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Full Length Test -E19

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2 Marks

Q.1

Sol. Magnetic susceptibility (χ) measures the degree of magnetization (M) of a material in response to an applied magnetic field intensity (H). It is defined as $\chi = M/H$. It indicates whether a material is diamagnetic, paramagnetic, or ferromagnetic based on its value.

Q.2

Sol. It is used in medium and high head plant. In case of sudden load thrown off water hammering effect occur inside the penstock due to sudden closing of control valve. This may damage the penstock, to protect the penstock from water hammering surge tank is used. In case of sudden load demand addition water in the surge tank is used to meet the load demand.

Q.3

Sol. It is defined as the ratio of actual loss during period to the loss assuming maximum current to flow over the same period.

$$\text{Loss load factor (G)} = \frac{\text{Actual loss (kWh) during a period}}{\text{loss (KWh) assuming maximum current to flow over the same period}}$$

Q.4

Sol. Time constant of RC circuit, $\tau = RC$

$$C_{eq} = 1 \text{ F} \parallel 1 \text{ F and connected with series}$$

$$C_{eq} = 2 \text{ F} \parallel 1 \text{ F} = \frac{2}{3} \text{ F}$$

$$R_{eq} = 3 + 3 = 6 \Omega$$

$$\tau = R_{eq} \times C_{eq} = \frac{2}{3} \times 6 = 4 \text{ sec}$$

Q.5

Sol. At $t = \infty$, then $s = 0$

Apply final value theorem at $F(s)$,

$$\lim_{s \rightarrow 0} sF(s) = \lim_{t \rightarrow \infty} f(t) = \frac{1}{2}$$

$$\lim_{s \rightarrow 0} \frac{s^2(s+1)}{s(s+a)} = \frac{1}{2}$$

$$\frac{2(0+1)}{0+a} = \frac{1}{2}$$

$$\frac{2}{a} = \frac{1}{2}$$

$$a = 4$$

Q.6

Sol. This theorem states that the current in branch X due to voltage source in branch Y of a linear bilateral network is same as the current in branch Y when the same voltage source is connected in branch X of the network.

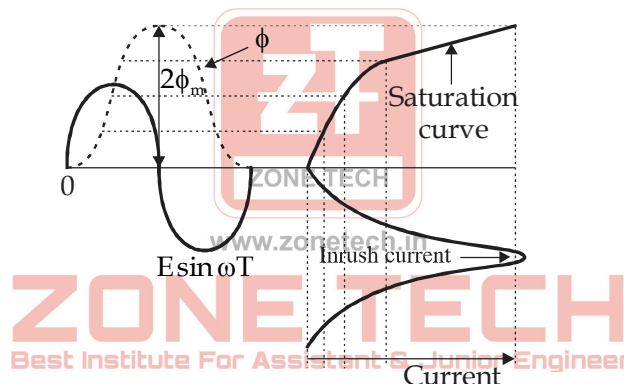
- Only one source should be present in the network.
- Initial condition must be zero.
- Network must be time invariant.
- Dependent source are not permitted.

Q.7

Sol. When commutation take place the coil under-going commutation is short-circuited by the brush. The time period during which the coil remains short-circuits is known as commutation time (T_c). If the reversal of current is completed by the end of commutation time, it is called ideal commutation under ideal condition no sparking will take place between brush and commutator segment. But if the reversal of current is not completed by that time than sparking will occur between brush and commutator segment which results in progressive damage to brush.

Q.8

Sol. Magnetizing inrush current in transformer is the current which is drawn by a transformer at the time of energizing the transformer. This current is transient in nature and exists for few milliseconds. The inrush current may be up to 10 times higher than normal rated current of transformer. The transformer inrush current is the maximum instantaneous current drawn by the primary of the transformer when their secondary is open circuit.



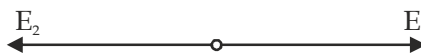
From the above figure, it is clear that inrush current is maximum when the supply voltage is switched on at zero voltage value.

Q.9

Sol. Detent Torque is defined as the torque at the maximum load that is applied to the shaft of the motor which is unexcited without causing continuous rotation. It is also known as Restraining Torque and is produced in the rotor of the permanent magnet motor.

Q.10

Sol. When two alternators are in exact synchronism, the two alternators have equal induced emfs which are in exact phase opposition, as shown in Fig. No circulating current flows round the local circuit.



So, synchronizing power then will be zero.

Q.11

Sol. The vector magnetic potential A is defined such that curl of vector magnetic potential is the flux density.

$$\vec{B} = \nabla \times \vec{A}$$

The definition requires that $\nabla \cdot \vec{B} = 0$. The vector magnetic potential $\vec{A}$ serves as an intermediate quantity from which $\vec{B}$ and hence $\vec{H}$ can be obtained. It is measured in Wb/m.



Q.12

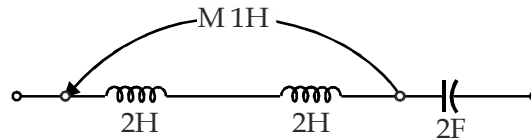
Sol. Infinite bus: Infinite bus concept is a simplifying assumption that is applied to buses or nodes with an infinite upstream fault capacity. The voltage at this bus or node is always constant and any downstream disturbances do not affect the voltage. In an infinite bus :

1. System frequency is constant, independent of power flow.
2. System voltage is constant, independent of reactive power consumed.

