K. J. SOMAIYA COLLEGE OF ENGINEERING
DEPARTMENT OF ELECTRONICS ENGINEERING
ELECTRONIC CIRCUITS
DC CIRCUITS

Numerical 1: For the circuit shown in figure 1, find:

a) Current I

b) Voltage between A and B (V_{ab})

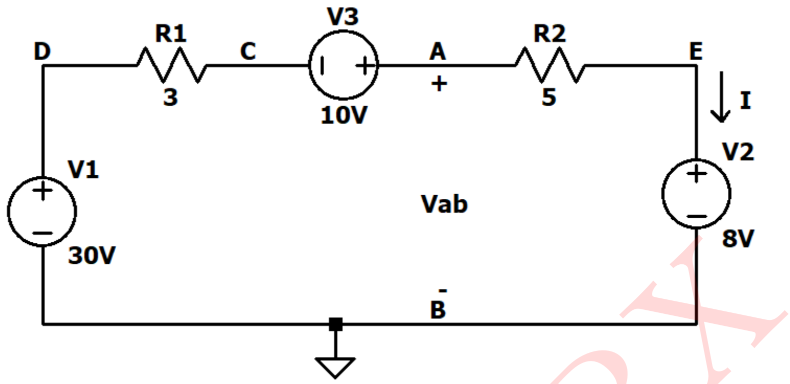


Figure 1: Circuit 1

Solution:

Case 1: To determine Current I

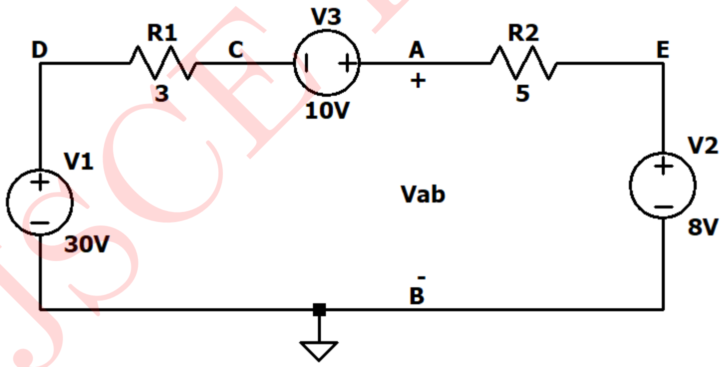


Figure 2: To determine Current I

Applying KVL to the loop,

$30 + 3I - 5I + 10 - 8 = 0$

$\therefore 32 - 8I = 0$

$\therefore 8I = 32$

$\therefore I = \dfrac{32}{8}$

$\therefore$ **Current** I **= 4A**

Case 2: To determine Voltage V_{ab}

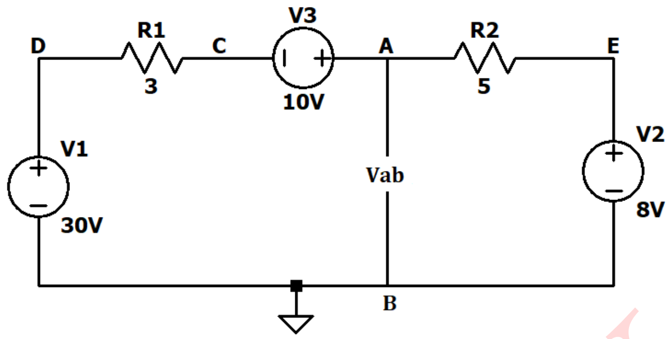


Figure 3: To determine Voltage V_{ab}

Applying KVL to the second loop,

$V_{ab} - 5I - 8 = 0$ ...(1)

Since, we know that $I = 4A$

Substituting the value of I in the equation (1)

$\therefore V_{ab} - 5 \times 4 - 8 = 0$

$\therefore V_{ab} - 20 - 8 = 0$

$\therefore V_{ab} = 20 + 8$

$\therefore V_{ab} = \mathbf{28V}$

SIMULATED RESULTS:

The given circuit is simulated in LTspice and the results obtained are as follows:

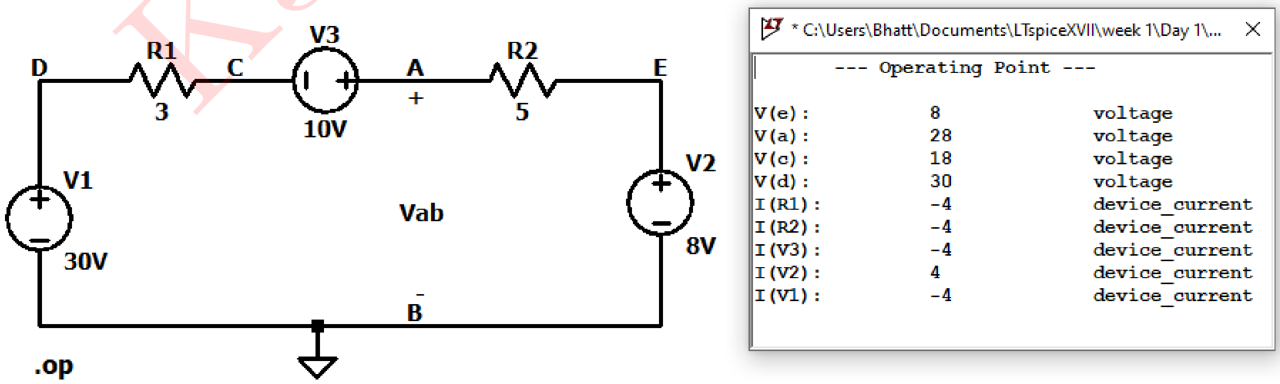


Figure 4: Circuit Schematic and Simulated Results

Comparison of theoretical and simulated values:

Parameters	**Theoretical Values**	**Simulated Values**
Current (I)	4A	4A
Voltage V_{ab}	28V	28V

Table 1: Numerical 1

Numerical 2: For the circuits shown in figure 5, find the equivalent resistance R_{eq}

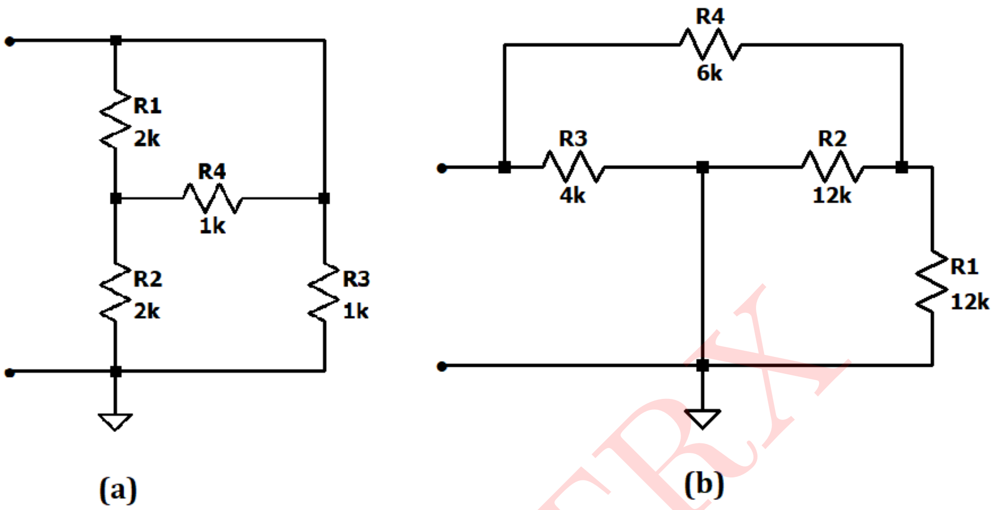


Figure 5: Circuit 2a and Circuit 2b

Solution:

Case 1 : Circuit 2a

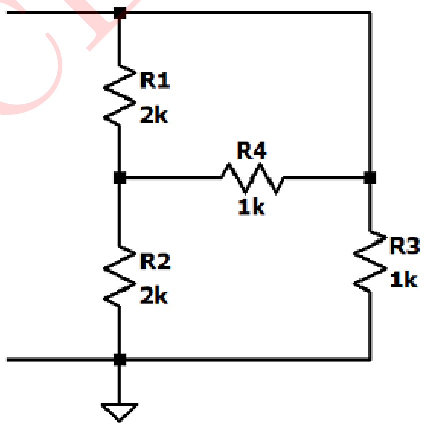


Figure 6: Circuit 2a

To get R_{eq}, we combine resistor in series and in parallel.

The resistor $R_1 = 2\ \text{k}\Omega$ and $R_4 = 1\ \text{k}\Omega$ are parallel.

$$\therefore 2\ \text{k}\Omega \parallel 1\ \text{k}\Omega = \frac{2}{2+1}$$

$$\therefore 2\ \text{k}\Omega \parallel 1\ \text{k}\Omega = \frac{2}{3}\ \text{k}\Omega = 0.666\ \text{k}\Omega$$

Thus, the circuit is reduced to figure 7

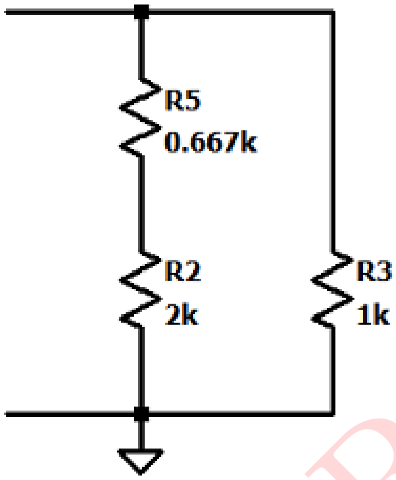


Figure 7: Modified circuit for figure 6

Now, resistors $R_5 = 0.666\ \mathrm{k\Omega}$ and $R_2 = 2\ \mathrm{k\Omega}$ are in series.

Hence, the equivalent resistance is

$0.6667\ \mathrm{k\Omega} + 2\ \mathrm{k\Omega} = 2.6667\ \mathrm{k\Omega}$

Now, the circuit is reduced to figure 8

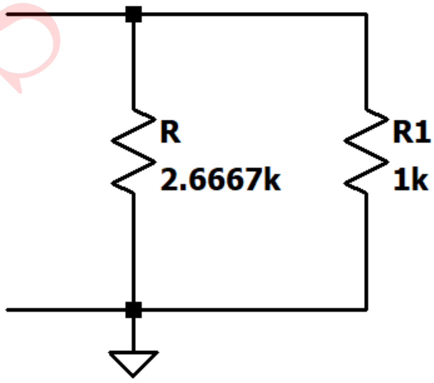


Figure 8: Modified Circuit for figure 7

Here, the resistor $R = 2.6667\ \mathrm{k\Omega}$ and $R_1 = 1\ \mathrm{k\Omega}$ are parallel.

$$\therefore 2.6667\ \mathrm{k\Omega} \parallel 1\ \mathrm{k\Omega} = \frac{2.6667}{2.6667 + 1}$$

$$\therefore 2\ \mathrm{k\Omega} \parallel 1\ \mathrm{k\Omega} = \frac{2}{3.6667}\ \mathrm{k\Omega}$$

$$\therefore 2\ \mathrm{k\Omega} \parallel 1\ \mathrm{k\Omega} = 0.72727\ \mathrm{k\Omega}$$

$$\therefore R_{eq} = \mathbf{727.27\ k\Omega}$$

Case 2 : Circuit 2b

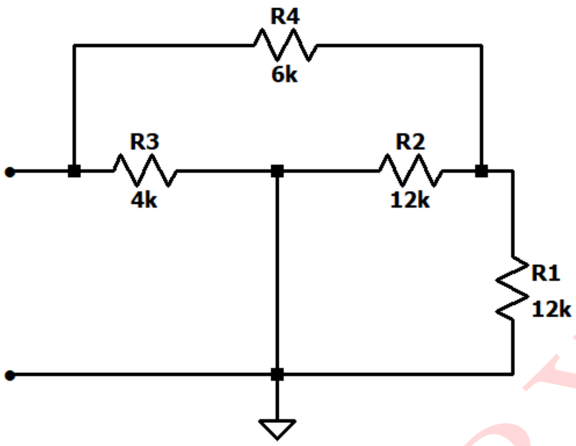


Figure 9: Circuit 2b

Solution:

Here the resistors $R_1 = 6$ kΩ, $R_2 = 12$ kΩ and $R_3 = 4$ kΩ form a delta network.

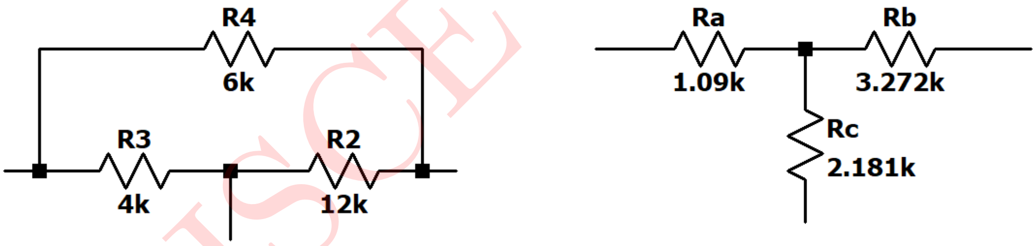


Figure 10: Star - Delta Transformation modified circuit

Therefore, using Star - Delta Transformation

The formulas are :

$$R_a = \frac{R_3 \times R_4}{R_1 + R_2 + R_3}$$

$$R_b = \frac{R_2 \times R_4}{R_1 + R_2 + R_3}$$

$$R_c = \frac{R_2 \times R_3}{R_1 + R_2 + R_3}$$

Substituting the values of resistors in the formula, we get

$R_a = \dfrac{4 \times 6}{4+6+12}$

$\therefore R_a = \dfrac{24}{22}$

$\therefore R_a = \mathbf{1.0909\ k\Omega}$

$R_a = \dfrac{12 \times 6}{4+6+12}$

$\therefore R_a = \dfrac{72}{22}$

$\therefore R_a = \mathbf{3.2728\ k\Omega}$

$R_a = \dfrac{12 \times 4}{4+6+12}$

$\therefore R_a = \dfrac{48}{22}$

$\therefore R_a = \mathbf{2.1818\ k\Omega}$

Now, the circuit is reduced to figure 11

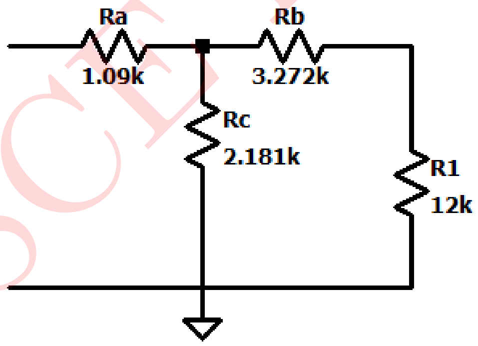


Figure 11: Modified circuit for figure 9

Now Resistor 3.2728 kΩ is in series with 12 kΩ

$\therefore 3.2728\ k\Omega + 12\ k\Omega = 15.2728\ k\Omega$

The circuit is reduced to to figure 12

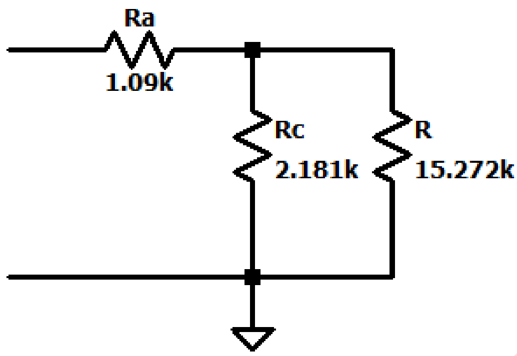


Figure 12: Modified circuit for figure 11

Now Resistor 15.2728 kΩ is in parallel with 2.181 kΩ

$\therefore$ 15.2728 kΩ $\|$ 2.181 kΩ $= \dfrac{152728 \times 2.181}{2.181 + 15.2728}$ kΩ

$\therefore$ 15.2728 kΩ $\|$ 2.181 kΩ $=$ 1.909 kΩ

Thus, finally circuit is reduced to figure 13

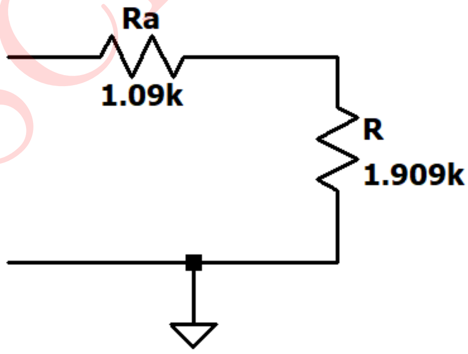


Figure 13: Modified circuit for figure 12

Now Resistor 1.09 kΩ is in series with 1.909 kΩ

$\therefore$ 1.09 kΩ + 1.909 kΩ = 2.999 kΩ

$\therefore R_{eq}$ = **2.999 kΩ**

SIMULATED RESULTS:

The given circuit is simulated in LTspice and the results obtained are as follows:

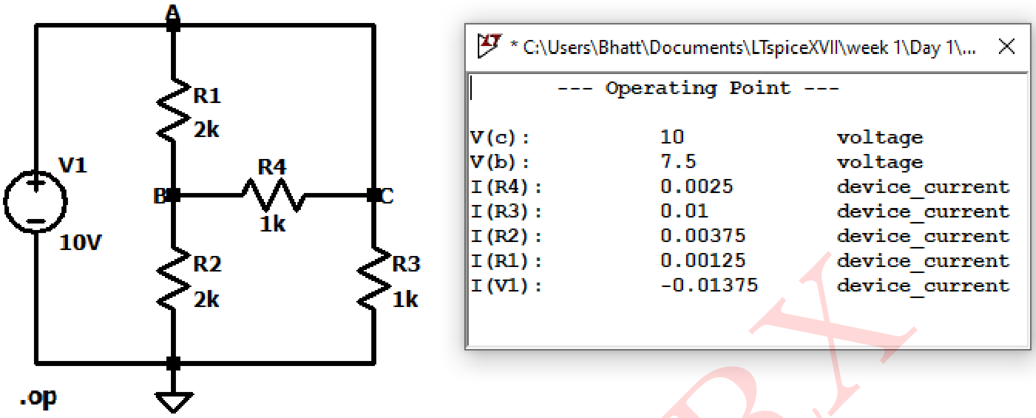


Figure 14: Circuit 2a Schematic and Simulated Results

Calculation:

$R_{eq} = \frac{V_1}{I_{V1}}$

$R_{eq} = \frac{10}{0.01375}$

$R_{eq} = \mathbf{727.27}\ \Omega$

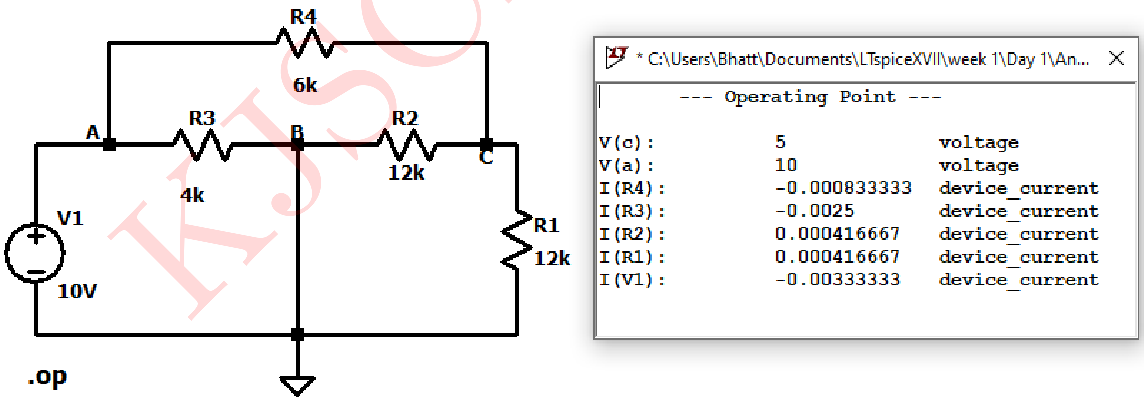


Figure 15: Circuit 2b Schematic and Simulated Results

Calculation:

$R_{eq} = \frac{V_1}{I_{V1}}$

$R_{eq} = \frac{10}{0.00333}$

$R_{eq} = \mathbf{3000}\ \Omega$

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
$R_{eq}(2a)$	727.3 Ω	727.3 Ω
$R_{eq}(2b)$	2999 Ω	3000 Ω

Table 2: Numerical 2

Numerical 3: Using Superposition theorem, calculate the magnitude and direction of the current through each resistor in the circuit of Figure 16

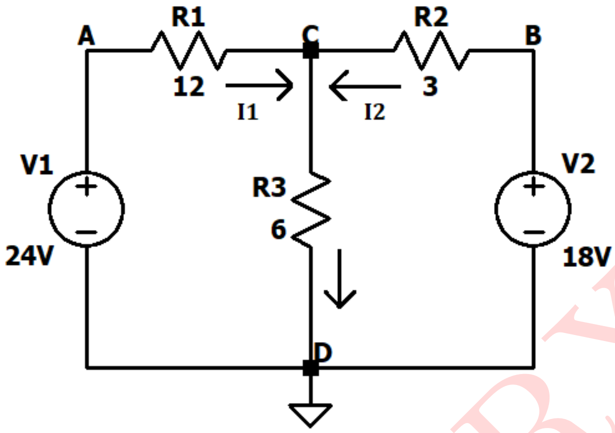


Figure 16: Circuit 3

Solution:

Case 1: 24V voltage source is active and 18V voltage source is inactive

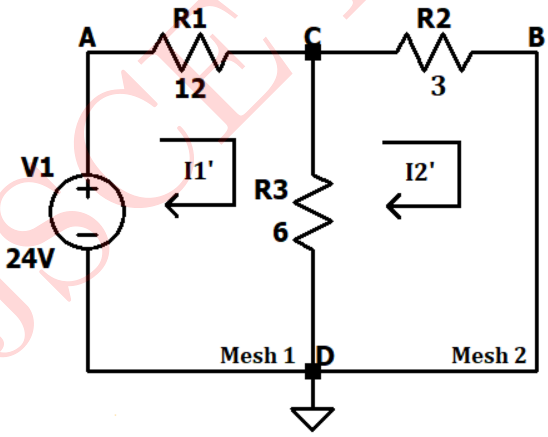


Figure 17: When only 24V voltage source is active

Let I_1' and I_2' be the current flowing through Mesh 1 and Mesh 2 in clockwise direction

Applying KVL to the Mesh 1,

$-12I_1' - 6(I_1' - I_2') + 24 = 0$

$\therefore -12I_1' - 6I_1' + 6I_2' + 24 = 0$

$\therefore -18I_1' + 6I_2' + 24 = 0$

$\therefore 18I_1' - 6I_2' = 24$ ...(1)

Applying KVL to Mesh 2,

$-3I_2' - 6(I_2' - I_1') = 0$

$\therefore -3I_2' - 6I_2' + 6I_1' = 0$

$\therefore -9I_2' + 6I_1' = 0$

$\therefore 9I_2' - 6I_1' = 0$ ...(2)

Solving equation (1) and (2) simultaneously, we get

$I_1' = 1.71429\text{A}$

$I_2' = 1.14286\text{A}$

Now let I_3' be the current flowing through branch CD in the downward direction

$\therefore I_3' = I_1' - I_2'$

$\therefore I_3' = 1.71429 - 1.14286$

$\therefore I_3' = 0.57143\text{A}$

Therefore, current flowing through the resistor R_1, R_2 and R_3 when only 24V voltage source is active is

$\mathbf{I_1' = 1.71429\ A}$

$\mathbf{I_2' = -\ 1.14286A}$

$\mathbf{I_3' = 0.57143A}$

Case 2 : 18V voltage source is active and 24V voltage source is inactive

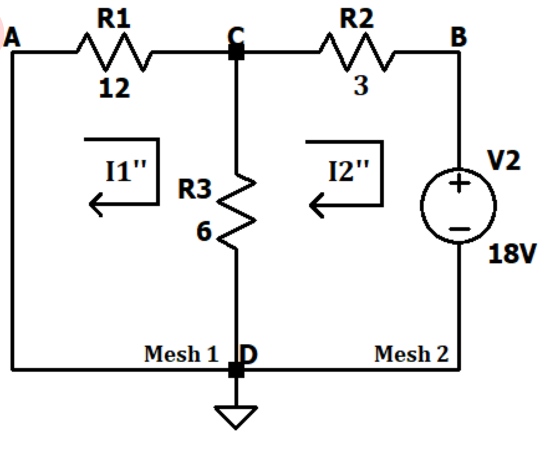


Figure 18: When only 18V voltage source is active

Let I_1'' and I_2'' be the current flowing through Mesh 1 and Mesh 2 in clockwise direction

Applying KVL to the Mesh 1,

$-12I_1'' - 6(I_1'' - I_2'') = 0$

$\therefore -12I_1'' - 6I_1'' + 6I_2'' = 0$

$\therefore -18I_1'' + 6I_2'' = 0$

$\therefore 18I_1'' - 6I_2' = 0$ ...(1)

Applying KVL to Mesh 2,

$-3I_2'' - 18 - 6(I_2'' - I_1'') = 0$

$\therefore -3I_2'' - 18 - 6I_2'' + 6I_1'' = 0$

$\therefore 6I_1'' - 9I_2'' - 18 = 0$

$\therefore 6I_1'' - 9I_2'' = 18$ ...(2)

Solving equation (1) and (2) simultaneously, we get

$I_1' = -\ 0.85714\text{A}$

$I_2' = -\ 2.57143\text{A}$

Now let I_3'' be the current flowing through branch CD in the downward direction

$\therefore I_3'' = I_1'' - I_2''$

$\therefore I_3'' = (-0.85714) - (-2.57143)$

$\therefore I_3'' = 2.57143 - 0.857143$

$\therefore I_3'' = 1.71429\text{A}$

Therefore, currents flowing through the resistor R_1, R_2 and R_3 when only 18V voltage source is active is

$\boldsymbol{I_1'' = -\ 0.85714\text{A}}$

$\boldsymbol{I_2'' = -\ 2.57143\text{A}}$

$\boldsymbol{I_3'' = 1.71429\text{A}}$

Using Superposition theorem,

Currents I_1' and I_1'' are flowing through resistor $R_1 = 12\ \Omega$

$\therefore I_1 = I_1' + I_1''$

$\therefore I_1 = 1.71429 + (-0.85714)$

$\therefore I_1 = 1.71429 - 0.85714$

$\therefore I_1 = 0.85714\text{A}$

Here, the positive sign denotes that the assumed direction is correct.

Hence, a current of 0.85714A is flowing through the 12 Ω resistor in clockwise direction.

Currents I_2' and I_2'' are flowing through resistor $R_2 = 3\ \Omega$

$\therefore I_2 = I_2' + I_2''$

$\therefore I_2 = 1.14286 + (-2.57143)$

$\therefore I_2 = 1.14286 - 2.57143$

$\therefore I_2 = -\ 1.42857\text{A}$

Here, the negative sign denotes that the assumed direction is wrong.

Hence, a current of 1.42857A is flowing through the 3 Ω resistor in anti-clockwise direction.

Also, I_3' and I_3'' are the currents flowing through resistor $R_3 = 6\ \Omega$

$\therefore I_3 = I_3' + I_3''$

$\therefore I_3 = 0.571429 + 1.71429$

$\therefore I_3 = 2.28571\text{A}$

Here, the positive sign denotes that the assumed direction is correct.

Hence, a current of 2.8571A is flowing through the 6 Ω resistor in clockwise direction.

Therefore, the current flowing through resistors 12 Ω, 3 Ω and 6 Ω are **0.85714A, 1.42857A** and **2.28571A** respectively.

SIMULATED RESULTS:

The given circuit is simulated in LTspice and the results obtained are as follows:

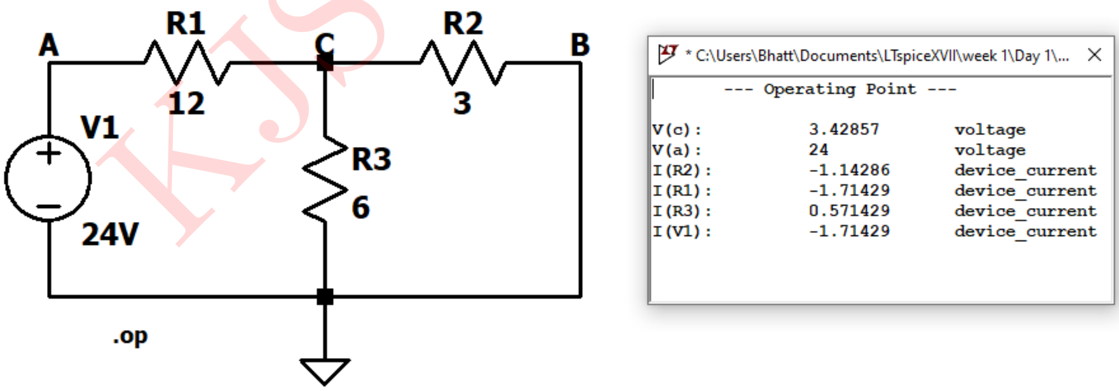


Figure 19: Circuit Schematic and Simulated Results: when only 24V voltage source is active

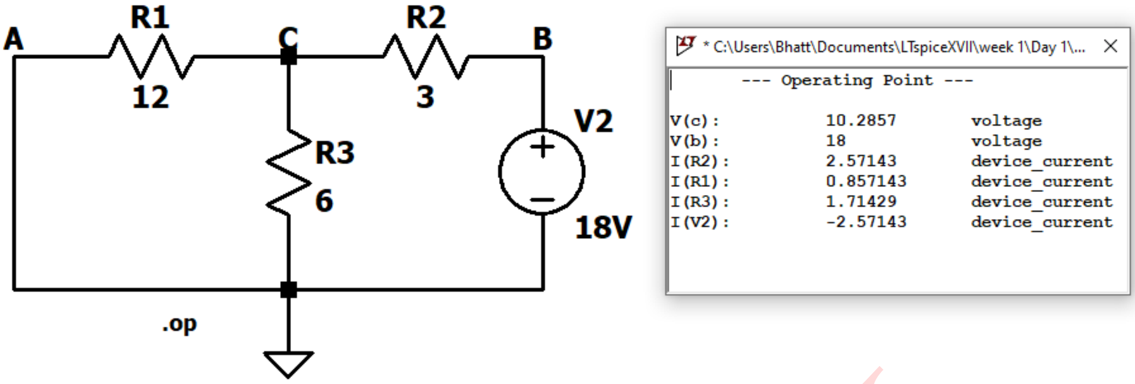


Figure 20: Circuit Schematic and Simulated Results: when only 18V voltage source is active

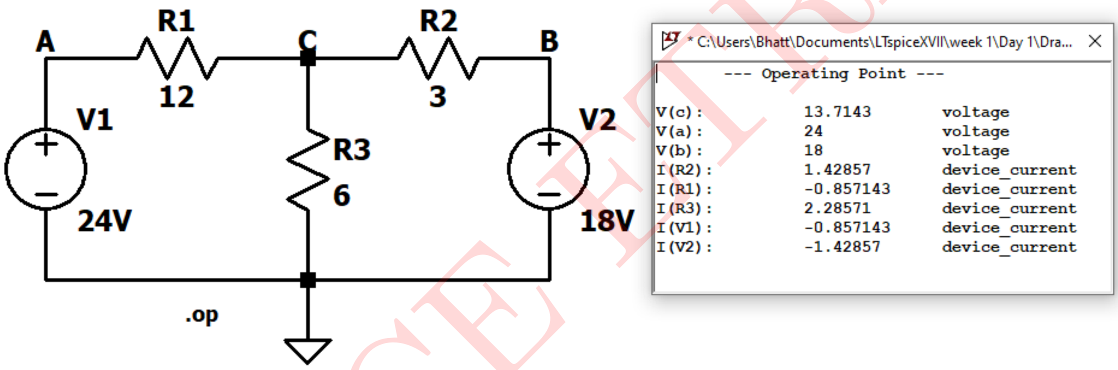


Figure 21: Circuit Schematic and Simulated Results: when both the sources are active

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
$I_{12\Omega}$	0.85714A	0.85714A
$I_{3\Omega}$	1.42857A	1.42857A
$I_{6\Omega}$	2.28571A	2.28571A

Table 3: Numerical 3

Numerical 4: For the circuit shown in Figure 22 find the current in R = 8 Ω resistance in the branch AB using superposition theorem.

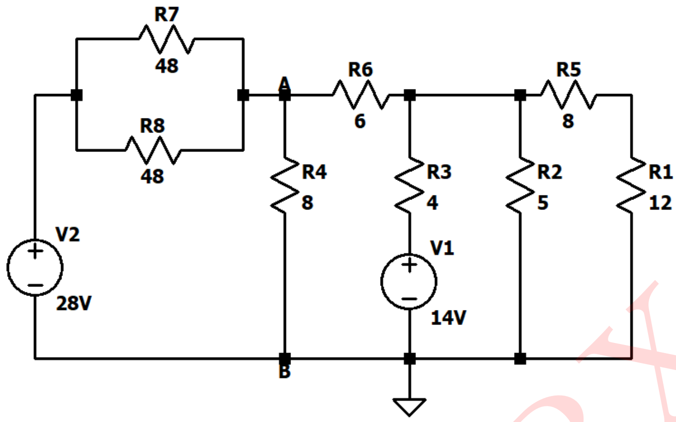


Figure 22: Circuit 4

Solution:

Case 1 : 28V voltage source is active and 14V voltage source is inactive

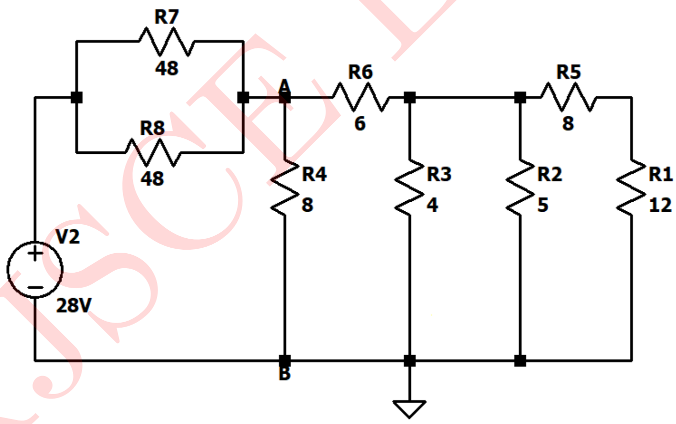


Figure 23: When only 28V voltage source is active

Resistors R_1 and R_5 i.e. 8 Ω and 12 Ω are in series

$\therefore$ 8 Ω + 12 Ω = 20 Ω

The resistors R_7 = 48 Ω and R_8 = 48 Ω are parallel.

$$\therefore 48\Omega \parallel 48\Omega = \frac{48 \times 48}{48 + 48}$$

$$\therefore 48\Omega \parallel 48\Omega = 24\ \Omega$$

Now the circuit is reduced to figure 24

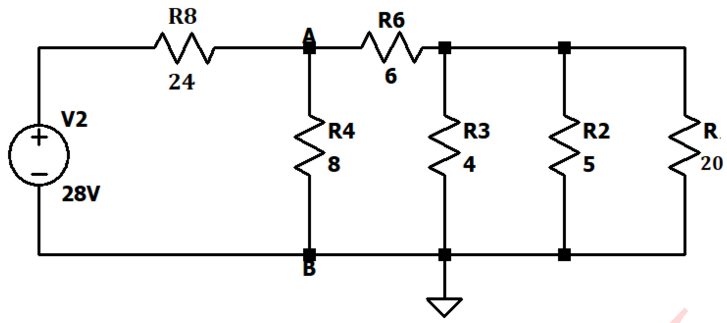


Figure 24: Modified circuit for figure 23

The resistors $R = 20\ \Omega$ and $R_2 = 5\ \Omega$ are parallel.

$\therefore 20\Omega \parallel 5\Omega = \dfrac{20 \times 5}{20 + 5}$

$\therefore 20\Omega \parallel 5\Omega = \dfrac{100}{24}\ \Omega$

$\therefore 20\Omega \parallel 5\Omega = 4\ \Omega$

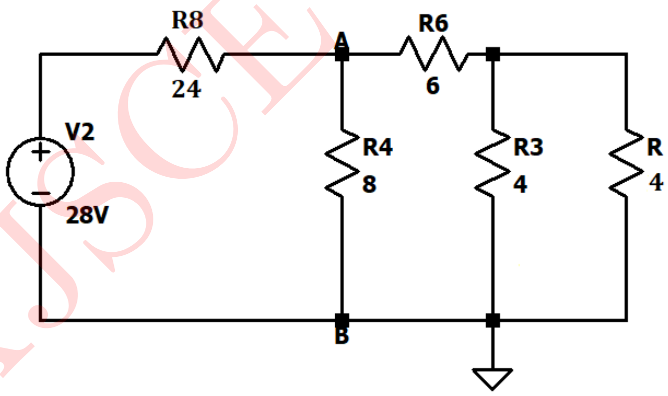


Figure 25: Modified circuit for figure 24

The resistors $R = 4\ \Omega$ and $R_3 = 4\ \Omega$ are parallel.

$\therefore 4\Omega \parallel 4\Omega = \dfrac{4 \times 4}{4 + 4}$

$\therefore 4\Omega \parallel 4\Omega = \dfrac{16}{8}\ \Omega$

$\therefore 4\Omega \parallel 4\Omega = 2\ \Omega$

Now the circuit is reduced to figure 26

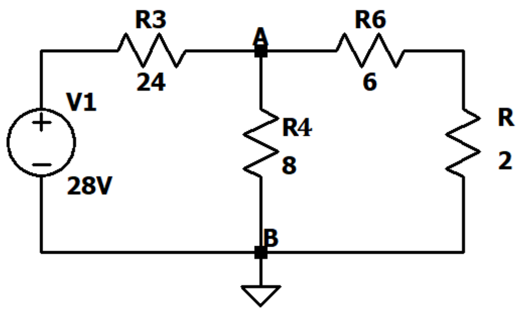


Figure 26: Modified circuit for figure 25

Resistors R and R_6 i.e. 2 Ω and 6 Ω are in series

$\therefore 2\ \Omega + 6\ \Omega = 8\ \Omega$

Using source transformation,

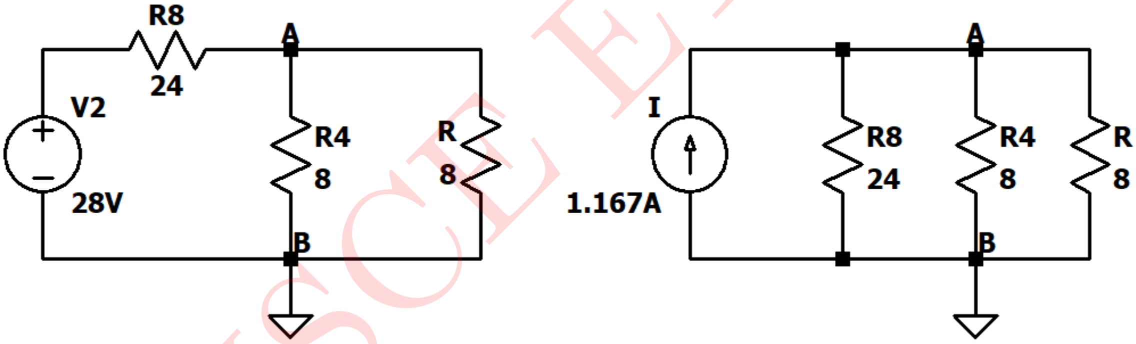


Figure 27: Source Transformation modified circuit for figure 26

$\because I = \dfrac{V_2}{R_8}$

$\therefore I = \dfrac{28}{24}$

$\therefore I = 1.167\text{A}$

The resistors $R = 8\ \Omega$ and $R_8 = 24\ \Omega$ are parallel.

