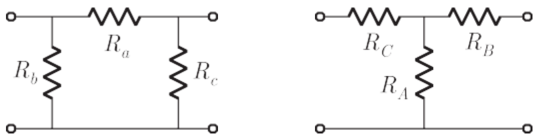
GATE SOLVED PAPER - EC

NETWORK ANALYSIS

2013 **ONE MARK**

Q. 1 Consider a delta connection of resistors and its equivalent star connection as shown below. If all elements of the delta connection are scaled by a factor k, $k > 0$, the elements of the corresponding star equivalent will be scaled by a factor of



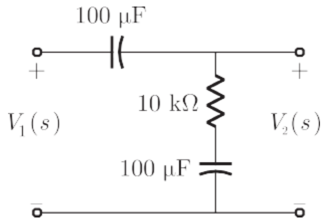
(A) k^2

(B) k

(C) $1/k$

(D) $\sqrt{k}$

Q. 2 The transfer function $\frac{V_2(s)}{V_1(s)}$ of the circuit shown below is



(A) $\frac{0.5s + 1}{s + 1}$ (B) $\frac{3s + 6}{s + 2}$

(C) $\frac{s + 2}{s + 1}$ (D) $\frac{s + 1}{s + 2}$

Q. 3 A source $v_s(t) = V \cos 100\pi t$ has an internal impedance of $(4 + j3)\,\Omega$. If a purely resistive load connected to this source has to extract the maximum power out of the source, its value in Ω should be

(A) 3

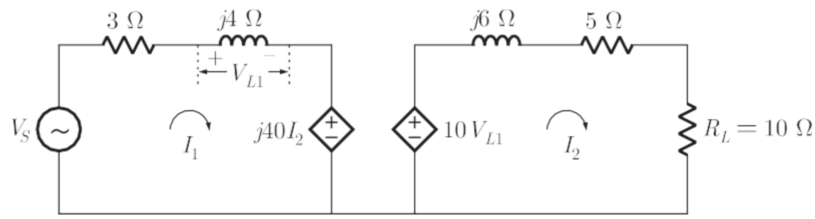
(B) 4

(C) 5

(D) 7

2013 **TWO MARKS**

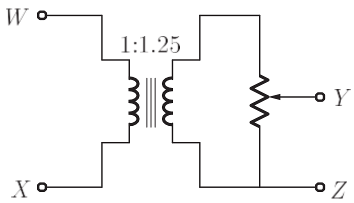
Q. 4 In the circuit shown below, if the source voltage $V_S = 100\angle 53.13^\circ$ V then the Thevenin's equivalent voltage in Volts as seen by the load resistance R_L is



(A) 100+90c (B) 800+0c

(C) 800+90c (D) 100+60c

Q. 5 The following arrangement consists of an ideal transformer and an attenuator which attenuates by a factor of 0.8. An ac voltage V_{WX1} = 100 V is applied across WX to get an open circuit voltage V_{YZ1} across YZ. Next, an ac voltage V_{YZ2} = 100 V is applied across YZ to get an open circuit voltage V_{WX2} across WX. Then, V_{YZ1} / V_{WX1}, V_{WX2} / V_{YZ2} are respectively,



(A) 125 / 100 and 80/100 (B) 100 / 100 and 80 /100

(C) 100 / 100 and 100/100 (D) 80 / 100 and 80 /100

Q. 6 Two magnetically uncoupled inductive coils have Q factors q_1 and q_2 at the chosen operating frequency. Their respective resistances are R_1 and R_2. When connected in series, their effective Q factor at the same operating frequency is

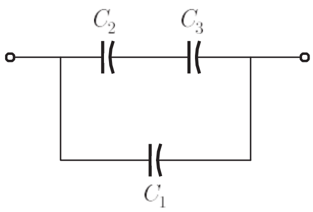
(A) $q_1 + q_2$

(B) ^1 / q_1h + ^1 / q_2h

(C) ^$q_1R_1 + q_2R_2$h/^$R_1 + R_2$h

(D) ^$q_1R_2 + q_2R_1$h/^$R_1 + R_2$h

Q. 7 Three capacitors C_1, C_2 and C_3 whose values are 10 mF, 5 mF, and 2 mF respectively, have breakdown voltages of 10 V, 5 V and 2 V respectively. For the interconnection shown below, the maximum safe voltage in Volts that can be applied across the combination, and the corresponding total charge in mC stored in the effective capacitance across the terminals are respectively,

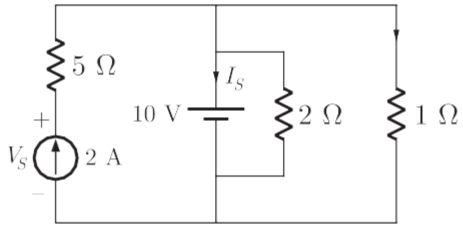


(A) 2.8 and 36 (B) 7 and 119

(C) 2.8 and 32 (D) 7 and 80

Common Data For Q. 8 and 9:

Consider the following figure



Q. 8 The current I_S in Amps in the voltage source, and voltage V_S in Volts across the current source respectively, are

(A) 13, − 20

(B) 8, − 10

(C) −8, 20

(D) −13, 20

Q. 9 The current in the 1W resistor in Amps is

(A) 2

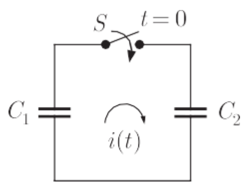
(B) 3.33

(C) 10

(D) 12

2012 ONE MARK

Q. 10 In the following figure, C_1 and C_2 are ideal capacitors. C_1 has been charged to 12 V before the ideal switch S is closed at $t = 0$. The current $i(t)$ for all t is



(A) zero by a current

(B) a step function

(C) an exponentially decaying function

(D) an impulse function

Q. 11 The average power delivered to an impedance (4 − j3) W
5 cos (100pt + 100) A is

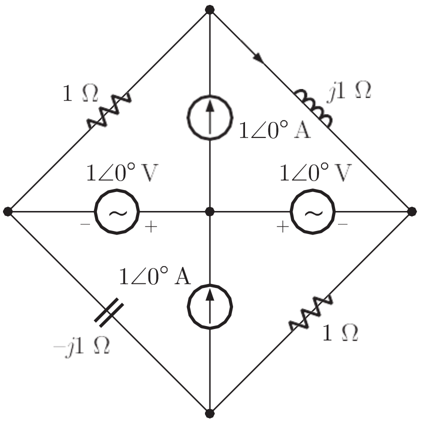
(A) 44.2 W

(B) 50 W

(C) 62.5 W

(D) 125 W

Q. 12 In the circuit shown below, the current through the inductor is

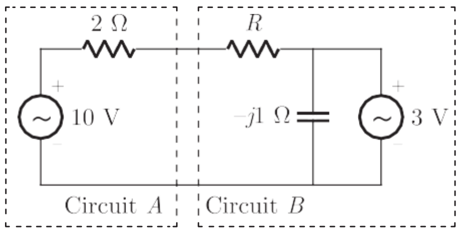


(A) $\frac{2}{1+j}$ A (B) $\frac{-1}{1+j}$ A

(C) $\frac{1}{1+j}$ A (D) 0 A

2012 TWO MARKS

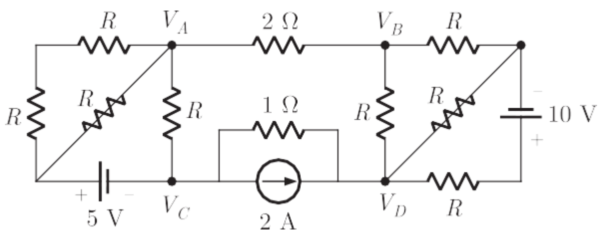
Q. 13 Assuming both the voltage sources are in phase, the value of R for which maximum power is transferred from circuit A to circuit B is



(A) 0.8 W (B) 1.4 W

(C) 2 W (D) 2.8 W

Q. 14 If $V_A - V_B = 6$ V then $V_C - V_D$ is



(A) −5 V (B) 2 V

(C) 3 V (D) 6 V

Common Data For Q. 15 and 16 :

With 10 V dc connected at port A in the linear nonreciprocal two-port network shown below, the following were observed :

(i) 1 W connected at port B draws a current of 3 A

(ii) 2.5 W connected at port B draws a current of 2 A

Q. 15 With 10 V dc connected at port A, the current drawn by 7 W connected at port B is

(A) 3/7 A (B) 5/7 A

(C) 1 A (D) 9/7 A

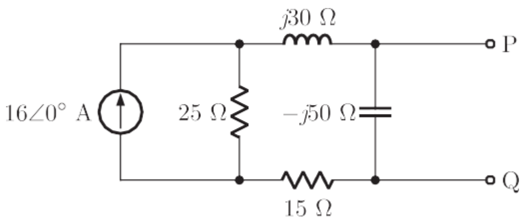
Q. 16 For the same network, with 6 V dc connected at port A, 1 W connected at port B draws 7 / 3 A. If 8 V dc is connected to port A, the open circuit voltage at port B is

(A) 6 V (B) 7 V

(C) 8 V (D) 9 V

2011 **ONE MARK**

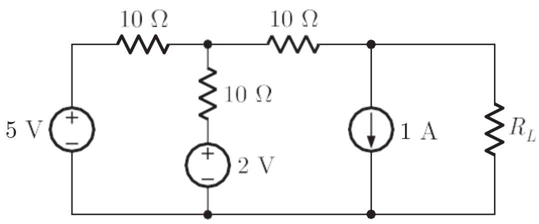
Q. 17 In the circuit shown below, the Norton equivalent current in amperes with respect to the terminals P and Q is



(A) $6.4 - j\,4.8$ (B) $6.56 - j\,7.87$

(C) $10 + j\,0$ (D) $16 + j\,0$

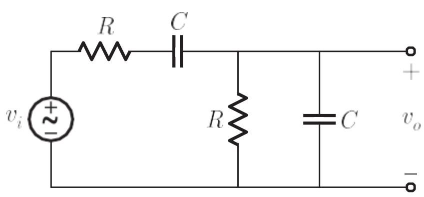
Q. 18 In the circuit shown below, the value of R_L such that the power transferred to R_L is maximum is



(A) 5 W (B) 10 W

(C) 15 W (D) 20 W

Q. 19 The circuit shown below is driven by a sinusoidal input $v_i = V_p \cos(t/RC)$. The steady state output v_o is

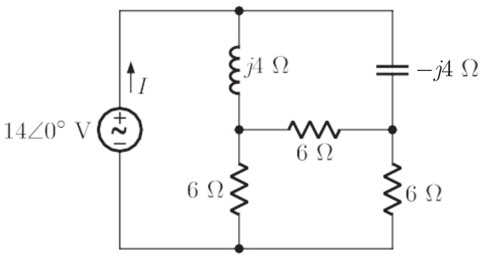


(A) $(V_p/3)\cos(t/RC)$ (B) $(V_p/3)\sin(t/RC)$

(C) $(V_p/2)\cos(t/RC)$ (D) $(V_p/2)\sin(t/RC)$

2011 TWO MARKS

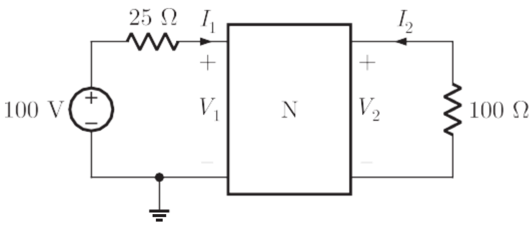
Q. 20 In the circuit shown below, the current I is equal to



(A) $1.4\angle 0^\circ$ A (B) $2.0\angle 0^\circ$ A

(C) $2.8\angle 0^\circ$ A (D) $3.2\angle 0^\circ$ A

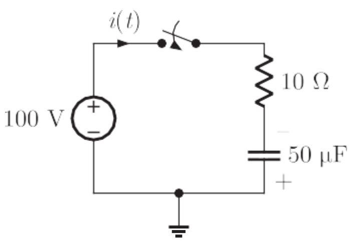
Q. 21 In the circuit shown below, the network N is described by the following Y matrix:
$Y = \begin{bmatrix} 0.1\text{ S} & -0.01\text{ S} \\ 0.01\text{ S} & 0.1\text{ S} \end{bmatrix}$. the voltage gain $\frac{V_2}{V}$ is



(A) 1/90 (B) –1/90

(C) –1/99 (D) –1/11

Q. 22 In the circuit shown below, the initial charge on the capacitor is 2.5 mC, with the voltage polarity as indicated. The switch is closed at time $t = 0$. The current $i(t)$ at a time t after the switch is closed is



(A) $i(t) = 15\exp(-2\times 10^3 t)$ A

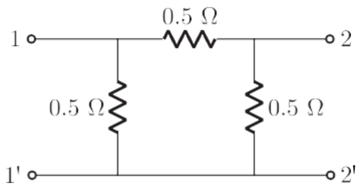
(B) $i(t) = 5\exp(-2\times 10^3 t)$ A

(C) $i(t) = 10\exp(-2\times 10^3 t)$ A

(D) $i(t) = -5\exp(-2\times 10^3 t)$ A

2010 ONE MARK

Q. 23 For the two-port network shown below, the short-circuit admittance parameter matrix is



(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

Q. 24 For parallel *RLC* circuit, which one of the following statements is NOT correct ?

(A) The bandwidth of the circuit decreases if *R* is increased

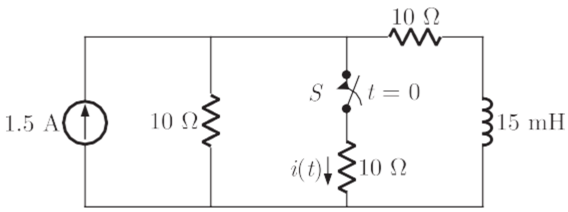
(B) The bandwidth of the circuit remains same if *L* is increased

(C) At resonance, input impedance is a real quantity

(D) At resonance, the magnitude of input impedance attains its minimum value.

2010 TWO MARKS

Q. 25 In the circuit shown, the switch *S* is open for a long time and is closed at $t = 0$. The current $i(t)$ for $t \geq 0^+$ is



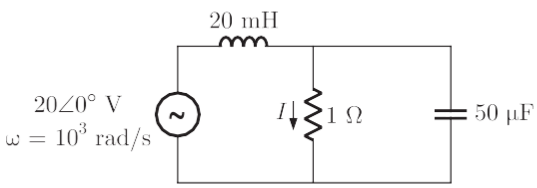
(A) $i(t) = 0.5 - 0.125e^{-1000t}$ A

(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

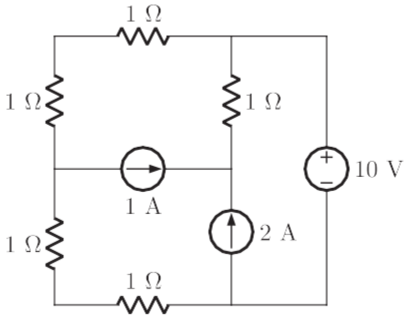
Q. 26 The current *I* in the circuit shown is



(A) $-j1$ A (B) $j1$ A

(C) 0 A (D) 20 A

Q. 27 In the circuit shown, the power supplied by the voltage source is

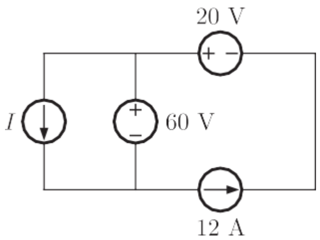


(A) 0 W (B) 5 W

(C) 10 W (D) 100 W

GATE 2009 ONE MARK

Q. 28 In the interconnection of ideal sources shown in the figure, it is known that the 60 V source is absorbing power.



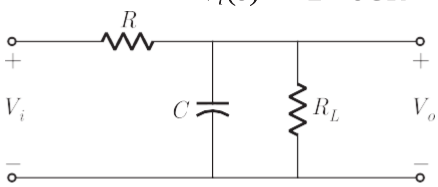
Which of the following can be the value of the current source I ?

(A) 10 A (B) 13 A

(C) 15 A (D) 18 A

Q. 29 If the transfer function of the following network is

$$\frac{V_o(s)}{V_i(s)} = \frac{1}{2 + sCR}$$

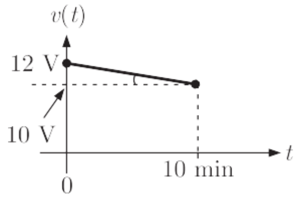


The value of the load resistance R_L is

(A) $\frac{R}{4}$ (B) $\frac{R}{2}$

(C) R (D) $2R$

Q. 30 A fully charged mobile phone with a 12 V battery is good for a 10 minute talk-time. Assume that, during the talk-time the battery delivers a constant current of 2 A and its voltage drops linearly from 12 V to 10 V as shown in the figure. How much energy does the battery deliver during this talk-time?

