DETAILS EXPLANATIONS

EE : Paper-1 (Paper-2) [Full Syllabus]

[PART : A]

1. ***KCL :***

At any junction (node) in an electric circuit the total current flowing towards that junction (or node) is equal to the total current flowing away from the junction (or node).

$$\Sigma I_{in} = \Sigma I_{out}$$

KVL :

In any closed loop in a network, the algebraic sum of the voltage drop taken around the loop is equal to the resultant emf acting in the loop.

i.e., $\Sigma V_{rises} = \Sigma V_{drops}$

2. It is an interconnected open set of branches which include all the nodes of the given graph. In a tree of the graph there cannot be any closed loop.

3.
- Deterioration of oil into gases so it needs periodic replacement.
- It may form explosive mixture with air i.e., fire hazards.
- Precipitation of carbon particles.

4. The number of twigs on a tree is always one less than the number of nodes. let N = Number of nodes then the total number of twigs will be (N – 1).

Also, if L represents the total number of links while B the total number of branches, then

$$L = B - (N - 1) = B - N + 1$$

5. Applying KCL we get

$$3\angle 15^\circ = I + 5\angle 45^\circ$$

or $I = 3\angle 15^\circ - 5\angle 45^\circ$

$= 2.90 + j0.78 - (3.54 + j3.54)$

$= -0.64 - j2.76$

or $I = 2.83\angle -103.06^\circ$ A

6. The interpoles mmf does two tasks, (i) it neutralises the armature cross flux in the commutating zone and (ii) in addition, it provides extra interpolar flux in the commutating zone so as to induce rotational emf in the commutated coil in such a direction as to nullify the reactance voltage.

7. Take a multimeter two terminals, indicating high resistance (about 100 Ω to 125 Ω) belong to field winding. The other two terminals showing low resistance (around 1Ω) belong to armature winding.

8.
- Armature reaction flux distorts the main field flux, under one pole tip it gets reduced while under the other pole tip. It gets augmented.
- The degree of augmentation is less than the degree of reduction in the pole-tip flux there is, therefore, a net reduction in the resultant flux.

9. An infinite bus bar means a source whose terminal voltage and frequency remains constant irrespective of a new voltage source is connected to it or a load is put on it. Thus, alternators on infinite bus bar means that their terminals voltage and frequency remain constant, equal to the bus-bar voltage and frequency.

10. Medium impedance of line is

$$Z_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$$

Not depend on length for lossless line

$$R = G = 0$$

$$Z_{os} = \sqrt{\frac{L}{C}}$$

Z_{0s} is called surge impedance.

11. All these existing modes in TM_{mn} which are having same frequency of TE_{mn} are called degenerating mode *example*.
TM_{23} and TE_{23}
TM_{11}, TE_{11} are degenerating mode.

12.
- Frequency of supply.
- Diameter of conductor.
- Distance between conductor.
- Relative permeability of conductor material.
- Conductivity of conductor.

13. According to splepain theory "If rate of rise of restriking voltage (RRRV) is reduced than dielectric build up strength, the arc will not restrike." To reduce RRRV there is damping provides using auxillary resistor.

14. Following method to minimize armature reaction.
- To reduce the armature flux ϕ_a, reluctance in the path of ϕ_a is increased using laminated pole shoe.
- By using non-uniform airgap i.e. minimum at centre and progressively increasing towards corners.
- Using compensating winding.

15. Reason of failure of voltage building up

- Residual flux is absent.
- Field terminals are wrong/connection wrong.
- Direction of rotation is wrong as E is reverse, If it is reversed so that ϕ_{res} will be destroyed.
- Field resistance is more than critical field resistance R_{fc}.
- Speed is less than critical speed i.e., $N < N_C$.

17. The exciting current of a transformer has two components, normely magnetizing current I_m and core-loss current I_c.
The function of magnetizing current I_m is to produce the necessary mmf to create the required mutual flux in the core. The function of core-loss current is to provide for the core loss in the transformer.

