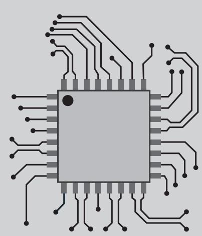
30 Years
Previous Solved Papers

GATE 2024

Electronics Engineering



- Fully solved with explanations
- Analysis of previous papers
- Topicwise presentation
- Thoroughly revised & updated

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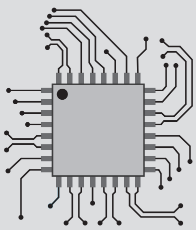

GATE - 2024

Electronics Engineering

Topicwise Previous GATE Solved Papers (1994-2023)

Editions

1st Edition	:	2007
2nd Edition	:	2008
3rd Edition	:	2009
4th Edition	:	2010
5th Edition	:	2011
6th Edition	:	2012
7th Edition	:	2013
8th Edition	:	2014
9th Edition	:	2015
10th Edition	:	2016
11th Edition	:	2017
12th Edition	:	2018
13th Edition	:	2019
14th Edition	:	2020
15th Edition	:	2021
16th Edition	:	2022
17th Edition	**:**	**2023**

Preface

B. Singh (Ex. IES)

Over the period of time the GATE examination has become more challenging due to increasing number of candidates. Though every candidate has ability to succeed but competitive environment, in-depth knowledge, quality guidance and good source of study is required to achieve high level goals.

The new edition of **GATE 2024 Solved Papers : Electronics Engineering** has been fully revised, updated and edited. The whole book has been divided into topicwise sections.

At the beginning of each subject, analysis of previous papers are given to improve the understanding of subject.

I have true desire to serve student community by way of providing good source of study and quality guidance. I hope this book will be proved an important tool to succeed in GATE examination. Any suggestions from the readers for the improvement of this book are most welcome.

B. Singh (Ex. IES)
Chairman and Managing Director
MADE EASY Group

GATE-2024

Electronics Engineering

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Network Theory

UNIT

I

CONTENTS

Network Theory

Syllabus

Circuit analysis: Node and mesh analysis, superposition, Thevenin's theorem, Norton's theorem, reciprocity. Sinusoidal steady state analysis: phasors, complex power, maximum power transfer. Time and frequency domain analysis of linear circuits: RL, RC and RLC circuits, solution of network equations using Laplace transform. Linear 2-port network parameters, wye-delta transformation.

Analysis of Previous GATE Papers

Exam Year	1 Mark Ques.	2 Marks Ques.	3 Marks Ques.	Total Marks
1994	4	1	–	**6**
1995	8	–	–	**8**
1996	3	1	–	**5**
1997	4	2	1	**11**
1998	6	–	–	**6**
1999	2	3	–	**8**
2000	3	2	–	**7**
2001	3	4	–	**11**
2002	2	2	–	**6**
2003	4	8	–	**20**
2004	5	5	–	**15**
2005	5	6	–	**17**
2006	6	–	–	**6**
2007	2	4	–	**10**
2008	2	7	–	**16**
2009	3	4	–	**11**
2010	2	4	–	**10**
2011	3	3	–	**9**
2012	4	4	–	**12**

Exam Year	1 Mark Ques.	2 Mark Ques.	Total Marks
2013	3	6	**15**
2014 Set-1	2	4	**10**
2014 Set-2	2	2	**6**
2014 Set-3	2	4	**10**
2014 Set-4	2	4	**10**
2015 Set-1	4	3	**10**
2015 Set-2	3	3	**9**
2015 Set-3	3	2	**7**
2016 Set-1	1	2	**5**
2016 Set-2	4	3	**10**
2016 Set-3	1	3	**7**
2017 Set-1	1	2	**5**
2017 Set-2	2	2	**6**
2018	1	3	**7**
2019	1	2	**5**
2020	3	2	**7**
2021	2	4	**10**
2022	2	3	**8**
2023	4	1	**6**

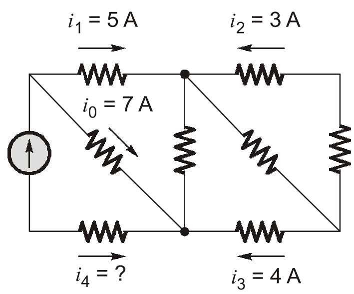
1 Basics of Network Analysis

1.1 Two 2 H inductance coils are connected in series and are also magnetically coupled to each other the coefficient of coupling being 0.1. The total inductance of the combination can be

(a) 0.4 H (b) 3.2 H
(c) 4.0 H (d) 4.4 H

[1995 : 1 M]

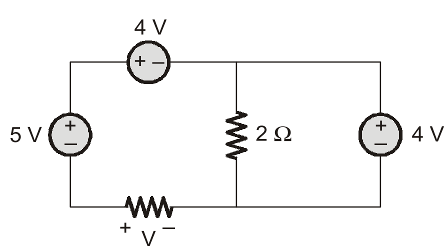
1.2 The current i_4 in the circuit of figure is equal to



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

[1997 : 1 M]

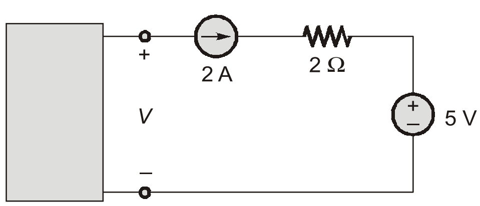
1.3 The voltage V in figure is equal to



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

[1997 : 1 M]

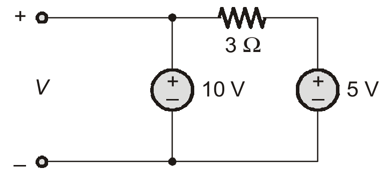
1.4 The voltage V in figure is always equal to



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

[1997 : 1 M]

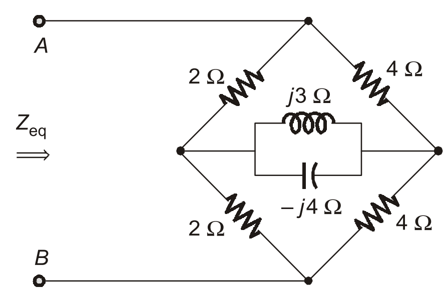
1.5 The voltage V in figure is



(a) 10 V (b) 15 V
(c) 5 V (d) None of the these

[1997 : 1 M]

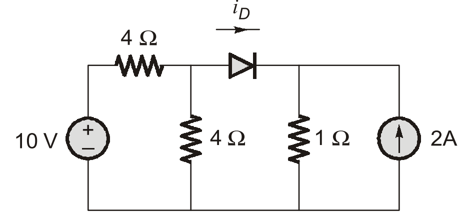
1.6 In the circuit of Fig. the equivalent impedance seen across terminals A, B is



(a) (16/3) Ω (b) (8/3) Ω
(c) (8/3 + 12 j) Ω (d) None of the above

[1997 : 2 M]

1.7 In the circuit shown in the figure the current i_D through the ideal diode (zero cut in voltage and zero forward resistance) equals



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

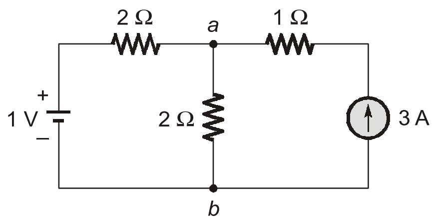
[1997 : 3 Marks]

1.8 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

[1998 : 1 M]

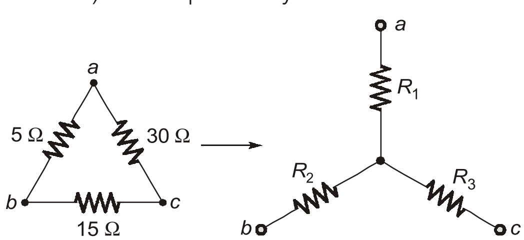
1.9 The voltage across the terminals a and b in Fig. is



