MADE EASY
India's Best Institute for IES, GATE & PSUs

Corporate Office (Delhi): 44-A/1 Kalu Sarai (Sarvapriya Vihar), New Delhi-16, **Ph:** 011-45124612, 9958995830
Visit us at: www.madeeasy.in | **E-mail us at:** info@madeeasy.in

Delhi | Hyderabad | Noida | Bhopal | Jaipur | Lucknow | Indore | Pune | Bhubaneswar | Kolkata | Patna

Open Lockdown Period Practice Series for GATE

(Also useful for ESE & Other Exams)

EE : ELECTRICAL ENGINEERING

TEST No. - 01 | ELECTRIC CIRCUITS

Read the following instructions carefully

1. This question paper contains 33 MCQ's & NAQ's. Bifurcation of the questions are given below:

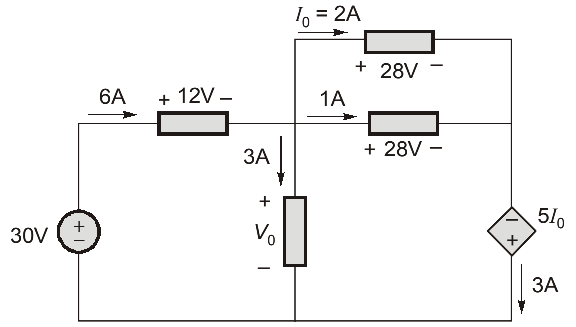
Subjectwise Test Pattern

Questions	Question Type	No. of Questions	Marks	Total Marks	Negative Marking
1 to 9	Multiple Choice Ques.	9	1	9	0.33
10 to 16	Numerical Answer Type Ques.	7	1	7	None
17 to 25	Multiple Choice Ques.	9	2	18	0.66
26 to 33	Numerical Answer Type Ques.	8	2	16	None
Total Questions : 33		**Total Marks : 50**		**Total Duration : 90 min**	

2. Choose the closest numerical answer among the choices given.

Multiple Choice Questions : Q.1 to Q.9 carry 1 mark each

Q.1 The voltage V_0 in the circuit shown below is,



(a) 20 V (b) 22 V
(c) 18 V (d) 19 V

1. (c)

Since total power absorbed or delivered in the circuit

$$\Rightarrow \quad \Sigma P = 0;$$

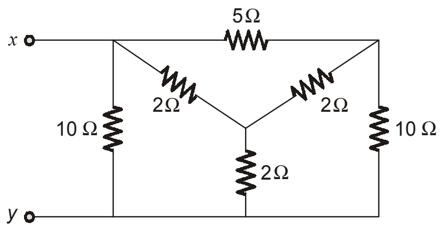
then $\quad -30 \times 6 + 6\times 12 + 3\ V_0 + 28 + 28 \times 2 - 3 \times 10 = 0$

$$72 + 84 + 3\ V_0 = 210;$$

or $\quad 3\ V_0 = 54$

$$\Rightarrow \quad V_0 = 18\text{ V}$$

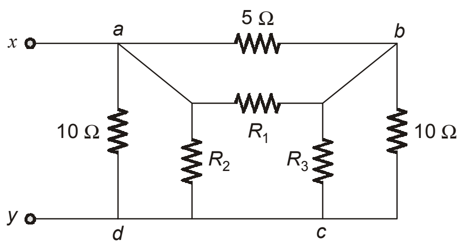
Q.2 The equivalent resistance between terminals x-y in the resistive network is



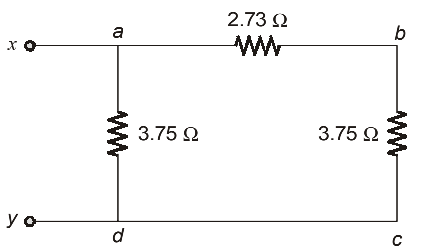
(a) 1.048 Ω (b) 2.105 Ω
(c) 3.045 Ω (d) 2.375 Ω

2. (d)

Converting Y circuit to Δ circuit, the circuit is as shown below,



Further simplifying the circuit we get,



$$R_1 = 2+2+\frac{2\times 2}{2+0} = 6\ \Omega$$

Due to symmetry of the network inside star network,

$$R_1 = R_2 = R_3 = 6\ \Omega$$

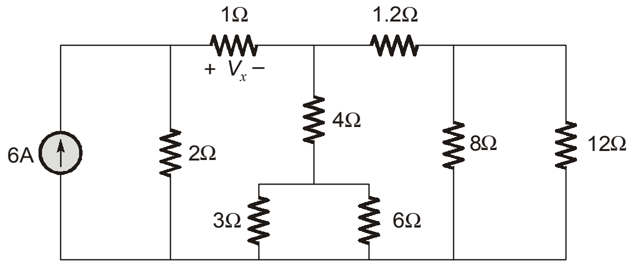
$$R_{ab} = \frac{5R_1}{5+R_1} = 2.73\ \Omega$$

$$R_{bc} = \frac{10R_3}{10+R_3} = 3.75\ \Omega$$

$$R_{ad} = \frac{10R_2}{10+R_2} = 3.75\ \Omega$$

$$R_{x-y} = R_{ad} \,||\, (R_{ab}+R_{bc}) = 2.375\ \Omega$$

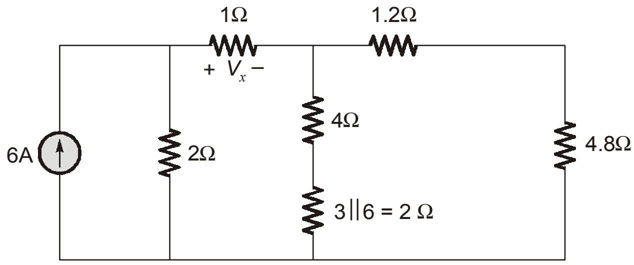
Q.3 In the circuit shown below the value of voltage V_x is



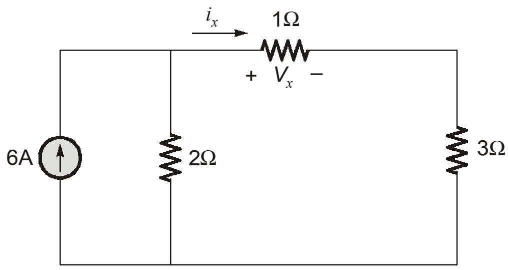
(a) 1 V
(b) 2 V
(c) 3 V
(d) 4 V

3. (b)

The given circuit can be reduced to below ckt.



