GATE 20 Years

Contents

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1. Network Theory

Gate Syllabus for this Chapter

Networks Theory:

Matrices Associated with Graphs; Incidence, Fundamental Cut-set and Fundamental Circuit Matrices. Solution Methods; Nodal and Mesh analysis. Network Theorems: Superposition, Thevenin and Norton's Maximum Power Transfer, Wye-Delta Transformation. Steady State Sinusoidal Analysis Using Phasors. Linear Constant Coefficient Differential Equations; Time-domain Analysis of Simple RLC Circuits, Solution of Network Equation Using Laplace Transform; Frequency-domain Analysis of RLC Circuits. 2-Port Network Parameters; Driving-point and Transfer Functions. State Equations for Networks.

Topics Related to Syllabus

1. **Basic Network Analysis and Network Topology**
2. **Initial Conditions; Time Varying Current and Differential Equation; Laplace Transform**
3. **Two-port Network**
4. **Network Theorem**
5. **Sinusoidal Steady State Analysis; Resonance; Power in AC Circuits; Passive Filters**

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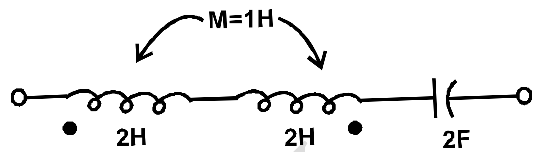
Previous Years GATE Question

1. Basic Network Analysis and Network Topology

Q1.1. The resonant frequency of the series circuit shown in figure is: [GATE-1990]

(a) $\frac{1}{4\pi\sqrt{2}}$ Hz (b) $\frac{1}{4\pi}$ Hz
(c) $\frac{1}{2\pi\sqrt{10}}$ Hz (d) $\frac{1}{4\pi\sqrt{2}}$ Hz



Q1.2. The response of an initially relaxed linear constant parameter network to a unit impulse applied at $t = 0$ is $4e^{-2t}$. The response of this network to a unit step function will be: [GATE-1990]

(a) $2[1 - e^{-2t}]\,u(t)$ (b) $4[e^{-1}\ \ e^{-2t}]\,u(t)$ (c) $\sin 2t$ (d) $(1 - 4e^{-4t})\,u(t)$

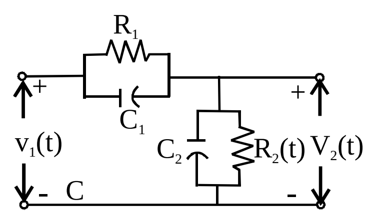
Q1.3. Two resistors R_1 and R_2 (in ohms) at temperature T_1 and T_1 K respectively, are connected in series. Their equivalent noise temperature is: [GATE-1991]

(a) $\frac{T_1R_1 + T_2R_2}{R_1}$ (b) $\frac{T_1R_1 + T_2R_2}{R_1 + R_2}$ (c) $\frac{T_1R_1}{R_1 + R_2}$ (d) $\frac{T_2R_2}{R_1 + R_2}$

Q1.4. For the compensated attenuator of figure, the impulse response under the condition $R_1C_1 = R_2C_2$ is: [GATE-1992]

(a) $\frac{R_2}{R_1+R_2}\left[1-e^{\frac{1}{R_1C_1}}\right]u(t)$ (b) $\frac{R_2}{R_1+R_2}\,\delta(t)$

(c) $\frac{R_2}{R_1+R_2}\,u(t)$ (d) $\frac{R_2}{R_1+R_2}\left[1+e^{\frac{1}{R_1C_1}}\right]u(t)$

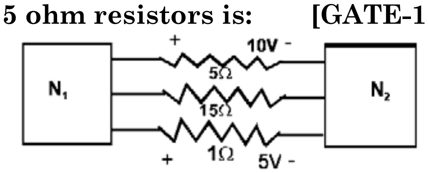


Q1.5. Relative to a given fixed tree of a network: [GATE-1992]

(a) Link currents form an independent set
(b) Branch voltage form an independent set
(c) Link currents form an independent set
(d) Branch voltage form an independent set

Q1.6. The two electrical sub network N_1 and N_2 are connected through three resistors as shown in figure. The voltage across 5 ohm resistor and 1 ohm resistor are given to be 10V and 5V, respectively. Then voltage across 15 ohm resistors is: [GATE-1993]

(a) –105 V (b) +105 V
(c) –15 V (d) +15 V



Q1.7. A network contains linear resistors and ideal voltage sources. If values of all the resistors are doubled, then the voltage across each resistor is: [GATE-1993]

(a) Halved (b) Doubled (c) Increases by four times (d) Not changed

Q1.8. The RMS value of a rectangular wave of period *T*, having a value of +V for a duration, ($T_1 < T$) and –V for the duration, $T - T_1 = T_2$, equals: [GATE-1995]

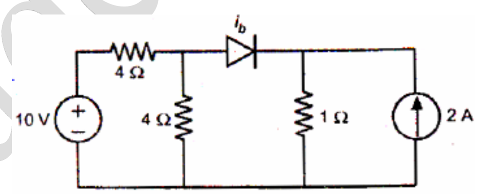
(a) V (b) $\frac{T_1 - T_2}{T}$ V (c) $\frac{V}{\sqrt{2}}$ (d) $\frac{T_1}{T_2}$ V

Q1.9. The number of independent loops for a network with *n* nodes and *b* branches is: [GATE-1996]

(a) $n - 1$
(b) $b - n$
(c) $b - n + 1$
(d) Independent of the number of nodes

Q1.10. In the circuit of figure, the current i_D through the ideal diode (zero cut in voltage and forward resistance) equals [GATE-1997]

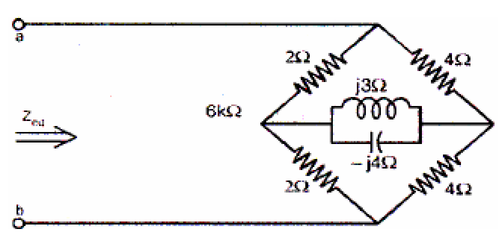
(a) 0 A
(b) 4 A
(c) 1 A
(d) None of these



Q1.11. In the circuit of figure, the equivalent impedance seen across terminals a, *b* is: [GATE-1997]

(a) $\left(\frac{16}{3}\right)\Omega$ (b) $\left(\frac{8}{3}\right)\Omega$

(c) $\left(\frac{8}{3} + 12j\right)\Omega$ (d) None of these



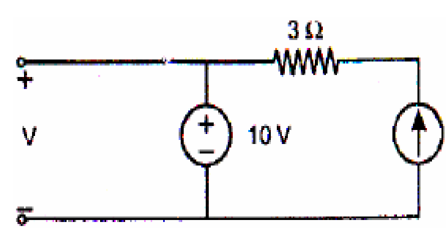
Q1.12. The voltage '*V*' in figure is: [GATE-1997]

(a) 10 V

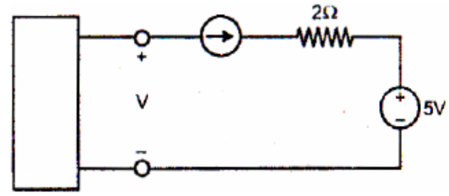
(b) 15 V

(c) 5 V

(d) None of these

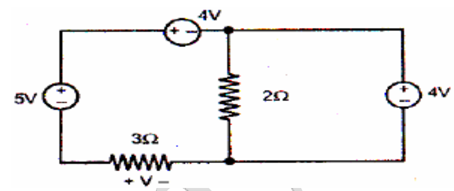


Q1.13. The voltage '*V*' in figure in always equal to: **[GATE-1997]**



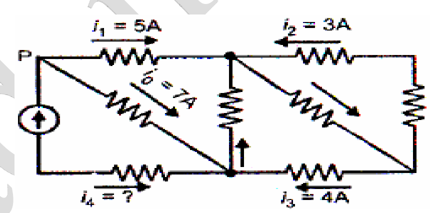
(a) 9 V
(b) 5 V
(c) 1 V
(d) None of these

Q1.14. The voltage '*V*' in figure is equal to: **[GATE-1997]**



(a) 3 V
(b) –3 V
(c) 5 V
(d) None of these

Q1.15. The current i_4 in the circuit of figure is equal to: **[GATE-1997]**

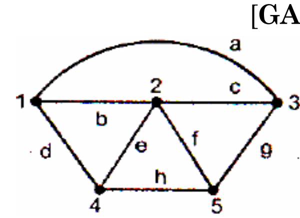


(a) 12 A
(b) –12 A
(c) 4 A
(d) None of these

Q1.16. The nodal method of circuit analysis is based on: **[GATE-1998]**
(a) KVL and Ohm's law (b) KCL and Ohm's law
(c) KCL and KVL (d) KCL, KVL and Ohm's law

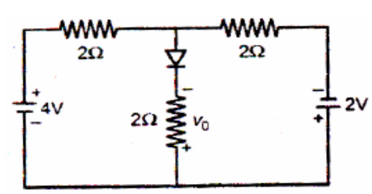
Q1.17. A network has 7 nodes and 5 independent loops. The number of branches in the network is: **[GATE-1998]**
(a) 13 (b) 12 (c) 11 (d) 10

Q1.18. Identify which of the following is NOT a three of the graph shown in figure: **[GATE-1999]**



(a) begh
(b) defg
(c) adhg
(d) aegh

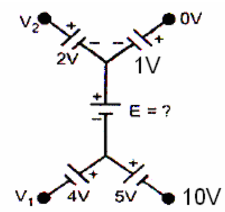
Q1.19. For the circuit in figure, the voltage v_0 is: **[GATE-2000]**



(a) 2 V
(b) 1 V
(c) –1 V
(d) None of these

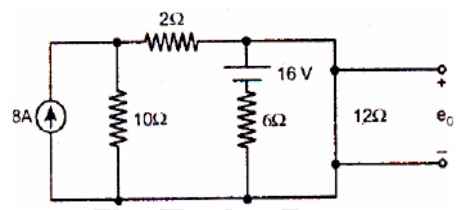
Q1.20. In the circuit of figure, the value of the voltage source *E* is: [GATE-2000]

(a) –16 V
(b) 4 V
(c) –6 V
(d) 16 V



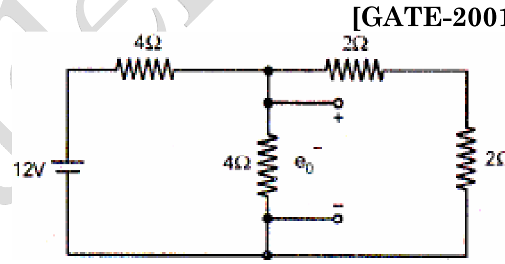
Q1.21. The voltage e_0 in figure is: [GATE-2001]

(a) 48 V
(b) 24 V
(c) 36 V
(d) 28 V



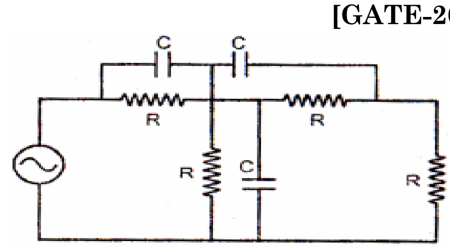
Q1.22. The voltage e_0 in figure is: [GATE-2001]

(a) 2 V
(b) $\frac{4}{3}$ V
(c) 4 V
(d) 8 V

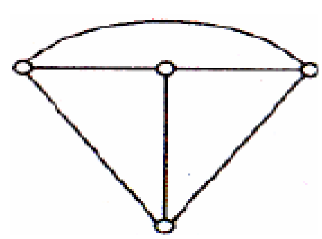


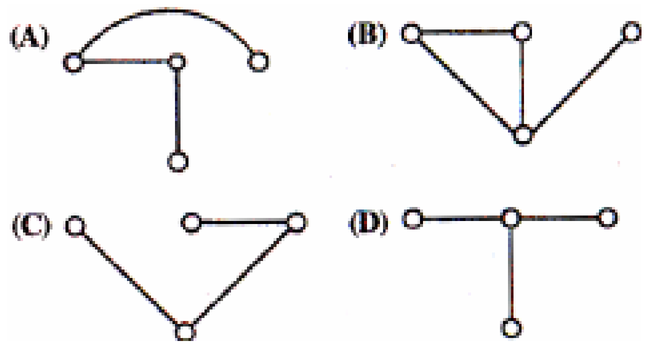
Q1.23. The minimum number of equations required to analyze the circuit shown in figure is [GATE-2003]

(a) 3
(b) 4
(c) 6
(d) 7



Q1.24. Consider the network graph shown in figure which one of the following is NOT a 'tree' of this graph? [GATE-2004]





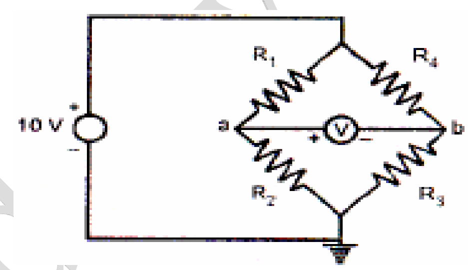
Q1.25. If $R_1 = R_2 = R_4 = R$ and R_3 =1. 1R in the bridge circuit shown in figure, then the reading in the ideal voltmeter connected between *a* and *b* is: [GATE-2005]

(a) 0.238 V

(b) 0.138 V

(c) –0.238 V

(d) 1 V



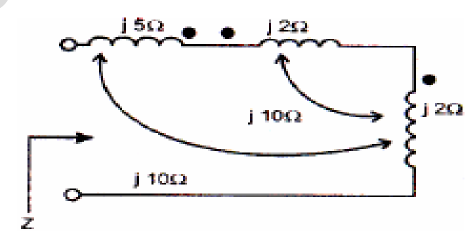
Q1.26. Impedance *Z* as shown in figure is: [GATE-2005]

(a) $j29\Omega$

(b) $j9\Omega$

(c) $j19\Omega$

(d) $j39\Omega$



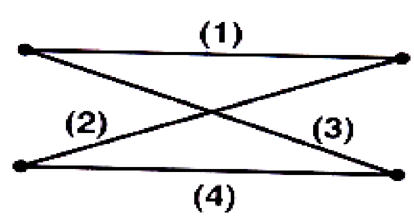
Q1.27. In the following graph, the number of trees (*P*) and number of cut-sets (*Q*) are: [GATE-2008]

(a) $P = 2$, $Q = 2$

(b) $P = 2$, $Q = 6$

(c) $P = 4$, $Q = 6$

(d) $P = 4$, $Q = 10$



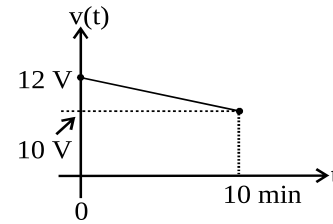
Q1.28. A fully charged mobile phone with a 12V battery is good for a 10 minutes talk-time. Assume that, during the talk-time, the battery delivers a constant current of 2A and its voltage drops linearly from 12V to 10V as shown in the figure. How much energy does the battery deliver this talk-time? [GATE-2009]

(a) 220 *J*

(b) 12 *kJ*

(c) 13.2 *kJ*

(d) 14.4 *kJ*



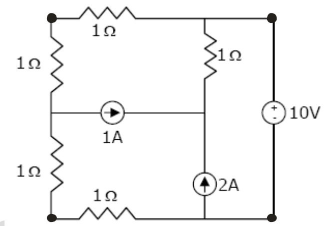
Q.1.29 In the circuit shown, the power supplied by the voltage source is: [GATE-2010]

(a) 0 W

(b) 5 W

(c) 10 W

(d) 100 W



2. Initial Conditions, Time-varying Current & Differential Equation, Laplace Transform

Q2.1. The necessary and sufficient condition for a rational function of *s*. *T*(*s*) to be driving point impedance of an *RC* network is that all poles and zeros should be:
(a) Simple and lie on the negative axis in the *s*-plane **[GATE-1991]**
(b) Complex and lie in the left half of the *s*-plane
(c) Complex and lie in the right half of the *s*-plane
(d) Simple and lie on the positive real axis of the *s*-plane

Q2.2. The voltage across an impedance in a network is $V(s) = Z(s)\ I(s)$, where $V(s)$, $Z(s)$, $I(s)$ are the Laplace transforms of the corresponding time function $v(t)$, $z(t)$ and $i(t)$. The voltage $v(t)$ is: [GATE-1991]

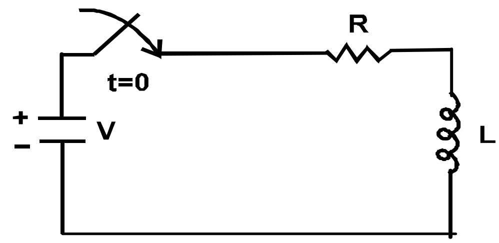
(a) $v(t) = z(t)\ v(t)$ (b) $v(t) = \int_0^t i(\tau)\cdot z(t-\tau)d\tau$

(c) $v(t) = \int_0^t i(\tau).z(t+\tau)d\tau$ (d) $v(t) = z(t) + v(t)$

Q2.3. Condition for valid input impedance is that maximum powers of the number of denominator polynomial may bigger at most by: [GATE-1993]
(a) 2 (b) 1 (c) 3 (d) 0

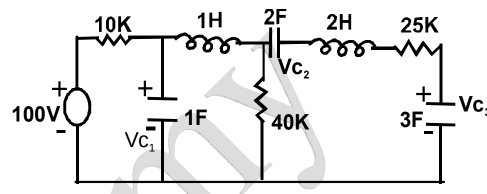
Q2.4. In the circuit shown in figure, assuming initial voltage and capacitors and currents through the inductors to be zero at the time of switching ($t = 0$), then at any time $t > 0$: [GATE-1996]

(a) Current increases monotonically with time
(b) Current decreases monotonically with time
(c) Current remains constant at V/R
(d) Current first increases then decreases



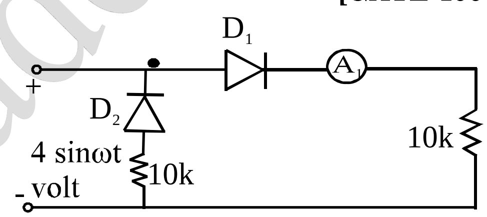
Q2.5. The voltages Vc_1, Vc_2, and Vc_3 across the capacitors in the circuit in figure, under steady state, are respectively [GATE-1996]

(a) 80 V, 32 V, 48 V
(b) 80 V, 48 V, 32 V
(c) 20 V, 8 V, 12 V
(d) 20 V, 12 V, 8 V