Q.13

Sol.

Given series circuit



$$L_{eq} = L_1 + L_2 = 2M$$

($\therefore$ Connected in subtractive polarity)

$$= 2 + 2 - 2 = 2$$

$\therefore$ Resonant frequency of the circuit

$$f_0 = \frac{1}{2\pi\sqrt{L_{eq}C}} = \frac{1}{2\pi\sqrt{2-2}} = \frac{1}{4\pi} \text{ Hz}$$

Q.14

Sol.

$$\begin{aligned} I_1 &= 2V_1 + V_2 \\ I_2 &= V_1 + V_2 \end{aligned}$$

Given equation of admittance parameter

$$[\text{Impedance}] = [\text{Admittance}]^{-1}$$

$$Y = \text{admittance matrix} = \begin{bmatrix} 2 & 1 \\ 1 & 1 \end{bmatrix}$$

$$[Y]^{-1} = \frac{\begin{bmatrix} 1 & -1 \\ -1 & 2 \end{bmatrix}}{1}$$

$$[Z] = \begin{bmatrix} 1 & -1 \\ -1 & 2 \end{bmatrix}$$

Q.15

Sol. $V_1 = 200 \text{ V}$, $V_2 = 200 \text{ V}$, $P_1 = 200 \text{ W}$, $P_2 = 50 \text{ W}$

Resistance of first filament lamps,

$$R_1 = \frac{V_1^2}{P_1} = \frac{200^2}{200} = 200 \Omega$$

And resistance of second filament lamps,

$$R_2 = \frac{V_2^2}{P_2} = \frac{200^2}{50} = 800 \Omega$$

If both lamps are connected in series then,

$$P = \frac{V^2}{V_{\text{total}}} = \frac{200^2}{800 + 200} = \frac{200^2}{1000} = 40 \text{ W}$$

Q.16

Sol. The main function of series reactors in power system is to bring down the fault level; series reactors are used as current limiting reactors to increase the impedance of a system. They are also used for neutral earthing.

Q.17

Sol. The main property of the R-L driving point impedance function is that the impedance at $s = \infty$ is always greater than the impedance at $s = 0$. poles and zeroes lie along negative (-ve) real axis and they are alternate. Zero lie nearest to the origin and pole away from the origin.

Q.18

Sol.

$$\text{S.R.} = \frac{\text{No load speed} - \text{Full load speed}}{\text{Full load speed}}$$

$$N_0 = N_{fl} + 10\% \text{ of } N_{fl} \quad (N_0 > N_{fl})$$

$$= 750 + \frac{10}{100} \times 750$$

$$= 750 + 75$$

$$= 825 \text{ rpm}$$

Q.19

Sol. in totating electrical machines, reluctance torque is produced when the reluctance, seen by the working flux, changes with the rotor movement.

Q.20

Sol. The maximum active power transfer capability of transmission line at a given surge impedance (Z_s) is called surge impedance loading. It is measured in watt or kW.

$$V_s = V_R$$

$$X = Z_s$$

In that condition

$$\text{SIL} = \frac{V_s^2}{Z_s}$$



5 Marks

Q.21

Sol. V- Curve shows the Effect of excitation on armature current for constant power output.
Inverted V- Curve shows the Effect of excitation on power factor for constant power output.

