Chapter 1

Module 1 Basic Concepts

1.1 Introduction

Resistors in series:
Consider two resistors R_1 and R_2 in series.

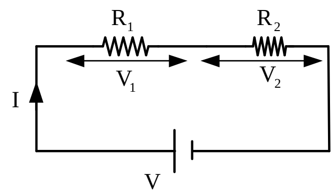


Figure 1.1

$$V = V_1 + V_2 = I(R_1 + R_2)$$
$$\frac{V}{I} = R_{eq} = R_1 + R_2$$

If n number of resistors R_1, R_2 ....., R_n are connected in series then the equivalent resistance Req is

$$R_{eq} = R_1 + R_2....., R_n$$

Resistors in parallel:
Consider two resistors are connected in parallel.

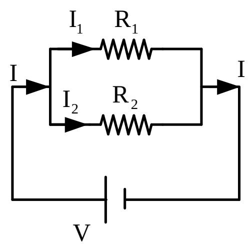


Figure 1.2

Current in each branch is

$$I_1 = \frac{V}{R_1}$$

$$I_2 = \frac{V}{R_2}$$

The current I is

$$\begin{aligned} I &= I_1 + I_2 \\ &= \frac{V}{R_1} + \frac{V}{R_2} \\ &= V\left(\frac{1}{R_1} + \frac{1}{R_2}\right) \\ \frac{I}{V} &= \left(\frac{1}{R_1} + \frac{1}{R_2}\right) = \frac{1}{R_{eq}} \end{aligned}$$

If n number of resistors are connected in parallel then

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} \cdots \frac{1}{R_n}$$

If only two resistors are connected in parallel then Equivalent resistance R_{eq} is

$$\begin{aligned} \frac{1}{R_{eq}} &= \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_1 + R_2}{R_1 R_2} \\ R_{eq} &= \frac{R_1 R_2}{R_1 + R_2} \end{aligned}$$

KIRCHHOFF'S RULES

1. **Current Law or Junction Rule or Kirchhoff'S Current Law (KCL):** ***The algebraic sum of electric currents at any junction in electrical network is always zero.***

   $$\sum_{i=1}^{n} I_n = 0$$

   or ***The sum of incoming currents towards the junction are equal to sum of outgoing currents at a junction.***

   This law is a statement of **conservation of charge**. If current reaching a junction is not equal to the current leaving the junction, charge will not be conserved.

2. **II Law or Loop Law or Junction Rule: Kirchhoff'S Voltage Law (KVL)**: ***The algebraic sum of changes in potential around any closed loop involving resistors and cells in the loop is zero.***

   This law represents **conservation of energy**. If the sum of potential changes around a closed loop is not zero, unlimited energy could be gained by repeatedly carrying a charge around a loop.

Sign convention for the application of Kirchoff's law

1. **While traversing in a loop the direction of current is in the same path then the potential drop at a resistance is -IR while in the in opposite direction it is +IR.**

2. **The emf is taken negative when we traverse from positive to negative terminal of the cell. The emf is taken positive when we traverse from negative to positive terminal of the cell.**

Example

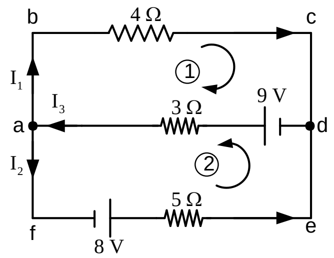


Figure 1.3

KCL for the junction at node 'a' is
Incoming current at node 'a' is I_3 and outgoing currents are I_1 and I_2.

$$I_3 = I_1 + I_2$$

sum of the currents meeting at node 'a' is zero OR

$$I_3 - I_1 - I_2 = 0$$

For the node 'd'

$$I_1 + I_2 = I_3$$
$$I_1 + I_2 - I_3 = 0$$

For the loop 1 abcda

$$\begin{aligned} -4I_1 + 9 - 3I_3 &= 0 \\ -4I_1 + 9 - 3(I_1 + I_2) &= 0 \\ 7I_1 + 3I_2 &= 9 \end{aligned} \tag{1.1}$$

For the loop 2 afeda

$$\begin{aligned} 8 - 5I_2 + 9 - 3I_3 &= 0 \\ 17 - 5I_2 - 3(I_1 + I_2) &= 0 \\ 3I_1 + 8I_2 &= 17 \end{aligned} \tag{1.2}$$

From Equation 1.1 and 1.2

$$\begin{aligned} 7I_1 + 3I_2 &= 9 \\ 3I_1 + 8I_2 &= 17 \end{aligned}$$

Solving the above equations

$$\begin{aligned} I_1 &= 0.446A \\ I_2 &= 1.95A \end{aligned}$$

Applying Node voltage method

$$\begin{aligned} \frac{V_a}{4} + \frac{V_a - 9}{3} + \frac{V_a + 8}{5} &= 0 \\ V_a\left[\frac{1}{4} + \frac{1}{3} + \frac{1}{5}\right] - 3 + \frac{8}{5} &= 0 \\ V_a &= 1.787 \end{aligned}$$

$$\begin{aligned} I_1 &= \frac{V_a}{4} = \frac{1.787}{4} = 0.4464 \\ I_2 &= \frac{V_a + 8}{5} = \frac{1.787 + 8}{5} = 1.954 \end{aligned}$$

Branch Current Rule

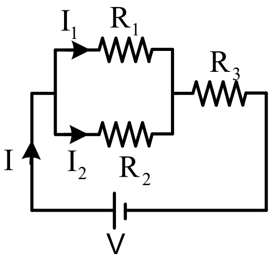


Figure 1.4

When two resistors are connected in parallel: Branch Current is

$$= \; Main\ Current \frac{Resistance\ of\ other\ branch}{Sum\ of\ resistances}$$

$$\begin{aligned} I_1 &= I\frac{R_2}{R_1+R_2} \\ I_2 &= I\frac{R_1}{R_1+R_2} \end{aligned}$$

Also it is given by

$$\begin{aligned} I_1 &= I\frac{R_P}{R_1} \\ I_2 &= I\frac{R_P}{R_2} \end{aligned}$$

where I is the main current and R_P is the parallel branch effective resistance.

$$\begin{aligned} R_P &= \frac{R_1R_2}{R_1+R_2} \\ I &= \frac{V}{R_P+R_3} \end{aligned}$$