(a) 0.5 V (b) 3.0 V
(c) 3.5 V (d) 4.0 V

[1998 : 1 M]

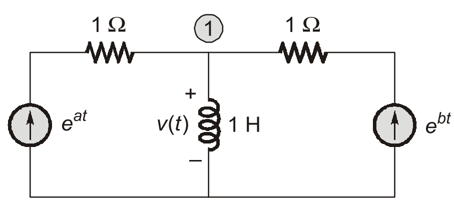
1.10 A Delta-connected network with its Wye-equivalent is shown in the figure. The resistances R_1, R_2 and R_3 (in ohms) are respectively



(a) 1.5, 3 and 9 (b) 3, 9 and 1.5
(c) 9, 3 and 1.5 (d) 3, 1.5 and 9

[1999 : 2 M]

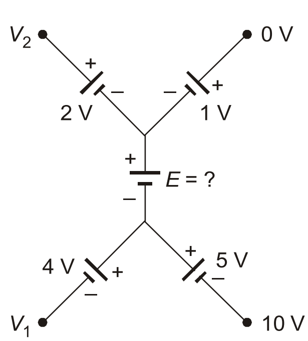
1.11 In the circuit of the figure, the voltage $v(t)$ is



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

[2000 : 1 M]

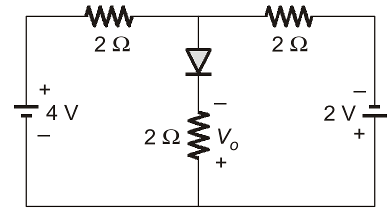
1.12 In the circuit of the figure, the value of the voltage source E is



(a) –16 V (b) 4 V
(c) –6 V (d) 16 V

[2000 : 1 M]

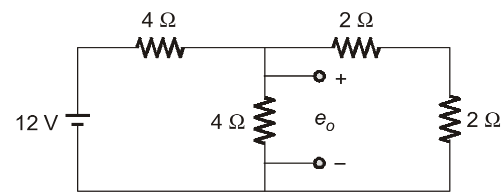
1.13 For the circuit in the figure, the voltage V_o is



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

[2000 : 2 M]

1.14 The voltage e_o in the figure is

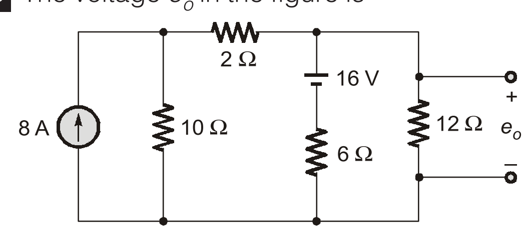


(a) 2 V (b) $\frac{4}{3}$ V
(c) 4 V (d) 8 V [2001 : 1 M]

1.15 If each branch of a Delta circuit has impedance $\sqrt{3}\,Z$, then each branch of the equivalent Wye circuit has impedance.

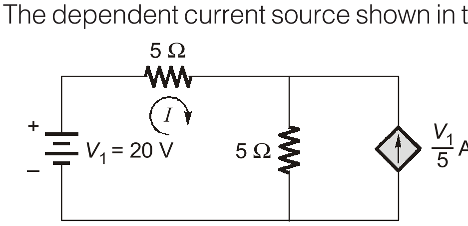
(a) $\frac{Z}{\sqrt{3}}$ (b) $3\,Z$
(c) $3\sqrt{3}\,Z$ (d) $\frac{Z}{3}$ [2001 : 1 M]

1.16 The voltage e_o in the figure is



(a) 48 V (b) 24 V
(c) 36 V (d) 28 V [2001 : 2 M]

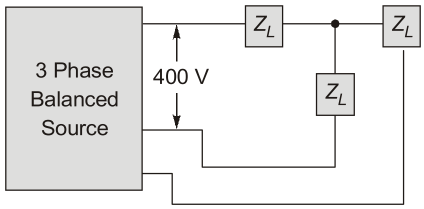
1.17 The dependent current source shown in the figure



(a) delivers 80 W (b) absorbs 80 W
(c) delivers 40 W (d) absorbs 40 W

[2002 : 1 M]

1.18 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

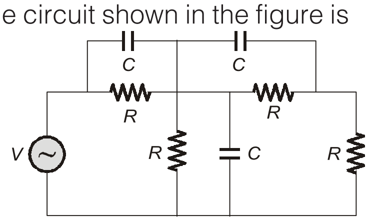


(a) $90\angle 32.44°$ (b) $80\angle 32.44°$
(c) $80\angle -32.44°$ (d) $90\angle -32.44°$

[2002 : 2 M]

1.19 The minimum number of equations required to analyze the circuit shown in the figure is

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

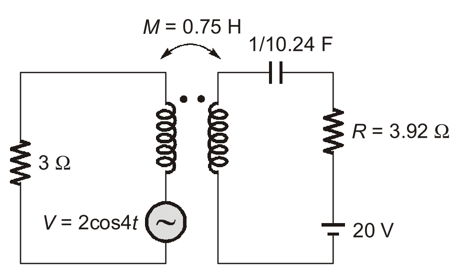


[2003 : 1 M]

1.20 Twelve 1 Ω resistances are used as edges to form a cube. The resistance between two diagonally opposite corners of the cube is

(a) $\frac{5}{6}$ Ω (b) 1 Ω
(c) $\frac{6}{5}$ Ω (d) $\frac{3}{2}$ Ω [2003 : 2 M]

1.21 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) $-(0.192 + j0.144)$

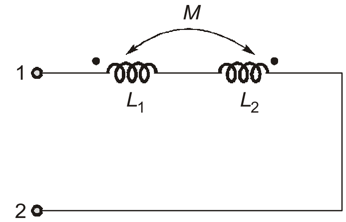
[2003 : 2 M]

1.22 An ideal sawtooth voltage waveform of frequency 500 Hz and amplitude 3 V is generated by charging a capacitor of 2 μF in every cycle. The charging requires

(a) constant voltage source of 3 V for 1 ms.
(b) constant voltage source of 3 V for 2 ms.
(c) constant current source of 3 mA for 1 ms.
(d) constant current source of 3 mA for 2 ms.

[2003 : 2 M]

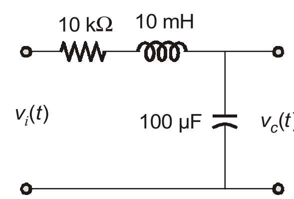
1.23 The equivalent inductance measured between the terminals 1 and 2 for the circuit shown in the figure is



(a) $L_1 + L_2 + M$ (b) $L_1 + L_2 - M$
(c) $L_1 + L_2 + 2M$ (d) $L_1 + L_2 - 2M$

[2004 : 1 M]

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



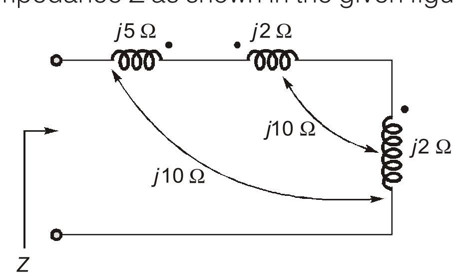
(a) $\dfrac{1}{s^2 + 10^6 s + 10^6}$

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

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

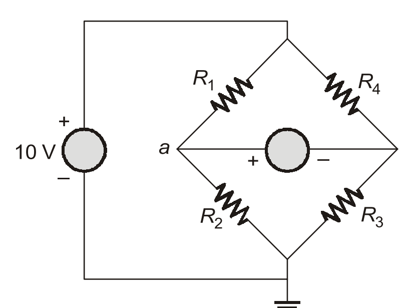
[2004 : 2 M]

1.25 Impedance Z as shown in the given figure is



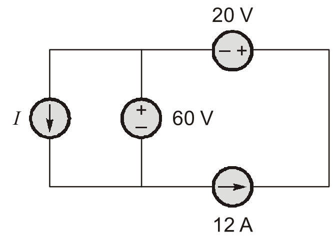
(a) $j29$ Ω (b) $j9$ Ω
(c) $j19$ Ω (d) $j39$ Ω [2005 : 2 M]

1.26 If $R_1 = R_2 = R_4 = R$ and $R_3 = 1.1\,R$ 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 [2005 : 2 M]

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

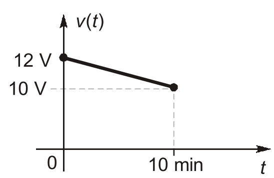


Which of the following can be the value of the current source I?