$P = \text{constant}$

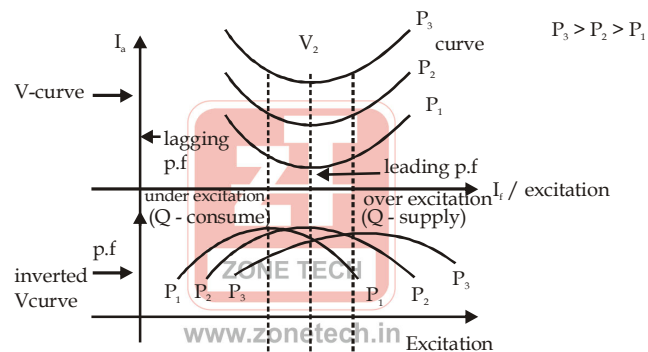
$V = \text{constant}$

$$\frac{EV}{X} \sin \delta = \text{const}$$

$$E \sin \delta = \text{const}$$

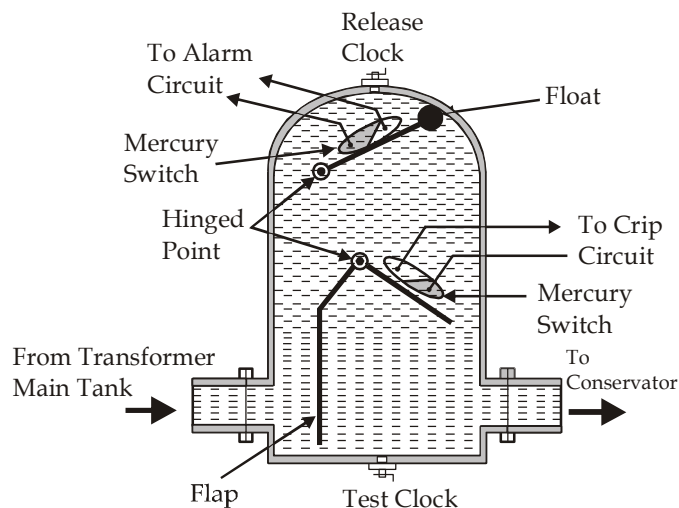
$$VI_a \cos \theta = \text{constant}$$

$$I_a \cos \theta = \text{constant}$$



Q.22

Sol. It is a gas actuated relay
It is usually installed in the pipe connected between conservator and the main T/F tank.
It is used for oil immersed T/F of rating more than 750 kVA



The upper element consist of a mercury type switch attach to a float

The lower element consist of a mercury switch mounted on a flap located in the direct path of the flow of oil is a serious fault occur in the transformer gas is generated.

When a fault take place in T/F. The oil as the tank get overheated ad gases are formed. The generation of gases is depending upon the fault is or the major (heavy short CKT)

Q.23

Sol.

$$Z(s) = \frac{(s+2)(s+4)}{(s+1)(s+3)} = \frac{s^2 + 6s + 8}{s^2 + 4s + 3}$$

$$M_1 = s^2 + 8, N_1 = 6s$$

$$M_2 = s^2 + 3, N_2 = 4s$$

$$M_1 M_2 - N_1 N_2 \geq 0$$

$$(s^2 + 8)(s^2 + 3) - 6s4s \geq 0$$

$$s^4 - 13s^2 + 24 \geq 0$$

$$\omega^4 + 13\omega^2 + 24 \geq 0$$

Z(s) positive real.

Q.24

Sol. Given: Load capacity

$$P_1 = 100 \text{ MW}$$

$$P_2 = 125 \text{ MW}$$

Loss coefficient

$$B_{11} = 10^{-3} \text{ MW}^{-1}$$

For system having two generating unit-

As we know loss formula-

$$P_L = P_1^2 B_{11} + P_2^2 B_{22} + 2P_1 P_2 B_{12}$$

Load connected at plant 2

So,

$$B_{12} = B_{22} = 0$$

$$P_L = P_1^2 B_{11}$$

$$\frac{\partial P_L}{\partial P_1} = 2P_1 B_{11} = 2 \times 100 \times 10^{-3} = 0.2$$

Penalty factor for plant 1-

$$\lambda_1 = \frac{1}{1 - \frac{\partial P_L}{\partial P_1}}$$

$$\lambda_1 = \frac{1}{1 - 0.2} = \frac{10}{8} = 1.25$$

Similarly,

$$\frac{\partial P_L}{\partial P_2} = 0$$



Penalty factor for plant - 2

$$\lambda_2 = \frac{1}{1 - \frac{\partial P_L}{\partial P_2}}$$

$$\lambda_2 = \frac{1}{1 - 0} = 1$$

$$\lambda_1 = 1.25 \text{ and } \lambda_2 = 1$$

Q.25

Sol. $H_1 = 6 \text{ MJ / MVA},$

$$f = 50 \text{ Hz}$$

$$H_2 = 4 \text{ MJ / MVA}$$

$$P_1 = 1.0 \text{ pu},$$

$$P_2 = 0.6 \text{ pu}$$

Then angular acceleration,

$$\frac{H_1 \times H_2}{H_1 + H_2} \times \frac{1}{180f} \cdot \frac{d^2 \delta_{12}}{dt^2} = P_1 - P_2$$

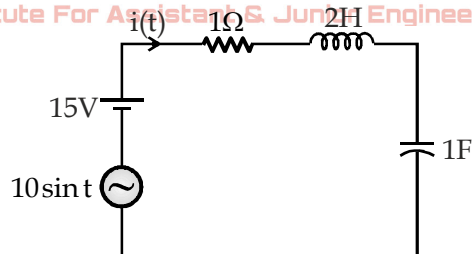
$$\frac{6 \times 4}{6 + 4} \times \frac{1}{180 \times 50} \cdot \frac{d^2 \delta_{12}}{dt^2} = 1.0 - 0.6$$

On solving,

$$\frac{d^2 \delta_{12}}{dt^2} = 1500 \text{ elec.degree / s}^2.$$

Q.26

Sol:



By the DC source, $\omega = 0$

$\therefore$

$i(t) = 0$ $i(t) = 0$ capacitor is open circuit.