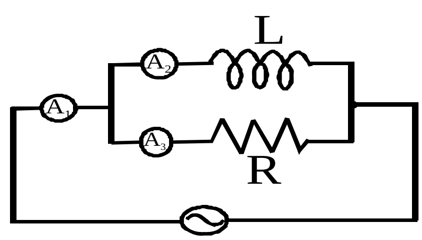
Q2.6. In the circuit of figure, assume that the diodes are ideal and the meter is an average indicating ammeter. The ammeter will read: [GATE-1996]

(a) $0.4\sqrt{2}$ A (b) 0.4 A
(c) $\frac{0.8}{\pi}$ A (d) $\frac{0.4}{\pi}$ A



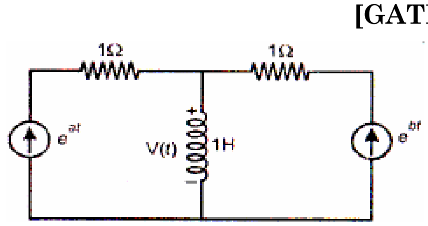
Q2.7. In figure, A_1, A_2 and A_3 are ideal ammeters. If A_2 and A_3 real 3A and 4A respectively, then A_1 should read: [GATE-1996]

(a) 1 A
(b) 5 A
(c) 7 A
(d) None of these



Q2.8. In the circuit of figure, the voltage $V(t)$ is: [GATE-2000]

(a) $e^{at} - e^{bt}$ (b) $e^{at} + e^{bt}$
(c) $ae^{at} - be^{bt}$ (d) $ae^{at} + be^{bt}$



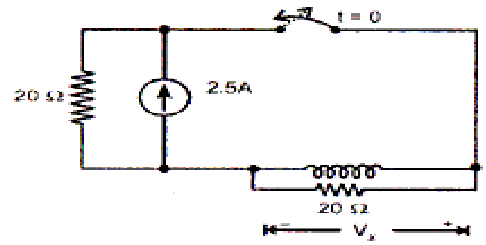
Q2.9. In figure the switch was closed for a long time before opening at $t = 0$. The voltage Vx at $t = 0^+$ is [GATE-2002]

(a) 25 V

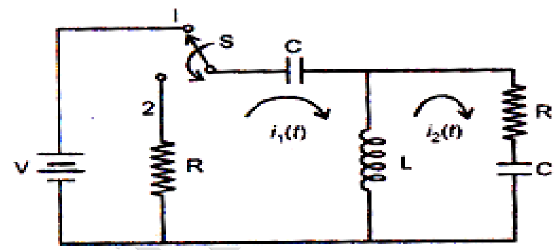
(b) 50 V

(c) –50 V

(d) 0 V



Q2.10. **$I_1(s)$ and $I_2(s)$ are the Laplace transform of $i_1(t)$ and $i_2(t)$ respectively. The equations for the loop currents $I_1(s)$ and $I_2(s)$ for the circuit shown in figure, after the switch is brought from position 1 to position 2 at $t = 0$, are:**



[GATE-2003]

(a) $$\begin{bmatrix} R+Ls+\frac{1}{Cs} & -Ls \\ -Ls & R+\frac{1}{Cs} \end{bmatrix}\begin{bmatrix} I_1 & (s) \\ I_2 & (s) \end{bmatrix} = \begin{bmatrix} \frac{V}{s} \\ 0 \end{bmatrix}$$

(b) $$\begin{bmatrix} R+Ls+\frac{1}{Cs} & -Ls \\ -Ls & R+\frac{1}{Cs} \end{bmatrix}\begin{bmatrix} I_1 & (s) \\ I_2 & (s) \end{bmatrix} = \begin{bmatrix} -\frac{V}{s} \\ 0 \end{bmatrix}$$

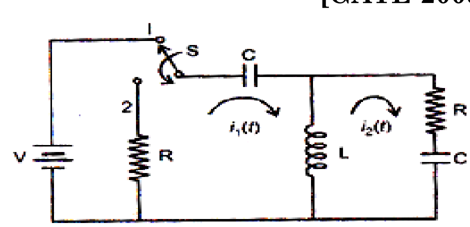
(c) $$\begin{bmatrix} R+Ls+\frac{1}{Cs} & -Ls \\ -Ls & RLs+\frac{1}{Cs} \end{bmatrix}\begin{bmatrix} I_1 & (s) \\ I_2 & (s) \end{bmatrix} = \begin{bmatrix} \frac{V}{s} \\ 0 \end{bmatrix}$$

(d) $$\begin{bmatrix} R+Ls+\frac{1}{Cs} & -Ls \\ -Ls & R+Ls+\frac{1}{Cs} \end{bmatrix}\begin{bmatrix} I_1 & (s) \\ I_2 & (s) \end{bmatrix} = \begin{bmatrix} -\frac{V}{s} \\ 0 \end{bmatrix}$$

Q2.11. **At $t = 0^+$, the current i_1 is:** **[GATE-2003]**

(a) $\frac{-V}{2R}$ (b) $\frac{-V}{R}$

(c) $\frac{-V}{4R}$ (d) zero



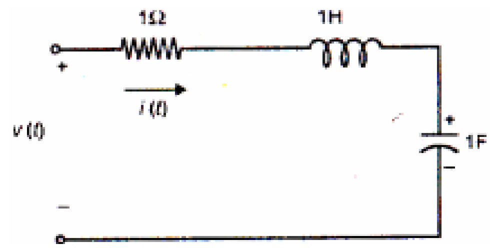
Q2.12. The circuit shown in figure has initial current $i_1(0^-)$ = 1A through the inductor and aninitial voltage $v_c(0^-) = -1$V across the capacitor. For input $v(t) = u(t)$, the Laplace transform of the current $i(t)$ $t \geq 0$ is: [GATE-2004]

(a) $\frac{s}{s^2+s+1}$

(b) $\frac{s+2}{s^2+s+1}$

(c) $\frac{s-2}{s^2+s+1}$

(d) $\frac{s+2}{s^2+s+1}$



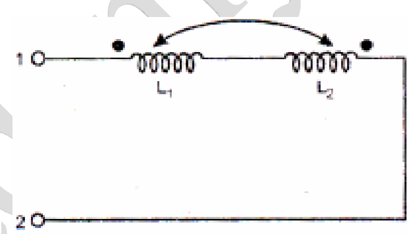
Q2.13. The equivalent inductance measured between the terminals 1 and 2 for the circuit shown in figure is: [GATE-2004]

(a) $L_1 + L_2 + M$

(b) $L_1 + L_2 - M$

(c) $L_1 + L_2 + 2M$

(d) $L_1 + L_1 - 2M$



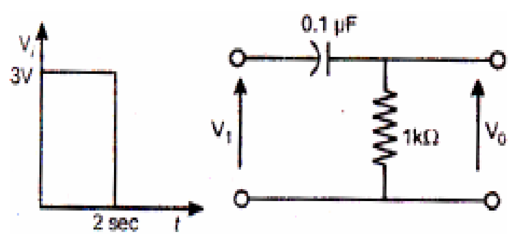
Q2.14. A square pulse of 3 volts amplitude is applied to *C–R* circuit shown in figure. The capacitor is initially uncharged. The output voltage v_o at time t = 2 sec is: [GATE-2005]

(a) 3 V

(b) –3 V

(c) 4 V

(d) –4 V



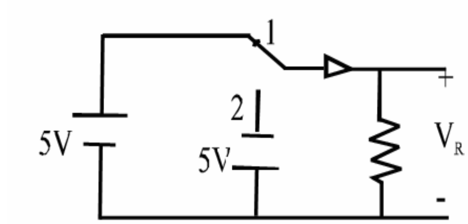
Q2.15. In the circuit shown below, the switch was concentred to position 1 at $t < 0$ and at t= 0, it is changed to position 2. Assume that the diode has zero voltage drop and a storage time t_s. For $t < 1 \leq t_s$, V_R is given by (all in volts): [GATE-2006]

(a) $V_R = -5$

(b) $V_R = +5$

(c) $0 \leq V_R = 5$

(d) $-5 < V_R < 0$



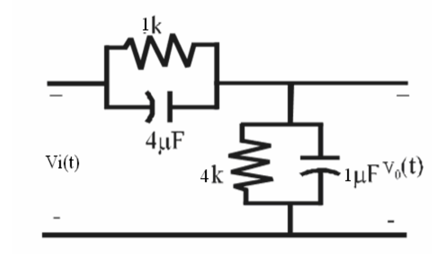
Q2.16. In the figure shown below, assume that all the capacitors are initially uncharged. If $V_i(t) = 10u(t)$ volts $V_0(t)$ is given by: **[GATE-2006]**

(a) $8\,e^{-0.004t}$ Volts

(b) $8\,(1 - e^{-t/0.004})$ Volts

(c) $8\,u(t)$ Volts

(d) 8 Volts



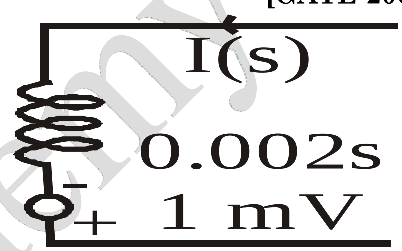
Q2.17. A 2 mH inductor with some initial current can be represented as shown below, where s is the Laplace transform variable, the value of initial current is: **[GATE-2006]**

(a) 0.5 A

(b) 2.0 A

(c) 1.0 A

(d) 0.0 A



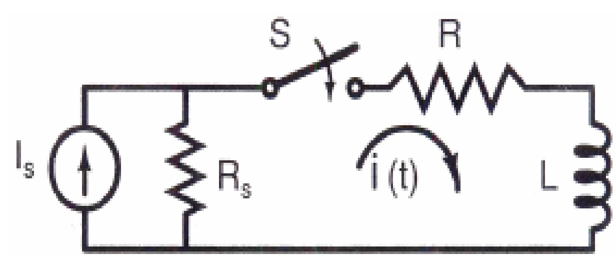
Q2.18. In the following circuit, the switch S is closed at $t = 0$. The rate of change of current $\frac{di}{dt}(0+)$ is given by **GATE-2008]**

(a) 0

(b) $\frac{R_S I_S}{L}$

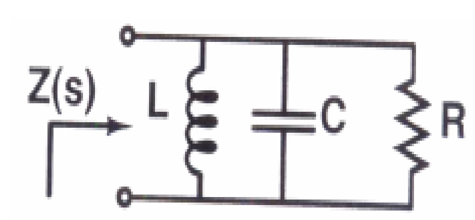
(c) $\frac{(R+R_S)I_S}{L}$

(d) ∞

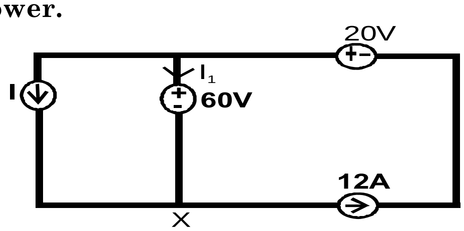


Q2.19. The driving-point impedance of the following network is given by $Z(s) = \frac{0.2s}{s^2 + 0.1s + 2}$. The component values are: **[GATE-2008]**

(a) $L = 5\text{H},\quad R = 0.5\Omega,\quad C = 0.1\text{F}$
(b) $L = 0.1\text{H},\quad R = 0.5\Omega,\quad C = 5\text{F}$
(c) $L = 5\text{H},\quad R = 2\Omega,\quad C = 0.1\text{F}$
(d) $L = 0.1\text{H},\quad R = 2\Omega,\quad C = 5\text{F}$



Q2.20. In the interconnection of ideal sources shown in the figure, it is known that the 60 V source is absorbing power. **[GATE-2009]**



Which of the following can be the value of the current source *I*?

(a) 10 A (b) 13 A (c) 15 A (d) 18 A

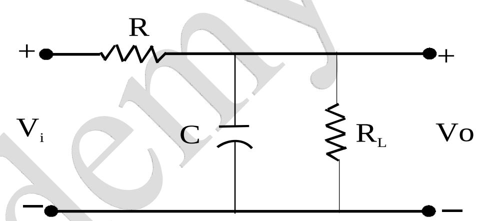
Q2.21. If the transfer function of the following network is $\frac{V_o(s)}{V_i(s)} = \frac{1}{2+sCR}$ the value of the load resistance R_L is: **[GATE-2009]**

(a) R/4

(b) R/2

(c) R

(d) 2 R



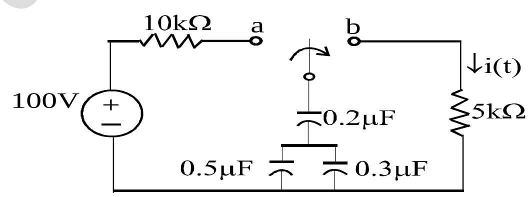
Q2.22. The switch in the circuit shown was on position a for a long time, and is moved to position *b* at time *t* = 0. The current *i*(*t*) for *t* > 0 is given by: **[GATE-2009]**

(a) $0.2e^{-125t}\,u(t)$ mA

(b) $20e^{-1250t}\,u(t)$ mA

(c) $0.2e^{-1250t}\,u(t)$ mA

(d) $20e^{-1000t}\,u(t)$ mA



Q2.23. The time-domain behavior of an *RL* circuit is represented by $L\frac{di}{dt} + Ri = V_0\left(1 + Be^{-Rt/L}\sin t\right)u(t)$. For an initial current of $i(0) = \frac{V_0}{R}$, the steady state value of the current is given by **[GATE-2009]**

(a) $i(t) \to \frac{V_0}{R}$ (b) $i(t) \to \frac{2V_0}{R}$ (c) $i(t) \to \frac{V_0}{R}(1+B)$ (d) $i(t) \to \frac{2V_0}{R}(1+B)$

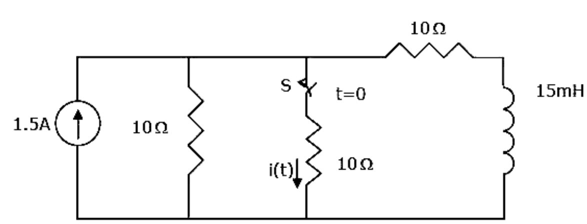
Q2.24. In the circuit shown, the switch *S* is open for a long time and is closed at *t* = 0. The current *i*(*t*) for *t* ≥ 0⁺ is: **[GATE-2010]**

(a) $i(t) = 0.5 - 0.125e^{-1000t}$ A

(b) $i(t) = 1.5 - 0.125e^{-1000t}$ A

(c) $i(t) = 0.5 - 0.5e^{-1000t}$ A

(d) $i(t) = 0.375e^{-1000t}$ A



3. Two-port Network

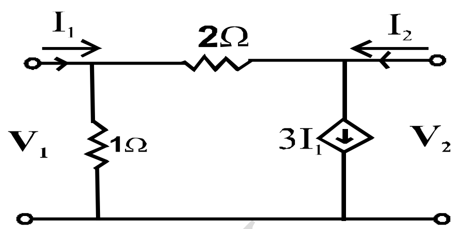
Q3.1. The open circuit impedance matrix of the two-port network shown in figure is: **[GATE-1990]**

(a) $\begin{bmatrix} -2 & 1 \\ -8 & 3 \end{bmatrix}$

(b) $\begin{bmatrix} -2 & -8 \\ 1 & 3 \end{bmatrix}$

(c) $\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$

(d) $\begin{bmatrix} -2 & -1 \\ -1 & 3 \end{bmatrix}$



Q3.2. Two two-port networks are connected in cascade. The combination is to represented as a single two-port networks. The parameters of the network are obtained by multiplying the individual: **[GATE-1991]**

(a) z-parameter matrix (b) h-parameter matrix
(c) y-parameter matrix (d) ABCD parameter matrix

Q3.3. For a two-port network to be reciprocal **[GATE-1992]**

(a) $Z_{11} = Z_{22}$ (b) $y_{21} = y_{12}$ (c) $h_{21} = -h_{21}$ (d) $AD - BC = 0$

Q3.4. The condition that a *z*-port network is reciprocal, can be expressed in terms of its ABCD parameters as: **[GATE-1994]**

(a) $AD - BC = 1$ (b) $AD - BC = 0$ (c) $AD - BC > 1$ (d) $AD - BC < 1$

Q3.5. The short-circuit admittance matrix of a two-port network is: **[GATE-1998]**

$$\begin{bmatrix} 0 & -1/2 \\ 1/2 & 0 \end{bmatrix}$$

The two-port network is:

(a) Non-reciprocal and passive (b) Non-reciprocal and active
(c) Reciprocal and passive (d) Reciprocal and active

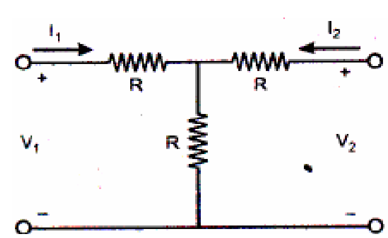
Q3.6. A two-port network is shown in figure. The parameter h_{21} for this network can begiven by: **[GATE-1999]**

(a) –1/2

(b) +1/2

(c) –3/2

(d) +3/2



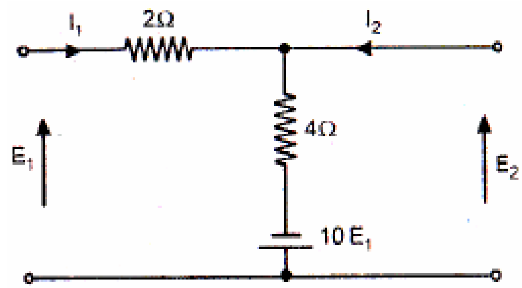
Q3.7. The Z parameters Z_{11} and Z_{21} for the 2-port network in figure are: [GATE-2001]

(a) $Z_{11} = -\frac{6}{11}\,\Omega;\quad Z_{21} = \frac{16}{11}\,\Omega$

(b) $Z_{11} = +\frac{6}{11}\,\Omega;\quad Z_{21} = \frac{4}{11}\,\Omega$

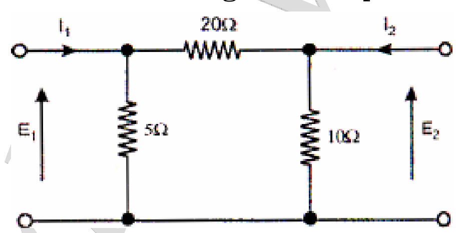
(c) $Z_{11} = +\frac{6}{11}\,\Omega;\quad Z_{21} = \frac{-16}{11}\,\Omega$

