corresponds to a definite energy of the electron called *energy level*. Thus *K, L, M, N* etc., represent energy levels. It is found that maximum number of electrons for different levels is fixed, for example *K*th level can have maximum of 2 electrons. Similarly, $L = 8$, $M = 18$, $N = 32$ and $O = 50$.

4.2. Shells and Sub-Shells. All the energy levels of an atom correspond to discrete energies, so that electrons exist in certain discrete levels only and no electron can have energy in between two energy levels. All energy levels or *shells* beyond the first (*K*th shell) are divided into *sub-shells*. The first sub-shell of any group is denoted by the letter *s*, the second by sub-shell *p*, the third by subshell *d* and the fourth by sub-shell *f*. For all practical purposes, sub-shells of each group may be considered as one energy level. The final capacities of the first four closed shells are given below.

Main Shell	*Sub - Shell*				*Total Capacity*
	s	*p*	*d*	*f*	
$K\ (n=1)$	2	—	—	—	2
$L\ (n=2)$	2	6	—	—	8
$M\ (n=3)$	2	6	10	—	18
$N\ (n=4)$	2	6	10	14	32

4.3. Isotopes and Isobars. Isotopes are the atoms of the same elements having same atomic number but different atomic mass. For example ${}_8O^{16}$, ${}_8O^{17}$, ${}_8O^{18}$, and ${}_6C^{12}$, ${}_6C^{13}$.

Isobars are the atoms of different elements having different atomic number but same atomic mass. For example ${}_{18}Ar^{40}$ ${}_{20}Ca^{40}$.

The number of electrons in the outermost orbit is known as *valence electron.*

From the knowledge of shells and sub-shells, the electronic configuration of atoms can be written. For

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(3) **Metallic Bond.** In this bond, atoms give up their valence electrons to form cloud of electrons which is shared by all atoms. After giving up valence electrons, the atoms become positive ions and the atoms are held together by electrostatic forces between positive ions and free electrons. This types of bond exists between elements having loosely held valence electrons so that they can be easily released to the common pool. This type of bond is generally predominant in metals like Fe. Ag, Na, and Cu.

Solids which are held together by this type of bonding have such properties as ductility and good electrical conductivity.

4.10. Semiconductors. Semiconductor is a material whose conductivity lies between conductors and insulators. Silicon and Germanium are most important semiconductors and both have four valence electrons. *i.e.*, electrons in the outer most shell of the atom.

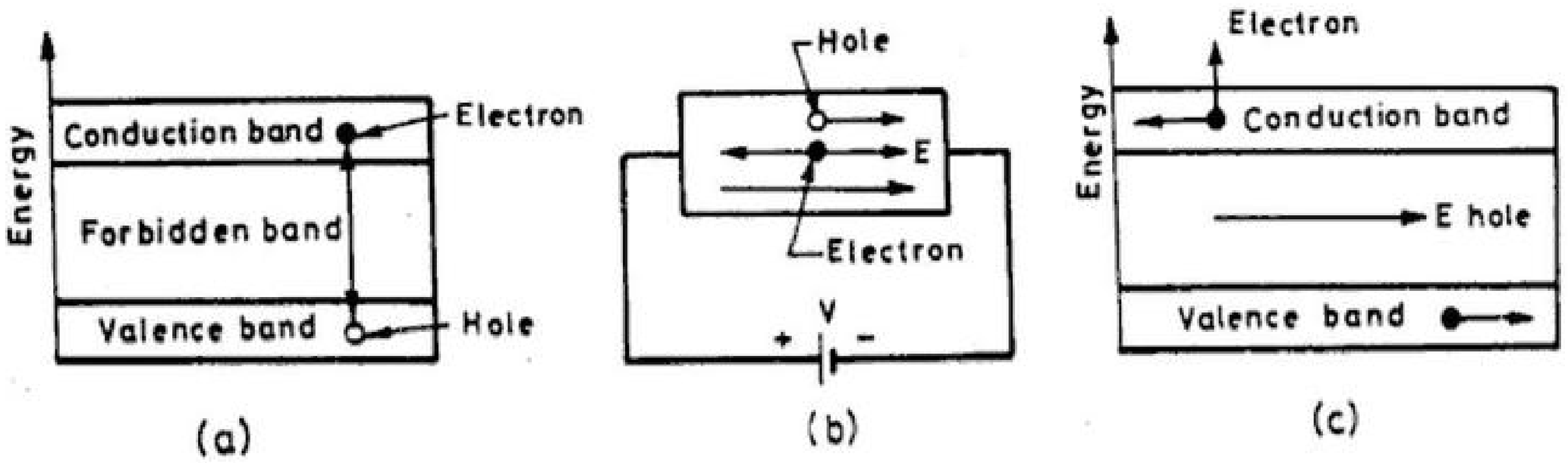


Fig 4.2

Valence electrons are bound in an energy band in which valence band positions are filled or unoccupied. This filled band is separated from a normally unoccupied higher energy band by a forbidden energy gap ΔE.

At room temperature, very few electrons exist in the conduction band. Since the current is proportional to the number of electrons in motion, the current is small, and hence the material has a higher resistance.

An occasional electron has enough energy to escape from the valence band and move to the conduction band as shown by the dots in Fig. 4.2.

When an energy band is completely filled, its electrons do not contribute to electrical conductivity as there are no open energy level to which they can move after absorbing energy from an electric field. Therefore, conductivity of a semiconductor at absolute zero temperature is zero.

4.11. The Conduction Process. As the temperature increases, some electrons receive energy greater than the gap energy ΔE and get transferred to the upper energy band. These electrons now contribute to the conduction. Therefore, as temperature increases, the resistance of a semiconductor decreases. This means that semiconductors have *negative temperature coefficient.*

In this transfer, these electrons leave holes in the valence band and this thermal breaking of the valence bands and formation of electron-hole pairs give rise to *intrinsic conductivity* of a semiconductor. The resistivity of a semiconductor lies roughly between 0.01 ohm-cm to 50 ohm-cm at room temperature.

When an electron is freed from the valence band, it takes an additional energy. On entering a hole in a valence band, this free electron releases this excess energy as a quantum of heat or light. This quantum is absorbed by another electron to break away from its valence band and create a new electron-hole pair. When an electric field is applied to the material as shown in Fig 4.2 (*b*), electron moves towards the positive battery terminal.

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$$\frac{1}{r_D} = \frac{di_D}{dv_D} = I_0 \frac{1}{V_T} \cdot e^{v_D/V_T}$$

$$\equiv \frac{i_D}{V_T} \text{ (because } v_D/V_T >> 1 \text{)}$$

$$r_D = \frac{V_T}{i_D} = \frac{25\ mV}{i_D} \text{ (at } 25^\circ C \text{)}.$$

4.19. Avalanche Breakdown. When a *PN*-junction is reverse biased, the minority carriers flowing through the junction acquire a kinetic energy which increases as the reverse voltage increases. At sufficiently high reverse voltage, the kinetic energy of carriers becomes so large that they knock out electrons from the covalent bonds of the semiconductor material. As a result of collisions, the liberated electrons in turn liberate more electrons and the current becomes very large leading to the breakdown of the crystal structure itself. This phenomenon is called *Avalanche breakdown.* Then the current is not controlled by the junction voltage but rather by the external circuits.

4.20. Zener Breakdown. Under a very high reverse voltage, the depletion region expands and the potential barrier increases leading to a very high electric field across the junction. This electric field will break some of the covalent bonds of the semiconductor atoms leading to a large number of free minority carriers. As a result, the reverse current increases tremendously.

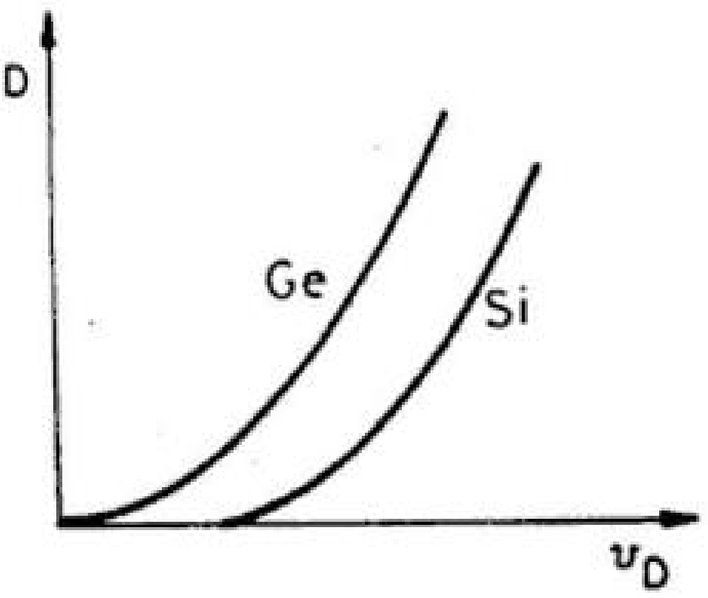


Fig. 4.4 (*a*)

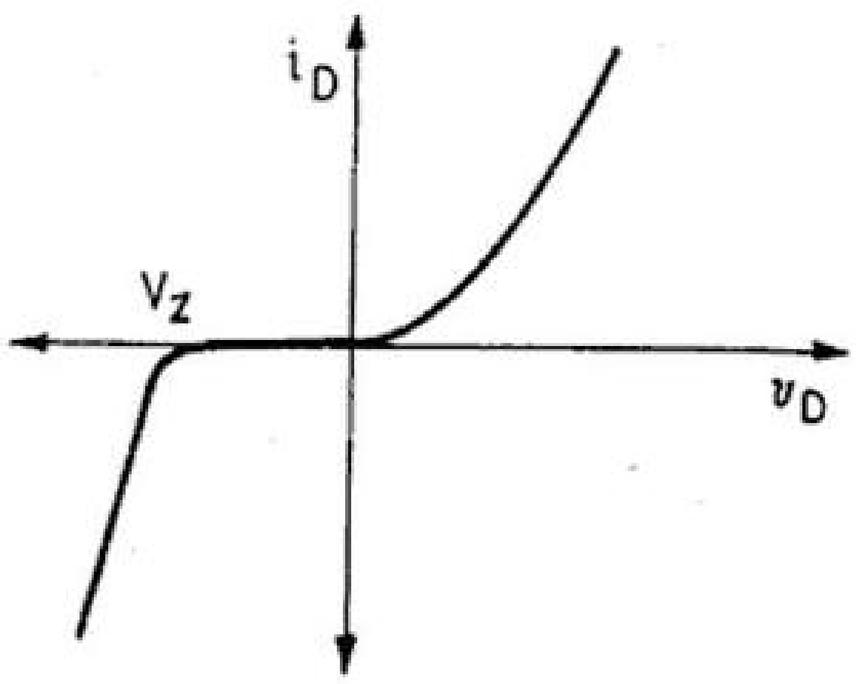


Fig. 4.4 (*b*)

In actual practice, avalanche breakdown is more pronounced than the zener breakdown.

The break down occurs at a particular and constant value of reverse voltage called the *breakdown voltage*. Therefore, this phenomenon can be utilised to provide constant reference voltage against variation of current within a considerable range. A *PN*-junction made to perform this function is called *zener diode*. Its characteristics are shown in Fig 4.4 (*b*).

The point on the characteristics where break down occurs, is called the knee-point and is more sharp in case of silicon diode.

4.21. Transistors. A transistor essentially consists of two *PN*-junctions connected back to back. Basically, it is a current sensitive device *i.e.*, it shifts current from a low impedance circuit to an high impedance circuit thus leading to power amplification. That is why the name transfer-resistor or transistor.

4.22. Current Flow Mechanism. The junction transistor consists two *PN*-junctions obtained by formation of three regions of *P*, *N* and *P* or *N*, *P* and *N*. These regions are called emitter *E*, base *B*, and collector *C*. Thus, there are two types of transistors *PNP*, *NPN*. Fig. 4.5 (*b*) shows the biasing arrangement of a *PNP* transistor.

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4.28. Hysteresis Loss. When materials are subjected to alternating flux, two types of losses occur- (*i*) hysteresis, and (*ii*) eddy current losses. When specimen is magnetised the variation between B and H is shown in Fig. 4.6. The loop obtained between B and H is called *Hysteresis loop*. Hysteresis result in the dissipation of energy which appears in the form of heat. The energy wasted in this manner is proportional to the area of the loop. The total loss due to magnetic hysteresis in a sample of volume v when subjected to magnetic reversal of frequency f is given as

$$W_h = \text{loop area} \times f \times v \text{ watts.}$$

Suppose the hysteresis loop is drawn to the scale given below:

$$1 \text{ cm} = x \, AT/m \text{ for } H, \text{ and}$$

$$1 \text{ cm} = y \, Wb/m^2 \text{ for } B$$

$$\text{Hysteresis loss} = (xy) \times \text{loop area} \times f \times v \text{ watts.}$$

Hysteresis loss depend upon the following factors:

(1) volume of the core (v).

(2) value of flux density (B_m) .

(3) frequency of the magnetic reversal (f) .

(4) grade of ferromagnetic material (η) .

4.29. Mechanical Properties. The mechanical properties of metals define the behaviour of metals under the action of external forces called loads. They are a measure of the strength and lasting characteristics of a metal in service and are of great importance in the design of machines and structures.

The most important mechanical properties are: (1) strength, (2) stiffness, (3) elasticity, (4) plasticity, (5) toughness, (6) brittleness, (7) ductility, (8) malleability, (9) hardness; and (10) creep.

(1) **Strength:** The strength of a metal is its capacity to withstand destruction under the action of external loads. The stronger the metal, the greater the load it can withstand.

The application of load to a part of a structure causes reduction forces to be set up on that part. The intensity of such reaction forces is called *stress*. This is expressed as the load divided by the cross-sectional area over which it is applied. Stress may be classified into three kinds: *tension*, *compression*, and *shear*. The initial deformation which occurs in a metal when it is stressed in called *strain*.

Ultimate strength: The maximum stress that any metal will with-stand before destruction is called its ultimate strength (Figure 4.8). The terms *tensile strength, compressive strength or shear strength* are also used depending on which type of stress is established. The *tenacity* of a metal is its ultimate strength in tension.

(2) **Stiffness:** The resistance of a metal to elastic deformation is called stiffness. A material which suffers slight deformation under load has a higher degree of stiffness.

The strength of a metal may be increased by alloying with some other metal but the stiffness of a metal may be increased very little in this way. As for example, if a steel beam sags too much under load, nothing will be gained by changing to a stronger steel. The strength will be increased, but if the load is the same, the beam will still sag about the same amount. The remedy is to increase the cross section of the beam.

(3) **Elasticity:** The elasticity of a metal is its power of coming back to its original shape after deformation when the loads are removed.

Elastic limit: Many materials behave to some extent like powerful elastic, and within limits, will recover their shape when the load on them is removed. This limit of the elasticity of a material is called the elastic limit (Fig 4.8). Beyond elastic limit, the material does not regain its original form and a permanent set occurs.

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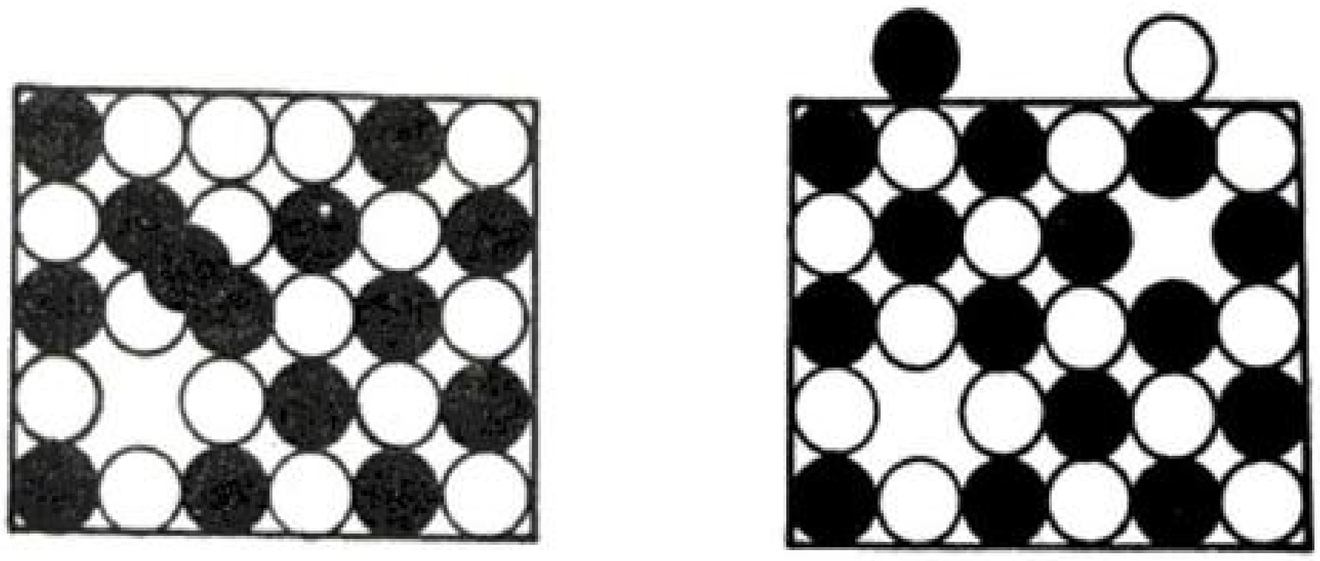


Fig. 4.9

4.34. Cold Working and Hot Working. Cold working is the plastic deformation which is carried out in a temperature region and over a time interval such that the strain hardening is not relieved automatically like drawing, shearing, squeezing and bending.

Hot working, is the plastic deformation of metals under such conditions of temperature and strain rate so that recovery processes take place simultaneously with deformation like rolling, forging, pipe welding, and hot piercing. In cold working, the material is only deformed and appreciable recovery take place along with simultaneous process of deformation and recovery. Possibility of crack formation is great in cold working but in hot working, cracks and blow holes are eliminated. In cold working, internal stresses are developed during working, but the material is free form internal stresses in hot working.

4.35. Recrystallisation. The process of replacement by heating of the cold worked structure of a metal by a new set of strain-free grains is known as process of recrystallization. At higher temperature, recrystallization occurs. New minute grains with low dislocation density start forming these grains which enlarge at the expense of their neighbours so that, ultimately, the original system of grains disappear and the new crystallised structure is obtained. The recrystallization behaviour of metal depends on the temperature initial grain size, amount of deformation and recovery composition.

4.36. Brittle Fracture. Brittle fracture is one in which the movement of crack in metals in very little. Plastic deformation of the metal is adjacent to the crack. Brittle fracture in metals is characterised by a rapid rate of crack propagation with no gross deformation and very little micro deformation. In some instances, this type of fracture can be caused by grain boundary films of hard-brittle second phase, like that formed by bismith in copper. In other cases, it may be due to concentration of solute in the metal to crystal boundaries. The tendancy for brittle fracture is increased by decreasing temperature, increasing strain rate and triaxial stress conditions, usually produced by a notch. A brittle fracture is characterised by separation normal to the tensile stress. Brittle fracture is comparatively rare. It is to be avoided because it occurs without warning and usually produces disastrous consequences.

4.37. Ductile Fracture. It occurs after appreciable plastic deformation. In the tensile test of a ductile material, the plastic deformation produces a necked region where the increase in strength due to strain hardening fails to compensate for the decrease in cross sectional area, the formation of neck introduces a triaxial state of stress in the region. It is important to note that ductile fracture occurs by slow tearing of the metal with the expenditure of considerable energy. A material may fall in ductile or in brittle manner depending on the testing conditions, temperature and strain rate. This fracture is less studied because it is really a serious problem.

4.38. Plastics. Plastics and synthetic resins may be classified as thermosetting and thermoplastic.

(*a*) *Thermosetting plastics:* These plastics are formed to shape under pressure and heat. They undergo a chemical change when moulded and cannot be resoftened by heating to reshape them, that is, they become

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of temperature of about 0.055°K. The temperature at which the transition taken place from the state of normal conductivity to that of super- conductivity is called transition temperature.

4.48. Composite Materials. It is often possible to produce a superior material by combining two or more materials, with properties unattainable in each of them separately. The material so produced is termed as a composite material. The combination is made up of material with complementary properties. For example, concrete is strong in compression and steel is strong in tension. Therefore, a situation may require food strength both in tension and compression in a structure. The concrete is reinforced with steel to combine the two strengths in one material-reinforced cement concrete. Other examples are glass fibre, reinforced plastics and carbon fibre, reinforced plastic and expanded polymers.

4.49. Electronic Components. Major types are as follows :

(*a*) **Resistors:** In carbon resistors, thin layer of carbon is deposited on the surface of a ceramic rod. The resistance value required determines the thickness of the carbon film. The exact value is obtained by cutting a groove in the form of a spiral in the carbon film.

A solid type carbon resistor consists of solid rod of special material composed of carbon and binding agent. Carbon pile resistors are made up of a number of carbon plates maintained under pressure. Its resistance value can be changed by changing the pressure on the carbon discs.

In wire-wound resistor, ceramic tubes having cap and lead assemblies are used as insulated bobbins. During winding, the machine allows a regular pitch and uniform tension to be applied to the wire of desirable resistance such as copper, constant an, nichrome and aluminium. The end connections to terminals are accomplished by welding or soldering. The coating is applied by dipping the resistor after the curing is done.

(*b*) **Transformers:** It is a static device to convert voltage from higher to low or vice-versa. It consists of mainly core, bobbin and winding. Bobbin is made of any plastic material to hold the core. Core is made of grain-oriented silicon steel or hot-rolled grain oriented silicon steel. It gives the easy path to the magnetic field. It has two windings - one is called primary winding and the other is called secondary winding, having different number of turns in both the windings. These windings are of insulated, hot-rolled annealed enamel copper. The winding of hot-rolled annealed copper is of different gauges depending upon the requirement. Over the winding, insulating glazed paper is wrapped. The terminals are soldered at the bobbin on both sides *i.e.*, primary and secondary.

(*c*) **Rectifiers:** Rectifiers convert ac into dc. It is mainly of two types - (*i*) Copper oxide rectifier, and (2) Selenium rectifier. Copper oxide rectifier is a plate of 99.98% pure copper on which a film of cuprous oxide is produced by special purpose. One side of plate is cleaned with cuprous oxide and an electrode is soldered directly to copper. The second electrode is soldered to cuprous oxide film. When positive potential is applied to the oxide layer and negative to the copper, and it corresponds to forward biasing of a P-N Junction. These rectifiers hence have low permissible current density. Selenium rectifier use more than 99.9% pure selenium. Crystalline selenium which has a melting point of 220°C is used for making rectifiers. It is constructed by using Nickel-plated steel plate. Selenium under pressure at 130°C is raised to 180°C to 215°C and put on the nickel plate making a layer of 1 mm on it. Crystalline selenium will change to grey crystallic selenium. Over this electrode of tin, an alloy is sprayed. This makes the active disc of the rectifiers and thus makes the selenium rectifier.

(*d*) **Chokes:** This is a device used to give blast of voltage. It consists of mainly bobbin, stamping and winding. Bobbin is made up of insulting material such as plastic to hold the stampings which are made up of mild steel of thin lamination which reduce the eddy current loss. Winding is done on these stampings of definite number of turns and a particular gauge. The input and output terminals are fixed on the insulating materials such as bakelite. Whole assembly is insulated by insulating paper. This assembly is put in a box of metallic sheet.

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47. The resistivity of a metal is a function of temperatue because
   A. the electron density varies with temperature
   B. the electron gas density varies with temperature
   C. the amplitude of vibratin of atoms does not vary with temperature
   D. None of these.

48. The crystal structure of most of the common metals is
   A. hexagonal B. cubic
   C. ortho-rhombic D. None of these

49. The Miller Indices are the same for
   A. perpendicular planes
   B. crystal planes C. parallel planes
   D. None of these.

50. The Miller Indices of the diagonal plane of a cube are
   A. 110 B. 111
   C. 100 D. None of these.

51. Line imperfection in a crystal is called
   A. Schottky defect B. Frenkel defect
   C. Edge dislocation D. None of these

52. In a cubic crystal, interplanner distance is equal to the cube edge length. The Miller Indices for that planes are
   A. [111] B. [100]
   C. [110] D. None of these

53. The missing of an atom from its normal site is
   A. Frenkel defect B. Interstial impurity
   C. Schottky defect D. None of these

54. Line defects play important role in
   A. self-diffusion B. deformation
   C. climb D. None of these

55. The conductivity of a metal is determined by
   A. the number of valence electrons per atom
   B. the electronic concentration and the mobility of the free electrons
   C. none of the above factors as mentioned in A and B
   D. All of these.

56. The velocity of an electron at the Fermi level of $5.0eV$ is
   A. 1.33×10^5 *m/sec* B. 3×10^3 *m/sec*
   C. 1.33×10^6 *m/sec.* D. *None of these.*

57. The drift velocity of an electron under the action of applied electric field is of the order of
   A. 10^{-14} B. 10^{-7}
   C. 10^7 D. None of these.

58. The mobility of an electron in a metal is expressed as
   A. $\frac{em}{t}$ B. $\frac{et}{m}$
   C. $\frac{mt}{e}$ D. None of these.

59. Resistivity of electrical conductors is most affected by
   A. temperature B. pressure
   C. composition D. None of these.

60. Electrons will collide with lattice atoms, if the atoms are
   A. very large
   B. displaced from their regular position
   C. close together
   D. None of these.

61. The resistivity of all normal metals as temperature is lowered
   A. tends to zero
   B. tends to a constant value
   C. at first decreases then increases
   D. All of these

62. Which of the following relations is correct?
   A. Flux = mmf × reluctance
   B. Conductivity = 1/Resistance
   C. Permeability = 1/Reluctivity
   D. None of these.

Answers : 47. (D), 48. (B), 49. (A), 50. (A), 51. (C), 52. (B), 53. (C), 54. (B), 55. (B), 56. (C), 57. (B), 58. (B), 59. (A), 60. (B), 61. (A), 62. (C).

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63. Reluctivity is analogous to
A. permeability B. conductivity
C. resistivity D. retentivity.

64. Magnetic susceptibility of material of relative permeability μ_r is given by
A. $\mu_0/(\mu_r - 1)$ B. $\mu_0/(\mu_r - 1)$
C. μ_0/μ_r D. μ_r/μ_0

65. Retentivity of a magnetic material is
A. the ability of retain residual magnetism
B. the demagnetisation force when field is reversed
C. the ability to cover up lag in flux when field is increasing
D. None of these.

66. On which of the following factors hysteresis loss does *not* depend?
A. magnetic field intensity
B. frequency of the field.
C. volume of the material
D. None of these.

67. Eddy currents in a core can be minimised by
A. decreasing the flux density
B. laminating the core
C. reducing core volume
D. decreasing the number of turns.

68. The relative permeability of paramagnetic materials is
A. Very high
B. slightly more than one
C. equal to one D. less than one

69. Magnetic susceptibility of medium is defined as ratio of
A. intensity of magnetisation of magnetic flux
B. magnetic field strength to mmf
C. intensity of magnetisation to field strength
D. None of these.

70. The unit of magnetic susceptibility is
A. Wb - m^2 B. Wb. A-m
C. Wb/A-m D. Wb/m^2

71. In a diamagnetic material, the effect of an applied magnetic field is that
A. a net dipole moment is induced in the material
B. the induced magnetisation is in opposition to applied field
C. there is a net reduction in flux density
D. All of these.

72. Above the curie temperature, a magnetic material becomes
A. ferromagnetic B. paramagnetic
C. diamagnetic D. None of these.

73. Magnetisation is nonlinearly related to the applied field in case of
A. diamagnetic material.
B. paramagnetic material
C. ferromagnetic material
D. All of these.

74. The concept of 'magnetic domains' is the basis of the theory of
A. diamagnetism B. paramagnetism
C. ferromagnetism D. All of these.

75. In the absence of external magnetic field
A. the domains are not magnetised
B. the net magnetisation is zero
C. the domain wall motion is irreversible
D. the domains are aligned in one direction.

76. When strong magnetic field is applied to ferromagnetic field, the domain wall motion becomes
A. constant B. irreversible
C. reversible D. static.

77. In antiferromagnetic materials, the spin moments associated with two sets of atoms are aligned
A. antiparallel to each other
B. parallel to each other

Answers : 63. (C), 64. (B), 65. (A), 66. (D), 67. (B), 68. (B), 69. (C), 70. (C), 71. (D), 72. (B), 73. (C), 74. (C), 75. (B), 76. (B), 77. (A)

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C. random to each other

D. antiparallel but of unequal magnitudes.

78. In ferromagnetic materials, the spin moments of two sets of atoms are aligned

A. antiparallel to each other

B. strong magnetic fields

C. very strong magnetic fields

D. alternating magnetic field.

79. Ferrites are sub-group of

A. ferromagnetic material

B. ferrimagnic material

C. diamagnetic material

D. paramagnetic material.

80. The conductivity of ferrites is

A. less than that of ferromagnetic materials

B. equal to that of ferromagnetic materials

C. greater than that of ferromagnetic materials

D. very high than that of ferromagnetic materials.

81. In ferromagnetic materials, the spin moments associated with two sets of atoms are aligned

A. antiparallel to each other

B. parallel to each other

C. random to each other

D. antiparallel but of unequal magnitude.

82. The net magnetic moment is zero in case of

A. ferromagnetic materials

B. ferrimagnetic materials

C. antiferromagnetic materials

D. None of these.

83. In ferromagnetic materials, the net magnetic moment created due to magnetisation by an applied field.

A. adds to the applied fields

B. subtracts from the applied fields

C. is normal to the applied fields

D. can be in any direction

84. The magnetisation vector M is defined as

A. dipole moment per unit volume

B. dipole moment per square metre

C. dipole moment per unit magnetic field

D. None of these.

85. The unit of magnetisation vector $\overline{M}$ is

A. ampere-m^2 B. ampere/-m^2

C. ampere/m D. ampere/m^3

86. Which one of following does *not* constitute a point defect in a crystal

A. self interstitial B. slip lines

C. vacancies D. None of these.

87. Energy formation of Schottky defect in a metal is of the order of

A. 1 joule B. 1 eV

C. $1.6 \times 10^{-19}\ eV$ D. 2 eV

88. A dislocation is a

A. lattic defect B. point defect

C. planer defect D. None of these.

89. The elastic strain in a material is

A. inversely proportional to the stress

B. reversible

C. time dependent

D. None of these.

90. The strain is always more than the engineering strain. Is the statement correct?

A. Correct

B. Incorrect

C. Correct under special conditions

D. None of these.

91. Which of the following metals is malleable but not ductile ?

A. Copper B. Silver

C. Lead D. None of these.

92. The stress at which a metal fails by fatigue lies?

A. in the elastic range

B. in the plastic range

Answers : 78. (C), 79. (B), 80. (A), 81. (B), 82. (C), 83. (A), 84. (A), 85. (C), 86. (A), 87. (B), 88. (B), 89. (B), 90. (A), 91. (C), 92. (A).

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C. near the fracture point of stress-strain curve
D. None of these.

93. In secondary creep,
A. recovery rate is equal to be work hardening rate
B. creep rate is independent of temperature
C. None of these.

94. Reduction in size of grains reduces
A. creep resistance
B. tensile strength
C. fatigue resistance
D. All of these.

95. Which of the following is high temperature property?
A. Impact strength B. Fatigue
C. Creep D. None of these.

96. Annealing of metals
A. removes internal stresses
B. increase the size of gains
C. decreases conductivity
D. None of these.

97. The formation of oxide film on a metal due to atmospheric exposure
A. reduces stiffiness B. reduces toughness
C. reduces creep limit D. None of these.

98. Brinell Hardness test uses
A. Diamond inventor
B. Hardened-steel ball intendor
C. None of these.

99. A material is elastic to
A. yeld point
B. elastic limit
C. limit of proportionality
D. None of these.

100. The usual size of powder metal particles is
A. 1 to 400 micron B. 1 to 100 micron
C. 1 to 800 micron D. None of these.

101. Annealing is used
A. to make soft steel
B. to make steel hard
C. to add carbon to steel
D. None of these.

102. In annealing process of Heat Treatment, cooling of steel is carried out in
A. air B. oil
C. water in the furnace itself
D. the furnace itself

103. Glass is a
A. brittle material B. tough material
C. ductile material D. None of these.

104. Plastic are
A. bad conductors of electricity
B. good conductors of electricity
C. good conductor of heat
D. None of these.

105. The Charpy Test of a material measures its
A. brittleness B. hardness
C. tensile strength D. fracturing stress.

106. Alpha brass is a/an
A. intermediate phase
B. interstitial compound
C. substitutional solid solution
D. None of these.

107. Bronze is an alloy of
A. copper and zinc
B. copper, zinc and tin
C. copper and tin
D. None of these.

108. Which of the following materials are visco-elastic in their properties?
A. Graphite B. Rubber
C. Glass D. None of these.

109. Stainless steels are alloys of
A. iron and nickel

Answers : 93. (A), 94. (A), 95. (C), 96. (A), 97. (B), 98. (B), 99. (B), 100. (B), 101. (A), 102. (D), 103. (A), 104. (A), 105. (A), 106. (C), 107. (C), 108. (B).

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B. iron, chromium and nickel

C. iron, chromium and molybdenum

D. None of these.

110. Austenite is

A. FCC iron with nearly 2% (max) carbon in solid solution

B. BCC iron with nearly 0.025% (max) carbon in solid solution

C. BCC iron with nearly 1% carbon is solid solution

D. None of these.

111. Which of the following metals have maximum magnetic permeability?

A. Pure iron

B. 4% silicon steel

C. Grain-oriented silicon tell

D. None of these.

112. Ferrite are

A. ferromagnetic

B. ferromagnetic

C. antiferomagnetic material

D. None of these.

113. The relative permeability of a material is 0.95. The material is

A. diagmagnetic B. paramagnetic

C. ferromagnetic D. None of these.

114. During the process of magnetisation of ferromagnetic material, the magnetic domains

A. expand first and then rotate

B. rotate first and then expand

C. neither expand not rotate

D. only expand.

115. High - frequency transformers cores are generally made from

A. Ferrites

B. Mu-metal

C. Mone-metal

D. None of these.

116. ALNICO is a

A. soft magnetic material

B. hard magnetic material

C. neither soft nor hard

D. None of these.

117. The antiferromagnetic material is

A. chromium B. copper

C. gold D. bismuth.

118. When the working temperature becomes more than Curie Temperature, the ferromagnetic material becomes

A. diamagnetic material

B. paramagnetic material

C. ferromagnetic material

D. ferrimagnetic.

119. The relative permeability of paramagnetic material is

A. less than unity

B. equal to unity

C. greater than unity

D. None of these.

120. The material used for permanent magnets are

A. soft magnetic material

B. hard magnetic material

C. neither of these

D. All of these.

121. The change in dimensions during the process of magnetisation is called

A. Skin effect B. Hall's effect

C. Magnetostriction D. None of these.

122. A dielectric of relative permitivity ε_r is introduced in an air capacitor of capacitance C_0 its capacitance will become.

A. $\frac{C_0}{\varepsilon_r}$ B. $\varepsilon_r C_0$

C. $\frac{\varepsilon_r}{C_0}$ D. $(1+\varepsilon_r) C_0$

Answers : 109. (B), 110. (A), 111. (C), 112. (A), 113. (A), 114. (A), 115. (A), 116. (B), 117. (A), 118. (B), 119. (C), 120. (B), 121. (C), 122. (B).

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B. ferrite magnets
C. large machine components made of steel
D. None of these.

172. Bainite structure in a steel is obtained by
A. isothermal transformation of austenite
B. tempering of martensite
C. None of these.

173. The main purpose of tempering hardening steel is to increase its
A. ductibility B hardness
C. carbon content D. None of these.

174. In ceramic insulators, glazes are used to improve
A. mechanical properties
B. chemical properties
C. electrical properties
D. None of these.

175. During recovery of a cold worked polycrystalline material, dislocations
A. rearrange B. multiply
C. migrate D. None of these.

176. The utectide mixture in steel is
A. a mixture of ferrite and cementite
B. mixture of ferrite and austenite
C. called ledeburite
D. None of these.

177. China clay is a major raw material for the production of
A. porcelain
B. refractory refractory
C. glass D. None of these.

178. Which of the following systems are isomorphous?
A. Copper-gold B. Bimuth-tin
C. Iron-vanadium D. None of these.

179. Polyethylene is produced by
A. condensation polymerisation
B. addition polymerisation
C. copolymerisation of ethylene monomers
D. All of these.

180. The temperature at which material becomes a glassy solid is called
A. melting temperature
B. glass transition temperature
C. freezing temperature
D. None of these.

181. Thermo-plastic and thermoset polymers differ in
A. thermal behaviour
B. mechanical behaviour
C. glass transition temperature
D. All of these.

182. Thermosetting polymers
A. have very few cross-links
B. can be easily remolded
C. are produced by condensation polymerisation
D. All of these.

183. The degree of crystallinity of a polymer is decreased by
A. absorption of water
B high cooling rate from liquid state
C. plastic deformation
D. All of these.

184. Plasticisers are added to plastic in order to
A. prevent deterioration
B. to improve the properties such as flexibility
C. control the polymerisation process
D. All of these.

185. As compared to metals, modulus of elasticity of plastics is usually
A. lesser B. greater
C. almost equal D. None of these.

186. Thermosetting polymers are
A. injection moulded B. cast moulded
C. exruded D. None of these.

Answers : 171. (C), 172. (A), 173. (A), 174. (A), 175. (A), 176. (A), 177. (A), 178. (A), 179. (B), 180. (B), 181. (A), 182. (C), 183. (B), 184. (B), 185. (A), 186. (B).

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A. nickel B. chromium
C. vanadium D. None of these.

229. The largest proportion of plane carbon steel is produced by
A. Acid Bessemer
B. Basic Bessemer
C. Electric Furnace process
D. None of these.

230. Machinability of plane carbon steel is improved by small addition of
A. silicon B. sulphur
C. phosphorous D. None of these.

231. Semiconductors have electrical conductivity of the following orders $(ohm\ cm)^{-1}$
A. 10^{-15} B. 10^{-3}
C. 10^{4} D. None of these.

232. With increase in temperature, electrical resistance of a semiconductor
A. increases B. decreases
C. remains constant D. None of these.

233. The impurity atoms in semiconductors
A. reduce the energy gap
B. increase the kinetic energy of valence electrons
C. inject more charge carriers
D. All of these.

234. With increase in temperature, the conductivity of an extrinsic semiconductor
A. decreases B. increases
B. remains constant. D. All of these.

235. The Half's Coefficient for a particular material was found to be zero. The material is
A. metal
B. intrinsic semi-conductor
C. insulator
D. Any of these

236. The thickness of the depletion layer in an *PN* junction is of the order of
A. 10^{-6}m B. 10^{-10}m
C. 10^{-4}m D. None of these.

237. A *PN* junction is
A. a rectifier B. an amplifier
C. an insulator D. None of these

238. The most important factor which can influence the operation of a *PN* junction is
A. impurity atom concentration
B. temperature
C. mobility of change carriers
D. All of these.

239. The material used for photo conductive cell is
A. ZnS B. PbS
C. CdS D. None of these.

240. It is possible to obtain *P*-type or *N*-type semiconductor from a single compound by adding Ge. That compound is
A. InSb B. GaP
C. GaAs D. None of these.

241. The material which is *not* a semiconductor is
A. selenium B. gallum-arsenide
C. silica D. carborundum

242. An element used in semiconductors whose atoms have three valence electrons is
A. germanium B. a donor
C. an acceptor D. silicon.

243. When a semiconductor is doped with a *P*-type impurity, each impurity atom will
A. acquire negative charge
B. acquire positive charge
C. remain electrically natural
D. give away one electron

244. When acceptor type impurity is added to a semiconductor material.
A. electrons are generated and material is called *N*-type
B. electrons are generated and material is called *P*-type

Answers : 228. (C), 229. (B), 230. (A), 231. (B), 232. (B), 233. (A), 234. (B), 235. (B), 236. (A), 237. (A), 238. (B), 239. (C), 240. (C), 241. (C), 242. (C), 243. (A).

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280. The donor atoms is an *N*-type semi-conductor at normal temperature
   A. carry a positive charge
   B. carry a negative charge
   C. are neutral.
   D. None of these.

281. The conductivity of a pure semi-conductor is
   A. proportional to temperature
   B. increase exponentially with temperature
   C. decreases exponentially w increasing temperature
   D. All of the above.

282. The donor atoms in an *N-type* semi-conductor at normal temperature
   A. carry a positive charge
   B. carry a negative charge
   C. are neutral
   D. None of these.

Answers : 280. (B), 281. (B), 282. (B).

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CHAPTER 5

DC MACHINES

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Chapter - 5

DC MACHINES

5.1. DC Generator. DC generator operates on the principle of the production of dynamically induced emf. To produce dynamically induced emf, a magnetic field and a conductor moving with respect to the field are essential. The current induced in the coil is collected and conveyed to the external load circuit by connecting the coil terminals to two continuous and insulated rings known as *slip rings* or *collector rings*.

DC machine mainly consists of four parts as shown in Fig. 5.1. Field magnets, armature, commutator and brushes.

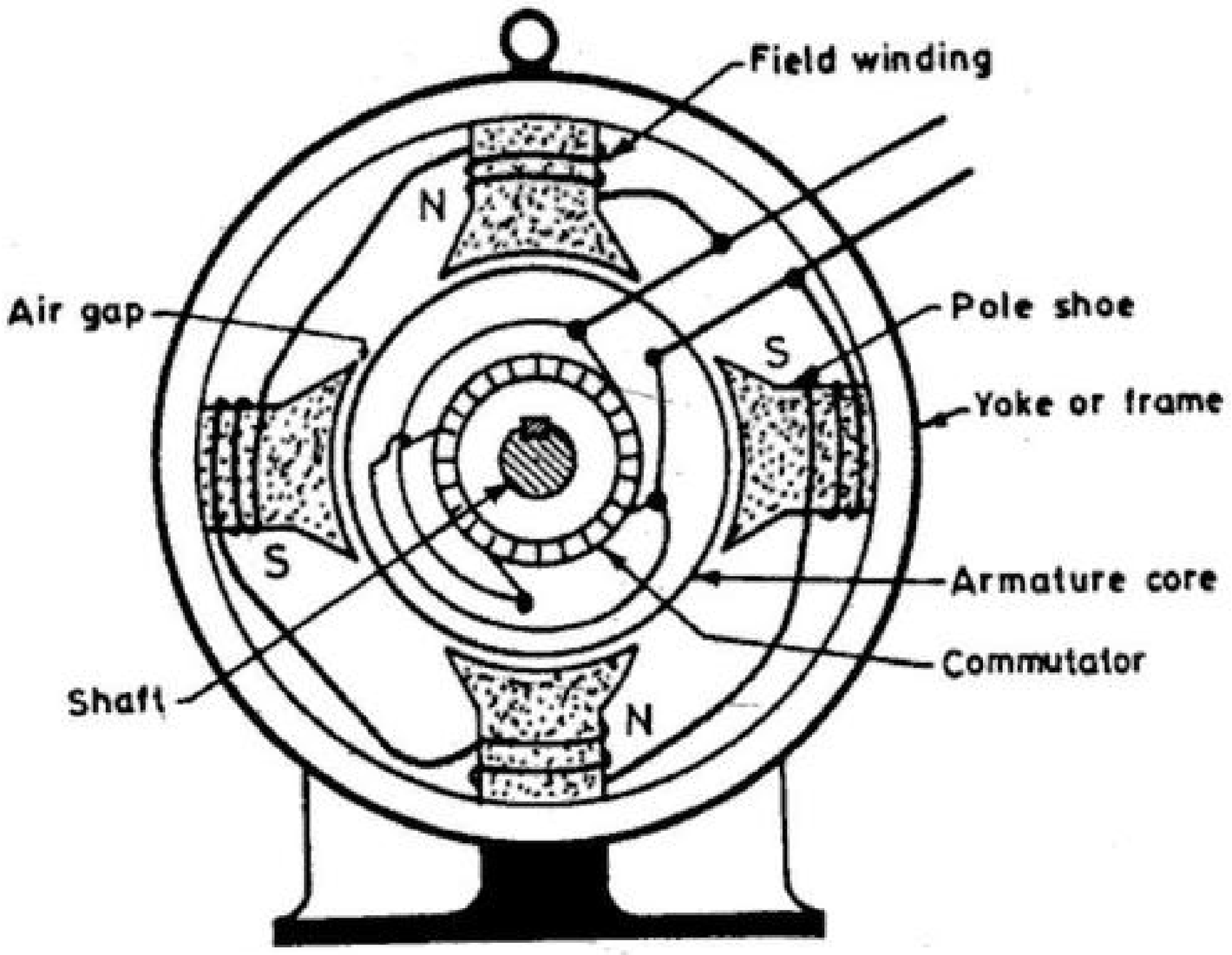


Fig. 5.1

The emf generated within the armature of a dc generator,

$$E_g = \frac{\Phi ZN}{60}\left(\frac{P}{A}\right) \text{ Volt}$$

where A = Number of parallel paths in armature.

= 2 for wave - winding.

= P for lap - winding.

N = Speed in RPM.

Z = Number of conductors in the armature.

Φ = Flux/pole in Wb.

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5.13. Types of DC Motors. Type of dc motors are listed below:

(I) Series-wound motors

(II) Shunt-wound motors

(III) Compound-wound motors

(i) Commutative type

(ii) Differential type

(I) Series Wound Motor:

(i) Back e.m.f.; $E_b = V - I\,(R_a + R_{se})$

(ii) $I_a = I_{se} = I$

(iii) Power Input = VI

(iv) Power developed, $P_{dev} = E_b I = VI - I^2\,(R_a + R_{se})$

(II) Shunt Wound Motor:

(i) $I_L = I_a + I_{sh}$

(ii) $I_{sh} = V/R_{sh}$

(iii) Back emf, $E_b = V - I_a R_a$

(iv) Power Input = VI_L

(v) Power developed, $P_{dev} = VI_L - VI_{sh} - I_a^2 R_a$

(III) Compound Wound Motor: This is of two types:

(a) Cumulative Compound; and (b) Differential Compound

Heating and Cooling Equations of DC machines are :

$$\theta = \theta_m\,(1 - e^{-t/T_h})$$

$$\theta = \theta_i\,(1 - e^{\ t/T_c})$$

where θ_m is the final temperature temperature rise while heating, °C, θ_i is the initial temperature rise over ambient medium °C T_h and T_c are the heating and cooling time constants 't' is the time (sec)

5.14. Speed Regulation. Speed regulation of dc motor is defined as the change in speed when load on the motor is reduced from full load to zero and is expressed as

$$\%\ \text{regulation} = \frac{N_0 - N_f}{N_f} \times 100$$

In a dc motor, speed is inversely proportional to flux per pole if supply voltage is constant. In case of dc shunt motor, the flux is constant, and the speed will approximately remain constant.

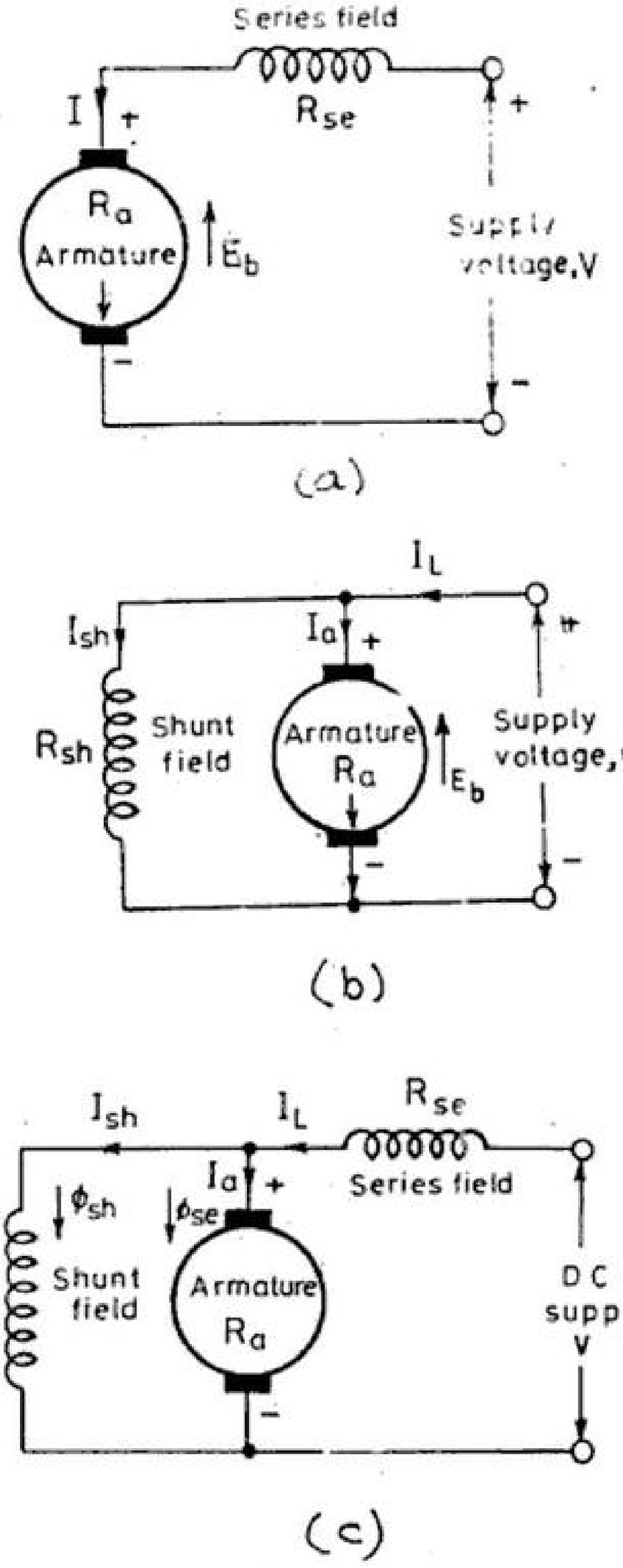


Fig. 5.5

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B. higher than no load speed at rated flux.
C. equal to no load speed at rated flux.
D. lower than no load speed at rated flux.

21. In a d.c. motor the iron losses occur in
A. the yoke. B. the armature
C. the field. D. None of these.

22. The dummy coil in d.c. machines is used to
A. eliminate reactance voltage.
B. eliminate armature reaction.
C. bring about mechanical balance of armature.
D. eliminate harmonics developed in the machine.

23. A simple method of increasing the voltage of an d.c. generator is
A. to decrease the air gap flux density
B. to increase the speed of rotation.
C. to decrease the speed of rotation.
D. to increase the length of the armature

24. The function of the starter in a d.c. machines is
A. to avoid the excessive current at starting.
B. to control the speed.
C. to avoid armature reaction
D. to avoid excess heating.

25. An external resistance is added in the series with the field of a d.c. shunt motor. When the motor runs, the effect of resistance is
A. to reduce the speed of the motor
B. to increase the speed of the motor.
C. to reduce the armature current drawn by the motor.
D. to reduce the losses

26. An external resistance added in the field of a d.c. shunt generator will
A. increase the speed of the generator
B. increase the voltage of the generator
C. decrease the voltage of the generator
D. increase the power delivered.

27. The speed of a d.c. shunt motor is required to be more than F.L. speed. This is possible by
A. increasing the armature current.
B. decreasing the armature current.
C. increasing the excitation current
D. reducing the field current

28. An emf is induced in the windings of an armature of a d.c. generator when the armature rotates in
A. alternating magnetic flux
B. magnetic field
C. electrostatic field
D. electromagnetic flux.

29. If the speed of d.c. generator is increased, the generated emf
A. increases.
B. decreases.
C. remains constant.
D. decreases and then increases.

30. If speed of a d.c. shunt motor increases, the back emf
A. increases.
B. decreases.
C. remains constant.
D. first decreases and then increases.

31. The function of a commutator in a d.c. generator is
A. to collect current from conductors.
B. to change d.c. to a.c.
C. to conduct the current to the brushes
D. to change a.c. to d.c.

32. The current flowing in the conductors of a d.c. motor is
A. a.c. B. d.c.
C. a.c as well as d.c. D. transients.

33. As the load is increased the speed of a d.c. shunt motor will
A. remain constant

Answers : 20. (C), 21. (A), 22. (C), 23. (B), 24. (A), 25. (B), 26. (C), 27. (D), 28. (B), 29. (A), 30. (A), 31. (D), 32. (A).

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B. increase proportionately

C. increase slightly

D. reduce slightly.

34. The current drawn by armature of a d.c. motor is

A. V/R_a B. E_b/R_a

C. $(V - E_b)/R_a$ D. $(E_b - V)/R_a$

35. If the current in the armature of d.c. series motor is reduced to 5%, the torque of the motor will become

A. 50% of the previous value

B. 25% of the previous value.

C. 150% of the previous value.

D. 125% of the previous value.

36. The current in the armature of a d.c. shunt generator is

A. $\frac{E - V}{R_a}$ B. E/R_a

C. $I_L + I_{sh}$ D. $\frac{E}{R_{sh}}$

37. The shunt current flowing in short shunt compound-wound motor is given by

A. $I_{sh} = \frac{V}{R_{sh}}$ B. $I_{sh} = \frac{V + I_{sc} R_{se}}{R_{sh}}$

C. $I_{sh} = V - \frac{I_{sc} R_{se}}{R_{sh}}$ D. None of these.

38. In d.c. shunt motor, it the terminal voltage is reduced to half and torque remains the same, then

A. speed will be half and armature current also will be half

B. speed will be half but armature current remains the same.

C. speed will be half and armature current becomes double.

D. speed and armature current will remain the same.

39. One d.c. motor drives another d.c. motor. The second d.c. motor when excited and driven, it

A. runs.

B. does not run as generator

C. runs as a generator.

D. also runs as a motor.

40. Armature torque of a d.c. motor is given by

A. $T = 0.159\ \phi\ Z I_a (P/A)$ kg m.

B. $T = 0.01620/2 I_a (P/A)$ N–m.

C. $T = 0.159\ \frac{E_b}{N}\ I_a$ N–m

D. None of these.

41. A 4-pole lap-wound armature has 480 conductors and a flux per pole of 25 m Wb. The emf generated, when running at 600 rpm, will be

A. 240 V B. 120 V

C. 60 V. D. 30 V.

42. The torque of a motor is

A. force in N – m acting on the rotor.

B. the product of tangential force on the rotor and its radius.

C. the electrical power in kW

D. the power given to load being driven by the motor.

43. The armature current drawn by any d.c. motor is proportional to

A. the voltage applied to the motor.

B. the torque required.

C. the flux required in the motor.

D. the speed of the motor.

44. The current delivered by a 4-pole d.c. shunt generator is 98 A. The shunt-field current is 2 A. The armature is lap-wound. The current per parallel-path is

A. 100 A B. 25 A

C. 50 A D. 12.5 A

45. The output power of any electrical motor is taken from

A. the armature.

B. the coupling mounted on the shaft

C. the conductors

Answers : 33. (D), 34. (C), 35. (B), 36. (A), 37. (B), 38. (C), 39. (C), 40. (C), 41. (B), 42. (B), 45. (B).

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D. the poles.

46. The power stated on the name plate of any motor is always.

A. the output power at the shaft

B. the power drawn in kVA

C. the power drawn in kW

D. the gross power

47. The exciting coils of any d.c. machine are wound

A. in the machine

B. in the armature slots

C. around the poles D. separately.

48. A starter is necessary to start a d.c. motor because

A. it starts the motor.

B. it limits the speed of the motor

C. it limits the back emf to a safe value

D. it limits the starting current to a safe value.

49. The efficiency of any electrical machine/apparatus will be high, if

A. its losses are minimum

B. its losses are more.

C. voltage applied is constant.

D. the current drawn is minimum.

50. The direction of rotation of a d.c. shunt motor is reversed by

A. reversing armature connections.

B. interchanging the armature and field connection.

C. adding resistance to the field circuit

D. reversing supply connections.

51. The armature of d.c. motors is laminated

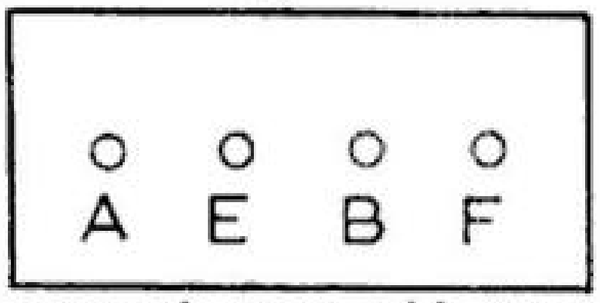
A. to reduce the hysteresis losses.

B. to reduce the eddy current losses.

C. to reduce the inductivity of armature.

D. to reduce the mass of the armature.

52. The terminal board of a motor is as shown in the diagram. Which type of motor is this?



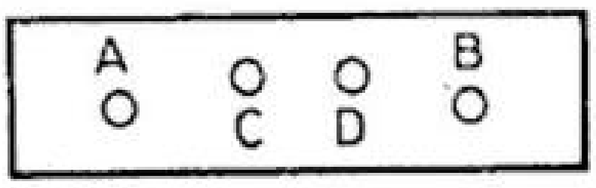
A. A compound motor with commutating pole winding.

B. A shunt motor with commutating pole winding.

C. A shunt motor with commutating pole winding. .

D. A series motor with commutating pole winding.

53. The terminal board of a motor is as shown in the diagram. Which type of motor is this?



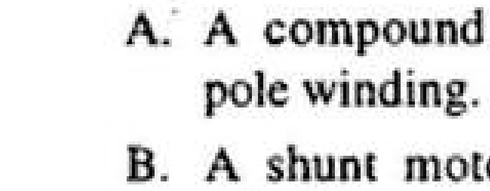
A. A compound motor with commutating pole winding.

B. A shunt motor with commutating pole winding.

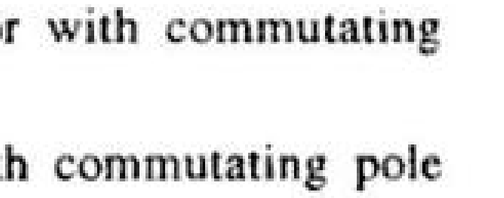
C. A shunt motor without commutating pole winding.

D. A series motor with commutating pole winding.

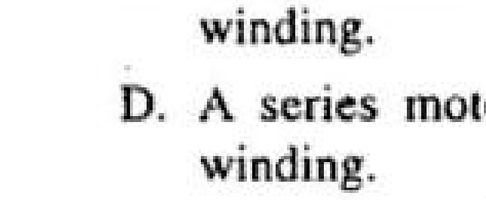
54. In which of the following sketches is the motor connected to run in anticlockwise direction?



(1)



(2)



(3)



(4)

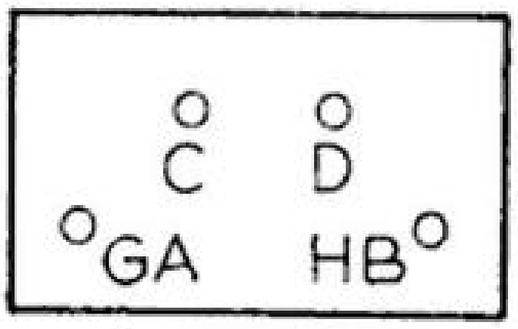
Answers : 46. (A), 47. (C), 48. (D), 49. (A), 50. (A), 51. (B), 52. (D), 53. (C).

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A. Sketch 1 B. Sketch 2
C. Sketch 3 D. Sketch 4

55. Which of the following is a correct statement about a series motor?
A. Its field winding consists of thicker wire and less turns.
B. It can run easily without load
C. It has an almost constant speed
D. It has poor torque.

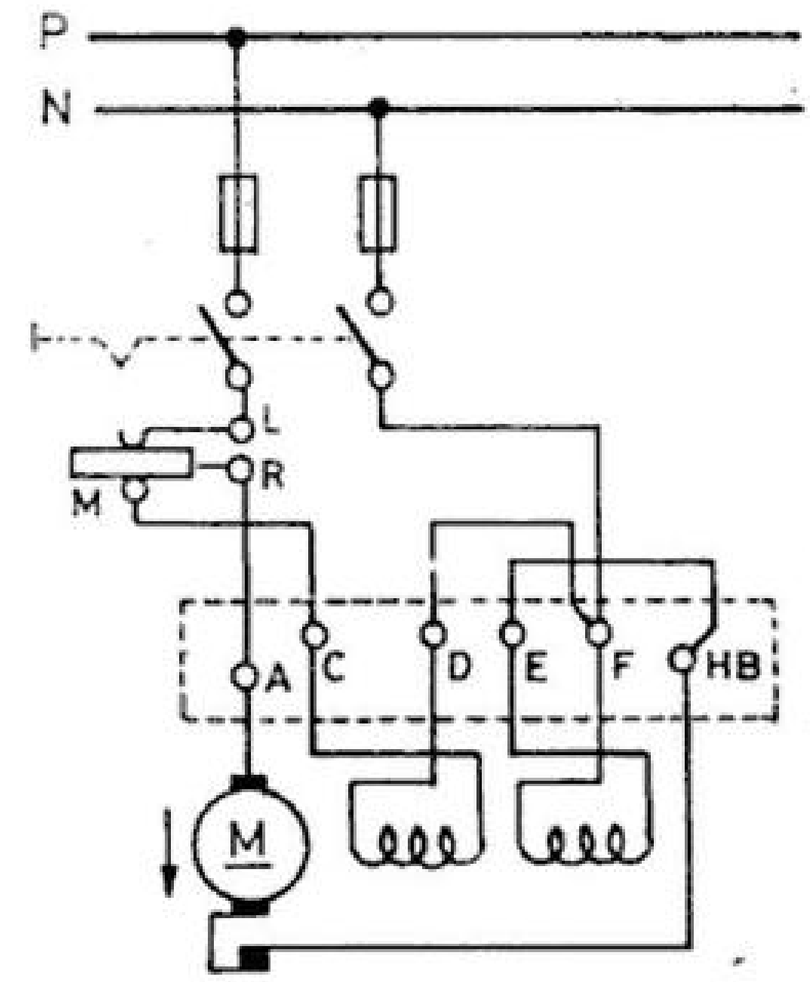
56. The terminal board of a motor is shown in the diagram given below. Which type of motor is this?



A. A compound motor without commutating pole winding.
B. A shunt motor with distributed commutating pole winding
C. A shunt motor without commutating pole winding
D. A series motor with distributed commutating pole winding.

57. Which of the following d.c. motors has the least drop in speed between no load to nominal load?
A. Shunt motor with commutating poles.
B. Series motor without commutating poles.
C. Compound motor without commutating poles.
D. Series motor with commutating poles.

58. What is represented by the diagram shown in the figure?



A. A compound generator with auxiliary series winding
B. A shunt generator with commutating pole winding and compensating winding.
C. A shunt motor with commutating pole winding and compensating winding
D. A compound motor with auxiliary series winding and commutating pole winding.

59. What happens if the field winding of a running shunt motor suddenly breaks open?
A. Its speed slows down.
B. Its speed becomes dangerously high
C. It gives out sparks
D. It stops at once.

60. The speed of a series motor at no load is
A. zero B. 3000 rpm
C. 3600 rpm D. infinity.

61. The speed of d.c. series motor decreases if the flux in the field winding
A. remains constant B. increases
C. decrease. D. None of these.

62. Which of the following motors is used to derive the constant speed line shafting lathes, blowers and fans?
A. D.C. shunt motor.
B. D.C. series motor
C. Commutative compound motor
D. None of these.

Answers : 54. (A), 55. (A), 56. (B), 57. (A), 58. (D), 59. (B), 60. (D), 61. (B), 62. (A).

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B. d.c. shunt motor

C. d.c. series generator

D. d.c. shunt generator.

75. Which of the following d.c. motors is suitable for high starting torque?

A. Shunt motor

C. Commutative compound motor.

C. Series motor

D. Compound motor

76. For which of the following d.c. motors is the typical field of application mentioned?

A. Shunt motor : electric trains

B. Series motor : machine tools

C. Series motor : belt drive

D. Compound motor : fly wheel drive.

77. The generator of a power station produces an electric pressure by

A. conversion of heat

B. magnetic induction

C. conversion of light

D. mechanical pressure.

78. Why is the air gap between stator and armature of an electric motor kept as small as possible?

A. To get stronger magnetic field

B. To make the rotation easier

C. To reach a higher speed of rotation

D. To improve the air circulation.

79. Which of the following types of generators gives constant voltage output at all loads?

A. Series generator

B. Shunt generator

C. Short shunt compound generator

D. Level compound generator.

80. Interpoles are meant for

A. increasing the speed of the motor

B. decreasing counter emf.

C. reducing sparking at the commutator.

D. converting armature current to d.c.

81. A d.c. shunt generator driven at a normal speed in the normal direction fails to build up armature voltage because

A. the resistance of the armature is high

B. there is no residual magnetism

C. the field current is too small

D. None of these.

82. Which of the following condition are necessary for build-up of a shunt generator?

I There must be some residual magnetism in the poles

II For the given direction of rotation, the shunt field coils should be correctly connected to the armature.

III If excited on open circuit, its shunt field resistance should be greater than the critical resistance.

IV If excited on load, then its shunt field resistance should be more than a certain minimum value of resistance, which is given by the internal characteristics.

A. (I) and (II) B. (II) and (III)

C. (I) and (II) D. (I), (II) and (IV)

83. An ideal d.c. generator has a regulation of

A. zero % B. 50 %

C. 75 % D. 100 %

84. Which of the following statements is *incorrect* in d.c. shunt generators about hysteresis loss?

A. It can be minimized by laminating the armature.

B. It is independent of lamination thickness

C. It depends upon the supply frequency

D. None of these.

85. Which of the following methods is most economical for finding the no-load losses of a large d.c. shunt motor ?

A. Hopkinson's test

B. Swinburne's test.

Answers : 74. (C), 75. (C), 76. (D), 77. (D), 78. (A), 79. (D), 80. (C), 81. (B), 82. (D), 83. (A), 84. (A), 85. (B).

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C. Retardation test.

D. None of these.

86. The rated speed of a given d.c. shunt motor is 1050 rpm. To run this machine at 1200 rpm, which of the following speed control scheme will be used

A. Armature current resistance control

B. Field resistance control.

C. Ward-Leonard control.

D. None of these.

87. The destroyed residual magnetism of a shunt generator may restored by connecting its shunt field to

A. earth B. generator

C. a battery D. None of these.

88. It is preferable to start a d.c. series motor with some mechanical load on it because

A. it will not run at no load

B. it acts as a starter to the motor

C. it may develop excessive speed and damage itself.

D. None of these.

89. If the flux of a d.c. motor approaches zero, its speed will approach

A. infinity B. zero

C. a stable value nearer to the rated speed

D. None of these.

90. As the load is increased, the speed of a shunt motor

A. remains constant B. increases slightly

C. reduces slightly D. None of these.

91. A 230 V d.c. series motor is connected to 230 V a.c. it will

A. run slowly

B. not run at all

C. run with less efficiency

D. None of these.

92. The main function of a commutator in d.c. motor is to

A. prevent sparking

B. convert a.c. to d.c.

C. reduce friction

D. convert d.c. to a.c.

93. Which of the following statements is *incorrect?* If a starter is not used with large d.c. motor, it will draw a starting current which

A. is many times its full-load current.

B. will produce excessive line voltage drop

C. will damage the commutator.

D. will produce very low starting torque.

94. The factor which does not cause decrease in the terminal voltage of a shunt generator is

A. armature resistance.

B. armature reaction

C. reduction in field current.

D. armature reactance.

95. A d.c. generator can be termed as

A. rotating amplifier. B. prime mover.

C. power pump D. None of these.

96. The function of equalizing connections in a lap wound d.c. generator is

A. to neutralise the armature reaction effect.

B. to avoid unequal distribution of currents at brushes.

C. to avoid short circuit current

D. None of these.

97. The function of compensating windings placed in slots in the pole shoes is

A. to neutralise cross magnetising effect.

B. to neutralise the demagnetising effect.

C. to neutralise both the effects.

D. to avoid flash over around the commutator.

98. In the case of parallel operation of compound generators, for proper division of load from no load to full load, it is essential that

A. the regulation of each armature should be the same

Answers : 86. (B), 87. (D), 88. (C), 89. (A), 90. (C), 91. (C), 92. (B), 93. (D), 94. (C), 95. (A), 96. (B), 97. (D), 98. (A).

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B. their series field resistances should be equal

C. their ratings should be identical.

D. None of these.

99. The simplest way to shift load from one shunt generator to the other running in parallel is to

A. adjust their field rheostats.

B. use equalizer connection.

C. add resistance in their armature circuit.

D. None of these.

100. For parallel operation, the polarities of two generators

A. must oppose each other

B. must be same

C. may or may not be same

D. None of these.

101. The parts of the armature electric circuit which take active part in e.m.f. generation are

A. The coil sides inside the slots.

B. the overhangs.

C. both the coil sides inside the slots and the overhangs.

D. the commutator segments.

102. The brushes of a d.c. machine are

A. physically placed in the interpolar axes and electrically connected to the coils in the polar axes.

B. physically placed in the interpolar axes and electrically connected to the coils in the interpolar axes.

C. physically placed in the polar axes and electrically connected to the coils in the interpolar axes.

D. physically placed in the polar axes and electrically connected to the coils in the polar axes.

103. The e.m.f. induced in the armature of a d.c. machine is

A. directly proportional to the flux and inversely proportional to the speed.

B. directly proportional to both the flux and the speed.

C. inversely proportional to both the flux and the speed

D. None of the above.

104. If the armature current of a d.c. motor is increased keeping the field flux constant, then the developed torque.

A. increases proportionally

B. decreases in inverse proportion

C. remains constant

D. increases proportional to square of the current.

105. The direction of induced e.m.f. in an armature coil of a d.c. machine is:

A. the same as that of the current for both the generator and the motor.

B. opposite to that of the current for both generator and the motor

C. the same as that of the current for the generator and opposite to that of the current for the motor

D. None of these.

106. In a d.c. machine the armature m.m.f. is always directed along the:

A. polar axis B. brush axis

C. interpolar axis D. None of the above.

107. The save from of the armature m.m.f. in a d.c. machine is

A. square B. rectangular

C. triangular D. sinusoidal.

108. In a d.c. machine without any brush shift, the shift of the magnetic neutral axes due to armature reaction is

A. in the direction of rotation for the generator and against the direction of rotation for the motor

B. in the direction of rotation for both the generator and the motor

Answers : 99. (A), 100. (A), 101. (A), 102. (C), 103. (B), 104. (A), 105. (C), 106. (B), 107. (C), 108. (A).

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C. against the direction of rotation for both the generator and the motor.

D. against the direction of rotation for the generator and in the direction of rotation for the motor.

109. Consider the following statements:
The armature relation m.m.f. in a d.c. machine is

I. stationary with respect to the field poles

II. rotating with respect to the field poles

III. rotating with respect to the armature.

State which of the following is correct.

A. only (I)

B. only (III)

C. both (I) and (III)

D. both (II) and (III)

110. The commutator of a d.c. machine acts as a

A. full-wave rectifier.

B. half-wave rectifier

C. controlled full-wave rectifier

D. controlled half-wave rectifier.

111. In a d.c. machine the armature reaction and the inductance of the commutating coils result in

A. over-commutation

B. sinusoidal commutation

C. linear commutation

D. under commutation.

112. Under-commutation gives rise to

A. sparking at the leading edge of the brush

B. sparking at the trailing edge of the brush

C. no sparking at all

D. sparking at the middle of the brush

113. For a d.c. generator if the brushes are given, a small amount of forward shift the effect of armature reaction is

A. totally demagnetizing

B. totally magnetizing

C. partly demagnetizing and partly cross-magnetizing.

D. totally cross-magnetizing.

114. In a d.c. motor if the brushes are given a backward shift, then

A. commutation is worsened and speed decreases

B. commutation is improved and speed decreases

C. commutation is unaffected and speed increases

D. commutation is improved and speed increases.

115. In a d.c. machine without interpoles to get improved commutation, the brush shift angle must be

A. varied with change in load

B. kept constant

C. 0 degree

D. None of the above.

116. Consider the following statements
The purpose of using interpoles in d.c. machines is to counteract

I. the demagnetizing effect of armature m.m.f. in the commutating zone.

II. the cross-magnetizing effect of armature m.m.f. in the commutating zone.

III. State which of the following is correct

A. only II B. only III

C. both II and III D. both I and III

117. In d.c. machines, the polarity of the interpole is

A. same as that of the main pole behind for the generators and that of the main pole ahead for the motors.

B. same as that of the main pole ahead for both the generators and the motors.

C. same as that of the main pole ahead for the generators and that of the main pole behind for the motor.

Answers : 109. (C), 110. (A), 111. (D), 112. (B), 113. (C), 114. (D), 115. (A), 116. (C), 117. (C).

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D. same are that of the main pole behind for both the generators and the motors.

118. Compared to the air-gap under the field-poles, the inter-pole air-gap is made:

A. larger for both the generators and the motors.

B. smaller for both the generators and larger for the motors

C. smaller for generators and larger for the motors.

D. larger for generators and smaller for the motors.

119. Consider the following statements
The purpose of using compensating winding in a d.c. machine is to counteract

I. armature reaction m.m.f. under the pole-faces.

II. armature reaction m.m.f. in the interpolar zone.

III. flashover between positive and negative brushes.

State which of the following is correct.

A. both I and III B. only III

C. both I and II D. both II and III

120. Compared to an uncompensated d.c. machine, the interpole as required in a compensated d.c. machine is

A. larger for the generators and smaller for the motors.

B. smaller for the generators and larger for the motors.

C. smaller for both the generators and the motors.

D. larger for both the generators and the motors.

121. A d.c. machine is provided with both interpole winding (IPW) and compensating winding (CPW) with respect to the armature

A. both IPW and CPW are in parallel.

B. both IPW and CPW are in series.

C. IPW is in series and CPW is in parallel.

D. IPW is in parallel and CPW is in series.

122. Consider the following statements.
Compensating windings are used in a d.c. motor which are intended to operate

I. with rapidly changing loads of wide range.

II. at constant speed over wide range of load.

III. over wide range of speed by field excitation control

State which of the following is correct

A. only I B. only III

C. both II and III D. both I and III.

123. Due to magnetic saturation, the flux per pole in a d.c. machine without brush shift

A. decreases in the generators and increases in the motors with load.

B. decreases in both the generators and the motors with load

C. increases in both the generators and the motors with load.

D. increases in the generators and decreases in the motors with load.

124. The core losses in a d.c. machine occur due to

A. hysteresis only B. eddy current only

C. armature current

D. both hysteresis and eddy currents.

125. The core losses in a d.c. machine occur in

A. the armature only B. the pole faces only

C. the yoke only

D. both the armature and the pole faces.

126. The hysteresis loss per unit weight is

A. proportional to the frequency

B. inversely proportional to the frequency

C. inversely proportional to the flux density

D. proportional to the thickness of laminations.

127. If the thickness of laminations is increased, then

A. the eddy current loss decreases

B. the eddy current loss increases

C. the hysteresis loss decreases

D. the hysteresis loss increases.

Answers : 118. (A), 119. (A), 120. (C), 121. (B), 122. (D), 123. (B), 124. (D), 125. (D), 126. (A), 127. (B).

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A. reversing the connections of the generator field terminals

B. reversing the connection of the generator armature terminals

C. reversing the connections of the motor armature terminals

D. None of these.

149. A d.c. shunt motor is driving a mechanical load at rated voltage and rated excitation. If the load torque becomes double then the speed of the motor.

A. increase slightly B. decreases slightly

C. becomes double D. becomes half

150. A d.c. series motor is driving a load with a diverter connected across its armature. If the diverter resistance is decreased, the speed of the motor

A. increases

B. decreases

C. remains unchanged

D. becomes zero

151. A d.c. series motor is running with a diverter connected across its field winding. If the diverter resistance is increased then the speed of the motor.

A. decreases

B. increases

C. remains unchanged.

D. becomes excessively high

152. Two d.c. series motors connected in series are driving the same mechanical load. If the motors are now connected in parallel the speed becomes

A. slightly less than double

B. slightly less than half

C. slightly more than double

D. slightly more than half

153. A d.c. series is running at rated speed with rated excitation. The motor has two resistances R_1 and R_2 connected across the armature and the field respectively. Speeds above the rated speed can be achieved by

A. decreasing R_1 only

B. increasing R_2 only

C. decreasing R_1 and increasing R_2

D. increasing R_1 and decreasing R_2

154. A d.c. series motor is running at rated speed without any additional resistance in series. If an additional resistance is placed in series, the speed of the motor.

A. increases B. decreases

C. remains unchanged

D. oscillates around the rated speed.

155. The most economic method of electrical braking is

A. regenerative braking

B. dynamic braking with self excitation

C. dynamic braking with separate excitation

D. plugging.

156. Plugging of d.c. motors is normally executed by

A. reversing the field polarity

B. reversing the armature polarity

C. reversing both armature and field polarity

D. connecting a resistance across the armature.

157. For non-reversing d.c. drives it is preferable to employ

A. regenerative braking

B. dynamic braking with separate excitation

C. dynamic braking with self excitation

D. plugging.

158. Consider the following statements on cross-field generators

I. to increase amplification factor compensating winding should be provided

II. the reversal of speed does not reverse the output voltage

Answers : 148. (A), 149. (B), 150. (B), 151. (A), 152. (C), 153. (D), 154. (B), 155. (A), 156. (B), 157. (B).

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B. high permeability
C. more mechanical strength
D. more mechanical strength and high permeability

183. Poles are made of laminated cores because it
A. increases the iron losses
B. reduces the eddy current losses
C. reduces the copper losses
D. reduces the friction losses.

184. A d.c. generator will not build up the voltage
A. if the field resistance is more than critical resistance
B. due to wrong direction of rotation
C. if it has lost the residual magnetism
D. Any one of the above three.

185. For battery charging which of the following d.c. generator is used.
A. series B. shunt
C. short shunt compound
D. long shunt compound

186. D.C. series generator is used for
A. lighting load B. battery charging
C. a booster D. None of these.

187. The internal characteristic of generator is the curve between
A. armature current and generated e.m.f.
B. load current and terminal voltage
C. field current and no load voltage
D. armature current and IR loop

188. E.m.f. of generator depends upon
A. number of poles
B. flux per pole
C. number of conductors
D. All of these.

189. The e.m.f. of a generator can be controlled by varying
A. flux
B. speed of the generator
C. number of poles
D. speed and flux both.

190. The load characteristic of a generator is the curve between
A. load voltage and field current
B. generated e.m.f. and armature current
C. load current and terminal voltage
D. load current and voltage drop in the armature winding

191. The resistance of shunt winding is
A. more than series winding
B. more than armature
C. less than series and armature
D. more than series and armature.

192. In series motor, the number of turns in the field pole is
A. more than shunt field
B. less than shunt field
C. less than armature
D. same as in shunt field

193. Motor converts
A. mechanical energy into electrical energy
B. electrical energy into mechanical energy
C. chemical energy into electrical energy
D. kinetic energy into mechanical energy

194. If one generator is to be taken out when two generators are running in parallel, the excitation of
A. first generator is reduced gradually
B. second generator is increased gradually
C. first is reduced and second is increased gradually and simultaneously
D. None of these.

195. Generators run in parallel because it
A. keeps stability of supply
B. gives facility of repairing, which results in fewer break down

Answers : 182. (D), 183. (B), 184. (D), 185. (B), 186. (C), 187. (A), 188. (D), 189. (D), 190. (C), 191. (D), 192. (C), 193. (B), 194. (C).

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232. The full load current of a 20 HP, 500 V d.c. motor will be closer to

A. 100 A B. 60 A

C. 35 A D. 15 A

233. The following controls are considered for d.c. motors:

I. Control of flux

II. Armature resistance control

III. Supply voltage control.

Which of the following controls play significant role in the speed control of d.c. motors?

A. I only B. II and III only

C. I and III only D. I, II and III

234. If the load current and flux of a d.c. motor are held constant and voltage applied across its armature is increases by 5%, the speed of motor will

A. increase by about 5%

B. reduce by about 5%

C. remain unaltered

D. depends on other factors.

235. The type of d.c. motor control preferred for applications when usually wide and very sensitive speed control is required, will be

A. Armature control

B. Ward-Leonard control

C. Voltage control

D. Flux control

236. The armature voltage control is considered as suitable, in case the d.c. machine is driven at

A. constant torque B. constant speed

C. constant power D. constant current

237. In a properly designed d.c. generator of 10 kW capacity, total losses may be of the order of

A. 50 W B. 500 W

C. 2500 W D. 5000 W

238. The insulation between the segments of commutator for d.c. machines is

A. wood B. paper

C. fabric D. mica

239. The d.c motor develops a torque of 140 N.m at 1400 rpm. If the motor now runs at 1000 rpm, the torque developed will be

A. 140 N.m B. 2000 N.m

C. 71 N.m D. 51 N.m

240. Usually wide and very sensitive speed control is required in case of

A. Reciprovating pumps

B. Colliery winders

C. Centrifugal blowers

D. Lathe machines.

241. The yoke of a *d.c.* machine

A. is laminated

B. is not laminated

C. may or may not be laminated

D. None of these.

242. The pole shoes of a d.c. machine

A. are always laminated

B. are never laminated.

C. are some times laminated

D. None of these.

243. The thickness of laminations is about

A. 2 mm B. 5 mm

C. 0.5 mm D. 10 mm

244. The ventilating ducts in most of the machines are

A. radial B. longitudinal

C. radial as well as longitudinal

D. None of these.

245. The yoke of *d.c.* machine

A. must be made of magnetic material

B. should preferably be made of magnetic material but can be made of non-magnetic material also.

Answers : 232. (C), 233. (D), 234. (A), 235. (B), 236. (A), 237. (B), 238. (D), 239. (A), 240. (B), 241. (B), 242. (A), 243. (C), 244. (C), 245. (A).

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where V and t being the volume and thickness of the core laminations.

Output current at which maximum efficiency occurs is given by

$$= Full\ load \sqrt{\frac{Iron\ Loss}{F.L.\ copper\ loss}}$$

6.8. All day efficiency. This is defined as

$$All\ day\ efficiency = \frac{Output\ in\ kWh}{Input\ in\ kWh}\ (for\ 24\ hours.)$$

The distribution transformers are designed to keep core losses minimum and copper losses are relatively less.

6.9. Parallel Operation. The conditions for successful parallel operation of the single phase transformers are:

1. The primary and secondary windings should be suitable for supply voltage and frequency.
2. The transformers should be properly connected with regard to polarity.
3. The transformation ratio should be identical.
4. The percentage impedance should be equal.

6.10. Scott Connection. It is used to accomplish three-phase to three-phase and three-phase to two-phase transformation.

As shown in Fig 6.5 one of the transformers, known as main transformer, has centre taps both on the primary and secondary windings. The other transformer has a 0.866 tap and is known as teaser transformer.

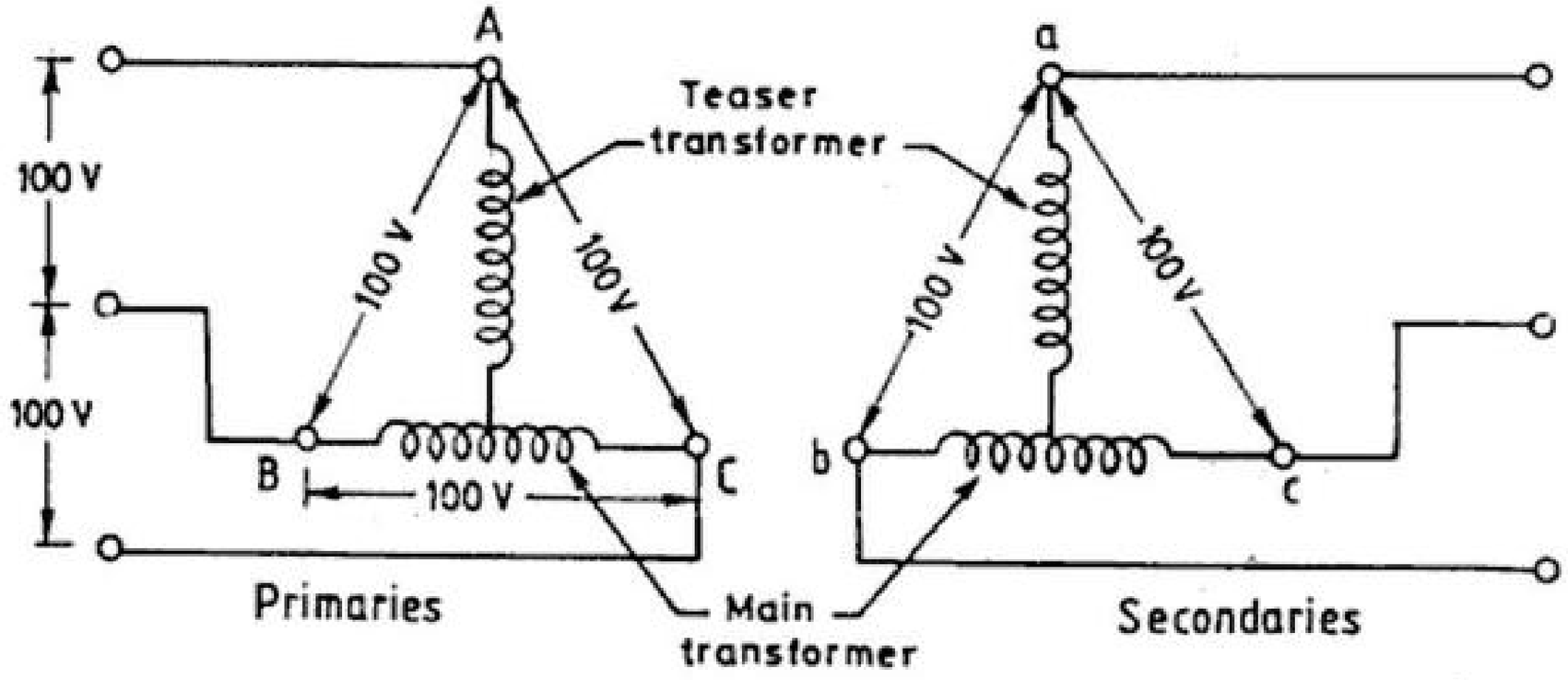


Fig. 6.5

Star-star connection is most suitable and economical for small high voltage transformation.