By the AC source $10 \sin t$.

$$\omega = 1$$

$$Z = R + j\omega L - \frac{1}{j\omega C}$$

$$Z = 1 + j \times 1 \times 2 - \frac{1}{j \times 1 \times 1} = 1 + j$$

$$i(t) = \frac{V}{Z} = \frac{10 \sin t}{(1 + j)} = 7.07 \sin(t - 45^\circ)$$

Q.27

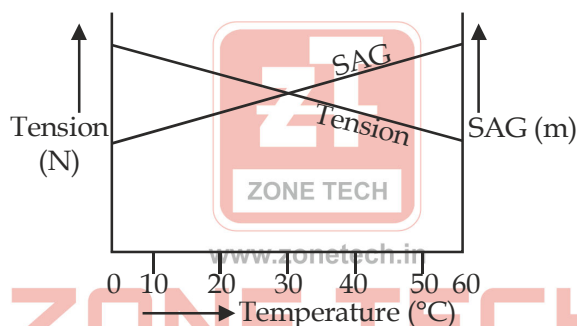
Sol. Maxwell's equations in free space (no free charges, no free currents) are:

- $\nabla \cdot \vec{E} = 0$
- $\nabla \cdot \vec{B} = 0$
- $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$
- $\nabla \times \vec{B} = \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t}$

These equations describe the relationship between the electric field ($\vec{E}$), magnetic field ($\vec{B}$), and how they propagate as electromagnetic waves in free space.

Q.28

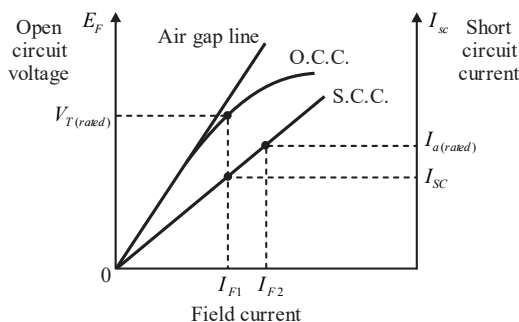
Sol. **Stringing chart:** it shows the effect of temperature on the sag and the tension of a given transmission line under loading conditions. This graph is called a stringing chart.



From the stringing chart, the sag and tension, can be obtained at any given temperature. The data for sag and tension to be allowed at a particular temperature too can be determined from this chart. When erecting transmission line conductors, the correct adjustment of sag and tension can, therefore, be ensured by consulting a stringing chart.

Q.29

Sol: **Short circuit ratio** is defined as the ratio of the field current required to produce rated voltage on open circuit to the field current required to produce rated armature current on short circuit while the machine mechanically runs at synchronous speed.



$$SCR = \frac{I_F \text{ at } V_{T(rated)}}{I_F \text{ at } I_{a(rated)}}$$



$$SCR = \frac{I_{F1}}{I_{F2}} = \frac{I_{SC}}{I_{a(rated)}} \quad \{I_F \propto I_{SC}\}$$

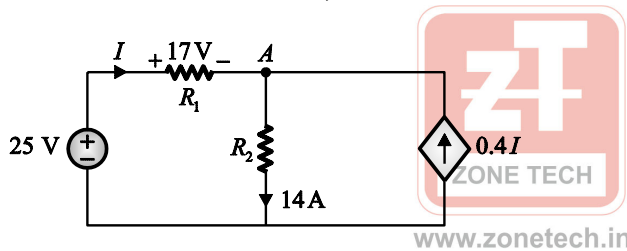
$$I_{SC} = \frac{V_{T(rated)} / \sqrt{3}}{X_{S(saturated)}}$$

$$I_{a(rated)} = \frac{V_{T(rated)} / \sqrt{3}}{X_{(rated)}}$$

$$SCR = \frac{X_{(rated)}}{X_{S(saturated)}} = \frac{1}{X_{S(saturated)}} \text{ pu}$$

Q.30

Sol. Given circuit is shown below,



Applying KCL at node A,

$$I + 0.4I - 14 = 0$$

$$I = 10 \text{ A}$$

Power supplied/delivered by the 25 V source is given by,

$$P_{25 \text{ V}} = 25 \times I$$

$$P_{25 \text{ V}} = 25 \times 10 = 250 \text{ W}$$

Hence, the power supplied/delivered by the 25 V source is 250 W.

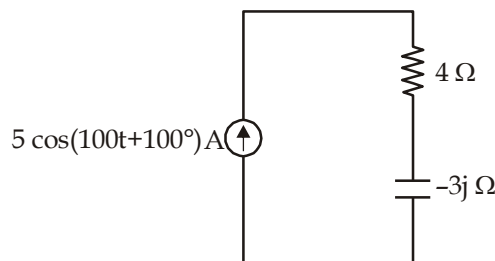
Hence, the power supplied/delivered by the 25 V source is **250 W**.

