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ESE 2024

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Director's Message

B. Singh (Ex. IES)

Engineering is one of the most chosen graduating field. Taking engineering is usually a matter of interest but this eventually develops into "purpose of being an engineer" when you choose engineering services as a career option.

Train goes in tunnel we don't panic but sit still and trust the engineer, even we don't doubt on signalling system, we don't think twice crossing over a bridge reducing our travel time; every engineer has a purpose in his department which when coupled with his unique talent provides service to mankind.

I believe *"the educator must realize in the potential power of his pupil and he must employ all his art, in seeking to bring his pupil to experience this power".* To support dreams of every engineer and to make efficient use of capabilities of aspirant, MADE EASY team has put sincere efforts in compiling all the previous years' ESE-Pre questions with accurate and detailed explanation. The objective of this book is to facilitate every aspirant in ESE preparation and so, questions are segregated chapterwise and topicwise to enable the student to do topicwise preparation and strengthen the concept as and when they are read.

I would like to acknowledge efforts of entire MADE EASY team who worked hard to solve previous years' papers with accuracy and I hope this book will stand up to the expectations of aspirants and my desire to serve student fraternity by providing best study material and quality guidance will get accomplished.

B. Singh (Ex. IES)
CMD, MADE EASY Group

Volume-I

ELECTRONICS & TELECOM. ENGG.

Objective Solved Questions

of UPSC Engineering Services Examination

Contents

■■■■

UNIT

I

Network Theory

Syllabus

Network graphs & matrices; Wye-Delta transformation; DC circuits-Ohm's & Kirchhoff's laws, mesh and nodal analysis, circuit theorems; Linear constant coefficient differential equations- time domain analysis of RLC circuits; Solution of network equations using Laplace transforms- frequency domain analysis of RLC circuits; 2-port network parameters-driving point & transfer functions; State equations for networks; Single-phase AC circuits, Steady state sinusoidal analysis.

Contents

1 Basics of Network Analysis

1.1 An ideal constant voltage source is connected in series with an ideal constant current source. Considered together, the combination will be a
(a) constant voltage source
(b) constant current source
(c) constant voltage and a constant current source or a constant power source
(d) resistance

[ESE-1999]

1.2 The circuit shown in Figure-I is replaced by that in Figure-II. If current 'I' remains the same, then R_0 then will be

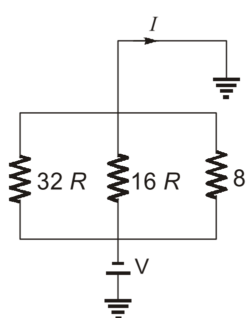


Figure I

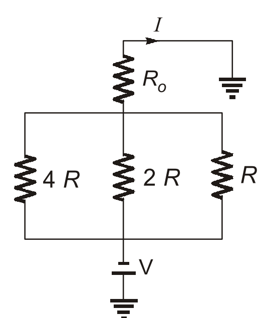


Figure II

(a) zero (b) R
(c) $2R$ (d) $4R$

[ESE-1999]

1.3 If the Π-network of Figure-I and T-network of Figure-II are equivalent, then the values of R_1, R_2 and R_3 will be respectively

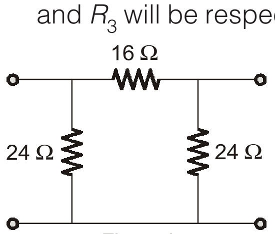


Figure I

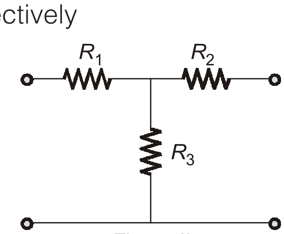
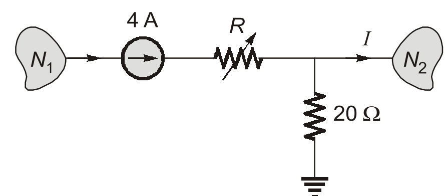


Figure II

(a) 9 Ω, 6 Ω and 6 Ω
(b) 6 Ω, 6 Ω and 9 Ω
(c) 9 Ω, 6 Ω and 9 Ω
(d) 6 Ω, 9 Ω and 6 Ω

[ESE-1999]

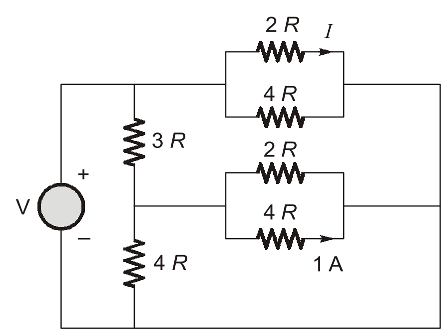
1.4 In the circuit shown in the figure, for R = 20 Ω the current 'I' is 2 A. When R is 10 Ω, the current 'I' would be



(a) 1 A (b) 2 A
(c) 2.5 A (d) 3 A

[ESE-1999]

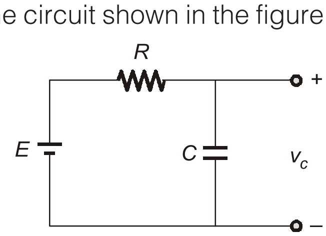
1.5 For the circuit shown in the figure, the current 'I' is



(a) indeterminable due to inadequate data
(b) zero
(c) 4 A
(d) 8 A

[ESE-1999]

1.6 Consider the following sets of values of E, R and C of the circuit shown in the figure



1. 2 V, 1 Ω and 1.25 F
2. 1.6 V, 0.8 Ω and 1 F
3. 1.6 V, 1 Ω and 0.8 F
4. 2 V, 1.25 Ω and 1 F

Which of these sets of E, R and C values will ensure that the state equation, $dv_c/dt = -1.25\ v_c + 2$ is valid?