Example 1

Find the current i_1 and i_2 for the circuit shown in Figure

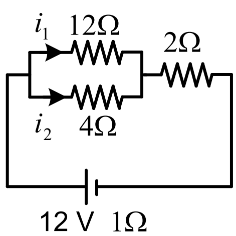


Figure 1.5

Solution:

12Ω and 4Ω are in parallel

$$\begin{aligned} R_T &= \frac{12\times 4}{12+4}+2 = 3+2 \\ &= 5\Omega \end{aligned}$$

Total Current I is

$$\begin{aligned} I &= \frac{E}{R_T+r} = \frac{12}{5+1} \\ &= 2A \end{aligned}$$

Using Method 1

$$\begin{aligned} i_1 &= 2A\frac{4}{4+12} = 0.5A \\ i_2 &= 2A\frac{12}{4+12} = 1.5A \end{aligned}$$

Using Method 2

$$\begin{aligned} i_1 &= 2A\frac{3}{12} = 0.5A \\ i_2 &= 2A\frac{3}{4} = 1.5A \end{aligned}$$

Example 2

Find the magnitude of I in ampere

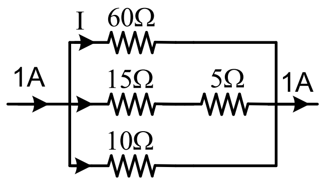


Figure 1.6

Solution:

Using Method 1

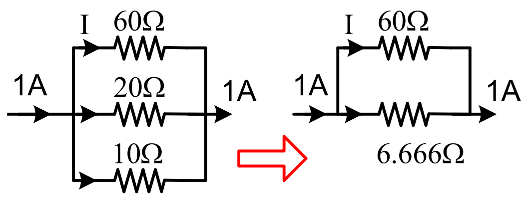


Figure 1.7

$$I = 1A\frac{6.6666}{60+6.6666} \simeq 0.1A$$

Using Method 2

When the Resistors 10, 15 and 60 Ω, are connected in parallel hence

$$\begin{aligned} \frac{1}{R_T} &= \frac{1}{10}+\frac{1}{20}+\frac{1}{60} \\ &= \frac{6+3+1}{60} = \frac{1}{6} \\ R_T &= 6 \end{aligned}$$

Current I_2 is

$$\begin{aligned} I &= 1A\frac{6}{60} \\ &= 0.1 \end{aligned}$$

Find the power dissipated in the 3 Ω resistor

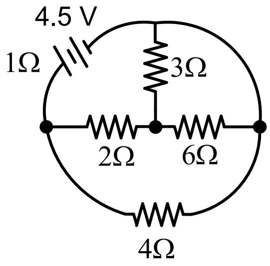


Figure 1.8

Solution: **Ans (b)**: The given circuit is redrawn.

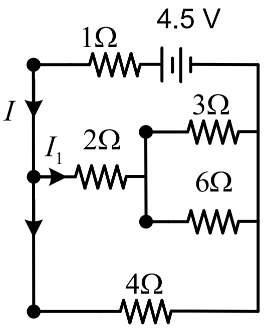


Figure 1.9

3 and 6 Ω are in parallel which is in series with 2 Ω

$$2 + (3||6) = 2 + \frac{6 \times 3}{6 \times 3} = 2 + 2 = 4\Omega$$

4Ω and 4Ω are in parallel which is in series with 1 Ω

$$1 + (4||4) = 1 + \frac{4 \times 4}{4 \times 4} = 1 + 2 = 3\Omega$$

The current I is

$$\frac{4.5}{3} = 1.5A$$

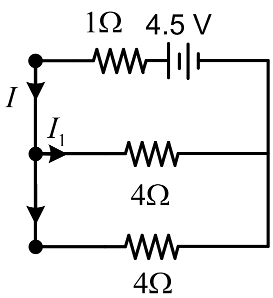


Figure 1.10

The current I_1 is

$$I_1 = 1.5A\frac{4}{4+4} = 0.75A$$

The current through 3 Ω is

$$I_3 = 0.75A\frac{6}{3+6} = 0.5A$$

The power dissipated in the 3 Ω is

$$(I_3)^2 \times 3 = (0.5)^2 \times 3 = 0.75W$$

For the circuit shown in Figure 1.11 find the value of current I_2

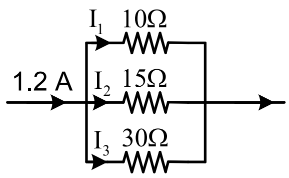


Figure 1.11

Solution: The total Resistance of the network is

$$\begin{aligned} \frac{1}{R_T} &= \frac{1}{10} + \frac{1}{15} + \frac{1}{30} \\ &= \frac{6}{30} = \frac{1}{5} \\ R_T &= 5 \end{aligned}$$

Current I_2 is

$$\begin{aligned} I_2 &= 1.2A\frac{5}{15} \\ &= 0.4 \end{aligned}$$

Find the current I flowing in the circuit as shown in Figure 1.12

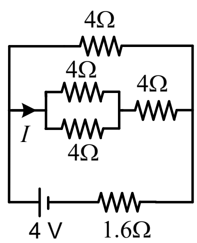


Figure 1.12

Solution:

The 4 Ω and 4 Ω are in parallel which combination is in series with 4 Ω

$$\frac{4 \times 4}{4+4} = 2\Omega$$

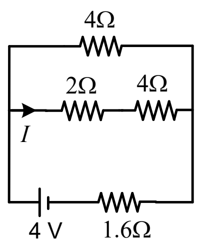


Figure 1.13

Again 4 Ω and 6 Ω are in parallel

$$\frac{4 \times 6}{4+6} = 2.4\Omega$$

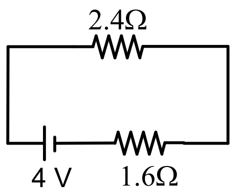


Figure 1.14

Current from battery is

$$I = \frac{4}{2.4 + 1.6} = 1A$$

The current I is

$$= 1A\frac{4}{4+6} = 0.4A$$

Find the magnitude of the current I for the circuit shown in Figure 1.15 is

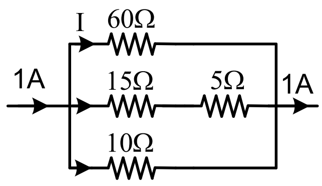


Figure 1.15

Solution: When the Resistors 10, 15 and 30 Ω, are connected in parallel hence

$$\begin{aligned}\frac{1}{R_T} &= \frac{1}{10} + \frac{1}{20} + \frac{1}{60}\\ &= \frac{6+3+1}{60} = \frac{1}{6}\\ R_T &= 6\end{aligned}$$