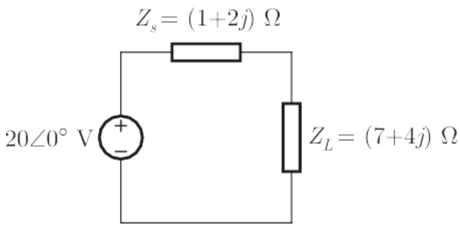


(A) 220 J (B) 12 kJ

(C) 13.2 kJ (D) 14.4 J

GATE 2009 **TWO MARK**

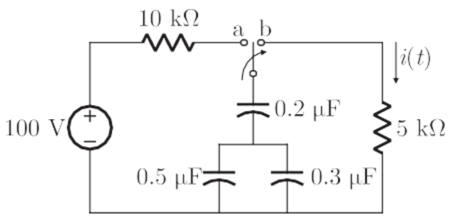
Q. 31 An AC source of RMS voltage 20 V with internal impedance $Z_s = (1 + 2j)$ W feeds a load of impedance $Z_L = (7 + 4j)$ W in the figure below. The reactive power consumed by the load is



(A) 8 VAR (B) 16 VAR

(C) 28 VAR (D) 32 VAR

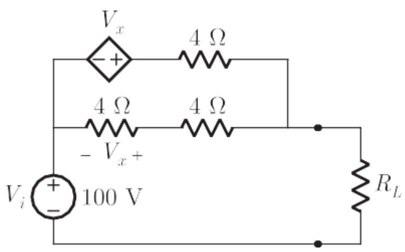
Q. 32 The switch in the circuit shown was on position a for a long time, and is move to position b at time $t = 0$. The current $i(t)$ for $t > 0$ is given by



(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

Q. 33 In the circuit shown, what value of R_L maximizes the power delivered to R_L?



(A) 2.4 W (B) $\frac{8}{3}$ W

(C) 4 W (D) 6 W

Q. 34 The time domain behavior of an RL circuit is represented by

$$L\frac{di}{dt} + Ri = V_0(1 + Be^{-Rt/L}\sin t)u(t).$$

For an initial current of $i(0) = \frac{V_0}{R}$, the steady state value of the current is given by

(A) $i(t) = \frac{V_0}{R}$

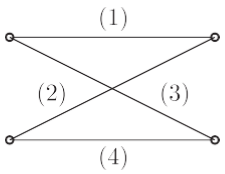
(B) $i(t) = \frac{2V_0}{R}$

(C) $i(t) = \frac{V_0}{R}(1+B)$

(D) $i(t) = \frac{2V_0}{R}(1+B)$

GATE 2008 ONE MARK

Q. 35 In the following graph, the number of trees (P) and the number of cut-set (Q) are



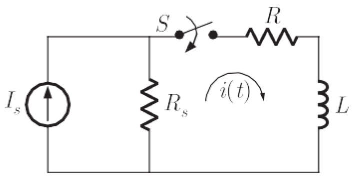
(A) $P = 2, Q = 2$

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

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

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

Q. 36 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



(A) 0

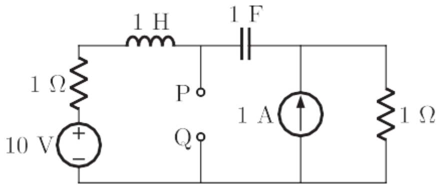
(B) $\frac{R_s I_s}{L}$

(C) $\frac{(R + R_s) I_s}{L}$

(D) 3

GATE 2008 TWO MARKS

Q. 37 The Thevenin equivalent impedance Z_{th} between the nodes P and Q in the following circuit is



(A) 1

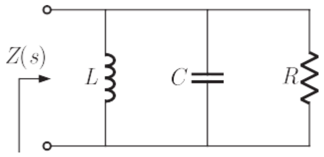
(B) $1 + s + \frac{1}{s}$

(C) $2 + s + \frac{1}{s}$

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

Q. 38 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

(A) $L = 5$ H, $R = 0.5\ \Omega, C = 0.1$ F

(B) $L = 0.1$ H, $R = 0.5\ \Omega, C = 5$ F

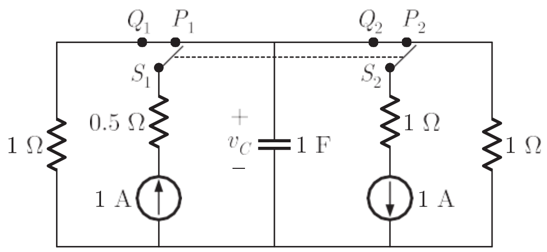
(C) $L = 5$ H, $R = 2\ \Omega, C = 0.1$F

(D) $L = 0.1$ H, $R = 2\ \Omega, C = 5$F

Q. 39 The circuit shown in the figure is used to charge the capacitor C alternately from two current sources as indicated. The switches S_1 and S_2 are mechanically coupled and connected as follows:

For $2nT \le t \le (2n+1)T$, $(n = 0, 1, 2,..)$ S_1 to P_1 and S_2 to P_2

For $(2n+1)T \le t \le (2n+2)T$, $(n = 0, 1, 2,...)$ S_1 to Q_1 and S_2 to Q_2



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

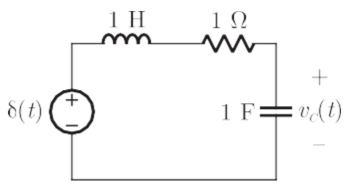
(B) $u(t) + 2\sum_{n=1}^{\infty} (-1)^n u(t - nT)$

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

(D) $\sum_{n=1}^{\infty} [0.5 - e^{-(t-2nT)} + 0.5e^{-(t-2nT)} - T]$

Common Data For Q.40 and 41 :

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



Q. 40 For $t > 0$, the output voltage $v_C(t)$ is

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

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

Q. 41 For $t > 0$, the voltage across the resistor is

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

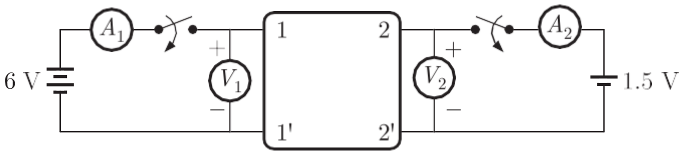
(B) $e^{-\frac{1}{2}t}\left[\cos\left(\frac{\sqrt{3}}{2}t\right) - \frac{1}{\sqrt{3}}\sin\left(\frac{\sqrt{3}}{2}t\right)\right]$

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

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

Statement for linked Answers Questions 42 and 43:

A two-port network shown below is excited by external DC source. The voltage and the current are measured with voltmeters V_1, V_2 and ammeters. A_1, A_2 (all assumed to be ideal), as indicated



Under following conditions, the readings obtained are:

(1) S_1 -open, S_2 - closed $A_1 = 0$, $V_1 = 4.5$ V, $V_2 = 1.5$ V, $A_2 = 1$ A

(2) S_1 -open, S_2 - closed $A_1 = 4$ A, $V_1 = 6$ V, $V_2 = 6$ V, $A_2 = 0$

Q. 42 The z -parameter matrix for this network is

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

Q. 43 The h -parameter matrix for this network is

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

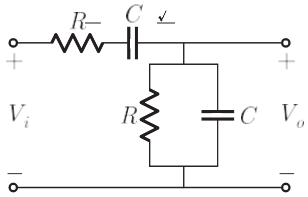
GATE 2007 ONE MARK

Q. 44 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

(A) $Z_L = R_s + jX_s$ (B) $Z_L = R_s$

(C) $Z_L = jX_s$ (D) $Z_L = R_s - jX_s$

Q. 45 The RC circuit shown in the figure is

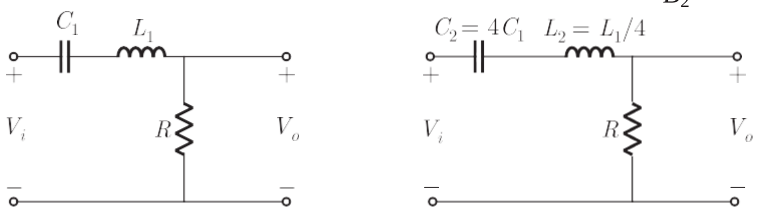


(A) a low-pass filter (B) a high-pass filter

(C) a band-pass filter (D) a band-reject filter

GATE 2007 **TWO MARKS**

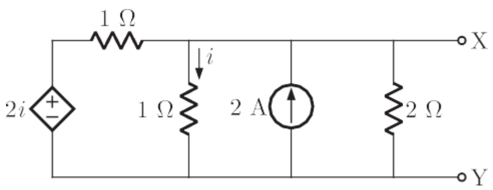
Q. 46 Two series resonant filters are as shown in the figure. Let the 3-dB bandwidth of Filter 1 be B_1 and that of Filter 2 be B_2. the value $\frac{B_1}{B_2}$ is



(A) 4 (B) 1

(C) 1/2 (D) 1/4

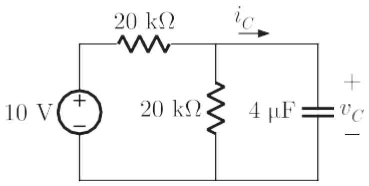
Q. 47 For the circuit shown in the figure, the Thevenin voltage and resistance looking into $X - Y$ are



(A) $\frac{4}{3}$ V, 2 W (B) 4 V, $\frac{2}{3}$ W

(C) $\frac{4}{3}$ V, $\frac{2}{3}$ W (D) 4 V, 2 W

Q. 48 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



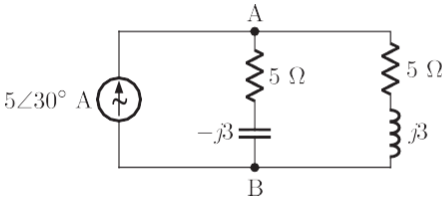
(A) $0.50 \exp(-25t)$ mA

(B) $0.25 \exp(-25t)$ mA

(C) $0.50 \exp(-12.5t)$ mA

(D) $0.25 \exp(-6.25t)$ mA

Q. 49 In the ac network shown in the figure, the phasor voltage V_{AB} (in Volts) is



(A) 0 (B) 5+30c

(C) 12.5+30c (D) 17+30c

GATE 2006 TWO MARKS

Q. 50 A two-port network is represented by *ABCD* parameters given by

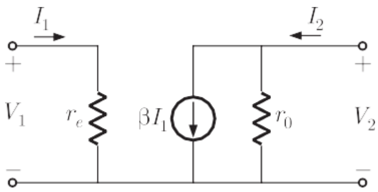
$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

If port-2 is terminated by R_L , the input impedance seen at port-1 is given by

(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) $\frac{B + AR_L}{D + CR_L}$

Q. 51 In the two port network shown in the figure below, Z_{12} and Z_{21} and respectively



(A) r_e and br_0 (B) 0 and $-br_0$

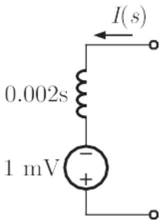
(C) 0 and br_o (D) r_e and $-br_0$

Q. 52 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

(A) *RL* network only (B) *RC* network only

(C) *LC* network only (D) *RC* as well as *RL* networks

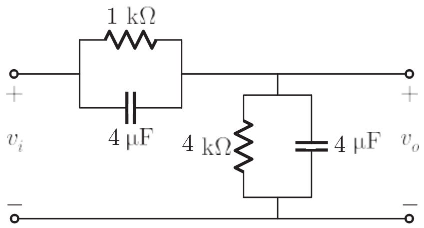
Q. 53 A 2 mH inductor with some initial current can be represented as shown below, where *s* is the Laplace Transform variable. The value of initial current is



(A) 0.5 A (B) 2.0 A

(C) 1.0 A (D) 0.0 A

Q. 54 In the figure shown below, assume that all the capacitors are initially uncharged. If $v_i(t) = 10u(t)$ Volts, $v_o(t)$ is given by



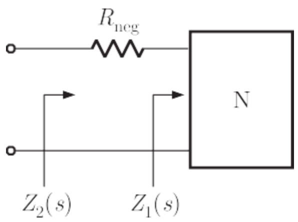
(A) $8e^{-t/0.004}$ Volts

(B) $8(1 - e^{-t/0.004})$ Volts

(C) $8u(t)$ Volts

(D) 8 Volts

Q. 55 A negative resistance R_{neg} is connected to a passive network N having driving point impedance as shown below. For $Z_2(s)$ to be positive real,



(A) $|R_{neg}| \leq \text{Re}\, Z_1(jw), \forall w$

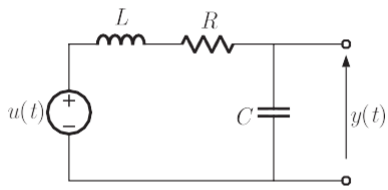
(B) $|R_{neg}| \leq |Z_1(jw)|, \forall w$

(C) $|R_{neg}| \leq \text{Im}\, Z_1(jw), \forall w$

(D) $|R_{neg}| \leq \angle Z_1(jw), \forall w$

GATE 2005 ONE MARK

Q. 56 The condition on R, L and C such that the step response $y(t)$ in the figure has no oscillations, is



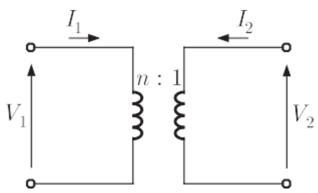
(A) $R \geq \frac{1}{2}\sqrt{\frac{L}{C}}$

(B) $R \geq \sqrt{\frac{L}{C}}$

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

(D) $R = \frac{1}{\sqrt{LC}}$

Q. 57 The $ABCD$ parameters of an ideal n: 1 transformer shown in the figure are $\begin{bmatrix} n & 0 \\ 0 & x \end{bmatrix}$



The value of x will be

(A) n (B) $\frac{1}{n}$

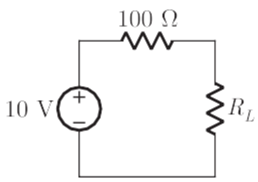
(C) n^2 (D) $\frac{1}{n^2}$

Q. 58 In a series RLC circuit, $R = 2$ kW, $L = 1$ H, and $C = \frac{1}{400}$ mF The resonant frequency is

(A) $2 \# 10^4$ Hz (B) $\frac{1}{p} \# 10^4$ Hz

(C) 10^4 Hz (D) $2p \# 10^4$ Hz

Q. 59 The maximum power that can be transferred to the load resistor R_L from the voltage source in the figure is



(A) 1 W (B) 10 W

(C) 0.25 W (D) 0.5 W

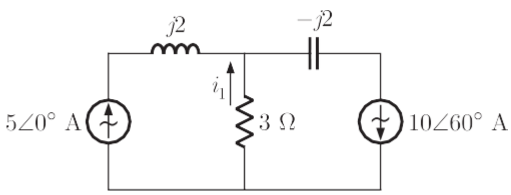
Q. 60 The first and the last critical frequency of an RC -driving point impedance function must respectively be

(A) a zero and a pole (B) a zero and a zero

(C) a pole and a pole (D) a pole and a zero

GATE 2005 TWO MARKS

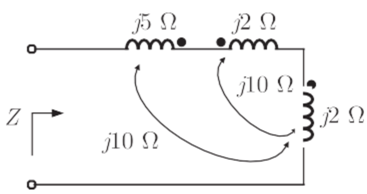
Q. 61 For the circuit shown in the figure, the instantaneous current $i_1(t)$ is



(A) $\frac{10\sqrt{3}}{2}\angle 90c$ A (B) $\frac{10\sqrt{3}}{2}\angle -90c$ A

(C) $5\angle 60c$ A (D) $5\angle -60c$ A

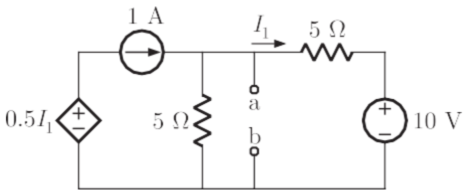
Q. 62 Impedance Z as shown in the given figure is



(A) $j29$ W (B) $j9$ W

(C) $j19$ W (D) $j39$ W

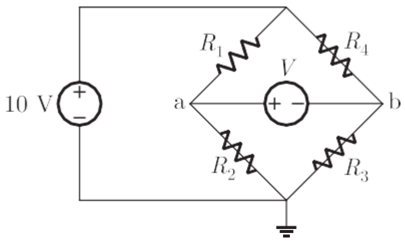
Q. 63 For the circuit shown in the figure, Thevenin's voltage and Thevenin's equivalent resistance at terminals a – b is



(A) 5 V and 2 W (B) 7.5 V and 2.5 W

(C) 4 V and 2 W (D) 3 V and 2.5 W

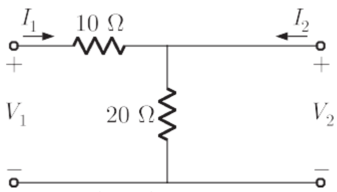
Q. 64 If $R_1 = R_2 = R_4 = R$ and $R_3 = 1.1R$ in the bridge circuit shown in the figure, then the reading in the ideal voltmeter connected between a and b is



(A) 0.238 V (B) 0.138 V

(C) –0.238 V (D) 1 V

Q. 65 The h parameters of the circuit shown in the figure are



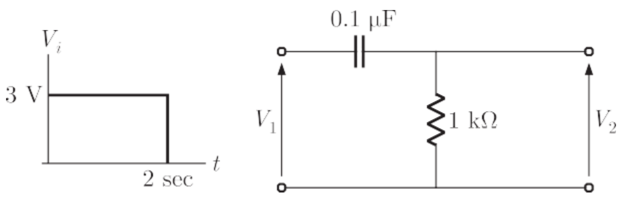
0.1 0.1 10 –1

(A) = –0.1 0.3 G (B) = 1 0.05 G

30 20 10 1

(C) = 20 20 G (D) = –1 0.05 G

Q. 66 A square pulse of 3 volts amplitude is applied to $C - R$ circuit shown in the figure. The capacitor is initially uncharged. The output voltage V_2 at time $t = 2$ sec is

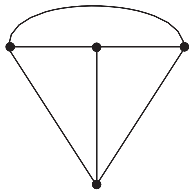


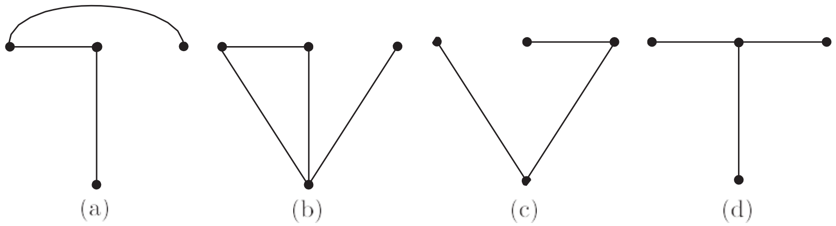
(A) 3 V (B) –3 V

(C) 4 V (D) –4 V

GATE 2004 ONE MARK

Q. 67 Consider the network graph shown in the figure. Which one of the following is NOT a 'tree' of this graph ?





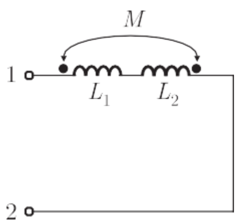
(A) a

(B) b

(C) c

(D) d

Q. 68 The equivalent inductance measured between the terminals 1 and 2 for the circuit shown in the figure is



and $C = 3$ F

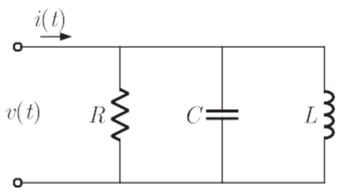
(A) $L_1 + L_2 + M$

(B) $L_1 + L_2 - M$

(C) $L_1 + L_2 + 2M$

(D) $L_1 + L_2 - 2M$

Q. 69 The circuit shown in the figure, with $R = \frac{1}{3}$ W, $L = \frac{1}{4}$ H has input voltage $v(t) = \sin 2t$. The resulting current $i(t)$ is



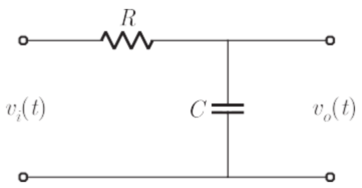
(A) $5\sin(2t + 53.1c)$

(B) $5\sin(2t - 53.1c)$

(C) $25\sin(2t + 53.1c)$

(D) $25\sin(2t - 53.1c)$

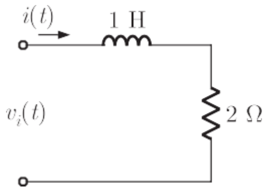
Q. 70 For the circuit shown in the figure, the time constant $RC = 1$ ms. The input voltage is $v_i(t) = \sqrt{2}\sin 10^3 t$. The output voltage $v_o(t)$ is equal to

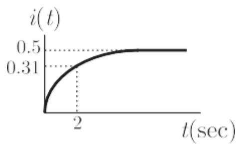


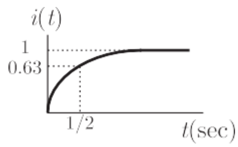
(A) $\sin(10^3 t - 45°)$ (B) $\sin(10^3 t + 45°)$

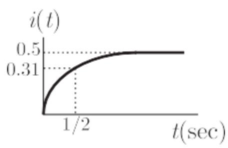
(C) $\sin(10^3 t - 53°)$ (D) $\sin(10^3 t + 53°)$

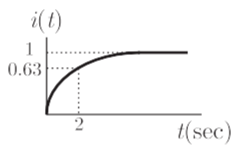
Q. 71 For the $R - L$ circuit shown in the figure, the input voltage $v_i(t) = u(t)$. The current $i(t)$ is



(A)


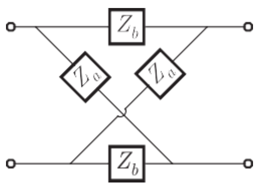
(B)


(C)


(D)


GATE 2004 TWO MARKS

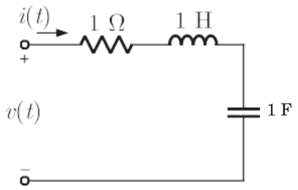
Q. 72 For the lattice shown in the figure, $Z_a = j2\ \Omega$ and $Z_b = 2\ \Omega$. The values of the open circuit impedance parameters $[z] = \begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix}$ are



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

Q. 73 The circuit shown in the figure has initial current $i_L(0^-) = 1$ A through the inductor and an initial voltage $v_C(0^-) = -1$ V across the capacitor. For input $v(t) = u(t)$, the Laplace transform of the current $i(t)$ for $t \geq 0$ is



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

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

Q. 74 The transfer function $H(s) = \frac{V_o(s)}{V_i(s)}$ of an RLC circuit is given by

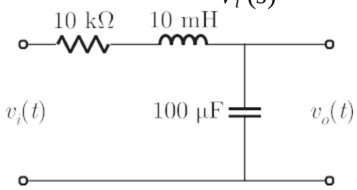
$$H(s) = \frac{10^6}{s^2 + 20s + 10^6}$$

The Quality factor (Q-factor) of this circuit is

(A) 25 (B) 50

(C) 100 (D) 5000

Q. 75 For the circuit shown in the figure, the initial conditions are zero. Its transfer function $H(s) = \frac{V_c(s)}{V_i(s)}$ is



(A) $\frac{1}{s^2 + 10^6 s + 10^6}$ (B) $\frac{10^6}{s^2 + 10^3 s + 10^6}$

(C) $\frac{10^3}{s^2 + 10^3 s + 10^6}$ (D) $\frac{10^6}{s^2 + 10^6 s + 10^6}$

Q. 76 Consider the following statements S1 and S2

S1 : At the resonant frequency the impedance of a series RLC circuit is zero.