Further it can be reduced as ;



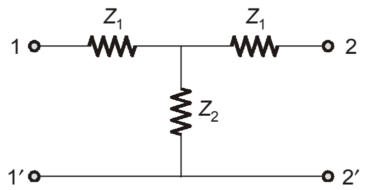
Now applying current division, we get

$$i_x = \frac{2}{2+1+3}\times 6 = 2\text{A};$$

$$V_x = 1\times 2 = 2\ \text{V}$$

Q.4 A symmetrical T-section has the following impedances at terminal 1 1′.

$Z_{OC} = 800\ \Omega$ $\qquad\qquad$ $Z_{SC} = 600\ \Omega$



The parameters Z_1, Z_2 of the network are:

(a) 400 Ω, 800 Ω $\qquad$ (b) 800 Ω, 800 Ω

(c) 400 Ω, 600 Ω $\qquad$ (d) 400 Ω, 400 Ω

4. (d)

$$Z_1 + Z_2 = 800, \text{ O.C condition}$$

$$Z_1 + \frac{Z_1 Z_2}{Z_1 + Z_2} = 600, \text{ S.C. condition}$$

$$Z_1 + \frac{Z_1(800 - Z_1)}{800} = 600$$

$$Z_1^2 = 1600\, Z_1 + 48 \times 10^4 = 0$$

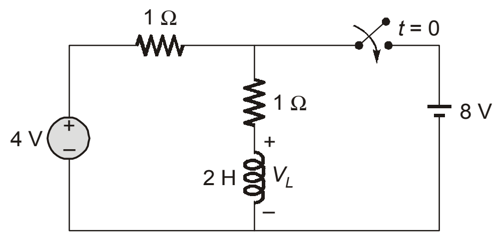
$$(Z_1 - 800)^2 = (\pm 400)^2$$

$$Z_1 = 400\ \Omega \text{ or } 1200\ \Omega$$

If $\quad Z_1 = 1200\ \Omega$ then $\quad Z_2 = -400\ \Omega$ (not possible)

therefore, $\quad Z_1 = 400\ \Omega, \quad Z_2 = 400\ \Omega$

Q.5 In the circuit shown below



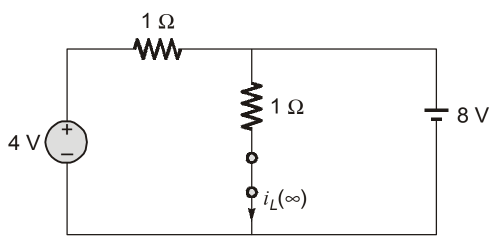
the switch is opened for a long time and it is closed at $t = 0$. The energy stored by the inductor at steady state is

(a) 50 J $\qquad$ (b) 100 J

(c) 64 J $\qquad$ (d) 54 J

5. (c)

at $t = \infty$, the circuit behaves as shown below

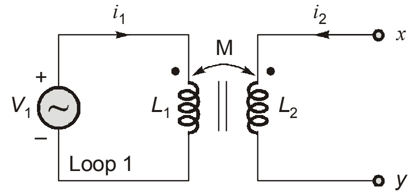


$$i_L(\infty) = \frac{8}{1} = 8\text{ A}$$

$$\text{Energy stored} = \frac{1}{2} L I^2$$

$$\Rightarrow \quad \frac{1}{2}(2)(8)^2 = 64\text{ J}$$

Q.6 In the circuit shown below, the open circuit voltage (V_{xy}) in term of M, is



(a) $M\dfrac{V_1}{L_1}$ (b) $M\dfrac{V_2}{L_2}$

(c) $M\dfrac{V_1}{L_2}$ (d) $M\dfrac{V_2}{L_1}$

6. (a)

Applying KVL,

$$V_{xy} - j\omega L_2\, i_2 - j\omega\, M\, i_1 = 0$$

as $\quad i_2 = 0$

then, $\quad V_{xy} - j\omega\, M\, i_1 = 0 \quad$ ...(i)

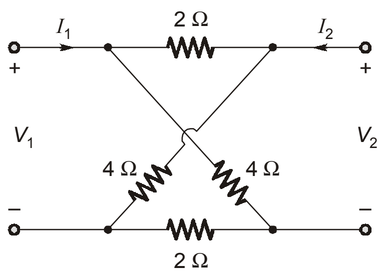
applying KVL in loop 1

$$V_1 = j\omega L_1\, i_1 \quad \text{...(ii)}$$

Using value of i_1 from equation (ii) in equation (i)

$$V_{xy} = j\omega M\left[\frac{V_1}{j\omega L_1}\right] = \frac{MV_1}{L_1}$$

Q.7 In the circuit shown below, open circuit parameters Z_{11} and Z_{21} are respectively,



(a) 3 Ω and 1 Ω (b) 4 Ω and 2 Ω

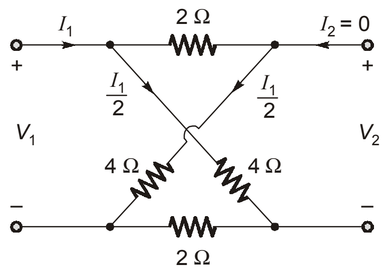
(c) 3 Ω and 4 Ω (d) 2 Ω and 1 Ω

7. (a)

For Z_{11} and Z_{21}

$$Z_{11} = \left.\frac{V_1}{I_1}\right|_{I_2=0}, \qquad Z_{21} = \left.\frac{V_2}{I_1}\right|_{I_2=0}$$

From the circuit as shown below, we can get



Output port O.C,

$$Z_{11} = \frac{V_1}{I_1} = 6 \parallel 6 = 3\Omega$$

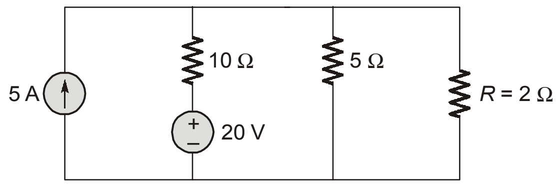
$$Z_{21} = \left.\frac{V_2}{I_1}\right|_{I_2=0},$$

Using KVL, we can get

$$-V_2 + \frac{4I_1}{2} - 2\frac{I_1}{2} = 0; \qquad \Rightarrow \qquad V_2 = I_1$$

then $$\frac{V_2}{I_1} = Z_{21} = 1\ \Omega$$

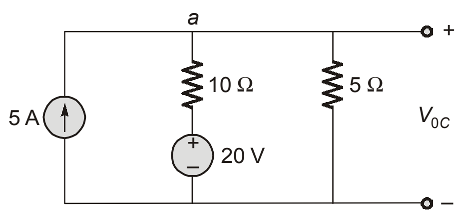
Q.8 The current flowing through resistor 'R' in the circuit shown below is