Current I_2 is

$$\begin{aligned} I &= 1A\frac{6}{60}\\ &= 0.1\end{aligned}$$

1.2 Source Transformation Technique

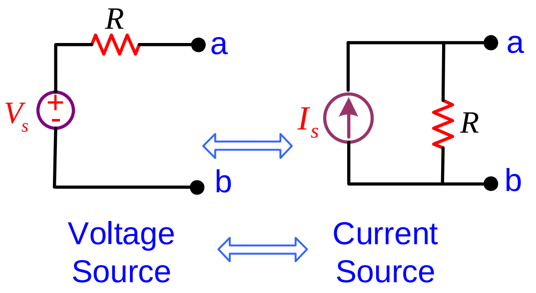


Figure 1.16

$$V_S = I_S R$$
$$I_S = \frac{V_S}{R}$$

Q 1) In the circuit below, use a source transformation to determine v_O.

Solution:

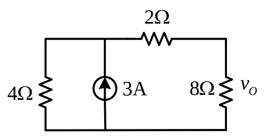


Figure 1.17

The transformed circuit is as shown in Figure 1.18. The current in the circuit is 0.857 A. The voltage across the resistor 8 Ω is

$$0.857 \times 8 = 6.857V$$

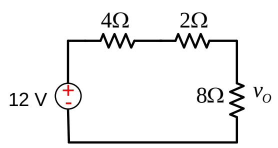


Figure 1.18

Q 2) For the circuit shown in Figure. 1.19, use a source transformation to determine v_O.

Solution:

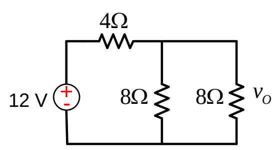


Figure 1.19

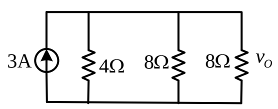


Figure 1.20

4 and 8 Ω are in parallel

$$R = \frac{4 \times 8}{4+8} = 2.66\ \Omega$$

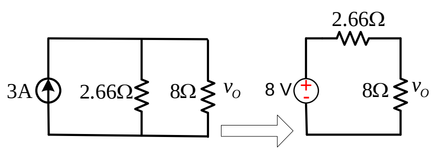


Figure 1.21

The current in the circuit

$$I = \frac{8}{10.667} = 0.75$$

The voltage across the resistor 8 Ω

$$0.75 \times 8 = 6V$$

Q 3) For the circuit shown in Figure determine the V_0 using source transformation.

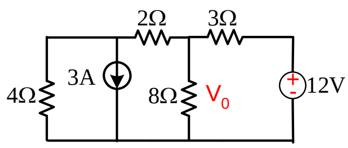


Figure 1.22

Solution:

Replace the current source and parallel resistance by voltage source in series with resistor

$$V = I \times R = 3 \times 4 = 12V$$

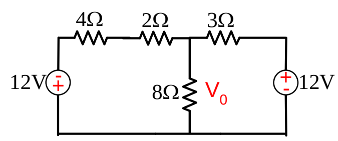


Figure 1.23

Now 4 Ω and 2 Ω are in series which are replaced by single resistance 6 Ω

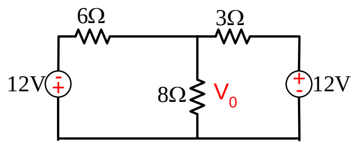


Figure 1.24

Replace the voltage sources by current source in parallel with resistance 6 Ω and 3 Ω

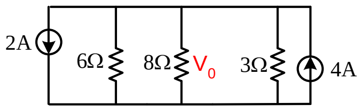


Figure 1.25

Replace two current sources by single current source and two parallel resistors 6 Ω and 3 Ω with single resistance. Current sources are in opposite directions. Again replace current source by voltage source in series with resistor 2 Ω

$$R = \frac{6 \times 3}{6 \times 3} = \frac{18}{9} = 2\Omega$$

The current in the circuit is

$$I = \frac{4}{8+2} = \frac{4}{10} = 0.4A$$

The voltage drop across 8 Ω is

$$V = 0.4A \times 8 = 3.2V$$

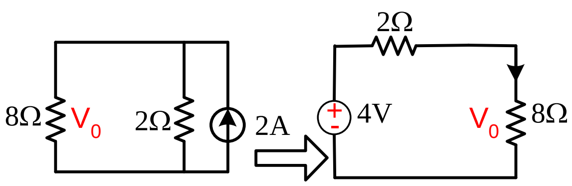


Figure 1.26

Q 4) In the circuit shown in Figure 1.17 determine the current i_1 through 5 Ω resistor by source transformation.

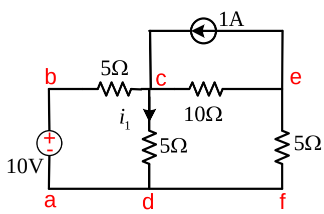


Figure 1.27

Solution: KVL cannot be applied due to the presence of current source. Transform the current source to voltage source.

$$V = I \times R = 1 \times 10 = 10V$$

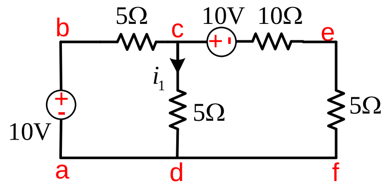


Figure 1.28

Now the 10 Ω and 5 Ω are in series

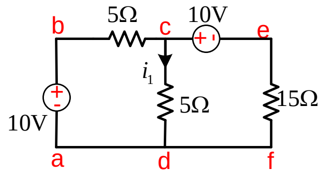


Figure 1.29

Replace the voltage source by current source. First current source is $I = \frac{V}{R} = \frac{10}{5} = 2A$ and the second source is and each resistors are in parallel with respective current sources $I = \frac{V}{R} = \frac{10}{15} = \frac{2}{3}A$