18.

$$\because \quad V_S = AV_R + BI_R$$

$$\Rightarrow \quad V_R = AV_R + BI_R$$

$$\Rightarrow \quad V_R(1 - A) = BI_R$$

$$\therefore \quad X_L = \frac{V_B}{I_R} = \frac{B}{1-A}$$

$$= \frac{200}{1-0.9} = 2000\ \Omega$$

19. Recombination is the process where an electron moves from the conduction band into the valence band so that a mobile electron-hole pair disappear. Classical mechanics requires that momentum be conserved in an encounter of two particles. Since the momentum is zero after recombination, this conservation law requires that the "colliding" electron and hole must have equal magnitudes of momentum and they must be travelling in opposite direction. This requirement is very stringent, and hence the probability of recombination by such a direct encounter is very small.

20.

- A state of material in which it has zero resistivity, is called super conductivity.
- At the state of super conductivity material shows diamagnetism property.
- Mercury (Hg) was first discovered super conductor material and observed that the resistivity of mercury vanished completely below 4.2 K, the transition from normal to super conductivity occurring over a very narrow range of temperature of the order of 0.05 K.
- The temperature at which superconductivity appears is called the critical temperature or transition temperature (T_c).

[PART : B]

21. ***Average Value :***

The arithmetic average of all the instantaneous values of an alternating quantity (current or voltage) over one cycle is called average value.

Effective Value :

The effective or rms value of alternating current is that steady current (DC) which when flowing through a given resistance for a given time produces the same amount of heat as produced by the alternating current when flowing through the same resistance for the same time.

Form Factor :

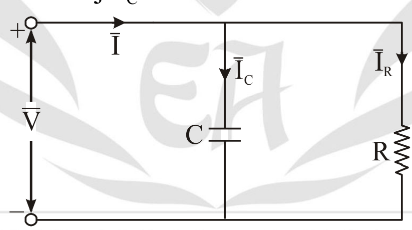
The ratio of the effective value to the average value is known as the form factor of a waveform of any shape (sinusoidal or non-sinusoidal).

Thus, Form factor,

$$K_f = \frac{V_{rms}}{V_{av}}$$

22. $\because$ $\bar{I}_R = \frac{\bar{V}}{R}$ i.e., $\bar{I}_R$ is along $\bar{V}$.

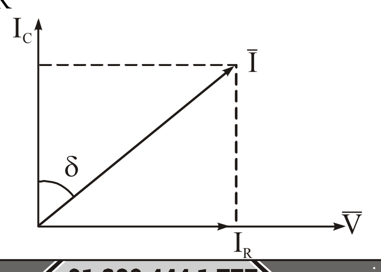
$\because$ $\bar{I}_C = \frac{\bar{V}}{-jX_C}$ i.e., $\bar{I}_C$ leads $\bar{V}$ by 90°



$\because$ Loss tangent or dissipation factor

$$D = \tan\delta = \frac{I_R}{I_C} = \frac{V/R}{V/X_C} = \frac{1}{\omega CR}$$

$$\Rightarrow \quad \frac{1}{R} = \omega C \tan\delta$$



∵ Dielectric loss

$$P_L = \frac{V^2}{R} = \omega C V^2 \tan\delta$$

23. Voltage at any instant

$$v_1 = 12.6 \text{ V}$$

Current at same instant

$$i_1 = 20 \text{ mA}$$

Inductive Reactance

$$X_L = \frac{v_1}{i_1} = \frac{12.6}{20m} = 630\ \Omega$$

Now, $X_L = \omega L = 2\pi f L$

or $$f = \frac{X_L}{2\pi L} = \frac{630}{2\pi \times 50 \times 10^{-6}}$$

$$= 2 \times 10^6 \text{ Hz} = 2 \text{ MHz}$$

24. $S_{1r} = 20$ kVA; $S_{2r} = 15$ kVA; $S_L = 25$ kVA

$Z_1 = 0.01\angle\theta\Omega$; $Z_2 = 0.015\angle\theta\ \Omega$

$$\frac{Z_1}{Z_2} = \frac{0.01\angle\theta}{0.015\angle\theta} = \frac{2}{3}$$

$$|\bar{S}_1 *| = \frac{\bar{S}_L *}{1+(Z_1/Z_2)} = \frac{\bar{S}_L *}{1+(2/3)}$$