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15. The transformer is commonly used because
   A. it has high efficiency
   B. frequency remains constant
   C. construction cost per kVA is less as compared to other machines
   D. All of these.

16. The e.m.f. induced in the secondary winding depends upon
   A. number of turns B. flux
   C. supply frequency D. All of these.

17. When the secondary of the transformer is loaded, the flux in the transformer will
   A. remain constant
   B. directly proportional to secondary current
   C. directly proportional to the current drawn by primary winging
   D. None of these.

18. When secondary of the transformer is loaded, the current in the primary side will
   A. not be effected
   B. increase
   C. decrease
   D. be the sum of no-load current and excessive current drawn due to the secondary current.

19. Class-*B* insulation can withstand a maximum temperature of
   A. 120°C B. 130°C
   C. 105°C D. 135°C

20. Electric power is transferred from one coil to the other coil in a transformer
   A. electrically B. electromagneucally
   C. magnetically D. physically

21. A transformer operates
   A. always at unity power factor.
   B. has its own power factor.
   C. at a power factor below a particular value
   D. at power factor dependi g on the power factor of the load.

22. The laminations are made from
   A. silicon sheet steel
   B. nickel alloy steel stamping
   C. low carbon steel
   D. chrome steel sheets

23. Which of the following is a correct statement about eddy current?
   A. Eddy currents improve the efficiency of a motor.
   B. Eddy currents do not influence the movement.
   C. Eddy currents heat up the metal parts.
   D. Eddy currents are used for are welding.

24. The steel for construction of transformer core is made to Have
   A. high permeability and low hysteresis loss.
   B. low permeability and high hysteresis loss.
   C. low permeability and low hysteresis loss.
   D. high permeability and high hysteresis loss

25. As compared to an amplifier, a transformer cannot
   A. increase the output voltage
   B. increase the output current
   C. increase output power
   D. None of these.

26. In an ideal transformer on no-load, the primary applied voltage is balanced by
   A. the secondary voltage
   B. the drop across resistances and reactance.
   C. the secondary induced emf.
   D. the primary induced emf.

27. The voltage transformation ratio is
   A. E_1/E_2 B. N_1/N_2
   C. E_2/E_1 D. None of these.

Answers : 15. (D), 16. (D), 17. (A), 18. (D), 19. (B), 20. (C), 21. (D), 22. (A), 23. (C), 24. (A), 25. (C), 26. (C), 27. (C).

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28. A sinusoidal emf
   A. lags the flux inducing it by 180°
   B. lags the flux inducing it by 90°
   C. leads the flux inducing it by 90°
   D. leads the flux inducing it by 180°

29. The no-load current of a transformer in terms of full load current is usually
   A. 1 to 3% B. 3 to 15%
   C. 9 to 12% D. 12 to 20%.

30. The magnitude of mutual flux in a transformer is
   A. low at low loads and high at high loads.
   B. high at low loads and low at high loads.
   C. same at all loads.
   D. varies at low loads and constant at high loads.

31. At every instant the direction of secondary current in a transformer must be such as to oppose any change in flux. This is in accordance with
   A. Faraday's laws. B. Joule's law
   C. Lenz's law. D. Coulomb's law.

32. What is the phase difference between the low and the high voltage of a YZ5 power transformer?
   A. 0° B. 75°
   C. 5° D. 150°

33. If in a transformer the secondary turns are doubled and at the same time the primary voltage is reduced by half, then the secondary voltage will
   A. be halved
   B. be four times as high
   C. not change
   D. be reduced to a quarter.

34. Transformers are rated in
   A. kW B. kV
   C. kWh D. kVA.

35. Which is the common method of cooling a power transformer?
   A. Air-cooling B. Air-blast cooling
   C. Oil-cooling D. Natural cooling.

36. What type of core is used for a high frequency transformer?
   A. Open iron core B. Air core
   C. Closed iron core D. None of these.

37. Which of the statements given below is true for the auto-transformer?
   A. It has to separate windings connected in series externally.
   B. It has only one winding
   C. It can only step down the voltage
   D. It is most suitable for power transformation.

38. The self-induced voltage of a coil depends upon
   A. the voltage applied to the coil
   B. the shape of the iron core
   C. the shape of the bobbin.
   D. the number of turns of the coil

39. Which of the following is a correct statement about eddy currents?
   A. Eddy currents improve the efficiency of a motor.
   B. Eddy currents heat up the copper winding.
   C. Eddy currents heat up the metal parts
   D. Eddy currents are used for arc welding.

40. The use of higher flux density in transformer design
   A. increases the weight per kVA
   B. decreases the weight per kVA
   C. increases the weight per kW
   D. decreases the weight per kW

41. The transformer oil used in transformers provides.
   A. insulation and cooling
   B. cooling and lubrication

Answers : 28. (B), 29. (A), 30. (C), 31. (C), 32. (D), 33. (C), 34. (D), 35. (C), 36. (B), 37. (B), 38. (D), 39. (C), 40. (B), 41. (A).

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C. insulation and lubrication

D. insulation, cooling and lubrication.

42. The induced e.m.f. in the secondary of a transformer will depend on

A. frequency of the supply only

B. number of turns in secondary only

C. maximum flux in the core only.

D. frequency, flux and number of turns in the secondary.

43. A transformer has a turns ratio of 1 to 10 and a resistance of 5000 ohms is connected across the secondary terminals. the resistance offered to a current flowing in the primary will be

A. 50 ohms B. 500 ohms

C. 5000 ohms D. 50 kilo ohms.

44. Two transformers are operating in parallel. They will share the load depending upon their

A. efficiency B. ratings.

C. leakage reactance.

D. per-unit impedance.

45. Which of the following stafements about a short-circuit power transformer is true?

A. There is a fuse in its primary circuit.

B. There is a bimetallic switch in its primary circuit.

C. There is a fast magnetic switch in its primary circuit.

D. The short-circuit current can continuously flow through it without causing a damage.

46. Why there is an enamel layer coated over the laminations of the transformer core?

A. To decrease the hum

B. To attain adhesion between the lamination.

C. To insulate the laminations against each other.

D. To prevent the corrosion of the laminations.

47. What is the efficiency of transformer compared with that of electrical motors of the same power?

A. Much smaller B. Some what small

C. About the same D. Much higher.

48. According to the name plate of a small transformer, the secondary normal voltage is 220 V. Which of the following statements about it is true?

A. The no-load voltage is more than 220V.

B. 220 V is the no-load voltage.

C. At a load which draws the rated current. the voltage becomes less than 220 V

D. The secondary voltage increases with increasing load.

49. Upon which factor does the short-circuit voltage of a transformer mainly depend. It depends

A. On the ohmic resistance of the primary winding.

B. On the ohmic resistance of the secondary winding.

C. On the cross-sectional area of their core.

D. On the magnitude of the leakage flux.

50. Which of the following statements about a transformer having a small short circuit voltage is true?

A. The transformation ratio of the transformer is small.

B. During operation the transformer has high iron losses.

C. During operation the transformer has high copper losses.

D. A high short-circuit current flows through the transformer

51. What is meant by the nominal short circuit voltage V_{SCN} of a transformer?

A. The voltage appearing across the secondary terminals when they are short-circuited.

Answers : 42. (D), 43. (A), 44. (D), 45. (D), 46. (C), 47. (D), 48. (A), 49. (D), 50. (D).

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B. After short-circuiting two secondary terminals, the voltage appearing across the primary terminals.

C. The primary voltage when the secondary terminals are short- circuited and the rated current flows through the primary winding.

D. The voltage across the primary terminals when the secondary terminals are short-circuited.

52. A 1000 V/400 V power transformer has a nominal short- circuit voltage V_{SC} = 40% Which of the following statements about it is true?

A. A voltage of 400 V appears across the short-circuited secondary terminals.

B. A voltage of 16 V appears across the short-circuited secondary terminals.

C. The primary voltage drops to 400 V when the secondary terminals are short-circuited.

D. When the secondary terminals are short-circuited, the rated current flows at the primary side at a primary voltage of 400 V.

53. What is the typical use of an auto-transformer?

A. Isolating transformer.

B. Toy transformer.

C. Control transformer

D. Variable transformer.

54. In any transformer, the voltage per turn in primary and secondary remains

A. always same.

B. always in ratio of K.

C. always different.

D. sometimes same.

55. The full load copper-loss and iron-loss of a transformer are 6400 watts and 5000 watts, respectively. The above copper loss and iron-loss at half load will be

A. 3200 W, 2500 W respectively

B. 3200 W, 5000 W respectively

C. 1600 W, 1250 W respectively

D. 1600 W, 5000 W respectively

56. In any single phase transformer, the primary and secondary induced voltages are

A. 180° out of phase. B 90° out of phase

C. in phase D. None of these.

57. The full load copper-loss of any transformer working at unity- power factor is W_c watts. The copper-loss at full load and at 0.8 p.f. will be

A. W_c watts. B. 0.8 W_c watts.

C. $W_c/.8^2$ watts. D. 0.8^2 W_c watts.

58. In parallel operation of two single-phase transformers, if the impedance triangles of the transformers are not identical in shape and size, then

A. power factors at which the transformers operate will be same but different from power factor of common load.

B. power factors at which the transformers operate and power factor of common load-all will be same.

C. power factor of one transformer and power factor of common load will be same.

D. power factors at which the transformers operate will be different from one another and again these will be different from power factor of common load.

59. The no load current taken by actual transformer lags the applied voltage by (approximately)

A. 80°

B. 60°

C. 50°

D. 30°.

60. The full load copper-loss in a transformer is 400 W. At half load, the copper-loss will be

A. 400 W

B. 200 W

C. 100 W

D. 50 W

Answers : 51. (C), 52. (D), 53. (D), 54. (A), 55. (D), 56. (C), 57. (C), 58. (D), 59. (A), 60. (C).

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61. A transformer is working at its maximum efficiency. Its iron-loss is 500 W. Its copper-loss will be

A. 250 W B. 300 W

C. 400 W D. 500 W.

62. An ideal transformer is one which

A. has a common core for its primary and secondary windings.

B. has no losses and magnetic leakage

C. has core of stainless steel and windings of pure copper metal

D. has interleaved primary and secondary windings.

63. Coupling between the two windings of a transformer can be increased by

A. increasing the number of turns in the two winding

B. increasing the primary voltage

C. interleaving the windings on a common core of low reluctance

D. reducing the insulation of the two windings.

64. In an ideal transformer, the no-load primary current I_0

A. lags behind V_1 by 90°

B. is in phase with V_1

C. leads V_1 by 90°

D. lags V_1 by an angle lying between 0° and 90°

65. The primary and secondary induced emfs E_1 and E_2 in a two- winding transformer are always

A. equal in magnitude

B. antiphase with each other

C. in-phase with each other

D. determined by load on transformer secondary

66. By definition, a step-down transformer is one in which

A. secondary current is more than primary current

B. secondary turns are less than primary turns

C. secondary winding consists of thinner copper wire

D. secondary power is less than primary power.

67. Three number of 10:1 transformers are connected in $Y-\Delta$ to supply a load at 230 V. The supply voltage of this transformer must be

A. 2300 V B. 4000 V

C. 23 V D. 40 V

68. Three units of 1:5 transformers are connected in $\Delta - Y$ to supply a 3-phase load from a 400 V, 3-phase source. The line voltage on the load side is

A. 1000 V B. 80V

C. 3464 V D. 803 V.

69. When two transformers of different KVA ratings are connected in parallels they divide the total load in proportion to their respective KVA ratings only when their.

A. KVA ratings are identical

B. efficiencies are equal

C. per unit impedances are equal

D. equivalent impedances are equal.

70. A transformer is working at its full load and its efficiency is also maximum. Its iron loss is 1000 W. Then, its copper-loss at half of full load will be

A. 250 W B. 300 W

C. 400 W D. 500 W

71. Distribution transformers are designed to have maximum efficiency nearly

A. at full load B. at 50% of F.L.

C. at no load. D. None of these.

72. Distribution transformers have good all day efficiency due to

A. low copper-loss

B. low iron-loss

Answers : 61. (D), 62. (B), 63. (C), 64. (A), 65. (C), 66. (B), 67. (C), 68. (C), 69. (C), 70. (A), 71. (B), 72. (B).

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C. low copper as well as iron losses

D. None of these.

73. The special silicon steel is used for laminations because

A. eddy current losses are reduced.

B. hysteresis losses are reduced.

C. both losses are reduced

D. None of these.

74. The yoke sections of transformers using hot-rolled laminations is made 15% greater than that of the core so as to

A. to reduce the copper-loss

B. to increase the size of transformers

C. to reduce the iron-loss in yoke and magnetizing current

D. to provide better cooling.

75. The concentric windings are used in core-type transformers with

A. HT winding placed next to core.

B. LT winding placed next to core.

C. LT winding on the outer side.

D. HT winding on the outer side.

76. Cross-over windings are used for

A. high voltage winding of small rating transformers.

B. low voltage winding of small rating transformers.

C. high voltage winding of large rating transformers

D. None of these.

77. Helical coils are very well suited for

A. HV winding of small rating transformers.

B. LV winding of large rating transformers.

C. HV winding of large rating transformers.

D. None of these.

78. In power transformers the tappings are provided on

A. high voltage side.

B. low voltage side.

C. in the middle of both windings.

D. LV as well as on HV side.

79. The advantage of putting tappings at the phase ends of a transformers is

A. to obtain fine variation of voltage.

B. to operate with ease

C. to reduce the number of bushings.

D. to obtain better regulation.

80. The input power to a three-phase transformer is given by

A. $\sqrt{3} \times V_{ph} I_{ph} \cos \phi$

B. $3 \times V_{ph} I_{ph} \sin \phi$

C. $3 \times V_1 I_c \sin \phi$

D. $3 \times V_{ph} I_{ph} \cos \phi$

81. In a three-phase delta transformers, one of the phase burns μ p. The transformer will supply

A. its full output rating.

B. zero output

C. 86.6% of its output rating.

D. 63% of its output rating.

82. Transformer transforms

A. frequency B. voltage

C. current D. power.

83. A step-up transformer increases

A. voltage B. current

C. power D. frequency

84. The voltage transformation ratio of a transformer is equal to the ratio of

A. secondary induced emf to primary induced emf

B. secondary terminal voltage to primary applied voltage.

C. primary turns to secondary turns

D. secondary current to primary current.

85. The primary and secondary windings of an ordinary transformer always have

A. different number of turns

Answers : 73. (B), 74. (C), 75. (B), 76. (A), 77. (B), 78. (A), 79. (C), 80. (D), 81. (C), 82. (B), 83. (A), 84. (A).

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B. same size of copper wire
C. a common magnetic circuit
D. separate magnetic circuits

86. In two-winding transformer, the emf per turns in secondary winding is always
A. equal to K times the induce emf per turn in primary
B. equal to 1/K times the induced emf per turn in primary
C. equal to the induced emf per turn in primary
D. greater than induced emf per turn in primary

87. For a given application, the transformation ratio of a transformer
A. is fixed but not constant
B. is constant but not fixed.
C. is dependent on secondary load
D. depends on which winding is used as primary

88. If you impress a d.c. voltage of 230 V to an unloaded 230 V 50 Hz transformer, the transformer may
A. burn
B. given very high secondary voltage
C. given secondary voltage according to the turn-ratio
D. None of these.

89. Three single-phase transformer, each with a 10 kVA rating are connected in a closed delta arrangement. If one transformer is taken out, the output capacity of the system will be
A. 20 kVA B. 8.66 kVA
C. 17.32 kVA D. 10 kVA

90. Special precaution to be taken when using a booster transformer is that
A. it should never be left open-circuit
B. there should be no fuse in the high voltage side
C. it should never be left close-circuit.
D. None of these.

91. The purpose of conservator in transformers is
A. to cool the windings.
B. to prevent moisture in the transformers
C. to take up contraction and expansion of oil
D. None of these.

92. When s 440/220 V transformer is connected to 400 V d.c. supply.
A. the output will be 220 V
B. the output will be 0 volts
C. the output will be less than 230 V
D. the transformer may burn

93. Two transformers when operating in parallel will share the load depending upon their
A. magnetising current
B. leakage reactance
C. per unit impedance
D. efficiency

94. Ferrite cores are used in high frequency transformer because it has
A. low permeability B. high hysteresis
C. low resistance D. high resistance.

95. The maximum temperature permitted for class A insulation is
A. 180° C B. 165° C
C. 120° C D. 105° C

96. The leakage flux of a transformer is defined as following:
A. it is the flux which is linked with the primary and the secondary winding
B. it is the magnetic flux which is linked either only with the primary or only with the secondary
C. it is the flux whose path is exclusively through the air
D. None of these.

Answers : 85. (C), 86. (C), 87. (A), 88. (A), 89. (C), 90. (C), 91. (C), 92. (D), 93. (C), 94. (D), 95. (D), 96. (B).

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97. For a 1.15 kVA, 460/230 V transformers connected to a standard single phase 50 Hz supply, the no load current is likely to be

A. 1.25 A B. 0.1 A

C. 0.5 A D. 2 A

98. A transformer has a core loss of 64 W and copper loss of 144 W, when it is carrying 20% overload current. The load at which this transformer will operate at the maximum efficiency is

A. 80% B. 66%

C. 120% D. 44%.

99. Compared to the secondary of a loaded step-up transformer, the primary has

A. lower voltage and higher current

B. higher voltage and lower current

C. lower voltage and lower current

D. higher voltage and higher current

100. Transformer cores are built up from laminations rather than from solid metal so that

A. oil penetrates the core more easily

B. eddy current loss is reduced

C. less insulation is required for the windings.

D. turn ratio is higher than voltage ratio.

101. The size of transformer core will depend on

A. frequency

B. flux density of the core material

C. area of the core

D. Both A and B are current

102. The equivalent resistance of a transformer primary winding having $K = 5$ and $R_1 = 0.1$ ohm when referred to secondary, is

A. 0.5 ohm B. 0.02 ohm

C. 0.004 ohm D. 2.5 ohms

103. In performing short-circuit test on a transformer, usually low- voltage side is short-circuited because it has

A. lower terminal voltage and higher current rating

B. more number of turns

C. low insulation

D. easy access

104. Iron loss in an actual transformer remains practically constant from no-load to full-load because

A. core flux remains practically constant

B. primary voltage remains constant

C. value of transformation ratio remains constant

D. permeability of transformer core remains constant.

105. Which of the following transformers is smallest?

A. 1 kVA, 50 Hz B. 1 kVA, 200 Hz

C. 1 kVA, 400 Hz D. 1 kVA, 600 Hz

106. If 500-kVA, 400 Hz transformer is operated at 100 Hz, its kVA rating is

A. 125 kVA B. 250 kVA

C. 500 kVA D. 2000 kVA

107. Under operating conditions the secondary of a current transformer is always short circuited because

A. it protects the primary circuits.

B. it is safe to human beings

C. it avoids core saturation and high voltage induction

D. None of these

108. Two transformers operating in parallel will share the load depending upon their

A. efficiency also B. ratings also

C. leakage reactance D. None of these.

109. Special silicon steel is used for the laminations of transformer because it has

A. high resistivity and high hysteresis loss

B. high resistivity and low hysteresis loss

C. low resistivity and low hysteresis loss

D. low resistivity and high hysteresis loss

Answers : 97. (B), 98. (A), 99. (A), 100. (B), 101. (D), 102. (D), 103. (A), 104. (A), 105. (D), 106. (A), 107. (C), 108. (B), 109. (B).

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122. An ideal power transformer will have maximum efficiency at a load such that
   A. copper loss is less than iron loss
   B. copper loss is equal to iron loss
   C. copper loss is higher than iron loss
   D. None of these.

123. At relatively light loads, transformer efficiency is low because
   A. secondary output is low
   B. transformer losses are negligible.
   C. fixed loss is high in proportion to the output
   D. copper los es are small

124. Under heavy loads, transformer efficiency is comparatively low because
   A. voltage drops both in primary and secondary become large
   B. secondary output is much less as compared to primary input
   C. copper loss becomes high in proportion to the output
   D. iron loss is increased considerably

125. The iron-losses of a transformer can be calculated by knowing the weights of
   A. core only B. yokes only
   C. copper winding only
   D. cores and yokes

126. With the increase in supply frequency of a transformer, there is
   A. decrease in rating
   B. increase in rating
   C. no change in rating
   D. None of these.

127. The main reason for using high voltage for long-distance power transmission is to
   A. provide industrial establishments with high voltage
   B. enable the national grid system to be used
   C. reduce time of transmission
   D. reduce transmission losses due to conductor resistance

128. A transformer having 1000 primary turns is connected to a 250 V a.c. supply for a secondary voltage of 400 V, the number of secondary turns should be
   A. 1600 B.250
   C. 400 D. 1250

129. An amplifier works best into an impedance of 500 ohms but is required to drive a speaker of 20 ohms impedance. The primary to secondary turns ratio of the matching transformer should be
   A. 1/5 B. 25
   C. 5 D. 1/25

130. The ordinary efficiency of a given transformer is maximum when
   A. it runs at half full-load
   B. it runs at full-load
   C. its copper loss equals iron loss
   D. it runs overload

131. The output current corresponding to maximum efficiency for a transformer having core loss of 100 W and equivalent resistance referred to secondary of 0.25 ohm is
   A. 20 A B. 25 A
   C. 5 A D. 400 A

132. The saving in copper achieved by converting two winding transformer into an auto-transformer is determined by
   A. voltage transformation ratio
   B. load on the secondary
   C. magnetic quality of core material
   D. size of the transformer core

133. The kVA rating of an isolation transformer increases when connected to an auto-transformer because of

Answers : 122. (B), 123. (C), 124. (C), 125. (D), 126. (B), 127. (D), 128. (A), 129. (C), 130. (C), 131. (A), 132. (A).

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A. iron-losses may destroy the insulation

B. iron-losses will heat up the oil of the transformer

C. the primary of distribution transformer is energized for all the twenty four hours

D. iron-losses produce time harmonics

147. An auto-transformer having a transformation ratio of 0.8 supplies a load of 3 kW. The power transferred conductively from primary to secondary is

A. 0.6 kW B. 2.4 kW

C. 1.5 kW D. 0.27 kW

148. If the load p.f. is 0.886, then the average p.f. of the V - bank is

A. 0.886 B. 0.75

B. 0.51 D. 0.65.

149. For supplying a balanced 3-phase load of 40-kVA rating of each transformer in V-V bank should be

A. 20 kVA B. 23 kVA

C. 34.6 kVA D. 25 kVA

150. The percentage over-loading of two 20-kVA transformers when supplying a balanced 3-phase load of 40 kVA in a V-V bank is

A. 15% B. 57.7%

C. 73.2% D. 33.3%

151. If full-load copper loss of a transformer is 1600 W, its copper loss at 75% full-load would be

A. 900 W B. 1200 W

C. 1600 W D. 1800 W

152. Silicon steel is preferred for transformer core because

A. it decrease the permeability of the core

B. it reduces both eddy current loss and hysteresis loss

C. it reduces resistivity of the core

D. it decreases the tensile strength

153. The magnetic properties of silicon steel crystal are best

A. along the cube edges

B. along the surface diagonals

C. along the cubic diagonals

D. None of the above.

154. The magnetic properties of cold rolled grain oriented silicon steel are excellent

A. against the direction of rolling

B. at right angles to the direction of rolling

C. along the direction of rolling

C. None of these.

155. For large power transformer the best utilisation of available core space can be made by using

A. rectangular core section

B. square core section

C. stepped core section

D. None of these.

156. Five limb core construction has an advantage over the three iimb core construction that

A. the eddy current loss is less

B. the magnetic reluctance of the three phases can be balanced

C. the hysteresis loss is less

D. the permeability is higher.

157. For cold-rolled grain-oriented silicon steel metred overlap is preferable for the core-yoke joints as

A. it improves mechanical strength

B. it makes better use of core space

C. it reduces magnetostriction

D. it reduces magnetising current and also the core-losses.

158. The direction of the central phase winding of a three-phase shell type transformer is reversed with respect to the outer phases to

A. save considerable amount of core material

B. reduce leakage fluxes

C. reduce short circuit forces

D. minimise eddy current loss.

Answers : 146. (C), 147. (B), 148. (B), 149. (B), 150. (A), 151. (A), 152. (B), 153. (A), 154. (C), 155. (C), 156. (B), 157. (D), 158. (A).

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159. Low voltage windings are placed nearer to the core in the case of concentric windings because it reduces
   A. hysteresis loss B. eddy current loss
   C. insulation requirement
   D. leakage fluxes

160. Spiral winding is suitable only for windings
   A. carrying very low current
   B. carrying very high current
   C. rated for high voltage.
   D. rated for low voltage.

161. Helical winding is suitable for
   A. low voltage winding of small transformers.
   B. high voltage winding of small transformers
   C. low voltage winding of large transformers
   D. high voltage winding of large transformers.

162. Cross-over winding is suitable for
   A. low voltage winding of small transformers
   B. high voltage winding of small transformers
   C. low voltage winding of large transformers
   D. high voltage winding of large transformers.

163. Continuous disc winding is suitable for
   A. low voltage winding of small transformers
   B. high voltage winding of small transformers
   C. low voltage winding of large transformers
   D. high voltage winding of large transformers.

164. Major insulation of a transformer is the insulation
   A. between the low-voltage winding and the core only
   B. between the low voltage and the high-voltage winding
   C. between the low-voltage winding and the core and also between the low-voltage and the high-voltage windings.
   D. the turns of the windings.

165. Minor insulation of a transformer is the insulation
   A. between the low-voltage and the high-voltage windings
   B. between the turns of the windings only
   C. between the layers of the windings only
   D. between the turns of the windings and also between the layers of the windings.

166. For voltage above 66 kV, condenser bushings are preferred over non-condenser bushings because
   A. the axial stresses can be eliminated
   B. the radial stress can be made independent of the radial thickness of the dielectric.
   C. optimum utilisation of the dielectric can be made due to uniform potential distribution which also reduces both the radial and the axial dimensions of the bushings.
   D. None of these.

167. For off-load tap changing, the best method is to use
   A. tap changers inside the tank operated by external selector switches.
   B. tap changers inside the tank but with no selector switch.
   C. tap changers outside the tank operated by selector switches
   D. tap changers outside the tank but with no selector switch.

168. For no-load tap changing, the best method is to use
   A. tap changers inside the tank operated by external selector switches.
   B. tap changers inside the tank but with no selector switch
   C. tap changers outside the tank operated by selector switch.
   D. None of these.

169. The transformer windings are tapped in the middle because

Answers : 159. (C), 160. (B), 161. (C), 162. (B), 163. (D), 164. (C), 165. (D), 166. (C), 167. (A), 168. (C).

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A. it eliminates radial forces on the windings
B. it eliminates axial forces on the windings.
C. it reduces insulation requirement
D. None of these.

170. Tappings are normally provided on the high voltage winding of a transformer
A. only because it has larger number of turns which allows smoother variation of voltage
B. only because it has to handle low currents
C. only because it is easily accessible physically
D. because it has large number of turns, as it has to handle low currents and is also easily accessible physically.

171. For distribution transformers of rating less than 50 kVA, it is better to use
A. plain sheet steel tanks only
B. corrugated tanks only
C. either plain sheet steel tanks or corrugated tanks
D. tubed tanks only

172. In general, for all sizes of distribution transformer, it is preferable to use
A. plain sheet steel tanks
B. tubed tanks
C. corrugated tanks
D. radiator tanks.

173. For small power transformers, it is preferable to use
A. tubed tanks
B. corrugated tanks
C. radiator tanks
D. tanks with separate coolers.

174. For large power transformer, it is preferable to use
A. corrugated tanks B. tubed tanks
C. radiator tanks
D. tanks with separate coolers.

175. A transformer may have two or more ratings depending on
A. the type of winding used
B. the type of cooling used.
C. the type of core used
D. the type of insulation used

176. Conservator is used.
A. to take up the expansion of oil due to temperature rise.
B. to act as an oil storage
C. for better cooling of the transformer
D. None of these.

177. Buchholz relay is placed
A. in between the conservator and the breather
B. in between the tank and the conservator
C. in between the h.v. winding and the bushing
D. in between the l.v. winding and the bushing

178. Buchholz relay is a
A. voltage sensitive device
B. current sensitive device
C. frequency sensitive device
D. gas actuated device.

179. Buchholz relay causes
A. tripping for major fault and alarm for minor faults
B. alarm for major fault and tripping for minor faults
C. tripping for both major and minor faults
D. alarm for both major and minor faults

180. Transformer oil is used as
A. insulant only
B. coolant only
C. both insulant and coolant
D. inert medium

Answers : 169. (B), 170. (D), 171. (C), 172. (B), 173. (A), 174. (D), 175. (B), 176. (A), 177. (B), 178. (D), 179. (A), 180. (C).

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181. Sludging of transformer oil means

A. continuous expansion and contraction due to heating and cooling

B. formation of semi-solid hydro-carbon due to heat and oxidation

C. decomposition of transformer oil under the influence of power arcs

D. evaporation of transformer oil due to heating

182. In a single-phase transformer, if leakage impedance drop is neglected, the flux in the magnetic core and the leakage flux linking a winding are

A. proportional to the applied voltage and proportional to the winding current respectively

B. both proportional to the applied voltage

C. proportional to the applied voltage respectively

D. both proportional to the winding current.

183. In a transformer the exciting current has two components-magnetising component and core-loss component. Neglecting leakage impedance drop.

A. both of them lag the impressed voltage by 90°

B. both of them are in phase with the impressed voltage

C. the former lags the impressed voltage by 90° while the latter is in phase with impressed voltage.

D. the former is in phase with the impressed voltage while the latter lags the impressed voltage by 90°.

184. A 4-kVA 400/200 V single-phase transformer has resistance of .02 p.u. and reactance of 0.6 p.u. What are its resistance and reactance referred to h.v. side?

A. .2 ohm and .6 ohm

B. .8 ohm and 2.4 ohm

C. .08 ohm and .24 ohm

D. 1 ohm and 3 ohm.

185. The flux in the transformer core supplied from a constant voltage source

A. slightly decreases with increase in inductive load

B. slightly increases with increase in inductive load

C. remains constant whatever may be the inductive load

D. increases with increase in its inductive load upto its rated capacity and remains constant if the inductive load is increased beyond its rated capacity.

186. A transformer has a percentage resistance of 1% and percentage reactance of 4%. Its regulation at power factor 0.8 lagging and 0.8 leading are respectively

A. 3.2% and - 1.6% B. 6% and -4%

C. 4.8% and -3.2% D. None of these.

187. If P_i be the iron loss and P_{cu} be the copper loss on full load, the following condition has to be satisfied to obtain maximum efficiency at 3/4 full-load:

A. $P_{cu} = 3/4\ P_i$ B. $P_{cu} = 4/3\ P_i$

C. $P_{cu} = 16/9\ P_i$ D. $P_{cu} = 9/16\ P_i$

188. For short-circuit and open-circuit test of a transformer the instruments are connected on

A. the 1.v. side and h.v. side respectively

B. the h.v. side and 1.v. side respectively

C. the h.v. side only

D. the 1.v. side only

189. For short-circuit and open-circuit test of a transformer the instruments are connected on

A. equivalent resistance and leakage reactance

B. equivalent resistance and core loss

C. magnetising current and equivalent leakage reactance

D. magnetising current and core loss.

*Answers : **181. (B), 182. (A), 183. (C), 184. (B), 185. (A), 186. (A), 187. (C), 188. (B), 189. (D).***

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190. If frequency be f, maximum flux density be B_m and Steinmetz's coefficient be η then eddy current loss in a transformer core is proportional to

A. $B_m f$ B. $B_m^2 f^2$

C. $B_m^2 f$ D. $B_m f^2$

191. Short circuit test was done on a transformer with a certain impressed voltage at rated frequency. If the short circuit is now done on the same transformer with the same magnitude of impressed voltage but at higher frequency. Then

A. both current magnitude and power factor increase

B. both current magnitude and power factor decrease

C. current magnitude decreases and power factor increases.

D. current magnitude increases and power factor decreases.

192. Open circuit test was done on a transformer with rated voltage at rated frequency. If the open circuit test was now done on the transformer with double the rated voltage at double the rated frequency.

A. both current magnitude and power factor increase

B. both current magnitude and power factor decrease.

C. current decreases and power factor increases.

D. current increases and power factor decreases.

193. The frequency of the impressed voltage of transformer is increased keeping its voltage magnitude fixed. Its

A. hysteresis loss increases and eddy current loss decreases

B. hysteresis loss decreases and eddy current loss increases

C. hysteresis loss decreases and eddy current remains constant.

D. hysteresis and eddy current loss both increase.

194. The frequency of the impressed voltage of a transformer is increased keeping its magnitude fixed. Of the two components of the exciting current.

A. the magnetising current increases and the core loss component decreases

B. the magnetising current decreases and the core loss component increases

C. the magnetising and core loss component both decrease

D. the magnetising and core loss components both increased

195. A three-phase transformer with delta-connected h.v. side and star-connected l.v. side gave the following symbol which also indicates phase displacement:

A. Dy 1 or Dy 11 B. DyO or Dy6

C. Dy1 only D. Dy11 only

196. A three-phase transformer with star-connected h.v. side and delta connected l.v. side can have the following symbol which also indicates phase displacements:

A. Yd0 only B. Yd11 only

C. Yd1 or Yd11 D. Yd0 or Yd6

197. Consider the following statements.

I. Dy1 and Yd11 transformers can operate in parallel

II. Yd1 and Yd11 transformers can operate in parallel

III. Yd1 and Dy1 transformers can operate in parallel

IV. Yd1 and Yz1 can operate in parallel.

Use the code below to indicate correct statements

A. II and III only B. I and II only

C. III and IV only D. All of these.

Answers : 190. (B), 191. (B), 192. (A), 193. (C), 194. (C), 195. (A), 196. (C), 197. (C).

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198. A delta-zigzag three-phase transformer can have the following symbol:
A. Dz0 or Dz6 B. Dz1 or Dz11
C. Dz0 only D. Dz6 only

199 A star-zigza three-phase transformer with star connection on h.v. side can have the following symbol:
A. Yz0 or Yz6 B. Yz1 or Yz11
C. Yz1 only C. Yz11 only

200. The utilization factors for transformers connected delta-zigzag and star-zigzag are respectively
A. 0.5 and 0.667 B. 0.667 and 0.75
C. 0.667 and 0.667 D. 0.886 and 0.886

201. The utilisation factor for transformers connected in open-delta or double-delta is
A. 0.866 B. 0.75
C. 0.667 D. 0.5

202. The magnitude of each of the voltage phasors represented by sides of a regular hexagon in a 6-phase system produced by double-delta connection of the secondaries of transformers is k times the voltage of each secondary winding. The value of k is
A. 1/2 B. 1
C. 3/2 D. $\sqrt{3}$

203. The magnitude of each of the voltage phasors represented by sides of a regular hexagon in a 6-phase system produced by double-star connection of the secondaries of transformers is k times the voltage of each secondary winding. The value of k is
A. 1/2 B. 1
C. 3/2 D. $\sqrt{3}$

204. The magnitude of each of the voltage phasors represented by sides of a regular hexagon in a 6-phase system produced by diameter connection of the secondaries of transformers is k times the voltage of each secondary winding. The value of k is
A. 1/2 B. 1
C. 3/2 D. $\sqrt{3}$

205. In 12-phase star-delta-double-star connection, voltage of each secondary star phase is k times the voltage on each side of the voltage polygon of 12 sides, the value of k being equal to
A. 1/2 sin 30° B. 1/2 sin 15°
C. 1/2 sin 10° D. 1/sin 30°

206. In 12-phase double-chord connection, voltage of each chord is equal to k times the voltage on each side of the voltage polygon of 12 sides, the value of k being equal to
A. sin 75°/sin 15° B. sin 60°/sin 12°
C. sin 75°/sin 20° D. sin 60°/sin 15°

207. In double-star zigzag connection in the secondary side of transformers for producing 12-phase supply system, the two sets of voltages of the secondary winding are k_1 and k_2 times the voltage of each output terminal neutral. The values of k_1 *and* k_2 are respectively.
A. sin 45°/sin 60°, sin 15°/sin 60°
B. sin 30°/sin 75°, sin 15°/sin 75°
C. sin 45°/2°/sin 30°, sin 15°/2°/sin 30°
D. sin 30°/sin 45°, sin 15°/sin 45°

208. A 110 V, 50 Hz single phase supply is needed from a 220 V, 50 Hz source. Determine the ratios of weights of copper needed in a two-winding transformer and an auto-transformer employed for the purpose
A. 2 : 1 B. 1 : 2
C. 3 : 1 D. 1 : 3

209. A two-winding transformer of voltage rating V_1/V_2 has the full-load voltage regulation of r p.u. at 0.8 p.f. lagging. What is the full-load regulation at 0.8 p.f. lagging if the auto-transformer formed by joining the two windings in series has the voltage rating $V_1/(V_1 + V_2)$. ?
A. r p.u.
B. $V_2/(V_1 + V_2)\, r$ p.u.
C. $V_1/(V_1 + V_2)\, r$ p.u.
D. $V_2/V_1\, r$ p.u.

Answers : 198. (A), 199. (B), 200. (D), 201. (A), 202. (D), 203. (B), 204. (A), 205. (B), 206. (A), 207. (A), 208. (A), 209. (B).

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210. Two single-phase transformers A and B of identical voltage ratings and equal turn-ratios operate in parallel. The magnitudes of effective impedances of the transformers are equal while resistance reactance ratio of A is higher than that of B. At a certain load

A. The magnitude of I_A is lower than that of I_B and I_A lags I_B

B. The magnitudes of I_A and I_B are equal and I_A is in phase with I_B.

C. The magnitudes of I_A and I_B are equal and I_A lags I_B.

D. The magnitudes of I_A and I_B are equal and I_A lags I_B.

211. A delta-star transformer with delta connection on the primary side operates in parallel with a star-delta transformer with star connection on the primary side. The ratio (primary turns per phase)/(secondary turns per phase) of the former is x times that of the latter while x is equal to

A. 1/3 B. $1/\sqrt{3}$

C. $\sqrt{3}$ D. 3

212. Consider the following statements concerning the utility of mesh-connected tertiary windings in star-star transformers.

I. It is used to suppress harmonic voltages.

II. It is used to allow flow of earth fault current for operation of protective devices.

III. It facilitates supply of single-phase loads.

IV. It provides low-reactance paths for zero-sequence currents

A. All of the above statements are correct.

B. Only I and II are correct

C. Only I II and III are correct

D. Only I II and IV are correct.

213. In star-star transformers distortion in voltage wave shape due to third harmonic flux and voltage unbalance on single-phase loads are minimum if they are

A. three-phase shell type

B. three-phase five-limb core type

C. three-phase three-limb core type

B. banks of single-phase transformers.

214. Maximum transient currents flow through a transformer winding when this is switched on with

A. secondary side open-circuited and when the input voltage wave is passing through zero value

B. the secondary short-circuited and when the input voltage wave is passing through zero value.

C. the secondary open-circuited and when the input voltage wave is passing through maximum value.

D. the secondary short-circuited and when the input voltage wave is passing through maximum value.

215. If V is the peak value of lightning impulse striking a terminal of a transformer winding of length l and $\alpha = \sqrt{C_g/C_s}$.

where C_g = total earth capacitance of the winding; and C_s = total self capacitance of the winding, then the peak voltage gradient at that terminal of the winding is

A. $(V\alpha/l)\tan h\alpha$ if the other terminal is grounded and $(V\alpha/l)\cot h\alpha$ if the other terminal is ungrounded.

B. $(V\alpha/l)\cot h\alpha$ if the other terminal is grounded and $(V\alpha/l)\tan h\,\alpha$ if the other terminal is ungrounded.

C. $(V\alpha/l)\tan h\,\alpha$ in both the cases of grounded and ungrounded terminal at the other end.

D. None of these.

216. To avoid breakdown of transformers under surges any one of the following except one may by adopted.

A. Use of surge absorbers.

B. Use of surge diverters.

Answers : 210. (C), 211. (D), 212. (A), 213. (C), 214. (B), 215. (B).

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C. Use of metal shields.

D. Reinforcement of end-turn insulation.

217. For back-to-back test of two identical transformers

A. Both the primaries and the auxiliary transformer have to be fed from voltage sources of rated frequency.

B. Both the primaries and auxiliary transformer may be fed from voltage sources of frequencies different from the rated frequency.

C. While the primaries have to be fed from a voltage source of rated frequency, the auxiliary transformer can be fed from a voltage source of frequency different from the rated frequency.

D. While the primaries can be fed from a voltage-source of frequency different from the rated frequency, the auxiliary transformer has to be fed from a voltage source of rated frequency.

218. Which one of the following statements is *incorrect*?

A. The thermal ability of a transformer to withstand short circuit is demonstrated by calculation, while its dynamic ability to withstand short circuit is demonstrated by actual short circuit.

B. The thermal ability of a transformer to withstand short circuit is demonstrated by calculation, while its dynamic ability of withstand short circuit is demonstrated by calculation.

C. Both the thermal ability and the dynamic ability of a transformer to withstand short circuit are demonstrated by calculations.

D. Both the thermal ability and dynamic ability of a transformer to withstand short circuit are demonstrated by actual short circuit.

219. For short-circuit test on a transformer, the number and duration of tests on a phase are.

A. 1 and .5 sec

B. 1 and 2 secs ± 10% tolerance.

C. 3 and 2 secs ± 10% tolerance.

D. 3 and .5 sec ± 10% tolerance.

220. As per the Indian Standards Specifications, the wave-front and wave-tail times with tolerances of impulses for lightning impulse tests are respectively

A. 1 μs ± 30%, 50 μs ± 20%

B. 1.2 μs ± 20%, 50 μs ± 30%

C. 1.2 μs ± 30%, 50 μs ± 20%

D. 1.5 μs ± 30%, 40 μs ± 20%.

221. The standard switching impulse as per I.S.I. has wave-front time and wave-tail time tolerances of

A. 200 μs ± 20%, 2000 μs ± 60% respectively

B. 250 μs ± 20%, 2500 μs ± 60% respectively

C. 250 μs ± 30%, 2500 μs ± 20% respectively

D. 300 μs ± 10%, 3000 μs ± 20% respectively

222. The voltage for induced potential tests on a transformer winding is k times its rated voltage and duration of test, if test frequency does not exceed twice the rated frequency, is s seconds. The values of k and s respectively are

A. 2, 30 B. 2, 60

C. 1, 5, 60 D. 2, 15

223. In an auto-transformer of voltage ratio V_1/V_2, $V_1 > V_2$, the fraction of power transferred inductively is

A. $V_1/(V_2 + V_1)$ B. V_2/V_1

C. $(V_1 - V_2)/(V_1 + V_2)$

D. $(V_1 - V_2)/V_1$

224. Distortion of the whole core and subsequent damage of the coil insulation due to intense local eddy currents may be caused by the failure of

A. the insulation between the laminations only

B. the insulation around the core damping bolts only

Answers : 216. (D), 217. (C), 218. (A), 219. (D), 220. (C), 221. (B), 222. (B), 223. (D).

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C. l.v. side at the middle

D. l.v. side at the middle.

250. For successful parallel operation of two single-phase transformers, the essential condition is that their

A. percentage impedances should be equal

B. turns ratios should be exactly equal.

C. polarities must be properly connected.

D. kVA ratings should be equal.

251. Two transformers operating in a parallel have different quality of their leakage impedances. For a load power factor of 0.8

A. both would operate at p.fs. less than 0.8

B. both would operate at p.fs. more than 0.8

C. both would operate at the same p.fs.

D. one would operate at p.f. 0.8 and other at p.f. less than 0.8.

252. Short-circuit test on a single-phase transformer gave the following data:

30 V at 50 Hz, 20 A, p.f. = 0.2 lagging

If S.C. test is performed on 30 V, 25 Hz, then short-circuit current is

A. decreased at p.f. < 0.2

B. increased at p.f. < 0.2

C. increased at p.f. > 0.2

D. increased at p.f. > 0.2

253. In a single-phase induction regulator, the output voltage can be varied

A. both in magnitude and phase

B. in magnitude only

C. in phase only

D. in magnitude less than the supply voltage.

254. Transformer-core laminations are made of

A. cast iron B. wrought iron

C. silicon steel D. cast steel

255. Transformer action requires a

A. constant magnetic flux

B. increasing magnetic flux

C. pulsating magnetic flux

D. alternating electric flux.

256. In an oil-filled transformer, oil is provided for

A. cooling

B. insulation

C. lubrication

D. both cooling and insulation

257. Transformer cores are laminated to reduce

A. eddy current loss

B. hysteresis loss

C. both eddy current and hysteresis loss

D. ohmic loss

258. CRGO laminations in a transformer are used to minimise

A. eddy current loss

B. hysteresis loss

C. both eddy current and hysteresis loss

D. ohmic loss.

259. An air-core transformer, as compared to iron-core transformer, has

A. less magnetic core loss

B. more magnetic core loss

C. no magnetic core loss

D. less ohmic loss.

260. One 200 V, 100 W bulbs is connected in series with the primary of a 200 V, 10 kVA transformer. If its secondary is left open circuited, then the bulb would have

A. full brightness

B. poor brightness

C. a little less than full brightness

D. more than full brightness.

261. In case of a power transformer, the no-load current in terms of rated current is

A. 10 to 20% B. 2 to 6%

C. 15 to 30% D. 30 to 50%

Answers : 249. (C), 250. (C), 251. (C), 252. (C), 253. (B), 254. (C), 255. (C), 256. (D), 257. (A), 258. (B), 259. (C), 260. (B), 261. (B).

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262. Transformer zero voltage regulation occurs at

A. unity p.f. B. leading p.f.

C. lagging p.f. D. zero p.f. leading.

263. Transformer maximum efficiency, for a constant load current, occurs at

A. 0.8 p.f. B. zero p.f. leading

C. zero p.f. lagging D. unity power factor

264. One transformer has leakage impedance of (1 + j 4) ohm and (3 +j 11) ohm for its primary and secondary windings respectively. This transformer has

A. h.v. primary

B. medium voltage primary

C. 1.v. primary D. None of these.

265. With core type transformers, the limbs are stepped to

A. reduce the iron material and, therefore, iron loss

B. reduce the conductor material and, therefore $I^2 R$ loss

C. provided better cooling

D. provide more mechanical strength to the core

266. For core type power transformers, both primary and secondary windings have circular coil sections, because this section

A. is easier to wind

B. requires minimum copper and, therefore, less $I^2 R$ loss

C. results in less core material and, therefore, less core loss.

D. l as the strongest mechanical shape.

267. If copper loss of a transformer at 7/8 th full-load is 4900 W, then its full-load copper would be

A. 5600 W B. 6400 W

C. 373 W D. 429 W

268. The maximum efficiency of a 100-kVA transformer having iron loss of 900 kW and FL.. copper loss of 1600 W occurs at

A. 56.3 kVA B. 133.3 kVA

C. 75 kVA D. 177.7 kVA

269. Which of the following statement regarding an ideal single-phase transformer having a turn ratio of 1:5 and drawing a current of 4 A from a 200 V a.c. supply is false?

A. it is step-up transformer

B. its secondary current is 0.8 A

C. its secondary current is 4 A

D. its secondary voltage is 1000 V.

270. Mark the *wrong* statement:

A. In a given ideal transformer, volt/turn is constant for a given primary voltage

B.* A transformer whose secondary current is greater than primary current is called step-up transformer

C. Hysteresis loss is proportional to supply frequency

D. Eddy current loss is reduced by laminating transformer core.

271. The iron-losses of a transformer can be calculated by knowing the weights of

A. cores only B. yokes only

C. copper winding only D. cores and yokes

272. With the increase in supply frequency of a transformer, there is

A. decrease in rating B. increase in rating

C. no change in rating D. None of these

273. The distribution transformers are designed to keep the iron- losses minimum because

A. iron-losses may destroy the insulation

B. iron-losses will heat up the oil of the transformer

C. the primary of distribution transformer is energized for all the twenty four hours

D. iron-losses produce time harmonics.

274. For minimum weight of a transformer, the weight of iron should be

A. greater than the weight of copper

Answers : 262. (B), 263. (D), 264. (C), 265. (B), 266. (D), 267. (B), 268. (C), 269. (C), 270. (B), 271. (D), 272. (B), 273. (C).

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B. less than the weight of copper

C. equal to the weight of copper

D. zero

275. Two transformers *A* and *B* are of same type with all linear dimensions in the ratio x:1 and having the same flux density, current density, frequency and window space factor. The outputs of transformer *A* and *B* are in the ratio of

A. $x : 1$ B. $x^2 : 1$

C. $x^3 : 1$ D. $x^4 : 1$

276. The essential condition for parallel operation of two single-phase transformers is that they should have same

A. polarity B. phase sequence

C. voltage ratio

D. percentage impedance.

277. Two transformers operating in parallel will share the load depending upon their

A. rating. B. leakage reactance

C. efficiency D. per-unit impedance

278. In the above question, copper and iron losses of both the transformers are in the ratio of

A. $x : 1$ B. $x^2 : 1$

C. $x^3 : 1$ D. $1 : 1$

279. 500 kVA, 400 V, 3-phase, 60 Hz transformer is replaced by similar transformer of frequency 50 Hz. Its rating will be

A. 680 kVA B. 500 kVA

C. 416 kVA D. None of these.

280. For transformers using cold rolled grain oriented steel, the area of yoke is taken

A. as 15 - 25% larger than that of core

B. as 15 - 20% smaller than that of core

C. equal to that of core

D. None of these.

281. Oil natural cooling with tubes is used for the transformers of capacity of

A. 30 kVA B. 500 kVA

C. 750 kVA D. 3000 kVA

282. Air blast cooling is provided for the transformers above a capacity of

A. 500 kVA B. 1000 kVA

C. 5000 kVA D. 10000 kVA

283. Which of the following methods is used for cooling of transformer upto a capacity of 10 MVA?

A. Oil natural cooling B. Air blast cooling

C. Forced oil cooling D. None of these.

284. For 3-to-3-phase conversion, which of the following given polyphase connections would you select?

A. delta/double-delta

B. star/double-star

C. delta/interconnected-star

D. delta/double-star

285. Out of the following choices for polyphase transformer connections which one will you select for three-to-two phase conversion?

A. scott B. star/star

C. double scott D. star/double-delta

286. When two identical transformers are available, then the best method to find their efficiency under load conditions is

A. short-circuit test

B. back-to-back test

C. open-circuit test

D. phase-sequence test

287. The main purpose of conducting no-load test on a transformer is to find out

A. value of flux produced under no-load condition

B. voltage/turn of the low-voltage winding

C. core loss in the transformer at rated voltage and under load conditions

D. its voltage regulation.

288. Leakage fluxes of a transformer may be minimised by

Answers : 274. (C), 275. (D), 276. (A), 277. (A), 278. (C), 279. (C), 280. (C), 281. (D), 282. (D), 283. (A), 284. (C), 285. (A), 286. (B), 287. (C).

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A. keeping the magnetising current to the minimum

B. reducing the reluctance of the iron core to the minimum.

C. minimizing the number of turns both one primary and secondary

D. sectionalizing and interleaving the primary and secondary windings.

289. Of the following statements concerning parallel operation of transformers, the one which is *not correct* is

A. transformers must have equal voltage ratings.

B. transformers must have same ratio of transformation

C. transformers must be operated at the same frequency

D. transformers must have equal kVA ratings.

290. The open-circuit test on a transformer is meant for measuring its

A. copper losses B. iron losses

C. insulation resistance

D. equivalent resistance.

291. A 100 ohms load has a p.f. of 0.8. A 1-k ohm generator supplies power to the load through a transformers. Best matching will be produced when transformers turn ratio is approximately

A. 3 : 1 B. 8 : 1

C. 10 : 1 D. 2 : 1

292. Oil is invariably used in large transformers in order to

A. insulate the coils

B. insulate the core

C. lubricate the core

D. lubricate the coils.

293. The secondary winding of a current transformer whose primary is carrying current should

A. not be open-circuited

B. not be short-circuited

C. always be open-circuited

D. not be connected to the current coil of a wattmeter

294. When applying a high-voltage test to the primary winding of a rebuilt transformer

A. secondary winding must be short-circuited

B. the secondary transformers case and core must be grounded.

C. one end of the primary must be grounded.

D. all other parts of the transformer must be grounded.

295. Before disconnecting an ammeter from an energised current transformer circuit, the current transformer

A. primary should be opened

B. secondary should be opened

C. primary should be shorted

D. secondary should be shorted.

296. If full rating of a transformer is 90 kW at a power factor of 0.9, then its kVA rating is

A. 81 B. 100

C. 90 D. 120.

297. An autotransformer is preferred to a conventional 2-winding transformer

A. because it is much safer to use an autotransformer

B. where large number of secondary taps are needed

C. where it is required to electrically isolate the two windings

D. where ratio of transformation is nearly one

298. Current transformers for meters and relays usually have

A. 10-A secondaries B. 5-A secondaries

C. 10 : 1 ratio D. 1 : 1 ratio

299. The main purpose of using an interphase transformer with a multi-anode rectifier is to

A. permit only one anode to fire at a time

Answers : 288. (D), 289. (D), 290. (B), 291. (A), 292. (A), 293. (A), 294. (B), 295. (D), 296. (B), 297. (D), 298. (B).

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B. cause the anodes to overlap in firing

C. shorten the period of firing of each anode

D. act as an insulating transformer between the power transformer and load.

300. Dust should never be allowed to accumulate on the windings and are of a dry-type transformer because it

A. may short-circuit the windings

B. tends to corrode metal surface

C. reduces dissipation of heat

D. absorbs oil and grease.

301. The relative polarity of the windings of a transformer may be determined by

A. short-circuit test B. open-circuit test

C. phasing out D. back-to-back test.

302. The most common cause of contamination by water of oil used in transformers located indoors is

A. condensation of moisture from air in the upper part of the tank

B. decomposition of organic matter in the oil

C. leaky bushings

D. use of filter blotters that have absorbed moisture from the air

303. Part of the transformer which is most subject to damage from overheating is

A. winding insulation B. frame or case

C. iron core D. copper winding

304. In general, the most important point to keep under constant watch during the operation of a transformers is its

A. primary voltage B. core loss

C. exciting current D. temperature.

305. In a 10 : 1 step-down 2200/220-V transformer, taps are changed to reduce the number of primary turns by 5%. The secondary voltage will nearly be

A. 209 V B. 231 V.

C. 240 V D. 225V

306. If the secondary of a 10 : 1 step-down transformer is connected to the primary of a 3 : 1 step-down transformer, the total step- down of both transformers is

A. 30 : 1 B. 7 : 1

C. 13 : 1 D. 3.3 : 1

307. Two single-phase transformer with a ratio of 1 : 2 are to be connected in parallel. The transformers may be connected in parallel by connecting lead *A* to lead *B* if voltmeter is connected between them it reads

A. 110 V B. 220 V

C. 0 V D. 440 V

308. The essential feature of an auto-transformer is that it

A. is more suited for single-phase supply

B. is completely automatic in its operation

C. uses only one winding

D. is particularly suited for situations where voltage transformation ratio exceeds unity

309. When secondary of the transformer is loaded, the primary current will

A. not be effected

B. draw more current

C. draw less current than the secondary current

D. be the vector sum of no load current and excessive current drawn due to the secondary current

310. When the secondary of the transformer is loaded, the flux in the transformer will

A. remain constant

B. directly proportional to secondary current

C. directly proportional to the excessive current drawn by primary winding

D. None of these.

311. The e.m.f. induced in the secondary winding depends upon

A. number of turns B. flux

C. supply frequency D. All of these

Answers : 299. (B), 300. (C), 301. (C), 302. (B), 303. (A), 304. (D), 305. (B), 306. (A), 307. (C), 308. (C), 309. (D),

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312. Shell type transformer is commonly used because
A. it has more magnetic flux leakage
B. it has less magnetic flux leakage
C. it has two magnetic paths
D. Both B and C are correct.

313. If the input voltage is 100 V and output voltage is 200 V, which side of the transformer windings will be primary
A. 200 V side
B. 100 V side
C. winding with more turns
D. winding with less turns

314. The transformation ratio of a transformer is
A. $\frac{I_2}{I_1}$ B. $\frac{V_1}{V_2}$
C. $\frac{N_2}{N_1}$ D. All of these.

315. Which of the following does not change in an ordinary transformer?
A. Voltage B. Current
C. Frequency D. Phase angle

316. The colour of fresh dielectric oil for a transformer is
A. pale yellow B. dark brown
C. while grey D. colourless

317. Core losses in a transformer are usually
A. 1% to 3% B. 10% to 15%
C. 25% to 30% D. 40% to 50%

318. An ideal transformer has secondary winding tapped at point *b*. The number of primary turns is 100 and the number of turns between *a* and *b* is 300 and between *b* and *c* is 2000. The transformer supplies a resistive load connected between *a* and *c* and drawing 7.5 kW. Moreover a load impedance of $10 \angle 45^\circ$ ohm is connected between *a* and *b*. The primary voltage is 1000 V. The primary current will be
A. $435 \angle -44^\circ$ A B. $453 \angle 44^\circ$ A
C. $906 \angle 44^\circ$ A D. $906 \angle -44^\circ$ A

319. In a transformer if in place of sine wave, a peaked voltage is fed to the primary,
A. the iron losses sill be less
B. the iron losses will be more
C. the copper losses will be less
D. the noise level will be low.

320. In a 25-kVA 3300/230 V, single-phase transformer the iron and full load copper losses are 350 W and 400 W respectively. The load at which the efficiency will be maximum, is
A. 25 kW B. 21.875 kW
C. 25 kVA D. 21.875 kVA

321. The colour of moist silica gel is
A. pale yellow B. pale pink
C. blue D. green.

322. The leakage impedances of primary and secondary windings of a transformer are (3 + j 4) ohms and (1 + j4) ohms respectively. It can be concluded that the transformers has
A. low voltage primary
B. low voltage secondary
C. high voltage secondary
D. no conclusion can be drawn on the basis of information provided.

323. Losses in a transformer are
I. Hysteresis losses
II. Eddy current losses
III. Copper losses
Open circuit test of a transformer gives
A. I only B. II only
C. II + III only D. I + II only

324. Class-*A* insulations can withstand
A. temperature rise of 150°C
B. maximum temperature of 105°C
C. temperature gradient of 105°C
D. heating rate of 105°C in 24 hours.]

Answers : 312. (D), 313. (B), 314. (C), 315. (C), 316. (A), 317. (A), 318. (D), 319. (A), 320. (D), 321. (C), 322. (B), 323. (D), 324. (B).

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325. Short circuit (SC) test and open circuit (OC) test on a 110 kVA, 4400/440V, 50 Hz transformer gave the following results.

O.C. Test: P = 1200 W, I = 2 A, V = 440 V

S.C. Test: P = 2000 W, I = 200 A, V = 18 V

Neglecting magnetising losses, if the transformer is supplying the rated current at 0.8 p.f. lagging, the voltage regulation will be nearly

A. 4.8% B. 9.6%
C. 90.4% D. 95.2%

326. The path of the magnetic fix in a transformer should have

A. low reluctance B. low resistance
C. high reluctance D. high resistance

327. The function of breather in a transformer is

A. to filter the transformer oil
B. to provide oxygen to the cooling oil
C. to provide cooling air
D. to arrest the flow of moisture when outside air enters the transformer.

328. In a transformer the phase difference between the primary and secondary voltage of a transformer is nearly

A. 0 deg B. 90 deg
C. 120 deg D. 180 deg.

329. The resistance and leakage reactance of 10 kVA, 60 Hz 2300/230 V distribution transformer are as follows:

Primary:	Secondary:
$R_1 = 4.20$ ohm	$R_2 = 0.042$ ohm
$X_1 = 5.50$ ohm	$X_2 = 0.055$ ohm

Leakage reactance referred to l.v. side is

A. 11 ohm B. 1.1 ohm
C. 0.11 ohm D. 0.011 ohm

330. Transformer works on

A. a.c. only B. d.c. only
C. a.c. and d.c. both D. pulsating d.c.

331. Full load copper losses are

A. 16 W B. 159 W
C. 1590 W D. 2000 W

332. Iron losses in a transformer occur in

A. core B. winding
C. insulating D. main body

333. The efficiency of a transformer depends on

A. current B. voltage
C. power factor D. None of these.

334. A 1600 kVA, 200 Hz transformer is operated at 50 Hz. Its kVA rating should be restricted to

A. 6400 B. 800
C. 400 D. 10000

335. In a single-phase core type two winding transformer

A. low voltage winding is put on one limb of the core and the high voltage winding on the other limb
B. one half of each winding is put on each limb of the core
C. Each limb carries two third of one winding and one third of the other.
D. None of these.

336. Transformers use laminated core

A. to reduce eddy current loss
B. to reduce eddy current and hysteresis/loss.
C. to reduce copper loss.
D. None of these.

337. In a transformer with closed magnetic coupling between primary and secondary windings,

A. efficiency will be high.
B. all day efficiency will be high
C. regulation will be good.
D. None of these.

338. The number of turns in the primary winding of a transformer depends on

A. input voltage
B. input current
C. both input voltage and current.
D. None of these.

Answers : 325. (A), 326. (A), 327. (D), 328. (D), 329. (C), 330. (C), 331. (B), 332. (A), 333. (C), 334. (C), 335. (B), 336. (A), 337. (C), 338. (A).

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339. A 10 kVA, 230/1000*V* single phase transformer is fed form a 230 *V* supply. The voltage across the load will be

A. 1000 *V* B. less than 1000 *V*

C. more than 1000 *V* D. 230 *V*

340. A 5 kVA 200/100 *V* single phase transformer delivers 50 *A* at rated voltage. The input current will be

A. 25 *A* B. less than 25 *A*.

C. more than 25 *A* D. 50 *A*

341. In a 10 kVA, 230/1000 *V* single-phase transformer, the no-load current will be about

A. 0.8 *A* B. 3 *A*

C. 0.5 *A* D. 10 *A*

342. A single-phase transformer has a turn ratio of 4 : 1. If the secondary winding has a resistance of 1 ohms, the secondary resistance as referred to the primary will be

A. 4 ohms B. 16 ohms

C. 3.5 ohms D. 0.25 ohms.

343. A single phase transformer has a turn ratio of 10:1. The primary winding has a resistance of 2.1 ohm and the secondary winding has a resistance 0.02 ohm. The total resistance as referred to primary is

A. 2.12 ohm B. 4.1 ohm

C. 0.041 ohm D. 2.3 ohm.

344. A transformer is supplying a unity power factor load. The power factor at primary terminal will be

A. about 0.95 lagging

B. about 0.95 leading

C. about 0.8 lagging

D. unity.

345. When the secondary winding of a transformer is short circuited, the power factor of the input is

A. unity B. about 0.7 lagging

C. about 0.7 leading D. about 0.2 lagging.

346. Under no load conduction, the power factor of a transformer is

A. zero

B. unity

C. about 0.4 lagging

D. about 0.7 lagging.

347. The voltage regulation of a well designed transformer is of the order of

A. 10% B. 50%

C. 2% D. 0.1%.

348. The full-load efficiency of a well designed transformer is around

A. 0.98 B. 0.9

C. 0.85 D. 0.7.

349. A distribution transformer should be selected on the basis of

A. efficiency

B. all day efficiency

C. voltage regulation.

D. None of these.

350 The iron losses in a 10 kVA, 240/100 V single phase transformer are 100 watts. The maximum efficiency occurs at full load. When the secondary current is 50 *A*, the copper losses in the transformer will be

A. 100 W B. 50 W

C. 25 W. D. 10 W

351. In a 4:1 turn ratio transformer the leakage reactance as referred to the secondary side is 0.05 pu; The leakage reactance as referred to primary

A. 0.05 ohm B. 0.05 pu

C. 0.8 pu D. 0.2 pu.

352. In a transformer the iron losses do not vary with load current because

A. iron losses are equal to copy losses.

B. core flux remain constant

C. core area is constant

D. None of these

Answers : 339. (B), 340. (C), 341. (B), 342. (B), 343. (B), 344. (A), 345. (A), 356. (C), 347. (C), 348. (A), 349. (B), 350. (C), 351. (B), 352. (B).

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353. In an unloaded transformer having a voltage ratio of 1000/230 *V* is connected to a 100 *V* d.c. supply
   A. the primary current will be very high as compared to rated current
   B. the primary current will be much less than the rated current.
   C. the primary current will be almost the same as the rated current
   D. None of these.

354. A transformer has a voltage regulation of 3% at full load 0.8 power factor lagging. At full load unity power factor, the regulation will be
   A. 3% B. negative
   C. less than 3% D. more than 3%.

355. A 5 kVA, 1000/100 *V* two winding transformer is used as an auto-transformer by connecting the two windings in the series so as to supply a 1000*AV* load from an 1100 *V supply. The maximum kVA which can be supplied to the load is*
   A. kVA B. 55 kVA
   C. 5.5 kVA D. 550 kVA

356. It is economical to use an auto-transformer when the transformation ratio is
   A. low B. high
   C. neither too high nor too low
   D. None of these.

357. In an auto-transformer the input voltage is V_1 input current is I_1 output voltage is V_2 and output current is I_2. The volt-amperes transferred conductively from the input to the output are equal to
   A. V_1I_2 B. V_2I_2
   C. $V_1(I_1 - I_2)$ D. None of these.

358. When a no load test is carried out on a 1000/100 *V* transformer, with *V* winding open, the wattmeter read 110 *W*. If the test is repeated with 1000 *V* winding open, the wattmeter will read
   A. 11 *W* B. 110 *W*
   C. 1.1 *W* D. 0.11 W

359. A transformer has iron losses equal to W_1 watts and full load copper losses equal to W_2 watts. If two such transformers are tested in a back to back test and full load current is flowing, the total input will be
   A. $2W_1$ B. $2W_2$
   C. $2(W_1 + W_2)$ D. $(W_1 + W_2)$

360. The no load test on a transformer is usually carried out by exciting the low voltage winding because
   A. the required power input is low
   B. the no load current becomes significant and can be conveniently measured
   C. it is not advisable to work on the high voltage side.
   D. None of these.

361. During a short circuit test, the iron losses are negligible because.
   A. the mutual flux is small
   B. the power factor is low
   C. the current is high
   D. None of these.

362. A 2000/200 *V* transformer is fed from a 2000 *V* supply. The transformer is supplying its rated load. The terminal voltage on the secondary side will be
   A. 200 *V* B. about 150 *V*
   C. about 195 *V* D. None of these.

363. Two equal sized transformers *A* and *B* are connected in parallel. The impedance of *A* is more than the impedance of *B*. Then
   A. both will share the load equally
   B. *A* will supply more load than *B*
   C. *B* will supply more load than *A*
   D. None of these.

364. A 500 kVA and a 200 kVA transformer are put in parallel. If it is desired that they should share the load in proportion to their ratings, then
   A. their impedances must be equal

Answers : 353. (A), 354. (C), 355. (B), 356. (A), 357. (A), 358. (B), 359. (C), 360. (B), 361. (A), 362. (C), 363. (C).

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B. their per unit impedances must be equal

C. their iron and copper losses must be equal

D. their iron loss should be less than copper losses.

365. Which of the following combinations of 3-phase transformers can successfully operate in parallel.

A. Y – Y and Y – Δ B. Δ – Y and Δ – Δ

C. Δ – Y and Δ – Y D. None of these.

366. A current transformer is used to measure a 100 *A* current by 5 *A* ammeter. The current transformer is a

A. step up transformer

B. step down transformer

C. power transformer

D. distribution transformer.

367. The tubes welded to the sides of the transformers

A. improve the efficiency of the transformer

B. improve the voltage regulation of the transformers

C. improve the cooling of the transformer

D. None of these.

368. The following precaution should be observed while using instrument transformers

A. secondary of a *CT* should never be open circuited

B. secondary of a *CT* should never be open circuited

C. secondary of a *CT* should never be open circuited

D. None of these.

369. The secondary of a *PT* is generally designed for

A. 220 *V* B. 110 *V*

C. 150 *V* D. 11 *V*

370. The secondary of a *CT* is generally designed for

A. 100 *A* B. 10 *A*

C. 5 *A* D. 0.5 *A*

371. One primary terminal and one secondary terminal of a two winding transformer are connected to an ohm meter. The meter will indicate

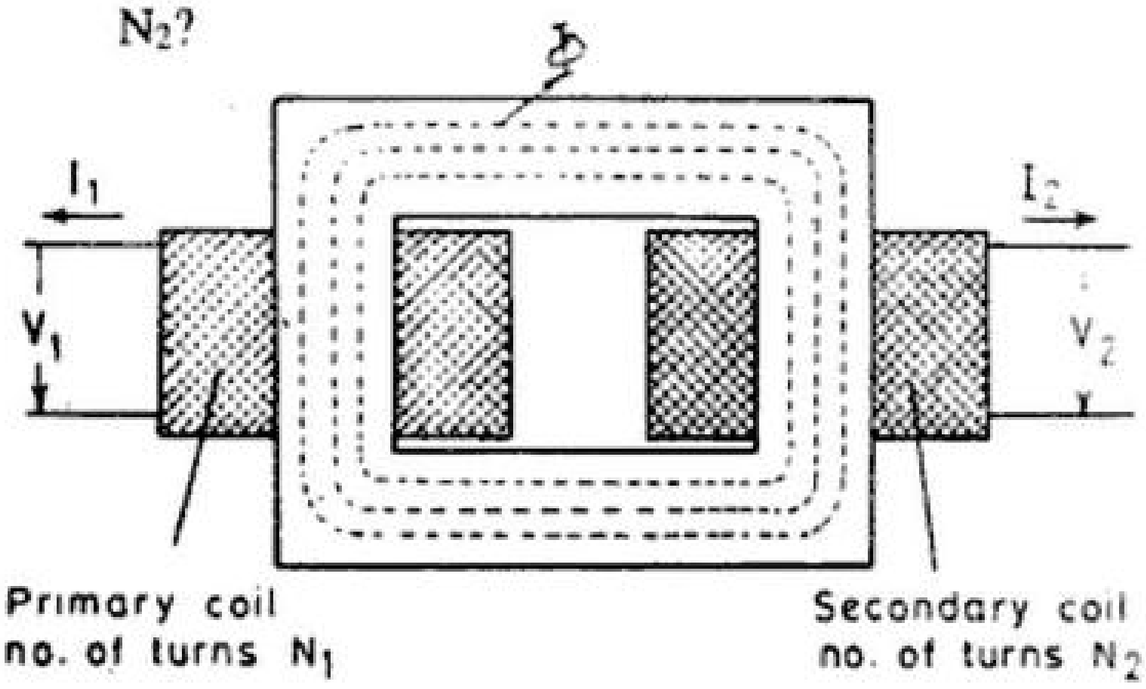
A. zero

B. infinity

C. a resistance equal to total winding resistance.

D. None of these.

372. The figure shows the schematic diagram of a transformer. What is the relation between the voltages V_1 and V_2 and the no. of turns N_1 and N_2?



A. $\frac{V_1}{V_2} = \frac{N_1}{N_2}$ B. $\frac{V_1}{V_2} = \frac{N_2}{N_1}$

C. $V_1 \times V_2 = N_1 \times N_2$

D. $V_1 \times N_1 = V_2 \times N_2$

373. The above figure shows the schematic diagram of a transformer. What is the relation between the currents I_1 and I_2 and the no. of the turns N_1 and N_2?

A. $I_1 \times I_2 = N_1 \times N_2$

B. $I_1 \times N_2 = I_2 \times N_1$

C. $\frac{I_1}{I_2} = \frac{N_1}{N_2}$

D. $\frac{I_1}{I_2} = \frac{N_2}{N_1}$

374. One of the windings of the transformer is made of thin wire and the other of thick wire. Which

Answers : 364. (B), 365. (C), 366. (A), 367. (C), 368. (A), 369. (B), 370. (C), 371. (B), 372. (A), 373. (D).

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statement is True ?

A. The winding made of thin wire is always the primary winding.

B. The winding made of thin wire is always the secondary winding.

C. The winding made of thin wire is always the low voltage winding.

D. The winding made of thin wire is always the high voltage winding.

375. What happens if a too much high voltage is applied to a transformer.?

A. The transformer draws a very high magnetising current and the primary winding destroyed.

B. The leakage flux becomes so large that the secondary voltage becomes lower in case the nominal primary voltage is applied.

C. The huming of the transformer becomes very loud, but there are no further disadvantages.

D. Due to very large hysteresis losses, the iron core heats up and burns.

376. The transformer principle is based on

A. self-induction.

B. mutual-induction

C. electric induction. D. the Lenz law.

Which loss does not occur in a transformer?

A. Eddy current loss B. I^2R loss

C. Hysteresis loss D. Friction loss

377. In case of transformer, would it be easily possible to generally use a frequency of 5 Hz instead of 50 Hz?

A. Yes, because the frequency of 50 Hz was selected arbitrarily. The frequency of 5 Hz would indeed be more favourable because the skin effect would be less.

B. Yes, but it is not done due to the high cost of changing the present system.

C. No, because in case of 5 Hz the insulation of cables and conductors should be stronger.

D. No, because for 5 Hz the number of turns of transformer coils (for the same cross-section of iron core) should be about 10 times more than for 50 Hz.

378. Why are transformer cores laminated?

A. Laminated cores are cheaper than solid cores.

B. There are fewer eddy current losses in laminated cores.

C. There are fewer hysteresis losses in laminated cores.

D. There is less humıng as compared to solid cores.

379. Which of the following statements about the huming of transformer is true?

A. The humming is caused by a vibrations of the low voltage winding through which the high current flows.

B. The humming is caused by the periodic force of attraction between the laminations of the core.

C The frequency of humming tone is 50 Hz

D. The frequency of humming tone is 2 x 50Hz = 100Hz.

380. What is meant by the leakage flux of transformer?

A. It is the flux which is linked with the primary and the secondary winding.

B. It is that part of the magnetic flux which is significant for radio interference.

C. It is the magnetic flux which is linked either only with the primary or only with the secondary winding.

D. The leakage flux in the transformer is the flux whose path is exclusively through the air.

381. Hysteresis loss in a transformer depends upon the

A. applied voltage.

B. type of core material.

Answers : 374. (D), 375. (A), 376. (B), 377. (D), 378. (B), 379. (D), 380. (C), 381. (B).

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C. number of laminations.

D. reactance of the winding.

382. The loss due to eddy currents in a transformer is

A. directly proportional to the current

B. indirectly proportional to the current.

C. indirectly proportional to the resistance of the winding.

D. directly proportional to the resistance of the winding.

383. Which of the following statements about a short-circuit proof transformer is true?

A. There is a fuse in its primary circuit.

B. There is a bimetallic switch in its primary circuit.

C. There is a fast magnetic switch in its primary circuit.

D. The short circuit current can continuously flow through it without causing a damage.

384. Why is there an enamel layer coated over the laminations of the transformer core?

A. To decrease the hum

B. To prevent the friction between the laminations.

C. To attain adhesion between the lamination

D. To insulate the laminations against each other.

385. What is the efficiency of transformers when compared with that of electrical motors of the same power?

A. Much smaller B. Somewhat smaller

C. About the same D. Much higher.

386. According to the name plate of a small transformer, the secondary nominal voltage is 220 V. Which of the following statements about it is true?

A. The no-load voltage is more than 220 V.

B. 220 V is the no-load voltage.

C. At a load which draws the rated current the voltage becomes less than 220 V.

D. The secondary voltage practically does not change when the transformer is loaded.

387. Upon which factor does the short circuit voltage of a transformer mainly depend?

A. On the ohmic resistance of the primary winding.

B. On the ohmic resistance of the secondary winding.

C. On the cross-sectional area of the iron core.

D. On the magnitude of the leakage flux.

388. Which of the following statements about a transformer having a small short circuit voltage is true?

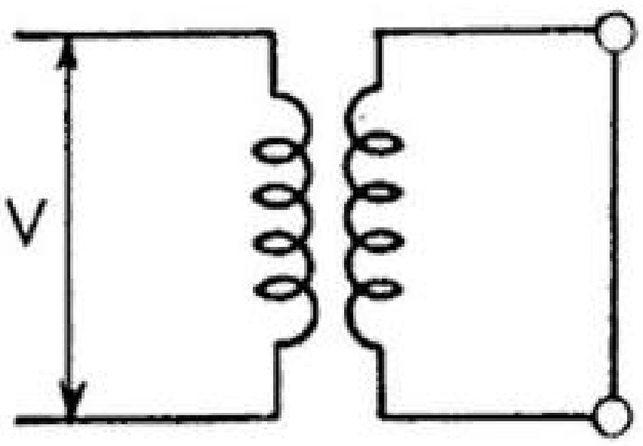
A. The transformation ratio of the transformer is small.

B. During operation, the transformer has high iron losses.

C. During operation, the transformer has high copper losses.

D. A high short circuit current flows through the transformer.

389. The rated current flows through the primary winding of the transformer shown. What is the voltage V called?



A. Short circuit voltage

B. Rated voltage

C. No load voltage

D. Operating voltage

390. What is meant by the nominal short circuit voltage V_{SCN} of transformer ?

A. Short circuit voltage

B. After short circuiting two secondary terminals, the voltage appearing across the

Answers : 382. (A), 383. (D), 384. (D), 385. (D), 386. (A), 387. (D), 388. (D), 389. (D).

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third and the short circuited terminals.

C. The primary voltage when the secondary terminals are short circuited and the rated current flows through the primary winding.

D. The voltage across the primary terminals when the secondary terminals are short circuited.

391. How is the nominal short circuit voltage represented?

A. As percentage of the rest voltage.

B. As percentage of the nominal transformation ratio.

C. As percentage of the no-load secondary voltage.

D. As percentage of the rated primary voltage.

392. A 10,000 V/400 V power transformer has a nominal short circuit voltage $V_{sc} = 4\%$. Which of the following statements about it is true?

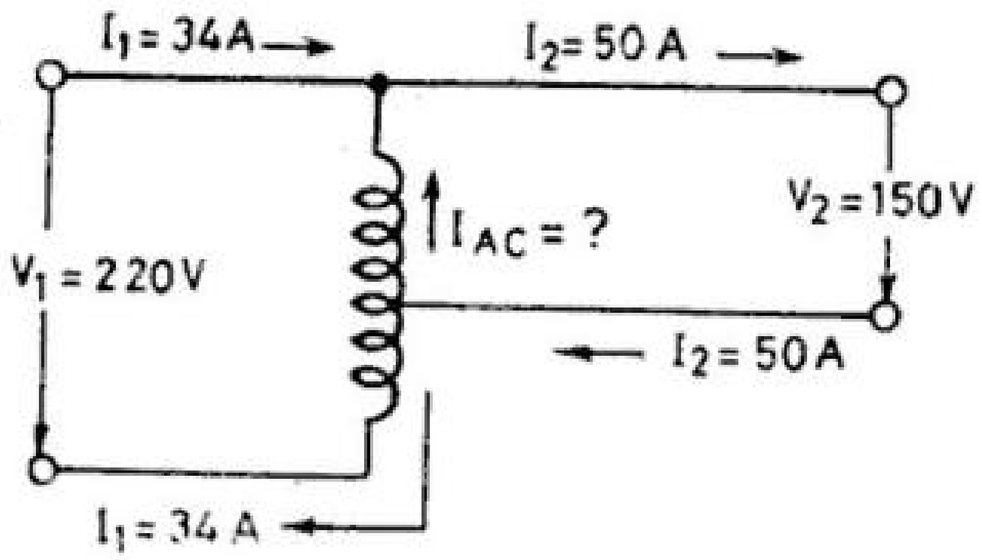
A. A voltage of 400 V appears across the short circuited secondary voltage.

B. A voltage of 16 V appears across the short circuited secondary terminals.

C. The primary voltage drops to 400 V when the secondary terminals are short circuited

D. When the secondary terminals are short circuited, the rated current flows at the primary side at a primary voltage of 400 V.

393. What is the current I_{AC} flowing through the auto-transformer shown in the figure?



A. $I_{AC} = 50A$ B. $I_{AC} = 34A$

C. $I_{AC} = 20A$ D. $I_{AC} = 16A$

394. What is the phase difference between the low and the high voltage of a Yz5 power transformer?

A. 0° B. 5°

C. 50° D. 150°

395. Which of the following statements is true about a Dy5 power transformer?

A. The high voltage winding is connected in star.

B. The high voltage winding is connected in zig-zag.

C. The low voltage winding is connected in star.

D. The low voltage winding is connected in delta.

396. What is the advantage of a distribution transformer of group Yz5 as compared to one of group Yy0?

A. It can be loaded unsymmetrically.

B. Its short circuit voltage is lower.

C. Its no-load current is lower.

D. Its efficiency is high

397. The efficiency of a transformer is calculated by using the relation

A. $\eta = \dfrac{\text{output} \times 100}{\text{output + copper losses}}$

B. $\eta = \dfrac{\text{output} \times 100}{\text{output + iron losses}}$

C. $\eta = \dfrac{\text{output} \times 100}{\text{itput + copper losses}}$

D. $\eta = \dfrac{\text{output} \times 106}{\text{output + copper losses + iron losses}}$

398. If in a transformer we double the secondary turns and at the same time reduce the primary voltage by half, then the secondary voltage will

A. be halved.

B. be four times as high

C. not change.

D. be doubled.

Answers : 390. (C), 391. (C), 392. (D), 393. (D), 394. (D), 395. (C), 396. (A), 397. (D), 398. (C).

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399. Transformers are rated in

A. kilo-watts. B. kilo-watthours.

C. kilo-volt-amperes. D. kilo-volts.

400. Which is the common method of cooling a power transformer?

A. Air-cooling B. Air-blast cooling

C. Oil-cooling D. Natural cooling

401. The efficiency of a power transformer is maximum at

A. nearly full load B. 1/2 full load.

C. 1/4 full load D. 1/8 full load.

402. What type of core is used for a high frequency transformer?

A. Open iron core

B. Closed iron core

C. Shell type iron core

D. Air core.

403. Which of the statements below is true about the auto-transformer?

A. It has two separate windings connected in series externally.

B. It has only one winding.

C. It can only step down the voltage.

D. It is most suitable for power transformation.

404. Which of the following is an instrument transformer?

A. Bell-transformer

B. Adjustable transformer

C. Ignition transformer

D. Current transformer

405. The self-induced voltage of a coil depends upon

A. the voltage applied to the coil.

B. the shape of the iron core.

C. the shape of the bobbin

D. the number of turns of the coil.

406. For a 100% efficient transformer, the primary winding has 1000 turns and the secondary 100 turns. If the power input to the above transformer is 1000 watts, the power output is

A. 1000 watts. B. 100 watts.

C. 10 watts. D. 10 kW.

407. If a high voltage is given to the primary and low voltage is taken from the secondary of transformer, it is called

A. step up B. step down

C. instrument transformer

D. stabiliser

408. Different types of transformer are

A. core type B. shell type

C. berry type D. All of these.

409. If d.c. supply is given to a transformer, it will

A. work

B. not work

C. given lower voltage than the rated voltage on secondary side

D. burn the winding.

410. Transformer works on the principle of

A. self induction

B. mutual induction

C. Faraday's law of electro magnetic induction

D. self and mutual induction both

Answers : 399. (C), 400. (C), 401. (A), 402. (D), 403. (B), 404. (D), 405. (D), 406. (A).

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CHAPTER 7

ALTERNATOR AND SYNCHRONOUS MACHINES

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Chapter 7

ALTERNATOR & SYNCHRONUS MACHINES

7.1. Alternator. An alternator consists of a stator and a rotor. The stator provides the armature windings whereas rotor provides the rotating magnetic field.

Basic Principle. When the rotor is rotated by the prime-mover, the stator winding or conductors are cut by the magnetic flux of the rotor magnetic poles. Hence an emf is induced in the stator conductors. The emf generated in the stator conductors is taken out from three leads connected to the stator winding as shown in Fig 7.1.

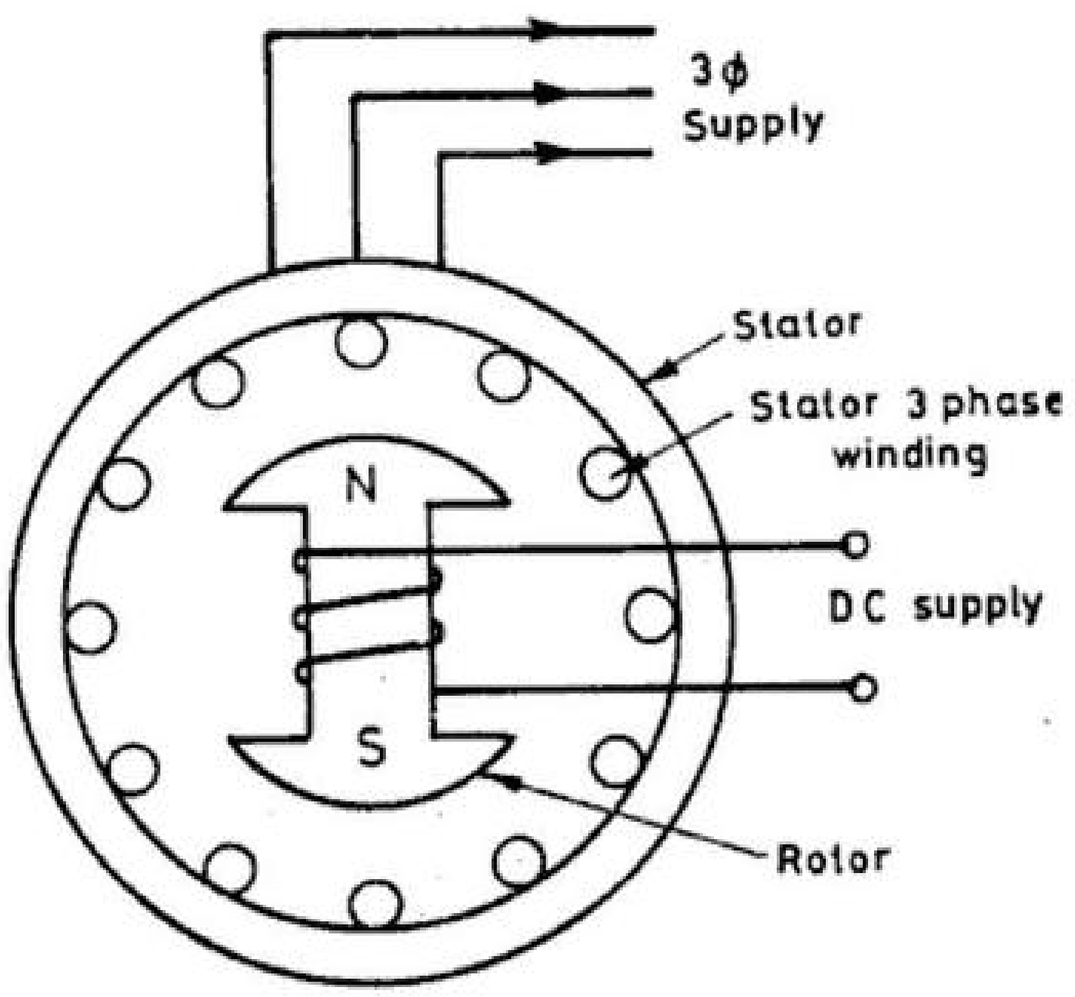


Fig. 7.1

7.2. Types of Pole. The rotors are of two types:- *salient pole type*, and *smooth cylindrical type*.

Salient pole type is used for low and medium speed alternators and smooth cylindrical type is used for turbo-alternator.