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

[ESE-1999]

1.7 If a coil has diameter 'd', number of turns 'N' and form factor 'F' then the inductance of the coil is proportional to

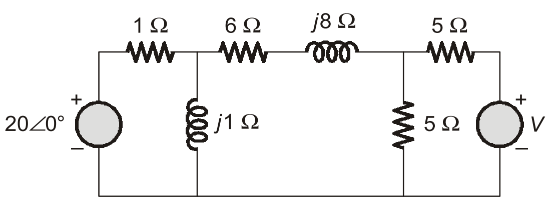
(a) N^2dF (b) Nd^2F
(c) N^2d^2/F (d) N^2d/F [ESE-2000]

1.8 A coil would behave as

(a) an inductor at high frequencies
(b) a capacitor at very low frequencies
(c) a capacitor at very high frequencies
(d) a resistor at high frequencies

[ESE-2000]

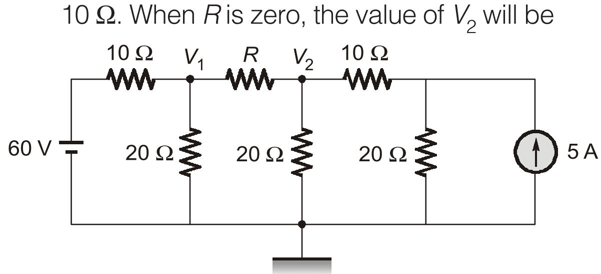
1.9 In the circuit shown below, if the power dissipated in the 6 Ω resistor is zero then V is



(a) $20\sqrt{2}\angle 45°$ (b) $20\angle 30°$
(c) $20\angle 45°$ (d) $20\sqrt{2}\angle 30°$

[ESE-2000]

1.10 In the circuit shown below, V_1 = 40 V when R is 10 Ω. When R is zero, the value of V_2 will be



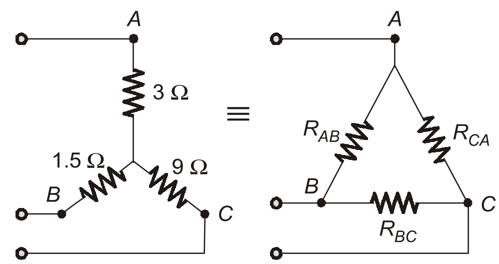
(a) 40 V (b) 30 V
(c) 20 V (d) 10 V [ESE-2000]

1.11 A network contains only independent current sources and resistors. If the values of all resistors are doubled, the values of the node voltages

(a) will become half
(b) will remain unchanged
(c) will become double
(d) cannot be determined unless the circuit configuration and the values of the resistors are known

[ESE-2000]

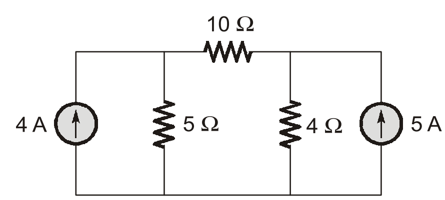
1.12 For the equivalent Δ Figure circuit shown in the given figure, the values of R_{AB} and R_{BC} are respectively



(a) 5 Ω and 15 Ω (b) 15 Ω and 30 Ω
(c) 30 Ω and 5 Ω (d) 20 Ω and 35 Ω

[ESE-2001]

1.13 In the circuit shown in the given figure, power dissipated in the 5 Ω resistor is



(a) zero (b) 80 W
(c) 125 W (d) 405 W

[ESE-2001]

1.14 Consider the following:

Energy storage capability of basic passive elements is due to the fact that

1. resistance dissipates energy
2. capacitance stores energy
3. inductance dissipates energy

Which of the above is/are correct?

(a) 1, 2 and 3 (b) 1 and 3
(c) 3 alone (d) 1 and 2

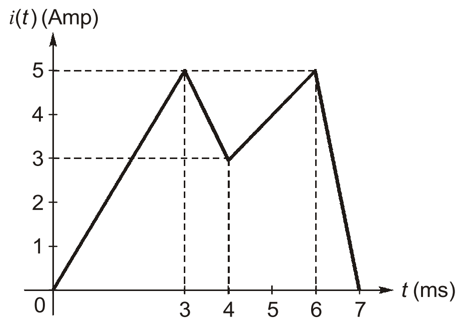
[ESE-2002]

1.15 $\sqrt{\frac{L}{C}}$ has the dimension of

(a) time (b) capacitance
(c) inductance (d) resistance

[ESE-2002]

1.16 A current $i(t)$ as shown in the figure is passed through a capacitor.

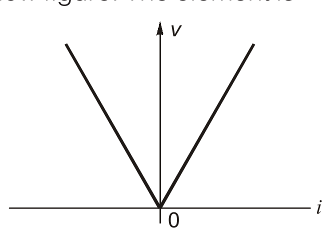


The charge (in micro-coulomb) acquired by the capacitor after 5 μs is

(a) 7.5 (b) 13.5
(c) 14.5 (d) 15

[ESE-2002]

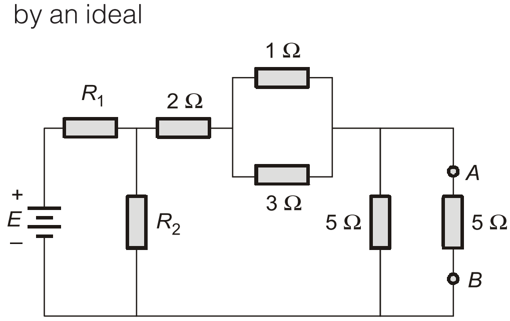
1.17 The v-i characteristic of an element is shown in the below figure. The element is



(a) Non-linear, active, non-bilateral
(b) Linear, active, non-bilateral
(c) Non-linear, passive, non-bilateral
(d) Non-linear, active, bilateral

[ESE-2003]

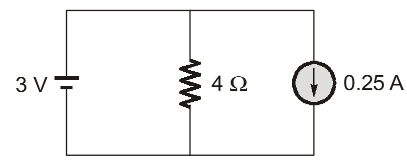
1.18 In the circuit shown below, the voltage across 2 Ω resistor is 20 V. The 5 Ω resistor connected between the terminals *A* and *B* can be replaced by an ideal



(a) Voltage source of 25 V with + terminal upward
(b) Voltage source of 25 V with + terminal downward
(c) Current source of 2 A upward
(d) Current source of 2 A downward

[ESE-2003]

1.19 The current flowing through the voltage source in the circuit shown below is



(a) 1.0 A (b) 0.75 A
(c) 0.5 A (d) 0.25 A

[ESE-2003]