$$= |0.6|\bar{S}_L *$$

$$|\bar{S}_2 *| = \frac{\bar{S}_L *}{1+(Z_2/Z_1)} = \frac{\bar{S}_L *}{1+(3/2)}$$

$$= |0.4|\bar{S}_L *$$

Magnitudes $S_1 = 0.6\ S_L = 0.6 \times 25 = 15$ kVA

$S_2 = 0.4\ S_L = 0.4 \times 25 = 10$ kVA

percentage utilization

$$\frac{S_1}{S_{1r}} = \frac{15}{20} = 0.75 = 75\% \text{ utilization}$$

$$\frac{S_2}{S_{2r}} = \frac{10}{15} = 0.67 = 67\% \text{ utilization}$$

T_1 is over utilized and T_2 is under utilized

$$\frac{Z_1}{Z_2} = \frac{2}{3};\ \frac{S_{2r}}{S_{1r}} = \frac{15}{10} = 0.75$$

$$\frac{Z_1}{Z_2} < \frac{S_{2r}}{S_{1r}}$$

$\therefore$ T_1 will be overloaded first.

i.e. for $S_{L(max)}$

$$S_1 = 0.6\ S_{L\ max} = S_{1r}$$

$$0.6\ S_{L\ max} = 20$$

$$\Rightarrow \quad S_{L\ max} = 33.33\ kVA$$

$$S_2 = 13.33\ kVA$$

$$S_1 = 0.6 \times 33.33$$

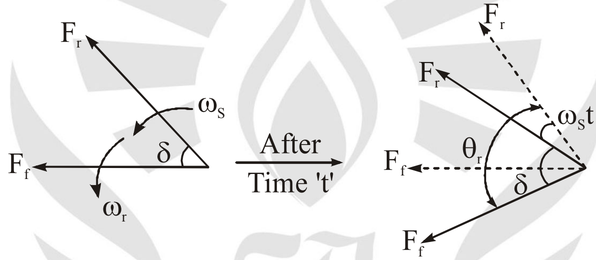
$$= 19.99\ kVA = 20\ kVA$$

25. Angular displacement in rotor

$$\theta_r = \omega_S t + \delta$$

Angular velocity

$$\omega_r = \frac{d\theta_r}{dt} = \omega_s + \frac{d\delta}{dt}$$



Angular acceleration

$$\alpha = \frac{d^2\theta_r}{dt^2} = \frac{d^2\delta}{dt^2}$$

$\because$ Acclerating torque

$$T_a = J\alpha$$

$\because$ Accelerating power

$$P_a = T_a \times \omega$$

$$P_a = J\omega\alpha$$

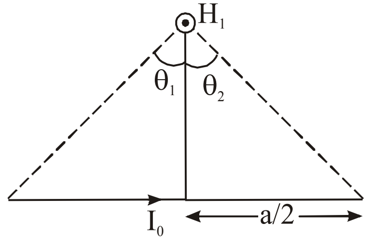
$$P_a = M\alpha$$

$$P_m - P_e = M\frac{d^2\delta}{dt^2}$$

$$\Rightarrow \quad M\frac{d^2\delta}{dt^2} + P_{em}\sin\delta = P_m$$

i.e., swing equation of rotor of generator.

26. H_1 is field due to single wire



$$\theta_1 = \theta_2 = 45^o$$

$$H_1 = \frac{I_o}{4\pi(a/2)}[\sin\theta_1 + \sin\theta_2]$$

$$= \frac{2I_o \times 2\sin 45^o}{4\pi a} = \left(\frac{I_o}{\pi a\sqrt{2}}\right)$$

$$H = 4H_1 = \left(\frac{2\sqrt{2}\,I_o}{\pi a}\right) \text{A/m.}$$

27. For a constant load current, the ohmic losses P_{sc} are constant. Core loss P_c is already find constant. There fore, total transformer losses are constant for a constant load current.