$\therefore 8\ \Omega \parallel 24\ \Omega = \dfrac{8 \times 24}{8 + 24}$

$\therefore 8\ \Omega \parallel 24\ \Omega = \dfrac{192}{32}\ \Omega$

$\therefore 8\ \Omega \parallel 24\ \Omega = 6\ \Omega$

Now the circuit is reduced to figure 28

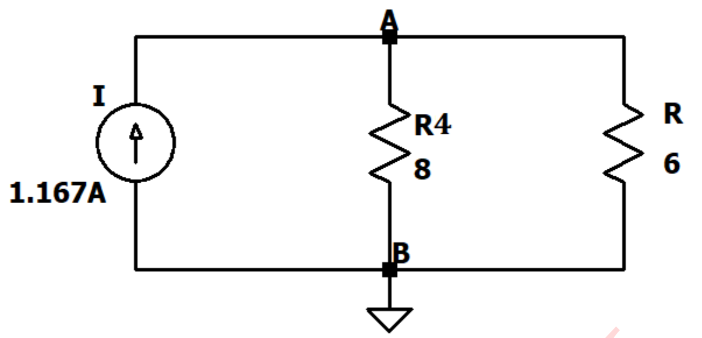


Figure 28: Modified circuit for figure 27

Let I' be the current flowing through 8 Ω resistor when only 24V voltage source is active

Using Current Division Rule,

$$I' = \mathrm{I} \times \frac{R}{R + R_4}$$

$$I' = 1.167 \times \frac{6}{6+8}$$

$$I' = 1.167 \times \frac{6}{14}$$

$$I' = \mathbf{0.5A}$$

Case 2 : 14V voltage source is active and 28V voltage source is inactive

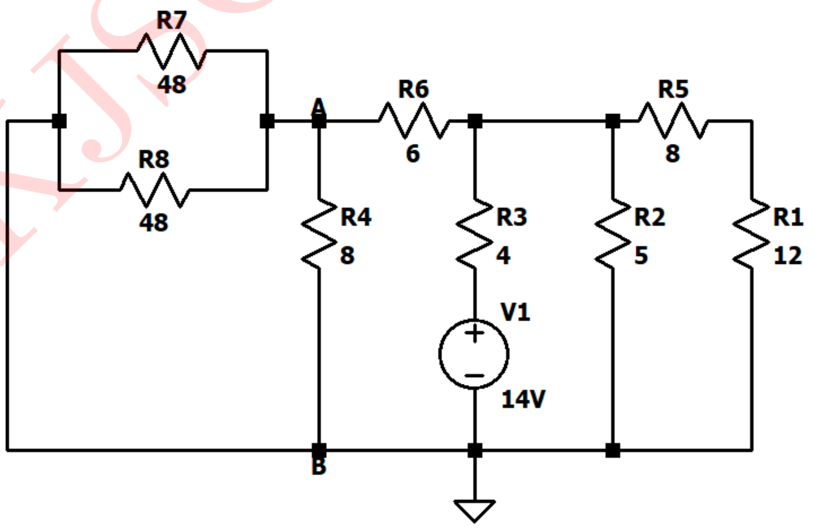


Figure 29: When only 14V voltage source is active

Resistors R_1 and R_5 i.e. 8 Ω and 12 Ω are in series

$\therefore$ 8 Ω + 12 Ω = 20 Ω

The resistors $R_7 = 48\ \Omega$ and $R_8 = 48\ \Omega$ are parallel.

$$\therefore 48\Omega \parallel 48\Omega = \frac{48 \times 48}{48 + 48}$$

$$\therefore 48\Omega \parallel 48\Omega = 24\ \Omega$$

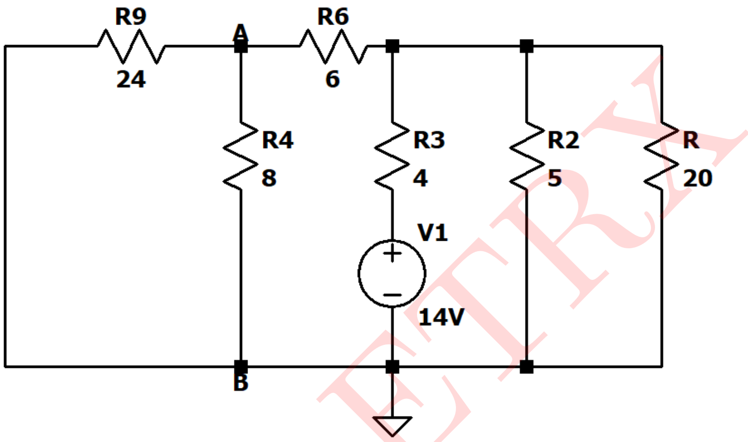


Figure 30: Modified circuit for figure 29

The resistors $R = 20\ \Omega$ and $R_2 = 5\ \Omega$ are parallel.

$$\therefore 20\Omega \parallel 5\Omega = \frac{20 \times 5}{20 + 5}$$

$$\therefore 20\Omega \parallel 5\Omega = 4\ \Omega$$

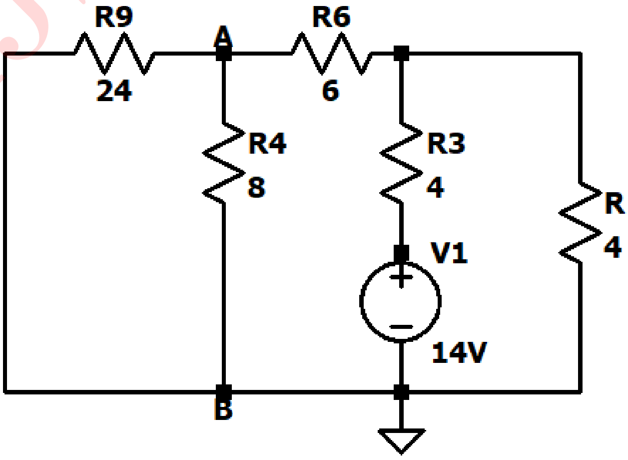


Figure 31: Modified circuit for figure 30

Using Source Transformation,

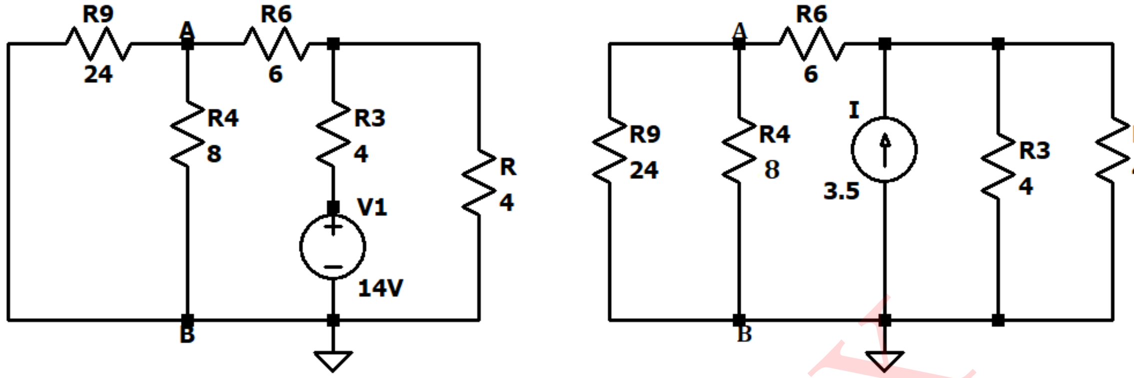


Figure 32: Source Transformation modified circuit for figure 31

$$\because I = \frac{V_1}{R_3}$$
$$\therefore I = \frac{14}{4}$$
$$\therefore I = 3.5\text{A}$$

The resistors $R = 4\ \Omega$ and $R_3 = 4\ \Omega$ are parallel.

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

Using Source Transformation,

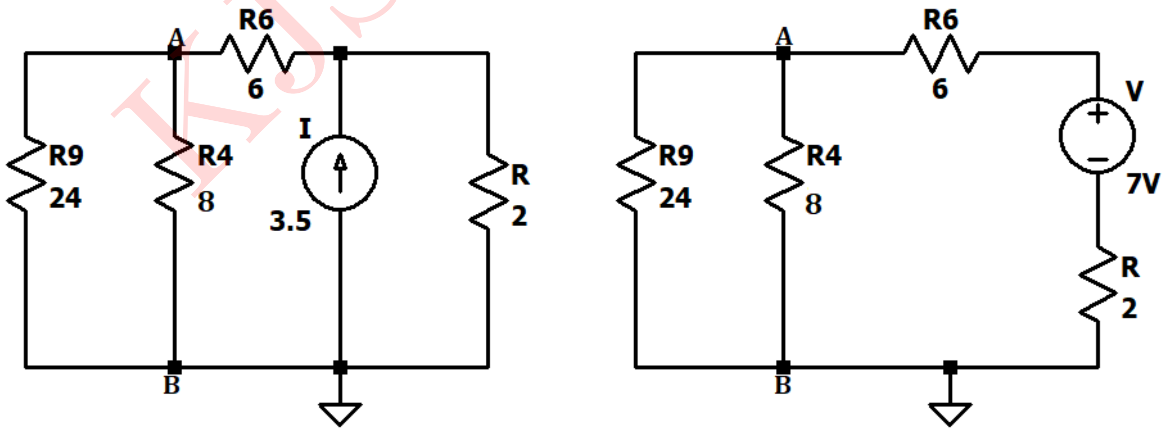


Figure 33: Source Transformation modified circuit for figure 32

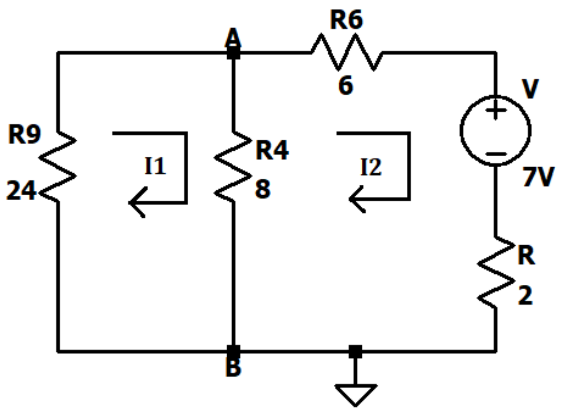


Figure 34: Modified circuit for figure 33

Applying KVL to Mesh 1,

$-24I_2 - 8(I_1 - I_2) = 0$

$\therefore -24I_1 - 8I_1 + 8I_2 = 0$

$\therefore -32I_1 + 8I_2 = 0$ ...(1)

Applying KVL to Mesh 2,

$-6I_2 - 2I_2 - 8(I_2 - I_1) - 7 = 0$

$\therefore -8I_2 - 8I_2 + 8I_1 - 7 = 0$

$\therefore -16I_2 + 8I_1$ - $7 = 0$

$\therefore 8I_1 - 16I_2 = 7$ ...(2)

Solving equation(1) and (2) simultaneously, we get

$I_1 = -$ 0.125A

$I_2 = -$ 0.5A

Current through branch AB when 14V is acting alone

$I'' = I_1 - I_2$

$I'' = (-0.125) - (-0.5)$

$I'' = 0.5 - 0.125$

$I'' = 0.375A$

Using Superposition theorem,

Current flowing through branch AB is

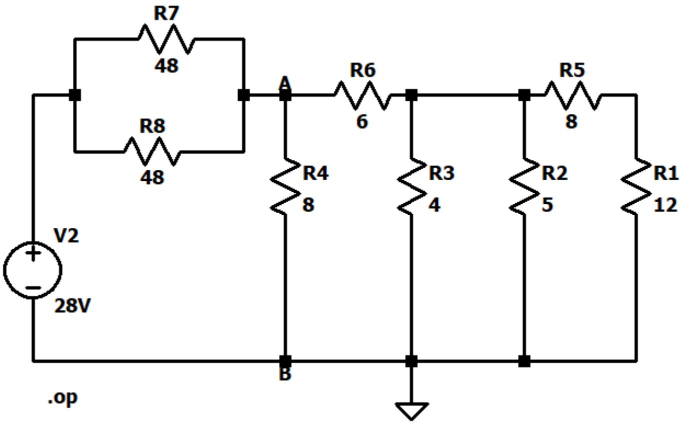
$I = I' + I''$

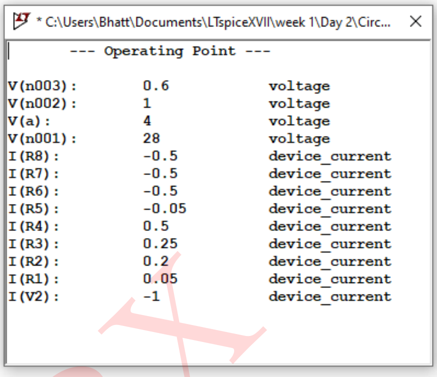
$I = 0.5 + 0.375$

I **= 0.875A**

SIMULATED RESULTS:

Above circuit is simulated in LTspice. The results are presented below:

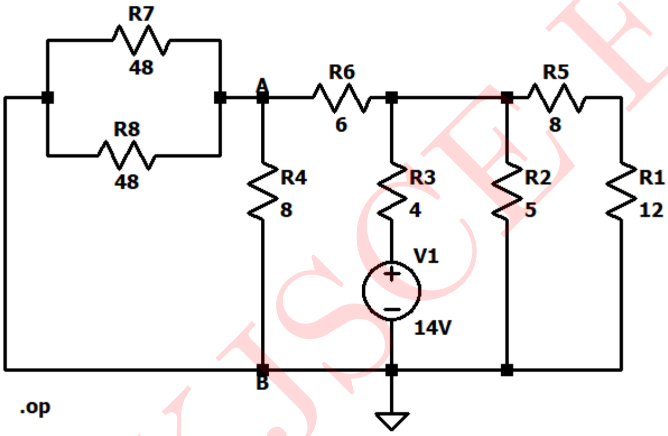


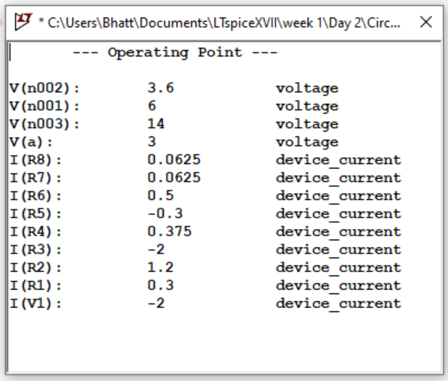


```
--- Operating Point ---

V(n003):     0.6       voltage
V(n002):     1         voltage
V(a):        4         voltage
V(n001):     28        voltage
I(R8):       -0.5      device_current
I(R7):       -0.5      device_current
I(R6):       -0.5      device_current
I(R5):       -0.05     device_current
I(R4):       0.5       device_current
I(R3):       0.25      device_current
I(R2):       0.2       device_current
I(R1):       0.05      device_current
I(V2):       -1        device_current
```

Figure 35: Circuit Schematic: when only 28V source is active

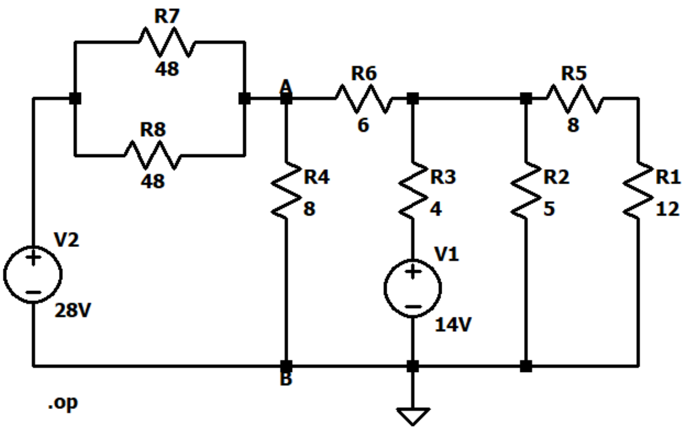


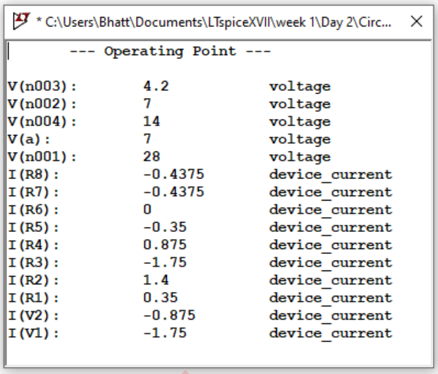


```
--- Operating Point ---

V(n002):     3.6       voltage
V(n001):     6         voltage
V(n003):     14        voltage
V(a):        3         voltage
I(R8):       0.0625    device_current
I(R7):       0.0625    device_current
I(R6):       0.5       device_current
I(R5):       -0.3      device_current
I(R4):       0.375     device_current
I(R3):       -2        device_current
I(R2):       1.2       device_current
I(R1):       0.3       device_current
I(V1):       -2        device_current
```

Figure 36: Circuit Schematic: when only 14V source is active




* C:\Users\Bhatt\Documents\LTspiceXVII\week 1\Day 2\Circ...

```
       --- Operating Point ---

V(n003):        4.2             voltage
V(n002):        7               voltage
V(n004):        14              voltage
V(a):           7               voltage
V(n001):        28              voltage
I(R8):          -0.4375         device_current
I(R7):          -0.4375         device_current
I(R6):          0               device_current
I(R5):          -0.35           device_current
I(R4):          0.875           device_current
I(R3):          -1.75           device_current
I(R2):          1.4             device_current
I(R1):          0.35            device_current
I(V2):          -0.875          device_current
I(V1):          -1.75           device_current
```

Figure 37: Circuit Schematic: when both the sources are active

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
I_{AB}	0.875A	0.875A

Table 4: Numerical 4

Numerical 5: In the circuit shown in figure 38, obtain the condition from maximum power transfer to the load R$_L$. Hence, determine the maximum power transfered.

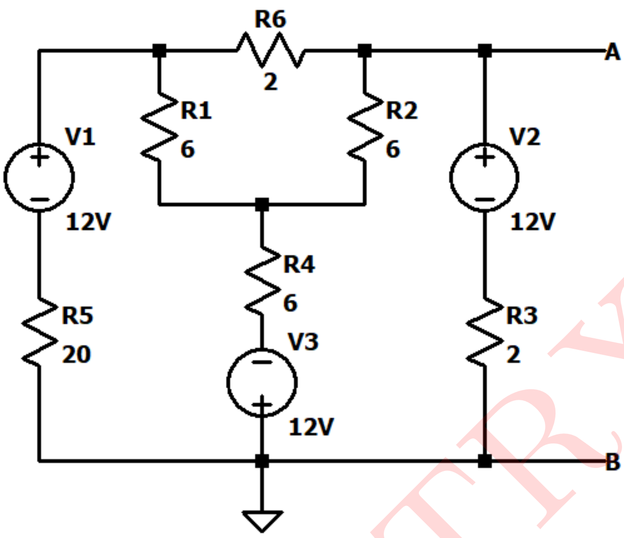


Figure 38: Circuit 5

Solution:

Case 1: To determine Thevenin's resistance (R_{th})

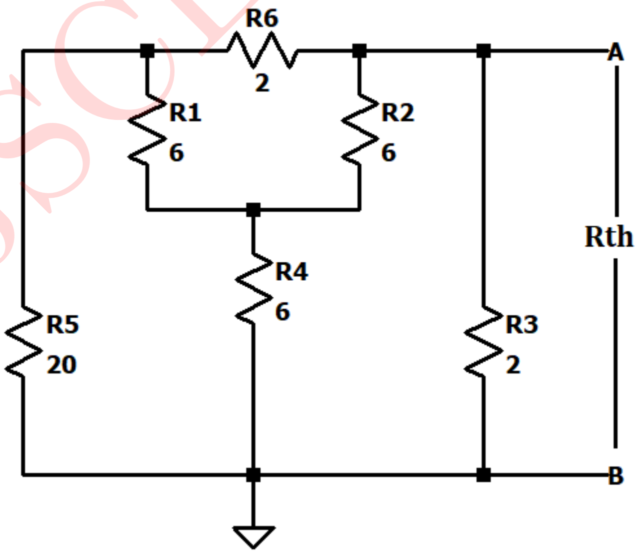


Figure 39: To determine R_{th}

Here the resistors $R_1 = 6\ \Omega$, $R_6 = 2\ \Omega$ and $R_2 = 6\ \Omega$ form a delta network.

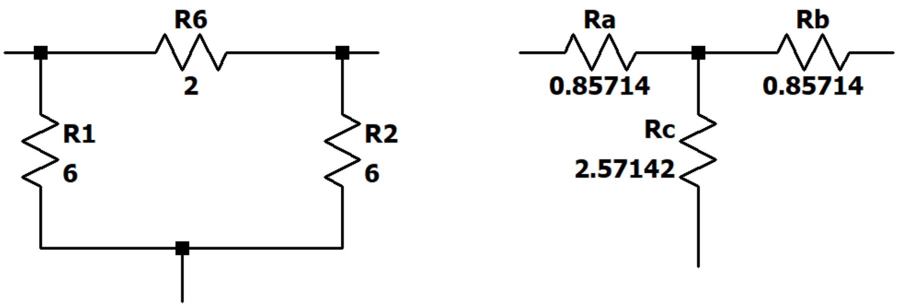


Figure 40: Star - Delta Transformation modified circuit for figure 39

Therefore, using Star - Delta Transformation

The formulas are :

$$R_a = \frac{R_1 \times R_6}{R_1 + R_2 + R_6}$$

$$R_b = \frac{R_2 \times R_6}{R_1 + R_2 + R_6}$$

$$R_c = \frac{R_2 \times R_1}{R_1 + R_2 + R_6}$$

Substituting the values of resistors in the formula, we get

$$R_a = \frac{6 \times 2}{6 + 2 + 6}$$

$$\therefore R_a = \frac{12}{14}$$

$$\therefore R_a = \mathbf{0.85714}\ \Omega$$

$$R_b = \frac{6 \times 2}{6 + 2 + 6}$$

$$\therefore R_b = \frac{12}{14}$$

$$\therefore R_b = \mathbf{0.85714}\ \Omega$$

$$R_c = \frac{6 \times 6}{6 + 2 + 6}$$

$$\therefore R_c = \frac{36}{14}$$

$$\therefore R_c = \mathbf{2.57142}\ \Omega$$

Now the circuit is reduced to figure 41

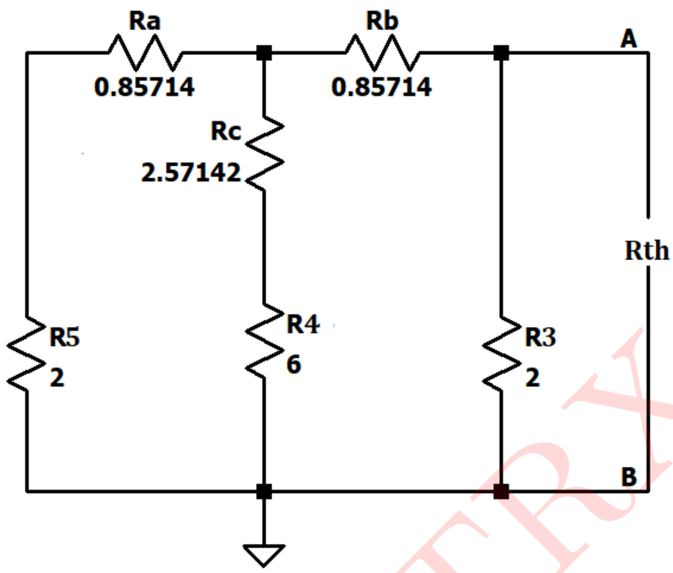


Figure 41: Modified circuit for figure 39

Now, resistor 2 Ω is in series with 0.85714 Ω

$\therefore$ 2 Ω + 0.85714 Ω = 2.85714 Ω

Also, resistor 6 Ω is in series with 2.5714 Ω

$\therefore$ 6 Ω + 2.5714 Ω = 8.5714 Ω

Now the circuit is reduced to figure 42

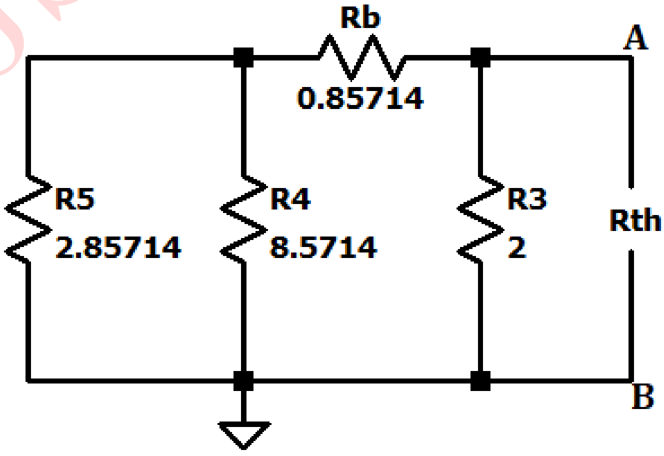


Figure 42: Modified circuit for figure 41

Now, resistor 2.85714 Ω is in parallel with 8.5714 Ω

$$\therefore 2.85714\ \Omega \parallel 8.5714\ \Omega = \frac{2.85714 \times 8.5714}{2.85714 + 8.5714}\ \Omega$$

$$\therefore 2.85714\ \Omega \parallel 8.5714\ \Omega = 2.14277\ \Omega$$

Also, resistor 0.85714 Ω is in series with 2.14277 Ω

$$\therefore 0.85714\ \Omega + 2.14277\ \Omega = 2.99991\ \Omega$$

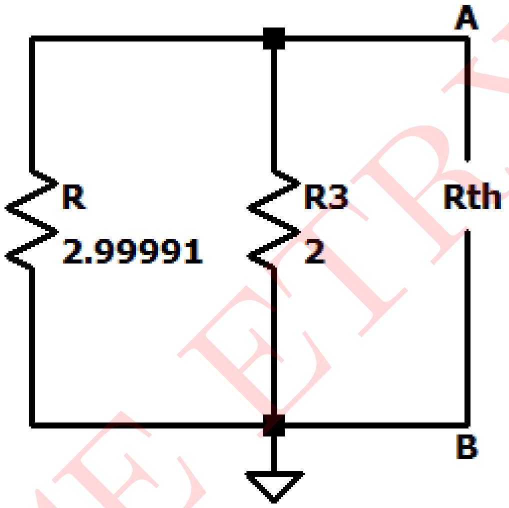


Figure 43: Modified circuit for figure 42

Now, resistor 2.99991 Ω is in parallel with 2 Ω

$$\therefore 2.99991\ \Omega \parallel 2\ \Omega = \frac{2.9999 \times 2}{2.99991 + 2}\ \Omega$$

$$\therefore 2.99991\ \Omega \parallel 2\ \Omega = 1.2\ \Omega$$

R_{th} = **1.2** Ω

Case 2 : To determine Thevenin's voltage (V_{th})