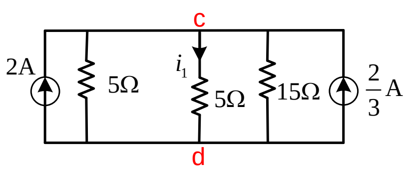


Figure 1.30

Now two current sources are in parallel they can be added and total current is

$$I = 2 + \frac{2}{3} = \frac{8}{3}A$$

The parallel resistances are added

$$R = \frac{5 \times 15}{5 + 15} = \frac{15}{4}\Omega$$

The equivalent circuit is as shown in Figure. The current source is replaced by voltage source which is as shown in Figure. The new voltage source is

$$V = I \times R = \frac{8}{3} \times \frac{15}{4} = 10V$$

The total resistance in the circuit is

$$R = \frac{15}{4} + 5 = \frac{35}{4} = 3.75 + 5 = 8.75\Omega$$

Current i_1 through 5 Ω resistor is

$$I = \frac{V}{R} = \frac{10}{35/4} = 1.142A$$

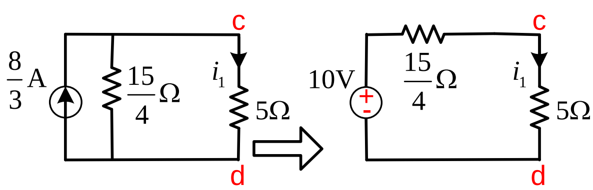


Figure 1.31

The other method to find current in the above circuit is

$$i_1 = Currrent \times \frac{Resistance\ in\ other\ baranch}{Total\ Resistance}$$

$$i_1 = \frac{8}{3} \times \frac{3.75}{3.75 + 5} = 1.142A$$

Q 5) In the circuit shown in Figure 1.32 determine the current I

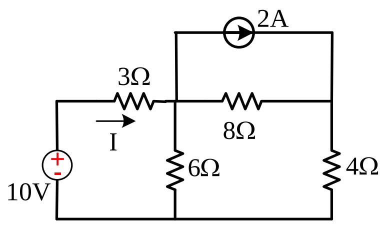


Figure 1.32

Solution:

KVL cannot be applied directly due to the presence of current source. Replace the current source into voltage source in series with 8 Ω and current source as

$$V = 2 \times 8 = 16Volts$$

Now the 8 Ω and 4 Ω are in series which are placed in series with voltage source.

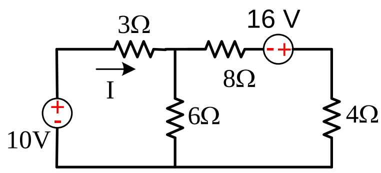


Figure 1.33

Replace the voltage source into current source in parallel with 12 Ω

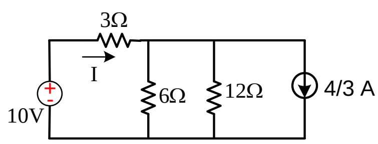


Figure 1.34

12 Ω and 6 Ω are in parallel. Current source can be replaced by voltage source the details are as shown in Figure

$$R = \frac{6 \times 12}{6 + 12} = 4\Omega$$

$$V = I \times R = \frac{4}{3} \times 4 = \frac{16}{3}Volts$$

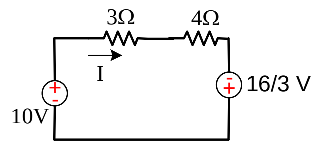


Figure 1.35

Current I is

$$\begin{aligned} \frac{16}{3} + 10 - 7 \times I &= 0 \\ \frac{16 + 30}{3} - 7I &= 0 \\ 7I &= \frac{46}{3} \\ I &= \frac{46}{3 \times 7} = 2.19A \end{aligned}$$

Q 6) In the circuit shown in Figure 1.17 determine current I by source transformation.

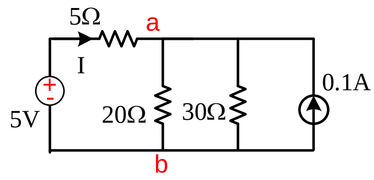


Figure 1.36

Solution:

First the parallel resistance is replaced by single resistor which is as shown in Figure

$$R = \frac{20 \times 30}{20 + 30} = \frac{600}{50} = 12\Omega$$

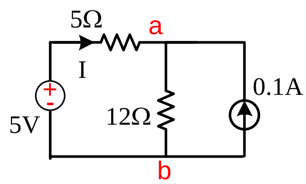


Figure 1.37

Now replace the current source in parallel with resistor by voltage source in series with resistor, which is as shown in Figure

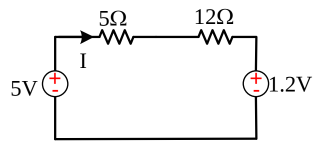


Figure 1.38

The current I in the circuit is

$$I = \frac{5 - 1.2}{5 + 12} = \frac{3.8}{17} = 0.224A$$

Q 7) In the circuit shown in Figure 1.39 determine the voltage v_0 across 100 Ω resistor

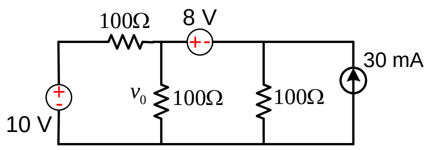


Figure 1.39

Solution:

Replace the current source by voltage source in series with 100 Ω resistor which is as shown in Figure.

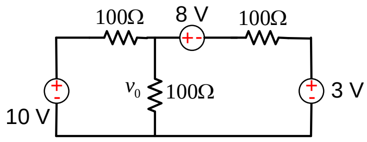


Figure 1.40

Voltage sources of 8 and 3 are in series which are replaced by single voltage source.