(d) $Z_{11} = \frac{4}{11}\,\Omega;\quad Z_{21} = \frac{4}{11}\,\Omega$



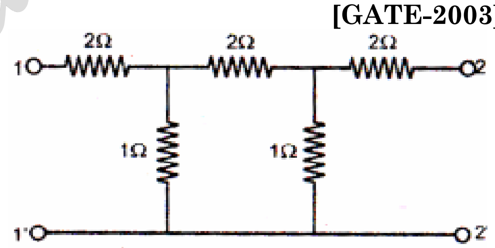
Q3.8. The admittance parameter Y_{12} in the two-port network in figure is: [GATE-2001]

(a) –0.2 mho
(b) 0.1 mho
(c) –0.05 mho
(d) 0.05 mho



Q3.9. The impedance parameters Z_{11} and Z_{12} of the two-port network in figure are: [GATE-2003]

(a) $Z_{11} = 2.75\,\Omega$ and $Z_{12} = 0.25\,\Omega$
(b) $Z_{11} = 3\,\Omega$ and $Z_{12} = 0.5\,\Omega$
(c) $Z_{11} = 3\,\Omega$ and $Z_{12} = 0.25\,\Omega$
(d) $Z_{11} = 2.25\,\Omega$ and $Z_{12} = 0.5\,\Omega$



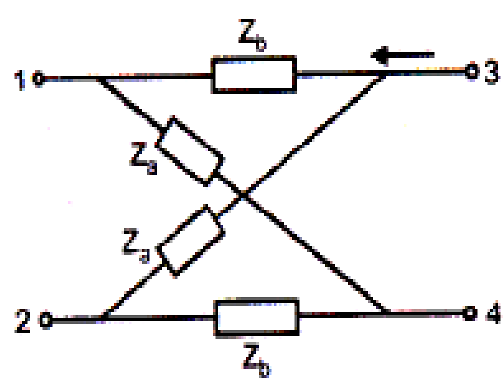
Q3.10. For the lattice shown in figure, $Z_a = j2\Omega$ and $Z_b = 2\Omega$. The values of the open circuit impedance parameters $Z = \begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix}$ are: [GATE-2004]

(a) $\begin{bmatrix} 1-j & 1+j \\ 1+j & 1+j \end{bmatrix}$

(b) $\begin{bmatrix} 1-j & 1+j \\ -1+j & 1-j \end{bmatrix}$

(c) $\begin{bmatrix} 1+j & 1+j \\ 1-j & 1-j \end{bmatrix}$

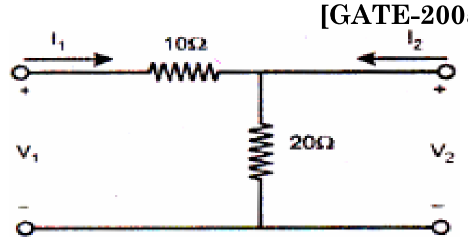
(d) $\begin{bmatrix} 1+j & -1+j \\ -1+j & 1+j \end{bmatrix}$



Q3.11. The *h* parameters of the circuit in figure are: **[GATE-2005]**

(a) $\begin{bmatrix} 0.1 & 0.1 \\ -0.1 & 0.3 \end{bmatrix}$ (b) $\begin{bmatrix} 10 & -1 \\ 1 & 0.05 \end{bmatrix}$

(c) $\begin{bmatrix} 30 & 20 \\ 20 & 20 \end{bmatrix}$ (d) $\begin{bmatrix} 10 & +1 \\ -1 & 0.05 \end{bmatrix}$



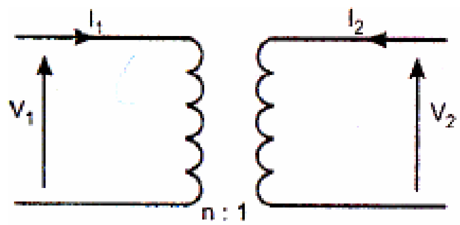
Q3.12. The ABCD parameters of an ideal n : 1 transformer shown in figure are $\begin{bmatrix} n & 0 \\ 0 & X \end{bmatrix}$. The value of X will be: **[GATE-2005]**

(a) n

(b) $1/n$

(c) n^2

(d) $1/n^2$



Q3.13. A two-port network is represented by ABCD parameters given by

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

If two-port is terminated by R_L, the input impedance seen at one-port is given by: **[GATE-2006]**

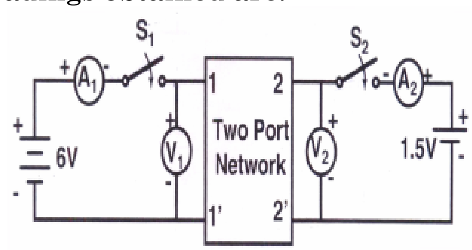
(a) $\frac{A + BR_L}{C + DR_L}$ (b) $\frac{AR_L + C}{BR_L + D}$ (c) $\frac{DR_L + A}{BR_L + C}$ (d) $\frac{B + AR_L}{D + CR_L}$

Statements for Linked Answers and Questions 3.14 and 3.15:

A two-port network shown below is excited by external DC sources. The voltages and the currents are measured with voltmeters V_1, V_2 and ammeters A_1, A_2 (all assumed to be ideal), as indicated. Under following switch condition, the readings obtained are:

(*i*) S_1 – Open, S_2 – Closed
$A_1 = 0\,\text{A},\ V_1 = 4.5\,\text{V},\ V_2 = 1.5\,\text{V},\ A_2 = 1\,\text{A}$

(*ii*) S_1 – Closed, S_2 – Open
$A_1 = 4\,\text{A},\ V_1 = 6\,\text{V},\ V_2 = 6\,\text{V},\ I_2 = 0\,\text{A}$



Q3.14. The *z*-parameter matrix for this network is: **[GATE-2008]**

(a) $\begin{bmatrix} 1.5 & 1.5 \\ 4.5 & 1.5 \end{bmatrix}$ (b) $\begin{bmatrix} 1.5 & 4.5 \\ 1.5 & 4.5 \end{bmatrix}$

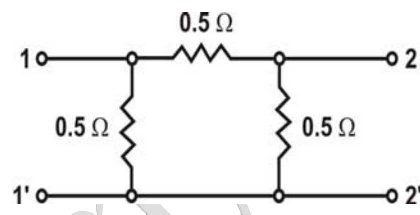
(c) $\begin{bmatrix} 1.5 & 4.5 \\ 1.5 & 1.5 \end{bmatrix}$ (d) $\begin{bmatrix} 4.5 & 1.5 \\ 1.5 & 4.5 \end{bmatrix}$

Q3.15. The *h*-parameter matrix for this network is: **[GATE-2008]**

(a) $\begin{bmatrix} -3 & 3 \\ -1 & 0.67 \end{bmatrix}$ (b) $\begin{bmatrix} -3 & -1 \\ 3 & 0.67 \end{bmatrix}$

(c) $\begin{bmatrix} 3 & 3 \\ 1 & 0.67 \end{bmatrix}$ (d) $\begin{bmatrix} 3 & 1 \\ -3 & -0.67 \end{bmatrix}$

Q3.16. For the two-port network shown below, the short-circuit admittance parameter matrix is: [GATE-2010]



(a) $\begin{bmatrix} 4 & -2 \\ -2 & 4 \end{bmatrix} S$

(b) $\begin{bmatrix} 1 & -0.5 \\ -0.5 & 1 \end{bmatrix} S$

(c) $\begin{bmatrix} 1 & 0.5 \\ 0.5 & 1 \end{bmatrix} S$

(d) $\begin{bmatrix} 4 & 2 \\ 2 & 4 \end{bmatrix} S$

4. Network Theorem

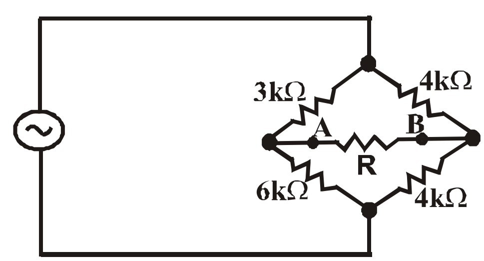
Q4.1. A generator of internal impedance 'Z_G' deliver maximum power to a load impedance, Z_p only if Z_p [GATE-1994]

(a) $Z_1 < Z_G$ (b) $Z_1 > Z_G$ (c) $Z_p = Z_G$ (d) $Z_1 = 2Z_G$

Q4.2 A ramp voltage, $v(t) = 100t$ volts, is applied to an RC differencing circuit with $R = 5\ k\Omega$ and $C = 4\ \mu F$. The maximum output voltage is: [GATE-1994]

(a) 0.2 volts (b) 2.0 volts (c) 10.0 volts (d) 50.0 volts

Q4.3. The value of the resistance, R, connected across the terminals A and B, (ref. figure), which will absorb the maximum power is: [GATE-1995]



(a) 4.00 $k\Omega$

(b) 4.11 $k\Omega$

(c) 8.00 $k\Omega$

(d) 9.00 $k\Omega$

Q4.4. Two 2H inductance coils are connected in series and are also magnetically coupled to each other the coefficient of coupling being 0.1. The total inductance of his combination can be: [GATE-1995]

(a) 0.4 H (b) 3.2 H (c) 4.0 H (d) 3.8 H

Q4.5. Superposition theorem is NOT applicable to networks containing: [GATE-1998]

(a) Nonlinear elements (b) Dependent voltage sources
(c) Dependent current sources (d) Transformers

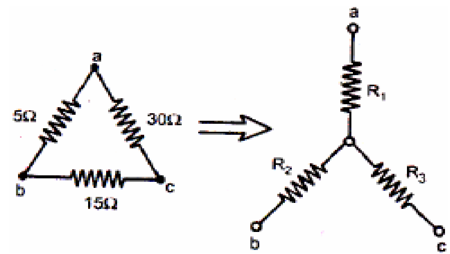
Q4.6. A delta-connected network with its Wyes-equivalent is shown in figure. The resistances R_1, R_2, and R_3 (in ohms) are respectively. [GATE-1999]

(a) 1.5, 3 and 9

(b) 3, 9 and 1.5

(c) 9, 3 and 1.5

(d) 3, 1.5 and 9



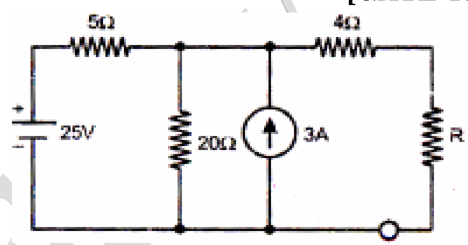
Q4.7. The value of R (in ohms) required for maximum power transfer in the network shown in figure is: [GATE-1999]

(a) 2

(b) 4

(c) 8

(d) 16



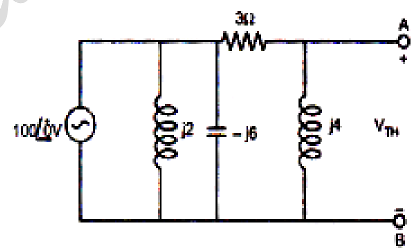
Q4.8. The Theremin equivalent voltage V_{TH} appearing between the terminals A and B of the network shown in figure is given by [GATE-1999]

(a) $j16\,(3 - j4)$

(b) $j16(3 + j4)$

(c) $16\,(3 + j4)$

(d) $16(3 - j4)$



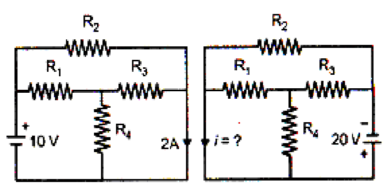
Q4.9. Use the data of Fig (a). The current i in the circuit of Fig (b) is: [GATE-2000]

(a) –2 A

(b) 2 A

(c) –4 A

(d) 4 A



(a) (b)

Q4.10. If each branch of a delta circuit has impedance $\sqrt{3}z$, then each branch of the equivalent Wye-circuit has impedance [GATE-2001]

(a) $3\sqrt{3}Z$

(b) $3Z$

(c) $\dfrac{Z}{\sqrt{3}}$

(d) $\dfrac{Z}{3}$

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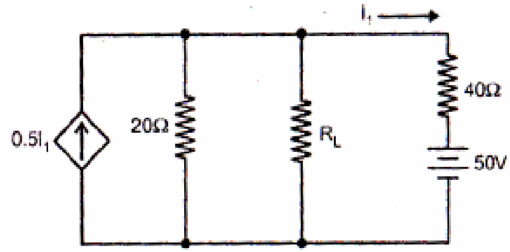
Q4.11. In the network of figure, the maximum power is delivered to R_L if its value is: [GATE-2002]

(a) 16 Ω

(b) $\frac{40}{3}$ Ω

(c) 60 Ω

(d) 20 Ω



Q4.12. Twelve 1Ω resistance are used as edges to form a cube. The resistance between two diagonally opposite corners of the cube is: [GATE-2003]

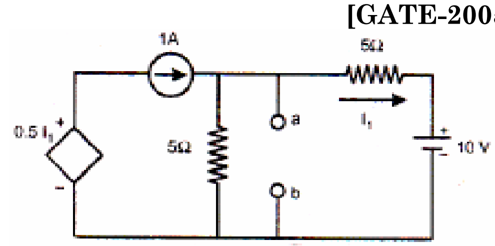
(a) $\frac{5}{6}$ Ω (b) 1 Ω (c) $\frac{6}{5}$ Ω (d) $\frac{3}{2}$ Ω

Q4.13. A source of angular frequency 1 rad/sec has a source impedance consisting of 1Ω resistance in series with 1H inductance. The load that will obtain the maximum power transfer is: [GATE-2003]

(a) 1Ω resistance
(b) 1Ω resistance in parallel with 1H inductance
(c) 1Ω resistance in series with 1F capacitor
(d) 1Ω resistance in parallel with 1F capacitor

Q4.14. For the circuit shown in figure. Thevenin's voltage and Thevenin's equivalent resistance at terminals a, b is: [GATE-2005]

(a) 5 V and 2
(b) 7.5 V and 2.5
(c) 4 V and 2
(d) 3 V and 2.5



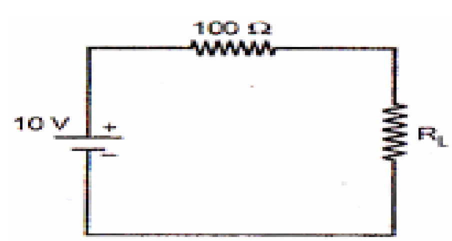
Q4.15. The maximum power that can be transferred to the load resistor R_L from the voltage source in figure is [GATE-2005]

(a) 1 W

(b) 10 W

(c) 0.25 W

(d) 0.5 W



Q4.16. An independent voltage source in series with an impedance $Z_S = R_S + jX_S$ delivers a maximum average power to a load impedance Z_L when [GATE-2007]

(a) $Z_L = R_S + jX_S$ (b) $Z_L = R_S$ (c) $Z_L = jX_S$ (d) $Z_L = R_S - jX_S$

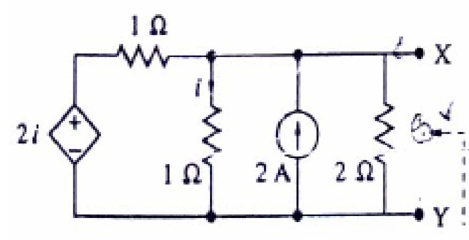
Q4.17. For the circuit shown in the figure, the Thevenin voltage and resistance looking into $X - Y$ are **[GATE-2007]**

(a) 4/3 V, 2 Ω

(b) 4V, 2/3 Ω

(c) 4/3 V, 2/3 Ω

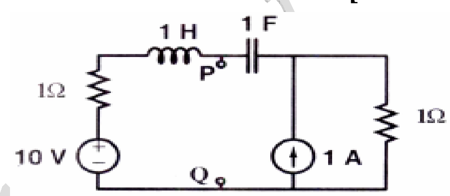
(d) 4 V, 2 Ω



Q4.18. The Thevenin equivalent impedance Z^{th} between the nodes P and Q in the following circuit is **[GATE-2008]**

(a) 1 (b) $1 + S + \frac{1}{S}$

(c) $2 + S + \frac{1}{S}$ (d) $\frac{S^2 + S + 1}{S^2 + 2s + 1}$



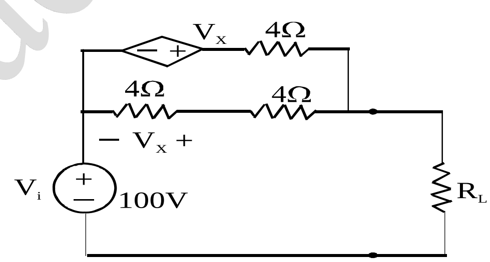
Q4.19. In the circuit shown, what value of R_L maximizes the power delivered to R_L? **[GATE-2009]**

(a) 2.4 Ω

(b) $\frac{8}{3}$ Ω

(c) 4 Ω

(d) 6 Ω



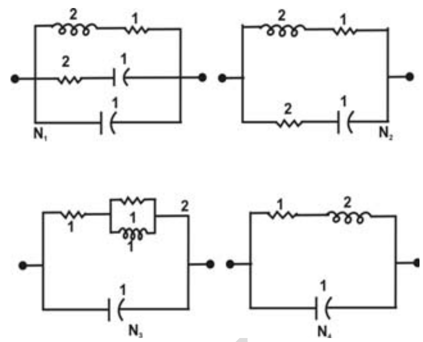
5. Sinusoidal Steady State Analysis, Resonance, Power in AC Circuits, Passive Filters

Q5.1. The transfer function of a simple RC network function as a controller is $G_C(s) = \frac{s + z_1}{s + p_1}$. The condition for the RC network to Act as a phase lead controller is: **[GATE-1990]**

(a) $p_1 < z_1$ (b) $p_1 = 0$
(c) $p_1 = z_1$ (d) $p_1 > z_1$

Q5.2. In a series RLC high Q circuit, the current peaks at a frequency: **[GATE-1991]**
(a) Equal to the resonant frequency
(b) Greater than the resonant frequency
(c) Less than the resonant frequency
(d) None of these

Q5.3. **Of the four network, N_1, N_2, N_3 and N_4 of figure, then network having identical driving-point function are:** **[GATE-1992]**



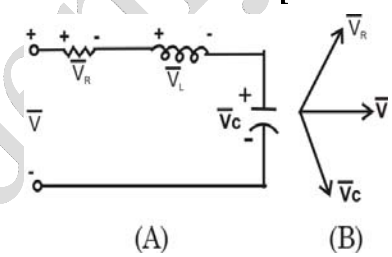
(a) N_1 and N_1

(b) N_2 and N_4

(c) N_1 and N_3

(d) N_1 and N_4

Q5.4. **For the series *R–L* circuit of Fig. (a), the partical phasor diagram at a certain frequency is shown in Fig. (b). The operating frequency of the circuit is:** **[GATE-1992]**



