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PART - A

2 Marks Questions

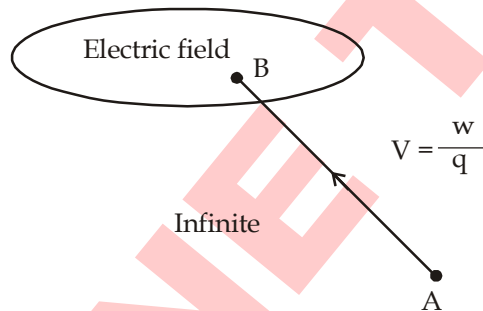
1.
Sol. It is define as the rate of change of charge or flow of current per unit time
2.
Sol. 1 Amp of electric current is equal to the 1 colomb of charge flow in 1 sec is any conducting medium.

$$I = \frac{dq}{dt} \text{ or } \frac{Q}{t} \frac{\text{colomb}}{\text{sec}} \text{ or Amp}$$

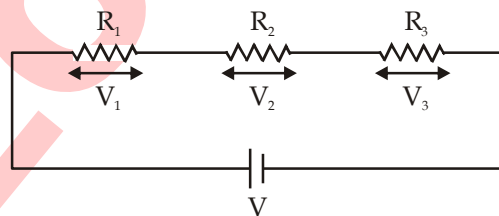
$$I = \frac{Q}{t} \frac{1\text{colomb}}{1\text{sec}} = 1 \text{ Amp}$$

3.
Sol. Total work done to bring a unit +ve charge from infinite to any point is electric field.

$$V = \frac{w}{q} \text{ or } \frac{\text{work done}}{\text{charge}} = \frac{\text{Joule}}{\text{C}} \text{ or volt}$$



4.
Sol.

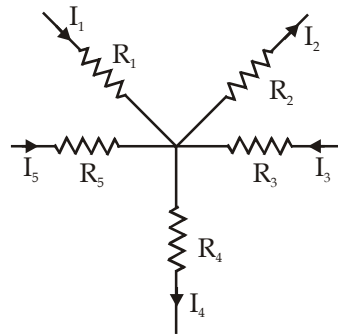


$$V_1 = \left(\frac{R_1}{R_1 + R_2 + R_3} \right) \times V$$

$$V_2 = \left(\frac{R_2}{R_1 + R_2 + R_3} \right) \times V$$

$$V_3 = \left(\frac{R_3}{R_1 + R_2 + R_3} \right) \times V$$

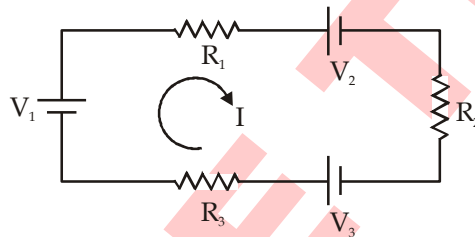
5.
Sol. It is based on conservation of charge. It states that, "The algebraic sum of currents at any node of a circuit is zero".



The sum of total incoming current is equal to the sum of total outgoing current.

$$I_1 + I_3 + I_5 = I_2 + I_4$$

6.
Sol. It is based on conservation of energy. It states that, "The algebraic sum of voltages in any closed path of network that is traversed in any single direction is zero".



$$-V_1 + IR_1 + V_2 + IR_2 - V_3 + IR_3 = 0$$

7.
Sol. Bulbs are designed to operate such that it offers high impedance to AC supply. Normally they have low resistance. When DC supply is applied, due to low resistance, the current through lamp would be so high that it may damage the bulb element.
8.
Sol. An electric network is any possible interconnection of electric circuit elements (e.g. R, L, and C) or branches. An electric circuit is a closed energized network. A network is not necessarily a circuit example T network.
9.
Sol. **Active network:** The network which has no current or voltage source is called passive network.
Passive network: The network which either has current or voltage source is called active network.
10.
Sol. The current through any conductor is directly proportional to the applied potential difference across it keeping physical condition unchanged.
11.
Sol. The resistance is the property of a material to oppose the flow of current in a material. Its unit is ohm.

12.

Sol. The vacuum and gas filled capacitor are used for high voltage and frequency applications.

13.

Sol. It is the property of a material by virtue of which it opposes any change of magnitude and direction of current passing through the conductor.

14.

Sol. The properties are high resistivity, resistance to oxidation, corrosion and moisture.

15.

Sol. It is the ability to store electric charge within it. Capacitance is a measure of charge per unit voltage that can be stored in an element.

16.

Sol. The instantaneous power delivered to circuit elements is the product of the instantaneous value of voltage and current of the element. In terms of energy, power is defined as "The time rate of change of energy is called power".

17.

Sol. The magnetic field intensity of a circuit is given by the mmf per unit length.

$$H = \frac{NI}{l} \text{ AT/m}$$

The magnetic flux density (B) and its intensity (field strength) in a medium can be related by the following equation,

$$B = \mu H$$

where

$\mu = \mu_0 \mu_r$ is the permeability of the medium in Henry/meter(H/m).

μ_0 = Absolute permeability of free space and is equal to $4\pi \times 10^{-7} \text{ H/m}$.

μ_r = Relative permeability of the medium

$\mu_r = 1$ for air and non-magnetic materials.

18.

Sol. The magnetic flux lines start and end in such a way that they form close loops. Weber (Wb) is the unit of magnetic flux(ϕ). Flux density (B) is the flux per unit area. Tesla or Wb/m^2 is the unit of flux density.

$$B = \frac{\phi}{A} \text{ Wb/m}^2 \text{ (or) Tesla}$$

Where B is a quantity called magnetic flux density in tesla, ϕ is the total flux in Webers and A is the area perpendicular to the lines in m^2 .

19.

Ans A measure of the ability of a coil to produce a flux is called the magnetomotive force (mmf). A coil with 'N' turns which is carrying a current of 'I' amperes constitutes a magnetic circuit and produce an mmf of NI ampere turns.

$$\text{MMF} = NI \text{ AT}$$

20.

Ans It is the property of the medium which opposes the passage of magnetic flux. Magnetic reluctance is analogous to resistance in the electric circuit.

Its unit is AT/Wb. Air has a much higher reluctance than iron or steel for this reason, magnetic circuits used in electrical machines are designed with very small air gaps.

$$\text{Reluctance} = \frac{\text{mmf}}{\text{flux}}$$

21.

Ans It is a conducting power for flux, it is a measure of receptiveness of the material of having magnetic flux developed in it. its unit is henry per meter

$$\text{Reluctance } R_l = \frac{l}{\mu A}$$

here μ is the permeability

22.

Sol. The property of coil due to which it opposes any increase or decrease of current or flux through it is called self-inductance.

23.

Sol. Mutual-inductance is the property of two coils because of which each opposes any change in the current flowing through the other by developing an induced emf.

24

Sol. **Active:-** Which generates electrical energy. These element acts as source.

Eg. Voltage source, current source.

Passive:- Which consumes electrical energy they acts as load.

Eg. Resistance, Inductance, Capacitance

25

Sol. **Linear:** A linear network is one for which the principle of superposition holds. If V- I characteristics is a straight line passing through origin, then it is called linear element.

Non-linear:- If V-I characteristics is not straight line then it is called Non-linear element.

26

Sol.

Unidirectional element: When element properties and characteristics depend on direction of current then the element is called as unidirectional element.

Bidirectional Element:

When element characteristics and properties are dependent of direction of the current then the element is called as bidirectional element.

27.

Sol. **lumped network**

A network in which physically separate resistors, capacitors and inductors can be represented.

distributed network

A network in which resistors, capacitors and inductors cannot be electrically separable and isolated as individual elements. A transmission line has distributed resistor, inductor and capacitor which are not isolated from the network.

28.

Sol. A generator which maintains its output current independent of the voltage across its terminals. It is indicated by a circle enclosing an arrow for reference current direction. An ideal current source has infinite internal resistance.

29.

Sol. A generator which maintains its value of potential independent of the output current. An AC source is indicated by a circle enclosing a wavy line. An ideal voltage source has zero internal resistance.

30.

Sol. Ideally the internal resistance of a voltmeter should be infinite and ideally the internal resistance of an ammeter should be zero.

31.

Sol. **D.C. quantity :-** The quantities which magnitude and direction remains constant irrespective to the time are called DC quantity.

A.C. quantity :- The quantity which magnitude and direction changes with time are called alternating current quantity.

32.

Sol. Time constant is defined as the time required by inductor for discharging current to remain 36.7% of initial current.

33.

Sol. The current through an inductor cannot change instantaneously. If an energy source is suddenly connected to an inductor then it will not cause current to flow initially. Thus inductor acts as open circuit for the new applied source at the instant of switching. If a current of value I_0 flows in the inductor at the instant switching takes place, that current will continue to flow. For the initial instant, the inductor may be considered as a current source of current I_0 .

34.

Sol. The voltage across a capacitor cannot change instantaneously. Since, we have $V = q/c$, hence zero charge corresponds to zero voltage. Thus for a suddenly applied energy source, voltage across capacitor is initially zero i.e. equivalent to a short circuit. Hence on connecting an uncharged capacitor to an energy source, a current flows instantaneously. But with an initial charge in the system, the capacitor is equivalent to a voltage source of value $V_0 = q_0/C$, where q_0 the initial charge.

35.

Sol. This theorem states that a linear, bilateral network consisting of active and passive elements can be replaced by a voltage source connected in series with impedance. The value of voltage source is equal to the open circuited voltage seen across the terminals and the impedance is equal to the impedance seen across the open circuited terminals with all sources replaced by their internal impedances.

36.

Sol. Thevenin's theorem is very useful in linear network analysis because using Thevenin's theorem a large part of network, often a complicated and uninteresting part, can be replaced by a very simple equivalent which enables us to make rapid calculations. It is very useful when it is desired to determine the current through or voltage across any one element in a network instead of going through the lengthy method of solving the network.



37.

Sol. All independent voltage sources are short circuited and all independent current sources are open circuited.

38.

Sol. This theorem states that the voltage across or current through any element due to multiple sources present in a linear network is equal to the algebraic sum of voltage across or current through that element due to individual source with all other sources replaced by their internal impedances.