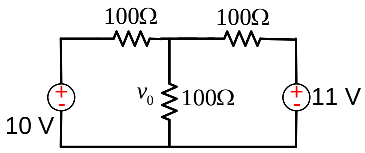


Figure 1.41

Replace the voltage source of 11 volts with current source in parallel with 100 Ω resistor.

$$I = \frac{11}{100} = 110mA$$

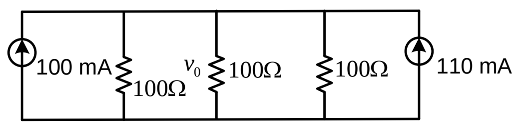


Figure 1.42

100 mA current source with 100 Ω resistor and 110 mA current source with 100 Ω resistor are in parallel which are replaced by single current source and single resistor as

$$I = 100 + 110 = 210mA$$

$$R = \frac{100 \times 100}{100 + 100} = 50\Omega$$

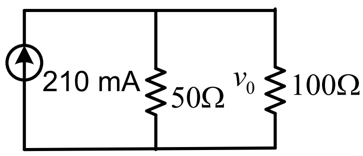


Figure 1.43

Current through 100 Ω resistor is

$$I = 210\frac{50}{50 + 100} = 70mA$$

Voltage across the 100 Ω resistor is

$$V = I \times R = 70 \times 10^{-3} \times 100 = 7V$$

Q 8) In the circuit shown in Figure 1.44 determine the current in the 12 Ω resistor using source transformation method

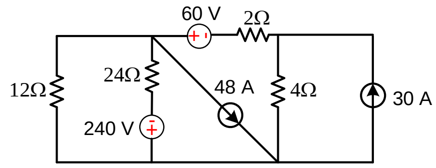


Figure 1.44

Solution:

Replace the current source and parallel resistor 4 Ω by voltage source in series with resistor 4 Ω

$$V = I \times R = 30 \times 4 = 120V$$

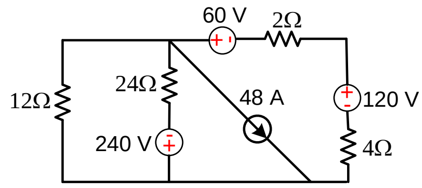


Figure 1.45

Replace the voltage sources and source resistors by single voltage source in series with single resistor 4 Ω

$$V = 60 + 120 = 180V$$

$$R = 2 + 4 = 6\Omega$$

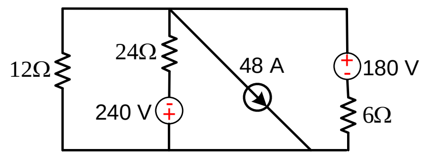


Figure 1.46

Replace 240 V voltage source in series resistor 24 Ω by a current source and 180 V voltage source in series resistor 6 Ω by a current source

$$I = \frac{V}{R} = \frac{240}{24} = 10A$$

$$I = \frac{V}{R} = \frac{180}{6} = 30A$$

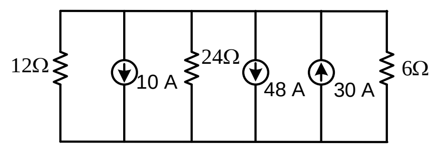


Figure 1.47

Current sources 10 A, 48A, and 30 A are in parallel. Replace these by single current source. Also replace parallel resistor by a single resistor.

$$I = 10 + 48 - 30A = 28A$$

$$R = \frac{24 \times 6}{24 + 6} = \frac{144}{30} = 4.8\Omega$$

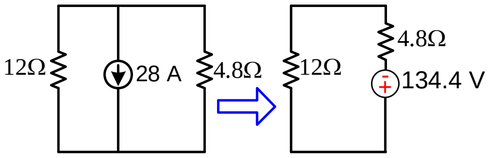


Figure 1.48

The current in 12 Ω resistor is sources 10 A, 48A, and 30 A are in parallel. Replace by single current source. Replace parallel resistors by a single resistor.

$$I = \frac{134.4}{12 + 4.8} = 8A$$

Q 9) In the circuit shown in Figure 1.52 determine the current in the 3 Ω resistor using source transformation method

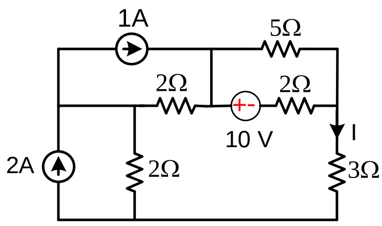


Figure 1.49

Solution:

Replace the 2 A current source and parallel resistor of 2 Ω by voltage source in series with resistor 2 Ω similarly replace the 1 A current source and parallel resistor of 2 Ω by voltage source in series with resistor 2 Ω

$$V = 2 \times 2 = 4V$$

$$V = 1 \times 2 = 2V$$

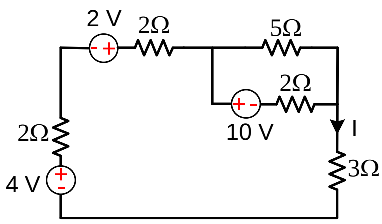


Figure 1.50

4 volts and 2 volts are in series and are added similarly 2 Ω 2 Ω resistors are in series and are added. Replace the 10 V voltage source by current source in parallel resistor of 2 Ω.

$$I = \frac{10}{2} = 5A$$

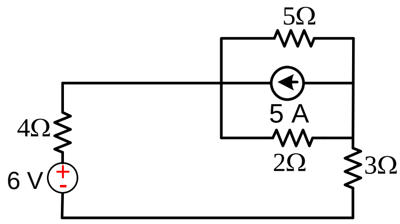


Figure 1.51

5 Ω and 2 Ω resistors are in parallel and are replaced by single resistor.

$$R = \frac{2 \times 5}{2 + 5} = 1.428\Omega$$

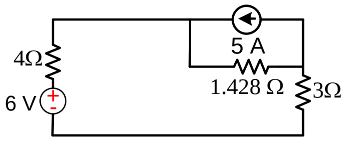


Figure 1.52

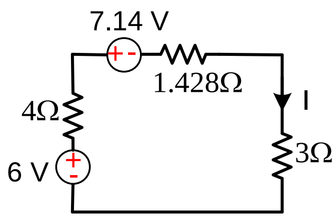


Figure 1.53

The current through 3 Ω is determined by applying KVL in the loop as:

$$I = \frac{7.14 - 6}{8.428} = 0.135\ A$$

Q 10) In the circuit shown in Figure 1.54 determine the currentI_x using source transformation method

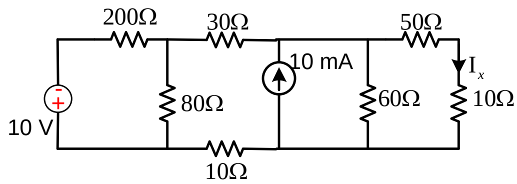


Figure 1.54

Solution:

Replace the voltage source of 10 V by current source in parallel with resistor of 200 Ω

$$I = \frac{10}{200} = 50\ mA$$

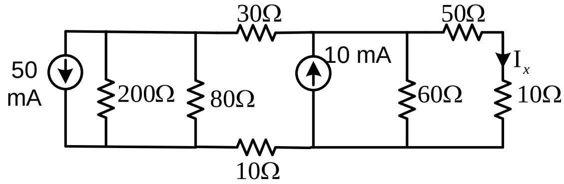


Figure 1.55

Replace the parallel resistors of 200 and 80 Ω by a single resistor

$$I = \frac{200 \times 80}{200 + 80} = 57.1\ \Omega$$

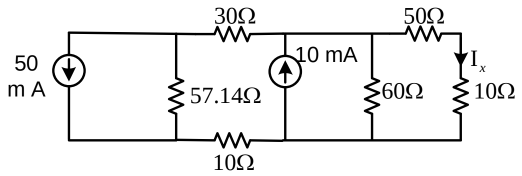


Figure 1.56

Replace the current source of 50 mA and parallel resistor of 57.14 Ω by voltage source

$$V = 50 \times 10^{-3} \times 57.14 = 2.857V$$

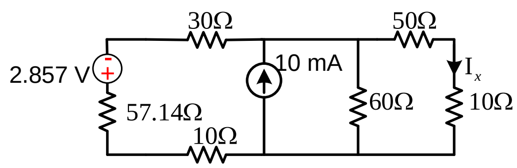


Figure 1.57

30 Ω, 57.14 Ω and 10 Ω are in series replace by single resistor

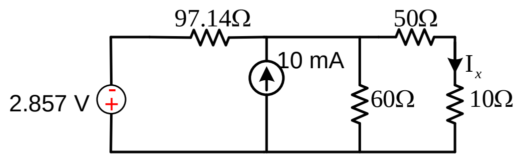


Figure 1.58

Replace the voltage source of 2.857 V by current source in parallel with resistor of 97.15 Ω

$$I = \frac{2.857}{97.15} = 29.41\ mA$$

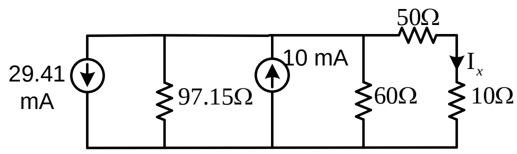


Figure 1.59

29.41 mA and 10 mA are in opposite directions and are in parallel, replace by single current source. Resistors 97.15 Ω 60 Ω are in parallel with single resistor of 37 Ω

$$I = 29.41 - 10 = 19.41\ mA$$

$$R = \frac{97.15 \times 60}{97.15 + 60} = 37\ \Omega$$

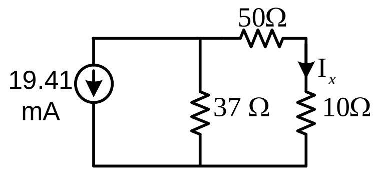


Figure 1.60

By Branch Rule

$$I_x \quad = \quad 19.41\frac{37}{37 + 60} = 7.42mA$$

Q 11) In the circuit shown in Figure 1.61 determine the current I_x using source transformation method

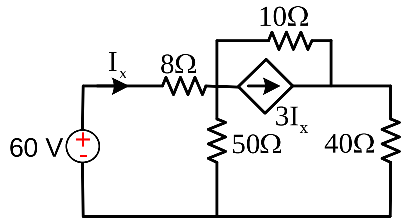


Figure 1.61

Solution:

Replace the current source and parallel resistor of 10 Ω by voltage source in series with resistor of 10 Ω.

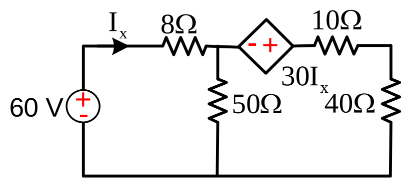


Figure 1.62

10 Ω and 40 are in series which are replaced by single resistor. Replace voltage source by current source.

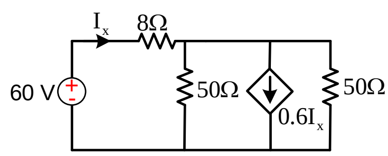


Figure 1.63

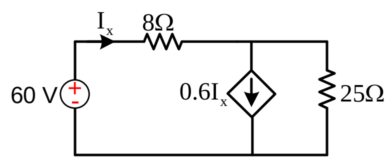


Figure 1.64

Replace the current source and parallel resistor of 25 Ω by voltage source in series with resistor of 25 Ω.

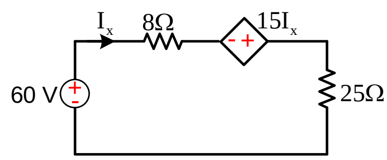


Figure 1.65

The current through I_x is determined by applying KVL in the loop as:

$$\begin{aligned} 60 - 8I_x + 15I_x - 25I_x &= 0 \\ 18I_x &= 60 \\ I_x &= \frac{60}{18} = 3.333A \end{aligned}$$

Q 12) In the circuit shown in Figure ?? determine the current I_1

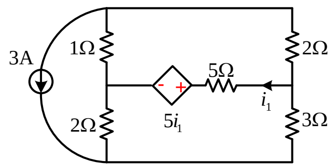


Figure 1.66

Solution:

For the given circuit there is a current source of 3A. Shift the current source between resistors 1 Ω 2 Ω. The modified circuit is as shown in Figure 1.67

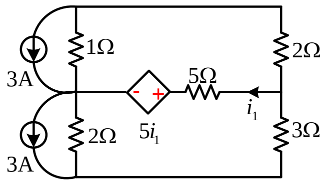


Figure 1.67

Convert current sources into voltage sources in series with resistor 1 Ω and 2 Ω.