(a) 4.38 A
(b) 10 A
(c) 5.38 A
(d) 3.38 A

8. (a)

Let R be removed, the circuit is shown as below

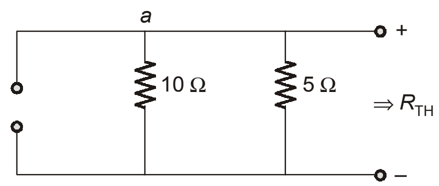


Now applying KCL at node a,

$$\frac{V_{oc}}{5} + \frac{V_{oc} - 20}{10} = 5$$

$$0.2\ V_{oc} + 0.1\ V_{oc} - 2 = 5$$

$$V_{oc} = 23.33\text{ V}$$



Now equivalent thevenin's resistance,

$$R_{Th} = \frac{10 \times 5}{10 + 5}$$

$$R_{Th} = 3.33\ \Omega$$

Current through $R = 2\ \Omega$ resistor,

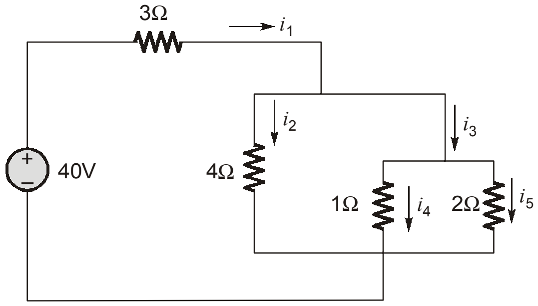
$$I_{2\Omega} = \frac{V_{oc}}{R_{Th} + R} = \frac{23.33}{3.33 + 2}$$

$$I_{2\Omega} = 4.38\text{ A}$$

Q.9 For the circuit shown below, the current i_3 is

(a) 7.2 A (b) 8.3 A

(c) 9.6 A (d) 10.2 A



9. (c)

The total equivalent resistance of the circuit ;

$$R_{eq} = 3 + (2 \,||\, 4 \,||\, 1) = 3 + 0.5714 = 3.5714\ \Omega$$

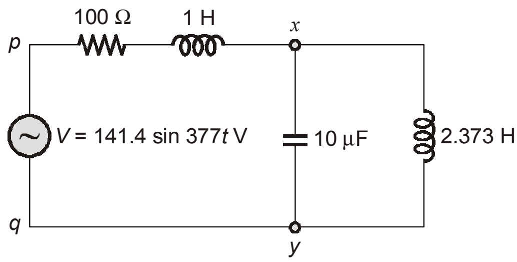
Now; $$i_1 = \frac{40}{3.5714} = 11.2A$$

$\because$ $$i_3 = \frac{4}{\left(4+\frac{2}{3}\right)} \times i_1 = \frac{4}{4.667} \times 11.2$$

$$i_3 = 9.6\text{ A}$$

Numerical Answer Type Questions : Q. 10 to Q. 16 carry 1 mark each

Q.10 The total power dissipated in the circuit shown below is _______ W.



10. 100 (99.00 to 101.00)

The net impedance between x-y terminals

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

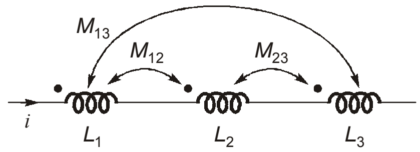
$$= \frac{\frac{2.373}{10 \times 10^{-6}}}{j\left(377 \times 2.373 - \frac{1}{377 \times 10 \times 10^{-6}}\right)} = -j377\ \Omega$$

$$\text{Total impedance} = -j377 + 100 + j377 = 100\ \Omega$$

$$I = \frac{141.4}{\sqrt{2} \times 100} = 1\text{ A}$$

$$\text{Power dissipated} = I^2R = 1^2 \times 100 = 100\text{ W}$$

Q.11 The total inductance of the three series connected coupled coils is ________ H.



Given:

$L_1 = 1$ H $\qquad L_2 = 2$ H $\qquad L_3 = 5$ H

$M_{12} = 0.5$ H $\qquad M_{23} = 1$ H $\qquad M_{13} = 1$ H

11. **13 (12.50 to 13.50)**

For coil 1 :

$$L_1 + M_{12} + M_{13} = 1 + 0.5 + 1$$
$$= 2.5 \text{ H}$$

For coil 2: $L_2 + M_{23} + M_{12} = 2 + 1 + 0.5 = 3.5$ H

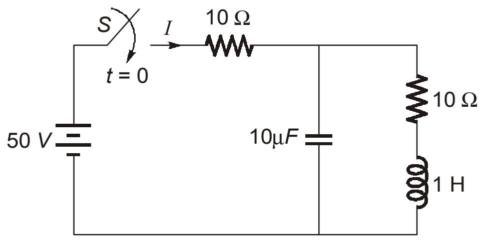
For coil 3: $L_3 + M_{13} + M_{23} = 5 + 1 + 7 = 7$ H

Net Inductance,

$\Rightarrow L_1 + M_{12} + M_{13} + L_2 + M_{23} + M_{12} + L_3 + M_{13} + M_{23}$

$$2.5 + 3.5 + 7 = 13 \text{ H}$$

Q.12 The network shown below was at rest initially. The value of initial current I when switch S is closed at $t = 0$ is ________ A.

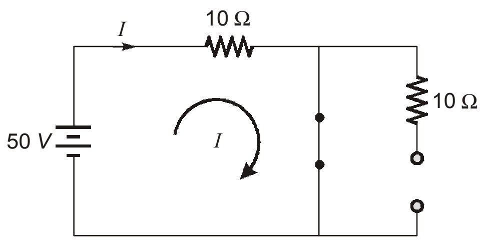


12. **5.00 (4.90 to 5.10)**

At $\quad t = 0^+$

$v_C(0^-) = v_C(0^+) = 0 \quad \Rightarrow$ short circuited

$i_L(0^-) = i_L(0^+) = 0 \quad \Rightarrow$ open circuited



Applying KVL

$$10I = 50$$
$$I = 5 \text{ A}$$

Q.13 A 220 V, 100 Hz ac source supplies a series RLC circuit with a capacitor and a coil. If the coil has 50 mΩ resistance and 5 mH inductance, then at resonance at f = 100 Hz, the lower half power frequency is ________ Hz.