39.

Sol.

Superposition theorem is very useful in linear network analysis because a complex network can be solved easily by breaking it in simpler networks and using superposition theorem. This theorem is very useful to calculate the voltage and current when more than one active source is present in the network.

40.

Sol. It states that for any given time, the sum and power delivered to each branch of any electric network is zero. In other words, the summation of instantaneous power or summation of complex power of sinusoidal sources in a electrical network is zero. Tellegen's theorem is applicable for any lumped network having elements which are linear or non-linear, active or passive, time-varying or time-invariant.

41.

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.

42.

Sol. This theorem states that, any number of current sources in parallel may be replaced by a single current source, whose current is the algebraic sum of individual source currents and source resistance is the parallel combination of individual source resistance.

43.

Sol. Electrical resonance occurs in an electric circuit at a particular resonant frequency when the imaginary parts of impedances and admittances cancels out each other. In some circuit, this happens when the impedance between the input and output of the circuit is almost zero and the transfer function is close to one.

44.

Sol. Q-factor is a dimensionless parameter that describes how underdamped an oscillator or resonator is, and characterizes a resonator's bandwidth relative to its centre frequency. It is expressed by:

$$Q = 2\pi \times \frac{\text{Energy stored}}{\text{Energy dissipated per cycle}}$$

45.

Sol. The study of resonance is very useful in the area of communication particularly. For example, the ability of a radio receiver to select a certain frequency transmitted by a station and to eliminate frequencies from other stations is based on the principle of resonance.

46.

Sol. A filter is an electrical network that can transmit signals within a specified frequency range.

47.

Sol. The active filter contains components like operational amplifier that introduce some gain in the signal.

48.

Sol. The Filter is used in voice frequency telegraphy, multi channel communication, TV broadcasting and telephony.

49.

Sol. An ideal filter would transmit signals under the pass-band frequencies without attenuation and completely suppress the signal with attenuation band of frequencies with a sharp cut-off profile.

50.

Sol. The frequency that separates the pass and attenuation band is known as cut-off frequency.

51.

Sol. This filter is a combination of two parallel tuned circuits. This is a special type of LC filter along with a particular BW frequency to be allowed through it.

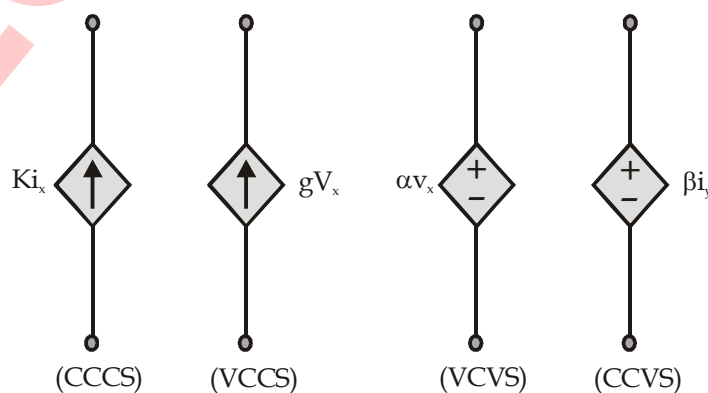
PART - B

5 Marks Questions

52.

Sol.: **Dependent or Controlled Source** are of the following types:

- (i) Voltage controlled voltage source (VCVS)
- (ii) Current controlled voltage source (CCVS)
- (iii) Current controlled current source (CCCS)
- (iv) Voltage controlled current source (VCCS)



In a controlled source the voltage or current (depending upon the type of source) is not constant but is dependent on a voltage or current at some other location in the network.

53.

Sol. Let suffix 1 represent lead and suffix 2 represent iron. We are given that

$$\rho_1 / \rho_2 = 49/24; \text{ if } i_2 = 1, i_1 = 1.8; \text{ if } L_1 = 1, L_2 = 1.47$$

Now, $R_1 = \rho_1 \frac{L_1}{A_1}$ and $R_2 = \rho_2 \frac{L_2}{A_2}$

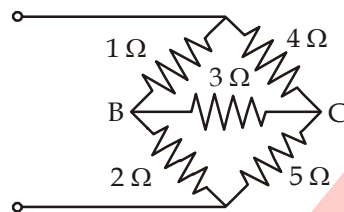
Since the two wires are in parallel, $i_1 = V/R_1$ and $i_2 = V/R_2$

$$\therefore \frac{i_2}{i_1} = \frac{R_1}{R_2} = \frac{\rho_1 L_1}{A_1} \times \frac{A_2}{\rho_2 L_2}$$

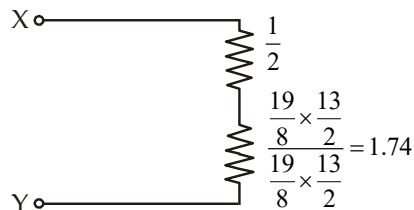
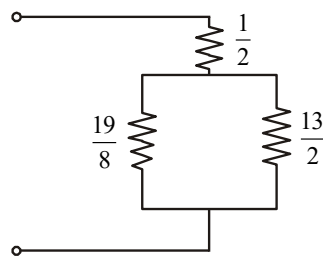
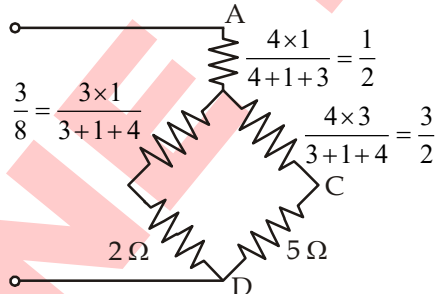
$$\therefore \frac{A_2}{A_1} = \frac{i_2}{i_1} \times \frac{\rho_2 L_2}{\rho_1 L_1} = \frac{1}{1.8} \times \frac{24}{49} \times 1.47 = 0.4$$

54.

Sol.



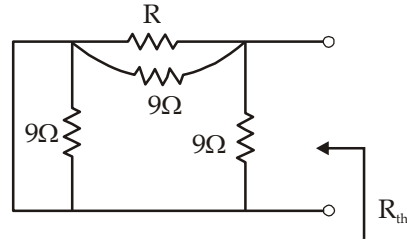
Converting Delta connection into star connection



$$R_{eq} = 0.5 + 1.74 = 2.24\Omega$$

55.

Sol.



R_{th} is calculated by shorting the voltage source and converting star into delta network.

$$R_{th} = \frac{9R}{9+R} \parallel 9 = \frac{9R}{2R+9}$$

For maximum power transfer,

$$R_{th} = R_L = 6 \Omega$$

$$\frac{9R}{2R+9} = 6$$

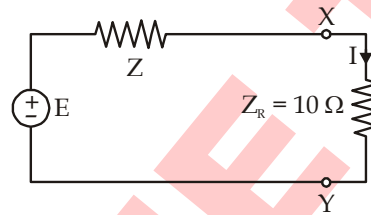
$$9R = 12R + 54$$

$$R = -18$$

The calculated value is negative this value is not possible hence the value of R is 0ohm

56.

Sol.



Where

$$E = \frac{E_1 Y_1 + E_2 Y_2 + E_3 Y_3}{Y_1 + Y_2 + Y_3}$$

$$= \frac{1 \times \frac{1}{1} + 2 \times \frac{1}{2} + 3 \times \frac{1}{3}}{\frac{1}{1} + \frac{1}{2} + \frac{1}{3}} = \frac{18}{11} \text{ volt}$$

$$Z = \frac{6}{11} \Omega$$

$$\therefore I = \frac{E}{Z + Z_R} = \frac{9}{58} A$$

57.

Sol.:

$$V_L = 400 V$$

for star connection

$$V_{ph} = \left(\frac{400}{\sqrt{3}} \right) = 231V;$$

$$R_{ph} = 10\Omega$$

$$I_{ph} = 231/10 = 23.1 A$$

$$P_{star} = 3 V_{ph} I_{ph} \cos \phi = 3 \times 231 \times 23.1$$

$$[\cos \phi = 1]$$

$$= 16kW$$

and

for Δ connection

$$V_{ph} \text{ for } \Delta \text{ connection is } 400 V$$

$$I_{ph} = \frac{400}{10} = 40 A$$

$$P_{delta} = 3 V_{ph} I_{ph} \cos \phi = 3 \times 400 \times 40 = 48kW$$

Note that the power consumed in Δ connection is three times the power consumed in star connection.

58.

Sol. Let the voltage in the a.c. circuit be $v = V_m \cos \omega t$ and the current $i = I_m \cos (\omega t - \phi)$ where the phase angle may be positive or negative according leading or lagging current.

$$\text{Instantaneous power} = vi = V_m \cos \omega t \cdot I_m (\cos \omega t - \phi)$$

$$= \frac{1}{2} V_m I_m [\cos \phi + \cos(2\omega t - \phi)]$$

The average of $\cos(2\omega t - \phi)$ is zero so that,

$$\text{average power in a.c. circuit} = \frac{1}{2} V_m I_m \cos \phi$$

$$\text{Rms value of } v = V = \frac{V_m}{\sqrt{2}}$$

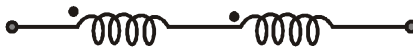
$$\text{Rms value of } i = I = \frac{I_m}{\sqrt{2}}$$

$$\text{Average power in a.c. circuit} = \frac{1}{2} V_m I_m \cos \phi = \left(\frac{V_m}{\sqrt{2}} \right) \left(\frac{I_m}{\sqrt{2}} \right) \cos \phi$$

$$= VI \cos \phi$$

59.

Sol.:



$$L_{eq1} = L_1 + L_2 + 2M = (2 \times 5 + 2 \times 2) \text{ mH} = 14 \text{ mH}$$

and



$$L_{eq2} = L_1 + L_2 - 2M = (2 \times 5 - 2 \times 2) \text{ mH} = 6 \text{ mH}$$

$$\text{Maximum ratio} = \frac{L_{eq1}}{L_{eq2}} = \frac{14}{6} = 2.33$$



60.