S2 : In a parallel GLC circuit, increasing the conductance G results in increase in its Q factor.

Which one of the following is correct?

(A) S1 is FALSE and S2 is TRUE

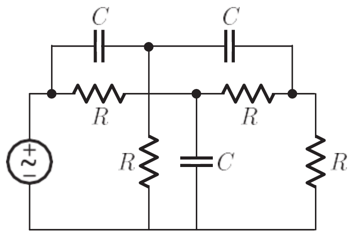
(B) Both S1 and S2 are TRUE

(C) S1 is TRUE and S2 is FALSE

(D) Both S1 and S2 are FALSE

GATE 2003 ONE MARK

Q. 77 The minimum number of equations required to analyze the circuit shown in the figure is



(A) 3 (B) 4

(C) 6 (D) 7

Q. 78 A source of angular frequency 1 rad / sec has a source impedance consisting of 1 W resistance in series with 1 H inductance. The load that will obtain the maximum power transfer is

(A) 1 W resistance

(B) 1 W resistance in parallel with 1 H inductance

(C) 1 W resistance in series with 1 F capacitor

(D) 1 W resistance in parallel with 1 F capacitor

Q. 79 A series RLC 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

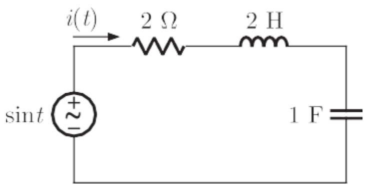
(A) 25

(B) 50

(C) 100

(D) 200

Q. 80 The differential equation for the current $i(t)$ in the circuit of the figure is



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

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

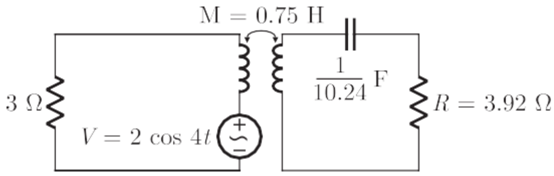
GATE 2003 TWO MARKS

Q. 81 Twelve 1 W resistance are used as edges to form a cube. The resistance between two diagonally opposite corners of the cube is

(A) $\frac{5}{6}$ W (B) 1 W

(C) $\frac{6}{5}$ W (D) $\frac{3}{2}$ W

Q. 82 The current flowing through the resistance R in the circuit in the figure has the form $P\cos 4t$ where P is

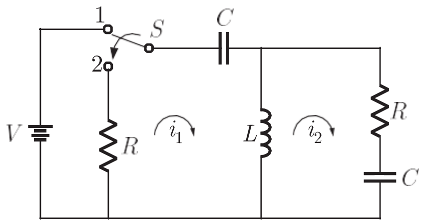


(A) $(0.18 + j0.72)$ (B) $(0.46 + j1.90)$

(C) $-(0.18 + j1.90)$ (D) $-(0.192 + j0.144)$

Common Data For Q. 83 and 84 :

Assume that the switch S is in position 1 for a long time and thrown to position 2 at $t = 0$.



Q. 83 At $t = 0^+$, the current i_1 is

(A) $\frac{-V}{2R}$ (B) $\frac{-V}{R}$

(C) $\frac{-V}{4R}$ (D) zero

Q. 84 $I_1(s)$ and $I_2(s)$ are the Laplace transforms 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 the figure, after the switch is brought from position 1 to position 2 at $t = 0$, are

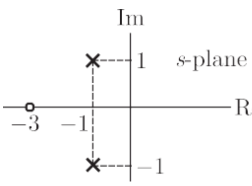
(A) $\begin{bmatrix} R+Ls+\frac{1}{Cs} & -Ls \\ -Ls & R+\frac{1}{Cs}\end{bmatrix}\begin{bmatrix} I_1(s) \\ I_2(s)\end{bmatrix} = \begin{bmatrix}\frac{V}{s} \\ 0\end{bmatrix}$

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

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

Q. 85 The driving point impedance $Z(s)$ of a network has the pole-zero locations as shown in the figure. If $Z(0) = 3$, then $Z(s)$ is



(A) $\frac{3(s+3)}{s^2+2s+3}$ (B) $\frac{2(s+3)}{s^2+2s+2}$

(C) $\frac{3(s+3)}{s^2+2s+2}$ (D) $\frac{2(s-3)}{s^2-2s-3}$

Q. 86 An input voltage $v(t) = 10\ 2\cos(t + 10c) + 10\ 5\cos(2t + 10c)$ V is applied to a series combination of resistance $R = 1$ W and an inductance $L = 1$ H. The resulting steady-state current $i(t)$ in ampere is

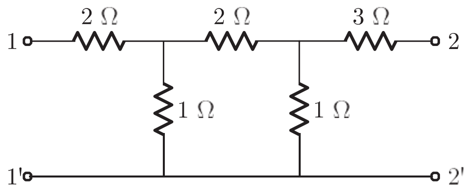
(A) $10\cos(t + 55c) + 10\cos(2t + 10c + \tan^{-1}2)$

(B) $10\cos(t + 55c) + 10\ \frac{3}{2}\cos(2t + 55c)$

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

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

Q. 87 The impedance parameters z_{11} and z_{12} of the two-port network in the figure are

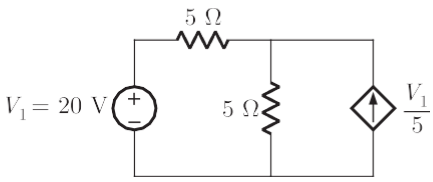


(A) $z_{11} = 2.75$ W and $z_{12} = 0.25$ W (B) $z_{11} = 3$ W and $z_{12} = 0.5$ W

(C) $z_{11} = 3$ W and $z_{12} = 0.25$ W (D) $z_{11} = 2.25$ W and $z_{12} = 0.5$ W

GATE 2002 ONE MARK

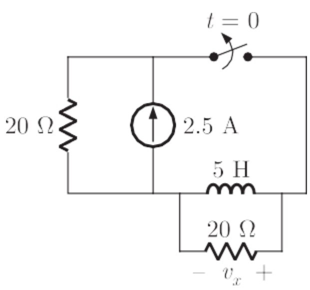
Q. 88 The dependent current source shown in the figure



(A) delivers 80 W (B) absorbs 80 W

(C) delivers 40 W (D) absorbs 40 W

Q. 89 In the figure, the switch was closed for a long time before opening at $t = 0$. The voltage v_x at $t = 0^+$ is

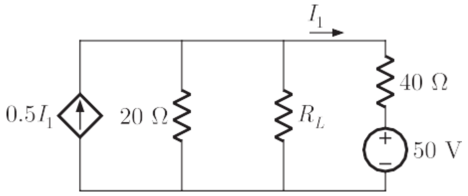


(A) 25 V (B) 50 V

(C) −50 V (D) 0 V

GATE 2002 TWO MARKS

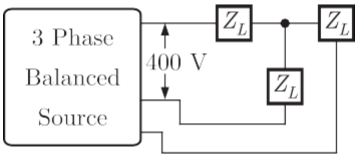
Q. 90 In the network of the fig, the maximum power is delivered to R_L if its value is



(A) 16 W (B) $\frac{40}{3}$ W

(C) 60 W (D) 20 W

Q. 91 If the 3-phase balanced source in the figure delivers 1500 W at a leading power factor 0.844 then the value of Z_L (in ohm) is approximately

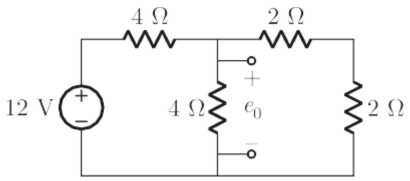


(A) 90+32.44c (B) 80+32.44c

(C) 80+ − 32.44c (D) 90+ − 32.44c

GATE 2001 ONE MARK

Q. 92 The Voltage e_0 in the figure is



(A) 2 V (B) 4 / 3 V

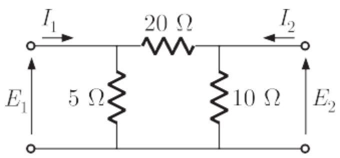
(C) 4 V (D) 8 V

Q. 93 If each branch of Delta circuit has impedance $\overline{3}Z$, then each branch of the equivalent Wye circuit has impedance

(A) $\frac{Z}{3}$ (B) 3Z

(C) $3\,3\overline{Z}$ (D) $\frac{Z}{3}$

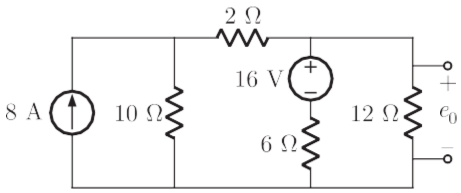
Q. 94 The admittance parameter Y_{12} in the 2-port network in Figure is



(A) −0.02 mho (B) 0.1 mho

(C) −0.05 mho (D) 0.05 mho

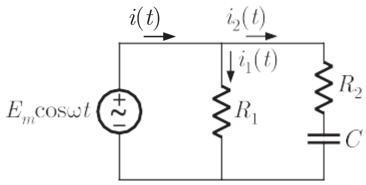
Q. 95 The voltage e_0 in the figure is



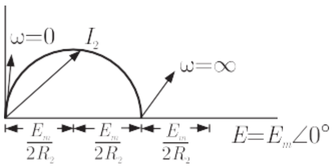
(A) 48 V (B) 24 V

(C) 36 V (D) 28 V

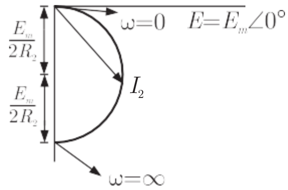
Q. 96 When the angular frequency W in the figure is varied 0 to 3, the locus of the current phasor I_2 is given by



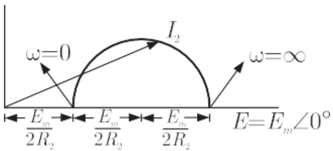
(A)



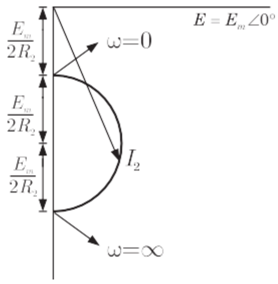
(B)



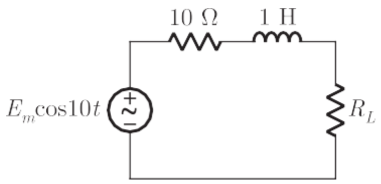
(C)



(D)



Q. 97 In the figure, the value of the load resistor R_L which maximizes the power delivered to it is

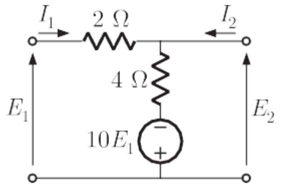


(A) 14.14 W (B) 10 W

(C) 200 W (D) 28.28 W

GATE 2001 TWO MARKS

Q. 98 The z parameters z_{11} and z_{21} for the 2-port network in the figure are



(A) $z_{11} = \frac{6}{11}$ W; $z_{21} = \frac{16}{11}$ W

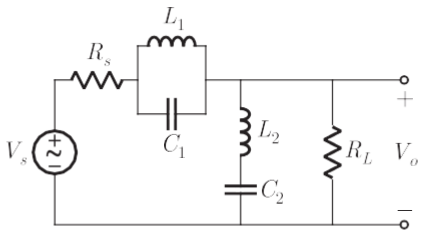
(B) $z_{11} = \frac{6}{11}$ W; $z_{21} = \frac{4}{11}$ W

(C) $z_{11} = \frac{6}{11}$ W; $z_{21} = -\frac{16}{11}$ W

(D) $z_{11} = \frac{4}{11}$ W; $z_{21} = \frac{4}{11}$ W

GATE 2000 ONE MARK

Q. 99 The circuit of the figure represents a



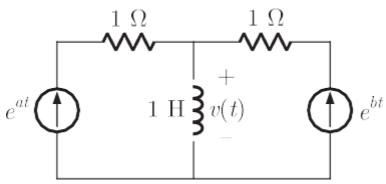
(A) Low pass filter

(B) High pass filter

(C) band pass filter

(D) band reject filter

Q. 100 In the circuit of the figure, the voltage $v(t)$ is



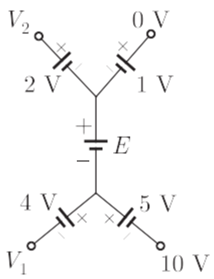
(A) $e^{at} - e^{bt}$

(B) $e^{at} + e^{bt}$

(C) $ae^{at} - be^{bt}$

(D) $ae^{at} + be^{bt}$

Q. 101 In the circuit of the figure, the value of the voltage source E is



(A) -16 V

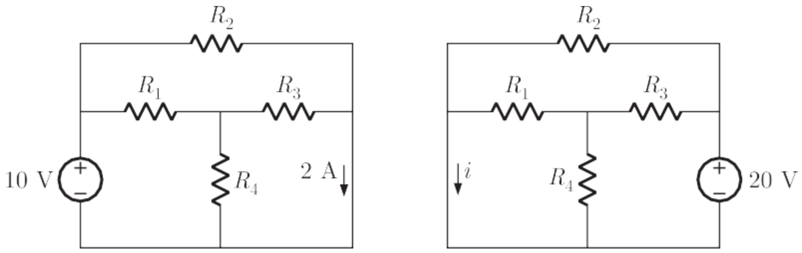
(B) 4 V

(C) -6 V

(D) 16 V

GATE 2000 TWO MARKS

Q. 102 Use the data of the figure (a). The current i in the circuit of the figure (b)



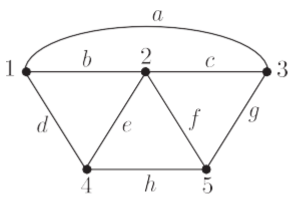
(a) (b)

(A) -2 A (B) 2 A

(C) -4 A (D) 4 A

GATE 1999 ONE MARK

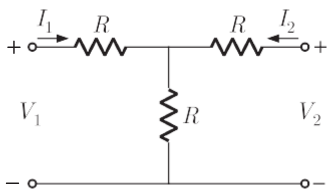
Q. 103 Identify which of the following is NOT a tree of the graph shown in the given figure is



(A) *begh* (B) *defg*

(C) *abfg* (D) *aegh*

Q. 104 A 2-port network is shown in the given figure. The parameter h_{21} for this network can be given by

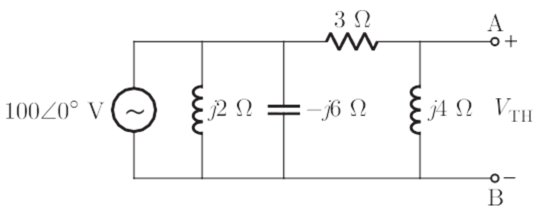


(A) $-1/2$ (B) $+1/2$

(C) $-3/2$ (D) $+3/2$

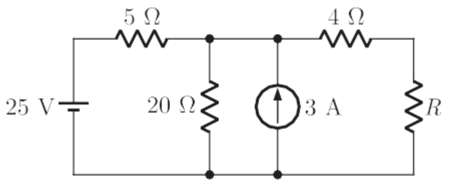
GATE 1999 TWO MARK

Q. 105 The Thevenin equivalent voltage V_{TH} appearing between the terminals A and B of the network shown in the given figure is given by



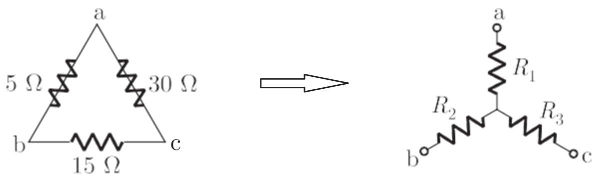
(A) $j16(3-j4)$ (B) $j16(3+j4)$
(C) $16(3+j4)$ (D) $16(3-j4)$

Q. 106 The value of R (in ohms) required for maximum power transfer in the network shown in the given figure is



(A) 2 (B) 4
(C) 8 (D) 16

Q. 107 A Delta-connected network with its Wye-equivalent is shown in the given figure. The resistance R_1, R_2 and R_3 (in ohms) are respectively



(A) 1.5, 3 and 9 (B) 3, 9 and 1.5
(C) 9, 3 and 1.5 (D) 3, 1.5 and 9

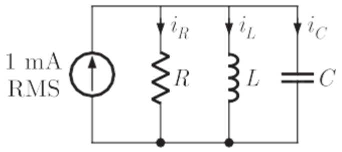
GATE 1998 **ONE MARK**

Q. 108 A network has 7 nodes and 5 independent loops. The number of branches in the network is
(A) 13 (B) 12
(C) 11 (D) 10

Q. 109 The nodal method of circuit analysis is based on
(A) KVL and Ohm's law (B) KCL and Ohm's law
(C) KCL and KVL (D) KCL, KVL and Ohm's law

Q. 110 Superposition theorem is NOT applicable to networks containing
(A) nonlinear elements (B) dependent voltage sources
(C) dependent current sources (D) transformers

Q. 111 The parallel RLC circuit shown in the figure is in resonance. In this circuit



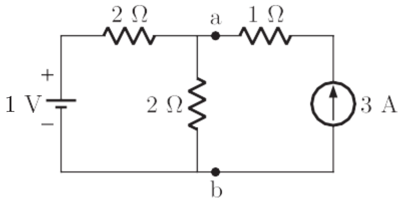
(A) $|I_R| < 1$ mA (B) $|I_R + I_L| > 1$ mA
(C) $|I_R + I_C| < 1$ mA (D) $|I_R + I_C| > 1$ mA

Q. 112 The short-circuit admittance matrix a two-port network is $\begin{bmatrix} 0 & -1/2 \\ 1/2 & 0 \end{bmatrix}$
The two-port network is

(A) non-reciprocal and passive (B) non-reciprocal and active

(C) reciprocal and passive (D) reciprocal and active

Q. 113 The voltage across the terminals *a* and *b* in the figure is



(A) 0.5 V (B) 3.0 V

(C) 3.5 V (D) 4.0 V

Q. 114 A high-Q quartz crystal exhibits series resonance at the frequency w_s and parallel resonance at the frequency w_p. Then