(a) 10 A (b) 13 A
(c) 15 A (d) 18 A **[2009 : 1 M]**

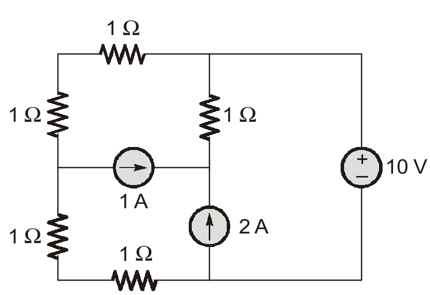
1.28 A fully charged mobile phone with a 12 V battery is good for a 10 minute talk-time. Assume that, during the talk-time the battery delivers a constant current of 2 A and its voltage drops linearly from 12 V to 10 V as shown in the figure. How much energy does the battery deliver during this talk-time?

(a) 220 J
(b) 12 kJ
(c) 13.2 kJ
(d) 14.4 J



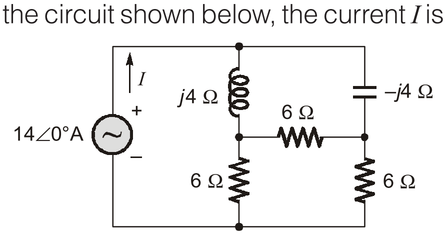
[2009 : 1 M]

1.29 In the circuit shown, the power supplied by the voltage source is



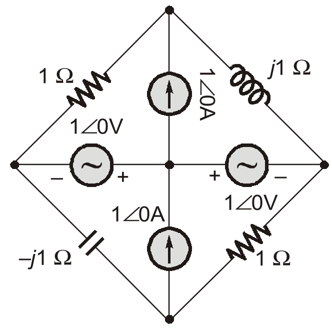
(a) 0 W (b) 5 W
(c) 10 W (d) 100 W **[2010 : 2 M]**

1.30 In the circuit shown below, the current I is equal to



(a) $1.4\angle 0°$ A (b) $2.0\angle 0°$ A
(c) $2.8\angle 0°$ A (d) $3.2\angle 0°$ A **[2011 : 2 M]**

1.31 In the circuit shown below, the current through the inductor is



(a) $\dfrac{2}{1+j}$ A (b) $\dfrac{-1}{1+j}$ A

(c) $\dfrac{1}{1+j}$ A (d) 0 A

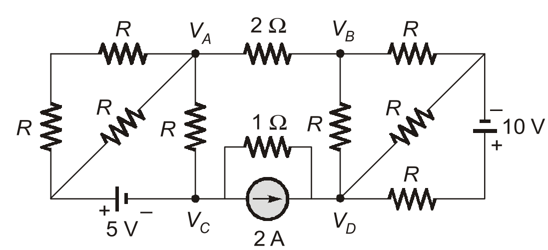
[2012 : 1 M]

1.32 The average power delivered to an impedance $(4 - j3)\Omega$ by a current $5\cos(100\pi t + 100)$ A is

(a) 44.2 W (b) 50 W
(c) 62.5 W (d) 125 W

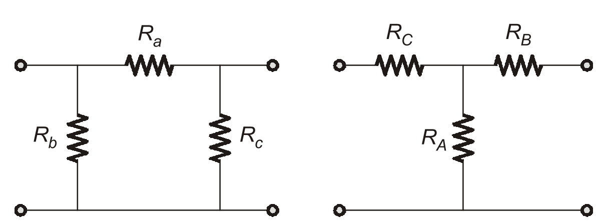
[2012 : 1 M]

1.33 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 **[2012 : 2 M]**

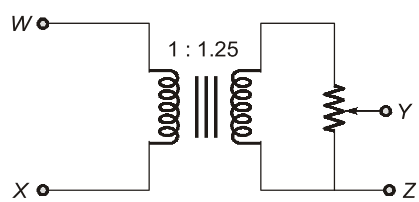
1.34 Consider a delta connection of resistors and its equivalent star connection as shown below. If all elements of the delta connection are scaled by a factor k, $k > 0$, the elements of the corresponding star equivalent will be scaled by a factor of



(a) k^2 (b) k
(c) $1/k$ (d) $\sqrt{k}$

[2013 : 1 M]

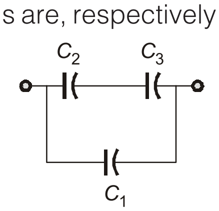
1.35 The following arrangement consists of an ideal transformer and an attenuator which attenuates by a factor of 0.8. An ac voltage $V_{WX_1} = 100$ V is applied across WX to get an open circuit voltage V_{YZ_1} across YZ. Next, an ac voltage $V_{YZ_2} = 100$ V is applied across YZ to get an open circuit voltage V_{WX_2} across WX. Then, V_{YZ_1}/V_{WX_1}, V_{WX_2}/V_{YZ_2} 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

[2013 : 2 M]

1.36 Three capacitors C_1, C_2 and C_3 whose values are 10 μF, 5 μF, and 2 μF 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 μC stored in the effective capacitance across the terminals are, respectively

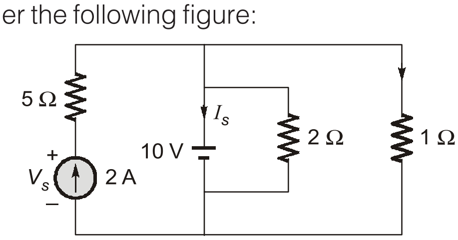


(a) 2.8 and 36 (b) 7 and 119
(c) 2.8 and 32 (d) 7 and 80

[2013 : 2 M]

Common Data For Questions 1.37 and 1.38:

Consider the following figure:



1.37 The current I_s in Amps in the voltage source, and voltage V_s in volts across the current source respectively, are

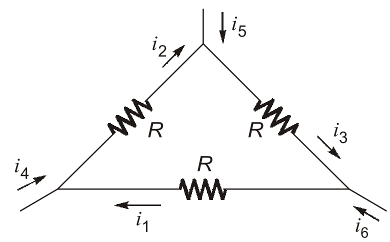
(a) 13, –20 (b) 8, –10
(c) –8, 20 (d) –13, 20 [2013 : 2 M]

1.38 The current in the 1 Ω resistor in Amps is

(a) 2 (b) 3.33
(c) 10 (d) 12

[2013 : 2 M]

1.39 Consider the configuration shown in the figure which is a portion of a larger electrical network



For $R = 1$ Ω and currents $i_1 = 2$ A, $i_4 = -1$ A, $i_5 = -4$ A, which one of the following is TRUE?