Now η is

$$\eta = \frac{V_2 I_2 \cos\theta_2}{V_2 I_2 \cos\theta_2 + \text{Constant losses (C)}}$$

pf at which maximum η occurs can be obtained by equation

$$\frac{d\eta}{d\theta_2} = 0$$

$$\frac{d\eta}{d\theta_2} = \frac{[V_2 I_2 \cos\theta_2 + C]V_2 I_2(-\sin\theta_2) - (V_2 I_2 \cos\theta_2)V_2 I_2(-\sin\theta_2)}{[V_2 I_2 \cos\theta_2 + C]^2} = 0$$

or $\sin\theta_2 = 0$ or pf $= \cos\theta_2 = 1$

Thus the maximum η for a constant load current, occurs at unity pf.

28.
- The first cause of hum and the noise, is the magnetostriction effect.
- The core construction, size and gauge of laminations and the degree of tightness of damping the core by nuts and bolts do influence the frequency of meachnical vibrations and therefore the noise in transformers.
- Joints in the core are also responsible for noise production through to a lesser degree. Most of the noise emission from a transformer may be reduced.

Methods to reduce it :

- By using low value of flux density in the core.
- By proper tightening of the core by clamps, bolts etc.
- By sound-insulating the transformer core from the tank wall in case of large transformers or by sound-insulating the transformer core from where it is installed in case of small transformers.

29. Fault current through relay

$$I = 5000 \times \frac{5}{400} = 62.5 \text{ A}$$

Plug setting of relay

$$I_p = \frac{125}{100} \times 5 = 6.25 \text{ A}$$

$$\because \quad PSM = \frac{I}{I_P} = \frac{62.5}{6.25} = 10$$

$$\because \quad t_{op} \; \alpha \; \frac{1}{PSM} \text{ and } t_{op} \; \alpha \; TMS$$

So,
$$t_{op_2} = t_{op_1} \times \frac{(TMS)_2}{(TMS)_1} \times \frac{(PSM)_1}{(PSM)_2} = 1.2 \times \frac{9.5}{1} \times \frac{1}{10}$$
$$= 0.06 \text{ sec} = 60 \text{ m sec}$$

30. The effect of brush shift can be examines from the developed view of the armature conductor and field poles, for this purpose, let the brushes be shifted in the forward direction for a generator or brackward direction for a motor. The peak of the triangular armature mmf wave is also shifted by the same angle, because armature mmf axis must coincide with the brush axis.

The flux per pole is reduced if the brushes are given a forward shift in case of generator or backward shift in case of a motor. This reduction in flux cause a decrease in the generator terminal voltage or an increase in the motor speed.

If the brushes are given a backward shift in a generator or forward shift in a motor, the flux per pole becomes more and as a result of it, the generator terminal voltage rises and the motor speed falls.

31.
- The absorption of electric energy by a dielectric material subjected to an alternating electric field is known as dielectric losses. The result in dissipation of the electric energy as heat in the material and in this dielectric constant in such case in a complex quantity where imaginary part corresponds the loss. So complex dielectric constant is expressed as

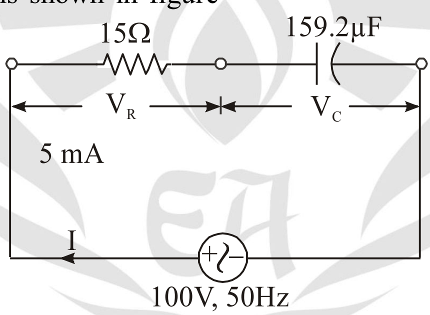
$$\in_r = \in_r' - j\in_r''$$

- The complex dielectric constant incorporates all the contributions of polarization.
- The imaginary part of the equation is so that rise to absorption of energy by the material from the alternating field.

32.
- Ceramics are dielectric material having large band gap (E_g). So in working temperature range they behave as an insulator.
- Some materials (ceramic) such as glass, paper, Teflon are very good electric insulators.
- These ceramics are used for high voltage power transmission because of their good insulating properties. These are normally glass, porcelain, or composite polymer materials.
- Insulators made from porcelain rich in alumina are used where high mechanical strength is criterion.
- Porcelain has a dielectric strength of 4 - 10 kV/mm.
- Recently some electric utilities have begain converting to polymer composite materials for some types of insulators.
- Ceramic insulator are also used at railway.