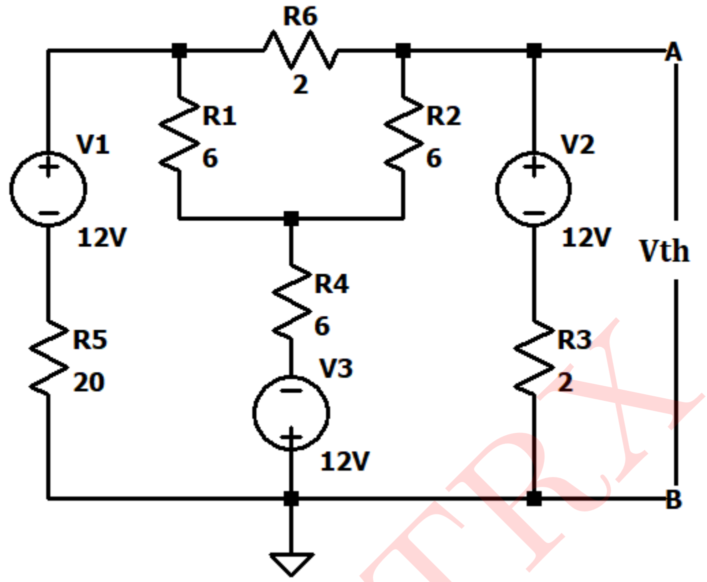


Figure 44: To determine V_{th}

Here the resistors $R_1 = 6\ \Omega$, $R_6 = 2\ \Omega$ and $R_2 = 6\ \Omega$ form a delta network.

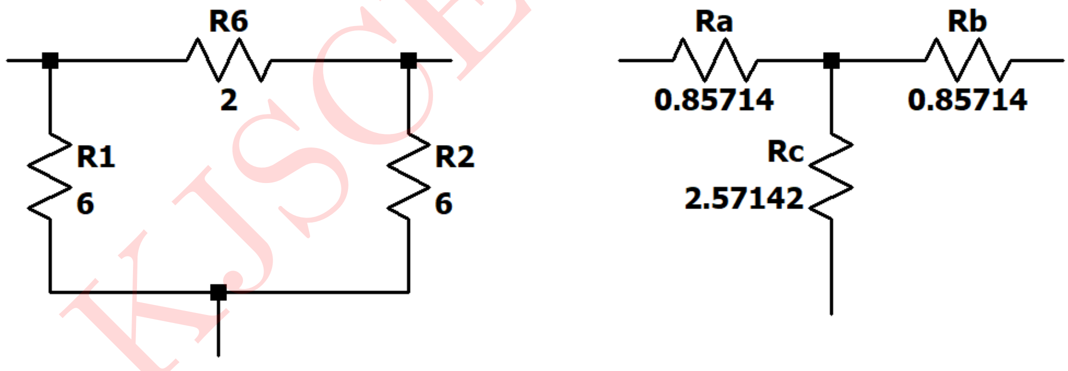


Figure 45: Star - Delta Transformation modified circuit for figure 44

Therefore, using Star - Delta Transformation

The formulas are :

$$R_a = \frac{R_1 \times R_6}{R_1 + R_2 + R_6}$$

$$R_b = \frac{R_2 \times R_6}{R_1 + R_2 + R_6}$$

$$R_c = \frac{R_2 \times R_1}{R_1 + R_2 + R_6}$$

Substituting the values of resistors in the formula, we get

$R_a = \dfrac{6 \times 2}{6+2+6}$

$\therefore R_a = \dfrac{12}{14}$

$\therefore R_a = \mathbf{0.85714\ \Omega}$

$R_b = \dfrac{6 \times 2}{6+2+6}$

$\therefore R_b = \dfrac{12}{14}$

$\therefore R_b = \mathbf{0.85714\ \Omega}$

$R_c = \dfrac{6 \times 6}{6+2+6}$

$\therefore R_c = \dfrac{36}{14}$

$\therefore R_c = \mathbf{2.57142\ \Omega}$

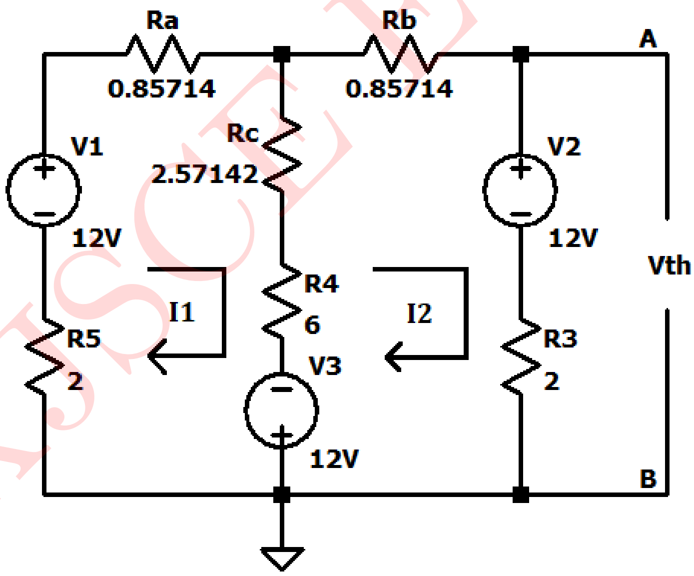


Figure 46: Modified circuit for figure 44

Let I_1 and I_2 be the current flowing through Mesh 1 and Mesh 2 in clockwise direction

Applying KVL to the Mesh 1,

$-0.857I_1 - 6I_1 - 2.571(I_1 - I_2) + 6I_2 + 12 + 12 - 2I_1 = 0$

$-0.857I_1 - 6I_1 - 2.571I_1 + 2.571I_2 + 6I_2 + 12 - 12 - 2I_1 = 0$

$\therefore -11.4284I_1 + 8.5714I_2 + 24 = 0$

$\therefore 11.4284I_1 - 8.5714I_2 = 24$ ...(1)

Applying KVL to Mesh 2,

$-0.857I_2 - 2I_2 - 12 - 12 - 6(I_2 - I_1) - 2.5714(I_2 - I_1) = 0$

$-0.857I_2 - 2I_2 - 24 - 6I_2 + 6I_1 - 2.5714I_2 + 2.5714I_1 = 0$

$\therefore -8.5714I_1 + 11.4284I_2 + 24 = 0$

$\therefore 8.5714I_1 - 11.4284I_2 = 24$ ...(2)

Solving equation(1) and (2) simultaneously, we get

$I_1 = 1.2\text{A}$

$I_2 = -\ 1.2\text{A}$

Applying KVL to Mesh 3,

$V_{th} - 12 - 2I_2 = 0$

$\therefore V_{th} = 12 + 2I_2$

$\therefore V_{th} = 12 + 2 \times -1.2$

$\therefore V_{th} = 12 - 2.4$

$V_{th} = \mathbf{9.6V}$

Thevenin's Equivalent circuit

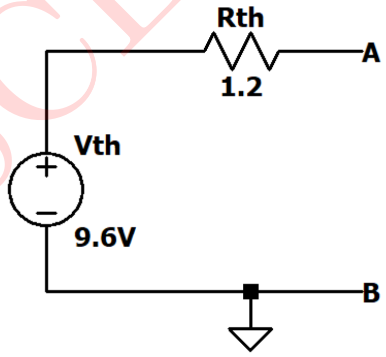


Figure 47: Thevenin's equivalent circuit

SIMULATED RESULTS:

The given circuit is simulated in LTspice and the results obtained are as follows:

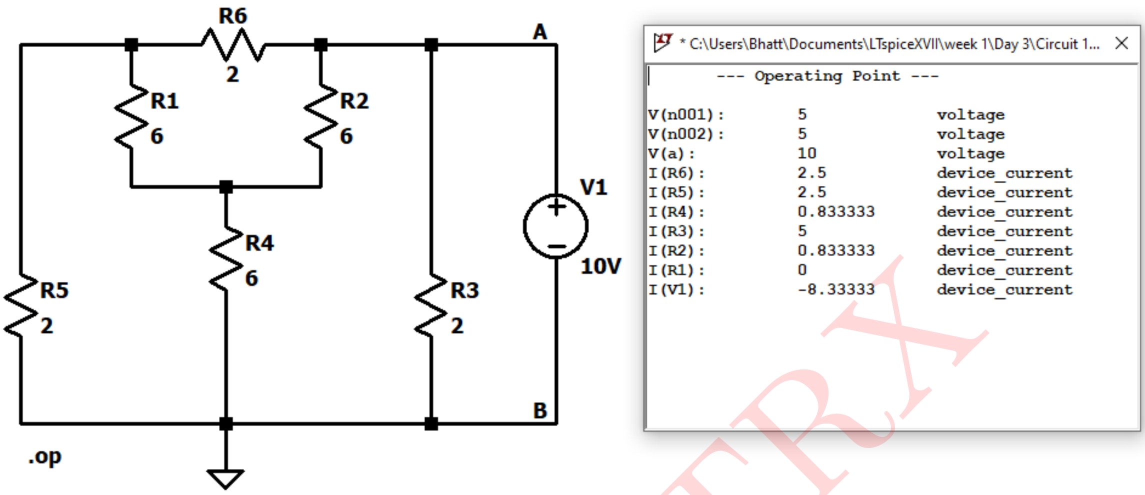


Figure 48: Circuit Schematic and Simulated Results: To determine Rth

Calculation:

$R_{th} = \dfrac{V_1}{I_{V1}}$

$R_{th} = \dfrac{10}{8.3333}$

$R_{th} = 1.2\ \Omega$

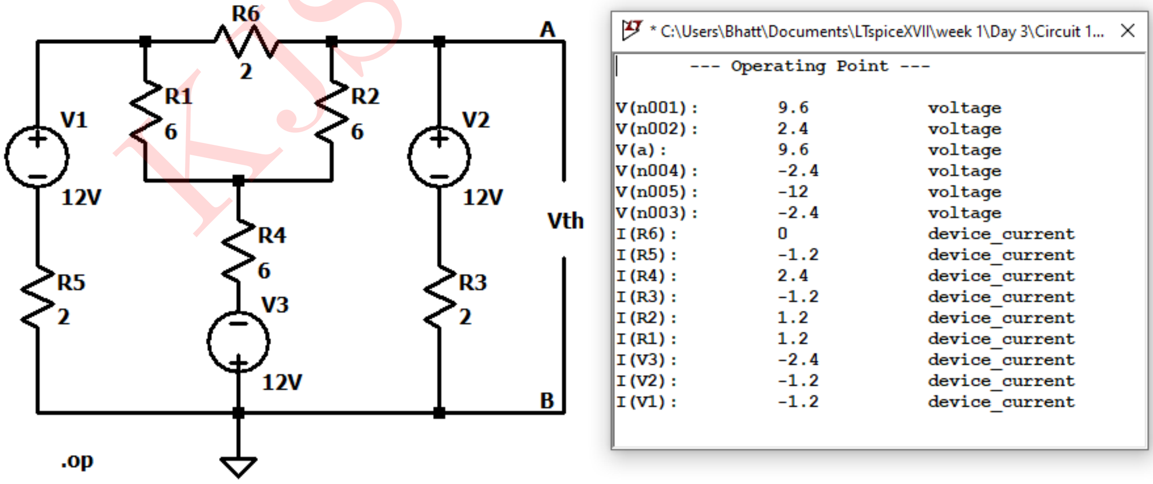


Figure 49: Circuit Schematic and Simulated Results: To determine Vth

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
V_{th}	9.6V	9.6V
R_{th}	1.2 Ω	1.2 Ω

Table 5: Numerical 5

Numerical 6: Find Thevenin's Equivalent Circuit for circuit 6 shown in figure 50

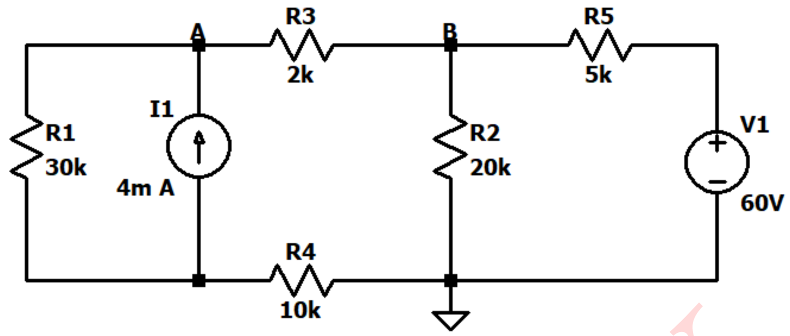


Figure 50: Circuit 6

Solution:

Case 1: To determine Thevenin's Resistance (R_{th})

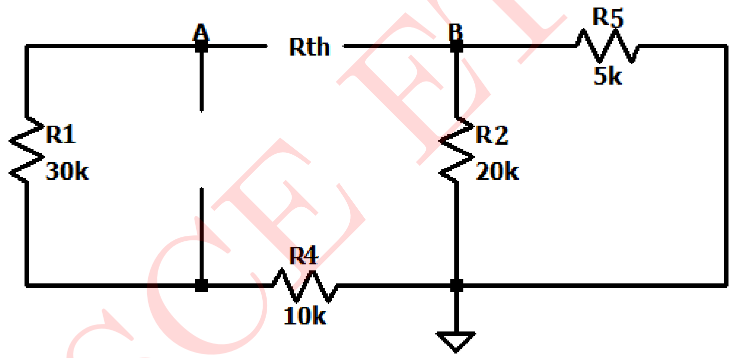


Figure 51: To determine R_{th}

The resistors $R_5 = 5\ \text{k}\Omega$ and $R_2 = 20\ \text{k}\Omega$ are parallel.

$\therefore 5\ \text{k}\Omega \parallel 20\ \text{k}\Omega = \dfrac{5 \times 20}{5 + 20}$

$\therefore 5\ \text{k}\Omega \parallel 20\ \text{k}\Omega = 4\ \text{k}\Omega$

Now, the circuit is reduced to figure 52

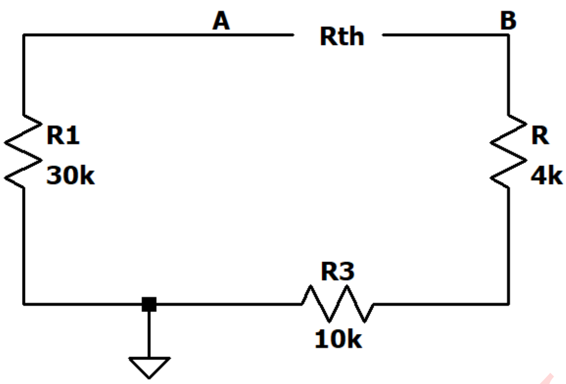


Figure 52: Modified circuit for figure 51

Resistors R_1, R and R_4 i.e. 30 kΩ, 4 kΩ and 10 kΩ are in series

$\therefore$ 30 kΩ + 4 kΩ + 10 kΩ= 44 kΩ

R_{th} = **44 kΩ**

Case 2: To determine Thevenin's voltage

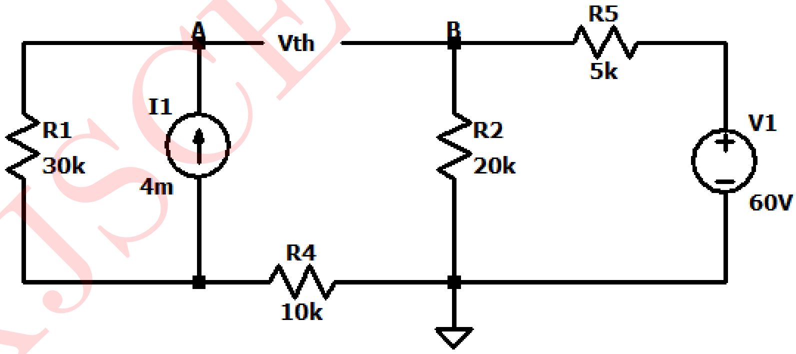


Figure 53: To determine V_{th}

Using source transformation,

$\because I = \dfrac{V_1}{R_5}$

$\therefore I = \dfrac{60}{5000}$

$\therefore I = 0.012$A

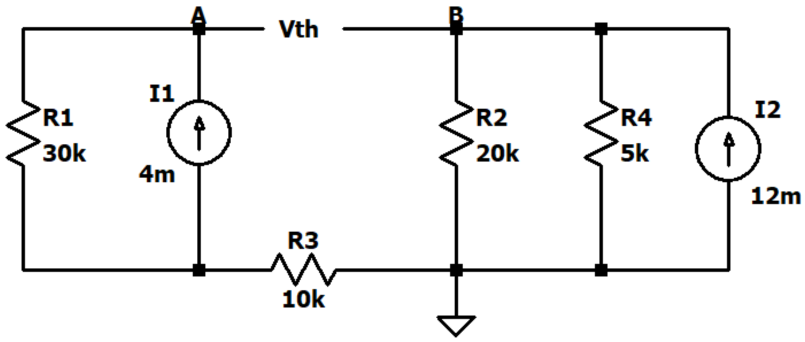


Figure 54: Source Transformation modified circuit for figure 53

The resistors $R_5 = 5\ \mathrm{k}\Omega$ and $R_2 = 20\ \mathrm{k}\Omega$ are parallel.