13. 99.20 (99.00 to 100.00)

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

$$100 = \frac{1}{2\pi\sqrt{5\times10^{-3}\times C}}$$

$$C = \frac{1}{4\pi^2\times100^2\times5\times10^{-3}} = 507\ \mu\text{F}$$

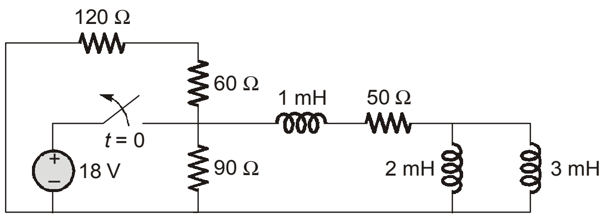
$$Q = \frac{\omega_0^2}{R} = \frac{2\pi\times100\times5\times10^{-3}}{50\times10^{-3}} = 62.83$$

$$\text{Bandwidth} = \frac{f_0}{Q} = \frac{100}{62.83} = 1.59\ \text{Hz}$$

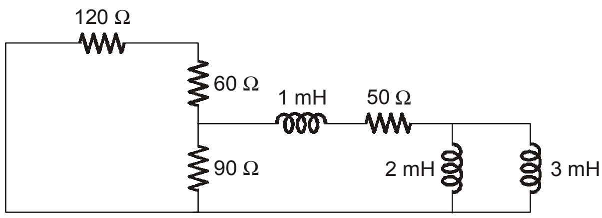
$$\text{lower half power frequency} = f_0 - \frac{\text{B.W.}}{2}$$

$$= 100 - \frac{1.59}{2} = 99.205\ \text{Hz}$$

Q.14 The time constant of the circuit is ________ μsec.



14. 20 (19.00 to 21.00)



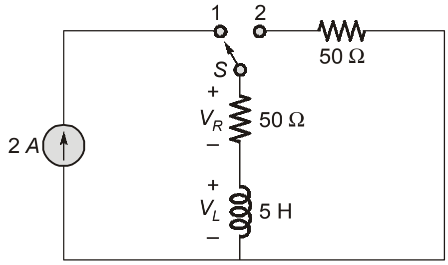
From the above circuit, we can get,

$$L_{eq} = \frac{2\times3}{2+3} + 1 = 2.2\ \text{mH}$$

$$R_{eq} = \frac{90(60+120)}{90+180} + 50 = 110\ \Omega$$

Time constant, $$\tau = \frac{L_{eq}}{R_{eq}} = \frac{2.2\times10^{-3}}{110} = 20\ \mu\text{sec}$$

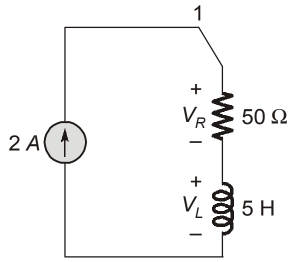
Q.15 In the circuit shown below switch S is kept at position 1 for a long time. Then at $t = 0$ the switch is transferred to position 2. The voltage (magnitude) across inductor at $t = 0^+$ is _____ (in Volts).



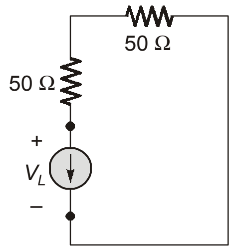
15. **200 (198.00 to 202.00)**

At $t = 0^-$, the circuit behaves as shown below

Current across inductor, $i_L(0^-) = 2$ A



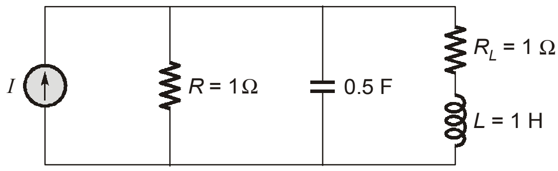
Now at $t = 0^+$, the circuit behaves as shown below



Now applying KVL in the circuit, we get,

$$V_L + 50(2) + 50(2) = 0$$
$$V_L = -200 \text{ Volts}$$
$$|V_L| = 200 \text{ Volts}$$

Q.16 In the circuit shown below, the value of admittance at resonant frequency is ________ ℧.



16. **1.50 (1.40 to 1.60)**

The circuit admittance seen by the current source is

$$Y = \frac{1}{R} + j\omega C + \frac{1}{R_L + j\omega L}$$
$$= \frac{1}{R} + j\omega C + \frac{R_L - j\omega L}{R_L^2 + \omega^2 L^2}$$
$$= \frac{1}{R} + \frac{R_L}{R_L^2 + \omega^2 L^2} + j\left(\omega C - \frac{\omega L}{R_L^2 + \omega^2 L^2}\right)$$

at resonance, imaginary part of Y must be zero

$$\omega_0 C = \frac{\omega_0 L}{R_L^2 + \omega_0^2 L^2}$$

$$R_L^2 + \omega_0^2 L^2 = \frac{L}{C}$$

$$\omega_0 = \left[\frac{1}{LC} - \frac{R_L^2}{L^2}\right]^{1/2}$$

Substituting value of L, R, C

$$\omega_0 = \left[\frac{1}{1\times 0.5} - \frac{1^2}{1^2}\right]^{1/2} = 1 \text{ rad/sec}$$

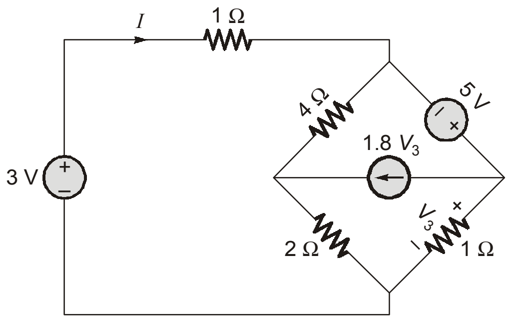
admittance at resonance is,

$$Y = \frac{1}{R} + \frac{R_L}{R_L^2 + \omega_0^2 L^2}$$

$$= 1 + \frac{1}{1+1^2 \cdot 1^2} = 1.5\,\mho$$

Multiple Choice Questions : Q.17 to Q.25 carry 2 marks each

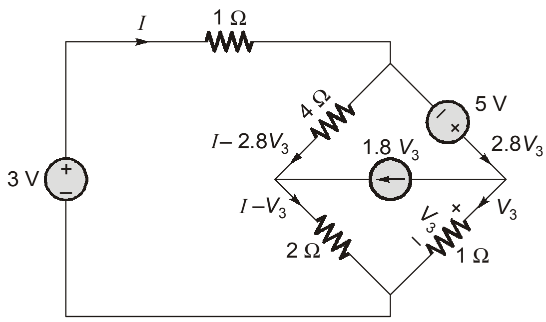
Q.17 Find I and V_3 in the circuit given below