1.20 Match **List-I** (Quantities) with **List-II** (Units) and select the correct answer:

List-I	List-II
A. R/L	**1.** Second
B. $1/LC$	**2.** Ohm
C. CR	**3.** $(\text{Radian/Second})^2$
D. $\sqrt{L/C}$	**4.** $(\text{Second})^{-1}$

Codes:

	A	B	C	D
(a)	4	3	1	2
(b)	3	4	2	1
(c)	4	3	2	1
(d)	3	4	1	2

[ESE-2003]

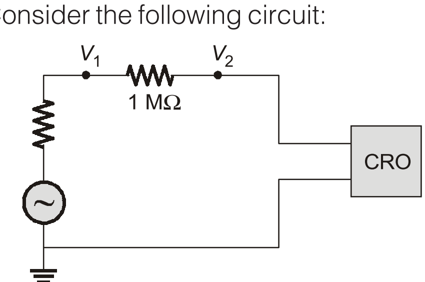
1.21 **Assertion (A):** Kirchhoff's voltage law states that a closed path in a network, the algebraic sum of all voltages in a single direction is zero.

Reason (R): Law of conservation of charge is the basis of this law.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2003]

1.22 Consider the following circuit:

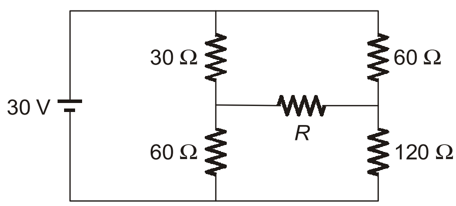


If V_1 = 5 V and V_2 = 3 V, then what is the input impedance of the CRO in the above circuit?

(a) 1 MΩ (b) 1.5 MΩ
(c) 3 MΩ (d) 5 MΩ

[ESE-2004]

1.23 Consider the following circuit:

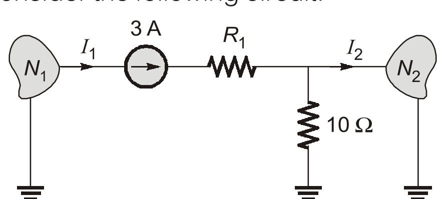


What is the power delivered to resistor R in the above circuit?

(a) –15 W
(b) 0 W
(c) 15 W
(d) Cannot be determined unless the value of R is known

[ESE-2004]

1.24 Consider the following circuit:

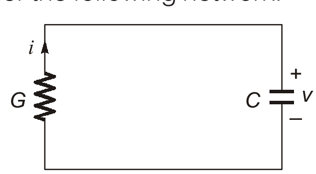


In the above circuit, the current I_2 is 2 A when the value of R_1 is 20 Ω. What will be the value of I_2, when R_1 is changed to 10 Ω?

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

[ESE-2004]

1.25 Consider the following network:



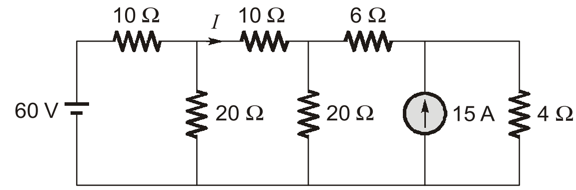
Which one of the following is the differential equation for v in the above network?

(a) $C\frac{dv}{dt} + Gv = 0$ (b) $G\frac{dv}{dt} + Cv = 0$

(c) $\frac{1}{C}\frac{dv}{dt} + Gv = 0$ (d) $C\frac{dv}{dt} - Gv = 0$

[ESE-2004]

1.26 Consider the following circuit:



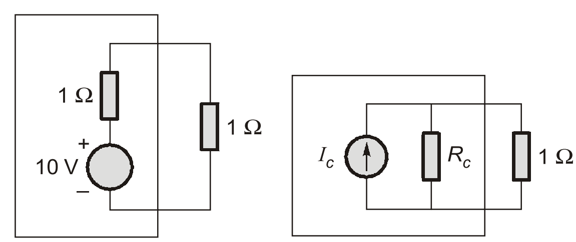
What is the current I in the above circuit?

(a) 0 A (b) 2 A
(c) 5 A (d) 6 A **[ESE-2004]**

1.27 Which one of the following statements is correct?
In a four-branch parallel circuit, 50 mA current flows in the each branch. If one of the branches opens, the current in the other branches

(a) increase (b) decrease
(c) are unaffected (d) double **[ESE-2004]**

1.28 Consider the following statements:
Network N_A in Fig. (a) can be replaced by the network N_B shown in Fig. (b) below, when I_c and R_c, respectively, are:



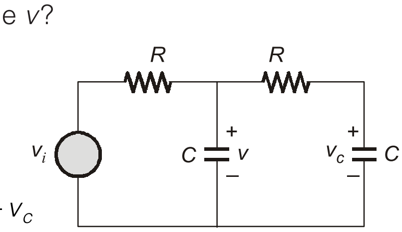
N_A Fig. (a) N_B Fig. (b)

1. 5 A and 2 Ω 2. 10 A and 1 Ω
3. 15 A and 1/2 Ω 4. 30 A and 1/5 Ω

Which of the following statements given above is/are correct?

(a) 1 only (b) 2, 3 and 4
(c) 1, 2, 3 and 4 (d) 2 and 3 **[ESE-2005]**

1.29 For the circuit given below, what is the expression for the voltage v?



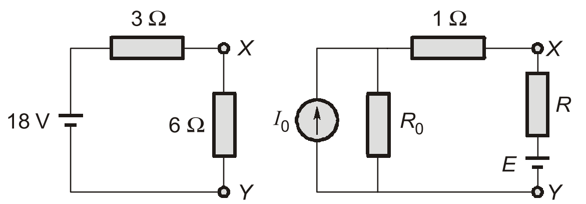
(a) $v + v_c$

(b) v_c

(c) $RC\frac{dv_c}{dt} - v_c$

(d) $RC\frac{dv_c}{dt} + v_c$ **[ESE-2005]**

1.30 If the two circuits shown below are equivalent, then which of the following is/are correct?



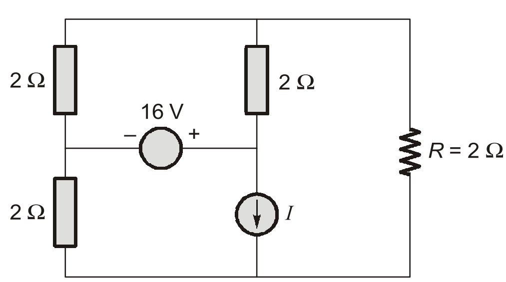
1. $E = 2$ V, $R = 5\ \Omega$
2. $E = 4$ V, $R = 4\ \Omega$
3. $E = 6$ V, $R = 3\ \Omega$
4. $E = 10$ V, $R = 1\ \Omega$