(A) w_s is very close to, but less than w_p

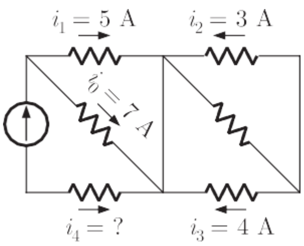
(B) $w_s << w_p$

(C) w_s is very close to, but greater than w_p

(D) $w_s >> w_p$

GATE 1997 ONE MARK

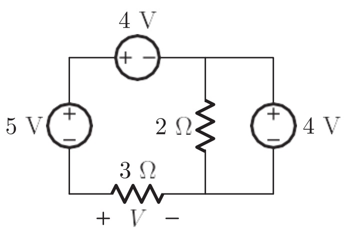
Q. 115 The current i_4 in the circuit of the figure is equal to



(A) 12 A (B) −12 A

(C) 4 A (D) None or these

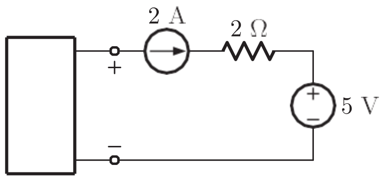
Q. 116 The voltage *V* in the figure equal to



(A) 3 V (B) − 3 V

(C) 5 V (D) None of these

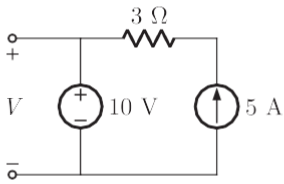
Q. 117 The voltage V in the figure is always equal to



(A) 9 V (B) 5 V

(C) 1 V (D) None of the above

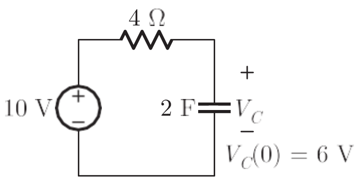
Q. 118 The voltage V in the figure is



(A) 10 V (B) 15 V

(C) 5 V (D) None of the above

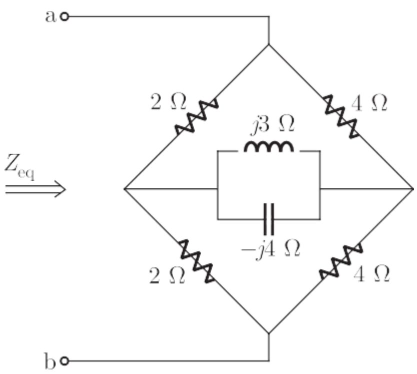
Q. 119 In the circuit of the figure is the energy absorbed by the $4\,\Omega$ resistor in the time interval $(0, 3)$ is



(A) 36 Joules (B) 16 Joules

(C) 256 Joules (D) None of the above

Q. 120 In the circuit of the figure the equivalent impedance seen across terminals a, b, is

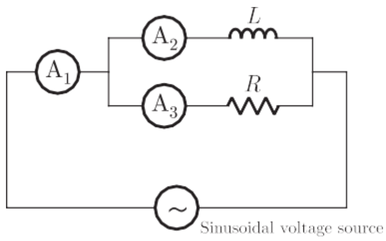


(A) $\left(\frac{16}{3}\right)\Omega$ (B) $\left(\frac{8}{3}\right)\Omega$

(C) $\left(\frac{8}{3}+12j\right)\Omega$ (D) None of the above

GATE 1996 ONE MARK

Q. 121 In the given figure, A_1, A_2 and A_3 are ideal ammeters. If A_2 and A_3 read 3 A and 4 A respectively, then A_1 should read

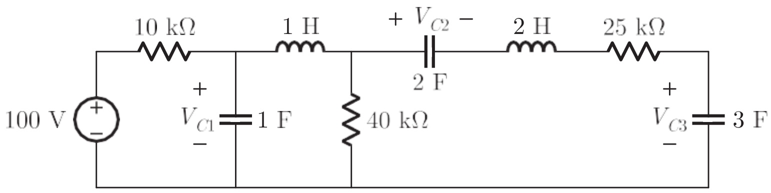


(A) 1 A (B) 5 A
(C) 7 A (D) None of these

Q. 122 The number of independent loops for a network with n nodes and b branches is
(A) $n - 1$
(B) $b - n$
(C) $b - n + 1$
(D) independent of the number of nodes

GATE 1996 TWO MARKS

Q. 123 The voltages V_{C1}, V_{C2}, and V_{C3} across the capacitors in the circuit in the given figure, under steady state, are respectively.



(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

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SOLUTIONS

Sol. 1 Option (B) is correct.

In the equivalent star connection, the resistance can be given as

$$R_C = \frac{R_b R_a}{R_a + R_b + R_c}$$

$$R_B = \frac{R_a R_c}{R_a + R_b + R_c}$$

$$R_A = \frac{R_b R_c}{R_a + R_b + R_c}$$

So, if the delta connection components R_a, R_b and R_c are scaled by a factor k then

$$R_A' = \frac{(kR_b)(kR_c)}{kR_a + kR_b + kR_c} = \frac{k^2}{k}\frac{R_b R_c}{R_a + R_b + R_c} = kR_A$$

Hence, it is also scaled by a factor k

Sol. 2 Option (D) is correct.

For the given capacitance, $C = 100mF$ in the circuit, we have the reactance.

$$X_C = \frac{1}{sC} = \frac{1}{s \times 100 \times 10^{-6}} = \frac{10^4}{s}$$

So,

$$\frac{V_2(s)}{V_1(s)} = \frac{\frac{10^4}{s} + 10^4}{\frac{10^4}{s} + 10^4 + \frac{10^4}{s}} = \frac{s+1}{s+2}$$

Sol. 3 Option (C) is correct.

For the purely resistive load, maximum average power is transferred when

$$R_L = \sqrt{R_{Th}^2 + X_{Th}^2}$$

where $R_{Th} + jX_{Th}$ is the equivalent thevenin (input) impedance of the circuit.

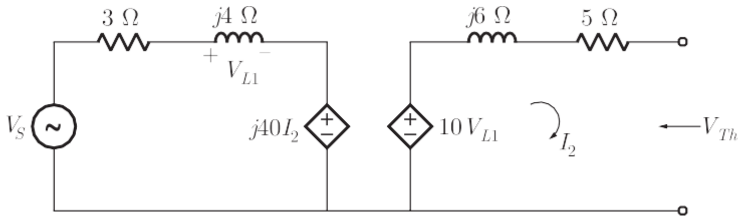
Hence, we obtain

$$R_L = \sqrt{4^2 + 3^2} = 5\ \Omega$$

Sol. 4 Option (C) is correct.

For evaluating the equivalent thevenin voltage seen by the load R_L, we open the circuit across it (also if it consist dependent source).

The equivalent circuit is shown below



As the circuit open across R_L so

$$I_2 = 0$$

or, $$j40I_2 = 0$$

i.e., the dependent source in loop 1 is short circuited. Therefore,

$$V_{L1} = \left(\frac{j4}{j4+3}\right) V_s$$

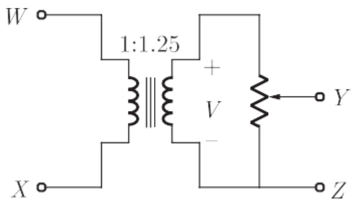
$$V_{Th} = 10\,V_{L1} = \frac{j40}{j4+3}\,100\angle 53.13^\circ = \frac{40\angle 90^\circ}{5\angle 53.13^\circ}\,100\angle 53.13^\circ$$

$$= 800\angle 90^\circ$$

Sol. 5 Option (C) is correct.

For the given transformer, we have

$$\frac{V}{V_{WX}} = \frac{1.25}{1}$$



Since, $\frac{V_{YZ}}{V} = 0.8$ (attenuation factor)

So, $\frac{V_{YZ}}{V_{WX}} = (0.8)(1.25) = 1$

or, $V_{YZ} = V_{WX}$

at $V_{WX_1} = 100$ V; $\frac{V_{YZ_1}}{V_{WX_1}} = \frac{100}{100}$

at $V_{WZ_2} = 100$ V; $\frac{V_{WX_2}}{V_{YZ_2}} = \frac{100}{100}$

Sol. 6 Option (C) is correct.

The quality factor of the inductances are given by

$$q_1 = \frac{\omega L_1}{R_1}$$

and

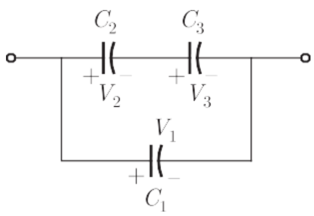
$$q_2 = \frac{\omega L_2}{R_2}$$

So, in series circuit, the effective quality factor is given by

$$Q = \frac{|X_{Leq}|}{R_{eq}} = \frac{\omega L_1 + \omega L_2}{R_1 + R_2}$$

$$= \frac{\frac{\omega L_1}{R_1 R_2} + \frac{\omega L_2}{R_1 R_2}}{\frac{1}{R_2} + \frac{1}{R_1}} = \frac{\frac{q_1}{R_2} + \frac{q_2}{R_1}}{\frac{1}{R_2} + \frac{1}{R_1}} = \frac{q_1 R_1 + q_2 R_2}{R_1 + R_2}$$

Sol. 7 Option (C) is correct.



Consider that the voltage across the three capacitors C_1, C_2 and C_3 are V_1, V_2 and V_3 respectively. So, we can write

$$\frac{V_2}{V_3} = \frac{C_3}{C_2} \qquad ....(1)$$

Since, Voltage is inversely proportional to capacitance

Now, given that $C_1 = 10\,mF$; $(V_1)_{max} = 10$V

$C_2 = 5\,mF$; $(V_2)_{max} = 5$ V

$C_3 = 2\,mF$; $(V_3)_{max} = 2$V

So, from Eq (1) we have

$$\frac{V_2}{V_3} = \frac{2}{5}$$

for $(V_3)_{max} = 2$

We obtain, $V_2 = \frac{2 \times 2}{5} = 0.8 \text{ volt} < 5$

i.e., $V_2 < (V_2)_{max}$

Hence, this is the voltage at C_2. Therefore,

$V_3 = 2$ volt

$V_2 = 0.8$ volt

and $V_1 = V_2 + V_3 = 2.8$ volt

Now, equivalent capacitance across the terminal is

$$C_{eq} = \frac{C_2 C_3}{C_2 + C_3} + C_1 = \frac{5 \times 2}{5 + 2} + 10 = \frac{80}{7} \text{ mF}$$

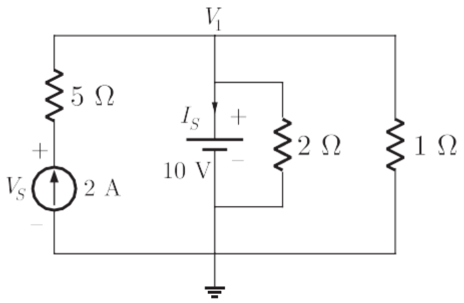
Equivalent voltage is (max. value)

$$V_{max} = V_1 = 2.8$$

So, charge stored in the effective capacitance is

$$Q = C_{eq} V_{max} = \left(\frac{80}{7}\right) \times (2.8) = 32 \text{ mC}$$

Sol. 8 Option (D) is correct.



At the node 1, voltage is given as

$V_1 = 10$ volt

Applying KCL at node 1

$$I_S + \frac{V_1}{2} + \frac{V_1}{1} - 2 = 0$$

$$I_S + \frac{10}{2} + \frac{10}{1} - 2 = 0$$

$$I_S = -13 \text{ A}$$

Also, from the circuit,

$$V_S - 5 \times 2 = V_1 \quad \& \quad V_S = 10 + V_1 = 20 \text{ volt}$$

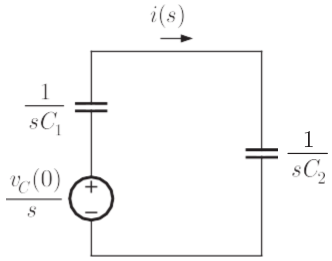
Sol. 9 Option (C) is correct.

Again from the shown circuit, the current in 1 Ω resistor is

$$I = \frac{V_1}{1} = \frac{10}{1} = 10 \text{ A}$$

Sol. 10 Option (D) is correct.

The s-domain equivalent circuit is shown as below.



$$I(s) = \frac{v_c(0)/s}{\frac{1}{C_1 s} + \frac{1}{C_2 s}} = \frac{v_c(0)}{\frac{1}{C_1} + \frac{1}{C_2}}$$

$$I(s) = \left(\frac{C_1 C_2}{C_1 + C_2}\right)(12\text{ V}) = 12C_{eq} \qquad v_C(0) = 12\text{ V}$$

Taking inverse Laplace transform for the current in time domain,

$$i(t) = 12C_{eq}\,\delta(t) \qquad \text{(Impulse)}$$

Sol. 11 Option (B) is correct.

In phasor form, $Z = 4 - j3 = 5\angle -36.86° \,\Omega$

$I = 5\angle 100°$ A

Average power delivered.

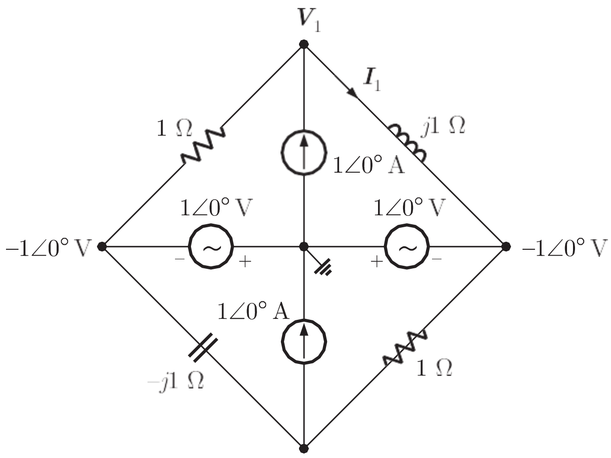
$$P_{avg.} = \frac{1}{2}|I|^2 Z\cos\theta = \frac{1}{2} \times 25 \times 5\cos 36.86° = 50\text{ W}$$

Alternate Method:

$$Z = (4 - j3)\,\Omega, \qquad I = 5\cos(100\pi t + 100)\text{ A}$$

$$P_{avg} = \frac{1}{2}\text{Re}\{|I|^2 Z\} = \frac{1}{2} \times \text{Re}\{(5)^2 \times (4 - j3)\} = \frac{1}{2} \times 100 = 50\text{ W}$$

Sol. 12 Option (C) is correct



Applying nodal analysis at top node.

$$\frac{V_1 + 1\angle 0°}{1} + \frac{V_1 + 1\angle 0°}{j1} = 1\angle 0°$$

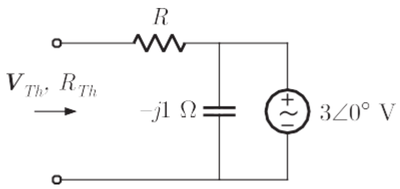
$$V_1(j1 + 1) + j1 + 1\angle 0° = j1$$

$$V_1 = \frac{-1}{1 + j1}$$

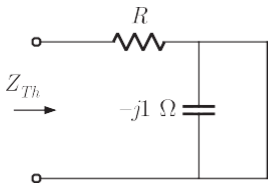
Current $\quad I_1 = \frac{V_1 + 1\angle 0°}{j1} = \frac{\frac{-1}{1+j} + 1}{j1} = \frac{j}{(1+j)j} = \frac{1}{1+j}$ A

Sol. 13 Option (A) is correct.

We obtain Thevenin equivalent of circuit B.



Thevenin Impedance :

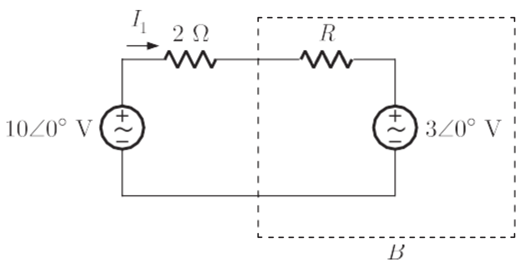


$$Z_{Th} = R$$

Thevenin Voltage :

$$V_{Th} = 3\angle 0^\circ \text{ V}$$

Now, circuit becomes as



Current in the circuit, $I_1 = \dfrac{10-3}{2+R}$

Power transfer from circuit A to B

$$P = (I_1)^2 R + 3I_1$$

$$= \left[\frac{10-3}{2+R}\right]^2 R + 3\left[\frac{10-3}{2+R}\right]$$

or $$P = \frac{42+70R}{(2+R)^2}$$

$$\frac{dP}{dR} = \frac{(2+R)^2 70 - (42+70R)2(2+R)}{(2+R)^4} = 0$$

$$(2+R)[(2+R)70 - (42+70R)2] = 0 \quad \Rightarrow \quad R = 0.8\ \Omega$$

Sol. 14 Option (A) is correct.

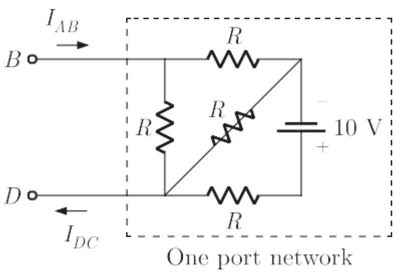
In the given circuit

$$V_A - V_B = 6 \text{ V}$$

So current in the branch will be

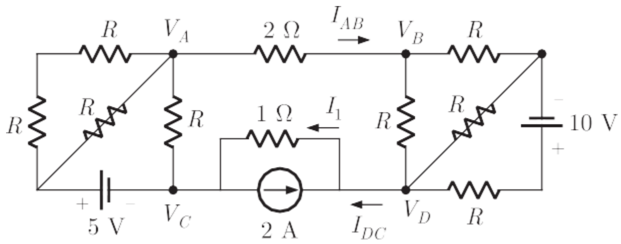
$$I_{AB} = \frac{6}{2} = 3 \text{ A}$$

We can see, that the circuit is a one port circuit looking from terminal BD as shown below



For a one port network current entering one terminal, equals the current leaving the second terminal. Thus the outgoing current from A to B will be equal to the incoming current from D to C as shown

i.e. $$I_{DC} = I_{AB} = 3\text{A}$$



The total current in the resistor 1 W will be

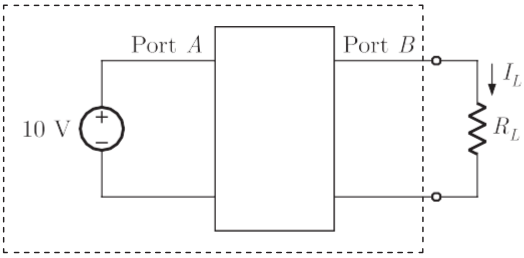
$$I_1 = 2 + I_{DC}$$ (By writing KCL at node D)

$$= 2 + 3 = 5\text{ A}$$

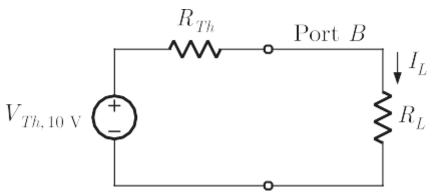
So, $$V_{CD} = 1 \# (-I_1) = -5\text{ V}$$

Sol. 15 Option (C) is correct.