[PART : C]

33. The circuit is shown in figure



we have $C = 159.2\ \mu F,\ R = 15\ \Omega,$

$V = 100\ V$ and $f = 50\ Hz.$

Voltage phasor

$$V = 100\angle 0^\circ$$

(i) Impedance : Capacitive Reactance

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi \times 50 \times 159.2 \times 10^{-6}} = 20\ \Omega$$

Impedance, $Z = R - jX_C = 15 - j20\ \Omega$

In polar form $Z = 25\angle -53.13^o$

(ii) Current : Effective Current

$$I = \frac{V}{Z} = \frac{100\angle 0^o}{25\angle -53.13^o}$$

$$I = 4\angle 53.13^o\ A$$

34. When a graph is given, first select a tree and remove all the links. When a link is replaced, a closed loop or circuit is formed circuits formed in this way are called fundamental tieset or F-Circuits or fundamental circuits orientation of an f circuit is given by the orientation of connecting link. The number of f circuits is same as the number of links for a graph. In a graph having b branches and n nodes, then no of tieset will be (b – n + 1). Figure below shows a tree and tie set for the graph shown in figure.

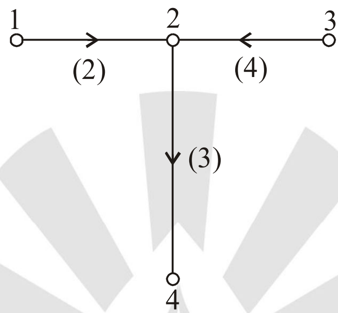


Figure (a) Tree

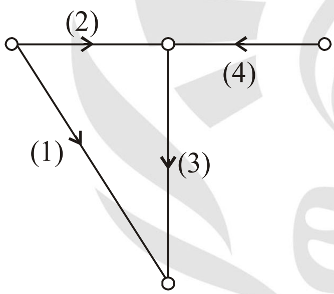


Figure (b) Tieset (1)

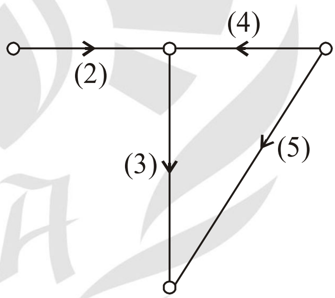


Figure (c) Tieset (5)

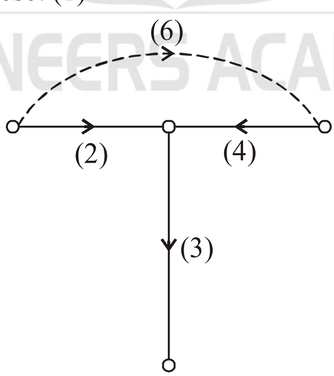


Figure (d) Tieset (6)

Here, $b = 6$ and $n = 4$

Number of tiests = b – n + 1 = 6 – 4 + 1 = 3

Tiest-1: {1, 2, 3}

Tiest-5: {5, 3, 4}

Tiest-6: {6, 2, 4}

The teset schedule will be written as

Tiesets	Branches→ 1	2	3	4	5	6
1	1	–1	–1	0	0	0
5	0	0	–1	–1	1	0
6	0	–1	0	1	0	1

Hence an f-circuit matrix or tieset matrix will be given as

$$B = \begin{bmatrix} 1 & -1 & -1 & 0 & 0 & 0 \\ 0 & 0 & -1 & -1 & 1 & 0 \\ 0 & -1 & 0 & 1 & 0 & 1 \end{bmatrix}$$

35. We know that

$$\tau = \frac{ksR_2E_{20}^2}{R_2^2 + (sX_{20})^2} \qquad ...(1)$$

It is seen that if R_2 and X_{20} are kept constant. The torque τ depends upon the slip s. The torque slip characteristic curve can be divided roughly into three regions:

- ***Low-Slip Region :***

  At Synchronous speed s = 0, therefore $\tau = 0$, when the speed is very near to synchronous speed. The slip is very low and $(sX_{20})^2$ is negligible in comparison with R_2. Therefore

$$\tau = \frac{k_1s}{R_2}$$

If R_2 is constant then

$$\tau = k_2s \qquad ...(2)$$

Relation shows that the torque is proportional to the slip. Hence the torque-slip curve is a straight line.