Sol.:

$$\begin{aligned}\text{reluctance } R_l &= \frac{l}{\mu A} \\ &= \frac{2\pi \times 10 \times 10^{-2}}{4\pi \times 10^{-7} \times 800 \times 50 \times 10^{-4}} \\ &= 1.25 \times 10^6 \text{ AT/wb}\end{aligned}$$

$$NI = \phi \times R_l$$

$$I = \frac{\phi}{N} \times R_l$$

$$\begin{aligned}&= \frac{2 \times 10^{-3} \times 1.25 \times 10^6}{100} \\ &= 25 \text{ A}\end{aligned}$$

61.

Sol :

ON state

$$R_{\text{ON}} = \frac{(V)^2}{P} = \frac{(240)^2}{40} = 1440 \Omega$$

$$R_t = R_0 [1 + \alpha \delta t]$$

$$1440 = 120 [1 + 4.5 \times 10^{-3} (t - 26)]$$

$$12 = 1 + 4.5 \times 10^{-3} (t - 26)$$

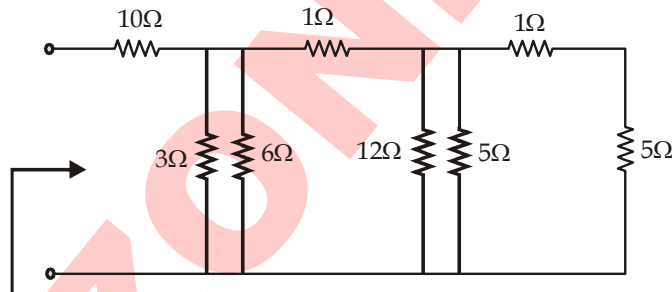
$$4.5 \times 10^{-3} (t - 26) = 11$$

$$\Rightarrow t - 26 = 11 / 4.5 \times 10^{-3}$$

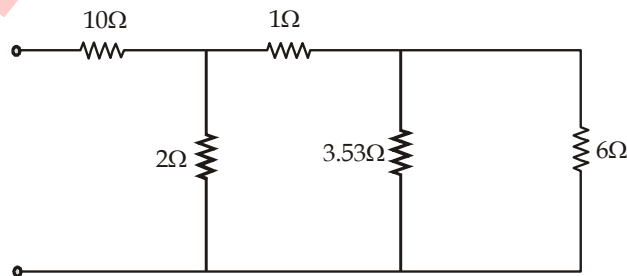
$$\Rightarrow t_{\text{final}} = 2470.4^\circ \text{C}$$

62.

Sol:-



$$R_{ab} = \left[\left[\{ (5+1) \} \parallel \{ (12 \parallel 5) \} + 1 \right] \parallel \{ (6 \parallel 3) \} + 10 \right]$$



$$R_{ab} = \left[\{ 6 \parallel 3.53 \} + 1 \right] \parallel 2 + 10$$

$$R_{ab} = 11.37 \Omega$$



63.

Sol:

The given signal is mathematically described as follows:-

$$v(t) = V_m \sin \omega t, 0 \leq \omega t \leq \pi$$

The average value for $T = \pi$ is $V_{av} = \frac{1}{T} \int_0^T v(t) dt$

$$= \frac{1}{\pi} \int_0^{\pi} V_m \sin \omega t d(\omega t) = 2V_m / \pi.$$

The RMS value is as follows:

$$V_{rms} = \sqrt{\frac{1}{\pi} \int_0^{\pi} (V_m \sin \omega t)^2 d(\omega t)} = V_m / \sqrt{2}$$

64.

Sol.: In circuit of

$$Y_L = \frac{1}{10 + j10} \text{ mho} = \frac{10 - j10}{100 + 100} = \frac{10}{100} - j \frac{10}{200}$$

and

$$Y_C = \frac{1}{R_C - j2} = \frac{R_C + j2}{R_C^2 + 4} \text{ mho}$$

at resonance, imaginary part of equivalent of Y_L and Y_C must be equal to zero

$$\text{i.e., } -j \frac{10}{200} + j \frac{2}{R_C^2 + 4} = 0$$

This gives $R_C = 6 \text{ ohm}$.

65.

Sol.

$$V(t) = 30 t^2, t > 0$$

$$= 0, t < 0$$

$$L = 6 \text{ H}$$

$$V_L = L \frac{di}{dt}$$

$$i = \frac{1}{L} \int V_L dt$$

$$= \frac{1}{6} \int V_L dt$$

$$= \frac{1}{6} \int 30 t^2 dt$$

$$= 5 \frac{t^3}{3} \Big|_0^5$$

$$i = 1.67 (5)^3 = 208.33 \text{ Amp}$$

$$E = \frac{1}{2} L i^2$$

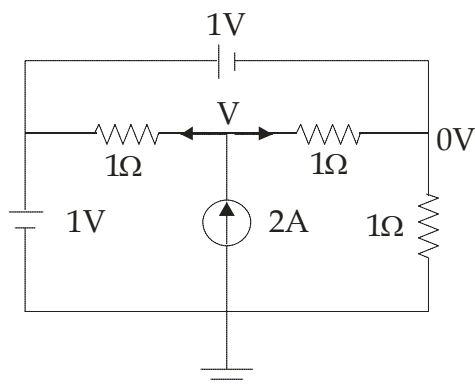
$$= \frac{1}{2} \times 6 \times (208.33)^2$$

$$= 130.21 \text{ kilo joule}$$



66.

Sol.



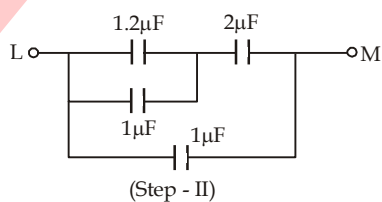
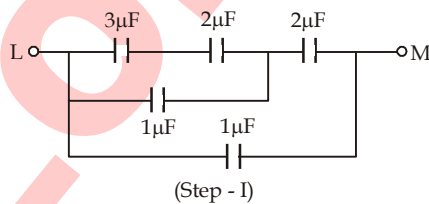
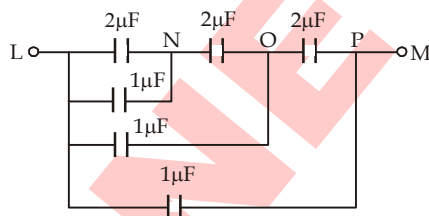
$$2 = \frac{V-1}{1} + \frac{V}{1}$$

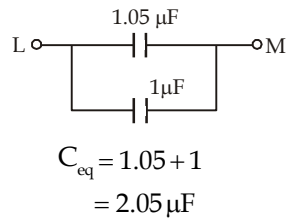
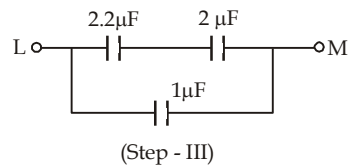
$$V = \frac{3}{2}$$

$$P = \frac{3}{2} \times 2 = 3W$$

67.

Sol.





68.

Sol.

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

$$f_0 = \frac{1}{2\pi}$$

As $L = 1$ and $C = 1$

$$1. \quad Q = \frac{1}{R} \sqrt{\frac{L}{C}} = \frac{1}{0.25} \sqrt{\frac{1}{1}} = 4$$

$$2. \quad \text{Bandwidth } (f_2 - f_1) = \frac{f_0}{Q} = \frac{1}{8\pi} \text{ Hz}$$

$$3. \quad \delta = \frac{1}{2Q} = \frac{1}{2 \times 4} = \frac{1}{8\pi} \text{ Hz}$$

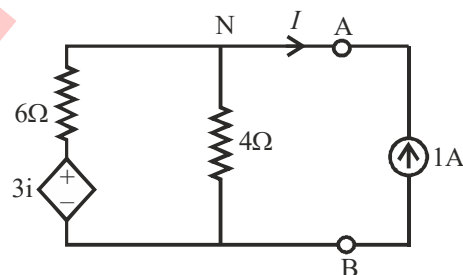
$$4. \quad \text{Under resonance}$$

$$Z = R$$

$$I = \frac{V}{R} = \frac{9/\sqrt{2}}{0.25} = \frac{36}{\sqrt{2}} = 25.2$$

69.

Sol. If an independent source is not present in the given circuit $V_{TH} = 0$. To get R_{TH} apply 1A current source at the terminal AB.



Applying KVL at node N, we get,

$$\frac{V_A - 3i}{6} + \frac{V_A}{4} = 1 \quad (1)$$

$$i = -1 \quad (2)$$



From equations (1) and (2), we get,

$$\frac{V_A - 3(-1)}{6} + \frac{V_A}{4} = 1 \quad \text{or}$$

$$2V_A + 6 + 3V_A = 12$$

$$5V_A = 12 - 6$$

$$V_A = \frac{6}{5} = 1.2$$

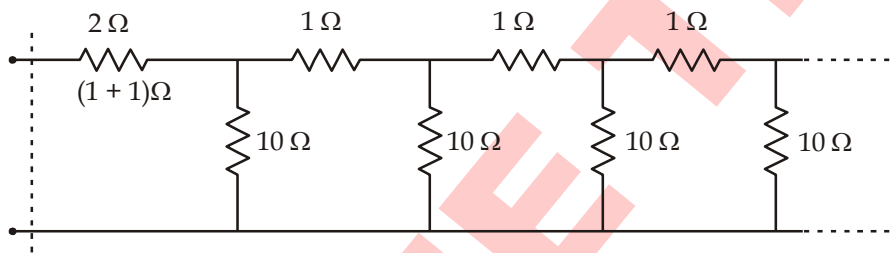
$$V_A = 1.2$$

$$V_{AB} = V_A - V_B \\ = 1.2 \text{ V}$$

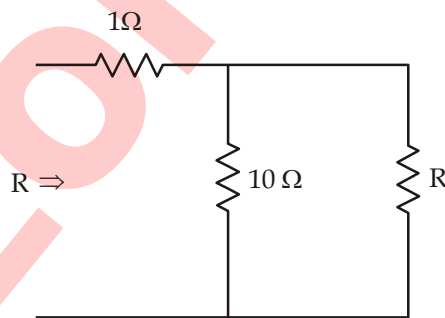
$$R_{TH} = \frac{V_{AB}}{I_S} = 1.2 \\ = 1.2 \Omega$$

70.