Select the correct answer using the codes given below:

(a) Only 1 and 2 (b) Only 3
(c) 1, 2, 3 and 4 (d) None of these

[ESE-2006]

1.31 In the circuit shown below, if the current through the resistor R is zero, what is the value of I?



(a) 1 A (b) 2 A
(c) 3 A (d) 4 A [ESE-2007]

1.32 Consider a circuit which consists of resistors and independent current sources, and one independent voltage source connected between the nodes i and j. The equations are obtained for voltage of n unknown nodes with respect to one reference node in the form

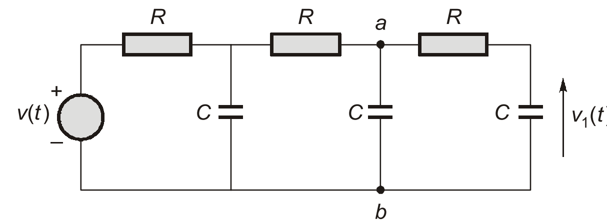
$$[\Delta]\begin{bmatrix} V_1 \\ V_2 \\ \vdots \\ V_n \end{bmatrix} = \begin{bmatrix} \vdots \\ \vdots \\ \vdots \\ \vdots \end{bmatrix}$$

What are the elements of the Δ?

(a) All conductances
(b) All resistances
(c) Mixed conductances
(d) Mixed conductances and resistances

[ESE-2008]

1.33 In the circuit shown below, what is the voltage $v_{ab}(t)$?



(a) $\dfrac{dv_1}{dt} + v_1$ (b) v_1

(c) $\dfrac{dv_1}{dt} + RCv_1$ (d) $RC\dfrac{dv_1}{dt} + v_1$

[ESE-2008]

1.34 In a network containing active components, output voltage

(a) will always be greater than input voltage
(b) will always be equal to the input voltage
(c) can be less than or greater than input voltage only
(d) will be less than, equal to or greater than input voltage

[ESE-2008]

1.35 **Assertion (A):** The Kirchhoff's current law states that the sum of currents entering at any node is equal to the sum of currents leaving that node.

Reason (A): The Kirchhoff's current law is based on the law of conservation of charge.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true [ESE-2008]

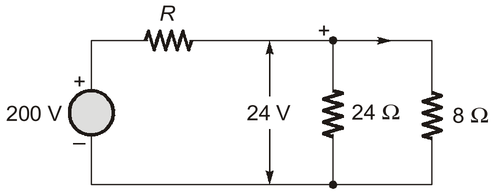
1.36 **Assertion (A) :** Ideal current sources and ideal voltage sources do not exist in reality.

Reason (R) : All sources have finite internal impedances.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2009]

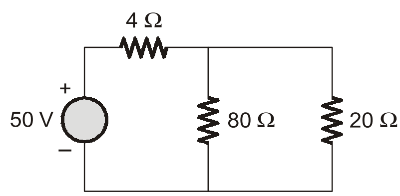
1.37 The value of R in the below circuit is



(a) 4 Ω (b) 40 Ω
(c) 44 Ω (d) 440 Ω

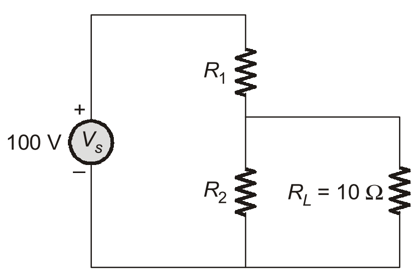
[ESE-2010]

1.38 The value of current in 80 Ω resistor of below circuit is



(a) 0.5 A (b) 2.0 A
(c) 5.0 A (d) 20.0 A [ESE-2010]

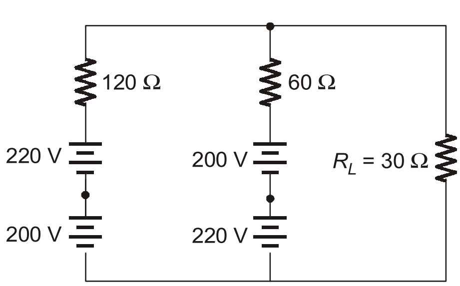
1.39 What is the voltage across the load resistance, R_L in the below circuit? The value of each resistor connected in the circuit is 10 Ω.



(a) 3.33 V (b) 33.33 V
(c) 333.33 V (d) 0 V

[ESE-2010]

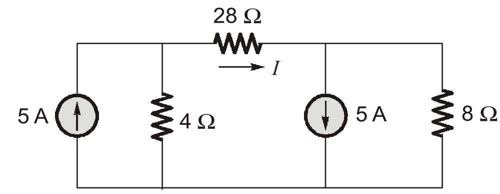
1.40 In the circuit shown below, the current through R_L is



(a) 6 A (b) 4 A
(c) 2 A (d) 0

[ESE-2010]

1.41 In the circuit shown below, the current I is



(a) 1 A (b) 1.5 A
(c) 2.5 A (d) 4 A

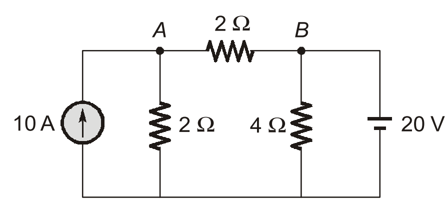
[ESE-2010]

1.42 It is required to find the current through a particular branch of a linear bilateral network without mutual coupling when the branch impedance takes four different values. Which one of the following methods will be preferred?