The frequency of alternating current produced is

$f = \frac{PN}{120}$ Hz , P and N being the no. of poles and speed.

7.3. Emf equation . The emf equation of an alternator is

$E = 4{\cdot}44\ K_c K_d \Phi f T$ volts/phase

where K_c is coil span factor and is equal to $\cos(\alpha/2)$, (α is the angle by which the coil span falls short), and

K_d is distribution factor and is equal to $\frac{\sin m\beta/2}{m \sin \beta/2}$, ($m$ is the number of slots/pole/phase) and

$$\beta = \left(\frac{180^c}{\text{No. of slots/pole}} \right)$$

7.4. Voltage Regulation. The terminal voltage V is less than open-circuit voltage E_o because of

(*i*) armature drop, IR_a

(*ii*) synchronous reactance drop IX_s, and

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7.7. Methods of Starting Synchronous Motors. Since the synchronous motors has no self-starting torque, therefore it is necessary that an external means is to be employed to start the motor. Various methods are described below.

I. D.C. source. The synchronous motor is coupled to a d.c. compound motor. whose speed is adjusted by a speed regulator. The synchronous motor is then excited and synchronized with the a.c. supply. At the moment of synchronizing the synchronous motor is switched on to a.c. mains and d.c. motor is disconnected from the d.c. supply mains or its field is strengthened until it begins to function as a generator. Otherwise synchronous motor will act as an a.c. motor with d.c. motor as its load.

2. By means of a.c. Motor. Synchronous motor with an exciter is coupled with a small induction motor. Before switching the a.c. supply to the synchronous motor it must be synchronized to the bus-bar. The induction motor used for starting should have lesser number of poles than synchronous motor so that it may be capable of bringing the synchronous motor to the synchronous speed. After normal operation has been established, the induction motor is sometimes uncoupled from the synchronous motor.

3. Self-starting. The synchronous motor can be made self-starting by providing a special winding on the rotor poles known as *damper winding* or *squirrel cage winding*. It consists of short-circuited-copper bars embeded in the face of the field pole. A.C. supply given to the stator produces a rotating magnetic field which causes the rotor to rotate. Therefore in the beginning the synchronous motor with damper winding starts as squirrel cage induction motor.

When the motor approaches its synchronous speed, the rotor winding is connected to the exciter winding so that the rotor is magnetically locked by the rotating field of the stator and thus the motor runs as synchronous motor.

7.8. Hunting. When a synchronous motor is connected to a varying load, a condition known as hunting is produced which may also occur if the supply frequency is pulsating (*e.g.* when connected to reciprocating engines). When a synchronous motor is on load, its rotor falls back in phase by a coupling angle δ. As the load is increased progressively, this angle also increases so as to produce more torque, to follow with the increased load. If there is sudden decrease in the load, the motor is immediately pulled up or advanced to a new value corresponding to a new load. But in this process, the rotor overshoots, hence it is again pulled back. In this way the rotor starts oscillating about its new position of equilibrium corresponding to new load. If the time period of these oscillation happens to be equal to natural time period of the machine, the mechanical resonance is set up. The amplitude of these oscillations is built up to a large value and may eventually become so great that the machine is thrown out of synchronism. To stop the build up of these oscillations, circuit dampers are employed which consist of short-copper bars embeded in the faces of the field poles of the motor. The oscillation of the rotor sets up eddy currents in the dampers which flow in such a way so as to suppress the oscillations.

7.9. Applications. Major applications of synchronous motors are:

1. It is used in power houses and substations in parallel with bus-bars to improve the power-factor.
2. In factories having large number of induction motors or other apparatus operating with lagging power factor, these motors are used in order to improve the power factor.
3. It is used as booster to control the voltage at the end of transmission line by varying its excitation.
4. It is used in rubber, textile and cement mills, and other big industries for power application.
5. It is used to derive continuously operating and constant speed equipment such as centrifugal pumps, blowers, and motor generators.

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QUESTION BANK IN ALTERNATORS AND SYNCHRONOUS MACHINES

1. Alternator generates
   A. d.c. B. a.c.
   C. d.c. and a.c. both. D. pulsating d.c.
2. Alternator works on the principle of
   A. mutual induction
   B. Faraday's laws of electro-magnetic induction
   C. self induction
   D. self and mutual induction
3. The rotor of the alternators requires
   A. d.c.
   B. a.c.
   C. pulsating d.c.
   D. None of the above.
4. In larger size alternators, flux is kept
   A. stationary
   B. rotating
   C. Either (A) or (B) is correct
   D. None of these
5. The rotor of the alternator has
   A. four slip rings
   B. three slip rings
   C. two slip rings
   D. no slip rings
6. The generator which gives d.c. supply to the rotor is called.
   A. convertor B. exciter
   C. invertor D. rectifier
7. The different types of rotor of an alternator are
   A. salient pole type
   B. cylindrical pole type
   C. both salient pole and cylindrical pole type
   D. None of these
8. Salient pole type rotors are generally used with prime movers of
   A. high speed
   B. low speed
   C. medium speed
   D. low and high speed
9. Cylindrical pole type rotors are generally used with prime movers of
   A. high speed B. low speed
   C. medium speed D. low and high speed
10. The frequency of e.m.f. generated depends upon
   A. speed of the alternator
   B. number of poles of the alternator
   C. type of alternator
   D. Both (A) and (B) are correct
11. An alternator running at 3000 r.p.m. generates voltage at 50 Hz. The number of poles of the alternator will be
   A. 8 poles B. 6 poles
   C. 4 poles D. 2 poles
12. The frequency of a 4 pole alternator running at 1500 r.p.m. will be
   A. 150 Hz B. 100 Hz
   C. 50 Hz D. 25 Hz
13. The salient pole type rotors are
   A. smaller in axial length
   B. larger in axial length

Answers : 1. (B), 2. (B), 3. (A), 4. (B), 5. (C), 6. (B), 7. (C), 8. (B), 9. (A), 10. (D), 11. (D), 12. (C).

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C. smaller in diameter

D. larger in diameter and smaller in axial length

14. The advantage of using short pitched winding in an alternator is that it

A. reduces harmonics in generated e.m.f.

B. saves copper used in the winding

C. gives the better shape to the waveform

D. All of these

15. The e.m.f. generated in an alternator depends upon

A. coil span factor

B. frequency

C. flux per pole

D. All the above three

16. If the speed of an alternator is changed from 3000 r.p.m. to 1500 r.p.m., the e.m.f. generated will become

A. twice B. half

C. one fourth D. four times

17. When the load of an alternator is thrown off, the terminal voltage will

A. increase B. decrease

C. remains same D. None of these

18. The regulation of an alternator is the ratio of

A. $\frac{V_0 - V}{V_0} \times 100\%$

B. $\frac{V_0 - V}{V} \times 100\%$

C. $\frac{V - V_0}{V_0} \times 100\%$

D. $\frac{V - V_0}{V} \times 100\%$

19. The conditions for running two alternators in parallel are

A. terminal voltage should be same

B. frequency should be same

C. phase sequence should be same

D. All the above three

20. The alternators are operated in parallel because

A. it is convenient and economical in repairing

B. it maintains better stability of supply

C. it is easy to install an additional unit as and when required

D. All the above three

21. Different methods of synchronising the alternators generally used are

A. Dark and bright lamp method

B. Stroboscopic method

C. Dark lamp method only

D. Both (A) and (B) are correct

22. When two alternators are running in parallel, if prime-mover of one of the alternators is disconnected, that alternator will

A. stop running

B. run as a synchronous motor

C. run as generator

D. None of these

23. When two alternators are running in parallel, if one of the alternator is to be disconnected, the

A. load shared by this alternator will be transferred to the other alternator before disconnecting

B. O.C.B. switch will be switched off

C. steam supply of the prime mover is stopped

D. load connected with the bus bar should be reduced

24. A 120 MW turbo-alternator is supplying power to 80 MW load at 0.8 p.f. lagging. Suddenly the steam supply to the turbine is cut off and the alternator remains connected to the supply network and the field supply also remains on. What will happen to the alternator?

A. The stator winding of the alternator will get burnt

B. The rotor winding of the alternator will get burnt

Answers : 13. (D), 14. (D), 15. (D), 16. (B), 17. (A), 18. (B), 19. (D), 20. (D), 21. (D), 22. (B), 23. (A).

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C. The alternator will continue to run as a synchronous motor rotating in the same direction

D. The alternator will continue to run as a synchronous motor rotating in opposite direction.

25. Two alternators are running in parallel. If the driving force of both the alternators is changed, this will result in change in

A. frequency B. back e.m.f.

C. generated voltage D. All of the above.

26. The frequency per revolution in an alternator is equal to

A. number of poles

B. number of armature conductors

C. number of pair of poles

D. None of these.

27. What will be the maximum speed at which the field of an alternator can be operated to develop 60 Hz?

A. 1800 r.p.m. B. 3600 r.p.m.

C. 7200 r.p.m. D. None of these.

28. A 90 slot stator has a three phase, six pole, short coiled winding, each coil of which spans from slot 1 to slot 14. Then the pitch factor is

A. 0.9 B. 0.978

C. 0.407 D. None of these

29. For a full pitch winding, the generated voltages in both coil sides are

A. exactly in phase

B. in quadrature

C. exactly 180° out of phase

D. approximately 180° out of phase

30. Distributed winding instead of concentrated winding has the effect of improving the shape of voltage as a sine wave and

A. increasing the speed of machine

B. adding rigidity and mechanical strength to winding

C. reducing armature reaction

D. None of these

31. In an alternator when the load increases then the terminal voltage due to armature reaction

A. drops

B. rises

C. either drops or rises

D. does not have any change

32. In a synchronous machine with damper winding, the damping torque at negative slip developed by damper winding acts

A. to reduce the speed

B. to increase the speed

C. either to increase or decrease the speed

D. None of these

33. Name the machine which is designed to run without mechanical attachment but with its excitation so controlled as to provide a load taking a purely reactive power is

A. an induction motor

B. a synchronous motor

C. a synchronous generator

D. a synchronous compensator

34. An alternator on open circuit generates 300V at 50 Hz, when the field current is 3.0A. Neglecting saturation, when the frequency is 25 Hz and the field current is 2 A, then the open circuit emf is

A. 50*V* B. 100 *V*

C. 200 *V* D. None of these

35. In a 3 - phase, star connected alternator a field current of 40 A produces full load current of 200 A on short circuit and 160 V on open circuit. If the resistance of the alternator is 0.5 ohm, then the value of synchronous reactance is

A. 5.78 ohms B. 16.5 ohms

C. 3.31 ohms D. 29 ohms

Answers : 24. (C), 25. (A), 26. (C), 27. (B), 28. (B), 29. (A), 30. (B), 31. (C), 32. (A), 33. (D), 34. (B), 35. (A).

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36. The Synchronous Impedance Method to find voltage regulation of an alternator is not considered an accurate method. This is because the value of synchronous impedance found is always
   A. more than its value under normal condition
   B. less than its value under normal condition
   C. equal to the synchronous reactance
   D. None of these

37. What are the experimental data required for Potier method for finding voltage regulation of alternators?
   A. No load curve, short circuit test values
   B. No load curve, zero power factor curve
   C. Zero power factor curve, short circuit test value
   D. None of these

38. A 3-phase, 11 kV, 5 MVA alternator has synchronous impedance of (1 + j10) ohm per phase. Its excitation is such that the generated e.m.f. is 14 kV. If the alternator is connected to infinite bus bar, then the maximum output at the given excitation is
   A. 15400 kW B. 8000 kW
   C. 6200 kW D. 5135 kW

39. A synchronous motor can run at
   A. a leading power factor
   B. unity power factor
   C. lagging or leading or unity power factor
   D. zero power factor

40. The power factor of the input power to a synchronous motor is adjusted by varying
   A. number of poles
   B. magnitude of excitation
   C. magnitude of armature reaction
   D. None of these

41. A induction motor is coupled to a synchronous motor. In order to bring up the synchronous motor to synchronous speed at starting, the pairs of pole of induction motor should be
   A. less than that of synchronous motor
   B. equal to that of synchronous motor
   C. greater than that of synchronous motor
   D. None of these

42. To be a shunt motor, the counter e.m.f. E_b should be always less than applied voltage V. To be a synchronous motor, the counter e.m.f. E_b should be, in magnitude
   A. always less than the terminal voltage
   B. always greater than the terminal voltage
   C. always equal to the terminal voltage
   D. either equal to, or less than, or greater than the terminal voltage

43. A 10 pole, 25 Hz alternator is directly coupled to, and is driven by a 60 Hz synchronous motor. Then the number of poles in a synchronous motor are
   A. 48 poles B. 12 poles
   C. 24 poles D. None of these

44. The power input to the d.c. field of a 15 *kVA* (input) synchronous motor is 6 percent of the rated a.c. input. Then the direct current that excites the field at 120 volts is
   A. 7.5 amps B. 125 amps
   C. 15 amps D. None of these

45. When a synchronous motor delivering rated load is adjusted so that counter e.m.f. equals terminal voltage at torque angle 30° then the impedance voltage drop in armature winding as a percentage of terminal voltage is
   A. 0% B. 51.8%
   C. 48.2% D. 100%

46. A synchronous condenser is installed to correct the 2400 *kVA*, 0.65 power factor load in a plant to unity. Then kilovolt ampere rating of condenser is
   A. 27 *kVA* B. 1560 *kVA*
   C. 1825 *kVA* D. 3690 *kVA*

Answers : 36. (A), 37. (B), 38. (D), 39. (C), 40. (B), 41. (A), 42. (D), 43. (C), 44. (A), 45. (B), 46. (C).

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75. A 3-phase synchronous motor with constant excitation is driving a certain load drawing electrical power from infinite bus at leading power factor. If the shaft load decreases.

A. the power angle, decreases while power factor increases.

B. the power angle increases while power factor decreases.

C. both power angle and power factor increase

D. both power angle and power factor decrease.

76. In 3-phase synchronous motor

A. the field M.M.F. lags airgap flux and the airgap flux lags the armature M.M.F.

B. the field M.M.F. leads the airgap flux and the airgap flux leads the armature M.M.F.

C. the field M.M.F. leads the airgap flux and the airgap flux lags the armature M.M.F.

D. the field M.M.F. lags the airgap flux and the airgap flux leads the armature M.M.F.

77. Consider the following statements:

I. A synchonous motor has no starting torque but when started it always runs at a fixed speed.

II. Neglecting residual magnetism, both cylindrical-rotor and salient pole synchronous motor produce some mechanical power even through the field is unexcited.

III. A single-phase reluctance motor is not self-starting even it paths for eddy currents are provided in the rotor

IV. A single-phase hysteresis motor is self-starting.

A. All of the above statements are correct

B. Only I, III and IV are correct

C. Only I and III are correct.

D. Only I is correct.

78. Which one of the following statements regarding a three-phase hysteresis motor is correct?

A. both eddy-current and hysteresis torques are effective during starting as well as running.

B. both eddy current and hysteresis torques are effective during starting while only hysteresis torque is effective during running.

C. only eddy current torque is effective during starting while only hysteresis torque is effective during running.

D. only hysteresis torque is effective during starting as well as running.

79. The number of slip rings of a single-phase and three-phase converters are respectively

A. 1 and 3 B. 2 and 3

C. 2 and 6 D. 1 and 6

80. Which one of the following statements regarding the ratios of line voltages and line currents on the a.c. side to that on the d.c. side of a rotary converter is true?

A. Both decrease with increase in number of phases.

B. Both increase with increase in number of phases.

C. The former increases while the latter decreases with increase in the number of phase.

D. The former decreases while the latter increases with increases in the number of phases.

81. Which one of the following statements regarding the ratios of line voltages and line currents on the a.c. side of that on the d.c. side of a polyphase converter is true?

A. The former is less that unity while the latter is greater than unity

B. The former is greater than unity while the latter is less than unity

C. Both are less than unity.

D. Both are greater than unity

Answers : 75. (D), 76. (A), 77. (C), 78. (B), 79. (B), 80. (A), 81. (C).

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91. The magnitude of the e.m.f. induced in the stator due to revolving flux will depend upon the
   A. speed of the motor
   B. d.c. excitation current
   C. load on the motor
   D. speed and rotor flux

92. Under no load running condition, the angle between induced voltage and supply voltage will be
   A. 180° B. 90°
   C. between 90° and 180°
   D. zero

93. Under running condition on load, the angle between the induced voltage and supply voltage will be
   A. zero B. 180°
   C. 90° D. None of these

94. Net stator voltage of synchronous motor is
   A. vector difference of E_b and V
   B. vector sum of E_b and V
   C. arithmetic difference of E_b and V
   D. arithmetic sum of E_b and V

95. If the field of synchronous motor is under excited, the power factor will be
   A. power factor angle
   B. synchromous angle
   C. torque angle
   D. angle of retardation

96. If the field of synchronous motor is under excited, the power factor will be
   A. more than unity B. unity
   C. lagging D. leading

97. If one of the 3-phase of synchronous motor is short circuited, motor will
   A. start B. not start
   C. over heated
   D. fail to pull into synchronism

98. The advantage of synchronous motor over slip-ring induction motor are that it's
   A. power factor can be varied
   B. speed can be easily varied
   C. speed is independent of supply frequency
   D. rotor has two slip rings

99. The standard full load power factor of a synchronous motor is
   A. unity
   B. unity or 0.8 leading
   C. unity or 0.8 lagging
   D. zero or 0.8 leading

100. The synchronous motor can be started by
   A. coupling with d.c. compound motor
   B. coupling with a.c. induction motor
   C. providing damper winding
   D. All of these.

101. The advantages of synchronous motor as compared to induction motor are that
   A. it runs at constant speed
   B. it can run over wide range of power factors both lagging and leading
   C. it's torque is less sensitive to change in supply voltage
   D. All of these

102. Rotor winding of the synchronous motor is excited by
   A. induction from stator current
   B. a.c. supply
   C. d.c. supply supplied by the exciter
   D. the revolving field

103. The speed of synchronous motor depends upon
   A. number of poles
   B. supply frequency
   C. Either A or B
   D. Both (A) and (B) are correct

104. The voltage supplied to the rotor of the synchronous motor is

Answers : 91. (B), 92. (D), 93. (D), 94. (A), 95. (C), 96. (C), 97. (B), 98. (A), 99. (B), 100. (D), 101. (D), 102. (C), 103. (D).

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A. 400 V, a.c. B. 400 V, d.c.
C. 100 to 250 V, d.c. D. $400/\sqrt{3}$ V, a.c.

105. The magnitude of the induced e.m.f. in the stator of a synchronous motor
A. is equal to the supply voltage
B. is less than the supply voltage
C. can be increased than the supply voltage
D. can be increased or decreased than the supply voltage

106. The exciting field coil of an alternator is generally excited by
A. a separate D.C. generator driven by some source.
B. a separate A.C. generator driven by some source
C. a D.C. generator coupled directly to the alternator shaft.
D. a battery.

107. Which of the following statements is true ?
A. An internal pole dynamo has a rotating magnetic field.
B. An internal pole dynamo has a rotating armature.
C. An external pole dynamo has a rotating magnetic field.
D. Alternators are usually of the external pole type.

108. For which of the following cases are synchronous machines used exclusively ?
A. For electric trains
B. For cranes
C. For machine tools
D. For large three phase generators

109. For what purpose the stroboscope instruments used ?
A. To synchronize synchronous motors.
B. To synchronize synchronous generators.
C. To synchronize induction motors.
D. To synchronize induction generators.

110. What is the use of the bright lamp circuit ?
A. It is used during synchronization to indicate equal voltages of generator and line.
B. It is used during synchronization to indicate that generator and line are having the same phase.
C. It is used to start synchronous motors.
D. It is used to indicate when the power factor of a synchronous motor is exactly 1.

111. A four-pole turbo-generator supplies a 50 Hz network. What should be the speed of the generator ?
A. 6000 rpm B. 3000 rpm
C. 1500 rpm D. 1000 rpm

112. An unexcited single phase synchronous motor is
A. reluctance motor B. universal motor
C. repulsion motor D. a.c. series motor

113. The damping winding in a synchronous motor is generally used
A. to provide starting torque only
B. to reduce noise level
C. to reduce eddy currents
D. to prevent hunting and provide the starting torque.

114. A 3-phase 400 *V*, 50 Hz synchronous motor is working at 50% load. In case an increase in the field current of the motor cause a reduction in the armature current, it can be concluded that
A. the motor is delivering reactive power to the mains
B. the motor is absorbing reactive power from the mains.
C. the motor is neither absorbing nor delivering reactive power
D. None of these.

Answers : 104. (C), 105. (D), 106. (C), 107. (A), 108. (D), 109. (B), 110. (B), 111. (C), 112. (A), 113. (D), 114. (B).

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115. A synchronous motor working on leading power factor and not driving any mechanical load is known as
   A. synchronous induction motor
   B. spinning motor
   C. synchronous condenser
   D. None of the above

116. The amortisseur winding in a synchronous motor
   A. provides starting torque only
   B. provides starting torque and eliminates hunting
   C. improves the power factor of the machine.

117. An over excited synchronous motor operates at
   A. unity power factor
   B. lagging power factor
   C. leading power factor
   D. None of these

118. Under full load running condition, the slip of a synchronous motor is
   A. 0
   B. about 0.2
   C. about 0.01.
   D. None of these.

119. When the synchronous motor is to be started, the field system is energised.
   A. in the very beginning.
   B. after the motor has attained a speed slightly less than the synchronous speed
   C. after the motor has attained synchronous speed and has been loaded.
   D. None of these.

120. When a synchronous motor is started, the field winding is initially
   A. short circuited
   B. open circuited
   C. excited by a d.c. source.
   D. None of these.

121. *V*-curves of a synchronous motor show the relation between
   A. armature current and field current
   B. applied voltage and field current
   C. applied voltage and armature current
   D. None of these.

122. For a given load, the armature current of a synchronous motor is minimum when the power factor is
   A. unity
   B. lightly less than unity and lagging
   C. slightly less than unity and leading
   D. None of these.

123. Synchronous motors generally have
   A. cylindrical rotor
   B. salient pole rotor.
   C. Both (A) and (B) are correct
   D. None of these.

124. A synchronous motor is supplying a certain load and is operating at unity power factor. If field current and terminal voltage are kept constant but the load is increased, the power factor
   A. will remain the same
   B. will become leading
   C. will become lagging
   D. None of these.

125. If the excitation and terminal voltage of a synchronous motor are kept constant and the load is increased then
   A. armature current decreases and power factor becomes more leading
   B. armature current increases and power factor becomes more leading
   C. armature current increases and power factor becomes more lagging
   D. None of these.

126. Synchronous motors are usually operated at
   A. unity power factor
   B. leading power factor

Answers : 115. (C), 116. (B), 117. (C), 118. (A), 119. (B), 120. (A), 121. (A), 122. (A), 123. (B), 124. (C), 125. (C), 126. (B).

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C. lagging power factor

D. None of these.

127. A salient pole synchronous motor is running at no load. Its field current is switched off. The motor will

A. come to stop

B. continue to run at synchronous speed

C. continue to run at a speed slightly less than synchronous speed.

D. None of these.

128. A synchronous motor always runs at synchronous speed because

A. of the action of amortisseur winding

B. the Lenz's law cannot be violated.

C. of magnetic locking between the stator and rotor.

D. None of these

129. In a synchronous motor

A. the generated emf must always be less than the terminal voltage

B. the generated emf must always be more than the terminal voltage

C. the generated emf can be less than or greater than the terminal voltage.

D. None of these.

130. As the load on a synchronous motor is increased, the torque angle

A. increases B. decreases

C. remains the same D. None of these.

131. An under excited synchronous motor operates at

A. unity power factor

B. leading power factor

C. lagging power factor

D. None of these.

132. Synchronous motors are used in

A. sizes greater than about 50H.P.

B. all si. ·s

C. generally small sizes

D. None of these.

133. A synchronous motor is supplying its rated load. If the excitation is increased

A. the power factor becomes more leading

B. the power factor becomes more lagging

C. the power factor becomes more lagging

D. None of these.

134. The power output of a synchronous motor is

A. directly proportional to synchronous reactance

B. inversely proportional to synchronous reactance

C. independent of synchronous reactance.

D. None of these.

135. In a synchronous motor

A. the rotor mmf and stator mmf are stationary with respect to each other

B. the speed of rotor mmf is slightly less than the speed of stator mmf.

C. the speed of rotor mmf is slightly more than the speed of stator mmf.

D. None of these.

136. In a 3-phase alternator the unsaturated synchronous reactance is 3 ohms per phase. The saturated synchronous reactance is

A. 3 ohms B. more than 3 ohms

C. less than 3 ohms D. None of these.

137. The short-circuit characteristic of an alternator is

A. always linear

B. always non-linear

C. sometimes linear and sometimes non-linear

D. None of these.

138. Under short circuit conditions, the power factor of an alternator is

A. almost zero lagging

B. unity

Answers : 127. (C), 128. 9C), 129. (C), 130. (A), 131. (C), 132. (A), 133. (A), 134. (B), 135. (A), 136. (C), 137. (A), 138. (A).

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C. about 0.6 lagging

D. None of these.

139. The synchronous impedance of a larger size modern alternator is about

A. 0.1 p.u. B. 0.4 p.u

C. 1.0 p.u. D. None of these.

140. The ratio of armature leakage reactance to synchronous reactance of a large size modern alternator is about

A. 0.05 B. 0.2

C. 0.6 D. 0.8

141. The rated voltage of alternators used in power stations in usually

A. 11 kV B. 66 kV

C. 132 kV D. 400 kV

142. High speed alternators usually have

A. salient pole rotors

B. cylindrical rotors

C. both salient pole and cylindrical rotors

D. None of these.

143. Cylindrical rotor alternators have

A. large length to diameter ratio

B. small length to diameter ratio

C. vertical configuration

D. None of these.

144. Salient pole machine have

A. large number of poles

B. small number of poles

C. small diameters

D. long cores.

145. To ensure proper cooling, cylindrical rotor alternators use

A. radial ducts only

B. axial ducts only

C. both radial and axial ducts

D. None of these.

146. The stators of modern alternators are wound for

A. 120° phase groups B. 60° phase groups

C. 240° phase groups

D. 180° phase groups.

147. Machine *A* has 120° phase groups and a second similar machine *B* has 60° phase groups in the armature winding. Then

A. breadth factor of machine *A* is higher than that of *B*

B. breadth factor of machine *B* is higher than that of *A*

C. both the machines have the same breadth factor

D. None of above.

148. Modern alternators usually have short pitched winding

A. to improve the voltage wave shape

B. to improve the magnitude of the generated voltage

C. to increase the machine rating

D. None of these.

149. The full pitch coil in an alternator, has a span of 18 slots. If it is desired to eliminate the third harmonic voltage, the coil span should be

A. 18 slots. B. 15 slots

C. 12 slots. D. 9 slots

150. A 3-phase alternator is delivering its rated current at rated terminal voltage. The power factor is 0.8 lagging and the field current is I_f. If the power factor is changed to 0.8 leading, the load current and terminal voltage remaining the same, the new value of field current is

A. I_f B. less than I_f

C. more than I_f D. None of above

151. If the armature current is leading the generated voltage by 90° the effect of armature reaction will be

A. demagnetising

B. magnetising

Answers : 139. (C), 140. (B), 141. (A), 142. (B), 143. (A), 144. (A), 145. (C), 146. (B), 147. (B), 148. (A), 149. (C), 150. (B), 151. (B).

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177. For a 3-phase uniformly distributed and narrow-spread winding, the distribution factor is

A. 0.9 B. 0.955

C. 0.965 D. 0.97.

178. The armature m.m.f. wave of a d.c. machine is

A. sinusoidal and depends on the speed.

B. square and independent of speed

C. sinusoidal and independent of speed

D. triangular and independent of speed

179. The armature m.m.f. wave for a d.c. machine is

A. sinusoidal and rotates w.r.t. armature

B. sinusoidal and rotates w.r.t. field

C. triangular and rotates w.r.t. armature

D. triangular and stationary w.r.t. armature.

180. If F_1 is the constant amplitude of fundamental rotating m.m.f. wave, then for the space harmonics of the order $6k+1$, the harmonic m.m.f. wave is of

A. constant amplitude and stationary in space

B. constant amplitude and rotates against F_1

C. varying amplitude and rotates along F_1

D. constant amplitude and rotates along F_1

181. Rotational losses in electrical machines consist of

A. friction and windage losses

B. stator core, friction and windage losses

C. rotor core, friction and windage losses

D. stray load losses and friction and windage losses.

182. Efficiency of electrical machines should be calculated by measuring

A. output and input B. losses and output

C. losses and input D. losses.

183. The efficiency of electrical machines is maximum when

A. Constant losses = (variable copper losses)^2

B. Constant losses = variable copper losses

C. Constant losses = $\sqrt{(\text{variable copper losses})}$

D. None of the above.

184. Electrical machines are designed to have maximum efficiency at

A. full load B. 50% of full load

C. near about full load D. no load.

185. In 3-phase a.c. machines, phase spread of 120° is preferred over a phase spread of 60°

A. true B. false

C. depends upon type of machine.

D. None of these.

186. The chording angle for eliminating 5the harmonics should be

A. 30° B. 34°

C. 36° D. 35°.

187. The m.m.f produced by a single phase winding is

A. pulsating and stationary

B. pulsating and rotating

C. constant in amplitude and stationary

D. constant in amplitude and rotating.

188. The material used for the magnetic circuit where high value of flux density required is

A. cast iron B. fero cobalt

C. soft steel D. gray cast iron

189. The material suitable for the manufacture of transformer and large turbo-alternator is

A. hot rolled grain oriented steel

B. cold rolled grain oriented steel.

C. cast steel.

D. None of these.

190. The material used for the magnetic circuit where high value of flux density required is

A. cast iron B. fero cobalt

C. soft steel D. gray cast iron

191. In aircraft industry, the material used for the conductor is

Answers : 177. (B), 178. (D), 179. (C), 180. (D), 181. (C), 182. (D), 183. (B), 184. (C), 185. (B), 186. (C), 187. (A), 188. (B), 189. (B), 190. (B).

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A. aluminium B. copper
C. silver D. iron

192 Which of the following class is mainly used in electrical machines for insulation

A. class Y B. class A
C. class F D. class C

193 The resistance of insulating material is

A. proportional to its resistivity
B. inversely proportional to its resistivity
C. independent of the temperature
D. independent of the temperature.

194. When a substance is placed in a magnetic field, its ability to get magnetised depends upon its

A. permittivity B. permeability
C. susceptibility D. None of these.

195. The material used, for the manufacture of armature cores of d.c. motors and dynamos, should have.

A. small B-H loop area
B. large B-H loop area
C. very large B-H loop area
D. None of these.

196. For steady flux and good mechanical properties, the material extensively used for magnetic circuit is

A. iron B. cast iron
C. grey cast iron D. cast steel

197. The maximum temperature permitted for Class-H is

A. 180°C B. 165°C
C. 120°C D. 105°C

198. When a three-phase synchronous motor is switched on, there exists a rotating magnetic field. The magnitude of this field flux

A. is constant at all loads
B. varies with load
C. varies with power factor
D. None of these.

199. When the excitation of synchronous motor is varied,

A. the pf and the armature current varies
B. The pf varies but the armature current does not vary
C. the armature current varies but the pf does not vary
D. neither the pf nor the armature current varies.

200. In a salient-pole synchronous generator connected to an infinite bus bar, maximum power is delivered at a power angle.

A. $\delta = 90^{\circ}$ B. $\delta = 45^{\circ}$
C. $45^{\circ} < \delta < 90^{\circ}$ D. $\delta = 0^{\circ}$

Answers : 191. (A), 192. (B), 193. (A), 194. (C), 195. (A), 196. (C), 197. (A), 198. (A), 199. (A), 200. (A).

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CHAPTER 8

INDUCTION MOTORS

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Chapter 8

INDUCTION MOTORS

8.1. Induction Motor. The polyphase induction motor is the most widely used a.c. motor because of its low cost, simple and extremely rugged construction, high efficiency, reasonably good power factor, and simple starting arrangement.

Principle of Operation of an Induction Motor. When a three- phase stator windings are fed by three-phase supply, a magnetic flux of constant magnitude but rotating at synchronous speed is set up. The flux passes through the air gap, and cuts the stationary rotor conductors.

Due to relative speed between the rotating magnetic flux and stationary conductors, an emf is induced in the conductors according to Faraday's law of electromagnetic induction and its direction is given by Fleming's right hand rule. Since the rotor conductors are in a closed circuit, rotor current is produced whose direction is such as to oppose the cause which is producing it. And the cause which produces the rotor current is the relative speed between the rotating flux of stator and stationary rotor conductors. Hence to reduce the relative speed, the rotor starts running in the same direction as that of the flux and tries to catch up with the rotating flux.

Induction motor consists of two parts-stationary part known as stator, and revolving part known as rotor. It is mainly of two types:

1. Squirrel cage type
2. Wound rotor type

The phase supply produces a rotating magnetic field which rotate at synchronous speed, given by $N_s = \frac{120f}{P}$

An induction motor cannot run at synchronous speed. If it were possible, by some means for the rotor to attain synchronous speed, the rotor would then be standing still with respect to the rotating flux with the result that no emf would be induced in the rotor, no rotor current would flow and therefore there would be no torque developed.

8.2. Induction Motor Relation. Slip of an induction motor is defined as

$$s = \frac{\text{synchronous speed - rotor speed}}{\text{synchronous speed}}$$

Rotor current frequency, $f' = \text{slip} \times \text{supply frequency}$

The starting torque is maximum when rotor resistance equals rotor reactance *i.e.*, $R_2 = X_2$.

The torque under running conditions is maximum at that value of slip s, which makes rotor reactance per phase equal to rotor resistance per phase.

$$s = \frac{R_2}{X_2}$$

The full load torque T_f and maximum torque T_{max} are related by

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$$\frac{T_f}{T_{max}} = \frac{2as}{a^2 + s^2}$$

where $$a = \frac{R_2}{X_2}$$

The torque/slip curve is shown in the Fig. 8.1

The slip of an inductor motors can be measured by actual measurement of motor speed or, comparing rotor and stator supply frequencies with d.c. moving coil millivolt-meter, and stroboscopic method.

Rotor copper loss in induction motor

$= s \times$ rotor input

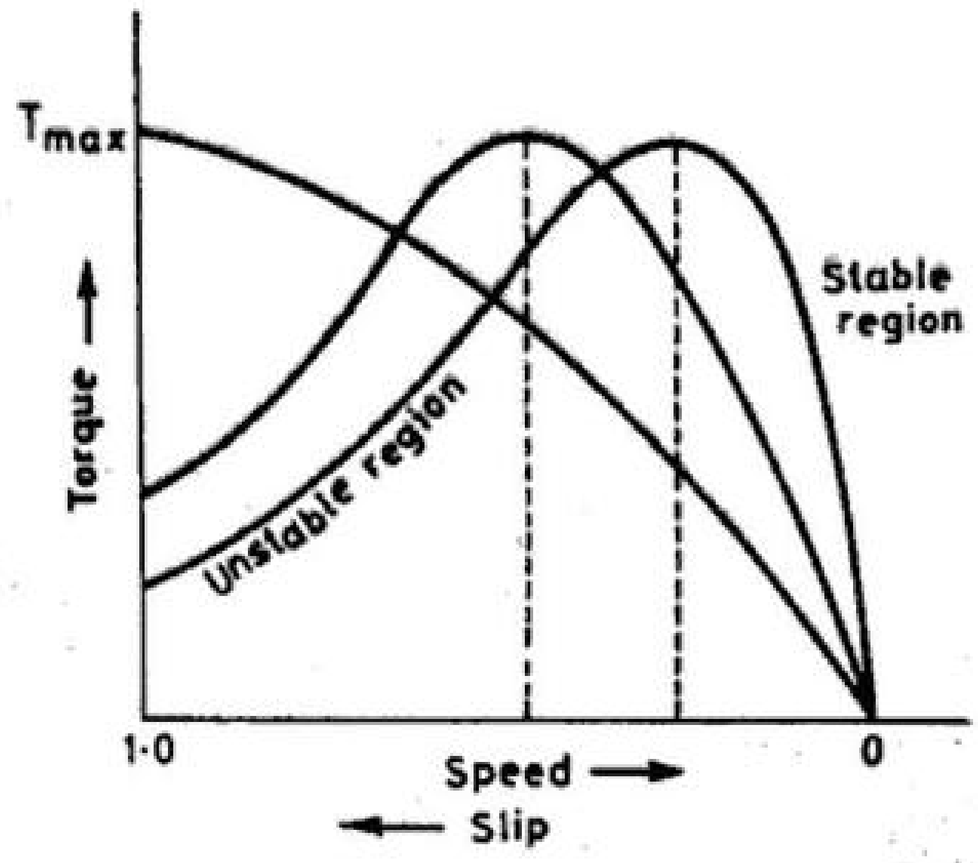


Fig. 8.1

8.3. Synchronous wattage of an induction motor is the power transferred across the air-gap to the rotor.

Torque in synchronous watt = rotor input.

The no load current is 40%-50% of full load current.

The electrical equivalent of mechanical load on motor = $R_2 (1/s - 1)$.

Power output of an induction motor is maximum when equivalent load resistance is equal to the stand-still leakage impedance of the motor, *i.e.*,

$$R_i = Z_{01}$$

Slip corresponding to maximum gross power output is given by

$$s_m = \frac{R_2'}{R_2' + Z_{0i}}$$

Maximum gross power output is given by

$$P_{g\,max} = \frac{3V_1^2}{2 (R_{01} + Z_{01})}$$ where V_1 is the input voltage

Gross torque, $$T_g = \frac{\text{rotor output in watts}}{2\pi N}$$

Rotor copper loss $= T_g \times 2\pi (N_s - N)$

$$\frac{\text{Rotor gross output}}{\text{Rotor input}} = (1 - s) = \frac{N}{N_s}$$

Rotor efficiency $$= \frac{N}{N_s}$$

$$\frac{\text{Rotor copper loss}}{\text{Rotor gross output}} = \frac{s}{1 - s}$$

8.4. Double Squirrel Cage Motor. A double squirrel cage motor consists of two independent cages on the same rotor one inside the other. The outer cage consists of a high resistance metal whereas the inner cage has low resistance copper bars. It has high starting torque without sacrificing its electrical efficiency under normal running conditions.

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8.5. Speed Control of Induction Motor. It can be achieved by either of the following methods:

(*i*) Changing the applied voltage

(*ii*) Changing the applied frequency

(*iii*) Changing the number of stator poles

(*iv*) Injecting an emf in the rotor circuit

(*v*) Cascading, and

(*vi*) Rotor rheostat control.

The speed of cumulative cascade set is $N_{sc} = \dfrac{120\,f}{P_a + P_b}$

where P_a and P_b are the numbers of poles of two machines.

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10. In terms of air-gap power, P_g the rotor copper loss and the mechanical power developed are given by
    A. sP_g and $(1-s)\,P_g$
    B. $(1-s)\,P_g$ and sP_g
    C. P_g and P/s
    D. P_g/s and $P_g(1-s)$

11. In a 3-phase induction motor, internal developed torque, T_e in terms of supply voltage, V_1 is proportional to:
    A. V_1 B. $\sqrt{V_1}$
    C. V_1^2 D. None of these.

12. In a 3-phase induction motor, slip for maximum torque, in terms of rotor resistance r_2 :
    A. independent of r_2
    B. directly proportional to r_2
    C. inversely proportional to r_2
    D. None of these.

13. In a 3-phase induction motor, the current is produced in the rotor conductors by
    A. giving a.c. supply
    B. giving d.c. supply
    C. induction effect
    D. pulsating d.c. supply

14. When 3-phase supply is given to the stator of the motor, a
    A. revolving field is set up
    B. pulsating field is set up
    C. revolving field at synchronous speed is set up
    D. revolving field at the rotor speed is set up

15. The direction of rotation of 3-phase revolving field can be changed by interchanging
    A. R and Y phases only
    B. B and Y phases only
    C. R and B phases only
    D. any two phases.

16. If any two phases of the three-phase supply are interchanged, motor will
    A. run in the same direction
    B. stop running
    C. run in the reverse direction
    D. draw high current

17. Different types of a 3-phase induction motors are
    A. squirrel cage B. sliping
    C. commutator D. All of these.

18. The rotor of a 3-phase induction motor rotates in the same direction as the direction of revolving field because of
    A. Faraday's laws of electro magnetic induction
    B. Lenz's law
    C. Fleming's right hand rule
    D. None of these.

19. The rotor of a 3-phase induction motor always runs at
    A. synchronous speed.
    B. less than synchronous speed
    C. more than synchronous speed.
    D. None of these.

20. The synchronous speed of the revolving field depends upon
    A. number of poles B. supply frequency
    C. flux
    D. (A) and (B) correct

21. In a 3-phase squirrel cage induction motor, the
    A. rotor conductors are kept open
    B. rotor conductors are short circuited through end rings
    C. ends of the rotor conductors are connected to sliping
    D. ends of the rotor conductors are short circuited through slipped.

Answers : 10. (A), 11. (C), 12. (B), 13. (C), 14. (C), 15. (D), 16. (C), 17. (D), 18. (B), 19. (B), 20. (D), 21. (B).

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22. In a 3-phase sliping induction motor, the number of poles in the rotor windings are kept
   A. same as of the number of stator poles
   B. more than the number of stator poles
   C. less than the number of stator poles
   D. independent of the stator pole.

23. At full load, the current induced in the rotor conductor of a 3- phase squirrel cage induction motor is
   A. more than rated current
   B. less than rated current
   C. nearly equal to rated current
   D. None of these.

24. The frequency of the induced e.m.f. in the rotor circuit is
   A. maximum at stand still
   B. zero at stand still
   C. maximum at synchronous speed
   D. None of these.

25. If one of the three phases of a 3-phase induction motor is disconnected while running at light load, it will
   A. stop running
   B. continue to run at same speed
   C. run at low speed
   D. run at high speed.

26. If the rotor terminals of a 3-phase slip-ring induction motor are not short-circuited and the supply is given to the stator, the motor will
   A. not start B. start running
   C. run at high speed D. run at low speed

27. Generally, a 3-phase slipring induction motor is started with
   A. DO.L. starter
   B. Star-delta starter
   C. Auto-transformer starter
   D. Stator-rotor starter

28. A 3-phase squirrel cage induction motor can be started with
   A. Stator rotor starter
   B. D.O.L. starter
   C. Star-Delta starter
   D. D.O.L. and Star Delta Starter both

29. A 3-phase, 4-pole induction motor works on 3-phase, 50 c/s, supply. If the slip of the motor is 4%, the actual speed with be
   A. 1500 r.p.m. B. 1460 r.p.m.
   C. 1440 r.p.m. D. 720 r.p.m.

30. A 3-phase, 6 pole induction motor operates on 440 V, 50 c/s supply. If the actual speed of the motor is 960 r.p.m, the slip will be
   A. 6% B. 5%
   C. 4% D. 0.4%

31. When the line voltage of an induction motor is reduced to 75% of its rated value, the starting current will reduce by
   A. 75% B. 50%
   C. 25%
   D. No change in the current

32. If the full load speed of a 4-pole, 3-phase induction motor is 1440 r.p.m. its speed at half load will be
   A. 1460 r.p.m. B. 1440 r.p.m
   C. 1400 r.p.m D. 1000 r.p.m.

33. The advantage of starting 3-phase induction motor with D.O.L starter in place of I.C.T.P. switch is
   A. starting current remains same
   B. provided with over load protection relay
   C. provided with under volt relay
   D. Both (B) and (C) are correct.

34. If a motor of lower speed is purchased in place of high speed motor, its cost will be
   A. same B. more
   C. less D. slightly less

Answers : 22. (A) 23. (C), 24. (A), 25. (B), 26. (A), 27. (D), 28. (D), 29. (C), 30. (C), 31. (C), 32. (A), 33. (D), 34. (B).

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35. The power drawn by 3-phase induction motor, when first run in star connection and then in delta connection, will be
   A. same
   B. $\sqrt{3}$ times the power taken in star connection
   C. 3 times the power taken in star connection
   D. $1/\sqrt{3}$ times the power taken in star connection.

36. If a 3-phase induction motor runs at 25% supply than the rated voltage, the motor will
   A. not start
   B. start at lower speed
   C. run at normal speed.
   D. get heated and damaged

37. If a 3-phase induction motor runs on 2-phase supply it will
   A. run at slow speed B. run with jerks
   C. likely to burn D. blow off the fuses

38. Star-delta and auto transformer starters are used with 3-phase induction motors because they
   A. have high starting torque
   B. may not run in reverse direction
   C. draw 5 to 7 times the full load current at the time of starting
   D. pick up high speed immediately

39. The speed of the squirrel cage induction motor can be controlled by
   A. changing supply frequency
   B. changing number of poles
   C. reducing supply voltage
   D All of these.

40. The speed of the slipring induction motor can be controlled by
   A. changing supply frequency
   B. changing number of poles
   C. changing the resistance of the rotor winding
   D. All of these.

41. The speed of the squirrel cage induction motor can be controlled from
   A. stator side B. rotor side
   C. stator and rotor sides both
   D. supply voltage side.

42. The speed of a 50-*Hz* induction motor under full load conditions is 720 r.p.m. The number of poles of the motor are
   A. 4 B. 2
   C. 8. D. None of these.

43. The speed of an induction motor is
   A. always less than the synchronous speed
   B. can be equal to or less than the synchronous
   C. always more than the synchronous speed.
   D. None of these.

44. The slip of an induction motor under full load condition is about
   A. 0.1 B. 0.03
   C. 0.2 D. 0.8

45. The speed of the rotor field of an induction motor
   A. is equal to synchronous speed
   B. is equal to motor speed
   C. is equal to zero
   D. None of these.

46. Majority of the induction motors have
   A. totally enclosed frame
   B. drip proof type frame
   C. totally enclosed fan closed frame.
   D. None of the these.

47. The squirrel-cage rotor of a 4-pole induction motor
   A. can be used for only 4 poleinduction motor
   B. can be used for motors having 2,4 or 8 poles only
   C. can be used for motor with any number of poles
   D. None of these.

Answers : 35. (C), 36. (D), 37. (C), 38. (C), 39. (D), 40. (D), 41. (A), 42. (C), 43. (A), 44. (B), 45. (A), 46. (C), 47. (C).

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48. The number of slip rings in a 3-phase wound motor induction motor is

A. 3 B. 4

C. 6 D. 12

49. The core of the rotor of a 3-phase induction motor

A. is always laminated

B. is solid

C. is sometimes laminated

D. None of these.

50. In a 50-Hz, 3-phase induction motor, frequency of rotor current is

A. 50

B. about 2 Hz

C. about 10 Hz

D. 0 Hz

51. In a 3-phase, 50 *Hz* induction motor the voltage between slip ring at standstill is 50 *V*. At full load, the slip is 0.04. The voltage between sliprings at full load is

A. 50 *V* B. 2 *V*

C. 20 *V* D. 1250 *V*

52. Under running condition the rotor circuit of a 3-phase induction motor is

A. always closed

B. always open

C. sometimes open and sometimes closed.

D. None of these.

53. Under blocked rotor conditions, a 3-phase induction motor is similar to a transformer

A. with secondary open-circuited

B. with secondary underloaded

C. with secondary short circuited

D. None of these.

54. The no load current of 3-phase, 10 hp, 400 *V* induction motor is about

A. 1 *A* B. 5 *A*

C. 10 *A* D. 20 *A*

55. In a 3-phase 50-Hz induction motor

A. rotor core losses are always equal to stator core losses

B. rotor core losses are very high as compared to stator core losses

C. rotor core losses are always very small as compared to stator core losses

D. None of these.

56. A 3-phase induction motor with wound rotor has a delta-connected stator winding. For proper operation, the rotor winding

A. must be delta connected

B. must be star connected

C. may be connected in delta or star.

D. None of these.

57. At $s = \infty$ the torque of a 3-phase induction motor is

A. 0 B. small

C. very high. D. high

58. At standstill the power factor of the rotor circuit of an induction motor is 0.2 lagging. At full load the power factor of the rotor circuit will be

A. 0.2 lagging B. about 0.8 lagging

C. almost unity. D. None of these.

59. A wound rotor induction motor runs with a slip of 0.03 when developing full load torque. its rotor resistance is 0.25 ohm per phase. If external resistance of 0.50 ohm per phase is connected across the slip rings, the slip for full load torque will be

A. 0.03 B. 0.06

C. 0.09 D. 0.01

60. A 5-hp motor is started, under no load by, the direct switching. The motor takes 30 seconds to come upto full speed. If started with a star-delta starter, the time taken by the motor to come to full speed will be

A. 30 seconds.

B. more than 30 seconds

Answers : 48. (A), 49. (A), 50. (B), 51. (B), 52. (A), 53, (C), 54. (B), 55. (C), 56. (C), 57. (A), 58. (C), 59. (C), 60. (B).

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C. less than 30 seconds.

D. None of these.

61. A 3-phase induction motor draws a current of 20 *A* from mains if started by direct switching. If an auto-transformer with 50% tapping is used for starting, the current drawn from the mains will be

A. 20 *A* B. 10 *A*

C. 5 *A* D. 40 *A*

62. In a double cage 3-phase induction motor

A. the inner cage has lower resistance and higher inductance as compared to the outer cage.

B. the inner cage has higher resistance as compared to the outer cage

C. the inner cage has higher resistance and higher inductance as compared to the outer cage.

D. None of these.

63. An induction motor has a starting torque of 320 N-m when started by directed switching. If started through an auto-transformer with 50% tapping, the starting torque will be

A. 0.05 N.m B. 80 N-m

C. 160 N-m D. 640 N-m

64. The ratio of no load current to full load current of a 3-phase induction motor is about

A. 0.05 B. 0.2

C. 0.5 D. 0.8.

65. An induction motor has a starting torque of 300 N-m when started by direct switching. If a star delta-starter is used for starting, the starting torque will be

A. 300 B. 173-2 N-m

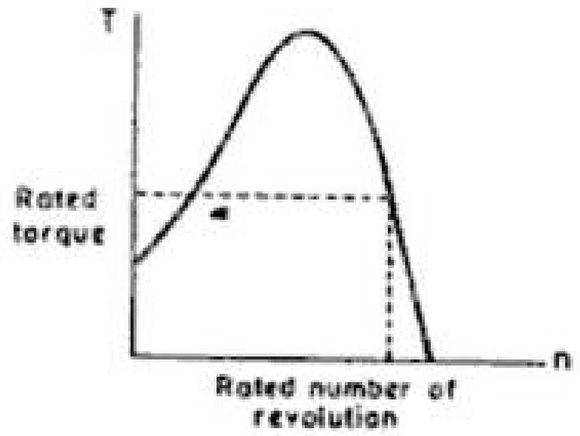
C. 100 N-m D. None of these.

66. The change in speed of a 3-phase induction motor from no load to full load is about

A. 2% B. 8%

C. 15% D. 50%

67. Which of the following motors is represented by the shown characteristic curve?



A. D.C. shunt motor B. D.C. series motor

C. D.C. compound motor

D. Asynchronous motor

68. What does the data 950 V/1030 A given on the name plate represent?

A. 950 V: The lowest stator voltage.

B. 950 V: The voltage across two short-circuited sliprings.

C. 950 V: The voltage across two sliprings when the motor is stationary.

D. 1030 A: Current drawn from the circuit at rated load.

69. Which of the following motors is used most frequently?

A. D.C. shunt motor

B. A.C. induction motor

C. Three phase commutator motor

D. Three phase induction motor

70. Which of the following motors requires the most complicated speed control arrangement?

A. Three phase squirrel cage induction motor.

B. Stator supplied three phase commutator motor

C. Rotor supplied three phase commutator motor.

D. D.C. shunt motor.

Answers : 61. (C), 62. (A), 63. (B), 64. (C), 65. (C), 66. (A), 67. (D), 68. (C), 69. (D), 70. (A).

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71. For which of the following fields of application is the three phase induction motor mainly suitable?
   A. For running of electric vehicles.
   B. For running of rolling mills where an exact speed control is required.
   C. For running of different mechanic tools where one or a few speeds are required.
   D. For running of paper machines (the paper quality depends upon the exact speed control).

72. Which of the following statements about the three phase induction motor is true?
   A. The speed of the induction motor cannot be controlled as easily and efficiently as that of a D.C. shunt motor
   B. The induction motor requires more maintenance than a D.C. motor.
   C. The price of an induction motor is much higher than that of a D.C. motor of the same power and speed.
   D. The induction motor is much more sensitive to overloads than a D.C. Motor.

73. What is the advantage of the slipring induction motor over the squirrel cage induction motor?
   A. It is suitable for higher speeds.
   B. Its efficiency is higher.
   C. Its power factor is higher.
   D. It can be started with the help of rotor resistances.

74. Which motor is widely used?
   A. A squirrel cage induction motor
   B. A slip-ring induction motor
   C. A wound rotor synchronous motor
   D. A salient pole synchronous motor.

75. Which of the following statements about the squirrel motor is true?
   A. The motor can run only in one direction.
   B. The laminations of the rotor should be properly insulated against one another
   C. The cage rotor is made of copper.
   D. The stator winding produces a rotating magnetic field.

76. What is the purpose of the blades in the squirrel cage induction motor?
   A. To dynamically balance the rotor
   B. To reduce the magnetic resistance of the rotor
   C. To reduce the electrical resistance of the rotor cage.
   D. To cool the rotor

77. An induction motor is running at its rated torque. The applied voltage is reduced from the rated value of 440 V to 320 V. What is the consequence of this?
   A. After some time the motor heats up to an inadmissible extent
   B. The current decreases.
   C. The motor stops.
   D. The speed reduces considerably.

78. Which of the following formula is used to calculate the synchronous speed of an induction motor?
   A. $n_s = p \times f$
   B. $n_s = \frac{60 \times p}{f}$
   C. $n_s = \frac{60 \times f}{p}$
   D. $n_s = \frac{f \times p}{60}$

79. An induction motor has a rated speed of 725 rpm. How many poles has its rotating magnetic field?
   A. 2 poles
   B. 4 poles
   C. 6 poles
   D. 8 poles

80. The rated speed of an induction motor is 1410 rpm. What is meant by the statement "the slip s = 0"?
   A. The speed of the motor is higher than the synchronous speed.
   B. The motor runs at a synchronous speed.
   C. The motor runs at its rated speed.
   D. The rotor is stationary

Answers : 71. (C), 72. (A), 73. (D), 74. (A), 75. (D), 76. (D), 77. (A), 78. (C), 79. (D), 80. (B).

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81. A machine is driven by an induction motor running at nominal speed. What happens if the counter torque of the machine becomes larger than the maximum torque of the motor?

A. The induction motor heats up to an inadmissible extent.

B. The induction motor stops.

C. The speed of the induction motor is reduced to less than half of its nominal speed.

D. The winding of the motor can be damaged because of high current strength.

82. What is the disadvantage of starting an induction motor with a star-delta starter?

A. The starting torque increases and the motor runs with jerks.

B. The starting torque is one third of the torque in case of the delta connection.

C. By changing over from star to delta connection a voltage peak is produced which endangers the insulation of the motor.

D. During starting, high losses are reduced.

83. An induction motor is started on the 220/380 V supply mains with the help of a star-delta starter. Which type of induction motor is this?

A. 220/380 V squirrel cage induction motor.

B. 220-380 V slipring induction motor

C. 380-660 V squirrel cage induction motor

D. 380/660 V slipring induction motor.

84. What is the advantage of starting a slipring induction motor with the help of rotor resistances as compared to other methods?

A. The starting current is reduced.

B. The starting torque increases due to the rotor resistances.

C. The starter has to be designed for only a very low current.

D. The starter can be built directly into the motor.

85. What is the advantage of the double squirrel cage rotor as compared to the round-bar cage rotor?

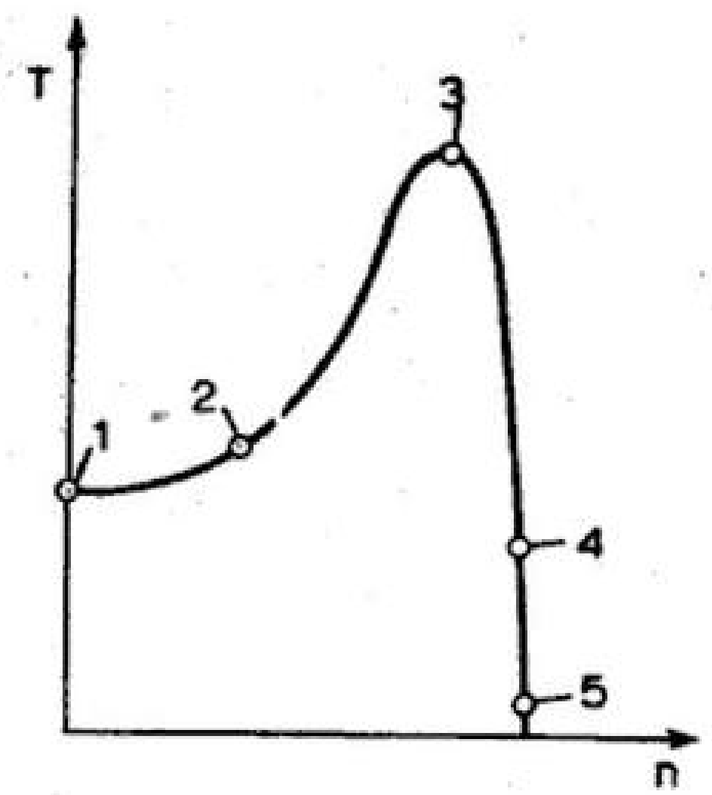
A. The efficiency of the motor is higher.

B. The power factor of the motor is higher.

C. The slip of the motor is larger.

D. The starting current of the motor is lower.

86. The figure shows the characteristics of an induction motor. What is the torque 1 called?



A. Maximum torque B. Starting torque

C. Rated torque D. Frictional torque

87. The above figure shows the characteristics of an induction motor. What is the torque marked 3 called?

A. Starting torque

B. Acceleratory torque

C. Maximum torque

D. Rated torque

88. The above figure shows the characteristics of an induction motor. At which point does the motor operate after starting and accelerating at the rated torque?

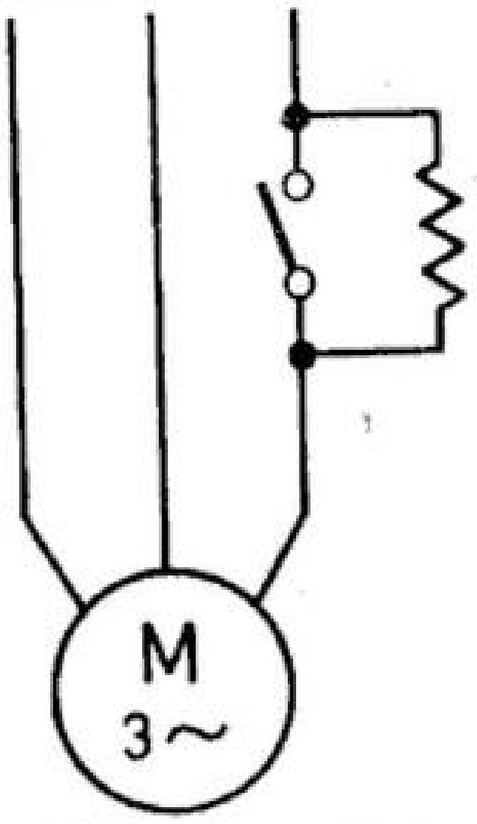
A. Point 1 B. Point 2

C. Point 3 D. Point 4

89. What is the use of the circuit shown in the diagram?

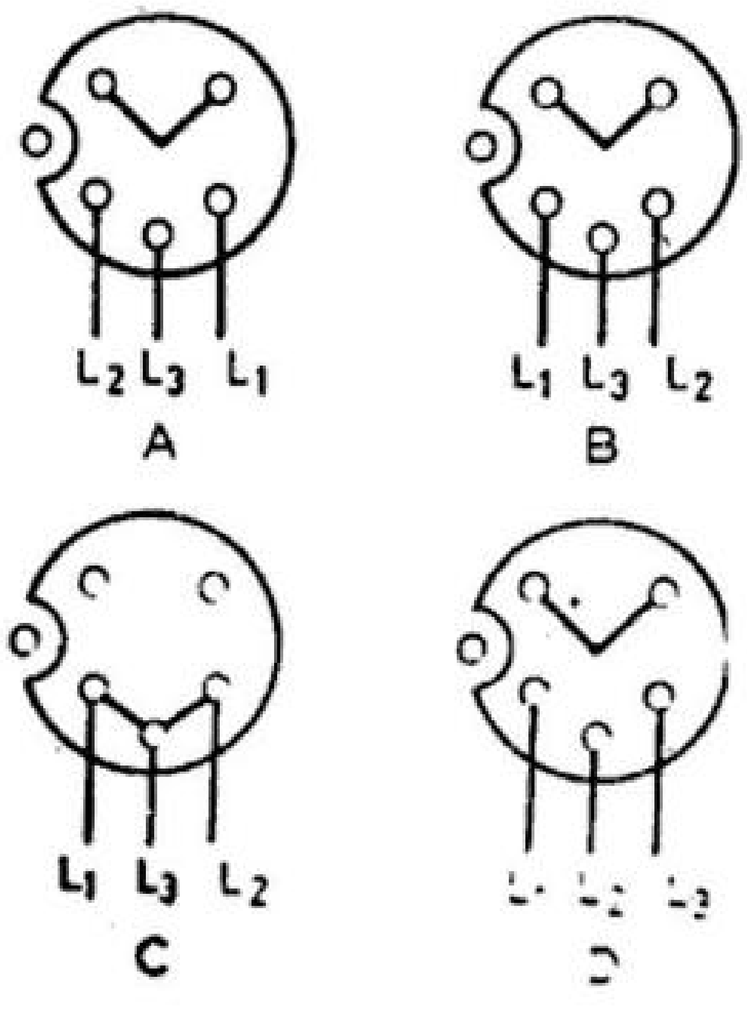
Answers : 81. (B), 82. (B), 83. (C), 84. (B), 85. (D), 86. (B), 87. (C), 88. (D).

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A. To reduce the starting current to a very low
B. To achieve a smooth starting
C. To attain a higher starting torque
D. To attain a higher maximum torque.

90. Which of the following connection is correct for the anti-clockwise rotation of an induction motor?



91. What is the disadvantage of the speed control of a slipring induction motor with the help of resistances in the rotor circuit?

A. This method of speed control is only applicable to motors having a power of more than 100 kW.
B. This method is associated with high losses.
C. By using this method the speed can only be controlled very broadly.
D. With reductions in speed the torque decreases considerably.

92. A three phase induction motor is running at a load of the rated torque. What happens when one of the outer mains in interrupted while the motor is running?

A. The motor stops immediately.
B. The motor stops after a few seconds.
C. The motor keeps running but draws more current
D. The motor keeps running and the current drawn does not change.

93. Which motor should *not* be operated on three phase supply?

A. A three phase commutator motor with anti-interference capacitor
B. A three phase induction motor with anti-interference capacitor
C. A three phase induction generator with exciting capacitor
D. A single phase induction motor

94. While starting an induction motor with star-delta starter at the stator position

A. The torque developed is 3 times as high as at the run position.
B. the torque developed is $\sqrt{3}$ times as high as at the run position.
C. the voltage per phase is $\frac{1}{\sqrt{3}}$ of the supply voltage
D. The current is $\frac{1}{\sqrt{3}}$ of the current at direct on line starting.

Answers : 89. (B), 90. (B), 91. (B), 92. (C), 93. (D), 94. (B).

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B. The induction motor stops

C. The speed of the induction motor is reduced to less than half of its normal speed

D. The winding of the motor can be damaged because of high current strength

107. A 3-phase, 4 pole induction motor with open circuited rotor is connected to a 400 V, 50 Hz. 3-phase supply. The motor will run at

A. 1500 rpm B. 1480 rpm

C. 1450 rpm D. None of these.

108. Two alternators *A* and *B* are running in parallel and sharing a load. It is desired to shift a part of the load presently shared by alternator *A* to *B*. This can be achieved by

A. Increasing the field current of *B* **and decreasing it for** *A*.

B. Increasing the machanical power input *to* the prime-mover of *B*

C. Decreasing the input mechanical power of the prime-mover of *A*.

D. None of these.

109. A 3-phase, 400-V 50Hz 4-pole induction motor is fed from a 3- phase, 400-V supply and runs at 1425 rpm. The frequency of the rotor emf is

A. 2.5 Hz B. 50 Hz

C. 48 Hz D. zero.

110. A change of 5% in supply voltage to a 3-phase induction motor will produce the approximate change in the torque of

A. 5% B. 7.5%

C. 10% D. 25%

111. The injected emf in the rotor of an induction motor must have

A. the same frequency as the slip frequency

B. the same phase as the motor emf

C. a high value for satisfactory speed control

D. None of these.

112. In a 3-phase induction motor the frequencies of induced emf's in the stator and the rotor are equal to 50Hz and 1.0 Hz, respectively, the slip in this case will be

A. 0.1% B. 2%

C. 0.2% D. 5%

113. The stator of an unloaded 3-phase, 6-pole, wound-rotor induction motor is connected to a 60-Hz source and the rotor is connected to a 25-Hz source. The rotor speed at which steady-state motor action will result is given by

A. 1200 rpm B 700 rpm

C. 500 rpm D. None of these.

114. A 50 Hz, 10 pole, 3-phase induction motor is used to drive a 60 Hz, 3-phase alternator. The pole number of the alternator should be

A. 10 B. 6

C. 12 D. None of these.

115. What is the advantage of starting a slip-ring induction motor with the help of the motor resistances as compared to other methods?

A. The starting current is reduced

B. The starting torque increases due to the rotor resistances

C. The starter has to be designed for only a very low current.

D. The starter can be built directly into the motor

116. What is the advantage of the double squirrel-cage rotor as compared to the round bar cage rotor?

A. The efficiency of the motor is higher

B. The power factor of the motor is higher

C. The slip of the motor is larger.

D. The starting current of the motor is lower.

117. At three-phase induction motor is running at load of the rated torque. What happens when one of the outer mains is interrupted while the motor is running?

A. The motor stops immediately

B. The motor stops after a few seconds.

Answers : 106. (B), 107. (D), 108. (A), 109. (A), 110. (C), 111. (A), 112. (B), 113. (B), 114. (C), 115. (B), 116. (D).

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C. The motor keeps running but draws more current

D. The motor keeps running and the current drawn does not change.

118. The no load current of an induction motor is

A. 1% of F.L. current

B. 10% of F.L. current

C. negligible

D. 40-50% of F.L. current

119. The field of an induction motor rotor rotates with reference to stator at

A. synchronous speed B. slip speed

C. rotor speed D. very low speed

120. The power factor of an induction motor at low load is low due to

A. high working component of I_o

B. high magnetising component of I_o

C. high speed

D. very low speed.

121. The rotor input, when rotor copper-loss in an induction motor is 600 W and slip is 3% is

A. 18 kW B. 200 kW

C. 20 kW D. 25 kW

122. The rotor output is 15 kW and the corresponding slip is 4%. The rotor copper loss is

A. 700 W B. 0.6 kW

C. 650 W D. 625 W

123. Frequency is 50 Hz and number of poles are 4. If rotor speed is 95%, the actual speed of motor is

A. 1425 rpm B. 1300 rpm

C. 1500 rpm D. None of these.

124. An a.c. voltage of 66.5 volts is applied across an impedance of (4.11 + j 8.44). The current is

A. 16 + j 2.36 A B. 16 + j 3.5 A

C. 15 + j 4A D. 16 - j 2.36 A

125. The mechanical load in an induction motor can be represented by

A. $(R_2/s - R_2)$ B. $(R_2\text{-}s, R_2)$

C. $1/s(R_2 - 1)$ D. $R_2 (1/s + 1)$

126. Maximum power is delivered in an induction motor when the load resistance R_L and internal impedance Z are

A. equal B. in 2 : 1 ratio

C. not equal D. in 1 : 2 ratio

127. Which of the following statements is *not true* for an induction motor?

A. If $(1 - s)$ is the power input to the rotor, the power lost in the rotor is $s\ (1 - s)$

B. Maximum torque of an induction motor is independent of the rotor resistance.

C. An induction motor can supply the load stably from s = 0 to $s = R_2/X_2$

D. The efficiency of an induction motor is maximum, when $R_2 = X_2$.

128. If the input to a table-fan motor is 'a' and its losses are x times 'a', its output will be equal to

A. ax watts B. a/x watts

C. $a(1 - x)$ D. $a - x/a$ watts

129. In an induction motor, the rotor input is 600 W and slip is 4%. The rotor copper-loss is

A. 700 W B. 0.6 kW

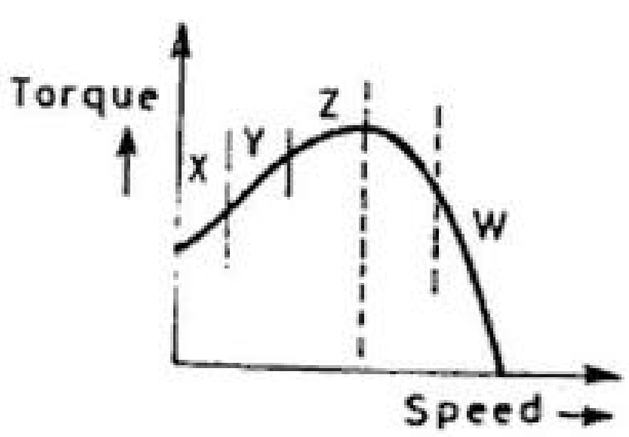
C. 650 W D. 24 W

130. The reactance per phase as compared to the resistance per phase of an induction motor is

A. quite high B. slightly large

C. almost same D. very small

131. In the torque/speed characteristics of an induction motor, stable region is



Answers : 117. (C), 118. (D), 119. (A), 120. (B), 121. (C), 122. (B), 123. (A), 124. (D), 125. (A), 126. (A), 127. (D), 128. (C), 129. (D), 130. (A).

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A. X B. Y
C. Z D. W

132. Which of the following is most economical method for starting single-phase motor?
A. Capacitor-start method
B. Split-phase method
C. Induction-start method
D. Resistance-start method

133. Which of the following motors is most suitable for signalling devices and timer
A. D.C. series motor
B. D.C. shunt motor
C. Two phase induction motor
D. Reluctance motor

134. A 500-V, 50-Hz motor takes a full-load current of 40 A at a factor of 0.85 lagging. If a capacitor of 80 μF is connected across the motor terminals, the power factor becomes
A. 0.72 B. 0.85
C. 0.97 D. 1.00

135. In the above problem. the full-load current falls to
A. 21 A B. 35 A
C. 42 A D. 47 A

136. Which of the following consumers draws inductive reactive power?
A. An electrical heater
B. A filament lamp
C. An electrolysis system which draws the current via transformers and rectifiers
D. A three-phase induction motor

137. Which of the following motors is used most frequently?
A. D.C. shunt motor
B. A.C. induction motor
C. Three-phase commutator motor
D. Three-phase induction motor

138. Which of the following motors requires the most complicated speed control arrangement?
A. Three-phase squirrel cage induction motor
B. Stator supplied three-phase commutator motor
C. Rotor supplied three phase commutator motor
D. D.C. shunt motor

139. For which of the following fields of application is three-phase induction motor mainly suitable?
A. For running of electric vehicles
B. For running of rolling mills where an exact speed control is required
C. For running of different machine tools where one or a few speeds are required
D. For running of paper machines (the paper quality depends upon the exact speed control)

140. What is the advantage of the slip ring induction motor over the squirrel-cage induction motor?
A. It is suitable for higher speeds.
B. Its efficiency is higher
C. Its power factor is higher.
D. It can be started with the help of rotor resistances.

141. The starting torque of the slip ring induction motor can be increased by
A. adding resistance to the rotor
B. adding resistance to stator
C. adding resistance to both
D. None of these.

142. A 400 kW, 3-phase, 440 V, 50 Hz induction motor has a speed of 950 rpm on full load. The machine has 6 poles. The slip of the machine will be
A. 0.06 B. 0.05
C. 0.04 D. 0.02

143. A change of 5% in supply voltage to an induction motor will produce a change approximately.
A. 5% in the rotor torque

Answers : 131. (D), 132. (A), 133, (D), 134. (C), 135. (B), 136. (D), 137. (D), 138. (A), 139. (C), 140. (D), 141. (A), 142. (B).

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B. 8% in the rotor torque

C. 20% in the rotor torque

D. None of these.

144. What will happen to rotor copper losses of the frequency of the input to an induction motor increases ?

A. Increases B. Decreases

C. Remains same D. None of these.

145. In an induction motor, if the phase sequence of applied voltage is changed

A. no back e.m.f. will be developed in rotor

B. no torque will be developed by rotor

C. speed will drop to zero

D. direction of rotation of motor will change

146. If a rotor of induction motor could be theoretically rotated at synchronous speed, the voltage that would be generated in the rotor, is

A. zero

B. equal to applied voltage

C. more than applied voltage

D. None of these

147. In a induction motor, if the rotor is locked, then the rotor frequency of induction motor will be

A. more than the supply frequency

B. zero

C. equal to the supply frequency

D. less than the supply frequency

148. In an induction motor, the rotor frequency is 4.5 Hz when the slip is 7.5%. Then the rotor frequency for the slip 2.5% is (assume supply frequency of 50 Hz)

A. 13.5 Hz B. 1.5 Hz

C. 0 Hz D. 1 Hz

149. When measuring the no load input to an induction motor, using two wattmeter method, it is necessary to subtract wattmeter readings, because the no load power factor is

A. lagging B. less than 0.5

C. unity D. zero

150. The speed of 25 Hz induction motor is 720 r.p.m. If speed at no load is 745 r.p.m., then the percent slip and percent regulation is

A. 0.667%, 3.47% B. 0.667%, 0.667%

C. 4%, 3.47% D. 4%, 0.667%

151. If the speed is 460 r.p.m. then the number of poles of a 50 Hz induction motor are

A. 4 B. 8

C. 12 D. 18

152. If a 3-phase, 60Hz, 10-pole induction motor has a full load slip of 0.075, then the speed of rotor relative to revolving field will be

A. 54 r.p.m. B. 1000 r.p.m.

C. zero r.p.m. D. 720 r.p.m.

153. A 3-phase, 440 *V*, 60Hz induction motor is to be operated at 25 Hz. The voltage that should be applied to the machine if the air gap flux density is to be maintained at its normal value is

A. 183 V B. 105.7 V

C. 609.7 V D. None of these.

154. The purpose of skewing of rotor slots in induction motor is:

A. to reduce the magnetic hum of motor

B. to increase the distribution factor

C. to reduce the locking tendency of rotor

D. to increase the breadth factor

155. In a 4 pole, 50 Hz, 3-phase induction motor, blocked rotor reactance per phase is four times the rotor resistance per phase. The speed at which maximum torque developed is

A. 1500 r.p.m. B. 1125 r.p.m.

C. 1000 r.p.m. D. None of the above

156. An induction motor has a rotor resistance of 0.02 ohm and a stand still reactance of 0.1 ohm. The value of total resistance of a starter for the rotor circuit for maximum torque to be inserted at starting is

A. 0.002 ohm B. 0.08 ohm

C. 0.8 ohm D. None of these

Answers : 143. (D), 144. (A), 145. (D), 146. (A), 147. (C), 148. (C), 149. (B), 150. (C), 151. (C), 152. (A), 153. (A), 154. (C), 155. (B), 156. (B).

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157. In an induction motor, the ratio of torque exerted at 4% slip to maximum torque, when slip at maximum torque is 12% will be

A. $\frac{3}{5}$ B. $\frac{5}{3}$

C. $\frac{1}{3}$ D. None of these

158. In an induction motor, the ratio of starting torque to maximum torque is 80%. The speed at maximum torque if the synchronous speed is 1500 r.p.m. is

A. 1290 r.p.m. B. 1360 r.p.m.

C. 1440 r.p.m. D. None of these

159. An induction motor has a slip of 2% at normal voltage. The slip when developing the same torque at 10% below normal voltage is

A. 1.65% B. 2.47%

C. 2.22% D. 1.82%

160. In an induction motor the rotor resistance is equal to stand- still reactance then the maximum torque is

A. less than starting torque

B. equal to starting torque

C. more than starting torque

D. None of these

161. In an induction motor the ratio of the rotor output to rotor input is 0.96. Then the percentage slip is

A. 0.04% B. 4%

C. 6% D. 12%

162. In an induction motor the ratio of starting current to full load current is 12.65 and the ratio of starting torque to full load torque is 1.6. Then percentage slip at full load is

A. 0.01% B. 0.5%

C. 1% D. None of these

163. In an induction motor the short circuit current of the motor at normal voltage is 5 times the full load current and the full load slip is 4%. The starting torque when star-delta switch used is equal to

A. 3 times full load torque

B. 0.33 times full load torque

C. 0.07 times full load torque

D. None of these

164. In an induction motor, the short circuit current at normal voltage is 4 times full load current and the full load slip is 3%. The percentage tapping of an auto transformer required to start the motor against 1/4 of full load torque is

A. 72.2%

B. 25%

C. 100%

D. None of these.

165. What is the speed of rotation of a 5th harmonic component in the stator of an induction motor?

A. 5 times the synchronous speed

B. 1/5 times the synchronous speed

C. 0.5 times the synchronous speed

D. None of these

166. Consider a cascaded set of two motors *A* and *B* with 4 poles and 6 poles respectively. The electric power transferred to motor *B* when the input to motor *A* is 25 *kW* (neglect losses) is

A. 16.67 *kW* B. 0.05 *kW*

C. 1.0 *kW* D. 10 *kW*

167. The complete circle diagram of an induction motor can be drawn with the help of data found from

A. no-load test

B. blocked rotor test

C. (A) and (B)

D. (A), (B) and stator resistance test.

168. The power scale of circle diagram of an induction motor can be found from

A. no-load test only

B. short-circuit test only

Answers : 157. (A), 158. (C), 159. (B), 160. (B), 161. (B), 162. (C), 163. (B), 164. (A), 165. (B), 166. (D), 167. (D), 168. (B).

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C. stator resistance test

D. none of these.

169. Which of the following is not determined by circle diagram ?

A. Output

B. Efficiency

C. Power factor

D. Frequency.

170. The torque of an induction motor in synchronous watt is equal to

A. rotor output

B. stator output

C. stator input

D. watts at rotor speeds.

171. The torque of a rotor in an induction motor under running condition is maximum

A. at unity value of the slip

B. at zero value of slip

C. at the value of slip which makes the rotor reactance half of the rotor resistance

D. at the value of slip which makes the rotor reactance per phase equal to its resistance per phase.

172. The shape of torque/slip curve of an induction motor is

A. hyperbola B. parabola

C. straight line

D. rectangular parabola.

173. When the frequency of the rotor of an induction motor is small it can be measured by

A. galvanometer

B. dc moving coil milli-voltmeter

C. dc moving coil ammeter

D. ac voltmeter.

174. The stator frame in an induction motor is used

A. as a return path for the flux

B. to hold the armature stampings/stator

C. to protect the whole machine

D. to ventilate the armature.

175. A three-phase 6 pole 50 Hz induction motor is working with 5% slip. The actual speed of the motor is

A. 1000 rpm

B. 950 rpm

C. 900 rpm

D. 850 rpm

176. The speed of a three phase cage-rotor induction motor depends on

A. frequency of the supply only

B. number of poles only

C. number of poles and frequency of the supply

D. input voltage.

177. In a three-phase induction motor, the power output is maximum when the equivalent load resistance is

A. equal to the stand-still resistance of the motor

B. equal to the stand-still impedance of the motor

C. equal to the stand-still reactance of motor

D. equal to none of the above.

178. A 440 V, 50 Hz 6 pole, three-phase induction motor has 3% slip. The relative speed between the rotor and stator magnetic field will be

A. zero

B. 970 rpm

C. 1,000 rpm

D. more than 1000 rpm.

179. A three-phase induction motor connected in star takes 5 A. When connected in delta, it will take

A. $5/\sqrt{3}$ A

B. $5\sqrt{3}$ A

C. 15 A.

D. 5A.

Answers : 169. (D), 170. (B), 171. (D), 172. (D), 173. (B), 174. (A), 175. (B), 176. (C), 177. (B), 178. (A), 179. (C).

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180. The slip of a 500 HP, 3 ϕ, 400V, 50 Hz induction motor is 5%. How many complete cycles will the rotor voltage make per minute?

A. 1000 B. 1200

C. 1500 D. 2000

181. A 15 HP, 400 V delta connected, 50Hz, 4-pole induction motor gives the following test results:

	Applied voltage	*Line current*	*Input power*
No-load Test	400V	8A	1.0 kW
Locked Toro Test	100V	25 A	1.75 kW

The short-circuit current with normal voltage will be

A. 8A B. 25A

C. 75A D. 100.

182. In the above problem, short-circuit input power with normal voltage will be

A. 2.4 kW, B. 3 kW

C. 25 kW D. 28 kW.

183. In the same problem, short-circuit power factor will be

A. 66.2° B. 78.6°

C. 0.2 D. 0.404.

184. The starting current of a three-phase induction motor is 60A at full load. The current drawn by the same motor at no-load will be

A. 10 A

B. 90 A

C. 60 A

D. dependent on line voltage.

185. Whenever any polyphase induction motor is loaded then

A. induced emf in the rotor increases and its frequency falls.

B. induced emf in the rotor increases and its frequency rises.

C. induced emf in the rotor remains constant.

D. induced emf decreases and frequency increases.

186. A three-phase, 8-pole, induction motor runs on 50 Hz supply. The rotor bar current makes 150 complete cycles per minute. Then the rotor moves, at a speed of

A. 710 rpm B. 713.5 rpm

C. 712.5 rpm D. none of these.

187. In three-phase slip ring induction motor, input is 440 V and the voltage at the slip rings is 110V. If an input of 110V is given to the slip rings, the stator voltages would be

A. 500 V

B. nearby equal to 440 V

C. nearly equal to 110 V

D. zero.

188. For a three-phase induction motor, input power on no load is $W_0 = 600$ watts and windage and friction losses is $W_f = 183$ watts. The stator copper-loss will be equal to

A. 783 W B. 600 W

C. 183 W D. 517 W.

189. Two induction motors have 12 poles and 8 poles respectively. If the supply frequency is 25Hz, the possible running speed of the set will be

A. 750 rpm B. 250 rpm

C. 100 rpm D. 150 rpm.

190. For good overall design of induction motor, the ratio L/τ for a fixed member of poles should be

A. 1.5 to 2 B. 1.0 to 1.25

C. 1.5 D. 1.

191. With larger values of L/τ ratio, the insulation cost

A. increases B. decreases

C. remains same D. none of these.

192. Imbalance in shaft of the induction motor occurs due to

A. air gap is not uniform

Answers : 180. (C), 181. (D), 182. (D), 183. (A), 184. (C), 185. (A), 186. (D), 187. (B), 188. (B), 189. (D), 190. (D), 191. (B), 192. (A).