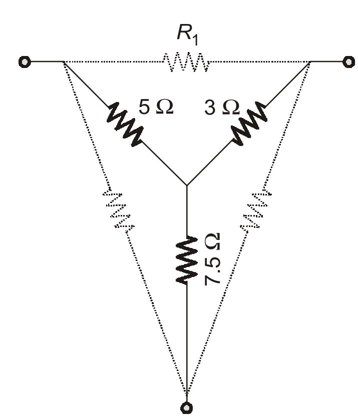
(a) $i_6 = 5$ A
(b) $i_3 = -4$ A
(c) Data is sufficient to conclude that the supposed currents are impossible
(d) Data is insufficient to identify the currents i_2, i_3 and i_6

[2014 : 1 M, Set-1]

1.40 A Y-network has resistances of 10 Ω each in two of its arms, while the third arm has a resistance of 11 Ω. In the equivalent Δ-network, the lowest value (in Ω) among the three resistances is ______.

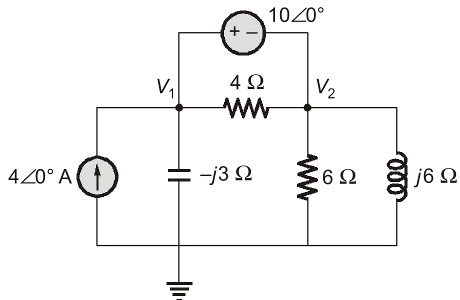
[2014 : 2 M, Set-1]

1.41 For the Y-network shown in the figure, the value of R_1 (in Ω) in the equivalent D-network is ____.



[2014 : 2 M, Set-3]

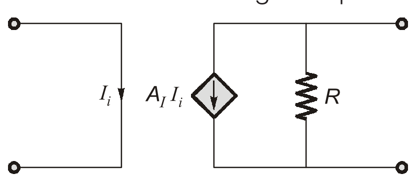
1.42 In the circuit shown in the figure, the value of node voltage V_2 is



(a) $22 + j2$ V (b) $2 + j22$ V
(c) $22 - j2$ V (d) $2 - j22$ V

[2014 : 2 M, Set-3]

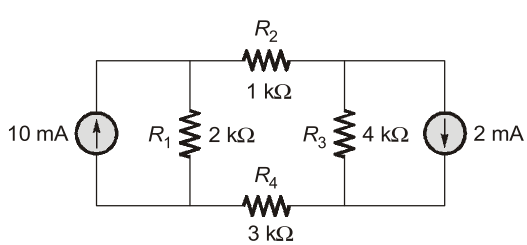
1.43 The circuit shown in the figure represents a



(a) voltage controlled voltage source
(b) voltage controlled current source
(c) current controlled current source
(d) current controlled voltage source

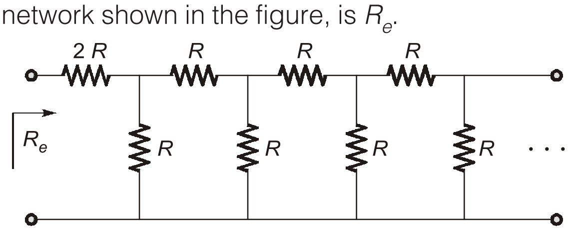
[2014 : 1 M, Set-4]

1.44 The magnitude of current (in mA) through the resistor R_2 in the figure shown is_______.



[2014 : 1 M, Set-4]

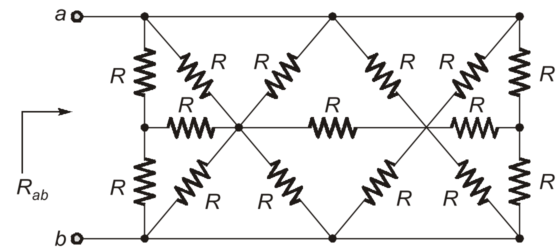
1.45 The equivalent resistance in the infinite ladder network shown in the figure, is R_e.



The value R_e/R is _______.

[2014 : 2 M, Set-4]

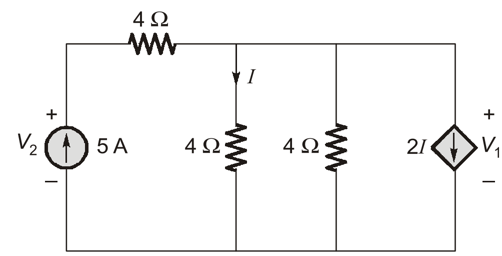
1.46 In the network shown in the figure, all resistors are identical with $R = 300\ \Omega$. The resistance R_{ab} (in Ω) of the network is _____________.



$R = 300\ \Omega$

[2015 : 1 M, Set-1]

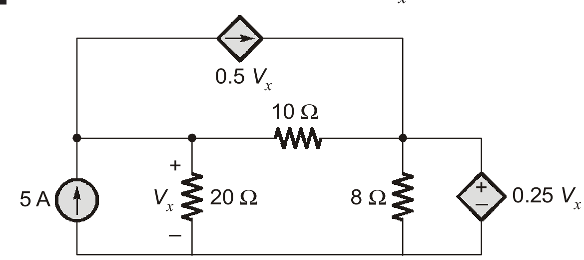
1.47 In the given circuit, the values of V_1 and V_2 respectively are



(a) 5 V, 25 V (b) 10 V, 30 V
(c) 15 V, 35 V (d) 0 V, 20 V

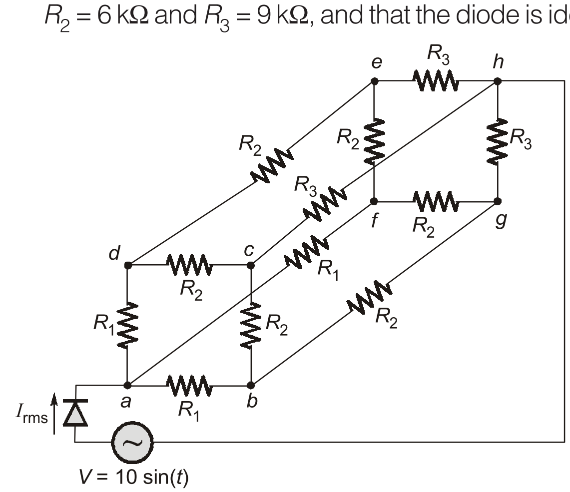
[2015 : 1 M, Set-1]

1.48 In the circuit shown, the voltage V_x (in Volts) is ____.



[2015 : 1 M, Set-3]

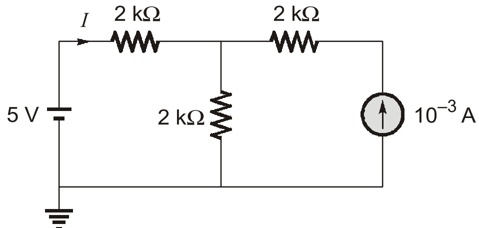
1.49 An AC voltage source $V = 10 \sin(t)$ volts is applied to the following network. Assume that $R_1 = 3$ kΩ, $R_2 = 6$ kΩ and $R_3 = 9$ kΩ, and that the diode is ideal.



RMS current I_{rms} (in mA) through the diode is ____.

[2016 : 2 M, Set-1]

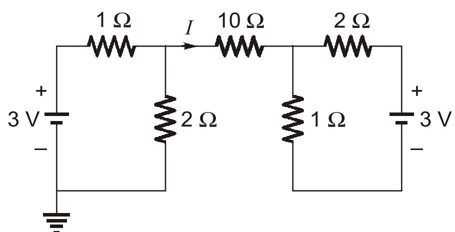
1.57 The current I in the circuit shown is ________.