$\therefore 20\ \mathrm{k}\Omega \parallel 5\ \mathrm{k}\Omega = \dfrac{20 \times 5}{20 + 5}$

$\therefore 20\ \mathrm{k}\Omega \parallel 5\ \mathrm{k}\Omega = \dfrac{100}{24}\ \mathrm{k}\Omega$

$\therefore 20\ \mathrm{k}\Omega \parallel 5\ \mathrm{k}\Omega = 4\ \mathrm{k}\Omega$

Now the circuit is reduced to figure 55

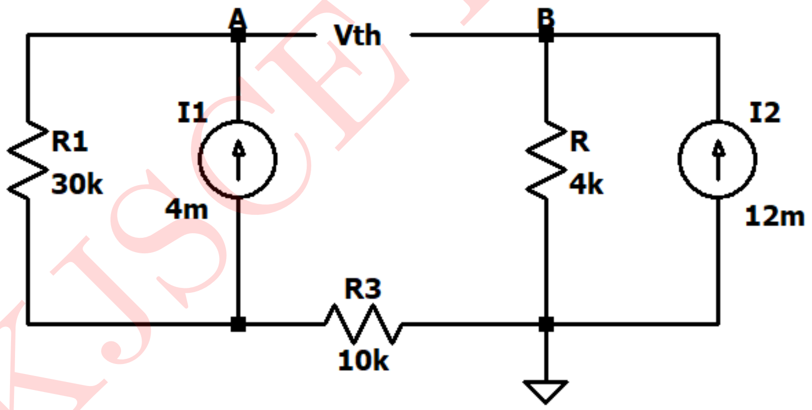


Figure 55: Modified circuit for figure 54

Using source transformation,

$\because V = I \times R_1$

$\therefore V = 4\mathrm{m} \times 30\ \mathrm{k}$

$\therefore V = 120\mathrm{V}$

Similarly

$\because V = I \times R$

$\therefore V = 12\mathrm{m} \times 4\ \mathrm{k}$

$\therefore V = 48\mathrm{V}$

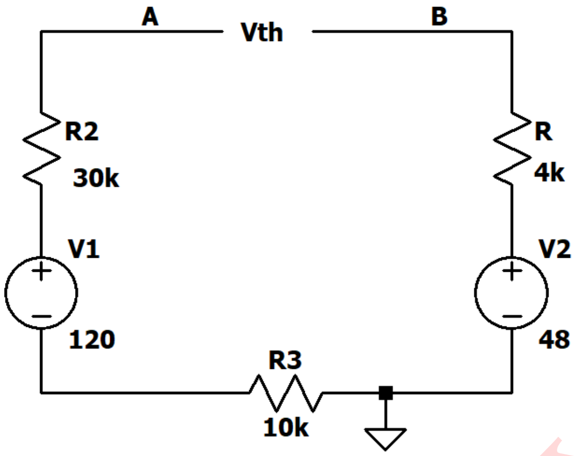


Figure 56: Source Transformation modified circuit for figure 55

$\because V_{th} = V_1 - V_2$

$\therefore V_{th} = 120 - 48$

$\therefore V_{th} = 72\text{V}$

Thevenin's Equivalent circuit

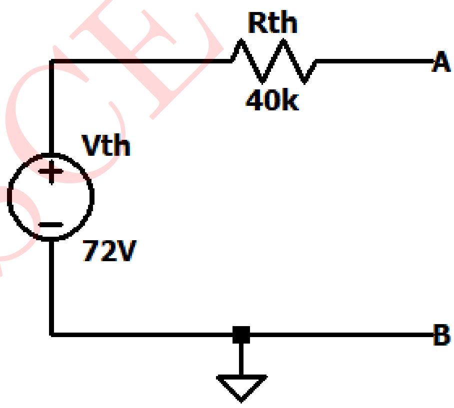


Figure 57: Thevenin's equivalent circuit

SIMULATED RESULTS:

Above circuit is simulated in LTspice. The results are presented below:

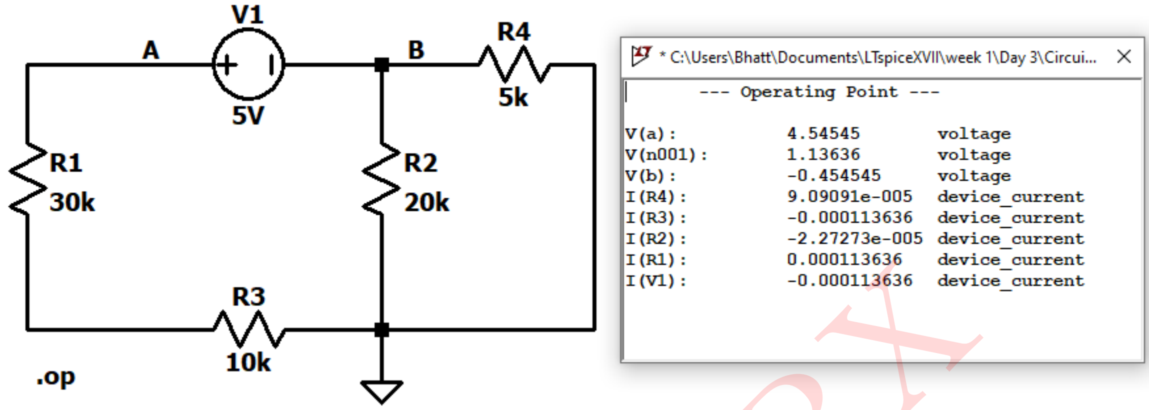


Figure 58: Circuit Schematic and Simulated Results: To determine R_{th}

Calculation:

$\because R_{th} = \dfrac{V_1}{I_{V1}}$

$\therefore R_{th} = \dfrac{5}{0.0001136}$

$\therefore R_{th} = 44 \text{ k}\Omega$

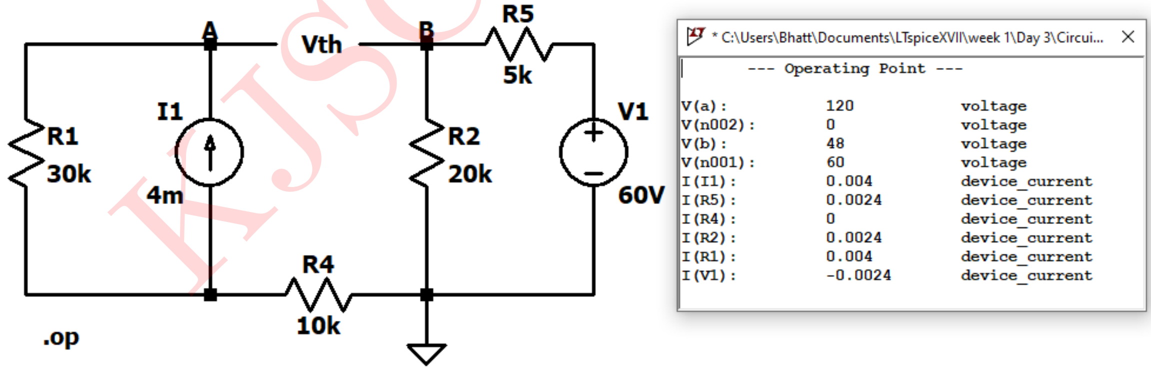


Figure 59: Circuit Schematic and Simulated Results: To determine V_{th}

Calculation:

$\because V_{th} = V_a - V_b$

$\therefore V_{th} = 120 - 48$

$\therefore V_{th} = 72\text{V}$

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
V_{th}	72V	72V
R_{th}	44 kΩ	44 kΩ

Table 6: Numerical 6

Numerical 7: Find the voltage across points A and B in the network shown in figure 60 using Norton's Theorem.

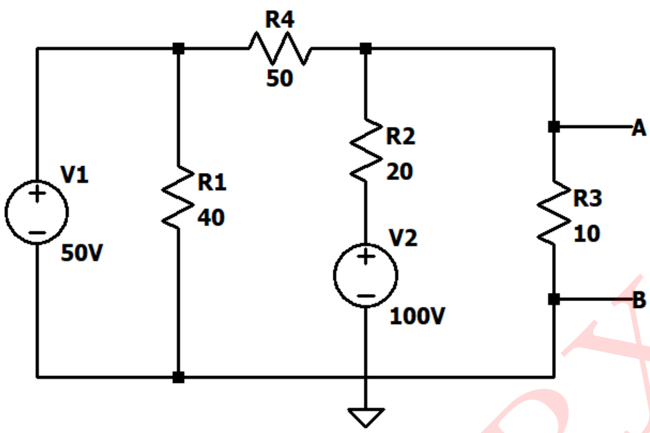


Figure 60: Circuit 7

Solution:

Case 1: To determine R_{th}

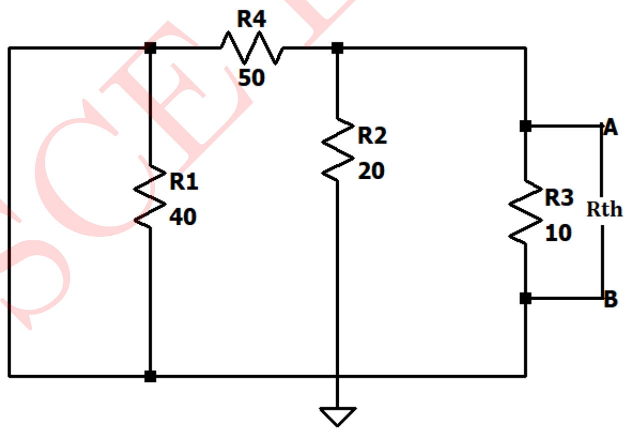


Figure 61: To determine R_{th}

Here, the resistor $R_1 = 40\ \Omega$ becomes redundant when the voltage source is replaced by a short circuit.

Now, the circuit is reduced to figure 62

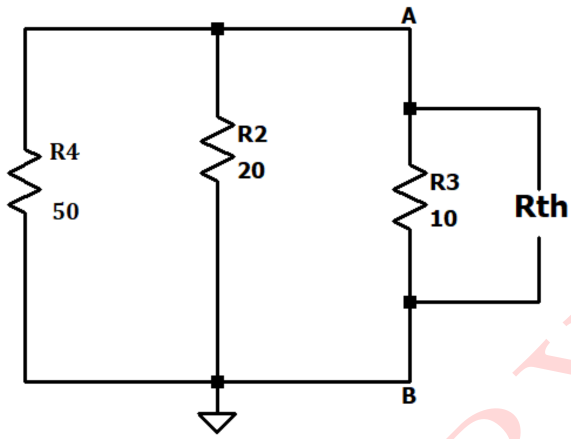


Figure 62: Modified circuit for figure 61

Now, resistors $R_4 = 50\ \Omega$ is in parallel with $R_2 = 20\ \Omega$

$\therefore 50\ \Omega \parallel 20\ \Omega = \dfrac{50 \times 20}{50 + 20}\ \Omega$

$\therefore 50\ \Omega \parallel 20\ \Omega = 14.2857\ \Omega$

Now, $14.2857\ \Omega$ is in parallel with $R_3 = 10\ \Omega$

$\therefore 14.2857\ \Omega \parallel 10\ \Omega = \dfrac{14.2857 \times 10}{14.2857 + 10}\ \Omega$

$\therefore 14.2857\ \Omega \parallel 10\ \Omega = 5.8824\ \Omega$

$R_{th} = \mathbf{5.8824}\ \Omega$

Case 2 : To determine I_{SC}

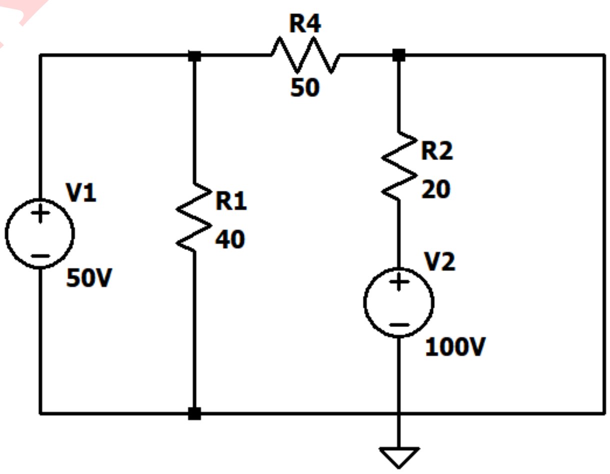


Figure 63: To determine I_{SC}

Here, R_2 becomes redundant due to the branch AB being replaced by a short circuit.

When only 50V voltage source is active

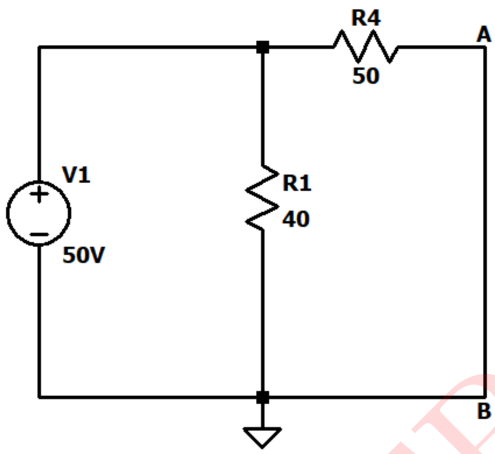


Figure 64: When only 50V voltage source is active

Current I_1 flowing through AB in clockwise direction is

$I_1 = \dfrac{V_1}{R_4}$

$\therefore I_1 = \dfrac{50}{50}$

$\therefore I_1 = 1\text{A}$ ...(1)

When only 100V voltage source is active

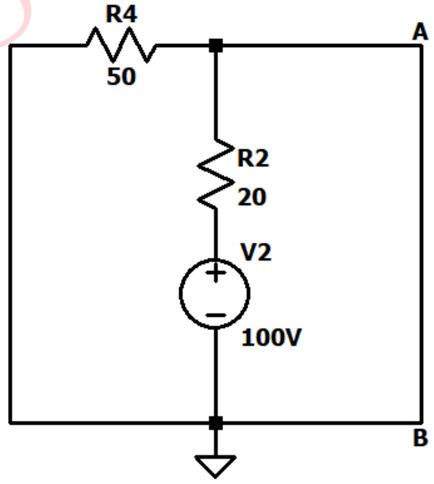


Figure 65: When only 100V voltage source is active

The current I_2 flowing through AB in clockwise direction is

$I_2 = \dfrac{V_2}{R_2}$

$\therefore I_2 = \dfrac{-100}{20}$

$\therefore I_2 = -5\text{A}$ ...(2)

Now, using Superposition Theorem

The current flowing through branch AB is

$I_{AB} = I_1 + I_2$

$\therefore I_{AB} = 1 - 5$

$\therefore I_{AB} = -4\text{A}$

Here the negative sign denotes that the current is flowing in anti-clockwise direction.

$\therefore\ I_{SC} = \mathbf{4A}$

Norton's Equivalent circuit

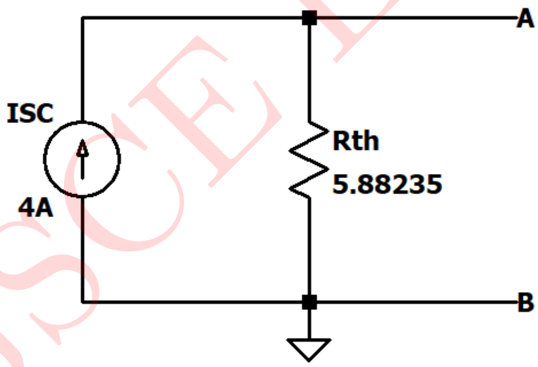


Figure 66: Norton's equivalent circuit

Now, voltage across branch AB is

$V_{AB} = I_{SC} \times R_{th}$

$\therefore V_{AB} = 4 \times 5.8824$

$\therefore V_{AB} = \mathbf{23.5V}$

SIMULATED RESULTS:

The given circuit is simulated in LTspice and the results obtained are as follows:

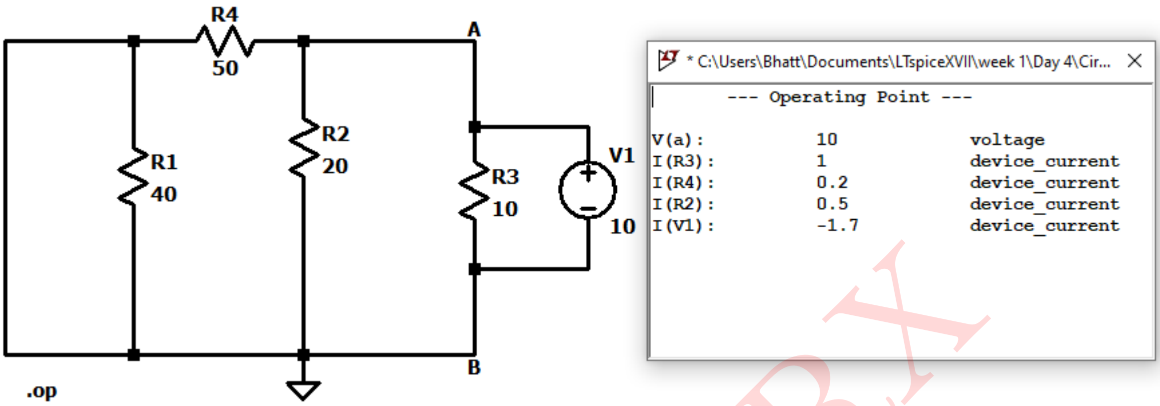


Figure 67: Circuit Schematic and Simulated Results: To determine R_{th}

Calculation:

$R_{th} = \dfrac{V_1}{I_{V1}}$

$\therefore R_{th} = \dfrac{10}{1.7}$

$\therefore R_{th} = 5.8824\ \Omega$

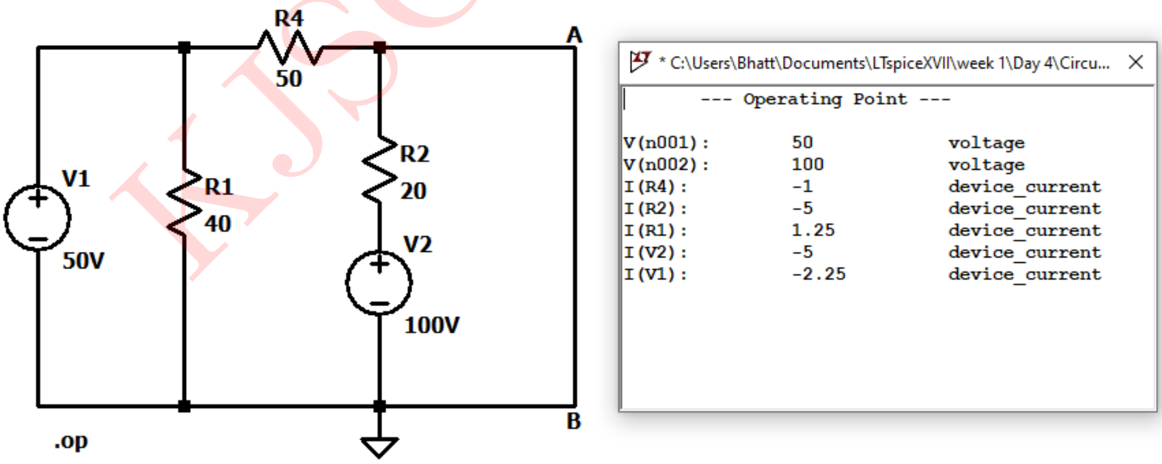


Figure 68: Circuit Schematic and Simulated Results: To determine I_{SC}

Calculation:

$I_{SC} = I_{R4} - I_{R2}$

$\therefore I_{SC} = 5 - 1$

$\therefore I_{SC} = 4\text{A}$

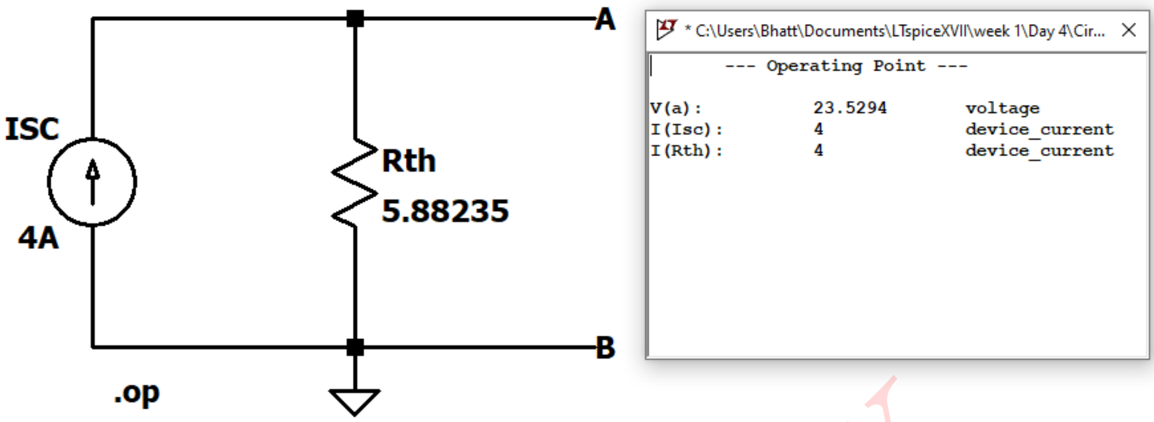


Figure 69: Circuit Schematic and Simulated Results

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
V_{th}	23.5V	23.5V

Table 7: Numerical 7

Numerical 8: Obtain Norton's Equivalent of terminal a-b and c-d of circuit 8 shown in figure 70

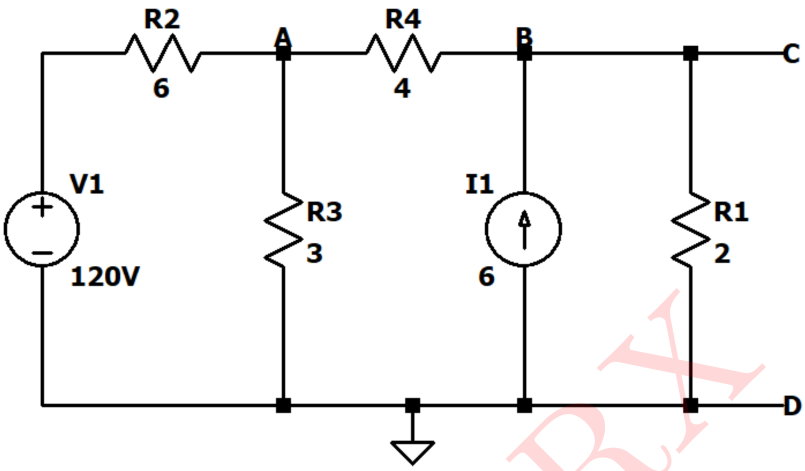


Figure 70: Circuit 8

i) Terminal A-B

Solution:

Case 1: To determine R_{th}

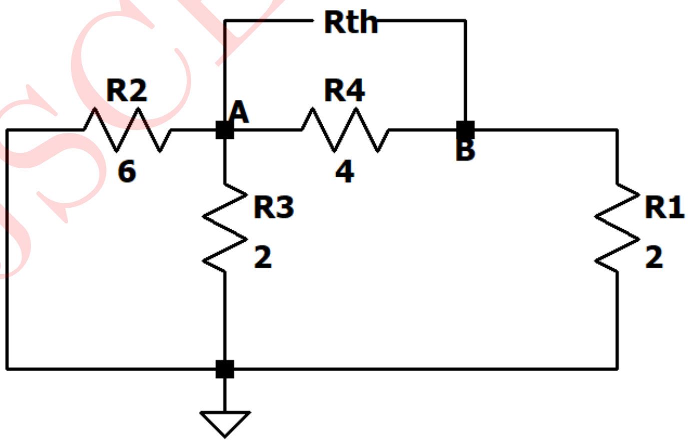


Figure 71: To determine R_{th}

Now, resistors $R_2 = 6\ \Omega$ is in parallel with $R_3 = 3\ \Omega$

$\therefore 6\ \Omega \parallel 3\ \Omega = \dfrac{6 \times 3}{6+3}\ \Omega$

$\therefore 6\ \Omega \parallel 3\ \Omega = 2\ \Omega$

The circuit is reduced to figure 72

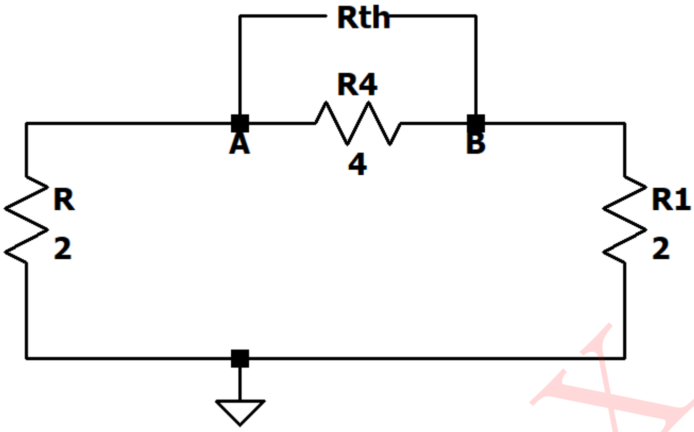


Figure 72: Modified circuit for figure 71

Now, resistors 2 Ω and 2 Ω are in series.