(a) 4.37 A, 2.62 V
(b) 5.37 A, 2.62 V
(c) 5.37 A, 3.62 V
(d) 4.37 A, 3.62 V

17. (c)

Showing the corresponding currents in all the branches, the circuit is shown as below



Now we apply KVL in outer loop

$$-3 + I(1) - 5 + V_3 = 0$$

$$I + V_3 = 8 \qquad \text{...(i)}$$

Applying KVL in bridge,

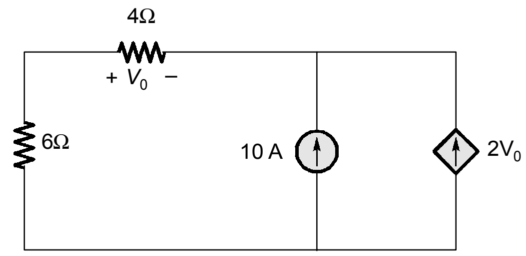
$$-5 + V_3 - 2(I - V_3) - 4(I - 2.8V_3) = 0$$

$$14.2\,V_3 - 6\,I = 5$$

$$I = 5.37\text{ A}$$

$$V_3 = 2.62\text{ V}$$

Q.18 The power absorbed by the dependent source is



(a) 90.75 W (b) 92.25 W
(c) 98.75 W (d) 99.25 W

18. (c)

Applying KCL at node

$$\frac{V_0}{4} + 10 + 2V_0 = 0;$$

Solving we get,

$$V_0 = -4.444\text{ V}$$

Current through the controlled source

$$i = 2V_0 = -8.888\text{A}$$

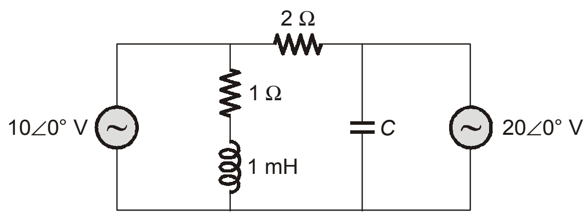
and the voltage across it,

$$V = (6+4)\times\frac{V_0}{4} = -11.111\text{ volts}$$

Hence, power absorbed by dependent source

$$P = (-8.888)(-11.111) = 98.75\text{ W}$$

Q.19 The circuit shown below operates at 50 Hz.



Complex power absorbed by the inductive branch and value of C if capacitor takes 10 VAR respectively will be

(a) $(19.01 + j28.17)$ VA and 43.2 μF (b) $(91.01 + j28.57)$ VA and 79.57 μF
(c) $(87.12 - j14.62)$ VA and 79.57 μF (d) $(87.12 - j14.62)$ VA and 67.24 μF

19. (b)

$$L = 1\text{ mH}$$

$$X_L = \omega L$$

$$= 2\pi \times 50 \times 1 \times 10^{-3}$$

$$X_L = 0.314\ \Omega$$

Current through inductive branch,

$$I_L = \frac{10\angle 0^\circ}{1+j0.314^\circ} = \frac{10\angle 0^\circ}{1.048\angle 17.34^\circ}$$

$$I_L = 9.54\angle -17.43^\circ \text{ A}$$

Complex power absorbed by inductive circuit,

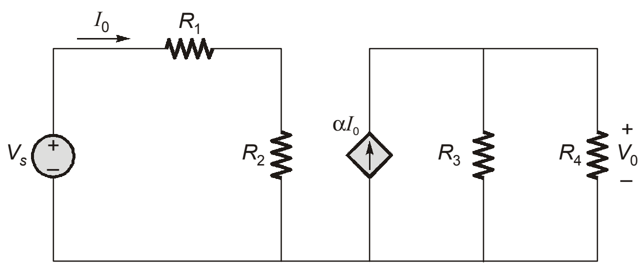
$$S = VI_L^*$$
$$= 10\angle 0^\circ \times 9.54\angle 17.43^\circ$$
$$= 95.4\angle 17.43^\circ \text{ VA}$$
$$S = 91.01 + j\,28.57 \text{ VA}$$

$$X_C = \frac{V_C^2}{Q_C} = \frac{20^2}{10} = 40\Omega$$

$$C = \frac{1}{2\pi \times 50 \times 40}$$

$$C = 79.57\ \mu\text{F}$$

Q.20 For the circuit shown below, what value of α will produce $\left|\frac{V_0}{V_s}\right| = 10$, for $R_1 = R_2 = R_3 = R_4$.



(a) 10 (b) 20
(c) 30 (d) 40

20. (d)

From the given circuit;

$$I_0 = \frac{V_s}{R_1+R_2}; \ \& \ V_0 = \alpha I_0 \times (R_3 \,||\, R_4)$$

$$V_0 = \frac{\alpha V_s}{R_1+R_2} \times \frac{R_3 R_4}{R_3+R_4}$$

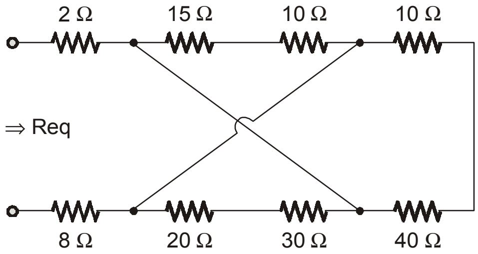
$$\frac{V_0}{V_s} = \frac{\alpha (R_3 R_4)}{(R_1+R_2)(R_3+R_4)}$$

For $R_1 = R_2 = R_3 = R_4$;

$$\left|\frac{V_0}{V_s}\right| = \frac{\alpha}{2R} \times \frac{R}{2} = \frac{\alpha}{4} = 10$$

$\Rightarrow$ $\alpha = 40$

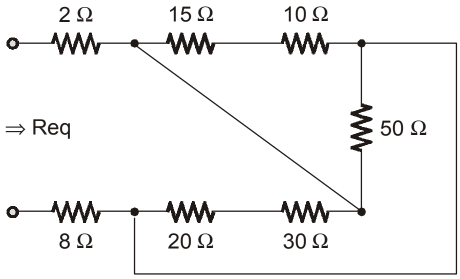
Q.21 The equivalent resistance R_{eq} for the following circuit is,



(a) 20.5 Ω (b) 24.5 Ω
(c) 22.5 Ω (d) 18.5 Ω

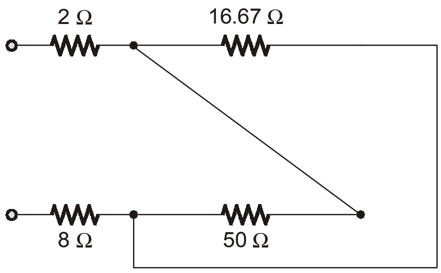
21. (c)

1st combine 10 Ω and 40 Ω resistors and redrawing the circuit.