Q.31

Sol Given,

$$i(t) = 5 \cos(100\pi t + 100^\circ) \text{ A and } Z = 4 - j3$$

The impedance Z represents a series RC circuit as under,



rms value of current, $I_{\text{rms}} = \frac{5}{\sqrt{2}}$

Average power consumed by a capacitor is zero. Average power consumed by an impedance is the power consumed by resistive component only. So, average power delivered to given impedance can be given as,

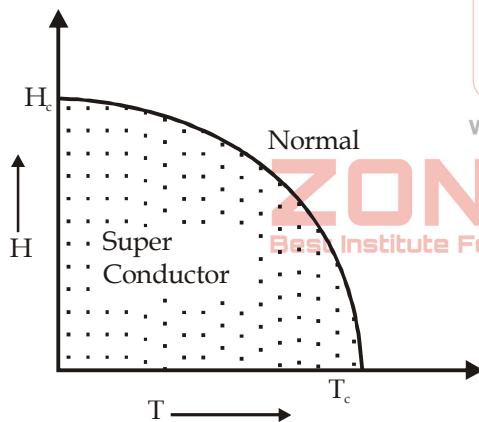
$$P = I_{\text{rms}}^2 \operatorname{Re}\{Z\}$$

$$\Rightarrow P = \left(\frac{5}{\sqrt{2}}\right)^2 \times 4 = 50 \text{ W}$$

Q.32

Sol. **Type-I (Soft Superconductor)**

1. The type-I super conductor becomes a normal conductor abruptly at critical magnetic field
2. Here we have only one critical field (H_c).
3. No mixed state exists.
4. Highest known critical field is 0.1 Tesla
5. Magnetic phase diagram



Type-II (Hard) Superconductor

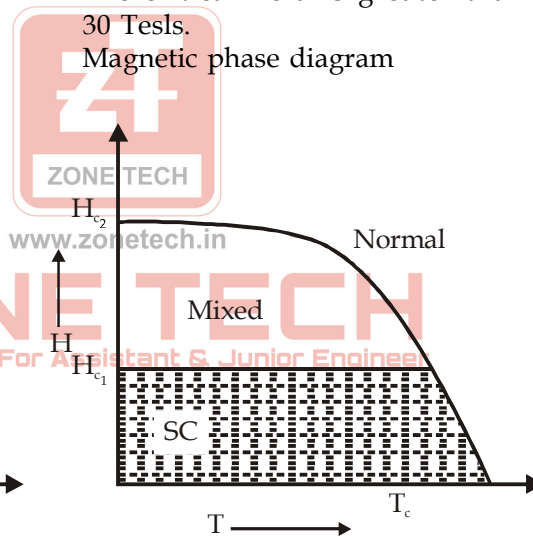
Type-II super conductor loss its super conducting property gradually, due to increase in magnetic field.

Here we have two critical fields (i.e.) Lower critical fields (H_{c1}) and Upper critical field (H_{c2}).

Mixed (or) vortex state is present.

The critical field is greater than type 1 (i.e.) upto 30 Tesls.

Magnetic phase diagram



6. Examples: Pb, Zn, Al, Zn, Ga, Hg

Examples Niobium, Vanadium

20 Marks

Q.33

Sol. Grading of a cable is the process of achieving uniform electrostatic stress in the dielectric of cable. This is achieved by making potential gradient equal throughout the dielectric layer. It can be done in two ways

- (i) capacitance grading
- (ii) Inter sheath grading.

Due to the Grading of cable Uniform stress in dielectric and there is Reduction in quantity of insulation.

$$V_r = 6.6 \text{ kV},$$

$$d = 1.5 \text{ cm}, r = \frac{d}{2} = 0.75 \text{ cm},$$

$$D = 3 \text{ cm}, R = \frac{D}{2} = 1.5 \text{ cm},$$

$$\rho = 1.3 \times 10^{12} \Omega\text{-m},$$

$$\epsilon_r = 3.5$$

Line length, $l = 4 \text{ km}$

(a) Insulation resistance is given by,

$$R_{\text{ins}} = \frac{\rho}{2\pi l} \ln \frac{R}{r}$$

$$R_{\text{ins}} = \frac{1.3 \times 10^{12}}{2\pi \times 4 \times 10^3} \times \ln \left(\frac{1.5}{0.75} \right)$$

$$R_{\text{ins}} = 3.585 \times 10^7 = 35.85 \text{ M}\Omega$$

Hence, the insulation resistance is $35.85 \text{ M}\Omega$.

(b) Capacitance of cable is given by,

$$C = \frac{2\pi\epsilon_0\epsilon_r}{\ln \frac{R}{r}} = \frac{2\pi \times 8.854 \times 10^{-12} \times 3.5}{\ln \frac{1.5}{0.75}}$$

$$C = 280.9 \times 10^{-12} \text{ F/m}$$

Total capacitance is given by,

$$C_T = C \times l = 280.9 \times 10^{-12} \times 4 \times 10^3$$

$$C_T = 1.123 \times 10^{-6} = 1.123 \mu\text{F}$$

Hence, the capacitance is $1.123 \mu\text{F}$.

(c) Maximum electric stress is given by,

$$g = \frac{V}{r \ln \left(\frac{R}{r} \right)} = \frac{\frac{6.6 \times 10^3}{\sqrt{3}}}{0.75 \times 10^{-2} \times \ln \left(\frac{1.5}{0.75} \right)}$$

$$g = 7.329 \times 10^5 \text{ V/m} = 732.9 \text{ kV/m}$$

Hence, the maximum electric stress in the insulation is **732.9 kV/m**.

Q.34

Sol.

From the waveform,

$$v(t) = \begin{cases} 1 \text{ V}; & 0 < t \leq 3 \\ -1 \text{ V}; & 3 < t \leq 5 \end{cases}$$

Time period of $v(t)$ is 5.