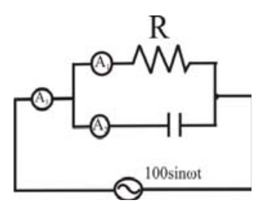
(a) Equal to the resonance frequency

(b) less than the resonance frequency

(c) greater than resonance frequency

(d) Not zero

Q5.5. **In figure and A_1, A_2 and A_3 are ideal ammeters. If A_1 reads 5A, A_2 reads 12A, then A_3 should read:** **[GATE-1993]**



(a) 7 A

(b) 12 A

(c) 13 A

(d) 17 A

Q5.6. **The response of an LCR circuit to a step input is over damped. If transfer function has:** **[GATE-1993]**

(a) Poles in the negative real axis
(b) Poles on imaginary axis
(c) Multiple poles on the negative real axis
(d) Multiple poles on the positive real axis

Q5.7. **A series *L–C–R* circuit, consisting of $R = 10\Omega, |X_L| = 20\Omega$ and $|X_C| = 20\Omega$, is connected across an AC supply of 200V rms. The rms voltage across the capacitor is:** **[GATE-1994]**

(a) $200 < -90^\circ$ V (b) $200 < +90^\circ$ V
(c) $400 < +90^\circ$ V (d) $400 < -90^\circ$ V

Q5.8. **A series *R–L–C* circuit has a *Q* of 100 and an impedance of $(100 + j0)\Omega$ at its resonant angular frequency of 10^7 rad/sec. The values of *R* and *L* are:** **[GATE-1995]**

(a) $100\Omega, 10^{-3}\text{H}$ (b) $10\Omega, 10^{2}\text{H}$ (c) $1000\Omega, 10\text{H}$ (d) $100\Omega, 100\text{H}$

Q5.9. **The current, $i(t)$, through a 10Ω resistor in series is equal to 3 + $4\sin(100t + 45°) + 4\sin(300t + 60°)$ amperes. The RMS value of the current and the power dissipated in the circuit are:** **[GATE-1995]**

(a) $\sqrt{41}$ A, 410 W, respectively (b) $\sqrt{35}$ A, 410 W, respectively
(c) 5 A, 250 W, respectively (d) 11 A, 1210 W, respectively

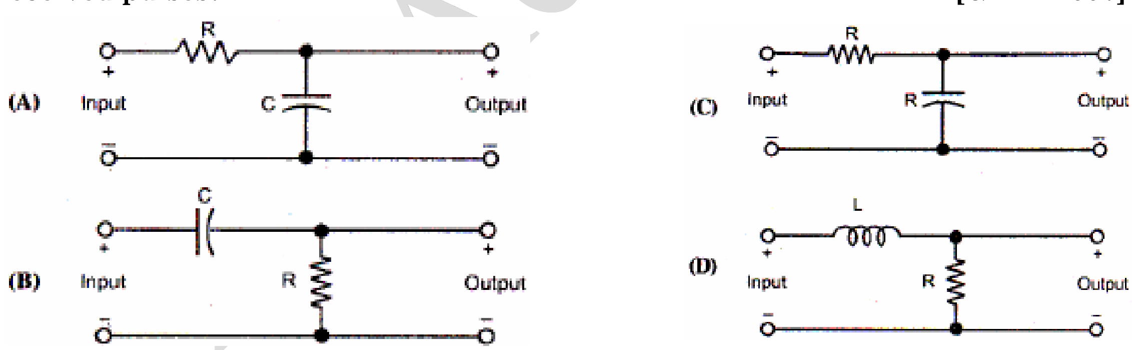
Q5.10. **Consider a DC voltage source connected to a series *R–C* circuit. When the steady-state reaches, the ratio of the energy stored in the capacitor to the total energy supplied by the voltage source is equal to:** **[GATE-1995]**

(a) 0.362 (b) 0.500 (c) 0.632 (d) 1.000

Q5.11. **ADC voltage source is connected across a series *R–L–C* circuit. Under steady conditions, the applied DC voltage drops entirely across the:** **[GATE-1995]**

(a) R only (d) L only (c) C only (d) R and L Combination

Q5.12. **A communication channel has first order low pass transfer function. The channel is used to transmit pulses at a symbol rate greater than the half-power frequency of the low pass function. Which of the network shown in figure can be used to equalize the received pulses?** **[GATE-1997]**



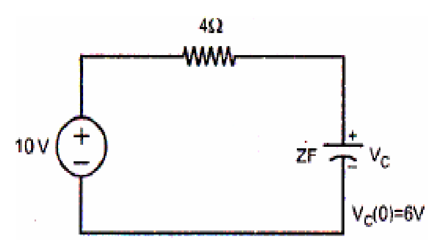
Q5.13. **In the circuit of figure the energy absorbed by the 4Ω resistor in the time interval (0, ∞) is:** **[GATE-1997]**

(a) 36 Joules

(b) 16 Joules

(c) 256 Joules

(d) None of these



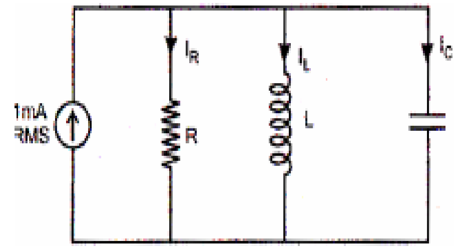
Q5.14. The parallel R-L-C circuit shown in figure is in resonance, In this circuit: **[GATE-1998]**

(a) $|I_R| < 1\text{mA}$

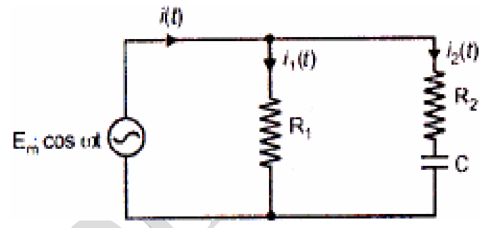
(b) $|I_R + I_L| > 1\text{mA}$

(c) $|I_R + I_C| < 1\text{mA}$

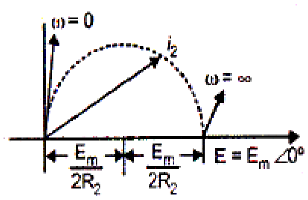
(d) $|I_R + I_C| > 5\text{mA}$



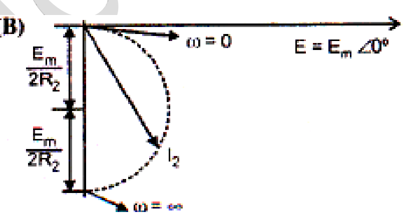
Q5.15. When the angular frequency ω in figure is varied from 0 to ∞, the locus of the current phasor I_2 is given by: **[GATE-2001]**



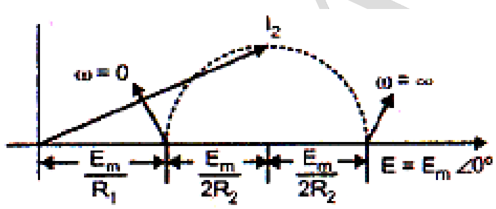
(A)



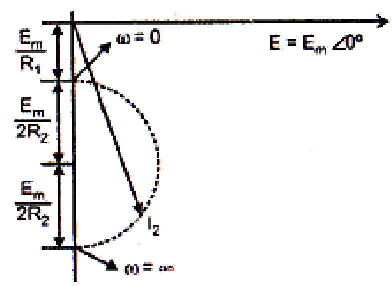
(B)



(C)



(D)



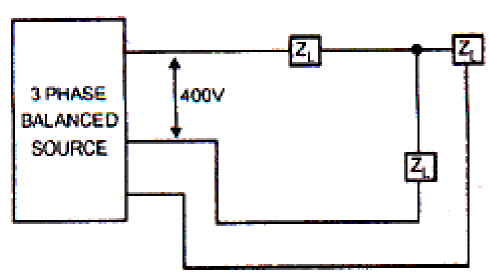
Q5.16. If the 3-phase balanced source in figure delivers 1500 W at a leading power factor of 0.844, then the value of Z_L (in ohm) is approximately: **[GATE-2002]**

(a) $90\angle 32.44°$

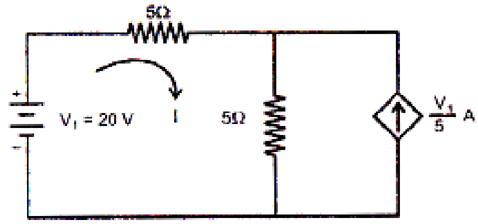
(b) $80\angle 32.44°$

(c) $80\angle -32.44°$

(d) $90\angle -32.44°$



Q5.17. The dependent current source shown in figure is: **[GATE-2002]**



(a) Delivers 80 W

(b) Absorbs 80 W

(c) Delivers 40 W

(d) Absorbs 40 W

Q5.18. An input voltage $v(t) = 10\sqrt{2}\cos(t+10°)+10\sqrt{5}\cos(2t+10°)\ V$ is applied to a series combination of resistance R = 1Ω and an inductance L = 1H. The resulting steady state current $i(t)$ in ampere is: **[GATE-2003]**

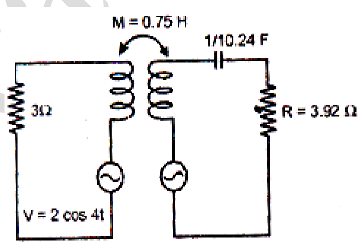
(a) $10\cos(t+55°)+10\cos(2t+100+\tan^{-1}2)$

(b) $10\cos(t+55°)+10\sqrt{\frac{3}{2}}\cos(2t+55°)$

(c) $10\cos(t-35°)+10\cos(2t+10°-\tan^{-1}2)$

(d) $10\cos(t-35°)+10\sqrt{\frac{3}{2}}\cos(2t-35°)$

Q5.19. The current flowing through the resistance R in the circuit in figure has the form P cos 4t, where P is: **[GATE-2003]**



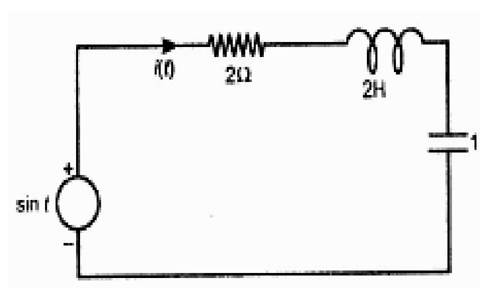
(a) $(0.18 + j0.72)$

(b) $(0.46 + j1.90)$

(c) $-(0.18 + j1.90)$

(d) $-(0.192 + j0.144)$

Q5.20. The differential equation for the current $i(t)$ in the circuit of figure is: **[GATE-2003]**



(a) $2\frac{d^2i}{dt^2}+2\frac{di}{dt}+i(t)=\sin t$

(b) $\frac{d^2i}{dt^2}+2\frac{di}{dt}+2i(t)=\cos t$

(c) $2\frac{d^2i}{dt^2}+2\frac{di}{dt}+i(t)=\cos t$

(d) $\frac{d^2i}{dt^2}+2\frac{di}{dt}+2i(t)=\sin t$

Q5.21. A series R–L–C circuit has a resonance frequency of 1 kHz and a quality factor Q = 100. If each of R, L and C is doubled from its original value, the new Q of the circuit is: **[GATE-2003]**

(a) 25 (b) 50 (c) 100 (d) 200

Q5.22. Consider the following statements $S1$ and $S2$ ($S1$: At the resonant frequency the impedance of a series $R–L–C$ circuit is zero; $S2$: In a parallel $G–L–C$ circuit, increasing the conductance G results in increase in its Q factor). Which one of the following is correct? [GATE-2004]

(a) $S1$ is FALSE and $S2$ is TRUE
(b) Both $S1$ and $S2$ are TRUE
(c) $S1$ is TRUE and $S2$ is FALSE
(d) Both $S1$ and $S2$ are FALSE

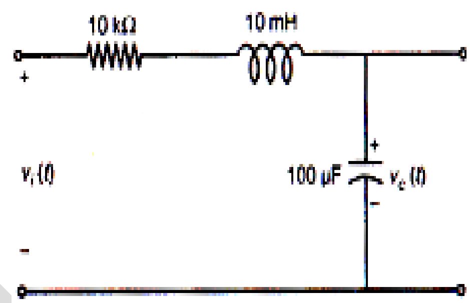
Q5.23. For the circuit shown in figure, the initial conditions are zero. Its transfer function is: [GATE-2004]

(a) $\dfrac{1}{s^2+10^6 s+10^6}$

(b) $\dfrac{10^6}{s^2+10^3 s+10^6}$

(c) $\dfrac{10^3}{s^2+10^3 s+10^6}$

(d) $\dfrac{10^6}{s^2+10^6 s+10^6}$

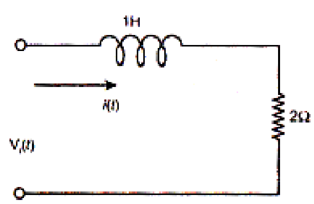


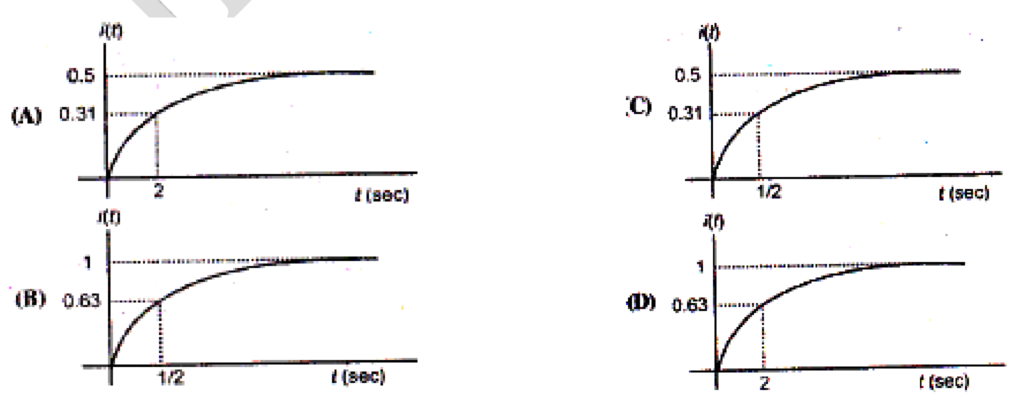
Q5.24. The transfer function $H(s)=\dfrac{V_o(s)}{V_i(s)}$ of an $R–L–C$ circuit is given by

$H(s)=\dfrac{10^6}{s^2+20s+10^6}$. The Quality factor ($Q$ - factor) of this circuit is: [GATE-2004]

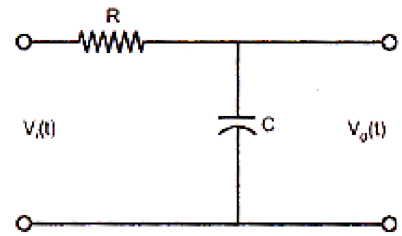
(a) 25 (b) 50 (c) 100 (d) 5000

Q5.25. For the $R–L$ circuit shown in figure the input voltage $v_i(t) = u(t)$. The current $i(t)$ is: [GATE-2004]





Q5.26. **For the circuit shown in figure the time constant $RC = 1$ ms. The input voltage is $v_i(t) = \sin 10^3 t$. The output voltage $v_o(t)$ is equal to:** **[GATE-2004]**



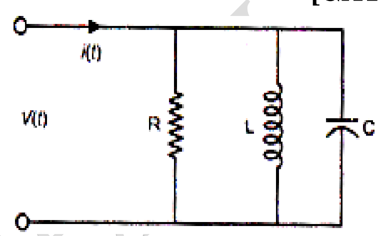
(a) $\sin(10^3t - 45°)$

(b) $\sin(10^3t + 45°)$

(c) $\sin(10^3t - 53°)$

(d) $\sin(10^3t + 53°)$

Q5.27. **The circuit shown in figure with $R = \frac{1}{3}\,\Omega$, $L = \frac{1}{4}$ H, $C = 3$ F has input voltage $v(t) = \sin 2t$. The resulting current $i(t)$ is:** **[GATE-2004]**



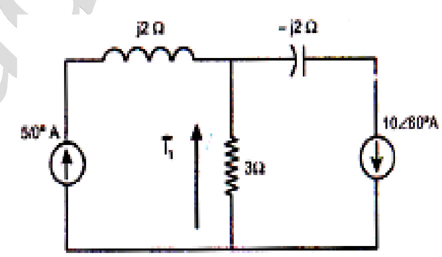
(a) $5\sin(2t + 53.1°)$

(b) $5\sin(2t - 53.1°)$

(c) $25\sin(2t + 53.1°)$

(d) $25\sin(2t - 53.1°)$

Q5.28. **For the circuit in figure, the instantaneous current $i_1(t)$ is:** **[GATE-2005]**



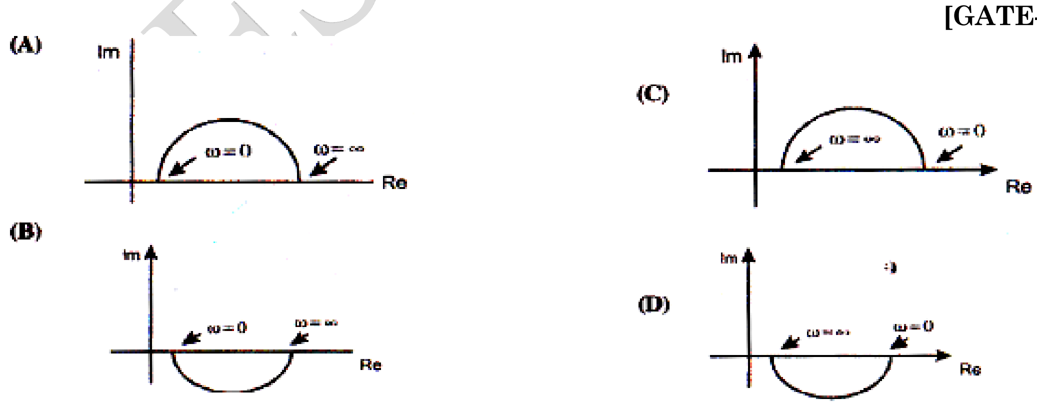
(a) $\frac{10\sqrt{3}}{2}\angle 90°$ Amps

(b) $\frac{10\sqrt{3}}{2}\angle -90°$ Amps

(c) $5\angle 60°$ Amps

(d) $5\angle -60°$ Amps

Q5.29. **Which one of the following polar diagrams corresponds to a lag network?** **[GATE-2005]**



Q5.30. **In a series RLC circuit $R = 2\ \text{k}\Omega$, $L = 1$ H and $C = 1/400$ µF. The resonate frequency is:** **[GATE-2005]**