$2\ \Omega + 2\ \Omega = 4\ \Omega$

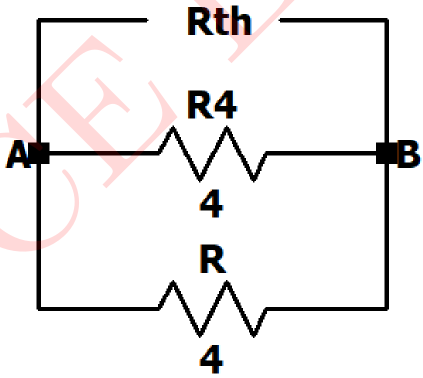


Figure 73: Modified circuit for figure 72

Here, resistors $R = 4\ \Omega$ and $R_4 = 4\ \Omega$ are in parallel.

$\therefore 4\ \Omega \parallel 4\ \Omega = \dfrac{4 \times 4}{4 + 4}\ \Omega$

$\therefore 4\ \Omega \parallel 4\ \Omega = 2\ \Omega$

$\therefore R_{th} = \mathbf{2}\ \Omega$

Case 2: To determine I_{SC}

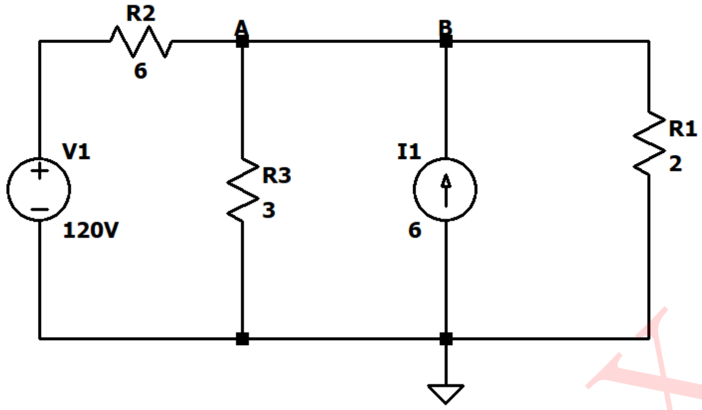


Figure 74: To determine I_{SC}

Using Source transformation,

$V_2 = I_1 \times R_1$

$\therefore V_2 = 6 \times 2$

$\therefore V_2 = 12\text{A}$

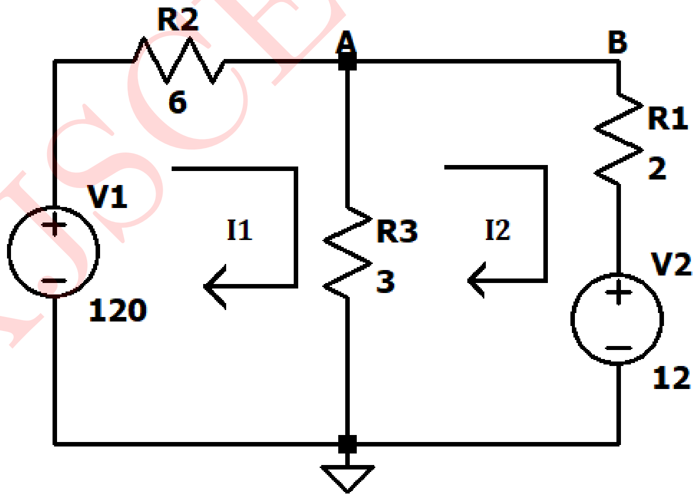


Figure 75: Source transformation modified circuit for figure 74

Let I_1 and I_2 be the current flowing through Mesh 1 and Mesh 2 in clockwise direction

Applying KVL to the Mesh 1,

$-6I_1 - 3(I_1 - I_2) + 120 = 0$

$\therefore -6I_1 - 3I_1 + 3I_2 + 120 = 0$

$\therefore -9I_1 + 3I_2 + 120 = 0$

$\therefore 9I_1 - 3I_2 = 120$ ...(1)

Applying KVL to the Mesh 2,

$-2I_2 - 3(I_2 - I_1) + 12 = 0$

$\therefore -2I_2 - 3I_2 + 3I_1 - 12 = 0$

$\therefore -5I_2 + 3I_1 - 12 = 0$

$\therefore 3I_1 - 5I_2 = 12$ ...(1)

Solving equation (1) and (2) simultaneously, we get

$I_1 = 15.6667A$

$I_2 = 7A$

Here, current flowing through Mesh 2 is I_{SC}

$\therefore I_{SC} = I_2 = \mathbf{7A}$

Norton's Equivalent circuit

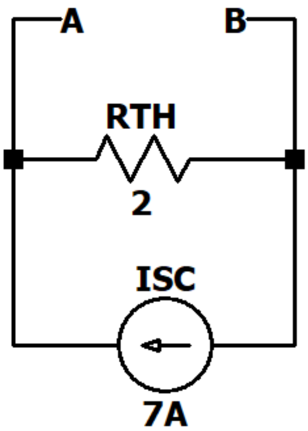


Figure 76: Norton's equivalent circuit

ii) Terminal C-D

Solution:

Case 1: To determine R_{th}

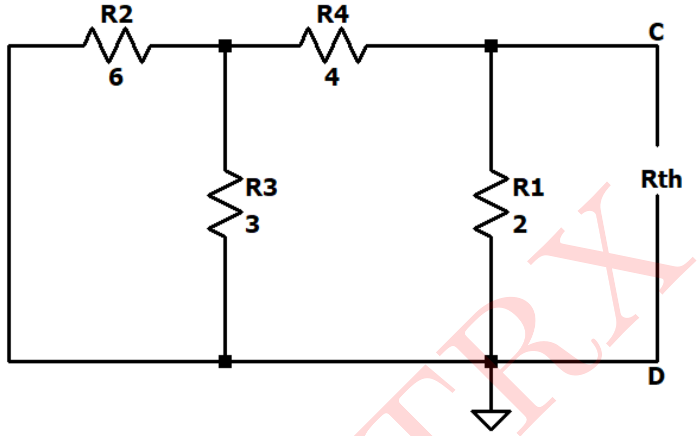


Figure 77: To determine R_{th}

Resistors $R_2 = 6\ \Omega$ is in parallel with $R_3 = 3\ \Omega$

$\therefore 6\ \Omega \parallel 3\ \Omega = \dfrac{6 \times 3}{6 + 23}\ \Omega$

$\therefore 6\ \Omega \parallel 3\ \Omega = 2\ \Omega$

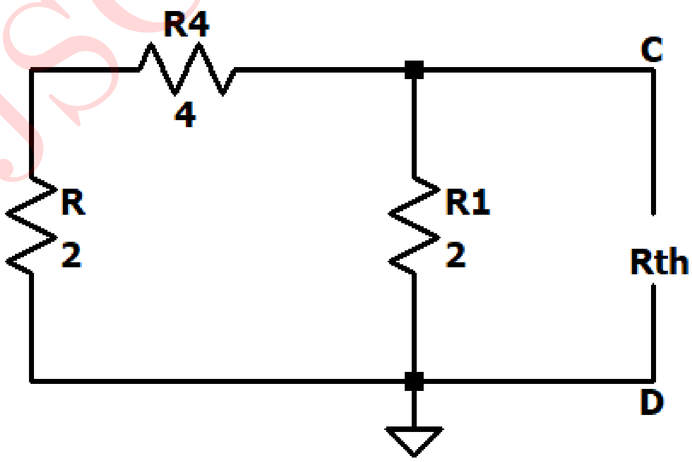


Figure 78: Modified circuit for figure 77

Now, resistor $2\ \Omega$ and $4\ \Omega$ are in series.

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

Also, resistors $R_1 = 2\ \Omega$ is in parallel with $R = 6\ \Omega$

$\therefore 2\ \Omega \parallel 6\ \Omega = \dfrac{2 \times 6}{2+6}\ \Omega$

$\therefore 2\ \Omega \parallel 6\ \Omega = 1.5\ \Omega$

R_{th} **= 1.5** Ω

Case 2: To determine I_{SC}

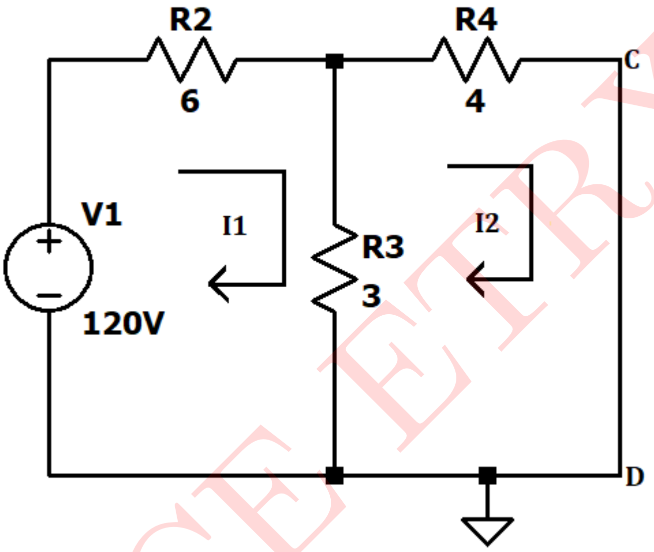


Figure 79: To determine I_{SC}

Let I_1 and I_2 be the current flowing through Mesh 1 and Mesh 2 in clockwise direction

Applying KVL to the Mesh 1,

$-6I_1 - 3(I_1 - I_2) + 120 = 0$

$\therefore -6I_1 - 3I_1 + 3I_2 + 120 = 0$

$\therefore -9I_1 + 3I_2 + 120 = 0$

$\therefore 9I_1 - 3I_2 = 120$ ...(1)

Applying KVL to the Mesh 2,

$-4I_2 - 3(I_2 - I_1) = 0$

$\therefore -4I_2 - 3I_2 + 3I_1 = 0$

$\therefore -7I_2 + 3I_1 = 0$

$\therefore 3I_1 - 7I_2 =$ ...(2)

Solving equation (1) and (2) simultaneously, we get

$I_1 = 15.5556$A

$I_2 = 6.6667$A

Here, I_{SC} is the current flowing through Mesh 2

$\therefore I_{SC} = I_2 =$ **6.6667A**

Norton's Equivalent circuit

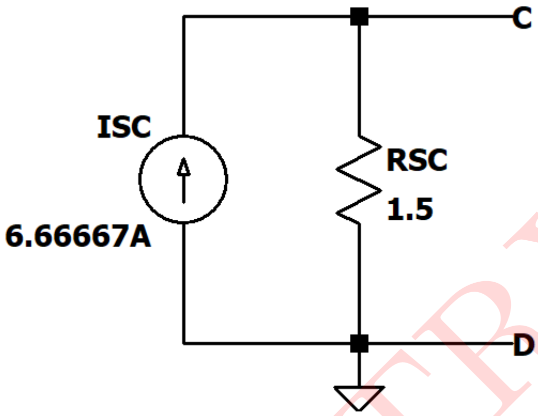


Figure 80: Norton's equivalent circuit

SIMULATED RESULTS:

The given circuit is simulated in LTspice and the results obtained are as follows:

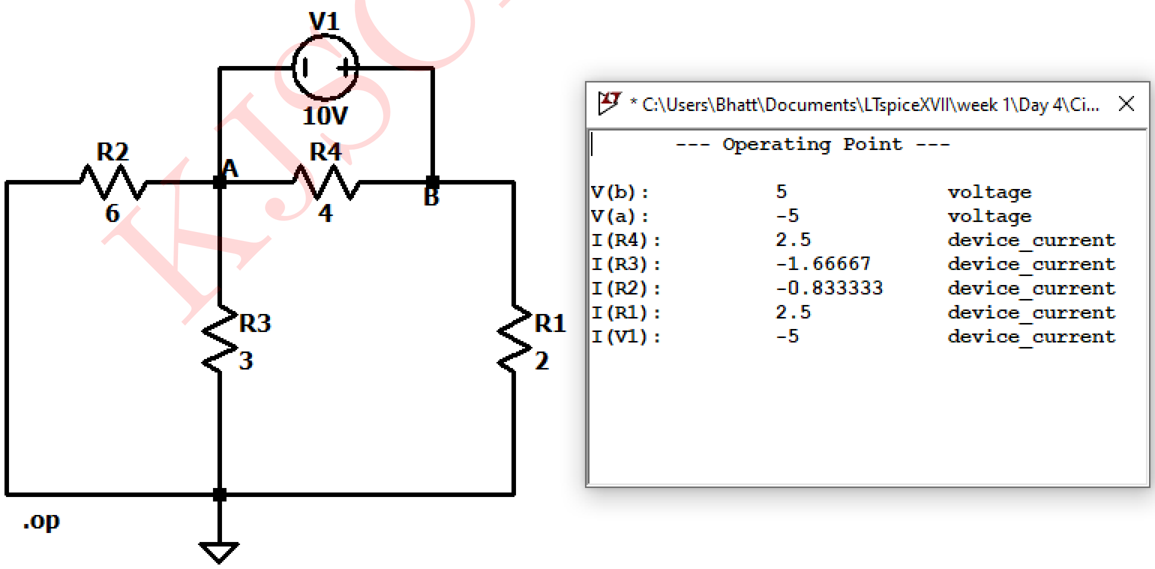


Figure 81: Circuit Schematic and Simulated Results: To determine R_{th} at terminal A-B

Calculation:

$R_{th} = \dfrac{V_1}{I_{V1}}$

$R_{th} = \dfrac{10}{5}$

$R_{th} = 2\ \Omega$

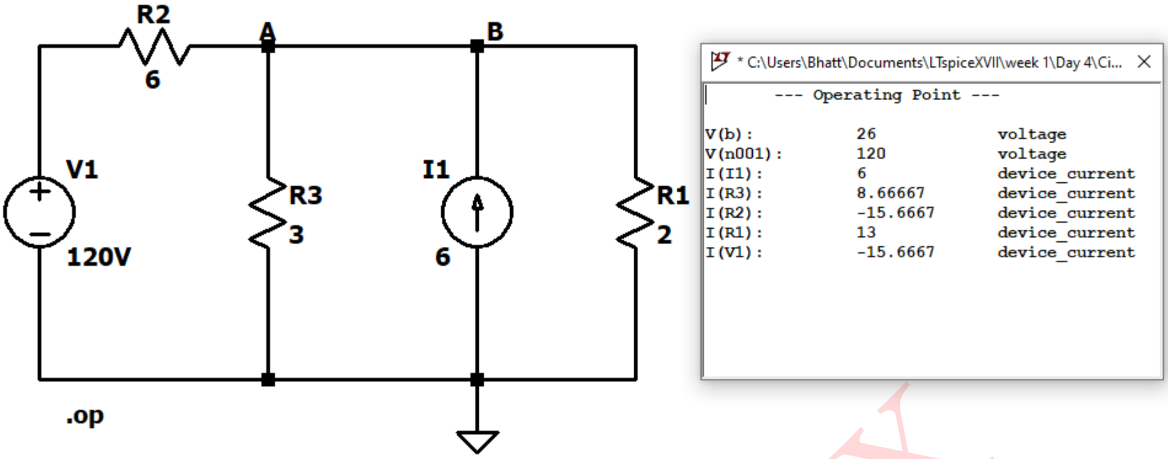


Figure 82: Circuit Schematic and Simulated Results: To determine I_{SC} at terminal A-B

Calculation:

$I_{SC} = I_{R2} + I_{R3}$

$I_{SC} = 15.6667 - 8.6667$

$I_{SC} = 7\text{A}$

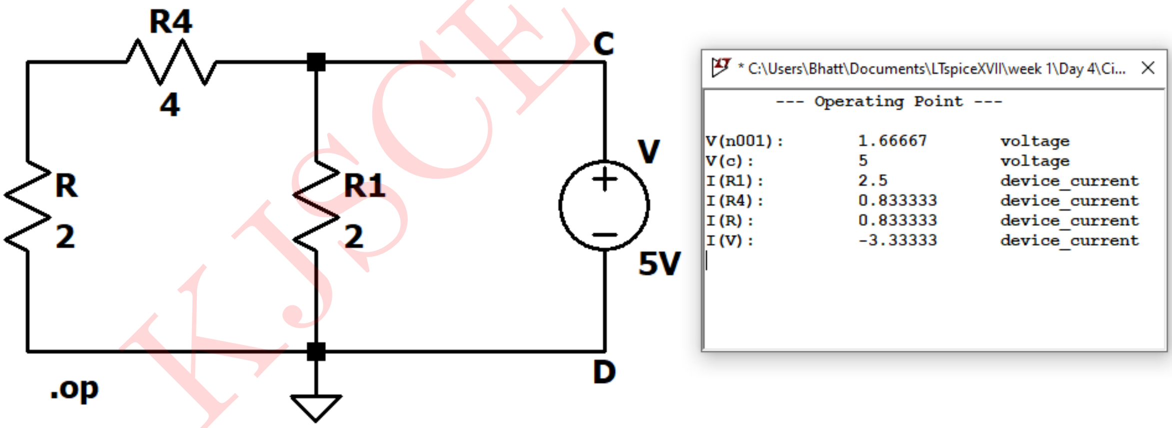


Figure 83: Circuit Schematic and Simulated Results: To determine R_{th} at terminal C-D

Calculation:

$R_{th} = \dfrac{V_1}{I_{V1}}$

$R_{th} = \dfrac{5}{3.33}$

$R_{th} = 1.5\ \Omega$

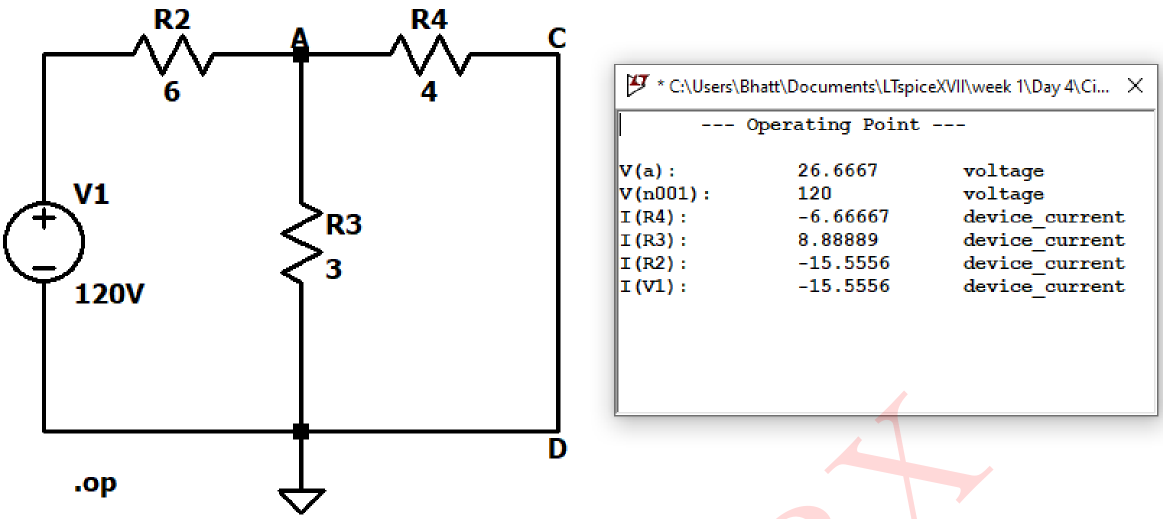


Figure 84: Circuit Schematic and Simulated Results: To determine I_{SC} at terminal C-D

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
R_{th}	4 Ω	4 Ω
I_{SC}	7A	7A

Table 8: Numerical 8 : Terminal A-B

Parameters	Theoretical Values	Simulated Values
R_{th}	1.5 Ω	1.5 Ω
I_{SC}	6.6667A	6.6667A