Sol.



$$R_{eq} = 1 + R$$



There, $R = 1 + \frac{10R}{10 + R}$

$$R(10 + R) = 10 + 11R$$

$$R^2 - R - 10 = 0$$

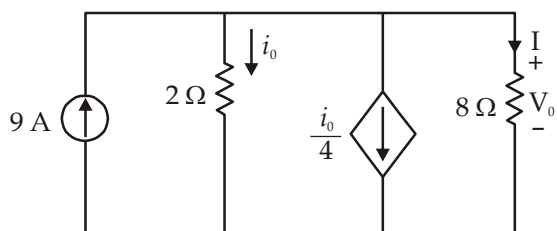
$$R = 3.7 \Omega$$

$$R_{eq} = 4.7 \Omega$$



71.

Sol.



Apply kcl

$$9 = i_0 + \frac{i_0}{4} + I$$

$$I = 9 - \left(i_0 + \frac{i_0}{4}\right)$$

$$I = \left(9 - \frac{5i_0}{4}\right)$$

$$V_0 = 8I$$

$$V_0 = 8\left(9 - \frac{5i_0}{4}\right)$$

$$V_0 + 10i_0 = 72 \quad \dots\dots(i)$$

The voltage drop across 2Ω

$$V_0 = i_0 \cdot 2$$

$$i_0 = \frac{V_0}{2}$$

put the value of i_0 in the equation (i)

$$V_0 + 5V_0 = 72$$

$$V_0 = 12V, \quad i_0 = 6A$$

72.

Sol. For the driving - point immittance function to be physically realizable it should be positive real function.

The necessary and sufficient conditions for a rational function $F(s)$ with real coefficients to be a positive real function (PRF) are:

1. $F(s)$ must have no poles in the right half of s -plane, i.e. $F(s)$ is analytic in right half of s -plane.
2. $F(s)$ may have simple poles on the $j\omega$ -axis with real and positive residues.
3. $\operatorname{Re}[F(s)] > 0$ for all $\operatorname{Re}(s) > 0$

if $F(s)$ is a positive real function (PRF), then $1/F(s)$ is also a positive real function.

Let
$$F(s) = \frac{p(s)}{q(s)}$$

Where $p(s)$ and $q(s)$ are polynomials in s and must have real coefficients.

Hence, $F(s)$ is real for $s = \sigma$. Further, $p(s)$ and $q(s)$ being real for $s = \sigma$;

4. complex zero must appear in conjugate pairs.

Note: A Positive real function $F(s)$ cannot have any poles and zero in the right half of s -plane. Any zeros of $p(s)$ and $q(s)$ on $j\omega$ -axis must be simple and $p(s)$ and $q(s)$ must be Hurwitz.

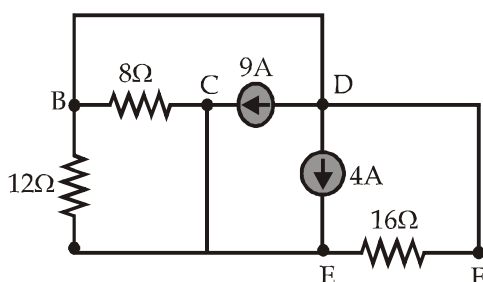


PART - C

20 Marks Questions

73.

Sol.:



Let

and

Using KCL at node B,

$$V_B = V_D = V_F = V_1$$

$$V_A = V_C = V_E = 0 \text{ V (reference)}$$

$$\frac{V_B - V_A}{12} + \frac{V_B - V_C}{8} + \frac{V_F - V_E}{16} + 9 + 4 = 0$$

$$\frac{V_1}{12} + \frac{V_1}{8} + \frac{V_1}{16} + 13 = 0$$

$$\frac{V_1}{3} + \frac{V_1}{2} + \frac{V_1}{4} + 52 = 0$$

$$\frac{13V_1}{12} = -52$$

$$V_1 = -48\text{V}$$

∴ Resistors always dissipates the power irrespective of direction of current flowing through them.

$$\therefore \text{Power dissipated across } 12\Omega \text{ resistor} = \frac{(48)^2}{12} = 192\text{W}$$

$$\text{Power dissipated across } 8\Omega \text{ resistor} = \frac{(48)^2}{12} = 288\text{W}$$

$$\text{Power dissipated across } 16\Omega \text{ resistor} = \frac{(48)^2}{16} = 144\text{W}$$

74.

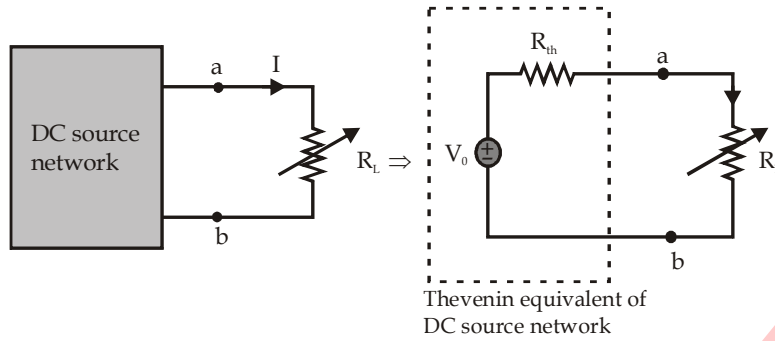
Sol.:

Statement:

A resistive load, being connected to a dc network, receives maximum power when the load resistance is equal to the internal resistance of the source internal resistance as seen from the load terminals.

Explanation:

A variable resistance R_L is connected to a dc source network as shown in figure.



Current
$$I = \frac{V_0}{R_{Th} + R_L}$$

while the power delivered to the resistance load R_L is

$$P_L = I^2 \cdot R_L = \left(\frac{V_0}{R_{Th} + R_L} \right)^2 \cdot R_L \quad \dots\dots\dots(i)$$

P_L can be maximized by varying R_L and hence maximum power can be delivered when $\left(\frac{dP_L}{dR_L} \right) = 0$

$\therefore$ Differentiating equation (i) w.r.t. o R_L

$$\begin{aligned} \frac{dP_L}{dR_L} &= \frac{(R_{Th} + R_L)^2 \cdot V_0^2 - V_0^2 R_L \{2(R_{Th} + R_L)\}}{(R_{Th} + R_L)^4} \\ &= \frac{V_0^2 (R_{Th} + R_L - 2R_L)}{(R_{Th} + R_L)^3} = \frac{V_0^2 (R_{Th} - R_L)}{(R_{Th} + R_L)^3} \end{aligned}$$

$$\frac{dP_L}{dR_L} = 0$$

So,
$$\frac{V_0^2 (R_{Th} - R_L)}{(R_{Th} + R_L)^3} = 0 \Rightarrow R_{Th} - R_L = 0 \Rightarrow R_L = R_{Th} \text{ (Condition for } P_{L_{\max}})$$

Again with,

$$R_L = R_{Th} \quad P_{\max} = \frac{V_0^2}{(R_{Th} + R_L)^2} \cdot R_L = \frac{V_0^2}{(R_{Th} + R_{Th})^2} R_{Th} = \frac{V_0^2}{4R_{Th}}$$

Since, the power transfer by the source would be $\frac{V_0^2}{4R_{Th}}$. the load power and source power being the same.

The total power supplied is.

$$P = 2 \left(\frac{V_0^2}{4R_{Th}} \right) = \frac{V_0^2}{2R_{Th}} = 2P_{\max}$$

During maximum power transfer the efficiency.

$$\% \eta = \frac{P_{\max}}{P} \times 100 = 50\%$$

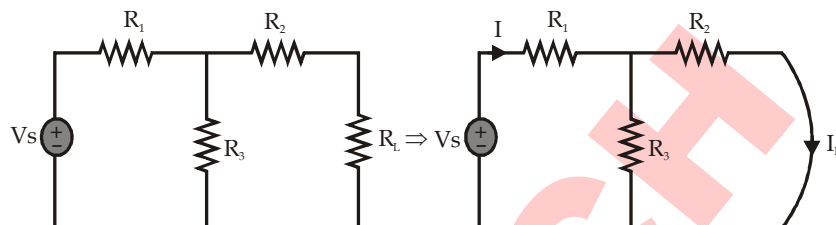
75.

Sol.:

Norton's theorem states that a linear two-terminal circuit can be replaced by an equivalent circuit consisting of a current source I_N in parallel with a resistor R_N where I_N is the short-circuit current through the terminals and R_N is the input or equivalent resistance at the terminals when the independent source are turned-off.

Explanation:

In order to find current through the load R_L by Norton's theorem, replace R_L by short-circuit.

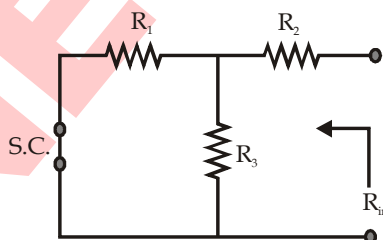


Current:

$$I = \frac{V_s}{R_1 + \left(\frac{R_2 R_3}{R_2 + R_3} \right)} \text{ and } I_N = I \left(\frac{R_3}{R_2 + R_3} \right)$$

Next, the short-circuit is removed and the independent source is deactivated.

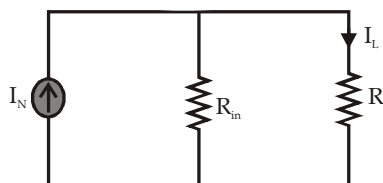
$$R_{in} = R_2 + \left(\frac{R_1 R_3}{R_1 + R_3} \right)$$



As per Norton's theorem, the equivalent source circuit would contain a current source in parallel to the internal resistance, the current source being the short-circuited current across the shorted terminals of the load resistor.

Norton's Equivalent Circuit:

$$I_L = I_N \left(\frac{R_N}{R_N + R_L} \right)$$



Norton's theorem is always valid irrespective of

(i) Nature of elements contained in the network of

(ii) Nature of voltage and current source

Norton's theorem is not valid for the network containing

(i) Non-linear elements

(ii) Unilateral elements such as P-n junction diode, transistor etc.