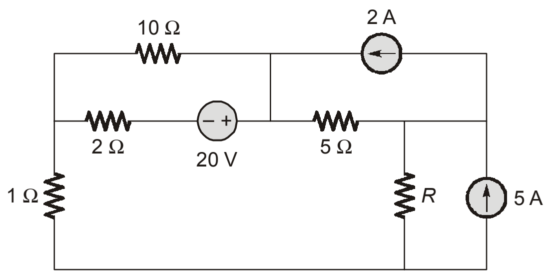
We now have,

$$(10\ \Omega + 15\ \Omega) \,||\, 50\ \Omega = 16.67\ \Omega$$



$$\text{equivalent resistance} = 2\Omega + (50\Omega \,||\, 16.67\Omega) + 8\Omega$$
$$= 22.5\ \Omega$$

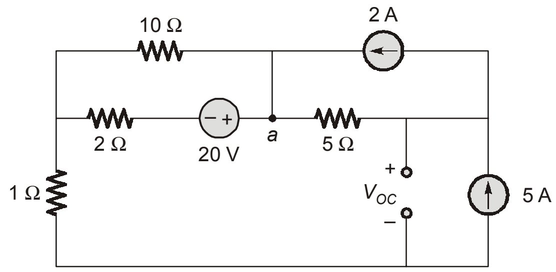
Q.22 The maximum power transferred to resistor *R* in the circuit shown below is



(a) 66 W (b) 55 W
(c) 45 W (d) 60 W

22. (a)

First R is removed and circuit behaves as shown below,



Current through 1 Ω resistor = 5 A (downwards)

Hence, $V_{1\Omega} = 5$ V

At node a, assuming node voltage V volts, applying KCL,

$$\frac{V-5}{10}+\frac{V-20-5}{2}+\frac{V-V_{oc}}{5} = 2$$

$$0.1\,V - 0.1\,(5) + 0.5\,V - 10 - 0.5\,(5) + 0.2\,V - 0.2\,V_{oc} = 2$$

$$0.8\,V - 0.6\,(5) = 12 + 0.2\,V_{oc}$$

$$0.8\,V - 0.2\,V_{oc} = 12 + 3 = 15 \qquad \text{...(i)}$$

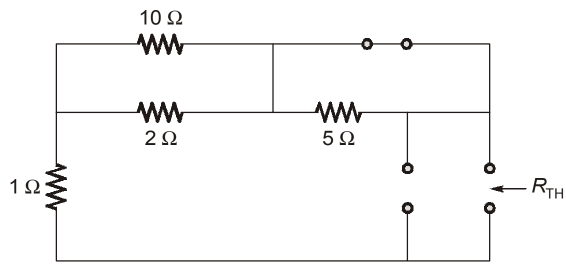
at node 6, nodal analysis

$$\frac{V_{oc}-V}{5}+2 = 5$$

$$0.2\,V_{oc} - 0.2\,V = 3 \qquad \text{...(ii)}$$

Solving equation (i) and (2)

$$V_{oc} = 45 \text{ V}$$

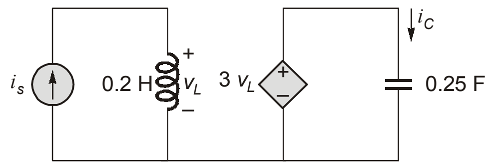


$$R_{Th} = \{(10 \parallel 2) + 1\} + 5$$

$$= \left(\frac{20}{12}+1\right)+5 = 7.67\ \Omega$$

$$P_{max} = \frac{V_{oc}^2}{4R} = \frac{45^2}{4\times 7.67} = 66 \text{ W}$$

Q.23 In the circuit of figure, $i_s(t) = 4 \sin 4t$ A. The $i_c(t)$ will be



(a) 4.6 sin 4t A
(b) –4.8 sin 4t A
(c) 9.8 sin 4t A
(d) –9.6 sin 4t A

23. (d)

The voltage across inductor is,

$$v_L = L\frac{di_L}{dt} = L\frac{di_s(t)}{dt}$$

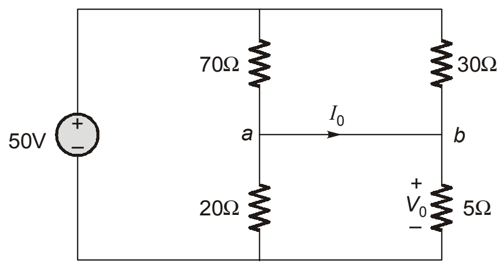
Current across capacitor is given by,

$$i_c = C\frac{dv_c}{dt}$$

$$v_c = 3v_L$$

$$\Rightarrow \quad i_c = 3C\frac{dV_L}{dt} = 3C.L\frac{d^2i_s(t)}{dt^2} = -9.6\sin 4t\text{ A}$$

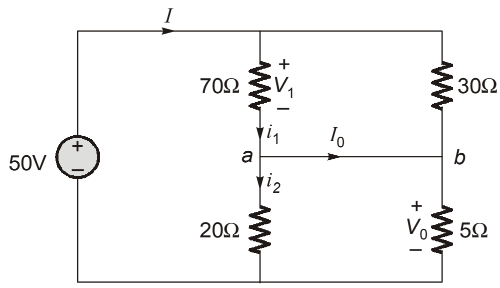
Q.24 The voltage V_0 and current I_0 in the given circuit are ;



(a) 8 V, 0.2 A
(b) 10 V, 0.2 A
(c) 8 V, 0.3 A
(d) 10 V, 0.3 A

24. (a)

$\because$ From, the circuit;