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{5}$$



Method 1 :

Amplitude of fundamental component,

$$A_1 = \sqrt{a_1^2 + b_1^2} \quad \dots(i)$$

$$a_1 = \frac{2}{T} \int_0^T v(t) \cos \omega t \, dt$$

$$a_1 = \frac{2}{5} \left[\int_0^3 1 \cdot \cos\left(\frac{2\pi}{5}t\right) dt + \int_3^5 (-1) \cos\left(\frac{2\pi}{5}t\right) dt \right]$$

$$a_1 = \frac{2}{5} \left[\left\{ \frac{\sin\left(\frac{2\pi}{5}t\right)}{\left(\frac{2\pi}{5}\right)} \right\}_0^3 - \left\{ \frac{\sin\left(\frac{2\pi}{5}t\right)}{\left(\frac{2\pi}{5}\right)} \right\}_3^5 \right]$$

$$a_1 = \frac{2}{5} \left[\frac{5}{2\pi} \left\{ \sin\left(\frac{6\pi}{5}\right) - 0 \right\} - \frac{5}{2\pi} \left\{ \sin 2\pi - \sin \frac{6\pi}{5} \right\} \right]$$

$$a_1 = \frac{2}{5} \times \frac{5}{2\pi} \times \left\{ \sin \frac{6\pi}{5} + \sin \frac{6\pi}{5} \right\}$$

$$a_1 = \frac{2}{\pi} \sin\left(\frac{6\pi}{5}\right) \quad \dots(ii)$$

Similarly,

$$b_1 = \frac{2}{T} \int_0^T v(t) \sin \omega t \, dt$$

$$b_1 = \frac{2}{5} \left[\int_0^3 1 \cdot \sin\left(\frac{2\pi}{5}t\right) dt + \int_3^5 (-1) \cdot \sin\left(\frac{2\pi}{5}t\right) dt \right]$$

$$b_1 = \frac{2}{5} \left[\left\{ \frac{-\cos\left(\frac{2\pi}{5}t\right)}{\left(\frac{2\pi}{5}\right)} \right\}_0^3 - \left\{ \frac{-\cos\left(\frac{2\pi}{5}t\right)}{\left(\frac{2\pi}{5}\right)} \right\}_3^5 \right]$$

$$b_1 = \frac{2}{5} \left[\frac{5}{2\pi} \left\{ 1 - \cos\left(\frac{6\pi}{5}\right) \right\} - \frac{5}{2\pi} \left\{ -\cos \frac{10\pi}{5} + \cos \frac{6\pi}{5} \right\} \right]$$

$$b_1 = \frac{2}{5} \left[\frac{5}{2\pi} \left\{ 1 - \cos\left(\frac{6\pi}{5}\right) \right\} - \frac{5}{2\pi} \left\{ \cos \frac{6\pi}{5} - 1 \right\} \right]$$

$$b_1 = \frac{2}{5} \times \frac{5}{2\pi} \left[2 \left\{ 1 - \cos \frac{6\pi}{5} \right\} \right]$$

$$b_1 = \frac{2}{\pi} \left\{ 1 - \cos\left(\frac{6\pi}{5}\right) \right\} \quad \dots(iii)$$



From equation (i),

Amplitude of fundamental component,

$$A_1 = \sqrt{a_1^2 + b_1^2}$$

$$A_1 = \sqrt{\left[\frac{2}{\pi} \sin \frac{6\pi}{5}\right]^2 + \left[\frac{2}{\pi} \left(1 - \cos \frac{6\pi}{5}\right)\right]^2}$$

$$A_1 = \sqrt{\frac{4}{\pi^2} \left\{ \sin^2 \frac{6\pi}{5} + 1 - 2 \cos \frac{6\pi}{5} + \cos^2 \frac{6\pi}{5} \right\}}$$

$$A_1 = \frac{2}{\pi} \sqrt{2 \left(1 - \cos \frac{6\pi}{5}\right)}$$

$$A_1 = 1.21 \text{ V} \approx 1.20 \text{ V}$$

Method 2 :

From complex exponential form of Fourier series, the complex coefficient, C_n is,

$$C_n = \frac{1}{T} \int_0^T f(t) e^{-j2\pi n t / T} dt$$

$$C_1 = \frac{1}{5} \int_0^5 v(t) \cdot e^{-j\frac{2\pi t}{5}} dt$$

$$C_1 = \frac{1}{5} \left[\int_0^3 e^{-j\frac{2\pi t}{5}} dt - \int_3^5 e^{-j\frac{2\pi t}{5}} dt \right]$$

$$C_1 = \frac{1}{5} \left[\left\{ \frac{e^{-j\frac{2\pi t}{5}}}{-j\frac{2\pi}{5}} \right\}_0^3 - \left\{ \frac{e^{-j\frac{2\pi t}{5}}}{-j\frac{2\pi}{5}} \right\}_3^5 \right]$$

$$C_1 = \frac{1}{-j2\pi} \left[\left\{ e^{-j\frac{2\pi 3}{5}} - 1 \right\} - \left\{ e^{-j\frac{2\pi 5}{5}} - e^{-j\frac{2\pi 3}{5}} \right\} \right]$$