Steps for solving a network using Norton's theorem:

Step-1: Remove the load resistor and find the internal resistance of source network by deactivating the independent sources:

- (i) all independent voltage source are short-circuited or replaced by their internal impedance.
- (ii) all independent current source are open-circuited or replaced by their internal impedance.
- (iii) all dependent voltage and current sources remain as it is.

Step-2 Short the load terminal and find the circuit current flowing through the shorted load terminals.

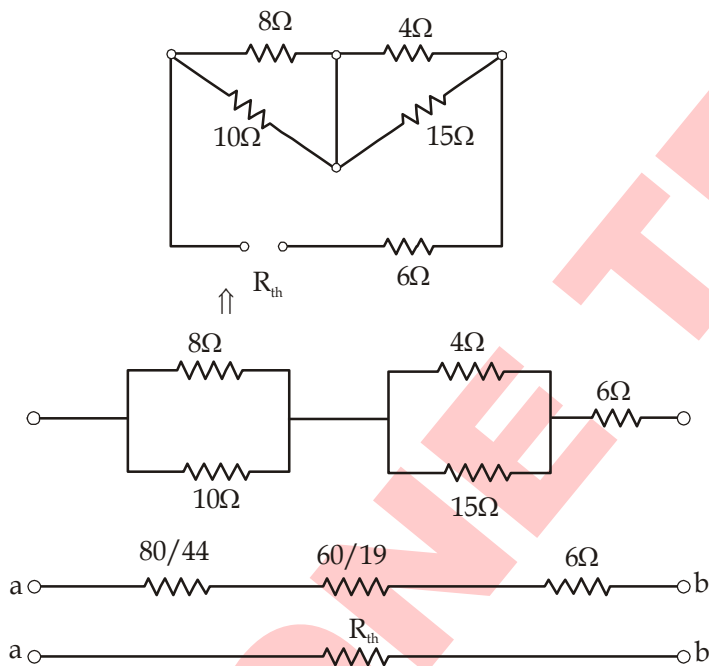
Step-3 Norton's equivalent circuit is drawn by keeping R_{in} in parallel to I_N .

Step-4 Reconnect the load resistance R_L across the load terminals and the current through it is I_L .

$$I_L = I_N \left(\frac{R_{in}}{R_{in} + R_L} \right)$$

76.

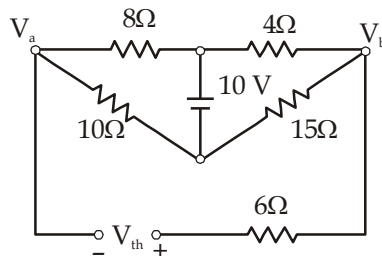
Sol. R_{th} calculated across to switch.



$$R_{th} = \frac{80}{18} + \frac{60}{19} + 6 = \frac{1520 + 1080 + 2052}{342}$$

$$R_{th} = \frac{4652}{342}$$

For calculation of V_{th} switch is open



$$V_a = 10 \times \frac{10}{18}$$

$$V_b = 10 \times \frac{15}{19}$$

$$V_{th} = V_b - V_a = \frac{10 \times 15}{19} - \frac{10 \times 10}{18}$$

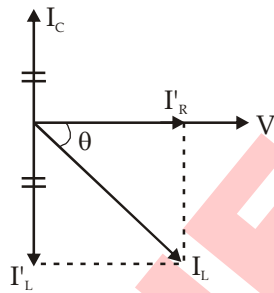
$$V_{th} = 10 \left(\frac{150}{19} - \frac{100}{18} \right) = \frac{150 \times 18 - 100 \times 19}{19 \times 18}$$

$$V_{th} = \frac{800}{342}$$

$$I = \frac{V_{th}}{R_{th}} = \frac{800 / 342}{4652 / 342} = \frac{800}{4652}$$

$$I = 0.171 \text{ Amp.}$$

77.
Sol.



where, $\tan \theta = \left(\frac{\omega L}{R} \right)$

From the phasor diagram,
For unity pf ($I_L' = I_C$)

where $I_L' = I_L \times \sin \theta = \frac{V}{\sqrt{R^2 + (\omega L)^2}} \times \frac{\omega L}{\sqrt{R^2 + (\omega L)^2}}$

and $I_C = V \times \omega C$

$$\omega C = \frac{\omega L}{R^2 + (\omega L)^2}$$

$$C = \frac{L}{R^2 + (\omega L)^2}$$

or

Let us consider the admittance of network looking from the voltage source.

$$y = \frac{1}{Z_C} + \frac{1}{Z_L} = jC\omega + \frac{1}{R + j\omega L}$$

$$= jC\omega + \frac{(R - j\omega L)}{R^2 + (\omega L)^2}$$

For unity pf, imaginary term of admittance (y) should be equal to zero.

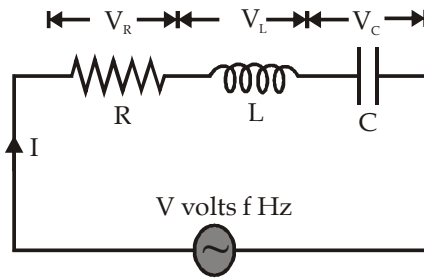
$$jC\omega - \frac{j\omega L}{R^2 + (\omega L)^2} = 0$$

$$\therefore C = \frac{L}{R^2 + (\omega L)^2}$$

78.

Sol.:

In the series RLC circuit of figure the circuit current I is given by



$$I = \frac{V}{Z} A$$

Where Z represents the equivalent impedance of the circuit

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

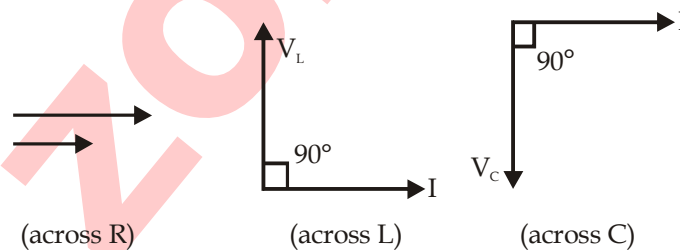
$$= R + j\left(\omega L - \frac{1}{\omega C}\right)$$

or,

$$Z = R + j(X_L - X_C)$$

$$= R + jX$$

where $(X_L - X_C)$ is X , the net reactance



Thus

$$I = \frac{V}{R + j(X_L - X_C)} = \frac{V}{R + jX} A$$

and voltage drop across resistance R is

$$V_R = IR \text{ (in phase with } I)$$

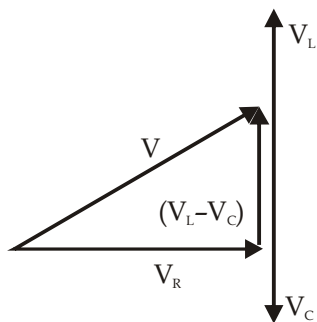
voltage drop across inductance L is

$$V_L = I X_L \text{ (leading } I \text{ by } 90^\circ)$$

voltage drop across capacitance C is

$$V_C = I X_C \text{ (lagging } I \text{ by } 90^\circ)$$

The phasor diagram of the variables of the entire circuit has been shown in figure



Resonance condition is obtained when $X_L = X_C$ in the series circuit [this is obtained by either decreasing the supply frequency when X_L would decrease and X_C would increase or by increasing the supply frequency making X_L to increase and X_C to decrease]

when $X_L = X_C$, $Z = R + j0 = R$

Also,
$$I_0 = \frac{V}{Z} = \frac{V}{R} A$$

[I_0 = current at resonance]

The p.f. (power factor) of the circuit becomes

$$\cos \phi = \frac{R}{Z} = \frac{R}{R} = 1$$

The expression of frequency of resonance can be obtained as follows:

Let ω_0 or f_0 be the frequency of at which

$$X_L = X_C$$

i.e.,
$$\omega_0 L = \frac{1}{\omega_0 C}$$

or,
$$\omega_0^2 = \frac{1}{LC} \text{ i.e., } \omega_0 = \frac{1}{\sqrt{LC}} \text{ rad/sec}$$

i.e.,
$$f_0 = \frac{1}{2\pi\sqrt{LC}} \text{ Hz}$$

79.

Sol. In series RLC circuit,

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

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

At half power points,



$$I = \frac{I_0}{\sqrt{2}} \text{ where } I_0 = \frac{V}{R} \quad (\text{Current at resonance})$$

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

$$\omega L - \frac{1}{\omega C} = \pm R$$

At lower half power point

$$\omega_1 L - \frac{1}{\omega_1 C} = -R$$

$$\omega_1^2 + \frac{R}{L} \omega_1 - \frac{1}{LC} = 0$$

$$\omega_1 = \frac{-R}{2L} \pm \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}}$$

At upper half power point

$$\omega_2 L - \frac{1}{\omega_2 C} = R$$

$$\omega_2^2 - \frac{R}{L} \omega_2 - \frac{1}{LC} = 0$$

$$\omega_2 = \frac{R}{2L} \pm \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}}$$

$$\omega_1 \omega_2 = \left[-\frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}} \right] \left[\frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}} \right]$$

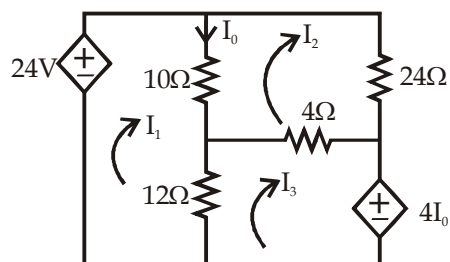
$$= \frac{1}{LC}$$

$$\therefore \omega_1 \omega_2 = \omega_0^2$$

$$\therefore \omega_0 = \sqrt{\omega_1 \omega_2}$$

80.