We can get ; $$I = \frac{50}{(70\|30)+(20\|5)} = \frac{50}{(21+4)} = 2A$$

$\because$ $$V_1 = 21\times I = 42\text{ V, \& } V_0 = 4I = 8\text{V}$$

$$i_1 = \frac{V_1}{70} = 0.6\text{ A; } i_2 = \frac{V_0}{20} = 0.4\text{ A}$$

Now, KCL at node '*a*', $$i_1 = i_2 + I_0\text{ ; } I_0 = 0.6 - 0.4 = 0.2\text{ A}$$

Hence, $$V_0 = 8\text{ V, } I_0 = 0.2\text{ A}$$

Q.25 A dc voltage of 100 V is applied to a coil having $R = 10\ \Omega$, $L = 10$ H, the value of current 0.1 sec after the switching on and the time taken by the current to reach half of its final value are respectively,

(a) 0.95 A, 0.69 sec
(b) 0.95 A, 0.49 sec
(c) 0.85 A, 0.69 sec
(d) 0.85 A, 0.49 sec

25. (a)

$$\text{Final current } I = \frac{V}{R} = \frac{100}{10} = 10 \text{ A}$$

$$T\text{(time contant)} = \frac{L}{R} = \frac{10}{10} = 1 \text{ sec}$$

The changing current is given by

$$i = I(1 - e^{-t/\tau})$$

or $$i = 10(1 - e^{-t})$$

Value of current 0.1 sec later is

$$i = 10(1 - e^{-0.1}) = 0.95 \text{ A}$$

Current half of final value will be

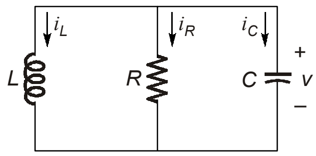
$$5 = 10(1 - e^{-t})$$

$$0.5 = (1 - e^{-t})$$

$$t = 0.69 \text{ sec}$$

Numerical Answer Type Questions : Q. 26 to Q. 33 carry 2 marks each

Q.26 In the circuit shown in figure, L = 1 mH and C = 100 μF, choose $R = 0.1\ R_C$. Where R_C is the value required to achieve critical damping, R = _____ $\times 10^{-3}\ \Omega$



26. 158.10 (157.50 to 158.50)

$$L = 1 \text{ mH}, C = 100\ \mu\text{F choose}$$

For critical damping, $$\xi = 1$$

and $$\xi = \frac{1}{2R_C}\sqrt{\frac{L}{C}} = 1$$

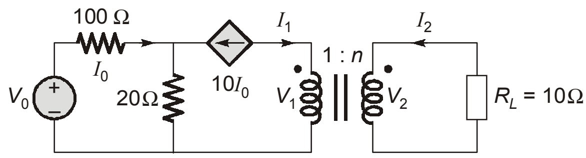
$$R_C = \frac{1}{2}\sqrt{\frac{L}{C}}$$

where R_C is the value required to achieve critical damping.

$$R_C = \frac{1}{2}\sqrt{\frac{10^{-3}}{10^{-4}}} = \frac{1}{2}\sqrt{10} = 1.581\ \Omega$$

given that $$R = 0.1\ R_C = 0.1581\ \Omega = 158.1\ \text{m}\Omega$$

Q.27 The voltage gain (magnitude) of the circuit shown below is _________ . (Assume n = 1/10)



27. 3.125 (2.600 to 3.400)

Applying KVL in the left most loop,

$$V_0 = 100\ I_0 + 20\ (I_0 - I_1)$$

$$= 100\ I_0 + 20\ (I_0 + 10\ I_0)$$

$$= 100\ I_0 + 220\ I_0$$

$$I_0 = \frac{V_0}{320}\text{ A}$$

$$I_1 = -10\,I_0 = -10\frac{V_0}{320} = \frac{-V_0}{32}$$

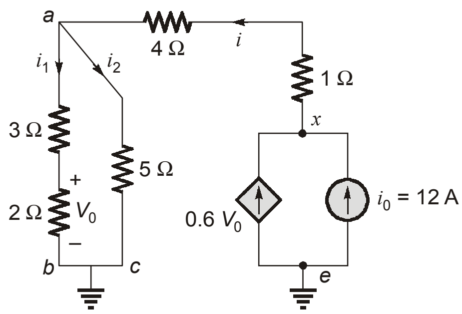
$$I_2 = \frac{-I_1}{n} = \frac{V_0}{32}\times 10 = \frac{10\,V_0}{32}$$

$$V_2 = -R_2\,I_2 = (-10)\left(\frac{10V_0}{32}\right) = \frac{-100}{32}V_0$$

$$\text{Voltage gain} = \frac{V_2}{V_0} = \frac{-100}{32} = -3.125$$

$$\left|\frac{V_2}{V_0}\right| = 3.125$$

Q.28 The potential at node 'x' with respect to 'e' is __________ V.



28. 225 (224.00 to 226.00)

Let the current be shown in the figure

$$i = 0.6\,V_0 + 12$$
$$i = i_1 + i_2$$

Since branches ab and ac have idential resistance,

Hence, $i_1 = i_2$

and $i = 12 + 0.6\,V_0 = 2i_1 = 2i_2$

$$V_0 = (i_1 \times 2)\text{ V}$$

$i = 2i_1$, we write

$$i_1 = \frac{i}{2} = \frac{1}{2}(12 + 0.6V_0)$$

and $V_0 = i_1 \times 2 = i_1 + 0.6\,V_0$

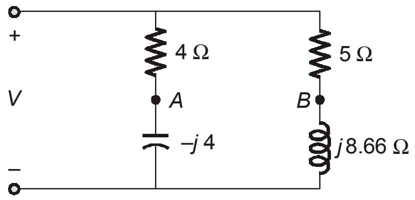
$$V_0 = i_1 \times 2 = 12 + 0.6\,V_0$$

Equation resistance across xe node is:

$$R_{xe} = (5\,\|\,5) + 4 + 1 = 7.5\ \Omega$$

$$V_{xe} = 0.6\,V_0 \times 7.5 + 12 \times 7.5$$
$$= 18 \times 7.5 + 12 \times 7.5$$
$$= 225\text{ V}$$

Q.29 In the parallel circuit shown in figure, the applied voltage V (magnitude only) is ________ V, where $V_{AB} = 48.3\angle 30°$ V.