(a) 1.25×10^{-3} A (b) 0.75×10^{-3} A
(c) -0.5×10^{-3} A (d) 1.16×10^{-3} A

[2022 : 1 M]

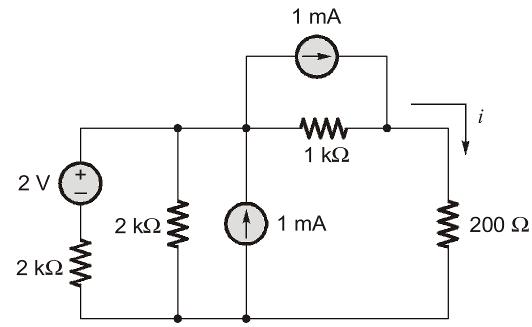
1.58 Consider the circuit shown in the figure. The current I flowing through the 10 Ω resistor is ________.



(a) 1 A (b) 0 A
(c) 0.1 A (d) –0.1 A

[2022 : 1 M]

1.59 In the circuit shown below, the current i flowing through 200 Ω resistor is ______ mA.
(rounded off to two decimal places).



[2023 : 1 M]

Answers Basics of Network Analysis

1.1 (d)	1.2 (b)	1.3 (a)	1.4 (d)	1.5 (a)	1.6 (b)	1.7 (c)
1.8 (b)	1.9 (c)	1.10 (d)	1.11 (d)	1.12 (a)	1.13 (d)	1.14 (c)
1.15 (a)	1.16 (d)	1.17 (a)	1.18 (d)	1.19 (a)	1.20 (a)	1.21 (*)
1.22 (d)	1.23 (d)	1.24 (d)	1.25 (b)	1.26 (c)	1.27 (a)	1.28 (c)
1.29 (a)	1.30 (b)	1.31 (c)	1.32 (b)	1.33 (a)	1.34 (b)	1.35 (b)
1.36 (c)	1.37 (d)	1.38 (c)	1.39 (a)	1.40 (29.09)	1.41 (10)	1.42 (d)
1.43 (c)	1.44 (2.8)	1.45 (2.62)	1.46 (100)	1.47 (a)	1.48 (8)	1.49 (1)
1.50 (d)	1.51 (5)	1.52 (–1)	1.53 (2.143)	1.54 (8)	1.55 (0.5)	1.56 (1)
1.57 (b)	1.58 (b)	1.59 (1.36)				

Explanations Basics of Network Analysis

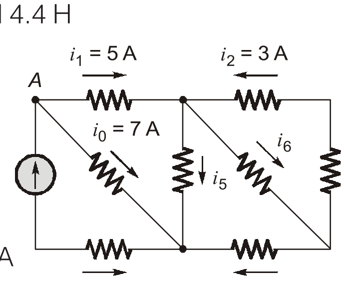
1.1 (d)

$$L = L_1 + L_2 \pm 2M$$
$$= L_1 + L_2 \pm 2k\sqrt{L_1 L_2}$$
$$L = 2 + 2 \pm 2(0.1)\sqrt{2 \times 2} = 4 \pm 0.4$$
L = 3.6 H and 4.4 H

1.2 (b)

Apply KCL at node A

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



1.3 (a)

Apply KVL, $V + 5 - 4 - 4 = 0$
$$V = 3\text{ V}$$

1.4 (d)

$$V = V_{2\text{ A}} + 2 \times 2 + 5 = V_{2\text{ A}} + 9$$

Since the voltage of 2 A current source is not known.
So, it is not possible to find the value of voltage V.

1.5 (a)

Voltage in parallel is always equal.

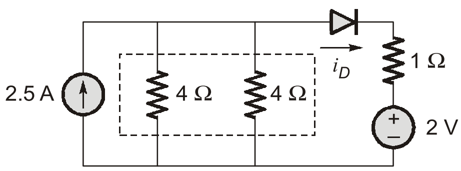
1.6 (b)

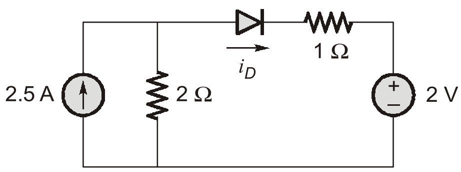
The bridge is balanced

$$Z_{eq} = (2 \parallel 4) + (2 \parallel 4)$$

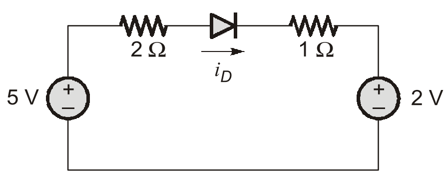
$$Z_{eq} = \frac{2\times4}{2+4} + \frac{2\times4}{2+4} = \frac{4}{3} + \frac{4}{3} = \frac{8}{3}\ \Omega$$

1.7 (c)





Using source transformation,



$$i_D = \frac{5-2}{2+1} = \frac{3}{3} = 1\text{ Amp.}$$

1.8 (b)

The nodal or mesh method is based on KCL and Ohm's law.

1.9 (c)

Apply superposition theorem

For 1 volt source

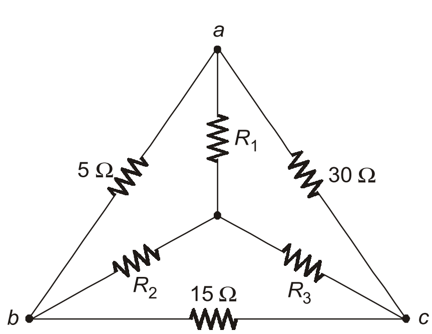
$$V_{ab_1} = 1\times\frac{2}{2+2} = 0.5\text{ V}$$

For 3 A source,

$$V_{ab_3} = 3\times\left(\frac{2}{2+2}\right)\times2 = 3\text{ V}$$

$$V_{ab} = V_{ab_1} + V_{ab_3} = 0.5 + 3 = 3.5\text{ V}$$

1.10 (d)



$$R_1 = \frac{5\times30}{5+30+15} = 3 \quad ; \quad R_2 = \frac{15\times5}{50} = 1.5$$

$$R_3 = \frac{15\times30}{50} = 9$$

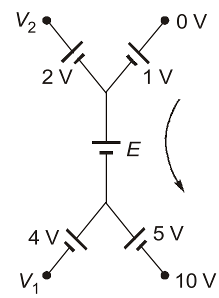
1.11 (d)

Applying KCL at the node (1),

$$e^{at} + e^{bt} = i_L(t)$$

$$\Rightarrow\ v(t) = L\frac{d}{dt}\left[e^{at} + e^{bt}\right] = ae^{at} + be^{bt}$$

1.12 (a)



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

$$E = -16\text{ V}$$

1.13 (d)

Since diode is forward bias it is taken as short circuit.

Applying KCL,

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

$$3\ V = 2 \qquad \Rightarrow V = 2/3$$

$$\Rightarrow \qquad V_o = -V = -\frac{2}{3}$$

1.14 (c)

Applying KCL, $\dfrac{e_o-12}{4} + \dfrac{e_o}{4} + \dfrac{e_o}{4} = 0$

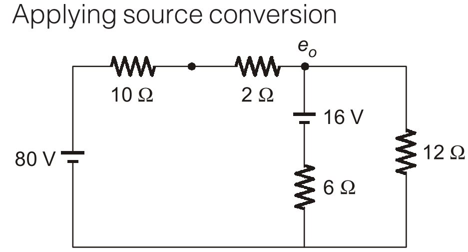
$$\Rightarrow \qquad 3e_o = 12 \qquad \therefore\ e_o = 4\text{ V}$$

1.15 (a)

$$Z_\Delta = 3Z_Y \qquad \Rightarrow \sqrt{3}\,Z_\Delta = 3Z_Y \quad ; \quad Z_Y = \frac{Z_\Delta}{\sqrt{3}}$$

1.16 (d)

Applying source conversion



$$\frac{e_o - 80}{12} + \frac{e_o}{12} + \frac{e_o - 16}{6} = 0$$

$$4e_o = 112$$

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

1.17 (a)

Applying KVL, $20 - 5I - 5\left(I + \frac{V_1}{5}\right) = 0$

$20 - 10I - 20 = 0$

$\Rightarrow \quad I = 0$

$\therefore$ Only dependent source acts.

$$\frac{V_1}{5} = 4 \text{ A}$$

Power delivered $= I^2R = 16 \times 5 = 80$ W

1.18 (d)

$$3V_pI_p\cos\theta = 1500$$

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

$$Z_L = \frac{V_L^2 \cdot \cos\theta}{1500} = \frac{400^2 \times 0.844}{1500} = 90\ \Omega$$

$$\theta = \cos^{-1}(0.844) = 32.44$$

As power factor is leading, load is capacitive so angle will be negative.