When 10 V is connected at port A the network is



Now, we obtain Thevenin equivalent for the circuit seen at load terminal, let Thevenin voltage is $V_{Th,10\text{ V}}$ with 10 V applied at port A and Thevenin resistance is R_{Th}.



$$I_L = \frac{V_{Th,10\text{ V}}}{R_{Th} + R_L}$$

For $R_L = 1$ W, $I_L = 3$ A

$$3 = \frac{V_{Th,10\text{ V}}}{R_{Th} + 1} \quad \text{...(i)}$$

For $R_L = 2.5\ \Omega$, $I_L = 2$ A

$$2 = \frac{V_{Th,10\text{ V}}}{R_{Th} + 2.5} \qquad \text{...(ii)}$$

Dividing above two

$$\frac{3}{2} = \frac{R_{Th} + 2.5}{R_{Th} + 1}$$

$$3R_{Th} + 3 = 2R_{Th} + 5$$

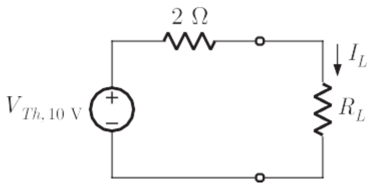
$$R_{Th} = 2\ \Omega$$

Substituting R_{Th} into equation (i)

$$V_{Th,10\text{ V}} = 3\,(2 + 1) = 9\text{ V}$$

Note that it is a non reciprocal two port network. Thevenin voltage seen at port B depends on the voltage connected at port A. Therefore we took subscript $V_{Th,10\text{ V}}$. This is Thevenin voltage only when 10 V source is connected at input port A. If the voltage connected to port A is different, then Thevenin voltage will be different. However, Thevenin's resistance remains same.

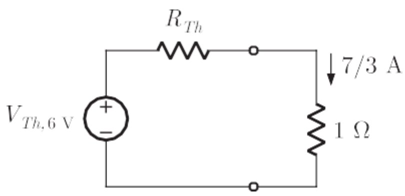
Now, the circuit is as shown below :



For $R_L = 7\ \Omega$, $\qquad I_L = \dfrac{V_{Th,10\text{ V}}}{2 + R_L} = \dfrac{9}{2 + 7} = 1$ A

Sol. 16 Option (B) is correct.

Now, when 6 V connected at port A let Thevenin voltage seen at port B is $V_{Th,6\text{ V}}$. Here $R_L = 1\ \Omega$ and $I_L = \frac{7}{3}$ A



$$V_{Th,6\text{ V}} = R_{Th} \times \frac{7}{3} + 1 \times \frac{7}{3} = 2 \times \frac{7}{3} + \frac{7}{3} = 7\text{ V}$$

This is a linear network, so V_{Th} at port B can be written as

$$V_{Th} = V_1 a + b$$

where V_1 is the input applied at port A.

We have $V_1 = 10$ V, $V_{Th,10\text{ V}} = 9$ V

$$\Rightarrow \qquad 9 = 10a + b \qquad \text{...(i)}$$

When $V_1 = 6$ V, $V_{Th,\,6\text{ V}} = 9$ V

$$\Rightarrow \qquad 7 = 6a + b \qquad \text{...(ii)}$$

Solving (i) and (ii)

$$a = 0.5,\ b = 4$$

Thus, with any voltage V_1 applied at port A, Thevenin voltage or open circuit voltage at port B will be

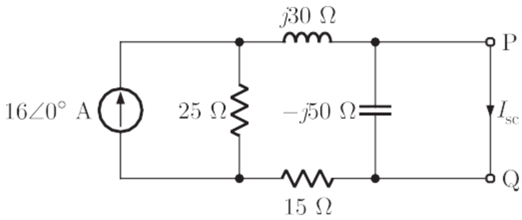
So, $V_{Th,V_1} = 0.5V_1 + 4$

For $V_1 = 8$ V

$$V_{Th,8\,\text{V}} = 0.5 \times 8 + 4 = 8 = V_{oc} \qquad \text{(open circuit voltage)}$$

Sol. 17 Option (A) is correct.

Replacing $P-Q$ by short circuit as shown below we have

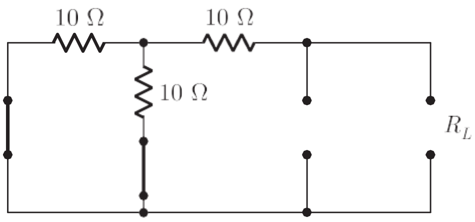


Using current divider rule the current I_{sc} is

$$I_{SC} = \frac{25}{25+15+j30}(16\angle 0) = (6.4 - j4.8) \text{ A}$$

Sol. 18 Option (C) is correct.

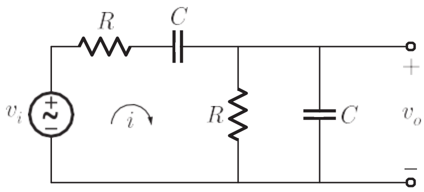
Power transferred to R_L will be maximum when R_L is equal to the Thevenin resistance. We determine Thevenin resistance by killing all source as follows :



$$R_{TH} = \frac{10 \times 10}{10+10} + 10 = 15\ \Omega$$

Sol. 19 Option (A) is correct.

The given circuit is shown below



For parallel combination of R and C equivalent impedance is

$$Z_p = \frac{R \cdot \frac{1}{j\omega C}}{R + \frac{1}{j\omega C}} = \frac{R}{1 + j\omega RC}$$

Transfer function can be written as

$$\frac{V_{out}}{V_{in}} = \frac{Z_p}{Z_s + Z_p} = \frac{\frac{R}{1+j\omega RC}}{R + \frac{1}{j\omega C} + \frac{R}{1+j\omega RC}}$$

$$= \frac{j\omega RC}{j\omega RC + (1 + j\omega RC)^2}$$

$$= \frac{j}{j + (1+j)^2} \qquad \text{Here } \omega = \frac{1}{RC}$$

$$\frac{V_{out}}{V_{in}} = \frac{j}{(1+j)^2 + j} = \frac{1}{3}$$

Thus $\quad v_{out} = b\frac{V_p}{3}l\cos(t/RC)$

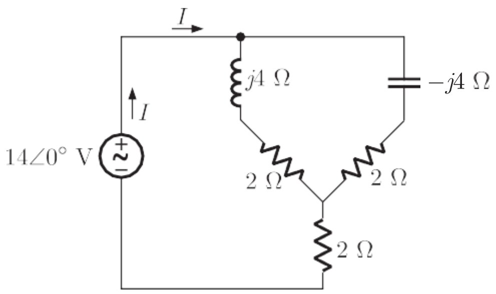
Sol. 20 Option (B) is correct.

From star delta conversion we have

Thus $\quad R_1 = \frac{R_a R_b}{R_a + R_b + R_c} = \frac{6.6}{6+6+6} = 2$ W

Here $\quad R_1 = R_2 = R_3 = 2$ W

Replacing in circuit we have the circuit shown below :



Now the total impedance of circuit is

$$Z = \frac{(2+j4)(2-j4)}{(2+j4)(2-j4)} + 2 = 7 \text{ W}$$

Current $\quad I = \frac{14+0c}{7} = 2+0c$

Sol. 21 Option (D) is correct.

From given admittance matrix we get

$I_1 = 0.1V_1 - 0.01V_2$ and ...(1)

$I_2 = 0.01V_1 + 0.1V_2$ ...(2)

Now, applying KVL in outer loop;

$V_2 = -100I_2$

or $\quad I_2 = -0.01V_2$ ...(3)

From eq (2) and eq (3) we have

$$-0.01V_2 = 0.01V_1 + 0.1V_2$$

$$-0.11V_2 = 0.01V_1$$

$$\frac{V_2}{V_1} = \frac{-1}{11}$$

Sol. 22 Option (A) is correct.

Here we take the current flow direction as positive.

At $t = 0^-$ voltage across capacitor is

$$V_C(0^-) = -\frac{Q}{C} = -\frac{2.5 \times 10^{-3}}{50 \times 10^{-6}} = -50 \text{ V}$$

Thus $V_C(0^+) = -50$ V

In steady state capacitor behave as open circuit thus

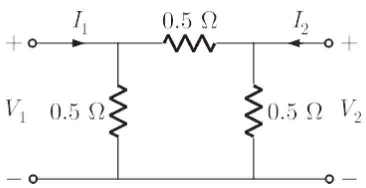
$$V(\infty) = 100 \text{ V}$$

Now,
$$V_C(t) = V_C(\infty) + (V_C(0^+) - V_C(\infty))e^{-t/RC}$$
$$= 100 + (-50 - 100)e^{\frac{-t}{10 \times 50 \times 10^{-6}}}$$
$$= 100 - 150e^{-(2 \times 10^3 t)}$$

Now
$$i_c(t) = C\frac{dV}{dt}$$
$$= 50 \times 10^{-6} \times 150 \times 2 \times 10^3 e^{-2 \times 10^3 t} \text{ A}$$
$$= 15e^{-2 \times 10^3 t}$$
$$i_c(t) = 15\exp(-2 \times 10^3 t) \text{ A}$$

Sol. 23 Option (A) is correct.

Given circuit is as shown below



Writing node equation at input port

$$I_1 = \frac{V_1}{0.5} + \frac{V_1 - V_2}{0.5} = 4V_1 - 2V_2 \quad \text{...(1)}$$

Writing node equation at output port

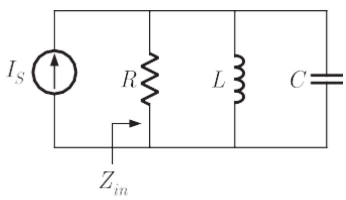
$$I_2 = \frac{V_2}{0.5} + \frac{V_2 - V_1}{0.5} = -2V_1 + 4V_2 \quad \text{...(2)}$$

From (1) and (2), we have admittance matrix

$$Y = \begin{bmatrix} 4 & -2 \\ -2 & 4 \end{bmatrix}$$

Sol. 24 Option (D) is correct.

A parallel *RLC* circuit is shown below :



Input impedance
$$Z_{\text{in}} = \frac{1}{\frac{1}{R} + \frac{1}{jwL} + jwC}$$

At resonance
$$\frac{1}{wL} = wC$$

So,
$$Z_{\text{in}} = \frac{1}{1/R} = R \quad \text{(maximum at resonance)}$$

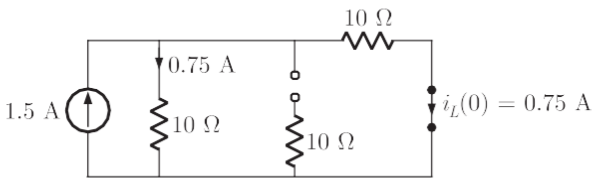
Thus (D) is not true.

Furthermore bandwidth is ω_B i.e $\omega_B \propto \frac{1}{R}$ and is independent of L,
Hence statements A, B, C, are true.

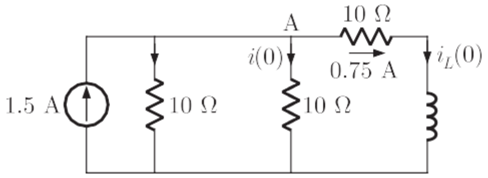
Sol. 25 Option (A) is correct.

Let the current $i(t) = A + Be^{-t/\tau}$ $\tau \rightarrow$ Time constant

When the switch S is open for a long time before $t < 0$, the circuit is



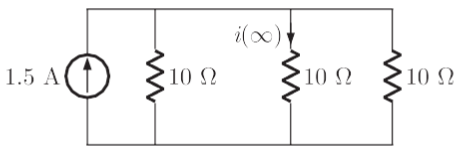
At $t = 0$, inductor current does not change simultaneously, So the circuit is



Current is resistor (AB)

$$i(0) = \frac{0.75}{2} = 0.375 \text{ A}$$

Similarly for steady state the circuit is as shown below



$$i(\infty) = \frac{1.5}{3} = 0.5 \text{ A}$$

$$\tau = \frac{L}{R_{eq}} = \frac{15 \times 10^{-3}}{10 + (10 \,||\, 10)} = 10^{-3} \text{ sec}$$

$$i(t) = A + Be^{-\frac{t}{1 \times 10^{-3}}} = A + Be^{-100t}$$

Now $i(0) = A + B = 0.375$

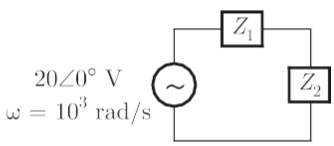
and $i(\infty) = A = 0.5$

So, $B = 0.375 - 0.5 = -0.125$

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

Sol. 26 Option (A) is correct.

Circuit is redrawn as shown below



Where, $Z_1 = j\omega L = j \times 10^3 \times 20 \times 10^{-3} = 20j$

$Z_2 = R \,||\, X_C$

$$X_C = \frac{1}{j\omega C} = \frac{1}{j \times 10^3 \times 50 \times 10^{-6}} = -20j$$

$$Z_2 = \frac{1(-20j)}{1-20j} \qquad R = 1\ \text{W}$$

Voltage across Z_2

$$V_{Z_2} = \frac{Z_2}{Z_1 + Z_2} \cdot 20\angle 0 = \frac{\left(\dfrac{-20j}{1-20j}\right)}{\left(20j - \dfrac{20j}{1-20j}\right)} \cdot 20$$

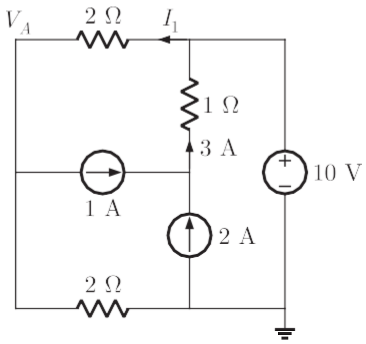
$$= \left(\frac{(-20j)}{20j+400-20j}\right) \cdot 20 = -$$

Current in resistor R is

$$I = \frac{V_{Z_2}}{R} = -\frac{j}{1} = -j\ \text{A}$$

Sol. 27 Option (A) is correct.

The circuit can be redrawn as



Applying nodal analysis

$$\frac{V_A - 10}{2} + 1 + \frac{V_A - 0}{2} = 0$$

$$2V_A - 10 + 2 = 0 = V_4 = 4\ \text{V}$$

Current, $$I_1 = \frac{10-4}{2} = 3\ \text{A}$$

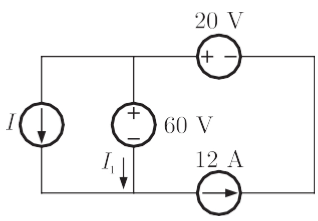
Current from voltage source is

$$I_2 = I_1 - 3 = 0$$

Since current through voltage source is zero, therefore power delivered is zero.

Sol. 28 Option (A) is correct.

Circuit is as shown below



Since 60 V source is absorbing power. So, in 60 V source current flows from + to - ve direction

So, $$I + I_1 = 12$$

$$I = 12 - I_1$$

I is always less then 12 A So, only option (A) satisfies this conditions.

Sol. 29 Option (C) is correct.

For given network we have

$$V_0 = \frac{(R_L \parallel X_C)\,V_i}{R + (R_L \parallel X_C)}$$

$$\frac{V_0(s)}{V_i(s)} = \frac{\frac{R_L}{1+sR_LC}}{R + \frac{R_L}{1+sR_LC}} = \frac{R_L}{R + RR_LsC + R_L}$$

$$= \frac{R_L}{R + RR_LsC + R_L} = \frac{1}{1 + \frac{R}{R_L} + RsC}$$

But we have been given

$$T.F. = \frac{V_0(s)}{V_i(s)} = \frac{1}{2 + sCR}$$

Comparing, we get

$$1 + \frac{R}{R_L} = 2 \quad \& \; R_L = R$$

Sol. 30 Option (C) is correct.

The energy delivered in 10 minutes is

$$E = \int_0^t VIdt = I\int_0^t Vdt = I \times Area$$

$$= 2 \times \frac{1}{2}(10 + 12) \times 600 = 13.2 \text{ kJ}$$

Sol. 31 Option (B) is correct.

From given circuit the load current is

$$I_L = \frac{V}{Z_s + Z_L} = \frac{20\angle 0^\circ}{(1+2j) + (7+4j)} = \frac{20\angle 0^\circ}{8+6j}$$

$$= \frac{1}{5}(8 - 6j) = \frac{20\angle 0^\circ}{10\angle \phi} = 2\angle -\phi \qquad \text{where } \phi = \tan^{-1}\frac{3}{4}$$

The voltage across load is

$$V_L = I_L Z_L$$

The reactive power consumed by load is

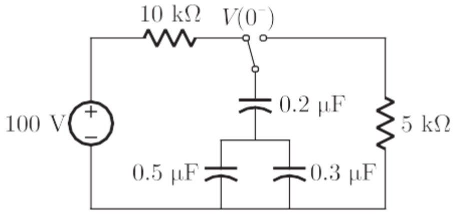
$$P_r = V_L I_L^* = I_L Z_L \times I_L^* = Z_L |I_L|^2$$

$$= (7 + 4j)\left|\frac{20\angle 0^\circ}{8+6j}\right|^2 = (7 + 4j) = 28 + 16j$$

Thus average power is 28 and reactive power is 16.

Sol. 32 Option (B) is correct.

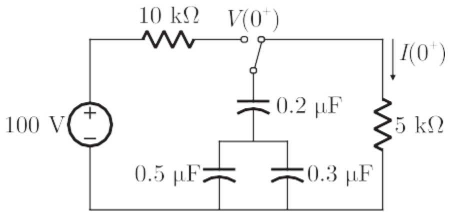
At $t = 0^-$, the circuit is as shown in fig below :



$$V(0^-) = 100 \text{ V}$$

Thus $$V(0^+) = 100 \text{ V}$$

At $t = 0^+$, the circuit is as shown below



$$I(0^+) = \frac{100}{5k} = 20 \text{ mA}$$

At steady state i.e. at $t = \infty$ is $I(\infty) = 0$

Now $$i(t) = I(0^+)e^{-\frac{t}{RC_{eq}}}u(t)$$

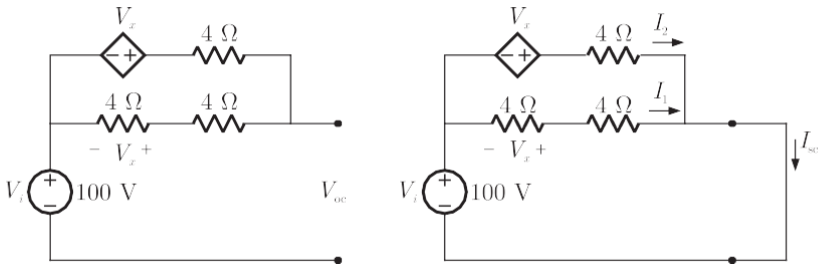
$$C_{eq} = \frac{(0.5m + 0.3m)0.2m}{0.5m + 0.3m + 0.2m} = 0.16\, m\text{ F}$$

$$\frac{1}{RC_{eq}} = \frac{1}{5 \times 10^3 \times 0.16 \times 10^{-6}} = 1250$$

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

Sol. 33 Option (C) is correct.