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B. overheating of the winding

C. rugged construction

D. slip rings.

193. The noise and tooth pulsation losses can be minimised by using

A. large number of open slots in stator

B. small number of open slots in stator

C. large number of narrow slots in stator

D. small number of narrow slots in stator.

194. Dispersion cofficient σ is the ratio of

A. magnetising current to supply voltage

B. magnetising current to ideal short circuit current

C. open circuit voltage to short circuit for the same excitation

D. none of these.

195. Maximum power factor is given by

A. $\frac{1\ \sigma}{1+\sigma}$ B. $\frac{1+\sigma}{1-\sigma}$

C. $\frac{1}{1+\sigma}$ D. $\frac{1}{1\ \sigma}$

196. Maximum power factor for dispersion coefficient of 0.05 will be

A. 0.905 B. 0.817

C. 0.605 D. 0.50.

197. To obtain maximum power factor of 0.9 the dispersion coefficient σ, will be

A. 0.5 B. 0.08

C. 0.05 D. 0.04

198. In an induction motor with star-delta starter at star position

A. the torque developed is three times as high as at the run position

B. the torque developed is $\sqrt{3}$ times as high as at the run position

C. the current is $\frac{1}{\sqrt{3}}$ times of the current at direct on line starting

D. none of these.

199. while starting an induction motor with star-delta starter at the star position

A. the torque developed is three times as high as at the run position

B. the torque developed is $\frac{1}{3}$ times that at the run position

C. the current is $\frac{1}{3}$ of the current at direct on line starting

D. none of these.

200. In two induction motors, running at the same speed and having same number of poles, the physical dimensions are in the ratio of 3:2. The output of both the motors will be in the ratio of

A. 3 : 2 B. 9 : 4

C. 27 : 8 D. 81 : 16.

201. In the above question, the iron-losses will be in the ratio of

A. 3 : 2 B. 9 : 4

C. 27 : 8 D. 81 : 16.

202. In the above question, the copper-losses will be in the ratio of

A. 3 : 2 B. 9 : 4

C. 27 : 8 D. 81 : 16.

203. If two phases open accidentally of three-phase supply of a running three-phase induction motor, the motor will

A. stop

B. run at high speed

C. continue to run depending on load

D. none of these.

204. If 3-phase induction motor is switched on with one phase disconnected, it

A. is likely to burn out

B. will run at very low speed

C. will not run at all

D. none of these.

205. In squirrel-cage induction motor, if the rotor is open, the rotor

Answers : 193. (C), 194. (B), 195. (A), 196. (A), 197. (C), 198. (B), 199. (C), 200. (D), 201. (C), 202. (C), 203. (C), 204. (A).

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A. high over-load capacity

B. low over-load capacity

D. no effect no over-load capacity

D. none of these.

219. A short air gap in an induction motor is necessary to achieve

A. increased over-load capacity

B. to reduce the pulsation loss

C. to reduce the noise

D. a good pf.

220. The large value of air gap length in an induction motor results in

A. increased over-load capacity

B. reducing the pulsation loss

C. providing better cooling

D. reducing the noise.

221. The length of air gap in an induction motor is given by

A. $0.2 + 2\sqrt{DL}$ mm.

B. $0.2 + \sqrt{2\,DL}$ mm.

C. $0.2\ \ 2\sqrt{DL}$ mm.

D. $0.2 + \sqrt{DL}$ mm.

222. In an induction motor, the motor fails to start when number of rotor slots is equal to number of stator slots this is known as

A. crawling B. cogging

C. synchronous cusps

D. none of these.

223. The simplest way to eliminate the harmonic induction torques is

A. integral slot winding

B. skewing

C. chording

D. none of these.

224. The motor noise, vibrations, cogging and synchronous cusps can be reduced by

A. chording

B. integral slot winding

C. skewing

D. increasing the air gap length.

225. The difference between stator slots and rotor slots in an induction motor should not be equal to p, $2p$, or $5p$ to avoid

A. crawling

B. noise and vibrations

C. synchronous cusps

D. magnetic locking.

226. Rotor slot of squirrel-cage induction motor are skewed slightly, so as to

A. increase the mechanical strength of rotor

B. make the rotor construction simplex

C. eliminate locking tendency of the rotor and to reduce the noise

D. save the amount of copper required.

227. In a 3-phase wound-rotor induction motor, 3-phase balanced supply is given to the rotor and stator winding is short-circuited. The rotor would

A. not run

B. run in the direction of rotating field

C. run against the direction of rotating field

D. run at half synchronous speed.

228. A 3-phase slip-ring induction motor has 4-pole stator and 2-pole rotor. If its stator is energised from 50 Hz source, the rotor would run at a speed

A. slightly less than 1500 r.p.m.

B. slightly less than 3000 r.p.m.

C. slightly less than 1200 r.p.m.

D. of zero r.p.m.

229. The rotor of an induction motor can't run at synchronous speed, if it did so then

A. rotor e.m.f. would be zero

B. rotor current would be zero

C. rotor torque would be zero

D. all of these.

Answers : 218. (A), 219. (D), 220. (A), 221. (A), 222. (B), 223. (C), 224. (C), 225. (C), 226. (C), 227. (C), 228. (D), 229. (D).

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230. A 3-phase induction motor is running at half-full load. If the fuse in one of the phases gets burnt, the motor would

A. come to standstill

B. continue running at the same speed

C. continue running at slightly reduced speed

D. continue running at an increased speed.

231. A 3-phase, 50 Hz, 4-pole squirrel cage induction motor has its stator rewound for 6 poles without any alterations in the rotor. The motor would now run at a speed

A. less than 1000 r.p.m.

B. less than 1500 r.p.m.

C. less than 3000 r.p.m.

D. zero r.p.m.

232. A 3-phase squirrel-cage induction motor, designed to operate with stator in star, requires W kg of copper for its stator winding. If this motor is to be designed to operate with stator in delta, then weight of stator copper would be

A. more than W kg

B. less than W kg

C. $\sqrt{3}\,W$ kg

D. $\frac{1}{\sqrt{3}}W$ kg

233. The rotor of a 3-phase induction motor is running at a speed of n_r r.p.s. The slip-frequency currents in the rotor would produce a field which is

A. startionary with respect to rotor

B. rotating at synchronous speed w.r.t. stator

C. rotating at n_r r.p.s. w.r.t. stator

D. rotating at small slip w.r.t. stator.

234. If the rotor of a 3-phase slip-ring induction motor is fed from balanced 3-phase supply with the stator short-circuited, then frequency of stator currents would be

A. sf B. $(2-s)f$

C. $(1-s)f$ D. $(s-1)f$

235. The stator of a 3-phase, 4-pole, slip-ring induction motor is fed from 50 Hz source and its rotor from 30 Hz source. The motor will run at

A. 1500 r.p.m. B. 900 r.p.m.

C. zero r.p.m. D. 2400 r.p.m.

236. The capacitor start motor uses

A. paper capacitor

B. electrolytic capacitor

C. air capacitor

D. None of above

237. The value of the capacitor in a capacitor start motor controls the

A. starting torque

B. speed of the motor

C. efficiency

D. None of above

238. Under no load conditions, the speed of a universal motor is limited by

A. supply frequency

B. supply voltage

C. windage and friction.

D. None of above

239. Which of the following motors does not use a centrifugal switch.

A. split phase motor

B. capacitor start capacitor run motor

C. shaded pole motor

D. None of above

240. Which of the following motors uses a commutator

A. universal motor B. split phase motor

C. shaded pole motor D. None of above

241. If a *d.c.* series motor is connected to an *a.c.* supply

A. the motor will not start

B. the motor will start but then come to a stop

C. the motor will start and run but will have poor performance

Answers : 230. (C), 231. (A), 232. (D), 233. (B), 234. (A), 235. (D), 236. (B), 237. (A), 238. (C), 239. (C), 240. (A), 241. (C).

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D. None of these

242. If a 3-phase, 4-pole 50 Hz induction motor runs at a speed of 1440 r.p.m., then the slip is

A. 0.03 B. 0.10

C. 0.04 D. 0.05.

243. If the rotor of a 3-phase induction motor is assumed purely resistive, then electromagnetic torque is

A. minimum with load angle of 90°

B. minimum with load angle of 90°

C. optimum with load angle of 90°

D. optimum with load angle of 0°

244. If the rotor of an induction motor is assumed purely inductive, then electromagnetic torque is

A. optimum with load angle $\delta = 0^\circ$

B. optimum with $\delta = 90^\circ$

C. maximum with $\delta = 90^\circ$

D. zero.

245. If both the supply voltage and frequency are reduced to 90% of their previous values in a 3-phase induction motor, then the new torque T_e in terms of its previous value is

A. 0.90 B. 1.11

C. 2.00 D. 1.00.

246. In a 3-phase induction motor, the maximum torque

A. is proportional to rotor resistance r_2

B. does not depend on rotor resistance r_2

C. is proportional to $\sqrt{r_2}$

D. None of these.

247. In a 3-phase induction motor, if stator impedance is neglected, then the slip at maximum torque is equal

A. $\frac{x_2}{r_2}$ B. $\frac{r_2}{x_2}$

C. $\sqrt{\frac{r_2}{x_2}}$ D. $\sqrt{\frac{x_2}{r_2}}$

248. If the auto-transformer tapping K is less than 1, then the starting torque of the cage induction motor with this auto-transformer starter is

A. $K \times$ Starting torque $T_{e\,st}$ with direct switching

B. $K^2 \times T_{st}$

C. $\frac{1}{K} \times T_{st}$

D. $\frac{1}{K^2} \times T_{st}$

249. A starting torque of 100 Nm is developed by an auto-transformer starter with a tapping of 40%. If the tapping of autotransformer starter is at 80%, then the starting torque would be

A. 200 Nm B. 50 Nm

C. 400 Nm D. 25 Nm.

250. With direct on line starter, a 3-phase delta-connected induction motor takes starting line current of 30A and develops a starting torque of 173.2 Nm. When started by star-delta starter, the starting line-current and starting torque are respectively equal to

A. 10 A, 100 Nm

B. 17.32 A, 100 Nm

C. 10 A, 57.73 Nm

D. 17.32 A, 57.73 Nm.

251. The complete circle diagram of a 3-phase induction motor can be drawn with the help of

A. running-light test alone

B. both running-light and blocked-rotor tests

C. running-light, blocked-rotor and stator-resistance tests

D. blocked rotor test alone.

252. The power factor of a delta-connected 3-phase, 50 kW induction motor is 0.4 when delivering 20% of its rated load. If its stator is reconnected in star, then its p.f.

Answers : 242. (C), 243. (C), 244. (E), 245. (D), 246. (B), 247. (B), 248. (B), 249. (C), 250. (C), 251. (C).

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A. remains unchanged
B. is improved
C. is worsened
D. none of these.

253. A 3-phase induction motor is running at slip s. If its two supply leads are interchanged, then its slip at that instant is equal to
A. $2s$ B. $1 - s$
C. $2 - s$ D. zero.

254. A 3-phase induction motor runs at 980 rpm. at no load. If its squirrel-cage rotor is replaced by solid cylinder, then its no-load speed would be
A. zero B. 980 rpm.
C. below 980 rpm. D. 490 rpm.

255. An induction motor in which the stator has the squirrel cage winding is
A. 3-phase squirrel cage motor
B. 1-phase induction motor
C. 1-phase ceiling fan
D. 1-phase table fan.

256. For satisfactory performance of a 3-phase 420 V, 60 Hz induction motor, the supply voltage at 50 Hz should be equal to
A. 420 V B. 380 V
C. 350 V D. 400 V.

257. A 3-phase wound-rotor induction motor, with star-connected rotor, runs clockwise. If the phase sequence of the rotor terminals is changed, then the motor would
A. not run
B. run clockwise
C. run anti-clockwise
D. None of these.

258. No-load current of a 3-phase induction motor in terms of its rated current is
A. 10 to 20% B. 2 to 6%
C. 20 to 30% D. 30 to 50%.

259. No-load p.f. of a 3-phase induction motor is
A. 0.2 B. 0.5
C 0.7 D. 0.85

260. Full-load p.f. of a 3-phase induction motor is generally
A. 0.2 B. 0.5
C. 0.7 D. 0.85

261. A 3-phase induction motor should have small air-gap length so that it has
A. more starting torque
B. more pull-out torque
C. better p.f.
D. improved efficiency.

262. Induction motors with open slots have
A. better p.f.
B. improved efficiency
C. more breakdown torque
D. less starting torque.

263. Induction motors A and B have efficiencies of 82 and 92% respectively. Motor A is
A. bigger than B B. smaller than B
C. equal to B D. none of these.

264. Two induction motors have no-load operating power factors of 0.1 and 0.3. The induction motor with 0.1 p.f. is
A. bigger than the other motor
B. smaller than the other motor
C. of the same size as the other motor.
D. None of these

265. Motor A has deeper and narrow slots, whereas motor B has shallow and wide slots. Induction motor A, as compared to motor B, has
A. more starting torque
B. more pull-out torque
C. less starting torque
D. more operating slip.

266. Closed windings are used for
A. a.c. machines

Answers : 252. (B), 253. (C), 254. (C), 255. (C), 256. (C), 257. (B), 258. (D), 259. (A), 260. (D), 261. (C), 262. (C), 263. (B), 264. (A), 265. (C).

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B. d.c. machines
C. d.c. commutator machines
D. both a.c. and d.c. commutator machines.

267. A multi-turn coil has
A. multi-coil-sides
B. one-coil side
C. two-coil-sides
D. four coil-sides.

268. Open windings are used for
A. d.c. machines
B. a.c. machines
C. a.c. commutator machines
D. d.c. commutator machines

269. Closed windings may be
A. single layer
B. double layer
C. both single layer and double layer
D. All of these.

27' Open windings may be
A. single layer
3. double layer
. both single and double layers
). none of these.

271. For C armature coils and P poles, the back pitch for simplex lap winding is

A. $\frac{2}{P}+K$ B. $\frac{2C}{P}-K$

C. $\frac{2C}{P}\pm K$ D. $2CP\pm K$.

272. For a simplex tap winding, the winding pitch is equal to

A. $+2$ B. $-?$

C. ± 1 D. ± 2.

273. For a simplex lap winding, the commutator pitch is equal to

A. $+1$ B. ± 1

C. -1 D. ± 2.

274. If y_b is the back pitch and u is the number of coil-sides per slot, then split coils can be avoided if the following quantity is an integer

A. $\frac{y_b+1}{u}$ B. $(y+1)$

C. $\frac{y_b-1}{u}$ D. y_b-1.

275. For C coils and P poles, the commutator pitch for simplex winding is

A. $\frac{C+1}{P/2}$ B. $\frac{C-1}{P/2}$

C. $\frac{C\pm 2}{P/2}$ D. $\frac{C\pm 1}{P/2}$

276. For C coils and P poles, the winding pitch for a simplex wave winding is

A. $\frac{2C\pm 1}{P/2}$ B. $\frac{2C+1}{P/2}$

C. $\frac{2C-2}{P/2}$ D. $\frac{2C\pm 1}{P}$

277. For simplex wave and lap windings, the back pitch y_b and front pitch y_f are as follows
A. y_b is odd, y_f is even
B. y_b is even, y_f is odd
C. both y_b and y_f are odd
D. both y_b and y_f are even.

278. A 3-phase, 52-slot, 8-pole machine can have a coil span of

A. 4 B. $7\frac{1}{2}$

C. 6 D. 8.

279. A 3-phase machine has 39 slots and 6 poles. This machine can have
A. integral-slot winding
B. integral-slot chorded winding
C. fractional-slot winding
D. none of these.

280. The number of parallel paths in an integral-slot winding with P poles are

A. P B. $2P$

Answers : 266. (D), 267. (C), 268. (B), 269. (B), 270. (C), 271. (C), 272. (D), 273. (B), 274. (C), 275. (D), 276. (D), 277. (C), 278. (C), 279. (D).

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B. Capacitor start

C. Resistance start

D. Capacitor start capacitor run.

295. The repulsion-start induction-run motor is used because of

A. high efficiency

B. high starting torque

C. minimum cost

D. good power factor.

296. The speed/load characteristics of a universal motor is same as that of

A. dc shunt motor B. dc series motor

C. ac motor D. none of these.

297. Which of the following motors has highest starting torque ?

A. Split-phase motor

B. Shaded pole motor

C. Capacitor-start motor

D. Repulsion motor.

298. An induction regulator is used to

A. regulate line voltages

B. regulate speed of induction motor

C. generate ac voltages

D. none of these.

299. Which of the following motors is used for unity power factor?

A. Squirrel-cage induction motors

B. Slip ring induction motor

C. Hysteresis motor

D. Schrage motor.

300. Two-phase twin induction voltage regulator is wound for four poles. When the input to it is 100 V/phase, the maximum and minimum output voltage are 120V and 80V per phase. If the output is to be changed from 120V to 90V, the angle through which the regulator should be turned is

A. 30^{o} B. 45^{o}

C. 60^{o} D. 90^{o}.

301. The rotating part of an *A-C* motor is called the

A. stator B. rotor

C. running winding D. starting winding

302. The squirrel-cage winding of a single-phase motor is placed in the

A. armature B. stator

C. rotor D. field

303. NEMA standards rate motors according to

A. frame number B. horsepower

C. voltage D. weight

304. Where or how is the performance data of a motor found?

A. In NEMA Standards

B. By taking electrical measurements

C. By calculation

D. On the motor's nameplate

305. Which of the following is a characteristic of a single-phase motor?

A. It is not self-starting

B. It is self-starting

C. It requires only one winding

D. It can rotate in one direction only

306. A rotating magnetic field is produced by the current in the two windings displaced by 90 electrical degrees. This is the principle of

A. phase timing

B. phase splitting

C. phase sequence

D. phase relationship

307. The speed of the rotating magnetic field in an induction motor is known as the

A. slip speed

B. effective speed

C. shaft speed

D. synchronous speed

Answers : 295. (B), 296. (B), 297. (C), 298. (A), 299. (D), 300. (C), 301. (B), 302. (C), 303. (A), 304. (D), 305. (A), 306. (B), 307. (D).

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308. After the starting winding is disconnected from the circuit, the motor continues to run only on the
   A. squirrel-cage winding
   B. running winding
   C. magnetic winding
   D. compensating winding

309. Most fractional horsepower motors have what type of bearings?
   A. Pain or sleeve bearings
   B. Ball or roller bearings
   C. Hard and annealed bearings
   D. Soft and porous bearings.

310. A single-phase motor is made self starting by the addition of a/an
   A. running winding B. starting winding
   C. electric starter D. autotransformer

311. A split-phase motor is started by connecting both the running winding and starting winding across the line in
   A. parallel B. series
   C. series-parallel
   D. an inductive coupling

312. If the rotor of a 3-phase induction motor is assumed purely resistive, then electromagnetic torque is
   A. minimum with load angle of 90°
   B. minimum with load angle of 90°
   C. optimum with load angle of 90°
   D. optimum with load angle of 0°

313. If the starting winding is left in the circuit, it will cause the motor to
   A. run faster B. run slower
   C. draw excessive current and overheat
   D. stall on right load

314. How can the direction of rotation of a split-phase be reversed?
   A. By using a reversing stater
   B. By reversing the connections to both windings
   C. By reversing the connections to the starting windings
   D. By changing the brush position

315. Instead of using three different windings per pole group in the stator, one large coil is wound called a
   A. lap winding B. wave winding
   C. complex winding D. skein winding

316. If all the stator coils of a motor are connected for the same magnetic polarity, there will be formed an equal number of
   A. consequent poles with opposite polarity
   B. consequent poles with the same polarity
   C. rotor poles with opposite polarity
   D. rotor poles with the same polarity

317. The stator winding makes an electrical contact with the motor frame. The winding is said to be
   A. open B. grounded
   C. lap wound D. skein wound

318. A megohmmeter reading of zero or low ohms is indicated between the stator winding and motor frame. The winding is
   A. open B. series connected
   C. grounded D. cross connected

319. An open in the centrifugal switch circuit gives an indication of a/an
   A. shorted winding
   B. shorted switch
   C. grounded winding
   D. open winding

320. A motor runs slower than normal. The defect may be
   A. worn bearings
   B. improper-size fuses
   C. open running winding
   D. wrong size brushes

Answers : 308. (B), 309. (A), 310. (B), 311. (A), 312. (A), 313. 9C), 314. (C), 315. (D), 316. (A), 317: (B), 318. (C), 319. (D), 320. (A).

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321. The capacitors used for *A-C* motor starting have no
   A. polarity makings
   B. voltage rating
   C. definite capacitance value
   D. dielectric rating

322. The capacitor in a capacitor-start motor is connected in series with the
   A. running winding
   B. starting winding and centrifugal switch
   C. compensating winding
   D. split-phase winding

323. Before a capacitor-start motor can reverse its direction of rotation, the
   A. centrifugal switch must be opened
   B. running winding must be opened
   C. starting winding must be connected to the line
   D. capacitor connections must be changed

324. The starting winding is connected for opposite polarity to reverse the direction of rotation of a motor running at full speed. This is accomplished by short-circuiting the
   A. centrifugal switch
   B. running winding
   C. starting winding D. capacitor

325. A dual-voltage single-phase motor can be operated on either
   A. 120/240 volts B. 208/240 volts
   C. 240/277 volts D. 240/480 volts

326. A permanent-split capacitor motor does NOT have
   A. a starting winding
   B. a centrifugal switch
   C. a squirrel-cage rotor
   D. reversing capabilities

327. The speed of a two-speed capacitor-run motor is decreased by
   A. increasing the capacitance value
   B. decreasing the capacitance value
   C. increasing the strength of the stator magnetic field
   D. decreasing the strength of the stator magnetic field

328. A 250 μF, 250 volt capacitor is defective. How many 250 μF, 150 volt capacitors are required and how are they connected to obtain 250 μF at 250 volts?
   A. Two connected in series
   B. Two connected in parallel
   C. Four connected in series parallel
   D. Four connected in parallel

329. Which formula is used to find the equivalent capacitance of two capacitors in series?
   A. $C_T = \frac{C_1 C_2}{C_1 + C_2}$ B. $C_T = C_1 + C_2$
   C. $C_T = \frac{C_1 C_2}{C_1 C_2}$ D. $C_T = C_1 - C_2$

330. A capacitor motor has difficulty of starting. What is the probable cause?
   A. Reversed magnetic field
   B. Shorted commutator segments
   C. Shorted windings
   D. All of the above

331. A repulsion start induction-run motor runs as an induction motor when the
   A. commutator segments are short circuited
   B. brushes are shifted to a neutral plane
   C. shorting devices are disconnected
   D. stator connections are reversed

332. The brushes in a repulsion motor are connected
   A. to the external supply
   B. to the stator winding
   C. together by a jumper wire
   D. for induction running only

Answers : 321. (A), 322. (B), 323. (C), 324. (A), 325. (A), 326. (B), 327. (D), 328. (C), 329. (A), 330. (C), 331. (A), 332. (C).

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333. In a repulsion-start, induction-run motor, all commutator segments are short-circuited by
   A. the brushes
   B. a short-circuiting device
   C. an induction winding
   D. equalizer connections

334. The short-circuiting device in a repulsion start induction-run motor operates by
   A. circulating currents
   B. magnetic attraction
   C. centripetal force
   D. centrifugal force

335. The commutator in a repulsion motor provides a means of connecting the
   A. armature windings
   B. stator windings
   C. short-circuiting device
   D. starting-winding

336. The repulsion motor starts and runs as a
   A. split-phase motor
   B. capacitor-start motor
   C. repulsion motor
   D. compound motor

337. Which of the following motors has a squirrel-cage winding embedded in the armature under the regular winding?
   A. compound motor
   B. repulsion-start, induction-run motor
   C. repulsion motor
   D. repulsion-induction motor

338. Changing the electrical connections to reverse the direction of rotation of a motor running at full speed is called
   A. slugging
   B. plugging
   C. dynamic braking
   D. brush shifting

339. Cross-connecting the commutator bars in repulsion motors minimises circulating currents caused by
   A. unequal airgaps between the stator and armature
   B. shorted brushes
   C. the short-circuiting device
   D. a shorted stator winding

340. Centrifugal short-circuiting mechanisms are used only in
   A. split-phase repulsion motors
   B. repulsion motors
   C. repulsion-induction motors
   D. repulsion start, induction-run motors

341. Applying *A.C.* to a *D.C.* shunt motor field causes a high impedance because of the winding's
   A. high resistance
   B. inductive reactance
   C. high induced voltage
   D. capacitive reactance

342. A *D.C.* series motor does *Not* operate satisfactorily on *A.C.* for which of the following reasons?
   A. poor efficiency on *A.C.*
   B. poor power factor on *A.C.*
   C. Excessive sparking on *A.C.*
   D. All of the above

343. To overcome the effects of poor power factor, an *A.C.* series motor uses
   A. laminated iron in the motor frame
   B. high resistance windings
   C. a brush shifting yoke
   D. more field turns than a *D.C.* field

344. The armature reaction is reduced in a universal motor by
   A. shifting the brushes
   B. increasing the number of armature coils
   C. using equalizer connections
   D. connecting a compensating winding in series with the armature.

Answers : 333. (B), 334. (D), 335. (A), 336. (C), 337. (D), 338. (B), 339. (A), 340. (D), 341. (B), 342. (D), 343. (A), 344. (D).

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345. An outstanding feature of a universal motor is its
   A. highest horsepower-per-pound ratio
   B. slow speed
   C. poor performance on D.C.
   D. best performance on 60 Hz power

346. Under no-load conditions, a universal motor tends to run away; its speed is limited only by
   A. the supply frequency
   B. the number of field poles
   C. windage and friction
   D. commutation

347. The recommended brush pressure to use in a Universal motor is
   A. 0.5 to 1.0 psi B. 1.0 to 1.5 psi
   C. 1.5 to 2.5 psi D. 2.5 to 3.5 psi

348. The most common mechanical method of providing speed reduction for universal motors is to use
   A. gearing B. brakes
   C. chains D. belts

349. Which of the following is common cause of brush sparking in a universal motor?
   A. Shorted armature winding
   B. Open armature winding
   C. High commutator mica
   D. All of the above

350. Early breakdown of winding insulation can be caused by
   A. low brush pressure
   B. dust, oil, or other contaminants
   C. high commutator mica
   D. All of the above

351. A rotating magnetic field in a shaded-pole motor is produced by using
   A. salient poles
   B. shading coils
   C. a capacitor
   D. a high inductance winding

352. What type of construction is used for most stator poles of a shaded-pole motor?
   A. Sailent pole
   B. Consequent pole
   C. Alternate pole
   D. Compensated pole

353. The magnetic flux in the shaded part of the stator pole
   A. aids the main pole
   B. leads the main pole magnetic flux
   C. lags the main pole magnetic flux
   D. is in phase with the main pole magnetic flux

354. The direction of rotation in a conventional shaded-pole motor can be reversed by
   A. reversing the line connections
   B. using a capacitor
   C. reversing the rotor
   D. reversing the stator poles 180 degree

355. The direction of rotation in a shaded-pole motor is always toward the
   A. main pole B. shaded pole
   C. salient pole D. consequent pole

356. Which of the following will determine whether or not the rotor of a synchronous motor locks into step with the rotating magnetic field?
   A. Rotor's construction
   B. Line frequency
   C. The speed of the rotating magnetic field
   D. The rate of rotor slip

357. The three types of single-phase synchronous motors are
   A. hysteresis, reluctance, repulsion
   B. hysteresis, reluctance, inductor
   C. reluctance, repulsion, shaded pole
   D. repulsion, shaded pole, inductor

Answers : 345. (A), 346. (C), 347. (C), 348. (A), 349. (D), 350. (B), 351. (B), 352. (A), 353. (C), 354. (D), 355. (B), 356. (B), 357. (B).

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358. The direction or rotation of a hysteresis motor is determined by the
   A. hysteresis loss
   B. magnetic retentivity of the rotor
   C. position of the shaded pole with respect to the main pole
   D. magnetic permeability of the stator

359. What motor is ideal for application, where start/stop timing is required, because of its quick starting and stopping action?
   A. Induction motor
   B. Shaded-pole motor
   C. Reluctance motor D. Hysteresis motor

360. The speed of an inductor motor depends on line frequency and the
   A. stator poles
   B. number of rotor teeth
   C. rotor slip
   D. shaded poles position

361. A synchro-transmitter sends an electrical signal to the
   A. synchro receiver B. motor field
   C. motor starter D. synchro generator

362. The stator windings of synchro transmitters and receivers are excited by
   A. The differential field flux
   B. the *A.C.* magnetic field of the rotor
   C. a *D.C.* source
   D. compensation windings

363. The effective voltage induced in any synchro transmitter coil depends on the angular position of the
   A. phase angle
   B. stator windings
   C. rotor windings
   D. coil's axis with respect to the rotor axis

364. Synchro receivers are electrically identical to
   A. split-phase motors
   B. 3-phase motors
   C. synchro-transmitters of the same size
   D. synchro control transformers of the same size

365. A synchro transmitter is rotated through an angle of 45 degree. The change in angle is called the
   A correspondence B. phase shift
   C. signal D. error

366. The stator voltages of synchro transmitter and receiver approach equality when the receiver
   A. sends a strong signal
   B. approaches correspondence
   C. approaches a critical angle
   D. produces a high torque

367. How are the stator and rotor windings connected in a differential synchro-transmitter?
   A. Series B. Parallel
   C. Wye D. Delta

368. The rotor windings of a synchro control transformer are
   A. never connected to the *A.C.* supply
   B. connected to the *A.C.* supply
   C. connected to the CT taps
   D. for 3-phase power input only

369. A system that controls speed, temperature, or position in relation to a reference is called
   A. control relay B. servomechanism
   C. tachometer C. thermostat

370. A servosystem possesses what four characteristics?
   A. Fast response, high accuracy, unattended control and remote control operation
   B. Good response, good accuracy, attended control and close operation
   C. Good regulation, high output, remote control, high power factor
   D. Low input, high output, good power factor, good service factor

Answers : 358. (C), 359. (A), 360. (B), 361. (A), 362. (B), 363. (D), 364. (C), 365. (A), 366. (B), 367. (C), 368. (A), 369. (B), 370. (A).

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371. In a servosystem, the voltage induced in the rotor of a control transformer is the
   A. driving voltage
   B. opposing the voltage
   C. error voltage
   D. quadrature voltage

372. A servocontrol system for *D.C.* motors is called a/an
   A. series control
   B. shunt control
   C. selsyn
   D. amplidyne

373. An amplidyne is actually a/an
   A. *D.C. amplifier*
   B. *A.C.* amplifier
   C. induction motor
   C. 3-phase generator

374. The residual magnetism is removed in an amplidyne by
   A. reversing the field windings
   B. shifting the brush yoke
   C. short-circuiting one set of brushes
   D. an *A.C.* magneto generator mounted on the amplidyne

375. A servosystem output drive motor should be
   A. a universal motor with reversing capabilities
   B. easily reversible, have required power, and good speed control
   C. easily reversible, highly sensitive, and have constant speed
   D. highly sensitive easily controlled and have variable speed.

376. The principle of the Wheatstone bridge is used in servosystems to
   A. measure system resistance
   B. position control shafts of mechanical devices
   C. amplify error signals
   D. produce equalising signals

377. In a servocontrol bridge and positioning loop system, the direction in which the load is driven depends on the
   A. polarity of the error voltage
   B. polarity of the supply voltage
   C. ratio of the bridge arms
   D. position of the load shaft

378. Servo actuators are designed to produce either
   A. constant speed or variable speed
   B. rotating motion or linear motion
   C. a *D.C.* output or an *A.C.* output-
   D. magnetizing force or demagnetizing force

379. The NEC permits which of the following statements to be applicable for single-phase fractional horsepower motors?
   A. One switch can be a disconnecting means and a controller
   B. Short-circuit protection and overload protection can be combined
   C. A single device can serve more than one function
   D. All the above

380. The size of the over current protection for a motor is based on the
   A. NEC tables
   B. branch circuit conductor size
   C. motor nameplate current rating
   D. horsepower rating

381. The NEC requires a motor to be within sight of the controller, or no further than
   A. 20 ft from the controller
   B. 50 ft from the controller
   C. 75 ft from the controller
   D. 100 ft from the controller

382. The motor circuit switch, or CB must disconnect the motor and its controller from
   A. all grounded conductors
   B. all ungrounded conductors
   C. the overload relays
   D. the branch circuit

Answers : 371. (C), 372. (D), 373. (A), 374. (D), 375. (B), 376. (B), 377. (A), 378. (B), 379. (D), 380. (C), 381. (B), 382. (B).

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383. Motor and controller frames must be grounded to
   A. prevent a potential above-ground
   B. have a common return path
   C. eliminate a grounding conductor
   D. isolate the motor from overcurrents

384. The nearest larger size standard fuse may be used by protection of single-phase circuits under which of the following condition?
   A. Rating of wires do not correspond to a standard size fuse.
   B. Current rating of motor does not correspond to a standard size fuse.
   C. Over load relays of the same size are not available.
   D. All the above.

385. Running overload protection in a manual starting switch is provided by a
   A. dual element fuse
   B. toggle switch
   C. thermal activated device
   D. snap action mechanism

386. When selecting a motor which of the following must be considered?
   A. Voltage and horsepower
   B. Speed and frame enclosure size
   C. Bearings and motor protectors
   D. All the above

387. The insulating materials used for motor windings are classified according to the
   A. motor horsepower rating
   B. levels of temperature rise
   C. overcurrent protection available
   D. controller size

388. Which of the following symbols indicate the correct classes of insulation used for motor windings?
   A. *A, B, C, D* B. *A, B, D, E*
   C. *A, B, F, H* D. *A, B, H, J*

389. By pushing and pulling the rotor shaft, a motor can be checked for
   A. end play B. side play
   C. firm mounting
   D. free shaft movement

390. Insulation resistance of a motor should be checked with a megohmmeter, and the reading recorded when the motor
   A. fails to start
   B. is first installed
   C. breaks down
   D. operates with an overload

391. A loss in the capacitance of a capacitor start motor results in reduced
   A. speed B. voltmeter
   C. armature reaction D. starting torque

392. Trouble in the armatures of repulsion and universal motors is usually caused by a/an
   A. shorted winding
   B. shorted commutator
   C. open winding
   D. open commutator

393. Armature short circuits can be detected and identified by which of the following tests?
   A. Bar-to-bar B. Voltage drop
   C. Growler D. All the above

394. The general area where electrical faults occur most often is in the motor
   A. control equipment B. brushes
   B. rotor D. All the above

395. Electrical noise cannot be heard with
   A. power on B. power off
   C. rotor locked D. defective bearings

396. The belt tension between the motor and driven machine should be
   A. tight
   B adjusted for 1/4-inch midpoint deflection

Answers : 383. (A), 384. (A), 385. (C), 386. (D), 387. (B), 388. (C), 389. (A), 390. (B), 391. (D), 392. (C), 393. (D), 394. (A), 395. (B).

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C. adjusted for 1/2 to 3/4-inch midpoint deflection

D. slack

397. Motor overheating is caused by which of the following faults?

A. Overloads

B. Shorted windings

C. Worn or dry bearings

D. All the above

398. Which of the following is required for evaluating and determining causes of trouble in motor circuitry?

A. A magneto

B. Test equipment

C. A current limiting switch

D. A *D.C.* supply

399. A single phase motor is

A. self starting

B. not self starting

C. self starting with the help of auxiliary winding

D. self starting with the help of capacitor in series.

400. Split phase single phase induction motor

A. has two stator winding connected in series across the supply

B. has two windings main and starting, of same value of resistance and reactance connected across the supply

C. has the main winding of low resistance and high reactance and starting winding of high resistance and low reactance

D. has main winding and starting winding both of high reactance and low resistance

401. In case of split phase induction motor

A. main winding is connected through centrifugal switch

B. starting winding is connected through centrifugal switch

C. both the windings are connected through centrifugal switch

D. None of the windings is connected through centrifugal switch

402. The starting torque of a 1-phase motor can be improved by connecting a capacitor

A. across the supply terminals

B. in series with the main windings

C. in series with the starting winding

D. with both the windings in series

403. If the capacitor of a single phase motor is short circuited, the motor will

A. start

B. not start

C. start with jerks

D. start and then stop

404. The starting torque of a capacitor start motor will be directly proportional to the angle which it makes between starting current and running current

A. $\sin \alpha$ B. $\tan \alpha$

C. $\cos \alpha/2$ D. $\cos \alpha$

405. The capacitor motor is generally used for exhaust fans because

A. it has higher full load efficiency

B. it has high starting torque

C. it has low running torque

D. All the above three

406. In a capacitor start, capacitor run motor, the type of capacitor used is

A. air capacitor

B. paper capacitor

C. dry type *a.c.* electrolytic capacitor

D. paper spaced oil filled type

407. The capacity of the capacitor connected in series with the starting winding of a ceiling fan is

A. 32 μF B. 16 μF

Answers : 396. (C), 397. (D), 398. (B), 399. (C), 400. (C), 401. (B), 402. (C), 403. (B), 404. (A), 405. (D), 406. (D).

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C. 4 μF D. 2 μF

408. The direction of rotation (DOR) of 1-phase capacitor motor (fan) can be reversed in interchanging connection of
   A. main winding and starting winding
   B. starting winding only
   C. main winding only
   D. any one of the starting or main winding

409. If the centrifugal switch of capacitor start, capacitor run motor is permanently short circuited
   A. the motor will not carry the load
   B. the motor will not pick up the speed
   C. the motor will draw very high current
   D. the capacitor may suffer a break down

410. The capacitor start, capacitor run motor is generally coupled with the air conditioner compressor because it
   A. takes low starting as well as running current
   B. is cheaper
   C. is quiet in operation
   D. does not require any maintenance

411. Shaded pole type motor is not generally used because it has
   A. poor starting torque
   B. poor power factor
   C. D.O.R. can not be easily reversed
   D. All the above three

412. The D.O.R. of a shaded pole type motor can be reversed by
   A. interchanging the supply terminals
   B. interchanging the main winding terminals
   C. reversing the position of the rotor
   D. None of the above

413. For high speed and high starting torque which of the following motor can be recommended.
   A. Shaded pole type motor
   B. Capacitor motor
   C. Universal motor
   D. Capacitor start capacitor run motor

414. Single phase universal motor can be used on
   A. a.c. B. d.c.
   C. a.c. and d.c. both D. rectified d.c.

415. Which single phase motor you will recommend for a pistol type drilling machine
   A. split phase motor
   B. capacitor motor
   C. shaded pole type motor
   D. universal motor

416. The rotating part of a 1-phase motor is called
   A. running winding B. rotor
   C. armature D. starting winding

417. When a single phase motor picks up predetermined speed, its starting winding is disconnected, but still it continue to run on
   A. compensating winding
   B. main winding
   C. starting winding
   D. rotor winding

418. The 1-phase fractional horse power motors are generally fitted with
   A. ball bearing
   B. sleeve bearing
   C. roller bearing
   D. sleeve and ball bearing both

419. If a 1-phase motor fails to start but gives huming noise, it is because of
   A. high voltage
   B. low voltage
   C. wrong connection
   D. winding may be short circuited

420. If the starting winding of a 1-phase motor is not disconnected, it will
   A. run at low speed

Answers : 407. (D), 408. (D), 409. (D), 410. (A), 411. (D), 412. (C), 413. (C), 414. (C), 415. (D), 416. (B), 417. (B), 418. (A), 419. (D).

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CHAPTER 9

MEASURING SYSTEMS AND INSTRUMENTATION

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where

T = torque, newton metre (N-m)

B = flux density in the air gap, weber/square metre (Wb/m^2)

A = effective coil area, square meter (m^2)

I = current in the movable coil, amperes (A) and

N = turns of wire on the coil.

This equation shows that the developed torque is directly proportional to the flux density of the field in which the coil rotates, the current in the coil, and the coil constants (area and number of turns).

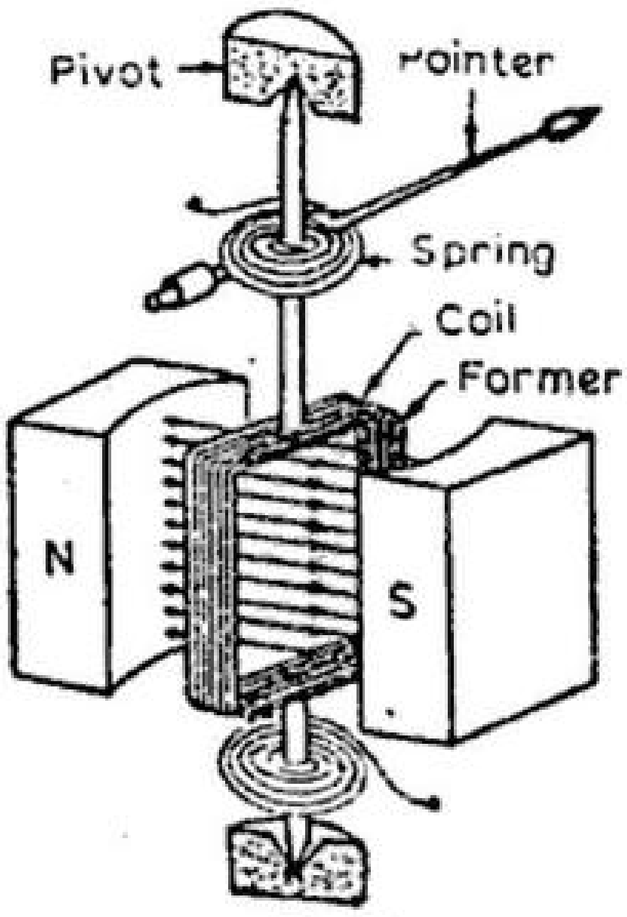


Fig. 9.1

9.3. Permanent Magnet Moving Coil Movement. The basic PMMC movement, also called the d' Arsonval movement, offers a large magnet in a given space and is used when maximum flux in the air gap is required. It provides an instrument with very low power consumption and low current required for full-scale deflection (*fsd*) . The permanent magnet is of horse-shoe form with soft iron pole pieces attached to it. Between the pole pieces is a cylinder of soft iron which serves to provide a uniform magnetic field in the air gap between the pole pieces and the cylinder. The coil is wound on a light metal frame and is mounted so that it can rotate freely in the air gap. The pointer, attached to the coil, moves over a graduated scale and indicates the angular deflection of the coil and therefore the current through the coil.

9.4. Temperature Compensation Movement. The basic PMMC, though inherently insensitive to temperature, may be further temperature-compensated by the appropriate use of series and shunt- resistors of copper and manganin. Both the magnetic field strength and spring tension decrease with an increase in temperature. The coil resistance increases with an increase in temperature. These changes tend to make the pointer read low for a given current with respect to magnetic field strength and coil resistance.

Temperature compensation is obtained with the help of *swamping resistors* in series with the movable coil. The swamping resistor is made of manganin (which has a temperature coefficient of practically zero) combined with copper in the ratio of 20/1 to 30/1. The total resistance of coil and swamping resistor increases slightly with a rise in temperature, but only just enough to counteract the change in the springs and magnet so that the overall temperature effect is zero.

9.5. Galvanometer Sensitivity. The sensitivity of galvanometer can be specified in terms of current sensitivity, voltage sensitivity and megohm sensitivity.

Current Sensitivity may be defined as the ratio of the deflection of the galvanometer to the current producing this deflection *i.e.*,

$$S_I = \frac{d}{I} \frac{mm}{\mu A}$$

where

d = deflection of the galvanometer in scale division in *mm*, and

I = galvanometer current in μA.

Voltage Sensitivity may be defined as the ratio of the galvanometer deflection to the voltage producing this deflection. Therefore,

$$S_V = \frac{d}{V} \frac{mm}{mV}$$

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where

d = deflection of the galvanometer in scale divisions in *mm*, and

V = voltage applied to the galvanometer in *mV*.

Megohm Sensitivity may be defined as the number of megohms required in series with the (CRDX shunted) galvanometer to produce one scale division deflection when 1 *V* is applied to the circuit. Numerically, it is equal to current sensitivity.

9.6. DC Ammeter. The coil winding of the PMMC movement is small and light and it can carry only very small currents. When large currents are to be measured, it is necessary to bypass the major part of the current through a resistance called a shunt, as shown in Fig 9.2 Clearly,

$$\text{Shunt Resistance} \quad R_{sh} = \frac{R_m}{(m-1)}$$

where

R_m = internal resistance of the movement (the coil),

R_{sh} = resistance of the shunt,

I_m = full-scale deflection current of the movement,

I_s = shunt current, and

I = full-scale current of the ammeter including the shunt.

m = Total current/current for full scale deflection

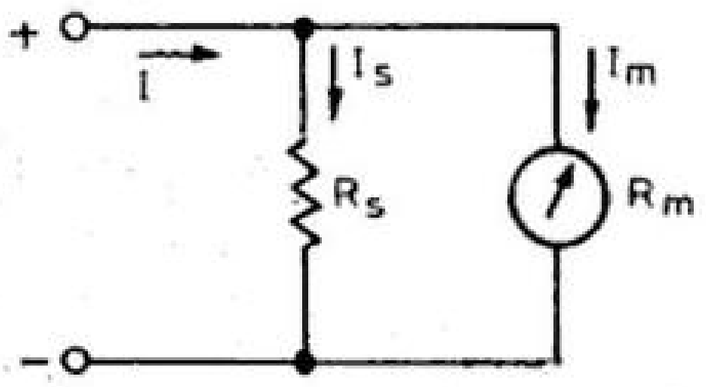


Fig. 9.2

Precautions

(*a*) An ammeter should never be connected across a source of e.m.f., otherwise it would draw damaging high currents as its resistance is low and as a result the delicate movement would be destroyed. It is always connected in series with a load so that the current is limited.

(*b*) The correct polarity should be observed. Reverse polarity causes the meter to deflect against the mechanical stop and this may damage the pointer.

(*c*) When using a multi-range meter, first the highest current range should be used. Then decrease the current range until substantial deflection is obtained. To increase accuracy of the observation, use the range that will give a reading as near to full-scale as possible.

9.7. DC Voltmeter. The basic d' Arsonal movement can be converted into a d.c. voltmeter with the addition of a series resistor, or multiplier, as shown in Fig 9.3. The multiplier limits the current through the movement so as not to exceed the value of the full-scale deflection current (I_{fsd}) .

It is connected across a souree of e.m.f. or a circuit component. The meter terminals are generally marked positive and negative since polarity must be observed.

The value of a multiplier, required to extend the voltage ranges is given below

$$R_s = (m-1)\,R_m$$

where

I_m = deflection current of the movement (I_{fsd}). R_m = internal resistance of the movement,

R_s = multiplier resistance, and V = full-range voltage of the instrument and

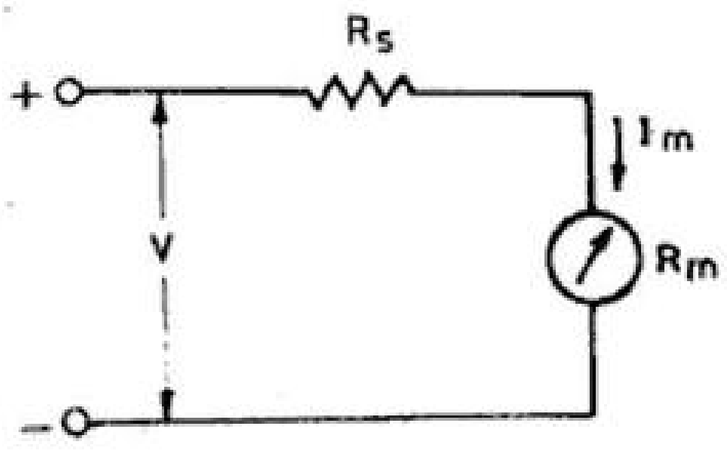


Fig. 9.3

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$$m = \frac{\text{voltage to be measured}}{\text{voltage for full scale deflection}}$$

9.8. Voltmeter Sensitivity (ohms-per-volt rating). The sensitivity, S, is essentially the reciprocal of the full scale deflection current of the basic movement, or

$$S = \frac{1}{I_{fsd}}\ \Omega/V$$

The total resistance of the voltmeter will be

$$R_{total} = S \times V$$

and

$$R_s = (S \times V) - R_m$$

where

S = sensitivity of the voltmeter, in Ω/V, V = the voltage range as set by the range switch,

R_m = internal resistance of the movement (plus the previous series resistors), and

R_s = resistance of the multiplier.

9.8. Ohm-meter. These are the instruments used to measure resistance. It is mainly of two types:

1. Series-type ohm-meter. 2. Shunt-type ohm-meter.

The Series-type Ohm-meter. It essentially consists of d' Arsonval movement connected in series with a resistance and a battery to a pair of terminals to which the unknown resistance is connected. The current through the movement then depends on the magnitude of the unknown resistor and the meter indication is proportional to the value of the unknown resistance provided that calibration problems are taken into account. Fig 9.4 shows the elements of single-range series ohm-meter.

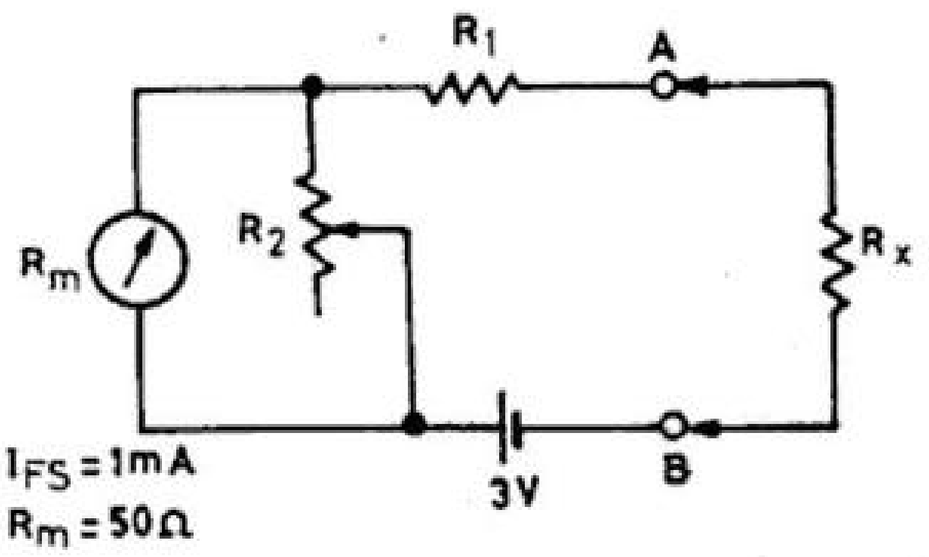


Fig. 9.4

When $R_c = 0$ (terminals A and B shorted), maximum current flows in the circuit under this condition and shunt resistor R_2, is adjusted until the movement indicates full-scale current. The full-scale current position of the pointer is marked 0 ohm on the scale. When $R_x = \infty$ (terminals A and B open), the current drops to zero and movement indicates zero current which is marked '∞' on the scale. Intermediate markings may be placed on the scale by connecting different known values of R_x to the instrument.

Shunt-type Ohm-meter. The circuit diagram of a shunt type ohmmeter is shown in Fig 9.5. In this circuit, it is necessary to have an off-on switch to disconnect the battery from the circuit when the circuit is not used. When $R_x = 0$ (A and B shorted), the meter current is zero. If $R_x = \infty$ (A and B open), a current finds a path only through the meter and by appropriate selection of the value of R_1, the pointer can be made to read full scale. This ohm-meter has zero mark at the left hand of scale (no current) and infinite mark at the right hand side of the scale. It is particularly used for low value resistors.

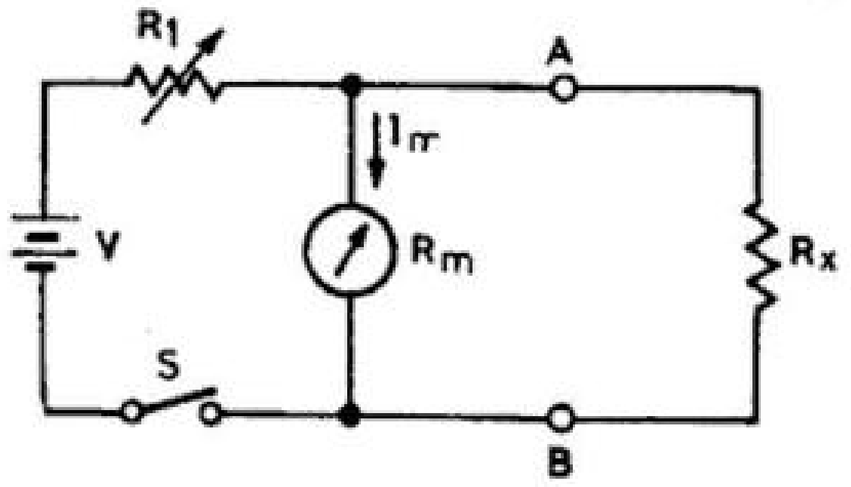


Fig. 9.5

9.9. Megger (Insulation Tester). It consists of a permanent magnet, closed-coil meter and a power

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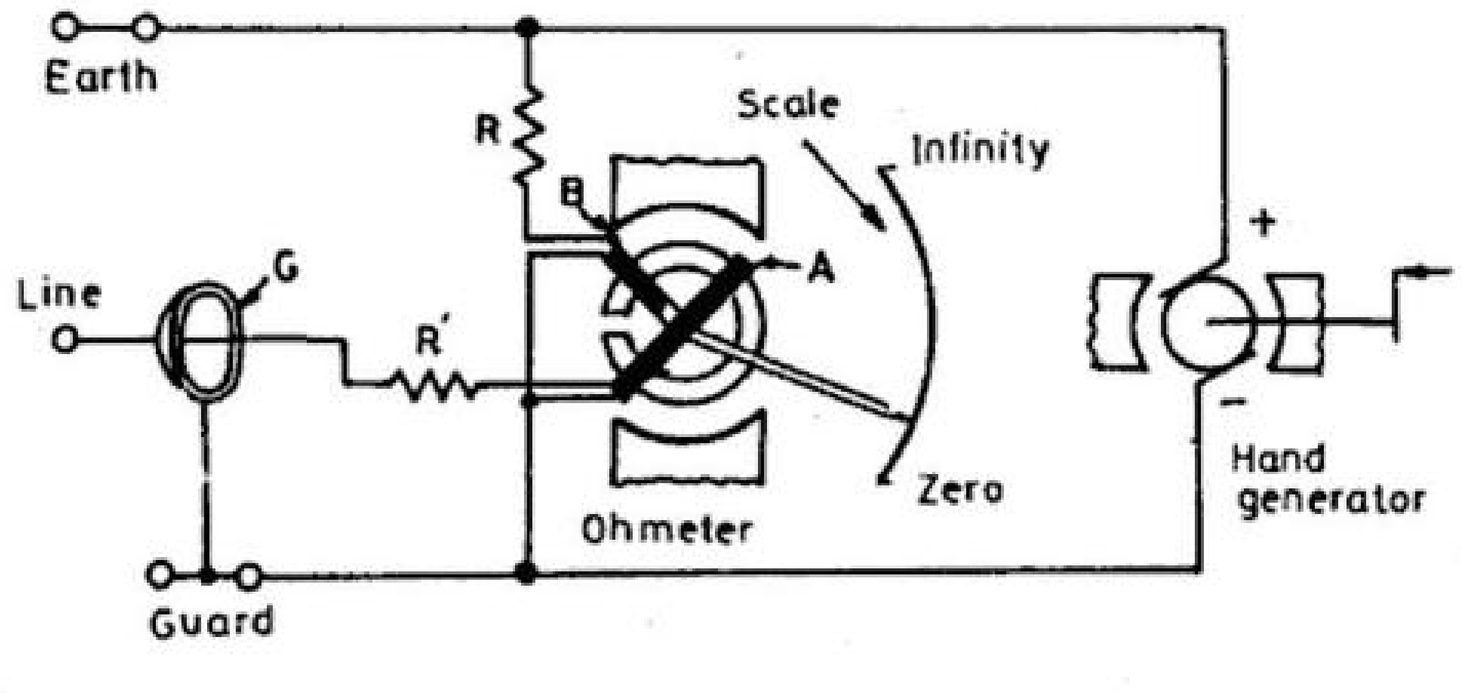


Fig. 9.6

supply that may be either a hand driven generator or a rectified a.c. supply as shown in the Fig 9.6. The two torque opposing coils are mounted rigidly together on a shaft that carries the pointer. The spirals that conduct current from the coils are made to have as little torque as possible. One of the moving coils is a current coil in series with the the generator, and the other coil is connected in series with a fixed resistor across the generator terminals. For any value of the unknown, the coils and the pointer take up a position such that the torques of the two coils are equal and balanced against one another, and thus the position of the coil is independent of the generator voltage because a change of voltage affects both the coils in the same proportion. The scale of the meter can be calibrated directly in the resistance value, with zero at one end and infinity at the other. The scale distribution depends upon the series resistor and on the shape of the magnet poles.

The megger is used very commonly to measure the insulation resistance of electrical machinery insulators, insulation bushings, and so on. The test is made with a moderately high voltage stress on the insulation. The generator (or the rectified a.c. supply) are made in different models for 100, 500, 1000, 2500 or 5000 volts.

9.10. Alternating-Current Indicating Instruments. If the PMMC movement carries an alternating current with positive and negative half cycles, the driving torque would be in one direction for the positive alternation, and in the other direction for the negative alternation. If the frequency of the a.c. is very low, the pointer would swing back and forth around the zero point on the meter scale.

To measure a.c. on a d' Arsonval movement, the signal can be made unidirectional by rectification of the a.c. Other methods use the heating effect of the alternating current to produce an indication of its magnitude.

9.11. Electrodynamo-meter. It is one of the most important a.c. movement and is often used in accurate a.c. voltmeters and ammeters, not only at the power line frequency but also in the lower audience frequency range. With some slight modifications the electro-dynamometer can be used as a wattmeter, var-meter, a power-factor, or a frequency meter.

The electrodynamometer uses the current under measurement to produce the necessary field flux. Fig. 9.7 shows a schematic arrange-ment of the parts of this movement. A fixed coil, split into two equal halves, provides the mag-

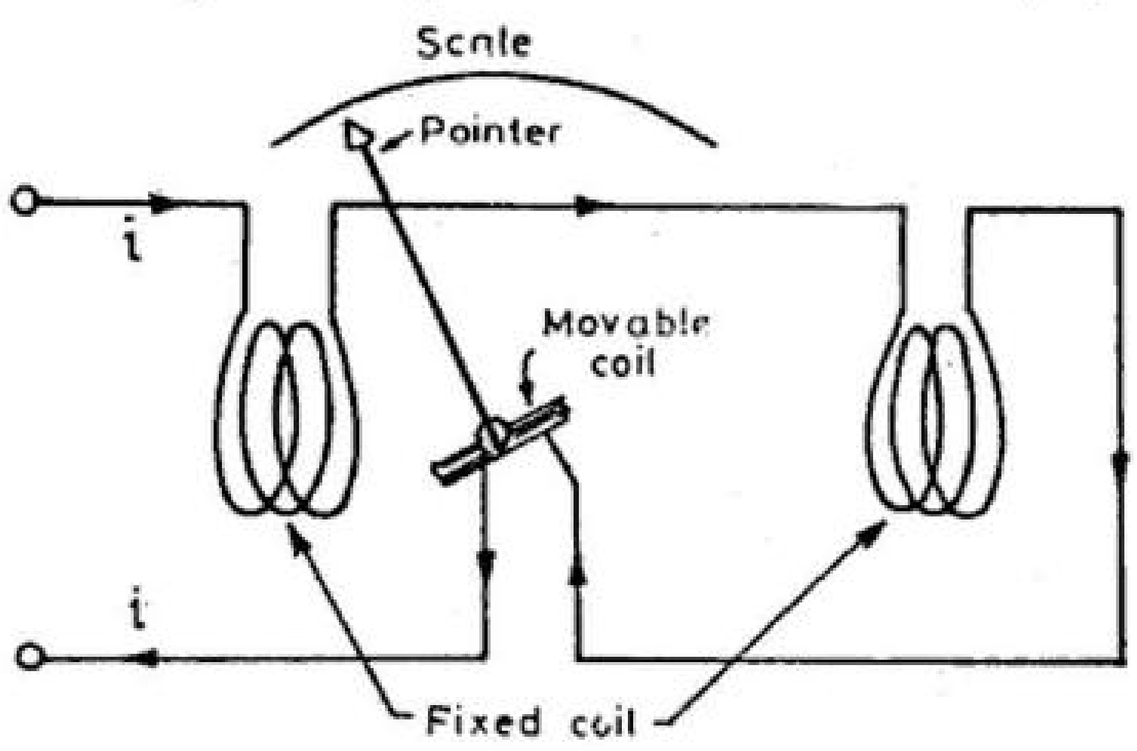


Fig. 9.7

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netic field in which the movable coil rotate. The two coil halves are connected in series with the moving coil and are fed by the current under measurement. The fixed coils are spaced far enough apart to allow passage of the shaft of the movable coil. The movable coil carriers a pointer which is balanced by counterweight. Its rotation is controlled by springs, similar to the *d'* Arsonval movement construction. The complete assembly is surrounded by a laminated shield to protect the instrument from stray magnetic fields which may affect its operation. Damping is provided by aluminium air vanes, moving in sector - shaped chambers. The entire movement is very solid and rigidly constructed in order to keep its mechanical dimensions stable and its calibration intact.

The torque developed by a coil suspended in a magnetic field is given by

$$T = B \times A \times I \times N$$

The scale of the electrodynamometer is usually calibrated in terms of the r.m.s. or effective value of the a.c.

9.12. Polyphase Wattmeter. Power measurements in a polyphase system require the use of two or more wattmeters. The total real power is then found by algebrically adding the readings of the individual wattmeters. If the neutral wire of the three-phase system is also present as in case of four-wire star-connected load, three wattmeters would be needed to make the total real power measurement.

Three Wattmeter Method. In this method, three wattmeters are connected, one in each phase. The three wattmeter readings add up to give the total power supplied. If the potential coils measure V_p and the current coils, I_p. The total power is $P_T = 3V_p I_p \cos \varphi$.

In three wire star system the neutral is usually not accessible. It is more convenient to use two wattmeter method.

Two Wattmeter Method. The two wattmeter method can be used in a three wire system for delta or star connected load.

The total power in a three-phase system $= \sqrt{3}\ V_L I_L \cos \phi$. This can prove that the power in three wire system is the sum of the readings of the two wattmeters. This method is also used to calculate the phase angle φ.

$$\tan \varphi = \sqrt{3}\ \frac{P_2 - P_1}{P_2 + P_1} \quad \text{for balanced load.}$$

Rective Power Measurements The rective power is given by

$$P_r = VI \sin \varphi$$

It indicates the exchange of power between the source and the load due to the reactance of the circuit. Reactive power can be measured by an instrument called the **varmeter.**

A varmeter is in effect a wattmeter in which the current in its potential coil has been shifted to lag the applied potential by 90°. Fig 9.8 shows the modified circuit of the varmeter. The current in the potential moving coil has been shifted 90° by means of a tapped inductor and a shunt resistor. The meter is now sensitive to reactive power and is calibrated in vars.

In three-phase three-wire system, the reactive power is given by

$$P_r = \sqrt{3}\ V_L I_L \sin \varphi$$

The reactive power in single phase varmeter is connected as shown in Fig 9.9. The meter reading must be multiplied by $\sqrt{3}$ when the meter is not calibrated for three-phase measurements.

9.13. Power Measurement at High Frequency. For the measurement of power at high frequency (in the microwave region) *absorption meters* are used. The two types of absorption meters which are extensively used in the band of frequencies from 500 MHz to 40 GHz are: 1. Calorimeter power meter, 2. Bolometer power meter.

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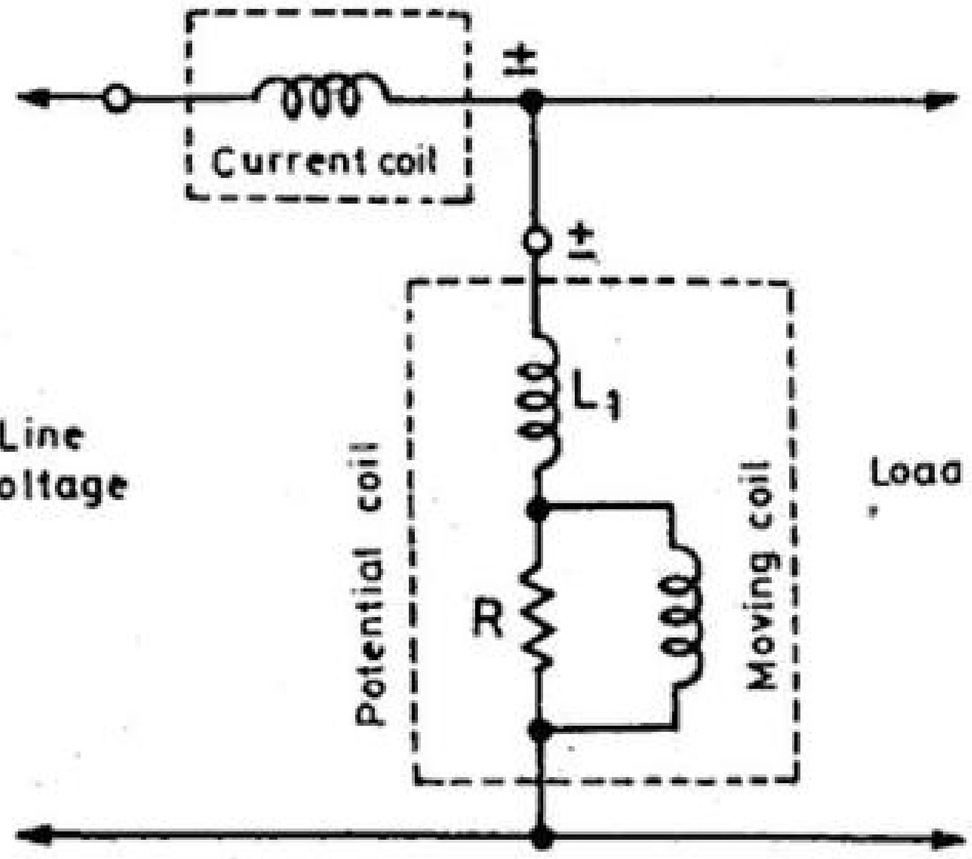


Fig. 9.8

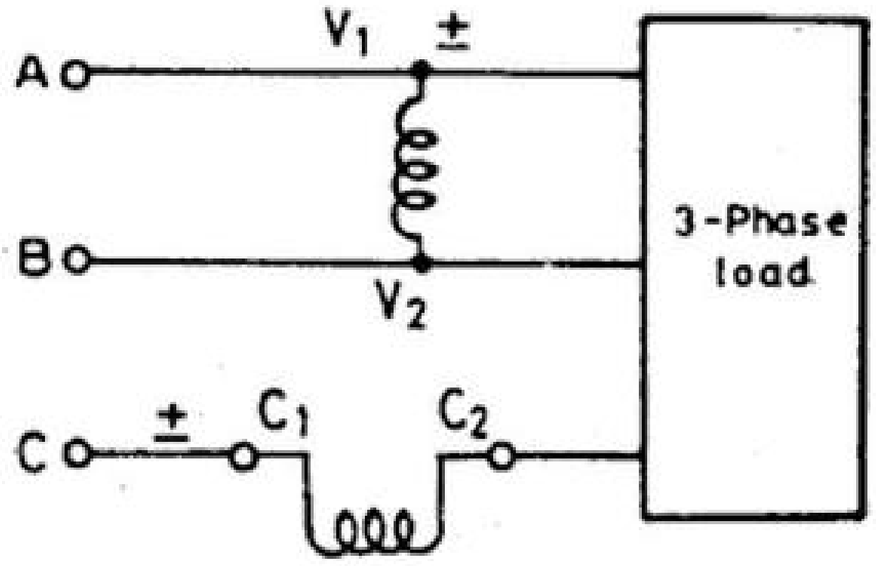


Fig. 9.9

Calorimeter Type Power Meter. The basic principle of operation of the calorimeter type power meter is quite simple as illustrated in Fig 9.10. A resistor is heated by the signal to be measured. The resistor is in a completely enclosed, well insulated fluid bath. The insulation of the walls of the bath are such that very little heat is allowed to radiate from the bath. If the bath temperature is measured before and after the signal is applied, the difference in temperature is a measure of the heat developed by the resistor. Knowing the volume, the specific heat of the fluid and the characteristics of the bath, the power can be calculated. The need to know the exact mass and specific heat of calorimeter bath material restricts the usage of the basic calorimeter power meter. Some of these difficulties are avoided in an instrument called the *substitution calorimeter*. Another calorimeter type instrument is the *comparison flow calorimeter*. In this instrument, the fluid is made to pass in separate streams by the input load and the comparison load. The power to the comparison load is a function of the difference in temperature between the loads.

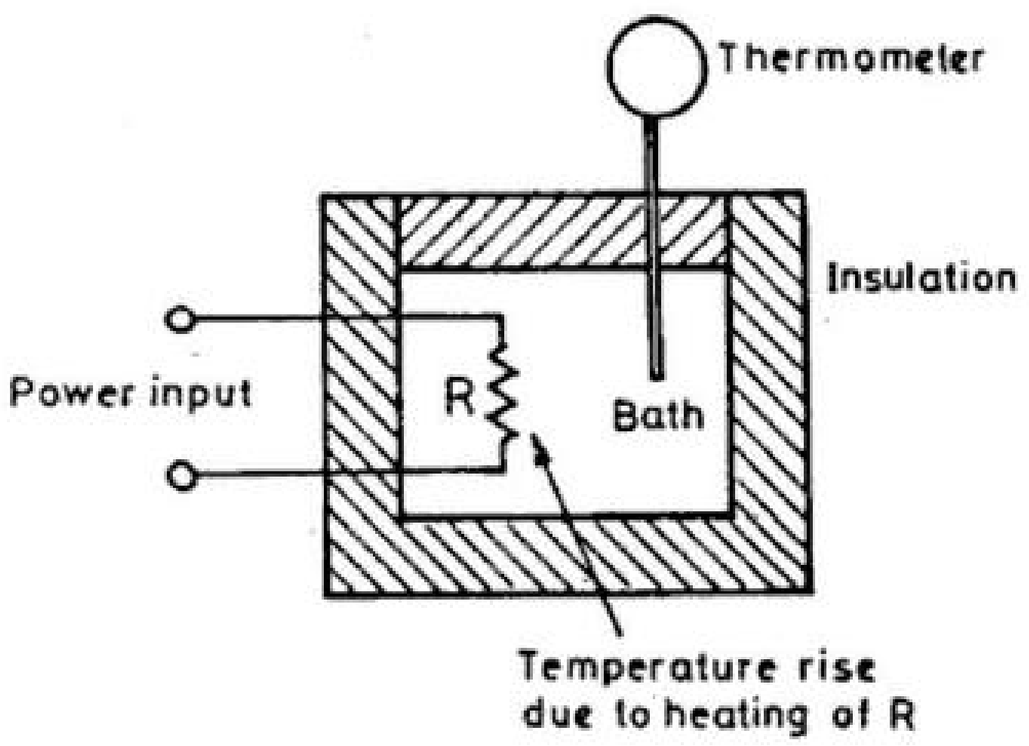


Fig. 9.10

Bolometer. The bolometer is basically a bridge circuit where one of the arms contains a temperature sensitive resistor. The temperature-sensitive resistor is balanced in the field of microwave signal whose power is to be measured. This is shown in Fig. 9.11 and a practical version in Fig. 9.12. The power is absorbed by the resistor and the heat generated causes a change in resistance. This change of resistance is measured with a bridge circuit. It consists of differential amplifier and a bridge. The bridge oscillates at a particular amplitude

Fig. 9.11

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when the bridge is unbalanced. The sensitive resistance elements R_T absorbs the power and heats itself until the bridge is very nearly balanced. The d.c. bias is then adjusted until the exact balance is achieved. Now the element is placed in the microwave field. The element absorbs the power and is heated, which causes a change in its resistance, thereby unbalancing the bridge. The unbalance is in a direction opposite to that of initial cold resistance. This action causes the output form the oscillator to decrease so as to effect the balance. The EVM circuit measures the amount of this power- decrease from the oscillator and displays the measurement as a power which is supplied by the microwave field.

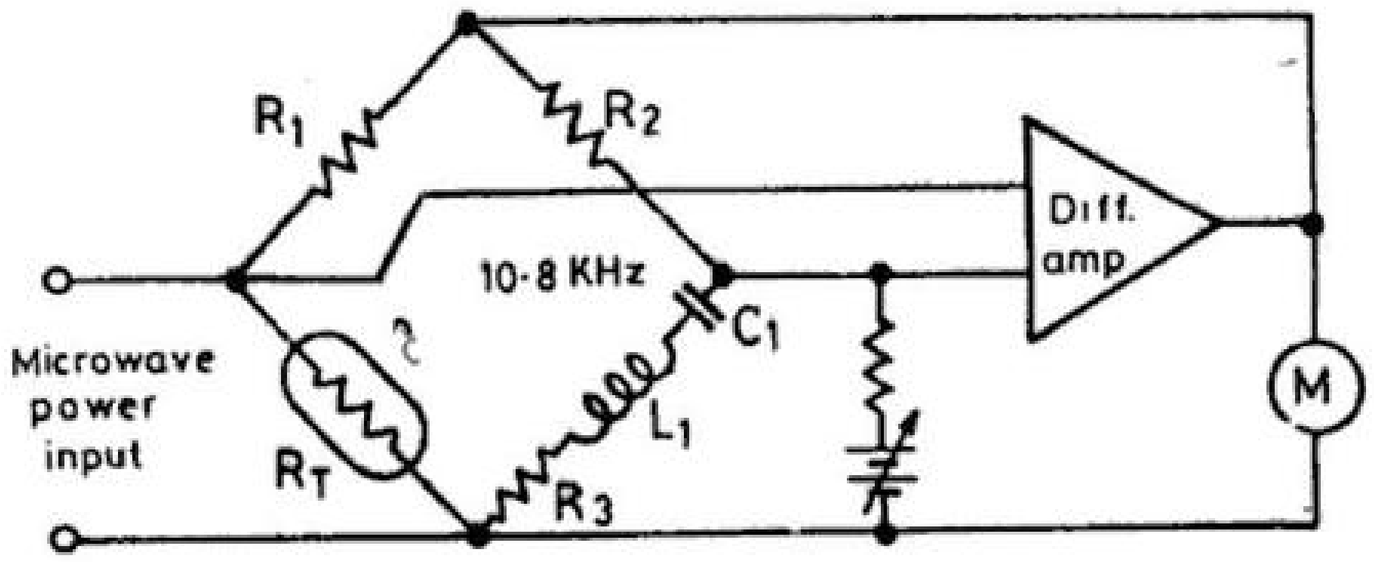


Fig. 9.12

Bolometer bridges use two types of element; *barretters* and *thermistors*. Barretters are metallic wires with positive temperature coefficient of resistance, and thermistors are resistors made of semiconductors material which has a negative temperature coefficient of resistance. The bolometer is customarily used for power measurements in the range 0.01-10 mW. In the range of 10 mW to 10W, a comparison-type calorimeter is suitable. Above 10 W, power measurements can be made by using attenuators and a low-power bolometer.

9.14. Watt-Hour Meter or Energy meter. It is used for the commercial measurement of electrical energy. Fig. 9.13 shows the elements of a single-phase watt-hour meter.

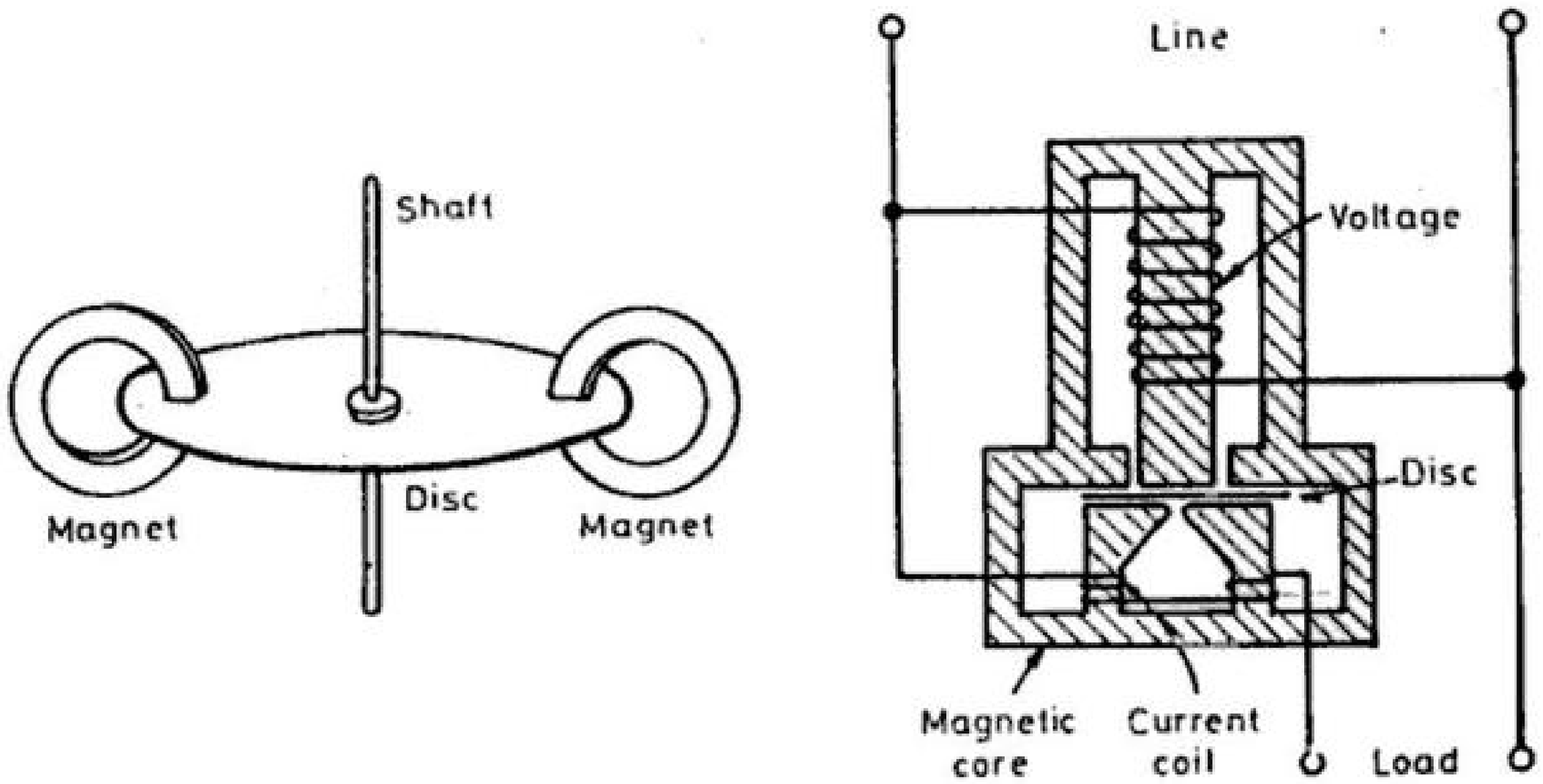


Fig. 9.13

The current coil is connected in series with the line and the voltage coil is connected across the line. Both coils are wound on a metal of special design providing two magnetic circuits. A light aluminium disc is suspended in the air gap of the current coil field which causes eddy currents to flow in the disc. The reaction of the eddy currents and the field of voltage coil creates a torque on the disc, causing it to rotate. The number of rotations of the disc is proportional to the energy consumed by the load in certain time interval.

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At very light loads, the voltage component of the field produces zero torque that is not directly proportional to the load. Compensation for error is provided by inserting a shading coil with the meter operating at 10 per cent of rated load. Two holes are drilled in the disc of energy meter on the opposite side of the spindle to eliminate creeping on no load.

9.15. Power-Factor Meter. It essentially measures the cosine of phase angle between voltage and current. The most common type is *crossed coil* power-factor meter. This instrument is basically an electrodynamometer movement where the moving element consists of two coils, mounted on the same shaft but at right angles to each other. The moving coils rotate in the magnetic field provided by the field coil that carries the line current.

The connections for this meter in a single-phase circuit are shown in Fig. 9.14. The field coil is connected as usual in series with the line and carries the line current. One coil of the movable element is connected in series with an inductor across the lines. Since no control springs are used, the balance position of the movable element depends on the resulting torque developed by the two crossed coils. When the movable element is in a balanced position, the contribution to the total torque by each element must be equal but of opposite sign.

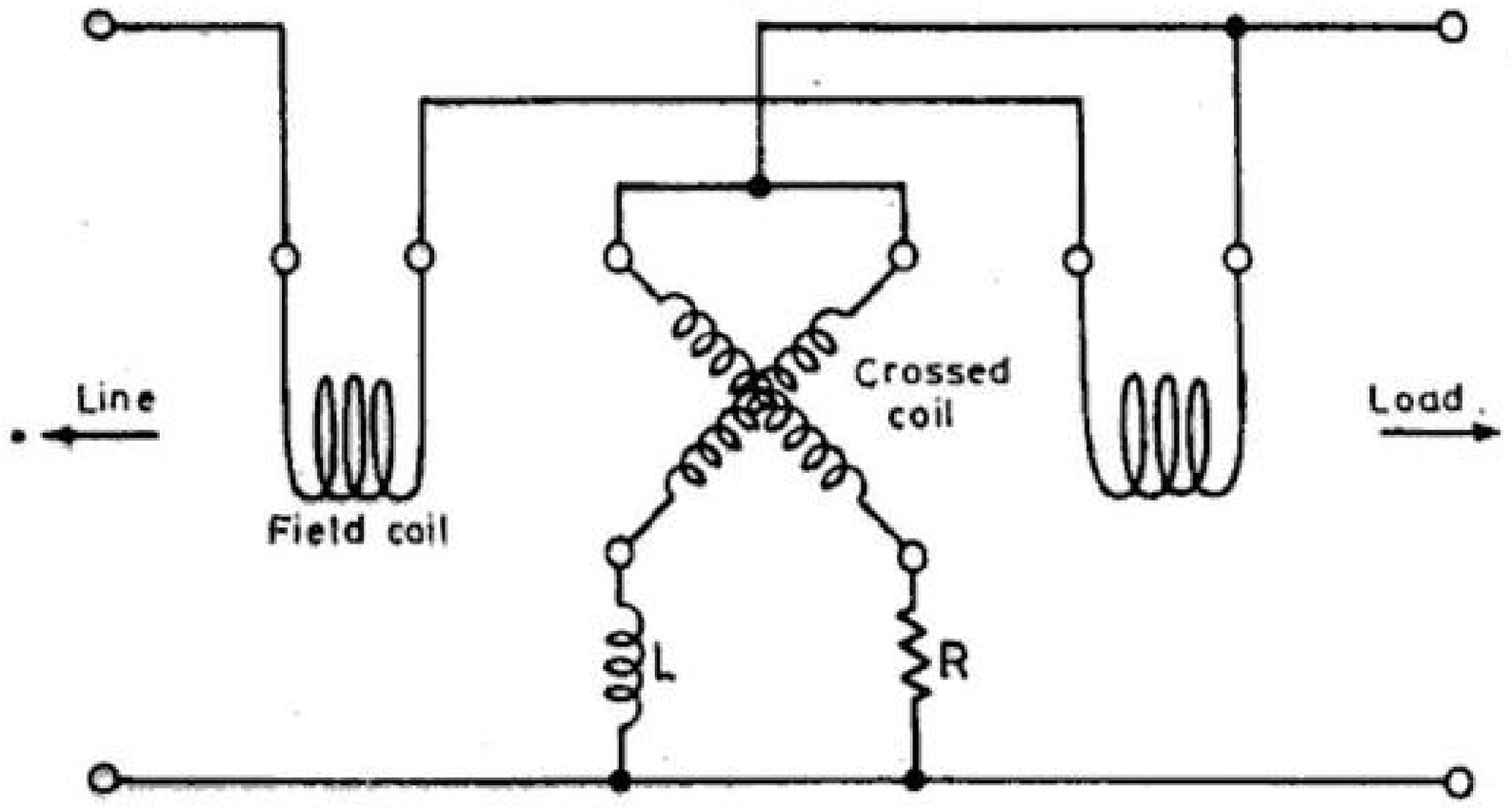


Fig. 9.14

The developed torque in each coil is a function of the current through the coil and therefore depends on the impedance of that coil circuit. The torque is also proportional to the mutual inductance between each part of the crossed coil and the stationary field coil. This mutual inductance depends on the angular position of the crossed-coil elements with respect to the position of the stationary field coil. When the movable element is at balance, it can be shown that its angular displacement is a function of the phase angle between line current (field coil) and line voltage (crossed coil). The indication of the pointer which is connected to the movable element, is calibrated directly in terms of the phase-angle or power-factor.

9.16 Frequency Meters. Indicating frequency-meters use the effect of frequency upon such factors as mutual inductance, resonance of a tuned circuit, and mechanical resonance. Three important types of frequency meters are described below.

Electrodynamo-meter type Frequency Meter. It is shown in Fig. 9.15. Here the field coil form part of two separated resonant circuits. Field coil 1 is in series with inductor L_1 and capacitor C_2, and forms a resonant circuit which is tuned to a frequency slightly below the low end of the instrument scale. Field coil 2 is in series with inductor L_2 and capacitor C_2, and form a resonant circuit which is tuned to a frequency slightly higher than the high end of the instrument scale. The torque on the movable element is proportional to the current through the moving coil.