(a) 2×10^4 Hz (b) $\frac{1}{\pi}\times10^4$ Hz (c) 10^4 Hz (d) $2\pi\times10^4$ Hz

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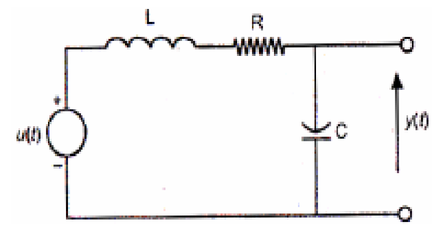
Q5.31. The condition on R, L and C such that the step response $y(t)$ in figure has no oscillations, is: **[GATE-2005]**

(a) $R \geq \frac{1}{2}\sqrt{\frac{L}{C}}$ (b) $R \geq \sqrt{\frac{L}{C}}$

(c) $R \geq 2\sqrt{\frac{L}{C}}$ (d) $R = \sqrt{\frac{L}{C}}$



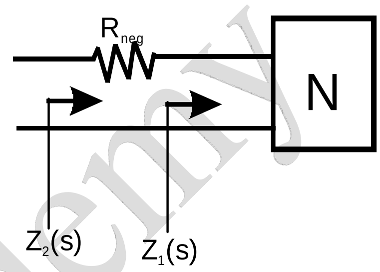
Q5.32. A negative resistance R_{neg} is connected to a passive network N having point impedance $Z_1(s)$ as shown below. For $Z_2(s)$ to be positive real: **[GATE-2006]**

(a) $\left|R_{neg}\right| \leq R_e Z_1(j\omega), \forall \omega$

(b) $\left|R_{neg}\right| \leq \left|Z_1(j\omega)\right|, \forall \omega$

(c) $\left|R_{neg}\right| \leq \left|IMZ_1(j\omega)\right|, \forall \omega$

(d) $\left|R_{neg}\right| \leq \left|\angle Z_1(j\omega)\right|, \forall \omega$



Q5.33. The first and the last critical frequencies (singularities) of a driving-point impedance function of a passive network having two kinds of elements, are a pole and a zero respectively. The above property will be satisfied by: **[GATE-2006]**

(a) *RL* network only (b) *RC* network only
(c) *LC* network only (d) *RC* as well as *RL* networks

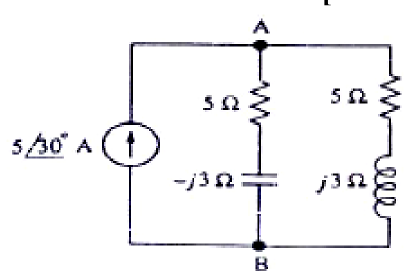
Q5.34. In the AC network shown in the figure, the phasor voltage V_{AB} (in volts) is **[GATE-2007]**

(a) 0

(b) $5\angle 30°$

(c) $12.5\angle 30°$

(d) $17\angle 30°$



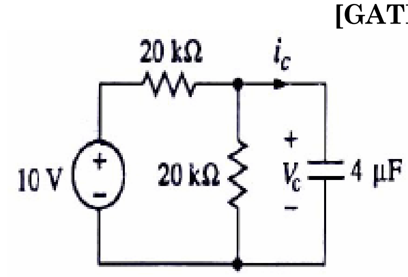
Q5.35. In the circuit shown, V_c is 0 volts at t = 0 sec. For t > 0, the capacitor current $i_c(t)$ where t is in seconds, is given by: **[GATE-2007]**

(a) 0.50 exp (–25 t) mA

(b) 0.25 exp (–25 t) mA

(c) 0.50 exp (–12.5 t) mA

(d) 0.25 exp (–6.25 t) mA



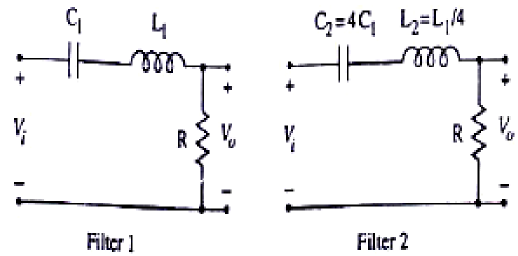
Q5.36. **Two series resonant filters are as shown in the figure. Let the 3-dB bandwidth of Filter 1 be B_1 and that of Filter 2 be B_2. The value of $\frac{B_1}{B_2}$ is** **[GATE-2007]**

(a) 4

(b) 1

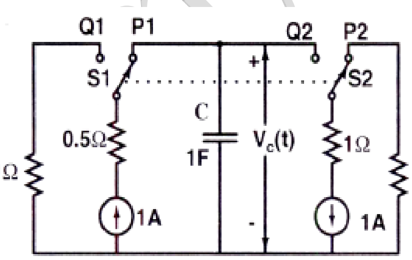
(c) $\frac{1}{2}$

(d) $\frac{1}{4}$



Q5.37. **The circuit shown in the figure is used to charge the capacitor C alternately from two current sources as indicated. The switches $S1$ and $S2$ are mechanically coupled and connected as follows:** **[GATE-2008]**

For $2nT \le t < (2n+1)T$
$(n = 0, 1, 2, ...)$
$S1$ to $P1$ and $S2$ to $P2$
For $(2n+1)T \le t < (2n+2)T$
$(n = 0, 1, 2, ...)$
$S1$ to $Q1$ and $S2$ to $Q2$



Assume that the capacitor has zero initial charge. Given that $u(t)$ is a unit step function, the voltage $V_C(t)$ across the capacitor is given by:

(a) $\sum_{n=0}^{\infty}(-1)^n tu(t-nT)$

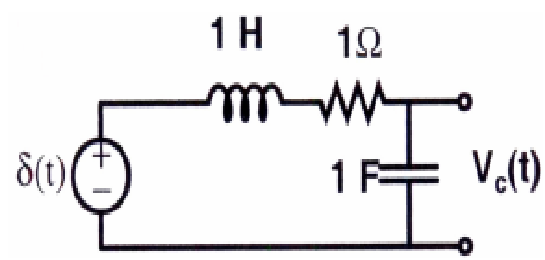
(b) $u(t)+2\sum_{n=0}^{\infty}(-1)^n u(t-nT)$

(c) $tu(t)+2\sum_{n=1}^{\infty}(-1)^n (t-nT)u(t-nT)$

(d) $\sum_{n=0}^{\infty}\left[0.5-e^{-(t-2nT)}+0.5e^{-(t-2nT-T)}\right]$

Common Data for Questions 38 and 39:

The following series RLC circuit with zero initial conditions is excited by a unit impulse function $\delta(t)$.



Q5.38. **For $t > 0$, the output voltage** **[GATE-2008]**

(a) $\frac{2}{\sqrt{3}}\left(e^{-\frac{1}{2}t}-e^{-\frac{\sqrt{3}}{2}t}\right)$

(b) $\frac{2}{\sqrt{3}}te^{+\frac{1}{2}t}$

(c) $\frac{2}{\sqrt{3}}te^{-\frac{1}{2}t}$

(d) $\frac{2}{\sqrt{3}}e^{-\frac{1}{2}t}\sin\left(\frac{\sqrt{3}}{2}t\right)$

Q5.39. For $t > 0$, the voltage across the resistor is **[GATE-2008]**

(a) $\frac{1}{\sqrt{3}}\left(e^{-\frac{\sqrt{3}}{2}t} - e^{-\frac{1}{2}t}\right)$

(b) $e^{-\frac{1}{2}t}\left[\cos\left(\frac{\sqrt{3}t}{2}\right) - \frac{1}{\sqrt{3}}\sin\left(\frac{\sqrt{3}t}{2}\right)\right]$

(c) $\frac{2}{\sqrt{3}}e^{-\frac{1}{2}t}\sin\left(\frac{\sqrt{3}t}{2}\right)$

(c) $\frac{2}{\sqrt{3}}e^{-\frac{1}{2}t}\cos\left(\frac{\sqrt{3}t}{2}\right)$

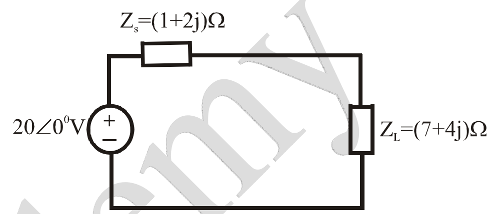
Q5.40. An AC source of *RMS* voltage 20V with internal impedance $Z_S = (1 + 2j)\Omega$ feeds a load of impedance $Z_L = (7 + 4j)\Omega$ in the figure below. The reactive power consumed by the load is **[GATE-2009]**

(a) 8 VAR

(b) 16 VAR

(c) 28 VAR

(d) 32 VAR



Q5.41. For parallel RLC circuit, which one of the following statements is NOT correct? **[GATE-2010]**

(a) The bandwidth of the circuit deceases if R is increased
(b) The bandwidth of the circuit remains same if L is increased
(c) At resonance, input impedance is a real quantity
(d) At resonance, the magnitude of input impedance attains its minimum value

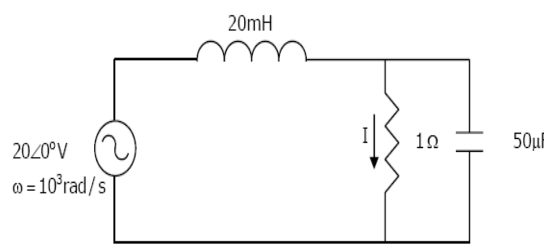
Q5.42. The current *I* in the circuit shown is: **[GATE-2010]**

(a) $-j1$ A

(b) $J1$ A

(c) 0 A

(d) 20 A



Answers with Explanation

1.1. Ans.(b)

For resonance

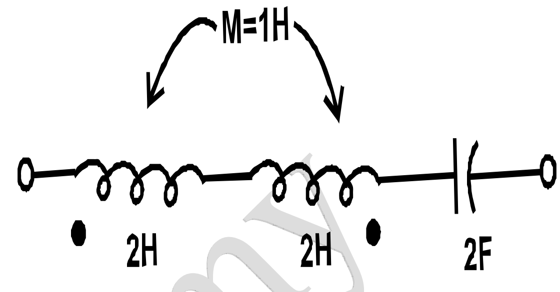
$$\frac{1}{\omega_o C} = \omega_o \text{Leq}$$

$$\text{Leq} = L_1 + L_2 - 2M$$

$$= 2 + 2 - 2\times 1 = 2\text{H}$$

$$\omega_o^2 = \frac{1}{2\times 2} = \frac{1}{4}; \qquad \omega_o = \frac{1}{2}$$

$$f_0 = \frac{1}{4\pi}\text{ Hz}$$



1.2. Ans.(a)

Response of linear network = 4 e^{-2t}

When unit impulse applied $h(t) = 4e^{-2t}$

If input is unit step then output is $y(t)$

$$y(s) = H(s)U(s)$$

$$y(s) = \frac{4}{S+2}\,\frac{1}{s} = \frac{4}{2}\left[\frac{1}{s} - \frac{1}{s+2}\right]$$

$$y(t) = 2\left[1 - e^{-2t}\right]u(t)$$

1.3. Ans.(b)

$$\text{Teq} = \frac{T_1R_1 + T_2R_2}{R_1 + R_2}$$

(Equivalent noise temp)

1.4. Ans.(b)

Input is impulse signal = $\delta(t)$

According standard result $V_2(t) = \dfrac{R_2}{R_1 + R_2}V_i(t)$ (for compensated network)

$$V_2(t) = \frac{R_2}{R_1 + R_2}\delta(t)$$

1.5. Ans.(a, d)

Relative to a given fixed tree of a network
Link currents form an independent set
Branch voltage form an independent set

1.6. Ans.(a)

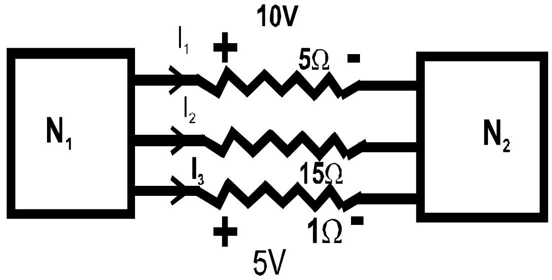
Using KCL for cut-set, that means current entering and leaving a cut-set is equal to zero

$I_1 + I_2 + I_3 = 0; \qquad \frac{10}{5} + I_2 + \frac{5}{1} = 0$

$I_2 = -7A$

Voltage across 15 Ω resistances

$= -7 \times 15 = -105$ V



1.7. Ans.(d)

1.8. Ans.(a)

$$\text{R.M.S. value of rectangular pulse} = \sqrt{\frac{1}{T}\int_0^T x^2(t)\cdot dt}$$

$$= \sqrt{\frac{1}{T}\left[\int_0^{T_1} V^2\cdot dt + \int_{T_1}^{T_1+T_2} (-V)^2\cdot dt\right]}$$

$$= \sqrt{\frac{V^2}{T}\left[T_1\right] + \frac{V^2}{T}\left[T_1 + T_2 - T_1\right]} = \sqrt{\frac{V^2}{T}\left[T_1 + T_2\right]}$$

But, $T_1 + T_2 = T = V$

1.9. Ans. **(c)**

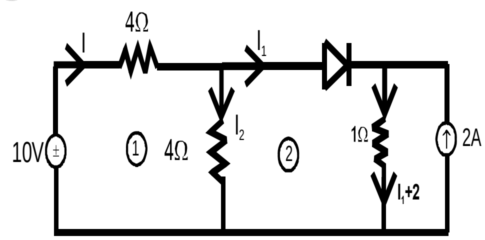
1.10. Ans. **(c)**

By analysis it is found that diode in feedback and current flow through diode only due to voltage source.

Applying KVL in loop (i)

$10\text{ V} - 4(I_1 + I_2) - 4I_2 = 0$

$10\text{ V} - 4I_1 + 8I_2 = 0 \qquad (i)$



Applying KVL in loop (ii)

$$I_1 + 2 - 4I_2 = 0; \qquad I_2 = \frac{I_1 + 2}{4} \qquad (ii)$$

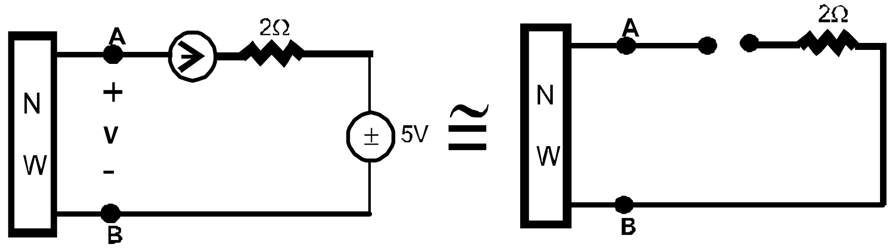
$$10 - 4I_1 - \frac{8(I_1 + 2)}{4}; \qquad 10 - 6I_1 - 4 = 0 \qquad I_1 = \frac{6}{6} = 1\text{A}$$

1.11. Ans.(b) It is balanced Wheatstone Bridge.

So, impendence across $ab = \frac{8 \times 4}{12} = \frac{8}{3}\Omega$

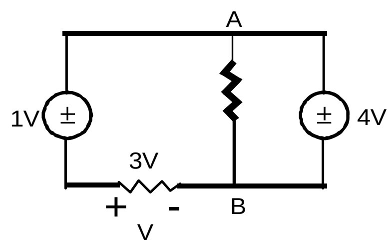
1.12. Ans.(a) V = 10 V (it is parallel to 10 V source)

1.13. Ans.(d) Apply Thenvine theorem across AB



So calculation of V_{AB} is not possible with network information, so (d) option is correct.

1.14. Ans.(a)



Note: — 5V and 4V source in L.H.S. can be combining and net voltage is l V.

Apply KVL in ABA loop

$$4 - V - 1 = 0$$

$$V = 3\text{ V}$$

1.15. Ans.(b)

KCL at node P

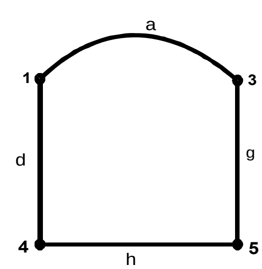
$$i_1 + i_0 + i_4 = 0 \;\Rightarrow\; -i_4 = i_1 + i_0 \;\Rightarrow\; -i_4 = 5 + 7 \;\Rightarrow\; i_4 = -12\text{ A}$$

1.16. Ans.(b) Nodal method of circuit analysis is based on KCL and ohm's law

1.17. Ans.(c) In network number of independent loop = $b - n + 1$

1.18. Ans.(c)

Adhg not a tree because it made a closed loop and in a tree close loop is not possible.



1.19. Ans.(d)

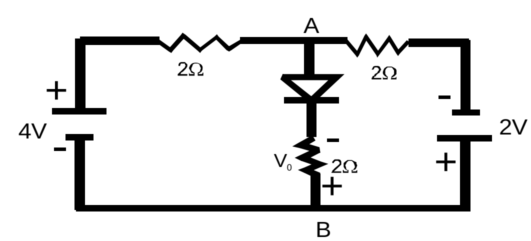
First we find bising of diode for that find voltage across AB

Suppose $V_{AB} = V$

By super position theorem

$V_{AB} = 1$ V

That means diode in feedback

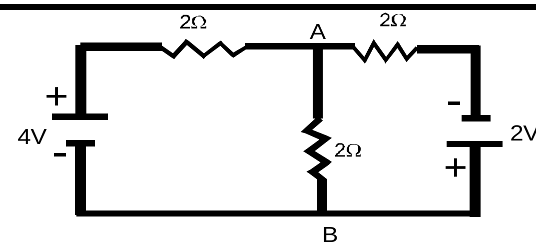


So,

Apply KCL at node A

$$\frac{V_A-4}{2}+\frac{V_A}{2}+\frac{V_A+2}{2}=0$$

$$V_A=\frac{2}{3},\quad V_A=-V_O,\quad V_O=-\frac{2}{3}$$

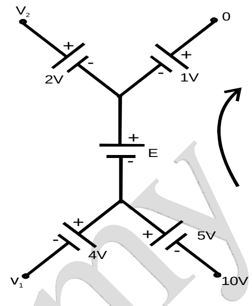


1.20. Ans.(a)

Applying KVL

$$-10-5+E-1=0$$

$$E=-16$$



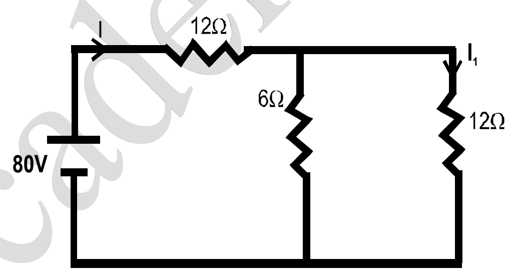
1.21. Ans.(d)

By super-position theorem

Case 1: Only current source is active (voltage source will be short circuit) then find current through 12 Ω resistances.