$$C_1 = \frac{1}{-j2\pi} \left[e^{-j\frac{2\pi 3}{5}} - 1 - 1 + e^{-j\frac{2\pi 3}{5}} \right]$$

$$C_1 = \frac{1}{j\pi} \left[1 - e^{-j\frac{2\pi 3}{5}} \right]$$

$$C_1 = \frac{1}{j\pi} \left[e^{j\frac{\pi 3}{5}} - e^{-j\frac{\pi 3}{5}} \right] e^{-j\frac{\pi 3}{5}}$$

$$C_1 = \frac{2}{\pi} \sin \frac{3\pi}{5} e^{-j\frac{3\pi}{5}}$$

$$|C_1| = \frac{2}{\pi} \left| \sin \frac{3\pi}{5} \right| = 0.6$$

In complex exponential form of Fourier series, half of the power is divided in negative frequencies.

Hence,
$$A_1 = \sqrt{2[|C_1|^2 + |C_{-1}|^2]} = 2|C_1|$$

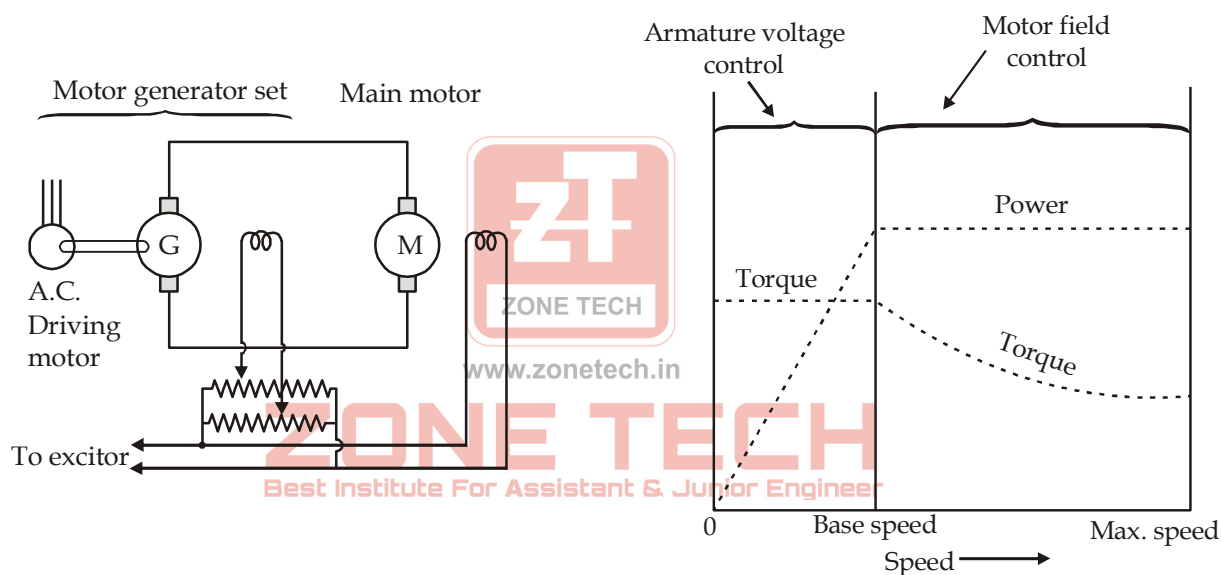
$$|C_{-1}| = |C_1| = 0.6$$

$$A_1 = 2 \times 0.6 \text{ V} = 1.20 \text{ V}$$

Q.35

Sol. Ward-Leonard System:- In this system M is the main d.c. motor whose speed is to be controlled and G is the separately excited d.c. generator driven by a three-phase driving motor (usually an induction motor). Motor speed control is obtained merely by changing the generator field current.

- In order to achieve wider speed control range speeds below base speed are obtained by armature voltage control and above base speed, by field flux control. For better utility of motor M, its armature current I_a is maintained equal to its rated current during its speed control.



- Below base speed, constant torque drive, armature voltage control is applicable for suitable controlling and above base speed, constant power drive, motor field flux control is applicable for suitable controlling. When both types of speed controls are employed, the overall speed range is 40 : 1.

Advantage:

- The advantages of ward-leonard system of speed control are as follows:
 - Its simplicity, wide range and smooth speed control.
 - Speed regulation is quite good.
- Control operations is not costly because its field circuits are low-power circuits.
- Efficiency at low speeds is higher.

Disadvantage:

- Higher initial cost, because three machines having rating equal to the full load output are required.