- ***Medium Slip region :***

  As slip increase (i.e. as the speed decrease with the increase in load). The term $(sX_{20})^2$ becomes large, so that R_2^2 may be neglected in comparision with $(sX_{20})^2$ and

$$\tau = \frac{k_3R_2}{sX_{20}^2} \qquad ...(3)$$

Thus the torque is inversely proportional to slip towards stands-still condition. The τ-s characteristic is represented by a rectangular hyperbola for intermediate values of the slip, the graph change from one form to another is doing so, it passes through the point of maximum torque when $R_2 = sX_{20}$. This torque is a measure of the short-time overloading capability of the motor.

- ***High Slip Region :***

The torque decrease beyond the point of maximum torque. The result is that the motor slows down and eventually stops, at this stage, the overload protection must immediately disconnect the motor from the supply to prevent damage due to overheating.

The motor operates for the values of the slip between s = 0 and $s = s_m$, where s_m is the value of the slip corresponding to maximum torque. For a typical induction motor, the pull-out torque is 2 to 3 times the rated full load torque. Thus, the motor can handle short-time over load. Without stalling the starting torque is about 1.5 times the rated full load torque. Figure shows the torque-slip curves for various values of rotor resistance.

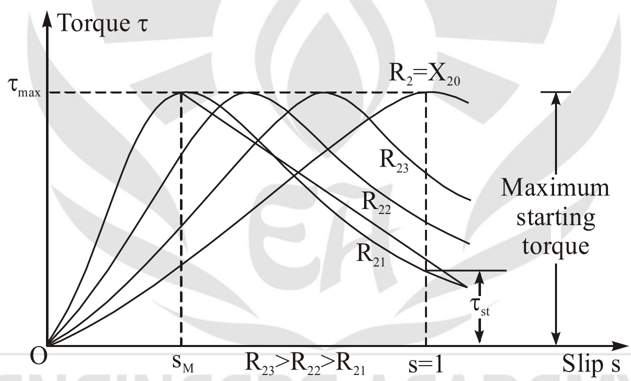


Figure : Torque Slip Curves.

It is seen that although the maximum torque is independent of rotor resistance, yet the exact location of τ_{max} is dependent on it. Greater the Value of R_2 greater is the value of slip at which maximum torque occurs. It is also seen that as rotor resistance is increases, the pull-out speed of the motor decreases. But the maximum torque remains constant.

36. When an external magnetic fieid is applied to a material, the value of electric resistance changes. This property of material is called magnetoresistance. Given,

Plate area = 1 cm^2 = 10^{-4} m^2

Thickness = 0.3 mm = 3×10^{-4} m

Concentration of free electrons in germanium

$$n = 2 \times 10^{19}/m^3$$

Mobility of electrons,

$$\mu_e = 0.36 \ m^2/V\text{-}s$$

Mobility of holes,

$$\mu_h = 0.17 \ m^2/V\text{-}s$$

Resistivity of germanium

$$\rho = \frac{1}{ne(\mu_e + \mu_h)}$$

$$\Rightarrow \rho = \frac{1}{2\times10^{19}\times1.6\times10^{-19}\times(0.36+0.17)}$$

$$= 0.59 \ \Omega\text{-m}$$

Resistance of germanium

$$R = \rho\frac{l}{A} = 0.59\times\frac{3\times10^{-4}}{1\times10^{-4}} = 1.77 \ \Omega$$

Current produced,

$$I = \frac{V}{R} = \frac{2}{1.77} = 1.13 \text{ A}$$

37. When a transformer is initially energized, there is a sudden inrush of primary current. The maximum value attained by the flux is over twice the normal flux. The core is driven into saturation with the result that the magnetizing current has a very high peak value. Let a sinsusoidal voltage

$$v_1 = V_{1m} \sin(\omega t + \alpha) \qquad ...(1)$$

Be applied to the primary of a transformer, the secondary of which is an open circuit here α the angle of the voltage at t = 0.