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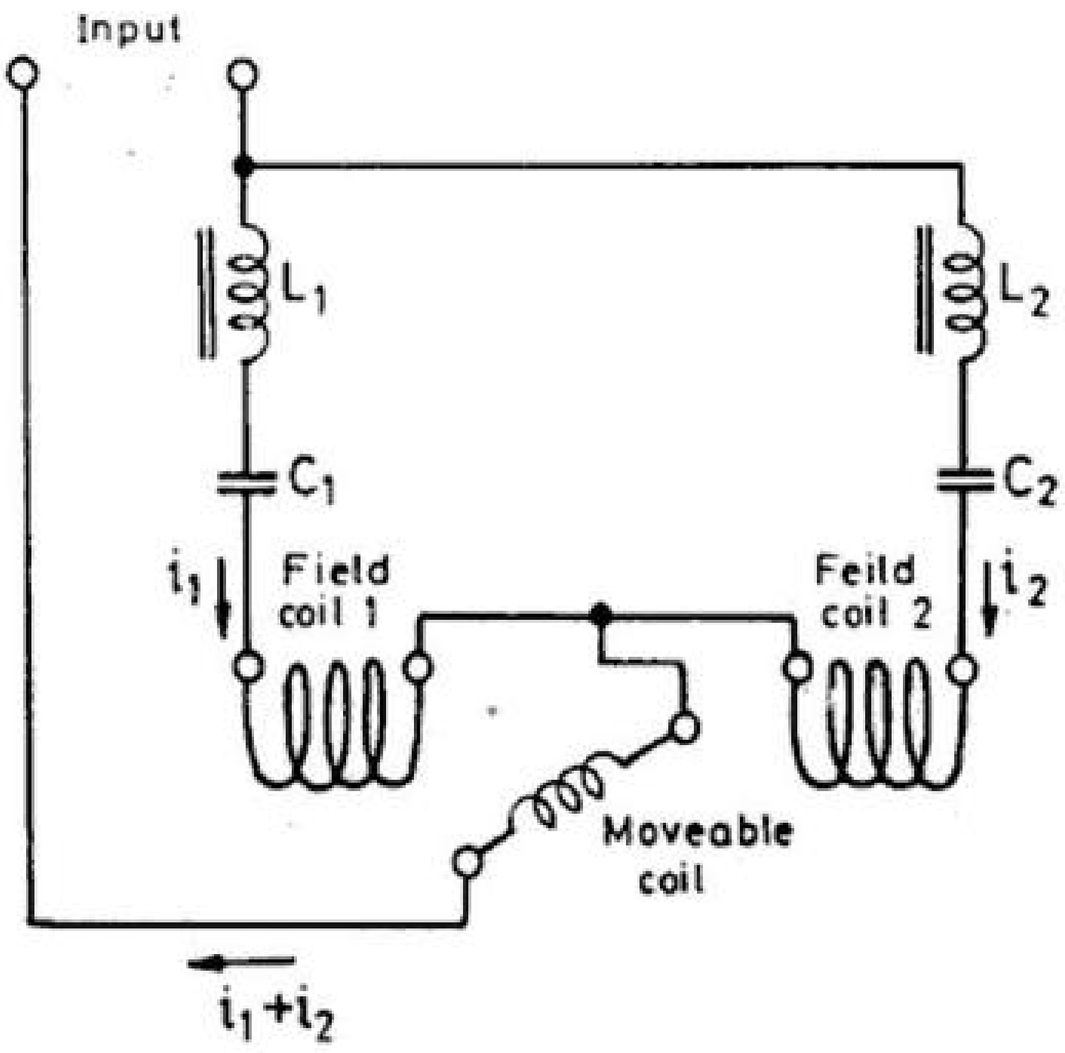


Fig. 9.15

The Tuned-Reed Frequency Meter. It operates on the principle of mechanical resonance. A series of reeds is fastened to a flexible common base which is mounted on the armature of an electromagnet. The coil of the electromagnet is energized form the a.c. power line whose frequency is to be determined. The reeds are tuned to an exact natural frequency by careful selection of their length and mass. The reed, which has a natural frequency equal to the frequency with which the electromagnet is energized, builds up a vibration. The vibration of the reed is visible at the front of the meter where the vibrating tip of the reed is seen through a window. If the frequency to be measured is intermediate between the natural frequencies of two adjacent reeds, both reeds will vibrate and the line frequency will be closest to the reed with the largest vibration. Interpolation between the natural frequencies of the reeds can be made very easily and accurately, since the reed frequencies are exact.

9.17. Instrument Transformers The transformer used for the measurement of current is called a *current transformer(CT)* and that for the measurement of voltage is known as *potential transformer(PT).*

The primary winding is so connected that the current being measured passes through it and secondary is connected to an ammeter.

In a PT, the primary is connected across the voltage being measured and the secondary to a voltmeter. The **Rated Burden** is the volt-ampere loading which is permissible without errors exceeding the limits for particular class of accuracy.

9.18. The Bridge Circuits. These are extensively used for measuring component values, such as resistance, inductance and capacitance, *etc.* The bridge circuit compares the value of an unknown component to that of an accurately known component. Its measurement accuracy is very high.

Wheatstone Bridge. It is used for the measurement of d.c. resistance and a simple version is shown in Fig. 9.16. The bridge has four resistor arms

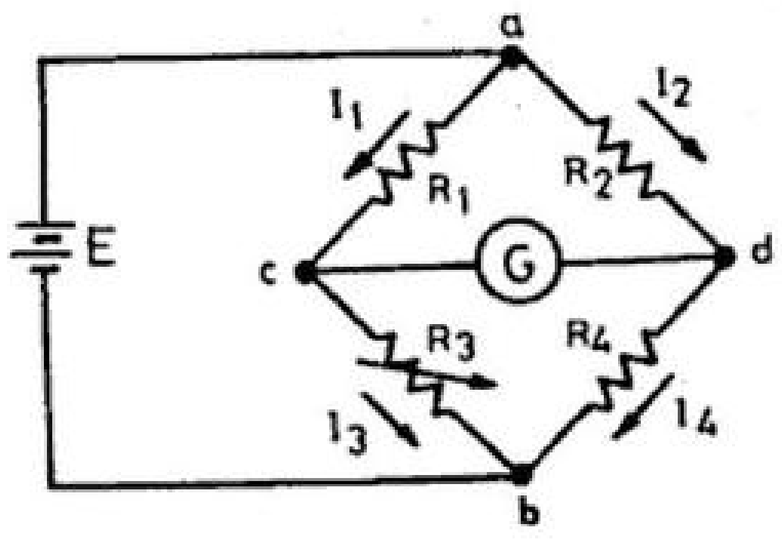


Fig. 9.16

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together with a source of emf and a null detector (usually a galvanometer). The bridge is said to be balanced when the potential difference across the galvanometer is zero volts so that there is no current through the galvanometer. Hence the bridge is balanced,

when, $$R_1 R_4 = R_2 R_3$$

The wheatstone bridge is widely used for precision measurement of resistance from approximately 1 ohm to the low mega-ohm range.

9.19. AC Bridges. AC bridge shown in Fig. 9.17 consists of four bridge arms, a source of excitation and a null detector. The power source supplies an a.c. voltage to the bridge at the desired frequency. At higher frequencies, an oscillator generally supplies the excitation voltage. The null detector must respond to a.c. unbalance currents and in its cheapest form consists of a pair of headphones. Other null detectors may be a.c. amplifier with an output meter or an electron ray tube indicator.

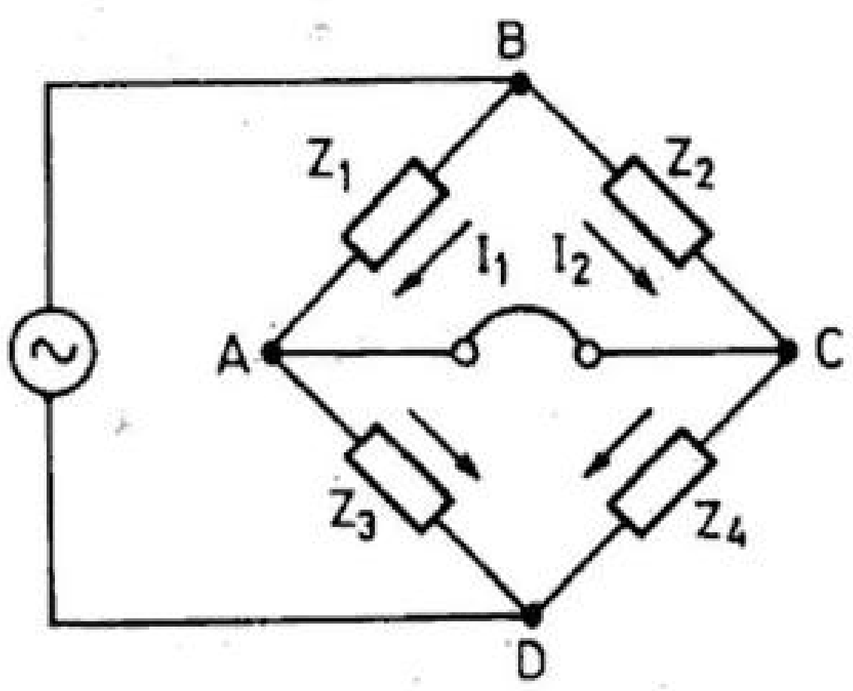


Fig. 9.17

The condition for bridge balance is

$$\bar{Z}_1 \bar{Z}_4 = \bar{Z}_2 \bar{Z}_3$$

Maxwell Bridge. It is shown in Fig 9.18 and it measures an unknown inductance in terms of known capacitance. One of the ratio arms has a resistance and capacitance in parallel.

$$R_x = \frac{R_2 R_3}{R_1}$$

$$L_x = R_2 R_3 C_1$$

Maxwell bridge is limited to the measurement of medium Q-coils ($1 < Q < 10$). It is unsuited for the measurement of coils with very low Q value ($Q < 1$)

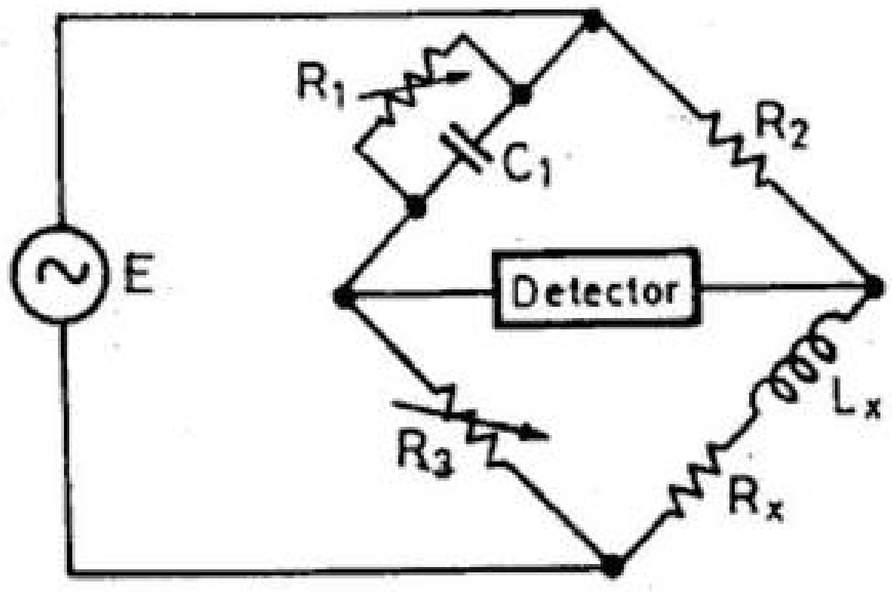


Fig. 9.18

Hay Bridge. Hay Bridge shown in Fig. 9.19, differs from the Maxwell bridge in having resistor R_1 in series with standard capacitor C_1 instead of being in parallel.

The value of R_x and L_x are given by

$$R_x = \frac{\omega^2 C_1^2 R_1 R_2 R_3}{1 + \omega^2 C_1^2 R_1^2}$$

$$L_x = \frac{R_2 R_3 C_1}{1 + \omega^2 C_1^2 R_1^2}$$

Hay bridge is suited for the measurement of high-Q inductors having Q more than 10.

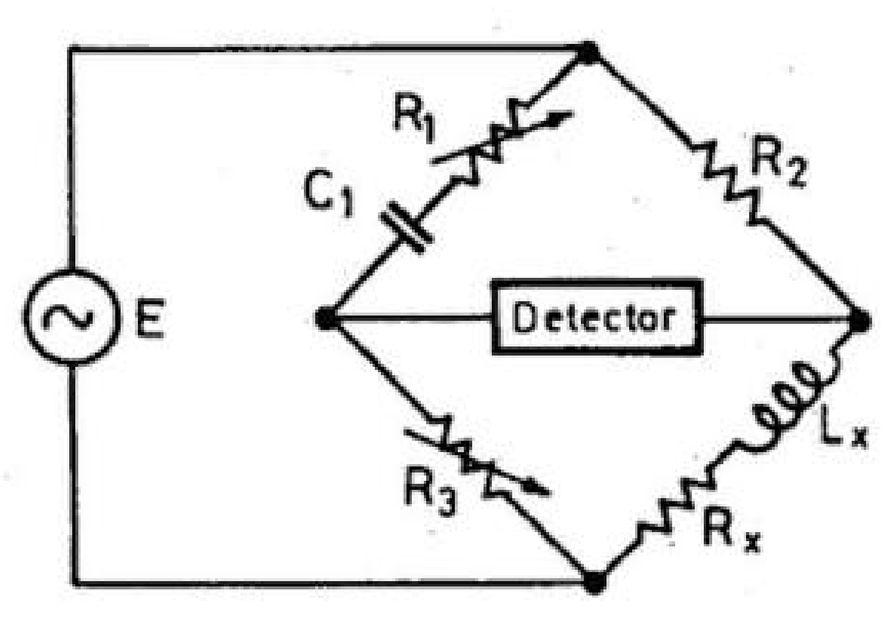


Fig. 9.19

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T = (number of horizontal div. of one cycle)

× (sweep speed in s/div.)

2. Lissajous Method. In this method the unknown signal waveform is fed into vertical input of the scope, and horizontal input of the oscillo scope is fed through a known frequency oscillator. With the sweep generator set to off, if both inputs are at same frequency, a circular pattern will appear on the screen. If the frequency to be measured is higher than the known frequency range, Lissajous pattern will result as shown in Fig 9.22

The frequency ratio is found by

$$f_v = \frac{n_h \cdot f_h}{n_v}$$

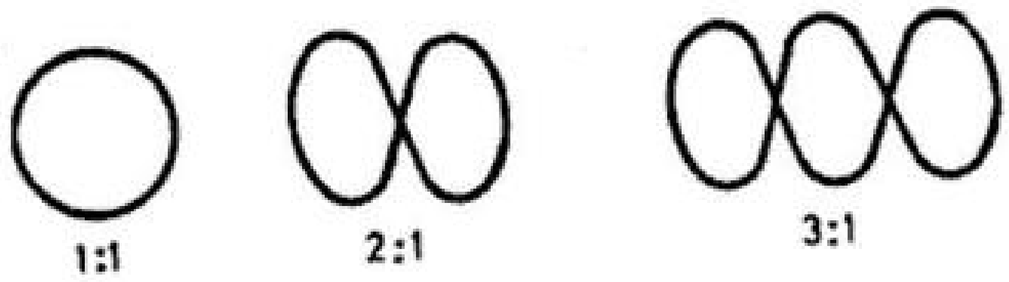


Fig. 9.22

where f_v = unknown frequency,

f_h = known frequency,

n_h = number of loops touching the horizontal tangent line, and

n_v = number of loops touching the vertical tangent line.

Phase Measurement. 1. Direct Method. The phase relationship between two sinusoids may be directly measured by viewing both waveforms on the oscilloscope and the delay line T_d between the two waveforms and the time period T is determined as shown in Fig. 9.23.

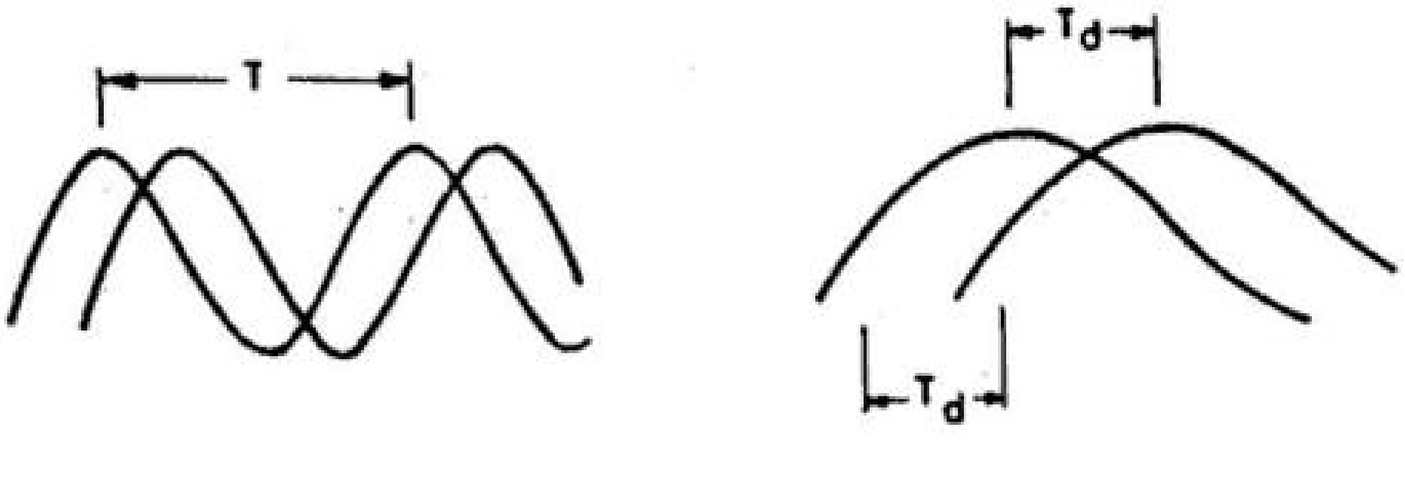


Fig. 9.23

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To make a measurement, the unknown coil is connected to the test terminals of the instrument and the circuit is tuned to resonance either by setting the oscillator to a given frequency and varying the internal resonating capacitor. The reading Q on the output meter must be multiplied by the index setting of the Q meter to obtain the actual Q value.

The inductance of the coil can be calculated from the known values of frequency f and resonating capacitance C. Since

$$X_L = X_C \text{ and } L = \frac{1}{(2\pi f)^2 C} \text{ Henry.}$$

9.23. Digital Voltmeters. The digital voltmeter (*DVM*) displays measurements of d.c. or a.c. voltages or discrete numerals instead of a pointer deflection on a continuous scale as in analog devices.

Advantages of digital voltmeters are:

1. It reduces human reading and interpolation errors.
2. It eliminates parallax error.
3. It increases reading speed.
4. It provides output in digital form suitable for reading.

Digital voltmeters can be classified as

(*a*) Ramp-type *DVM*.

(*b*) Integrating *DVM*.

(*c*) Continuous balance *DVM*.

(*d*) Successive approximation *DVM*.

Ramp-type DVM. The operating principle of the ramp-type *DVM* is based on the measurement of the time it takes for a linear ramp voltage to raise from zero to the level of the input voltage or to decrease from the level of the input voltage to zero. This time interval t is measured with an electronic time- interval counter and the count is displayed as a number of digits on electronic indicating devices.

Conversion from a voltage to a time interval is illustrated in Fig. 9.26.

At the start of the measurement cycle, a ramp voltage is initiated. This voltage can be positive-going or negative going. The negative-going ramp is continuously compared with the unknown input voltage. At the instant the ramp voltage equals the unknown voltage, a coincidence circuit generates a pulse which opens a gate as shown in Fig. 9.27.

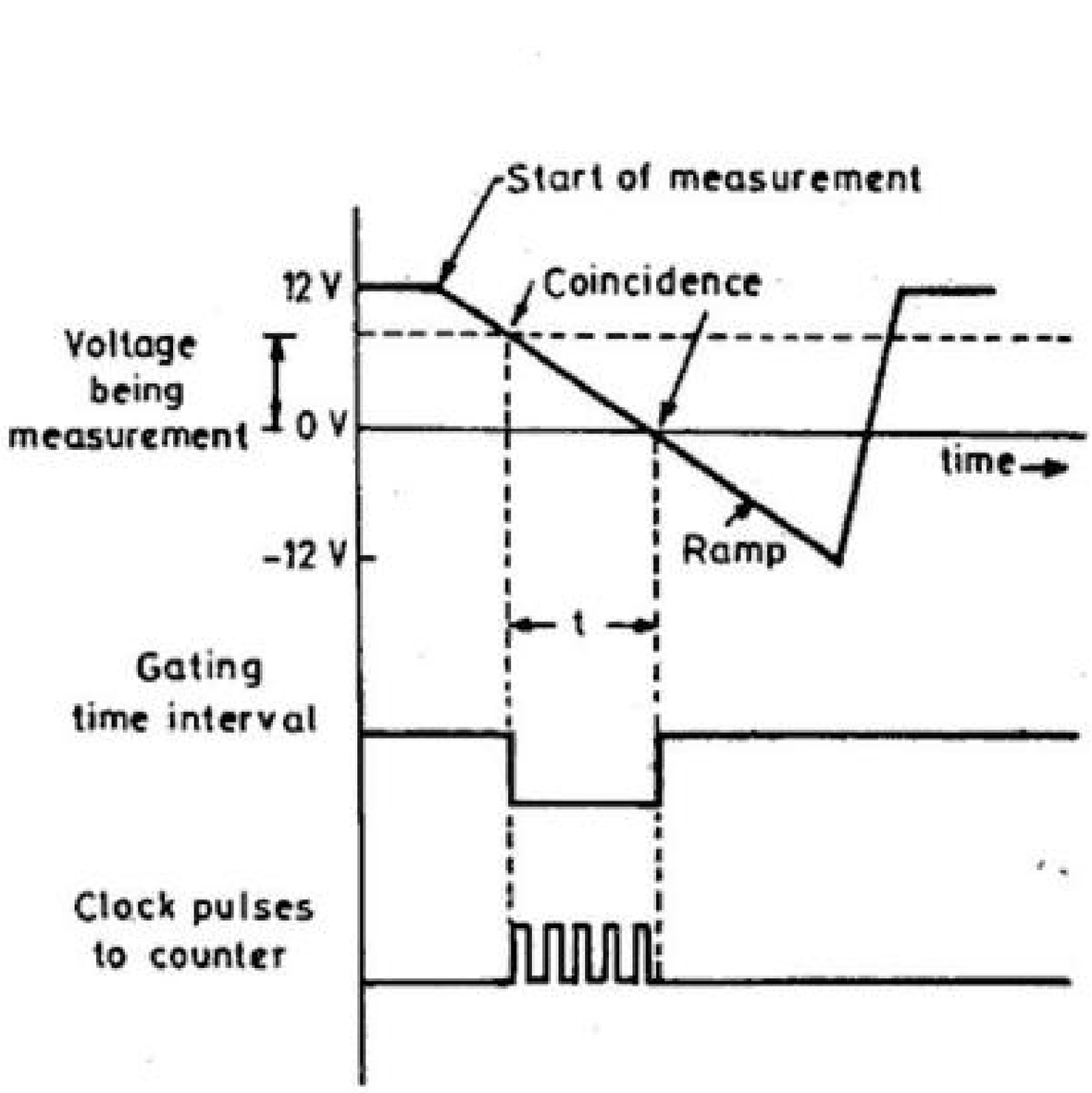


Fig. 9.26

The ramp voltage continues to decrease with time until finally it reaches zero voltage and a second comparator generates clock pulse which closes the gate. An oscillator generates clock pulses which are allowed to pass through the gate to a number of decade counting units which totalize the number of pulses passed

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Sensitivity - It is approximately equal to the length significant digit of the reading.

Resolution - It is the inherent ability of a display to resolve one digit out of the total number of being displayed.

Accuracy - It is expressed in two parts. The first part is a percentage of the actual reading: the second part is given as a percentage of the full scale reading or a number of least significant digit. For example, accuracy: ± 1 % of reading, ± 1 digit.

9.24. Process Instrumentation. An instrumentation system generally consists of three major elements:

1. an input device.
2. processing device or signal-conditioning device, and
3. output device.

The input device receives the quantity under measurement and delivers a proportional electrical signal to the signal conditioning device. Here the signal is amplified, filtered and modified to a format acceptable to the output device. The output device may be simple indicating meter, a *CRO* or a chart recorder for visual display. It may be magnetic tape recorder.

The input quantity for most instrumentation system is non- electrical. In order to use electrical methods and technique for measurement, the non-electrical quantity is converted into an electrical signal by a device called *transducer.*

Force-Summing Devices. The mechanical elements that are used to convert applied force into a displacement are called force summing devices such as:

1. Diaphragm 2. Bellows 3. Bourdon tube 4. Straight tube
5. Pivot torque tube.

Different-types of Transducers are :

(1) Capacitor Transducer (2) Inductive Transducer

(3) Linear Variable Differential Transducer (LVDT) (4) Piezoelectric Transducer

(5) Metallic Resistance Strain Gauge.

$$R = \rho L/A = \rho L/CD^2$$

The *gauge factor* is defined as unit change in resistance to unit change in length.

$$G.F. = \frac{dR/R}{dL/L} = \frac{dR/R}{\varepsilon_a}$$

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QUESTION BANK IN MEASURING SYSTEMS AND INSTRUMENTATIONS

1. The meter used for measuring electrical quantities are
   A. Tachometer
   B. Micrometer
   C. Measuring Instruments
   D. Spherometer
2. The meter used for electrical power is called
   A. kWh meter B. Voltmeter
   C. Ammeter D. Wattmeter
3. The meter used for measuring potential difference of a circuit is called
   A. voltmeter B. ammeter
   C. energy meter D. ohm meter
4. The meter used for measuring current of an electrical circuit is called
   A. voltmeter B. ammeter
   C. potentiometer D. multimeter
5. The meter used for measuring electrical energy of consumer is called
   A. wattmeter B. ampere hour meter
   C. kWh meter D. avometer
6. The essential requirement of measuring instrument is
   A. deflecting torque
   B. controlling torque
   C. damping torque
   D. All the above three
7. The deflecting torque can be produced by
   A. gravity control B. spring control
   C. air friction D. magnetically
8. The controlling torque can be produced
   A. electrostatically B. thermally
   C. by using hair spring D. by fluid friction
9. The damping torque can be produced by
   A. eddy currents B. gravity control
   C. electrostatically D. thermally
10. Electrostatic effect for producing deflecting torque is used in
    A. ammeters B. voltmeters
    C. wattmeters D. energy meters
11. Thermal effect is used for producing deflecting torque is
    A. wattmeter B. energy meter
    C. ammeter D. All of the above
12. Electrodynamic effect is used for the operation of
    A. wattmeter B. voltmeter
    C. ammeter D. All of the above
13. Chemical effect is used for the operation of
    A. voltmeter
    B. ammeter
    C. ampere hour meter
    D. kWh meter
14. The spring controlled meter is
    A. not portable
    B. portable
    C. should be mounted in a definite position
    D. None of the above.
15. In spring controlling instruments, controlling torque
    A. can be adjusted easily

Answers : 1. (C), 2. (D), 3. (A), 4. (B), 5.(C), 6. (D), 7. (D), 8. (C), 9. (A), 10. (B), 11. (C), 12. (D), 13. (C), 14. (B).

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B. can not be adjusted easily
C. remains same
D. varies with the load

16. For controlling torque, spring controlling method; is
A. generally use
B. rarely used
C. always used
D. never used

17. The advantage of spring control instrument is:
A. it is subjected to fatigue
B. the controlling torque can be adjusted easily
C. being the spring light in weight, there is no increase in weight of the moving system
D. that rise of temperature, does not effect the controlling torque

18. The advantage of gravity control method is that, it is
A. costly
B. not very simple method
C. affected by temperature
D. not subject to fatigue

19. The disadvantage of gravity control method is that, it is
A. kept in vertical position
B. light in weight
C. graduated uniformally
D. costly

20. For controlling the vibrations of the disc of A.C. energy meter, damping torque is produced by
A. eddy current
B. chemical effect
C. electrostatic effect
D. magnetic effect.

21. Moving iron instruments are
A. attraction type
B. repulsion type
C. attraction and repulsion type
D. dynamometer type

22. Moving coil instruments are
A. permanent magnet type
B. dynamometer type
C. induction type
D. permanent magnet and dynamometer type

23. Moving iron instruments can be used on
A. a.c. and d.c. both
B. a.c. only
C. d.c. only
D. half wave rectified a.c.

24. Moving coil permanent magnet instruments can be used on
A. a.c. and d.c.
B. a.c. only
C. d.c. only
D. half wave rectified a.c.

25. The scale of moving iron (M.I.) instrument is
A. uniform
B. cramped
C. first uniform then conjusted
D. None of the above

26. The cost of M.I. instrument as compared to M.C. instrument is
A. high B. low
C. same D. very high

27. The accuracy of M.C. instruments as compared to M.I. instrument is
A. high B. low
B. same
D. reasonable accurate

28. M.C. instrument is
A. robust
B. accurate
C. consumes less power
D. possesses all the above three advantages

Answers : 15. (B), 16. (A), 17. (C), 18. (D), 19. (A), 20. (A), 21. (C), 22. (D), 23. (A), 24. (C), 25. (B), 26. (A), 27. (A), 28. (D).

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29. The consumption of M.I. instrument as compared of M.C. instrument is

A. same B. more

B. less D. very small

30. For increasing the range of an ammeter, connect

A. a high value resistance in series with the ammeter coil

B. a high value resistance in parallel with the ammeter coil

C. a low value resistance in parallel with the ammeter coil

D. a low value resistance in series with the ammeter coil

31. For increasing the range of voltmeter, connect a

A. high value resistance in series with voltmeter

B. low value resistance in series with voltmeter

C. high value resistance in parallel with voltmeter

D. low value resistance in parallel with voltmeter

32. A galvanometer can be used for measuring current and voltage of a circuit by

A. shunt only

B. connecting high value of resistance in series only

C. shunt for measuring current and high resistance in series for voltage

D. without shunt and series resistance

33. The cost of ammeter as compared to voltmeter is

A. same B. higher

C. lower D. very high

34. Two voltmeters of same range one M.I. type and other M.C. type are connected in parallel for measuring a.c. supply voltage, if the reading of M.I. type is 300 V, the reading of M.C. type will be

A. higher than M.I. type

B. lower than M.I. type

C. same D. zero

35. How you will identify whether the mater is M.I. type or M.C. type from

A. the type of scale

B. the marking of the terminals

C. the symbol given on the meter plate

D. All the above three

36. The meter used for measuring power of the circuit is called

A. kWh meter B. wattmeter

C. multimeter D. voltmeter

37. The meter used for measuring electrical energy is called

A. kWh meter B. wattmeter

C. multimeter D. ammeter

38. Most commonly used wattmeter is

A. indusction type B. electrostatic type

C. dynamometer type

D. moving iron type

39. The dynamometer type wattmeter is used on

A. a.c. only

B. d.c. only

C. a.c. and d.c. both

D. full wave rectified

40. Which of the following advantages, the dynamometer wattmeter has

A. uniform scale

B. can work on a.c. and d.c. both

C. high accuracy

D. All the above three

41. At low power factor the dynamometer wattmeter will cause

A. no error

Answers : 29. (B), 30. (C), 31. (A), 32. (C), 33. (C), 34. (D), 35. (D), 36. (B), 37. (A), 38. (C), 39. (C), 40. (D).

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B. serious error
C. minute error
D. None of the above

42. In dynamometer type of wattmeter, which of the coil is split up into two parts
A. pressure coil B. current coil
C. pressure coil and current coil both
D. None of the above

43. Which of the following types of damping is most commonly employed in the dynamometer type wattmeter
A. fluid friction B. eddy current
C. air friction
D. air and fluid friction both

44. A wattmeter can be used
A. only for one rated current
B. for different rated current without any change
C. different rating current with change of connection without multiplier
D. with different currents with change of connections and multiplier

45. Wattmeters are available for different rating of
A. currents
B. voltages
C. currents and voltages both
D. currents and voltages with the use of multiplier

46. The most commonly used type of single phase energy meter is
A. dynamometer type
B. electrostatic type
C. induction type
D. moving coil type

47. The energy meter used for measuring energy of a d.c. circuit is
A. ampere hour type
B. induction type
C. electrostatic type
D. dynamometer type

48. The meter constant of energy meter is given by
A. rev./kW B. rev./kWh
C. rev./watt D. rev./kWh

49. The essential requirements of a single phase meter are
A. recording mechanism
B. operating mechanism
C. moving mechanism
D. All the above three

50. The series magnet of a single phase Energy meter consists of coil of
A. thin wire of few turns
B. thick wire of few turns
C. thick wire of more turns
D. thin wire of more turns

51. The current coil of single phase Energy meter is wound on
A. one limb of the laminated core
B. both the limbs of the laminated core with different turns
C. both the limbs of the laminated core with same number of turns
D. the centre of the limb on the laminated core

52. The pressure coil of a single phase Energy meter is wound on
A. one limb of the laminated core
B. both the limbs of the laminated core with different turns
C. both the limbs of the laminated core with same number of turns
D. the centre of the limb on the laminated one

53. The pressure coil consists of
A. more number of turns of fine wire
B. less number of turns of fine wire
C. less number of turns of thick wire
D. more number of turns of thick wire

Answers : 41. (B), 42. (B), 43. (C), 44. (D), 45. (D), 46. (C), 47. (A), 48. (B), 49. (C), 50. (B), 51. (C), 52. (D), 53. (A).

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54. The current in the pressure coil is proportional to
   A. load current
   B. line current
   C. supply voltage
   D. supply voltage and line current both

55. The current in the pressure coil will lag behind the voltage by 90° because of high
   A. inductance
   B. resistance
   C. Capacitance
   D. resistance and low inductance

56. The speed of energy meter can be controlled by
   A. series magnet B. braking magnet
   C. shunt magnet D. shading band

57. The friction error of single phase Energy meter can be reduced by
   A. adjusting braking magnet
   B. shunt magnet
   C. series magnet
   D. short circuited loops

58. The creeping error in single phase Energy mater can be minimised by
   A. adjusting braking magnet
   B. use of short circuited loops on the outer limbs of the shunt magnet
   C. drilling two holes in the disc on the opposite side of the spindle
   D. adjusting the shaded band

59. The name plate of a single phase Energy meter generally provides.
   A. meter constant
   B. voltage and frequency
   C. current
   D. All the above three

60. The meter constant of a single phase Energy meter installed in a house is 4800 rev./kWh, if 5 lamps of 100 W each are connected in the circuit. The number of rev./min. will be
   A. 40 B. 80
   C. 120 D. 160

61. Megger is used for measuring
   A. low resistance
   B. high resistance
   C. medium resistance
   D. very low resistance

62. Megger can be used for testing
   A. open circuit only
   B. short circuit only
   C. open and short circuit both
   D. high resistance circuit only

63. Megger is a combination of
   A. motor and generator
   B. generator and voltmeter
   C. generator and ammeter
   D. generator and ohm meter

64. Speed of the megger is kept at
   A. 100 r.p.m. B. 120 r.p.m.
   C. 140 r.p.m. D. 160 r.p.m

65. The megger voltage for testing 250 V installation should be
   A. 1000 V B. 500 V
   C. 300 V D. 100 V

66. The megger voltage for testing 500 V installation should be
   A. 1000 V B. 500 V
   C. 300 V D. 250 V

67. Which of the megger is better for testing installation
   A. battery operated
   B. generator operated
   C. integrated circuit operated
   D. motor operated

Answers : 54. (C), 55. (A), 56. (B), 57. (D), 58. (C), 59. (D), 60. (A), 61. (B), 62. (C), 63. (D), 64. (D), 65. (B), 66. (A), 67. (B).

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81. The leads of a multimeter are connected for a.c. voltage. If a resistance is to be measured
   A. change of one lead to another jacket
   B. change of both the leads to other jacket
   C. one leads is kept common and the other lead is changed to another jacket
   D. no change in leads

82. Which of the multimeter is more sensitive and accurate
   A. integrated circuit type
   B. digital type
   C. pointer type
   D. None of the above

83. For measuring a value of resistance which of the meter will give accurate result
   A. ohm meter
   B. multimeter
   C. potentiometer
   D. vaccum tube voltmeter (V.T.V.M.)

84. The most essential instrument required by a T.V. technician is
   A. voltmeter
   B. megger
   C. ohm meter
   D. avometer

85. If the battery of the multimeter is weak, it will give
   A. accurate reading B. more reading
   C. less reading D. no reading

86. The meter used for electrical power is called
   A. kWh meter B. Voltage
   C. Ammeter D. Wattmeter

87. The meter used for measuring potential difference of a circuit is called
   A. Voltmeter B. Ammeter
   C. Energy meter D. Ohm meter

88. A basis d.c. meter movement may be used to measure a.c. through the use of a
   A. rectifier
   B. resistor in series with the meter movement
   C. coil in series with the meter movement
   D. capacitor

89. The main advantage of electrostatic instrument is that
   A. it is suitable for measurement of high voltage and currents
   B. it is suitable for measurement of very low voltages and currents in the milli range
   C. it takes negligible current from the source
   D. its construction is very robust and cheap

90. Electrostatic instruments are suitable for the measurement of
   A. a.c. and d.c. voltages
   B. a.c. voltage and current
   C. d.c. voltage and current
   D. a.c. voltage only

91. Electrostatic instruments work on the principle of
   A. repulsion of unlike poles
   B. attraction of like poles
   C. attraction between positive and negative charge
   D. repulstion between negative charges

92. The three advantages of moving iron instruments are
   A. high sensitivity, uniform scale and robust construction
   B. uniform scale, robust construction and relatively cheap
   C. high sensitivity, uniform scale and relatively cheap
   D. robust construction, relatively cheap and use able for a.c. and d.c.

93. Wattmeter measures
   A. apparent power B. true power
   C. volt ampere D. volt ampere reactive

Answers : 81. (C), 82. (A), 83. (D), 84. (D), 85. (C), 86. (D), 87. (A), 88. (A), 89. (C), 90. (A), 91. (C), 92. (D), 93. (B).

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94. A shunt in conjunction with a shunt type ammeter is used in measuring d.c. current where
   A. it is desired to isolate the instrument from main circuit
   B. the current fluctuates greatly in value
   C. it is not practical to carry the full load current through the instrument
   D. the accompanying d.c. voltage is high

95. Electrostatic voltmeters are particularly suitable for measuring high voltages because the construction is simplified due to
   A. large electrostatic forces
   B. small electros. forces
   C. large value of current
   D. small value of current

96. High a.c. voltage are usually measured with a:
   A. voltmeter and current transformer
   B. millivoltmeter and shunt
   C. voltmeter and multiplier
   D. voltmeter and potential transformer

97. Unless otherwise a.c. meters indicate
   A. maximum value
   B. average value
   C. effective value of r.m.s.
   D. crest value

98. Half wave rectifier type a.c. meters are used as voltmeters. They cannot be used as ammeters because
   A. pointer would oscillate with a.c.
   B. a.c. current would be too small to read
   C. a.c. current would be excessive
   D. a.c. is changed to d.c.

99. A wattmeter has four connections. These connection put the fixed coil in
   A. parallel with the load and moving coil in series with the load
   B. series with the load and moving coil in parallel with the load
   C. series-parallel with the load and moving coil in parallel with the load
   D. series with the load and moving coil also in series with the load.

100. One of the most useful instrument for measurement of potential difference, current and resistance is
   A. a wattmeter
   B. an electrostatic instrument
   C. a megger D. multimeter

101. To increase the range of an a.c. ammeter you would use
   A. a current transformer
   B. a potential transformer
   C. an inductance across the meter
   D. a condenser across the meter

102. Large currents in d.c. circuit are practically always measured with
   A. an ammeter and shunts
   B. a milliammeter and multiplier.
   C. an ammeter and current transformer
   D. a millivoltmeter and shunt

103. A voltmeter has an accuracy of ± 3 percent of full scale 250 V range is employed to read 150 V. The actual voltage value will fall within the range
   A. 140.5 to 150.5 V B. 143 to 150 V.
   C. 142.5 to 157.5 V D. 147 to 153 V

104. In a voltmeter, there are hundred divisions on 0-200 V range. One tenth of each divisions can be read with certainty. The resistance of the meter is 100 ohms. The resolution of the instrument is
   A. 0.2 V B. 0.1 V
   C. 0.02 V D. 0.01 V

105. In the above question, the instrument sensivity is
   A. 10 ohm/V B. 20 ohm/V
   C. 1 ohm/V D. 0.5 ohm/V

Answers : 94. (C), 95. (A), 96. (D), 97. (C), 98. (A), 99. (B), 100. (D), 101. (A), 102. (A), 103. (C), 104. (A), 105. (D).

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106. What is the purpose of providing a mirror behind the pointer in measuring instruments?
   A. the scale is illuminated through the mirror
   B. with the help of the mirror it can be seen whether the pointer is bent or not
   C. the mirror is semi-transparent so as to allow the observation of the interior of the instrument.
   D. reading errors due to inclined by removing parallex between the pointer and its image in the mirror.

107. The range of a zero centred voltmeter having scale from -10 V to + 10 V is
   A. 0 -20 V
   B. -10 V to + 10 V
   C. 0 -10 V
   D. 10 –20 V

108. A 100 mA meter has accuracy of ± 2 percent. Its accuracy while reading 50 mA will be
   A. ± 1% B. ± 2%
   C. ± 4% D. ± 20%

109. Which of the following meters has the best accuracy?
   A. Moving-iron meter
   B. Moving-coil meter
   C. Rectifier-type meter
   D. Thermocouple meter

110. Hysteresis in an instrument means
   A. the repeatability of the instrument
   B. the reliability of the instrument
   C. the change in same reading when input is first increased and then decreased
   D. the inaccuracy due to change in temperature

111. Threshold of sensitivity with respect to instruments is
   A. the maximum signal which can be measured
   B. the value of sensitivity on the highest scale
   C. the value of sensitivity on the lowest scale
   D. the smallest signal that results in a detectable output

112. The reliability of an instrument means
   A. the life of the instrument
   B. the extent which the characteristics remain linear
   C. degree to which repeatability continues to remains with specific limits
   D. All the above

113. Sensitivity of a voltmeter is expressed as
   A. Volt/Ohms B. Ohms/Volt
   C. Ohms Volt D. 1/Ohms. Volt

114. The shunt resistance in an ammeter is usually
   A. less than meter resistance
   B. equal to meter resistance
   C. greater than meter resistance
   D. of any value

115. The function of a shunt in an ammeter is to
   A. by pass the current
   B. increase the current in the coil
   C. decrease the voltage drop
   D. increase the meter resistance

116. Which of the following damping methods is common in moving coil instruments?
   A. Air damping
   B. Fluid damping
   C. Spring damping
   D. Eddy-current damping

117. Moving coil instruments are used
   A. in a.c. circuits only
   B. both in a.c. and d.c. circuits
   C. in d.c. circuits only
   D. for measuring voltage only

118. In moving-coil meters, damping is provided by
   A. the aluminium frame
   B. damping vane

Answers : 106. (D), 107. (B), 108. (C), 109. (B), 110. (C), 111. (D), 112. (C), 113. (B), 114. (A), 115. (A), 116. (D), 117. (C), 118. (A).

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C. damping vane in an air tight chamber

D. None of these

119. Damping provides

A. braking action on a meter pointer

B. good accuracy

C. starting torque on the meter pointer

D. counter torque to deflection torque

120. Megger in its operation is based upon

A. moving-coil meter

B. moving-iron meter

C. dynamic-meter

D. electrostatic meter

121. Megger essentially is a

A. megohmmeter

B. shunt-type ohmmeter

C. series-type ohmmeter

D. dynamometer

122. Megger is an instrument to measure

A. very low resistance

B. insulation resistance

C. Q of a coil

D. inductance of a coil

123. Basically an ohmmeter consists of

A. d.c. current meter

B. low voltage d.c. power source

C. current limiting resistors

D. All of these

124. An ohmmeter is a device which

A. measures the resistance of a circuit

B. can locate open-circuit

C. can locate short-circuits

D. All of these

125. What will happen if a voltmeter is connected like an ammeter in series to the load?

A. The meter will burn out

B. the measurement will be too high

C. an inadmissably high current will flow

D. there will be almost no current in the circuit

126. A resistor of 10 k-ohms with 5% tolerance is connected in series with a 5 k-ohms resistor of 10% tolerance. What is the tolerance limit of the series network?

A. 5% B. 6.67%

C. 10% D. 8.33%

127. A resistor of 10 k-ohms with a tolerance of 5% is connected in parallel with a 5 k-ohms resistor of 10% tolerance. What is the tolerance limit for the parallel network?

A. 5% B. 6.67%

C. 10% D. 8.33%.

128. It is found that 10 A current passes through a resistor of 10 ohms value. The resistor has 5% tolerance. The error in measurement of current can be as high as 5%. What is the maximum error in measurement of power, calculated from the measured value of 1 and the nominal value of resistor?

A. 100W B. 150W

C. 50W D. 200W

129. Some wire-wound resistors have bifilar winding. This type of winding is used to

A. increase the thermal stability

B. reduce the tolerance

C. reduce the inductance of winding

D. double the power rating of the resistors

130. The e.m.f. of Weston standard cell is measured using

A. moving-iron meter

B. moving-coil meter

C. digital volt-meter

D. potentiometer method

131. In a gravity controlled instrument, the deflection angle is proportional to

A. measurand

B. square of the measurand

Answers : 119. (A), 120. (A), 121. (A), 122. (B), 123. (D), 124. (D), 125. (D), 126. (B), 127. (D), 128. (B), 129. (C), 130. (D).

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C. sine-inverse of measured

D. sine of the measured

132. In a moving iron meter, the deflecting torque is proportional to

A. square of the current through the coil

B. current through the coil

C. sine of the measurand

D. square-root of the measurand.

133. In a moving-coil instrument, the deflecting torque is proportional to

A. current

B. square of the current

C. square-root of the current

D. sine of the measurand

134. The full-scale deflection current of an ammeter is 1 mA and its internal resistance is 100 ohms. If this meter is to have full deflection at 5A, what is the vlaue of the shunt resistance to be used?

A. 49.99 ohms B. 1/49.99 ohms

C. 1 ohm D. 2 ohms

135. The full-scale deflection current of a meter is 1 mA and its internal resistance is 100 ohms. This meter is to have full deflection when 100V is measured. What is the value of series resistor to be used?

A. 99.99 k-ohms B. 100 k-ohms

C. 99.99 ohms D. 100 ohms

136. Electrostatic instruments are normally used for

A. low current measurements

B. high current measurements

C. low voltage measurements

D. high voltage measurements

137. No eddy current and hysteresis losses occur in

A. Electro-static instruments

B. PMMC type isntruments

C. Moving iron instruments

D. None of these.

138. Two voltmeters have the same range 0-400V. The internal impedances are 30,000 ohms and 20,000 ohms. If they are connected in series and 600V be applied across them, the readings are:

A. 360V and 240V

B. 300V and 300V

C. 400V and 200V

D. None of these.

139. Two ammeters, one with full-scale current of 1mA and internal resistance of 100 ohms, and the other a full-scale current of 10mA and internal resistance of 25 ohms, are in parallel. What is the total current these two meters can carry without any meter reading out of scale?

A. 1 mA B. 10 mA

C. 14 mA D. 5 mA

140. A meter has a full-scale angle of 90° at a current of 1A. This meter has perfect square-law response. What is the current when the deflection angle is 45°?

A. 0.5 A B. 0.65 A

C. 0.707 A D. 0.87 A

141. A non-sinusoidal voltage is fed to both a moving-iron voltmeter and a rectifier-type instrument. The readings are 12.1V and 11.1V respectively. The harmonic content as a percentage of average value is

A. 10% B. 100%

C. 43.4% D. 63.8%

142. Hot-wire instruments give

A. the average value

B. the rms value calculated from the average value

C. the rms value from the peak value and the crest factor

D. the true rms value based on heat produced.

143. A rectifier instrument is used to measure a square-wave a.c. of amplitude 100V. This meter would read

Answers : 131. (C), 132. (A), 133. (A), 134. (B), 135. (A), 136. (D), 137. (A), 138. (A), 139. (D), 140. (C), 141. (C), 142. (D).

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A. 111 V B. 100 V
C. 90 V D. 70.7 V

144. Creeping is observed in
A. Watt-hour meter
B. power factor meters
C. wattmeter
D. Ammeter

145. A C.T. is overloaded when
A. the load connected to it is less than its burden
B. its terminals are short-circuited
C. when its terminals are oepn-circuited
D. when the primary current is 110% of its rated value

146. The errors in C.T. are mainly due to
A. leakage flux
B. excitation emf required
C. core losses
D. copper losses

147. The VA rating of instrument transformers is normally near
A. 0.1 VA B. 10 VA
C. 100 VA D. None of these.

148. The main error in a dynamometer type wattmeter is due to
A. pressure coil inductance
B. pressure coil capacitance
C. mutual inductance
D. None of these.

149. Induction type wattmeter operation is based on
A. electro-static forces
B. thermo-electric effect
C. hall effect
D. eddy current flow.

150. Inductance is measured by
A. Wien bridge B. Schering bridge
C. M. well's bridge D. Hay bridge

151. Schering bridge is used to measure
A. dielectric loss B. the inductance
C. low resistance D. mutual inductance

152. Which bridge is used to determine frequency?
A. Anderson bridge B. De Sauty's bridge
C. Wien bridge D. None of these.

153. Ionic wind voltmeter is used for measuring
A. low voltage
B. interwinding capacitance
C. leakage inductance D. high voltage

154. The instrument used normally to check the insulation resistance is
A. multimeter B. ohm-meter
C. megger D. None of these.

155. The deflection depends on the average value in
A. Moving-iron meter B. Rectifier meter
C. Hot wire meter D. None of these.

156. Two voltmeters 'A' and 'B' are connected in series across d.c. line 'A' reads 100 volts and has a resistance 100 ohms 'B' has a total resistance of 15,000 ohms. What is the line voltage?
A. 220 V B. 400 V
C. 250 V D. 230 V

157. To the y-input of a CRO a signal defined by 10 sin 100t is applied. To the x-input, the signal 10 cos 100t is fed. The gain for both x-channel and y-channel is the same. The screen shows
A. sinusoidal signal B. a straight line
C. an ellipse D. a circle

158. A CRO uses
A. electromagnetic focussing
B. electro-static focussing
C. both focussing techniques
D. no focussing technique

159. Steradian is a
A. base unit B. derived unit
C. supplementary unit
D. unit for measuring susceptance

Answers : 143. (A), 144. (A), 145. (C), 146. (C), 147. (B), 148. (A), 149. (A), 150. (C), 151. (A), 152. (C), 153. (D), 154. (C), 155. (B), 156. (C), 157. (D), 158. (B), 159. (C).

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160. Siemens is a unit for measuring
   A. conductance B. resistance
   C. flux density D. electric field

161. Manganin is
   A. an insulator material
   B. a semiconductor material
   C. used for making inductor
   D. an alloy used to make standard resistors

162. In order to obtain fast response, the meters should have
   A. no damping
   B. a damping coefficient of about 0.1
   C. a damping coefficient of about 0.7
   D. critical damping

163. It can be stated that
   A. P.T. operates at almost the same flux density as a C.T.
   B. P.T. operates with a higher flux density than a C.T.
   C. P.T. operates with considerably lower flux density than a C.T.
   D. no generalisation can be made with regard to the flux densities in C.T. and P.T.

164. The standard secondary voltage for a P.T. is
   A. 1 V B. 5 V
   C. 50 V D. 100 V

165. In a ballistic galvanometer, the deflecting torque is proportional to
   A. the current through coil
   B. square of current through coil
   C. square-root current through coil
   D. sine of measurand

166. A galvanometer has
   A. air-friction damping
   B. fluid-friction damping
   C. spring coil damping
   D. eddy current damping

167. A rectifier type instrument is connected to 100V d.c. and is operated in the d.c. measuring mode. It reads
   A. 111 V B. 90 V
   C. 50 V D. 100 V

168. The form factor in a.c. means the ratio of
   A. Peak value to average value
   B. Peak value to r.m.s. value
   C. R.M.S. value to average value
   D. R.M.S. value to peak value

169. A CRO can display
   A. a.c. signals
   B. d.c. signals
   C. both a.c. and d.c. signals
   D. time-invariant signals

170. To measure flux, devices used are based on
   A. voltaic effect
   B. piezo-electric effect
   C. hall's effect
   D. photo-voltaic effect

171. Which meter is suitable for the measurement of 10mV at 50MHz?
   A. Moving-iron voltmeter
   B. VTVM
   C. Electrostatic voltmeter
   D. C.R.O.

172. The absolute measurement of resistance is done by
   A. Ohm's law method B. Bridge method
   C. Rayleigh method D. Lorenz method

173. The internal resistance of an ammeter should be
   A. very small B. medium
   C. high D. infinity

174. Two voltmeters one with a full scale reading of 100V and another with a full scale reading of 200V, are connected in series across a 100V

Answers : 160. (A), 161. (D), 162. (A), 163. (D), 164. (B), 165. (A), 166. (D), 167. (A), 168. (C), 169. (C), 170. (C), 171. (D), 172. (D), 173. (A).

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supply. The internal resistance of both meters is the same. What are the readings ?

A. 100 V and 0 V B. 0 V and 100 V

C. 75 V and 25 V D. 50 V and 50 V

175. Low resistance is measured by

A. De sauty's bridge

B. Maxwell's bridge

C. Kelvin's double bridge

D. Wien bridge

176. Two milliammeters, with a full-scale current of 1mA and 10mA, are connected in parallel and they read 0.5mA and 2.5mA respectively. Their internal resistances are in the ratio of

A. 1 : 10 B. 10 : 1

C. 1 : 5 D. 5 : 1

177. The C.T. supplies current to the current coils of a wattmeter, power facor meter, energy meter and an ammeter. The connection is

A. all coils in parallel

B. all coils in series

C. series-parallel connection with two in each arm

D. None of these.

178. A P.T. is a device which is

A. electro-statically coupled

B. electrically coupled

C. electromagnetically coupled

D. None of these.

179. Using a C.T. has

A. poorer overload capacity than a P.T.

B. the same overload capacity as a P.T

C. a higher overload capacity than a P.T.

D. None of these.

180. The resistance can be measured most precisely by

A. Voltmeter-ammeter method

B. bridge method

C. multimeter

D. VTVM

181. The current coil of a wattmeter is connected to the C.T. of R-phase. The potential coil is connected across Y and B phases. The wattmeter measures

A. active power in R phase

B. active power of Y phase

C. reactive power in R phase

D. power proportional to 3-phase power if the load is balanced.

182. The problem of Electro-static coupling in a transformer is acute at

A. low frequencies

B. power frequencies

C. high frequencies

D. high load on the transformer

183. For an instrument to have a wide range, the instrument should have

A. linear scale B. square-law scale

C. exponential scale D. logarithmic scale

184. For measurement and control, Instruments should preferably have

A. dead zone and dead time

B. linear output and fast response

C. non-linear output

D. a highly damped response

185. The error of an instrument is normally given as a percentage of

A. measured value B. full-scale vlaue

C. mean value D. r.m.s. value

186. Two Wattmeter method can be used for measurement of Power.

A. for balanced power

B. for unbalanced power

C. for reactive power measurement

D. for all three purposes mentioned above.

187. A moving coil ammeter has a full scale deflection of 50 μ A and a coil resistance of 1000

Answers : 174. (D), 175. (C), 176. (D), 177. (B), 178. (C), 179. (C), 180. (B), 181. (C), 182. (C), 183. (D), 184. (B), 185. (B), 186. (D).

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ohms. The value of the shunt resistance required for the instrument ot be converted to read a full scale reading of 1 amp will be

A. .05 ohm B. 0.85 ohm

C. .1 ohm D. 1.0 ohm

188. An alternating current of 50 Hz has a maximum value of 10 amps. Wha. will be the value of current $\frac{1}{600}$ second after it has reached the maximum

A. 5 amps B. 8.66 amps

C. 7.5 amps D. 10 amps

189. In three phase power measurement by Two Wattmeter method the power factor of load will be

A. $\sqrt{3}\frac{(W_1 - W_2)}{W_1 + W_2}$

B. $W_1 + W_2$

C. $\frac{W_1 - W_2}{W_1 + W_2}$

D. $\frac{W_1 \ W_2}{\sqrt{W_1 + W_2}}$

190. In two wattmeter method of measuring 3-phase power, power factor is 0.5, then one of the wattmeter will read

A. $\frac{W}{2}$ B. zero

C. $\sqrt{2}\ W$ D. $\frac{W}{\sqrt{3}}$

191. An oscilloscope indicates

A. peak to peak value of voltage

B. d.c. value of voltage

C. R.M.S. value

D. average value

192. A milliammeter can be used as

A. voltmeter and ammeter

B. wattmeter

C. ohmmeter

D. frequency meter

193. A permanent niagnet moving coil ammeter has a coil resistance of 99 Ω and full seal deflection (fsd) current of 0.1mA. Shunt resistance is 1 Ω. Current through the meter at 0.5fsd is

A. 0.07 mA B. 0.05 mA

C. 0.025 mA D. 0.1 mA

194. Which of the following instrument can be used for measurement of alternating current only?

A. Permanent magnet type ammeter

B. Induction type ammeter

C. Moving-iron voltmeter

D. Moving-iron ammeter

195. Which of the following meter has a linear scale?

A. Thermocouple meter

B. Moving-iron meter

C. Hot-wire meter

D. Moving-coil meter

196. A 10 MHz, CRO has

A. 5 MHz sweep

B. 10 MHz vertical oscillator

C. 10 MHz horizontal oscillator

D. 10 MHz supply frequency

197. The thermocouple instruments do not have

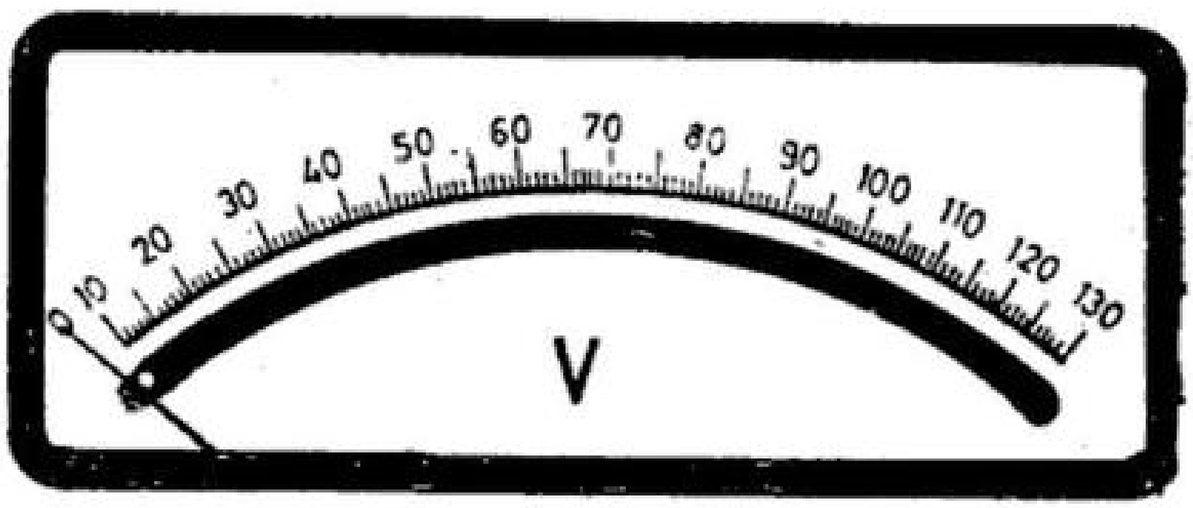
A. high sensitivity

B. absence of frequency error

C. independence of ambient temperature

D. high degree of measuring accuracy.

198. Which of the statements about the measuring instrument shown in the figure is true?



Answers : 187. (A), 188. (B), 189. (A), 190. (B), 191. (A), 192. (A), 193. (B), 194. (B), 195. (D), 196. (C), 197. (D), 198. (C).

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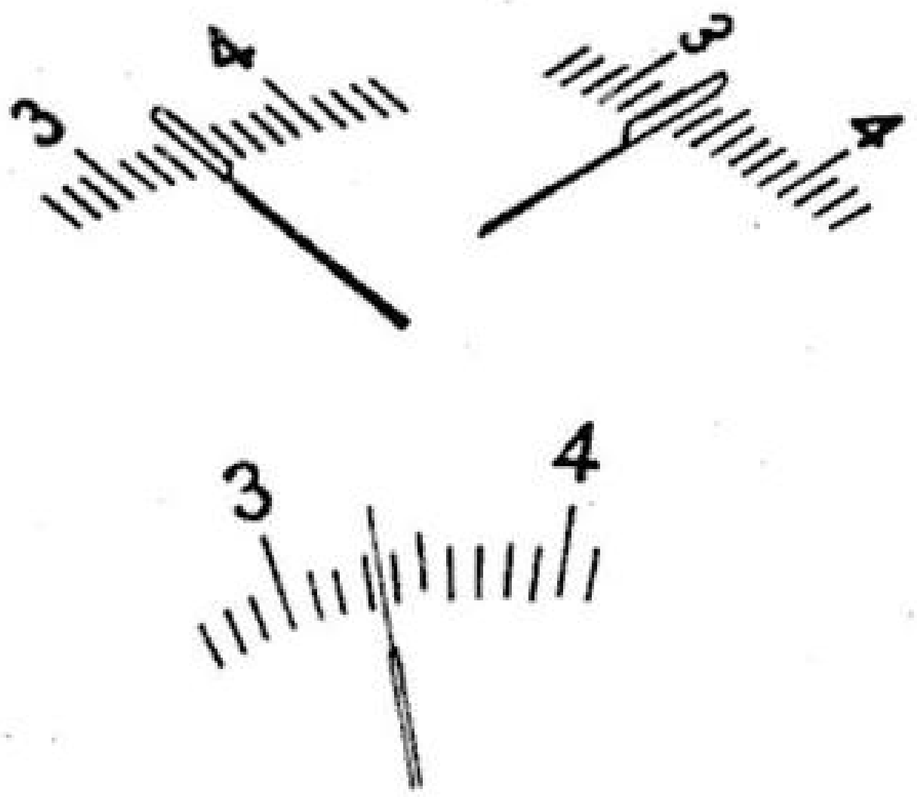
A. The instrument is made to be used in vertical positon

B. The instrument is only suitable for the measurement of high frequency voltages

C. It is a precision instrument

D. None of these.

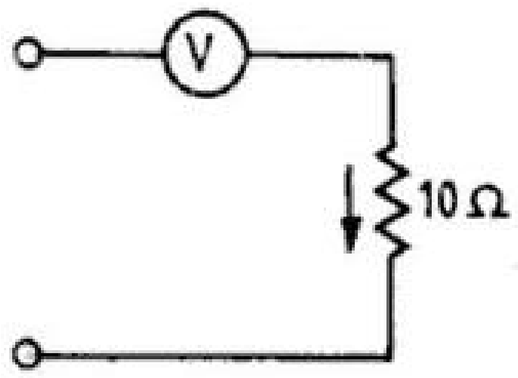
199. What is the correct reading on the scale shown in Figure



A. 3.5 B. 3.25

C. 3.35 D. 3.4.

200. A voltmeter is connected in a circuit as shown in the diagram. Which of the following statements is True?



A. The voltmeter is connected correctly

B. The indicated voltage does not correspond to V

C. The voltmeter shall be damaged in this connection

D. The pointer can only remain at zero.

201. The resolution of an indicating instrument is

A. the smallest change in the output reading due to drifting of pointer

B. the smallest change in applied stimulus that will indicate a detectable change in deflection

C. the difference between various reading for the same applied stimulus

D. None of these.

202. What should be the accuracy classes of industrial measuring instruments?

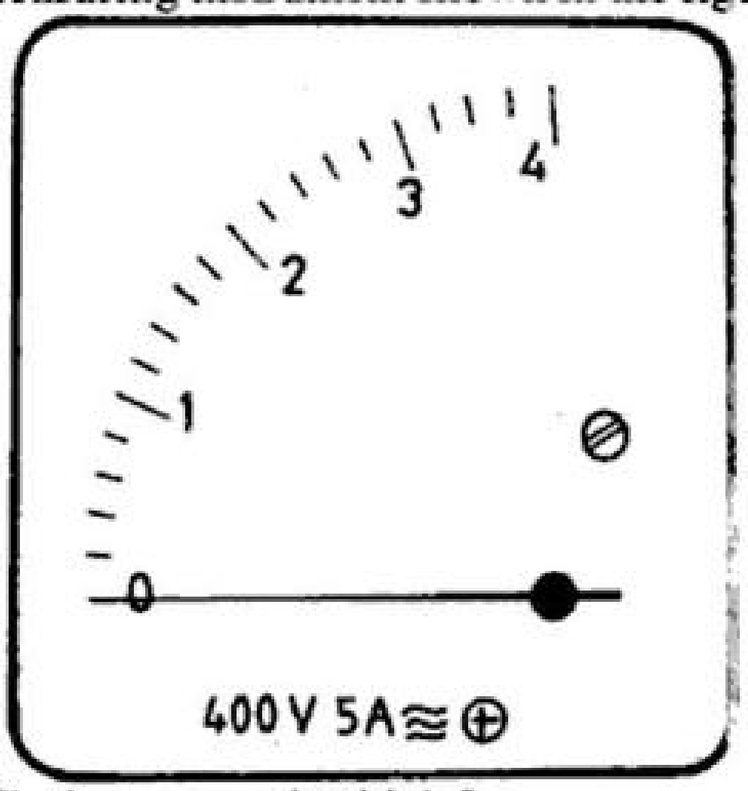
A. Accuracy classes 1.0, 0.2 and 0.5

B. Accuracy classes 0.5 and 1.

C. Accuracy classes 0.5, 1, 1.5, 2.5 and 5.

D. Accuracy classes 1, 1.5, 2.5 and 5.

203. Which of the following statements is true about the measuring instrument shown in the figure?



A. The instrument is a high frequency measuring instrument

B. The test voltage of the instrument is 400V.

C. The instrument is designed to be used in horizontal position

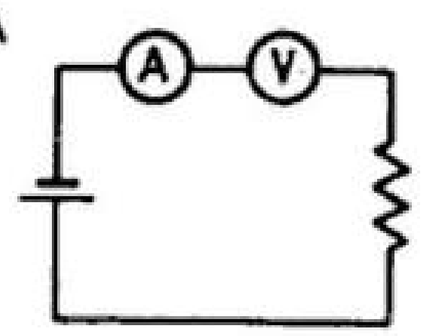
D. The current coil can be loaded upto 5A.

204. In which of the circuits are the ammeter and the voltmeter connected correctly?

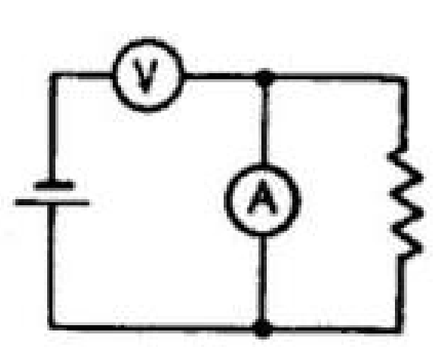
Answers : 199. (C), 200. (B), 201. (B), 202. (D), 203. (C).

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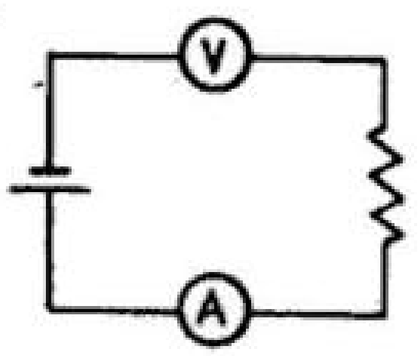
A



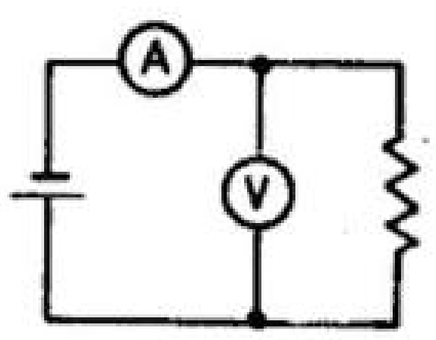
B



C



D

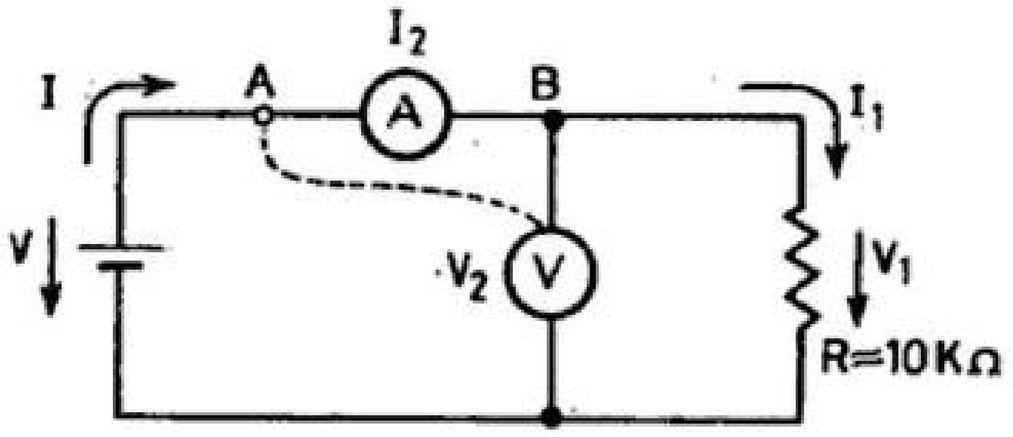


A. Circuit 1 B. Circuit 2
C. Circuit 3 D. Circuit 4.

205. The range of a zero-centred voltmeter having scale from -10V to + 10V is
A. 0 – 20V B. – 10 V to + 10 V
C. 0 – 10 V D. 10 – 20 V.

206. In the above question the span of the voltmeter is
A. 0 V B. – 10 V
C. 10 V D. 20 V.

207. Which of the following statements to determine the value of resistance R in the circuit shown is true?



A. The indicated current I_1 is smaller than I.
B. The voltage V_2 indicated by the voltmeter is higher than the voltage V_1 across the consumer
C. The voltage V_2 indicated by the voltmeter is less than the voltage V_1 across the consumer
D. For a more accurate result, the voltmeter should be connected in front of the ammeter (point A).

208. Which of the following statements about the internal resistance of measuring instruments is true?
A. The internal resistance of ammeters should be very small and that of voltmeters very high
B. The internal resistance of ammeters should be very high and that of voltmeters very small
C. The internal resistance of ammeters and voltmeters should be very small
D. The internal resistance of ammeters and voltmeters should be very high.

209. Six separate readings taken to measure a voltage are given below:

I	II	III	IV	V	VI
1.49,	1.51,	1.50,	1.49,	1.52,	1.50

The most precise readings are
A. II, III, VI B. III, VI
C. II, III D. II, VI.

210. In the above question, the precisions of I and III readings are
A. + 99.3%, 100% B. 0%, – 99.3%
C. 0%, – .01% D. + 99.3%, – 99.3%.

211. Meter accuracy is determined by
A. half-scale deflection B. full-scale deflection
C. one-fourth of full scale deflection
D. one-tenth of full-scale deflection.

212. Senstivity inaccuracy of a recording instrument means
A. the amount of input required to produce unit pen deflection
B. the smallest signal required to produce detectable output
C. the maximum error in senstivity displayed by a pen
D. degree to which the instrument is not sensitive enough to repeat readings.

Answers : 204. (D), 205. (B), 206. (D), 207. (D), 208. (D), 209. (B), 210. (D), 211. (B), 212. (C).

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213. On which of the following factors the senstivity inaccuracy of an instrument does *not* depend?
   A. Hysteresis or dead bond
   B. Amplitude distortion
   C. Frequency response
   D. All of these.

214. The static error band of an instrument implies
   A. the accuracy of the instrument
   B. the error produced when the pen is stopped at some deflection
   C. the irrepeatibility of the instrument
   D. the error introduced in low varying inputs.

215. the static error band of an instrument does *not* include
   A. hysteresis in the instrument
   B. non-linearity
   C. electrical drift D. none of these.

216. The accuracy of a 0 – 10mA meter is ± 10 percent. A full scale reading of 10mA may be due to a current of
   A. 9 mA B. 11 mA
   C. either 9 mA or 11 mA
   D. 12 mA.

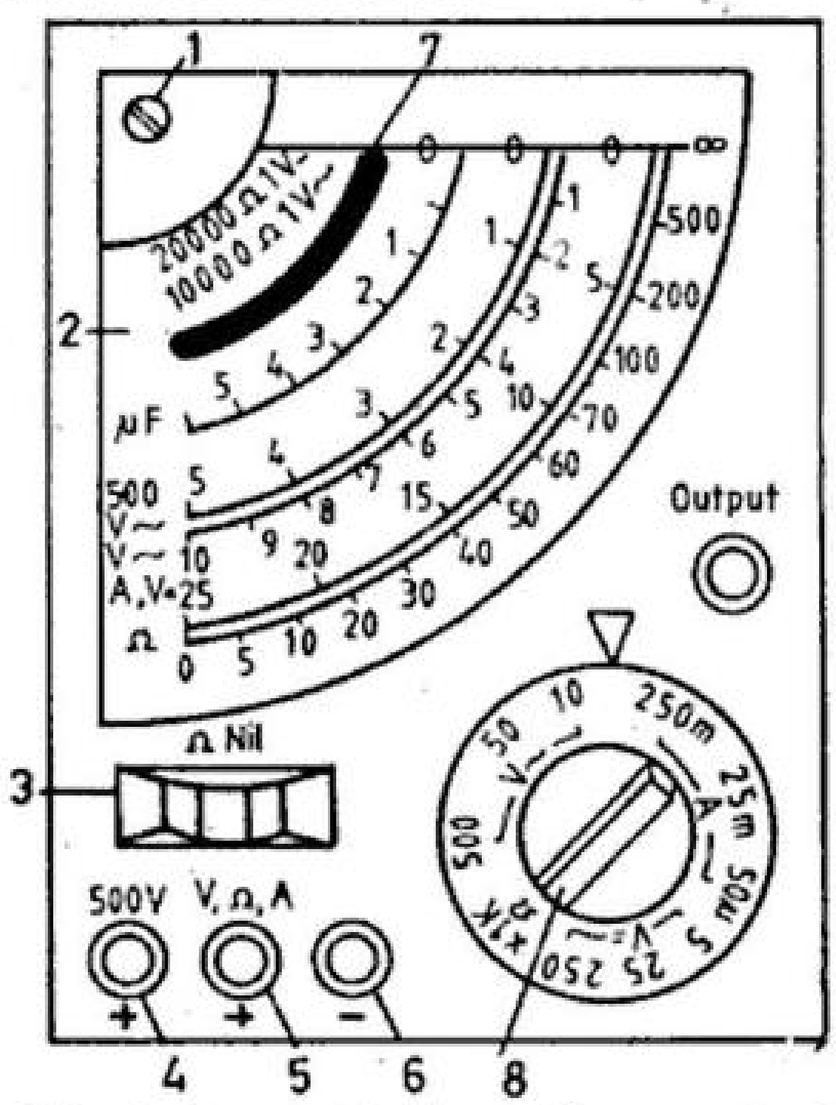
217. In the above question, if the meter is used to measure an actual current of 5mA, the percentage error will be
   A. + 10% B. – 10%
   C. + 16% D. + 16%

218. In an instrument, the error when reading at half-scale is
   A. less than full-scale error
   B. equal to full-scale error
   C. greater than-full scale error
   D. equal to half of full-scale error.

219. A 100mA meter has accuracy of ± 2 percent. Its accuracy while reading 10mA will be
   A. ± 0.2% B. ± 2%
   C. ± 4% D. ± 20%.

220. If the zero-adjust screw of a moving coil meter is turned to the left, the pointer moves
   A. upscale to the right
   B. off scale to the left
   C. half-scale in the centre
   D. full-scale to the right

221. While the instrument is adjusted for measuring direct current, it is by mistake used to measure an alternating current. The scale selected is suitable for the current to be measured. What happens to the instrument?



   A. The instrument indicates the correct value of the current
   B. The pointer does not deflect
   C. The instrument is damaged after a short while
   D. The pointer deflects forcefully to the end of the scale.

222. With the help of the above shown multirange instrument, a current is to be measured which is expected to be about 5 mA. Which of the ranges should be selected before the meter is connected into the circuit?
   A. 250 mA B. 25 mA

Answers : 213. (D), 214. (B), 215. (C), 216. (C). 217. (C), 218. (C), 219. (D), 220. (A), 221. (B), 222. (B).

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C. 2.5 mA D. 50 A.

223. What is the function of part marked 3 in the instrument shown above?

A. To select the measuring range

B. For changing over from current to voltage measurement

C. For zero-adjustment in case of resistance measurements.

D. For zero-adjustment in case of current and voltage measurements.

224. The internal resistance of the meter shown in the above figure is

A. 100 B. 1000

C. 10,000 D. 100,000.

225. To reduce the effect of a voltmeter upon the circuit under test, we should

A. decrease the multiplier resistance

B. get an instrument with higher internal resistance

C. use a parallel resistor

D. use an ac meter with rectifier.

226. To increase the range of a voltmeter

A. a low resistance is connected in series

B. a low resistance is connected in parallel

C. a high resistance is connected in series

D. a high resistance is connected in parallel.

227. What is the function of the zero-adjust control in a multimeter?

A. It serves to conduct the current

B. With this control, the sensitivity of the meter can be changed

C. The zero point is corrected with the help of this control

D. The moving parts can be tightened to the casing with the help of this control-screw.

228. If a moving-iron type ammeter is connected in a circuit, and we interchange its connection, then

A. it will give no deflection

B. its reading will not change

C. it will deflect in the opposite direction

D. it will burn out.

229. The main reason for using springs in a measuring instrument is

A. to conduct the current to the coils

B. to hold the pivot in position

C. to control the pointer movement

D. to minimise the vibration of the pointer.

230. A moving iron type instrument has

A. a linear scale (uniform scale)

B. a nonlinear scale

C. its deflection directly proportional to the current

D. its deflection directly proportional to the voltage.

231. In moving-coil instruments, the scale used is

A. non-linear scale B. linear scale

C. square law scale D. log scale

232. Two meters X and Y require 40 mA and 50mA, respectively, to give full-scale deflection, then

A. X is more sensitive

B. Y is more sensitive

C. both are equally sensitive

D. sensitivity can not be judged with the given information.

233. The megohn sensitivity of a galvnometer having current sensitivity of 10 μA is

A. 1×10^4 ohm/V B. 10×10^4 ohm/V

C. 10×10^5 ohm/V D. 10×10^6 ohm/V.

234. External shunts are generally used for measuring currents greater than about

A. 5 A B. 10 A

C. 15 A D. 30 A.

235. The value of shunt required for 1 mA meter with resistance of 75 ohms to convert it to the range 0-1 mA is

Answers : 223. (D), 224. (C), 225. (B), 226. (C), 227. (C), 228. (B), 229. (C), 230. (B), 231. (B), 232. (A), 233. (B), 234. (D).

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A. 8.33 ohms B. 0.758 ohm
C. 0.751 ohm
D. no shunt is required.

236. Which of the following ranges of a meter requires the smallest shunt resistance?
A. 0 - 10 mA B. 0 - 100 mA
C. 0 - 1 A D. 0 - 10 A.

237. If the approximate value of the current to be measured is not known, measurement should start on
A. the lowest range and then increase the range
B. the highest range and then increase the range
C. the middle range and then decrease the range
D. the middle range and then increase the range.

238. A certain 50 μA meter measurement has resistance of 90 ohms. The value of shunt current when the meter is used to measure a maximum current of 0.5 mA will be
A. 0.00005 A B. 0.00045 A
C. 0.00050 A D. 0.00055 A.

239. In the above question, the value of the shunt resistance should be
A. 5 Ω B. 10 Ω
C. 90 Ω D. 100 Ω.

240. A certain 50 mA meter movement has a resistance of 90 ohms. The value series multiplier needed to make the instrument read 5V maximum will be
A. 97 kΩ B. 66 kΩ
C. 99.9 kΩ D. 197 kΩ.

241. The value of multiplier resistor to measure 0-25V with 10mA meter of resistance of 1000 ohms is
A. 1000 ohms B. 1500 ohms
C. 2000 ohms D. 2500 ohms.

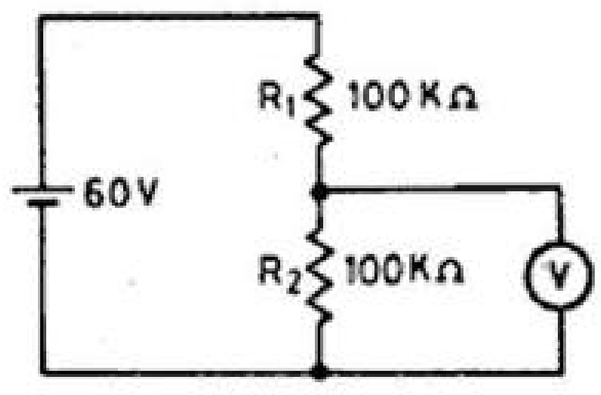
242. When ac voltage is connected to a PMMC meter, then
A. the meter will get damaged
B. the reading is zero
C. the pointer will oscillate to and fro
D. the pointer will not move at all.

243. A very accurate voltmeter gives inaccurate reading when used to measure voltage across a low resistnace because
A. the sensitivity of the meter is high
B. the sensitivity of the meter is too low
C. the higher scale has been selected
D. the voltmeter is drawing too low current.

244. A voltmeter uses a meter with $I_{FS} = 2$ mA. Its sensitivity is
A. 2000 ohms/V B. 2000 V/ohm
C. 500 ohms/V D. 500 V/ohm.

245. The above voltmeter has two ranges 0 - 50 V and 0 - 150 V. The resistances of the voltmeter on the two ranges are
A. 100 kΩ and 100 kΩ
B. 100 kΩ and 300 kΩ
C. 25 kΩ and 75 kΩ
D. 25 kΩ and 25 kΩ.

246. In the figure shown below, a 1000 ohms/V meter set on the 0-100V range is connected across resistance R_2. The total resistance on this range will be



A. 50 kΩ B. 100 kΩ
C. 200 kΩ D. 400 kΩ.

247. In the above question, the total circuit resistance across the battery will be
A. 50 kΩ B. 100 kΩ
C. 150 kΩ D. 200 kΩ.

248. In the same question, the meter will reao
A. 20 V B. 28.5 V
C. 30 V D. 40 V.

Answers : 235. (D), 236. (D), 237. (B), 238. (B), 239. (B), 240. (D), 241. (D), 242. (B), 243. (B), 244. (C), 245. (C), 246. (B), 247. (C), 248. (A).

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249. In the same question, the error in measuring voltage across R_2 is

A. zero B. 5%

C. 17% D. 33%.

250. The function of swamping resistor put in series with the moving coil of a moving coil meter is

A. to achieve full-scale sensitivity of the meter

B. to reduce the full-scale current

C. to compensate for transporative variations

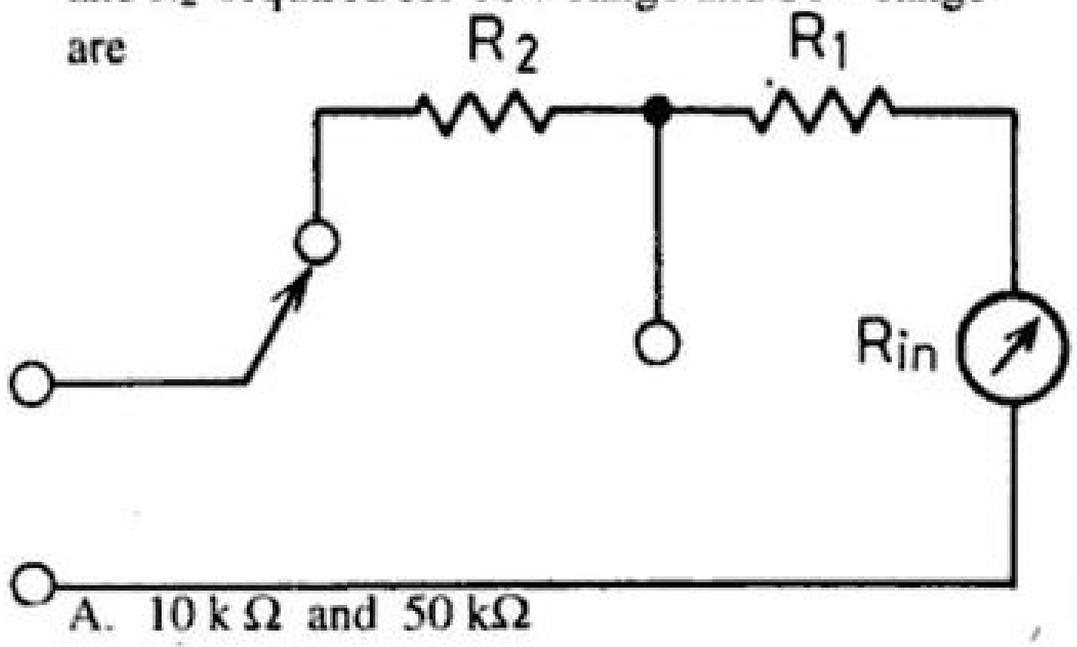
D. to increase the field strength.

251. It is desired to convert a 1-mA meter movement with an internal resistance of 100 ohms into a 0-100mA ammeter. The required value of the shunt resistance is about

A. 100 ohms B. 99 ohms

C. 10 ohms D. 1 ohms.

252. For the voltmeter circuit shown below, the basic '*d*' Arsnoval meter used has full scale current of 1mA and meter resistance of 100 ohms. The value of the series resistances R_1 and R_2 required for 10V range and 50V range are



A. 10 kΩ and 50 kΩ

B. 9.9 kΩ and 40 kΩ

C. 20 kΩ and 80 kΩ

D. 200 kΩ and 250 kΩ.

253. A '*d*' Arsnoval meter has full scale current of 1mA and internal resistance of 200ohms. It is converted into a 0-100V voltmeter. The current sensitivity of the voltmeter and its total resistance respectively are

A. 200 V/ohms and 9.8 kΩ

B. 200 ohms/V and 10 kΩ

C. 100 V/ohms and 1000 kΩ

D. 1000 ohms/V and 100 kΩ.

254. A voltmeter with low sensitivity is connected across two points in a highly resistive circuit. The reading of the meter would be

A. lower than the actual voltage

B. higher than the actual voltage

C. same as the actual voltage

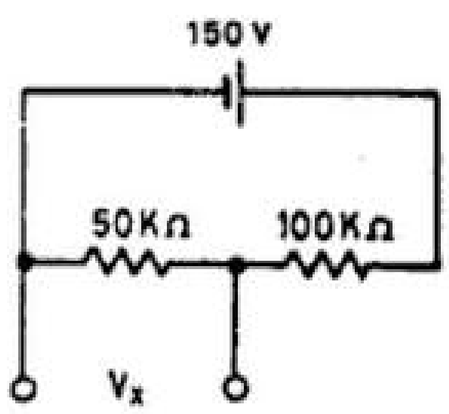
D. quite accurate.