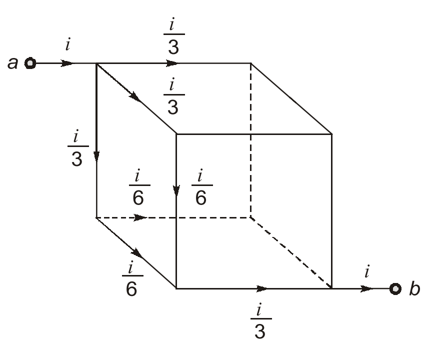
$$\theta = -32.44°$$

1.19 (a)

As voltage at 1 node is known

$\therefore$ using nodal analysis only 3 equations required.

1.20 (a)



$$V_{ab} = \frac{i}{3} \times 1 + \frac{i}{6} \times 1 + \frac{i}{3} \times 1$$

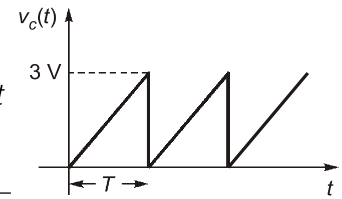
$$\Rightarrow \quad R_{eq} = \frac{V_{ab}}{i} = \frac{5}{6}\ \Omega$$

1.21 (*)

Question is incomplete as L_1 and L_2 are not given.

1.22 (d)

$$v_c(t) = \frac{1}{C}\int_0^T i\, dt$$



Here, $T = \frac{1}{f} = \frac{1}{500}$

$= 2$ msec

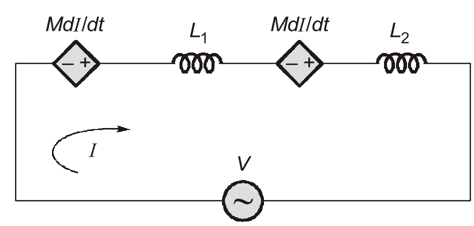
$C = 2\ \mu$F

$$\Rightarrow \quad 3 = \frac{i}{2\,\mu\text{F}} T$$

$$i = \frac{3 \times 2\,\mu\text{F}}{T} = \frac{3 \times 2\,\mu\text{F}}{2\text{ msec}} = 3\text{ mA}$$

Hence, the charging requires constant current source of 3 mA for 2 msec.

1.23 (d)



If current enters the dotted terminals of coil 1 then a voltage is developed across coil 2 whose higher potential is at dotted terminals.

$$V = \frac{-MdI}{dt} + \frac{L_1 dI}{dt} - \frac{MdI}{dt} + L_2\frac{dI}{dt}$$

$$= (L_1 + L_2 - 2M)\frac{dI}{dt} \qquad V = L_{eq}\frac{dI}{dt}$$

1.24 (d)

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

$$= \frac{1}{s^2(10 \times 10^{-3} \times 100 \times 10^{-6}) + s(10 \times 10^3 \times 100 \times 10^{-6}) + 1}$$

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

1.25 (b)

$X = X_1 + X_2 + X_3 + 2X_m - 2X_m$

$= (j5 + j2 + j2 + j20 - j20)\ \Omega$

$= j9\ \Omega$ (one additive & other subtractive)

1.26 (c)

$$V_a = 5 \qquad (R_1 = R_2)$$

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

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

1.27 (a)

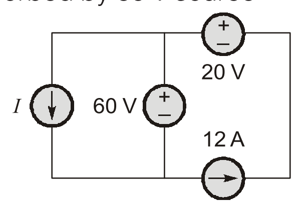
Since, the power is absorbed by 60 V source

$$I' = 12 - I$$

$$\Rightarrow \quad I' > 0$$

$$12 - I > 0$$

$$I < 12 \text{ A}$$



1.28 (c)

$$P = VI$$

$$\text{Energy} = P \cdot t = V \cdot It = (V.t)I$$

$$I = 2\text{A} \quad \text{(given)}$$

$$V \cdot t = \text{Area under } V - t \text{ curve}$$

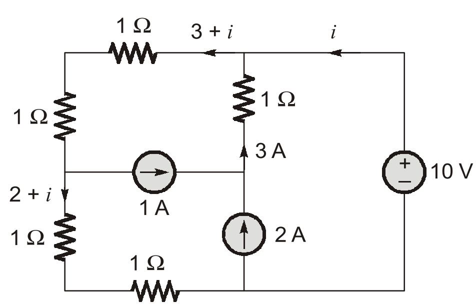
$$V \cdot t = \left(\frac{1}{2} \times 2 \times 600\right) + (10 \times 600)$$

$$= 600 + 6000$$

$$V \cdot t = 6600$$

$$E = (6600) \times 2 = 13200 = 13.2 \text{ kJ}$$

1.29 (a)



Applying KVL in outer loop,

$$(3 + i)2 + (2 + i)2 = 10$$

$$\Rightarrow \quad 6 + 2i + 4 + 2i = 10$$

$$\Rightarrow \quad 4i = 0$$

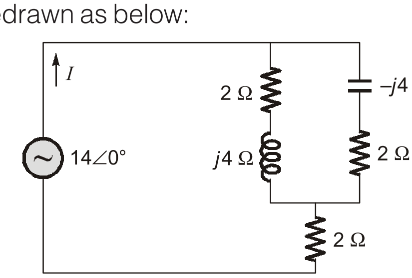
$$\Rightarrow \quad i = 0$$

Power supplied by the voltage source,

$$P = Vi = 10 \times 0 = 0 \text{ W}$$

1.30 (b)

Converting delta into star, the circuit can be redrawn as below:



Equivalent impedance of the circuit,

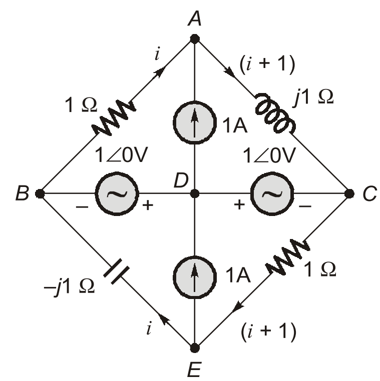
$$Z = (2 + j4) || (2 - j4) + 2$$

$$\Rightarrow \quad Z = \frac{(2 + j4)(2 - j4)}{2 + j4 + 2 - j4} + 2 = \frac{4 + 16}{4} + 2 = 7\,\Omega$$

Therefore,

$$\text{Current,} \quad I = \frac{14\angle 0°}{7} = 2\angle 0° \text{ A}$$

1.31 (c)



According to KCL at node D there will be no current in voltage sources.