(a) Mesh analysis
(b) Thevenin's equivalent circuit
(c) Nodal analysis
(d) Superposition theorem

[ESE-2010]

1.43 The current through the branch AB in the figure shown is

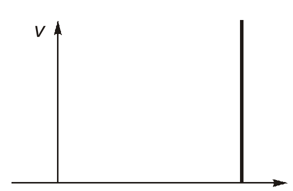


(a) 10 A, from A to B
(b) 10 A, from B to A
(c) 0
(d) 20 A, from B to A

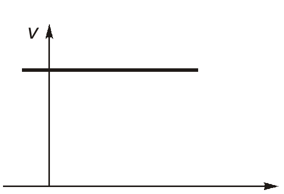
[ESE-2011]

1.44 Which one of the following gives the V-I characteristic of an ideal voltage source?

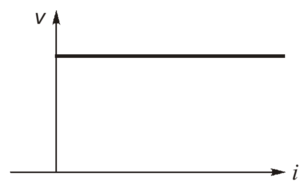
(a)



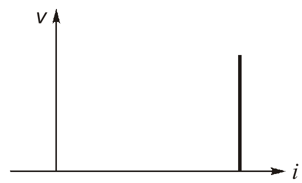
(b)



(c)

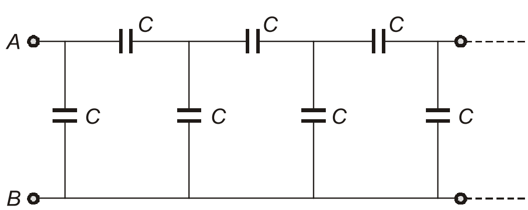


(d)



[ESE-2011]

1.45 The effective capacitance across *AB* of the infinite ladder shown in the below figure is



(a) $(1+\sqrt{3})C$ (b) $(1+\sqrt{7})C$

(c) $(1+\sqrt{5})C$ (d) $\frac{(1+\sqrt{5})}{2}C$

[ESE-2012]

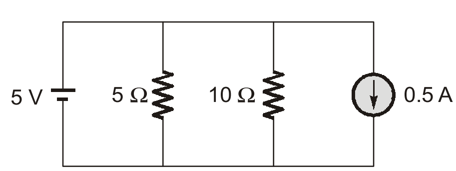
1.46 A capacitor of capacitance *C* is charged by connecting it to a battery of emf *E*. The capacitor is now disconnected and reconnected to the battery with the polarity reversed. The heat developed in the connecting wires is

(a) $0.5\ CE^2$ (b) CE^2

(c) $2\ CE^2$ (d) $3\ CE^2$

[ESE-2012]

1.47 The total resistance faced by the voltage source having zero internal resistance in the circuit is

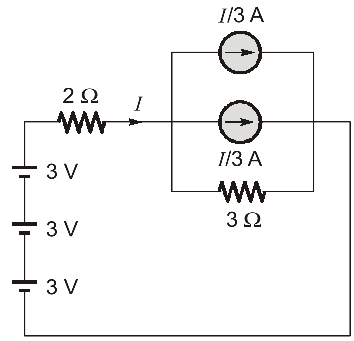


(a) 10 Ω (b) 5 Ω

(c) 2.5 Ω (d) 1.5 Ω

[ESE-2012]

1.48 In the circuit, the voltage across 3 Ω resistance is

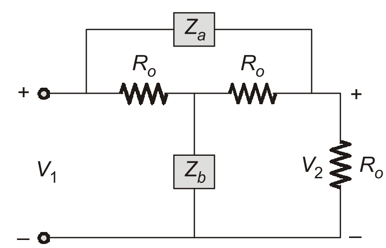


(a) 1 V (b) 3 V

(c) 6 V (d) 9 V

[ESE-2012]

1.49 The condition under which the input impedance at port 1 for the below network will be equal to R_o is



(a) $Z_a + Z_b = R_o$ (b) $Z_a Z_b = R_o^2$

(c) $Z_a/Z_b = 1$ (d) $Z_b/Z_a = 1/2$

[ESE-2012]

1.50 A coil of inductance 2 H and resistance 1 Ω is connected to a 10 V battery with negligible internal resistance. The amount of energy stored in the magnetic field is

(a) 8 J (b) 50 J

(c) 25 J (d) 100 J [ESE-2013]

1.51 The total capacitance of two capacitors is 25 F when connected in parallel and 4 F when connected in series. The individual capacitances of the two capacitors are

(a) 1 F and 24 F (b) 3 F and 21 F

(c) 5 F and 20 F (d) 10 F and 15 F

[ESE-2013]

1.52 Two lamps each of 230 V and 60 W rating are connected in series across a single phase 230 V supply. The total power consumed by the two lamps would be

(a) 120 W (b) 60 W

(c) 30 W (d) 15 W

[ESE-2013]

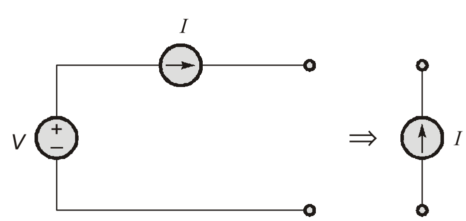
Answers Basics of Network Analysis

1.1 (b)	1.2 (d)	1.3 (b)	1.4 (b)	1.5 (d)	1.6 (d)	1.7 (c)	1.8 (c)	1.9 (a)
1.10 (a)	1.11 (c)	1.12 (a)	1.13 (b)	1.14 (d)	1.15 (d)	1.16 (d)	1.17 (a)	1.18 (a)
1.19 (a)	1.20 (a)	1.21 (c)	1.22 (b)	1.23 (b)	1.24 (b)	1.25 (a)	1.26 (a)	1.27 (c)
1.28 (b)	1.29 (d)	1.30 (c)	1.31 (d)	1.32 (a)	1.33 (d)	1.34 (c)	1.35 (a)	1.36 (a)
1.37 (c)	1.38 (a)	1.39 (b)	1.40 (a)	1.41 (b)	1.42 (b)	1.43 (c)	1.44 (b)	1.45 (d)
1.46 (c)	1.47 (c)	1.48 (b)	1.49 (b)	1.50 (d)	1.51 (c)	1.52 (c)	1.53 (d)	1.54 (d)
1.55 (b)	1.56 (a)	1.57 (c)	1.58 (d)	1.59 (c)	1.60 (b)	1.61 (c)	1.62 (d)	1.63 (b)
1.64 (b)	1.65 (c)	1.66 (d)	1.67 (d)	1.68 (c)	1.69 (d)	1.70 (a)	1.71 (c)	1.72 (b)
1.73 (a)	1.74 (*)	1.75 (d)	1.76 (a)	1.77 (c)	1.78 (a)	1.79 (c)	1.80 (d)	1.81 (c)
1.82 (a)	1.83 (d)	1.84 (d)	1.85 (b)	1.86 (c)	1.87 (b)	1.88 (c)	1.89 (b)	1.90 (a)
1.91 (c)	1.92 (b)	1.93 (b)						