For P_{max} the load resistance R_L must be equal to thevenin resistance R_{eq} i.e. $R_L = R_{eq}$. The open circuit and short circuit is as shown below



The open circuit voltage is

$$V_{oc} = 100 \text{ V}$$

From fig $$I_1 = \frac{100}{8} = 12.5 \text{ A}$$

$$V_x = -4 \times 12.5 = -50 \text{ V}$$

$$I_2 = \frac{100 + V_x}{4} = \frac{100 - 50}{4} = 12.5 \text{ A}$$

$$I_{sc} = I_1 + I_2 = 25 \text{ A}$$

$$R_{th} = \frac{V_{oc}}{I_{sc}} = \frac{100}{25} = 4\ \Omega$$

Thus for maximum power transfer $R_L = R_{eq} = 4\ \Omega$

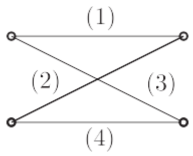
Sol. 34 Option (A) is correct.

Steady state all transient effect die out and inductor act as short circuits and forced response acts only. It doesn't depend on initial current state. From the given time domain behavior we get that circuit has only R and L in series with V_0. Thus at steady state

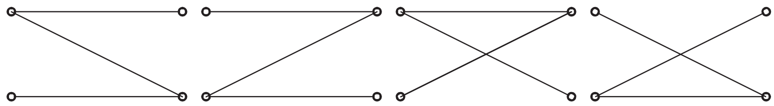
$$i(t) \approx i(\infty) = \frac{V_0}{R}$$

Sol. 35 Option (C) is correct.

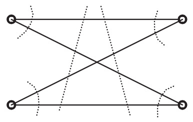
The given graph is



There can be four possible tree of this graph which are as follows:

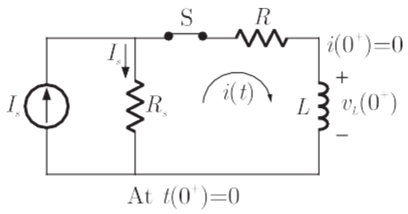


There can be 6 different possible cut-set.



Sol. 36 Option (B) is correct.

Initially $i(0^-) = 0$ therefore due to inductor $i(0^+) = 0$. Thus all current I_s will flow in resistor R and voltage across resistor will be $I_s R_s$. The voltage across inductor will be equal to voltage across R_s as no current flow through R.



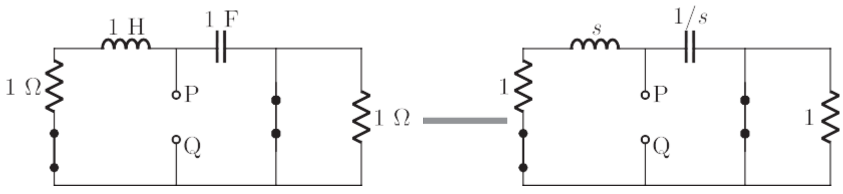
Thus $\quad v_L(0^+) = I_s R_s$

but $\quad v_L(0^+) = L\frac{di(0^+)}{dt}$

Thus $\quad \frac{di(0^+)}{dt} = \frac{v_L(0^+)}{L} = \frac{I_s R_s}{L}$

Sol. 37 Option (A) is correct.

Killing all current source and voltage sources we have,



$$Z_{th} = (1+s) \parallel \left(\frac{1}{s}+1\right)$$

$$= \frac{(1+s)(\frac{1}{s}+1)}{(1+s)+(\frac{1}{s}+1)} = \frac{[\frac{1}{s}+1+1+s]}{s+\frac{1}{s}+1+1}$$

or $\quad Z_{th} = 1$

Alternative :

Here at DC source capacitor act as open circuit and inductor act as short circuit. Thus we can directly calculate thevenin Impedance as 1 W

Sol. 38 Option (D) is correct.

$$Z(s) = R \left\| \frac{1}{sC} \right\| sL = \frac{\frac{s}{C}}{s^2 + \frac{s}{RC} + \frac{1}{LC}}$$

We have been given

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

Comparing with given we get

$$\frac{1}{C} = 0.2 \text{ or } C = 5 \text{ F}$$

$$\frac{1}{RC} = 0.1 \text{ or } R = 2\ \Omega$$

$$\frac{1}{LC} = 2 \text{ or } L = 0.1 \text{ H}$$

Sol. 39 Option (C) is correct.

Voltage across capacitor is

$$V_c = \frac{1}{C}\int_0^t i\,dt$$

Here $C = 1$ F and $i = 1$ A. Therefore

$$V_c = \int_0^t dt$$

For $0 < t < T$, capacitor will be charged from 0 V

$$V_c = \int_0^t dt = t$$

At $t = T$, $V_c = T$ Volts

For $T < t < 2T$, capacitor will be discharged from T volts as

$$V_c = T - \int_T^t dt = 2T - t$$

At $t = 2T$, $V_c = 0$ volts

For $2T < t < 3T$, capacitor will be charged from 0 V

$$V_c = \int_{2T}^t dt = t - 2T$$

At $t = 3T, V_c = T$ Volts

For $3T < t < 4T$, capacitor will be discharged from T Volts

$$V_c = T - \int_{3T}^t dt = 4T - t$$

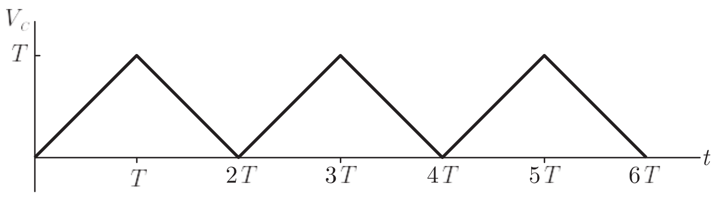
At $t = 4T$, $V_c = 0$ Volts

For $4T < t < 5T$, capacitor will be charged from 0 V

$$V_c = \int_{4T}^t dt = t - 4T$$

At $t = 5T, V_c = T$ Volts

Thus the output waveform is



Only option C satisfy this waveform.

Sol. 40 Option (D) is correct.

Writing in transform domain we have

$$\frac{V_c(s)}{V_s(s)} = \frac{\frac{1}{s}}{\left(\frac{1}{s} + s + 1\right)} = \frac{1}{(s^2 + s + 1)}$$

Since $V_s(t) = \delta(t) \Rightarrow V_s(s) = 1$ and

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

or $$V_c(s) = \frac{2}{\sqrt{3}}\left[\frac{\frac{\sqrt{3}}{2}}{(s + \frac{1}{2})^2 + \frac{3}{4}}\right]$$

Taking inverse Laplace transform we have

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

Sol. 41 Option (B) is correct.

Let voltage across resistor be v_R

$$\frac{V_R(s)}{V_S(s)} = \frac{1}{\left(\frac{1}{s} + s + 1\right)} = \frac{s}{(s^2 + s + 1)}$$

Since $v_s = \delta(t) \Rightarrow V_s(s) = 1$ we get

$$V_R(s) = \frac{s}{(s^2 + s + 1)} = \frac{s}{(s + \frac{1}{2})^2 + \frac{3}{4}}$$

$$= \frac{(s + \frac{1}{2})}{(s + \frac{1}{2})^2 + \frac{3}{4}} - \frac{\frac{1}{2}}{(s + \frac{1}{2})^2 + \frac{3}{4}}$$

or $$v_R(t) = e^{-\frac{1}{2}} \cos\frac{\sqrt{3}}{2} t - \frac{1}{2} \# \frac{2}{\sqrt{3}} e^{-\frac{1}{2}} \sin\frac{\sqrt{3}}{2} t$$

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

Sol. 42 Option (C) is correct.

From the problem statement we have

$$z_{11} = \frac{v_1}{i_1}\Big|_{i_2 = 0} = \frac{6}{4} = 1.5\Omega$$

$$z_{12} = \frac{v_1}{i_2}\Big|_{i_1 = 0} = \frac{4.5}{1} = 4.5\Omega$$

$$z_{21} = \frac{v_2}{i_1}\Big|_{i_2 = 0} = \frac{6}{4} = 1.5\Omega$$

$$z_{22} = \frac{v_2}{i_2}\Big|_{i_1 = 0} = \frac{1.5}{1} = 1.5\Omega$$

Thus z -parameter matrix is

$$\begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix} = \begin{bmatrix} 1.5 & 4.5 \\ 1.5 & 1.5 \end{bmatrix}$$

Sol. 43 Option (A) is correct.

From the problem statement we have

$$h_{12} = \frac{v_1}{v_2}\Big|_{i_1 = 0} = \frac{4.5}{1.5} = 3$$

$$h_{22} = \frac{i_2}{v_2}\Big|_{i_1 = 0} = \frac{1}{1.5} = 0.67$$

From z matrix, we have

$$v_1 = z_{11}i_1 + z_{12}i_2$$
$$v_2 = z_{21}i_1 + z_{22}i_2$$

If $v_2 = 0$ then $\frac{i_2}{i_1} = \frac{-z_{21}}{z_{22}} = \frac{-1.5}{1.5} = -1 = h_{21}$

or $i_2 = -i_1$

Putting in equation for v_1, we get

$$v_1 = (z_{11} - z_{12})\, i_1$$
$$\left.\frac{v_1}{i_1}\right|_{v_2=0} = h_{11} = z_{11} - z_{12} = 1.5 - 4.5 = -3$$

Hence h -parameter will be

$$\begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} = \begin{bmatrix} -3 & 3 \\ -1 & 0.67 \end{bmatrix}$$

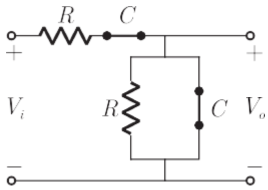
Sol. 44 Option (D) is correct.

According to maximum Power Transform Theorem

$$Z_L = Z_s^* = (R_s - jX_s)$$

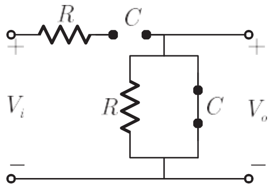
Sol. 45 Option (C) is correct.

At $w \to \infty$, capacitor acts as short circuited and circuit acts as shown in fig below



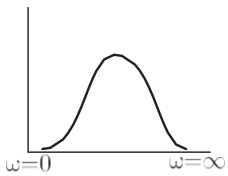
Here we get $\frac{V_0}{V_i} = 0$

At $w \to 0$, capacitor acts as open circuited and circuit look like as shown in fig below



Here we get also $\frac{V_0}{V_i} = 0$

So frequency response of the circuit is as shown in fig and circuit is a Band pass filter.



Sol. 46 Option (D) is correct.

We know that bandwidth of series RLC circuit is $\frac{R}{L}$. Therefore

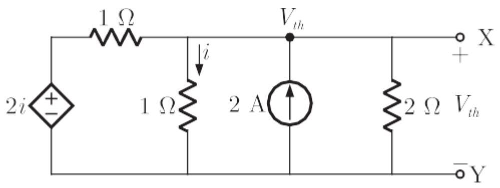
Bandwidth of filter 1 is $B_1 = \frac{R}{L_1}$

Bandwidth of filter 2 is $B_2 = \frac{R}{L_2} = \frac{R}{L_1/4} = \frac{4R}{L_1}$

Dividing above equation $\frac{B_1}{B_2} = \frac{1}{4}$

Sol. 47 Option (D) is correct.

Here V_{th} is voltage across node also. Applying nodal analysis we get



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

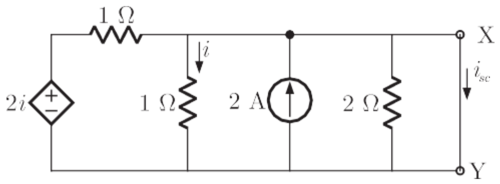
But from circuit $\qquad i = \frac{V_{th}}{1} = V_{th}$

Therefore

$$\frac{V_{th}}{2} + \frac{V_{th}}{1} + \frac{V_{th} - 2V_{th}}{1} = 2$$

or $\qquad V_{th} = 4$ volt

From the figure shown below it may be easily seen that the short circuit current at terminal $X\,Y$ is $i_{sc} = 2$ A because $i = 0$ due to short circuit of 1 W resistor and all current will pass through short circuit.



Therefore $\qquad R_{th} = \frac{V_{th}}{i_{sc}} = \frac{4}{2} = 2$ W

Sol. 48 Option (A) is correct.

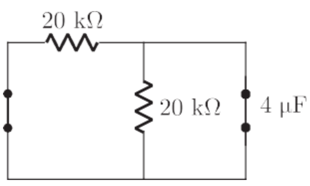
The voltage across capacitor is

At $t = 0^+$, $\qquad V_c(0^+) = 0$

At $t = 3$, $\qquad V_C(3) = 5$ V

The equivalent resistance seen by capacitor as shown in fig is

$$R_{eq} = 20 \| 20 = 10k\text{W}$$



Time constant of the circuit is

$$T = R_{eq} C = 10k \# 4m = 0.04 \text{ s}$$

Using direct formula

$$V_c(t) = V_C(3) - [V_c(3) - V_c(0)]e^{-t/T}$$

$$= V_C(3)(1 - e^{-t/T}) + V_C(0)e^{-t/T} = 5(1 - e^{-t/0.04})$$

or $\qquad V_c(t) = 5(1 - e^{-25t})$

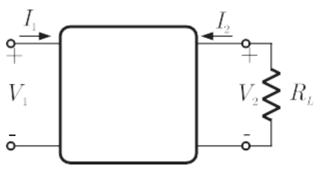
Now $$I_C(t) = C\frac{dV_C(t)}{dt}$$
$$= 4 \# 10^{-6} \# (-5 \# 25e^{-25t}) = 0.5e^{-25t} \text{ mA}$$

Sol. 49 Option (D) is correct.

Impedance $$= (5-3j) \parallel (5+3j) = \frac{(5-3j) \# (5+3j)}{5-3j+5+3j}$$
$$= \frac{(5)^2 - (3j)^2}{10} = \frac{25+9}{10} = 3.4$$
$$V_{AB} = \text{Current} \# \text{Impedance} = 5{+}30c \# 34 = 17{+}30c$$

Sol. 50 Option (D) is correct.

The network is shown in figure below.



Now $$V_1 = AV_2 - BI_2 \quad ...(1)$$
and $$I_1 = CV_2 - DI_2 \quad ...(2)$$
also $$V_2 = -I_2 R_L \quad ...(3)$$

From (1) and (2) we get

Thus $$\frac{V_1}{I_1} = \frac{AV_2 - BI_2}{CV_2 - DI_2}$$

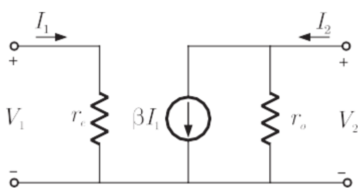
Substituting value of V_2 from (3) we get

Input Impedance $$Z_{in} = \frac{-A \# I_2 R_L - BI_2}{-C \# I_2 R_L - DI_2}$$

or $$Z_{in} = \frac{AR_L + B}{CR_L + D}$$

Sol. 51 Option (B) is correct.

The circuit is as shown below.



At input port $$V_1 = r_e I_1$$
At output port $$V_2 = r_0(I_2 - bI_1) = -r_0 bI_1 + r_0 I_2$$

Comparing standard equation
$$V_1 = z_{11}I_1 + z_{12}I_2$$
$$V_2 = z_{21}I_1 + z_{22}I_2$$
$$z_{12} = 0 \text{ and } z_{21} = -r_0 b$$

Sol. 52 Option (B) is correct.

For series RC network input impedance is
$$Z_{ins} = \frac{1}{sC} + R = \frac{1+sRC}{sC}$$

Thus pole is at origin and zero is at $-\frac{1}{RC}$

For parallel RC network input impedance is

$$Z_{in} = \frac{\frac{1}{sC}R}{\frac{1}{sC} + R} = \frac{sC}{1 + sRC}$$

Thus pole is at $-\frac{1}{RC}$ and zero is at infinity.

Sol. 53 Option (A) is correct.

We know $$v = \frac{Ldi}{dt}$$

Taking Laplace transform we get

$$V(s) = sLI(s) - Li(0^+)$$

As per given in question

$$-Li(0^+) = -1 \text{ mV}$$

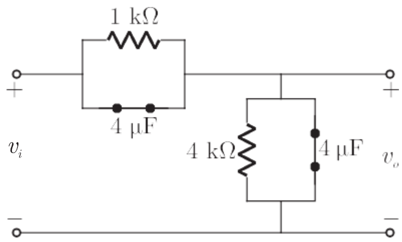
Thus $$i(0^+) = \frac{1 \text{ mV}}{2 \text{ mH}} = 0.5 \text{ A}$$

Sol. 54 Option (B) is correct.

At initial all voltage are zero. So output is also zero.

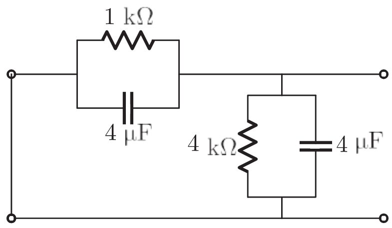
Thus $$v_0(0^+) = 0$$

At steady state capacitor act as open circuit.



Thus, $$v_0(3) = \frac{4}{5} \# v_i = \frac{4}{5} \# 10 = 8$$

The equivalent resistance and capacitance can be calculate after killing all source



$$R_{eq} = 1 \| 4 = 0.8 \text{ kW}$$

$$C_{eq} = 4 \| 1 = 5 \text{ m F}$$

$$T = R_{eq} C_{eq} = 0.8\text{kW} \# 5\text{mF} = 4 \text{ ms}$$

$$v_0(t) = v_0(3) - [v_0(3) - v_0(0^+)] e^{-t/T}$$

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

$$v_0(t) = 8(1 - e^{-t/0.004}) \text{ Volts}$$

Sol. 55 Option (A) is correct.

Here $Z_2(s) = R_{neg} + Z_1(s)$

or $Z_2(s) = R_{neg} + \text{Re } Z_1(s) + j \text{ Im } Z_1(s)$

For $Z_2(s)$ to be positive real, Re $Z_2(s)$ \$ 0

Thus $R_{neg} + \text{Re } Z_1(s)$ \$ 0

or $\text{Re } Z_1(s)$ \$ $- R_{neg}$

But R_{neg} is negative quantity and $- R_{neg}$ is positive quantity. Therefore

$$\text{Re } Z_1(s) \$ |R_{neg}|$$

or $|R_{neg}|$ # $\text{Re } Z_1(jw)$ For all w.

Sol. 56 Option (C) is correct.

Transfer function is

$$\frac{Y(s)}{U(s)} = \frac{\frac{1}{sC}}{R + sL + \frac{1}{sC}} = \frac{1}{s^2LC + scR + 1} = \frac{\frac{1}{LC}}{s^2 + \frac{R}{L}s + \frac{1}{LC}}$$

Comparing with $s^2 + 2xw_n s + w_n^2 = 0$ we have

Here $2xw_n = \frac{R}{L}$,

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

Thus $x = \frac{R}{2L}\sqrt{LC} = \frac{R}{2}\ \frac{C}{L}$

For no oscillations, x \$ 1

Thus $\frac{R}{2}\sqrt{\frac{C}{L}}$ \$ 1

or R \$ $2\ \frac{L}{C}$

Sol. 57 Option (B) is correct.

For given transformer

$$\frac{I_2}{I_1} = \frac{V_1}{V_2} = \frac{n}{1}$$

or $I_1 = \frac{I_2}{n}$ and $V_1 = n V_2$

Comparing with standard equation

$$V_1 = AV_2 + BI_2$$

$$I_1 = CV_2 + DI_2$$

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} n & 0 \\ 0 & \frac{1}{n} \end{bmatrix}$$

Thus $x = \frac{1}{n}$

Sol. 58 Option (B) is correct.