255. A low voltage is measured on a higher scale of a voltmeter. The measurement would have

A. low accuracy B. low resolution

C. low precision D. all of these.

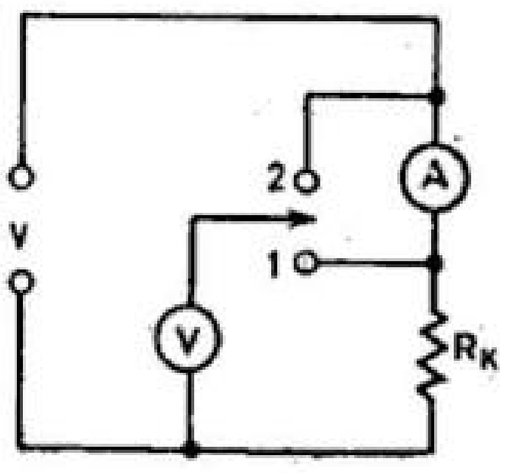
256. In the circuit given below, the voltage V_x is measured first by an electronic voltmeter and then by a multimeter having 20000 ohms/volt, using its 150 V scale. The corresponding two readings are



A. 50 V and 48.4 V B. 60 V and 36.5 V

C. 80 V and 45.5 V D. 80 V and 60.2 V.

257. In order to measure accurately a low value resistance R_X placed in the circuit shown below, it is necessary that



Answers : 249. (D), 250. (C), 251. (D), 252. (B), 253. (D), 254. (A), 255. (D), 256. (A).

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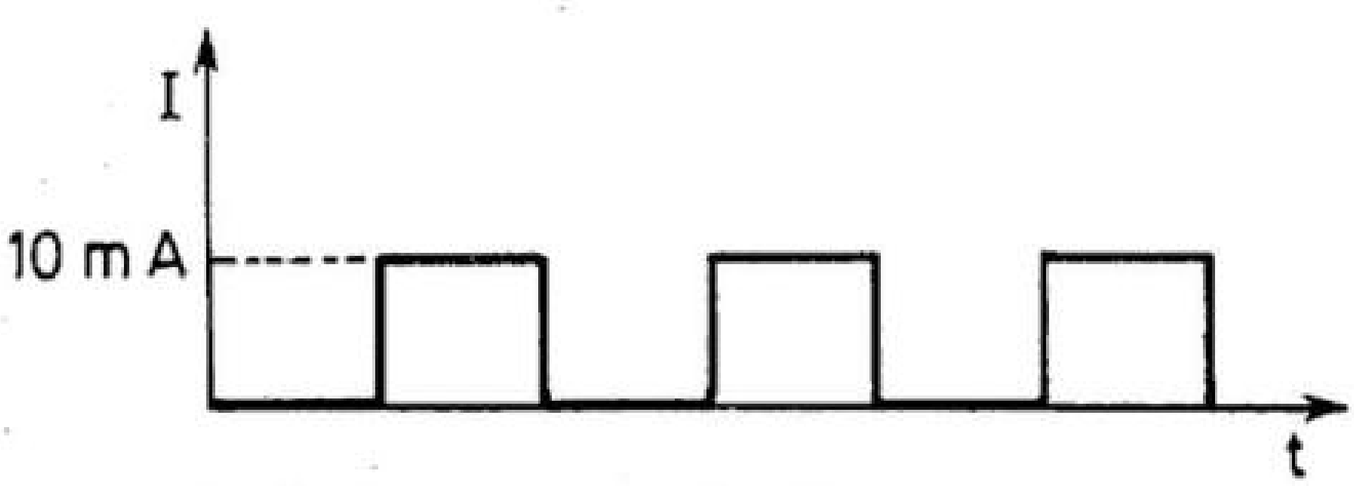
A. switch should be in position 1

B. switch should be in position 2

C. the input voltage should be high

D. the input voltage should be low.

258. The waveform shown in figure below is given to a dc meter. The reading of the meter will be



A. 5 mA B. 10 mA

C. 7.1 mA D. 6.3 mA.

259. A moving-iron ammeter and a simple moving-coil ammeter are placed in series with the load in a half-wave rectifier circuit. The reading of the ac instrument is 5A. The reading of the other instrument would be

A. 2.8 A B. 2.5 A

C. 3.18 A D. 4.6 A.

260. The disadvantage associated with an electrodynamic instrument is that

A. it consumes more power

B. it has low torque-to weight ratio

C. its frequency range is low

D. all of these.

261. An electrodynamic meter can be used to measure

A. ac voltages B. dc voltages

C. dc as well as ac voltage

D. dc voltages but for ac voltages rectification is necessary.

262. The advantage of a moving-iron instrument is that

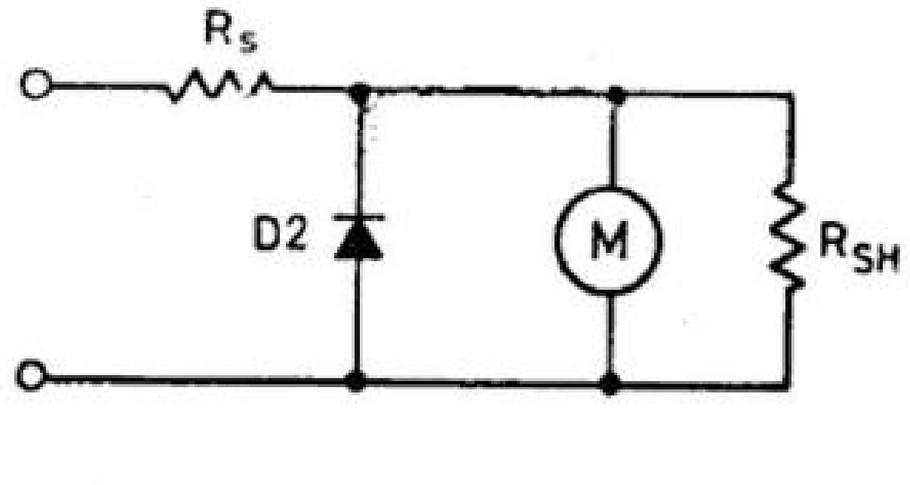
A. it has linear scale

B. its current sensitive is high

C. it can be used under severe overload conditions

D. it can be used at high frequencies.

263. The figure below shows a typical ac voltmeter in a multimeter. The function of R_{SH} is



A. to increase meter current

B. to reduce meter resistance

C. to limit the meter current to its full-scale value

D. to make the rectifier D_1 operate in linear region.

264. In the same circuit, the function of diode D_2 is

A. to avoid reverse leakage current of D_1 in the negative cycle of the input

B. to short-circuit over-range voltages

C. to provide full-wave rectification

D. to previde half-wave rectification.

265. In the same circuit, meter resistance is 100 ohms, full-scale meter current is 1mA, R_{SH} is 100 ohms and forward resistance of each diode is 400 ohms. The total resistance of the instrument is

A. 5 kΩ B. 2.25 kΩ

C. 4.2 kΩ D. 1.8 kΩ.

266. In the same problem, the value of the multiplier R_S needed for 0-10 V range is

A. 2.25 kΩ B. 2.25 kΩ

C. 1.85 kΩ D. 1.8 kΩ.

267. Which one of the following is *not* an advantage of an electrostatic voltmeter?

A. It consumes no power

Answers : 257. (A), 258. (A), 259. (C), 260. (D), 261. (C), 262. (C), 263. (D), 264. (A), 265. (B), 266. (D).

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B. It has infinite impedance

C. It has linear scale

D. The deflection of the instrument is independent of the input waveform.

268. A 35 dc supply is connected across a resistance of 600 ohms in series with an unknown resistance R. A voltmeter having a resistance of 1.2 $k\Omega$ is connected across 600 ohms resistane and reads 5V. The value of resistance R will be

A. 120 ohms B. 500 ohms

C. 1.7 $k\Omega$ D. 2.4 $k\Omega$.

269. A moving-coil millameter of range 0-10 mA and coil resistance 75 ohms (independent of temperature variations) has been adopted by wire-wound resister to read 0-1A. If this resistor is accurate at 10°C and the temperature coefficient of the wire is + 0.5 percent/°C, the error at a room temperature of 30°C will be

A. 0.009 A low B. 0.036 A high

C. 0.091 A high D. 0.115 A low.

270. The current flowing in a circuit consists of a dc of 3A and an ac of peak value 2A. The readings of amoving-coil ammeter and moving-iron ammeter will be

A. 1 A and 2.51 A, respectively

B. 2.5 A and 3.15 A, respectively

C. 3 A and 3.32 A, respectively

D. 3.5 A and 4.36 A, respectively.

271. A peak reading voltmeter has been calibrated with a sine wave signal and scaled in rms volts. If a square wave signal ± 1V peak is applied, the meter reading will be

A. 0.535 V B. 0.707 V

C. 1 V D. 1.75 V.

272. A bridge type rectifier meter and a thermocouple meter employ moving-coil movement for indication. Both are calibrated on a 100Hz sinusoidal waveform. If a 100 Hz rectangular waveform is applied to each, the ratio of their readings will be

A. 2 : 1 B. 1.11 : 1

C. 1.41 : 1 D. 1.21 : 1

273. The coil of a moving-coil meter is wound with 45 turns on a former 15 mm square. If it is suspended in an air gap, where the flux density is 0.08 Wb/m^2, the value of the torque on the coil when the current in it is 30mA, will be

A. $86 \times 10^{-7}\ N/m$

B. $176 \times 10^{7}\ N/m$

C. $243 \times 10^{-7}\ N/m$

D. $348 \times 10^{7}\ N/m$.

274. A moving-iron voltmeter has a coil with 1000 turns and a resistance of 2.5 $k\Omega$. It gives full-scale deflection with an applied voltage of 100V. The number of turns required to convert the meter to read full-scale deflection of 20A will be

A. 20 turns B. 40 turns

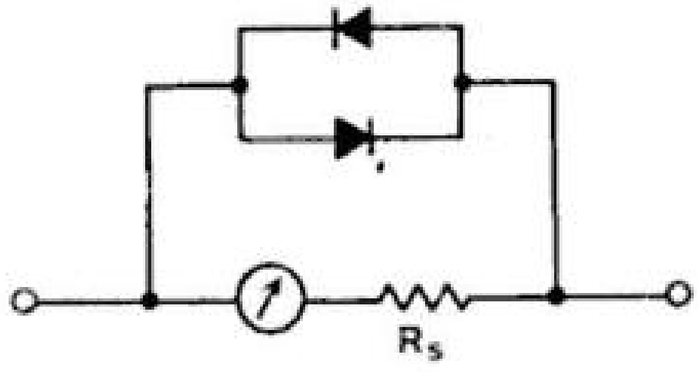
C. 60 turns D. 80 turns.

275. A rectifier-type meter is calibrated in rms values for a pure sine wave. If a current waveform with rms value of 72.4 A and average value of 69.5 A is applied to it, the percentage error will be about

A. 1% high B. 3% low

C. 5% high D. 7% high.

276. The function of diodes is



A. to rectify the ac input

B. to reduce the meter resistance in both directions

C. to protect the meter against overloads

D. none of these.

Answers : 267. (C), 268. (D), 269. (C), 270. (C), 271. (B), 272. (B), 273. (C), 274. (A), 275. (C), 276. (C).

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277. Which of the following instruments is used to measure current in a long extension wire?
   A. Ammeter with a shunt
   B. Thermocouple type meter
   C. Current transformer
   D. Voltage transformer.

278. The secondary of a current temperature is
   A. never left short-circuited
   B. never left open-circuited
   C. always kept open-circuited
   D. none of these.

279. The secondary of a current transformer is never left open-circuited because otherwise
   A. heat dissipation in the core will be very high
   B. the core will be saturated and permanently magnetised rendering it useless
   C. secondary voltage will be very large
   D. all of these.

280. The ratio error in current tansformer is due to
   A. power factor of primary
   B. wattless component of the current in the primary
   C. exciting current
   D. leakage flux.

281. Alternating current *cannot* be measured directly by
   A. hot-wire ammeter
   B. moving-iron ammeter
   C. moving-coil ammeter
   D. thermocouple type ammeter.

282. What will happen if a voltmeter is connected like an ammeter in series to the load?
   A. The meter will burn out
   B. The measurement will be too high
   C. An inadmissably high current will flow
   D. There will be almost no current in the circuit.

283. A thermocouple motor can be used to measure
   A. dc current only
   B. ac current only
   D. both ac as well as dc currents
   D. rms values only.

284. Which of the following instruments will read true rms value irrespective of the signal waveform?
   A. Moving-coil meter
   B. Moving-iron meter
   C. Electronic meter
   D. Thermocouple meter.

285. Which of the following meter is *not* a current meter ?
   A. Moving-coil meter
   B. Hot-wire type meter
   C. Thermocouple meter
   D. None of these.

286. Which of the following meters *cannot* measure dc?
   A. Moving-coil meter
   B. Dynamometer
   C. Moving-iron meter
   D. Rectifier type moving-coil meter.

287. Which of the following meters *cannot* measure both dc as well as ac?
   A. Moving-iron meter
   B. Dynometer
   C. Thermocouple meter
   D. Induction-type meter

288. Clamp-on ammeter is used for
   A. low ac current
   B. high ac current
   C. low dc current
   D. high dc current.

289. In a series ohmmeter, the resistance to be measured is connected in

Answers : 277. (C), 278. (B), 279. (D), 280. (C), 281. (C), 282. (D), 283. (C), 284. (D), 285. (D), 286. (D), 287. (D), 288. (B), 289. (A).

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A. series with the meter
B. parallel with the meter
C. series with the battery
D. none of these.

290. Shunts are used in series ohmmeter to
A. spread out the range
B. protect from the burning
C. increase accuracy
D. measure the current.

291. The instrument used for making a resistance of 100 MΩ is
A. ohmmeter
B. multimeter
C. VTVM
D. megger.

292. Which of the following conditions is *not* required for using an ohmeter?
A. The circuit under test should be deenergised
B. all large capacitors are discharged
C. zero adjustment is made by short-circuiting the leads
D. the meter should be set on the lowest range.

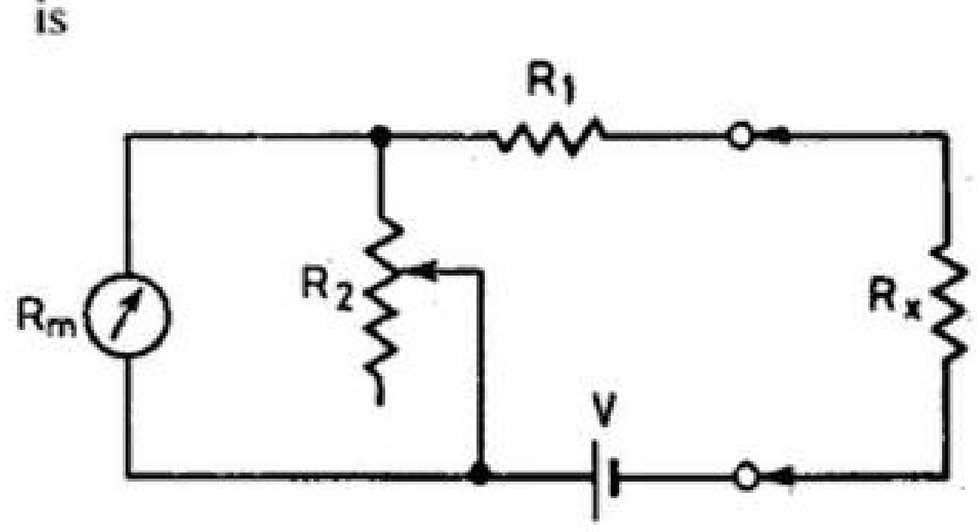
293. Which of the following equipments is *not* a part of meggar?
A. Hand crank
B. Moving-coil meter
C. A coil of high inductance
D. Gear box generator.

294. With its measurement terminals open-circuited, the 'infinity' reading on meggar is due to
A. current in the coil connected across the measurement points
B. unit in the coil connected across the generator
C. current in both the coils
D. zero deflection of the pointer.

295. When measuring a high resistance, the pointer of shunt-ohmmeter will show
A. more deflection
B. less deflection
D. zero deflection
D. constant deflection.

296. The shunt type ohmmeter cannot be used for high resistances measurements because
A. battery supplies low current due to discharging
B. the scale is highly cramped for high values
C. very small resistance is required for mid-scale deflection
D. very low meter resistance shorts the high unknown resistance.

297. In the ohmmeter circuit shown below, the mid-scale resistance is 2 kΩ, $V = 3$V, $R_m = 50$ ohms, and $I_{FS} = 1$mA. The total battery current is



A. 2 mA
B. 5.1 mA
C. 1.5 mA
D. 1.7 mA.

298. In the above problem, is the battery discharges by 10%, the maximum value of R_2 to compensate for the drop in voltage is
A. 200 ohms
B. 143 ohms
C. 100 ohms
D. 80 ohms.

299. Basically an ohmmeter consists of
A. dc current meter
B. low voltage dc power source
C. current limiting resistors

Answers : 289. (A), 290. (A). 291. (D), 292. (D), 293. (C), 294. (A), 295. (A), 296. (B), 297. (C), 298. (B), 299. (C).

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D. all of these.

300. In the above problem, the values of R_1 and R_2 should be
   A. 1600 ohms and 55 ohms, respectively
   B. 1.97 kΩ and 100 ohms respectively
   C. 5.2 k Ω and 200 ohms respectively
   D. 6.5 6.5 kΩ and 1.2 k Ω respectively.

301. The total impedance of the above ohmmeter is
   A. 1.9 kΩ B. 4.7 kΩ
   C. 2 kΩ D. 50 ohms.

302. In a multimeter, the ohm scale is clustered at left hand side because
   A. I_m varies non-linearly with R_x.
   B. $\frac{d\theta}{dR_x}$ is very low for low values of R_x.
   C. $\frac{d\theta}{dR_x}$ is very low for high values of R_x.
   D. $\frac{d\theta}{dR_x}$ is very large for high values of R_x.

303. VTVM provides more accurate readings in high resistance circuits as compared to voltmeter because of its
   A. high V/ohm ratings
   B. high ohms/V ratins
   C. low meter resistance
   D. high resolution.

304. The FETVM employes FETs' in
   A. cascade mode
   B. differential mode
   C. cascode mode
   D. commod mode.

305. In a VTVM of various ranges, the voltage difference between the plates corresponds to
   A. half-scale deflection of the water
   B. full-scale deflection of the meter
   C. rms value of the maximum voltage
   D. dc value of the maximum voltage.

306. A VTVM is more reliable as compared to multimeter for measuring voltage across low impedance because
   A. its sensitivity is very high
   B. it offers high input impedance
   C. it does not alter the measured voltage
   D. all of these.

307. A dc VTVM can be used to measure ac voltages up to about 250 MHz with the help of
   A. *RC* circuit B. *RF* probe
   C. rectifier D. none of these.

308. Which of the following conditions is *not* true in using an ohmmeter?
   A. The resistance to be measured should not be in parallel with any component.
   B. There should be no voltage other than the voltage osurce inside the meter.
   C. The circuit should be open-circuited.
   D. None of these.

309. Continuity measurements in servicing planted-circuit boards can be done by
   A. impedance meter B. ohmmeter
   C. meggar D. VTVM.

310. Which of the following instruments have the highest input impedance?
   A. Ohmmeter B. VOM
   C. VTVM D. FETVM.

311. A VTVM of impedance 20 MΩ is used to measure voltage across a 5 kΩ resistance with 10 V supply placed across it. The reading of the meter will be
   A. zero B. 10 V
   C. 25 V D. 50 V.

312. The power of a 100 kW transmeter can be measured by
   A. voltmeter-ammeter consometer
   B. bolometer
   C. wattmeter
   D. calorimetric method.

Answers : 300. (B), 301. (C), 302. (C), 303. (B), 304. (B), 205. (B), 306. (D), 307. (B), 308. (D), 309. (B), 310. (D), 311. (B), 312. (D).

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313. A simple moving-coil meter cannot be used to measure radio-frequency currents because
   A. the meter inducted would cause an inductive reactance in the circuit
   B. large amount of heat dissipation will be present
   C. damping of the meter becomes difficult at radio-frequencies
   D. the meter is not very accurate at radio-frequencies.

314. Which of the following meters is most suitable for measuring radio frequency currents?
   A. Moving-ciol meter
   B. Moving-iron meter
   C. Thermocouple meter
   D. VTVM.

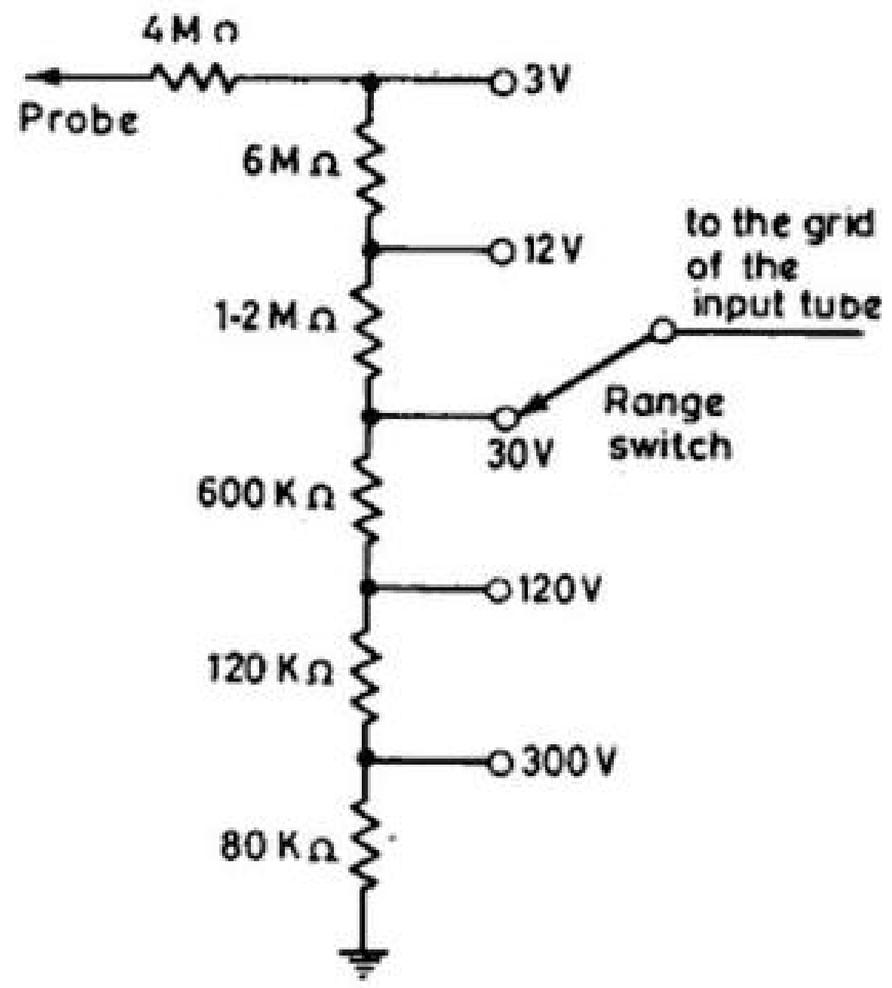
315. At high frequencies the accuracy of all the measuring meters
   A. increases B. decreases
   C. remains the same
   D. depends upon the type of meter.

316. In which of the following instruments, bridge rectifier is used to measure ac voltages?
   A. AC multimeter
   B. AC VTVM
   C. Thermocouple
   D. none of these.

317. Which of the following instruments is used almost exclusively to measure radio frequency currents?
   A. Moving-coil meter
   B. Rectifier-type Moving coil meter
   C. Iron-Vane meter
   D. Thermocouple meter

318. AC/DC VTVM is a
   A. moving coil instrument
   B. moving iron instrument
   C. both moving coil/moving iron instruments
   D. dynamometer type instrument.

319. In the range selection circuit of a VTVM shown below, the grid input voltages for full scale deflection for 0-3 V range and 0-30V range are



   A. 1.5 V. 3 V.
   B. 3 V. 3 V.
   C. 2 V. 2 V.
   D. 1.5 V. 2 V.

320. A radio frequency (rf) probe in VTVM is used to measure
   A. high resistance
   B. low resistance
   C. low frequency voltages
   D. high frequency voltages.

321. One advantage which a VTVM has over VOM is
   A. greater portability
   B. low power consumption
   C. lower input impedence
   D. the ability to measure wider ranges of voltage and resistance.

Answers : 313. (A), 314. (C), 315. (B), 316. (D), 317. (D), 318. (A), 319. (C), 320. (D), 321. (D).

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322. In a balanced Wheatstone bridge $R_1 = 33\ k\Omega$ $K_2 = 47\ k\Omega$ $R_3 = R_x$ and $R_4 = 94\ k\Omega$, the value of R_x is

A. 14.7 kΩ B. 47 kΩ

C. 66 kΩ D. 157 kΩ.

323. In a Wheatstone bridge, the known resistances are correct to within ± 0.1 %. The accuracy to which an unknown resistance can be measured will be

A. 0.1% B. 0.3%

C. 0.4% D. 0.5%.

324. In a Wheatstone bridge, all resistances are of value R ohms and the battery has zero internal resistance. The value of the galvanometer resistance for the maximum sensitivity of the bridge should be

A. R ohms B. 1.5 R ohms

C. 2 R ohms D. 4 R ohms.

325. Wheatstone bridge is analogous to

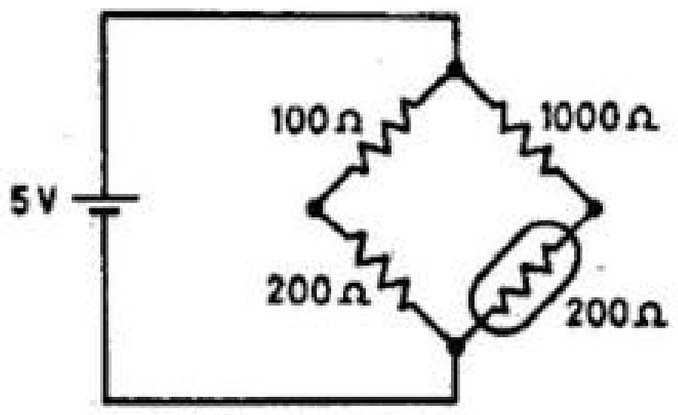
A. gear train

B. simple lever system

C. cantilever

D. none of these.

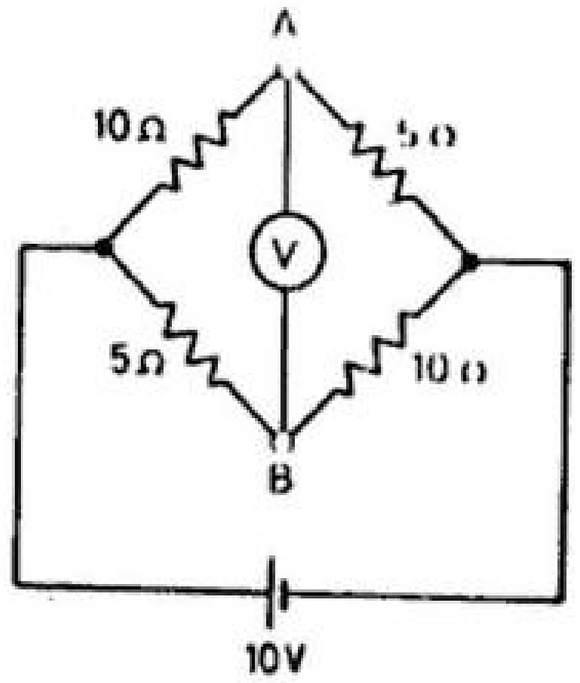
326. The bridge circuit given below employs a NTC of 2000 ohms resistance at ambient temperature. When temperature falls, NTC resistance changes by 5 ohms. The unbalanced voltage across the galvanometer would be



A. 2.2 mV B. 1.2 V

C. 0.5 V D. 10.1 mV.

327. In the circuit shown below, the voltmeter will read



A. 0 V B. 5 V

C. 8 V D. 3.3 V.

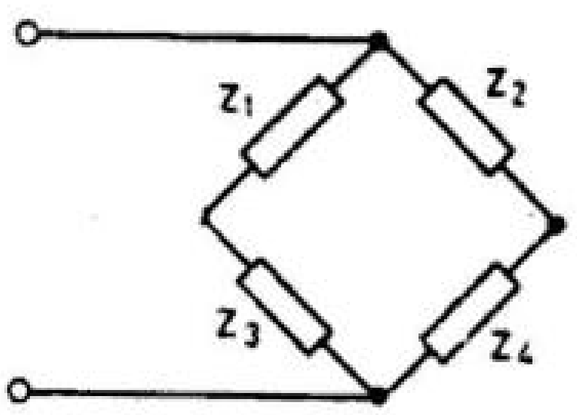
328. The three impedances of an ac bridge are :

$Z_1 = 200\Omega \angle 60^\circ$,

$Z_2 = 400\ \Omega \angle -90^\circ$,

$Z_3 = 300\ \Omega\ \angle 0^\circ$.

The value of Z_4 for the bridge to be balanced is



A. $150\Omega \angle 30^\circ$,

B. $400\Omega \angle -90^\circ$

C. $300\Omega \angle +90^\circ$

D. $600\Omega \angle -150^\circ$.

329. The simplest and most convenient form of detector used in a Wheatstone bridge for audio frequency range is

A. galvanometer

B. vibration galvanometer

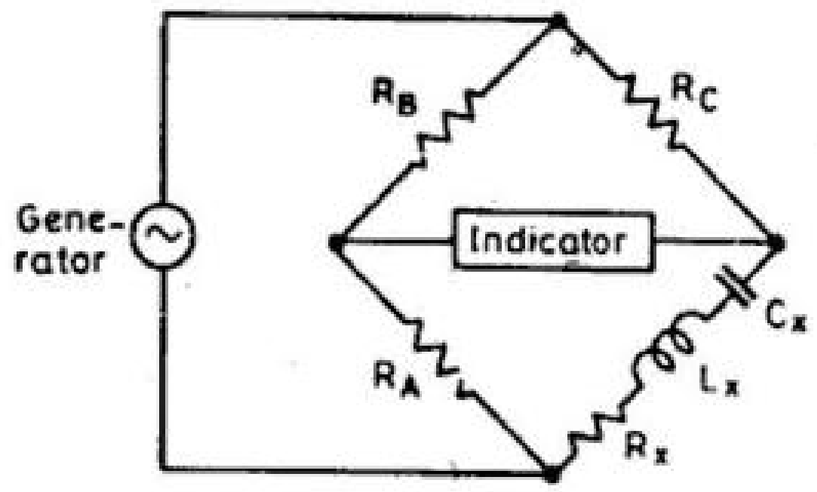
C. pair of headphones

D. cathode ray tube indicator

Answers : 322. (C), 323. (B), 324. (A), 325. (B), 326. (A), 327. (D), 328. (D), 329. (C).

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330. Which of the following indicators *cannot* be used in the bridge shown below?



A. Ac voltmeter B. Earphones
C. Tuning eye tubes D. none of these.

331. In the above circuit, of the audio generator is turned to resonant frequency, the volume in the pair of earphones used as indicator will be
A. maximum
B. minimum
C. zero
D. varying atlernatively.

332. In the same circuit, if an (rf) generator is employed, then it is necessary to incorporate in the system
A. a frequency meter
B. an ac voltmeter
C. a modulator and a detector
D. an oscilloscope.

333. Very small resistances can be measured more accurately by
A. resistance box
B. kelvin-double bridge
C. Anderson bridge
D. Schering bridge.

334. Inductance is measured in terms of capacitance and resistance by
A. Schering bridge
B. Anderson bridge
C. Maxwell-wein bridge
D. Wein bridge.

335. Carey-Foster bridge is specially designed to determine
A. the high resistance of the wire
B. the internal resistance of the battery
C. the difference between two nearly equal resistances
D. the emf of the voltage source.

336. Schering bridge can be used to measure
A. capacitance and its power factor
B. Q of a coil
C. inductance and its Q-value
D. very small resistance.

337. Which of the following bridges is used to measure inductance of a high Q-inductor?
A. Maxwell bridge
B. Hay bridge
C. Wien bridge
D. Anderson bridge.

338. Which of the following bridge is used to measure inductance of a low Q-inductor?
A. Maxwell bridge
B. Hay bridge
C. Wien bridge
D. Anderson bridge

339. The resolution of a digital voltmeter with 4-digit display is
A. 1/4 B. 1/1000
C. 1/10000 D. 0.1%.

340. The accuracy of a digit voltmeter is specified as
A. percentage of the actual reading
B. percentage of the full scale reading
C. number of least significant digits
D. all of these.

341. The accuracy of a digit voltmeter for dc voltage is specified as ± 1% of reading, ± 1 digit. This implies that
A. full-scale reading can be inaccurate by 1%.

Answers : 330. (D), 331. (B), 332. (C), 333. (B), 334. (B), 335. (C), 336. (A), 337. (B), 338. (A), 339. (C), 340. (D).

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B. full-scale reading can be inaccurate by one digit at the most insignificant level

C. actual reading can be inaccurate by one digit

D. none of these.

342. In a digital voltmeter, the oscillator frequency is 400 KHz, the ramp voltage falls from 8V to 0V in 20 m sec. The number of pulses counted by the counter is

A. 800 B. 2000

C. 4000 D. 8000.

343. In the above problem, if the oscillator frequency decreases to 390 KHz, a measurement of exactly 8V dc would give a display of

A. 7.600 B. 7.800

C. 8.000 D. 7.90.

344. Pulses from the clock of frequency 100 KHz pass through the counter of digital multimeter during a gate period 5.75 m sec. The number of pulses counted by the counter will be

A. 57500 pulses B. 5750 pulses

C. 575 pulses D. 57.5 pulses.

345. Which of the following statement is *not* a disadvantage of a digital voltmeter?

A. It cannot measure non-linear parameters

B. It is comparatively high priced

C. Its circuitery is more complex

D. Its accuracy changes with the reading taken.

346. A certain meter has a sensitivity of 50 000Ω/V. The current required to deflect the meter movement to full-scale will be

A. 5 μ A B. 10μ A

C. 20μ A D. 50μ A.

347. In digit voltmeter, 'over-ranging' implies that

A. next 4 digits are switched on

B. 1/2-digit is switched off

C. 1/2-digit is switched on

D. an indicator short growing.

348. A digital voltmeter has 4 $\frac{1}{3}$-digit display. The 1V range can read upto

A. 9999 B. 9.999

C. 1 9999 D. 19999.

349. A digital voltmeter has 41/2-digit display. The 1000 V range can be upto

A. 9999 B. 9.999

C. 1.9999 D. 19999.

350. A digital voltmeter reading is 17.76V. Its sensitivity would be

A. 0.06 V B. 0.7 V

C. 0.03 V D. 1%.

351. The potentiometer wire should have

A. high specific resistance and high temperature coefficient

B. high specific resistance and low temperature coefficient

C low specific resistance and high temperature coefficient

D. low specific resistance and low temperature coefficient.

352. Sensitivity of a potentiometer can be increased by

A. decreasing the length of potentiometer wire

B. increasing the length of potentiometer wire

C. decreasing the current in potentiometer wire

D. decreasing the resistance in the rheostat in series with the battery.

353. The cell used in a potentiometer is

A. a Dry cell

B. a Danial cell

C. a Lachlanche cell

D. a Lead assumulator.

354. The deflection of hot-wire instruments depends on

A. instantaneous value of current

Answers : 341. (B), 342. (D), 343. (B), 344. (C), 345. (D), 346. (C), 347. (C), 348. (C), 349. (D), 350. (A), 351. (B), 352. (B), 353. (D).

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B. average value of current

C. rms value of current D. none of these.

355. Induction type single-phase energymeter is

A. an ampere-hour meter

B. true watt-hour meter

C. wattmeter D. none of these.

356. Volt-Box is basically a device used to

A. measure the voltage

B. measure the power

C. extend the range of potentiometer

D. measure the current.

357. The total power delivered to a three-phase load is equal to

A. algebraic difference of two-wattmeter readings

B. algebraic sum of two-wattmeter readings

C. vectorial difference of two-wattmeter readings

D. vectorial sum of the two-wattmeters readings.

358. In the two-wattmeter method for balanced load, the readings of the wattmeters are 3 kW and 1kW respectively, the latter being obtained after reversing the connections to the current coil of one-wattmeter, the power measured is

A. 4 W B. 2 W

C. 1 W D. 0.5 W.

359. In the above problem, the power factor is

A. 0.095 B. 0.184

C. 0.277 D. 0.526.

360. One of the method to measure power output of a radio transmitter while it is radiating is

A. electrostatic meter

B. three-wattmeter method

C. three-ammeter method

D. two-wattmeter method.

361. The three-phase four-wire energymeter is used to measure

A. three phase unabalanced energy

B. three phase balanced energy

C. two phase energy

D. single phase energy

362. Electrodynamic types of instruments are used commonly for the measurement of

A. voltage B. current

C. resistance D. power.

363. Which power is measured with the help of an induction wattmeter?

A. The apparent power

B. The reactive power

C. The true power and the reactive power

D. Only the true power.

364. A wattmeter is reading backwards in an experiment. Upscale reading can be obtained by reversing

A. pressure coil connection only

B. current coil connection only

C. both pressure as well as current coil connections

D. either the pressure connection or the current connection.

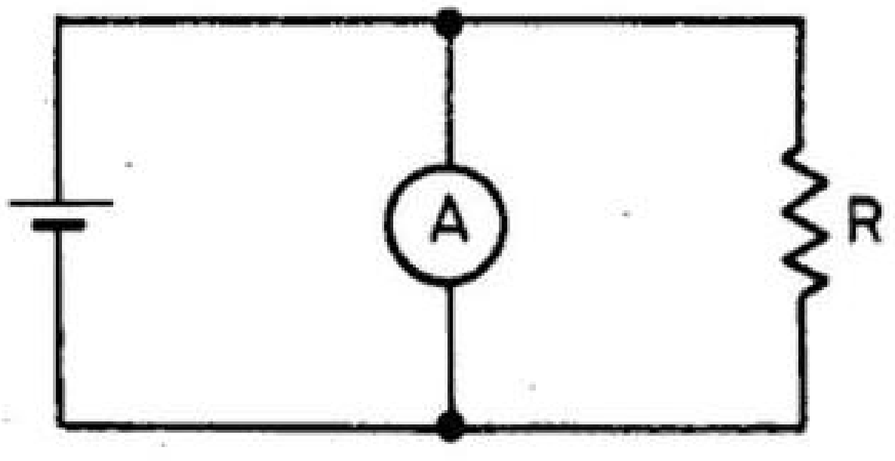
365. A consumer is connected to an alternating voltage. The power consumed is measured with the help of wattmeter. Which of the following powers is indicated by the wattmeter?

A. Apparent power B. True power

C. Reactive power

D. The product of voltage and current ($V \times I$).

366. An ammeter is connected in a circuit as shown in the diagram. Which of the following statements is true?

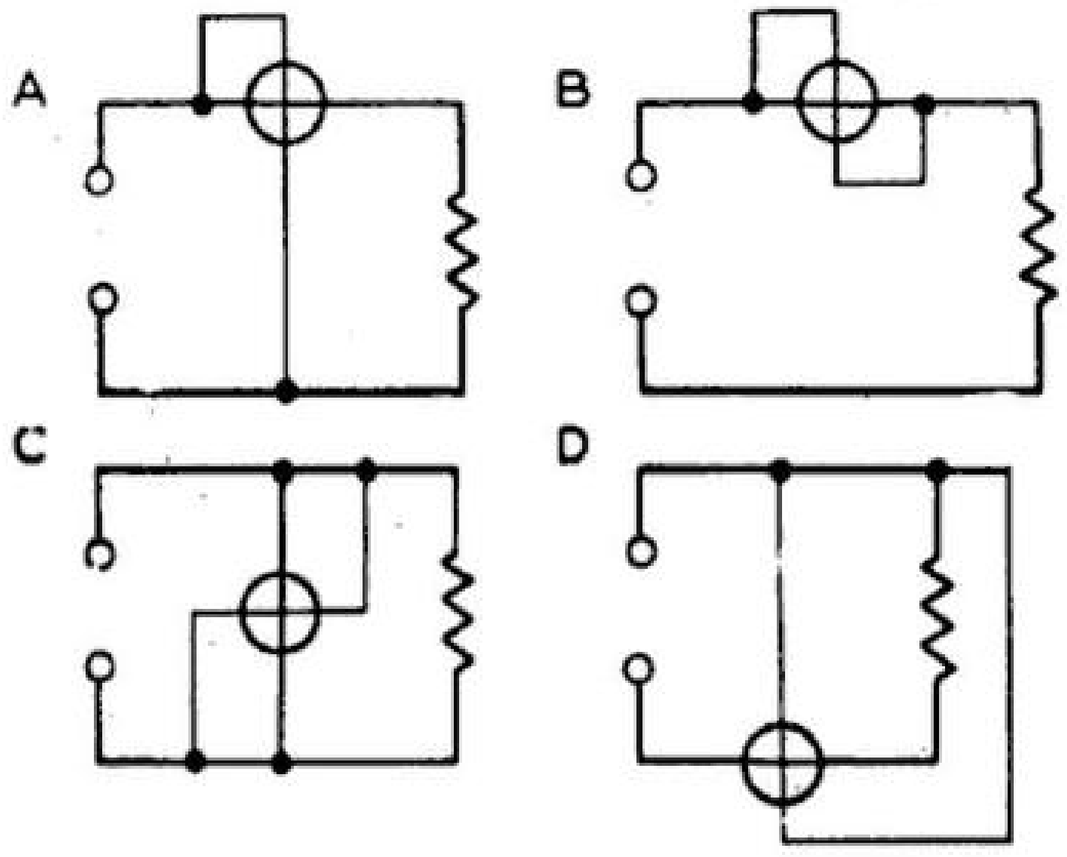


Answers : 354. (C), 355. (B), 356. (C), 357. (B), 358. (B), 359. (C), 360. (C), 361. (A), 362. (D), 363. (D), 364. (D), 365. (B).

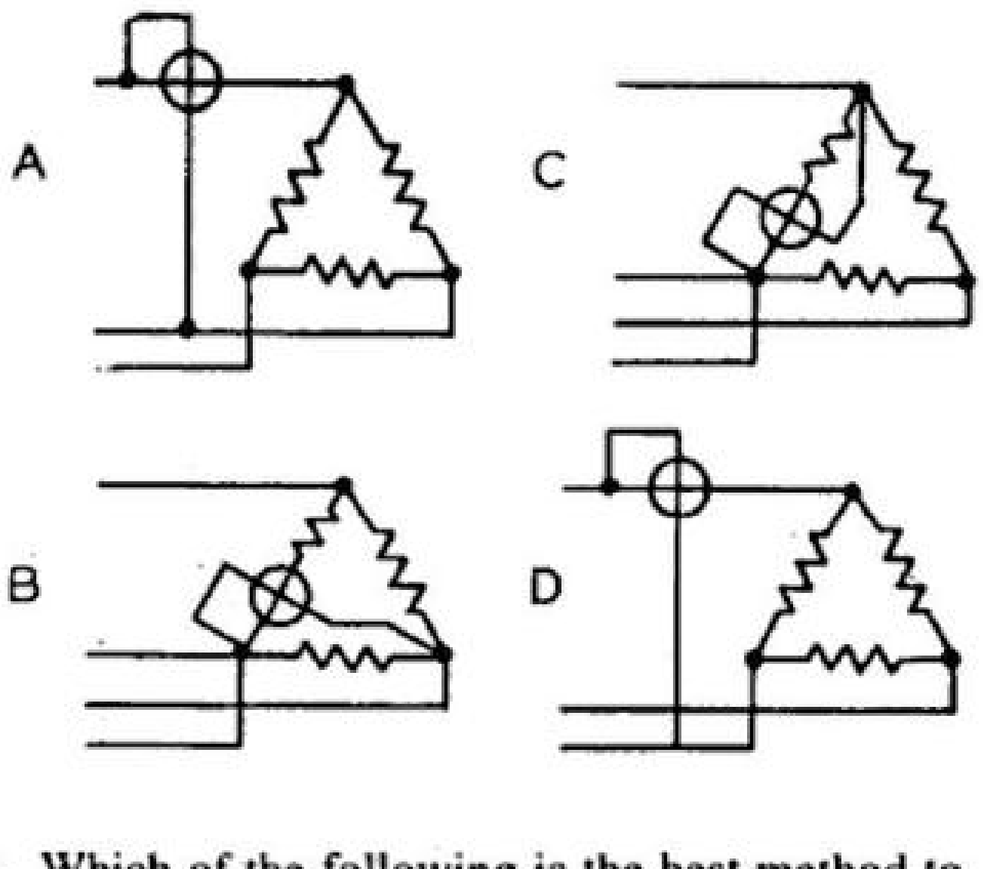
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A. The ammeter is connected correctly
B. the ammeter indicates a too small current
C. The ammeter indicates a too high current
D. The ammeter short circuits the voltage source and the measuring system of the instrument is destroyed.

367. The power drawn by a resistance R is to be measured by a wattmeter. In which of the circuits is the wattmeter connected correctly?



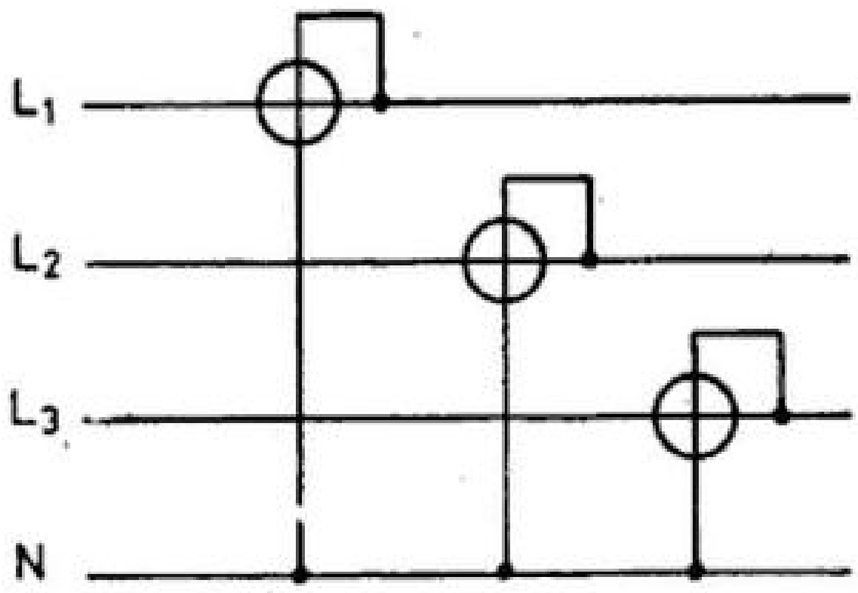
368. With which of the following circuits can the power consumed in the phase of the delta connected resistances be measured?



369. Which of the following is the best method to mesure the energy consumed by an electric heater?
A. a wattmeter and a stop-watch
B. An energymeter
C. A voltmeter and an ammeter
D. An ammeter and a stop-watch.

370. The power in an alternating current circuit is to be measured. The expected current is more than 5 A for which the current coil of the wattmeter is designed. How can this measurement be carried out?
A. By connecting a resistance in series with the current coil
B. By connecting a resistance parallel to the current coil
C. By connecting a measuring capacitor parallel to the current coil
D. By connecting the current coil with a current transformer.

371. When is this complicated connection shown in the figure used for the measurement of power?



A. For a three phase four wire system having an unbalanced load
B. For a three-phase four wire system having a balanced load including inductive resistances
C. For a three-phase four wire system having a balanced load including capacitive resistances
D. Only in high voltage circuits up to 6 kV.

Answers : 366. (D), 367. (A), 368. (C), 369. (B), 370. (D), 371. (A).

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372. The potential coil of a wattmeter is designed for minimum inductance. Therefore, the current through it is
   A. inversely proportional to the voltage and out of phase with it
   B. proportional to the voltage and out of phase with it
   C. proportional to the voltage and in phase with it
   D. inversely proportional to the voltage and in phase with it.

373. Creeping in energy-meters implies that
   A. fast rotation of the rotor with current coil excited
   B. slow rotation of the rotor with current coil excited
   C. slow rotation of the rotor with only voltage coil excited
   D. none of these.

374. Creeping in energy meters can be prevented by providing
   A. one hole on the disc
   B. two holes on opposite side of the disc
   C. extra voltage coil in the meter
   D. none of these.

375. The *major* cause for creeping in energy-meter is
   A. over compensation for friction
   B. vibrations
   C. stray magnetic fields
   D. excessive voltage across the potential coil.

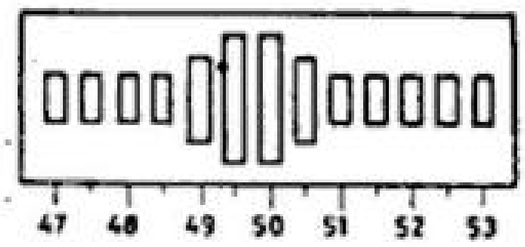
376. Which of the following instruments is used for domestic and industrial installations now-a-days?
   A. Induction-type watt-hour meter
   B. Mercury Motor type energymeter
   C. Commutator type energymeter
   D. None of these.

377. The Instrument used for the measurement of power at 500 MHz is
   A. bolometer
   B. compensated wattmeter
   C. electrodynometer wattmeter
   D. none of these.

378. Which statement is *not* true for a power factor meter?
   A. It consists of two coils mounted at right angles to each other
   B. Balance position depends upon the resulting torque developed by the two coils
   C. The restoring torque is provided by a control spring
   D. The deflection is proportional to the phase angle between field coil and crossed coil.

379. A current of 0.5 A flows in an inductive winding, when 100V at a frequency of 50Hz is applied to the winding. A wattmeter records that power consumed is 12.5 W. The power factor will be
   A. 0.88 B. 0.76
   C. 0.54 D. 0.25.

380. What frequency is indicated by the shown reed frequency meter?



   A. 49 Hz B. 49.5 Hz
   C. 49.75 Hz D. 50 Hz.

381. Essentially, the reed frequency is a
   A. oscillatory measuring system
   B. vibrational measuring system
   C. deflection measuring system
   D. recording measuring system.

382. The Q-meter works on the principle of
   A. series resonant circuit
   B. parallel resonant circuit

Answers : 372. (C), 373. (C), 374. (B), 375. (A), 376. (A), 377. (A), 378. (C), 379. (D), 380. (C), 381. (D), 382. (A).

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C. Moving-iron voltagemeter

D. Electrostatic voltmeter.

406. Which of the following instruments can be used to measure primary current of a transformer connected to mains?

A. Current transformer

B. Induction type meter

C. Moving-iron meter

D. Electrostatic meter.

407. The disadvantage of a Maxwell bridge is that

A. both inductance and Q of a coil cannot be measured

B. measurement is not independent of frequency

C. induction cannot be measured over wide ranges of Q.

D. number of components is large.

408. In the measurement of high frequency resistance of a coil by resistance variation method, the current in the circuit was 2 mA with zero added resistance and 1.6 mA when a resistance of 2.5 ohms was added. The coil resistance would be

A. 10 ohms B. 15 ohms

C. 20 ohms D. 25 ohms.

409. Which of the following meters is suitable for radio frequency measurement?

A. Electrical resonance frequency meter

B. Hetrodyne frequency meter

C. Weston frequency meter

D. none of these.

410. The best method of measuring a resistance of the order of 100 kiloohms is

A. ammeter-voltmeter method

B. potentiometer method

C. Kelvin double bridge method

D. ohmmeter.

411. Most of the faults in cables are caused by

A. open-circuit

B. short-circuit

C. breakdown of cable insulation

D. none of these.

412. The focus adjustment of an oscillograph varies

A. the grid voltage of CRT

B. the filament voltage

C. second anode voltage

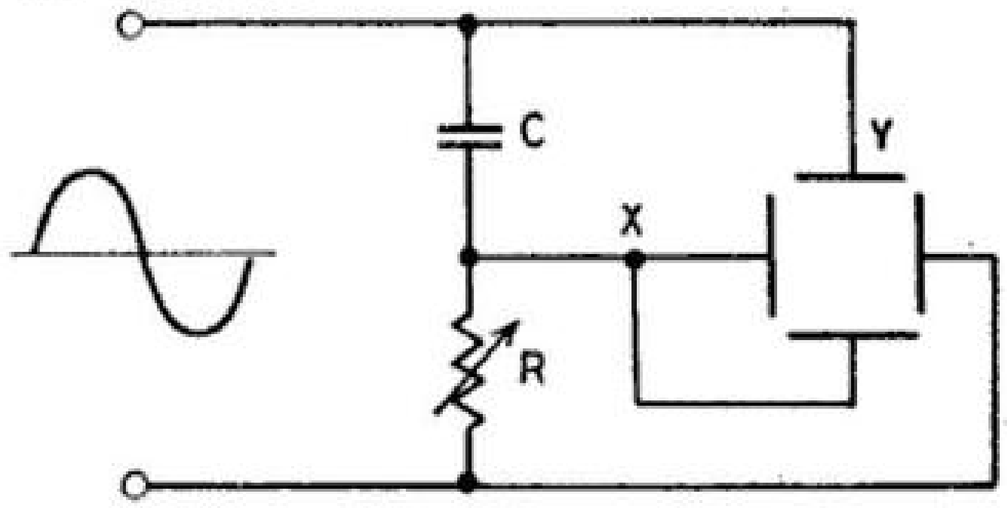
D. the accelerating voltage.

413. When 30 V dc is applied to the vertical deflecting plates of a cathode ray tube, the bright spot moves 1cm away from the centre. If 30V ac is applied, then the movement of the spot will be nearly

A. 1 cm B. 1.5 cm

C. 2 cm D. 3 cm.

414. In the time-base circuit shown below, the supply frequency is 50 Hz and capacitance is 2 μF. The value of resistance R to give a circular time base for equal sensitivities of the X and Y plates is



A. 500 Ω B. 1.6 kΩ

C. 4.7 kΩ D. 47 kΩ

415. In the above problem, the value of R for sensitivities of the X and Y plates equal to 0.45 and 0.55 mm/V respectively, will be

A. 1.2 kΩ B. 1.6 kΩ

C. 1.946 kΩ D. 3.215 kΩ.

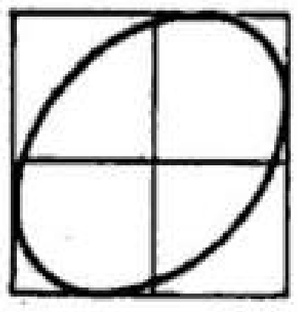
416. Two sine waves of same amplitude and phase are applied to the vertical and horizontal inputs of an oscilloscope. The pattern on the screen will be

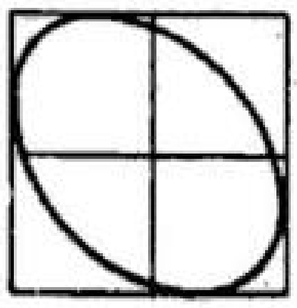
Answers : 405. (D), 406. (C), 407. (C), 408. (A), 409. (B), 410. (D), 411. (C), 412. (C), 413. (D), 414. (B), 415. (C).

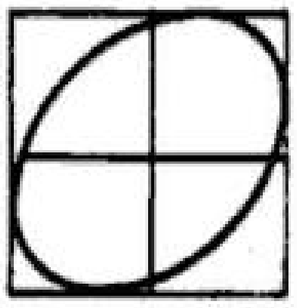
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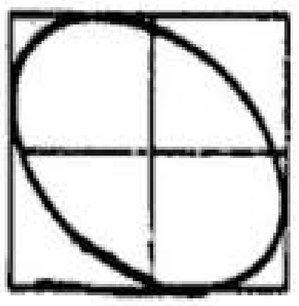


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A 

B 

C 

D 

421. A CRT has a deflection factor of 18 V/cm. The amount of deflection observed on the screen for deflection voltage of 54 V is

A. 3 cm B. 18 cm

C. 54 cm D. 0.056 cm

422. The deflection sensitivity of a CRT is given as 0.2 mm/V. The voltage applied to the deflection plates for a deflection of 3 inches is

A. 6 B. 15

C. 381 D. 375

423. A sinusoidal waveform of 5 kHz is applied to the vertical input of a free running oscilloscope. The horizontal sweep speed is set so that a full cycle takes 0.4 sec. The resulting display for one sweep of beam is

A. a sawtooth B. a sine wave

C. two cycles of the input signal

D. 12.5 kHz

424. A sinusoidal waveform as seen on an oscilloscope has peak to peak amplitude of 6 cm. If the vertical sensitivity setting is 5V/cm the pat to peak and rms values are

A. 30,212 B. 5, 3.54

C. 21.2, 30 D. 15, 10.61

425. Lissajous patterns are used to measure

A. voltage and frequency

B. frequency and phase shift

C. frequency and amplitude distortion

D. amplitude and flux

426. In modern electronic multimeter, a FET or MOSFET is preferred over BJT because

A. its input resistance is high

B. its input resistance is high and does not change with range switch

C. its input resistance is low

D. it is cheaper

427. Two helical springs are used in a D'Arsonval meter movement because

A. its improves damping

B. it compensates for temperature changes

C. it controls the deflecting torque effectively

D. it improves torque-weight ratio

428. A thermocouple ammeter is used to measure a 10 MHz sine wave and it indicates a current of 2A in a pure resistance. The peak current in this waveform is

A. 2 A B. 2.83 A

C. 0.2 A D. 20 A

429. 1 mA d.c. meter whose resistance is 10 ohms is calibrated to read rms volts when used in a bridge rectifier circuit with semi-conductor devices. Assuming ideal diode the full scale reading of the meter for a sinusoidal input voltage applied in series with a 5K ohm resistance is

A. 5.57 B. 7.871

C. 5.01 D. 5

Answers : 420. (B), 422. (A), 423. (C), 424. (B), 425. (B), 426. (B), 427. (B), 428. (B). 429. (A).

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A. balanced load and balanced source

B. balanced source with three-phase, three-wire unbalanced load

C. unbalanced source with three-phase, three-wire balanced load

D. balanced source with three-phase, four-wire unbalanced load

448. In which one of the following types of A to D converters the conversion time is practically independent of the amplitude of the analog signal

A. The dual slope integrating type

B. Successive approximation type

C. Counter ramp type

D. Tracking type.

449. The current in a circuit consists of a DC component of 10 A superposed on a 50 Hz sinusoidal component of rms value of 10A. The reading shown by a PMMC ammeter will be

A. $10\sqrt{2}$ B. $\frac{20}{\pi}$

C. 10 D. $10+\frac{10}{\pi}$

450. Which instrument has identical calibration for a.c. well as d.c. values?

A. Hot-wire type B. Moving-coil type

C. Induction type D. Moving-iron type

451. Wien bridge is useful for measuring

A. very high frequency

B. low frequency

C. medium frequency

D. high frequency

452. One single phase wattmeter operating on 230 V and 5A for 5 hours makes 1940 revolutions. Meter constant in revolutions is 400. What is the power factor of the load?

A. 1 B. 0.8

C. 0.7 D. 0.6

453. Ryall crest voltmeter is used for the measurement of

A. a.c. voltage of any form

B. low frequency voltage

C. high d.c. voltage

D. high a.c. voltage

454. A moving iron ammeter may be compensated for frequency erros by

A. a shunt resistance B. a series inductance

C. shunt capacitance D. series resistance

455. For power measurement of three-phase circuit by two wattmeter method, when the value of power factor is less than 0.5 lagging

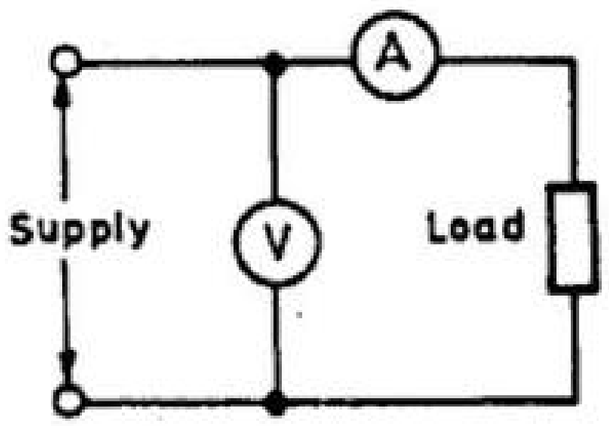
A. one of the wattmeters will read zero

B. both give the same readings

C. one of the wattmeter current connections will have to be reversed

D. pressure coil of the wattmeter will have to be reversed.

456. In the circuit shown, through oversight, the meters have been interchanged. This is likely to result in



A. damage to ammeter

B. damange to voltmeter

C. damange to both

D. no damage

457. Which wave has the least form factor?

A. square wave B. rectangular wave

C. sine wave D. triangular wave

Answers : 447. (B), 448. (B), 449. (C), 450. (A), 451. (D), 452. (B), 453. (D), 454. (C), 455. (C), 456. (A), 457. (A).

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458. Jewels are used in instruments to provide

A. damping B. controlling torque

C. reduce noise D. bearing

459. The thermocouple instrument will measure

A. current B. voltage

C. flux D. none of these.

460. Three resistances have the following ratings

(i) 150 Ω at 5%

(ii) 100 Ω at 5%

(iii) 200 Ω at 5%

the percentage error when all the three are connected in sc ; will be

A. ±5% B. $\pm\frac{5}{3}$ %

C. 15% D. +5%

461. Frequency upto which the electrostatic instruments can be used without serious loss of accuracy is

A. 100 Hz B. 100 kHz

C. 1 MHz D. 10 MHz

462. With a sweep time 10 m-seconds across the screen the approximate horizontal sawtooth frequency will be

A. 50 Hz B. 100 Hz

C. 1 kHz D. 500 Hz

463. In the case of PMMC rectifier type instruments, the deflecting torque is proportional to

A. average value of a.c.

B. r.m.s. of a.c.

C. instantaneous value

D. peak vlaue

464. Inductance and capacitance in the electrostatic system of units has the dimensions of

A. mass B. mass-time

C. mass length/time D. length.

465. The practical unit of energy is kWH. The unit of energy in the SI is the joule. The number of joules in kWH is

A. 3.6 B. 3.6×10^{6}

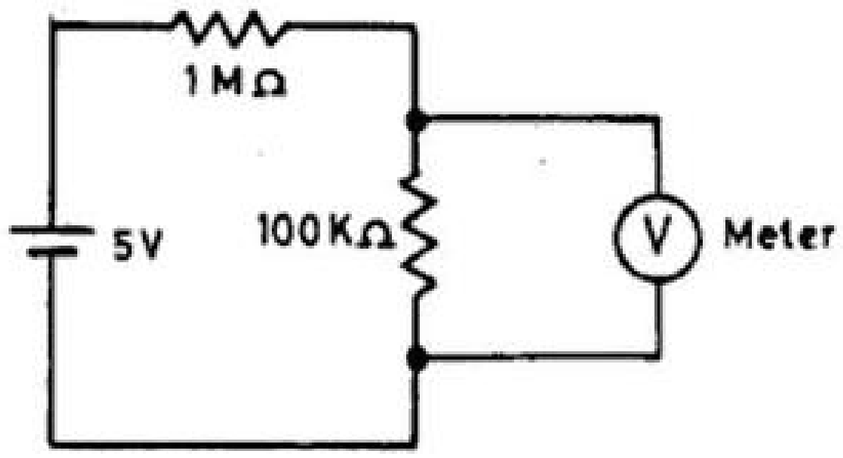
C. 3.6×10^{-6} D. 10^{-6}

466. The voltage of a battery if a charge of 3×10^{-4}C resides on the positive battery terminal and possessing 6×10^{-2}J of energy is

A. 2 B. 200

C. 0.2 D. 10^{2}

467. A 20,000 ohms/V meter is used to measure the voltage across 100K on 0-1 V scale as in the circuit. The voltage measured is



A. 5 V B. 0.45 V

C. 4.45 V D. 0.082 V

468. A 1000 ohms/V meter is used to measure a resistance on 150 V scale. The meter resistance is

A. 150 K B. 1 K

C. 6.67 ohms D. 0.001 ohm

469. The preferred damping condition for indicating instrument is

A. critically damped

B. a damping coefficient of 0.8 to 1

C. overdamped

D. underdamped.

470. The material most preferred for ocntrol spring is

A. German silver B. Platinum silver

C. Silicon bronze D. Phosphor bronze

471. A spring controlled indicating instrument has a deflection of 90° for maximum current I. The corresponding deflection for a gravity controlled instrument is

Answers : 458. (D), 459. (A), 460. (C), 461. (B), 462. (B), 463. (A), 464. (D), 465. (B), 466. (B), 467. (D), 468. (A), 469. (B), 470. (D).

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A. 90° B. 120°

C. 30° D. 0°.

472. The reading of an electrodynamometer ammeter when a current

$i = 8 - 6\sqrt{2}\sin\left(\omega t + \frac{\pi}{2}\right)$ is passed through it will be

A. 8 A B. $6\sqrt{2}$ A

C. $8 - 6\sqrt{2}$ A D. 10 A

473. Two wattmeters connected to measure the power in a 3 ϕ, balanced delta connected load read $W_1 = 12$ kW $W_2 = 15$ kW respectively.

If the same load be connected in star the wattmeters would read

A. $W_1 = 8.66$ kW $W_2 = 6.93$ kW

B. $W_1 = 6.93$ kW $W_2 = 8.66$ kW

C. $W_1 = 5$kW $W_2 = 4$kW

D. $W_1 = 4$ kW $W_2 = 5$kW

474. Alternating current cannot be measured directly by

A. hot-wire ammeter

B. moving-iron ammeter

C. moving-coil ammeter

D. thermocouple type ammeter

475. On an oscilloscope, the Lissajous pattern of eight keeps on changing the shape when the ratio of frequencies is

A. not exactly 1:1

B. not exactly 2:1

C. exactly 3 :1

D. exactly 4:

476. A moving waveform on an oscilloscope can be made stationary by adjusting

A. horizontal position control

B. coarse frequency control

C. sync-amplitude control

D. vertical positioning control.

477. A wattmeter can measure

A. a.c. power only

B. d.c. power only

C. a.c. as well as d.c. power

D. d.c. power and a.c. power after rectification

478. A multimeter consists of

A. voltmeter and ohmmeter

B. voltmeter and current meter

C. Current meter and ohmmeter

D. voltmeter, current meter and ohmmeter

479. The number of coils in the meter of beggar is

A. one B. two

C. three D. four

480. Piezo-electric crystal can be used to measure

A. temperature B. velocity

C. acceleration D. flow

481. Piezometer is used to measure

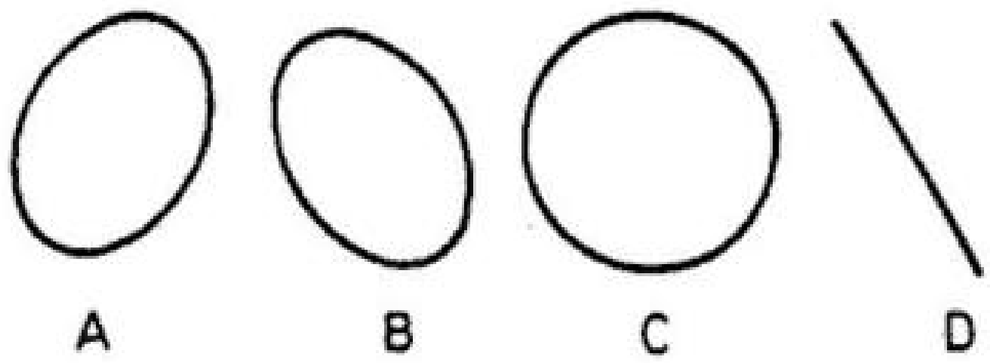
A. pressure in pipes and channels

B. very high pressure

C. very low pressures

D. difference of pressure between two points

482. The sinusoidal voltages of equal frequency but phase difference of 120° are simultaneously applied to the two pairs of the deflection plates of CRT. The Lissajeous figure traced on the screen will be



Answers : 471. (C), 472. (D), 473. (D), 474. (C), 475. (B), 476. (C), 477. (C), 478. (D), 479. (B), 480. (C), 481. (C), 482. (B).

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483. Two sine waves of same amplitude and phase are applied to the vertical and horizontal inputs of an oscilloscope. The pattern on the screen will be

A. circle B. ecllipse

C. horizontal line D. None of these.

484. In a force-balance transducer

A. the output and the sensing element is amplified

B. the output is feed back to an element which causes a force- summing member to return to its zero position

C. the magnitude feed back determines the output of the transducer

A. All of these

485. The bridge used for the measurement of dielectric loss of capacitance is

A. Anderson bridge

B. Maxwell bridge

C. Hay bridge

D. Schering bridge.

486. The dissipation factor of capacitor can be measured by using a

A. potentiometer

B. Campbell bridge

C. Schering bridge

D. Galvanometer.

487. The bridge used for the. measurement of capacitance is

A. Schering bridge

B. Wheatstone bridge

C. Wein's bridge

D. Hay's bridge.

488. For a good 0.05 microfarad capacitor, ohm-meter reading should

A. not move at all

B. go quickly to 100 ohm approximately, and remain there

C. show low resistance momentarily and back off to a very high resistance

D. show high resistance momentarily and then a very low resistance

489. If a capacitor shows charging but the final resistance reading is appreciably less than normal, the capacitor is

A. satisfactory

B. leaky

C. of high capacitance value

D. of low capacitance value.

490. The ohmmeter reading for a shorted capacitor is

A. zero

B. few kilo ohms

C. few mega ohms

D. infinity

491. The current through the current coil of a watt-meter is $I = 1 + 2 \sin \omega t$ amperes and the voltage across the potential coil is $V = 2 + 3 \sin \omega t$ volts. The wattmeter is calibrated to read the average power in watts. The reading of the wattmeter is watts is

A. 8.00 B. 5.05

C. 2.00 D. 0.

492. The following voltage is fed to an electro-dynamometer meter:

$e = 100 \sin \omega t + 50 \sin (\omega t + 45^\circ)$

The meter will show a reading of nearly

A. 110 V B. 91 V

C. 79 V D. 55 V

493. A instrument transformer is used to extend the range of which type of instrument?

A. Electrostatic type

B. Induction type

C. Moving coil type

D. All of the above.

494. Loss of change method of measurement of resistance is used for

Answers : 483. (D), 484. (A), 485. (D), 486. (C), 487. (A), 488. (D), 489. (B), 490. (D), 491. (C), 492. (C), 493. (B).

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A. low resistances
B. medium resistances
C. variable resistances
D. high value resistances

495. Holes are drilled on the opposite sides of the spindle of an energy meter to
A. avoid creep on load
B. balance the disc
C. dissipate heat generated due to eddy currents
D. increase the deflection torque

496. Which of the following instrument does not use the effect of current for measurement purposes?
A. Moving coil ammeter
B. Electrostatic ammeter
C. Hot wire ammeter
D. Rectifier ammeter

497. In electrostatic instruments and deflecting torque is proportional to (V = applied voltage)
A. V B. V^2
C. $1/V$ D. $1/V^2$

498. Which multiple of basic unit is 'atto'?
A. 10^{-9} B. 10^{-1}
C. 10^{-15} D. 10^{-18}

499 Which of the following devices *cannot* be used to measure pressure?
A. LVDT B. Strain gauge
C. Pyrometer D. Pirani gauge

500 Which of the following devices can measure pressure directly?
A. LVDT B. Stain gauge
C. Rotameter D. Bourden tube

501 Which of the following additional devices is required in order to measure pressure using LVDT?
A. Strain gauge B. Pitot tube
C. Rotameter D. Bourden tube

502 The principle of Pirani gauge is based on
A. humidity of the medium
B. thermal conductivity of the medium
C. combustibility of the medium
D. None of these

503 Load cell essentially is a
A. thermistor
B. strain gauge
C. photo-voltaic cell
D. None of these

504 Which of the following quantities *cannot* be measured by load cell?
A. Level B. Pressure
C. Temperature D. Weight

505 The function of dummy bridge employing strain gauge is to provide
A. stability
B. temperature compensation
C. linearity
D. None of these

506 A differential transformer is a
A. variable inductance transducer
B. variable pressure transducer
C. constant displacement transducer
D. constant pressure transformer.

507 Which of the following means can measure only pressure?
A. Bell type meter
B. Redioactive method
C. Diaphragm
D. Bellow

508 In radioactive method, the receiver measures level by recording
A. the number of radio-active particles received.
B. the time taken by the rays to reach the receiver.
C. the direction of the rays

Answers : 494. (D), 495. (A), 496. (B), 497. (B), 498. (D), 499. (C), 500. (D), 501. (D), 502. (B), 503. (B), 504. (C), 505. (B), 506. (A), 507. (B), 508. (B).

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D. All of these.

509 Pirani gauge is used to measure

A. very high pressure

B. very low pressure

C. atmospheric pressure

D. All of these

510 Piezometer is used to measure

A. pressure in pipes and channels

B. very high pressure

C. very low pressure

D. difference of pressure between two points

511 The best method for the measurement of temperatures of hot bodies radiating energy in the visible spectrum is

A. bolometer B. optical pyrometers

C. thermocouples D. thermopile

512. Thermistors have

A. high and negative temperature coefficient

B. low and negative temperature coefficient

C. high and positive temperature coefficient

D. low and positive temperature coefficient

513 Which of the following device is used to measure flow in open channels?

A. Venturimeter B. Rotameter

C. Orifice D. Pitot tube

514 Which of the following devices is used to measure flow of air around an aeroplane?

A. Venturimeter B. Rotameter

C. Orifice B. Anemometer

515 Which of the following means *cannot* measure flow of non- conducting medium?

A. Orifice

B. Electro-magnetic meter

C. Turbine meter

D. Rotameter

516 In a pitot tube,

A. velocity head is converted to pressure head

B. pressure head is converted to velocity head

C. velocity head is converted to datum head

D. differential pressure is produced across the tube

517 If a restriction is placed in a pipe, the flow through the restriction will

A. increase

B. remain constant

C. decrease

D. depend upon the type of restriction

518 If a large number of restrictions are installed along a pipe, the pressure at the pipe output will become

A. less B. more

C. remains constant D. varies randomly

519 In restriction type flow measuring devices, if the differential pressure is ΔP the flow will be proportional to

A. ΔP B. $\sqrt{\Delta P}$

C. $\frac{1}{\Delta P}$ D. $\frac{1}{\sqrt{\Delta P}}$

520 Ring-balance meter *cannot* measure

A. pressure

B. differential pressure

C. flow

D. mass-flow rate

521 The function of square root extractor in flow measuring system is

A. to perform square root of flow

B. to perform square root of differential pressure

C. to improve the accuracy

D. to eliminate dead zone

522 Hydrometer is used to determine

A. specific gravity of liquids

B. relative humidity

C. specific gravity of solids

D. specific gravity of gases

Answers : 509. (B), 510. (C), 511. (B), 512. (A), 513. (D), 514. (B), 515. (B), 516. (A), 517. (A), 518. (B), 519. (B), 520. (D), 521. (B), 522. (A).

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523 For pipes, laminar flow occurs when Reynold number is

A. less than 2000

B. between 2000 and 4000

C. more than 4000

D. None of these

524 For pipes, turbelent flow occurs when Reynold number is

A. less than 2000

B. between 2000 and 4000

C. more than 4000

D. None of these

525 Hot-wire anemometer is used to measure

A. pressure of gases

B. liquid discharges

C. very low pressures

D. gas velocities

526 Rotameter is used to measure

A. rotation B. flow

C. viscosity D. specific gravity

527 Flow of water is a pipe of about 3 metres diameter can be measured by

A. orifice plate B. venturi meter

C. rotameter D. pitot tube

528 The meter measuring total flow in a liquid employs

A. square root extraction

B. differentiation

C. planimeter

D. variable area meter

529 A flow measuring system with a square-root extractor has

A. linear scale

B. non-linear scale

C. mass-flow scale

D. None of these

530 Which of the following is *not* an element of electropenumatic pressure transmitter?

A. LVDT

B. Bellows

C. Flapper-nozzle mechanism

D. Operational Amplifier

531 Variations in very fine thickness, say of paper is to be monitored continuously in a paper industry. The most suitable transducer will be

A. Strain gauge

B. LVDT

C. Diaphragm

D. Capacitance transducer

532 The pH value of a solution is defined as

A. log (OH^- ion concentration)

B. -log (H^+ ion concentration)

C. log (H^+ ion concentration)

D. -log 1/(OH^- ion concentration)

533 The *pH* value of pure water is

A. zero B. 1

C. 7 D. infinite

534 The *pH* value of strong sulphuric acid is

A. zero B. -1

B. 11 D. 14

535 The *pH* value of a strong alkaline solution is about

A. zero B. -1

B. 7 D. 14

536 The function of the reference electrode in a pH meter is

A. to measure average *pH* value

B. to produce a constant voltage

C. to provide temperature compensation

D. to produce a constant current

537 Piezo-electric crystal can be used to measure

A. temperature B. velocity

C. acceleration D. flow

Answers : 523. (A), 524. (C), 525. (D), 526. (B), 527. (D), 528. (C), 529. (A), 530. (C), 531. (B), 532. (B), 533. (C), 534. (B), 535. (D), 536. (B), 537. (C).

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538 In a force-balance transducer

A. the output of the sensing element is amplified

B. the output is fed back to an element which causes a force- summing member to return to its zero position

C. the magnitude of the feed back determines the output of the transducer

D. All of these

539 Which of the following statements is *wrong* for thermocouple measuring instruments?

A. They read rms values.

B. If calibrated on d.c., they cannot be used for a.c. signals.

C. They are incapable of standing any overloads.

D. Their calibration does not change with time or temperature.

540 The direction of current in case of antimony-bismuth thermocouple will be

A. from antimony to bismuth at the cold junction.

B. from antimony to bismuth at the hot junction.

C. from bismuth to antimony at cold junction.

D. None of these.

541 Thermocouple used in radio micrometer and thermo-galvanometer is

A. antimony-bismuth couple

B. copper coustantan couple

C. copper-iron couple

D. iron-copper couple

542 Which of the following devices can be used to give an indication for temperature changes?

A. Bourdon gauge B. Thermister

C. Thermocouple D. All of these

543 Which of the following material for strain gauge has the highest gauge factor?

A. Nicrome B. Constantan

C. Isoelastic D. Platinum

544 Which of the following device is used for the measurement of low pressures below atmospheric pressure?

A. Pirani gauge B. Strain gauge

C. Ionization gauge D. Compound gauge

545 In a microphone, the acoustic energy is converted into

A. vibrations

B. pressure energy

C. magnetic impulses

D. thermal energy

546 A silicon solar cell is basically a

A. photoconductive cell

B. photoemissive cell

C. photovoltaic cell

D. None of these

547 Which of the following is electromechanical device?

A. Direct current motor

B. LVDT

C. Induction relay

D. None of these

548 Cadmium sulphide cell is a

A. solar cell

B. dry cell

C. photovoltaic cell

D. photoconductive cell

549 Which of the following instrument can be used for the measurement of temperatures above 1500°K?

A. Mercury thermometer

B. Gas thermometer

C. Thermo-electric pyrometer

D. Any of these

550 When damping of an instrument is adjusted to enable the pointer to rise quickly to its deflected position without overshooting, in that case the instrument is said to be

Answers : 538. (D), 539. (B), 540. (A), 541. (A), 542. (D), 543. (D), 544. (A), 546. (C), 547. (B), 548. (D), 549. (C).

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A. dead beat B. off beat
C. over-damped D. under-damped

551 An alternating voltage of sinusoidal waveform is maintained across a reactor and a non-reactor and *X*-plates across the resistor. The oscilloscope has equal deflection sensitivities along the *X* and *Y*-axis.

The oscillogram is an ellipse contained within a rectangle 60 mm wide (in *X*-direction) and 72 mm high (in the *Y*-direction) and the width of the ellipse in the *X*- axis is 36 cm.

The impedance of the reactor at the supply frequency will be

A. 60 ohm B. 600 ohm
C. 6000 ohm D. 60,000 ohm

552 In the above case the power factor will be

A. 0.8 B. 0.6
C. 0.5 D. 0.1

553 Two sinusoidal quantities are said to be in phase quadrature, when

A. their amplitude is identical
B. their frequency is identical
C. their wave shapes are identical
D. their phase difference is 90°

554 A compound pressure gauge can measure

A. pressure above atmospheric pressure only
B. pressure below atmospheric pressure only
C. both pressures above as well as below atmospheric pressure
D. fluctuating pressures

555 A slide wire potentiometer is used to measure the voltage between two points of a certain d.c. circuit. The potentiometer reading is 1.0 volt. Across the same two points when a 10,000 ohm/V voltmeter is connected, the indicated reading in the voltmeter is 0.5 V on its 5 A range. The input resistance between two points is

A. 5000 ohm B. 10,000 ohm
C. 25,000 ohm D. 50,000 ohm

556 In which instrument, the deflecting torque depends on frequency?

A. Hot wire instruments
B. Moving coil instruments
C. Moving iron instruments
D. Induction type instruments

557 The resolution of a digital voltmeter with 3-digit display is

A. 1/3 B. 1/1000
C. 3% D. 1%

558 LVDT can be used to measure

A. acceleration B. velocity
C. displacement D. Any of these

559 Which statement is true for Rosette?

A. It consists of shielding device for instrument
B. It is a heat dissipating device
C. It controls noise in instruments
D. It consists of three strain gauges oriented in different directions

560 A seismic transducer is generally used in the instruments for the measurement of

A. temperature
B. relative humidity
C. vibration
D. None of the above

561 The measurable quantity in case of a thermo couple is

A. current B. e.m.f.
C. magnetic flux D. linear expansion

562 A substance that changes its electrical resistance when light falls on it, is known as

A. photo voltaic substance
B. photoconductive substance
C. photoelectric substance
D. None of these

563 Piezoelectric transducer works under the variation of

Answers : 550. (A), 551. (C), 552. (A), 553. (D), 554. (C), 555. (D), 556. (D), 557. (B), 558. (D), 559. (D), 560. (C), 561. (B), 562. (B).

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A. intensity of light
B. pressure intensity
C. temperature variation
D. All of the above

564 Which of the following is *not* a transducer?
A. Strain gauge
B. Microphone
C. Potentiometer
D. Thermocouple

565 A bolometer is used in the measurement of
A. VSWR
B. High voltages
C. Transmission losses
D. Microwave power

566. LVDT is a
A. displacement transducer
B. velocity transducer
C. acceleration transducer
D. pressure transducer

567. The speed transducer using a drag cup rotor has the main advantage of
A. very high accuracy
B. low energy requirement
C. cheaper construction
D. None of above

568. The resistance of a resistance strain gauge is likely to be
A. 5 ohms
B. 50 ohms
C. 150 ohms
D. 5000 ohms

569. Mostly resistance strain gauges have a gauge factor of about
A. 2 B. 10
C. 100 D. 0.2

570. The gauge factor of a semiconductor strain gauge is about
A. 5 B. 2
C. 100 D. 0.5

571. In a strain measuring equipment, using a resistance strain gauge, the output quantity is
A. resistance
B. voltage
C. current
D. impedance

572. In a thermocouple temperature transducer, the output voltage is generally measured by a
A. high resistance voltmeter
B. high resistance milli-voltmeter
C. low resistance voltmeter
D. None of above

573. If the temperature increases by 10°C, the resistivity of a thermistor is likely to become
A. one half of initial value
B. one fiftieth of initial value
C. twice the initial value
D. None of above

574. An *E*-transformer is a
A. displacement transducer
B. velocity transducer
C. acceleration transducer
D. None of above

575. Rectifier instruments are generally not free from
A. wave shape erros
B. frequency and wave shape erros
C. frequency, wave shape, and temperature erros
D. none of these.

576. A bolometer is used in the measurement of
A. transmission losses
B. high voltages
C. micro-wave power
D. VSWR.

Answers : 563. (B), 564. (C), 565. (D), 566. (A), 567. (B), 568. (C), 569. (A), 570, (C), 571. (B), 572. (B), 573. (B), 574. (A), 575. (C), 576. (C)

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C. around 1000 ohms

D. none of these.

590. As compared to an absorption type of frequency meter, a hetrodyne type of frequency meter can give

A. higher frequency

B. same frequency

C. low accuracy

D. none of these.

591. In a VTVM, alternating voltage measurement corresponds to

A. saw tooth wave inputs

B. square wave inputs

C. sine wave inputs

D. none of these.

592. LVDT is always used as

A. secondary transducer

B. primary transducer

C. primary signal generator

D. none of these.

593. A CRO cannot be used for the measurement of

A. voltage B. current

C. frequency D. power.

594. Two 200V d.c. voltmeters having resistances of 15 k-ohm and 10 k-ohm are connected in series. The safe voltage which can be measured by this combination will be

A. 400V B. $200\sqrt{2}$ V

C. 200 V D. 100 V.

595. Electrostatic instruments

A. can be used on dc only

B. when used on ac measure rms value whatever the waveform

C. are highly sensitive to eddy current errors

D. none of the these.

596. Bolometers are used for measurement of

A. optical inputs

B. thermal radiations

C. electrical signals

D. temperature inputs.

597. In a pH meter, which of the following measures the pH value?

A. voltage difference between electrodes

B. temperature difference between electrodes

C. pressure difference between electrodes

D. colour of electrodes.

598. Phosphor coating for CRO tubes is provided on the

A. inside surface

B. outside surface

C. both sides of the surface .

D. none of these.

599. An accurate ammeter must have a resistance of

A. high value

B. low value

C. very low value.

D. None.

600. A delay line is used in high speed CRO to introduce time delay in

A. vertical channel

B. horizontal channel

C. in the cathode Z-axis of CRT.

D. None of these.

601. The ratio of voltage reflected from the load to the voltage applied to the load is called the

A. reflection loss

B. SWR

C. return loss

D. None of these.

602. Deflection sensitivity of a CRT is

A. directly proportional

B. inversely proportional to

C. does not depend on the distance between the deflecting plates and screen

D. None.

Answers : 590. (A), 591. (C), 592. (A), 593. (D), 594. (C), 595. (B), 596. (B), 597. (A), 598. (A), 599. (C), 600. (A), 601. (B), 602. (A).