Suppose for the moment we neglect core losses and primary resistance, then

$$V_1 = T_1\frac{d\phi}{dt} \qquad ...(2)$$

Where, T_1 = Primary winding turns

ϕ = Flux in core

In the steady state

$$V_{1m} = \omega\phi_m T_1 \qquad ...(3)$$

From equation (1) and (2)

$$T_1\frac{d\phi}{dt} = V_{1m}\sin(\omega t + \alpha)$$

$$\frac{d\phi}{dt} = \frac{V_{1m}}{T_1}\sin(\omega t + \alpha) \qquad ...(4)$$

From equation (3) and (4)

$$\frac{d\phi}{dt} = w\phi_m \sin(\omega t + \alpha) \qquad ...(5)$$

integration of equation (5) gives

$$\phi = -\phi_m \cos(\omega t + \alpha) + \phi_C \quad ...(6)$$

Where, ϕ_C is the constant of integration to be found from initial conditions at t = 0. Assume that when the transformer was last disconnected from the supply line, a small residual flux ϕ_r remained in the core. Thus at t = 0, $\phi = \phi_r$ substituting these value in equation (6)

$$\phi_r = -\phi_m \cos\alpha + \phi_C$$

$$\therefore \qquad \phi_C = \phi_r + \phi_m \cos\alpha \qquad ...(7)$$

equation (6) then becomes

$$\phi = \phi_m\cos(\omega t+\alpha)+\phi_r+\phi_m\cos\alpha ...(8)$$

$[\phi_m\cos(\omega t + \alpha)] \rightarrow$ Steady-state component of flux ϕ_{ss})

$(\phi_r+\phi_m\cos\alpha \rightarrow$ Transient component of flux ϕ_C.)

If the transformer is switched on at $\alpha = 0$, then $\cos\alpha = 1$.

$$\phi_C = \phi_r + \phi_m$$

Under this condition

$$\phi = \phi_m \cos\omega t + \phi_r + \phi_m \qquad ...(9)$$

At $\qquad \omega t = \pi$

$$\phi = \phi_m\cos\pi + \phi_r + \phi_m = 2\phi_m + \phi_r$$

Thus, the core flux attaining the maximum value of flux equal to $(2\phi_m + \phi_r)$, which is over twice the normal flux. This is known as doubling effect. Consequently, the core goes into deep saturation. The magnetizing current required for producing such a large flux in the core may be as large as 10 times the normal magnetizing current. Same times the rms value of magnetizing current may be larger than the primary rated current of the transformer. This inrush current may produce electromagnetic force about 25 times the normal value. Therefore the winding of large transformers are strongly braced, due to this inrush current may large humming due to magnetostriction of the core.

If the transformer is connected to the supply line near a possitive or negative voltage maximum, the current inrush will be minimized, it is usually impractical to attempt to connect a transformer at predetermined time in the voltage cycle.

For tunately, inrush current do not occur as might be thought the magnitude of inrush current is also less than the value calculated by purely theoritical considerations.

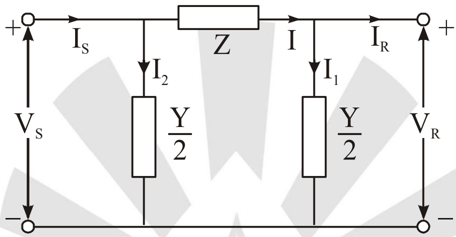
38. $\because \quad I_1 = \frac{Y}{2}V_R$

$\because \quad I = I_1 + I_R = \frac{Y}{2}V_R + I_R$

$\because \quad V_S = V_R + ZI$

$\Rightarrow \quad V_S = V_R + Z\left(\frac{Y}{2}V_R + I_R\right)$

$\Rightarrow \quad V_S = \left(1+\frac{YZ}{2}\right)V_R + ZI_R \quad ...(1)$



Compare with

$V_S = AV_R + BI_R \qquad \left(A = 1+\frac{YZ}{2}, B = Z\right)$

$\because \quad I_2 = \frac{Y}{2}V_S$

$= \frac{Y}{2}\left\{\left(1+\frac{YZ}{2}\right)V_R + ZI_R\right\}$

$= \frac{Y}{2}\left(1+\frac{YZ}{2}\right)V_R + \frac{YZ}{2}I_R$

$\because \quad I_S = I_2 + I$

$= \left[\frac{Y}{2}\left(1+\frac{YZ}{2}\right)V_R + \frac{YZ}{2}I_R\right] + \left[\frac{Y}{2}V_R + I_R\right]$