We have $L = 1H$ and $C = \frac{1}{400}$ # 10^{-6}

Resonant frequency

$$f_0 = \frac{1}{2p\sqrt{LC}} = \frac{1}{2p\sqrt{1 \# \frac{1}{400} \# 10^{-6}}}$$

$$= \frac{10^3 \# 20}{2p} = \frac{10^4}{p} \text{ Hz}$$

Sol. 59 Option (C) is correct.
Maximum power will be transferred when $R_L = R_s = 100W$ In this case voltage across R_L is 5 V, therefore

$$P_{max} = \frac{V^2}{R} = \frac{5 \# 5}{100} = 0.25 \text{ W}$$

Sol. 60 Option (C) is correct.
For stability poles and zero interlace on real axis. In RC series network the driving point impedance is

$$Z_{ins} = R + \frac{1}{Cs} = \frac{1 + sRC}{sC}$$

Here pole is at origin and zero is at $s =- 1/RC$, therefore first critical frequency is a pole and last critical frequency is a zero.
For RC parallel network the driving point impedance is

$$Z_{inp} = \frac{R\frac{1}{Cs}}{R + \frac{1}{Cs}} = \frac{R}{1 + sRC}$$

Here pole is $s =- 1/RC$ and zero is at 3, therefore first critical frequency is a pole and last critical frequency is a zero.

Sol. 61 Option (A) is correct.
Applying KCL we get

$$i_1(t) + 5+0c = 10+60c$$

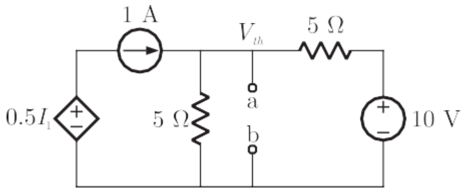
or $$i_1(t) = 10+60c - 5+0c = 5 + 5.3j - 5$$

or $$i_1(t) = 5 \quad 3 +90c = \frac{10}{2} \quad 3 +90c$$

Sol. 62 Option (B) is correct.
If $L_1 = j5W$ and $L_3 = j2W$ the mutual induction is subtractive because current enters from dotted terminal of $j2W$ coil and exit from dotted terminal of $j5W$. If $L_2 = j2W$ and $L_3 = j2W$ the mutual induction is additive because current enters from dotted terminal of both coil.

Thus $$Z = L_1 - M_{13} + L_2 + M_{23} + L_3 - M_{31} + M_{32}$$
$$= j5 + j10 + j2 + j10 + j2 - j10 + j10 = j9$$

Sol. 63 Option (B) is correct.
Open circuit at terminal ab is shown below

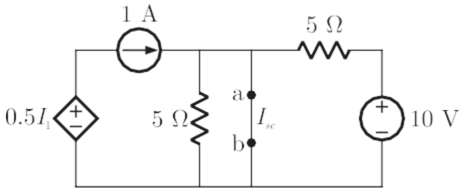


Applying KCL at node we get

$$\frac{V_{ab}}{5} + \frac{V_{ab} - 10}{5} = 1$$

or $$V_{ab} = 7.5 = V_{th}$$

Short circuit at terminal ab is shown below



Short circuit current from terminal ab is

$$I_{sc} = 1 + \frac{10}{5} = 3 \text{ A}$$

Thus $$R_{th} = \frac{V_{th}}{I_{sc}} = \frac{7.5}{3} = 2.5 \text{ W}$$

Here current source being in series with dependent voltage source make it ineffective.

Sol. 64 Option (C) is correct.

Here $V_a = 5$ V because $R_1 = R_2$ and total voltage drop is 10 V.

Now $$V_b = \frac{R_3}{R_3 + R_4} \# 10 = \frac{1.1}{2.1} \# 10 = 5.238 \text{ V}$$

$$V = V_a - V_b = 5 - 5.238 =- 0.238 \text{ V}$$

Sol. 65 Option (D) is correct.

For h parameters we have to write V_1 and I_2 in terms of I_1 and V_2.

$$V_1 = h_{11}I_1 + h_{12}V_2$$

$$I_2 = h_{21}I_1 + h_{22}V_2$$

Applying KVL at input port

$$V_1 = 10I_1 + V_2$$

Applying KCL at output port

$$\frac{V_2}{20} = I_1 + I_2$$

or $$I_2 =- I_1 + \frac{V_2}{20}$$

Thus from above equation we get

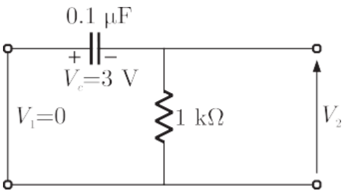
$$\begin{bmatrix} h_{11} & h_{12} \\ h_{12} & h_{22} \end{bmatrix} = \begin{bmatrix} 10 & 1 \\ -1 & 0.05 \end{bmatrix}$$

Sol. 66 Option (B) is correct.

Time constant $RC = 0.1 \# 10^{-6} \# 10^{3} = 10^{-4}$ sec

Since time constant RC is very small, so steady state will be reached in 2 sec.

At $t = 2$ sec the circuit is as shown in fig.



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

$$V_2 =- V_c =- 3 \text{ V}$$

Sol. 67 Option (B) is correct.

For a tree there must not be any loop. So a, c, and d don't have any loop. Only b has loop.

Sol. 68 Option (D) is correct.

The sign of M is as per sign of L If current enters or exit the dotted terminals of both coil. The sign of M is opposite of L If current enters in dotted terminal of a coil and exit from the dotted terminal of other coil.

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

Sol. 69 Option (A) is correct.

Here $w = 2$ and $V = 1\angle 0^\circ$

$$Y = \frac{1}{R} + jwC + \frac{1}{jwL}$$

$$= 3 + j2 \times 3 + \frac{1}{j2 \times \frac{1}{4}} = 3 + j4$$

$$= 5\angle \tan^{-1}\frac{4}{3} = 5\angle 53.11^\circ$$

$$I = V * Y = (1\angle 0^\circ)(5\angle 53.1^\circ) = 5\angle 53.1^\circ$$

Thus $$i(t) = 5\sin(2t + 53.1^\circ)$$

Sol. 70 Option (A) is correct.

$$v_i(t) = \sqrt{2}\sin 10^3 t$$

Here $w = 10^3$ rad and $V_i = \sqrt{2}\angle 0^\circ$

Now $$V_0 = \frac{\frac{1}{jwC}}{R + \frac{1}{jwC}} . V_t = \frac{1}{1 + jwCR} V_i$$

$$= \frac{1}{1 + j \times 10^3 \times 10^{-3}} \sqrt{2}\angle 0^\circ$$

$$= 1\angle -45^\circ$$

$$v_0(t) = \sin(10^3 t - 45^\circ)$$

Sol. 71 Option (C) is correct.

Input voltage $$v_i(t) = u(t)$$

Taking Laplace transform $$V_i(s) = \frac{1}{s}$$

Impedance $$Z(s) = s + 2$$

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

or $$I(s) = \frac{1}{2}\left[\frac{1}{s} - \frac{1}{s+2}\right]$$

Taking inverse Laplace transform

$$i(t) = \frac{1}{2}(1 - e^{-2t})u(t)$$

At $t = 0$, $i(t) = 0$

At $t = \frac{1}{2}$, $i(t) = 0.31$

At $t = \infty$, $i(t) = 0.5$

Graph (C) satisfies all these conditions.

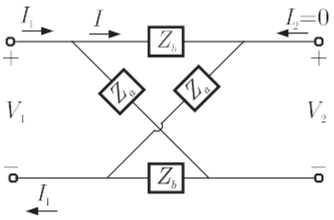
Sol. 72 Option (D) is correct.

We know that

$$V_1 = z_{11}I_1 + z_{12}I_2$$
$$V_2 = z_{11}I_1 + z_{22}I_2$$

where
$$z_{11} = \frac{V_1}{I_1}\Big|_{I_2=0}$$
$$z_{21} = \frac{V_2}{I_1}\Big|_{I_1=0}$$

Consider the given lattice network, when $I_2 = 0$. There is two similar path in the circuit for the current I_1. So $I = \frac{1}{2}I_1$



For z_{11} applying KVL at input port we get

$$V_1 = I(Z_a + Z_b)$$

Thus
$$V_1 = \frac{1}{2}I_1(Z_a + Z_b)$$
$$z_{11} = \frac{1}{2}(Z_a + Z_b)$$

For Z_{21} applying KVL at output port we get

$$V_2 = Z_a\frac{I_1}{2} - Z_b\frac{I_1}{2}$$

Thus
$$V_2 = \frac{1}{2}I_1(Z_a - Z_b)$$
$$z_{21} = \frac{1}{2}(Z_a - Z_b)$$

For this circuit $z_{11} = z_{22}$ and $z_{12} = z_{21}$. Thus

$$\begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix} = \begin{bmatrix} \frac{Z_a + Z_b}{2} & \frac{Z_a - Z_b}{2} \\ \frac{Z_a - Z_b}{2} & \frac{Z_a + Z_b}{2} \end{bmatrix}$$

Here $Z_a = 2j$ and $Z_b = 2\Omega$

Thus
$$\begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix} = \begin{bmatrix} 1+j & j-1 \\ j-1 & 1+j \end{bmatrix}$$

Sol. 73 Option (B) is correct.

Applying KVL,

$$v(t) = Ri(t) + \frac{L\,di(t)}{dt} + \frac{1}{C}\int_0^{\infty} i(t)\,dt$$

Taking L.T. on both sides,

$$V(s) = RI(s) + LsI(s) - Li(0^+) + \frac{I(s)}{sC} + \frac{v_c(0^+)}{sC}$$

$$v(t) = u(t) \text{ thus } V(s) = \frac{1}{s}$$

Hence $\frac{1}{s} = I(s) + sI(s) - 1 + \frac{I(s)}{s} - \frac{1}{s}$

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

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

Sol. 74 Option (B) is correct.

Characteristics equation is

$$s^2 + 20s + 10^6 = 0$$

Comparing with $s^2 + 2\xi\omega_n s + \omega_n^2 = 0$ we have

$$\omega_n = \sqrt{10^6} = 10^3$$

$$2\xi\omega = 20$$

Thus $2\xi = \frac{20}{10^3} = 0.02$

Now $Q = \frac{1}{2\xi} = \frac{1}{0.02} = 50$

Sol. 75 Option (D) is correct.

$$H(s) = \frac{V_0(s)}{V_i(s)} = \frac{\frac{1}{sC}}{R + sL + \frac{1}{sC}} = \frac{1}{s^2 LC + sCR + 1}$$

$$= \frac{1}{s^2(10^{-2} \times 10^{-4}) + s(10^{-4} \times 10^4) + 1}$$

$$= \frac{1}{10^{-6}s^2 + s + 1} = \frac{10^6}{s^2 + 10^6 s + 10^6}$$

Sol. 76 Option (D) is correct.

Impedance of series RLC circuit at resonant frequency is minimum, not zero. Actually imaginary part is zero.

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

At resonance $\omega L - \frac{1}{\omega C} = 0$ and $Z = R$ that is purely resistive. Thus S_1 is false

Now quality factor $Q = R\sqrt{\frac{C}{L}}$

Since $G = \frac{1}{R}$, $Q = \frac{1}{G}\sqrt{\frac{C}{L}}$

If $G \uparrow$ then $Q \downarrow$ provided C and L are constant. Thus S_2 is also false.

Sol. 77 Option (B) is correct.

Number of loops $= b - n + 1$

$=$ minimum number of equation

Number of branches $= b = 8$

Number of nodes $= n = 5$

Minimum number of equation $= 8 - 5 + 1 = 4$

Sol. 78 Option (C) is correct.

For maximum power transfer

$$Z_L = Z_S^* = R_s - jX_s$$

Thus $Z_L = 1 - 1j$

Sol. 79 Option (B) is correct.

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

When R, L and C are doubled,

$$Q' = \frac{1}{2R}\sqrt{\frac{2L}{2C}} = \frac{1}{2R}\sqrt{\frac{L}{C}} = \frac{Q}{2}$$

Thus $$Q' = \frac{100}{2} = 50$$

Sol. 80 Option (C) is correct.

Applying KVL we get,

$$\sin t = Ri(t) + L\frac{di(t)}{dt} + \frac{1}{C}\int i(t)\,dt$$

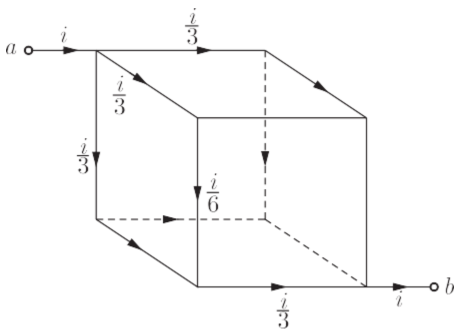
or $$\sin t = 2i(t) + 2\frac{di(t)}{dt} + \int i(t)\,dt$$

Differentiating with respect to t, we get

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

Sol. 81 Option (A) is correct.

For current i there is 3 similar path. So current will be divide in three path



so, we get

$$V_{ab} - \left(\frac{i}{3}\times 1\right) - \left(\frac{i}{6}\times 1\right) - \left(\frac{1}{3}\times 1\right) = 0$$

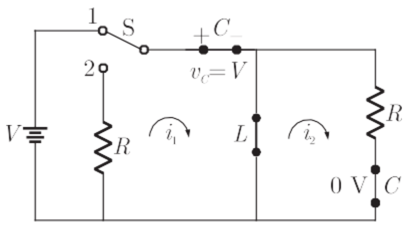
$$\frac{V_{ab}}{i} = R_{eq} = \frac{1}{3} + \frac{1}{6} + \frac{1}{3} = \frac{5}{6}\ \Omega$$

Sol. 82 Option ( ) is correct.

Data are missing in question as L_1&L_2 are not given.

Sol. 83 Option (A) is correct.

At $t = 0^-$ circuit is in steady state. So inductor act as short circuit and capacitor act as open circuit.

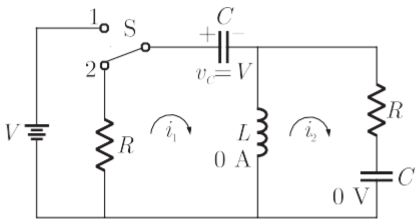


At $t(0^-)$

At $t = 0^-$, $\quad i_1(0^-) = i_2(0^-) = 0$

$$v_c(0^-) = V$$

At $t = 0^+$ the circuit is as shown in fig. The voltage across capacitor and current in inductor can't be changed instantaneously. Thus



At $t(0^+)$

At $t = 0^+$, $\quad i_1 = i_2 = -\dfrac{V}{2R}$

Sol. 84 Option (C) is correct.

When switch is in position 2, as shown in fig in question, applying KVL in loop (1),

$$RI_1(s) + \frac{V}{s} + \frac{1}{sC} I_1(s) + sL[I_1(s) - I_2(s)] = 0$$

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

$$z_{11}I_1 + z_{12}I_2 = V_1$$

Applying KVL in loop 2,

$$sL[I_2(s) - I_1(s)] + RI_2(s) + \frac{1}{sC} I_2(s) = 0$$

$$Z_{12}I_1 + Z_{22}I_2 = V_2$$

or $\quad -sLI_1(s) + \left[R + sL + \dfrac{1}{sc}\right] I_2(s) = 0$

Now comparing with

$$\begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

we get

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

Sol. 85 Option (B) is correct.

$$\text{Zeros} = -3$$

$$\text{Pole}_1 = -1 + j$$

$$\text{Pole}_2 = -1 - j$$

$$Z(s) = \frac{K(s+3)}{(s+1+j)(s+1-j)} = \frac{K(s+3)}{(s+1)^2 - j^2} = \frac{K(s+3)}{(s+1)^2 + 1}$$

From problem statement $Z(0)|_{w=0} = 3$

Thus $\dfrac{3K}{2} = 3$ and we get $K = 2$

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

Sol. 86 Option (C) is correct.

$$v(t) = \underbrace{10\sqrt{2}\cos(t + 10c)}_{v_1} + \underbrace{10\sqrt{5}\cos(2t + 10c)}_{v_2}$$

Thus we get $w_1 = 1$ and $w_2 = 2$

Now $Z_1 = R + jw_1L = 1 + j1$

$Z_2 = R + jw_2L = 1 + j2$

$$i(t) = \frac{v_1(t)}{Z_1} + \frac{v_2(t)}{Z_2} = \frac{10\sqrt{2}\cos(t + 10c)}{1 + j} + \frac{10\sqrt{5}\cos(2t + 10c)}{1 + j2}$$

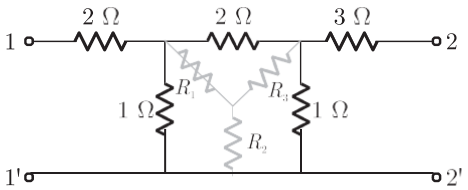
$$= \frac{10\sqrt{2}\cos(t + 10c)}{\sqrt{1^2 + 2^2} + \tan^{-1}1} + \frac{10\sqrt{5}\cos(2t + 10c)}{\sqrt{1^2 + 2^2}\tan^{-1}2}$$

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

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

Sol. 87 Option (A) is correct.

Using 3- Y conversion

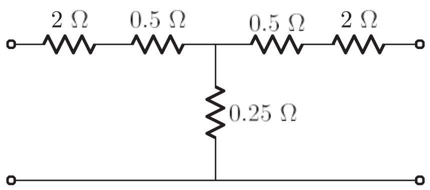


$$R_1 = \frac{2 \# 1}{2 + 1 + 1} = \frac{2}{4} = 0.5$$

$$R_2 = \frac{1 \# 1}{2 + 1 + 1} = \frac{1}{4} = 0.25$$

$$R_3 = \frac{2 \# 1}{2 + 1 + 1} = 0.5$$

Now the circuit is as shown in figure below.

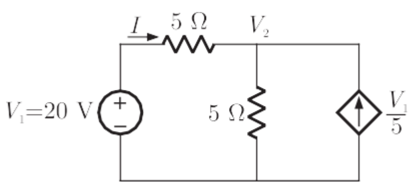


Now $z_{11} = \frac{V_1}{I_1}\Big|_{I_2 = 0} = 2 + 0.5 + 0.25 = 2.75$

$z_{12} = R_3 = 0.25$

Sol. 88 Option (A) is correct.

Applying KCL at for node 2,



$$\frac{V_2}{5} + \frac{V_2 - V_1}{5} = \frac{V_1}{5}$$

or $\qquad V_2 = V_1 = 20 \text{ V}$

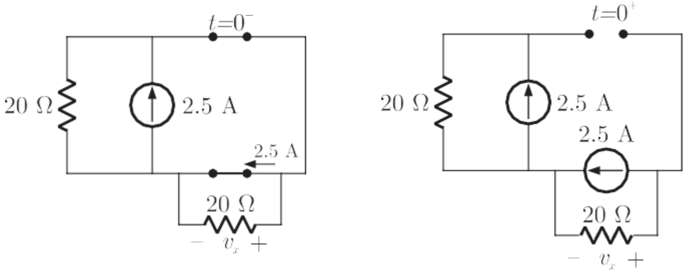
Voltage across dependent current source is 20 thus power delivered by it is

$$PV_2 \times \frac{V_1}{5} = 20 \times \frac{20}{5} = 80 \text{ W}$$

It deliver power because current flows from its + ive terminals.

Sol. 89 Option (C) is correct.