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603. Wien's bridge is usually used for measuring
   A. capacitance
   B. resistance.
   C. frequency
   D. None of these.

604. The torque developed in a PMMC meter is
   A. directly proportional to
   B. inversely proportional to
   C. does not change with the flux density in the air gap.
   D. None of these.

605. Electric current is measured with a/an
   A. ammeter
   B. voltmeter
   C. ohmmeter
   D. megohmmeter

606. What instrument is used to measure the amount of electrical power being consumed?
   A. Wattmeter
   B. Watthour meter
   C. Kilowatt-hour meter
   D. All of the above

607. What must flow in the coil of any meter to produce a movement of the pointer?
   A. Voltage B. Current
   C. Resistance D. Watts

608. The two principal parts of a PM-MC galvanometer are
   A. pivots and jewelled bearings
   B. needle and scale
   C. iron core and case
   D. coil and magnet.

609. Careless handling of an electrical meter may result in damage to its
   A. pivots and jeweled bearings
   B. needle and scale
   C. iron core and case
   D. coil and magnet

610. What is the purpose of shielding a meter with soft iron?
   A. Keep moisture out of the movement
   B. Protect the meter movement from stray magnetic fields
   C. Prevent damage from rough handling
   D. All of the above

611. The range of an ammeter may be extended by the use of a
   A. shunt in series
   B. shunt in parallel
   C. multiplier in series
   D. multiplier in parallel

612. A current measuring instrument can be used to measure voltage by
   A. adding resistance in series
   B. adding resistance in parallel
   C. using larger wire in the coil
   D. using a high resistance shunt

613. The range of a voltmeter may be extended by the use of a
   A. shunt in series
   B. shunt in parallel
   C. multiplier in series
   D. multiplier in parallel

614. When selecting a meter range scale to test a circuit, you should select the range that will indicate near the
   A. top of the scale
   B. mid-point of the scale
   C. bottom of the scale
   D. trial-and-error average point

615. How should a D-C ammeter be connected in a circuit being tested?
   A. In series with the shunt, in parallel with the circuit,

Answers : 603. (A), 604. (A), 605. (A), 606. (A), 607. (B), 608. (D), 609. (A), 610. (B), 611. (B), 612. (A), 613. (C), 614. (B).

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B. In series with the circuit, in parallel with the shunt

C. In series with both the shunt and the circuit

D. In parallel with both the shunt and the circuit.

616. Where on the scale is an electrical meter likely to be most accurate?

A. Top of the scale

B. Upper two-thirds of the scale

C. Lower third of the scale

D. Bottom of the scale

617. Before connecting a meter to measure an unknown current or voltage, it is best to

A. start with the highest range and work down

B. start with the lowest range and work up

C. select an estimated mid-range

D. use the trial and error method

618. Which of the following is likely to affect the accuracy of an electrical meter?

A. Bringing the voltage up too fast

B. Using it on too low a voltage

C. Working with it on a steel work-bench

D. All of the above.

619. How should a D-C voltmeter be connected in a circuit being tested?

A. In series with the multiplier, in parallel with the circuit

B. In series with the circuit, in parallel with the multiplier

C. In series with both the multiplier and the circuit

D. In parallel with both the multiplier and the circuit.

620. How should the leads of a PM-MC meter be connected in a circuit?

A. Red to black

B. Positive to negative

C. Red to negative, black to positive

D. Red to positive, black to negative

621. A thermocouple instrument can be used on

A. A-C circuits only

B. D-C circuits only

C. polyphase circuits only

D. A-C or D-C circuits

622. If the current increases by three times through a thermocouple heater strip, the heat output will increase by

A. 3 times B. 6 times

C. 9 times D. 12 times

623. A thermal meter differs from a thermocouple meter in that a thermal meter

A. produces a small D-C current

B. has heaters

C. can be used for current or voltage measurement

D. produces pointer deflection directly by heat

624. What values are measured by the two separate bimetallic elements of a thermal wattmeter?

A. heater temperature and ambient temperature

B. Voltage and current values

C. kW and kVAR

D. Kilowatts and kVA

625. The source of energy for operating an ohmmeter is obtained from

A. the line being measured

B. any 120 volt source

C. a rectifier cell

D. a battery

626. An ohmmeter is calibrated by shorting the test leads together and adjusting the pointer to zero by means of

A. a small screw driver

B. the COMMON jack

Answers : 615. (B), 616. (B), 617. (A), 618. (C), 619. (A), 620. (D), 621. (D), 622. (C), 623. (D), 624. (B), 625. (D).

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C. the variable resistor

D. a pointer spring

627. When, if ever, may an ohmmeter be used in an energized circuit?

A. When the potential is less than 125 volts

B. Only when an instrument transformer is used

C. Only when one side is grounded

D. Never

628. Multiplication features are incorporated in an ohmmeter to enable the meter to

A. measure very high resistance values

B. measure values with the least error

C. be multipurpose in its application

D. have less power consumption

629. If it takes 0.02 mA. To deflect the pointer of an ohmmeter to half scale when set in multiplier position R × 1, how much current is required to give the same deflection when set in position R × 100?

A. 0.2 mA. B. 0.02 mA.

C. 0.002 mA. D. 2.0 mA.

630. The megohmeter is expressly designed to measure which of the following?

A. Very low resistances

B. Very high resistances

C. Faulted power lines

D. Overload protection devices

631. Before and after taking megohmmeter tests of large equipment, be sure to

A. discharge charged capacitors

B. adjust the pointer to midpoint

C. check output voltage of generator

D. ground the instrument

632. What type record can help you to be aware of a circuit's insulation condition?

A. Resistance test record

B. Power demand record

C. Record of maximum loads

D. Record of power factor resistance

633. A good industrial plant grounding system should provide protection against

A. overloads due to power surges

B. static electricity from friction

C. over voltages

D. insulation breakdown

634. What is the highest common voltage rating for megohmmeter instrument generators?

A. 500 volts B. 100 volts

C. 2500 volts D. 5000 volts

635. The operation of the moving-iron vane meter depends on

A. a rectifier

B. retentivity

C. induced current

D. magnetic induction

636. A moving-iron meter will operate on

A. A-C circuits only

B. D-C circuits only

C. either A-C or D-C circuits

D. A-C or D-C when a rectifier is used

637. A thin aluminum or copper vane attached to the moving element is positioned between the poles of a small magnet in A-C instruments to provide

A. magnetic damping

B. magnetic repulsion

C. stable operating current

D. uniform scale reading

638. More power is required to operate a moving-iron meter than a PM-MC meter because of the magnetic circuit's high

A. resistance

B. reluctance

C. retentivity

D. resilience

Answers : 626. (C), 627. (D), 628. (B), 629. (B), 630. (B), 631. (A), 632. (A), 633. (B), 634. (D), 635. (D), 636. (C), 637. (A), 638. (B).

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639. Which of the following meter mechanisms is adaptable to a greater variety of measurements?
   A. Inclined coil
   B. Moving-iron vane
   C. Electrodynamometer
   D. Permanent magnet-moving coil

640. Electrodynamometers ar used extensively for the measurement of
   A. magnetic lines of force
   B. resistivity
   C. capacitor networks
   D. power

641. When an electrodynamometer is used to measure power, it is graduated to indicate the
   A. maximum power pulses
   B. minimum power pulses
   C. instantaneous power pulse
   D. average of the power pulses

642. A rectifier is used in an instrument for the purpose of
   A. measuring high voltage values
   B. measuring high current values
   C. converting A-C into d-c
   D. making the instrument more stable

643. The useful life of a rectifier can be extended if the temperature is kept below 140°F. For this reason rectifiers are
   A. stacked
   B. made with fins
   C. bridge connected
   D. series connected

644. The out put voltage of a rectifier or diode is called
   A. pulsating D-C
   B. sine wave output
   C. half-wave reactance
   D. unidirectional current

645. A wattmeter measures what electrical values?
   A. Potential
   B. Energy
   C. Power
   D. All of the above.

646. When connecting a wattmeter in a circuit, how should the coils be connected?
   A. Current in parallel/potential in series
   B. Current in series/potential in parallel
   C. Current in parallel/potential in parallel
   D. Current in series/potential in series

647. If a wattmeter is used in a circuit where its safe voltage or current rating is exceeded, the meter will
   A. not be affected
   B. operated erratically
   C. immediately peg the pointer
   D. not indicate the overload

648. What does the reading of the first dial on the right of a 4-dial watthourmeter indicate?
   A. Number of single units
   B. Total watts each hour
   C. Maximum value the meter can register
   D. Multiplier value of the preceding dial

649. A varmeter is used to indicate the
   A. internal A-C overloads
   B. out-of-phase voltage change
   C. amount of reactive power
   D. amount of true power

650. A demand meter is a means of indicating which of the following?
   A. Peak power periods
   B. A high load factor
   C. Low kWh consumption
   D. All of the above

651. Which of the following demand meter readings are normal terms?
   A. Kilovars
   B. Kilowatts

Answers : 639. (C), 640. (D), 641. (D), 642. (C), 643. (B), 644. (A), 645. (C), 646. (B), 647. (D), 648. (A), 649. (C), 650. (D).

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C. Kilovolt-amperes

D. All of the above

652. Which of the following does a power factor meter indicate?

A. Continuous power

B. Power difference between phases

C. The current is leading or lagging the voltage

D. Reactive and useful power

653. An industrial analyzer is NOT suitable for measuring which of the following?

A. Power B. Resistance

C. Current D. Power factor

654. Without external voltage transformers, the industrial analyzer can be used on circuits up to

A. 600 volts B. 480 volts

C. 240 volts D. 120 volts

655. What three electrical quantities can be measured by a multimeter?

A. Voltage, current, and watts

B. Voltage, current and resistance

C. Voltage, current, and amperes

D. Voltage, watts, and VARs

656. A multimeter is often called a VOM, which is an abbreviation for volt-ohm.

A. meter B. megameter

C. milliammeter D. microammeter

657. A multimeter has different shunts, which increase the

A. current range B. voltage ranges

C. resistance range D. impedance range

658. A multimeter use different multiplers to increase the

A. current range B. voltage range

C. resistance range D. impedance range

659. To measure resistance with a multimeter, the pointer must first be adjusted (with the test leads shorted together) to zero on the ohms scale by the

A. range switch

B. selector switch

C. meter zero screw

D. zero ohms adjustment

660. Which of the following. is measured with a Wheat stone bridge?

A. Current B. Resistance

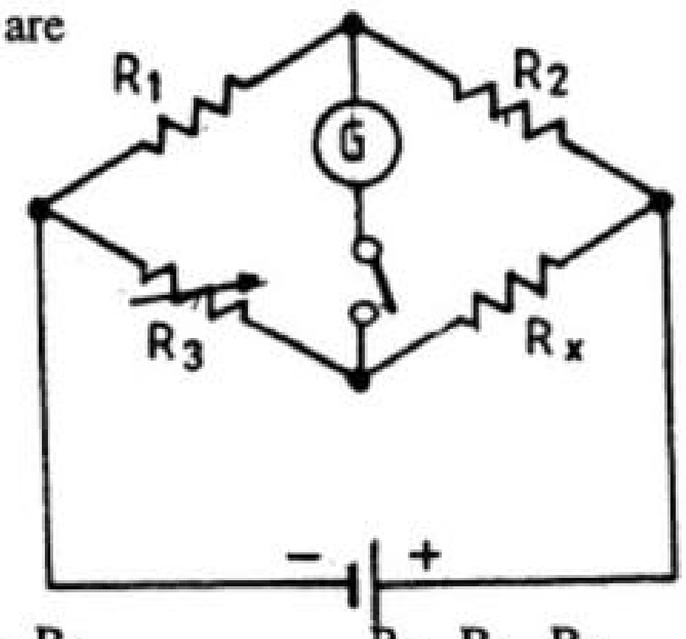
C. Voltage D. Power

661. When a Wheatstone bridge is balanced, the galvanometer reads

A. zero current B. maximum current

C. zero voltage D. maximum voltage

662. In the illustration below the ratio arms of the bridge are



A. R_1, R_3 B. R_1, R_2

C. R_3, R_x D. R_2, R_3

663. In the circuit shown above, the variable arm of the bridge is

A. R1 B. R2

C. R3 D. R4

664. What type of a bridge circuit is used to measure inductance and capacitance?

A. Wheatstone bridge B. D-C bridge

C. A-C bridge D. A-C, D-C bridge

665. What is the most simple electrical indicating instrument used on a control panel?

A. D-C voltmeter B. A-C ammeter

C. Synchroscope D. Light bulb

Answers : 651. (D), 652. (C), 653. (B), 654. (A), 655. (B), 656. (C), 657. (A), 658. (B), 659. (D), 660. (B), 661. (A), 662. (B), 663. (C), 664. (C), 665. (D).

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666. A bulb-type voltage tester is recommended only for circuits at or under how many volts?
A. 120 volts B. 240 volts
C. 480 volts D. 600 volts

667. The pocket-type tester, sometimes called the "Wiggy", is used to indicate approximate
A. current B. resistance
C. voltage D. impedance

668. A pocket-type voltage tester will indicate
A. D-C voltage only
B. A-C voltage only
C. A-C or D-C voltage
D. both voltage and resistance

669. When ringing out the wires in a conduit for identification, use a/an
A. voltmeter B. ammeter
C. megohmmeter D. continuity tester

670. A rotation tester is used to determine the phase sequence of the leads for a/an
A. single phase motor B. D-c motor
C. 3-phase motor D. A-C or D-C motor

671. A phase sequence indicator is used to determine the phase sequence of any energized
A. 3-phase line B. single phase line
C. D-C line D. telephone line

672. Which of the following most accurate when you synchronize alternators with the lamp method?
A. Three bright lamps
B. Three dark lamps
C. One bright, two dark lamps
D. Two bright, one dark lamp

673. Electric utility companies require frequency meters that indicates frequency within
A. one cycle-per-second
B. two cycles-per-second
C. 60 cycles-per-second
D. a fraction of a cycle-per-second

674. Grounds, shorts, and opens in small motor or generator armatures can be easily detected with a/an
A. armature bridge B. growler
C. point-to-point test
D. armature coil detector

675. The main advantage of a strip-chart recorder is that is provides a
A. record you can see at a glance
B. record for long unattended periods
C. daily record on a single sheet
D. record of voltage and current, using the same instrument

676. What type drive motor is likely to provide the most reliable record over a long period of time?
A. Hand-wound spring drive
B. Synchronous motor drive
C. Electric motor wound spring drive
D. Battery powered motor drive

677. An inkless recorder is recommended for circuits in which
A. there is excessive vibration
B. excessive heat or cold may be encountered
C. values fall within a narrow range
D. readings may fluctuate rapidly

678. In which of the following situations does a round-chart recorder have the greatest advantage?
A. Each day's record must be kept individually
B. The instrument is left unattended
C. A record is needed over a long period of time
D. Values fluctuate rapidly

679. When selecting a measuring instrument, be sure its range is
A. higher than the value being measured
B. below that of the circuit being tested

Answers : 666. (A), 667. (C), 668. (C), 669. (D), 670. (C), 671. (A), 672. (D), 673. (D), 674. (B), 675. (B), 676. (C), 677. (D), 678. (A), 679. (A).

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C. mid-way on the scale

D. on the lower third of the scale

680. Which of the following disturbance may permanently affect instrument accuracy?

A. A short circuit on a nearby conductor

B. Operating near an unshielded instrument

C. Passing through a stray magnetic field

D. All of the above

681. When connecting a wattmeter into a circuit, be sure the terminals are connected so that the

A. current coil is in parallel; potential coil in series

B. potential coil is in parallel; current coil in series

C. current and potential coils are in parallel

D. current and potential coils are in series

682. When current transformers are not in use, the secondary should be

A. fused

B. open-circuited

C. short-circuited

D. grounded with the primary

683. Before connecting an ohmmeter to a circuit, take steps to ensure that

A. the circuit is energized

B. all capacitors are discharged

C. all switches are closed

D. all inductors are discharged

684. When calibrating a megohmmeter with the test probes open, the pointer should stop at

A. any place on the scale

B. the midpoint on the scale

C. zero

D. infinity

685. One advantages that the VTVM has, that a VOM does not have, is

A. low input impedance

B. high input impedance

C. it does not measure current

D. it measures power only

686. On disadvantage that the VTVM has, that a VOM does not have, is

A. low input impedance

B. high input impedance

C. it does not measure current

D. it measures power only

687. To measure resistance, both the VTVM and VOM require

A. a battery or D-C source

B. electron tubes

C. s120-volt source

D. internal shunts

688. Which of the following can be measured by a VTVM?

A. Voltage and resistance

B. Voltage and current

C. Voltage and power

D. Current and resistance

689. A VTVM uses a circuit with

A. an iron vane meter movement

B. electron tubes

C. a frequency multiplier

D. a high current power source.

690. The oscilloscope is used to check what elements of a circuit?

A. voltage, current, and resistance

B. Voltage, current, and power

C. Frequency, phase, and waveshape

D. Frequency, power, and waveshape

691. The picture on an oscilloscope screen is produced by

A. A Electrone beam

B. a moving vane

C. a T-V type camera

D. an intensity control

Answers : 680. (A), 681. (B), 682. (C), 683. (B), 684. (D), 685. (B), 686. (C), 687. (A), 688. (A), 689. (B), 690. (C), 691. (A).

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692. To observe its pattern on the scope screen, A-C voltage is applied to the

A. sawtooth generator

B. vertical deflection plates

C. horizontal deflection plates

D. electron gun

693. What is the waveshape of the voltage applied to the horizontal deflection plates that causes the electron beam to move steadily across the scope screen?

A. A-C sine wave B. D-C wave

C. Sawtooth wave D. Square wave

694. For a pattern of one cycle of a 60 Hz power source to appear on the scope screen, the horizontal and vertical deflection frequencies must be

A. 30 Hz B. 40 Hz

C. 60 Hz D. 120 hz

Answers : 692. (B), 693. (C), 694. (C).

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CHAPTER 10

POWER SYSTEM-I (GENERATION, TRANSMISSION AND DISTRIBUTION)

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Chapter 10

GENERATION, TRANSMISSION AND DISTRIBUTION

10.1 Introduction

Energy is the basic necessity for the economic development of a country. Many functions necessary to present-day living comes to halt when the supply of electrical energy stops. The modern society is so much dependent upon the use of electrical energy that it has become a part and parcel of our life. The survival of industrial undertakings and our social structures depends upon low cost and uninterrupted supply of electrical energy. In fact, the advancement of a country is measured in terms of per capita consumption of electrical energy.

The most common method of generating energy is by means of electric machines generally called *generator or alternator*. These machines convert mechanical energy into electrical energy when coupled to prime movers.

Electrical energy is produced from energy available in various forms in nature. These sources of energy are :

(*i*) Solar (*ii*) Wind (*iii*) Water (*iv*) Fuels (*v*) Nuclear energy

Out of these sources, the energy due to sun and wind has not been utilised on large scale due to a number of limitations. At present, the other three sources, *i.e.* water, fuels and nuclear energy, are primarily used for generation of electrical energy.

10.2 Generating Stations

The generating stations are classified as under :

Hydroelectric Stations. Water is a great potential source of energy. The generating stations which obtain energy from water are called *Hydro-Electric* Stations. Water is stored at a suitable place, it possesses potential energy because of the head created. This water energy can be converted into mechanical energy with the help of water turbines. The water turbine drives the alternator which converts mechanical energy into electrical energy. This method of generation of electrical energy has become very popular because it has low production and maintenance cost.

Steam Power Station (Fuels). Main sources of energy are fossil fuels i.e. solid fuel as coal, liquid fuel as oil and gas fuel as natural gas. The heat energy of these fuels is converted into mechanical energy by suitable prime movers such as steam engines, steam turbines and internal combustion engines etc. The prime movers drive the alternators which convert mechanical energy into electrical energy.

Nuclear Power Station. It was discovered that large amount of heat energy is liberated by the fission of Uranium and other fissionable materials. It is estimated that heat produced by 1 kgm of nuclear fuel is equal

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$P = 2.46 \times 10^{-3}\ D^2\ \mu^3$ Watts Where D is the blade diameter in feet and μ is the velocity is miles/hr.

Tidal Energy is obtained by closing of a bay with a dam, allowing it to fill during periods of high tide, and recovering the energy as it empties during periods of low tide. For a maximum tidal head H, the average tidal power obtained per unit area of tidal bay is given approximately by

$$P_{av} = 0.219\ H^2\ \text{MW/km}^2$$

10.5. Terms Commonly used in System Operation

Firm Power : It is the power intended to be always available.

Cold Reserve : It is that reserve generating capacity which is available for service but is not in operation.

Hot Reserve : It is that reserve generating capacity which is in operation but is not in service.

Spinning Reserve : It is that generating capacity which is connected to bus and is ready to take load.

Connected Load : It is the sum of continuous ratings of all the equipments connected to the supply system.

Maximum Demand : It is the greatest demand of load on power station during a given period.

Demand Factor : It is the ratio of maximum demand on the power station to its connected load, *i.e.*

$$\text{Demand Factor} = \frac{\text{Maximumdemand}}{\text{Connectedload}}$$

Average Load : The average of loads occurring on the power station in a given period is known as average load or average demand.

$$\text{Daily average load} = \frac{\text{No. of units (kWh) generated in a day}}{\text{24 hours}}$$

$$\text{Monthly average load} = \frac{\text{No. of units generated in a month}}{\text{No. of hours in a month}}$$

$$\text{Yearly average load} = \frac{\text{No. of units generated in a year}}{\text{8760 hours}}$$

Load Factor : The ratio of average load to the maximum demand during a given period is known as load factor.

$$\text{Load factor} = \frac{\text{Average load}}{\text{Maximum demand}}$$

Diversity Factor: The ratio of the sum of individual maximum demands to the maximum demand on the power station is known as diversity factor

$$\text{Diversity factor} = \frac{\text{Sum of individual maximum demands}}{\text{Maximum demand on power station}}$$

$$\text{Capacity factor} = \frac{\text{Actual energy produced}}{\text{Maximum energy that could have been produced}}$$

$$= \frac{\text{Average demand}}{\text{Plant capacity}}$$

$$\text{Reserve capacity} = \text{Plant capacity} - \text{Maximum demand}$$

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Utilization Factor (Plant Use Factor) : It is the ratio of kWh generated to the product of plant capacity and the number of hours for which the plant was in operation.

$$\text{Plant Use Factor} = \frac{\text{Station output in kWh}}{\text{Plant capacity} \times \text{Hours of use}}$$

10.6. Base Load and Peak Load on Power Station

Base Load: The unvarying load which occurs almost the whole day on the station is known as base load.

Peak Load : The various peak demands of load over and above the base load of the station is known as peak load.

Economics of Power Generation. The art of determining per unit cost of production of electrical energy is known as economics of power generation. Cost of electrical energy can be divided into three parts namely (*i*) Fixed cost (*ii*) Semi fixed cost and (*iii*) Running cost.

$$\text{Total Annual Cost of Energy} = \text{Fixed Cost} + \text{Semi fixed Cost} + \text{Running Cost}$$

$$= \text{Rs. } (a + b\,\text{kW} + c\,\text{kWh})$$

Methods for Determining Depreciation. There is reduction in cost of equipment and other property of the plant every year due to depreciation. There are three methods for determining the annual depreciation namely.

(*a*) Straight Line method, (*b*) Diminishing Value Method, (*c*) Sinking Fund Method

(*a*) **Straight Line Method.** In this method annual depreciation charge $= (P - S)/n$ where P is initial cost of equipment, S is Salvage value after the useful life of the plant and n is the useful life of equipment in years.

(*b*) **Diminishing Value Method.** Depreciation for the 1st year $= P\,[\,1 - (S/P)^{1/n}\,]$ where P is capital cost of equipment, S scrap value after useful life and n is the useful life of equipment in years.

(*c*) **Sinking Fund Method.** A uniform annual depreciation charge.

$$q = (P - S)\left[\frac{r}{(1+r)^n - 1}\right]$$

where P is initial value of equipment, n is the useful life of equipment in years, S is scrap value after useful life and r is annual rate of interest expressed in decimal.

Types of Tariff. The rate at which electrical energy is supplied to a consumer is known as tariff. There are several types of tariff, commonly used types of tariff are: (*i*) Simple tariff (*ii*) Flat rate tariff (*iii*) Block rate tariff (*iv*) Two-part tariff (*v*) Maximum demand tariff (*vi*) Power factor tariff (*vii*) Three part tariff *i.e.*, Total charge = Rs. $(a + b\,\text{kW} + c\,\text{kWh})$

VARIOUS SYSTEMS OF TRANSMISSION OF ELECTRICAL POWER

Though in practice 3-phase 3-wire a.c. system is universally used for transmission and 3-phase 4-wire a.c. system is used for distribution of electric power but for other purposes other systems may also be used. The various systems for power transmission are:

(*a*) *DC systems:*

(*i*) D.C. two-wire (*ii*) D.C. two-wire with mid point earthed (*iii*) D.C. three-wire system

(*b*) *Single phase a.c. systems:*

(*i*) Single phase two-wire (*ii*) Single phase two-wire with mid point earthed (*iii*) Single phase three-wire

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(*c*) *Two-phase ac systems:*

(*i*) Two-phase four-wire (*ii*) Two-phase three-wire

(*d*) *Three phase ac systems:*

(*i*) Three-phase 3-wire (*ii*) Three-phase 4-wire

It is difficult to decide the best system without making comparison. The basis for comparison between the various systems of power transmission is usually economy *i.e.* volume of copper required.

10.7. Comparison of Volume of Copper for Various Systems of Transmission

The following assumptions are made while calculating the volume of copper for various systems:

1. The power transmitted over all the systems is same.
2. The length of transmission line is same in each system.
3. The line loss in all the systems is same.

Table 10.1. Comparison of Various Systems of Transmission

System		*Same maximum voltage to earth*	*Same maximum voltage between conductors*
(*a*) DC System			
(*i*)	Two-wire	1	1
(*ii*)	Two-wire midpoint earthed	0.25	1
(*iii*)	Three-wire	0.3125	1.25
(*b*) Single Phase System			
(*i*)	Two-wire	$\frac{2}{\cos^2\phi}$	$\frac{2}{\cos^2\phi}$
(*ii*)	Two-wire with mid-point earthed	$\frac{0.5}{\cos^2\phi}$	$\frac{2}{\cos^2\phi}$
(*iii*)	Three wire	$\frac{0.625}{\cos^2\phi}$	$\frac{2.5}{\cos^2\phi}$
(*c*) Two-Phase System			
(*i*)	Two-phase, four-wire	$\frac{0.5}{\cos^2\phi}$	$\frac{2}{\cos^2\phi}$
(*ii*)	Two-phase, three-wire	$\frac{1.457}{\cos^2\phi}$	$\frac{2.194}{\cos^2\phi}$
(*d*) Three-Phase System			
(*i*)	Three-phase, three-wire	$\frac{0.5}{\cos^2\phi}$	$\frac{1.5}{\cos^2\phi}$
(*ii*)	Three-phase, four-wire	$\frac{0.583}{\cos^2\phi}$	$\frac{1.75}{\cos^2\phi}$

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(*iv*) Arc lamps which operate at low power factor.

Advantages of Power Factor Improvement. The following are the advantages of the improved power factor:

(1) The kW capacity of the prime movers is better utilized.

(2) This increases the kilowatt capacity of the alternators.

(3) The kW capacity of transformers and the lines are increased.

(4) The efficiency of every plant is increased.

(5) The overall cost per unit decreases.

(6) The regulation of the lines is improved.

Methods of Improving Power Factor. The following equipments are generally used to improve the power factor.

(*i*) *Static Capacitors*. The capacitor is connected in parallel with the supply mains as shown in Fig. 10.1 (*a*) and take current leading by 90° from the mains which neutralizes the reactive lagging component of the load current.

10.10. Power Factor Improvement by Static Capacitors

If the p.f. cos ϕ_1 of load is known and is to be improved to cos ϕ_2 as shown in Fig. 10.1 (*b*). The value of capacitor C can be calculated as follows. The active component of current which is to remain constant, $I_a = I \cos \phi_1$.

The quadrature component of load current without capacitor $= I_a \tan \phi_1$

The quadrature component of load current with capacitor $= I_a \tan \phi_2$

Current taken by capacitor, $I_C = I_a \tan \phi_1 - I_a \tan \phi_2$

Applied Voltage, $V = I_C X_C = I_C \cdot \dfrac{1}{2 \pi fC}$

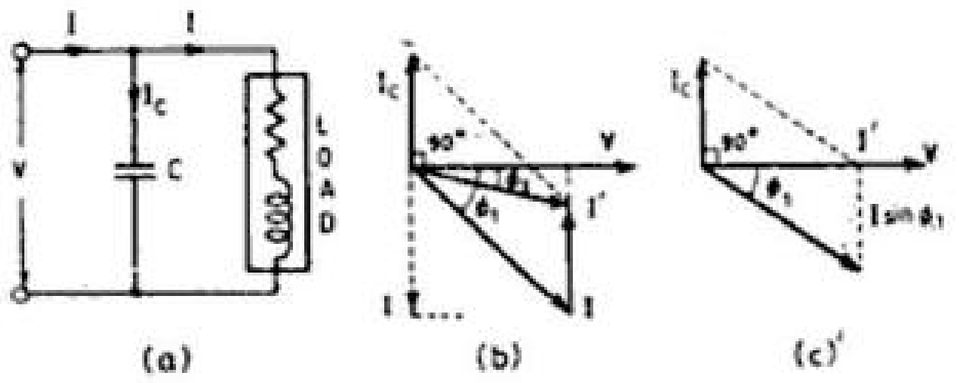
Value of Capacitor, $C = I_C / 2 \pi fV$

If the power factor of the load is to be improved upto unity, the phasor diagram is shown in Fig. 10.1(*c*).

Then $I_C = I \sin \phi_1$

and $C = I_C / 2 \pi fV$

(*ii*) *Synchronous Condenser*. The synchronous condenser is also called as synchronous motor. This is the only motor which can be worked at leading power factor at the same time this can supply mechanical power.



10.1

10.11. Power Factor Improvement by Synchronous Condenser

Let P be the active power of load and cos ϕ_1 is the p.f. which is to be improved to cos ϕ_2 when synchronous condenser takes active power P_s from the supply. The rating and p.f. at which the synchronous condenser is operating can be calculated as follows. The power triangle of the loads are shown in Fig. 10.2(*a*). Reactive Power of Load, $P_r = P_1 \tan \phi_1$. When synchronous condenser is connected in the circuit, Total load (active power) $P = P_1 + P_s$.

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Total reactive power, $P_r = P \tan \phi_2$

Reactive power supplied by the synchronous condenser $P_{rs} = P_r - P_{r1}$

The power triangle for the synchronous condenser is shown in Fig. 10.2. (*b*).

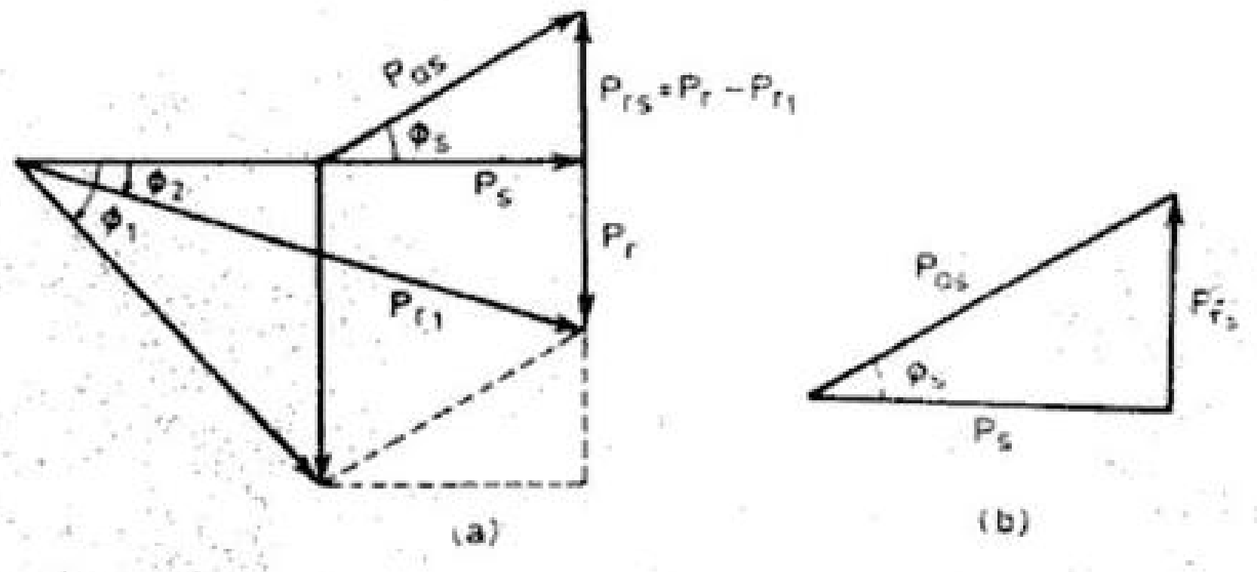
Rating (kVA of Synchronous condenser,

$$P_{as} = \sqrt{(P_s)^2 + (P_{rs})^2}$$

Power factor of synchronous condenser,

$$\cos \phi_2 = \frac{P_s}{P_{as}}$$

(*iii*) *Phase Advancers.* These are special commutator machines which improve the power factor of induction motor



10.2 (b)

Location of Power Factor Improvement Apparatus. Power factor improvement apparatus should always be located near the equipment/machinery which is responsible for low power factor. If synchronous condensers are to be used for improving the power factor of the transmission line, then the best location for these will be at the receiving end. Synchronous condensers thus installed will relieve both the transmission line and generators from the excessive current. However, if synchronous condensers are installed near the generators then only generators will be relieved from the excessive lagging current component and the transmission line will have to carry more than the normal current.

The Most Economical Power Factor. Although it may appear that if the installation has a unity power factor, it is the best, actually it may not be an economical notion, since, to improve the power factor (no doubt the kVA demand is decreased by neutralizing the reactive kVA with a leading reactive kVA provided by a plant) also costs something. In practice the most economical power factor is that for which the annual saving is maximum.

10.12. Transmission-Line parameters

Transmission line is one of the major components of a power system and may be represented quantitatively by a combination of three characteristics or parameters; its resistance, inductance and capacitance. These are known as constants or parameters of the transmission line. The performance of the transmission line depends upon these constants. In this chapter different methods are discussed to calculate these constants for a given transmission line.

Resistance. The most significant effect of the resistance of transmission-line conductors is the copper loss $I^2 R$ in the line. The resistance also produces voltage drop (IR) affecting the voltage regulation of the line.

The d.c. resistance R of a conductor of length l and cross-sectional area A is

$$R = \rho \frac{l}{A} \text{ ohms} \qquad ...(1)$$

where ρ is the *resistivity* of the material of the conductor in ohm-meters. The d.c. resistance of a conductor is affected only by the operating temperature, and it increases linearly with the temperature. However, when a conductor is transmitting alternating current, the current-density distribution across the conductor cross section is nonuniform and is a function of the ac frequency. This phenomenon, known as the *skin effect*, causes the ac

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$$L = \frac{\mu_0}{8\pi}\left(1 + 4\ \ln\ \frac{D}{r}\right) = 2\left(\frac{1}{4} + \ln\ \frac{D}{r}\right) \times 10^{-7}\ \text{H/m} \qquad ...(6)$$

where r is the conductor radius and D is the spacing between conductors In practice, the three conductors of a three-phase line are seldom equilaterally spaced. The usual nonsymmetrical spacing produces unequal inductances in the three phases, leading to unequal voltage drops and an imbalance in the line. To offset this imbalance, the positions of the conductors are interchanged at regular intervals along the line. This practice is known as *transposition* and is illustrated in Fig. 10.3, which also shows the unequal spacings between conductors. The average per-phase inductance for a transposed line is still given by Eqn. (6), except that the spacing D in the equation is replaced by the equivalent spacing D_e obtained from

$$D_e = (D_{ab}\ D_{bc}\ D_{ca})^{1/3} \qquad ...(7)$$

where the distances D_{ab}, D_{bc} and D_{ca} are as shown in Fig. 10.3.

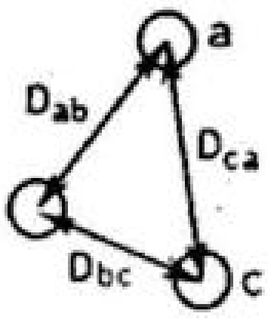
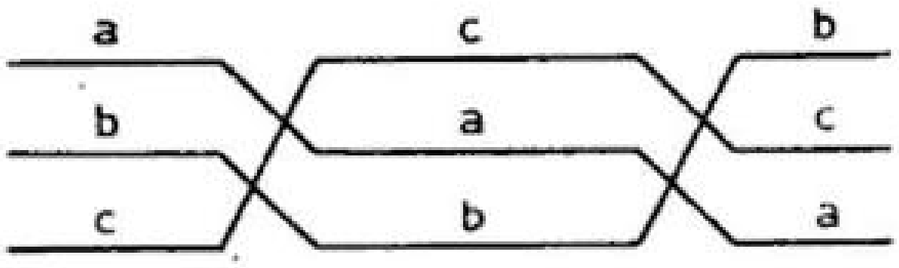
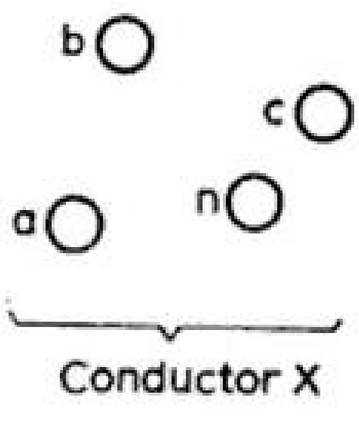


Fig. 10.3





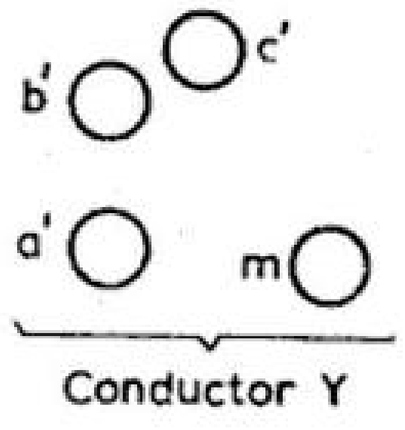


Fig. 10.4

10.15. Inductance of Composite Conductors

These expressions for the line inductance must be modified for application to a transmission line that consists of composite conductors. In particular, let a single-phase line consist of two composite conductors, as shown in Fig. 10.4. Conductor X is composed of n identical and parallel filaments, each of which carries the current I/n. Conductor Y, which is the return circuit for the current in conductor X, is composed of m identical and parallel filaments, each of which carries the current I/m. Distance between pairs of elements are designated by D with appropriate subscripts. The inductance L_x of conductor X then may be shown to be

$$L_X = 2 \times 10^{-7} \ln \frac{\sqrt[mn]{(D_{aa'}\ D_{ab'}\ D_{ac'} \ldots D_{am})(D_{ba'}\ D_{bb'}\ D_{bc'} \ldots D_{bm}) \ldots (D_{na'}\ D_{nb'}\ D_{nc'} \ldots D_{nm})}}{\sqrt[n^2]{(D_{aa}\ D_{ab}\ D_{ac} \ldots D_{an})(D_{ba}\ D_{bb}\ D_{bc} \ldots D_{bn}) \ldots (D_{na}\ D_{nb}\ D_{nc} \ldots D_{nm})}}\ (\text{H/m}) \qquad ...(8)$$

where $D_{kk} = r'_k = r_k\, e^{-1/4}$ is the geometric mean radius (GMR) of the *kth conductor. Notice that the* numerator in Eqn. (8) involves the *mnth root of the product of nm* terms; each of those terms is the distance from one of the n filaments of conductor X to one of the m filaments of conductor Y, and there are a total of mn distances. The *mnth root of the product of nm* distances is called a geometric mean distance. For two conductors X and Y, as in Fig. 10.4, it is called the *mutual* geometric mean distance between them and abbreviated D_m or GMD.

The n^2 root of the product of n^2 distances occurring in the denominator of Eqn. (8) is abbreviated D_s and called the *self* GMD of conductor X. In like manner, r' for a separate filament or wire is often called its self GMD. The self GMD is also sometimes loosely termed the *geometric mean radius* and abbreviated GMR.

In terms of D_m and D_s, Eqn. (8) becomes

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$$L_X = 2 \times 10^{-7} \ln \frac{D_m}{D_s} \text{ H/m} \qquad ...(9)$$

The inductance L_Y of conductor Y can be determined in a similar manner, and the total line inductance becomes

$$L = L_X + L_Y \qquad ...(10)$$

10.16. Inductance of Double-Circuit, Three-Phase Line

The per-phase inductance of a double-circuit, three-phase, transposed, transmission line as shown in Fig. 10.5 is given by

$$L = 2 \times 10^{-7} \ln \frac{\text{GMD}}{\text{GMR}} \text{ H/m} \qquad ...(11)$$

In terms of the symbols of Fig. 10.5, which shows a transposed three-phase line, Eqn. (11) may be written as

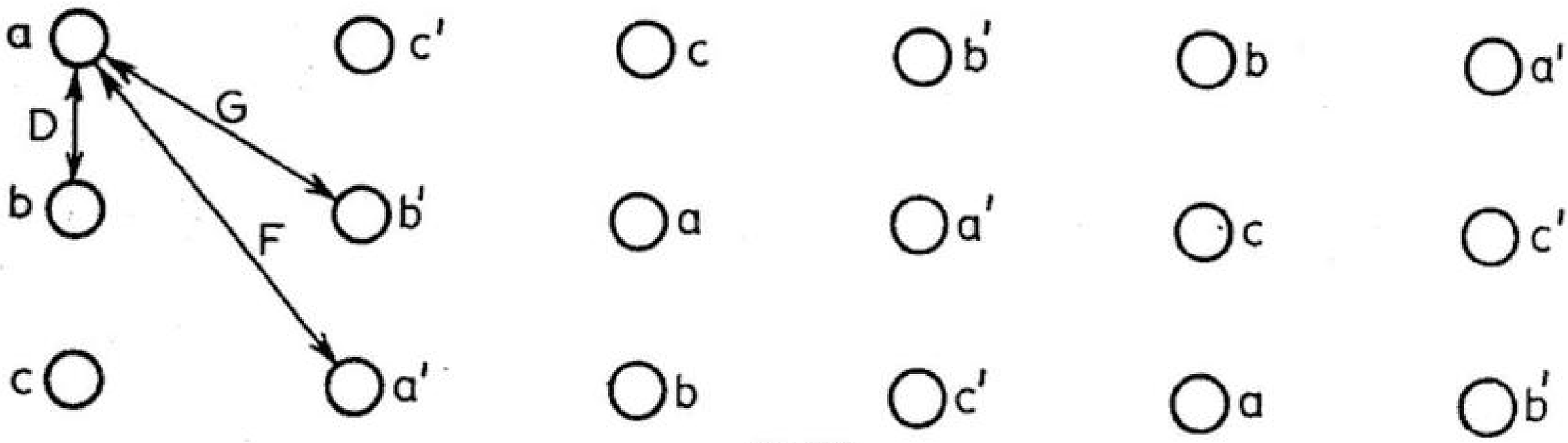


Fig. 10.5

$$L = 2 \times 10^{-7} \ln \frac{\sqrt[6]{2}\ \sqrt{D}\ \sqrt[3]{G}}{\sqrt{r'}\ \sqrt[3]{F}} \qquad ...(12)$$

where r' is the GMR of the conductor.

Capacitance. The shunt capacitance per unit length of a single- phase, two-wire transmission line is given by

$$C = \frac{\pi \varepsilon_0}{\ln (D/r)} \text{ Farad/metre} \qquad ...(13)$$

where ε_0 is the permittivity of free space. For a three-phase line with equilaterally space conductors, the per-phase (or line-to-neutral) capacitance is

$$C = \frac{2 \pi \varepsilon_0}{\ln (D/r)} \text{ F/m} \qquad ...(14)$$

To account for the actual unequal spacings between conductors and the transposition of the line, D in Eqn. (14) is replaced with D_e of Eqn. (7), as is done in computing the inductance of a transposed line.

For the double-circuit transmission line of Fig. 10.5 the per- phase capacitance is given by

$$C = \frac{4 \pi \varepsilon_0}{\ln [\sqrt[3]{2} (D/r) (G/F)^{2/3}]} \text{ F/m} \qquad ...(15)$$

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The capacitance of an overhead transmission line is affected by the ground, which distorts its electric field. The effect of the earth is simulated by assuming the existence of mirror-image conductors, as far below ground level as the transmission line is above it (Fig. 10.6). The image conductors carry charges with polarities

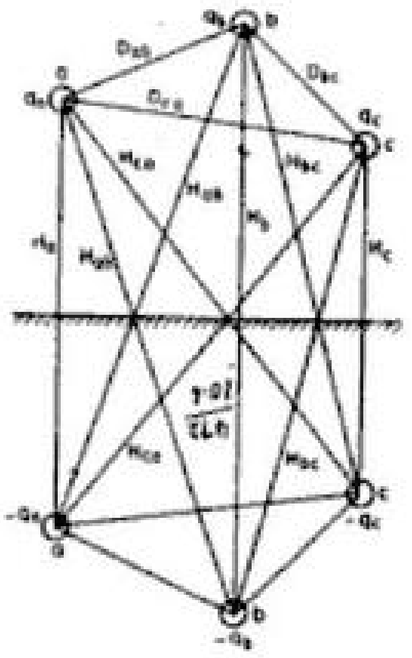


Fig. 10.6

opposite to those of the real conductors, as shown. Now the capacitance to neutral is given by

$$C_n = \frac{2\pi\varepsilon_0}{\ln\,(D_e/r) - \ln\,(\sqrt[3]{H_{ab}\,H_{bc}\,H_{ca}}/\sqrt[3]{H_a\,H_b\,H_c})}\ \text{F/m} \qquad ...(16)$$

where D_e is given by Eqn. (7), the H's is are defined in Fig. 10.6, and r is the conductor radius.

Using the concept of the GMD, we may write the capacitance to neutral of a nonsymmetrical three-phase ouble-circuit line as

$$C_n = \frac{2\pi\varepsilon_0}{\ln\,(\text{GMD/GMR})} = \frac{2\pi\varepsilon_0}{\ln\,(D_m/D_s)}\ \text{F/m} \qquad ...(17)$$

Substituting the numerical value for ε_0 in Eqn. (17) yields

$$C_n = \frac{10^{-9}}{18\,\ln\,(D_m/D_s)}\ \text{F/m} \qquad ...(18)$$

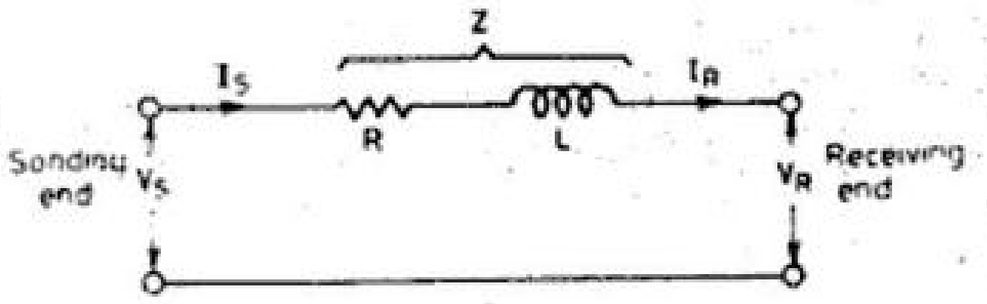
10.17. Short-Transmission Line

The short transmission line is represented by the lumped parameters R and L, as shown in Fig. 10.7. Notice that R is the resistance per phase and L is the inductance phase of the *entire line*. The line is shown to have two ends: the sending end designated by the subscript S at the generator, and the receiving end designated R at the load. Quantities of significance here are the voltage regulation and efficiency of transmission are defined as follows for lines of all lengths.

$$\text{Voltage regulation} = \frac{|V_S - V_R|}{|V_R|} \times 100 \qquad ...(19)$$

$$\text{Efficiency of transmission} = \frac{\text{power at receiving end}}{\text{power at sending end}}$$

$$= \frac{P_R}{P_S} \qquad ...(20)$$



where V_R is the receiving-end voltage.

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10.18. Medium-Length Transmission line

In a medium-length transmission line the shunt effect due to the capacitance is not negligible. Two representations for such a line are shown in Figs. 10.8 and 10.9 they are known as the *Nominal-π circuit* and

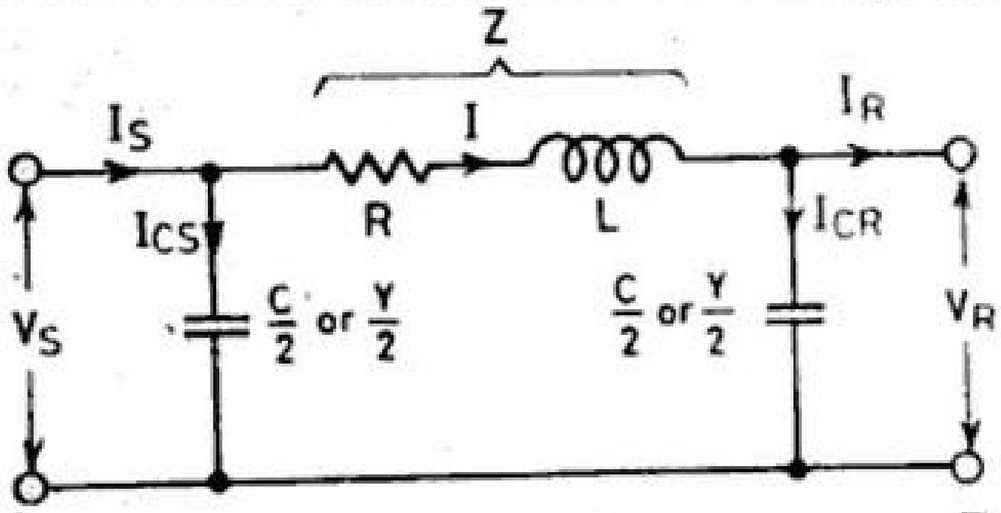
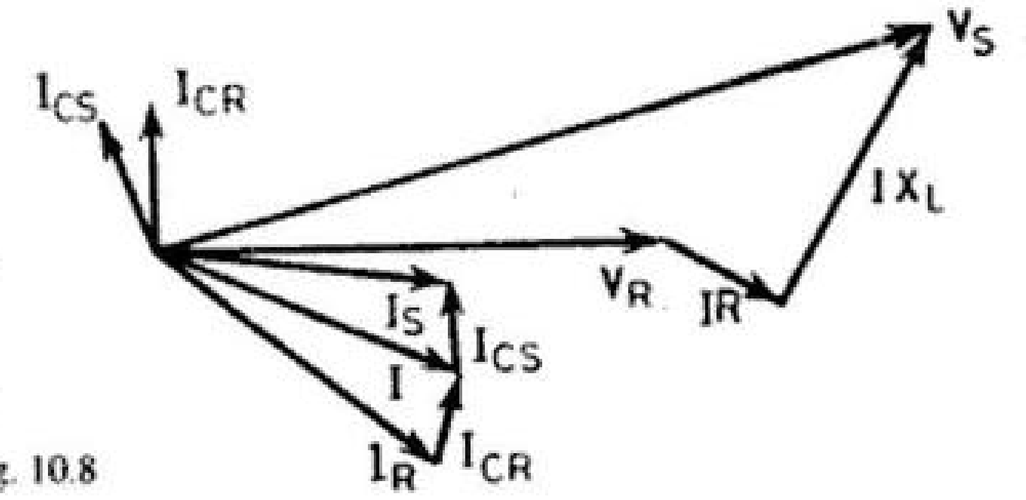


Fig. 10.8



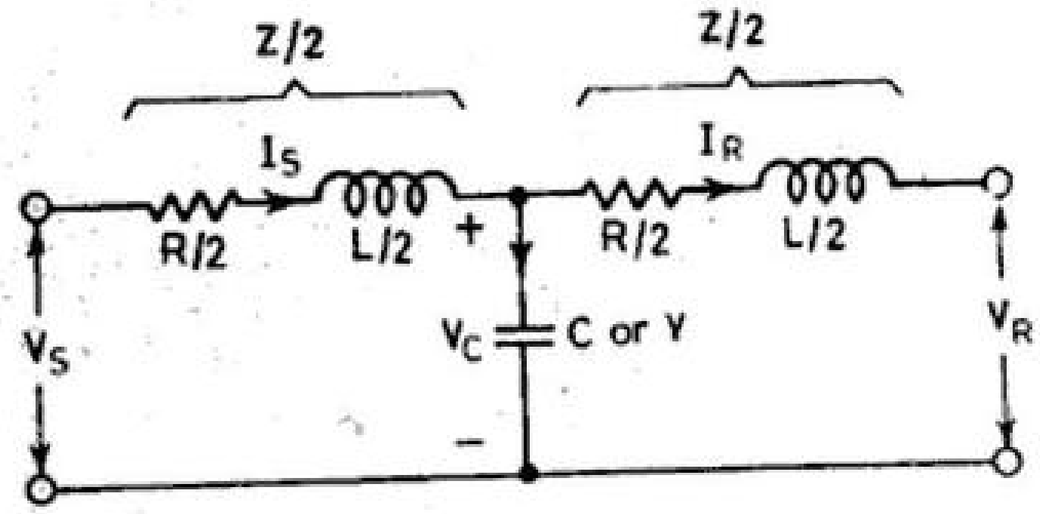
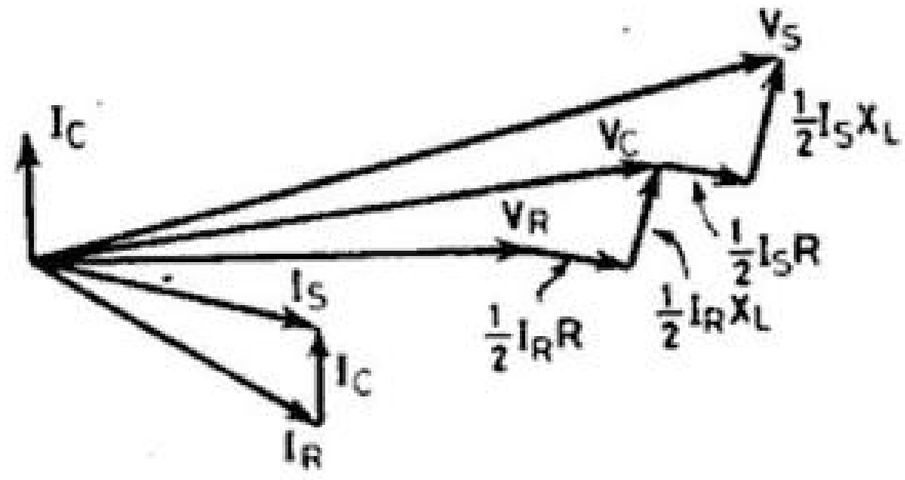


Fig. 10.9



the *Normal-T circuit* of the transmission line, respectively. The figures also show the phasor diagrams for lagging power-factor conditions. These diagrams are of help in understanding the relationships between currents and voltages along the line.

10.19. Long Transmission line

The parameters of a *long line* are considered to be distributed over the entire length of the line. One phase of a long line, of length L is shown in Fig. 10.10. The voltage V at any point along this line is given by

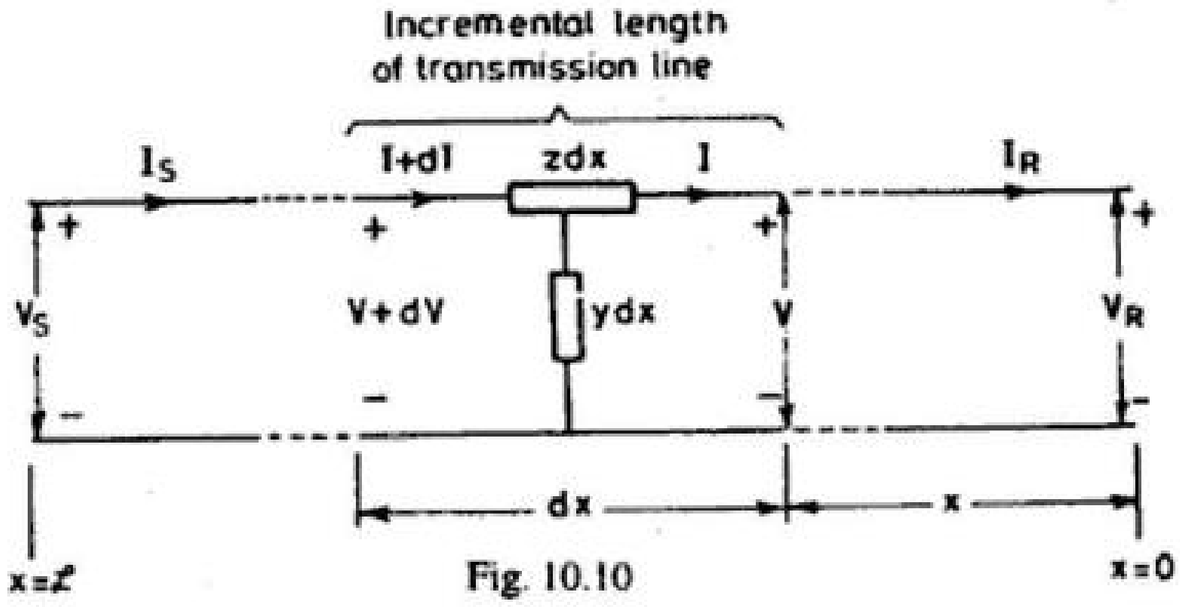


Fig. 10.10

$$\frac{d^2 V}{dx^2} = \gamma^2 V \qquad \ldots(21)$$

where $\gamma = \sqrt{yz}$, is the shunt admittance per unit length of the line. z is the series impedance per unit length. and γ is known as the propagation constant. A solution to Eqn. (21) is

$$V = \frac{1}{2} V_R (e^{\gamma x} + e^{-\gamma x}) + \frac{1}{2} I_R Z_c (e^{\gamma x} - e^{-\gamma x}) \qquad \ldots(22)$$

where $Z_c = \sqrt{z/y}$ is called the characteristic impedance of the line. The current I at any point along the line is given by

$$I = \frac{1}{2} \frac{V_R}{Z_c} (e^{\gamma x} - e^{-\gamma x}) + \frac{1}{2} I_R (e^{\gamma x} + e^{-\gamma x}) \qquad \ldots(23)$$

Equations (4) and (5) may be expressed in terms of hyperbolic function as

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Electrical Stress in a Single-Core Cable. The insulating material in a cable constitutes a dielectric and has a certain dielectric strength. If this dielectric strength is exceeded during the operation of the cable, the insulation will break down. Hence the cable must be designed so that the electric field strength, at the surface of the conductor does not exceed that required to break down the insulation. However, if the cable is designed with a relatively low line-to-ground voltage gradient, the overall size of the cable becomes too large; on the other hand, if the voltage gradient is made large so as to allow reduction of the cable diameter , then the dielectric loss may become too large and may lead to excessive heating of the cable. It has been found that the optimal ratio of the radius of the cable to the radius of the conductor is given by

$$\frac{R_1}{R_2} = e = 2.718 \qquad ...(32)$$

where R_1 and R_2 are the radius of sheath and conductor. Smaller ratios will result in unstable cable operation, in that the dielectric will tend to break down. Any ratio exceeding 2.718 will result in satisfactory cable operation. For economic reasons, however, it is best to maintain R_1/R_2 close to 2.718.

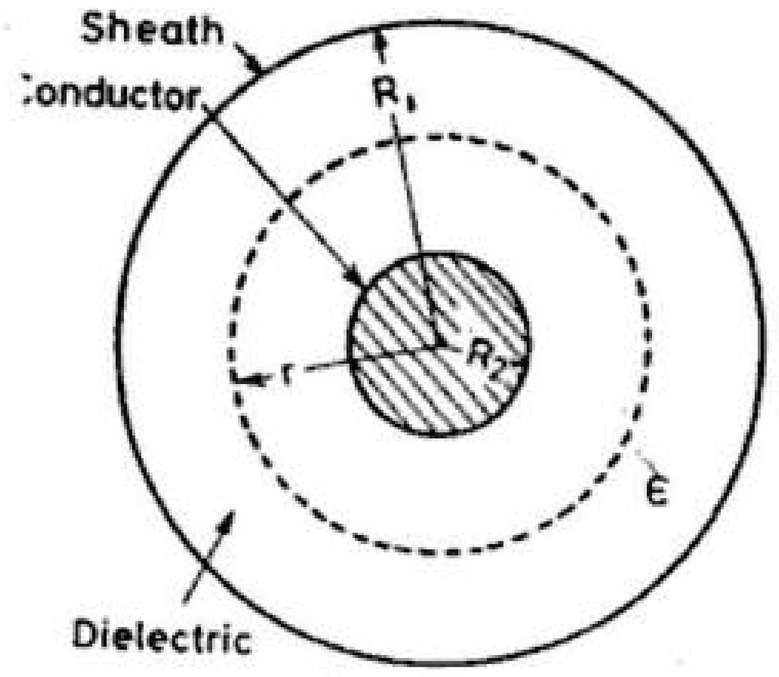


Fig. 10.12

Grading of Cables. The cable in Fig. 10.12 is filled with a single layer of a single dielectric, but many cables contains several layers of dielectrics. The dielectric materials in such a cable are chosen and distributed so as to minimize the difference between the maximum and minimum electric field strengths in the able. This process is known as grading, and two types are commonly used: capacitance grading and intersheath grading.

In capacitance grading, two or more layers of different dielectrics are used to insulate a cable, *e.g.*, two such layers are shown in Fig. 10.13. The permittivities of these layers are so chosen that the maximum field strength is the same in both regions. The corresponding variation of the electric field E with radius r is shown in Fig. 10.13. For equal maximum field strengths.

$$\varepsilon_1 R_2 = \varepsilon_2 R_3 \qquad ...(33)$$

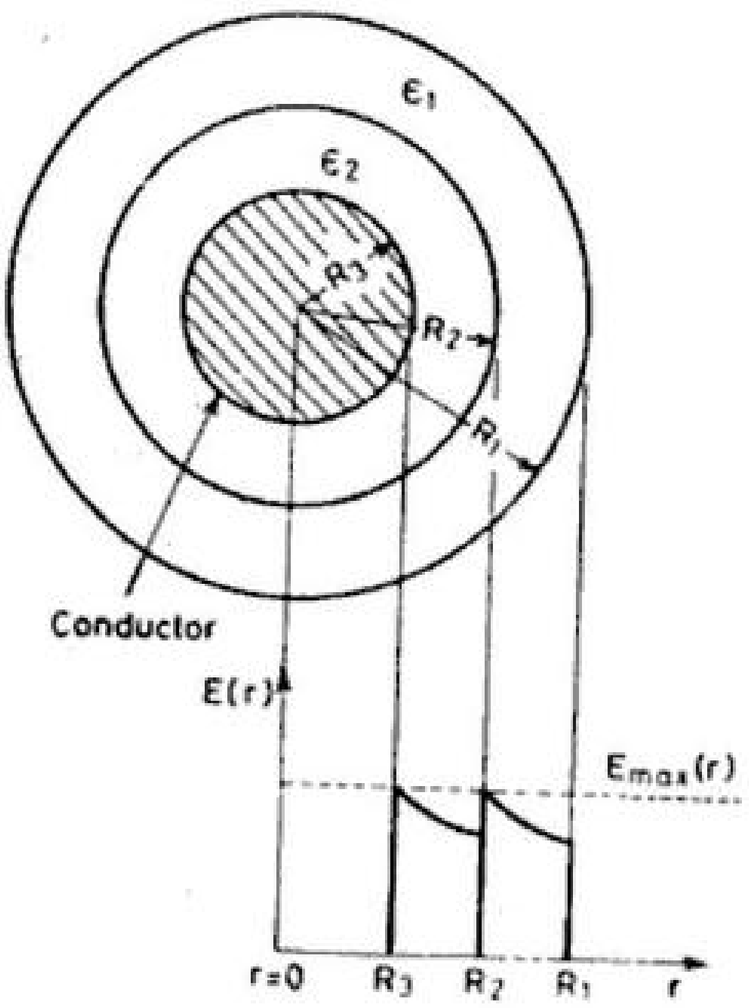


Fig. 10.13

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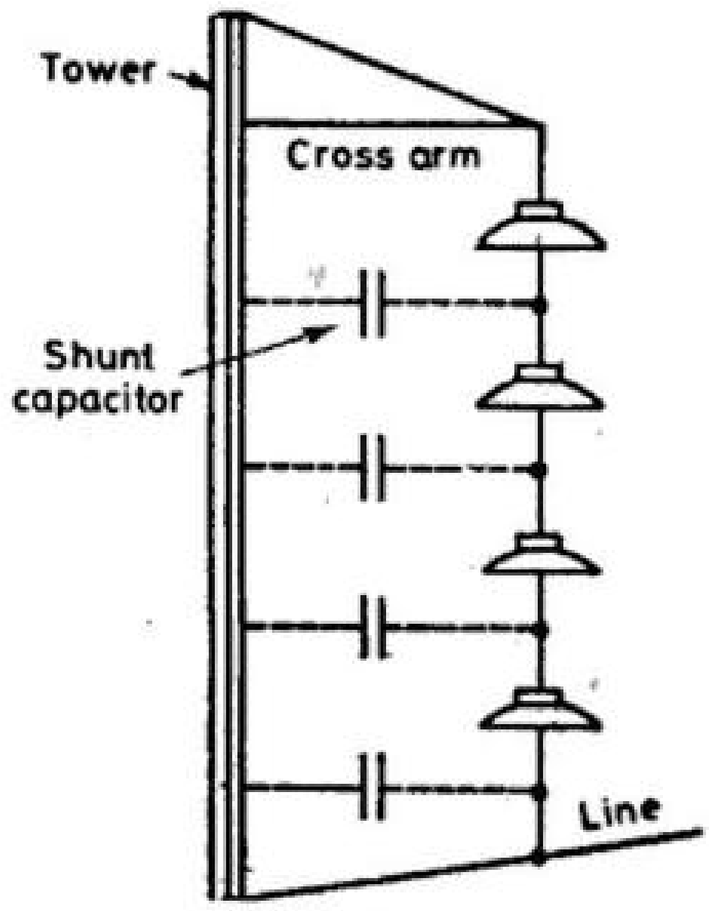


Fig. 10.21

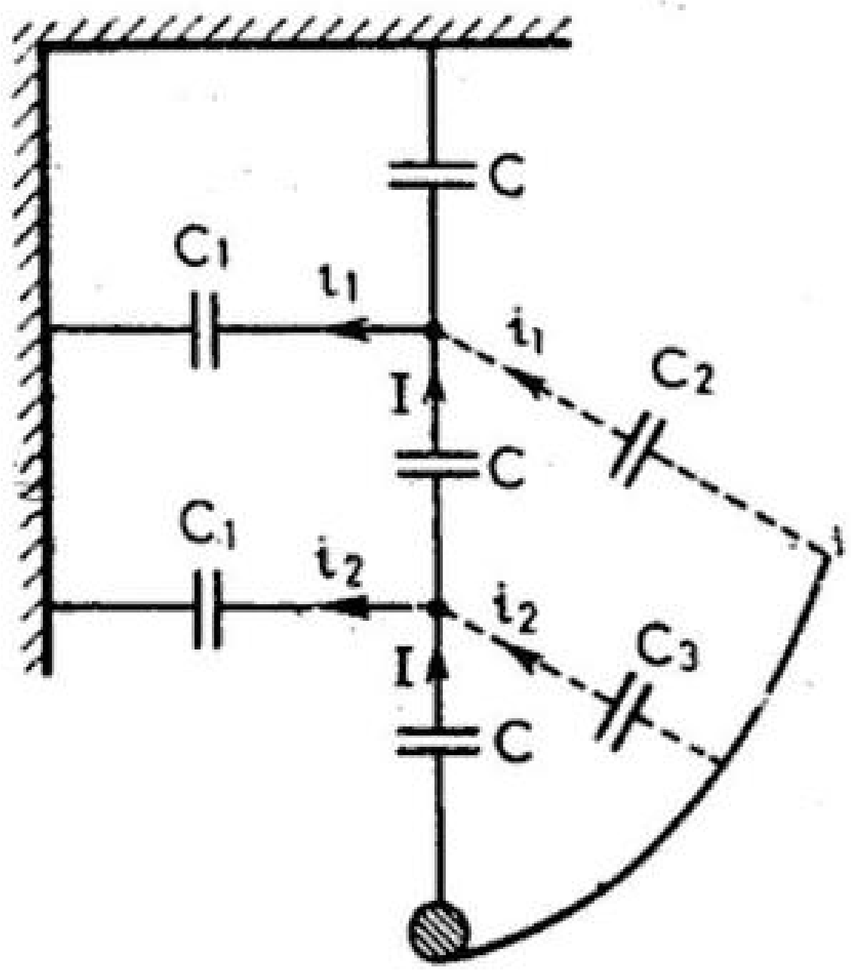


Fig. 10.22

(*c*) *By Using a Guard Ring.* The potential across each unit in a string can be equalised by using a guard ring which is a metal ring electrically connected to the conductor and surrounding the bottom insulator as shown in Fig. 10.22. The guard ring introduces capacitance between metal fittings and the line conductor. The guard ring is contoured in such a way that shunt capacitance currents i_1, i_2, etc. are equal to metal fitting—line capacitance currents i_1, i_2 etc. The result is that same charging current I flows through each unit of string. Consequently, there will be uniform potential distribution across the units.

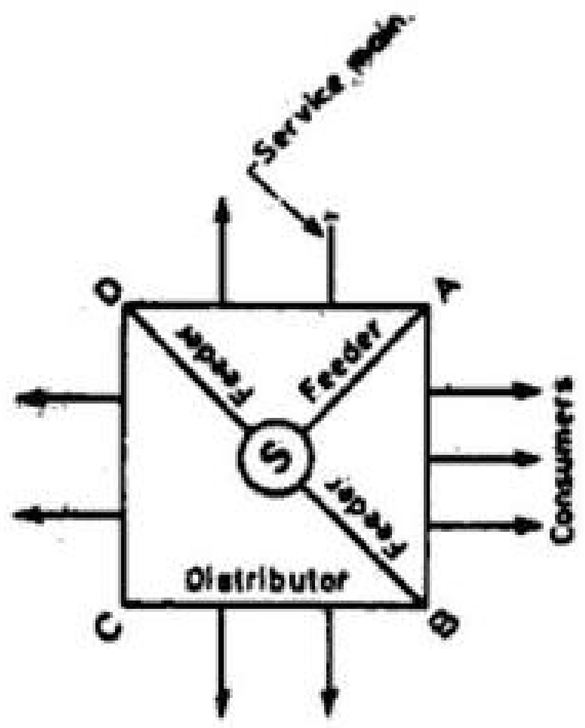


Fig. 10.23

Distribution System. The part of power system by which electric power is distributed among various consumers for their local use in known as *distribution system.*

In general the distribution system is that part of power system which distributes electric power from major sub-stations to the consumers as per their requirement. A low tension distribution system is shown in Fig. 10.23 which comprises the *feeders, distributors* and *service mains.*

(*i*) *Feeder.* A line or conductor which connects the major station to the distributor is known as *feeder.* It is to feed the electric power (or energy) to the distributor. In Fig. 10.23., *SA*, *SB* and *SD* are the feeders. Since no tapping is taken from the feeder, generally it carries same current throughout its length. The current carrying capacity is the main consideration taken into account while designing a feeder.

(*ii*) *Distributor.* A line or conductor to which various consumers are connected through service mains is known as *distributor.* It is to distribute electric power among various consumers, thus a number of tappings are taken from the distributor. Hence, it carries different currents along its length. In Fig. 10.23, *AB*, *BCD* and

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DA are the distributors. While designing a distributor, voltage drop along the length of the distributor is the main consideration.

(*iii*) *Service mains*. A line (conductor or cable) which connects the consumer to the distributor is known as *service mains*. It is designed as per the connected load of the consumer.

Classification of Distribution System. The distribution system may be classified.

1. According to nature of current. According to the nature of current the distribution system may be classified as.

(*a*) D.C. distribution system (*b*) A.C. distribution system

A.C. distribution system is almost universally employed due to its several advantages over d.c. distribution system.

2. According to nature of construction. According to nature of construction, the distribution system may be classified as.

(*a*) Overhead distribution system. (*b*) Underground distribution system.

Overhead system, being cheaper, is mostly employed in our country. However, underground system is employed in thickly populated areas where overhead system may not be practicable. It is also employed in big cities because of its better look.

3. According to the scheme of connections. According to the scheme of connections, the distribution system may be classified as

(*a*) Radial System (*b*) Ring main system

(*c*) Inter-connected system

Inter-connected system is preferred because of its better reliability.

D.C. Distribution. Though electric power is almost exclusively generated, transmitted and distributed as a.c. but for certain applications (*e.g.* for Electro-chemical works, for the operation of variable speed machinery d.c. motors etc.) is absolutely necessary. For this purpose, a.c. is converted into d.c. at the sub-station and is then distributed by (*i*) 2-wire system or (*ii*) 3-wire system.

(*i*) *Two-wire d.c. system*. It consists of two-wires one is outgoing (positive) conductor and the other is return (negative) conductor as shown in Fig. 10.24.

(*ii*) *Three-wire d.c. system*. It consists of three- wire, two outers (positive and negative outer) and a middle or neutral wire which is earthed at the sub-station. The voltage between any outer and neutral is V, whereas, voltage between the two outers is twice to this value *i.e.* $2V$. Thus two voltages are available to the consumers. The lamp loads (low voltage loads) are connected between any outer and neutral, whereas the motor loads (high voltage loads) are connected across the two outer as shown in Fig. 10.25. The current flowing through the neutral is very small (only unbalance current which will be zero when the load is balanced), therefore, generally area of cross-section or neutral is taken half as compared to either of the outer.

A.C. Distribution. The electric power (or energy) is invariably generated, transmitted and distributed in the form of alternating current. The main reason of adopting a.c. system for generation, transmission and distribution of electric power is that the alternating voltage can conveniently be changed to any desired value with the help of a transformer. It can be increased to economical value for transmission and can be decreased to a safe value for utilisation of electric power.

Generally, a.c. distribution system is classified as (*i*) primary distribution system and (*ii*) secondary distribution system.

1. *Primary distribution system*. The bulk consumers are supplied generally at high voltage (11 kV) and

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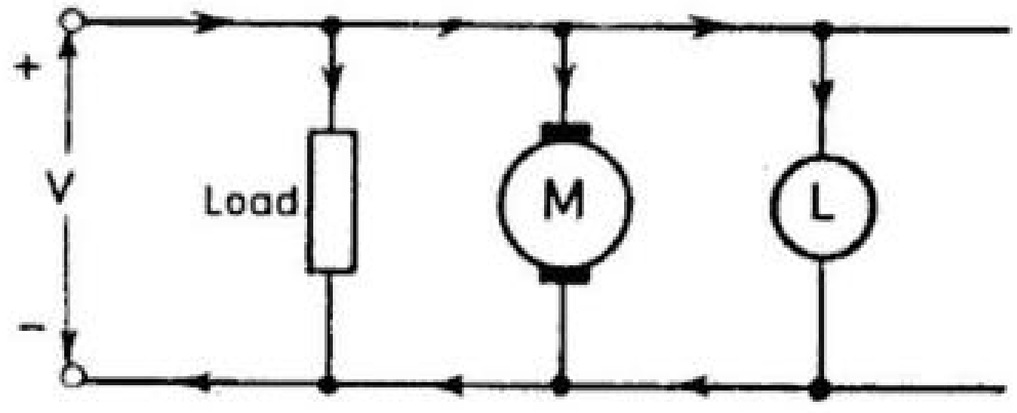


Fig. 10.24

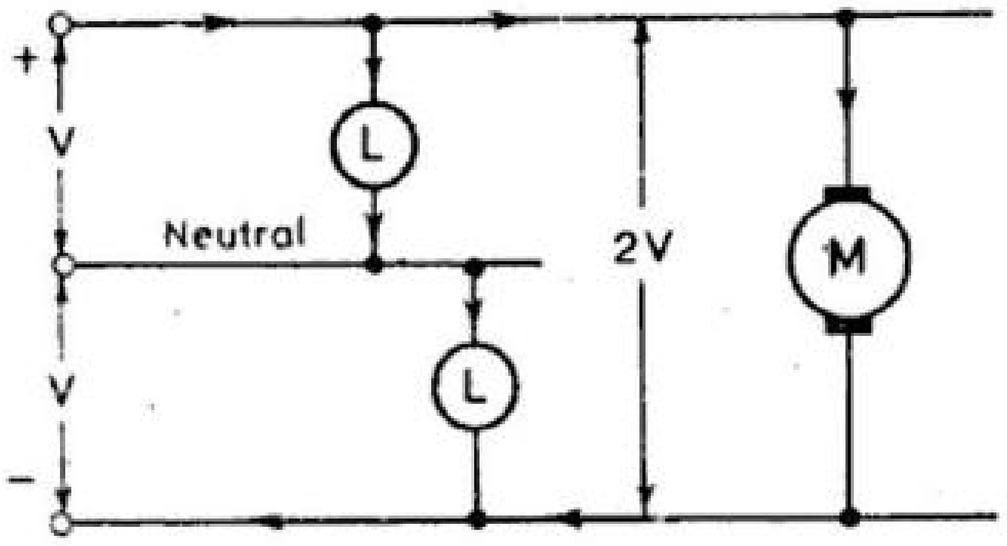


Fig. 10.25

the system by which they are supplied is called *primary distribution system*. However, the distribution voltage may also be 6.6 kV or 3.3 kV which depends upon the amount of power to be conveyed by the distributor and its length (distance from sub-station). The consumers install their own transformer to step-down the voltage for utilisation of electric power. The primary distribution is carried out by 3-phase, 3-wire system due to economic distributions.

2. *Secondary distribution system.* The small consumers are supplied at low voltage (400/230 V) and the system by which they are supplied is called secondary distributed system. The secondary distribution employs 400/230 V, 3 phase, 4-wire system, where 400 V is the line voltage and 230 V is the phase voltage.

10.26. Connection Schemes of Distribution System.

The following connection schemes of distribution system are generally employed.

1. **Radial System.** In radial system, separate feeders radiate from a single sub-station and feed the distributors at one end only. A single line diagram of a radial system for d.c. and a.c. distribution is shown in Figs. 10.26(*a*) and (*b*) respectively. Here sub-station (*S*) supplies power to a distributor (*AB*) at end (*A*) through feeder (*SC*). This system is only employed when power is generated at low voltage and the suostation is located at the centre of the load.

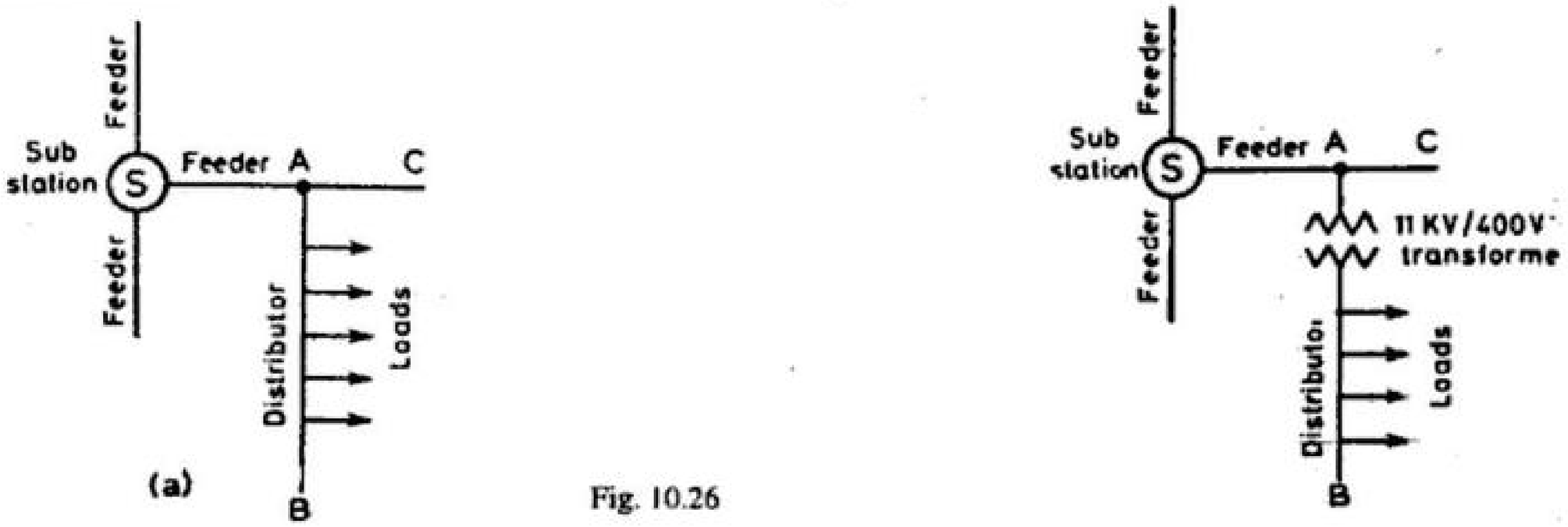


Fig. 10.26

Advantages. (*i*) Its initial cost is minimum. (*ii*) It is the simplest distribution system.

Disadvantages. (*i*) The end of the distribution nearest to the feeding end would be heavily loaded.

(*ii*) The consumers are dependent on single feeder and distribution. Therefore, when fault occurs on the feeder or distributor, the supply is cut off to all the consumers who are on the side of the fault away from the sub-station.

(*iii*) The consumers at the far end (*B*) of the distributor would be subjected to serious voltage fluctuations because of the changing load on the distributor. Due to the above limitations this system is used for short distances only.

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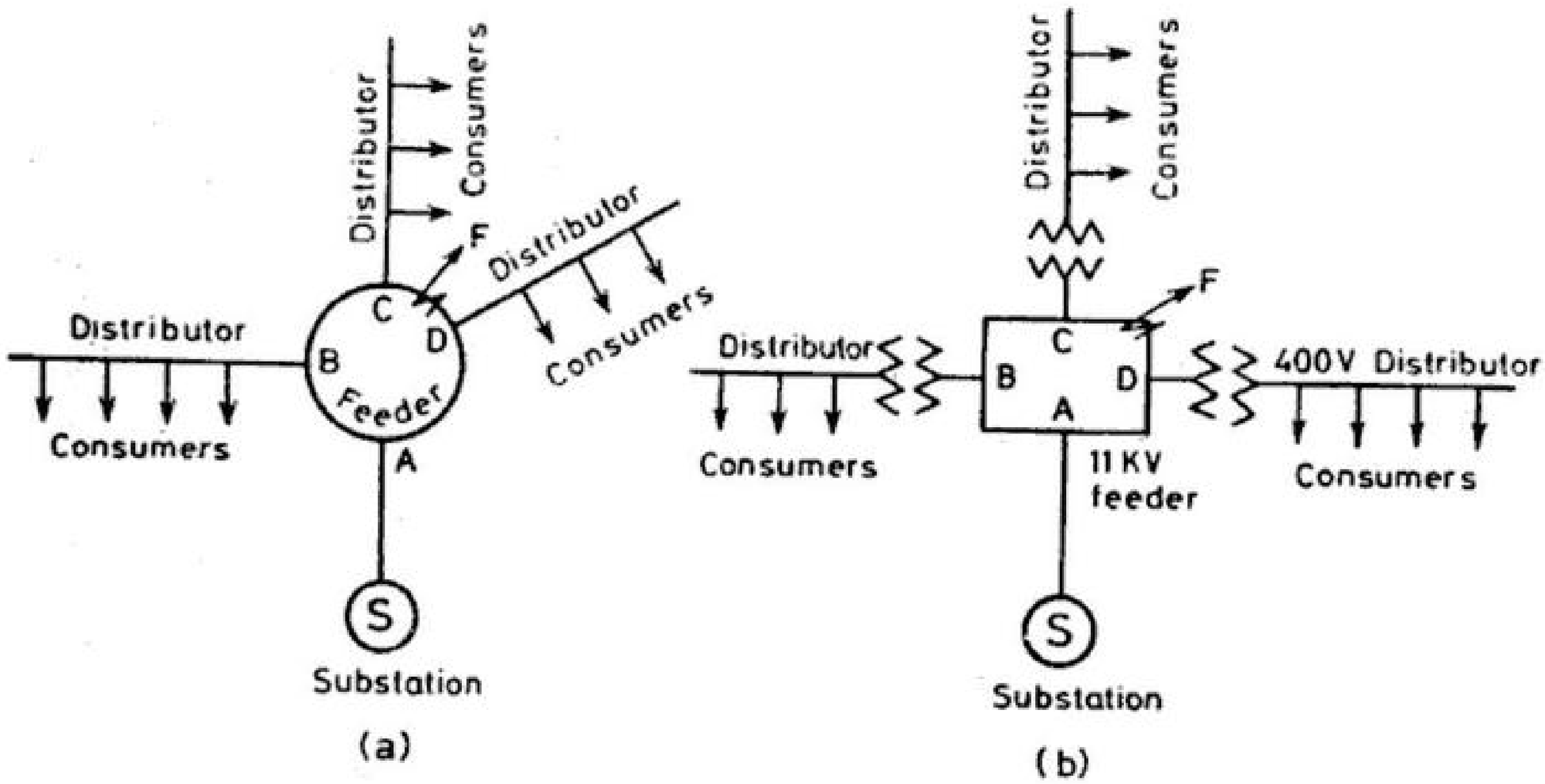


Fig. 10.27

2. **Ring main System.** In this system, the feeder closes on itself *i.e.* it forms a complete ring and hence the name ring main system. Figs. 10.27(*a*) and (*b*) show respectively d.c. and a.c. ring main system, where (*ABCDA*) is the closed feeder supplied by the sub-station *S* at point, *A*. The various distributors are connected to points *B*, *C* and *D* of the feeder as shown.