Sol. Assume mesh current in loops.



$$24 - 10(I_1 - I_2) - 12(I_1 - I_3) = 0$$

$$22 I_1 - 10 I_2 - 12 I_3 = 24 \quad \dots(i)$$

$$-10(I_2 - I_1) - 24I_2 - 4(I_2 - I_3) = 0$$

$$+10 I_1 - 38 I_2 + 4 I_3 = 0 \quad \dots(ii)$$

$$-4(I_3 - I_2) - 4I_0 - (I_3 - I_1) 12 = 0$$

$$12 I_1 + 4 I_2 - 16I_3 - 4 I_0 = 0 \quad \dots(iii)$$

$$I_0 = I_1 - I_2 \quad \dots(iv)$$

Now from (iii) and (iv)

$$8 I_1 + 8 I_2 - 16 I_3 = 0 \quad \dots(v)$$

Now solving equation (i), (ii) and (v)

from equation (i) & (ii)

$$13 I_1 - 31 I_2 = 6 \quad \dots(vi)$$

from equation (ii) & (v)

$$I_1 = 3 I_2 \quad \dots(vii)$$

from equation (vi) & (vii)

$$I_2 = 3/4 \text{ A}$$

hence

$$I_1 = 9/4 \text{ A}$$

Now from equation (iv)

$$I_0 = \frac{6}{4} = 1.5 \text{ A}$$

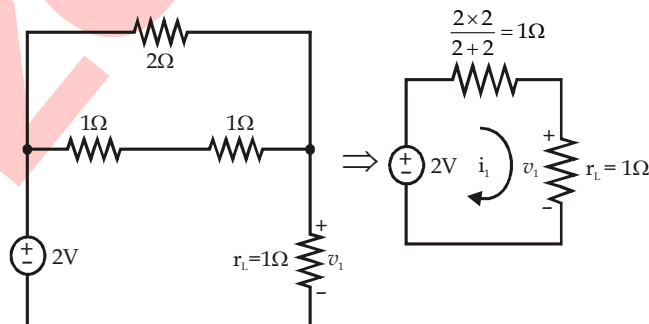
81.

Sol.:

Let us first take the 2 V source and deactivating the current sources

$$i_1 = \frac{2}{\frac{2 \times 2}{2+2} + 1} = 1 \text{ A}$$

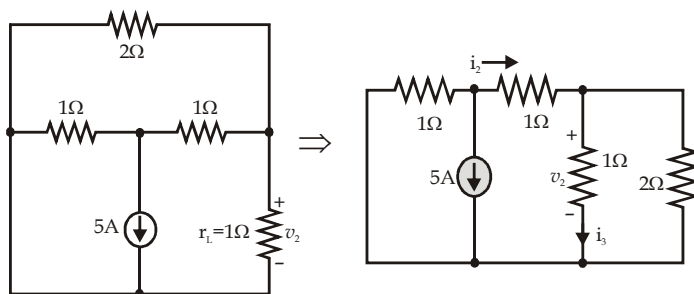
$$\therefore v_1 \text{ (drop across } r_L \text{ due to 2 V source)} \\ = 1 \times 1 = 1 \text{ V}$$



Next, taking the 5A current source only

$$i_2 = (-5) \frac{1}{1+1+\frac{2}{3}} = (-5) \frac{3}{8} = -\frac{15}{8} \text{ A}$$



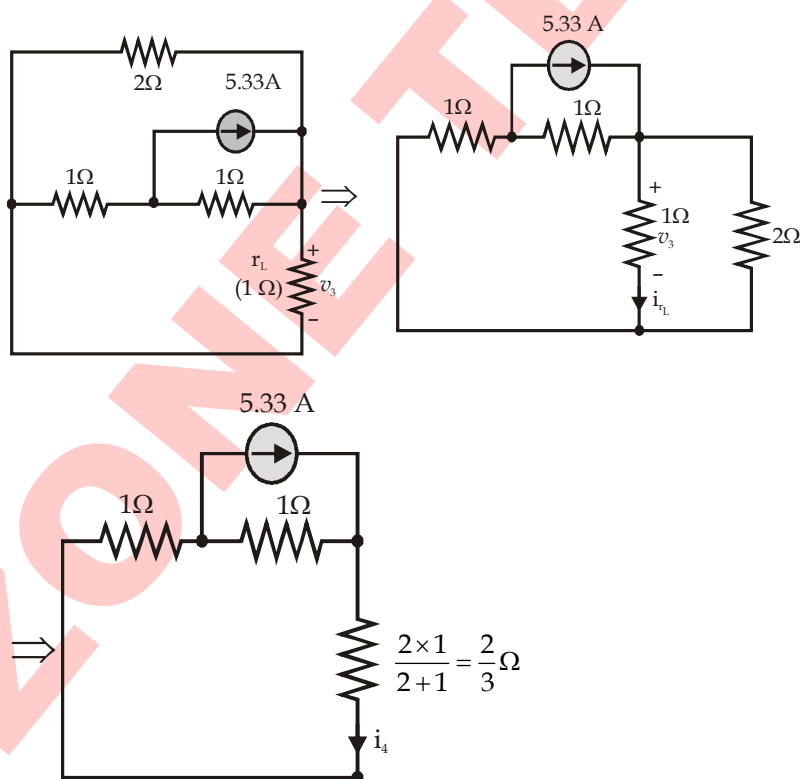


$$\therefore i_3 = -\left(\frac{15}{8}\right) \frac{2}{1+2} = -\left(\frac{15}{8}\right) \frac{2}{3} = -\frac{5}{4} A$$

This gives $v_2 = -\frac{5}{4} \times 1 = -\frac{5}{4} V$

Next, taking the 5.33 A current source only

$$i_4 = 5.33 \frac{1}{\frac{2}{3} + 2} = 3 A$$



This gives

$$i_{r_L} = 3 \frac{2}{2+1} = 2 A$$

$$\therefore v_3 = 2 \times 1 = 2 V$$

By Superposition,

$$v_L = v_1 + v_2 + v_3 = 1 + \left(-\frac{5}{4}\right) + 2 = \frac{7}{4} V$$

$$= 1.75 V$$

82.

Sol.:

$$Z_{BC} = \frac{Z_1 Z_2}{Z_1 + Z_2}$$

However,

$$Z_1 = (4 + j8)\Omega = 8.95\angle 63.45^\circ\Omega$$

and

$$Z_2 = (3 + j4)\Omega = 5\angle 53.13^\circ\Omega$$

$$Z_1 + Z_2 = (7 + j12)\Omega = 13.89\angle 59.74^\circ\Omega$$

Thus,

$$Z_{BC} = \frac{8.95\angle 63.45^\circ \times 5\angle 53.13^\circ}{13.89\angle 59.74^\circ}$$

$$= \frac{44.7\angle 116.58^\circ}{13.89\angle 59.74^\circ}$$

$$= 3.218\angle 56.84^\circ = (1.76 + j2.69)\Omega$$

However,

$$Z_{AB} + Z_{BC} = Z_{AC}$$

This,

$$= (3.76 + j3.69)\Omega$$

$$= 5.268\angle 44.45^\circ$$

This gives

$$I = \frac{V}{Z_{AC}} = \frac{200\angle 0^\circ}{5.268\angle 44.45^\circ}$$

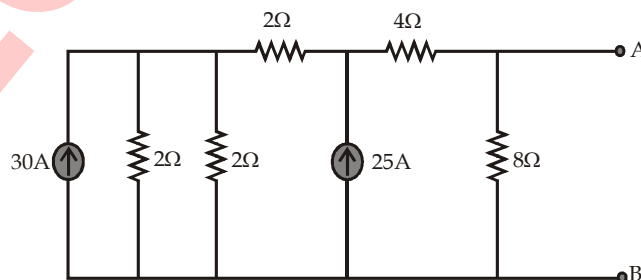
$$= 37.965\angle -44.45^\circ \text{ A}$$

$$= (22.1 - j 26.59) \text{ A}$$

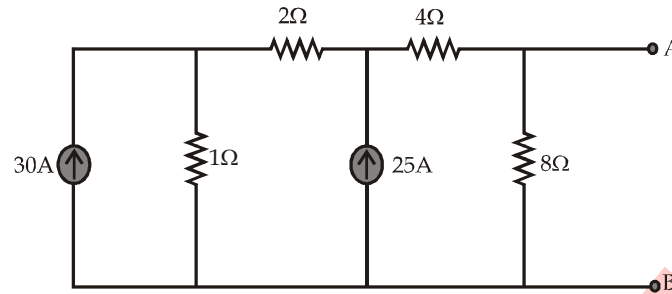
83.

Sol.:

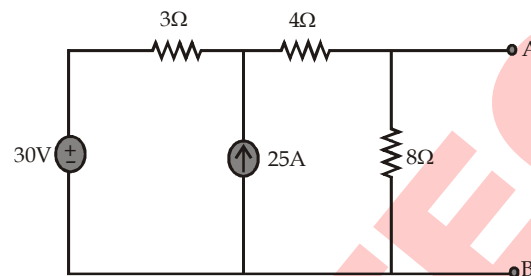
By (60 V) voltage source changes to respective current source.



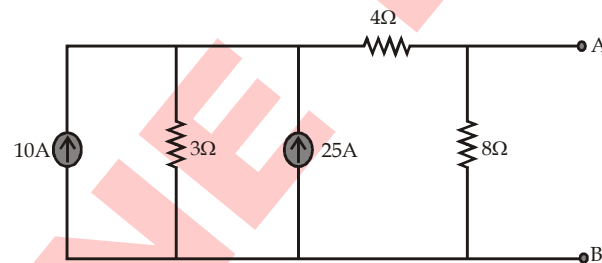
Now we combine the parallel resistance



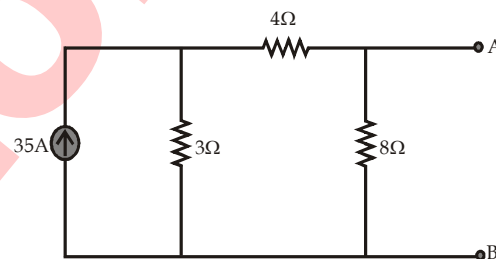
Then we are going to change current source (30A) to respective voltage source



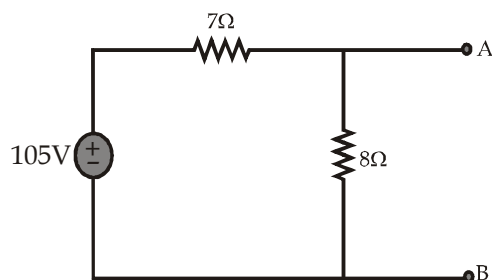
By changing (30 V) voltage source to respective current source



We combining current source



Now we make voltage source 35 A into current source



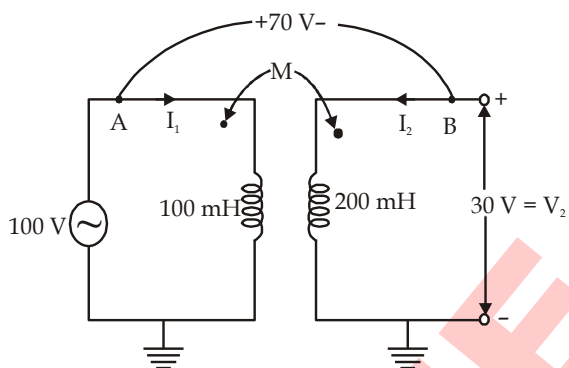
then by potential divider rule

$$V_{AB} = \frac{105}{15} \times 8 = 56V$$

84.