Explanations Basics of Network Analysis

1.1 (b)

Ideal current-source in series with any element is redundant



1.2 (d)

From fig. I, $R'_{eq} = \dfrac{1}{\dfrac{1}{32R}+\dfrac{1}{16R}+\dfrac{1}{8R}} = \dfrac{32R}{7}$

From fig. II, $R''_{eq} = \dfrac{1}{\dfrac{1}{4R}+\dfrac{1}{2R}+\dfrac{1}{R}} = \dfrac{4R}{7}$

equating both

$$R'_{eq} = R''_{eq} + R_0$$

$$\Rightarrow \quad R_0 = \frac{32R}{7} - \frac{4R}{7} = \frac{28R}{7} = 4R$$

1.3 (b)

Equivalent T-network impedances are

$$R_1 = \frac{24\times 16}{24+16+24} = \frac{24\times 16}{64} = 6\ \Omega$$

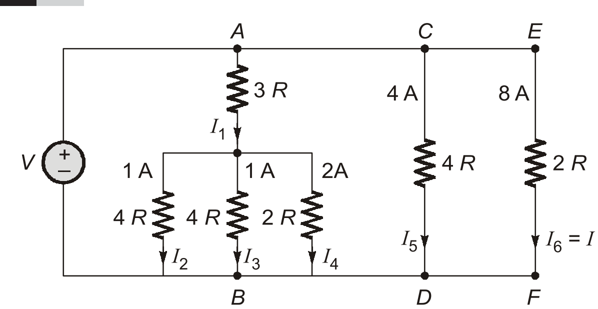
$$R_2 = \frac{24\times 16}{24+16+24} = \frac{24\times 16}{64} = 6\ \Omega$$

$$R_3 = \frac{24\times 24}{24+16+24} = \frac{24\times 24}{64} = 9\ \Omega$$

1.4 (b)

The current 'I' is independent of R. So, it will remain 2 A.

1.5 (d)



Given, $I_3 = 1$ A

then $I_2 = 1$ A

$I_4 = 2$ A

Using KCL, $I_1 = 1 + 1 + 2 = 4$ A

Equivalent resistance of branch AB

$R_{AB} = 3R + 4R \parallel 4R \parallel 2R$

$R_{AB} = 4R$

$I_5 = I_1 = 4$ A $\qquad (\therefore R_{CD} = R_{AB})$

then $I_6 = 8$ A $= I$

1.6 (d)

Applying KVL,

$-E + Ri + v_c = 0$

But, $i = C\dfrac{dv_c}{dt}$

So, $-E + RC\dfrac{dv_c}{dt} + v_c = 0$

$$\frac{dv_c}{dt} = \frac{E}{RC} - \frac{v_c}{RC}$$

Comparing with the given equation, i.e.

$$\frac{dv_c}{dt} = 1.25v_c + 2$$

$$\frac{1}{RC} = 1.25 \quad \text{... (i)}$$

$$\frac{E}{RC} = 2 \quad \text{... (ii)}$$

The values given in sets 2 & 3 satisfy the above equations.

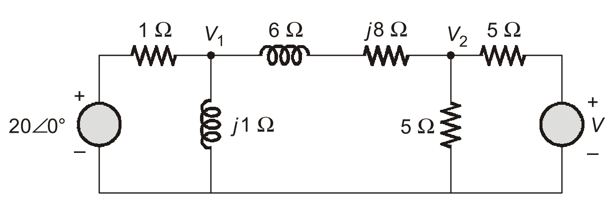
1.7 (c)

Inductance, $L \propto \dfrac{N^2 A}{F}$

But $A = \pi d^2/4$

$\therefore \quad L \propto \dfrac{N^2 d^2}{F}$

1.9 (a)



$$V_1 = \frac{j1}{1+j1}\cdot 20\angle 0^\circ$$

$\Rightarrow \quad V_1 = \dfrac{20}{\sqrt{2}}\angle 45^\circ$

Power dissipated in 6 Ω resistor is zero.

⇒ current through 6 Ω resistor is zero.

$\Rightarrow \quad V_1 = V_2$

$$V_2 = \frac{20}{\sqrt{2}}\angle 45^\circ = \frac{5}{5+5}\cdot V = \frac{V}{2}$$

$\Rightarrow \quad V = 20\sqrt{2}\angle 45^\circ$

1.10 (a)

V_1 is independent of R.

when $R = 0$, $V_1 = 40$ V

Since $R = 0$, so $V_1 = V_2$

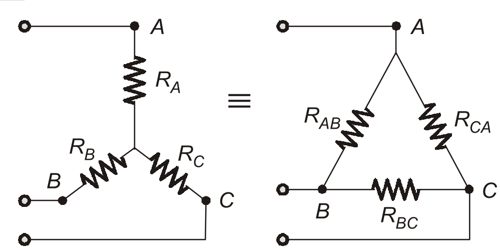
$\Rightarrow \quad V_2 = 40$ V

1.11 (c)

Since the network contains only independent current sources, so changing all resistors in the same proportion the current through each branch will remain same but node voltages will change in the same proportion. Hence, doubling all resistors, node voltages will be doubled.

Note: If there are only independent voltage sources, then doubling all resistors, the node voltages will remain same but the current through each branch will be half.