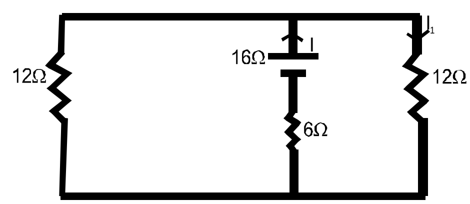
By current source conversion

$$I=\frac{80}{16}=5\,\text{A};\qquad I_1=\frac{6}{18}\times 5=\frac{30}{18}\,\text{A}$$



Case 2: By current source suppression only voltage source will be in active mode

$$I=\frac{16}{12};\qquad I_1=\frac{16}{24}$$



Total current through $12\,\Omega$ resistance $=\frac{30}{18}+\frac{16}{24}=\frac{120+48}{72}=\frac{168}{72}$

So, $e_0=\frac{168}{72}\times 12=28\,\text{V}$

1.22. Ans.(c) Current through $4\,\Omega=1\,\text{A}$

So, $e_0 = 4\times 1 = 4$ V

1.23. Ans.(b)

Minimum number of equations required for analysis of network

Number of equation = $b - n + 1$

Where, n = number of nodes; b = number of branches in the question

$n = 4;\quad b = 7$

So number of equations required = 7 – 4 + 1 = 4

1.24. Ans.(b) Tree of network graph will not have any close loop.

1.25. Ans.(c)

$$V_a = \frac{R_2}{R_1+R_2}\times 10 = \frac{R}{R+R}\times 10 = 5\,\text{V}$$

$$V_b = \frac{R_3}{R_3+R_4}\times 10 = \frac{1.1R}{1.1R+R}\times 10 = \frac{1.1}{2.1}\times 10 = \frac{110}{21}$$

$$V_a - V_b = 5 - \frac{110}{21} = -0.238\,\text{V}$$

1.26. Ans.(b) Total impedance $Z = 5j + 2j + 2j + 10j - 10j = 9j$

1.27. Ans.(c)

1.28. Ans.(c) Energy delivers during talk time

$$E = \int_{t=0}^{t=600Sec} V\cdot I\cdot dt; \qquad I = 2A; \qquad V = \frac{-t}{300}+12$$

$$\text{So, } E = \int_0^{600} 2\left(-\frac{t}{300}+12\right)\cdot dt$$

$$E = 13.2\,kJ$$

1.29. Ans.(a) By superposition (I is current delivered by 10 V source),

$I_{10} = 2.5$ A; $I_1 = -0.5$ A; $I_2 = -2$ A; I = OA; P = OW

2.1. Ans.(a)

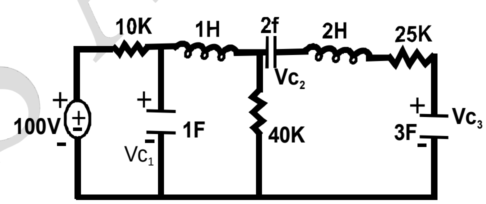
2.2. Ans.(b)

2.3. Ans.(b) Other than (more than one), impedance physically not possible

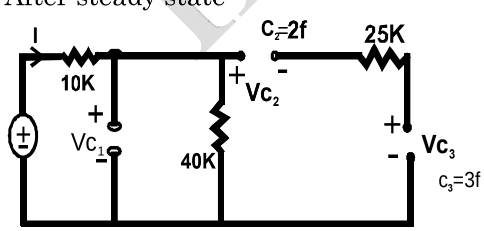
2.4. Ans.(c) Inductor will be like as short circuit because voltage source is D.C.

So, current through $R = \frac{V}{R}$, current remains constant at V/R

2.5. Ans.(b)



After steady state



At steady state $I = \frac{100}{50k} = 2\,\text{mA}$

So, $Vc_1 = 100 - 10\times 2\,\text{mA}\times 10^3 = 80\,\text{V}$,

but $Vc_1 = Vc_2 + Vc_3$ (by KVL)

We know $V \alpha \frac{1}{C}$

→ So voltage across will be higher than C_3

→ By option checking only option B satisfy this condition $Vc_2 + Vc_3 = 80$ V and $Vc_2 > Vc_3$

2.6. Ans.(d) A_1 reads current that flow through this in, half cycle (average value)

$$I_{\text{avg}}\Big/_{\text{for half cycle}} = \frac{I_m}{\pi} = \frac{V_m}{10\pi} = \frac{4}{10\pi} = \frac{0.4}{\pi}$$

2.7. Ans.(b) Current through A_1 will be vector sum of current through A_2 and A_3

$$|A_1| = \sqrt{A_2^2 + A_3^2} = \sqrt{16+9} = \sqrt{25} = 5\,\text{A}$$

2.8. Ans.(d) Voltage across inductor = $v(t)$; Current flowing through inductor $= \frac{1}{L}\int v(t)\cdot dt$

Applying KCL at middle node $e^{at} + e^{bt} = \frac{1}{L}\int v(t)\cdot dt$

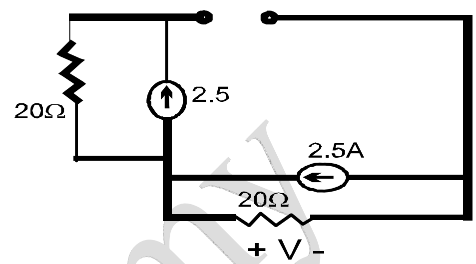
Differentiate both side $L = 1\,\text{H}$; $v(t) = ae^{at} + be^{bt}$

2.9. Ans.(c)

At $t = 0^-$ inductor will like short circuit and 2.5A current flow through inductor at $t = 0^+$

$V = 2.5 \times 20 = 50\text{V}$

but $Vx = -V = -50$ V

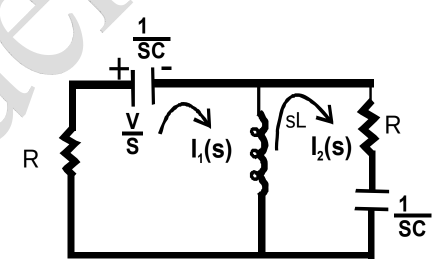


2.10. Ans.(d)

KVL in loop (i)

So, $I_1(s)\cdot R + \frac{V}{s} + I_1(s)\cdot\frac{1}{sC} + [I_1(s) - I_2(s)]sL = 0$

$I_1(s)\left[R + \frac{1}{sc} + sL\right] - I_2(s)\cdot sL = \frac{-V}{s}$



KVL in loop (ii)

$[I_2(s) - I_1(s)]sL + I_2(s)R + I_2(s)\cdot\frac{1}{sc} = 0;$ $\quad -I_1(s)\cdot sL + I_2(s)\left[R + sL + \frac{1}{sc}\right] = 0$

$$\begin{bmatrix} R + \frac{1}{sc} + sL & -sL \\ -sL & R + sL + \frac{1}{sc} \end{bmatrix}\begin{bmatrix} I_1(s) \\ I_2(s) \end{bmatrix} = \begin{bmatrix} -\frac{V}{s} \\ o \end{bmatrix}$$

2.11. Ans.(a)

At $t \to 0^+$ Inductor behaves like open circuit and capacitor as short circuit

So, $i_1(t) = \frac{-V}{2R}$

2.12. Ans.(b)

$$V(t) = Ri(t) + \frac{Ldi(t)}{dt} + \frac{1}{C}\int_0^{\infty} i(t)\cdot dt$$

Take laplace transform in both side

$$V(s) = RI(s) + LsI(s) - LI(o^+) + \frac{I(s)}{Cs} + \frac{V_c(o^+)}{s};\ \frac{1}{s} = I(s) + sI(s) - 1 + \frac{I(s)}{s} + \frac{1}{s}$$

$$I(s) = \frac{s+2}{s^2+s+1}$$

2.13. Ans.(d) Equivalent impedance $L_{eq} = L_1 + L_2 - 2M$

2.14. Ans.(b) Time constant of circuit T = Req.Ceq $= 1\times10^3 \times 0.1\times10^{-6} = 1\times10^{-4}$ sec, but applied pulse duration is 2 sec, so upto 2 sec capacitor will become fully charge $Vc = 3V$ and output voltage $Vo = -Vc = -3V$

2.15. Ans.(a) Immediate after F.B. to R.B. diode show, same resistance as in F.B. till all storage charge at junction not removed. So, for $0 < t \le ts$, V_R will be –5V and after $t > ts$, V_R will be become 0.

2.16. Ans.(b) **Method 1:**

We Know capacitor in unchanged capacitor behaves like short circuit and fully change condition behave like open circuit. So, in $V_0(t)$ function if we put $t \to \infty$

$V_0(t)$ will be equal to $= \frac{4}{5}\times 10 = 8$ Volt

So, by option checking method (b) option satisfy this condition only.

Method 2:

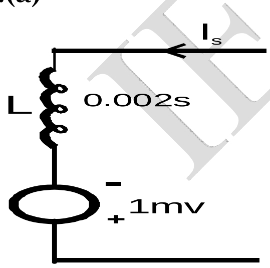
$$V_0(t) = V(\infty) - \left[V(\infty) - V(0)\right]e^{-}\frac{t}{T}$$

$V(\infty) = 8\,V$; $V(0) = 0\,V$; $T = R_{eq}\,C_{eq}$; $R_{eq} = 4\,||\,1 = 0.8\,k\Omega$

$C_{eq} = 4 + 1 = 5\,\mu f$; $T = 8\times5\times10^{-6}\times10^3 = 4\,m\sec$

$V_0(t) = 8 - (8-0)e^{-t/0.004} = 8(1 - e^{-t/0.004})$

2.17. Ans.(a)



$$V = L\frac{dI}{dt}$$

Take L transform both side $V(s) = sLI(s) - LI(o)$

By the initial condition $LI(o)$=1 mv

$I(o) = I(o) = 0.5$ A

So, $I(o) = 0.5$ A

2.18. Ans.(b) At $t = 0$ when switch will close, inductor L will behaves like open circuit. Total voltage $I_S\,R_S$ will drop across L

$$I_S R_S = L\frac{di(0+)}{dt} \Rightarrow \frac{di(0+)}{dt} = \frac{I_S R_S}{L}$$

2.19. Ans.(d)

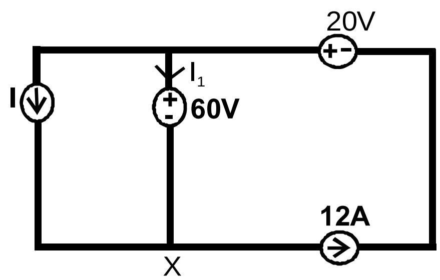
$$Z(s) = \frac{0.2s}{s^2 + 0.1s + 2}$$

Circuit is parallel RLC

$$Y(s)=\frac{1}{Z(s)}=\frac{s^2}{0.2s}+\frac{0.1s}{0.2s}+\frac{2}{0.2s}\quad\Rightarrow Y(s)=5s+\frac{1}{2}+\frac{10}{s}\quad\Rightarrow Y(s)=Cs+\frac{1}{R}+\frac{1}{LS}$$

$C=5\,\text{F},\ R=2\Omega,\ \ L=0.1\,\text{H}$

2.20. Ans.(a)



Direction of current that flowing through 60 shown in figure

Apply KCL at X

$$I+I_1=12$$

$$I=12-I_1 \qquad (i)$$

Only option (a) can be satisfying this condition.

2.21. Ans.(c)

$$\frac{V_0(S)}{V_i(S)}=\frac{1}{2+sCR} \qquad (i)$$

Given in question

$$\frac{V_o(S)}{V_i(S)}=\frac{\dfrac{R_L}{1+sR_LC}}{\dfrac{R_L}{1+sR_LC}+R}=\frac{RL}{sRR_LC+(R_L+R)} \qquad (ii)$$

Compare (i) and (ii)

$$R\ =\ R_L$$

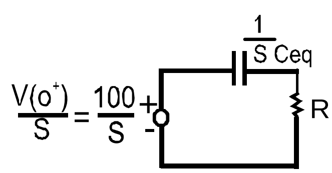
2.22. Ans.(b)

When switch on position for long time that means number of current will flow through circuit because capacitance become fully charged.

$C_{eq}=(0.5+0.3)\,||\,(0.2)\ \mu\text{F}=0.16\ \mu\text{F}$

Total potential across $C_{eq}=100\,\text{V}$

Now when switch turn to position b equivalent circuit diagram



$$RC_{eq}=5\times10^3\times0.16\times10^{-6}=0.8\times10^{-3}$$

$$i(t)=\frac{V(o^+)}{R}e^{-t/RC}\ u(t)=\frac{100}{5}\ e^{-t/8\times10^{-4}}\ u(t)$$

$$=20\,e^{-1250t}\ u(t)\ \text{mA}$$

2.23. Ans.(a) Take Laplace in both side and put initial conditions, then solve.

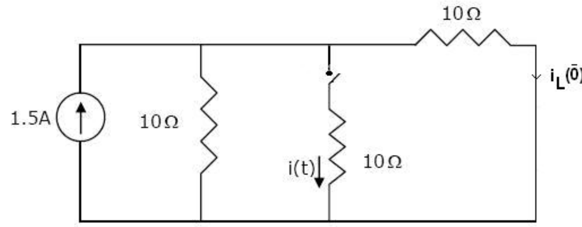
2.24. Ans.(a)

So, $i_L(\bar{0}) = 0.75\,\text{A}$

But at $t = 0^+$, switch is closed and $i_L(0^-) = i_L(0^+) = 0.75$ A

So, value of $i(t)$ at

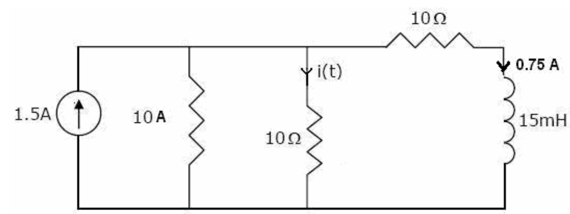
$$t = 0 = \frac{1.5 - 0.75}{2} = 0.375\,\text{A}$$



and at $t = \infty$, value of $i(t)$

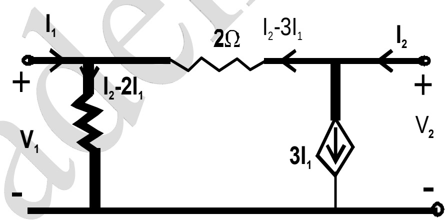
will be $i(t = \infty) = \dfrac{1.5}{3} = 0.5\,\text{A}$

Because 15 mH, inductor will be short circuited. These conditions are full-filled only in option (a).



3.1. Ans.(a)

$$V_1 = Z_{11}I_1 + Z_{12}I_2; \quad V_2 = Z_{21}I_1 + Z_{22}I_2$$
$$V_1 = -2I_1 + I_2; \quad V_2 = 2I_2 - 6I_1 - V_1$$
$$V_2 = -8I_1 + 3I_2$$
$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} -2 & 1 \\ -8 & 3 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$



3.2. Ans.(d) Transmission parameters will be multiplied.

3.3. Ans.(b, c)

$$Y_{21} = Y_{12}; \qquad h_{21} = -h_{12}$$

3.4. Ans.(a)

3.5. Ans.(b)

$$[Y] = \begin{bmatrix} 0 & \frac{-1}{2} \\ \frac{1}{2} & 0 \end{bmatrix} \quad \{Y_{12} \neq y_{21}\}$$

So, network is non-reciprocal because Y_{12} is negative that mean either energy storing or providing device available, so network is active also.

3.6. Ans.(a)

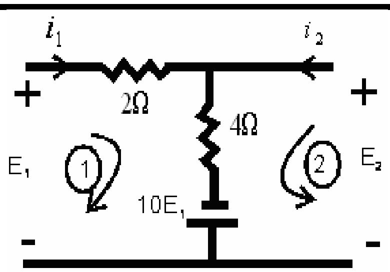
$$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}; \quad \{\text{where, } V_1 = h_{11}I_1 + h_{12}V_2,\ I_1 = h_{21}I_1 + h_{22}V_2\}$$

if $V_2 = 0$; $\qquad \dfrac{I_2}{I_1} = h_{21} \qquad (i)$

Applying KVL in R.H.S.

$$R(I_1 + I_2) + I_2R = 0; \qquad RI_1 + 2RI_2 = 0; \qquad \frac{I_2}{I_1} = \frac{-1}{2}$$

3.7. Ans.(c)



$$Z_{11} = \frac{E_1}{i_1}\Big/_{\text{at } i_2 = 0}$$

Apply KVL in loop (i)

$$E_1 - 2i_1 - 4i_1 + 10E_1 = 0; \qquad 11E_1 = 6i_1$$

$$\frac{E_1}{i_1} = \frac{6}{11} = Z_{11}$$

$$\Rightarrow \quad Z_{21} = \frac{E_2}{i_1}\Big/_{at \ i_2 = 0}$$

KVL in loop (ii)

$$E_2 - 4i_1 + 10E_1 = 0; \quad E_1 = \frac{6}{11}i_1; \quad E_2 - 4i_1 + \frac{60}{11}i_1 = 0$$

$$E_2 = -\frac{16}{11}i_1; \quad \frac{E_2}{i_1} = \frac{-16}{11} = Z_{21}$$

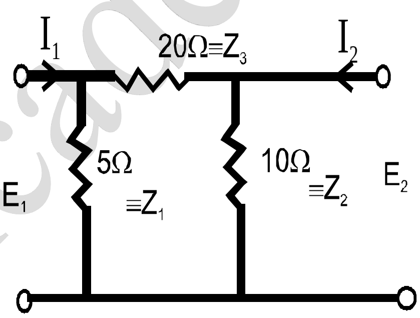
3.8. Ans.(c)

It is π network

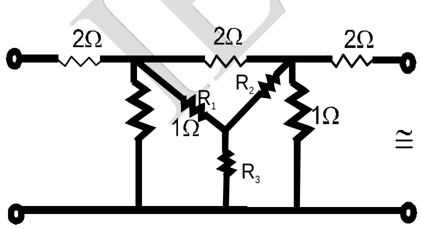
$$[Y] = \begin{bmatrix} y_1 + y_3 & -y_3 \\ -y_3 & y_2 + y_3 \end{bmatrix} \equiv \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix}$$

$$= \begin{bmatrix} \frac{1}{z_1} + \frac{1}{z_3} & -\frac{1}{z_3} \\ -\frac{1}{z_3} & \frac{1}{z_2} + \frac{1}{z_3} \end{bmatrix}$$

$$Y_{12} = \frac{-1}{z_3} = \frac{-1}{20} = -0.05$$



3.9. Ans.(a)



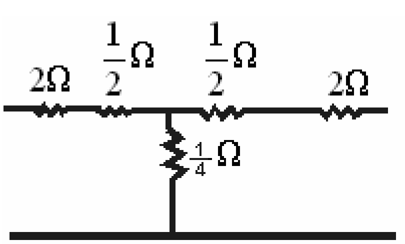
By Δ to Y

$$R_1 = \frac{2 \times 1}{4} = \frac{2\Omega}{4} = \frac{1}{2}\,\Omega$$

$$R_2 = \frac{2 \times 1}{4} = \frac{2\Omega}{4} = \frac{1}{2}\,\Omega$$

$$R_3 = \frac{1 \times 1}{2 \times 2} = \frac{1}{4}\,\Omega$$

$$Z = \begin{bmatrix} z_1 + z_3 & z_3 \\ z_3 & z_2 + z_3 \end{bmatrix} = \begin{bmatrix} 2.75 & 0.25 \\ 0.25 & 2.75 \end{bmatrix}$$



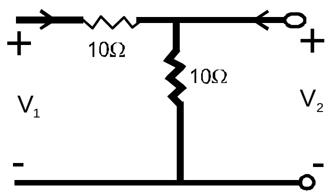
Please check above figure

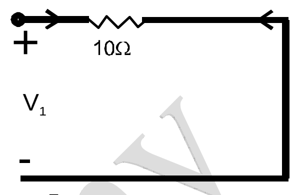
3.10. Ans.(d) Given circuit is lattice network

So, Z parameters (according standard result)

$$Z = \begin{bmatrix} \dfrac{Z_a + Z_b}{2} & \dfrac{Z_a - Z_b}{2} \\ \dfrac{Z_a - Z_b}{2} & \dfrac{Z_a + Z_b}{2} \end{bmatrix} = \begin{bmatrix} 1+j & -1+j \\ -1+j & 1+j \end{bmatrix}$$

3.11. Ans.(d)





$V_1 = h_{11} I_1 + h_{12} V_2$; $\quad I_2 = h_{21} I_1 + h_{22} V_2$

if $V_2 = 0$; $\dfrac{V_1}{I_1} = h_{11}$ and $\dfrac{I_2}{I_1} = h_{21}$

$I_1 = -I_2$; $\quad \dfrac{I_2}{I_1} = -1 = h_{21}$; $\quad V_1 = 10\, I_1$

$\dfrac{V_1}{I_1} = 10 = h_{11}$; $\quad h_{11} = 10$; $\quad h_{21} = -1$

Note: — Only option d satisfy this values we can solve for h_{12} and h_{22} by making $I_1 = 0$.