Table 9: Numerical 8 : Terminal C-D

Numerical 9: Use Norton's theorem to find V_0 in circuit 9 shown in figure 85

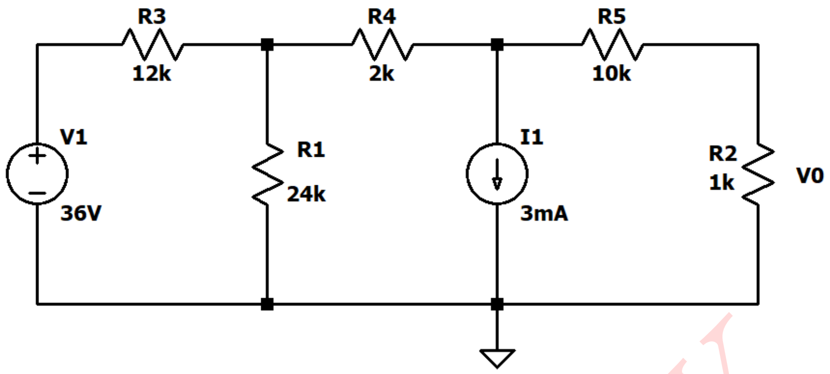


Figure 85: Circuit 9

Solution:

Case 1: To determine R_{th}

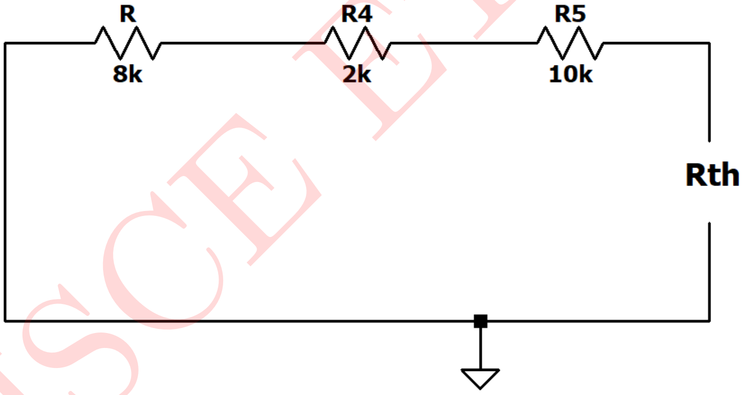


Figure 86: To determine Norton's resistance (R_{th})

Resistors $R_1 = 24$ kΩ and $R_3 = 12$ kΩ are in parallel.

$$\therefore 24\ \text{k}\Omega \parallel 12\ \text{k}\Omega = \frac{24 \times 12}{24 + 12}\ \Omega$$

$$\therefore 24\ \text{k}\Omega \parallel 12\ \text{k}\Omega = 8\ \text{k}\Omega$$

Thus, the circuit is reduced to figure 87

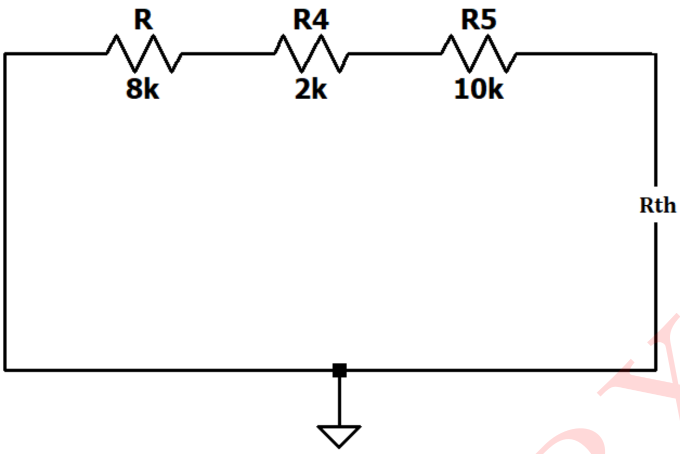


Figure 87: Modified circuit for figure 86

Now, resistor 2 kΩ, 8 kΩ and 10 kΩ are in series.

$\therefore$ 2 kΩ + 8 kΩ + 10 kΩ = 20 kΩ

$\therefore R_{th}$ = **20 kΩ**

Case 2: To determine I_{SC}

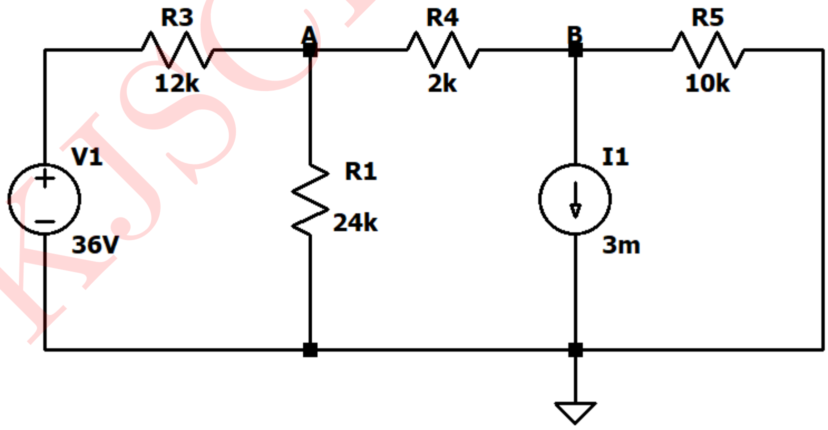


Figure 88: To determine I_{SC}

Applying KCL at Node A,

$$\frac{V_A - 36}{12} + \frac{V_A}{24} + \frac{V_A - V_B}{2} = 0$$

$\therefore 0.625V_A - 0.5V_B - 3 = 0$

$\therefore 0.625V_A - 0.5V_B = 3$ ...(1)

Applying KCL at Node B,

$$\frac{V_B - V_A}{2} + 3 + \frac{V_B}{10} = 0$$

$\therefore -0.5V_A + 0.6V_B - 3 = 0$

$\therefore 0.5V_A - 0.6V_B = 3$ ...(2)

Solving equation (1) and (2) simultaneously, we get

$V_A = 2.4$V

$V_B = 3$V

Now, current flowing through $R_4 = 10$ kΩ is

$$I_{10k\Omega} = \frac{V_B}{10k}$$

$$I_{10k\Omega} = \frac{3}{10k}$$

$I_{10k\Omega} = = 0.3$ mA

Also, $I_{SC} = I_{10k\Omega}$

$\therefore I_{SC}$ **= 0.3 mA**

Norton's Equivalent circuit

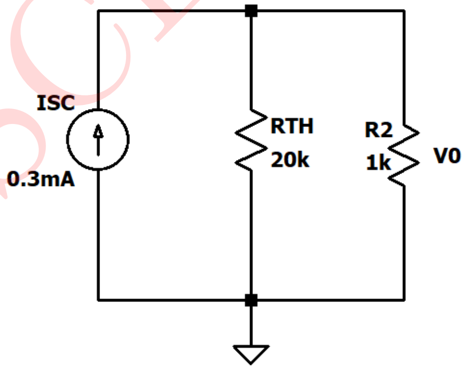


Figure 89: Norton's equivalent circuit

Resistor 20 kΩ and 1 kΩ are in parallel.

$$\therefore 10 \text{ k}\Omega \parallel 1 \text{ k}\Omega = \frac{10 \times 1}{10 + 1} \text{ k}\Omega$$

$\therefore 10 \text{ k}\Omega \parallel 1 \text{ k}\Omega = 0.9523 \text{ k}\Omega$

Now,

$V_0 = I_{SC} \times 0.9523\ \mathrm{k\Omega}$

$V_0 = 0.3\ \mathrm{mA} \times 0.9523\ \mathrm{k\Omega}$

$V_0 = \mathbf{0.28571V}$

SIMULATED RESULTS:

The given circuit is simulated in LTspice and the results obtained are as follows:

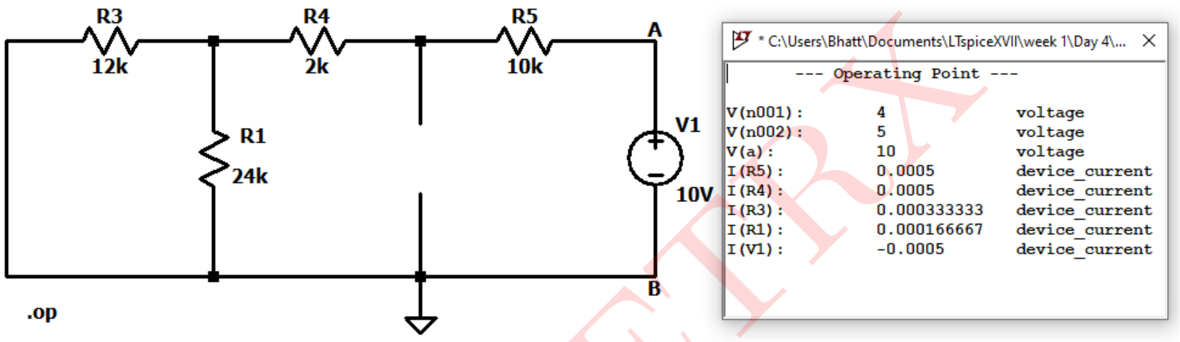


Figure 90: Circuit Schematic and Simulated Results: To determine R_{th}

Calculation:

$R_{th} = \dfrac{V_1}{I_{V1}}$

$R_{th} = \dfrac{10}{0.0005}$

$R_{th} = 20\ \mathrm{k\Omega}$

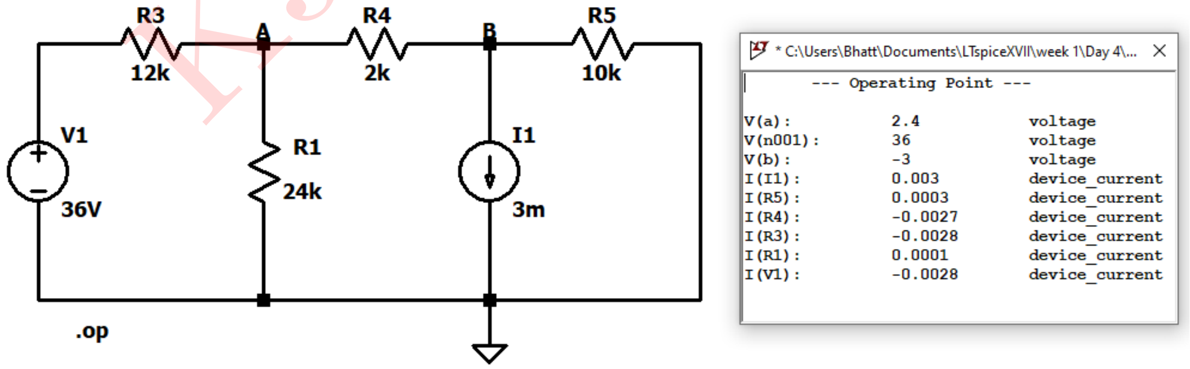


Figure 91: Circuit Schematic and Simulated Results: To determine I_{SC}

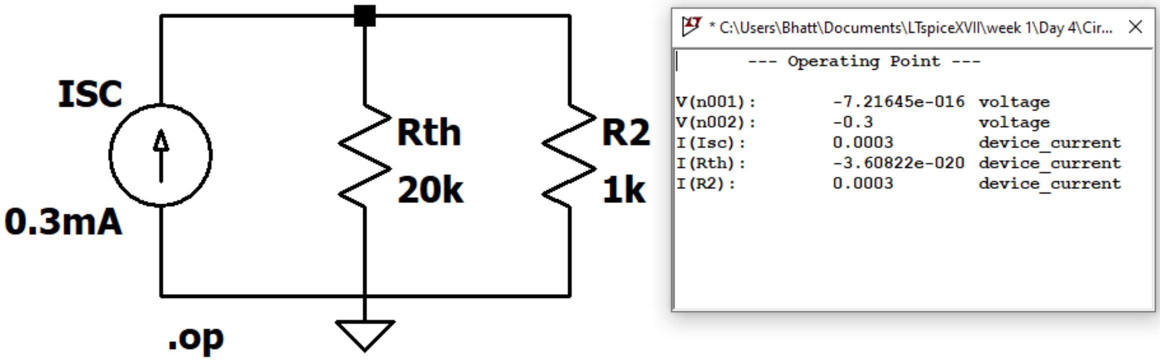


Figure 92: Circuit Schematic and Simulated Results

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
V_0	0.28571V	0.28571V

Table 10: Numerical 9

Numerical 10: In the circuit shown in figure 93, obtain the condition from maximum power transfer to the load R_L. Hence, determine the maximum power transferred.

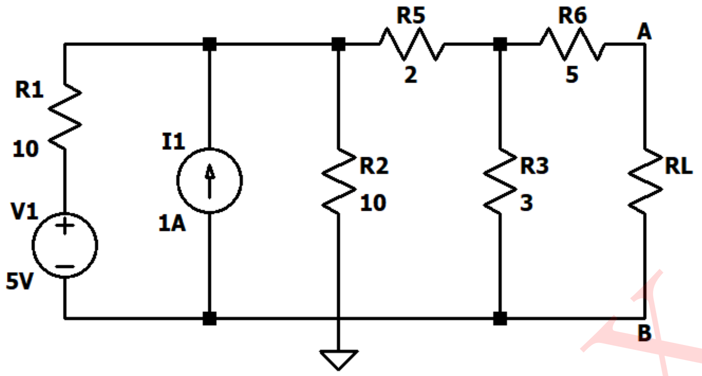


Figure 93: Circuit 10

Solution:

Case 1: To determine R_{th}

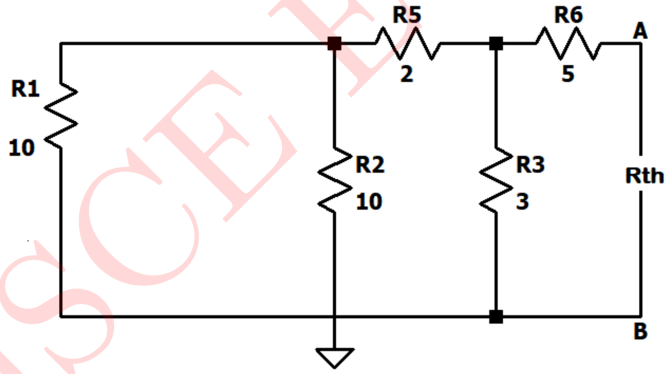


Figure 94: To determine R_{th}

Here, resistor 10 Ω is in parallel with 10 Ω

$$\therefore 10\ \Omega \parallel 10\ \Omega = \frac{10 \times 10}{10 + 10}\ \Omega$$

$$\therefore 10\ \Omega \parallel 10\ \Omega = \frac{100}{20}\ \Omega$$

$$\therefore 10\ \Omega \parallel 10\ \Omega = 5\ \Omega$$

Now, the circuit is reduced to figure 95

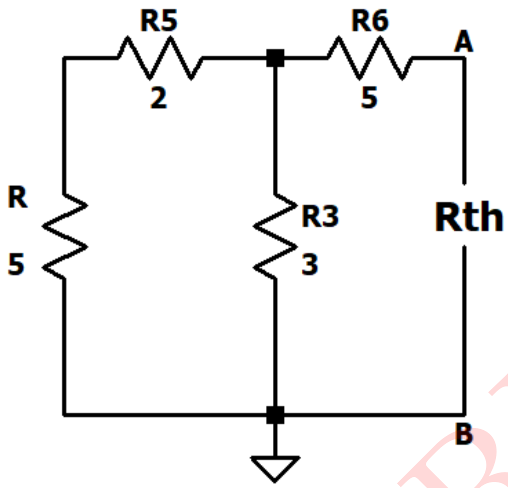


Figure 95: Modified circuit for figure 94

Resistor 2 Ω is in series with 5 Ω

$\therefore 2\ \Omega + 5\ \Omega = 7\ \Omega$

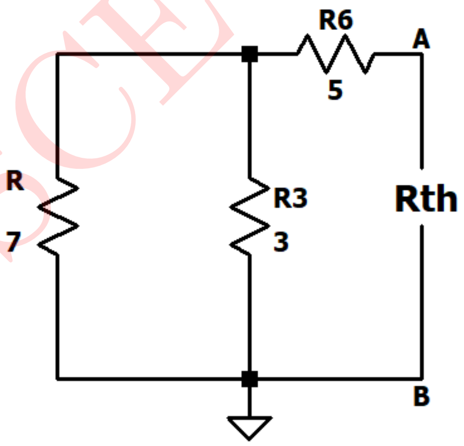


Figure 96: Modified circuit for figure 95

Now, resistor 7 Ω is in parallel with 3 Ω

$\therefore 7\ \Omega \parallel 3\ \Omega = \dfrac{7 \times 3}{7+3}\ \Omega$

$\therefore 7\ \Omega \parallel 3\ \Omega = 2.1\ \Omega$

Also, resistor 2.1 Ω is in series with 5 Ω

$\therefore 2.1\ \Omega + 5\ \Omega = 7.1\ \Omega$

$\therefore R_{th} = \mathbf{7.1}\ \Omega$

Case 2 : To determine V_{th}

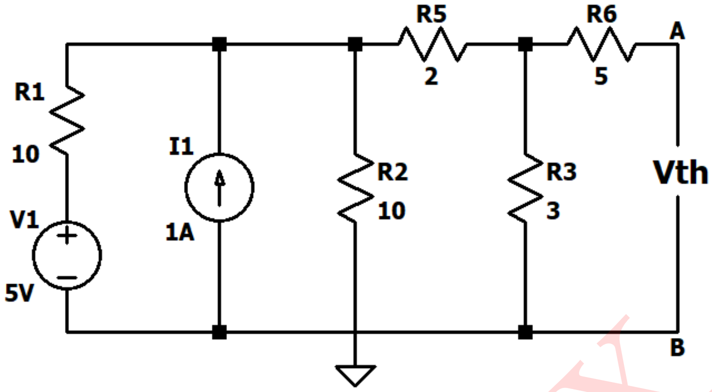


Figure 97: To determine V_{th}

Using source transformation,

$\because I_2 = \dfrac{V_1}{R_1}$

$\therefore I_2 = \dfrac{5}{10}$

$\therefore I_2 = 0.5\text{A}$

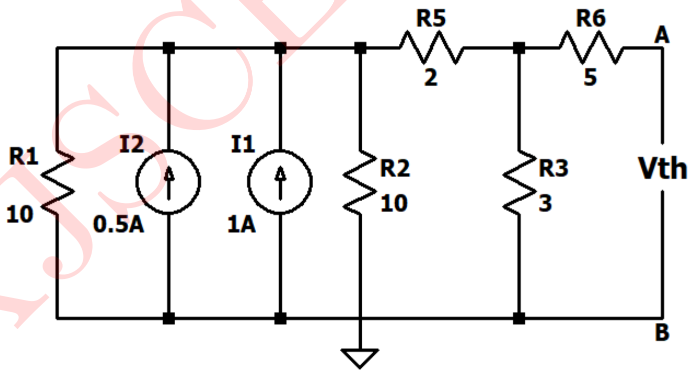


Figure 98: Source Transformation modified circuit for figure 97

Also, Current sources I_1 and I_2 are in parallel

$\therefore I = I_1 + I_2$

$\therefore I = 1 + 0.5$

$\therefore I = 1.5\text{A}$

Now, the circuit is reduced to figure 99

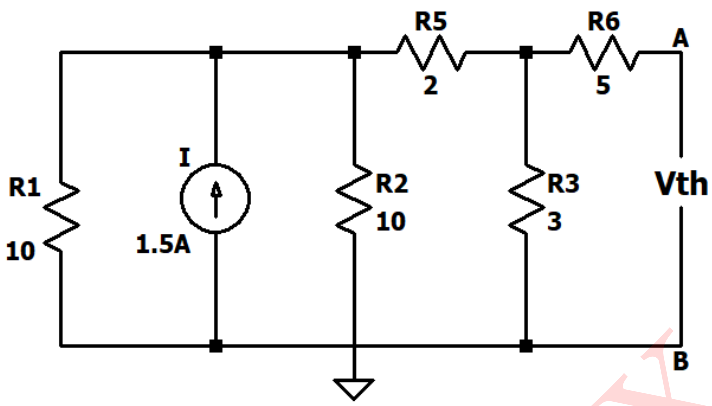


Figure 99: Modified circuit for figure 98

Here, resistor 10 Ω is in parallel with 10 Ω

$\therefore 10\ \Omega \parallel 10\ \Omega = \dfrac{10 \times 10}{10 + 10}\ \Omega$

$\therefore 10\ \Omega \parallel 10\ \Omega = 5\ \Omega$

Using source transformation,

$\because V = I \times R_1$

$\therefore V = 5 \times 1.5$

$\therefore V = 7.5\text{V}$

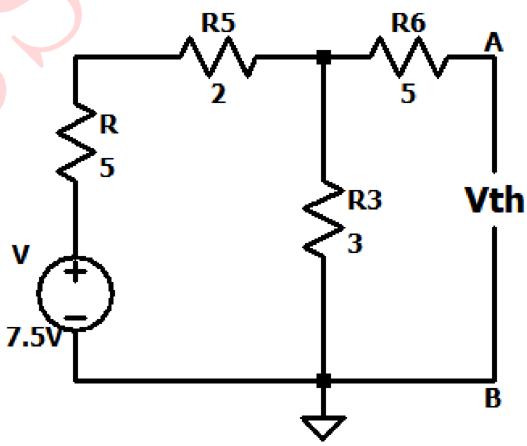


Figure 100: Source Transformation modified circuit for figure 99

Now, resistor 2 Ω is in series with 5 Ω

$\therefore 2\ \Omega + 5\ \Omega = 7\ \Omega$

Using source transformation,

$\because I = \dfrac{V_1}{R_1}$

$\therefore I = \dfrac{7.5}{7}$

$\therefore I = 1.0714\text{A}$

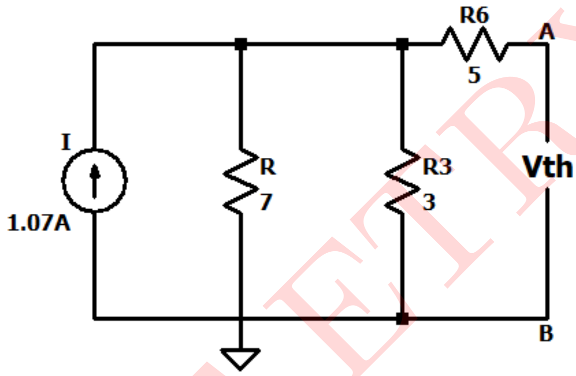


Figure 101: Source Transformation modified circuit for figure 100

Now, resistor 7 Ω is in parallel with 3 Ω

$\therefore 7\ \Omega \parallel 3\ \Omega = \dfrac{7 \times 3}{7+3}\ \Omega$

$\therefore 7\ \Omega \parallel 3\ \Omega = 2.1\ \Omega$

Now, the circuit is reduced to figure 102

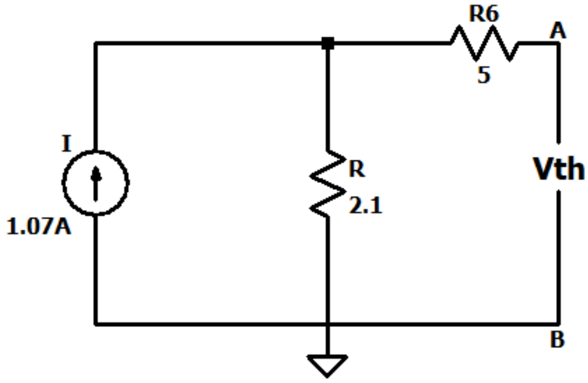


Figure 102: Modified circuit for figure 101

Now,

$V_{th} = I \times R$

$\therefore V = 1.0714 \times 2.1$

$\therefore V = 2.25\text{V}$

$\therefore V_{th} = \mathbf{2.25V}$

Also, according to Maximum Power Transfer Theorem, maximum power will be transferred to R_L when the load resistance is equal to the resistance of the network.