According to KCL at node A current through inductor will be

$$i_1 = i + 1 \qquad \text{...(1)}$$

Applying KVL in loop $ACDBA$ we have

$$1 \times i + (i+1)\, j1 + 1\angle 0 - 1\angle 0 = 0$$

$$i + (i + 1)j = 0$$

$$(1 + j)i = -j$$

$$i = \frac{-j}{1 + j} \qquad \text{...(2)}$$

Therefore from (1) and (2) we have

$$i_1 = i + 1 = \frac{-j}{j + 1} + 1 = \frac{1}{1 + j}$$

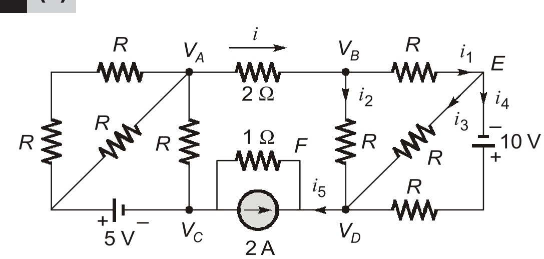
1.32 (b)

Average power is same as RMS power.

$$P = I^2_{\text{rms}}\, R = \left(\frac{5}{\sqrt{2}}\right)^2 \times 4 = \frac{25}{2} \times 4 = 50 \text{ W}$$

Note: Power is consumed only by resistance i.e. by real part of impedance.

1.33 (a)



$$i = \frac{V_A - V_B}{2} = \frac{6}{2} = 3\text{ A} \quad \text{...(i)}$$

KCL at node B, we have

$$i = i_2 + i_1$$
$$i_2 + i_1 = 3\text{ A} \quad \text{...(ii)}$$

KCL at node E, we have

$$i_1 = i_3 + i_4 \quad \text{...(iii)}$$

KCL at node D we have

$$i_5 = i_2 + i_3 + i_4 = i_2 + i_1 = 3\text{ A}$$

KCL at node F, we have

$$i_6 + 2 + i_5 = 0$$
$$i_6 = -2 - i_5 = -5\text{ A}$$

So, $V_C - V_D = 1 \times i_6 = -5\text{ V}$

1.34 (b)

$$R_A = \frac{R_b R_c}{R_a + R_b + R_c}$$
$$R'_a = kR_a; \quad R'_b = kR_b; \quad R'_c = kR_c$$
$$R'_A = \frac{kR_b \cdot kR_c}{kR_a + kR_b + kR_c} = \frac{k^2 R_b R_c}{k(R_A + R_b + R_c)}$$
$$= k \times \frac{R_b R_c}{R_a + R_b + R_c}$$
$$R'_A = kR_A$$

1.35 (b)

$$V_{YZ_1} = 100 \times 1.25 \times 0.8 = 100\text{ V}$$

In second case, when 100 V is applied at YZ terminals, this whole 100 V will appear across the secondary winding.

Hence, $V_{wx_2} = \frac{100}{1.25} = 80\text{ V}$

$$\Rightarrow \quad \frac{Y_{YZ_1}}{Y_{wx_1}} = \frac{100}{100}, \frac{V_{wx_2}}{V_{YZ_2}} = \frac{80}{100}$$

1.36 (c)

$$Q = CV$$
$$Q_1 = C_1 V_1 = 10 \times 10^{-6} \times 10 = 100\ \mu\text{C}$$
$$Q_2 = C_2 V_2 = 5 \times 10^{-6} \times 5 = 25\ \mu\text{C}$$
$$Q_3 = C_3 V_3 = 2 \times 10^{-6} \times 2 = 4\ \mu\text{C}$$

Capacitors C_2 and C_3 are in series.
In series charge is same.
So, the maximum charge on C_2 and C_3 will be minimum of $(Q_2, Q_3) = \min(25\ \mu\text{C}, 4\ \mu\text{C}) = 4\ \mu\text{C} = Q_{23}$.
In series the equivalent capacitance of C_2 and C_3 is

$$C_{23} = \frac{C_2 C_3}{C_2 + C_3} = \frac{5 \times 2}{5 + 2} = \frac{10}{7}\mu\text{F}$$

So, the equivalent voltage

$$V_{23} = \frac{Q_{23}}{C_{23}} = \frac{4 \times 10^{-6}}{\frac{10}{7} \times 10^{-6}} = \frac{28}{10} = 2.8\text{ V}$$

In parallel, the voltage is same.

$$V_1 = V_{23} = 2.8\text{ V}$$

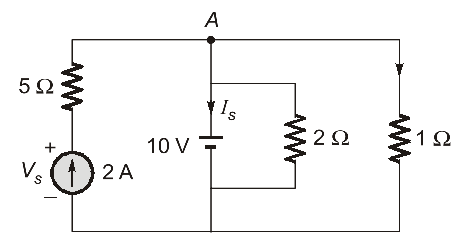
Charge in capacitor C_1,

$$Q_1 = C_1 V_1 = 10 \times 10^{-6} \times 2.8 = 28\ \mu\text{C}$$

In parallel, the total charge

$$Q = Q_1 + Q_{23} = 4 + 28 = 32\ \mu\text{C}$$

1.37 (d)



Voltage across 1 Ω resistance,

$$V_1 = 10\text{ V}$$

Current through 1 Ω resistance,

$$I_1 = \frac{10}{1} = 10\text{ Amp.}$$

Voltage across 2 Ω resistance,

$$V_2 = 10\text{ V}$$

Current through 2 Ω resistance,

$$I_2 = \frac{10}{2} = 5\text{ Amp.}$$

Apply KCL at node A,

$$-2 + I_s + I_2 + I_1 = 0$$
$$I_s = 2 - I_1 - I_2 = 2 - 10 - 5$$
$$I_s = -13\text{ Amp}$$

Voltage at node A,

$$V_A = 10\text{ V}$$
$$V_s - 10 = 10\text{ V}$$
$$V_s = 10 + 10 = 20\text{ V}$$

1.38 (c)

The current in the 1 Ω resistor

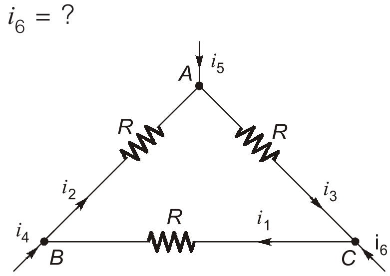
$$I_1 = \frac{10}{1} = 10\text{ Amp.}$$

1.39 (a)

Given data: $i_1 = 2\text{ A}, i_4 = -1\text{ A}, i_5 = -4\text{ A}$
$R = 1\ \Omega$

To calculate:

$$i_6 = ?$$



Using KVL at all the three nodes we get,
At node A,

$$i_5 - i_3 + i_2 = 0 \quad \text{...(i)}$$

At node B,

$$i_4 + i_1 - i_2 = 0 \quad \text{...(ii)}$$

At node C,

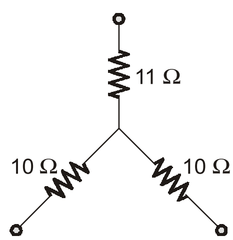
$$i_6 + i_3 - i_1 = 0 \quad \text{...(iii)}$$

By putting the value of i_3 and i_2 from equation (i) and (ii) in equation (iii) we get,

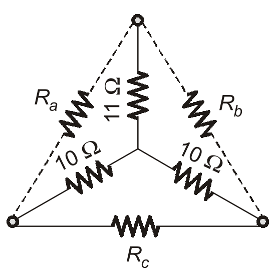
$$i_6 + (i_2 + i_5) - i_1 = 0$$
$$i_6 + (i_1 + i_4 + i_5) - i_1 = 0$$
$$\therefore \quad i_6 + (2 - 1 - 4) - 2 = 0$$
$$i_6 = 5 \text{ A}$$

1.40 (29.09)

According to the question



The equivalent Δ-network of the above Y-network is



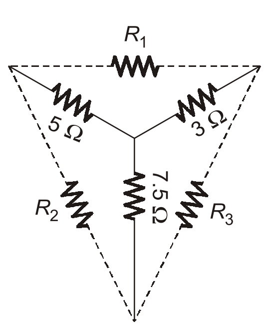
$$\text{Here, } R_a = 10 + 11 + \frac{10 \times 11}{10} = 32\ \Omega$$

$$R_b = 10 + 11 + \frac{10 \times 11}{10} = 32\ \Omega$$

$$R_c = 10 + 10 + \frac{10 \times 10}{11} = 29.09\ \Omega$$

Hence, the lowest value among the three resistances is 29.09 Ω.