Sol.

Since $V_{AB} = 70V$ and supply voltage is $100V$ therefore, $V_2 = 30V$ ($V_2 = 100 - 70 = 30V$)



Since secondary is open circuit hence

$$I_2 = 0$$

At primary, the magnitude of loop Voltage is

$$\omega \cdot I_1 (100 \text{ mH}) = 100V \quad \dots (i)$$

At secondary the voltage is developed due to I_1 only since secondary is open circuit. i.e. mutual inductance considered

$$\omega \cdot M I_1 = 30V \quad \dots (ii)$$

putting ωI_1 from equation (i) in (ii), we have

$$\frac{100}{100 \times 10^{-3}} M = 30$$

or

$$M = 30 \times 10^{-3}$$

$$M = 30 \text{ mH}$$

85.

Sol:

For the given $i(t)$ and $v(t)$

$$v(t) = K \frac{di(t)}{dt} \text{ where, } K = 2$$

$$\text{Compare with } v(t) = L \frac{di(t)}{dt}$$



Therefore, the circuit element is an inductor with $L = 2 \text{ H}$

(or)

From the given $i(t) \sim t$ and $v(t) \sim t$ waveforms

$$i(t) = \begin{cases} t & 0 \leq t \leq 2 \\ 0 & 2 \leq t \end{cases}$$

$$\frac{di}{dt} = \begin{cases} 1 & 0 \leq t < 2 \\ 0 & 2 \leq t \end{cases}$$

$$\text{And } 2 \frac{di}{dt} = \begin{cases} 2 & 0 \leq t < 2 \\ 0 & 2 \leq t \end{cases}$$

But this is the given $V(t)$

$$\therefore v(t) = 2 \frac{di}{dt}, L = 2$$

Hence the element must be an inductance of 2H .

86.

Sol.

$$I_1 = I_t \left[\frac{30 + j40}{30 + j40 + 30 - 40j} \right]$$

$$1 = I_t \left[\frac{50 \angle \tan^{-1}(4/3)}{60} \right]$$

$$I_t = \frac{60}{50 \angle \tan^{-1}\left(\frac{4}{3}\right)}$$

$$I_t = 1.2 \angle \tan^{-1}\left(\frac{-4}{3}\right)$$

$$V_{AB} = 5 \times I_t$$

$$V_{AB} = 5 \times 1.2 \angle \tan^{-1}\left(\frac{-4}{3}\right)$$

$$= 6 \angle \tan^{-1}\left(\frac{-4}{3}\right)$$

$$V_{BC} = 1(30 - j40)$$

$$= 50 \angle \tan^{-1}\left(\frac{-4}{3}\right)$$

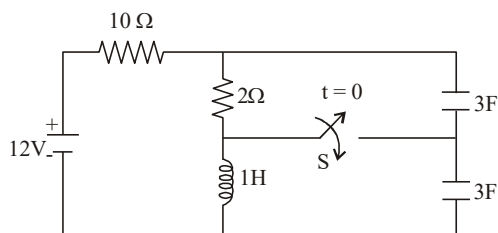
$$V = V_{AB} + V_{BC}$$

$$V = 6 \angle \tan^{-1}\left(\frac{-4}{3}\right) + 50 \angle \tan^{-1}\left(\frac{-4}{3}\right)$$

$$V = 56 \angle \tan^{-1}\left(\frac{-4}{3}\right)$$

87.

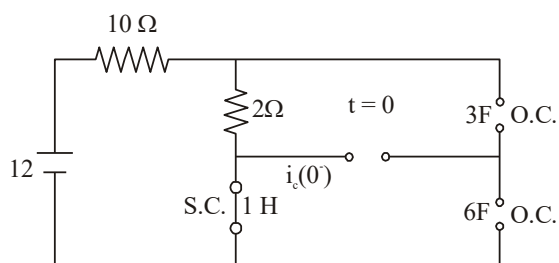
sol.



At steady state

L → Short Circuit

C → Open Circuit



$$i_L(0^-) = i_L(0^+) \\ = \frac{12}{(10+2)} = 1\text{A}$$

voltage across 2 ohm resistor is $= 2 \times 1 = 2$ volt

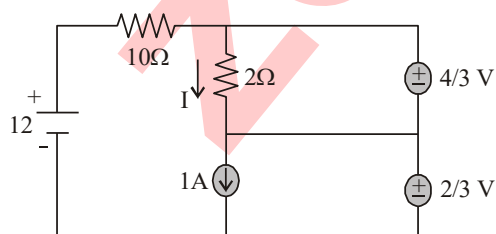
voltage across 3F capacitor is

$$V_3 = \frac{2 \times 6}{3+6} = \frac{4}{3} \text{ volt}$$

voltage across 6F capacitor is

$$V_6 = \frac{2 \times 3}{3+6} = \frac{2}{3} \text{ volt}$$

At

 $t = 0^+$ current through R at $t = 0$ is

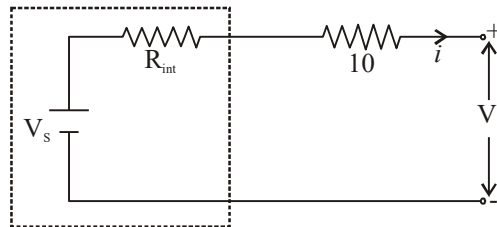
$$I = \frac{4/3}{2}$$

$$I = \frac{2}{3} \text{ Amp}$$



88.

Sol. Let internal resistance is R_{int}



→ From curve

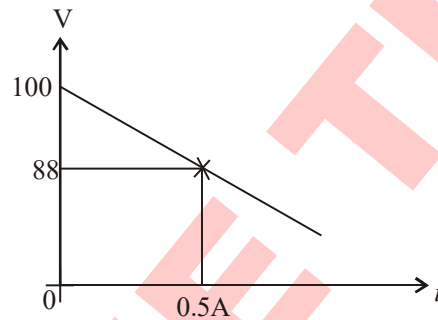
At $i = 0, v = 100$ volt

From circuit

when $i = 0$

$$e = V = V_s$$

$$\therefore V_s = 100 \text{ volt}$$



From curve equation of line is $y = -mx + c$

$$v = -\frac{(100-88)}{0.5}i + 100$$

$$v = -\frac{12}{0.5}i + 100$$

$$v = -24i + 100$$

$$\text{At } v = 0, i = \frac{100}{24}$$

From circuit at $v = 0$

$$i = \frac{V_s}{R_{\text{int}} + 10}$$

$$\frac{100}{24} = \frac{100}{R_{\text{int}} + 10}$$

$$R_{\text{int}} = 24 - 10$$

$$R_{\text{int}} = 14\ \Omega$$



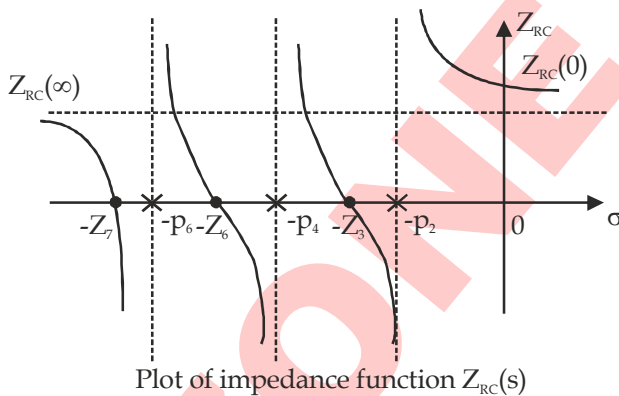
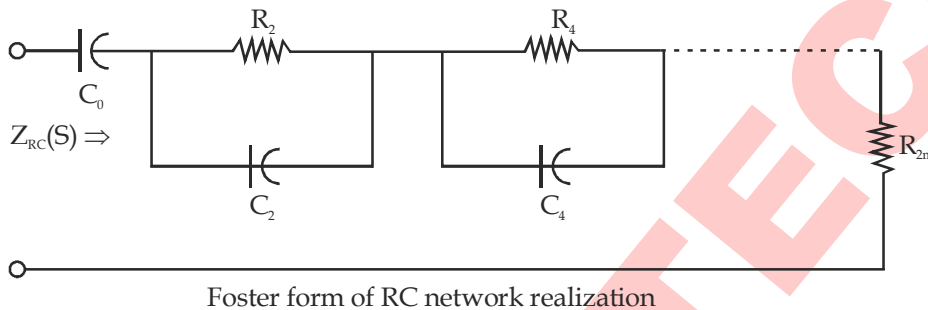
89.

Sol. Properties of R-C driving point impedance functions:

- The poles and zeros are located on the negative real axis of the s-plane.
- Poles and zeros alternate along the negative real axis.
- The critical frequency nearest to the origin is a pole.
- The last critical frequency is a zero.
- The slope of the impedance curve is negative
- $Z_D(0) > Z_D(\infty)$

The driving point impedance,
$$Z_D(s) = H \frac{(s-s_1)(s-s_3)\dots(s-s_{2m-1})}{(s-s_2)(s-s_4)\dots(s-s_{2m-2})}$$

For $Z_D(s)$, the degree in s of numerator polynomial is greater than that of denominator polynomial by one.