3.12. Ans.(b)

$$\left.\frac{I_2}{I_1} = \frac{V_1}{V_2} = \frac{n}{2}; \qquad \begin{matrix} I_2 = nI_1 \\ V_1 = nV_2 \end{matrix}\right\} \qquad (i)$$

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

But according the question

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} n & o \\ o & x \end{bmatrix}$$

$A = n,\ B = o,\ C = o,\ D = x$

So, $V_1 = AV_2$; $\quad I_1 = -DI_1$; $\quad \dfrac{I_1}{I_2} = -D = \dfrac{1}{n} \cong D = \dfrac{1}{n} = X$

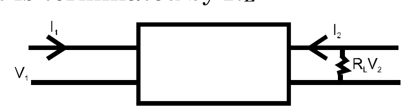
3.13. Ans.(d)

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

$V_1 = AV_2 - BI_2 \qquad (i)$

$I_1 = CV_2 - DI_2 \qquad (ii)$

Two-port is terminated by R_L



$V_2 = -I_2 R_L \qquad (iii)$

$$\frac{V_1}{I_1} = \frac{AV_2 - BI_2}{CV_2 - DI_2} = \frac{-AR_L I_2 - BI_2}{-CR_L I_2 - DI_2} = \frac{AR_L + B}{CR_L + D} = \text{input impedance}$$

3.14. Ans.(c)

$$V_1 = Z_{11}I_1 + Z_{12}I_2; \quad V_2 = Z_{21}I_1 + Z_{22}I_2; \quad Z_{12} = \frac{V_1}{I_2}/_{I_1=0} = \frac{4.5}{1} = 4.5$$

$$Z_{22} = \frac{V_2}{I_2}/_{I_1=0} = \frac{1.5}{1} = 1.5; \quad Z_{11} = \frac{V_1}{I_1}/_{I_2=0} = \frac{6}{4} = 1.5; \quad Z_{12} = \frac{V_2}{I_1}/_{I_1=0} = \frac{6}{4} = 1.5$$

$$\text{So } z-\text{parameter matrix } = \begin{bmatrix} 1.5 & 4.5 \\ 1.5 & 1.5 \end{bmatrix}$$

3.15. Ans.(a)

$$V_1 = h_{11}I_1 + h_{12}V_2; \quad I_2 = h_{21}I_1 + h_{22}V_2$$

$$(i) \quad h_{12} = \frac{V_1}{V_2}/_{I_1=0} = \frac{4.5}{1.5} = 3; \quad (ii)\ h_{22} = \frac{V_2}{V_2}/_{I_1=0} = \frac{1}{1.5} = 0.67$$

$$(iii)\ h_{11} = \frac{V_1}{I_1}$$

$$V_2 = Z_{21}I_1 + Z_{22}I_2 = 0; \quad I_2 = -\frac{Z_{21}I_1}{Z_{22}}$$

$$V_1 = Z_{11}I_1 + Z_{12}\left(-\frac{Z_{21}I_1}{Z_{22}}\right) \Rightarrow \frac{V_1}{I_1} = \left(Z_{11} - \frac{Z_{12}Z_{21}}{Z_{22}}\right) = h_{11} = 1.5 - \frac{4.5\times1.5}{1.5} = -3$$

$$(iv)\ h_{21} = \frac{I_2}{I_1}/_{V_2=0} = \frac{-Z_{21}}{Z_{22}} = \frac{-1.5}{1.5} = -1; \quad h = \begin{bmatrix} -3 & 3 \\ -1 & 0.67 \end{bmatrix}$$

3.16. Ans.(a)

$$Y_{11} = \frac{1}{0.5} + \frac{1}{0.5} = 4; \quad Y_{12} = Y_{21} = -2; \quad Y_{22} = \frac{1}{0.5} + \frac{1}{0.5} = 4$$

4.1. Ans.(c) According maximum power transfer theorem

4.2. Ans.(b) Ramp voltage = $100t$

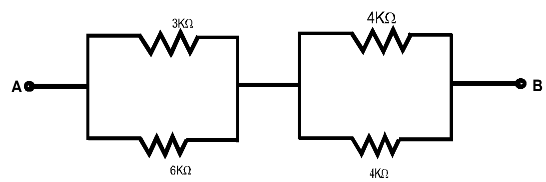
$$\text{Output of } RC \text{ differentiating circuit } = RC\frac{dV_i(t)}{dt} = 5\times10^3 \times 4\times10^{-6}\times100$$

$$= 20\times10^{-1} = 2 \text{ volts}$$

4.3. Ans.(a)

R^{th} across A.B for R^{th} voltage source become S.C. and circuit will like as

$$R^{th} = \frac{3\times6}{9} + \frac{4\times4}{8} = 2+2 = 4\ k\Omega$$



So, value of R should be equal to R^{th}, according maximum power transfer theorem.

4.4. Ans.(d)

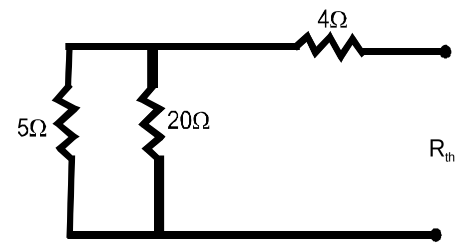
$$L_{eq} = L_1 + L_2 \pm K\sqrt{L_1L_2} = 2+2\pm0.1\sqrt{2\times2} = 2+2\pm0.2 = 3.8 \text{ or } 4.2$$

4.5. Ans.(a) Super position theorem application only for linear and bidirectional element.

4.6. Ans.(d) $R_1 = \frac{5\times 30}{50} = 3\Omega;$ $R_2 = \frac{5\times 15}{50} = 1.5\Omega;$ $R_3 = \frac{15\times 30}{50} = 9\Omega$

4.7. Ans.(c)

For maximum power transfer value of R should be conjugate symmetric with impedance of circuit (according maximum power transfer theorem) in circuit only resistance the R should be equal to require of circuit after removing R, for that find R^{th} across R. Terminal (Voltage source = ss.c and Current source = open circuit)



$$R^{th} = \frac{5\times 20}{25} + 4 = 8\Omega$$

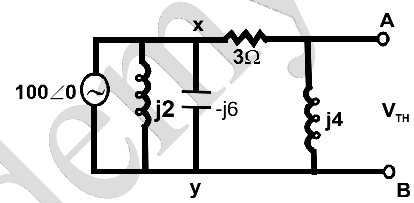
So, $R = 8\Omega$

4.8. Ans.(a)

Voltage across $xy = 100\angle 0$

By voltage division rule

$$V^{th} = 100\angle 0 \, \frac{4j}{j4+3} = j16(3-4j)$$

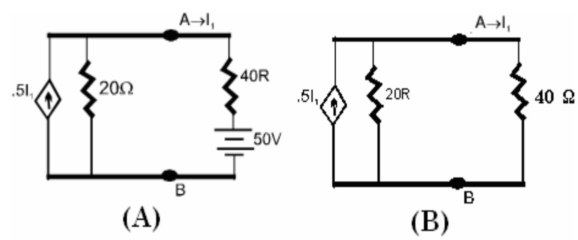


4.9. Ans.(c) By reciprocity theorem position and value of excitation change and double respectively so current will be double in magnitude, direction of source change so direction of current also will change.

4.10. Ans.(a) Impedance of each branch of Wye-circuit $= \frac{\sqrt{3}\,Z \times \sqrt{3}\,Z}{3\sqrt{3}\,Z} = \frac{Z}{\sqrt{3}}$

4.11. Ans.(a)

For maximum power delivered to R_L calculate R^{th} across R_L terminal connect voltage source V across AB and current provided by V is I then $\frac{V}{I} = R^{th};$ $I - I_1$



KCL at A

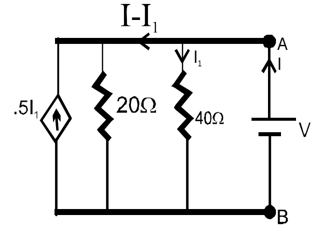
$$I + 0.5I_1 - \frac{V}{20} - \frac{V}{40} = 0$$

$$I_1 = \frac{V}{40}; \quad I + \frac{V}{80} = \frac{V}{20} + \frac{V}{40}$$

$$I = V\left(\frac{1}{20} + \frac{1}{40} - \frac{1}{80}\right)$$

$$\frac{V}{I} = \frac{80}{5} = 16\Omega_1$$

So, R_L should be $= 16\Omega$



4.12. Ans.(a)

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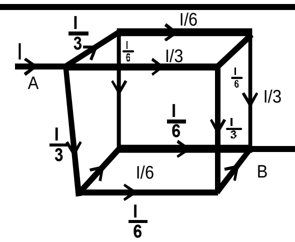
$$V_{AB} = \frac{I}{3}\times R + \frac{I}{6}\times R + \frac{I}{3}\times R$$

$$R = 1\ \Omega;\quad \frac{V_{AB}}{I} = \frac{5}{6}\ \Omega$$



4.13. Ans.(c)

$$Zs = \overline{Z_L}$$

Note: — Load impedance should be conjugated symmetric with source impedance, for maximum power transfer.

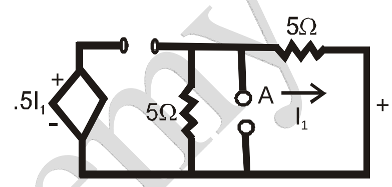
4.14. Ans.(b)

Apply KCL at node a

$$\frac{V^{th}}{5} + \frac{V^{th} - 10}{5} = 1$$

$V^{th} = 7.5$ V

For R^{th} calculation make independent current source open, and independent voltage source short circuit, and dependent source will not change.



$$R^{th} \cong R_{ab} = 5\,||\,5 = 2.5\ \Omega$$

4.15. Ans.(c) For maximum power transfer

$$R_L = R_S$$

$$P = \frac{V^2}{4R_L} \text{ or } \frac{V^2}{4Rs} = \frac{10\times 10}{4\times 100} = 0.25 \text{ W}$$

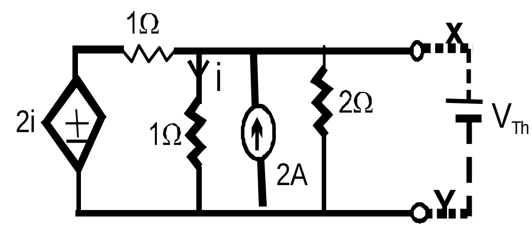
4.16. Ans.(d) For maximum power transfer from the source to the load impedance, load impedance should be complex conjugate of the source impedance. So, if source impedance $Z_S = R_S + jX_S$, then $= R_S - jX_S$.

4.17. Ans.(d)

Apply KCL at X

$$2 = \frac{V^{th}}{2} + \frac{V^{th}}{1} + \frac{V^{th} - 2i}{1}$$

But $i = \frac{V^{th}}{1}$, So $V^{th} = 4$ volt



$I_{sc} = 2\,$A (if we short xy, $V^{th} = 0$)

So, $R^{th} = \frac{V^{th}}{I_{sc}} = \frac{4}{2} = 2\ \Omega$ and $V^{th} = 4$ volt, $\{R^{th} = 2\ \Omega\}$

4.18. Ans.(a)

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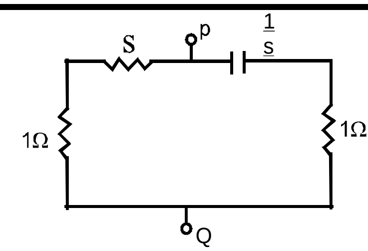
Independent voltage source will become short circuit, and independent current source will become open circuit



$$Z^{th} = (s+1) \,||\, \left(s + \frac{1}{s}\right) = 1$$

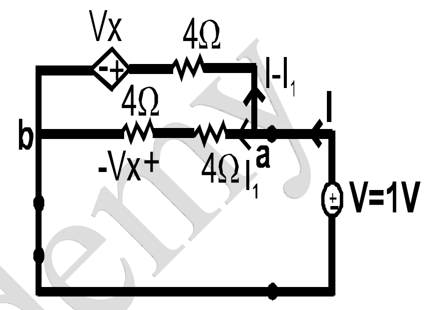
4.19. Ans.(c)

For $P_{\max}$

$$R_L = R_{eq}$$

Apply Thenvin Theorem.

Apply KVL in aba



$$4(I - I_1) + V_X - V_X - 4I_1 = 0$$

$$4I - 4I_1 - 4I_1 = 0 \quad \Rightarrow I_1 = \frac{I}{2}$$

Again apply KVL in aba loop

$$1 = 4I_1 + 4I_1 = 8I_1 = 8 \times \frac{I}{2}$$

$$\frac{1}{I} = R_{eq} = 4\Omega$$

5. Sinusoidal Steady State Analysis, Resonance, Power in AC Circuits, Passive Filters

5.1. Ans.(d)

5.2. Ans.(a) In series RLC high Q circuit, the current peaks at a frequency equal to the resonant frequency because at this condition circuit impedance minimum and current maximum.

5.3. Ans.(c) Driving-point function is $\frac{V_1}{I_1}$ or $\frac{I_1}{V_1}$; $\frac{V_1}{I_1} =$ driving-point impedance function

$\frac{I_1}{V_1} =$ driving-point admittance function by analysis $\frac{V_1}{I_1}$ is equal for N_1 and N_3.

5.4. Ans.(b, d) According to phasor diagram current is leading to voltage. So, net behavior of circuit is capacitive. So, operating frequency < Resonant frequency.

5.5. Ans.(c)

$$|A_3| = \sqrt{|A_1|^2 + |A_2|^2}$$

5.6. Ans.(c) For over-damped multiple poles on the negative real axis.

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5.7. Ans.(d) A series *L–C–R* circuit $R = 10\Omega,\ |X_L| = 20\Omega,\ |X_C| = 20\,\Omega$ circuit in resonance. So, current flowing in circuit $= \frac{200}{R} = 20\,\text{A}$ rms voltage across capacitor = 20 × 20 = 400, but voltage is lagging to current. So, voltage across 'c' $= 400\angle -90$.

5.8. Ans.(a) A series *R–L–C* circuit has

$Q = 100;$ $Z = 100 + j0 = R,$

$\omega_o = 10^7\,\text{rad/sec};$ $R = 100\,\Omega;$ $Q_o = \frac{\omega_o L}{R} \Rightarrow Q_o = 100 = \frac{10^7 \times L}{100};$ $L = 10^{-3}$

5.9. Ans.(c)

Current through resistance

$i(t) = 3 + 4\sin(100t + 45°) + 4\sin(300t + 60°)$

R.M.S. value fo current $= \sqrt{i^2_{1rms} + i^2_{2rms} + i^2_{3rms}}$

where, $i_1 = 3;$ $i_2 = 4\sin(100t + 45°);$ $i_3 = 4\sin(300t + 60)$

$i_{1rms} = 3;$ $i_{2rms} = \frac{4}{\sqrt{2}};$ $i_{3rms} = \frac{4}{\sqrt{2}}$

$i_{rms} = \sqrt{9 + 8 + 8} = 5\,\text{A}$

Power dissipated in circuit $= i^2_{rms} \times R = 25 \times 10 = 250\,\text{W}$

5.10. Ans.(b) Energy store in $C = \frac{1}{2}CV^2 = \frac{1}{2} \times CV^2$ total energy provide by source = 2 times

energy stores in capacitor required ration $= \frac{\frac{1}{2}CV^2}{CV^2} = \frac{1}{2} = 0.5.$

5.11. Ans.(c) Impedance offered by $C = \frac{1}{wC} = \frac{1}{o.C} = \infty;$ impedance offered by $L = \omega L = o.L = 0$. So, DC voltage drop entirely across = C.