Q.36

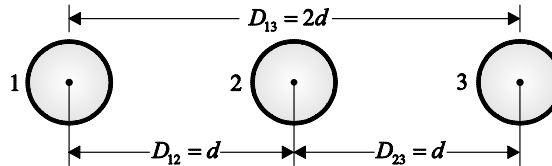
Sol. Advantages of using bundled conductors

- Reduced reactance
- Reduced voltage gradient
- Reduced coronaloss due to large cross-sectional area

- Reduced radio interference
- Reduced characteristic or surge impedance or surge impedance
- Increased characteristic impedance loading
- Improved voltage regulation
- Improved stability margin
- Increased power transmission capacity with reduced power loss leading to increased efficiency of transmission

Case 1: Horizontal spacing

Three conductors of radius r are arranged in flat spacing



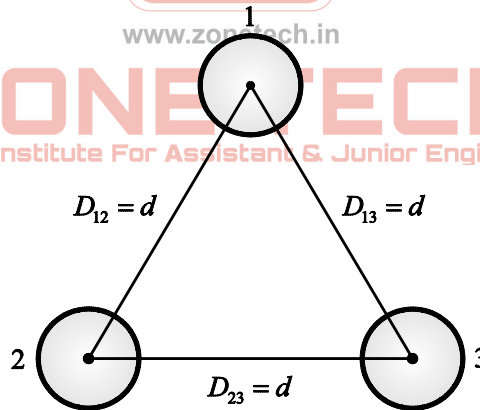
Geometric mean distance,

$$D_m = \sqrt[3]{D_{12} \cdot D_{23} \cdot D_{13}}$$

$$D_m = \sqrt[3]{d \times d \times 2d} = 1.26d$$

Case 2: Equilateral spacing

Three conductors of radius r are arranged in equilateral triangle.



New geometric mean distance,

$$D'_m = \sqrt[3]{D_{12} \cdot D_{23} \cdot D_{13}}$$

$$D'_m = \sqrt[3]{d \times d \times d} = d \quad \dots (ii)$$

From equation (i) and (ii), $D'_m < D_m$

For 3- ϕ overhead transmission line, average capacitance per phase and average inductance per phase are given by,

$$C_{ph} = \frac{2\pi\epsilon_0}{\ln\left(\frac{D_m}{r}\right)} \text{ F/m}$$

$$L_{ph} = 2 \times 10^{-7} \ln\left(\frac{D_m}{r}\right) \text{ H/m}$$

$$C_{ph} \propto \frac{1}{\ln\left(\frac{D_m}{r}\right)} \text{ and } L_{ph} \propto \ln\left(\frac{D_m}{r}\right)$$

From flat horizontal spacing (D_m, C_{ph}, L_{ph}) to equilateral spacing (D'_m, C'_{ph}, L'_{ph})

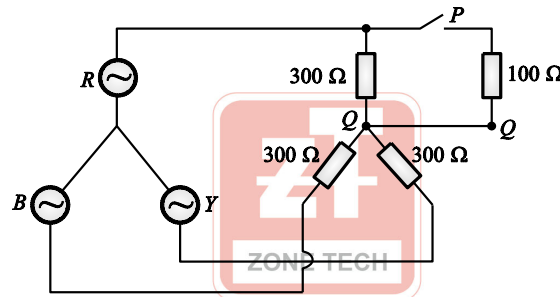
$$D'_m < D_m \Rightarrow C'_{ph} > C_{ph}$$

$$L'_{ph} < L_{ph}$$

average capacitance increases and average inductance decreases.

Q.37

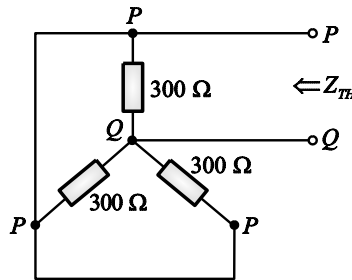
Sol. Given circuit is shown below,



Calculation of Z_{TH} :

(when dependent sources are not present)

Replace all independent sources by their internal resistance, i.e. short circuit all the independent voltage sources ($R_{in} = 0$) and open circuit all the independent current sources ($R_{in} = \infty$).



All resistance 300Ω are in parallel thus, its thevenin equivalent resistance,

$$Z_{TH} = 300 \parallel 300 \parallel 300 = 150 \parallel 300$$

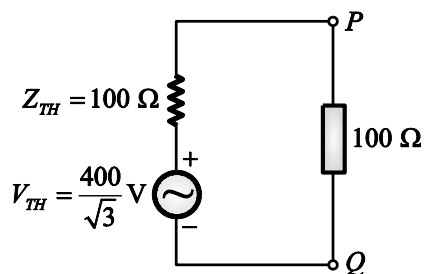
$$Z_{TH} = \frac{150 \times 300}{150 + 300} = \frac{150 \times 300}{450} = 100\Omega$$

Calculation of V_{TH} in star connection, line voltage and phase voltage relation is given below,

$$\text{Line voltage} = \sqrt{3} \times \text{Phase voltage}$$

$$(V_L)_{rms} = \sqrt{3} \times (V_{ph})_{rms}$$

Thevenin's equivalent circuit:



RMS voltage across PQ is,

$$V_{PQ} = 100 \times \frac{\frac{400}{\sqrt{3}}}{100 + 100} \text{ [By VDR]}$$

$$V_{PQ} = \frac{400}{\sqrt{3} \times 2} = \frac{200}{\sqrt{3}} = 115.47 \text{ V}$$

Hence, the rms value of voltage across 100Ω resistor is 115.47 V.



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