1.12 (a)



$$R_{AB} = R_A + R_B + \frac{R_A R_B}{R_C}$$

$$R_A = \frac{R_{AB}\times R_{CA}}{R_{AB}+R_{BC}+R_{CA}}$$

$$R_{AB} = 3 + 1.5 + \frac{3\times 1.5}{9}$$

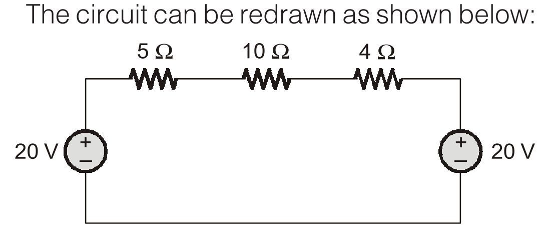
$= 3 + 1.5 + 0.5 = 5$ Ω

$$R_{BC} = 9 + 1.5 + \frac{9\times 1.5}{3}$$

$= 9 + 1.5 + 4.5 = 15$ Ω

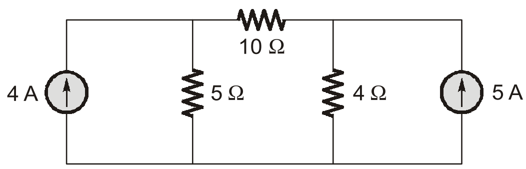
1.13 (b)

The circuit can be redrawn as shown below:



Net current in 10 Ω resistor is zero.

The whole 4 A current flows only through 5 Ω resistor.



Power dissipated in the 5 Ω resistor,

$$P = (4)^2\, 5 = 80 \text{ W}$$

1.14 (d)

Resistance dissipates energy and inductance and capacitance store the energy.

1.15 (d)

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

$$L = V_L\frac{dt}{di} \text{ V sec/A}$$

$$i = C\frac{dv}{dt}$$

$$C = i\times\frac{dt}{dv} \text{ A sec/V}$$

$$\sqrt{\frac{L}{C}} = \sqrt{\frac{\text{V sec/A}}{\text{A sec/V}}}$$

$$= \sqrt{\frac{\text{V sec}}{\text{A}}\times\frac{\text{V}}{\text{A sec}}} = \frac{V}{R} = R$$

1.16 (d)

Charge $q(t) = \int i(t)dt$

= Area under the curve from $t = 0$ to $t = 5$.

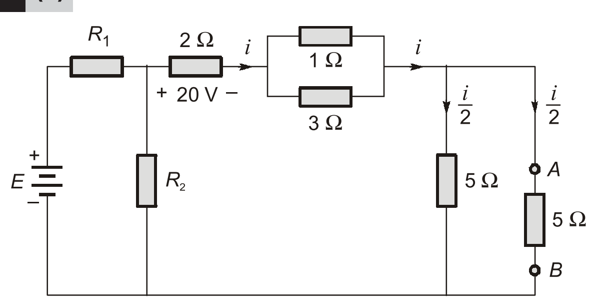
$$= \frac{1}{2}\times5\times3+\frac{1}{2}\times(5+3)\times1+\frac{1}{2}\times(3+4)\times1$$

$$= \frac{1}{2}(15+8+7)\mu\text{C} = 15\ \mu\text{C}$$

1.17 (a)

Slope of the characteristic is negative between –∞ to 0; so characteristic is of active element.

1.18 (a)



The current through 2 Ω resistor,

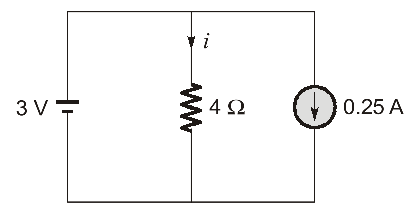
$$i = \frac{20}{2} = 10 \text{ A}$$

This current will divide equally in both 5 Ω resistors.

$$V_{AB} = 5\times5 = 25 \text{ V}$$

So, the 5 Ω resistor connected between the terminals A and B can be replaced by an ideal voltage source of 25 V with +ve terminal upward.

1.19 (a)



$$i = \frac{3}{4} = 0.75 \text{ A}$$

Current flowing through the voltage source

$$= 0.75 + 0.25 = 1 \text{ A}$$

1.20 (a)

(i) Time constant

$\tau = \frac{L}{R} = CR$ (measured in seconds)

(ii) $\omega = \frac{1}{\sqrt{LC}}$ (measured in rad/s)

(iii) $\sqrt{\frac{L}{C}} = R$ (measured in Ohms)

1.21 (c)

(i) KVL is based on the law of conservation of energy.
(ii) KCL is based on the law of conservation of charge.

1.22 (b)

Current flowing through 1 MΩ resistor,

$$i = \frac{V_1-V_2}{10^6} = \frac{5-3}{10^6} = 2\ \mu\text{A}$$

Input impedance of the CRO,

$$Z_{in} = \frac{V_2}{i} = \frac{3}{2} = 1.5 \text{ M}\Omega$$

1.23 (b)

It is a balanced Wheatstone bridge. The current through R is zero. So power delivered to R is zero.

1.24 (b)

I_2 is independent of R_1. So, I_2 will remain 2 A whatever be the value of R_1.

1.25 (a)

$$i = C\frac{dv}{dt}$$

Applying KVL,

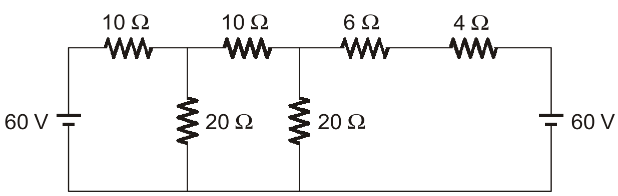
$$\frac{1}{G}i + v = 0$$

$$\Rightarrow \quad i + Gv = 0$$

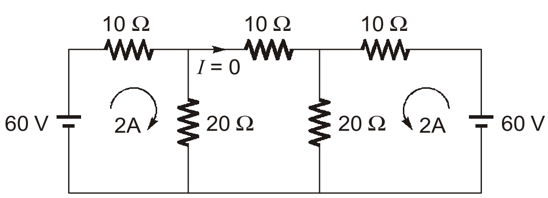
$$\Rightarrow \quad C\frac{dv}{dt} + Gv = 0$$

1.26 (a)

Using source transformation, the circuit is redrawn.



Further,



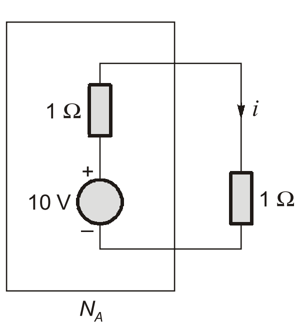
It is a symmetrical network.

So, $\quad I = 0$.