29. 50 (49.00 to 51.00)

By voltage division in 2 branches

$$V_{AX} = \frac{-j4}{4-j4}\text{ V} = \frac{1}{1+j}\text{ V}$$

$$V_{BX} = \frac{j8.66}{5+j8.66}\text{V}$$

$$V_{AB} = V_{AX} - V_{BX}$$

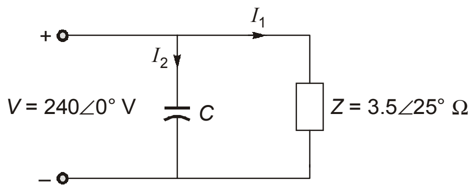
$$= \left(\frac{1}{1+j} - \frac{j8.66}{5+j8.66}\right)\text{V} = \frac{1}{-0.268+j1}\text{V}$$

$$V = (-0.268 + j1)\,V_{AB}$$

$$= (1.03\angle 105°)(48.3\angle 30°)$$

$$= 50\angle 135°\text{ V}$$

Q.30 ________ μF capacitance C must be provided by the capacitor bank in the figure given below to improve the power factor to 0.95 lagging. Frequency is 50 Hz.



30. 113.5 (112.00 to 115.00)

Before addition of capacitor bank,

$$\text{pf} = \cos 25° = 0.906 \text{ lag}$$

$$I_1 = \frac{240\angle 0°}{3.5\angle 25°} = 68.6\angle -25° \text{ A}$$

$$S = V_{\text{eff}}\, I_{\text{eff}}^{*}$$

$$= (240\angle 0°)(68.6\angle 25°) = 14921.45 + j\,6958$$

After improvement, the triangle has the same P, but its angle is $\cos^{-1} 0.95 = 18.19°$

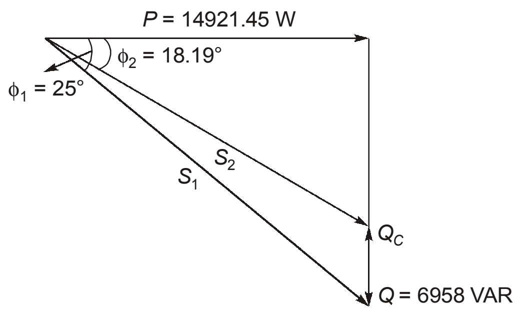
From the triangle,

$$\frac{6958 - Q_c}{14921.45} = \tan 18.19°$$

$$Q_c = 2053.52 \text{ VAR}$$

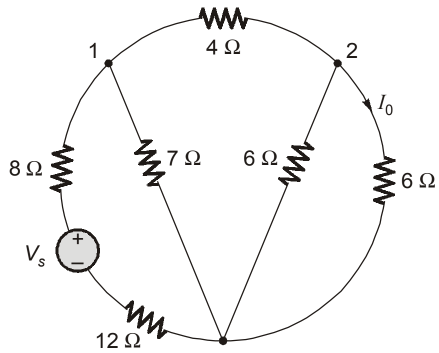
$$X_C = \frac{V_C^2}{Q_C}$$

$$X_C = 28.05\ \Omega$$



$$C = \frac{1}{2\pi \times 50 \times 28.05} = 1.135 \times 10^{-4}$$
$$= 113.5\,\mu\text{F}$$

Q.31 For the network shown below, the value of V_s is __________ V which makes $I_0 = 7.5$ mA.



31. 0.705 (0.680 to 0.730)

The node voltage method will be used and the matrix form of equation are

Voltage at node 1 $= V_1$

Voltage of node 2 $= V_2$

Applying KCL at node 1,

$$\frac{V_1}{20} + \frac{V_1}{7} + \frac{V_1}{4} - \frac{V_2}{4} = \frac{V_s}{20}$$

$$\frac{31}{70}V_1 - \frac{V_2}{4} = \frac{V_s}{20} \quad \text{...(i)}$$

Applying KCL at node 2,

$$-\frac{V_1}{4} + \frac{V_2}{4} + \frac{V_2}{6} + \frac{V_2}{6} = 0$$

$$\frac{7}{3}V_2 = V_1 \quad \text{...(ii)}$$

From equation (i),

$$\frac{31}{70} \times \frac{7}{3}V_2 - \frac{V_2}{4} = \frac{V_s}{20}$$

$$V_2 = 0.0638\, V_s$$

From circuit,

$$I_0 = 7.5 \times 10^{-3} = \frac{V_2}{6} = \frac{0.0638\, V_s}{6}$$

$$V_s = 0.705 \text{ V}$$

Q.32 A series RLC resonant circuit has a resonance frequency of 1.5 MHz and bandwidth of 10 kHz. If $C = 150$ pF, then the value of resistance R is _____ Ω.

32. 4.715 (4.500 to 5.000)

For a series reasonance circuit

Bandwidth $$f_2 - f_1 = \frac{R}{2\pi L}$$

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

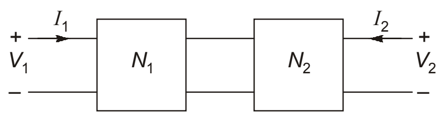
$$L = \frac{1}{(2\pi f_0)^2 \cdot C}$$

$$R = 2\pi L \cdot (f_2 - f_1) = \frac{2\pi(f_2 - f_1)}{(2\pi f_0)^2 \cdot C} = \frac{f_2 - f_1}{2\pi f_0^2 \cdot C}$$

$$= \frac{10 \times 10^3 \times 10^{12}}{2 \times \pi (1.5 \times 10^6)^2 \times 150}$$

$$R = 4.715\ \Omega$$

Q.33 Two identical networks are connected in cascaded as shown in figure. Transmission matrix for one network is $\begin{bmatrix} 1 & 4 \\ 3 & 2 \end{bmatrix}$. The value of Z_{12} is _____ (in ohms).



33. 11.11 (11.00 to 11.50)

If two networks are connected in cascaded, their transmission matrices are multiplied to get overall transmission matrix

$$T = \begin{bmatrix} 1 & 4 \\ 3 & 2 \end{bmatrix} \begin{bmatrix} 1 & 4 \\ 3 & 2 \end{bmatrix}$$

$$\Rightarrow \quad \begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} 13 & 12 \\ 9 & 16 \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

$$V_1 = 13V_2 - 12I_2 \quad \text{...(i)}$$

$$I_1 = 9V_2 - 16I_2 \quad \text{...(ii)}$$

$$Z_{12} = \left.\frac{V_1}{I_2}\right|_{I_1=0}$$

Putting $I_1 = 0$ in equation (ii)

$$9V_2 = 16I_2$$

$$V_2 = \frac{16}{9}I_2$$

$$V_1 = 13V_2 - 12I_2 = 13 \times \frac{16}{9}I_2 - 12I_2$$

$$\frac{V_1}{I_2} = Z_{12} = 11.11\ \Omega$$

❍❍❍❍