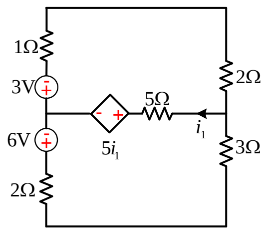


Figure 1.68

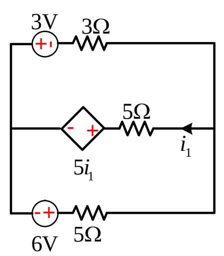


Figure 1.69

Now convert voltage sources into current sources in parallel with resistors as shown in Figure

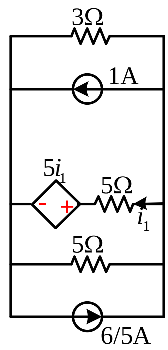


Figure 1.70

Current source 1 A and $\frac{6}{5}$ A are in opposite directions, replace by single current source and also replace parallel resistors 3 Ω and 5 Ω by a single resistor

$$I_{eq} = \frac{6}{5} - 1 = \frac{1}{5} = 0.2A$$

$$R_{eq} = \frac{3 \times 5}{3 + 5} = \frac{15}{8} = 1.875\Omega$$

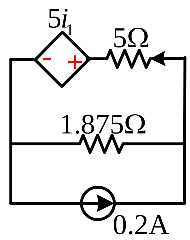


Figure 1.71

Replace the 0.2A current source and parallel resistor 1.875 Ω by voltage source in series with 1.875 Ω resistor

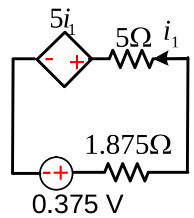


Figure 1.72

Apply KVL for the loop

$$\begin{aligned} 0.375 - 6.875i_1 - 5i_1 &= 0 \\ 0.375 - 11.875i_1 &= 0 \end{aligned}$$
$$i_1 = \frac{11.875}{0.375} = 31.67A$$

1.3 Question Papers

2019 Dec (2018 Scheme) 1 a). Using source transformation technique find the current through 5 Ω resistor for the circuit shown in Figure 1.73.

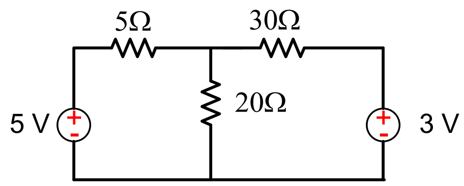


Figure 1.73: 2019-Dec-Question Paper

Solution:

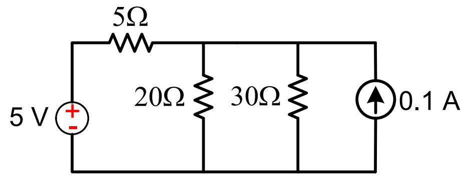


Figure 1.74

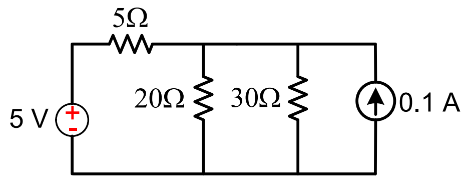


Figure 1.75

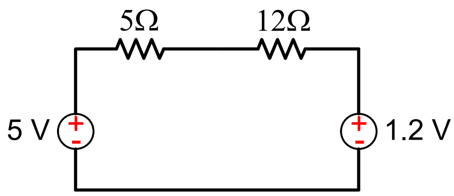


Figure 1.76

The current through 5 Ω resistor is

$$I = \frac{12-5}{17} = 0.4117\ A$$

JAN-2018 Use source transformation to convert as shown in Figure 1.77 to a single current source in parallel with single resistor

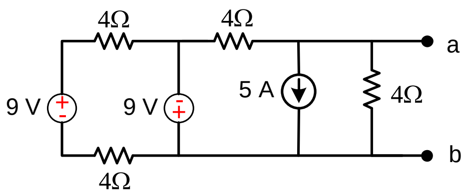
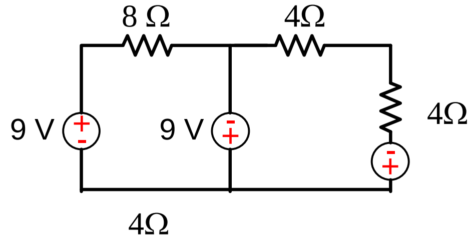
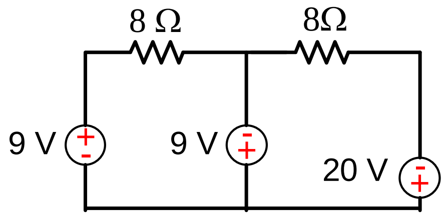
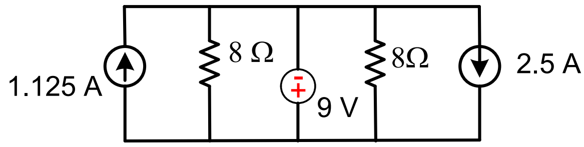


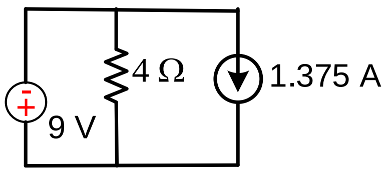
Figure 1.77: JAN-2018-Question Paper

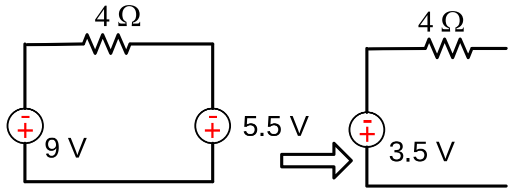
Solution:



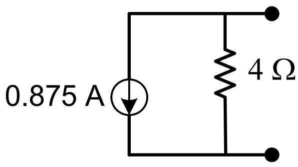








The equivalent current source is



JULY-2017 Calculate the current through 2 Ω resistor for the circuit as shown in Figure 1.78 using source transformation

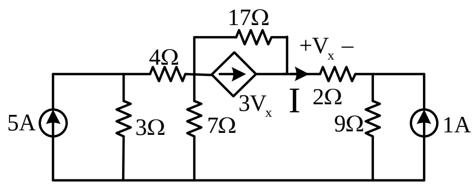


Figure 1.78: JULY-2017-Question Paper

Solution: Replace the each current source 5 A in parallel with 3 Ω resistor by voltage source, 1 A in parallel with 9 Ω resistor by voltage source and 3 V_x current sources in parallel with resistor of 17 Ω by voltage source which is as shown in Figure 1.79

$$V_1 = I \times R = 5 \times 3 = 15V$$
$$V_2 = I \times R = 9 \times 1 = 9V$$
$$V_1 = I \times R = 3V_x \times 17 = 51V$$