$\therefore R_L = 7.1\ \Omega$

Thevenin's Equivalent circuit

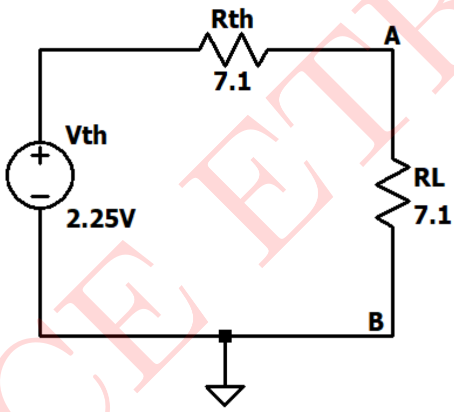


Figure 103: Thevenin's equivalent circuit

Maximum Power transferred is

$$P_{max} = \frac{V_{th} \times V_{th}}{4R_L}$$

$$P_{max} = \frac{2.25 \times 2.25}{4 \times 7.1}$$

$$P_{max} = 178.257\text{mW}$$

SIMULATED RESULTS:

The given circuit is simulated in LTspice and the results obtained are as follows:

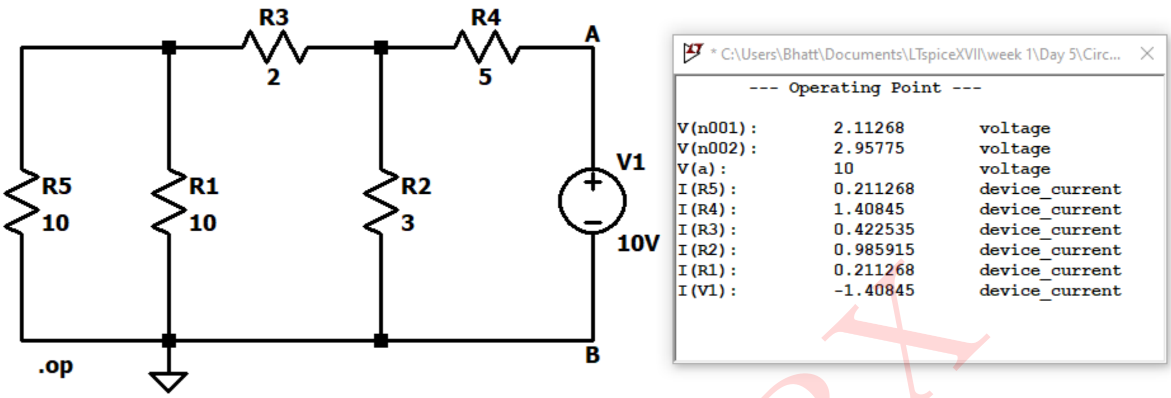


Figure 104: Circuit Schematic and Simulated Results: To determine Rth

Calculation:

$$R_{th} = \frac{V_1}{I_{V1}}$$

$$R_{th} = \frac{10}{1.40845}$$

$$R_{th} = 7.1\ \Omega$$

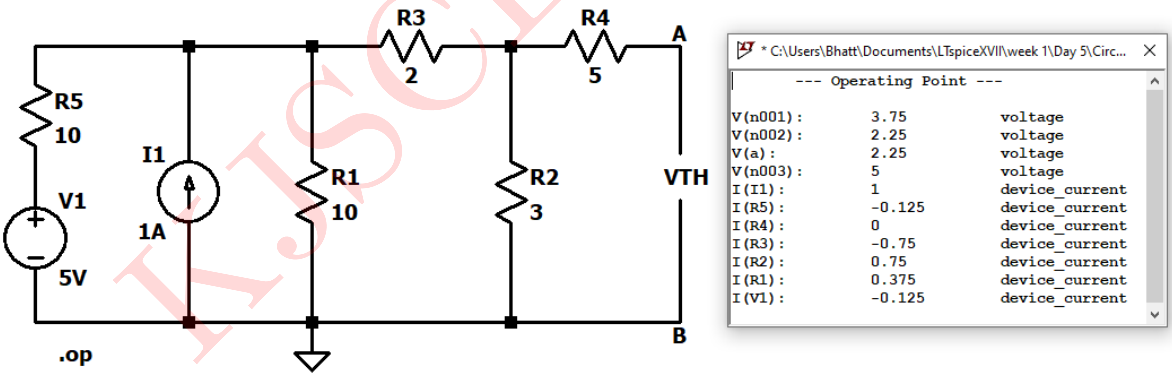


Figure 105: Circuit Schematic and Simulated Results: To determine Vth

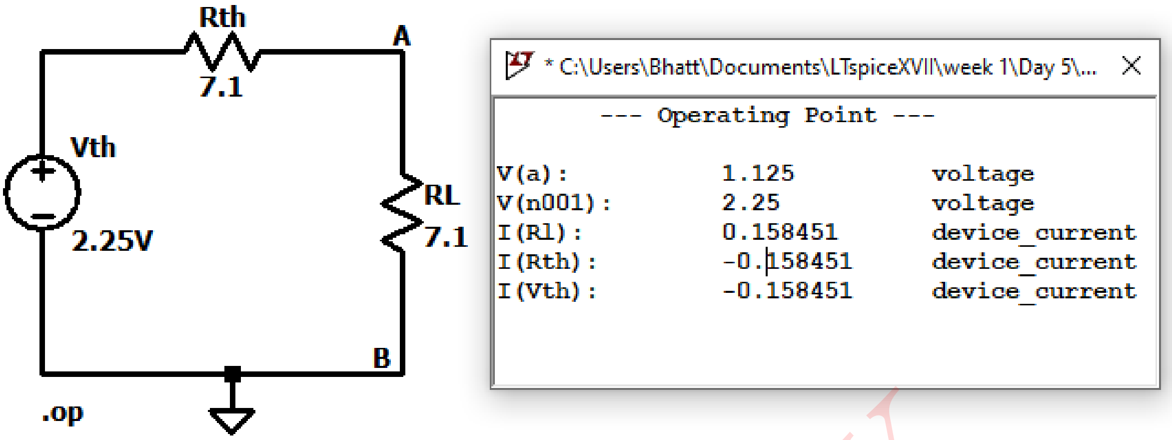


Figure 106: Circuit Schematic and Simulated Results

Calculation:

$P_{max} = I \times I \times R_L$

$P_{max} = 0.1584 \times 0.1584 \times 7.1$

$P_{max} = 178.257\text{mW}$

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
R_L	7.1 Ω	7.1 Ω
P_{max}	178.257mW	178.257mW

Table 11: Numerical 10

Numerical 11: The variable resistor R is adjusted until it absorbs the maximum power from the circuit shown in figure 107
(a) Calculate the value of R for maximum power
(b) Determine the maximum power absorbed by R

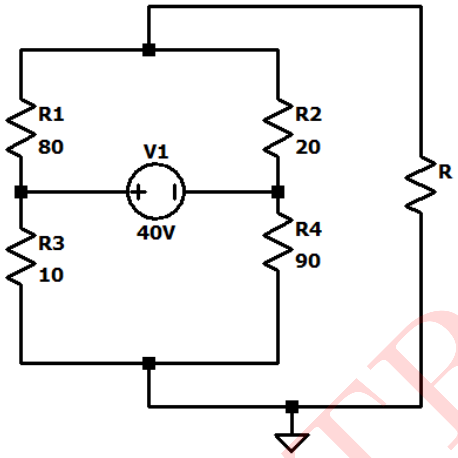


Figure 107: Circuit 11

Solution:

Case 1: To determine R_{th}

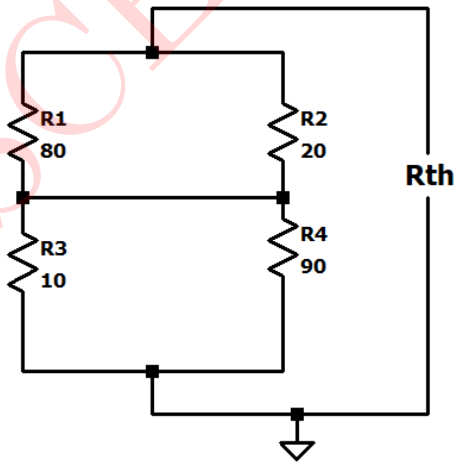


Figure 108: To determine R_{th}

Here, resistor 80 Ω is in parallel with 20 Ω

$$\therefore 80\ \Omega \parallel 20\ \Omega = \frac{80 \times 20}{80 + 20}\ \Omega$$

$$\therefore 80\ \Omega \parallel 20\ \Omega = 16\ \Omega$$

Also, resistor 90 Ω is in parallel with 10 Ω

$$\therefore 90\ \Omega \parallel 10\ \Omega = \frac{90 \times 10}{90 + 10}\ \Omega$$

$$\therefore 90\ \Omega \parallel 10\ \Omega = 9\ \Omega$$

The circuit is reduced to figure 109

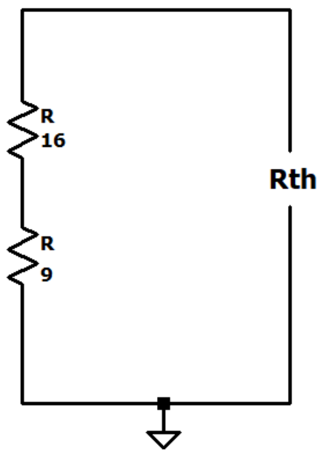


Figure 109: Modified circuit for figure 108

Also, resistor 16 Ω is in series with 9 Ω

$\therefore$ 16 Ω + 9 Ω = 25 Ω

$\therefore R_{th} = \mathbf{25}\ \Omega$

Case 2: To determine V_{th}

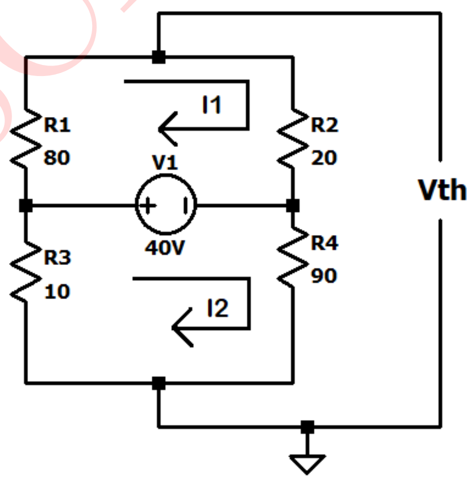


Figure 110: To determine V_{th}

Let I_1 and I_2 be the current flowing through Mesh 1 and Mesh 2 in clockwise direction

Applying KVL to the Mesh 1,

$-80I_1 - 20I_1 = -40$

$\therefore -100I_1 = -40$

$\therefore I_1 = \dfrac{40}{100}$

$\therefore I_1 = 0.4\text{A}$

Applying KVL to Mesh 2,

$-40 - 90I_2 - 10I_2 = 0$

$\therefore -100I_2 = 40$

$\therefore I_2 = \dfrac{40}{-100}$

$\therefore I_2 = -\ 0.4\text{A}$

The negative sign denotes that the current I_2 flows in anti-clockwise direction.

Applying KVL to Mesh 3,

$V_{th} - 90I_2 - 20I_1 = 0$

$\therefore V_{th} = 90I_2 + 20I_1$

$\therefore V_{th} = 90 \times 0.4 + 20 \times -0.4$

$\therefore V_{th} = 36 - 8$

$\therefore V_{th} = \mathbf{28V}$

Now, according to Maximum Power Transfer Theorem, maximum power will be transferred to R when the load resistance is equal to the resistance of the network.

$\therefore R = 25\Omega$

Thevenin's Equivalent circuit

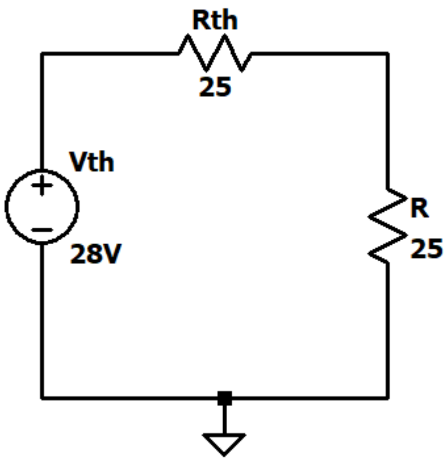


Figure 111: Thevenin's equivalent circuit

Maximum Power transferred is

$$P_{max} = \frac{V_{th} \times V_{th}}{4R_L}$$

$$P_{max} = \frac{28 \times 28}{4 \times 25}$$

$$P_{max} = 7.84 \text{ W}$$

SIMULATED RESULTS:

The given circuit is simulated in LTspice and the results obtained are as follows:

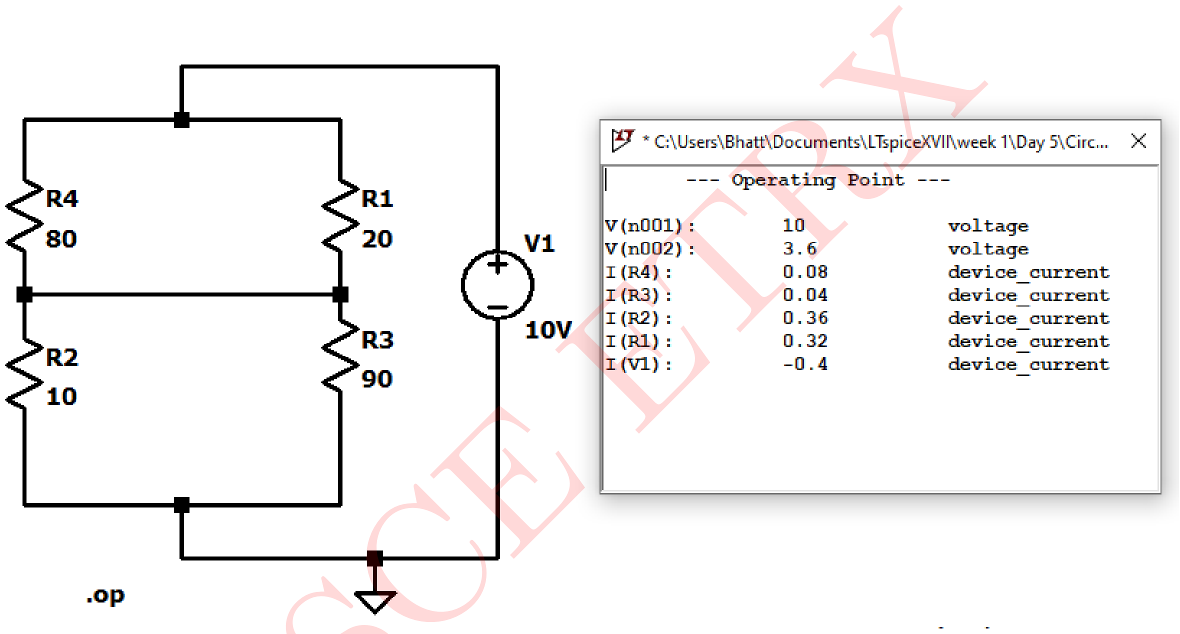


Figure 112: Circuit Schematic and Simulated Results: To determine R_{th}

Calculation:

$$R_{th} = \frac{V_1}{I_{V1}}$$

$$\therefore R_{th} = \frac{10}{0.4}$$

$$\therefore R_{th} = 25 \ \Omega$$

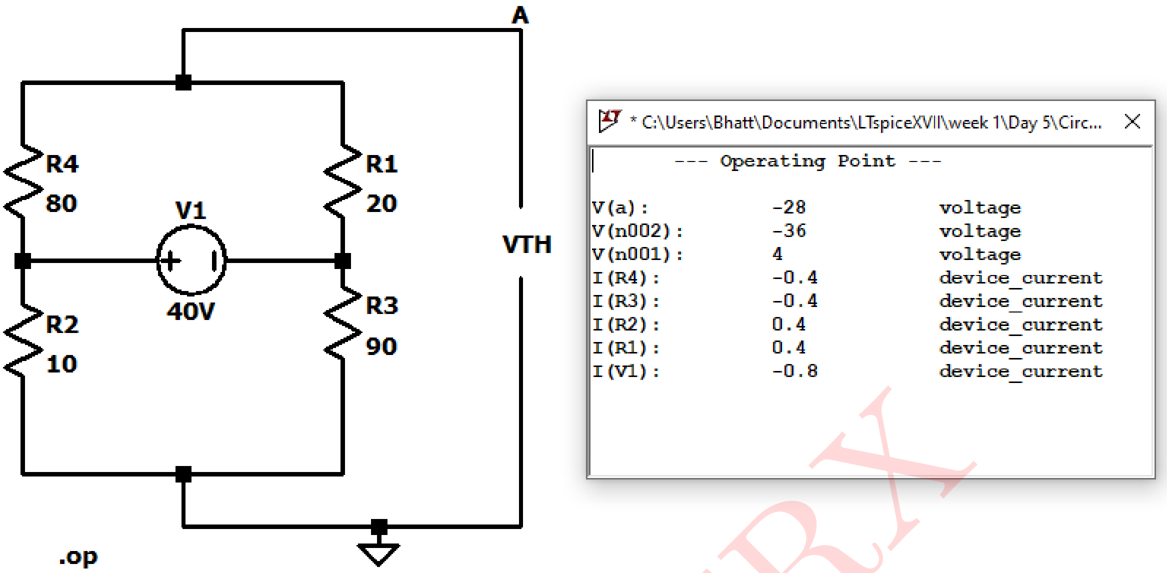


Figure 113: Circuit Schematic and Simulated Results: To determine Vth

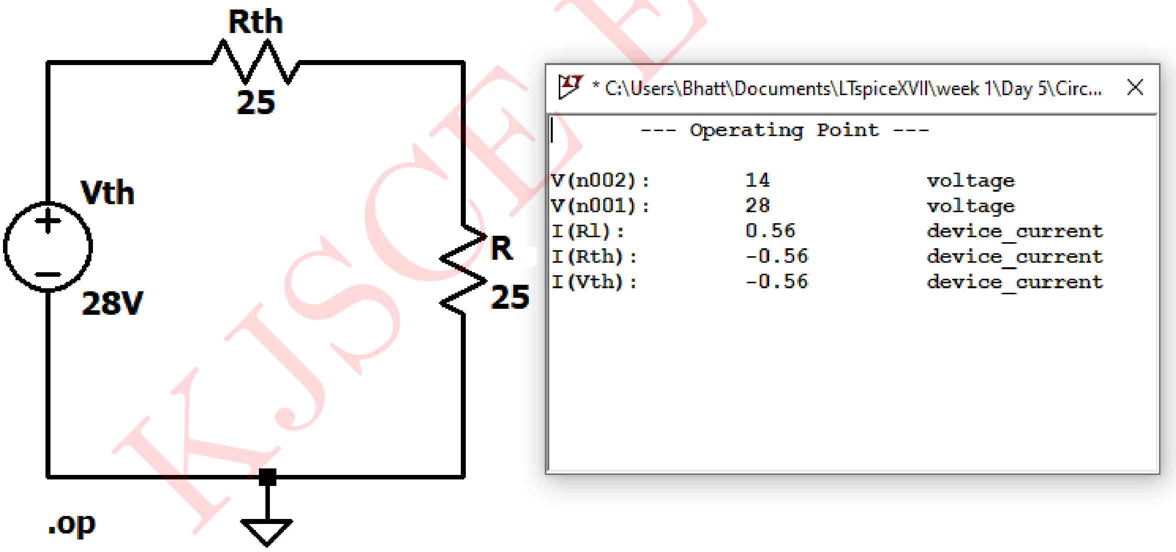


Figure 114: Circuit Schematic and Simulated Results

Calculation:

$P_{max} = I \times I \times R$

$P_{max} = 0.56 \times 0.56 \times 25$

$P_{max} = 7.84\text{W}$

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
R	25 Ω	25 Ω
P_{max}	7.84W	7.84W

Table 12: Numerical 11