1.41 (10)



Using star-delta conversions,
The value of R_1 is given by

$$= 5 + 3 + \frac{5 \times 3}{7.5} = 10$$

1.42 (d)

Using the concept of super node, we get

$$V_1 - V_2 = 10\angle 0° \quad \text{...(i)}$$

$$= \frac{V_1}{-3j} + \frac{V_2}{6j} + \frac{V_2}{6} = 4\angle 0° \quad \text{...(ii)}$$

$$= \frac{-2V_1 + V_2 + jV_2}{6j} = 4\angle 0° \quad \text{...(iii)}$$

From equation (i) and (iii)

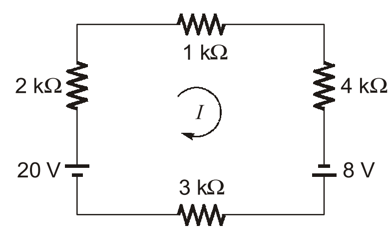
$$V_2 = \frac{20 + j24}{(-1 + j)} = \frac{31.241\angle 50.194}{\sqrt{2}\angle 135°}$$

$$= 22.091\ \angle{-84.806}$$

$$\text{or} \quad V_2 = 2 - 22j$$

1.44 (2.8)

Using source transformation, we get,



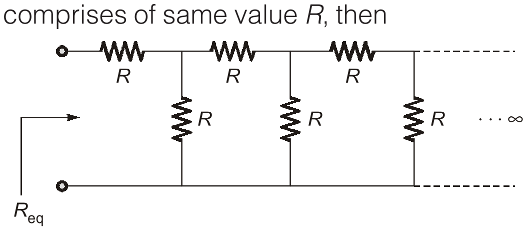
Applying KVL in above circuit, we get,

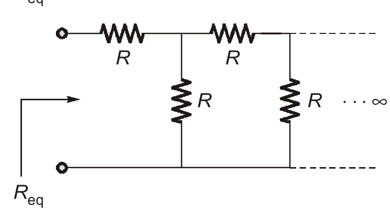
$$20 - 2I - I - 4I + 8 - 3I = 0$$

$$\text{or} \quad 28 = 10I \qquad \text{or} \quad I = 2.8 \text{ mA}$$

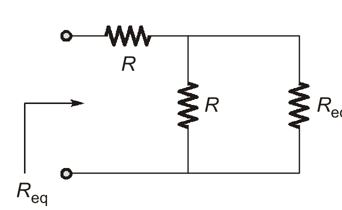
1.45 (2.62)

For an infinite ladder network, if all the resistance are comprises of same value R, then





Or,

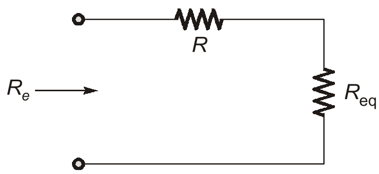


$$\therefore \quad R_{eq} = R + \frac{R \cdot R_{eq}}{R + R_{eq}} \quad \text{...(i)}$$

After solving equation (i) we get,

$$R_{eq} = \left(\frac{1+\sqrt{5}}{2}\right)R \quad \text{...(ii)}$$

From the given question, the circuit can be redraw as



$$\therefore \quad R_e = R + R_{eq} \quad \text{...(iii)}$$

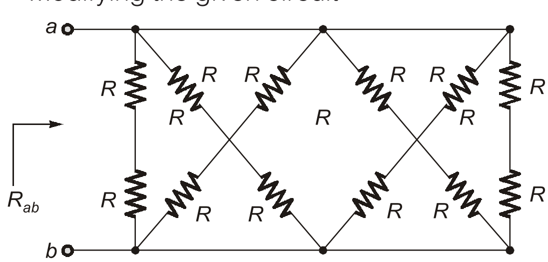
From equation (ii) and (iii) we get,

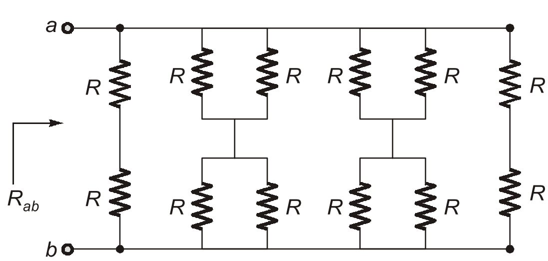
$$R_e = R + \left(\frac{1+\sqrt{5}}{2}\right)R = 2.618\,R \quad \text{...(iv)}$$

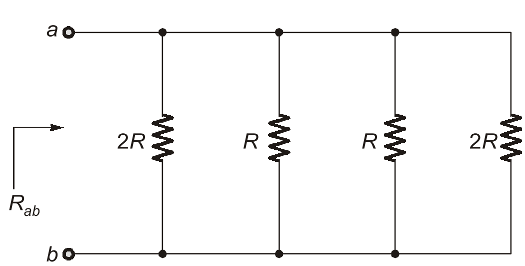
$$\text{or} \quad \frac{R_e}{R} = 2.618 = 2.62$$

1.46 (100)

Modifying the given circuit



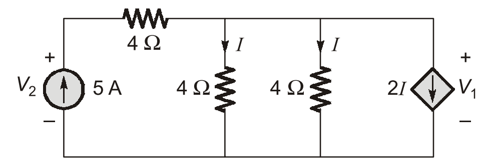




$$R_{ab} = \left(\frac{1}{2R} + \frac{1}{R} + \frac{1}{R} + \frac{1}{2R}\right)^{-1}$$

$$= \frac{R}{3} = \frac{300}{3} = 100\ \Omega$$

1.47 (a)



Current flowing through both the parallel 4 Ω will be I.

So, $V_2 = 4(I + I + 2I) + 4I$ by KVL

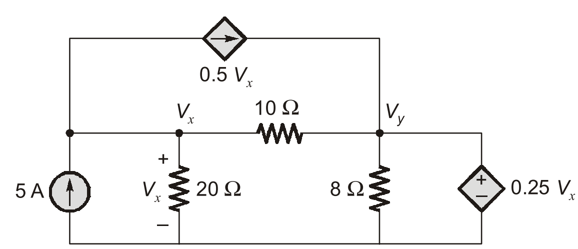
$I + I + 2I = 5$ by KCL

$$I = \frac{5}{4}A$$

$$V_2 = 4 \times 5 + \frac{4 \times 5}{4} = 25\ \text{V}$$

$$V_1 = 4I = \frac{4 \times 5}{4} = 5\ \text{V}$$

1.48 (8)



$$\frac{V_x}{20} + \frac{V_x - V_y}{10} + 0.5\,V_x = 5\ \text{A}$$

$$V_x\left[\frac{1}{20} + \frac{1}{10} + 0.5\right] = 5 + \frac{V_y}{10}$$

$$13\ V_x = 100 + 2\ V_y \quad \text{...(i)}$$

and also, $V_y = 0.25\ V_x$ ...(ii)

Solving equations (i) and (ii), we have

$$52\ V_y = 100 + 2\ V_y$$

$$\Rightarrow \quad 50\ V_y = 100 \quad \Rightarrow \quad V_y = 2\ \text{V}$$

$$V_x = 4\ V_y = 8\ \text{V}$$

1.49 (1)