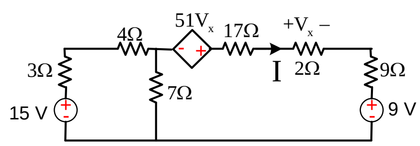


Figure 1.79: JULY-2017-Question Paper

From the figure it is observed that $V_x = 2 \times I$
Replace the voltage source of 15 V in series (3+4) Ω resistor by current source

$$I = \frac{15}{7} = 2.14\ A$$

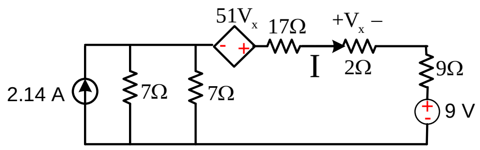


Figure 1.80: JULY-2017-Question Paper

7 Ω and 7 Ω are in parallel replace by single resistor

$$R = \frac{7 \times 7}{7+7} = 3.5\ \Omega$$

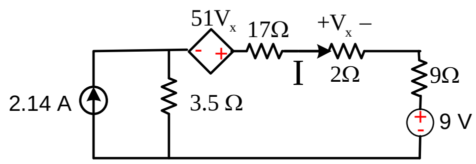


Figure 1.81: JULY-2017-Question Paper

Replace the current by source voltage source in series 3.5 Ω resistor

$$V = 2.14 \times 3.5 = 7.49V$$

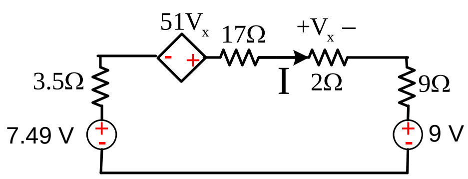


Figure 1.82: JULY-2017-Question Paper

From the figure it is observed that $V_x = 2 \times I$
Apply the KVL for the circuit by using $V_x = 2 \times I$

$$\begin{aligned} 7.49 - 51V_x - 9 - 29.5I &= 0 \\ -1.51 - 51 \times 2I - 29.5I &= 0 \\ -1.51 - 102I - 29.5I &= 0 \\ -1.51 - 131I &= 0 \\ I = \frac{1.51}{131} &= 11.5\ mA \end{aligned}$$

JULY-2016 Using source transformation find the current through R_L in the circuit as shown in Figure 1.83

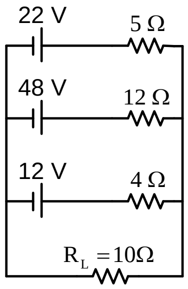


Figure 1.83: JULY-2016-Question Paper

Solution:

Solution:

Replace the each voltage sources into current sources in parallel with resistor which is as shown in Figure 1.84

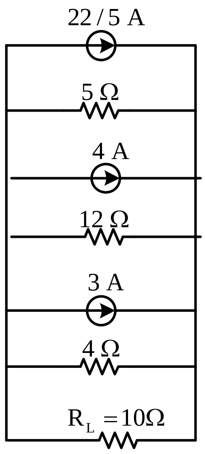


Figure 1.84: JULY-2016-Question Paper

Each current sources are in parallel, add these current source and replace the parallel resistor by single resistor, the modified circuit is as shown in Figure 1.85

$$I = I_1 + I_2 + I_3 = \frac{22}{5} + 4 + 3 = 11.4A$$

$$\frac{1}{R} = \frac{1}{5} + \frac{1}{12} + \frac{1}{4} = 0.533$$

$$R = \frac{1}{0.533} = 1.875$$

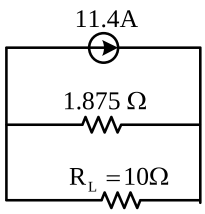


Figure 1.85: JULY-2016-Question Paper

Current source in parallel with resistor is replaced voltage source which is as shown in Figure 1.86

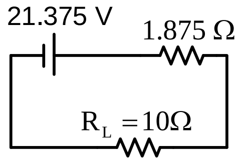


Figure 1.86: JULY-2016-Question Paper

Current through R_L is, by KVL

$$21.375 - I \times 11.875 = 0$$

$$I = \frac{21.375}{11.875} = 1.8A$$

JULY-2014 Using source transformation find the power delivered by 50 V source i given network of as shown in Figure 1.87

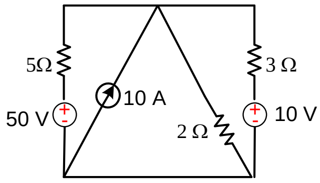


Figure 1.87: JULY-2014-Question Paper

Solution:

The redrawn circuit is as shown in Figure

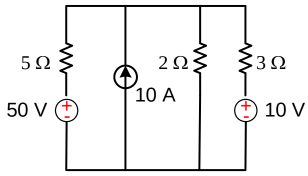


Figure 1.88

Replace the 10 V voltage source in series with 3 Ω by current source in parallel with 3 Ω resistor.

$$I = \frac{V}{I} = \frac{10}{3}A$$

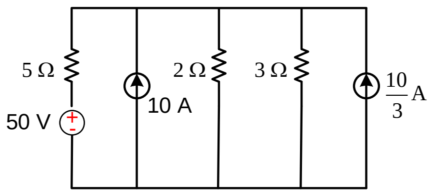


Figure 1.89

Replace current sources 10 A and in parallel with $\frac{10}{3}$ A by single current source and parallel resistors by single resistor

$$I = 10 + \frac{10}{3} = \frac{40}{3}$$

$$R = \frac{2 \times 3}{2+3} = \frac{6}{3}\Omega$$

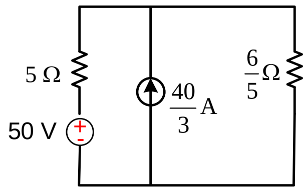


Figure 1.90

Replace the current source $\frac{40}{3}$ A in parallel with $\frac{10}{3}$ resistor by a voltage source in series with resistor

$$R = \frac{6}{3} = 1.2\Omega$$

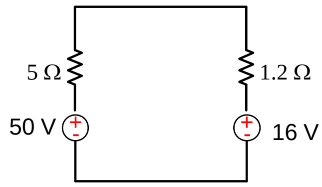


Figure 1.91

By applying KVL in the circuit is

$$50 - 16 - I \times 6.2 = 0$$

$$I = \frac{34}{6.2} = 5.48A$$

The power delivered by 50 V source is

$$P = 50 \times I = 50 \times 5.48 = 274W$$