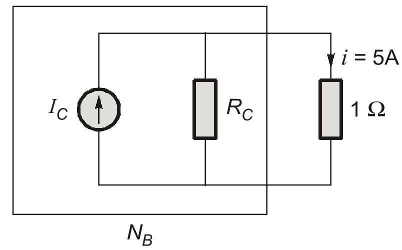
1.27 (c)

Since, it being parallel circuit, the voltage across each branch is fixed and will not change on opening one of the branches. Since $V = iR$, therefore, currents in the other branches are also unaffected.

1.28 (b)



$$i = \frac{10}{1+1} = 5\text{ A}$$



$$i = 5 = \frac{R_C}{R_C + 1} \cdot I_C$$

Following values satisfy the above equation.

(i) 10 A and 1 Ω

(ii) 15 A and $\frac{1}{2}\Omega$

(iii) 30 A and $\frac{1}{5}\Omega$

1.29 (d)

$$-v + Ri + v_c = 0$$

$$\Rightarrow -v + RC\frac{dv_c}{dt} + v_c = 0$$

$$\Rightarrow v = RC\frac{dv_c}{dt} + v_c$$

1.30 (c)

$$V_{XY} = \frac{6}{6+3} \times 18 = 12\text{ V}$$

Current through terminal X-Y is I = $\frac{18}{9}$ = 2A.

$$V_{XY} = IR + E$$

$$V_{XY} = 2R + E$$

Putting the values given,

(i) $2 \times 5 + 2 = 12$

(ii) $2 \times 4 + 4 = 12$

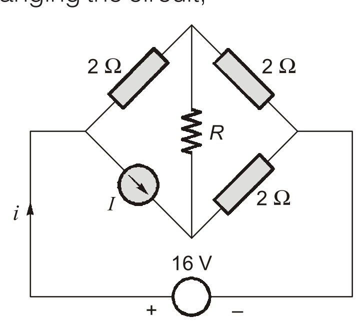
(iii) $2 \times 3 + 6 = 12$

(iv) $2 \times 1 + 10 = 12$

All values satisfy the equation.

1.31 (d)

Rearranging the circuit,



The given circuit is a Wheatstone's bridge. So, the current source I can be replaced by 2 Ω.

$$i = \frac{16}{R_{eq}}$$

where, $R_{eq} = (2 + 2) \parallel (2 + 2) = 2\ \Omega$

$$i = \frac{16}{2} = 8\ \text{A}$$

The current i will divide equally because the network is symmetric.

Therefore, $I = 4$ A.

1.33 (d)

$$v_{ab}(t) = Ri + v_1(t)$$

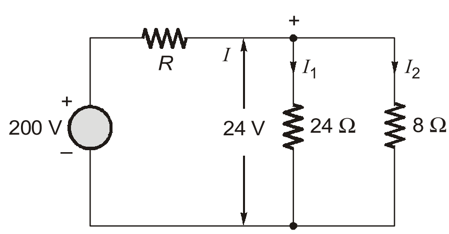
but $$i = C \cdot \frac{dv_1(t)}{dt}$$

So, $$v_{ab}(t) = RC\frac{dv_1}{dt} + v_1$$

1.34 (c)

Active element has property of internal amplification.

1.37 (c)



$$I_1 = \frac{24}{24} = 1\ \text{A}$$

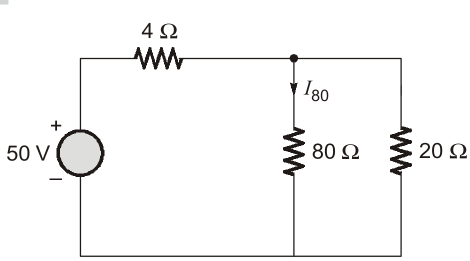
$$I_2 = \frac{24}{8} = 3\ \text{A}$$

$\therefore$ $$I = I_1 + I_2 = 1 + 3 = 4\ \text{A}$$

Now $$I = \frac{200 - 24}{R} = 4$$

$\Rightarrow$ $$R = \frac{176}{4} = 44\ \Omega$$

1.38 (a)



Applying KCL at node 1,

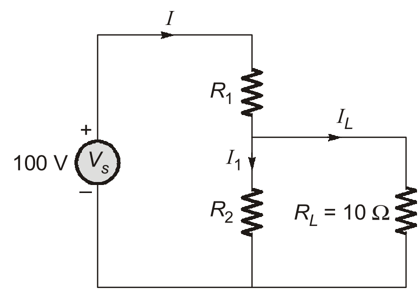
$$\frac{V_1 - 50}{4} + \frac{V_1}{80} + \frac{V_1}{20} = 0$$

$$V_1 = 40\ \text{V}$$

$\therefore$ $$I_{80} = \frac{V_1}{80} = \frac{40}{80}$$

$$I_{80} = 0.5\ \text{A}$$

1.39 (b)



Given, $R_1 = R_2 = R_L = 10\ \Omega$

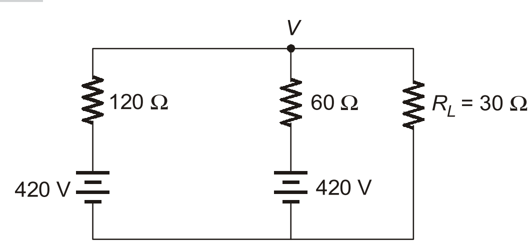
$$I = \frac{100}{R_1 + \frac{R_2 \times R_L}{R_2 + R_L}} = \frac{100}{10 + 5} = \frac{100}{15}$$

$\therefore$ $$I_L = I_1 = \frac{I}{2} = \frac{100}{30}\ \text{A}$$

So, voltage across R_L

$$V_L = I_L R_L = \frac{100}{30} \times 10 = 33.333\ \text{V}$$

1.40 (a)



Applying KCL at node V

$$\frac{V - 420}{120} + \frac{V - 420}{60} + \frac{V}{30} = 0$$

$$\frac{V}{120} + \frac{V}{60} + \frac{V}{30} = \frac{420}{120} + \frac{420}{60}$$

$$V = 180\ \text{volt}$$

$\therefore$ Current through R_L is

$$I_L = \frac{V}{R_L} = \frac{180}{30} = 6\ \text{A}$$