When switch was closed, in steady state, $i_L(0^-) = 2.5$ A

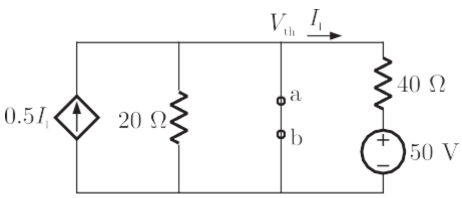


At $t = 0^+$, $i_L(0^+) = i_L(0^-) = 2.5$ A and all this current of will pass through 2 W resistor. Thus

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

Sol. 90 Option (A) is correct.

For maximum power delivered, R_L must be equal to R_{th} across same terminal.



Applying KCL at Node, we get

$$0.5I_1 = \frac{V_{th}}{20} + I_1$$

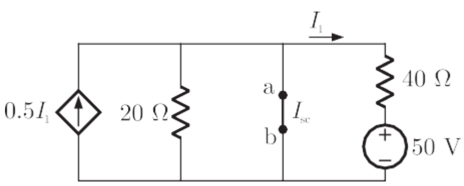
or $\qquad V_{th} + 10I_1 = 0$

but $\qquad I_1 = \frac{V_{th} - 50}{40}$

Thus $\qquad V_{th} + \frac{V_{th} - 50}{4} = 0$

or $\qquad V_{th} = 10 \text{ V}$

For I_{sc} the circuit is shown in figure below.



$$I_{sc} = 0.5I_1 - I_1 = -0.5I_1$$

but $\qquad I_1 = -\frac{50}{40} = -1.25 \text{ A}$

$$I_{sc} = -0.5 \times -12.5 = 0.625 \text{ A}$$

$$R_{th} = \frac{V_{th}}{I_{sc}} = \frac{10}{0.625} = 16\ \Omega$$

Sol. 91 Option (D) is correct.

$I_P, V_P \Rightarrow$ Phase current and Phase voltage
$I_L, V_L \Rightarrow$ Line current and line voltage

Now $\quad V_P = \left(\frac{V_L}{\sqrt{3}}\right)$ and $I_P = I_L$

So, $\quad \text{Power} = 3V_P I_L \cos\theta$

$$1500 = 3\left(\frac{V_L}{\sqrt{3}}\right)(I_L)\cos\theta$$

also $\quad I_L = \left(\frac{V_L}{\sqrt{3}\,Z_L}\right)$

$$1500 = 3\left(\frac{V_L}{\sqrt{3}}\right)\left(\frac{V_L}{\sqrt{3}\,Z_L}\right)\cos\theta$$

$$Z_L = \frac{(400)^2(.844)}{1500} = 90\ \Omega$$

As power factor is leading

So, $\quad \cos\theta = 0.844 \Rightarrow \theta = 32.44$

As phase current leads phase voltage

$$Z_L = 90\angle -\theta = 90\angle -32.44^\circ$$

Sol. 92 Option (C) is correct.

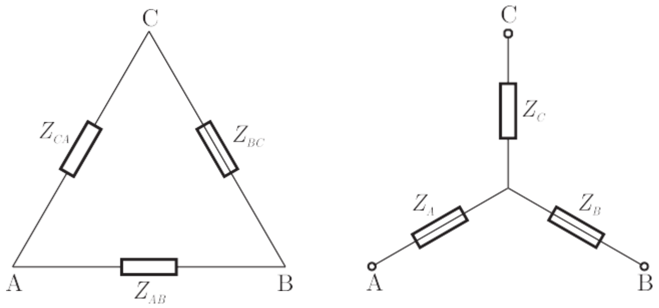
Applying KCL, we get

$$\frac{e_0 - 12}{4} + \frac{e_0}{4} + \frac{e_0}{2+2} = 0$$

or $\quad e_0 = 4\ \text{V}$

Sol. 93 Option (A) is correct.

The star delta circuit is shown as below



Here $\quad Z_{AB} = Z_{BC} = Z_{CA} = \sqrt{3}\,Z$

and
$$Z_A = \frac{Z_{AB}Z_{CA}}{Z_{AB} + Z_{BC} + Z_{CA}}$$

$$Z_B = \frac{Z_{AB}Z_{BC}}{Z_{AB} + Z_{BC} + Z_{CA}}$$

$$Z_C = \frac{Z_{BC}Z_{CA}}{Z_{AB} + Z_{BC} + Z_{CA}}$$

Now
$$Z_A = Z_B = Z_C = \frac{\sqrt{3}Z\,\sqrt{3}Z}{\sqrt{3}\,Z + \sqrt{3}\,Z + \sqrt{3}\,Z} = \frac{Z}{\sqrt{3}}$$

Sol. 94 Option (C) is correct.

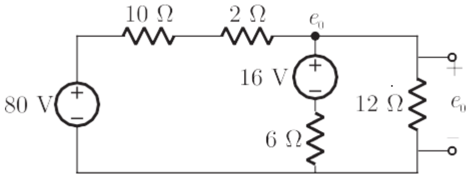
$$\begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} = \begin{bmatrix} y_1 + y_3 & -y_3 \\ -y_3 & y_2 + y_3 \end{bmatrix}$$

$$y_{12} = -y_3$$

$$y_{12} = -\frac{1}{20} = -0.05 \text{ mho}$$

Sol. 95 Option (D) is correct.

We apply source conversion the circuit as shown in fig below.



Now applying nodal analysis we have

$$\frac{e_0 - 80}{10 + 2} + \frac{e_0}{12} + \frac{e_0 - 16}{6} = 0$$

or $$4e_0 = 112$$

$$e_0 = \frac{112}{4} = 28 \text{ V}$$

Sol. 96 Option (A) is correct.

$$I_2 = \frac{E_m \angle 0°}{R_2 + \frac{1}{jwC}} = E_m \angle 0° \frac{jwC}{1 + jwCR_2}$$

$$\angle I_2 = \frac{\angle 90°}{\angle \tan^{-1} wCR_2}$$

$$I_2 = \frac{E_m wC}{\sqrt{1 + w^2 C^2 R_2^2}} \angle (90° - \tan^{-1} wCR_2)$$

At $w = 0$ $$I_2 = 0$$

and at $w = \infty$, $$I_2 = \frac{E_m}{R_2}$$

Only figure given in option (A) satisfies both conditions.

Sol. 97 Option (A) is correct.

$$X_s = wL = 10\ \Omega$$

For maximum power transfer

$$R_L = \sqrt{R_s^2 + X_s^2} = \sqrt{10^2 + 10^2} = 14.14\ \Omega$$

Sol. 98 Option (C) is correct.

Applying KVL in LHS loop

$$E_1 = 2I_1 + 4(I_1 + I_2) - 10E_1$$

or $$E_1 = \frac{6I_1}{11} + \frac{4I_2}{11}$$

Thus $z_{11} = \frac{6}{11}$

Applying KVL in RHS loop

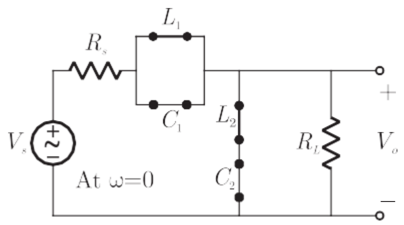
$$E_2 = 4(I_1 + I_2) - 10E_1$$

$$= 4(I_1 + I_2) - 10\left(\frac{6I_1}{11} + \frac{4I_2}{11}\right) = -\frac{16I_1}{11} + \frac{4I_2}{11}$$

Thus $z_{21} = -\frac{16}{11}$

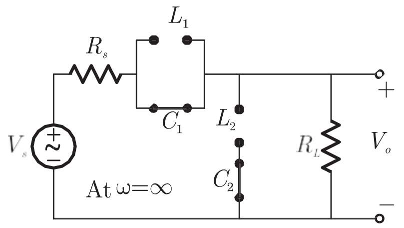
Sol. 99 Option (D) is correct.

At $w = 0$, circuit act as shown in figure below.



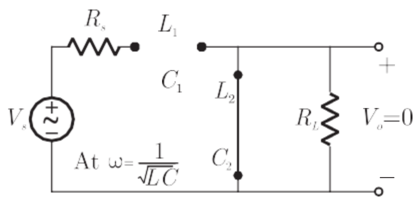
$$\frac{V_0}{V_s} = \frac{R_L}{R_L + R_s} \qquad \text{(finite value)}$$

At $w = 3$, circuit act as shown in figure below:



$$\frac{V_0}{V_s} = \frac{R_L}{R_L + R_s} \qquad \text{(finite value)}$$

At resonant frequency $w = \sqrt{\frac{1}{LC}}$ circuit acts as shown in fig and $V_0 = 0$.



Thus it is a band reject filter.

Sol. 100 Option (D) is correct.

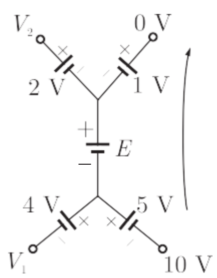
Applying KCL we get

$$i_L = e^{at} + e^{bt}$$

Now $$V(t) = v_L = L\frac{di_L}{dt} = L\frac{d}{dt}[e^{at} + e^{bt}] = ae^{at} + be^{bt}$$

Sol. 101 Option (A) is correct.

Going from 10 V to 0 V



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

or $$E = -16\text{ V}$$

Sol. 102 Option (C) is correct.

This is a reciprocal and linear network. So we can apply reciprocity theorem which states "Two loops A & B of a network N and if an ideal voltage source E in loop A produces a current I in loop B, then interchanging positions an identical source in loop B produces the same current in loop A. Since network is linear, principle of homogeneity may be applied and when volt source is doubled, current also doubles.

Now applying reciprocity theorem

$i = 2$ A for 10 V

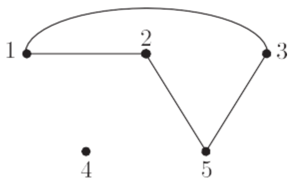
$V = 10$ V, $i = 2$ A

$V = -20$ V, $i = -4$ A

Sol. 103 Option (C) is correct.

Tree is the set of those branch which does not make any loop and connects all the nodes.

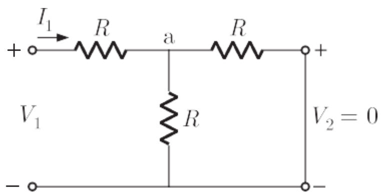
abfg is not a tree because it contains a loop*l* node (4) is not connected



Sol. 104 Option (A) is correct.

For a 2-port network the parameter h_{21} is defined as

$$h_{21} = \frac{I_2}{I_1}\bigg|_{V_2 = 0 \text{(short circuit)}}$$



Applying node equation at node a we get

$$\frac{V_a - V_1}{R} + \frac{V_a - 0}{R} + \frac{V_a - 0}{R} = 0$$

$$3V_a = V_1 \quad \& \ V_a = \frac{V_1}{3}$$

Now $$I_1 = \frac{V_1 - V_a}{R} = \frac{V_1 - \frac{V_1}{3}}{R} = \frac{2V_1}{3R}$$

and $$I_2 = \frac{0 - V_a}{R} = \frac{0 - \frac{V_1}{3}}{R} = \frac{-V_1}{3R}$$

Thus $$\frac{I_2}{I_1}\bigg|_{V_2 = 0} = h_{21} = \frac{-V_1/3R}{2V_1/3R} = \frac{-1}{2}$$

Sol. 105 Option (A) is correct.

Applying node equation at node A

$$\frac{V_{th} - 100\,(1 + j0)}{3} + \frac{V_{th} - 0}{4j} = 0$$

or $$4jV_{th} - 4j100 + 3V_{th} = 0$$

or $$V_{th}(3 + 4j) = 4j100$$

$$V_{th} = \frac{4j100}{3 + 4j}$$

By simplifying

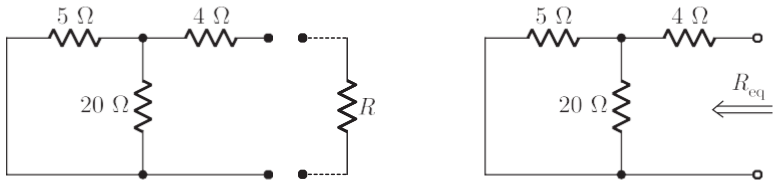
$$V_{th} = \frac{4j100}{3 + 4j} \# \frac{3 - 4j}{3 - 4j}$$

$$V_{th} = 16j\,(3 - j4)$$

Sol. 106 Option (C) is correct.

For maximum power transfer R_L should be equal to R_{Th} at same terminal.

so, equivalent Resistor of the circuit is



$$R_{eq} = 5W \| 20W + 4W$$

$$R_{eq} = \frac{5.20}{5 + 20} + 4 = 4 + 4 = 8\ W$$

Sol. 107 Option (D) is correct.

Delta to star conversion

$$R_1 = \frac{R_{ab}R_{ac}}{R_{ab} + R_{ac} + R_{bc}} = \frac{5 \# 30}{5 + 30 + 15} = \frac{150}{50} = 3\ W$$

$$R_2 = \frac{R_{ab}R_{bc}}{R_{ab} + R_{ac} + R_{bc}} = \frac{5 \# 15}{5 + 30 + 15} = 1.5\ W$$

$$R_3 = \frac{R_{ac}R_{bc}}{R_{ab} + R_{ac} + R_{bc}} = \frac{15 \# 30}{5 + 30 + 15} = 9\ W$$

Sol. 108 Option (C) is correct.

$$\text{No. of branches} = n + l - 1 = 7 + 5 - 1 = 11$$

Sol. 109 Option (B) is correct.

In nodal method we sum up all the currents coming & going at the node So it is based on KCL. Furthermore we use ohms law to determine current in individual branch. Thus it is also based on ohms law.

Sol. 110 Option (A) is correct.

Superposition theorem is applicable to only linear circuits.

Sol. 111 Option (B) is correct.

Sol. 112 Option (B) is correct.

For reciprocal network $y_{12} = y_{21}$ but here $y_{12} = -\frac{1}{2}$! $y_{21} = \frac{1}{2}$. Thus circuit is non reciprocal. Furthermore only reciprocal circuit are passive circuit.

Sol. 113 Option (C) is correct.

Taking b as reference node and applying KCL at a we get

$$\frac{V_{ab} - 1}{2} + \frac{V_{ab}}{2} = 3$$

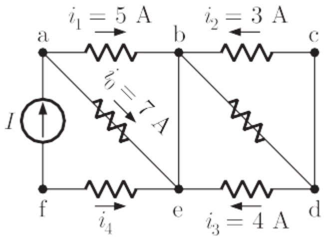
or $$V_{ab} - 1 + V_{ab} = 6$$

or $$V_{ab} = \frac{6+1}{2} = 3.5 \text{ V}$$

Sol. 114 Option (A) is correct.

Sol. 115 Option (B) is correct.

The given figure is shown below.



Applying KCL at node a we have

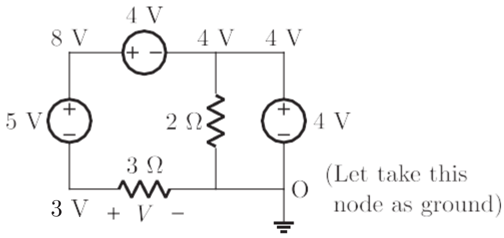
$$I = i_0 + i_1 = 7 + 5 = 12 \text{ A}$$

Applying KCL at node f

$$I = - i_4$$

so $$i_4 = - 12 \text{amp}$$

Sol. 116 Option (A) is correct.



so $$V = 3 - 0 = 3 \text{ volt}$$

Sol. 117 Option (D) is correct.

Can not determined V without knowing the elements in box.

Sol. 118 Option (A) is correct.

The voltage V is the voltage across voltage source and that is 10 V.

Sol. 119 Option (B) is correct.

Voltage across capacitor

$$V_C(t) = V_C(\infty) + (V_C(0) - V_C(\infty))\, e^{\frac{-t}{RC}}$$

Here $V_C(\infty) = 10$ V and $V_C(0) = 6$ V. Thus

$$V_C(t) = 10 + (6-10)\, e^{\frac{-t}{RC}} = 10 - 4e^{\frac{-t}{RC}} = 10 - 4e^{\frac{-t}{8}}$$

Now $$V_R(t) = 10 - V_C(t)$$

$$= 10 - 10 + 4e^{\frac{-t}{RC}} = 4e^{\frac{-t}{RC}}$$

Energy absorbed by resistor

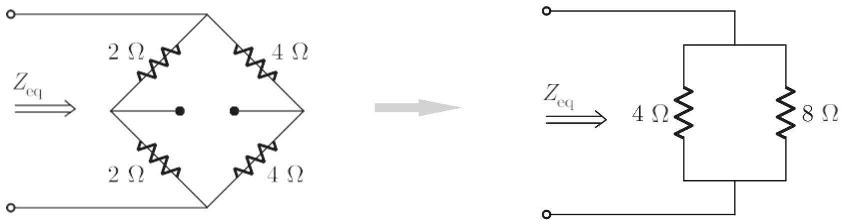
$$E = \int_0^{\infty} \frac{V_R^2(t)}{R} = \int_0^{\infty} \frac{16e^{\frac{-t}{4}}}{4} = \int_0^{\infty} 4e^{\frac{-t}{4}} = 16 \text{ J}$$

Sol. 120 Option (B) is correct.

It is a balanced whetstone bridge

$$\left(\frac{R_1}{R} = \frac{R_3}{R_4}\right)$$

so equivalent circuit is



$$Z_{eq} = (4\Omega \parallel 8\Omega) = \frac{4 \times 8}{4+8} = \frac{8}{3}$$

Sol. 121 Option (B) is correct.

Current in A_2, $I_2 = 3$ amp

Inductor current can be defined as $I_2 = -3j$

Current in A_3, $I_3 = 4$

Total current $I_1 = I_2 + I_3 = 4 - 3j$

$$|I| = \sqrt{(4)^2 + (3)^2} = 5 \text{ amp}$$

Sol. 122 Option (C) is correct.

For a tree we have $(n-1)$ branches. Links are the branches which from a loop, when connect two nodes of tree.

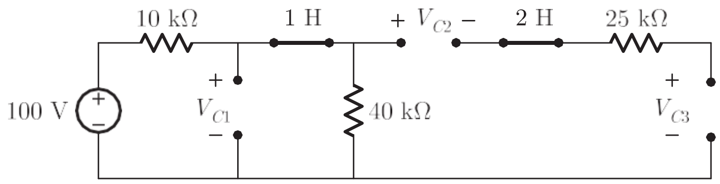
so if total no. of branches = b

$$\text{No. of links} = b - (n-1) = b - n + 1$$

Total no. of links in equal to total no. of independent loops.

Sol. 123 Option (B) is correct.

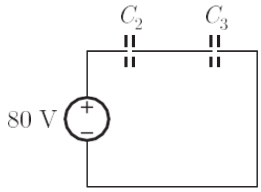
In the steady state condition all capacitors behaves as open circuit & Inductors behaves as short circuits as shown below :



Thus voltage across capacitor C_1 is

$$V_{C_1} = \frac{100}{10+40} \times 40 = 80 \text{ V}$$

Now the circuit faced by capacitor C_2 and C_3 can be drawn as below :



Voltage across capacitor C_2 and C_3 are

$$V_{C_2} = 80 \frac{C_3}{C_2 + C_3} = 80 \times \frac{3}{5} = 48 \text{ volt}$$

$$V_{C_3} = 80\frac{C_2}{C_2 + C_3} = 80 \times \frac{2}{5} = 32 \text{ volt}$$

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