5.12. Ans.(b)

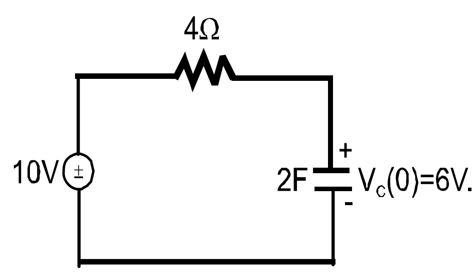
5.13. Ans.(b)

Applying KVL in closed loop circuit

$10 = 4\,i(t) + \frac{1}{c}\int i(t)\cdot dt$

Take Laplace in both side

$\frac{10}{S} = 4I(s) + \frac{1}{2}\frac{I(s)}{S} + \frac{V(0^+)}{s}$



$$\frac{10}{S} = I(s)\left[\frac{8S+1}{2S}\right] + \frac{6}{S} \Rightarrow I(s)\left[\frac{8S+1}{2S}\right] = \frac{4}{S} \Rightarrow I(s) = \frac{8}{8S+1}$$

$i(t) = e^{-t/8}$

Energy absorbed by the $4\,\Omega$ resistor in $(o, \propto)$ interval

$$W = \int_0^\infty i^2(t)R\cdot dt = \int_0^\infty e^{-2t/8} 4\cdot dt = 4\int_0^\infty e^{-t/8} 4\cdot dt = 4\left[\frac{e^{-t/4}}{\frac{-1}{4}}\right]_0^\infty = -16[0-1] = 16 \text{ jouls}$$

5.14. Ans.(a) At frequency of resonance the network represent a resistive network, input voltage and current are in phase; input admittance has minimum value so, that input impedance has maximum value current drawn by network from mains has minimum value.

$$I = V\sqrt{\frac{1}{R^2} + \left(\omega C - \frac{1}{\omega L}\right)^2}; \qquad \text{but } \left(\omega C - \frac{1}{\omega L}\right)^2 = 0; \quad V = I_R R \qquad (i)$$

Current through inductor $= -\dfrac{V}{j\omega L}$, because current in lagging with voltage.

So, $|I_R + I_L| < 1$; Similiary $|I_R + I_C| > 1$ and $|I_R| < 1$

5.15. Ans.(a)

Method 1 :

$$i_{2(t)} = \frac{E_m \cos\omega t}{R_2 + \frac{1}{j\omega C}} \qquad \{\text{at } \omega = 0\}$$

$$i_2(t) = \frac{E_m}{\infty} = 0 \qquad \{\text{at } \omega = \infty\}$$

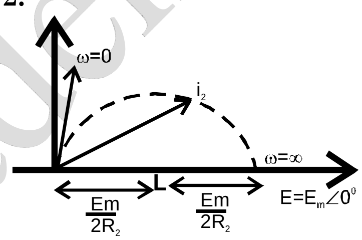
In this condition we can find only maximum possible value by case limitation.

$$i_{2(t)} = \frac{E_m}{R_2}; \qquad \angle i_2(t)\Big/_{\text{at } \omega = 0} = 90$$

$$\angle i_2(t)\Big/_{\text{at } \omega = \infty} = 0$$

By option checking only option (a) satisfy both conditions.

Method 2:



$$i_2(t) = \frac{E_m \cos\omega t}{R_2 + \frac{1}{j\omega C}}$$

$$\frac{E_m\cdot\omega C}{\sqrt{1+\omega^2C^2R_2^2}}\angle 90 - \tan^{-1}\omega CR_2$$

at $\omega \to 0$; $|i_2(t)| = 0,\ \angle i(t) = 90°$

at $\omega \to \infty$; $|i_2(t)| = \dfrac{E}{R_2}$ $|i(t)| = 0$

5.16. Ans.(d)

In star connection total power supplied $= 3V_P I_P\cos\theta$ or $V_L\, I_L \cos\theta$

$$3\times\frac{V_L}{\sqrt{3}}.\frac{V_L}{\sqrt{3}Z_L}\cdot\cos\theta = 1500$$

$$Z_L = \frac{3V_L{}^2\cos\theta}{3\times 1500}; \qquad V_L = 400\,\text{V}$$

$$Z_L = \frac{3\times 1600\times 0.844}{3\times 1500} = 90\,\Omega$$

Power factor is positive, so load will be capacitive and $\theta = -ve$ value

$\theta = -\cos^{-1}(0.844) = -32.44°$; $\quad Z_L = 90\angle -32.44°$

5.17. Ans.(a)

Applying KVL

$$V_1 - 5I - 5\left(I + \frac{V_1}{5}\right) = 0 \;\Rightarrow V_1 = 20\,\text{V}; \qquad 20 - 5I - 5\left(I + \frac{20}{5}\right) = 0 \;\Rightarrow I = 0$$

That means current flow in $5\,\Omega$ resistor only due to dependent source $\frac{V_1}{5} = \frac{20}{5} = 4\,\text{A}$.

So, power delivered dependent source $= I^2R = 16 \times 5 = 80\,\text{W}$.

5.18. Ans.(c)

Input voltage

$V(t) = 10\sqrt{2}\cos(t+10) + 10\sqrt{5}\cos(2t+10)\,V; \qquad Z = R + j\omega 1 = 1 + j\omega 1 = 1 + j\omega$

Steady state current $i(t) = ?$

$$i(t) = \frac{V(t)}{Z} = \frac{10\sqrt{2}\cos(t+10)}{1+j\omega} + \frac{10\sqrt{5}\cos(2t+10)}{1+j\omega} = \frac{10\sqrt{2}\cos(t+10)}{1+j} + \frac{10\sqrt{5}\cos(2t+10)}{1+j2}$$

$$= \frac{10\sqrt{2}\cos(t+10)}{\sqrt{2}\angle 45} + \frac{10\sqrt{5}\cos(2t+10)}{\sqrt{5}\angle\tan^{-1}(2)} = 10\cos(t-35) + 10\cos(2t + 10 - \tan^{-1}2)$$

5.19. Ans.(*) Incomplete question (value of L_1 is not given)

5.20. Ans.(c)

$$V(t) = Ri(t) + \frac{Ldi(t)}{dt} + \frac{1}{C}\int i(t)\cdot dt$$

$$\sin t = 2i(t) + \frac{2di(t)}{dt} + 1\int i(t)\cdot dt; \qquad \cos t = 2\frac{di(t)}{dt} + \frac{2d^2i(t)}{dt^2} + i(t)$$

5.21. Ans.(b)

$$\left.\begin{aligned} Q &= \frac{f_0}{B.\omega},\; f_0 = \frac{1}{2\pi}\;\frac{1}{\sqrt{LC}} \\ B\omega &= \frac{R}{L} \text{ for series } (RLC) \end{aligned}\right\} Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

If R, L, C all element doubled them $Q' = \frac{Q}{2} = \frac{100}{2} = 50$

5.22. Ans.(d) (i) At resonant frequency impedance of series RLC circuit is purely resistive

(ii) For parallel RLC circuit

$$Q = R\sqrt{\frac{C}{L}} = \frac{1}{G}\sqrt{\frac{C}{L}} \qquad \{\text{if } G\uparrow \text{ them } Q\downarrow\}$$

So, S_1 and S_2 both statements are wrong.

5.23. Ans.(d) $$\frac{V_{C(s)}}{V_{1(s)}} = \frac{\frac{1}{SC}}{R + SL + \frac{1}{SC}} = \frac{1}{S^2LC + SLR + 1} = \frac{1/LC}{S^2 + S\frac{R}{L} + \frac{1}{LC}} = \frac{10^6}{S^2 + 10^6 S + 10^6}$$

5.24. Ans.(b)

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$$H(s) = \frac{10^6}{s^2 + 20s + 10^6} \simeq \frac{\omega_n^2}{s^2 + 2\varepsilon\,\omega_n s + \omega_n^2}$$

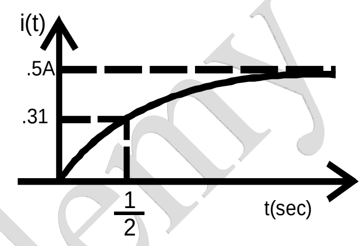
$$Q = \frac{\omega_n}{BW} \qquad \{\omega_n = 10^3 \text{ and } BW = 20\}$$

$$Q = \frac{10^3}{20} = \frac{1000}{20} = 50$$

Note: — In series circuit of RLC, $BW = \frac{R}{L}$

5.25. Ans. (c)

Time constant $= \frac{L}{R} = \frac{1}{2} = 0.5\,\text{sec}$. At steady state, L behaves like short circuit. So, current through $R = \frac{1}{2} = 0.5\,\text{V}$.



5.26. Ans.(a)

By voltage division rule $Vo(t) = V_1(t)\dfrac{\frac{1}{j\omega C}}{R + \frac{1}{j\omega C}} = \sqrt{2}\sin 10^3 t\left[\dfrac{\frac{1}{j\times 10^3 \times C}}{R + \frac{1}{j\times 10^3 C}}\right]$

$$= \sqrt{2}\sin 10^3 t\left[\frac{\frac{1}{j\times 10^3 \times C}}{R + \frac{1}{j\times 10^3 C}}\right]$$

$$= \sqrt{2}\sin 10^3 t\left[\frac{1}{j10^3 RC + 1}\right]$$

But $RC = 1\times 10^{-3}$

$$Vo(t) = \sqrt{2}\sin 10^3 t\left[\frac{1}{j+1}\right] = \sqrt{2}\sin 10^3 t \times \frac{1}{\sqrt{2}}\angle -45 = \sin(10^3 t - 45°)$$

5.27. Ans.(a)

Circuit is parallel RLC circuit $i(t) = v(t)Y = \sin 2t\left[\frac{1}{R} + \frac{1}{j\omega C} + j\omega C\right]$

$$= \sin 2t\left[\frac{1}{R} + \frac{1}{j\omega C} + j\omega C\right]$$

Note: — $\omega = 2\ (\sin 2t \equiv \sin \omega t)$

$$i(t) = \sin 2t\left[\frac{1}{1/3} + \frac{1}{j\times 2\times \frac{1}{4}} + j\times 2\times 3\right]$$
$$= \sin 2t[3 - j2 + j6] = \sin 2t[3 + j4] = 5\sin(2t + 53.1°)$$

5.28. Ans.(a)

By superposition theorem, when $5\angle 0°$A source inacrive and remove $10\angle 60$A (Open), then $i_1 = -5\angle 0°$, when $10\angle 60$A in active and remove $5\angle 0$ (open) $i_1 + 10\angle 60$. So, total current $= 10\times\frac{1}{2} + 10\times\frac{\sqrt{3}}{2}j - 5\times 1 = 10\frac{\sqrt{3}}{2}jA \cong \frac{10\sqrt{3}}{2}\angle 90°$A.

5.29. Ans.(d) If ω increases, phase shift is decrease for lag network.

5.30. Ans.(b)

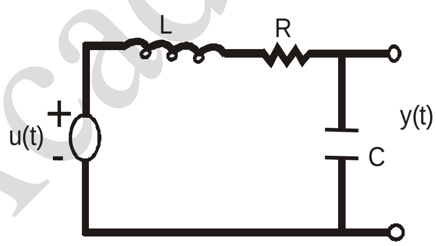
In series RLC circuit $R = 2\,\text{k}\Omega$, $L = 1\,\text{H}$ and $C = \frac{1}{400}\,\mu\text{F}$

Resonant frequency $= \frac{1}{2\pi}\sqrt{\frac{1}{LC}} = \frac{1}{2\pi}\frac{1}{\sqrt{1\times\frac{1}{400}\times 10^{-6}}} = \frac{1}{2\pi}\times 20\times 10^{3} = \frac{1}{\pi}\times 10^{4}$ Hz

5.31. Ans.(c)

Transfer function of the circuit

$$\frac{Y(s)}{U(s)} = \frac{\frac{1}{sc}}{R + sL + \frac{1}{sc}}$$



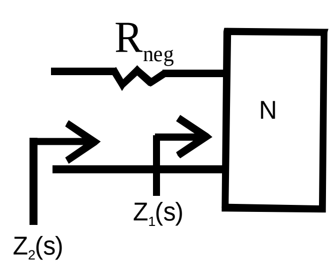
$$\frac{Y(s)}{U(s)} = \frac{1}{s^2LC + sCR + 1} = \frac{\frac{1}{LC}}{s^2 + s\frac{R}{L} + \frac{1}{LC}} \cong \frac{\omega_n^2}{s^2 + 2\varepsilon\omega_n s + \omega_n^2}$$

$$\omega_n^2 = \frac{1}{LC} \Rightarrow \omega_n = \frac{1}{\sqrt{LC}} \Rightarrow 2\xi\omega_n = \frac{R}{L} \Rightarrow 2\xi\times\frac{1}{\sqrt{LC}} = \frac{R}{L} \Rightarrow 2\xi = R\sqrt{\frac{C}{L}} \Rightarrow \xi = \frac{R}{2}\sqrt{\frac{C}{L}}$$

For no oscillation condition $\xi \geq 1$; $\frac{R}{2}\sqrt{\frac{C}{L}} \geq 1$.

5.32. Ans.(a)

For $Z_2(s) \to$ positive real
$R_eZ(s) \geq |R_{neg}| \Rightarrow |R_{neg}| \leq R_eZ_1(j\omega)$
for all ω.



5.33. Ans.(b) If first critical frequency = pole; second critical frequency = 3ero
Then, passive network is RC network only

5.34. Ans.(d)

Phasor voltage V_{AB} is = ?

$$V_{AB} = \text{Current} \times \text{impedance}$$
$$= 5\angle 30 \times (\text{impedance between } A \ \& \ B)$$
$$= 5\angle 30 \times \left[(5 - j3) \,||\, (5 + j3)\right] = 5\angle 30 \times \left[\frac{(5 - j3) \times (5 + j3)}{5 - j3 + 5 + j3}\right]$$
$$= 5\angle 30 \times \left[\frac{25 - j15 + j15 + 9)}{10}\right] = 5\angle 30 \times \frac{34}{10}$$

5.35. Ans.(a)

We know $I_C(t) = I_C(\infty) - [I_C(\infty) - I_C(0)]e^{-t/T}$
where, $I_C(\infty)$ = current through capacitor at $\to \infty$

Note: — We know capacitor behaves like short circuit at $t = 0$, but open circuit at $t \to \infty$. So, $I_C(\infty) = 0$

$$I_C[0^+] = \frac{10\,\text{V}}{20\,\text{k}\Omega} = 0.5\,\text{mA}$$

T = time constant of charging of capacitor $= R_{eq}C$

$$R_{eq} = (20\,\text{k}\Omega) \,||\, (20\,\text{k}\Omega) = 10\,\text{k}\Omega$$
$$T = 10 \times 10^3 \times 4 \times 10^{-6} = 40 \times 10^{-3} = 40\,\text{m sec}$$

So, $I_C(t) = 0 - [0 - 0.5]e^{t/40\sec} = 0.5e^{-\left(\frac{t \times 1000}{40}\right)} = 0.5e^{-25t}$ mA

$I(t) = 0.5\exp(-25t)\,\text{mA}$

5.36. Ans.(d) 3-dB bandwidth of Filter 1 is B_1 and 3-dB bandwidth of Filter 2 is B_2.

Note: — Filter is RLC circuit and band width of series RLC circuit is $= \frac{R}{L}$. So, for

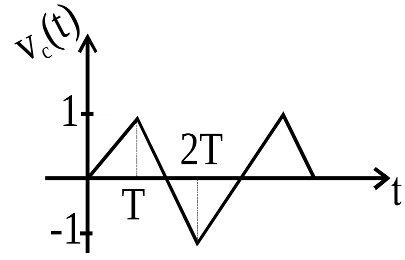
$$B_1,\ BW = \frac{R}{L_1} \text{ for } B_2,\ BW = \frac{R}{L_2}$$

$$\frac{B_1}{B_2} = \frac{R/L_1}{R/L_2} = \frac{L_2}{L_1} = \frac{L_1/4}{L_1} = \frac{1}{4} \qquad \left(\text{where, } L_2 = \frac{L_1}{4}\right)$$

5.37. Ans.(c)

Time constant of discharging of capacitor is double than, time constant of charging of capacitor. So waveform of V_C is

$$V_C = tu(t) - 2(t - T)\ u(t - 2T) + 2(t - 2T)u(t - 2T)$$
$$= tu(t) + 2\sum_{n=1}^{\infty}(-1)n(t - nT)u(t - nT)$$



5.38. Ans.(d)

Voltage across capacitor

$$V_C(s) = \frac{1}{\left(s+1+\frac{1}{s}\right)} \cdot \frac{1}{s}\ V_i(s); \qquad V_i(s) = 1$$

$$V_C(t) = \frac{1}{\left(s+1+\frac{1}{s}\right)} \cdot \frac{1}{s}; \qquad V_C(t) = \frac{2}{\sqrt{3}} e^{-\frac{t}{2}} \sin\left(\frac{\sqrt{3}}{2}t\right)$$

5.39. Ans.(b)

Voltage across resistor

$$V_R(s) = \frac{1}{\left(s+1+\frac{1}{s}\right)} \times 1 = \frac{s}{s^2+s+1} = \frac{s+\frac{1}{2}}{\left(s+\frac{1}{2}\right)^2 + \left(\frac{\sqrt{3}}{2}\right)^2} - \frac{\frac{1}{2}}{\left(s+\frac{1}{2}\right)^2 + \left(\frac{\sqrt{3}}{2}\right)^2}$$

$$V_R(t) = e^{-t/2}\left[\cos\left(\frac{\sqrt{3}}{2}t\right) - \frac{1}{\sqrt{3}}\sin\left(\frac{\sqrt{3}}{2}t\right)\right]$$

5.40. Ans.(c)

$$I = \frac{20}{1+2j+7+4j} = \frac{10}{4+3j} = \frac{10}{5}\angle -\tan^{-1}\left(\frac{3}{4}\right) = 2\angle\theta$$

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

Reactive power = VI $\sin\theta = 20\times 2\times \sin\left[\tan^{-1}\left(\frac{3}{4}\right)\right] = 40\times\sin(37°) \cong 24$ VAR

5.41. Ans.(d)

Bandwidth $= \frac{1}{RC}, \frac{1}{Z_i} = \frac{1}{R} + \frac{1}{X_L} + \frac{1}{X_C}$. Thus it is maximum at resonance.

5.42. Ans.(a)

$20\,mH \to +|20\,j$ & $50\,\mu F \to -20\,j$

Now apply KCL

$$\frac{V-V_x}{20\,j} = \frac{V_x}{1} + \frac{V_x}{-20\,j}$$

$$\Rightarrow V - V_x = (20\,j)V_x - V_x$$

$$\Rightarrow V = 20\,j.V_x$$

$$\Rightarrow V_x = \frac{20}{20\,j} = 1 \text{ with angle } -90°$$

So, $I = \frac{V_x}{1} = 1$ with angle $-90°$

So, $I = (-1\,j)$