Advantages. (*i*) Each distributor is supplied (*via*) two feeders, for example the distributor connected at point *C* is fed (*via*) feeder *ABC* and *ADC*. This reduces the voltage fluctuations at the consumers' terminals to some extent.

(*ii*) The system is more reliable since each distributors is fed (*via*) two feeders. In the event of fault on any section of feeder, the continuity of supply can be maintained. For instant, suppose fault occurs at any point *F* of section *CD* of the feeder. Then section *CD* for the feeder can be isolated for repairs and at the same time continuity of supply is maintained to all the consumers.

3. Interconnected system. In this system, the feeder ring is energized by two or more than two generating stations or sub- stations. Figs. 10.28 (*a*) and (*b*) show the single line diagram of d.c. and a.c. interconnected system respectively, where the closed feeder ring *ABCA* is supplied by two generating or sub-stations S_1 and S_2 at points *X* and *Y* respectively. Distributors are connected to the feeder at point *A*, *B* and *C*.

Advantages. (*i*) It increases the reliability of supply. (*ii*) During overload hours, the area fed from one generating station can be fed from other generating station. Thus it reduces the reserved plant capacity, improves the service reliability and increases the load factor and efficiency of the system.

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37. For self excitation of induction generator, it is desirable economically to connect capacitors in
   A. star connection
   B. delta connection
   C. both star and delta
   D. None of these

38. Which of the following materials is used as a moderator:
   A. Graphite
   B. Boron
   C. Sodium potassium liquid
   D. Plutonium

39. The capital cost per MW is highest in case of
   A. Steam power plants
   B. Nuclear power plants
   C. Gas turbine power plants
   D. Diesel engine power plants

40. A diesel power plant is best suited as
   A. base load plant
   B. stand by plant
   C. general purpose plant
   D. Any of the above

41. Which of the following place is not associated with nuclear power plants in India?
   A. Tarapur B. Bangalore
   C. Kota D. Narora

42. Which of the following plant has least running cost per kWh?
   A. Diesel power plant
   B. Nuclear power plant
   C. Thermal power plant
   D. Hydro-electric plant

43. Which of following installation at consumer premises usually provides peak load?
   A. Air conditioner
   B. Arc furnace
   C. Cold storage compressor
   D. Air blower running continuously

44 The cost of fuel transportation is minimum in
   A. thermal plant B. nuclear plant
   C. hydroelectric plant D. diesel plant

45. The cheapest plant in operation and maintenance is
   A. thermal power B. hydro-power
   C. nuclear power D. diesel power

46. Economisers are used to heat
   A. air B. steam
   C. feed water D. None of these

47. India's first nuclear power plant was built at
   A. Rana Pratap Sagar B. Trombay
   C. Tarapur D. Kalpakkam

48. The first nuclear power plant was commissioned in
   A. USA B. USSR
   C. India D. France

49. The overall thermal efficiency of a thermal power plant lies in the range
   A. 25% to 30% B. 35% to 40%
   C. 45% to 60% D. 65% to 80%

50. Tidal power could not be harnessed in the past as
   A. it could not be utilised at the proper position of the load curve
   B. lack of technological development
   C. it depends upon the seasonal changes
   D. None of these

51. Of all the plants, the minimum quantity of fuel is required in
   A. hydro plants
   B. nuclear power plants
   C. thermal power plant
   D. None of these

Answers : 37. (B), 38. (A), 39. (B), 40. (B), 41. (B), 42. (D), 43. (B), 44. (C), 45. (B), 46. (C), 47. (C), 48. (B), 49. (A), 50. (B), 51. (B).

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52. Water is supplied to a boiler at
   A. atmospheric pressure
   B. more than the steam pressure in the boiler
   C. at 120 kg/cm^2
   D. None of these

53. For low head and high discharge, the hydraulic turbine used is
   A. Francis turbine
   B. Kaplan turbine
   C. Pelton wheel
   D. None of these

54. Run away speed of a pelton wheel is
   A. full load speed
   B. actual speed operating at no load
   C. no load speed when governor mechanism fails
   D. 80% greater than the normal speed

55. The suitable turbine used for harnessing tidal power is
   A. Francis turbine B. Pelton turbine
   C. Kaplan turbine D. None of these

56. A Kaplan turbine is
   A. inward flow, impulse turbine
   B. outward flow, reaction turbine
   C. a high head mixed flow turbine
   D. low head axial flow turbine

57. Economisers are normally used when boiler pressure exceeds
   A. 70 kg/cm^2 B. 50 kg/cm^2
   C. 30 kg/cm^2 D. for all pressures

58. In power plants, the condenser normally used is
   A. Surface type
   B. Jet type
   C. Both surface and jet type
   D. Regenerative type

59. The fertile material is
   A. U_{235} B. U_{233}
   C. Plutonium D. U_{238}

60. The fissile material is
   A. U_{232} B. Thorium
   C. Plutonium D. None of these

61. The nuclear reactor starts generation when
   A. the material to be converted should be placed around the core
   B. the core should be placed around the fertile material
   C. the material to be converted should be intermixed with core
   D. None of these

62. If natural uranium is used as the fuel, the moderator to be used is
   A. Ordinary water
   B. Graphite
   C. Born
   D. None of these

63. The moderator used in fast breeder reactor is
   A. heavy water B. graphite
   C. ordinary water D. Any of the above

64. The enriched Uranium consists of approximately
   A. 10% of U_{235} and 90% of U_{238}
   B. 20% of U_{235} and 80% of U_{238}
   C. 30% of U_{235} and 70% of U_{238}
   D. None of these

65. Which of the following generating stations has minimum running cost while in operation?
   A. Thermal power station
   B. Nuclear power station
   C. Hydro power station
   D. None of these

66. Which of the following methods of generating electric power from sea water is more advantageous?

Answers : 52. (B), 53. (B), 54. (C), 55. (C), 56. (D), 57. (A), 58. (A), 59. (D), 60. (C), 61. (A), 62. (D), 63. (D), 64. (A), 65. (C).

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A. Wave power B. Ocean currents
C. Tidal power D. None of these

67. In India, the first tidal power plant is likely to come up in
A. Bay of Bengal B. Korba
C. Singrauli D. Gulf of Kutch

68. Nuclear Reactor generally employs
A. Fusion
B. Fission
C. Both fusion and fission
D. None of these

69. In water turbines, the run away speed of Pelton turbine is
A. 1.8 times the rated speed
B. 2 to 2.2 times the rated speed
C. 2.5 to 2.8 times the rated speed
D. 3 to 4 times the rated speed

70. For a thermal power plant, which is not the fixed cost?
A. Interest on capital B. Depreciation
C. Cost of fuel D. All of these

71. A diesel power plant is best suited for
A. base load plant
B. peak load plant
C. general purpose plant
D. None of these.

72. A gas turbine power plant usually suits for
A. peak load operation
B. base load operation
C. permanent operation
D. None of these.

73. Which power plant cannot have single unit of 100 MW ?
A. Steam power plant
B. Nuclear power plant
C. Hydro electric power plant
D. Diesel power plant

74. Diesel engine power plants usually run on
A. High speed diesel oil
B. Kerosene
C. Light diesel oil
D. None of these.

75. Which of the following can be used as fuel for closed cycle gas turbine plant?
A. Wood B. Furnace oil
C. Any gas D. Any of these.

76. The useful life of a diesel engine in a power plant is expected to be
A. one year B. five years
C. fifteen years D. fifty years.

77. Which of the following plant is expected to have the longest expected life?
A. Hydroelectric plant
B. Steam plant
C. Diesel plant
D. None of these.

78. Anything having heat value can be used as fuel in case of
A. diesel engines
B. petrol engine
C. closed cycle turbines
D. None of these.

79. Hydrogen is used for cooling of large size generators. because
A. it has high thermal conductivity
B. it is light
C. if offers reduced fire risk
D. All of these.

80. Tidal power plant is being installed in India near
A. Gulf of Cambay B. Cochin
C. Vishakhapatnam D. None of these.

81. A nuclear power plant is invariably used as a
A. base load plant

Answers : 66. (C), 67. (D), 68. (B), 69. (A), 70. (C), 71. (B), 72. (A), 73. (D), 74. (C), 75. (D), 76. (C), 77. (A), 78. (C), 79. (D), 80. (A).

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B. peak load plant
C. stand-by plant
D. spinning reserve plant.

82. Air will not be the working substance in a
A. Diesel engine
B. Petrol engine
C. Open cycle gas turbine
D. Closed cycle gas turbine.

83. Major share of power produced in India is through
A. Thermal power plants
B. Hydro electric power plants
C. Nuclear power plants
D. Diesel power plants.

84. Which of the following place is not associated with nuclear power plants in India?
A. Delhi B. Tarapur
C. Kota D. Narora

85. Which of the following plants is almost inevitable used as base load plant?
A. Gas turbine plant
B. Diesel engine plant
C. Pumped storage plant
D. Nuclear power plant

86. A thermal power station was designed to burn coal containing 12% ash. When the plant actually started operating, coal having 22% ash was made available. Which unit of the plant will need major modifications?
A. Water treatment plant
B. Pulverising unit
C. Ash handling unit
D. Cooling towers.

87. Efficiency is secondary consideration in case of
A. peak load plants
B. base load plants
C. both peak load and base load plants
D. None of these.

88. Which of the following plants will take least time in starting from cold conditions to full load operation?
A. Nuclear power plant
B. Steam power plants
C. Hydro-electric plants
D. Gas turbine plant.

89. During load shedding
A. system voltage is reduced
B. system frequency is reduced
C. some loads are switched off
D. system power factor is changed.

90. For the same plant size, initial cost of which plant is the highest?
A. Steam power plant
B. Diesel engine plant
C. Nuclear power plant
D. Gas turbine plant.

91. In a steam power plant which component needs maximum maintenance
A. Condenser
B. Boiler
C. Turbine
D. Water treatment plant

92. The input-output equation of a 0.5 MW power house is given by $I = 30 + 0.8\,L + 0.5\,L^2$, where I is in millions of kcal per hour and L is in megawatts

The input when the plant was running at no load will be:
A. 0.5 kcal/hr B. 21.3 kcal/hr
C. 30×10^6 kcal/hr. D. zero.

93. Total input when the plant was generating 35 MW will be
A. 181×10^6 kcal/hr
B. 250×10^6 kcal/hr

Answers : 81. (B), 82. (D), 83. (A), 84. (A), 85. (D), 86. (C), 87. (A), 88. (D), 89. (C), 90. (C), 91. (B), 92. (C).

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C. equal to the sending end

D. None of these.

214. The voltage of a generator and an infinite bus are given as $0.92\angle 10^\circ$ and $1.0\angle 0^\circ$ respectively. The generator acts as a

A. shunt coil

B. shunt capacitor

C. The data is insufficient to find

D. None of these.

215. For a synchronous phase modifier, the load angle is

A. 0° B. 25°

C. 30° D. None of these

216. The charging reactance of 50 km length of line is 1500 ohms, the charging reactance for 100 km, length of line will be

A. 1500 ohms B. 3000 ohms

C. 750 ohms D. 600 ohms.

217. Phase modifier normally installed in the case of

A. Short transmission line

B. Medium length line

C. Long length lines

D. For all length lines.

218. Ferranti effect on long overhead lines is experienced when it is

A. lightly loaded

B. on full load at u.p.f.

C. on full load at 0.8 p.f. lag

D. In all these cases.

219. If the supply frequency increases, the skin effect is

A. decreased B. increased

C. remains same D. None of these

220. An overhead transmission line has appreciable inductance because the loop it forms has

A. large cross-sectional area

B. small cross-sectional area

C. zero cross-sectional area

D. None of these

221. The skin effect does not depend on

A. A nature of material

B. Size of wire

C. Supply frequency

D. Ambient temperature.

222. If the conductor diameter decreases, inductance of the line

A. decreases B. increases

C. remains same D. None of these

223. If the capacitance between two conductors of a three-phase line is 4μF, then the capacitance of each conductor to neutral is

A. 4 μF B. 8 μF

C. 12 μF D. 16 μF

224. If the length of the transmission line is increased, its capacitance

A. increases B. decreases

C. remains same D. None of these

225. For the overhead transmission lines, the self GMD method is used to evaluate

A. inductance

B. capacitance

C. inductance and capacitance

D. None of these

226. The a.c. resistance of conductor is more than d.c. resistance due to

A. Proximity effect

B. Sking effect

C. Both (A) and (B) are correct

D. None of these

227. If the length of the transmitting tower decreased, the inductance of the line will

A. increase

B. decrease

C. remain same

D. None of these

Answers : 213. (C), 214. (A), 215. (A), 216. (C), 217. (C), 218. (A), 219. (B), 220. (A), 221. (D), 222. (B), 223. (B), 224. (A), 225. (A), 226. (C), 227. (C).

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228. The skin effect of the conductor increases the effective value of
   A. resistance of the conductor
   B. reactance of the conductor
   C. capacitance of the conductor
   D. None of these

229. If the capacitance between two conductors of a 3-phase line is 6 μF, the capacitance of each conductor to neutral will be
   A. 3 μF B. 12 μF
   C. 6 μF D. 1.5 μF.

230. The power loss in an overload transmission line is mainly due
   A. impedance of the line conductor
   B. resistance of each conductor
   C. inductance of each conductor
   D. capacitance of each conductor

231. The economic size of conductor is determined by
   A. A Kirchhoff's Law B. Ohm's Law
   C. Kelvin's Law D. Faraday's Law

232. The economic transmission voltage is one for which
   A. The current is restricted to a particular value
   B. The cost of transmission is minimum
   C. The total cost of conductor material is minimum
   D. The height of towers is minimum

233. There is no skin effect in d.c. transmission lines
   A. True B. False

234. The capacitance of the transmission line will be affected if distance between conductors and earth is varied
   A. True B. False

235. String Chart is useful in
   A. finding the sag in the conductor
   B. in the design of Tower
   C. in the design of insulator string
   D. finding the distance between tower.

236. The presence of earth wire in case of overhead lines
   A. increases the capacitance
   B. increases the inductance
   C. decreases the capacitance
   D. decreases the inductance.

237. For an exciting a.c. transmission line, the string efficiency is 80%. Now if d.c. voltage is supplied for the same set up, the string efficiency will be
   A. 80% B. less than 80%
   C. more than 80% D. 100%

238. The sag of a power line with 100 m span is 1m, what will be the sag if the height of the line is increased by 20%
   A. 1.6m B. 1.5 m
   C. 2 m D. 2.5 m

239. If ACSR conductor has specification as 48/7, which of the following statement is correct for the conductor ?
   A. The conductor has 48 strands
   B. The conductor has 55 strands
   C. The conductor has 48 aluminium and 7 steel strands
   D. The conductor has 48 steel and 7 aluminium strands.

240. The potential across the various discs of suspension string is different because of
   A. series capacitance
   B. shunt capacitance
   C. series and shunt capacitance
   D. None of these

241. In a string of suspension insulators, maximum voltage appears across the unit
   A. nearest to the conductor
   B. nearest to the cross-arm

Answers : 228. (A), 229. (B), 230. (B), 231. (C), 232. (B), 233. (A), 234. (A), 235. (A), 236. (A), 237. (B), 238. (A), 239. (C),

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C. maximum voltage is independent of the location

D. None of these

242. The span of transmission line between towers takes the form of

A. Hyperbola B. Parabola

C. Catenary D. None of these

243. In a transmission line, sag depends only on

A. the tension in the conductor

B. height of the tower

C. conductor material

D. All of these

244. The purpose of guarding the transmission line is:

A. To reduce the earth capacitance of the lowest unit

B. To increase the earth capacitance of the lowest unit

C. To reduce the transmission losses

D. None of these

245. The string efficiency of an insulator can be increased by:

A. Increasing the number of strings in the insulator

B. Reducing the number of strings

C. Correct grading of insulators of various capacitances

D. None of these

246. If the shunt capacitance is reduced then the string efficiency is

A. increased

B. decreased

C. constant

D. independent of shunt capacitance.

247. If sag in an overhead line increases, tension in the line

A. increase B. decreases

C. remains same D. None of these

248. By using guard ring, string efficiency is

A. increased

B. decreased

C. constant

D. independent of shunt capacitance

249. Suspension type insulators are used for voltages beyond

A. 220 V B. 400 V

C. 11 kV D. 33 kV

250. The discs of the strain insulators are used in

A. Vertical plane only B. Horizontal plane

C. Both the planes D. None of these

251. The most commonly used material for insulators of overhead lines is

A. porcelain B. glass

C. mica D. PVC

252. What type of insulator will be used if the direction of the transmission line is to be changed ?

A. Pin-type B. Suspension type

C. Strain type D. Shakle type

253. Pin type insulators are used for transmission and distribution of electric power at voltage upto

A. 11 kV B. 33 kV

C. 66 kV D. 110 kV.

254. The type of insulator that can be used either in horizontal or vertical position

A. Pin-type B. Suspension type

C. Strain type D. Shakle type

255. Ferranti effect on transmission line means

A. rise in receiving end voltage on lagging load

B. rise in receiving end voltage on leading load

C. rise in receiving end voltage on no load

D. None of these

256. The value of the breakdown stress of atmospheric air is nearly

Answers : 242. (B), 243. (D), 244. (A), 245. (C), 246. (A), 247. (B), 248. (A), 249. (D), 250. (A), 251. (A), 252. (B), 253. (A), 254. (D), 255. (C).

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A. 0.3 kV/cm B. 3 kV/cm
C. 30 kV/cm D. 300 kV/cm

257. What is the main purpose of using bundled conductors for EHV lines ?
A. To get reduced reactance
B. To get reduced surge impedance
C. To get reduced voltage gradient
D. To get corona free operation

258. What will be the surge impedance of a 25 miles long underground cable, if its value for 50 miles long cable is 50 ohms ?
A. 25 ohms B. 50 ohms
C. 100 ohms D. None of these

259. For a given receiving-end voltage in a long transmission line, the sending-end voltage is more than the actual value when calculated by
A. Load end capacitance method
B. Nominal-T method
C. Nominal-π method
D. None of these

260. For a transmission line the constants A, B, C and D are related as
A. $AD - BC = 1$ B. $BC - AD = 1$
C. $\sqrt{AD - BC} = 0.5$ D. $\sqrt{AD - BC} = 1.2$.

261. Transposition of transmission lines is adopted to make
A. reactance uniform throughout the line
B. zero reactance at through out the line
C. capacitance inform throughout the line
D. None of these.

262. Skin effect is
A. proportional to frequency
B. proportional to square of frequency
C. inversely proportional to frequency
D. independent of frequency.

263. Conductor configuration determines
A. inductance B. sag
C. voltage D. current

264. Why are shunt reactors connected at the receiving end of long transmission line system ?
A. To increase terminal voltage
B. To compensate voltage rise caused by capacitive charging at light load
C. To improve power factor
D. None of these

265. The highest transmission voltage in India is
A. 400 kV B. 230 kV
C. 220 kV D. 132 kV

266. The most commonly used generation voltage in India is
A. 11 kV B. 6.6 kV
C. 2.2 kV D. 33 kV.

267. The voltage of the single phase supply to residential consumers is
A. 400 V B. 230 V
C. 220 V D. 110 V

268. Large industrial consumers are supplied electrical energy at
A. 400 V B. 66 kV
C. 11 kV D. 400 kV

269. Most of the high voltage transmission lines in India are
A. underground B. overhead
C. Both (A) and (B) are correct.
D. None of these

270. The distributors for residential areas are
A. single phase
B. three phase three wire
C. three phase four wire.
D. None of above.

271. The loads on distributors systems are generally
A. unbalanced
B. balanced
C. Either balanced or unbalanced
D. None of these

Answers : 256. (C), 257. (D), 258. (B), 259. (C), 260. (B), 261. (A), 262. (A), 263. (A), 264. (B), 265. (A), 266. (A), 267. (B), 268. (B), 269. (B), 270. (C), 271. (A).

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B. Three-phase, 3-wire *a.c.* system

C. Three-phase, 4-wire *a.c.* system

D. None of these.

305. The total connected load and the number of points on a lightning sub-circuit should not exceed.

A. 700 W and 8 points respectively

B. 800 W and 10 points respectively

C. 900 W and 10 points respectively

D. 1000 W and 10 points

306. The total connected load and the number of points on a power sub-circuit should not exceed

A. 2000 W and 2 points respectively

B. 3000 W and 3 points respectively

C. 4000 W and 3 points respectively

D. 4000 W and 3 points

307. The minimum permissible size of the aluminium cable for lightning circuits is

A. 1.2 sq. mm B. 1.5 sq. mm

C. 2.2 sq. mm D. 3.5 sq. mm

308. The minimum permissible size of the aluminium cable for power circuits is

A. 1.5 sq. mm B. 2.0 sq. mm

C. 2.5 sq. mm D. 3 sq. mm

309. A light controlled by two switches requires

A. single pole single throw switches

B. double pole single throw switches

C. single pole double throw switches

D. None of these.

310. The purpose of earthing electric appliances is

A. to provide safety against shock

B. to ensure that the appliance works properly

C. to ensure that the appliance gets full voltage

311. For a fuse wire of diameter d, the fusing current is proportional to

A. $\sqrt{d}$ B. $d^{1.2}$

C. $d^{1.5}$ D. None of these.

312. A lighting sub-circuit has 100-W lamps. If the rated current of the fuse in this circuit is 5A the maximum number of light points on this circuit without violating regulations and safety should be

A. 8 B. 10

C. 12 D. None of these.

313. The insulation resistance to earth of an installation should be about

A. 1 mega ohm B. 0.5 mega ohm

C. 0.2 mega ohm D. None of these.

314. The resistance of human body of about

A. 100 ohms B. 500 ohms

C. 1000 ohms D. 10 ohms

315. The earth continuity conductor is generally made of

A. copper B. aluminium

C. steel D. bronze

316. The minimum permissible size of the earth continuity conductor is

A. 6 sq. mm B. 8 sq. mm

C. 10 sq. mm D. 12 sq. mm

317. The length of earthing electrode is about

A. 0.5 m B. 1.0 m

C. 2.5 m D. 5 m

318. The resistance of the earth continuity conductor is about

A. 20 ohms B. 2 ohms

C. 5 ohms D. 50 ohms

319. A fuse is inserted in

A. phase wire

B. neutral wire

C. both the phase wire and the neutral wire

D. earth continuity conductor.

320. Which of the following will not contribute to low power factor ?

A. Partially loaded induction motors

Answers : 304. (C), 305. (B), 306. (A), 307. (B), 308. (C), 309. (C), 310. (A), 311. (C), 312. (A), 313. (A), 314. (C), 315. (C), 316. (A), 317. (C), 318. (B), 319. (A).

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C. Rs. 48,500 D. Rs. 31,400

346. The life of underground cables is taken as

A. 10 year B. 20 years

C. 25 years D. 40 years

347. For the hydro-electric plant, the life of a RCC dam is taken as

A. 5 years B. 10 years

C. 40 years D. 100 years.

348. A 500 kW plant costs Rs. 1000 per kW installed. Fixed charges are estimated at 14% and operating cost is 13 paise per kWh. The plant averages 200 kW for 5000 hours of the year, 450 kW for 1200 hrs and 80 kW for the remaining period. The average cost production of electricity per kWh will be nearly

A. 5 paise B. 12 paise

C. 17 paise D. 27 paise

349. Two tariffs are offered

(I) Rs. 200 plus 5 paise per unit

(II) A flat rate of 30 paise per unit

From the above it can be concluded that

A. Tariff I will give lower charges upto 800 kWh.

B. Tariff I will given lower charges for consumrtion of more than 800 kWh

C. Tariff II will give lower charges for consumption of more than 800 kWh

D. Both will give identical charges beyond 1500 kWh.

350. For a power plant the expenditure on which of the following item is expected to be negligible?

A. Wages B. Taxes

C. Insurance D. Publicity

351. A 120-MW generator is usually

A. air cooled B. hydrogen cooled

C. oxygen cooled D. nitrogen cooled.

352. Maximum span in case of wooden poles is usually restricted to

A. 50 m. B. 175 m.

C. 100 m. D. 200 m.

353. A consumer takes a steady load of 200 kW at a power factor of 0.85 lagging for 8 hours per day and 315 days per annum. The annual payment under the tariff of Rs. 80 per annum per kVA plus 10 paise per kWh will be

A. Rs. 5040 B. Rs. 50,400

C. Rs. 69,200 D. Rs. 84,400

354. The average charge per kWh when the load factor is 20% will be

A. 3 paise B. 5 paise

C. 7 paise

D. cannot be determined on the basis of the information provided.

355. The average charges per kWh for the above question will be least when the plant load factor is

A. 100% B. 75%

C. 50% D. 20%

356. Which statement about the daily load curve is valid ?

A. The area under the curve gives the average demand

B. The ratio of the area under the curves to the total area of rectangle in which it is contained gives the load factor for the day

C. The peak of the curve gives the installed capacity of the plant.

D. The area of the curves divided by the number of hours gives load factor.

357. An equipment purchased for Rs. 10,000 two years ago has a market value of Rs. 13,000 at present. It can be concluded that

A. the value has depreciated according to straight line method

B. the value has depreciated according to diminishing value method

C. the value has depreciated according to sinking fund method

D. the value has appreciated with the time.

Answers : 346. (D), 347. (D), 348. (C), 349. (B), 350. (D), 351. (B), 352. (A), 353. (C), 354. (C), 355. (A), 356. (D), 357. (D).

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358. A certain plant has fixed cost of Rs. 40,000 and a salvage value of Rs. 4000 at the end of a useful life of 20 years. The depreciated value of the plant at the end of 10 years will be least when calculated by

A. Straight line Method

B. Sinking fund Method

C. Diminishing value Method

D. None of these.

359. In the above problem, its value will be highest when calculated by (interest being 6% compounded annually)

A. Straight line Method

B. Sinking fund Method

C. Diminishing value Method

D. None of these.

360. Low power factor is usually not due to

A. incandescent lamp B. induction motors

C. arc lamps D. fluorescent tubes

361. In a synchronous machine, in case the axis of field flux is in line with the armature flux, then

A. the machine is working as synchronous motor

B. the machine is working as synchronous generator

C. the machine is floating

D. the machine will not work.

362. The resistance of the dry skin of human body, between the tip of the left hand finger and right hand finger, is of the order of

A. 100 ohms B. 200 ohms

C. 10 K D. 100 K

363. If the resistance of dry skin of human body is 100 K, the resistance of the wet body will be

A. 100 K B. 200 K

C. 5000 K D. 5000 ohms

364. The effect of electric shock on human, body depends on

A. voltage B. current

C. duration of contact D. All of these

365. A current of 10 milliamperes through human body will

A. cause mild sensation

B. affect muscle control

C. affect breathing

D. cause death

366. Death is almost certain when the current through human body is

A. 10 mA B. 20 mA

C. 40 mA D. 100 mA

367. For extinguishing electrical fires

A. Water should be used

B. Carbon dioxide fire extinguisher should be used

C. Foam type fire extinguisher should be used

D. Carbon tetrachloride fire extinguisher should be used.

368. First aid for electric shock victim is

A. bandage

B. cover with blanket

C. pouring water on body

D. artificial respiration

369. HRC fuses provide best protection against

A. short circuits B. lightening

C. sparking D. fire

370. Sparking occurs when a load is switched off because the circuit has high

A. inductance B. resistance

C. capacitance D. magnetism

371. Zero sequence component always flows through

A. phase wires B. neutral wire

C. earth wire D. any of the above.

372. Domestic supply of 220 V, 50 Hz signifies that peak value of voltage waveform is

A. 220 V B. 155 V

C. 185 V D. 310 V

Answers : 358. (C), 359. (B), 360. (A), 361. (C), 362. (D), 363. (D), 364. (D), 365. (A), 366. (D), 367. (D), 368. (D), 369. (A), 370. (A), 371. (B), 372. (D).

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373. The safest value of current which the human body can sustain for more than 3 seconds is

A. 1 A B. 0.5 A

C. 100 mA D. 9 mA.

374. Which lightening stroke is most dangerous ?

A. Direct stroke on tower top

B. Direct stroke on ground wire

C. Direct stroke on line conductor

D. Indirect stroke on conductor

375. Which of the following is the protective device against lightening over voltages ?

A. Rod gaps B. Surge absorbers

C. Horn gaps D. All of these.

376. A coaxial line is filled with a dielectric of relative permittivity 9. If V denotes the velocity of propagation in free space, the velocity of propagation in the line will be

A. $3V$ B. V

C. $V/3$ D. $V/9$

377. When a power plant is not able to meet the demand of consumers it will resort to

A. penalishing high load consumers by increasing the charges for electricity

B. power factor improvement at the generators

C. efficient plant operation

D. load shedding.

378. Load shedding is possible through

A. voltage reduction

B. frequency reduction

C. switching off the loads

D. Any of these

379. In case of inter-connected system for stable operation the passive element that can be used as interconnecting element is

A. capacitor

B. reactor

C. resistor D. Any of these.

380. Area under the daily load curve divided by 24 gives

A. average load

B. maximum demand

C. units generated D. None of these.

381. The knowledge of diversity factor helps in determining

A. average load B. units generated

C. plant capacity D. None of these.

382. Annual load factor is determined from the load curve based on

A. daily B. weekly

C. monthly D. annually.

383. The connected load of a consumer is 2 kW and his maximum demand is 1.5 kW. The load factor of the consumer is

A. 0.75 B. 0.375

C. 1.33 D. None of these.

384. The maximum demand of a consumer is 2 kW and his daily energy consumption is 20 units. Its load factor is

A. 10.15 B. 41.6%

C. 50% D. 60%.

385. In order to have lower cost of electrical generation

A. the load factor and diversity factor should be high

B. the load factor should be low but diversity factor high

C. the load factor should be high but diversity factor low.

D. the load factor and diversity factor should be low.

386. It is always economical to improve the p.f. of an installation to

A. zero

B. unity

C. a little less than unity

D. a little more than unity.

Answers : 373. (D), 374. (C), 375. (D), 376. (C), 377. (D), 378. (D), 379. (B), 380. (A), 381. (C), 382. (D), 383. (D), 384. (B), 385. (A), 386. (C).

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387. Which method of raising depreciation fund gives heavier changes in the initial years of plant life.
   A. Straight line method
   B. Sinking fund method
   C. Both A and B are correct
   D. None of these.

388. Power plant having maximum demand more than installed capacity will have utilisation factor
   A. less than 100% B. equal to 100%
   C. more than 100% D. None of these.

389. The annual cost characteristics of two plants are given as
   $C_1 = 5\ kW_1 + 0.02\ kWhr.$
   and $C_2 = 7\ kW_2 + 0.015\ kWhr.$
   Which plant can be selected for base load operation?
   A. Plant 1
   B. Plant 2
   C. Any of the two plants
   D. None of these.

390. The choice of number and size of units in a station is governed by best compromise between
   A. A plant load factor and plant capacity factor
   B. Plant capacity factor and plant use factor
   C. Plant load factor and plant use factor
   D. None of these.

391. If a plant has zero reserve capacity, the plant load factor always
   A. equals plant capacity factor
   B. is greater than plant capacity factor
   C. is less than plant capacity factor
   D. None of these.

392. If some reserve capacity is available in a power plant
   A. Its use factor is always greater than its capacity factor
   B. Its use factor equals the capacity factor
   C. Its use factor is always less than its capacity factor
   D. None of these.

393. Diversity factor has direct effect on the
   A. Fixed cost of unit generated
   B. Variable cost of unit generated
   C. Both fixed and variable costs of unit generated
   D. None of these.

394. More efficient plants are used as
   A. base load stations
   B. peak load stations
   C. both (A) and (B) correct
   D. None of these.

395. In an interconnected grid system, the diversity factor of the whole system.
   A. decreases B. increases
   C. remains same D. None of these.

396. The value of demand factor is
   A. less than one B. greater than one
   C. equal to one D. None of these.

397. The value of diversity factor is
   A. less than one B. more than one
   C. equal to one D. None of these.

398. A diesel power plant is generally used as
   A. base load station B. peak load station
   C. both A and B D. None of these.

399. In India, the system adopted for transmission of electric power has
   A. Three-phase three wire system
   B. Three-phase four wire system
   C. Both (A) and (B) are correct
   D. None of these.

Answers : 387. (A), 388. (C), 389. (B), 390. (B), 391. (A), 392. (A), 393. (A), 394. (A), 395. (B), 396. (A), 397. (B), 398. (B), 399. (A).

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CHAPTER 11

POWER SYSTEM-II (PROTECTION, STABILITY AND HIGH VOLTAGE)

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Chapter 11

POWER SYSTEM - II (PROTECTION, STABILITY AND HIGH VOLTAGE)

11.1 Fault Calculations

(*a*) Procedure of fault calculation is as follows:

(*i*) Draw a single line diagram of the system in which the machines and system components are represented by their symbols.

(*ii*) Draw the reactance diagram of the system.

(*iii*) For symmetrical faults, only positive sequence network is taken.

(*iv*) For unsymmetrical faults, method of symmetrical components is applied in which three sequence networks are drawn.

(*b*) The per unit system is used for fault calculations. The per unit reactance of machines given are referred to their ratings as their bases. The *kV, I, Z, kVA* are expressed as per unit or percentage of their selected bases; only two bases, (usually kV and kVA) are selected first than the remaining two bases are calculated.

Per unit impedance of electrical equipment is $\varepsilon_z = IZ/V$ p.u.

(*c*) The p.u. impedance is also given by the following expression:

$$\text{Base } Z = \frac{[\text{ Base kV }]^2}{[\text{ Base kVA }]} \times 1000$$

$$\text{p.u. } Z = \frac{\text{Ohmic } Z}{\text{Base } Z} = \frac{Z \,.\, [\text{ Base kVA }]}{[\text{ Base kV }]^2 \times 1000}$$

$$\% Z = \frac{Z \,.\, [\text{ Base kVA }]}{10\ [\text{ Base kV }]^2}$$

$$\text{Change of Base:} \quad \text{p.u. } Z_{old} = \text{p.u. } Z_{old} \times \left[\frac{\text{kVA Base New}}{\text{kVA Base Old}}\right] \times \left[\frac{\text{kV Base Old}}{\text{kV Base New}}\right]^2$$

Percentage Impedance = 100 p.u. impedance

(*d*) When all the reactance have been referred to the same base kVA, then total impedance or reactance upto the fault point is calculated. This may involve solution of series parallel circuits or star/delta conversion or vice-versa.

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(*e*) Short circuit kVA $= \left[\frac{100}{\%\, Z} \times \text{Base kVA} \right]$

Short circuit current (r.m.s.) $= \frac{\text{Short circuit kVA}}{\sqrt{3} \times \text{kV (line)}}$. amp

11.2. Terms Related to Fault Calculations

(*i*) **Percentage Reactance**. It is defined as % Reactance $= \frac{\text{Reactance} \times [\text{kVA}]}{10\,[\text{kV}]^2}$

(*ii*) **Percentage reactance at base kVA.** Since different plants in any system have different kVA ratings, it is necessary to convert all reactance to a common kVA rating base.

$$\%\ \text{Reactance at base kVA} = \frac{\text{Base kVA}}{\text{Plant kVA}} \times \text{reactnace at plant kVA}$$

11.3. Reactances of Synchronous Machines

An example of a three phase symmetrical fault is a sudden short at the terminal of a synchronous generator. The symmetrical trace of a short-circuit stator-current wave is shown in Fig. 11.1. The name whose envelope is shown may be divided into three periods. The subtransient period, lasting for the first few cycles, during which the current decrement is very rapid; the transient period, covering a relatively longer period during which the current decrement is more moderate; and finally the strady-state period. The currents during these three periods are limited by various reactances of the synchronous machine. These currents and reactances are defined here, provided the alternator was operating at no load before the occurrence of a three phase fault at its terminals.

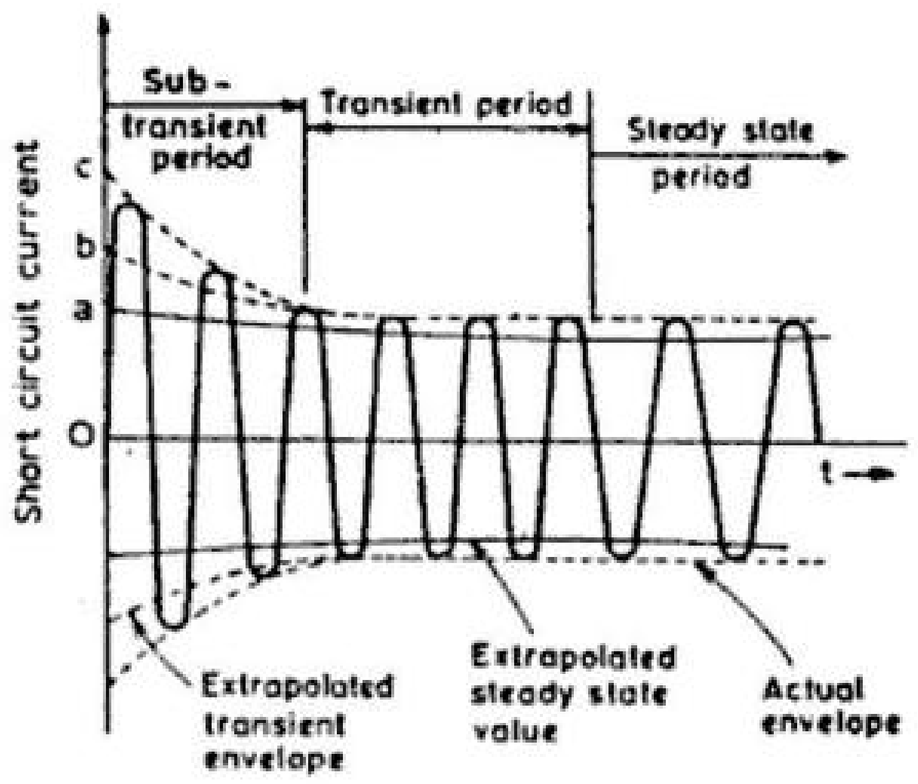


Fig. 11.1

For an alternator operating at no load before the fault occurs the, voltage of the alternator $|E_g|$ divided by the *steady state current* $|I|$ (r.m.s. value) is known as the (*d*-axis) *synchronous reactance* X_d (since the power factor during short circuit is low).

If the envelope of the short circuit current is extended back to zero time and the first few cycles (where the decrement is very rapid) are neglected, the *transient current* (r.m.s. value) is $|I'|$ the ratio $|E_g|/|I'|$ is known as the (*d*-axis) *transient reactance* X_d'. Similarly the r.m.s. value of the current determined by the intercept of the current envelope with zero time is called sub-transient current $|I''|$ and $|E_g|/|I''|$ is known as (*d* -axis) *sub-transient reactance* X_d''.

In analytical work steady state, transient and sub-transient currents are expressed as phasors usually with E_g as reference.

If the alternator is unloaded when the fault occurs, the machine is represented by the no-load voltage to neutral in series with proper reactance. (Resistance also may be taken into account for greater accuracy.)

Asymmetrical Short Circuit Currents. It is well known that if the short circuit of an alternator occurs at an instant at which the voltage is zero there is a doubling effect and the current wave is off-set from zero. In general the short circuit current contains a d.c. component.

The asymmetrical current reaches its first peak at the end of first half cycle. The d.c. component in this

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11.10. Inertia Constant And Swing Equation

The angular momentum and inertia constant play an important role in determining the stability of a synchronous machine. The *per-unit constant H* is defined as the kinetic energy stored in the rotating parts of the machine *at synchronous speed* per unit megavolt ampere (MVA) rating of the machine.

$$H = \frac{\text{Stored energy in maga joules}}{\text{Rating in MVA}}$$

Thus, if G is the *MVA* rating of the machine, then $GH = \frac{1}{2} J \omega_s^2$ ...(1)

where J is the polar moment of inertia of all rotating parts in kilogram-m^2 and ω_s is the angular synchronous velocity in electrical radians per second. If M is the corresponding angular momentum, then

$$M = J \omega_s \qquad ...(2)$$

Since $\omega_s = 360 f$ electrical degrees per second, Eqns. (1) and (2) yield

$$GH = \frac{1}{2} M \omega_s = \frac{1}{2} M (360) f \text{ or } M = \frac{GH}{180 f} \text{ MJ. sec/electrical degree}$$

$$= \frac{GH}{\pi f} \text{ Megajoules. sec/radian}$$

where f is the frequency of rotation.

The Swing Equation

$$\frac{H}{180 f} \frac{d^2 \delta}{dt^2} = P_i - P_e = P_a \text{ per unit} \qquad ...(3)$$

The Swing Equation contains information regarding the machine dynamics and stability.

H CONSTANT ON A COMMON MVA BASE

An inertia constant H_{mach} based on a machine's own MVA rating may be converted to a value H_{syst} relative to the system base S_{syst} with the formula

$$H_{syst} = H_{mach} \cdot \frac{S_{mach}}{S_{syst}}$$

A convenient system base value is 100 MVA.

11.11. Critical Clearing Angle

If a disturbance or fault occurs in a system, δ begins to increase under the influence of positive accelerating power, and the system will become unstable if δ becomes very large. There is a critical angle which the fault must be cleared if the system is to remain stable and the equal-area criterion is to be satisfied. This angle in known as the *critical clearing angle* δ_0.

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QUESTION BANK IN PROTECTION, STABILITY AND HIGH VOLTAGE

1. When all the three phases are short circuited it gives rise to
   A. Asymmetrical fault currents
   B. Symmetrical fault current
   C. Zero current D. None of these.
2. What will happen if a short circuit occurs on the system?
   A. Very small current flows through the system
   B. Heavy current flows through the system
   C. No current flows through the system
   D. None of these.
3. The most common type of fault on the overhead transmission line is
   A. single line to ground fault
   B. double into to ground fault
   C. three-phase fault
   D. line to line fault
4. Which fault gives rise to symmetrical fault currents?
   A. Single line to ground fault
   B. Line to line fault
   C. Double line to ground fault
   D. Three phase fault.
5. A 1000 kVA transformer with 5% reactance will have a reactance of 10% at
   A. 1000 kVA base B. 2000 kVA base
   C. 3000 kVA base D. 4000 kVA base.
6. If the percentage reactance of the system upto the fault point is 20% and the base kVA is 10,000 then the short circuit kVA is
   A. 10 MVA. B. 20 MVA
   C. 50 MVA D. 60 MVA
7. Short circuit kVA is obtained by multiplying the base kVA by
   A. 10/% X B. 20/% X
   C. 50/% X D. 100/% X.
8. Reactors are used at various points in the power system to
   A. limit short circuit current
   B. increase short circuit current
   C. avoid short circuit
   D. None of these.
9. The use of reactors permits installation of circuit breakers of the
   A. lower rating B. higher rating
   C. same rating D. None of these.
10. The p.u impedance value of an alternator corresponding to base values of 13.2 kV and 30 MVA is 02 p.u. The p.u. value for the base values 13.8 kV and 50 MVA will be
    A. 0.106 p.u. B. 0.206 p.u.
    C. 0.306 p.u. D. 0.318 p.u.
11. Base impedance of the power system is given by
    A. $\frac{(\text{Base kV})^2 \times 1000}{\text{Base kVA}}$
    B. $\frac{(\text{Base kVA})^2 \times 10^3}{\text{Base kV}}$

Answers : 1. (B), 2. (B), 3. (A), 4. (D), 5. (B), 6. (C), 7. (D), 8. (A), 9. (A), 10. (C), 11. (A).

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C. $\frac{(\text{Base kVA})^2}{\text{Base kV}}$

D. None of these

12. If a 5 A fuse is blown frequently in a house lighting circuit, it is required to

A. insert a fuse of higher current rating

B. insert a fuse of higher voltage rating

C. check the load

D. None of these.

13. HRC fuse provide best protection against

A. open circuits B. short-circuits

C. over load D. reverse current

14. Ground wire is used to

A. give the support to the tower

B. to connect the circuit conductor or other device to an earth-plate

C. to avoid overloading

D. to give good regulation.

15. The size of the earth wire is determined by

A. the ampere capacity of the service wires

B. the atmospheric conditions

C. the voltage of the service wires

D. None of these.

16. The grounding is generally done at the

A. receiving end B. supply end

C. the middle of receiving and supply end

D. None of these.

17. The most common type of three phase in unsymmetrical fault is

A. single line to ground

B. line to line

C. double line to ground

D. three phase

18. In a balanced three phase system, negative and zero phase sequence currents are

A. equal B. zero

C. different D. None of these

19. The positive and negative sequence impedance of a transmission line are

A. equal B. zero

C. different D. None of these

20. The zero sequence impedance of different elements of power system is generally

A. equal B. zero

C. different C. None of these

21. On the occurrence of an unsymmetrical fault which sequence component is always more than the negative sequence component?

A. Zero sequence

B. Positive sequence

C. Both are correct

D. None of these.

22. The zero sequence impedance of an element in a power system is generally different from

A. positive sequence impedance

B. negative sequence impedance

C. both A and B are correct

D. None of these.

23. The operator 'a' rotates the vector in the anticlockwise direction by

A. 90° B. 120°

C. 180° D. None of these.

24. Which of the following equation is correct

A. $1 + a + a^2 = 0$ B. $a + a^2 = 1$

C. $1 + a^3 = 0$ D. None of these

25. Which of the following equation is correct

A. $a^2 = 0.5 + j\,0.866$

B. $a^2 = -0.5 + j\,0.866$

C. $a^2 = -0.5 - j\,0.866$

D. $a^2 = j\,0.866$

26. The positive sequence component of voltage at the point of fault is zero when it is a

A. three phase fault C. L-L-G fault

B. L-L fault D. L-G fault

Answers : 12. (C), 13. (B), 14. (B), 15. (A), 16. (B), 17. (A), 18. (B), 19. (A), 20. (C), 21. (B), 22. (C), 23. (B), 24. (A), 25. (C), 26. (A).

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27. The positive, negative and zero sequence impedances of a solidly grounded system under steady state condition always follow the relations

A. $Z_1 > Z_2 > Z_0$ B. $Z_1 < Z_2 < Z_0$

C. $Z_0 < Z_1 < Z_2$ D. None of these.

28. When a fault occurs on the system a circuit breaker

A. opens automatically

B. closes automatically

C. opens manually

D. None of these.

29. If the length of the arc of circuit breaker increases, its resistance

A. be extinguished B. decreases

C. remains same D. None of these.

30. If the dielectric strength of the medium between contacts builds up more rapidly than the restriking voltage, then the arc will

A. be extinguished

B. not be extinguished

C. increase

D. None of these.

31. Current chopping mainly occurs in

A. oil circuit breaker

B. air blast circuit breaker

C. vacuum circuit breaker

D. SF_6 circuit breaker.

32. Capacitive current breaking results in

A. short circuits B. open circuits

C. voltage surges D. None of these.

33. The speed of circuit interruption in Forced blast circuit breaker is

A. slow B. medium

C. fast D. None of these.

34. The property of contact materials, to limit current chopping in vacuum circuit breaker, should have

A. high vapour pressure and high conductivity

B. high vapour pressure and low conductivity

C. low vapour pressure and low conductivity

D. None of these.

35. For the interruption of high voltages and low current, the circuit breaker (CB) preferred is

A. Air blast CB. B. Oil CB

C. Vacuum CB D. All are correct.

36. A fault is more severe from the view point of RRRV if it is a

A. short length fault

B. medium length line fault

C. long length line fault

D. None of these.

37. The rate of rise of restriking voltage depends on

A. the type of circuit braker

B. the inductance of the system only

C. the capacitance of the system

D. the inductance and capacitance of the system only.

38. A three phase breaker is rated at 2000 MVA, 33 kV, its making current will be:

A. 35kA. B. 70 kA

C. 89 kA D. 160 kA

39. The normal practice to specify the making current of a circuit breaker in terms of

A. r.m.s value B. peak value

C. average value D. None of these.

40. Resistance switching is normally resorted in case of

A. Air blast CB B. Bulk oil CB

C. Minimum oil CB. D. All types of CBs.

41. If the inductance and capacitance of a system are 1.0 H and 0.01 μF and the instantaneous value of interrupted current is 10 amps, the voltage across the breaker contacts will be:

Answers : 27. (A), 28. (A), 29. (A), 30. (A), 31. (B), 32. (C), 33. (C), 34. (B), 35. (C), 36. (A), 37. (D), 38. (C), 39. (B), 40. (A).

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A. 50 kV B 100 kV
C 60 kV D. 57 kV.

42. The trip coil of a CB is connected through 40% transformers. If normal line current is 100 amp. and circuit breaker opens at 120% normal line current, the trip mechanism should be set to operate when the trip current is
A. 2 amps. B. 2.5 amps.
C. 3 amps. D. 5 amps.

43. For remote operation, CB must be equipped with a
A. time delay trip B. shunt trip
C inverse time trip D. None of these.

44. Which of the following CBs is generally used in Railway applications?
A. Air break CB B. Minimum oil CB
C. Bulk oil CB. D. SF_6 CB

45. Which of the following CBs is preferred for EHT applications?
A. Air break CB. B. Minimum oil CB
C. Bulk oil CB. D. SF_6 CB

46. In CB, the arcing contacts are made of
A. porcelain
B copper tungsten alloy
C aluminum alloy
D. electrolytic copper.

47 Which statement is correct?
A. SF_6 gas is Toxic
B. SF_6 gas is lighter than air
C. SF_6 gas is yellow in colour
D. SF_6 gas has pungent smell.

48. A relay performs the function of
A. fault isolation B. fault detection
C. fault prevention D. all are correct.

49. The relay operating coil is supplied through
A. fuse
B. power transformer
C. Instrument Transformer
D. None of these.

50. Choose the correct statement:
A. 1 VA relay is less sensitive than 5 VA relay
B. 1 VA relay is more sensitive than 5 VA relay
C. 1 VA and 5 VA relay have the same sensitiveness
D None of these.

51. An overcurrent relay having a current setting of 125% is connected to a supply circuit through a current transformer of ratio 400/5. The pick up value is
A. 6.25 amps B. 10 ams
C. 12.5 amps D. 15 amps.

52. The pick up value of a relay is 7.5 amps and fault current in relay coil is 30 amps. Its plug setting multiplier is
A. 2 amps. B. 4 amps.
C. 6 amps. D. 8 amps.

53. Most of the relays on service on electric power system are
A. electronic relays
B. electro-mechanical relays
C. thermal relays
D. None of these.

54. Back up protection is generally employed for protection against
A. short circuit faults only
B. open circuit faults only
C. short and open circuit faults
D. None of these.

55. If the fault current is 2000 amps, the relay setting is 50% and CT ratio is 400/5, the plug setting multiplier will be
A. 23 amps B. 50 amps
C. 15 amps D. None of these.

56. If the phase angle of voltage coil of a directional relay is 50, the maximum torque angle of

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relay is

A. 25 B. 100

C. 130 D. None of these.

57. A Mho relay is a:

A. voltage restrained directional relay

B. voltage controlled over current relay

C. directional restrained over current relay

D. directional restrained over voltage relay.

58. The Buchholtz relay protect a transformer from:

A. a turn to turn fault

B. all types of internal faults

C. winding to winding faults

D. None of these.

59. The number of pilot wires required for protecting 3-phase transmission lines using translay system of protection is

A. 6 B. 4

C. 3 D. 2.

60. Current transformers for relays and meters usually have

A. 5 amp secondary 10 amp secondary

C. 20 amp secondary D. None of these.

61. The main function of under voltage protective device generally used with a motor starter is

A. to open supply circuit voltage

B. to control the motor voltage

C. to prevent the opening of the supply circuit

D. None of these.

62. Differential relays are used to protect the equipment against

A. internal faults B. reverse current

C. over current D. None of these.

63. The least expensive protection for overcurrent in LV system is

A. isolator B. Oil circuit breaker

C. rewirable fuse D. Air break CB.

64. Impedance relay can be used for

A. earth faulty

B. phase fault only

C. both earth and phase faults

D. None of these.

65. To protect the power transformer with star-delta connection against fault, the current transformer secondaries will have

A. delta-delta connection

B. delta-star connection

C. star-star connection

D. star-delta connection.

66. In Mertz Price protection, the CTs secondaries of delta-star power transformer will be in

A. star-delta B. star-star

C. delta-star D. delta-delta.

67. If the fault occurs near an impedance relay, the V/I ratio will be

A. constant for all distance.

B. higher than the value if the fault occurs away from the relay

C. lower than the value if the fault occurs away from the relay

D. None of these.

68. A 50 Hz, 4 pole, turbo generator rated at 20 MVA, 13.2 kV has an inertia constant H = 4 kW. sec/kVA. The kinetic energy stored in the rotor at synchronous speed is:

A. 20 Megajoules B. 40 Megajoules

C. 80 Kilojoules D. 80 Megajoules

69. The inertia constants of two groups of machines which do not swing together are M_1 and M_2. The equivalent inertia constant of the system is

A. $M_1 + M_2$ B. $\sqrt{M_1 + M_2}$

C. $M_1 M_2 / M_1 + M_2$ D. $M_1 + M_2 / M_1 M_2$

70. If the inertia constant H of a machine of 200 MVA is 2 p.u., its value corresponding to 400 MVA will be:

Answers : 56. (D), 57. (A), 58. (B), 59. (D), 60. (A), 61. (A), 62. (A), 63. (C), 64. (C), 65. (B), 66. (A), 67. (C), 68. (D), 69. (C).

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A. 4 p.u. B. 3 p.u.
C. 2 p.u. D. 1 p.u.

71. The inertia constant of two groups of machines which do not swing together are M_1 and M_2 such that $M_1 > M_2$. It is proposed to add some inertia to one of the two groups of machine for improving the transient stability of the system. It should be added to,
A. M_1 B. M_2
C. $M_1 + M_2$ D. None of these.

72. Transient stability can be improved by
A. Increasing the system voltage
B. Decreasing the system voltage
C. Keeping the system voltage constant
D. None of these.

73. Transient stability can be improved by using governors attached to the turbines of
A. low speed B. high speed
C. constant speed D. None of these.

74. Which of the following methods is the best for improving the transient stability?
A. Using Voltage Regulators
B. Using High Speed Circuit Breakers.
C. Using Lightning Arrestors.
D. None of these.

75. An alternator having an induced e.m.f of 1.6 p.u. is connected to an infinite bus of 1.0 p.u. If the bus bar has reactance of 0.6 p.u. and alternator has reactance of 0.2 p.u., the maximum power that can be transferred is given by
A. 2 p.u. B. 2.67 p.u.
C. 5 p.u. D. 6 p.u.

76. For stability and economic reasons, we operate the transmission line with power angle in the range
A. 10° to 25° B. 30° to 45°
C. 60° to 75° D. 65° to 80°

77. If the torque angle of an alternator increases indefinitely, the system will show
A. instability B. stability
C. None of these.

78. If P_m is the maximum power transferred, the loss on the system is
A. $P_m/2$ B. $P_m/3$
C. $P_m/4$ D. None of these.

79. The maximum power which can be transferred through the system without loss of stability under sudden disturbances is referred as
A. Steady State Limit
B. Transient Stability Limit
C. Dynamic stability Limit
D. None of these.

80. Power can be transferred only if reactance is
A. absent B. present
C. zero D. None of these.

81. The sending end voltage of a feeder with reactance 0.2 p.u. is 1.2 p.u. If the reactive power supplied at the receiving end of the feeder is 0.3 p.u., the approximate drop of volts in the feeder is:
A. 0.2 p.u. B. 0.06 p.u.
C. 0.05 p.u. D. 0.072 p.u.

82. Which of the following statement is Incorrect.
A. Transient stability limit is lower than steady state stability.
B. An early fault clearing means poor chance of maintaining system stability
C. A system has better chances of maintaining synchronism if the generators are fitted with fast acting automatic voltage regulators.
D. The use of automatic reclosing circuit breakers improves the system stability.

83. Which of the following statement is Wrong
A. A salient pole machine is more stable than a cylindrical rotor machine
B. Present day generators are less stable than the generators made a few years ago

Answers : 70. (D), 71. (B), 72. (A), 73. (B), 74. (B), 75. (A), 76. (B), 77. (B), 78. (A), 79. (B), 80. (B), 81.(C), 82. (B).

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C. An early fault clearing means better chances of maintaining system stability

D. Transient stability is more than steady state stability limit.

84. The relay with inverse time characteristic will operate within

A. 5 sec B. 5 to 10 sec

C. 10 to 15 sec D. 15 to 20 sec

85. Which of the following materials cannot be used for contacts of switching devices ?

A. Copper B. Copper alloys

C. Aluminium D. Silver

86. In which of the following circuits there may be zero sequence components ?

A. Line voltage of star circuit

B. Phase voltage of star circuit

C. Line current of delta circuit

D. None of these

87. What is the most serious problem in vacuum circuit breaker ?

A. Poor arc quenching

B. Low thermal stability

C. Current chopping

D. All of these

88. In case of power transformer protection by differential relay, why are the CTs connected on secondary star side of transformer is in delta?

A. To avoid response to external fault

B. To avoid response to internal fault

C. To avoid response to CT short circuits

D. None of these

89. When can 2 O/L + 1 E/L scheme be used instead of 3 O/L + 1 E/L scheme to protect a feeder ?

A. If the neutral is solidly earthed

B. If the neutral is not earthed

C. If the transformer is star-star connected

D. None of these

90. An over current relay of current rating 5 A and setting 150% is connected to the secondary of CT of ratio 300:5. Then the current in the lines for which the relay picks up is

A. 300 A B. 450 A

C. 150 A D. 200 A.

91. Which frequency would the lighting arrester for protection of equipment allow to pass ?

A. Fundamental frequency component

B. Power frequency component

C. Both fundamental and power frequency component

D. All of these.

92. In a 3-phase system, the phasor sum of phase current is zero. It means absense of

A. Positive sequence component

B. Negative sequence component

C. Zero sequence component

D. All of these.

93. The positive sequence reactance will be equal to negative sequence reactance in case of

A. transformer B. transmission line

C. generator D. motor

94. Rated making capacity of breaker is equal to

A. $\sqrt{2} \times$ rated symmetrical breaking capacity

B. $2.55 \times$ rated symmetrical breaking capacity

C. $1 \times$ rated symmetrical breaking capacity

D. None of these

95. In load-flow study of a power system, what are the quantities specified at a load bus ?

A. $|P|$ and $|V|$ B. P and V

C. P and Q D. P and δ

96. The critical clearing time is related to

A. steady state stability limit

B. transient stability limit

C. short-circuit current limit

D. None of these

Answers : 83. (D), 84. (C), 85. (C), 86. (B), 87. (C), 88. (A), 89. (A), 90. (B), 91. (B), 92. (C), 93. (A), 94. (B), 95. (C), 96. (B).

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97. In what way are long EHV transmission lines in interconnected power systems generally protected ?
   A. Over current protection
   B. Pilot protection
   C. Distance protection
   D. Differential protection.

98. The disadvantages of Gauss Seidel Method over Newton's method in load flow programmes are?
   A. More memory requirement and less accuracy
   B. More programming effort and less accuracy
   C. Less accuracy and more iterations
   D. None of these

99. For transformer protection a differential relay is biased to avoid mal-operations due to
   A. inrush current
   B. saturation of current transformers
   C. mismatching of current ratio of current transformers
   D. current setting multipliers

100. When a circuit breaker interrupt a small inductive current, chopping is most likely to occur when the breaker is
   A. an oil circuit breaker
   B. an air-blast circuit breaker
   C. SF_6 circuit breaker
   D. All of these.

101. In case of protective relays which are energised through PTs and CTs, the relation between the primary and secondary impedances seen by the relay is equal to
   A. PT ratio/CT ratio B. CT ratio/PT ratio
   C. 1.0 D. $(\text{CT ratio/PT ratio})^2$

102. The surge impedance of a 100 km long underground cable is 50 ohms. The surge impedance for a 40 km length of similar cable would be
   A. 50 ohms B. 60 ohms
   C. 70 ohms D. 80 ohms.

103. For which line is carrier-current protection scheme normally used ?
   A. HV transmission lines only
   B. HV cables only
   C. HV transmission lines and cables
   D. All of these.

104. Mho relay is used to protect
   A. Long transmission lines
   B. Medium length lines
   C. Short length lines
   D. All of these.

105. Reactance relay is used to protect against
   A. Earth faults only B. Phase faults only
   C. Over voltage fault D. None of these

106. If the fault current is 2000 amps, the relay setting is 50% and the C.T. ratio is 400/5. The plug setting multiplier will be
   A. 5 B. 6
   C. 8 D. 10

107. The most economic load on an overhead line is
   A. Less than the natural load
   B. Equal to the natural load
   C. Greater than the natural load
   D. None of these

108. As compared with circuit breaker, for the same rupturing capacity, the actual current to be interrupted by an HRC fuse is
   A. Much less B. Much more
   C. Equal D. None of these

109. The stability of arc in Vacuum circuit breaker depends on
   A. The contact material
   B. Its vapour pressure
   D. The circuit parameters
   D. All of these

Answers : 97. (B), 98. (C), 99. (C), 100. (B), 101. (B), 102. (A), 103. (A), 104. (A), 105. (A), 106. (D), 107. (C), 108. (A), 109. (D).

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110. The impulse ratio of a rod gap is
A. 0 to 1.0 B. 1.2 to 1.5
C. 1.6 to 1.8 D. 2 to 2.2

111. Shunt compensation in an EHV line is used to improve
A. stability B. fault level
C. voltage profile D. All of these

112. For stability and economic reasons, the transmission line is operated with power angle in the range
A. $10^\circ - 25^\circ$ B. $30^\circ - 45^\circ$
C. $60^\circ - 75^\circ$ D. $65^\circ - 80^\circ$

113. The rate of rise of restriking voltage depends upon
A. the type of Circuit Breaker
B. the inductance of the system only
C. the capacitance of the system only
D. the inductance and capacitance of the system

114. The making current of 3-phase breaker with rating 2000 MVA, 33 kV will be
A. 35 kA B. 50 kA
C. 70 kA D. 89 kA

115. A combination of HRC fuse and circuit breaker is used, the circuit breaker operates for
A. low overload currents
B. short-circuit currents
C. under all abnormal current
D. All of these

116. Which of the following is correct statement regarding insulators and lightning arresters ?
A. The insulators and lighting arresters should have high impulse ratio
B. The insulators and lightning arresters should have low impulse ratio
C. The insulator should have high impulse ratio and lightning arrester low
D. The lightning arrester should have high impulse ratio but insulator low

117. The leakage resistance of a 50 km long cable is 1 Mohm. For a 100 km long cable, it will be
A. 1 Mohm B. 2 Mohm
C. 0.66 Mohm D. None of these

118. Resistance switching is used in
A. bulk oil circuit breakers
B. minimum oil circuit breakers
C. air-blast circuit breakers
D. all types of breakers

119. Rotating machines are protected against lightning surges by a combination of
A. lightning conductor and capacitor
B. lightning conductor and lightning arrester
C. lightning arrester and capacitor
D. None of these

120. The passive element that is used as interconnecting element for the stable operation of interconnected system is
A. reactor B. resistor
C. capacitor
D. resistor and capacitor

121. If two synchronous generators connected in parallel loose synchronism, it will lead to
A. stalling of generators
B. wild fluctuations in current
C. wild fluctuations in current and voltage
D. None of these

122. A generator is connected to a synchronous motor, it is preferable to have from stability point of view,
A. generator neutral reactance grounded and motor neutral resistance grounded
B. generator and motor neutrals resistance grounded
C. generator and motor neutrals reactance grounded
D. generator neutral resistance and motor neutral reactance grounded

Answers : 110. (B), 111. (C), 112. (B), 113. (D), 114. (D), 115. (A), 116. (C), 117. (D), 118. (C), 119. (C), 120. (A), 121. (C), 122. (D).

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123. A 50 Hz, 4 pole turbo-alternator rated at 20 MVA, 13.2 kV has an inertia constant H = 4 kW sec/kVA. The K.E. stored in the rotor at synchronous speed is

A. 80 kilojoules B. 80 megajoules

C. 40 megajoules D. 20 megajoules

124. Which relays are required for complete protection of 3-phase line ?

A. Three phase and three-earth fault relays

B. Three-phase and two-earth fault relays

c. Two-phase and two-earth fault relays

D. Two-phase and one-earth fault relays

125. The order of the lightning discharge current is

A. 10 kA B. 100 A

C. 1 A D. 1 μ A

126. Why does the minimum oil circuit breaker has less volume of oil ?

A. There is insulation between contacts

B. The oil between the breaker contacts has greater strength

C. Solid insulation is provided for insulating the contacts from earth

D. None of these

127. Load flow study is used for

A. fault calculations B. stability studies

C. system planning D. All of these

128. How is arcing on transmission lines prevented?

A. By circuit breaker

B. By protective relay

C. By inductor in the neutral

D. By capacitor in the neutral

129. If in a line, the loading corresponds to the surge impedance loading, the voltage at the receiving end is

A. greater than sending end

B. less than sending end

C. equal to the sending end

D. None of these

130. The making current of a circuit breaker is specified in terms of

A. rms value B. peak value

C. average vale D. Either of these

131. Consider two groups of machines which do not swing together and their inertia constants respectively are M_1 and M_2 such that $M_1 > M_2$. If some inertia is to be added to one of the two groups of machines for improving the transient stability of the system. It should be added to

A. M_1 B. M_2

C. Either M_1 or M_2

D. The transient stability can not be improved

132. The inertia constants of two groups of machines which do not swing together are M_1 and M_2. The equivalent inertia constant of the system is given by

A. $M_1 + M_2$

B. $M_1 - M_2$ if $M_1 > M_2$

C. $\frac{M_1 \ M_2}{M_1 + M_2}$

D. $\sqrt{M_1 \ M_2}$

133. The higher the initial load,

A. the larger the critical clearing angle

B. the lower the critical clearing angle

C. the critical clearing angle can have any value

D. None of these

134. The energy in a lightning stroke can be as high as

A. 10 Unit B. 100 Units

C. 250 Units D. 1000 Units

135. From the view-point of RRRV, a fault is more serious if it is a

A. short-length line fault

B. medium length line fault

C. long line fault

D. Any of these

Answers : 123. (B), 124. (D), 125. (A), 126. (C), 127. (C), 128. (C), 129. (C), 130. (B), 131. (B), 132. (C), 133. (B), 134. (C), 135. (A).

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150. Which relay is used to detect and protect internal faults of transformer ?
   A. Buchholz relay B. Directional relay
   C. Thermal relay D. Distance relay

151. Impulse insulation breakdown strength of the protected equipment must be
   A. greater than that of the protecting device
   B. equal to the protecting device
   C. less than that of the protecting device
   D. None of these

152. Surge protector provides
   A. high impedance to normal voltage
   B. low impedance to surge
   C. both (A) and (B).
   D. None of these

153. Merz-Price Current protection is also called
   A. under-voltage protection
   B. over-current protection
   C. differential protection
   D. distance protection

154. In which type of fault, maximum short-circuit current occurs
   A. Three-phase faults to ground
   B. Double line fault to ground
   C. Single line fault to ground
   D. None of these

155. Back-up protection is used to protect
   A. overvoltages B. overcurrents
   C. transient current D. short-circuits

156. In a dynamically stable system, oscillations of synchronous machines following load changes will
   A. decrease with time B. increase with time
   C. not occur D. None at all

157. When large bulk power is to be transmitted, the reason for using in HV Transmission is that
   A. line losses are less
   B. no technical problem is efficient
   C. the line is very efficero
   D. None of these

158. An isolator operates under
   A. no load condition
   B. full load condition
   C. 50% load condition
   D. fault condition

159. The lightning arrester is connected
   A. in series with the line
   B between line and earth
   C. to a pole near the line
   D. None of these

160. In a dynamically unstable system
   A. oscillations may increase until synchronism is lost
   B. governor action has no effect
   C. load system is less than energy input
   D. None of these

161. Relays using induction disc principle operate
   A. only on DC
   B. only on AC
   C. Either on DC and AC
   D. None of these

162 Which of the following does not influence the strength of an electric shock to a human body?
   A. Duration of current flow
   B. Frequency
   C. Voltage
   D. Ambient temperature

163 Earthing is necessary to give protection against
   A. voltage fluctuation
   B. overloading
   C. danger of electric shock
   D. high temperature of the conductors

164 The primary function of a fuse is to
   A. protect the appliance

Answers : 150. (A), 151. (A), 152. (C), 153. (C), 154. (A), 155. (D), 156. (A), 157. (A), 158. (A), 159. (B), 160. (A), 161. (B), 162. (D), 163. (C).

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B. open the circuit.

C. prevent excessive currents

D. protect the line.

165 A thermal protection switch is able to protect against

A. overload B. over voltage

C. temperature D. short circuit.

166 In which of the following cases are delay fuses used ?

A. For the protection of light circuits.

B. For the protection of power out-let circuits.

C. For the protection of fluorescent lamps.

D. For the protection of motors.

167 It is a fatal to touch a live wire because

A. the human body becomes part of the electric circuit.

B. the voltage may cause burns to the skin.

C. the current may cause burns to the skin or inside the body.

D. it causes damage to the heart and nerve system.

168 A fuse is able to protect a circuit when

A. it is fitted at the end of the circuit

B. the size of the fuse wire is appropriate for the load.

C. the size of the fuse wire is appropriate for the size of the line.

D. the fuse is fitted as the beginning of the circuit.

169 When extra stop buttons are added to an existing starter control circuit they must be

A. in series with the contactor coil.

B. parallel to the overload.

C. parallel to the start button

D. in series with the motor

170 A single phase motor protection switch is adjusted according to

A. the maximum starting current

B. the cross-sectional area of the feeding line.

C. the rated current.

D. the capacity of the fuse

171 An isolating switch is operated under load in an old installation. Which of the following statements is correct ?

A. An arc is produced which can destroy the switching section.

B. If the switch is operated sufficiently fast, the circuit is interrupted correctly.

C. The circuit is interrupted correctly. However, the contacts of the isolating switch must be changed.

D. The nominal current can be interrupted five times with the help of an isolating switch.

172 How is the isolating switch operated?

A. By revolving crank drive.

B. By the help of a switching rod.

C. By the help of a compressed air drive.

D. By the help of a compressed air motor.

173 When is the arc produced by the breaking of an alternating current extinguished ?

A. When the product of current and voltage, i.e. the power, is the lowest.

B. When the voltage is at its maximum value.

C. When the current is at its maximum value.

D. When the current reaches its zero value.

174 In thermal overcurrent delay relays and overcurrent fast relays, which of the following statements is true ?

A. The thermal overcurrent delay relays are bimetallic switches.

B. The thermal overcurrent delay relays are based upon the magnetic effect of current.

C. The overcurrent fast relays are bimetallic switches.

D. The thermal overcurrent delay relays as well as the overcurrent fast relays are bimetallic switches.

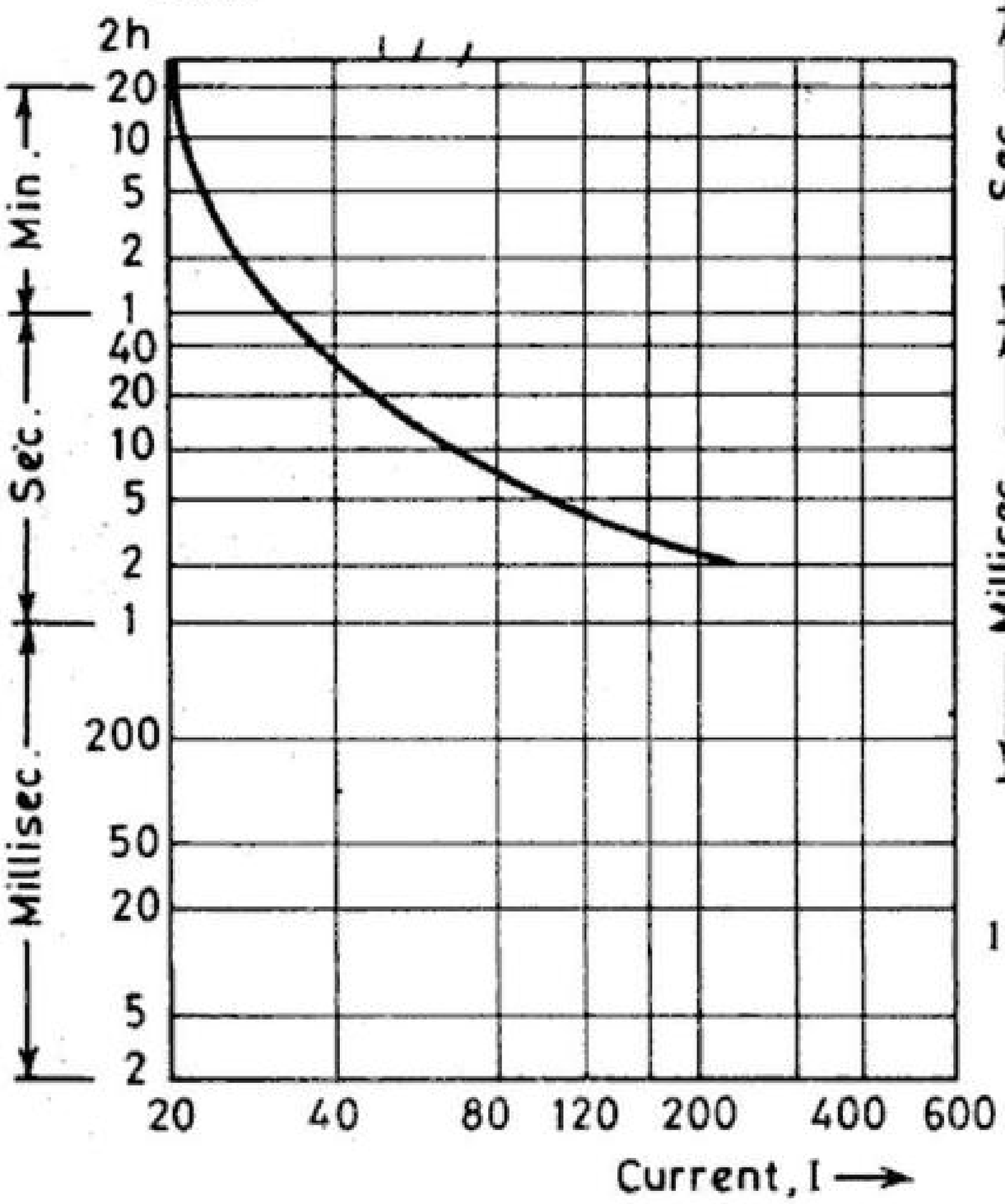
Answers : 164. (C), 165. (A), 166. (D), 167. (A), 168. (D), 169. (A), 170. (C), 171. (A), 172. (B), 173. (D), 174. (A).

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179 A nominal current of 20 *A* is set at the motor protective switch whose characteristic is shown in the figure. After how much time does the switch operate in case of an overcurrent of 30 *A* ?



A. After about 2 sec

B. After about 5 sec

C. After about 20 sec

D. After about 2 minutes.

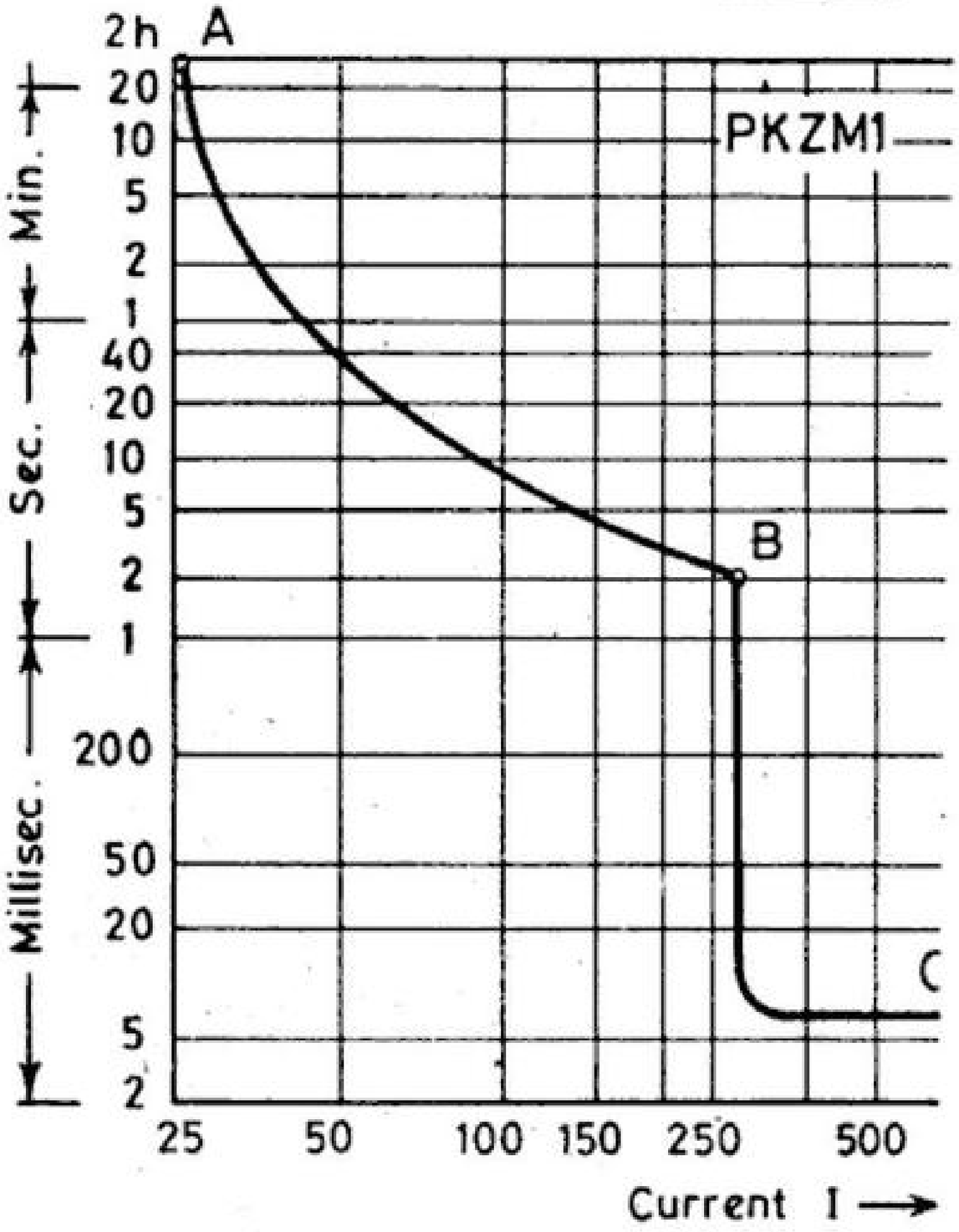
180 A nominal current of 25 *A* is set at the motor protective switch whose characteristic is shown in the figure. In which of the following cases does the switch operate ?

A. When a switching current surge of 245 *A* flows for 5 ms.

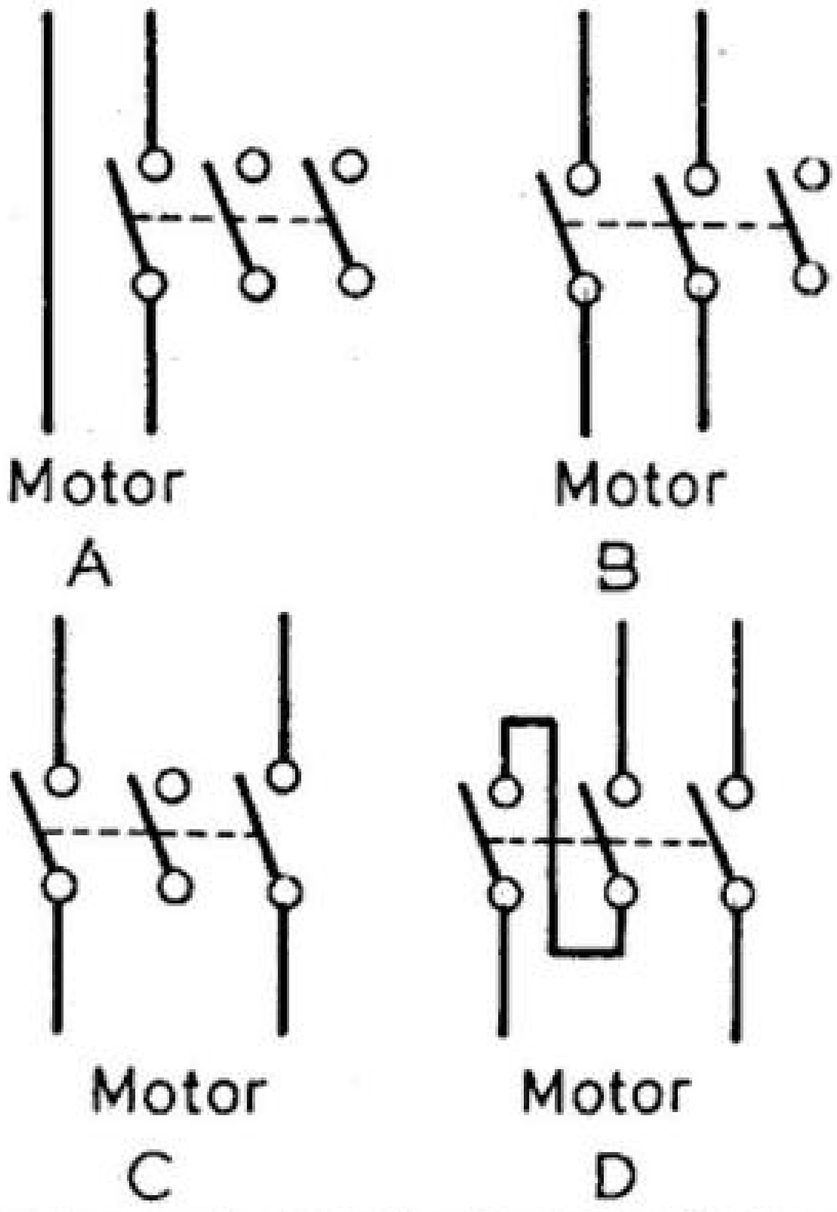
B. When 250 A flow for 1 sec

C. When 150 *A* flow for 5 sec

D. When 50 *A* flow for 20 sec



181 A three-phase contactor is to be used for a 220-V dc motor. Which of the following circuits can be used for this purpose ?



Answers : 179. (D), 180. (C), 181. (D).

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B. high resistance to thermal deterioration

C. high dielectric loss

D. freedom from gaseous inclusions.

196. The variety of paper used for insulation purpose is

A. blotting paper B. rice paper

C. Craft paper D. None of these.

197. Which variety of mica is hard and brittle?

A. Muscovite B. Phlogopite

C. Fibiolite D. Lipidolite.

198. Professional grade electronic components means

A. low cost components

B. miniature size components

C. highly reliable components

D. accurate value components.

199. Professional grade electronic components are invariably used in

A. F.M. transistors

B. TV

C. Power apparatus

D. Space applications.

200. Van de Graaf generators are useful for

A. Very high voltage and low current applications.

B. Very high voltage and high current applications

C. Constant high voltage and current applications

D. None of these.

201. In a Van de Graaf generator, the width of the belt is 1m and surface charge density permissible is 30×10^{-6} C/m^2. To supply a current of 300 μ A, the velocity of belt should be

A. 1m/sec B. 5 m/sec

C. 15m/sec D. None of these.

202. Surface charge density in a Van de Graaf generator is 30×10^{-6} C/m^2. The radius of electrode to charge to 10 MV will be

A. 0.16m B. 0.295 m

C. 1.234 m D. None of these.

203. The radius of the HT electrode is 1 metre in Van de Graaf generator. If the electric field is 21/kV/ cm, the maximum potential to which the electrode can be charge is

A. 2.1 MV B. 21 MV

C. 4 MV D. None of these.

204. In Van de Graaf generator, output voltage is controlled by

A. controlling the corona source voltage

B. controlling the belt speed

C. controlling the lower spray point

D. All of these.

205. A Tesla coil is a

A. cascaded transformer

B. coreless transformer

C. high frequency resonant transformer

D. low impedance transformer.

206. Switching surge is

A. high voltage d.c.

B. high voltage a.c.

C. short duration transient voltage

D. low impedance transformer.

207. Moles bridge is used to measure

A. properties of dielectric at d.c.

B. dispersion in insulation

C. high frequency high voltages

D. modulation ratio frequencies.

208. Insulators for high voltage applications are tested for

A. power frequency tests

B. impulse tests

C. Both (A) and (B) are correct

D. None of these.

Answers : 195. (C), 196. (C), 197. (D), 198. (C), 199. (D), 200. (A), 201. (A), 202. (B), 203. (A), 204. (A), 205. (C), 206. (C), 207. (B), 208. (C).

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QUESTION BANK IN ELECTRICAL AND ELECTRONICS ENGINEERING

The book is designed to meet the following broad objectives:

- To provide a complete and comprehensive work for assimilation of principles, concepts, systems; their application in the field of electrical and electronics engineering and to bring out the interconnections among these fields.
- To provide the essential fundamentals in each field which should be able to facilitate the student to understand actual circuits and systems.
- To introduce practical circuits and systems and up-to-date developments, thus giving an industry-oriented perspective.
- To facilitate the student to evaluate his progress step by step with the help of Programmed Multiple Choice Questions designed for planned exposure to new concepts and reinforce further learning.
- To provide sufficient number of multiple Choice Question designed to test gains in knowledge, understanding and application aspects of learning.

Prof. Harish C. Rai is presently, Adviser, All India Council for Technical Education, New Delhi-2. Formerly, Examination Controller, IP University, Delhi, and Professor in the Department of Electrical and Electronics Engineering, C.R. State College of Engineering, Murthal (Sonepat) Haryana. He received his Graduate and Post Graduate Degrees from Delhi College of Engineering, Delhi and Ph.D. Degree in Electrical Engineering from IIT, Delhi in 1991.

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