Note: The steady state response of a linear time-invariant network to a sinusoidal input excitation, is a sinusoid with the same frequency as the driving function but of different phase and amplitude.

90

Sol. The necessary conditions for a network function to be a driving point function, with common factors: numerator polynomial $p(s)$ and denominator polynomial $q(s)$ cancelled, are listed below :

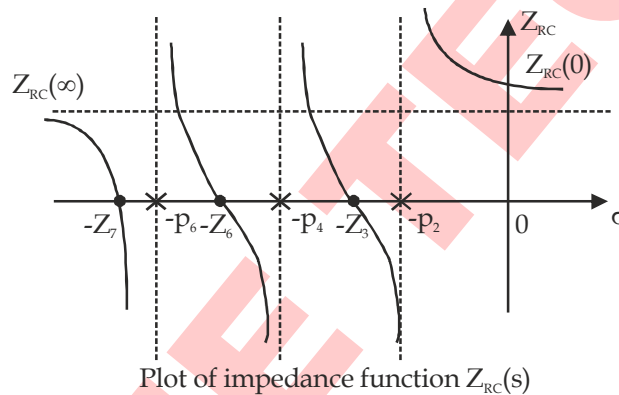
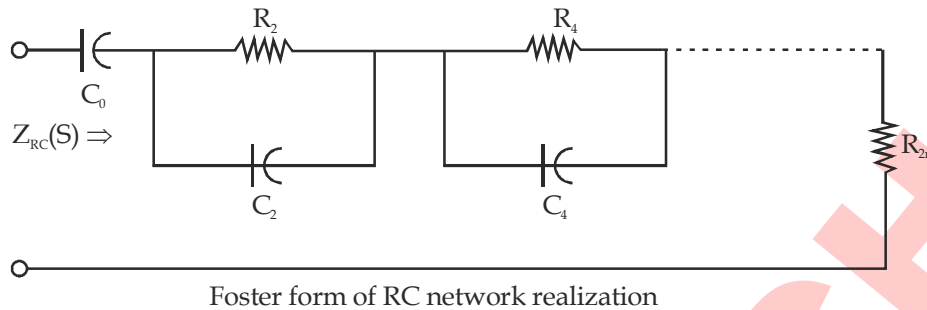
1. The coefficients in the polynomials $p(s)$ and $q(s)$ of $N(s) = \frac{p(s)}{q(s)}$ must be real and positive.
2. Complex or imaginary poles and zero must be conjugate.
3. (i) The real part of all poles and zeros must not be positive.
(ii) If the real part is zero, then that pole or zero must be simple.
4. The polynomials $p(s)$ and $q(s)$ must not have missing terms between the highest and lower degree, unless all even or odd terms are missing.
5. The degree of $p(s)$ and $q(s)$ may differ by either zero or one only.
6. The terms of lowest degree in $p(s)$ and $q(s)$ may differ in degree by one at the most.



The driving point impedance,

$$Z_0(s) = H \frac{(s-s_1)(s-s_3)\dots(s-s_{2m-1})}{(s-s_2)(s-s_4)\dots(s-s_{2m-2})}$$

For $Z_D(s)$, the degree in s of numerator polynomial is greater than that of denominator polynomial by one.



Note: The steady state response of a linear time-invariant network to a sinusoidal input excitation, is a sinusoid with the same frequency as the driving function but of different phase and amplitude.

91.

- Sol.**
- The Foster forms are obtained by partial fraction expansion of a given driving point impedance function $F(s)$ and the Cauer forms by continued fraction expansion of $F(s)$
 - The Foster first form deals with the driving point impedance function and the second form deals with the admittance function
 - The Cauer first form is obtained by expanding the given function in continued fraction about infinity and the second form is obtained by expanding the given function into a continued fraction about origin

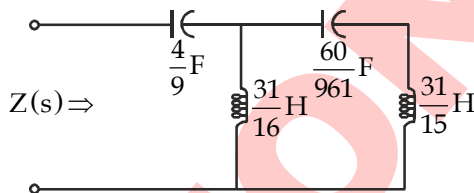
$$Z(s) = \frac{s^4 + 10s^2 + 9}{s^3 + 4s}$$

Cauer second form of realisation can be obtained by continued fraction expansion of $Z(s)$ till all the terms are exhausted after arranging numerators and denominator polynomial of $Z(s)$ in ascending order of ' s ' as

$$Z(s) = \frac{9 + 10s^2 + s^4}{4s + s^3}$$

$$\begin{array}{r}
 4s + s^3 \overline{) 9 + 10s^2 + s^4} \left(\frac{9}{4s} \rightarrow Z \right. \\
 \underline{9 + \frac{9}{4}s^2} \\
 \frac{31}{4}s^2 + s^4 \overline{) 4s + s^3} \left(\frac{16}{31s} \rightarrow Y \right. \\
 \underline{4s + \frac{16}{31}s^3} \\
 \frac{15}{31}s^3 \overline{) \frac{31}{4}s^2 + s^4} \left(\frac{961}{60s} \rightarrow Z \right. \\
 \underline{\frac{31}{4}s^2} \\
 s^4 \overline{) \frac{15}{31}s^3} \left(\frac{15}{31s} \rightarrow Y \right. \\
 \underline{\frac{15}{31}s^3} \\
 X
 \end{array}$$

$$Z(s) = \frac{9}{4s} + \frac{1}{\frac{16}{31s} + \frac{1}{\frac{1}{961} + \frac{1}{\frac{15}{31s}}}}$$



92.

Sol. (i) Properties of Hurwitz Polynomial:

1. If the polynomial $P(s)$ can be written as

$$P(s) = a_n s^n + a_{n-1} s^{n-1} + \dots + a_1 s + a_0$$

Then all the coefficients a_i must be positive

2. If $P(s)$ has even part $M(s)$ and odd part $N(s)$, then roots of both $M(s)$ and $N(s)$ lies on $j\omega$ -axis only.
3. If $P(s)$ is either even or odd, all its roots are on the $j\omega$ -axis (including origin)
4. The continued fraction expansion (CFE) of $\frac{M(s)}{N(s)}$ or $\frac{N(s)}{M(s)}$ yields all positive quotient terms.



$$\begin{aligned}\psi(s) &= \frac{M(s)}{M(s)} \text{ or } \frac{N(s)}{M(s)} \\ &= q_1 s + \frac{1}{q_1 s + \frac{1}{q_2 s + \frac{1}{q_3 s + \frac{1}{\ddots + q_n s}}}}\end{aligned}$$

The quotients $q_1, q_2, \dots, q_n$ must be positive.

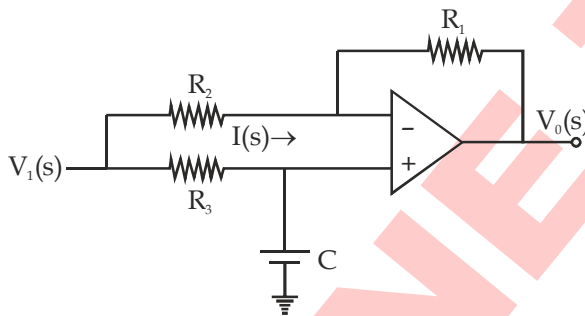
5. If $P(s) = P_1(s) \times P_2(s)$ then $P(s)$ will be Hurwitz if $P_1(s)$ and $P_2(s)$ are individually Hurwitz.

6. If $P(s)$ has only even or odd part then CFE of $P(s)$ and its derivative $P'(s)$ yields all positive quotient terms.

(ii) **Zero of transmission function** are those complex frequencies at which a transfer function, relating response $C(s)$ at the output port and the excitation $R(s)$ at the input port, vanishes i.e. no output appears at the output port inspite of non zero excitation at input port.

93.

Sol. Given circuit diagram



Applying the superposition theorem we get

$$V_0(s) = \frac{R_1}{R_2} V_1(s)$$

$$V_0(s) = \left(1 + \frac{R_1}{R_2}\right) \left(\frac{V_1(s) 1/s}{R_3 + 1/s} \right) = \left(1 + \frac{R_1}{R_2}\right) \left(\frac{V_1(s)}{1 + R_3 s} \right)$$

Adding both we get,
$$V_0(s) = \frac{-R_1}{R_2} V_1(s) + \left(1 + \frac{R_1}{R_2}\right) \frac{V_1(s)}{1 + R_3 s}$$

Given $R_1 = R_2, R_3 = 1/10$

Substituting these values in above equation

$$\frac{V_0(s)}{V_i(s)} = -1 + (2) \frac{1}{1 + s/10} = 1 + \frac{20}{10 + s}$$

$$\frac{V_0(s)}{V_i(s)} = \frac{(10 - s)}{(10 + s)}$$

For finding step response, we have to take input voltage $V_i(t) = 1 \Rightarrow V_i(s) = 1/s$



$$V_0(s) = \frac{1}{s} \left(\frac{(10-s)}{(s+10)} \right) = \frac{10}{s(s+10)} - \frac{s}{s(10+s)}$$

$$= \frac{1}{s} - \frac{1}{s+10} - \frac{1}{s+10} = \frac{1}{s} - \frac{2}{s+10}$$

Applying inverse laplace transform

$$V_0(t) = L^{-1} \left[\frac{1}{s} - \frac{2}{s+10} \right] = u(t) - 2e^{-10t}u(t)$$

$$V_0(t) = (1 - 2e^{-10t})u(t)$$

94.

Sol. Realisation of impedance function $z(s)$ using Foster-I form:

$$Z(s) = \frac{s(s^2 + 10)}{(s^2 + 4)(s^2 + 16)}$$

$$\frac{z(s)}{s} = \frac{1}{2} \left[\frac{S}{S^2 + 4} + \frac{S}{S^2 + 16} \right]$$

$$= \frac{1}{(2s + 8/s)} + \frac{1}{(2s + 32/s)}$$

The network realisation is shown below