$= \frac{Y}{2}\left(1+\frac{YZ}{2}+1\right)V_R + \left(\frac{YZ}{2}+1\right)I_R$

$\Rightarrow I_S = Y\left(1+\frac{YZ}{4}\right)V_R + \left(1+\frac{YZ}{2}\right)I_R \quad ...(2)$

Compare with

$I_S = CV_R + DI_R \qquad \left[C = Y\left(1+\frac{YZ}{4}\right), D = 1+\frac{YZ}{2}\right]$

So, the ABCD parameters are

$A = D = 1+\frac{YZ}{2}; \; B = Z; \; C = Y\left(1+\frac{YZ}{4}\right)$

39. Shows in the figure connections of a capacitor-start motor. It has a cage rotor and its stator has two windings namely, the main winding and the auxilary winding (starting winding) the two winding are displaced 90° in space a capacitor C_s is connected in series with the starting windings a centrifugal switch S is also connected as shown in figure.

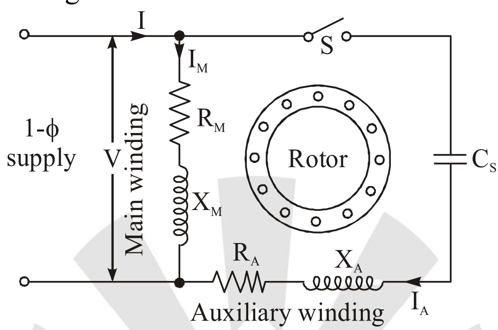


Figure (a) : Circuit Diagram

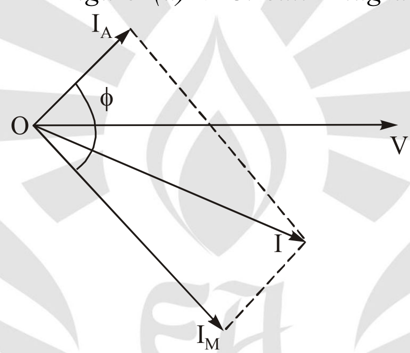


Figure (b) : Phasor Diagram

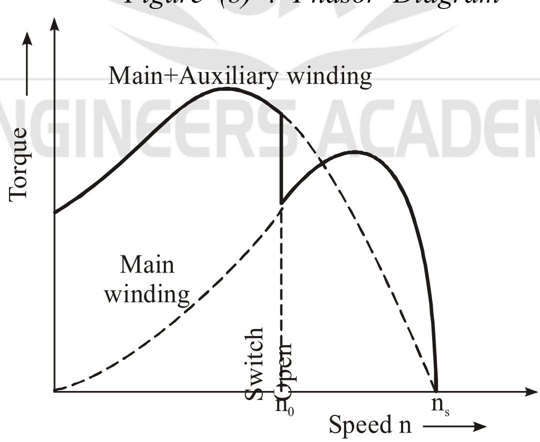


Figure (c) : Torque-Speed Characteristic

Figure : Capacitor Start Motor

Thus the windings are displaced 90^o electrical and their mmf's are equal in magnitude but 90^o apart in time phase.

Therefore the motor acts like a balanced two-phase motor As the motor approaches its rated speed, the auxilary winding and the starting capacitor C_s are disconnected automatically by the centrifugal switch S mounted on the shaft. The motor is so named because it uses the capacitor only for the purpose of starting.

Motor Characteristics :

The capacitor-start motor develops a much higher starting torque(3.0 to 4.5 times the full load torque) than does an equally rated resistance-start motor the value of the starting capacitor must be large and the starting-winding resistance low to obtain a high starting torque.

Because of high VAR rating of the capacitor required, electrolytic capacitors of the order of 250 μF are used. The capacitor C_s is short duty capacitor. The torque-speed characteristic of the motor is shown in figure(c), which also shows that the starting torque is high.

Capacitor start motors have high cost because of the additional cost of the capacitor.

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